ENGINEERING AND EXPEDITIONARY WARFARE CENTER

CONTRACT REPORT
CR-NAVFAC-EXWC-EV-1303
JULY 2013

FINAL REPORT

QUANTIFYING LIFE CYCLE ENVIRONMENTAL FOOTPRINTS OF SOIL AND GROUNDWATER REMEDIES

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REPORT DOCUMENTATION PAGE

FORM APPROVED
OMB NO. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
31-07-2013	Contract Report	June 2011-July 2013

4. TITLE AND SUBTITLE
Quantifying Life-Cycle Environmental Footprints of Soil and Groundwater Remedies

5a. CONTRACT NUMBER
N6258311C0568, N6258311C0569,N6258311C0570

5b. GRANT NUMBER
N/A

5c. PROGRAM ELEMENT NUMBER
N/A

6. AUTHOR(S)
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5d. PROJECT NUMBER
ER-201127

5e. TASK NUMBER
N/A

5f. WORK UNIT NUMBER
N/A

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Naval Facilities Engineering and Expeditionary Warfare Center
1000 23rd Avenue
Port Hueneme, CA 93043

8. PERFORMING ORGANIZATION REPORT NUMBER
CR-NAVFAC EXWC-EV-1303

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
SERDP/ESTCP
4800 Mark Center Drive, Suite 17D08
Alexandria, VA 22350-3605

10. SPONSOR / MONITOR'S ACRONYM(S)
SERDP/ESTCP

11. SPONSOR / MONITOR'S REPORT NUMBER(S)
ER-201127

12. DISTRIBUTION / AVAILABILITY STATEMENT
Distribution Statement A: Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The objective of Environmental Security Technology Certification Program (ESTCP) project ER-201127 (the "project") is to demonstrate/validate (dem/val) two currently used publicly available Department of Defense (DoD) green and sustainable remediation (GSR) spreadsheet tools (SiteWise™ and SRT™) and benchmark these tools against an industry accepted Life-Cycle Assessment (LCA) software package (SimaPro®).

SiteWise™ was updated from Version 2 to Version 3 as part of this project based on initial results from the demonstration sites and associated recommendations from the Benchmark Team. Many of the improvements pertained to methods or footprint factors for calculation of footprint values, and others pertained to ease of use or formatting.
SRT™ was updated from Version 2.1 to Version 2.3 as part of this project, based on initial results from the demonstration sites and associated recommendations from the Benchmark Team. Many of the improvements pertained to methods or footprint factors for calculation of footprint values, and others pertained to ease of use or formatting.
Revisions made to SiteWise™ and SRT™ are summarized in this report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Karla Harre
Click here	Click here	Click here	U	114	19b. TELEPHONE NUMBER *(include area code)* 805-982-2636

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

FINAL REPORT

QUANTIFYING LIFE-CYCLE ENVIRONMENTAL FOOTPRINTS OF SOIL AND GROUNDWATER REMEDIES

ESTCP Project # ER-201127

JULY 2013
Final Version 7/26/13

PREPARED BY NAVAL FACILITIES ENGINEERING AND EXPEDITIONARY WARFARE CENTER AND TETRA TECH

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LIST OF ACRONYMS AND ABBREVIATIONS

AFCEC	Air Force Civil Engineer Center
Alt	alternative
Army	United States Army
Alameda	Former Naval Air Station Alameda OU2B
ASTM	American Society for Testing and Materials
Beale	Beale Air Force Base, Site 35
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalents
CRREL	US Army Cold Regions Research and Engineering Lab
cy	cubic yards
DALY	disability adjusted life years
dem/val	Demonstrate/validate
DNAPL	dense non-aqueous phase liquid
DOD	Department of Defense
ELCD	European Reference Life-Cycle Database
EPA	United States Environmental Protection Agency
ERT2	Environmental Restoration and Technology Transfer
ESTCP	Environmental Security Technology Certification Program
EVO	emulsified vegetable oil
FBR	fluidized bed reactor
FS	feasibility study
GAC	granular activated carbon
GBR	gravel bed reactor
gpm	gallons per minute
GSR	green and sustainable remediation
ICs	institutional controls
IGD	Interim Guidance Document
Inf	infrastructure
ISCO	in-situ chemical oxidation
ISO	International Organization for Standardization
ISTT	in-situ thermal treatment
ITRC	Interstate Technology and Regulatory Council
IX	ion exchange
Kg	kilogram
LRAFB	Little Rock Air Force Base
LCA	Life-Cycle Assessment
LCI	Life-Cycle Inventory

LCIA	Life-Cycle Impact Assessment
Little Rock	Little Rock Air Force Base (LRAFB), Former Skeet Range
MNA	Monitored Natural Attenuation
MJ	Megajoule
MMBTU	Million British Thermal Units
MT	metric ton
NAVFAC EXWC	Naval Facilities Engineering and Expeditionary Warfare Center
NOx	nitrogen oxide emissions
NWIRP	Naval Weapons Industrial Reserve Plant McGregor Area M
O&M	Operations and Maintenance
OSRTI	Office of Superfund Remediation and Technology Innovation
OUSD	Office of the Under Secretary of Defense
P&T	pump and treat
PM	particulate matter (in this report has same meaning as PM10)
PM10	particulate matter less than 10 microns
POTW	publicly owned treatment works
PRB	permeable reactive barrier
PVC	polyvinyl chloride
RACER	Remedial Action Cost Engineering and Requirements
RPM	remedial project manager
SEFA	Spreadsheets for Environmental Footprint Analysis
SDD	Sustainable Design and Development
SOx	sulfur oxide emissions
SRT™	Sustainable Remediation Tool
SVOCs	semi-volatile organic compounds
TRACI	Tool for the Reduction and Assessment of Chemical and other environmental Impacts
Travis	Travis Air Force Base, Site DP039
USACE	United States Army Corps of Engineers
USACE EM CX	United States Army Corps of Engineers Environmental Munitions Center of Expertise
USLCI	U.S. Life-cycle Inventory
VOCs	volatile organic compounds

GLOSSARY OF SELECTED KEY TERMS

Definitions are provided below for key terms used throughout this report. These definitions describe how the terms are used within this report.

Bias	Bias is present if one of the tools generally calculates footprints that are higher than the other tool, for one or more sustainability metrics.
Boundary	Determines the extent of the processes to be included in the Life-Cycle Assessment (LCA) study. In this report the specific boundary evaluated pertained to inclusion or exclusion of infrastructure (see definition of infrastructure below).
CO_2e	Greenhouse gas (GHG) emissions reported in carbon dioxide equivalent. This includes carbon dioxide plus other greenhouse gases such as methane. The gases other than carbon dioxide are converted to an equivalent amount of carbon dioxide based on relative global warming potential versus carbon dioxide, and the results for all the greenhouse gases are then summed together. SimaPro® and SiteWise™ perform calculation of CO_2e, but SRT™ is representative only of CO_2.
Footprint	The quantitative result for one of the sustainability metrics. For instance, the footprint for energy use might be 1.5 million megajoules for a specific remedy alternative.
Footprint Factor	A factor that converts an input or process into a footprint. For instance, a footprint factor will indicate how much NOx is emitted per gallon of diesel fuel combusted.
Infrastructure	A type of system boundary considered in this study. "Without Infrastructure" considers only the direct resource usage of a process. For example, truck transport footprints calculated "without infrastructure" only account for footprints associated with fuel used during the transport process. However, footprints calculated "with infrastructure" account for other contributions to footprints associated with the transport process such as the construction of the truck and maintenance of the road network.
Impact Assessment	Describes environmental impacts (e.g., acidification, smog) that result from footprints. SiteWise™ and SRT™ do not include impact assessment calculations.

Input	Values and choices entered into one of the tools that form the basis of the footprint calculations. In SiteWise™ and SRT™ the input includes (but is not limited to) selections (e.g., type of material, type of equipment) and quantities (e.g., mass, volume, time). In SimaPro® the input includes (but is not limited to) processes (e.g., a specific representation of truck transport for a specific mass and distance, a specific representation of material production for a specific mass). In SimaPro® a combination of processes can be grouped into "assemblies."
Life-Cycle	When considering "cradle to grave," the life-cycle includes environmental impacts from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling.
Process	An item in a SimaPro® database that represents an activity (e.g., transport via airplane) or production of a material (e.g., production of steel) which serves as a basis for footprint calculations.
Qualitative	Qualitative refers to analysis and conclusions without reference to calculated values (informed assertions).
Quantitative	Quantitative refers to analysis and conclusions based on calculated values.
Result Ratio	One footprint result divided by another footprint result, where the larger number is in the numerator and the smaller number is in the denominator (i.e., result ratio is always greater than or equal to 1.0).
Sensitivity Analysis	In this study, refers to evaluation of different footprints calculated by SimaPro when different processes are selected to represent a specific material.
Sustainability Metric	A specific category for which quantitative footprints are calculated. In this study there were five sustainability metrics (energy use, CO_2e or CO_2, NOx, PM10, and SOx).
Work-Around	An approach used to overcome a technical or usability limitation in one of the tools being evaluated.

ACKNOWLEDGMENTS

The project team consisted of the following organizations:

- Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC)
    - Tanwir Chaudhry, Sarah Rollston, Karla Harre

- Tetra Tech
    - Doug Sutton, Rob Greenwald, Mike Pavarini, Sandra Goodrow, Erin Walsh

- United States Army Corps of Engineers Environmental Munitions Center of Expertise (US ACE EM CX)
    - Carol Dona, Dave Becker

- Air Force Civil Engineer Center (AFCEC)
    - Mahalingam Ravichandran, Paul Jurena

- Battelle Memorial Institute
    - Russell Sirabian, Sam Moore

- GSI Environmental
    - Anna Zabierek, Ann Smith, Chuck Newell, Claire Krebs, Vera Stoynova, Vivian Yates

- Avenue C Advisors
    - H. Scott Matthews

- CH2M HILL
    - Doug Downey, Paul Favara, Melissa Mora

NAVFAC EXWC led the project, and had the overall responsibility for ensuring that the goals of the project were met. NAVFAC EXWC also served as the liaison to the Navy sites and contributed to overall technology transfer and project execution. Tetra Tech (including subcontractor H. Scott Matthews) conducted the Life-Cycle Assessment (LCA) analysis for the demonstration sites, was the primary author of the reports, provided LCA expertise, performed the comparison of results to the benchmark tool, and performed the sensitivity evaluations. Battelle was responsible for applying SiteWise™ to three Army/Navy military facilities, while concurrently GSI and their team (including CH2M Hill) were responsible for supplying studies for three Air Force sites that had completed SRT™ applications. Subsequent to initial results from the comparison to the LCA software, Battelle and GSI implemented improvements to their corresponding DoD tools (SiteWise™ and SRT™). Air Force Civil Engineering Center

(AFCEC) served as liaison to Air Force sites and provided technical review and technology transfer. The United States Army Corps of Engineers (USACE) served as liaison to the Army site and provided technical review and technology transfer. Detailed point of contact information is provided in Appendix A.

We would also like to thank all of the site personnel and contractors associated with the six demonstration sites associated with this Environmental Security Technology Certification Program (ESCTP) project. The demonstration sites were as follows:

- US Army Cold Regions Research and Engineering Lab (CRREL)
- Former Naval Air Station Alameda OU2B (Alameda)
- Naval Weapons Industrial Reserve Plant McGregor Area M (NWIRP)
- Beale Air Force Base, Site 35 (Beale)
- Little Rock Air Force Base (LRAFB), Former Skeet Range (Little Rock)
- Travis Air Force Base, Site DP039 (Travis)

Their time and efforts are greatly appreciated.

EXECUTIVE SUMMARY

Objectives

The objective of Environmental Security Technology Certification Program (ESTCP) project ER-201127 (the "project") is to demonstrate/validate (dem/val) two currently used publicly available Department of Defense (DoD) green and sustainable remediation (GSR) spreadsheet tools (SiteWise^{TM} and SRT^{TM}) and benchmark these tools against an industry accepted Life-Cycle Assessment (LCA) software package (SimaPro®).

Project Design

The ESTCP project team consisted of the following four teams:

- SiteWise^{TM} Team –This team applied the SiteWise^{TM} tool and also updated the SiteWise^{TM} tool as part of the project. Battelle, the developer of the SiteWise^{TM} tool, was the sole party in this team.

- SRT^{TM} Team – This team applied the SRT^{TM} tool and also updated the SRT^{TM} tool as part of the project. GSI, the developer of the SRT^{TM} tool, led this team with support from co-developer CH2M Hill.

- Benchmark Team – This team was independent of the SiteWise^{TM} and SRT^{TM} teams, and was responsible for operating the LCA software (SimaPro®), evaluating the results of SiteWise^{TM} and SRT^{TM} against the LCA software, leading the project briefings, and leading the preparation of project reports. Tetra Tech and Dr. H. Scott Matthews (Avenue C Advisors, LLC) comprised the Benchmark Team.

- DoD Team – This team consisted of representatives from the Air Force Civil Engineering Center (AFCEC), Navy (NAVFAC EXWC), and United States Army Corps of Engineers (USACE). These representatives interfaced with installations, offered general guidance throughout the project, and provided input during tool evaluation and report preparation.

During this project SimaPro® was applied for six demonstration sites that consisted of a total of 20 remedy alternatives. For three of the demonstration sites (Army/Navy installations), consisting of 15 remedial alternatives, the SiteWise^{TM} tool was applied for comparison to the SimaPro® results. For the other three demonstration sites (Air Force installations), consisting of 5 remedial alternatives, the SRT^{TM} tool was applied for comparison to the SimaPro® results. Each tool uses footprint factors (e.g., how much NOx is emitted per gallon of diesel fuel combusted) to convert an input or process into a footprint. Comparison of the footprints calculated by SimaPro® and the DoD tools were made for the following five sustainability metrics (the units for the metrics often differ between the tools and require conversion for comparison):

- Greenhouse gas (GHG) emissions which are calculated for multiple greenhouse gases and reported as carbon dioxide equivalent (CO_2e) in SimaPro® and SiteWise™, and calculated for carbon dioxide (CO_2) and reported as CO_2 in SRT™
- Total energy use
- Nitrogen oxide emissions (NOx)
- Particulate matter (less than 10 microns) emissions ("PM10," which in this report is sometimes also abbreviated as "PM")
- Sulfur oxide emissions (SOx)

The dem/val of the DoD tools was performed in three phases:

- Phase 1 - An initial application of the tools was performed to i) develop initial results by comparing footprints calculated by the DoD tools and SimaPro® and ii) identify gaps in the functionality or robustness in the DoD tools.

- Phase 2 - Improvements (including additions and revisions to footprint factors) were then implemented in the DoD tools based on gaps identified in the initial application.

- Phase 3 - Subsequent to the incorporation of tool improvements, a second application of the DoD tools was performed with another comparison made to the SimaPro® results.

Concurrent study activities also included the following:

- During the study a chart was developed to help guide users of the DoD tools in specifying footprint factors for materials that might not be otherwise represented in the tools. This is a significant improvement compared to simply not accounting for any footprint from production of such materials.

- Three of the methods for life-cycle impact assessment (LCIA) included in the version of SimaPro® used in the study were demonstrated for one of the remedy alternatives evaluated in the study. LCIA is used to evaluate the effect of an activity on a particular impact category such as acidification or smog. SiteWise™ and SRT™ do not include LCIA.

Findings

Findings from the project include the following:

- Both SiteWise™ and SRT™ are simple for an environmental professional to understand and apply (i.e., typically requires less than one day of training), are MS-

Excel based (which is a standard DoD software program), and are designed specifically for application to common environmental remedies. By contrast, SimaPro® requires more significant time for training and application, is a general purpose tool not designed specifically for environmental remedies, and requires purchase and licensing for use by environmental professionals.

- A large number of significant improvements were made to the SiteWise™ and SRT™ tools by the tool developers during Phase 2 of this project. SiteWise™ changed from Version 2 to Version 3, and SRT™ changed from Version 2.1 to Version 2.3. Many of the improvements pertained to calculation of footprints (based on the initial phase of the project), and others pertained to ease of use or formatting. A few examples of the numerous improvements to both DoD tools are provided below (the full set of improvements is described in Section 5.9 of the report):

  - Examples of SiteWise™ Version 3 improvements:

    - Includes calculations for NOx, PM, and SOx for material production, whereas Version 2 only calculated the CO_2e and energy footprints for material production.

    - Footprint factors for electricity have been updated and now include impact of transmission and distribution losses as well as resource extraction.

    - Electricity generation efficiency factors (a component of the electricity footprint factors) are now broken down by state instead of a national average, and particulate matter emissions is now included for electricity use.

    - Footprint factors were modified for items such as laboratory analysis, water and wastewater treatment, tillage, generators, and area stabilization.

  - Examples of SRT™ Version 2.3 improvements:

    - Added option for application of state-specific values to represent local electricity mixtures for calculating total energy used, and updated the national average default value for electricity mixtures.

    - Revised and improved footprint factors for bioremediation substrate, oxidants, and granular activated carbon.

    - Incorporated energy footprint for production of PVC for more representative footprint factors. Added clarifying language to remove ambiguity related to life-cycle (cradle to grave) and production (cradle to gate) footprint factors.

- Break-out of diesel consumption values into on-road and off-road categories to account for differences in NOx and PM emissions due to transport versus heavy equipment use. Updated fuel efficiency values for all on road and off road equipment.

- There are no remedy alternatives where the footprint totals were within a factor of 1.2 (i.e., 20%) between the DoD tool and SimaPro® for all five sustainability metrics evaluated, suggesting that variations in footprints of greater than 20% are typical (i.e., should be expected) when comparing the DoD tools and SimaPro®. However, with a few notable exceptions (discussed in the report) the DoD tools provide total footprints for remedy alternatives that are generally comparable to SimaPro® results.

    - For CO_2e and energy, the total remedy footprints from SiteWise™ Version 3 were always within a factor of 1.6 of the results from SimaPro® (i.e., not extremely different) and 10 of the 15 alternatives evaluated were within a factor of 1.2.

    - With the exception of Little Rock, for CO_2 and energy, the total footprints for each remedy alternative from SRT™ Version 2.3 are always within a factor of 1.7 of the results from SimaPro® (i.e., not extremely different).

    - If total footprints for remedy alternatives at the same site are compared, the ranked alternatives based on footprints are mostly (but not always) in agreement between the tools.

- There are many decisions for the user to make when using SimaPro® regarding choices for processes (e.g., selections for materials or transportation) and the footprints may vary considerably depending on those choices. The best choice will typically not be clear to a typical environmental project user (and in some cases there may not be a best choice), so it is not clear that SimaPro® results provide for a true "benchmark." The DoD tools require fewer choices for input (i.e., the process for specific remedy items is more clearly defined within the tool). Footprint differences between tools do not imply results from the DoD tools are invalid. Depending on the scenario and process selections of the SimaPro® user, the footprints from the DoD tool may be more applicable to a specific remedy than the SimaPro® footprints.

- As would be expected, the footprints calculated by SimaPro® "without infrastructure" are lower than the footprints calculated "with infrastructure." The effect of changing the system boundary to include infrastructure varies by alternative and sustainability metric. In some cases, changing the boundary impacts footprints by 5% or less, and in other cases it impacts footprints by more than 40%. This is one factor that complicates the use of SimaPro® as a benchmark.

  - Conversely, the footprint factors used in SiteWise™ and SRT™ generally do not include infrastructure. For example, truck transportation in SiteWise™ considers the fuel combusted for truck transport and the process of extracting crude oil and refining it into diesel fuel; however, SiteWise™ does not include infrastructure items such as the construction of the truck. For SRT™, transportation by truck considers only the fuel combustion by default. A help button within the tool and User Guide provides the user guidance on how to consider production emissions apart from combustion. For the other materials or processes represented in these tools, the inclusion or exclusion of infrastructure in the footprint factors depends on the source of the footprint factors (the SRT User Guide documents the inclusion or exclusion of infrastructure).

- A sensitivity analysis was performed to illustrate how footprints calculated by SimaPro® might vary due to different processes selected by the user. The following five materials were evaluated: steel, vegetable oil, PVC, gravel, and cement. The results of the sensitivity analysis indicated that there are a multitude of viable material options available to represent a specific material in SimaPro® (e.g., many different processes available to choose from for "steel"), and the SimaPro® results are highly sensitive to the choices the user makes. For a set of potentially viable SimaPro® processes for a specific material, the minimum and maximum footprint results calculated by SimaPro® typically differ by a factor greater than 2 and sometimes differ by a factor of 10 or more. There are some instances where the result from the DoD tool falls within the range of the SimaPro® results. However, there are also instances where the DoD tool result is higher than the highest SimaPro® result or lower than the lowest SimaPro® result.

- The remedy item that contributes most to the footprints depends on the remedy. Electricity use, fuel use, materials, transportation, and disposal were all indicated as the highest contributor for one of the sustainability metrics for at least one remedy alternative.

- Some bias (high and low) is evident when the DoD tool footprints are compared to the SimaPro® footprints. In specific cases where SimaPro® accounts for items that are not accounted for in one of the DoD tools, there is bias towards higher results in SimaPro®. For other items, however, it is not possible to make a general statement regarding systematic bias because SimaPro® results being higher or lower than one of the DoD tools could simply be due to user selections in SimaPro® (as discussed above).

- The SimaPro® tool is more expensive than the SiteWise™ and SRT™ tools in all aspects summarized below.

Cost Element	Estimated Costs: SiteWise™ and SRT™	Estimated Cost: SimaPro®
Start-Up Software Cost Training/learning	 Free $400 to $1,600	 $ 3,000 to $12,000 $ 2,400 to $ 8,000
Annual Maintenance Costs Software Updates	 Free	 $1,500/yr or more
Estimated Application Costs Per Project executed by a professional trained to use the software	$3,000 to $10,000	$5,000 to $15,000

- As detailed in Section 8.3 there are significant limitations for SimaPro® with respect to ability to share files for collaboration, peer review, and documentation. The database libraries for SimaPro® are large and complex, and each SimaPro® project depends directly on these libraries. As a result, SimaPro® projects are difficult to transfer to others. In contrast, both DoD tools allow the user to provide the tool spreadsheets to peers, collaborators, or reviewers (e.g., via email). In SimaPro® there is also the potential for updates to the libraries to change the results for previously conducted projects, so while updates are generally considered a positive this can unfortunately pose a significant challenge for quality control and repeatability.

<u>Conclusions/Recommendations</u>

Key conclusions from the study include the following:

- In general, all of the tools appear to provide reasonable footprints for sustainability metrics representing GHGs, energy use, and criteria pollutants (the criteria pollutants calculated by the DoD tools are NOx, PM, and SOx).

    - The results from the DoD tools were not demonstrated to always be within a factor of 1.2 of the SimaPro® results. However, SimaPro® provides varied results (based on user selections) that also differ from each other by more than a factor of 1.2.

    - It is expected that use of any of the tools to rank footprints for competing remedy alternatives will produce generally similar rankings (though perhaps not the same exact rankings) and provide adequate results for the decisions they are intended to support.

- The DoD tools have distinct advantages over SimaPro® with respect to cost, ease of use, and ability to share files for collaboration, peer review, and documentation.

- Significant improvements were made to both DoD tools as part of this project, with respect to both the calculation of footprints and the usability of the tools.

- Although the two DoD tools were not directly compared against each other in this project, it is evident based on the dem/val activities performed in this project that there are differences in the footprint factors used to calculate footprints from user inputs.

Key recommendations from the study include the following:

- Use of the SiteWise™ and SRT™ tools should generally be preferred for use over the SimaPro® tool for DoD projects. SimaPro® would be recommended for cases where outputs for footprints other than those offered by the DoD tools are needed.

- It is recommended that future efforts focus on improving standardization between tools used for DoD projects.

    - Based on this dem/val effort, efforts to standardize footprint factors are difficult to base on results from SimaPro®, and would be better achieved by consensus of experts in the field.

    - Improved consistency between DoD tools would also result from standardizing the sustainability metric for global warming to CO_2e.

- The DoD tools should continue to be improved over time to add any items/processes that are not well represented in the tools.

1.0 INTRODUCTION

Green and Sustainable Remediation (GSR) has become an essential element of soil and groundwater remediation activities.

- GSR tools quantify the secondary effects (i.e., unintended environmental impacts) that the remediation has on the environment (e.g., resource consumption and emissions of pollutants).

- These impacts can be quantified with respect to "sustainability metrics" such as emissions of greenhouse gases, energy use, and emissions of priority pollutants (e.g., nitrogen oxides, sulfur oxides, and particulate matter).

- A footprint is quantitative result for one of the sustainability metrics. For instance, the footprint for energy use might be 1.5 million megajoules (MJ) for a specific remedy alternative.

- Tools are available that allow remedy managers to estimate and report the footprints for existing remediation activities and/or potential remedy alternatives, and to evaluate options for reducing the footprints while meeting the regulatory requirements governing a remedy.

- These tools utilize footprint factors to convert an input or process into a footprint. For instance, a footprint factor will indicate how much nitrogen oxide emissions (NOx) result per gallon of diesel fuel combusted.

The purpose of this project is to demonstrate/validate (dem/val) two currently used, publicly available Department of Defense (DoD) GSR spreadsheet tools (SiteWise™ and SRT™) and benchmark these tools against an industry accepted Life-Cycle Assessment (LCA) software package (SimaPro®). The DoD tools have been and continue to be applied at DoD facilities, but to date, the accuracy and completeness of the calculated footprints have not been compared to an appropriate benchmark.

For this project, GSR tools were applied to six demonstration sites that included a total of 20 remedial alternatives:

- Three demonstration sites included SiteWise™ and SimaPro®.

- Three demonstration sites included SRT™ and SimaPro®.

The two DoD tools were not compared directly to each other. Based on the analysis of initial results for these demonstration sites, improvements to the two DoD tools were recommended. The tool developers were subsequently able to implement many of these recommendations as part of this project. Results from the tools from before and after tool modifications are presented in this report.

1.1 BACKGROUND

SiteWise™ and SRT™ are spreadsheet-based GSR quantification tools developed for DoD that utilize literature referenced footprint factors to convert remedy information into footprints for specific sustainability metrics. SimaPro®, a general-use LCA software package, guides its user through the four steps of the LCA process as defined by International Organization for Standardization (ISO) Standards 14040 and 14044 (discussed in more detail in Section 2.1). The SimaPro® software and its process models are generally more robust than the two DoD tools (and other similar non-DoD tools) with respect to processes included and options for output, but as a result SimaPro® is more complicated and expensive for an environmental professional to apply because it is not structured specifically for environmental remedies and selecting the best processes to represent remedy items can be challenging (specifics are discussed later in this report).

1.2 OBJECTIVES OF THE DEMONSTRATION

The overall technical objective of the project is to dem/val two currently used, publicly available DoD tools for GSR and benchmark these tools against an industry accepted LCA software package (SimaPro®). The project has the following specific objectives:

- For a variety of environmental remedies at DoD sites, dem/val the ability of the SiteWise™ and SRT™ tools to quantify footprints using SimaPro® as a benchmark, and document the significant differences in functionality and results between the DoD tools and SimaPro®. The two DoD tools are benchmarked separately against SimaPro® and are not compared to each other.

- Document and compare the differences in footprints calculated by the DoD tools relative to footprints calculated by SimaPro®.

- Identify commonly used materials and/or activities that are not well represented in the tools, and suggest how such items can best be represented using generic inputs or other work-arounds.

- Identify which improvements to the SiteWise™ and SRT™ tools (such as revised footprint factors, addition of materials or activities, etc.) are needed. Implement improvements that can be made to SiteWise™ and SRT™ within the project budget (performed by the respective tool developers, both of which are part of the project team).

- Document the practices, procedures, and nuances of applying LCA software to remediation.

- Conduct sensitivity analyses that evaluate the sensitivity of footprints to key inputs of LCA tools, as well as how far back in the supply chain the analysis accounts for (i.e., “system boundary”).

1.3 REGULATORY DRIVERS

1.3.1 Executive Orders

Current DoD policy regarding GSR is driven by the following two Executive Orders regarding Federal Agencies:

- Executive Order 13514

  EO 13514 seeks "to establish an integrated strategy towards sustainability in the Federal Government and to make reduction of greenhouse gas emissions a priority for Federal agencies" (Federal Register, October 8, 2009). The EO establishes goals for reductions in greenhouse gases, energy consumption, and potable and industrial water use by Federal agencies.

- Executive Order 13423

  The purpose of EO 13423 is to "strengthen the environmental, energy, and transportation management of Federal agencies" (Federal Register, January 26, 2007). The goals established under this EO include the improvement of energy efficiency and reduction of greenhouse gas emissions to conduct the agencies' mission in an environmentally, economically and fiscally sound, integrated, continuously improving, efficient and sustainable manner.

1.3.2 Programs to Implement GSR in DoD and Regulatory Agencies

In August of 2009, the office of the Under Secretary of Defense (OUSD) released a memorandum regarding GSR stating its commitment to conducting DOD's environmental program in a sustainable manner, in accordance with EO 13423. The memorandum stresses the need to decrease energy demand for existing and future remedial systems and consider other available options to minimize the environmental impact of these systems. The memorandum provides areas where opportunities to implement GSR practices exist, including the following:

- Sustainability analysis during remedy selection

- Sustainability analysis on existing remedial systems

- Reduction in energy, water, and emissions of greenhouse gases (GHGs) and criteria air pollutants

- Waste minimization practices

- Use of passive sampling techniques

- Implementation of in situ remedial technologies such as enhanced bioremediation, phytoremediation

- Minimizing the overall environmental footprint of the remedial system and monitoring program (OUSD, 2009)

The Defense Environmental Restoration Program (DERP) Management Manual (DoD 2012) supersedes the OUSD Memorandum from 2009 and instructs DoD Components to consider and implement GSR opportunities in all phases of remediation and for all DoD environmental remediation projects, when feasible, and ensure the use of GSR remediation practices, where practicable based on economic and social benefits, as well as costs. In addition, the March 2012 DERP Manual gives phase-specific instruction for GSR consideration in the Feasibility Study and Remedial Action Work Plan (Design) phases, and within optimization evaluations performed in the Remedial Operation phase.

A brief summary of GSR programs for the Navy, Army, Air Force, EPA, and the Interstate Technology and Regulatory Council (ITRC) is provided below.

United States Navy - For facilitating Navy-wide application of GSR at remediation sites, the Navy issued a guidance document titled Guidance for Green and Sustainable Remediation (GSR) (NAVFAC, June 2011) that expands on the concepts and application of GSR within the framework of optimization principles, and provides remedial project managers (RPMs) with a clear approach to incorporating GSR in the remediation process. In addition, Naval Facilities Engineering Command (NAVFAC) issued a directive in August 2010 that requires GSR evaluations to be conducted at all sites during remedy selection. The Department of the Navy (DON) issued an policy memorandum, *Policy for Optimizing Remedial and Removal Actions at all DON Environmental Restoration Program Sites* (DON, April 2012), that requires among other things that GSR be incorporated into the optimization process and that SiteWise™ is used in all GSR actions. In addition, this policy requires that opportunities to evaluate GSR practices shall be considered and implemented throughout all phases of remediation.

United States Army (Army) and United States Army Corps of Engineers (USACE) - In compliance with EO 13423, the Army has outlined its approach to GSR in the FY 2010-2011 Army Environmental Cleanup Strategic Plan (Army, 2009). The Plan states, “the Army’s approach to ‘green remediation’ seeks to preserve our natural resources, minimize energy use, minimize carbon dioxide emissions, maximize recycling and reuse of materials, and minimize the Army’s environmental footprint.” The approach encourages “project managers to seek opportunities to incorporate options for minimizing the impact on the environment of cleanup actions undertaken at Army installations.” The USACE prepared an Interim Guidance Document (IGD) 10-01: *Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects* (USACE, March 2010). Subsequently, the Army funded a study performed by the USACE to provide information and recommendations for the consideration and/or development of Army-wide GSR guidance and policy. This study: 1) followed the consideration and incorporation of GSR practices into Army environmental remediation projects; 2) ascertained the effectiveness of the GSR practices that are considered and incorporated and 3) provided procedures by which GSR practices that are shown to be effective can be identified, considered, implemented and documented by project teams working on Army sites. The Army is currently considering Army-wide GSR policy and guidance based on the results of the study.

United States Air Force - The *Air Force Sustainable Ops Policy Statement* (AF, 2001) states that "it is Air Force policy to apply sustainable development concepts in the planning, design, construction, environmental management, operation, maintenance and disposal of facilities and infrastructure projects, consistent with budget and mission requirements." In a memorandum distributed on July 31, 2007, HQ USAF issued the *Air Force Sustainable Design and Development (SDD) Policy*. The goal of this policy is to reduce the environmental impact and total ownership cost of facilities; improve energy efficiency and water conservation; and provide safe, healthy, and productive built environments. This policy also directs facilities to be consistent with the Energy Policy Act of 2005 and Executive Order 13423 (AF SDD, 2007).

United States Environmental Protection Agency - The EPA distinguishes between "green remediation" and "green & sustainable remediation." Green remediation considers only the environmental impacts of remedy implementation, whereas GSR considers these environmental impacts plus financial considerations and societal considerations. EPA's green remediation policies are summarized in the *Principles for Greener Cleanups*, the *Superfund Green Remediation Strategy*, and the ten EPA Regional Greener Cleanups policies. All of these EPA documents are available at www.cluin.org/greenremediation. In general the EPA principles and policies promote strategies and practices that reduce the environmental footprints of remedies in five core areas: energy, air quality (including greenhouse gas emissions), water, materials & waste, and land & ecosystems. Regarding footprint quantification, EPA has developed a document titled *Methodology for Understanding and Reducing a Project's Environmental Footprint* (EPA 542-R-12-002, 2012) and accompanying footprint calculation spreadsheets called Spreadsheets for Environmental Footprint Analysis (SEFA). The document and spreadsheets encourage the use of environmental footprint quantification, presents specific green remediation metrics to quantify, and presents a methodology for the process of quantifying those metrics or footprints. Similar to the DoD tools evaluated in this project, SEFA is a Microsoft Excel spreadsheet-based tool.

ITRC - The ITRC GSR team developed a guidance document titled *Green and Sustainable Remediation - A Practical Framework* (ITRC 2011) for evaluating and implementing GSR in remediation programs. The team included representatives from regulatory agencies from 15 states, thus indicating a significant interest in GSR from state regulatory agencies. The team did not develop any footprint calculation tools, and the guidance document referred to SRT™, SiteWise™, and other tools for footprint calculations pertaining to remediation systems. The ITRC GSR team is currently providing on-line training about the GSR framework.

1.4 FOOTPRINTS EVALUATED

For this project, comparison of the footprints calculated by SimaPro® and the DoD tools were made for the following five sustainability metrics (the units for the metrics often differ between the tools and require conversion for comparison):

- GHG emissions which are calculated for multiple greenhouse gases and reported as carbon dioxide equivalent (CO_2e) in SimaPro® and SiteWise™, and calculated for carbon dioxide (CO_2) and reported as CO_2 in SRT™

- Total energy use

- NOx

- Particulate matter (less than 10 microns) emissions (“PM10,” which in this report is sometimes also abbreviated as “PM”)

- Sulfur oxide emissions (SOx)

These five metrics were the focus of the project per the Demonstration Plan, and were chosen because they are the metrics provided as output by each of the tools. Water use for remediation (e.g., for mixing with chemicals) can have footprints, such as GHG emissions and energy use to extract/transport/treat potable water, and these footprints were included in this project to the extent each tool included such calculations for water use (discussed below). Actual use of water as a resource, and re-use or reclamation of water, were not addressed as separate metrics in this project because they are not included as output by all three tools. Additionally, addressing water reclaimed by successful remediation is subject to complicating factors, such as differentiating between “limited use” and “full use” of the resource resulting from the remediation (and the definition of “limited use” and “full use”). Reclamation of water due to successful remediation is perhaps best addressed qualitatively as part of a site-specific GSR evaluation.

2.0 TECHNOLOGY

For this dem/val project, the following three GSR quantification tools were evaluated:

- SimaPro® (LCA software)
- SiteWise™
- SRT™

SimaPro® is for-purchase software that is widely used for many types of LCA evaluations. However, it is not specifically designed for assessment of soil and groundwater remedies. SiteWise™ and SRT™ are publicly available (freeware) spreadsheet-based tools that are specifically designed for soil and groundwater remedies. The details of the three technologies are discussed below.

2.1 TECHNOLOGY DESCRIPTION

2.1.1 SimaPro® (LCA Software) Description

SimaPro®, developed by Pré Consultants in the Netherlands, allows the modeling of products and systems from a life-cycle perspective.

- SimaPro® can cost between $3,000 and $12,000 dollars to purchase depending on the number of user licenses and features, with additional annual costs in service and support, if required.

- The SimaPro® LCA software provides a user interface and tools to facilitate the use of life-cycle inventory databases in LCA studies that are consistent with governing ISO Standards 14040:2006 and 14044:2006.

- SimaPro® comes fully integrated with life-cycle databases that are purchased (for instance, Ecoinvent is an optional database that can be purchased) and SimaPro® can be used in a variety of applications, including footprint calculation, environmental impact of products or services, and product design comparisons.

SimaPro® provides functionality to guide the user through four steps of the ISO standard process:

- Definition of goal and scope
- Inventory of system inflows and outflows
- Impact assessment
- Interpretation of results

These four steps are described in more detail below.

<u>Definition of Goal and Scope</u> – This step allows the user to document a description of the project, select the libraries of information that will be used for the project, define the functional unit to be studied, and assign boundaries and data quality requirements. Defining the functional unit establishes a common unit for comparison (e.g., complete remedy, volume of water or soil treated, or years of operation and maintenance). The system boundary establishes the resources and processes included in the study. Setting the system boundary to include only on-site activities would result in significantly different results than setting the system boundary to include transportation, materials manufacturing, and/or obtaining raw materials. The system boundary should be consistent when conducting LCA on two products or processes and should be selected to include all data that are consistent with the goal of the study. The system boundary is usually depicted in a flow chart figure that is prepared external to SimaPro®. An example diagram of system boundary for a pump and treat (P&T) system is illustrated in Figure 1. Energy and resources enter the system on the left part of Figure 1, and impacts to the environment resulting from the P&T remedy leave the system boundary on the right-hand side of Figure 1. In addition to the activities conducted within the treatment plant, the system boundary in this illustration includes i) the production of various items such as aluminum, steel, granular activated carbon, ii) electricity and transportation of these items to the treatment plant process, and iii) various resulting emissions and wastes. This type of figure is not produced within SimaPro® but helps represent the information represented in SimaPro®.

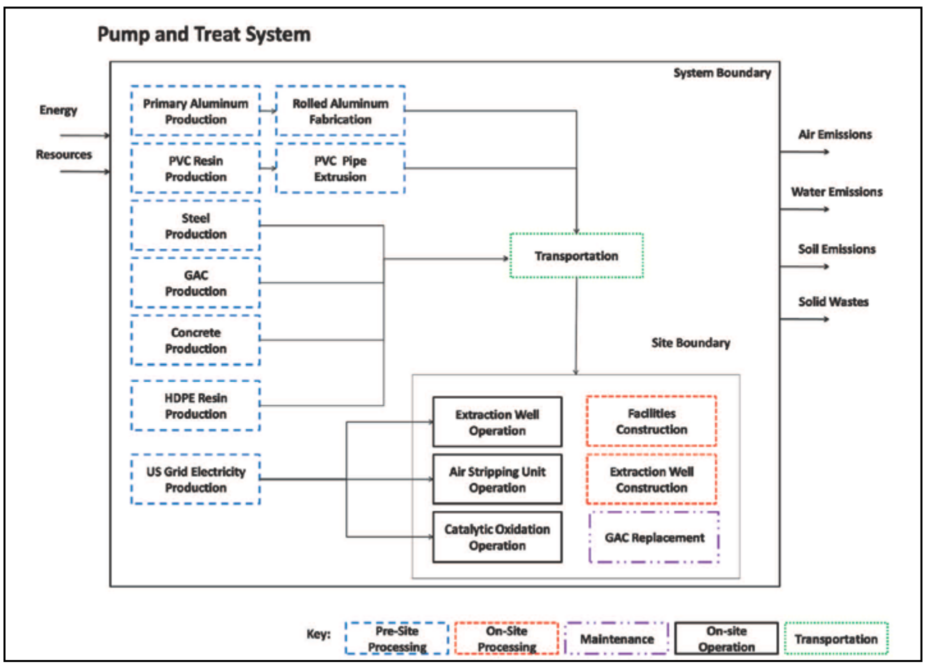


Figure 1: LCA Schematic for Pump and Treat Remedy *(Higgins and Olson, 2009)*

<u>Inventory of System Inflows and Outflows</u> – The user enters information into SimaPro® to represent the inflows of energy and resources into the system and the outflows of wastes and products of the system. SimaPro® organizes the information into a process network using detailed process-level data for thousands of processes to graphically display the various contributions to a functional unit of the product or system that is being evaluated. An example of a SimaPro® process network for a remedy that includes both pump and treat and bioremediation is illustrated in Figure 2. The yellow boxes at the top represent the "life-cycle" process of a bioremediation remedy component, a pump and treat remedy component, and the combined remedy. The blue boxes represent the "assembly" of these life-cycle remedies, and the grey boxes represent the various processes that contribute to the remedies. SimaPro® uses this information and the underlying life-cycle inventory databases to convert the processes into "environmental flows" (i.e., footprints) for sustainability metrics such as energy usage, GHG emission, NOx emissions, etc. The red bar indicates the relative contribution of each process within the hierarchy to a specific sustainability metric. SimaPro® and the associated life-cycle inventory databases have data for a wide variety of sustainability metrics, including but not limited to total energy use, GHG emissions, NOx emissions, SOx emissions, PM emissions, heavy metals emissions, radioactivity released, wastes generated, and water usage.

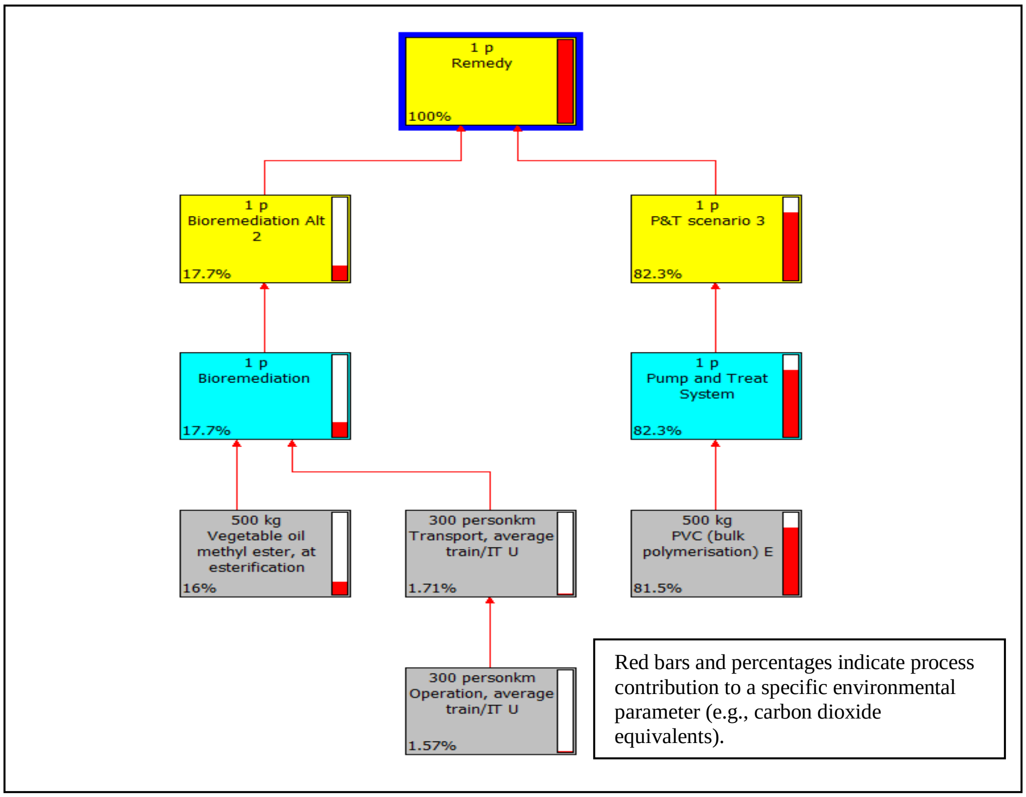


Figure 2: SimaPro® Process Network

Impact Assessment – An impact assessment converts the quantified footprints into actual environmental impacts such as climate change, acidification/eutrophication, release of carcinogens, ecotoxicity, etc. SimaPro® and its support databases provide the information required to conduct an impact assessment and perform the calculations. Many different impact assessment frameworks are available in SimaPro, such as TRACI, EcoImpact, and ReCiPe. For some parameters, the impact assessment step introduces additional uncertainty or variability into the overall LCA. For example, release of a toxic pollutant in one location may have a different toxic effect than a release in another location, and the impact assessment may not capture these subtleties.

Interpretation of Results – SimaPro® also provides graphical output to directly use in reporting and to aid in interpretation of the study. Figure 3 illustrates one type of figure produced by SimaPro®. This figure shows the normalized output from an example impact assessment for three alternatives. In this figure, a single bar in each impact assessment category on the x-axis that represents the highest contributor to that category is assigned a value of 100%, with the alternate strategies shown at the normalized impact magnitude relative to the highest value. For environmental remedies, results for competing alternatives could be compared. This example demonstrates how alternatives are unlikely to dominate across all impact assessment categories, and thus why an impact assessment is useful in describing areas where design changes can be made to reduce impact.

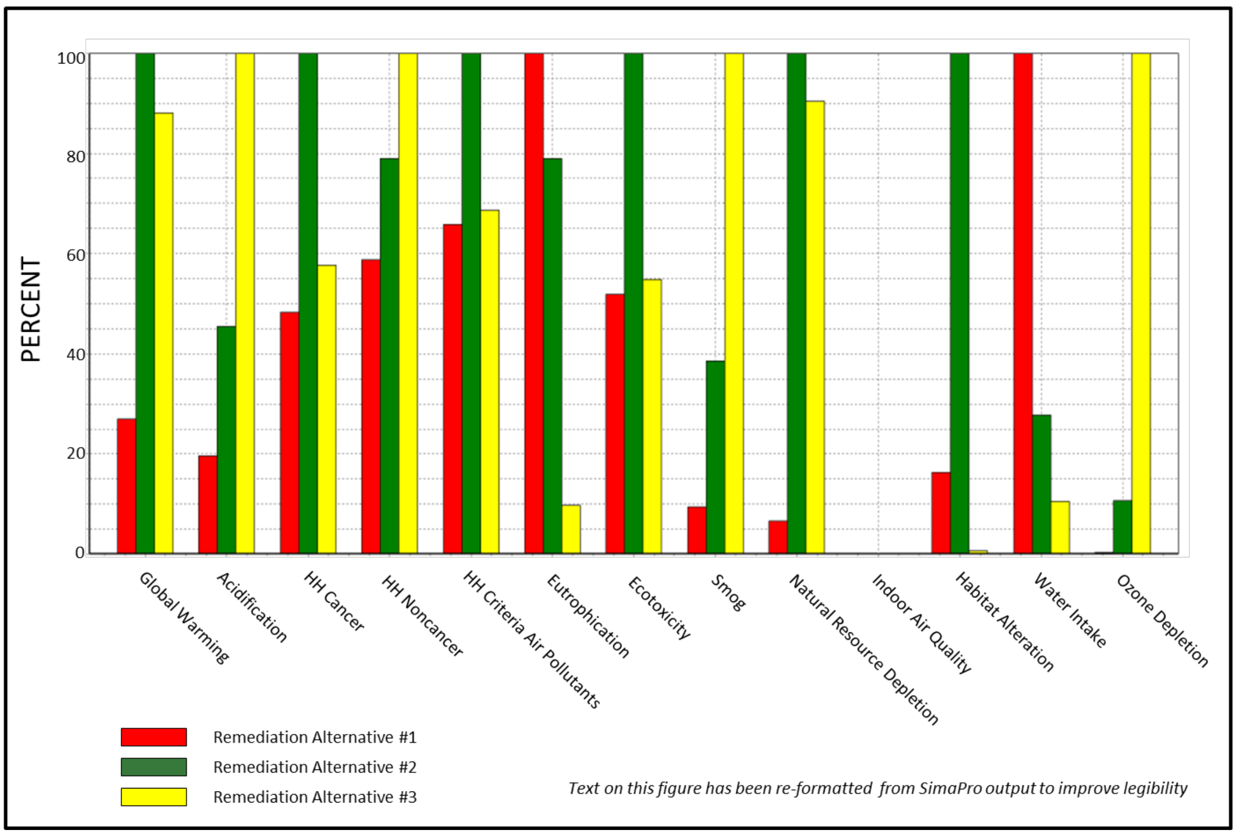


Figure 3: SimaPro® Impact Assessment Comparison of Three Alternative Remediation Scenarios

2.1.2 SiteWise™ Description

SiteWise™ is a Microsoft Excel-based tool that quantifies sustainability metrics of multiple remedial alternatives/technologies based on site-specific information. The tool's initial development was by Battelle as part of its internal research and development program. The initial tool was applied to conduct GSR assessments of some remedial sites for the Navy and USACE. The Navy and USACE collaborated for the further development of the tool for public use (Figure 4). Since then, two versions of the tool have been released in the public domain at the Navy's Environmental Restoration and Technology Transfer (ERT2) website:

> https://portal.navfac.navy.mil/portal/page/portal/navfac/navfac_ww_pp/navfac_nfesc_pp/environmental/erb/gsr/gsr-t2tool

SiteWise™ Version 2 was used for the initial evaluations for the demonstration sites in this study. This version was upgraded to SiteWise™ Version 3 as a part of this ESTCP project based on findings from the initial evaluations, and SiteWise™ Version 3 was used for the final evaluations for the demonstration sites in this study.

Figure 4: SiteWise™ Version 3 Welcome Screen

A GSR assessment in SiteWise™ is carried out using a building block approach where the remedial alternatives are first broken down into modules that are not specific to particular technologies. The tool structure is flexible enough to allow consideration of virtually any remedy type. The user enters information regarding material use for remedial activities, remedial system's utility (water and electric) consumption, vehicles and distances for transportation related to remedial activities, and on-site equipment use in the tool. The information is entered into tables on an "input sheet" by typing values and choosing elements of dropdown menus.

Figure 5 is a screen shot of an example input sheet from SiteWise™. The white cells are user inputs while the yellow cells are dropdown menus that give the user a selection of choices that are built into the tool to choose from. The tool calculates footprints for sustainability metrics based on the information entered by the user. The following sustainability metrics are calculated by SiteWise™ using footprint factors that are provided in a lookup table:

- Total energy use (million British Thermal Units (MMBTU))
- GHG emissions (metric tons of CO_2e)
- On-site and total NOx emissions (metric tons of NOx)
- On-site and total SOx emissions (metric tons of SOx)
- On-site and total PM (less than 10 microns) emissions (metric tons of PM_{10})
- Accident/safety risk (number of work related injuries, number of work related fatalities, and lost hours due to work related injury)
- Resource Consumption (tons of top soil used, gallons of groundwater lost, cubic yard of landfill space)
- Water use (gallons)
- Electricity usage (in megawatt-hours) and percent electricity from renewable sources

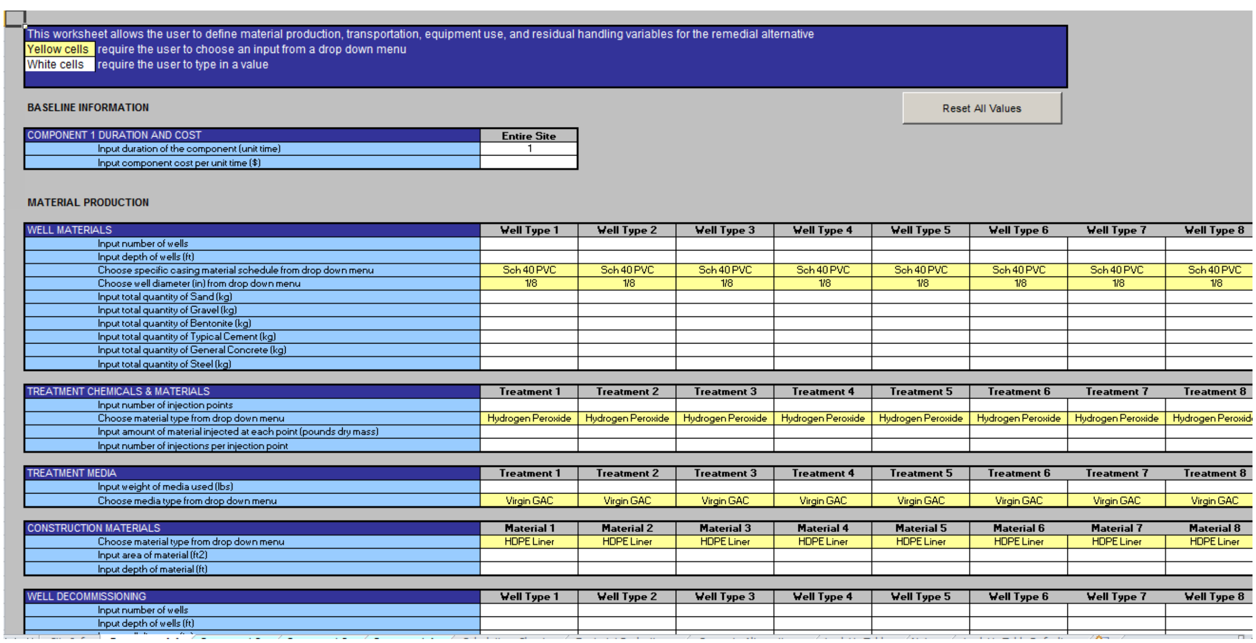


Figure 5: Screen Shot of a Portion of an Input Sheet from SiteWise™ Version 3

Features of SiteWise™ include the following:

- For each remedy alternative evaluated, the calculations are made on various tabs organized by component (this could be by remedy phase or any other user-defined component type) and summarized in tables and charts on a summary folder for that alternative.

- Another final summary file presents the data for all alternatives evaluated for a comparative analysis between different remedial alternatives.

- SiteWise™ includes an evaluation of footprint reduction methods, mostly related to reduction in energy consumption. SiteWise™ includes calculation modules for landfill gas microturbines, solar energy, wind energy, and use of renewable energy certificates as part of its renewable energy application.

- SiteWise™ conducts a comparative analysis of several different remedial alternatives, making it well suited for use during the remedy selection phase. The tool can also be used to conduct an analysis of a planned remedy during the design phase or the operation and/or LTM of an existing remedy, making it useful as part of optimization studies.

In SiteWise™, footprint factors for GHG emissions and energy used for materials, fuel, and electricity are life-cycle based. The boundary condition that is drawn for calculating the life-cycle-based footprint factors is around the entire life-cycle or 'cradle-to-grave' of the material used or fuel/electricity consumed. This means that complete life-cycle emissions for material production is taken into account. The analysis includes energy used and emissions due to production and transportation of raw materials, manufacturing of consumable materials, fabrication of installed equipment (e.g., pumps, PVC piping), production of the electricity, and on-site operation, maintenance, and monitoring of remediation systems. SiteWise™ does not conduct an impact assessment (a component of the LCA process) to convert the footprints for sustainability metrics into environmental impacts such as acidification and ecotoxicity.

The SiteWise™ spreadsheets allow for full transparency of all calculations and provide referenced footprint factors for activities and materials. Fuel usage rates are provided for various forms of transportation and various types of equipment. Electricity usage can be entered using one of three methods, including actual lump-sum usage, usage based on fluid head and flow rate, and usage based on motor size. State-specific footprint factors are provided for calculating emissions from electricity generation to account for different types of electrical generation in different parts of the country, and a module exists that allows the user to input custom blends of electricity sources (e.g., percent from coal plants, hydroelectric, wind turbines, etc.).

2.1.3 SRT™ Description

The Sustainable Remediation Toolkit (SRT™) is built on the Microsoft Excel platform and is structured using analytical "tiers." This tiered structure allows the user to choose the level of effort and detail appropriate for the project at hand.

- Tier 1 (simpler tier) calculations are based on rules-of-thumb that are widely used in the environmental remediation industry. A user might choose Tier 1 if the analysis needs to be completed quickly, if detailed or extensive site-specific data are not readily available, if a highly site-specific evaluation is not required, or if the objective is to make general comparisons between remediation technologies.

- Tier 2 calculations are more detailed and allow user to incorporate more site-specific factors. Tier 2 is recommended for when evaluations are not time sensitive, detailed site-specific data are readily available, or more stand-alone results are required such as for evaluating existing systems or projects that have advanced to the feasibility study (FS) stage. At the FS stage, conceptual designs should be available, allowing the user to enter more site-specific inputs, resulting in more accurate outputs tailored to the project.

SRT™ Version 2.1 was used for the initial evaluations for the demonstration sites in this study. This version was upgraded to SRT™ Version 2.3 as a part of this ESTCP project based on findings from the initial evaluations, and SRT™ Version 2.3 was used for the final evaluations for the demonstration sites in this study. A website link for the recently revised version of SRT is not currently available but the updated tool will be posted on AFCEC public website in the near future.

The tool is designed to serve three general purposes:

- Planning for the future implementation of remediation technologies at a particular site; Comparing remediation approaches on the basis of sustainability metrics; and
- Evaluating optimization of remediation technology systems already in place.

SRT™ allows the user to evaluate multiple technologies simultaneously which is a benefit during planning/evaluation of either a singular treatment technology (e.g., long-term monitoring) for one type of media, or for combined treatment technologies to address impacts to both soil and groundwater (e.g., excavation and P&T). SRT™ allows users to estimate footprints for sustainability metrics for the following eight common remedial action technologies, grouped by affected media (soil and groundwater):

Soil Remediation:
- i) Excavation
- ii) Soil Vapor Extraction
- iii) Thermal Treatment

Groundwater Remediation:
- iv) Pump and Treat
- v) Enhanced Bioremediation
- vi) Permeable Reactive Barrier
- vii) In Situ Chemical Oxidation
- viii) Long-term Monitoring / Monitored Natural Attenuation

The **Main Screen** allows users to view and select the remedy technologies by media type (see Figure 6). The **Main Screen** also provides a quick link (View/Edit Factors) to the sheet containing footprint factors, where the user can adjust default footprint factors to more representative site-specific values or assumptions.

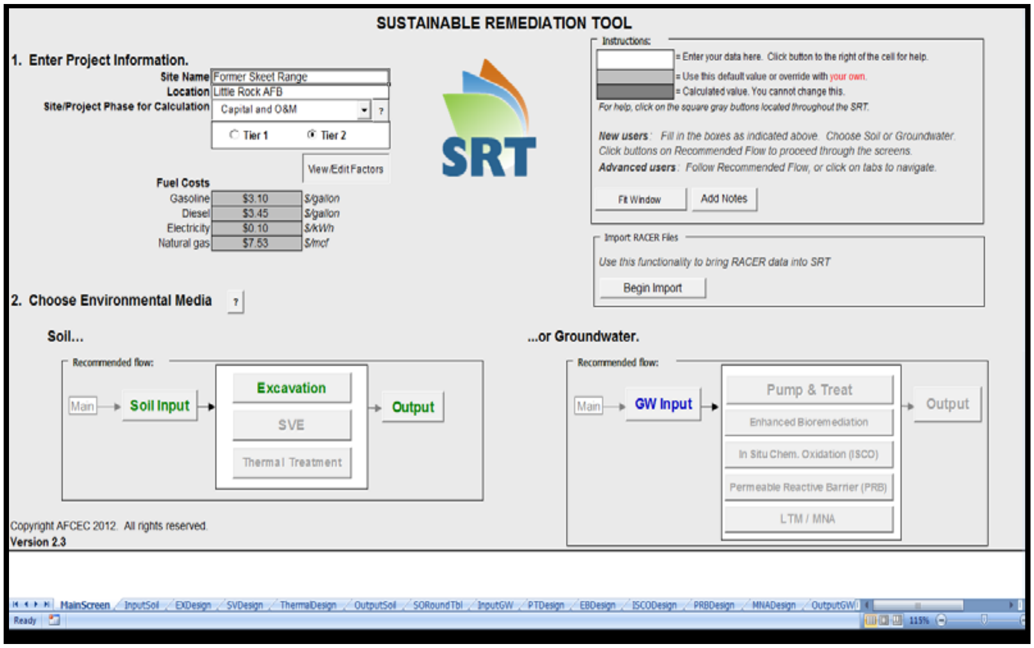


Figure 6: SRT™ Main Screen

After selecting to evaluate soil or groundwater, the user is directed to three types of screens: Input, Technology, and Output. The **Input Screen** for either Soil or Groundwater gathers general information used for all technologies, such as description of the contamination present and general site-specific information (see Figure 7a).

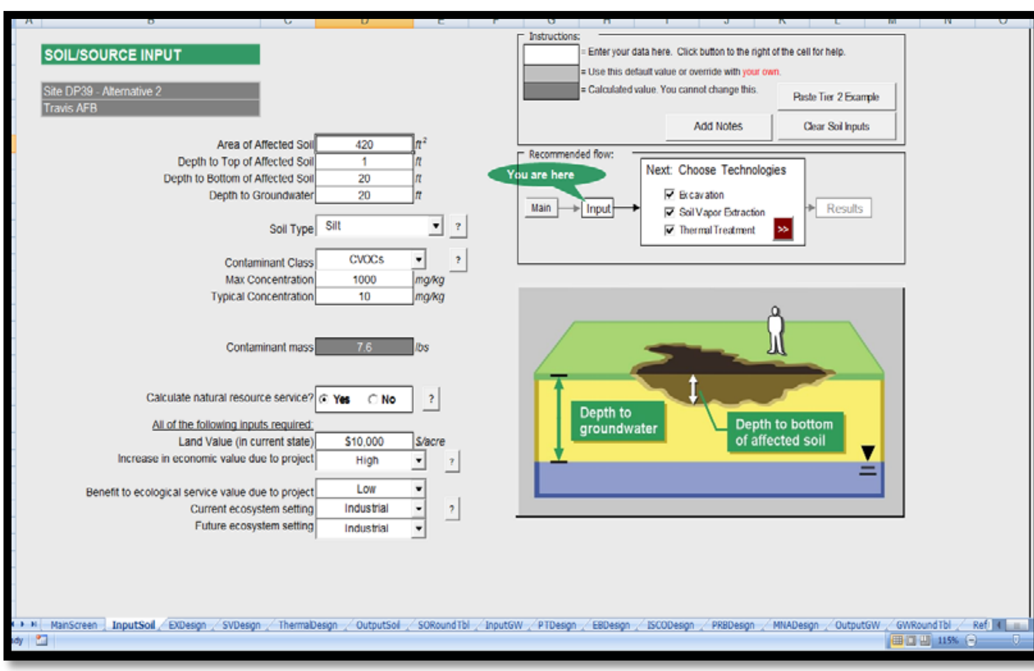


Figure 7a: SRT™ Input Screen for Soil

The **Input Screen** is followed by the **Technology Screens**, which require the user to enter various inputs regarding system design and materials and consumables (see Figure 7b). Finally, the user is directed to the **Output Screens**. Throughout the tool, there are direct site-specific user inputs as well as defaults and calculated values based on rules of thumb or algorithms. Many of the calculated values can be overridden by the user if more site-specific data or newer literature reference values are available.

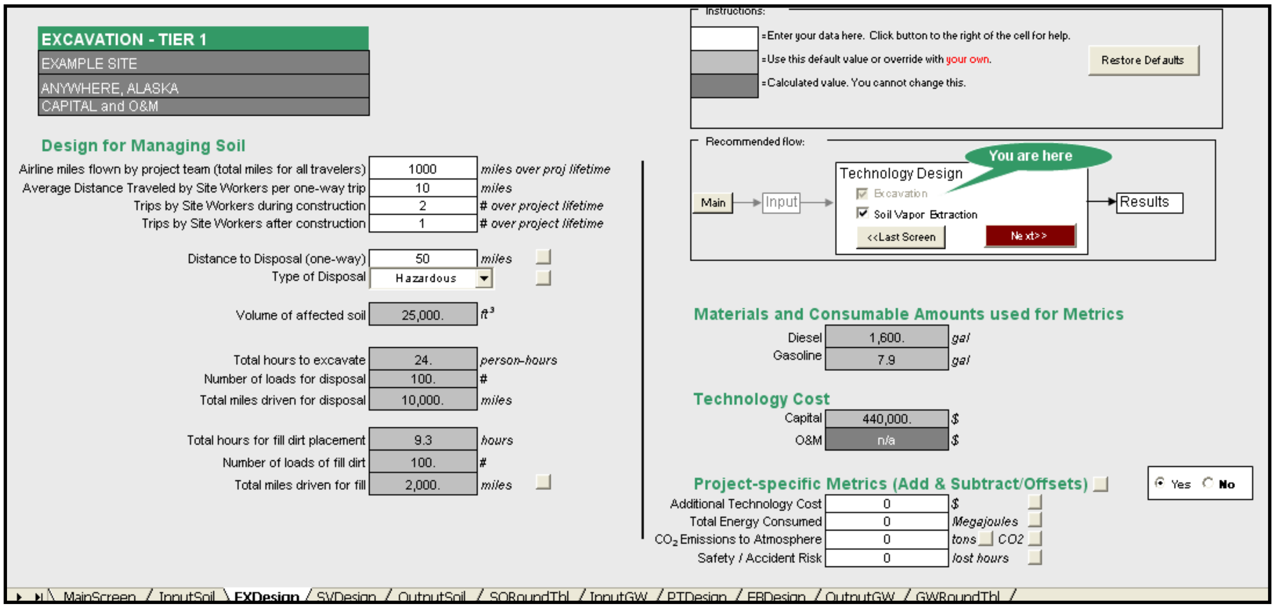


Figure 7b: SRT™ Technology Screen for Excavation

The **Output Screen** displays the calculated footprints for sustainability metrics (carbon dioxide emissions, criteria pollutant emissions, economic cost, energy consumption, safety / accident risk, and change in resource service from land and/or groundwater). These metrics are organized by environmental media so that soil or groundwater technologies can be compared side-by-side. Other innovative features of the tool include the following:

- Conversion of all sustainability metrics to a consistent set of units (for example, converting carbon emissions to life-cycle costs using existing carbon offset costs set by carbon trading markets).
- Use of Scenario Planning, where different futures for carbon offset costs and energy costs are presented to the users (for example, the user can view the results of the sustainability calculations for either a "Business as Usual" scenario, or a "Carbon Constrained World" scenario).
- Use of a consensus-building virtual meeting room, where different decision-makers can weigh the importance of different sustainability metrics (for example, one stakeholder might weigh economic cost as the most important metric, while another stakeholder might weigh carbon emissions as the most important metric).

The Tier 2 portion of the tool has the same calculation scheme used in Tier 1 but with a significantly increased set of parameters that can be changed by the user. While Tier 1 estimates consumables and allows users to override these default values, it does not permit the user to change the internal default values in order to allow users with limited site-specific information or with limited time to complete a basic evaluation. However, Tier 2 allows the user to directly input quantities of consumables and allows users to input their own specific internal values. For example, in Tier 1 the user has to use an internal default footprint factor for the pounds of carbon dioxide emitted per pound of PVC used in piping and other equipment. However, in Tier 2 the user can enter a specific footprint factor for pounds of carbon dioxide emitted per pound of PVC used, to account for detailed data and assumptions the user would like to incorporate. In terms of input data, the user would have to enter approximately 100 input variables to complete a Tier 1 analysis of all eight technologies. A Tier 2 user has the option of entering anywhere between 110 and 600 input variables, greatly increasing the power, flexibility, and specificity of the tool.

2.2 TECHNOLOGY DEVELOPMENT

The SiteWise™ and SRT™ tools were advanced tools that were already being employed for DoD projects (and other projects) at the time this ESTCP project began. As part of this ESTCP project, further development of each tool was implemented based on initial results from the evaluations for the demonstration sites (i.e., based on preliminary comparisons to the benchmark tool). These further developments to the tools (and the observations from Phase 1 of the Study that suggested the need for improvements) are described in detail in Section 5.9 of this report.

2.3 ADVANTAGES AND LIMITATIONS OF THE TECHNOLOGY IDENTIFIED PRIOR TO THE STUDY

This section identifies key advantages and limitations of the various tools identified prior to the study (i.e., in the Demonstration Plan). Other advantages and disadvantages of the various tools identified during the execution of the project are discussed later in this report (see Sections 5 to 8).

2.3.1 SimaPro® Advantages (Limitations of DoD Tools)

Advantages of the SimaPro® LCA Software relative to the DoD tools identified prior to execution of this project included the following:

- SimaPro® software is a mature technology (first released in 1990) that is able to readily support the production of models and reports that conform to the relevant LCA ISO standards, and it has been applied in numerous studies (though generally for manufacturing rather than for environmental remediation projects). SiteWise™ and SRT™ are also mature technologies (first released in 2011 and 2010, respectively) that have been applied at multiple DoD facilities, but these tools do not conform to ISO standards.

- SimaPro® can be purchased with the Ecoinvent database, which is a leading global proprietary life-cycle inventory database that is generally more robust than publicly available databases (e.g., NREL US LCI). By purchasing support service contracts for the software, the user can incorporate updates to the databases over time. The DoD tools each include their own database with footprint factors developed from publicly available sources, but currently, there is no standard process for the default footprint factors in SiteWise™ and SRT™ to be updated over time.

- SimaPro® can create assemblies or processes of more complex products or activities that might be used in remediation but are not already included in a life-cycle inventory database. An example might be a custom assembly for an innovative remediation substrate for bioremediation or oxidation that consists of specific blend of materials. SiteWise™ and SRT™ have the ability to add in other "known" quantities, emissions, or environmental effects for materials, but do not have the inherent ability to utilize life-cycle inventories to create new assemblies or processes for future use.

- The SimaPro® software incorporates impact assessment, which is a component of LCA analysis that is not incorporated within SiteWise™ or SRT™. Impact assessment converts the sustainability metrics into environmental impacts such as acidification, climate change, and ecotoxicity.

2.3.1 DoD Tool Advantages (Limitations of SimaPro®)

Advantages of SiteWise™ and SRT™ relative to SimaPro® identified prior to execution of this project included the following:

- SiteWise™ and SRT™ are freeware, whereas SimaPro® requires an up-front purchase of between $3,000 to $12,000 for a single user (includes support for one year), plus additional costs of approximately $1,500 per year for a single user for support beyond the first year.

- SiteWise™ and SRT™ are designed specifically for application to environmental remedies. Therefore, the input sheets request information in a form that is generally familiar to environmental professionals. SimaPro® is a general LCA support tool and is not designed specifically for environmental remediation. As a result, the SimaPro® input has a significant learning curve, and is relatively more complicated and/or difficult to navigate for soil and groundwater remedies. Also, specific footprint factors for materials or activities specific to typical environmental remedies (e.g., granular activated carbon) are not always defined within SimaPro®.

- SiteWise™ and SRT™ are Microsoft Excel ® based. Microsoft Excel ® is easily available and universally used. Both DoD tools let the user change most of the inputs and information in the tool and enter user-specific information. In SiteWise™ the specific calculations performed by the tool are also transparent to the user within the spreadsheet. In SRT™ the calculations are not transparent to the user within the tool but are provided to the user in the User's Guide. The user has less control over the calculations in SimaPro®.

- SiteWise™ and SRT™ were developed by DoD contractors, and therefore these tools can be modified and improved in the future based on needs or specifications of the DoD. However, DoD and other government agencies cannot influence specifications or future improvements for SimaPro®.

3.0 PERFORMANCE OBJECTIVES

The quantitative and qualitative performance objectives are listed in Tables 1a and 1b, respectively. These are slightly modified from the Demonstration Plan, as noted. The demonstration results are detailed in Section 5 (and associated appendices) and evaluation of those results with respect to the performance objectives is presented in Section 6.

Table 1a: Quantitative Performance Objectives

Performance Criteria	Data Requirements	Success Criteria
Footprint Contributor Ranking	Rank the top 10 contributors to each sustainability metric and verify that the order is the same for the DoD tool and the benchmark (SimaPro®)	Success is defined according to whether or not the ranking of contributions between the tools is the same. This assessment is quantitatively performed in a "binary" manner (i.e., the rankings are the same, or the rankings are not the same). To the extent that they differ, those differences are qualitatively assessed to identify if the differences are significant.
Result Ratios*	This is evaluated quantitatively for each sustainability metric (e.g., NOx) by determining the ratio between the tool results (larger result divided by smaller result, positive in one direction and negative in the other direction)	Success is defined according to the degree to which the quantified output values differ. Ratios greater than 1.2 are considered significant, and the primary causes for such differences are explored.
Boundary Effects**	Boundary conditions are extended in SimaPro® and the effects are evaluated quantitatively for each sustainability metric (e.g., NOx) by determining the ratio between the tool results (larger result divided by smaller result, positive in one direction and negative in the other direction)	The previous two performance objectives are re-calculated for the case with SimaPro® run with more extensive boundaries.***
Sensitivity analysis***	For several items, assess the range of footprint obtained from the benchmark tool based on viable competing selections by the user, and compare those to footprints obtained with the DoD tools.	A successful outcome results if footprints from the DoD tools are within the range of reasonable values from the benchmark tool.
Correlation or bias?	For each DoD tool, the results for particular sustainability metrics (e.g., NOx) from all the associated demonstration remedies are compared to SimaPro® results to illustrate potential correlation or bias in the results. For example, are the DoD tool results consistently higher, lower, or unbiased relative to the SimaPro® results?	Success is indicated if the quantitative results suggest there is no consistent bias introduced by using one of the tools.

**The Demonstration Plan considered the use of percentage difference rather than ratios, but the percentages were less useful because their magnitudes are unlimited when the DoD tool value is higher than the benchmark value but are limited to zero when the DoD tool value is lower than the benchmark value. Ratios are more meaningful and were applied for the study.*

***This was determined to not be practical as stated, and instead the comparison was made between the total footprint for each remedy plus additional sensitivity runs specifically addressing this boundary condition.*

****This was modified from the sensitivity analysis described in the Demonstration Plan because of the observation during project execution that many viable selections were available for processes in the benchmark tool.*

Table 2b: Qualitative Performance Objectives

Performance Criteria	Data Requirements	Success Criteria
Technical confidence?	This is evaluated when results differ by a ratio of more than 1.2 for a sustainability metric between the DoD tool result and the benchmark result, and the relative degree of confidence in one result versus the other is qualitatively evaluated based on discussion among the project team.	For cases where there are differences greater than a ratio of 1.2 for a sustainability metric between the DoD tool result and the benchmark result, success is achieved if a technical justification can be established for having more confidence in one of the results.
Functionality comparison	A list of key functionality in SimaPro® not included in the DoD tools (and vice versa).	Adding functionality to SiteWise™ and/or SRT™ within this ESTCP project to address functionality limitations relative to SimaPro®.
"Work around" vs. accurate representation	An inventory of "work-arounds" for SimaPro® and the DoD tools that are employed during the evaluations to overcome limitations.	Identifying practical "work-arounds" for the GSR tools to effectively model the demonstration remedies.
Learning Curve	The process of learning about each tool and successfully completing a well-documented evaluation will be analyzed.	Success is defined by understanding the background required to implement these tools for the benefit of the remediation sites, identifying if SimaPro® has a significantly greater learning curve than the DoD tools, and highlighting techniques for efficiently applying SimaPro® to soil and groundwater remedies.

3.1 FOOTPRINT CONTRIBUTOR RANKING (QUANTITATIVE)

This performance objective addresses the extent to which the SiteWise™ and SRT™ results agree with SimaPro® results on the remedy components that are the largest contributors to footprints for each sustainability metric (e.g., total energy use, NOx emissions, etc.). This is evaluated quantitatively by ranking the top 10 contributors to the footprint for each sustainability metric (for key sub-items established for each remedy alternative), and verifying that the order is the same for the DoD tool and the benchmark (SimaPro®). This assessment is quantitatively performed in a simple "binary" manner (i.e., the rankings <u>are</u> the same, or the rankings <u>are not</u> the same) and is not affected by the underlying quantities beyond the rank.

The data required to evaluate the ranking of the footprint contributors for each remedy component are the footprints for the various sustainability metrics. Success is defined according to whether or not the ranking of contributions between the tools is the same. To the extent that they differ, those differences are qualitatively assessed to identify if the differences are significant.

To better describe the "qualitative" aspect of the evaluation, three simple (hypothetical) examples are provided in Table 2.

Table 2: Example of Ranked Footprint Contributors

	Ranks for Contributors to Energy Use (DoD Tool)	***Ranks for Contributors to Energy Use (SimaPro®)***
Example 1	*1. Electricity Use (62%)* *2. Materials Production (18%)* *3. Personnel Transportation (16%)* *4. Equipment Transportation (4%)*	*1. Electricity Use (64%)* *2. Materials Production (18%)* *3. Personnel Transportation (13%)* *4. Equipment Transportation (5%)*
Example 2	*1. Electricity Use (62%)* ***2. Materials Production (18%)*** ***3. Personnel Transportation (16%)*** *4. Equipment Transportation (4%)*	*1. Electricity Use (61%)* ***2. Personnel Transportation (18%)*** ***3. Materials Production (17%)*** *4. Equipment Transportation (4%)*
Example 3	*1. Electricity Use (62%)* ***2. Materials Production (18%)*** ***3. Personnel Transportation (16%)*** *4. Equipment Transportation (4%)*	*1. Electricity Use (46%)* ***2. Personnel Transportation (32%)*** ***3. Materials Production (12%)*** *4. Equipment Transportation (10%)*

In Example 1, the quantitative result would be "the rankings are the same for each tool." In Examples 2 and 3, the quantitative result would be "the rankings are not the same for each tool" because the 2nd ranked contributor in the DoD tool is the 3rd ranked contributor in SimaPro®, and vice versa.

To the extent that the rankings differ, those differences are qualitatively assessed to identify if the differences are significant.

- In Example 2, the contribution from "materials production" and "personnel transportation" are quite similar, so the change in ranking between DoD tool and SimaPro® is not particularly significant.

- In Example 3, the contribution from "materials production" and "personnel transportation" are quite different, so the change in ranking does appear to be significant and some attempt can be made to determine and explain why such different results were provided by each tool.

The "significance" of any differences in ranking is best done qualitatively because it is too difficult to define a specific statistic that would be meaningful in all cases that might occur.

3.2 RESULT RATIO (QUANTITATIVE)

Result ratios to quantify the differences in footprint results between the tools being compared are evaluated quantitatively for each sustainability metric (e.g., NOx) by determining the ratio by which the DoD tool result differs from the benchmark result (larger result divided by smaller result, positive in one direction and negative in the other direction). Examples of the result ratio calculation are provided in Table 3.

Table 3: Example of "Result Ratio" Calculations

SimaPro® Result	DoD Tool Result	Result Ratio
50	20	2.5
100	25	4.0
20	50	-2.5
25	100	-4.0

The data required for this performance objective includes all model parameters representing the site and its remedial functions, and resulting tool output. Differences greater than a ratio of 1.2 (similar to a difference of 20 percent) are considered significant.

3.3 BOUNDARY EFFECTS (QUANTITATIVE)

The boundary condition evaluated in this study refers to how far back in the supply chain of material/activities that the analysis accounts for. SimaPro® was executed with two different boundaries: "with infrastructure" and "without infrastructure," and the results were compared. For example, airplane transport "without infrastructure" might account for just the fuel combustion (which is included in the DoD tools), but "with infrastructure" might also account for construction of the airplane, construction of the airport, and operation for the airport (which are not included in the DoD tools). The total footprints of each remedy alternative, calculated with and without infrastructure, are compared to determine the significance of this boundary condition.

3.4 SENSITIVITY ANALYSIS (QUANTITATIVE)

Many different processes can be selected in SimaPro® to represent some remedy items (e.g., a specific material such as PVC). The most meaningful sensitivity analysis is to assess the range of footprint results obtained from the benchmark tool for viable process alternatives, and to compare those results to footprints obtained from the DoD tools. A successful outcome occurs if results from the DoD tools are within the range of reasonable values from the benchmark tool.

3.5 CORRELATION OR BIAS (QUANTITATIVE)

For each DoD tool, the footprints for sustainability metrics (e.g., NOx) from all the associated demonstration remedies are compared against SimaPro® results to illustrate potential correlation or bias in the results. Are the DoD tool results consistently higher, lower, or unbiased relative to the SimaPro® results? Success is indicated if the quantitative results suggest there is no consistent bias introduced by using one of the tools.

3.6 TECHNICAL CONFIDENCE (QUALITATIVE)

When footprints differ by more than a result ratio of 1.2 (i.e., 20%) between the DoD tool result and the benchmark result, the relative degree of confidence in one result versus the other is qualitatively evaluated based on discussion among the project team. For cases where the result ratio is greater than 1.2, success is achieved if a technical justification can be established for having more confidence in one of the results. For example, the DoD tools may more reasonably model the type of diesel engine and air emission controls typical for environmental remediation than SimaPro®, which could increase confidence in the DoD tool results over the SimaPro® results.

3.7 COMPARING FUNCTIONALITY (QUALITATIVE)

The objective is to identify a list of key functionality in SimaPro® not included in the DoD tools (and vice versa). Success is established if this functionality can be added to the DoD tools within the scope of this ESTCP project to make them more effective. The need to create new assemblies or processes in SimaPro® to effectively model the remedy is also documented.

3.8 "WORK AROUNDS" (QUALITATIVE)

"Work-arounds" to limitations in SimaPro® and the DoD tools for modeling the demonstration remedies are documented along with a qualitative discussion about what doubt, if any, that these "work-arounds" could cause in the confidence of applying SimaPro® or the DoD tools to environmental remedies. The identification of such "work-arounds" is considered a success for this performance objective.

3.9 EXTENT OF THE LEARNING CURVE (QUALITATIVE)

A review of the process of learning about each tool and successfully completing a well-documented evaluation is analyzed. Success is defined by:

- Understanding the background required to implement these tools for the benefit of the remediation sites;
- Identifying if SimaPro® has a significantly greater learning curve than the DoD tools; and
- Highlighting techniques for efficiently applying SimaPro® to soil and groundwater remedies.

4.0 SITE DESCRIPTION

The six demonstration sites that were ultimately chosen for this dem/val project were as follows:

<u>Evaluated with SiteWise™ and SimaPro®</u>

- US Army Cold Regions Research and Engineering Lab (CRREL), Hanover, NH
- Former Naval Air Station Alameda OU2B (Alameda), Alameda, CA
- Naval Weapons Industrial Reserve Plant McGregor Area M (NWIRP), McGregor, TX

<u>Evaluated with SRT™ and SimaPro®</u>

- Beale Air Force Base, Site 35 (Beale), Beale Air Force Base, CA
- Little Rock Air Force Base, Former Skeet Range (Little Rock), Jacksonville, AR
- Travis Air Force Base, Site DP039 (Travis), Travis Air Force Base, CA

Figure 8 shows the locations of the six selected demonstration sites.

Figure 8: Locations of Selected Demonstration Sites

A brief summary of the remedial alternatives evaluated with SiteWise™ and SimaPro® is presented in Table 4a, and a brief summary of the remedial alternatives evaluated with SRT™ and SimaPro® is presented in Table 4b. Specifics regarding the remedy at each demonstration site, and how the input was derived for the remedy alternatives at each demonstration site, are detailed in the "Coordination of Site Input Data" sheets included in Appendix B.

Table 4a: Remedy Alternatives Evaluated with SiteWise™ and SimaPro®

Alternative	Description of Remedy Elements
CRREL Alt 1	Existing pump and treat (P&T) system that involves extraction of 500 gallons per minute (gpm) and the following treatment: • Greensand filters and permanganate injection for metals removal • Air stripping via two packed tower air strippers in series • Treatment of air stripper off-gas via vapor phase carbon • Re-use of the treated water for cooling at the facility • Water conditioning by carbon dioxide addition and filtration
CRREL Alt 2	Modification of CRREL Alt 1 in which the two packed tower air strippers are replaced with one new tray stripper
CRREL Alt 3	Modification of CRREL Alt 1 in which the greensand filters and air strippers (and associated off-gas treatment) are replaced with liquid phase activated carbon vessels and addition of a biocide and sequestering agent
CRREL Alt 4	Replacement P&T system that extracts and treats 40 gpm with liquid phase activated carbon and addition of a biocide and sequestering agent
Alameda Alt G-2	Groundwater remedial alternative involving the following: • In-situ thermal treatment (ISTT) applied to an area of over 29,000 square feet • 500-foot long permeable reactive barrier (PRB) to control plume migration • Monitored natural attenuation (MNA) and institutional controls (ICs)
Alameda Alt G-3a	Groundwater remedial alternative involving the following: • ISTT applied to an area of over 29,000 square feet • Shallow groundwater treatment with in-situ chemical oxidation (ISCO) • MNA and ICs
Alameda Alt G-3b	Groundwater remedial alternative involving the following: • ISTT applied to an area of over 29,000 square feet • Shallow groundwater treatment with in-situ bioremediation involving injection of emulsified vegetable oil • MNA and ICs
Alameda Alt G-4	Groundwater remedial alternative involving the following: • Installation and operation of a P&T system with ultraviolet oxidation treatment and reinjection of treated water • Over 1,100 feet of PRBs installed through direct-push injections • Plume and performance groundwater monitoring and ICs
Alameda Alt S-2	Soil excavation remedial alternative in which over 7,000 cubic yards (cy) of soil is moved and over 4,000 cy of soil is disposed of off-site (some as hazardous waste and some as non-hazardous waste)

Alternative	Description of Remedy Elements
McGregor Alt 1	Existing groundwater remedy with the following: • Extraction and treatment of approximately 130 gpm on average with a fluidized bed bioreactor or fluidized bed reactor (FBR) • O&M of seven biobarriers • Performance monitoring
McGregor Alt 2	Modification of McGregor Alt 1 in which the average extraction rate is approximately 65 gpm
McGregor Alt 3	Modification of McGregor Alt 1 in which the FBR is replaced with ion exchange (IX)
McGregor Alt 4	Modification of McGregor Alt 1 in which the FBR is replaced with construction and operation of a gravel bed reactor (GBR)
McGregor Alt 5	Modification of McGregor Alt 1 in which the FBR is replaced with construction and operation of constructed wetlands
McGregor Alt 6	Construction and modification of biowalls consisting of vegetable oil, mushroom compost, wood chips, and limestone

Alt = Alternative

Table 4b: Remedy Alternatives Evaluated with SRT™ and SimaPro®

Alternative	Description of Remedy Elements
Beale Alt 2	• Excavation and off-site disposal of over 2,000 cy of soil • Construction and operation of a mulch bioreactor, well installation, and monitoring.
Beale Alt 3	• Excavation and off-site disposal of over 2,000 cy of soil • ISCO with 21 injection wells and 21,000 pounds of oxidant • Well installation and monitoring
Little Rock	Excavation of over 13,000 cy of soil, stabilization of some soil with cement, and off-site disposal
Travis Alt 1	• Extraction and treatment of approximately 2 gpm of groundwater with a system assumed to consist of an air stripper • Groundwater monitoring
Travis Alt 2	• Construction and operation of a bioreactor • Installation of a biobarrier involving injection of 54,000 pounds of emulsified vegetable oil • Groundwater monitoring

Alt = Alternative

Each of the final demonstration sites presents characteristics that contribute to the overall quality and diversity of remedial actions evaluated for the study. A summary regarding the extent to which the site selection criteria for the study are addressed by these six demonstration sites is presented below.

Technology Diversity

Multiple remedial technologies are represented within the selection of these six demonstration sites. Table 5 displays the technologies for each of the demonstration sites.

Table 5: Remedial Technologies for Each Demonstration Site

Technology	Site
Pump and Treat System	CRREL (air stripping with off-gas treatment, metals treatment, re-use of treated water) NWIRP (fluidized bed reactor) Travis (recycled to bioreactor)
Biobarriers	NWIRP, Alameda, Travis
In-situ bioremediation systems	Travis (substrate injections to an in-situ bioreactor)
In-situ chemical oxidation	Beale, Alameda
Soil excavation with offsite disposal	Beale, Little Rock, Alameda
Monitored Natural Attenuation (MNA)	Beale, Alameda, Travis
Phytoremediation	Travis
Potential Construction Component	CRREL, NWRIP
In-Situ Thermal Treatment (Six-Phase Treatment)	Alameda

Remedy Phase Diversity

The six selected demonstration sites include three in the Feasibility Study (FS) (i.e., remedy selection) phase, and three in the Operations and Maintenance (O&M) phase, as follows:

- FS Phase: Beale, Travis, Alameda
- O&M Phase: CRREL, NWIRP, Little Rock

It is important to note that two of the three demonstration sites in the O&M phase (CRREL and NWIRP) recently had optimization evaluations performed, and modifications to the existing remedies are being considered. Thus, there is also somewhat of a “remedy selection” aspect to those two demonstration sites as well.

Complexity

As can be seen on Tables 4a and 4b, all six demonstration sites include multiple remedial technologies to evaluate with GSR tools, providing adequate site complexity for this project. In addition, the six demonstration sites include a diverse set of contaminants including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOCs), metals, perchlorate, pesticides, and dense non-aqueous phase liquid (DNAPL).

Information Quality

The three Air Force demonstration sites (Beale, Little Rock, and Travis) all previously had an evaluation completed or in-progress with the SRT tool (consistent with the proposal for this ESTCP project). Therefore, the data required for these demonstration sites were readily available. Two of the other three demonstration sites (CRREL and NWIRP) are in the O&M phase for which optimization evaluations had recently been performed. These optimization evaluations provided an initial basis for the alternatives considered in the evaluations with the GSR tools. For Alameda, an FS was recently completed, and initial information for the GSR evaluation was obtained from information in the Remedial Action Cost Engineering and Requirements (RACER) cost estimates augmented, where needed, by estimates provided by the Installation.

Implementation Potential

Installation personnel for all six demonstration sites expressed an interest in having these evaluations performed for their sites, and indicated that they will consider the results regarding future remedy implementation for those sites. Furthermore, the fact that three of the six demonstration sites are in the remedy selection phase, and two of the other three demonstration sites are considering modifications to the existing remedies based on recent optimization evaluations, increases the possibility that results from the GSR tools could be of use to the DoD Installation teams for future remedy considerations.

5.0 TESTING DESIGN

5.1 CONCEPTUAL EXPERIMENTAL DESIGN

As summarized in Section 4, a total of six demonstration sites, consisting of a total of 20 remedy alternatives, were selected. SimaPro® was applied to all the demonstration sites. SiteWise™ was applied to three of the demonstration sites (consisting of 15 remedy alternatives), and SRT™ was applied to the other three demonstration sites (consisting of 5 remedy alternatives).

The ESTCP project team consisted of the following four teams (key points of contact are listed in Appendix A):

- SiteWise™ Team –This team applied the SiteWise™ tool and also updated the SiteWise™ tool as part of the project. Battelle, the developer of the SiteWise™ tool, was the sole party in this team.

- SRT™ Team – This team applied the SRT™ tool and also updated the SRT™ tool as part of the project. GSI, the developer of the SRT™ tool, led this team with support from co-developer CH2M Hill.

- Benchmark Team – This team was independent of the SiteWise™ and SRT™ teams, and was responsible for operating the LCA software (SimaPro®), evaluating the results of SiteWise™ and SRT™ against the LCA software, leading the project briefings, and leading the preparation of project reports. Tetra Tech and Dr. H. Scott Matthews (Avenue C Advisors, LLC) comprised the Benchmark Team.

- DoD Team – This team consisted of representatives from the Air Force Civil Engineering Center (AFCEC), Navy, and United States Army Corps of Engineers (USACE). These representatives interfaced with installations, offered general guidance throughout the project, and provided input during tool evaluation and report preparation.

Further details of the experimental design for the demonstration sites are presented in the subsequent sections of this report.

5.2 BASELINE CHARACTERIZATION

The output of a GSR or LCA analysis is heavily dependent on the remedy parameters that provide input values into the tools. Therefore, the project team defined common input information for each of the tools applied to a given demonstration remedy so that, to the extent possible, differences in output from the tools could be attributed to differences in the tools rather than to variation in the input information. The result was a detailed "**Coordination of Site Data Input**" document developed for each demonstration site by the Benchmark Team and subsequently reviewed by the other project teams. These documents are included in Appendix B.

The "**Coordination of Site Data Input**" for each demonstration site included the values (and basis) for the following types of information ultimately represented within the tools:

- On-site electricity use (the Demonstration Plan indicated any on-site renewables would be documented, but no on-site renewables were identified).
- Fuel type and use for personnel transportation.
- Fuel type and use for transport of materials, equipment, and waste.
- Materials consumed on-site, reported in mass or volume of each material type.
- Volume of off-site water treatment associated with the remedy (such as at a Publicly Owned Treatment Works, or POTW),
- Mass of off-site waste disposal,
- Volume of water usage associated with the remedy, and the source of that water.

Where the information was not available from site documents or operators, estimates were provided by the Benchmark Team based on available information and reviewed by other members of the project team. This overall approach ensured that both evaluation teams were provided standardized information in suitable form to be represented in the respective tools.

5.3 TREATABILITY OR LABORATORY STUDY RESULTS

Not applicable to this project.

5.4 DESIGN AND LAYOUT OF TECHNOLOGY COMPONENTS

See Sections 2.0 to 2.3 of this report for a discussion regarding the design and layout of the technology components (i.e., the GSR tools).

5.5 FIELD TESTING

The information described in the "**Coordination of Site Data Input**" document for each demonstration site (see Section 5.2 and Appendix B) was represented in SimaPro® for each of the six demonstration sites. Information was entered into SiteWise™ for the three demonstration sites that are Army/Navy projects (CRREL, Alameda, and NWIRP), and information was entered into SRT™ for the three demonstration sites that are Air Force projects (Beale, Little Rock, and Travis).

The field testing was performed in three phases:

- Phase 1 - An initial application of the tools was performed to i) develop initial results by comparing footprints calculated by the DoD tools and SimaPro® and (ii) identify gaps in the functionality or robustness in the DoD tools.

- Phase 2 - Improvements (including additions and revisions to footprint factors) were then implemented in the DoD tools.

- Phase 3 - Subsequent to implementation of improvements to each DoD tool, a second application of the DoD tools was performed, with another comparison made to the SimaPro® results.

SimaPro® is not designed specifically for remediation, and the SimaPro® user was required to select processes to represent remedy items from a wide variety of possible choices not tailored for remediation scenarios. For several items, the Benchmark Team assessed the range of quantitative footprint results obtained from the benchmark tool (SimaPro®) based on viable process choices by the user, and compared those to values obtained with the DoD tools. This is a form of "sensitivity" analysis regarding variability in the benchmark tool that is discussed further in Section 5.10.2

SimaPro® also has the ability to convert footprint results into actual "impacts" through a Life-Cycle Impact Assessment (LCIA), or "impact assessment," which characterize environmental impacts (e.g., acidification) that result from the emissions or release of pollutants that are quantified by the LCA software. For one of the demonstration remedies, Tetra Tech documented the "impact assessment" component of the LCA analysis. This particular aspect of LCA is not included in either SiteWise™ or SRT™, and illustrating this additional aspect of LCA for one of the demonstration remedies provides a more complete benchmarking for the DoD tools and illustrates the benefit of the impact assessment output compared with the calculated inventory output. This is discussed in Section 5.12.

5.6 SAMPLING METHODS

Field sampling was not a part of this project, so this is not applicable.

5.7 QUANTITATIVE RESULTS: SITEWISE™ VERSUS SIMAPRO®

5.7.1 Footprint Totals for Remedy Alternatives

SiteWise™ (Version 2 and 3) and SimaPro® were compared for 15 demonstration site remedy alternatives. The footprint totals for each of the entire alternatives are presented in Table 6 (i.e., the total footprint values for each alternative). The SimaPro® results are presented "with infrastructure" and "without infrastructure" so impacts of that type of boundary condition could be assessed (a more detailed discussion regarding infrastructure is provided in Section 5.10.1).

Table 6: SiteWise™ Versus SimaPro® Results – Footprint Totals for Remedy Alternatives

Site/Alternative/Model	CO_2e (MT)	Energy (MMBtu)	NOx (MT)	PM 10 (MT)	SOx (MT)
CRREL Alt 1/SiteWise V2	17,860	305,747	15.74	0.921	38.293
CRREL Alt 1/SiteWise V3	17,577	355,921	23.41	13.982	72.551
CRREL Alt 1/SimaPro with Inf	17,015	359,761	28.37	1.403	96.946
CRREL Alt 1/SimaPro w/o Inf	16,886	357,300	27.94	1.210	96.538
CRREL Alt 2/SiteWise V2	17,019	287,098	15.02	0.921	36.320
CRREL Alt 2/SiteWise V3	15,620	292,851	20.39	12.744	65.877
CRREL Alt 2/SimaPro with Inf	16,014	336,350	26.77	1.393	90.022
CRREL Alt 2/SimaPro w/o Inf	15,887	333,933	26.36	1.204	89.618
CRREL Alt 3/SiteWise V2	11,830	216,025	6.62	0.017	17.850
CRREL Alt 3/SiteWise V3	12,060	223,442	15.77	9.447	45.278
CRREL Alt 3/SimaPro with Inf	14,268	302,327	23.73	1.426	79.102
CRREL Alt 3/SimaPro w/o Inf	14,138	299,526	23.28	1.247	78.707
CRREL Alt 4/SiteWise V2	71,241	62,070	138.37	1.517	68.852
CRREL Alt 4/SiteWise V3	4,772	63,271	9.94	2.547	15.482
CRREL Alt 4/SimaPro with Inf	4,676	85,425	8.66	1.175	17.045
CRREL Alt 4/SimaPro w/o Inf	4,042	77,770	7.12	0.388	16.141
Alameda Alt G-2/SiteWise V2	5,838	101,379	3.16	0.115	1.989
Alameda Alt G-2/SiteWise V3	5,279	89,913	6.81	3.476	11.746
Alameda Alt G-2/SimaPro with Inf	4,719	79,174	10.52	3.020	33.426
Alameda Alt G-2/SimaPro w/o Inf	4,671	78,022	10.37	2.950	33.288
Alameda Alt G-3A/SiteWise V2	5,583	106,653	3.23	0.134	2.001
Alameda Alt G-3A/SiteWise V3	5,364	103,935	10.05	4.003	11.701
Alameda Alt G-3A/SimaPro with Inf	7,244	127,333	13.64	1.171	38.533
Alameda Alt G-3A/SimaPro w/o Inf	7,045	123,537	13.01	0.893	37.829
Alameda Alt G-3B/SiteWise V2	4,754	97,165	2.95	0.107	1.968
Alameda Alt G-3B/SiteWise V3	4,530	90,732	5.15	2.888	8.813
Alameda Alt G-3B/SimaPro with Inf	5,048	93,818	9.83	0.541	33.825
Alameda Alt G-3B/SimaPro w/o Inf	4,976	92,222	9.59	0.436	33.622
Alameda Alt G-4/SiteWise V2	8,481	210,464	6.30	0.084	4.788
Alameda Alt G-4/SiteWise V3	8,338	170,064	7.31	6.024	15.258
Alameda Alt G-4/SimaPro with Inf	10,314	171,417	17.88	2.449	79.706
Alameda Alt G-4/SimaPro w/o Inf	10,266	170,384	17.74	2.348	79.562

Site/Alternative/Model	CO_2e (MT)	Energy (MMBtu)	NOx (MT)	PM 10 (MT)	SOx (MT)
Alameda Alt S-2/SiteWise V2	1,199	18,876	1.82	3.806	0.751
Alameda Alt S-2/SiteWise V3	1,314	20,987	3.50	4.623	2.793
Alameda Alt S-2/SimaPro with Inf	1,241	21,813	5.80	0.577	1.424
Alameda Alt S-2/SimaPro w/o Inf	928	13,308	4.26	0.286	0.848
NWIRP Alt 1/SiteWise V2	2,621	36,022	1.35	0.067	2.081
NWIRP Alt 1/SiteWise V3	2,351	33,903	1.79	1.509	2.545
NWIRP Alt 1/SimaPro with Inf	2,424	48,144	12.14	0.283	11.962
NWIRP Alt 1/SimaPro w/o Inf	2,377	46,916	12.00	0.232	11.800
NWIRP Alt 2/SiteWise V2	2,011	25,675	0.91	0.059	1.191
NWIRP Alt 2/SiteWise V3	1,682	23,425	1.16	0.885	1.480
NWIRP Alt 2/SimaPro with Inf	1,723	32,928	10.95	0.203	7.407
NWIRP Alt 2/SimaPro w/o Inf	1,695	32,194	10.72	0.173	7.312
NWIRP Alt 3/SiteWise V2	2,247	41,403	0.69	0.109	0.912
NWIRP Alt 3/SiteWise V3	2,254	41,016	3.25	1.147	4.323
NWIRP Alt 3/SimaPro with Inf	1,545	31,185	5.95	0.241	6.887
NWIRP Alt3/SimaPro w/o Inf	1,486	29,796	5.76	0.173	6.688
NWIRP Alt 4/SiteWise V2	1,281	19,782	0.89	0.624	1.010
NWIRP Alt 4/SiteWise V3	1,327	19,772	1.49	1.418	1.819
NWIRP Alt 4/SimaPro with Inf	1,318	25,221	6.42	0.216	5.539
NWIRP Alt 4/SimaPro w/o Inf	1,272	24,075	6.27	0.164	5.397
NWIRP Alt 5/SiteWise V2	1,681	28,240	0.81	0.043	0.932
NWIRP Alt 5/SiteWise V3	1,870	30,093	3.84	1.235	5.597
NWIRP Alt 5/SimaPro with Inf	1,412	35,678	7.41	0.312	5.472
NWIRP Alt 5/SimaPro w/o Inf	1,331	33,726	7.12	0.217	5.275
NWIRP Alt 6/SiteWise V2	608	10,284	1.40	1.069	0.233
NWIRP Alt 6/SiteWise V3	760	12,530	2.78	1.421	2.490
NWIRP Alt 6/SimaPro with Inf	632	15,063	4.51	0.257	0.858
NWIRP Alt 6/SimaPro w/o Inf	557	13,044	4.16	0.183	0.699

Alt = Alternative (Alternatives were summarized in Table 4a)
MT = metric tons = 1,000 kg
MMBTU = million British Thermal Units
Inf – Infrastructure (with; w/o = without)

Table 7 and Table 8 present similar results, but in a format that illustrates the result ratios between the SiteWise™ and SimaPro® results (a positive value indicates the SimaPro® footprint was higher, and a negative value indicates the SiteWise™ footprint was higher). Table 7 presents the comparison for SimaPro® results that include infrastructure, and Table 8 presents the comparison for SimaPro® results without infrastructure. The method for calculating result ratios was presented in Section 3.2.

Table 7: SiteWise™ Versus SimaPro® Results – Result Ratios for Remedy Alternatives (SimaPro® Results Include Infrastructure)

	Result Ratio SiteWise V2 versus SimaPro					Result Ratio SiteWise V3 versus SimaPro					
	CO2e	Energy	NOx	PM	SOx		CO2e	Energy	NOx	PM	SOx
CRREL Alt 1	-1.0	1.2	1.8	1.5	2.5	CRREL Alt 1	-1.0	1.0	1.2	-10.0	1.3
CRREL Alt 2	-1.1	1.2	1.8	1.5	2.5	CRREL Alt 2	1.0	1.1	1.3	-9.1	1.4
CRREL Alt 3	1.2	1.4	3.6	83.2	4.4	CRREL Alt 3	1.2	1.4	1.5	-6.6	1.7
CRREL Alt 4	-15.2	1.4	-16.0	-1.3	-4.0	CRREL Alt 4	-1.0	1.4	-1.1	-2.2	1.1
Alameda G2	-1.2	-1.3	3.3	26.2	16.8	Alameda G2	-1.1	-1.1	1.5	-1.2	2.8
Alameda G3a	1.3	1.2	4.2	8.8	19.3	Alameda G3a	1.4	1.2	1.4	-3.4	3.3
Alameda G3b	1.1	-1.0	3.3	5.0	17.2	Alameda G3b	1.1	1.0	1.9	-5.3	3.8
Alameda G4	1.2	-1.2	2.8	29.1	16.6	Alameda G4	1.2	1.0	2.4	-2.5	5.2
Alameda S2	1.0	1.2	3.2	-6.6	1.9	Alameda S2	-1.1	1.0	1.7	-8.0	-2.0
NWIRP Alt 1	-1.1	1.3	9.0	4.2	5.7	NWIRP Alt 1	1.0	1.4	6.8	-5.3	4.7
NWIRP Alt 2	-1.2	1.3	12.0	3.5	6.2	NWIRP Alt 2	1.0	1.4	9.5	-4.4	5.0
NWIRP Alt 3	-1.5	-1.3	8.6	2.2	7.5	NWIRP Alt 3	-1.5	-1.3	1.8	-4.8	1.6
NWIRP Alt 4	1.0	1.3	7.2	-2.9	5.5	NWIRP Alt 4	-1.0	1.3	4.3	-6.6	3.0
NWIRP Alt 5	-1.2	1.3	9.1	7.3	5.9	NWIRP Alt 5	-1.3	1.2	1.9	-4.0	-1.0
NWIRP Alt 6	1.0	1.5	3.2	-4.2	3.7	NWIRP Alt 6	-1.2	1.2	1.6	-5.5	-2.9

Orange shading - SiteWise higher *Blue shading - SimaPro higher* *Alt = Alternative*

Table 8: SiteWise™ Versus SimaPro® Results – Result Ratios for Remedy Alternatives (SimaPro® Results Do Not Include Infrastructure)

	Result Ratio SiteWise V2 versus SimaPro					Result Ratio SiteWise V3 versus SimaPro					
	CO2e	Energy	NOx	PM	SOx		CO2e	Energy	NOx	PM	SOx
CRREL Alt 1	-1.1	1.2	1.8	1.3	2.5	CRREL Alt 1	-1.0	1.0	1.2	-11.6	1.3
CRREL Alt 2	-1.1	1.2	1.8	1.3	2.5	CRREL Alt 2	1.0	1.1	1.3	-10.6	1.4
CRREL Alt 3	1.2	1.4	3.5	72.7	4.4	CRREL Alt 3	1.2	1.3	1.5	-7.6	1.7
CRREL Alt 4	-17.6	1.3	-19.4	-3.9	-4.3	CRREL Alt 4	-1.2	1.2	-1.4	-6.6	1.0
Alameda G2	-1.2	-1.3	3.3	25.6	16.7	Alameda G2	-1.1	-1.2	1.5	-1.2	2.8
Alameda G3a	1.3	1.2	4.0	6.7	18.9	Alameda G3a	1.3	1.2	1.3	-4.5	3.2
Alameda G3b	1.0	-1.1	3.2	4.1	17.1	Alameda G3b	1.1	1.0	1.9	-6.6	3.8
Alameda G4	1.2	-1.2	2.8	27.9	16.6	Alameda G4	1.2	1.0	2.4	-2.6	5.2
Alameda S2	-1.3	-1.4	2.3	-13.3	1.1	Alameda S2	-1.4	-1.6	1.2	-16.2	-3.3
NWIRP Alt 1	-1.1	1.3	8.9	3.5	5.7	NWIRP Alt 1	1.0	1.4	6.7	-6.5	4.6
NWIRP Alt 2	-1.2	1.3	11.8	2.9	6.1	NWIRP Alt 2	1.0	1.4	9.3	-5.1	4.9
NWIRP Alt 3	-1.5	-1.4	8.3	1.6	7.3	NWIRP Alt 3	-1.5	-1.4	1.8	-6.6	1.5
NWIRP Alt 4	-1.0	1.2	7.0	-3.8	5.3	NWIRP Alt 4	-1.0	1.2	4.2	-8.7	3.0
NWIRP Alt 5	-1.3	1.2	8.8	5.1	5.7	NWIRP Alt 5	-1.4	1.1	1.9	-5.7	-1.1
NWIRP Alt 6	-1.1	1.3	3.0	-5.8	3.0	NWIRP Alt 6	-1.4	1.0	1.5	-7.8	-3.6

Orange shading - SiteWise higher *Blue shading - SimaPro higher* *Alt = Alternative*

Observations from Tables 6 to 8 include the following:

- One major improvement to SiteWise™ during the project was the addition of footprints for NOx, PM, and SOx calculated for materials production, so footprint totals for these parameters are generally higher for SiteWise™ Version 3 compared to SiteWise™ Version 2 (which did not include NOx, PM, and SOx footprints for materials production). Also in SiteWise™ Version 2, PM was not calculated for electricity consumption but it is for Version 3 which results in greater PM emissions in Version 3. Other changes were made in Version 3 with respect to electricity footprint factors.

- For CRREL Alt 4, SiteWise™ Version 2 had particularly large footprints for CO_2e and energy, due primarily to the representation of water disposal to the publicly owned treatment works (POTW). These footprint factors were modified in SiteWise™ Version 3, significantly improving the match between tools.

- The CO_2e and energy footprints more closely match between SiteWise™ and SimaPro® than the footprints for NOx, PM, and SOx. There is likely more variability in footprint factors for the three criteria pollutants than CO_2e and energy.

    - For example, if a certain amount of fuel is used, the energy and CO_2e should be a relatively straightforward calculation and there should not be much variability between tools.

    - However, for the three criteria pollutants, the amount of pollutant emitted per gallon of fuel can be quite different depending on the type of equipment used or source of the footprint factors, resulting in more potential variability for those footprint factors.

- There are no alternatives where the total footprints are within a factor of 1.2 between tools for all metrics, suggesting that variations in footprint results of greater than 20% are typical (i.e., should be expected) when comparing SiteWise™ and SimaPro®.

    - However, for CO_2e and energy, the total footprints for each remedy alternative from SiteWise™ Version 3 are always within a factor of 1.6 of the results from SimaPro® (i.e., not extremely different) and are within a factor of 1.2 for 10 of the 15 alternatives (both with and without infrastructure).

- Visual inspection of Table 6 suggests that even though the tool results do not generally agree within a factor of 1.2, SiteWise™ Version 3 provides results that are generally comparable to SimaPro®.

- The ranking of alternatives at a given site based on footprint results generally agrees between SiteWise™ Version 3 and SimaPro®.

  - For instance, for CRREL all six alternatives rank in the same order with both tools, for each of the five sustainability metrics.

  - For the other two sites, the rankings are similar between tools but do not match exactly. This will depend on specific items in the remedy alternatives and the footprint factors for those specific items.

- When comparing SiteWise™ Version 3 to SimaPro® with respect to the total footprints for remedy alternatives, the CO_2e results show little or no bias as to which tool is higher. However, the energy, NOx, and SOx show some bias in that they are generally higher for SimaPro®, and the PM is generally higher for SiteWise™.

- As expected, the footprints calculated by SimaPro® "without infrastructure" are lower than the footprints calculated "with infrastructure." The effect of changing the system boundary to include infrastructure varies by alternative and sustainability metric. In general, adding infrastructure had a small effect on remedy footprint totals relative to the overall difference in footprint totals between the tools. This is further quantified and discussed in 5.10.1 and Section 6.1.3.

All remedy items included in the SimaPro® calculations were also included in the SiteWise™ Version 3 calculations, so no differences are attributable to items being left out of one of the tools. However, there is potential variability in the benchmark tool footprints based on processes selected in SimaPro® to represent remedy items (discussed in Sections 6 and 8 of this report).

5.7.2 Components of Remedy Alternatives

A more detailed comparison of SiteWise™ and SimaPro® results, broken down by remedy components, is provided in the following appendices:

- Appendix C: Results by Remedy Components – SiteWise™ Version 3 versus SimaPro®

- Appendix D Results by Remedy Components – SiteWise™ Version 2 versus SimaPro®

Each of these appendices contains one page per remedy alternative. On the top of the page is a table that provides (for each of the five sustainability metrics) the rank and percent contribution for different components of the remedy alternative. The components are ordered as follows:

- "Elec" – Electricity use
- "Fuel" – Fuel use
- "Mat" – Materials use
- "Trans" – Transportation
- "Water" – Water use
- "Disp" – Disposal

On the bottom of each page of those appendices is a result ratio between the two tools (similar to the result ratio presented earlier for the remedy alternative totals). The results for percent contributions and result ratios are provided as ranges, so as not to violate license agreements for any of the SimaPro® libraries. These comparisons were made to the SimaPro® results "with infrastructure" because those SimaPro® values better represent the full life-cycle.

For SiteWise™ Version 3, there is a one-to-one comparison with SimaPro® for every remedy component of every alternative. This is not the case for SiteWise™ Version 2, because SiteWise™ Version 2 did not calculate some footprints (e.g., PM for electricity usage was not calculated in Version 2, and all three criteria pollutants considered in this study were not calculated for materials production in Version 2). Additional observations from Appendix C (i.e., for SiteWise™ Version 3) include the following:

- The rankings for the footprint contributors are generally similar, but do not match exactly. For example, for Alameda Alt G-3A, both tools indicate that electricity use for ISTT is the highest contributor for CO_2e, energy and SOx. SiteWise™ also indicates that electricity use for ISTT is the highest contributor for PM, but SimaPro® indicates that the iron use for ISCO is the highest contributor for PM and the ISTT for electricity is the second highest contributor. Conversely, SiteWise™ indicates that hydrogen peroxide use is the highest contributor for NOx, but SimaPro® indicates that the ISTT electricity is the highest contributor for NOx and the hydrogen peroxide use is the second highest contributor.

- The remedy item that contributes most to the footprints depends on the remedy. Electricity use is the highest contributor for many of the alternatives, but not always. For instance, granular activated carbon (GAC) and water disposal to a publicly owned treatment works (POTW) in CRREL Alt 4 have higher contributions than electricity for some of the sustainability metrics.

- The result ratios indicate some patterns regarding bias. For instance, PM in SiteWise™ Version 3 is typically much higher than the SimaPro® results for electricity and disposal in a landfill, but is typically lower than the SimaPro® results for transportation.

There is potential variability in the benchmark tool footprints based on processes selected in SimaPro® to represent remedy items (discussed in Sections 6 and 8 of this report).

5.8 QUANTITATIVE RESULTS: SRT™ VERSUS SIMAPRO®

5.8.1 Footprint Totals for Remedy Alternatives

SRT™ (Version 2.1 and 2.3) and SimaPro® were compared for 5 demonstration site remedy alternatives. The footprint totals for each of the entire alternatives are presented in Table 9 (i.e., the total footprint values for each alternative). The SimaPro® results are presented "with infrastructure" and "without infrastructure" so impacts of that type of boundary condition could be assessed. A more detailed discussion regarding infrastructure is provided in Section 5.10.1.

The SRT™ footprints have "round" numbers consistent with the rounding that is performed within that tool.

Table 9: SRT™ Versus SimaPro® Results – Footprints Totals for Remedy Alternatives

Site/Alternative/Model	CO_2* (short tons)	Energy (MJ)	NOx (short tons)	PM10 (short tons)	SOx (short tons)
Beale Alt 2/SRT V2.1	34	460,000	0.17	0.008	0.003
Beale Alt 2/SRT V2.3	35	490,000	0.23	0.014	0.003
Beale Alt 2/SimaPro with Inf	48	930,000	0.35	0.029	0.065
Beale Alt 2/SimaPro w/o Inf	43	810,892	0.34	0.025	0.052
Beale Alt 3/SRT V2.1	85	560,000	0.20	0.010	0.018
Beale Alt 3/SRT V2.3	59	920,000	0.35	0.042	0.087
Beale Alt 3/SimaPro with Inf	98	1,776,660	0.71	0.058	0.157
Beale Alt 3/SimaPro w/o Inf	86	1,516,578	0.68	0.045	0.128
Little Rock/SRT Tier 1 V2.1	110	1,500,000	0.92	0.044	0.001
Little Rock/SRT Tier 2 V2.3	150	1,900,000	1.20	0.072	0.001
Little Rock/SimaPro with Inf	665	8,106,623	3.45	0.268	0.589
Little Rock/SimaPro w/o Inf	533	4,241,511	2.64	0.172	0.384
Travis Alt 1/SRT V2.1	1,307	21,073,000	7.73	2.701	14.007
Travis Alt 1/SRT V2.3	596	21,110,000	0.23	0.097	0.147
Travis Alt 1/SimaPro with Inf	1,013	21,807,645	1.43	0.068	7.668
Travis Alt 1/SimaPro w/o Inf	1,005	21,657,822	1.4	0.054	7.646
Travis Alt 2/SRT V2.1	621	194,000	0.07	0.004	0.013
Travis Alt 2/SRT V2.3	191	6,877,000	0.46	0.192	0.227
Travis Alt 2/SimaPro with Inf	229	9,636,676	0.68	0.064	0.311
Travis Alt 2/SimaPro w/o Inf	214	9,306,808	0.63	0.046	0.276

**SRT calculates CO2, but the SimaPro values are CO_2e (i.e., includes other greenhouse gases)*
Alt = Alternative (Alternatives were summarized in Table 4b)
Short ton = 2000 lbs
MJ = megajoules
Inf – Infrastructure (with; w/o = without)

Tables 10 and 11 present similar results, but in a format that illustrates the result ratios between the SRT™ and SimaPro® results (a positive value indicates the SimaPro® footprint was higher, and a negative value indicates the SRT™ footprint was higher). Table 10 presents the comparison for SimaPro® results that include infrastructure, and Table 11 presents the comparison for SimaPro® results without infrastructure. The method for calculating result ratios was presented in Section 3.2.

Table 10: SRT™ Versus SimaPro® Results – Result Ratios for Remedy Alternatives (SimaPro® Results Include Infrastructure)

Result Ratio SRT V2.1 versus SimaPro						Result Ratio SRT V2.3 versus SimaPro					
	CO2	Energy	NOx	PM	SOx		CO2	Energy	NOx	PM	SOx
Beale Alt 2	1.4	2.0	2.1	3.6	21.7	Beale Alt 2	1.4	1.9	1.5	2.1	21.7
Beale Alt 3	1.2	3.2	3.6	5.8	8.7	Beale Alt 3	1.7	1.9	2.0	1.4	1.8
Little Rock	6.0	5.4	3.8	6.1	589.0	Little Rock	4.4	4.3	2.9	3.7	589.0
Travis Alt 1	-1.3	1.0	-5.4	-39.7	-1.8	Travis Alt 1	1.7	1.0	6.2	-1.4	52.2
Travis Alt 2	-2.7	49.7	9.7	16.0	23.9	Travis Alt 2	1.2	1.4	1.5	-3.0	1.4

SRT calculates CO2, but the SimaPro values are CO2e (i.e., includes other greenhouse gases)
Orange shading - SRT higher *Blue shading - SimaPro higher* *Alt = Alternative*

Table 11: SRT™ Versus SimaPro® Results – Result Ratios Remedy Alternatives (SimaPro® Results Do Not Include Infrastructure)

Result Ratio SRT V2.1 versus SimaPro						Result Ratio SRT V2.3 versus SimaPro					
	CO2	Energy	NOx	PM	SOx		CO2	Energy	NOx	PM	SOx
Beale Alt 2	1.3	1.8	2.0	3.1	17.3	Beale Alt 2	1.2	1.7	1.5	1.8	17.3
Beale Alt 3	1.0	2.7	3.4	4.5	7.1	Beale Alt 3	1.5	1.6	1.9	1.1	1.5
Little Rock	4.8	2.8	2.9	3.9	384.0	Little Rock	3.6	2.2	2.2	2.4	384.0
Travis Alt 1	-1.3	1.0	-5.5	-50.0	-1.8	Travis Alt 1	1.7	1.0	6.1	-1.8	52.0
Travis Alt 2	-2.9	48.0	9.0	11.5	21.2	Travis Alt 2	1.1	1.4	1.4	-4.2	1.2

SRT calculates CO2, but the SimaPro values are CO2e (i.e., includes other greenhouse gases)
Orange shading - SRT higher *Blue shading - SimaPro higher* *Alt = Alternative*

Observations from Tables 9 to 11 include the following:

- The results from SRT™ Version 2.3 are generally closer to the SimaPro® results than SRT™ Version 2.1. This is due to improvements made to the SRT™ tool during the course of the project.

- For Travis Alt 2, SRT™ Version 2.1 had particularly low footprints for each of the sustainability metrics other than CO_2. This has to do with footprint factors for vegetable oil (bioremediation substrate) which is the dominant footprint contributor for this remedy. SRT™ Version 2.1 only calculated a CO_2 footprint for vegetable oil, whereas SRT™ Version 2.3 calculates a footprint for each of the sustainability metrics for vegetable oil (and also uses a smaller footprint factor for the CO_2 footprint).

- For Travis Alt 1, SRT™ Version 2.1 had much higher values for the three criteria pollutant footprints (NOx, PM, and SOx) than SRT™ Version 2.3. This is due to the fact that the SRT™ Version 2.3 incorporates a local, rather than national, electricity mix.

- For several alternatives (Beale Alt 2, Little Rock, and Travis Alt 1) the SOx value calculated by SRT™ Version 2.3 is much smaller than the SimaPro® result. The cause differs by alternative. For Beale Alt 2 and Little Rock, the reason is that the primary SOx contributor(s) in SimaPro® (e.g., landfill activities associated with soil disposal) were not represented within the SRT™ tool (transport of soil for disposal is accounted for in the excavation total, but the landfill operations footprint is not fully considered). For Travis Alt 1, the difference is primarily the result of a difference in the SOx footprint factor for electricity use.

- The SRT™ results are nearly always less than the SimaPro® results for each sustainability metric, indicating some bias. This is primarily due to the fact that there were many remedy items (e.g., cement production) represented in the SimaPro® tool that not were not represented in the SRT™ tool (see Appendix E and Appendix F for specific examples), which in some cases is due to limitations in the SRT™ tool.

- There are no alternatives where the total footprints are within a factor of 1.2 between tools for all metrics, suggesting that variations in footprint results of greater than 20% are typical (i.e., should be expected) when comparing SRT™ and SimaPro®.

    - With the exception of Little Rock, for CO_2 and energy, the total footprints for each remedy alternative from SRT™ Version 2.3 are always within a factor of 1.7 of the results from SimaPro® (i.e., not extremely different). As detailed in Appendix E, For Little Rock very large contributors to the CO_2e and energy footprints in SimaPro® were not represented in SRT™ (cement production and landfill operations for soil disposal).

- Visual inspection of Table 9 suggests that even though the tool results do not generally agree within a factor of 1.2, SRT™ Version 2.3 provides results that are generally comparable to SimaPro® (although there are some exceptions for reasons noted above).

- The ranking of alternatives at a given site based on footprint results generally agrees between SRT™ Version 2.3 and SimaPro® (this evaluation is somewhat limited since two of the sites had two alternatives and the other site had one alternative).

    - For Beale both alternatives rank in the same order with both tools, for each of the five sustainability metrics.

    - For Travis, the rankings are the same for CO2e and energy between tools, but do not match for the criteria pollutants. This will depend on specific items in the remedy alternatives and the footprint factors for those specific items.

- As expected, the footprints calculated by SimaPro® "without infrastructure" are lower than the footprints calculated "with infrastructure." The effect of changing the system boundary to include or exclude infrastructure varies by alternative and sustainability metric. In general, adding infrastructure had a small effect on remedy footprint totals relative to the overall difference in footprint totals between the tools. This is further quantified and discussed in 5.10.1 and Section 6.1.3.

There is some variability in the benchmark tool footprints based on processes selected in SimaPro® to represent remedy items (discussed in Sections 6 and 8 of this report), which impacts comparisons between tools. Some variance between tools is due to the original program design specifications and objectives of SRT™ which do not include some remedy items and calculations included in the SimaPro® calculations. Additionally, per the design of the project, the SRT™ tool was applied to the demonstration sites prior to this Study, which limited some input values relative to Coordination of Site Data Input sheets developed for the Air Force sites.

5.8.2 Components of Remedy Alternatives

A more detailed comparison of SRT™ and SimaPro® results, broken down by remedy components, is provided in the following Appendices:

- Appendix E: Results by Remedy Components – SRT™ Version 2.3 versus SimaPro®

- Appendix F Results by Remedy Components – SRT™ Version 2.1 versus SimaPro®

Each of these appendices contains one page per remedy alternative. On the top of the page is a table that provides (for each of the five footprint types) the rank and percent contribution for different components of the remedy alternative. The components are ordered as follows:

- "Elec" – Electricity use
- "Fuel" – Fuel use
- "Mat" – Materials use
- "Trans" – Transportation
- "Water" – Water use
- "Disp" – Disposal

On the bottom of each page of those appendices is a result ratio between the two tools (similar to the result ratio presented earlier for the remedy alternative totals). The results for percent contributions and result ratios are provided as ranges, so as not to violate license agreements for any of the SimaPro® libraries. These comparisons were made to the SimaPro® results "with infrastructure" because those SimaPro® values better represent the full life-cycle.

SRT was designed as a screening tool for specific types of remediation common at AFCEC sites, and therefore does not include all of the remedy items represented by SimaPro®. In some cases, the highest contributors according to SimaPro® were not included in the SRT™ evaluations. For instance, for Little Rock, SimaPro® indicates the highest contributor to CO_2 is the use of cement, but this material is not represented in SRT™. Water use is also not represented in SRT™, but for these demonstration sites water use did not contribute significantly to the footprints based on the SimaPro® results.

Additional observations from Appendix E (i.e., for SRT™ Version 2.3) include the following:

- Notwithstanding the issues described above, the rankings for the footprint contributors are often similar, but do not match exactly. For example, Travis Alt 1 has one-to-one comparison for each remedy component, and electricity is ranked as the highest contributor, for each sustainability metric, by both tools. However, SRT™ indicates that transportation of personnel for O&M is the second highest contributor for NOx (10-50% contribution) but SimaPro® indicates that transportation of personnel for O&M is the third highest contributor for NOx (1-10% contribution) and that fuel for drilling is the second highest contributor for NOx.

- The remedy item that contributes most to the footprints depends on the remedy. Electricity use, fuel use, materials production, transportation, and disposal were all indicated as the highest contributor for one of the sustainability metrics for at least one alternative.

- The result ratios for specific remedy components indicate less overall bias than the results for the remedy totals, which indicates that the bias observed for remedy totals (i.e., SimaPro® footprints are almost always higher than SRT™) is primarily due to items not included in the SRT™ evaluations.

There is potential variability in the benchmark tool footprints based on processes selected in SimaPro® to represent remedy items (discussed in Sections 6 and 8 of this report).

5.9 SUMMARY OF IMPROVEMENTS MADE TO SITEWISE™ AND SRT™

5.9.1 SiteWise™ Improvements Implemented During This Project

SiteWise™ was updated from Version 2 to Version 3 as part of this project based on initial results from the demonstration sites and associated recommendations from the Benchmark Team. Many of the improvements pertained to methods or footprint factors for calculation of footprint values, and others pertained to ease of use or formatting. Revisions made to SiteWise™ from Version 2 to Version 3 are summarized in Tables 12a and 12b.

Table 12a: Summary of SiteWise™ Improvements that Impact Footprints

Revisions that Impact Footprint Results	
Observations by Benchmark Team for SiteWise™ Version 2	**Revisions Implemented in SiteWise™ Version 3**
Inconsistencies were noted with respect to whether life-cycle impacts were calculated for all fuel burning equipment.	Life-cycle impacts are now calculated for all activities requiring fuel use. The criteria pollutants calculated by the tool (NOx, PM, and SOx) are calculated as either on-site or off-site, and a total criteria pollutants impact is also reported in summaries.
SiteWise™ did not include footprint factors for several materials that are commonly used in remediation.	A list of commonly used materials in environmental remediation has been developed by the project team and impacts associated with manufacturing these typical materials have been analyzed. From this effort, five generic materials were added to the materials list; these selections include "Very Low," "Low," "Medium," "High," and "Very High" Impact Materials (see Section 5.11).
There was limited robustness in the calculation of NOx, SOx and PM. For materials, only CO_2e and energy are calculated.	Criteria pollutants (NOx, PM, and SOx) are now included for material use. Previously only energy use and CO_2e were calculated for material use.
Comparisons made for materials indicated many significant differences between SiteWise™ and SimaPro® results, and SiteWise™ did not include asphalt which is a commonly used material.	Several materials were updated with more accurate footprint factors. These include: Virgin GAC, Steel, and Vegetable Oil. Additionally, asphalt was added to the materials list. Footprint factors for Laboratory Analysis, Water and Wastewater treatment, Tillage, Generators, and Area Stabilization were updated with better sources to provide more reasonable estimates for total impact of each activity.
For equipment/material transportation, SimaPro® has the option to allow shared truckloads to account for cases where equipment or material will be transported by a common carrier rather than a dedicated truck. SiteWise™ did not have that option and thus required an assumption that all road transportation is done via a dedicated truck.	Equipment Road Transportation input is now separated into Dedicated-Load Road Transportation and Shared-Load Road Transportation. Shared-Load Road Transportation calculations (new for this version) use a ton-mileage approach. Dedicated-Load Road Transportation now also has the option for the user to select for empty return trips to be automatically calculated.

Revisions that Impact Footprint Results	
Observations by Benchmark Team for SiteWise™ Version 2	**Revisions Implemented in SiteWise™ Version 3**
Electricity emissions were generally (but not always) larger in SimaPro®. Some specific issues that were identified are as follows: • SiteWise™ used 2005 eGRID summary table for much of its data. More recent data are available. • SimaPro® includes the energy and emissions results for resource extraction and transmission (i.e., pre-combustion). SiteWise™ does not include energy or emissions for resource extraction or transmission. • For energy use, SiteWise™ assumes that for every unit of electricity used onsite, three times that amount of energy was used to generate that electricity at an offsite facility. By contrast, SimaPro® has specific footprint factors for energy used to generate a kWh of electricity from a particular fuel source. • PM is not calculated for electricity. • Although SiteWise™ allows for the selection of a custom blend of electricity, the user must do all calculations outside the tool to determine what the footprint factors are for the custom blend.	For impacts due to electricity generation, SiteWise™ Version 3 includes the following changes. • eGRID 2012 v1.0 (calendar year 2009 data) summary tables are used instead of 2005 data as footprint factors for CO_2, CH_4, N_2O, CO2e, NO_x, and SO_2 by state. • Transmission and distribution losses from eGRID 2012 v1.0 are now added to resource extraction (i.e., life-cycle impacts which have already been used in SiteWise™) to determine the final energy and emissions associated with electricity generation. • Heat input data and total electrical generation data by state from eGRID 2012v1.0 are used to develop efficiency factors for electrical generation by state. This addresses all primary forms of electrical generation reported in eGRID (coal, oil, hydro, natural gas, biomass, nuclear, wind, solar, and geothermal). Efficiency factors are supplied for each resource by state—where available—and also as national average efficiency by resource. Efficiency factors are calculated as the ratio of the each state’s net annual electrical generation (from all sources, including nuclear, solar, wind, etc.) to the state’s annual heat input, with equations for renewable resources satisfying the First Law of Thermodynamics. • PM emissions are included in addition to the existing NOx and SOx emissions. Total PM emissions are sourced from the 2008 National Emission Inventory by state and merged with data from eGRID 2012 v1.0 to develop PM footprint factors by state. • In the event that a user wants to use a custom blend of energy sources, a separate worksheet is included to assist in the calculation of impacts and efficiency of a custom feedstock blend. The user can then manually input the results into the Lookup Table for a different region under the “other” category.

Table 12b: Summary of SiteWise™ Improvements that Impact Usability/Formatting

Revisions that Impact Usability or Formatting	
Observations by Benchmark Team for SiteWise™ Version 2	**Revisions Implemented in SiteWise™ Version 3**
In many cases, the six columns available in the SiteWise™ inputs sheets were not sufficient. In particular multiple trips for transport of personnel or equipment or materials are often combined by user due to limited spaces for input.	The number of columns in SiteWise™ has been increased from 6 to 12 to allow for more inputs to be included per component. In addition, for equipment transportation, SiteWise™ has an option to include the footprint for an empty return trip. This eliminates the need for an additional column with a zero weight load to account for the empty return trip.
Tab names for SiteWise™ (i.e., Remedial Investigation, Remedial Action Construction, Remedial Action Operation, and Long Term Monitoring) may not be appropriate for each type of remedy.	Tabs for SiteWise™ have been renamed "Component 1, …, Component 4" rather than names for the various phases of the remediation process. These four component tabs are now identical; with each allowing the user the option to specify component duration. The user can provide the names for each component in the Input Sheet under the Site Info tab. These names are carried through the results presentation as headers in the output figures and graphs in addition to the output sheets. This adds flexibility for the user.
In the input sheet, values would need to be changed in both the "Look Up Table" tab and the "Look Up Table Defaults" tab in order for these changes to be preserved when an alternative is generated and then subsequently re-imported into SiteWise™. Unfortunately, this would change the look up table defaults for all other alternatives generated using that input sheet.	The Lookup Table values are preserved when an alternative is generated; it does not permanently alter the "Lookup Table Defaults" nor does it change with subsequent runs.
The generation of the alternative function would only save the input and summary output sheets but not the calculation sheets.	The generation of the alternative includes all of the calculation sheets in the generated folder with all links broken in addition to the Input Sheet and Summary Sheet.
SiteWise™ could not determine grout/steel and other material use from linear feet of wells installed. This had to be determined outside of model.	A separate worksheet has been added to calculate the amount of materials consumed for each well type. This sheet requires the user to input information such as well diameter, borehole diameter, and other well dimensions. The tool calculates the amount of materials consumed, allowing the user to manually input the information into the main input sheet. Impacts from these additional materials are now included in the results.

Revisions that Impact Usability or Formatting	
Observations by Benchmark Team for SiteWise™ Version 2	**Revisions Implemented in SiteWise™ Version 3**
In some cases, the user may have a known value for the setting of a variable frequency drive (VFD) motor but SiteWise™ had no method of calculating the energy consumption from that data requiring the calculation to be done outside the tool.	For pumps and other electrical units equipped with VFDs, an additional calculations line has been included within the Input Sheet to assist in the calculation of electricity usage based on VFD settings.
On output sheets, the footprint factors and the actual emissions values were denoted by the same cell color, making it more difficult to readily view results.	On output sheets, the footprint factors and the actual emissions values are denoted by a different cell color to make it easier to readily view results.
On the output sheets, the different sheets had different formats depending on what results they are reporting.	Each output sheet has the same format regardless of what results they are reporting. This makes post-processing of results easier.
It would be useful for the tools to provide information regarding the amount of total electricity used and the percent of that which is from renewable sources. SiteWise™ did not report the amount of electricity from renewable sources.	Electricity use and percent electricity from renewable sources is now reported.
When comparing alternatives, it would be useful to have a single chart that indicates the relative value for all metrics. SiteWise™ has a separate chart for each metric but did not have one chart for all metrics.	The Final Summary spreadsheet now includes a chart of normalized comparisons of impacts between alternatives. This chart is intended to be used in conjunction with the qualitative impacts table also included in the Final Summary spreadsheet.
The scales for the charts within SiteWise™ would set automatically based on the data. This was fine for the maximum but this would sometimes cause the minimum to be a value other than zero and this would sometimes exaggerate the differences among alternatives.	Vertical axes for all charts throughout SiteWise™ have been set for a minimum of zero.
Headings that are changed in the input sheet did not transfer to the output sheets, which makes locating input specific emissions more difficult.	Notes inserted into any cell in the Input Sheet are now saved when that Outputs are generated. These notes are preserved when the alternative is reloaded in the Input Sheet.

Revisions that Impact Usability or Formatting	
Observations by Benchmark Team for SiteWise™ Version 2	**Revisions Implemented in SiteWise™ Version 3**
It would be useful to have compatibility between Versions 2 and 3 of SiteWise™ to allow users to upload a Version 2 input sheet into Version 3. Since SiteWise™ downloads are free, there is no need to have Version 3 input sheets upload to a Version 2 program.	Version 3 Input Sheet loading is backwards compatible with Version 2 inputs (i.e., Version 3 can be used to load Version 2 generated Input Sheets). Pop-up notes direct the user within the tool on how to properly update the Version 2 inputs for Version 3 output generation. This is necessary because some key calculation infrastructure has changed between the Versions (e.g., the user must now specify electricity resource mix by state instead of by region).
User notes had to be kept outside of the SiteWise™ input sheet. It would be useful to have a spot within SiteWise™ to keep notes.	A Notes tab has been included in the Input Sheet for documenting changes in the Lookup Table.
It would be useful to have a method for tracking changes made in the lookup table.	Changes in the Lookup Table are now automatically highlighted.
It would be useful to inform the users of the need to make edits to the lookup table upon selection of a custom input factor.	On the Input Sheet, with any selection of a custom input factor, the user is notified by a pop-up note that the Lookup Table must be edited.

5.9.2 Suggested Future SiteWise™ Improvements

- Development of a User Guide for SiteWise™ Version 3 to accompany the public release of SiteWise™ Version 3. This will be funded by NAVFAC EXWC.

- Validation of footprint factors using objectives including reputability, robustness, relevance, recency, and possibly other criteria to decrease variation of results between DoD and EPA tools and to avoid duplication of efforts resulting from multi-tool analyses.

5.9.3 SRT™ Improvements Implemented During This Project

SRT™ was updated from Version 2.1 to Version 2.3 as part of this project, based on initial results from the demonstration sites and associated recommendations from the Benchmark Team. Many of the improvements pertained to methods or footprint factors for calculation of footprint values, and others pertained to ease of use or formatting. Revisions made to SRT™ from Version 2.1 to Version 2.3 are summarized in Tables 13a and 13b.

Table 13a: Summary of SRT™ Improvements that Impact Footprints

Revisions that Impact Footprint Results	
Observations by Benchmark Team for SRT™ Version 2.1	**Revisions Implemented in SRT™ Version 2.3**
The electricity footprint factor used for the SRT application is a default national average rather than one based on the local or regional grid.	State-specific values have been provided to calculate a local electricity mix and explained in Guide and Tool help buttons.
The bioremediation substrate CO_2 footprint factor for SRT is a factor of 5 to 10 higher than the corresponding footprint factor used in the SimaPro analysis, and the oxidant CO_2 footprint factor for SRT is a factor of 2 to 5 higher than the corresponding footprint factor used in the SimaPro analysis.	The footprint factors for bioremediation substrate and oxidants were revised to reflect recent research, and calculations and footprint factors within the tool were reviewed and revised where necessary.
The rates for drilling fuel consumption are determined differently in different modules and should likely be clarified (e.g., ISCO=10 gal/day and monitoring wells=32 gal/day).	Default drilling rates now assume the same rig type is used across all technologies. To aid the User, values for alternate equipment have been provided within the User Guide.
The SRT drilling footprints are generally lower than the SimaPro drilling footprints by a factor of 2 or more for all parameters. The SRT footprints for all parameters except sulfur oxide (SOx) are lower than the corresponding footprints from SimaPro for backfill transportation and soil disposal transportation.	Fuel efficiency for on-road and non-road activities were updated. Diesel emission footprint was revised to distinguish between on-road and non-road activities, affecting mainly nitrogen oxide (NOx) and particulate matter (PM10). Emissions due to landfill activities (i.e., transport and soil spreading) were incorporated for excavation and permeable reactive barrier (PRB) technologies. Clarifying language was added to the User Guide along with Help buttons in theTool.
Energy required to manufacture PVC is not being properly represented.	Footprint factor was updated and Tool calculations modified to include energy footprints from all materials including PVC.
The footprint factors for gasoline and diesel reference NREL but it is unclear if these are life-cycle values or just fuel combustion values.	The Tool default footprints have been updated so that only combustion processes contribute for the energy sources tracked in the Tool. A supplementary list of footprint contributors not accounted for in the defaults has been supplied in the User Guide and Tool Help buttons in the Tool.

Revisions that Impact Footprint Results	
Observations by Benchmark Team for SRT™ Version 2.1	**Revisions Implemented in SRT™ Version 2.3**
The SRT personnel transportation footprints for CO_2 and energy are higher than the corresponding SimaPro footprints by a factor of 2 to 5, while the footprints for airline transportation are more than an order of magnitude less than the corresponding SimaPro footprints.	Updated the footprint assumptions associated with air travel and vehicle travel. References are documented in the User Guide.
Footprint factors for energy, NOx, PM10, and SOx should be consistently applied. It appears inconsistent to include energy, NOx, PM10, and SOx for on-site fuel use, transportation, electricity, PVC, and steel but not for other significant materials or activities, such as emulsified vegetable oil (EVO) or oxidants.	Calculations in the Tool were revised to include the energy footprints of all materials. Documentation provided in User Guide and Tool Help buttons. When available, additional materials footprint factors were identified and updated. The Tool architecture has been updated to allow the User to add previously unavailable factors for tracked materials.
The SRT was unclear and inconsistent on which process in the life-cycle of materials and energy sources were the primary contributors to the corresponding energy and emissions footprint.	The Tool default footprints have been updated so that only combustion processes contribute for the energy sources tracked in the Tool, and only production values contribute for the raw materials tracked in the Tool. A supplementary list of footprint contributors not accounted for in the defaults has been supplied to the User, where possible. Clarifying language was added to the User Guide along with Help buttons in Tool.
The SRT includes CO_2 footprint footprint factors for oxidants, zero valent iron, bioremediation substrate and activated carbon. However, SRT does not include energy, NOx, PM, or SOx footprint footprint factors for these materials.	Calculations in the Tool were revised to include the CO_2 footprints for all materials. Where available, additional materials footprint factors were identified and updated.

Table 13b: Summary of SRT™ Improvements that Impact Usability/Formatting

Revisions that Impact Usability or Formatting	
Observations by Benchmark Team for SRT™ Version 2.1	**Revisions Implemented in SRT™ Version 2.3**
The SRT tool and associated manual are not clear on whether greenhouse gas footprints are reported as carbon dioxide (CO_2) or CO_2 equivalents.	CO_2 footprint is calculated and reported as tons CO_2, not equivalents (i.e., greenhouse gases other than carbon dioxide are not included). This clarification was added to the Guide and Tool help buttons.
There is an error in the manual for "Pump & Treat Variables & Calculations" under polyvinyl chloride (PVC).	The equation was reviewed and the User Guide updated to reflect the correct calculation.
Button "Calculate Natural Resource Service" on "Input soil" and "Input Groundwater" needs to be checked "No" in order to obtain certain calculations in next sheets. These calculations appear to have no relation to the "Natural Resource Service." The "No" to "Calculate Natural Resource Service" should be "No" by default.	Default preserved as "Yes" to encourage project managers to consider the natural resource effects of the remediation process. Language has been added to the Tool and User Guide clarifying that if set to "Yes," subsequent cells must be filled.
There is no room available for the User to make notes that clarify user inputs.	Comment field added to each editable page.
More clarification in the Help buttons would facilitate Tool use. Some Help buttons are not fully displayed.	Added several buttons clarifying the input processes. Reviewed all existing buttons and made consistent and visible.
User Guide is somewhat redundant and needs content restructuring and additional guidance on software use.	Default values and references for each technology were consolidated into a single Appendix B. Content was restructured to facilitate use. The "Quick Start" and "Technology Checklists" were incorporated into the User Guide. Clarifying language and lookup tables explaining modifications implemented in SRT™ Version2.3 was added.

5.9.4 Suggested Future SRT™ Improvements

There were additional parameters (e.g., water use) that could not be evaluated by SRT™ for this project, and which are deferred for possible future implementation. Suggested future revisions include the following:

- Calculate CO_2e rather than CO_2 for the sustainability metric representing GHG emissions.

- To the extent possible given the structure and intent of the tool, incorporate remedy items not currently represented in the tool (e.g., water use, for total amount used and for emissions generated from the consumption of water).

- Develop an “alternate module” for soil and groundwater that will allow the user to apply various forms of equipment use, materials, transportation, and other activities without specifying a technology.

- Validation of footprint factors using objectives including reputability, robustness, relevance, recency, and possibly other criteria to decrease variation of results between DoD and EPA tools and to avoid duplication of efforts resulting from multi-tool analyses.

- To the extent possible, augment the output to better quantify the specific contributors to the total footprints within each technology module.

5.10 SENSITIVITY ANALYSES REGARDING SIMAPRO® OPTIONS

5.10.1 Extending SimaPro® Boundary to Include Infrastructure

Many LCA databases, tools, and models discuss results with and without the consideration of infrastructure. The line between including and excluding infrastructure is an example of a system boundary in an LCA or GSR analysis. For vehicle use, in addition to the fuel use, an expanded boundary that includes infrastructure could also consider processes such as vehicle construction and road use (i.e., road deterioration). Ecoinvent LCI data modules available in SimaPro® explicitly show whether they are infrastructure processes or not.

To illustrate the sensitivity of SimaPro® results to this type of boundary condition, several items were represented in SimaPro® both “with infrastructure” and “without infrastructure.” Descriptions of these items from within SimaPro® are provided in Appendix G (including the specific names of the processes selected). Figure 9 (for the CO_2e sustainability metric) represents the percent contribution of infrastructure when infrastructure is included for the processes listed in Appendix G. On Figure 9 each bar represents 100 percent of the footprint total, and the red upper portion indicates the percentage of the total that is due to the “with infrastructure” option. Similar plots for energy, NOx, PM, and SOx are presented in Appendix G.

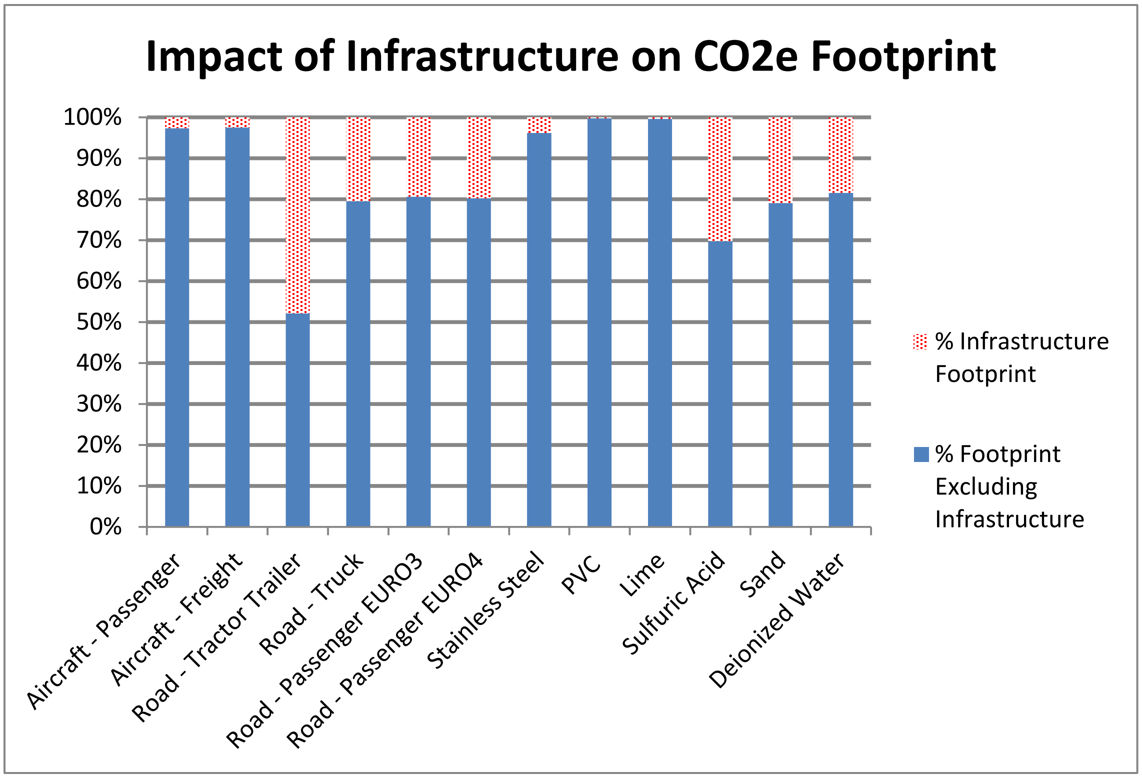


Figure 9: Impact of "Infrastructure" on SimaPro® CO2e Footprint, Selected Items

This figure (and the figures in Appendix G for the other sustainability metrics) illustrate that some items are affected by the addition of infrastructure more than others.

- In general, the impact of infrastructure on transport footprints is significantly larger than the impact of infrastructure on materials footprints. A primary reason is that the lifespan of a transport vehicle such as a tractor trailer is shorter than the lifespan of a chemical facility used to manufacture materials, and the depreciation occurs more rapidly for the tractor trailer, such that footprints (e.g., CO_2e) for infrastructure are greater for transport than for materials.

- For the materials evaluated, some have almost no impact from the infrastructure (e.g. lime or PVC resin), whereas others have a greater impact from infrastructure (e.g. sulfuric acid).

The SimaPro® assemblies and life-cycles that were created in this study for each remedial option of each demonstration site used processes from various libraries. Some of the specific processes included infrastructure and some did not based on how they were defined in the LCI library (even if the "with infrastructure" option was applied overall), and furthermore some databases or database items include more "infrastructure processes" than others. Therefore, the SimaPro® results reflect infrastructure to some degree but it is hard to fully quantify.

The footprint factors used in SiteWise^{TM} and SRT^{TM} generally do not include infrastructure. For example, truck transportation in SiteWise^{TM} considers the fuel combusted for truck transport and the process of extracting crude oil and refining it into diesel fuel; however, SiteWise™ does not include infrastructure items such as the construction of the truck. For SRT™, transportation by truck considers only the fuel combustion by default. A help button within the tool and User Guide provides the user guidance on how to consider production emissions apart from combustion, as well as default values when available. For the other materials or processes represented in these tools, the inclusion or exclusion of infrastructure in the footprint factors depends on the source of the footprint factors (the SRT User Guide documents the inclusion or exclusion of infrastructure).

5.10.2 Variation in SimaPro® for Different Choices for Selected Materials

There are often many processes that can be selected within SimaPro® to represent a specific item associated with a remedy. This partly results from the fact that SimaPro® is a general-use LCA tool and not tailored for environmental remedies. This is less of an issue with the DoD tools because the developers have pre-determined a "process" for typical components of environmental remedies, so the user does not need to choose among many possible options.

To gain some insight regarding the variability of results from SimaPro® that might result from different choices by the user regarding SimaPro® processes, an analysis was performed for different processes selected for specific materials. The variability of the SimaPro® footprint results was evaluated, and the results from SiteWise™ and SRT™ were also compared to the universe of SimaPro® results that were obtained. The materials that were selected for this sensitivity evaluation are summarized in Table 14.

Table 14: Materials Selected for Sensitivity Analysis

Material	Number of SimaPro® Processes Considered in Sensitivity Evaluation	Mass Evaluated for Sensitivity Comparisons
Steel	8	1,000 kg
Vegetable Oil	8	1,000 kg
PVC	10	1,000 kg
Gravel	8	1,000,000 kg
Cement	9	1,000 kg

In each case the SimaPro® evaluations included the infrastructure component of the footprints when the choice to include or exclude infrastructure was available. Appendix H contains the information pertinent to the sensitivity evaluation for each material listed above, in order, as follows:

- The SimaPro® description of each of the processes evaluated for the sensitivity analysis;

- Selected charts illustrating how SiteWise™ results compare to the variability of the SimaPro® results; and

- Selected charts illustrating how SRT™ results compare to the variability of the SimaPro® results.

This analysis is presented in a manner that honors the proprietary nature of some of the database values utilized by SimaPro®. The comparison charts in Appendix H include the following information for each material:

- Tables that indicate the average, median, minimum, maximum, and standard deviation of the SimaPro® results for the five sustainability metrics (CO_2e, energy, NOx, PM, and SOx) for the range of processes selected, as well as results for SiteWise™ or SRT™.

- A chart that illustrates the SiteWise™ or SRT™ results, in units of standard deviations away from the average SimaPro® result (i.e., a value of 1σ indicates the SiteWise™ or SRT™ result is higher than the average SimaPro® result by 1 standard deviation, as determined from the variability of the SimaPro® results).

- A second chart that illustrates if the SiteWise™ or SRT™ results are near the high end or low end of the SimaPro® results based on percentile distribution (i.e., a value of 40% indicates the SiteWise™ or SRT™ result is higher than 40% of the SimaPro® results).

The results indicate there is considerable variation in the SimaPro® results depending on the processes selected. Table 15 summarizes the variability of the SimaPro® results.

Table 15: Variability of SimaPro® Results for Different Processes Selected

Material*	Minimum	Maximum	Average	Median	Standard Deviation
Steel					
CO2e (MT)	0.420	2.042	1.292	1.299	0.516
Energy (MMBTU)	8.449	29.305	17.403	16.492	8.423
NOx (MT)	0.00098	0.00451	0.00243	0.00230	0.00133
PM (MT)	0.00003	0.00648	0.00259	0.00203	0.00243
SOx (MT)	0.00112	0.00485	0.00275	0.00253	0.00124
Vegetable Oil					
CO2e (MT)	0.689	2.724	1.657	1.853	0.676
Energy (MMBTU)	8.334	123.080	52.644	51.560	37.749
NOx (MT)	0.00221	0.00789	0.00578	0.00651	0.00184
PM (MT)	0.00017	0.00762	0.00184	0.00059	0.00273
SOx (MT)	0.00107	0.00091	0.00245	0.00243	0.00113

Material*	Minimum	Maximum	Average	Median	Standard Deviation
PVC					
CO_2e (MT)	1.556	3.254	2.318	2.249	0.638
Energy (MMBTU)	49.005	65.066	56.750	56.867	5.555
NO_x (MT)	0.00311	0.00626	0.00444	0.00419	0.0011
PM (MT)	0.00016	0.00158	0.00080	0.00054	0.00054
SO_x (MT)	0.00261	0.02170	0.00712	0.00551	0.00593
Gravel					
CO_2e (MT)	0.048	13.037	3.861	2.628	3.903
Energy (MMBTU)	0.630	160.538	71.929	57.759	50.697
NO_x (MT)	0.00027	0.04022	0.01864	0.01803	0.01091
PM (MT)	0.00000	0.00451	0.00193	0.00204	0.00153
SO_x (MT)	0.00004	0.02933	0.00973	0.00752	0.00907
Cement					
CO_2e (MT)	0.445	1.370	0.872	0.821	0.291
Energy (MMBTU)	2.705	8.356	4.134	3.600	1.699
NO_x (MT)	0.00070	0.00350	0.00141	0.00114	0.00083
PM (MT)	0.00000	0.00052	0.00013	0.00010	0.00015
SO_x (MT)	0.00031	0.00433	0.00116	0.00044	0.00139

**See Table 14 for the number of processes evaluated for each material, and see Appendix H for a description of those processes*
MMBTU- Million British Thermal Units
MT- Metric Ton

Observations from Table 15 and the charts in Appendix H include the following:

- A user is faced with making choices to select processes in SimaPro® to represent remedy items, and the decision of which process to select will often not be clear to a typical professional in the remediation industry.

- The SimaPro® results vary significantly depending on the processes selected by the user, with the minimum and maximum footprints from SimaPro® typically different by a factor greater than 2 and sometimes different by a factor of 10 or more.

- Comparison of the SiteWise™ and SRT™ footprints to the average SimaPro® footprints (charts in Appendix H) is complicated. For some of the selected materials, SiteWise™ and/or SRT™ does not calculate footprints for one or more of the sustainability metrics, though that was reduced by the tool improvements made during this project.

- There are some instances where the footprint from the DoD tool falls within the range of the SimaPro® results. However, in some cases the footprint from the DoD tool is higher than the highest value in the range of SimaPro® results or lower than the lowest value in the range of SimaPro® results.

Overall, these results indicate that comparison of results from SiteWise™ or SRT™ to SimaPro® is highly complex, and is perhaps not possible in an absolute sense because of the many potential choices available for processes in SimaPro® and the associated variability in the footprints calculated by SimaPro®.

5.11 SUGGESTED FOOTPRINT FACTORS FOR GENERIC MATERIALS

During the execution of the project there was consensus among the project team that there would be value in establishing a chart that could help guide users in specifying footprint factors for materials that might not be represented in the tools. This chart is presented as Table 16, and is based on representative footprint factors based on SimaPro® results for selected materials.

Table 16: Chart of Suggested Footprint Factors for Generic Materials

Category	CO2 Categorizer (per kg of material)	# of Materials in Each Category	Generic Values for each Category Based on SimaPro Results for Select Materials (for 1 kg of material)					Materials Each Category is Based on (In order from greatest CO2 emissions to smallest)
			Energy (MJ)	CO2 eq (kg)	Nox (kg)	Sox (kg)	PM (kg)	Text represents name of option as selected in SimaPro
Very High - 5	> 5 kg CO2 eq	2	100	10	0.02	0.02	0.001*	Potassium nitrate, as N, at regional storehouse/RER S
								Virgin GAC_Assembly_1kg
High - 4	> 2 - 5 kg CO2 eq	6	60	3	0.006	0.008	0.001*	Chromium steel 18/8, at plant/RER S
								Anionic resin, at plant/CH S
								PVC pipe E
								Glass fibre, at plant/RER S
								HDPE pipes E
								Regen_GAC_1kg
Medium - 3	> 1 - 2 kg CO2 eq	9	30	1	0.003	0.005	0.001*	Acetic acid, 98% in H2O, at plant/RER S
								Reinforcing steel, at plant/RER S
								Cationic resin, at plant/CH S
								Ammonium nitrate phosphate, as P2O5, at regional storehouse/RER S
								Sodium persulfate, at plant/GLO S
								Green Sand_1kg
								Potassium permanganate, at plant/RER S
								Hydrogen peroxide, 50% in H2O, at plant/RER S
								Sodium hydroxide, 50% in H2O, production mix, at plant/RER S
Low - 2	> 0.05 - 1 kg CO2 e	12	10	0.5	0.001	0.002	0.0004	Soybean oil, at oil mill/US S
								Sodium hypochlorite, 15% in H2O, at plant/RER S
								Iron (III) chloride, 40% in H2O, at plant/CH S
								Carbon dioxide liquid, at plant/RER S
								Cement, unspecified, at plant/CH S
								Lime, hydrated, loose, at plant/CH S
								Bentonite, at processing/DE S
								Iron sulphate, at plant/RER S
								Sulphuric acid, liquid, at plant/RER S
								Molasses, from sugar beet, at sugar refinery/CH S
								Pellets, iron, at plant/GLO S
								HCl, 36% in H2O, from reacting propylene and chlorine, at plant/RER S
Very Low - 1	0 - 0.05 kg CO2 eq	3	0.2	0.01	4.00E-05	3.00E-05	2.00E-05	Graphite, at plant/RER S
								Gravel, unspecified, at mine/CH S
								Sand, at mine/CH S

* The generic value for PM is based on the average PM emissions of all materials in the top three categories (average of 17 materials)

Generic values are visually representative of SimaPro® results (accounting for the range and distribution of values but not in a statistically rigorous manner). The third column indicates the number of materials associated with that group (which are each identified in the last column).

The following approach was employed to develop the chart (in a manner that honored the proprietary aspects of some of the databases employed by SimaPro® because the suggested footprint factors are based on a range of values from SimaPro® for multiple materials, and no specific footprint factor from SimaPro® for any one specific material is identified):

1. Select a group of representative materials to evaluate within SimaPro®, based on a unit mass of 1 kg. These materials are listed on Table 16, and the SimaPro® descriptions for each are presented in Appendix I.

2. Categorize these materials into groups based on the CO_2e footprints (see groupings in the second column of Table 16).

3. Establish a representative value for each sustainability metric (energy, CO_2e, NOx, PM, and SOx) for each category of materials determined in Step 2, based on visual inspection of the SimaPro® footprints (i.e., accounting for the range and distribution of SimaPro® footprints but not in a rigorous statistical manner).

The idea of the chart (for a unit of 1 kg of material) is as follows:

- If a material listed in the last column on the chart (Table 14) is not included in the tool, and the user wants to include that material, it is suggested that the user input a generic material in the tool using the footprint factors illustrated on the chart corresponding to that material.

- If a generic material is not included on the chart (Table 14) or in the tool, but a CO_2e per kg can be established for the material, categorize the generic material based on column 2 of the chart (i.e., similarity of CO_2e footprint). Then, input a generic material in the tool using the known CO_2e footprint factor plus the footprint factors for the other footprints (energy, NOx, PM, and SOx) illustrated on the chart for that category of CO_2e.

- If a generic material is not included on the chart (Table 14) or in the tool, and a CO_2e per kg cannot be established for the material, categorize the generic material based on similarity to one or more other materials in the last column of the chart and input a generic material in the tool using the footprint factors illustrated on the chart for the corresponding category of CO_2e.

It is evident from the second column of the Table 16 that use of these generic factors still leaves a significant degree of uncertainty in the results. For example, the "high" category has a single CO_2e footprint factor to represent a range from 2 kg to 5 kg of CO_2e per kg of material. Using the specified representative footprint factor of 3 could result in overestimating the footprint by a factor of 1.5 or underestimating the footprint by a factor of 1.7. Although not shown in the table, the variability for the other sustainability metrics is more significant. Nevertheless, the use of the footprint factors suggested in this table for generic materials is a significant improvement compared to simply not accounting for any footprint from use of such materials.

5.12 IMPACT ASSESSMENT FOR ONE DEMONSTRATION SITE

Per the Demonstration Plan, a life-cycle impact assessment (LCIA) was performed to demonstrate the full scope of SimaPro's^{TM} capabilities. SiteWise^{TM} and SRT^{TM} do not have the capabilities to perform an impact assessment. A LCIA is used to evaluate the effect of an activity on a particular impact category such as global warming and acidification. The required components of an impact assessment are classification and characterization. Classification refers to classifying various types of emissions from the activity into the different potential impact categories. For example, CO_2 would be classified as a greenhouse gas that impacts the global warming category and SOx might be classified into "respiratory effects" and "acidification" because it affects both of these impact categories. Characterization refers to the combining the various emissions into a single reference unit. For example, CO_2 emissions and methane emissions would be converted into CO_2e by applying characterization factors to the emissions.

There are also optional steps to an impact assessment. These are normalization, grouping and ranking, and weighting. Normalization involves dividing the impact category results by a "normal" value to determine the relative impact of the activity relative to impacts from other sources. Grouping, ranking, and weighting are various means of attempting to consolidate the various impact categories into a smaller number of categories or one single score. For example, with several assumptions for the relative scale of the impacts, ecotoxicity and acidification could be grouped into a single ecological category.

There are approximately 25 methods to calculate impact assessments included in SimaPro®. Three of the methods included in the version of SimaPro® used for this study are as follows:

- Tool for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI 2.0) V3.03
- Eco Indicator 99 (E) V2.08
- CML 2001 (all impact categories) V2.05

TRACI is an impact assessment method appropriate for North America that was developed by the EPA using input parameters consistent with locations within the United States. Eco Indicator 99 (E) is a widely used European impact assessment method (the "E" stands for "egalitarian," one of three weighting options for the method). CML 2001 (all impact categories) is a methodology developed by the Center for Environmental Science of Leiden University in the Netherlands.

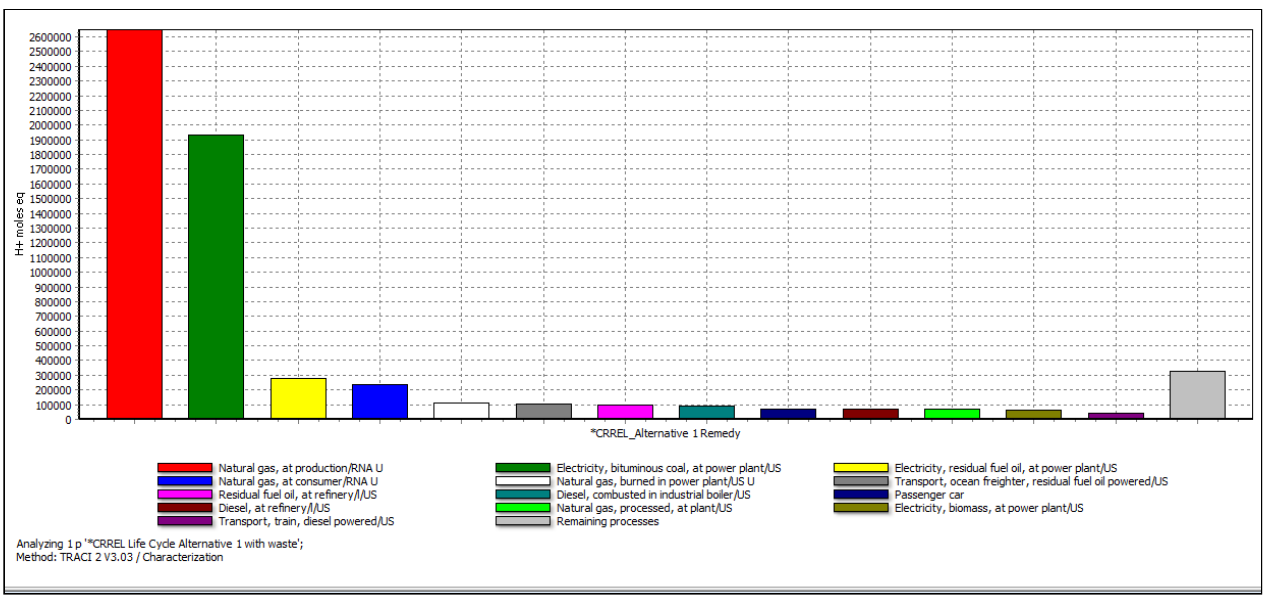
Examples of impact assessment results are presented below for remedy Alternative 1 at the CRREL demonstration site (CRREL Alternative 1) using the three impact assessment methods described above. These are intended to be examples and represent just some of the many possible output formats for impact assessment in SimaPro®.

The TRACI method performs impact assessment for nine different environmental and human health concerns. SimaPro® includes only the classification and characterization steps for the TRACI method. The impacts calculated by SimaPro® using the TRACI method are presented in Table 17.

Table 17: Impact Category Values for CRREL Alternative 1, TRACI Method

Impact category	Unit	Total
Global warming	kg CO_2 eq	17,000,000
Acidification	H+ moles eq	6,140,000
Carcinogenics	kg benzene eq	36,100,000
Non carcinogenics	kg toluene eq	322,000,000
Respiratory effects	kg PM2.5 eq	23,600,000
Eutrophication	kg N eq	5,940,000
Ozone depletion	kg CFC-11 eq	0.884
Ecotoxicity	kg 2,4-D eq	8,910,000
Smog	g NOx eq	93,900,000

SimaPro® also has the ability to individually list the substances contributing to a certain impact category, as well as the percentage of contribution. Figure 10 illustrates these contributions for the acidification category and highlights the percentage of a specific component's contribution to acidification in total moles of hydrogen ion equivalent for CRREL Alternative 1. By identifying the highest contributors, the user can analyze the potential for reductions by considering substitutions for a high contributor such as natural gas (in red) in this example.



Acidification:total moles of hydrogen ion equivalent (H+ moles eq)

Figure 10: Contributions to the Acidification Impacts for CRREL Alternative 1 Using the TRACI Method

The CML and Eco Indicator methods define different impact categories and use different units than TRACI in the characterization step. Figure 11 shows CML's impact assessment categories after the characterization and normalization steps (a full description of each category is beyond the scope of this report). To obtain the normalized values for each impact category, each equivalent value for each category in the characterization step was divided or normalized by the total equivalent annual world-wide emissions estimated by the CML developers. For example, the global warming potential associated with the remedy is approximately 4×10^{-7} or 0.00004% of the annual world-wide emissions of greenhouse gases. The normalized results for CRREL Alternative 1 determine the order of magnitude for the environmental problems relative to the existing environmental issues, thus potentially reducing the number of impact categories on which the user might focus.

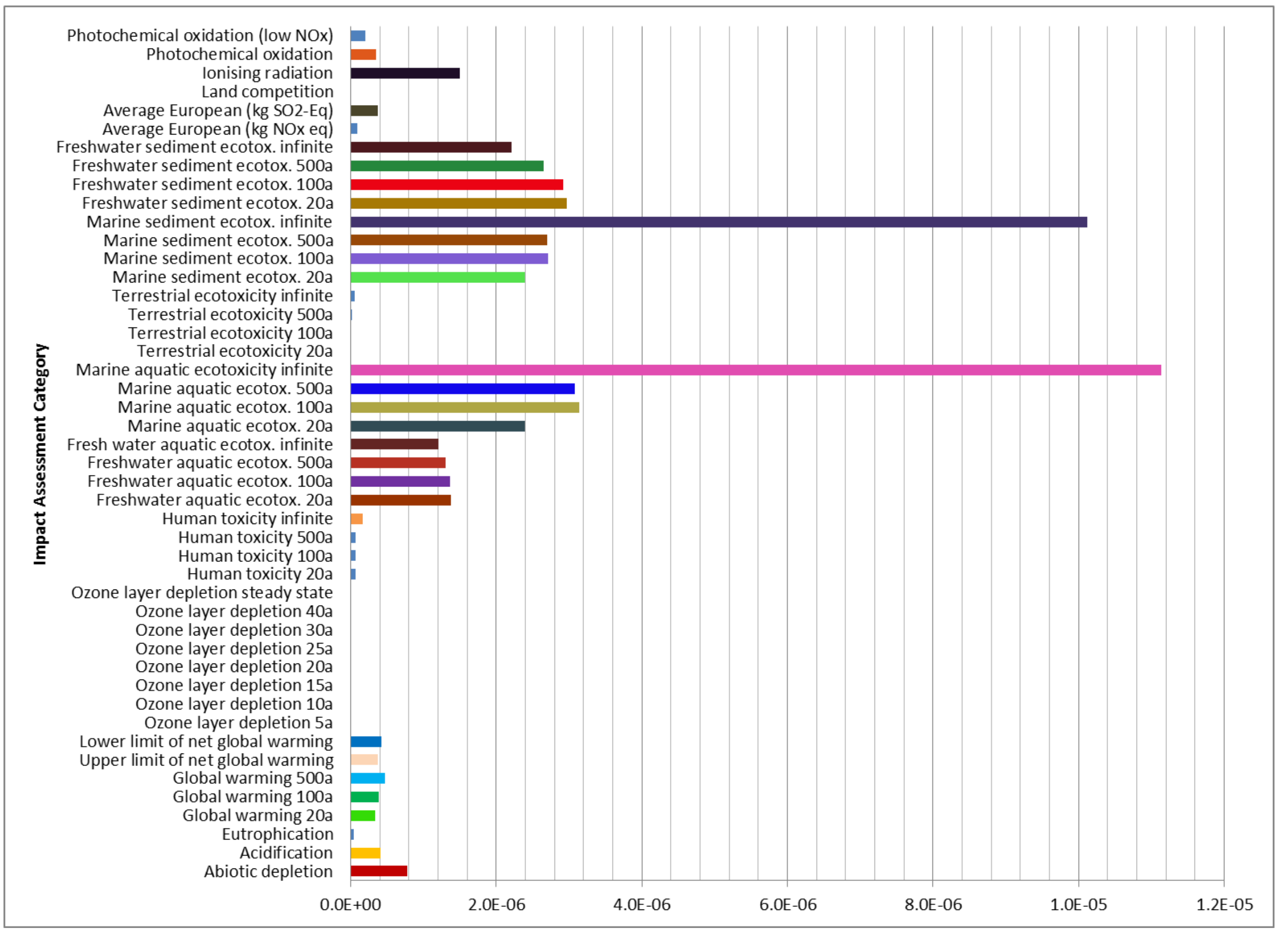
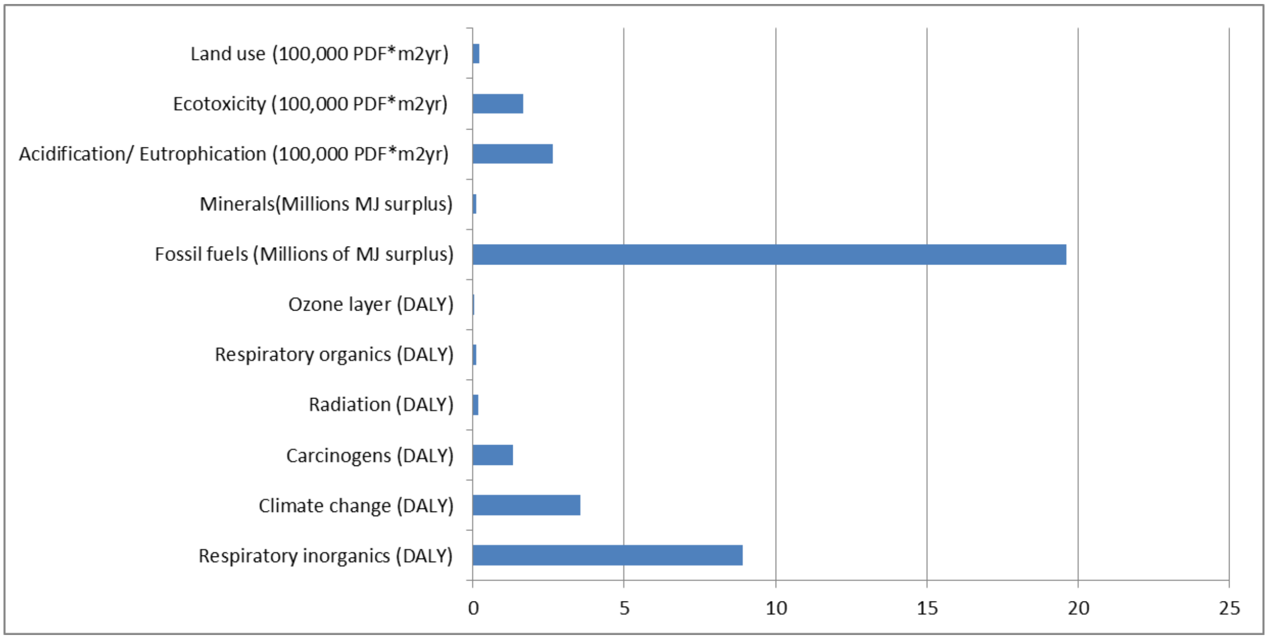


Figure 11: CML Impact Assessment Normalization for CRREL Alternative 1

Figure 12 shows the Eco Indicator damage assessment for CRREL Alternative 1, which is similar to the characterization except the characterization units are further consolidated to allow similar categories to be summed together. The units used for both the Eco Indicator characterization and damage assessment are intended to more directly convey the impacts on humans and the environment than the units used by TRACI and CML. For example, effects on humans are reported as the disability adjusted life years (DALY), which is a prediction of how many years of life are lost due to death or years of life disabled. Converting to units such as DALY involves additional assumptions and exposure modeling within Eco Indicator relative to TRACI and CML and therefore may be subject to more uncertainty.



Damage to Human Health: DALY- disability adjusted life years
*Damage to Ecosystem Quality: PDF*m2yr- potentially disappeared fraction of species*
Damage to Resources: Millions of Megajoules of surplus energy

Figure 12: Eco Indicator 99 (E) Impact Assessment for CRREL Alternative 1

In summary, impact assessment is a "next step" that can be performed after footprints are calculated, to evaluate impacts caused by those footprints. There are multiple methods and multiple options for performing the impact assessment in SimaPro®, and this section only provides some examples. The DoD tools do not include impact assessment.

6.0 PERFORMANCE ASSESSMENT

6.1 QUANTITATIVE PERFORMANCE OBJECTIVES

6.1.1 Footprint Contributor Ranking

This objective provides the extent to which the SiteWise™ and SRT™ footprints agree with SimaPro® results on the remedy components that are the largest contributors to each quantified environmental parameter (e.g., total energy use, NOx emissions, etc.). This objective is evaluated quantitatively by ranking the top 10 contributors to each sustainability metric and verifying that the order is the same for the DoD tool and the benchmark (SimaPro®). This assessment is quantitatively performed in a "binary" manner (i.e., the rankings are the same, or the rankings are not the same).

The results in Appendix C to Appendix F illustrate the rankings of the remedy footprint contributors for the DoD tool compared to SimaPro®. In general, the rankings are not identical, and as such the DoD tools do not strictly meet this quantitative objective. Observations regarding the rankings for footprint contributors (based on results presented in Appendix C to Appendix F) were discussed in Section 5.7.2 (SiteWise™) and 5.8.2 (SRT™).

Based on the evaluations discussed in this report regarding sensitivity of SimaPro® results to processes selected by the user (see Section 5.10.2 and Section 6.1.4) and/or the inclusion or exclusion of infrastructure (see Section 5.10.1 and Section 6.1.3), SimaPro® can provide multiple footprint results that differ from each other significantly based on user options. These differences are enough to change the rankings of one or more contributors. In general, it appears that the contributor rankings derived by SimaPro® may be sufficiently uncertain that a difference in the contributor rankings between a DoD tool and SimaPro® does not necessarily indicate a deficiency in the DoD tool. Depending on the scenario and input decisions of the SimaPro® user, the DoD tool results may be more applicable to a specific remedy than the SimaPro® results.

6.1.2 Result Ratio

This objective is evaluated quantitatively for each sustainability metric (e.g., NOx) by determining the ratio by which the DoD tool result differs from the benchmark result (larger result divided by smaller result, positive in one direction and negative in the other direction). Per the performance objectives, ratios greater than1.2 are considered significant.

- The result ratios for remedy alternative totals were presented in Section 5.7.1 (SiteWise™ versus SimaPro®) and Section 5.8.1 (SRT™ versus SimaPro®). As discussed in those sections of the report, there are no remedy alternatives where the footprint totals were within a factor of 1.2 between the DoD tool and SimaPro® for all five sustainability metrics evaluated, suggesting that variations in footprints of greater than 20% are typical (i.e., should be expected) when comparing the DoD tools and SimaPro®. However, with a few notable exceptions (discussed in the report) the DoD tools provide total footprints for remedy alternatives that are generally comparable to SimaPro® results.

- For CO_2e and energy, the total remedy footprints from SiteWise™ Version 3 were always within a factor of 1.6 of the results from SimaPro® (i.e., not extremely different) and 10 of the 15 alternatives evaluated were within a factor of 1.2.

- With the exception of Little Rock, for CO_2 and energy, the total footprints for each remedy alternative from SRT™ Version 2.3 are always within a factor of 1.7 of the results from SimaPro® (i.e., not extremely different).

- If total footprints for remedy alternatives at the same site are compared, the ranked alternatives based on footprints are mostly (but not always) in agreement between the tools.

Result ratios for components of remedy alternatives are indicated in Appendix C to Appendix F (bottom of each page). Clearly, many of the individual remedy components have DoD tool results that differ from the SimaPro® results by more than a factor of 1.2 and high results for some components partially offset low results from other components.

Based on the evaluations discussed in this report regarding sensitivity of SimaPro® results to processes selected by the user (see Section 5.10.2 and Section 6.1.4) and/or the inclusion or exclusion of infrastructure (see Section 5.10.1 and Section 6.1.3). It appears that SimaPro® may not serve as a strict "benchmark." In cases where SimaPro® accounts for items that are not accounted for in one of the DoD tools, that clearly is a cause for discrepancy. In other cases, however, it is not clear that results that differ by more than a ratio of 1.2 indicate a deficiency in the DoD tool, because there is no clear evidence that the footprint factors used in the DoD tool are invalid Those footprint factors may in some cases be more applicable to the specific remedy item than the footprint factors used in SimaPro® for the processes selected by the user.

6.1.3 Effects of the System Boundary With and Without Infrastructure

The results for remedy alternative totals were presented in Section 5.7.1 (SiteWise™ versus SimaPro®) and Section 5.8.1 (SRT™ versus SimaPro®). The SimaPro® results were calculated "with infrastructure" and "without infrastructure." This allows the impact of that system boundary to be quantitatively evaluated.

The results indicate that for remedy alternative totals the impact of this system boundary varies from "minimal" to "significant." A summary of the percent reduction in the SimaPro® result for each remedy alternative when infrastructure is not included is provided in Table 18.

Table 18: Impact of Infrastructure System Boundary on Footprint Totals

	Percent Reduction in SimaPro Result Without Infrastructure				
	CO_2e	Energy	NOx	PM	SOx
CRREL Alt 1	0.76	0.68	1.49	13.77	0.42
CRREL Alt 2	0.79	0.72	1.55	13.57	0.45
CRREL Alt 3	0.90	0.93	1.93	12.56	0.50
CRREL Alt 4	13.56	8.96	17.79	67.02	5.30
Alameda G2	1.01	1.45	1.45	2.30	0.41
Alameda G3a	2.75	2.98	4.61	23.71	1.83
Alameda G3b	1.43	1.70	2.43	19.31	0.60
Alameda G4	0.47	0.60	0.78	4.11	0.18
Alameda S2	25.22	38.99	26.60	50.45	40.44
NWIRP Alt 1	1.97	2.55	1.15	17.91	1.35
NWIRP Alt 2	1.65	2.23	2.06	15.01	1.27
NWIRP Alt 3	3.82	4.45	3.05	28.00	2.88
NWIRP Alt 4	3.53	4.54	2.32	24.12	2.56
NWIRP Alt 5	5.72	5.47	3.83	30.57	3.60
NWIRP Alt 6	11.90	13.40	7.80	28.84	18.52
Beale Alt 2	8.75	8.45	4.53	17.48	16.81
Beale Alt 3	11.89	14.64	5.26	22.18	18.66
Little Rock	19.88	47.68	23.39	35.82	34.78
Travis Alt 1	0.79	0.69	1.86	20.39	0.28
Travis Alt 2	6.62	3.42	7.71	27.93	11.42

The greatest boundary effect is generally for PM, where the inclusion of infrastructure generally accounts for more than 10% of the footprint and often accounts for more than 20% of the footprint. For other footprints, the boundary effect is generally less than 5% but is significantly higher (in some cases more than 20%) for some alternatives.

The variability in Table 18 is explained by the discussion in Section 5.10.1 regarding the sensitivity evaluation performed in this project regarding the "with infrastructure" and "without infrastructure" boundary condition. That analysis indicates that the impacts of this boundary condition are typically greater for transport than for materials, the impacts vary in magnitude from one transport selection to another or one materials selection to another, and the impacts are typically greater for PM than the other footprints. Thus, for alternatives where transport dominates the footprint, such as Alameda Alt S-2 and Little Rock, the boundary effect will tend to be quite significant.

To evaluate how this impacts the “result ratio” calculation, consider the following example.

- If the DoD tool yields a footprint of 1,200 and the SimaPro® result “with infrastructure” is 1,000 the results would differ by a ratio of 1.2 (i.e., within the target initially established in this project).

- If the user decides to exclude infrastructure in SimaPro®, and the boundary effect is 5%, then the SimaPro® footprint will be 950 and the result ratio will grow to 1.26.

- For cases where the boundary effect is 20% the SimaPro® footprint will be 800 and the result ratio will grow to 1.50.

- For cases where the boundary effect is 40% the SimaPro® footprint will be 600 and the result ratio will grow to 2.0.

These types of variations are all within the range of observed infrastructure effects in the results for pilot project alternatives (see Table 18 above), as well as the observed range in variation for infrastructure effects noted in sensitivity analysis for individual items conducted in this project (see Section 5.10.1). Thus, the evaluation of this performance objective indicates the selection of the system boundary does impact the results for other performance criteria in this study, and therefore, is significant. However, as noted in Section 5, for total remedy footprints adding infrastructure generally had a small effect on remedy footprint totals relative to the overall difference in footprint totals between the tools.

6.1.4 Sensitivity Analysis of Selections in SimaPro®

It was observed during project execution that many different choices for processes were available in the benchmark tool to represent specific remedy items. The most meaningful sensitivity analysis was to assess the range of footprints obtained from the benchmark tool for a range of viable selections for processes to represent specific items, and to compare those results to those obtained from the DoD tools. A successful outcome with respect to this metric would occur if footprints from the DoD tools are within the range of reasonable footprints from the benchmark tool.

The results of sensitivity analysis for production of five materials were presented in Section 5.10.2 (and Appendix H). That evaluation considered how footprints from SimaPro® might vary due to different processes selected by the user in SimaPro® for those materials. Evaluation of this performance metric indicates that SimaPro® results are sensitive to the processes selected by the user. This is complicated by the naming convention of the processes which abbreviate countries of origin and boundaries. The evaluation also indicates that the results provided by the DoD tools sometimes do not fall within the range of results the benchmark tool for a variety of potential processes used to represent specific remedy items. Note that this performance objective would be further complicated by the boundary effect discussed in Section 6.1.3 if that was also considered within the sensitivity analysis. One advantage of the DoD tools is that the selection of inputs for the user is more simple and clear.

6.1.5 Correlation or Bias

For each DoD tool, the footprints for particular sustainability metrics (e.g., NOx) from all the associated demonstration remedies were compared to SimaPro® footprints to illustrate potential correlation or bias in the results. For remedy alternative totals, these comparisons were provided in Tables 7 and 8 (SiteWise™ versus SimaPro®, with and without infrastructure) and in Tables 10 and 11 (SRT™ versus SimaPro®, with and without infrastructure). For components of remedy alternatives, these comparisons are provided in Appendix C to Appendix F.

For remedy totals, there appears to be some bias for the current versions of the tools:

- For SiteWise™ Version 3, there is little bias for the CO_2e footprint (i.e., not consistently higher or lower in one tool), but for three of the sustainability metrics (energy, NOx, and SOx) the SimaPro® results are generally higher than the SiteWise™ results (even when infrastructure is excluded in SimaPro®). For PM, the SiteWise™ results are generally much higher than the SimaPro® result.

- For SRT Version 2.3, most footprint results were higher in SimaPro® than in SRT™ (even when infrastructure is excluded in SimaPro®), and much of this is explained by the fact that many items for these remedies were represented in SimaPro® but not in SRT™ (see Appendix E and F).

For individual components of remedies, observations regarding bias include the following:

- For SiteWise™, the result ratios for remedy components indicate some patterns. For instance, PM in SiteWise™ Version 3 is typically much higher than the SimaPro® results for electricity and disposal in a landfill, but is typically lower than the SimaPro® results for transportation.

- For SRT™, the result ratios for specific remedy components indicate less overall bias than the results for the remedy totals, which indicates the bias observed for remedy totals is primarily due to items not included in the SRT™ evaluations.

Success would be indicated if the quantitative results suggest there is no consistent bias introduced by using one of the tools. The results clearly indicate some bias compared to the SimaPro® results for these pilot projects.

- In cases where SimaPro® accounts for items that are not accounted for in one of the DoD tools, that clearly is a cause for discrepancy that would lead to bias towards higher results in SimaPro®.

- For other items, however, it is not possible to make a general statement regarding systematic bias because (as discussed in Sections 6.1.3 and Section 6.1.4) there are so many potential variations in the benchmark result due to choices for processes and boundary condition (i.e., SimaPro® results being higher or lower than one of the DoD tools could simply be due to user selections in SimaPro®).

6.2 QUALITATIVE PERFORMANCE OBJECTIVES

6.2.1 Technical Confidence

This performance objective seeks to determine if there is more technical confidence in the output from SiteWise™ and or SRT™ versus SimaPro®, or vice versa.

- Initially it was envisioned that this would be evaluated for differences greater than a ratio of 1.2 between the DoD tool and SimaPro®.

- This is not practical given the large number of such discrepancies, and the variations in potential SimaPro® results due to different processes and/or boundary effects.

Therefore, this performance objective and what is considered success was revised, and is addressed in a more holistic manner.

It is the opinion of the ESTCP project team that all of the tools provide reasonable results, regardless of whether or not the DoD tool results are within a factor of 1.2 of the SimaPro® results.

- Visual inspection of Table 6 (SiteWise™ versus SimaPro®) and Table 9 (SRT™ versus SimaPro®) suggests that the tools provide results that are generally comparable.

- Given the potential variability in SimaPro® results (for reasons discussed throughout this report) it is not clear that there is more technical confidence in the results of the DoD tools or SimaPro®. However, from the perspective of a typical environmental professional who might apply these tools, the variety of input selection choices in SimaPro® may be overwhelming, and perhaps more significantly, would likely result in undesired variability in results from one user to the next (due to different choices made for inputs and system boundary).

- The more clearly defined inputs and associated footprint factors in the DoD tools likely reduce such variability and increase technical confidence in tool application.

6.2.2 Comparing Functionality

SimaPro® is essentially a user interface to several Life-Cycle Inventory (LCI) libraries and impact assessment methods. Therefore, the functionality that SimaPro® has relative to the DoD tools is either a result of the user interface or the content of the libraries. Specific examples are as follows:

- The SimaPro® user interface provides network-type graphics that help the user better understand the various contributions and the interrelated nature of various contributions. The SimaPro® user generally sees the material that contributes to the footprint and also the resources that went into the manufacturing of that material.

- SimaPro® provides access to several LCI libraries, some within the public domain and some that are proprietary. Although this functionality has the downside of providing the typical environmental user with a potentially overwhelming number of options, this functionality also provides an advanced user with a wide variety of processes that are not available in the DoD tools. Although the DoD tools could be modified to include all of the public domain LCI libraries, the DoD tools could not incorporate the proprietary libraries without paying a substantial fee. It is possible that the DoD tools might be able to incorporate some aggregate or modified average or statistical range of the individual proprietary processes.

- SimaPro® provides the user with the option of creating assemblies for multiple processes.

    - For example, granular activated carbon (a common material used in environmental remediation) is not included in the LCI libraries included in SimaPro®. However, based on information available in literature, a SimaPro® user can create a GAC "assembly" using the appropriate quantities of various processes. The DoD tools do not include this capability. New assemblies would need to be created outside of the DoD tools, documented, and then input into the DoD tools.

    - Similarly, an advanced SimaPro® user can take an existing process in the Ecoinvent library and modify the contributors to that process. For example, if the SimaPro® user wants to use material (e.g., potassium permanganate) and notices that the electricity blend used in the Ecoinvent process of manufacturing potassium permanganate is different than the actual electricity blend for manufacturing the potassium permanganate used at their particular site, the user can make a copy of the Ecoinvent potassium permanganate process and then change the assumptions regarding the electricity blend used in that process. As noted above, this would be well beyond the capability of a typical environmental user.

- A number of impact assessment methods are also included in SimaPro®, allowing the user to convert the CO_2e, energy, NOx, PM and SOx emissions into relevant impacts. For example, the NOx and SOx emission can be combined to determine the acidification impact and the human respiratory impact. The DoD tools do not have the inherent capability of conducting an impact assessment.

- A SimaPro® project can be organized in a variety of ways based on the desired organization of the output. For example, in this study, the SimaPro® projects included intermediate assemblies for categories such as electricity, materials, and transportation so that results could be output in these categories. The contribution categories and associated outputs in the DoD tools are set by the tool design.

In general, the above-noted functionality for SimaPro® primarily benefits an advanced SimaPro® user or LCA expert, but may not benefit a typical environmental user expected for most GSR applications.

There are a number of functionality features offered by either or both of the DoD tools that are beneficial to the environmental user that are not offered by SimaPro®. Both DoD tools are tailored for environmental applications. Both DoD tools allow the user to provide the tool spreadsheets to peers, collaborators, or reviewers (e.g., via email). The Tier 1 evaluation offered by SRT™ provides useful calculations for remedies where specific quantities are not yet defined. SiteWise™ also includes calculations useful for environmental remedy applications such as a module to module to calculate well construction materials, calculations of electricity use based on known pump flow rate and head (or motor horsepower, load, and efficiency), and calculation of fuel use from oxidizers. The input and output from the DoD tools is organized according to remedy items that would be generally familiar to a typical environmental user. The contribution categories and associated outputs in the DoD tools are set by the tool design, and this set design and pre-determined organization actually facilitates rather than limits use for the DoD tools for environmental projects

A specific inconsistency is that the tools do not all use the same sustainability metric to represent greenhouse gas emissions (CO_2e which includes GHGs other than CO2 versus just CO_2),

6.2.3 SimaPro® Project Organization and "Work-Arounds"

SimaPro® was not designed to evaluate the environmental footprints of remediation projects. Below is a brief description of SimaPro's™ organization, how SimaPro® might be used to evaluate a footprint for a remediation project, and several "work-arounds" that are helpful for using SimaPro® for this purpose.

SimaPro® provides a user interface to process LCI libraries and impact assessment methods.

- A user begins by creating a "project" within SimaPro®. Within this project, the user creates several building blocks including "processes," "assemblies," and "life-cycles."
    - Processes are fundamental units of activities such as transportation, excavation, electricity, or material production. For most environmental projects, it is likely that users would choose pre-existing processes from the LCI libraries offered by SimaPro® rather than creating new processes.

  - A user can combine various processes into "assemblies." These assemblies are custom combinations of processes and might represent a material that is a mixture of other materials, a specified amount of transportation, an intermediate assembly that is created only to organize results, or even an entire remedy (excluding any disposal).

  - A life-cycle is an assembly plus an "end-of-life" treatment such as disposal. The user can calculate the footprints associated with any one process, assembly, or life-cycle at any time.

- When a user creates an assembly or life-cycle within a project, that assembly or life-cycle can only be used by that project. Therefore, if a series of remedies will be evaluated that use several of the same user-defined assemblies, the user might consider evaluating each of these remedies as separate assemblies or life-cycles within the same project. Otherwise, the user-defined assemblies (e.g., for GAC) that are common to all of the projects will need to be copied from one project to another and the future changes or corrections to an assembly in one project might not be made in other projects, perhaps resulting quality control issues.

An environmental remedy might be represented as a life-cycle (that consists of an assembly representing the whole remedy without disposal) plus a disposal scenario such as landfill disposal. The assembly that represents the whole remedy might consist of several other assemblies that are created by the user for organization purposes only. These assemblies would optimally be chosen to be consistent with footprint reporting categories such as electricity, materials, materials transportation, personnel transportation, and heavy equipment use. Each of these assemblies would in turn consist of the various processes and sub-assemblies that represent specific aspects of a remedy. The figure in Appendix J illustrates a portion of a SimaPro® network diagram of the Little Rock remedy used in this study. The grey boxes are pre-existing processes (including materials) from the LCI libraries, light blue boxes are custom-made assemblies, and the yellow boxes are custom made life-cycles.

Representing disposal or other end-of-life treatment in SimaPro® can be difficult for environmental projects because waste disposal in SimaPro® can only be considered for materials that are used. This is problematic for some remedies, such as excavation and disposal remedies, where the material for disposal (e.g., soil) already exists without a footprint. If soil from one of the LCI libraries is added to the remedy assembly, SimaPro® will consider the footprint of obtaining that soil from that LCI library even though the footprint of excavating the soil is likely being represented by other processes or user-defined assemblies describing heavy equipment use. A "work around" for this problem is to create a user-defined "dummy soil" process or assembly that has that has no footprint (by referring to an existing dummy process in the USCLI database that has no footprint).

Representing disposal or other end-of-life treatment in SimaPro® is also difficult because SimaPro® is designed to provide end-of-life treatment for all materials within a life-cycle. This can be challenging if the materials require different end-of-life treatments, some of which may not have a footprint (e.g., injection into the subsurface as part of the remedy that is characterized by other assemblies or processes). There are several choices for representing these various end-of-life treatments. One possibility is to “disassemble” the assembly and define individual disposal scenarios for each end-of-life treatment. This is the approach generally chosen in this project because it allowed all disposal to be tracked together so that the user could calculate the footprint of all disposal as one category.

In some cases processes associated with environmental remedies are not included in the LCI libraries offered by SimaPro®. Some specific types of heavy equipment use, heavy equipment use based on time rather than volume of soil moved, granular activated carbon (GAC), and emulsified vegetable oil are all examples. For specific types of heavy equipment use or heavy equipment use based on time, the fuel usage was determined outside of SimaPro® using the EPA 2012 *Methodology for Understanding and Reducing a Project’s Environmental Footprint* (EPA 542-R-12-002, 2012) and then entered into SimaPro® as diesel combustion from a generic combustion engine. For GAC or emulsified vegetable oil, assemblies representing the materials and processes for manufacturing these items were created based on available literature.

The output flows of SimaPro® are also different than the output of the DoD tools. First, the SimaPro® output includes many more parameters. Second, the SimaPro® output can be the “inventory,” which includes emissions of each parameter, and/or the “characterization,” which includes pre-determined combinations of parameters based on an impact assessment methodology. The “inventory” provides output for parameters tracked in this projects such as CO_2, methane, nitrous oxide, NOx, various other greenhouse gases, SOx, particulate matter less than 2.5 microns, particulate matter between 2.5 and 10 micros, and particulate matter greater than 10 microns. SimaPro will also show output flows for hundreds of other flow types as well, such as specific organic chemicals. Total energy use and total greenhouse gas emissions as CO_2 equivalents (CO_2e) are examples of output from characterization. Therefore, to obtain values for CO_2e, the user must choose an impact assessment method to calculate the CO_2e and cumulative energy demand. For the purpose of this study, the TRACI method was used to calculate CO_2e because TRACI is a recognized impact assessment method developed by EPA for use in North America. The single-score impact assessment method for cumulative energy demand was used to obtain total energy use. For particulate matter, the user needs to be careful to choose the correct output for their study. If directly emitted particulate matter smaller than 10 microns is desired, then the user will need to extract the relevant values from the inventory (e.g., particulate matter less than 2.5 microns and particulate matter between 2.5 and 10 microns) and sum them together, taking care that the summation accounts for any potential difference in units (e.g., grams for one parameter and milligrams for another). If the user chooses a characterization output that resembles particulate matter, the result might include particulates that could result from transformation of NOx or SOx in the atmosphere after it is emitted.

The information from some of the LCI libraries is proprietary. As a result, the user should be mindful of how results of the project are reported so that proprietary information is not compromised. For example, if a project reports the footprint for one particular material or process, readers of the report could obtain the proprietary LCI information. For this reason, the user should consider reporting results at a higher level after several items have been combined.

6.2.4 Extent of the Learning Curve

Observations include the following:

- In general, both SiteWise™ and SRT™ are easy to use, and either tool can be learned by a typical environmental professional in less than one day. The DoD tools are MS-Excel based, which most environmental professionals are comfortable using.

- The DoD tools are also designed specifically for application to environmental remedies, which makes them much easier for an environmental professional to understand and apply. By contrast, SimaPro® is not simple for a typical environmental professional to use. There are many decisions for the user to make when using SimaPro® regarding choices for processes (e.g., to represent materials or transportation) and the results may vary considerably depending on those choices. However, the best choice will typically not be clear to a typical environmental project user (and in some cases there may not be a best choice).

The latter issue is highlighted in the discussion of sensitivity analysis for SimaPro® options presented in this report. The choices for representing remedy items are much easier to navigate and select from in SiteWise™ and SRT™. This is discussed in more detail in Section 8.2.

7.0 COST ASSESSMENT

This section addresses the costs of implementing the use of the GSR footprint tool software at a DoD site. There is no direct costs savings that results from applying the software to calculate footprints. Indirectly, it is expected that alternatives with lower footprints (e.g., energy) will frequently also have lower costs, but that was not evaluated in this effort.

7.1 COST MODEL

Table 19 provides a summary of the estimated costs for obtaining and applying these tools for a typical GSR application at a DoD site.

Table 19: Estimated Costs to Apply the Tools at a Typical DoD Site

Cost Element	Estimated Costs: SiteWise™ and SRT™	Estimated Cost: SimaPro®
<u>Start-Up</u>		
Software Cost	Free	$ 3,000 to $12,000
Training/learning	$400 to $1,600*	$ 2,400 to $ 8,000**
<u>Annual Maintenance Costs</u>		
Software Updates	Free	$1,500/yr or more
<u>Estimated Application Costs</u>		
Per Project executed by a professional trained to use the software	$3,000 to $10,000	$5,000 to $15,000

*Assuming a first-time user might require 4 to 8 hours to become familiar with the tools and a range of hourly costs of $100 to $200 per hour (however advanced features would take longer.)

**Assuming a first-time user might require 24 to 40 hours to become familiar with the tool (self-study or a course from a third-party) and a range of hourly costs of $100 to $200 per hour (however advanced features would take longer.)

In summary, the DoD tools are available to download at no cost, and a typical environmental engineer requires minimal training to use these tools, whereas SimaPro™ requires purchase and more extensive training, and typically includes annual maintenance costs.

7.2 COST DRIVERS

The major cost drivers for applying any one of these tools, which result in the range of cost estimates provided above for tool application, include the following:

- Project complexity, which particularly increases with the number of different remedial technologies and/or number of remedial alternatives.
- Input parameters not represented in the tool, because such input parameters may result in the user needing to research appropriate footprint factors or choosing and documenting

appropriate surrogates.

- Availability of data, because information is easier to obtain for operating remedies (based on actuals) rather than planned/designed remedies where estimates are required.

- Degree to which results need to be broken down by specific inputs rather than totals.

- Extent of reporting and documentation of results (i.e., a few tables versus a short memo versus a full-scale report).

- Technical experience of the user, because the more experience the user has with this tool, the less it will cost to apply. Also, an experienced technical user will most likely require less time to become acclimated with the tool.

A cost driver specific to SimaPro® is the extent to which there are multiple possible process choices for a remedy component (e.g., type of steel or type of truck transport) because it requires the user to develop a basis for making that choice and/or performing a sensitivity analysis (which quickly becomes overwhelming when there are many such choices for many different remedy items).

7.3 COST ANALYSIS

As detailed in Table 19, the SimaPro® tool is more expensive than the SiteWise™ and SRT™ tools in all of the following categories:

- Cost to obtain the tool
- Learning to use the tool
- Applying the tool to projects

Thus, it only is logical to use SimaPro® over the other DoD tools if there is a perceived technical benefit. The results from this project, however, do not suggest that there is a great advantage to using SimaPro® compared to the DoD tools for footprinting at DoD sites, unless the user specifically wants to incorporate some aspect of analysis that SimaPro® offers that the DoD tools do not include (e.g., sustainability metrics that the DoD tools do not calculate or the results of impact assessments). It should be noted, however, that some impact assessment methods are public domain and can be applied externally to the DoD tools to obtain impact assessment information if desired (although this could increase cost of applying the DoD tool).

Since there are no cost savings from the use of these tools that have been quantified in this project, there is no attempt to calculate any sort of payback period or return on investment for the use of these tools at a specific site. However, some attempt has been made to compare the cost of using the DoD tools to the cost of using SimaPro® for the entire DoD complex. Assuming 1,000 DoD sites have a footprint analysis performed, and analysis with a DoD tool costs approximately $5,000 less than analysis with SimaPro®, there is savings of approximately $5M. That number may double (or more) if costs of software purchases and training for SimaPro®

across the DoD components are included. The cost of developing both tools and implementing this project is on the order of $1M to $2M so there is an excellent return on that investment across the DoD complex as more footprint evaluations are performed over time.

8.0 IMPLEMENTATION ISSUES

The following implementation issues merit discussion:

- Software availability and documentation
- Ease of use
- Key tool limitations
- Regulatory issues

Each of these issues is discussed below.

8.1 SOFTWARE AVAILABILITY AND DOCUMENTATION

SiteWise™ and SRT™ are publicly available (i.e., freeware) spreadsheet-based technologies that are specifically designed for soil and groundwater remedies. The tools are easily downloaded from public websites. These tools are well documented. A beneficial feature of the SiteWise™ tool regarding documentation is that all spreadsheet cells are visible including formulas, so every calculation in the tool itself is transparent to the user. A beneficial feature of the SRT™ tool regarding documentation is the option for Scenario Planning, where different futures for carbon offset cost and energy costs are available to users and the importance of different sustainability metrics can be given project-specific levels of importance. It is also easy for users of the DoD tools to send the Microsoft Excel spreadsheet files to other professionals (e.g., via email) allowing for easy exchange of input and results for purposes of collaboration or peer review. This is a significant feature with respect to documentation for specific project applications.

In contrast, SimaPro® is not freeware and can cost between approximately $3,000 to $12,000 to purchase depending on the number of user licenses and features (with additional costs in service and support if required). The Benchmark Team found the documentation for SimaPro® provided with the tool to be difficult to understand given the complexity of the software, and the many options within the tool were found to be difficult to understand using available documentation (see discussion regarding "ease of use" in Section 8.2). The calculations within SimaPro® are not transparent to the user. Unlike the DoD tools, files for SimaPro® are not easily exchanged with other professionals for collaboration or peer review, partly because those individuals also need to purchase the software, and because the backup/archive features are not well documented and are highly complicated by which versions of libraries each user has licensed and maintains (see Section 8.3). This is a significant shortcoming of SimaPro® with respect to documentation for specific project applications, especially for analysis of public projects where it might be expected that the models would be sharable with other parties for review or assessment.

For the DoD tools the footprint factors are documented in the tool lookup tables and/or the tool documentation. One challenge with SimaPro® is that the user must spend additional time documenting which LCI items were used in a study, and failure to do so in a detailed manner could result in other users being unable to reproduce results. While much of the data accessed via SimaPro® is from public sources, data such as that from Ecoinvent are not public and are subject to protections under the software license. In this ESTCP project, various demonstration site inputs for SimaPro® utilized Ecoinvent data that cannot be publically shared to readers. This causes an additional documentation gap for users of the software that is significant. Licenses for reuse of proprietary database values can be purchased for re-distribution within a third-party tool, but a substantial cost (thousands of dollars), and these licenses would significantly increase the cost of a project. Costs for acquiring various types of licenses for subsequent redistribution of Ecoinvent data were evaluated in this project, and ultimately were found to be extremely complicated and costly (particularly compared to the free and fully documented footprint factors used by SiteWise™ and SRT™). Although there is likely value to these licenses and the Ecoinvent data for many practitioners, only a handful of Ecoinvent data entries are relevant to the remediation field and the benefits of the additional costs to use or license these items do not appear to outweigh the additional costs for a typical DoD GSR project.

8.2 EASE OF USE

Both DoD tools are simple to use and require minimal training (few hours). They are both MS-Excel based, which most environmental professionals are comfortable using. They are also both designed specifically for application to environmental remedies, which makes them much easier for an environmental professional to apply to a GSR project. For example, the DoD tools readily account for well construction. This activity is not represented in SimaPro®, but could be created by a user and employed on future projects. That is, SimaPro® can become friendlier for use in environmental projects, but significant upfront time would be needed by each user to create user-defined assemblies and processes that are common to environmental projects and already well represented in the DoD tools.

SiteWise™ has some specific features which enhance ease of use. For instance, it is very easy in SiteWise™ to specify a sole input item and see the resulting footprints of that specific item in the results. All of the results can be cut from the output files (individual results or summed results) with full precision, allowing for easy post-processing and evaluation of results. Many features were added in Version 3 to further enhance ease of use (e.g., more columns, automatically identify return trips for materials transport, etc.).

SRT™ is designed in a tiered manner to allow the user the flexibility to select the level of effort and detail appropriate for the project at hand. The different tiers (Tier 1 and 2) make it simple to develop estimates for key sustainability metrics associated with a remedy footprint, by calculating inputs based on site-specific data.

There are many choices in the various LCI libraries, and the documentation or descriptions provided within SimaPro® are likely difficult for a typical environmental user to interpret and use as a basis for confidently selecting input for a project. External lengthy descriptions are available, but this would take additional time for the reader to obtain these additional descriptions and understand the content. As discussed in Section 7.1, the learning curve is much greater for SimaPro® compared to the DoD tools.

8.3 KEY TOOL LIMITATIONS

For the DoD tools, a number of limitations identified in the initial phase of the project were addressed by revisions to the tools. There are clearly differences in footprint factors used by all the tools, but this is not so much a limitation of individual tools as it is a need for standardization between tools. There are some limitations of the DoD tool functionality compared to SimaPro®. For instance, the DoD tools do not incorporate impact assessment in the manner SimaPro® does, and do not include the universe of sustainability metrics that SimaPro® does. However, these are relatively minor limitations for the typical DoD user for a GSR project. Note that SimaPro® offers many features and processes for general LCA projects that are beyond the functionality of the DoD tools, since the DoD tools are targeted to footprint evaluations for environmental remedies.

There were limitations identified in Phase 1 of the study for both DoD tools. Almost all of the SiteWise limitations that were identified in Phase 1 were able to be addressed in Phase 2 of the study. Most of the SRT limitations that were identified in Phase 1 were able to be addressed in Phase 2 of the study. Additionally, there are some program structure restrictions within SRT™ that were identified in this project (e.g., transparency of calculations), and are attributed to the program architecture requirements stipulated by the Air Force (commissioned tool design). These restrictions were, therefore, unable to be revised in Version 2.3. That level of transparency is not always needed for footprint calculations, but for the purpose of this project, the restrictions on the transparency of the internal SRT™ calculations increased the level of effort, in some cases, required to break-out components of the overall footprint of a specific module or the entire remedy. For the purpose of this project, the Benchmark Team re-created the SRT™ calculations in a separate spreadsheet (i.e., without the user interface) to breakout the footprint contributions from various remedy components for comparison to SimaPro® footprint contributions. This is possible as the SRT™ User's Guide provides details on program calculations and assumptions. For SRT™ remedies outside of the eight the remedy-based modules (e.g., bioreactor) sometimes cannot be easily represented in the tool. Finally, the outputs from SRT™ are rounded within the tool, which makes validating tool results more challenging.

As mentioned in Section 1.4, the tools to do not uniformly address (1) footprints (e.g., GHG emissions) due to water use; or (2) quantification of water used, reused, or reclaimed as a resource. Additional details for each tool are provided below.

- SimaPro® can calculate footprints (e.g., GHG emissions or energy use) associated with direct use of potable water such as for mixing chemicals at the site, and such calculations were included in this project. SimaPro® can also quantify water use associated with various processes (e.g., manufacture of materials), and SimaPro® also has an ability to represent re-use of water to offset other footprints, but does not have specific functionality to represent water reclaimed by successful remediation.

- SiteWise™ calculates water treatment footprints (e.g., GHG emissions or energy use) associated with direct use of potable water such as for mixing chemicals at the site, and such calculations were included in this project. SiteWise™ quantifies water use for production of electricity, but SiteWise™ does not calculate water use for most processes such as manufacture of materials. However, SiteWise™ does allow the user to enter water consumed (or reclaimed by inputting a negative value) within each component and it also allows the user to enter the quantity of water recycled as part of a footprint reduction package. The quantities entered are then included in the output from the tool.

- The current version of SRT™ does not calculates footprints (e.g., GHG emissions or energy use) associated with direct use of potable water such as for mixing chemicals at the site, and does not assess water use as a sustainability metric. It is anticipated that future revisions of SRT™ will include conversion calculations to account for: i) direct water use during remediation; ii)indirect water use in life-cycle processes such as the production of materials; and iii) potentially water reclaimed as an outcome of remediation activities.

SimaPro® has been a valuable resource in this comparison project because of its industry popularity and its acceptance and inclusion of key popular global LCA data sources. However use of SimaPro® comes with some downsides as detailed below.

- While creating models in SimaPro® is relatively straightforward (albeit with an extended learning curve), exporting and sharing the models with other parties is difficult. Even for parties with a SimaPro® license, the process of sharing model results is burdensome. A main reason for this burden is the volume of information in the libraries contained within SimaPro®. There are two ways of sharing projects. In the export option, all project flows are exported and saved to an archive. Importing the resulting archive in another computer with SimaPro® takes several hours. Each flow (in the case of this project, 16,000 of them) either has to be individually verified for import, or the user needs to decide in advance to automatically import all flows. This may sound like a simple decision but given how data are stored in libraries, accepting all flows can overwrite existing model/flow data on the receiving computer, which is not desirable. The restore from backup option is much faster, requiring only about 15 minutes. Overall, the sharing process is very time consuming, and potentially destructive to existing models. Various levels of QA/QC would be needed to ensure no change in local data. Thus, there are significant limitations for SimaPro® with respect to ability to share files for collaboration, peer review, and documentation.

- SimaPro® handles updated data in potentially unexpected ways. Typically the underlying databases in SimaPro® are updated once or twice a year. Since these are not "mission critical" updates not all users perform them. The impact of these updates is that a project which simply refers to a data source within SimaPro® may give one result for the original database version and a different result for an updated version. This can also lead to problems with repeating results. There are limited ways to identify such discrepancies, although one identification method is when importing projects discrepancies are noted – but a user is typically going to choose to accept "all 16000 potential changes" instead of seeing specific problems individually.

- SimaPro® is a user interface to LCI data from various sources. The base version of SimaPro® available includes the US NREL LCI database, the European Reference Life-

Cycle Database (ELCD), the European Ecoinvent database, and several other sources. The databases often duplicate life-cycle processes, meaning multiple data sources in SimaPro® are available for similar items (e.g., multiple data sources on consuming electricity). This can cause confusion for the user regarding which database values to select. Even within a given LCI database, especially a large database like Ecoinvent, there are several options for similar items. Aside from the geographical factors (i.e., United States vs. Europe), the timestamps may be significantly different.

- A large majority of data in SimaPro® is from European sources or applicable to European processes (the software itself is made in the Netherlands). While one should expect the production processes nowadays to be comparable amongst economies of the developed world, there are many known discrepancies between US and European production. In other cases there are known reasons why European process data are not representative (e.g., electricity mixes and impacts of energy production). These various factors could bias the result when applying the data to US problems or processes.

- The date of record for data can be quite old. The Ecoinvent database has some information dated from the 1980s and earlier.

8.4 REGULATORY ISSUES

Emissions of GHGs and other impacts resulting from soil and groundwater remediation are becoming a greater concern for regulatory agencies. Regulatory agencies are still evaluating how and whether to include considerations of GSR to interpret footprint results and how to consider them within the GSR process and the remediation process as whole. EPA and several states have issued guidance, factsheets, and/or have implemented GSR programs. This topic has also been a recent focus of ITRC guidance and an American Society for Testing and Materials (ASTM) subcommittee. Findings from this project and tool revisions will improve footprint calculation and enhance the understanding of factors that affect these calculations, which will facilitate acceptance of future GSR evaluations.

The uncertainties and variation in the results outlined in this report argue for standardization between tools, and particularly the use of the footprint factors used in the tools, to alleviate any skepticism from regulators regarding use of these tools. Also, the results of this study indicate that the DoD tools allow for easy transmission of the files to regulators (or contractors for the regulator) for review. The ability for the regulator to obtain the files and confirm the analyses is a significant advantage provided by the DoD tools.

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APPENDICES

APPENDIX A:

Points of Contact
(Alphabetical by Name)

POINT OF CONTACT Name	ORGANIZATION Name/Address	Phone E-mail	Role in Project
Chaudhry, Tanwir	NAVFAC EXWC 1100 23rd Ave Port Hueneme, CA 93043	Phone: 805.982.1627 Tanwir.chaudhry@navy.mil	Co-PI/DoD Team
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Sutton, Doug	Tetra Tech 2 Paragon Way Freehold, NJ 07728	Phone:732.409.0344 Doug.Sutton@tetratech.com	Benchmark Team
Zabierek, Anna	GSI Environmental Inc. 9600 Great Hills Trail, Suite 350E Austin, TX 78759	Phone: (512) 346-4474 alwhiting@gsi-net.com	SRT Team

APPENDIX B:

Coordination of Site Input Data for the Six Demonstration Sites

- **Cold Regions Research and Engineering Lab, Hanover, NH (CRREL)**
- **Former Naval Air Station Alameda OU2B, Alameda, CA (Alameda)**
- **Naval Weapons Industrial Reserve Plant McGregor Area M, McGregor, TX (NWIRP)**
- **Beale Air Force Base, Site 35, CA (Beale)**
- **Little Rock Air Force Base, Former Skeet Range, Jacksonville, AR (Little Rock)**
- **Travis Air Force Base, Site DP039, CA (Travis)**

Coordination of Site Data Input:
Cold Regions Research and Engineering Lab (CRREL)

FOR

QUANTIFYING LIFE-CYCLE ENVIRONMENTAL FOOTPRINTS
OF SOIL AND GROUNDWATER REMEDIES

ESTCP Project # ER-201127

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INTRODUCTION

The US Army Cold Regions Research and Engineering Lab (CRREL) in Hanover, NH has a Trichloroethylene (TCE) plume emanating from the area of a large TCE spill and "ice well" where TCE was used as a refrigerant for freezing ice in the 200-foot deep well. The groundwater plume originates in an area of low permeability, but discharges into a high permeability "channel" (a buried glacial esker).

There is currently an operating pump and treat (P&T) system that utilizes extraction from four water production wells to capture impacted groundwater. The treated water from those four wells (referred to as the NCCW-1 system) is then mixed with untreated water from one other supply well (referred to as the NCCW-2 system), and that combined flow is used for non-contact cooling prior to discharge to the Connecticut River.

Information and data required for a GSR footprint evaluation for the groundwater remedy at CRREL was developed from the following data sources:

- Remediation System Evaluation (RSE), TCE Ground Water Treatment (USACE EM CX, Draft Final Report, September 2010)

- Conceptual Design Report pH Level control and Greensand Filter Study (Stanley Report), U.S. Army Corps of Engineers, Vicksburg District, Vicksburg, Mississippi, (Stanley Consultants) Cold Regions Research & Engineering Laboratory, Hanover, New Hampshire, Final April 2009.

- E-mails and discussions with Dave Becker, US Army Corps of Engineers (USACE) and Byron Young (CRREL)

For this evaluation, footprints will be evaluated for four alternatives:

- Alternative 1 is the "current system" based on the RSE evaluation, augmented/modified by subsequent information provided by Dave Becker and Byron Young. This system includes groundwater extraction and treatment of approximately 500 gpm (sometimes more). The treatment includes greensand filters and associated permanganate injection for metals removal, air stripping via two packed tower air strippers in series, treatment of air stripper off-gas (heated) via vapor phase carbon, and re-use of the treated water for non-contact cooling at the overall laboratory facility (a portion of the re-used water requires addition of CO_2 to control calcium and pH, followed by solids removal with bag filters).

- Alternatives 2 to 4 are based on recommendations provided in the RSE report:
    - Alternative 2 includes switching the two packed tower air strippers in the current system to one new tray stripper

- Alternative 3 includes elimination of the greensand filters and air strippers (and associated vapor phase carbon) from the current system, and replaces those items with liquid phase carbon plus a biocide and a sequestering agent.

- Alternative 4 assumes that a new groundwater recovery well with a 3 HP pump pumping at a low rate of approximately 40 gpm can be added to effectively capture enough of the TCE plume that the remaining production wells will not require treatment prior to use for cooling. This alternative uses the same treatment process as Alternative 3, but at a substantially reduced rate (i.e., a typical treatment rate of only 40 gpm in Alternative 4 versus a typical treatment rate of 500 gpm in the other alternatives).

The intent of this document is to provide a basis for the development of input for the SimaPro and SiteWise tools for these alternatives.

ALTERNATIVE 1:
CURRENT SYSTEM

System Overview

The current system, in place since 1994, includes the following elements:

- Extraction wells
    - The NCCW-1 system consists of 4 extraction wells to be treated. The wells typically pump at 400 to 500 gpm total but are able to pump up to the treatment plant capacity of 850 gpm. At the time of the RSE these wells were pumped intermittently at the maximum capacity of 350 to 450 gpm per well, but subsequently these wells were fitted with variable frequency drives and are now all reportedly pumped at once but at a lower rate per well. The current well settings are as follows:
        - Extraction Well 1 - 165 +/- gpm @ 55 Hz
        - Extraction Well 2 - 150 +/- gpm @ 55 Hz
        - Extraction Well 4 - 60 gpm +/- @ 60 Hz
        - Extraction Well 5 - 56 gpm +/- @ 60Hz

      These are set to match the current facility demand of 205 gpm from the FERF building and 225 - 275 gpm by the main lab.
    - The NCCW-2 system consists of 1 extraction well that does not require treatment and is therefore not part of the remedy, and that pumping will not be a part of the footprint analysis.
- Permanganate addition and greensand filtration
    - Extracted water is pretreated with potassium permanganate followed by greensand filtration for removal of iron and manganese. The permanganate is required for metals removal with greensand and also serves as a biocide.
    - Permanganate is added via metering pump (electricity use for this metering pump is assumed to be de minimis relative to other pumps and blowers) and a static mixer that requires no additional electricity use.
    - Two greensand filters (each 120 inches diameter) operate in parallel when online or singly when one is offline for backwashing.

  - Typical flow rates are generally between the original design basis of 250 to 400 gpm per greensand filter.

  - Backwashing is performed at a flow rate of 350 gpm, and backwashing also historically required a blower for the "air wash" portion of the cycle but that blower is no longer needed based on recent modifications to the filter media as indicated by Byron Young. For purposes of footprinting, backwashing is estimated to occur once every four days. Backwashing uses one 25 HP pump for approximately 10 minutes.

  - Water used for backwash water is discharged to a 10,000 gallon receiving tank prior to discharge (at 25 gpm) to the Publicly Owned Treatment Works (POTW), via gravity.

- Packed tower air stripping to remove TCE (two strippers in series)

  - Each stripper is 84-inch diameter and 29.5-foot tall, fiberglass, with 304 SS supports and fasteners, and are designed to be operated with up to 840 gpm of water and 3,864 SCFM air per tower (air to water ratio of 34:1) to remove approximately 96% of the TCE per tower and achieve a 5 ppb final effluent concentration at an influent loading of 4,000 ppb.

  - The extraction pumps convey the water to the top of the first stripper, and a pump is required to convey the water to the top of the second stripper.

- Vapor phase GAC treatment for air effluent from the strippers (includes heating)

  - The RSE indicates the air exhaust from the air strippers is heated prior to being passed through the GAC. This heat is produced by the on-site with the air passed through a hot water exchanger to elevate the temperature of the saturated air by approximately 20 degrees F and reduce the relative humidity to approximately 50% prior to entering the two GAC units.

  - The RSE states that the two vapor phase GAC units (assumed to be one for each stripper) each have 10,000 lbs of GAC that is changed every two years. This GAC is certified regenerated carbon, based on information provided by the site team.

- Injection of CO_2 to air stripper effluent to control calcium and pH (site documents indicate that this is to replace CO2 that is lost in the air stripping process, thus the added CO2 can be assumed to be equivalent to the amount of CO2 lost to the atmosphere).

  - CO_2 injection (80,000 lbs per year) is accomplished from a 30-ton Liquid Carbonic cylinder/tank

  - Prior to 2007 CO_2 was added after water was pumped from the air stripper effluent by the high lift pump (see below), but the RSE indicates that was discontinued in 2007 and currently the CO_2 injections occur in each of the two air stripper effluent reservoirs.

- Discharge of treated water for use as non-contact cooling water and subsequent discharge to surface water
  - One pump can bring up to 500 gpm from the treatment plant to the Main Lab Reservoir for subsequent use for cooling (called the "high lift" pump), and that water is subsequently run through a set of 7 50-micron bag filters in parallel
  - Another pump can bring up to 200 gpm from the treatment plant to the Frost Effects Research Facility (FERF) for use as cooling. The site team indicated that transfer to the FERF is very infrequent, and is excluded from this analysis.
- Monitoring (sampling personnel are assumed to be already onsite for other reasons)
  - Monthly monitoring for treatment system effluent (VOCs)
  - Quarterly monitoring for 5 production wells (VOCs)
  - Annual monitoring at 14 monitoring wells using Passive Diffusion Bags (PDBs) for VOCs (the RSE mentions that sampling is temporarily being done by rigid porous-polyethylene (RPP) samplers to allow sampling for 1,4-Dioxane, but it is assumed that ultimately sampling will return to use of PDBs).

All of the pumps are in pairs for redundancy, such that one is used and one is a backup. The system is expected to operate for a long time, and 30 years is being assumed for the footprint evaluation.

Other information provided by the site team includes the following:

- The site team reports that the remedy uses 116,750 kWh/year. However, this appears to be substantially too low given the motor requirements for the identified pumps and blowers, and it is possible that the site team has not included all of the motors (i.e., perhaps some of the motors are on different meters).
- The four well houses each use ceiling/wall unit electric space heaters (120VAC)
- Each change of the greensand generates 20 tons of residual greensand shipped to a non-hazardous landfill in Coventry, VT and for footprinting it is assumed the greensand is changed every five years.
- For this footprint analysis, O&M costs are not being evaluated

Detailed Basis for Footprint Evaluation

Tables 1-A through 1-I summarize the information that will serve as the basis for the footprint evaluation of Alternative 1 ("Current System") and the input parameters to SimaPro and SiteWise. ***Note all of these values are for a 30 year time period.***

Much of the footprint of the current remedy comes from the energy used for pumps, heating and air blowers. The characteristics of that electrical power can be determined through the use of the United States Environmental Protection Agency's (EPA's) Emissions & Generation Resource Integrated Database (eGRID). These environmental characteristics include the resource mix for electricity that is used in the area along with many other attributes. CRREL is located within the eGRID Subregion named Northeast Power Coordinating Council New England (NEWE). Data on renewable versus nonrenewable sources of electricity in this region, compiled during 2004-2005, can be seen in Table 1-J.

ALTERNATIVE 2:
SWITCH TO TRAY STRIPPER

Overview of Alternative 2

They key item of Alternative 2 with respect to footprint results over the long-term operation of the system is switching the two packed tower air strippers in the current system to one new tray stripper.

For Alternative 2, changes versus the current system include the following:

- The replacement of the air stripping towers with a tray air stripper
- Add influent equalization tank (20,000 gallon steel). Includes the installation of 12" slab on grade (288 ft^2)
- Add transfer pump from equalization tank to tray stripper (assume 15 HP). Assume this can utilize the current pump for the second air stripper so no new pump would be needed.
- Polyvinyl Chloride (PVC) pipe, 4" (includes trenching to 3 feet ft deep, 200 linear ft)
- Replace the high lift pump (15 HP, 500 gpm) with a larger pump to allow more flow to Main Lab Reservoir (assume 30 HP).
- Addition of a Supervisory Control and Data Acquisition (SCADA) system, a centralized system that would manage the complexities of the supply/demand of the facilities cooling water demands.
- The addition of motorized control valves to better manage the flows of normal operations and the backwashing of the GSF
- Upgrade to fuel tank and utilization of the existing heat exchanger hot water supply to reduce the humidity of the contaminated process air prior to passing through the GAC system (RACER appendix to RSE includes a 7.5 KW, 25,600 BTU Hazardous Air Heater)
- Upgrade of treatment building to protect system components from the elements

Detailed Basis for Footprint Evaluation

Tables 2-A through 2-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 2 ("Switch to Tray Stripper") and the input parameters to SimaPro and SiteWise. ***<u>Note all of these values are for a 30 year time period.</u>***

The projected remedy components for Alternative 2 were originally presented in the April 2010 Remedial System Evaluation by the US Army Corps of Engineers (USACE). These initial recommendations did not include a detailed design presentation for this alternative and therefore professional judgment was used to provide reasonable design specifications. Notations in the related tables provide information on the basis of the estimates made to quantify data input to the footprinting tools.

Much of the footprint of the Alternative 2 remedy continues to come from the energy used for the extraction pumps, heating and air blowers. The characteristics of that electrical power can be determined in a similar manner to the "Current Remedy", using a signature source mix based on eGRID data for that region (see Table 1-J). Estimated materials needed for the recommended construction components of this remedy were also included.

ALTERNATIVE 3: SWITCH TO GAC

Overview of Alternative 3

They key item of Alternative 3 with respect to footprint results over the long-term operation of the system is elimination of the greensand filters and air strippers (and associated vapor phase carbon) from the current system. Those items would be replaced with liquid phase carbon plus a biocide and a sequestering agent.

For Alternative 3, changes versus the current system include the following:

- Eliminate permanganate (materials) and associated feeder pump
- Eliminate greensand filtration and associated backwashing (eliminates backwash pump if one actually exists, and also eliminates waste disposal of water to POTW as well as sludge).
- Eliminate packed tower stripper blowers (2)
- Eliminate current heating of air for vapor phase GAC
- Eliminate vapor phase GAC (materials, disposal)
- Add influent equalization tank (20,000 gallon steel). Includes the installation of 12” slab on grade (288 ft^2)
- Add transfer pump from equalization tank to GAC (assume 15 HP) - Assume this can utilize the current pump for the second air stripper so no new pump would be needed.
- Polyvinyl Chloride (PVC) pipe, 4” (includes trenching to 3 feet ft deep, 200 linear ft)
- Replace the high lift pump (15 HP, 500 gpm) with a larger pump to allow more flow to Main Lab Reservoir (assume 30 HP)
- Addition of a Supervisory Control and Data Acquisition (SCADA) system, a centralized system that would manage the complexities of the supply/demand of the facilities cooling water demands.
- Add liquid phase GAC tanks suitable for 850 gpm
- Add liquid phase GAC usage/disposal (estimated by TT GEO to be 120,000 lbs. per year; 20,000 lbs changed six times per year, based on 450 gpm and 4000 ppb)
- Add biocide (materials and metering pump)

- Add sequestering agent such as citric acid after the GAC (materials and metering pump)

Detailed Basis for Footprint Evaluation

Tables 3-A through 3-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 3 ("Switch to GAC") and the input parameters to SimaPro and SiteWise. ***Note all of these values are for a 30 year time period.***

The projected remedy components for Alternative 3 were originally presented in the April 2010 Remedial System Evaluation by the US Army Corps of Engineers (USACE). These initial recommendations did not include a detailed design presentation for this alternative and therefore professional judgment was used to provide reasonable design specifications. Notations in the related tables provide information on where estimates were used to quantify data input to the footprinting tools.

Much of the footprint of the Alternative 3 remedy continues to come from the energy used for the extraction pumps as well as from the GAC used in this remedy. The electrical power is characterized in a similar manner to the first two remedies, allowing for a unique distribution of source inputs to the electrical energy consumed. Data on renewable versus nonrenewable sources of electricity in this region, compiled during 2004-2005, can be seen in Table 1-J. The amount of liquid GAC was estimated through professional judgment based on the flow rate and contaminant concentrations reported at this site. Estimated materials needed for the recommended construction components of this remedy were also included.

ALTERNATIVE 4:
SWITCH TO GAC AT SUBSTANTIALLY LOWER FLOW RATE

Overview of Alternative 4

Alternative 4 assumes that a new groundwater recovery well with a 3 HP pump at a low rate of approximately 40 gpm can be added to effectively capture enough of the TCE plume that the remaining production wells will not require treatment prior to use for cooling. This alternative uses the same treatment process as Alternative 3, but at a substantially reduced rate (i.e., a typical treatment rate of 40 gpm in Alternative 4 versus a typical treatment rate of 500 gpm in the other alternatives).

For Alternative 4, changes versus the current system include the following:

- Eliminate permanganate (materials) and associated feeder pump
- Eliminate greensand filtration and associated backwashing (eliminates backwash pump if one actually exists, and also eliminates waste disposal of water to POTW as well as sludge).
- Eliminate packed tower stripper blowers (2)
- Eliminate current heating of air for vapor phase GAC
- Eliminate vapor phase GAC (materials, disposal)
- Add influent equalization tank (10,000 gallon steel). Includes the installation of 12" slab on grade (288 ft^2)
- Add transfer pump from equalization tank to GAC (assume 3 HP, lower than that required in Alternative 3)
- Polyvinyl Chloride (PVC) pipe, 4" (includes trenching to 3 feet ft deep, 200 linear ft)
- Addition of a Supervisory Control and Data Acquisition (SCADA) system, a centralized system that would manage the complexities of the supply/demand of the facilities cooling water demands.
- Add liquid phase GAC tanks suitable for 40 gpm (Estimated by TT GEO to require one 10,000 gallon vessel)
- Add liquid phase GAC usage/disposal (Estimated by TT GEO to require 26,000 lbs per year, based on 40 gpm and 10,000 ppb)

- Add biocide (materials and metering pump)
- Add sequestering agent such as citric acid after the GAC (materials and metering pump)
- Add new extraction well (160 ft deep, 6-inch casing, 20 ft screen, PVC)
- Add piping from new extraction well (50 ft, schedule 80 PVC)
- Pump for new extraction well (3 HP)

Detailed Basis for Footprint Evaluation

Tables 4-A through 4-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 4 ("Switch to GAC at a Substantially Lower Flow Rate") and the input parameters to SimaPro and SiteWise. ***Note all of these values are for a 30 year time period.***

The projected remedy components for Alternative 4 were originally presented in the April 2010 Remedial System Evaluation by the US Army Corps of Engineers (USACE). These initial recommendations did not include a detailed design presentation for this alternative and therefore professional judgment was used to provide reasonable design specifications. Notations in the related tables provide information on where estimates were used to quantify data input to the footprinting tools.

The footprint of the Alternative 4 remedy includes the energy used for the new extraction pump and depicts a reduced footprint associated with the overall electrical use. The amount of liquid GAC was estimated through professional judgment based on the updated flow rate and contaminant concentrations reported at the site of the new well. Estimated materials needed for the recommended construction components of this remedy were also included.

TABLES

Note:

> **These tables were originally created based on comparison of SimaPro to SiteWise Version 2. The last column indicates any changes between input for SiteWise Version 2 and SiteWise Version 3.**

Table 1-A: Electricity Use: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction Well 1 (NCCW-1 system) • 30 HP, capacity 165 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	2,044,240 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-01* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 2044.240 p*	*TDH* = 150 ft *Q* = 165 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	
Extraction Well 2 (NCCW-1 system) • 30 HP, nominal capacity 150 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	1,858,400 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-02* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 1858.400 p*	*TDH* = 150 ft *Q* = 150 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	
Extraction Well 4 (NCCW-1 system) • HP unknown, 60 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	743,360 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-04* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 743.360 p*	*TDH* = 150 ft *Q* = 60 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	
Extraction Well 5 (NCCW-1 system) • 20 HP, capacity 56 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	693,803 kWh *See Equation 1* *Name: CECRL-05* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 693.803 p*	*TDH* = 150 ft *Q* = 56 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Metering Pump for Perchlorate • 6 gallons per hour • Assume to be "de minimis" and excluded for this analysis	• Stanley Report p. 1-5	0 kWh *(Not entered into SimaPro)*	0 kWh	
Blowers for Air Strippers (2 in series) • Each designed to be operated with up to 840 gpm water and 3864 SCFM air per tower (ratio of 34:1) • Based on internet search for used equipment this is a 30 HP blower	• RSE for SCFM • Internet search for HP	11,070,991 kWh *See Equation 2* *SimaPro Assembly Name: Air Blowers, NY 2612 Alum* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 11070.991 p*	30 HP Number of units = 2 L = 80% η_m = 85% 262,800 hrs *See Equation 2 for definitions*	
Pump for Influent to Second Stripper • 15 HP	• Stanley Report P. 1-5 "pump, low lift"	2,767,478 kWh *See Equation 2* *SimaPro Assembly Name: Pump, low lift (one)* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 2767.478p*	HP = 15 HP Number of units = 1 L = 80% η_m = 85% 262,800 hrs *See Equation 2 for definitions*	
Discharge pump from Second Stripper to Main Lab Reservoir • 10 HP	• Stanley Report P. 1-5 "pump, high lift"	1,845,165 kWh *See Equation 2* *SimaPro Assembly Name: Pump, high lift (one)* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 1845.165p*	HP = 10 HP Number of units = 1 L = 80% η_m = 85% 262,800 hrs *See Equation 2 for definitions*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Backwash Pump • 25 HP • Assumes two pumps • Intermittent use (assumed one 10 minute session every four days for 30 years, equates to 456.25 hours per pump over 30 years)	• Dave Becker (e-mail of 1/17/2011) • Backwash frequency of once per 4 days is approximate based on information provided by site team	16,017 kWh *See Equation 2* *SimaPro Assembly Name: Pump, backwash* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 16.017 p*	HP= 25 HP Number of Units=2 L=80% η_m =85% *456.25 hours (each pump)=* *See equation 2 for details*	
Production well housing heaters • Ceiling/wall mounted electric space heater, 120 VAC • Assume one per each of the four well houses	• These heaters are mentioned in Byron Young email of 12/19/11 • Usage rate and power ratings not provided. Estimated by TT GEO to be 5 kW of continuous use each heater, for 4 months per year for 30 years.	5kW x 24hours x 120 days per year x 30 years x 4 heaters= 1,728,000 kWh *SimaPro Assembly Name: Heater for well housing* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 1728 p*	5kW x 24hours x 120 days per year x 30 years x 4 heaters= 1,728,000 kWh	
Management Factor for Additional Electricity not accounted for in major units Example: Lights, plug leads	• Estimated to be 5 kw	5 kW x 262,800 hours in 30 years=1314000 kWh *SimaPro Assembly Name: Management Factor for Electrical* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 1314 p*	1314000 kWh	

Additional assumptions:

- *assume pump efficiency of 75% and motor efficiency of 80% for extraction pumps*
- *assume load of 80% and motor efficiency of 85% efficiency for all process pumps and blowers, based on professional judgment.*
- *for extraction wells, assume total dynamic head of 150 feet based on depth to water of 110 feet, air stripper height of approximately 30 feet, and friction losses of approximately 10 feet.*
- *continuous operation assumes is 8,760 hours per year.*
- *Values in table are for 30 year duration*

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Equation 1	Equation 2
$$kWh = \frac{TDH\ \times Q}{3956 \times \eta_p \times \eta_m} \times 0.746 \times hours\ of\ operation$$ *TDH = total dynamic head (ft)* *Q = flow rate (gpm)* *3956 = conversion factor used to convert ft-gpm to HP* *0.746 = conversion factor from HP to kW* η_p *= efficiency of pump (%)* η_m *= efficiency of motor (%)*	$$kWh = \frac{HP \times L}{\eta_m} \times N \times 0.746 \times hours\ of\ operationhours\ of\ operation$$ *HP = motor size (HP)* *L = capacity (%)* *N = number of units operating* *0.746 = conversion factor from HP to kW* η_m *= efficiency of motor (%)*

Table 1-B: Fuel Use for Equipment: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Boiler • The heat exchanger uses hot water from this boiler to heat air from the off gas of the air stripper	• Boiler and associated fuel tank mentioned in RSE p. 19 • Fuel type and usage not provided, estimated by TT GEO to be fuel oil (diesel) at 5000 gallons per year.	5000 gallons per year x 30 years= 150,000 gallons of diesel fuel *SimaPro AssemblyName: Process Used: Diesel, combusted in industrial boiler/US (USLCI) Amount input: 150,000 gal**	5000 gallons per year x 30 years= 150,000 gallons of fuel oil entered into “Other Fueled Equipment”	

Values in table are for 30 year duration

Table 1-C: Materials Use: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Vapor Phase GAC • 2 units each 10,000 lbs • Assume both units changed once every 2 years • Regenerated carbon	• Change frequency based on RSE p.12 • Regenerated carbon based on information provided by site team	20,000 x 15 = 300,000 pounds of regenerated GAC *SimaPro Assembly Name: GAC Composite for CRREL_Alt1* *Materials/Assemblies used: GAC_Composite for Regen_1kg* *Amount input: 300,000 lbs/2.2 kg per pound= 136,000p*	20,000 x 15 = 300,000 pounds of regenerated GAC	
Potassium Permanganate • 0.6% solution (5 lbs per day) • Potassium Permanganate by Cairox • Stored in 55 gallon drums	• RSE p.11	5 × 365 x 30 = 54,750 pounds *Name: Potassium Permanganate* *Materials/Assemblies used: Potassium permanganate, at plant/RER U (EcoInvent)* *Amount input: 54,750 lbs*	5 × 365 x 30 = 54,750 pounds (surrogate: hydrogen peroxide)	
Carbon Dioxide* • 80,000 lbs per year • Should equate to 80,000 lbs per year of CO2 emissions in addition to footprint to produce the material	• RSE p.11 • Usage from site team e-mail of 1/25/2012	80,000 x 30= 2,400,000* pounds *SimaPro Assembly Name: Carbon Dioxide* *Materials/Assemblies used: Carbon dioxide liquid, at plant/RER U (EcoInvent)* *Amount input: 2,400,000 lbs*	80,000 x 30= 2,400,000* pounds (surrogate: soda ash)	Use surrogate "Low Impact Material (Generic)"

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters • 7 bags in parallel, changed weekly • Assume polypropylene • Assume 1 lbs each when shipped to site	• Change frequency in Stanley Report p. 1-2 • Material and weight based on professional judgment	7 × 52 x 30 = 10,920 pounds *SimaPro Assembly Name: Filter Bag Train of 7 bags Materials/Assemblies used: Polypropylene fibres (PP), crude oil based, production mix, at plant, PP granulate without additives (ELCD) Amount input: 10920 lbs*	7 × 52 x 30 = 10,920 pounds (surrogate: HDPE liner)	
Passive Diffusion Bags for Sampling • 14 bags annually (seems de minimis, assume should be excluded from evaluation)	• RSE p. 14	0 pounds *(not included in SimaPro)*	0 pounds *(not included in SiteWise)*	
Greensand • Assumed volume for original delivery and for change every 5 years • Each delivery is for 20 tons of greensand	• Site Team e-mail, 1/23/2012	20 tons per delivery Delivered to site 6 times over the course of the remedy: 20 tons x2000 lbs per ton x 6 events= 240,000 lbs *SimaPro Assembly Name: Greensand Materials/Assemblies used: Greensand_1kg Amount input: 240,000 lbs/2.2 kg per lbs=109091p*	20 tons per delivery Delivered to site 6 times over the course of the remedy: 20 tons x2000 lbs per ton x 6 events= 240,000 lbs SiteWise input: Ion Exchange Resin	Use surrogate “Medium Impact Material (Generic)”

Values in table are for 30 year duration
**the carbon dioxide has a footprint to produce, and in addition should be assumed to result in an additional 80,000 lbs/year of CO2 emissions after it is used because it is replacing that amount of CO2 lost from the air stripper.*

Table 1-D: Transport for Materials, Equipment, and Samples: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Vapor Phase GAC • 20,000 lbs every 2 years • Assume return trip has a 10% increase in weight of carbon to be regenerated • Assume 100 miles each way of transport	• Change frequency based on RSE p. 12 • Distance for transport not provided and is estimated by TT GEO	• Distance: 1 trip per change with fresh GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds= 10 tons • Distance: 1 trip per change with spent GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds (10 tons) + 10% = 11 *SimaPro Assembly Name: Transport of GAC* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 15,000 tmi* *Plus 16,500 tmi*	• Distance: 1 trip per change with fresh GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds= 10 tons • Distance: 1 trip per change with spent GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds (10 tons) + 10% = 11 tons	Ton-mile basis
Potassium Permanganate • 0.6% solution (5 lbs per day) • Site team indicates deliveries are very infrequent- will assume once every three years • Assume transport distance of 100 miles • Assume entire load dedicated to deliver this load so an empty trip should be included for each delivery	• RSE p.11 • Assumptions for delivery frequency, transport distance and empty trips made by TT GEO	• Distance for deliveries: 10 trips x 100 miles per trip=1,000 miles • Weight per delivery trip is 5 x 365 x 3= 5475 pounds= 2.74 tons (Empty trips included) *SimaPro Assembly Name: Transport of Potassium Permanganate* *Process used: Transport, Transport, aircraft, freight/US (USLCI)* *Amount input: 2740 tmi*	• Distance for deliveries: 10 trips x 100 miles per trip=1,000 miles • Weight per delivery trip is 5 x 365 x 3= 5475 pounds= 2.74 tons • Distance for empty trips: 10 trips x 100 miles per trip=1,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Carbon Dioxide • 80,000 lbs per year • Site team did not indicate frequency of delivery, assume once per year • Assume transport distance of 100 miles • Assume entire load dedicated to deliver this load so an empty trip should be included for each delivery	• RSE p.11 • Assumptions for delivery frequency, transport distance and empty trips made by TT GEO	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 80,000 pounds= 40 tons (Empty trips included) *SimaPro Assembly Name: Transport of CO2* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 120,000 tmi*	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 80,000 pounds= 40 tons • Distance for empty trips: 30 trips x 100 miles per trip=3,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)
Bag Filters • 7 bags in parallel, changed weekly • Assume polypropylene • Assume 1 lb each when shipped to site • Site team did not indicate frequency of delivery, assume once per year • Assume transport distance of 100 miles • Assume partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• Change frequency in Stanley Report p. 1-2 • Material and weight based on professional judgment • Assumptions for delivery frequency, transport distance and empty trips made by TT GEO	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1 x 7 x 52=364 lbs = 0.182 tons *SimaPro Assembly Name: Transport of Bag Filters* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 546 tmi*	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1 x 7 x 52=364 lbs = 0.182 tons • Fuel: diesel	Ton-mile basis

Item for Footprint Evaluation	**Source of Information and/or Comments**	**Input Values to SimaPro**	**Input Values to SiteWise Version 2**	**Changes to Input for SiteWise Version 3**
Coolers for Sampling • Assume 12 coolers per year (1 per month) • Assume 10 lbs per cooler to site • Assume 30 lbs per cooler from site • Assume pick up via light truck • Lab in Concord, NH, distance is 65 miles	• RSE p. 14 for sampling frequency • Weights based on professional judgment	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs (0.005 tons) • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs (0.015 tons) *SimaPro Assembly Name: Transport of coolers during sampling* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 117 tmi** *And* *351 tmi**	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs • Fuel: diesel	Ton-mile basis
Greensand • Assumed volume for original delivery and for change every 6 years • Each delivery is for 20 tons of greensand • Assume distance for delivery is 100 miles	• Volume of greensand found in Site Team e-mail, 1/23/2012	• Distance for deliveries: 6 trips x 100 miles per trip=600 miles • Weight per delivery trip is 20 tons *(Empty trips included)* *SimaPro Assembly Name: Transport of Greensand* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 600 miles 20 tons per trip = 12000 tmi**	• Distance for deliveries: 6 trips x 100 miles per trip=600 miles • Weight per delivery trip is 20 tons • Distance for return trip: 6 trips x 100 miles per trip=600 miles • Weight per delivery return trip is 0 tons • Fuel: diesel	Ton-mile basis (no empty trip)

Values in table are for 30 year duration

Table 1-E: Waste Transport/Disposal: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters • 7 bags in parallel, changed weekly • Assume 2 lbs each when used • Assume 1 shipment per year to non-hazardous landfill in Coventry VT, 93 miles one way • Assume partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• Change frequency in Stanley Report p. 1-2 • Weight of bags an d frequency of shipments based on professional judgment • Landfill location based on greensand disposal location provided by site team • Dispose of 2 times the weight due to accumulated material in discarded filters.	• Distance for disposal: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2 x 7 x 52=728 lbs = 0.364 tons *Name: Waste Transport for Bag Filters* *Process used: Transport, municipal waste collection, lorry 21t/CH/ U (EcoInvent)* *Amount input: 1016 tmi** *Disposal scenarios: "Filter bag disposal" and "filtered sediment disposal", which each dispose of 5.46 short tons of waste to "Disposal, concrete, 5% water, to inert material landfill/CH U.*	• Distance for deliveries: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2 x 7 x 52=728 lbs = 0.364 tons	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Water from Backwashes • Goes to POTW, via gravity • RSE says 5100 gallons per backwash, backwash frequency once per 4 days	• Discharge to POTW based on RSE p.4 • Backwash frequency of once per 4 days is approximate based on information provided by site team • Unit conversion: 3.785 kg in a gallon	• Include as “water lost” to consumption • 5100 gal/event * (365/4) events/yr * 30 yr = 13,961,250 gallons=52,843,331 kg *Waste Scenario Process Name: water to POTW, which refers to “POTW Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U”. This process is a modified version of “Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U” in which the units were converted from m3 to kg so that the waste treatment process could be accessed by a disposal scenario.* *No transport of waste necessary*	• Include as “water lost” to consumption • 5100 gal/event * (365/4) events/yr * 30 yr = 13,961,250 gallons This was modeled in two places: 1) under POTW to calculate the impact of the POTW in treating that water and 2) under resources lost to show that this water was taken from the aquifer and wasted rather than being beneficially used as cooling water	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Sludge from Backwashes • Manual cleaning of the tank • Assume shipped with bag filters to non-hazardous landfill in Coventry VT, 93 miles one way • Assume 2,000 lbs per year	• Manual cleaning based on RSE p.13 • Weight estimated by TT GEO based on professional judgment	• Distance for deliveries: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2,000 lbs = 1 ton *Name: Waste Transport for Backwash Sludge* *Materials/Assemblies used: Transport, municipal waste collection, lorry 21t/CH/ U (EcoInvent)* *Amount input: 2790 tmi** *Waste Scenario Process: Other (TT Created)- Landfill disposal of sludge, 60,000 lbs, Waste Scenario/treatment: Disposal, concrete, 5% water, to inert material landfill/CH U 100%*	• Distance for deliveries: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2000 lbs = 1 ton	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Green Sand Filter change out waste • Shipped to non-hazardous landfill located in Coventry, Vermont • 20 tons shipped in fall of 2010 • Assume 1 disposal event per 5 years • Assume an empty trip and a full trip for each disposal event	• Landfill location and weight of disposal provided in email from site team • Site Team e-mail, 1/23/2012	• Distance for disposal: 6 trips x 93 miles per trip=558 miles • Weight per delivery trip is 20 tons (Empty trips included) *Name: Waste Transport for Greensand* *Materials/Assemblies used: Transport, municipal waste collection, lorry 21t/CH/ U (EcoInvent)* *Amount input: ((93miles x 6 trips) x 1.6 km per mile)x (20 metric tons x 0.907 mt per short ton)=16,195.4 tkm* *Waste Scenario Process: Other (TT Created)- Landfill disposal of greensand, 528,000 kg, Waste Scenario/treatment: Disposal, concrete, 5% water, to inert material landfill/CH U (Ecoinvent)*	• Distance for disposal: 6 trips x 93 miles per trip=558 miles • Weight per delivery trip is 20 tons • Distance for empty trips: 6 trips x 93 miles per trip=558 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)

Values in table are for 30 year duration

Table 1-F: Transport for Personnel: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
System O&M (Operator) • Two days per week for approximately 8 hours each day • Coming from Concord (65 miles one way)	• email from site team	Transportation- car Person Miles= 405,600 *Name: Transport of Personnel Round Trip, Materials/Assemblies used: Passenger car (LCA Food DK) Amount input: 405600 miles*	• Distance per trip is 130 miles round trip • Vehicle- assume car (gasoline) • Trips= 2 times per weekx52 weeks per yearx30 years =3,120 round trips • One person (driver)	
Sampling personnel • On-site anyway	• Email from site team	• none	• none	

Values in table are for 30 year duration

Table 1-G: Potable Water Use: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 1-H: Non-Potable Water Use: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
System O&M • Since all this water was otherwise being used for non-contact cooling, it is assumed that no non-potable water is being diverted from use as a resource by the remedy except for water sent via gravity to POTW (see waste disposal)	• Assumption	• 0 gallons*	• 0 gallons*	

**water sent to POTW from backwash included in "waste disposal"*

Table 1-I: Known Use of On-Site Renewables: Alternative 1 (Current System)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 1-J: eGRID Subregion, NEWE, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	15.1508	20,425,383.70
Oil	9.7991	13,210,553.60
Gas	36.6478	49,406,296.00
Other Fossil	1.4623	1,971,392.70
Nuclear	25.6388	34,564,611.00
Other Unknown / Purchased Fuel	0.0077	10,355.70
Nonrenewable Total	88.7064	119,588,592.60
Renewable Resource		
Wind	0.0085	11,486.00
Solar	0	0
Geothermal	0	0
Biomass	5.2768	7,113,803.50
Hydro	6.0083	8,100,005.10
Renewable Total	11.2936	15,225,294.60

Table 2-A: Electricity Use: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction Well 1 (NCCW-1 system) • 30 HP, capacity 165 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	2,044,240 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-01* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 2044.240 p*	*TDH* = 150 ft *Q* = 165 gpm $\eta_m \times \eta_p$ = 0.6 262,800 hrs *See Equation 1 for definitions*	
Extraction Well 2 (NCCW-1 system) • 30 HP, nominal capacity 150 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	1,858,400 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-02* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 1858.400 p*	*TDH* = 150 ft *Q* = 150 gpm $\eta_m \times \eta_p$ = 0.6 262,800 hrs *See Equation 1 for definitions*	
Extraction Well 4 (NCCW-1 system) • HP unknown, 60 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	743,360 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-04* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 743.360 p*	*TDH* = 150 ft *Q* = 60 gpm $\eta_m \times \eta_p$ = 0.6 262,800 hrs *See Equation 1 for definitions*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction Well 5 (NCCW-1 system) • 20 HP, capacity 56 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	693,803 kWh *See Equation 1* *Name: CECRL-05 Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 693.803 p*	*TDH* = 150 ft *Q* = 56 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	
Blower/Blower Motor for Tray Air Stripper (1) •	• Based on professional judgment	*See Equation 2* *SimaPro Assembly Name: Electricity_Blower for tray_Alt2 Materials/Assemblies used: 1000 kWh NEWE Source Mix AT CONSUMER Amount: 5535.5p*	HP=30 Number of units = 1 L = 80% η_m = 85 % 262,800 hrs *See Equation 2 for definitions*	
Transfer pump from equalization tank • 15 HP	• Based on professional judgment	2,767,748 kWh *See Equation 2* *SimaPro Assembly Name: Electricity_Transfer Pump_Alt2 Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 2767.8 p*	HP = 15 HP Number of units = 1 L = 80% η_m = 85% 262,800 hrs *See Equation 2 for definitions*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Replacement pump for more flow to Main Lab Reservoir • Assume 30 HP	• This will replace the "pump, high lift" • Based on professional judgment	5,535,496 kWh *See Equation 2* *SimaPro Assembly Name: Electricity_Replacement Pump_Alt2* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 5535.5p*	HP = 30 HP Number of units = 1 L = 80% η_m = 85% 262,800 hrs *See Equation 2 for definitions*	
Backwash Pump • 25 HP • Assumes two pumps • Intermittent use (assumed one 10 minute session every four days for 30 years, equates to 456.25 hours per pump over 30 years)	• Dave Becker (e-mail of 1/17/2011) • Backwash frequency of once per 4 days is approximate based on information provided by site team	16,017 kWh *See Equation 2* *SimaPro Assembly Name: Pump, backwash* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 16p*	HP= 25 HP Number of Units=2 L=80% η_m =85% *456.25 hours (each pump)=* *See equation 2 for details*	
Production well housing heaters • Ceiling/wall mounted electric space heater, 120 VAC • Assume one per each of the four well houses	• These heaters are mentioned in Byron Young email of 12/19/11 • Usage rate and power ratings not provided. Estimated by TT GEO to be 5 kW of continuous use each heater, for 4 months per year for 30 years.	5kW x 24hours x 120 days per year x 30 years x 4 heaters= 1,728,000 kWh *SimaPro Assembly Name: Heater for well housing* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 1728 p*	5kW x 24hours x 120 days per year x 30 years x 4 heaters= 1,728,000 kWh	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Management Factor for Additional Electricity not accounted for in major units Example: Lights, plug leads, SCADA system, motorized control valves	• Estimated to be 5 kW	5 kW x 262800 hours in 30 years=1314000 kWh *SimaPro Assembly Name: Management Factor for Electrical Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 1314 p*	1314000 kWh	

Additional assumptions:

- *assume pump efficiency of 75% and motor efficiency of 80% for extraction pumps*
- *assume load of 80% and motor efficiency of 85% efficiency for all process pumps and blowers, based on professional judgment.*
- *for extraction wells, assume total dynamic head of 150 feet based on depth to water of 110 feet, air stripper height of approximately 30 feet, and friction losses of approximately 10 feet.*
- *continuous operation assumes is 8,760 hours per year.*
- *Values in table are for 30 year duration*

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Equation 1	Equation 2
$$kWh = \frac{TDH \times Q}{3956 \times \eta_p \times \eta_m} \times 0.746 \times hours\ of\ operation$$	$$kWh = \frac{HP \times L}{\eta_m} \times N \times 0.746 \times hours\ of\ operationhours\ of\ operation$$
TDH = total dynamic head (ft) *Q = flow rate (gpm)* *3956 = conversion factor used to convert ft-gpm to HP* *0.746 = conversion factor from HP to kW* η_p *= efficiency of pump (%)* η_m *= efficiency of motor (%)*	*HP = motor size (HP)* *L = capacity (%)* *N = number of units operating* *0.746 = conversion factor from HP to kW* η_m *= efficiency of motor (%)*

Table 2-B: Fuel Use for Equipment: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Boiler • The heat exchanger uses hot water from this boiler to heat air from the off gas of the air stripper	• Boiler and associated fuel tank mentioned in RSE p. 19 • Fuel type and usage not provided, estimated by TT GEO to be fuel oil (diesel) at 5000 gallons per year. • (Keeping boiler in footprint. Not including the hazardous air heater only mentioned in RACER, not in RSE.)	5000 gallons per year x 30 years= 150,000 gallons of diesel fuel *SimaPro AssemblyName: Process Used: Diesel, combusted in industrial boiler/US (USLCI) Amount input: 150,000 gal**	5000 gallons per year x 30 years= 150000 gallons of fuel oil	
Construction Equipment Excavator/trencher: for placement of 4” PVC pipe, 3 feet deep for a length of 200 linear feet –movement of 3 x 3 x 200ft=1800 ft^3 Excavator- placement of influent equalization tank and concrete pad -Assume movement of 2088 ft^3 for slab	• Estimated based on professional judgment	2088 ft^3 of soil moved, at 78 lbs of soil per cubic foot= 162864 lbs of soil moved *SimaPro Assembly Name: Fuel for equip for Pipe Laying and Slab Materials/Assemblies used: Excavator, technology mix, 100 kW, Construction GLO Amount input: (2088ft^3 x 78lbs per ft^3) p=162,864 lbs*	2088 ft^3 of soil moved, at 78 lbs of soil per cubic foot= 162864 lbs of soil moved	

Values in table are for 30 year duration

Table 2-C: Materials Use: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Vapor Phase GAC • 2 units each 10,000 lbs • Assume both units changed once every 2 years • Regenerated carbon	• Change frequency based on RSE p.12 • Regenerated carbon based on information provided by site team	20,000 x 15 = 300,000 pounds of regenerated GAC *SimaPro Assembly Name: GAC Composite for CRREL Materials/Assemblies used: GAC_Composite for Regen_1kg Amount input: 300,000 lbs/2.2 kg per pound= 136,000p*	20,000 x 15 = 300,000 pounds of regenerated GAC	
Potassium Permanganate • 0.6% solution (5 lbs per day) • Potassium Permanganate by Cairox • Stored in 55 gallon drums	• RSE p.11	5 × 365 x 30 = 54,750 pounds *Name: Potassium Permanganate Materials/Assemblies used: Potassium permanganate, at plant/RER U (EcoInvent) Amount input: 54,750 lbs*	5 × 365 x 30 = 54,750 pounds (surrogate: hydrogen peroxide)	
Carbon Dioxide • 80,000 lbs per year • Should equate to 80,000 lbs per year of CO2 emissions in addition to footprint to produce the material	• RSE p.11 • Usage from site team e-mail of 1/25/2012	80,000 x 30= 2,400,000* pounds *SimaPro Assembly Name: Carbon Dioxide Materials/Assemblies used: Carbon dioxide liquid, at plant/RER U (EcoInvent) Amount input: 2,400,000 lbs*	80,000 x 30= 2,400,000* pounds (surrogate: soda ash)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters • 7 bags in parallel, changed weekly • Assume polypropylene • Assume 1 lb each when shipped to site	• Change frequency in Stanley Report p. 1-2 • Material and weight based on professional judgment	7 × 52 x 30 = 10,920 pounds *SimaPro Assembly Name: Filter Bag Train of 7 bags Materials/Assemblies used: Polypropylene fibres (PP), crude oil based, production mix, at plant, PP granulate without additives (ELCD) Amount input: 10920 lbs*	7 × 52 x 30 = 10,920 pounds (surrogate: HDPE liner)	
Passive Diffusion Bags for Sampling • 14 bags annually (seems de minimis, assume should be excluded from evaluation)	• RSE p. 14	0 pounds	0 pounds	
Greensand • Assumed volume for original delivery and for change every 5 years • Each delivery is for 20 tons of greensand	• Site Team e-mail, 1/23/2012	20 tons per delivery Delivered to site 6 times over the course of the remedy: 20 tons x2000 lbs per ton x 6 events= 240,000 lbs *SimaPro Assembly Name: Greensand v2 Materials/Assemblies used: Greensand_1kg Amount input: 240,000 lbs x 2.2 kg per lbs=528,000p*	20 tons per delivery Delivered to site 6 times over the course of the remedy: 20 tons x2000 lbs per ton x 6 events= 240,000 lbs SiteWise input: Ion Exchange Resin	Use surrogate “Medium Impact Material (Generic)”

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Construction (Material)-Tray Air Stripper	Alternative presented in RSE Size estimated by TT based on professional judgment of design for necessary existing flow rate and contaminant concentration. Size necessary requires 7,800 lbs of stainless steel	7,800 lbs. of steel *SimaPro Assembly Name: Materials_Alt2_Tray Air Stripper* *Materials/Assemblies used: Chromium steel 18/8, at plant/RER U, Amount input: 7800 lbs*	7,800 lbs of stainless steel	
Construction Materials <u>Influent Equalization Tank</u> -20,000 gallon steel vessel -12,250 lbs of steel required <u>For Slab</u> -288 ft^3 -41,472 lbs of concrete -750 steel for reinforcement	Vessel size from Appendix C, RACER Phase Technology Cost Detail Report Amount of steel required for vessel not provided. Estimated by TT GEO to require 12, 250 lbs. of steel.	*SimaPro Assembly Name: Materials_Alt2_Influent Eq Tank and Slab* *1st Materials/Assemblies used: Iron and steel, production mix/US (USLCI) Amount input: 12250 lbs* *2nd Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent) Amount input: 41472 lbs* *3rd Materials/Assemblies used: Reinforcing steel, at plant/RER S(Ecoinvent) Amount input: 750 lbs*	12,250 lbs of steel for tank 750 lbs of steel for reinforcement 41,472 lbs of concrete (SiteWise will assume this is concrete)	
Construction Materials-Polyvinyl Chloride (PVC) pipe -4", 200 linear feet	Weight of PVC nor provided. Assumed 2 lbs per linear foot (http://www.engineeringtoolbox.com/pvc-cpvc-pipes-dimensions-d_795.html)	2 x 200 lbs= 400 lbs of PVC *SimaPro Assembly Name: PVC Pipe* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 400 lbs*	2lbs per foot x 200 linear feet= 400 lbs of PVC Input to SiteWise: 200 feet of Sch 40 PVC	

Values in table are for 30 year duration

Table 2-D: Transport for Materials, Equipment, and Samples: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Vapor Phase GAC • 20,000 lbs every 2 years • Assume return trip has same weight of carbon to be regenerated • Assume 100 miles each way of transport	• Change frequency based on RSE p. 12 • Distance for transport not provided and is estimated by TT GEO	• Distance: 1 trip per change with fresh GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds= 10 tons • Distance: 1 trip per change with spent GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds (10 tons) + 10% = 11 *SimaPro Assembly Name: Transport of GAC* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 15,000 tmi* *Plus 16,500 tmi*	• Distance: 1 trip per change with fresh GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds= 10 tons • Distance: 1 trip per change with spent GAC x 15 changes x 100 miles per trip=1500 miles • Weight per trip is 20,000 pounds (10 tons) + 10% = 11 tons	Ton-mile basis
Potassium Permanganate • 0.6% solution (5 lbs per day) • Site team indicates deliveries are very infrequent- will assume once every three years • Assume transport distance of 100 miles • Assume entire load dedicated to deliver this load so an empty trip should be included for each delivery	• RSE p.11 • Assumptions for delivery frequency, transport distance and empty trips made by TT GEO	• Distance for deliveries: 10 trips x 100 miles per trip=1,000 miles • Weight per delivery trip is 5 x 365 x 3= 5475 pounds= 2.74 tons (Empty trips included) *SimaPro Assembly Name: Transport of Potassium Permanganate* *Process used: Transport, Transport, aircraft, freight/US (USLCI)* *Amount input: 2740 tmi**	• Distance for deliveries: 10 trips x 100 miles per trip=1,000 miles • Weight per delivery trip is 5 x 365 x 3= 5475 pounds= 2.74 tons • Distance for empty trips: 10 trips x 100 miles per trip=1,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Carbon Dioxide • 80,000 lbs per year • Site team did not indicate frequency of delivery, assume once per year • Assume transport distance of 100 miles • Assume entire load dedicated to deliver this load so an empty trip should be included for each delivery	• RSE p.11 • Assumptions for delivery frequency, transport distance and empty trips made by TT GEO	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 80,000 pounds= 40 tons (Empty trips included) *SimaPro Assembly Name: Transport of CO_2* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 120,000 tmi**	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 80,000 pounds= 40 tons • Distance for empty trips: 30 trips x 100 miles per trip=3,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty return)
Bag Filters • 7 bags in parallel, changed weekly • Assume polypropylene • Assume 1 lb each when shipped to site • Site team did not indicate frequency of delivery, assume once per year • Assume transport distance of 100 miles • Assume partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• Change frequency in Stanley Report p. 1-2 • Material and weight based on professional judgment • Assumptions for delivery frequency, transport distance and empty trips made by TT GEO	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1 x 7 x 52=364 lbs = 0.182 tons *SimaPro Assembly Name: Transport of Bag Filters* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 546 tmi**	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1 x 7 x 52=364 lbs = 0.182 tons • Fuel: diesel	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Coolers for Sampling • Assume 12 coolers per year (1 per month) • Assume 10 lbs per cooler to site • Assume 30 lbs per cooler from site • Assume pick up via light truck • Lab in Concord, NH, distance is 65 miles	• RSE p. 14 for sampling frequency • Weights based on professional judgment	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs *SimaPro Assembly Name: Transport of coolers during sampling* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 117 tmi** *And* *351 tmi**	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs • Fuel: diesel	Ton-mile basis
Greensand • Assumed volume for original delivery and for change every 6 years • Each delivery is for 20 tons of greensand • Assume distance for delivery is 100 miles	• Volume of greensand found in Site Team e-mail, 1/23/2012	• Distance for deliveries: 6 trips x 100 miles per trip=600 miles • Weight per delivery trip is 20 tons (Empty trips included) *SimaPro Assembly Name: Transport of Greensand* *Process used: Transport, single unit truck, kiesel powered/US* *Amount input: 600 miles 20 tons per trip = 12000 tmi**	• Distance for deliveries: 6 trips x 100 miles per trip=600 miles • Weight per delivery trip is 20 tons • Distance for return trip: 6 trips x 100 miles per trip=600 miles • Weight per delivery return trip is 0 tons • Fuel: diesel	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for Construction: Tray Air Stripper • One time delivery of 7,800 lbs • Assumed vendor location: Tauton, Ma (http://www.neepsystems.com/): 163 miles one way	• Weight and vendor location found through internet search	• 7,800 lbs • 163 miles one way *SimaPro Assembly Name: Transport of Materials for Tray Stripper_Alt2* *Process used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: (7800 lbs/2000 lbs per ton) x 163 miles=636 tmi**	• 7,800 lbs • 163 miles one way • Fuel: diesel	Ton-mile basis
Transport for Construction: Excavation/Trenching Equipment	• Assumed a single excavator with a weight of 26 tons • Assume a distance of 30 miles	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 7800 lbs/2000 lbs per ton=26 tons *SimaPro Assembly Name: Transport for Construction Equp_Alt2* *Process used: Transport, tractor and trailer/CH U* *Amount input: (7800 lbs/2000 lbs per ton) x 30 miles=780 tmi** *Empty trip included*	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 7800 lbs/2000 lbs per ton=26 tons • Distance for return trip: 30 miles • Weight per return trip is 0 tons	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Influent equalization tank (12,250 lbs of steel plus 750 lbs of steel for reinforcement) Assume delivery distance is 100 miles	• Assume influent equalization tank and steel for reinforcement are delivered to site together, once for construction	• Distance for deliveries 100 miles per trip • Weight per delivery trip is (12,250 + 750) lbs/2000 lbs per short ton= 6.5 tons *SimaPro Assembly Name: Transport of Steel for tanks_Alt2* *Process used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 650 tmi*[*]	• Distance for deliveries 100 miles per trip • Weight per delivery trip is (12,250 + 750) lbs/2000 lbs per short ton= 6.5 tons • Distance for return trip 100 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)
Concrete (41,472 lbs) Assume delivery distance is 10 miles	• Assumes concrete is delivered as a separate delivery from a vendor that is located 10 miles away (there are three cement vendors within 10 miles of Hanover, NH)	• Distance for deliveries 10 miles per trip • Weight per delivery trip is 41,472lbs/2000 lbs per short ton= 20.1 tons *SimaPro Assembly Name: Transport of Concrete_Alt2* *Process used: Transport, lorry 20-28t, fleet average/CH U* *Amount input: 201 tmi*[*] *Empty trip included*	• Distance for deliveries 10 miles per trip • Weight per delivery trip is 41,472lbs/2000 lbs per short ton= 20.1 tons • Distance for return trip 10 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for construction-PVC -400 lbs, one time	• Assume vendor for PVC located within a 30 mile radius	*SimaPro Assembly Name: Transport of PVC_Alt2* *Process used: Transport, tractor and trailer/CH U* *Amount input: =(400lbs/2000lbs per ton) x 30 miles=6 tmi** *Empty trip included*	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 400lbs/2000 lbs per short ton= 0.2 tons • Distance for return trip 30 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)

Values in table are for 30 year duration

Table 2-E: Waste Transport/Disposal: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters • 7 bags in parallel, changed weekly • Assume 2 lbs each when used • Assume 1 shipment per year to non-hazardous landfill in Coventry VT, 93 miles one way • Assume partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• Change frequency in Stanley Report p. 1-2 • Weight of bags an d frequency of shipments based on professional judgment • Landfill location based on greensand disposal location provided by site team • Dispose of 2 times the weight due to accumulated material in discarded filters.	• Distance for disposal: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2 x 7 x 52=728 lbs = 0.364 tons *Name: Waste Transport for Bag Filters* *Process used: Transport, municipal waste collection, lorry 21t/CH/ U (EcoInvent)* *Amount input: 1016 tmi** *Disposal scenarios: "Filter bag disposal" and "filtered sediment disposal", which each dispose of 5.46 short tons of waste to "Disposal, concrete, 5% water, to inert material landfill/CH U.*	• Distance for deliveries: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2 x 7 x 52=728 lbs = 0.364 tons	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Water from Backwashes • Goes to POTW, via gravity • RSE says 5100 gallons per backwash, backwash frequency once per 4 days	• Discharge to POTW based on RSE p.4 • Backwash frequency of once per 4 days is approximate based on information provided by site team • Unit conversion: 3.785 kg in a gallon	• Include as "water lost" to consumption • 5100 gal/event * (365/4) events/yr * 30 yr = 13,961,250 gallons=52,843,331 kg *Waste Scenario Process Name: water to POTW, which refers to "POTW Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U". This process is a modified version of "Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U" in which the units were converted from m3 to kg so that the waste treatment process could be accessed by a disposal scenario.* *No transport of waste necessary*	• Include as "water lost" to consumption • 5100 gal/event * (365/4) events/yr * 30 yr = 13,961,250 gallons This was modeled in two places: 1) under POTW to calculate the impact of the POTW in treating that water and 2) under resources lost to show that this water was taken from the aquifer and wasted rather than being beneficially used as cooling water	
Sludge from Backwashes • Manual cleaning of the tank • Assume shipped with bag filters to non-hazardous landfill in Coventry VT, 93 miles one way • Assume 2,000 lbs per year	• Manual cleaning based on RSE p.13 • Weight estimated by TT GEO based on professional judgment	• Distance for deliveries: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2,000 lbs = 1 ton *Name: Waste Transport for Backwash Sludge Materials/Assemblies used: Transport, municipal waste collection, lorry 21t/CH/ U (EcoInvent)* *Amount input: 2790 tmi(short ton)* *Waste Scenario Process: Other (TT Created)-Landfill disposal of sludge, 60,000 lbs, Waste Scenario/treatment: Disposal, concrete, 5% water, to inert material landfill/CH U 100%*	• Distance for deliveries: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2000 lbs = 1 ton	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Green Sand Filter change out waste • Shipped to non-hazardous landfill located in Coventry, Vermont • 20 tons shipped in fall of 2010 • Assume 1 disposal event per 5 years • Assume an empty trip and a full trip for each disposal event	• Landfill location and weight of disposal provided in email from site team • Site Team e-mail, 1/23/2012	• Distance for disposal: 6 trips x 93 miles per trip=558 miles • Weight per delivery trip is 20 tons (Empty trips included) *Name: Waste Transport for Greensand Materials/Assemblies used: Transport, municipal waste collection, lorry 21t/CH/ U (EcoInvent)* *Amount input: ((93miles x 6trips) x 1.6 km per mile)x 20 metric tons=17,900 tkm* *Waste Scenario Process: Other (TT Created)-Landfill disposal of greensand, 528,000 kgs, Waste Scenario/treatment: Disposal, concrete, 5% water, to inert material landfill/CH U 100%*	• Distance for disposal: 6 trips x 93 miles per trip=558 miles • Weight per delivery trip is 20 tons • Distance for empty trips: 6 trips x 93 miles per trip=558 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty return)

Values in table are for 30 year duration

Table 2-F: Transport for Personnel: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
System O&M (Operator) • Two days per week for approximately 8 hours each day • Coming from Concord (65 miles one way)	• email from site team	• Transportation- car Person Miles= 405,600 *Name: Transport of Personnel Round Trip, Materials/Assemblies used: Passenger car (LCA Food DK) Amount input: 405600 miles*	• Distance per trip is 130 miles round trip • Vehicle- assume car (gasoline) • Trips= 2 times per weekx52 weeks per yearx30 years =3,120 round trips • One person (driver)	
Sampling personnel • On-site anyway	• Email from site team	• none	• none	

Values in table are for 30 year duration

Table 2-G: Potable Water Use: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

Table 2-H: Non-Potable Water Use: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
System O&M • Since all this water was otherwise being used for non-contact cooling, it is assumed that no non-potable water is being diverted from use as a resource by the remedy except for water sent via gravity to POTW (see waste disposal)	• Assumption	• 0 gallons*	• 0 gallons*	

**water sent to POTW from backwash included in "waste disposal"*

Table 2-I: Known Use of On-Site Renewables: Alternative 2 (Switch to Tray Stripper)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 3-A: Electricity Use: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction Well 1 (NCCW-1 system) • 30 HP, capacity 165 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	2,044,240 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-01 Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 2044.240 p*	*TDH* = 150 ft *Q* = 165 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	
Extraction Well 2 (NCCW-1 system) • 30 HP, nominal capacity 150 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	1,858,400 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-02 Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 1858.400 p*	*TDH* = 150 ft *Q* = 150 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	
Extraction Well 4 (NCCW-1 system) • HP unknown, 60 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	743,360 kWh *See Equation 1* *SimaPro Assembly Name: CECRL-04 Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER*	*TDH* = 150 ft *Q* = 60 gpm $\eta_m \times \eta_p = 0.6$ 262,800 hrs *See Equation 1 for definitions*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
		Amount input: 743.360 p		
Extraction Well 5 (NCCW-1 system) • 20 HP, capacity 56 gpm • VFD added after RSE • Use Equation 1 to calculate electric usage	• HP and capacity from Stanley Report page 1-6 • Presence of VFD from Byron Young email of 12/19/11	693,803 kWh *See Equation 1* *Name: CECRL-05 Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 693.803 p*	*TDH* = 150 ft *Q* = 56 gpm $\eta_m \times \eta_p$ = 0.6 262,800 hrs *See Equation 1 for definitions*	
Pump , Transfer • 15 HP	• Based on professional judgment	2,767,748 kWh *See Equation 2 SimaPro Assembly Name: Electricity_Transfer Pump_Alt2 Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 2767.8 p*	HP = 15 HP Number of units = 1 L = 80% η_m = 85% 262,800 hrs hrs *See Equation 2 for definitions*	
Pump, Replacement • 30 HP	• Based on professional judgment	5,535,496 kWh *See Equation 2* *SimaPro Assembly Name: Pump, Replacement Materials/Assemblies*	HP = 30 HP Number of units = 1 L = 80% η_m = 85% 262,800 hrs *See Equation 2 for definitions*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
		used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 5535.5p		
Production well housing heaters • Ceiling/wall mounted electric space heater, 120 VAC • Assume one per each of the four well houses	• These heaters are mentioned in Byron Young email of 12/19/11 • Usage rate and power ratings not provided. Estimated by TT GEO to be 5 kW of continuous use each heater, for 4 months per year for 30 years.	5kW x 24hours x 120 days per year x 30 years x 4 heaters= 1,728,000 kWh *SimaPro Assembly Name: Heater for well housing Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 1728 p*	5kW x 24hours x 120 days per year x 30 years x 4 heaters= 1,728,000 kWh	
Management Factor for Additional Electricity not accounted for in major units Example: Lights, plug leads, motorized control valves, biocide pump, SCADA system	• Estimated to be 5 kw	5 kW x 262,800 hours in 30 years=1314000 kWh *SimaPro Assembly Name: Management Factor for Electrical Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 1314 p*	1314000 kWh	

Additional assumptions:

- *assume pump efficiency of 75% and motor efficiency of 80% for extraction pumps*
- *assume load of 80% and motor efficiency of 85% efficiency for all process pumps and blowers, based on professional judgment.*
- *for extraction wells, assume total dynamic head of 150 feet based on depth to water of 110 feet, air stripper height of approximately 30 feet, and friction losses of approximately 10 feet.*

- *continuous operation assumes is 8,760 hours per year.*
- *Values in table are for 30 year duration*

\Equation 1	Equation 2
$$kWh = \frac{TDH \times Q}{3956 \times \eta_p \times \eta_m} \times 0.746 \times hours\ of\ operation$$ TDH = total dynamic head (ft) Q = flow rate (gpm) 3956 = conversion factor used to convert ft-gpm to HP 0.746 = conversion factor from HP to kW η_p = efficiency of pump (%) η_m = efficiency of motor (%)	$$kWh = \frac{HP \times L}{\eta_m} \times N \times 0.746 \times hours\ of\ operationhours\ of\ operation$$ HP = motor size (HP) L = capacity (%) N = number of units operating 0.746 = conversion factor from HP to kW η_m = efficiency of motor (%)

Table 3-B: Fuel Use for Equipment: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Construction Equipment Excavator/trencher: for placement of 4" PVC pipe, 3 feet deep for a length of 200 linear feet – movement of 3 x 3 x 200ft=1800 ft^3 Excavator- placement of influent equalization tank and concrete pad -Assume movement of 288 ft^3 for slab	• Estimated based on professional judgment	2088 ft^3 of soil moved, at 78 lbs of soil per cubic foot= 162,864 lbs of soil moved *SimaPro Assembly Name: Fuel Use_Alt3_Pipe Laying and Slab Materials/Assemblies used: Excavator, technology mix, 100 kW, Construction GLO Amount input: (2088ft^3 x 78lbs per ft^3) p=162,864 lbs*	2088 ft^3 of soil moved, at 78 lbs of soil per cubic foot= 162864 lbs of soil moved	

Values in table are for 30 year duration

Table 3-C: Materials Use: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Liquid Phase GAC • 20,000 lbs (to fill two 10,000 lbs vessels • Assume changed six times per year	• Change frequency based on professional calculations of requirements based on flow • Assume customer generated carbon (regenerated)	20,000 x 6 x 30 = 3,600,000 pounds of liquid GAC *SimaPro Assembly Name: GAC Composite for CRREL_Alt3* *Materials/Assemblies used: GAC_Composite for Regen_1kg* *Amount input: 3,600,000 lbs/ 2.2 lbs per kg= 1.64E6 p*	20,000 x 6 x 30 = 3,600,000 pounds of liquid GAC	
Bag Filters • 7 bags in parallel, changed weekly • Assume polypropylene • Assume 1 lb each when shipped to site	• Change frequency in Stanley Report p. 1-2 • Material and weight based on professional judgment	7 × 52 x 30 = 10,920 pounds *SimaPro Assembly Name: Filter Bag Train of 7 bags* *Materials/Assemblies used: Polypropylene fibres (PP), crude oil based, production mix, at plant, PP granulate without additives (ELCD)* *Amount input: 10920 lbs*	7 × 52 x 30 = 10,920 pounds (surrogate: HDPE liner)	
Construction (Material) <u>Influent Equalization Tank</u> -20,000 gallon steel vessel -12,250 lbs of steel required <u>For Slab</u> -288 ft^3 -41,472 lbs of concrete -750 steel for reinforcement	Vessel size from Appendix C, RACER Phase Technology Cost Detail Report Amount of steel required for vessel not provided. Estimated by TT GEO to require 12, 250 lbs. of steel.	*SimaPro Assembly Name: Materials_Alt2_Influent Eq Tank and Slab* *1st Materials/Assemblies used: Iron and steel, production mix/US* *Amount input: 12250 lbs* *2nd Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 41472 lbs* *3rd Materials/Assemblies used: Reinforcing steel, at plant/RER S* *Amount input: 750 lbs*	12,250 lbs of steel for tank 750 lbs of steel for reinforcement 41,472 lbs of cement	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Liquid GAC tank 10,900 lbs of steel for each of two tanks		*SimaPro Assembly Name: Materials_Alt3_Lqd GAC tanks Materials/Assemblies used: Iron and steel, production mix/US (USLCI) Amount input: 10,900 lbs x 2=21,800 lbs*	21,800 lbs of steel	
Construction (Material)-Polyvinyl Chloride (PVC) pipe -4", 200 linear feet	Assume 2 lbs per linear foot (http://www.engineeringtoolbox.com/pvc-cpvc-pipes-dimensions-d_795.html)	2 x 200 lbs= 400 lbs of PVC *SimaPro Assembly Name: Materials_Alt3_PVC Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 400 lbs*	2lbs per foot x 200 linear feet= 400 lbs of PVC	
Sequestering Agent (Citric Acid) -2 ppm	-RSE -Calculated for 450 gpm: 3939 pounds per year	3939 lbs x 30 years= 118170 lbs *SimaPro Assembly Name: Materials_Alt3_Sequestering Agent Materials/Assemblies used: EDTA, ethylenediaminetetraacetic acid, at plant/RER U Amount input: 118170 lbs*	118170 lbs of citric acid (surrogate used: acetic acid)	Use surrogate "High Impact Material (Generic)"
Biocide -5 ppm	-RSE -Name brand of potential biocide noted: Tolcide -Calculated for 450 gpm: 9847.5 lbs	9847.5 lbs x 30 years=295425 lbs *SimaPro Assembly Name: Materials_Alt3_Biocide Materials/Assemblies used: Biocides, for paper production, unspecified, at plant/RER U Amount input:295425 lbs*	295425 lbs of biocide (Surrogate used: sodium hypochlorite)	

Values in table are for 30 year duration

Table 3-D: Transport for Materials, Equipment, and Samples: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Liquid Phase GAC • 20,000 lbs six times per year • Assume return trip has an increase of 10% in its weight of carbon to be regenerated • Assume 100 miles each way of transport	• Change frequency based on professional judgment • Distance for transport not provided and is estimated by TT GEO	• Distance: 1 trip per change with fresh (regenerated) GAC x 180 changes x 100 miles per trip=18,000 miles • Weight per trip is 20,000 pounds= 10 short tons • 10 ton x 18,000 miles= 180,000 tmi* • Distance: 1 trip per change with spent GAC x 180 changes x 100 miles per trip= 18,000 miles • Weight per trip is 11 short tons • 11 tons X 18,000 miles= 198,000 tmi* *SimaPro Assembly Name: Transport of GAC_Alt3* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 180,000 tmi** *Plus 198,000 tmi**	• Distance: 1 trip per change with fresh GAC x 180 changes x 100 miles per trip=18,000 miles • Weight per trip is 20,000 pounds= 10 short tons • 10 ton x 18,000 miles= 180,000 tmi* • Distance: 1 trip per change with spent GAC x 180 changes x 100 miles per trip= 18,000 miles • Weight per trip is 11 short tons • 11 tons X 18,000 miles= 198,000 tmi*	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters • 7 bags in parallel, changed weekly • Assume polypropylene • Assume 1 lb each when shipped to site • Site team did not indicate frequency of delivery, assume once per year • Assume transport distance of 100 miles • Assume partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• Change frequency in Stanley Report p. 1-2 • Material and weight based on professional judgment • Assumptions for delivery frequency, transport distance and empty trips made by TT GEO	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1 x 7 x 52=364 lbs = 0.182 tons *SimaPro Assembly Name: Transport of Bag Filters* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 546 tmi*	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1 x 7 x 52=364 lbs = 0.182 tons • Fuel: diesel	Ton-mile basis
Coolers for Sampling • Assume 12 coolers per year (1 per month) • Assume 10 lbs per cooler to site • Assume 30 lbs per cooler from site • Assume pick up via light truck • Lab in Concord, NH, distance is 65 miles	• RSE p. 14 for sampling frequency • Weights based on professional judgment	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs *SimaPro Assembly Name: Transport of coolers during sampling* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 117 tmi* *And* *351 tmi*	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs • Fuel: diesel	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Influent equalization tank (12,250 lbs of steel plus 750 lbs of steel for reinforcement) Assume delivery distance is 100 miles	• Assume influent equalization tank and steel for reinforcement are delivered to site together, once for construction	• Distance for deliveries 100 miles per trip • Weight per delivery trip is (12,250 + 750)lbs/2000 lbs per short ton= 6.5 tons *SimaPro Assembly Name: Transport of Steel for tanks_Alt2* *Process used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 650 tmi**	• Distance for deliveries 100 miles per trip • Weight per delivery trip is (12,250 + 750)lbs/2000 lbs per short ton= 6.5 tons • Distance for return trip 100 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)
Concrete (41,472 lbs) Assume delivery distance is 10 miles	• Assumes concrete is delivered as a separate delivery from a vendor that is located 10 miles away (there are three cement vendors within 10 miles of Hanover, NH)	• Distance for deliveries 10 miles per trip • Weight per delivery trip is 41,472lbs/2000 lbs per short ton= 20.1 tons *SimaPro Assembly Name: Transport of Concrete_Alt2* *Process used: Transport, lorry 20-28t, fleet average/CH U* *Amount input: 201 tmi** *Empty trip included*	• Distance for deliveries 10 miles per trip • Weight per delivery trip is 41,472lbs/2000 lbs per short ton= 20.1 tons • Distance for return trip 10 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Liquid GAC tank (10,900 lbs of steel) Assume delivery distance is 50 miles	• Assume tanks are delivered as a separate delivery from a vendor that is located 50 miles away	• Distance for deliveries 50 miles per trip • Weight per delivery trip is (10,900 x 2)lbs/2000 lbs per short ton= 10.9 tons *SimaPro Assembly Name: Transport of Liquid GAC tank_Alt3* *Process used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 545 tmi** *Empty trip included*	• Distance for deliveries 50 miles per trip • Weight per delivery trip is (10,900 x 2)lbs/2000 lbs per short ton= 10.9 tons • Distance for return trip: 50 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)
PVC (400 lbs) Assume delivery distance is 30 miles	• Assume PVC is delivered on one separate delivery from vendor located within 30 miles	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 400 lbs/2000 lbs per short ton= 0.2 tons *SimaPro Assembly Name: Transport of PVC_Alt2* *Process used: Transport, tractor and trailer/CH U Amount input: 6 tmi** *Empty trip included*	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 400 lbs/2000 lbs per short ton= 0.2 tons • Distance for return trip: 30 miles • Weight per return trip is 0 tons	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for Construction: Excavation/Trenching Equipment	• Assumed a single excavator with a weight of 26 tons • Assume a distance of 30 miles	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 7800 lbs/2000 lbs per ton=26 tons *SimaPro Assembly Name: Transport of Material_Alt3_Constr Equip* *Process used: Transport, tractor and trailer/CH U* *Amount input: (7800 lbs/2000 lbs per ton) x 30 miles=780 tmi** *Empty trip included*	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 7800 lbs/2000 lbs per ton=26 tons • Distance for return trip: 30 miles • Weight per return trip is 0 tons	Ton-mile basis (no empty return)
Transport of Sequestering Agent 118170 lbs over a 30 year period (based on 2 ppm for 450 gpm)	• RSE • Assume distance to vendor, 50 miles • Assume ground transport, van, gasoline • 2 tons delivered once per year for 30 years with a 50 mile distance from vendor = 3000 ton mile	3000 tmi* *SimaPro Assembly Name: Transport of Materials_Alt3_Sequestering Agent* *Process used: Transport, van <3.5t/RER U* *Amount input: 3000 tmi** *Empty trip included*	2 tons delivered once per year for 30 years Distance from vendor: 50 miles Assume: Van, gasoline	Ton-mile basis
Transport of Biocide -295425 lbs over a 30 year period (based on 5 ppm for 450 gpm) 5 tons delivered once per year for 30 years with a distance of 50 miles from vendor.	• RSE • Assume distance to vendor, 50 miles • Assume ground transport, van, gasoline	7500 tmi* *SimaPro Assembly Name: Transport of Materials_Alt3_Biocide* *Process used: Transport, van <3.5t/RER U* *Amount input: 7500 tmi**	5 tons delivered once per year for 30 years Distance from vendor: 50 miles Assume van, gasoline	Ton-mile basis

Values in table are for 30 year duration

Table 3-E: Waste Transport/Disposal: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters • 7 bags in parallel, changed weekly • Assume 2 lbs each when used • Assume 1 shipment per year to non-hazardous landfill in Coventry VT, 93 miles one way • Assume partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• Change frequency in Stanley Report p. 1-2 • Weight of bags an d frequency of shipments based on professional judgment • Landfill location based on greensand disposal location provided by site team	• Distance for disposal: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2 x 7 x 52=728 lbs = 0.364 tons *Name: Waste Transport for Bag Filters* *Process used: Transport, municipal waste collection, lorry 21t/CH/ U (EcoInvent)* *Amount input: 1016 tmi** *Disposal scenarios: "Filter bag disposal" and "filtered sediment disposal", which each dispose of 5.46 short tons of waste to "Disposal, concrete, 5% water, to inert material landfill/CH U.*	• Distance for deliveries: 30 trips x 93 miles per trip=2,790 miles • Weight per delivery trip is 2 x 7 x 52=728 lbs = 0.364 tons Assume only one way	Ton-mile basis

Values in table are for 30 year duration

Table 3-F: Transport for Personnel: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
System O&M (Operator) • Two days per week for approximately 8 hours each day • Coming from Concord (65 miles one way)	• email from site team	• Transportation- car Person Miles= 405,600 *Name: Transport of Personnel Round Trip, Materials/Assemblies used: Passenger car (LCA Food DK) Amount input: 405600 miles*	• Distance per trip is 130 miles round trip • Vehicle- assume car (gasoline) • Trips= 2 times per weekx52 weeks per yearx30 years =3,120 round trips • One person (driver)	
Sampling personnel • On-site anyway	• Email from site team	• none	• none	

Values in table are for 30 year duration

Table 3-G: Potable Water Use: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

Table 3-H: Non-Potable Water Use: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
System O&M • Since all this water was otherwise being used for non-contact cooling, it is assumed that no non-potable water is being diverted from use as a resource by the remedy except for water sent via gravity to POTW (see waste disposal)	• Assumption	• 0 gallons*	• 0 gallons*	

Table 3-I: Known Use of On-Site Renewables: Alternative 3 (Switch to Liquid Phase Carbon)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 4-A: Electricity Use: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Pump for Proposed New Well • 3 HP • Assume no VFD added • Assume operating conditions 40 gpm, continuous.	• HP provided by Dave Becker, e-mail of 1/17/2012 • Flow from RSE	553,550 kWh *See Equation 2* *SimaPro Assembly Name: Electricity_Alt4_Pump for new well* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 553.55 p*	HP= 3 HP Number of Units=1 L=80% η_m =85% *262,800 hours* *See equation 2 for details*	
Production well housing heaters • Ceiling/wall mounted electric space heater, 120 VAC • Assume one per each of the four well houses	• These heaters are mentioned in Byron Young email of 12/19/11 • Usage rate and power ratings not provided. Estimated by TT GEO to be 5 kW of continuous use each heater, for 4 months per year for 30 years.	5kW x 24hours x 120 days per year x 30 years x 1 heaters= 432,000 kWh *SimaPro Assembly Name: Electricity_Alt4_Well Housing Heaters* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 432 p*	5kW x 24hours x 120 days per year x 30 years x 1 heaters= 432,000 kWh	
Transfer pump from equalization tank (Smaller than other transfer pumps) • 3 HP	• Assume the transfer pump requirements for this alternative are smaller than those for Alternative 3. • Based on professional judgment	553,549.6 kWh *See Equation 2* *SimaPro Assembly Name: Electricity_Alt4_Transfer Pump* *Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER* *Amount input: 553.5 p*	HP = 3 HP Number of units = 1 L = 80% η_m = 85% 262,800 hrs *See Equation 2 for definitions*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Management Factor for Additional Electricity not accounted for in major units Example: Lights, plug leads, motorized control valves, SCADA system	• Estimated to be 5 kw	5 kW x 262,800 hours in 30 years=1314000 kWh *SimaPro Assembly Name: Management Factor for Electrical Materials/Assemblies used: 1000 KWh NEWE Source Mix AT CONSUMER Amount input: 1314 p*	1,314,000 kWh	

Additional assumptions:

- *assume pump efficiency of 75% and motor efficiency of 80% for extraction pumps*
- *assume load of 80% and motor efficiency of 85% efficiency for all process pumps and blowers, based on professional judgment.*
- *for extraction wells, assume total dynamic head of 150 feet based on depth to water of 110 feet, air stripper height of approximately 30 feet, and friction losses of approximately 10 feet.*
- *continuous operation assumes is 8,760 hours per year.*
- *Values in table are for 30 year duration*

Equation 1	Equation 2
$kWh = \frac{TDH \times Q}{3956 \times \eta_p \times \eta_m} \times 0.746 \times hours\ of\ operation$ *TDH = total dynamic head (ft)* *Q = flow rate (gpm)* *3956 = conversion factor used to convert ft-gpm to HP* *0.746 = conversion factor from HP to kW* η_p *= efficiency of pump (%)* η_m *= efficiency of motor (%)*	$kWh = \frac{HP \times L}{\eta_m} \times N \times 0.746 \times hours\ of\ operationhours\ of\ operation$ *HP = motor size (HP)* *L = capacity (%)* *N = number of units operating* *0.746 = conversion factor from HP to kW* η_m *= efficiency of motor (%)*

Table 4-B: Fuel Use for Equipment: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Construction Equipment Excavator/trencher: for placement of 4" PVC pipe, 3 feet deep for a length of 200 linear feet – movement of 3 x 3 x 200ft=1800 ft^3 Excavator- placement of influent equalization tank and concrete pad -Assume movement of 288 $ft^\#$ for slab	• Estimated based on professional judgment	2088 ft^3 of soil moved, at 78 lbs of soil per cubic foot= 162,864 lbs of soil moved *SimaPro Assembly Name: Fuel Use_Alt3_ Pipe Laying and Slab* *Materials/Assemblies used: Excavator, technology mix, 100 kW, Construction GLO* *Amount input: (2088ft^3 x 78lbs per ft^3) p=162,864 lbs*	2088 ft^3 of soil moved, at 78 lbs of soil per cubic foot= 162864 lbs of soil moved	
Construction Equipment for placement of new well Assume air rotary rig, 500 HP Rate: up to 200 feet per 8 hour day 75% load factor 0.05 gallons of fuel per HP-hr Well depth: 160 feet deep with 6 inch casing	• RSE • Assumptions based on TT professional judgment	500 x 75% x 160/200 x 8 hours x 0.05 = 120 gallons of fuel *SimaPro Assembly Name: Fuel Use_Construction Equip for new well* *Processes Used: Diesel, combusted in industrial equipment/US* *Amount Input: 120 gal**	Diesel 120 gallons	

Values in table are for 30 year duration

Table 4-C: Materials Use: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Liquid Phase GAC • 26,000 lbs 2.6 times per year (based on 40 gpm and 10,000 ppb)	• Change frequency based on professional judgment: requirement of 26,000 lbs per year in two 10,000 lbs vessels, in series.	26,000 x 2.6 x 30 = 2,028,000 pounds of liquid GAC *SimaPro Assembly Name: GAC Composite for CRREL Alt4 Materials/Assemblies used: GAC_Composite for Regen_1kg Amount input: 2,028,000 lbs/2.2 kg per pound= 921,818.2p*	26,000 x 2.6 x 30 = 2,028,000 pounds of liquid GAC	
Sequestering Agent (Citric Acid) -2 ppm	RSE Calculated for 40 gpm: 350.13 pounds per year	350.13 lbs x 30 years= 10504 lbs *SimaPro Assembly Name: Material Use_Alt4_Sequestering Agent Materials/Assemblies used: EDTA, ethylenediaminetetraacetic acid, at plant/RER U Amount input: 10504 lbs*	10504 lbs of citric acid (surrogate used: acetic acid)	Use surrogate “High Impact Material (Generic)”
Biocide- material and pump -5 ppm	RSE Name brand of potential biocide noted: Tolcide Calculated for 40 gpm: 875.3 lbs per year	875.3 lbs x 30 years= *26260* lbs *SimaPro Assembly Name: Material Use_Alt4_Biocide Materials/Assemblies used: Biocides, for paper production, unspecified, at plant/RER U Amount input: 26260 lbs*	26260 lbs of biocide (surrogate used: sodium hypochlorite)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Construction (Material) <u>Influent Equalization Tank</u> -20,000 gallon steel vessel -12,250 lbs of steel required <u>For Slab</u> -288 ft^3 -41,472 lbs of concrete -750 steel for reinforcement	Vessel size from Appendix C, RACER Phase Technology Cost Detail Report Amount of steel required for vessel not provided. Estimated by TT GEO to require 12, 250 lbs. of steel.	*SimaPro Assembly Name: Materials_Alt2_Influent Eq Tank and Slab* *1st Materials/Assemblies used: Iron and steel, production mix/US* *Amount input: 12250 lbs* *2nd Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 41472 lbs* *3rd Materials/Assemblies used: Reinforcing steel, at plant/RER S* *Amount input: 750 lbs*	12,250 lbs of steel for tank 750 lbs of steel for reinforcement 41,472 lbs of concrete (SiteWise will assume this is concrete)	
Liquid GAC tank 10,000 lbs. vessel, two units 8,100 lbs of steel for each of two tanks	Estimated by TT based on professional judgment	Steel 2 x 8,100 lbs=16,200 lbs of steel *SimaPro Assembly Name: Material Use_Alt4_Steel for GAC tank* *Materials/Assemblies used: Iron and steel, production mix/US (USLCI)* *Amount input: 8,100 x 2 =16,200 lbs*	Steel 2 x 8,100 lbs=16,200 lbs of steel	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PVC 4" PVC, 200 linear feet	Assume 2 lbs per linear foot (http://www.engineeringtoolbox.com/pvc-cpvc-pipes-dimensions-d_795.html)	2 x 200 lbs= 400 lbs of PVC *SimaPro Assembly Name: Materials_Alt3_PVC* *Materials/Assemblies used: PVC pipe E* *Amount input: 400 lbs*	2 lbs per linear foot x 200 linear feet = 400 lbs of PVC	
Piping -from new extraction Well AND within new extraction Well (new construction for Alternative 4) -160 feet deep well -50 feet for piping from well -6 inch casing -20 foot screen -PVC -Schedule 80 PVC	• Appendix C, RACER Cost Estimates • Assume 5.61 lbs per foot (http://www.usplastic.com/catalog/files/drawings/pipespecs.pdf)	• 50 feet x 5.61 lbs per foot= 280.5 lbs plus • 160 feet x 5.61 lbs per foot= 897.6 lbs *SimaPro Assembly Name: Materials Use_Alt4_PVC from new ex well* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 897.6+280.5=1178 lbs*	50 ft + 160 ft= 210 feet of 6" diameter pipe, Schedule 80	

Values in table are for 30 year duration

Table 4-D: Transport for Materials, Equipment, and Samples: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Liquid Phase GAC • 26,000 lbs six times per year • Assume return trip has 10% additional weight • Assume 100 miles each way of transport	• Change frequency based on professional judgment • Distance for transport not provided and is estimated by TT GEO	• Distance: 1 trip per change with fresh GAC x 2.6 changes per year x 30 years x 100 miles per trip= 7,800 miles • Weight per trip is 26,000 pounds= 13 short tons • Distance: 1 trip per change with spent GAC x 2.6 times per year for 30 years x 100 miles per trip=7,800 miles • Weight per trip is 14.3short tons *SimaPro Assembly Name: Transport of GAC_Alt 4 Process used: Transport, single unit truck, diesel powered/US Amount input: 101,400 tmi* Plus 111,540 tmi**	• Distance: 1 trip per change with fresh GAC x 2.6 changes per year x 30 years x 100 miles per trip= 7,800 miles • Weight per trip is 26,000 pounds= 13 short tons • Distance: 1 trip per change with spent GAC x 2.6 times per year for 30 years x 100 miles per trip=7,800 miles • Weight per trip is 14.3short tons	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Coolers for Sampling • Assume 12 coolers per year (1 per month) • Assume 10 lbs per cooler to site • Assume 30 lbs per cooler from site • Assume pick up via light truck • Lab in Concord, NH, distance is 65 miles	• RSE p. 14 for sampling frequency • Weights based on professional judgment	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs *SimaPro Assembly Name: Transport of coolers during sampling* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 117 tmi* *And* *351 tmi*	• Distance for deliveries: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per delivery trip is 10 lbs • Distance for shipments: 12 coolers per year x 30 years x 65 miles per trip=23,400 miles • Weight per shipment trip is 30 lbs • Fuel: diesel	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Sequestering Agent -10504 lbs over a 30 year period (based on 2 ppm for 40 gpm) 0.175 tons per year	• RSE • Assume distance to vendor, 50 miles • Assume ground transport, van, gasoline	262.6 tmi* *SimaPro Assembly Name: Transport of Materials_Alt4_Sequestering Agent* *Process used: Transport, van <3.5t/RER U* *Amount input: 262.6 tmi** *Empty trip included*	Delivery: 0.175 tons per year for 30 years Mileage: 50 miles one way Return trip: 0 tons per year for 30 years Mileage: 50 miles one way Assume: van, gasoline	Ton-mile basis (no empty return)
Transport of Biocide -26260 lbs over a 30 year period (based on 5 ppm for 40 gpm) 0.43 tons per year	• RSE • Assume distance to vendor, 50 miles • Assume ground transport, van, gasoline	656.5 tmi* *SimaPro Assembly Name: Transport of Materials_Alt4_Biocide* *Process used: Transport, van <3.5t/RER U* *Amount input: 656.5tmi**	656.5 tmi* Van, gasoline	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for Construction: Excavation/Trenching Equipment	• Assumed a single excavator with a weight of 26 tons • Assume a distance of 30 miles	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 7800 lbs/2000 lbs per ton=26 tons *SimaPro Assembly Name: Transport for Construction Equp_Alt2* *Process used: Transport, tractor and trailer/CH U* *Amount input: (7800 lbs/2000 lbs per ton) x 30 miles=780 tmi** *Empty trip included*	• Distance for deliveries 30 miles per trip • Weight per delivery trip is 7800 lbs/2000 lbs per ton=26 tons • Distance for return trip: 30 miles • Weight per return trip is 0 tons	Ton-mile basis (no empty return)
Transport of drilling vehicle to site Assume vehicle similar to large truck	• Assume large truck • Assume one way distance of 50 miles	• Distance to vendor= 50 miles one way • Surrogate for drilling rig similar to "heavy duty" vehicle, assumed to be a 15 tons truck *SimaPro Assembly Name: Transport of Drilling Vehicle_Alt4* *Process used: Operation, lorry 3.5-16t, fleet average/RER U* *Amount input: 100 miles*	• Assume "heavy duty" truck • Assume two drillers • Assume one day, round trip • 50 miles, one way	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Influent equalization tank (12,250 lbs of steel plus 750 lbs of steel for reinforcement) Assume delivery distance is 100 miles	• Assume influent equalization tank and steel for reinforcement are delivered to site together, once for construction	• Distance for deliveries 100 miles per trip • Weight per delivery trip is (12,250 + 750)lbs/2000 lbs per short ton= 6.5 tons *SimaPro Assembly Name: Transport of Steel for tanks_Alt2* *Process used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 650 tmi**	• Distance for deliveries 100 miles per trip • Weight per delivery trip is (12,250 + 750)lbs/2000 lbs per short ton= 6.5 tons • Distance for return trip 100 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)
Concrete (41,472 lbs) Assume delivery distance is 10 miles	• Assumes concrete is delivered as a separate delivery from a vendor that is located 10 miles away (there are three cement vendors within 10 miles of Hanover, NH)	• Distance for deliveries 10 miles per trip • Weight per delivery trip is 41,472lbs/2000 lbs per short ton= 20.1 tons *SimaPro Assembly Name: Transport of Concrete_Alt2* *Process used: Transport, lorry 20-28t, fleet average/CH U* *Amount input: 201 tmi** *Empty trip included*	• Distance for deliveries 10 miles per trip • Weight per delivery trip is 41,472lbs/2000 lbs per short ton= 20.1 tons • Distance for return trip 10 miles per trip • Weight per delivery trip is 0 tons	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PVC 400 lbs (trenching) plus1178 lbs (new extraction well) Assume delivery distance is 30 miles Schedule 80 PVC 50 feet + 160 feet Assume delivery distance is 30 miles	• Appendix C, RACER Cost Estimates • Assume 5.61 lbs per foot (http://www.usplastic.com/catalog/files/drawings/pipespecs.pdf) • Assume well PVC is delivered in a single separate delivery from vendor located within 30 miles	• Distance for delivery 30 miles per trip • Weight per delivery trip is (400+1178) lbs/2000 lbs per short ton= 0.789 tons *SimaPro Assembly Name Transport of PVC_Alt4 Process used: Transport, tractor and trailer/CH U Amount input: 23.7 tmi** *Empty trip included*	• Distance for deliveries 30 miles per trip • Weight per delivery trip is (400+ 1178) lbs/2000 lbs per short ton= 0.789 tons • Distance for return trip: 30 miles • Weight per return trip is 0 tons	Ton-mile basis (no empty return)
Liquid GAC tanks, two -8,100 lbs of steel, each	• Assume a 50 mile delivery from vendor	• Distance for deliveries 50miles per trip • Weight per delivery trip is 16,200 lbs/2000 lbs per short ton= 8.1 tons *SimaPro Assembly Name: Transport of Steel for tanks_Alt4 Process used: Transport, lorry 3.5-16t, fleet average/RER U Amount input: 405 tmi** *Empty trip included*	• Distance for deliveries 50 miles per trip • Weight per delivery trip is 16,200 lbs/2000 lbs per short ton= 8.1 tons • Distance for return trip: 50 miles • Weight per return trip is 0 tons	Ton-mile basis (no empty return)

Values in table are for 30 year duration

Table 4-E: Waste Transport/Disposal: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Water (Extracted from new well, after treatment) Assume treated water is sent to wastewater treatment plant	• 40 gpm • 1 gallon of water = 3.78 kg	40 gpm x 525,948.766 minutes in a year x 30 years=631138519.2 gallons of treated water sent to wastewater treatment plant= 2,389,014,987.79 kg No transport to disposal. *SimaPro Waste Scenario Process Name: wastewater to potw* *Process used: Water, to "Used: Treatment, sewage, unpolluted, to wastewater treatment, class 3/CH U"* *Amount input: 2.39E9*	• 2,389,014,987.79 kg of water sent to POTW	

Values in table are for 30 year duration

Table 4-F: Transport for Personnel: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
System O&M (Operator) • Two days per week for approximately 8 hours each day • Coming from Concord (65 miles one way)	• email from site team	• Transportation- car Person Miles= 405,600 *Name: Transport of Personnel Round Trip, Materials/Assemblies used: Passenger car (LCA Food DK) Amount input: 405600 miles*	• Distance per trip is 130 miles round trip • Vehicle- assume car (gasoline) • Trips= 2 times per weekx52 weeks per yearx30 years =3,120 round trips • One person (driver)	
Sampling personnel • On-site anyway	• Email from site team	• none	• none	

Values in table are for 30 year duration

Table 4-G: Potable Water Use: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

Table 4-H: Non-Potable Water Use: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None identified				

Table 4-I: Known Use of On-Site Renewables: Alternative 4 (GAC at Lower Flow Rate)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3

**Does not include percentage of renewable energy associated with electricity mix from grid*

Coordination of Site Data Input: Alameda Point OU-2B

For

QUANTIFYING LIFE-CYCLE ENVIRONMENTAL FOOTPRINTS OF SOIL AND GROUNDWATER REMEDIES

ESTCP Project # ER-201127

TABLE OF CONTENTS

List of Tables

INTRODUCTION

Operable Unit 2B (OU-2B) at Alameda Point in Alameda, CA consists of Installation Remediation sites 3, 4, 11, and 21. The following are brief descriptions of these four sites:

- Site 3 is the Abandoned Fuel Storage area and is impacted with lead, PAHs and petroleum hydrocarbons including benzene, ethylbenzene, and naphthalene.

- Site 4 is associated with Building 360 (Aircraft Engine Facility) and is impacted by chlorinated solvents and metals. Polychlorinated biphenyls (PCBs) and pesticides have also been detected in the soil and remain present soil after limited excavation and removal of an oil water separator.

- Site 11 is associated with Building 360 (Engine Test Cell) and the soil at this site has limited polyaromatic hydrocarbon (PAH) and metals.

- Site 21 is associated with Building 162 (Ship Fitting and Engine Repair) and is primarily impacted by chlorinated solvents.

The April 2011 *Revised Draft Revision 2 Feasibility Study Report Operable Unit 2B, Installation Restoration Sites 3, 4, 11, and 21* prepared by Oneida Total Integrated Enterprises LLC on behalf of Naval Facilities Engineering Command documents analysis of remedial alternatives for these four sites.

Information and data required for a GSR footprint evaluation for the groundwater remedy at Alameda Point was from this document including the cost estimating data in Appendix C and the Sustainable Environmental Remediation Evaluation provided in Appendix D.

For this evaluation, footprints will be evaluated for the following soil and groundwater remedial alternatives:

- Soil Alternatives:
    - S-2 – Excavation and Disposal of Impacted Soil

- Groundwater Alternatives:
    - G-2 – In-Situ Thermal Treatment (ISTT) of Hot-Spots, Control/Treatment at the Seaplane Lagoon using Permeable Reactive Barriers (PRBs), Monitored Natural Attenuation (MNA), and Institutional Controls (ICs)

    - G-3 – Hot-Spots Treatment, Shallow Groundwater Treatment, MNA, and ICs

    - G-4 – Treatment of Entire Plume using Groundwater Recirculation, PRBs, and ICs

Alternatives S-1 and G-1 are "No-Action" alternatives for soil and groundwater are assumed to have no environmental footprint. A brief description of the other alternatives is as follows:

- Alternative S-2 involves the following (see Tables 3, 5, and 7 of Appendix C of the FS):
    - Excavation and off-site disposal of impacted soil from Sites 3, 4, and 11
    - Dewatering and confirmation sampling
- Alternative G-2 involves the following (see Table 9 of Appendix C of the FS):
    - ISTT construction and operation
    - PRB installation for Control/Treatment at the Seaplane Lagoon
    - MNA of remaining groundwater plume
    - Institutional controls
- Alternative G-3a involves the following (see Table 11 of Appendix C of the FS):
    - ISTT remedy – same as G-2
    - Shallow groundwater treatment with in-situ chemical oxidation
    - MNA
    - Institutional controls
- Alternative G-3b involves the following (see Table 13 of Appendix C of the FS):
    - ISTT remedy – same as G-2
    - Shallow groundwater treatment with in-situ bioremediation
    - MNA – same as G-3a
    - Institutional controls
- Alternative G-4 involves the following (see Table 15 of Appendix C of the FS):
    - Groundwater extraction, treatment, and reinjection
    - PRB installation
    - Plume and performance monitoring
    - Institutional controls

The intent of this document is to provide a basis for the development of input for the SimaPro and SiteWise tools for these alternatives.

ALTERNATIVE S-2:
SOIL REMEDIATION OF SITES 3, 4, AND 11

Remedy Overview

The following table summarizes the excavation-related activities at the three sites included in Alternative S-2 (see Tables 3, 5, and 7 of Appendix C of the FS).

Parameter	Site 3	Site 4	Site 11	Total
Excavated Soil for Disposal	3,900 bcy	7,282 bcy	1,750 bcy	12,932
Excavated Uncontaminated Overburden	2,950 bcy	0 bcy	1,500 bcy	4,450
Maximum Depth of Excavation	8 feet bgs	15 feet bgs	8 feet bgs	Varies
Number of confirmation samples	25 (lead) 15 (PAH)	10 (PCBs*) 50 (As & An*)	20 (PAH)	Varies
Number of clean fill samples	13	16	6	35
Volume of Backfill	3,900 bcy	7,282 bcy	1,750 bcy	12,932
Volume of hazardous waste disposal	1,700 bcy	7,282 bcy	0 bcy	8,982
Volume of non-hazardous waste disposal	2,200 bcy	0 bcy	1,750 bcy	3,950
One-way transport distance for hazardous waste	200 miles	200 miles	NA	NA
One-way transport distance for non-hazardous waste	41 miles	NA	41 miles	NA

Site 3 excavation includes separate excavations for lead and PAH contaminated soil
Site 4 excavation includes separate excavation for PCB/pesticide contaminated soil and arsenic/antimony contaminated soil
Site 11 excavation includes excavation of PAH contaminated soil
PCBs refers to both PCB and pesticide analyses in this instance*
As & An refers to arsenic and antimony*

As indicated in the RACER input provided in Appendix C of the FS, excavation is assumed to require dewatering. After excavation, soil would be temporarily stockpiled and characterized for disposal. Confirmation soil samples would be collected from the sidewalls and bottoms of the excavations. The excavations will then be backfilled with unclassified fill. The disposal of the water is not considered as a cost of this remedy within the RACER files and therefore was not considered as an input to the GSR analysis.

Tetra Tech (TT) will estimate the parameters that are unavailable. Estimated data will include the distance of the laboratory relative to the site, the method of transportation for the samples to the laboratory, the round trip distance traveled by site workers and number of workers necessary for this alternative. TT will estimate the time to remedy operation and completion and equipment required, if information is not provided by site documents.

Detailed Basis for Footprint Evaluation

Tables S-2A through S-2I summarize the information that will serve as the basis for the footprint evaluation of Alternative S-2 ("Soil Remedy") and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-2: GROUNDWATER - ISTT OF HOT-SPOTS, CONTROL/TREATMENT AT SEAPLANE LAGOON USING PRB, MNA, AND ICS

Remedy Overview

Alternative G-2 involves the following (see Table 9 of Appendix C of the FS):

- ISTT remedy
  - Installation of 55 ISTT electrodes and co-located vapor extraction wells addressing approximately 29,100 square feet of hot-spots with depths ranging from 15 to 40 feet
  - Installation of power control units with a total of 3,100 kW
  - Installation of a vapor extraction piping and blowers
  - Operation of the ISTT system, including heating, vapor extraction, and vapor treatment with granular activated carbon (GAC)
  - Installation of 28 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 855 feet, including total combined screen length of 280 feet
  - 5 rounds of groundwater sampling from 53 monitoring wells (new and existing) for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, temperature, VOCs, and metals
- Control/Treatment at the Seaplane Lagoon
  - Installation of a 500-foot PRB to a depth of approximately 70 feet bgs by injection of 165 cubic yards of zero-valent iron with direct-push drill rigs (50 injection points)
  - Installation of 18 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 810 feet, including total combined screen length of 180 feet
  - 43 rounds of groundwater sampling from 18 wells over the course of 36 years for DO, ORP, pH, ferrous iron, VOCs, anions, metals, dissolved gases, and alkalinity
  - Two replacements of the PRB media with the same quantity and same method

- MNA (interpretation of data based on information provided in Table 9)
  - Installation of 68 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 2,690 feet, including total combined screen length of 680 feet
  - 17 rounds of groundwater sampling from 126 wells over the course of the first 10 years
  - 10 rounds of groundwater sampling from 96 wells over the course of years 11 through 20
  - 10 rounds of groundwater sampling from 66 wells over the course of years 21 through 30
  - 6 rounds of groundwater sampling from 36 wells over the course of years 31 through 36
  - Samples from all wells would be analyzed for DO, ORP, pH, and VOCs
  - 25% of the samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, total organic carbon (TOC), and dissolved gases
- Institutional controls
  - Activities with a negligible contribution to the footprint
- Replacement Wells
  - Based on TT interpretation of Table 9, 28 monitoring wells will need to be replaced over the course of the remedy. These wells are estimated to have an average depth of 45 feet, with 10 feet of screen. A hollow stem auger will be used to drill, and 2-inch Schedule 40 PVC will be placed for wells.

Detailed Basis for Footprint Evaluation

Tables G-2-A through G-2-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-2 and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-3A: GROUNDWATER - ISTT OF HOT-SPOTS, SHALLOW GROUNDWATER TREATMENT WITH ISCO, MNA, AND ICS

Remedy Overview

Alternative G-3a involves the following (see Table 11 of Appendix C of the FS):

- ISTT remedy – same as G-2
- Shallow groundwater treatment with in-situ chemical oxidation
    - 3 events
    - 656 injection points via direct-push per event from 5 to 30 feet bgs
    - 370,000 gallons of 12% hydrogen peroxide per event
    - 370,000 gallons of chelated iron catalyst per event
    - Installation of 29 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 730 feet, including total combined screen length of 290 feet
    - 6 rounds of groundwater sampling from 55 monitoring wells (new and existing) for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, ferrous iron, VOCs, and metals
- MNA
    - Installation of 39 new 2-inch schedule 40 PVC monitoring wells by hollow-stem auger with a total combined well depth of 1,960 feet, including total combined screen length of 390 feet
    - 8 rounds of groundwater sampling from 71 wells over the course of the first 3 years
    - 9 rounds of groundwater sampling from 126 wells over the course of years 4 through 10
    - 10 rounds of groundwater sampling from 88 wells over the course of years 11 through 20

    - 8 rounds of groundwater sampling from 50 wells over the course of years 21 through 28

    - Samples from all wells would be analyzed for DO, ORP, pH, and VOCs

    - 25% of the samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, total organic carbon (TOC), and dissolved gases

- Institutional controls

    - Activities with a negligible contribution to the footprint

- Replacement Wells

    - Based on TT interpretation of Table 9, 28 monitoring wells will need to be replaced over the course of the remedy. These wells are estimated to have an average depth of 45 feet, with 10 feet of screen. A hollow stem auger will be used to drill, and 2-inch Schedule 40 PVC will be placed for wells.

Detailed Basis for Footprint Evaluation

Tables G-3A-A through G-3A-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-3A and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-3B: GROUNDWATER - ISTT OF HOT-SPOTS, SHALLOW GROUNDWATER TREATMENT WITH BIOREMEDIATION, MNA, AND ICS

Remedy Overview

Alternative G-3b involves the following (see Table 13 of Appendix C of the FS):

- ISTT remedy – same as G-2
- Shallow groundwater treatment with in-situ bioremediation
  - One event with 656 injection points injecting 1,427 drums of EOS® emulsified oil (plus water) via direct-push from 5 to 30 feet bgs
  - A second event with 328 injection points injecting 713 drums of EOS® emulsified oil (plus water) via direct-push from 5 to 30 feet bgs
  - Installation of performance monitoring wells as in G-3a
  - 10 rounds of groundwater sampling from 55 monitoring wells (new and existing) for dissolved oxygen (DO), oxidation-reduction potential (ORP), pH, ferrous iron, VOCs, and metals
- MNA – same as G-3a
- Institutional controls
  - Activities with a negligible contribution to the footprint

Detailed Basis for Footprint Evaluation

Tables G-3B-A through G-3B-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-3B and the input parameters to SimaPro and SiteWise.

ALTERNATIVE G-4: GROUNDWATER – TREATMENT OF ENTIRE PLUME USING RECIRCULATION, PRBS, AND ICS

Remedy Overview

Alternative G-4 involves the following (see Table 15 of Appendix C of the FS):

- Recirculation systems
  - Installation of 19 6-inch PVC extraction wells
  - Installation of 24 6-inch PVC injection wells
  - Estimated combined flow rate of 100 gpm
  - 450 feet of 4-inch PVC pipe
  - 2,500 feet of 6-inch PVC pipe
  - 100 feet of 8-inch PVC pipe
  - Installation of UV/oxidation treatment system
  - Operation of the recirculation system and treatment system for 35 years
  - Installation of 68 2-inch PVC monitoring wells via hollow stem auger with a total depth of 2,690 feet and a total screened interval of 680 feet
  - 17 rounds of groundwater sampling from 126 wells over the course of the first 10 years
  - 10 rounds of groundwater sampling from 96 wells over the course of years 11 through 20
  - 10 rounds of groundwater sampling from 66 wells over the course of years 21 through 30
  - 5 rounds of groundwater sampling from 36 wells over the course of years 31 through 35
  - Samples from all wells would be analyzed for DO, ORP, pH, and VOCs.

    - 25% of the samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, total organic carbon (TOC), and dissolved gases

- Installation of two PRBs
    - 600-foot PRB constructed via direct-push injection of 170 cubic yards of zero valent iron
    - 500-foot PRB constructed via direct-push injection of 165 cubic yards of zero valent iron
    - Installation of 36 2-inch PVC monitoring wells via hollow stem auger with a total depth of 1,620 feet and a total screened interval of 360 feet
    - 42 rounds of groundwater sampling from 36 wells over the course of 35 years for DO, ORP, pH, ferrous iron, VOCs, anions, metals, dissolved gases, and alkalinity

Detailed Basis for Footprint Evaluation

Tables G-4-A through G-4-I summarize the information that will serve as the basis for the footprint evaluation of Alternative G-4 and the input parameters to SimaPro and SiteWise.

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TABLES

Note:

These tables were originally created based on comparison of SimaPro to SiteWise Version 2. The last column indicates any changes between input for SiteWise Version 2 and SiteWise Version 3.

Tables for Alternative S-2

Table S2-A: Electricity Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Trash Pump	• Need based on comments in the Feasibility Study. No details or estimates for use provided. • Due to time of rental for trash pump (75 gpm, total 19 days), electricity usage assumed by TT to be de minimis to the footprint of this remedy. (Less than 1000 kWh)	de minimis	de minimis	

Table S2-B: Fuel Use for Equipment: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Heavy equipment for soil excavation • Assume an excavator (diesel) will be used to move 17,382 yd^3 (includes 12,932 yd^3 of excavated soil and 4,450 yd^3 excavated uncontaminated overburden)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Assumed use of excavator (TT estimate)	• Excavator to move 17,382 yd^3 *SimaPro Assembly Name: Fuel Use_S2_Excavation* *Process used: Excavation, hydraulic digger/RER U (Ecoinvent)* *Amount input: 17382 cu yd*	• Excavator to move 17,382 yd^3	
Heavy equipment for soil backfill • Assume an excavator (diesel) will be used to move 17,382 yd^3 (includes 12,932 yd^3 of backfill plus replacement of 4,450 yd^3 of uncontaminated overburden)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Assumed use of excavator (TT estimate)	• Excavator to move 17,382 yd^3 *SimaPro Assembly Name: Fuel Use_S2_Backfill* *Process used: Excavation, hydraulic digger/RER U (Ecoinvent)* *Amount input: 17382 cu yd*	• Excavator to move 17,382 yd^3	
Heavy equipment used for compaction • Assume a compactor	• Based on TT professional judgment of compaction equipment fuel consumption rate and required use.	• 1,000 gallons of diesel fuel *SimaPro Assembly Name: Fuel Use_S2_Compactor* *Process Used: Diesel, combusted in industrial equipment/US(USLCI)* *Amount input: 1000 gal**	• 1,000 gallons of diesel fuel entered into “Industrial Combustion Engine”	
Dump truck used on site	• Assume fuel consumption rate of 1 gal/hr on site • Site team reported an estimate of 120 days of use for construction equipment • 120 days x 8 hrs per day = 960 gallons of diesel	• 960 gallons of diesel *SimaPro Assembly Name: Fuel Use_S2_Dump Truck* *Process Used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 960 gal**	• 960 gallons of diesel	

Table S2-C: Materials Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Clean fill for excavated area • 12,932 yd^3 of clean soil	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards	• 12,932 yd^3 x 1.5 tons per yd^3 =19,398 tons of clean soil *SimaPro Assembly Name: Material Use_S2_Fill* *Materials/Assemblies used: Gravel, unspecified, at mine/CH U (Ecoinvent)* *Amount input: 19398 tn.sh*	• 19,398 tons of clean soil Input to SiteWise: Soil 38,796,000 lbs	

Table S2-D: Transport for Materials, Equipment, and Samples: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transportation of equipment • Excavator for excavation and backfill • Compactor	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight of equipment based on professional estimates • TT estimated that vehicle transporting each piece of equipment delivers equipment to site, leaves empty, returns to site empty and leaves with equipment, for a total of two round trips for each equipment use.	• 2 trips x 50 miles one way= 100 miles • Excavator weighs 26 tons • Diesel fuel AND • 2 trips x 50 miles one way= 100 miles • Compactor weighs 5 tons • Diesel fuel *Empty trips included* *SimaPro Assembly Name: Transport of Materials_S2_Equipment Process used: Transport, single unit truck, diesel powered/US (USLCI) Amount input: 2600 ton-miles AND 500 ton-miles*	• 2 trips x 50 miles one way=100 miles • Excavator weighs 26 tons • Assume diesel fuel AND • 2 trips x 50 miles one way= 100 miles • Compactor weighs 5 tons • Assume diesel fuel AND • 4 x 50= 200 miles return trip • Weight 0 tons • Assume diesel fuel	
Transport of clean fill for excavated area • 12,932 yds^3	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards • TT estimated dump truck volume of 20 yards • 12,932 yds^3 x 1.5 tons per yds^3 = 19,398 tons clean soil • 19,398 tons soil / 30 tons per dump truck = 647 dump truck loads (trips) • TT estimated 50 miles from fill source to site	• 647 trips x 50 miles one way = 32,350 miles • Weight of load for each trip = 30 tons *Empty trip included* *SimaPro Assembly Name: Transport of Materials_S2_clean fill Process used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent) Amount: 970,500 ton-miles*	Delivery • 647 trips • 30 tons • 50 miles one way Empty return trips • 647 trips • 0 tons • 50 miles one way	Ton-mile basis (no empty return)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for Samples to Lab	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C reports: o Chemical profiling will be performed for the dewatered soil and the water that results from the dewatering process o Confirmation soil samples taken from the bottom and sidewalls of the excavated pit will be taken to ensure compliance with RAOs. o Sampling for backfill for clean confirmation sampling will also take place • TT estimates this sampling to require 20 trips to lab • TT estimated a distance of 50 miles, one way, to lab	• 20 trips x 100 miles round trip to lab = 2000 miles • Assume light truck, gasoline *SimaPro Assembly Name: Transport_S2_samples to lab* *Process used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount: 2000 miles*	• 20 trips x 100 miles round trip to lab = 2000 miles • Assume light truck, gasoline	

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.

Table S2-E: Waste Transport/Disposal: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of excavated soil to hazardous landfill • 8,982 yd^3 (13,473 tons) of excavated soil	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards • TT estimated dump truck volume of 20 yards • TT estimated 20 yd^3 (30 ton) dump truck volume • Dump truck volume and volume of soil transported requires 450 loads of soil • TT estimated 200 miles one way from site to landfill	• 450 trips x 200 miles one way = 90,000 miles one way driven for disposal • 30 tons each load • 90,000 miles x 30 tons= 2,700,000 tmi *Empty trip included* *SimaPro Assembly Name: Waste_S2_Transport of excavated soil* *Process used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent)* *Amount: 2700000 ton mile* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill* *30 tons x 450 trips = 13,473 tons*	Transport to landfill • 30 ton dump truck volume • 450 trips • 90,000 miles one way from site to landfill Empty trip • 0 ton dump truck volume • 450 trips • 90,000 miles one way from site to landfill 30 tons x 450 trips = 13,473 tons to hazardous landfill	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of excavated soil to non-hazardous landfill • 3950 yd^3 of excavated soil	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated 1.5 tons per cubic yards; 3950 yd^3 x 1.5 tons per yd^3 = 5925 tons • TT estimated dump truck volume of 30 tons • 5925 tons / 30 tons per load requires 198 loads of soil • 41 miles one way from site to Altamont Landfill (FS)	• 41 miles x 198 trips = 8,118 miles one way driven for disposal • 30 tons load • 8,118 miles x 30 tons= 243,540 tmi *Empty trip included* *SimaPro Assembly Name: Waste_S2_Transport of excavated soil NON hazardous* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount: 243540 ton mile* *Disposal as LC with dummy soil input.* *30 tons x 198 trips = 5,925 tons to non-hazardous landfill (Disposal, concrete, 5% water, to inert material landfill/CH U)*	Transport to landfill • 30 ton dump truck volume • 198 trips • 8,118 miles one way from site to landfill Empty trip: • 0 ton dump truck volume • 198 trips • 8,118 miles one way from site to landfill 30 tons x 198 trips = 5,925 tons to non-hazardous landfill	

Table S2-F: Transport for Personnel: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport to site for labor performing excavation and backfilling	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Site team estimates 120 days for the crew to be on site to complete remedy • TT estimated four person crew • TT estimated 25 miles, one way for site labor to travel to site	• 4 x 120 = 480 trips • 50 miles, round trip • 480 trips x 50 miles round trip = 24000 miles • Assume car, gasoline • One passenger per vehicle *SimaPro Assembly Name: Trans for Personnel_S2_labor ex and backfill Materials/Assemblies used: Transport, passenger car/RER U (Ecoinvent) Amount input: 24000 pmi*	• 4 x 120 = 480 trips • 50 miles, round trip • Assume car, gasoline • One passenger per vehicle	

Table S2-G: Potable Water Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No significant use of potable water identified for this alternative				

Table S2-H: Non-Potable Water Use: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No significant use of non-potable water identified for this alternative				

Table S2-I: Known Use of On-Site Renewables: Alternative S-2 (Excavation and Off-site Disposal)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No significant use of on-site renewables identified for this alternative				

Table J: eGRID Subregion CAMX--WECC, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	11.9033	26,141,141.50
Oil	1.1747	2,579,750.70
Gas	42.2704	92,830,630.50
Other Fossil	1.0291	2,259,976.30
Nuclear	16.4631	36,154,898.00
Other Unknown / Purchased Fuel	0.0943	207,005.90
Nonrenewable Total	72.9348	160,173,402.90
Renewable Resource		
Wind	1.9396	4,259,490.60
Solar	0.2444	536,713.30
Geothermal	4.6211	10,148,526.60
Biomass	2.6088	5,729,247.80
Hydro	17.6513	38,764,274.90
Renewable Total	27.0652	59,438,253.30

Tables for Alternative G-2

Table G2-A: Electricity Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Operation of ISTT Electrodes and vapor extraction • Includes 55 ISTT electrode	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 200 kWh per yd^3 based on TT engineering estimate (heating and vapor extraction) • Soil treated: 29,100 ft^2 x 36 ft = 1,047,600 ft^3= 38,800 yd^3 • 38,800 yd^3 x 200 kWh per yd^3 = 7,760,000 kWh	7,760,000 kWh *SimaPro Assembly Name: Electricity_G2_Op of ISTT Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 7760 p*	7,760,000 kWh	
PRB				
Pump for use with direct push injection rig	• TT estimated a 2.5 kWh daily electrical usage • (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C RACER appendix provides time for use of rig at 180 days • At 2.5 kWh per day x 180 days = 450 kWh	450 kWh *SimaPro Assembly Name: Electricity_G2_pump for direct push Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 0.450 p*	450 kWh	

Table G2-B: Fuel Use for Equipment: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Equipment used for the construction of the ISTT system: • Installation of 55 ISTT electrodes and co-located vapor extraction wells (to address 29,100 ft^2 of hot spots with average depth of 36 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "Comparison of Construction Materials" provided by NAVFAC • 3-inch Schedule 80 steel pipe within a 12-inch diameter borehole • 55 electrodes to 36 feet deep = 1,980 linear feet • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 20, 8-hr days = 160 hours of use. • To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 160 x 0.050 x 0.75 = 900 gals (refer to EPA, 2012, pg 59)	• Equipment Type: Hollow stem auger • 55 electrodes to 36 feet deep = 1,980 linear feet • 160 hours Fuel Use= 900 gals *SimaPro Assembly Name: Process Used: Diesel, combusted in industrial equipment/US (USLCI) Amount input: 900 gal**	• Hollow stem auger • 160 hours of use	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Equipment used for the installation of 28 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 855 feet (including screen length of 280 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 9 days, 8-hr days= 72 hours of use. • To calculate fuel use for SimaPro input the following equation was employed: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 72 x 0.050 x 0.75 = 405 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • Drilling 855 linear feet 72 hours of use *SimaPro Assembly Name: Fuel_G2_construction 28 wells* *Process Used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 405 gal**	• Hollow stem auger • 72 hours of use	
PRB				
Direct Push Rig, Truck Mounted, Non-Hydraulic • Sampling and PRB media installation (By injection of 165 yds^3 of zero valent iron with direct push drill rigs • 180 days of use	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (RACER pdf pg. 148) • 180 days x 8 hours per day = 1,440 hours (on-site use) • TT estimates use of a 60 HP direct push rig: Fuel Use (gal) = HP x hrs x BSFC x PLF = 60 x 1440 x 0.050 x 0.75 = 3240 gals (refer to EPA, 2012, pg 59)	• Direct push rig • 1,440 hours 3240 gals of fuel *SimaPro Assembly Name:* *Process Used: Diesel, combusted in industrial equipment/US(USLCI)* *Amount input: 3240 gal**	• Direct push rig • 1,440 hours	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Equipment used for the installation of 18 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 810 feet (including screen length of 180 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 810 linear feet / 100 feet per day = 8.1, 8 hour days = 64.8 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 64.8 x 0.050 x 0.75 = 364.5 gals (refer to EPA, 2012, pg 59) •	• Hollow stem auger • 8.1 linear feet • 64.8 hours • 364.5 gals *SimaPro Assembly Name: Process Used: Diesel, combusted in industrial equipment/US(USLCI) Amount input: 364.5 gal**	• Hollow stem auger • 8.1 linear feet • 64.8 hours	
Equipment used for the PRB Media Replacement • Two replacement events, total	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated the two replacement events as being twice the amount of equipment use in the original placement (1,440 hours x 2 = 2,880 hours) • Fuel Use = 2 x 3240 gals = 6480 gals	• Direct push drill: • 2,880 hours • Fuel use = 6480 gals *SimaPro Assembly Name: Fuel_G2_PRB_PRB replacement media Process Used: Diesel, combusted in industrial equipment/US(USLCI) Amount input: 6480gal**	• Direct push drill • 2,880 hours	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
MNA				
Equipment used for the installation of 68 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 2,690 feet (including screen depth of 680 feet)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012). • 2,690 linear feet / 100 feet per day = 27, 8 hour days = 216 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 216 x 0.050 x 0.75 = 1215 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 2,690 linear feet • 216 hours of use • Fuel use = 1215 gals *SimaPro Assembly Name: Fuel_G2_MNA_68 wells installed* *Process Used: Diesel, combusted in industrial equipment/US(USLCI)* *Amount input: 1215 gal**	• Hollow stem auger • 216 hours of use	
Replacement of monitoring wells • Using hollow stem auger • Total combined depth of 1,260 ft (28 wells at an average of 45 feet deep)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf page 32) • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) 1,260 linear feet / 100 feet per day = 12.6, 8-hr days = 100.8 hours of use • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 100.8 x 0.050 x 0.75 = 567 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,260 linear feet • 100.8 hours of use Fuel use = 567 hours *SimaPro Assembly Name: Fuel_G2_MNA_replacement of monitoring wells* *Diesel, combusted in industrial equipment/US(USLCI)* *Amount input: 567gal**	• Hollow stem auger • 100.8 hours of use	

Table G2-C: Materials Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment ***(all capital construction equipment not listed below, that is required, is assumed to be on-site , stored in Building 5 and reused from a previous pilot (Comparison of Construction Materials document provided by NAVFAC)therefor it is not being footprinted as a part of this GSR analysis, or are de minimis items.***				
GAC • Carbon change out for liquid and vapor phase units	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "List of ERH Materials and Estimated Technology Costs" provided by NAVFAC • TT professional judgment: carbon units will require quarterly carbon change outs for one year. • Estimates of carbon required developed from volume of GAC used in 2007 pilots, TT estimated the following usage (document above) based on those pilot studies: o Two 8,000 lbs vapor phase units o Two 3,000 lbs liquid phase units o Total per quarter = 22,000 lbs	22,000 lbs x 4 fills = 88,000 lbs. of GAC / 2.2 lbs per kg = 40,000 kg *SimaPro Assembly Name: Material_G2_ISTT_GACMaterials/Assemblies used: Virgin GAC Assembly_1kg(TT assembly) Amount input: 40000 p*	88,000 lbs. of GAC	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Drilled Electrodes composition • Steel pipe (370 lbs/electrode) • Graphite (8,400 lbs/electrode) • Steel shot (1,040 lbs/electrode)	• Document, "Comparison of Construction Materials" provided by NAVFAC • Steel pipe: 370 lbs/electrode x 55 electrodes = 20,350 lbs of steel • Graphite: 8,400 lbs/electrode x 55 electrodes = 462,000 lbs of graphite • Steel shot: 1,040 lbs/electrode x 55 electrodes = 57,200 lbs of steel shot • Total Steel: Steel pipe + steel shot = 20,350 + 57,200 = 77,550 lbs of total steel	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs *SimaPro Assembly Name: Material_G2_ISTT_Electrodes* *Materials/Assemblies used: Steel, billets, at plant/US(USLCI)* *Amount input: 77550 lb* *AND* *Materials/Assemblies used: Graphite, at plant/RER U (Ecoinvent)* *Amount input: 462000 lb*	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite (Surrogate for graphite, Material A with one-half the emission footprint of iron) Amount: 462,000 lbs	Surrogate for graphite Use "Low Impact Material (Generic)"
PVC (for 28 new monitoring wells) • 2-inch, Schedule 40 • 855 ft total combined length • 280 feet of screen	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 581.4 lbs PVC	581.4 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_ISTT_PVC 28 mon wells* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 581.4*	Input to SiteWise: 855 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 855 ft = 11,115 lbs of grout/cement / 2000 lbs per ton = 5.6 tons of cement	5.6 tons of cement *SimaPro Assembly Name: Material_G2_ISTT_Grout Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent) Amount input: 5.6 tn.sh.*	5.6 tons of cement Input to SiteWise: 11,200 lbs Typical Cement	
PRB				
Zero valent iron (a.k.a. "iron filings") • 165 cubic yards for injection	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (RACER pg 148) • Density of zero valent iron = ~2.6 grams/cm^3(http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • 2.6 g/cm^3 x 764554.858 cm^3 per yd^3/ 453.6 g per pound / 2000 lbs per ton = 2.19 ton per yd^3 ZVI. • 165 yds^3 of ZVI x 2.19 tons per cubic yard = 361.35 tons ZVI	361.35 tons zero valent iron (iron filings) *SimaPro Assembly Name: Material_G2_PRB_iron filings Materials/Assemblies used: Pellets, iron, at plant/GLO U (Ecoinvent) Amount input: 361.35*	361.35 tons zero valent iron (iron filings) Input to SiteWise: 722,700 lbs ZVI	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PVC (for 18 new monitoring wells) • 2-inch, Schedule 40 • 810 ft combined length • 180 screen length	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 810 ft x 0.68 lbs per ft = 550 lbs PVC	550 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_PRB_PVC 18 mw* *Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 550*	Input to SiteWise: 810 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	
Two replacements of PRB media • 165 cubic yards for injection x 2 replacements = 330 cubic yards zero valent iron	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Density of zero valent iron = ~2.6 grams/cm^3 (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • (2.6 g/cm^3 x 764554.858 cm^3 per yard / 453.6 g per pound / 2000 lbs per ton = 2.19 ton per cubic yd ZVI. • 165 yds^3 of ZVI x 2.19 tons per cubic yard = 361.35 tons ZVI x 2= 722.7 tons ZVI	722.7 tons zero valent iron (iron filings) *SimaPro Assembly Name: Material_G2_PRB_two iron filings replacements* *Materials/Assemblies used: Pellets, iron, at plant/GLO U (Ecoinvent)* *Amount input: 722.7 tn.sh*	722.7 tons yards zero valent iron (iron filings)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Grout for Well Installation	• 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 810 ft = 10,530 lbs of grout/cement	10,530 lbs of cement *SimaPro Assembly Name: Material_G2_PRB grout Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent) Amount input: 10530 lb*	10,530 lbs of cement	
MNA				
PVC (for 68 new monitoring wells) • 2-inch, Schedule 40 • 2,690 ft combined length	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 2,690 ft x 0.68 lbs per ft = 1829 lbs PVC	1829 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_MNA PVC 68 mw Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 1829 lb*	1829 lbs of Schedule 40 PVC Input to SiteWise: 2,690 ft of 2" Sch 40 PVC (Reference Table 1-C from SiteWise spreadsheet provides a weight of 0.72 lbs/foot for 2" Sch 40 PVC pipe)	
PVC (for Replacement Wells) • 2-inch, Schedule 40 • 1,260 ft combined length	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,260 ft x 0.68 lbs per ft = 856.8 lbs of Schedule 40 PVC	856.8 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_MNA PVC replacement wells Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 856.8 lb*	856.8 lbs of Schedule 40 PVC Input to SiteWise: 1,260 ft of 2" Sch 40 PVC (Reference Table 1-C from SiteWise spreadsheet provides a weight of 0.72 lbs/foot for 2" Sch 40 PVC pipe)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Grout for Well Installation (for 68 new monitoring wells) • 2,690 ft combined length	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 2,690 ft= 34,970 lbs of grout/cement	34,970 lbs of cement *SimaPro Assembly Name: Material_G2_MNA grout mw Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent) Amount input: 34970 lb*	34,970 lbs of cement (Typical cement)	
Grout for Well Installation (for Replacement Wells) • 1,260 ft combined length	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1,260 ft=16,380 lbs of grout/cement	16,380 lbs of cement *SimaPro Assembly Name: Material_G2_MNA grout rw Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent) Amount input: 16380*	16,380 lbs of cement (Typical cement)	

Table G2-D: Transport for Materials, Equipment, and Samples: G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Transport of material for 55 electrodes.	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Delivery of steel pipe: 1 trip with 20,350 lbs (10.2 tons) • Delivery of graphite: 8 trips delivering 462,000 lbs (231 tons) o TT estimates 30 tons per truck, for 8 trucks necessary to deliver entire load. • Delivery of steel shot: 1 trip with 57,200 lbs (28.6 tons) • TT estimates distance from vendor to site at approximately 50 miles.	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trip Weight: 28.6 tons Miles, one way: 50 miles *SimaPro Assembly Name: Transport_G2_ISTT electrode materials* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent) Amount input: 510 tmi* *Materials/Assemblies used: Transport, lorry >32t, EURO5/RER U (Ecoinvent) Amount input: 12000 tmi* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent) Amount input: 1430 tmi Empty trips included*	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trips Weight: 28.6 tons Miles, one way: 50 miles <u>Steel pipe</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 RETURN trips Weight: 0 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 miles	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of PVC • 855 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) 855 ft x 0.68 lbs per ft = 582 lbs of Schedule 40 PVC / 2000 lbs per ton = 0.3 tons Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 15*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	Ton-mile basis (no empty trip)
Transport of Cement for Well Installation	• 11,115 lbs of grout/cement (as per Table G2-C) • 11,115 lbs / 2000 lbs per ton = 5.56 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trips with 5.6 tons per trip	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 280*	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	
Transport of heavy equipment used for electrode installation and well placement • Hollow stem auger	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C One mob. one demob., TT estimated as de minimis	de minimis	de minimis	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of samples • 5 rounds of sampling from 53 monitoring wells (DO, ORP, pH, temp, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimate of number of trips based on five wells per day being sampled. Sampling would take place over ~53 days and lab would pick up samples every other day, resulting number of trips would be ~27. • TT estimated the distance to lab as being 50 miles	27 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport_G2_ISTT sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 2700 miles*	27 trips 50 miles, one way Van, gasoline	
Transport of GAC	Total GAC required per quarter = 22,000 lbs TT estimated 1 flatbed truck for delivery TT estimated distance as 50 miles Weight per quarterly trip = 11 tons Assume spent GAC is sent back to regeneration facility on same truck that delivered the new batch of GAC.	• (4 delivery trips + 4 return trips) x 50 miles = 400 miles • Weight of load = 11 tons • 4400 ton-miles *SimaPro Assembly Name: Transport_G2_ISTT_GAC* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent)* *Amount input: 4400 ton-miles*	# of trips: 4 11 tons, each 50 miles, one way # of trips: 4 (back to regeneration facility) 11 tons, each 50 miles, one way	Ton-mile basis
PRB				

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of PVC • 810 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 810 ft x 0.68 lbs per ft = 551 lbs / 2000 lbs per ton = 0.3 tons of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_PRB_PVC* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US(USLCI)* *Amount input: 15 ton-miles*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50	Ton-mile basis (no empty trip)
Transport of Cement for well installation	• 10,530 lbs of grout/cement (as per Table G2-C) • 10,530 lbs / 2000 lbs per ton = 5.3 tons cement • TT estimates 20 tons of cement per delivery truck • 1 trips with 5.3 tons per trip	# of trips: 1 delivery trip Weight: 5.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_PRB_Cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 265 ton-miles*	# of trips: 1 delivery trip Weight: 5.3 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	
Transport of samples • 43 rounds of sampling from 18 wells over 36 years (DO, ORP, pH, ferrous iron, VOCs, anions, metals, dissolved gases, and alkalinity)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • If five wells per day are sampled, sampling would take place over ~155 days and lab would pick up samples every other day, resulting number of trips would be ~78. • TT estimated distance to lab as 50 miles	78 trips 100 miles, round trip Van, gasoline *SimaPro Assembly Name: Transport_G2_PRB sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 7800 mile*	78 trips 50 miles, one way Van, gasoline	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of PRB media • Initial plus two replacements • 165 yds^3 of zero valent iron each trip for three events	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 3 one way trips • Density of zero valent iron = ~2.6 grams/cm^3 (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • 165 yds^3 x 2.19 tons per yard = 361.35 tons of ZVI • Assume flatbed delivery of 40 tons per trip • 10 x 3 =30 trips of 50 miles, one way (potential vendor located in Berkley, Ca)	30 trip x 40 tons x 50 miles 60,000= ton-miles *Empty return trip included* *SimaPro Assembly Name: Transport_G2_PRB media* *Materials/Assemblies used: Truck 40t (LCA Food)* *Amount input: 60000 ton-mile*	# of trips: 30 40 tons, each 50 miles, one way # of trips: 30 (empty) 0 tons, each 50 miles, one way	Ton-mile basis (no empty trip)
MNA				
Transport of PVC • 2,690 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 2,690 ft x 0.68 lbs per ft = 1,829 lbs of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.9 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_MNA_PVC* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 45 ton-mile*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.9 tons Miles, one way: 50	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Cement for well installation (for 68 new monitoring wells)	• 34,970 lbs of grout/cement (as per Table G2-C) • 34,970 lbs / 2000 lbs per ton = 17.49 tons cement • Assume 20 tons of cement per delivery truck • 18 trips with ~20 tons per trip	# of trips: 18 delivery trip Weight: 20 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_MNA cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 18000*	# of trips: 18 delivery trip Weight: 20 tons Miles, one way: 50 # of trips: 18 return trip Weight: 0 tons Miles, one way: 50	
Transport of Cement for well installation (for Replacement Wells)	• 16,380 lbs of grout/cement (as per Table G2-C) • 16,380 lbs / 2000 lbs per ton = 8.2 tons cement • Assume 20 tons of cement per delivery truck • 1 trip with 8.2 tons per trip	# of trips: 1 delivery trip Weight: 8.2 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_MNA cement replacement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U (Ecoinvent)* *Amount input: 410*	# of trips: 1 delivery trip Weight: 8.2 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Samples, parsed by time period within remedy: • 17 rounds x 126 wells = 2142 well samples • 10 rounds x 96 wells = 960 well samples • 10 rounds x 66 wells = 660 well samples • 6 rounds x 36 wells = 216 well samples • 2142 + 960 + 660 + 216 = 3978 samples total • 25% of samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, TOC and dissolved gases	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Frequency of sampling, number of people sampling, miles to lab and weight of coolers estimated by TT. • TT estimated trips to lab: If 5 wells are sampled per day and samples are picked up every other day: 398 trips • Assume 50 miles, one way, to lab • Assume van/light truck	398 trips x 100 miles round trip= 39,800 miles 39,800 miles *SimaPro Assembly Name: Transport_G2_MNA sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U (Ecoinvent)* *Amount input: 39800 mile*	39,800 miles Van, light truck Gasoline	

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.

Table G2-E: Waste Transport/Disposal: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Soil Transport and Disposal after placement of ISTT electrodes • 1.6 tons of soil cuttings produced per electrode • TT estimated the need for hazardous disposal of soil cuttings • 200 miles one way from site to landfill	• Document, "Comparison of Construction Materials" provided by NAVFAC • 55 electrodes x 1.6 tons per electrode = 88 tons of soil • TT estimated 3 trucks needed for removal from site	• 3 trips • 29.3tons of soil each trip • Transported to at hazardous landfill 200 miles, one way *SimaPro Assembly Name: Waste Transport_G2_soil disposal Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U (Ecoinvent) Amount input: 17,580 ton-miles* *Empty trip included* *Disposal:* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill, 88 tn.sh)*	3 trips 29.3 tons of soil each trip Transported to at hazardous landfill 200 miles, one way AND 3 empty trips 0 tons each trip Distance: 200 miles, one way AND Disposal: 88 tons of soil Hazardous landfill	Ton-mile basis (no empty trip)
Soil cuttings from all monitoring wells assumed to be non-hazardous and reused on site.		de minimis	de minimis	

Table G2-F: Transport for Personnel: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Total trips to site by personnel: 813 trips Installation of ISTT electrodes and vapor extraction wells • TT estimated to require 4 people on site for 20 work days. (80 trips) Installation of ISTT treatment system components • TT estimated requiring 5 people on site for 100 work days (500 trips) Operation of ISTT • TT estimated requiring 100 trips to site per year, for one person (100 trips) Installation of 28 monitoring wells • TT estimated requiring 3 people on site for 9 working days (27 trips) Sampling • 53 days on site for two people (106 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Trips: 80 + 500 + 100 + 27 + 106 = 813 trips total • Assume use of car (gasoline)	813 trips x 70 miles round trip = 56,910 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_ISTT Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U Amount input: 56910 pmi*	56,910 miles by car (gasoline)	
PRB				
Total trips to site by personnel: 1,390 trips Installation of PRB (including 18 wells) • Estimated to require 2 people on site for 180 days (360 trips) • Estimated to require 2 people on site for 2 events x 180 days per event for replenishment of PRB media (720 trips) Sampling • 155 days on site for two people (310 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Trips: 360 + 720 + 310 = 1,390 • Assume use of car (gasoline)	1,390 trips x 70 miles round trip = 97,300 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_PRB Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U Amount input: 97300 pmi*	97,300 miles by car (gasoline)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Project Engineer and Field Technician • 288 + 1800 hours= 261 days • 261 round trips x 2 people = 522 trips	• Hours per person as per RACER Appendix to the Alameda FS (pdf pg 346)\ • TT estimated 50 miles round trip commuting distance	• 522 trips x 50 miles = 26,100 miles by car, gasoline • One passenger per vehicle *SimaPro Assembly Name: Transport for Personnel_G2_PRB (see above)* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 26100 pmi*	• 522 trips x 50 miles = 26,100 miles by car, gasoline • One passenger per vehicle	
MNA				
Sampling Personnel (see Table G2-D) events parsed by time period within remedy: • 17 rounds x 126 wells = 2142 well samples • 10 rounds x 96 wells = 960 well samples • 10 rounds x 66 wells = 660 well samples • 6 rounds x 36 wells = 216 well samples • 2142 + 960 + 660 + 216 = 3978 samples total • 796 days on site, per person x 2 people = 1,592 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. • Frequency of sampling and number of people sampling estimated by TT. • TT estimated 50 miles, one way, from home to site for each person sampling	1,592 trips x 100 miles round trip = 159,200 miles Car, gasoline One passenger per vehicle *SimaPro Assembly Name: Transport for Personnel_G2_MNA* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 159200* pmi	1,592 trips x 100 miles round trip = 159,200 miles Car, gasoline One passenger per vehicle	

Table G2-G: Potable Water Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G2-C): • ISTT: 11,115 lbs of cement PRB: 10,530 lbs of cement • PRB: 10,530 lbs of cement • MNA: 34,970 lbs of cement • MNA: 16,380 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement (EPA, 2012) • Total cement = 11,115 + 10,530 + 34,970 + 16,380 = 73,015 lbs • 73,015 lbs/ 94 lbs of neat cement x 6 gallons water = 4660.53 gallons of water x 8.34 lbs per gallon = 38868.82 lbs /2000 lbs per ton = 19.43 tons	4660.53 gallons of water Allocated: ISTT- 15.23 % = 2.96 tons PRB- 14.42 % = 2.80 tons MNA- 70.35 % = 13.67 tons *SimaPro Assembly Name: Potable Water_G2_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U (Ecoinvent)* *Amount input: 2.96 sh.tn. (ISTT), 2.80 sh.tn. (PRB) and 13.67 sh.tn (MNA)*	4660.53 gallons of water	

Table G2-H: Non-Potable Water Use: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No significant non-potable water use identified for this alternative				

Table G2-I: Known Use of On-Site Renewables: Alternative G-2 (ISTT, PRBs and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• No known use of on-site renewable energy sources for this remedy				

Tables for Alternative G-3A

Table G3A-A: Electricity Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Operation of ISTT Electrodes and vapor extraction • Includes 55 ISTT electrode	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 200 kWh per yd^3 based on TT engineering estimate (heating and vapor extraction) • Soil treated: 29,100 ft^2 x 36 ft = 1,047,600 ft^3= 38,800 yd^3 • 38,800 yd^3 x 200 kWh per yd^3 = 7,760,000 kWh	7,760,000 kWh *SimaPro Assembly Name: Electricity_G2_Op of ISTT Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 7760 p*	7,760,000 kWh	
In Situ Chemical Oxidation				
Pump for use with ISCO injection	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 219 days for remedy • TT estimated a 2.5 kWh daily electrical usage based on TT engineering estimate. • At 2.5 kWh per day x 219 days = 547.5 kWh x 3 events = 1,642.5 kWh	1,642.5 kWh *SimaPro Assembly Name: Electricity_G3_ISCO_Pump Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 1.6425 p*	1,642.5 kWh	

Table G3A-B: Fuel Use for Equipment: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Equipment used for the construction of the ISTT system: • Installation of 55 ISTT electrodes and co-located vapor extraction wells (to address 29,100 ft^2 of hot spots with average depth of 36 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "Comparison of Construction Materials" provided by NAVFAC • 3-inch Schedule 80 steel pipe within a 12-inch diameter borehole • 55 electrodes to 36 feet deep = 1,980 linear feet • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 20, 8-hr days = 160 hours of use.	• Equipment Type: Hollow stem auger • 55 electrodes to 36 feet deep = 1,980 linear feet • 160 hours *SimaPro Assembly Name: Fuel_G2_ISTT construction* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 900 gal**	• Hollow stem auger • 160 hours of use	
Equipment used for the installation of 28 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 855 feet (including screen length of 280 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 9 days, 8-hr days= 72 hours of use.	• Hollow stem auger • Drilling 855 linear feet 72 hours of use *SimaPro Assembly Name: Fuel_G2_ISTT_construction 28 wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 405 gal**	• Hollow stem auger • 72 hours of use	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Chemical Oxidation				
Direct Push Rig, Truck Mounted, Non-Hydraulic • 656 injection points • Depth from 5-30 ft bgs	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B (Appendix C) • 219 days of operation • Professional estimate assuming 3 injections point completed per day = 219 days of operation x 8hrs =1750 hours x 3 events = 5,250 hours • TT estimates use of a 60 HP direct push rig: Fuel Use (gal) = HP x hrs x BSFC x PLF = 60 x 5250 x 0.050 x 0.75 = 11812.5 gals (refer to EPA, 2012, pg 59)	• Direct push rig • 5,250 hours • 11812.5 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_ISCO_injection rig* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 11812.5 gal**	• Direct push rig • 5,250 hours	
Equipment used for the installation of 29 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 730 feet (including screen length of 290 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 730 linear feet / 100 feet per day = 7.3, 8 hour days = 58.4 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 58.4 x 0.050 x 0.75 = 328.5 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 730 linear feet • 58.4 hours • 328.5 gals fuel *SimaPro Assembly Name: Fuel Use_G3a_ISCO_Install 29 wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 328.5 gal**	• Hollow stem auger • 730 linear feet • 58.4 hours	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
MNA				
Equipment used for the installation of 39 new 2-inch Schedule 40 PVC wells • Using hollow stem auger • Total combined depth of 1,960 feet (including screen depth of 390 feet)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 19.6, 8-hr days. • 1,960 linear feet / 100 feet per day = 19.6, 8 hour days = 157 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 157 x 0.050 x 0.75 = 883.125 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,960 linear feet • 157 hours of use • 883,125 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_MNA_install 39 mw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 883.125 gal**	• Hollow stem auger • 157 hours of use	
Replacement of monitoring wells • Using hollow stem auger • Total combined depth of 1,575 ft (35 wells at an average of 45 feet deep)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf page 32) • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 15.75, 8 hour days • 1,575 linear feet / 100 feet per day = 15.75, 8-hr days = 126 hours of use • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 126 x 0.050 x 0.75 = 708.75 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,575 linear feet • 126 hours of use • 708.75 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_MNA_install 35 rw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 708.75 gal**	• Hollow stem auger • 126 hours of use	

Table G3A-C: Materials Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment ***(all capital construction equipment not listed below, that is required, is assumed to be on-site , stored in Building 5 and reused from a previous pilot (Comparison of Construction Materials document provided by NAVFAC)therefor it is not being footprinted as a part of this GSR analysis, or are de minimis items.***				
GAC • Carbon change out for liquid and vapor phase units	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "List of ERH Materials and Estimated Technology Costs" provided by NAVFAC • TT professional judgment: carbon units will require quarterly carbon change outs for one year. • Estimates of carbon required developed from volume of GAC used in 2007 pilots, TT estimated the following usage (document above) based on those pilot studies: o Two 8,000 lbs vapor phase units o Two 3,000 lbs liquid phase units o Total per quarter = 22,000 lbs	22,000 lbs x 4 fills = 88,000 lbs. of GAC / 2.2 lbs per kg = 40,000 kg *SimaPro Assembly Name: Material_G2_ISTT_GACMaterials /Assemblies used: Virgin GAC Assembly_1kg* *Amount input: 40000 p*	88,000 lbs. of GAC	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Drilled Electrodes composition • Steel pipe (370 lbs/electrode) • Graphite (8,400 lbs/electrode) • Steel shot (1,040 lbs/electrode)	• Document, "Comparison of Construction Materials" provided by NAVFAC • Steel pipe: 370 lbs/electrode x 55 electrodes = 20,350 lbs of steel • Graphite: 8,400 lbs/electrode x 55 electrodes = 462,000 lbs of graphite • Steel shot: 1,040 lbs/electrode x 55 electrodes = 57,200 lbs of steel shot • Total Steel: Steel pipe + steel shot = 20,350 = 57,200 = 77,550 lbs of total steel	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs *SimaPro Assembly Name: Material_G2_ISTT_Electrodes* *Materials/Assemblies used: Steel, billets, at plant/US* *Amount input: 77550 lb* *AND* *Graphite, at plant/RER U* *Materials/Assemblies used: Graphite, at plant/RER U* *Amount input: 462000 lb*	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs	Surrogate for graphite Use "Low Impact Material (Generic)"
PVC (for 28 new monitoring wells) • 2-inch, Schedule 40 • 855 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 581.4 lbs PVC	581.4 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_ISTT_PVC 28 mon wells* *Materials/Assemblies used: PVC pipe E* *Amount input: 581.4*	581.4 lbs of Schedule 40 PVC	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 855 ft = 11,115 lbs of grout/cement / 2000 lbs per ton = 5.6 tons of cement	5.6 tons of cement *SimaPro Assembly Name: Material_G2_ISTT_Grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 5.6 tn.sh.*	5.6 tons of cement	
In Situ Chemical Oxidation				
PVC (for 29 new monitoring wells) • 2-inch, Schedule 40 • 730 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs PVC	496 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_ISCO pvc 29 mw* *Materials/Assemblies used: PVC pipe E (Industry data 2.0)* *Amount input: 496 lb*	Input to SiteWise: 730 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 730 ft = 9,490 lbs of grout/cement / 2000 lbs per ton = 4.75 tons of cement	4.75 tons of cement *SimaPro Assembly Name: Material Use_G3a_ISCO grout* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 4.75 tn.sh*	4.75 tons of cement	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
12% Hydrogen Peroxide • 3 events • 370,000 gallons each event	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Specific gravity of H_2O_2 = 1.045 • H_2O_2 lbs = 1,110,000 gallons x 8.34 lbs per gallons x 1.045 *0.12 = 1,160,877 lbs H_2O_2 • Water = 1,110,000 gallons x 8.34 lbs per gallon x 1.045 x 0.88/8.34 = 1,020,756 gallons of water *Note: Water use for solutions is accounted for in this "Materials" table and not in the "Potable Water" table. This is done to ensure that transportation weight include the water that is used to make the solutions in an offsite facility.*	$H_2O_{2=}$ 1,160,877 lbs of pure H_2O_2 AND Water= 1,020,756 gallons Surrogate for SimaPro: for use of only hydrogen peroxide material (50%), use the following input: • 2,321,754 lbs (2 x 1,160,877lbs) of 50% H_2O_2 solution is needed to yield 1,160,877 lbs of pure H_2O_2 • Half of the required amount of 50% H_2O_2 solution is water. • 50% H_2O_2 solution therefore yields 139,193 gallons (1,160,877 lbs ÷ 8.34 of water • Additional 881,563 gallons of water (1,020,756 gallons – 139,193 gallons) is needed, which is 7,352,235 lbs of water *SimaPro Assembly Name: Material Use_G3a_ISCO_H2O2* *Materials/Assemblies used: Hydrogen peroxide, 50% in H2O, at plant/RER U (Ecoinvent)* *Amount input: 2,231,754 lb* *AND* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 7,352,235 lb*	$H_2O_{2=}$ 1,160,877 lbs AND Water= 1,020,756 gallons	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Chelated Iron Catalyst • 3 events • 370,000 gallons each event • Assume 4% ferrous sulfate solution	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 3 x 370,000 gallons = 1,110,000 gallons of Chelated Iron Catalyst • 4% ferrous sulfate solution has a specific gravity of 1.0375 and 0.3463 lbs of $FeSO_4$ per gallon. (http://www.qccorporation.com/Liquid-Ferrous-Sulfate-Solutions.php) • $FeSO_4$ = 1,110,000 gallons x 0.3463 lbs per gallon = 384,393 lbs $FeSO_4$ • Water = 1,110,000 gallons x 8.34 lbs per gallon x 1.1.0375 x 0.96/8.34 = 1,105,560 gallons of water x 8.34 lbs per gallon = 9,220,370.4 lbs *Note: Water use for solutions is accounted for in this "Materials" table and not in the "Potable Water" table. This is done to ensure that transportation weight include the water that is used to make the solutions in an offsite facility.*	384,393 lbs $FeSO_4$ AND 1,105,560 gallons of water *SimaPro Assembly Name: Material Use_G3a_ISCO_iron* *Materials/Assemblies used: Iron sulphate, at plant/RER U (Ecoinvent)* *Amount input: 384393 lb* *AND* *Materials/Assemblies used: Tap water, at user/RER U (Ecoinvent)* *Amount input: 9220370.4 lb*	384,393 lbs $FeSO_4$ (Input to SiteWise as ZVI) AND 1,105,560 gallons of water	Surrogate for iron Use "Low Impact Material (Generic)"

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
MNA				
PVC (for 39 new monitoring wells) • 2-inch, Schedule 40 • 1,960 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1333 lbs PVC	1333 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc 39 mw Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 1333 lb*	Input to SiteWise: 1960 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	
PVC (for Replacement Wells) • 2-inch, Schedule 40 • 1,575 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC	1,071 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc rw Materials/Assemblies used: PVC pipe E* *Amount input: 1071 lb*	1,071 lbs of Schedule 40 PVC	
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1960 ft = 25,480 lbs of grout/cement / 2000 lbs per ton = 12.74 tons of cement	12.74 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 12.74 tn.sh*	12.74 tons of cement	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1,575 ft = 20,475 lbs of grout/cement / 2000 lbs per ton = 10.24 tons of cement	10.24 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout 2* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 10.24 tn.sh*	10.24 tons of cement	

Table G3A-D: Transport for Materials, Equipment, and Samples: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Transport of material for 55 electrodes.	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Delivery of steel pipe: 1 trip with 20,350 lbs (10.2 tons) • Delivery of graphite: 8 trips delivering 462,000 lbs (231 tons) o TT estimates 30 tons per truck, for 8 trucks necessary to deliver entire load. • Delivery of steel shot: 1 trip with 57,200 lbs (28.6 tons) • TT estimates distance from vendor to site at approximately 50 miles.	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trip Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trip Weight: 28.6 tons Miles, one way: 50 miles *SimaPro Assembly Name: Transport_G2_ISTT electrode materials* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 510 tmi* *Materials/Assemblies used: Transport, lorry >32t, EURO5/RER U* *Amount input: 12000 tmi* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 1430 tmi* *Empty trips included*	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trips Weight: 28.6 tons Miles, one way: 50 miles <u>Steel pipe</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 RETURN trips Weight: 0 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 miles	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of PVC • 855 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) 855 ft x 0.68 lbs per ft = 582 lbs of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT pvc Materials/Assemblies used: Transport, single unit truck, diesel powered/US Amount input: 15*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50	Ton-mile basis
Transport of Cement for Well Installation	• 11,115 lbs of grout/cement (as per Table G2-C) • 11,115 lbs / 2000 lbs per ton = 5.56 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trips with 5.6 tons per trip	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT cement Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U Amount input: 280*	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	
Transport of heavy equipment used for electrode installation and well placement • Hollow stem auger	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C One mob. one demob., TT estimated as de minimis	de minimis	de minimis	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for sampling • 5 rounds of sampling from 53 monitoring wells (DO, ORP, pH, temp, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimate of number of trips based on five wells per day being sampled. Sampling would take place over ~53 days and lab would pick up samples every other day, resulting number of trips would be ~27. • TT estimated the distance to lab as being 50 miles	27 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport_G2_ISTT sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 2700 mile*	27 trips 50 miles, one way Van, gasoline	
Transport of GAC	Total GAC required per quarter = 22,000 lbs TT estimated 1 flatbed truck for delivery TT estimated distance as 50 miles Weight per quarterly trip = 11 tons Assume spent GAC is sent back to regeneration facility on same truck that delivered the new batch of GAC.	• (4 delivery trips + 4 return trips) x 50 miles = 400 miles • Weight of load = 11 tons • 4400 ton-miles *SimaPro Assembly Name: Transport_G2_ISTT_GAC* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 4400 ton-miles*	# of trips: 4 11 tons, each 50 miles, one way # of trips: 4 (back to regeneration facility) 11 tons, each 50 miles, one way	Ton-mile basis
In Situ Chemical Oxidation				

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of PVC • 730 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs of Schedule 40 PVC	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 12.5 ton-mile*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50	Ton-mile basis
Transport of Cement for Well Installation	• 9,490 lbs of grout/cement (as per Table G3A-C) • 9,490 lbs / 2000 lbs per ton = 4.75 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 4.75 tons per trip • Assume a vendor distance of 50 miles	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 237.5 ton-mile*	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Hydrogen Peroxide • 3 events • 370,000 gallons each event	• Delivery to site 3 times • Assume specific gravity of full preparation =1.045 • 370,000 gallons x 3 events x 8.33 lbs per gallon x 1.045 = 9,662,383.5 lbs / 2000 lbs per ton = 4831.2 tons • TT estimated that delivery truck can contain 21tons. Therefore, 231 delivery trucks would be required • TT estimated a vendor distance of 50 miles, one way	231 trips x 50 miles, one way x 21 tons = 242,550 ton-miles *Empty trips included* *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_H2O2* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 242550 ton-mile*	Delivery: 231 trips 50 miles 21 tons Return trips: 231 trips 50 miles 0 tons	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Chelated Iron Catalyst • 3 events • 370,000 gallons each event • Assume the solution contains.4 % ferrous sulfate	• Delivery to site 3 times • 4% ferrous sulfate solution has a specific gravity of 1.0375 and 0.3463 lbs of $FeSO_4$ per gallon. http://www.qccorporation.com/Liquid-Ferrous-Sulfate-Solutions.php • 3 x 370,000 gallons x 8.33 lbs per gallon x 1.0375 = 9593036 lbs / 2000 lbs per ton = 4,796.5 tons • TT estimates that delivery truck can contain 22 tons, 219 delivery trucks would be required • TT estimated a vendor distance of 50 miles, one way	219 trips x 50 miles, one way x 22 tons = 240,900 ton-miles *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_iron* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 240900 ton-mile*	Delivery: 219 trips 50 miles Weight: 22 tons Return trips: 219 trips 50 miles Weight: 0 tons	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for sampling for ISCO • 6 rounds of sampling from 55 monitoring wells (DO, ORP, pH, ferrous iron, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B • TT estimated trips to site for sampling based on five wells per day being sampled, therefor sampling would take place over ~66 days and lab would pick up samples every other day, resulting number of trips would be ~33. • TT estimated distance to lab as 50 miles	33 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3a_ISCO_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 3300 mile*	33 trips 50 miles, one way Van, gasoline	
MNA				
Transport of PVC(for 39 new monitoring wells) • 1,960 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1,333 lbs of Schedule 40 PVC x 2000 lbs per ton = 0.67 tons PVC • TT estimated 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc 39 mw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 33.5 ton-mile*	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of PVC (for Replacement Wells) • 1,575 ft combined length • 2-inch, Schedule 40	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC = 0.54 tons PVC • TT estimated 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc rw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 27 ton-mile*	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	Ton-mile basis (no empty trip)
Transport of Cement for well installation (Monitoring Wells)	• 25,480 lbs of grout/cement (as per Table G2A-C) • 25,480 lbs / 2000 lbs per ton = 12.74 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 12.74 tons per trip	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement mw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 637 ton-mile*	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	
Transport of Cement for well installation (for Replacement Wells)	• 20,475 lbs of grout/cement (as per Table G2A-C) • 20,475 lbs / 2000 lbs per ton = 10.24 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trip with 10.24 tons per trip	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement rw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 512 ton-mile*	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Samples, parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 126 wells = 1134 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 50 wells = 400 well samples • 568 + 1134 + 880 + 400 = 2982 samples total • 25% of samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, TOC and dissolved gases	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated trips necessary for transport of samples based on five wells per day being sampled, sampling would take place over ~597days and lab would pick up samples every other day, resulting number of trips would be ~298. • TT estimated distance to lab is 50 miles	298 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3a_MNA_sampling Materials/Assemblies used: Operation, van < 3,5t/RER U Amount input: 29800 mile*	298 trips 50 miles, one way Van, gasoline	

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.

Table G3A-E: Waste Transport/Disposal: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
ISTT				
Soil Transport and Disposal after placement of ISTT electrodes • 1.6 tons of soil cuttings produced per electrode • Assume hazardous disposal • 200 miles one way from site to landfill	• Document, "Comparison of Construction Materials" provided by NAVFAC • 55 electrodes x 1.6 tons per electrode = 88 tons of soil • TT estimated 3 trucks are needed for removal from site	• 3 trips • 29.3tons of soil each trip • Transported to at hazardous landfill 200 miles, one way *SimaPro Assembly Name: Waste Transport_G2_soil disposal* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 17,580 ton-miles* *Empty trip included* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill,, 88 tn.sh*	3 trips 29.3 tons of soil each trip Transported to at hazardous landfill 200 miles, one way AND 3 empty trips 0 tons each trip Distance: 200 miles, one way AND Disposal: 88 tons of soil Hazardous landfill	Ton-mile basis (no empty trip)
Soil cuttings from all monitoring wells assumed to be non-hazardous and reused on site.		de minimis	de minimis	

Table G3A-F: Transport for Personnel: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Total trips to site by personnel: 813 trips Installation of ISTT electrodes and vapor extraction wells • Estimated to require 4 people on site for 20 work days. (80 trips) Installation of ISTT treatment system components • Estimated to require 5 people on site for 100 work days. (500 trips) Operation of ISTT • Estimated to require 100 trips to site per year, for one person (100 trips) Installation of 28 monitoring wells • Estimated to require 3 people on site for 9 working days (27 trips) Sampling • 53 days on site for two people (106 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline)	813 trips x 70 miles round trip = 56,910 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_ISTT* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 56910 m*	56,910 miles by car (gasoline)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Chemical Oxidation				
Total trips to site by personnel: 2,103 trips Injection of 656 injection points • Estimated to require 3 people on site for 219 days x 3 events (1971 trips) Includes driller, drillers helper and geologist. Sampling • 66 days on site for two people (132 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline)	2,103 trips x 70 miles round trip = 147,210 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_G3a_ISCO_total* *Materials/Assemblies used: Operation, passenger car, petrol, fleet average 2010/RER U* *Amount input: 147210 mile*	147,210 miles by car (gasoline) Assume one person per vehicle	
MNA				
Sampling Personnel (see Table G2-D) events parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 128 wells = 1,152 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 21 wells = 168 well samples • 568 + 1152 + 880 + 168 = 2768 samples total • 554 days on site, per person x 2 people = 1108 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. • Frequency of sampling and number of people sampling estimated by TT. • TT estimated 50 miles, one way, from home to site for each person sampling	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle *SimaPro Assembly Name: Transport of Personnel_G3a_MNA_total* *Materials/Assemblies used: Operation, passenger car, petrol, fleet average 2010/RER U* *Amount input: 110800 mile*	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle	

Table G3A-G: Potable Water Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G2-C): • ISTT: 11,115 lbs of cement • ISCO: 9,490 lbs of cement • MNA: 25,480 lbs of cement • MNA: 20,475 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement (EPA, 2012) • Total cement = 11,115 + 9,490 + 25,480 + 20,475 = 66,560 lbs • 66,560 lbs/ 94 lbs of neat cement x 6 gallons water = 4248.5 gallons of water	4248.5 gallons of water *SimaPro Assembly Name: Potable Water_G3a_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U (Ecoinvent)* *Amount input: 2.96 tn.sh (ISTT), 2.52 tn.sh (ISCO), and 12.23 (MNA)tn.sh*	4248.5 gallons of water	
Water use for solutions	• *Note: Water use for solutions is accounted for in the "Materials" table and not in this "Potable Water" table. This is done to ensure that transportation weight include the water that is used to make the solutions in an offsite facility.*			

Table G3A-H: Non-Potable Water Use: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No significant use of non-potable water identified				

Table G3A-I: Known Use of On-Site Renewables: Alternative G-3A (ISTT, ISCO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• No known use of on-site renewable energy sources for this remedy				

Tables for Alternative G-3B

Table G-3B-Table A: Electricity Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Operation of ISTT Electrodes and vapor extraction • Includes 55 ISTT electrode	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 200 kWh per yd^3 based on TT engineering estimate (heating and vapor extraction) • Soil treated: 29,100 ft^2 x 36 ft = 1,047,600 ft^3= 38,800 yd^3 • 38,800 yd^3 x 200 kWh per yd^3 = 7,760,000 kWh	7,760,000 kWh *SimaPro Assembly Name: Electricity_G2_Op of ISTT Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 7760 p*	7,760,000 kWh	
Bioremediation				
Pump for use with bio injection	• TT estimated a 2.5 kWh daily electrical usage based on TT engineering estimate. • At 2.5 kWh per day x 300 days (includes both events) = 750 kWh	750 kWh *SimaPro Assembly Name: Electricity_G3b_Bio_injection pump Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER Amount input: 0.75 p*	750 kWh	

Table G-3B-Table B: Fuel Use for Equipment: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Equipment used for the construction of the ISTT system: • Installation of 55 ISTT electrodes and co-located vapor extraction wells (to address 29,100 ft^2 of hot spots with average depth of 36 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, "Comparison of Construction Materials" provided by NAVFAC • 3-inch Schedule 80 steel pipe within a 12-inch diameter borehole • 55 electrodes to 36 feet deep = 1,980 linear feet • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 20, 8-hr days = 160 hours of use.	• Equipment Type: Hollow stem auger • 55 electrodes to 36 feet deep = 1,980 linear feet • 160 hours • Fuel Use= 900 gals *SimaPro Assembly Name: Fuel_G2_ISTT construction* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 900 gal**	• Hollow stem auger • 160 hours of use	
Equipment used for the installation of 28 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 855 feet (including screen length of 280 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 9 days, 8-hr days= 72 hours of use.	• Hollow stem auger • Drilling 855 linear feet • 72 hours of use *SimaPro Assembly Name: Fuel_G2_construction 28 wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 405 gal**	• Hollow stem auger • 72 hours of use	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bioremediation				
Direct Push Rig, Truck Mounted, Non-Hydraulic • 656 injection points initial event plus 328 points in second event = 984 injection points • Depth from 5-30 ft bgs	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B • 300 days (including both events) of operation x 8hrs =2400 hours • TT estimates use of a 60 HP direct push rig: Fuel Use (gal) = HP x hrs x BSFC x PLF = 60 x 2400 x 0.050 x 0.75 = 5400 gals (refer to EPA, 2012, pg 59)	• Direct push rig • 2,400 hours • 5400 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3b_Bio_rig for injections* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 5400 gal**	• Direct push rig • 2,400 hours	
Equipment used for the installation of 29 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 730 feet (including screen length of 290 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 730 linear feet / 100 feet per day = 7.3, 8 hour days = 58.4 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 58.4 x 0.050 x 0.75 = 328.5 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 730 linear feet • 58.4 hours • 328.5 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3b_Bio_auger for 29 wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 328.5 gal**	• Hollow stem auger • 730 linear feet • 58.4 hours	
MNA				

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Equipment used for the installation of 39 new 2-inch Schedule 40 PVC wells • Using hollow stem auger • Total combined depth of 1,960 feet (including screen depth of 390 feet)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 19.6, 8-hr days. • 1,960 linear feet / 100 feet per day = 19.6, 8 hour days = 157 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 157 x 0.050 x 0.75 = 883.125 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,960 linear feet • 157 hours of use • 883,125 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3a_MNA_install 39 mw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 883.125 gal**	• Hollow stem auger • 157 hours of use	
Replacement of monitoring wells • Using hollow stem auger • Total combined depth of 1,575 ft (35 wells at an average of 45 feet deep)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf page 32) • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 15.75, 8 hour days • 1,575 linear feet / 100 feet per day = 15.75, 8-hr days = 126 hours of use • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 126 x 0.050 x 0.75 = 708.75 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1,575 linear feet • 126 hours of use • 708.75 gallons of fuel *SimaPro Assembly Name: Fuel Use_G3_MNA_install 35 rw* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 708.75 gal**	• Hollow stem auger • 126 hours of use	

Table G3B-Table C: Materials Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
GAC • Carbon change out for liquid and vapor phase units	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C and document, “List of ERH Materials and Estimated Technology Costs” provided by NAVFAC • TT professional judgment: carbon units will require quarterly carbon change outs for one year. • Estimates of carbon required developed from volume of GAC used in 2007 pilots, TT estimated the following usage (document above) based on those pilot studies: o Two 8,000 lbs vapor phase units o Two 3,000 lbs liquid phase units o Total per quarter = 22,000 lbs	22,000 lbs x 4 fills = 88,000 lbs. of GAC / 2.2 lbs per kg = 40,000 kg *SimaPro Assembly Name: Material_G2_ISTT_GACMaterial s/Assemblies used: Virgin GAC Assembly_1kg* *Amount input: 40000 p*	88,000 lbs. of GAC	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Drilled Electrodes composition • Steel pipe (370 lbs/electrode) • Graphite (8,400 lbs/electrode) • Steel shot (1,040 lbs/electrode)	• Document, "Comparison of Construction Materials" provided by NAVFAC • Steel pipe: 370 lbs/electrode x 55 electrodes = 20,350 lbs of steel • Graphite: 8,400 lbs/electrode x 55 electrodes = 462,000 lbs of graphite • Steel shot: 1,040 lbs/electrode x 55 electrodes = 57,200 lbs of steel shot • Total Steel: Steel pipe + steel shot = 20,350 = 57,200 = 77,550 lbs of total steel	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs *SimaPro Assembly Name: Material_G2_ISTT_Electrodes* *Materials/Assemblies used: Steel, billets, at plant/US* *Amount input: 77550 lb* *AND* *Graphite, at plant/RER U* *Materials/Assemblies used: Graphite, at plant/RER U* *Amount input: 462000 lb*	Material: Steel Amount: 77,550 lbs PLUS Material: Graphite Amount: 462,000 lbs	Surrogate for graphite Use "Low Impact Material (Generic)"
PVC (for 28 new monitoring wells) • 2-inch, Schedule 40 • 855 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 581.4 lbs PVC	581.4 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material_G2_ISTT_PVC 28 mon wells* *Materials/Assemblies used: PVC pipe E* *Amount input: 581*	Input to SiteWise: 855 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 855 ft = 11,115 lbs of grout/cement / 2000 lbs per ton = 5.6 tons of cement	5.6 tons of cement *SimaPro Assembly Name: Material_G2_ISTT_Grout Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent) Amount input: 5.6 tn.sh.*	5.6 tons of cement Input to SiteWise: Typical Cement 11,200 lbs	
Bioremediation				
PVC (for 29 new monitoring wells) • 2-inch, Schedule 40 • 730 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs PVC	496 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3_Bio_pvc 29 mw Materials/Assemblies used: PVC pipe E Amount input: 496 lb*	Input to SiteWise: 730 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 730 ft = 9,490 lbs of grout/cement / 2000 lbs per ton = 4.75 tons of cement	4.75 tons of cement *SimaPro Assembly Name: Material Use_G3b_Bio_grout Materials/Assemblies used: Cement, unspecified, at plant/CH U Amount input: 4.75 sh. tn*	4.75 tons of cement Input to SiteWise: Typical Cement 9,500 lbs	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Emulsified Vegetable Oil (EOS ®) • 1,427, 55-gallon drums for initial event plus 713 drums for second event = 2,140 total drums	See RACER pdf 602 • 2140 drums x 55 gallons per drum = 117,700 gallons of emulsified vegetable oil • If specific gravity of EOS = 1, then 117700 gallons x 8.34 lbs per gallon = 981618 lbs / 2000 lbs per ton = 490.809 tons	2140 x 55 = 117,700 gallons of emulsified vegetable oil = 490.81tons *SimaPro Assembly Name: Material Use_G3_Bio_EOS* *Materials/Assemblies used:* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U* *(surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations*	2140 x 55 = 117,700 gallons of emulsified vegetable oil Input to SiteWise: 1,284,065 lbs (conversion of gallons to pounds based on a vegetable oil density of 10.912 lbs/gal)	
MNA				
PVC (for 39 new monitoring wells) • 2-inch, Schedule 40 • 1,960 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1333 lbs PVC	1333 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc 39 mw* *Materials/Assemblies used: PVC pipe E Amount input: 1333 lb*	Input to SiteWise: 1,960 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PVC (for Replacement Wells) • 2-inch, Schedule 40 • 1,575 ft combined length	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC	1,071 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_G3a_MNA pvc rw Materials/Assemblies used: PVC pipe E Amount input: 1071 lb*	Input to SiteWise: 1,071 feet of 2" Sch 40 PVC (Note: Table 1-C in SiteWise spreadsheet provide a conversion factor of 0.72 lbs/ft)	
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1960 ft = 25,480 lbs of grout/cement / 2000 lbs per ton = 12.74 tons of cement	12.74 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout Materials/Assemblies used: Cement, unspecified, at plant/CH U Amount input: 12.74 tn.sh*	12.74 tons of cement Input to SiteWise: Typical Cement 25,480 lbs	
Grout for Well Installation	• Amounts calculated assume the grout use over the full length of well depth, recognizing it as an oversimplification to account for the offset by use of sand interval, cement pad and wells caps. • 13 lbs of grout per foot of well depth (EPA, 2012) • 13 lbs per foot x 1,575 ft = 20,475 lbs of grout/cement / 2000 lbs per ton = 10.24 tons of cement	10.24 tons of cement *SimaPro Assembly Name: Material Use_G3a_MNA grout 2 Materials/Assemblies used: Cement, unspecified, at plant/CH U Amount input: 10.24 tn.sh*	10.24 tons of cement Input to SiteWise: Typical Cement 20,480 lbs	

Table G-3B-Table D: Transport for Materials, Equipment, and Samples: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Transport of material for 55 electrodes.	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Delivery of steel pipe: 1 trip with 20,350 lbs (10.2 tons) • Delivery of graphite: 8 trips delivering 462,000 lbs (231 tons) o TT estimates 30 tons per truck, for 8 trucks necessary to deliver entire load. • Delivery of steel shot: 1 trip with 57,200 lbs (28.6 tons) • TT estimates distance from vendor to site at approximately 50 miles.	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trip Weight: 28.6 tons Miles, one way: 50 miles *SimaPro Assembly Name: Transport_G2_ISTT electrode materials* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 510 tmi* *Materials/Assemblies used: Transport, lorry >32t, EURO5/RER U* *Amount input: 12000 tmi* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 1430 tmi* *Empty trips included*	<u>Steel pipe</u> # of trips: 1 delivery trip Weight: 10.2 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 trips Weight: 30 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 delivery trips Weight: 28.6 tons Miles, one way: 50 miles <u>Steel pipe</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 <u>Graphite</u> # of trips: 1 x 8 = 8 RETURN trips Weight: 0 tons Miles, one way: 50 miles <u>Steel Shot</u> # of trips: 1 RETURN trips Weight: 0 tons Miles, one way: 50 miles	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of PVC • 855 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 855 ft x 0.68 lbs per ft = 582 lbs of Schedule 40 PVC	<u>Schedule 40 PVC pipe</u> # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT pvc Materials/Assemblies used: Transport, single unit truck, diesel powered/US Amount input: 15*	<u>Schedule 40 PVC pipe</u> # of trips: 1 delivery trip Weight: 0.3 tons Miles, one way: 50	Ton-mile basis
Transport of Cement for Well Installation	• 11,115 lbs of grout/cement (as per Table G2-C) • 11,115 lbs / 2000 lbs per ton = 5.56 tons cement • TT estimated 20 tons of cement per delivery truck • 1 trips with 5.6 tons per trip	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 *SimaPro Assembly Name: Transport_G2_ISTT cement Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U Amount input: 280*	# of trips: 1 delivery trip Weight: 5.6 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	
Transport of heavy equipment used for electrode installation and well placement • Hollow stem auger	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C One mob. one demob., TT estimated as de minimis	de minimis	de minimis	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for sampling • 5 rounds of sampling from 53 monitoring wells (DO, ORP, pH, temp, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • If five wells per day are sampled, sampling would take place over ~53 days and lab would pick up samples every other day, resulting number of trips would be ~27. • Assume distance to lab is 50 miles	27 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport_G2_ISTT sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 2700 mile*	27 trips 50 miles, one way Van, gasoline	
Transport of GAC	Total GAC required per quarter = 22,000 lbs TT estimated 1 flatbed truck for delivery TT estimated distance as 50 miles Weight per quarterly trip = 11 tons Assume spent GAC is sent back to regeneration facility on same truck that delivered the new batch of GAC.	• (4 delivery trips + 4 return trips) x 50 miles = 400 miles • Weight of load = 11 tons • 4400 ton-miles *SimaPro Assembly Name: Transport_G2_ISTT_GAC* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 4400 ton-miles*	# of trips: 4 11 tons, each 50 miles, one way # of trips: 4 (back to regeneration facility) 11 tons, each 50 miles, one way	Ton-mile basis

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bioremediation				
Transport of PVC • 730 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 730 ft x 0.68 lbs per ft = 496 lbs of Schedule 40 PVC	<u>Schedule 40 PVC pipe</u> # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3b_Bio_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 12.5 ton-mile*	<u>Schedule 40 PVC pipe</u> # of trips: 1 delivery trip Weight: 0.25 tons Miles, one way: 50	Ton-mile basis
Transport of Cement for Well Installation	• 9,490 lbs of grout/cement (as per Table G3A-C) • 9,490 lbs / 2000 lbs per ton = 4.75 tons cement • Assume 20 tons of cement per delivery truck • 1 trip with 4.75 tons per trip • Assume a vendor distance of 50 miles	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3b_Bio_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 237.5 ton-mile*	# of trips: 1 delivery trip Weight: 4.75 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of EOS • 2140 drums, total	• TT estimates that delivery truck can contain 30 tons per tractor trailer delivery (~113 drums) • Estimate 17 trips to deliver drums • TT estimates a vendor distance of 500 miles, one way	17 trips x 500 miles, one way x 30 tons = 255,000 ton-miles *SimaPro Assembly Name: Transport of Materials_G3b_Bio_EOS* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 255000 ton mile*	Delivery: 17 trips 500 miles 30 tons Return trips: 17 trips 500 miles 0 tons	Ton-mile basis (no empty trip)
Transport for sampling for bioremediation • 10 rounds of sampling from 55 monitoring wells (DO, ORP, pH, ferrous iron, metals and VOCs)	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B • TT estimated transport requirements based on five wells per day being sampled, sampling taking place over ~110 days and lab would picking up samples every other day, resulting in a number of trips of ~55. • TT estimates distance to lab as 50 miles •	55 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3b_Bio_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 5500*	55 trips 50 miles, one way Van, gasoline	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
MNA				
Transport of PVC(for 39 new monitoring wells) • 1,960 ft of 2-inch, Schedule 40 PVC pipe	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,960 ft x 0.68 lbs per ft = 1,333 lbs of Schedule 40 PVC x 2000 lbs per ton = 0.67 tons PVC • TT estimates 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc 39 mw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 33.5 ton-mile*	# of trips: 1 delivery trip Weight: 0.67 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	Ton-mile basis (no empty trip)
Transport of PVC (for Replacement Wells) • 1,575 ft combined length • 2-inch, Schedule 40	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Weight estimated using 0.68 lbs/ft (EPA, 2012) • 1,575 ft x 0.68 lbs per ft = 1,071 lbs of Schedule 40 PVC = 0.54 tons PVC • TT estimates 50 miles distance to vendor	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_pvc rw* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 27 ton-mile*	# of trips: 1 delivery trip Weight: 0.54 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Cement for well installation (Monitoring Wells)	• 25,480 lbs of grout/cement (as per Table G2A-C) • 25,480 lbs / 2000 lbs per ton = 12.74 tons cement • TT estimates 20 tons of cement per delivery truck • 1 trip with 12.74 tons per trip	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement mw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 637 ton-mile*	# of trips: 1 delivery trip Weight: 12.74 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	
Transport of Cement for well installation (for Replacement Wells)	• 20,475 lbs of grout/cement (as per Table G2A-C) • 20,475 lbs / 2000 lbs per ton = 10.24 tons cement • TT estimates 20 tons of cement per delivery truck • 1 trip with 10.24 tons per trip	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G3a_MNA_cement rw* *Materials/Assemblies used: Transport, lorry 7.5-16t, EURO5/RER U* *Amount input: 512 ton-mile*	# of trips: 1 delivery trip Weight: 10.24 tons Miles, one way: 50 # of trips: 1 return trip Weight: 0 tons Miles, one way: 50	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Samples, parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 126 wells = 1134 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 50 wells = 400 well samples • 568 + 1134 + 880 + 400 = 2982 samples total • 25% of samples would also be analyzed for metals, nitrate/nitrite, sulfate/sulfide, TOC and dissolved gases	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • TT estimated trips necessary for transport of samples based on five wells per day being sampled, sampling would take place over ~597days and lab would pick up samples every other day, resulting number of trips would be ~298. • TT estimated distance to lab is 50 miles	298 trips 50 miles, one way Van, gasoline *SimaPro Assembly Name: Transport of Materials_G3a_MNA_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 29800 mile*	298 trips 50 miles, one way Van, gasoline	

***Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.**

Table G-3B-Table E: Waste Transport/Disposal: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
ISTT				
Soil Transport and Disposal after placement of ISTT electrodes • 1.6 tons of soil cuttings produced per electrode • Assume hazardous disposal • 200 miles one way from site to landfill	• Document, “Comparison of Construction Materials” provided by NAVFAC • 55 electrodes x 1.6 tons per electrode = 88 tons of soil • TT estimated 3 trucks needed for removal from site	• 3 trips • 29.3tons of soil each trip • Transported to at hazardous landfill 200 miles, one way *SimaPro Assembly Name: Waste Transport_G2_soil disposal* *Materials/Assemblies used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 17,580 ton-miles* *Empty trip included* *Disposal as a life-cycle with dummy soil input. Disposal, inert material, 0%, water to sanitary landfill/CH U as a surrogate for a hazardous waste landfill,, 88 tn.sh , 88 tn.sh*	3 trips 29.3 tons of soil each trip Transported to at hazardous landfill 200 miles, one way AND 3 empty trips 0 tons each trip Distance: 200 miles, one way AND Disposal: 88 tons of soil Hazardous landfill	Ton-mile basis (no empty trip)

Table G-3B-Table F: Transport for Personnel: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
In Situ Thermal Treatment				
Total trips to site by personnel: 813 trips Installation of ISTT electrodes and vapor extraction wells • Estimated to require 4 people on site for 20 work days. (80 trips) Installation of ISTT treatment system components • Estimated to require 5 people on site for 100 work days. (500 trips) Operation of ISTT • Estimated to require 100 trips to site per year, for one person (100 trips) Installation of 28 monitoring wells • Estimated to require 3 people on site for 9 working days (27 trips) Sampling • 53 days on site for two people (106 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estiamted an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline)	813 trips x 70 miles round trip = 56,910 miles by car (gasoline) *SimaPro Assembly Name: Transport for Personnel_G2_ISTT* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 56910 m*	56,910 miles by car (gasoline)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bioremediation				
Total trips to site by personnel: 1,120 trips Injection of 656 + 328 injection points to take 300 days • Estimated to require 3 people on site for 300 days (900 trips) Includes driller, drillers helper and geologist. Sampling • 110 days on site for two people (220 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimated an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline)	1,120 trips x 70 miles round trip = 78,400 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_Bio* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 78400 pmi*	78,400 miles by car (gasoline) Assume one person per vehicle	
MNA				
Sampling Personnel (see Table G2-D) events parsed by time period within remedy: • 8 rounds x 71 wells = 568 well samples • 9 rounds x 128 wells = 1,152 well samples • 10 rounds x 88 wells = 880 well samples • 8 rounds x 21 wells = 168 well samples • 568 + 1152 + 880 + 168 = 2768 samples total • 554 days on site, per person x 2 people = 1108 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. • Frequency of sampling and number of people sampling estimated by TT. • TT estimated 50 miles, one way, from home to site for each person sampling	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle *SimaPro Assembly Name: Transport of Personnel_G3a_MNA_total* *Materials/Assemblies used: Operation, passenger car, petrol, fleet average 2010/RER U* *Amount input: 110800 mile*	1108 trips x 100 miles round trip = 110,800 miles Car, gasoline One passenger per vehicle	

Table G-3B-Table G: Potable Water Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G2-C): • ISTT: 11,115 lbs of cement • BIO: 9,490 lbs of cement • MNA: 25,480 lbs of cement • MNA: 20,475 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement • Total cement = 11,115 + 9,490 + 25,480 + 20,475 = 66,560 lbs • 66,560 lbs/ 94 lbs of neat cement x 6 gallons water = 4248.5 gallons of water	4248.5 gallons of water *SimaPro Assembly Name: Potable Water_G3b_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 2.96 tn.sh (ISTT), 2.52 tn.sh (BIO), and 12.23(MNA) tn.sh*	4248.5 gallons of water	
Water for EOS injections	• TT estimated the EVO would be delivered as a 5% solution by volume and that the water used is potable water from a fire hydrant or equivalent source. • Total EOS injected = 117,700 gallons / 0.05 = 2,340,000 gallons of solution, of which 95% is water: 2,340,000 x 0.95 = 2,223,000 gallons water required	Water: 2,223,000 gallons x 8.34 lbs per gallon = 18,539,820 lbs = 9269.91 tons *SimaPro Assembly Name: Potable Water_G3b_water for EOS injections* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 9269.91 tn.sh*	2,223,000 gallons of water	

Table G-3B-Table H: Non-Potable Water Use: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No significant use of non-potable water identified				

Table G-3B-Table I: Known Use of On-Site Renewables: Alternative G-3B (ISTT, BIO and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• No known use of on-site renewable energy sources for this remedy				

Tables for Alternative G-4

Table G-4-Table A: Electricity Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Recirculation System				
Extraction well pump influent to supply an estimated combined flow rate of 100 gpm plus 100 gpm for recirculation/reinjection, for a total of – 200 gpm • Operation of recirculation and treatment system for 35 years	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • See Equation 1, below. Assume an efficiency of 0.8 for motor and 0.75 for pump and a TDH=55 ft. • Estimated daily energy requirement = 83 kWh per day (24 hour operation) • 83 kWh x 365 days x 35 years = 1,060, 325 kWh for entire remedy	1,060, 325 kWh *SimaPro Assembly Name: Electricity Use_G4_pump for recirc* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 1060.325 p*	1,060, 325 kWh	
Operation of UV/oxidation treatment system • Operation of recirculation and treatment system for 35 years	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 60 kW unit • 60 kW x 306,600 hours = 18,396,000 kWh	18,396,000 kWh *SimaPro Assembly Name: Electricity Use_G4_UV ox* *Materials/Assemblies used: Electricity CAMX-WECC1000 kWh at CONSUMER* *Amount input: 18396 p*	18,396,000 kWh	

Equation 1

$$kWh = \frac{TDH \times Q}{3956 \times \eta_p \times \eta_m} \times 0.746 \times hours\ of\ operation$$

TDH = total dynamic head (ft)
Q = flow rate (gpm)
3956 = conversion factor used to convert ft-gpm to HP
0.746 = conversion factor from HP to kW
η_p = efficiency of pump (%)
η_m = efficiency of motor (%)

Table G4-B: Fuel Use for Equipment: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Recirculation System				
Equipment to install wells: • 1,311 linear feet for extraction wells • 1,680 linear feet for injection wells • 2,690 linear feet for monitoring wells • Total 5,681 linear feet	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) takes 57, 8-hr days = 456 hours of use. • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 456 x 0.050 x 0.75 = 2565 gals (refer to EPA, 2012, pg 59)	Hollow stem auger 456 hours of use. 2565 gallons of fuel *SimaPro Assembly Name: Fuel Use_G4_Recirc_install wells_auger* *Process Used: Diesel, combusted in industrial equipment/US* *Amount input: 2565 gal**	Hollow stem auger 456 hours of use.	
Equipment to install trenching/piping • Equipment required: small backhoe, loader and compactor to excavate and replace approximately 228 bcy	• Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (pdf pgs 795-798) • Assume fuel use de minimis	de minimis	de minimis	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PRB				
Equipment to install • East PRB: 600 foot PRB via direct push injection of 165 cubic yards of zero valent iron (60 injection locations), 220 days • West PRB: 500 foot PRB via direct push injection of 165 cubic yards of zero valent iron (50 injection locations), 180 days	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C (See RACER pdf, pg 816) • 400 days x 8 hrs per day = 3,200 hours • Direct push rig • TT estimates use of a 60 HP direct push rig: Fuel Use (gal) = HP x hrs x BSFC x PLF = 60 x 3200 x 0.050 x 0.75 = 7200 gals (refer to EPA, 2012, pg 59	• Direct push rig • 3,200 hours of use • 7200 gallons of fuel *SimaPro Assembly Name: Fuel Use_G4_PRB_injection Process Used: Diesel, combusted in industrial equipment/US Amount input: 7200 gal**	• Direct push rig • 3,200 hours of use	
Equipment used for the installation of 36 new 2-inch PVC wells • Using hollow stem auger • Total combined depth of 1,620 feet (including screen length of 360 ft)	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Hollow stem auger drilling 100 linear feet per day (EPA, 2012) • 1620 linear feet / 100 feet per day = 17, 8 hour days = 136 hours • TT estimates use of a 150 HP hollow stem auger: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 136x 0.050 x 0.75 = 765 gals (refer to EPA, 2012, pg 59)	• Hollow stem auger • 1620 linear feet • 136 hours • 765 gallons of fuel *SimaPro Assembly Name: Fuel Use_G4_PRB_wells Process Used: Diesel, combusted in industrial equipment/US Amount input: 765 gal**	• Hollow stem auger • 1620 linear feet • 136 hours	

Table G4-C: Materials Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Recirculation System ***(individual one-time construction components considered de minimis if less than 1% of energy usage)***				
PVC • 19 6-inch extraction wells (95 + 380 linear feet, pg 674 RACER) • 24 6-inch injection wells (120 + 1,560 linear feet, pg 676 RACER) • 450 feet of 4-inch pipe • 2,500 feet of 6-inch pipe • 100 feet of 8-inch pipe • 2,690 feet of 2-inch wells	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 8”=5.39 lbs per linear foot • 6”=3.53 lbs per linear foot • 4”=2.01 lbs per linear foot • 2”= 0.68 lbs per linear foot • ((95+380+120+1,560+2,500) x 3.53 lbs per linear foot)=16,432 lbs PVC • 450 x 2.01 lbs per linear feet = 905 lbs PVC • 100 x 5.39 lbs per linear feet = 539 lbs PVC • 2,690 x 0.68 lbs per linear feet = 1,829 lbs PVC	16,432 + 905 + 539 + 1,829 = 19,705 lbs of PVC *SimaPro Assembly Name: Material Use_G4_Recirc_pvc multiple applications Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 19705 lb*	19,705 lbs of PVC Input to SiteWise 19,705 lbs PVC (entered in “Bulk Materials”)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Grout for installation of wells • 100 feet of 8" PVC • 4,655 feet of 6" PVC • 450 feet of 4" PVC • 2,690 feet of 2" PVC	Cement requirement for well installation (as per EPA, 2012): • 8" PVC requires 32 lbs per foot • 6" PVC requires 25 lbs per foot • 4" PVC requires 19 lbs per foot • 2" PVC requires 13 lbs per foot • 100 feet x 32 lbs per foot = 3,200 lbs of cement • 4,655 feet x 25 lbs per foot = 116,375 lbs of cement • 450 feet x 10 lbs per foot = 4,500 lbs of cement • 2,690 feet x 13 lbs per foot = 34,970 lbs of cement • Total cement = 3,200 + 116,375 + 4,500 + 34,970 = 159,045 lbs of cement / 2000 lbs per ton = 79.5 ton	79.5 ton of cement *SimaPro Assembly Name: Material Use_G4_Recirc_grout Materials/Assemblies used: Cement, unspecified, at plant/CH U Amount input: 79.52*	159,045 lbs of cement	
PRB				
PRB media • 165 cubic yards for injection x 2 replacements = 330 cubic yards zero valent iron	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Density of zero valent iron = ~2.6 grams/cm^3 (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • (2.6 g/cm^3 x 764554.858 cm^3 per yard / 453.6 g per pound / 2000 lbs per ton = 2.19 ton per cubic yd ZVI. • 165 yds^3 of ZVI x 2.19 tons per cubic yard = 361.35 tons ZVI x 2= 722.7 tons ZVI	722.7 tons zero valent iron (iron filings) *SimaPro Assembly Name: Material_G4_PRB_iron filings Materials/Assemblies used: Pellets, iron, at plant/GLO U (Ecoinvent) Amount input: 722.7 tn.sh*	722.7 tons yards zero valent iron (iron filings)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PVC • 1,620 feet of 2-inch PVC wells	• 2” Schedule 40 PVC = 0.68 lbs per linear foot (EPA, 2012) • 1,620 x 0.68 lbs per linear foot = 1,102 lbs of PVC	1,102 lbs of PVC *SimaPro Assembly Name: Material Use_G4_PRB_pvc Materials/Assemblies used: PVC pipe E (Industry data 2.0) Amount input: 1102 lb*	1,620 ft. of PVC	
Grout for installation of wells • 1,620 feet of 2” PVC	• 2” PVC Schedule 40 requires 13 lbs of cement per foot (EPA, 2012) • 1,620 ft x 13 lbs per foot = 21,060 lbs of cement	21,060 lbs of cement *SimaPro Assembly Name: Material Use_G4_PRB_grout Materials/Assemblies used: Cement, unspecified, at plant/CH U Amount input: 21060 lb*	21,060 lbs of cement	

Table G4-D: Transport for Materials, Equipment, and Samples: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Recirculation System				
Transport of 19,705 lbs of PVC	10 tons of PVC	# of trips: 5 delivery trip Weight: 2 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_Recirc_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input: 500 ton-miles*	Schedule 40 PVC pipe # of trips: 5 delivery trip Weight: 2 tons Miles, one way: 50	Ton-mile basis
Transportation of cement for well installation	• 159,045 lbs of cement for recirculation system well installation (from Table G4-C) • 159,045 lbs x 2000 lbs per ton = 79.5 tons of cement • Assume 20 tons of cement per delivery truck • 4 trips with ~ 20 tons per trip	# of trips: 4 delivery trips Weight: 20 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_Recirc_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 4000 ton mile*	# of trips: 4 delivery trip Weight: 20 tons Miles, one way: 50 # of trips: 4 return trips Weight: 0 tons Miles, one way: 50	
Transportation for one time use construction equipment considered de minimis, either because it is a single round trip, or because equipment may be on-site		de minimis	de minimis	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Samples • 3,852 samples total	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Frequency of sampling, number of people sampling and miles to lab estimated by TT. • TT estimated trips: 5 wells are sampled per day and samples are picked up every other day: 385 trips • TT estimated 50 miles, one way, to lab • Van/light truck	385 trips x 100 miles round trip= 38,500 miles 38,500 miles *SimaPro Assembly Name: Transport of Materials_G4_Recirc_sampli ng* *Materials/Assemblies used: Operation, van < 3,5t/RER U* *Amount input: 38500 mile*	38,500 miles Van, light truck Gasoline	
PRB				
Transport of 330 yds^3 iron filing	(Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • 2 one way trips • Density of zero valent iron = ~2.6 $grams/cm^3$ (http://homepages.uwp.edu/li/research/papers/2002/2C-35.pdf) • 165 yds^3 x 2 x 2.19 tons per yard = 722.7 tons of ZVI • Assume flatbed delivery of 40 tons per trip • 19 trips of 50 miles, one way (potential vendor located in Berkley, Ca)	19 trip x 40 tons x 50 miles 38,000 ton-miles *Empty return trip included* *SimaPro Assembly Name: Transport_G4_PRB iron* *Materials/Assemblies used: Truck 40t* *Amount input: 38000 ton mile*	# of trips: 19 40 tons, each 50 miles, one way # of trips: 19 return trips Weight: 0 tons Miles, one way: 50 # of trips: 19 (empty) 0 tons, each 50 miles, one way	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of 1,102 lbs of PVC	0.5 tons of PVC	# of trips: 1 delivery trip Weight: 0.5 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_PRB_pvc* *Materials/Assemblies used: Transport, single unit truck, diesel powered/US* *Amount input:25 ton-miles*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 0.5 tons Miles, one way: 50 # of trips: 1 return trips Weight: 0 tons Miles, one way: 50	Ton-mile basis (no empty trip)
Transport of cement for installation of wells	21,060 lbs of cement (as per Table G4-C) • 21,060 lbs / 2000 lbs per ton = 10.53 tons of cement • TT estimates 20 tons of cement per delivery truck • 1 trips with 10.5 tons per trip	# of trips: 1 delivery trip Weight: 10.5 tons Miles, one way: 50 *SimaPro Assembly Name: Transport of Materials_G4_PRB_cement* *Materials/Assemblies used: Transport, lorry 3.5-7.5t, EURO5/RER U* *Amount input: 525 ton-miles*	Schedule 40 PVC pipe # of trips: 1 delivery trip Weight: 10.5 tons Miles, one way: 50 # of trips: 1 return trips Weight: 0 tons Miles, one way: 50	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Samples • 1,512 samples total	• (Revised Draft Revision 2) Feasibility Study Report, Operable Unit 2B, Appendix C • Frequency of sampling, number of people sampling and miles to lab estimated by TT. • If 5 wells are sampled per day and samples are picked up every other day: 151 trips • TT estimates 50 miles, one way, to lab • Van/light truck	151 trips x 100 miles round trip= 15,100 miles *SimaPro Assembly Name: Transport of Materials_G4_PRB_sampling* *Materials/Assemblies used: Operation, van < 3,5t/RER U Amount input: 15100 mile*	15,100 miles Van, light truck Gasoline	

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.

Table G4-E: Waste Transport/Disposal: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Recirculation System				
No significant wastes identified				
PRB				

Table G4-F: Transport for Personnel: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Recirculation System				
Transport for recirculation system related items • 2 people to site for 770 days of sampling (1540 trips) • Estimated to require 3 people on site for 57 days (171 trips) Includes driller, driller's helper and geologist. (referencing time spent on auger use for well drilling) • System installation crew (includes trenching crew): 72 days, 5 man crew = 360 trips	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimates an average of 35 miles, one way, per person, from home to site. • Assume use of car (gasoline) • 2,071 total one way trips	2,071 trips x 70 miles round trip = 144,970 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_G4_Recirc* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 144970 pmi*	144,970 miles by car	
PRB				
Total trips to site by personnel: 1,806 trips Installation of PRB (including 36 wells) • Driller, drillers helper, and project engineer for 400 days (1200 trips) Sampling • 303 days on site for two people (606 trips)	• Data on trip distance and number of trips by personnel not provided by site documentation. Data estimated by TT. • TT estimates an average of 35 miles, one way, per person, from home to site. • Car (gasoline)	1,806 trips x 70 miles round trip = 126,420 miles by car (gasoline) *SimaPro Assembly Name: Transport of Personnel_G4_PRB* *Materials/Assemblies used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 126420 pmi*	126,420 miles by car (gasoline)	

Table G4-G: Potable Water Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Water use for the blending of cement for well installation. Weight of cement included in water consumption calculations include the following wells (See Table G4-C): • Recirculation system: 159,045 lbs of cement • PRB: 21,060 lbs of cement	• Water consumption is based on a blended density of 15 lbs per gallon mixed with 94 lbs of neat cement • Total cement = 159,045 + 21,060 = 180,105 lbs • 180,105 lbs/ 94 lbs of neat cement x 6 gallons water = 11,496 gallons of water x 8.34 lbs per gallon = 95876.64 lbs	• 95,876.64 lbs of water • 88.3 % Recirc: 84,659.07 lbs • 11.7 % PRB: 11,217.57 lbs *SimaPro Assembly Name: Potable Water_G4_blend for cement* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 84659.07 lb (Recirc) and 11217.57 lb (PRB)*	11,496 gallons of water	

Table G4-H: Non-Potable Water Use: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No significant non-potable water use identified				

Table G4-I: Known Use of On-Site Renewables: Alternative G-4 (Recirculation and PRBs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No known use of on-site renewable energy sources for this remedy				

Coordination of Site Data Input for: Area M, Naval Weapons Industrial Reserve Plant, McGregor, Texas (NWIRP)

FOR

QUANTIFYING LIFE-CYCLE ENVIRONMENTAL FOOTPRINTS

OF SOIL AND GROUNDWATER REMEDIES

ESTCP Project # ER-201127

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INTRODUCTION

NWIRP McGregor is a former government owned, contractor operated facility that was in operation until 1995. Due to past activities on the site, the groundwater has been contaminated with perchlorate, pesticides, semi-volatile organic compounds (SVOCs), and volatile organic compounds (VOCs). The perchlorate plume at "Area M" is currently being managed by a pump and treat (P&T) system for plume control at the property line, with treatment of extracted water via a fluidized bed reactor (FBR), and seven in-situ bio-barriers for treatment of the off-site portion of the perchlorate plume.

Information and data required for a GSR footprint evaluation for the groundwater remedy for Area M at NWIRP McGregor was developed from the following data sources:

- Groundwater Monitoring and Sampling Optimization Report (GW Optimization Report), Naval Weapons Industrial Reserve Plant, McGregor, Texas, Geosyntec and CH2MHill, April 11, 2011

- Evaluation and Optimization of Fluidized Bed Reactor & In Situ Biowall Performance (FBR Optimization Report), Naval Weapons Industrial Reserve Plant, McGregor, Texas, Brady G2, Geosyntec and CH2MHill, April 15, 2011

- DRAFT Permeable Reactive Barrier (PRB) Sustainability, Cost, and Performance Report (PRB Report), August 2011 (not for general distribution)

The April 2011 reported entitled "Evaluation and Optimization of Fluidized Bed Reactor & In Situ Biowall Performance" provided recommendations for potential future modifications to the P&T system:

- Optimization of the existing extraction system

    - Modify trench operation to reduce the amount of water to be treated
    - Modify the pumps at Pump Station B to reduce electricity usage

- Consideration of alternative technologies to the FBR that would be more capable of addressing rapid changes in the influent flow rates and result in reduced operating costs

    - Ion Exchange (IX) with Single Use Resins
    - Bioreduction using gravel bed reactor (GBR)
    - Treatment Wetlands

For this evaluation, footprints will be evaluated for the following items:

- Alternative 1: Existing Extraction System, FBR, and Bio-Barrier O&M
- Alternative 2: Optimized Extraction System, FBR, and Bio-Barrier O&M
- Alternative 3: Replace FBR with IX

- Alternative 4: Replace FBR with GBR
- Alternative 5: Replace FBR with Treatment Wetlands
- Alternative 6: Additional Biowall Construction

For alternatives 2 through 6, the electricity associated with the extraction pump flow rate will be estimated based on projected electrical reduction that correlates with the alternative remedy in place. This information is deduced from projected cost tables provided with the FBR Optimization Report.

The intent of this document is to provide a basis for the development of input for the SimaPro and SiteWise tools for these alternatives.

Alternative 1: Existing Extraction System, FBR, and Bio-Barrier O&M

System Overview

The current system includes the following elements:

- Extraction Trenches
  - Trenches B and C feed into Trench A via gravity.
  - Trench A feeds into Pump Station B.
  - Individual extraction rates of the three trenches cannot be controlled because a single water level set point in Pump Station B controls the rate of flow for all three trenches.
  - The initial construction of the trenches is not being footprinted here.
  - No footprints are directly associated with trench operation.

- Pump Station B
  - Pump Station B contains two pumps that take water from Trench A and transport it to either the FBR for treatment or to Lagoon A for storage. Each of the two pumps contain a 15 horsepower (hp) motor. Each pump is rated to deliver 780 gpm against 55 feet total dynamic head. Since startup, the long-term average treatment flow rates to the FBR have been 130 gpm. Testing has indicated that a single pump must operate at a flow rate of approximately 400 gpm in order to effectively deliver feed flow to the FBR at the minimum required pressure. (FBR Optimization Report, p. 13).
  - Footprinting will be performed for normal operations, which is for only one of the two pumps to operate (the other pump operates during storm conditions when the collection trenches receive greater flows). For typical operation (to be footprinted), one pump operates continuously and pumps at 400 gpm (FBR Optimization Report, p.14). The FBR takes 130 gpm of that on average, and the remaining 270 gpm is recycled back to Pump Station B. (FBR Report, p.14). This approach allows the pump at Pump Station B to exceed its minimum recommended flow rate. For footprinting purposes, a 15 hp motor at 80% load and 75% efficiency (Tetra Tech estimate) is assumed to operate continuously.
  - There is also a backup diesel pump that will activate if the level reaches the high-level set point, but it is only sporadically used and will not be footprinted.

- Fluidized Bed Reactor (FBR)
  - The FBR is 7.5-foot-diameter by 21-foot-high stainless steel vessel that was initially filled with 11,900 pounds of granular activated carbon (GAC). The initial construction and initial GAC is not being footprinted here.
  - The approximate operational volume of the reactor is 6,950 gallons. The GAC provides a high amount of surface area for biological film growth. During operation, the GAC media is hydraulically fluidized at a specific flow rate to ensure adequate mixing and performance. The GAC media must be continuously fluidized to prevent compacting of the media and/or rapid decay of the

microorganisms. Effluent from the FBR is discharged to Soil Cell C (and occasionally Soil Cells A and B) for polishing before final discharge to an outfall.
    - The granular activated carbon is estimated by TT to require replacing approximately 10% of its total volume each year due to loss during normal operating procedures.
    - Average feed flow from Pump Station B into the FBR is 130 gpm (ranges from 40 to 260 gpm). The flow rate required for fluidization in the FBR is 400 gpm (FBR Optimization Report, p.13). The difference is made up by internal recycle of effluent from the FBR. It has been assumed that 10 HP of electricity is used to sustain the recycle process (pg. 14, FBR Optimization Report).
    - Acetic acid is used as the organic carbon source and phosphoric acid is added as a phosphorous source to supplement biomass growth. (FBR Optimization Report, pg. 30). According to site team input, "For the past two (2) years the average acetic acid usage is 31,500 lbs or approximately 3,600 gallons. The average phosphoric acid use is 700 lbs or approximately 55 gallons. These containers are shipped from Univar in Dallas which is approximately 150 miles away from the site."
    - Influent lines were found to have carbon packing onto influent strainer and causing influent flow to drop well below the set point. This carbon buildup, assumed to come from the base of Trench A, led to the use of 300 micron bag filters.
    - Discharge of ~130 gpm is via gravity, so no footprints are to be calculated regarding the FBR discharge.

- O&M of seven bio-barriers in Area M
    - The biowalls consist of shallow trenches, 2.5 to 4.5 feet wide, keyed into the non-water-bearing zone, and oriented perpendicular to the hydraulic gradient. The biowalls and the fill materials will be considered in place and will not be footprinted as a part of this evaluation. Carbon amendments (emulsified vegetable oil) are now injected into the biowalls on a periodic basis to replenish the electron donor supply as needed. It is assumed at this point that there will be no additional biowalls added to Area M.
        - Periodic carbon replenishment used EOS diluted approximately 7:1 with water (p.60 of PRM optimization report)
        - In general, the biotrenches on NWIRP McGregor did not require carbon replenishment until four to five years after installation.
        - No M area trenches were replenished in 2006, 2007, or 2008
        - Trenches M-2, M-3 and M-5 received carbon replenishment in 2009, and trenches M2-and M-3 were recommended for additional carbon replenishment in 2010.
        - Exact quantities of EOS used are not clear. However, pg. 34 of PRB Report indicates that 880 gallons of EOS was used in 2009 for three Area M trenches plus 3 Area S trenches. TT estimated approximately half was for the M Area trenches.

    - To estimate annual EOS use for footprinting, TT estimated that Area M will require approximately 300 gallons of EOS per year, diluted with 2100 gallons of water from a fire hydrant.
    - Transportation of EOS – TT has estimated 300 gallons of EOS used per year based on recent usage.
    - TT estimated that pump use for injection of EOS is negligible from a footprint perspective.

- Sampling
  - Currently monitoring 44 wells in Area M
  - Generally, wells are sampled annually, but some have been sampled twice per year
  - Wells are sampled using low flow methods
  - Assumptions as to how many shipments, how shipped and approximately how many coolers per event have been based on professional experience of 2 people performing the sampling, 2 wells sampled per day, 2 coolers produced per day for 22 days per year.
  - The site team reported that the lab is located in Nashville, Tennessee, located approximately 785 miles from the site. TT will assume transport of the samples by air.

- Transport of Personnel to and from site
  - Fluidized Bed Reactor
    - The site team reports that there is typically one technician on-site no less than two days per week. This technician is coming from a distance of 140 miles from the site.
  - Biowall carbon injections
    - Includes pump maintenance (quarterly), generator and diesel pump maintenance (annually), air compressor maintenance (annually) and electrician (quarterly)
    - TT estimated total of 12 visits per year, driving car (gasoline) for a 50 mile, one way trip to site.
  - Sampling and O&M:
    - TT estimated 22 sampling days per year (44 wells, 2 people sampling)
    - TT estimated that each person drives his/her individual vehicle (light truck) to the site
    - TT estimated each person is coming from a distance of 50 miles away from site

Detailed Basis for Footprint Evaluation

Tables 1-A through 1-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 1 (“Existing Conditions”) and the input parameters to SimaPro and SiteWise.

Much of the footprint of the current remedy comes from the energy used for the pumps.

Information regarding the sources used for energy generation in this area, including renewable versus nonrenewable sources of electricity in this region, compiled during 2004-2005, can be seen in Table 1-J and I-K. The eGRID sub-region map does not show the resolution required to identify whether NWIRP McGregor is located in the SRMV-SERC Mississippi Valley Region or the ERCT—ERCOT All Region, so both tables are provided here. The source allocation for both of these regions were averaged and used as the sources of electricity generation for the NWIRP McGregor site.

Alternative 2: Optimized Extraction System, FBR, and Bio-Barrier O&M

System Overview

Relative to Alternative 1:

- TT estimated continuous operation of one VFD pump in Pump Station B delivering 65 gpm of continuous feed to the FBR (FBR Optimization Report, p. 11) rather than current 15 HP pump.
- 50% lower use of acetic acid and phosphoric acid in FBR (FBR Optimization Report, p. 11)
- Lower feed presumably means higher flow for recycle pump at FBR, so TT will estimate that bag filter use can be cut in half
- Sampling – approximately19 of 44 MWs removed from sampling area M based on a MAROS analysis

Detailed Basis for Footprint Evaluation

Tables 2-A through 2-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 2 and the input parameters to SimaPro and SiteWise.

Alternative 3: Replace FBR with Ion Exchange (IX)

System Overview

Alternative 3 would replace the existing FBR treatment with Ion Exchange (IX) requiring single-use resins, where the perchlorate in contaminated water is replaced by chloride on the surface of anion exchange resins. This alternative does not require pilot testing (proven technology), does not generate brine, and is less prone to system shock. The FBR Optimization Report (p. 32) states the following: "Given the reduced influent perchlorate concentrations, it is anticipated that IX treatment would be economically competitive with the existing FBR. It should be noted that successful implementation of IX treatment would be dependent on resolving the recent treatment system biofouling issues, as biofouling of the IX resin would be undesirable. In addition, if the biofouling issue is resolved and an increase in influent perchlorate concentrations results, the potential effects of the increased influent perchlorate concentrations on IX removal efficiency would need to be evaluated.

The implementation of this technology would include the following items based on FBR Optimization Report (p. 39-40):

- Would be constructed adjacent to the existing FBR system.

- For the conceptual design, the peak flow rate was estimated to be 500 gpm with an average flow rate of 150 gpm. To accommodate this flow rate, three HP® 810SYS resin vessels would be installed in series. Each resin vessel holds approximately 175 cubic feet of resin.

- Estimated that the resin in the lead vessel would need to be replaced every 8 months, assuming an average flow rate of 150 gpm.

- The estimated annual operating expenses for an IX system are presented in Table 2-6 of the FBR Optimization and Evaluation report. Overall, the annual operating costs for IX treatment are expected to be less than for an FBR. The lower costs are predominantly due to reduced labor, analytical, and electricity costs.
    - IX treatment systems require less operator labor to run as the daily maintenance is significantly less than performed on an FBR.
    - Given the resin vessel configuration and the anticipated resin performance, we believe that perchlorate sampling for the system would only be required once per month. Perchlorate samples would be limited to the influent, in between the resin vessels (2 samples), and the effluent. The list of monitoring parameters required by the permit could likely be reduced. The number of process control samples for IX treatment compared to FBR treatment is less.
    - Electricity costs are expected to be 43% less than the electricity costs of the FBR system given the reduced power requirements to pump water through the resin vessels compared to suspending the biological media of the FBR.

  - Resin costs for IX treatment are greater than the corresponding donor/nutrient expenses of the FBR, but the increased expenses are more than offset by the cost reductions estimated for the remaining line items.

- To mitigate the potential for biofouling of the IX resin, some form of pretreatment would likely be necessary. Options for pretreatment would include the installation of a sand filter or a GBR. TT will assume the installation of a sand filter for the purposes of evaluating the environmental footprint for this study.

Design parameters are not currently available for the alternative remedies being considered by this GSR analysis. TT will estimate design parameters for the IX and provide references in the related tables of data.

Detailed Basis for Footprint Evaluation

Tables 3-A through 3-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 3 and the input parameters to SimaPro and SiteWise.

Alternative 4: Replace FBR with Gravel Bed Reactor

System Overview

An emerging treatment technology, the gravel bioreactor (GBR) system uses a water-tight reactor packed with coarse gravel media to support an attached biofilm. This system needs to be roughly 10-times larger than the FBR in order to treat an equivalent treatment flow, but is installed below grade. The electron donor system can be controlled to maintain the redox state under changing conditions.

Alternative 4 consists of an at-grade GBR that consists of the following components:

- A water-tight reactor packed with coarse gravel media to support an attached biofilm
  - The size of the system is typically 10-times larger than the FBR for an equivalent treatment flow, but the system will be below grade
- Mechanical and hydraulic components designed to approximate plug flow within the reactor
- An electron donor system that can be controlled to maintain the redox state
  - System allows for precise redox control under changing conditions

Since this system maintains quasi-steady state biologic and hydraulic conditions within the media, the only routine O&M requirements would be maintaining the electron donor and source water delivery systems, and periodic performance monitoring and effluent quality analysis.

Design parameters are not currently available for the alternative remedies being considered by this GSR analysis. TT will estimate design parameters for the GBR and provide references in the related tables of data.

Detailed Basis for Footprint Evaluation

Tables 4-A through 4-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 4 and the input parameters to SimaPro and SiteWise.

Alternative 5: Replace FBR with Treatment Wetlands

A second emerging technology that was retained for consideration for Area M was the use of the treatment wetland. The treatment wetland is an engineered system that uses the microbial processes of wetlands to assimilate or degrade the contaminant.

System Overview

A treatment wetland is an engineered system that uses microbial processes mediated by plants to treat water, relying on the interaction of the contaminant with plant roots, and their associated rhizosphere microorganisms, to assimilate or degrade the contaminant.

The benefits of the treatment wetland system are:

- A semi-passive nature
  - Degradation occurs with minimal active control or introduction of energy or nutrient sources (although pumping between cells may still be required)
- The ability to eliminate Soil Cell C for polishing
- The ability to utilize Soil Cells A and B (possibly also Soil Cell C) for conversion to treatment wetlands
- Construction is relatively low in capital cost

Although there is a lack of large scale field studies, the space necessary for this technology is present in Area M. Therefore, treatment wetlands have been retained for further consideration.

Design parameters are not currently available for the alternative remedies being considered by this GSR analysis. TT will estimate design parameters for the treatment wetlands and provide references in the related tables of data.

Detailed Basis for Footprint Evaluation

Tables 5-A through 5-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 5 and the input parameters to SimaPro and SiteWise.

Alternative 6: Additional Biowall Construction

Alternative 6 would increase the number of biowalls on Area M that are currently addressing the perchlorate contamination. For footprinting purposes, the additional biowalls will be modeled as an individual remedy alternative so that the results produced are stand-alone and can be evaluated as such or combined with any other remedy alternative presented.

System Overview

Information regarding the estimated fuel, material consumption, transportation and waste disposal was provided by Jeff James, P.E., NWIRP McGregor site manager. The proposed design summary includes the construction of four overlapping biowall segments in the area just north of the perimeter road leading from Area M to the existing fluidized bed reactor (FBR) treatment system. Each biowall would be approximately 20-feet deep and 510 feet long, providing for approximately 20 feet of overlap between segments.

The biowalls would be backfilled with a mushroom compost mixture, similar to the following:

- Approximately 20% mushroom compost saturated with soybean oil
- Approximately 20% three-quarter-inch wood chips
- Approximately 60% one-inch washed, crushed limestone aggregate to maintain the permeability of the fill.

A two inch PVC diffuser pipe will be placed in drainage aggregate at the base of each trench, so that carbon amendments can be added as needed. Three or more monitoring ports will be installed within the treatment materials. These ports will be constructed with approximately 2,000 feet of 1-inch diameter PVC that includes 5-ft long pre-pack screened interval.

Since most monitoring wells in this area have been previously abandoned, new monitoring wells are expected to be installed approximately 100 feet from the historic edges of the plume. It has been estimated that 580 feet of 2” diameter PVC pipe will be required for these newly installed monitoring wells.

The following is a list of the construction equipment necessary to investigate and construct the trenches, and includes the number of working days that each piece is estimated to be utilized:

- Air-rotary drill rig- needed for 5 days for soil borings for preliminary investigation
- Trencor-Jetco 1460HD “Rock Trencher” – needed for 10 days
- Articulating dump truck — needed for 20 days
- Tandem dump truck — needed for 20 days
- Wedge-footed roller — needed for 20 days
- Backhoe — needed for 20 days
- Rubber-tired Loader — needed for 20 days

The materials required for backfilling the trenches would need to be trucked to the site from vendors. The spoil material from the excavation of the trenches would also need to be hauled to a landfill since the material would likely be deemed a Class I Non-Hazardous Waste. The estimated number of truckloads, volume, vendor location, and mileage for each material is as follows:

- Mushroom compost — 48 truckloads (712 yards)
- Monterey Mushroom, 5816 State Highway 75 S, Madisonville, TX 77864
- Estimated total mileage is 12,000 miles
- 1-inch crushed limestone — 143 truckloads (2134 yards)
- Franklin Industrial Minerals, 13960 FM 439 Rd., Nolanville, TX 76559
- Estimated total mileage is 15,415 miles
- 3/4 –inch pine wood chips — 48 truckloads (712 yards)
- CLW, Inc, 4873 State Highway 146 S, Livingston, TX 77351
- Estimated mileage is 18,816 miles
- Soybean Oil — 3 truckloads (14,224 gallons)
- 4800 Main St. #326, Kansas City, MO 64112
- Estimated mileage is 3,960 miles
- Haul cut material to landfill — 238 truckloads (3556 cubic yards)
- CSC Disposal & Landfill, 01 Republic Way, Avalon, TX 76623
- Estimated mileage is 40,650 miles

Mileage for personnel to oversee the project would be approximately 500 miles as the oversight would be provided by personnel from the Dallas/Fort Worth area. With this taken into account, the total anticipated mileage for the construction phase of the project would be approximately 92,000 miles.

Routine operation and maintenance of the biowalls would involve semi-annual sampling over an assumed 30 year period. Additionally, supplemental carbon addition would be required approximately every three years. Assuming 1,000 miles per year for travel from Dallas/Fort Worth for sampling and 2,232 miles every three years for emulsified oil delivery (one roundtrip truck load from Delafield, WI), approximately 52,000 vehicle miles would be associated with biowall maintenance.

Detailed Basis for Footprint Evaluation

Tables 6-A through 6-H summarize the information that will serve as the basis for the footprint evaluation of Alternative 6 and the input parameters to SimaPro and SiteWise.

TABLES

Note:

These tables were originally created based on comparison of SimaPro to SiteWise Version 2. The last column indicates any changes between input for SiteWise Version 2 and SiteWise Version 3.

Table 1-A: Electricity Use: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Pump • Two submersible pumps, only one operational at one time • each 15 HP, each rated to deliver 780 gpm against 55 feet TDH. Set point entered by operator. No VFD. • Previous conditions indicate that pump must operate at 400 gpm to deliver the minimum required pressure to the FBR • Recycle Pump to recycle 270 gpm (400 minus 130 gpm) • The recycle line that discharges back to Pump Station B is manually controlled by the operator based on pressure	• FBR Optimization Report, pg 13 • TT estimated continual operation of one or the other pump at one time, for 30 year remedy • The 400 gpm included in the calculation, includes both the pumping and recycling process • 10 HP of electricity that is accounted for in the original submersible pump electricity usage is used to sustain the recycle process	1,817,102 kWh *See Equation 1* *SimaPro Assembly Name: Elec_Alt_1_Pump Materials/Assemblies used: 1000kWh ERCT/RMV Source Mix AT CONSUMER Amount input: 1817.102 p*	*TDH* = 55 ft *Q* =400 gpm $\eta_m \times \eta_p$ = 0.6 Hours: 262,800 1,817,102 kWh *See Equation 1 for definitions*	
• Backup diesel pump that activates if the level reaches the high-level set point.	• Only used occasionally • To be considered “de minimis” for the sake of footprinting.	de minimis	de minimis	

Additional assumptions:

- *assume pump efficiency of 75% and motor efficiency of 80% for extraction pumps*
- *continuous operation assumes 8,760 hours per year.*

Equation 1

$$kWh = \frac{TDH \times Q}{3956 \times \eta_p \times \eta_m} \times 0.746 \times hours\ of\ operation$$

TDH = total dynamic head (ft)
Q = flow rate (gpm)
3956 = conversion factor used to convert ft-gpm to HP
0.746 = conversion factor from HP to kW
η_p *= efficiency of pump (%)*
η_m *= efficiency of motor (%)*

Table 1-B: Fuel Use for Equipment: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor				
Off-road forklift for acid deliveries	• FBR Optimization Report • (Table 2-4 estimates $4,000 per year) • Estimated to be 5 gallons of diesel fuel use per year or 150 gallons over the 30 year remedy. • Considered to be de minimis	de minimis	de minimis	
Sampling/O&M				
Field truck • Gasoline • Assuming $3.00 per gallon	• FBR Optimization Report • Table 2-5 says $6,400 per year for gasoline • Result=2,133 gallons per year for 30 years	2133 gallons per year x 30 years = 64,000 gallons of gasoline used over the 30 year remedy *SimaPro Assembly Name: Fuel_Alt1_Field Truck* *Process used: Gasoline, combusted in equipment/US* *Amount input: 64000 gal**	64,000 gallons of gasoline into "Personnel Transportation – Road" by using 640,000 miles at 10 miles per gallon.	
Emergency Generator and Pump	• Diesel fuel • Cost lumped in with "toilet, ice locker, trash service", etc. ($8,200 per year) • Based on above information, fuel use for emergency generator assumed to be de minimis.	de minimis	de minimis	

Table 1-C: Materials Use: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor				
Granular Activated Carbon for FBR vessel • Initially filled with 11,900 pounds of GAC.	• Reports do not specify change out schedule • Estimated by TT to require replacement of approximately 10% of its total volume each year due to loss during normal operating procedures. • Assume virgin GAC	10% of 11,900= 1,190 lbs of replacement GAC per year 1,190 lbs x 30 yrs = 35,700 lbs of virgin GAC over the course of the remedy /2.2 kg per lb = 16227.27 *SimaPro Assembly Name: Material_Alt 1_FBR_GAC Materials/Assemblies used: GAC_1 kg Virgin Amount input: 16227.27 p*	35,700 lbs of Virgin GAC	
Acetic acid	• FBR Optimization Report • Site team input estimates: 3,600 gallons per year of acetic acid or 31,500 lbs (solution) per year (equating to a specific gravity of 1.05) • TT estimated the use of a 10% solution • Acetic acid = 108,000 gallons x 8.34 lbs per gallon x 1.05 x 0.10 = 94,575.6 lbs of acetic acid • Water = 108,000 gallons x 8.34 lbs per gallon x 1.05 x 0.90/8.34 = 102,060 gallons of water	94,575.6 lbs of acetic acid 102,060 gallons of water *SimaPro Assembly Name: Material_Alt1_FBR_AceticAcid 10% Materials/Assemblies used: Acetic acid, 98% in H2O, at plant/RER/U Amount input: 94575.6 lbs AND Materials/Assemblies used: Tap water, at user/RER Amount input: 851180.4 lbs*	94,575.6 lbs of acetic acid 102,060 gallons of water	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Phosphoric acid	• Site team estimate: 55 gallons, or 700 lbs of phosphoric acid per year of phosphoric acid • TT estimated the use of a 75% solution, specific gravity ~1.6) • Phosphoric Acid: 1650 gallons x 8.34 lbs per gallon x 1.6 x 0.75 = 16513.2 lbs of phosphoric acid • Water = 1650 gallons x 8.34 lbs per gallon x 1.6 x 0.25/8.34 = 660 gallons of water	16513.2 lbs of phosphoric acid AND 660 gallons of water Note: water for use in preparation of solution is accounted for prior to delivery to site *SimaPro Assembly Name: Material_Alt 1_FBR_Phosphoric Acid* *Materials/Assemblies used: Phosphoric acid, fertilser grade, 70%, at plant/U S* *Amount input: 16513,2 lb* *AND* *Assembly used: Tap water, at user/RER S* *Amount input: 5504.4 lbs*	16513.2 lbs of phosphoric acid AND 660 gallons of water (surrogate for phosphoric acid required by SiteWise: used acetic acid)	Use surrogate "Low Impact Material (Generic)"

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters	• Site team indicates that the system uses an average of 100 filter bags every 3 months (assumed to be polypropylene) • Site team also reported that the weight of each shipment, which consists of 100 filter bags, is under 10 pounds. • Bags are shipped four times per year (100 bags x 4 times per year = 400 bags per year x 30 years = 12,000 bags over the course of the remedy) • 12,000 bags x 1 lb per 10 bags = 1,200 lbs of polypropylene • During use, bags are assumed to remove an equivalent amount of sediments (i.e., 1200 lbs or 0.6 tons over the course of the remedy) • Additionally, during use, bags are assumed to remove the carbon lost from the bioreactor (1,190 lbs of carbon per year or 0.6 tons per year or 18 tons)	1,200 pounds *SimaPro Assembly Name: Material_Alt1_FBR_Filter bags* *Materials/Assemblies used: Polypropylene fibres (PP), crude oil based, production mix, at plant, PP granulate without additives (ELCD)* *Amount input: 1,200 lbs* *Dummy_Cement bags, at plant/US as a surrogate for filtered material* *Amount input: 18.6 tn.sh* *Manufacturing of surrogate for filtered material has no footprint. Material is added to the filter bag assembly so that it can be considered in the disposal scenario*	1,200 pounds (surrogate: HDPE liner)	
Biowalls				
Electron Donor Replenishment (EOS™) for biowalls	• PBR Report • TT estimated that biowalls for Area M would require approximately 300 gallons per year • Typical s.g.for vegetable oil =1, therefore: 300 gallons x 8.33 lbs per gallon= 2499 lbs x 30 years= 74,970 lbs	74,970 lbs of vegetable oil *SimaPro Assembly Name: Materials_Alt1_Biowall_EOS* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U (surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations*	74,970 lbs of vegetable oil	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Sampling/O&M				
Sampling equipment • 44 wells sampled at Area M on an annual basis	• Estimated based on reduction recommendations in GW Optimization Report • Material consumed during sampling will be considered de minimis	de minimis	de minimis	

Table 1-D: Transport for Materials, Equipment, and Samples: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor				
Transport of Granular Activated Carbon (for FBR vessel)	• Required amount estimated by TT • 1,190 lbs (0.6 tons) GAC delivered once per year • TT estimated a vendor distance of 100 miles	0.6 tons x 100 miles one way= 60 ton-mile per year x 30 years= 1,800 ton-mile *SimaPro Assembly Name: Transport of Materials_Alt 1_FBR_ GAC* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 1800 tmi**	• Distance for delivery= 100 miles, one way • Weight per delivery=0.6 tons • Number of trips over remedy= 30 Empty return trips: • Distance = 100 miles, one way • Weight = 0 tons • Number of trips over remedy= 30 Diesel	Ton-mile basis (no empty trip)
Delivery of phosphoric and acetic acid solution to site	• TT estimate: 900 gallons of acetic acid (s.g.=~1) and 13.75 gallons of phosphoric acid (s.g.=~1.6) are delivered together four times per year • 900 gallons x (1.05 x 8.34 lbs/gallon)=7881.3 lbs= 3.75 tons per quarter • 13.75 gallons x (1.6 x 8.34 lbs/gallon)= 183.5 lbs= 0.092 tons per quarter • Site team reported a vendor delivery distance of 150 miles • TT estimated quarterly deliveries (120) of 3.84 tons of solutions.	• 3.84 tons total weigh delivered 4 times per year • 150 miles one way 3.84 x 4 x 150 = 69120 ton-mile (Empty trips included) *SimaPro Assembly Name: Transport of Materials_Alt 1_FBR_acids* *Process used: Transport, single truck, diesel powered/US* *Amount input: 69,120 tmi**	• Distance for deliveries: 120 trips x 150 miles per trip=18,000 miles • Weight per delivery trip is 3.84 tons • Distance for empty trips: 120 trips x 150 miles per trip=18,000 miles • Weight per empty trip is 0 tons • Fuel: diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Bag Filters • Site team reported using 100 bags every three months • Site team reported that 100 bags weighs less than 10 lbs • Polypropylene	• Site team reported a transport distance of 170 miles, from supplier in San Antonio, Texas (who receives it from the manufacturer in Somerton, Arizona) • 10 lb delivery 120 times over the course of a 30 year remedy, • TT estimated partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• Distance for deliveries: 120 trips x 170 miles per trip=20,400 miles • Weight per delivery trip is 10 lbs/2000 lbs per ton = 0.005 tons *SimaPro Assembly Name: Transport of Materials_Alt1_FBR_Bag Filters* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 102 tmi**	• Distance for deliveries: 120 trips x 170 miles per trip=20,400 miles • Bag filters represent 1% of the cargo on the truck from San Antonio to the vicinity of the site. Therefore, mileage should be 1% of the total miles (1% x 20,400 = 204 miles • Weight per delivery trip is 0.005 tons Fuel: diesel • No empty return trip required	Ton-mile basis
Transport of forklift for movement of phosphoric and acetic acid deliveries	• TT estimated average vendor used for heavy equipment is 50 miles away, one way • TT estimated 8,000 lbs average forklift • TT estimated annual use of forklift • TT estimated two round trips for vehicle to deliver and pick up forklift per quarter.	• Distance: 8 trips per year with forklift x 30 years x 50 miles= 12,000 miles • Weight of forklift: 4 tons Empty trips included *SimaPro Assembly Name: Transport of Materials_Alt 1_FBR_ Forklift* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 48,000 tmi**	• Distance: 8 trips per year with forklift x 30 years x 50 miles= 12,000 miles • Weight of forklift: 4 tons • Distance: 8 return trips per year x 30 years x 50 miles=12,000 miles • Weight: 0 tons • Fuel type: diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
Transport of biowall donor replenishment	• PRB Report, pg. 34 • 300 gallons (maximum) per year with a s.g.= 1. (http://www.eosremediation.com/products/Density.html • Weight: 300 gallons x 8.33 lbs per gallon= 2499 lbs = 1.25 tons per delivery • TT estimated annual replenishment • TT estimated 100 miles, one way, to vendor	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons (Empty trips included) *SimaPro Assembly Name: Transport of Materials_Alt1_Biowalls_donor replen* *Process used: Transport, single unit truck, diesel powered/US* • *Amount input: 3750 ton-mile*	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons • Distance for empty trips: 30 trips x 100 miles per trip=3,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)
Sampling/O&M				
Transport of Cooler during sampling events • Sampling Events (44 wells sampled once per year) • TT estimated the following parameters for sampling: o 1 well per cooler, or 22 coolers total, used annually o 30 lbs when full of samples o Air transport	• Groundwater Optimization Report • TT estimated sample transport based on 2 people performing the sampling, 2 wells sampled per day, 2 coolers produced per day for 22 days per year. • Site team reports that the location of the lab is approximately 785 miles from the site, therefore TT presumed samples traveled by air. • Weight per shipment trip is 2 x 30 lbs (0.03 tons)	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip= 518,100 miles • Weight per shipment= 0.03 tons • Air transport *Name: Transport of Materials_Alt1_O&M_Samples* *Process used: Transport, aircraft, freight/US* *Amount input: 15,543 tmi**	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip=518,100 miles • Weight per shipment = 0.03 tons • Air transport*	

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.

Table 1-E: Waste Transport/Disposal: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor				
Bag Filters • Polypropylene • Additional waste is filtered sediments and carbon	• Annual shipments to landfill based on professional judgment (used bags stored in drums on site until annual disposal trip) • Assume non-hazardous landfill (TT estimate) • Assume 25 miles to landfill, one annual trip (TT estimate)	• Distance to landfill: 30 trips x 25 miles per one way trip=750 miles • Weight per trip is 0.04 tons + 0.6 tons (excess carbon loss)= 0.64 ton total per trip *Name: Waste Transport_Alt 1_FBR_Bag Filters* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 480 tmi** *Disposal: Referring to assembly: Material_Alt1_FBR_Filter bags (total weight of 19.2 tn.sh)* *Waste treatment is Disposal, concrete, 5% water, to inert material landfill/CH U*	• Distance for deliveries: 30 trips x 25 miles per trip=750 miles • Weight per delivery trip is 0.64 tons No empty return trip 0.64 ton x 30 years= 19.2 tons disposed in non-hazardous landfill (total remedy) Input to SiteWise: 19 tons to non-hazardous landfill	Ton-mile basis (no empty trip)

Table 1-F: Transport for Personnel: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor				
Transport for one technician for valve adjustments	• Site team reports that there is typically one technician on-site no less than two days per week. • Site team reported this technician is traveling approximately 140 miles, one way.	2 days per week x 52 weeks per year x 30 years x 140 miles = 436800 miles by car *SimaPro Assembly Name: Transport for Personnel_Alt1_FBR* *Materials/Assemblies used: Transport, passenger car/RER U* *Amount input: 436800 miles*	436800 miles by car (gasoline) Labor: 2*52*8*30=24,960 hrs of operator	
Biowalls				
Transport for personnel, estimated at a total of 12 trips, includes: • Personnel to inject carbon into biowall • Pump maintenance (TT estimated a quarterly maintenance • Emergency generator and diesel pump maintenance • Air compressor maintenance • Electrician	• Table 2-5 of FBR Optimization Report • Assumptions of number of personnel and frequency of visits estimated by TT. • 12 trips per year x 30 years = 360 trips • TT estimated one person driving car (gasoline) for 50 miles trip, one way.	360 trips x 100 miles round trip= 36,000 miles traveled by car *SimaPro Assembly Name: Transport for Personnel_Alt1_Biowall* *Materials/Assemblies used: Transport, passenger car/RER U* *Amount input: 36000 miles*	36,000 miles traveled by car (gasoline) 1 person per car Labor: 360*8=2880 hrs of operator	
Sampling/O&M				
Transport for personnel to and from sampling events	• TT estimated 22 trips per year (44 wells, 2 people sampling) • TT estimated each person drives individual vehicle to site (light truck) • TT estimated a distance of 50 miles, one way	2 vehicles x 22 trips per year x 100 miles round trip x 30 years = 132,000 miles *SimaPro Assembly Name: Transport for Personnel_Alt1_Sampling* *Materials/Assemblies used: Transport, passenger car/RER U* *Amount input: 132000 pmi*	1320 trips x 100 miles = 132,000 miles 1 person per vehicle, car and gasoline Labor: 2*22*8*30=10,560 hrs of scientific/tech	

Table 1-G: Potable Water Use: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowall				
Water use for EVO replenishment based on a 1:7 ratio (EVO to water) for injections.	• FBR and Biowall Optimization Report (page 60) • EVO use estimated to be 300 gallons per year • TT estimated use of potable water from local hydrant (TT estimate)	300 x 7 = 2100 gallons per year x 30 years = 63,000 gallons x 8.34 lbs per gallon = 525,420 lbs *SimaPro Assembly Name: Potable Water_Alt 1_Biowall_EVO replen* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 525420 lbs*	63,000 gallons of potable water	
Water used to create solutions for acetic acid and phosphoric solutions		No input for SimaPro. Water is accounted for upon choosing solution type.	Water use included with acetic and phosphoric acid solutions in Table C, “Material Use”	

Table 1-H: Non-Potable Water Use: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 1-I: Known Use of On-Site Renewables: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 1-J: eGRID Subregion, SRMV—SERC Mississippi Valley, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	21.1991	34,168,945.70
Oil	3.3369	5,378,483.80
Gas	45.156	72,782,955.40
Other Fossil	2.2801	3,675,117.00
Nuclear	24.4717	39,443,770.00
Other Unknown / Purchased Fuel	0.2182	351,712.20
Nonrenewable Total	96.662	155,800,984.10
Renewable Resource		
Wind	0	0
Solar	0	0
Geothermal	0	0
Biomass	2.0667	3,331,208.60
Hydro	1.2713	2,049,072.70
Renewable Total	3.338	5,380,281.30

Table 1-K: eGRID Subregion, ERCT—ERCOT All, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	37.0621	118,995,890.00
Oil	0.4774	1,532,913.40
Gas	47.5239	152,586,004.60
Other Fossil	1.2381	3,975,204.40
Nuclear	11.9078	38,232,493.00
Other Unknown / Purchased Fuel	0.1741	558,908.80
Nonrenewable Total	98.3834	315,881,414.30
Renewable Resource		

Electricity Source	Fuel Mix %	MWh
Wind	1.2362	3,969,110.80
Solar	0	0
Geothermal	0	0
Biomass	0.0666	213,691.10
Hydro	0.3139	1,007,804.10
Renewable Total	1.6166	5,190,606.00

Table 2-A: Electricity Use: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor (Optimized)				
Pump • Modification of existing pumps and inclusion of a VFD and omission of the recirculation component • Electrical usage reduction of 43% from existing conditions (based on O&M cost reduction projection in Table 2-6 of FBR Optimization Report)	• FBR Optimization Report • TT estimated continual operation for 30 year remedy (TT estimate)	1,035,748 kWh *SimaPro Assembly Name: Elec_Alt_2_Pump Materials/Assemblies used: 1000kWh ERCT/SRMV Source Mix AT CONSUMER Amount input: 1035.748 p*	1,035,748 kWh	
• Backup diesel pump that activates if the level reaches the high-level set point.	• Only used occasionally • To be considered "de minimis" for the sake of footprinting.	de minimis	de minimis	

Table 2-B: Fuel Use for Equipment: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor (Optimized)				
Off-road forklift for acid deliveries • Assuming 50% reduction in the amount of acetic acid and phosphoric acid required • TT estimated site continues to receive shipments on a quarterly basis (TT estimate)	• FBR Optimization Report (Table 2-4 estimates $4,000 per year for existing conditions) • Estimated to be 5 gallons of diesel fuel use per year or 150 gallons over the 30 year remedy. • Considered to be de minimis	de minimis	de minimis	
Sampling/O&M				
Field Truck • Gasoline • Assuming $3.00 per gallon	• FBR Optimization • Table 2-5 says $6,400 per year for gasoline • Result=2,133 gallons per year for 30 years	2133 x 30 = 64,000 gallons of gasoline used over the 30 year remedy *SimaPro Assembly Name: Fuel_Alt1_Field Truck Process used: Gasoline, combusted in equipment/US Amount input: 64000 gal**	64,000 gallons of gasoline into "Personnel Transportation – Road" by using 640,000 miles at 10 miles per gallon.	
Emergency Generator and Pump	• Diesel fuel • Cost lumped in with "toilet, ice locker, trash service", etc. ($8,200 per year) • Based on above information, fuel use for emergency generator assumed to be de minimis.	de minimis	de minimis	

Table 2-C: Materials Use: Alternative 2 (Optimization of Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor (Optimized)				
Granular Activated Carbon for FBR vessel • Initially filled with 11,900 pounds of GAC.	• Reports do not specify change out schedule • Estimated by TT to require replacement of approximately 10% of its total volume each year due to loss during normal operating procedures. • Assume virgin GAC	10% of 11,900= 1,190 lbs of replacement GAC per year 1,190 lbs x 30 yrs = 35,700 lbs of virgin GAC over the course of the remedy /2.2 kg per lb = 16227.27 *SimaPro Assembly Name: Material_Alt 1_FBR_GAC* *Materials/Assemblies used: GAC_1 kg Virgin* *Amount input: 16227.27 p*	35,700 lbs of Virgin GAC	
• Acetic acid	• FBR Optimization Report, 50% reduction (page 11) • Reduction based on site team estimates of usage for existing remedy (See Table 1-C) • 50% of existing usage of acetic acid = 0.50 x 94,575.6 lbs = 47287.8 lbs of acetic acid • 50 % of existing usage of water = 0.50 x 851180.4 lbs = 425590.2 lbs of water (51030 gallons of water)	47,287.8 lbs of acetic acid plus 51,030 gallons of water *SimaPro Assembly Name: Material_Alt2_FBR_AceticAcid10%* *Materials/Assemblies used: Acetic acid, 98% in H2O, at plant/RER U* *Amount input: 47287.8lb* *Materials/Assemblies used: Tap water, at user/RER S* *Amount input: 425590.2 lb*	47,287.8 lbs of acetic acid plus 51,030 gallons of water	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• Phosphoric acid	• FBR Optimization Report, 50% reduction, pg 11 • Reduction based on site team estimates of usage for existing remedy (See Table 1-C) • 50 % of existing usage of phosphoric acid = 0.50 x 16513.2 lbs = 8256.6 lbs of phosphoric acid • 50 % of existing usage of water = 0.50 x 660 gallons = 330 gallons x 8.34 lbs per gallon = 2752.2 lbs of water	300 gallons of phosphoric acid *SimaPro Assembly Name: Materials_Alt2_FBR_Phosphoric Acid* *Materials/Assemblies used: Phosphoric acid, fertiliser grade, 70% in H2O, at plant/US S* *Amount input: 8256.6 lb* *AND* *Materials/Assemblies used: Tap water, at user/RER S* *Amount input: 2752.2 lb*	8,256.6 lbs of phosphoric acid Plus 330 gallons of water (surrogate for phosphoric acid required by SiteWise: used acetic acid)	Use surrogate “Low Impact Material (Generic)”
Bag Filters • Polypropylene	• Site team reported using approximately 100 filter bags every three months (at 10 filter bags per pound) for existing conditions (see Table 1-C) • Bag filters and mass of filtered material can be halved for this alternative (TT estimate)	600 pounds *SimaPro Assembly Name: Material_Alt2_FBR_Filter bags* *Materials/Assemblies used: Polypropylene fibres (PP), crude oil based, production mix, at plant, PP granulate without additives (ELCD)* *Amount input: 600 lbs* *Dummy_Cement bags, at plant/US as a surrogate for filtered material* *Amount input: 18.6 tn.sh* *Manufacturing of surrogate for filtered material has no footprint. Material is added to the filter bag assembly so that it can be considered in the disposal scenario*	600 pounds (surrogate: HDPE liner)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
Electron Donor Replenishment (EOS™)	• PBR Report • TT estimated that biowalls for Area M only would require approximately 300 gallons per year • Typical s.g.of vegetable oil =1, therefore: 300 gallons x 8.33 lbs per gallon= 2499 lbs x 30 years= 74,970 lbs	74,970 lbs of vegetable oil *SimaPro Assembly Name: Materials_Alt1_Biowall_EOS* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U (surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations*	74,970 lbs of vegetable oil	
Sampling/O&M				
Sampling equipment • 25 wells sampled at Area M on an annual basis	• Estimated based on reduction recommendations in GW Optimization Report • Material consumed during sampling will be considered de minimis	de minimis	de minimis	

Table 2-D: Transport for Materials, Equipment, and Samples: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor (Optimized)				
Transport of Granular Activated Carbon (for FBR vessel)	• Required amount estimated by TT • 1,190 lbs GAC delivered once per year • TT estimated a vendor distance of 100 miles	0.6 tons x 100 miles one way= 60 ton-mile per year x 30 years= 1,800 ton-mile *SimaPro Assembly Name: Transport of Materials_Alt 1_FBR_ GAC* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 1800 tmi**	• Distance for delivery= 100 miles, one way • Weight per delivery=0.6 tons • Number of trips over remedy= 30 Empty return trips: • Distance = 100 miles, one way • Weight =0 tons • Number of trips over remedy= 30	Ton-mile basis (no empty trip)
Delivery of phosphoric acid to site	• TT estimate for existing conditions • Reduction of volume by half as per FBR Optimization Report • Acetic acid: 1800 gallons per year x (1 x 8.34 lbs/gallon)=15012 lbs= 7.5 tons per year • 27.5 gallons x (1.6 x 8.33 lbs/gallon)= 367 lbs= 0.18 tons • 7.7 tons per year / 4 deliveries per year = 1.925 tons delivered per quarter • TT estimated a vendor delivery distance of 100 miles	• ~1.925 tons total weight, if ¼ of annual need is delivered together on a quarterly basis • 150 miles, one way, 4 times per year for 30 years= 18,000 miles (Empty trips included) *SimaPro Assembly Name: Transport_Alt2_ phosphoric and acetic acid* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 34650 tmi**	• Distance for deliveries: 120 trips x 150 miles per trip= 18,000 miles • Weight per delivery trip is 1.925 tons • Distance for empty trips: 120 trips x 150 miles per trip= 18,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Bag Filters • TT estimated one half of the bag use as compared with existing conditions • Polypropylene • Site team reports distance to vendor of 170 miles • TT estimated that this trip would be a partial load dedicated to deliver this load so an empty trip should not be included for each delivery	• TT estimated that optimization would require one half the bags of the existing remedy or 200 bags per year for 30 years • TT estimated a delivery of 100 bags come twice per year, for 60 trips total • Assumptions for delivery frequency, transport distance and empty trips made by TT • Site team reports that 100 bags weigh less that 10 lbs	• Distance for deliveries: 60 trips x 170 miles per trip=10,200 miles • Weight per delivery trip is 10 lbs/2000 lbs per ton = 0.005 tons Note: No empty return trip should be included in footprint for this process. SimaPro may overpredict. *SimaPro Assembly Name: Transport of Bag Filters* *Process used: Transport, single unit truck, diesel powered/US (USLCI)* *Amount input: 51 tmi**	• Distance for deliveries: 60 trips x 170 miles per trip=10,200 miles • Weight per delivery trip is 0.005 tons • Bag filters represent 1% of the cargo on the truck from San Antonio to the vicinity of the site. Therefore, mileage should be 1% of the total miles (1% x 10,200 = 102 miles • Fuel: diesel No empty return trip.	Ton-mile basis
Transport of forklift for movement of phosphoric and acetic acid deliveries	• TT estimated average vendor used for heavy equipment is 50 miles away, one way • TT estimated 8,000 lbs average forklift • TT estimated quarterly use of forklift	• Distance: 8 trips per year with forklift x 30 years x 50 miles= 12,000 miles • Weight of forklift: 4 tons Empty trips included *SimaPro Assembly Name: Transport of Materials_Alt 1_FBR_ Forklift* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 48,000 tmi**	• Distance: 8 trips per year with forklift x 30 years x 50 miles= 12,000 miles • Weight of forklift: 4 tons • Distance: 8 return trips per year x 30 years x 50 miles=12,000 miles • Weight: 0 tons • Fuel type: diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
Biowall donor replenishment • TT estimated annual replenishment • TT estimated 100 miles, one way, to vendor	• PRB Report, pg. 34 • 300 gallons (maximum) per year with a s.g.= 0.96 to 1. Will calculate using 1. (http://www.eosremediation.com/products/Density.html • Weight: 300 gallons x 8.33 lbs per gallon= 2499 lbs = 1.25 tons per delivery	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons (Empty trips included) *SimaPro Assembly Name: Transport of Materials_Alt1_Biowalls_donor replen* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 3750 tmi**	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons • Distance for empty trips: 30 trips x 100 miles per trip=3,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)
Sampling/O&M				
Transport of Samples during Sampling Events (25 wells, a reduction of 19 wells from existing conditions, sampled once per year)	• Groundwater Optimization Report • TT professional estimate based on 2 people performing the sampling, 2 wells sampled per day, 2 coolers produced per day for 13 days per year. • Site team reported a distance of 785 miles to lab, one way • Weight per shipment trip is 2 x 30 lbs (0.03 tons)	• Distance for deliveries: 13 sampling days per year x 30 years x 785 miles per one way trip=306,150 miles • Weight per shipment ~0.03tons Air transport *SimaPro Assembly Name: Transport_Alt2_Coolers for sampling* *Process used: Transport, aircraft, freight/US* *Amount: 9184.5 tmi**	• Distance for pick up: 13 sampling days per year x 30 years x 785 miles per one way trip=306,150 miles • Weight per shipment ~0.03 tons Air transport*	

Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.

Table 2-E: Waste Transport/Disposal: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor				
Bag Filters • TT estimated bag usage at half the filter bags as compared to existing conditions= 200 bags per year • Polypropylene • TT estimated 100 miles to landfill	• TT estimated annual disposal • TT estimated non-hazardous landfill • TT estimated 25 miles to landfill, one annual trip	• Distance to landfill: 30 trips x 25 miles per one way trip=750 miles • Weight per trip is 0.02 tons + 0.6 tons (excess carbon loss)= 0.62 ton total per trip *Name: Waste Transport of Bag Filters_Alt2 Process used: Transport, single unit truck, diesel powered/US Amount input: 465 tmi** *Disposal: Referring to assembly: Material_Alt2_FBR_Filter bags (total weight of 18.6 tn.sh) Waste treatment is Disposal, concrete, 5% water, to inert material landfill/CH U*	• Distance for deliveries: 30 trips x 25 miles per trip=750 miles • Weight per delivery trip is 0.62 tons No empty return trip 0.62 tons x 30 years= 18.6 tons disposed in non-hazardous landfill (total remedy) Input to SiteWise: 19 tons	Ton-mile basis (no empty trip)

Table 2-F: Transport for Personnel: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor (Optimized)				
Transport for one technician for daily reduced by 50% from existing conditions	• Site team reports that there is typically one technician on-site no less than two days per week for existing conditions, so one technician, once per week for optimized conditions • Site team reported this technician is traveling approximately 140 miles, one way.	1 days per week x 52 weeks per year x 30 years x 140 miles = 218,400 miles by car *SimaPro Assembly Name: Transport for Personnel_Alt1_FBR Materials/Assemblies used: Transport, passenger car/RER U Amount input: 218400 pmi*	218,400 miles by car (gasoline) Labor: 1*52*8*30=12,480 hrs of operator	
Biowalls				
Transport for personnel, estimated at a total of 12 trips, includes: • Personnel to inject carbon into biowall • Pump maintenance (TT estimated quarterly maintenance) • Emergency generator and diesel pump maintenance • Air compressor maintenance o Electrician	• Table 2-5 of FBR Optimization Report • Assumptions of number of personnel and frequency of visits estimated by TT. • 12 visits per year x 30 years = 360 trips • TT estimated one person driving car (gasoline) for 50 miles trip, one way.	360 trips x 100 miles = 36,000 miles traveled by car *SimaPro Assembly Name: Transport for Personnel_Alt1_Biowall Process used: Transport, passenger car/RER U Amount input: 36000pmi*	36,000 miles traveled by car, gasoline Single passenger Labor: 360*8=2880 hrs of operator	
Sampling/O&M				
Transport for personnel for sampling events	• TT estimated 13 trips per year (25 wells, 2 people sampling) • TT estimated each person drives individual vehicle to site (light truck) • TT estimated a distance of 50 miles, one way	780 trips x 100 miles = 78,000 miles by car *SimaPro Assembly Name: Transport for Personnel_Alt2_Sampling Process used: Transport, passenger car/RER U Amount input: 78000 pmi*	78,000 miles Car, gasoline Single passenger Labor: 780*8=6240 hrs	

Table 2-G: Potable Water Use: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowall				
Water use for EVO replenishment based on a 1:7 ratio (EVO to water) for injections.	• FBR Optimization Report and TT professional estimate. • EVO use estimated to be 300 gallons per year • Assume use of potable water from local hydrant (TT estimate)	300 x 7 = 2100 gallons per year x 30 years = 63,000 gallons x 8.34 lbs per gallon = 525,420 lbs *SimaPro Assembly Name: Potable Water_Alt 1_Biowall_EVO replen* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 525420 lbs*	63,000 gallons of potable water	
Water used to create solutions for acetic acid and phosphoric solutions		No input for SimaPro. Water is accounted for upon choosing solution type.	Water use included with acetic and phosphoric acid solutions in Table C, “Material Use”	

Table 2-H: Non-Potable Water Use: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 2-I: Known Use of On-Site Renewables: Alternative 2 (Optimization of Alternative 1)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 3-A: Electricity Use: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction/IX				
Electrical Usage • Electrical usage reduction of 57% from existing conditions (based on FBR Optimization Report, Table 2-6, electricity cost data)	• FBR Optimization Report • TT estimated continual operation for 30 year remedy • This option likely includes modification of existing pumps and inclusion of a VFD and omission of the recirculation component for the IX resin option to achieve the reduction in energy consumption noted in Table 2-6.	781,354 kWh *SimaPro Assembly Name: Electricity_Alt 3_Ex/IX Materials/Assemblies used: 1000kWh ERCT/SRMV Source Mix AT CONSUMER Amount input: 781.354 p*	781,354 kWh	
Backup diesel pump that activates if the level reaches the high-level set point.	• Only used occasionally • To be considered “de minimis” for the sake of footprinting.	de minimis	de minimis	

Table 3-B: Fuel Use for Equipment: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Demolition of Fluidized Bed Reactor				
Heavy Equipment for the Demolition of FBR and construction of concrete pad for IX vessels • TT estimated excavator for five days	• No mention of this in FBR Optimization Report • Estimates based on professional judgment • Excavator: 5 days at 50 gallons per day	250 gallons of diesel *SimaPro Assembly Name: Fuel Use_Alt 3_FBR_Equip for Demo* *Process used:: Diesel, combusted in industrial equipment /US* *Amount input: 250 gal*	250 gallons of diesel Labor: Assume crew of two for 40 hours, total of 80 hrs of Construction under RA-C	
Sampling/O&M				
Field Truck • Gasoline • Assuming $3.00 per gallon	• FBR Optimization • Table 2-6 says $2,600 per year for gasoline • Result=867 gallons per year for 30 years	867 x 30 = 26,000 gallons of gasoline used over the 30 year remedy *SimaPro Assembly Name: Fuel Use_Alt3_O&M_Field Truck* *Process used: Gasoline, combusted in equipment/US* *Amount input: 26000 gal*	26,000 gallons of gasoline into "Personnel Transportation – Road" by using 260,000 miles at 10 miles per gallon.	
Emergency Generator and Pump	• Diesel fuel • Cost lumped in with "toilet, ice locker, trash service", etc. ($8,200 per year) • Based on above information, fuel use for emergency generator TT estimated to be de minimis.	de minimis	de minimis	

Table 3-C: Materials Use: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction/IX				
Sand filter • Designed for 500 gpm to match IX capacity design	-Steel for vessel: TT estimated to be 9' high by 12' in diameter for ~ 12,000 lbs of steel -36,000 lbs of concrete for 250 ft3 concrete slab -625 lbs of steel reinforcement in slab	• Steel: 12,000 lbs. for vessel plus 625 lbs for concrete slab reinforcement • Cement: 36,000 lbs *SimaPro Assembly Name: Material Use_Alt3_EX/IX_Sand Filter* *Materials/Assemblies used: Iron and steel, production mix/US (USLCI)* *Amount input: 12000 lb* *AND* *Materials/Assemblies used: Reinforcing steel, at plant/RER U (Ecoinvent)* *Amount input: 625 lb* *AND* *Materials/Assemblies used: Cement, unspecified, at plant/CH U (Ecoinvent)* *Amount input: 36000 lb*	• Steel: 12,000 lbs. for vessel plus 625 lbs for reinforcement • Concrete: 36,000 lbs	
Sand -340 ft^3 initial filling, -change out every 8 years	-Sand (TT estimated 100 lbs per ft^3) -34,000 lbs of sand per fill, delivered 4 times over the course of the remedy= 4 x 34,000 =136,000 lbs total sand necessary for remedy.	136,000 lbs sand *SimaPro Assembly Name: Material Use_Alt3_EX/IX_Sand* *Materials/Assemblies used: Silica sand, at plant/DE U (Ecoinvent)* *Amount input: 136000 lb*	136,000 lbs sand	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Resin • Initial three vessels filled with 42,000 lbs. • Change out frequency of lead vessel every 8 months • 14,000 lbs. of resin per vessel	• 42,000 lbs. for the initial fill of the three vessels • Change out frequency for lead resin vessel (first in series of the three vessels) estimated to be once every 8 months (14,000 lbs every 8 months)	42,000 + ((12*30)/8)*14,000)= 672,000 lbs of resin *SimaPro Assembly Name: Material Use_Alt3_EX/IX_Resin* *Materials/Assemblies used: Cationic resin, at plant/CH U (Ecoinvent)* *Amount input: 672000 lb*	672,000 lbs of ion exchange resin	
IX vessel construction • Steel (8' diameter, 7' high) • 15,500 lbs for each of the three vessels	• Reference FSB Optimization Report for reference to use of "HP 810 Sys by Siemens" (http://www.water.siemens.com/SiteCollectionDocuments/Product_Lines/Westates_Carbon/Brochures/WS-HP-DS-0910.pdf	15,500 lbs x 3 vessels= 46,500 lbs of steel *SimaPro Assembly Name: Material Use_Alt3_EX/IX_IX vessel construction* *Materials/Assemblies used: Iron and steel, production mix/US(USLCI)* *Amount input: 46500 lb*	46,500 lbs of steel	
Concrete Slab for IX vessel placement	• Estimated through professional judgment • 400 ft^3 • 57,600 lbs of concrete • 1000 lbs of steel for reinforcement	• 57,600 lbs of concrete • 1000 lbs of steel *SimaPro Assembly Name: Material Use_Alt3_EX/IX_Slab for IX vessel* *Materials/Assemblies used: Reinforcing steel, at plant/RER U* *Amount input: 1000 lbAND* *Materials/Assemblies used: Cement, unspecified, at plant/CH U* *Amount input: 57600 lb*	• 57,600 lbs of concrete • 1000 lbs of steel	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
• Electron Donor Replenishment (EOS[TM]) for biowalls	• PBR Report • TT estimated that biowalls for Area M only would require approximately 300 gallons per year • Typical s.g. of vegetable oil =1, therefore: 300 gallons x 8.33 lbs per gallon= 2499 lbs x 30 years= 74,970 lbs	74,970 lbs of vegetable oil *SimaPro Assembly Name: Materials_Alt1_Biowall_EOS* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U (surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations*	74,970 lbs of vegetable oil	
Sampling/O&M				
Sampling equipment • 25 wells sampled at Area M on an annual basis	• Estimated based on reduction recommendations in GW Optimization Report • Material consumed during sampling will be considered de minimis	de minimis	de minimis	

Table 3-D: Transport for Materials, Equipment, and Samples: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction/IX				
Transport of Sand	• Estimated by TT • 4 deliveries of 34,000 lbs of sand • Vendor distance of 100 miles	• Distance for delivery: 4 trips x 100 miles per trip=400 miles Weight per delivery trip is 17 tons *SimaPro Assembly Name: Transport of Materials_Alt3_EX/IX_Sand* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 6800 tmi**	• Distance for delivery: 4 trips x 100 miles per trip=400 miles • Weight per delivery trip is 17 tons • Distance for empty trips: 4 trips x 100 miles per trip=400 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)
Transport of concrete for slab (for IX vessel placement)	• Estimated by TT • TT estimated 3,300 lbs per cubic yd • 18 cubic yards total • TT estimated 9 cubic yard loads per truckload, for 2 loads of concrete (2 round trips) • TT estimated vendor distance of 50 miles	• Distance for delivery: 2 trips x 50 miles per trip=100 miles Weight per delivery trip is 15 tons *SimaPro Assembly Name: Transport of Materials_Alt3_EX/IX_Cement* *Process used: Transport, lorry >16t, fleet average/RER UAmount input: 1500 tmi**	• Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 15 tons • Distance for empty trips: 2 trips x 50 miles per trip=100 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of concrete for slab (for sand filter vessel placement)	• Estimated by TT • TT estimated 3,300 lbs per cubic yd • 11 cubic yards total (approximately 18 tons of concrete) • TT estimated 9 cubic yard loads per truckload, for 2 loads of concrete (2 round trips), each with approximately 9 tons of concrete • TT estimated vendor distance of 50 miles	• Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 9 tons *SimaPro Assembly Name: Transport of Materials_Alt3_EX/IX_Cement SF slab* *Process used: Transport, lorry >16t, fleet average/RER U* *Amount input: 900 tmi**	• Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 9 tons • Distance for empty trips: 2 trips x 50 miles per trip=100 miles • Weight per empty trip is 0 tons • Diesel	Ton-mile basis (no empty trip)
Transport of sand filter vessels to site	• Weight and vendor distance estimated by TT • 12,000 lbs + 625 lbs = 12,625 lbs total weight / 2000 lbs per ton = 6.5 tons • TT estimated vendor distance of 50 miles • One round trip	• Distance for delivery: 1 trips x 50 miles per trip=50 miles • Weight per delivery trip is 6.5 tons • *SimaPro Assembly Name: Transport of Materials_Alt3_EX/IX_SF vessels* *Process used: Transport, lorry >16t, fleet average/RER U* *Amount input: 325 tmi**	• Distance for delivery: 1 trips x 50 miles per trip=50 miles • Weight per delivery trip is 6.5 tons • Distance for empty trips: 1 trips x 50 miles per trip=50 miles • Weight per empty trip is 0 tons • Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of IX vessels to site	• Weight and vendor distance estimated by TT • 15,500 x 3 vessels = 46,500 lbs / 2000 lbs per ton = 23.25 tons • TT estimated vendor distance of 500 miles • One round trip	• Distance for delivery: 1 trips x 500 miles per trip=500 miles • Weight per delivery trip is 23 tons *SimaPro Assembly Name: Transport of Materials_Alt3_EX/IX_IX vessels* *Process used: Transport, lorry >32t, EURO5/RER U* *Amount input: 11500 tmi**	• Distance for delivery: 1 trips x 500 miles per trip=500 miles • Weight per delivery trip is 23 tons • Distance for empty trips: 1 trips x 500 miles per trip=500 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of IX for initial fill and for change outs	• Change outs every 8 months • 1 round trip with 42,000 lbs (for initial fill) for all three vessels • 42,000 lbs / 2000 lbs per ton = 21 tons • 45 round trips (for change out every 8 months) with 14,000 lbs for each change out • 14,000 lbs / 2000 lbs per ton = 7 tons • TT estimated vendor distance of 500 miles	• Distance for initial delivery: 1 trips x 500 miles per trip=500 miles • Weight per delivery trip is 21 tons AND • Distance for change out delivery: 45 trips x 500 miles per trip=22,500 miles Weight per delivery trip is 7 tons *SimaPro Assembly Name: Transport of Materials_Alt3_EX/IX_resin* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 10500 tmi** *AND* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 157500 tmi**	• Distance for initial delivery: 1 trips x 500 miles per trip=500 miles • Weight per delivery trip is 21 tons • Distance for empty trips: 1 trips x 500 miles per trip=500 miles • Weight per empty trip is 0 tons AND • Distance for change out delivery: 45 trips x 500 miles per trip=22,500 miles • Weight per delivery trip is 7 tons • Distance for empty trips: 1 trips x 500 miles per trip=22,500 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of the excavator	• TT estimated 26 ton excavator • Two round trips (one for drop off and one to pick up at end of construction) • TT estimated vendor distance of 50 miles	• Distance for delivery: 2 trips x 50 miles one way=100 miles one way • Weight per delivery trip is 26 tons *SimaPro Assembly Name: Transport of Materials_Alt3_Excavator* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 2600 tmi**	• Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 26 tons • Distance for empty trips: 2 trips x 50 miles per trip=100 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)
Transport of the crane for initial offload of initial resin and for each change out of the resin.	• TT estimated a 22 ton crane • 45 changeouts + initial fill= 46 trips • TT estimated a 50 miles to vendor	• Distance for delivery: 46 trips x 50 miles one way=2300 miles Weight per delivery trip is 22 tons *SimaPro Assembly Name: Transport of Materials_Alt3_EX/IX_Crane* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 50,600 tmi**	• Distance for delivery: 46 trips x 50 miles per trip=2300 miles • Weight per delivery trip is 22 tons • Distance for empty trips: 46 trips x 50 miles per trip=2300 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
Biowall donor replenishment • TT estimated annual replenishment • TT estimated 100 miles, one way, to vendor	• PRB Report, pg. 34 • 300 gallons (maximum) per year with a s.g.= 0.96 to 1. Will calculate using 1. (http://www.eosremediation.com/products/Density.html • Weight: 300 gallons x 8.33 lbs per gallon= 2499 lbs = 1.25 tons per delivery	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons (Empty trips included) *SimaPro Assembly Name: Transport of Materials_Alt1_Biowalls_donor replen Process used: Transport, single unit truck, diesel powered/US* *Amount input: 3750 tmi**	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons • Distance for empty trips: 30 trips x 100 miles per trip=3,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)
Sampling/O&M				
Transport of Cooler during sampling events • Similar to existing condition (Table 1-D) • Sampling Events (44 wells sampled once per year) • TT estimated 1 well per cooler, or 22 coolers total, used annually • TT estimated 30 lbs when full of samples • TT estimated air transport	• Groundwater Optimization Report • TT estimated sample transport based on 2 people performing the sampling, 2 wells sampled per day, 2 coolers produced per day for 22 days per year. • Site team reports that the location of the lab is approximately 785 miles from the site • Weight per shipment trip is 2 x 30 lbs (0.03 tons)	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip= 518100 miles • Weight per shipment= 0.03 tons • Air transport *Name: Transport of Materials_Alt1_O&M_Samples Process used: Transport, aircraft, freight/US* *Amount input: 15543 tmi**	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip=518100 miles • Weight per shipment = 0.03 tons • Air transport*	

**Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.*

Table 3-E: Waste Transport/Disposal: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor Demolition				
Demo waste from FBR -carbon, steel, scraps, pipes, pumps	• Assumed de minimis (estimated to be one roll off, once time during the remedy)	de minimis	de minimis	
Extraction/IX				
Sand from sand filter change out	• 34,000 lbs per trip x 3 trips to non-hazardous landfill (total of 51 tons) • TT estimated landfill distance is 25 miles	• Distance for transport to landfill: 3 trips x 25 miles one way=75 miles • Weight per delivery trip is 17 tons *SimaPro Assembly Name: Waste Transport_Alt3_EX/IX_sand* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 1275 tmi** Non-hazardous landfill *Refers to assembly Materials Use_Alt3_EX/IX_Sand, which includes 68 tons* *75% (51 tons) of the total sand assembly is allocated to a disposal scenario with a footprint* *25% (remaining 17 tons) of total sand assembly is allocated to a dummy disposal process with no footprint* *Waste Scenario/Treatment: Disposal, concrete, 5% water, to inert material landfill/CH S*	• Distance for transport to landfill: 3 trips x 25 miles per trip=75 miles • Weight per delivery trip is 17 tons • Distance for empty trips: 3 trips x 25 miles per trip=75 miles • Weight per empty trip is 0 tons Diesel Placement of 51 tons of sand in non-hazardous landfill	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
IX change out material to landfill	• Total mass of resin used is 672,000 lbs, which is 14,000 lbs (7 tons) per vessel with initial filling of 3 vessels and 45 subsequent changeouts over life of remedy • 45 disposal trips from 7 ton changeouts and 1 final disposal trip with 21 tons14,600 lbs (7.3 tons) per trip, which is the average calculated from 672,000 lbs divided by 46 total trips • TT estimated landfill distance is 25 miles	• Distance for transport to landfill: 46 trips x 25 miles one way=1,150 miles Weight per delivery trip is 7.3 tons *SimaPro Assembly Name: Waste Transport_Alt3_EX/IX_resin* *Process used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 8,395 tmi** *Non-hazardous landfill* *Process: Waste Specification* *Name: 1-Disposal of Alt3 Resin* *Amount: 672000 lb* *Waste Scenario/Treatment: Disposal, concrete, 5% water, to inert material landfill/CH U (Ecoinvent)*	• Distance for transport to landfill: 46 trips x 25 miles per trip=1,150 miles • Weight per delivery trip is 7.3 tons • Distance for empty trips: 46 trips x 25 miles per trip=1,150 miles • Weight per empty trip is 0 tons Diesel Placement of 336 tons of IX resin into non-hazardous landfill	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Sludge from sand filter	• Estimated by TT • 2000 lbs per year based on similar processes • TT estimated non-hazardous landfill • TT estimated landfill distance is 25 miles • TT estimated storage in drums and annual pick up for transport to landfill • TT estimated backwash water goes to head of treatment or to Lagoon A	• Distance for transport to landfill: 30 trips x 25 miles one way=750 miles Weight per delivery trip is 1 tons *SimaPro Assembly Name: Waste Transport_Alt3_EX/IX_sludge from SF* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 750 tmi** *Placement of 30 tons of sludge into non-hazardous landfill: Life Cycle Process, Waste Specification Name: "Alt 3 Sludge Waste Scenario: Inert to Sanitary Landfill"* *Waste Scenario/Treatment: Disposal, inert material, 0% water, to sanitary landfill/CH S*	• Distance for transport to landfill: 30 trips x 25 miles per trip=750 miles • Weight per delivery trip is 1 tons • Distance for empty trips: 30 trips x 25 miles per trip=750 miles • Weight per empty trip is 0 tons Diesel for transportation fuel Placement of 30 tons of sludge into non-hazardous landfill	Ton-mile basis (no empty trip)

Table 3-F: Transport for Personnel: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Sampling/O&M				
Transport for personnel to and from sampling events -Similar to the sampling plan not optimized	• TT estimated 22 trips per year (44 wells, 2 people sampling) • TT estimated each person drives individual vehicle to site (light truck) • TT estimated a distance of 50 miles, one way	2 vehicles x 22 trips per year x 100 miles round trip x 30 years = 132,000 miles *SimaPro Assembly Name: Transport for Personnel_Alt3_O&M* *Processes used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 132000 pmi*	1320 trips x 100 miles = 132,000 miles 1 person per vehicle, car, gasoline Labor: 1320*8=10,560 hrs of scientific/tech	
Biowall				
Transport for personnel, estimated at a total of 12 trips, includes: • Personnel to inject carbon into biowall • Pump maintenance (TT estimated quarterly maintenance • Emergency generator and diesel pump maintenance • Air compressor maintenance o Electrician	• Table 2-5 of FBR Optimization Report • Assumptions of number of personnel and frequency of visits estimated by TT. • 12 visits per year x 30 years = 360 trips • TT estimated one person driving car (gasoline) for 50 miles trip, one way.	360 trips x 100 miles = 36,000 miles traveled by car *SimaPro Assembly Name: Transport for Personnel_Alt1_Biowall* *Materials/Assemblies used: Transport, passenger car/RER U* *Amount input: 36000 miles*	36,000 miles traveled by car, gasoline One passenger per vehicle Labor: 360*8=2880 hrs of operator	
EX/IX				
Transport for one technician for daily reduced by 60% from existing conditions	• Existing conditions estimated 547,00 miles by car over the life of the remedy • 547,000 x 0.4 = ~219,000 miles • Reduction based on FBR Optimization Report (based on reduction in labor cost)	219,000 miles by car *SimaPro Assembly Name: Transport for Personnel_Alt3_EX/IX* *Process used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 219000* pmi	219,000 miles by car, gasoline One passenger per car Labor: 24960 existing cond * 0.4 = 9984 hrs of operator	

Table 3-G: Potable Water Use: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowall				
Water use for EVO replenishment based on a 1:7 ratio (EVO to water) for injections.	• FBR Optimization Report and TT professional estimate. • EVO use estimated to be 300 gallons per year • TT estimatedd use of potable water from local hydrant	300 x 7 = 2100 gallons per year x 30 years = 63,000 gallons x 8.34 lbs per gallon = 525,420 lbs *SimaPro Assembly Name: Potable Water_Alt 1_Biowall_EVO replen* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 525420 lbs*	63,000 gallons of potable water	

Table 3-H: Non-Potable Water Use: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 3-I: Known Use of On-Site Renewables: Alternative 3 (Extraction, IX, Biowalls, O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 4-A: Electricity Use: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction/GBR				
Electrical Usage • Electrical usage reduction of 57% from existing conditions (based on FBR Optimization Report, Table 2-7, electricity cost data)	• FBR Optimization Report • TT estimated continual operation for 30 year remedy • This option likely includes modification of existing pumps and inclusion of a VFD and omission of the recirculation component for the GBR option to achieve the reduction in energy consumption noted in Table 2-7.	781,354 kWh *SimaPro Assembly Name: Electricity_Alt 4_GBR Assembly used: 1000kWh ERCT/SRMV Source Mix AT CONSUMER Amount input: 781.354 p*	781,354 kWh	
Backup diesel pump that activates if the level reaches the high-level set point.	• Only used occasionally • To be considered “de minimis” for the sake of footprinting.	de minimis	de minimis	

Table 4-B: Fuel Use for Equipment: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Demolition of Fluidized Bed Reactor				
Demolition of FBR • TT estimated excavator for two days	• No mention of this in FBR Optimization Report • 2 days at 50 gallons per day	100 gallons of diesel *SimaPro Assembly Name: Fuel Use_Alt4_FBR Demo* *Process used: Diesel, combusted in industrial equipment /US* *Amount input: 100 gal*	100 gallons of diesel Assume a total of 80 hours of construction labor is needed for the conversion from FBR to GBR.	
Gravel Bed Reactor				
Construction equipment for excavation of area to house GBR • Excavator to remove 350 yd^3	• Excavator • Removal of 350 yd^3	• Excavator • Removal of 350 yd^3 *SimaPro Assembly Name: Fuel Use_Alt4_GBR_excavator* *Process used: Excavation, hydraulic digger/RER U* *Amount input: 350 cu.yd*	• Excavator • Removal of 350 yd^3	
Sampling O&M				
Field Truck • Gasoline • Assuming \$3.00 per gallon	• FBR Optimization • Table 2-7 says \$3,000 per year for gasoline • Result=1,000 gallons per year for 30 years	1,000 x 30 = 30,000 gallons of gasoline used over the 30 year remedy *SimaPro Assembly Name: Fuel Use_Alt4_O&M_field truck* *Process used: Gasoline, combusted in equipment /US* *Amount input: 30000 gal*	30,000 gallons of gasoline into “Personnel Transportation – Road” by using 300,000 miles at 10 miles per gallon.	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Emergency Generator and Pump	• Diesel fuel • Cost lumped in with "toilet, ice locker, trash service", etc. ($8,200 per year) • Based on above information, fuel use for emergency generator assumed to be de minimis.	De minimis	De minimis	

Table 4-C: Materials Use: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction/GBR				
Construction of concrete GBR -TT estimated 20' x 40 ' x 12' (~350 yd^3) - wall thickness of 1' -10 x the size of the FBR=70,000 gallons -TT estimated open top design	• Size based on estimate from FBR Optimization Report • 2240 ft^3 of concrete=83 yd^3 • At 94 lbs per cubic foot (EPA, 2012), 83 yd^3 x 27 ft^3 per yd^3 x 94 lbs per ft^3 = 210654 lbs of cement	210654 lbs of cement *SimaPro Assembly Name: Material Use_Alt4_GBR_construction* *Process used: Cement, unspecified, at plant/CH U* *Amount input: 210654 lb*	83 yd^3 of concrete Input to SiteWise: 331,004 lbs (Based on a conversion factor for cement of 3,988 lbs per yd3 (SiteWise Table 1-C reports Hammond, 2008 as 2730 kg/m3 for general concrete))	
Gravel fill for GBR -350 yd^3 initial fill -TT estimated change out every 5 years	• TT calculations based on estimated design dimensions • Course gravel (as per FBR Optimization Report), TT estimated between ½ inch to 1 inch diameter, based on photo in FBR Optimization Report • Change out not listed in report, but is based on TT professional judgment • At 1.5 tons per cu. yd, 2450 yd^3 x 1.5 tons per yd^3 = 3675 tons	3675 tons of gravel (7,350,000 lbs) *SimaPro Assembly Name: Material Use_Alt4_GBR_gravel fill* *Process used: Gravel, unspecified, at mine/CH U* *Amount input: 3675 tn.sh*	2,450 yd^3 of gravel Input to SiteWise: 6,913,900 lbs (Based on a conversion factor for gravel of 2822 pounds per cubic yard or 1.411 tons per yard)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Acetic acid for Electron Donor to GBR • Donor is similar to FBR	• FBR Optimization Report • Site team input estimates: 3,600 gallons per year of acetic acid or 31,500 lbs (solution) per year (equating to a specific gravity of 1.05) • TT estimated a 10% solution • Acetic acid = 108,000 gallons x 8.34 lbs per gallon x 1.05 x 0.10 = 94,575.6 lbs of acetic acid • Water = 108,000 gallons x 8.34 lbs per gallon x 1.05 x 0.90/8.34 = 102,060 gallons of water	94,575.6 lbs of acetic acid 102,060 gallons of water *SimaPro Assembly Name: Material_Alt1_FBR_AceticAcid10%* *Materials/Assemblies used: Acetic acid, 98% in H2O, at plant/RER/U* *Amount input: 94575.6 lbs* *AND* *Materials/Assemblies used: Tap water, at user/RER* *Amount input: 892880.4lbs*	94,575.6 lbs of acetic acid 102,060 gallons of water	
Phosphoric acid for electron donor to GBR • Donor is similar to the FBR	• Site team estimate: 55 gallons, or 700 lbs of phosphoric acid per year of phosphoric acid • TT estimated a 75% solution, specific gravity ~1.6) • Phosphoric Acid: 1650 gallons x 8.34 lbs per gallon x 1.6 x 0.75 = 16513.2 lbs of phosphoric acid • Water = 1650 gallons x 8.34 lbs per gallon x 1.6 x 0.75/8.34 = 660 gallons of water	16513.2 lbs of phosphoric acid AND 660 gallons of water Note: water for use in preparation of solution is accounted for prior to delivery to site *SimaPro Assembly Name: Materials_Alt 1_FBR_Phosphoric Acid* *Materials/Assemblies used: Phosphoric acid, fertilser grade, 70%, at plant/U S* *Amount input: 16513,2 lb* *AND* *Assembly used: Tap water, at user/RER S* *Amount input: 5504.4 lbs*	16513.2 lbs of phosphoric acid AND 660 gallons of water (Input to SiteWise required a surrogate for phosphoric acid. User chose "acetic acid".) (Input rounded to 16513 by user)	Use surrogate "Low Impact Material (Generic)"

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
Electron Donor Replenishment (EOS™)	• PBR Report • TT estimated that biowalls for Area M only would require approximately 300 gallons per year • Typical s.g. for vegetable oil=1, therefore: 300 gallons x 8.33 lbs per gallon= 2499 lbs x 30 years= 74,970 lbs	74,970 lbs of vegetable oil *SimaPro Assembly Name: Materials_Alt1_Biowall_EOS* *Materials/Assemblies used:* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U* *(surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations*	74,970 lbs of vegetable oil	
Sampling/O&M				
• Sampling equipment • 44 wells sampled at Area M on an annual basis	• Estimated based on reduction recommendations in GW Optimization Report • Material consumed during sampling will be considered de minimis	de minimis	de minimis	

Table 4-D: Transport for Materials, Equipment, and Samples: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction/GBR				
Transport of gravel	• Each change out requires 18 truckloads of ~20 yd^3 each (350 yds^3 total) x 7 events (initial plus 6 change outs)=126 round trips • ~30 tons of gravel each trip (assuming 1.5 tons per yd^3) • TT estimated distance to gravel vendor is 50 miles •	• Distance for delivery: 126 trips x 50 miles per trip=6,300 miles Weight per delivery trip is 30 tons *SimaPro Assembly Name: Transport of Materials_Alt4_GBR_gravel* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 189,000 ton-mile**	• Distance for delivery: 126 trips x 50 miles per trip=6,300 miles • Weight per delivery trip is 30 tons • Distance for empty trips: 126 trips x 50 miles per trip=6,300 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)
Transport for heavy equipment for construction of GBR, initial gravel loading and change out loading	• 14 round trips (initial plus 6 gravel change out events, transport vehicle will drop off, leave and come back to site to pick up equipment) • 30 tons excavator • TT estimated distance of 50 miles	• Distance for delivery: 14 trips x 50 miles per trip=700 miles Weight per delivery trip is 30 tons *SimaPro Assembly Name: Transport of Materials_Alt4_GBR_hvy equip* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 21000 ton-mile*	• Distance for delivery: 14 trips x 50 miles per trip=700 miles • Weight per delivery trip is 30 tons • Distance for empty trips: 14 trips x 50 miles per trip=700 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of concrete	• ~10 round trips for concrete trucks (83 yd^3 total, from Table 4-C) • Each trip volume = 9 yd^3 at 1.95 tons per cubic yard = ~18tons • TT estimated distance to concrete vendor = 50 miles	• Distance for delivery: 10 trips x 50 miles per trip=500 miles Weight per delivery trip is 18 tons *SimaPro Assembly Name: Transport of Materials_Alt4_GBR_cement* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 9,000 ton-mile*[*]	• Distance for delivery: 10 trips x 50 miles per trip=500 miles • Weight per delivery trip is 18 tons • Distance for empty trips: 4 trips x 100 miles per trip=500 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)
Transport of forklift for movement of phosphoric and acetic acid deliveries	• TT estimated same as Existing Conditions • TT estimated average vendor used for heavy equipment is 50 miles away, one way • TT estimated delivery vehicle drops off equipment, leaves and returns on a separate day for pick up • TT estimated 8,000 lbs average forklift • TT estimated quarterly use of forklift	• Distance: 8 trips per year with forklift x 30 years x 50 miles= 12,000 miles • Weight of forklift: 4 tons Empty trips included *SimaPro Assembly Name: Transport of Materials_Alt 1_FBR_ Forklift* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 48,000 ton-mile*	• Distance: 8 trips per year with forklift x 30 years x 50 miles= 12,000 • Weight of forklift: 4 tons • Distance: 8 return trips per year x 30 years x 50 miles=12,000 miles • Weight: 0 tons • Fuel type: diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Delivery of phosphoric and acetic acid solution to site	• TT estimate: 900 gallons of acetic acid (s.g.=~1) and 13.75 gallons of phosphoric acid (s.g.=~1.6) are delivered together four times per year • 900 gallons x (1. x 8.34 lbs/gallon)=7506 lbs= 3.75 tons per quarter • 13.75 gallons x (1.6 x 8.34 lbs/gallon)= 183.5 lbs= 009 tons per quarter • Site team reported a vendor delivery distance of 150 miles • TT estimated quarterly deliveries or 120 deliveries of 3.84 tons of solutions.	• 3.84 tons total weight, delivered together • 150 miles, one way, 4 times per year for 30 years= 18000 miles (Empty trips included) *SimaPro Assembly Name: Transport of Materials_Alt 1_FBR_acids* *Process used: Transport, single truck, diesel powered/US* *Amount input: 69,120 ton-mile*	• Distance for deliveries: 120 trips x 150 miles per trip=18,000 miles • Weight per delivery trip is 3.84 tons • Distance for empty trips: 120 trips x 150 miles per trip=18,000 miles • Weight per empty trip is 0 tons Fuel: diesel	Ton-mile basis (no empty trip)
Biowalls				
Transport of biowall donor replenishment	• PRB Report, pg. 34 • 300 gallons (maximum) per year with a s.g.= 1. (http://www.eosremediation.com/products/Density.html • Weight: 300 gallons x 8.33 lbs per gallon= 2499 lbs = 1.25 tons per delivery • TT estimated annual replenishment TT estimated 100 miles, one way, to vendor	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons (Empty trips included) *SimaPro Assembly Name: Transport of Materials_Alt1_Biowalls_donor replen* *Process used: Transport, single unit truck, diesel powered/US* *Amount input: 3750 ton-mile*	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons • Distance for empty trips: 30 trips x 100 miles per trip=3,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Sampling/O&M				
Transport of Cooler during sampling events • Similar to existing condition (Table 1-D) • Sampling Events (44 wells sampled once per year) • TT estimated 1 well per cooler, or 22 coolers total, used annually • TT estimated 30 lbs when full of samples • TT estimated air transport	• Groundwater Optimization Report • TT estimated sample transport based on 2 people performing the sampling, 2 wells sampled per day, 2 coolers produced per day for 22 days per year. • Site team reports that the location of the lab is approximately 785 miles from the site • Weight per shipment trip is 2 x 30 lbs (0.03 tons)	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip= 518100 miles • Weight per shipment= 0.03 tons • Air transport *Name: Transport of Materials_Alt1_O&M_Samples* *Process used: Transport, aircraft, freight/US* *Amount input: 15,543 ton-mile*	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip=518100 miles • Weight per shipment = 0.03 tons • Air transport	

**Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.*

Table 4-E: Waste Transport/Disposal: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor Demolition				
Demo waste from FBR -carbon -steel -scraps, pipes, pumps	• Assumed de minimis (estimated to be one roll off, once time during the remedy)	de minimis	de minimis	
Extraction/GBR				
Disposal of gravel	• Each change out requires 18 truckloads of ~20 yd^3 each (350 yds^3 total) 6 changeout events, 18 truckloads per event (108 total round trips), with 30 tons of gravel (assuming 1.5 tons per yd^3) per truckload • 108 truckloads of 30 tons is 3,240 tons • Note that considering only disposal of 6 changeouts (and leaving last load of gravel in place) reduces disposal amount from approximately 3675 tons of gravel to 3240 tons of gravel • TT estimated non-hazardous landfill • TT estimated distance to landfill is 25 miles	• Distance for delivery: 108 trips x 25 miles per trip= 2,700 miles • Weight per delivery trip is 30 tons *SimaPro Assembly Name: Waste Transport_Alt4_GBR_gravel* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 81,000 ton-mile** *AND* *Landfill Disposal: Disposal in a non-hazardous landfill of 3240 tons of gravel:* *88.2% (3240 tons) of the total gravel assembly is allocated to a disposal scenario with a footprint* *11.8% (remaining 435 tons) of total gravel assembly is allocated to a dummy disposal process with no footprint* *Waste Scenario/Treatment: Disposal, concrete, 5% water, to inert material landfill/CH S*	• Distance for delivery: 108 trips x 25 miles per trip= 2,700 miles • Weight per delivery trip is 30 tons • Distance for empty trips: 108 trips x 25 miles per trip= 2,700 miles • Weight per empty trip is 0 tons Diesel for transportation fuel AND Disposal in a non-hazardous landfill of 3240 tons of gravel	Ton-mile basis (no empty trip)

Table 4-F: Transport for Personnel: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Sampling/O&M				
Transport for personnel for sampling events • Similar to sampling plan not optimized	• TT estimated 22 trips per year (44 wells, 2 people sampling) • TT estimated each person drives individual vehicle to site (light truck) • TT estimated a distance of 50 miles, one way	2 vehicles x 22 trips per year x 100 miles round trip x 30 years = 132,000 miles *SimaPro Assembly Name: Transport for Personnel_Alt1_Sampling Materials/Assemblies used: Transport, passenger car/RER U Amount input: 132000 miles*	1320 trips x 100 miles = 132,000 miles 1 person per vehicle, car and gasoline Labor: 1320*8=10,560 hrs of scientic/tech	
Biowalls				
Transport for personnel, estimated at a total of 12 trips, includes: • Personnel to inject carbon into biowall • Pump maintenance (TT estimated quarterly maintenance • Emergency generator and diesel pump maintenance • Air compressor maintenance o Electrician	• Table 2-5 of FBR Optimization Report • Assumptions of number of personnel and frequency of visits estimated by TT. • 12 visits per year x 30 years = 360 trips • TT estimated one person driving car (gasoline) for 50 miles trip, one way.	360 trips x 100 miles = 36,000 miles traveled by car *SimaPro Assembly Name: Transport for Personnel_Alt1_Biowall Materials/Assemblies used: Transport, passenger car/RER U Amount input: 36000 miles*	36,000 miles traveled by car, gasoline Single passenger per vehicle Labor: 360*8=2880 hrs of operator	
EX/GBR				
Transport for one technician for daily reduced by 52% from existing conditions	• Existing conditions estimated 436,800 miles by car over the life of the remedy • 436,800 x 0.48 = ~209,664 miles • Reduction based on FBR Optimization Report, Table 2-7 compared to Existing Conditions	209,664 miles by car *SimaPro Assembly Name: Transport of Personnel_Alt4_EX/GBR Process used: Transport, passenger car, petrol, fleet average/RER U Amount input: 209664 pmi*	209,664 miles by car, gasoline Single passenger per vehicle Labor: 24,960 original condition * 0.48 = 11,981 hrs of operator	

Table 4-G: Potable Water Use: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowall				
Water use for EVO replenishment based on a 1:7 ratio (EVO to water) for injections.	• FBR Optimization Report and TT professional estimate. • EVO use estimated to be 300 gallons per year • Assumed use of potable water from local hydrant (TT estimate)	300 x 7 = 2100 gallons per year x 30 years = 63,000 gallons x 8.34 lbs per gallon = 525,420 lbs *SimaPro Assembly Name: Potable Water_Alt 1_Biowall_EVO replen Materials/Assemblies used: Tap water, at user/RER U Amount input: 525420 lbs*	63,000 gallons of potable water	
Water used to create solutions for acetic acid and phosphoric solutions		No input for SimaPro. Water is accounted for upon choosing solution type.	Water use included with acetic and phosphoric acid solutions in Table C, “Material Use”	

Table 4-H: Non-Potable Water Use: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 4-I: Known Use of On-Site Renewables: Alternative 4 (Extraction, GBR, Biowall O&M)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 5-A: Electricity Use: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Extraction/Treatment Wetlands				
• Electrical usage reduction of 57% from existing conditions (based on FBR Optimization Report, Table 2-8, electricity cost data)	• FBR Optimization Report • TT estimated continual operation for 30 year remedy • This option likely includes modification of existing pumps and inclusion of a VFD and omission of the recirculation component to achieve the reduction in energy consumption noted in Table 2-8.	781,354 kWh *SimaPro Assembly Name: Electricity_Alt 4_GBR Assembly used: 1000kWh ERCT/SRMV Source Mix AT CONSUMER Amount input: 781.354 p*	781,354 kWh	
• Backup diesel pump that activates if the level reaches the high-level set point.	• Only used occasionally • To be considered “de minimis” for the sake of footprinting.	de minimis	de minimis	

Table 5-B: Fuel Use for Equipment: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Demolition of Fluidized Bed Reactor				
Demolition of FBR • TT estimated excavator for two days	• No mention of this in FBR Optimization Report • 2 days at 50 gallons per day	100 gallons of diesel fuel *SimaPro Assembly Name: Fuel Use_Alt4_FBR Demo* *Process used: Diesel, combusted in industrial equipment /US* *Amount input: 100 gal*	100 gallons of diesel fuel Labor: assume two people for 2 days, for total of 32 hours for FBR demo. Wetland Construction labor estimated under personnel transportation.	
Treatment Wetlands				
Construction equipment for excavation, grading and earth moving for construction of treatment wetlands. -Excavation	• Excavate 6000 yd^3 of plant matter and sediment, approximately 1 foot deep from the bottom of Cell A (from Optimization Report, amount estimated by TT) • TT estimated existing surface depression adds additional volume to wetlands beyond the 6000 yd^3 of excavation • TT estimated no disposal, spread on site	Excavator 6000 yd^3 of material moved *SimaPro Assembly Name: Fuel Use_Alt5_Wetlands_excavator* *Process used: Excavation, hydraulic digger/RER U* *Amount input: 6000 cu.yd*	Excavator 6000 yd^3 of material moved	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3

Dump truck/loader for removal of excavated soil	• Movement of 6,000 yd^3
	  • Assuming average production rate of 500 yd^3 per day for 12 days (96 hours)
	  • TT estimates use of a 200 HP loader: Fuel Use (gal) = HP x hrs x BSFC x PLF = 200 x 96 x 0.050 x 0.75 = 720 gals (refer to EPA, 2012, pg 59)
		Loader
		96 hours
		720 gallons of fuel
		
		SimaPro Assembly Name: Fuel Use_Alt5_Wetlands_loader
		Process used: Diesel, combusted in industrial equipment /US
		Amount input: 720 gal
			Loader
			96 hours of use (vs. movement of 6,000 yd^3) *please note which option used*	

Heavy equipment (#1) to fill for wetland -Excavator	• FBR Report • 3900 yd^3 of gravel • 10,900 yd^3 of sand and mulch • FBR Optimization report (provides thickness, estimated for area of Cell A)	Excavator 3,900 + 10,900 = 14,800 yd^3 of material moved *SimaPro Assembly Name: Fuel Use_Alt5_Wetlands_excavator for fill* *Process used: Excavation, hydraulic digger/RER U* *Amount input: 14800 cu. yd*	Excavator 14,800 yd^3 of material moved	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Heavy equipment (#2) to fill for wetland -Dozer and loader	• Movement of 3900 yd^3 gravel (8 days with two pieces of equipment) • Movement of mulch 10,900 yd^3 (22 days with both pieces of equipment) • 30 days total for two pieces of equipment • 240 hours each piece of equipment • TT estimates use of a 200 HP loader: Fuel Use (gal) = HP x hrs x BSFC x PLF = 200 x 240 x 0.050 x 0.75 = 1800 gals (refer to EPA, 2012, pg 59)	Loader, 240 hours, 14,800 yd^3 Dozer, 240 hours, 14, 800 yd^3 1800 gallons of fule *SimaPro Assembly Name: Fuel Use_Alt5_Wetlands_loader to fill* *Process used: Diesel, combusted in industrial equipment/US* *Amount input: 1800 gal*	• Loader, 240 hours vs. 14,800 yd^3 moved • Dozer, 240 hours, 14,800 yd^3 moved *please note which option used*	
Sampling O&M				
Field Truck • Gasoline • Assuming $3.00 per gallon	• FBR Optimization • Table 2-8 says $3,000 per year for gasoline • Result=1,000 gallons per year for 30 years	1,000 x 30 = 30,000 gallons of gasoline used over the 30 year remedy *SimaPro Assembly Name: Fuel Use_Alt4_O&M_field truck* *Process used: Gasoline, combusted in equipment/US* *Amount input: 30000 gal*	30,000 gallons of gasoline into "Personnel Transportation – Road" by using 300,000 miles at 10 miles per gallon.	

Table 5-C: Materials Use: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Treatment Wetlands				
Gravel	• FBR Optimization report (provides thickness, estimated for area of Cell A) • 3900 yd^3 of gravel • TT estimates 1.5 tons per cubic yard, therefor 3900 cubic yards x 1.5 tons per cubic yard = 5850 tons of gravel	5850 tons of gravel *SimaPro Assembly Name: Material Use_Alt5_gravel* *Material used: Gravel, unspecified, at mine/CH U* *Amount input: 5850 tn.sh*	3,900 yd^3 of gravel Input to SiteWise: 11,025,300 lbs (Based on a conversion factor for gravel of 2827 pounds per cubic yard or 1.41 tons/yd3)	
Sand and Mulch	• FBR Optimization Report (provides thickness, and specified “Sand layer, mixed with mulch or other source of organic carbon) • TT estimated a 70/30 mix, TT estimate • 7,630 yd^3 of sand at 1.5 tons per cubic yard (EPA, 2012): 7630 yd^3 x 1.5 tons per yd^3 = 11445 tons of sand. • 3,270 yd^3 of mulch	• 11445 tons of sand (22,890,000 lbs) AND • 3,270 yd^3 of mulch *SimaPro Assembly Name: Material Use_Alt5_sand and mulch* *Material used: Sand, at mine/CH U (Ecoinvent)* *Amount input: 11445 tn.sh* *AND* *Material used: Wood chips, mixed, u=120%, at forest/RER U* *Amount input: 3270 yd^3*	• 7,630 yd^3 of sand AND • 3,270 yd^3 of mulch Input to SiteWise: • 23,714,040 lbs of sand AND • 3407340 lbs of mulch (Based on a conversion factor for sand of 3108 pounds per cubic yard (1.55 tons/yd3) and for mulch of 1042 pounds per cubic yard (0.521 tons/yd3))	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PVC liner	• FBR Optimization Report • Liner type not specified in report • TT estimated 20 mil PVC liner in the base (420 x 400') (Dimensions of Cell A) • 168000 ft^2 x 20/1000/12=280 ft^3 of PVC • 0.13 lbs per ft^2 (http://www.coloradokoi.com/pond.htm)	21,840 lbs PVC of 20 mil PVC liner *SimaPro Assembly Name: Material Use_Alt5_PVC Liner* *Process used: PVC film E (Industry data 2.0)* *Amount input: 21840 lb*	280 ft^3 of 20 mil PVC liner vs, 21,840 lbs PVC *Russell said he used the 21,840 lbs PVC (he said that "SiteWise has no option for PVC liner. It does have an option for HDPE liner but that has a higher footprint than straight HDPE but lower footprint than straight PVC so it makes more sense to use PVC"*	
Pipe	• TT estimated PVC • Estimated to be 4" pipe diameter • Estimated to require 4020 lengths of 20 ft= 8,000 linear feet • Schedule 40 PVC • 2.012 lbs per foot of pipe (EPA, 2012)	16,096 lbs of PVC *SimaPro Assembly Name: Material Use_Alt5_PVC pipe* *Material used: PVC pipe E (Industry data 2.0)* *Amount input: 16096 lb*	Pipe diameter= 4 inch Schedule 40 PVC Pipe length: 400 lengths of 20 ft =8,000 ft	
Seed (for wetland plants)	• 168,000 square feet or 3.86 acres 20 lbs per acre or ½ lb per 1,000 square feet (as per http://www.ernstseed.com/seed-mix/?category-id=26	de minimis	de minimis	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
Electron Donor Replenishment (EOS™)	• PBR Report • TT estimated that biowalls for Area M only would require approximately 300 gallons per year • Typical s.g.of vegetable oil =1, therefore: 300 gallons x 8.33 lbs per gallon= 2499 lbs x 30 years= 74,970 lbs	74,970 lbs of vegetable oil *SimaPro Assembly Name: Materials_Alt1_Biowall_EOS Materials/Assemblies used: 60% Soybean oil, at oil mill/US U 4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid) 10% Propylene glycol, liquid, at plant/RER/U (surrogate for emulsifier) 26% Tap water, at user/RER U 100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations*	74,970 lbs of vegetable oil	

Table 5-D: Transport for Materials, Equipment, and Samples: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Treatment Wetlands				
Transport of Gravel	• FBR Optimization report (provides thickness, estimated for area of Cell A) • 3900 yd^3 of gravel • 195 round trips with 20 cubic yards per truck (30 tons) • TT estimated 50 miles to vendor	• Distance for delivery: 195 trips x 50 miles per trip=9,750 miles • Weight per delivery trip is 30 tons *SimaPro Assembly Name: Transport of Materials_Alt5_Wetlands_Gravel* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 292,500 ton-mile*[*]	• Distance for delivery: 195 trips x 50 miles per trip=9,750 miles • Weight per delivery trip is 30 tons • Distance for empty trips: 195 trips x 50 miles per trip=9,750 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Sand and Mulch	• FBR Optimization Report (provides thickness, and specified "Sand layer, mixed with mulch or other source of organic carbon) • Weight per delivery is 20 yards (30 tons) • 10,900 yds^3/20= 545 round trips • TT estimated 50 miles to vendor	• Distance for delivery: 545 trips x 50 miles per trip=27,250 miles Weight per delivery trip is 30 tons *SimaPro Assembly Name: Transport of Materials_Alt5_Wetlands_sand and mulc* *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 817,500 ton-mile**	• Distance for delivery: 545 trips x 50 miles per trip=27,250 miles • Weight per delivery trip is 30 tons • Distance for empty trips: 545 trips x 50 miles per trip=27,250 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)
Transport of PVC liner and pipe	• FBR Optimization Report • Note: PVC liner and pipe is estimated to be a total of 19 tons. The weight for delivery for the sand and mulch was estimate to be much larger, making the delivery of the PVC de minimis.	de minimis	de minimis	
Transport of Seed (for wetland plants)	• 168,000 square feet or 3.86 acres 20 lbs per acre or ½ lb per 1,000 square feet (as per http://www.ernstseed.com/seed-mix/?category-id=26 • Assume de minimis	de minimis	de minimis	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of heavy equipment (Mob/Demob), each piece	• One time mob/demob • Excavator, 35 tons • Bulldozer, 18 tons • Loader, 30 tons • 6 round trips (a flatbed for each piece of equipment). Note that delivery vehicle will make delivery to site and leave site empty and then return to site to pick up the equipment. The result will be two trips with equipment weight and two empty trips for each piece of equipment. • TT estimated vendor distance, 50 miles	• Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 35 tons AND • Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 18 tons AND • Distance for delivery: 2 trips x 50 miles per trip=100 miles Weight per delivery trip is 30 tons *SimaPro Assembly Name: Transport of Materials_Alt5_Wetlands_hvy equip* *Process used: Transport, lorry >32t, EURO5/RER U* *Amount input: 3500 ton-mile** AND *Process used: Transport, lorry 16-32t, EURO5/RER UAmount input: 1800 ton-mile** AND *Process used: Transport, lorry 16-32t, EURO5/RER U* *Amount input: 3000 ton-mile**	• Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 35 tons AND • Distance for delivery: 2 trips x 50 miles per trip=100 miles • Weight per delivery trip is 18 tons AND • Distance for delivery: 2 trips x 50 miles per trip=100 miles Weight per delivery trip is 30 tons AND • Distance for empty trips: 6 trips x 50 miles per trip=300 miles • Weight per empty trip is 0 tons Diesel	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowalls				
Transport of biowall donor replenishment	• PRB Report, pg. 34 • 300 gallons (maximum) per year with a s.g.= 1. (http://www.eosremediation.com/products/Density.html • Weight: 300 gallons x 8.33 lbs per gallon= 2499 lbs = 1.25 tons per delivery • TT estimated annual replenishment • TT estimated 100 miles, one way, to vendor	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons (Empty trips included) *SimaPro Assembly Name: Transport of Materials_Alt1_Biowalls_donor replen Process used: Transport, single unit truck, diesel powered/US* • *Amount input: 3750 ton-mile*	• Distance for deliveries: 30 trips x 100 miles per trip=3,000 miles • Weight per delivery trip is 1.25 tons • Distance for empty trips: 30 trips x 100 miles per trip=3,000 miles • Weight per empty trip is 0 tons	Ton-mile basis (no empty trip)
Sampling/O&M				
Transport of Cooler during sampling events • Similar to existing condition (Table 1-D) • Sampling Events (44 wells sampled once per year) • TT estimated 1 well per cooler, or 22 coolers total, used annually • TT estimated 30 lbs when full of samples • TT estimated air transport	• Groundwater Optimization Report • TT estimated sample transport based on 2 people performing the sampling, 2 wells sampled per day, 2 coolers produced per day for 22 days per year. • Site team reports that the location of the lab is approximately 785 miles from the site • Weight per shipment trip is 2 x 30 lbs (0.03 tons)	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip= 518100 miles • Weight per shipment= 0.03 tons • Air transport *Name: Transport of Materials_Alt1_O&M_Samples Process used: Transport, aircraft, freight/US Amount input: 15,543 ton-mile*	• Distance for deliveries: 22 sampling days per year x 30 years x 785 miles per one way trip=518100 miles • Weight per shipment = 0.03 tons • Air transport	

**Note: The transportation for the samples to the lab will be the single aspect of the laboratory analysis that will be evaluated as a part of the full remedy footprint. Other aspects of the laboratory analysis will be considered separately in the study given the uncertainty in the footprint associated with laboratory analysis.*

Table 5-E: Waste Transport/Disposal: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Fluidized Bed Reactor Demolition				
Demo waste from FBR -carbon -steel -scraps, pipes, pumps	• Assumed de minimis (estimated to be one roll off, once time during the remedy)	de minimis	de minimis	

Table 5-F: Transport for Personnel: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Treatment Wetlands				
Transport for worker to perform seaming/welding of liner seam	• 3 man crew • 5 days on site • TT estimated distance to site for each crew member is 50 miles, one way • TT estimated car, gasoline	• 5 x 50 x 3= 750 miles • Car, gasoline *SimaPro Assembly Name: Transport for Personnel_Alt5_Wetlands_seaming work* *Process used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 750 pmi*	• 750 miles • Car, gasoline Single passenger per vehicle Labor: 3*5*8=120 hrs construction	
Equipment operators (construction of wetland), 3 man crew for 45 days	• Estimated by TT • TT estimated distance to site for each crew member is 50 miles • TT estimated small truck, diesel	• 45 x 3 x 100 round trip= 13,500 miles • Small truck, diesel *SimaPro Assembly Name: Transport for Personnel_Alt5_Wetlands_equp operatr* *Process used: Operation, van < 3,5t/RER U* *Amount input: 13500 mile*	• 13,500 miles • Small truck, diesel Single passenger per vehicle Labor: Input 3*45*8=1080 hrs less 154 hrs already calculated by SiteWise for equipment operators for an input of 926 hrs of construction	
Sampling/O&M				
• Transport for one technician (System O&M) for daily reduced by 60% from existing conditions	• Reduction based on FBR Optimization Report (based on reduction in labor cost) • 436,800 x 0.4= 174,720 miles	174,720 miles by car *SimaPro Assembly Name: Transport for Personnel_Alt5_O&M_tech* *Process used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 174720 pmi*	174,720 miles by car, gasoline Single passenger per vehicle Labor: 24,960 hrs from original condition * 0.4 = 9984 hrs of scientic/tech	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport for personnel, estimated at a total of 12 trips, includes: • Personnel to inject carbon into biowall • Pump maintenance (TT estimated quarterly maintenance • Emergency generator and diesel pump maintenance • Air compressor maintenance o Electrician	• Table 2-5 of FBR Optimization Report • Assumptions of number of personnel and frequency of visits estimated by TT. • 12 visits per year x 30 years = 360 trips • TT estimated one person driving car (gasoline) for 50 miles trip, one way.	360 trips x 100 miles = 36,000 miles traveled by car *SimaPro Assembly Name: Transport for Personnel_Alt5_O&M_personnel* *Process used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 36000 pmi*	36,000 miles traveled by car, gasoline Single passenger per vehicle Labor: 360*8=2880 hrs of operator	

Table 5-G: Potable Water Use: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Biowall				
Water use for EVO replenishment based on a 1:7 ratio (EVO to water) for injections.	• FBR Optimization Report and TT professional estimate. • EVO use estimated to be 300 gallons per year • Assumed use of potable water from local hydrant (TT estimate)	300 x 7 = 2100 gallons per year x 30 years = 63,000 gallons x 8.34 lbs per gallon = 525,420 lbs *SimaPro Assembly Name: Potable Water_Alt 1_Biowall_EVO replen* *Materials/Assemblies used: Tap water, at user/RER U* *Amount input: 525420 lbs*	63,000 gallons of potable water	

Table 5-H: Non-Potable Water Use: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 5-I: Known Use of On-Site Renewables: Alternative 5 (Treatment Wetlands)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 6-A: Electricity Use: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
No electricity required for the installation or O&M of the Additional Biowalls				

Table 6-B: Fuel Use for Equipment: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Additional Area M Biowall Construction				
Air Rotary Drill • For 5 days for soil borings for preliminary investigation	• Site Manager e-mail, 5/2012 • Fuel consumption calculated using Exhibit 3.11B in EPA, 2012 assuming rotary drill is 500 HP (professional judgment). 500 HP x 0.75 PLF (partial load factor) x 0.05 gal per HP hr (BSFC, Brake Specific Fuel Capacity) = 18.75 gph • Assumed equipment used for an 8 hour day • 8 hrs/day x 5 days x 18.75 gph = 750 gallons of diesel fuel consumed	750 gallons of diesel fuel consumed *SimaPro Assembly Name: Fuel Use_Alt6_air rotary drill* *Process used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 750 gal**	750 gallons of diesel fuel consumed Input as 40 hours of air rotary rig rather than 750 gallons Labor: As calculated by SiteWise	
Rock Trencher • For 10 days • T1255 Hydrostatic Rock Trencher : 630 HP	• Site Manager e-mail, 5/2012 • Fuel consumption rate calculated (EPA, 2012): 630 HP x 0.75 PLF x 0.05 BSFC = 23.6 gph • Assumed equipment use for an 8 hour day • 8 hrs/day x 10 days x 23.6 gph = 1890 gallons of diesel fuel consumed	1890 gallons of diesel fuel consumed *SimaPro Assembly Name: Fuel Use_Alt6_Rock Trencher* *Process used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 1890 gal**	1890 gallons of diesel fuel consumed Input as trencher (600 to 750 hp) operating for 80 hours rather than 1890 gallons. Labor: As calculated by SiteWise	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Dump Truck-Articulating • For 20 days	• Site Manager e-mail, 5/2012 • Fuel consumption rate calculated (EPA, 2012) assuming 400 HP dump truck (professional judgment): 400 HP x 0.75PLF x 0.05 BSFC = 15 gph • Assumed equipment use for an 8 hour day • 8 hrs/day x 20 days x 15 gph = 2400 gallons of diesel fuel consumed	2400 gallons of diesel fuel consumed *SimaPro Assembly Name: Fuel Use_Alt6_Dump Truck A* *Process used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 2400 gal**	2400 gallons of diesel fuel consumed Input under ICE consuming 15 gph for 160 hours Labor: Added 160 hrs of construction.	
Dump Truck- Tandem	• Site Manager e-mail, 5/2012 • Fuel consumption rate calculated (EPA, 2012) assuming 400 HP dump truck (professional judgment): 400 HP x 0.75PLF x 0.05 BSFC = 15 gph • Assumed equipment use for an 8 hour day • 8 hrs/day x 20 days x 15 gph = 2400 gallons of diesel fuel consumed	2400 gallons of diesel fuel consumed *SimaPro Assembly Name: Fuel Use_Alt6_Dump Truck T* *Process used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 2400 gal**	2400 gallons of diesel fuel consumed Input under ICE consuming 15 gph for 160 hours Labor: Added 160 hrs of construction.	
Roller • For 20 days	• Site Manager e-mail, 5/2012 • Fuel consumption rate calculated (EPA, 2012) assuming 150 HP roller (professional judgment): 150 HP x 0.75 PLF x 0.05 BSFC = 5.625 gph • Assumed equipment use for an 8 hour day • 8 hrs/day x 20 days x 5.625 gph = 900 gallons of diesel fuel consumed	900 gallons of diesel fuel consumed *SimaPro Assembly Name: Fuel Use_Alt6_Roller* *Process used: Diesel, combusted in industrial equipment/US (USLCI)* *Amount input: 900 gal**	900 gallons of diesel fuel consumed Input under ICE consuming 5.625 gph for 160 hours Labor: Added 160 hrs of construction.	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Backhoe • For 20 days	• Site Manager e-mail, 5/2012 • Fuel consumption rate calculated (EPA, 2012) assuming 175 HP (professional judgment): 175 HP x 0.75 PLF x 0.05 BSFC= 6.5625 gph • Assumed equipment use for an 8 hour day • 8 hrs/day x 20 days x 6.5625 gph = 1050 gallons of diesel fuel consumed	1050 gallons of diesel fuel consumed *SimaPro Assembly Name: Fuel Use_Alt6_Backhoe Process used: Diesel, combusted in industrial equipment/US (USLCI) Amount input: 1050 gal**	1050 gallons of diesel fuel consumed Input under ICE consuming 6.5625 gph for 160 hours Labor: Added 160 hrs of construction.	
Loader • For 20 days	• Site Manager e-mail, 5/2012 • Fuel consumption rate calculated (EPA, 2012) assuming 200 HP (professional judgment): 200 HP x 0.75 PLF x 0.05 BSFC = 7.5 gph • Assumed equipment use for an 8 hour day • 8 hrs/day x 20 days x 7.5 gph = 1200 gallons of diesel fuel consumed	1200 gallons of diesel fuel consumed *SimaPro Assembly Name: Fuel Use_Alt6_Loader Process used: Diesel, combusted in industrial equipment/US (USLCI) Amount input: 1200 gal**	1200 gallons of diesel fuel consumed Input under ICE consuming 7.5 gph for 160 hours Labor: Added 160 hrs of construction.	

Table 6-C: Materials Use: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Additional Area M Biowall Construction				
Mushroom Compost • 712 cubic yards	• Site Manager e-mail, 5/2012 • Mushroom compost will be assumed to have a similar density than that of bark mulch: 0.4 tons/cubic yard (EPA, 2012) • 712 cubic yards x 0.4 tons per cubic yard = 285 tons of mushroom compost, total	285 tons of mushroom compost *SimaPro Assembly Name: Material Use_Mushroon Compost* *Materials used: Compost, at plant/CH U (Ecoinvent)* *Amount input:285 tn.sh*	285 short tons of mushroom compost Input to SiteWise: 570,000 lbs of mulch (surrogate) (Based on a conversion factor of 2000 lbs/short ton)	
Crushed Limestone • 2134 cubic yards	• Site Manager e-mail, 5/2012 • Density applied for crushed limestone is 1.5 tons per cubic yard (EPA, 2012 density for sand/gravel/soil) • 2134 cubic yards x 1.5 tons per cubic yard = 3201 tons of limestone, total	3201 tons of limestone *SimaPro Assembly Name: Material Use_Alt6_Limestone* *Materials used: Gravel, unspecified, at mine/CH U (Ecoinvent)* *Amount input:3201 tn.sh*	3201 tons of limestone Input to SiteWise: 6,402,000 lbs of gravel (surrogate) (Based on a conversion factor of 2000 lbs/short ton)	
Pine Wood Chips • 712 cubic yards	• Site Manager e-mail, 5/2012 • 712 cubic yards x 0.4 tons per cubic yard = 285 tons of pine wood chips, total	712 cubic yards of pine wood chips *SimaPro Assembly Name: Material Use_Wood Chips* *Materials used: Wood chips, softwood, u=140%, at forest/RER U,* *Amount input:712 yd^3*	285 tons of pine wood chips Input to SiteWise: 570,000 lbs of mulch (surrogate) (Based on a conversion factor of 2000 lbs/short ton	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
PVC • For construction of newly installed monitoring wells • 580 feet of 2" PVC	• Site Manager e-mail, 5/2012 • Assume Schedule 40: 0.681 lbs/foot (EPA, 2012) • 580 feet x 0.681 lbs/ft = 395 lbs Schedule 40 PVC	395 lbs Schedule 40 PVC *SimaPro Assembly Name: Material Use_PVC Mon Wells* *Materials used: PVC pipe E (Industrial Data 2.0)* *Amount input:395 lbs*	395 lbs Schedule 40 PVC Input to SiteWise: 580 feet of 2 inch sch 40 PVC Note: SiteWise uses conversion factor of 0.72 lbs/foot for 2" Schedule 40PVC pipe (www.harvel.com/pipepvc-sch40-80-dim.asp)	
PVC • Diffuser pipes for addition of carbon amendments • 2000 feet of 1" PVC	• As per Site Manager (Jeff James) 5/23/2012 e-mail • Assume Schedule 40: 0.31 lbs per foot (Charlotte Pipe Product Manual) • 2000 ft x 0.31 lbs/ft = 620 lbs of PVC	620 lbs of Schedule 40 PVC *SimaPro Assembly Name: Material Use_PVC Diffuser Pipes* *Materials used: PVC pipe E (Industrial Data 2.0)* *Amount input:620 lbs*	620 lbs of Schedule 40PVC Input to SiteWise: 2000 feet of 1 inch sch 40 PVC Note: SiteWise uses conversion factor of 0.72 lbs/foot for 2" Schedule 40PVC pipe (www.harvel.com/pipepvc-sch40-80-dim.asp)	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Emulsified Oil • Initial treatment • 3 truckloads	• Site Manager e-mail, 5/2012 • 4741.3 gallons per truckload x 7.6776 lbs per gallon (density provided by Site Manager) = 36,402 lbs (18.2 tons) per truckload x 3 = 54.6 tons of emulsified oil for initial injection	54.6 tons of emulsified oil *SimaPro Assembly Name: Material Use_EVO Initial Injections* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U (surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations* *Amount input:54.6 tn.sh*	54.6 tons of emulsified oil Input to SiteWise: 109,200 lbs vegetable oil	
Additional Area M Biowall O&M				
Emulsified Oil • Initial treatment • 1 truckload of emulsified oil required every 3 years	• Site Manager e-mail, 5/2012 • 18.2 tons per truckload (see above) x 10 events (over a 30 year remedy period) = 182 tons of emulsified oil consumed for O&M	182 tons of emulsified oil *SimaPro Assembly Name: Material Use_EVO O&M* *60% Soybean oil, at oil mill/US U* *4% Acetic acid, 98% in H2O, at plant/RER U (surrogate for lactic acid)* *10% Propylene glycol, liquid, at plant/RER/U (surrogate for emulsifier)* *26% Tap water, at user/RER U* *100 kWh of Electricity, low voltage, at grid/US U for mixing and plant operations* *Amount input:182 tn.sh*	182 tons of emulsified oil Input to SiteWise: 364,000 lbs vegetable oil	

Table 6-D: Transport for Materials, Equipment, and Samples: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Additional Area M Biowall Construction				
Transport of Mushroom Compost • 15 cubic yards per truckload x 0.4 tons per cubic yard = 6 tons of mushroom compost per delivery load	• As per Site Manager (Jeff James) 5/23/2012 e-mail • 48 round trips of 250 miles • 48 x 125 = 6000 miles with 6 ton load • 48 x 125 = 6000 miles empty return trip	6000 miles with 6 ton load *SimaPro Assembly Name: Transport of Materials_Alt6_Mushroom* *Process used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent)* *Amount input:36000 tmi**	• Distance for delivery= 125 miles, one way • Weight per delivery= 6 tons • Number of trips = 48 Empty return trips: • Distance for return trip = 125 miles, one way • Weight per delivery= 0 tons • Number of trips = 48	Ton-mile basis (no empty trip)
Transport of Crushed Limestone • 15 cubic yards per truckload x 1.5 tons per cubic yard = 22.5 tons of limestone per delivery load	• As per Site Manager (Jeff James) 5/23/2012 e-mail • 143 round trips of 108 miles • 143 x 54= 7722 miles with 22.5 ton load • 143 x 54= 7722 miles empty return trip	7722 miles with 22.5 ton load *SimaPro Assembly Name: Transport of Materials_Alt6_Limestone* *Process used: Transport, lorry >16t, fleet average/RER U (Ecoinvent)* *Amount input: 173745 tmi**	• Distance for delivery= 54 miles, one way • Weight per delivery= 22.5 tons • Number of trips = 143 Empty return trips: • Distance for return trip = 125 miles, one way • Weight per return trip= 0 tons • Number of trips = 143	Ton-mile basis (no empty trip)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of Pine Wood Chips • 15 cubic yards per truckload x 0.4 tons per cubic yard = 6 tons of pine wood chips per delivery load	• As per Site Manager (Jeff James) 5/23/2012 e-mail • 48 round trips of 392 miles • 48 x 196 = 9408 miles with 6 tons load • 48 x 196= 9408 miles empty return trip	9408 miles with 6 ton load *SimaPro Assembly Name: Transport of Materials_Alt6_Wood Chips* *Process used: Transport, lorry 3.5-16t, fleet average/RER U (Ecoinvent)* *Amount input: 56448tmi**	• Distance for delivery= 196 miles, one way • Weight per delivery= 6 tons • Number of trips = 48 Empty return trips: • Distance for return trip = 196 miles, one way • Weight per return trip= 0 tons • Number of trips = 48	Ton-mile basis (no empty trip)
Transport of PVC • For construction of newly installed monitoring wells and the diffuser pipes	• As per Site Manager (Jeff James) • Estimated distance to vendor 100 miles round trip • Weight of PVC = 395 lbs for monitoring wells and 640 lbs for diffuser pipes (assumed delivered together) = 1035 lbs / 2000 lbs per ton = 0.5175 tons • 1 trip x 50 miles = 50 miles with 0.5175 ton load • 1 trip x 50 miles = 50 miles empty return trip	*Considered de minimis*	*Considered de minimis*	

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Transport of emulsified oil for initial injection	• As per Site Manager • Three truckloads with the estimated distance to vendor 200 miles round trip (600 miles total) • Weight of one truckload of emulsified vegetable oil is 18.2 tons (4741.3 gallons x 7.6776 lbs per gallon = 36,402 lbs (18.2 tons) per delivery) • 3 trips x 100 miles = 300 miles with a 18.2 ton load • 3 trips x 100 miles = 300 miles for empty return trip	300 miles with 18.2 ton load *SimaPro Assembly Name: Transport of Materials_Alt6_EVO initial injection* *Process used: Transport, lorry >16t, fleet average/RER U (Ecoinvent)* *Amount input: 5460 tmi**	• Distance for delivery= 100 miles, one way • Weight per delivery= 18.2 tons • Number of trips = 3 Empty return trips: • Distance for return trip = 100 miles, one way • Weight per return trip= 0 tons • Number of trips = 3	Ton-mile basis (no empty trip)
Additional Area M Biowall O&M				
Transport of emulsified oil for initial injection	• As per Site Manager • One truckload per reinjection event with the estimated round trip distance to vendor 200 miles • 10 reinjection events over the course of a remedy • Weight of one truckload of emulsified vegetable oil is 18.2 tons (4741.3 gallons x 7.6776 lbs per gallon = 36,402 lbs (18.2 tons) per delivery) • 10 trip x 100 miles = 1000 miles with a 18.2 ton load • 10 trips x 100 miles = 1000 miles for empty return trip	1000 miles with 18.2 ton load *SimaPro Assembly Name: Transport of Materials_Alt6_EVO re- injection* *Process used: Transport, lorry >16t, fleet average/RER U (Ecoinvent)* *Amount input: 18200 tmi**	• Distance for delivery= 100 miles, one way • Weight per delivery= 18.2 tons • Number of trips = 10 Empty return trips: • Distance for return trip = 100 miles, one way • Weight per return trip= 0 tons • Number of trips = 10	Ton-mile basis (no empty trip)

Table 6-E: Waste Transport/Disposal: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Additional Area M Biowall Construction				
Haul cuttings to landfill	• As per Site Manager • 238 trips of 171 miles each (round trip) • Each truckload carries 15 cubic yards with cuttings having an estimated density of 1.5 tons per cubic yard (EPA, 2012) = 22.5 tons per truckload • 238 x 85.5 miles with 22.5 ton load • 238 x 85.5 miles for empty return trip **Disposal:** 3570 cubic yards x 1.5 tons per cubic yard = 5355 tons of soil disposed in a non-hazardous landfill	20,349 miles with 22.5 ton load *SimaPro Assembly Name: Waste Transport_Alt6_Soil Cuttings* *Process used: Transport, lorry >16t, fleet average/RER U (Ecoinvent)* *Amount input: 457852.5tmi** *Disposal:* *Waste Scenario Treatment: (Other) Alt 6 Soil Cuttings Disposal* *Disposal, concrete, 5% water, to inert material landfill/CH U* *Disposed of: Dummy_Disposal, solid waste, unspecified, to inert material landfill/kg/RNA* *Amount: 5355 tn. sh*	• Distance for delivery to landfill: 238 trips x 85.5 miles per trip=20,349 miles • Weight per delivery trip is 22.5 tons Empty return trips • Distance for return trip: 238 trips x 85.5 miles per trip=20,349 miles • Weight per delivery trip is 0 tons **Disposal:** • 5355 tons of soil disposed in non-hazardous landfill	Ton-mile basis (no empty trip)

Table 6-F: Transport for Personnel: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Additional Area M Biowall Construction				
Transport for personnel to oversee construction	• As per Site Manager • Estimated total: 500 miles	500 miles by car *SimaPro Assembly Name: Trans of Person_Alt6_Construction* *Process used: Transport, passenger car, petrol, fleet average/RER U (Ecoinvent)* *Amount input: 500 pmi*	500 miles by car (gasoline) Assumed one person Labor: Assume that in addition to the equipment operators, that an additional 800 hours of on-site labor	
Additional Area M Biowall O&M				
Transport for semi-annual sampling	• As per Site Manager • Estimated as 1000 miles per year for 30 years	30,000 miles by car *SimaPro Assembly Name: Trans of Person_Alt6_Sampling* *Process used: Transport, passenger car, petrol, fleet average/RER U (Ecoinvent)* *Amount input: 30000 pmi*	30,000 miles by car (gasoline) Assumed one person Labor: Assumed number of trips is 30,000/100 miles per trip or 300 trips. Time on site is 300*8=2400 hrs of scientific/tech	

Table 6-G: Potable Water Use: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
Additional Area M Biowall Construction				
Water use for initial emulsified oil injection based on a 1:7 ratio (oil to water) for injections	• If initial injection requires 14,224 gallons of oil, then the amount of water required would be 14, 224 x 7 = 99,568 gallons	99,568 gallons of water x 8.34 lbs per gallon = 830,397 lbs of water *SimaPro Assembly Name: Water Use_Initial Injections Material used: Tap water, at user/RER U (Ecoinvent) Amount input: 830397lb*	99,568 gallons of water	
Additional Area M Biowall O&M				
Water use for EVO replenishment • Once every three years, one truckload	• If each three year re-injection event requires 4,741.3 gallons of oil, then the amount of water required would be 4,741.3 x 7 = 33,189.3 gallons • 33,189.3 gallons x 10 events = 331,893 gallons of water consumed for reinjection events	331,893 gallons of water x 8.34 lbs per gallon = 2,767,987 lbs of water *SimaPro Assembly Name: Water Use_Re-injections Process used: Tap water, at user/RER U (Ecoinvent) Amount input: 2767987*	331,893 gallons of water	

Table 1-H: Non-Potable Water Use: Alternative 1 (Existing Conditions)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
• None identified				

Table 6-I: Known Use of On-Site Renewables: Alternative 6 (Additional Biowalls)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SiteWise Version 2	Changes to Input for SiteWise Version 3
None Identified				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Coordination of Site Data Input: Beale Air Force Base

FOR

QUANTIFYING LIFE-CYCLE ENVIRONMENTAL FOOTPRINTS OF SOIL AND GROUNDWATER REMEDIES

ESTCP Project # ER-201127

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INTRODUCTION

Site 35 (Bldg 1322) at Beale Air Force Base in California was used as weapons storage area from its construction in 1958 until the late 1970s. Currently, the site is used for weapons storage, equipment maintenance, and office space and is roughly 95% unpaved. Sources of contamination identified at Site 35 include: a release of solvents to the ground surface near the concrete foundations of the former sheds; septic system leaks; and historical spills/discharges of cleaning solutions to the ground surface, ephemeral drainages, and seasonal creeks. The release of solvents is estimated to have occurred before the mid-1980s. The subsurface consists of alluvial deposits, and groundwater occurs at depths of 55 to more than 80 feet below ground surface (bgs) at the site. The contaminants of concern are VOCs including: trichloroethylene (TCE); 1,1-dichloroethene (DCE); and carbon tetrachloride. TCE has the highest concentrations in groundwater (up to approximately 2,000 µg/l), and high vapor concentrations near the shed foundations in the source area indicate that dense non-aqueous phase liquid (DNAPL) may be present in the source area. VOCs in groundwater have migrated approximately 500 feet downgradient of the source area in the direction of groundwater flow.

Beale AFB has prepared a draft FS to address groundwater contamination at Site 35. Three alternatives under evaluation in the FS include:

- Alternative 1: No Action (including no land use controls). This alternative was not included in the project because this alternative has no footprint.

- Alternative 2: Excavation, In Situ Bioreactor, Monitored Natural Attenuation (MNA) Assessment (maintain land use controls)

    - Excavation of 2,130 cubic yards of soil in the source area and off-site disposal

    - Installation of a mulch bioreactor inside the excavation

    - Use of solar-powered pumps for recirculation of contaminated groundwater through the bioreactor (bioreactor expected to operate for 10 years)

    - Monitoring for 10 years during the active remedy and then during a subsequent MNA period for 30 years following the bioreactor (i.e., monitoring of an average of 7 wells over a 40-year total cleanup period)

- Alternative 3: Excavation, In Situ Chemical Oxidation, and MNA

    - Excavation of 2,130 cubic yards of soil in the source area and off-site disposal

    - Installation of 21 injection wells for in situ oxidation using sodium permanganate

- One initial oxidant injection and two follow-up injections over a 2-year period

- Monitoring for 2 years during the active remedy and then during a subsequent MNA period for 30 years (i.e., monitoring of an average of 7 wells over a 32-year total cleanup period)

Information and data required for a GSR footprint evaluation for the groundwater remedy at Beale AFB was developed from the following data sources:

- *Sustainable Remediation Tool Application to Support a Feasibility Study for Site 35 on Beale Air Force Base, CA* (CH2MHill, 2012)

The intent of this document is to provide a basis for the development of input for the SimaPro® and SRT™ tools for these alternatives.

ALTERNATIVE 2:
EXCAVATION/BIOREACTOR FOLLOWED BY MNA

Overview of Alternative 2

They key items of Alternative 2 with respect to footprint results over the long-term operation of the system are the excavation and disposal of source area soils, installation and operation of the mulch bioreactor, and monitoring for 40 years.

Input data to the SRT™ for Alternative 2 was established in one SRT™ file. The EXDesign (excavation) and MNADesign (MNA) modules were used. The inputs for the "InputSoil" tab and the "InputGW" tab are presented below. The inputs EXDesign and MNADesign tabs are presented in Tables 1-A through 1-J.

Soil/Source Inputs				
Area of affected soil (ft^2)	2300			
Depth to top of affected soil (ft)	0			
Depth to bottom of affected soil (ft)	25			
Depth to groundwater (ft)	50			
Soil type	Silt			
Contaminant class	1			
Maximum concentration (mg/Kg)	1000			
Typical concentration (mg/Kg)	50			
Groundwater Inputs				
	Zone 1	Zone 2	Zone 3	Zone 4
width (ft)	100	75	150	
length (ft)	75	300	500	
Concentration low (ug/L)	200	100	5	
Concentration high (ug/L)	2000			
Contaminant class	CVOCs			
Depth to groundwater (ft)	50			
Depth to top of formation (ft)	50			
Thickness of water bearing media (ft)	20			
Aquifer media	Sand (poorly graded)			
Hydraulic Conductivity	0.005 cm/s			
Hydraulic gradient	0.001			

Additional information for Alternative 2 includes the following:

- The bioreactor construction and operation includes the following information:

- Excavation and off-site disposal of 2,130 cubic yards of soil from the source area.
- Installation of a mulch bioreactor inside the excavation, represented in SRT by 2,130 cubic yards of mulch backfill. Bioreactor operation estimated at 10 years.
- Use of solar-powered pumps to recirculate TCE-contaminated groundwater through the bioreactor. This will require 30 square feet of solar panels.
- Monitoring of an average of four wells over the 40-year cleanup period.
- The installation of four, seventy foot deep monitoring wells

Detailed Basis for Footprint Evaluation

Tables 1-A through 1-I summarize the information that will serve as the basis for the footprint evaluation of Alternative 2 and the input parameters to SimaPro® and SRT™.

ALTERNATIVE 3:
EXCAVATION/ISCO FOLLOWED BY MNA

Overview of Alternative 3

They key items of Alternative 3 with respect to footprint results over the long-term operation of the system are the excavation and disposal of source area soils, installation and operation of the ISCO system, and monitoring for 32 years.

Input data to the SRT for Alternative 2 was established in one SRT™ file. The EXDesign (excavation), ISCODesign (ISCO), and MNADesign (MNA) modules were used. The inputs for the "InputSoil" tab and the "InputGW" tab are the same as those for Alternative 2. The inputs EXDesign, ISCODesign, and MNADesign tabs are presented in Tables 2-A through 2-J.

Components of Alternative 3 include the following:

- Excavation and off-site disposal of 2,130 cubic yards of soil from the source area.
- Installation of 21 injection wells for in situ oxidation.
- One initial sodium permanganate injection and two follow-up injections over a 2-year period with a total of 21,000 pounds of injected oxidant.
- Monitoring of an average of seven wells over the 32-year cleanup period.
- The installation of four, seventy foot deep monitoring wells

In the summary provided by the Project Team, the estimated capital cost for the active remediation is $830,000 and the estimated annual cost for monitoring is $8,250 per year for a total of 32 years.

Detailed Basis for Footprint Evaluation

Tables 2-A through 2-I summarize the information that will serve as the basis for the footprint evaluation of Alternative 3 and the input parameters to SimaPro® and SRT™.

Tables for Alternative 2: Excavation and Bioreactor/MNA

Table 1-A: Electricity Use: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation/LUCs				
Pumps for recirculation inside bioreactor • Solar-powered	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 3	None*	None*	None*

**no electricity is input to the tools because in this case there is no grid-connected energy use. If there was grid-connected energy use, that would be entered here, and it would then be offset by the amount of renewable electricity used in place of grid electricity. However, that is not the case here.*

Table 1-B: Fuel Use for Equipment: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation/Bioreactor				
Fuel use for equipment for excavation • Excavator (diesel) will be used to move 2,130 yd^3	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • 15 days for excavation (TT estimated, based on rate of excavation experienced at Little Rock AFB)	Excavator to move 2,130 yd^3 *SimaPro Assembly Name: Fuel Use_Alt2_excavation* *Materials/Assemblies used: Excavation, skid-steer loader/RER U* *Amount input: 2130 cu yd*	Input into EXDesign tab: Values were automatically populated into the EXDesign tab from the InputSoil tab resulting in the following calculated values: • Volume of affected soil: 2,130 yd^3 • Hours to excavate: 52 The default values for excavator fuel consumption rate (3 gal/hr).	No changes from V2.1 except for the following: SRT-specified excavator fuel use of 5.5 gal/hr was used.

Item for Footprint Evaluation	**Source of Information and/or Comments**	**Input Values to SimaPro®**	**Input Values to SRT™ V2.1**	**Input Values to SRT™ V2.3**
Fuel use for equipment to backfill • Excavator (diesel) will be used to install 2,130 yd^3 of mulch for backfill	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls.	Excavator to install 2,130 yd^3 of mulch *SimaPro Assembly Name: Fuel Use_Alt2_backfill excavator* *Materials/Assemblies used: Excavation, skid-steer loader/RER U* *Amount input: 2130 cu yd*	Input into EXDesign tab: Values were automatically populated into the EXDesign tab from the InputSoil tab resulting in the following calculated values: • Area: 2,300 ft^2 • Total volume of affected soil: 2,130 yd^3 • Fill spread rate:200 yd^3/hr • Rate of water compaction: 174.3 yd^3/hr • Spread and compaction rate: 645 yd^3/hr • Total hours for fill dirt placement: 21 hours Excavator fuel consumption rate: 3 gal/hr	No changes from V2.1 except for the following: SRT-specified excavator fuel use of 5.5 gal/hr was used. SRT calculated the following: • Total hours for dirt placement + landfill activities (loader/spreader): 39 hrs

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Fuel use for the vehicle to distribute on-site water for dust suppression	• TT estimated that dust suppression was a part of the excavation process • TT estimated water use based on correlation to use at Little Rock remedy. The volume of soil excavated from the Beale site is 16% of the volume removed at Little Rock. The daily use of water at the Little Rock site was 10,000 gallons per day. The duration of water application at Little Rock was 146 days. • Distance traveled by water truck estimated by TT (professional judgment) • Daily water use at Beale AFB: 10,000 x 0.16 = 1,600 gallons • Duration of water application at Beale AFB: 146 x 0.16 ~ 23 days	• Daily water use=1600 gallons per day • Duration of water application =23 days • Estimated distance traveled per day by water truck =10 miles • 36,800 gallons x 8.3lbs per gallons/2000 lbs per ton=153 tons per remedy, 6.64 tons per day • 6.64 tons per day x 10 miles= 66.4 tmi per day x 23 days= 1527.2 tmi for full remedy *SimaPro Assembly Name: Fuel Use_Alt 2_dust suppression* *Process used:* *Amount input: Transport, lorry 3.5-16t, fleet average/RER U* *Amount: 1527.2 tmi*[*]	Fuel used for distribution of water for dust suppression is not included in SRT analysis.	Fuel used for distribution of water for dust suppression is not included in SRT analysis.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Fuel use for dump truck for excavated soil disposal • See Table 2-E, Waste Transport	See Table 2-E, Waste Transport	See Table 2-E, Waste Transport	See Table 2-E, Waste Transport	See Table 2-E, Waste Transport
MNA/LUCs				

Item for Footprint Evaluation	**Source of Information and/or Comments**	**Input Values to SimaPro®**	**Input Values to SRT™ V2.1**	**Input Values to SRT™ V2.3**
Equipment for installation of monitoring wells • 280 feet of linear drilling	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • SRT Fuel Consumption Rate, Drilling: 32 gallons per day • SRT calculates 280 linear feet of drilling, a drilling rate of 100 ft/day, a fuel consumption rate of 32 gallons per day, for total fuel (diesel; capital phase) : 89.6 gallons • To calculate fuel use for SimaPro: assume 280 ft of drilling with a hollow stem auger. EPA methodology (including production rate of 100 ft per 8-hour day) for fuel consumption: Fuel Use = HP x hrs x BSFC x PLF = 150 x 22.4 hrs x 0.050 x 0.75 = 126 gals (refer to EPA, 2012, pg 59)	Total Fuel used: 126 gallons diesel *SimaPro Assembly Name: Fuel Use_Alt2_MNA intall mon wells* *Process Used: Diesel, combusted in industrial equipment/US Amount: 126 gal**	MNADesign Tab: Drilling • Number of monitoring wells: 4 • Length of PVC, per well: 70 ft • Fuel consumption rate (default): 32 gallons per day Total fuel for drilling: 89.6 gallons	MNADesign Tab: The default drilling rate for SRT changed to 33.6 gal/day from 32 gal/day.

Table 2-C: Materials Use: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation/Bioreactor				
Mulch for bioreactor • 2130 cubic yards	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 3 & 5 • Density of mulch : 0.4 tons per cubic yard (EPA, 2012) • 2130 yd^3 x 0.4 tons per yd^3 = 852 tons	852 short ton (sh. tn.) 2130 yd^3 x 0.4 tons/yd^3=852 tons Assumed to be a waste product of local tree pruning and yard clippings with no footprint *SimaPro Assembly Name: Materials Use_Alt2_Bark_No_Footprint*	SRT does not account for the use of this material	SRT accounts for mulch in the PRB module. No entry for mulch is provided but there is also no footprint for mulch in SRT.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Solar panels • 30 square feet of solar panels	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 5 says "The GHG emissions associated with 30 square feet of solar panel manufacturing was included as 0.13 tons of GHG."	30 ft^2 *SimaPro Assembly Name: Material Use_Alt2_ExBio_Solar Panels* *Materials/Assemblies used: Photovoltaic laminate, CIS, at plant/DE/I U* *Amount input: 30 sq ft*	SRT does not account for the use of this material	SRT does not account for the use of this material
MNA/LUCs				
PVC for installation of monitoring wells • Four wells • PVC length: 70-foot per well	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • SRT uses a conversion factor of 2.03 lbs/ft of PVC, for a total of 2,600 lbs of PVC • For SimaPro, use 2.012 lbs per linear foot (as per EPA, 2012) : 4 x 70ft = 280 ft x 2.012 lbs per foot = 563.4 lbs of PVC	563.4 lbs of PVC *SimaPro Assembly Name: Materials Use_Alt2_PVC for mon wells* *Materials/Assemblies used: PVC pipe E* *Amount input: 568.4*	• Number of monitoring wells: 4 • Length of piping, per well: 70 feet • Conversion factor: 2.03 lbs/ft	No changes

Tables for Alternative 2 (Excavation/Bioreactor Followed By MNA)
Beale AFB Demonstration Project

Table 2-D: Transport for Materials, Equipment, and Samples: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation/Bioreactor				
Transport of equipment for excavation and backfill • 26 tons excavator	• SRT Application to Support a FS for Site 35 on Beale AFB, CA • TT estimates 30 miles from equipment vendor to site, 2 round trips (one to bring equipment, one to pick up equipment)= 60 miles one way • TT estimates excavator weighs 52,000 lbs (26 tons)	60 miles x 26 tons = 1560 ton-miles *SimaPro Assembly Name: Transport of Materials_Alt2_ExBio_excavator* *Process used: Transport, tractor and trailer/CH U* *Amount input: 1560 ton-mile*	SRT does not account for the transport of the equipment to the site.	SRT does not account for the transport of the equipment to the site.
Transport for the mulch for bioreactor (called "fill" in SRT Spreadsheet) • 15 miles from delivery site • 4.8 tons per load, 200 loads • Fuel type: diesel	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 3 & 5 • SRT Spreadsheet , EXDesign input tab (mileage, loads, weight) • Cell E23 of completed SRT says 200 loads for number of loads of fill dirt, but cell E53 says 230 for number of loads of fill dirt. 200 appears to be correct since cell E61 has 6000 total miles driven for fill (at 15 miles one way) • Default fuel: Diesel (page 14 of SRT User Guide)	• Total miles (one way) for fill dirt delivery: 15 miles x 200 deliveries = 3000 miles • Weight per load for mulch: 12 yd^3 at 0.4 tons per yd^3 lbs mulch density = 4.8 tons per delivery *SimaPro Assembly Name: Transport for Materials_Alt2_ExBio_backfill* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 4.8 x 3000miles=14400 tmi**	• Input into EXDesign tab: • 15 miles, one way, from delivery site • 230 loads • Total miles driven for fill: 6,900 • Dump truck volume for moving fill: 12 yd^3 (note that SRT does not distinguish between the soil (that is the fill default) and the mulch)	No changes except for default SRT fuel usage rate for a dump changed from 8 mpg to 6 mpg.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Transport of solar panels	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 5 • 30 square feet of solar panels, estimated to weigh 78 lbs total • TT estimated transport distance of: 100 miles	3.9 tmi* *SimaPro Assembly Name: Transport of Materials_Alt2_ExBio_solar panels* *Material/Assembly used: Delivery van <3.5t* *Amount input: 3.9 tmi**	This is not represented in SRT.	This is not represented in SRT.
MNA/LUCs				
Coolers for sampling • Monitoring 4 wells (average) over 40 yrs • Sampling frequency: once per year • Assume 1 cooler per year • Assume 10 lbs per cooler to site • Assume 30 lbs per cooler from site • Assume pick up via light truck • Assume location of lab is 75 miles away	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 3 for sampling frequency • SRT Application document says an average of seven wells will require monitoring over a 32 year period, but input to SRT (and related input spreadsheet) has four monitoring wells. • Weight of coolers will be considered de minimis and only mileage for transport will be considered.	• Distance for deliveries: 1 cooler per year x 40 years x 75 miles per trip= 3000 miles • Distance for shipments: 1 cooler per year x 40 years x 75 miles per trip= 3000 miles *SimaPro Assembly Name: Transport of Materials_Alt2_MNA_samples* *Process used: Operation, van < 3,5t/CH U* *Amount input: 6000 miles*	Transport of coolers either not represented in SRT or assumed to be transported with sampling personnel	Transport of coolers either not represented in SRT or assumed to be transported with sampling personnel

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Transport of drilling vehicle to site	• TT estimates use of vehicle similar to large truck as surrogate for drilling rig • TT estimates one way distance of 50 miles	• Distance to vendor= 50 miles one way • Surrogate for drilling rig similar to "heavy duty" vehicle, assumed to be a 15 ton truck *SimaPro Assembly Name: Transport of Materials_Alt2_MNA_drilling vehicle* *Process used: Operation, lorry 3.5-16t, fleet average/RER U* *Amount input: 100 miles*	SRT does not account for the transport of the equipment to the site.	SRT does not account for the transport of the equipment to the site.

Table 2-E: Waste Transport/Disposal: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation/Bioreactor				
Off-site disposal of excavated soil	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • 2130 cy yards excavated at a weight of 1.2825 tons per cubic yard (95 lbs per cubic foot) • Soil expansion (fluff) factor of 1.3. • Soil transported in loads of 12 cy, which is a total of approximately 230 trips (2130 x 1.3 / 12). • 2,732 tons transported a one-way distance of 5 miles	2,732 tons x 5 miles = 13,660 ton-miles *SimaPro Assembly Name: Waste Transport_Alt2_ExBio_Soil Disposal* *Processes used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 13,660 ton-miles* *Transport separate from disposal process* *Waste Scenario Process: Alt2_Disposal of Soil* *Waste Scenario/treatment: Disposal, concrete, 5% water, to inert material landfill/CH U* *Amount 100%*	Input into EXDesign tab: Total miles driven for disposal (2300 miles): • Number of loads for disposal: 230 • One way distance to disposal: 5 miles Dump truck fuel use rate: 8 mpg	No changes except for default SRT fuel usage rate for a dump changed from 8 mpg to 6 mpg.

Table 2-F: Transport for Personnel: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation/Bioreactor				
Travel by Site Workers • average distance traveled by site workers is 70 miles, one way • trips by site workers during construction: 20 trips • trips by site workers after construction: 40	• SRT spreadsheet	60 trips x 140 miles round trip = 8400 person miles *SimaPro Assembly Name: Transportation of Personnel_Alt2_ExBio_site worker* *Process used: Transport, passenger car, petrol, fleet average 2010/RER U* *Amount input: 8400 pmi*	Input into EXDesign tab: • 20 trips during construction • 40 trips after construction (including monitoring) • average distance traveled by site workers is 70 miles, one way	No changes.
MNA/LUCs				
Travel by Site Workers • average distance traveled by site workers is 70 miles, one way • trips by site workers during construction: 4 trips • trips by site workers after construction: 40	• SRT spreadsheet	88 trips x 140 miles round trip = 12,320 person miles (equal to the number of miles in the SRT input) *SimaPro Assembly Name: Transportation of Personnel_Alt2_MNA LUCs_sitewrkr* *Process used: Transport, passenger car, petrol, fleet average 2010/RER U* *Amount input: 12,320 pmi*	Input into MNADesign tab: • 4 trips during construction • 1 characterization sampling event • 4 sampling events in the first year • 40 trips after construction • 39 trips for sampling once per year for the remaining 39 years • average distance traveled by site workers is 70 miles, one way • (4+1+4) x 2 x 70 + (40+39) x 2 x 70 = 12,320 miles	No changes.

Table 2-G: Potable Water Use: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
None.				

Table 2-H: Non-Potable Water Use: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Water for dust control	• Amount of water required for dust suppression during excavation and placement of bioreactor has been estimated by TT. • TT estimated approximately 5 trips/day for water truck with capacity of 2,000 gallons for 23 working days	5 x 2000 x 23= 230,000 gallons *SimaPro Assembly Name: Non-Potable Water_Alt2_ExBio_water dust control* *Assembly used: Tap water, at user/RER U* *Amount input: 1,909,000 lbs*	SRT does not have an input option for water use.	SRT does not have an input option for water use.

Table 2-I: Known Use of On-Site Renewables: Alternative 2 (Excavation/Bioreactor/40 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Pumps for recirculation inside bioreactor • Solar-powered	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 3	No input to SimaPro	None*	None*

**see comment regarding Table 2-A*

Table 2-J: eGRID Subregion, CAMX, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	11.9033	26,141,141.5
Oil	1.1747	2,579,750.7
Gas	42.2704	92,830,630.5
Other Fossil	1.0291	2,259,976.3
Nuclear	16.4631	36,154,898.0
Other Unknown / Purchased Fuel	0.0943	207,005.9
Nonrenewable Total	72.9348	160,173,402.9
Renewable Resource		
Wind	1.9396	4,259,490.6
Solar	0.2444	536,713.3
Geothermal	4.6211	10,148,526.6
Biomass	2.6088	5,729,247.8
Hydro	17.6513	38,764,274.9
Renewable Total	27.0652	59,438,253.3

Tables for Alternative 3: Excavation/ISCO/MNA

Table 3-A: Electricity Use: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
None identified				

Table 3-B: Fuel Use for Equipment: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation				
Fuel use for equipment for excavation • Excavator (diesel) will be used to move 2,130 yd^3	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • 15 days for excavation (TT estimated, based on rate of excavation experienced at Little Rock AFB)	Excavator to move 2,130 yd^3 *SimaPro Assembly Name: Fuel Use_Alt2_excavation* *Materials/Assemblies used: Excavation, skid-steer loader/RER U* *Amount input: 2130 cu yd*	Input into EXDesign tab: Values were automatically populated into the EXDesign tab from the InputSoil tab resulting in the following calculated values: • Volume of affected soil: 2,130 yd^3 • Hours to excavate: 52 The default values for excavator fuel consumption rate (3 gal/hr).	No changes from V2.1 except for the following: SRT-specified excavator fuel use of 5.5 gal/hr was used.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Fuel use for equipment to backfill • Excavator (diesel) will be used to backfill 2,130 yd^3 of soil	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls.	Excavator to backfill 2,130 yd^3 of soil *SimaPro Assembly Name: Fuel Use_Alt3_backfill excavator* *Materials/Assemblies used: Excavation, skid-steer loader/RER U* *Amount input: 2130 cu yd*	Input into EXDesign tab: Values were automatically populated into the EXDesign tab from the InputSoil tab resulting in the following calculated values: • Area: 2,300 ft^2 • Total volume of affected soil: 2,130 yd^3 • Fill spread rate:200 yd^3/hr • Rate of water compaction: 174.3 yd^3/hr • Spread and compaction rate: 645 yd^3/hr • Total hours for fill dirt placement: 21 hours Excavator fuel consumption rate: 3 gal/hr	No changes from V2.1 except for the following: SRT-specified excavator fuel use of 5.5 gal/hr was used. SRT calculated the following: • Total hours for dirt placement + landfill activities (loader/spreader): 39 hrs

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Fuel use for the vehicle to distribute on-site water for dust suppression	• TT estimated that dust suppression was a part of the excavation process • TT estimated water use based on correlation to use at Little Rock remedy. The volume of soil excavated from the Beale site is 16% of the volume removed at Little Rock. The daily use of water at the Little Rock site was 10,000 gallons per day. The duration of water application at Little Rock was 146 days. • Distance traveled by water truck estimated by TT (professional judgment) • Daily water use at Beale AFB: 10,000 x 0.16 = 1,600 gallons • Duration of water application at Beale AFB: 146 x 0.16 ~ 23 days	• Daily water use=1600 gallons per day • Duration of water application =23 days • Estimated distance traveled per day by water truck =10 miles • 36,800 gallons x 8.3lbs per gallons/2000 lbs per ton=153 tons per remedy, 6.64 tons per day • 6.64 tons per day x 10 miles= 66.4 tmi per day x 23 days= 1527.2 tmi for full remedy *SimaPro Assembly Name: Fuel Use_Alt 2_dust suppression* *Process used:* *Amount input: Transport, lorry 3.5-16t, fleet average/RER U* *Amount: 1527.2 tmi**[*]	Fuel used for distribution of water for dust suppression is not included in SRT analysis.	Fuel used for distribution of water for dust suppression is not included in SRT analysis.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Fuel use for dump truck for excavated soil disposal • See Table 2-E, Waste Transport	See Table 2-E, Waste Transport	See Table 2-E, Waste Transport	See Table 2-E, Waste Transport	See Table 2-E, Waste Transport
ISCO				

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Fuel use for equipment for installation of injection wells • 21 injection wells • Length of well: 65 feet	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • 21 injection wells and length of well is 65 feet. 21 x 65 ft = 1,365 feet total drilling depth • SRT uses a drilling fuel consumption rate of 10 gal/day • To calculate fuel use for SimaPro assume 1,365 ft of drilling with a hollow stem auger and use EPA methodology (including production rate of 100 ft per 8-hour day) for fuel consumption: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 109.2 hrs x 0.050 x 0.75 = 614.25 gals (refer to EPA, 2012, pg 59)	614.25 gallons diesel *SimaPro Assembly Name: Fuel Use_Alt3_ISCO_well installation* *Process Used: Diesel, combusted in industrial equipment/US Amount: 614.25gal**	Input into ISCODesign tab: • 21 injection wells • Length of well: 65 feet Drilling rate: 100 ft/day • Drilling fuel consumption: 10 gal/day Total fuel for drilling: 136.5 gallons (diesel) Note: Total fuel usage for drilling and oxidant delivery is overridden with a value of 250 gal.	MNADesign Tab: The default fuel usage for drilling in SRT is 33.6 gal/day instead of 10 gal/day.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
MNA				
Equipment for installation of monitoring wells • 280 feet of linear drilling	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • SRT Fuel Consumption Rate, Drilling: 32 gallons per day • SRT calculates 280 linear feet of drilling, a drilling rate of 100 ft/day, a fuel consumption rate of 32 gallons per day, for total fuel (diesel; capital phase) : 89.6 gallons • To calculate fuel use for SimaPro: assume 280 ft of drilling with a hollow stem auger. EPA methodology (including production rate of 100 ft per 8-hour day) for fuel consumption: Fuel Use = HP x hrs x BSFC x PLF = 150 x 22.4 hrs x 0.050 x 0.75 = 126 gals (refer to EPA, 2012, pg 59)	Total Fuel used: 126 gallons diesel *SimaPro Assembly Name: Process Used: Diesel, combusted in industrial equipment/US Amount: 126 gal**	Drilling • Number of monitoring wells: 4 • Length of PVC, per well: 70 ft • Fuel consumption rate (default): 32 gallons per day Total fuel for drilling: 89.6 gallons	MNADesign Tab: The default drilling rate for SRT changed to 33.6 gal/day from 32 gal/day.

Table 3-C: Materials Use: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation				
Soil for fill • 2130 cubic yards	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • Density of sand/gravel/soil : 1.5 tons per cubic yard (EPA, 2012) • 2130 yd^3 x 1.5 tons per yd^3 = 3,195 tons	• 3195 short ton (sh. tn.) *SimaPro Assembly Name: Materials Use_Alt3_Ex_Soil for Backfill* *Materials/Assemblies used: Sand, at mine/CH U* *Amount input: 3195 tn.sh*	Footprints for the soil, sand or gravel (as materials) are not included in SRT.	Footprints for the soil, sand or gravel (as materials) are not included in SRT.
ISCO				
Sodium Permanganate • One initial injection and two follow-up injections	• SRT Application to Support a FS for Site 35 on Beale AFB, CA (page 5) and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • Amount of oxidant as per completed SRT spreadsheet • Oxidant: 21,000 lbs	• 21,000 lbs sodium permanganate • Surrogate used: Potassium Permanganate *SimaPro Assembly Name: Materials Use_Alt3_ISCO_Sodium Permanganate* *Materials/Assemblies used: Potassium permanganate, at plant/RER U* *Amount input:* 21000 lbs	Input into ISCODesign tab: • Mass of oxidant initial event: 13,000 lbs; • Mass of oxidant subsequent events: 6500 lbs. • Total mass of oxidant= 21,000 lbs	No changes.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
PVC for ISCO Injection well construction	• SRT Application to Support a FS for Site 35 on Beale AFB, CA (page 5) and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • 21 wells x 65 feet deep= 1,365 linear feet • SRT default: 2.03 lbs per foot for weight of PVC (therefore estimate that this is to represent 4" Schedule 40 PVC pipe) • For SimaPro, use 2.012 lbs per linear foot (as per EPA, 2012) : 1,365 ft x 2.012 lbs per foot = 2746.4 lbs of PVC	2746.4 lbs of PVC *SimaPro Assembly Name: Materials Use_Alt3_ISCO_pvc for inject well constr* *Materials/Assemblies used: PVC pipe E* *Amount input: 2746.4 lb*	• Length of PVC, per well: 65 ft • Number of injection points: 21 • Default: 2.03 lbs per linear foot (4" Schedule 40 PVC)	No changes.
MNA				
PVC for installation of monitoring wells • Four wells • PVC length: 70-foot per well	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • SRT uses a conversion factor of 2.03 lbs/ft of PVC, for a total of 2,600 lbs of PVC • For SimaPro, use 2.012 lbs per linear foot (as per EPA, 2012) : 4 x 70ft = 280 ft x 2.012 lbs per foot = 563.4 lbs of PVC	• 563.4 lbs of PVC *SimaPro Assembly Name: Materials Use_Alt2_PVC for mon wells* *Materials/Assemblies used: PVC pipe E* *Amount input: 568.4*	• Number of monitoring wells: 4 • Length of piping, per well: 70 feet • Conversion factor: 2.03 lbs/ft	No changes.

Table 3-D: Transport for Materials, Equipment, and Samples: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation				
Transport of equipment for excavation and backfill • 26 tons excavator	• SRT Application to Support a FS for Site 35 on Beale AFB, CA • TT estimates 30 miles from equipment vendor to site, 2 round trips (one to bring equipment, one to pick up equipment)= 60 miles one way • TT estimates excavator weighs 52,000 lbs (26 tons)	60 miles x 26 tons = 1560 ton-miles *SimaPro Assembly Name: Transport of Materials_Alt2_ExBio_excavator* *Process used: Transport, tractor and trailer/CH U* *Amount input: 1560 tmi*	SRT does not account for the transport of the equipment to the site.	SRT does not account for the transport of the equipment to the site.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Transport for fill (soil) for backfill • 15 miles from delivery site • 15.4 tons per load, 200 loads • Fuel type: diesel	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 3 & 5 • SRT Spreadsheet , EXDesign input tab (mileage, loads, weight) • Cell E23 of completed SRT says 200 loads for number of loads of fill dirt, but cell E53 says 230 for number of loads of fill dirt. 200 appears to be correct since cell E61 has 6000 total miles driven for fill (at 15 miles one way) • Diesel fuel type is default input for excavation and dump truck as per page 14 of SRT User Guide	• One-way distance for fill delivery: 15 miles • Weight of fill 3,195 short tons (2,130 cy x 1.5 tons per cy). • 47,925 ton-miles (15 miles x 3,195 tons) *SimaPro Assembly Name: Transport of Materials_Alt3_Soil for backfill* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 47,925 ton-mile*	Input into EXDesign tab: • 15 miles, one way, from delivery site • 230 loads • Total miles driven for fill: 6,900 • Dump truck volume for moving fill: 12 yd^3	No changes except for default SRT fuel usage rate for a dump changed from 8 mpg to 6 mpg.
ISCO				

Item for Footprint Evaluation	**Source of Information and/or Comments**	**Input Values to SimaPro®**	**Input Values to SRT™ V2.1**	**Input Values to SRT™ V2.3**
Transport of Sodium Permanganate • One initial injection and two follow-up injections • Distance to oxidant supplier: 500 miles, one way • Oxidant load delivery capacity: 10,000 lbs per truck load • Fuel type assumed: diesel • SRT assumes a fuel consumption rate of 17.6 mpg for oxidant delivery	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 5 • SRT fuel consumption rate from SRT Users Guide, page 24 • 2000 miles x 17.6 mpg= 114 gallons (from SRT completed spreadsheet)	• 2 trips of 500 miles, one way • 10,000 lbs (5 tons) per truckload *SimaPro Assembly Name: Transport of Materials_Alt 2_ISCO_sodium permang* *Process used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 5000 tmi**	• Distance to oxidant supplier: 500 • Oxidant load delivery capacity: 10,000 lbs per truck load • Number of loads for oxidant: 3 • Total miles driven for oxidant: 3,000 miles Note: Total diesel usage for drilling and oxidant delivery is overridden with a value of 250 gal.	• Distance to oxidant supplier: 50 • Oxidant load delivery capacity: 10,000 lbs per truck load • Number of loads for oxidant: 3 • Total miles driven for oxidant: 300 miles Total fuel for drilling and oxidant delivery is calculated by SRT to be 500 gal.
MNA				
Coolers for sampling • Monitoring 4 wells (average) over 40 yrs • Sampling frequency: once per year • Assume 1 cooler per year • Assume 10 lbs per cooler to site • Assume 30 lbs per cooler from site • Assume pick up via light truck • Assume location of lab is 75 miles away	• SRT Application to Support a FS for Site 35 on Beale AFB, CA; p. 3 for sampling frequency • SRT Application document says an average of seven wells will require monitoring over a 32 year period, but input to SRT (and related input spreadsheet) has four monitoring wells. • Weight of coolers will be considered de minimis and only mileage for transport will be considered.	• Distance for deliveries: 1 cooler per year x 40 years x 75 miles per trip= 3000 miles • Distance for shipments: 1 cooler per year x 40 years x 75 miles per trip= 3000 miles *SimaPro Assembly Name: Transport of Materials_Alt2_MNA_samples* *Process used: Operation, van < 3,5t/CH U* *Amount input: 6000 miles*	Transport of coolers either not represented in SRT or assumed to be transported with sampling personnel	Transport of coolers either not represented in SRT or assumed to be transported with sampling personnel

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Transport of drilling vehicle to site Assume vehicle similar to large truck	• Assume large truck • Assume one way distance of 50 miles	• Distance to vendor= 50 miles one way • Surrogate for drilling rig similar to “heavy duty” vehicle, assumed to be a 15 tons truck *SimaPro Assembly Name: Transport of Materials_Alt2_MNA_drilling vehicle* *Process used: Operation, lorry 3.5-16t, fleet average/RER U* *Amount input: 100 miles*	SRT does not account for the transport of the equipment to the site.	SRT does not account for the transport of the equipment to the site.

Table 3-E: Waste Transport/Disposal: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation				
• Off-site disposal of excavated soil	• SRT Application to Support a FS for Site 35 on Beale AFB, CA and SRT spreadsheet, "Beale Site 35 Tier 2.xls. • 2130 cy yards excavated at a weight of 1.2825 tons per cubic yard (95 lbs per cubic foot) • Soil expansion (fluff) factor of 1.3. • Soil transported in loads of 12 cy, which is a total of approximately 230 trips (2130 x 1.3 / 12). • 2,732 tons transported a one-way distance of 5 miles	2,732 tons x 5 miles = 13,660 ton-miles *SimaPro Assembly Name: Waste Transport_Alt2_ExBio_Soil Disposal* *Processes used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 13,660 ton-miles* *Transport separate from disposal process* *Waste Scenario Process: Alt2_Disposal of Soil* *Waste Scenario/treatment: Disposal, concrete, 5% water, to inert material landfill/CH U* *Amount 100%*	Input into EXDesign tab: Total miles driven for disposal (2300 miles): • Number of loads for disposal: 230 • One way distance to disposal: 5 miles • Dump truck fuel use rate: 8 mpg	No changes except for default SRT fuel usage rate for a dump changed from 8 mpg to 6 mpg.

Table 3-F: Transport for Personnel: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation				
Travel by Site Workers • average distance traveled by site workers is 70 miles, one way • trips by site workers during construction: 20 trips • trips by site workers after construction: 40	• SRT spreadsheet	60 trips x 140 miles round trip = 8400 person miles *SimaPro Assembly Name: Transportation of Personnel_Alt2_ExBio_site worker* *Process used: Transport, passenger car, petrol, fleet average 2010/RER U* *Amount input: 8400 pmi*	Input into EXDesign tab: • 20 trips during construction • 40 trips after construction (including monitoring) • average distance traveled by site workers is 70 miles, one way	No changes.
ISCO				
Travel by Site Workers • average distance traveled by site workers is 70 miles, one way • trips by site workers during construction: 30 trips • trips by site workers after construction: 16	• SRT spreadsheet	46 trips x 140 miles round trip = 6440 person miles *SimaPro Assembly Name: Transportation of Personnel_Alt3_ISCO_site workers Transport, passenger car, petrol, fleet average/RER U* *Amount input: 6440 pmi*	Input into ISCODesign tab: • 30 trips during construction • 16 trips after construction (including monitoring) • average distance traveled by site workers is 70 miles, one way	No changes.
MNA				

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Travel by Site Workers • average distance traveled by site workers is 70 miles, one way • trips by site workers during construction: 4 trips • trips by site workers after construction: 40	• SRT spreadsheet	44 trips x 140 miles round trip = 6,160 person miles *SimaPro Assembly Name: Transportation of Personnel_Alt2_MNA LUCs_sitewrkr* *Process used: Transport, passenger car, petrol, fleet average/RER U* *Amount input: 6,160 pmi*	Input into MNADesign tab: • 4 trips during construction • 40 trips after construction (including monitoring) • average distance traveled by site workers is 70 miles, one way	No changes.

Table 3-G: Potable Water Use: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Excavation				
None.				
ISCO				
None.				
MNA				
None.				

Table 3-H: Non-Potable Water Use: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Water for dust control	• Amount of water required for dust suppression during excavation and placement of bioreactor has been estimated by TT. • TT estimated approximately 5 trips/day for water truck with capacity of 2,000 gallons for 23 working days	5 x 2000 x 23= 230,000 gallons *SimaPro Assembly Name: Non-Potable Water_Alt2_ExBio_water dust control* *Assembly used: Tap water, at user/RER U* *Amount input:230000 x 8.3 lbs per gallon= 1,909,000 lbs*	SRT does not have an input option for water use.	SRT does not have an input option for water use.

Table 3-I: Known Use of On-Site Renewables: Alternative 3 (Excavation/ISCO/32 Years MNA/LUCs)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro	Input Values to SRT	
None Identified				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 3-J: eGRID Subregion, CAMX, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	11.9033	26,141,141.5
Oil	1.1747	2,579,750.7
Gas	42.2704	92,830,630.5
Other Fossil	1.0291	2,259,976.3
Nuclear	16.4631	36,154,898.0
Other Unknown / Purchased Fuel	0.0943	207,005.9
Nonrenewable Total	72.9348	160,173,402.9
Renewable Resource		
Wind	1.9396	4,259,490.6
Solar	0.2444	536,713.3
Geothermal	4.6211	10,148,526.6
Biomass	2.6088	5,729,247.8
Hydro	17.6513	38,764,274.9
Renewable Total	27.0652	59,438,253.3

Coordination of Site Data Input:
Little Rock Air Force Base Skeet Range

FOR

QUANTIFYING LIFE-CYCLE ENVIRONMENTAL FOOTPRINTS
OF SOIL AND GROUNDWATER REMEDIES

ESTCP Project # ER-201127

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INTRODUCTION

Little Rock Air Force Base (LRAFB) is located approximately 17 miles northeast of Little Rock and adjacent to the City of Jacksonville, in Pulaski County, Arkansas. The Former Skeet Range, which was associated with the recreational Old Rod and Gun Club, is located on the east side of LRAFB, north of the Explosive Ordinance Disposal (EOD) Range, and south of the Small Arms Training Area. A Comprehensive Site Evaluation (CSE) Phase I Study performed in 2005 reported that the Former Skeet Range was operated from 1965 to 1973 and estimated the total area to be 15.5 acres. The Phase I Study listed lead shot and polycyclic aromatic hydrocarbons (PAHs) from clay target debris as known or suspected munitions constituents.

In 2009, field investigation activities were performed during a site-specific Remedial Investigation (RI) to define the lateral extent of metals and PAHs in surface soil and the vertical extent of these constituents in subsurface soil and groundwater. There were 47 grids within the Former Skeet Range identified as containing soils with metals and /or PAHs above residential medium-specific screening levels (MSSL). From 2010 through 2011, soil from these 47 grids was excavated and disposed off-site. The site was backfilled with certified clean soil and small trees were planted to restore the area. Mulch was spread within the excavated area to prevent erosion and the natural topography was restored for drainage purposes.

Information and data required for a GSR footprint evaluation of the soil excavation and disposal at the Former Skeet Range at LRAFB was developed from the following data sources:

- *Little Rock Air Force Base: Skeet Range SRT Analysis* (Preliminary Draft, GSI Environmental, 2011) – Specific input to the SRT™ tool is documented in Appendix A of that report.

- *Draft Remedial Action Completion Report* (August 2011)

This GSR evaluation has only one alternative (soil excavation and disposal). However, the SRT™ analysis was performed using both “Tier 1” and the more site-specific “Tier 2”.

The intent of this document is to provide a basis for the development of input for the SimaPro® and SRT™ tools for this remedial action.

ALTERNATIVE 1:
SOIL EXCAVATION

Overview of Alternative 1

They key items of Alternative 1 with respect to footprint results are the excavation and disposal of contaminated soils, backfill with clean soil, site restoration, and transport of personnel, materials, and equipment. Basic data provided in *Little Rock Air Force Base: Skeet Range SRT Analysis* (Preliminary Draft, GSI Environmental, 2011) includes the following:

Inputs	Unit	Tier 1	Tier 2
Gasoline Cost	($/gallon)	3.10	3.10
Diesel Cost	($/gallon)	3.45	3.45
Natural Gas Cost	($/mcf)	7.53	7.53
Area of Affected Soil	(ft2)	704,758	704,758
Depth to Top of Affected Soil	(ft)	0	0
Soil Type		Clay	Clay
Contaminant Class		Non-Hazardous	Non-Hazardous
Airline miles flown by project team	(total miles)	28,000	28,000
Average Distance Traveled by Site Workers per one-way trip	(miles)	1	1
Trips by Site Workers during construction		184	184
Trips by Site Workers after construction		18	18
Distance to Disposal	(one-way, miles)	10	10
CO2 Emissions to Atmosphere Offset	(tons CO2)	0	-0.46
Dump Truck Volume for Disposal	(cy)	12	18.11
Dump Truck Volume for Moving Fill	(cy)	12	18.11
Distance from Site to Fill Source	(one way, miles)	10	15

SRT^{TM} default values are shaded, site-specific values are not shaded.

Components of Alternative 1 include the following:

- Excavation of 13,051.07 cubic yards of contaminated soil and backfill of excavated area with clean fill (704,757 ft^2 x 0.5 ft. deep)
    - Excavation project duration of approximately 92 days
    - Used Caterpillar 324 excavator with a blade attachment
    - Stabilization process
        - 16 days of stabilization work
        - Equipment includes the same loader and water truck as the excavation work used (diesel)
        - 4,320 yd^3
        - Using 14 dump trucks that carry 27 tons of cement each

- A water truck was used to spray water over the project area to maintain dust control.
  - 146 days of dust suppression
  - 10,000 gallons of water per day

- Air transport of personnel to and from site
  - Contractor personnel traveled (via plane) between California and Arkansas ~4 times roundtrip, for a total estimate of 12,800 miles flown
  - Contractor personnel traveled (via plane) between Texas and Arkansas biweekly, for a total estimate of 16,000 miles flown

- Vehicle transport of personnel to and from site
  - Daily trips to the site were approximately 2 miles round trip
  - Workers traveled to and from the site for ~92 days during the excavation project and for 9 days after the excavation project, for a total of 101 round trips (i.e., 202 miles driven)

- Off-site disposal of excavated soil in a non-hazardous landfill
  - For Tier 2, dump truck capacity is 22 tons, or 18.11 cubic yards of clay soil (using average density of 90 lbs./ft^3)
  - One-way distance from the site to the landfill is 10 miles
  - 940 dump truck loads needed for disposal
  - Total of 18,800 miles driven for disposal

- Transport of clean backfill to excavated area
  - For Tier 2, dump truck capacity is 22 tons, or 18.11 cubic yards of clay soil (using average density of 90 lbs./ft^3)
  - One-way distance from fill source to excavated area is 15 miles
  - 940 dump truck loads needed for fill
  - Total of 28,200 miles driven for fill

- Site Restoration
  - Hardwood and pine trees were planted to offset CO_2 emissions, resulting in a change from an industrial region to a grassland/rangeland
  - Based on information provided by the SRT, CO_2 sequestration rates due to the change in the biome type were calculated to be 0.46 tons CO_2 per year
  - Timber from site clearing that could not be recycled and sold was chopped and used as mulch for erosion control

- Sampling
  - Soil confirmation testing will be performed, but shipping of coolers and samples does not appear to have been included in the SRT analysis. It is unclear whether this testing will involve field screening and/or off-site lab analysis.

Detailed Basis for Footprint Evaluation

Tables 1-A through 1-I summarize the information that will serve as the basis for the footprint evaluation of Alternative 1 and the input parameters to SimaPro® and SRT™.

Table 1-A: Electricity Use: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
None identified	N/A	None	None	None

Table 1-B: Fuel Use for Equipment: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Heavy equipment for soil excavation • Assume an excavator (diesel) will be used to move 352,378.79 ft^3 (13,051.07 yd^3) • 92 days for excavation	• Little Rock AFB: Skeet Range SRT Analysis; p. 3&4 • Caterpillar 324 excavator with a blade attachment based Remedial Action Completion Report	Excavator (assumed) to move 13,051.07 yd^3 *SimaPro Assembly Name: Fuel Use for Excavation Equipment* *Materials/Assemblies used: Excavation, hydraulic digger/RER U* *Amount input: 13052 cu yd*	Input into EXDesign tab: To calculate "total hours to excavate" (result-52 person-hours): • Volume of affected soil: 13,052 yd^3 • Soil density: 90 lb/ft^3 • Excavation rate: 53 tons per hour • Excavator fuel consumption rate: 3 gal/hr	No changes from V2.1 except for the following: SRT-specified excavator fuel use of 5.5 gal/hr was used.
Heavy equipment for soil backfill • Assume an excavator (diesel) will be used to move 352,378.79 ft^3 (13,051.07 yd^3) • 92 days for excavation	• Little Rock AFB: Skeet Range SRT Analysis; p. 3&4	Excavator (assumed) to move 13,051.07 yd^3 *SimaPro Assembly Name: Fuel Use for Fill Equipment* *Materials/Assemblies used: Excavation, hydraulic digger/RER U* *Amount input: 13052 cu yd*	Input into EXDesign tab: To calculate "Total hours for fill dirt placement": • Area of affected soil: 704757.58 • Number of loads of fill dirt: 940 • Dump truck volume:18.11 cu yd • Rate of water compaction: 174.3 cu yd per hour • Total volume of fill dirt/spread and compaction rate: (17023.4/654= 26.03, cells that are calculated from other cells)	No changes from V2.1 except for the following: SRT-specified excavator fuel use of 5.5 gal/hr was used. SRT calculated the following: • Total hours for dirt placement + landfill activities (loader/spreader): 360 hrs

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Equipment used to Stabilize with Cement • 16 days of excavator use • Assume 142 yd^3 stabilized per day moved (determined from rate of earth movement during excavation	• Comment on returned document by Ty T. Ta (attached to 1/23/12 email)	16 x 142 = 2270 yd^3 *SimaPro Assembly Name: Fuel Use_Equip to Stabilize* *Materials/Assemblies used: Excavation, hydraulic digger/RER U* *Amount input: 2270 cu yd*	Not included in SRT analysis.	Not included in SRT analysis.
Planting 3,155 trees were planted: • Types of trees: • Willow Oak • Green Ash • Pine • Nuttall Oak • Bald Cypress • Elm • Sycamore • Black Willow • Shumard Oak	• Comment on returned document by Ty T. Ta (attached to 1/23/12 email)	704757.58 sq ft of planting (using planter) *SimaPro Assembly Name: Fuel Use_Planter* *Materials/Assemblies used: Planting/CH U* *Amount input: 704757.58 sq ft*	Not included in SRT analysis	Not included in SRT analysis.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
On-site distribution of water • Daily water use=10,000 gallons per day • Duration of water application =146 day • Estimated distance traveled per day by water truck =10 miles • 1,460,000 gallons x 8.3lbs per gallons/2000 lbs per ton=6059 tons per remedy; 41.5 tons per day • 41.5 tons per day x 10 miles= 415 tmi per day x 146 days= 60590 tmi for full remedy	• Comment on returned document by Ty T. Ta (attached to 1/23/12 email)	60590 tmi *SimaPro Assembly Name: Fuel Use_On site distribution of water* *Materials/Assemblies used: Transport, lorry 3.5-16t, fleet average/RER U* *Amount input: 60590 tmi*	Not included in SRT analysis	Not included in SRT analysis

Table 1-C: Materials Use: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Clean fill for excavated area • 13,051.07 yd^3 clean soil	• Little Rock AFB: Skeet Range SRT Analysis; assumed based on p. 3&4 and Appendix A • SRT does not include a footprint for the material used as clean fill. • SimaPro will not include a footprint for the material due to the unknown nature or origin of the fill.	13,051.07 yd^3 clean soil *SimaPro Assembly Name: Material Use_Clean Fill_no footprint* *Materials/Assemblies used: soil, fill, borrow (no footprint)* *Amount input: 19578 tn.sh*	Footprints for the soil, sand or gravel (as materials) are not included in SRT.	Footprints for the soil, sand or gravel (as materials) are not included in SRT.
Hardwood and pine trees 3,155 trees were planted: • Types of trees: • Willow Oak • Green Ash • Pine • Nuttall Oak • Bald Cypress • Elm • Sycamore • Black Willow • Shumard Oak	• Little Rock AFB: Skeet Range SRT Analysis; p. 4 • Comment on returned document by vpy (attached to 1/23/12 email)	• Fuel Use for planting has been accounted for in previous table • SimaPro support does not recommend the use of carbon offset values due to the low validation rate of those numbers in the literature. (Phone conversation with Shawn Blennis)	-0.46 tons CO_2 emissions to atmosphere noted in documents but not entered into SRT.	-0.46 tons CO_2 emissions to atmosphere
Stabilization Cement	• Little Rock AFB: Skeet Range SRT Analysis; page 6 • Comment on returned document by Ty T. Ta (attached to 1/23/12 email)	• 4320 yd^3 of soil stabilized • Total needed: 378 tons of cement required *SimaPro Assembly Name: Material_Cement for Stabilization* *Materials/Assemblies used: Portland cement, strength class Z 42.5, at plant/CH U* *Amount input: 378 tn.sh*	Cement is not an input for SRT.	Cement is not an input for SRT.

Table 1-D: Transport for Materials, Equipment, and Samples: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Equipment for excavation and backfill	• Little Rock AFB: Skeet Range SRT Analysis; p. 3&4 • Comment on returned document by vpy (attached to 1/23/12 email)	• 30 miles one way • Excavator weighs 52,000 lbs • Assume diesel fuel *SimaPro Assembly Name: Transport of equip for excavation and backfill* *Process used: Transport, tractor and trailer/CH U* *Amount input: 780 tmi*	SRT does not account for the transport of the equipment to the site.	SRT does not account for the transport of the equipment to the site.
Hardwood and pine trees • 3155 trees, assumed to be 5 lbs each • Transported by tractor trailer from 25 miles away • Transport fuel type: diesel	• Little Rock AFB: Skeet Range SRT Analysis; p. 4	197 ton miles *SimaPro Assembly Name: Transport of trees* *Process used: Transport, tractor and trailer/CH U* *Amount input: 197 tmi*	SRT does not account for the transport of the trees to the site.	SRT does not account for the transport of the trees to the site.
Transport of clean fill for excavated area • 13,051.07 yd^3 clean soil • 18.11 yd^3 dump truck volume • 940 loads of fill dirt • 15 miles one way from site to fill source • 28,000 total miles driven for fill • 28,000 total miles driven with 18.11 yd^3 (22 tons) load	• Little Rock AFB: Skeet Range SRT Analysis; Appendix A	294000 tmi *SimaPro Assembly Name: Transport of Clean Fill* *Process Used: Transport, lorry 20-28t, fleet average/CH U* *Amount input: 294000 tmi*	• 18.11 yd^3 dump truck volume • 940 loads of fill dirt • 15 miles one way from site to fill source	No changes except for default SRT fuel usage rate for a dump changed from 8 mpg to 6 mpg.

Item for Footprint Evaluation	**Source of Information and/or Comments**	**Input Values to SimaPro®**	**Input Values to SRT™ V2.1**	**Input Values to SRT™ V2.3**
Transport of Cement for Stabilization • Uses 14 dump truck carrying 27 tons of cement per truck • Distance from vendor to site: 100 miles • 14 x 27 x 100= 37800 tmi	• Little Rock AFB: Skeet Range SRT Analysis; page 6 • Comment on returned document by Ty T. Ta (attached to 1/23/12 email)	37,800 ton miles *SimaPro Assembly Name: Transport of cement Process Used: Transport, lorry 20-28t, fleet average/CH U Amount input: 37800 tmi*	SRT does not account for the transport of the cement to the site.	SRT does not account for the transport of the cement to the site.

Table 1-E: Waste Transport/Disposal: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Transport of excavated soil to landfill • 13,051.07 yd^3 excavated soil • 18.11 yd^3 dump truck volume • 940 loads of soil • 10 miles one way from site to landfill • 18,800 total miles driven for disposal • 18,800 total miles driven with 18.11 yd^3 (22 tons) load • 9,400 miles x 22 tons= 413,600 tmi • SimaPro assumes empty trip	• Little Rock AFB: Skeet Range SRT Analysis; Appendix A	206800 ton miles *SimaPro Assembly Name: Transport of soil for disposal* *Process Used: Transport, lorry 20-28t, fleet average/CH U Amount input: 206800 tmi* *Waste Disposal: Modeled as additional Life Cycle named: Soil disposal. Process: Landfill disposal of soil, Waste Scenario: Disposal, concrete, 5% water, to inert material landfill/CH U, 100%*	• 18.11 yd^3 dump truck volume • 940 loads of soil • 10 miles one way from site to landfill	No changes except for default SRT fuel usage rate for a dump changed from 8 mpg to 6 mpg.

Table 1-F: Transport for Personnel: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Air Travel: Contractor, round trip California to Arkansas • 4 trips • Total estimate of 12,800 miles round trip • Based on the above information (and assuming ~3,200 miles round trip for one trip), only one traveler is assumed	• Little Rock AFB: Skeet Range SRT Analysis; p. 4	28,800 miles entered (total air miles for all travelers over project lifetime) *SimaPro Assembly Name: Transport of Personnel_Air Travel* *Process Used: Transport, aircraft, passenger/RER U* *Amount input: 28800 pmi*	28,800 miles entered (total air miles for all travelers over project lifetime)	No changes.
Daily trips to the site • ~2 miles round trip • Travel to and from site for 92 days during excavation project • Travel to and from site for 9 days after excavation project • Based on assumptions for air travel above, assume 3 personnel traveling to site daily • Based on SRT inputs for trips by site workers, assume all 3 workers carpool in one vehicle • Assume light truck, gasoline	• Little Rock AFB: Skeet Range SRT Analysis; p. 4 and Appendix A	404 miles, round trip, driven in a car, gasoline *SimaPro Assembly Name: Transport_Site Workers_404 miles Process Used: Transport, passenger car/RER U* *Amount input: 404 pmi*	• 1 mile average distance traveled per one-way trip • 184 trips during construction • 18 trips after construction	No changes.

Table 1-G: Potable Water Use: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
None identified	N/A	None	None	None.

Table 1-H: Non-Potable Water Use: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Water for dust control	• Little Rock AFB: Skeet Range SRT Analysis; p. 6 indicates water truck was used • Quantity of water provided by comment in document by Ty T. Ta	• Approximately 5 trips/day for water truck with capacity of 2,000 gallons for 146 working days • 5 x 2000 x 146= 1,460,000 gallons x 8.3 lbs per gallon = 12,118,000 lbs /2000 lbs per tn.sh = 6059 tn.sh.	SRT does not have an input option for water use.	SRT does not have an input option for water use.

Table 1-I: Known Use of On-Site Renewables: Alternative 1 (Soil Excavation)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
CO_2 sequestration due to change in biome type • 0.46 tons CO_2 offset	• Little Rock AFB: Skeet Range SRT Analysis; p. 4	LCA advisors suggest not including a carbon uptake allocation due to the low reliability of the data.	-0.46 tons CO_2 emissions to atmosphere noted in documents but not entered into SRT.	-0.46 tons CO_2 emissions to atmosphere

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 1-J: eGRID Subregion, SRMV, 2004-2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	21.1991	34,168,945.7
Oil	3.3369	5,378,483.8
Gas	45.1560	72,782,955.4
Other Fossil	2.2801	3,675,117.0
Nuclear	24.4717	39,443,770.0
Other Unknown / Purchased Fuel	0.2182	351,712.2
Nonrenewable Total	96.6620	155,800,984.1
Renewable Resource		
Wind	0.0000	0.0
Solar	0.0000	0.0
Geothermal	0.0000	0.0
Biomass	2.0667	3,331,208.6
Hydro	1.2713	2,049,072.7
Renewable Total	27.0652	5,380,281.3

Coordination of Site Data Input: Travis Air Force Base, Site DP039

For

Quantifying Life-Cycle Environmental Footprints of Soil and Groundwater Remedies

ESTCP Project # ER-201127

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INTRODUCTION

Travis Air Force Base, in Solano County, California, serves as Military Air Command Headquarters to the 22nd Air force, as well as a medical center. It consists largely of runways and related installations. Industrial operations include various shops where aircraft components were cleaned with solvents. Site DP039 consists of a former rock-filled acid neutralization sump approximately 65 feet west of Building 755, in the northern portion of the West/Annexes/Basewide Operable Unit (WABOU). Until 1978, a pipeline ran from a sink drain within Building 755 to the sump. Based on preliminary assessment data, Building 755 was originally used to test rocket engines, but only petroleum-based liquid fuel was used at the site as part of rocket engine testing. Since 1968, Building 755 has been the location of the Battery and Electric Shop. Before 1978, battery acid solutions and chlorinated solvents reportedly were discharged into the Building 755 sink and drained to the sump. In July 1993, the sump and surrounding soil was removed and disposed of off-base.

Information and data required for a GSR footprint evaluation of the current remedy and one future alternative remedy were developed from the following sources:

- Sustainable Remediation Tool Application at Site DP039, Travis Air Force Base, (CH2MHill, March 2012)
- SRT Spreadsheets: “SRT rev2_1_DP39_Alt 1.xls” and “Copy of SRT rev2_1_DP39_Alt 2.xls” (provided by Doug Downey, CHM2Hill by e-mail attachment on 3/12/2012)

The groundwater chemicals of concern (COC) are trichloroethene (TCE), 1,1-Dichloroethene (1,1-DCE) 1,2-Dichloroethane (1,2-DCA), 1,1,1-Trichloroethane (1,1,1-TCA), tetrachloroethene (PCE), methylene chloride, bromodichloromethane, and acetone. TCE is the most prevalent COC for Site DP039. A 500 ug/L TCE plume extends approximately 1,400 feet downgradient (southeast) of known source area.

Until 2008, the Site DP039 groundwater extraction system consisted of two (2) dual phase extraction (DPE) wells that addressed source area groundwater and soil vapor. In November 2008, both of these extraction wells were taken offline to facilitate construction and operation of a source area bioreactor as an AFCEE technology demonstration project. The bioreactor was constructed in an approximately 400-square-foot excavation surrounding one extraction well. The 20-feet deep excavation was backfilled with a 50/50 mixture of gravel and tree mulch sprayed with emulsified vegetable oil (EVO). An extraction well in the immediate area was salvaged and is currently used as a monitoring well for the bioreactor study. One extraction well is located approximately 8 feet downgradient of the edge of the bioreactor and is currently used to circulate groundwater within the bioreactor. This extraction well is equipped with a solar-powered pump which circulates water from the source area and into the top of the bioreactor.

Downgradient of the bioreactor, a large phytoremediation treatability study area has been established. The phytoremediation treatability study area consists of 400 tree plantings engineered to hydraulically control and remove volatile organic compound (VOC) mass from the shallow groundwater. A biobarrier consisting of several injection wells has also been constructed and is operated. Monitored natural attenuation (MNA) is assumed for the remainder of the plume.

The Sustainable Remediation Tool was employed to evaluate the two options offered in the Feasibility Study. These two options include:

<u>Alternative 1:</u>
This alternative includes the continuation of the groundwater extraction and treatment (GET) system. The extracted water is treated in a larger central treatment system, but for the simplicity of this analysis is assumed to be treated with an air stripper prior to discharge into a nearby creek or to an irrigation system. Since there is currently an interim pumping system on site that is available for restarting, the metrics considered for the GSR analysis includes only those for re-starting the system and for the operation and maintenance of that system. Construction costs are assumed for well replacement only.

<u>Alternative 2:</u>
This alternative includes the discontinuation of the current groundwater extraction and treatment operations, operation of the on-going phytoremediation remedy, construction and operation of the bioreactor, construction and operation of the biobarrier injection wells, and MNA of a downgradient portion of the plume.

ALTERNATIVE 1: CONTINUATION OF THE GET AND MNA

The key items included in Alternative 1 with respect to footprint results are the two groundwater extraction pumps (estimated to continue operation for 30 years) with a combined pumping rate of 2.4 gpm. The extracted water is treated in a central treatment plant, but for the simplicity of this analysis, it is assumed that the extracted water is treated with an air stripper prior to discharge or use in irrigation. The remedy requires O&M once per week for 30 years also requires semi-annual sampling of 15 monitoring wells for 30 wells. The 15 monitoring wells and 2 extraction wells are assumed to require replacement after 15 years.

Input data to the SRT™ for Alternative 1 was established in one SRT™ file. The PTDesign (pump and treat) and MNADesign (MNA/LUC) modules were used. The input to the "InputGW" tab is provided in the following table. The inputs to the PTDesign and MNADesign tabs are presented in Tables 1-A through 1-J.

Groundwater Inputs				
	Zone 1	Zone 2	Zone 3	Zone 4
width (ft)	210	300	500	
length (ft)	400	500	1400	
Concentration low (ug/L)	500	400	100	
Concentration high (ug/L)	8000	500	400	
Contaminant class	CVOCs			
Depth to groundwater (ft)	20			
Depth to top of formation (ft)	20			
Thickness of water bearing media (ft)	25			
Aquifer media	Sand (well graded)			
Hydraulic gradient	0.001			

Components of Alternative 1 used in the PTDesign and MNADesign modules include the following:

- Electricity: 10 HP (7.5 kW) is assumed by the site team to provide sufficient electricity to power the remedy, including the following considerations:
  - 2 extraction wells have a combined pumping rate of 2.4 gpm and will be operated for 30 years (SRT™ Application at Site DP039, Results).
  - Water treatment provided by an air stripper
  - Operating time equals 8,320 hours per year for 30 years

- Transport of personnel:
  - O&M visits for the groundwater extraction system were estimated at 15 miles one way, once a week for 30 years for a sum of 1,560 miles annually (47,000 over the 30 year remedy).

    - Semi-annual sampling of 15 monitoring wells for 30 years, 60 miles per year (30 miles round trip, twice per year)

- Replacement of monitoring wells as specified by the site team: 15 monitoring wells, each with a depth of 45 feet for a total depth of 675 feet

- Replacement of the extraction wells as implied by the site team
    - 2 extraction wells, each with a depth of 55 feet for a total depth of 90 feet
    - 10 feet of steel screen and 45 feet of PVC screen
    - 1300 pounds of steel for steel screen and other steel involved in extraction well construction

ALTERNATIVE 2: PHYTOREMEDIATION, BIOREACTOR, BIOBARRIER, AND MNA

(Discontinuation of groundwater extraction and treatment)

The remedy for Alternative 2 assumes that the existing pump and treat system would be permanently taken out of operation. The remedy would consist of operation of the on-going phytoremediation remedy, construction and operation of the bioreactor, construction and operation of the biobarrier injection wells, and MNA of a downgradient portion of the plume.

Input data to the SRT™ for Alternative 2 was established in one SRT™ file. The EXDesign (excavation), EBDesign (biobarrier), and MNADesign (MNA/LUC) modules were used. The input to the "InputSoil" and "InputGW" tabs is provided in the following table. The inputs to the EXDesign, EBDesign, and MNADesign tabs are presented in Tables 2-A through 2-H.

Soil/Source Inputs				
Area of affected soil (ft^2)	420			
Depth to top of affected soil (ft)	1			
Depth to bottom of affected soil (ft)	20			
Depth to groundwater (ft)	20			
Soil type	Silt			
Contaminant class	CVOCs			
Maximum concentration (mg/Kg)	1000			
Typical concentration (mg/Kg)	10			
Groundwater Inputs				
	Zone 1	Zone 2	Zone 3	Zone 4
width (ft)	210	300	400	
length (ft)	400	500	1000	
Concentration low (ug/L)	1000	700	500	
Concentration high (ug/L)	8000	1000	700	
Contaminant class	CVOCs			
Depth to groundwater (ft)	20			
Depth to top of formation (ft)	20			
Thickness of water bearing media (ft)	25			
Aquifer media	Sand (well graded)			
Hydraulic gradient	0.001			

Additional information for Alternative 2 includes the following:

- O&M for the phytoremediation remedy consists of 1 visit per year for 30 years and is represented using the EXDesign module by adding 30 visits on top of the existing 40 visits for bioreactor O&M
- The bioreactor construction and operation includes the following information, which is input into SRT™ in the EXDesign module and EBDesign module):

  - EXDesign Module
    - Construction of the bioreactor, including excavation and disposal of 296 cubic yards of original soil and backfill with mulch/gravel mixture
    - Contaminated water will be pumped through organic mulch mixture using an existing extraction well powered by solar panels.
    - O&M is assumed to require 4 visits per year for 10 years (total of 40 visits)
  - EBDesign Module
    - Rejuvenation of the bioreactor with 500 gallons of EVO every two years for 10 years of operation (a total 2,500 gallons added over 5 events)

- Biobarrier (EBDesign module)
  - Installation of 10 injection wells was included in analysis (with one additional well included in the EBDesign module to account for EVO used in the bioreactor)
  - One initial EVO injection and 5 follow-up injections, with 9,000 gallons of substrate injected per event for a total of 54,000 gallons
  - O&M includes semi-annual site visits for performance monitoring for 30 years

- MNA (MNADesign module)
  - Travel for sampling: 30 miles per round trip, twice per year, for 30 years

Table 1-A: Electricity Use: Alternative 1 (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
		GET		
Extraction Wells and Air Stripper	• SRT Application at Site DP039 (SRT Alternative 1 Assumptions) includes estimate of 10 HP (7.5 kW) of electricity needed to extract and treat water • SRT Users Guide, pg 54: kWh = power requirement in horsepower x 0.7457 x operating time (hrs)	1,900,000 kWh *SimaPro Assembly Name: 1-Electricity_Alt1 Materials/Assemblies used: 1000 KWh WECC Source Mix AT CONSUMER Amount input: 1,900 p*	Input to "PTDesign" tab of SRT includes: • Purpose: Remediation • Duration: 30 yrs • Treatment Method: Air Stripping • Total pumping rate: 2.4 gpm • Power requirements: 7.5 kW • Operating time: 8,320 hrs	No changes.

Table 1-B: Fuel Use for Equipment (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
GET				
Fuel Use for Extraction Well Replacement • Drill for extraction well installation • 2 extraction wells, 55 ft each	• SRT input file (SRT rev2_1_DP39_Alt 1.xls) • SRT calculates 110 linear feet of drilling, a drilling rate of 100 ft/day, a fuel consumption rate of 32 gallons per day, for total diesel fuel use of 35 gallons. • To calculate fuel use for SimaPro assume 110 ft of drilling with a hollow stem auger and use EPA methodology (including production rate of 100 ft per 8-hour day) for fuel consumption: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 8.8 x 0.050 x 0.75 = 49.5 gals (refer to EPA, 2012, pg 59)	Fuel Use = 49.5 gallons (diesel) *SimaPro Assembly Name: Fuel use_Alt1_extraction well installation* *Process Used: Diesel, combusted in industrial equipment/US* *Amount: 49.5*	Input to "PTDesign" tab of SRT includes: • Number of wells: 2 (2 acres, 1 well per acre) • Length of PVC per well: 45 ft • Steel casing per well: 10 ft • Linear feet for drilling: 110 ft • Drilling rate: 100 ft/day • Drilling fuel consumption rate: 32 gal/day	Input to "PTDesign" tab of SRT includes: • Number of wells: 2 (2 acres, 1 well per acre) • Length of PVC per well: 35 ft • Steel casing per well: 10 ft • Linear feet for drilling: 90 ft • Drilling rate: 100 ft/day • Drilling fuel consumption rate: 33.6 gal/day (change in SRT default)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
MNA				
Fuel Use for Monitoring Well Replacement • Drill for monitoring well installation • 15 monitoring wells, 45 ft each	• SRT input file (SRT rev2_1_DP39_Alt 1.xls) • SRT calculates 675 linear feet of drilling, a drilling rate of 100 ft/day, a fuel consumption rate of 32 gallons per day, for total diesel fuel use of 216 gallons. • To calculate fuel use for SimaPro assume 675 ft of drilling with a hollow stem auger and use EPA methodology (including production rate of 100 ft per 8-hour day) for fuel consumption: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 54 x 0.050 x 0.75 = 304 gals (refer to EPA, 2012, pg 59)	Fuel use = 304 gallons *SimaPro Assembly Name: Fuel use_Alt1_monitoring well installation* *Process Used: Diesel, combusted in industrial equipment/US* *Amount: 304 gal**	Input to "MNADesign" tab of SRT includes: • Number of wells – 15 • Length of PVC per well – 45 ft • Linear feet for drilling: 675 ft • Drilling rate: 100 ft/day • Drilling fuel consumption rate: 32 gal/day	No changes except for defaut drilling fuel consumption rate of 33.6 gal/day instead of 32 gal/day.

Table 1-C: Materials Use (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
GET				
PVC for extraction well replacement • 2 wells • PVC length: 45 feet per well	• SRT input file (SRT rev2_1_DP39_Alt 1.xls) • SRT uses a conversion factor of 2.03 lbs/ft of 4-inch PVC, for a total of 180 lbs of PVC • For SimaPro, use the same amount of PVC as calculated by SRT	180 lbs of PVC *SimaPro Assembly Name: PVC_Alt1_extraction wells* *Materials/Assemblies used: PVC pipe E* *Amount input: 180 lb*	Input to "PTDesign" tab of SRT includes: • Number of wells: 2 (2 acres, 1 well per acre) • Length of PVC per well: 45	Input to "PTDesign" tab of SRT includes: • Number of wells: 2 (2 acres, 1 well per acre) • Length of PVC per well: 35 ft

Steel for extraction wells screens and other items	• SRT input file (SRT rev2_1_DP39_Alt 1.xls)
	  • 2 wells
	  • 10 ft of steel pipe per well
	  • 50 lbs other steel per well
	  • 950 lbs of other steel for system
	  • Total of 1300 pounds of steel
		1300 lbs of steel
		
		SimaPro Assembly Name: Steel_Alt1_extraction wells
		Materials/Assemblies used: Steel, low-alloyed, at plant/RER S
		Amount input: 1300lb
			Input to "PTDesign" tab of SRT includes:
			• Number of wells: 2 (2 acres, 1 well per acre)
			• 10 ft of steel pipe per well
			• 50 lbs other steel per well
			• 950 lbs of other steel for system
				No changes.

MNA				

PVC for monitoring well replacement
• 15 wells
• Well length: 45 feet per well
	• SRT input file (SRT rev2_1_DP39_Alt 1.xls)
	  o 15 wells
	  o 45 ft per well
	  o 2.03 lbs of PVC per foot (assumes a 4-inch well)
	  o round to nearest 100 lbs
		1400 lbs of PVC
		
		SimaPro Assembly Name: PVC_Alt1_Monitoring Wells
		Materials/Assemblies used: PVC pipe E
		Amount input: 1400 lb
			Input to "MNADesign" tab of SRT includes:
			• Number of wells: 15
			• Length of PVC per well: 45
				No changes.

Table 1-D: Transport for Materials, Equipment, and Samples: Alternative 1 (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Transport of PVC & steel for extraction well and monitoring well replacement	Assumed to be transported to site by driller. Driller transport is considered de minimis for SimaPro and is not calculated by SRT			

Table 1-E: Waste Transport/Disposal: Alternative 1 (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Drill cuttings	assumed to be spread at drilling location			

Table 1-F: Transport for Personnel Alternative 1 (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
GET				
Vehicle use for O&M • O&M is assumed to require weekly visits for 30 years (1560 trips total), with 30 mile round trips	• SRT Application at Site DP039, "Sustainability metrics for vehicle use for GET O&M" • SRT input file (SRT rev2_1_DP39_Alt 1.xls) • SRT assumes 15 mpg (cell E109 on PTDesign tab)	• 1560 trips of 30 miles round trip = 46,800 miles • Assume car, gasoline *SimaPro Assembly Name:Transport Personnel_Alt1_O&M* *Process used: Transport, passenger car/RER U* *Amount input: 46800 pmi*	Input to "PTDesign" tab of SRT includes: • Average distance traveled by site workers per one-way trip: 15 miles • trips by site workers after construction: 1560 over project lifetime • duration: 30 yrs In SRT, gasoline use = 47,000 miles traveled / 15 mpg = 3,134 gal	No change except for default value for vehicle mileage (travel) changed from 15 mpg to 22.8 mpg.
Vehicle used for well replacement	• Not calculated by SRT • Considered to be de minimis for SimaPro			
MNA				
Vehicle use for well sampling • Assumes semi-annual sampling, 30 miles round trip (60 miles annually), for 30 years	• SRT Application at Site DP039, "Sustainability metrics for vehicle use for semi-annual sampling" • SRT input file (SRT rev2_1_DP39_Alt 1.xls) o 0 baseline events o 2 events in the first year o 2 events per year in subsequent years o Sampling for 30 years	• 1,800 miles • Assume small truck, gasoline *SimaPro Assembly Name:Transport Personnel_Alt1_sampling* *Process used: Transport, passenger car/RER U* *Amount input: 1800 pmi*	Input to "MNADesign" tab of SRT includes: • 60 events after construction • 1 baseline events • 4 events in the first year • 2 events per year in subsequent years • Sampling for 30 years • 15 miles one way to site • Miles traveled (O&M): 3500	No change except for default value for vehicle mileage (travel) changed from 15 mpg to 22.8 mpg.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Vehicle used for well replacement	• Not calculated by SRT • Considered to be de minimis for SimaPro			

Table 1-G: Potable Water Use Alternative 1 (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Potable water use for well drilling, equipment decontamination, and groundwater sampling is	• Assumed to be de minimis			

Table 1-H: Non-Potable Water Use Alternative 1 (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
No significant non-potable water use identified other than groundwater extraction for treatment.				

Table 1-I: Known Use of On-Site Renewables (GET/MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
None				

**Does not include percentage of renewable energy associated with electricity mix from grid*

Table 1-J: eGRID Subregion CAMX—WECC California, 2005 Characteristics

Electricity Source	Fuel Mix %	MWh
Nonrenewable Resource		
Coal	11.9033	26,141,141.50
Oil	1.1747	2,579,750.70
Gas	42.2704	92,830,630.50
Other Fossil	1.0291	2,259,976.30
Nuclear	16.4631	36,154,898.00
Other Unknown / Purchased Fuel	0.0943	207,005.90
Nonrenewable Total	72.9348	160,173,402.90
Renewable Resource		
Wind	1.9396	4,259,490.6
Solar	0.2444	536,713.3
Geothermal	4.6211	10,148,526.6
Biomass	2.6088	5,729,247.8
Hydro	17.6513	38,764,274.9
Renewable Total	27.0652	59,438,253.3

Table 2-A: Electricity Use: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
None noted. Solar panels provide the electrical power to the extraction well pump for the recirculation through the bioreactor.	• SRT Application at Site DP039, "Bioreactor"	None	None.	None.

Table 2-B: Fuel Use for Equipment: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
ISB				
Excavator and dump truck for construction of 296 CY bioreactor	• SRT input file (Copy of SRT rev2_1_DP39_Alt 2.xls) • SRT Application at Site DP039, "Sustainability metrics for Bioreactor Construction and O&M activities" • At 95 lbs per ft^3 (SRT, EXDesign cell E41), affected soil = 296 yd^3 x 2565 lbs per yd^3 = 759,000 lbs or 380 tons	• Excavator • Removal of 296 yd^3 AND • Dump Truck, to landfill • 10 miles, one way • 10 miles x 380 tons = 3,800 tmi *Empty return trip included in SimaPro calculations* *SimaPro Assembly Name: Fuel use_Alt2_Equip for construction* *Materials/Assemblies used: Excavation, hydraulic digger/RER U (296 cu.yd) and Transport, lorry 7.5-16t, EURO5/RER U (3800tmi*)*	Input to "EXDesign" tab of SRT includes: • Volume of affected soil: 296 CY • one-way distance to disposal: 10 miles • total miles driven for disposal and fill: 1320 miles SRT calculates total hours to excavate = volume of affected soil (296 CY, or 7980 cubic feet) x soil density (95 lbs/cubic ft) x (1 ton / 2000 lbs) x (1 / rate of excavation of 53 tons/hr) = 7.2 hrs SRT calculates total diesel use based on an excavator fuel consumption rate of 3 gal/hr, a dump truck fuel use rate of 8 mpg, for a total of 200 gal diesel	No changes except the default fuel use rate for the excavator changed from 3 gal/hr to 5.5 gal/hr and the fuel use rate for a dump truck changed from 8 mpg to 6 mpg. Total fuel use for excavation, backfill, and dump truck use is 280 gal.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Biobarrier				
Drill for installation of biobarrier EVO 50-ft deep injection wells (10 wells)	• SRT input file (Copy of SRT rev2_1_DP39_Alt 2.xls) • To calculate fuel use for SimaPro assume 500 ft of drilling (10 wells) with a hollow stem auger and use EPA methodology (including production rate of 100 ft per 8-hour day): Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 40 x 0.050 x 0.75 = 225 gals (refer to EPA, 2012, pg 59)	• Fuel use= 225 gallons *SimaPro Assembly Name: Fuel use_Alt2_EVO wells* *Process Used: Diesel, combusted in industrial equipment/US* *Amount: 225 gal**	Input to "EBDesign" tab of SRT includes: • Area treated: 4,000 ft^2 • Injection well spacing: 22 ft • Calculated value of 11wells • Length of PVC: 50 ft per well SRT calculates 550 linear feet of drilling, a drilling rate of 100 ft/day, a fuel consumption rate of 32 gallons per day, for total diesel fuel use of 176 gallons.	No changes except for defaut drilling fuel consumption rate of 33.6 gal/day instead of 32 gal/day.
MNA				
Fuel Use for Monitoring Well Replacement • Drill for monitoring well installation • 15 monitoring wells, 45 ft each	• SRT input file (SRT rev2_1_DP39_Alt 1.xls) • SRT calculates 675 linear feet of drilling, a drilling rate of 100 ft/day, a fuel consumption rate of 32 gallons per day, for total diesel fuel use of 216 gallons. • To calculate fuel use for SimaPro assume 675 ft of drilling with a hollow stem auger and use EPA methodology (including production rate of 100 ft per 8-hour day) for fuel consumption: Fuel Use (gal) = HP x hrs x BSFC x PLF = 150 x 54 x 0.050 x 0.75 = 304 gals (refer to EPA, 2012, pg 59)	Fuel use = 304 gallons *SimaPro Assembly Name: Fuel use_Alt1_monitoring well installation* *Process Used: Diesel, combusted in industrial equipment/US* *Amount: 304 gal**	Input to "MNADesign" tab of SRT includes: • Number of wells – 15 • Length of PVC per well – 45 ft • Linear feet for drilling: 675 ft • Drilling rate: 100 ft/day • Drilling fuel consumption rate: 32 gal/day	No changes except for defaut drilling fuel consumption rate of 33.6 gal/day instead of 32 gal/day.

Table 2-C: Materials Use: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Phytoremediation				
Fertilizer for phytoremediation	• Considered to be de minimis for SimaPro • Not calculated by SRT			
ISB and Biobarrier				
Mulch/gravel backfill, assumed to be 296 cubic yards	• SRT input file (Copy of SRT rev2_1_DP39_Alt 2.xls) • SRT Application at Site DP039, "Sustainability metrics for Bioreactor Construction and O&M activities" • 50/50 mix of mulch/gravel (according to "Current Remedy" section of SRT document) • Bulk density of mulch = 0.4 tons per cubic yard (EPA, 2012) • Bulk density of gravel = 1.5 tons per cubic yard	• Mulch: 150 cubic yards x 0.4 tons per cubic yard = 59 tons assumed to be mulch derived from tree trimming and yard clipping waste with no footprint AND • Gravel 150 yards x 1.5 tons per cubic yard = 222 tons *SimaPro Assembly Name: Material_Alt2_mulch/gravel Materials/Assemblies used: Gravel, unspecified, at mine/CH S (222 tn.sh)*	SRT does not account for footprint of gravel or mulch	SRT accounts for mulch in the PRB module but not in the excavation module. The PRB module was not use for this analysis, so mulch was not included. The SRT emission factors for mulch are 0, so there would be no footprint from mulch anyway. SRT does no account for the footprint associated with gravel as a material.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
PVC for 10 injection wells	• SRT Application at Site DP039, "Sustainability metrics for Bioreactor Construction and O&M activities" states 50 ft per injection well for 10 wells for a total of 500 ft. • SRT uses a conversion factor of 2.03 lbs/ft of 4-inch PVC for 1,000 lbs of PVC • The number of wells in the Travis Alt 2 SRT spreadsheet (recived 3/12/12) was overwritten by the value "11" making the weight of the PVC required for the wells 1100 lbs. • For SimaPro, use the same amount as calculated by SRT	1,100 lbs of PVC *SimaPro Assembly Name: PVC_Alt2_injection wells* *Materials/Assemblies used: PVC pipe E* *Amount input: 1100 lb*	Input to "EBDesign" tab of SRT includes: • Area treated: 4,000 ft^2 • Injection well spacing: 22 ft • Number of wells: 11 (overwritten) • Length of PVC – 50 ft • SRT uses a conversion factor of 2.03 lbs/ft of PVC, for a total of 1100 lbs of PVC	No changes.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
EVO for bioreactor and biobarrier	• SRT input file (Copy of SRT rev2_1_DP39_Alt 2.xls) • SRT Application at Site DP039 states bioreactor will require rejuvenation with 500 gallons of EVO every 2 years for 10 years of bioreactor operation (2500 gallons total) • SRT Application at Site DP039 states biobarrier will require an initial injection plus 5 follow-up injections, with 9,000 gallons EVO per event (54,000 gal total, calculated by SRT) • Total EVO used throughout remedy = 2,500 + 54,000 gallons = 56,500 gallons of EVO • SRT uses a default density for "donor" of 7.89 lbs per gallon	56,500 gallons of vegetable oil x 7.89 lbs/gal = 450,000 lbs after rounding *SimaPro Assembly Name: Materials_Alt2_EVO* *Materials/Assemblies used: Soybean oil, at mill/US U* *Amount input: 450,000 lb*	Input to "EBDesign" tab of SRT includes: Substrate volume for biobarrier calculated by SRT based on aquifer volume. The following entries were modified to account for multiple follow-up injections: • Area treated: 4,000 ft^2 • Volume treated: 720,000 ft^3 o Volume of 120,000 ft^3 for one biobarrier injection o Multiply by 6 to account for 6 injections • Percent of pore space for donor: 0.01 These inputs yield a total calculated volume of 54,000 gallons of EVO after rounding and a weight of 430,000 lbs after rounding	No changes.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
MNA				
PVC for monitoring well replacement • 15 wells • Well length: 45 feet per well	• SRT input file (SRT rev2_1_DP39_Alt 1.xls) o 15 wells o 45 ft per well o 2.03 lbs of PVC per foot (assumes a 4-inch well) o round to nearest 100 lbs	1400 lbs of PVC *SimaPro Assembly Name: PVC_Alt1_Monitoring Wells* *Materials/Assemblies used: PVC pipe E* *Amount input: 1400 lb*	Input to "MNADesign" tab of SRT includes: • Number of wells: 15 • Length of PVC per well: 45	No changes.

Table 2-D: Transport for Materials, Equipment, and Samples: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
ISB, Biobarrier and MNA				
Transport of PVC for wells	• Assumed to be transported to site by driller. Driller transport is considered de minimis for SimaPro and is not calculated by SRT			
EVO Transport	• See Table 2-C for EVO amounts: • 450,000 lbs total o 20,000 lbs for bioreactor o 430,000 lbs of biobarrier • Divide by 2,000 pounds per ton = 225 tons • Tetra Tech estimate of 50 miles one-way for delivery	• 50 x 225 tons = 11,250 tmi *Empty return trips accounted for in SimaPro* *SimaPro Assembly Name:Transport_Al2_EVO biobar and bioreact* *Process used: Transport, lorry >32t, EURO5/RER U* *Amount input: 11,250 tmi**	Transport of bioremediation reagents is not calculated by SRT.	Transport of bioremediation reagents is not calculated by SRT.

Table 2-E: Waste Transport/Disposal: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
ISB				
296 CY of affected soil from bioreactor excavation was disposed of within 10 miles of the site	• See Table 2-B for tons of soil for disposal (380 tons)	Transport included in Table 2-B AND Disposal to landfill: 380 tons *SimaPro Disposal Scenario Name: Disposal of Excavated Soil to Landfill Referring to Assembly: Dummy soil excavated* *Waste Scenrio: Landfill/CH U* *Amount input: 100%*	Dump truck fuel use accounted for above. SRT does not include any additional footprints for landfilling of waste materials.	Dump truck fuel use accounted for above. SRT accounts for landfilling activities within the on-site excavator fuel usage rate of 5.5 gal/hr.

Table 2-F: Transport for Personnel: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Phytoremediation				
Phytoremediation	• SRT Application at Site DP039, "Sustainability metrics for Bioreactor Construction and O&M activities" • 1 trip annually for 30 years • 15 miles each way (30 miles round trip)	30 trips x 30 miles = 900 miles *SimaPro Assembly Name:Transport Personnel_Alt2 phytoremediation* *Process used: Transport, passenger car/RER U* *Amount input: 900 pmi*	Input to "EXDesign" tab of SRT includes: • Average distance traveled by site workers per one-way trip: 15 miles • Trips by site workers after construction is 70, of which 30 is for phytoremediation and 40 is for bioreactor (see below)	No changes except for the default fuel use rate changed from 15 mpg to 22.8 mpg.
ISB				
Construction	• SRT Application at Site DP039, "Sustainability metrics for Bioreactor Construction and O&M activities" • 30 trips during construction • 15 miles each way (30 miles round trip)	30 trips x 30 miles = 900 miles *SimaPro Assembly Name:Transport Personnel_Alt2 ISB construction* *Process used: Transport, passenger car/RER U* *Amount input: 900 pmi*	Input to "EXDesign" tab of SRT includes: • Average distance traveled by site workers per one-way trip: 15 miles • Trips by site workers during construction is 30	No changes except for the default fuel use rate changed from 15 mpg to 22.8 mpg.
O&M	• SRT Application at Site DP039, "Sustainability metrics for Bioreactor Construction and O&M activities" • 4 trips annually for 10 years • 15 miles each way (30 miles round trip)	40 trips x 30 miles = 1,200 miles *SimaPro Assembly Name: Transport Personnel_Alt2_bioreactor* *Process used: Transport, passenger car/RER U* • *Amount input: 1200 pmi*	Input to "EXDesign" tab of SRT includes: • Average distance traveled by site workers per one-way trip: 15 miles • trips by site workers after construction is 70, of which 30 is for phytoremediation and 40 is for bioreactor (see above)	No changes except for the default fuel use rate changed from 15 mpg to 22.8 mpg.

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Biobarrier				
Construction	• SRT Application at Site DP039, “Sustainability metrics for Bioreactor Construction and O&M activities” • 30 trips during construction • 15 miles each way (30 miles round trip)	30 trips x 30 miles = 900 miles *SimaPro Assembly Name: Transport Personnel_Alt2_biobarrier Process used: Transport, passenger car/RER U Amount input: 900 pmi*	Input to “EBDesign” tab of SRT includes: • Average distance traveled by site workers per one-way trip: 15 miles • trips by site workers during construction is 30	No changes except for the default fuel use rate changed from 15 mpg to 22.8 mpg.
O&M	• SRT Application at Site DP039, “Sustainability metrics for Bioreactor Construction and O&M activities” • Semi-annual trips for 30 years for site visits and performance monitoring (60 trips) • 15 miles each way (30 miles round trip)	• 1,800 miles traveled • Assume small truck, gasoline *SimaPro Assembly Name: Transport Personnel_Alt2_biobarrier_ O&M Process used: Transport, passenger car/RER U Amount input: 1800pmi*	Input to “EBDesign” tab of SRT includes: • Average distance traveled by site workers per one-way trip: 15 miles • trips by site workers after construction is 60	No changes except for the default fuel use rate changed from 15 mpg to 22.8 mpg.
MNA				

Vehicle use for well sampling
• Assumes semi-annual sampling, 30 miles round trip (60 miles annually), for 30 years
	• SRT Application at Site DP039, “Sustainability metrics for vehicle use for semi-annual sampling”
	• SRT input file (SRT rev2_1_DP39_Alt 1.xls)
	  o 0 baseline events
	  o 2 events in the first year
	  o 2 events per year in subsequent years
	  o Sampling for 30 year
		• 1,800 miles
		• Assume small truck, gasoline
		
		SimaPro Assembly Name:Transport Personnel_Alt1_sampling Process used: Transport, passenger car/RER U Amount input: 1800 pmi
			Input to “MNADesign” tab of SRT includes:
			• 60 events after construction
			• 1 baseline events
			• 4 events in the first year
			• 2 events per year in subsequent years
			• Sampling for 30 years
			• 15 miles one way to site
			• Miles traveled (O&M): 3500
				No change except for default value for vehicle mileage (travel) changed from 15 mpg to 22.8 mpg.

Table 2-G: Potable Water Use: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
Water use for EVO injections	Tetra Tech estimate: assume a 5% donor solution is injected. 450,000 lbs divided by 5% is 9,000,000 lbs of which 95% is water. Water is 8.34 lbs per gallon such approximately 1,000,000 gallons of water is used.	1,000,000 gallons of potable water	The footprint associated with potable water use is not calculated by the EBDesign module in SRT.	The footprint associated with potable water use is not calculated by the EBDesign module in SRT.

Table 2-H: Non-Potable Water Use: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
No significant non-potable water use identified other than groundwater extraction for treatment.				

Table 2-I: Known Use of On-Site Renewables: Alternative 2 (Phytoremediation, ISB, Bioreactor, and MNA)

Item for Footprint Evaluation	Source of Information and/or Comments	Input Values to SimaPro®	Input Values to SRT™ V2.1	Input Values to SRT™ V2.3
• Solar powered pump for recirculation of extracted water for bioreactor • Consists of five 50-watt, 17.4V solar panels			The use of renewable energy is not represented in SRT.	The use of renewable energy is not represented in SRT.

**Does not include percentage of renewable energy associated with electricity mix from grid*

APPENDIX C:

Results by Remedy Components – SiteWise^{TM} Version 3 versus SimaPro®

CRREL Alt 1

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	3	10% - 50%	2	10% - 50%	3	10% - 50%	2	10% - 50%	4	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%
Elec - Blower	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%
Elec - Transfer Pumps	4	10% - 50%	3	10% - 50%	4	10% - 50%	3	10% - 50%	5	10% - 50%	3	10% - 50%	3	10% - 50%	4	10% - 50%	4	10% - 50%	3	10% - 50%
Elec - Backwash Pump	15	<1%	17	<1%	15	<1%	15	<1%	15	<1%	19	<1%	15	<1%	20	<1%	13	<1%	12	<1%
Elec - Heater Well Housing	6	1% - 10%	5	1% - 10%	6	1% - 10%	5	1% - 10%	6	1% - 10%	5	1% - 10%	6	1% - 10%	6	1% - 10%	6	1% - 10%	4	1% - 10%
Elec - Other	7	1% - 10%	7	1% - 10%	7	1% - 10%	6	1% - 10%	7	1% - 10%	7	1% - 10%	7	1% - 10%	7	1% - 10%	7	1% - 10%	5	1% - 10%
Fuel - Boiler & Fuel Tank	5	1% - 10%	4	10% - 50%	5	1% - 10%	4	1% - 10%	3	10% - 50%	4	10% - 50%	5	1% - 10%	5	1% - 10%	3	10% - 50%	6	1% - 10%
Mat - GAC	8	1% - 10%	8	1% - 10%	9	<1%	8	1% - 10%	8	1% - 10%	9	1% - 10%	9	<1%	10	1% - 10%	8	1% - 10%	8	<1%
Mat - Potassium Permanganate	11	<1%	12	<1%	11	<1%	11	<1%	10	<1%	14	<1%	10	<1%	13	<1%	10	<1%	11	<1%
Mat - Carbon Dioxide	2	10% - 50%	6	1% - 10%	2	10% - 50%	7	1% - 10%	1	10% - 50%	8	1% - 10%	4	1% - 10%	3	10% - 50%	5	10% - 50%	7	1% - 10%
Mat - Filter Bags	14	<1%	15	<1%	12	<1%	13	<1%	13	<1%	18	<1%	14	<1%	16	<1%	12	<1%	14	<1%
Mat - Greensand	10	<1%	10	<1%	8	<1%	10	<1%	9	1% - 10%	11	<1%	8	<1%	9	1% - 10%	9	<1%	10	<1%
Trans - GAC	16	<1%	16	<1%	16	<1%	17	<1%	17	<1%	13	<1%	19	<1%	17	<1%	19	<1%	17	<1%
Trans - Potassium Permanganate	21	<1%	23	<1%	21	<1%	24	<1%	23	<1%	24	<1%	23	<1%	26	<1%	23	<1%	23	<1%
Trans - CO2	12	<1%	11	<1%	13	<1%	12	<1%	14	<1%	10	<1%	18	<1%	14	<1%	18	<1%	13	<1%
Trans - Bag Filters	24	<1%	25	<1%	25	<1%	26	<1%	25	<1%	25	<1%	25	<1%	25	<1%	25	<1%	25	<1%
Trans - coolers	26	<1%	21	<1%	26	<1%	21	<1%	26	<1%	22	<1%	26	<1%	19	<1%	26	<1%	21	<1%
Trans - Greensand	17	<1%	19	<1%	17	<1%	19	<1%	19	<1%	17	<1%	20	<1%	22	<1%	20	<1%	19	<1%
Trans - Waste Backwash Sludge	20	<1%	18	<1%	20	<1%	18	<1%	22	<1%	15	<1%	22	<1%	15	<1%	22	<1%	18	<1%
Trans - Waste Greensand	18	<1%	13	<1%	18	<1%	14	<1%	20	<1%	12	<1%	21	<1%	12	<1%	21	<1%	15	<1%
Trans - Waste Bag Filters	23	<1%	20	<1%	23	<1%	20	<1%	24	<1%	20	<1%	24	<1%	18	<1%	24	<1%	20	<1%
Trans - Personnel	9	<1%	9	1% - 10%	10	<1%	9	<1%	12	<1%	6	1% - 10%	12	<1%	8	1% - 10%	15	<1%	9	<1%
Disp - Filter bags	25	<1%	26	<1%	24	<1%	25	<1%	21	<1%	26	<1%	17	<1%	24	<1%	17	<1%	26	<1%
Disp - Greensand	19	<1%	22	<1%	19	<1%	22	<1%	16	<1%	21	<1%	11	<1%	21	<1%	14	<1%	22	<1%
Disp - POTW Backwash Water	13	<1%	14	<1%	14	<1%	16	<1%	11	<1%	16	<1%	13	<1%	11	1% - 10%	11	<1%	16	<1%
Disp - Sludge	22	<1%	24	<1%	22	<1%	23	<1%	18	<1%	23	<1%	16	<1%	23	<1%	16	<1%	24	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Blower	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Backwash Pump	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Heater Well Housing	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Other	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Fuel - Boiler & Fuel Tank	1 - 1.2 (SP)	1 - 1.2 (SP)	1 - 1.2 (SW)	5 - 10 (SW)	2 - 5 (SW)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	1 - 1.2 (SW)
Mat - Potassium Permanganate	1 - 1.2 (SW)	1 - 1.2 (SW)	2 - 5 (SW)	5 - 10 (SW)	2 - 5 (SW)
Mat - Carbon Dioxide	2 - 5 (SW)	5 - 10 (SW)	5 - 10 (SW)	5 - 10 (SW)	5 - 10 (SW)
Mat - Filter Bags	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Greensand	1.2 - 2 (SP)	1.2 - 2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Trans - GAC	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Potassium Permanganate	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	2 - 5 (SW)	>10 (SP)
Trans - CO2	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Bag Filters	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - coolers	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Greensand	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Waste Backwash Sludge	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Greensand	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Bag Filters	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - Filter bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - Greensand	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - POTW Backwash Water	1.2 - 2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SP)	2 - 5 (SW)
Disp - Sludge	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
GAC = granular activated carbon
CO2 = carbon dioxide used in treatment system
POTW = publicly owned treatment works
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

CRREL Alt 2

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	3	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	5	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%
Elec - Blower	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	4	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%
Elec - Transfer Pumps	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%
Elec - Backwash Pump	17	<1%	19	<1%	16	<1%	16	<1%	17	<1%	21	<1%	16	<1%	23	<1%	15	<1%	12	<1%
Elec - Heater for Well Housing	6	1% - 10%	5	1% - 10%	5	1% - 10%	5	1% - 10%	6	1% - 10%	5	1% - 10%	5	1% - 10%	6	1% - 10%	6	1% - 10%	4	1% - 10%
Elec - Other	7	1% - 10%	7	1% - 10%	7	1% - 10%	6	1% - 10%	7	1% - 10%	7	1% - 10%	7	1% - 10%	8	1% - 10%	7	1% - 10%	5	1% - 10%
Fuel - Boiler & Fuel Tank	5	10% - 50%	4	10% - 50%	4	1% - 10%	4	1% - 10%	3	10% - 50%	4	10% - 50%	4	1% - 10%	5	1% - 10%	4	10% - 50%	6	1% - 10%
Fuel - Equipment	31	<1%	29	<1%	31	<1%	29	<1%	27	<1%	29	<1%	27	<1%	29	<1%	22	<1%	31	<1%
Mat - GAC	8	1% - 10%	8	1% - 10%	9	<1%	8	1% - 10%	8	1% - 10%	9	1% - 10%	9	<1%	11	1% - 10%	8	1% - 10%	8	<1%
Mat - Potassium Permanganate	11	<1%	12	<1%	11	<1%	11	<1%	10	1% - 10%	14	<1%	10	<1%	14	<1%	10	<1%	11	<1%
Mat - Carbon Dioxide	4	10% - 50%	6	1% - 10%	6	1% - 10%	7	1% - 10%	1	10% - 50%	8	1% - 10%	6	1% - 10%	4	10% - 50%	5	1% - 10%	7	1% - 10%
Mat - Filter Bags	15	<1%	17	<1%	12	<1%	13	<1%	15	<1%	20	<1%	15	<1%	18	<1%	14	<1%	15	<1%
Mat - Greensand	10	<1%	10	<1%	8	1% - 10%	10	<1%	9	1% - 10%	11	<1%	8	<1%	10	1% - 10%	9	<1%	10	<1%
Mat - Construct Tray Air Stripper	14	<1%	15	<1%	15	<1%	15	<1%	13	<1%	15	<1%	17	<1%	7	1% - 10%	13	<1%	13	<1%
Mat - Construct Eq Tank and Slab	16	<1%	14	<1%	17	<1%	18	<1%	14	<1%	18	<1%	12	<1%	17	<1%	12	<1%	18	<1%
Mat - PVC pipe	24	<1%	26	<1%	22	<1%	26	<1%	21	<1%	28	<1%	21	<1%	26	<1%	18	<1%	24	<1%
Trans - GAC	18	<1%	18	<1%	18	<1%	19	<1%	19	<1%	13	<1%	22	<1%	19	<1%	23	<1%	19	<1%
Trans - Potassium Permanganate	23	<1%	27	<1%	24	<1%	28	<1%	26	<1%	27	<1%	26	<1%	31	<1%	27	<1%	27	<1%
Trans - CO2	12	<1%	11	<1%	13	<1%	12	<1%	16	<1%	10	<1%	20	<1%	15	<1%	21	<1%	14	<1%
Trans - Bag Filters	28	<1%	30	<1%	29	<1%	31	<1%	30	<1%	30	<1%	30	<1%	30	<1%	30	<1%	29	<1%
Trans - Coolers	30	<1%	23	<1%	30	<1%	23	<1%	31	<1%	25	<1%	31	<1%	22	<1%	31	<1%	23	<1%
Trans - Greensand	19	<1%	21	<1%	19	<1%	21	<1%	22	<1%	19	<1%	23	<1%	25	<1%	24	<1%	21	<1%
Trans - Materials/Equip Construct	25	<1%	24	<1%	26	<1%	25	<1%	28	<1%	24	<1%	28	<1%	21	<1%	28	<1%	25	<1%
Trans - Waste Backwash Sludge	22	<1%	20	<1%	23	<1%	20	<1%	25	<1%	16	<1%	25	<1%	16	<1%	26	<1%	20	<1%
Trans - Waste Greensand	27	<1%	13	<1%	27	<1%	14	<1%	29	<1%	12	<1%	29	<1%	13	<1%	29	<1%	16	<1%
Trans - Waste Bag Filters	20	<1%	22	<1%	20	<1%	22	<1%	23	<1%	22	<1%	24	<1%	20	<1%	25	<1%	22	<1%
Trans - Personnel	9	<1%	9	1% - 10%	10	<1%	9	<1%	12	<1%	6	1% - 10%	13	<1%	9	1% - 10%	17	<1%	9	<1%
Disp - Filter bags	29	<1%	31	<1%	28	<1%	30	<1%	24	<1%	31	<1%	19	<1%	28	<1%	20	<1%	30	<1%
Disp - Greensand	21	<1%	25	<1%	21	<1%	24	<1%	18	<1%	23	<1%	11	<1%	24	<1%	16	<1%	26	<1%
Disp - POTW for Backwash Water	13	<1%	16	<1%	14	<1%	17	<1%	11	<1%	17	<1%	14	<1%	12	1% - 10%	11	<1%	17	<1%
Disp - Sludge	26	<1%	28	<1%	25	<1%	27	<1%	20	<1%	26	<1%	18	<1%	27	<1%	19	<1%	28	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Blower	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Backwash Pump	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Heater for Well Housing	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Other	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Fuel - Boiler & Fuel Tank	1 - 1.2 (SP)	1 - 1.2 (SP)	1 - 1.2 (SW)	5 - 10 (SW)	2 - 5 (SW)
Fuel - Equipment	5 - 10 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	1 - 1.2 (SW)
Mat - Potassium Permanganate	1 - 1.2 (SW)	1 - 1.2 (SW)	2 - 5 (SW)	5 - 10 (SW)	2 - 5 (SW)
Mat - Carbon Dioxide	2 - 5 (SW)	1.2 - 2 (SW)	5 - 10 (SW)	2 - 5 (SW)	2 - 5 (SW)
Mat - Filter Bags	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Greensand	1.2 - 2 (SP)	1.2 - 2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Construct Tray Air Stripper	1.2 - 2 (SW)	1.2 - 2 (SP)	1 - 1.2 (SW)	5 - 10 (SP)	1 - 1.2 (SW)
Mat - Construct Eq Tank and Slab	1.2 - 2 (SP)	1.2 - 2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	2 - 5 (SW)
Mat - PVC pipe	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Trans - GAC	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Potassium Permanganate	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	2 - 5 (SW)	>10 (SP)
Trans - CO2	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Bag Filters	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Coolers	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Greensand	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Materials/Equip Construct	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Backwash Sludge	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Greensand	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Bag Filters	1.2 - 2 (SW)	1.2 - 2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - Filter bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - Greensand	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - POTW for Backwash Water	1.2 - 2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SP)	2 - 5 (SW)
Disp - Sludge	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
Eq = equalization
PVC = polyvinyl chloride
GAC = granular activated carbon
CO2 = carbon dioxide used in treatment system
POTW = publicly owned treatment works
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

CRREL Alt 3

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	3	10% - 50%	3	10% - 50%	2	10% - 50%	2	10% - 50%	3	10% - 50%	2	10% - 50%	2	10% - 50%	4	10% - 50%	2	10% - 50%	2	10% - 50%
Elec - Transfer Pumps	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	1	10% - 50%
Elec - Heater for Well Housing	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	5	1% - 10%	4	1% - 10%	5	1% - 10%
Elec - Other	5	1% - 10%	6	1% - 10%	5	1% - 10%	5	1% - 10%	5	1% - 10%	7	1% - 10%	5	1% - 10%	7	1% - 10%	5	1% - 10%	6	1% - 10%
Fuel - Equipment	19	<1%	17	<1%	19	<1%	17	<1%	15	<1%	17	<1%	15	<1%	18	<1%	14	<1%	19	<1%
Mat - GAC	2	10% - 50%	2	10% - 50%	3	10% - 50%	3	10% - 50%	1	10% - 50%	3	10% - 50%	3	10% - 50%	1	10% - 50%	3	10% - 50%	4	1% - 10%
Mat - Filter Bags	11	<1%	12	<1%	10	<1%	11	<1%	10	<1%	12	<1%	10	<1%	12	<1%	9	<1%	12	<1%
Mat - Construct Tanks and Slab	9	<1%	11	<1%	11	<1%	12	<1%	7	<1%	11	<1%	7	<1%	11	<1%	7	<1%	11	<1%
Mat - PVC	13	<1%	16	<1%	13	<1%	16	<1%	12	<1%	16	<1%	13	<1%	16	<1%	11	<1%	15	<1%
Mat - Sequestering Agent	10	<1%	7	1% - 10%	9	<1%	7	1% - 10%	9	<1%	9	1% - 10%	8	<1%	6	1% - 10%	8	<1%	7	<1%
Mat - Biocide	6	1% - 10%	5	1% - 10%	6	1% - 10%	6	1% - 10%	6	1% - 10%	5	1% - 10%	6	1% - 10%	3	10% - 50%	6	1% - 10%	3	1% - 10%
Trans - GAC	8	<1%	9	<1%	8	<1%	9	<1%	11	<1%	8	1% - 10%	11	<1%	10	1% - 10%	12	<1%	9	<1%
Trans - Bag Filters	16	<1%	18	<1%	17	<1%	19	<1%	18	<1%	18	<1%	18	<1%	19	<1%	18	<1%	17	<1%
Trans - Coolers	18	<1%	14	<1%	18	<1%	14	<1%	19	<1%	15	<1%	19	<1%	15	<1%	19	<1%	14	<1%
Trans - Material/Equip Construct	14	<1%	15	<1%	14	<1%	15	<1%	16	<1%	14	<1%	16	<1%	14	<1%	16	<1%	16	<1%
Trans - Chemicals	12	<1%	10	<1%	12	<1%	10	<1%	13	<1%	10	<1%	14	<1%	9	1% - 10%	15	<1%	10	<1%
Trans - Waste Bag Filters	15	<1%	13	<1%	15	<1%	13	<1%	17	<1%	13	<1%	17	<1%	13	<1%	17	<1%	13	<1%
Trans - Personnel	7	1% - 10%	8	1% - 10%	7	<1%	8	1% - 10%	8	<1%	6	1% - 10%	9	<1%	8	1% - 10%	10	<1%	8	<1%
Disp - Filter bags	17	<1%	19	<1%	16	<1%	18	<1%	14	<1%	19	<1%	12	<1%	17	<1%	13	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Heater for Well Housing	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Other	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Fuel - Equipment	5 - 10 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	1 - 1.2 (SW)
Mat - Filter Bags	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Construct Tanks and Slab	1 - 1.2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	5 - 10 (SW)	2 - 5 (SW)
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Mat - Sequestering Agent	5 - 10 (SP)	5 - 10 (SP)	5 - 10 (SP)	2 - 5 (SP)	2 - 5 (SP)
Mat - Biocide	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	5 - 10 (SP)
Trans - GAC	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Bag Filters	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Coolers	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Material/Equip Construct	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Chemicals	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Bag Filters	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - Filter bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
PVC = polyvinyl chloride
GAC = granular activated carbon
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

CRREL Alt 4

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	5	1% - 10%	4	10% - 50%	5	1% - 10%	4	1% - 10%	3	10% - 50%
Elec - Heater for Well Housing	6	1% - 10%	6	1% - 10%	6	1% - 10%	6	1% - 10%	6	1% - 10%	8	1% - 10%	6	1% - 10%	8	1% - 10%	6	1% - 10%	5	1% - 10%
Elec - Transfer Pumps	4	1% - 10%	5	1% - 10%	4	1% - 10%	5	1% - 10%	4	1% - 10%	6	1% - 10%	4	10% - 50%	6	1% - 10%	4	1% - 10%	4	10% - 50%
Elec - Other	3	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	3	1% - 10%	4	10% - 50%	1	10% - 50%	3	1% - 10%	3	10% - 50%	1	10% - 50%
Fuel - Equipment	12	<1%	14	<1%	13	<1%	14	<1%	10	<1%	12	<1%	10	<1%	14	<1%	11	<1%	14	<1%
Mat - GAC	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%
Mat - Sequestering Agent	11	<1%	11	<1%	12	<1%	10	<1%	12	<1%	11	<1%	11	<1%	10	<1%	9	<1%	10	<1%
Mat - Biocide	10	<1%	8	1% - 10%	10	<1%	8	1% - 10%	9	<1%	9	1% - 10%	8	<1%	7	1% - 10%	8	<1%	7	1% - 10%
Mat - Construct Tanks and Slab	9	<1%	10	<1%	9	<1%	11	<1%	7	<1%	10	<1%	7	<1%	11	<1%	7	<1%	11	<1%
Mat - PVC	13	<1%	13	<1%	11	<1%	12	<1%	13	<1%	16	<1%	13	<1%	13	<1%	10	<1%	12	<1%
Trans - GAC	8	1% - 10%	9	1% - 10%	8	1% - 10%	9	<1%	11	<1%	7	1% - 10%	12	<1%	9	<1%	13	<1%	9	<1%
Trans - Coolers	16	<1%	15	<1%	16	<1%	15	<1%	16	<1%	15	<1%	16	<1%	16	<1%	16	<1%	15	<1%
Trans - Chemicals	15	<1%	12	<1%	15	<1%	13	<1%	15	<1%	13	<1%	15	<1%	12	<1%	15	<1%	13	<1%
Trans - Material/Equip Construct	14	<1%	16	<1%	14	<1%	16	<1%	14	<1%	14	<1%	14	<1%	15	<1%	14	<1%	16	<1%
Trans - Personnel	7	1% - 10%	7	1% - 10%	7	1% - 10%	7	1% - 10%	8	<1%	3	10% - 50%	9	<1%	4	1% - 10%	12	<1%	8	1% - 10%
Disp - POTW	2	10% - 50%	3	10% - 50%	3	10% - 50%	3	1% - 10%	1	10% - 50%	2	10% - 50%	3	10% - 50%	1	50% - 90%	2	10% - 50%	6	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Heater for Well Housing	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Elec - Other	1 - 1.2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	1.2 - 2 (SP)
Fuel - Equipment	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	1 - 1.2 (SW)
Mat - Sequestering Agent	5 - 10 (SP)	5 - 10 (SP)	5 - 10 (SP)	2 - 5 (SP)	2 - 5 (SP)
Mat - Biocide	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	5 - 10 (SP)
Mat - Construct Tanks and Slab	1 - 1.2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	5 - 10 (SW)	2 - 5 (SW)
Mat - PVC	1 - 1.2 (SP)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Trans - GAC	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Coolers	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Chemicals	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Material/Equip Construct	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - POTW	1.2 - 2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SP)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
PVC = polyvinyl chloride
GAC = granular activated carbon
POTW = publicly owned treatment works
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.

Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-2

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Op of ISTT	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	2	10% - 50%	1	50% - 90%	1	50% - 90%	2	1% - 10%	2	10% - 50%	1	>90%
Elec - Pump for Direct Push	17	<1%	17	<1%	17	<1%	17	<1%	17	<1%	17	<1%	15	<1%	17	<1%	14	<1%	16	<1%
Fuel - Hollow Stem Auger Drilling	6	<1%	7	<1%	6	<1%	8	<1%	4	1% - 10%	3	1% - 10%	4	1% - 10%	5	<1%	5	<1%	7	<1%
Fuel - Direct Push Drilling	8	<1%	3	1% - 10%	8	<1%	3	1% - 10%	5	1% - 10%	2	10% - 50%	5	1% - 10%	3	1% - 10%	6	<1%	4	<1%
Mat - ISTT Electrodes	3	10% - 50%	5	1% - 10%	2	10% - 50%	5	1% - 10%	3	10% - 50%	9	<1%	3	1% - 10%	6	<1%	3	10% - 50%	5	<1%
Mat - GAC	4	1% - 10%	2	1% - 10%	4	1% - 10%	2	1% - 10%	16	<1%	5	1% - 10%	18	<1%	4	1% - 10%	11	<1%	2	1% - 10%
Mat - Grout	9	<1%	10	<1%	12	<1%	12	<1%	6	<1%	12	<1%	6	<1%	12	<1%	4	<1%	13	<1%
Mat - PVC	13	<1%	13	<1%	13	<1%	13	<1%	9	<1%	15	<1%	10	<1%	14	<1%	7	<1%	12	<1%
Mat - Iron Filings	2	10% - 50%	4	1% - 10%	3	1% - 10%	4	1% - 10%	1	10% - 50%	4	1% - 10%	2	10% - 50%	1	50% - 90%	1	10% - 50%	3	1% - 10%
Trans - Materials ISTT	14	<1%	14	<1%	14	<1%	14	<1%	14	<1%	13	<1%	14	<1%	13	<1%	16	<1%	14	<1%
Trans - Materials MNA	10	<1%	9	<1%	9	<1%	9	<1%	10	<1%	7	1% - 10%	12	<1%	7	<1%	12	<1%	10	<1%
Trans - Materials PRB	12	<1%	12	<1%	11	<1%	11	<1%	12	<1%	6	1% - 10%	13	<1%	10	<1%	15	<1%	9	<1%
Trans - Personnel ISTT	11	<1%	11	<1%	10	<1%	10	<1%	11	<1%	11	<1%	11	<1%	11	<1%	13	<1%	11	<1%
Trans - Personnel MNA	5	1% - 10%	6	<1%	5	<1%	6	<1%	7	<1%	8	1% - 10%	8	<1%	8	<1%	9	<1%	6	<1%
Trans - Personnel PRB	7	<1%	8	<1%	7	<1%	7	<1%	8	<1%	10	<1%	9	<1%	9	<1%	10	<1%	8	<1%
Trans - Waste Soil	15	<1%	15	<1%	15	<1%	15	<1%	15	<1%	14	<1%	16	<1%	15	<1%	17	<1%	15	<1%
Water - Potable for Cement	18	<1%	18	<1%	18	<1%	18	<1%	18	<1%	18	<1%	17	<1%	18	<1%	18	<1%	18	<1%
Disp - Soil	16	<1%	16	<1%	16	<1%	16	<1%	13	<1%	16	<1%	7	<1%	16	<1%	8	<1%	17	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Op of ISTT	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Elec - Pump for Direct Push	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Fuel - Hollow Stem Auger Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - ISTT Electrodes	5 - 10 (SW)	>10 (SW)	>10 (SW)	>10 (SW)	>10 (SW)
Mat - GAC	1.2 - 2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	1.2 - 2 (SW)	5 - 10 (SW)	5 - 10 (SW)
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Mat - Iron Filings	>10 (SW)	5 - 10 (SW)	2 - 5 (SW)	2 - 5 (SP)	>10 (SW)
Trans - Materials ISTT	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials MNA	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials PRB	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel ISTT	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel PRB	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable for Cement	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
ISTT = in-situ thermal treatment
PVC = polyvinyl chloride
PRB = permeable reactive barrier
MNA = monitored natural attenuation
GAC = granular activated carbon
Trans = transportation
Water - Potable = potable water from a public water source
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-3A

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Op of ISTT	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	2	10% - 50%	1	10% - 50%	1	50% - 90%	2	10% - 50%	1	10% - 50%	1	50% - 90%
Elec - ISCO Pump	18	<1%	18	<1%	18	<1%	18	<1%	17	<1%	18	<1%	15	<1%	18	<1%	10	<1%	15	<1%
Fuel - Hollow Stem Drilling	8	<1%	9	<1%	8	<1%	10	<1%	5	1% - 10%	4	1% - 10%	5	1% - 10%	6	1% - 10%	6	<1%	9	<1%
Fuel - Direct Push Drilling	9	<1%	4	1% - 10%	9	<1%	4	1% - 10%	6	1% - 10%	3	10% - 50%	6	1% - 10%	3	1% - 10%	7	<1%	4	<1%
Mat - GAC	5	1% - 10%	3	1% - 10%	6	<1%	3	1% - 10%	18	<1%	5	1% - 10%	19	<1%	5	1% - 10%	14	<1%	3	1% - 10%
Mat - ISTT Electrodes	3	10% - 50%	6	1% - 10%	2	10% - 50%	6	<1%	3	10% - 50%	8	<1%	3	1% - 10%	8	1% - 10%	3	10% - 50%	5	<1%
Mat - PVC	14	<1%	15	<1%	14	<1%	14	<1%	11	<1%	16	<1%	12	<1%	15	<1%	8	<1%	12	<1%
Mat - Grout	11	<1%	11	<1%	12	<1%	13	<1%	7	<1%	13	<1%	7	<1%	13	<1%	5	<1%	14	<1%
Mat - H2O2	2	10% - 50%	2	10% - 50%	3	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	2	10% - 50%	1	50% - 90%	2	10% - 50%	2	10% - 50%
Mat - ISCO iron	4	1% - 10%	10	<1%	4	1% - 10%	8	<1%	4	10% - 50%	11	<1%	4	1% - 10%	7	1% - 10%	4	10% - 50%	7	<1%
Trans - Materials ISTT	15	<1%	14	<1%	15	<1%	15	<1%	15	<1%	14	<1%	16	<1%	14	<1%	17	<1%	16	<1%
Trans - Materials ISCO	6	1% - 10%	5	1% - 10%	5	1% - 10%	5	1% - 10%	8	<1%	6	1% - 10%	10	<1%	4	1% - 10%	12	<1%	6	<1%
Trans - Materials MNA	13	<1%	13	<1%	13	<1%	12	<1%	14	<1%	10	<1%	14	<1%	11	<1%	16	<1%	13	<1%
Trans - Personnel ISTT	12	<1%	12	<1%	11	<1%	11	<1%	12	<1%	12	<1%	13	<1%	12	<1%	15	<1%	11	<1%
Trans - Personnel ISCO	7	1% - 10%	7	<1%	7	<1%	7	<1%	9	<1%	7	<1%	9	<1%	9	<1%	11	<1%	8	<1%
Trans - Personnel MNA	10	<1%	8	<1%	10	<1%	9	<1%	10	<1%	9	<1%	11	<1%	10	<1%	13	<1%	10	<1%
Trans - Waste Soil	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%	15	<1%	17	<1%	16	<1%	18	<1%	17	<1%
Water - Potable for Cement	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	18	<1%	19	<1%	19	<1%	19	<1%
Disp - Soil	17	<1%	17	<1%	17	<1%	17	<1%	13	<1%	17	<1%	8	<1%	17	<1%	9	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Op of ISTT	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Elec - ISCO Pump	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Fuel - Hollow Stem Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - GAC	1.2 - 2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - ISTT Electrodes	5 - 10 (SW)	>10 (SW)	>10 (SW)	>10 (SW)	>10 (SW)
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	1.2 - 2 (SW)	5 - 10 (SW)	5 - 10 (SW)
Mat - H2O2	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	1.2 - 2 (SW)	1.2 - 2 (SP)
Mat - ISCO iron	>10 (SW)	>10 (SW)	>10 (SW)	5 - 10 (SW)	>10 (SW)
Trans - Materials ISTT	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials ISCO	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials MNA	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel ISTT	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel ISCO	1 - 1.2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA	1 - 1.2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable for Cement	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
ISTT = in-situ thermal treatment
ISCO = in-situ chemical oxidation
PVC = polyvinyl chloride
H2O2 = hydrogen peroxide
MNA = monitored natural attenuation
GAC = granular activated carbon
Trans = transportation
Water - Potable = potable water from a public water source
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-3B

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Op of ISTT	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	10% - 50%	1	50% - 90%	1	50% - 90%	1	10% - 50%	1	50% - 90%	1	>90%
Elec - Op of BIO Inj Pump	18	<1%	18	<1%	18	<1%	18	<1%	18	<1%	18	<1%	15	<1%	18	<1%	11	<1%	17	<1%
Fuel - Hollow Stem Drilling	6	1% - 10%	8	<1%	6	<1%	8	<1%	4	1% - 10%	4	1% - 10%	4	1% - 10%	6	1% - 10%	5	<1%	7	<1%
Fuel - Direct Push Drilling	11	<1%	5	1% - 10%	10	<1%	5	<1%	5	1% - 10%	2	10% - 50%	5	<1%	4	1% - 10%	6	<1%	5	<1%
Mat - GAC	4	1% - 10%	3	1% - 10%	4	1% - 10%	3	1% - 10%	17	<1%	5	1% - 10%	18	<1%	3	1% - 10%	14	<1%	2	1% - 10%
Mat - ISTT Electrodes	2	10% - 50%	4	1% - 10%	2	10% - 50%	6	<1%	2	10% - 50%	7	<1%	3	1% - 10%	7	1% - 10%	3	10% - 50%	4	<1%
Mat - PVC	13	<1%	14	<1%	13	<1%	13	<1%	10	<1%	15	<1%	10	<1%	14	<1%	7	<1%	11	<1%
Mat - Grout	9	<1%	10	<1%	11	<1%	12	<1%	6	<1%	12	<1%	6	<1%	12	<1%	4	1% - 10%	13	<1%
Mat - Veg Oil	3	10% - 50%	2	1% - 10%	3	10% - 50%	2	10% - 50%	3	10% - 50%	3	1% - 10%	2	10% - 50%	2	10% - 50%	2	10% - 50%	3	1% - 10%
Trans - Materials ISTT	15	<1%	13	<1%	14	<1%	14	<1%	15	<1%	13	<1%	16	<1%	13	<1%	17	<1%	15	<1%
Trans - Materials BIO	5	1% - 10%	6	1% - 10%	5	<1%	4	1% - 10%	7	<1%	6	1% - 10%	12	<1%	5	1% - 10%	13	<1%	6	<1%
Trans - Materials MNA	12	<1%	12	<1%	12	<1%	11	<1%	14	<1%	9	<1%	14	<1%	9	1% - 10%	16	<1%	12	<1%
Trans - Personnel ISTT	10	<1%	11	<1%	9	<1%	10	<1%	12	<1%	11	<1%	13	<1%	11	<1%	15	<1%	10	<1%
Trans - Personnel BIO	8	<1%	9	<1%	8	<1%	9	<1%	9	<1%	10	<1%	11	<1%	10	1% - 10%	12	<1%	9	<1%
Trans - Personnel MNA	7	<1%	7	<1%	7	<1%	7	<1%	8	<1%	8	<1%	9	<1%	8	1% - 10%	10	<1%	8	<1%
Trans - Waste Soil	16	<1%	15	<1%	15	<1%	15	<1%	16	<1%	14	<1%	17	<1%	15	<1%	18	<1%	16	<1%
Water - Potable (Cement/Veg Oil)	14	<1%	16	<1%	17	<1%	16	<1%	11	<1%	17	<1%	8	<1%	16	<1%	8	<1%	14	<1%
Disp - Soil	17	<1%	17	<1%	16	<1%	17	<1%	13	<1%	16	<1%	7	<1%	17	<1%	9	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Op of ISTT	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Elec - Op of BIO Inj Pump	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Fuel - Hollow Stem Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - GAC	1.2 - 2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - ISTT Electrodes	5 - 10 (SW)	>10 (SW)	>10 (SW)	>10 (SW)	>10 (SW)
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	1.2 - 2 (SW)	5 - 10 (SW)	5 - 10 (SW)
Mat - Veg Oil	1 - 1.2 (SW)	1.2 - 2 (SP)	1 - 1.2 (SW)	2 - 5 (SW)	2 - 5 (SW)
Trans - Materials ISTT	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials BIO	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials MNA	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel ISTT	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel BIO	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA	1 - 1.2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Cement/Veg Oil)	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
ISTT = in-situ thermal treatment
Bio = In-situ bioremediation
PVC = polyvinyl chloride
MNA = monitored natural attenuation
GAC = granular activated carbon
Trans = transportation
Water - Potable = potable water from a public water source
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-4

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Pump for Recirc	3	1% - 10%	2	1% - 10%	2	1% - 10%	2	1% - 10%	5	1% - 10%	3	1% - 10%	3	1% - 10%	4	1% - 10%	3	1% - 10%	2	1% - 10%
Elec - UV ox	1	50% - 90%	1	>90%	1	50% - 90%	1	>90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	2	10% - 50%	1	50% - 90%	1	>90%
Fuel - Hollow Stem Auger Drilling	6	<1%	7	<1%	5	<1%	8	<1%	3	1% - 10%	4	1% - 10%	5	<1%	5	<1%	6	<1%	8	<1%
Fuel - Direct Push Drilling	9	<1%	3	<1%	9	<1%	3	<1%	4	1% - 10%	2	1% - 10%	6	<1%	3	1% - 10%	7	<1%	4	<1%
Mat - PVC	8	<1%	9	<1%	7	<1%	6	<1%	7	<1%	11	<1%	7	<1%	6	<1%	5	<1%	5	<1%
Mat - Grout	4	<1%	4	<1%	8	<1%	10	<1%	6	1% - 10%	10	<1%	4	<1%	10	<1%	4	1% - 10%	9	<1%
Mat - PRB Iron filings	2	1% - 10%	5	<1%	3	1% - 10%	4	<1%	2	10% - 50%	5	1% - 10%	2	10% - 50%	1	50% - 90%	2	10% - 50%	3	<1%
Trans - Materials Recirc	10	<1%	10	<1%	10	<1%	9	<1%	10	<1%	9	<1%	10	<1%	9	<1%	10	<1%	11	<1%
Trans - Materials PRB	11	<1%	11	<1%	11	<1%	11	<1%	11	<1%	7	<1%	11	<1%	11	<1%	11	<1%	10	<1%
Trans - Personnel Recirc	5	<1%	6	<1%	4	<1%	5	<1%	8	<1%	6	<1%	8	<1%	7	<1%	8	<1%	6	<1%
Trans - Personnel PRB	7	<1%	8	<1%	6	<1%	7	<1%	9	<1%	8	<1%	9	<1%	8	<1%	9	<1%	7	<1%
Water - Potable for Cement	12	<1%	12	<1%	12	<1%	12	<1%	12	<1%	12	<1%	12	<1%	12	<1%	12	<1%	12	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Pump for Recirc	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Elec - UV ox	1.2 - 2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	5 - 10 (SW)	5 - 10 (SP)
Fuel - Hollow Stem Auger Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - PVC	1 - 1.2 (SP)	1 - 1.2 (SP)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	1.2 - 2 (SW)	5 - 10 (SW)	5 - 10 (SW)
Mat - PRB Iron filings	>10 (SW)	5 - 10 (SW)	2 - 5 (SW)	2 - 5 (SP)	>10 (SW)
Trans - Materials Recirc	1 - 1.2 (SW)	1 - 1.2 (SP)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Materials PRB	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel Recirc	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel PRB	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Water - Potable for Cement	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
UV ox = UV Oxidation
PVC = polyvinyl chloride
PRB = permeable reactive barrier
Trans = transportation
Recirc = recirculation
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt S-2

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavator	7	1% - 10%	7	1% - 10%	6	1% - 10%	7	<1%	4	1% - 10%	9	1% - 10%	4	<1%	7	1% - 10%	4	1% - 10%	7	1% - 10%
Fuel - Compactor	8	<1%	8	<1%	8	<1%	8	<1%	6	1% - 10%	6	1% - 10%	6	<1%	8	1% - 10%	5	<1%	8	1% - 10%
Fuel - Dump Truck	9	<1%	9	<1%	9	<1%	9	<1%	7	1% - 10%	8	1% - 10%	7	<1%	9	1% - 10%	6	<1%	9	1% - 10%
Mat - Fill	1	10% - 50%	5	1% - 10%	1	10% - 50%	4	1% - 10%	1	10% - 50%	4	1% - 10%	3	10% - 50%	4	1% - 10%	1	50% - 90%	4	1% - 10%
Trans - Equipment	12	<1%	12	<1%	12	<1%	12	<1%	12	<1%	11	<1%	12	<1%	12	<1%	12	<1%	11	<1%
Trans - Clean Fill	3	10% - 50%	2	10% - 50%	4	10% - 50%	3	10% - 50%	8	1% - 10%	3	10% - 50%	8	<1%	3	10% - 50%	8	<1%	2	10% - 50%
Trans - Samples to Lab	11	<1%	11	<1%	11	<1%	11	<1%	11	<1%	12	<1%	11	<1%	11	<1%	11	<1%	12	<1%
Trans - Personnel	10	<1%	10	<1%	10	<1%	10	<1%	10	<1%	10	<1%	10	<1%	10	<1%	10	<1%	10	<1%
Trans - Waste Soil (Haz)	2	10% - 50%	1	50% - 90%	2	10% - 50%	1	10% - 50%	5	1% - 10%	1	10% - 50%	5	<1%	1	10% - 50%	7	<1%	1	10% - 50%
Trans - Waste Soil (Non-Haz)	6	1% - 10%	4	1% - 10%	7	1% - 10%	6	1% - 10%	9	<1%	7	1% - 10%	9	<1%	6	1% - 10%	9	<1%	5	1% - 10%
Disp - Soil (Haz)	4	10% - 50%	3	10% - 50%	3	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	1	50% - 90%	2	10% - 50%	2	10% - 50%	3	10% - 50%
Disp - Soil (Non-Haz)	5	1% - 10%	6	1% - 10%	5	1% - 10%	5	1% - 10%	3	10% - 50%	5	1% - 10%	2	10% - 50%	5	1% - 10%	3	1% - 10%	6	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Excavator	1.2 - 2 (SW)	2 - 5 (SW)	1 - 1.2 (SW)	1 - 1.2 (SP)	2 - 5 (SW)
Fuel - Compactor	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	2 - 5 (SP)
Fuel - Dump Truck	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	2 - 5 (SP)
Mat - Fill	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SW)	>10 (SW)	>10 (SW)
Trans - Equipment	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Clean Fill	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Samples to Lab	1 - 1.2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil (Haz)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Soil (Non-Haz)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Disp - Soil (Haz)	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)
Disp - Soil (Non-Haz)	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
Trans = transportation
Disp - landfill activities associated with soil disposal
Haz = hazardous
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 1

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Pumps	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	2	10% - 50%	1	50% - 90%	1	10% - 50%	1	50% - 90%	1	50% - 90%
Fuel - Field Truck	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	1	50% - 90%	3	1% - 10%	2	10% - 50%	5	<1%	2	1% - 10%
Mat - GAC	4	1% - 10%	4	1% - 10%	8	1% - 10%	3	1% - 10%	16	<1%	4	1% - 10%	17	<1%	5	1% - 10%	13	<1%	3	1% - 10%
Mat - Acetic Acid	5	1% - 10%	5	1% - 10%	4	1% - 10%	4	1% - 10%	3	1% - 10%	6	<1%	2	1% - 10%	4	1% - 10%	2	10% - 50%	6	1% - 10%
Mat - Phosphoric Acid	8	<1%	11	<1%	7	1% - 10%	11	<1%	7	1% - 10%	11	<1%	6	<1%	7	1% - 10%	4	1% - 10%	4	1% - 10%
Mat - Filter bags	13	<1%	13	<1%	13	<1%	12	<1%	12	<1%	15	<1%	10	<1%	12	<1%	6	<1%	12	<1%
Mat - Veg Oil	7	1% - 10%	7	1% - 10%	6	1% - 10%	6	1% - 10%	6	1% - 10%	9	<1%	4	1% - 10%	8	1% - 10%	3	1% - 10%	7	<1%
Trans - GAC	15	<1%	15	<1%	15	<1%	15	<1%	17	<1%	14	<1%	16	<1%	15	<1%	17	<1%	15	<1%
Trans - FBR Acids	10	<1%	8	<1%	9	<1%	8	<1%	9	<1%	5	1% - 10%	12	<1%	10	<1%	14	<1%	9	<1%
Trans - Bag Filters	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	18	<1%	19	<1%	19	<1%	19	<1%	19	<1%
Trans - Forklift	12	<1%	9	<1%	11	<1%	9	<1%	11	<1%	8	<1%	14	<1%	11	<1%	15	<1%	10	<1%
Trans - Veg Oil	14	<1%	14	<1%	14	<1%	14	<1%	14	<1%	12	<1%	15	<1%	13	<1%	16	<1%	14	<1%
Trans - O&M Samples	9	<1%	12	<1%	12	<1%	13	<1%	4	1% - 10%	13	<1%	11	<1%	17	<1%	7	<1%	13	<1%
Trans - Personnel FBR	3	1% - 10%	3	1% - 10%	3	1% - 10%	5	1% - 10%	5	1% - 10%	3	1% - 10%	5	<1%	3	10% - 50%	8	<1%	5	1% - 10%
Trans - Personnel Biowall	11	<1%	10	<1%	10	<1%	10	<1%	10	<1%	10	<1%	9	<1%	9	1% - 10%	11	<1%	11	<1%
Trans - Personnel Sampling	6	1% - 10%	6	1% - 10%	5	1% - 10%	7	1% - 10%	8	1% - 10%	7	<1%	7	<1%	6	1% - 10%	9	<1%	8	<1%
Trans - Waste Bag Filters	18	<1%	16	<1%	17	<1%	17	<1%	18	<1%	17	<1%	18	<1%	18	<1%	18	<1%	17	<1%
Water - Potable (Veg Oil Inject)	17	<1%	18	<1%	18	<1%	18	<1%	15	<1%	19	<1%	13	<1%	16	<1%	12	<1%	16	<1%
Disp - Filter Bags	16	<1%	17	<1%	16	<1%	16	<1%	13	<1%	16	<1%	8	<1%	14	<1%	10	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SW)	2 - 5 (SP)
Fuel - Field Truck	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - GAC	1.2 - 2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Acetic Acid	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Phosphoric Acid	2 - 5 (SW)	2 - 5 (SW)	2 - 5 (SW)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - Filter bags	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Veg Oil	1 - 1.2 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Trans - GAC	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - FBR Acids	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Bag Filters	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Forklift	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Veg Oil	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel FBR	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Bag Filters	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Filter Bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
GAC = granular Activated Carbon
FBR = fluidized Bed Reactor
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 2

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Pumps	2	10% - 50%	1	10% - 50%	1	10% - 50%	1	50% - 90%	1	50% - 90%	2	10% - 50%	1	50% - 90%	2	10% - 50%	1	50% - 90%	1	50% - 90%
Fuel - Field Truck	1	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	1	50% - 90%	2	1% - 10%	1	10% - 50%	5	<1%	2	10% - 50%
Mat - GAC	4	1% - 10%	3	1% - 10%	6	1% - 10%	3	1% - 10%	16	<1%	3	1% - 10%	17	<1%	4	1% - 10%	13	<1%	3	1% - 10%
Mat - Acetic Acid	7	1% - 10%	6	1% - 10%	4	1% - 10%	5	1% - 10%	3	1% - 10%	9	<1%	3	1% - 10%	6	1% - 10%	2	1% - 10%	6	1% - 10%
Mat - Phosphoric Acid	11	<1%	11	<1%	8	<1%	11	<1%	7	1% - 10%	11	<1%	6	<1%	8	1% - 10%	4	1% - 10%	4	1% - 10%
Mat - Filter bags	14	<1%	14	<1%	13	<1%	12	<1%	12	<1%	15	<1%	11	<1%	13	<1%	6	<1%	12	<1%
Mat - Veg Oil	6	1% - 10%	5	1% - 10%	5	1% - 10%	4	1% - 10%	4	1% - 10%	6	<1%	4	1% - 10%	5	1% - 10%	3	1% - 10%	7	<1%
Trans - GAC	15	<1%	15	<1%	15	<1%	15	<1%	17	<1%	14	<1%	16	<1%	15	<1%	17	<1%	15	<1%
Trans - FBR Acids	12	<1%	10	<1%	11	<1%	10	<1%	11	<1%	7	<1%	14	<1%	11	<1%	15	<1%	11	<1%
Trans - Bag Filters	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%	19	<1%
Trans - Forklift	10	<1%	8	<1%	10	<1%	8	<1%	10	<1%	5	<1%	12	<1%	10	<1%	14	<1%	9	<1%
Trans - Veg Oil	13	<1%	12	<1%	14	<1%	13	<1%	14	<1%	12	<1%	15	<1%	12	<1%	16	<1%	13	<1%
Trans - O&M Samples	9	<1%	13	<1%	12	<1%	14	<1%	5	1% - 10%	13	<1%	13	<1%	18	<1%	7	<1%	14	<1%
Trans - Personnel FBR	3	1% - 10%	4	1% - 10%	3	1% - 10%	6	1% - 10%	6	1% - 10%	4	1% - 10%	5	<1%	3	10% - 50%	8	<1%	5	1% - 10%
Trans - Personnel Biowall	8	<1%	9	<1%	9	<1%	9	<1%	9	<1%	10	<1%	9	<1%	9	1% - 10%	11	<1%	10	<1%
Trans - Personnel Sampling	5	1% - 10%	7	1% - 10%	7	1% - 10%	7	1% - 10%	8	<1%	8	<1%	8	<1%	7	1% - 10%	10	<1%	8	<1%
Trans - Waste Bag Filters	18	<1%	16	<1%	17	<1%	17	<1%	18	<1%	17	<1%	18	<1%	17	<1%	18	<1%	17	<1%
Water - Potable (Veg Oil Inject)	17	<1%	18	<1%	18	<1%	18	<1%	15	<1%	18	<1%	10	<1%	16	<1%	12	<1%	16	<1%
Disp - Filter Bags	16	<1%	17	<1%	16	<1%	16	<1%	13	<1%	16	<1%	7	<1%	14	<1%	9	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SW)	2 - 5 (SP)
Fuel - Field Truck	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - GAC	1.2 - 2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Acetic Acid	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Phosphoric Acid	2 - 5 (SW)	2 - 5 (SW)	2 - 5 (SW)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - Filter bags	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Veg Oil	1 - 1.2 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Trans - GAC	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - FBR Acids	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Bag Filters	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Forklift	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Veg Oil	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel FBR	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Bag Filters	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Filter Bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
GAC = granular Activated Carbon
FBR = fluidized Bed Reactor
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 3

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Alt 3	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	2	10% - 50%	1	50% - 90%	2	10% - 50%	2	10% - 50%	1	50% - 90%
Fuel - Equip for Demo (Diesel)	15	<1%	14	<1%	16	<1%	15	<1%	10	<1%	9	<1%	12	<1%	14	<1%	12	<1%	13	<1%
Fuel - Field Truck (Gasoline)	3	10% - 50%	3	10% - 50%	3	1% - 10%	3	10% - 50%	3	1% - 10%	1	50% - 90%	6	1% - 10%	3	10% - 50%	9	<1%	3	1% - 10%
Mat - Sand Filter	12	<1%	10	1% - 10%	12	<1%	11	<1%	7	1% - 10%	13	<1%	7	1% - 10%	11	1% - 10%	5	1% - 10%	9	<1%
Mat - Sand	20	<1%	18	<1%	20	<1%	18	<1%	17	<1%	20	<1%	15	<1%	18	<1%	10	<1%	16	<1%
Mat - Resin	1	50% - 90%	2	10% - 50%	1	50% - 90%	2	10% - 50%	1	50% - 90%	3	10% - 50%	2	10% - 50%	1	10% - 50%	1	50% - 90%	2	10% - 50%
Mat - IX Vessel (Steel)	7	1% - 10%	9	1% - 10%	8	1% - 10%	9	<1%	4	1% - 10%	15	<1%	4	1% - 10%	16	<1%	3	1% - 10%	8	<1%
Mat - Slab IX Vessel (Steel/Concrete)	14	<1%	8	1% - 10%	15	<1%	12	<1%	13	<1%	10	<1%	11	<1%	9	1% - 10%	6	<1%	12	<1%
Mat - Veg Oil	8	1% - 10%	7	1% - 10%	6	1% - 10%	4	1% - 10%	6	1% - 10%	7	1% - 10%	5	1% - 10%	7	1% - 10%	4	1% - 10%	5	<1%
Trans - Sand	17	<1%	16	<1%	17	<1%	16	<1%	19	<1%	18	<1%	20	<1%	15	<1%	20	<1%	18	<1%
Trans - Construct Materials/Equip	10	<1%	11	<1%	9	<1%	8	<1%	14	<1%	8	<1%	17	<1%	8	1% - 10%	18	<1%	11	<1%
Trans - Resin	6	1% - 10%	5	1% - 10%	7	1% - 10%	6	1% - 10%	12	<1%	5	1% - 10%	13	<1%	5	1% - 10%	15	<1%	7	<1%
Trans - Veg Oil	18	<1%	19	<1%	18	<1%	19	<1%	20	<1%	16	<1%	21	<1%	19	<1%	21	<1%	19	<1%
Trans - O&M Samples	9	<1%	17	<1%	11	<1%	17	<1%	5	1% - 10%	17	<1%	16	<1%	21	<1%	8	<1%	17	<1%
Trans - Personnel O&M Sampling	5	1% - 10%	6	1% - 10%	5	1% - 10%	7	1% - 10%	11	<1%	6	1% - 10%	10	<1%	6	1% - 10%	14	<1%	6	<1%
Trans - Personnel Biowall	11	<1%	12	<1%	10	<1%	10	<1%	15	<1%	11	<1%	14	<1%	10	1% - 10%	16	<1%	10	<1%
Trans - Personnel EX/IX	4	1% - 10%	4	1% - 10%	4	1% - 10%	5	1% - 10%	8	<1%	4	1% - 10%	8	<1%	4	1% - 10%	11	<1%	4	1% - 10%
Trans - Waste (Sand/Resin/Sludge)	16	<1%	13	<1%	14	<1%	14	<1%	18	<1%	12	<1%	19	<1%	12	<1%	19	<1%	14	<1%
Water - Potable (Veg Oil Inject)	21	<1%	21	<1%	21	<1%	21	<1%	21	<1%	21	<1%	18	<1%	20	<1%	17	<1%	21	<1%
Disp - Sand/Resin	13	<1%	15	<1%	13	<1%	13	<1%	9	<1%	14	<1%	3	1% - 10%	13	<1%	7	<1%	15	<1%
Disp - Sludge	19	<1%	20	<1%	19	<1%	20	<1%	16	<1%	19	<1%	9	<1%	17	<1%	13	<1%	20	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Alt 3	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SW)	2 - 5 (SP)
Fuel - Equip for Demo (Diesel)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	2 - 5 (SP)
Fuel - Field Truck (Gasoline)	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - Sand Filter	1.2 - 2 (SP)	1.2 - 2 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	2 - 5 (SW)
Mat - Sand	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SW)	1.2 - 2 (SP)
Mat - Resin	2 - 5 (SW)	2 - 5 (SW)	2 - 5 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - IX Vessel (Steel)	1.2 - 2 (SW)	2 - 5 (SW)	5 - 10 (SW)	>10 (SW)	5 - 10 (SW)
Mat - Slab IX Vessel (Steel/Concrete)	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)
Mat - Veg Oil	1 - 1.2 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Trans - Sand	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Construct Materials/Equip	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Resin	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Veg Oil	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel O&M Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel EX/IX	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste (Sand/Resin/Sludge)	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Sand/Resin	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - Sludge	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
IX = ion Exchanage
EX - excavation
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 4

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Alt 4	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	50% - 90%	1	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	1	10% - 50%	1	50% - 90%
Fuel - FBR Demo	19	<1%	19	<1%	19	<1%	19	<1%	13	<1%	16	<1%	13	<1%	18	<1%	12	<1%	19	<1%
Fuel - GBR Excavator	22	<1%	21	<1%	21	<1%	21	<1%	19	<1%	21	<1%	20	<1%	19	<1%	14	<1%	22	<1%
Fuel - Field Truck (Gasoline)	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	5	1% - 10%	1	50% - 90%	6	1% - 10%	1	10% - 50%	9	<1%	2	1% - 10%
Mat - GBR Construction Concrete	13	1% - 10%	3	1% - 10%	16	<1%	9	1% - 10%	9	1% - 10%	9	1% - 10%	7	1% - 10%	9	1% - 10%	6	1% - 10%	9	<1%
Mat - Gravel Fill	5	1% - 10%	14	<1%	5	1% - 10%	12	<1%	2	10% - 50%	13	<1%	3	1% - 10%	10	1% - 10%	3	10% - 50%	14	<1%
Mat - AceticAcid	4	1% - 10%	4	1% - 10%	3	1% - 10%	3	1% - 10%	4	10% - 50%	7	1% - 10%	4	1% - 10%	4	1% - 10%	2	10% - 50%	4	1% - 10%
Mat - Phosphoric Acid	10	1% - 10%	15	<1%	10	1% - 10%	15	<1%	8	1% - 10%	15	<1%	8	<1%	8	1% - 10%	7	1% - 10%	3	1% - 10%
Mat - Veg Oil	9	1% - 10%	8	1% - 10%	9	1% - 10%	4	1% - 10%	7	1% - 10%	11	1% - 10%	5	1% - 10%	11	1% - 10%	4	1% - 10%	6	1% - 10%
Trans - Gravel	7	1% - 10%	6	1% - 10%	8	1% - 10%	6	1% - 10%	12	<1%	4	1% - 10%	11	<1%	5	1% - 10%	13	<1%	8	<1%
Trans - GBR Heavy Equip	17	<1%	16	<1%	17	<1%	16	<1%	18	<1%	17	<1%	19	<1%	16	<1%	20	<1%	16	<1%
Trans - GBR Cement	18	<1%	17	<1%	18	<1%	17	<1%	20	<1%	18	<1%	21	<1%	17	<1%	21	<1%	17	<1%
Trans - Forklift	16	<1%	12	1% - 10%	14	<1%	13	<1%	17	<1%	10	1% - 10%	18	<1%	15	<1%	19	<1%	13	<1%
Trans - Acids	14	1% - 10%	10	1% - 10%	12	1% - 10%	11	1% - 10%	15	<1%	6	1% - 10%	16	<1%	14	1% - 10%	18	<1%	11	<1%
Trans - Veg Oil	20	<1%	20	<1%	20	<1%	20	<1%	21	<1%	19	<1%	22	<1%	20	<1%	22	<1%	20	<1%
Trans - O&M Samples	11	1% - 10%	18	<1%	15	<1%	18	<1%	6	1% - 10%	20	<1%	15	<1%	22	<1%	8	<1%	18	<1%
Trans - Personnel O&M Sampling	6	1% - 10%	7	1% - 10%	7	1% - 10%	7	1% - 10%	11	1% - 10%	8	1% - 10%	10	<1%	7	1% - 10%	11	<1%	7	1% - 10%
Trans - Personnel Biowall	15	1% - 10%	13	<1%	13	<1%	14	<1%	16	<1%	14	<1%	12	<1%	13	1% - 10%	15	<1%	15	<1%
Trans - Personnel EX/GBR	3	1% - 10%	5	1% - 10%	4	1% - 10%	5	1% - 10%	10	1% - 10%	5	1% - 10%	9	<1%	3	1% - 10%	10	<1%	5	1% - 10%
Trans - Waste (Gravel)	12	1% - 10%	11	1% - 10%	11	1% - 10%	10	1% - 10%	14	<1%	12	1% - 10%	14	<1%	12	1% - 10%	17	<1%	12	<1%
Water - Potable (Veg Oil Inject)	21	<1%	22	<1%	22	<1%	22	<1%	22	<1%	22	<1%	17	<1%	21	<1%	16	<1%	21	<1%
Disp - Gravel	8	1% - 10%	9	1% - 10%	6	1% - 10%	8	1% - 10%	3	10% - 50%	3	1% - 10%	1	10% - 50%	6	1% - 10%	5	1% - 10%	10	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Alt 4	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SW)	2 - 5 (SP)
Fuel - FBR Demo	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	2 - 5 (SP)
Fuel - GBR Excavator	1 - 1.2 (SP)	1 - 1.2 (SW)	2 - 5 (SP)	2 - 5 (SP)	1 - 1.2 (SW)
Fuel - Field Truck (Gasoline)	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - GBR Construction Concrete	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	1.2 - 2 (SW)
Mat - Gravel Fill	5 - 10 (SW)	2 - 5 (SW)	2 - 5 (SW)	>10 (SW)	>10 (SW)
Mat - AceticAcid	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - Phosphoric Acid	2 - 5 (SW)	2 - 5 (SW)	2 - 5 (SW)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - Veg Oil	1 - 1.2 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Trans - Gravel	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - GBR Heavy Equip	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - GBR Cement	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Forklift	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Acids	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Veg Oil	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel O&M Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel EX/GBR	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste (Gravel)	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Gravel	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
FBR = fluidized Bed Reactor
GBR = gravel Bed Reactor
EX - excavation
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 5

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Alt 5	1	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	2	10% - 50%	1	10% - 50%	4	10% - 50%	2	10% - 50%	1	50% - 90%
Fuel - FBR Demo	15	<1%	15	<1%	15	<1%	15	<1%	13	<1%	13	<1%	12	<1%	13	<1%	12	<1%	15	<1%
Fuel - Wetlands Construct Equip	11	1% - 10%	6	1% - 10%	11	1% - 10%	9	1% - 10%	4	1% - 10%	4	1% - 10%	7	1% - 10%	5	1% - 10%	7	<1%	10	1% - 10%
Fuel - Field Truck (Gasoline)	3	10% - 50%	2	10% - 50%	3	10% - 50%	3	10% - 50%	5	1% - 10%	1	50% - 90%	5	1% - 10%	3	10% - 50%	9	<1%	2	1% - 10%
Mat - Gravel	5	1% - 10%	11	1% - 10%	5	1% - 10%	11	1% - 10%	3	1% - 10%	8	1% - 10%	3	10% - 50%	8	1% - 10%	3	1% - 10%	11	<1%
Mat - Sand/Mulch	2	10% - 50%	7	1% - 10%	1	10% - 50%	2	10% - 50%	1	50% - 90%	5	1% - 10%	2	10% - 50%	2	10% - 50%	1	50% - 90%	7	1% - 10%
Mat - PVC Liner	8	1% - 10%	9	1% - 10%	8	1% - 10%	8	1% - 10%	8	1% - 10%	10	<1%	6	1% - 10%	9	1% - 10%	5	1% - 10%	5	1% - 10%
Mat - PVC Pipe	10	1% - 10%	10	1% - 10%	10	1% - 10%	10	1% - 10%	10	1% - 10%	11	<1%	8	<1%	10	1% - 10%	6	1% - 10%	8	1% - 10%
Trans - Veg Oil	9	1% - 10%	8	1% - 10%	9	1% - 10%	5	1% - 10%	9	1% - 10%	9	<1%	4	1% - 10%	11	1% - 10%	4	1% - 10%	9	1% - 10%
Trans - Gravel	7	1% - 10%	4	1% - 10%	7	1% - 10%	6	1% - 10%	12	<1%	6	1% - 10%	11	<1%	6	1% - 10%	13	<1%	6	1% - 10%
Trans - Sand/Mulch	4	10% - 50%	3	10% - 50%	4	1% - 10%	4	1% - 10%	7	1% - 10%	3	1% - 10%	10	<1%	1	10% - 50%	10	<1%	3	1% - 10%
Trans - Heavy Equip	14	<1%	13	<1%	14	<1%	13	<1%	15	<1%	16	<1%	16	<1%	14	<1%	16	<1%	13	<1%
Trans - Veg Oil	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%	14	<1%	17	<1%	15	<1%	17	<1%	16	<1%
Trans - O&M Samples	12	1% - 10%	14	<1%	12	<1%	14	<1%	6	1% - 10%	15	<1%	13	<1%	17	<1%	8	<1%	14	<1%
Trans - Personnel for Construction	13	<1%	12	<1%	13	<1%	12	<1%	14	<1%	12	<1%	14	<1%	12	1% - 10%	15	<1%	12	<1%
Trans - Personnel O&M/Sampling	6	1% - 10%	5	1% - 10%	6	1% - 10%	7	1% - 10%	11	<1%	7	1% - 10%	9	<1%	7	1% - 10%	11	<1%	4	1% - 10%
Water - Potable (Veg Oil Inject)	17	<1%	17	<1%	17	<1%	17	<1%	17	<1%	17	<1%	15	<1%	16	<1%	14	<1%	17	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Alt 5	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SW)	2 - 5 (SP)
Fuel - FBR Demo	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	2 - 5 (SP)
Fuel - Wetlands Construct Equip	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SP)
Fuel - Field Truck (Gasoline)	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - Gravel	5 - 10 (SW)	2 - 5 (SW)	2 - 5 (SW)	>10 (SW)	>10 (SW)
Mat - Sand/Mulch	>10 (SW)	1 - 1.2 (SP)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)
Mat - PVC Liner	1 - 1.2 (SP)	1 - 1.2 (SP)	1 - 1.2 (SW)	1 - 1.2 (SP)	1 - 1.2 (SW)
Mat - PVC Pipe	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Trans - Veg Oil	1 - 1.2 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Trans - Gravel	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Sand/Mulch	1 - 1.2 (SW)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Heavy Equip	1 - 1.2 (SW)	1 - 1.2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)
Trans - Veg Oil	1 - 1.2 (SP)	1 - 1.2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel for Construction	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Personnel O&M/Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
PVC = polyvinyl chloride
Trans = transportation
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 6

SiteWise (Version 3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Air Rotary Drill	11	1% - 10%	9	1% - 10%	11	1% - 10%	12	<1%	7	1% - 10%	7	1% - 10%	7	<1%	9	1% - 10%	7	<1%	10	1% - 10%
Fuel - Contruction Equipment	2	10% - 50%	2	10% - 50%	5	10% - 50%	3	10% - 50%	1	10% - 50%	1	10% - 50%	4	1% - 10%	1	10% - 50%	6	1% - 10%	2	10% - 50%
Mat - Mushroon Compost	4	1% - 10%	4	10% - 50%	3	10% - 50%	11	<1%	3	10% - 50%	8	1% - 10%	5	1% - 10%	11	1% - 10%	2	10% - 50%	11	<1%
Mat - Limestone	7	1% - 10%	11	1% - 10%	7	1% - 10%	9	1% - 10%	6	1% - 10%	10	1% - 10%	3	1% - 10%	7	1% - 10%	4	1% - 10%	7	1% - 10%
Mat - Wood Chips	4	1% - 10%	13	<1%	3	10% - 50%	2	10% - 50%	3	10% - 50%	12	<1%	5	1% - 10%	10	1% - 10%	2	10% - 50%	12	<1%
Mat - PVC	14	<1%	14	<1%	14	<1%	14	<1%	12	<1%	14	<1%	12	<1%	14	<1%	8	<1%	14	<1%
Mat - Veg Oil	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	2	10% - 50%	3	1% - 10%	2	10% - 50%	2	10% - 50%	1	10% - 50%	1	10% - 50%
Trans - Mushroom	12	1% - 10%	8	1% - 10%	12	<1%	8	1% - 10%	13	<1%	9	1% - 10%	14	<1%	8	1% - 10%	14	<1%	8	1% - 10%
Trans - Limestone	8	1% - 10%	6	1% - 10%	8	1% - 10%	6	1% - 10%	9	<1%	5	1% - 10%	10	<1%	5	1% - 10%	11	<1%	5	1% - 10%
Trans - Wood Chips	9	1% - 10%	7	1% - 10%	9	1% - 10%	7	1% - 10%	10	<1%	6	1% - 10%	13	<1%	6	1% - 10%	13	<1%	6	1% - 10%
Trans - Veg Oil	13	<1%	12	<1%	13	<1%	13	<1%	15	<1%	11	<1%	15	<1%	13	<1%	15	<1%	13	<1%
Trans - Personnel Construction	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%	16	<1%
Trans - Personnel Sampling	10	1% - 10%	10	1% - 10%	10	1% - 10%	10	<1%	11	<1%	13	<1%	11	<1%	12	1% - 10%	12	<1%	9	1% - 10%
Trans - Waste Soil Cuttings	3	10% - 50%	3	10% - 50%	2	10% - 50%	4	1% - 10%	8	1% - 10%	2	10% - 50%	8	<1%	3	10% - 50%	10	<1%	3	10% - 50%
Water - Potable (Veg Oil Inject)	15	<1%	15	<1%	15	<1%	15	<1%	14	<1%	15	<1%	9	<1%	15	<1%	9	<1%	15	<1%
Disp - Soil Cuttings	6	1% - 10%	5	1% - 10%	6	10% - 50%	5	1% - 10%	5	10% - 50%	4	1% - 10%	1	50% - 90%	4	10% - 50%	5	1% - 10%	4	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Air Rotary Drill	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Contruction Equipment	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	2 - 5 (SP)
Mat - Mushroon Compost	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)	>10 (SW)	>10 (SW)
Mat - Limestone	5 - 10 (SW)	2 - 5 (SW)	2 - 5 (SW)	>10 (SW)	>10 (SW)
Mat - Wood Chips	>10 (SW)	1.2 - 2 (SP)	>10 (SW)	>10 (SW)	>10 (SW)
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)	1 - 1.2 (SW)
Mat - Veg Oil	1 - 1.2 (SP)	2 - 5 (SP)	1 - 1.2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Trans - Mushroom	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Limestone	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Wood Chips	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Veg Oil	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel Construction	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil Cuttings	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil Cuttings	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents

NOx = nitrogen oxides

PM = particulate matter less than 10 microns

SOx = sulfur oxides

Rank = rank of footprint contributor relative to other footprint contributors for a particular metric

Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor

Fuel = fuel use for on-site equipment use

Mat = materials production for specified material

PVC = polyvinyl chloride

Trans = transportation

Disp - Soil (landfill) = landfill activities associated with soil disposal

Water - Potable = potable water from a public water source

SP = SimaPro

SW = SiteWise

Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger

No SW = SiteWise does not provide a value for comparison to SP

No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.

Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro

Blue shading - SimaPro result higher than SiteWise

"No SW" - Not calculated in SiteWise

APPENDIX D:

Results by Remedy Components – SiteWise^{TM} Version 2 versus SimaPro®

CRREL Alt 1

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	4	10% - 50%	2	10% - 50%		0	2	10% - 50%	3	10% - 50%	2	10% - 50%
Elec - Blower	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%		0	1	10% - 50%	1	10% - 50%	1	10% - 50%
Elec - Transfer Pumps	3	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	5	10% - 50%	3	10% - 50%		0	4	10% - 50%	4	10% - 50%	3	10% - 50%
Elec - Backwash Pump	16	<1%	17	<1%	16	<1%	15	<1%	11	<1%	19	<1%		0	20	<1%	8	<1%	12	<1%
Elec - Heater Well Housing	7	1% - 10%	5	1% - 10%	6	1% - 10%	5	1% - 10%	6	1% - 10%	5	1% - 10%		0	6	1% - 10%	5	1% - 10%	4	1% - 10%
Elec - Other	8	1% - 10%	7	1% - 10%	7	1% - 10%	6	1% - 10%	7	1% - 10%	7	1% - 10%		0	7	1% - 10%	7	1% - 10%	5	1% - 10%
Fuel - Boiler & Fuel Tank	5	1% - 10%	4	10% - 50%	4	1% - 10%	4	1% - 10%	2	10% - 50%	4	10% - 50%	1	>90%	5	1% - 10%	2	10% - 50%	6	1% - 10%
Mat - GAC	10	1% - 10%	8	1% - 10%	9	<1%	8	1% - 10%		0	9	1% - 10%		0	10	1% - 10%		0	8	<1%
Mat - Potassium Permanganate	12	<1%	12	<1%	11	<1%	11	<1%		0	14	<1%		0	13	<1%		0	11	<1%
Mat - Carbon Dioxide	4	10% - 50%	6	1% - 10%	5	1% - 10%	7	1% - 10%		0	8	1% - 10%		0	3	10% - 50%		0	7	1% - 10%
Mat - Filter Bags	14	<1%	15	<1%	12	<1%	13	<1%		0	18	<1%		0	16	<1%		0	14	<1%
Mat - Greensand	9	1% - 10%	10	<1%	8	1% - 10%	10	<1%		0	11	<1%		0	9	1% - 10%		0	10	<1%
Trans - GAC	17	<1%	16	<1%	17	<1%	17	<1%	14	<1%	13	<1%	9	<1%	17	<1%	15	<1%	17	<1%
Trans - Potassium Permanganate	20	<1%	23	<1%	20	<1%	24	<1%	17	<1%	24	<1%	12	<1%	26	<1%	18	<1%	23	<1%
Trans - CO2	15	<1%	11	<1%	15	<1%	12	<1%	12	<1%	10	<1%	8	<1%	14	<1%	14	<1%	13	<1%
Trans - Bag Filters	18	<1%	25	<1%	18	<1%	26	<1%	15	<1%	25	<1%	10	<1%	25	<1%	16	<1%	25	<1%
Trans - coolers	13	<1%	21	<1%	13	<1%	21	<1%	9	<1%	22	<1%	7	<1%	19	<1%	13	<1%	21	<1%
Trans - Greensand	21	<1%	19	<1%	21	<1%	19	<1%	19	<1%	17	<1%	13	<1%	22	<1%	19	<1%	19	<1%
Trans - Waste Backwash Sludge	19	<1%	18	<1%	19	<1%	18	<1%	16	<1%	15	<1%	11	<1%	15	<1%	17	<1%	18	<1%
Trans - Waste Greensand	22	<1%	13	<1%	22	<1%	14	<1%	20	<1%	12	<1%	14	<1%	12	<1%	20	<1%	15	<1%
Trans - Waste Bag Filters	24	<1%	20	<1%	23	<1%	20	<1%	21	<1%	20	<1%	15	<1%	18	<1%	21	<1%	20	<1%
Trans - Personnel	11	<1%	9	1% - 10%	10	<1%	9	<1%	8	<1%	6	1% - 10%	4	1% - 10%	8	1% - 10%	10	<1%	9	<1%
Disp - Filter bags	26	<1%	26	<1%	26	<1%	25	<1%	18	<1%	26	<1%	6	<1%	24	<1%	12	<1%	26	<1%
Disp - Greensand	23	<1%	22	<1%	24	<1%	22	<1%	10	<1%	21	<1%	3	1% - 10%	21	<1%	9	<1%	22	<1%
Disp - POTW Backwash Water	6	1% - 10%	14	<1%	14	<1%	16	<1%	3	10% - 50%	16	<1%	2	1% - 10%	11	1% - 10%	6	1% - 10%	16	<1%
Disp - Sludge	25	<1%	24	<1%	25	<1%	23	<1%	13	<1%	23	<1%	5	<1%	23	<1%	11	<1%	24	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Blower	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Backwash Pump	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Heater Well Housing	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Other	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - Boiler & Fuel Tank	1 - 1.2 (SP)	1 - 1.2 (SP)	1 - 1.2 (SW)	5 - 10 (SW)	2 - 5 (SW)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Potassium Permanganate	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Carbon Dioxide	2 - 5 (SW)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - Filter Bags	1.2 - 2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Greensand	2 - 5 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Trans - GAC	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Potassium Permanganate	>10 (SW)	>10 (SW)	1.2 - 2 (SP)	>10 (SW)	>10 (SP)
Trans - CO2	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Bag Filters	>10 (SW)	>10 (SW)	1.2 - 2 (SW)	>10 (SW)	5 - 10 (SP)
Trans - coolers	>10 (SW)	>10 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	5 - 10 (SP)
Trans - Greensand	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Waste Backwash Sludge	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Greensand	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Bag Filters	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - Filter bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - Greensand	1.2 - 2 (SW)	2 - 5 (SP)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - POTW Backwash Water	>10 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SW)	>10 (SW)
Disp - Sludge	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
GAC = granular activated carbon
CO2 = carbon dioxide used in treatment system
POTW = publicly owned treatment works
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

CRREL Alt 2

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	3	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	5	10% - 50%	3	10% - 50%		0	3	10% - 50%	4	10% - 50%	3	10% - 50%
Elec - Blower	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	4	10% - 50%	2	10% - 50%		0	2	10% - 50%	3	10% - 50%	2	10% - 50%
Elec - Transfer Pumps	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%		0	1	10% - 50%	2	10% - 50%	1	10% - 50%
Elec - Backwash Pump	18	<1%	19	<1%	18	<1%	16	<1%	11	<1%	21	<1%		0	23	<1%	8	<1%	12	<1%
Elec - Heater for Well Housing	7	1% - 10%	5	1% - 10%	6	1% - 10%	5	1% - 10%	6	1% - 10%	5	1% - 10%		0	6	1% - 10%	5	1% - 10%	4	1% - 10%
Elec - Other	8	1% - 10%	7	1% - 10%	7	1% - 10%	6	1% - 10%	7	1% - 10%	7	1% - 10%		0	8	1% - 10%	7	1% - 10%	5	1% - 10%
Fuel - Boiler & Fuel Tank	5	10% - 50%	4	10% - 50%	4	1% - 10%	4	1% - 10%	2	10% - 50%	4	10% - 50%	1	>90%	5	1% - 10%	1	10% - 50%	6	1% - 10%
Fuel - Equipment	31	<1%	29	<1%	31	<1%	29	<1%	23	<1%	29	<1%	17	<1%	29	<1%	15	<1%	31	<1%
Mat - GAC	10	1% - 10%	8	1% - 10%	9	1% - 10%	8	1% - 10%		0	9	1% - 10%		0	11	1% - 10%		0	8	<1%
Mat - Potassium Permanganate	12	<1%	12	<1%	11	<1%	11	<1%		0	14	<1%		0	14	<1%		0	11	<1%
Mat - Carbon Dioxide	4	10% - 50%	6	1% - 10%	5	1% - 10%	7	1% - 10%		0	8	1% - 10%		0	4	10% - 50%		0	7	1% - 10%
Mat - Filter Bags	16	<1%	17	<1%	12	<1%	13	<1%		0	20	<1%		0	18	<1%		0	15	<1%
Mat - Greensand	9	1% - 10%	10	<1%	8	1% - 10%	10	<1%		0	11	<1%		0	10	1% - 10%		0	10	<1%
Mat - Construct Tray Air Stripper	14	<1%	15	<1%	16	<1%	15	<1%		0	15	<1%		0	7	1% - 10%		0	13	<1%
Mat - Construct Eq Tank and Slab	15	<1%	14	<1%	14	<1%	18	<1%		0	18	<1%		0	17	<1%		0	18	<1%
Mat - PVC pipe	28	<1%	26	<1%	26	<1%	26	<1%		0	28	<1%		0	26	<1%		0	24	<1%
Trans - GAC	19	<1%	18	<1%	19	<1%	19	<1%	14	<1%	13	<1%	9	<1%	19	<1%	16	<1%	19	<1%
Trans - Potassium Permanganate	22	<1%	27	<1%	22	<1%	28	<1%	17	<1%	27	<1%	12	<1%	31	<1%	19	<1%	27	<1%
Trans - CO2	17	<1%	11	<1%	17	<1%	12	<1%	12	<1%	10	<1%	8	<1%	15	<1%	14	<1%	14	<1%
Trans - Bag Filters	20	<1%	30	<1%	20	<1%	31	<1%	15	<1%	30	<1%	10	<1%	30	<1%	17	<1%	29	<1%
Trans - Coolers	13	<1%	23	<1%	13	<1%	23	<1%	9	<1%	25	<1%	7	<1%	22	<1%	13	<1%	23	<1%
Trans - Greensand	23	<1%	21	<1%	23	<1%	21	<1%	19	<1%	19	<1%	13	<1%	25	<1%	20	<1%	21	<1%
Trans - Materials/Equip Construct	27	<1%	24	<1%	27	<1%	25	<1%	22	<1%	24	<1%	16	<1%	21	<1%	23	<1%	25	<1%
Trans - Waste Backwash Sludge	21	<1%	20	<1%	21	<1%	20	<1%	16	<1%	16	<1%	11	<1%	16	<1%	18	<1%	20	<1%
Trans - Waste Greensand	24	<1%	13	<1%	24	<1%	14	<1%	20	<1%	12	<1%	14	<1%	13	<1%	21	<1%	16	<1%
Trans - Waste Bag Filters	26	<1%	22	<1%	25	<1%	22	<1%	21	<1%	22	<1%	15	<1%	20	<1%	22	<1%	22	<1%
Trans - Personnel	11	<1%	9	1% - 10%	10	<1%	9	<1%	8	<1%	6	1% - 10%	4	1% - 10%	9	1% - 10%	10	<1%	9	<1%
Disp - Filter bags	30	<1%	31	<1%	30	<1%	30	<1%	18	<1%	31	<1%	6	<1%	28	<1%	11	<1%	30	<1%
Disp - Greensand	25	<1%	25	<1%	28	<1%	24	<1%	10	<1%	23	<1%	3	1% - 10%	24	<1%	9	<1%	26	<1%
Disp - POTW for Backwash Water	6	1% - 10%	16	<1%	15	<1%	17	<1%	3	10% - 50%	17	<1%	2	1% - 10%	12	1% - 10%	6	1% - 10%	17	<1%
Disp - Sludge	29	<1%	28	<1%	29	<1%	27	<1%	13	<1%	26	<1%	5	<1%	27	<1%	12	<1%	28	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Blower	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Backwash Pump	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Heater for Well Housing	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Other	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - Boiler & Fuel Tank	1 - 1.2 (SP)	1 - 1.2 (SP)	1 - 1.2 (SW)	5 - 10 (SW)	2 - 5 (SW)
Fuel - Equipment	5 - 10 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Potassium Permanganate	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Carbon Dioxide	2 - 5 (SW)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - Filter Bags	1.2 - 2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Greensand	2 - 5 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - Construct Tray Air Stripper	1.2 - 2 (SW)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Construct Eq Tank and Slab	1 - 1.2 (SP)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - PVC pipe	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Trans - GAC	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Potassium Permanganate	>10 (SW)	>10 (SW)	1.2 - 2 (SP)	>10 (SW)	>10 (SP)
Trans - CO2	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Bag Filters	>10 (SW)	>10 (SW)	1.2 - 2 (SW)	>10 (SW)	5 - 10 (SP)
Trans - Coolers	>10 (SW)	>10 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	5 - 10 (SP)
Trans - Greensand	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Materials/Equip Construct	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Backwash Sludge	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Greensand	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Bag Filters	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - Filter bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	>10 (SW)
Disp - Greensand	1.2 - 2 (SW)	2 - 5 (SP)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - POTW for Backwash Water	>10 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SW)	>10 (SW)
Disp - Sludge	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
Eq = equalization
PVC = polyvinyl chloride
GAC = granular activated carbon
CO2 = carbon dioxide used in treatment system
POTW = publicly owned treatment works
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

CRREL Alt 3

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	3	10% - 50%	3	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%		0	4	10% - 50%	2	10% - 50%	2	10% - 50%
Elec - Transfer Pumps	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%		0	2	10% - 50%	1	10% - 50%	1	10% - 50%
Elec - Heater for Well Housing	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	3	10% - 50%	4	1% - 10%		0	5	1% - 10%	3	10% - 50%	5	1% - 10%
Elec - Other	5	1% - 10%	6	1% - 10%	5	1% - 10%	5	1% - 10%	4	1% - 10%	7	1% - 10%		0	7	1% - 10%	4	1% - 10%	6	1% - 10%
Fuel - Equipment	19	<1%	17	<1%	19	<1%	17	<1%	13	<1%	17	<1%	9	<1%	18	<1%	10	<1%	19	<1%
Mat - GAC	2	10% - 50%	2	10% - 50%	3	10% - 50%	3	10% - 50%		0	3	10% - 50%		0	1	10% - 50%		0	4	1% - 10%
Mat - Filter Bags	12	<1%	12	<1%	11	<1%	11	<1%		0	12	<1%		0	12	<1%		0	12	<1%
Mat - Construct Tanks and Slab	10	<1%	11	<1%	10	<1%	12	<1%		0	11	<1%		0	11	<1%		0	11	<1%
Mat - PVC	17	<1%	16	<1%	16	<1%	16	<1%		0	16	<1%		0	16	<1%		0	15	<1%
Mat - Sequestering Agent	8	<1%	7	1% - 10%	8	<1%	7	1% - 10%		0	9	1% - 10%		0	6	1% - 10%		0	7	<1%
Mat - Biocide	6	1% - 10%	5	1% - 10%	6	1% - 10%	6	1% - 10%		0	5	1% - 10%		0	3	10% - 50%		0	3	1% - 10%
Trans - GAC	9	<1%	9	<1%	9	<1%	9	<1%	6	<1%	8	1% - 10%	3	1% - 10%	10	1% - 10%	8	<1%	9	<1%
Trans - Bag Filters	14	<1%	18	<1%	14	<1%	19	<1%	9	<1%	18	<1%	5	<1%	19	<1%	11	<1%	17	<1%
Trans - Coolers	11	<1%	14	<1%	12	<1%	14	<1%	7	<1%	15	<1%	4	1% - 10%	15	<1%	7	<1%	14	<1%
Trans - Material/Equip Construct	16	<1%	15	<1%	17	<1%	15	<1%	12	<1%	14	<1%	8	<1%	14	<1%	13	<1%	16	<1%
Trans - Chemicals	13	<1%	10	<1%	13	<1%	10	<1%	8	<1%	10	<1%	6	<1%	9	1% - 10%	9	<1%	10	<1%
Trans - Waste Bag Filters	15	<1%	13	<1%	15	<1%	13	<1%	10	<1%	13	<1%	7	<1%	13	<1%	12	<1%	13	<1%
Trans - Personnel	7	1% - 10%	8	1% - 10%	7	<1%	8	1% - 10%	5	<1%	6	1% - 10%	1	50% - 90%	8	1% - 10%	5	<1%	8	<1%
Disp - Filter bags	18	<1%	19	<1%	18	<1%	18	<1%	11	<1%	19	<1%	2	10% - 50%	17	<1%	6	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Heater for Well Housing	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Other	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - Equipment	5 - 10 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Filter Bags	1.2 - 2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Construct Tanks and Slab	1.2 - 2 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Sequestering Agent	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Mat - Biocide	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - GAC	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Bag Filters	>10 (SW)	>10 (SW)	1.2 - 2 (SW)	>10 (SW)	5 - 10 (SP)
Trans - Coolers	>10 (SW)	>10 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	5 - 10 (SP)
Trans - Material/Equip Construct	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Chemicals	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Bag Filters	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - Filter bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
PVC = polyvinyl chloride
GAC = granular activated carbon
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

CRREL Alt 4

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Well Pumps	4	<1%	4	1% - 10%	4	1% - 10%	4	1% - 10%	3	<1%	5	1% - 10%		0	5	1% - 10%	3	<1%	3	10% - 50%
Elec - Heater for Well Housing	6	<1%	6	1% - 10%	6	1% - 10%	6	1% - 10%	5	<1%	8	1% - 10%		0	8	1% - 10%	5	<1%	5	1% - 10%
Elec - Transfer Pumps	4	<1%	5	1% - 10%	4	1% - 10%	5	1% - 10%	3	<1%	6	1% - 10%		0	6	1% - 10%	3	<1%	4	10% - 50%
Elec - Other	3	<1%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	<1%	4	10% - 50%		0	3	1% - 10%	2	1% - 10%	1	10% - 50%
Fuel - Equipment	14	<1%	14	<1%	15	<1%	14	<1%	7	<1%	12	<1%	3	<1%	14	<1%	6	<1%	14	<1%
Mat - GAC	2	1% - 10%	1	10% - 50%	1	10% - 50%	1	10% - 50%		0	1	10% - 50%		0	2	10% - 50%		0	2	10% - 50%
Mat - Sequestering Agent	12	<1%	11	<1%	12	<1%	10	<1%		0	11	<1%		0	10	<1%		0	10	<1%
Mat - Biocide	11	<1%	8	1% - 10%	11	<1%	8	1% - 10%		0	9	1% - 10%		0	7	1% - 10%		0	7	1% - 10%
Mat - Construct Tanks and Slab	8	<1%	10	<1%	8	<1%	11	<1%		0	10	<1%		0	11	<1%		0	11	<1%
Mat - PVC	15	<1%	13	<1%	14	<1%	12	<1%		0	16	<1%		0	13	<1%		0	12	<1%
Trans - GAC	9	<1%	9	1% - 10%	9	<1%	9	<1%	9	<1%	7	1% - 10%	5	<1%	9	<1%	9	<1%	9	<1%
Trans - Coolers	10	<1%	15	<1%	10	<1%	15	<1%	8	<1%	15	<1%	4	<1%	16	<1%	8	<1%	15	<1%
Trans - Chemicals	13	<1%	12	<1%	13	<1%	13	<1%	10	<1%	13	<1%	6	<1%	12	<1%	10	<1%	13	<1%
Trans - Material/Equip Construct	16	<1%	16	<1%	16	<1%	16	<1%	11	<1%	14	<1%	7	<1%	15	<1%	11	<1%	16	<1%
Trans - Personnel	7	<1%	7	1% - 10%	7	1% - 10%	7	1% - 10%	6	<1%	3	10% - 50%	2	<1%	4	1% - 10%	7	<1%	8	1% - 10%
Disp - POTW	1	>90%	3	10% - 50%	3	10% - 50%	3	1% - 10%	1	>90%	2	10% - 50%	1	>90%	1	50% - 90%	1	>90%	6	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Well Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Heater for Well Housing	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Transfer Pumps	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Elec - Other	1 - 1.2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - Equipment	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SP)	2 - 5 (SW)	1.2 - 2 (SW)
Mat - GAC	1 - 1.2 (SP)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Sequestering Agent	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Mat - Biocide	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Mat - Construct Tanks and Slab	1.2 - 2 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - PVC	1 - 1.2 (SP)	1 - 1.2 (SW)	No SW	No SW	No SW
Trans - GAC	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Coolers	>10 (SW)	>10 (SW)	1.2 - 2 (SW)	2 - 5 (SW)	5 - 10 (SP)
Trans - Chemicals	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Material/Equip Construct	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Disp - POTW	>10 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SW)	>10 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
PVC = polyvinyl chloride
GAC = granular activated carbon
POTW = publicly owned treatment works
Trans = transportation
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-2

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Op of ISTT	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%		0	2	1% - 10%	1	>90%	1	>90%
Elec - Pump for Direct Push	17	<1%	17	<1%	17	<1%	17	<1%	12	<1%	17	<1%		0	17	<1%	9	<1%	16	<1%
Fuel - Hollow Stem Auger Drilling	6	<1%	7	<1%	6	<1%	8	<1%	2	10% - 50%	3	1% - 10%	1	10% - 50%	5	<1%	2	1% - 10%	7	<1%
Fuel - Direct Push Drilling	8	<1%	3	1% - 10%	8	<1%	3	1% - 10%	3	10% - 50%	2	10% - 50%	2	10% - 50%	3	1% - 10%	3	1% - 10%	4	<1%
Mat - ISTT Electrodes	4	1% - 10%	5	1% - 10%	3	1% - 10%	5	1% - 10%		0	9	<1%		0	6	<1%		0	5	<1%
Mat - GAC	3	10% - 50%	2	1% - 10%	4	1% - 10%	2	1% - 10%		0	5	1% - 10%		0	4	1% - 10%		0	2	1% - 10%
Mat - Grout	9	<1%	10	<1%	12	<1%	12	<1%		0	12	<1%		0	12	<1%		0	13	<1%
Mat - PVC	13	<1%	13	<1%	13	<1%	13	<1%		0	15	<1%		0	14	<1%		0	12	<1%
Mat - Iron Filings	2	10% - 50%	4	1% - 10%	2	1% - 10%	4	1% - 10%		0	4	1% - 10%		0	1	50% - 90%		0	3	1% - 10%
Trans - Materials ISTT	14	<1%	14	<1%	14	<1%	14	<1%	10	<1%	13	<1%	9	<1%	13	<1%	11	<1%	14	<1%
Trans - Materials MNA	10	<1%	9	<1%	9	<1%	9	<1%	6	<1%	7	1% - 10%	7	1% - 10%	7	<1%	7	<1%	10	<1%
Trans - Materials PRB	12	<1%	12	<1%	11	<1%	11	<1%	9	<1%	6	1% - 10%	8	<1%	10	<1%	10	<1%	9	<1%
Trans - Personnel ISTT	11	<1%	11	<1%	10	<1%	10	<1%	7	<1%	11	<1%	6	1% - 10%	11	<1%	8	<1%	11	<1%
Trans - Personnel MNA	5	1% - 10%	6	<1%	5	<1%	6	<1%	4	<1%	8	1% - 10%	4	1% - 10%	8	<1%	5	<1%	6	<1%
Trans - Personnel PRB	7	<1%	8	<1%	7	<1%	7	<1%	5	<1%	10	<1%	5	1% - 10%	9	<1%	6	<1%	8	<1%
Trans - Waste Soil	15	<1%	15	<1%	15	<1%	15	<1%	11	<1%	14	<1%	10	<1%	15	<1%	12	<1%	15	<1%
Water - Potable for Cement	18	<1%	18	<1%	18	<1%	18	<1%	13	<1%	18	<1%	11	<1%	18	<1%	13	<1%	18	<1%
Disp - Soil	16	<1%	16	<1%	16	<1%	16	<1%	8	<1%	16	<1%	3	10% - 50%	16	<1%	4	<1%	17	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Op of ISTT	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Elec - Pump for Direct Push	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Fuel - Hollow Stem Auger Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - ISTT Electrodes	2 - 5 (SW)	5 - 10 (SW)	No SW	No SW	No SW
Mat - GAC	2 - 5 (SW)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Iron Filings	>10 (SW)	5 - 10 (SW)	No SW	No SW	No SW
Trans - Materials ISTT	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials MNA	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials PRB	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel ISTT	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel PRB	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable for Cement	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
ISTT = in-situ thermal treatment
PVC = polyvinyl chloride
PRB = permeable reactive barrier
MNA = monitored natural attenuation
GAC = granular activated carbon
Trans = transportation
Water - Potable = potable water from a public water source
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-3A

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Op of ISTT	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	10% - 50%		0	2	10% - 50%	1	>90%	1	50% - 90%
Elec - ISCO Pump	18	<1%	18	<1%	18	<1%	18	<1%	14	<1%	18	<1%		0	18	<1%	10	<1%	15	<1%
Fuel - Hollow Stem Drilling	8	<1%	9	<1%	8	<1%	10	<1%	2	10% - 50%	4	1% - 10%	1	10% - 50%	6	1% - 10%	2	1% - 10%	9	<1%
Fuel - Direct Push Drilling	9	<1%	4	1% - 10%	9	<1%	4	1% - 10%	3	10% - 50%	3	10% - 50%	2	10% - 50%	3	1% - 10%	3	1% - 10%	4	<1%
Mat - GAC	2	10% - 50%	3	1% - 10%	4	1% - 10%	3	1% - 10%		0	5	1% - 10%		0	5	1% - 10%		0	3	1% - 10%
Mat - ISTT Electrodes	4	1% - 10%	6	1% - 10%	3	1% - 10%	6	<1%		0	8	<1%		0	8	1% - 10%		0	5	<1%
Mat - PVC	14	<1%	15	<1%	14	<1%	14	<1%		0	16	<1%		0	15	<1%		0	12	<1%
Mat - Grout	11	<1%	11	<1%	12	<1%	13	<1%		0	13	<1%		0	13	<1%		0	14	<1%
Mat - H2O2	3	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	10	<1%	2	10% - 50%	5	1% - 10%	1	50% - 90%	6	<1%	2	10% - 50%
Mat - ISCO iron	5	1% - 10%	10	<1%	5	1% - 10%	8	<1%	9	<1%	11	<1%	4	1% - 10%	7	1% - 10%	5	<1%	7	<1%
Trans - Materials ISTT	15	<1%	14	<1%	15	<1%	15	<1%	12	<1%	14	<1%	11	<1%	14	<1%	13	<1%	16	<1%
Trans - Materials ISCO	6	1% - 10%	5	1% - 10%	6	<1%	5	1% - 10%	4	<1%	6	1% - 10%	8	1% - 10%	4	1% - 10%	9	<1%	6	<1%
Trans - Materials MNA	13	<1%	13	<1%	13	<1%	12	<1%	11	<1%	10	<1%	10	<1%	11	<1%	12	<1%	13	<1%
Trans - Personnel ISTT	12	<1%	12	<1%	11	<1%	11	<1%	7	<1%	12	<1%	9	1% - 10%	12	<1%	11	<1%	11	<1%
Trans - Personnel ISCO	7	1% - 10%	7	<1%	7	<1%	7	<1%	5	<1%	7	<1%	6	1% - 10%	9	<1%	7	<1%	8	<1%
Trans - Personnel MNA	10	<1%	8	<1%	10	<1%	9	<1%	6	<1%	9	<1%	7	1% - 10%	10	<1%	8	<1%	10	<1%
Trans - Waste Soil	16	<1%	16	<1%	16	<1%	16	<1%	13	<1%	15	<1%	12	<1%	16	<1%	14	<1%	17	<1%
Water - Potable for Cement	19	<1%	19	<1%	19	<1%	19	<1%	15	<1%	19	<1%	13	<1%	19	<1%	15	<1%	19	<1%
Disp - Soil	17	<1%	17	<1%	17	<1%	17	<1%	8	<1%	17	<1%	3	10% - 50%	17	<1%	4	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Op of ISTT	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Elec - ISCO Pump	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Fuel - Hollow Stem Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - GAC	2 - 5 (SW)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - ISTT Electrodes	2 - 5 (SW)	5 - 10 (SW)	No SW	No SW	No SW
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - H2O2	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - ISCO iron	5 - 10 (SW)	2 - 5 (SW)	>10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Materials ISTT	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials ISCO	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials MNA	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel ISTT	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel ISCO	1 - 1.2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA	1 - 1.2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable for Cement	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
ISTT = in-situ thermal treatment
ISCO = in-situ chemical oxidation
PVC = polyvinyl chloride
H2O2 = hydrogen peroxide
MNA = monitored natural attenuation
GAC = granular activated carbon
Trans = transportation
Water - Potable = potable water from a public water source
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-3B

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Op of ISTT	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%		0	1	10% - 50%	1	>90%	1	>90%
Elec - Op of BIO Inj Pump	18	<1%	18	<1%	18	<1%	18	<1%	13	<1%	18	<1%		0	18	<1%	10	<1%	17	<1%
Fuel - Hollow Stem Drilling	5	1% - 10%	8	<1%	5	<1%	8	<1%	2	10% - 50%	4	1% - 10%	1	10% - 50%	6	1% - 10%	2	1% - 10%	7	<1%
Fuel - Direct Push Drilling	11	<1%	5	1% - 10%	10	<1%	5	<1%	3	1% - 10%	2	10% - 50%	2	10% - 50%	4	1% - 10%	3	1% - 10%	5	<1%
Mat - GAC	2	10% - 50%	3	1% - 10%	4	1% - 10%	3	1% - 10%		0	5	1% - 10%		0	3	1% - 10%		0	2	1% - 10%
Mat - ISTT Electrodes	3	1% - 10%	4	1% - 10%	3	1% - 10%	6	<1%		0	7	<1%		0	7	1% - 10%		0	4	<1%
Mat - PVC	13	<1%	14	<1%	14	<1%	13	<1%		0	15	<1%		0	14	<1%		0	11	<1%
Mat - Grout	9	<1%	10	<1%	12	<1%	12	<1%		0	12	<1%		0	12	<1%		0	13	<1%
Mat - Veg Oil	4	1% - 10%	2	1% - 10%	2	1% - 10%	2	10% - 50%		0	3	1% - 10%		0	2	10% - 50%		0	3	1% - 10%
Trans - Materials ISTT	15	<1%	13	<1%	15	<1%	14	<1%	11	<1%	13	<1%	10	<1%	13	<1%	12	<1%	15	<1%
Trans - Materials BIO	7	<1%	6	1% - 10%	7	<1%	4	1% - 10%	5	<1%	6	1% - 10%	8	1% - 10%	5	1% - 10%	9	<1%	6	<1%
Trans - Materials MNA	12	<1%	12	<1%	13	<1%	11	<1%	10	<1%	9	<1%	9	<1%	9	1% - 10%	11	<1%	12	<1%
Trans - Personnel ISTT	10	<1%	11	<1%	9	<1%	10	<1%	8	<1%	11	<1%	7	1% - 10%	11	<1%	8	<1%	10	<1%
Trans - Personnel BIO	8	<1%	9	<1%	8	<1%	9	<1%	6	<1%	10	<1%	6	1% - 10%	10	1% - 10%	7	<1%	9	<1%
Trans - Personnel MNA	6	<1%	7	<1%	6	<1%	7	<1%	4	<1%	8	<1%	5	1% - 10%	8	1% - 10%	6	<1%	8	<1%
Trans - Waste Soil	16	<1%	15	<1%	16	<1%	15	<1%	12	<1%	14	<1%	11	<1%	15	<1%	13	<1%	16	<1%
Water - Potable (Cement/Veg Oil)	14	<1%	16	<1%	11	<1%	16	<1%	7	<1%	17	<1%	4	10% - 50%	16	<1%	4	<1%	14	<1%
Disp - Soil	17	<1%	17	<1%	17	<1%	17	<1%	9	<1%	16	<1%	3	10% - 50%	17	<1%	5	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Op of ISTT	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Elec - Op of BIO Inj Pump	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Fuel - Hollow Stem Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - GAC	2 - 5 (SW)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - ISTT Electrodes	2 - 5 (SW)	5 - 10 (SW)	No SW	No SW	No SW
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - Veg Oil	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - Materials ISTT	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials BIO	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Materials MNA	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel ISTT	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel BIO	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA	1 - 1.2 (SP)	1 - 1.2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Cement/Veg Oil)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
ISTT = in-situ thermal treatment
Bio = In-situ bioremediation
PVC = polyvinyl chloride
MNA = monitored natural attenuation
GAC = granular activated carbon
Trans = transportation
Water - Potable = potable water from a public water source
Disp - landfill activities associated with soil disposal
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt G-4

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Pump for Recirc	3	1% - 10%	2	1% - 10%	2	1% - 10%	2	1% - 10%	3	1% - 10%	3	1% - 10%		0	4	1% - 10%	2	1% - 10%	2	1% - 10%
Elec - UV ox	1	50% - 90%	1	>90%	1	>90%	1	>90%	1	50% - 90%	1	50% - 90%		0	2	10% - 50%	1	>90%	1	>90%
Fuel - Hollow Stem Auger Drilling	6	<1%	7	<1%	5	<1%	8	<1%	2	1% - 10%	4	1% - 10%	1	50% - 90%	5	<1%	3	1% - 10%	8	<1%
Fuel - Direct Push Drilling	9	<1%	3	<1%	9	<1%	3	<1%	4	1% - 10%	2	1% - 10%	2	10% - 50%	3	1% - 10%	4	<1%	4	<1%
Mat - PVC	8	<1%	9	<1%	7	<1%	6	<1%		0	11	<1%		0	6	<1%		0	5	<1%
Mat - Grout	4	<1%	4	<1%	8	<1%	10	<1%		0	10	<1%		0	10	<1%		0	9	<1%
Mat - PRB Iron filings	2	1% - 10%	5	<1%	3	1% - 10%	4	<1%		0	5	1% - 10%		0	1	50% - 90%		0	3	<1%
Trans - Materials Recirc	10	<1%	10	<1%	10	<1%	9	<1%	7	<1%	9	<1%	5	1% - 10%	9	<1%	7	<1%	11	<1%
Trans - Materials PRB	11	<1%	11	<1%	11	<1%	11	<1%	8	<1%	7	<1%	6	<1%	11	<1%	8	<1%	10	<1%
Trans - Personnel Recirc	5	<1%	6	<1%	4	<1%	5	<1%	5	<1%	6	<1%	3	1% - 10%	7	<1%	5	<1%	6	<1%
Trans - Personnel PRB	7	<1%	8	<1%	6	<1%	7	<1%	6	<1%	8	<1%	4	1% - 10%	8	<1%	6	<1%	7	<1%
Water - Potable for Cement	12	<1%	12	<1%	12	<1%	12	<1%	9	<1%	12	<1%	7	<1%	12	<1%	9	<1%	12	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Pump for Recirc	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Elec - UV ox	1.2 - 2 (SP)	1.2 - 2 (SW)	2 - 5 (SP)	No SW	>10 (SP)
Fuel - Hollow Stem Auger Drilling	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Direct Push Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	1.2 - 2 (SP)	2 - 5 (SP)
Mat - PVC	1 - 1.2 (SP)	1 - 1.2 (SP)	No SW	No SW	No SW
Mat - Grout	1 - 1.2 (SW)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - PRB Iron filings	>10 (SW)	5 - 10 (SW)	No SW	No SW	No SW
Trans - Materials Recirc	1 - 1.2 (SW)	1 - 1.2 (SP)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Materials PRB	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel Recirc	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel PRB	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Water - Potable for Cement	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
UV ox = UV Oxidation
PVC = polyvinyl chloride
PRB = permeable reactive barrier
Trans = transportation
Recirc = recirculation
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

Alameda Alt S-2

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavator	7	1% - 10%	7	1% - 10%	6	1% - 10%	7	<1%	3	1% - 10%	9	1% - 10%	3	<1%	7	1% - 10%	3	1% - 10%	7	1% - 10%
Fuel - Compactor	8	1% - 10%	8	<1%	8	<1%	8	<1%	5	1% - 10%	6	1% - 10%	5	<1%	8	1% - 10%	5	<1%	8	1% - 10%
Fuel - Dump Truck	9	<1%	9	<1%	9	<1%	9	<1%	6	1% - 10%	8	1% - 10%	6	<1%	9	1% - 10%	6	<1%	9	1% - 10%
Mat - Fill	1	10% - 50%	5	1% - 10%	1	10% - 50%	4	1% - 10%		0	4	1% - 10%		0	4	1% - 10%		0	4	1% - 10%
Trans - Equipment	12	<1%	12	<1%	12	<1%	12	<1%	11	<1%	11	<1%	11	<1%	12	<1%	11	<1%	11	<1%
Trans - Clean Fill	4	10% - 50%	2	10% - 50%	4	1% - 10%	3	10% - 50%	7	1% - 10%	3	10% - 50%	7	<1%	3	10% - 50%	7	<1%	2	10% - 50%
Trans - Samples to Lab	11	<1%	11	<1%	11	<1%	11	<1%	10	<1%	12	<1%	10	<1%	11	<1%	10	<1%	12	<1%
Trans - Personnel	10	<1%	10	<1%	10	<1%	10	<1%	9	<1%	10	<1%	9	<1%	10	<1%	9	<1%	10	<1%
Trans - Waste Soil (Haz)	2	10% - 50%	1	50% - 90%	2	10% - 50%	1	10% - 50%	4	1% - 10%	1	10% - 50%	4	<1%	1	10% - 50%	4	<1%	1	10% - 50%
Trans - Waste Soil (Non-Haz)	6	1% - 10%	4	1% - 10%	7	1% - 10%	6	1% - 10%	8	<1%	7	1% - 10%	8	<1%	6	1% - 10%	8	<1%	5	1% - 10%
Disp - Soil (Haz)	3	10% - 50%	3	10% - 50%	3	10% - 50%	2	10% - 50%	1	50% - 90%	2	10% - 50%	1	50% - 90%	2	10% - 50%	1	50% - 90%	3	10% - 50%
Disp - Soil (Non-Haz)	5	1% - 10%	6	1% - 10%	5	1% - 10%	5	1% - 10%	2	10% - 50%	5	1% - 10%	2	10% - 50%	5	1% - 10%	2	10% - 50%	6	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Excavator	1.2 - 2 (SW)	2 - 5 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	1.2 - 2 (SW)
Fuel - Compactor	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Fuel - Dump Truck	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Mat - Fill	5 - 10 (SW)	5 - 10 (SW)	No SW	No SW	No SW
Trans - Equipment	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Clean Fill	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Samples to Lab	1 - 1.2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Personnel	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil (Haz)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Waste Soil (Non-Haz)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Disp - Soil (Haz)	1 - 1.2 (SW)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)
Disp - Soil (Non-Haz)	1.2 - 2 (SW)	2 - 5 (SP)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
Trans = transportation
Disp - landfill activities associated with soil disposal
Haz = hazardous
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 1

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Pumps	1	10% - 50%	1	50% - 90%	1	50% - 90%	1	50% - 90%	1	50% - 90%	2	10% - 50%		0	1	10% - 50%	1	>90%	1	50% - 90%
Fuel - Field Truck	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	1	50% - 90%	1	50% - 90%	2	10% - 50%	2	<1%	2	1% - 10%
Mat - GAC	3	10% - 50%	4	1% - 10%	4	1% - 10%	3	1% - 10%		0	4	1% - 10%		0	5	1% - 10%		0	3	1% - 10%
Mat - Acetic Acid	5	1% - 10%	5	1% - 10%	5	1% - 10%	4	1% - 10%	12	<1%	6	<1%	8	<1%	4	1% - 10%	8	<1%	6	1% - 10%
Mat - Phosphoric Acid	12	<1%	11	<1%	10	<1%	11	<1%	16	<1%	11	<1%	15	<1%	7	1% - 10%	16	<1%	4	1% - 10%
Mat - Filter bags	15	<1%	13	<1%	15	<1%	12	<1%		0	15	<1%		0	12	<1%		0	12	<1%
Mat - Veg Oil	11	<1%	7	1% - 10%	9	<1%	6	1% - 10%		0	9	<1%		0	8	1% - 10%		0	7	<1%
Trans - GAC	14	<1%	15	<1%	14	<1%	15	<1%	10	<1%	14	<1%	12	<1%	15	<1%	13	<1%	15	<1%
Trans - FBR Acids	6	1% - 10%	8	<1%	6	1% - 10%	8	<1%	6	1% - 10%	5	1% - 10%	5	1% - 10%	10	<1%	7	<1%	9	<1%
Trans - Bag Filters	17	<1%	19	<1%	19	<1%	19	<1%	15	<1%	18	<1%	14	<1%	19	<1%	15	<1%	19	<1%
Trans - Forklift	8	1% - 10%	9	<1%	8	1% - 10%	9	<1%	7	<1%	8	<1%	7	1% - 10%	11	<1%	9	<1%	10	<1%
Trans - Veg Oil	13	<1%	14	<1%	13	<1%	14	<1%	9	<1%	12	<1%	11	<1%	13	<1%	12	<1%	14	<1%
Trans - O&M Samples	9	<1%	12	<1%	12	<1%	13	<1%	3	1% - 10%	13	<1%	9	<1%	17	<1%	3	<1%	13	<1%
Trans - Personnel FBR	4	1% - 10%	3	1% - 10%	3	1% - 10%	5	1% - 10%	4	1% - 10%	3	1% - 10%	2	10% - 50%	3	10% - 50%	4	<1%	5	1% - 10%
Trans - Personnel Biowall	10	<1%	10	<1%	11	<1%	10	<1%	8	<1%	10	<1%	6	1% - 10%	9	1% - 10%	10	<1%	11	<1%
Trans - Personnel Sampling	7	1% - 10%	6	1% - 10%	7	1% - 10%	7	1% - 10%	5	1% - 10%	7	<1%	3	1% - 10%	6	1% - 10%	5	<1%	8	<1%
Trans - Waste Bag Filters	16	<1%	16	<1%	16	<1%	17	<1%	13	<1%	17	<1%	13	<1%	18	<1%	14	<1%	17	<1%
Water - Potable (Veg Oil Inject)	19	<1%	18	<1%	18	<1%	18	<1%	14	<1%	19	<1%	10	<1%	16	<1%	11	<1%	16	<1%
Disp - Filter Bags	18	<1%	17	<1%	17	<1%	16	<1%	11	<1%	16	<1%	4	1% - 10%	14	<1%	6	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Pumps	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - Field Truck	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - GAC	2 - 5 (SW)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Acetic Acid	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Phosphoric Acid	1.2 - 2 (SW)	2 - 5 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Filter bags	1.2 - 2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Veg Oil	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - GAC	>10 (SW)	>10 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	>10 (SP)
Trans - FBR Acids	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Bag Filters	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Trans - Forklift	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Veg Oil	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel FBR	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Bag Filters	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Filter Bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
GAC = granular Activated Carbon
FBR = fluidized Bed Reactor
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 2

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Pumps	2	10% - 50%	1	10% - 50%	1	10% - 50%	1	50% - 90%	1	50% - 90%	2	10% - 50%		0	2	10% - 50%	1	>90%	1	50% - 90%
Fuel - Field Truck	1	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	1	50% - 90%	1	50% - 90%	1	10% - 50%	2	<1%	2	10% - 50%
Mat - GAC	3	10% - 50%	3	1% - 10%	3	1% - 10%	3	1% - 10%		0	3	1% - 10%		0	4	1% - 10%		0	3	1% - 10%
Mat - Acetic Acid	8	1% - 10%	6	1% - 10%	5	1% - 10%	5	1% - 10%	14	<1%	9	<1%	9	<1%	6	1% - 10%	11	<1%	6	1% - 10%
Mat - Phosphoric Acid	14	<1%	11	<1%	11	<1%	11	<1%	16	<1%	11	<1%	15	<1%	8	1% - 10%	16	<1%	4	1% - 10%
Mat - Filter bags	16	<1%	14	<1%	15	<1%	12	<1%		0	15	<1%		0	13	<1%		0	12	<1%
Mat - Veg Oil	11	<1%	5	1% - 10%	9	1% - 10%	4	1% - 10%		0	6	<1%		0	5	1% - 10%		0	7	<1%
Trans - GAC	13	<1%	15	<1%	13	<1%	15	<1%	10	<1%	14	<1%	12	<1%	15	<1%	13	<1%	15	<1%
Trans - FBR Acids	5	1% - 10%	10	<1%	6	1% - 10%	10	<1%	5	1% - 10%	7	<1%	5	1% - 10%	11	<1%	7	<1%	11	<1%
Trans - Bag Filters	18	<1%	19	<1%	19	<1%	19	<1%	15	<1%	19	<1%	14	<1%	19	<1%	15	<1%	19	<1%
Trans - Forklift	6	1% - 10%	8	<1%	7	1% - 10%	8	<1%	7	1% - 10%	5	<1%	7	1% - 10%	10	<1%	8	<1%	9	<1%
Trans - Veg Oil	12	<1%	12	<1%	12	<1%	13	<1%	9	<1%	12	<1%	11	<1%	12	<1%	12	<1%	13	<1%
Trans - O&M Samples	10	<1%	13	<1%	14	<1%	14	<1%	3	1% - 10%	13	<1%	10	<1%	18	<1%	3	<1%	14	<1%
Trans - Personnel FBR	4	1% - 10%	4	1% - 10%	4	1% - 10%	6	1% - 10%	4	1% - 10%	4	1% - 10%	2	10% - 50%	3	10% - 50%	4	<1%	5	1% - 10%
Trans - Personnel Biowall	9	<1%	9	<1%	10	<1%	9	<1%	8	<1%	10	<1%	6	1% - 10%	9	1% - 10%	9	<1%	10	<1%
Trans - Personnel Sampling	7	1% - 10%	7	1% - 10%	8	1% - 10%	7	1% - 10%	6	1% - 10%	8	<1%	4	1% - 10%	7	1% - 10%	6	<1%	8	<1%
Trans - Waste Bag Filters	15	<1%	16	<1%	16	<1%	17	<1%	12	<1%	17	<1%	13	<1%	17	<1%	14	<1%	17	<1%
Water - Potable (Veg Oil Inject)	19	<1%	18	<1%	18	<1%	18	<1%	13	<1%	18	<1%	8	<1%	16	<1%	10	<1%	16	<1%
Disp - Filter Bags	17	<1%	17	<1%	17	<1%	16	<1%	11	<1%	16	<1%	3	1% - 10%	14	<1%	5	<1%	18	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Pumps	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - Field Truck	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - GAC	2 - 5 (SW)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - Acetic Acid	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Phosphoric Acid	1.2 - 2 (SW)	2 - 5 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Filter bags	1.2 - 2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Veg Oil	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - GAC	>10 (SW)	>10 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	>10 (SP)
Trans - FBR Acids	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1 - 1.2 (SW)	>10 (SP)
Trans - Bag Filters	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Trans - Forklift	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Veg Oil	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel FBR	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Bag Filters	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Filter Bags	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
GAC = granular Activated Carbon
FBR = fluidized Bed Reactor
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 3

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Alt 3	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	1	50% - 90%	2	10% - 50%		0	2	10% - 50%	1	>90%	1	50% - 90%
Fuel - Equip for Demo (Diesel)	17	<1%	14	<1%	17	<1%	15	<1%	6	1% - 10%	9	<1%	6	1% - 10%	14	<1%	9	<1%	13	<1%
Fuel - Field Truck (Gasoline)	3	10% - 50%	3	10% - 50%	3	1% - 10%	3	10% - 50%	2	10% - 50%	1	50% - 90%	2	10% - 50%	3	10% - 50%	4	<1%	3	1% - 10%
Mat - Sand Filter	9	<1%	10	1% - 10%	9	<1%	11	<1%		0	13	<1%		0	11	1% - 10%		0	9	<1%
Mat - Sand	20	<1%	18	<1%	19	<1%	18	<1%		0	20	<1%		0	18	<1%		0	16	<1%
Mat - Resin	1	50% - 90%	2	10% - 50%	1	50% - 90%	2	10% - 50%		0	3	10% - 50%		0	1	10% - 50%		0	2	10% - 50%
Mat - IX Vessel (Steel)	6	1% - 10%	9	1% - 10%	6	1% - 10%	9	<1%		0	15	<1%		0	16	<1%		0	8	<1%
Mat - Slab IX Vessel (Steel/Concrete)	15	<1%	8	1% - 10%	16	<1%	12	<1%		0	10	<1%		0	9	1% - 10%		0	12	<1%
Mat - Veg Oil	11	<1%	7	1% - 10%	8	<1%	4	1% - 10%		0	7	1% - 10%		0	7	1% - 10%		0	5	<1%
Trans - Sand	18	<1%	16	<1%	18	<1%	16	<1%	14	<1%	18	<1%	14	<1%	15	<1%	15	<1%	18	<1%
Trans - Construct Materials/Equip	12	<1%	11	<1%	12	<1%	8	<1%	10	<1%	8	<1%	11	<1%	8	1% - 10%	12	<1%	11	<1%
Trans - Resin	5	1% - 10%	5	1% - 10%	5	1% - 10%	6	1% - 10%	7	1% - 10%	5	1% - 10%	7	1% - 10%	5	1% - 10%	8	<1%	7	<1%
Trans - Veg Oil	13	<1%	19	<1%	13	<1%	19	<1%	11	<1%	16	<1%	12	<1%	19	<1%	13	<1%	19	<1%
Trans - O&M Samples	8	<1%	17	<1%	11	<1%	17	<1%	3	1% - 10%	17	<1%	9	<1%	21	<1%	3	<1%	17	<1%
Trans - Personnel O&M Sampling	7	1% - 10%	6	1% - 10%	7	1% - 10%	7	1% - 10%	8	1% - 10%	6	1% - 10%	5	1% - 10%	6	1% - 10%	7	<1%	6	<1%
Trans - Personnel Biowall	10	<1%	12	<1%	10	<1%	10	<1%	9	<1%	11	<1%	8	<1%	10	1% - 10%	10	<1%	10	<1%
Trans - Personnel EX/IX	4	1% - 10%	4	1% - 10%	4	1% - 10%	5	1% - 10%	4	1% - 10%	4	1% - 10%	3	1% - 10%	4	1% - 10%	5	<1%	4	1% - 10%
Trans - Waste (Sand/Resin/Sludge)	14	<1%	13	<1%	14	<1%	14	<1%	13	<1%	12	<1%	13	<1%	12	<1%	14	<1%	14	<1%
Water - Potable (Veg Oil Inject)	21	<1%	21	<1%	20	<1%	21	<1%	15	<1%	21	<1%	10	<1%	20	<1%	11	<1%	21	<1%
Disp - Sand/Resin	16	<1%	15	<1%	15	<1%	13	<1%	5	1% - 10%	14	<1%	1	50% - 90%	13	<1%	2	1% - 10%	15	<1%
Disp - Sludge	19	<1%	20	<1%	21	<1%	20	<1%	12	<1%	19	<1%	4	1% - 10%	17	<1%	6	<1%	20	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Alt 3	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - Equip for Demo (Diesel)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Fuel - Field Truck (Gasoline)	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - Sand Filter	1 - 1.2 (SP)	1.2 - 2 (SW)	No SW	No SW	No SW
Mat - Sand	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Mat - Resin	2 - 5 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - IX Vessel (Steel)	2 - 5 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - Slab IX Vessel (Steel/Concrete)	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Mat - Veg Oil	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - Sand	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Construct Materials/Equip	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Resin	1.2 - 2 (SW)	1.2 - 2 (SW)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Veg Oil	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel O&M Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel EX/IX	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste (Sand/Resin/Sludge)	1.2 - 2 (SW)	1.2 - 2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Sand/Resin	1.2 - 2 (SW)	1.2 - 2 (SP)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)
Disp - Sludge	1 - 1.2 (SW)	2 - 5 (SP)	1.2 - 2 (SP)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
IX = ion Exchanage
EX - excavation
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 4

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Alt 4	1	10% - 50%	1	10% - 50%	1	10% - 50%	1	50% - 90%	1	10% - 50%	2	10% - 50%		0	2	10% - 50%	1	50% - 90%	1	50% - 90%
Fuel - FBR Demo	20	<1%	19	<1%	20	<1%	19	<1%	9	<1%	16	<1%	8	<1%	18	<1%	14	<1%	19	<1%
Fuel - GBR Excavator	22	<1%	21	<1%	22	<1%	21	<1%	15	<1%	21	<1%	16	<1%	19	<1%	10	<1%	22	<1%
Fuel - Field Truck (Gasoline)	2	10% - 50%	2	10% - 50%	2	10% - 50%	2	10% - 50%	3	10% - 50%	1	50% - 90%	2	1% - 10%	1	10% - 50%	4	<1%	2	1% - 10%
Mat - GBR Construction Concrete	12	1% - 10%	3	1% - 10%	15	<1%	9	1% - 10%		0	9	1% - 10%		0	9	1% - 10%		0	9	<1%
Mat - Gravel Fill	5	1% - 10%	14	<1%	5	1% - 10%	12	<1%		0	13	<1%		0	10	1% - 10%		0	14	<1%
Mat - AceticAcid	4	1% - 10%	4	1% - 10%	3	1% - 10%	3	1% - 10%	17	<1%	7	1% - 10%	10	<1%	4	1% - 10%	8	<1%	4	1% - 10%
Mat - Phosphoric Acid	16	<1%	15	<1%	12	1% - 10%	15	<1%	19	<1%	15	<1%	18	<1%	8	1% - 10%	19	<1%	3	1% - 10%
Mat - Veg Oil	14	<1%	8	1% - 10%	11	1% - 10%	4	1% - 10%		0	11	1% - 10%		0	11	1% - 10%		0	6	1% - 10%
Trans - Gravel	10	1% - 10%	6	1% - 10%	10	1% - 10%	6	1% - 10%	10	<1%	4	1% - 10%	9	<1%	5	1% - 10%	13	<1%	8	<1%
Trans - GBR Heavy Equip	18	<1%	16	<1%	18	<1%	16	<1%	14	<1%	17	<1%	15	<1%	16	<1%	17	<1%	16	<1%
Trans - GBR Cement	19	<1%	17	<1%	19	<1%	17	<1%	16	<1%	18	<1%	17	<1%	17	<1%	18	<1%	17	<1%
Trans - Forklift	9	1% - 10%	12	1% - 10%	9	1% - 10%	13	<1%	8	1% - 10%	10	1% - 10%	7	<1%	15	<1%	9	<1%	13	<1%
Trans - Acids	6	1% - 10%	10	1% - 10%	7	1% - 10%	11	1% - 10%	7	1% - 10%	6	1% - 10%	5	<1%	14	1% - 10%	7	<1%	11	<1%
Trans - Veg Oil	17	<1%	20	<1%	17	<1%	20	<1%	13	<1%	19	<1%	14	<1%	20	<1%	16	<1%	20	<1%
Trans - O&M Samples	11	1% - 10%	18	<1%	14	<1%	18	<1%	4	1% - 10%	20	<1%	11	<1%	22	<1%	3	<1%	18	<1%
Trans - Personnel O&M Sampling	7	1% - 10%	7	1% - 10%	8	1% - 10%	7	1% - 10%	6	1% - 10%	8	1% - 10%	4	<1%	7	1% - 10%	6	<1%	7	1% - 10%
Trans - Personnel Biowall	13	1% - 10%	13	<1%	13	<1%	14	<1%	11	<1%	14	<1%	6	<1%	13	1% - 10%	11	<1%	15	<1%
Trans - Personnel EX/GBR	3	1% - 10%	5	1% - 10%	4	1% - 10%	5	1% - 10%	5	1% - 10%	5	1% - 10%	3	<1%	3	1% - 10%	5	<1%	5	1% - 10%
Trans - Waste (Gravel)	15	<1%	11	1% - 10%	16	<1%	10	1% - 10%	12	<1%	12	1% - 10%	13	<1%	12	1% - 10%	15	<1%	12	<1%
Water - Potable (Veg Oil Inject)	21	<1%	22	<1%	21	<1%	22	<1%	18	<1%	22	<1%	12	<1%	21	<1%	12	<1%	21	<1%
Disp - Gravel	8	1% - 10%	9	1% - 10%	6	1% - 10%	8	1% - 10%	2	10% - 50%	3	1% - 10%	1	>90%	6	1% - 10%	2	10% - 50%	10	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Alt 4	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - FBR Demo	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Fuel - GBR Excavator	1 - 1.2 (SP)	1 - 1.2 (SW)	2 - 5 (SP)	2 - 5 (SP)	1 - 1.2 (SP)
Fuel - Field Truck (Gasoline)	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - GBR Construction Concrete	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Mat - Gravel Fill	5 - 10 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - AceticAcid	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Phosphoric Acid	1.2 - 2 (SW)	2 - 5 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Mat - Veg Oil	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - Gravel	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - GBR Heavy Equip	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - GBR Cement	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Forklift	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Acids	2 - 5 (SW)	2 - 5 (SW)	5 - 10 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Veg Oil	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel O&M Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Biowall	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel EX/GBR	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste (Gravel)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Gravel	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
FBR = fluidized Bed Reactor
GBR = gravel Bed Reactor
EX - excavation
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading,
Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 5

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Elec - Alt 5	1	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	1	10% - 50%	2	10% - 50%		0	4	10% - 50%	1	>90%	1	50% - 90%
Fuel - FBR Demo	15	<1%	15	<1%	16	<1%	15	<1%	8	1% - 10%	13	<1%	6	1% - 10%	13	<1%	9	<1%	15	<1%
Fuel - Wetlands Construct Equip	10	1% - 10%	6	1% - 10%	10	1% - 10%	9	1% - 10%	2	10% - 50%	4	1% - 10%	2	10% - 50%	5	1% - 10%	2	1% - 10%	10	1% - 10%
Fuel - Field Truck (Gasoline)	3	10% - 50%	2	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	1	50% - 90%	1	10% - 50%	3	10% - 50%	4	<1%	2	1% - 10%
Mat - Gravel	5	1% - 10%	11	1% - 10%	4	1% - 10%	11	1% - 10%		0	8	1% - 10%		0	8	1% - 10%		0	11	<1%
Mat - Sand/Mulch	2	10% - 50%	7	1% - 10%	1	10% - 50%	2	10% - 50%		0	5	1% - 10%		0	2	10% - 50%		0	7	1% - 10%
Mat - PVC Liner	8	1% - 10%	9	1% - 10%	7	1% - 10%	8	1% - 10%		0	10	<1%		0	9	1% - 10%		0	5	1% - 10%
Mat - PVC Pipe	9	1% - 10%	10	1% - 10%	8	1% - 10%	10	1% - 10%		0	11	<1%		0	10	1% - 10%		0	8	1% - 10%
Trans - Veg Oil	12	<1%	8	1% - 10%	11	<1%	5	1% - 10%		0	9	<1%		0	11	1% - 10%		0	9	1% - 10%
Trans - Gravel	7	1% - 10%	4	1% - 10%	9	1% - 10%	6	1% - 10%	7	1% - 10%	6	1% - 10%	5	1% - 10%	6	1% - 10%	7	<1%	6	1% - 10%
Trans - Sand/Mulch	4	1% - 10%	3	10% - 50%	5	1% - 10%	4	1% - 10%	5	1% - 10%	3	1% - 10%	4	1% - 10%	1	10% - 50%	6	<1%	3	1% - 10%
Trans - Heavy Equip	16	<1%	13	<1%	15	<1%	13	<1%	11	<1%	16	<1%	11	<1%	14	<1%	12	<1%	13	<1%
Trans - Veg Oil	13	<1%	16	<1%	13	<1%	16	<1%	10	<1%	14	<1%	10	<1%	15	<1%	10	<1%	16	<1%
Trans - O&M Samples	11	1% - 10%	14	<1%	12	<1%	14	<1%	4	1% - 10%	15	<1%	7	1% - 10%	17	<1%	3	<1%	14	<1%
Trans - Personnel for Construction	14	<1%	12	<1%	14	<1%	12	<1%	9	<1%	12	<1%	8	1% - 10%	12	1% - 10%	11	<1%	12	<1%
Trans - Personnel O&M/Sampling	6	1% - 10%	5	1% - 10%	6	1% - 10%	7	1% - 10%	6	1% - 10%	7	1% - 10%	3	10% - 50%	7	1% - 10%	5	<1%	4	1% - 10%
Water - Potable (Veg Oil Inject)	17	<1%	17	<1%	17	<1%	17	<1%	12	<1%	17	<1%	9	<1%	16	<1%	8	<1%	17	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Elec - Alt 5	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	No SW	2 - 5 (SP)
Fuel - FBR Demo	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Fuel - Wetlands Construct Equip	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	2 - 5 (SP)	1.2 - 2 (SP)
Fuel - Field Truck (Gasoline)	1 - 1.2 (SW)	1 - 1.2 (SP)	>10 (SP)	1.2 - 2 (SP)	>10 (SP)
Mat - Gravel	5 - 10 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - Sand/Mulch	>10 (SW)	1 - 1.2 (SP)	No SW	No SW	No SW
Mat - PVC Liner	1 - 1.2 (SP)	1 - 1.2 (SP)	No SW	No SW	No SW
Mat - PVC Pipe	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Trans - Veg Oil	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - Gravel	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Sand/Mulch	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Heavy Equip	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Veg Oil	5 - 10 (SW)	5 - 10 (SW)	2 - 5 (SP)	1.2 - 2 (SW)	>10 (SP)
Trans - O&M Samples	>10 (SW)	5 - 10 (SW)	5 - 10 (SW)	>10 (SW)	2 - 5 (SW)
Trans - Personnel for Construction	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Trans - Personnel O&M/Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)

Definitions

CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Elec = electricity Use
Fuel = fuel use for on-site equipment use
Mat = materials production for specified material
PVC = polyvinyl chloride
Trans = transportation
Water - Potable = potable water from a public water source
SP = SimaPro
SW = SiteWise
Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger
No SW = SiteWise does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.

Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro
Blue shading - SimaPro result higher than SiteWise
"No SW" - Not calculated in SiteWise

NWIRP Alt 6

SiteWise (Version 2) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2e				Energy				NOx				PM				SOx			
	SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro		SiteWise		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Air Rotary Drill	12	1% - 10%	9	1% - 10%	12	1% - 10%	12	<1%	3	1% - 10%	7	1% - 10%	3	<1%	9	1% - 10%	3	1% - 10%	10	1% - 10%
Fuel - Contruction Equipment	1	10% - 50%	2	10% - 50%	4	10% - 50%	3	10% - 50%	1	50% - 90%	1	10% - 50%	2	1% - 10%	1	10% - 50%	2	10% - 50%	2	10% - 50%
Mat - Mushroon Compost	4	10% - 50%	4	10% - 50%	2	10% - 50%	11	<1%		0	8	1% - 10%		0	11	1% - 10%		0	11	<1%
Mat - Limestone	7	1% - 10%	11	1% - 10%	7	1% - 10%	9	1% - 10%		0	10	1% - 10%		0	7	1% - 10%		0	7	1% - 10%
Mat - Wood Chips	4	10% - 50%	13	<1%	2	10% - 50%	2	10% - 50%		0	12	<1%		0	10	1% - 10%		0	12	<1%
Mat - PVC	14	<1%	14	<1%	14	<1%	14	<1%		0	14	<1%		0	14	<1%		0	14	<1%
Mat - Veg Oil	2	10% - 50%	1	10% - 50%	1	10% - 50%	1	10% - 50%		0	3	1% - 10%		0	2	10% - 50%		0	1	10% - 50%
Trans - Mushroom	10	1% - 10%	8	1% - 10%	10	1% - 10%	8	1% - 10%	7	<1%	9	1% - 10%	9	<1%	8	1% - 10%	9	<1%	8	1% - 10%
Trans - Limestone	9	1% - 10%	6	1% - 10%	9	1% - 10%	6	1% - 10%	6	<1%	5	1% - 10%	8	<1%	5	1% - 10%	8	<1%	5	1% - 10%
Trans - Wood Chips	8	1% - 10%	7	1% - 10%	8	1% - 10%	7	1% - 10%	5	<1%	6	1% - 10%	7	<1%	6	1% - 10%	6	<1%	6	1% - 10%
Trans - Veg Oil	13	<1%	12	<1%	13	<1%	13	<1%	10	<1%	11	<1%	10	<1%	13	<1%	10	<1%	13	<1%
Trans - Personnel Construction	16	<1%	16	<1%	16	<1%	16	<1%	11	<1%	16	<1%	11	<1%	16	<1%	11	<1%	16	<1%
Trans - Personnel Sampling	11	1% - 10%	10	1% - 10%	11	1% - 10%	10	<1%	8	<1%	13	<1%	6	<1%	12	1% - 10%	7	<1%	9	1% - 10%
Trans - Waste Soil Cuttings	3	10% - 50%	3	10% - 50%	6	1% - 10%	4	1% - 10%	4	1% - 10%	2	10% - 50%	5	<1%	3	10% - 50%	5	<1%	3	10% - 50%
Water - Potable (Veg Oil Inject)	15	<1%	15	<1%	15	<1%	15	<1%	9	<1%	15	<1%	4	<1%	15	<1%	4	<1%	15	<1%
Disp - Soil Cuttings	6	1% - 10%	5	1% - 10%	5	10% - 50%	5	1% - 10%	2	10% - 50%	4	1% - 10%	1	>90%	4	10% - 50%	1	50% - 90%	4	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Air Rotary Drill	1.2 - 2 (SW)	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SW)	1 - 1.2 (SW)
Fuel - Contruction Equipment	1 - 1.2 (SW)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SW)	5 - 10 (SP)
Mat - Mushroon Compost	1.2 - 2 (SP)	>10 (SW)	No SW	No SW	No SW
Mat - Limestone	5 - 10 (SW)	2 - 5 (SW)	No SW	No SW	No SW
Mat - Wood Chips	>10 (SW)	1.2 - 2 (SP)	No SW	No SW	No SW
Mat - PVC	1 - 1.2 (SW)	1 - 1.2 (SW)	No SW	No SW	No SW
Mat - Veg Oil	2 - 5 (SP)	2 - 5 (SP)	No SW	No SW	No SW
Trans - Mushroom	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Limestone	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Wood Chips	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Veg Oil	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel Construction	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel Sampling	1.2 - 2 (SW)	1 - 1.2 (SW)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Waste Soil Cuttings	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Water - Potable (Veg Oil Inject)	1.2 - 2 (SW)	2 - 5 (SW)	1.2 - 2 (SW)	>10 (SW)	1.2 - 2 (SP)
Disp - Soil Cuttings	1.2 - 2 (SW)	1.2 - 2 (SW)	1 - 1.2 (SW)	>10 (SW)	2 - 5 (SW)

Definitions

CO2e = carbon dioxide equivalents

NOx = nitrogen oxides

PM = particulate matter less than 10 microns

SOx = sulfur oxides

Rank = rank of footprint contributor relative to other footprint contributors for a particular metric

Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor

Fuel = fuel use for on-site equipment use

Mat = materials production for specified material

PVC = polyvinyl chloride

Trans = transportation

Disp - Soil (landfill) = landfill activities associated with soil disposal

Water - Potable = potable water from a public water source

SP = SimaPro

SW = SiteWise

Result Ratio = ratio of SW result to SP result or ratio of SP result to SW result, which ever is larger

No SW = SiteWise does not provide a value for comparison to SP

No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SW result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.

Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SW result is 2.5 times higher than the SP result, the entry would indicate "2-5 (SW)" with orange shading, indicating

Orange shading - SiteWise result higher than SimaPro

Blue shading - SimaPro result higher than SiteWise

"No SW" - Not calculated in SiteWise

APPENDIX E:

Results by Remedy Components – SRT™ Version 2.3 versus SimaPro®

Beale Alt 2

SRT (Version 2.3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavation/Backfill Equip	2	10% - 50%	7	1% - 10%	3	10% - 50%	7	1% - 10%	2	10% - 50%	5	1% - 10%	2	10% - 50%	4	1% - 10%	4	1% - 10%	7	1% - 10%
Fuel - Drilling	6	1% - 10%	8	1% - 10%	7	1% - 10%	8	1% - 10%	6	1% - 10%	4	1% - 10%	7	<1%	6	1% - 10%	7	<1%	9	1% - 10%
Mat - Mulch/gravel		0		0		0		0		0		0		0		0		0		0
Mat - Solar Panels		0	10	<1%		0	11	<1%		0	12	<1%		0	11	<1%		0	11	<1%
Mat - PVC for wells	7	1% - 10%	9	1% - 10%	6	1% - 10%	9	1% - 10%	7	<1%	9	<1%	6	<1%	9	1% - 10%	1	50% - 90%	8	1% - 10%
Trans - Excavation/Backfill Equip	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	50% - 90%	2	10% - 50%	2	1% - 10%	2	10% - 50%
Trans - Solar Panels		0	13	<1%		0	13	<1%		0	13	<1%		0	13	<1%		0	13	<1%
Trans - MNA samples		0	5	1% - 10%		0	5	1% - 10%		0	6	1% - 10%		0	8	1% - 10%		0	6	1% - 10%
Trans - Drill Rig		0	12	<1%		0	12	<1%		0	10	<1%		0	12	<1%		0	12	<1%
Trans - Personnel Construction	5	10% - 50%	6	1% - 10%	5	10% - 50%	6	1% - 10%	5	1% - 10%	8	1% - 10%	5	1% - 10%	7	1% - 10%	6	1% - 10%	5	1% - 10%
Trans - Personnel MNA/LUC	3	10% - 50%	4	1% - 10%	2	10% - 50%	4	1% - 10%	4	1% - 10%	7	1% - 10%	4	1% - 10%	5	1% - 10%	3	1% - 10%	3	10% - 50%
Trans - Disposal	4	10% - 50%	3	10% - 50%	4	10% - 50%	3	1% - 10%	3	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	5	1% - 10%	4	1% - 10%
Water - Non-Potable		0		0		0		0		0		0		0		0		0		0
Disp - Soil (Landfill)		0	1	10% - 50%		0	1	50% - 90%		0	1	10% - 50%		0	1	10% - 50%		0	1	10% - 50%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2	Energy	NOx	PM	SOx
Fuel - Excavation/Backfill Equip	2 - 5 (SRT)	1.2 - 2 (SRT)	2 - 5 (SRT)	1 - 1.2 (SRT)	>10 (SP)
Fuel - Drilling	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)
Mat - Mulch/gravel	No Footprint	No Footprint	No Footprint	No Footprint	No Footprint
Mat - Solar Panels	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - PVC for wells	1.2 - 2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Trans - Excavation/Backfill Equip	2 - 5 (SRT)	1.2 - 2 (SRT)	2 - 5 (SRT)	1.2 - 2 (SRT)	>10 (SP)
Trans - Solar Panels	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - MNA samples	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Drill Rig	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel Construction	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1 - 1.2 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA/LUC	1.2 - 2 (SRT)	1 - 1.2 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Disposal	1 - 1.2 (SP)	1.2 - 2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)
Water - Non-Potable	No Footprint	No Footprint	No Footprint	No Footprint	No Footprint
Disp - Soil (Landfill)	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified ı
PVC = polyvinyl chloride
Trans = transportation
MNA/LUC = monitored natural attenuation / land-use controls
Disp - Soil (landfill) = landfill activi
Water - Non-potable = water from non-potable source
Water - Potable = potable water from a public water source
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP
No Footprint = It is assumed for both tools that there is not footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.

Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

SRT v2.3 accounts for landfill activities by increasing the fuel consumption rate for on-site equipment for excavation. As a result, the "fuel" categories are high for SRT and the soil disposal category is listed as "No SRT".

Beale Alt 3

SRT (Version 2.3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavation/Backfill Equip	5	1% - 10%	10	1% - 10%	6	1% - 10%	10	1% - 10%	3	10% - 50%	6	1% - 10%	3	1% - 10%	7	1% - 10%	6	<1%	10	1% - 10%
Fuel - Drilling	4	10% - 50%	4	10% - 50%	5	10% - 50%	6	1% - 10%	5	1% - 10%	1	10% - 50%	5	1% - 10%	4	1% - 10%	5	<1%	6	1% - 10%
Mat - Backfill		0	6	1% - 10%		0	4	1% - 10%		0	4	1% - 10%		0	3	10% - 50%		0	5	1% - 10%
Mat - Oxidant	2	10% - 50%	3	10% - 50%	1	10% - 50%	3	10% - 50%	2	10% - 50%	7	1% - 10%	1	50% - 90%	5	1% - 10%	1	50% - 90%	1	10% - 50%
Mat - PVC for wells	7	1% - 10%	8	1% - 10%	4	10% - 50%	7	1% - 10%	7	1% - 10%	11	1% - 10%	7	<1%	9	1% - 10%	2	10% - 50%	4	10% - 50%
Trans - Excavation/Backfill Equip	1	10% - 50%	1	10% - 50%	2	10% - 50%	2	10% - 50%	1	10% - 50%	3	10% - 50%	2	10% - 50%	2	10% - 50%	4	<1%	3	10% - 50%
Trans - Oxidant	8	<1%	11	1% - 10%	8	<1%	11	1% - 10%	8	1% - 10%	9	1% - 10%	8	<1%	10	1% - 10%	8	<1%	11	1% - 10%
Trans - Samples		0	9	1% - 10%		0	9	1% - 10%		0	10	1% - 10%		0	11	<1%		0	9	1% - 10%
Trans - Drill Rig		0	13	<1%		0	13	<1%		0	12	<1%		0	13	<1%		0	13	<1%
Trans - Personnel	3	10% - 50%	5	1% - 10%	3	10% - 50%	5	1% - 10%	6	1% - 10%	8	1% - 10%	6	1% - 10%	8	1% - 10%	3	<1%	7	1% - 10%
Trans - Disposal	6	1% - 10%	7	1% - 10%	7	1% - 10%	8	1% - 10%	4	10% - 50%	5	1% - 10%	4	1% - 10%	6	1% - 10%	7	<1%	8	1% - 10%
Water - Non-Potable		0	12	<1%		0	12	<1%		0	13	<1%		0	12	<1%		0	12	<1%
Disp - Soil (Landfill)		0	2	10% - 50%		0	1	10% - 50%		0	2	10% - 50%		0	1	10% - 50%		0	2	10% - 50%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2	Energy	NOx	PM	SOx
Fuel - Excavation/Backfill Equip	2 - 5 (SRT)	1.2 - 2 (SRT)	2 - 5 (SRT)	1 - 1.2 (SRT)	>10 (SP)
Fuel - Drilling	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Mat - Backfill	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - Oxidant	1 - 1.2 (SRT)	1 - 1.2 (SRT)	2 - 5 (SRT)	5 - 10 (SRT)	2 - 5 (SRT)
Mat - PVC for wells	1.2 - 2 (SP)	1 - 1.2 (SRT)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Trans - Excavation/Backfill Equip	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Oxidant	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Samples	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Drill Rig	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Disposal	1 - 1.2 (SP)	1.2 - 2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)
Water - Non-Potable	No SRT	No SRT	No SRT	No SRT	No SRT
Disp - Soil (Landfill)	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
PVC = polyvinyl chloride
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Non-potable = water from a non-potable source
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading,
Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

SRT accounts for landfill activities by increasing the fuel consumption rate for on-site equipment for excavation. As a result, the "fuel" categories are high for SRT and the soil disposal category is listed as "No SRT".

Little Rock

SRT (Version 2.3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavation/Fill	2	10% - 50%	7	1% - 10%	2	10% - 50%	7	1% - 10%	2	10% - 50%	6	1% - 10%	2	10% - 50%	6	1% - 10%	2	10% - 50%	6	1% - 10%
Fuel - Dust Control		0	5	1% - 10%		0	5	1% - 10%		0	5	1% - 10%		0	5	1% - 10%		0	5	1% - 10%
Fuel - Soil Stabilization		0	10	<1%		0	10	<1%		0	9	<1%		0	8	<1%		0	10	<1%
Fuel - Other		0	11	<1%		0	11	<1%		0	10	<1%		0	12	<1%		0	11	<1%
Mat - Cement		0	1	10% - 50%		0	3	10% - 50%		0	4	10% - 50%		0	3	10% - 50%		0	2	10% - 50%
Trans - Clean Fill	1	10% - 50%	3	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	3	10% - 50%
Trans - Cement		0	6	1% - 10%		0	6	1% - 10%		0	7	1% - 10%		0	7	1% - 10%		0	7	1% - 10%
Trans - Other Materials		0	12	<1%		0	12	<1%		0	12	<1%		0	10	<1%		0	12	<1%
Trans - Personnel Air	4	1% - 10%	8	<1%	4	1% - 10%	8	1% - 10%	4	<1%	8	<1%	4	<1%	11	<1%	5	<1%	8	1% - 10%
Trans - Personnel Vehicle	5	<1%	13	<1%	5	<1%	13	<1%	5	<1%	13	<1%	5	<1%	13	<1%	4	1% - 10%	13	<1%
Trans - Soil Disposal	3	10% - 50%	4	1% - 10%	3	10% - 50%	4	10% - 50%	3	10% - 50%	3	10% - 50%	3	10% - 50%	4	10% - 50%	3	10% - 50%	4	10% - 50%
Water - Potable		0	9	<1%		0	9	<1%		0	11	<1%		0	9	<1%		0	9	<1%
Disp - Landfill		0	2	10% - 50%		0	1	10% - 50%		0	1	10% - 50%		0	1	10% - 50%		0	1	10% - 50%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2	Energy	NOx	PM	SOx
Fuel - Excavation/Fill	2 - 5 (SRT)	2 - 5 (SRT)	2 - 5 (SRT)	1.2 - 2 (SRT)	>10 (SP)
Fuel - Dust Control	No SRT	No SRT	No SRT	No SRT	No SRT
Fuel - Soil Stabilization	No SRT	No SRT	No SRT	No SRT	No SRT
Fuel - Other	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - Cement	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Clean Fill	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Cement	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Other Materials	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel Air	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SP)	>10 (SP)
Trans - Personnel Vehicle	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	2 - 5 (SP)
Trans - Soil Disposal	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)
Water - Potable	No SRT	No SRT	No SRT	No SRT	No SRT
Disp - Landfill	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
Trans = transportation
Disp - landfill = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading,
Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

SRT accounts for landfill activities by increasing the fuel consumption rate for on-site equipment for excavation. As a result, the "fuel" categories are high for SRT and the soil disposal category is listed as "No SRT".

Travis Alt 1

SRT (Version 2.3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Electricity	1	>90%	1	>90%	1	>90%	1	>90%	1	50% - 90%	1	>90%	1	>90%	1	50% - 90%	1	>90%	1	>90%
Fuel - Drilling	3	<1%	3	<1%	4	<1%	3	<1%	3	1% - 10%	2	1% - 10%	5	<1%	4	1% - 10%	5	<1%	4	<1%
Mat - PVC for wells	6	<1%	4	<1%	3	<1%	4	<1%	4	1% - 10%	4	<1%	4	<1%	5	1% - 10%	2	1% - 10%	3	<1%
Mat - Steel for wells	4	<1%	5	<1%	6	<1%	5	<1%	6	<1%	5	<1%	6	<1%	3	1% - 10%	3	1% - 10%	5	<1%
Trans - Personnel Sampling	5	<1%	6	<1%	5	<1%	6	<1%	5	<1%	6	<1%	3	<1%	6	<1%	6	<1%	6	<1%
Trans - Personnel O&M	2	1% - 10%	2	1% - 10%	2	1% - 10%	2	1% - 10%	2	10% - 50%	3	1% - 10%	2	1% - 10%	2	1% - 10%	4	<1%	2	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2	Energy	NOx	PM	SOx
Electricity	1.2 - 2 (SP)	1 - 1.2 (SP)	5 - 10 (SP)	1.2 - 2 (SRT)	>10 (SP)
Fuel - Drilling	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	>10 (SP)	>10 (SP)
Mat - PVC for wells	1.2 - 2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Mat - Steel for wells	1.2 - 2 (SRT)	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	1.2 - 2 (SP)
Trans - Personnel Sampling	2 - 5 (SRT)	2 - 5 (SRT)	1 - 1.2 (SRT)	1.2 - 2 (SP)	>10 (SP)
Trans - Personnel O&M	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
PVC = polyvinyl chloride
Trans = transportation
O&M = operations and maintenance
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.

Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

Travis Alt 2

SRT (Version 2.3) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Drilling	2	1% - 10%	2	1% - 10%	3	1% - 10%	2	<1%	3	1% - 10%	2	10% - 50%	3	<1%	2	1% - 10%	4	<1%	3	1% - 10%
Fuel - Excavation	4	1% - 10%	7	<1%	5	<1%	8	<1%	2	1% - 10%	7	<1%	2	<1%	9	1% - 10%	5	<1%	8	<1%
Mat - Mulch/Gravel			9	<1%			9	<1%			8	<1%			8	1% - 10%			9	<1%
Mat - PVC for Wells	5	1% - 10%	3	1% - 10%	2	1% - 10%	3	<1%	5	<1%	4	1% - 10%	5	<1%	4	1% - 10%	2	1% - 10%	2	1% - 10%
Mat - Veg Oil	1	>90%	1	>90%	1	>90%	1	>90%	1	50% - 90%	1	50% - 90%	1	>90%	1	50% - 90%	1	>90%	1	50% - 90%
Trans - Veg Oil			6	<1%			6	<1%			5	1% - 10%			6	1% - 10%			7	<1%
Trans - Personnel	3	1% - 10%	5	1% - 10%	4	<1%	5	<1%	4	1% - 10%	6	<1%	4	<1%	5	1% - 10%	3	<1%	6	1% - 10%
Disposal -Soil			4	1% - 10%			4	<1%			3	1% - 10%			3	1% - 10%			4	1% - 10%
Water - Potable			8	<1%			7	<1%			9	<1%			7	1% - 10%			5	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Drilling	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	5 - 10 (SP)	>10 (SP)
Fuel - Excavation	2 - 5 (SRT)	2 - 5 (SRT)	5 - 10 (SRT)	2 - 5 (SRT)	>10 (SP)
Mat - Mulch/Gravel	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - PVC for Wells	1.2 - 2 (SP)	1 - 1.2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Mat - Veg Oil/Substrate	1 - 1.2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SRT)	1.2 - 2 (SP)
Trans - Veg Oil	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Disposal -Soil	No SRT	No SRT	No SRT	No SRT	No SRT
Water - Potable	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
Veg oil = vegetable oil used as a bioremediation substrate
Trans = transportation
Disposal - Soil = landfill activities associated with soil disposal
Water - Potable = potable water from a public water source
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.
Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

SRT accounts for landfill activities by increasing the fuel consumption rate for on-site equipment for excavation. As a result, the "fuel" categories are high for SRT and the soil disposal category is listed as "No SRT".

APPENDIX F:

Results by Remedy Components – SRT™ Version 2.1 versus SimaPro®

Beale Alt 2

SRT (Version 2.1) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavation/Backfill Equip	5	1% - 10%	7	1% - 10%	5	1% - 10%	7	1% - 10%	3	10% - 50%	5	1% - 10%	3	10% - 50%	4	1% - 10%	6	<1%	7	1% - 10%
Fuel - Drilling	6	1% - 10%	8	1% - 10%	6	1% - 10%	8	1% - 10%	4	1% - 10%	4	1% - 10%	5	1% - 10%	6	1% - 10%	7	<1%	9	1% - 10%
Mat - Mulch/gravel		0		0		0		0		0		0		0		0		0		0
Mat - Solar Panels		0	10	<1%		0	11	<1%		0	12	<1%		0	11	<1%		0	11	<1%
Mat - PVC for wells	7	1% - 10%	9	1% - 10%	7	1% - 10%	9	1% - 10%	7	<1%	9	<1%	7	<1%	9	1% - 10%	1	>90%	8	1% - 10%
Trans - Excavation/Backfill Equip	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	50% - 90%	2	10% - 50%	1	50% - 90%	2	10% - 50%	2	1% - 10%	2	10% - 50%
Trans - Solar Panels		0	13	<1%		0	13	<1%		0	13	<1%		0	13	<1%		0	13	<1%
Trans - MNA samples		0	5	1% - 10%		0	5	1% - 10%		0	6	1% - 10%		0	8	1% - 10%		0	6	1% - 10%
Trans - Drill Rig		0	12	<1%		0	12	<1%		0	10	<1%		0	12	<1%		0	12	<1%
Trans - Personnel Construction	3	10% - 50%	6	1% - 10%	3	10% - 50%	6	1% - 10%	6	1% - 10%	8	1% - 10%	6	1% - 10%	7	1% - 10%	4	1% - 10%	5	1% - 10%
Trans - Personnel MNA/LUC	2	10% - 50%	4	1% - 10%	2	10% - 50%	4	1% - 10%	5	1% - 10%	7	1% - 10%	4	1% - 10%	5	1% - 10%	3	1% - 10%	3	10% - 50%
Trans - Disposal	4	10% - 50%	3	10% - 50%	4	10% - 50%	3	1% - 10%	2	10% - 50%	3	10% - 50%	2	10% - 50%	3	10% - 50%	5	<1%	4	1% - 10%
Water - Non-Potable		0		0		0		0		0		0		0		0		0		0
Disp - Soil (Landfill)		0	1	10% - 50%		0	1	50% - 90%		0	1	10% - 50%		0	1	10% - 50%		0	1	10% - 50%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Excavation/Backfill Equip	1 - 1.2 (SRT)	1 - 1.2 (SRT)	1 - 1.2 (SP)	2 - 5 (SP)	>10 (SP)
Fuel - Drilling	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Mat - Mulch/gravel	No Footprint	No Footprint	No Footprint	No Footprint	No Footprint
Mat - Solar Panels	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - PVC for wells	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Trans - Excavation/Backfill Equip	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1 - 1.2 (SP)	>10 (SP)
Trans - Solar Panels	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - MNA samples	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Drill Rig	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel Construction	2 - 5 (SRT)	1.2 - 2 (SRT)	1 - 1.2 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Personnel MNA/LUC	2 - 5 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Disposal	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Water - Non-Potable	No Footprint	No Footprint	No Footprint	No Footprint	No Footprint
Disp - Soil (Landfill)	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = Rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = Percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
PVC = polyvinyl chloride
Trans = transportation
MNA/LUC = monitored natural at
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Non-potable = water fron
Water - Potable = potable water from a public water source
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP
No Footprint = it is assumed for both tools that there is no footprint for this component

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.

Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

Beale Alt 3

SRT (Version 2.1) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavation/Backfill Equip	7	1% - 10%	10	1% - 10%	6	1% - 10%	10	1% - 10%	4	10% - 50%	6	1% - 10%	5	10% - 50%	7	1% - 10%	6	<1%	10	1% - 10%
Fuel - Drilling	6	1% - 10%	4	10% - 50%	5	1% - 10%	6	1% - 10%	3	10% - 50%	1	10% - 50%	3	10% - 50%	4	1% - 10%	5	<1%	6	1% - 10%
Mat - Backfill		0	6	1% - 10%		0	4	1% - 10%		0	4	1% - 10%		0	3	10% - 50%		0	5	1% - 10%
Mat - Oxidant	1	10% - 50%	3	10% - 50%		0	3	10% - 50%		0	7	1% - 10%		0	5	1% - 10%		0	1	10% - 50%
Mat - PVC for wells	5	1% - 10%	8	1% - 10%	3	10% - 50%	7	1% - 10%	7	1% - 10%	11	1% - 10%	7	1% - 10%	9	1% - 10%	1	>90%	4	10% - 50%
Trans - Excavation/Backfill Equip	3	10% - 50%	1	10% - 50%	2	10% - 50%	2	10% - 50%	1	10% - 50%	3	10% - 50%	1	10% - 50%	2	10% - 50%	3	<1%	3	10% - 50%
Trans - Oxidant	8	1% - 10%	11	1% - 10%	7	1% - 10%	11	1% - 10%	5	1% - 10%	9	1% - 10%	6	1% - 10%	10	1% - 10%	7	<1%	11	1% - 10%
Trans - Samples		0	9	1% - 10%		0	9	1% - 10%		0	10	1% - 10%		0	11	<1%		0	9	1% - 10%
Trans - Drill Rig		0	13	<1%		0	13	<1%		0	12	<1%		0	13	<1%		0	13	<1%
Trans - Personnel	2	10% - 50%	5	1% - 10%	1	10% - 50%	5	1% - 10%	6	1% - 10%	8	1% - 10%	4	10% - 50%	8	1% - 10%	2	<1%	7	1% - 10%
Trans - Disposal	4	1% - 10%	7	1% - 10%	4	1% - 10%	8	1% - 10%	2	10% - 50%	5	1% - 10%	2	10% - 50%	6	1% - 10%	4	<1%	8	1% - 10%
Water - Non-Potable		0	12	<1%		0	12	<1%		0	13	<1%		0	12	<1%		0	12	<1%
Disp - Soil (Landfill)		0	2	10% - 50%		0	1	10% - 50%		0	2	10% - 50%		0	1	10% - 50%		0	2	10% - 50%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Excavation/Backfill Equip	1 - 1.2 (SRT)	1 - 1.2 (SRT)	1 - 1.2 (SP)	2 - 5 (SP)	>10 (SP)
Fuel - Drilling	2 - 5 (SP)	2 - 5 (SP)	5 - 10 (SP)	2 - 5 (SP)	>10 (SP)
Mat - Backfill	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - Oxidant	2 - 5 (SRT)	No SRT	No SRT	No SRT	No SRT
Mat - PVC for wells	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Trans - Excavation/Backfill Equip	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Oxidant	1 - 1.2 (SRT)	1 - 1.2 (SP)	1 - 1.2 (SRT)	1.2 - 2 (SP)	>10 (SP)
Trans - Samples	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Drill Rig	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel	2 - 5 (SRT)	2 - 5 (SRT)	1 - 1.2 (SP)	1.2 - 2 (SP)	>10 (SP)
Trans - Disposal	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Water - Non-Potable	No SRT	No SRT	No SRT	No SRT	No SRT
Disp - Soil (Landfill)	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = Rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = Percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
PVC = polyvinyl chloride
Trans = transportation
Disp - Soil (landfill) = landfill activities associated with soil disposal
Water - Non-potable = water from a non-potable source
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.

Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

Little Rock

SRT (Version 2.1) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Excavation/Fill	3	10% - 50%	7	1% - 10%	3	10% - 50%	7	1% - 10%	3	10% - 50%	6	1% - 10%	3	10% - 50%	6	1% - 10%	3	10% - 50%	6	1% - 10%
Fuel - Dust Control		0	5	1% - 10%		0	5	1% - 10%		0	5	1% - 10%		0	5	1% - 10%		0	5	1% - 10%
Fuel - Soil Stabilization		0	10	<1%		0	10	<1%		0	9	<1%		0	8	<1%		0	10	<1%
Fuel - Other		0	11	<1%		0	11	<1%		0	10	<1%		0	12	<1%		0	11	<1%
Mat - Cement		0	1	10% - 50%		0	3	10% - 50%		0	4	10% - 50%		0	3	10% - 50%		0	2	10% - 50%
Trans - Clean Fill	1	10% - 50%	3	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	2	10% - 50%	1	10% - 50%	3	10% - 50%
Trans - Cement		0	6	1% - 10%		0	6	1% - 10%		0	7	1% - 10%		0	7	1% - 10%		0	7	1% - 10%
Trans - Other Materials		0	12	<1%		0	12	<1%		0	12	<1%		0	10	<1%		0	12	<1%
Trans - Personnel Air	4	<1%	8	<1%	4	<1%	8	1% - 10%	4	<1%	8	<1%	4	<1%	11	<1%	5	<1%	8	1% - 10%
Trans - Personnel Vehicle	5	<1%	13	<1%	5	<1%	13	<1%	5	<1%	13	<1%	5	<1%	13	<1%	4	<1%	13	<1%
Trans - Soil Disposal	1	10% - 50%	4	1% - 10%	1	10% - 50%	4	10% - 50%	1	10% - 50%	3	10% - 50%	1	10% - 50%	4	10% - 50%	1	10% - 50%	4	10% - 50%
Water - Potable		0	9	<1%		0	9	<1%		0	11	<1%		0	9	<1%		0	9	<1%
Disp - Landfill		0	2	10% - 50%		0	1	10% - 50%		0	1	10% - 50%		0	1	10% - 50%		0	1	10% - 50%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Excavation/Fill	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SRT)	1.2 - 2 (SP)	>10 (SP)
Fuel - Dust Control	No SRT	No SRT	No SRT	No SRT	No SRT
Fuel - Soil Stabilization	No SRT	No SRT	No SRT	No SRT	No SRT
Fuel - Other	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - Cement	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Clean Fill	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Cement	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Other Materials	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel Air	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)	>10 (SP)
Trans - Personnel Vehicle	2 - 5 (SRT)	2 - 5 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Trans - Soil Disposal	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)
Water - Potable	No SRT	No SRT	No SRT	No SRT	No SRT
Disp - Landfill	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = Rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = Percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
Trans = transportation
Disp - landfill = landfill activities associated with soil disposal
Water - Potable = potable water from a publi
SP = SimaPro
Result Ratio = ratio of SRT result to SP result c
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.

Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

Travis Alt 1

SRT (Version 2.1) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Electricity	1	>90%	1	>90%	1	>90%	1	>90%	1	>90%	1	>90%	1	>90%	1	50% - 90%	1	>90%	1	>90%
Fuel - Drilling	3	<1%	3	<1%	3	<1%	3	<1%	2	<1%	2	1% - 10%	3	<1%	4	1% - 10%	5	<1%	4	<1%
Mat - PVC for wells	6	<1%	4	<1%	5	<1%	4	<1%	4	<1%	4	<1%	5	<1%	5	1% - 10%	2	<1%	3	<1%
Mat - Steel for wells	5	<1%	5	<1%	6	<1%	5	<1%	6	<1%	5	<1%	6	<1%	3	1% - 10%	3	<1%	5	<1%
Trans - Personnel Sampling	4	<1%	6	<1%	4	<1%	6	<1%	5	<1%	6	<1%	4	<1%	6	<1%	6	<1%	6	<1%
Trans - Personnel O&M	2	1% - 10%	2	1% - 10%	2	1% - 10%	2	1% - 10%	3	<1%	3	1% - 10%	2	<1%	2	1% - 10%	4	<1%	2	<1%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Electricity	1.2 - 2 (SRT)	1 - 1.2 (SP)	5 - 10 (SRT)	>10 (SRT)	1.2 - 2 (SRT)
Fuel - Drilling	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	2 - 5 (SP)	>10 (SP)
Mat - PVC for wells	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Mat - Steel for wells	1.2 - 2 (SRT)	1.2 - 2 (SP)	1.2 - 2 (SP)	>10 (SP)	1.2 - 2 (SP)
Trans - Personnel Sampling	2 - 5 (SRT)	2 - 5 (SRT)	1 - 1.2 (SRT)	1.2 - 2 (SP)	>10 (SP)
Trans - Personnel O&M	2 - 5 (SRT)	2 - 5 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = Rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = Percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
PVC = polyvinyl chloride
Trans = transportation
O&M = operations and maintenance
SP = SimaPro
Result Ratio = ratio of SRT result to SP result c
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.

Orange shading - SRT result higher than SimaPro
Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

Travis Alt 2

SRT (Version 2.1) versus SimaPro

Rank and Percent Contribution of Various Footprint Contributors for the Remedial Alternative

	CO2 (SRT) and CO2e (SimaPro)				Energy				NOx				PM				SOx			
	SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro		SRT		Simapro	
	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.	Rank	Cont.
Fuel - Drilling	3	<1%	2	1% - 10%	2	10% - 50%	2	<1%	1	50% - 90%	2	10% - 50%	1	50% - 90%	2	1% - 10%	3	<1%	3	1% - 10%
Fuel - Excavation	4	<1%	7	<1%	4	10% - 50%	8	<1%	2	10% - 50%	7	<1%	2	10% - 50%	9	1% - 10%	4	<1%	8	<1%
Mat - Mulch/Gravel		0	9	<1%		0	9	<1%		0	8	<1%		0	8	1% - 10%		0	9	<1%
Mat - PVC for Wells	5	<1%	3	1% - 10%	3	10% - 50%	3	<1%	4	1% - 10%	4	1% - 10%	4	1% - 10%	4	1% - 10%	1	>90%	2	1% - 10%
Mat - Veg Oil	1	>90%	1	>90%		0	1	>90%		0	1	50% - 90%		0	1	50% - 90%		0	1	50% - 90%
Trans - Veg Oil		0	6	<1%		0	6	<1%		0	5	1% - 10%		0	6	1% - 10%		0	7	<1%
Trans - Personnel	2	1% - 10%	5	1% - 10%	1	10% - 50%	5	<1%	3	1% - 10%	6	<1%	3	10% - 50%	5	1% - 10%	2	<1%	6	1% - 10%
Disposal -Soil		0	4	1% - 10%		0	4	<1%		0	3	1% - 10%		0	3	1% - 10%		0	4	1% - 10%
Water - Potable		0	8	<1%		0	7	<1%		0	9	<1%		0	7	1% - 10%		0	5	1% - 10%

Result Ratios of Various Footprint Contributors for the Remedial Alternative

Remedy Item	CO2e	Energy	NOx	PM	SOx
Fuel - Drilling	1.2 - 2 (SP)	1.2 - 2 (SP)	2 - 5 (SP)	1.2 - 2 (SP)	>10 (SP)
Fuel - Excavation	1.2 - 2 (SRT)	1.2 - 2 (SRT)	2 - 5 (SRT)	1.2 - 2 (SRT)	>10 (SP)
Mat - Mulch/Gravel	No SRT	No SRT	No SRT	No SRT	No SRT
Mat - PVC for Wells	1.2 - 2 (SP)	1.2 - 2 (SP)	1.2 - 2 (SP)	5 - 10 (SP)	1 - 1.2 (SRT)
Mat - Veg Oil	2 - 5 (SRT)	No SRT	No SRT	No SRT	No SRT
Trans - Veg Oil	No SRT	No SRT	No SRT	No SRT	No SRT
Trans - Personnel	2 - 5 (SRT)	2 - 5 (SRT)	1.2 - 2 (SP)	2 - 5 (SP)	>10 (SP)
Disposal -Soil	No SRT	No SRT	No SRT	No SRT	No SRT
Water - Potable	No SRT	No SRT	No SRT	No SRT	No SRT

Definitions

CO2 = carbon dioxide
CO2e = carbon dioxide equivalents
NOx = nitrogen oxides
PM = particulate matter less than 10 microns
SOx = sulfur oxides
Rank = Rank of footprint contributor relative to other footprint contributors for a particular metric
Cont. = Percent contribution of a sustainability metric footprint for a particular footprint contributor
Fuel = fuel use for on-site equipment use
Mat = materials use for specified material
Veg oil = vegetable oil used as a bioremediati
Trans = transportation
Disposal - Soil = landfill activities associated v
Water - Potable = potable water from a public water source
SP = SimaPro
Result Ratio = ratio of SRT result to SP result or ratio of SP result to SRT result, which ever is larger
No SRT = SRT does not provide a value for comparison to SP

Notes:

Footprint contributions are provided as a range. For example, if the SRT result for a particular contributor is 5% of the total NOx footprint, then the range 1% - 10% is provided.
Result ratios are provided as a range and are labeled and color coded to indicate the tool with the larger result. For example, if the SRT result is 2.5 times higher than the SimaPro result, the entry would indicate "2-5 (SRT)" with orange shading, indicating the result ratio is between 2 and 5, and SRT has the higher value. If the SimaPro result s 1.5 times higher than the SRT result, the entry would indicate "1.2 - 2 (SP) with blue shading, indicating the result ratio is between 1.2 and 2, and SimaPro has the higher result.

Orange shading - SRT result higher than SimaPro

Blue shading - SimaPro result higher than SRT
"No SRT" - Not calculated in SRT

APPENDIX G:

Sensitivity of “Boundary Condition” With and Without Infrastructure

APPENDIX G:
Sensitivity of "Boundary Condition" With and Without Infrastructure

Many LCA databases, tools, and models discuss results with and without the consideration of infrastructure. The line between including and excluding infrastructure is an example of a system boundary in an LCA or GSR analysis. For vehicle use, in addition to the fuel use, an expanded boundary that includes infrastructure could also consider processes such as vehicle construction and road use (i.e., road deterioration). Ecoinvent LCI data modules available in SimaPro® explicitly show whether they are infrastructure processes or not.

To illustrate the sensitivity of SimaPro® results to this type of boundary condition, several processes were represented in SimaPro® both "with infrastructure" and "without infrastructure." Descriptions of these processes from within SimaPro® are provided at the end of this appendix (including the specific names of the processes selected). The following figures illustrate the percent contribution of infrastructure when the infrastructure is included:

- Figure G-1: Infrastructure Contribution for CO_2e
- Figure G-2: Infrastructure Contribution for Energy
- Figure G-3: Infrastructure Contribution for NOx
- Figure G-4: Infrastructure Contribution for PM
- Figure G-5: Infrastructure Contribution for SOx

On charts G-1 to G-5, each bar represents 100 percent of the footprint total when infrastructure is included, and the red upper portion indicates the percentage of the total that is due to the "with infrastructure" option.

It is also important to note that differentiating "with infrastructure" and "without infrastructure" can only easily be accomplished with SimaPro® when using the "unit process" version of a particular material or process from the Ecoinvent database. Choosing the "system process" version of the same material or process from Ecoinvent or choosing any process from another LCI database provided by SimaPro® does not subtract the infrastructure components of the footprints when the "exclude infrastructure" option button is checked. Entries from other LCI databases such as the U.S. Life-cycle Inventory (USLCI) database or the European Reference Life Cycle Database (ELCD) do not have multiple versions of process that include or exclude infrastructure. Moreover, the inclusion or exclusion of infrastructure in these and other databases varies from item to item. For example, transport by truck (lorry in the European-based databases) is significant for many of the Ecoinvent truck transportation items but is considered negligible and is not included in the ELCD database.

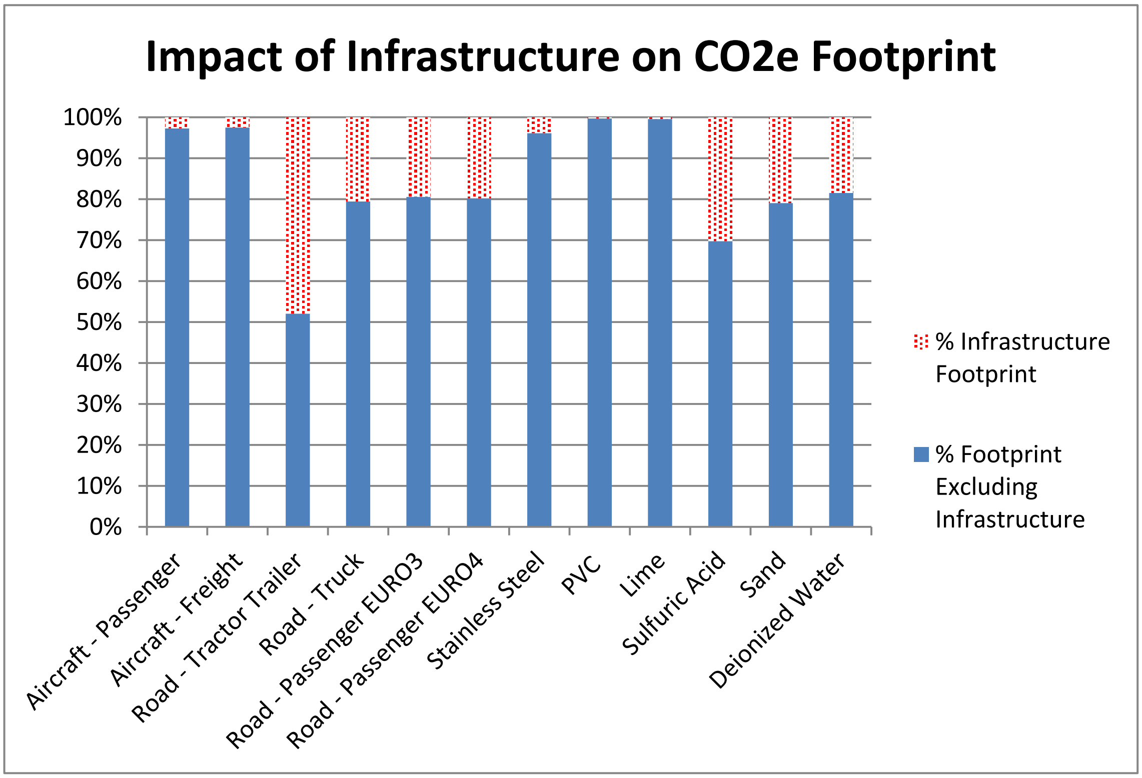


Figure G-1: Impact of "Infrastructure" on SimaPro® CO_2e Footprint, Selected Items

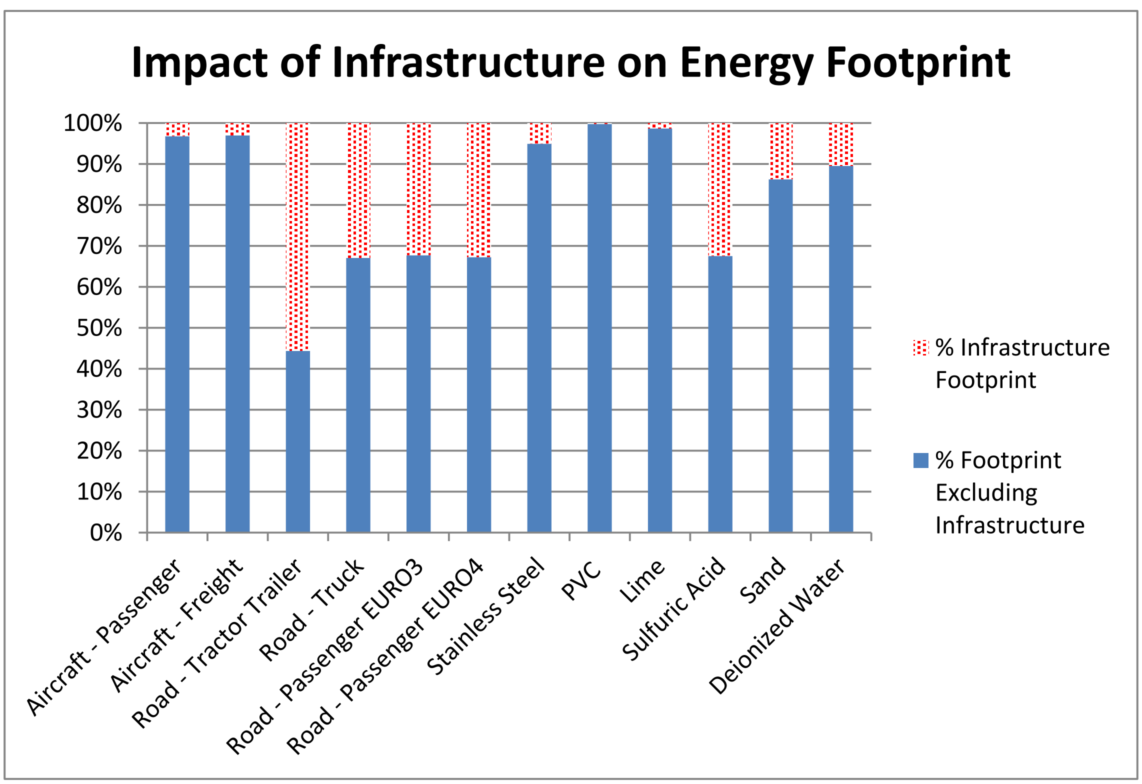


Figure G-2: Impact of "Infrastructure" on SimaPro® Energy Footprint, Selected Items

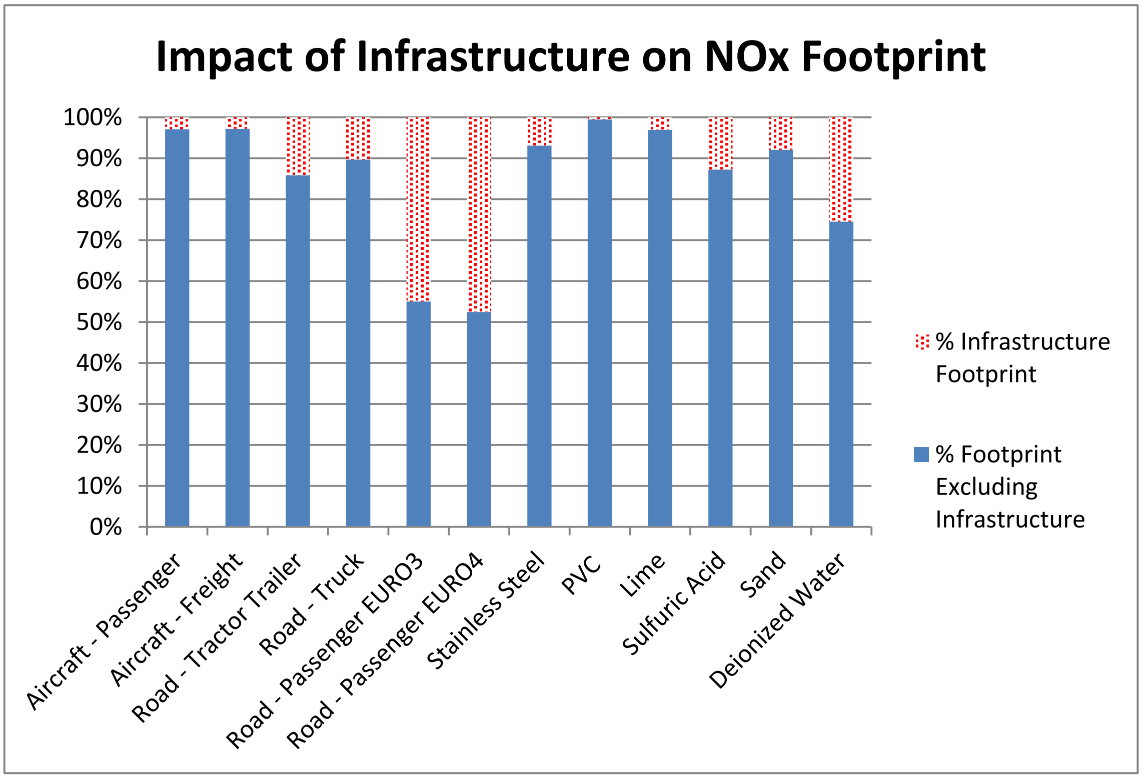


Figure G-3: Impact of “Infrastructure” on SimaPro® NOx Footprint, Selected Items

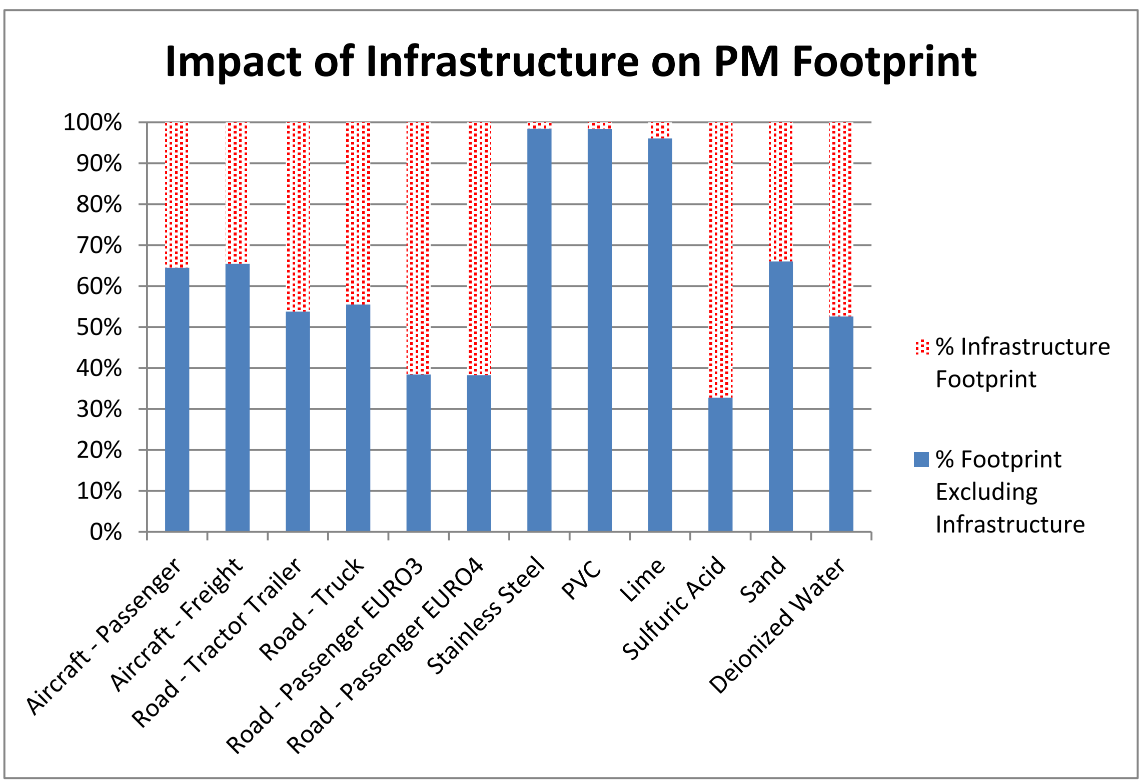


Figure G-4: Impact of “Infrastructure” on SimaPro® PM Footprint, Selected Items

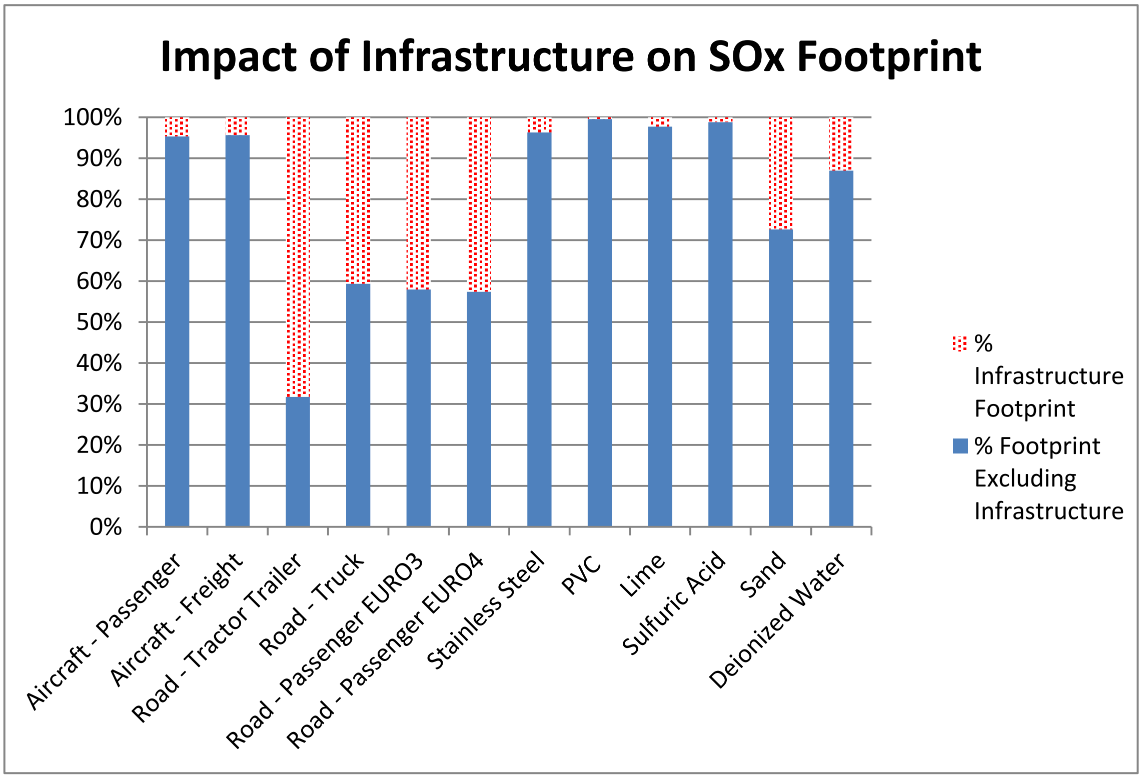


Figure G-5: Impact of "Infrastructure" on SimaPro® SOx Footprint, Selected Items

Various aspects of infrastructure add to the footprints. For example, passenger car transport infrastructure includes manufacture and maintenance of the car, building of the road, and maintenance of the road. For sulfuric acid production, the main infrastructure component is the chemical plant (including facilities maintenance and building construction).

The impact of infrastructure on the CO_2e footprint (Figure G-1) is generally similar to the impact of infrastructure on energy (Figure G-2) for these items, with some slight differences (e.g., infrastructure represents about 20% of the total CO_2e footprint for sand and de-ionized water, but only about 10% of the energy footprint for those items). However, for the NOx (Figure G-3), PM (Figure G-4), and SOx (Figure G-5), the contribution from infrastructure increases significantly ((particularly PM), and for some items infrastructure represents more than 50% of the pollutant footprint.

The contribution of infrastructure can differ between footprints for the same item. For instance, for "aircraft-freight" the contribution of infrastructure is relatively small (~5%) for each footprint category except PM, for which the infrastructure contribution is ~35% (see Figure G-4). For that item, the difference is most likely the result of relatively low PM emissions during aircraft operation and relatively higher PM emission during manufacturing.

The specific SimaPro® processes used for the evaluation of the "with infrastructure" and "without infrastructure" boundary condition (illustrated on Figures G-1 to G-5) are summarized below.

SPECIFIC LCI PROCESS DATA SOURCES USED TO GENERATE FIGURES G-1 to G-5

The following table summarizes the specific process data sources extracted from within the SimaPro LCA tool that were used to generate the chart for generic materials shown in the final report (Table 16). Columns are defined as follows:

- The Material identifies the general type the material.
- The Process Name refers to the name of the process in the SimaPro tool that was selected to represent the material.
- The Category refers to the category within the SimaPro browsing function.
- The Library refers to which of the LCI databases the Process Name is sourced from (typically the ecoinvent library).
- The Description is the metadata available for the Process Name and is directly copied from SimaPro.

No attempt is made to formally format this table or to identify all abbreviations in the SimaPro descriptions.

Material	Process Name	Category	Library	Description
Sand	Sand, at mine/CH U	Minerals	Ecoinvent unit processes	Translated name: Sand, ab Abbau Included processes: Includes the whole manufacturing process for digging of gravel round and sand (no crushed gravel), internal processes (transport, etc.), and infrastructure for the operation (machinery). The land-use of the mine (incl. unpaved roads) is included directly, while the land-use of the paved roads and buildings are included in the module "mine, gravel/sand". Recultivation of closed mines is taken into account. No environmental burdens from administration are included. No dust included because it is mostly a "wet" process and no wastewater included because process water is not polluted (only sand and gravel) and therefore directly seeped. Remark: The multi output-process 'mining, gravel / sand' delivers the co-products 'sand, at mine' and 'gravel, round, at mine'. The typical production mix in Switzerland is: sand 35% and round gravel 65%. From the total sectoral production volume (100%) of mined gravel round, crushed and sand, about 85% is gravel round and sand. ; Geography: For some exchanges RER-modules have been used as proxy Technology: typical technology for Swiss production Version: 2.2 Energy values: Undefined Percent representativeness: 100.0 Production volume: 29750000 t/a Local category: Mineralische Baustoffe Local subcategory: Zuschlags- Füllstoffe Source file: 00478.XML

Material	Process Name	Category	Library	Description
Sulphuric Acid	Sulphuric acid, liquid, at plant/RER U	Chemicals \ Acids (Inorganic)	Ecoinvent unit processes	Translated name: Schwefelsäure, flüssig, ab Werk Included processes: Inventory Includes the obtention of SO2-containing gas (by means of oxidation of the sulphur containing raw materials: elemental sulphur, pyrites, other sulphide ores or spent acids). It includes also the convertion of SO2 to SO3 and the absorption of SO3 into solution (sulfuric acid in water) to yield Sulphuric acid. Remark: Manufacturing process starting with sulphur-containing raw materials (elemental sulphur, pyrites, ores and spent acids) is considered, plus consumption of auxiliaries, energy, infrastructure and land use, as well as transportation of raw materials, auxiliaries and wastes. The generation of solid wastes and emissions into air and water and wastes. Transport and storage of the final product sulphuric acid are not included. No byproducts or coproducts are considered. Transient or unstable operations are not considered, but the production during stable operation conditions. Emissions to air are considered as emanating in a high population density area. Emissions into water are assumed to be emitted into rivers. Wastes are assumed to be sent to landfill. Inventory refers to 1 kg 100% sulphuric acid, liquid, at plant. Since the sulphuric acid can be considered a as byproduct from the processing of sulphide ores (other than pyrites), for this study it is considered that the sulphuric acid produced by smelter gas burning is obtained "gratis“. As mentioned above, this process contributes with 35% to the total production. Consequently, in order to subtract the contribution of this process to the overall average, all the values for inputs and outputs presented in the report have been balanced by multiplying them by 0.65 before entering the values in the present excel files in ecoinvent database. CAS number: 007664-93-9; Formula: H2SO4; Geography: European average values Technology: part of the sources consider the average technology used in European sulphuric acid production plants. The others consider the state-of-the-art technology in Europe. Time period: Values based on literature using data from unknown date, and reports with data from 1990 to 2000, approximately. Version: 2.2 Energy values: Undefined Production volume: unknown Local category: Chemikalien Local subcategory: Anorganika Source file: 00350.XML

Material	Process Name	Category	Library	Description
Lime	Lime, hydrated, loose, at plant/CH U	Chemicals \ Inorganic	Ecoinvent unit processes	Translated name: Kalk, gelöscht, lose, ab Werk Included processes: Includes the processes: slaking, crushing, dust abatement (cyclone), transportation and storing. A part of the total heating energy for "production" and "administration" is included. Equipment included in the infrastructure: 1 swing hammer crusher, 2 cyclone dust catchers, 1 lime slaking plant, 2 conveyor worms, and 1 silo. Remark: Infrastructure data are estimated based on a tour and sketches of the process. The value of the infrastructure is normalized with a annual production capacity of about 20'000 tons of product per year. The estimated lifespan of the machines is 25 years. There are no significant dust emissions as a dust control system is installed. This product exists also packed.; Formula: Ca(OH)2; Geography: data are from only one company in Switzerland (KFN), for some exchanges RER-modules have been used as proxy Technology: The company KFN works on a technically high level. Effective dust control systems are installed. Version: 2.2 Energy values: Undefined Percent representativeness: 50.0 Production volume: 37'000t Local category: Mineralische Baustoffe Local subcategory: Bindemittel Source file: 00486.XML
Aircraft Travel	Transport, aircraft, passenger/RER U	Transport / Air	Ecoinvent unit processes	Translated name: Transport, Passagierflugzeug Included processes: The module calls the modules addressing: operation of aircraft; production of aircraft; construction and land use of airport; operation, maintenance and disposal of airport. Remark: Inventory refers to the entire transport life cycle. Airport infrastructure expenditures and environmental interventions are accounted for using an weighted average (75vs25) of Intra-European and Intercontinental freight transport performance at unique airport in Zurich. Each passenger is attributed 100 kg. Aircraft manufacturing is allocated based on the total life span of an aircraft (5.59E+10) and its transport performance (256 passengers/unit).; Geography: Data from Switzerland is employed as a first estimate for Europe. Technology: For aircraft operation merley passenger jets are included in the average data. For the manufacturing of aircrafts modern production technologies are taken into account. Version: 2.2 Energy values: Undefined Percent representativeness: 0.0 Local category: Transportsysteme Local subcategory: Luft Source file: 01895.XML

Material	Process Name	Category	Library	Description
Aircraft Travel	Transport, aircraft, freight/RER U	Transport / Air	Ecoinvent unit processes	Translated name: Transport, Luftfracht Included processes: The module calls the modules addressing: operation of aircraft; production of aircraft; construction and land use of airport; operation, maintenance and disposal of airport. Remark: Inventory refers to the entire transport life cycle. Airport infrastructure expenditures and environmental interventions are accounted for using an weighted average (95vs5%) of Intra-European and Intercontinental freight transport performance at unique airport in Zurich. Aircraft manufacturing is allocated based on the total life span of an aircraft (5.59E+10) and its transport performance (23.5t/unit).; Geography: Data from Switzerland is employed as a first estimate for Europe. Technology: For aircraft operation merley passenger jets are included in the average data. For the manufacturing of aircrafts modern production technologies are taken into account. Version: 2.2 Energy values: Undefined Percent representativeness: 0.0 Local category: Transportsysteme Local subcategory: Luft Source file: 01892.XML
Passenger Car	Transport, passenger car, petrol, EURO3/CH U	Transport / Road	Ecoinvent unit processes	Translated name: Transport, Pkw, Benzin, EURO3 Included processes: operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road. Remark: Inventory refers to the entire transport life cycle. For road infrastructure, expenditures and environmental interventions due to construction, renewal and disposal of roads have been allocated based on the Gross tonne kilometre performance. Expenditures due to operation of the road infrastructure, as well as land use have been allocated based on the yearly vehicle kilometre performance. For the attribution of vehicle share to the transport performance a vehicle life time performance of 2.39E05 pkm/vehicle has been assumed.; Geography: The data for vehicle operation and road infrastructure reflect Swiss conditions. Data for vehicle manufacturing and maintenance represents generic European data. Data for the vehicle disposal reflect the Swiss situation. Technology: Petrol, Euro3 Time period: Year in which Euro-standard is coming into effect. Version: 2.2 Energy values: Undefined Percent representativeness: 100.0 Production volume: not known Local category: Transportsysteme Local subcategory: Strasse Source file: 06588.XML

Material	Process Name	Category	Library	Description
Passenger Car	Transport, passenger car, petrol, EURO4/CH U	Transport / Road	Ecoinvent unit processes	Translated name: Transport, Pkw, Benzin, EURO4 Included processes: operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road. Remark: Inventory refers to the entire transport life cycle. For road infrastructure, expenditures and environmental interventions due to construction, renewal and disposal of roads have been allocated based on the Gross tonne kilometre performance. Expenditures due to operation of the road infrastructure, as well as land use have been allocated based on the yearly vehicle kilometre performance. For the attribution of vehicle share to the transport performance a vehicle life time performance of 2.39E05 pkm/vehicle has been assumed.; Geography: The data for vehicle operation and road infrastructure reflect Swiss conditions. Data for vehicle manufacturing and maintenance represents generic European data. Data for the vehicle disposal reflect the Swiss situation. Technology: Petrol, Euro4 Time period: Year in which Euro-standard is coming into effect. Version: 2.2 Energy values: Undefined Percent representativeness: 100.0 Production volume: not known Local category: Transportsysteme Local subcategory: Strasse Source file: 06589.XML
Stainless Steel	Chromium steel 18/8, at plant/RER U	Metals \ Ferro	Ecoinvent unit processes	Translated name: Chromstahl 18/8, ab Werk Included processes: Mix of differently produced steels and hot rolling Remark: represents Average of World and European production mix. This is assumed to correspond to the consumption mix in Europe; Geography: Data relate to plants in the EU Technology: technology mix Version: 2.2 Synonyms: high alloyed steel, stainless steel Energy values: Undefined Production volume: unknown Local category: Metalle Local subcategory: Gewinnung Source file: 01072.XML

Material	Process Name	Category	Library	Description
Freight Transport	Transport, lorry >16t, fleet average/RER U	Transport / Road	Ecoinvent unit processes	Translated name: Transport, Lkw >16t, Flottendurchschnitt Included processes: operation of vehicle; production, maintenance and disposal of vehicles; construction and maintenance and disposal of road. Remark: Inventory refers to the entire transport life cycle. For road infrastructure, expenditures and environmental interventions due to construction, renewal and disposal of roads have been allocated based on the Gross tonne kilometre performance. Expenditures due to operation of the road infrastructure, as well as land use have been allocated based on the yearly vehicle kilometre performance. For the attribution of vehicle share to the transport performance a vehicle life time performance of 540000 tkm/vehicle has been assumed.; Geography: The data for vehicle operation and road infrastructure reflect Swiss conditions. Data for vehicle manufacturing and maintenance represents generic European data. Data for the vehicle disposal reflect the Swiss situation. Technology: Diesel, various emission treatment standards Version: 2.2 Energy values: Undefined Percent representativeness: 100.0 Production volume: 1.72E12 Mio tkm Local category: Transportsysteme Local subcategory: Strasse Source file: 01943.XML
PVC	Polyvinylchloride, at regional storage/RER U	Plastics / Thermoplasts	EcoInvent	Translated name: Polyvinylchlorid, ab Regionallager Included processes: This dataset establishes an average European PVC mix out of the two important PVC types (suspension, emulsion PVC). Furthermore, this dataset contains an average transport from the production site to a regional storage site. Remark: see included processes CAS number: 009002-86-2; Geography: European distribution of two types of PVC (extrapolated to 100%) Technology: Present production technology mix. Time period: date of publication Version: 2.2 Synonyms: PVC Energy values: Undefined Percent representativeness: 94.0 Production volume: 6.2 Mt (capacity, 2000) Local category: Kunststoffe Local subcategory: Polymere (Granulate) Source file: 01840.XML

Material	Process Name	Category	Library	Description
Water	Water, deionised, at plant/CH U	Water / Industry Water	Ecoinvent unit processes	Translated name: Wasser, entionisiert, ab Werk Included processes: Energy for operation, chemicals used for regeneration, transport of chemicals to plant, emissions from regeneration chemicals, infrastructure of plant and replacement of spent exchane resin. Process does not include very small units (cartridges) or very large units with >>100 m3/h (power stations). Other production methods as reverse osmosis electrodialysis or distillation are not covered with this process (only ion exchange). Remark: Large uncertainties exist due to influence of raw water quality and operation mode on regeneration chemical demand and electricity used. CAS number: 007732-18-5; Formula: H2O; Geography: Data mainly from european producers but also from Literature and U.S. companies. Raw water data from Switzerland (drinking water of Zurich and Basel). For electricity demand swiss supply mix used. Technology: Process includes a strong cation exchanger a degasser and a strong anion exchanger. unit is operated with counterflow regeneration. Obtained water quality about 1 uS/cm for the conductivity and a silica content (as SiO2) of 5-25 ug/l. As water resource tap water from a public supply with a total hardnes of 1.71 mol/m3 (range 0.7 - 3.2) was assumed. No lime decarbonation as pre-treatment is used. Time period: Time of literature publication. Measurements took place partly before this period. Version: 2.2 Synonyms: demineralised water Energy values: Undefined Production volume: unknown Local category: Wasserversorgung Local subcategory: Bereitstellung Source file: 02292.XML

Material	Process Name	Category	Library	Description
Transport	Transport, tractor and trailer/CH U	Transport / Road	Ecoinvent Unit Process	Translated name: Transport, Traktor und Pneuwagen Included processes: The inventory takes into account the diesel fuel consumption and the amount of agricultural machinery and of the shed, which has to be attributed to the road transport of goods, with a tractor and two tyre trailers, (goods were not considered). Also taken into consideration is the amount of emissions and heat waste to the air from combustion and the emission to the soil from tyre abrasion during the transport. The following activities where considered part of the work process: preliminary work at the plant, like attaching the trailer to the tractor; road transport for 1 km and concluding work, like uncoupling the machine. Not included are dust other than from combustion and noise. Remark: Heavy road transport and 2 tyre-trailers of max. 8t loading capacity either. Mean velocity when loaded = 15 km/h. Mean velocity when empty = 25 km/h. deadhead (over the same distance) included. Transported goods not included. FU is one t of good transported for one km.; Geography: The inventories are based on measurements made by the FAT, in Switzerland. Technology: Emissions and fuel consumption by the newest models of tractors set into operation during the period from 1999 to 2001. Time period: Measurements were made in the last few years (1999-2001). Version: 2.2 Energy values: Undefined Local category: Landwirtschaftliche Produktionsmittel Local subcategory: Arbeitsprozesse Source file: 00188.XML

APPENDIX H:

Sensitivity Analysis Regarding Materials

<u>Includes</u>

- **Specific LCI Process Data Sources**
    - **Steel**
    - **Vegetable Oil**
    - **PVC**
    - **Gravel**
    - **Cement**

- **Selected Charts Including SiteWise™ Results**

- **Selected Charts Including SRT™ Results**

APPENDIX H:
SENSITIVITY ANALYSIS REGARDING MATERIALS

A sensitivity analysis was performed to illustrate how footprints from SimaPro® might vary due to different processes selected by the user in SimaPro® for those materials. The variability of the SimaPro® footprint results was evaluated, and the results from SiteWise™ and SRT™ also compared to the universe of SimaPro® results that were obtained. The materials that were selected for this sensitivity evaluation are summarized below.

Material	Number of SimaPro® Processes Considered in Sensitivity Evaluation	Mass Evaluated for Sensitivity Comparisons
Steel	8	1,000 kg
Vegetable Oil	8	1,000 kg
PVC	10	1,000 kg
Gravel	8	1,000,000 kg
Cement	9	1,000 kg

In each case the SimaPro® evaluations included the infrastructure component of the footprints when the choice to include or exclude infrastructure was available. This appendix is organized as follows:

- The specific LCI process data sources used in SimaPro® to represent the materials listed above
- Selected charts including SiteWise™ results
- Selected charts including SRT™ results

These sensitivity analyses demonstrate the degree to which the footprint results calculated by SimaPro® might be affected by the specific choices of processes selected by the user. As described in the report, effort was made to find a set of comparable data sources for each material that was fairly representative of the global data available. The results indicate there is considerable variation in the SimaPro® results depending on the processes selected. Table 15 in the main report summarizes the variability of the SimaPro® results.

Tables are provided below that describe the specific LCI processes evaluated for each material. The columns are defined as follows:

- The **Process Name** refers to the name of the process in the SimaPro tool that was selected to represent the material.
- The **Year** is the date of the data used for that **Process Name**.
- The **Library** refers to which of the LCI databases the **Process Name** is sourced from.
- The **Unit** is the functional unit basis of the **Process Name**.
- The **Country** is which geographical location the process is representative of.
- The **Description** is the metadata available for the Process Name and is directly copied from SimaPro.

No attempt is made to formally format this table or to identify all abbreviations in the SimaPro descriptions.

Steel Processes Evaluated (8)

Process name	Year	Library	Unit	Country	Description
Iron and steel, production mix/kg/US	2008	U.S. LCI Database	kg	US	Included processes: Mixing process - calls US LCI existing processes Remark: Important note: although most of the data in the US LCI database has undergone some sort of review, the database as a whole has not yet undergone a formal validation process. Please email comments to lci@nrel.gov.; Geography: USA
reinforcing steel, at plant/kg/RER	2007	Ecoinvent	kg	Switzerland	Included processes: Mix of differently produced steels and hot rolling Remark: represents Average of World and European production mix. This is assumed to correspond to the consumption mix in Europe; Geography: Data relate to plants in the EU
Steel hot rolled section, blast furnace and electric arc furnace route, production mix	2010	ELCD 2.0	kg	Germany	Use advice for data set: The data set includes the burden and credit associated with the recycling of steel scrap during steel production, manufacturing and End-of-Life. For this, the current global average recycling rate is estimated to be 80 %. For specific steel data set requests contact the European Confederation of Iron and Steel Industries, Eurofer (European data): www.eurofer.org; the World Steel Association, worldsteel (Global data): www.worldsteel.org and APEAL (Steel packaging data): www.apeal.org.; Technical purpose of product or process: A steel section rolled in a hot rolling mill. Steel section includes I-beams, H-beams, wide-flange beams, and sheet piling. It can be found on the market for direct use. This product is used in construction, multi-story buildings, industrial buildings, bridge trusses, vertical highway supports, and riverbank reinforcement.; Technology description including background system: Raw material extraction and processing, e.g. coal, iron ore, etc., and recycling of steel scrap, Coke making, Sinter, Blast Furnace, Basic Oxygen Furnace, Hot strip mill. DEAM database also used. Electric Arc Furnace Route and section rolling. Steel product manufacturing route can be found in Appendices 1 and 2 of the worldsteel LCA Methodology Report. The worldsteel Recycling Methodology describes the implementation of the method in detail, incorporating a burden for using steel scrap in the steel making process and a credit for the end of life recycling of steel scrap. Steelmaking processes shown in flow diagram. Inputs included in the LCI relate to all raw material inputs, including steel scrap, energy, water, and transport.

Process name	Year	Library	Unit	Country	Description
Steel rebar, blast furnace and electric arc furnace route, production mix, at plant	2010	ELCD 2.0	kg	Germany	Use advice for data set: The data set includes the burden and credit associated with the recycling of steel scrap during steel production, manufacturing and End-of-Life. For this, the current global average recycling rate is estimated to be 80 %. For specific steel data set requests contact the European Confederation of Iron and Steel Industries, Eurofer (European data): www.eurofer.org; the World Steel Association, worldsteel (Global data): www.worldsteel.org and APEAL (Steel packaging data): www.apeal.org.; Technical purpose of product or process: A steel reinforcing bar (rebar) is rolled in a hot rolling mill. It can be found on the market for direct use or is further processed into finished products by the manufacturers. This product is used to strengthen concrete in highway and building construction. It is also used as a primary product for the wire rod process.; Technology description including background system: Raw material extraction and processing, e.g. coal, iron ore, etc., and recycling of steel scrap, Coke making, Sinter, Blast Furnace, Basic Oxygen Furnace, Hot strip mill. DEAM database also used. Electric Arc Furnace Route and section rolling. Steel product manufacturing route can be found in Appendices 1 and 2 of the worldsteel LCA Methodology Report. The worldsteel Recycling Methodology describes the implementation of the method in detail, incorporating a burden for using steel scrap in the steel making process and a credit for the end of life recycling of steel scrap. Steelmaking processes shown in flow diagram. Inputs included in the LCI relate to all raw material inputs, including steel scrap, energy, water, and transport.
steel, converter, low-alloyed, at plant/kg/RER	2010	Ecoinvent	kg	Switzerland	Included processes: Transports of hot metal and other input materials to converter, steel making process and casting. Remark: This process produces primary steel. Scrap is only used for cooling the liquid steel.; Geography: Data relate to plants in the EU
steel, converter, unalloyed, at plant/kg/RER	2007	Ecoinvent	kg	Switzerland	Included processes: Transports of hot metal and other input materials to converter, steel making process and casting. Remark: This process produces primary steel. Scrap is only used for cooling the liquid steel.; Geography: Data relate to plants in the EU
steel, electric, un- and low-alloyed, at plant/kg/RER	2007	Ecoinvent	kg	Switzerland	Included processes: Transports of scrap metal and other input materials to electric arc furnace, steel making process and casting. Remark: This process produces secondary steel. Only scrap is used as iron bearing input.; Geography: Data relate to plants in the EU

Process name	Year	Library	Unit	Country	Description
steel, low-alloyed, at plant/kg/RER	2007	Ecoinvent	kg	Switzerland	Included processes: Mix of differently produced steels and hot rolling Remark: represents Average of World and European production mix. This is assumed to correspond to the consumption mix in Europe; Geography: Data relate to plants in the EU

Vegetable Oil Processes Evaluated (8)

Process name	Year	Library	Unit	Country	Description
Crude palm kernel oil, at plant/kg/RNA	2008	U.S. LCI Database	kg	US	Remark: Important note: although most of the data in the US LCI database has undergone some sort of review, the database as a whole has not yet undergone a formal validation process. Please email comments to lci@nrel.gov.; Geography: North America
palm kernel oil, at oil mill/kg/MY	2006	Ecoinvent	kg	Switzerland	Included processes: This process includes the extraction of palm oil, palm kernel oil and palm kernel meal, from palm fruit bunches. Energy supply from extracted solids (fibres, shells, digester solids and empty fruit bunches) and treatment of specific wastewater effluents are taken into account. System boundary is at the oil mill. Remark: Inventory refers to the production of 1 kg palm oil, respectively palm kernel oil and palm kernel meal, from palm oil. The multioutput-process 'palm fruit bunches, in oil mill' delivers the co-products 'palm oil, at oil mill', 'palm kernel oil, at oil mill' and 'palm kernel meal, at oil mill'. Economic allocation with allocation factor of 81.3% to palm oil, 17.3% to palm kernel oil, and 1.4% to palm kernel meal. Allocation of CO2 emissions is done according to carbon balance.; Geography: Data from various literature references (incl. specific Malaysian and Indonesian industrial data)
Palm kernel oil, processed, at plant/kg/RNA	2008	U.S. LCI Database	kg	US	Remark: Important note: although most of the data in the US LCI database has undergone some sort of review, the database as a whole has not yet undergone a formal validation process. Please email comments to lci@nrel.gov.; Geography: North America (US and Canada)

Process name	Year	Library	Unit	Country	Description
palm oil, at oil mill/kg/MY	2006	Ecoinvent	kg	Switzerland	Included processes: This process includes the extraction of palm oil, palm kernel oil and palm kernel meal, from palm fruit bunches. Energy supply from extracted solids (fibres, shells, digester solids and empty fruit bunches) and treatment of specific wastewater effluents are taken into account. System boundary is at the oil mill. Remark: Inventory refers to the production of 1 kg palm oil, respectively palm kernel oil and palm kernel meal, from palm oil. The multioutput-process 'palm fruit bunches, in oil mill' delivers the co-products 'palm oil, at oil mill', 'palm kernel oil, at oil mill' and 'palm kernel meal, at oil mill'. Economic allocation with allocation factor of 81.3% to palm oil, 17.3% to palm kernel oil, and 1.4% to palm kernel meal. Allocation of CO2 emissions is done according to carbon balance.; Geography: Data from various literature references (incl. specific Malaysian and Indonesian industrial data)
rape oil, at oil mill/kg/CH	2006	Ecoinvent	kg	Switzerland	Included processes: This process includes the transport of rape seeds to the mill, and the processing of the seeds to rape oil and rape meal. The oil extraction refers to the cold-press extraction technique. System boundary is at the oil mill. Remark: Inventory refers to the production of 1 kg rape oil, respectively rape meal. The multioutput-process 'rape seeds, in oil mill' delivers the co-products 'rape oil, at oil mill' and 'rape meal, at oil mill'. Economic allocation with allocation factor of 74.3% to rape oil. Allocation is done according to carbon balance for CO2 emissions.; Geography: Data from biodiesel producers in CH, industrial data
rape oil, at oil mill/kg/RER	2006	Ecoinvent	kg	Switzerland	Included processes: This process includes the transport of rape seeds to the mill, and the processing of the seeds to rape oil and rape meal. The oil extraction refers to the solvent extraction technique. System boundary is at the oil mill. Remark: Inventory refers to the production of 1 kg rape oil, respectively rape meal. The multioutput-process 'rape seeds, in oil mill' delivers the co-products 'rape oil, at oil mill' and 'rape meal, at oil mill'. Economic allocation with allocation factor of 74.3% to rape oil. Allocation is done according to carbon balance for CO2 emissions.; Geography: Data from different plants worldwide, mostly in Europe (incl. literature data)

Process name	Year	Library	Unit	Country	Description
soya oil, at plant/kg/RER	2004	Ecoinvent	kg	Switzerland	Included processes: The inventory includes the conditioning (but not the drying) of the beans previous extraction. It also includes the production of soya scrap. Remark: Manufacturing process starting with dry soja beans (basically imported from overseas) is considered, plus consumption of auxiliaries, energy, infrastructure and land use, as well as gneration of emissions into air and water. Transport of the raw materials and auxiliaries is also included. The generation of the co-product soya scrap is considered. 28% of the inputs and outputs are allocated to soya oil and 72% to soya scrap. (basing on price) Generation and transportation of solid wastes are not included due to the lack of data. Transport and storage of the final products are not included. Transcient or unstable operations are not considered, but the production during stable operation conditions. Emissions to air are considered as emanating in a high population density area. Emissions into water are assumed to be emitted into rivers. Inventory refers to 1 kg soya oil. The module "pentane" is used to report the consumption of hexane, since the latter is not available in ecoinvent database. Main literature sources are Reusser 1994, Cederberg 1998 and von Däniken et al. 1995.
soybean oil, at oil mill/kg/US	2006	Ecoinvent	kg	Switzerland	Included processes: This process includes the transport of soybeans to the mill, and the processing of soybeans to soybean oil and meal. System boundary is at the oil mill. Remark: Inventory refers to the production of 1 kg soybean oil, respectively soybean meal (incl. hulls). The multioutput-process 'soybeans, in oil mill' delivers the co-products 'soybean oil, at oil mill' and 'soybean meal, at oil mill'. Economic allocation with allocation factor of 34.5% to oil and 65.5 to meal. Allocation is done according to carbon balance for CO2 emissions.; Geography: Data from an industrial oil mill in the US, described in US study

PVC Processes Evaluated (10)

Process name	Year	Library	Unit	Country	Description
Polyvinyl chloride resin, at plant/kg/RNA	2008	U.S. LCI Database	kg	US	Remark: Important note: although most of the data in the US LCI database has undergone some sort of review, the database as a whole has not yet undergone a formal validation process. Please email comments to lci@nrel.gov.; Geography: North America (US and Canada)
Polyvinylchloride resin (B-PVC), bulk polymerisation, production mix, at plant	2010	ELCD 2.0	kg	Italy	Use advice for data set: The LCI data set should be used for LCI/ LCA studies where bulk PVC is used along the production chain.; Technical purpose of product or process: Bulk PVC is used for specific types of hard sheets and bottles.; Technology description including background system: Bulk or mass polymerisation: Unlike suspension or emulsion polymerisation, bulk polymerisation is carried out in the complete absence of water, protective colloids or emulsifying agents. This process relies on the fact that the polymer is insoluble in the monomer and precipitates out to form grains that have no tendency to agglomerate. The main problem is the difficulty in heat removal and this problem is solved by carrying out the polymerisation in two stages. In the first stage, vinyl chloride monomer is mechanically agitated ion a vertical autoclave with the appropriate initiators until a conversion of 7-10% is achieved. This first pre-polymerisation step determines the number of particles that will be formed. Heat is removed by continuously condensing the VCM vapour above the liquid reaction mixture. The pre-polymer is then transferred to a horizontal autoclave equipped with a slow paddle. Here, the particles already formed grow by the formation of further polymer. The process is stopped when 70-90% of the monomer has been converted.
Polyvinylchloride resin (E-PVC), emulsion polymerisation, production mix, at plant	2010	ELCD 2.0	kg	Italy	Use advice for data set: The LCI data set should be used for LCI/ LCA studies where emulsion PVC is used along the production chain.; Technical purpose of product or process: Emulsion PVC is primarily used for coating applications such as PVC coated fabrics.; Technology description including background system: Emulsion polymerisation: In this process, surfactants (soaps) are used to disperse the vinyl chloride monomer in water. The monomer is trapped inside soap micelles are protected by the soap and polymerisation takes place using water soluble initiators. The process can be either continuous or batch but both lead to a polymer latex which is a very fine suspension of polymer particles (~ 0.1µm diameter) in water.

Process name	Year	Library	Unit	Country	Description
PVC (suspension polymerisation) E	2007	PlastEur	kg	Brussels	Production of PVC in a suspension polymerisation process. Suspension PVC is the general purpose grade and is used for most rigid PVC applications and most flexible applications. Typical uses: pipes, profiles, building materials, cable insulation, foils and various product made by injection moulding.
Polyvinylchloride resin (S-PVC), suspension polymerisation, production mix, at plant	2010	ELCD 2.0	kg	Italy	Use advice for data set: The LCI data set should be used for LCI/ LCA studies where suspension PVC is used along the production chain, e.g. sheet calendaring, pipe extrusion, film extrusion or injection moulding, for a product.; Technical purpose of product or process: Suspension PVC is the general purpose grade and is used for most rigid PVC applications such as pipes, profiles, other building materials and hard foils. It is also plasticised and used for most flexible applications such as cable insulation, soft foils and medical products.; Technology description including background system: Suspension polymerisation: Liquid vinyl chloride is insoluble in water and disperses to fine droplets when mechanically agitated. The droplets remain in suspension as long as the agitation continues. Polymerisation is carried out in pressurised vessels under the influence of heat and initiators and/or catalysts, which are soluble in the water. A typical initiator is an organic peroxide. The reaction is exothermic and the heat evolved is carried to the sides of the reaction vessel by the water. Suspensions agents known as protective colloids are added to the reactor to prevent the monomer droplets coalescing and the polymer particles from agglomerating. When the desired conversion is reached, the batch is transferred to a blow down vassel. Several batches may be transferred to this vassel for blending. Unreacted monomer is recovered and recycled back to the polymerisation reactor.
polyvinylchloride, bulk polymerised, at plant/kg/RER	2009	Ecoinvent	kg	Switzerland	Included processes: Data represent a mix of the two other types of PVC (suspension, emulsion PVC), according to their production volumes, due to a lack of respective data from PlasticsEurope about bulk PVC.
polyvinylchloride, emulsion polymerised, at plant/kg/RER	2010	Ecoinvent	kg	Switzerland	Included processes: Aggregated data for all processes from raw material extraction until delivery at plant Remark: Data are from the Eco-profiles of the European plastics industry (PlasticsEurope). Not included are the values reported for: recyclable wastes, amount of air / N2 / O2 consumed, unspecified metal emission to air and to water, mercaptan emission to air, unspecified CFC/HCFC emission to air, dioxin to water. The amount of "sulphur (bonded)" is assumed to be included into the amount of raw oil.

Process name	Year	Library	Unit	Country	Description
polyvinylchloride, suspension polymerised, at plant/kg/RER	2010	Ecoinvent	kg	Switzerland	Included processes: Aggregated data for all processes from raw material extraction until delivery at plant Remark: Data are from the Eco-profiles of the European plastics industry (PlasticsEurope). Not included are the values reported for: recyclable wastes, amount of air / N2 / O2 consumed, unspecified metal emission to air and to water, mercaptan emission to air, unspecified CFC/HCFC emission to air, dioxin to water. The amount of "sulphur (bonded)" is assumed to be included into the amount of raw oil.
PVC (bulk polymerisation) E	2007	PlastEur	kg	Brussels	Production of PVC in a bulk polymerisation process. Typical uses: specific types of hard sheets and bottles.
PVC (emulsion polyerisation) E	2007	PlastEur	kg	Brussels	Production of PVC in an emulsion polymerisation process. Typical uses: coating applications such as PVC coated fabrics.

Gravel Processes Evaluated (8)

Process name	Year	Library	Unit	Country	Description
_14 Clay and soil from quarry, DK	2003	DK Input Output Database 2003	kg	Denmark	The weight of the product is in dry solid (DS). The product in wet weight has DS content: 76%. The production volume of the activity '_14 Clay and soil from quarry, DK' in Denmark is 1144 thousand tonnes (DS). Of the total supply of the product '_14 Clay and soil from quarry, DK' (domestic and imported) 6% is imported. Price information: The price of the product is 0.02 EUR2003 per kg DS. The product category belongs to NACE classification: 14.22. Metadata and literature references are available in the 'System description' of the DK and EU27 IO-databases.
_17 Clay and soil from quarry, EU27	2003	DK Input Output Database 2003	kg	Denmark	The weight of the product is in dry solid (DS). The product in wet weight has DS content: 76%. The production volume of the activity '_17 Clay and soil from quarry, EU27' is 237490 thousand tonnes (DS). The EU27 economy is considered as a closed economy. Consequently there is no distinction between domestic and foreign production. Price information: The price of the product is 0.03 EUR2003 per kg DS. The product category belongs to NACE classification: 14.22. Metadata and literature references are available in the 'System description' of the DK and EU27 IO-databases.
gravel, crushed, at mine/kg/CH	2010	Ecoinvent	kg	Switzerland	Included processes: includes the whole manufacturing process, internal processes (transport, etc.) and infrastructure. No administration is included. Dust emission (particulates >PM10, >PM2.5 <PM10 and <PM2.5) share according to "mining limestone" process. Recultivation is taken into account. Remark: From the total amount (100%) of mined gravel round, crushed and sand, about 15% is crushed gravel. Dust emission size shares (for particulates >PM10, 2.5<PM<10, and <PM2.5) are assumed equal to "mining limestone" process.; Geography: For some exchanges RER-modules have been used as proxy

Process name	Year	Library	Unit	Country	Description
Gravel 2/32, wet and dry quarry, production mix, at plant, undried RER S	2010	ELCD database 2.0	kg	Italy	Use advice for data set: The data set represents a cradle to gate inventory. It can be used to characterise the supply chain situation of the respective commodity in a representative manner. Combination with individual Systemes using this commodity enables the generation of user-specific (product) LCAs.; Technical purpose of product or process: Standard mineral product used as natural aggregates in the construction industry according to the applied technology.; Technology description including background system: The life cycle assessment of sand and gravel covers the quarring of stone and its preparation. The preparation of the raw mineral begins with the washing of the stone grains that have been extracted from the repository. By adding clean water, the raw mineral is released from elutriated constituents such as loam and clay and from foreign substances such as wood, kaolin, coal, metal etc. in various washing stages. It is then sorted by size in vibration sieves or in an upstream classifier. Grits and sand with and SiO2 content greater than 96 % are known as quartz grit and quartz sand (quartz grains). The assessment includes the life cycle from energy generation and raw material supply to the finished product on the factory gate. The infrastructure and the production of the manufacturing facility is not considered. Transports 'gate to building site' are not part of the system and have to be considered afterwards. The background system is addressed as follows: Electricity, Thermal energy: The electricity (and thermal energy as by-product) used is modelled according to the individual country-specific situation. The country-specific modelling is achieved on multiple levels. Firstly the individual power plants in service are modelled according to the current national grid. This includes net losses and imported electricity. Second, the national emission and efficiency standards of the power plants are modelled. Third, the country-specific fuel supply (share of resources used, by import and / or domestic supply) including the country-specific properties (e.g. element and energy contents) are accounted for. Fourth, the import, transport, mining and exploration processes for the energy carrier supply chain are modelled according to the specific situation of each power-producing country. The different mining and exploration techniques (emissions and efficiencies) in the different exploration countries are accounted for according to current engineering knowledge and information. Transports: All relevant and known transport processes used are included. Overseas transport including rail and truck transport to and from major ports for imported bulk resources are included. Furthermore all relevant and known pipeline and / or tanker transport of gases and oil imports are included. Energy carriers: Coal, crude oil, natural gas and uranium are modelled according to the specific import situation (see electricity). Refinery products: Diesel, gasoline, technical gases, fuel oils, basic oils and residues such as bitumen are modelled via a country-specific, refinery parameterized model. The refinery model represents the current national standard in refinery techniques (e.g. emission level, internal energy consumption,...) as well as the individual

Process name	Year	Library	Unit	Country	Description
Sand 0/2, wet and dry quarry, production mix, at plant, undried RER S	2010	ELCD database 2.0	kg	Italy	Use advice for data set: The data set represents a cradle to gate inventory. It can be used to characterise the supply chain situation of the respective commodity in a representative manner. Combination with individual Systemes using this commodity enables the generation of user-specific (product) LCAs.; Technical purpose of product or process: Standard mineral product used as natural aggregates in the construction industry according to the applied technology.; Technology description including background system: The life cycle assessment of sand and gravel covers the quarring of stone and its preparation. The preparation of the raw mineral begins with the washing of the stone grains that have been extracted from the repository. By adding clean water, the raw mineral is released from elutriated constituents such as loam and clay and from foreign substances such as wood, kaolin, coal, metal etc. in various washing stages. It is then sorted by size in vibration sieves or in an upstream classifier. Grits and sand with and SiO_2 content greater than 96 % are known as quartz grit and quartz sand (quartz grains). The assessment includes the life cycle from energy generation and raw material supply to the finished product on the factory gate. The infrastructure and the production of the manufacturing facility is not considered. Transports 'gate to building site' are not part of the system and have to be considered afterwards. The background system is addressed as follows: Electricity, Thermal energy: The electricity (and thermal energy as by-product) used is modelled according to the individual country-specific situation. The country-specific modelling is achieved on multiple levels. Firstly the individual power plants in service are modelled according to the current national grid. This includes net losses and imported electricity. Second, the national emission and efficiency standards of the power plants are modelled. Third, the country-specific fuel supply (share of resources used, by import and / or domestic supply) including the country-specific properties (e.g. element and energy contents) are accounted for. Fourth, the import, transport, mining and exploration processes for the energy carrier supply chain are modelled according to the specific situation of each power-producing country. The different mining and exploration techniques (emissions and efficiencies) in the different exploration countries are accounted for according to current engineering knowledge and information. Transports: All relevant and known transport processes used are included. Overseas transport including rail and truck transport to and from major ports for imported bulk resources are included. Furthermore all relevant and known pipeline and / or tanker transport of gases and oil imports are included. Energy carriers: Coal, crude oil, natural gas and uranium are modelled according to the specific import situation (see electricity). Refinery products: Diesel, gasoline, technical gases, fuel oils, basic oils and residues such as bitumen are modelled via a country-specific, refinery parameterized model. The refinery model represents the current national standard in refinery techniques (e.g. emission level, internal energy consumption,...) as well as the individual

Process name	Year	Library	Unit	Country	Description
gravel, unspecified, at mine/kg/CH	2003	Ecoinvent	kg	Switzerland	Included processes: includes the whole manufacturing process, internal processes (transport, etc.) and infrastructure. No administration is included. Recultivation is taken into account. Remark: Mix of round and crushed gravel, allocation based on production of 4 swiss gravel plants: 79% round gravel and 21% crushed gravel; Geography: For some exchanges RER-modules have been used as proxy
sand, at mine/kg/CH	2010	Ecoinvent	kg	Switzerland	Included processes: Includes the whole manufacturing process for digging of gravel round and sand (no crushed gravel), internal processes (transport, etc.), and infrastructure for the operation (machinery). The land-use of the mine (incl. unpaved roads) is included directly, while the land-use of the paved roads and buildings are included in the module "mine, gravel/sand". Recultivation of closed mines is taken into account. No environmental burdens from administration are included. No dust included because it is mostly a "wet" process and no wastewater included because process water is not polluted (only sand and gravel) and therefore directly seeped. Remark: The multioutput-process 'mining, gravel / sand' delivers the co-products 'sand, at mine' and 'gravel, round, at mine'. The typical production mix in Switzerland is: sand 35% and round gravel 65%. From the total sectoral production volume (100%) of mined gravel round, crushed and sand, about 85% is gravel round and sand. ; Geography: For some exchanges RER-modules have been used as proxy
gravel, round, at mine/kg/CH	2010	Ecoinvent	kg	Switzerland	Included processes: Includes the whole manufacturing process for digging of gravel round and sand (no crushed gravel), internal processes (transport, etc.), and infrastructure for the operation (machinery). The land-use of the mine (incl. unpaved roads) is included directly, while the land-use of the paved roads and buildings are included in the module "mine, gravel/sand". Recultivation of closed mines is taken into account. No environmental burdens from administration are included. No dust included because it is mostly a "wet" process and no wastewater included because process water is not polluted (only sand and gravel) and therefore directly seeped. Remark: The multioutput-process 'mining, gravel / sand' delivers the co-products 'sand, at mine' and 'gravel, round, at mine'. The typical production mix in Switzerland is: sand 35% and round gravel 65%. From the total sectoral production volume (100%) of mined gravel round, crushed and sand, about 85% is gravel round and sand. ; Geography: For some exchanges RER-modules have been used as proxy

Cement Processes Evaluated (9)

Process name	Year	Library	Unit	Country	Description
_45 Cement, virgin, DK	2003	DK Input Output Database 2003	kg	Denmark	The weight of the product is in dry solid (DS). The product in wet weight has DS content: 100%. The production volume of the activity '_45 Cement, virgin, DK' in Denmark is 2001 thousand tonnes (DS). Of the total supply of the product '_45 Cement, virgin, DK' (domestic and imported) 14% is imported. Price information: The price of the product is 0.08 EUR2003 per kg DS. The product category belongs to NACE classification: 26.5(disaggr.). Metadata and literature references are available in the 'System description' of the DK and EU27 IO-databases.
blast furnace slag cement, at plant/kg/CH	2004	Ecoinvent	kg	Switzerland	Included processes: includes the manufacturing processes mixing and grinding, internal processes (transport, etc.) and infrastructure. No administration and no packing is included. Special inputs: blast furnace slag, not balanced as it is waste from iron production. Remark: Part of total Swiss cement production: 2%. Composition: gypsum 4%, blast furnace slag 50%, clinker 46%; Geography: For some exchanges RER-modules have been used as proxy
cement, unspecified, at plant/kg/CH	2004	Ecoinvent	kg	Switzerland	Included processes: mix of different types of cement, based on CH statistics: 2% blast furnace slag cement, 50% portland calcareous cement, 40% portland cement, resistance class Z 42.5, 6% portland cement, resistance class Z 52.5, 2% portland slag sand cement; Geography: For some exchanges RER-modules have been used as proxy
portland calcareous cement, at plant/kg/CH	2004	Ecoinvent	kg	Switzerland	Included processes: includes the manufacturing processes mixing and grinding, internal processes (transport, etc.) and infrastructure (specific machines and plant). No administration and no packing is included. Special inputs: additional milling substances for example dust from the cement rotary kiln, fly ash, silica dust, limestone; these are not balanced as they are wastes to which no burdens are allocated within ecoinvent. Remark: Part of total Swiss cement production: 50%. Composition: gypsum 5%, additional milling substances 16%, clinker 79%; Geography: For some exchanges RER-modules have been used as proxy

Process name	Year	Library	Unit	Country	Description
portland slag sand cement, at plant/kg/CH	2004	Ecoinvent	kg	Switzerland	Included processes: includes the manufacturing processes mixing and grinding, internal processes (transport, etc.) and infrastructure (specific machines and plant). No administration and no packing is included. Special inputs: blast furnace slag, not balanced as it is waste from iron production Remark: Part of total Swiss cement production: 2%. Composition: gypsum 5%, blast furnace slag 19%, clinker 76%; Geography: For some exchanges RER-modules have been used as proxy
Portland cement, at plant/kg/US	2008	U.S. LCI Database	kg	US	Included processes: (1) Quarry and crush: extracting raw material from the earth, crushing to 5-cm (2-inch) pieces, and conveying and stockpiling. (2) Raw meal preparation: recovering materials from stockpiles, proportioning to the correct chemical composition, and grinding and blending. (3) Pyroprocess: processing raw meal to remove water, calcining limestone and causing the mix components to react to form clinker, cooling and storing the clinker. (4) Finish grind: reclaiming the clinker from storage, adding gypsum and grinding to a fine powder, and conveying to storage. It also includes transporting all fuel and materials from their source to the cement plant. That is, it includes the emissions, such as from burning fuel in internal combustion engines, to transport the materials to the cement plant. It also includes combustion of fuel in the cement kiln. Remark: Portland cement is a hydraulic cement composed primarily of hydraulic calcium silicates. Hydraulic cements harden by reacting chemically with water. During this reaction, cement combines with water to form a stonelike mass, called paste. When the paste (cement and water) is added to aggregates (sand and gravel, crushed stone, or other granular materials) it binds the aggregates together to form concrete, the most widely used construction material. Although the words “cement” and “concrete” are used interchangeably in everyday usage, cement is one of the constituents of concrete. Cement is a very fine powder and concrete is a stonelike material. Cement constitutes 8 to 15 percent of concrete’s total mass by weight. Using cement LCI data incorrectly as concrete LCI data is a serious error., 2002 for fuels and electricity consumption; 2000 for raw material consumption and transportation modes and distances; and 1993 to 2004 for emissions. Important note: although most of the data in the US LCI database has undergone some sort of review, the database as a whole has not yet undergone a formal validation process. Please email comments to lci@nrel.gov.; Geography: United States.

Process name	Year	Library	Unit	Country	Description
Portland cement (CEM I), CEMBUREAU technology mix, EN 197-1, CEMBUREAU production	2010	ELCD 2.0	kg		Use advice for data set: The data should be used in LCA studies where Portland cement is used within the product chain. Transportation of Portland cement from the cement plant and any further use has to be taken into account additionally since the data base on a cradle-to-gate approach. The inputs secondary fuel, secondary fuel renewable and gypsum suspension as well as waste (unspecific) are considered as environmental burden free and none upstream processes have to be connected to this data set.; Technical purpose of product or process: Portland cement (CEM I) is used as binding material in the construction sector in particular as essential constituent of concrete and mortar.; Technology description including background system: Cement is a hydraulic binder, i.e. a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water. Portland cement (CEM I) consists of Portland cement clinker and minor additional constituents whereas Portland cement clinker has at least a part of 95% of the sum of both. Additionally calcium sulphate is added to the other constituents of Portland cement (CEM I) during its manufacture to control its setting. Raw material extraction, raw meal preparation, clinker burning, cement grinding and dispatch are included in the consideration of the cement plant. The different common technologies for clinker burning (dry process, semi-dry/semi-wet process, wet process) have been taken into account. Furthermore, the supply (extraction, preparation, transport) of raw materials, fuels, and electricity is included. The background system is addressed as follows: Electricity: CEMBUREAU specific electricity mix was used based on the electricity mix of CEMBUREAU member countries (ELCD data) in proportion to their relative cement production. Data sets from the GaBi databases 2006 were used in very few cases where such data were not available. Transports: All relevant and known transport processes are included using ELCD data. Energy carriers and raw materials are modelled according to the specific situation in Europe by using the ELCD database. Data sets of the GaBi databases 2006 were used in case ELCD data were not available.

Process name	Year	Library	Unit	Country	Description
portland cement, strength class Z 42.5, at plant/kg/CH	2004	Ecoinvent	kg	Switzerland	Included processes: includes the manufacturing processes mixing and grinding, internal processes (transport, etc.) and infrastructure (specific machines and plant). No administration and no packing is included. Special inputs: additional milling substances for example dust from the cement rotary kiln, fly ash, silica dust, limestone; these are not balanced as they are wastes to which no burdens are allocated within ecoinvent. Remark: Part of total Swiss cement production: 40%. Composition: gypsum 5%, additional milling substances 5%, clinker 90%; Geography: For some exchanges RER-modules have been used as proxy
portland cement, strength class Z 52.5, at plant/kg/CH	2004	Ecoinvent	kg	Switzerland	Included processes: includes the manufacturing processes mixing and grinding, internal processes (transport, etc.) and infrastructure (specific machines and plant). No administration and no packing is included. Special inputs: additional milling substances for example dust from the cement rotary kiln, fly ash, silica dust, limestone; these are not balanced as they are wastes to which no burdens are allocated within ecoinvent. Remark: Part of total Swiss cement production: 6%. Composition: gypsum 6%, additional milling substances 3%, clinker 91%; Geography: For some exchanges RER-modules have been used as proxy

Selected Charts with SiteWise™ Results

The comparison charts below include the following information for each material:

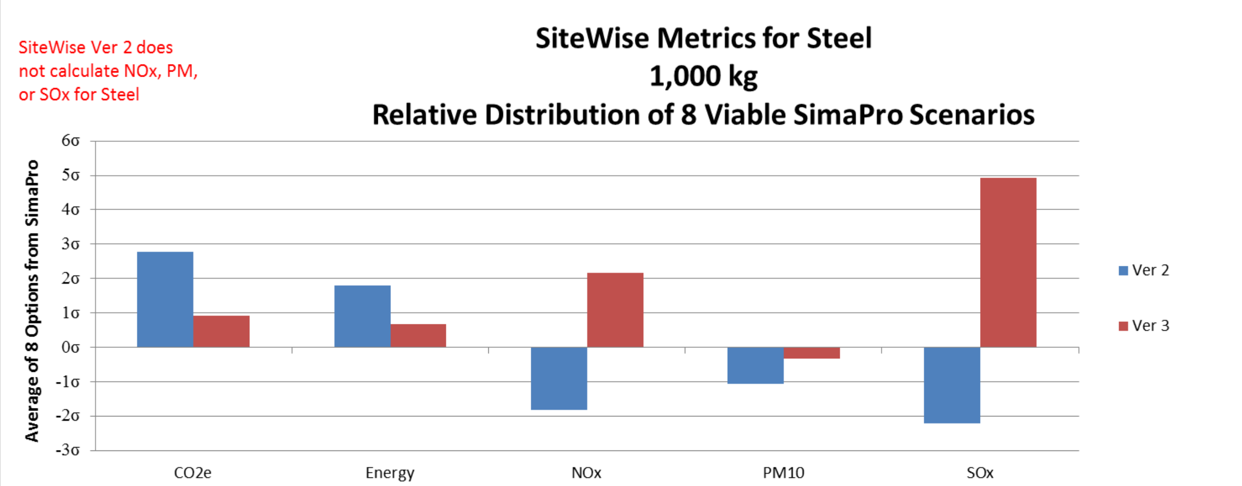
- Tables that indicate the average, median, minimum, maximum, and standard deviation of the SimaPro® results for the five sustainability metrics (CO2e, energy, NOx, PM, and SOx) for the range of processes selected, as well as the results for SiteWise™.

- A chart that illustrates the SiteWise™ results, in units of standard deviations away from the average SimaPro® result (i.e., a value of 1σ indicates the SiteWise™ result is higher than the average SimaPro® result by 1 standard deviation, as determined from the variability of the SimaPro® results).

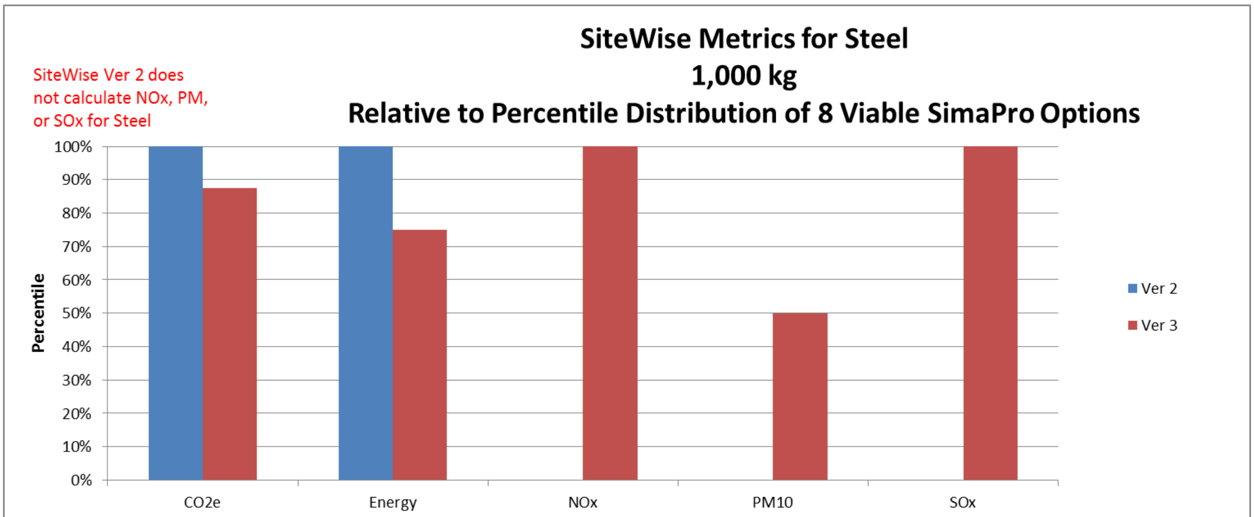
- A second chart that illustrates if the SiteWise™ results are near the high end or low end of the SimaPro® results based on percentile distribution (i.e., a value of 40% indicates the SiteWise™ result is higher than 40% of the SimaPro® results).

For some of the selected materials, SiteWise™ Version 2 did not calculate footprints for one or more of the sustainability metrics, though that was eliminated in Version 3 by the tool improvements made during this project. There are some instances where the footprint from the DoD tool falls within the range of the SimaPro® results. However, in some cases the footprint from the DoD tool is higher than the highest value in the range of SimaPro® results or lower than the lowest value in the range of SimaPro® results. Overall, these results indicate that comparison of results from SiteWise™ to SimaPro® is highly complex, and is perhaps not possible in an absolute sense because of the many potential choices available for processes in SimaPro® and the associated variability in the footprints calculated by SimaPro®.

Steel



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 8 SimaPro Options	1.292	17.403	0.00243	0.00259	0.00275
St. Dev. Of 8 SimaPro Options	0.516	8.423	0.00133	0.00243	0.00124
Min. of 8 Simapro Options	0.420	8.449	0.00098	0.00003	0.00112
Max. of 8 SimaPro Options	2.042	29.305	0.00451	0.00648	0.00485
Sitewise Version 2	2.719	32.643	0.00000	0.00000	0.00000
Sitewise Version 3	1.770	23.127	0.00531	0.00177	0.00885

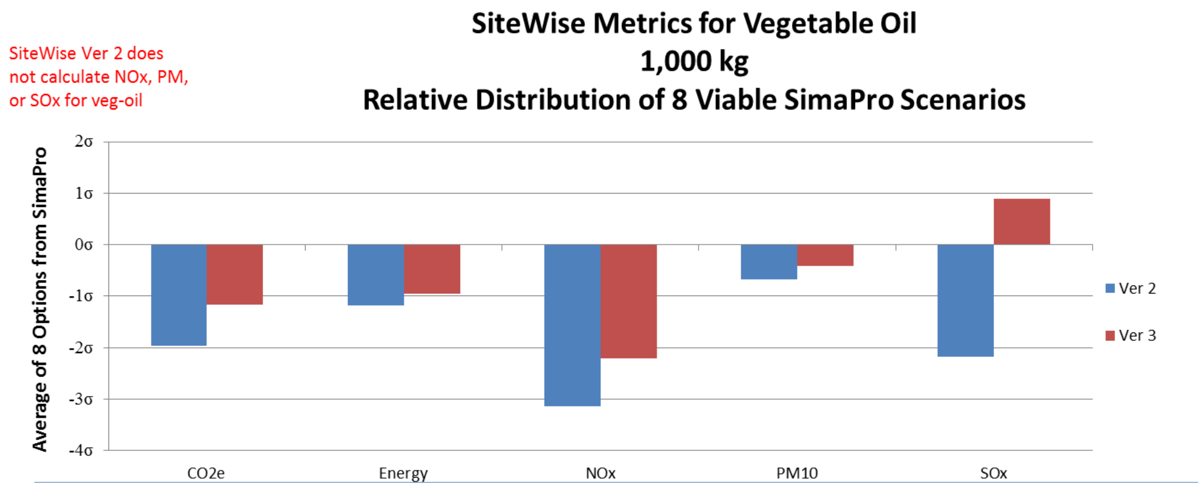


	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 8 SimaPro Options	1.299	16.492	0.00230	0.00203	0.00253
Min. of 8 SimaPro Options	0.420	8.449	0.00098	0.00003	0.00112
Max. of 8 SimaPro Options	2.042	29.305	0.00451	0.00648	0.00485
SiteWise Version 2	2.719	32.643	0.00000	0.00000	0.00000
SiteWise Version 3	1.770	23.127	0.00531	0.00177	0.00885

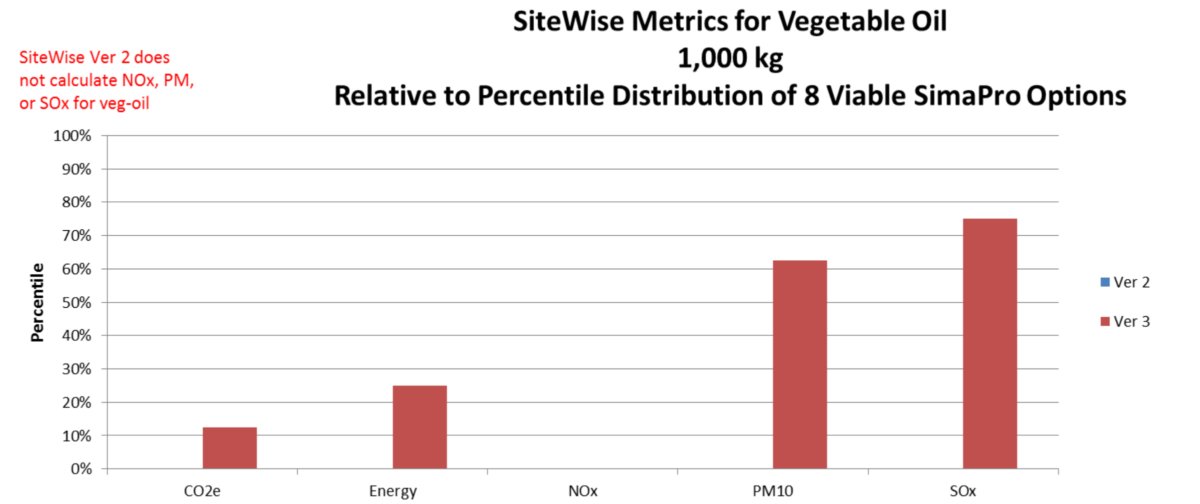
Notes:

- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.
- On the bottom chart there is no bar plotted for sustainability metric if the SiteWise result is lower than the smallest SimaPro result.

Vegetable Oil



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 8 SimaPro Options	1.657	52.644	0.00578	0.00184	0.00245
St. Dev. Of 8 SimaPro Options	0.676	37.749	0.00184	0.00273	0.00113
Min. of 8 Simapro Options	0.689	8.334	0.00221	0.00017	0.00107
Max. of 8 SimaPro Options	2.724	123.080	0.00789	0.00762	0.00389
Sitewise Version 2	0.330	8.056	0.00000	0.00000	0.00000
Sitewise Version 3	0.865	16.402	0.00173	0.00069	0.00346



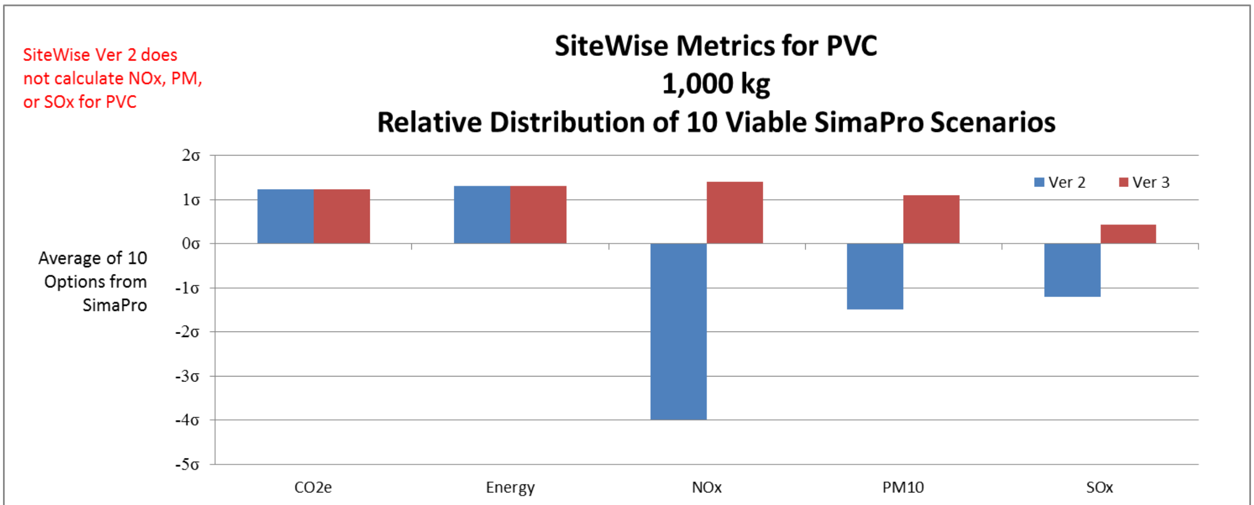
	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 8 SimaPro Options	1.853	51.560	0.00651	0.00059	0.00243
Min. of 8 SimaPro Options	0.689	8.334	0.00221	0.00017	0.00107
Max. of 8 SimaPro Options	2.724	123.080	0.00789	0.00762	0.00389
SiteWise Version 2	0.330	8.056	0.00000	0.00000	0.00000
SiteWise Version 3	0.865	16.402	0.00173	0.00069	0.00346

Notes:

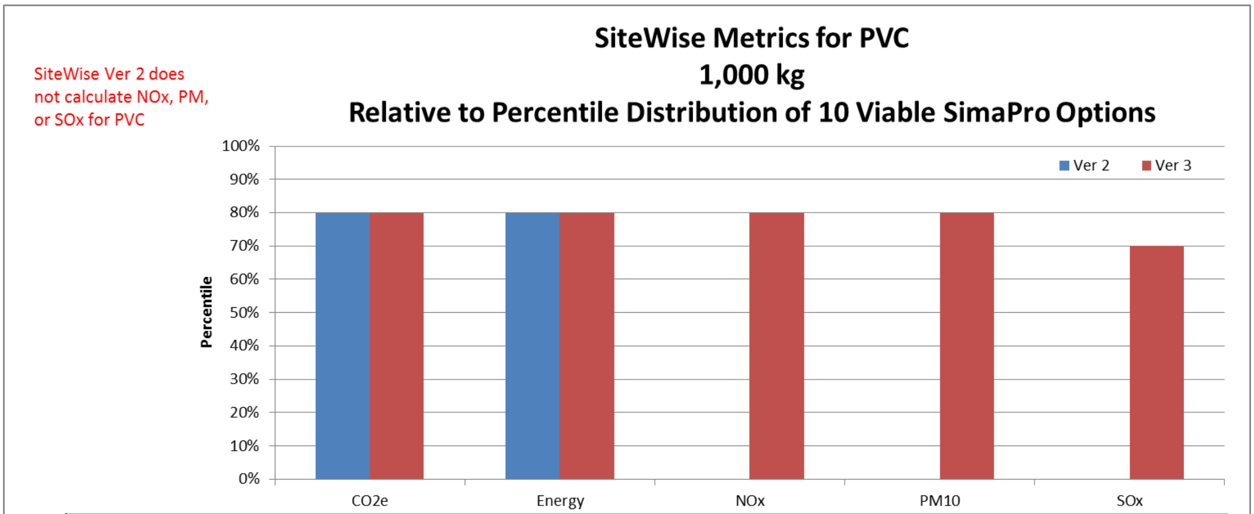
- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.

- On the bottom chart there is no bar plotted for sustainability metric if the SiteWise result is lower than the smallest SimaPro result.

PVC



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 10 SimaPro Options	2.318	56.750	0.00444	0.00080	0.00712
St. Dev. Of 10 SimaPro Options	0.638	5.555	0.00111	0.00054	0.00593
Min. of 10 Simapro Options	1.556	49.005	0.00311	0.00016	0.00261
Max. of 10 SimaPro Options	3.254	65.066	0.00626	0.00158	0.02170
Sitewise Version 2	3.109	63.978	0.00000	0.00000	0.00000
Sitewise Version 3	3.109	63.978	0.00600	0.00140	0.00970

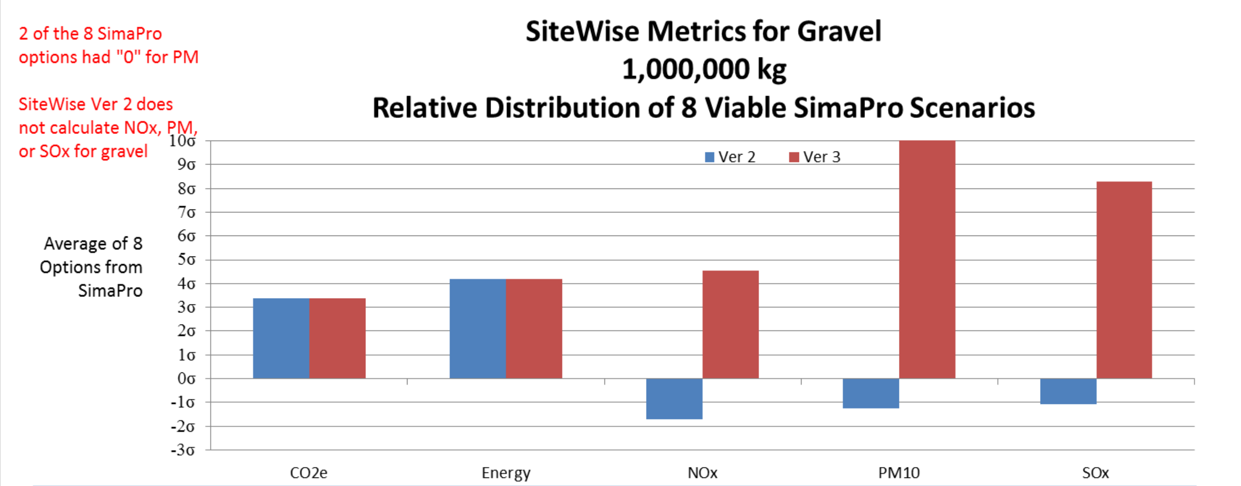


	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 10 SimaPro Options	2.249	56.867	0.00419	0.00054	0.00551
Min. of 10 SimaPro Options	1.556	49.005	0.00311	0.00016	0.00261
Max. of 10 SimaPro Options	3.254	65.066	0.00626	0.00158	0.02170
SiteWise Version 2	3.109	63.978	0.00000	0.00000	0.00000
SiteWise Version 3	3.109	63.978	0.00600	0.00140	0.00970

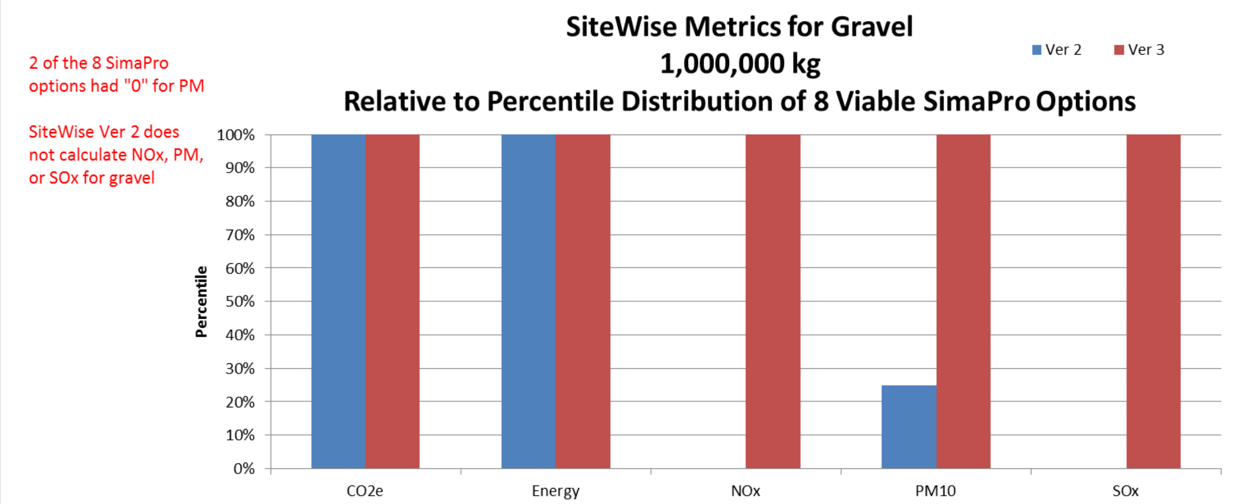
Notes:

- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.
- On the bottom chart there is no bar plotted for sustainability metric if the SiteWise result is lower than the smallest SimaPro result.

GRAVEL



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 8 SimaPro Options	3.861	71.929	0.01864	0.00193	0.00973
St. Dev. Of 8 SimaPro Options	3.903	50.697	0.01091	0.00153	0.00907
Min. of 8 Simapro Options	0.048	0.630	0.00027	0.00000	0.00004
Max. of 8 SimaPro Options	13.037	160.538	0.04022	0.00451	0.02933
Sitewise Version 2	17.000	284.345	0.00000	0.00000	0.00000
Sitewise Version 3	17.000	284.345	0.06800	0.03400	0.08500

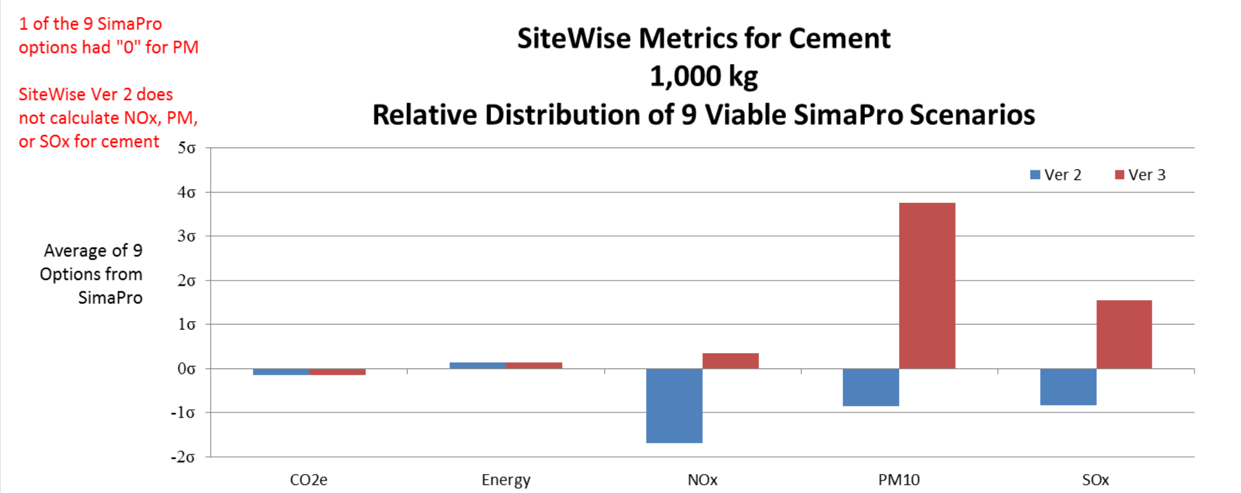


	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 8 SimaPro Options	2.628	57.759	0.01803	0.00204	0.00752
Min. of 8 SimaPro Options	0.048	0.630	0.00027	0.00000	0.00004
Max. of 8 SimaPro Options	13.037	160.538	0.04022	0.00451	0.02933
SiteWise Version 2	17.000	284.345	0.00000	0.00000	0.00000
SiteWise Version 3	17.000	284.345	0.06800	0.03400	0.08500

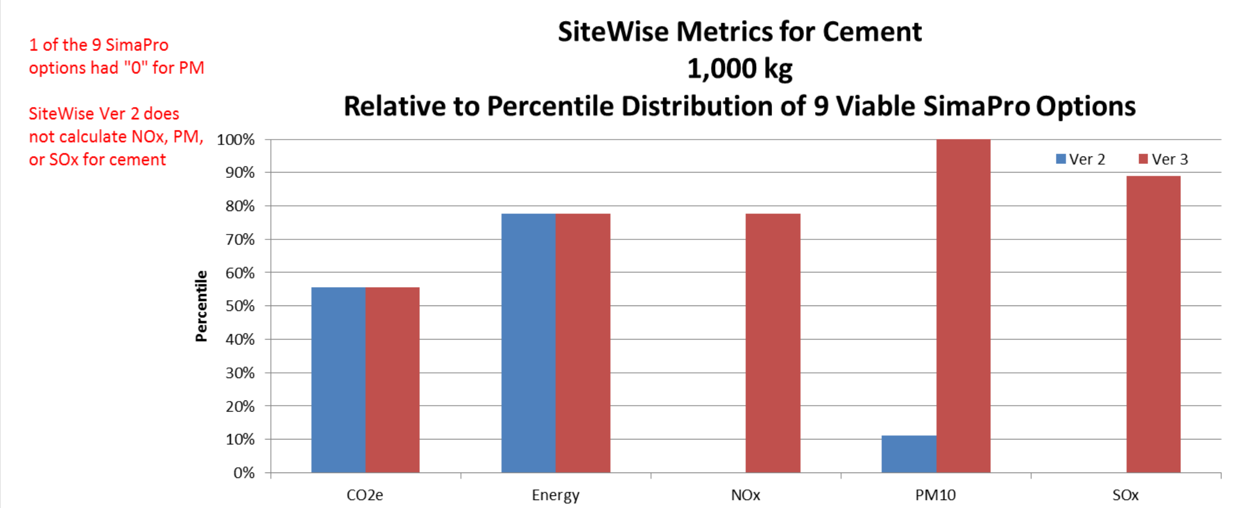
Notes:

- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.
- On the bottom chart there is no bar plotted for sustainability metric if the SiteWise result is lower than the smallest SimaPro result.

CEMENT



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 9 SimaPro Options	0.872	4.134	0.00141	0.00013	0.00116
St. Dev. Of 9 SimaPro Options	0.291	1.699	0.00083	0.00015	0.00139
Min. of 9 Simapro Options	0.445	2.705	0.00070	0.00000	0.00031
Max. of 9 SimaPro Options	1.370	8.356	0.00350	0.00052	0.00433
Sitewise Version 2	0.830	4.360	0.00000	0.00000	0.00000
Sitewise Version 3	0.830	4.360	0.00170	0.00070	0.00330



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 9 SimaPro Options	0.821	3.600	0.00114	0.00010	0.00044
Min. of 9 SimaPro Options	0.445	2.705	0.00070	0.00000	0.00031
Max. of 9 SimaPro Options	1.370	8.356	0.00350	0.00052	0.00433
SiteWise Version 2	0.830	4.360	0.00000	0.00000	0.00000
SiteWise Version 3	0.830	4.360	0.00170	0.00070	0.00330

Notes:

- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.
- On the bottom chart there is no bar plotted for sustainability metric if the SiteWise result is lower than the smallest SimaPro result.

Selected Charts with SRT™ Results

The comparison charts below include the following information for each material:

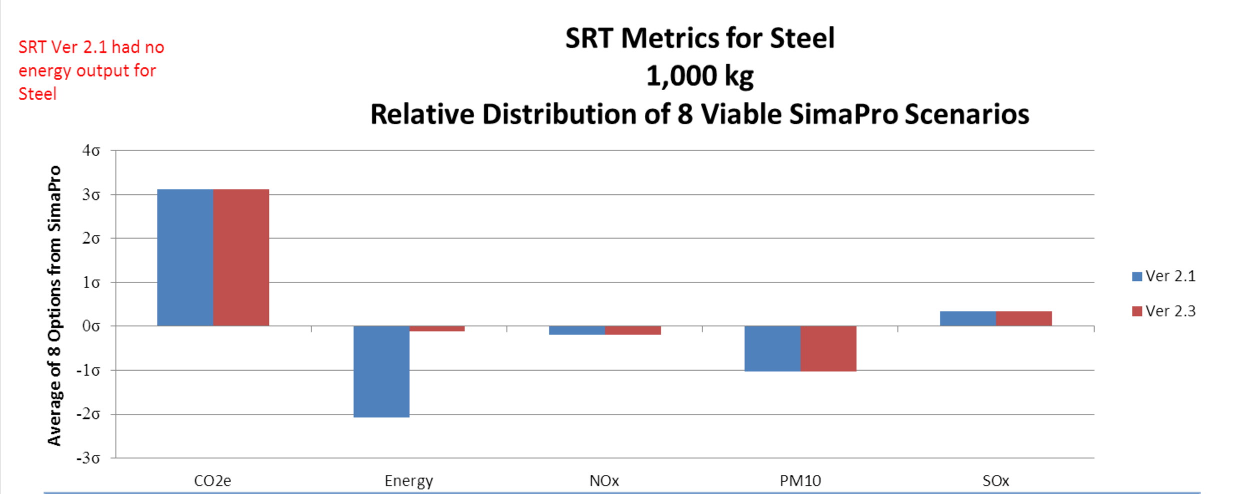
- Tables that indicate the average, median, minimum, maximum, and standard deviation of the SimaPro® results for the five sustainability metrics (CO2e, energy, NOx, PM, and SOx) for the range of processes selected, as well as the results for SRT™.

- A chart that illustrates the SRT™ results, in units of standard deviations away from the average SimaPro® result (i.e., a value of 1σ indicates the SRT™ result is higher than the average SimaPro® result by 1 standard deviation, as determined from the variability of the SimaPro® results).

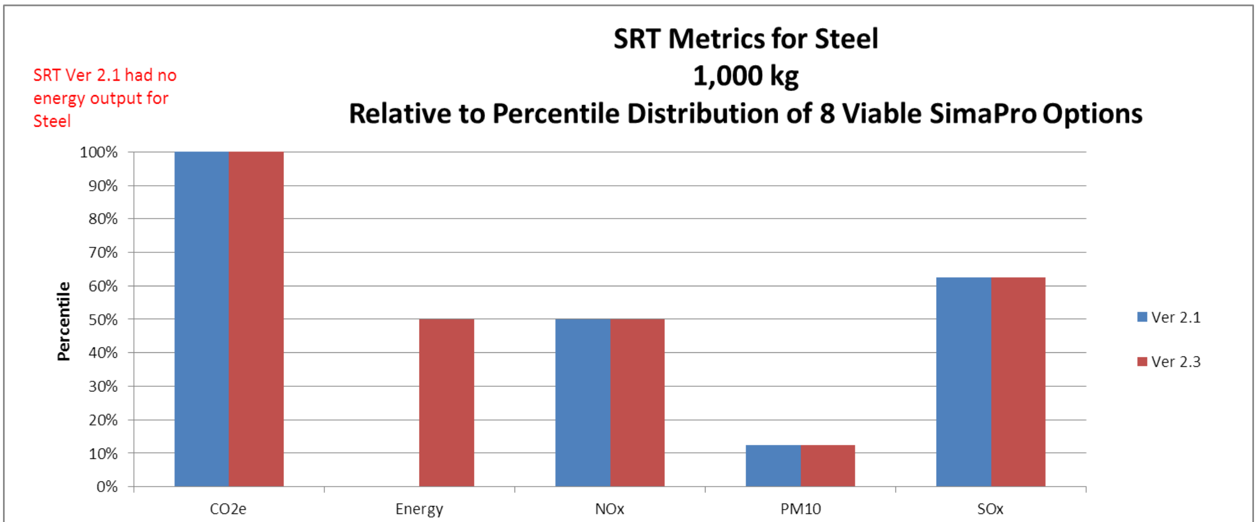
- A second chart that illustrates if the SRT™ results are near the high end or low end of the SimaPro® results based on percentile distribution (i.e., a value of 40% indicates the SRT™ result is higher than 40% of the SimaPro® results).

For some of the selected materials, SRT™ did not calculate footprints for one or more of the sustainability metrics. There are some instances where the footprint from the DoD tool falls within the range of the SimaPro® results. However, in some cases the footprint from the DoD tool is higher than the highest value in the range of SimaPro® results or lower than the lowest value in the range of SimaPro® results. Overall, these results indicate that comparison of results from SRT™ to SimaPro® is highly complex, and is perhaps not possible in an absolute sense because of the many potential choices available for processes in SimaPro® and the associated variability in the footprints calculated by SimaPro®.

Steel



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 8 SimaPro Options	1.292	17.403	0.00243	0.00259	0.00275
St. Dev. Of 8 SimaPro Options	0.516	8.423	0.00133	0.00243	0.00124
Min. of 8 Simapro Options	0.420	8.449	0.00098	0.00003	0.00112
Max. of 8 SimaPro Options	2.042	29.305	0.00451	0.00648	0.00485
SRT Version 2.1	2.903	0.000	0.00218	0.00009	0.00318
SRT Version 2.3	2.903	16.507	0.00218	0.00009	0.00318

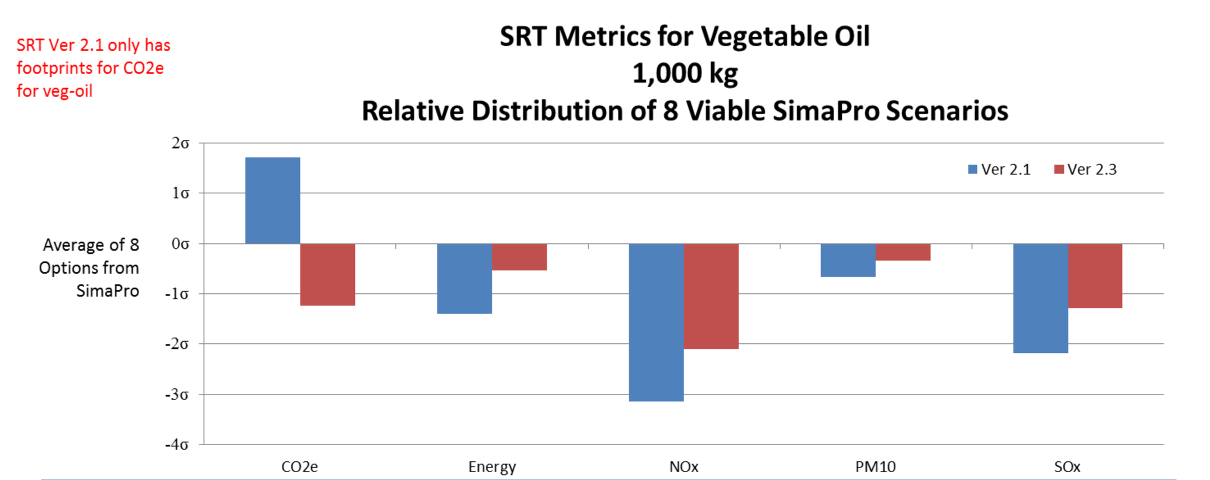


	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 8 SimaPro Options	1.299	16.492	0.00230	0.00203	0.00253
Min. of 8 SimaPro Options	0.420	8.449	0.00098	0.00003	0.00112
Max. of 8 SimaPro Options	2.042	29.305	0.00451	0.00648	0.00485
SRT Version 2.1	2.903	0.000	0.00218	0.00009	0.00318
SRT Version 2.3	2.903	16.507	0.00218	0.00009	0.00318

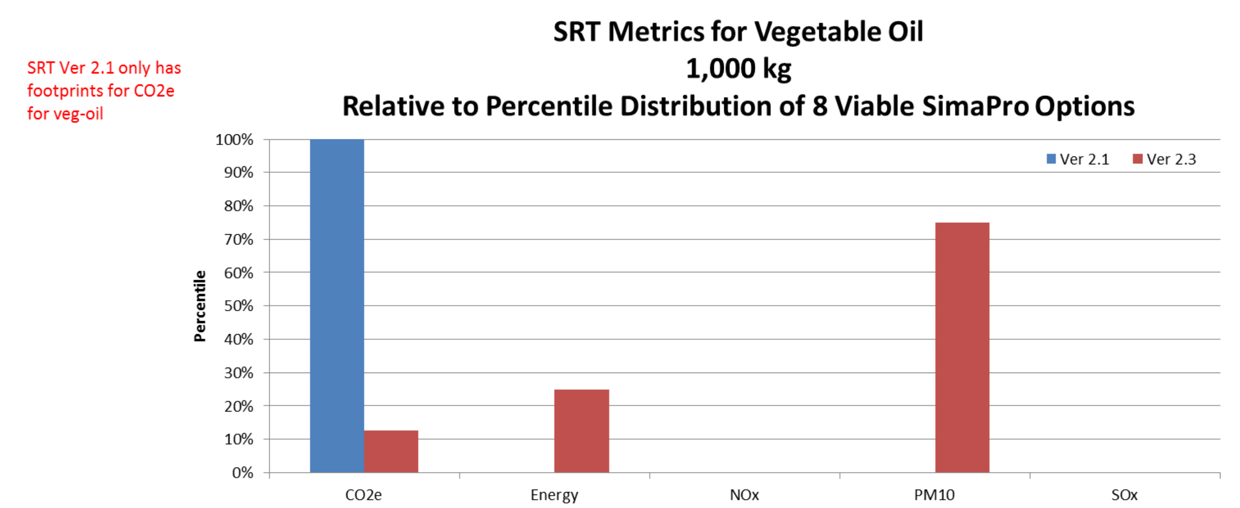
Notes:

- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.
- On the bottom chart there is no bar plotted for sustainability metric if the SRT result is lower than the smallest SimaPro result.

Vegetable Oil



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 8 SimaPro Options	1.657	52.644	0.00578	0.00184	0.00245
St. Dev. Of 8 SimaPro Options	0.676	37.749	0.00184	0.00273	0.00113
Min. of 8 Simapro Options	0.689	8.334	0.00221	0.00017	0.00107
Max. of 8 SimaPro Options	2.724	123.080	0.00789	0.00762	0.00389
SRT Version 2.1	2.812	0.000	0.00000	0.00000	0.00000
SRT Version 2.3	0.816	32.389	0.00191	0.00091	0.00100

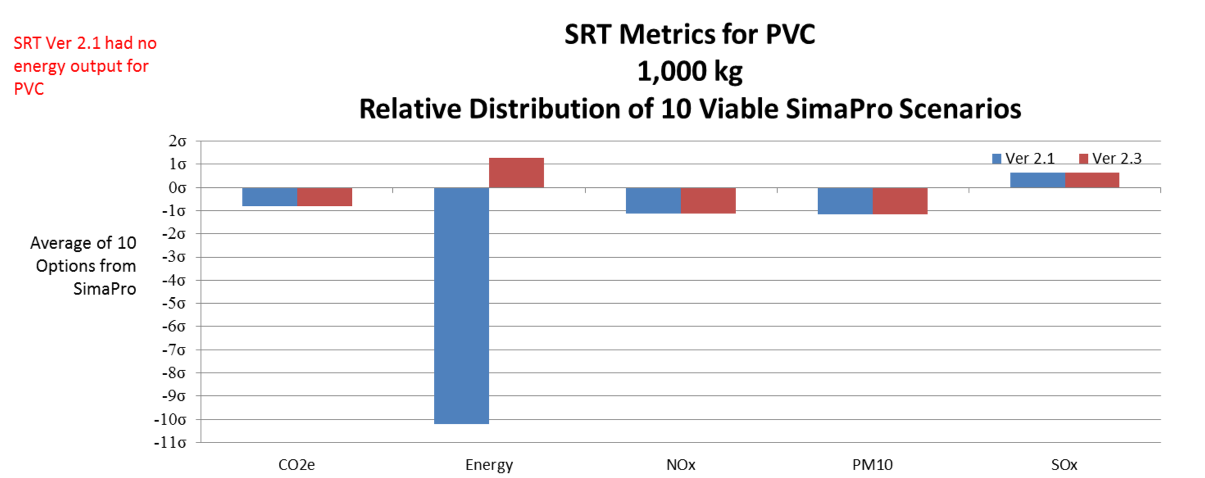


	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 8 SimaPro Options	1.853	51.560	0.00651	0.00059	0.00243
Min. of 8 SimaPro Options	0.689	8.334	0.00221	0.00017	0.00107
Max. of 8 SimaPro Options	2.724	123.080	0.00789	0.00762	0.00389
SRT Version 2.1	2.812	0.000	0.00000	0.00000	0.00000
SRT Version 2.3	0.816	32.389	0.00191	0.00091	0.00100

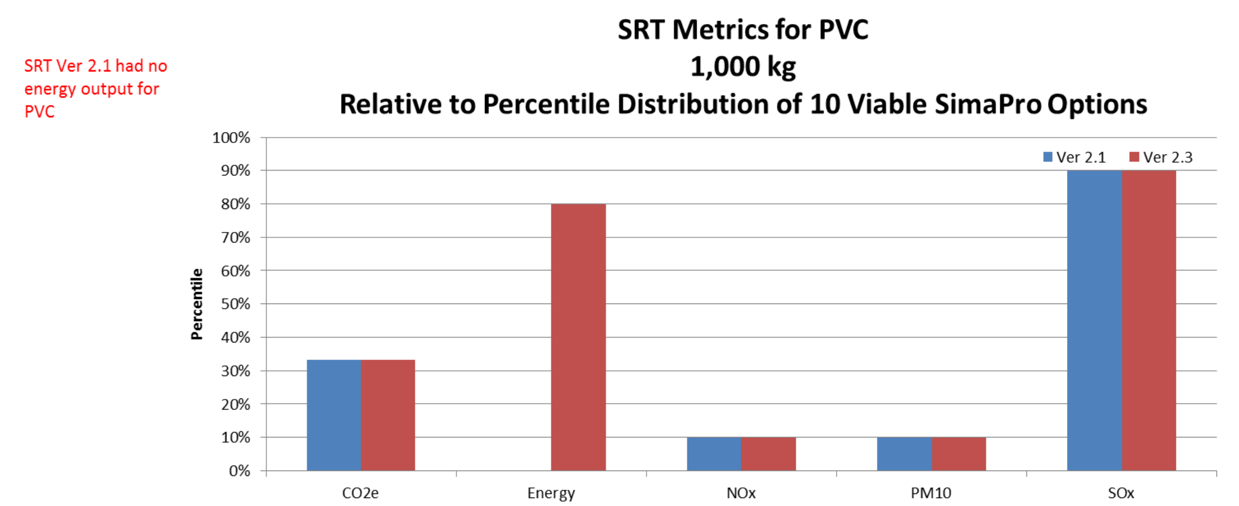
Notes:

- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.
- On the bottom chart there is no bar plotted for sustainability metric if the SRT result is lower than the smallest SimaPro result.

PVC



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Average of 10 SimaPro Options	2.318	56.750	0.00444	0.00080	0.00712
St. Dev. Of 10 SimaPro Options	0.638	5.555	0.00111	0.00054	0.00593
Min. of 10 Simapro Options	1.556	49.005	0.00311	0.00016	0.00261
Max. of 10 SimaPro Options	3.254	65.066	0.00626	0.00158	0.02170
SRT Version 2.1	1.814	0.000	0.00318	0.00018	0.01089
SRT Version 2.3	1.814	63.941	0.00318	0.00018	0.01089



	CO2e (MT)	Energy (MMBTU)	Nox (MT)	PM10 (MT)	SOx (MT)
Median of 10 SimaPro Options	2.512	56.867	0.00419	0.00054	0.00551
Min. of 10 SimaPro Options	1.582	49.005	0.00311	0.00016	0.00261
Max. of 10 SimaPro Options	3.254	65.066	0.00626	0.00158	0.02170
SRT Version 2.1	1.814	0.000	0.00318	0.00018	0.01089
SRT Version 2.3	1.814	63.941	0.00318	0.00018	0.01089

Notes:

- If footprints for one or more of the sustainability metrics were not calculated by the specific version of the tool it is highlighted in yellow.
- On the bottom chart there is no bar plotted for sustainability metric if the SRT result is lower than the smallest SimaPro result.

APPENDIX I:

Specific LCI Process Data Sources Used for Developing Chart for Generic Materials (Table 16)

APPENDIX I:
SPECIFIC LCI PROCESS DATA SOURCES USED FOR DEVELOPING CHART FOR GENERIC MATERIALS (TABLE 16)

The following table summarizes the specific process data sources extracted from within the SimaPro LCA tool that were used to generate the chart for generic materials shown in the final report (Table 16). Columns are defined as follows:

- The **Material** identifies the general type the material.
- The **Process Name** refers to the name of the process in the SimaPro tool that was selected to represent the material.
- The **Category** refers to the category within the SimaPro browsing function.
- The **Library** refers to which of the LCI databases the **Process Name** is sourced from (typically the ecoinvent library).
- The **Description** is the metadata available for the Process Name and is directly copied from SimaPro.

No attempt is made to formally format this table or to identify all abbreviations in the SimaPro descriptions.

Material	Process Name	Category	Library	Description
Cement	Cement, unspecified, at plant/CH S	Construction\ Binders	Ecoinvent system processes	Translated name: Zement, unspezifisch, ab Werk Included processes: mix of different types of cement, based on CH statistics: 2% blast furnace slag cement, 50% portland calcareous cement, 40% portland cement, resistance class Z 42.5, 6% portland cement, resistance class Z 52.5, 2% portland slag sand cement; Geography: For some exchanges RER-modules have been used as proxy Technology: Typical technology for Swiss production Version: 2.2 Synonyms: Fabrik, Betrieb, company, firmmineralisch, Isolation, Dämm, matte, platte, mineral, insulation, mat, board Energy values: Undefined Percent representativeness: 100.0 Production volume: 2688303 t/a Local category: Mineralische Baustoffe Local subcategory: Bindemittel Source file: 00484.XML

Material	Process Name	Category	Library	Description
Sand	Sand, at mine/CH S	Minerals	Ecoinvent system processes	Translated name: Sand, ab Abbau Included processes: Includes the whole manufacturing process for digging of gravel round and sand (no crushed gravel), internal processes (transport, etc.), and infrastructure for the operation (machinery). The land-use of the mine (incl. unpaved roads) is included directly, while the land-use of the paved roads and buildings are included in the module "mine, gravel/sand". Recultivation of closed mines is taken into account. No environmental burdens from administration are included. No dust included because it is mostly a "wet" process and no wastewater included because process water is not polluted (only sand and gravel) and therefore directly seeped. Remark: The multioutput-process 'mining, gravel / sand' delivers the co-products 'sand, at mine' and 'gravel, round, at mine'. The typical production mix in Switzerland is: sand 35% and round gravel 65%. From the total sectoral production volume (100%) of mined gravel round, crushed and sand, about 85% is gravel round and sand. ; Geography: For some exchanges RER-modules have been used as proxy Technology: typical technology for Swiss production Version: 2.2 Energy values: Undefined Percent representativeness: 100.0 Production volume: 29750000 t/a Local category: Mineralische Baustoffe Local subcategory: Zuschlags- Füllstoffe Source file: 00478.XML
Gravel	Gravel, unspecified, at mine/CH S	Minerals	Ecoinvent system processes	Translated name: Kies, unspezifisch, ab Abbau Included processes: includes the whole manufacturing process, internal processes (transport, etc.) and infrastructure. No administration is included. Recultivation is taken into account. Remark: Mix of round and crushed gravel, allocation based on production of 4 swiss gravel plants: 79% round gravel and 21% crushed gravel; Geography: For some exchanges RER-modules have been used as proxy Technology: typical technology for Swiss production Version: 2.2 Synonyms: Kies, Zuschlagstoff, gravel, aggregate Energy values: Undefined Percent representativeness: 100.0 Production volume: 24500000 t/a Local category: Mineralische Baustoffe Local subcategory: Zuschlags- Füllstoffe Source file: 00465.XML

Material	Process Name	Category	Library	Description
Steel (not SS)	Reinforcing steel, at plant/RER S	Metals \ Ferro	Ecoinvent system processes	Translated name: Armierungsstahl, ab Werk Included processes: Mix of differently produced steels and hot rolling Remark: represents Average of World and European production mix. This is assumed to correspond to the consumption mix in Europe; Geography: Data relate to plants in the EU Technology: technology mix Version: 2.2 Synonyms: carbon steel, unalloyed steel Energy values: Undefined Production volume: unknown Local category: Metalle Local subcategory: Gewinnung Source file: 01141.XML
Stainless Steel	Chromium steel 18/8, at plant/RER S	Metals \ Ferro	Ecoinvent system processes	Translated name: Chromstahl 18/8, ab Werk Included processes: Mix of differently produced steels and hot rolling Remark: represents Average of World and European production mix. This is assumed to correspond to the consumption mix in Europe; Geography: Data relate to plants in the EU Technology: technology mix Version: 2.2 Synonyms: high alloyed steel, stainless steel Energy values: Undefined Production volume: unknown Local category: Metalle Local subcategory: Gewinnung Source file: 01072.XML
PVC	PVC pipe E	Plastics \ Thermoplasts	Industry data 2.0	Production of PVC pipes, including production of PVC resin, transport of the resin to the converter, the conversion process itself and packaging of the finished product for onward despatch. In pipe extrusion the molten polymer is extruded through an annular die and cooled by passing through a water trough. The effects of stabilisers have been ignored so that in the calculations all of the weight of the pipe is assumed to be PVC homopolymer. Before using the data of this proces you should ensure that you have read the description of the methodology used. See the system model.
HDPE	HDPE pipe E	Plastics \ Thermoplasts	Industry data 2.0	none

Material	Process Name	Category	Library	Description
Bentonite	Bentonite, at processing/DE S	Chemicals \ Inorganic	Ecoinvent system processes	Translated name: Borcarbid, ab Werk Included processes: Production od boron carbide including materials, energy uses, infrastructure and emissions. Remark: The process "boron carbide, at plant, GLO" is modelled for the production of boron carbide from boric oxide in the world. Raw materials are modelled with a stoechiometric calculation. Emissions are calculated estimated. Infrastructure and transports are calculated with standard values. Energy consumptions are taken from literature. CAS number: 012069-32-8; Formula: BC4; Geography: The inventory is modelled for the world. Technology: Reduction of boric oxide Time period: Time of publications Version: 2.2 Synonyms: black diamond, tetrabor Energy values: Undefined Percent representativeness: 100.0 Production volume: unknown Local category: Chemikalien Local subcategory: Anorganika Source file: 07213.XML
Virgin GAC	Virgin GAC_Assembly_1kg	Custom assembly	Tetra Tech calculation	Materials: Bituminous coal, at mine/US = 1.2 kg Lignite coal, at surface mine/US = 1.2 kg Processes: Heat, natural gas, at industrial furnace > 100kW/RER S = 18.6 MJ On-site electricity average E = 0.1 kWh On-site steam average E = 1 kg Transport, lorry >32t, EURO5/RER U = 8 tkm Lignite coal, combusted in industrial boiler/US = 1.4 kg
Regenerated GAC	Regen_GAC_1kg	Custom assembly	Tetra Tech calculation	Assemblies: Virgin GAC Assembly_1kg = 0.1 p Regenerated GAC Assembly_1kg = 0.9 p Regenerated GAC Assembly_1kg = Processes: Heat, natural gas, at industrial furnace > 100kW/RER S = 18.6 MJ On-site electricity average E = 0.1 kWh On-site steam average E = 1 kg

Material	Process Name	Category	Library	Description
Hydrochloric Acid	Hydrochloric acid, 36% in H2O, from reacting propylene and chlorine, at plant/RER S	Chemical \ Acids (Inorganic)	Ecoinvent system processes	Translated name: Chlorwasserstoff, 36% in H2O, aus der Reaktion von Propylen mit Chlor, ab Werk Included processes: Multi-output process that produces three outputs from the reaction of propylene with chlorine: allyl chloride, hydrochloric acid (36wt%) and 1,3-dichloropropene. Remark: Liquid propene is reacted with gaseous chlorine; Geography: RER Technology: based on industry data in the US and Europe Version: 2.2 Energy values: Undefined Local category: Chemikalien Local subcategory: Anorganika Source file: 06249.XML
Potassium permanganate	Potassium permanganate, at plant/RER S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Kaliumpermanganat, ab Werk Included processes: Manganese dioxide oxidation process including materials, energy uses, infrastructure and emissions. Remark: The multioutput-process "Manganese dioxide oxidation" delivers the co-products potassium permanganate and hydrogen. The allocation is based on stoechiometric calculation.; Geography: The inventory is modelled for the Europe.. Technology: Oxidation of manganese dioxide Time period: Time of publications. Version: 2.2 Energy values: Undefined Percent representativeness: 100.0 Production volume: na Local category: Chemikalien Local subcategory: Anorganika Source file: 11210.XML
Green Sand	Green Sand_1kg	Custom assembly	Tetra Tech calculation	Materials: Sand, at mine/CH S = 0.25 kg Gravel, unspecified, at mine/CH S = 0.25 kg Manganese oxide (Mn2O3), at plant/CN U = 0.5 kg Processes: Transport, lorry > 32t, EURO5/RER U = 0.5 tkm

Material	Process Name	Category	Library	Description
Sulphuric Acid	Sulphuric acid, liquid, at plant/RER S	Chemicals\Acids (Inorganic)	Ecoinvent system processes	Translated name: Schwefelsäure, flüssig, ab Werk Included processes: Inventory Includes the obtention of SO2-containing gas (by means of oxidation of the sulphur containing raw materials: elemental sulphur, pyrites, other sulphide ores or spent acids). It includes also the convertion of SO2 to SO3 and the absorption of SO3 into solution (sulfuric acid in water) to yield Sulphuric acid. Remark: Manufacturing process starting with sulphur-containing raw materials (elemental sulphur, pyrites, ores and spent acids) is considered, plus consumption of auxiliaries, energy, infrastructure and land use, as well as transportation of raw materials, auxiliaries and wastes. The generation of solid wastes and emissions into air and water and wastes. Transport and storage of the final product sulphuric acid are not included. No byproducts or coproducts are considered. Transcient or unstable operations are not considered, but the production during stable operation conditions. Emissions to air are considered as emanating in a high population density area. Emissions into water are assumed to be emitted into rivers. Wastes are assumed to be sent to landfill. Inventory refers to 1 kg 100% sulphuric acid, liquid, at plant. Since the sulphuric acid can be considered a as byproduct from the processing of sulphide ores (other than pyrites), for this study it is considered that the sulphuric acid produced by smelter gas burning is obtained "gratis“. As mentioned above, this process contributes with 35% to the total production. Consequently, in order to subtract the contribution of this process to the overall average, all the values for inputs and outputs presented in the report have been balanced by multiplying them by 0.65 before entering the values in the present excel files in ecoinvent database. CAS number: 007664-93-9; Formula: H2SO4; Geography: European average values Technology: part of the sources consider the average technology used in European sulphuric acid production plants. The others consider the state-of-the-art technology in Europe. Time period: Values based on literature using data from unknown date, and reports with data from 1990 to 2000, approximately. Version: 2.2 Energy values: Undefined Production volume: unknown Local category: Chemikalien Local subcategory: Anorganika Source file: 00350.XML

Material	Process Name	Category	Library	Description
Sodium Hydroxide	Sodium hydroxide, 50% in H2O, production mix, at plant/RER S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Natriumhydroxid, 50% in H2O, Produktionsmix, ab Werk Included processes: Process establishing an average European sodium hydroxide production from the three different electrolysis cell technologies (mercury, diaphragm, membrane) Remark: Modul that establishs only an average of the different technologies used for sodium hydroxide production - thus no process-specific emissions are included into this dataset. CAS number: 001310-73-2; Formula: NaOH; Geography: European average values Technology: see general comments Version: 2.2 Synonyms: Caustic soda, Sodium hydrate, Lye, lye, caustic, soda lye, White Caustic Energy values: Undefined Percent representativeness: 100.0 Production volume: Equivalent of NaOH from European Cl2 production in 2000 of 9697265 tonnes Local category: Chemikalien Local subcategory: Anorganika Source file: 00336.XML
Generic organic acid	Acetic acid, 98% in H2O, at plant/RER S	Chemical\Acids (Organic)	Ecoinvent system processes	Translated name: Essigsäure, 98% in H2O, ab Werk Included processes: production including refining. Remark: Theoretical data from process analysis. Only the most important flows are taken into account. Energy demand is calculated. CAS number: 000064-19-7; Formula: C2H4O2 Technology: The process stands for the Monsanto process in which methanol reacts with carbon monoxide under the influence of a rhodium catalyst. It is assumed that 50% of the off-gas is burned as fuel, thus VOC emissions are reduced and CO2 is higher. Version: 2.2 Synonyms: Ethansäure Energy values: Undefined Production volume: unknown Local category: Chemikalien Local subcategory: Organisch Source file: 00360.XML

Material	Process Name	Category	Library	Description
Lime	Lime, hydrated, loose, at plant/CH S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Kalk, gelöscht, lose, ab Werk Included processes: Includes the processes: slaking, crushing, dust abatement (cyclone), transportation and storing. A part of the total heating energy for "production" and "administration" is included. Equipment included in the infrastructure: 1 swing hammer crusher, 2 cyclone dust catchers, 1 lime slaking plant, 2 conveyor worms, and 1 silo. Remark: Infrastructure data are estimated based on a tour and sketches of the process. The value of the infrastructure is normalized with a annual production capacity of about 20'000 tons of product per year. The estimated lifespan of the machines is 25 years. There are no significant dust emissions as a dust control system is installed. This product exists also packed.; Formula: Ca(OH)2; Geography: data are from only one company in Switzerland (KFN), for some exchanges RER-modules have been used as proxy Technology: The company KFN works on a technically high level. Effective dust control systems are installed. Version: 2.2 Energy values: Undefined Percent representativeness: 50.0 Production volume: 37'000t Local category: Mineralische Baustoffe Local subcategory: Bindemittel Source file: 00486.XML
Zero valent iron	Pellets, iron, at plant/GLO S	Metals\Ferro\Production	Ecoinvent system processes	Translated name: Pellets, Eisen, ab Werk Included processes: Blending, mixing and sintering. Emissions are abated Remark: Inputs and air emissions from different sources. No transport of iron ore because pellets are fabricated at mine; Geography: Inputs relate to the global average. Emissions relate to European plants Technology: Strate grate and grate kiln process Version: 2.2 Energy values: Undefined Percent representativeness: 65.0 Production volume: 1.54E11 kg/a Local category: Metalle Local subcategory: Gewinnung Source file: 01131.XML

Material	Process Name	Category	Library	Description
Hydrogen Peroxide	Hydrogen peroxide, 50% in H2O, at plant/RER S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Wasserstoffperoxid, 50% in H2O, ab Werk Included processes: This module contains material and energy input, production of waste and emissions for the production of hydrogen peroxide by the anthrachinone process. Transport and infrastructure have been estimated. The input of 215 g air is not reported in the data according to the methodology of the study. Remark: data based on a study, performed by EMPA and Boustead Consulting, commissioned by CEFIC CAS number: 007722-84-1; Formula: H2O2; Geography: average data from 8 European producers Technology: average technology used from these European producers Version: 2.2 Synonyms: dihydrogen dioxide, Hydroperoxide, Hioxy, Oxydol, Peroxan, peroxide Energy values: Undefined Local category: Chemikalien Local subcategory: Anorganika Source file: 00284.XML
Sodium Persulfate	Sodium persulfate, at plant/GLO S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Natriumpersulfat, ab Werk Included processes: Production of sodium persulfate including materials, energy uses, infrastructure and emissions. Remark: The process "asodium persulfate, at plant, GLO" is modelled for the production of sodium persulfate from sulfuric acid and sodium hydroxide in the world. Raw materials are modelled with a stoechiometric calculation. Energy consumptions and emissions are estimated. Infrastructure and transports are calculated with standard values. CAS number: 007775-27-1; Formula: Na2O8S2; Geography: The inventory is modelled for the world. Technology: Reaction of sulfuric acid, hydrogen peroxide, and sodium peroxide. Time period: Time of publications Version: 2.2 Synonyms: sodium peroxydisulfate Energy values: Undefined Percent representativeness: 100.0 Production volume: unknown Local category: Chemikalien Local subcategory: Anorganika Source file: 07232.XML

Material	Process Name	Category	Library	Description
Fertilizer #1 - nitrate	Potassium nitrate, as N, at regional storehouse/RER S	Chemicals\Fertilisers (inorganic)	Ecoinvent system processes	Translated name: Kaliumnitrat, als N, ab Regionallager Included processes: The unit process inventory takes into account the production of potassium nitrate from potassium chloride and nitric acid. Transports of raw materials and intermediate products to the fertiliser plant as well as the transport of the fertiliser product from the factory to the regional department store were included. Production and waste treatment of catalysts, coating and packaging of the final fertiliser products were not included. Infrastructure was included by means of a proxy module. Remark: Refers to 1 kg N, resp. 1 kg K2O in potassium nitrate with a N-content of 14.0% and a K2O-content of 44.0%. The multioutput-process 'potassium nitrate, at regional storehouse' delivers the co-products 'potassium nitrate phosphate, as N, at regional storehouse' and 'potassium nitrate phosphate, as K2O, at regional storehouse'. Allocation factors are based on the energy requirements of the respective nutrients for the production processes: 61% for 'potassium nitrate phosphate, as N, at regional storehouse' and 39% for 'potassium nitrate phosphate, as K2O, at regional storehouse' (exceptions see report). The allocated inventories must always be used simultaneously. CAS number: 007757-79-1; Formula: KNO3; Geography: According to the reference of this inventory, the European average is derived from mean values of several fertiliser plants within Europe. The production of raw materials and/or intermediates outside Europe was taken into account by considering the production technology in the respective country and the relative import shares. Technology: Production inventory was derived from detailed literature studies and specifications from the manufacturer, relevant for the European production. Transport specifications of the fertiliser product to the regional department store, which were not included in the reference used for this inventory, were complemented by data given in Patyk & Reinhardt (1997). Time period: Year when the principal reference used for this inventory was published. Version: 2.2 Energy values: Undefined Local category: Landwirtschaftliche Produktionsmittel Local subcategory: Mineraldünger Source file: 00052.XML

Material	Process Name	Category	Library	Description
Fertilizer #2 - phosphate	Ammonium nitrate phosphate, as P2O5, at regional storehouse/RER S	Chemicals\Fertilisers (inorganic)	Ecoinvent system processes	Translated name: Ammoniumnitratphosphat, als P2O5, ab Regionallager Included processes: The unit process inventory takes into account the production of ammonium nitrate phosphate from ammonia and rock phosphate. Transports of raw materials and intermediate products to the fertiliser plant as well as the transport of the fertiliser product from the factory to the regional department store were included. Production and waste treatment of catalysts, coating and packaging of the final fertiliser products were not included. Infrastructure was included by means of a proxy module. Remark: Refers to 1 kg N, resp. 1 kg P2O5 in ammonium nitrate phosphate with a N-content of 8.4% and a P2O5-content of 52.0%. The multioutput-process 'ammonium nitrate phosphate, at regional storehouse' delivers the co-products 'ammonium nitrate phosphate, as N, at regional storehouse' and 'ammonium nitrate phosphate, as P2O5, at regional storehouse'. Allocation factors are based on the energy requirements of the respective nutrients for the production processes: 48% for 'ammonium nitrate phosphate, as P2O5, at regional storehouse' and 52% for 'ammonium nitrate phosphate, as N, at regional storehouse' (exceptions see report). The allocated inventories must always be used simultaneously. CAS number: 057608-40-9; Formula: NH4NO3*Ca(H2PO4)2; Geography: According to the reference of this inventory, the European average is derived from mean values of several fertiliser plants within Europe. The production of raw materials and/or intermediates outside Europe was taken into account by considering the production technology in the respective country and the relative import shares. Technology: Production inventory was derived from detailed literature studies and specifications from the manufacturer, relevant for the European production. Transport specifications of the fertiliser product to the regional department store, which were not included in the reference used for this inventory, were complemented by data given in Patyk & Reinhardt (1997). Time period: Year when the principal reference used for this inventory was published. Version: 2.2 Energy values: Undefined Local category: Landwirtschaftliche Produktionsmittel Local subcategory: Mineraldünger Source file: 00039.XML

Material	Process Name	Category	Library	Description
Graphite	Graphite, at plant/RER S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Graphit, ab Werk Included processes: Raw materials, machineries and energy consumption for production, estimated emissions to air from production and infrastructure of the site (approximation). No water emissions. Remark: The functional unit represent 1 kg of milled graphite. Large uncertainty of the process data due to weak data on the production process.; Geography: Data are used here as European average. Technology: Data approximated with data from lime mining, crushing and milling. Version: 2.2 Energy values: Undefined Production volume: worldwide 873 kt in 2001 Local category: Chemikalien Local subcategory: Anorganika Source file: 00281.XML
Vegetable Oil	Soybean oil, at oil mill/US S	Agricultural\ Food Oil	Ecoinvent system processes	Translated name: Sojaöl, ab Werk Included processes: This process includes the transport of soybeans to the mill, and the processing of soybeans to soybean oil and meal. System boundary is at the oil mill. Remark: Inventory refers to the production of 1 kg soybean oil, respectively soybean meal (incl. hulls). The multioutput-process 'soybeans, in oil mill' delivers the co-products 'soybean oil, at oil mill' and 'soybean meal, at oil mill'. Economic allocation with allocation factor of 34.5% to oil and 65.5 to meal. Allocation is done according to carbon balance for CO2 emissions.; Geography: Data from an industrial oil mill in the US, described in US study Technology: Typical oil mill designed for soybean oil solvent extraction (incl. pre-cracking of soybeans, dehulling, oil extraction, meal processing and oil purification), US context. Time period: Data from 1998 to 2005, current technology for soybean oil extraction Version: 2.2 Energy values: Undefined Percent representativeness: 0.0 Production volume: Approx. 46 Mt of soybeans were processed to oil and meal in 2003 in the US Local category: Biomasse Local subcategory: Brenn- und Treibstoffe Source file: 06660.XML

Material	Process Name	Category	Library	Description
Molasses	Molasses, from sugar beet, at sugar refinery/CH S	Agricultural\Food\Byproducts	Ecoinvent system processes	Translated name: Melasse, aus Zuckerrüben, ab Zuckerherstellung Included processes: This dataset includes the transport of sugar beets to the sugar refinery, and the processing of sugar beets to sugar, molasses (72% dry matter) and pulps (25.6% dry matter). System boundary is at the sugar refinery. Treatment of waste effluents is included. Packaging of the sugar is not included. Remark: Inventory refers to the production of 1 kg sugar, respectively 1 kg of molasses (72% dry matter) and 1 kg of pulps (25.6% dry matter). The multioutput-process 'sugar beet, in sugar refinery' delivers the co-products 'sugar, from sugar beet, at sugar refinery' and 'molasses, from sugar beet, at sugar refinery' and 'pulps, from sugar beet, at sugar refinery. Economic allocation with allocation factor for common stages of 91.7% to sugar, 4.5% to molasses and 3.8% to pulps. Allocation is done according to carbon balance for CO2 emissions.; Geography: Data is from sugar producer in CH, industrial data Technology: Sweet juice is extracted from the sugar beets by diffusion. The juice is then purified and crystallized to sugar. Molasses come as a by-product of the crystallization process. Time period: Data from 1998 to 2005, typical technology for the production of sugar from sugar beet Version: 2.2 Energy values: Undefined Percent representativeness: 0.0 Production volume: Production of sugar was 250 kt in Switzerland in 2004 Local category: Biomasse Local subcategory: Andere Source file: 06554.XML
Ferrous sulfate	Iron sulphate, at plant/RER S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Eisensulfat, ab Werk Included processes: Rough estimation of the electricity use for purification of the by-product. No data for infrastructure and emissions Remark: Iron sulphate is a by-product of steel and iron manufacturing. CAS number: 007720-78-7; Formula: $FeSO_4$; Geography: Investigation for CH. Technology: Chemical product for waste water treatment. Time period: Time of publication. Version: 2.2 Energy values: Undefined Production volume: Not known. Local category: Metalle Local subcategory: Gewinnung Source file: 01102.XML

Material	Process Name	Category	Library	Description
CO2	Carbon dioxide liquid, at plant/RER S	Chemicals\Gases	Ecoinvent system processes	Translated name: Kohlendioxid flüssig, ab Werk Included processes: This module contains material and energy input and emissions for the production of liquid carbon dioxide out of waste gases from different production processes. Water consumption and infrastructure have been estimated. Remark: The functional unit represents 1 kg of liquid carbon dioxide. Data are based on a Swiss study about different cooling mediums. CAS number: 000124-38-9; Formula: CO2; Geography: Data based on literature study about differnt cooling mediums used in Switzerland. Data are assumed to be valuable for European conditions. Technology: Extraction of carbon dioxide out of waste gas streams from different production processes with a 15-20% MEA (monoethanolamine) solution, followed by a purification and a liquefaction step, using each electricity as energy source. Time period: date of published literature Version: 2.2 Energy values: Undefined Production volume: unknown Local category: Chemikalien Local subcategory: Anorganika Source file: 00262.XML
Fiberglass	Glass fibre, at plant/RER S	Glass\Construction	Ecoinvent system processes	Translated name: Glasfaser, ab Werk Included processes: Gate to gate inventory for the production of glass fibre. Remark: Inventory based on a state of the art report for the European glass manufacturing industry. Data had to be estimated from ranges given for different parameters. CAS number: 065997-17-3; Geography: 26 furnaces operating at 12 sites in Europe Technology: Recuperative or oxy-fuel fired furnaces. Time period: Time of publication Version: 2.2 Synonyms: fibreglass, fiberglass, fibrous glass filter media Energy values: Undefined Percent representativeness: 100.0 Production volume: 475000 tonnes. Local category: Glas Local subcategory: Bauglas Source file: 00808.XML

Material	Process Name	Category	Library	Description
Iron chloride	Iron (III) chloride, 40% in H2O, at plant/CH S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Eisen(III)-Chlorid, 40% in H2O, ab Werk Included processes: Production of aquaous iron(III) chloride solution from scrap iron, spent pickling acids, hydrogen chloride and chlorine. Average process for Switzerland. Process electricity demand included. No fuel for process heat included due to exothermal process. No credits given for possible heat export. Land use and infrastructure of plant only roughly included. Remark: Data represent about 80% of the production in Switzerland. The highest uncertainties exist for the emission data due to variations of the source materials. Also the data for energy use contains uncertainties because no complete energy balance of the plants was available. In general the infrastructure data has a high uncertainty because of missing specific data an approximation with an average chemical production plant was used. CAS number: 007705-08-0; Formula: FeCl3; Geography: Data valid for production processes used in Switzerland. Various processes with location RER used. Technology: Inventory refers to technology used for production in Switzerland. Excess chlorine can be used in NaOCl production and therfor no chlorine emissions to air occur. Version: 2.2 Synonyms: iron chloride, iron trichloride Energy values: Undefined Percent representativeness: 80.0 Production volume: estimated to 8'000-10'000 t as 100% FeCl3 or 20'000-25'000 t as 40% solution Local category: Chemikalien Local subcategory: Anorganika Source file: 00292.XML
Sodium Hypochlorite	Sodium hypochlorite, 15% in H2O, at plant/RER S	Chemicals\Inorganic	Ecoinvent system processes	Translated name: Natriumhypochlorit, 15% in H2O, ab Werk Included processes: includes all precursor compounds except for chlorine, which is treated as process air emissions, transports and infrastructure Remark: Production of NaOCl from chlorine emissions captured in 50% sodium hydroxide solution. CAS number: 007681-52-9; Formula: NaOCl; Geography: RER Technology: based on literature data and plant data in Europe and North America Version: 2.2 Energy values: Undefined Production volume: unknown Local category: Chemikalien Local subcategory: Anorganika Source file: 00337.XML

Material	Process Name	Category	Library	Description
Ion exchange resin	Anionic resin, at plant/CH S	Chemicals\Others	Ecoinvent system processes	Translated name: Anionenharz, ab Werk Included processes: Raw materials and chemicals used for production, transport of materials to manufacturing plant, estimated emissions and wastes from production (incomplete), estimation of enegry demand and infrastructure of the plant. Remark: The functional unit represent 1 kg of moist resin. The moisture content of the assessed resins is 50 wt-% corresponding a resin with 6-8 wt-% divinylbenzene (DVB) crosslinking. Bulk weight of th moist (hydrated) resin: 1.10 kg/m3. Large uncertainty of the process due to weak data on the production processes.; Geography: Data used has no specific geographical origin (stoechiometry). Average europenan processes used. Transport requirements and Electricity mix for Switzerland. Technology: Production of a type I strong base anion exchanger resin (chloride form) for water treatment with a process yield of 95%. Resin functionalisation (chloromethylation) with chloromethyl methyl ether and (amination) with trimethylamine (TMA) followed by a rinsing process. Chloromethylation step with dichloromethane as solvent. A solvent regeneration with 85% yield was assumed. The production of the crosslinked copolymer beads from styrene and DVB was approximised with linear polystyrene. Time period: Time of literature publication. Measurements took place partly before this period. Version: 2.2 Synonyms: anion resin, anion exchange resin, strong basic anion exchange resin, SBA Energy values: Undefined Production volume: unknown Local category: Chemikalien Local subcategory: Organisch Source file: 00373.XML

Material	Process Name	Category	Library	Description
Ion exchange resin	Cationic resin, at plant/CH S	Chemicals\Others	Ecoinvent system processes	Translated name: Kationenharz, ab Werk Included processes: Raw materials and chemicals used for production, transport of materials to manufacturing plant, estimated emissions and wastes from production (incomplete), estimation of enegry demand and infrastructure of the plant. Remark: The functional unit represent 1 kg of moist resin. The moisture content of the assessed resins is 50 wt-% corresponding a resin with 6-8 wt-% divinylbenzene (DVB) crosslinking. Bulk weight of th moist (hydrated) resin: 1.28 kg/m3. Large uncertainty of the process due to weak data on the production processes.; Geography: Data used has no specific geographical origin (stoechiometry). Average europenan processes used. Transport requirements and Electricity mix for Switzerland. Technology: Production of a strong acidic cation exchanger resin (hydrogen form) for water treatment with a process yield of 95%. Resin activation (sulfonation) with concentrated sulphuric acid followed by a rinsing process. The production of the crosslinked copolymer beads from styrene and DVB was approximised with linear polystyrene. Time period: Time of literature publication. Measurements took place partly before this period. Version: 2.2 Synonyms: cation resin, cation exchange resin, strong acidic cation exchange resin, SAC Energy values: Undefined Production volume: unknown Local category: Chemikalien Local subcategory: Organisch Source file: 00380.XML

APPENDIX J:

Portion of a SimaPro® Network Diagram of the Little Rock Remedy

Portion of a SimaPro™ network diagram of the Little Rock Remedy