# Using SiteWise™

# Presentation Overview

- Introduction to SiteWise™
- How to Use SiteWise™
  - Input Sheets
  - Calculations and Metrics
  - Output Tables and Graphics
  - Interpretation of Results for a Site
- Application of SiteWise™ during Project Phases
  - Remedy Evaluation
  - Remedial Design
  - Remedial Action Operation (RA-O) and Long-Term Monitoring (LTM)
- Environmental Footprint Reduction
- Summary and Conclusions

# Purpose

- This presentation will show you SiteWise™, and give you enough understanding of it to know:

- **When to use it**
- **How to go about using it**

# Introduction to the SiteWise™ GSR Tool

- Originally developed by Battelle but now further development performed jointly with the Navy and USACE in a collaborative effort
- Series of Excel spreadsheets to calculate the environmental footprint of remediation in terms of sustainability metrics
- A user-friendly *streamlined life-cycle analysis (LCA)* tool that can be applied to any phase of the remedial action
  - Considers *life-cycle impacts* such as emissions due to manufacturing of materials consumed during remedial action

# Metrics of SiteWise™

## Metrics calculated with tool:

- *Energy Consumption*
  - Expressed as BTUs
- *Greenhouse Gases Emitted*
  - Expressed as metric tons $CO_2e$
    - Includes $CO_2$, $CH_4$, and $N_2O$
- *Criteria Air Pollutants Emitted*
  - NOx, SOx, PM in metric tons
- *Water Impacts*
  - Expressed as gallons
- *Worker Safety*
  - Accidental injury and death

## Metrics evaluated outside tool:

- *Resource Consumption*
  - Includes land, top soil, surface water and aquifer impacts, landfill space
- *Ecological Impacts*
- *Community Impacts*
  - Includes noise, traffic, odors

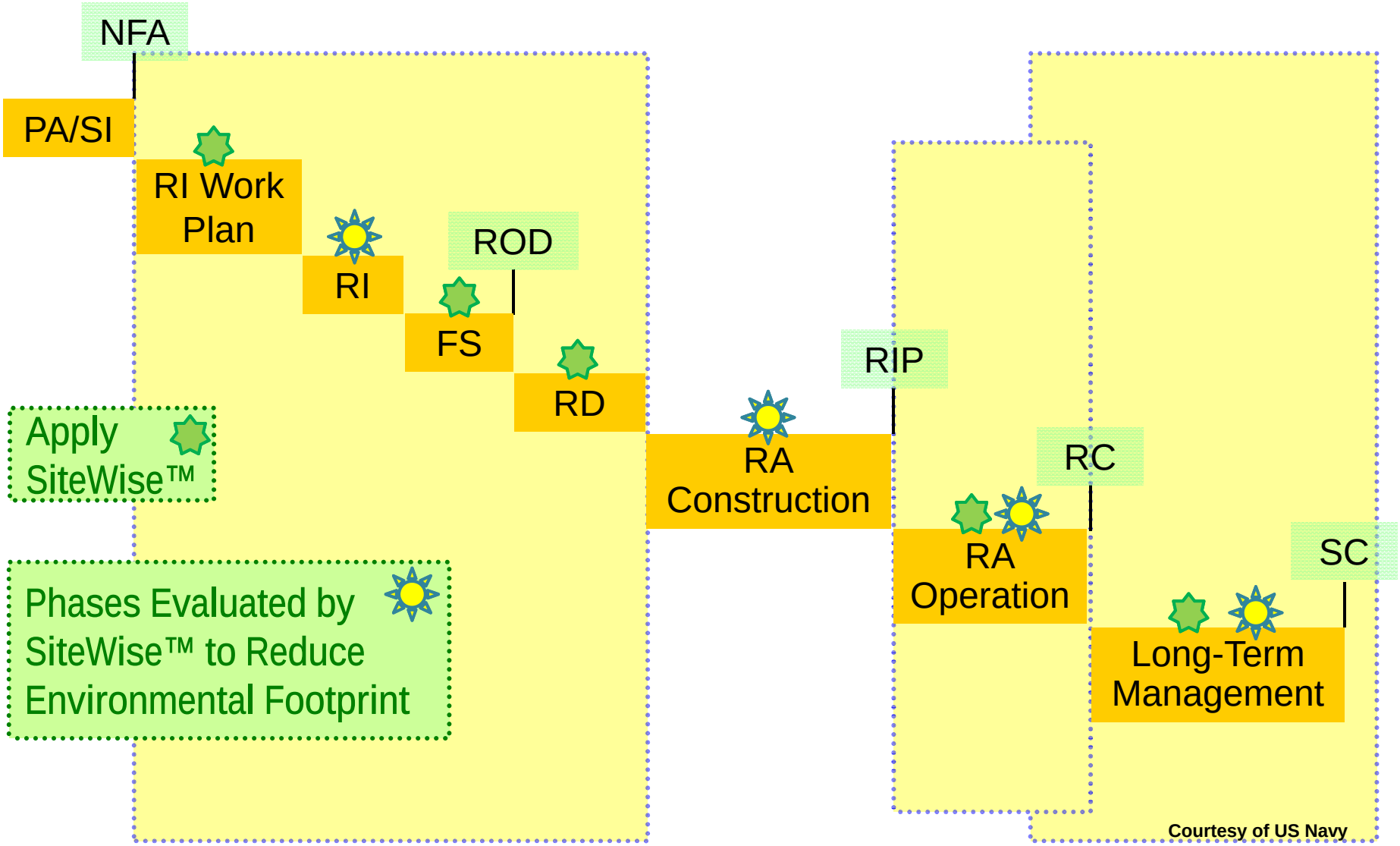
# SiteWise™ Framework

- Remedial Action is broken down into phases (each with own spreadsheet)
  - Remedial Investigation
  - Remedial Action Construction
  - Remedial Action Operation
  - Long-Term Monitoring
- Each phase broken down into activities (each with tab in spreadsheet)
  - Material production
  - Transportation – personnel
  - Transportation – equipment
  - Equipment used – earthwork
  - Equipment used – pumps
  - Equipment used – other electric
  - Equipment used – other
  - Residual handling

# Capabilities of the Tool

- Applicable to many remedial actions
- Flexible
  - Tool can be used for any remedy and at any phase of remedial action
  - Well suited for treatment train approach
- User-Friendly
  - Excel platform provides easy accessibility and use
- Transparent, not a “black-box” software, with all functionalities open to public
- Tool architecture makes it easier to focus on all high footprint activities of a remedial action

# When to Use SiteWise™ to Reduce Environmental Footprint



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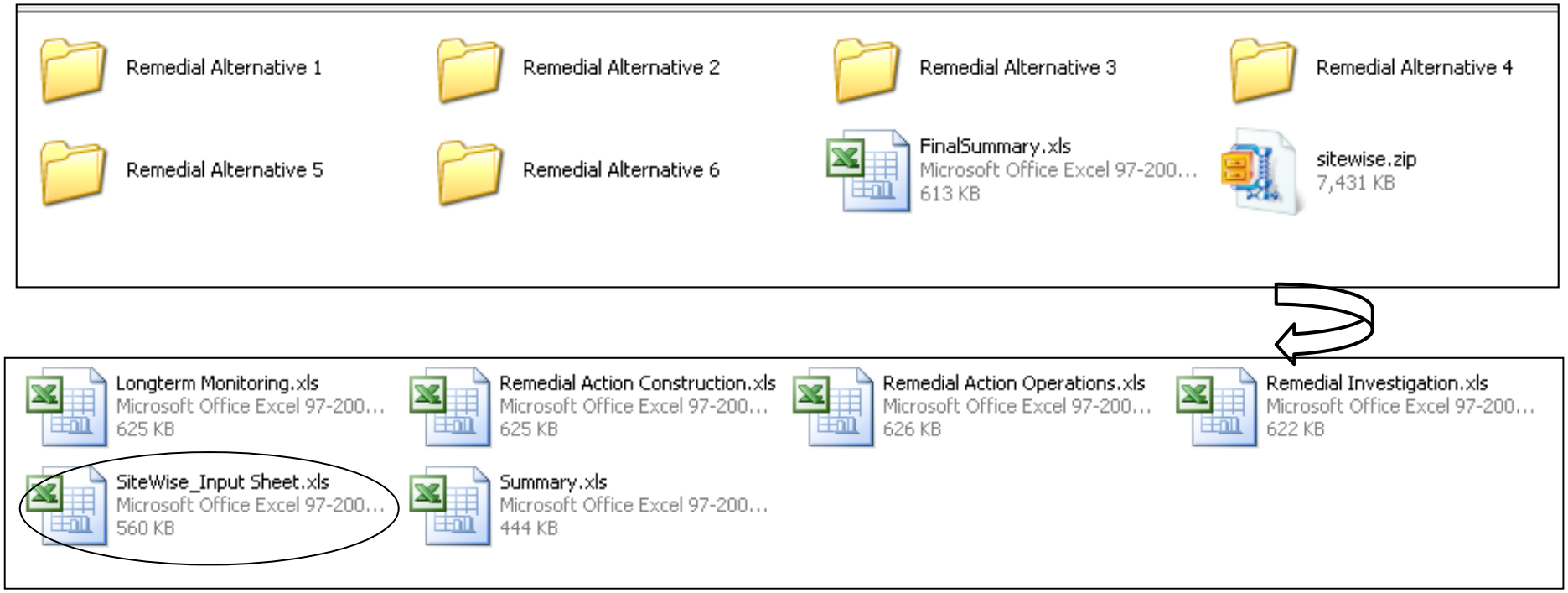
# SiteWise™ Start-Up Screen

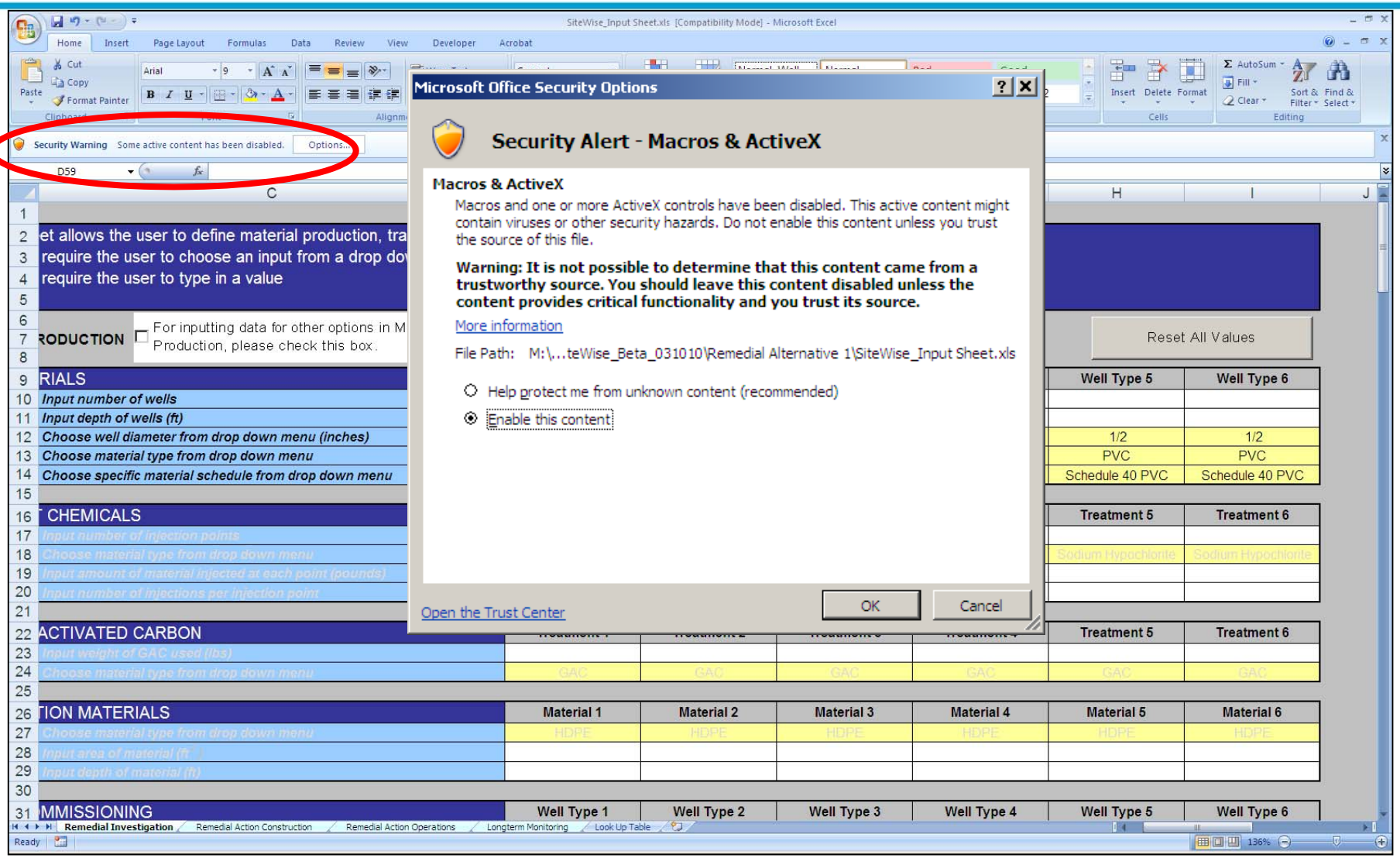



**Courtesy of US Navy**

# Input Sheets

- Inputs required to run SiteWise™ are from activities undertaken during the entire remedial action
- Activities include:
  - *Material* used during different phases of remedial action
  - *Transportation* of personnel and equipment
    - Mode of travel, number of personnel, weight of material and equipment
  - Energy consumption due to *equipment use*
    - Pumps, blowers, compressors, drilling and excavation equipment, etc.
  - *Residual Management* and handling
    - Waste recycling, incineration, etc.

# SiteWise™ Input Sheet – Enable Macros!




Courtesy of US Navy

# SiteWise™ Input Sheet (cont.)

For inputting data into un-highlighted activities that might be pertinent to your site

This worksheet allows the user to define material production, transportatio ... the remedial alternative

Yellow cells require the user to choose an input from a drop down menu

White cells require the user to type in a value

Reset All Values

**MATERIAL PRODUCTION**

For inputting data for other options in Material Production, please check this box.

| WELL MATERIALS | Well Type 1 | Well Type 2 | Well Type 3 | Well Type 4 | Well Type 5 |
|---|---|---|---|---|---|
| Input number of wells | | | | | |
| Input depth of wells (ft) | | | | | |
| Choose well diameter (in) from drop down menu | 1/2 | 1/2 | 1/2 | 1/2 | 1/2 |
| Choose material type from drop down menu | Steel | Steel | PVC | PVC | PVC |
| Choose specific material schedule from drop down menu | Schedule 40 Steel | Schedule 40 Steel | Schedule 40 PVC | Schedule 40 PVC | Schedule 40 PVC |

| TREATMENT CHEMICALS | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 | Treatment 5 |
|---|---|---|---|---|---|
| Input number of injection points | | | | | |
| Choose material type from drop down menu | ISCO Chemical | Sodium Hypochlorite | Urea | EZVI | Sodium Hypochlorite |
| Input amount of material injected at each point (lbs) | | | | | |
| Input number of injections per injection point | | | | | |

| GAC | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 | Treatment 5 |
|---|---|---|---|---|---|
| Input weight of GAC used (lbs) | | | | | |
| Choose material type from drop down menu | GAC | GAC | GAC | GAC | GAC |

| CONSTRUCTION MATERIALS | Material 1 | Material 2 | Material 3 | Material 4 | Material 5 |
|---|---|---|---|---|---|
| Choose material type from drop down menu | HDPE | HDPE | HDPE | HDPE | HDPE |
| Input area of material ($ft^2$) | | | | | |
| Input depth of material (ft) | | | | | |

| WELL DECOMMISSIONING | Well Type 1 | Well Type 2 | Well Type 3 | Well Type 4 | Well Type 5 |
|---|---|---|---|---|---|
| Input number of wells | | | | | |
| Input depth of wells (ft) | | | | | |
| Choose well diameter (in) from drop down menu | 1/2 | 1/2 | 1/2 | 1/2 | 1/2 |
| Choose material from drop down menu | Soil | Soil | Soil | Soil | Soil |

# Input Sheet – Material Production

| WELL MATERIALS | Well Type 1 | Well Type 2 | Well Type 3 | Well Type 4 | Well Type 5 |
|---|---|---|---|---|---|
| Input number of wells | | | | | |
| Input depth of wells (ft) | | | | | |
| Choose well diameter (in) from drop down menu | 1/2 | 1/2 | 1/2 | 1/2 | 1/2 |
| Choose material type from drop down menu | Steel | Steel | PVC | PVC | PVC |
| Choose specific material schedule from drop down menu | Schedule 40 Steel | Schedule 40 Steel | Schedule 40 PVC | Schedule 40 PVC | Schedule 40 PVC |

| TREATMENT CHEMICALS | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 | Treatment 5 |
|---|---|---|---|---|---|
| Input number of injection points | | | | | |
| Choose material type from drop down menu | ISCO Chemical | Sodium Hypochlorite | Urea | EZVI | Sodium Hypochlorite |
| Input amount of material injected at each point (lbs) | | | | | |
| Input number of injections per injection point | | | | | |

| GAC | Treatment 1 | Treatment 2 | Treatment 3 | Treatment 4 | Treatment 5 |
|---|---|---|---|---|---|
| Input weight of GAC used (lbs) | | | | | |
| Choose material type from drop down menu | GAC | GAC | GAC | GAC | GAC |

| CONSTRUCTION MATERIALS | Material 1 | Material 2 | Material 3 | Material 4 | Material 5 |
|---|---|---|---|---|---|
| Choose material type from drop down menu | HDPE | HDPE | HDPE | HDPE | HDPE |
| Input area of material ($ft^2$) | | | | | |
| Input depth of material (ft) | | | | | |

| WELL DECOMMISSIONING | Well Type 1 | Well Type 2 | Well Type 3 | Well Type 4 | Well Type 5 |
|---|---|---|---|---|---|
| Input number of wells | | | | | |
| Input depth of wells (ft) | | | | | |
| Choose well diameter (in) from drop down menu | 1/2 | 1/2 | 1/2 | 1/2 | 1/2 |
| Choose material from drop down menu | Soil | Soil | Soil | Soil | Soil |

# Input Sheet – Transportation

| PERSONNEL TRANSPORTATION - ROAD | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 |
|---|---|---|---|---|---|---|
| Will DIESEL-run vehicles be retrofitted with an emission reduction technology? | Yes | No | Yes | Yes | Yes | Yes |
| Choose vehicle type from drop down menu | Cars | Cars | Cars | Cars | Cars | Cars |
| Choose fuel used from drop down menu | Gasoline | Gasoline | Gasoline | Gasoline | Gasoline | Gasoline |
| Input distance traveled per trip (miles) | | | | | | |
| Input number of trips taken | | | | | | |
| Input number of travelers | | | | | | |
| Input estimated vehicular fuel economy (mi/gal) (Input only if known for the vehicle selected, otherwise a default will be used by the tool) | | | | | | |

| PERSONNEL TRANSPORTATION - AIR | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 |
|---|---|---|---|---|---|---|
| Input distance traveled (miles) | | | | | | |
| Input number of travelers | | | | | | |
| Input number of flights taken | | | | | | |

| PERSONNEL TRANSPORTATION - RAIL | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 |
|---|---|---|---|---|---|---|
| Choose vehicle type from drop down menu | Intercity rail | Commuter rail | Transit Rail | Intercity rail | Commuter rail | Intercity rail |
| Input distance traveled (miles) | | | | | | |
| Input number of trips taken | | | | | | |
| Input number of travelers | | | | | | |

| EQUIPMENT TRANSPORTATION - ROAD | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 |
|---|---|---|---|---|---|---|
| Will DIESEL-run vehicles be retrofitted with an emission reduction technology? | Yes | Yes | Yes | Yes | Yes | Yes |
| Choose fuel used from drop down menu | Gasoline | Gasoline | Gasoline | Gasoline | Gasoline | Gasoline |
| Input distance traveled (miles) | | | | | | |
| Input weight of equipment transported (tons) | | | | | | |

| EQUIPMENT TRANSPORTATION - AIR | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 |
|---|---|---|---|---|---|---|
| Input distance traveled (miles) | | | | | | |
| Input weight of equipment transported (tons) | | | | | | |

| EQUIPMENT TRANSPORTATION - RAIL | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 |
|---|---|---|---|---|---|---|
| Input distance traveled (miles) | | | | | | |
| Input weight of load (tons) | | | | | | |

| EQUIPMENT TRANSPORTATION - WATER | Trip 1 | Trip 2 | Trip 3 | Trip 4 | Trip 5 | Trip 6 |
|---|---|---|---|---|---|---|
| Input distance traveled (mile) | | | | | | |
| Input weight of load (tons) | | | | | | |

# Input Sheet – Equipment Use (Earthwork and Pumps)

| EARTHWORK | Equipment 1 | Equipment 2 | Equipment 3 | Equipment 4 | Equipment 5 | Equipment 6 |
|---|---|---|---|---|---|---|
| Choose earthwork equipment type from drop down menu | Dozer | Dozer | Dozer | Dozer | Dozer | Dozer |
| Choose fuel type from drop down menu | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel |
| Input volume of material to be removed ($yd^3$) | | | | | | |

| WELL DRILLING | Event 1 | Event 2 | Event 3 | Event 4 | Event 5 | Event 6 |
|---|---|---|---|---|---|---|
| Input number of drilling locations | | | | | | |
| Choose drilling method from drop down menu | Direct Push | Direct Push | Direct Push | Direct Push | Direct Push | Direct Push |
| Input time spent drilling at each location (hr) | | | | | | |
| Input depth of wells (ft) | | | | | | |
| Choose fuel type from drop down menu | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel |

For each pump, select only one of the three methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused pump columns or unused methods

| PUMP OPERATION | Pump 1 | Pump 2 | Pump 3 | Pump 4 | Pump 5 | Pump 6 |
|---|---|---|---|---|---|---|
| Choose method from drop down | Method 1 | Method 3 | Method 1 | Method 1 | Method 1 | Method 1 |
| Method 1 - ELECTRICAL USAGE IS KNOWN | | | | | | |
| Input pump electrical usage (KWh) | | | | | | |
| | | | | | | |
| Method 2 - PUMP HEAD IS KNOWN | | | | | | |
| Input flow rate (gpm) | | | | | | |
| Input total head (ft) | | | | | | |
| Input number of pumps operating | | | | | | |
| Input operating time for each pump (hrs) | | | | | | |
| Input pump efficiency (default already present, user override possible) | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| Input specific gravity (default already present, user override possible) | 1 | 1 | 1 | 1 | 1 | 1 |
| | | | | | | |
| Method 3 - NAME PLATE SPECIFICATIONS ARE KNOWN | | | | | | |
| Input pump horsepower (hp) | | | | | | |
| Input number of pumps operating | | | | | | |
| Input operating time for each pump (hrs) | | | | | | |
| Input pump load (default already present, user override possible) | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Input pump motor efficiency (default already present, user override possible) | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| | | | | | | |
| Region | | | | | | |
| Choose region from drop down menu (see figure) | SRVC | SPSO | SRMV | SPSO | SPSO | SPNO |

| DIESEL AND GASOLINE PUMPS | Pump 1 | Pump 2 | Pump 3 | Pump 4 | Pump 5 | Pump 6 |
|---|---|---|---|---|---|---|
| Choose fuel type from drop down menu | Gasoline | Gasoline | Gasoline | Gasoline | Gasoline | Gasoline |
| Choose horsepower range from drop down menu | 2-Stroke: 0 to 1 | 4-Stroke: 100 to 175 | 2-Stroke: 0 to 1 | 2-Stroke: 25 to 40 | 2-Stroke: 0 to 1 | 2-Stroke: 0 to 1 |
| Equipment operating hours (hrs) | | | | | | |
| Fuel consumption rate (gal/hr) | | | | | | |

# Input Sheet – Equipment Use (Other)

For each type of equipment, select only one of the methods to calculate energy and GHG emissions
Enter "0" for all user input values for unused equipment columns or unused methods

| GENERAL EQUIPMENT USE | Equipment 1 | Equipment 2 | Equipment 3 | Equipment 4 | Equipment 5 | Equipment 6 |
|---|---|---|---|---|---|---|
| Choose type of equipment from drop down | Blower | Blower | Blower | Blower | Blower | Blower |
| Choose method from drop down | Method 1 | Method 1 | Method 1 | Method 1 | Method 1 | Method 1 |
| Method 1 - NAME PLATE SPECIFICATIONS ARE KNOWN | | | | | | |
| Input equipment horsepower (hp) | | | | | | |
| Input number of equipments operating | | | | | | |
| Input operating time for each equipment (hrs) | | | | | | |
| Input equipment load (default already present, user override possible) | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 | 0.8 |
| Input motor efficiency (default already present, user override possible) | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| | | | | | | |
| Method 2 - ELECTRICAL USAGE IS KNOWN | | | | | | |
| Input equipment electrical usage, if known (KWh) | | | | | | |
| | | | | | | |
| Region | | | | | | |
| Choose region from drop down menu (see figure) | SPSO | SPNO | HIOA | AZNM | AZNM | AZNM |

| GENERATORS | Generator 1 | Generator 2 | Generator 3 | Generator 4 | Generator 5 | Generator 6 |
|---|---|---|---|---|---|---|
| Choose fuel type from drop down menu | Diesel | Biodiesel 20 | Diesel | Diesel | Diesel | Diesel |
| Choose horsepower range from drop down menu | 3 to 6 | 300 to 600 | 175 to 300 | 50 to 75 | 25 to 40 | 16 to 25 |
| Input operating hours (hr) | | | | | | |

| AGRICULTURAL EQUIPMENT | Tillage Tractor 1 | Tillage Tractor 2 | Tillage Tractor 3 | Tillage Tractor 4 | Tillage Tractor 5 | Tillage Tractor 6 |
|---|---|---|---|---|---|---|
| Choose fuel type from drop down menu | Biodiesel 20 | Diesel | Biodiesel 20 | Diesel | E-Diesel | Diesel |
| Input area to till (acre) from drop down menu | | | | | | |
| Choose soil condition from drop down menu | Firm untilled soil | Soft or sandy soil | Previously tilled soil | Firm untilled soil | Previously tilled soil | Soft or sandy soil |
| Choose soil type from drop down menu | Loamy Soil | Clay Soil | Loamy Soil | Sandy Soil | Loamy Soil | Clay Soil |
| Input time available (work days) | | | | | | |
| Input depth of tillage (in) | | | | | | |

| STABILIZATION EQUIPMENT | Equipment 1 | Equipment 2 | Equipment 3 | Equipment 4 | Equipment 5 | Equipment 6 |
|---|---|---|---|---|---|---|
| Choose stabilization equipment type from drop down menu | Roller | Roller | Roller | Roller | Roller | Roller |
| Choose fuel type from drop down menu | Diesel | Diesel | Diesel | Diesel | Diesel | Diesel |
| Input area ($ft^2$) | | | | | | |
| Input time available (work days) | | | | | | |

| MIXING EQUIPMENT | Mixer 1 | Mixer 2 | Mixer 3 | Mixer 4 | Mixer 5 | Mixer 6 |
|---|---|---|---|---|---|---|
| Choose fuel type from drop down menu | Gasoline | Gasoline | Gasoline | Gasoline | Gasoline | Diesel |
| Choose horsepower range from drop down menu | 1 to 3 | 1 to 3 | 1 to 3 | 3 to 6 | 11 to 16 | 6 to 11 |
| Input volume ($yd^3$) | | | | | | |
| Input production rate ($yd^3$/hr) | | | | | | |
| Input consumption rate (gal/hr) | | | | | | |

# Input Sheet – Residual Handling and Site Data

| RESIDUE DISPOSAL/RECYCLING | Soil Residue | Residual Water | Material Residue | Other Residuals | Other Residuals | Other Residuals |
|---|---|---|---|---|---|---|
| Will DIESEL-run vehicles be retrofitted with an emission reduction technology? | Yes | Yes | Yes | Yes | Yes | Yes |
| Input weight of the waste transported to landfill or recycling per trip (tons) | | | | | | |
| Choose vehicle type from drop down menu | Light truck | Heavy Duty | Heavy Duty | Light truck | Light truck | Light truck |
| Choose fuel used from drop down menu | Gasoline | Gasoline | Gasoline | Diesel | Gasoline | Diesel |
| Input total number of trips | | | | | | |
| Input number of miles per trip | | | | | | |

| WASTE INCINERATION | Incineration 1 | Incineration 2 | Incineration 3 | Incineration 4 | Incineration 5 | Incineration 6 |
|---|---|---|---|---|---|---|
| Input metric tons of soil or waste to be incinerated | | | | | | |

| THERMAL OXIDIZERS | Oxidizer 1 | Oxidizer 2 | Oxidizer 3 | Oxidizer 4 | Oxidizer 5 | Oxidizer 6 |
|---|---|---|---|---|---|---|
| Choose oxidizer type from drop down menu | Simple Thermal Oxidizer | Recuperative Thermal Oxidizer | Simple Thermal Oxidizer | Simple Thermal Oxidizer | Simple Thermal Oxidizer | Simple Thermal Oxidizer |
| Choose fuel type from drop down menu | natural gas | Propane | natural gas | natural gas | natural gas | natural gas |
| Input waste gas flow rate (scfm) | | | | | | |
| Input time running (hours) | | | | | | |
| Input waste gas inlet temperature (F) | | | | | | |
| Input contaminant concentration (ppmV) | | | | | | |

| WATER USE | Treatment System 1 | Treatment System 2 | Treatment System 3 | Treatment System 4 | Treatment System 5 | Treatment System 6 |
|---|---|---|---|---|---|---|
| Input water disposed/collected during treatment (gal) | | | | | | |
| Input water disposed/collected during site preparation (gal) | | | | | | |
| Input water disposed/collected during sampling (gal) | | | | | | |
| Input water disposed/collected during site closeout (gal) | | | | | | |

| LANDFILL METHANE EMISSIONS | Landfill 1 | Landfill 2 | Landfill 3 | Landfill 4 | Landfill 5 | Landfill 6 |
|---|---|---|---|---|---|---|
| Input landfill methane emissions (metric tons) | | | | | | |

| OTHER KNOWN ONSITE ACTIVITIES | Entire Site |
|---|---|
| Input energy usage (MMBTU) | |
| Water consumption (gallon) | |
| Input $CO_2$ emission (metric ton) | |
| Input $N_2O$ emission (metric ton $CO_2$ e) | |
| Input $CH_4$ emissions (metric ton $CO_2$ e) | |
| Input NOx emission (metric ton) | |
| Input SOx emission (metric ton) | |
| Input $PM_{10}$ emission (metric ton) | |
| Input fatality risk | |
| Input injury risk | |

# Look-Up Tables

**Table 2c: Air travel lifecycle impact**

| | |
|---|---|
| kg $CO_2$ / passenger mile[a] | 0.277 |
| g $CH_4$ / passenger mile[a] | 0.0104 |
| g $N_2O$ / passenger mile[a] | 0.0085 |
| mg $SO_2$ / passenger mile[b] | 140 |
| mg $NO_x$ / passenger mile[b] | 670 |
| mg $PM_{10}$ / passenger mile[b] | 32 |
| MPG[c] | 2.65 |
| BTU / passenger mile[d] | 3261 |

[a] Values obtained from EPA Climate Leaders "Commuting, Business Travel and Product Transport" Guidance, pg 7 Table 4 (May 2008)
[b] Values obtained from Chester, Mikhail, & Horvath, Arpad. (2008). Environmental Life-cycle Assessment of Passenger Transportation: A Detailed Methodology for Energy, Greenhouse Gas and Criteria Pollutant Inventories of Automobiles, Buses, Light Rail, Heav
[c] Values obtained from EPA Climate Leaders "Direct Emissions from Mobile Combustion Sources" Guidance, pg 12 Table 4 (May 2008)
[d] Values obtained from "Transportation Energy Data Book". U.S. Department of Energy (June 2008)

**Table 2d: Air cargo transportation lifecycle impact**

| | |
|---|---|
| kg $CO_2$/ ton mile[a] | 1.527 |
| g $N_2O$ / ton mile[a] | 0.0479 |
| g $CH_4$ / ton mile[a] | 0.0417 |
| g $NO_x$ / ton mile[b] | 6.1800 |
| g $SO_x$ / ton mile[b] | 2.2100 |
| g $PM_{10}$ / ton mile[b] | 0.8100 |
| BTU / ton mile[c] | 9,600 |

[a] Values obtained from EPA Climate Leaders "Commuting, Business Travel and Product Transport" Guidance, pg 12 Table 8 (May 2008)
[b] Values obtained from Facanha, Cristiano and Arpad Horvath. Evaluation of Life-Cycle Air Emission Factors of Freight Transportation. Environ. Sci. Technol. 2007, 41, 7138-7144
[c] Values for fuel consumption obtained from "Transportation Energy Data Book". U.S. Department of Energy (June 2008)

## Example inventories include fuel consumption rates and emissions factors for vehicle and rail travel

- Includes $CO_2$, $CH_4$, and $N_2O$ emissions factors

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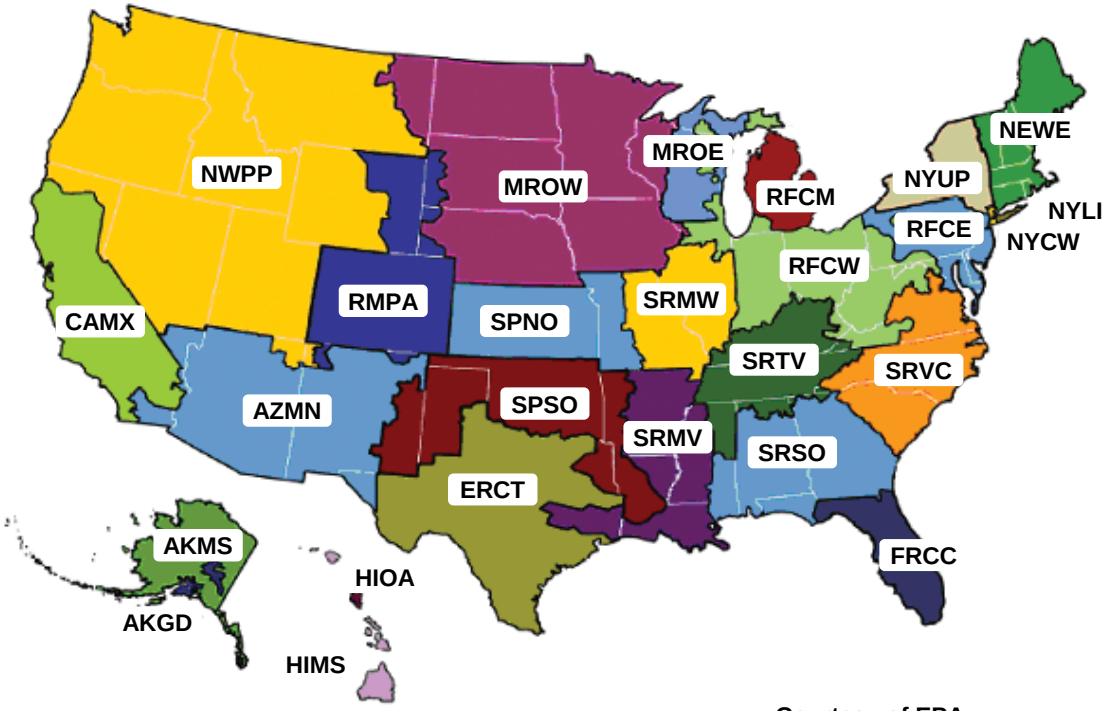
# Basis for Calculations – Energy and Air Emissions

- Electricity Consumption
  - Estimate electricity consumption for all significant sources
    - Tool assists with procedures to estimate consumption based on:
      - Nameplate inventory, equipment performance requirements, or known electricity usage
  - Input location on coded map embedded in tool
  - Linked lookup table provides air emission values per MW-hr and MMBTU of electricity use in a particular location
    - Values obtained from government sources, including EPA Climate Leaders and DOE EIA publications

# GHG Emissions for Electric Power Consumption

- GHG emission calculated based on site location
- GHG generation per unit power consumption can vary by greater than 2:1 depending on location
- Custom energy profiles can be added into the tool




Courtesy of EPA

# Basis for Calculations – Energy and Air Emissions (cont.)

- Transportation➔ Linked lookup tables provide fuel usage and air emissions as a function of several inputs
  - Mode (e.g., road, rail, air or water transportation)
  - Vehicle type (e.g., cars, SUVs, light trucks, heavy trucks, etc.)
  - Fuel type (gasoline, diesel, biodiesel 20, E-diesel)
  - Miles traveled
  - Material weight
  - Energy use is reported in BTUs
  - Air emission values obtained from government sources, including EPA Climate Leaders, GREET, Mobile 6, Non-road, and AP-42

# Basis for Calculations – Energy and Air Emissions (cont.)

- Material use
  - Tool assists in calculating mass of materials
    - For example, linked look-up tables are used to calculate mass of well material based on material used (e.g., PVC or steel), length, diameter and schedule
  - Linked look-up tables provide life-cycle numbers for energy consumption and air emission factors for various materials, including
    - PVC
    - Fuels
    - Steel
    - GAC
    - Biostimulant such as molasses, Veg Oil
    - Oxidant such as $H_2O_2$
  - Variety of sources used for above calculations

# Basis for Calculation – Accident Risk

- Linked look-up tables include accident and injury statistics (from government agencies) for various activities including transportation (road, rail, air), construction and other industries
- Transportation risk is based on miles traveled
  - Fatality/Injury Risk = (miles traveled * Fatality/Injury Rate)/100,000,000
    - Number of fatalities or injuries per 100,000,000 passenger miles for different modes of transportation
- Construction risk is based on hours worked
  - Fatality/Injury Risk = (hours worked * Fatality/Injury Rate)/200,000,000
    - Number of fatalities or injuries per 100,000 workers or 200,000,000 hours worked (assuming average of 2,000 hours worked per year)

# Metrics that are Not Quantified by SiteWise™

| | |
|---|---|
| Ecological Impacts | • Introduction of invasive species<br>• Changes in ecosystem structure or shifts in the geographic distribution and extent of major ecosystem types<br>• Disturbance to soil and surface water bodies<br>• Destruction of habitats |
| Resource Consumption | • Resources that are not specifically identified in other metrics, e.g., landfill space and top soil |
| Community Impacts | • Local disturbances and health & safety issues caused by remedial activities, such as:<br>• Noise<br>• Traffic issues, including accidents during transportation<br>• Odor<br>• Dust<br>• Emissions of VOCs and other contaminants |

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# Output Broken Down to Individual Activity in a Particular Phase of Remedial Action

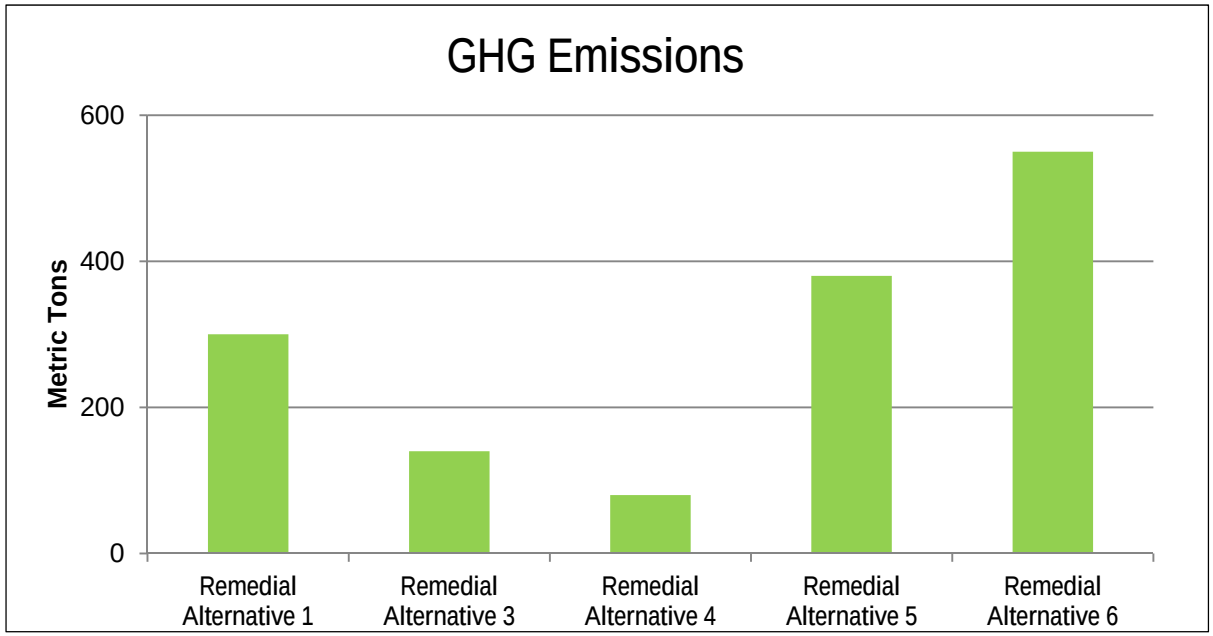
**Sustainable Remediation - Environmental Footprint Summary**

**Alternative Enhanced Bioremediation — In situ Enhanced Bioremediation, MNA, Shallow Soil Excavation, and LUCs**

| Phase | Activities | GHG Emissions metric ton | Total Energy Used MMBTU | Water Impacts gallons | $NO_x$ Emissions metric ton | $SO_x$ Emissions metric ton | $PM_{10}$ Emissions metric ton | Accident Risk Fatality | Accident Risk Injury |
|---|---|---|---|---|---|---|---|---|---|
| Remedial Investigation | Consumables | 0.00 | 0.0E+00 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 0.00 | 0.0E+00 | NA | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Transportation-Equipment | 0.00 | 0.0E+00 | NA | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Equipment Use | 0.00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Residual Handling | 0.00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Sub-Total | 0.00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Remedial Action Construction | Consumables | 0.00 | 0.0E+00 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 0.34 | 3.8E+00 | NA | 6.4E-04 | 9.4E-05 | 4.4E-05 | 2.1E-05 | 1.5E-03 |
| | Transportation-Equipment | 0.28 | 7.2E+00 | NA | 1.7E-03 | 2.2E-04 | 1.3E-04 | 7.2E-07 | 1.5E-04 |
| | Equipment Use | 6.36 | 6.7E+01 | 0.0E+00 | 2.6E-02 | 7.4E-03 | 2.5E-03 | 4.8E-06 | 2.0E-03 |
| | Residual Handling | 130.06 | 1.3E+03 | 0.0E+00 | 3.5E-01 | 4.6E-02 | 2.7E-02 | 3.7E-06 | 7.8E-04 |
| | Sub-Total | 137.04 | 1.40E+03 | 0.00E+00 | 3.78E-01 | 5.33E-02 | 3.01E-02 | 3.05E-05 | 4.50E-03 |
| Remedial Action Operations | Consumables | 10.49 | 2.6E+02 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 0.26 | 2.8E+00 | NA | 4.9E-04 | 7.0E-05 | 3.3E-05 | 1.4E-05 | 1.0E-03 |
| | Transportation-Equipment | 0.24 | 5.2E+00 | NA | 1.1E-03 | 1.5E-04 | 8.8E-05 | 4.8E-07 | 1.0E-04 |
| | Equipment Use | 0.68 | 8.9E+00 | 2.7E+01 | 3.9E-03 | 7.8E-04 | 2.9E-04 | 4.8E-06 | 2.1E-03 |
| | Residual Handling | 0.94 | 7.8E+00 | 2.2E+02 | 2.5E-03 | 3.3E-04 | 2.0E-04 | 3.4E-07 | 7.1E-05 |
| | Sub-Total | 12.61 | 2.81E+02 | 2.47E+02 | 8.05E-03 | 1.33E-03 | 6.13E-04 | 1.99E-05 | 3.28E-03 |
| Long-Term Monitoring | Consumables | Activities | 3.5E+00 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 1.21 | 1.6E+01 | NA | 2.3E-03 | 4.0E-04 | 1.8E-04 | 4.8E-05 | 3.5E-03 |
| | Transportation-Equipment | 0.21 | 1.8E+00 | NA | 5.6E-04 | 7.3E-05 | 4.4E-05 | 2.4E-07 | 5.0E-05 |
| | Equipment Use | 0.93 | 1.3E+01 | 0.0E+00 | 5.5E-03 | 9.1E-04 | 4.2E-04 | 7.3E-07 | 3.1E-04 |
| | Residual Handling | 6.75 | 5.6E+01 | 0.0E+00 | 1.8E-02 | 2.4E-03 | 1.4E-03 | 6.8E-07 | 1.4E-04 |
| | Sub-Total | 9.10 | 9.01E+01 | 0.00E+00 | 2.65E-02 | 3.74E-03 | 2.07E-03 | 4.99E-05 | 3.97E-03 |
| **Total** | | **1.6E+02** | **1.8E+03** | **2.5E+02** | **4.1E-01** | **5.8E-02** | **3.3E-02** | **1.0E-04** | **1.2E-02** |

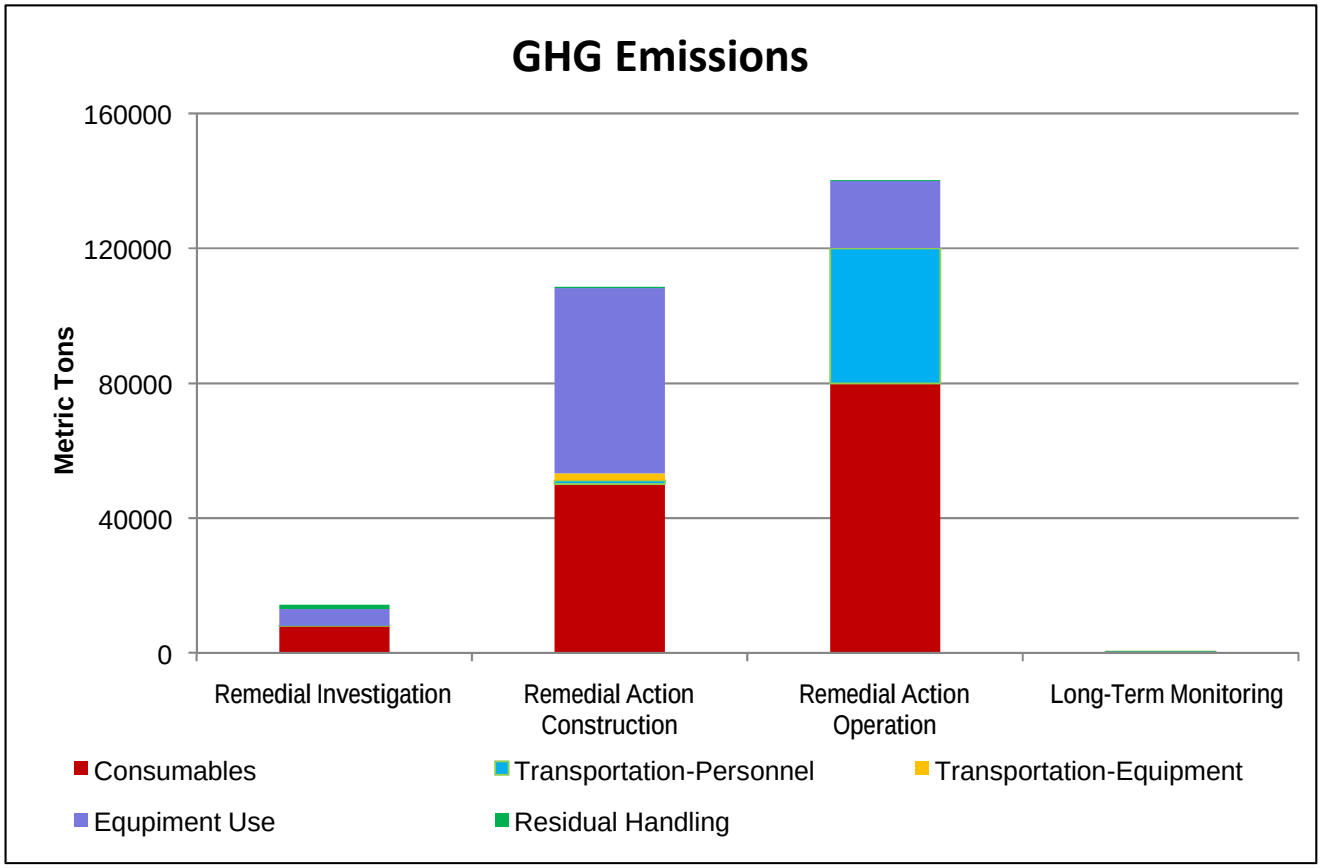
# Different Graphical Outputs for Comparing Metrics and Remedial Alternatives

| Remedial Alternatives | GHG Emissions | Total Energy Used | Water Consumption | $NO_x$ emissions | $SO_x$ Emissions | $PM_{10}$ Emissions | Accident Risk Fatality | Accident Risk Injury |
|---|---|---|---|---|---|---|---|---|
| | metric ton | MMBTU | gallons | metric ton | metric ton | metric ton | | |
| Remedial Alternative 1 | 300.00 | 3.05E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Remedial Alternative 3 | 140.00 | 3.05E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Remedial Alternative 4 | 80.00 | 3.05E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Remedial Alternative 5 | 380.00 | 2.20E-01 | 0.00E+00 | 6.00E-05 | 1.00E-06 | 1.00E-06 | 1.51E-08 | 3.14E-06 |
| Remedial Alternative 6 | 550.00 | 2.20E-01 | 0.00E+00 | 6.00E-05 | 1.00E-06 | 1.00E-06 | 1.51E-08 | 3.14E-06 |




- Comparative graphic shown for GHG emissions
- Similar graph is generated for each metric

# Different Graphical Outputs for Comparing Metrics and Remedial Alternatives (cont.)




- Graphic illustrates which phases of the project have large footprints and which specific elements in each phase have large footprints

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# How are Results of GSR Analysis Used?

- Different sites have different priorities – GSR metrics are weighed based on the site stakeholders priorities
- Most metrics calculations work within a certain accuracy range
  - Therefore, a GHG footprint between different alternatives that is within the accuracy range can be considered similar
    - Comparison between different alternatives can also be based on a qualitative analysis assuming all metrics of the same priority
    - A metric's impact can be considered high or low relative to each other

| Alternative | Impact Assessment | GHG Emissions | Energy Usage | Air Emissions | Collateral Risk | Community Impacts | Resources Lost | Water Usage |
|---|---|---|---|---|---|---|---|---|
| Enhanced Bioremediation | Relative Impact | Low | Low | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | Biostiumulant Production and transportation & equip during shallow GW excavation | Biostiumulant Production and transportation and equip during shallow GW excavation | Biostiumulant Production and transportation and equip during shallow GW excavation | Transportation related to long term groundwater monitoring and transportation and equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | Biostiumulant Production |
| ISCO | Relative Impact | Low to Medium | Low to Medium | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | Oxidant Prod,, transportation & equip during shallow GW excavation | Oxidant Prod., transportation & equip during shallow GW excavation | Oxidant Prod., transportation & equip during shallow GW excavation | Transportation & equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | Chemical Oxidant Production |
| ISCR | Relative Impact | Low to Medium | Low to Medium | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | ZVI production, transportation & equip during shallow GW excavation | ZVI Production, transportation & equip during shallow GW excavation | ZVI Production, transportation & equip during shallow GW excavation | Transportation & equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | ZVI Production |
| ERH | Relative Impact | High | High | High | Medium | Low | Medium | High |
| | Impact Drivers | Electrical Usage | Electrical Usage | Electrical Usage | System Construction and Operation | Land Use Controls during the period of application | Lost groundwater | Electrical Production |
| Excavation | Relative Impact | Medium | Low to Medium | Medium | High | High | High | Low |
| | Impact Drivers | Transportation & Disposal | Transportation & Disposal | Transportation & Disposal | Excavation to 20 ft | Disturbance due to increased traffic | Landfill Space and lost groundwater | Production of PVC for wells and GAC for water treatment |

# Typical Findings

- Aggressive and high-cost remedies usually have greater environmental footprints than less-aggressive and lower-cost remedies
  - High-footprint activities generally involve active remediation techniques requiring heavy machinery, equipment, etc.
- Comparative results are often as expected, but not always
  - In situ air sparging (IAS)/soil vapor extraction (SVE) had greater impact than excavation for one site, but SVE had lesser impact than excavation for another
- Results are significantly impacted by assumptions
  - For example, the number of ISCO injections that are assumed will have significant affect on the comparison
  - Similar to the way cost estimates are impacted during FS
  - Where uncertainties exist, sensitivity analysis could be performed to understand the effects of the assumptions

# High-Footprint Activities to Look For

| Activity | Metrics Most Impacted |
|---|---|
| Transportation (for materials and waste as well as personnel during RA-O & LTMgt) | Emissions of GHGs, criteria pollutants, consumption of energy, accident risk (particularly death) |
| Operation of mechanical equipment (e.g., pumps, blowers, compressors) | Emissions of GHGs, consumption of energy |
| Drilling/Well installation | Emissions of GHGs, criteria pollutants, consumption of energy, accident risk (particularly injury) |
| Consumption of chemicals or other materials (e.g., oxidants, ZVI, biostimulants, GAC) | Emissions of GHGs, consumption of energy |

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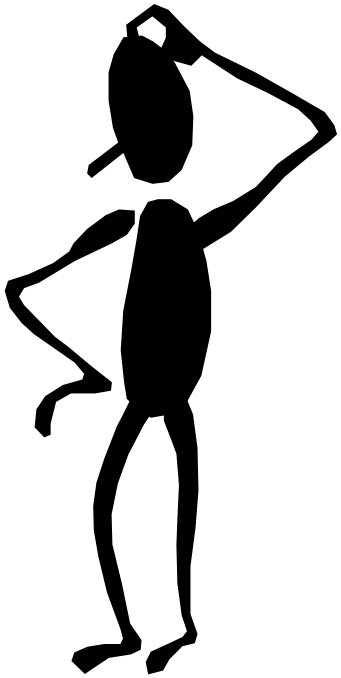
# Application of SiteWise™ in Determining the Most Sustainable Option among Remedial Alternatives

- Remedy selection represents the greatest environmental footprint reduction potential
  - Footprint differences between remedies can be quite large
  - Less-aggressive/less-costly remedies tend to have a lower footprint
  - SiteWise™ helps you to quantify those differences so they can be considered in the remedy selection process
- Without quantified metrics, it is difficult to determine what approach is really green compared to another

# What is Really Green?

*Greeeeeen technologies, get your green technologies here*



Quantified metrics can help determine what approach is really green vs. perception

# Putting Metrics into Perspective

- Other conventional criteria still apply
  - Under CERCLA, GSR metrics are viewed as fitting into existing nine criteria
  - Work being done to map GSR metrics into CERCLA-nine
- Regulators and stakeholders sometimes leery of green washing
  - Don't use GSR metrics as an excuse for no-action or passive remediation techniques that are not completely protective
- Regardless of GSR metrics, a remedy that does not meet the remedial action objectives is not a sustainable solution

# SiteWise™ Results Are Not the Only Factor

Calculated environmental footprint is an important factor but remedies must still be protective of human health and the environment

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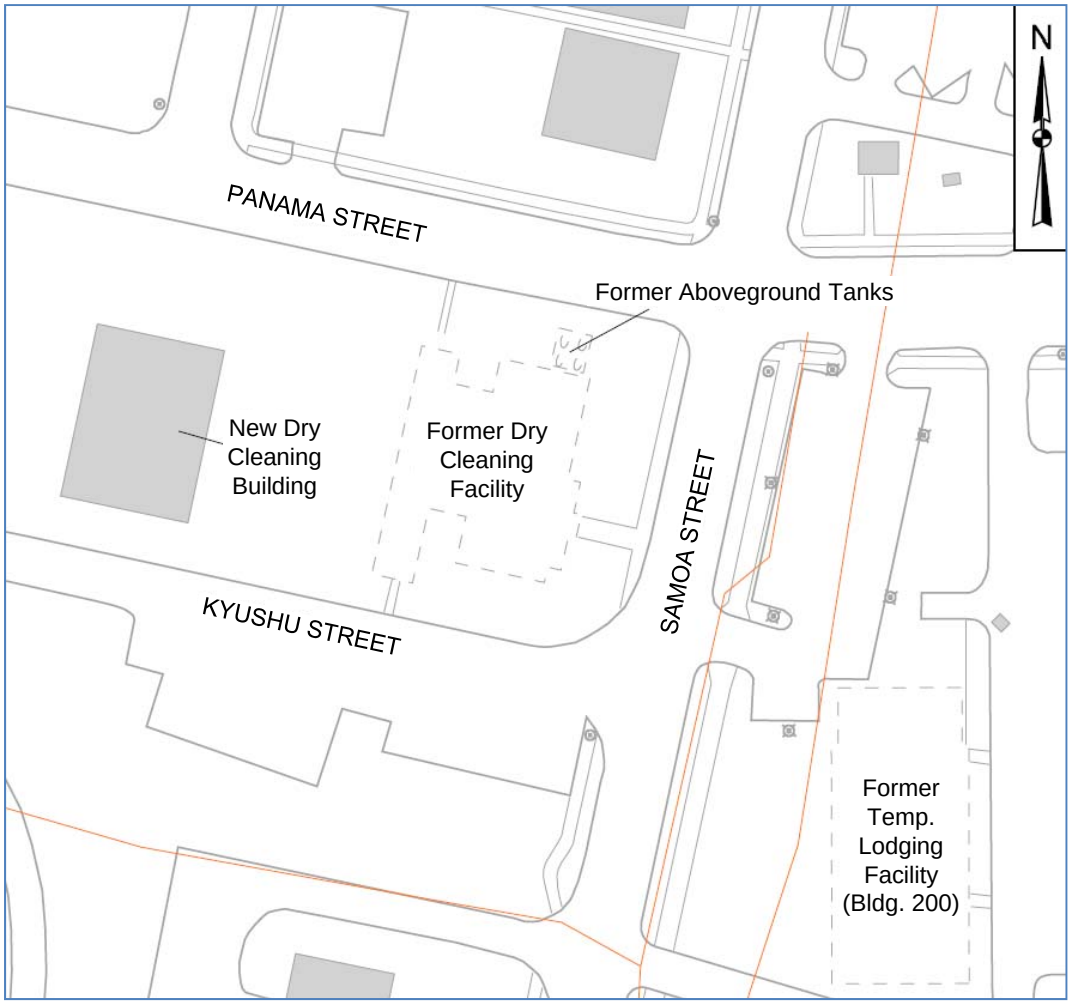
# Using SiteWise™ During Remedy Evaluation

- Case Study: Site 45 Marine Corps Recruit Depot, Parris Island, SC (hereafter Parris Island)
  - Former dry cleaning facility
  - Contamination in soil and groundwater caused by PCE release from an aboveground storage tank



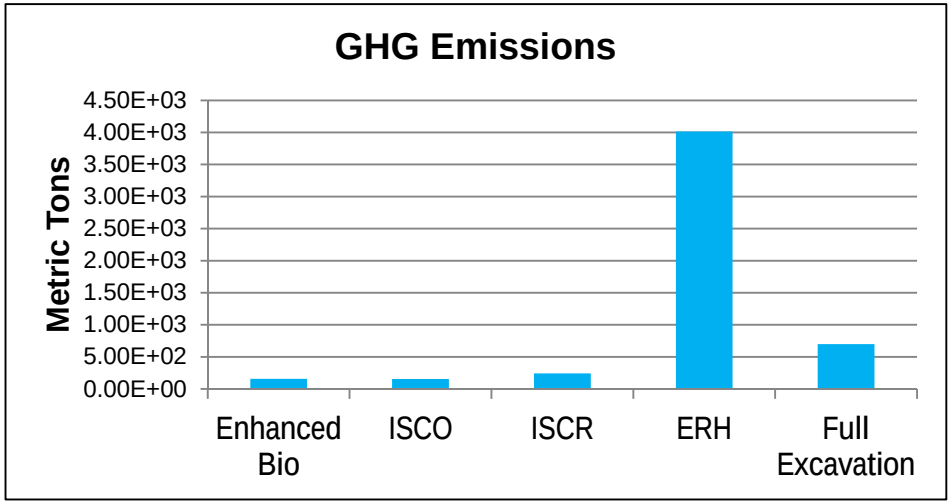

**Courtesy of US Navy**

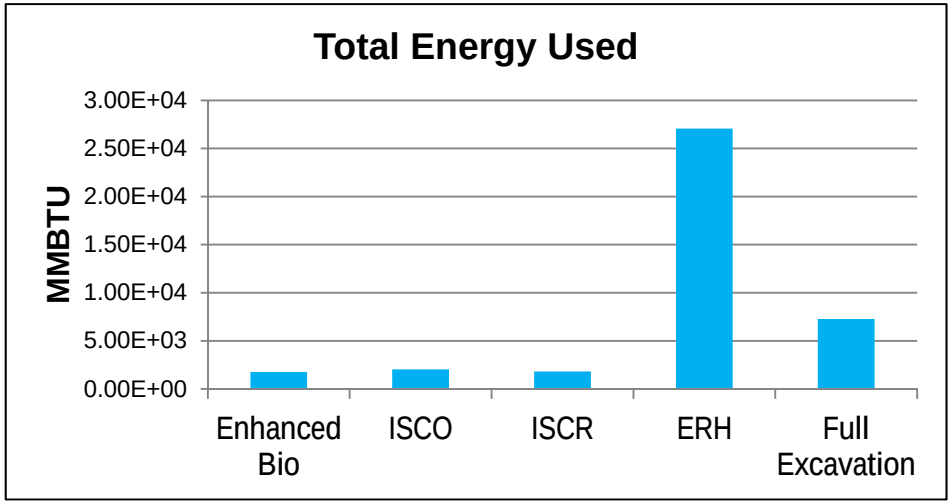
# Case Study: Site 45 Parris Island

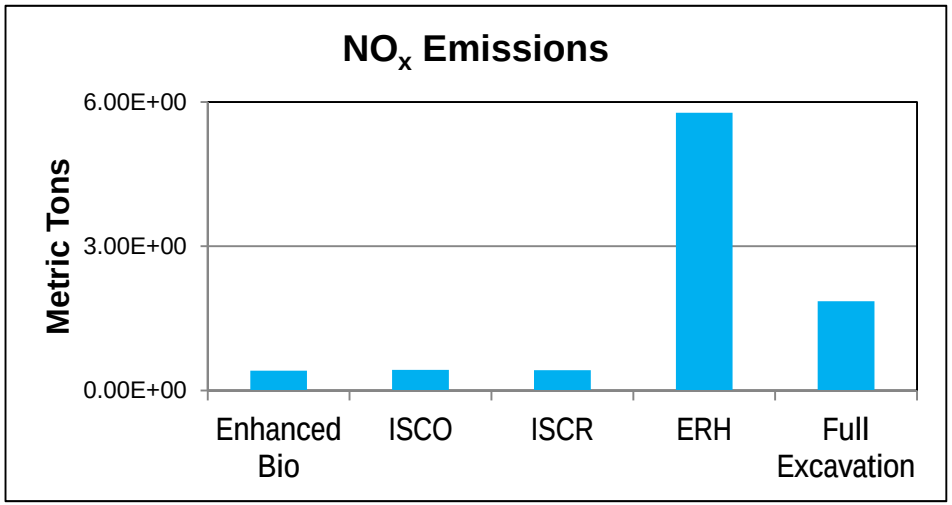
- Five alternatives evaluated
  - Enhanced bioremediation with shallow soil excavation
  - In situ chemical oxidation (ISCO) with shallow soil excavation
  - In situ chemical reduction (ISCR) with shallow soil excavation
  - Electro-resistance heating (ERH) with limited excavation
  - Full excavation of contaminated zone

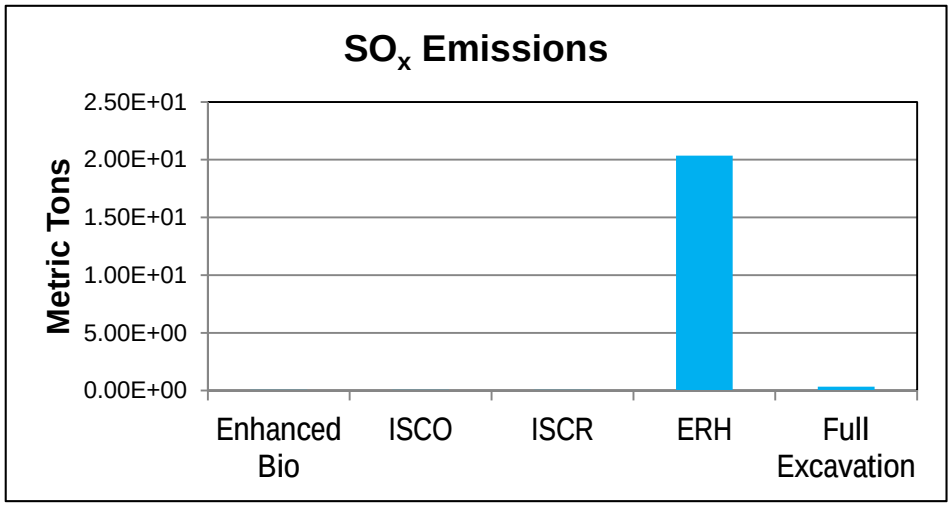
| Remedial Alternatives | GHG Emissions | Total Energy Used | Water Consumption | $NO_x$ emissions | $SO_x$ Emissions | $PM_{10}$ Emissions | Accident Risk Fatality | Accident Risk Injury |
|---|---|---|---|---|---|---|---|---|
| | metric ton | MMBTU | gallons | metric ton | metric ton | metric ton | | |
| Enhanced Bio | 158.92 | 1.78E+03 | 2.47E+02 | 4.12E-01 | 5.83E-02 | 3.28E-02 | 1.00E-04 | 1.17E-02 |
| ISCO | 230.67 | 2.99E+03 | 8.11E+01 | 4.31E-01 | 6.15E-02 | 3.42E-02 | 1.46E-04 | 2.08E-02 |
| ISCR | 243.82 | 1.81E+03 | 2.70E+01 | 4.22E-01 | 5.98E-02 | 3.36E-02 | 1.15E-04 | 1.52E-02 |
| ERH | 4014.90 | 2.71E+04 | 3.97E+06 | 5.77E+00 | 2.04E+01 | 1.71E-02 | 1.64E-04 | 2.25E-02 |
| Full Excavation | 698.97 | 7.27E+03 | 1.52E+06 | 1.86E+00 | 3.33E-01 | 1.45E-01 | 3.43E-04 | 2.86E-02 |

# Parris Island: Remedy Comparison Graphics (Energy, Emissions of GHG, NOx and SOx )

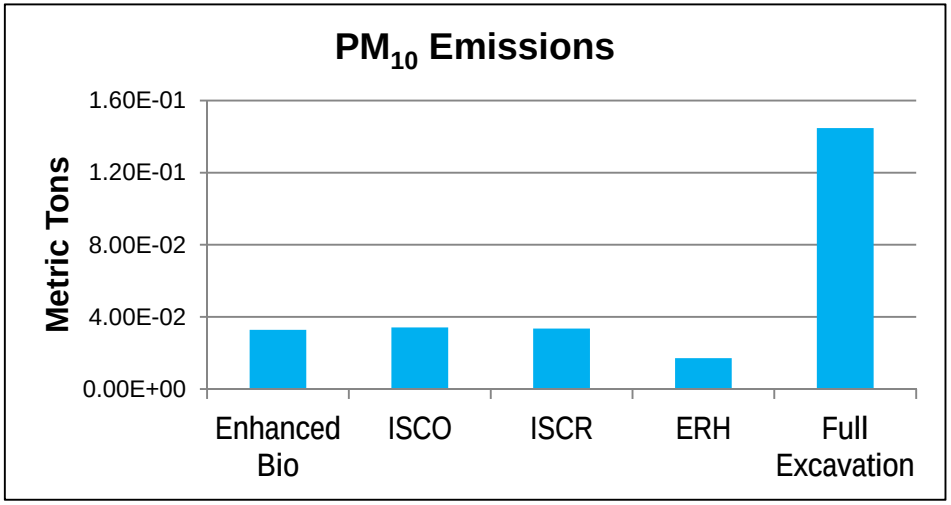


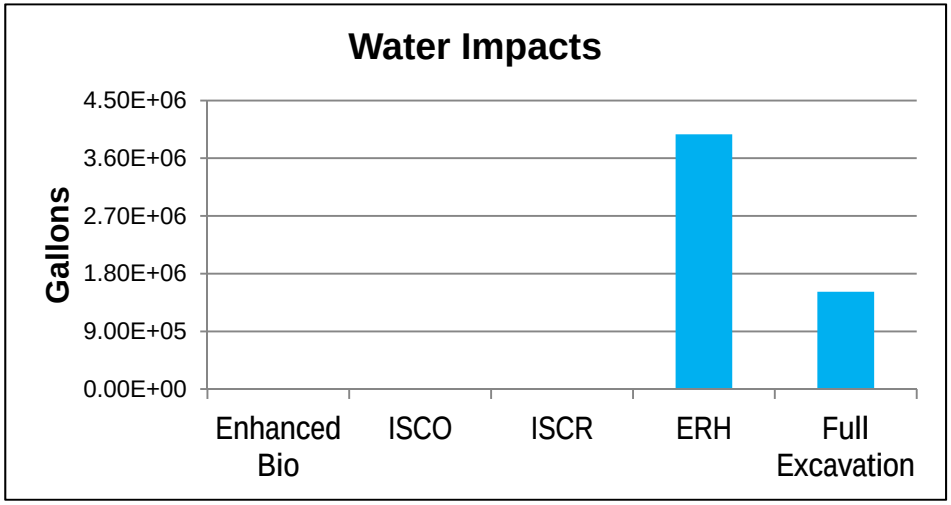



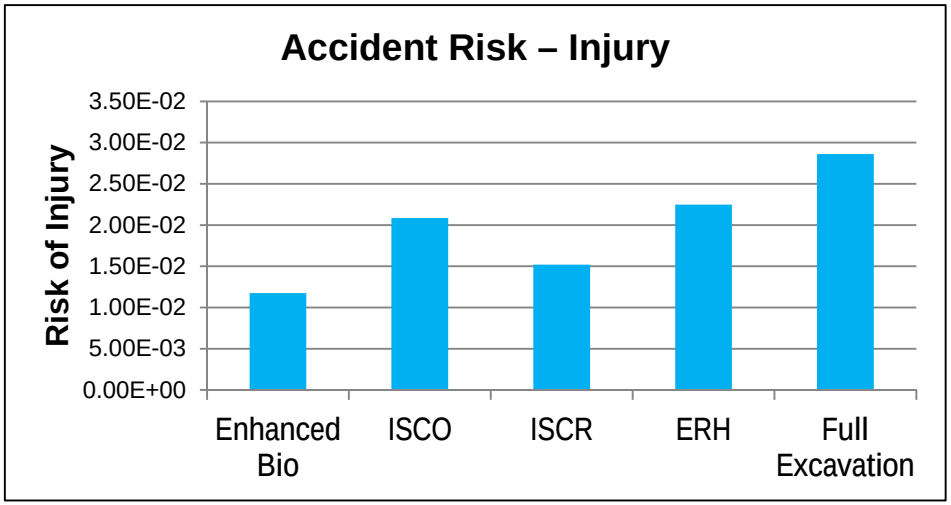



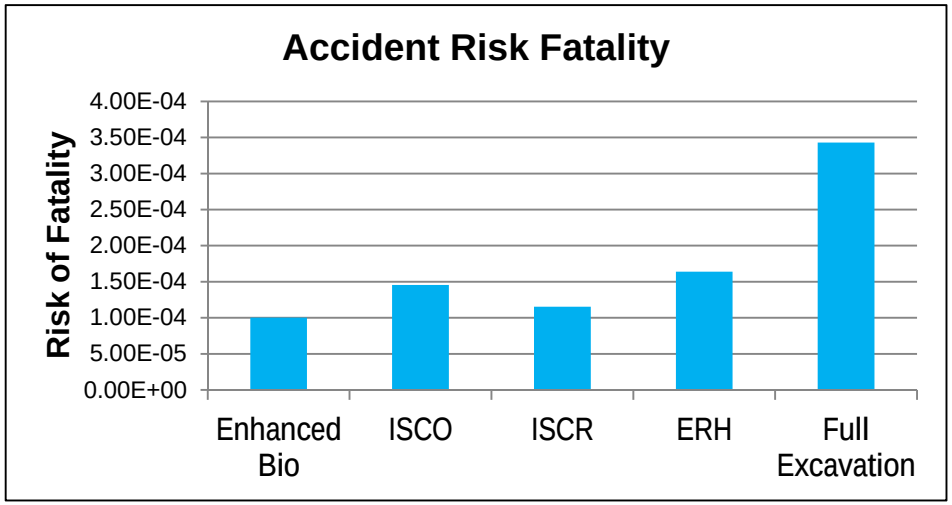



# Parris Island: Remedy Comparison Graphics (PM10, Water, Accident Risk)



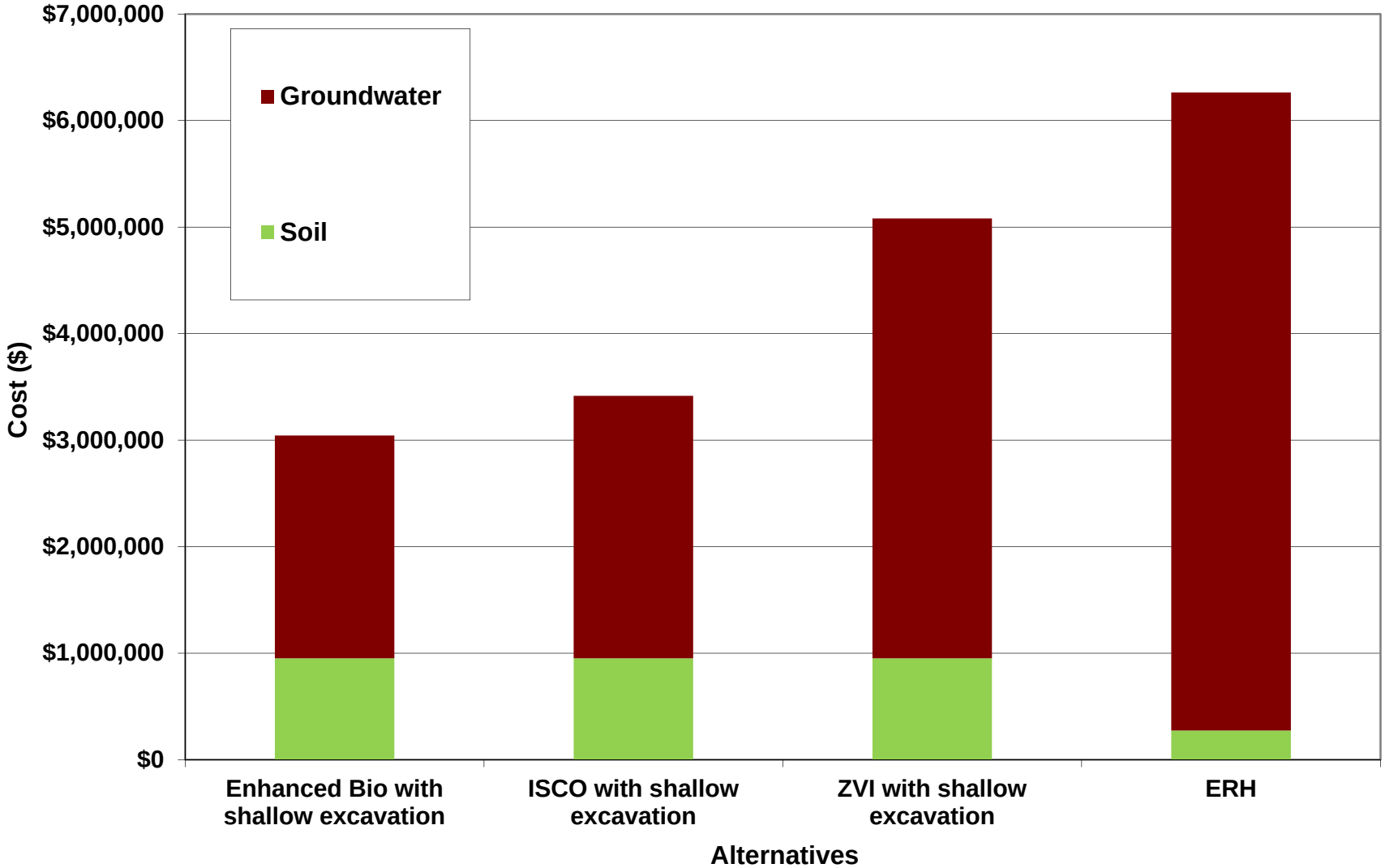



# Parris Island: Remedy Comparison Summary Table

| Alternative | Impact Assessment | GHG Emissions | Energy Usage | Air Emissions | Collateral Risk | Community Impacts | Resources Lost | Water Usage |
|---|---|---|---|---|---|---|---|---|
| Enhanced Bioremediation | Relative Impact | Low | Low | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | Biostiumulant Production and transportation & equip during shallow GW excavation | Biostiumulant Production and transportation and equip during shallow GW excavation | Biostiumulant Production and transportation and equip during shallow GW excavation | Transportation related to long term groundwater monitoring and transportation and equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | Biostiumulant Production |
| ISCO | Relative Impact | Low to Medium | Low to Medium | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | Oxidant Prod,, transportation & equip during shallow GW excavation | Oxidant Prod., transportation & equip during shallow GW excavation | Oxidant Prod., transportation & equip during shallow GW excavation | Transportation & equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | Chemical Oxidant Production |
| ISCR | Relative Impact | Low to Medium | Low to Medium | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | ZVI production, transportation & equip during shallow GW excavation | ZVI Production, transportation & equip during shallow GW excavation | ZVI Production, transportation & equip during shallow GW excavation | Transportation & equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | ZVI Production |
| ERH | Relative Impact | High | High | High | Medium | Low | Medium | High |
| | Impact Drivers | Electrical Usage | Electrical Usage | Electrical Usage | System Construction and Operation | Land Use Controls during the period of application | Lost groundwater | Electrical Production |
| Excavation | Relative Impact | Medium | Low to Medium | Medium | High | High | High | Low |
| | Impact Drivers | Transportation & Disposal | Transportation & Disposal | Transportation & Disposal | Excavation to 20 ft | Disturbance due to increased traffic | Landfill Space and lost groundwater | Production of PVC for wells and GAC for water treatment |

# Parris Island: Cost Evaluation




Note: Excavation alternative not evaluated

# Summary of Parris Island Sustainability Analysis during Remedy Evaluation

- Comparative analysis indicates that enhanced bioremediation and ISCO have the lowest footprint
- Cost and footprint seem to correlate for this site
  - Remedies with the lowest environmental footprint also have the lowest cost
- Sustainability analysis supports the selection of enhanced bioremediation as the preferred remedy

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# Using SiteWise™ to Conduct Different Analyses and Identify Technologies that can Help Decrease the Environmental Footprint

- Why do sustainability analysis during Remedial Design?
  - Must first understand what causes the footprint before it can be efficiently and effectively reduced
  - Haphazard footprint reduction will likely do more harm than good
- Consider the old 80:20 rule
  - 80% of the impacts are caused by 20% of the activities
- Can use SiteWise™ to help identify elements of selected remedy that results in the greatest impacts on footprint
- Can now focus footprint reduction techniques on the activities that cause the greatest footprint

# Case Study: Parris Island Enhanced Bioremediation

- Same inputs as comparative analysis
  - At design stage may have more precise inputs
- Remedy output files include
  - Detailed breakdown of footprint for each metric
    - By phase and by activity
  - Graphical outputs identify the high footprint activities
    - SiteWise™ allows user to quickly determine what specific elements of the remedy have the largest footprint for each remedy
- Perform sensitivity analysis
  - Modify inputs for the high footprint activities

# Case Study: Parris Island Enhanced Bioremediation

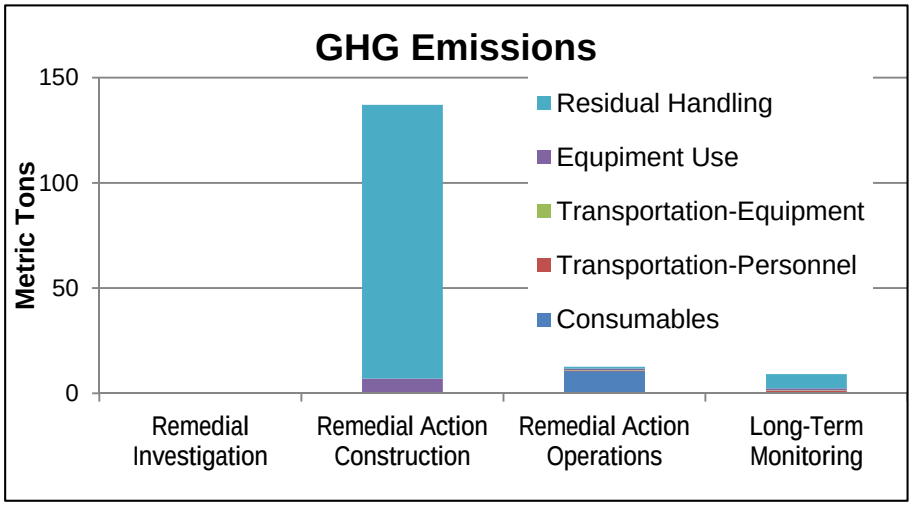
## Tabular results of each metric broken down by each element of remediation

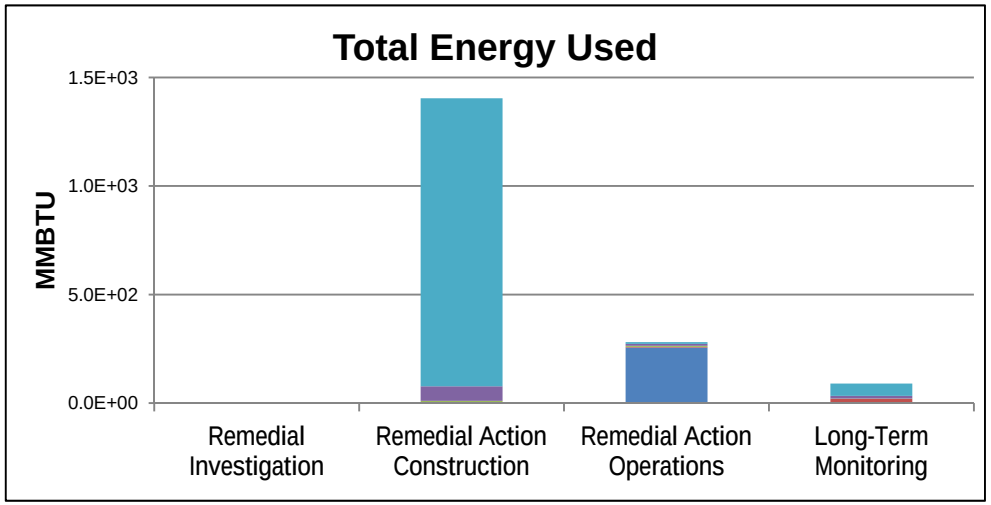
**Sustainable Remediation - Environmental Footprint Summary**

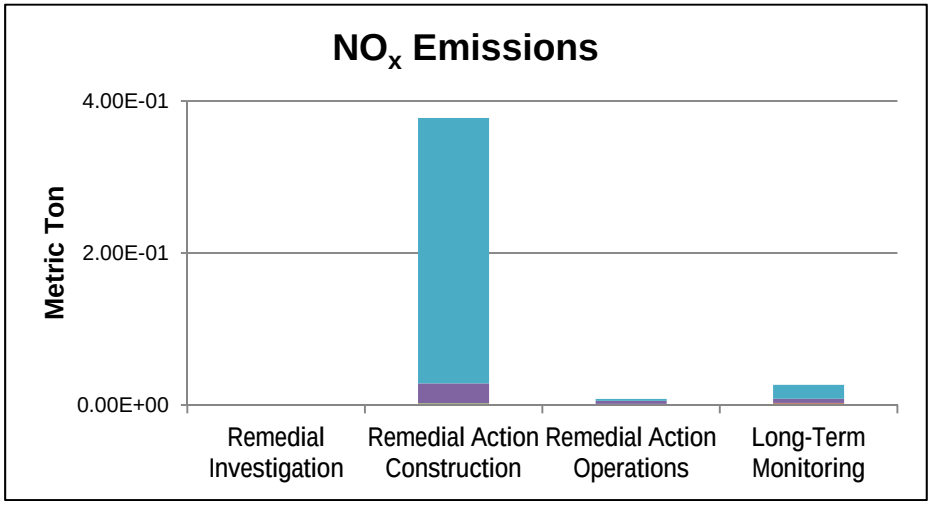
**Alternative Enhanced Bioremediation — In situ Enhanced Bioremediation, MNA, Shallow Soil Excavation, and LUCs**

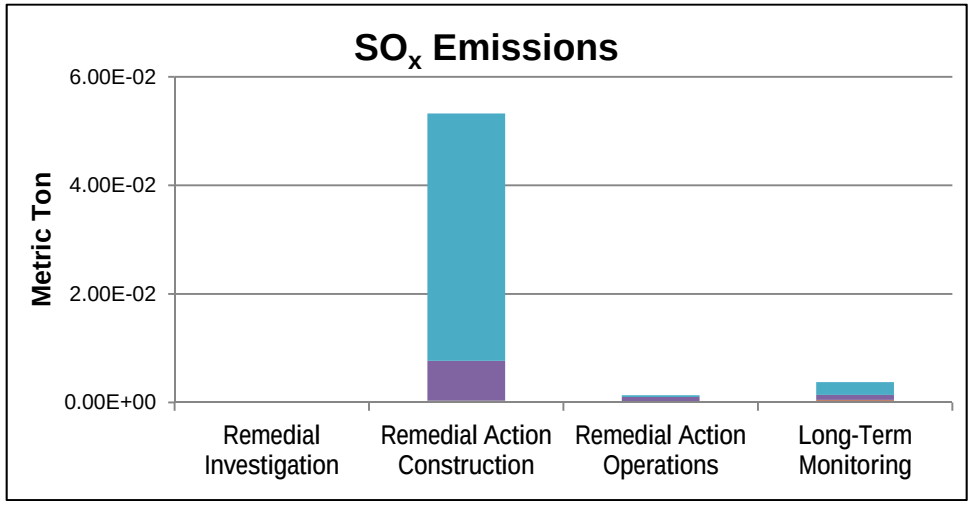
| Phase | Activities | GHG Emissions metric ton | Total Energy Used MMBTU | Water Impacts gallons | $NO_x$ Emissions metric ton | $SO_x$ Emissions metric ton | $PM_{10}$ Emissions metric ton | Accident Risk Fatality | Accident Risk Injury |
|---|---|---|---|---|---|---|---|---|---|
| Remedial Investigation | Consumables | 0.00 | 0.0E+00 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 0.00 | 0.0E+00 | NA | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Transportation-Equipment | 0.00 | 0.0E+00 | NA | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Equipment Use | 0.00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Residual Handling | 0.00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 | 0.0E+00 |
| | Sub-Total | 0.00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Remedial Action Construction | Consumables | 0.00 | 0.0E+00 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 0.34 | 3.8E+00 | NA | 6.4E-04 | 9.4E-05 | 4.4E-05 | 2.1E-05 | 1.5E-03 |
| | Transportation-Equipment | 0.28 | 7.2E+00 | NA | 1.7E-03 | 2.2E-04 | 1.3E-04 | 7.2E-07 | 1.5E-04 |
| | Equipment Use | 6.36 | 6.7E+01 | 0.0E+00 | 2.6E-02 | 7.4E-03 | 2.5E-03 | 4.8E-06 | 2.0E-03 |
| | Residual Handling | 130.06 | 1.3E+03 | 0.0E+00 | 3.5E-01 | 4.6E-02 | 2.7E-02 | 3.7E-06 | 7.8E-04 |
| | Sub-Total | 137.04 | 1.40E+03 | 0.00E+00 | 3.78E-01 | 5.33E-02 | 3.01E-02 | 3.05E-05 | 4.50E-03 |
| Remedial Action Operations | Consumables | 10.49 | 2.6E+02 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 0.26 | 2.8E+00 | NA | 4.9E-04 | 7.0E-05 | 3.3E-05 | 1.4E-05 | 1.0E-03 |
| | Transportation-Equipment | 0.24 | 5.2E+00 | NA | 1.1E-03 | 1.5E-04 | 8.8E-05 | 4.8E-07 | 1.0E-04 |
| | Equipment Use | 0.68 | 8.9E+00 | 2.7E+01 | 3.9E-03 | 7.8E-04 | 2.9E-04 | 4.8E-06 | 2.1E-03 |
| | Residual Handling | 0.94 | 7.8E+00 | 2.2E+02 | 2.5E-03 | 3.3E-04 | 2.0E-04 | 3.4E-07 | 7.1E-05 |
| | Sub-Total | 12.61 | 2.81E+02 | 2.47E+02 | 8.05E-03 | 1.33E-03 | 6.13E-04 | 1.99E-05 | 3.28E-03 |
| Long-Term Monitoring | Consumables | Activities | 3.5E+00 | NA | NA | NA | NA | NA | NA |
| | Transportation-Personnel | 1.21 | 1.6E+01 | NA | 2.3E-03 | 4.0E-04 | 1.8E-04 | 4.8E-05 | 3.5E-03 |
| | Transportation-Equipment | 0.21 | 1.8E+00 | NA | 5.6E-04 | 7.3E-05 | 4.4E-05 | 2.4E-07 | 5.0E-05 |
| | Equipment Use | 0.93 | 1.3E+01 | 0.0E+00 | 5.5E-03 | 9.1E-04 | 4.2E-04 | 7.3E-07 | 3.1E-04 |
| | Residual Handling | 6.75 | 5.6E+01 | 0.0E+00 | 1.8E-02 | 2.4E-03 | 1.4E-03 | 6.8E-07 | 1.4E-04 |
| | Sub-Total | 9.10 | 9.01E+01 | 0.00E+00 | 2.65E-02 | 3.74E-03 | 2.07E-03 | 4.99E-05 | 3.97E-03 |
| **Total** | | **1.6E+02** | **1.8E+03** | **2.5E+02** | **4.1E-01** | **5.8E-02** | **3.3E-02** | **1.0E-04** | **1.2E-02** |

# Parris Island: Detailed Graphical Analysis (Energy and Emissions of GHG, NOx and SOx)

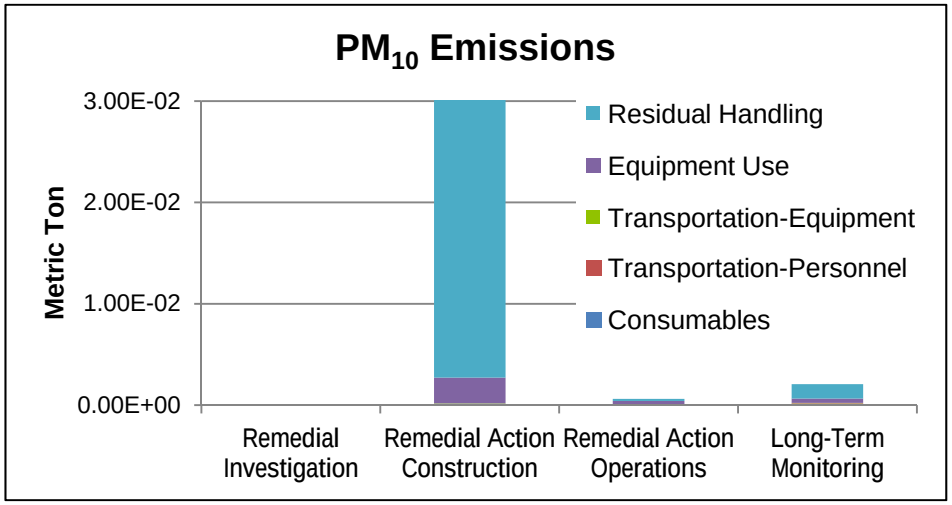


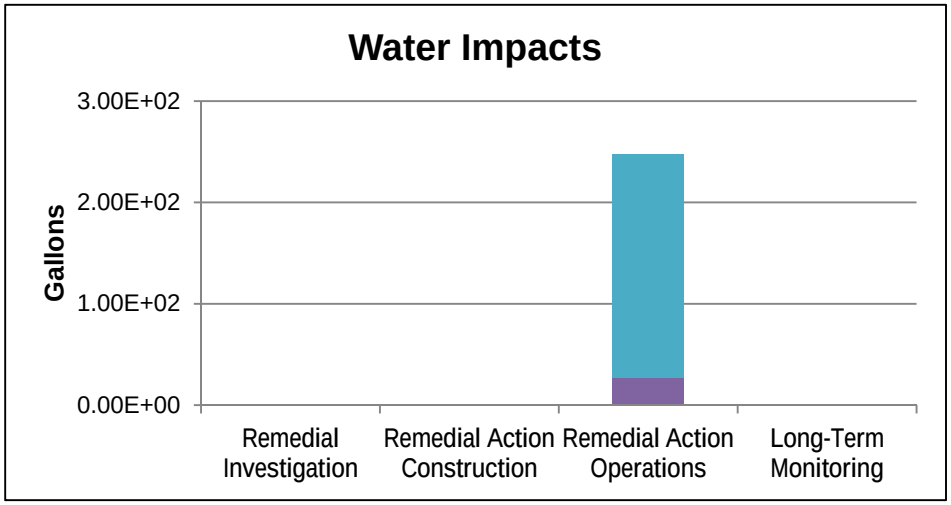



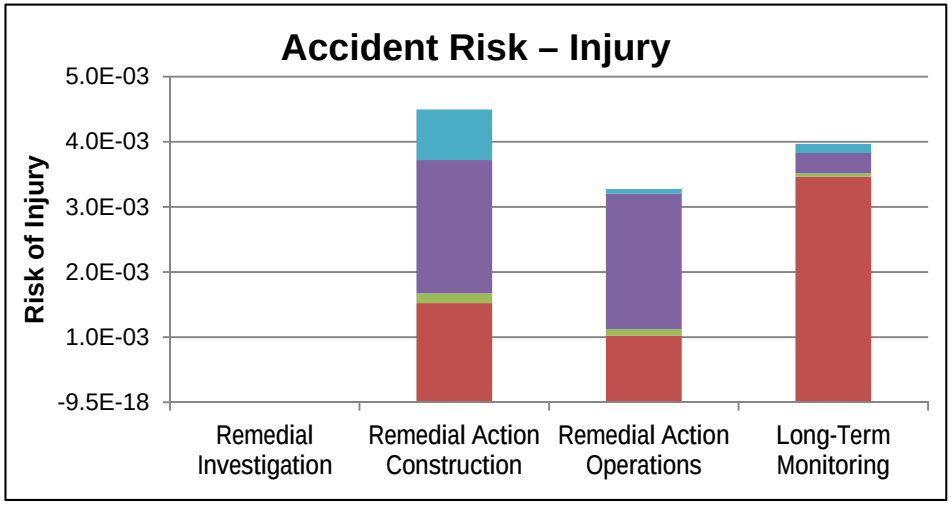



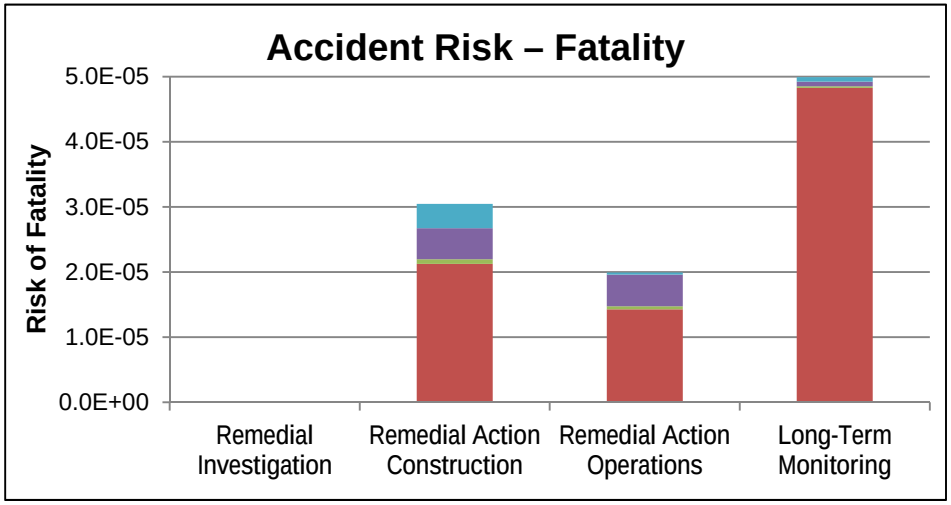



# Parris Island: Detailed Graphical Analysis (PM10, Water, Accident Risk)

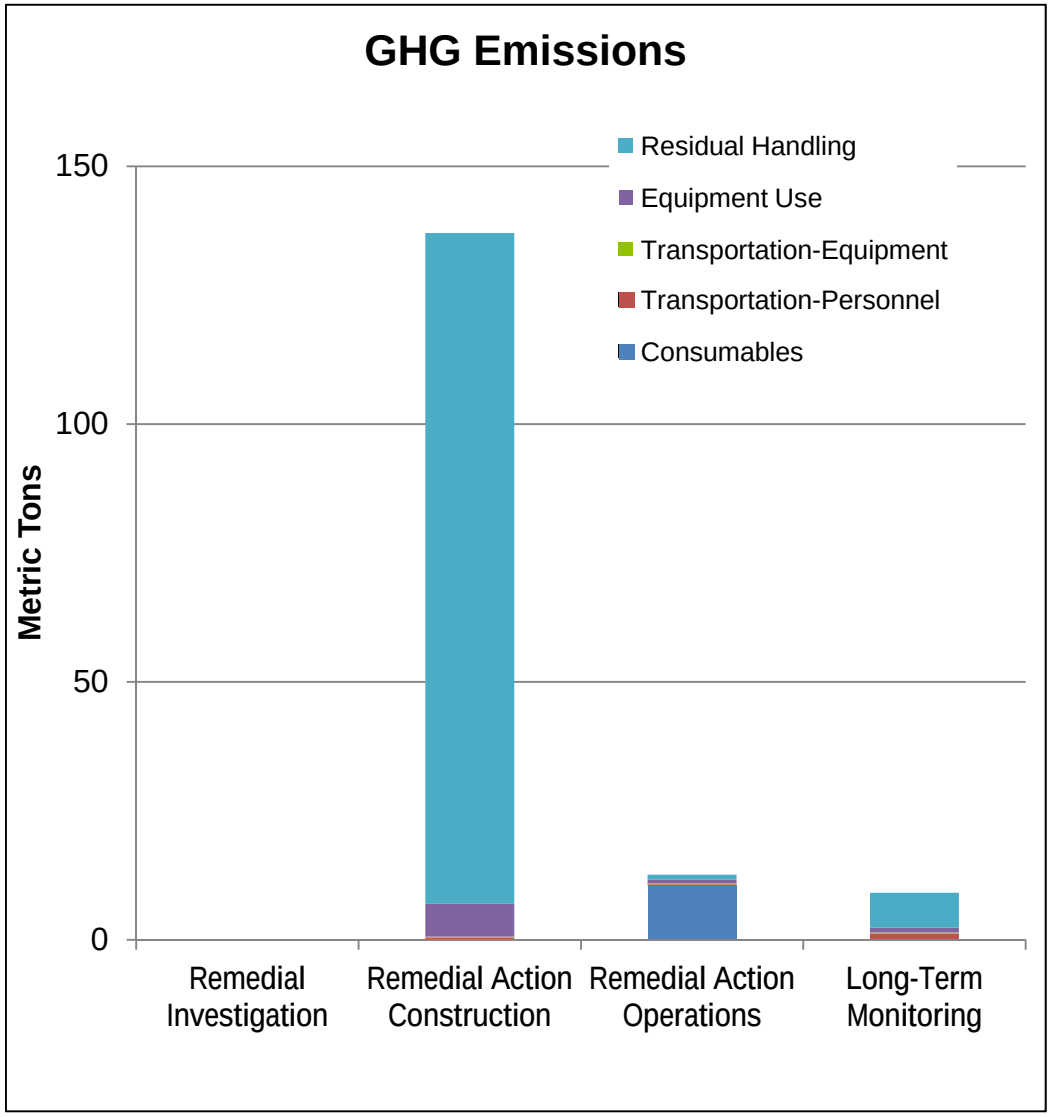


# Parris Island: Detailed Graphical Analysis (GHG Emissions)




## High-Footprint Elements

- Production of biostimulant
- Equipment transportation of excavated soils
- Operation of drill rigs

# Case Study: Parris Island Remedy Comparison plus Identification of High-Footprint Activities

| Alternative | Impact Assessment | GHG Emissions | Energy Usage | Air Emissions | Collateral Risk | Community Impacts | Resources Lost | Water Usage |
|---|---|---|---|---|---|---|---|---|
| Enhanced Bioremediation | Relative Impact | Low | Low | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | Biostiumulant Production and transportation & equip during shallow GW excavation | Biostiumulant Production and transportation and equip during shallow GW excavation | Biostiumulant Production and transportation and equip during shallow GW excavation | Transportation related to long term groundwater monitoring and transportation and equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | Biostiumulant Production |
| ISCO | Relative Impact | Low to Medium | Low to Medium | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | Oxidant Prod,, transportation & equip during shallow GW excavation | Oxidant Prod., transportation & equip during shallow GW excavation | Oxidant Prod., transportation & equip during shallow GW excavation | Transportation & equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | Chemical Oxidant Production |
| ISCR | Relative Impact | Low to Medium | Low to Medium | Low | Low | Medium | Medium | Medium |
| | Impact Drivers | ZVI production, transportation & equip during shallow GW excavation | ZVI Production, transportation & equip during shallow GW excavation | ZVI Production, transportation & equip during shallow GW excavation | Transportation & equip during shallow GW excavation | Disturbance due to increased traffic during shallow excavation | Landfill space for shallow excavation | ZVI Production |
| ERH | Relative Impact | High | High | High | Medium | Low | Medium | High |
| | Impact Drivers | Electrical Usage | Electrical Usage | Electrical Usage | System Construction and Operation | Land Use Controls during the period of application | Lost groundwater | Electrical Production |
| Excavation | Relative Impact | Medium | Low to Medium | Medium | High | High | High | Low |
| | Impact Drivers | Transportation & Disposal | Transportation & Disposal | Transportation & Disposal | Excavation to 20 ft | Disturbance due to increased traffic | Landfill Space and lost groundwater | Production of PVC for wells and GAC for water treatment |

# Parris Island: Identify Footprint Reduction Methods to Address High-Footprint Elements

| High Footprint Element | Potential Footprint Reduction Method | Adjustments to SiteWise™ Inputs for Sensitivity Analysis |
|---|---|---|
| Transportation of excavated soils | • Proper site characterization to minimize volume excavated while being sufficiently protective<br>• Rail shipments<br>• Greener fuels<br>• After treatment controls | • Tons of soil shipped<br>• Mode of transportation<br>• Selection of fuel drop down menu<br>• Selection of control from menu |
| Drill rig operation | • Greener fuels<br>• After treatment controls | • Selection of fuel drop down menu<br>• Selection of control from menu |
| Biostimulant production | • Additional design/pilot testing to optimize injection strategy | • Mass of material used |
| Personnel transportation | • Optimization monitoring plans to reduce trips to the site while still meeting objectives of the program | • Number of trips |

# Summary of Parris Island Sustainability Analysis during Remedial Design

- High-footprint elements of the remedy where identified
- Footprint reduction methods identified to address those high-footprint elements
- Inputs to SiteWise™ adjusted to determine the benefit of each footprint reduction method

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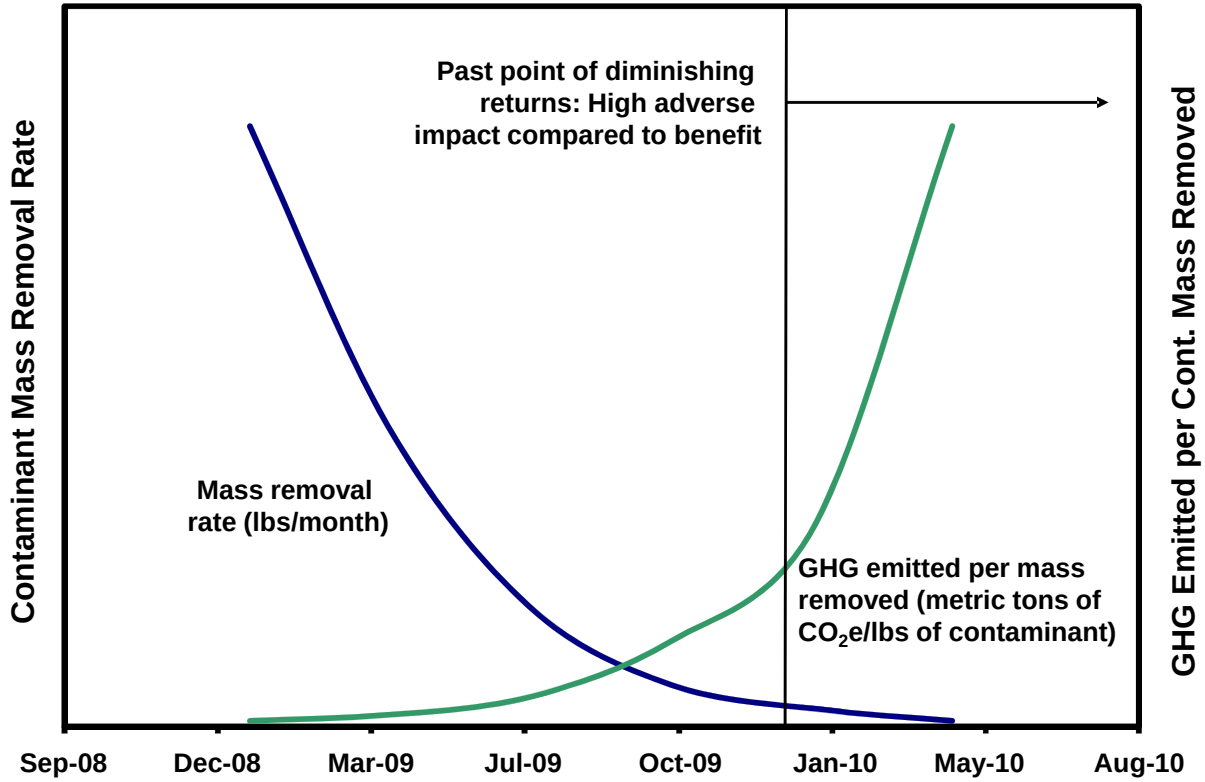
  - Remedial Design
  - Remedial Action Operation (RA-O) and Long-Term Monitoring (LTM)
- Environmental Footprint Reduction
- Summary and Conclusions

# Using SiteWise™ to Reduce the Environmental Footprint of Remedial Operation (RA-O) and Long-Term Monitoring (LTM)

- Sustainability analysis during remedial action operation (RA-O)/long-term monitoring (LTM)
  - Calculate annual footprint associated with routine operations
  - Calculate total footprint to complete (FTC)
- Use the results to:
  - Consider alternatives to current approach to reduce the footprint
  - Prevent systems from operating beyond point of diminishing returns
  - Avoid needless footprint increase with limited cleanup benefit
  - Optimize exit strategies

# Performance Objectives Tied to Exit Strategies to Avoid Systems Operating Beyond Point of Diminishing Returns

- Exit strategy can be for entire system
  - Transition to less-active technology (e.g., air sparging to MNA)
- Exit strategy for certain components
  - Eliminate unit process or change technology (e.g., thermal oxidizer to carbon or direct discharge)



# Case Study: USACE Site in Cornhusker Nebraska (Cornhusker)

- Pump and Treat System
  - 400 gallon-per-minute (GPM) system
  - Treatment includes liquid-phase granular activated carbon (GAC)
  - System is used for hydraulic control
- Enhanced bioremediation
  - Periodic injection of biostimulants to treat chlorinated VOCs in situ
- Long-term monitoring performed twice per year

# Cornhusker: Summary of Inputs

- Material Production (Consumables)
  - One carbon change-out every 8 months
    - 30,000 lbs per year of carbon; all activated carbon was virgin granular activated carbon
  - Initial injection of biostimulant: 499,724 lbs of westblend (molasses-based) and 34,699 lbs of Newman's own (vegetable oil-based)
    - Input as 100% vegetable oil since vegetable oil and molasses have similar emission factors
- Personnel Transportation
  - Operator transportation: 2 operators, each traveling 250 days per year at a distance of 7 miles per roundtrip for one operator and 15 miles per roundtrip for other operator, both the operators drive light trucks
  - Monitoring personnel:
    - Mob: 2 crews comprising of 2 people traveling 300 miles roundtrip twice a year in a light truck
    - Daily travel: 25 miles for 28 days (14 days/crew) in a light truck

# Cornhusker: Summary of Inputs (cont.)

- Equipment and Material Transportation
  - Transportation of virgin GAC 800 miles each way in an on-road truck
    - Since this occurs 1.5 times a year, it was input as one trip of 1,200 miles each way
    - Weight of GAC was 20,000 lbs and the return weight was assumed to be 40,000 lbs to account for the extra weight of wet carbon
- Residual Management
  - Three 55-gallon drums of sludge transported 10 miles to a subtitle D non-hazardous landfill every month

# Cornhusker: Summary of Inputs (cont.)

- Equipment Use
  - 50-hp compressor runs 550 hrs/mo, variable frequency drive (VFD) and runs at 40% of its capacity and 90% motor efficiency
  - 4.3-hp fan runs 550 hrs/mo at 80% nameplate loading and 90% motor efficiency
  - 15 0.4 KW bulbs run for 50 hours per week
  - Five 75,000-BTU/hour heaters operate for 7 months a year for 20% of the time
  - Geoprobe used to make 300 injections at 50 ft below ground surface requiring 1 hour per injection
  - 10-hp groundwater extraction pump running continuously at 80% of nameplate loading and 86% motor efficiency
  - 15-hp VFD pump operating continuously at 60% pump efficiency pumping 400 gpm at 40 ft total dynamic head
  - 25-hp transfer pump operating continuously at 80% nameplate loading and 86% efficiency

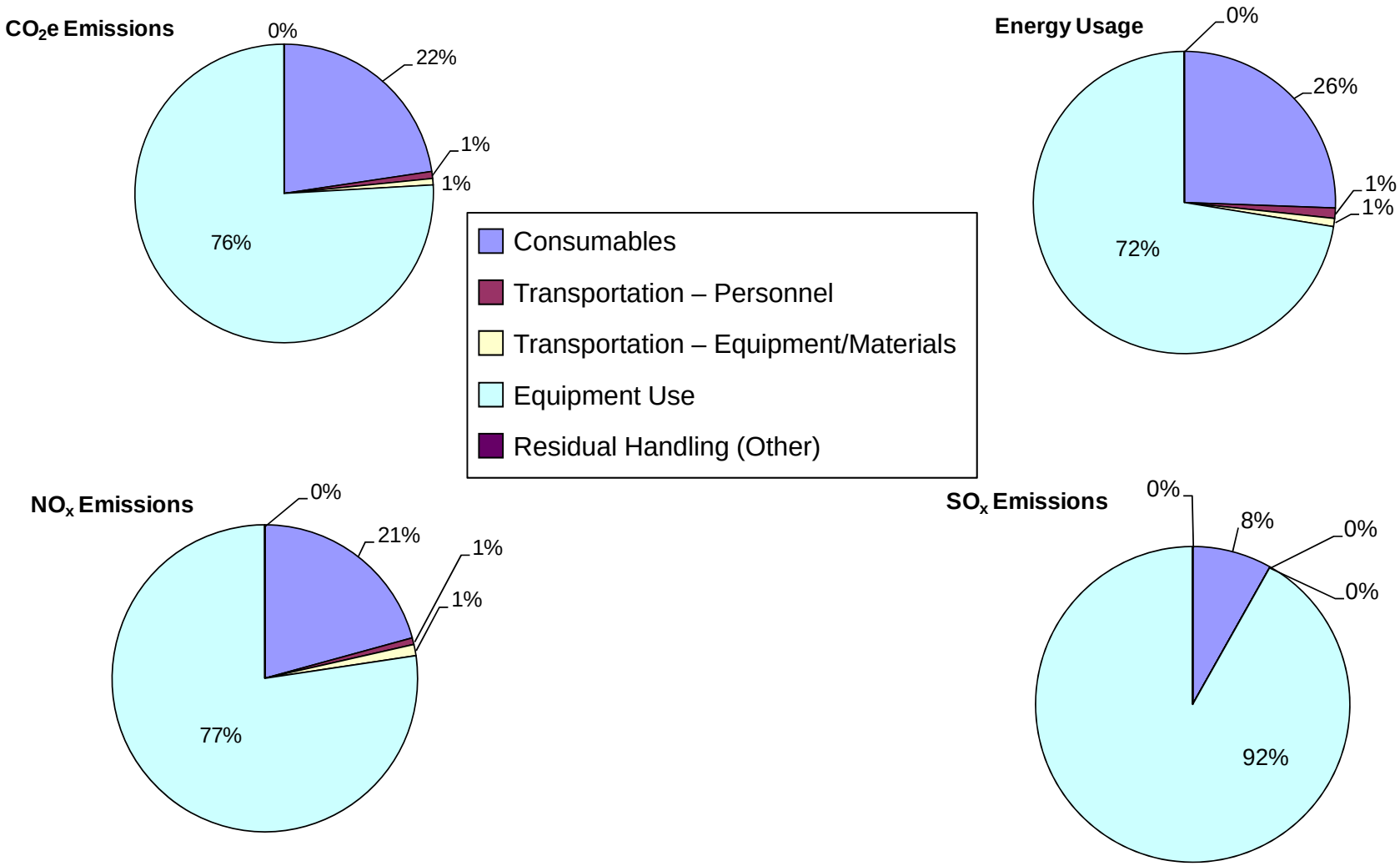
# Cornhusker:
# Selected Rows from Tool Screen Pump Analysis

| | | 10 hp Ex Pump | 15 hp Ex Pump | 25 hp Trans Pump |
|---|---|---|---|---|
| Method 1 - IF NAME PLATE SPECIFICATIONS ARE KNOWN | | | | |
| USER INPUT | *Input Pump horsepower (hp)* | 10 | 0 | 25 |
| USER INPUT | *Input Number of pumps operating* | 1 | 0 | 1 |
| USER INPUT | *Input Operating Time for each pump (hrs)* | 8760 | 0 | 8760 |
| | *Input Pump Load* | 0.8 | 0.8 | 0.8 |
| | *Input Pump Motor Efficiency* | 0.86 | 0.9 | 0.86 |
| Method 2 - IF PUMP HEAD IS KNOWN | | | | |
| USER INPUT | *Input flow rate (gpm)* | 0 | 400 | 0 |
| USER INPUT | *Input total head (ft)* | 0 | 40 | 0 |
| USER INPUT | *Input Number of pumps operating* | 0 | 1 | 0 |
| USER INPUT | *Input Operating Time for each pump (hrs)* | 0 | 8760 | 0 |
| | *Input pump Efficiency* | 0.6 | 0.6 | 0.6 |
| | *Input specific gravity* | 1 | 1 | 1 |
| | *Pump horsepower (hp)* | 0.00 | 6.74 | 0.00 |
| Method 3 - IF ELECTRICAL USAGE IS KNOWN | | | | |
| USER INPUT | *Input Pump Electrical Usage (KWh)* | 0 | 0 | 0 |
| | ENERGY OUTPUT | | | |
| | **Energy Usage (MWH)** | **6.1E+01** | **4.4E+01** | **1.5E+02** |

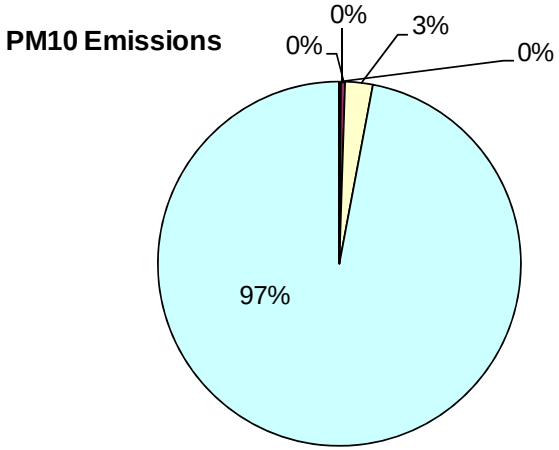
# Cornhusker: Summary of Results

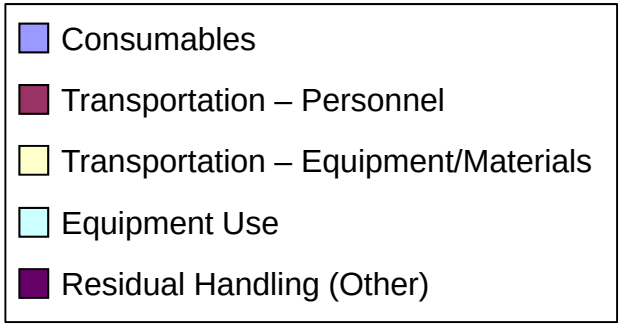
| Activities | $CO_2e$ Emissions | $NO_x$ Emissions | $SO_x$ Emissions | PM10 Emissions | Energy used | Collateral Risk Fatality | Collateral Risk Injury |
|---|---|---|---|---|---|---|---|
| | metric ton | metric ton | metric ton | metric ton | MMBTU | | |
| Consumables | 127.88 | 2.7E-01 | 1.2E-01 | 1.6E-05 | 1.6E+03 | NA | NA |
| Transportation-Personnel | 4.33 | 9.2E-03 | 9.2E-05 | 4.4E-05 | 6.7E+01 | 9.1E-05 | 6.5E-03 |
| Transportation-Equip/materials | 3.87 | 1.6E-02 | 1.2E-04 | 2.9E-04 | 5.3E+01 | 5.8E-06 | 1.2E-03 |
| Equipment Use | 428.61 | 1.0E+00 | 1.3E+00 | 1.1E-02 | 4.4E+03 | 1.8E-05 | 7.8E-03 |
| Residual Handling (Other) | 0.13 | 2.5E-04 | 3.1E-06 | 4.5E-06 | 1.4E+00 | 7.5E-08 | 1.6E-05 |
| Total | 564.81 | 1.31E+00 | 1.46E+00 | 0.01 | 6.09E+03 | 1.1E-04 | 1.6E-02 |

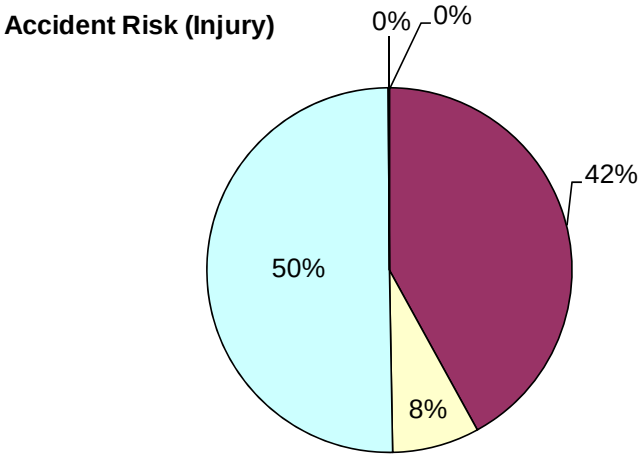
# Cornhusker: Summary of Results (cont.)

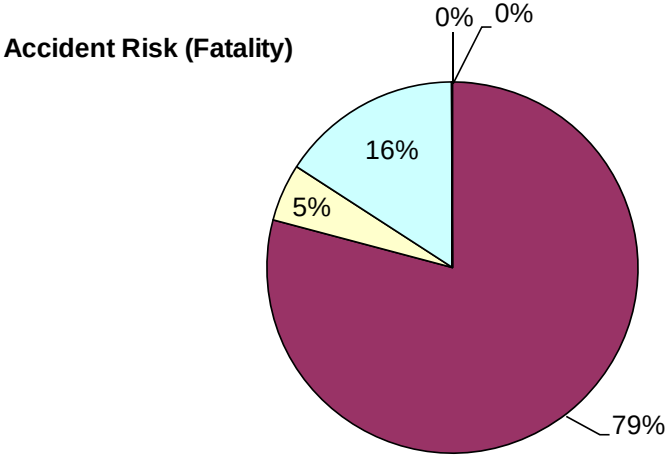


# Cornhusker: Summary of Results (cont.)



# Cornhusker: Identification of High Environmental Footprint Activities

- Production of biostimulant and GAC
- Equipment Use
  - In particular air compressors, transfer pumps, and building heaters
- The 10-hp extraction pump has a greater environmental impact than 15-hp VFD pump

# Cornhusker: Potential Footprint Reduction Methods

- Evaluate air compressor system to reduce air consumption
  - e.g., replace the air dryer with a more efficient system
- Replace the transfer pump with a VFD unit
- Pump all groundwater using 15-hp VFD pump
- Evaluate carbon efficiency for optimal operations
- Optimize injection strategy to ensure judicious use of biostimulant

# Summary of Cornhusker Sustainability Analysis during RA-O/LTM

- Annual footprint calculated for each metric
- High-footprint elements were identified
- Footprint reduction methods developed

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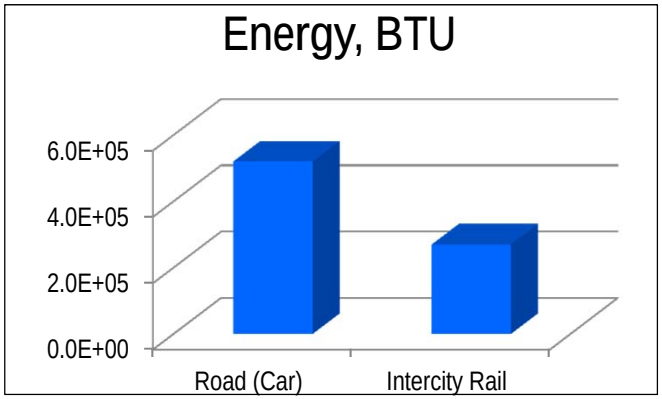
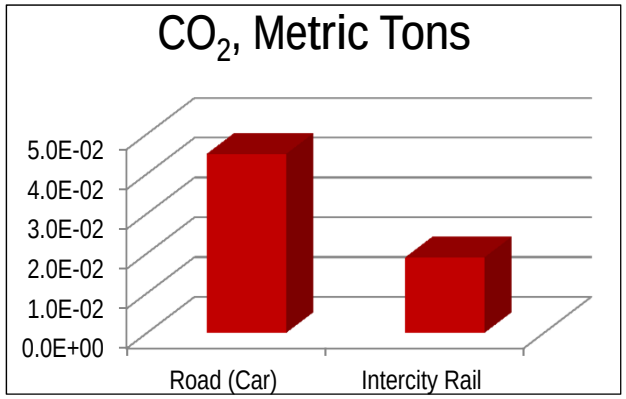
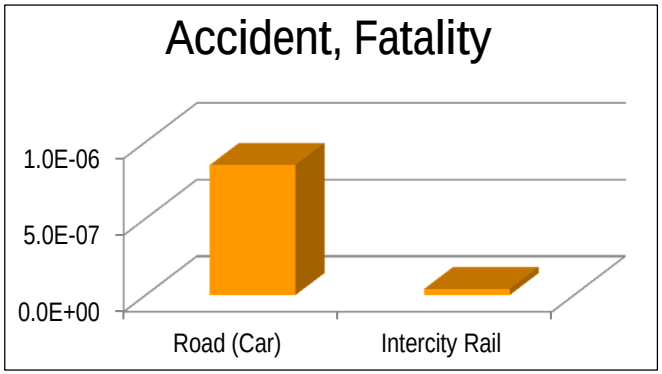
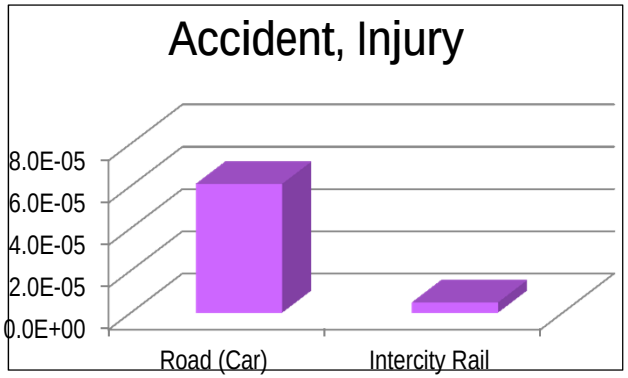
# Footprint Reduction Techniques for Transportation – Rail vs. Road

- SiteWise™ options for personnel travel via rail include:
  - Intercity rail, commuter rail, and transit rail
- Example of personnel travel for 100 miles



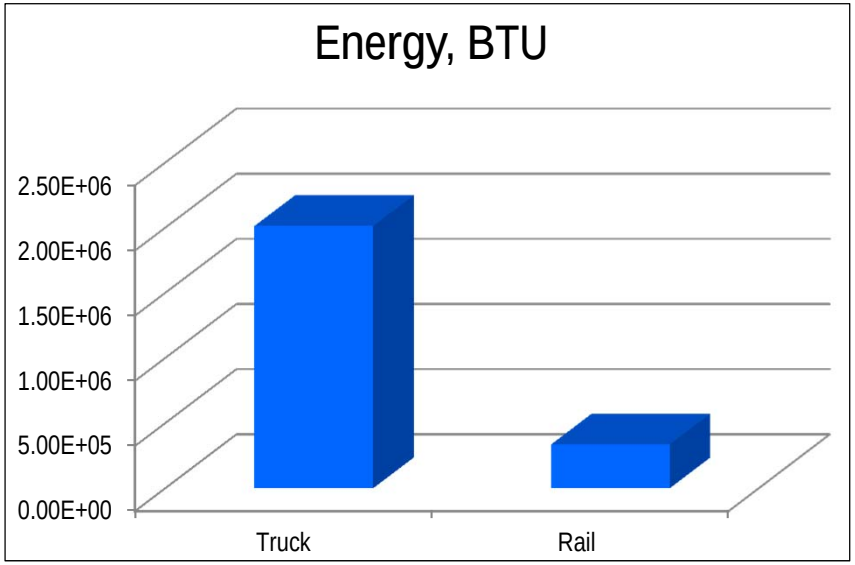



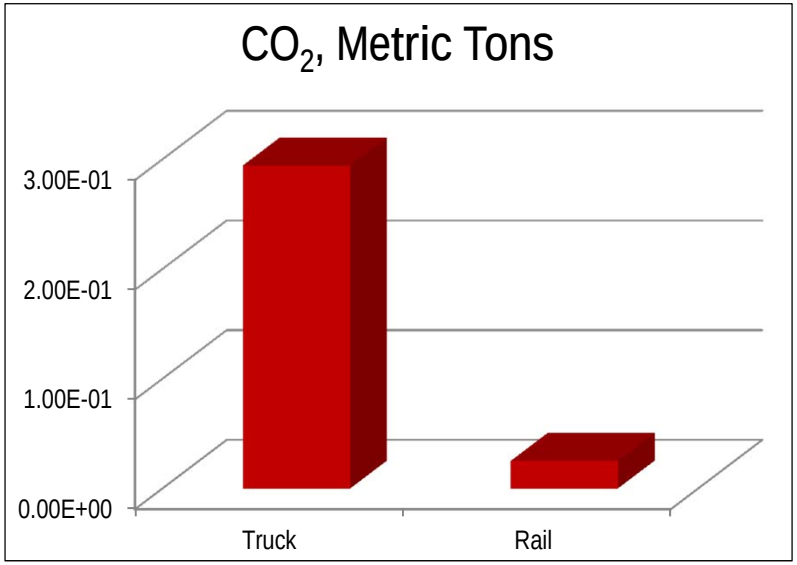



# Footprint Reduction Techniques for Transportation – Rail vs. Road (cont.)

- Equipment transportation via rail
- Example of transportation of 10 tons for 100 miles

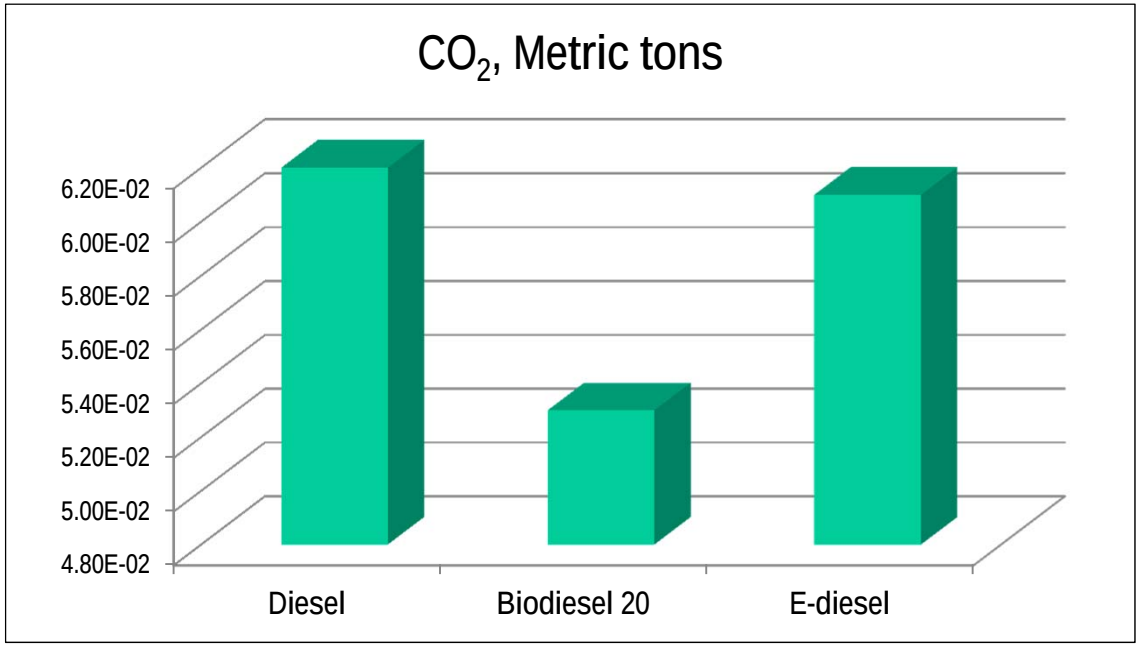



- Accident risk (fatality and injury) for rail shipments is zero
  - It is assumed that accidental injury or death associated with the shipment would not be attributed to site activities

# Footprint Reduction Techniques for Transportation – Alternative Fuels

- Fuel options in SiteWise™
  - Gasoline, diesel, biodiesel 20, E-Diesel
- Example of transportation of 10 tons for 100 miles



# Footprint Reduction Techniques for Transportation – After-Treatment Devices

- SiteWise™ includes a general universal 50% reduction (average) in PM emissions for diesel engines to be retrofitted with after-treatment devices listed below
  - Diesel Oxidation Catalyst (DOC) (40%-50% reduction)
  - Diesel Particulate Filter (DPF) (50%-90% reduction)
- Look-up tables include percent reduction for criteria pollutants
  - User can replace percent reduction with alternate values

# Footprint Reduction Techniques – Energy Conservation

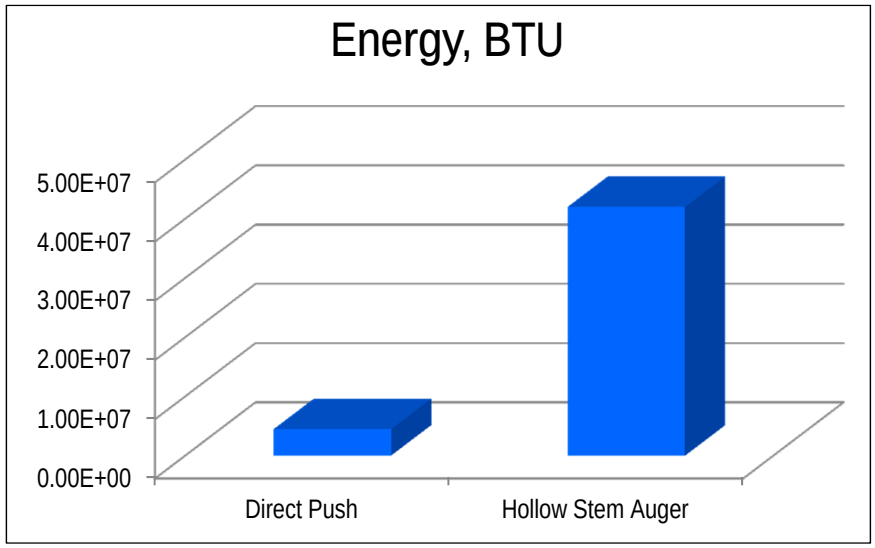
- High- or premium-efficiency motors
  - Default motor efficiency can be adjusted based on known values by the user
    - Premium-efficiency motors can reduce power consumption by approximately 5% compared to standard-efficiency motors
- Use of variable-frequency drive (VFD) versus single-speed
  - Pump worksheet includes options for inputting actual power, performance requirement (flow and head), or nameplate
    - Performance requirement option simulates VFD
    - Nameplate simulates single speed
    - Cornhusker case study demonstrated benefit of VFD

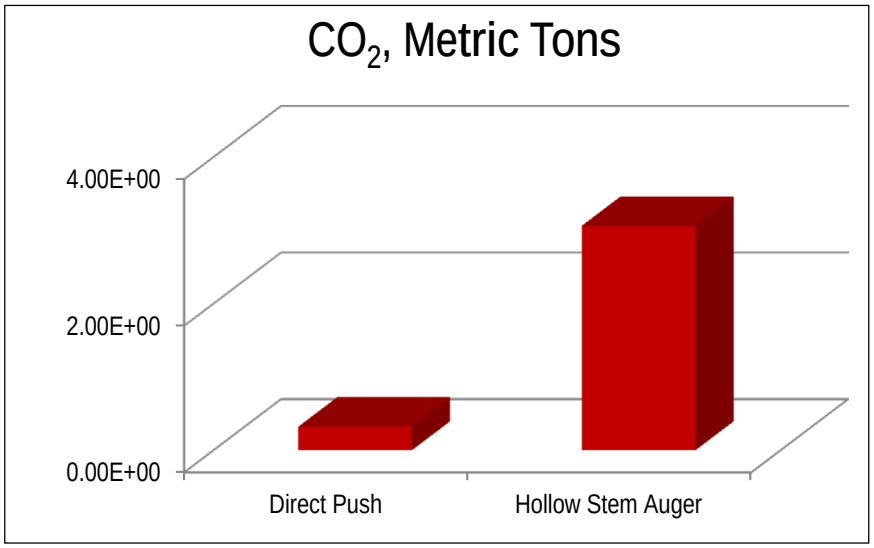
# Footprint Reduction Techniques – Renewable Energy

- On-site or purchased off-site
- SiteWise™ includes option of inputting site-specific factors for energy source
- To input site-specific factors into look-up table, select "custom" option from energy region dropdown menu

# Available Techniques – Drilling Options

- Well diameter and material
- Direct-push (DP) versus hollow-stem auger (HSA)
- Example: DP rig versus HSA operating for 40 hours



# Other Easily Applicable Footprint Reduction Techniques

- Once baseline is established, any input can be adjusted as part of a sensitivity analysis
  - Optimize equipment selection to reduce horsepower
  - Improve site characterization and risk assessment to reduce soil excavation or treatment volume
  - Treatability testing to reduce mass of treatment chemical used
  - Optimize monitoring plan to reduce trips to site
- Changes in footprint for each option can be viewed independently or as a whole to determine the impact on footprint reduction

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# Take-Home Points

- What is SiteWise™?
  - Streamlined LCA tool
    - Not as precise as a rigorous LCA used in industrial applications
    - Ease of use allows sustainability analysis to be performed efficiently and consistently for remediation projects
  - Excel-based and NMCI compatible
  - Public availability and transparency of inputs and factors helps achieve regulatory acceptance
- How can SiteWise™ help implement GSR?
  - Incorporate environmental footprint into decision making process
  - Determine high-footprint activities associated with a remedy
  - Perform sensitivity analysis to prioritize footprint reduction methods
  - Apply to overall remedy, parts of remedies and treatment trains

# Take-Home Points (cont.)

- Sustainability analysis can be performed in key project phases
  - Remedial investigation (RI) work plan
    - Identify and prioritize footprint-reduction methods for RI
  - Remedy selection
    - Most important time to perform sustainability analysis
    - Allows GSR metrics to be considered as part of remedy selection
    - Can result in greatest overall footprint reduction
  - Design
    - Identify and prioritize methods to reduce the footprint of remedy
  - RA-O/LTM
    - Identify and prioritize methods to reduce the footprint of RA-O/LTM
    - Allows GSR metrics to be incorporated into exit strategy