Incorporation of Carbon Footprint Estimates into Remedial Alternatives Evaluations

Christopher Glenn, P.E., LEED GA, Treadwell & Rollo

Lowell Kessel, P.G., R.E.A., EnviroLogek

Wednesday, June 16, 2010

Green Remediation Conference

Amherst, Massachusetts

Green Business Program

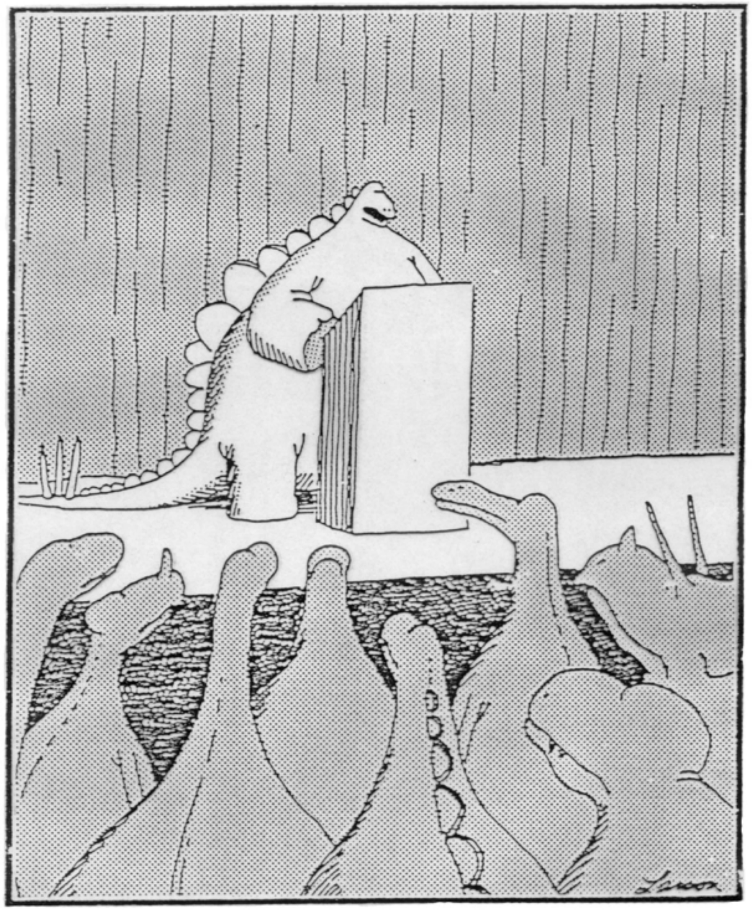
Treadwell&Rollo

Purpose: To compare carbon footprint estimates of remedial technologies at two case study sites.

→ 1) containment site, and 2) source area remediation site

→ Evaluate the contributions to carbon footprint

→ Evaluate sensitivity of inputs



"The picture's pretty bleak, gentlemen... The world's climates are changing, the mammals are taking over, and we all have a brain about the size of a walnut."

Definition

"A remedy or combinations of remedies whose net benefit on human health and the environment is maximized through the judicious use of limited resources"

- Sustainable Remediation Forum (SuRF)

→ This paper focuses on the Green House Gas (GHG) footprint

→ Local and regional effects such as air and water quality, economic development, quality of life, water use, accident risk, etc. are also important

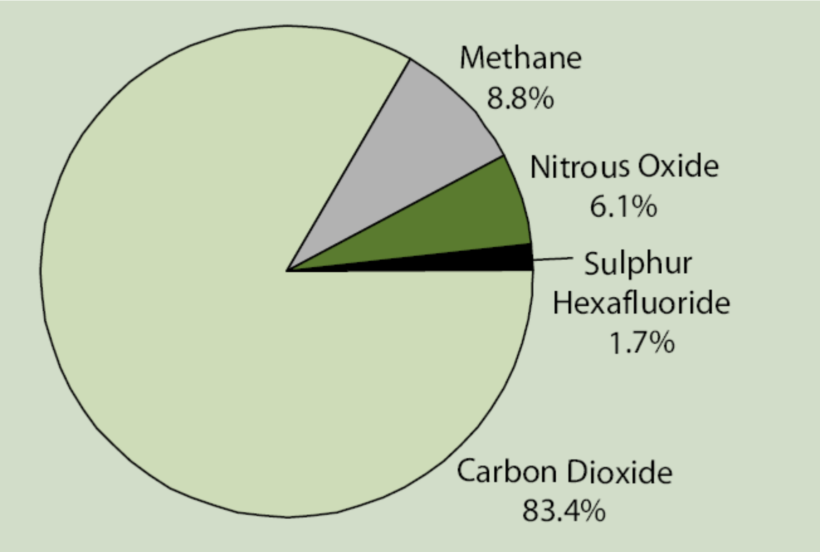
Green Business Program

Treadwell&Rollo

Causes

- Climate change is the gradual change in global temperature and influenced by accumulation of greenhouse gasses (GHG) in the atmosphere

- Six main GHGs:
  - → Carbon Dioxide (CO_2)
  - → Methane (CH_4)
  - → Nitrous Oxide (N_2O)
  - → Hydrofluorocarbons (HFCs)
  - → Perfluorocarbons (PFCs)
  - → Sulphur hexafluoride (SF_6)



Impacts

- Flooding/Sea Level Rise
- Economic Disruption
- Disease
- Water Shortages
- Increased Storm Severity
- Disruption of Habitat and Ecosystems
- Damage to Earth’s Treasures (glaciers, coral reefs, dependent wildlife etc)

Background

- Carbon Footprint Assessment is an accounting of GHG emissions due to an action involving energy use
  - → Direct: GHG source operated on-site
  - → Indirect: GHG emissions off-site as a result of the on-site activity (for example, due to manufacture of a material)

Typical Categories for Remediation Projects

1) Transportation of Personnel
   → by car, plane, rail, etc
2) Transportation of Equipment and Supplies
   → by truck, big rig, train, etc
3) Fuel for Equipment Usage
   → e.g., drill rigs, trenchers, forklifts
4) On-Site Electricity Usage
   → e.g., pumps, blowers
5) Materials Production and Equipment Manufacturing
   → Steel, PVC, reagents, well materials
6) Waste Disposal/Recycling
   → GAC, waste soils, etc

Green Business Program

Treadwell&Rollo

Basis for Calculation

- Our carbon footprint is based on actual remedial designs for sites
- Carbon footprint calculation uses “middle-of-the road” input values from available sources
  - → Other remediation tools (SRT and SiteWise)
  - → U.S. Government/EPA
  - → Trade/Industry Organizations
- The range of available inputs typically varied +/- 10-20% for most items, but some had a much greater variability
  - → Items with highest variability highlighted in next slides

Carbon Footprint Assessment

Basis for Calculation

	Units	Range of Values	Value	+/- Range
Personal Vehicle Fuel Efficiency	miles per gallon	N/A	17.6	N/A
Mid-Sized Truck Fuel Efficiency	miles per gallon	N/A	7.9	N/A
Full-Sized Truck Fuel Efficiency	miles per gallon	N/A	6.4	N/A
CO_2 per Train lb-mile	pounds per lb-mile	2.06×10^{-5} to 2.77×10^{-5}	2.77×10^{-5}	14%

Green Business Program

Treadwell&Rollo

Carbon Footprint Assessment

Basis for Calculation

	Units	Range of Values	Value	+/- Range
Drill Rig Fuel Consumption (Direct Push)	gallons per hour	0.8 to 3.0	1.9	58%
Drill Rig Fuel Consumption (HSA)	gallons per hour	3.0 to 7.2	5.1	41%
Trencher Fuel Consumption	gallons per hour	N/A	6	N/A
Forklift Fuel Consumption	gallons per hour	N/A	2	N/A
*CO2 equiv per kWh of electricity	CO2 eq per kWh	0.524 to 1.34	0.915	46%

*Some factors are Region Specific

Green Business Program

Treadwell&Rollo

Carbon Footprint Assessment

Basis for Calculation

	Units	Range of Values	Value Used	+/- Range
CO_2 per pound of PVC produced	CO_2 eq per pound	1.824 to 2.50	2.162	16%
CO_2 per pound of Steel produced	CO_2 eq per pound	2.72 to 2.95	2.834	4%
CO_2 per pound of Edible Oil produced	CO_2 eq per pound	0.33 to 2.8	1.565	79%
CO_2 per pound of Sand produced	CO_2 eq per pound	N/A	0.005	N/A
CO_2 per pound of Grout produced	CO_2 eq per pound	0.83 to 1.0	0.915	9%
CO_2 per pound of GAC produced	CO_2 eq per pound	1.91 to 2.71	2.31	17%

Green Business Program

Treadwell&Rollo

A Manufacturing Site in Santa Clara, California

• Chlorinated Solvent Plume in Groundwater

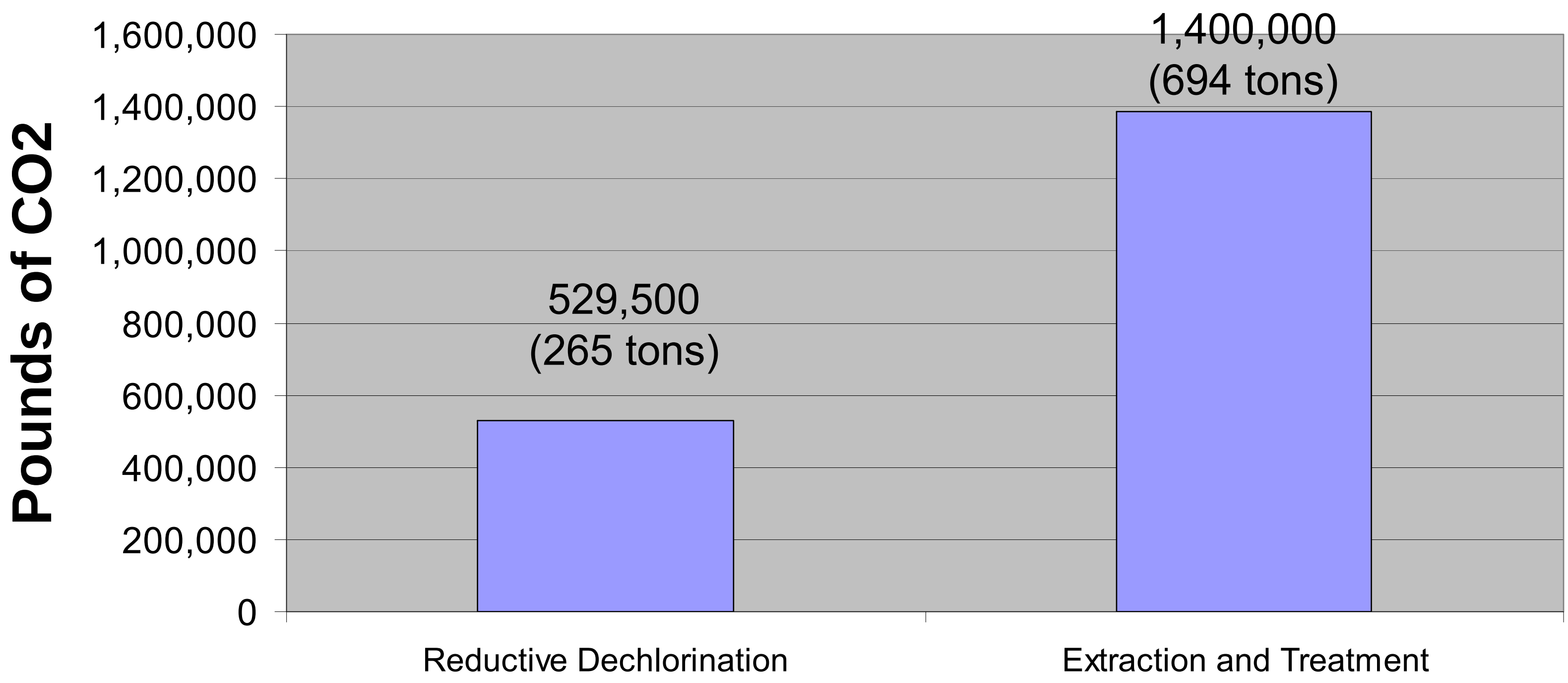
• GOAL to re-evaluate options for containment of groundwater "contamination."

• Alternative Containment Technologies Considered:

→ **Continued GWETS Operation with optimization**
→ **In-Situ Reductive Biobarrier using Vegetable Oil**
→ In-Situ Permeable Reactive Barrier Using Iron

Results

Containment Technology Lifetime Carbon Footprint Comparison

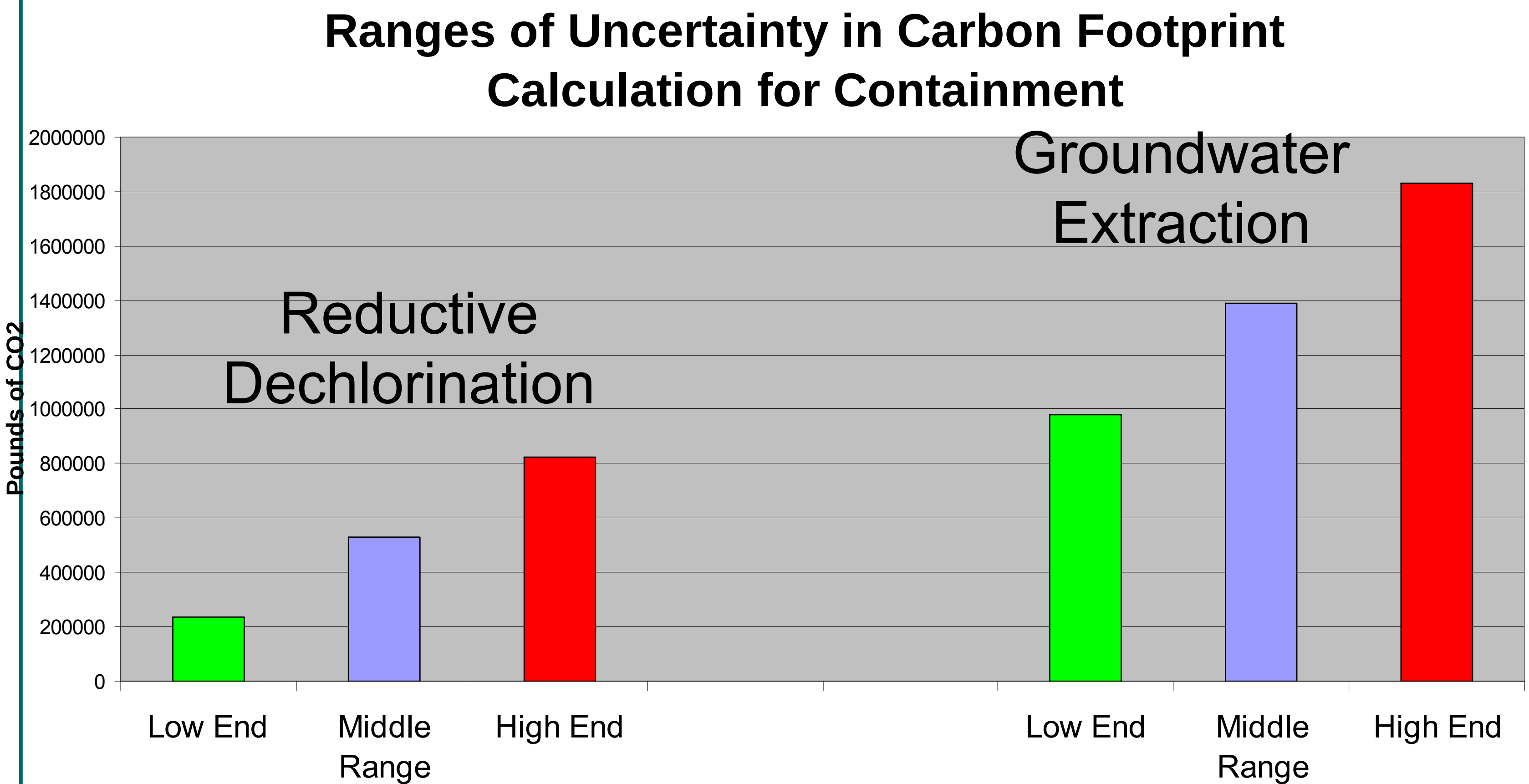


- Extraction and Treatment has 2-3 times higher footprint than Reductive Dechlorination
- Assumes 30 year lifetime for containment

Green Business Program

Treadwell&Rollo

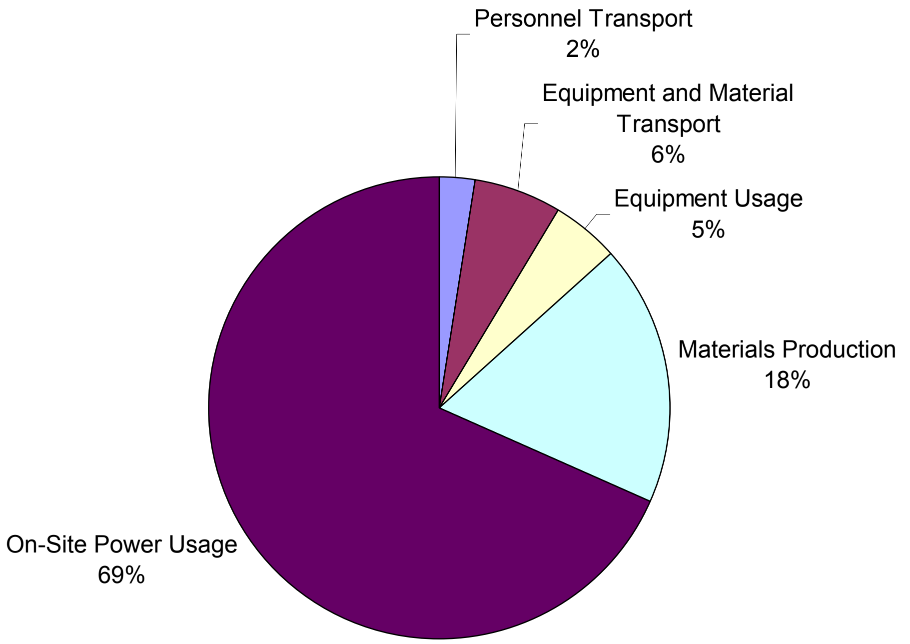
Sensitivity Analysis



- Reductive Dechlorination footprint range is always lower than for groundwater extraction, but the difference between the two is greatly affected by uncertainty.

Contribution to Footprint

Contibution to Groundwater Extraction Carbon Footprint



- The largest contribution to the carbon footprint for groundwater extraction is the power usage for pumps and treatment system
  - → Note that power usage footprint has wide range of uncertainty

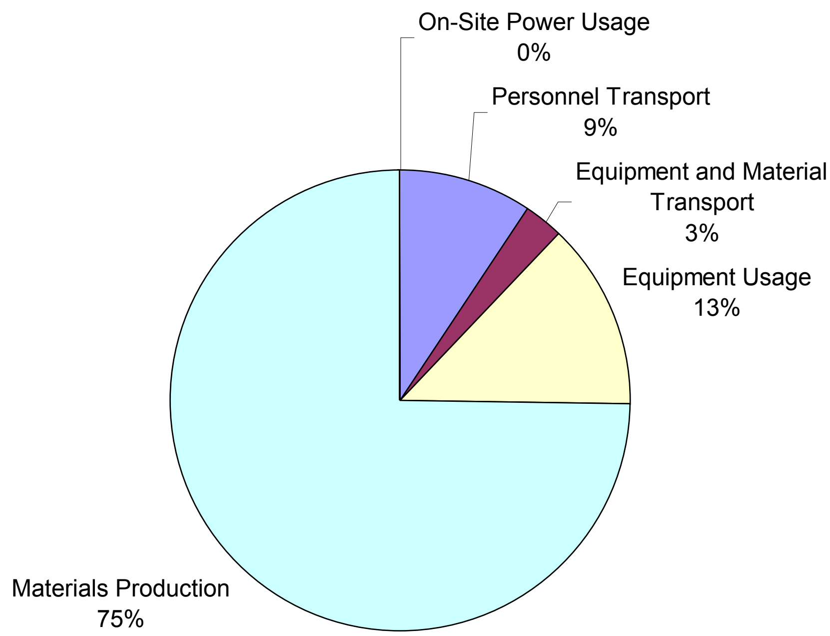
GREEN BUSINESS PROGRAM

Treadwell&Rollo

Results

Contribution to Footprint

Contibution to Reductive Dechlorination Carbon Footprint

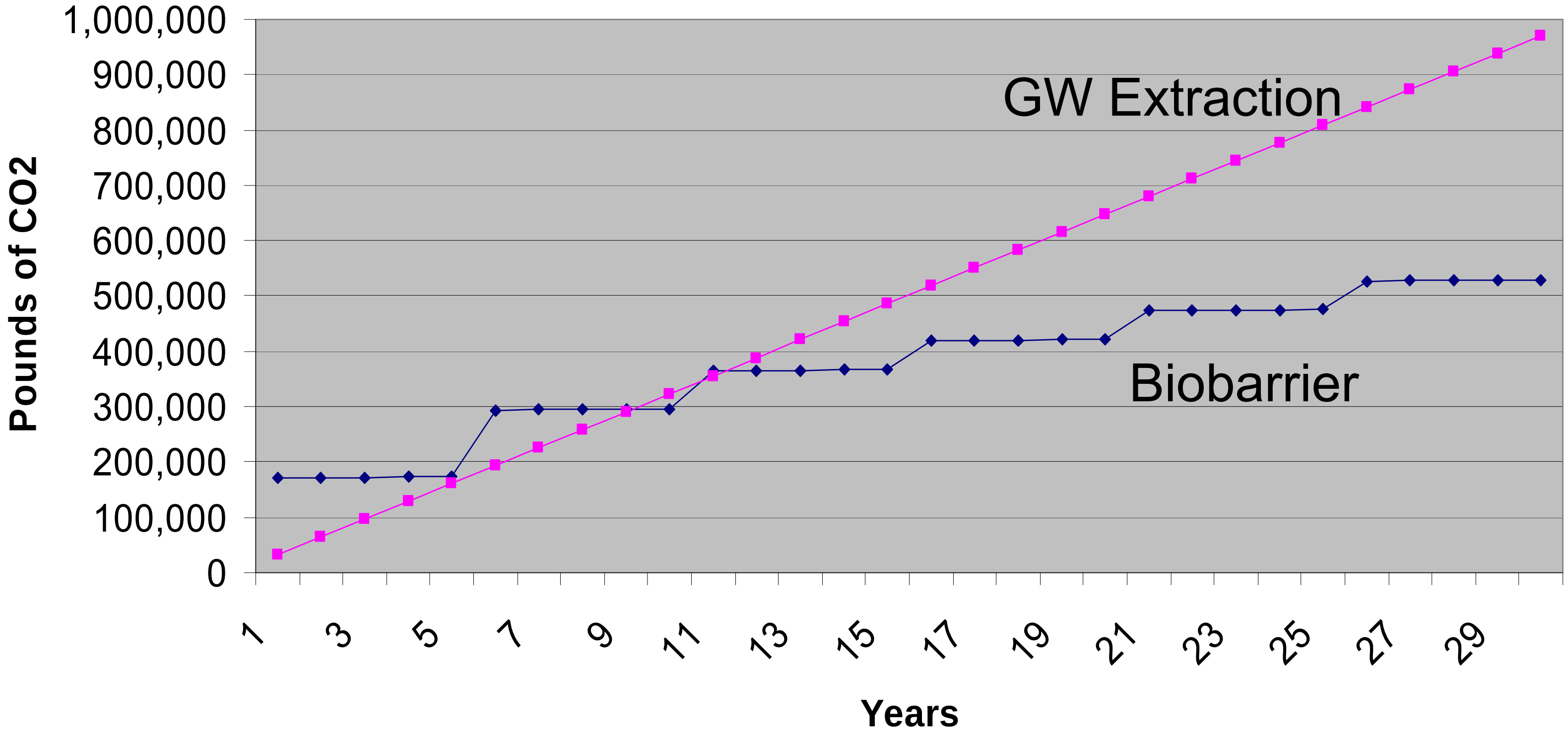


- The largest contribution to the carbon footprint for reductive dechlorination is the production of oil reagent
  - → Note that oil reagent footprint has wide range of uncertainty

Results

The Bottom Line

Replace GW Extraction System with In-Situ Reductive Biobarrier



- Replacing GW Extraction with In Situ Biobarrier results in long-term reduction in carbon footprint

GREEN BUSINESS PROGRAM

Treadwell&Rollo

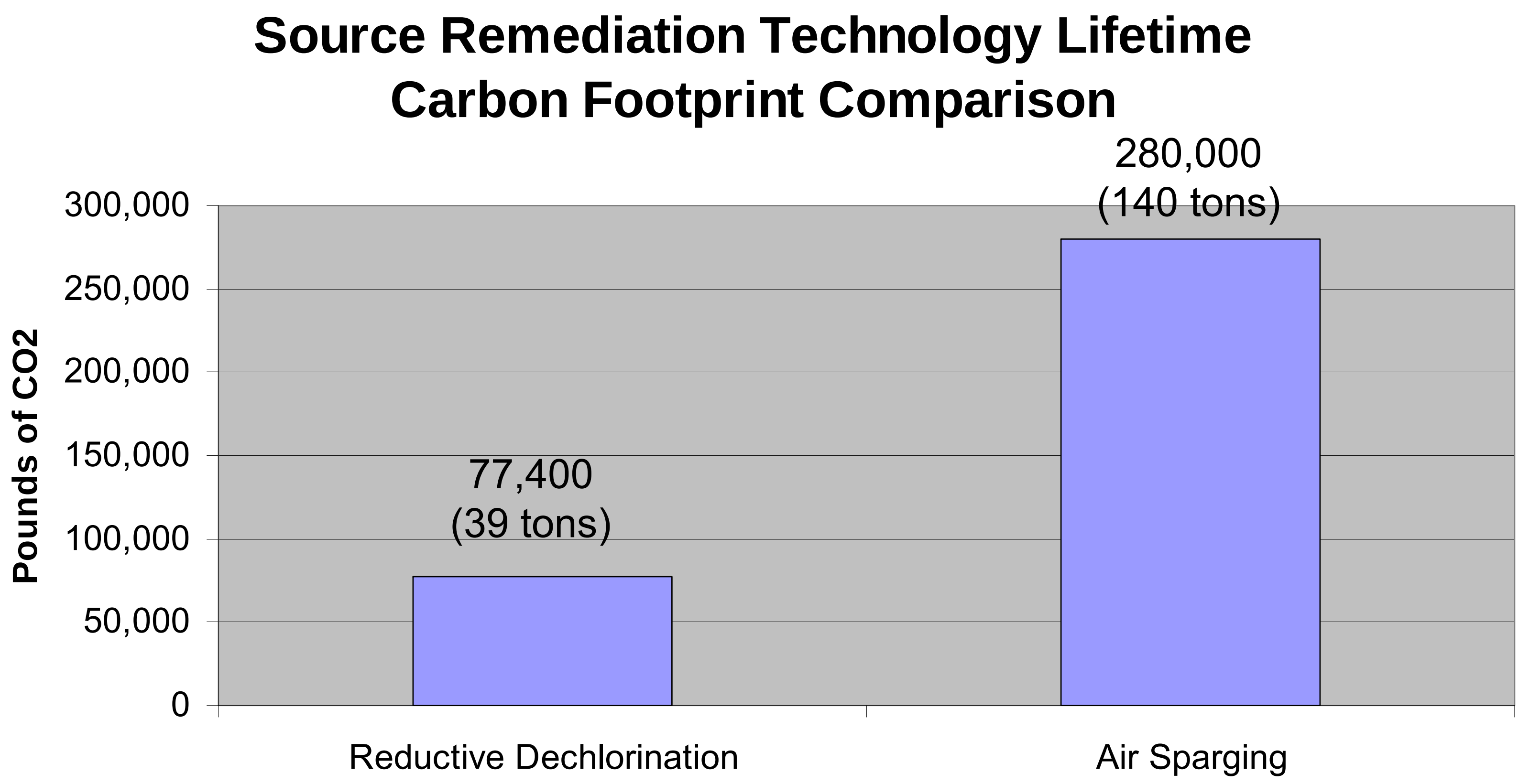
Former Dry Cleaner in Modesto, California

• PCE Plume in Groundwater

• Evaluating technologies for remediation of groundwater "source area."

• Remediation Technologies Considered:

→ No Action
→ **Air Sparging**
→ **In-Situ Bioremediation using Vegetable Oil**
→ Groundwater Extraction and Treatment
→ Thermal Desorption
→ In Situ Oxidation
→ In Situ Reduction Using Zero Valent Iron



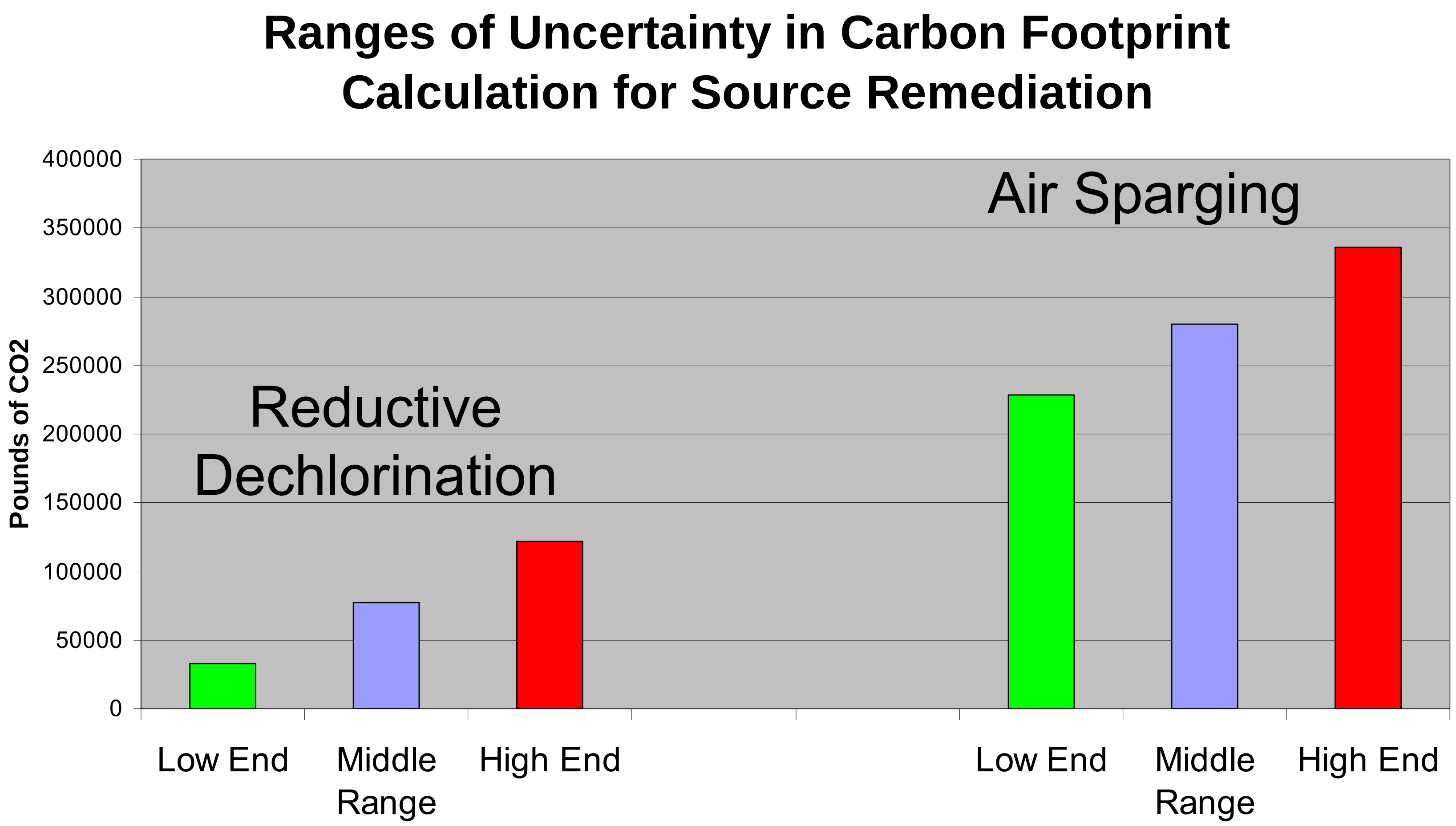
- Air Sparging has 3-4 times higher footprint than Reductive Dechlorination
- Assumes 2yrs sparging vs. 2 biostimulation events over 2yrs

Green Business Program

Treadwell&Rollo

Results

Sensitivity Analysis



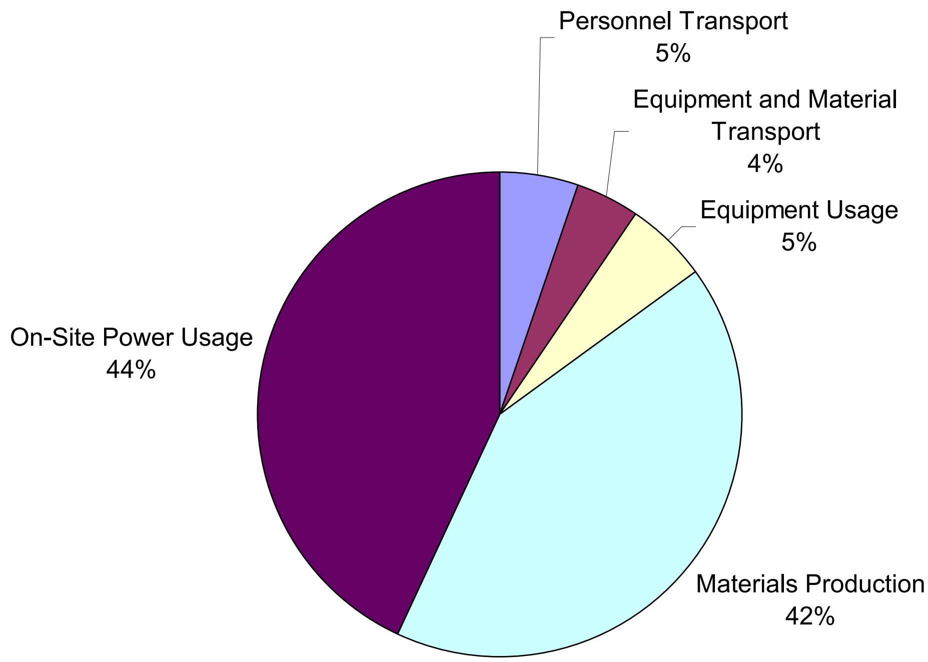
• Reductive Dechlorination footprint range is always lower than for Air Sparging, but the difference between the two is somewhat affected by uncertainty.

Green Business Program

Treadwell&Rollo

Contribution to Footprint

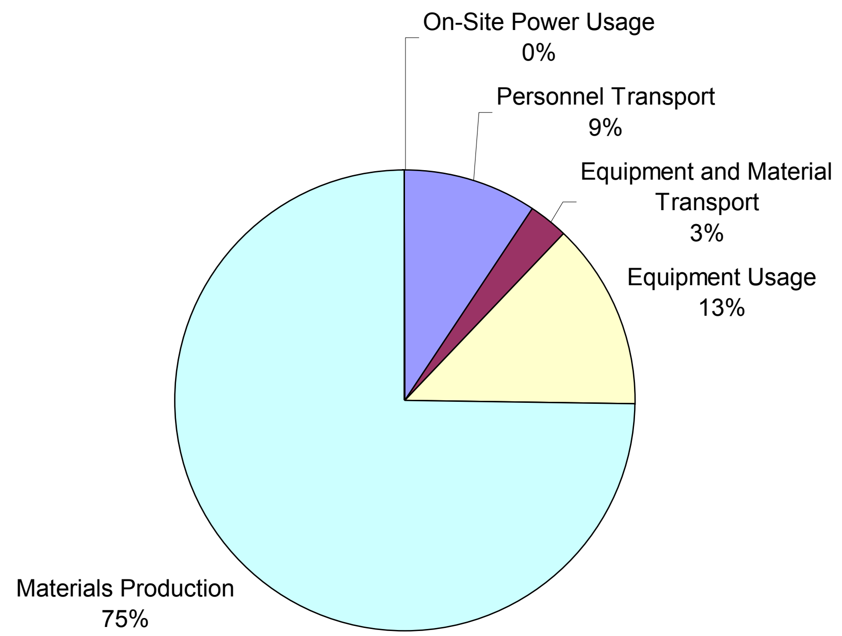
Contibution to Air Sparging Carbon Footprint



- The contribution to the carbon footprint for air sparging is dominated by the power usage for blowers and production of GAC and materials for the treatment system and wells.

Contribution to Footprint

Contibution to Reductive Dechlorination Carbon Footprint



- The largest contribution to the carbon footprint for reductive dechlorination is the production of oil reagent
  - → Note that oil reagent footprint has wide range of uncertainty

Green Business Program

Treadwell&Rollo

Conclusions

1) Replacement of an Existing GW Extraction System with an In Situ Reductive Dechlorination Biobarrier offers long-term reduction in carbon footprint.
2) Reduction in water resource loss is achieved with bioremediation vs groundwater extraction and treatment (7.27M gal/yr)
3) Net benefit in footprint is not achieved for many years in some cases when re-evaluating existing systems or remediation programs (10yrs in case study one)
4) In Situ Reductive Dechlorination offers more favorable carbon footprint than air sparging.

Conclusions

5) Can look at largest contributors “low hanging fruit” to reduce carbon footprint of technologies
   - → Renewable energy?
   - → Greener veg oil option?
   - → Greener GAC or alternative technologies?

6) Environmental field needs to work together to bridge large range of uncertainty in carbon footprint estimates for large contributors and incorporate into estimates
   - → Especially for vegetable oil reagent and electricity
   - → Models are only as effective as the data used

7) Value comes from lifecycle considerations, not short term considerations

Questions?

Christopher Glenn, P.E., LEED GA
Treadwell & Rollo
Oakland, California
cnglenn@treadwellrollo.com

Lowell Kessel, P.G., REA
Envirologek
Los Angeles, California (Go Lakers!)
lkessel@envirologek.com

Green Business Program

Treadwell&Rollo