



## SUSTAINABILITY IN REMEDIATION

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# Introduction

## Sustainability – triple bottom line

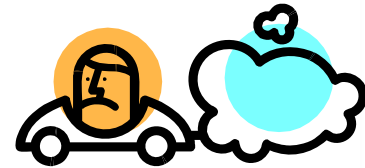
- economic vitality
- environmental rejuvenation
- social enrichment

# Problem Formulation

- Have a contaminated site that requires assessment and remediation
- How much carbon is created during the assessment and remediation phases of the project?
- How do the different types of remedial technologies compare?

# Considerations

- release of further contaminants during the remediation process
- petroleum hydrocarbon contamination present in the subsurface soils and groundwater
- identifying, delineating, remediating, and confirming conditions on the site



# Assumptions

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- CO<sub>2</sub> as surrogate for total green house gas emissions
- TPH exclusively



# ASSUMPTIONS

- Soil 10,000 ppm TPH
- Groundwater  
100,000 L  
100 ppb TPH
- soils density 2,000 Kg/m<sup>3</sup>

# Assumptions

- 5 km from the consultant office
- 10 km from the contractor's facilities
  - equipment storage,
  - ex situ treatment facilities
  - reinstatement material
  - analytical laboratory.
- Vapour extraction system is 500 km away from site



# Reference

- Emissions for fuels  
2.7 kg CO<sub>2</sub>/L
- Emission for electricity  
0.61 kg CO<sub>2</sub>/kWh
- Density TPH  
0.85 kg/L
- TPH CO<sub>2</sub>  
6,353 kg
- Attenuation  
80% ex situ and in situ  
50% risk assessment



# CO<sub>2</sub> Calculations

Associated with TPH contamination

$$\frac{\text{Impacted soil weight} * \text{TPH concentration} * \text{emission coefficient}}{\text{TPH density}}$$

[1]



# CO<sub>2</sub> Calculations

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Associated with Vehicular Travel

*fuel consumption rate \* total distance \* emission coefficient*

[2]



# CO<sub>2</sub> Calculations

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Associated with Site Operations

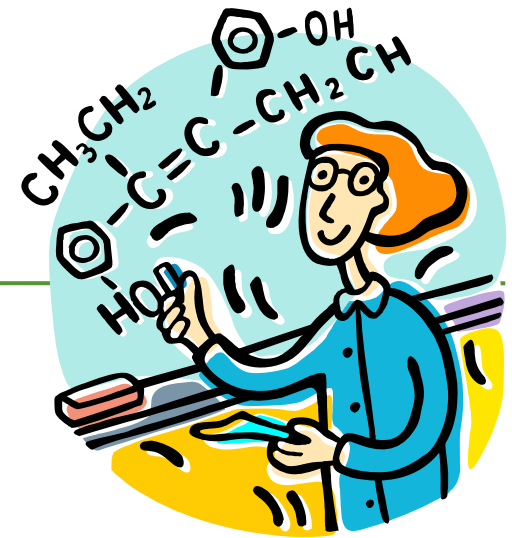
*fuel consumption rate \* operating hours \* emission coefficient*

[3]



# CO<sub>2</sub> Calculations

Associated with Electrical Generation



*years operation \* electrical consumption \* emission coefficient*

[4]

Only total electrical reduction results in reduction of CO<sub>2</sub> production, sourcing from green sources prevents that green electricity from being used elsewhere.



# Case Study

- Ex situ – excavate and replace
- In situ – vapour extraction
- Risk Assessment

# Fuel Consumption Factors

Vehicle	Fuel Consumption	
	L/100km	L/hour
Prius Hybrid	5	
Camry Hybrid	7	
Float Truck	35	
Ford F250	27	
Volvo EC360B Excavator		25
Drill Rig		25
Dump Truck	35	25
Vacuum Truck	35	25
Sakai 400 Compactor	22	

# ASSUMPTIONS - Baseline

- Ten boreholes  
(6-8m)
- plume measuring 5m x 10m x 2m
- at a uniform depth of 2m below  
overburden soils

# Baseline Investigation Quantities

Activity	Total
Mob/Demob - Daylighter and Operator	20 km
Mob/Demob Field Tech	30 km
Mob/Demob Supervisor	10 km
Mob/Demob Drill Operators	40 km
Mob/Demob Drill Rig	20 km
Operating Daylighter	5 hours
Operating Drill Rig	10 hours
Transporting Samples to the lab	40 km

# Carbon Check

From Source

6 353 Kg

From Baseline  
Assessment

1 500 Kg

# Ex Situ

- excavate and replace with clean fill
- overburden is removed by an excavator and stored on site
- dump truck haulage to an ex situ treatment facility
- returns with a load of reinstatement material
- fill is placed in the excavation in one metre lifts
- compacted with a vibratory roller
- Dewatering by vacuum truck while the excavation is open



# Ex Situ Remediation Quantities

Activity	Total
Mob/demob field tech	50 km
Mob/demob supervisor	10 km
Mob/demob excavator	20 km
Mob/demob excavator operator	100 km
Excavator operation	65 hours
Mob.demob dump truck	220 km

# Ex Situ Remediation Quantities (cont'd)

Activity	Total
Dump truck operation	20 hours
Mob/demob vac truck	60 km
Vacuum Truck operation	13 hours
Mob/demob compactor	20 m
Compactor operation	8 hours
Transport of samples to lab	60 km

# Carbon Check Ex Situ

From Source

80% - **5080 Kg**

From Baseline Assessment

**1 500 Kg**

Ex Situ Total

**13,000 Kg**

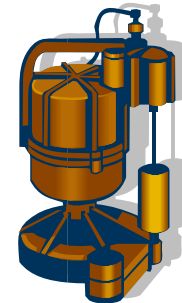


# In Situ

- vapour extraction system
- additional investigation to design the system 50% of the baseline
- source location for the vapour extraction system 500 km from the site.

# In Situ

- two years at 500,000 kWh per year.
- The water air sparged with 80% attenuation of the TPH (insignificant).
- confirmation of remediation 50% of baseline.



# In Situ Remediation Quantities

Activity	Total
Mob/demob Field Tech	240 km
Mob/demob supervisor	10 km
Mob/demob vapour extraction system	1000 km
Mob/demob drill operators	100 km
Mob/demob drill rig	20 km
Operation of drill rig	50 hours

# Carbon Check In Situ

From Source

- 80% - **5080 Kg**

From Baseline Assessment

**1 500 Kg**

From Design Assessment

**750 Kg**

From Confirmation of Remediation

**750 Kg**

From system operation

**600 000 Kg**

**In Situ Total**

**625 000Kg**

# Risk Assessment

- data from baseline investigation
- data from an additional detailed investigation
  - contaminants present
  - the receptors
  - the pathways
- assumption of no offsite migration



# Carbon Check Risk Assessment

From Source

- 50% - **3 275 Kg**

From Baseline Assessment

**1 500 Kg**

From Design Assessment

**1 500 Kg**

From Confirmation of  
Remediaiton

**750 Kg**

**Risk Assessment  
Total**

**7 000Kg**

# Conclusions

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Ex Situ – 13 tonnes

In Situ – 625 tonnes

Risk Assessment – 7 tonnes

# Conclusions

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Offset costs at \$5/tonne – going rate

Ex situ - \$65



In Situ - \$3125

Risk Assessment - \$35



## LEED Rating System and Addendum New Construction and Major Renovation

- Credit 3 for Sustainable Sites -  
Redevelopment of Contaminated  
Sites.
- One point for remediation as required  
by provincial programs for a site  
classified by the regulatory agency as  
a contaminated site.

## LEED Green Building Rating System Commercial Interiors

- Credit 1 for Sustainable Sites - Site Selection.
- One half point is available for a building located on a brownfield redevelopment, confirmed either through a CSA Z769 Phase II Environmental Site Assessment or the regulatory agency.



# References

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*Bento et al., Bioremediation of soil contaminated by diesel oil, Brazilian Journal of Microbiology, vol.34, suppl. 1, November 2003.*

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*Canada Green Building Council, LEED Canada Green Building Rating System for Commercial Interiors, Version 1.0, September 2006*

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*Congress for New Urbanism, Natural Resources Defense Council and U.S. Green Building Council, Pilot Version, LEED for Neighborhood Development Rating System, February 2007*