Green Remediation

Estimating the Environmental Footprint at a Corrective Action Clean-up

Pilot Study at Romic East Palo Alto

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Green Remediation

Theory:

Consider all environmental effects of remedy implementation and incorporate options to maximize the net environmental benefit of cleanup actions.

Implementation:

Installation of "greener" remedies

Development of metrics for estimating environmental footprints

Overview

- **How we conducted our Pilot Study:**

  methodology and results

- **Applying the results to our clean-up sites**

- **Importance of using Life-Cycle Assessment principles**

Pilot Site: Romic East Palo Alto

- 14-acre hazardous waste management facility
- Soil and ground water contaminated with VOCs (such as TCE and PCE)
- Contamination to a depth of 80 feet

Purpose of the Pilot Study

- **Compare the environmental footprints of three alternative remedies at Romic**

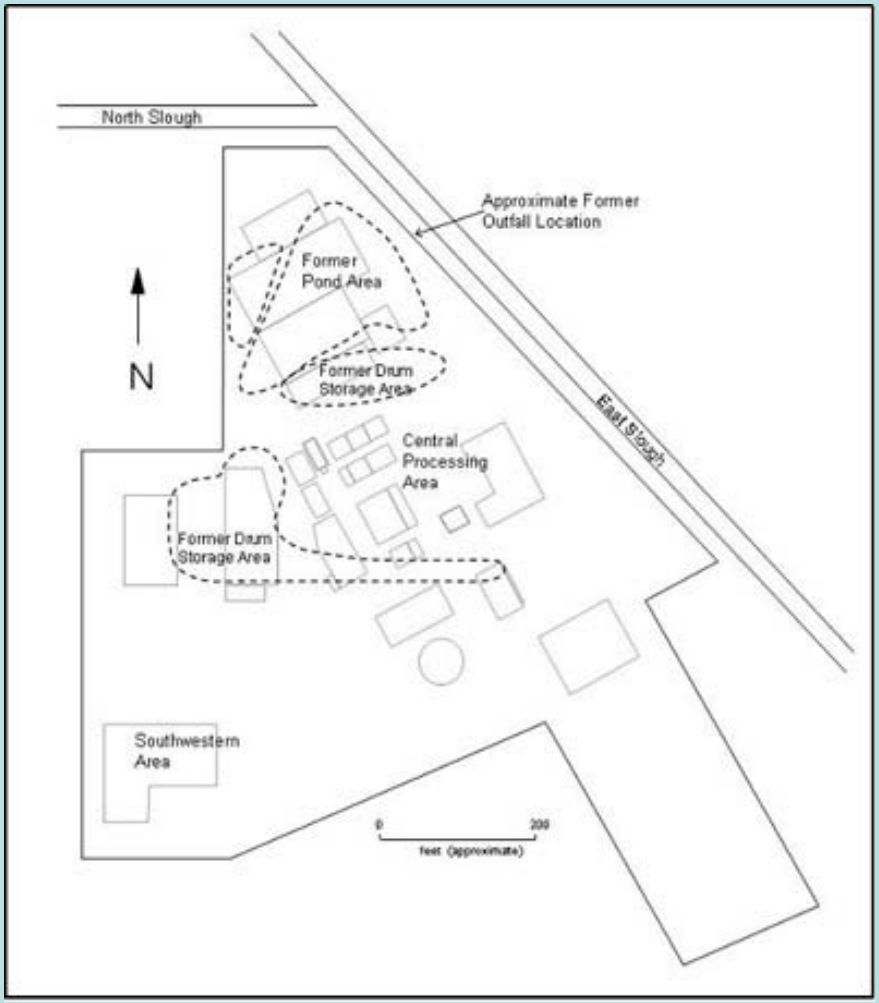
  - Is it possible to determine the environmental footprint of the alternative remedies?

  - Did we select the "greenest" remedy?

  - How important is off-site manufacture for the environmental footprint?

- **Develop a methodology to be used for estimating environmental footprints**

Remedy Alternatives at Romic



Alternative 2 (Hybrid)

Extraction wells *and* bioinjection wells

30 years to complete

Alternative 3 (Bioremediation)

Bioinjection wells only

10 years to complete

Alternative 4 (Pump and Treat)

Extraction wells only

40 years to complete

Alternative 3 has already been chosen for Romic, so this analysis did not affect the remedy decision.

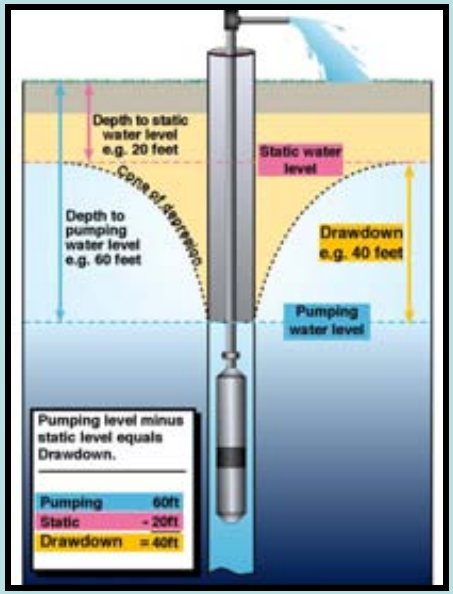
Remedy Alternatives at Romic

Bioremediation:

uses injections of cheese whey and molasses mixed with fresh water

Pump and Treat:

treatment of ground water in an air stripper followed by carbon filters



Boundaries of the Pilot Study

Functional Unit:

Ground water remediation.

Temporal Boundary:

Construction and active life of each alternative remedy.

System Boundary:

On-Site Activities (Level 1)

Transport To and From Site (Level 2)

Manufacture Off-Site (Level 3)

At Romic We Evaluated…

Resources and Energy Used

- **Water**
- **Construction Materials**
- **Electricity**
- **Fossil Fuel**

Wastes Generated

- **Spent Carbon**
- **Wastewater**

Air Emissions

- **NO_X, SO_X, PM, CO_2**

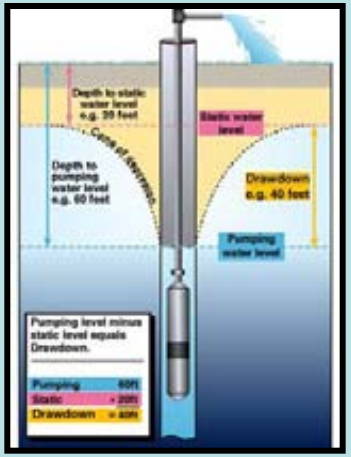






Level 1: On-Site Activities

Well Construction



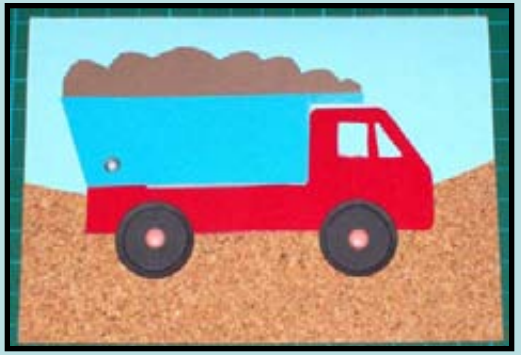
Groundwater Extraction

BioInjections

Groundwater Treatment

Level 2: Transport To and From Site

Operators to Site



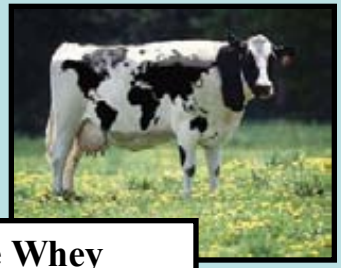
Wastes off Site

Materials to Site

Level 3: Off-Site Manufacture

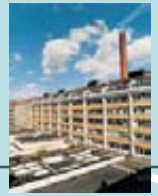
PVC Pipe Manufacture

Gravel Mining



Cheese Whey Processing

Electricity Production



PVC Pipe Manufacture

Mine

Gravel to site

PVC pipe to Site

Level 2: Transport

Operators to Site

Operators to Site

Spent Carbon Regeneration

Carbon to and from Site

Level 1: On Site

Well Construction

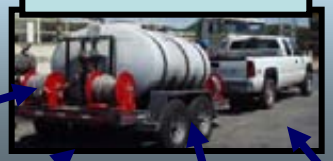
Groundwater Treatment

Drill Cuttings Off Site

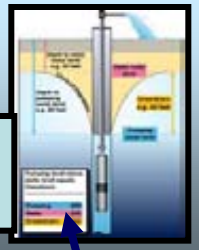
Treated Water to Sewage

Operators and Equipment to Site

BioInjections



Groundwater Extraction



Electricity to Sites

Dairy Farm

Cheese Whey to Site

Molasses to Site

Water to Site

Operators to Site

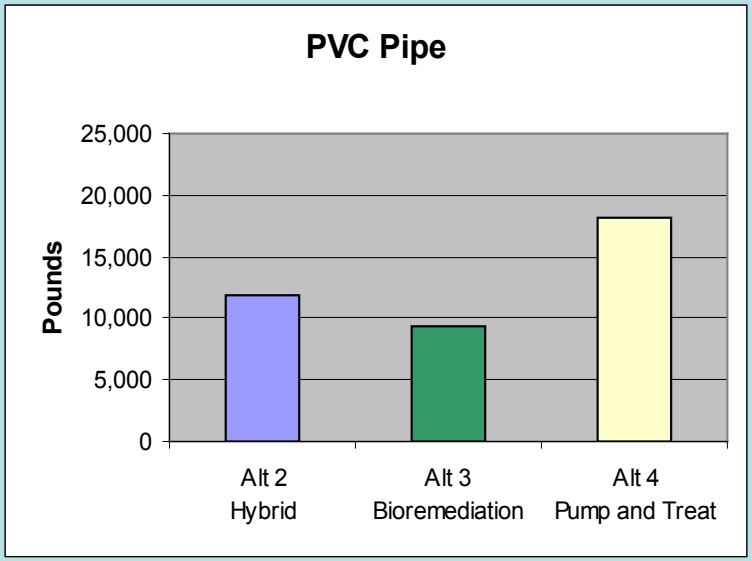
Power Plant

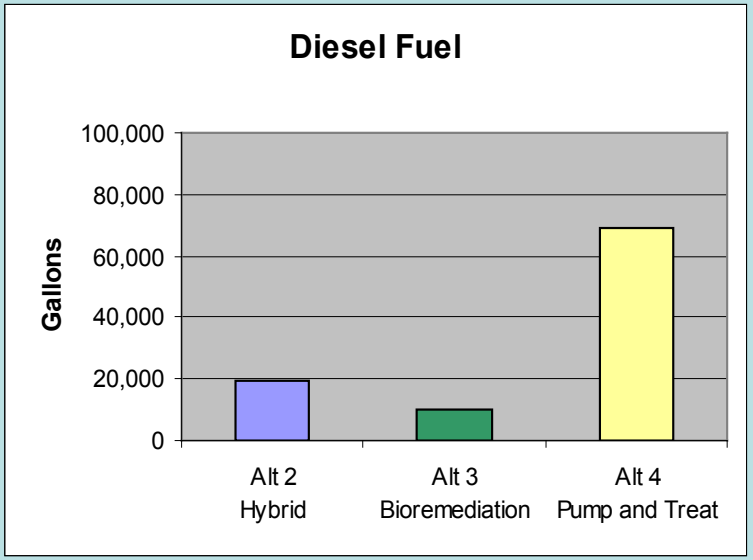
Molasses Manufacture

Level 3: Manufacture

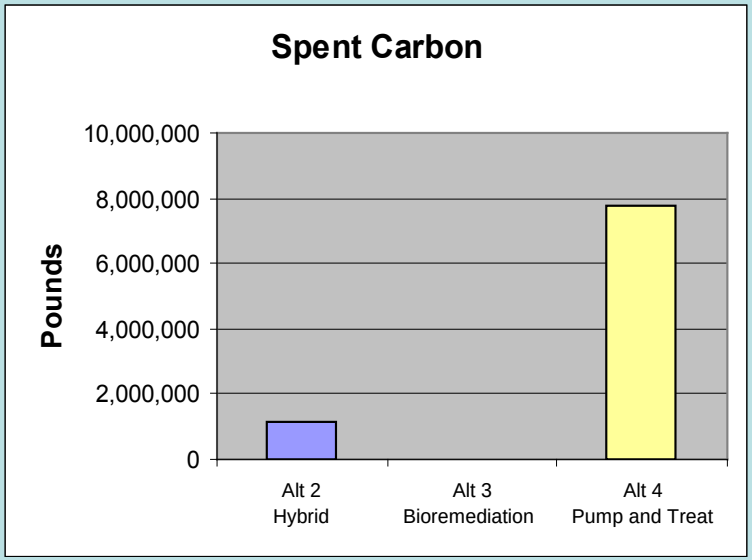
Pilot study is still in progress and results at this stage are preliminary.

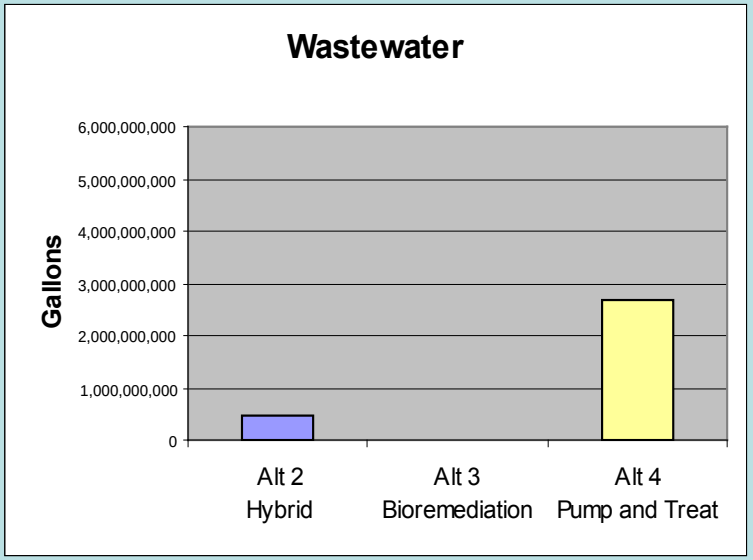
Results – Materials and Fuel





Results – Wastes Generated

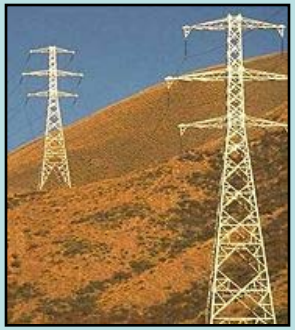




Levels 1, 2, and 3 Combined

Adding Level 3 (Off-site Manufacture) to the mix

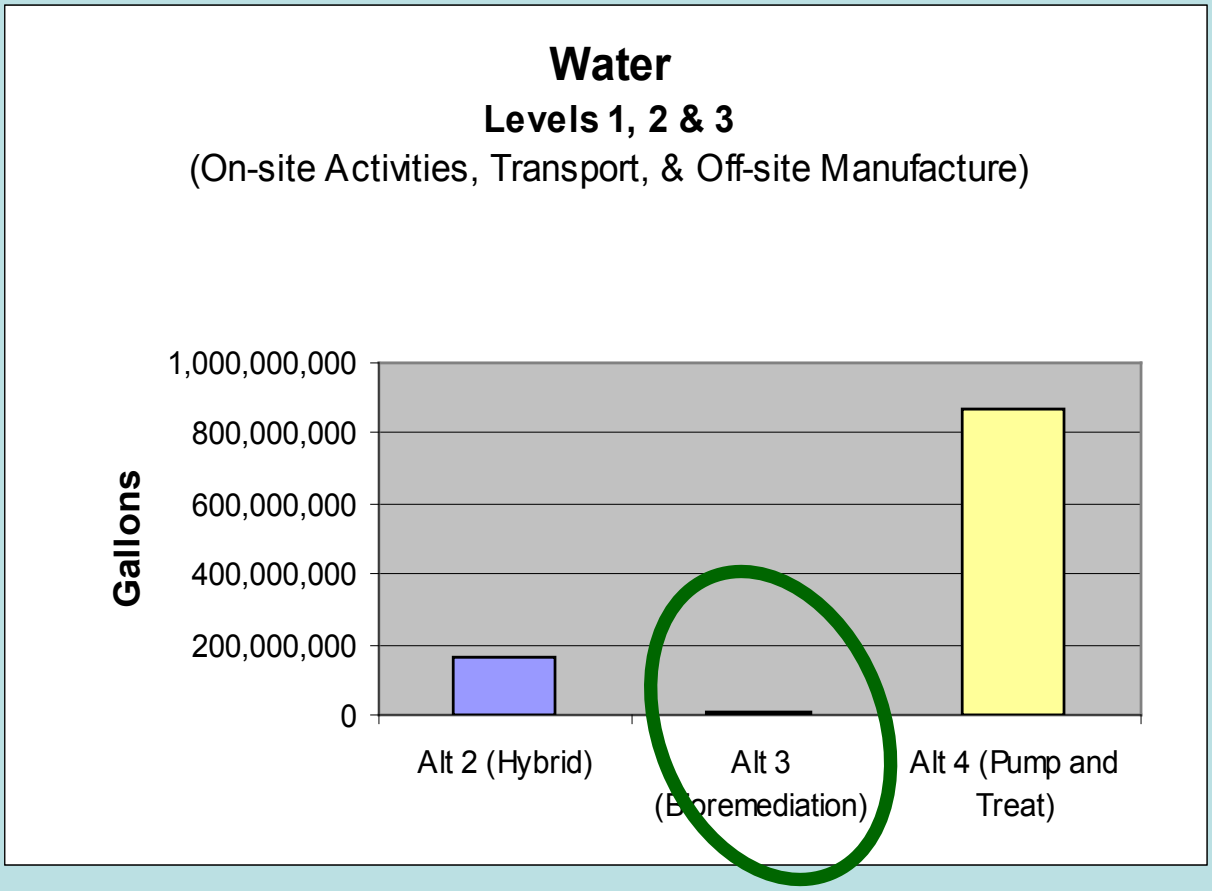
water used



electricity required

carbon dioxide emitted

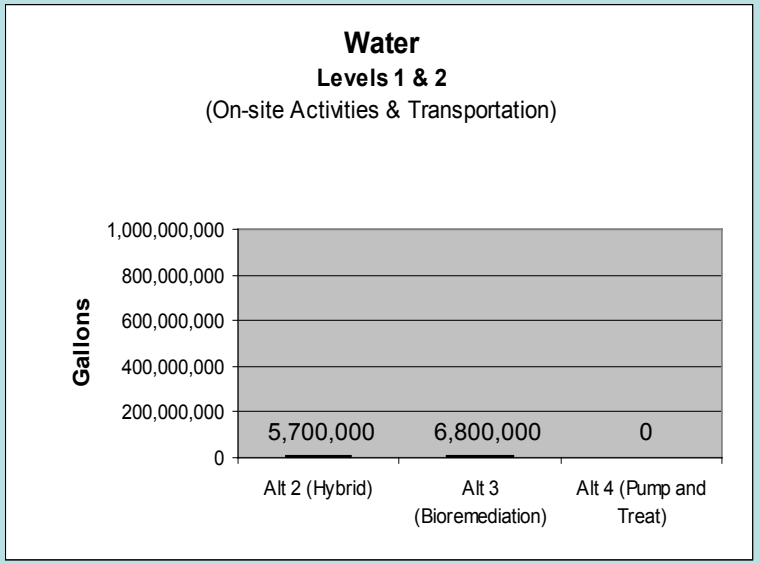
Results – Water

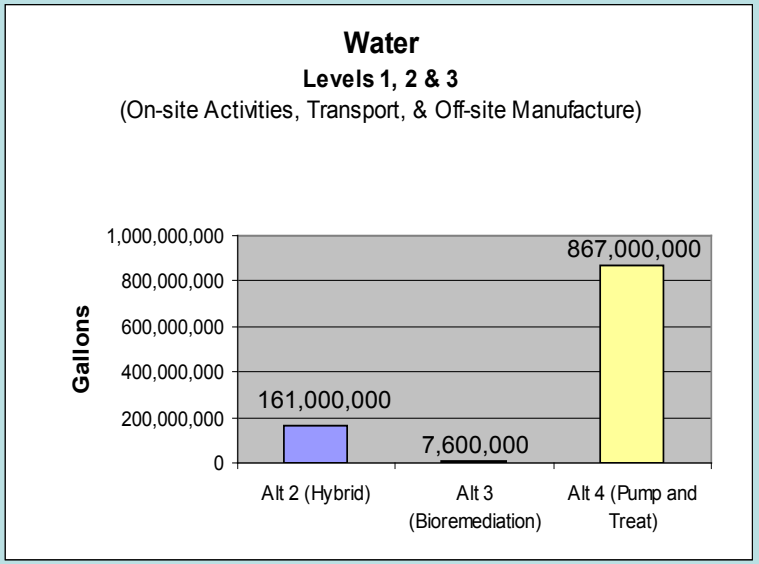


These values are for the life-time of each alternative remedy.

Results – Water

Including Level 3 (manufacturing) in the analysis substantially increases our estimate of the water footprint.





<u>Not</u> including off-site manufacturing

Including off-site manufacturing

Results – Water

Issues related to water:

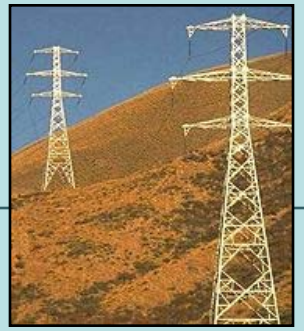
- Water withdrawn *versus* water consumed.

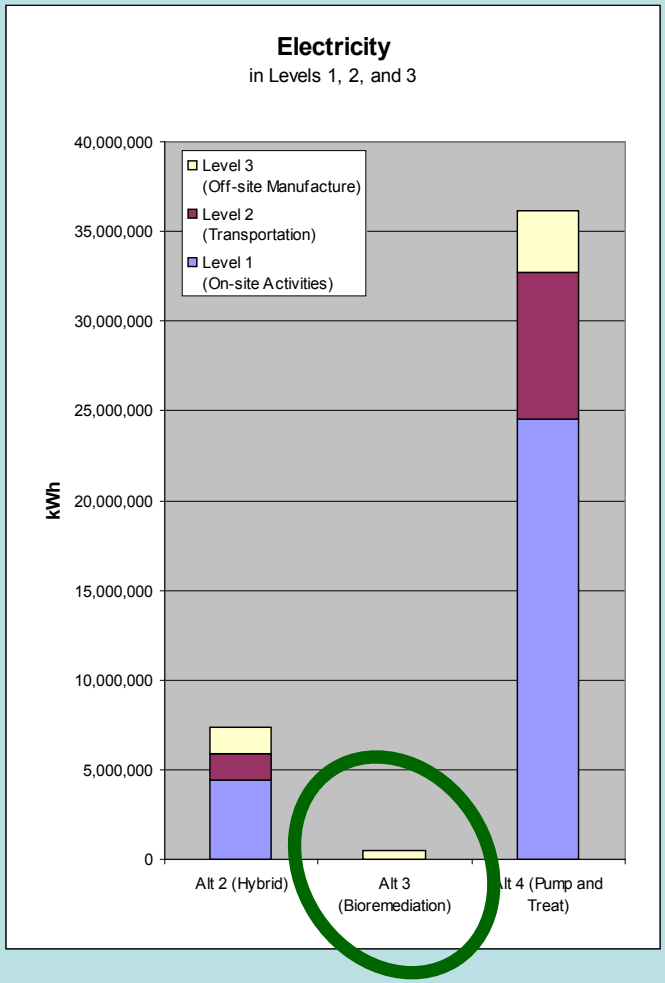
- Water withdrawn in "water scarce" areas *versus* water withdrawn in "water abundant" areas.

- Potable *versus* non-potable water.

Maybe, not all water is equal… how should we take this into consideration?

Results – Electricity





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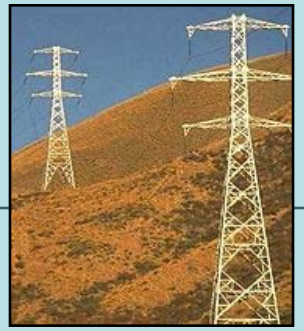
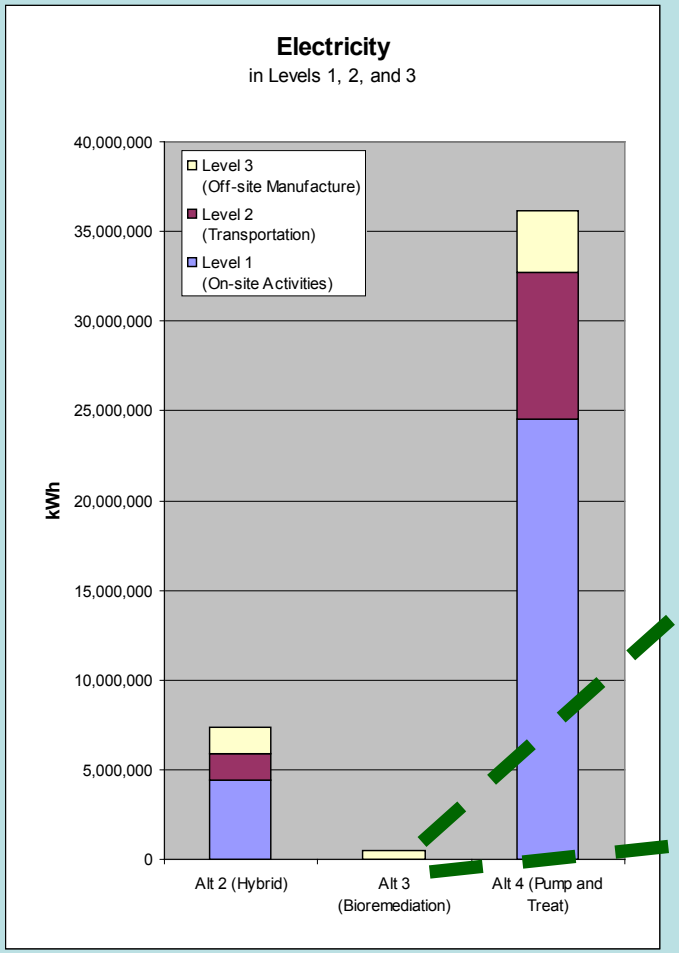
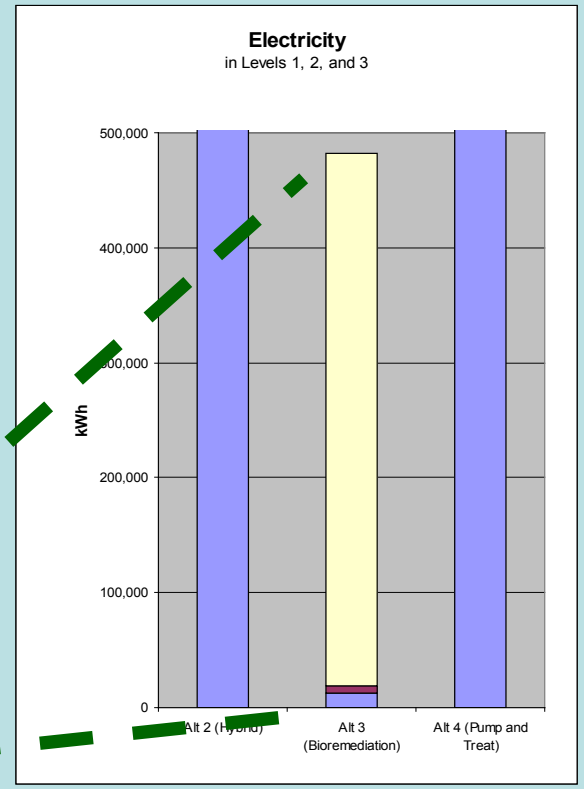
Results – Electricity



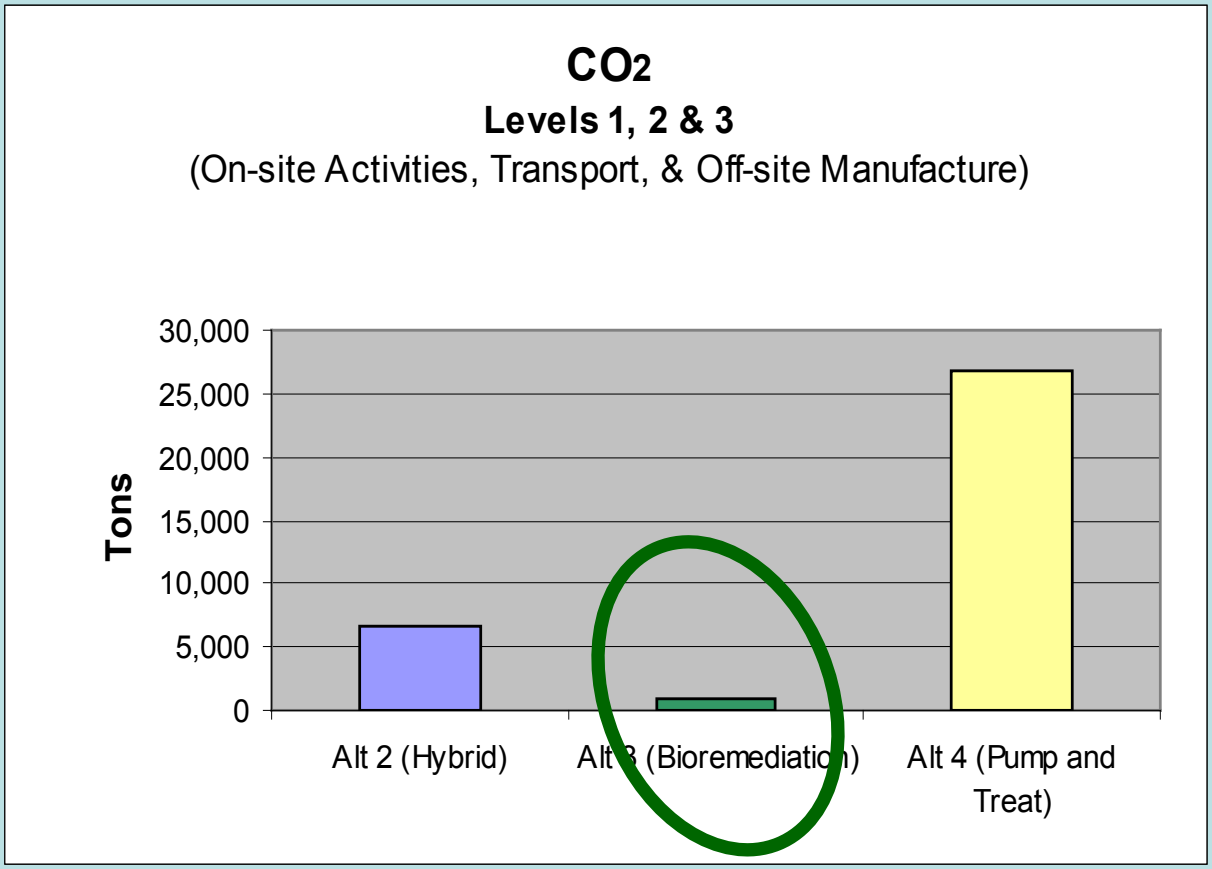




We are used to taking into account on-site electricity in evaluating environmental footprints.

However, electricity required for transport and manufacture are also important.

Results – CO_2 Emissions



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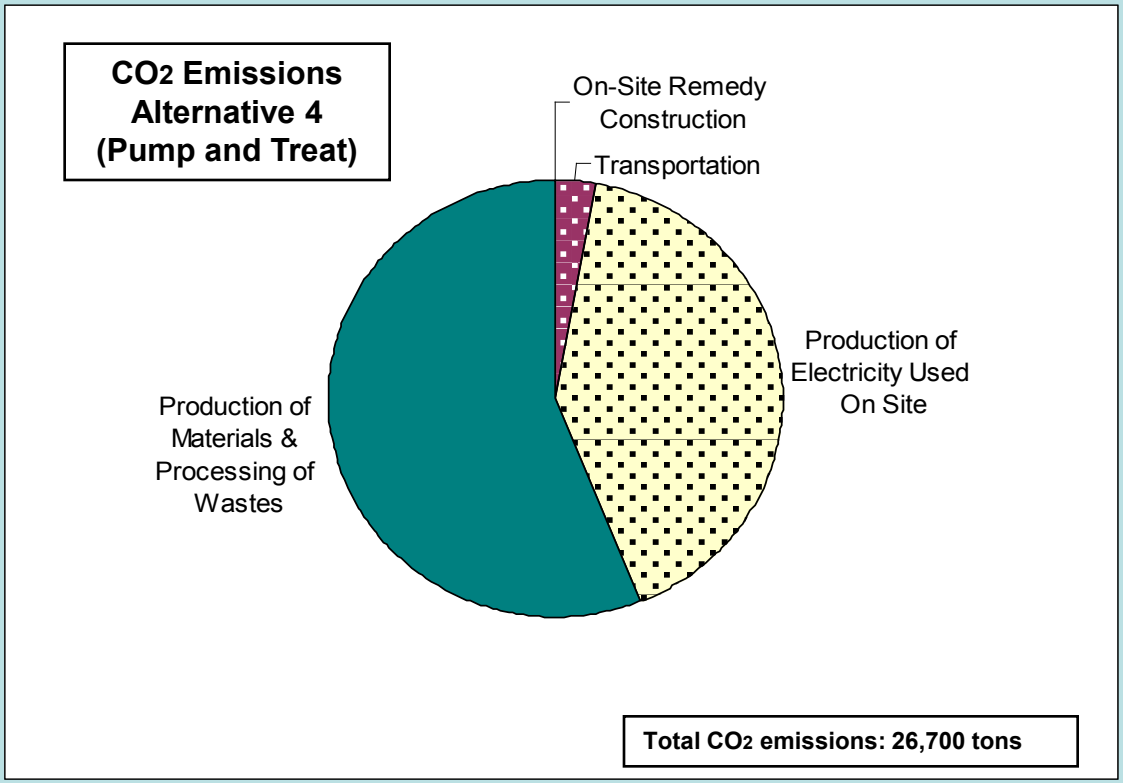
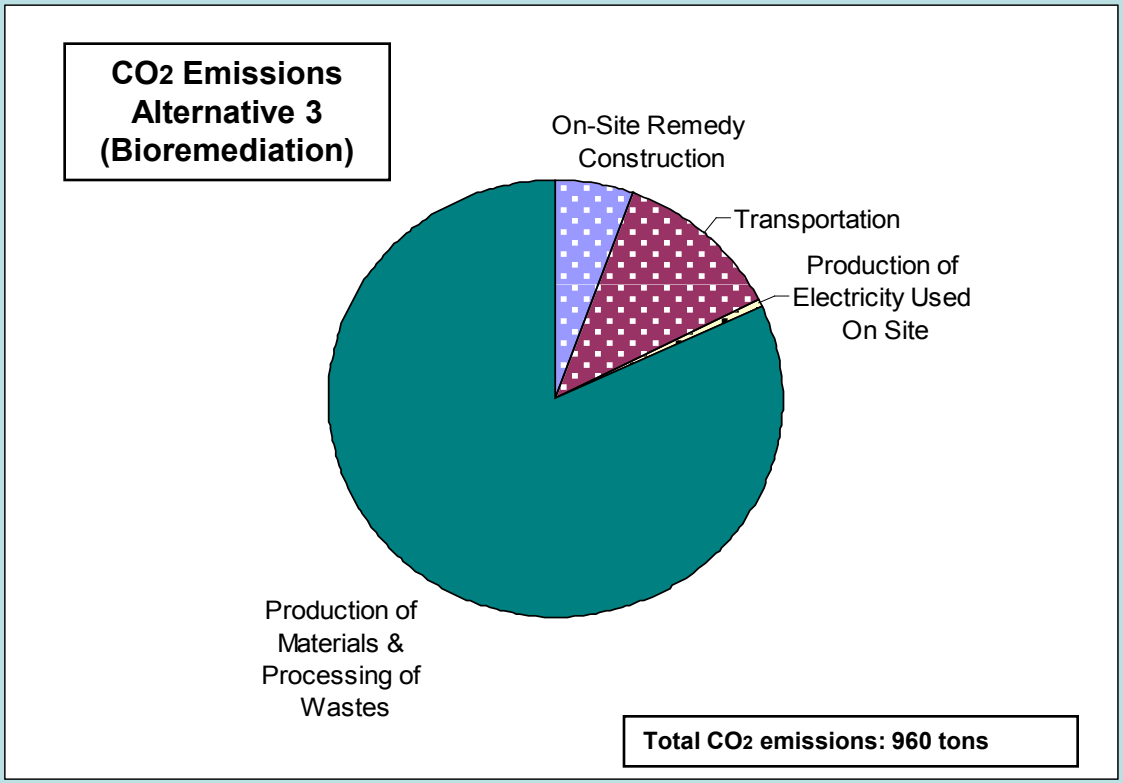
Results – CO_2 Emissions



Off-site activities, even those not related to production of electricity used on-site, are a big part of the CO_2 footprint.

Results – CO_2 Emissions



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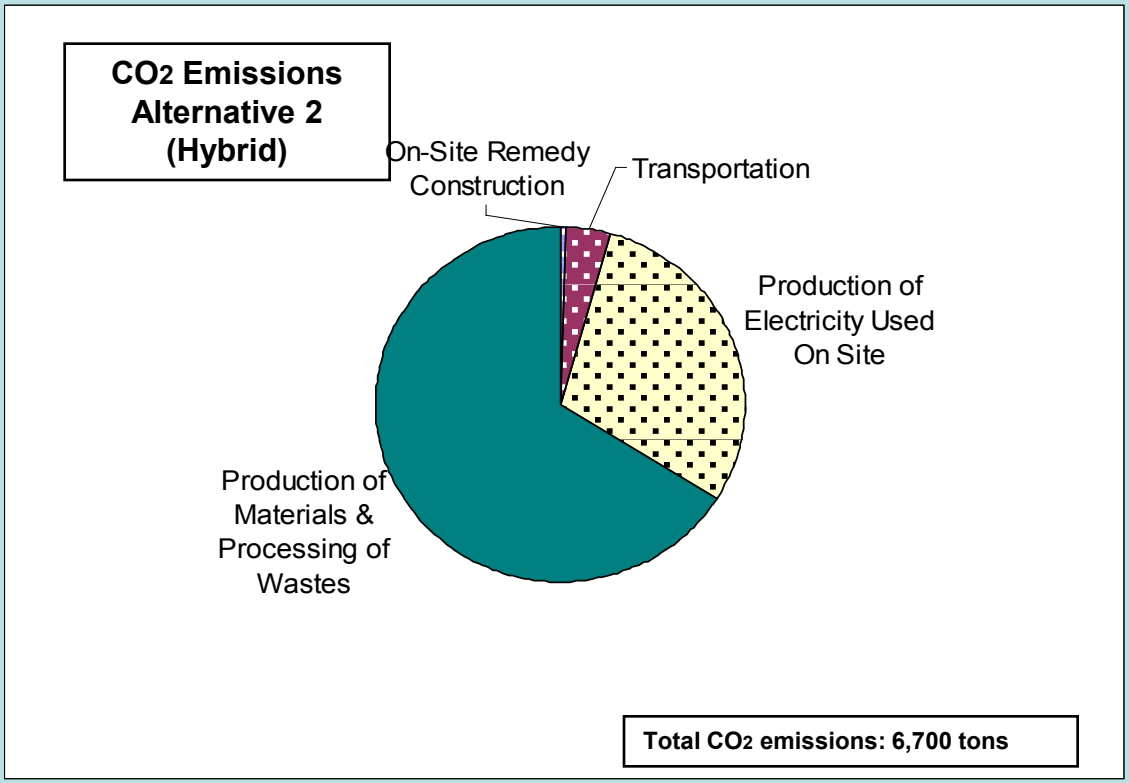


Off-site activities, even those not related to production of electricity used on-site, are a big part of the CO_2 footprint.

Results – CO_2 Emissions

Issues related to CO_2:

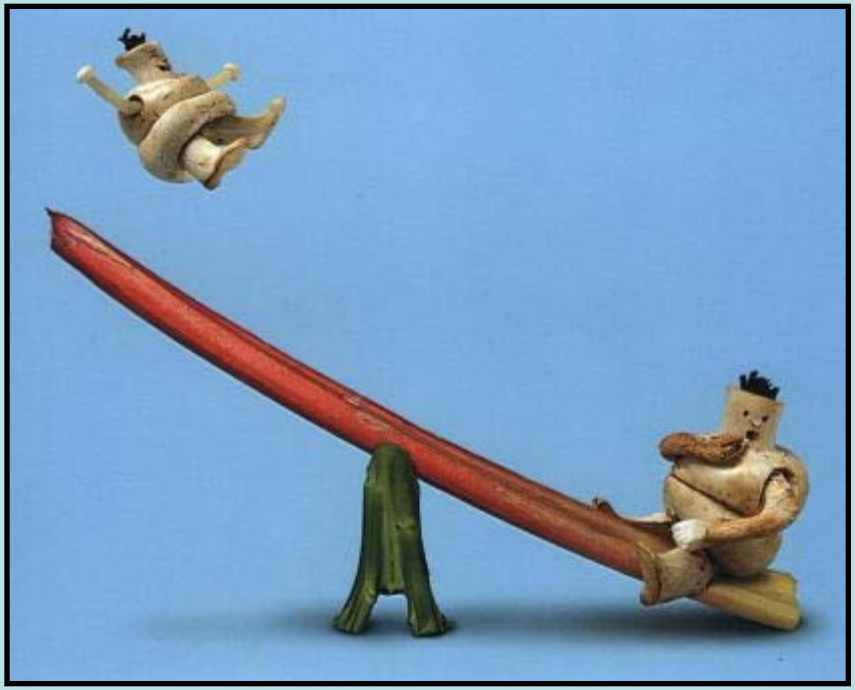
- Finding CO_2 emissions factors that include resource extraction as well as manufacturing.

- Taking into account likely lower emissions of CO_2 per unit material produced in the future.

- Being careful not to "double count" in reporting electricity requirements and CO2 footprint of the remedy.

Identify which materials and activities contribute the greatest to the CO_2 footprint and research them thoroughly.

Applying results to our clean-up sites



We need to balance the various aspects of the environmental footprints.

Applying results to our clean-up sites

- **Balance local effects with global effects:**

  water resources

  greenhouse gas emissions

  particulate emissions

- **Balance effects of disparate items:**

  natural resource depletion

  waste generation

  environmental contamination

  years to complete remedy

Applying results to our clean-up sites

- **Balancing disparate environmental impacts will be specific from site to site.**
- **Metrics for environmental impacts are not the only factor at a clean-up site, but should be seen as one of several balancing factors.**
- **In all cases the remedy must first meet threshold criteria, such as protection of human health and the environment.**

Life-Cycle Assessment Principles

Improving the Pilot Study --

We performed complete (but back-of-the-envelope) Level 3 calculations for:

- Water use
- Electricity use
- CO_2 emissions

We would like to add Level 3 calculations for:

- Wastes generated
- Fossil fuels consumed
- Air toxics emitted

We are working with EPA life-cycle analysis experts in ORD (Cincinnati) and with OSRTI to improve and add to our Level 3 calculations.

Life-Cycle Assessment Principles

Improving the Pilot Study --

Run calculations for other remedial activities at Romic:

- soil excavation
- groundwater monitoring
- capping contaminated areas

Life-Cycle Assessment Principles

- **Life-Cycle Assessment principles helped us greatly in developing our conceptual approach**
  - **Quantify on- and off-site environmental impacts**
  - **Distinguish between local and global impacts**
  - **Compare relative impacts of remedial technologies in a more comprehensive way**
  - **Focus our efforts in reducing the environmental impacts of a remedy**

Life-Cycle Assessment Principles

Develop a methodology based on Life-Cycle Assessment principles for estimating environmental footprints

- **Conduct Pilot Studies at three additional sites**
- **Streamline the methodology**
  - **identify aspects of remedies that make the largest contribution to the overall footprints and focus on those**
- **Establish a library of data inputs**
- **Designed for regulatory staff and site owners in all clean-up programs**

Key Points

- **Yes, it's feasible to estimate the environmental footprint of a clean-up remedy.**
- **Importance of including off-site manufacturing in estimations of the environmental footprint.**
- **A streamlined methodology would be helpful for conducting this type of analysis at other sites.**

Promoting Green Remediation

Reducing the Environmental Footprints of Our Site Clean-ups