BRAC Innovation

National Defense Industrial Association

Richmond, Virginia
April 8, 2003

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The BRAC Process

Turning a *Sow's Ear* into a *Silk Purse*

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BRAC Goals

- Divestiture of DoD real estate
- Public and regulatory acceptance
- Minimization of costs and ongoing liability

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Beneficial Approaches

- Phytoremediation
- Constructed Wetlands
- Composting
- Landfill Redevelopment
- Microturbine Revenues

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Phytoremediation

Use of plants to remediate contaminated soil and / or groundwater.

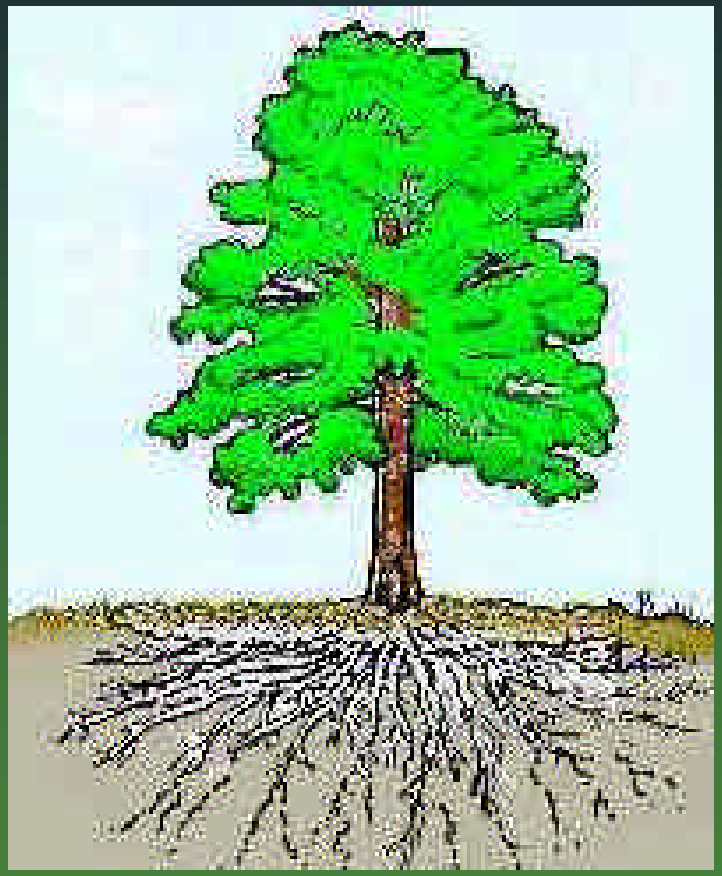

Image by Gleba et al., 1999

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Phytoremediation: The Approaches

<u>Phytoremediation:</u> the use of plants and soil amendments for the removal of contaminants from soil (greek *phytos*=plant)

<u>Phytoextraction:</u> the use of plants and soil amendments for the removal of concentrated contaminants in roots and above-ground shoots

<u>Phytostabilization:</u> the use of plants and soil amendments for chemical sequestration and physical containment

<u>Multi-tier Approach:</u> the use of more than one of the above approaches

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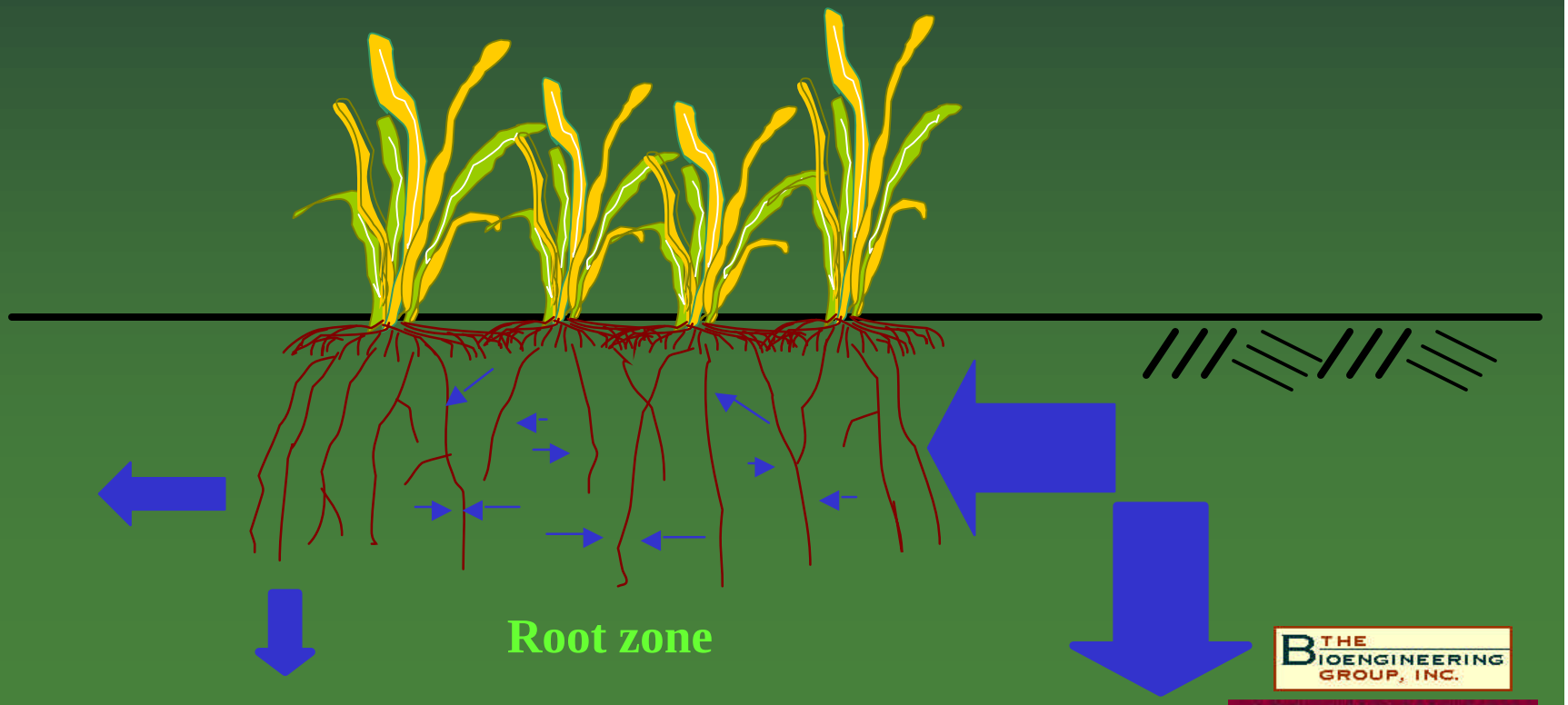
Phytoremediation: The Processes

Certain plants and the bacteria associated with their root zones are capable of: selective uptake of targeted heavy metals, degradation of hydrocarbons, breakdown of complex chemicals, and changes in soil hydrology



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Phytoremediation: The Advantages

Cost:

Low capital and operating costs
Metal recycling provides further economic advantages

Performance:

Permanent treatment solution
In situ application avoids excavation
Applicable to a variety of contaminants
Can augment conventional remediation

Other:

Public acceptance; aesthetically pleasing
Compatible with risk-based remediation

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Phytoremediation: Cost Effectiveness

Soil

(all figures in dollar per ton)

Chemical Treatment	$100-$500	Soil Washing	$75-$200
Soil Flushing (in situ)	$40-$190	Vitrification (reag)	$75-$90
Vitrification (thermal)	$250-$425	Thermal Desorp.	$150-$500
Thermal Treatment	$170-$300	Electrokinetics	$20-$200
Incineration	$200-$1500	Landfilling	$100-$500

Phytoremediation $25-$100

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Argonne National Laboratory West, Idaho Falls, Idaho

Description: Various sites at the Argonne National Laboratory are contaminated with wastes generated from the scientific and engineering research facilities.

Contaminants: Heavy metals (chromium, mercury, selenium, silver, zinc)

Treatment: Establishment of Prairie Cascade hybrid willow, canola, and kochia

Results: Successful implementation of willow

Cost: Not provided

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Twin Cities Army Ammunition Plant, Arden Hills, Minnesota

Description: The Twin Cities Army Ammunition Plant (TCAAP) is 2,370-acre facility used for production and storage of small arms ammunition and artillery shell materials.

Contaminants: Heavy metals (antimony, arsenic, barium, beryllium, chromium, lead, thallium)

Treatment: Crop establishment of corn and mustards

Results: Reduction of contaminants was limited due to poor quality of soils and inhibited plant growth. Future remediation will include application of fertilizers, irrigation, soil amendments as needed, and deep tilling.

Cost: $30.34 per cubic yard of soil per year

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Watertown Arsenal BRAC Site

Phytoremediation on Charles River, MDC
Olmsted Greenway, Watertown, Massachusetts

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Mill Creek, Cincinnati, Phytoremediation Construction Detail

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2 Years after Construction—Effective remediation and high habitat value

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The use of plants to remediate contaminated soils in upland and riverbank areas…

…results in improved water quality and enhanced ecological habitat value.

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Constructed Wetlands

Wetlands can effectively remove ***explosives*** and ***trace metals*** from surface and groundwater.

(Best et al. 2000, Knight et al. 1999, Best et al. 1997, Price et al. 1997, Goodrich-Mahoney 1996, Gupta et al. 1994)

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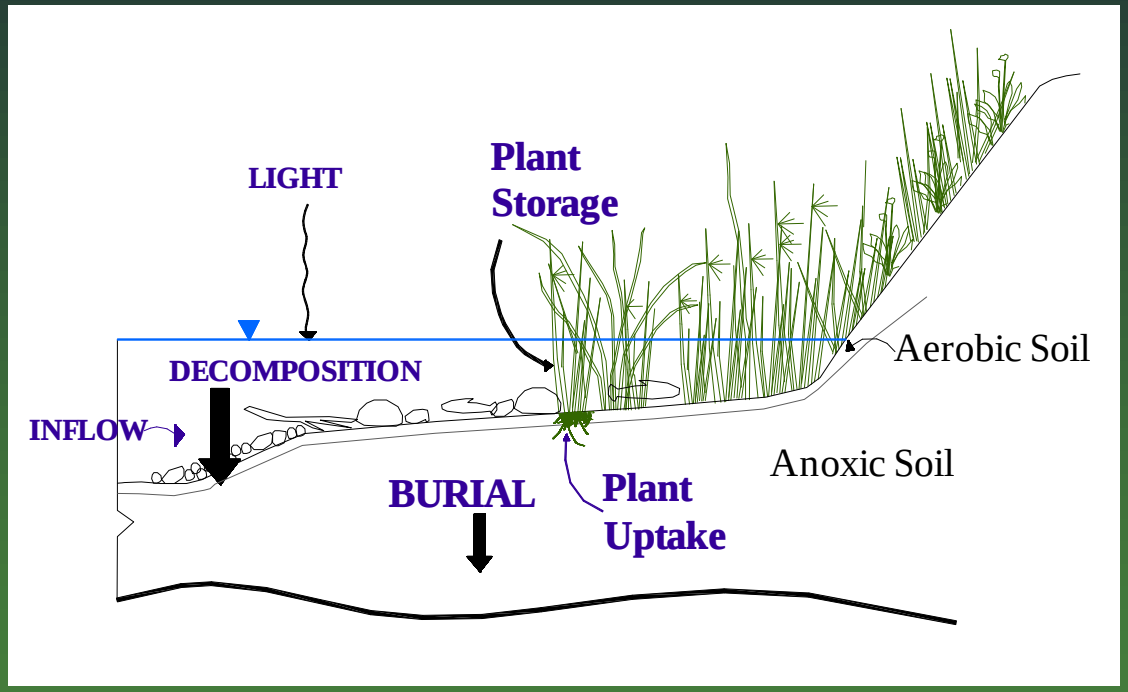
Mechanisms for Explosives and Metal Removal

- Binding to soils, sediments, particulates
- Precipitation
- Uptake by plants, including algae and bacteria



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Wetland Efficiencies for Removal

Explosives

TNT	79-99 %
RDX	50-99%
TNB	99%
HMX	50-99%
24DNT	58%
26DNT	61%

(Best et al. 2000)

Heavy Metals

Cu	63-96 %
Cd	70-99%
Al	-33-63%
Fe	58.2-80%
Mn	43-98%
Pb	65-83%

(Kadlec and Knight 1996)

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Constructed Wetlands: Issues

- Explosive and metals toxicity for submersed and emergent vegetation
- Possibility of bioaccumulation
- Long-term reliability for metals
- Remediation
- Limited research
- "…an environmentally-friendly and cost-effective alternative for traditional methods"

  Best et al. 2000

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Constructed Wetlands: Case Studies

The USACE has performed numerous studies to evaluate the effectiveness of wetland treatment for explosive and heavy metals removal. Studies include experiments in:

- **Chattanooga, TN 2000**
- **Burlington, IA 1998**
- **Grand Island, NE**

These studies included the evaluation of both surface and subsurface wetland systems.

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BRAC Site, Devens, Massachusetts

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Treatment wetlands and composting

Devens: high public satisfaction and successful results

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Composting

Potential Treatment for Explosives and Other Military Contamination

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Compost Can Degrade . . .

- **Explosives**
  - **TNT**
  - **DNT**
  - **RDX**
  - **HMX**
- **Refined petroleum fuels**
- **Crude Oil**
- **PAHs**
- **Propellants**
- **PCP**

(Peramaki 1999)

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Composting Process

- Ex situ process
- Soils are mixed with bulking agents and soil amendments
- Aerobic process
- Microbes digest contaminants

Courtesy of Cornell WMI

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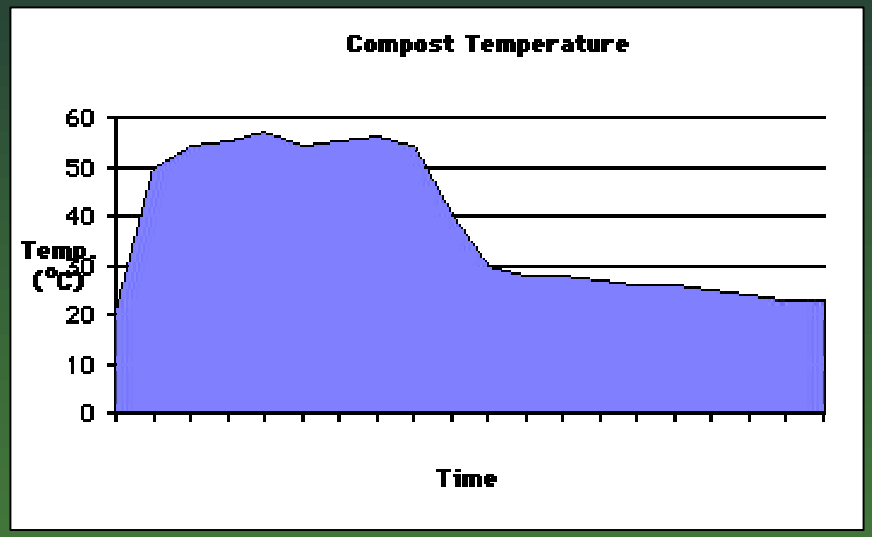
Composting Process

- Metabolic activity of the microbes raises the temperature of the mixture to 55 – 65°C
- Process typically takes 15 – 20 days
- The compost is then removed to a “curing area” for several months, after which it is ready for land application



Courtesy of Cornell WMI

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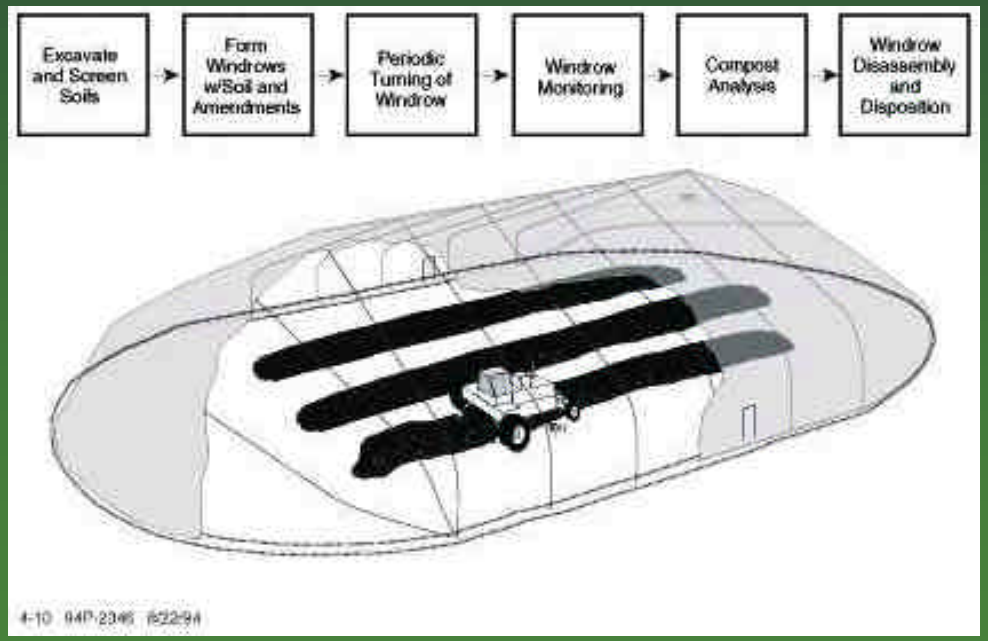
Typical Compost Mix

- 30% contaminated soil
- Bulking agents (wood chips, straw)
- Soil amendments (manure, alfalfa)



Courtesy of FRTR

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Best Applications

- Contamination to depths of less than 20 feet
- Contaminants which are biodegradable
- Contaminants which form strong bonds with humic substances

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Advantages

- High temperatures allow bioremediation during cold seasons
- High temperatures accelerate soil chemical reactions
- High humic content increases soil reactivity
- Simple and inexpensive
- End product is non-toxic
- Potential revenue from sale of finished compost

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Umatilla Army Depot, OR

- Contaminated during decommissioning of bombs in the 1950s and 1960s
- TNT, RDX and HMX
- Full-scale remediation
- Achieved non-detect levels
- Cost: $351/ton
- Saved $2.6 million over incineration

(Wright 1996, EPA 1997)

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Hawthorne Army Depot, NV

- Contaminated by the disposal of explosives-laden water
- TNT, RDX, HMX, yellow-D
- Full-scale pilot study
- All explosives degraded to goal levels within 28 days
- Also degraded PCP in pallets used for wood chips
- Cost: $250/cu yd

(Brunner, 1999)

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Other Military Sites Using Compost for Remediation

- Pueblo Chemical Depot, CO
- Sierra Army Depot, CA
- Naval Surface Warfare Center, IN
- Joliet Army Ammunition Plant, IL
- Bangor Naval Submarine Base, WA
- Louisiana Army Ammunition Plant, LA
- Badger Army Ammunition Plant, WI
- Tooele Army Depot, UT
- Seymour Johnson Air Force Base, NC

(EPA 1997, Gray 1999, Block 2001)

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USACE estimates that $200 million could be saved by using compost to clean the remaining US munitions sites across the country.

(EPA 1997)

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Landfill and Other Contaminated Site Redevelopment

Brownfields

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BRAC Installation Turnover Challenges

- Former landfill sites
- Range locations
- Other areas with residual contamination
- Local Redevelopment Authority / Restoration Advisory Board concerns

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Specific Landfill Redevelopment Issues

- Methane hazards
- Post-closure care O&M costs
- Differential settlement issues
- Buried hazardous wastes

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Carson Town Center, California
Landfill Redevelopment

- Built atop Golden Eagle Landfill
- Former petroleum refinery
- 150,000 sf department store with parking
- Expansion in progress
- LFG protection and GW investigation

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Industry Hills Resort Complex, California Landfill Redevelopment

- Built atop landfill
- 400 room Sheraton Hotel
- Golf courses, tennis center, parking
- LFG systems – heat all hot water

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Ironwood Sport Complex, Lorton, Virginia
Landfill Redevelopment

- Built atop municipal landfill
- Driving range, miniature golf, and batting cages
- LFG systems and site consulting

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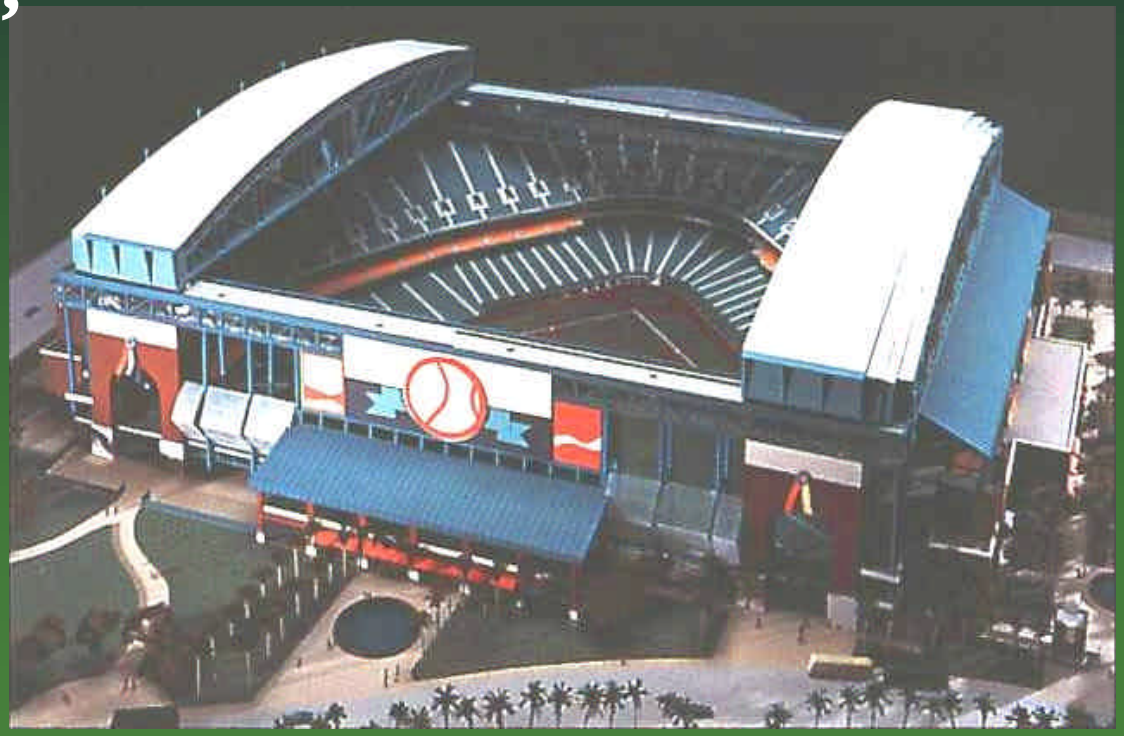
Bank One Ballpark, Phoenix, Arizona
Brownfields Redevelopment

- Environmental assessments, investigation, and remediation
- 276 sites
- Asbestos, USTs, historical buildings



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Bishops Canyon Recreation Complex
Los Angeles, California
Brownfields Redevelopment

- Landfill closure and end-use plans
- Baseball and soccer fields
- Nature walks and bike trails
- Overlooks Dodger Stadium

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Roger Penske Auto Raceway, Fontana, California
Brownfields Redevelopment

- Constructed 14-acre membrane cap
- In-situ soil vapor extraction
- On-site soil treatment
- Off-site disposal: 7,000 cy of soils, 21,000 tons of residuals

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Microturbine Technology Characteristics

- Applicable to smaller landfills (e.g., military)
- Tolerates lower methane content (e.g., 30% to 35%)
- Extremely low air emissions
- Sizes: from 30 to 250 kW

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Microturbine Economics

- **Total Capital Cost:**

  $1,800 to $3,000 per kW

- **Long-Term O&M Cost:**

  2.0¢ to 2.5¢ per kWh

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Optimal Circumstances

- Retail Deferral
- High Power Cost Region
- Multiple Units
- Need for Hot Water
- Availability of Incentives

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LFG Fired Microturbine Design & Design/Construct Experience

Location	Size/Type	On Line	Scope
Jamacha LF San Diego, CA	300 kW Honeywell	June 01	DC
Jamacha LF San Diego, CA	280 kW I-R	Feb 02	DC
OII LF Monterey Park, CA	420 kW I-R	July 02	DC
Acme LF Martinez, CA	280 kW I-R	July 02	D
Calabasas LF Calabasas, CA	300 kW Capstone	July 02	DC
Eastern Regional LF Truckee, CA	120 kW Capstone	Oct 02	D

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Air Force Landfill Power Generation Potential

- Fifteen Air Force landfills greater than 10 acres in size are present at seven bases in California
- Fourteen are closed and one is open
- Very preliminary landfill gas estimates: 4,340 kW = $5.1M per year @ 13.5¢/kWh retail rate or $1.5M per year @ 4.0¢/kWh wholesale rate

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Change the Dynamics …

Enhanced Remediation Paradigm--Restoration

- ✓ **Beneficial Use of Sites**
- ✓ **Ecological Outputs**
- ✓ **Utilization of Problem Resources**
- ✓ **Improved Economics**
- ✓ **Favorable Public Relations**

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Opportunities?…..

- ✓ **Sites with dispersed / residual contaminants**
- ✓ **Particularly challenging landfill and other disposal sites**
- ✓ **Sites with sensitive resources**
- ✓ **High profile Public Relations challenges**

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