Green Remediation and Sustainability Introductory Comments

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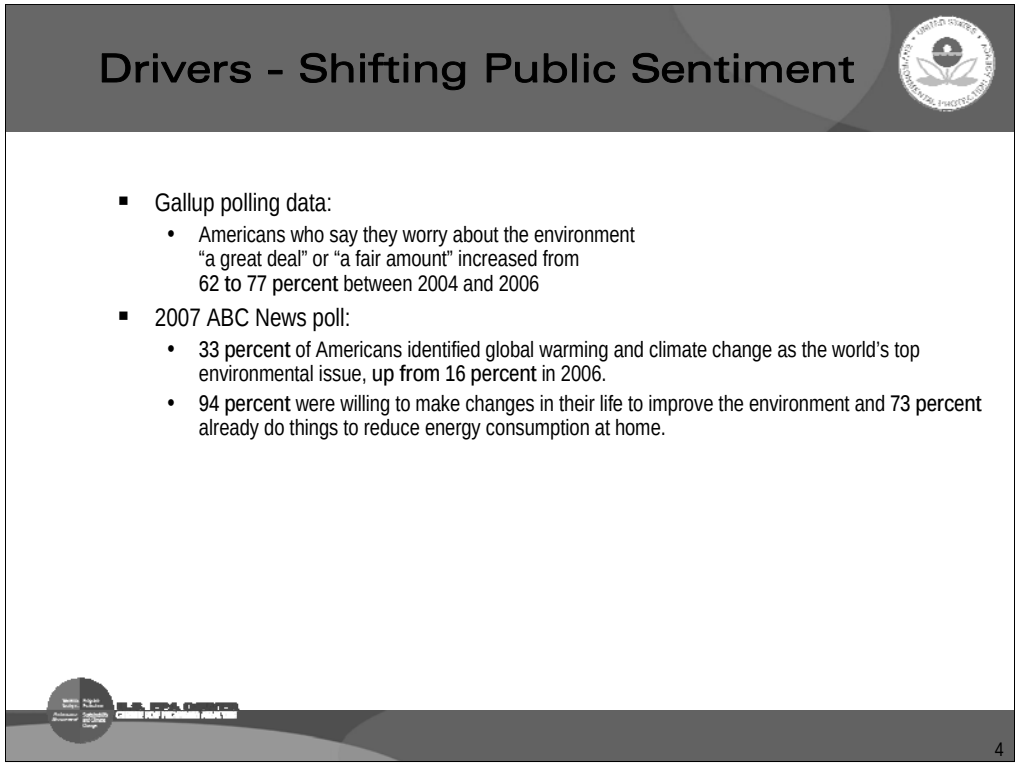
Green Remediation - Introduction

- Drivers for going Green
- Sustainable Development
- EPA's Office of Solid Waste & Emergency Response (OSWER)
  - Materials Management and Life Cycle Analysis
  - Land Management – Sustainable Approaches
- Green Remediation Framework

Drivers - Green Goes Mainstream

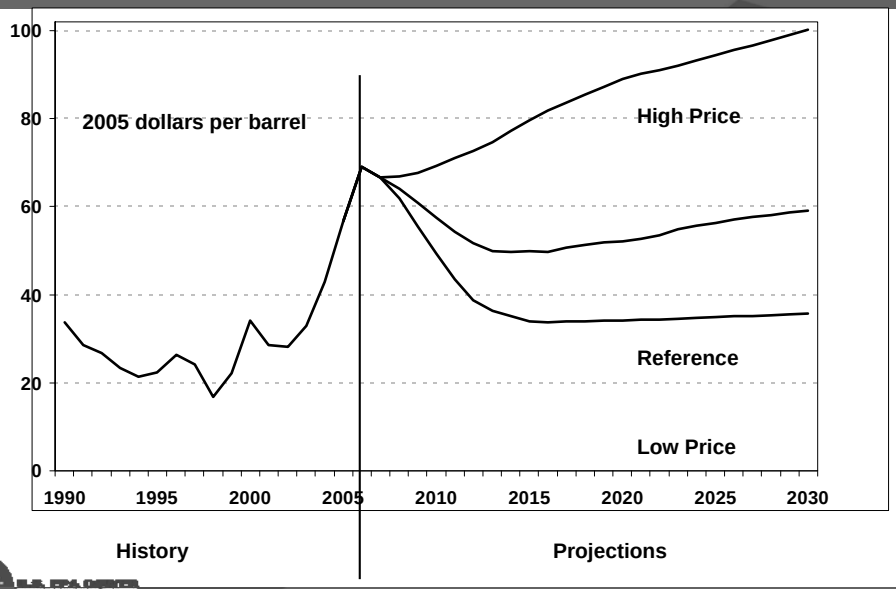


Gallup polling data show that the number of Americans who say they worry about the environment "a great deal" or "a fair amount" increased from **62 to 77 percent** between 2204 and 2006 (poll taken before the release of An Inconvenient Truth) *Newsweek, July 17, 2006, p. 43*

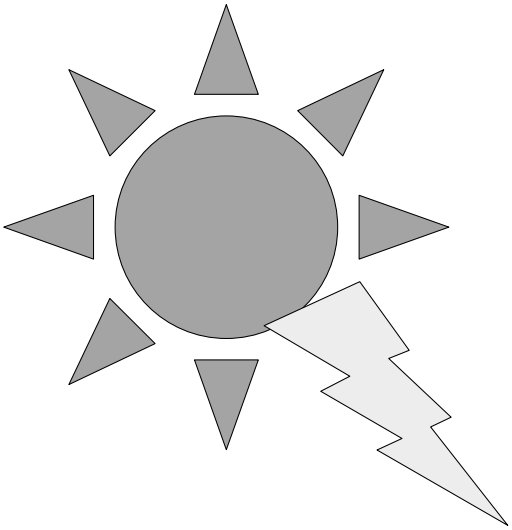
ABC news poll

(http://abcnews.go.com/Technology/GlobalWarming/story?id=3057534&page=1)

Drivers - Energy Prices



Drivers - Climate Change



Drivers – Climate Change and Energy Programs

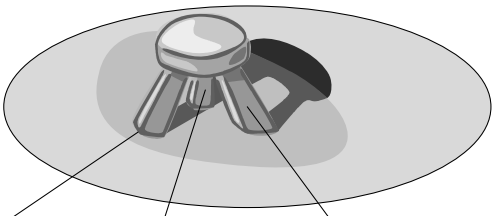
- State, Local, NGO, business, international, community initiatives
- 35 states have renewable portfolio standards (RPS)
  - Specifies a percentage of total energy to be derived from renewable sources
- 19 states have public benefit funds (PBFs)
  - Supports energy efficiency and renewable energy projects; collected through small charge to electric customers or utility contributions 22 states have GHG inventories
- 23 states have energy efficiency standards
- 22 states have carbon sequestration programs
- Regional Initiatives
  - 6 Regional GHG Initiatives composed of states collaborating to create “cap and trade” systems and address GHG emissions across broad geographic areas
  - Regional Greenhouse Gas Initiative (RGGI) will cap carbon emissions in 11 northeastern states. Initial auction of carbon allowances to be held in summer 2008

More Drivers

- Advances in Engineering and Manufacturing
- Public Policy
- Global Economic and Development Changes

You
&
Me

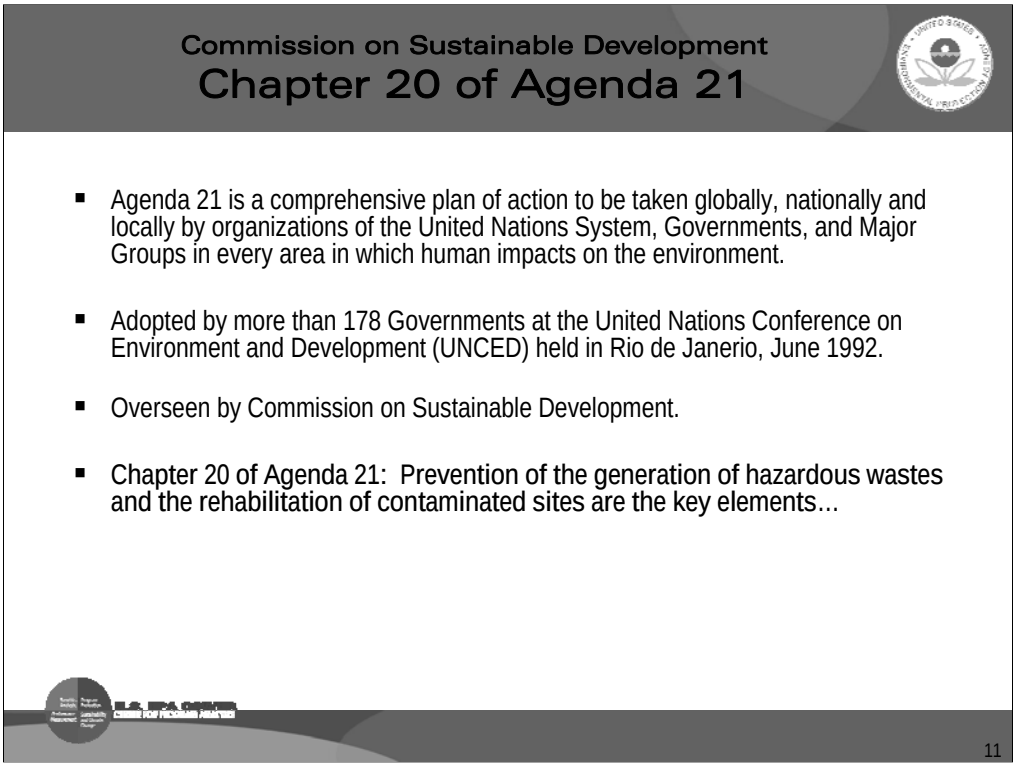
Sustainable Development



Sustainable Development

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

WCED "Our Common Future"
(The Brundtland Report, 1987)



Agenda 21, the Rio Declaration on Environment and Development, and the Statement of principles for the Sustainable Management of Forests were

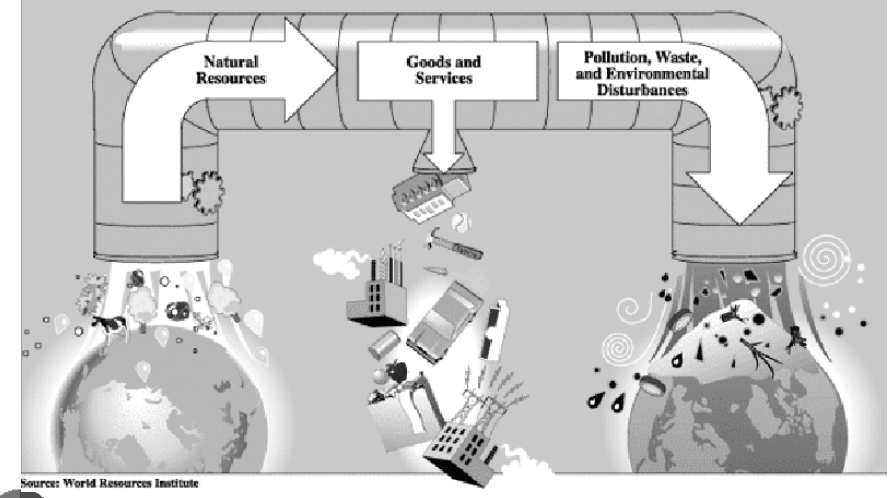
Words are powerful. At the same time...

You say tomãto, I say tomato͡

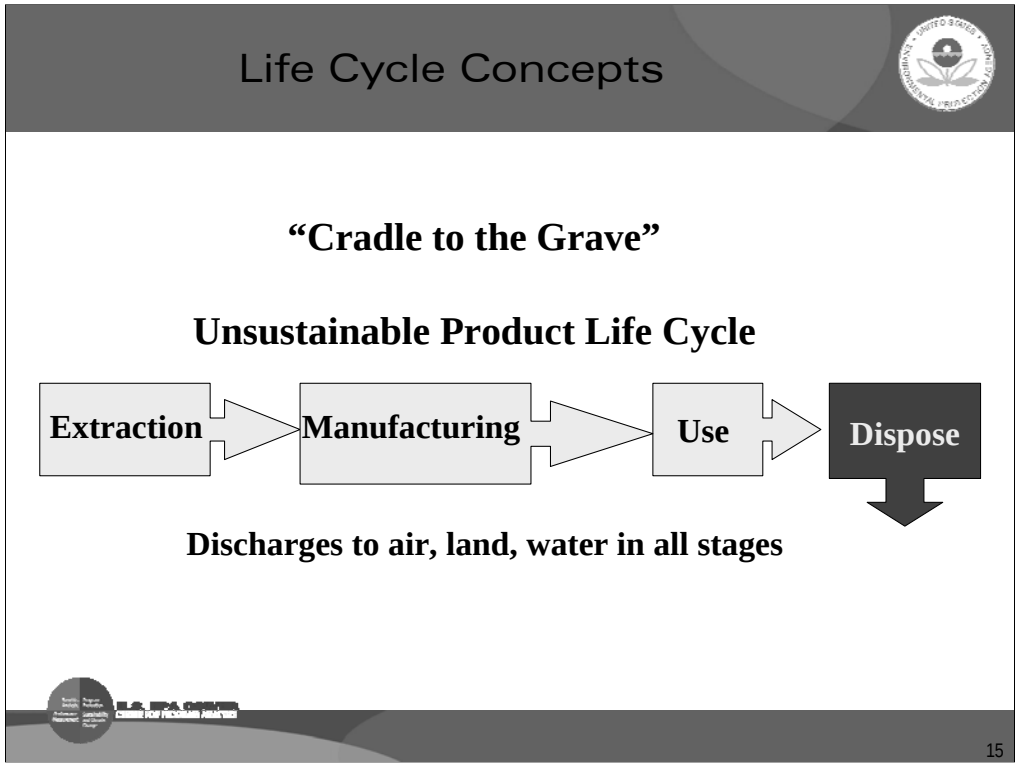
EPA
Office of Solid Waste & Emergency Response (OSWER)

- Materials Management*
- Land Management*
- Emergency Preparedness and Response

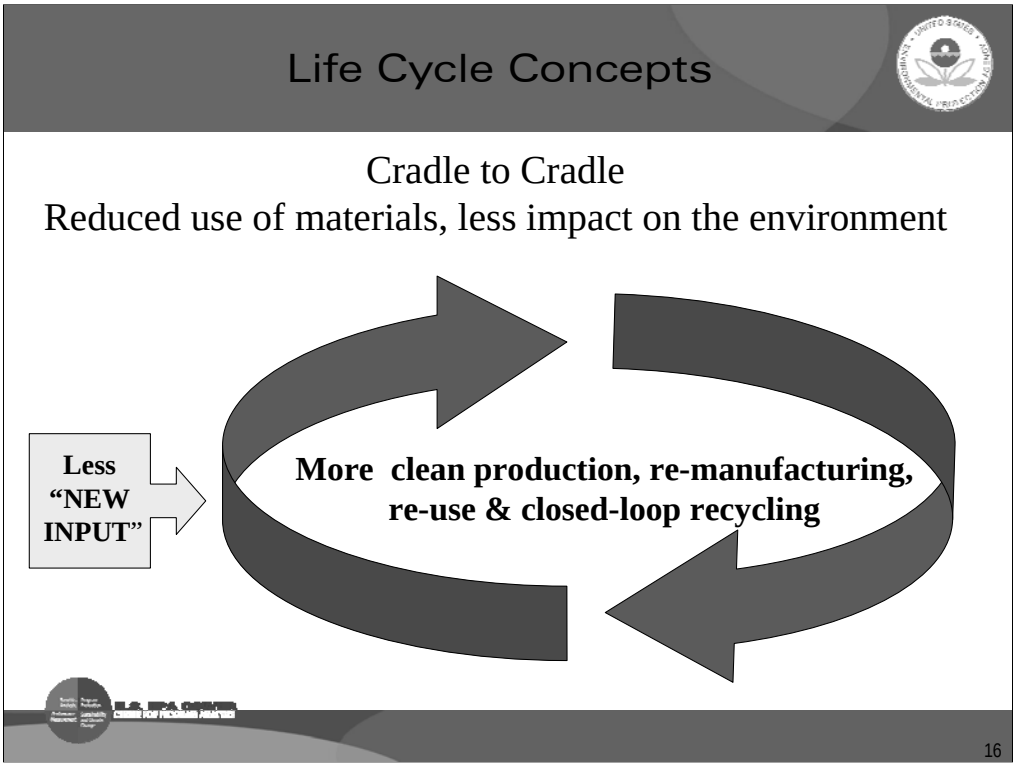
The Materials Cycle



Source: World Resources Institute



A traditionally used IE metaphor critiques dominant extraction, production, use, consumption and disposal as overly linear. A type I system as described by Allenby is linear, virgin materials enter the system, are used only once, and then are disposed of as waste. Think of the language problem in terms of how language embodies a way of thinking, such as "waste" vs. "residual". A waste has no further use to both a given process as well as surrounding system, while residual have no further use to a given process, but can be reused within the system. A principle of industrial ecology is that no economic activity should generate waste, just residuals.



A traditionally used metaphor seeks to inspire a better future that is cleaner, safer and sustainable. Type II and III systems tend toward the development of internal cycling loops and activities within an economy. Internal reuse of materials become quite predominant and the velocity of materials flow through the system is reduced. Material management is important yet the full theoretical cyclicity of a Type III system has not been achieved. A type III system is dominated by energy inputs.

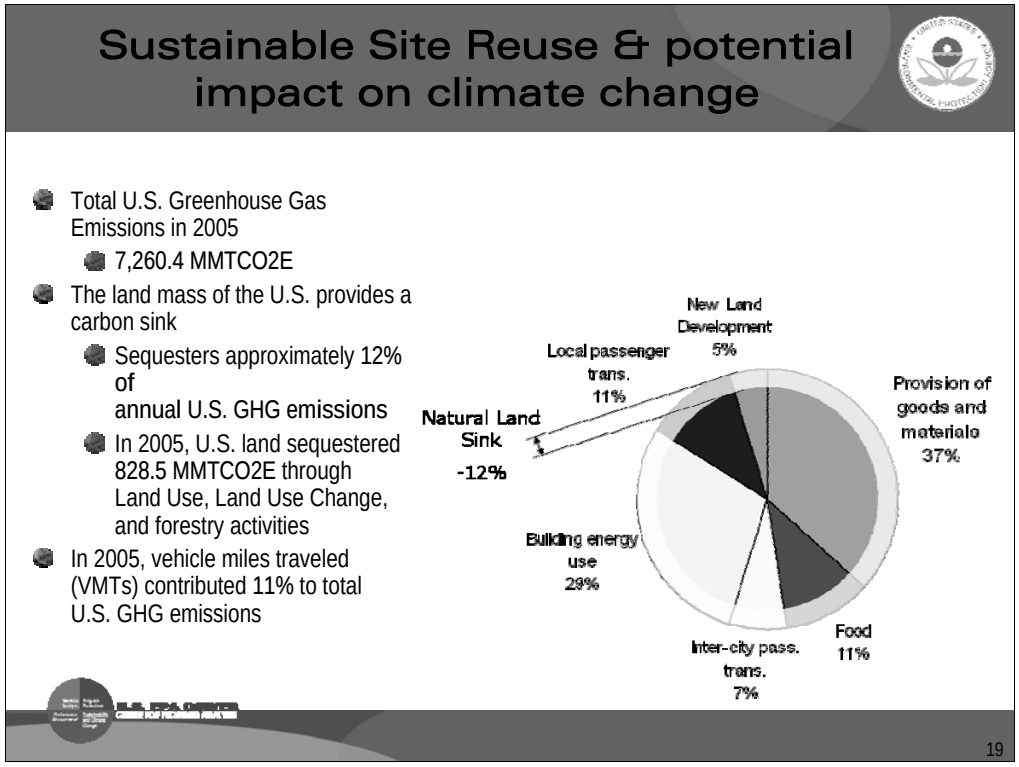
Life Cycle Concepts and Remediation

- Life Cycle Analysis of the property
- Life Cycle Analysis of the product
- Life Cycle Tools applied to remedial decision making

Framing the life cycle analysis

Land Management

1. Sustainable site reuse
2. Clean energy on sites
3. Land restoration to increase carbon sinks
4. Greener remediation



1. Sources:

Bullet #1 - **Evaluation of Effects of New Development on Changes in Carbon Stocks and Greenhouse Gas Emissions (foundation paper);** http://www.epa.gov/climatechange/emissions/downloads06/07CR.pdf

Bullet#2 – http://www.epa.gov/climatechange/emissions/downloads06/07CR.pdf

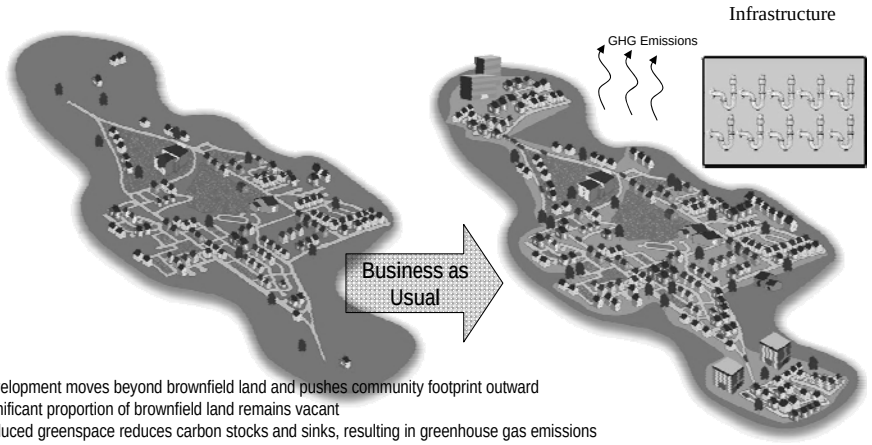
Pie Chart – presentation provided by Josh Stolaroff

Sustainable Site Reuse & potential impact on climate change

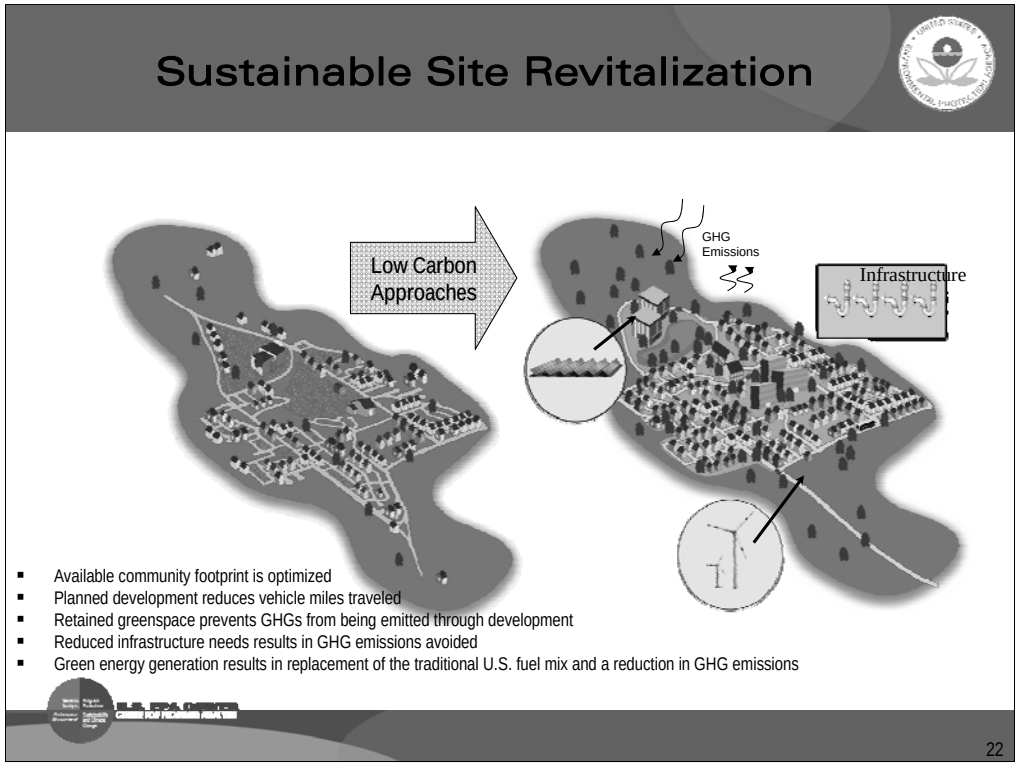
- An average of 2.2 million acres of greenspace are developed each year in the U.S.
  - Results in loss of carbon in soil and vegetation from natural land sink
  - OSWER completing analysis to estimate CO2 equivalent and percent of total USGHG emissions
- New infrastructure is constructed to provide services to developed greenspace
  - Construction of highways, streets, bridges, tunnels; and water, sewer, and pipeline construction result in GHG emissions
  - OSWER completing analysis to estimate CO2 equivalent and percent of total USGHG emissions
- Emissions from growth in VMT are projected to increase 48% by 2030 if sprawling land development patterns continue*
- In 2030, about half of U.S. buildings will have been built after 2000 = opportunity**

*Urban Land Institute
**Nelson, Brookings Institute

Business as Usual Land Use Approaches



- Development moves beyond brownfield land and pushes community footprint outward
- Significant proportion of brownfield land remains vacant
- Reduced greenspace reduces carbon stocks and sinks, resulting in greenhouse gas emissions
- Increased infrastructure needs results in increased greenhouse gas emissions
- Vehicle miles traveled increase

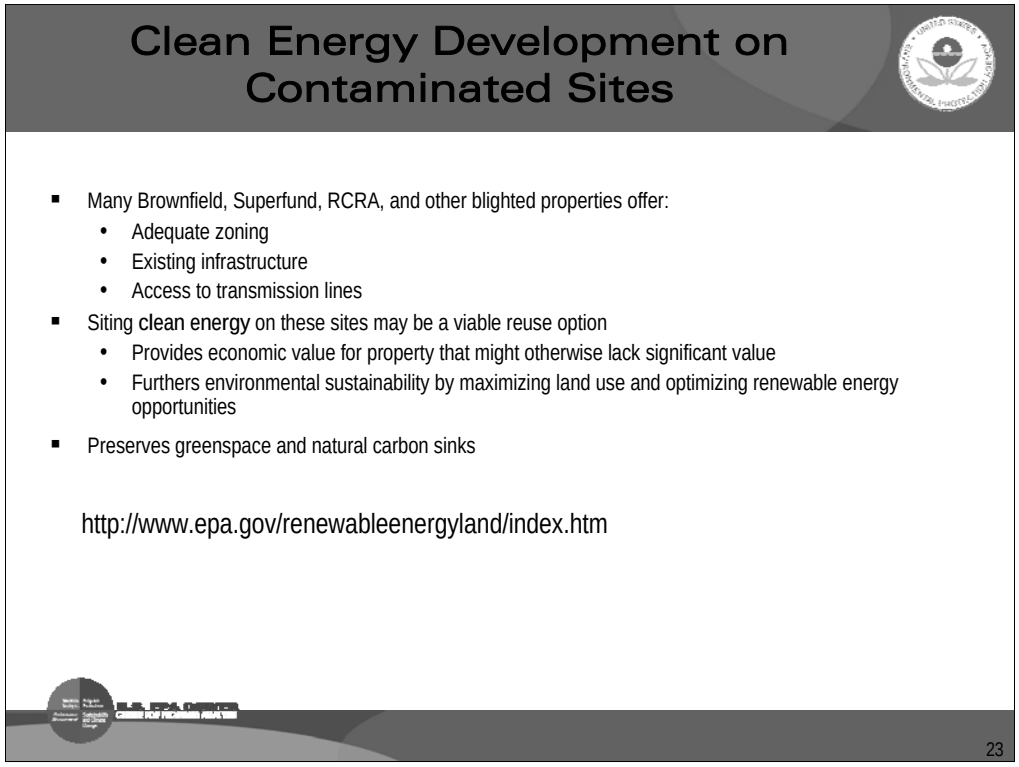


Land graphic –sustainable land management approaches

Reuse land with green buildings and cleaner energy

Limit sprawl, new infrastructure, VMT

Change the arrow to “new pardaim or something cool



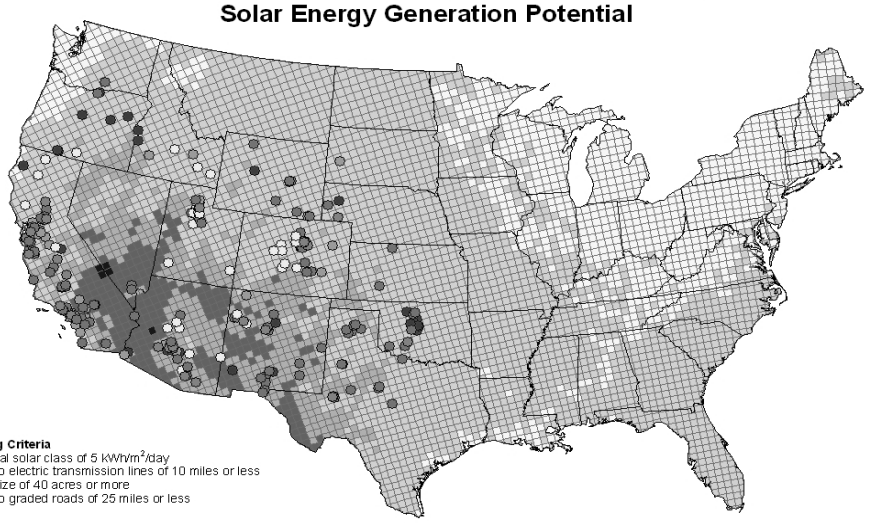
Renewable energy development as a reuse strategy for contaminated land can provide economic value for property that might otherwise lack significant value while also furthering environmental sustainability by maximizing land use and optimizing renewable energy opportunities.

- In Regions 1 and 7, wind turbines are proposed in several locations to operate an expanded groundwater treatment system and power a groundwater circulation well.
- At one of these sites the turbine generated 13,335kWh of electricity, displacing an estimated 17,882 pounds of carbon dioxide/year.
- In addition, solar and wind electrical generation have been installed at sites in Region 1 and 9 and Region 9 has three renewable energy pilots in process.

OWSER has analyzed ACRES and CERCLIS data to identify Brownfields and NPL sites that are located within five miles of an electricity transmission line and have a wind or solar classification suitable to support commercial grade electricity production (wind class greater than 3.5 and a solar class > 5).

- An estimated 196,707 acres of Brownfields and NPL sites were found to qualify for potential wind generation and 397,294 acres of Brownfields and NPL sites were found to qualify for potential solar generation.

EPA Tracked Sites with Utility Scale Photovoltaic (PV) Solar Energy Generation Potential



Screening Criteria
CSP annual solar class of 5 kWh/m^2/day
Distance to electric transmission lines of 10 miles or less
Property size of 40 acres or more
Distance to graded roads of 25 miles or less

EPA Tracked Sites	Solar Resource (kWh/m^2/day)
Abandoned Mine Land	2.43 - 3.99
Brownfield	4.00 - 5.99
RCRA	6.00 - 6.99
Federal Superfund	7.00 - 7.99
Non-Federal Superfund	8.00 - 8.99

Developed by SRA International for EPA. Results are based on preliminary site screening. For further information, please see the accompanying data guidelines.

24

EPA United States Environmental Protection Agency

State Incentives for Achieving Clean Energy Development on Contaminated Lands

The development of clean energy on formerly used land offers many economic and environmental benefits. Combining clean energy and contaminated land cleanup incentives can allow investors and communities to create economically viable clean energy and redevelopment projects. This document provides information about incentives in your state that can be leveraged for clean energy and development of contaminated land.

Incentives for Clean Energy

Funding (grants, loans, bonds, etc.)

Connecticut Clean Energy Fund (CCEF)
www.ctinnovations.com/funding/ccef/about.php

Promotes, develops, and invests in clean energy sources for sustainable energy for the benefit of Connecticut ratepayers. Provides incentive programs to businesses and developers.

Onsite Renewable Distributed Generation
www.ctinnovations.com/funding/ccef/renewable_dg.php

Provides grants of up to $4 million to install systems that generate energy from renewable sources including wind, solar, fuel cells, biomass, landfill gas, and certain types of hydropower. The total available funding for this program is $32.75 million. Applicants must be commercial, industrial, or institutional facilities.

Operational Demonstration Program
www.ctinnovations.com/funding/ccef/demo_project.php

Provides up to $750,000 for demonstration projects that have a high likelihood of developing into a commercial product within a reasonable period of time. Projects must have a capacity of at least one kilowatt (or the functional equivalent for hydrogen generation). Fund requires a front-loaded 25% cash cost-share for any funding provided; in-kind contributions are accepted under certain conditions.

100 Project Initiatives
www.ctinnovations.com/funding/ccef/project_100.php

Allows for state electric companies to enter into 10-year contracts for not less than 100 MW of Class I renewable capacity at a price of up to 5.5¢ per kilowatt-hour (kWh). Designed to encourage financing of renewable energy projects, stimulate the development of new projects, and increase the available supply of renewable energy.

DPUC – Low Interest Loans for Customer-Side Distributed Resources
www.dpuc.state.ct.us/Electric.nsf/AllPOpenView&Start=1&Count=30&Expand=1.19#1.1

Offers grants to eligible baseload distributed-generation (DG) projects of $450 per kilowatt, up to a maximum of 65MW, to retail end-use customers of electric distribution companies for the installation of customer-side distributed resources.

Technical Assistance and Other Incentives

Mass Energy – Renewable Energy Certificate Incentive
www.massenergy.com/Solar.REC.Sale.html

Offers to purchase renewable energy certificates at a rate of $30 per MW-hour (or $.03 per kWh) for a period of three years from PV systems.

Tax Incentives (abatements, deductions, credits, etc.)

Sales Tax Exemption for Solar and Geothermal Systems
www.ct.gov/DRS

100% sales tax exemption for solar and geothermal heat pumps. Eligible solar equipment includes solar electricity generating systems and passive or active solar water or space heating systems, including equipment related to such systems, and sales of services relating to their installation.

Net Metering

www.state.ct.us/dpuc/

Connecticut requires net metering to no limit for generation using Class I renewable energy sources (e.g., solar, wind, biomass, wave or tidal power). Contact the Connecticut PUC regarding potential opportunities.

Quick Facts

Public Benefit Fund (PBF)	Yes ☑ No ☐
Renewable Portfolio Standard *27% by 2020*	Yes ☑ No ☐
Net Metering	Yes ☑ No ☐
Interconnection Standards	Yes ☑ No ☐

Electric Power Industry Generation by Primary Energy Source (2006)

Petroleum-Fired	3.7%	Nuclear	47.8%
Natural Gas-Fired	30.2%	Hydroelectric	1.6%
Coal-Fired	12.3%	Other Renewables	2.2%

Points of Contact

Connecticut Clean Energy Fund
www.ctcleanenergy.com
Lee Dondy, lee.dondy@ctinnovations.com, (860) 257-2336
Dale Hedman, dale.hedman@ctinnovations.com, (860) 563-5851 Ext.331

Connecticut Department of Public Utility Control
www.state.ct.us/DPUC/
Paul Carver, paul.carver@po.state.ct.us, (860) 827-2773

Mass Energy
Kelly Muellman, kelly@massenergy.com, (617) 524-3950

Sales and Use Tax Exemption
www.ct.gov/DRS
Connecticut Department of Revenue Services, Public Information Officer (860) 297-5962

Information current as of December 2007

Connecticut Incentives for Clean Energy – Page 1

Incentives for Development of Contaminated Land

Funding (grants, loans, bonds, etc.)

Special Contaminated Property Remediation and Insurance Fund (SCPRIF)
www.ct.gov/ecd/cwp/view.asp?a=1101&q=249824

Provides low-interest, five year loans to municipalities and private entities for Phase II and III investigations and demolition costs. Applicants must have completed a Phase I Assessment. Interest (3% APR) is paid during the term of the loan and the principal is repaid at the end of the term of the loan or when the site is later sold or leased or when the environmental remediation is complete. There is no loan limit or standard loan amount for SCPRIF.

Connecticut Brownfields Redevelopment Authority (CBRA)
www.ctbrownfields.com/default.asp

Provides grants up to $10,000,000 to investors, developers, and business owners who undertake redevelopment projects on brownfields sites. The cash grant funding is available through tax increment financing (TIF) and the value of the grant is based on the future incremental municipal property taxes to be generated by the project; it cannot be combined with municipal real estate tax abatements.

Urban Sites Remedial Action Fund (USRAF)
www.ct.gov/ecd/cwp/view.asp?a=1101&q=249844

Provides funds primarily for site investigation, studies, and design; operations and maintenance; removals, and remedial actions on commercial or industrial sites. The state can commit unlimited public funds to prepare the planning and implementation of the site remediation. Several project types and criteria are eligible for assistance; however the site must be in a distressed community or targeted investment community.

Connecticut Development Authority Direct, Guaranteed, or Participating Loans
www.cdcfa.com/CMSLibr/default.asp?CMSLib_Page=4&Info=Direct+Loans

Loans available from $250,000 to $5 million to assist with brownfields remediation and redevelopment. Terms are tailored to each transaction up to 20 years.

Tax Incentives (abatements, credits, etc.)

Industrial Site Investment Tax Credit Program
www.ct.gov/ecd/cwp/view.asp?a=1101&q=249822

Offers an eligible investor a dollar-for-dollar corporate tax credit of up to 100% of their investment up to a maximum of $100,000,000, for investments made in real property, or improvements to real property, located within Connecticut that has been subject to environmental contamination.

Urban Site Investment Tax Credit Program
www.ct.gov/ecd/cwp/view.asp?a=1101&q=249842

Offers an eligible investor a dollar-for-dollar corporate tax credit of up to 100% of their investment up to a maximum of $100,000,000. An eligible Urban Site Investment Project is defined as an investment that will add significant new economic activity, increase employment in a new facility, and generate significant additional tax revenues to the municipality and the state.

Enterprise Zone Program
www.ct.gov/ecd/cwp/view.asp?a=1099&q=249766

Provides tax abatement for five years and 80% of local property taxes on real estate improvements located within Enterprise Zones, or 10 years/50% tax credit, seven-year minimum deferral of increased taxes resulting from property value rise after remediation has been completed.

Limitations on Liability

Voluntary Remediation Programs – Covenant Not to Sue
www.ct.gov/dep/cwp/view.asp?a=2715&q=325026&depNav_GID=1626

Provides a covenant not to sue—an assurance that the state will not require further cleanup in the future for historical contamination—upon completion of all requirements of the state's Voluntary Remediation Program. This tool reduces the risk of liability to the property owner.

Quick Facts

Limitations on Liability	Yes ☑ No ☐
Number of State-Tracked Contaminated Properties: Includes Urban Sites Remedial Action Program, Voluntary Remediation Program, and Property Transfer Program sites	164
Number of EPA CERCLIS Sites: Sites identified for potential investigation under the federal Superfund Program	402
Number of EPA Brownfields Properties: Properties being funded or addressed under the EPA Brownfields Program	313

1-There may be some overlap among the categories listed and sites listed may not represent all potentially contaminated sites in Connecticut.

Points of Contact

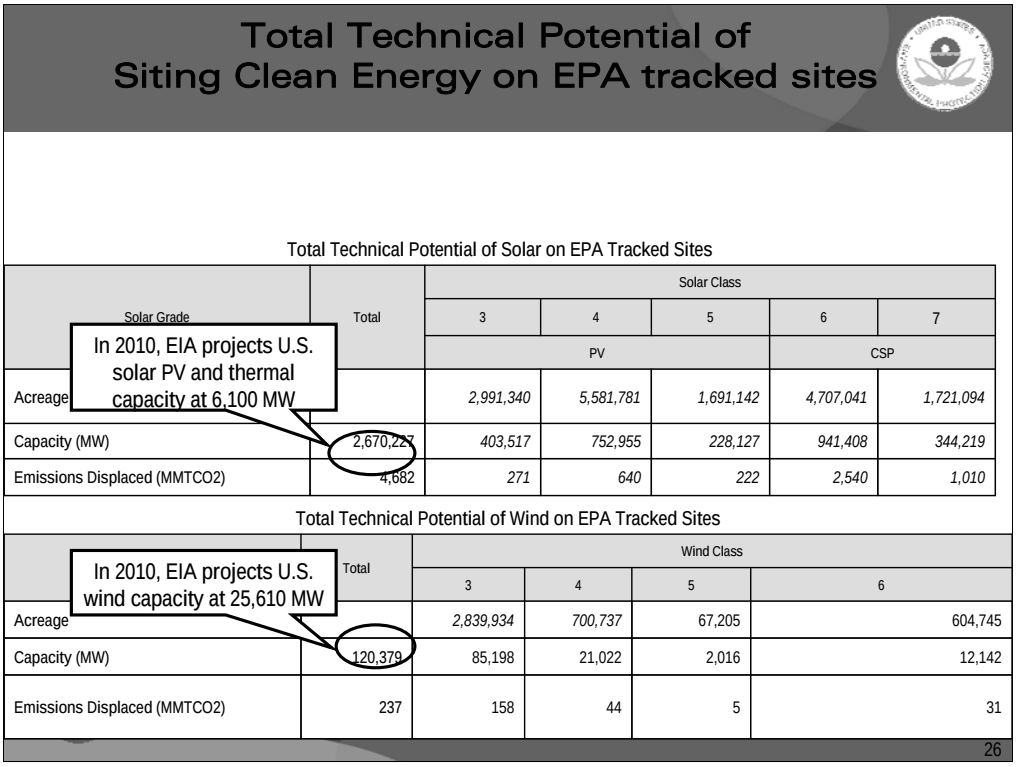
Connecticut Department of Environmental Protection (DEP)
www.dep.state.ct.us/wtr/remediation/index.htm
Graham Stevens, graham.stevens@po.state.ct.us, (860) 424-4166

Department of Economic and Community Development
SCPRIF
Ned Moore, edwin.moore@po.state.ct.us, (860) 270-8148
Urban and Industrial Site Investment Tax Credit Programs
Robert Rigney, robert.rigney@po.state.ct.us, (860) 270-8110
Enterprise Zone Program
Anne Karas, anne.karas@po.state.ct.us, (860) 270-8143

CBRA/CDA
Cynthia Petruzzello, (860) 258-7833

Information current as of December 2007

Connecticut Incentives for Development of Contaminated Land – Page 2



Total Technical Potential of Siting Clean Energy on EPA tracked sites

Total Technical Potential of Solar on EPA Tracked Sites

Solar Grade	Total	Solar Class				
		3	4	5	6	7
		PV			CSP	
Acreage		*2,991,340*	*5,581,781*	*1,691,142*	*4,707,041*	*1,721,094*
Capacity (MW)	2,670,227	*403,517*	*752,955*	*228,127*	*941,408*	*344,219*
Emissions Displaced (MMTCO2)	4,682	*271*	*640*	*222*	*2,540*	*1,010*

In 2010, EIA projects U.S. solar PV and thermal capacity at 6,100 MW

Total Technical Potential of Wind on EPA Tracked Sites

	Total	Wind Class			
		3	4	5	6
Acreage		*2,839,934*	*700,737*	67,205	604,745
Capacity (MW)	120,379	85,198	21,022	2,016	12,142
Emissions Displaced (MMTCO2)	237	158	44	5	31

In 2010, EIA projects U.S. wind capacity at 25,610 MW

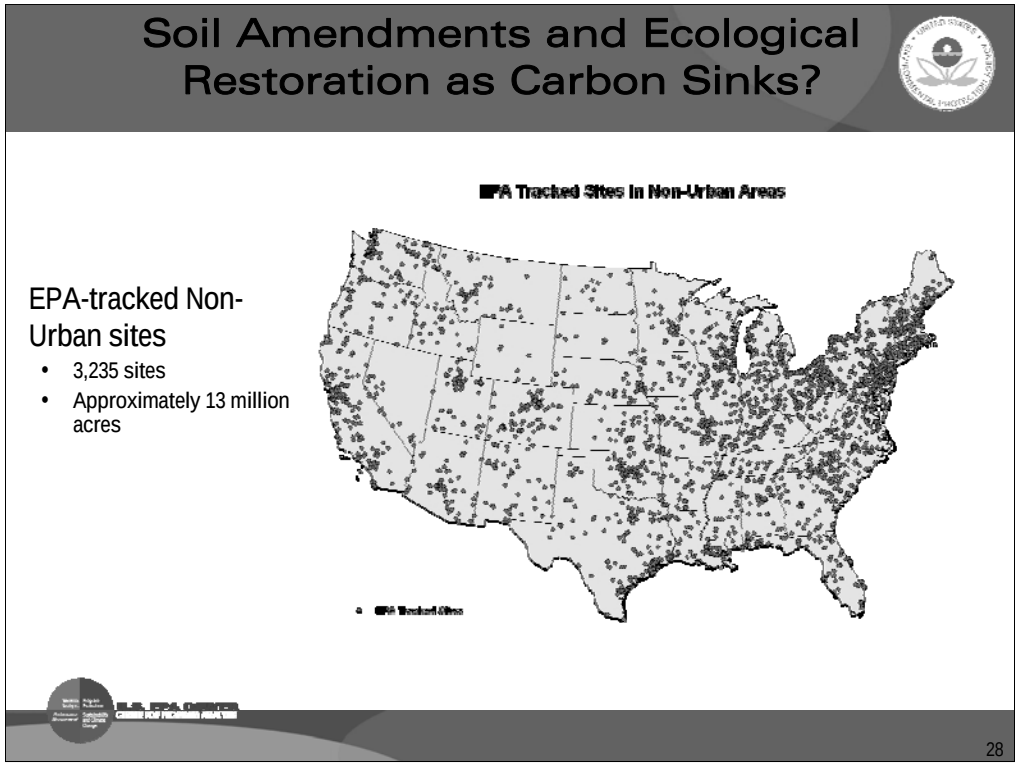
26

Brownfield properties alone can exceed the Energy Information Administration's projections for solar and wind energy in 2010.

All sites at three or above. May be some overlap over between solar and wind.

Soil Amendments and Ecological Restoration as Carbon Sinks?

- Approximately 13.6 million acres of non-urban EPA-tracked land
- Approximately 3.2 million acres of abandoned mine land
- Average rate of carbon storage in mine lands reclaimed to forest is 21 to 25 MTCO2 per year.
  - 70-81 MMTCO2E per year
- We are currently estimating total technical potential of organic soil amendments and ecological restoration.
- OSWER has draft protocol form sampling and analysis to account for carbon assets associated with soil amendments and re-vegetation.



1. Total Number of EPA Tracked Sites: 9,202

2. Mapped all EPA contaminated sites against U.S. Census Urbanized Areas data layer.

Urbanized Area, 2,804,247 acres 17%
Urbanized areas include a central city and the surrounding densely settled territory that together have a population of 50,000 or more and a population density generally exceeding 1,000 people per square mile.

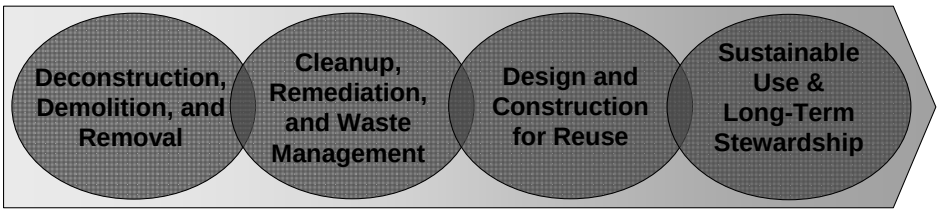
Urban Cluster, 335,886 acres 2%
Urban clusters are areas with at least 2,500 people near an urbanized area.

Remote, 13,642,549 acres 81%
All other areas are considered remote.

Green/Greener Remediation

- Commitment to optimal solutions
- Costs of fuel and electricity
- Remediation footprint
- Remediation optimization
- Remediation options selection criteria

So, how do we "Green" Our Programs?



Use a systems approach; Look for environmental opportunities; identify and balance tradeoffs

30

Some Examples of Greener Approaches




Deconstruction, Demolition, and Removal

- Reuse/recycle deconstruction and demolition materials
- Reuse materials on site whenever possible
- Consider future site use and reuse existing infrastructure
- Preserve/Reuse Historic Buildings
- Use clean diesel and low sulfur fuels in equipment and noise controls for power generation
- Retain native vegetation and soils, wherever possible
- Protect water resources from runoff and contamination

Cleanup, Remediation, and Waste Management

- Power machinery and equipment using clean fuels
- Use renewable energy sources, such as solar, wind, and methane to power remediation activities
- Improve energy efficiency of chosen remediation strategies
- Select remediation approaches, such as phytoremediation, that reduce resource use and impact on air, water, adjacent lands, and public health
- Employ remediation practices that can restore soil health and ecosystems and, in some cases, sequester carbon through soil amendments and vegetation

Design and Construction for Reuse

- Use Energy Star, LEED, and GreenScapes principles in both new and existing buildings
- Reduce environmental impact by reusing existing structures and recycling industrial materials
- Incorporate natural systems to manage stormwater, like green roofs, landscaped swales, and wetlands
- Incorporate Smart Growth principles that promote more balanced land uses, walkable neighborhoods, and open space
- Create ecological enhancements to promote biodiversity and provide wildlife habitat and recreation

Sustainable Use and Long Term Stewardship

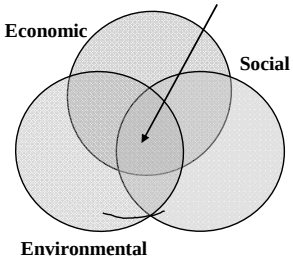
- Reduce use of toxic materials in manufacturing, maintenance, and use of buildings and land
- Minimize waste generation, manage waste properly, and recycle materials used/generated
- Maintain engineering and institutional controls on site where waste is left in place
- Reduce water use by incorporating water efficient systems and use native vegetation to limit irrigation
- Maximize energy efficiency and increase use of renewable energy
- Take appropriate steps to prevent (recontamination)

SOME BENEFITS ACHIEVED BY ADOPTING GREEN APPROACHES IN THE

Economic Benefits

- Achieve lifecycle **cost savings** associated with **green remediation** and **buildings**.
- **Reduce energy footprint** and **save resources** by using energy efficient equipment/processes and renewable energy.
- **Qualify** for **tax benefits** associated with brownfield redevelopment and LEED certification.
- **Reduce construction costs**, **reduce disposal fees**, and **gain** a **new source of revenue** by recycling materials onsite.
- **Increase property value** by incorporating **Green Design** and **Smart Growth** principles, which can bring more business, people, and revenues into the community.
- **Improve employee satisfaction** and **productivity** through green building design.

Optimal Sustainable Revitalization



Social Benefits

- Improve **public health** of work force and community.
- **Create** more **walkable, accessible**, and **livable neighborhoods** by incorporating Smart Growth principles and ecological enhancements.
- Improve **aesthetics** and **public safety** by cleaning up and reusing blighted areas.
- Create **jobs** for the community and higher **tax revenues** for local government by creating new construction, commercial, and industrial opportunities and increasing property values.
- **Reduce construction traffic, noise, dust**, and **safety concerns** by reusing existing buildings and by employing deconstruction and material recovery practices.

Environmental Benefits

- **Reduce greenhouse gas (GHG) emissions** by incorporating energy efficient processes, using renewable energy sources, recycling materials, and implementing activities that sequester carbon.
- **Improve air quality** by employing Smart Growth principles, making ecological enhancements, and incorporating Green Design features.
- **Preserve greenspace and slow suburban sprawl** by cleaning up and reusing contaminated properties and facilitating their reuse.
- **Conserve resources, reduce landfill disposal, and limit the environmental impact of waste hauling** by recycling and reusing industrial materials.
- **Increase biodiversity and restore watersheds** by incorporating ecological enhancements and preserving green infrastructure.
- **Reduce long-term impact of structures** on the environment and resource use by incorporating green approaches in building and landscaping construction, including stormwater management.

32

"Guidelines for Making Environmentally-Sound Decisions in the Superfund Remedial Process"

- USEPA, Region 5 – May 1993
- " The purpose of this document is to introduce the pollution prevention philosophy to those involved in cleanups – both in Superfund and RCRA. The method used to accomplish this is by providing specific waste reduction activities in the Superfund remedial process…"
- *The hope is that once the pollution prevention philosophy has been embraced, project managers will identify other opportunities for making environmentally sound decisions.* ***Set up a recycling corner in the trailer on-site; restore wetlands; or plant trees to help offset, even in the slightest way, global climate change "***

Catherine Allen
OSWER Center for Program Analysis
Washington DC, USA
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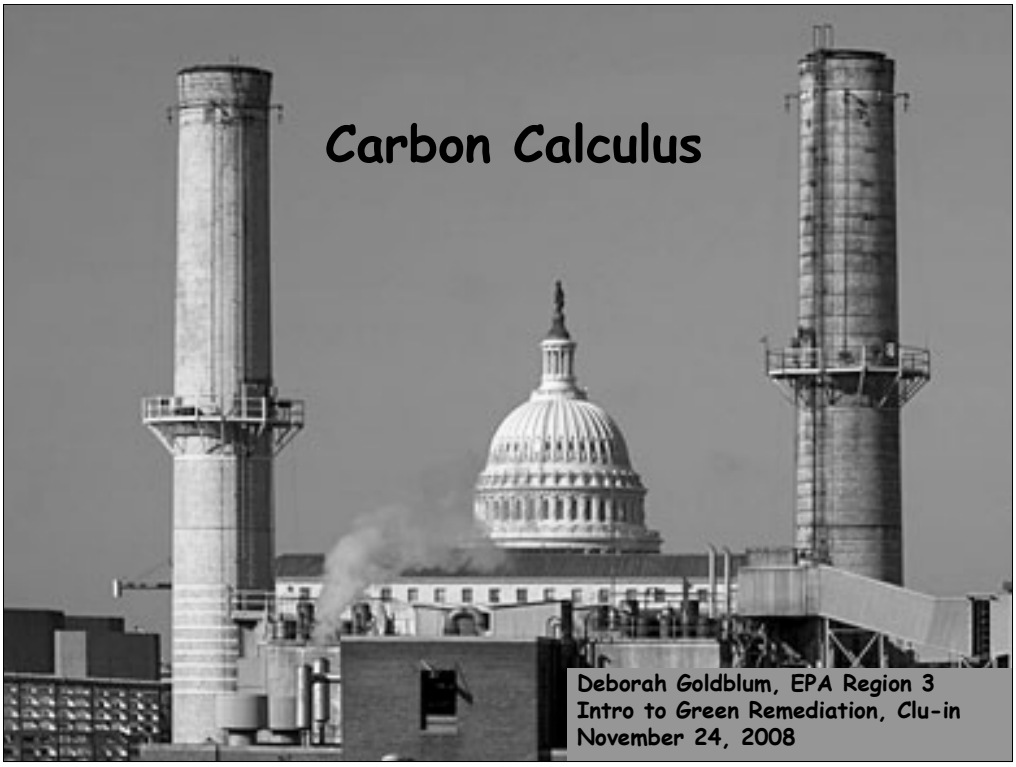

Carbon Calculus
Deborah Goldblum, EPA Region 3
Intro to Green Remediation, Clu-in
November 24, 2008

Green Cleanups Basics

Maximize the net environmental benefit of a cleanup

- Use resources wisely
- Consider the big environmental picture
- Integrate cleanup with reuse

36

RCRA Remedy Selection Criteria

Threshold Criteria

- Protect Human Health & the Environment
- Control Sources
- Meet Cleanup Objectives

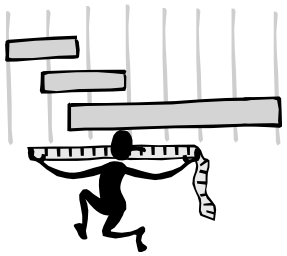
Balancing Factors

- Long-term reliability
- Reduction of toxicity, mobility or volume
- Short-term effectiveness
- Ease of implementation
- Cost
- Community acceptance
- State acceptance
- Sustainability

37

Objectives

- Develop sustainability framework
  - Factors (common language)
  - Measures
- Process for implementation



38

Sustainability Framework

- land use
- water use
- air impacts
- energy
- PM-10
- human exposure hours
- NO_X
- CO_2
- local issues
- treatment vs. containment
- SO_X
- occupational risk
- recycled materials

39

Sustainability Measurement Factors

- Greenhouse Gases & Energy
  - CO_2
  - Energy
- Resources Consumed/Recycled
  - Soil & Solid Material
  - Water
  - Land

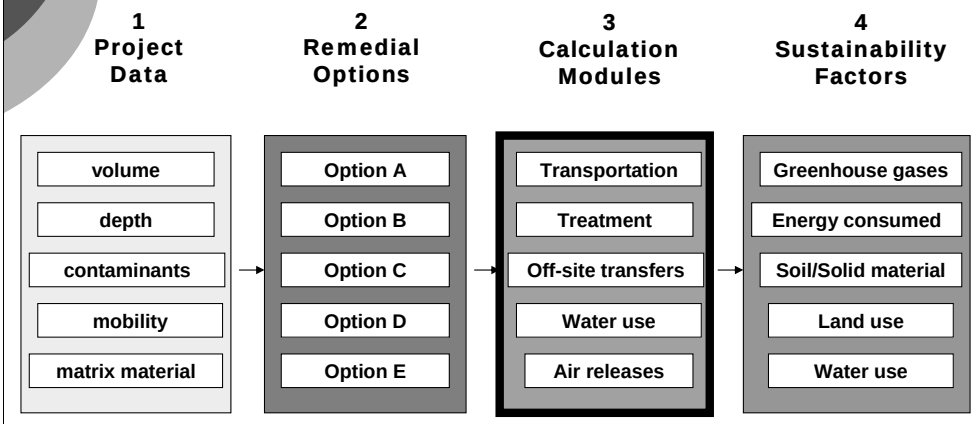

DuPont Martinsville, VA
Unit H1
North
Fire Training Area
DuPont Precision Concepts (DPC) Building
Smith River
Minneapolis
Detroit
Chicago
New York
Martinsville
Memphis
Charlotte
New Orleans
Jacksonville
1980's-1990's

Credit & Debit Matrix

Media or Impact	Credit (+)	Debit (-)
Greenhouse Gases & Energy		
Carbon Dioxide (CO_2 equivalents)	❑ Sequestered in-situ ❑ Sequestered by plants	❑Generated by fuel & energy for cleanup ❑Generated by manufacture of consumables ❑Generated by management of residuals ❑Sequestration loss by vegetation removal
Energy (kWh)	❑Renewable energy created and used by remedy	❑ Used for remediation ❑ Used for manufacture of consumables ❑ Used for management of residuals
Resource Conservation		
Soil/Solid Material (tons)	❑ Reused-recycled soil or soil-substitute ❑ Improved soil usability	❑Off-site soil required for remedy ❑Off-site disposal
Water (gallons)	❑ Reused-recycled	❑Public or surface water use ❑Groundwater captured for remediation – where resource is critical
Land (acres)	❑No limitation to anticipated use ❑Wetlands created or upgraded ❑Conservation easement	❑Permanent limited use

42

Conceptual Framework for Sustainability Analysis

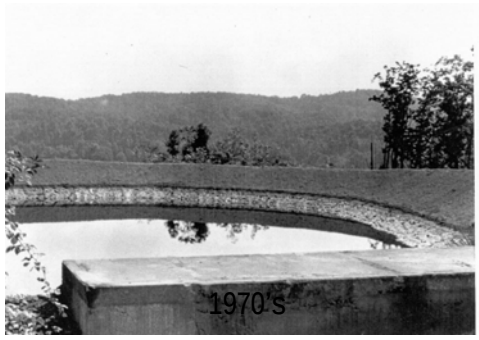


43

Step 1 – Project Data

Unit H1

- Former finish oil disposal pond
- Chlorinated VOCs in soil & groundwater
- PCBs, arsenic (coal ash) in soil
- About 100' diameter; impacts 3.5 to 8 feet bgs
- Groundwater about 90' bgs
- Soil volume 63,000 cf



Step 2 - Remedial Options
Unit H1

Cleanup source to achieve MCLs throughout the plume

- Excavate (source material removal) and landfill + MNA
- Excavate & ex-situ thermal treatment + MNA
- Cap + MNA
- Soil vacuum extraction (SVE) + MNA
- Zero valent iron (ZVI) in-situ treatment + MNA

PASS THRESHOLD CRITERIA

45

Step 3 – Identify Components
ZVI Treatment + MNA

Task	Item	Quantities
Mobilization and Site Prep	Time Staff Equipment	10 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Man lift, forklifts (2), crane, mix head, others
Crane and Mix Head Assembly	Time	5 day
Shallow Soil Mixing	Time Staff Equipment Materials	17 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Mix head/crane, fork lifts, excavator 70 ton ZVI, 50 ton bentonite, 200 ton kiln dust 130,000 gal water
Demob, including grading	Time Staff Equipment	4 days 11 - 1 Super, 1 Eng'r, 9 Operators & Laborers Excavator, man lift, forklifts (2), crane, mix head

Step 3 - Quantify Components
ZVI Treatment + MNA

Fuel for remedy

- Mobilization/demobe
- Soil mixing
- Regrading
- Sub-base installation
- Delivery of ZVI
- Delivery of kaolinite
- Delivery of flyash
- Sampling events

Consumables

- ZVI
- bentonite
- kiln dust

Gasoline (gallons)

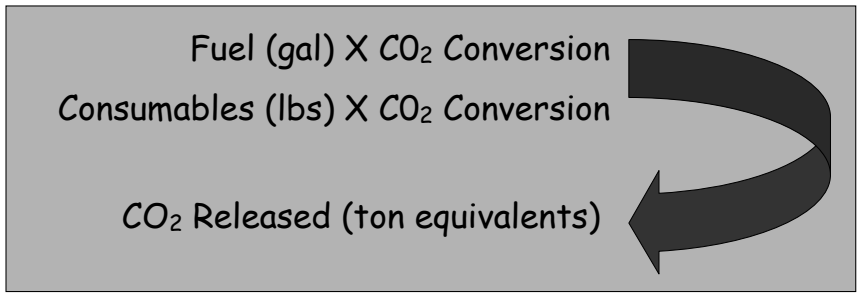
Diesel (gallons)

47

Process Model Examples - CO_2 Emissions

Combustion of Fuels			CO2 emissions				
Fuel	**Quantity**	**Unit**	**Pre-Combustion**	**Combustion**	**Total**	**Data Source**	Total GWP kg CO2 eq
			lb CO2	lb CO2	lb CO2		
Diesel	1000	Gal	3258	22543	25801	nrel.gov/lci	
Gasoline	1000	Gal	2776	17403	20179	nrel.gov/lci	
	Quantity	**Unit**	kg CO2	kg CO2	kg CO2		
Diesel	1	kg	0.46	3.18	3.64	nrel.gov/lci	
Gasoline	1	kg	0.46	2.86	3.31	nrel.gov/lci	
Propane	1	kg	0.48	3.00	3.48	ecoinvent	3.59
Consumables	**Quantity**	**Unit**	kg CO2	kg CO2	kg CO2		Total GWP kg CO2 eq
Electricity, US Average	1	kWh			0.85	nrel.gov/lci	0.861
Electricity, US Average	1	kWh			0.73	MSU data	0.77
Cement	1	kg			0.74	Ecoinvent	0.77
Concrete	1	cubic yard			195.47	Ecoinvent	202.53
HDPE Sheet	1	kg			2.41	Plastics Europe	2.47
High Alloy Steel Pipe	1	kg			4.99	Ecoinvent	5.31
Carbon Steel Pipe	1	kg			1.85	Ecoinvent	2.02
PVC pipe	1	kg			2.35	Industry data	2.58
Activated Carbon	1	kg			6.45	Kirk-Othmer,nrel.gov/lci	
Asphalt	1	USD			2.00	US Input-Output DB	2.49
Zero Valent Iron	1	kg			1.21	Ecoinvent	1.32
Kiln Dust	1	kg			0.74	Co-product of Cemer	0.77
Bentonite	1	kg			0.44	Ecoinvent	0.47
Transportation - Use the table below from NREL, then the combustion data above to get to energy and CO2							
	Quantity	**Unit**	lb CO2	lb CO2	lb CO2		
Xport - Tractor trailor	1000	ton-miles	34.2	236.7	270.9	nrel.gov/lci	
	10.5	Gal Diesel					
	Quantity	**Unit**	kg CO2	kg CO2	kg CO2		
Xport - Tractor trailor	1000	tonne-kg	0.009	0.059	0.068	nrel.gov/lci	
	18.67	Gal Diesel					
	Quantity	**Unit**	kg CO2	kg CO2	kg CO2		
Earthwork	1000	kg earth	0.244	1.688	1.932	Ecoinvent	
	0.53	kg Diesel					

Step 3 - Multiply X Conversion Factors
ZVI Treatment + MNA



ZVI Treatment	→	**170 CO_2 ton equivalents**
MNA	→	**5 CO_2 ton equivalents**
		175 CO_2 ton equivalents

Step 4 – Sustainability Factors
ZVI Treatment + MNA

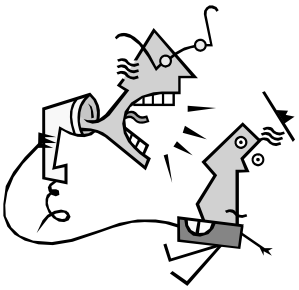
Media or Impact	Credit (+)	Debit (-)
Greenhouse Gases & Energy		
Carbon Dioxide (CO_2 equivalents)	0 CO_2 ton equivalents from contaminant destruction	175 CO_2 ton equivalents from remedy & consumables
Energy (kWh)	0 kWh of renewable energy generated	791,000 kWh of energy used by remedy & consumables
Resource Conservation		
Soil/Solid Material (tons)	0	200 tons of soil required to cap area
Land (acres)	<1 acre available for use	0 acres with permanent limited use
Water (gallons)	0 gallons reused/recycled	130,000 gallons of water used

Greenhouse Gases

	ZVI In Situ Treatment +MNA	Excavation & Off-Site Disposal +MNA	Ex-Situ Thermal Treatment + MNA	Soil Vapor Extraction + MNA	Capping + MNA
CO_2 Equivalents (tons)	175	255	595	165	29

Feedback

- Leads to more innovation
- Fosters collaborative process
- More robust evaluation



- Dangerous – too much opportunity for monkey business
- Remedy at every site will be natural attenuation
- Slow down cleanup due to review time

52

Potential Solutions

- Streamline the carbon analysis
  - Fuel Use
  - Energy Use
  - Key Consumables
- "Rules of Thumb"
- Develop Green Cleanup Standards
  - Type of Energy Use
  - CO2 Evaluation
  - Water Use
  - Soil/Materials Use/Reuse
  - Ecosystem Enhancements

Credit & Debit Matrix

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54

Green Cleanup Goals

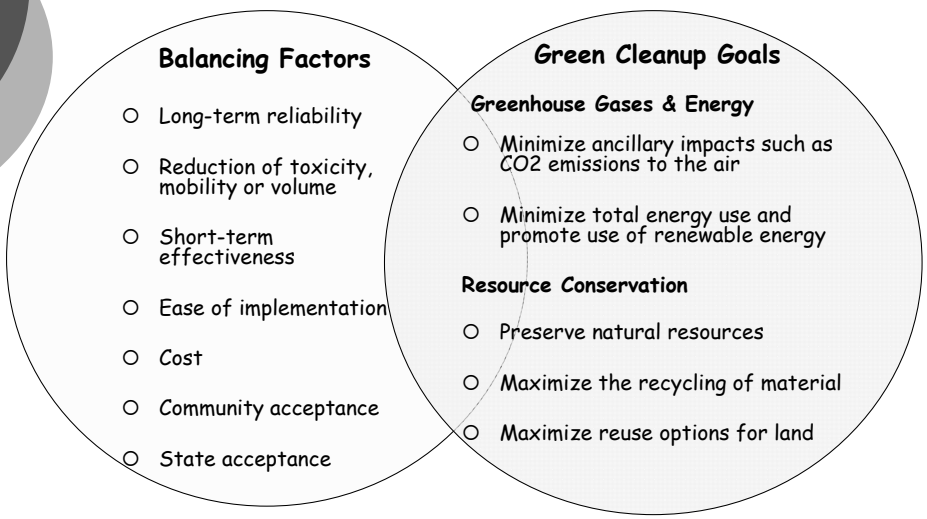
Greenhouse Gases & Energy

- Minimize ancillary impacts such as CO2 emissions to the air
- Minimize total energy use and promote use of renewable energy

Resource Conservation

- Preserve and restore natural resources
- Maximize the recycling of material
- Maximize reuse options for land

Looking Forward



56

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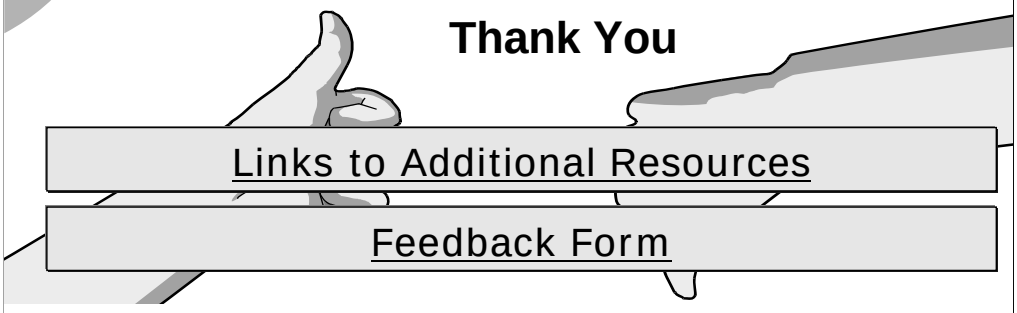
~~After viewing the links to additional~~ resources, please complete our online feedback form.

Thank You



Links to Additional Resources

Feedback Form

58