

Air Force Center for Engineering and the Environment

Integrity - Service - Excellence



Building Sustainability into the Air Force Remediation Process

**Erica Becvar, AFCEE/TDV
Environment, Energy and
Sustainability Symposium (E²S²)
6 May 2009**

AECOM ENVIRONMENT

 **GSI**
ENVIRONMENTAL

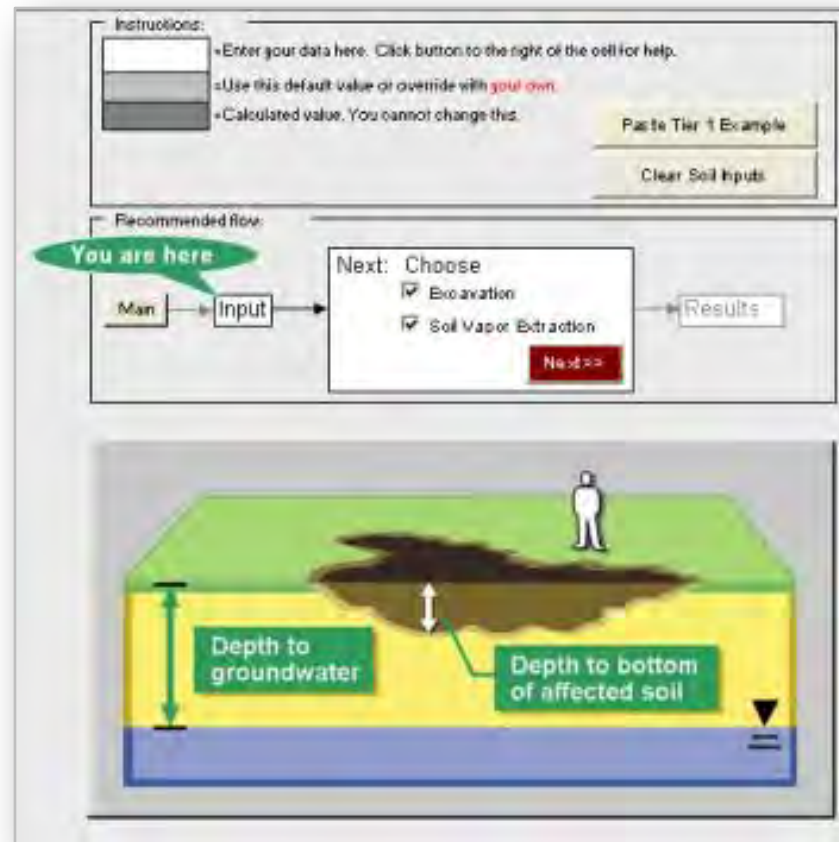
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Sustainability in AF Remediation: Presentation Overview

- **“Green” remediation**
 - **Technologies**
 - **Approaches**
- **Challenge**
- **Solution**
- **Sustainable Remediation Tool (SRT) – How does it work?**
- **Status**
- **Resources**





Sustainability in AF Remediation: **“Green” Remediation**

- **Sustainability metrics not new endeavor**
- **ER programs focus on cost, risk reduction, compliance with existing laws, and other metrics**
- **Sustainable approaches investigated and promoted for years**
- **Some treatment technologies inherently sustainable and generally considered “green”**

EPA on green: Considers all environmental effects of remedy implementation; incorporates options to maximize net environmental benefit of cleanup actions



Phytoremediation, Travis AFB, CA



Sustainability in AF Remediation: **USAF “Green” Remediation**

Goal has always been to reduce remediation system costs

Focus has been on working with and leveraging Mother Nature

50% of current AF systems considered “Green”

Sustainable remediation technology examples:

- **Phytoremediation – 5**
- **LNAPL recovery – 16**
- **Passive in situ treatment**
- **Wetlands**
- **Enh bio – 114**
- **MNA – 105**
- **Biowalls – 11**
- **Solar-powered systems – 7**
- **PBDS – 5 (ANG alone)**



Solar-powered in situ bioreactor, Altus AFB, OK



Sustainability in AF Remediation: **USAF “Green” Remediation**

Beginning to purposefully analyze sustainability as part of selection criteria for new remediation systems as well as for optimization

- **MMR, MA – Wind turbine to power groundwater cleanup**
- **Altus AFB, OK –**
 - **Solar-powered in situ bioreactor with pump**
 - **Biowall replaces pump-and-treat**
- **Travis AFB, CA – Solar-powered pumps for pump-and-treat system; in situ bioreactor**
- **Hickam AB, HI – Solar-powered in situ bioreactor**
- **Patrick AFB, FL – Solar-powered aerator**
- **Kennedy Space Center, FL –**
 - Solar-powered recirculation system**
- **Sustainable Remediation Tool**



Wind turbine, MMR, MA



Solar-powered in situ bioreactor, Travis AFB, CA



Solar-powered pumps, Travis AFB, CA



Sustainability in AF Remediation: **USAF “Green” Remediation**

In addition to some remediation technologies inherently sustainable, various approaches applied to restoration programs:

- **ERP-O (Environmental Restoration Program – Optimization)**
- **LTMO (Long-term monitoring optimization)**
- **Groundwater modeling**
- **PBM (Performance-based Management)**
- **Contract regionalization**



These optimize existing remediation and monitoring systems, and provide holistic and systematic results-based assessment of restoration programs to expedite site closure



Remedial Process Optimization (RPO)

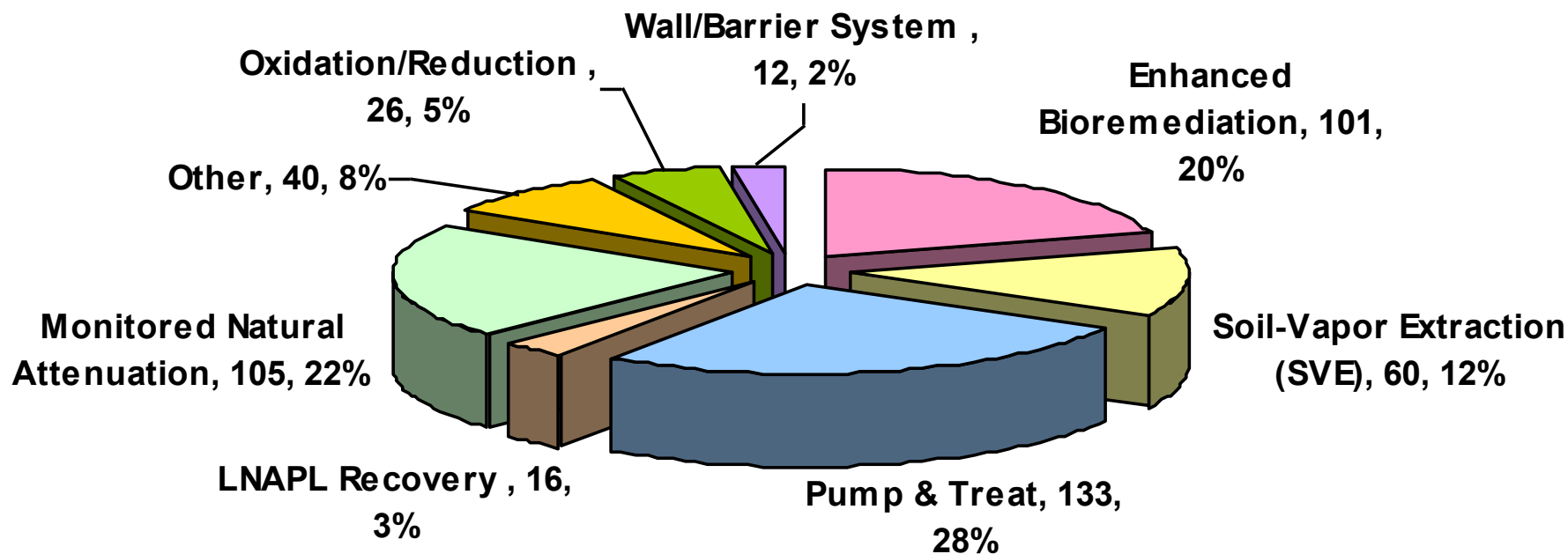
- **Systematic approach for evaluating existing cleanup & monitoring systems with goal of improving effectiveness & reducing overall site cleanup costs without increasing risks**
- **All cleanup activities, both interim and final**
- **Mandated in Air Force RPO „04Policy**
- **Accelerate RC by achieving site cleanup levels more efficiently**
- **Optimize in-place cleanup systems and LTM to minimize O&M cost**
- **Move away from active/energy consumptive remediation systems**
- **Uses several tools, e.g., PTT, SRT**





Sustainability in AF Remediation: RPO Driver

FY07 Number of Systems by Technology

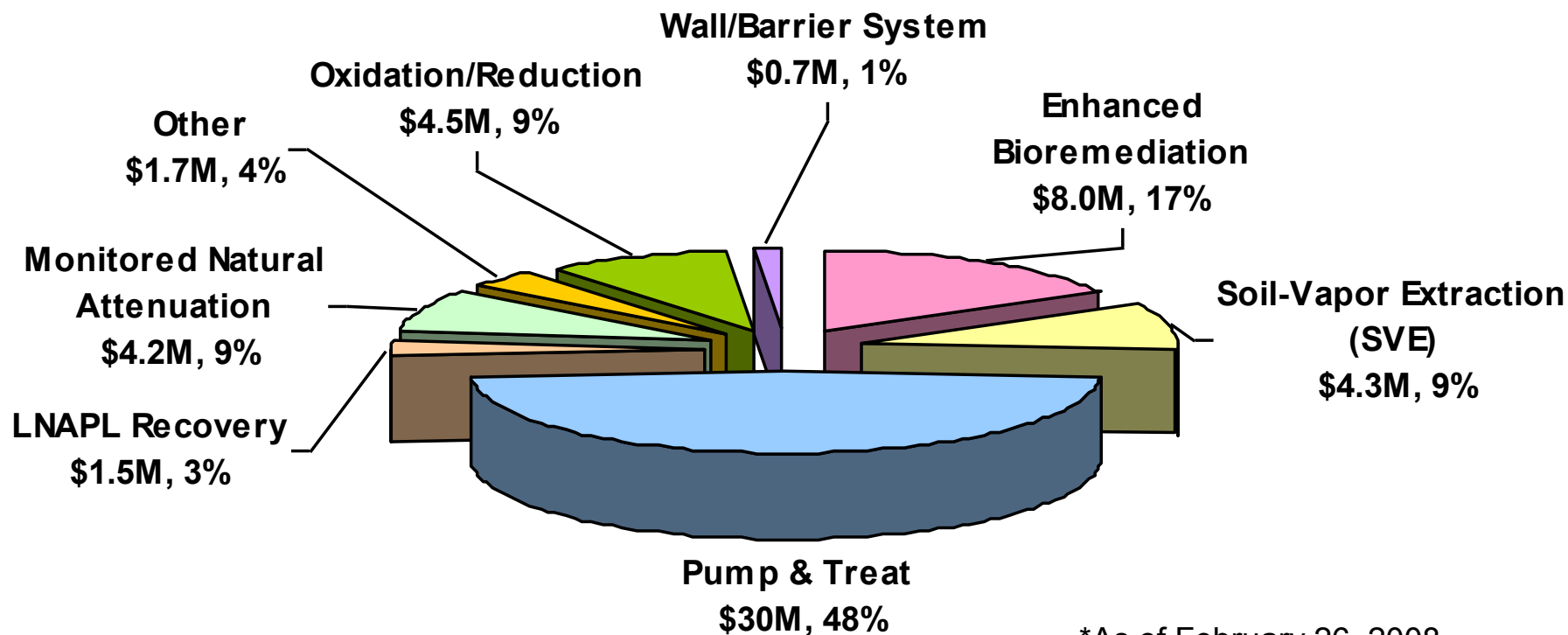


*As of February 26, 2008



Sustainability in AF Remediation: RPO Driver

FY07 System Cost by Technology

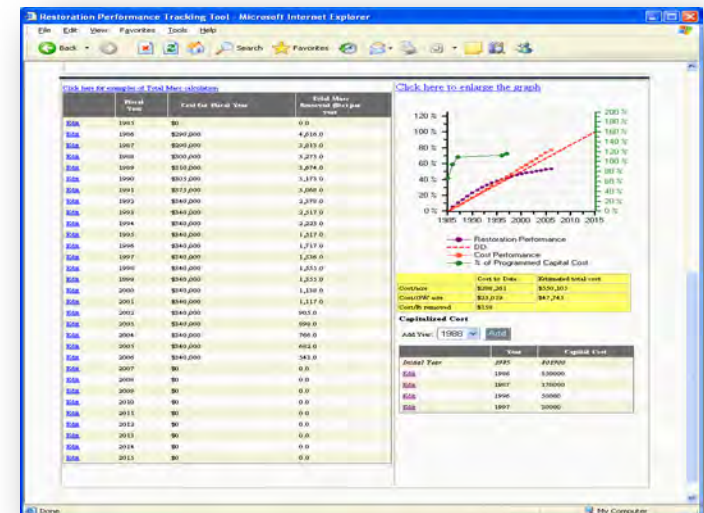


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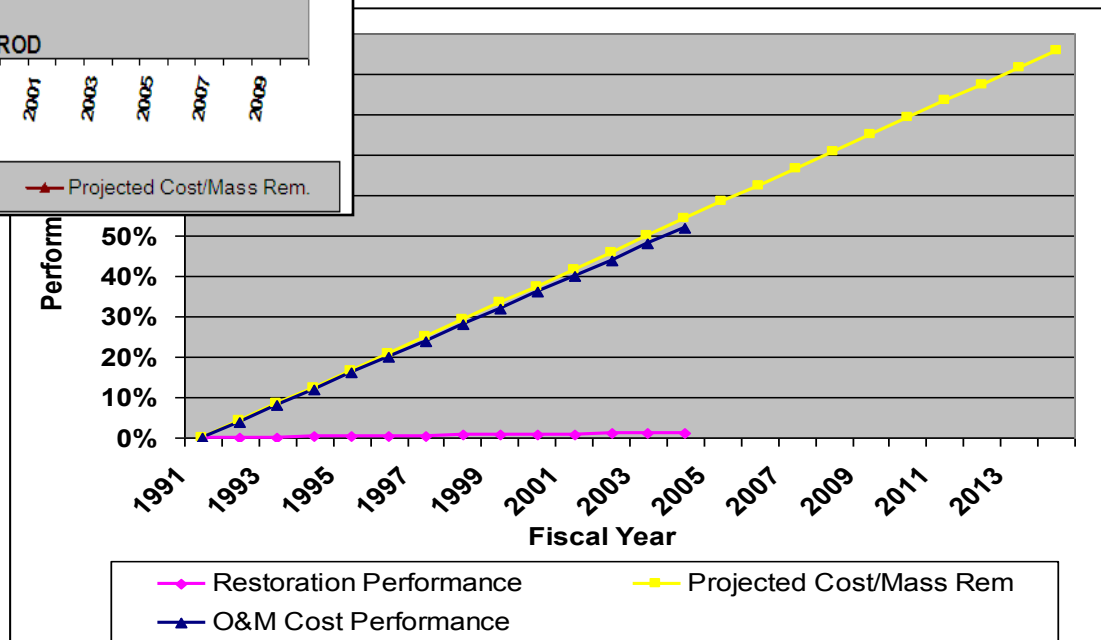
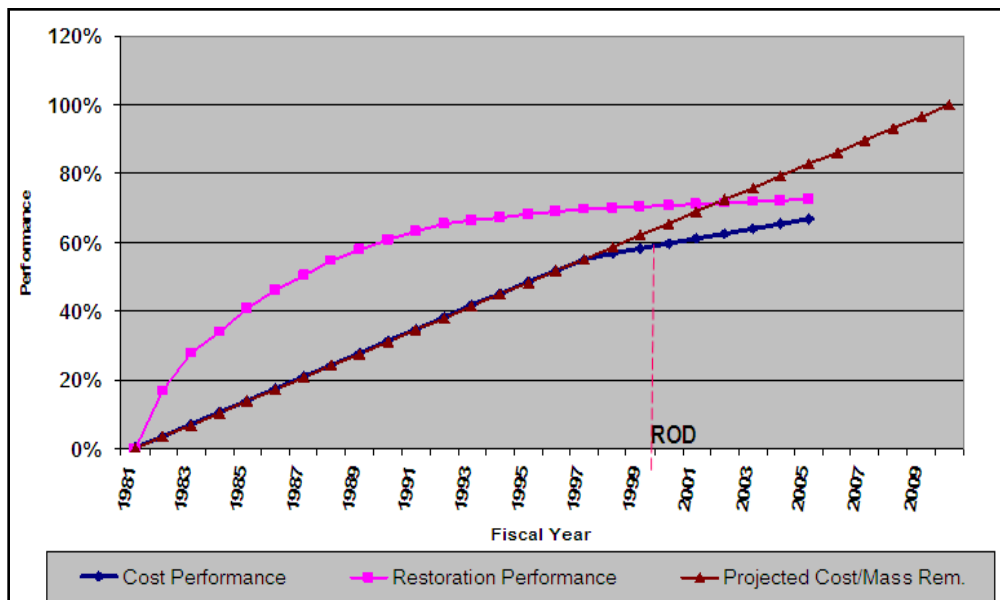
Sustainability in AF Remediation : Performance Tracking Tool (PTT)

- Remedial objectives evaluation tool as Excel™ spreadsheets
- Addresses two key questions:
 1. Is contaminant mass being reduced at anticipated rate?
 2. Is the O&M cost consistent with projections?
- Current technologies: P&T, SVE, bioslurping, MNA, dual-phase extraction, solvent extraction
- Calculates actual and compares to expected mass removal
- Promotes regular evaluation of remedial system performance
- Illustrated ineffectiveness of two P&T systems – resulted in system shutdown, cost savings > \$2M/yr





Sustainability in AF Remediation : PTT Example Case Studies





Sustainability in AF Remediation: Challenge

The Challenge...

Historical approach to contaminated sites **does not fully consider sustainability** concepts.

New paradigm for remediation propelled by **Executive Order (EO) 13423**, January 2007.

Call to operate in “**sustainable manner**” leaves government environmental restoration professionals with **need for tools** to help develop sustainable remediation practices.

Sustainable: “to create and maintain conditions, under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic, and other requirements of present and future generations of Americans” (EO 13423, Bush 2007)



Sustainability in AF Remediation: ***Solution***

A Solution...

Develop **Sustainable Remediation Tool (SRT)** to help **AFCEE environmental professionals** incorporate **sustainability** concepts into their **remediation decision making** process (e.g., PBEM, RRM, ERP-O) for:

- i) **Planning future remediation implementation**
- ii) **Optimizing operating remediation sites**

Tool will be available as **freeware**





Sustainability in AF Remediation: ***Solution***

What the Tool Does

Estimates sustainability metrics for specific technologies:

- 1. Excavation**
- 2. Soil Vapor Extraction**
- 3. Pump and Treat**
- 4. Enhanced Bioremediation**



Next release will have additional technology modules



Sustainability in AF Remediation: ***Solution***

What the Tool Does

Sustainability metrics developed:

- **Carbon dioxide** emissions to atmosphere
- Total **energy** consumed
- **Change** in resource service
- Technology **cost**
- **Safety / Accident risk**

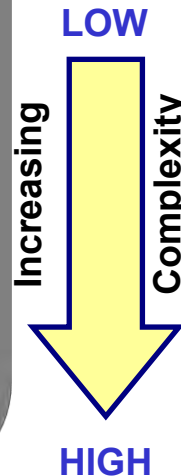
Next release will have **add additional metrics**



Levels of Complexity for Calculation Tools

GW Modeling

- Hand calculations
- Analytical models
- Numerical models

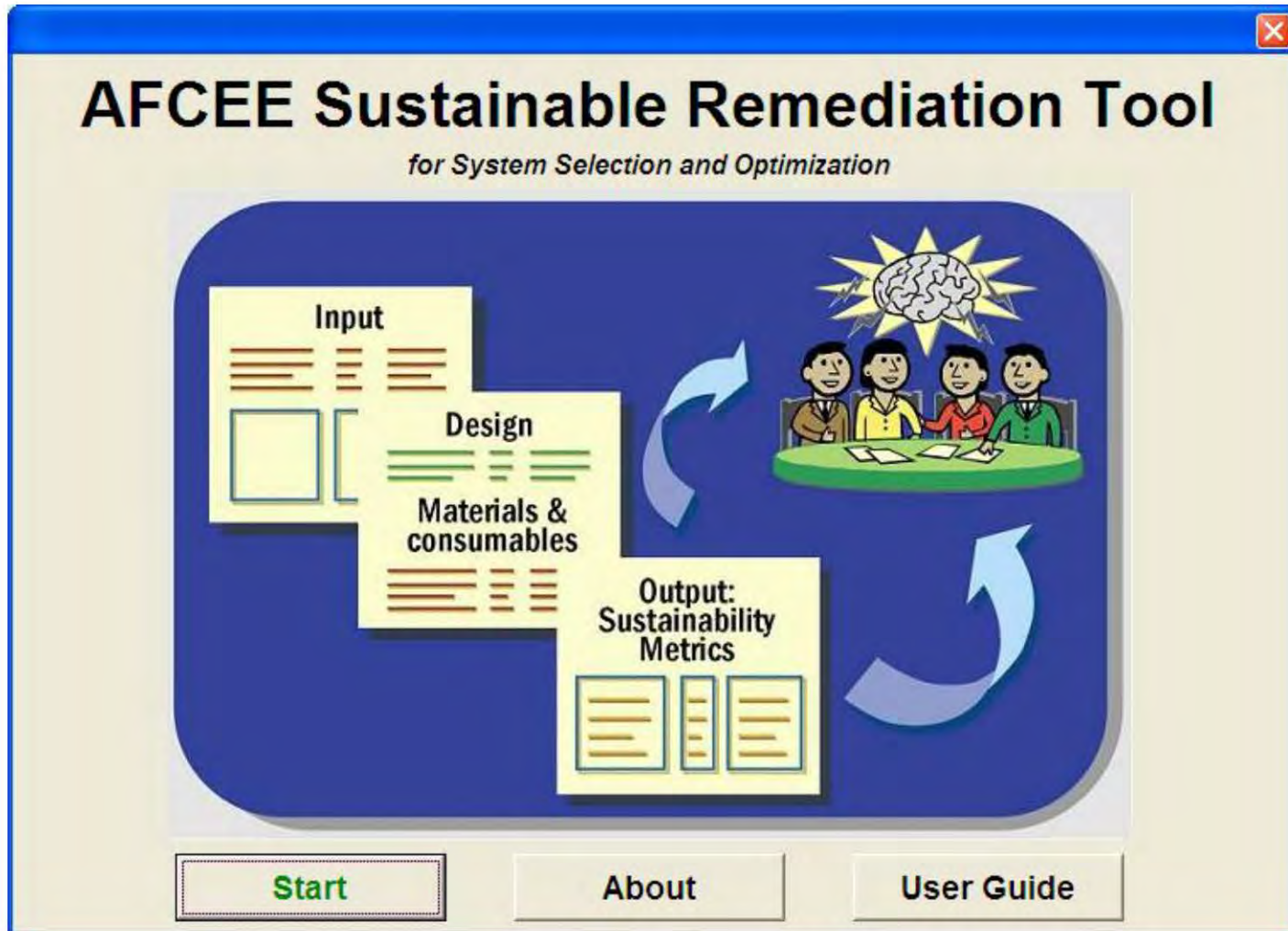


Sustainability (?)

- Hand calculations
- **Spreadsheets**
- Full-blown Life Cycle Analysis



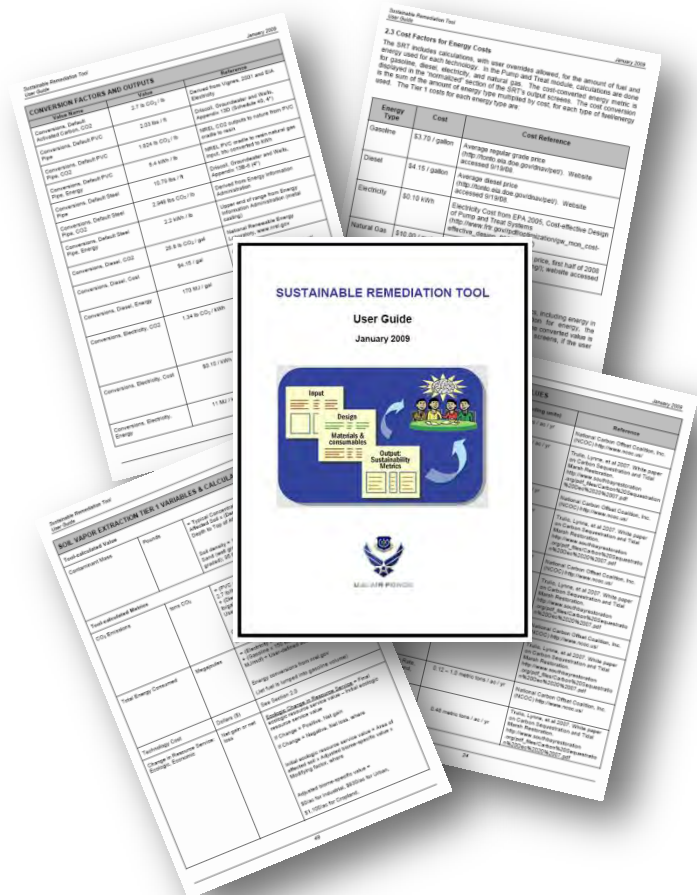
Sustainability in AF Remediation: **SRT – How Does it Work?**





Sustainability in AF Remediation: ***SRT – How Does it Work?***

- **User's Guide**
 - **Background**
 - **What the SRT does**
 - **Tier 2 System**
 - **FAQs**
 - **Referenced values**
 - **Acronyms and abbreviations**
 - **Technology costs and other detailed calculations**
- **SRT checklist**
 - **Soil input**
 - **Groundwater input**
 - **Technology input**





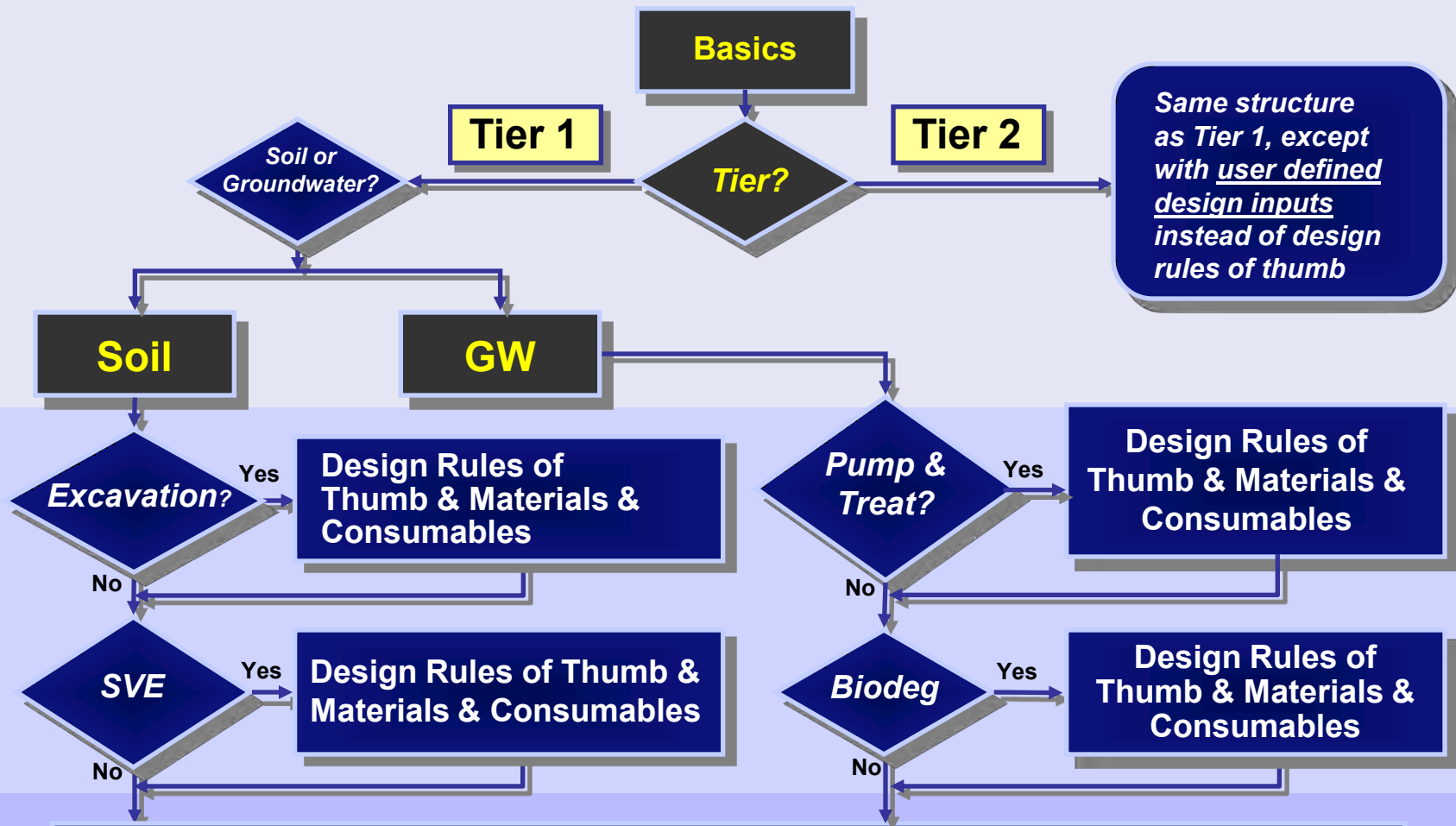
Sustainability in AF Remediation: ***SRT – How Does it Work?***

**Like RBCA
Toolkit!**

Tiers of Varying Detail

	Tier 1	Tier 2
Calculation Basis:	“Rules of Thumb”	User-entered detailed design
Time Required:	1 - 2 hrs	1 - 2 days
Tier 1 Advantages:	Tier 2 Advantages:	
	✓ Shorter execution than Tier 2 ✓ Extensive built-in defaults ✓ Simpler user inputs ✓ Most appropriate before a Feasibility Study	✓ More site-specific results ✓ More default user-overrides ✓ Most appropriate after a Feasibility Study ✓ More appropriate for optimization of existing systems

1



2

3

Outputs:

“Non-normalized” and “Normalized”

- CO₂ (tons)
- Energy (megajoules)
- Cost (\$)
- Safety/Accident Risk (lost hours) (not normalized)
- Resource Service Change



Sustainability in AF Remediation: *SRT – How Does it Work?*

By project phase – Capital, O&M, or capital and O&M

Add & subtract offsets – Technology cost;
total energy consumed; CO₂ emissions;
Safety/accident risk

Current and future ecosystem setting –
Industrial, urban, cropland, grassland,
forest

Increase in economic value and benefit to
ecological service

Springboard for features – CO₂ Scenarios;
energy scenarios; Stakeholder Roundtable

SOIL/SOURCE INPUT

Area of Affected Soil: 1000 sq ft
Depth to Top of Affected Soil: 10 ft
Depth to Bottom of Affected Soil: 20 ft
Depth to Groundwater: 30 ft
Soil Type: 1
Contaminant Class: 1
Risk Concentration: 1
Typical Concentration: 1
Contaminant mass: 1
Land Value (in current state): 1000000
Increase in economic value due to project: 1000000
Benefit to ecological service value due to project: 1000000
Future ecosystem setting: 1

EXCAVATION - TIER 1

Volume of affected soil: 1000000 cu ft
Volume of soil to be excavated: 1000000 cu ft
Total hours to excavate: 1000000 hours
Number of trucks for disposal: 1000000 trucks
Total miles driven for disposal: 1000000 miles
Total hours for 10 day placement: 1000000 hours
Number of trucks on the job: 1000000 trucks
Total miles driven for 10 days: 1000000 miles

SOIL/SOURCE RESULTS

Non-normalized Calculations on natural units

Category	Value	Unit
Excavation	1000000	cu ft
Transportation	1000000	miles
Disposal	1000000	trucks
Placement	1000000	hours

Normalized/Cost-based Results converted in dollars

Category	Value	Unit
Excavation	1000000	\$
Transportation	1000000	\$
Disposal	1000000	\$
Placement	1000000	\$

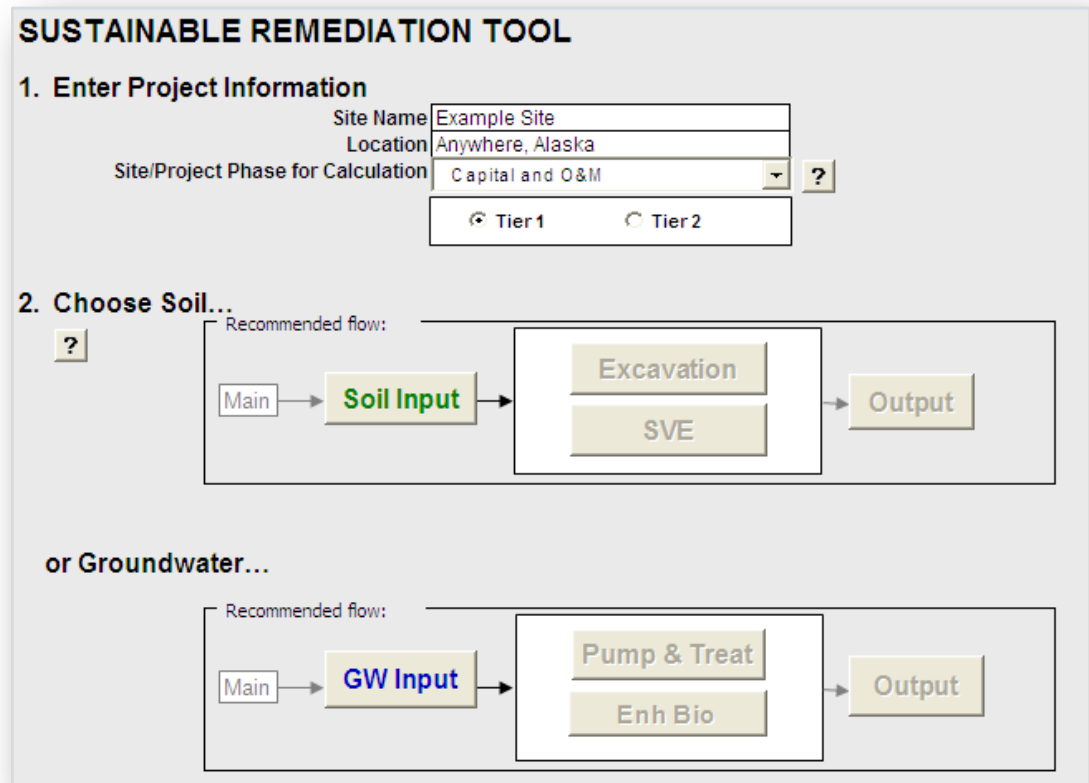


Sustainability in AF Remediation:

SRT – How Does it Work?

Basic Input Screen

- Once opened and saved, user taken to **Main Screen**.
 - **Site Name** and **Location**
 - **Site/Project Phase**
 - For **existing system**, choose “**O&M only**.”
 - **Tier 1** or **Tier 2**
 - **Soil or groundwater**
 - **Help icons** throughout





Sustainability in AF Remediation: SRT – How Does it Work?

EXCAVATION - TIER 1

Example

Example

CAPITAL and O&M

Design for Managing Soil

Airline miles flown by project team (total miles for all travelers)	1000	miles over proj lifetime
Average Distance Traveled by Site Workers per one-way trip	10	miles
Trips by Site Workers during construction	2	# over project lifetime
Trips by Site Workers after construction	1	# over project lifetime

Distance to Disposal (one-way) miles
Type of Disposal

Volume of affected soil cu ft
Volume of affected soil cu yd

Total hours to excavate person-hours
Number of loads for disposal #
Total miles driven for disposal miles
Total hours for fill dirt placement hours
Number of loads of fill dirt #
Total miles driven for fill miles

Instructions:

=Enter your data here. Click button to the right of the cell for help.

=Use this default value or override with **your own**.

=Calculated value. You cannot change this.

Restore Defaults

Show Inputs

Recommended flow:



Materials and Consumable Amounts used for Metrics

Diesel gal
Gasoline gal

Technology Cost

Capital \$
O&M \$

Project-specific Metrics (Add & Subtract/Offsets)

☐ Yes ☒ No



Sustainability in AF Remediation: ***SRT – How Does it Work?***

Example Carbon Emission Calculation

$$2,500 \text{ lb PVC} \times \frac{2 \text{ lb CO}_2}{1 \text{ lb PVC}} \times \frac{0.453 \text{ kg}}{1 \text{ lb}} \times \frac{0.001 \text{ metric ton}}{1 \text{ kg}} = 2 \text{ metric tons CO}_2 \text{ emitted}$$

“Non-normalized” natural units

$$\times \frac{\$5}{1 \text{ ton CO}_2} = \$10 \text{ CO}_2 \text{ offset}$$

“Normalized” \$ units

Example Energy Consumed Metric

$$32 \text{ gal gas} \times \frac{150 \text{ MJ}}{1 \text{ gal gas}} = 4,800 \text{ MJ energy}$$

“Non-normalized” natural units

$$32 \text{ gal gas} \times \frac{\$42.00}{1 \text{ gal gas}} = \$64$$

“Normalized” \$ units



Sustainability in AF Remediation: SRT – How Does it Work?

Output Screen

- Normalized or non-normalized results
- NPV of technology cost available
- Gains subtracted from normalized costs

- Springboard for features:

- CO₂ Scenarios
- Energy Scenarios
- Stakeholder Roundtable

SOIL/SOURCE RESULTS

Instructions:

- =Enter your data here.
- =Use this default value or override with **your own**.
- =Calculated value. You cannot change this.

Recommended flow:

Main → Input → Technology Design → Results (You are here*)

Show Inputs <<Last Screen

* Normalize metrics to see more, go back to Inputs to adjust & compare, go back to Main (Tier 1/2 or GW), or Exit.

	Non-normalized <i>Calculations in natural units</i>			Normalized/Cost-based <i>Results converted to dollars</i>		
	Excavation	SVE		Excavation	SVE	
Carbon Dioxide Emissions to Atmosphere	21.	130.	tons CO ₂	\$130.	\$780.	dollars
CO ₂ per pound of contaminant	170.	1,000.	lbs CO ₂ per lb contam			
Total Energy Consumed	270,000.	370,000.	Megajoules	\$6,700.	\$22,000.	
Technology Cost	480,000.	210,000.	dollars	\$470,000.	\$190,000.	
Cost per pound of contaminant	1,900.	840.	dollars per lb contam			
Safety/Accident Risk	0.53	0.025	lost hours			
	1.1E-02	5.2E-04	injury risk			
Change in Resource Service for Land - Economic	Net Gain	Net Gain		\$110.	\$110.	
Change in Resource Service for Land - Ecologic	Net Gain	Net Gain		\$53.	\$53.	
Normalize?	☒ Yes ☐ No			\$480,000.	\$210,000.	\$

Scenarios

Scenarios

Cost of energy + Normalized technology cost = Non-normalized technology cost total

CALCULATION NOTE:
Gains, in bold, are subtracted to get the total cost.
"Gains reduce the total cost."

Total cost is flagged, if there is overall cost benefit.

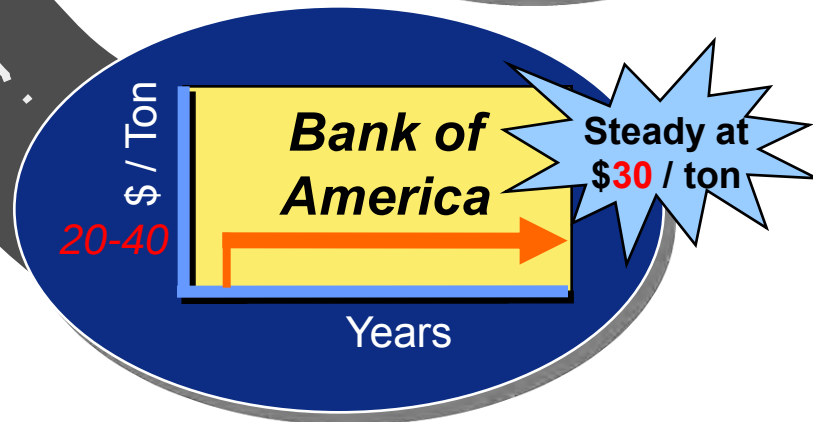
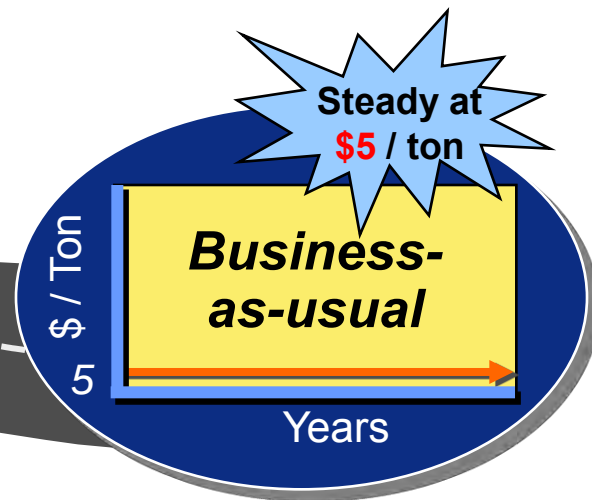
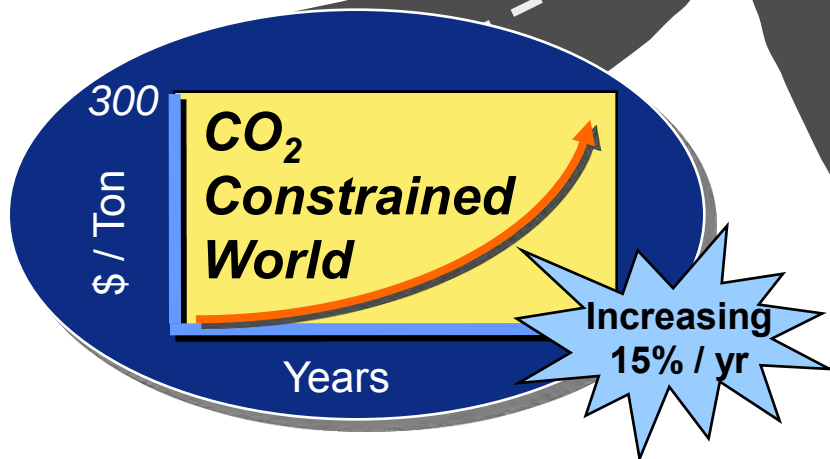
Round Table



Sustainability in AF Remediation: **SRT – Feature**

CO₂ Scenarios

Consider long-term
costs of projects
given various CO₂
scenarios





Sustainability in AF Remediation: ***SRT – Feature***

Stakeholder Roundtable - Reaching a Consensus



GROUNDWATER ROUND TABLE - WEIGH THE RESULTS

	Person 1	Person 2	Person 3	Person 4	Person 5
Carbon Dioxide Emissions to Atmosphere	High	Medium	Low	Don't Use	Medium
Total Energy Consumed	Medium	Low	Don't Use	High	Medium
Technology Cost	Low	Don't Use	High	Medium	Low
Change in Resource Service for Land	High	Medium	Low	Don't Use	High



Sustainability in AF Remediation: **SRT – Feature**

Stakeholder Roundtable - Reaching a Consensus

Pump and Treat

Normalized/Cost-based Starting Point

Carbon Dioxide Emissions to Atmosphere	\$340,000.	dollars
Total Energy Consumed	\$8,700,000.	
Technology Cost	\$58,000,000.	
Change in Resource Service	\$550,000.	
	\$57,000,000.	

Consensus (Average) Results

\$310,000.	dollars
\$7,800,000.	
\$46,000,000.	
\$610,000.	
\$54,000,000.	

KEY POINT:

Starting cost is different than
consensus cost



Sustainability in AF Remediation: **SRT – Status**

Where We Are

- **Beta testing**
 - **Completed February 2009**
- **Release of SRT**
 - **www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation**
 - **email erica.becvar@brooks.af.mil**

Where We Are Going

- **Implementing through RPO**
- **Couple with use of PTT**
- **Additional technology modules and metrics**
- **Continuing to partner with regulators, industry, Services, etc.**
- **Potential integration with RACER™ costing tool**





Sustainability in AF Remediation: For Further Information

AFCEE ERP-O Website

www.afcee.af.mil/resources/restoration/rpo/index.asp

AFCEE Sustainable Remediation Web Site

www.afcee.af.mil/resources/technologytransfer/programsandinitiatives/sustainableremediation/index.asp

EPA on Green Remediation

www.clu-in.org/greenremediation/

ITRC on Green Sustainable Remediation

www.itrcweb.org/teampublic_GSR.asp

2010 AFCEE Technology Transfer Workshop

www.afcee.af.mil/resources/technologytransfer/technologytransferworkshop/index.asp

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Questions / Discussion



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