Air Force Center for Engineering and the Environment

Integrity - Service - Excellence

Low-Energy Technologies and Uncertainty Analysis

Federal Remediation Technologies Roundtable
May 13, 2010

Year of the Air Force Family

Dr. Sam Brock
AFCEE/TDV
13 May 2010

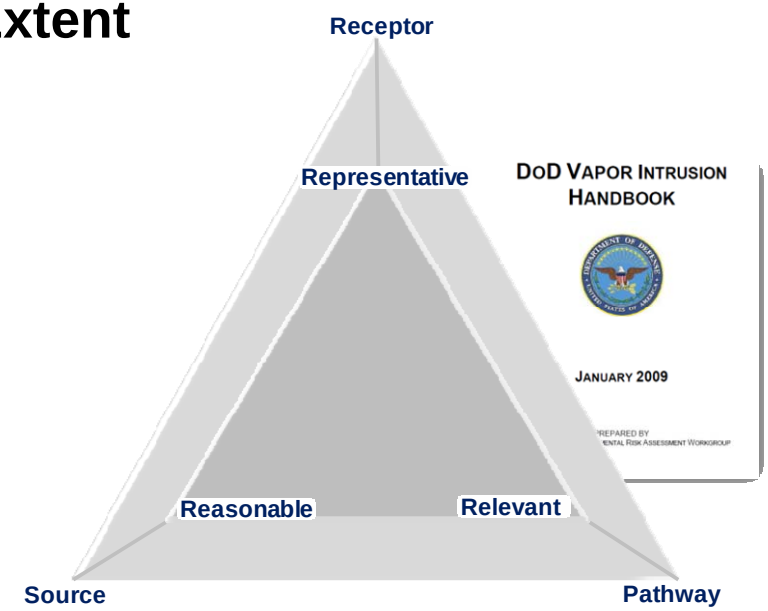
Overview

- Understanding Risk and Uncertainty
- Environmental Restoration Program – Optimization (ERP-O)
- ERP-O Performance data/ Lessons Learned
- Emerging Issues
- Remediation Performance Risk Management Guidance

Year of the Air Force Family

Air Force Risk-Based Approach

- **Decisions Risk-Based to Maximum Extent**
- **Follow National and DOD Guidance**
  - **Risk Assessment to be**
    - **Reasonable**
    - **Relevant and**
    - **Representative**
  - **Multiple Lines of Evidence - ITRC 2007**
- **Risk Triangle**
  - **Source, Pathway, Receptor**



- **EPA Government Performance and Results Act (GPRA) Environmental Restoration Goals**
  - **Human Exposure Pathways under control**
  - **No Off-Site groundwater Migration**
  - **Restoration of contaminated media to the extent Practicable**

Understanding Risk

- **Coupling a toxicology MODEL with an exposure MODEL to predict probability of an adverse health outcome**
  - **Benzene-exposed rats develop leukemia → extrapolate to human subpopulations → calculate concentration in water that may cause effects**
  - **Develop site specific exposure equations for various scenarios**

Essentially, all models are wrong, some are useful.

George Box, 1987

What is Uncertainty?

- **Risk = Likelihood X Consequences**

Uncertainty

- **The components of risk are**
  - **Likelihood of occurrence**
  - **Consequences of occurrence**

Uncertainty = Lack of Knowledge
- Outcome different from Expected
- **Model** used / **Parameters** used
- Better Data **can** reduce uncertainty

Variability = real identifiable differences between individual cases
- A single action/approach is not optimal in every case
- Better Data **cannot** reduce variability

Identifying Uncertainty

Intended Consequence

- Human exposure pathways under control
- No off-site groundwater migration
- Restoration of contaminated media to the extent practicable

Unintended Consequence

- In-situ performance risks
- Remediation is too slow
- Community impacts/accidents
- Ecological impacts
- Legal issues

Performance Risk Management

- A course of action that addresses all risks related to the remediation process
  - Risks associated with site investigation, remedy selection, implementation and close out
  - Holistic, life cycle basis

Consider Likelihood of Attaining Goals

  - Overstated likelihood of success
  - Incorrect Parameters (Cost vs. Certainty)
  - Omitting consequence of action
- Objective
  - Maximize the certainties in the cleanup process to protect human health and the environment

Year of the Air Force Family

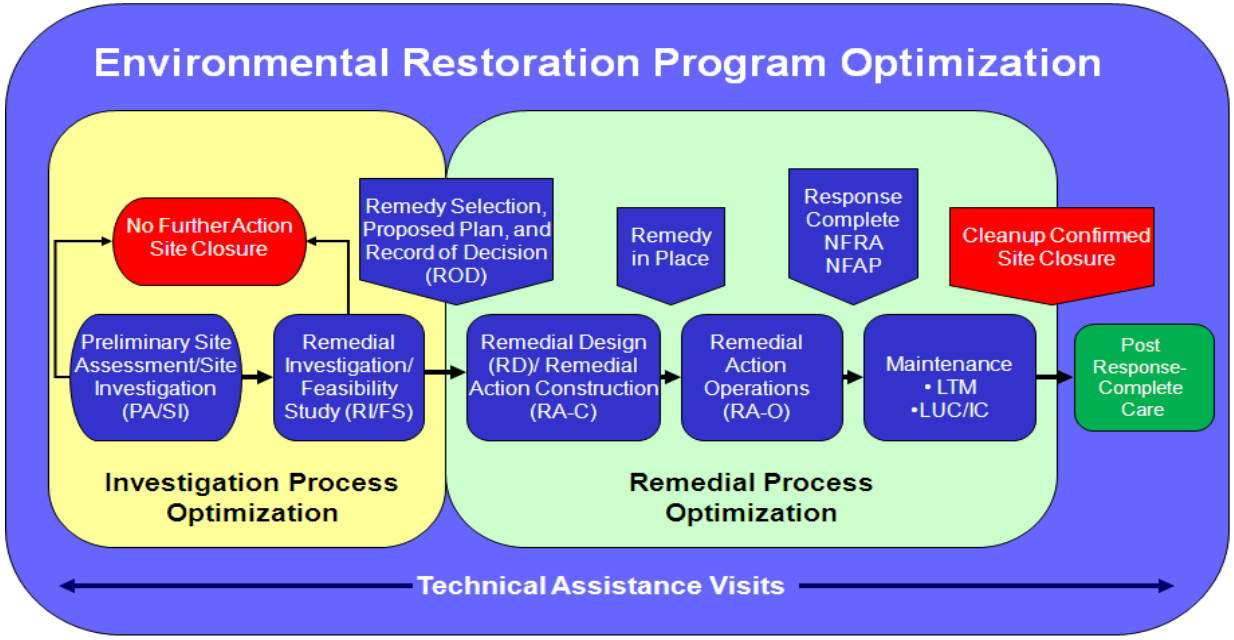
Environmental Restoration Program Optimization

Environmental Restoration Program Optimization (ERP-O)

- A *comprehensive and systematic* review of an installation's cleanup activities
- Remediate natural infrastructure resources to sustain *current and planned* mission use

- Environmental Restoration Program Optimization encompasses three environmental program processes
  - Investigation Process Optimization (IPO)
  - Remedial Process Optimization (RPO)
  - Post Closure Care

- Promote/incorporate *sustainability principles*
- Ensure remedy *effectiveness*, first; then optimize remedy *efficiency*



Year of the Air Force Family

Process Optimization

An Iterative/Systematic Planning Approach for:

Evaluating Remedial Study Programs **with the Goal of Improving Overall:**

- ✓ **Investigation Effectiveness (through Triad or RSC)**
- ✓ **Time and Cost to Achieve RIP Milestone**
- ✓ **Development/Update of a CSM for Decision Makers**

Evaluating Existing/Proposed Remediation Processes **with the Goal of Improving Overall:**

- ✓ **Remediation Effectiveness**
- ✓ **Reduction in Cleanup Time and Costs**
- ✓ **Timely Feedback to Decision Makers**
- ✓ **Efficiency**

Final Decommissioning Activities Leading to Site Closure **with the Goal of Improving Overall:**

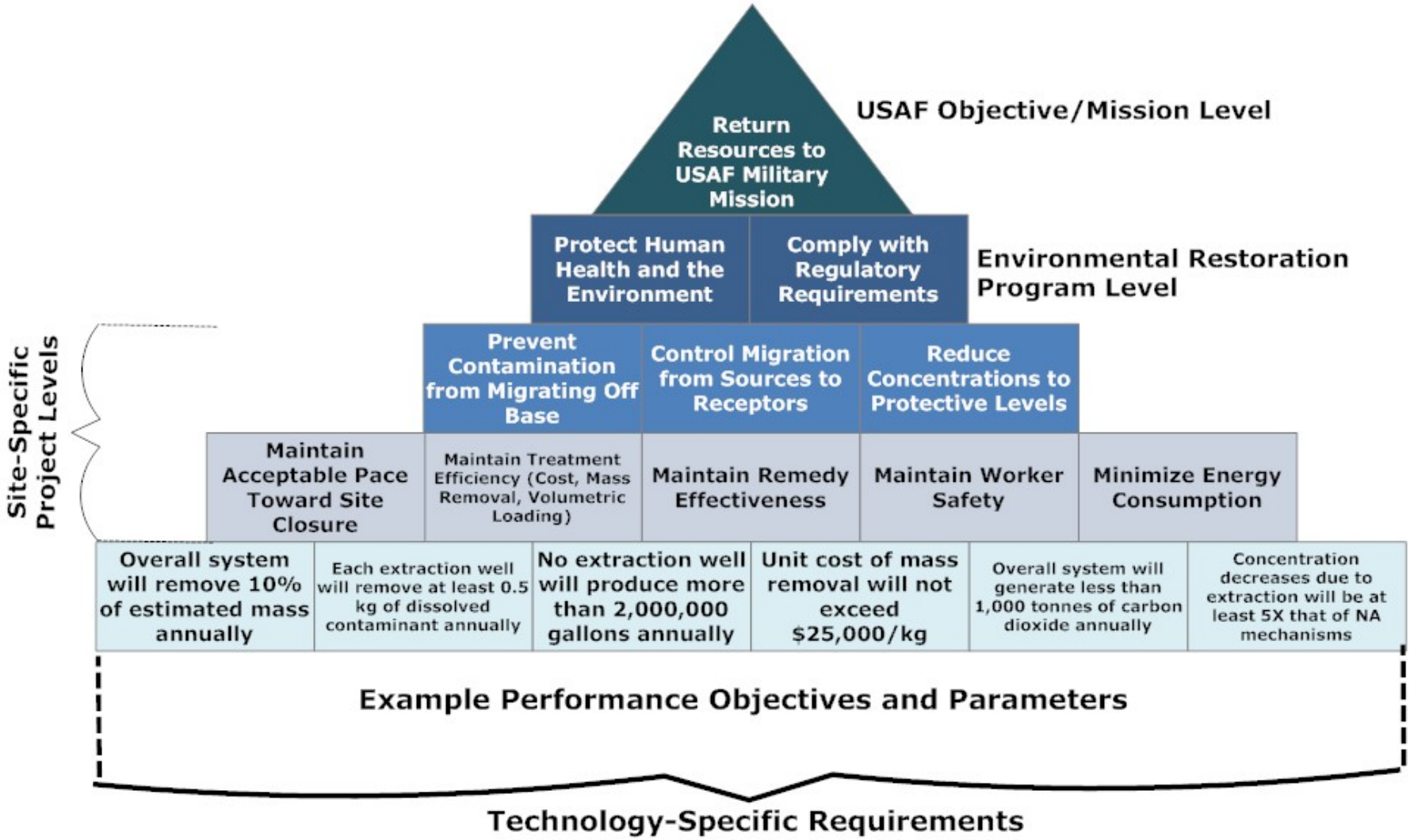
- ✓ **Well Decommissioning**
- ✓ **System Decommissioning**
- ✓ **RCRA permit Closure**
- ✓ **Removal from NPL**

Estimating Uncertainty

- Judgment & Checklists
- Performance Measures
- Decision Support
  - Matrices
  - Probability distributions
- Probabilistic Risk Analysis

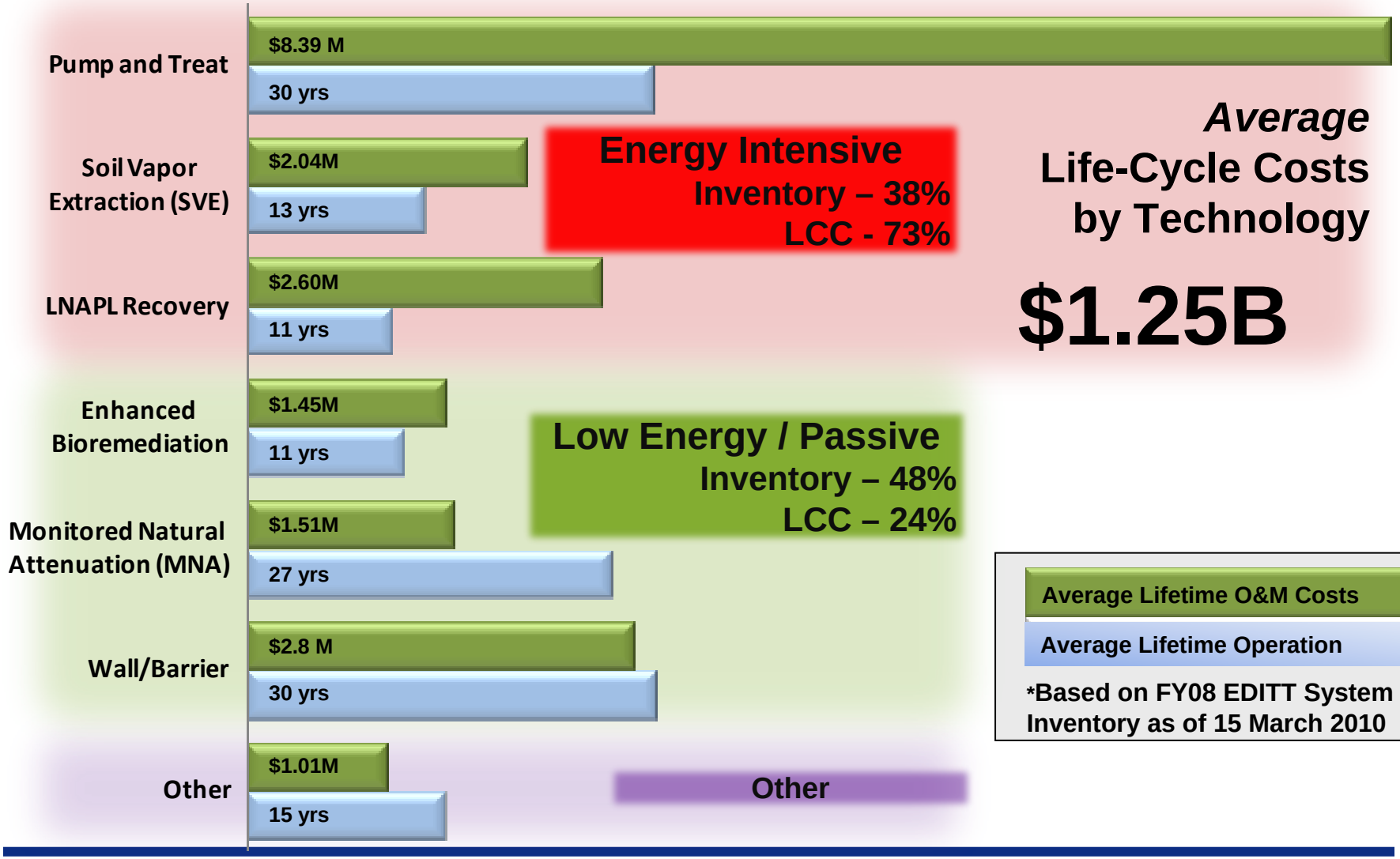
Year of the Air Force Family

Performance Measures -Develop a Hierarchy of Objectives



Year of the Air Force Family

AF Environmental Restoration Program

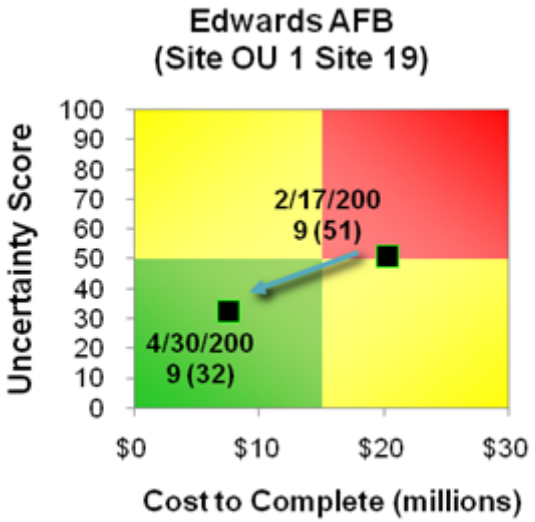


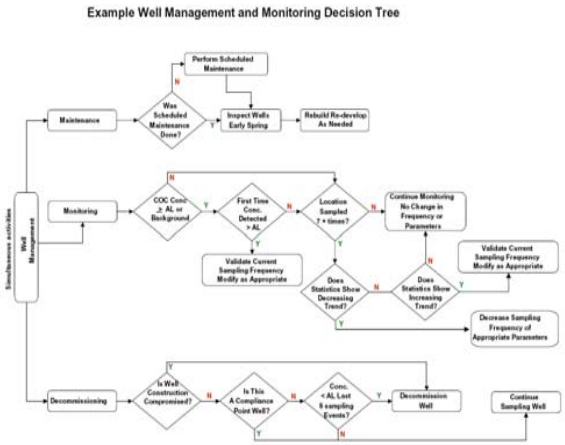
12

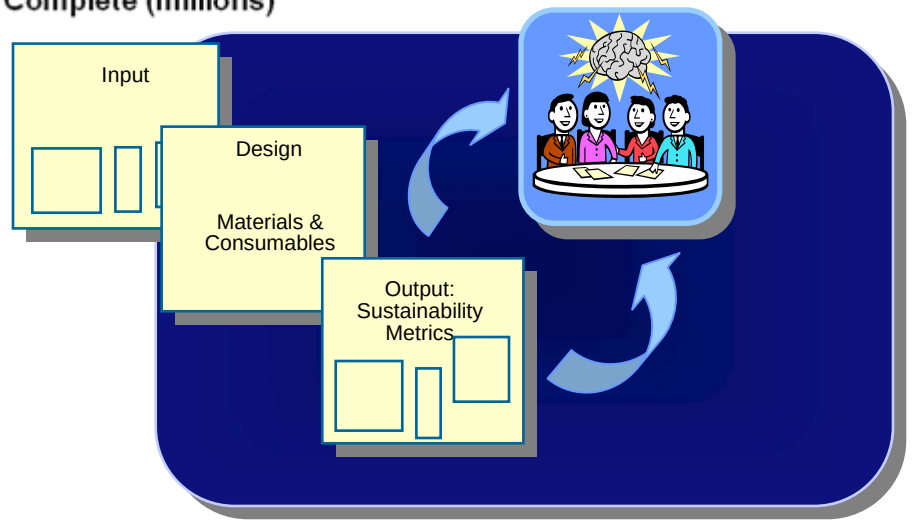
ERP-O Tools

Support Tools

- ✓Uncertainty Tool
- ✓Sustainability Tool
- ✓Performance Tracking
- ✓Recommendation Tracking
- ✓LTMO
- ✓EDITT







Year of the Air Force Family

Sustainable Remediation Tool

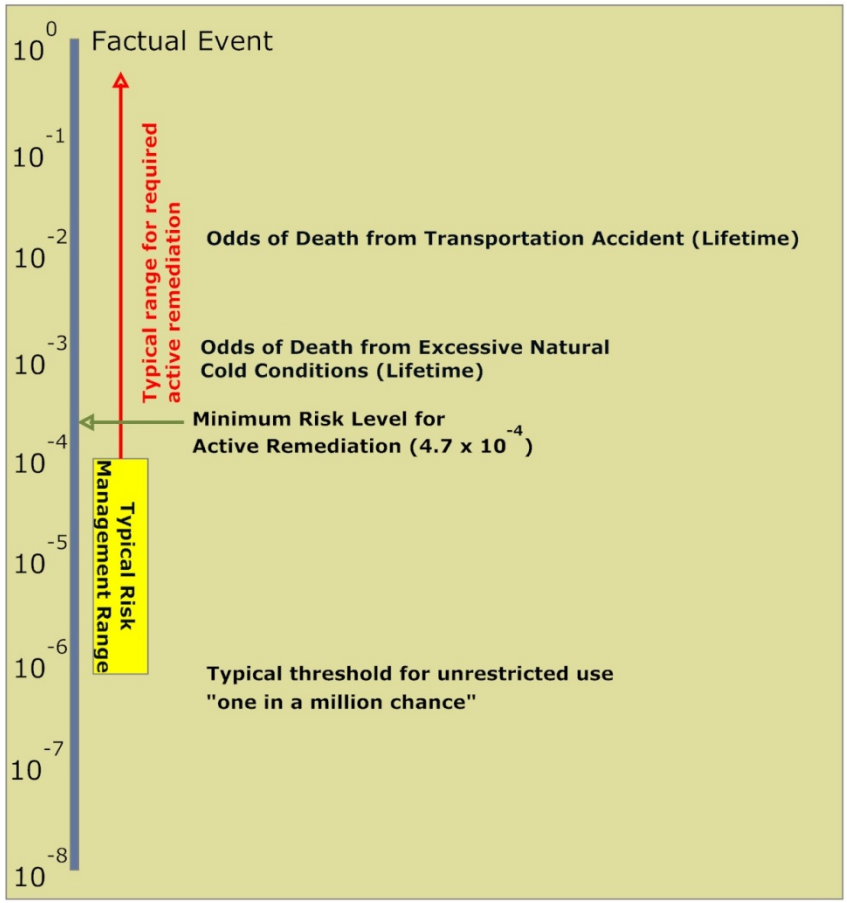
What the Sustainable Remediation Tool (SRT) does:

- Optimization tool … helps drive and influence GSR technology selection
- Used in future planning and optimization of existing systems
- Provides lifetime sustainability assessment
- Works in concert with Performance Tracking Tool (PTT) to evaluate performance and reduce time to site closure
- Virtual roundtable for all-party consensus
- Estimates sustainability metrics for 8 specific technologies
- Sustainability metrics estimated:
- Carbon dioxide emissions to atmosphere
- Total energy consumed
- Change in resource service
- Safety / Accident risk
- Technology cost
- NOx
- SOx
- PM10
- 15 sustainability assessments over past 8 months
- 2010 release – Interface with RACER and additional features, metrics, and technology modules

SRT

SRT Example -Risk to Workers

- By operating the groundwater treatment system:
  - Risk to workers ~ 1 X10^{-3}
  - Risk to community ~ 1 X10^{-4}
- Risk to HH & Eco from ground water ~ 1 X10^{-6}
- Is active remediation really justified?
  - Alternative to remediation



Year of the Air Force Family

Resources Protected

- **Evaluation of resources being protected**
- **Technology vs. Energy Use**
- **Is active remediation really justified?**
  - **Alternative to remediation**

Groundwater restoration at California installation

- ***Consuming 1.5M KWH/yr***
- ***Removing < 50 grams of TCE/yr***
- ***Producing 750 tons of CO2***
- ***$3.6M/lb TCE removed***

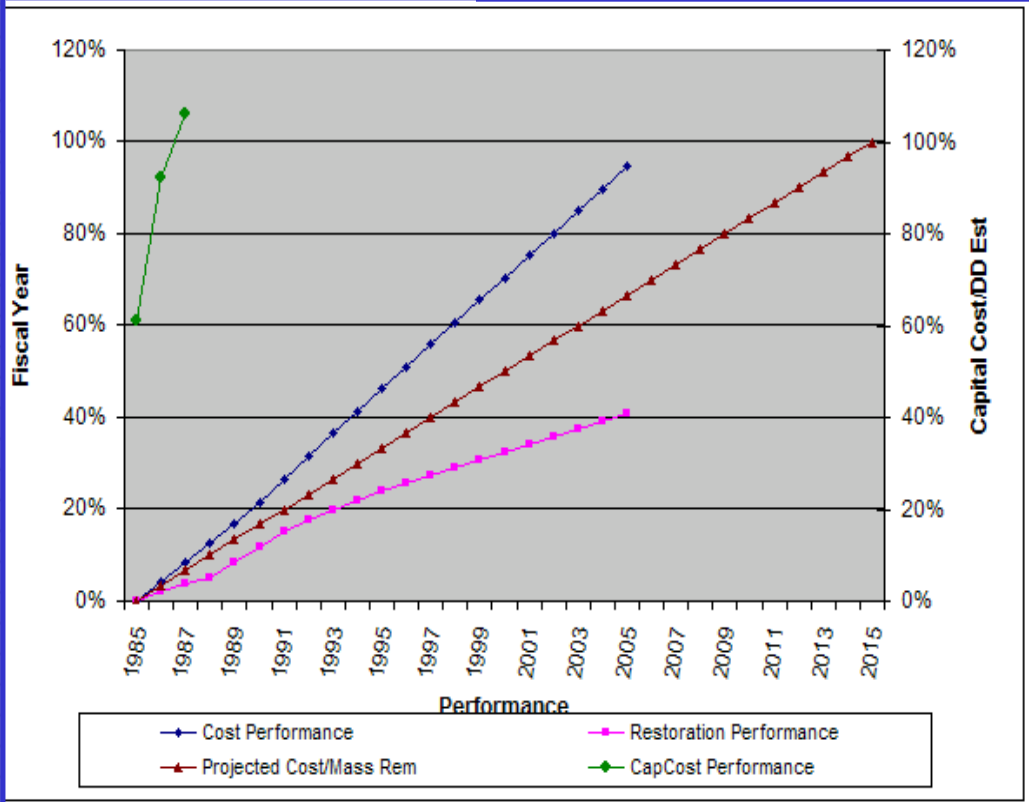
Year of the Air Force Family

Lessons Learned Performance Tracking Tool

Capital Cost by Fiscal Year	Operation & Maintenance Cost by Fiscal Year	Projected Costs/Mass Removed (from DD)	Capital Cost as Percent DD Est.	O&M as Percent of CTC	Total Pecent Mass Removed
$ 195,000	$ -	0%	61%	0%	0%
$ 100,000	$ 290,000	3%	92%	4%	2%
$ 45,000	$ 290,000	7%	106%	8%	4%
	$ 300,000	10%		13%	5%
	$ 310,000	13%		17%	8%
	$ 305,000	17%		21%	12%
	$ 375,000	20%		27%	15%
	$ 340,000	23%		32%	18%
	$ 340,000	27%		36%	20%
	$ 340,000	30%		41%	22%
	$ 340,000	33%		46%	24%
	$ 340,000	37%		51%	26%
	$ 340,000	40%		56%	27%
	$ 340,000	43%		61%	29%
	$ 340,000	47%		66%	31%
	$ 340,000	50%		70%	32%
	$ 340,000	53%		75%	34%
	$ 340,000	57%		80%	36%
	$ 340,000	60%		85%	37%
	$ 340,000	63%		90%	39%
	$ 340,000	67%		95%	41%
		70%			
		73%			
		77%			
		80%			
		83%			
		87%			
		90%			
		93%			
		97%			
		100%			

Total Mass at RA-O Start-Up (lb	30000
Cost-To-Complete (CTC) ($)	$ 7,000,000
DD Capital Cost Est	$ 320,000
Impacted Acres	23
Acre-ft of groundwater impacte	265
RA-O Start Year (from DD)	1985
RA-O Completion Year	2015

	To Date	Estimated total cost
Cost/Acre	$ 288,261	$ 117,832
Cost/Acre feet	$ 25,019	$ 10,227
Cost/lb removed	$ 541	
Total O&M Costs	$ 6,630,000	
Total Mass Removed	12,263 lbs	
Portion of DD Mass Rem	40.9%	



Remedial Project Risk Management

Risk Planning

Table 2-1 Example Matrix for Evaluation Risk Level						
		Impact or Consequence of Occurrence				
		Negligible	Marginal	Significant	Critical	Crisis
Likelihood of Occurrence	*Very Likely*	Low	Moderate	High	High	High
	Likely	Low	Moderate	High	High	High
	Unlikely	Low	Low	Moderate	Moderate	High
	Very Unlikely	Low	Low	Low	Low	High

Definitions

- **Emerging Contaminants:** **Chemicals & materials that have pathways to enter the environment and present <u>potential</u> unacceptable human health or environmental risks**

  …and either

  - **they do not have regulatory peer-reviewed human health standards**

    …or

  - **the regulatory standards are evolving due to new science, detection capabilities, or pathways**

- **Emerging Issues:** **Items such as exposure pathways, sampling strategies, policy, or quality assurance that potentially impact cleanup schedules, increases cost, alters the technical approach, or necessitates developing new partnerships**
- ***e.g., vapor intrusion, reinvestigation, emerging technologies, and sustainability***

Emerging Issues Tool

	Technical Value	Political Value	Regulatory Value
AFCEE	0.4	0.2	0.2
USAF	0.1	0.2	0.2
SAF	0.1	0.3	0.2
DoD	0.1	0.2	0.2
Other	0.3	0.1	0.2

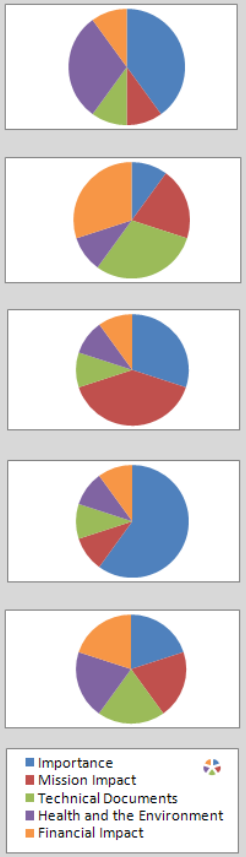
Rating Entity	Factor	Drive
AFCEE	Importance	0.4
	Mission Impact	0.1
	Technical Documents	0.1
	Health and the Environment	0.3
	Financial Impact	0.1

Rating Entity	Factor	Drive
USAF	Importance	0.1
	Mission Impact	0.2
	Technical Documents	0.3
	Health and the Environment	0.1
	Financial Impact	0.3

Rating Entity	Factor	Drive
SAF	Importance	0.3
	Mission Impact	0.4
	Technical Documents	0.1
	Health and the Environment	0.1
	Financial Impact	0.1

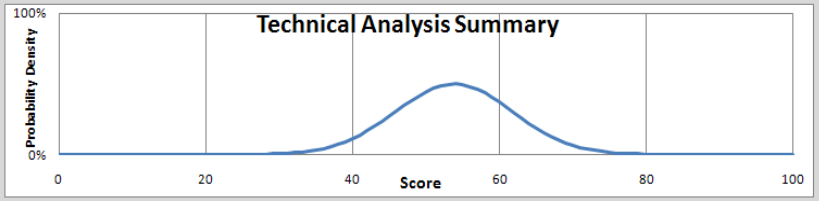
Rating Entity	Factor	Drive
DoD	Importance	0.6
	Mission Impact	0.1
	Technical Documents	0.1
	Health and the Environment	0.1
	Financial Impact	0.1

Rating Entity	Factor	Drive
Other	Importance	0.2
	Mission Impact	0.2
	Technical Documents	0.2
	Health and the Environment	0.2
	Financial Impact	0.2

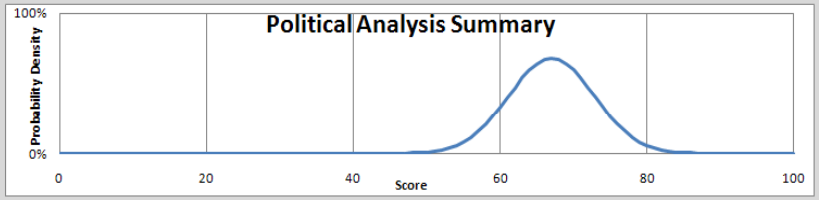


- Detailed parameter input, such as weightings for each Factor
- Rating Entities input Score and Certainty for the Technical Analysis
- Result of analysis; the PDF curve and confidence of Response Levels are displayed for the Technical Analysis

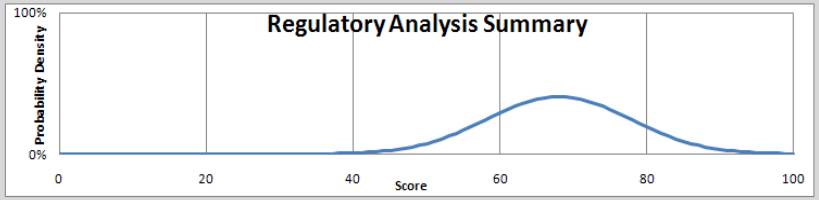
Emerging Issues Tool (cont)



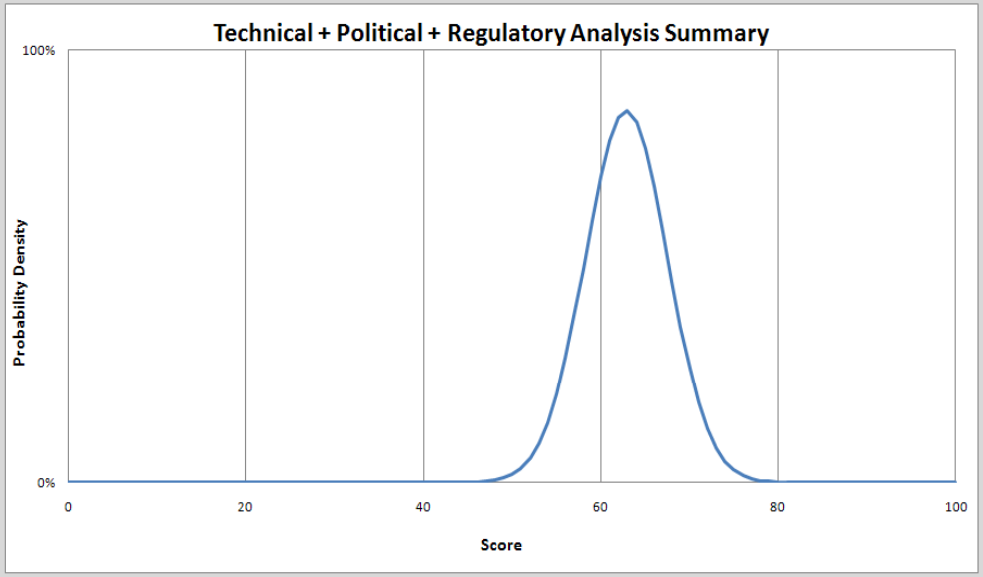
Mean	Stnd Deviation
5.38	0.800544758



Mean	Stnd Deviation
6.7	0.58439711



Mean	Stnd Deviation
6.8	0.981178152



	Probability of Occurrence	Response Level Confidence
Response Level 0	0.00%	0.00%
Response Level 1	0.00%	0.00%
Response Level 2	26.83%	26.83%
Response Level 3	73.16%	99.99%
Response Level 4	0.01%	100.00%

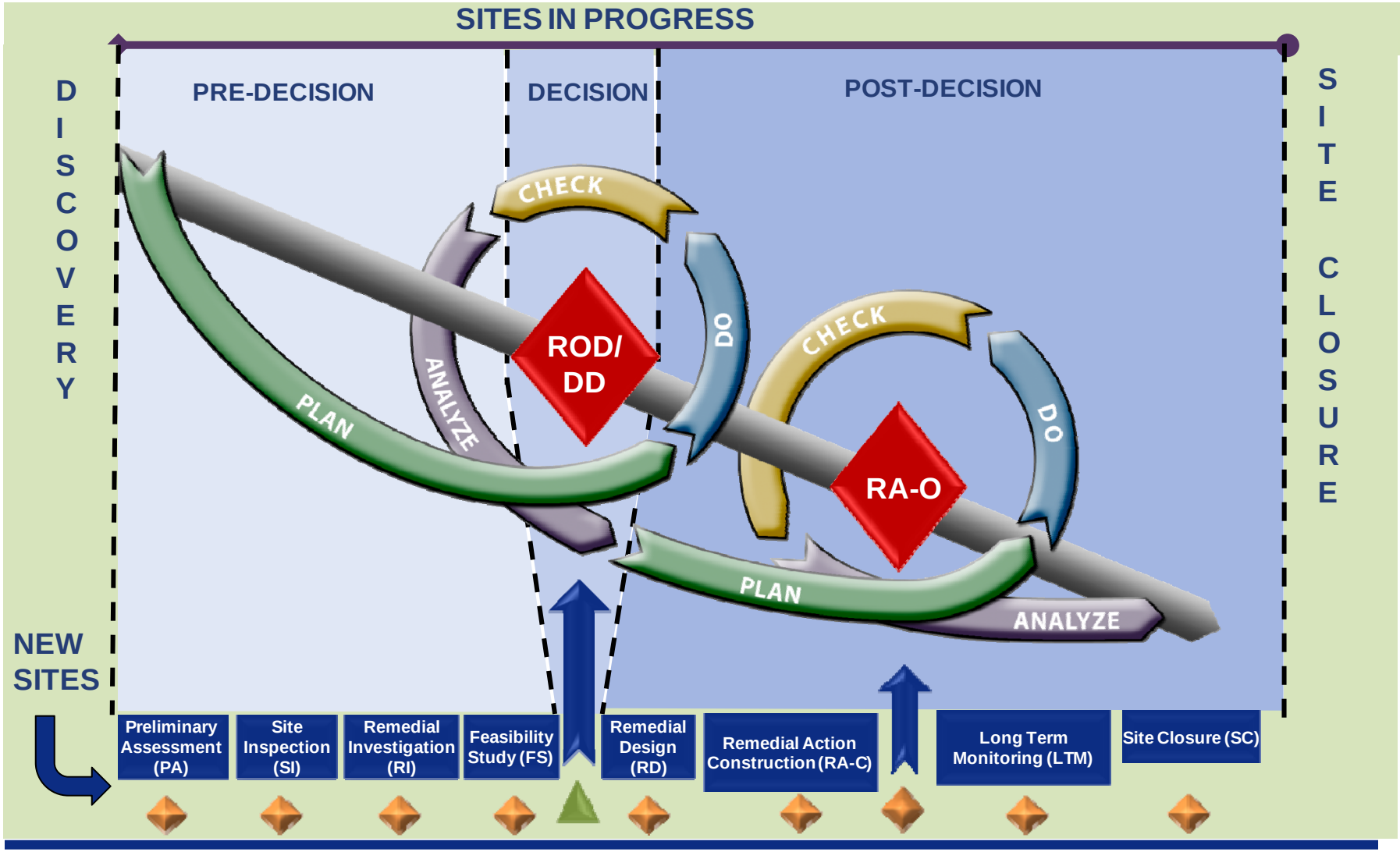
Mean	Stnd Deviation
6.28704	0.464424877

- Stats for Technical, Political, and Regulatory Analysis displayed separately…

- Result of combining the Technical Analysis, Political Analysis, and the Regulatory Analysis shown as a PDF curve and confidence of Response Levels.

Year of the Air Force Family

Restoration Performance Risk Management



Conclusions

1. **Address Site Life Cycle / Start Early**
2. **Analyze performance & generate performance data**
3. **Develop performance measures to leverage experience and lessons learned**
4. **Improve estimates until:**
   - **Risk is below decision criteria**
   - **More knowledge doesn't change estimated risk**
   - **Stakes (consequences) are low (not high enough to warrant further work)**

Year of the Air Force Family

Questions?

Contact Information:

Dr. Sam Brock AFCEE/TDV
Email: samuel.brock@us.af.mil
Brooks City-Base, San Antonio TX 78235-5112
(210) 395-8429; DSN 969-8429