



2003 AFCEE Technology Transfer Workshop

San Antonio, Texas

Promoting Readiness through Environmental Stewardship

AFCEE Performance Monitoring Technologies (PMT) Matrix

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- **Basis**
 - **Evaluating a Remediation Technology**
 - **Available Products**
 - **Performance Monitoring Technologies**
- Matrix**
- **Function/Focus**
 - **Organization**
 - **Form**

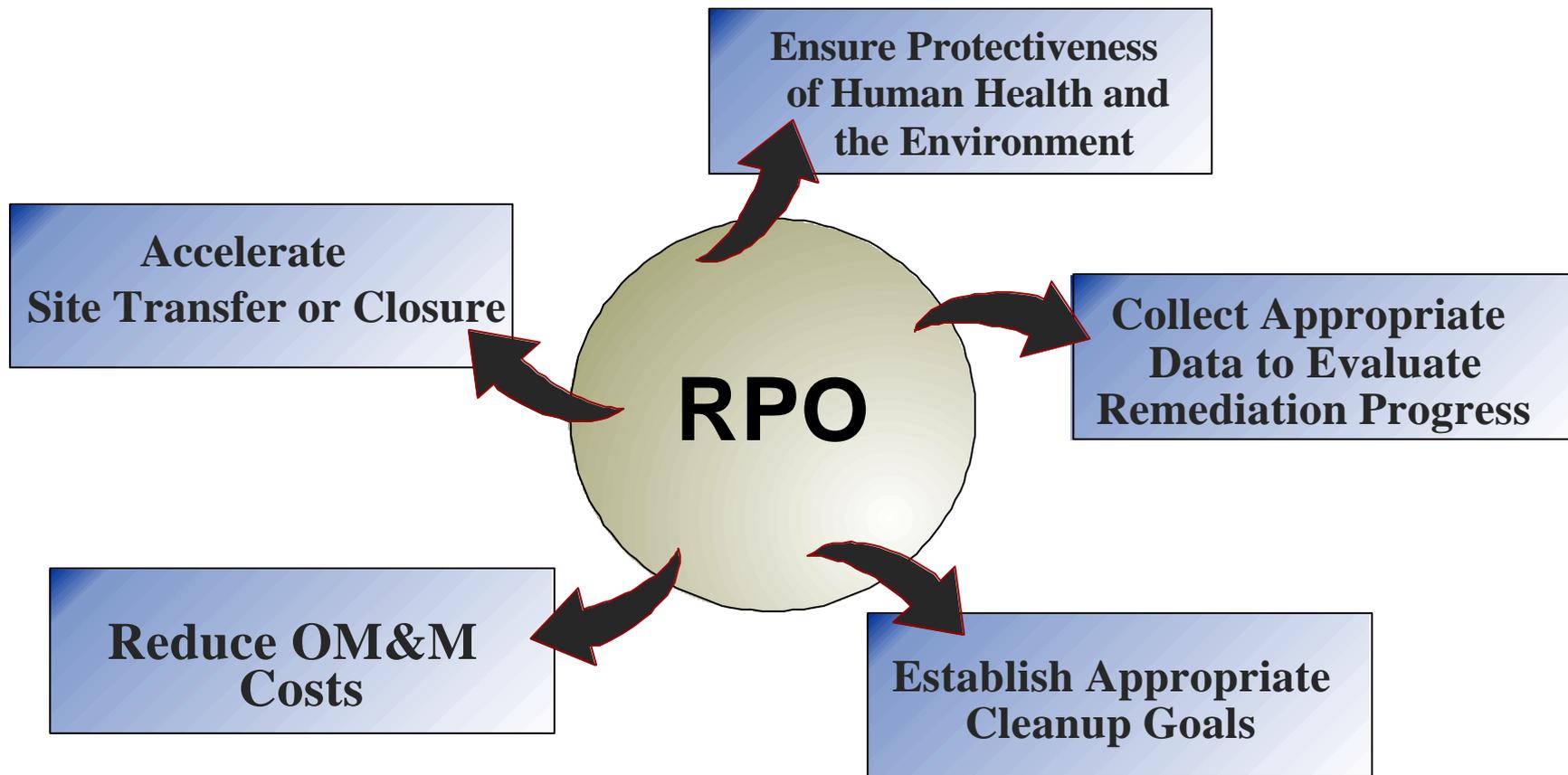


Impetus for Remed. Technol. Eval.

- During current decade DOD will spend >\$1billion/year on OM&M of environmental remediation systems (RPO Handbook, 1999)
- Remedial Process Optimization (RPO) Program
 - Tiered (Phase I and II)
 - Phase I monitors progress toward site cleanup goals
 - Phase II involves more detailed technology evaluation, including Remedial System Optimization (RSO)
 - Works with other regulatory requirements



Benefits of RPO



(Source: AFCEE RPO Handbook, 1999)



Phase II RPO

- **Review Existing Remediation Goals**
- **Design Review:**
 - **Validate Conceptual Site Model**
 - **Define Technology Evaluation Criteria**
 - **Evaluate Presence of Limiting Conditions**
- **Collect Additional Performance Data**
- **Evaluate System Effectiveness**



Technology Evaluation Criteria

- **Cost**
- **Performance**
- **Duration of Operation**



Performance Evaluation Goals

- **RPO**
 - **Ability to Attain Cleanup Goals (Effectiveness)**
 - **Optimized Operation (Efficiency)**
 - **Protective of Human Health and the Environment (Remedy Protectiveness)**

- **OPS Demonstration at BRAC Sites (CERFA)**
 - **Operating as Designed (“Properly”)**
 - **Ability to Attain Cleanup Goals (“Successfully”)**



Performance Evaluation Goals

- **RCRA**
 - **Protective of Human Health at Point of Compliance of SWMU (Remedy Protectiveness)**

- **5-Year ROD Review (CERCLA)**
 - **Ability to Attain ARARs (Reduction of Risk to Human Health and the Environment)**



Available Tools for Technology Eval.

■ **Technology Information/Profiles**

- **Federal Remediation Technologies Roundtable (FRTR): Screening Matrix and Reference Guide (www.frtr.gov)**
- **AFCEE Remediation Matrix - Hierarchy of Preferred Alternatives**
- **USEPA Technology Innovation Office (www.clu-in.org)**

■ **Sampling & Analysis Method Selection**

- **FRTR: Field Sampling and Analysis Matrix**
- **USEPA: Field Analytical Technol. Encyclopedia (www.fate.clu-in.org)**
- **AFCEE: Draft Analytical Protocol for 13 High-Priority Treatment Technologies**



PMT Matrix: Function

- **Information Tool**
- **Identifies required measurements specific to each technology in the FRTR/AFCEE Matrix**
- **Provides concise reference for minimum remedial action system monitoring to support:**
 - **5-Year ROD reviews**
 - **Operating Properly & Successfully (OPS) demonstrations**
 - **Remedial System Optimization (RSO) initiatives**



PMT Matrix: Organization

- **Contaminated Solid Media (26)**
 - Soil
 - Sediment
 - Sludge

- **Contaminated Aqueous Media (28)**
 - Groundwater
 - Surface Water
 - Leachate



PMT Matrix: (Org.) Technol. Types

- **In Situ Biological**
- **In Situ Physical/Chemical**
- **In Situ Thermal (solid media only)**
- **Ex Situ Biological**
- **Ex Situ Physical/Chemical**
- **Ex Situ Thermal (solid media only)**
- **Containment**
- **Air Emission / Off-Gas (aqueous media only)**



PMT Matrix: Form (2'x3' Poster)



The Air Force Center for Environmental Excellence

Performance Monitoring Technology Matrix

Solid Media (Soil, Sediment, and Sludge)

Technology	Organic Compounds										Inorganic Compounds										Microbes									
	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs						
In Situ Biological Treatment																														
Bioventing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Enhanced Bioremediation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Nature Mimicry (SIS)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Phytoremediation (Phytoreactors)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
In Situ Physical / Chemical Treatment																														
Soil Fracturing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Soil Flushing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Soil Vapor Extraction (SVE)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Soil/Water Extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
In Situ Thermal Treatment																														
Thermal Enhanced SVE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Ex Situ Biological Treatment																														
Bioleach	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Composting	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Landfarming	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Slurry Phase Biological Treatment	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Ex Situ Physical / Chemical Treatment																														
Chemical Extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Chemical Reduction/Oxidation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Membrane Separation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Soil Washing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Soil Vapor Extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Soil/Water Extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Ex Situ Thermal Treatment																														
Hot Gas Decontamination	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Incineration	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Open Burn / Open Oxidation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Thermal Desorption	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Containment																														
Standard RCRA Landfill Cap	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Engineered Landfill Cap	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Other																														
Excavation, Removal, and Disposal	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					

Aqueous Media (Groundwater, Surface Water, and

Technology	Organic Compounds										Inorganic Compounds										Microbes									
	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs	PAHs	PCBs	PCDDs	PCDFs						
In Situ Biological Treatment																														
Enhanced Aerobic Biodegradation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Enhanced Anaerobic Biodegradation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Nature Mimicry	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Phytoremediation (Phytoreactors)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
In Situ Physical / Chemical Treatment																														
Air Sparging	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Bioventing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Directional Wells	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Deep Well Extraction	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Hot Water / Steam Sparging	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Hydrofracturing	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
In-Situ Sparging / Recirculation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Passive / Reactive Treatment Walls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Ex Situ Biological Treatment																														
Bioreactors	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Constructed Wetlands	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Ex Situ Physical / Chemical Treatment																														
Air Oxidation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Air Stripping	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Liquid Phase Carbon Adsorption	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Air Exchange	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Precedent Oxidation Plant	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Separation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Sparging Injection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Containment																														
Slurry Walls	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Curfem Pumping	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Deep Well Injection	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Air Emulsion / Off-Gas Treatment																														
Scrubbers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Thermal Oxidation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Ultraviolet Oxidation	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					
Vapor Phase Carbon Adsorption	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓					

Legend:
 ✓ - Success
 ✗ - Failure
 C - Contaminant Transfer/Conversion
 D - Delay
 E - Effective
 F - Failure
 G - Groundwater
 H - High
 I - Ineffective
 J - Low
 K - Low
 L - Low
 M - Low
 N - Low
 O - Low
 P - Low
 Q - Low
 R - Low
 S - Low
 T - Low
 U - Low
 V - Low
 W - Low
 X - Low
 Y - Low
 Z - Low

Comments:
 1. Contaminant Transfer/Conversion (C) is defined as the transfer of a contaminant from one medium to another, such as from groundwater to surface water, or from soil to groundwater.
 2. Delay (D) is defined as a significant delay in the implementation of a technology.
 3. Effective (E) is defined as a technology that is shown to be effective in the field.
 4. Failure (F) is defined as a technology that is shown to be ineffective in the field.
 5. Groundwater (G) is defined as a technology that is used to treat groundwater.
 6. High (H) is defined as a technology that is used to treat high concentrations of a contaminant.
 7. Ineffective (I) is defined as a technology that is shown to be ineffective in the field.
 8. Low (L) is defined as a technology that is used to treat low concentrations of a contaminant.
 9. Low (L) is defined as a technology that is used to treat low concentrations of a contaminant.
 10. Low (L) is defined as a technology that is used to treat low concentrations of a contaminant.



PMT Matrix: Form (Web Profiles)

- **Definition of Effective Performance**
- **List of Measurements of Effective Performance**
- **Details on Required Measurements of Performance**
 - **Parameters and their Locations**
 - **Effectiveness Indicators**
 - **Monitoring Frequency**
- **Recommended Analytical Methods**
- **Summary Table**



QUESTIONS?



Limitations

- **Amount of available information**
 - **Conventional technology**
 - **Innovative technology**
- **Time variant behavior and the reduction in performance monitoring over time**
- **Not a cost estimating tool**
 - **Site-specific inputs required for determining cost**