

# Early Decision Framework for Integrating Sustainable Risk Management for Complex Remediation Sites

Drivers, Barriers, and Performance Metrics

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**CDM  
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# Outline

- Problem Statement
- Literature Review\*
  - *\*Drivers and barriers*
- Early Decision Framework
  - *\*performance metrics and tools*
- Take Home Messages



# Problem Statement

- “Complex Sites” often have significant underlying technical challenges, which limit the ability to achieve stringent (i.e. promulgated) remediation goals within a reasonable timeframe and in a resource-effective manner.



# Problem Statement

- Shortcomings of Risk-Based Cleanup Guidance
  - Lack of framework on developing site-specific primary and secondary risk management cleanup objectives
  - Site characterization without remedy or re-use in mind
  - Lack of remedy secondary performance metrics
  - Lack of consideration of stakeholder needs

# Problem Statement

Lack of sustainability considerations during project planning

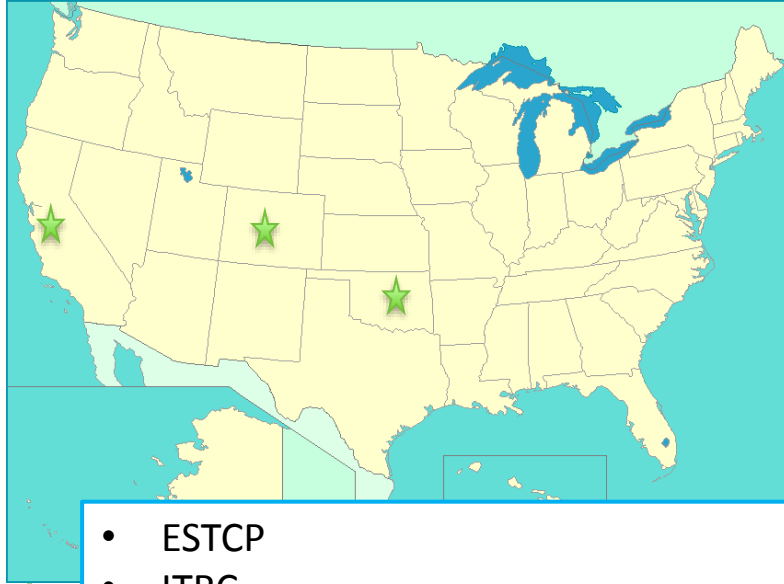
- Several remediation attempts made or continue to be implemented
  - Costly and resource intensive
- Sites enter “no man’s land”
  - Underuse and low value asset





# Literature Review

# Literature Review



- ESTCP
- ITRC
- NRC
- US AFCEE
- USEPA

Contaminated Land  
Rehabilitation Network for  
Environmental Technologies  
(CLARINET)



National  
Environmental  
Protection  
Council (NEPC)



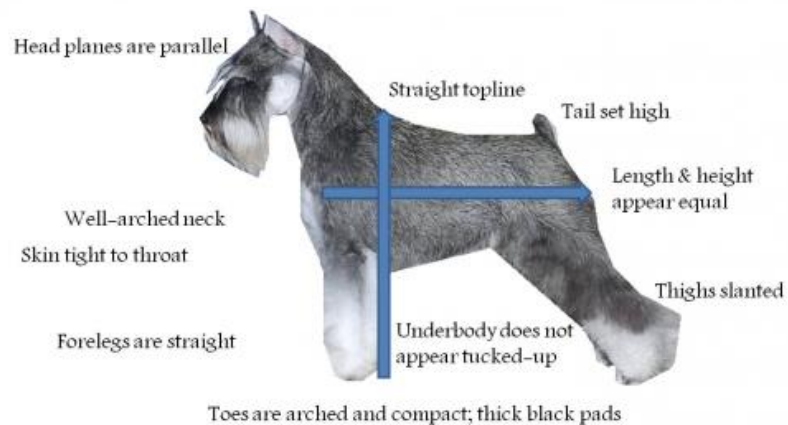
# Risk-Based Cleanup Approaches

1. Adaptive site management (i.e., site management using phased approach)
2. Alternate concentration levels (ACLs)/Risk characterization
3. Applicable or relevant and appropriate requirements (ARAR) waiver
4. "Conditional Closure" or "Low Threat" Closure
5. Deed, zone, use restrictions / alternate endpoints
6. Groundwater management zone
7. Groundwater reclassification
8. Long-term monitoring/natural attenuation
9. Technical impracticability waiver
10. Treatment and Closure in Place
11. Water Quality Trading



# Risk-Based Cleanups: Drivers & Barriers

## Characteristics



## Obstacles



# What are the DRIVERS to risk-based cleanups?

## Physical/Environmental Characteristics

- 14 Drivers
- Technical Limitations
  - Complex geology
  - Low permeability geologic zones
  - Inaccessibility
  - Presence of NAPL
  - Long dilute plumes
  - Regional, widespread contamination
- Recalcitrant Compounds
  - Mining and mineral processing sites
  - Sediment sites
- Resuspension of Contaminants
  - Sediment Sites



# What are the DRIVERS to risk-based cleanups?

## Socio-Economic Characteristics

### ■ 9 Drivers

### ■ Redevelopment and Regeneration

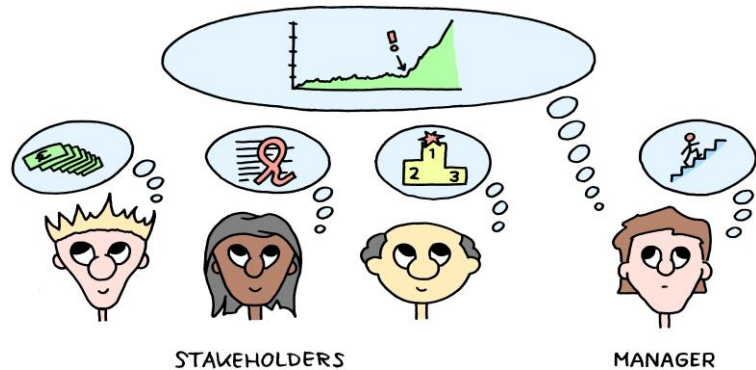
- Restorations of ecosystem services\*
- Revitalization of local economies
- Improvement in community's quality of life\*

### ■ Detrimental Impacts

- Local community disruption\*

### ■ Success Story in Brownfields

- International prospective of contaminated land



\* - Also considered a sustainable remediation objective

# What are the DRIVERS to risk-based cleanups?

## Risk Management Characteristics

- 9 Drivers
- Technical Limitations
  - Unsuccessful pilot studies and remedy implementation
- Limited Benefit
  - Future use, water quality, time-frame, and risk reduction\*
- Negative Impacts
  - Ecosystem is thriving\*
  - Health and safety\*
- Beneficial Drivers
  - Leveraging PRP involvement
  - Reduction in triple bottom line impacts\*



\* - Also considered a sustainable remediation objective

# What are the BARRIERS to risk-based cleanups?

## Physical/Environmental Characteristics

- Commingled plumes, resulting in different cleanup objective among stakeholders
- CSM insufficient to properly evaluate performance of a risk-based cleanup approach
- Long-term property restrictions, thus driving cleanup to more stringent standards



# What are the **BARRIERS** to risk-based cleanups?

## Socio-Economic Characteristics

- Fear that it will stop innovation
- Lack of research funding
- Local community\* priorities/values support cleanup to promulgated standards (e.g., tribal land)
- Need to plan and designate for re-use\*  
early in project planning



\* - Also considered a sustainable remediation objective

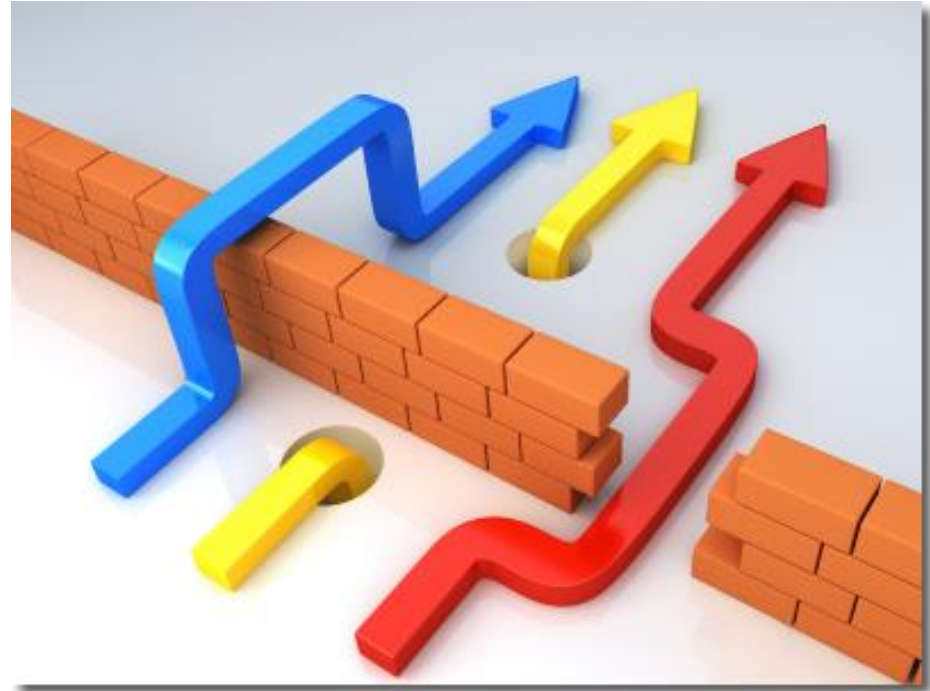
# What are the BARRIERS to risk-based cleanups?

## Risk Management Characteristics

- 20 Barriers
- Uncertainty
  - Tracking performance
  - Emerging contaminants
- Litigation
  - Stakeholder conflicts and perception
- Political Obstacles
  - Non-compliance, reopening decision documents, and opposing regulatory frameworks

# Utilizing Drivers to **OVERCOME** Barriers

- Address
  - Uncertainty
  - Risk Perception
  - Stakeholder Conflicts







# Early Decision Framework

# Step 1: Utilize Drivers

1

## **Develop Conceptual Site Model/Identify if Site Characteristics Support a Risk-based Approach**

Are drivers present that support consideration of a risk-based cleanup approach?

What are the barriers to risk-based cleanup and can they be mitigated?

*(Table 3 – Drivers)*

— NO → Risk-based cleanup not applicable at this time

YES



# Step 2: Develop Secondary Performance Metrics

- Establish declining/stable/asymptotic contaminant concentration trends
- Establish natural attenuation rate to control contaminants
- Establish no potential receptors nor pathways connected to sources
- Establish performance-based criteria using the natural systems such as:
  - Productivity (organism count, biomass)
  - Species richness/diversity
  - Functional diversity
- Establish plume containment
- Interim remedial measure criteria
- Recover, reprocess, and reuse wastes
- Reduce contaminant bioavailability and mobility
- Reduce contaminant concentrations  
Reduce plume longevity
- Reduce leachability
- Reduce mass
- Reduce mass discharge
- Short-term numerical remediation goals
- Site-specific risk-based ecological/human health risk assessment criteria
- Source zone control

2

## Develop Site-specific Performance Metrics

What site-specific performance metrics are applicable?  
(Table 4 – Metrics)

# Step 2: Develop Secondary Performance Metrics

- Establish declining/stable/asymptotic contaminant concentration trends
- Establish natural attenuation rate to control contaminants
- Establish no potential receptors nor pathways connected to sources
- Establish no net change in media using the natural systems such as:
  - Productivity (organism count, biomass)
  - Species richness/diversity
  - Functional diversity
- Establish plume containment
- Interim remedial measure criteria
- Recover, reprocess, and reuse wastes
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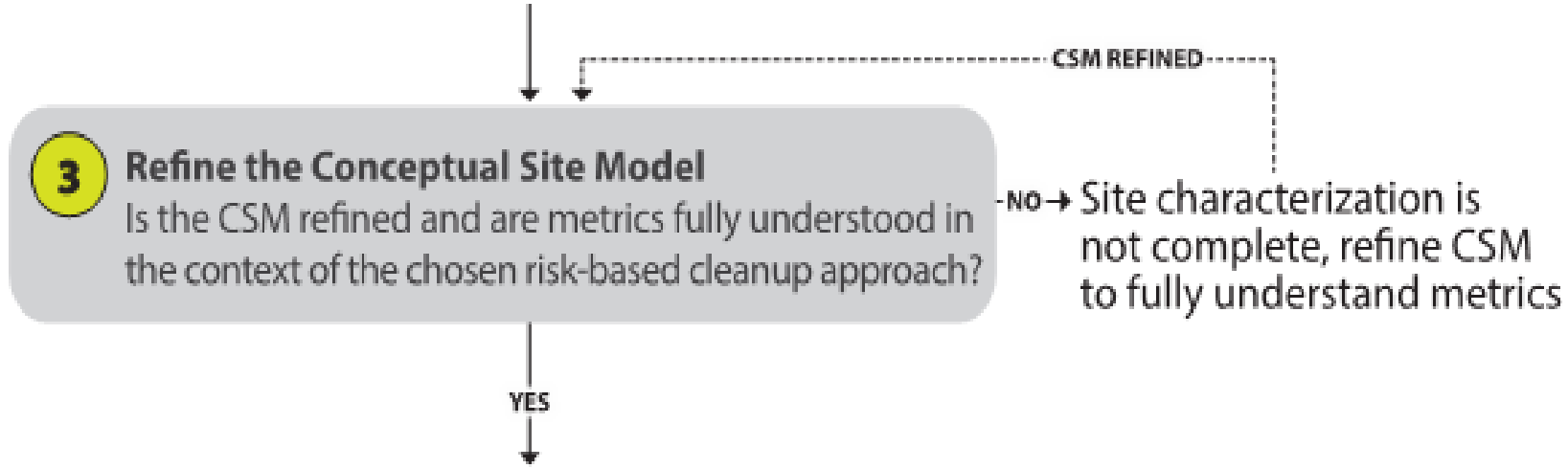
## Sustainability Metrics!

2

### Develop Site-specific Performance Metrics

What site-specific performance metrics are applicable?  
(Table 4 – Metrics)

# Step 3: Refine the CSM



*\*Have not moved to remedy evaluation stage!*



# Step 4: Utilize Risk Management Strategies

4

## Identify Risk-based Cleanup Approach

Based on drivers and metrics, which risk-based cleanup approaches are applicable? (*Table 2 – Approaches*)



*\*Now we can take off towards the  
remedy evaluation stage!*



# Step 5: SMART Objectives

**5** **Develop Site-specific Cleanup Objectives**  
Develop SMART objectives that support meeting the requirements of the risk-based approach, align with the performance metrics, and can be measured using available tools. (*Table 4 – Tools*)

- Quantitative
  - (e.g., reduction targets of contaminants and emissions)
- Qualitative
  - (e.g., source zone control and redevelopment timeframe)
- Support meeting the requirements of the risk-based approach
- Align performance metrics
- Can be measured using available tools



# Sustainable Risk Management



# Take Home Messages: Sustainable Risk Management

- Framework provides guidance to align risk assessment and sustainable remediation objectives



# Take Home Messages:

## Sustainable Risk Management

- Utilize risk assessor and sustainable remediation experts early in the project life cycle!
- Metrics and tools to utilize drivers and overcome barriers
  - *Address risk perception*
  - *Address uncertainty*
  - *Show transparency*



# Take Home Messages: Sustainable Risk Management

Sustainable  
Remediation BMP

- Identified importance of stakeholder engagement and managing remediation objectives
  - Community Surveys
  - Multi-Criteria Decision Analysis





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