An Industry Perspective on Remediation Portfolio Optimization Efforts

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Presentation Overview

- Drivers for Optimization
- Optimization Objectives and Strategies
- Best Practices and Lessons Learned Examples
- Conclusions

Drivers to improve and optimize remediation program

Project lookbacks revealed cost-saving opportunities:

- Observations:
  - Systems run past point of practical limit of mass recovery in attempt to achieve soil/groundwater remedial objectives
  - Scope creep beyond initial project design
  - Failure to satisfy remediation drivers and achieve objectives resulting in multiple remedial attempts

  → Leading to higher than expected remediation costs and timeframe

- Root causes: Inconsistent remediation decision-making
  - Technology selection
  - Remediation system design
  - System operation and optimization
  - System performance monitoring and criteria
  - Shutdown strategy and decisions

Remediation Portfolio Optimization Objectives

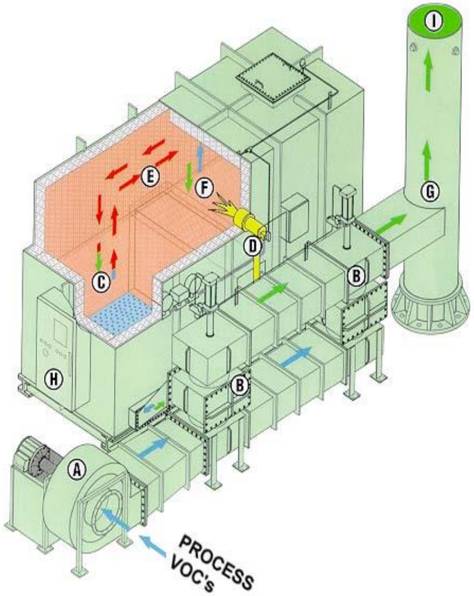
- Improve safety and reliability of mechanical systems
- Reduce average system operation lifecycle (improve efficiency)
- Reduce remediation recycles and scope creep
- Consistency in remedial alternative selection, design and project execution, based on:
  - Hydrogeological conditions and sufficient source delineation
  - Clarity and agreement on remediation drivers and objectives
  - Feasibility assessments; probability of success evaluation
  - Performance and shutdown criteria
  - Safe and reliable system designs

Optimization Strategies

- Build Organizational Capability: Adopt a “learning organization” approach
  - Centralized subject matter expert peer teams
- Standardization: Best practices for safe, reliable and efficient system operation
  - Standard system designs
  - Standardize procedures for performance monitoring, optimization, shutdown
- Incorporate probability of success and consequences analysis with lifecycle cost estimates
- Supply chain optimization: contracting strategies, change management

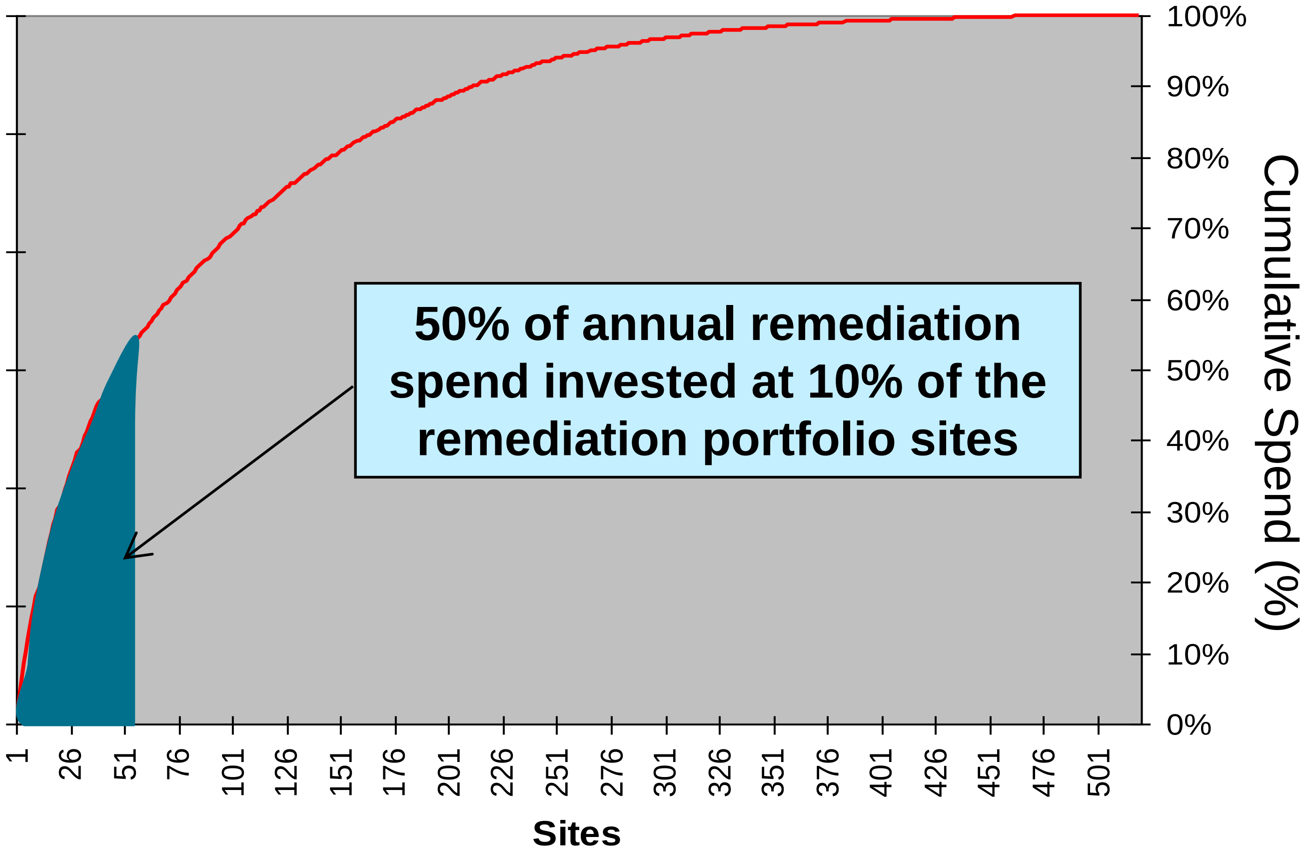
Organizational Capability:
Centralized Subject Matter Expert Peer Team

- Comprised of Chevron and consultant experts, Chevron project manager
- Leverage diverse expert experience
  - Geologists and engineers; technical and business perspectives
- Develop and communicate best practices/ lessons learned
  - Technology evaluation and selection, strategy alignment
  - Remediation design, optimization and monitoring
- Remediation performance reviews and lookbacks
- Quality control remediation strategies:
  - Improve alignment between technology selection/design and stakeholder remediation objectives



Peer Review Focus on Higher Cost Remediation Projects

- Mechanical Remediation Systems
- Excavations

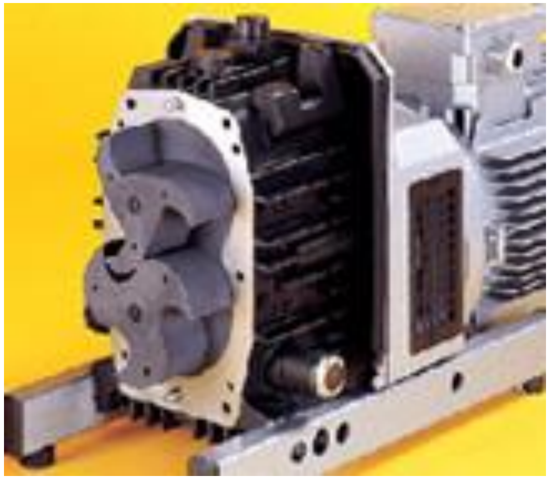


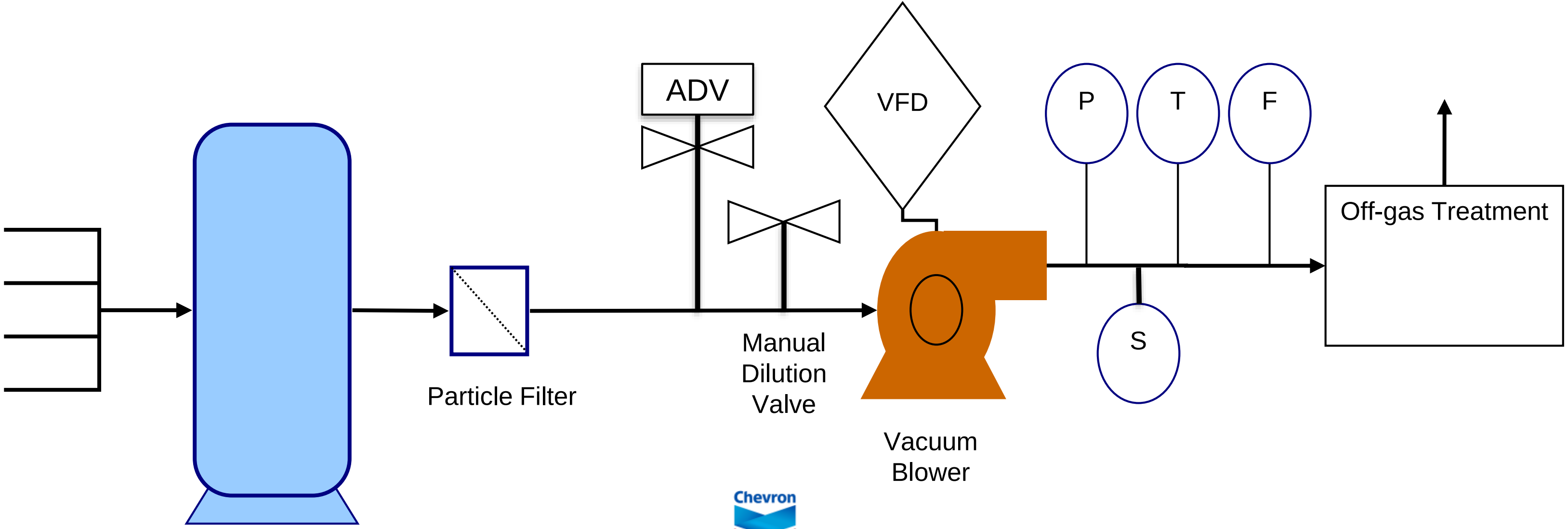
50% of annual remediation spend invested at 10% of the remediation portfolio sites

Standardization
System designs

Objectives

- Reliably achieve subsurface performance requirements
- Effective critical safety devices
- Equipment provides high uptime operation, minimize treatment process bottleneck
- Facilitate capital equipment reuse





Standardization of Best Practices
Performance monitoring, optimization, shutdown

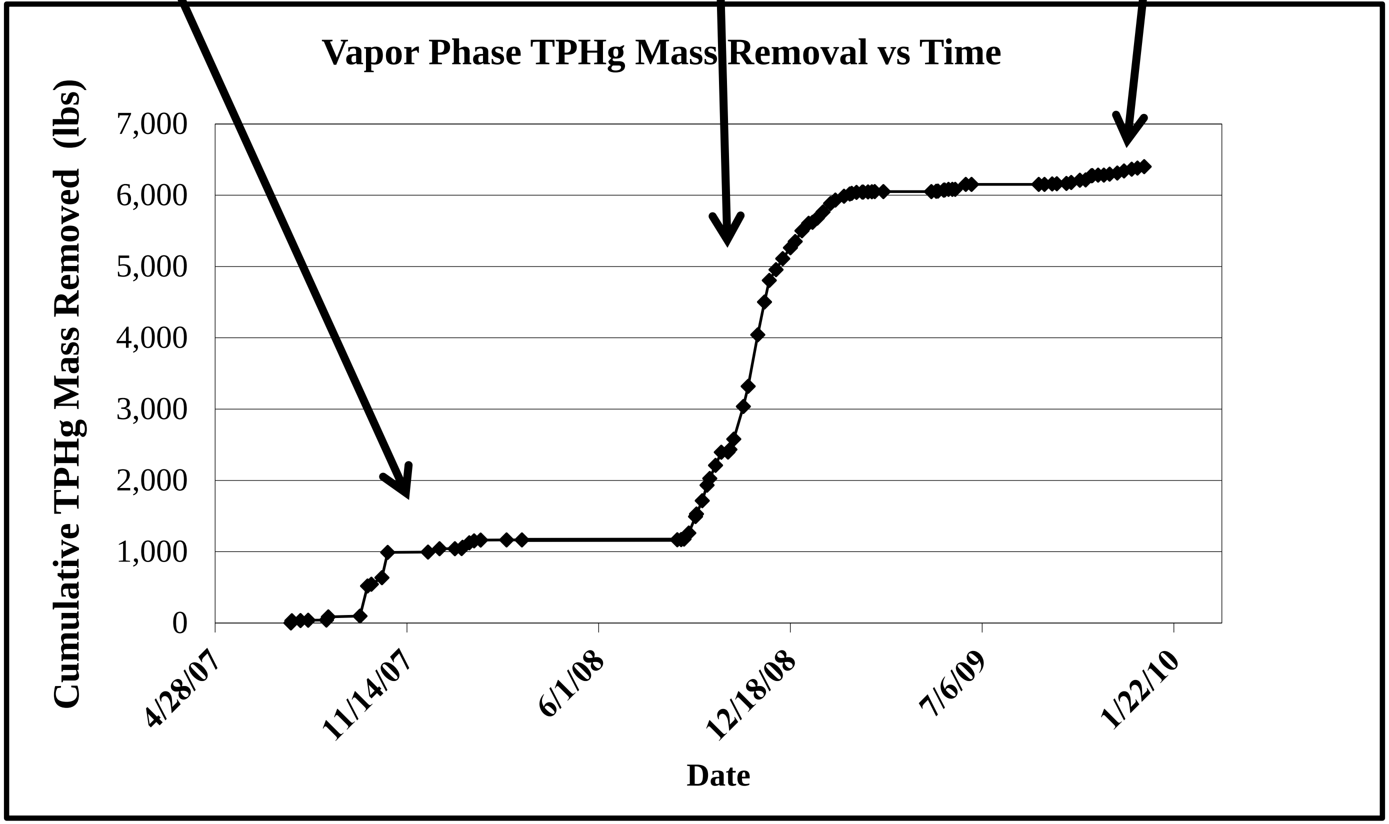
- Focus monitoring and timely optimization decisions on key performance criteria
  - Early - Recognize need to modify system design or operation
  - Later – Drive pace to achieve shutdown criteria
- Need to decouple system shutdown criteria from soil and groundwater remedial objectives
  - Do not continue to operate system that has reached practical limit of mass recovery
- Have a system “exit strategy” plan
  - Anticipate approach to practical limit of remedial benefit
  - Proactive communications and remedial success demonstration activities

Optimization and Efficiency Evaluation
System Vapor Mass Removal Data

Inefficient Initial Operation for 1 year

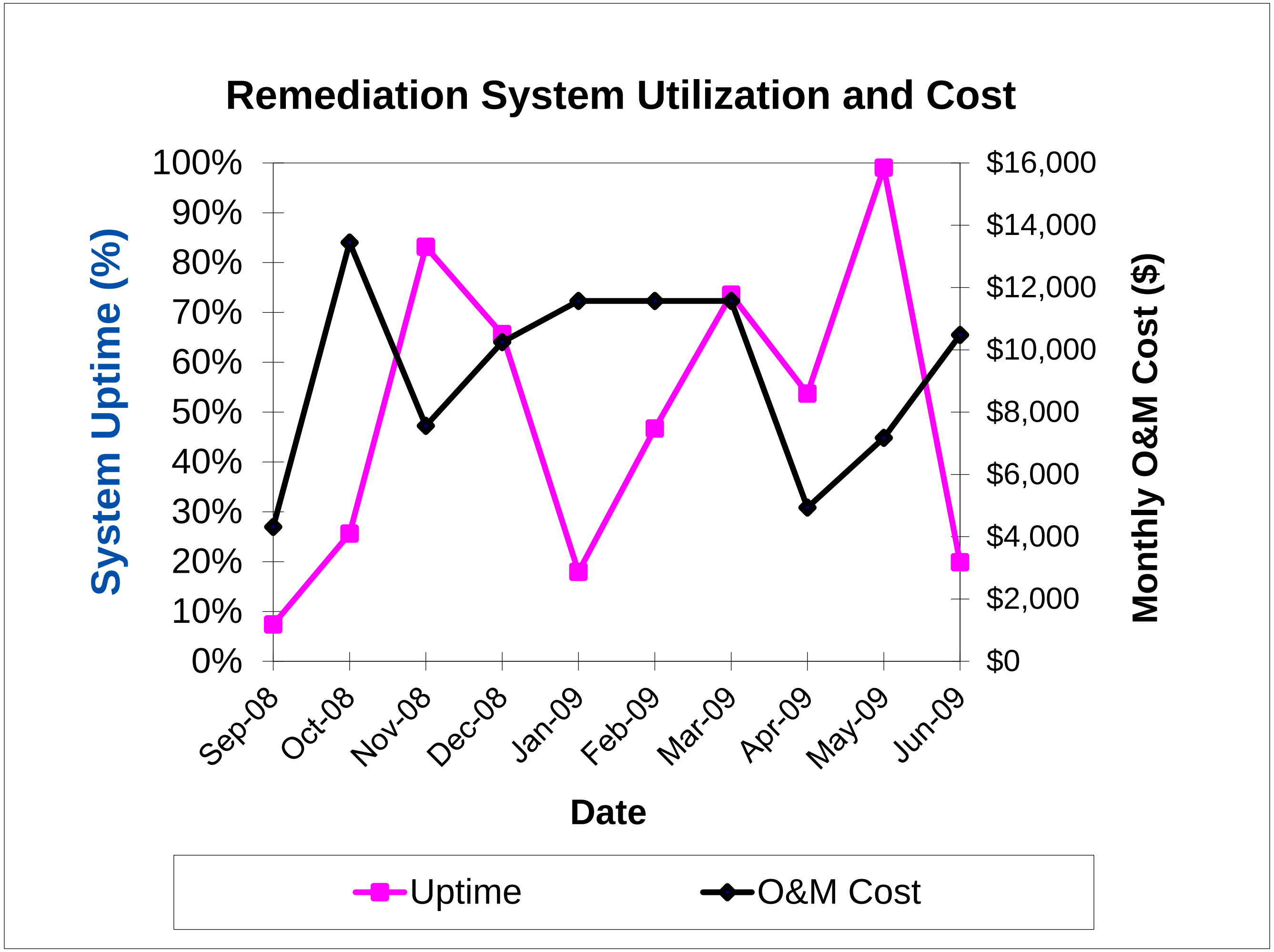
Effective Mass Recovery for 5 months

Shut down 10 months after recovery limit reached



Could have achieved same endpoint in less than 1 year (60% less time)

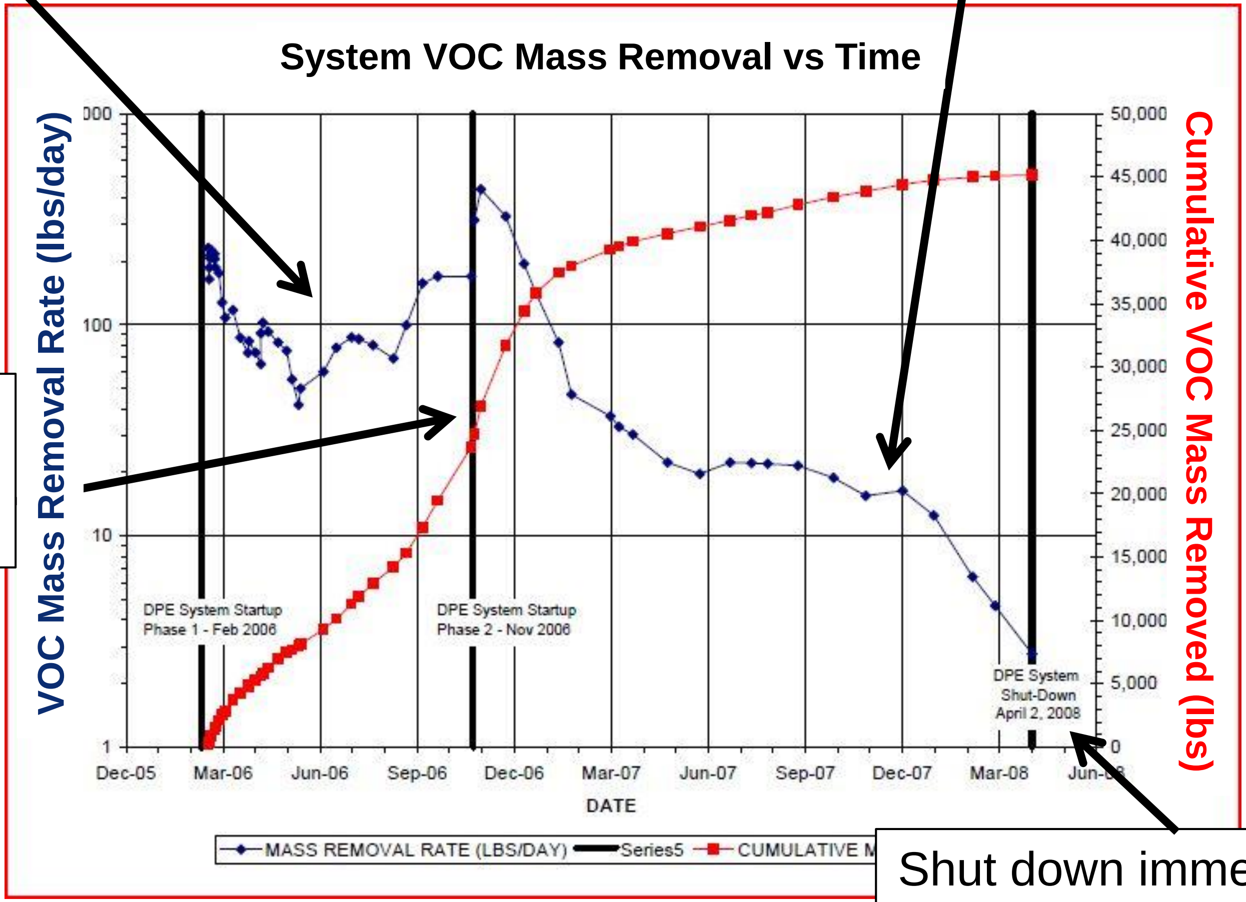
Higher O&M Costs During Poor Uptime Periods



Example of Efficient Optimization and Shutdown Decisions

High mass recovery sustained upon startup

Efficiently driven to low mass recovery



Efficiently integrated Phase 2 extraction array

Shut down immediately upon achieving mass recovery practical limit

Standardization of Best Practices
Activities Prior To Remediation Implementation

- Sufficient delineation and proactive stakeholder engagement prior to remediation selection and design will help:
  - Align remedial strategy with site conditions and stakeholder expectations
  - Right-size remediation design
  - Avoid scope creep
    - Excavation Scenario: Dig much more dirt than planned
    - Mechanical System Scenario: Need to expand well array, extend period of active remediation after completing planned remedial scope

- Proactive agreement with stakeholders include
  - Location-specific remediation success objectives
  - Basis (criteria) for system shutdown
  - Conditions needed to move to more passive remedial alternatives

Incorporate probability of success into alternative selection

- Focus on only NPV does not always drive best selection
  - – Lowest cost alternative not always the best
    - Particularly in cases where higher cost alternative has a high probability of success, and lower cost alternatives have significant uncertainty

- Understand key failure criteria
  - – Site-specific subsurface characteristics indicating likelihood of failure
    - Pilot tests, hydrogeological characterization
  - – System performance criteria that must be achieved to avoid failure

- Understand consequence of failure
  - – remedial recycle potential, liability management

➢ Focus on a toolbox of a few well-understood technologies
  - Want technologies with measurable performance criteria and remedial progress metrics, and can knowledgably adjust to efficiently manage, optimize and shut down
  - Less favorable (greater uncertainty) for “black box” and novel alternatives

Summary

- Critical to incorporate probability of success and contingency costs into alternative selection

- A clear understanding of drivers, location-specific remedial objectives and source delineation is critical to optimizing system design and level of effort

- The majority of remedial failures and cost overruns are due to:
  - Poor understanding of hydrogeological factors that influence failure risk
  - Inadequate source delineation
  - Inattention to key remediation system performance and shutdown criteria
  - Insufficient monitoring and optimization practices

- Use of standardized remedial equipment design provides not only safe and reliable operation, but also yields significant cost savings opportunities (capital reuse)

- Effective change management is critical
  - Maintain understanding of site history, prior decisions, recommendations and expectations when internal or external project managers change