PRINCIPLES OF ENVIRONMENTAL RESTORATION AND THEIR APPLICATION TO STREAMLINING INITIATIVES

U.S. Army Environmental Center

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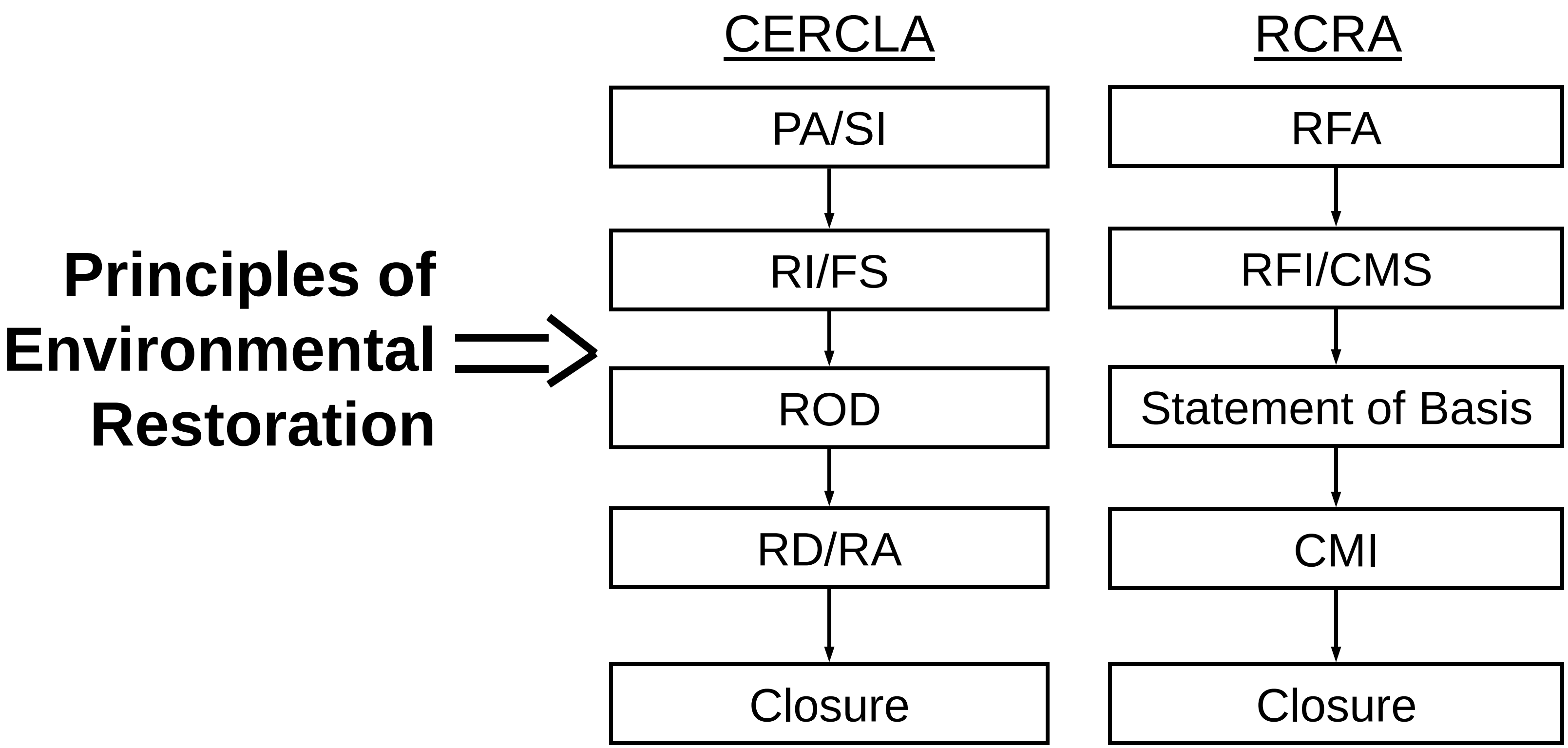
Principles of Environmental Restoration
and Their Application
to Streamlining Initiatives

Introduction

Agenda

- Introduction
- Principles of Environmental Restoration
  - ✓ Communication and Cooperation
  - ✓ Problem Identification and Definition
  - ✓ Identification of Likely Response Actions
  - ✓ Uncertainty Management
- Developing Exit Strategies
- PER Workshops

An Approach, Not A Process



Genesis

- Pilot demonstrations of streamlining initiatives
  - ✓ SACM
  - ✓ SAFER
- Distillation of Principles from successes and failures
- Data Quality Objectives Guidance
- Development of joint DOE/EPA training and manuals
- Lessons learned from ITRT have distilled into present course

Common Approaches Encountered

- Assume ARAR Exceedance Necessitates Remediation
- Use PRG to Screen for Removal Actions
- Characterize Incomplete Pathways
- Define PTM with Risk Threshold

Cost/Benefit Analysis

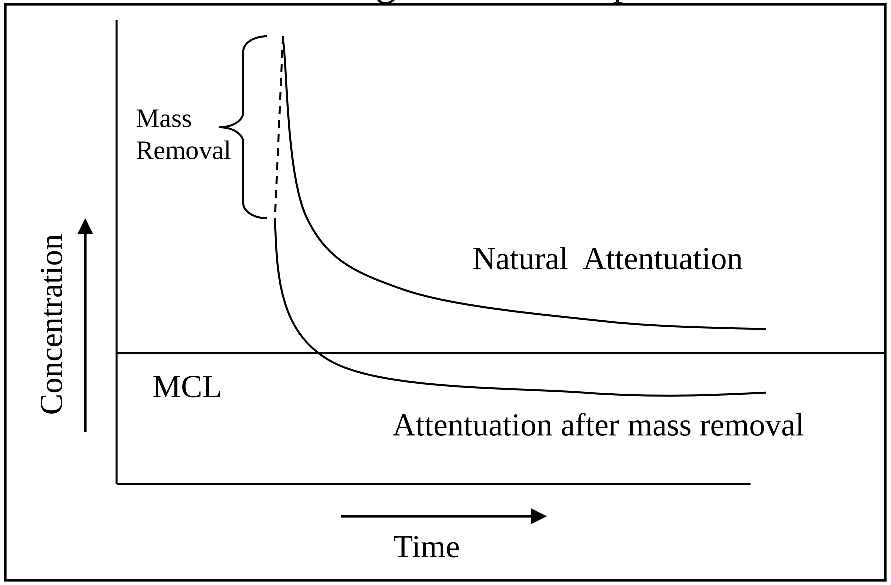
- 7/27 Redundant Plume Studies vs Watershed
- 13/27 DQO Process
- Confuse Data Gaps with Data Needs
- 6/27 Remedy Cost More Than Resource Value
- 9/27 Amenable to MNA
- 12/27 Require Exit Strategy

Risk-Based Decision Making

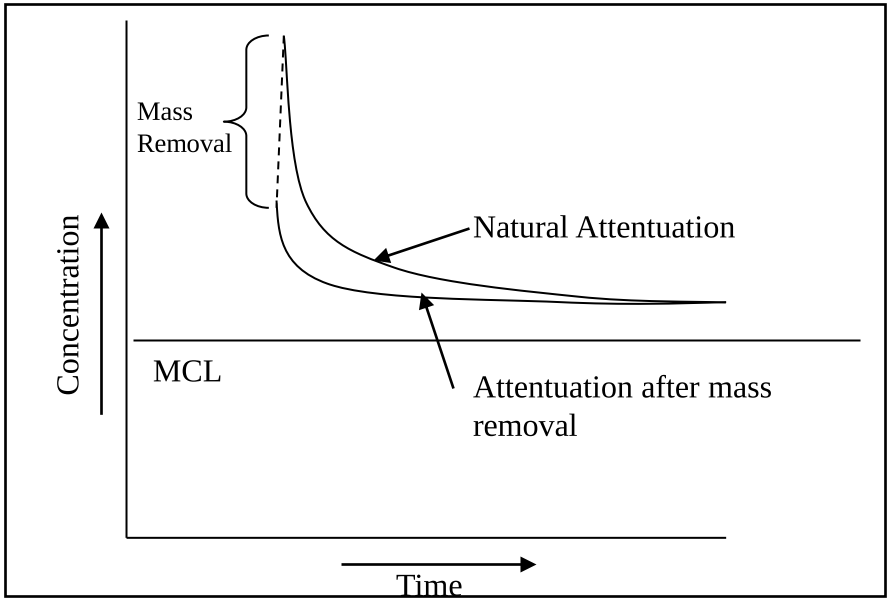
- 9/27 Risk Calculated for Scenarios not in Future Use Plan
- 10/27 CSM Developed as Product, Not Planning Tool
- 8/27 Risk Based on Background Metal Concentrations

Mass Removal Does Not Ensure Accelerated Resource Restoration

Model assumed when mass removal is proposed for matrix controlled ground water plume



Actual response to mass removal. Matrix controls position of asymptote regardless of starting inventory



Other Recommendations

- Need to Identify Legal Drivers in Advance
- Need Top Down, Tiered Approach to Ecological Risk Assessment
- Need to Document and Communicate Decisions Earlier

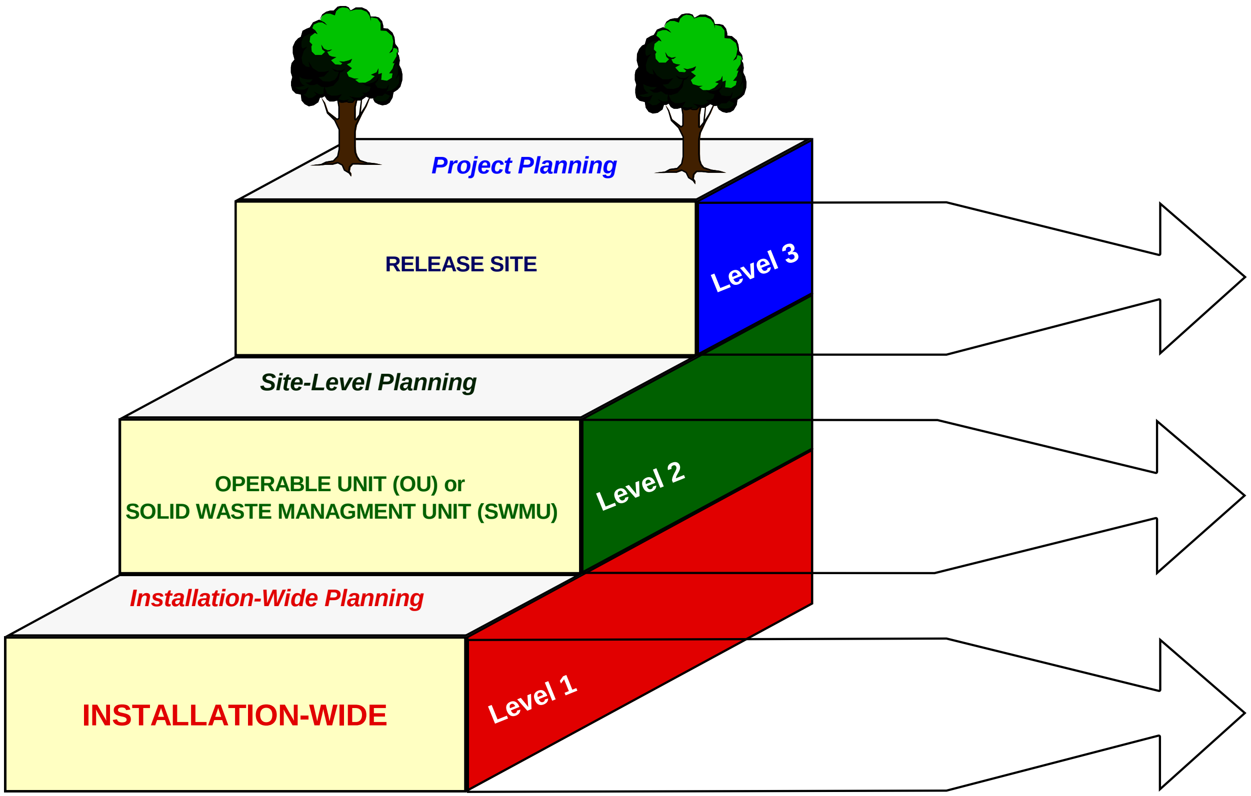
Four Principles of Environmental Restoration

- Developing effective communication and cooperation with a project management team is essential
- Clear, concise, and accurate problem identification and definition are critical
- Early identification of likely response actions is possible, prudent, and necessary
- Uncertainties are inherent and will always need to be managed

Key Assertions

- Principles are implicit in the NCP and RCRA corrective action policies
- Adherence to the principles saves time and reduces costs
- Traditional "barriers" to streamlining can be overcome through teamwork and early agreement
- Proper focus of environmental restoration is implementing response actions
- All stakeholders want to achieve acceptable levels of risk

Applying the Principles at Different "Activity" Levels



Outcomes /Objectives

- Rapid decision on whether to take action and what kind of action
- Rapid identification of data needs

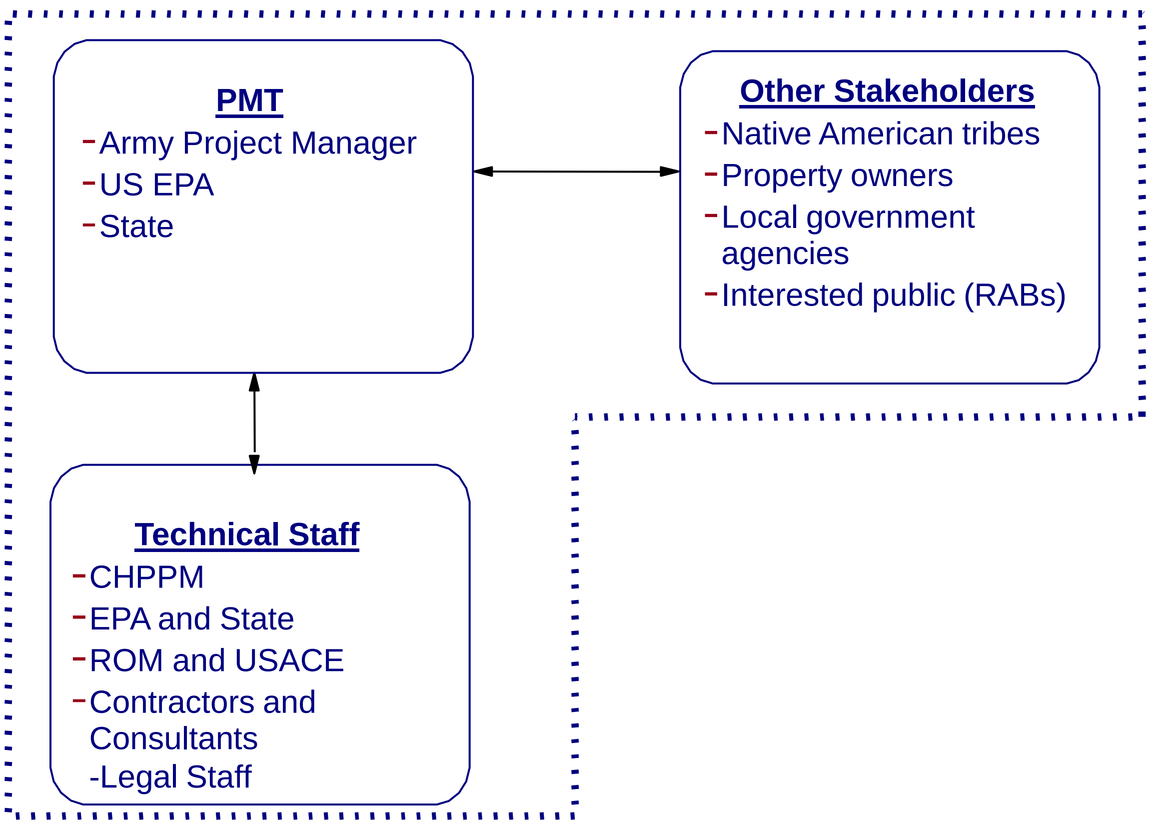
- Cost/schedule reduction
- Efficiencies of scale

- Coordination with other programs
- Strategic use of site resources

Principles of Environmental Restoration

Principle: Developing Effective Communication and Cooperation with a Project Management Team is Essential

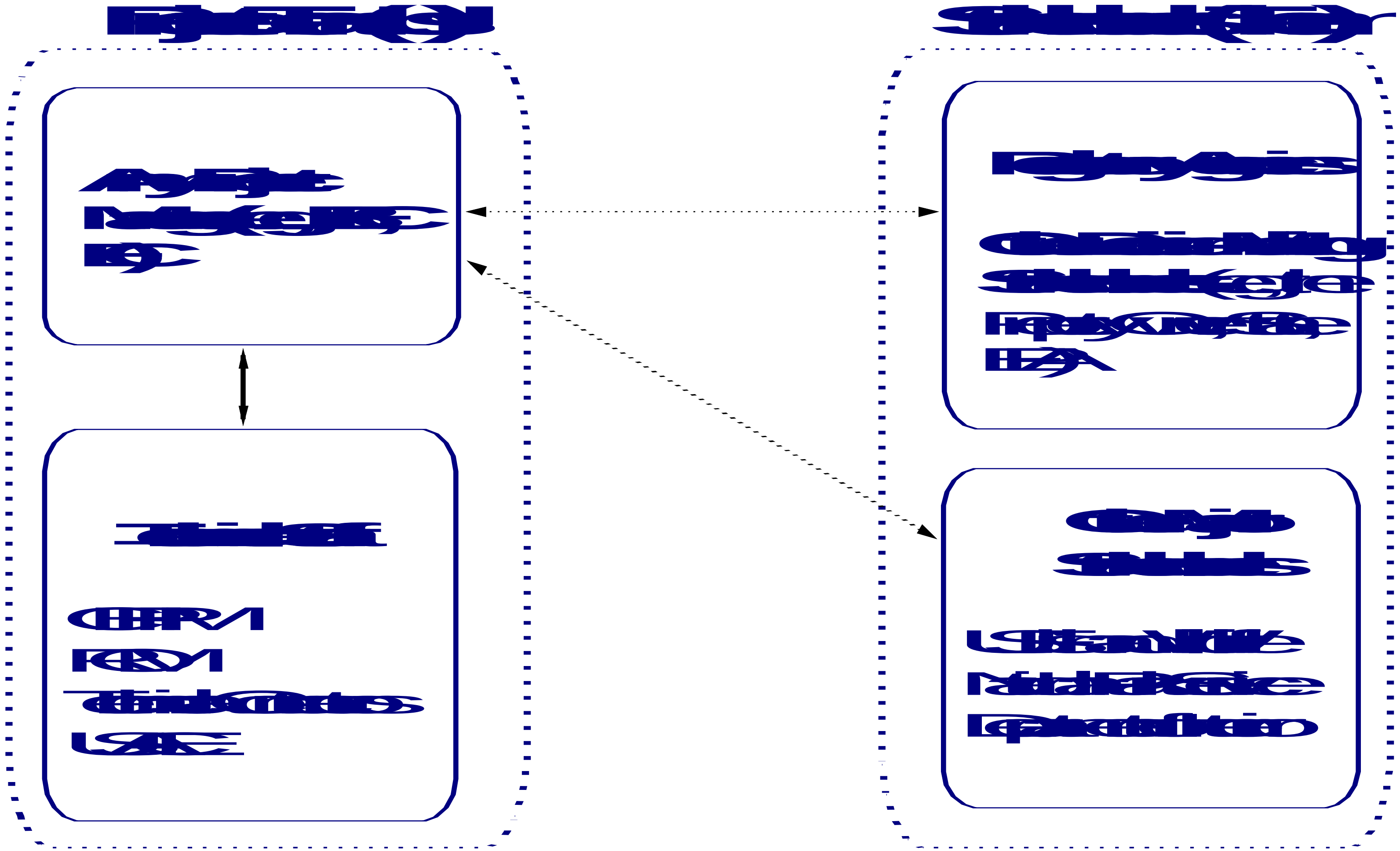
Proposed Paradigm: Project Management Team Approach



Project Management Team

- Includes those with the responsibility to represent their agencies interests (roughly equates to BCT or the TRC)
- Owns the process as well as the product
- Discusses all major aspects of the project
- Each member represents the public's best interests

Current Paradigm (What We'd Like to Change)



PMT's Key Activities

- Planning:
  - ✓ What are the decisions to be made?
  - ✓ What are the decision criteria?
  - ✓ What data support making the decisions?
  - ✓ What confidence level does the decision require?
  - ✓ What are the consequences of a decision error?

PMT's Key Activities (cont'd)

- Communication
  - ✓ Upward to management
  - ✓ Outward to stakeholders
- Documentation
  - ✓ Formalize agreements
  - ✓ Ensure knowledge management

Documentation

- Documents / Reports Are:
  - ✓ A vehicle to archive decisions and logic
  - ✓ A means of managing knowledge for future stakeholders
  - ✓ A complement to other means of communication with stakeholders
- Documents / Reports are Not:
  - ✓ Milestones or endpoints
  - ✓ A supplement or primary mode of communication with stakeholders

The New Paradigm

- Common Approach
  - ✓ Use DOCUMENTS
  - ✓ To COMMUNICATE
  - ✓ In hopes of reaching AGREEMENT
- Preferred Approach
  - ✓ COMMUNICATE
  - ✓ To reach AGREEMENT
  - ✓ Memorialize in DOCUMENT

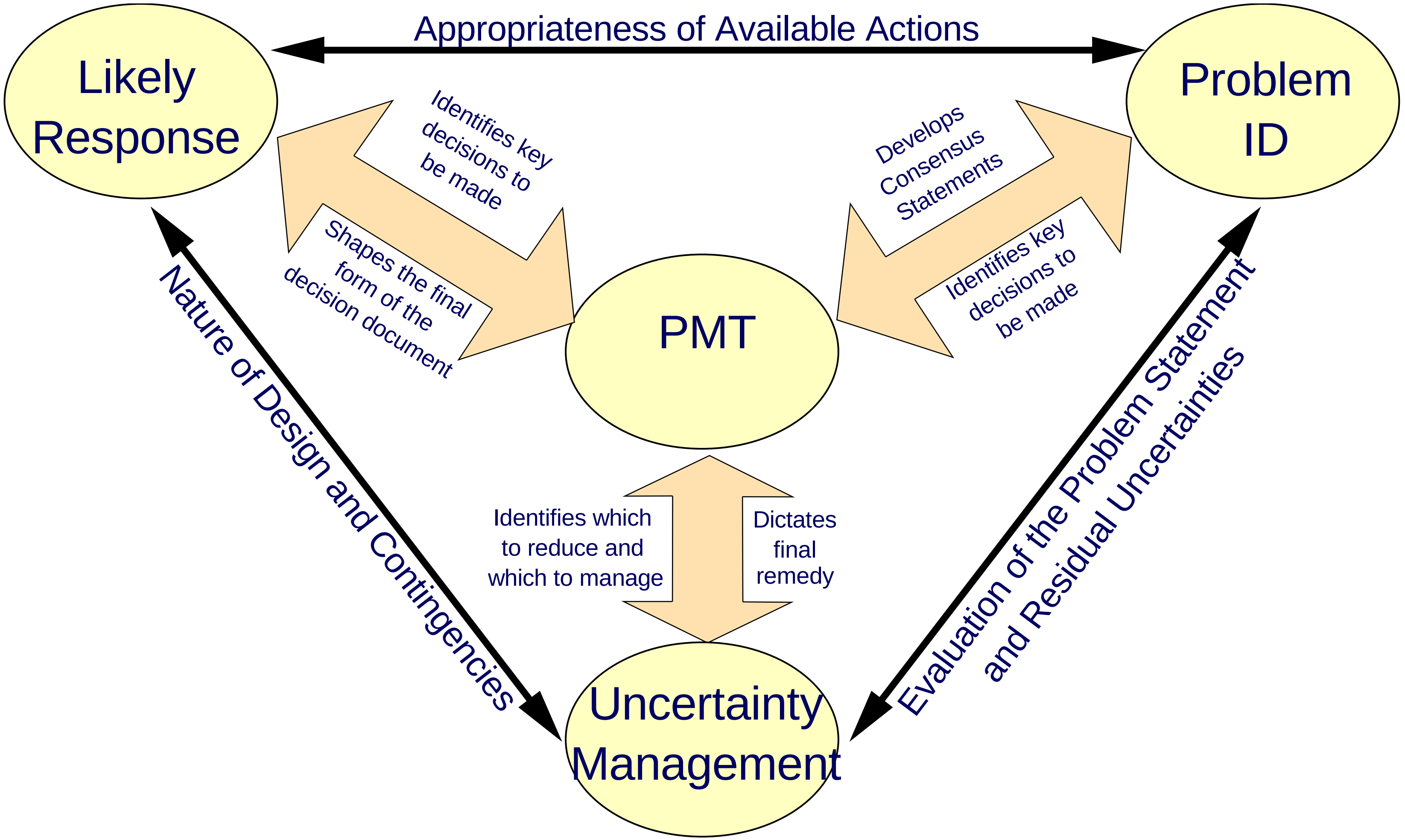
Challenges to an Effective Project Management Team

Challenges:

- ✓ Lack of empowerment
- ✓ Budget constraints
- ✓ Fear of sharing (and taking) responsibility
- ✓ Existing relationships

- The best approach to meeting these challenges is to develop a working PMT and jointly make decisions

PMT Implements the Other Three Principles



Principles of Environmental Restoration

Principle: Clear, concise, and accurate problem identification and definition are critical to successful closeout

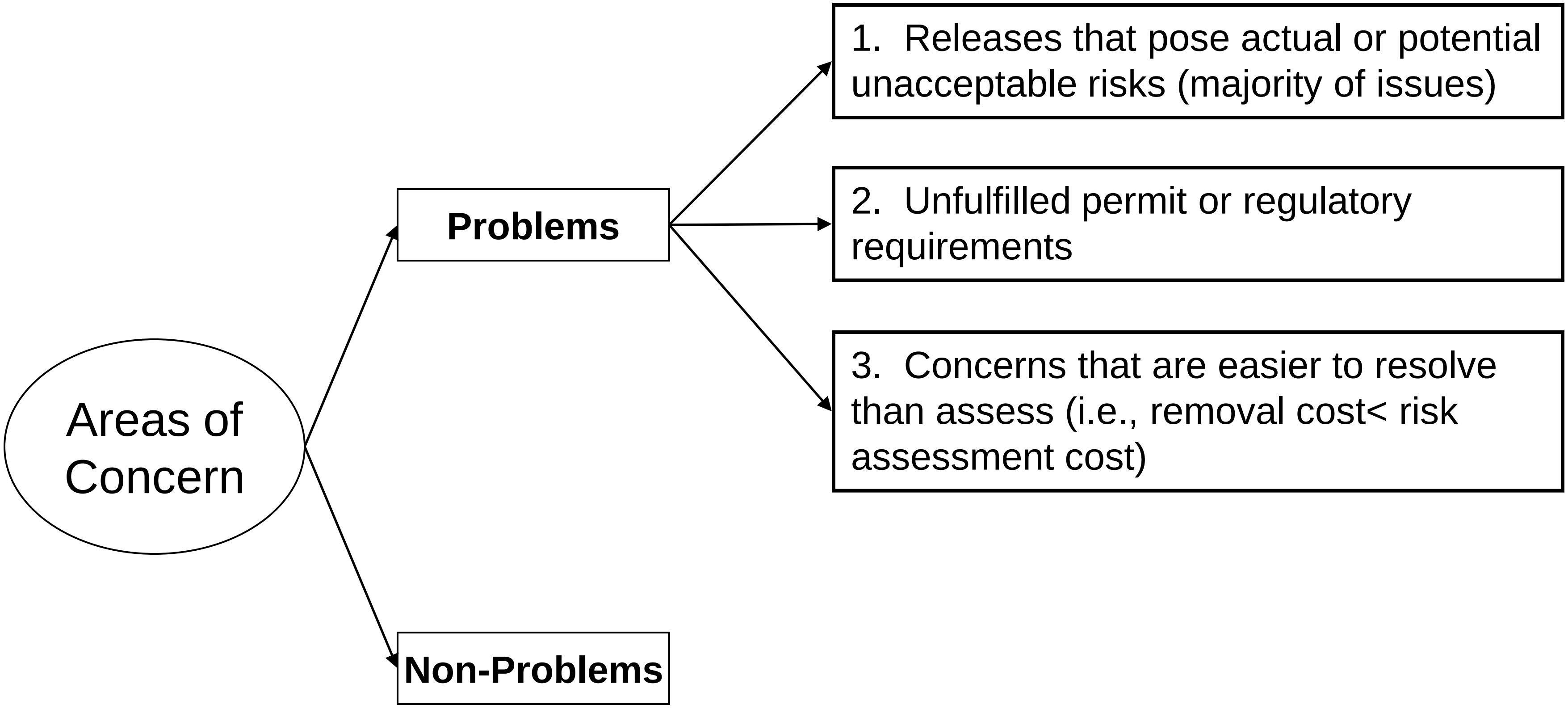
Environmental Restoration is Driven by Two Key Questions

- Do we have a problem?
- If yes, what should we do about it?

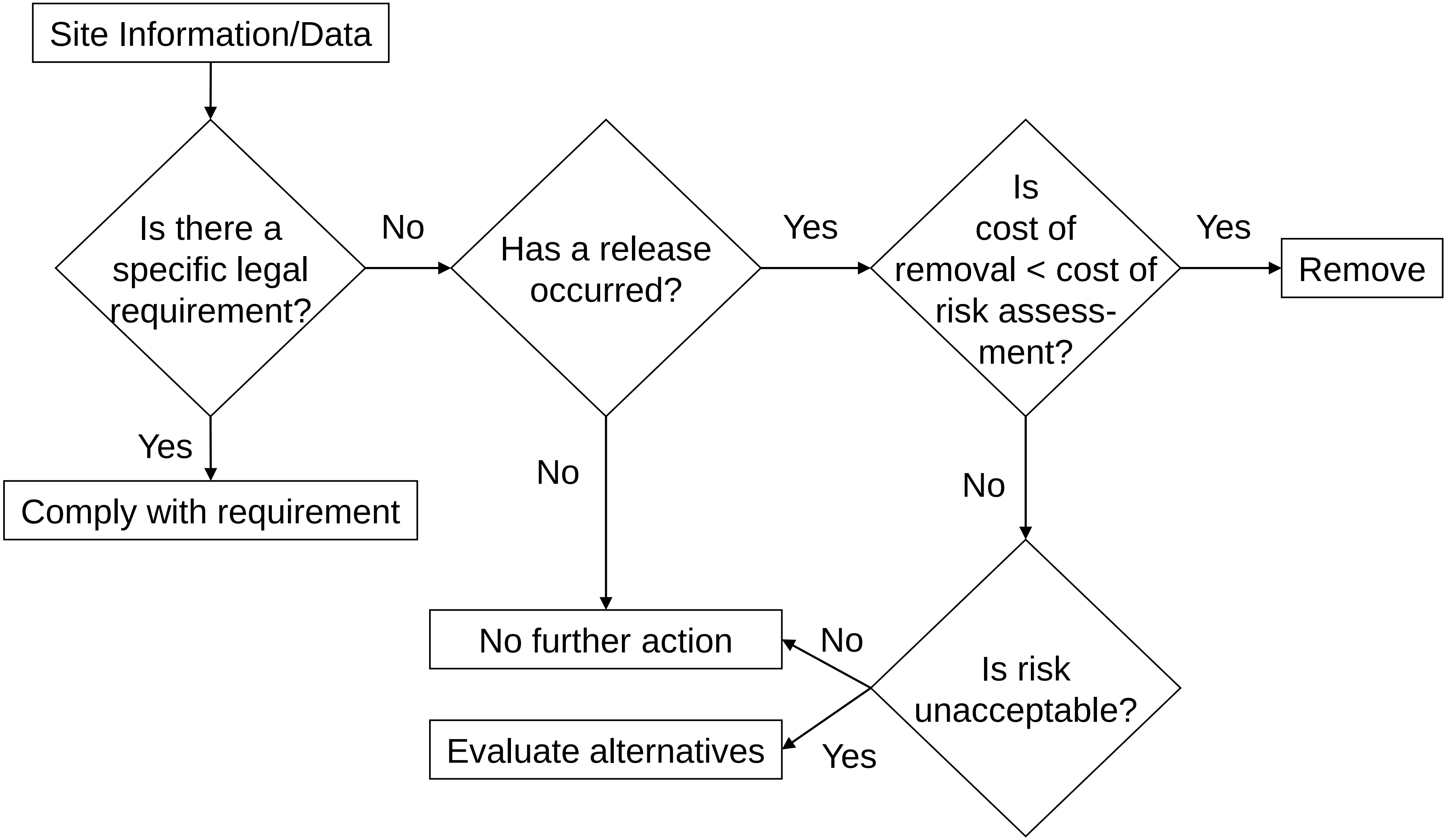
What is a Problem?

- A problem is a condition posing real *or potential* unacceptable risk, or a condition that requires a response.

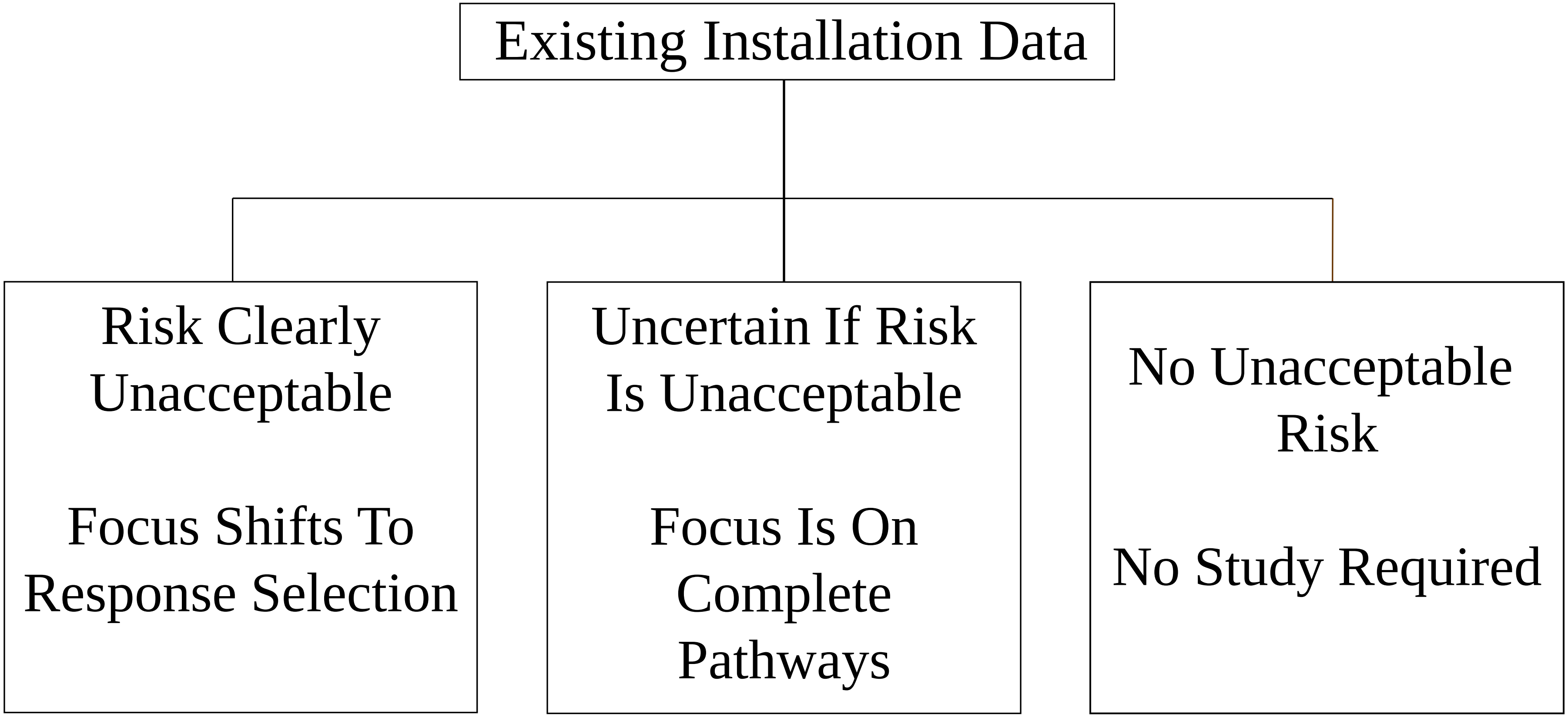
Types of Problems



Logic Flow for Addressing Site Problems



Focus of Risk-Based Studies



Why Focus on Problem Definition?

- Problems are what you scope, decide to act on, and ultimately remediate
- The process of defining problems identifies information needs
- Problems are not necessarily operable units or areas of concern

Poor Problem Definition Leads To:

- Poor project focus
  - ✓ Overly extensive or ineffective investigation (e.g., trying to remove insignificant uncertainties)
  - ✓ Extended process to decide on remedy
- Poor project execution
  - ✓ Not fixing the problem
  - ✓ Fixing the wrong problem
  - ✓ Fixing the problem at greater cost than needed
- Prolonging site closeout
- Inappropriate exit strategy

How Do We Communicate Problems?

- A problem statement is a clear, concise description of a condition that needs a response

- A problem statement provides linkage to the key decisions that need to be made at any point in time by:
  - ✓ Specifying the condition requiring a response
  - ✓ Reflecting the current conceptual model of the site
  - ✓ Evolving with our knowledge of the site

Documenting Problems Through Problem Statements

- Problem statements define the circumstances that require a response

- Key components of a problem statement include:
  - ✓ Media
  - ✓ Contaminants and concentrations
  - ✓ Volumes
  - ✓ Regulatory or other drivers

Problem Statements Help Define Data Sufficiency

- Necessary data: Results could substantially change the content of the problem statement

- Sufficient data: All problem statements can be written for a release site

- When a problem statement can be written, the focus of decisions and therefore data collection shifts to what response is appropriate

Examples of Problem Statements

- Lead is found in excess of preliminary remediation goals, 400 ppm, in top 2 feet of soil over an area equal to or greater than one-quarter acre.

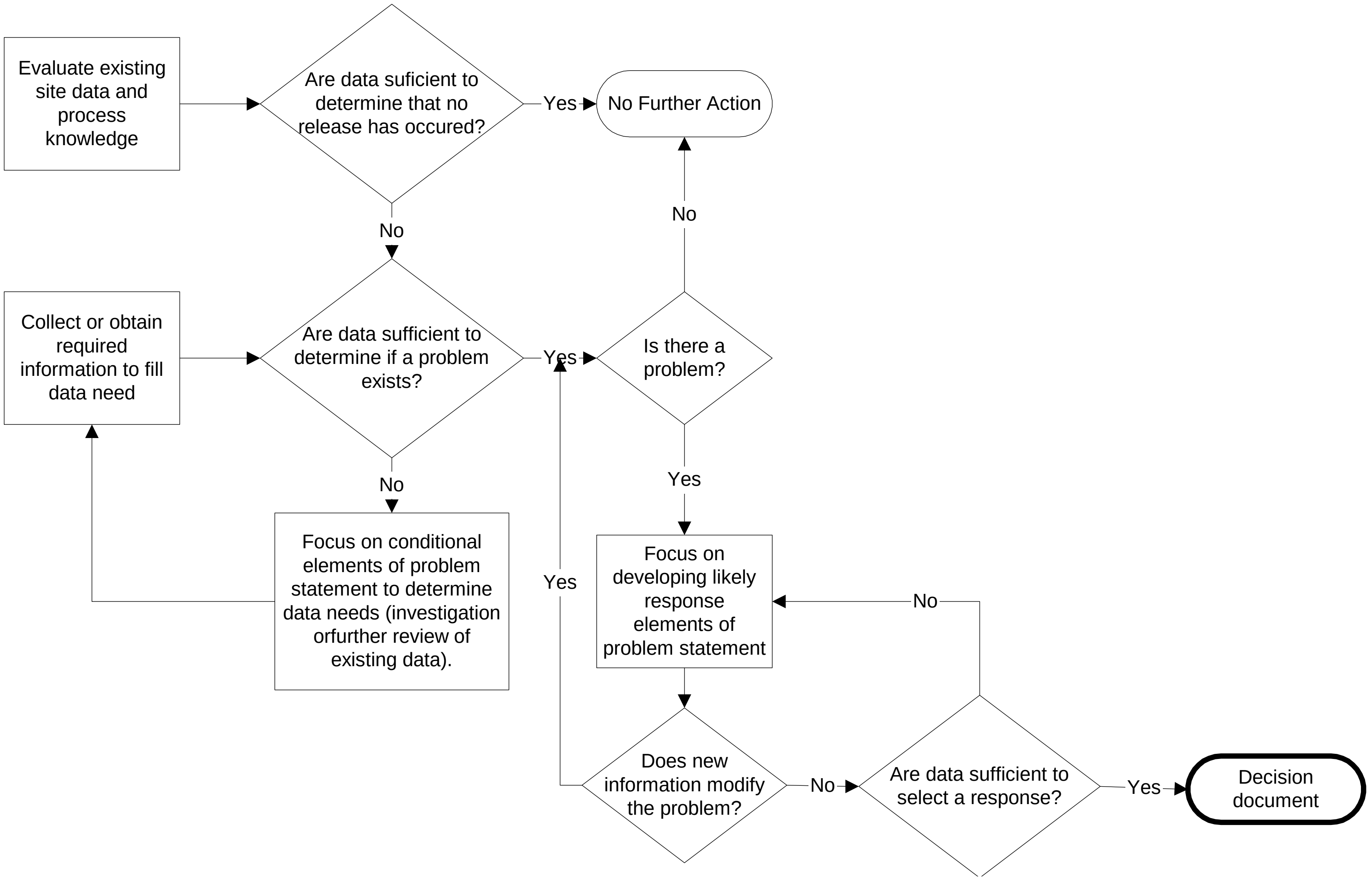
- Ground water quality data confirm contamination beneath the installation above MCLs for TCE while historic* use of bulk liquid solvents indicate a strong likelihood that at least a portion of the contaminant residues are present as DNAPLs. Off-site migration is indicated, but not confirmed, and the nature of residual source materials in the vadose zone is unknown.

*Records indicate storage of bulk liquid in tanks and maintenance of large inventories on site.

No Risk-Based Problem

- No history of release or information suggesting a probable release; or
- Data indicate concentrations below site screening levels at agreed level of confidence.
- Site conditions are such that there are no possible pathways to a receptor.

Decision Logic



Documenting Problems through a Conceptual Site Model

- A conceptual site model is a depiction of key elements and interfaces which describe the fate and transport of contaminants from source to receptor at a given installation

Uses of the CSM

- Organize and communicate installation data
- Represent interrelationships that need to be understood to identify and prioritize problems/responses
- Identify uncertainties
- Provide basis for evaluating effectiveness of potential responses
- Communicate effectively with stakeholders

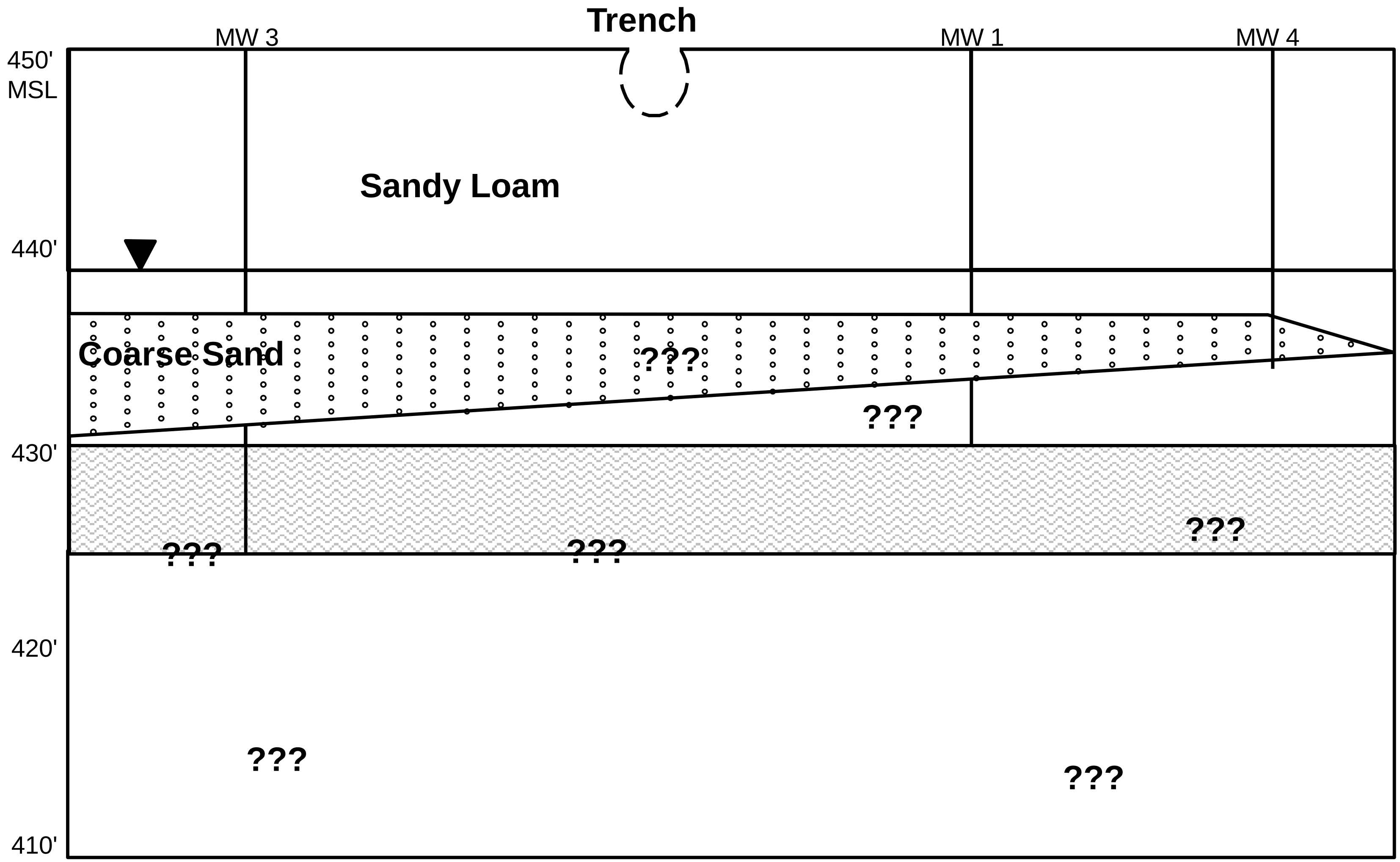
What is a Good CSM?

- A good CSM does the following:
  - ✓ Identifies and locates contaminants, sources, release and transport mechanisms, pathways, exposure modes, and receptors
  - ✓ Delineates contaminant, concentrations in media, and flux rates by pathway in narrative and graphical forms
  - ✓ Quantifies background concentrations for each formation or unit
  - ✓ Explicitly recognizes and evaluates uncertainties (known and unknown conditions)
  - ✓ Evolves with data

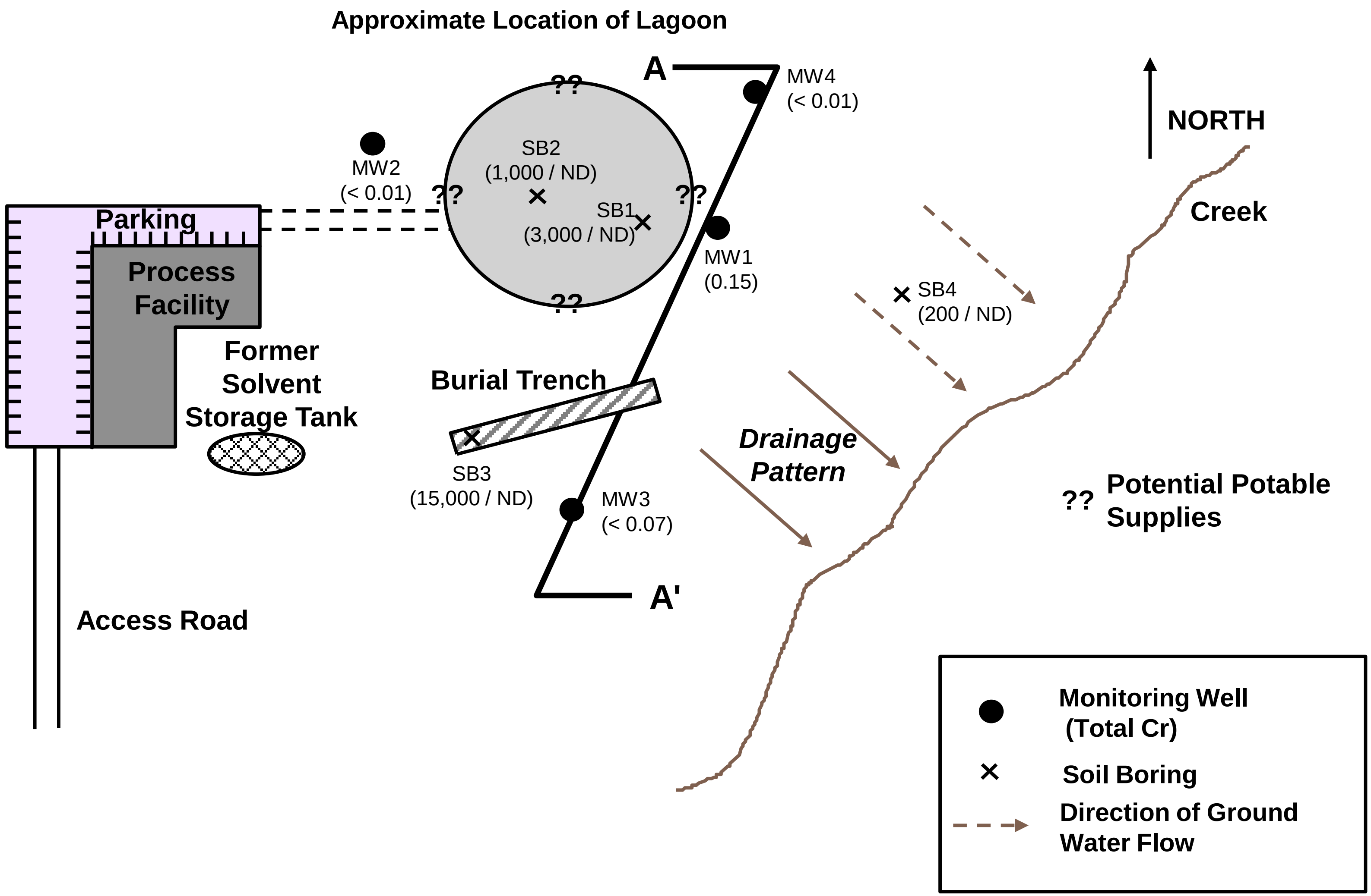
What are the Common Forms and Elements of CSM?

- Narrative Summary
- Installation Maps
- Vertical Profile
- Tabular Data
- Flow Diagram

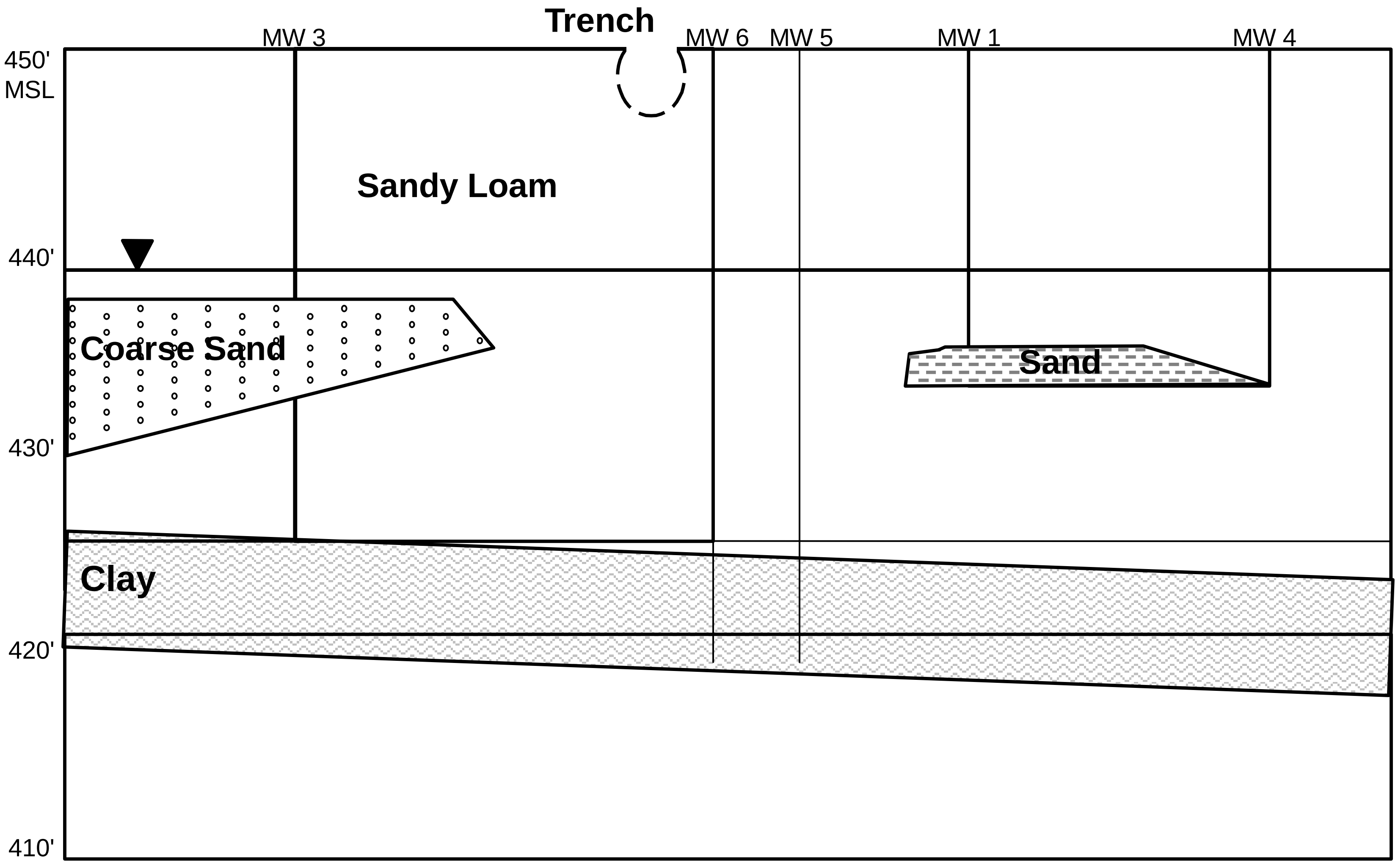
Example Initial Vertical Profile



Example Initial Installation Map



Example Expanded Vertical Profile

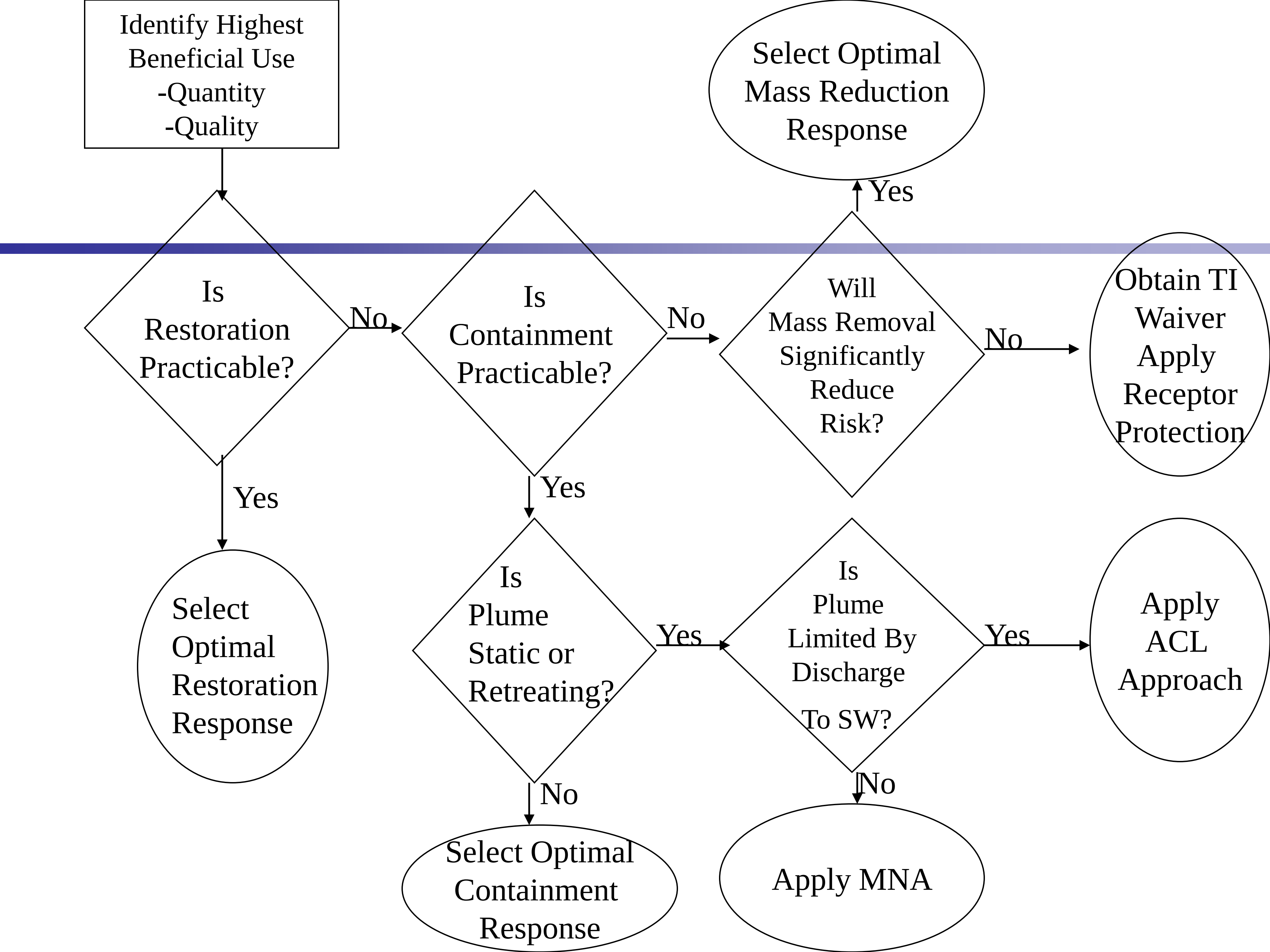


Evidence of the Presence of DNAPLs

- Required
  - ✓ Physical-chemical properties
- Indicative
  - ✓ Pattern of use
  - ✓ Pattern of evidence
- Confirmatory
  - ✓ Direct observation

Strategy for Investigation of Site Ground Water

- Restore Ground Water to Its Highest Beneficial Use
  - ✓ Maximum Yield
  - ✓ Quality
  - ✓ DNAPL
- Stop Plume Growth and Migration
  - ✓ Temporal Trends at Perimeter
  - ✓ Direction of Flow and Points of Dscharge
- Reduce Toxicity, Mobility, and/or Volume
  - ✓ Quantify Risk Reduction Associated with Proposed Remedy


Identify Highest Beneficial Use
-Quantity
-Quality
Is Restoration Practicable?
No
Yes
Select Optimal Restoration Response
Is Containment Practicable?
No
Yes
Is Plume Static or Retreating?
No
Select Optimal Containment Response
Yes
Will Mass Removal Significantly Reduce Risk?
Yes
Select Optimal Mass Reduction Response
No
Obtain TI Waiver Apply Receptor Protection
Is Plume Limited By Discharge To SW?
Yes
Apply ACL Approach
No
Apply MNA

Principle: Early identification of likely response actions is possible, prudent, and necessary

What are we going to do about a problem if response is required?

Early Identification of Likely Response Action(s) Allows:

- Early focus on appropriate remedial action objectives and an exit strategy
- Early consideration of potential response action implications
- Development of a hierarchy of probable technologies for a defined problem
- Early consideration of presumptive remedies, generic approaches, and a phased response to remediation
- Implementation of removal and/or interim actions

When to Identify Likely Response Actions

- As early as possible
- Absolute minimum information
  - ✓ Identity of contaminant(s)
  - ✓ Identity of media
- May occur before problem statement is complete

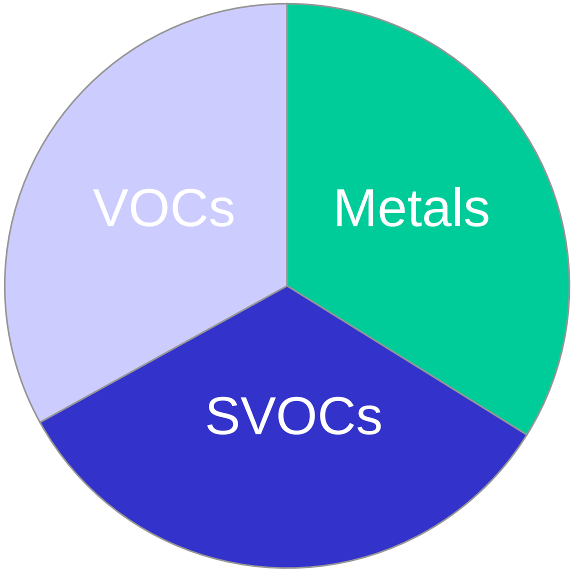
Determining Likely Response Actions

- Likely response actions are based on historical knowledge of what remedies work and do not work on different problems and installation conditions

- Hierarchy of preferred technologies is a short list of likely responses arising from cumulative experience/knowledge

Available Presumptive Technologies for Contaminated Soils

- Soil Vapor Extraction
- Thermal Desorption
- Incineration



- Reclamation
- Immobilization
- Containment

- Bioremediation
- Thermal Desorption
- Incineration

Preferred Remedies for Groundwater Remediation

- Monitored Natural Attenuation
- High permeability:
  - ✓ Recirculating Wells
  - ✓ In Situ Air Sparging
  - ✓ Bioremediation/ Fenton's Reagent
  - ✓ Pump and Treat
- Low permeability (may justify technical impracticability waiver):
  - ✓ Treatment Barriers
  - ✓ Enhanced Permeability
  - ✓ Electrokinetics

Data Requirements for Remedy Selection

- Necessary Data - Any information, the value of which could change the selection of a remedy to an alternative
- Sufficient Data - Characterization of an installation relative to the selected technology’s fatal flaws and key design parameters

Fatal Flaws and Selection Parameters

- Once likely response actions have been identified, determining fatal flaws will help the PMT choose between remedies
- Fatal flaws are installation conditions or parameter values that would make a remedy impossible to implement effectively or less desirable relative to other remedies
- Selection parameters are conditions or characteristics for which values will affect whether one remedy is preferred over another and how the selected remedy would be designed
- Design basis questions are a tool provided to identify fatal flaws and selection parameters for most common remedies

Examples of Fatal Flaws and Selection Parameters

- Examples of fatal flaws for possible remedies:
  - ✓ Caps - waste buried below water table
  - ✓ Excavation - contaminant lies below buildings in active use
  - ✓ Permeable Treatment Wall - absence of an impermeable layer to key the wall into
- Examples of selection parameters:
  - ✓ Caps - Nature of release mediums at issue (e.g., volatilization vs. infiltration or direct contact)
  - ✓ Excavation - Depth of contamination
  - ✓ Permeable Treatment Wall - Aquifer permeability

Documenting Likely Response Actions

- Decision rules link problem statements with likely response actions
  - ✓ Example: If lead is found in the top 2 feet of soil at concentrations in excess of a preliminary remediation goal of 400 ppm across one quarter acre or more, then the soil will be removed and treated for reclamation and/or immobilization of the lead.

Principle: Uncertainties are inherent and will always need to be managed

Why Focus on Uncertainty?

- Uncertainty management is essential for accelerated progress in site restoration because it helps make decisions when "perfect information" is not available
- Resolution of all uncertainties or unknown conditions is unlikely
- Yet, project managers must still:
  - ✓ Make decisions when uncertainties exist
  - ✓ Effectively communicate how uncertainties are addressed
  - ✓ Be able to distinguish between significant and insignificant uncertainties

Uncertainties = Data Gaps

- Example Data Gaps:
  - ✓ The volume of sludge in a surface impoundment to be excavated is unknown
  - ✓ Existing data cannot determine whether contours of a TCE-contaminated plume are static or retreating and monitored natural attenuation is being evaluated for application
  - ✓ An innovative technology is recommended, but there is skepticism as to its ability to meet objectives

Examples of Uncertainties

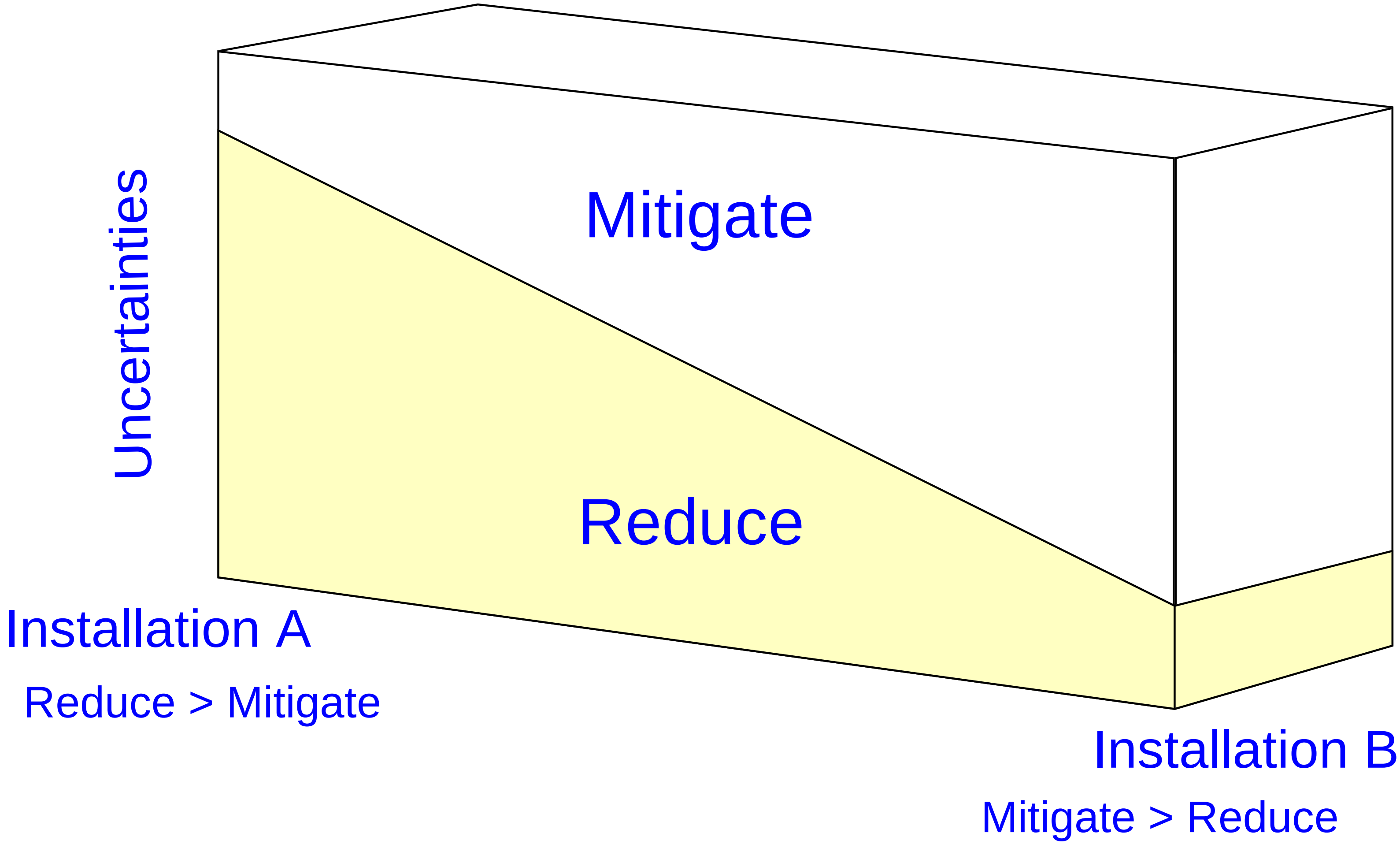
- A developer of nearby residential properties has secured a right-of-first refusal from the existing owner/operator to purchase a 10-acre parcel previously remediated to industrial cleanup standards. The parcel has an institutional zoning control in place specifically designed to maintain a non-residential land use

- Treatment and disposal are proposed, but it is not clear if RCRA Phase IV Land Disposal Restriction Criteria will apply to residuals

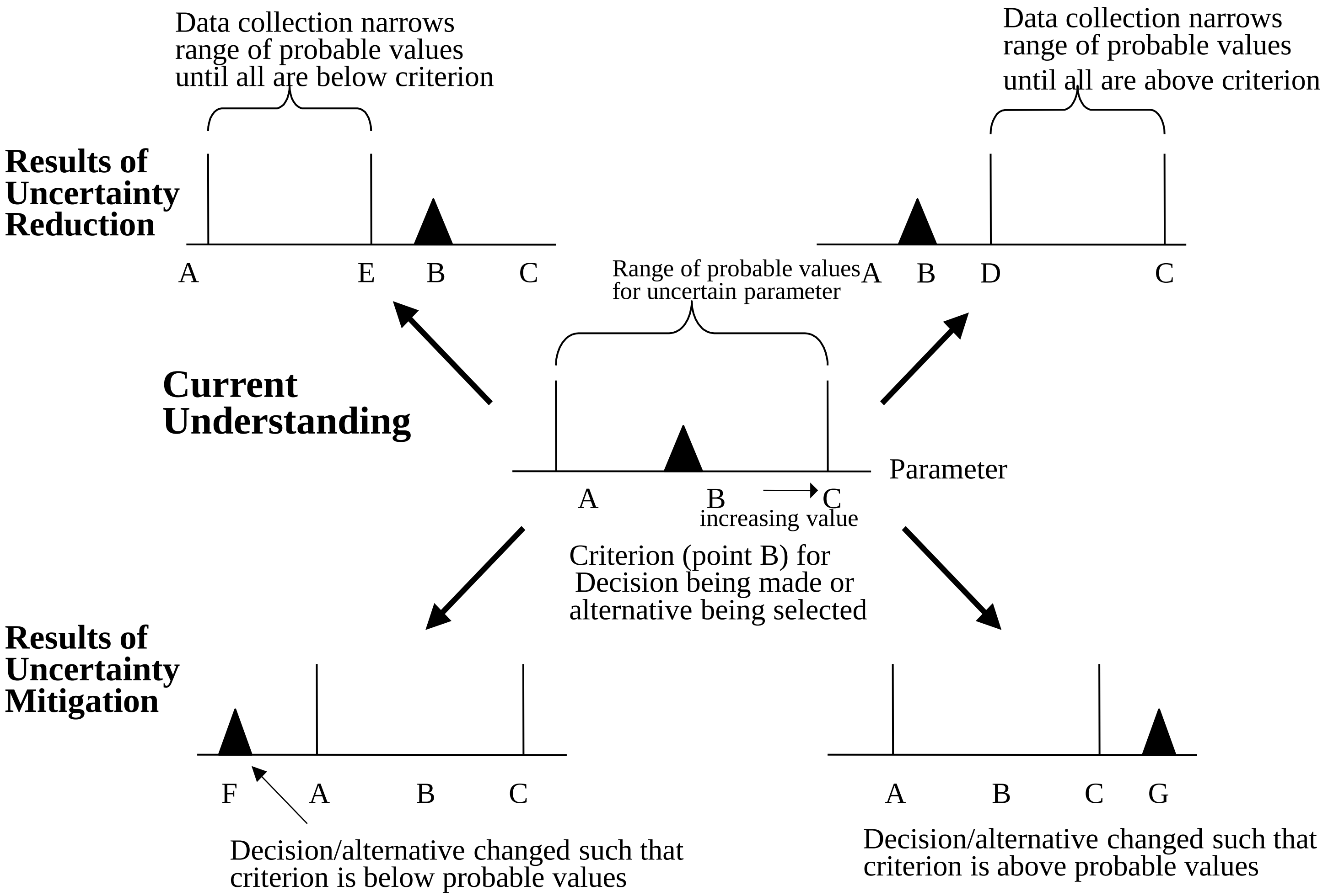
Uncertainty Management: Key Concepts

- Understand the type of uncertainty and its impact on project decisions
  - ✓ Data gaps do not necessarily equal data needs
- Evaluate tradeoffs between costs of data collection and "decisional benefits" obtained
- Achieve project management team consensus to optimally balance:
  - ✓ Data collection
  - ✓ Contingency planning

The Optimal Amount of Uncertainty is Installation-Specific



Options for Uncertainty Management



Management Tradeoff

	Reduce	Mitigate
Release Type:	Landfill	Landfill
Remedy:	Cap	Exhume
Uncertainty:	Waste below water table	Volume to be excavated

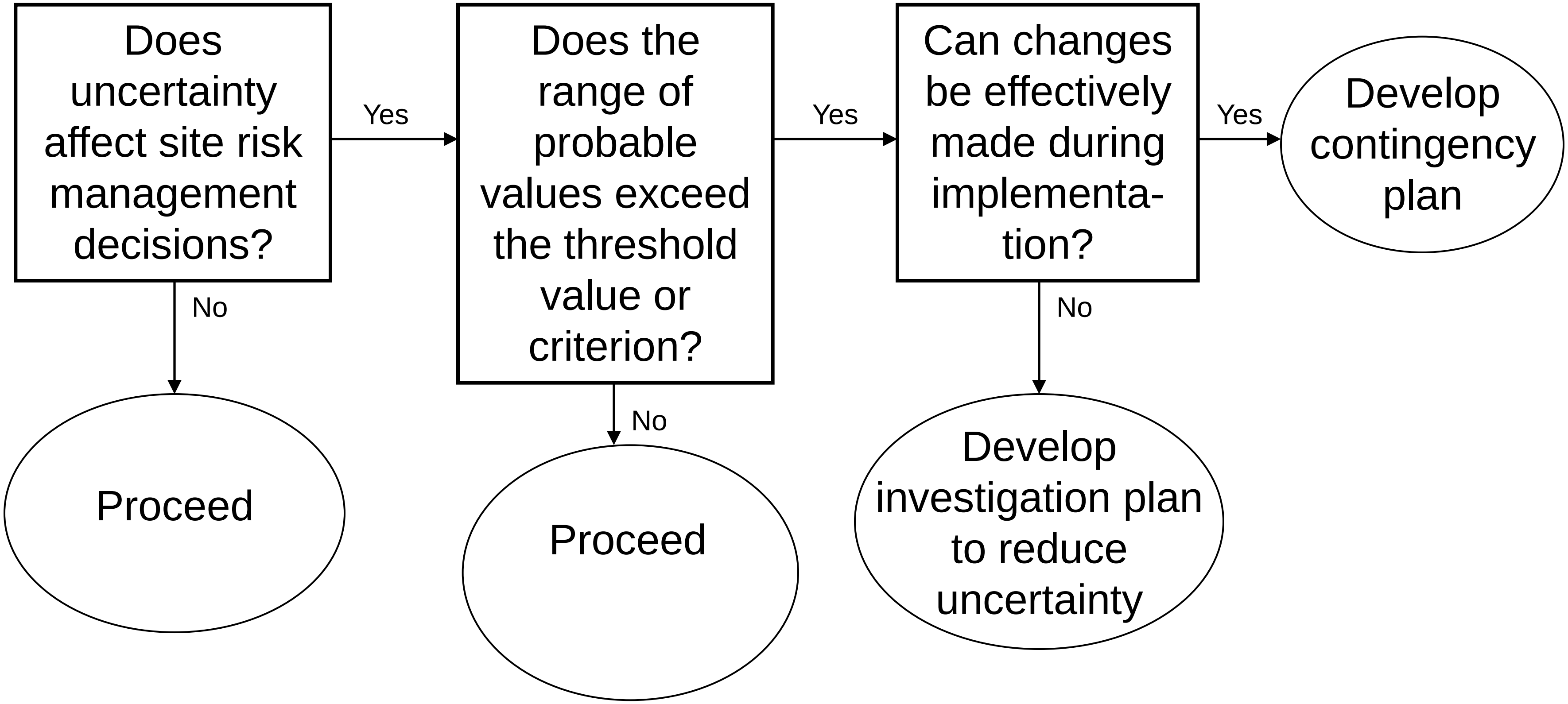
Sources of Uncertainty

- Installation characterization
- Technology selection
- Regulatory requirements
  - ✓ Administrative processes
- Future Land Use

Impact of Uncertainties

- An uncertainty can be:
  - ✓ Insignificant to implementing the project and solving the problem (i.e., value of unknown parameters will not change the decision being made):
    - for example, presence of single drum in a landfill
  - ✓ Significant and needs to be:
    - reduced prior to response (i.e., data need); or
    - mitigated during the response through contingency planning

Uncertainty Management Approach



Organizing Uncertainty Information

- Uncertainty can be characterized by the following information
  - ✓ Likely or expected condition
  - ✓ Reasonable deviation from the expected condition
  - ✓ Probability of occurrence
  - ✓ Time to respond
  - ✓ Potential impact on problem response/resolution
  - ✓ Monitoring plan
  - ✓ Contingency plan
- Uncertainty management changes emphasis from assessment to implementation

Categorizing Impact of Uncertainties

Consider a landfill which is to be exhumed to meet regulatory requirements for closure.

Probable Condition	Reasonable Deviation	Probability of Occurrence	Time to Respond	Potential Impact	Monitoring/ Investigation	Contingency Plan
Saturated soil conductivity expected to be 10E(-4) cm/s	Conductivity likely to range from 10E(-2) to 10E(-7) cm/s	High (based on existing hydrogeologic data)	Long	Low - May impact the drainage of rainwater if <10E(-4) cm/s	N/A	Insignificant - No impact on likely response action.
Soil is expected to be stable (i.e., greater than Class C)	Soil may be unstable (i.e., <50% or soil is less stable than Class C)	Low (based on results of previous slump tests)	Short (excavation face may sluff or cave in)	High - Threat to worker safety - Could increase cost or delay schedule	Conduct visual inspections an additional slump tests	Significant - Shore walls - Lay back excavation
Contents are expected to be solid waste only	Hazardous waste may be encoun-tered	Medium (based on process knowledge	Short (to prevent excavation from being delayed)	High - May delay excavation - May increase disposal costs and change handling requirements - May pose worker safety problems	Sample and analyze excavated materials; compare results to regulatory criteria	Significant - Develop contingency plans for excavation, storage, and disposal of hazardous waste; analyze cost impacts to ensure available funding

When Do You Evaluate and Manage Uncertainties?

- In work planning:
  - ✓ based on existing data,
  - ✓ based on understanding of programmatic expectations, and
  - ✓ as part of program development for a large site with multiple problems.
- During any necessary investigations:
  - ✓ as new data become available, and
  - ✓ as conceptual site model becomes sufficient to focus on likely response actions.

When Do You Evaluate and Manage Uncertainties? (cont.)

- During remedy evaluation:
  - ✓ as key performance and technology characteristics are evaluated
- During remedy implementation:
  - ✓ based on results of monitoring and observations during implementation
- Throughout all phases:
  - ✓ as basis for more effective communication about why work is being conducted

In Summary: What Does Categorizing Uncertainties Do?

- Forces explicit statements and consensus on uncertainties that may exist
- Establishes agreed to approaches to manage uncertainties
- Makes explicit the needs for data collection and/or contingency planning
- Helps document how the response will proceed
- Facilitates closeout by minimizing pursuit of unneeded data

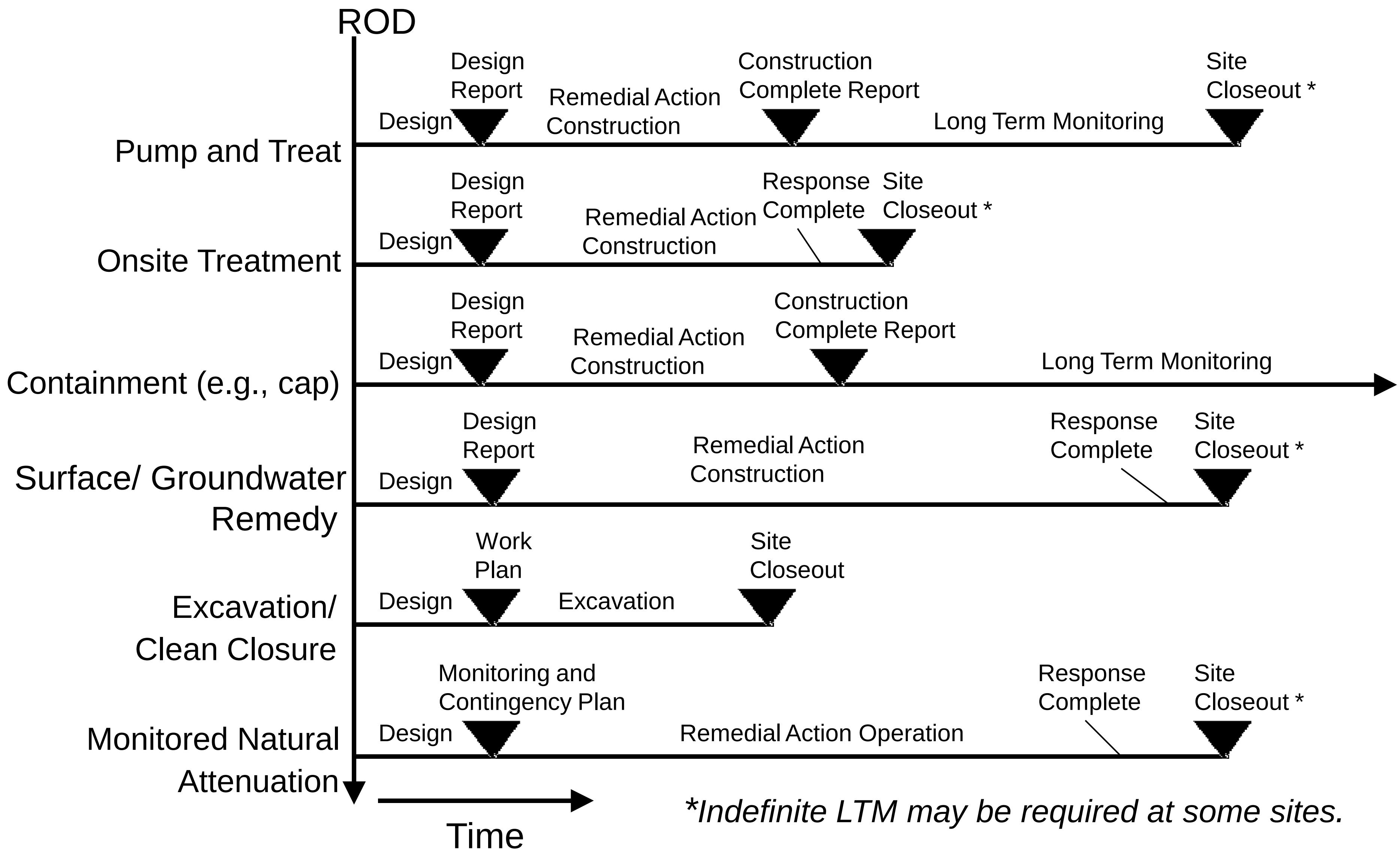
Principles of Environmental Restoration

Developing An Exit Strategy

What is an Exit Strategy?

- Exit strategy:
  - ✓ Defines the conditions or end state to be achieved;
  - ✓ The actions necessary to reach those conditions; and
  - ✓ The amount, type, and derivation of data necessary to demonstrate the condition has been reached
- Comprised of two key elements:
  - ✓ Closure Strategy
  - ✓ Contingency plans
- Should be developed as part of process of establishing remediation goals

Exit Strategies Largely Depend on Remedy Selected



***Indefinite LTM may be required at some sites.**

Closure Strategy

- Identifies necessary and sufficient data to demonstrate that the desired end state (e.g., long-term monitoring state) has been reached
  - ✓ What?
  - ✓ Where?
  - ✓ How?
  - ✓ How often?
  - ✓ Under what conditions?
- Data interpretation and decision process

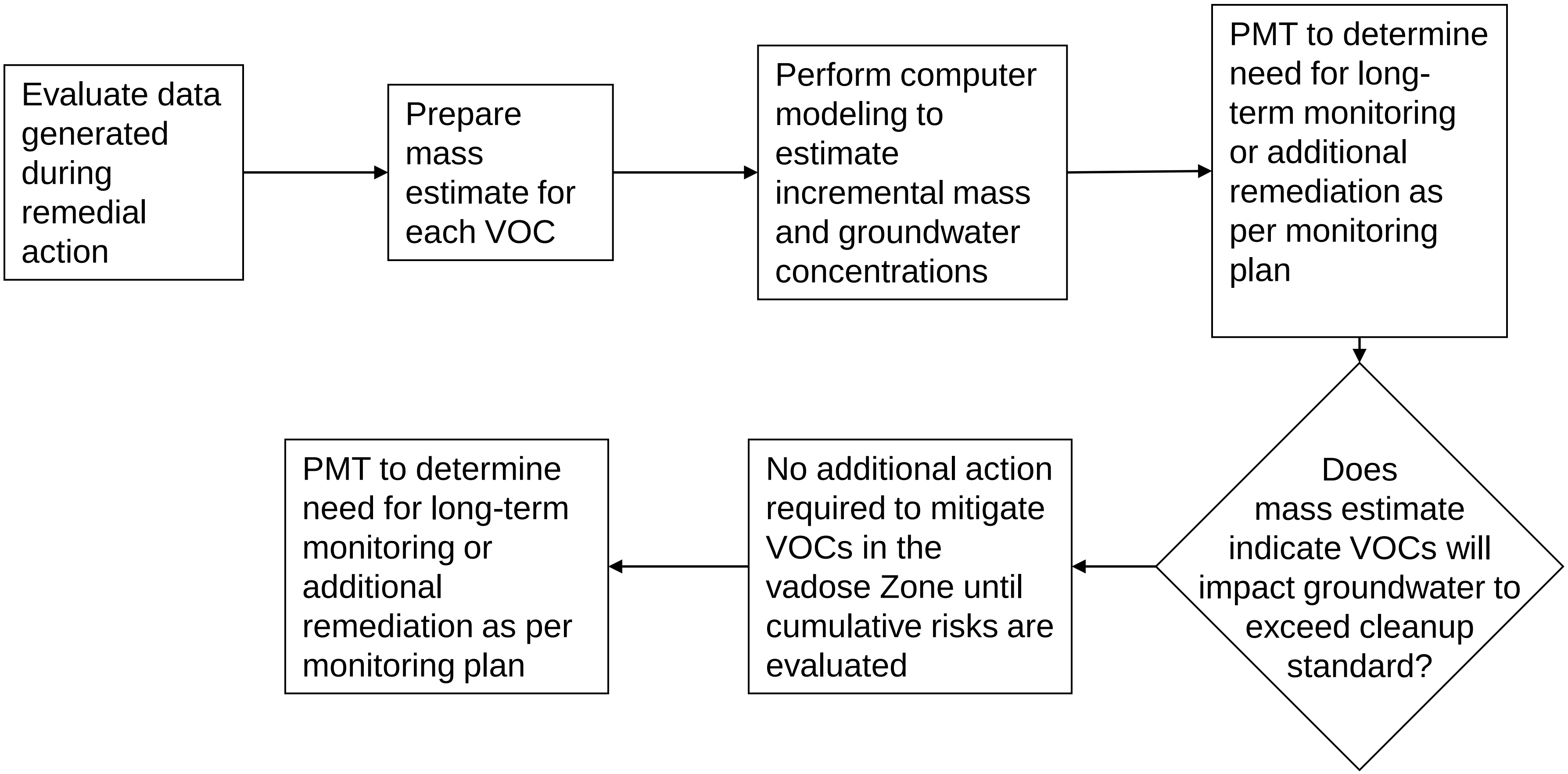
Monitoring Program

- Monitoring program consists of:
  - ✓ Performance monitoring
  - ✓ Detection monitoring
  - ✓ Ambient monitoring
- Implemented to manage uncertainty in performance of the remedy:
  - ✓ If monitoring data indicate system failure, contingency can be implemented to mitigate potential impact
  - ✓ If monitoring data verify predicted down trends (i.e., successful performance), exit strategy can be implemented to reduce long-term costs

Developing "Ramp-Down" Strategy for Monitoring Program

- Prior to entering into monitoring program, need to establish decision rules describing when monitoring requirements can be reduced
  - ✓ At what point can certain analytes be eliminated from analysis?
  - ✓ When can the monitoring frequency be reduced?
  - ✓ What criteria will be used to reduce the number and/or location of monitoring wells?

Example of an Exit Strategy*



Focus on Performance Metrics/Criteria

- Operational performance metrics/criteria assure that response remains protective
  - ✓ Involves periodically revisiting problem from its initial identification and definition through its final remediation

- May include
  - ✓ Monitoring contaminant migration and response effectiveness,
  - ✓ Inspecting disposal cells,
  - ✓ Enforcing access restrictions

Documentation

- Construction Complete Report
  - ✓ Documents as-builts
  - ✓ Defines any remedial action operation requirements
  - ✓ Defines when desired end state is reached to document achieving target
  - ✓ Defines any long-term care requirements
- Provides vital information for future stewards and long-term care organizations

Elements and Source of Completion/Closure Reports

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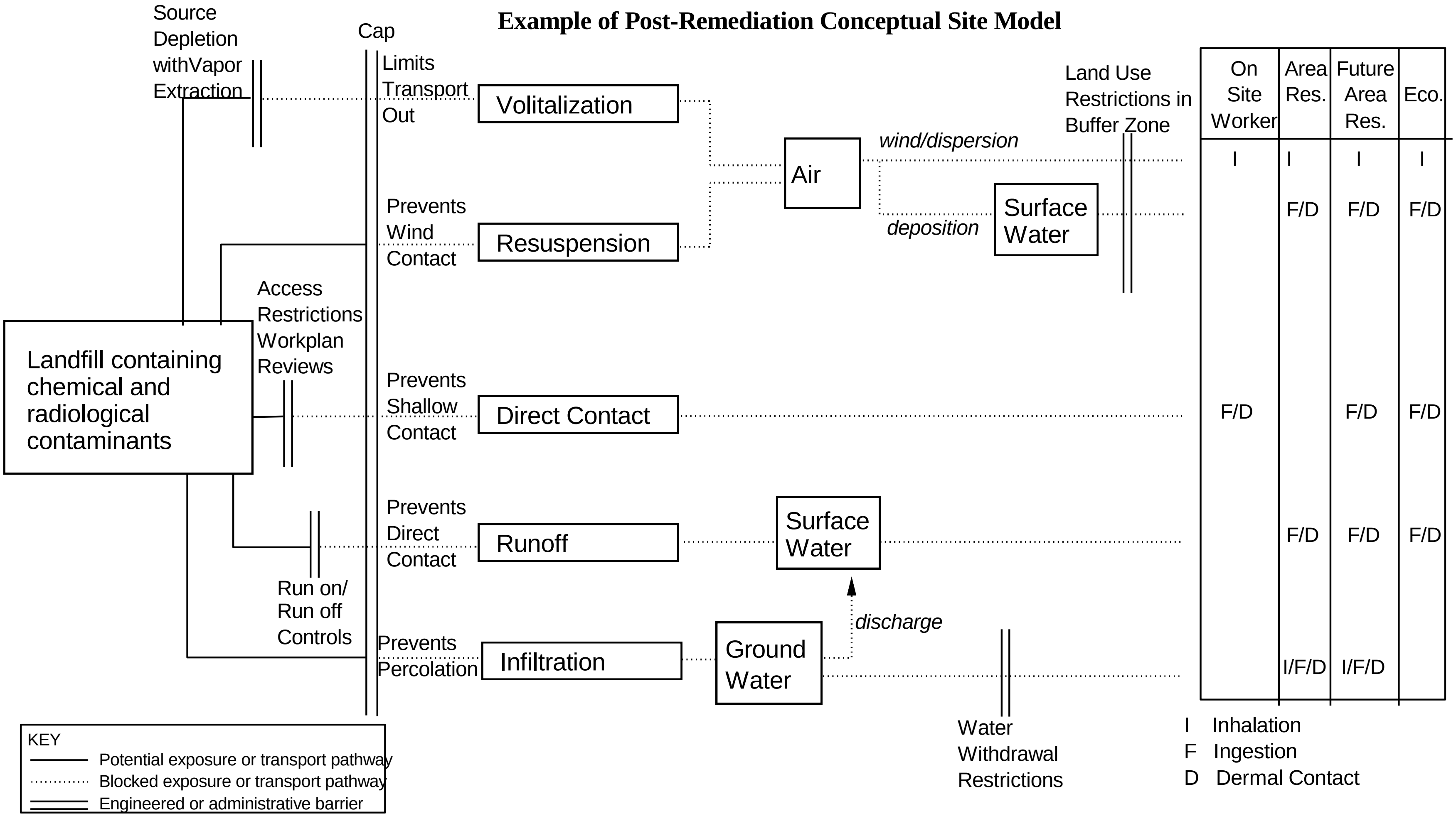
Role of Project Management Team

- Project Management Team is responsible for sharing appropriate response information and data with long-term care authorities
- Conducts five-year reviews
- Delegates authority for future actions as appropriate
- Assures knowledge management (archiving) for future stakeholders

Example of Post-Remediation Conceptual Site Model



Components of End State	Description
Waste Characteristics	One landfill remains on site. Contaminants include: NO, CHCL, DCE, Toluene, H_3, C_{14}, and DCA. The estimated volume of material disposed in the landfill is 420,000 y_3 based on historical records and knowledge of past practices.
Unit Characteristics	Landfill is approximately 50 - 60 feet above the upper huydrostratigraphic unit (HSU) and approximately 80 ft. above the lower HSU of the groundwater aquifer. The contaminants detected in the upper HSU include: $CHCl_3$, DCA, Cr, NO_3, DCE, Toluene, H_3, and C_{14}. Contaminants detected in lower HSU include: Cr, NO, CHCl3, DCE, Toluene, H_3, C_{14}, and DCA.
Barriers in Place	One single-layer cap with a design life of 30 years covers the landfill. Vapor extraction system installed and operated until concentrations drop below threshold. Land use restriction covenants in place such that: (1) There can be no digging in the landfill area; and (2) There shall be no agriculture or residential use of groundwater; pumping groundwater from wells is prohibited.
Other Key Assumptions to Maintain Protectiveness	Land use will remain industrial. Monitored natural attenuation will demonstrate that contaminants in the groundwater are below MCLs in 20 years. Remaining contaminants in landfill are will not continue to leach to the groundwater. An alternate water supply is provided to local residents.

Application of the Principles in the Post-Construction Phase

Principle	Post-Construction
▪ Project management team	▪ Review data and communicate direction
▪ Problem statement	▪ Define long-term monitoring state
▪ Early response	▪ Post-construction activities and decision criteria for exit
▪ Uncertainty management	▪ Monitoring plan/ contingencies

Principles Apply Regardless of Regulatory Framework

RI/FS — Decision Document — RD/RA — Construction Complete — O&M — Closure / End State — LTM-Stewardship

RCRA	CERCLA	Common Requirements
RFA	PA/SI	Identify releases and need for further investigation
RFI	RI	Characterizes the nature and extent of contaminant releases (uncertainty reduction). Determine potential human and environmental risk.
CMS	FS	Identification, evaluation, and screening of remedial alternatives (uncertainty mitigation)
Statement of Basis	Proposed Plan	Identification and public notice of the preferred alternative
Permit Modification	ROD	REMEDY SELECTION
CMD	RD	Development of detailed plans for selected remedy
CMI	RA	Construction, testing, and implementation of selected remedy
Closure/Post-Closure	Completion	Construction completed and post-construction plans in place
Closure/Post-Closure	Closure	Specific cleanup levels reached and remedial activities complete.

Principles of Environmental Restoration

PER Workshops

PER Workshop Deliveries

- Longhorn AAP
- Ft. Ritchie
- Seneca AD
- Marion LTA
- Ravenna AAP
- Operational Support Command
- Lompoc DB
- Deseret AD
- Picatinny Arsenal
- Aberdeen Proving Grounds

PER Workshop

- 2 Days
  - ✓ Optional technical assistance on Day 3
- 10-30 Trainees
- Army Staff and Regulators
- Key Issues for Exercises

- Standard Delivery
- Site-Specific Tailoring
- Handbook

For Additional Information

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SUPPORTING MATERIALS

- Decision Logic Diagrams
- Design Basis
- Workshop Handbook
- Guidance Manual