U.S. DEPARTMENT OF ENERGY | OFFICE OF ENVIRONMENTAL MANAGEMENT

A Discussion of the Cost Estimate Classification System for the Environmental Remediation Industries

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The Cost Estimate Classification System for Environmental Remediation

How much does the cleanup of a contaminated site cost?

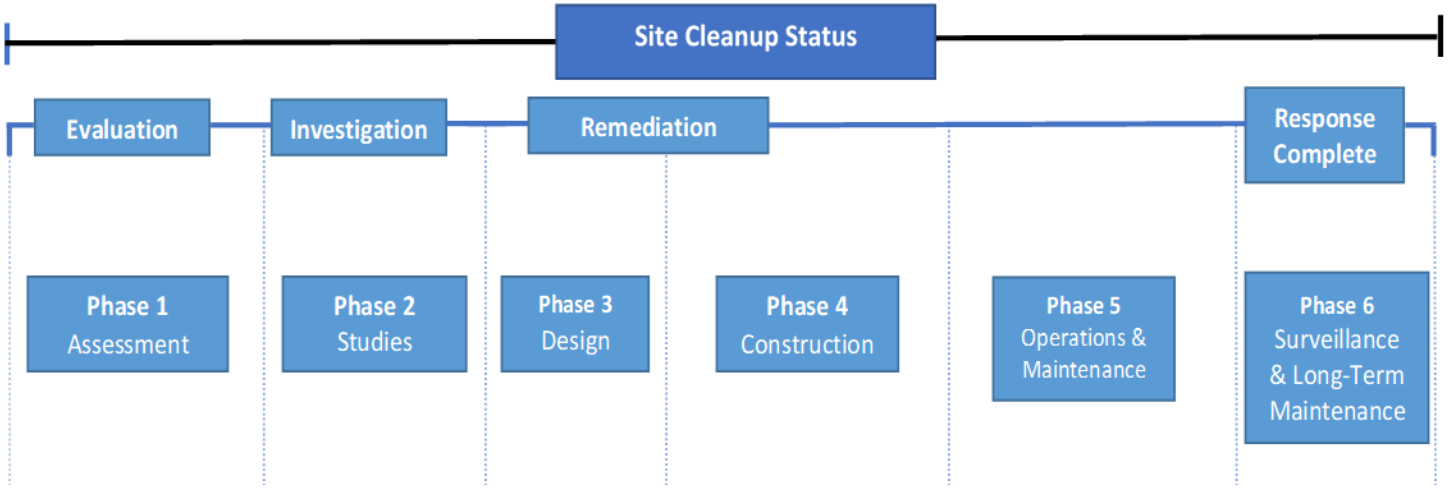
- AACE has developed a methodology, which maps the classes of a project's cost estimate with a general project scope definition maturity.
  - Originally discussed in Recommended Practice (RP) 17R-97: Cost Estimate Classification System
- This methodology has been applied across a wide variety of industries: Professional Guidance Document (PGD) 01, Guide to Cost Estimate Classification Systems
- We used these techniques to develop RP 107R-19: Cost Estimate Classification System – As Applied in Engineering, Procurement, and Construction for the Environmental Remediation Industries
  - Published February 27, 2020
  - This is for the Life-Cycle of an environmental cleanup – not just construction

Organization of an Environmental Remediation Cleanup Project

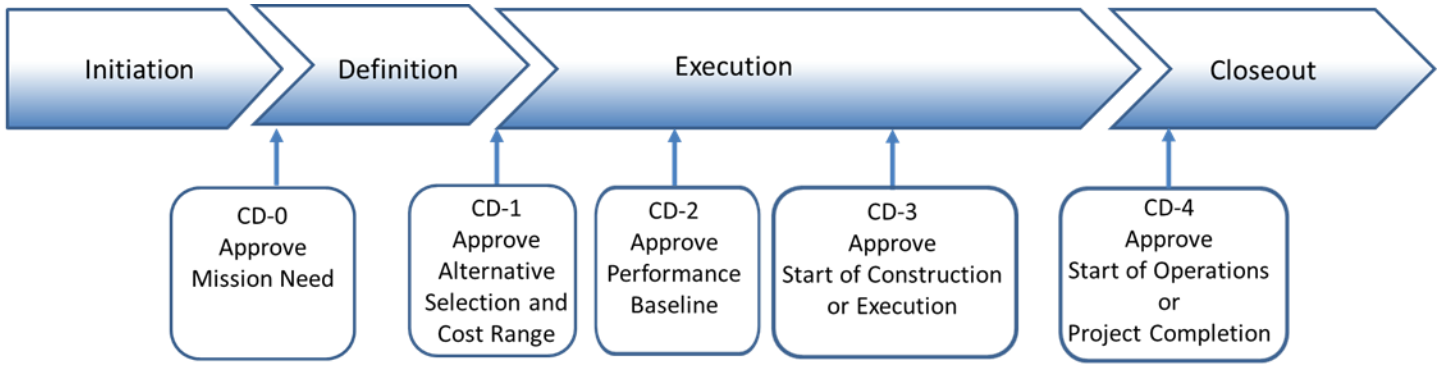
- Per CERCLA/RCRA regs and ASTM Standard 2150, Standard Classification for Life-Cycle Environmental Work Elements – Environmental Cost Element Structure (ECES), there are 6 defined phases to a cleanup:
  - Phase 1 – Preliminary Assessment – Initial evaluation and inspection.
  - Phase 2 - Studies - Characterization, detailed investigation, risk assessment, development and evaluation of remedial options, as well as treatability studies and the selection of the preferred alternative(s) for the cleanup.
  - Phase 3 - Design - The engineering design and pre-construction activities of remediation alternatives. This includes detailed studies and final design of the selected remediation alternative.
  - Phase 4 – Construction/Implementation of remediation alternative (selected in Phase 2). Includes start-up but excludes all operations.
  - Phase 5 - Operations and Maintenance (O&M) – All operations and maintenance activities for the selected treatment or remediation alternatives.
  - Phase 6 - Surveillance and Long-Term Maintenance (SLTM) – Operations (Phase 5) have ceased. This phase includes post closure surveillance and long-term monitoring.
- Note: RP 124R-22: Project Code of Accounts, As Applied in the Environmental Remediation Industries (based upon ASTM Standard 2150, Standard Classification for Life-Cycle Environmental Work Elements - ECES, completed public review and a final draft will soon be published.

The Six Phases of a Cleanup Project And Project Maturity – Critical Decisions

The Life cycle phases for an environmental Project (see below) – generally align with environmental laws



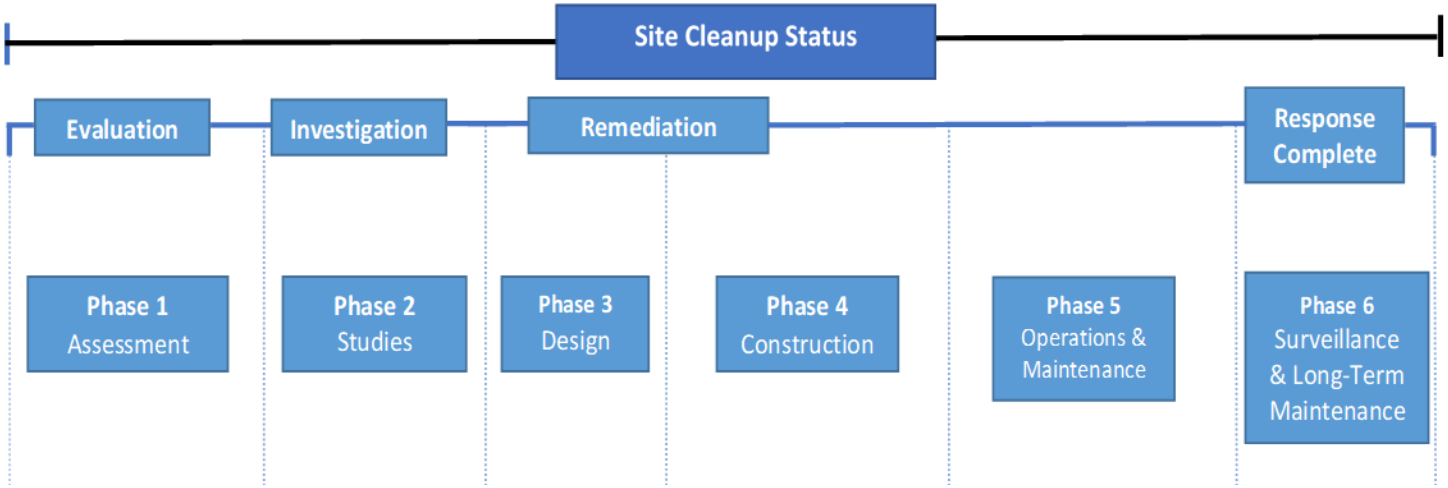
DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets, Project maturity must be approved through a series of four Critical Decisions (CDs), CD-0 through CD-4 that reflect a project's maturity and are depicted below.



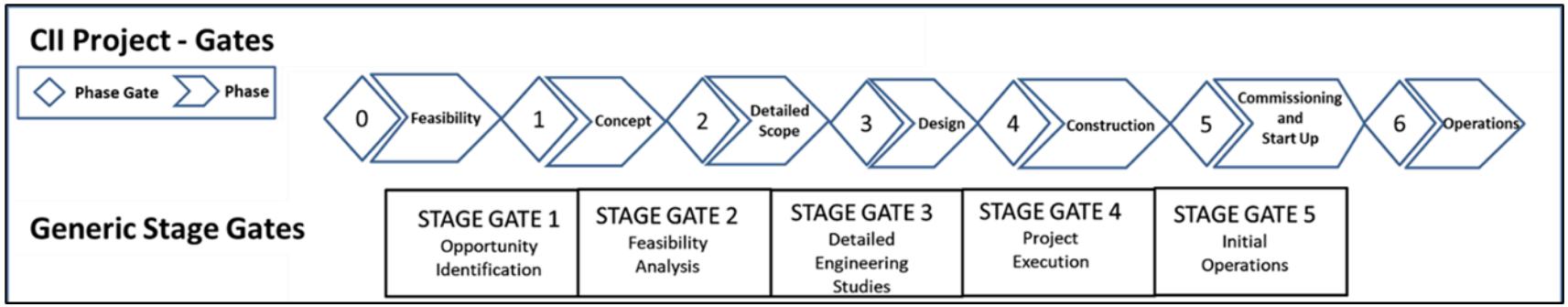
Not a simple or straightforward alignment.

The Six Phases of a Cleanup Project And Project Maturity – Stage Gate

The Life cycle phases for an environmental Project (see below) – generally align with environmental laws



The Construction Industries Institute (CII) Stage Gate System is another way to determine a project's maturity , depicted below.

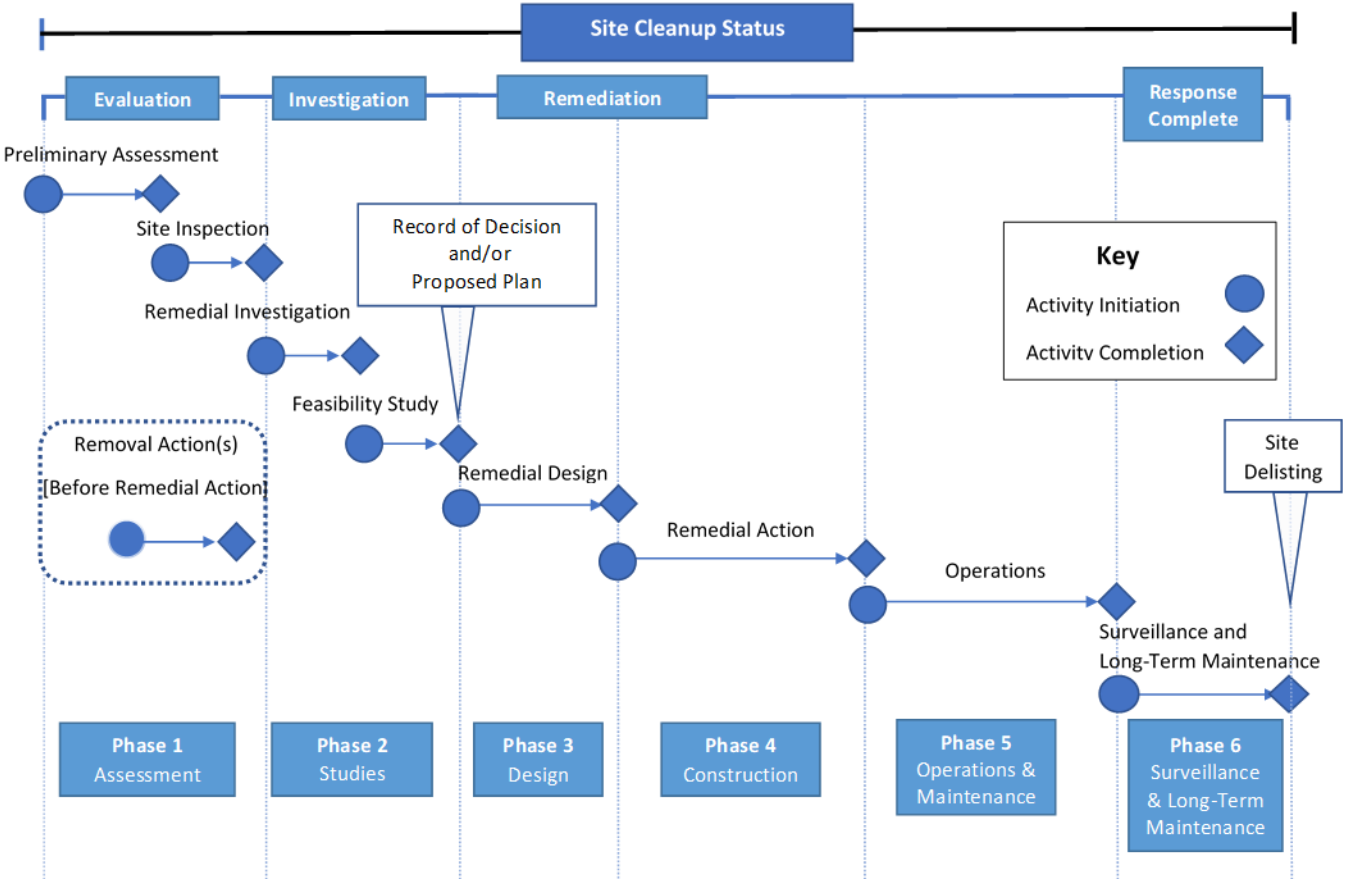


Also, not a simple or straightforward alignment.

Measuring the Maturity of a Cleanup Project

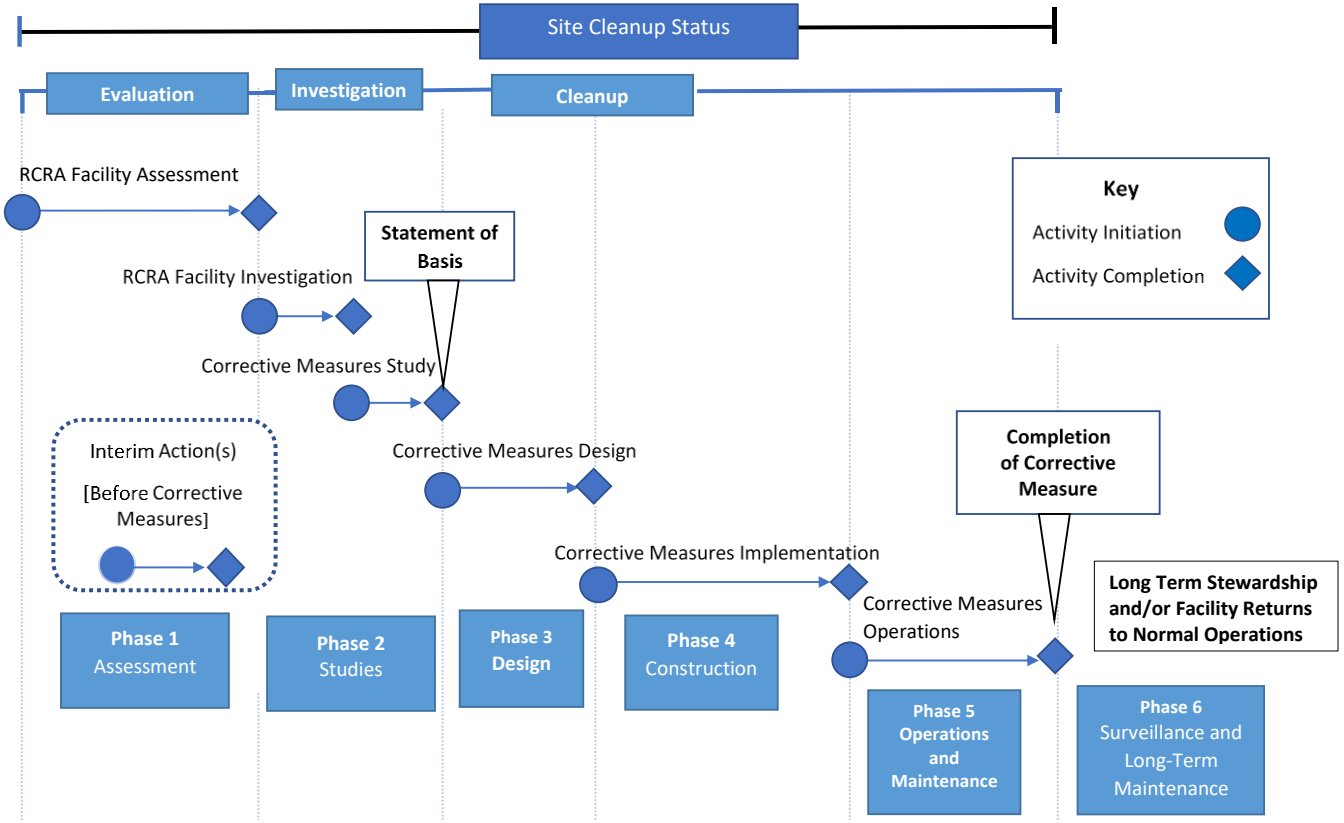
Using Regulatory Documents and Engineering Deliverables

The Six Phases of a CERCLA Project



The life cycle phases for a CERCLA project

The Six Phases of a RCRA Project



The life cycle phases for a RCRA project

Required documentation for RCRA and CERCLA

General Phases in the Cleanup Process		CERCLA Documentation	RCRA Documentation
Phase 1	Conduct site surveys and investigations	• Preliminary assessment/site inspection (PA/SI) report	• RCRA facility assessment (RFA) report
Phase 2	In depth investigations as well as development and selection of remedial alternatives	• Remedial investigation (RI) report • Feasibility study (FS) report **Remedy Selection:** • Proposed plan • Draft record of decision • Final record of decision (ROD)	• RCRA facility investigation (RFI) report • Corrective measures study (CMS) report **Remedy Selection:** • Corrective action plan • Final RCRA permit modification
Phase 3	• Detailed design, plans and specifications • Detailed implementation plans	• Remedial design • Remedial action implementation plan • Waste management plan • Cost estimates and detailed schedules	• RCRA corrective measure implementation plan • Associated detailed schedule and cost estimates
Phase 4	• Physical construction activities • Implementation of actual cleanup	• Execution of the remedial design – installation of equipment, excavation, etc. • Detailed execution schedules and cost estimates	• Corrective measures implementation • Detailed execution schedules and cost estimates
Phase 5	• Operations and maintenance (if any) associated with the cleanup • The site is removed from the National Priority List	• Operations and maintenance plan (if needed) • Operations and maintenance (if any) reports associated with the remedial action e.g. operation of a pump and treat facility • CERCLA 5-year review report	• Operations and maintenance plan and Manual (if needed) • Operations and maintenance (if any) reports associated with the corrective measure
Phase 6	• Routine monitoring • Enforcing any long-term site restrictions	• Site surveillance and/or maintenance reports • CERCLA 5-year review report	• Site surveillance and/or maintenance reports

Table 1 – Phases of Environmental Cleanup as well as required documentation for RCRA and CERCLA

The Cost of a Cleanup Project

The Cost and Accuracy Range for Environmental Projects as a Function of Maturity

Cost Ranges of Environmental Projects – Defining Factors

Cost ranges for the various classes are summarized in Table 2 listing the five cost estimate classes related to the following factors:

- **The Maturity Level of Project Definition:** The completion (in percentage) of the project definition deliverables;
- **End Usage:** The purpose of the estimate including a description of what the estimate should deliver for this phase.
- **The Methodology:** The method(s) used to estimate the cost
- **Expected Accuracy Range:** The degree to which the final cost outcome of a project varies from the single point value estimated

Cost Accuracy Ranges of Environmental Projects

	Primary Characteristic	Secondary Characteristic		
ESTIMATE CLASS	MATURITY LEVEL OF PROJECT DEFINITION DELIVERABLES	END USAGE	METHODOLOGY	EXPECTED ACCURACY RANGE
Class 5	0% to 2%	(Phase 1) Early investigations and preliminary planning; preliminary assessment/site inspection (PA/SI); RCRA facility assessment (RFA) report and federal facility compliance agreement.	Capacity factored, parametric models, judgment, or analogy	L: -20% to -50% H: +30% to +175%
Class 4	1% to 15%	(Phase 1 and/or 2) In depth investigations, evaluation of remedial alternatives and remedy selection; remedial investigation/feasibility study (RI/FS) facility investigation (RFI) and corrective measures study (CMS)	Equipment factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	(Phase 2 and/or 3) Preliminary planning and design of selected remedy; record of decision; preliminary remedial design Initial estimates for O&M and LTM	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +45%
Class 2	30% to 75%	(Phase 3, 4, 5 and/or 6) Intermediate Remedial Design Refined estimates for O&M and LTM. Final remedial action/remedial action implementation plan (RA/RAIP); corrective measure implementation plan (CMP); construction and remedial action	Detailed unit cost with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	(Phase 4, 5 and/or 6) Pre-Final/Final Remedial Design Detailed/remedial action, operations and maintenance and long-term monitoring plans and detailed cost estimates	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

Table 2 – Cost Estimate Classification Matrix for the Environmental Remediation Industries

Basis for Cost and End Use: Class 5 and Class 4

Cost class 5 estimates are at the beginning of an environmental project for estimating project costs based on preliminary studies and investigations.

- The end use for this cost class is for preliminary studies
- This cost class is based upon studies of completed hazardous waste site remediation projects resulted in a cost range between +175% to -50%.

Cost class 4 estimates are developed early in an environmental project when additional characterization and further investigation create a better understanding of the site

- The end use for this cost class is for developing estimates for each of the alternatives in order to select the preferred project option(s).
- It is also based upon studies of completed hazardous waste site remediation projects, accounting for the increased project maturity, the resultant in a cost range is between +50% to -30%.

Basis for Cost and End Use: Class 3

Cost class 3 estimates occur when an environmental project matures further, the remediation approach has been selected, and the design develops to the "preliminary planning and design" stage.

The cost range for this class of estimate is based upon the following studies of two DOE CERCLA cleanups:

- The cleanup at the Rocky Flats Environmental Technology Site (RFETS) - A direct comparison of the baseline estimates with actual costs through closure resulted in a range of costs for the projects that comprise the RFETS cleanup program with a range between 20% greater than the baseline cost to 46.8% less than the baseline cost.
- The East Tennessee Technology Park (ETTP) Three Building Project, part of a non-time critical removal action (NTCRA) - the accuracy of the engineering evaluation/cost analysis (EE/CA) (de facto baseline) cost estimate of $253 million, when compared to the actual project cost of $356 million yields a 40.7% difference greater than the baseline cost.
  - Significant lessons were learned from this project that served the remaining ETTP cleanup effort, the EE/CA estimated significant cost savings due to recycling could not be realized due to the moratorium on recycling across the DOE Complex.

Basis for Cost and End Use: Class 2 and Class 1

Cost class 2 estimates can be prepared:

- For either the construction of the remediation technology or for operations and maintenance (if applicable) when remedial design is nearing completion (or is completed); or
- For long term monitoring and surveillance, at the end of operations when sufficient information is known

Cost class 1 estimates can be prepared:

- For the remedial action when the remedial design is nearing completion (or is completed) and vendor quotes are available to support the estimate for the construction of the remediation technology;
- For operations and maintenance (if needed), when the remedial action phase is completed, and necessary operations equipment (as well as supplies) is purchased and installed; or
- For long-term monitoring and surveillance, when the operations phase has been completed.

A Challenge with Class 2 and Class 1 Estimates

The Bad News

- For both Class 2 and Class 1 cost estimates detail scope information for both Phase 5 and Phase 6 can be estimated with high accuracy with one significant exception:
  - The specific number of years required to support cleanup operations as well as surveillance and long term monitoring (SLTM) can be highly variable and difficult to predict.

The Good News

- The costs for many Operations and Maintenance as well as SLTM activities are relatively low cost - therefore, variation in the specific SLTM activities (e.g., number of five-year reviews) has a minimal effect on the life cycle cost of most specific projects.

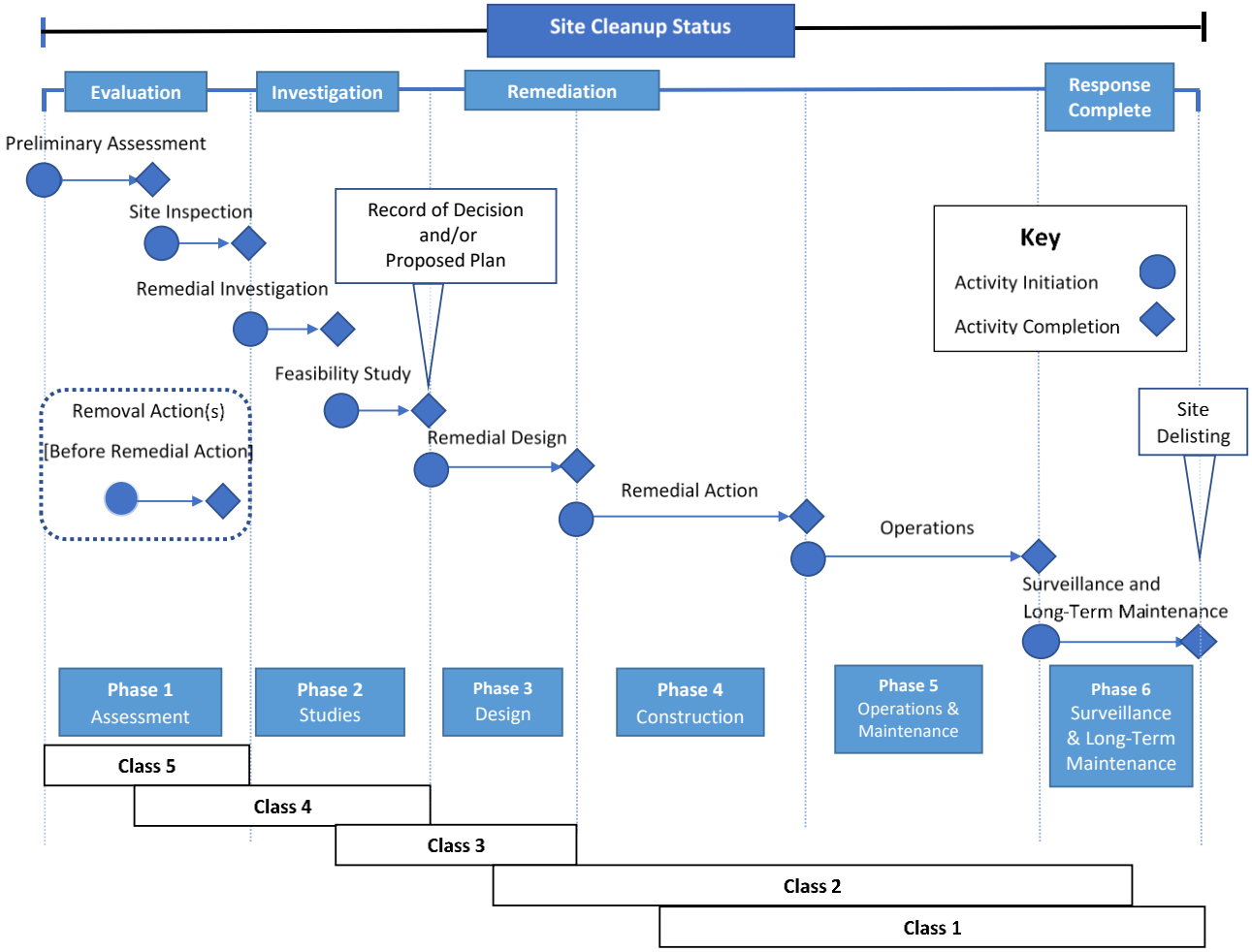
The Need for More Information

- The cost estimates versus completed project costs used as the basis listed in this paper and the Recommended Practice will benefit from more examples.

- The quality of this cost data will improve with analyses of more cost estimates compared with the actual costs of completed projects.

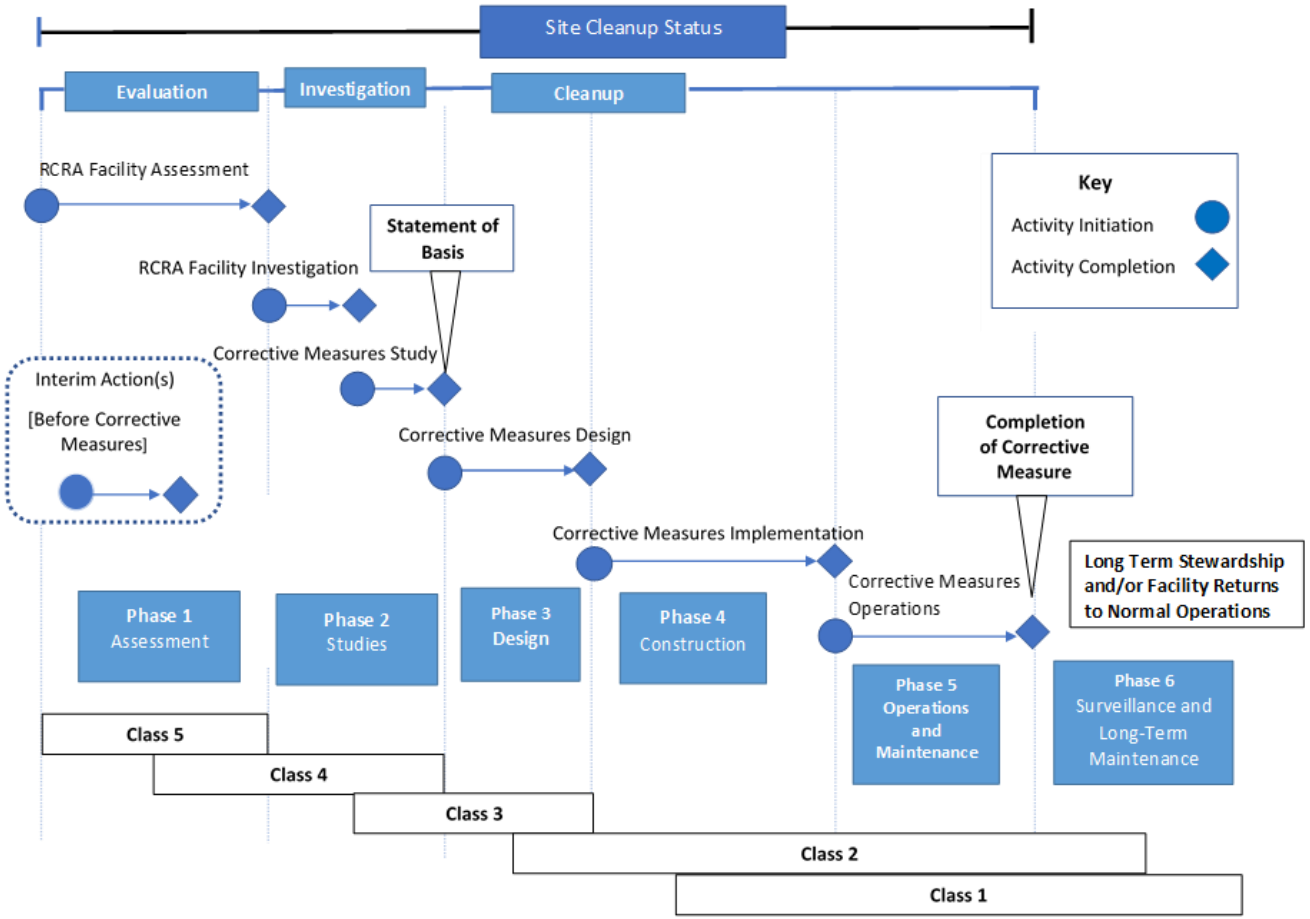
The Cost Classes of a CERCLA Project

The life cycle phases for a CERCLA project with Cost Classifications.



The Cost Classes of a RCRA Project

The life cycle phases for a RCRA project with Cost Classifications.



The Critical Decision Assessment Tool (CDAT)

- An additional step in documenting the maturity level of project definition is to use a project definition rating system – a tool for measuring the completeness of project scope definition.
- Environmental remediation projects are known for a high level of inherent uncertainty due in part to the limitations of site characterization and cleanup technology effectiveness in different situations; estimates need to appropriately accommodate these risks.
- An environmental PDRI tool has been periodically updated and revised and is now called the Project Critical Decision Assessment Tool (CDAT)
- The CDAT can be tailored for general environmental projects (outside of DOE) with minor modifications to accommodate for specific requirements.
- This is discussed in an upcoming paper PM-3796, *An Adaptable and Comprehensive Project Assessment Tool* which will be presented at the upcoming AACE Expo in San Antonio at the end of June 2022.

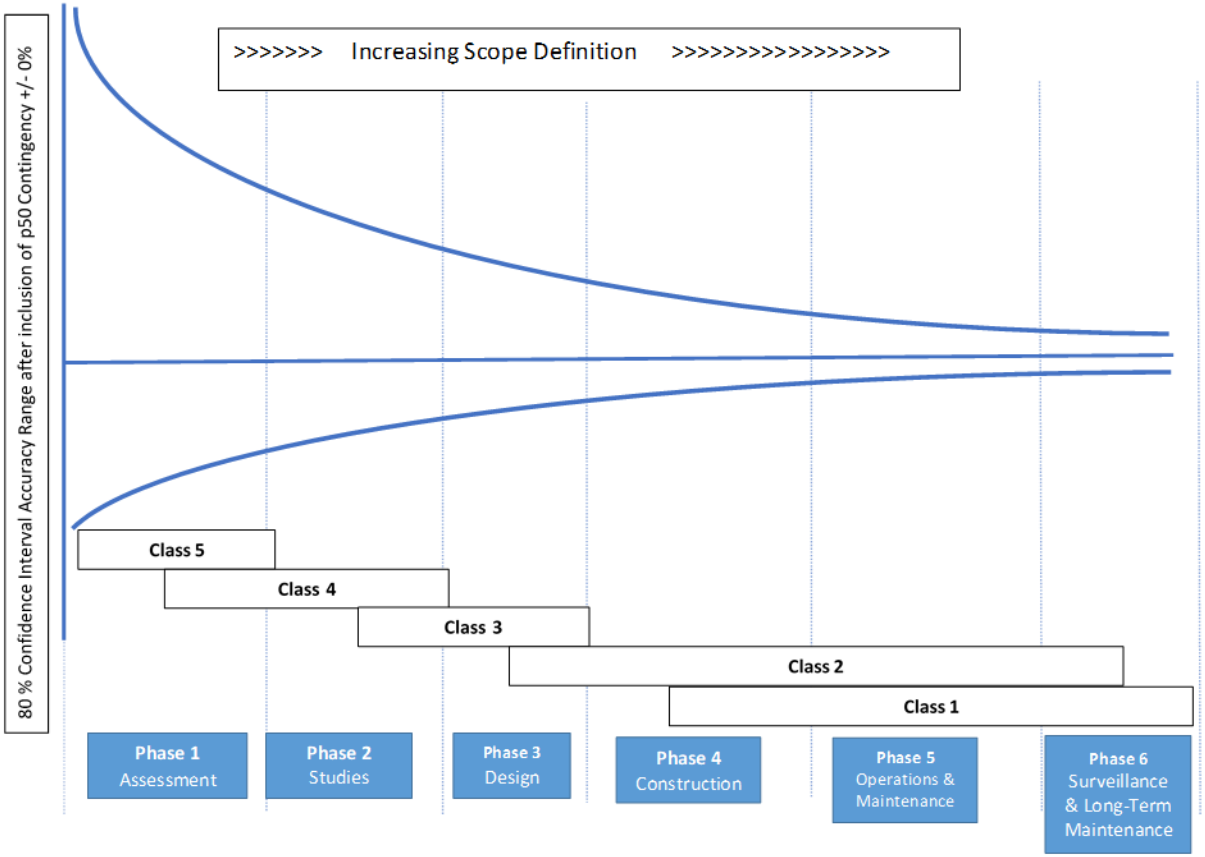
Risk and the Cost Estimate

- The accuracy range for any particular estimate is expected to fall into the estimate classes identified - depending on the technical and project deliverables (as well as other variables) including the risks associated with each estimate.
- Environmental remediation projects are known for a high level of inherent uncertainty due in part to the limitations of site characterization and cleanup technology effectiveness in different situations; estimates need to appropriately accommodate these risks.
- In addition, environmental projects are under the scrutiny of a wide variety of stakeholders that review and approve the activities and oversee the work.
  - This results in risks of either delays in the approval of the submittals or work restrictions at the site.

Risk and Cost Estimate Accuracy

As a project progresses and matures the estimate accuracy increases:

- This figure shows a general (non-representative) relationship trend between estimate accuracy and the estimate classes
- This figure also shows that the estimating accuracy ranges overlap with the estimate classes that are unique for a specific project.



Conclusions

Conclusions

With this presentation :

- A clear description of the environmental cleanup projects within the CERCLA and RCRA framework using a six-phase system that provides a general description of the requisite steps for an environmental remediation project
- The general process of determining the maturity of an environmental cleanup project is provided along with the cost ranges for these projects
- The cost ranges for each class of estimate for environmental projects and the basis for each class of estimate are discussed.
- The important role of risk in cost estimate and schedule development for environmental remediation projects has been discussed.

Extra Slides

Environmental Cost Element Structure - Background

- The EM ACE Team along with other environmental cleanup Agencies (EPA, NAVFAC, NASA, Air Force, Army, and the USACE) developed the ECES to establish standard, repeatable cost categories, with definitions, for environmental cleanup cost estimates and cost collection efforts.
- The Interagency version of the ECES was further modified and adopted by ASTM as standard E-2150 and its Adjunct E-2150A.
- This Standard and it accompanying Adjunct, contain an exhaustive listing of environmental cost elements together with a dictionary of their definitions.
- In addition, standard secondary (non-cost) parameters were also developed to normalize, sort, compare, and analyze cost data.