ENVIRONET
Cost Estimation

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Acknowledgements

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• Christian can be contacted at christian.kunze@amec.com if you have any specific questions related to the costing up of uranium mining projects.
Lecture Structure

- Early considerations.
- Phases of cost estimation.
- How cost may change over time.
- Cost estimation methods.
- Accounting approaches.
Remediation Costs Money!
Early considerations

- Many people are unfamiliar with how best to approach costing up environmental remediation projects.
- Link into the project management and planning process – an accurate project plan should help the costing process.
- Always remember that you may have more than one option/solution for the problem in hand.
- The decision making process will generally require these option variants to be costed.

- Many of the activities will not be dissimilar to typical construction projects.
  - Site preparation activities
  - Construction of facilities
  - Material costs
  - Labour costs.
Early considerations

• There are however also variances with typical construction projects;
  • Remediation work is often driven by environmental regulations and consent orders.
  • Schedule is often driven by legally enforceable milestones and deadlines.

• Clean up levels are often determined by;
  • Regulations
  • Available technologies

• Environmental Remediation work may have risks
  • You could make the situation worse.
  • May lead to cross contamination of aquifers.
  • Planning or regulatory approval not granted.
  • Technologies may not work as expected.
  • You run out of available funding.
  • Stakeholders may disagree with your proposals.
Mining: provisions for ER (1)

Figure 1: Total closure provisions (for sample set of companies)

Total closure provisions (USD millions)

- 2000
- 2001
- 2002
- 2003
- 2004
- 2005

Source: Annual Financial Statements for the 27 mining companies analysed (Appendix 1)

Source: Deloitte
Mining: provisions for ER (2)

Figure 2: Sector ratios of closure provisions to tangible fixed assets

Source: Annual Financial Statements for the 27 mining companies analysed (Appendix 1)

Source: Deloitte
Key Messages

• Provisions for Environmental Rehabilitation are on the rise;
  ▪ Relative to assets.
  ▪ In absolute terms.
• ER is taken more seriously in the operation phase of a mine.
• Similar trends can be seen in other industries, too.
• But somebody must have estimated the costs for ER in the first place.
Topics of this course

• **Not** where the funds may come from.
• But **how to estimate** how much is needed.
• Different aspects to consider;
  - Conceptual issues of cost estimates
  - Technical methods to estimate costs
  - Regulatory background
  - Practical experience and useful resources
• **While some generic messages exist** , the following guidance is primarily attributed to the uranium mining perspective.
Cost estimation is part of an iterative optimization process.

1. Definition of remediation objectives
2. Identification of remediation technologies
3. Estimating the costs of each option
4. Optimization procedure (ALARA)
5. Re-definition of objectives and options?
Definition of end-state

- Whitehorse Initiative (1994): „site is returned to a self-sustaining and diverse ecosystem, compatible with a healthy environment and with human activities.”
- IAEA Layperson’s Guide to Environmental Remediation (2010, draft): „Desire of community (...) will imply costs that may not be justified from a scientific and technical point of view“
Define remediation objectives and options to meet these objectives

- Remediation objectives depend on the after-use of a site
- Legislation may be very prescriptive, e.g.,
  - Exhalation of Rn-222 < 20 pCi/m²/s
  - Hydraulic permeability of clay barrier < 1E-9 m/s
- But this is far from a real optimization approach
- Risk-based approach is more appropriate
- Objectives may be revised if it turns out that costs are unaffordably high
Consider the entire life cycle of a remediation project

- Capex and short-term costs are not sufficient
- Consider also long-term measures such as
  - operation of water treatment plants,
  - monitoring and site surveillance,
  - maintenance of the re-vegetation on covered areas,
  - corrective action should any of the technical controls fail
- Monitoring is pointless if no funds are available to implement corrective measures
Conceptual site models (CSM)

Create or support the quantitative understanding of the;
- Main parameters.
- Critical processes.
- Links between sub-systems.

Allow to identify those areas where refined data are needed in order to take better decisions.

Allow to estimate time horizons, basic design parameters (flow rates, concentration ranges,…).

Can be gradually refined as more data are available.
Phases of cost estimation

1. Site reconnaissance, walkover survey, engineering judgement.
2. Experience, sometimes quotations from vendors and contractors.
3. Design-based cost estimate, BoQ, tenders, bids.
4. Contracting and implementation.
5. Claims, variations, “value engineering“.
6. Review of costs after completion.
Reduction of uncertainty?

• In each phase, uncertainties are supposed to become smaller.
• But we are permanently deceived by unpleasant surprises.
• Costs (almost) never decrease.
• That‘s because detailed designs create the (wrong) impression that we could foresee what happens.
Costs may change over time

- Expectations of stakeholders and regulators may change.
- Consensus reached at an earlier time may be challenged by a new regulator, or changed community preferences for the remediation solution.
- Domestic and/or industrial wastes are dumped on a legacy site, increasing the amount of waste or contaminated area which needs to be remediated.
- Scrap may be scavenged, leading to changed volumes of rubble.
- Contamination plumes which were originally confined to a small area may be dispersed with time so that more contaminated groundwater must be pumped and treated.
Costs may change over time (2)

- Designs may need to be changed or updated, because;
  - They are flawed, incomplete, not according to best practice.
  - Regulations may have changed.
  - New data are available which necessitate to review remediation options.
- Decision, public consultation and permitting procedures must be re-started.
- Prices have accelerated due to inflation or escalation.
Costing radiation protection measures in ER project costs

• Either: detailed cost assessment of;
  ▪ Training for workers.
  ▪ Information of the public.
  ▪ Equipment (monitoring, decontamination).
  ▪ Dosimeters, read-out services, special experts, documentation, record keeping,…
  ▪ Time needed to do RP activities.

• Or simple markup on conventional civil works. 5-10 % are usually appropriate.
Costs of administration and supporting projects

- Funding management is part of the whole remediation management system
- Donor organizations have their funding, procurement and financial controlling rules, implemented in the country by “Project Implementation Units” (PIU, PMU)
- Interaction between technical, social and economical issues: supporting projects may be necessary such as
  - Training of authorities
  - Social impact, public health assessment
  - Stakeholder involvement, public consultations with communities and final site owners
Test plots and pilot plants

- Testing parts of the remedial solution (e.g., cover systems, water treatment flowsheets) may help to avoid expensive errors.
- Often, however;
  - Project time is too short to do any testwork.
  - Managers are not aware of the need and benefits of testwork.
  - No funds have been allocated for tests.
- Whenever possible, cost estimates should include testwork.
Example: test plot at Wismut
Time horizon of long-term activities

• Long-term models require more input data than are usually available
• Long-term costs will disappear in the „discounting fog“ anyway when calculating the NPV
• Make simple estimates of the long-term processes (order of magnitude)
• Make the remediation design robust with respect to failure of single design elements
Some observations (1)

- All remediation is site-specific.
- Off-the-shelf solutions are rarely available.
- Unit costs such as treatment per m³ of soil, water etc. can only be given after a careful analysis. Be cautious with vendors claiming otherwise.

- Technology decisions are often taken;
  - Without a clear conceptual understanding of the site.
  - Without enough data to support a decision.
Some observations (2)

• Data obtained during the operation phase of a site are enough to develop remediation solutions and support costing.

• How much of the remediation costs can be recovered by selling an „added value“? Different experience;
  - Population density is not the decisive factor.
  - But value of the land, property development and economic growth.
Cost estimation methods

• Tenders, bids, quotations;
  ▪ Real market prices.
  ▪ Require careful preparation of specifications.
  ▪ Response may take a long time.
• Cost database;
  ▪ Every engineering firm has its own.
  ▪ Quickly done.
  ▪ Needs permanent updating to reflect market changes.
Cost estimation methods (2)

• Parametric cost estimation;
  - E.g., Wismut estimates capex of mine water treatment plant: \( C(Q) = C(Q_0) \times \left[\frac{Q}{Q_0}\right]^{0.6} \)
  - Reasonable results (in some cases).

• Statistical evaluation of ER projects;
  - Evaluate many similar ER projects and extract statistical relationship between quantities and costs.
  - E.g., demolition of contaminated buildings.
  - Radioactively contaminated buildings require more work time and additional equipment.
Example: Demolition costs at Wismut

• WT (Working Time, in person-hours) =
  • 0.24 hours per m³ volume of the building +
  • 0.14 hours per ton of reinforcement scrap
• ET (Equipment Time, in hours) =
  • 0.04 hours per m³ volume of the building +
  • 0.13 hours per ton of reinforcement scrap
• Labour cost = unit labour cost per hour x WT
• Equipment cost = unit equipment cost per hour x ET
• “Working time” and “Equipment time” are quite universal
  ▪ Assuming similar level of skills and equipment everywhere
• But unit costs for labour and equipment are site-specific.
Probabilistic models: GoldSim

Probabilistic simulation
Graphically, object oriented
Typical questions answered by probabilistic cost models

- How likely are total costs exceeding xxx €?
- What are the chances we could spend less than yyy €?
- What are the most cost-sensitive parameters in the entire process (particularly in complex systems).
- But:
  - People are not used to dealing with probabilities.
  - Probabilistic cost models often provide too much information, which confuses decision makers.
Spreadsheet cost estimation tools

- Many examples available on the internet
- Based on MS Excel
- Over-simplified (?)
- Compromise may be probabilistic add-on’s (@Risk etc.)
Useful resources

• IAEA: Cost Estimate of Environmental Remediation Projects (Draft, in progress)
• Numerous publications and guidelines on provisions for ER, e.g.,
  ▪ World Bank (M. Sassoon)
  ▪ ICMM (G. Miller)
  ▪ European Commission („MonTec Study“)
• Example: Commission Decision 2009/335/EC, based on MonTec Study
2009/335/EC calculation guidelines

• Details requirements of Art. 14 of Mine Waste Directive 2006/21/EC.
• Calculation of financial guarantees (and thus costs) shall be based on;
  ▪ environmental impacts and on human health.
  ▪ definition of the rehabilitation and after use.
  ▪ environmental standards and objectives.
  ▪ the technical measures to achieve standards.
  ▪ estimated time scale of impacts.
  ▪ take long-term activities into account.
Accounting approaches

• Examples for ER in the mining industry.
• KPMG;
  ▪ Provisions for closure and environmental rehabilitation.
  ▪ Global trends.
• Price Waterhouse Coopers;
  ▪ Accounting standards for decommissioning and closure costs.
• Other industry sectors also available.
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