

Probabilistic Assessment of Landfill Remediation Costs

CSVA 2011 Conference
Toronto, Ontario
Nov 14 -16, 2011

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Introduction

- Landfill management involves many uncertainties
- Closure and maintenance costs might be understood late in landfill life, but not in early operating stages
- Remediation costs due to unexpected discharges are unknown
- Regulatory agencies can require financial assurance for future remediation and closure (e.g., bonds)

Introduction

- Multiple landfill sites throughout Australia
- EPA (Victoria) regulations required financial assurance as a condition of operation
- Operation, closure, and post-closure liabilities
 - Remedial action
 - Site rehabilitation
 - Site aftercare

Financial Assurance – Remedial Action

- Events categorized as remedial action
 - Leachate seepage through liner(s)
 - Failure of leachate collection system(s)
 - Failure of leachate dam
 - Surface and/or ground water contamination
 - Illegal dumping
 - Adverse landfill subsidence
 - Migration of landfill gas
 - Landfill fires
 - Excessive erosion of cap

Financial Assurance – Remedial Action

- Financial assurance often provided through participation in mutual fund approved by EPA
- Mutual fund members insure each other (in effect) against potential future liability
- For operators unwilling to participate in mutual fund, individual financial assurance is required:

$$\text{AU\$}200,000 + 16T_{\text{avg}}$$

T_{avg} = average tonnage for past 3 yrs for operating facility, projected average for new facility

Financial Assurance – Remedial Action (RA)

- Quantitative risk analyses –alternative to prescriptive formula or mutual fund
- Used to define ranges of future potential remediation costs
- Basis = 95% upper confidence limit of costs
- Analysis must include all listed uncertain events under “remedial action” category

Financial Assurance – Site Rehabilitation (SR)

- Actions categorized as site rehabilitation
 - Capping and revegetation
 - Installation of gas collection infrastructure (if not already installed)
 - Installation of leachate collection systems (if not already installed)
 - Infrastructure decommissioning when no longer required

Financial Assurance – Site Rehabilitation (SR)

- Financial assurance calculated based on 3rd party undertaking closure
- Cost estimated for largest area of landfill that may be open (uncapped) at any time
- Must include for minimum of two cells (operating and most recently closed cell)

Financial Assurance – Site Aftercare (SA)

- Actions categorized as site aftercare
 - Inspection of cap and all infrastructure
 - Repairs
 - Landscape maintenance
 - Leachate treatment/disposal
 - Decommissioning of leachate storage ponds
 - On-going gas and groundwater monitoring
 - Maintaining monitoring systems
 - Management of landfill gas

Financial Assurance – Site Aftercare (SA)

- Default management period of 30 years (subject to extension if needed)
- Demonstration that conditions have stabilized can result in shorter periods
- Some landfills permitted 10 year period
- Cost estimates must include all actions listed in category
- Future costs must be inflation-adjusted

Financial Assurance – Provision

- Assurance assessed case-by-case
 - Letter of credit from bank
 - Certificates of title
 - Personal and bank guarantees
 - Bonds
 - Insurance
 - Mutual fund
 - ...other forms of security

Risk-Based Analysis of RA Costs

- Group of landfill operators and owners – 7 landfills
- Solid inert waste landfills
- EPA RA financial assurance criteria thought onerous
- Quantitative risk analysis of RA costs undertaken
- 10 year post-closure period agreed with EPA

Risk-Based Analysis of RA Costs

Steps undertaken

1. List of comprehensive & non-overlapping significant pollution problems
2. Group of experts convened to assess risks
3. Characterized risks
 - a. Likelihood of occurrence
 - b. Potential consequences
4. Developed & implemented “Monte-Carlo” simulation model

Risk-Based Analysis of RA Costs

1. 95th percentile RA cost derived from results
 - a. Present value
 - b. Future value (allowing for annual 2% cost growth)
 - c. Net present value allowing for discounted cash flow as well as annual cost growth
2. EPA required use of future value for assurance

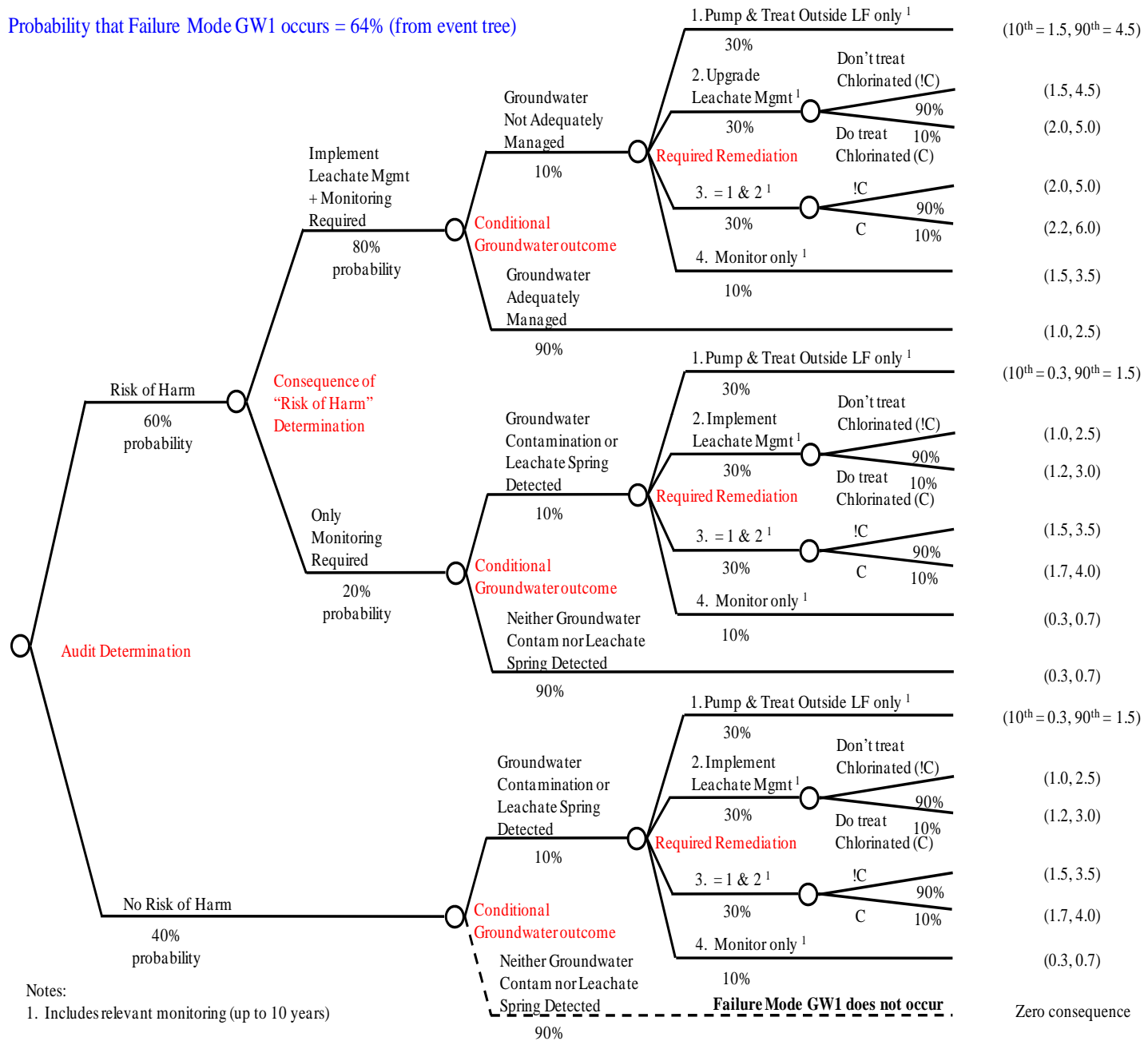
Risk-Based Analysis of RA Costs

- General categories of events very broad
- Failure modes and outcomes developed with operators and experts – clarity of scope
- Consequences elicited using “event trees”
 - Convenient graphic tool
 - Assists quantifying multiple outcomes associated with same broad risk

Consequences of Failure Mode GW1. Groundwater Pollution on West Side (all causes)

Assessed Uncertain Direct Costs Given Outcome
(Normally distributed with 10th, 90th percentiles)
(2006 \$M)

Probability that Failure Mode GW1 occurs = 64% (from event tree)

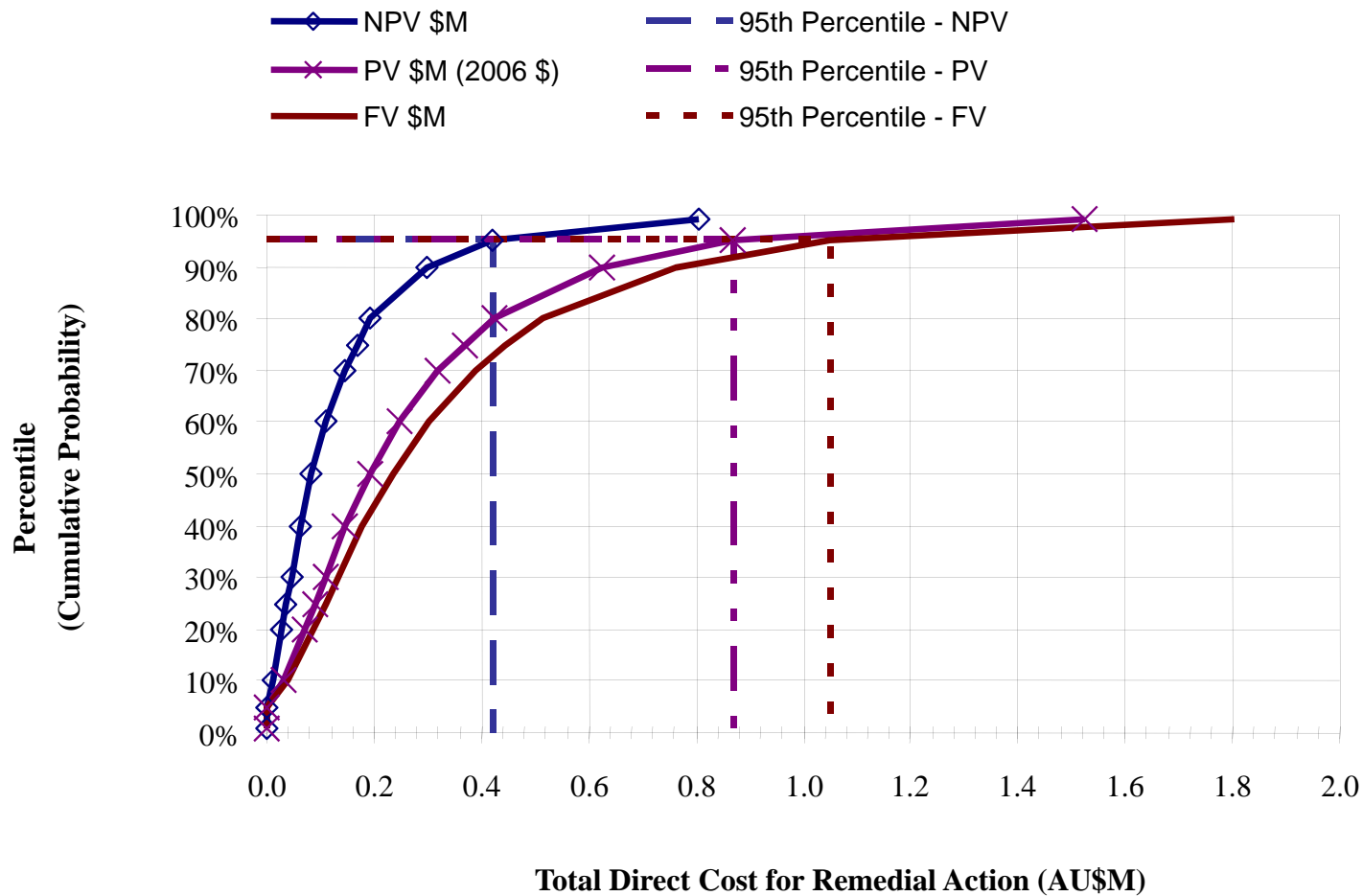


Notes:

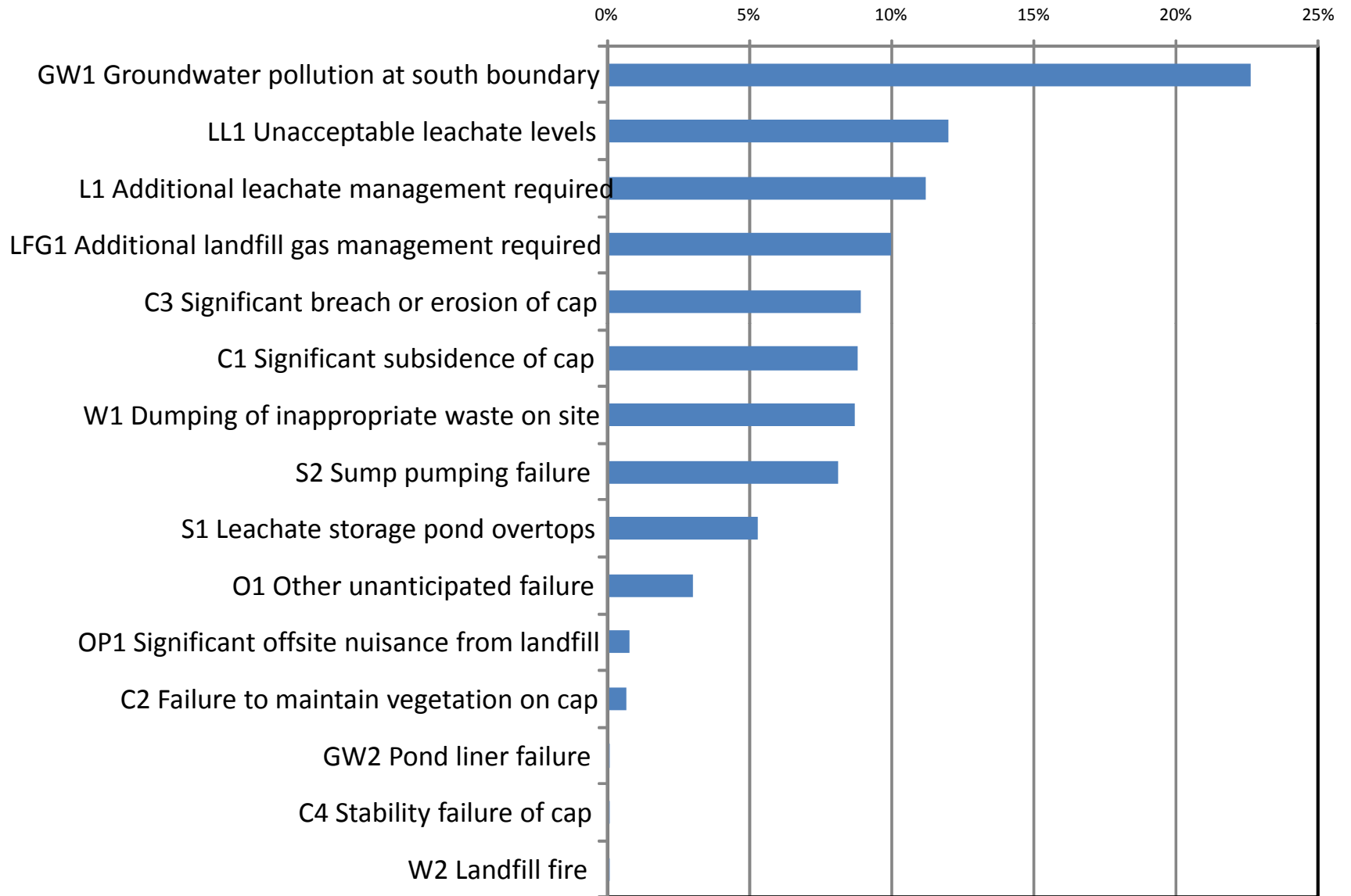
1. Includes relevant monitoring (up to 10 years)

Risk-Based Analysis of RA Costs

Results for one landfill



Contribution to 95th Percentile Total FV Direct Cost



Closing Remarks

- 7 landfills evaluated
- 95th percentile FV costs ranged from \$0.5 to \$1.2 M
- 95th percentile costs significantly less than regulation-driven default minimum values
- Permitted viable financial solutions
- Maintained sufficient reserves to address future environmental risks

Closing Remarks

QUESTIONS?

Closing Remarks

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