The Discipline of Honest Future Thinking and Benefits to Optimization of Existing Systems

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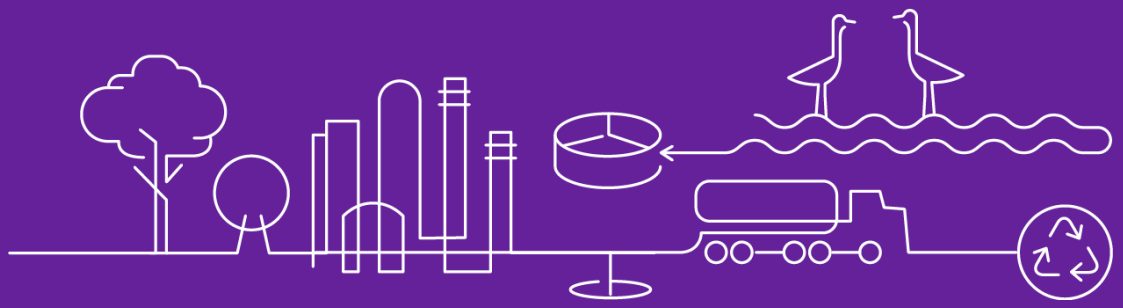


Delivering Sustainable Solutions to Complex Local Challenges, Worldwide

Fourth International Symposium on Bioremediation and Sustainable Environmental Technologies

Agenda

- Symptoms of suboptimal performance
- Elixir's to improve outcomes
  - Scenario planning
  - Applying probabilities
  - Using results for revising the path forward
- Tools that can be used
- Closing and recommendations

Key Take-Away Points

- Decisions should be made on cost-ranges and probabilities
- Different options have different risk profiles
- Use of tools to identify uncertainties and plan for them
- Think of cleanup as a grouping of probabilities
  - Rarely a straight line from start to finish

Houston, we have a problem

Symptom

- Stuck in a perpetual phase of O&M and there is no end in site
- The remedy is not working as planned, no contingency planning
- The annual spend does not drive down long-term liability in a meaningful way
- The remedy is clear and cleanup goal clear, but path is not

What enables symptom

- Contaminant reduction against time and money not defined
- Status quo easier than changing
- Simple anecdotal evidence used to persuade stakeholders
- Annual data is not being used to update the CSM
- Too optimistic about results to date

The Good and the Bad in the Remediation Industry with Honest Future Thinking

The Good

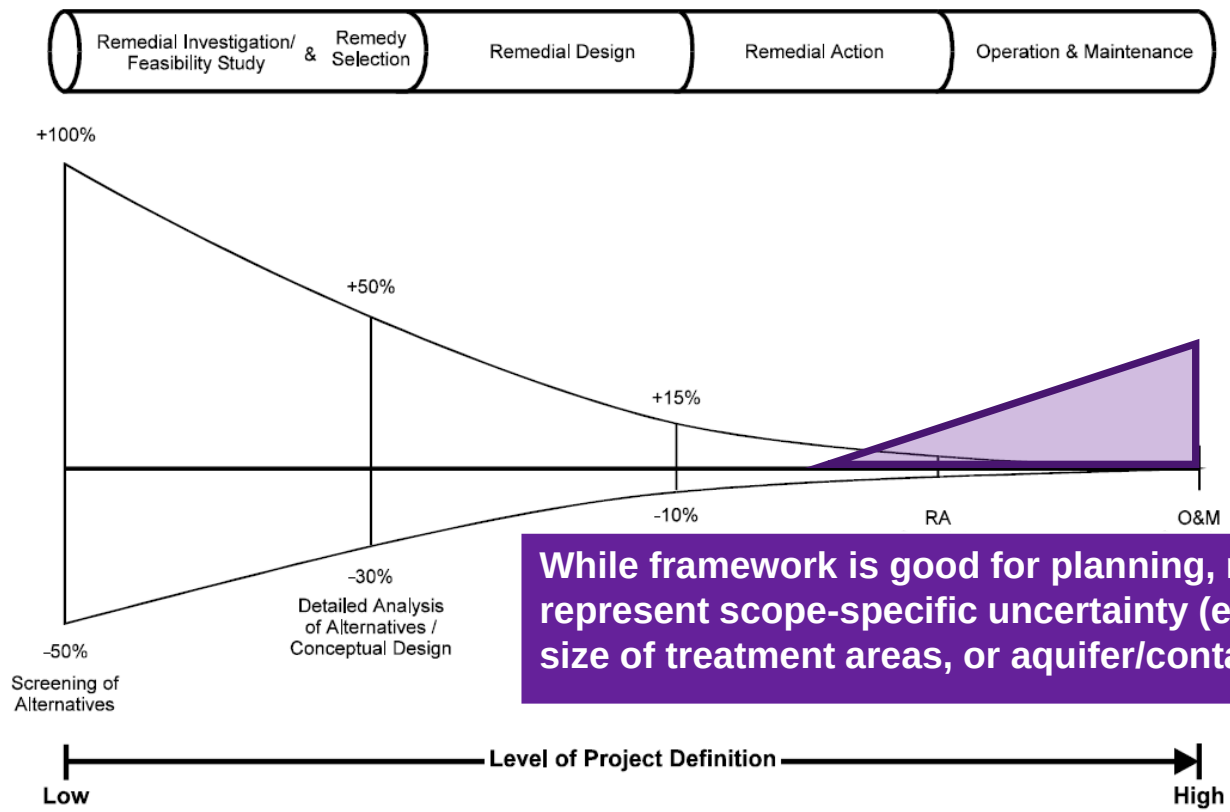
- We can accurately design and construct remedies
- O&M costs easily tracked
- We have 30 plus years of experience with some technologies
- *Excel is an easy tool to use to develop cost estimates*
- We know where we are and where we want to go

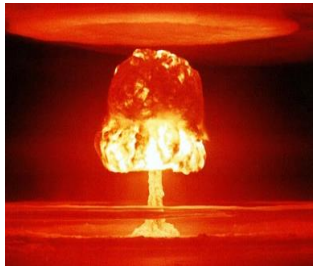
The Bad

- The time of remediation is uncertain
- We often do not leverage this knowledge and work in our own echo chambers
- *Excel is an easy tool to use to develop cost estimates*
- We don't often utilize guideposts to assess our progress

From: A Guide to Developing and Documenting Cost Estimates During the Feasibility Study (EPA, 2000)

Exhibit 2-3
Expected Cost Estimate Accuracy Along the Superfund Pipeline





While framework is good for planning, never intended to represent scope-specific uncertainty (e.g., time of remediation, size of treatment areas, or aquifer/contaminant characteristics)

Place to Start: Scenario Planning

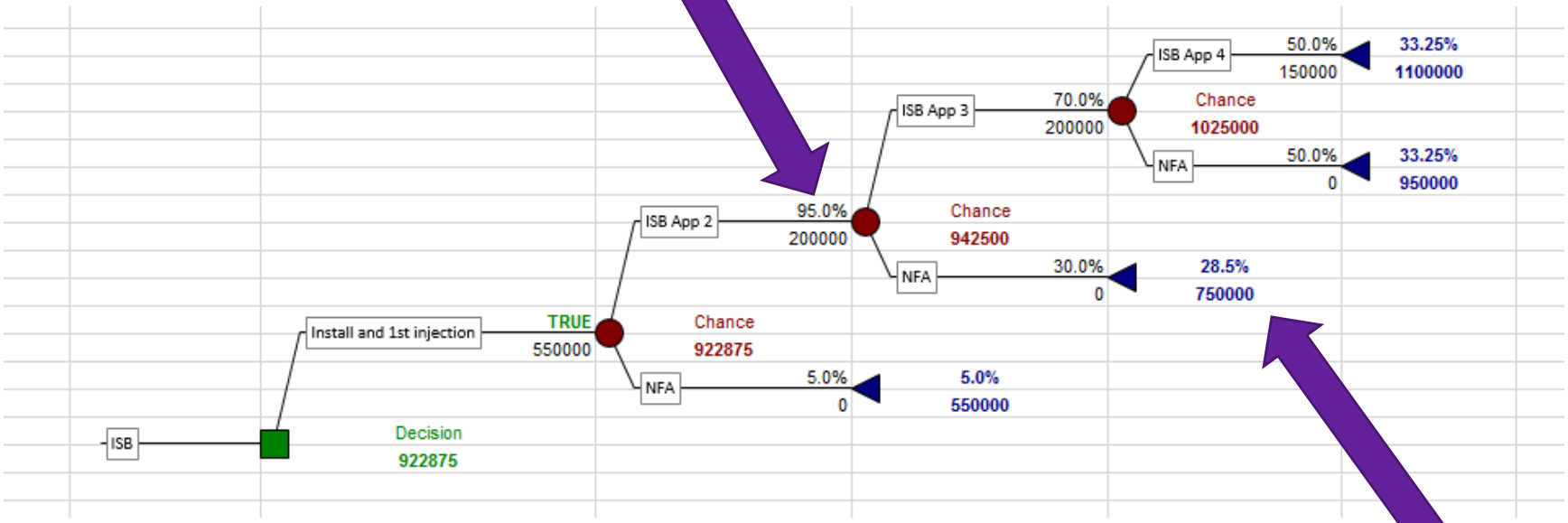
- Requires team to think about future events – play “what if”
- More brains are better, bring together diversity of opinion and experience
  - More industry experience
  - Diversity of opinion
- Identify potential fatal flaws and walk-away conditions
- Drives thinking of options, contingencies and when they should be activated

Example Scenario

- Install injection points and deliver two rounds of EVO
- Transition to MNA
- Anticipate closure in 7 years
- But what if two rounds isn’t enough
- What if you needed four rounds?

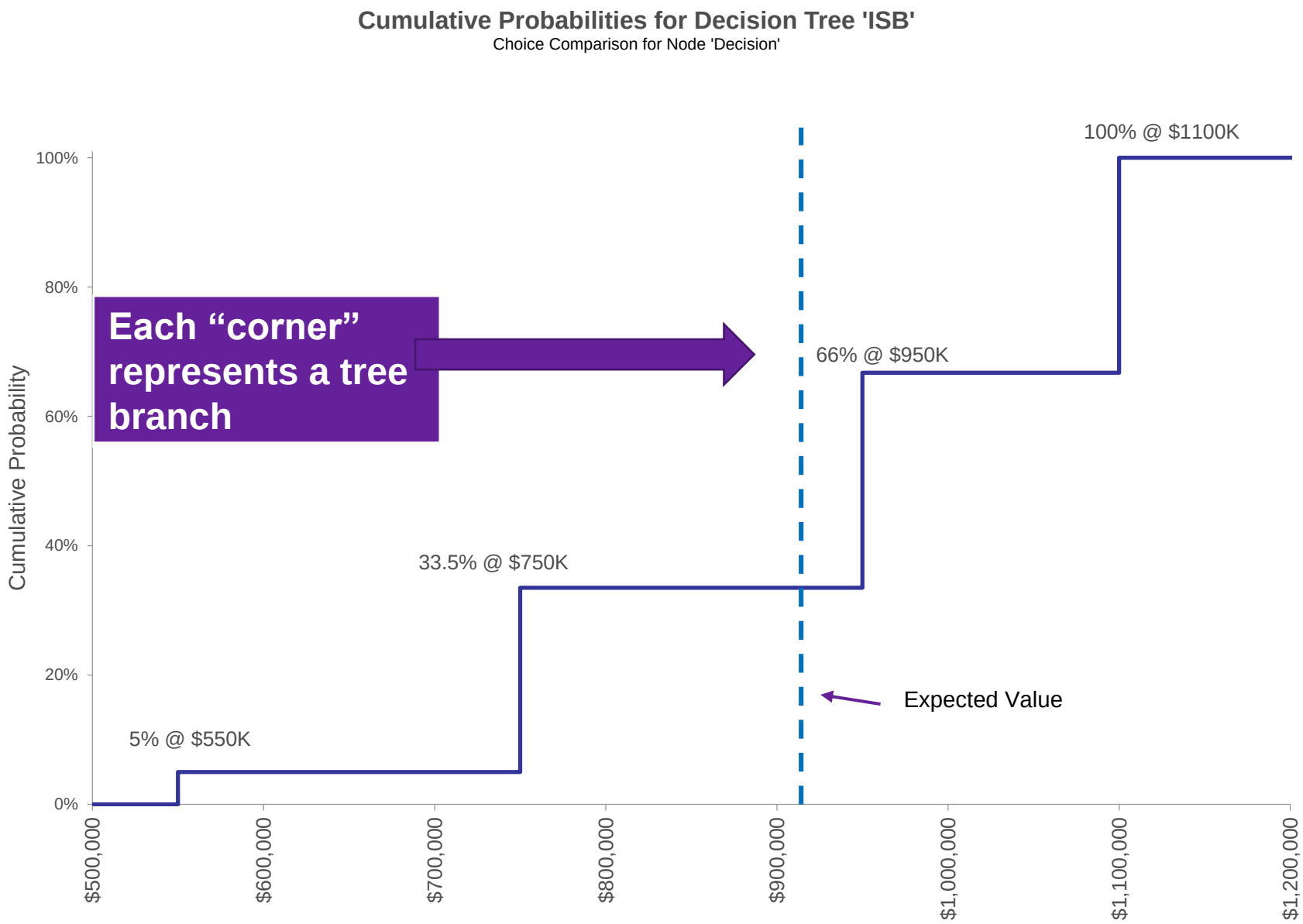
Decision Tree Management Software

Probability of series of Injection events

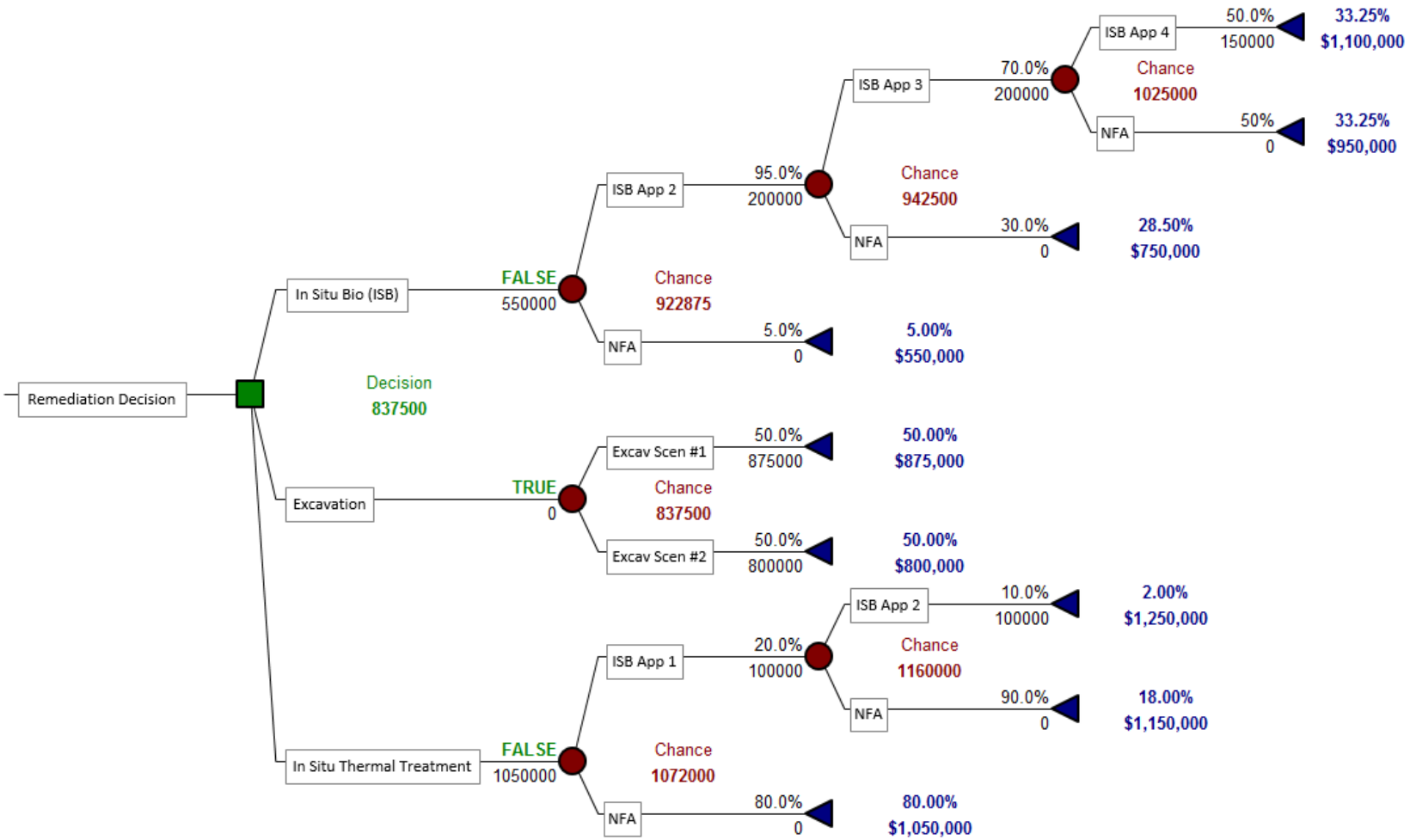


Costs and probability of each occurrence

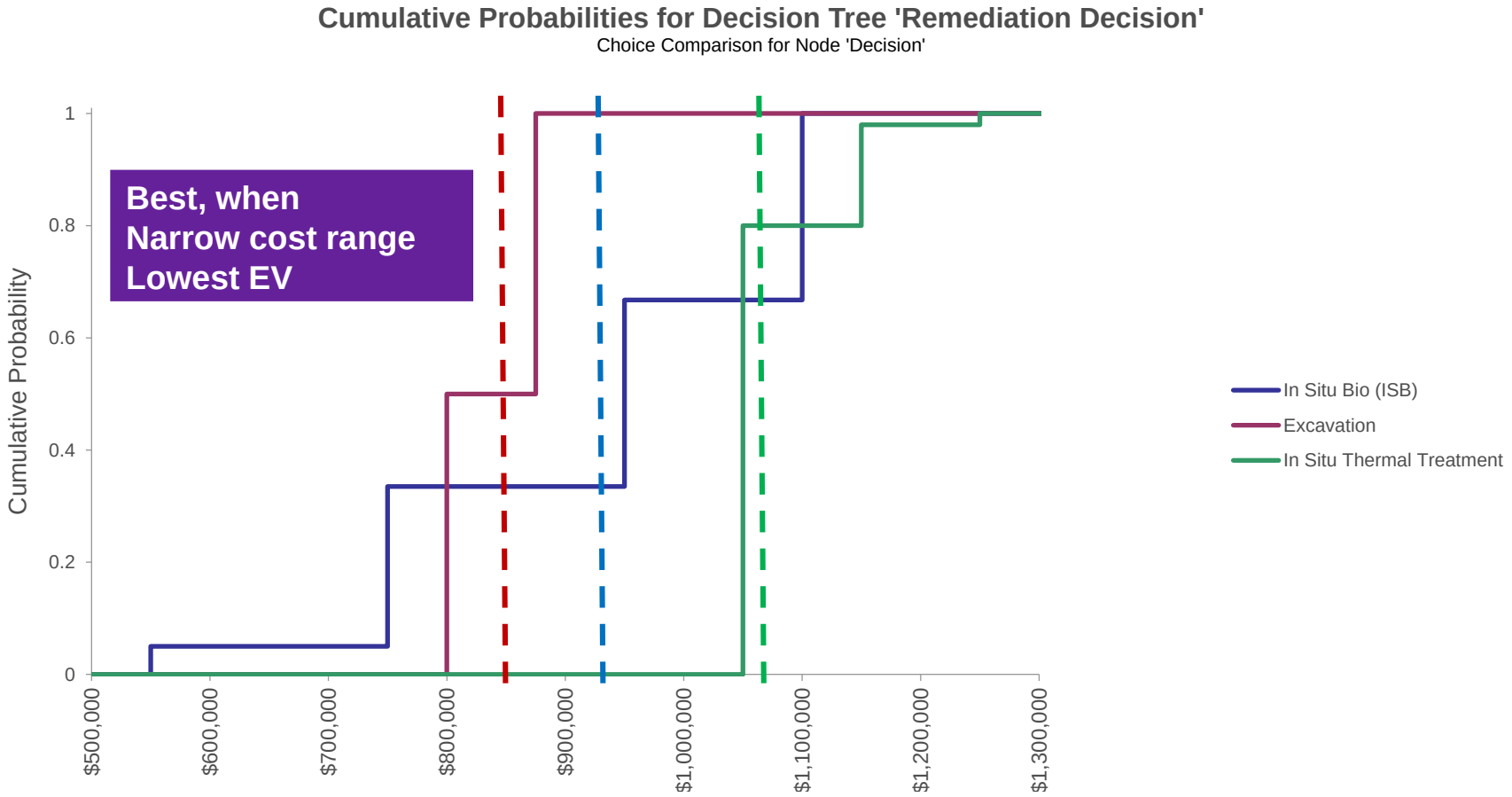
Risk Profile of Potential Outcomes



Decision Tree Management
Is there a better option?

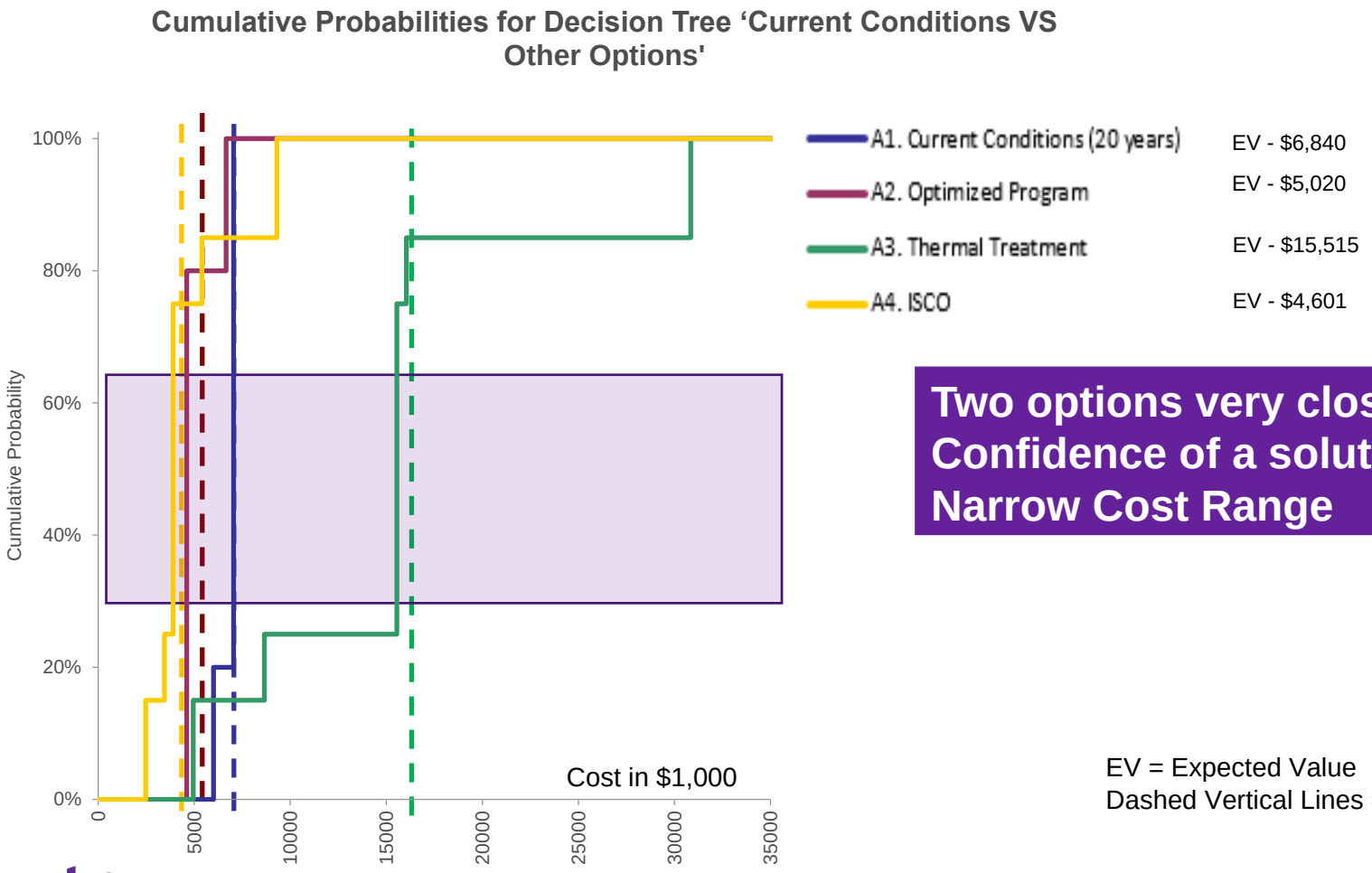


Stacked Risk Profile of Three Options



Risk Profiles for Different Technologies

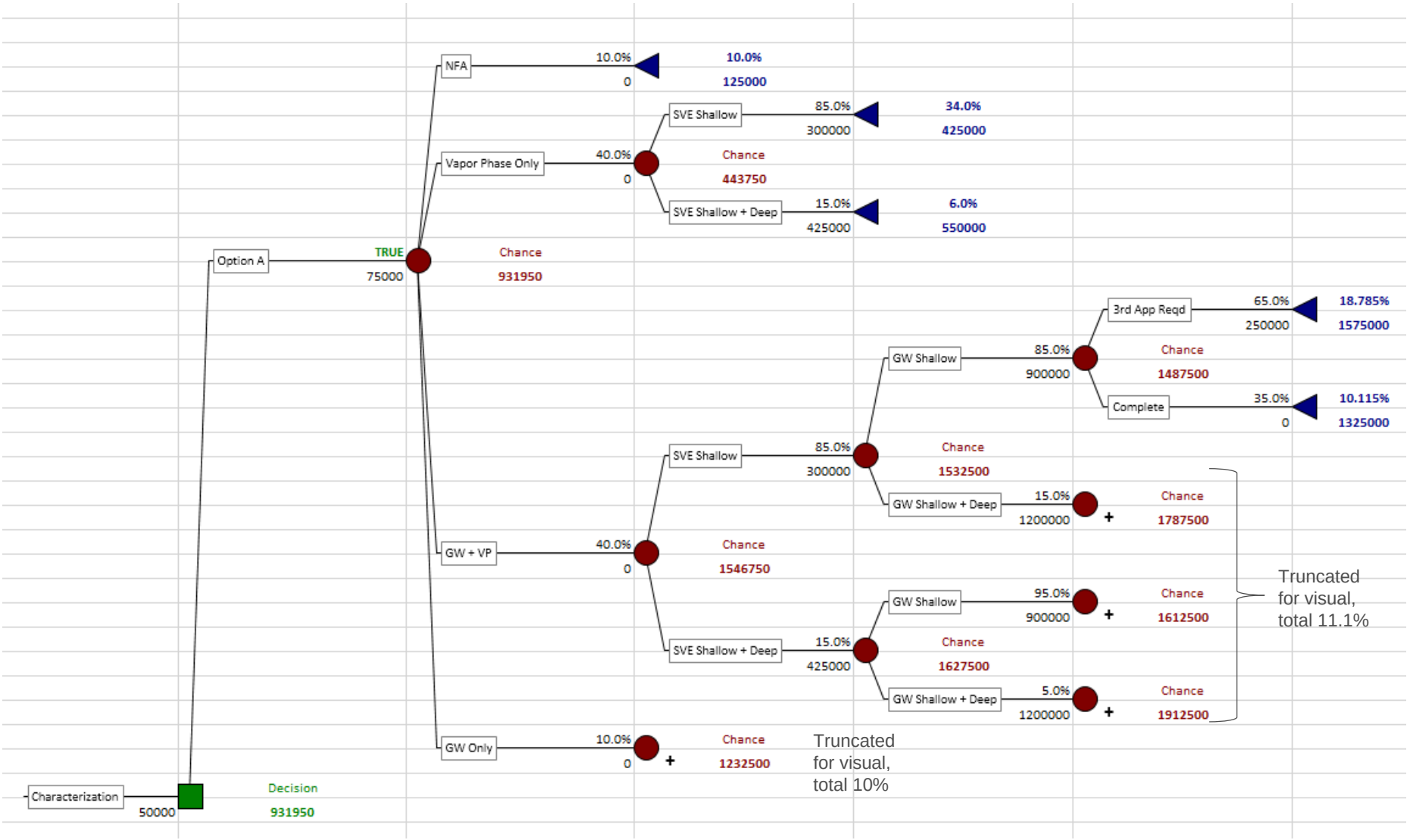
1. Based on EV, A2 and A4 are very close
2. A3 is the most expensive and has a low probability of being competitive with the other options
3. A1 is marginally more expensive than A2 and A4



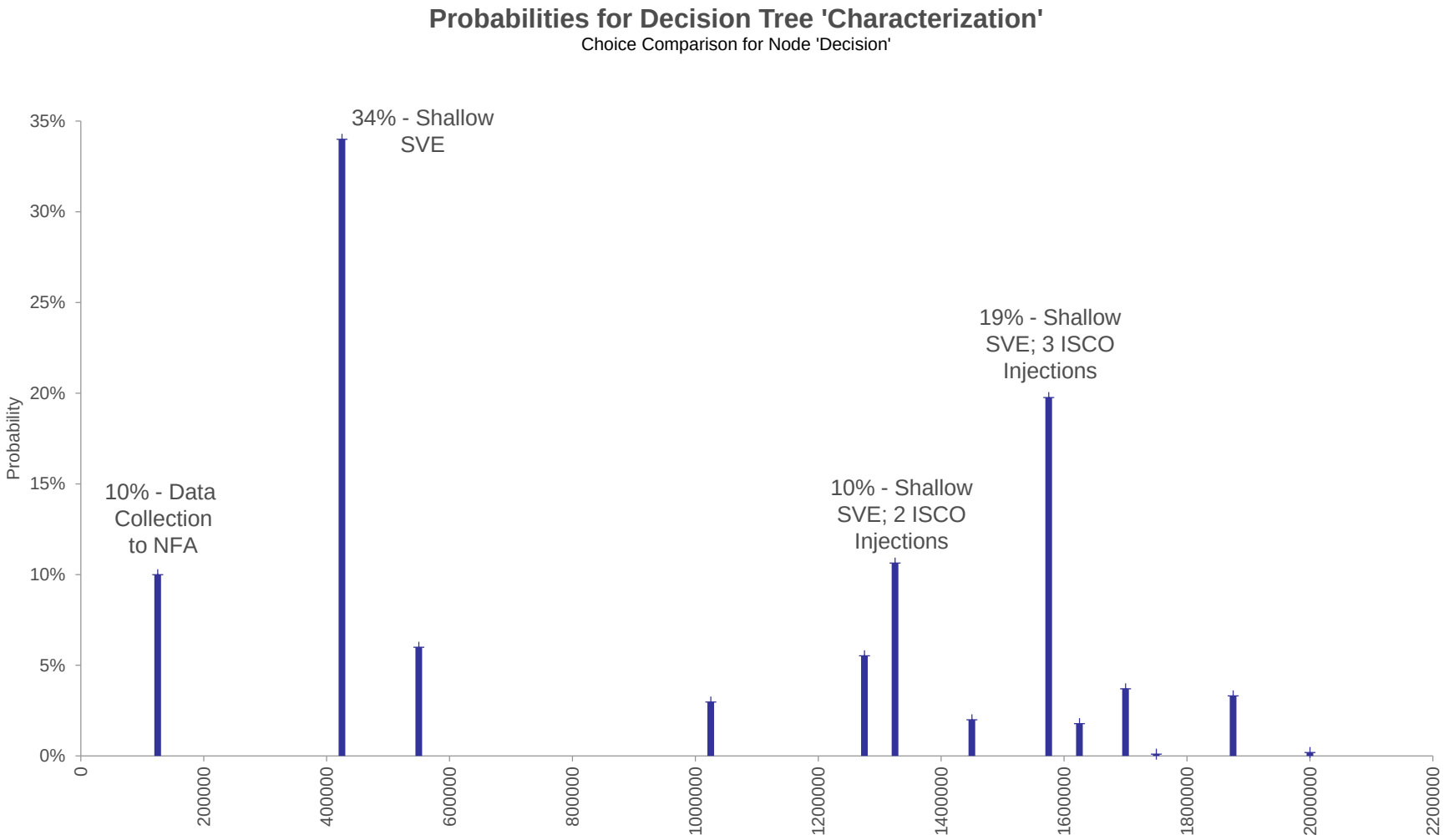
Two options very close
Confidence of a solution
Narrow Cost Range

EV = Expected Value
Dashed Vertical Lines = EV on Chart

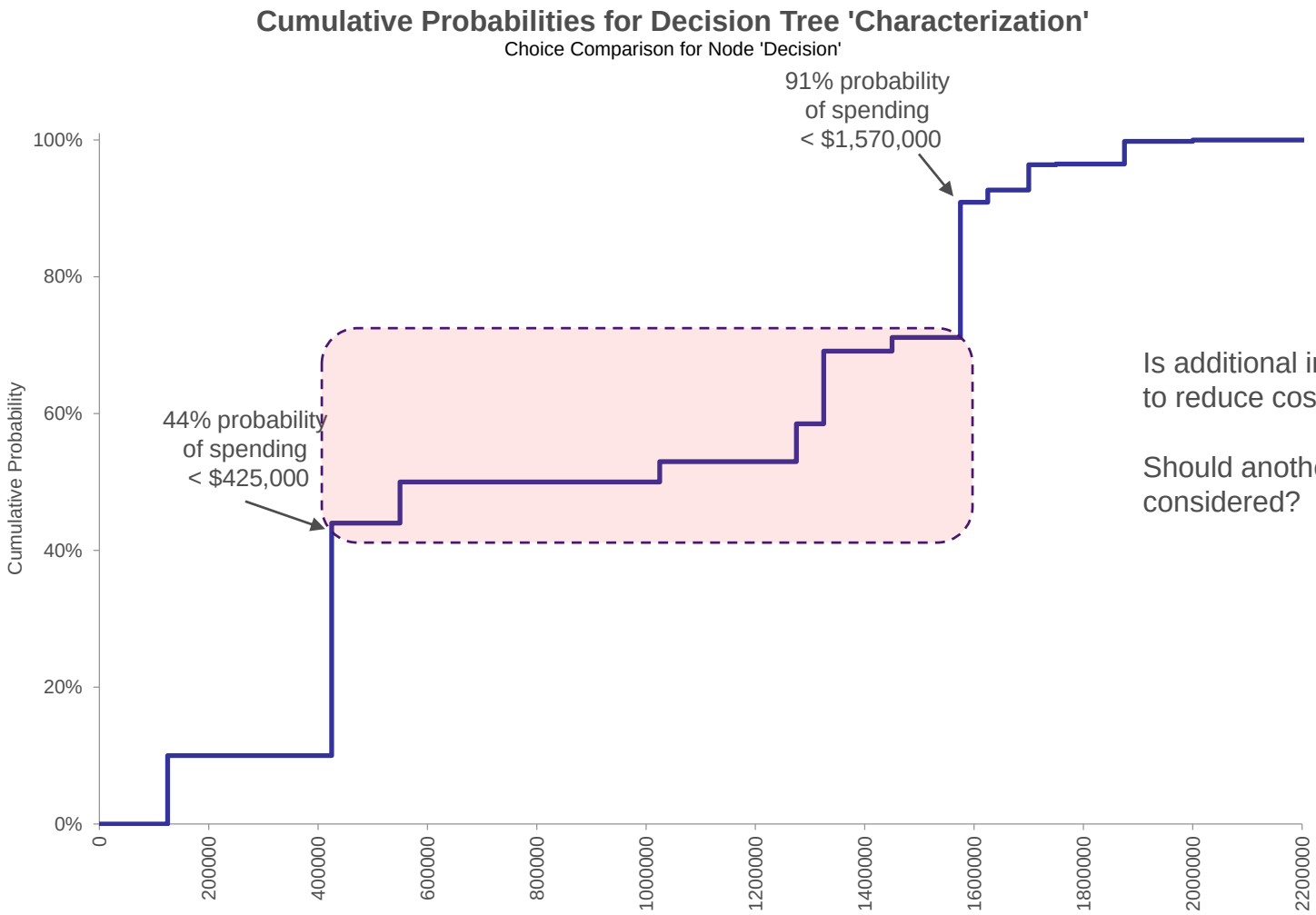
Decision Tree Mgmt Helps Us Visualize Potential Future Outcomes of Decisions



Probabilities Plot Provides Team Focus on Likely Outcomes



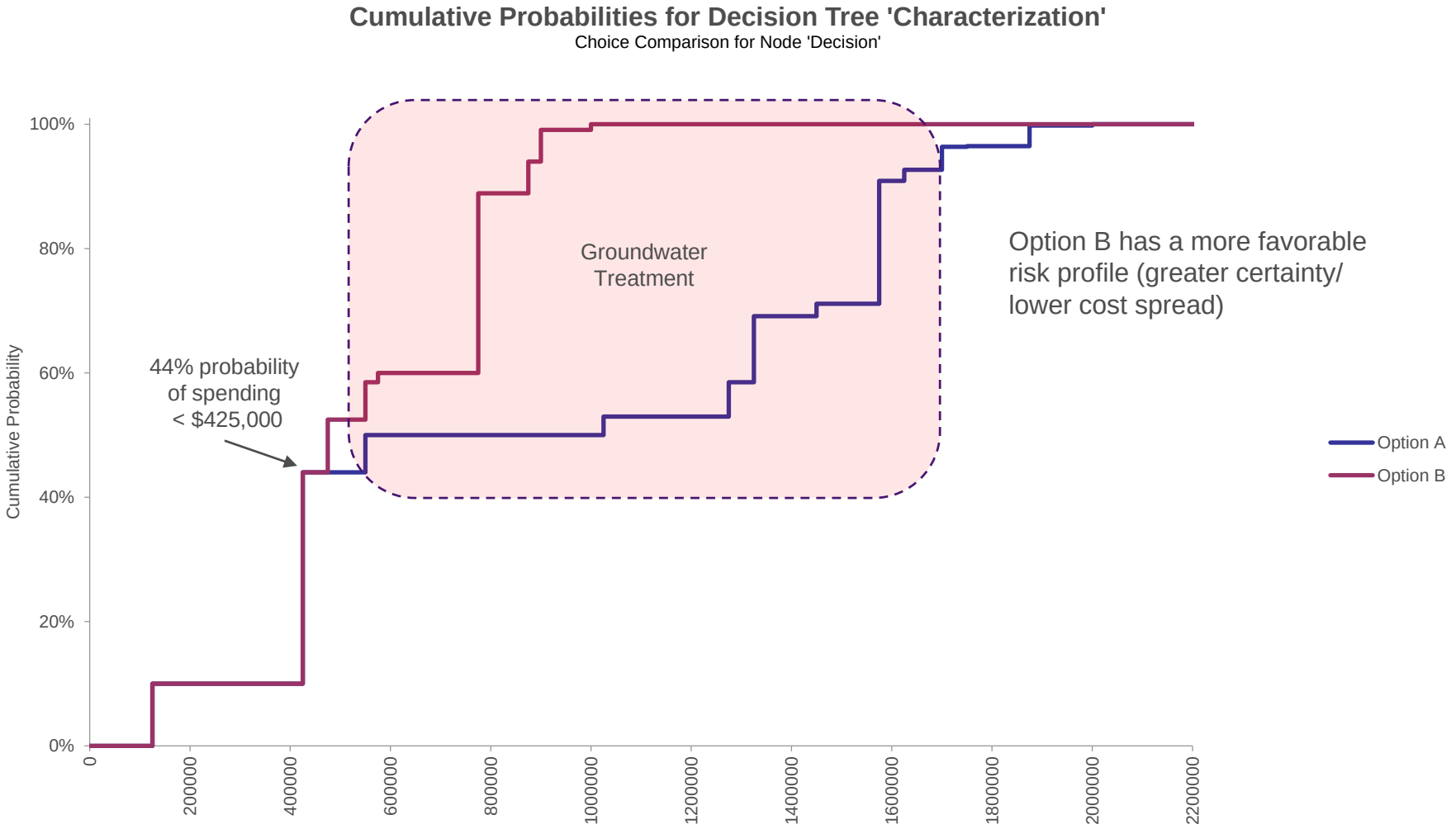
Risk Profile Shows Cost and Confidence



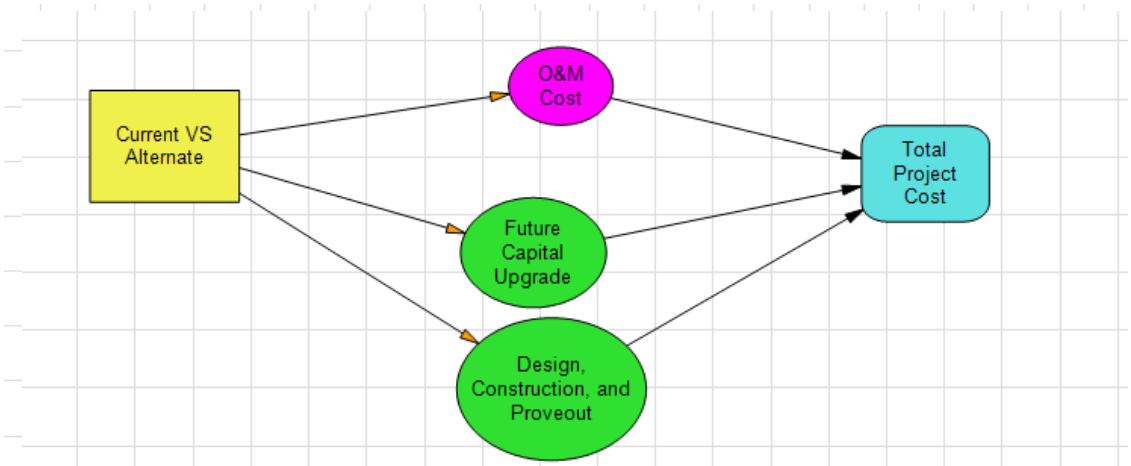
Is additional information needed to reduce cost uncertainty?

Should another option be considered?

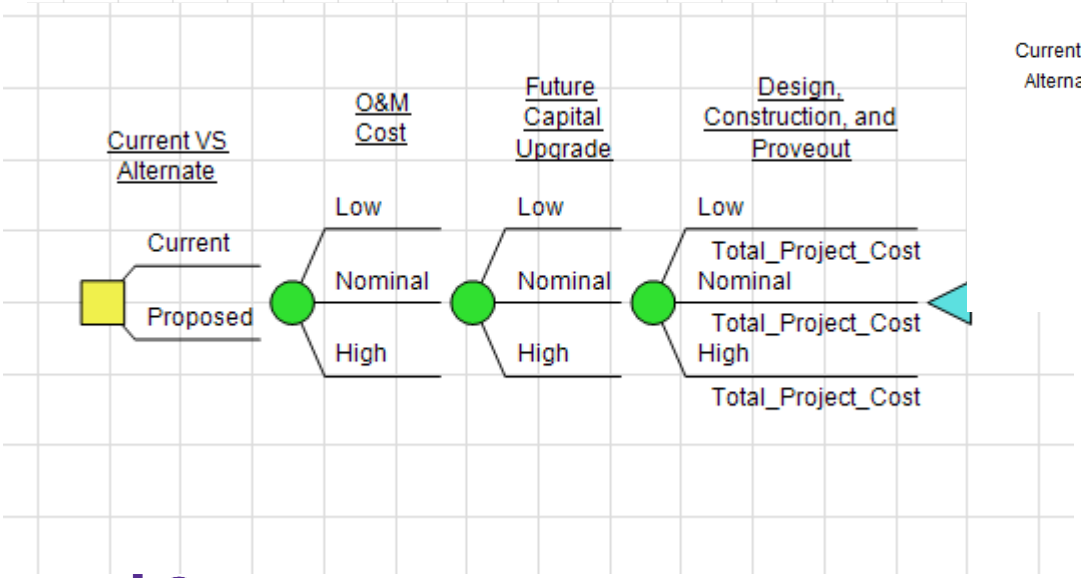
An Alternative Approach is Identified to Improve the Risk Profile

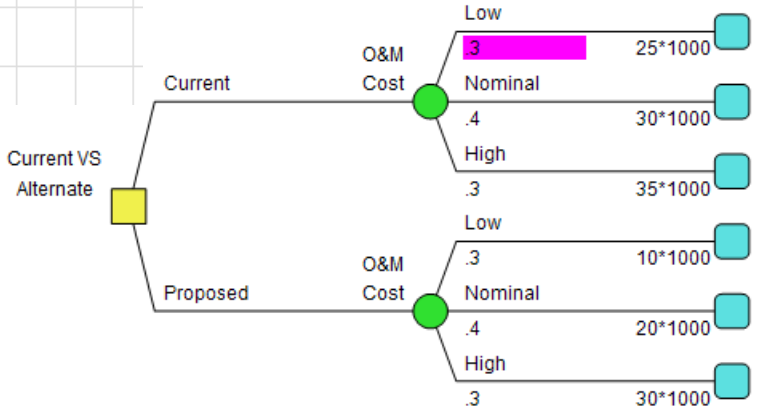


A Simpler Way to Construct Trees

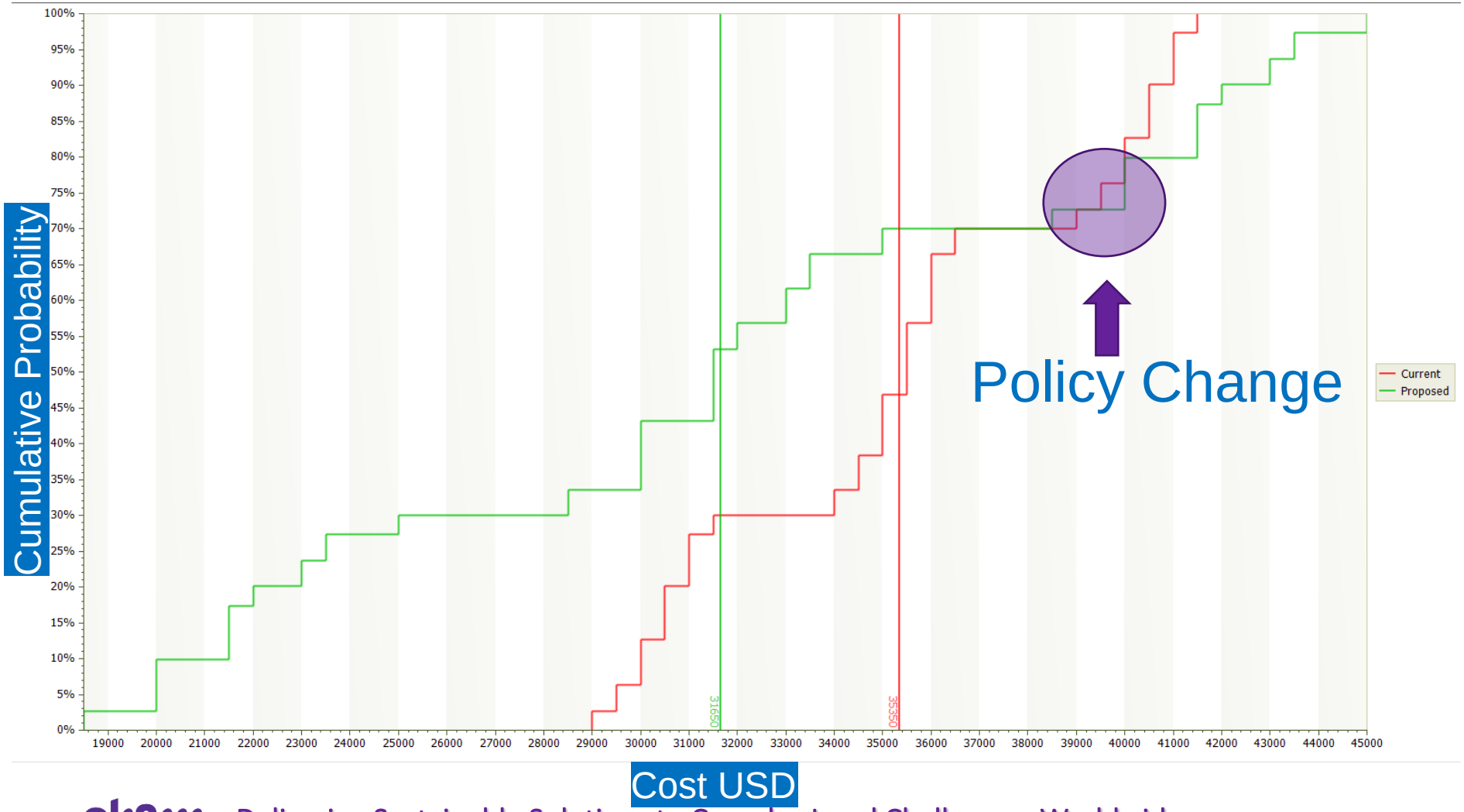


Three Variables
Three Options for Each
Two Options
3^3*2 = 54 Branches

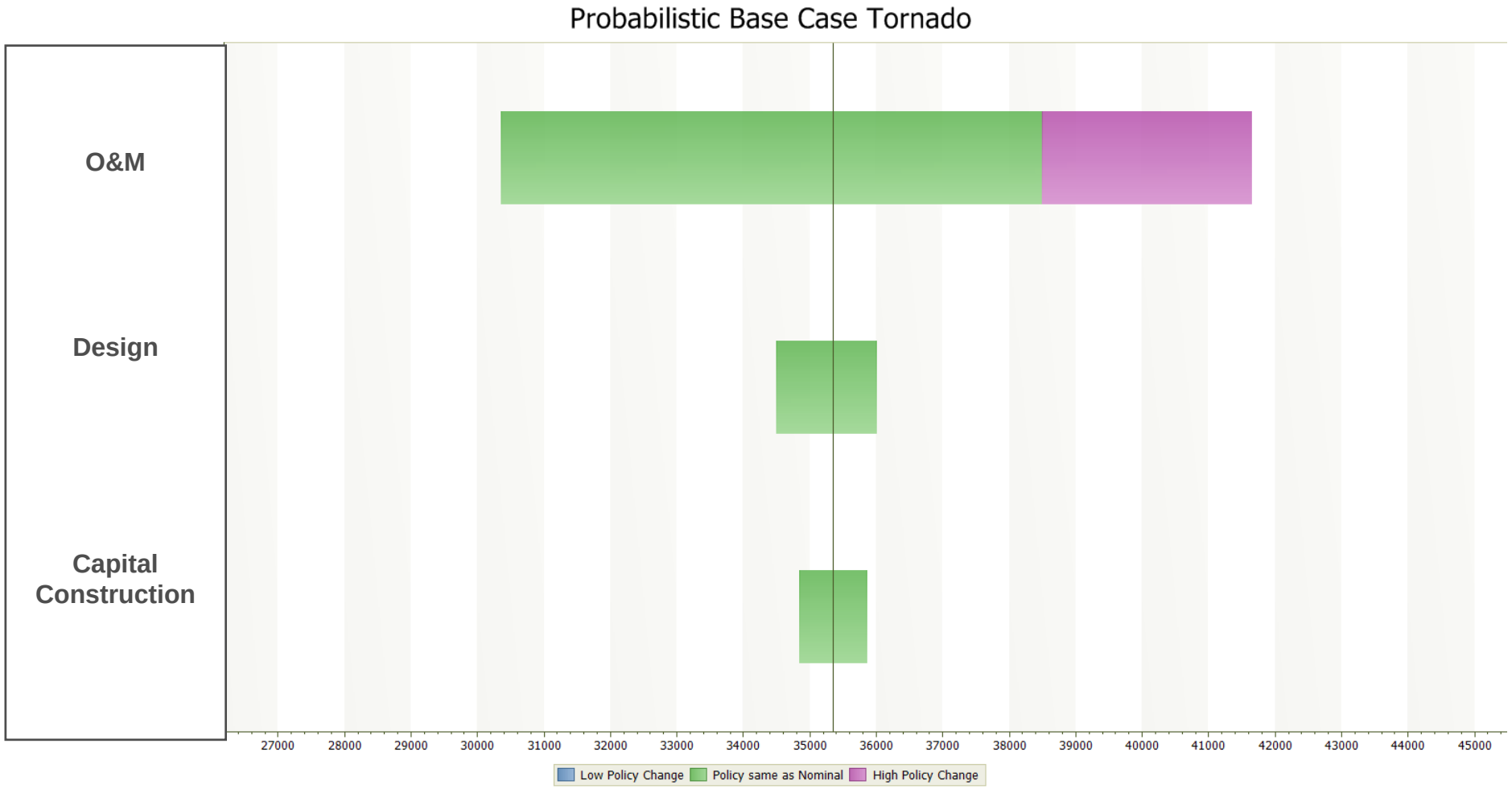




Decision Tree Management
Cumulative Probability of Two Alternatives

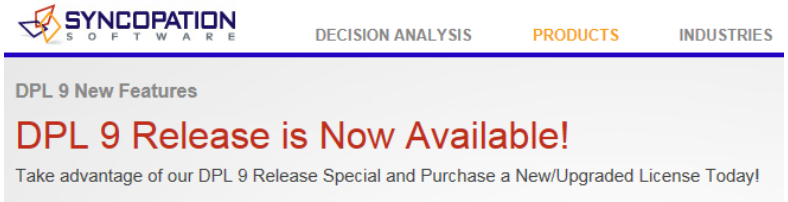


Decision Tree Management
Tornado Diagram Can Identify Policy Change



Tools For Decision Trees

Builds models in Excel

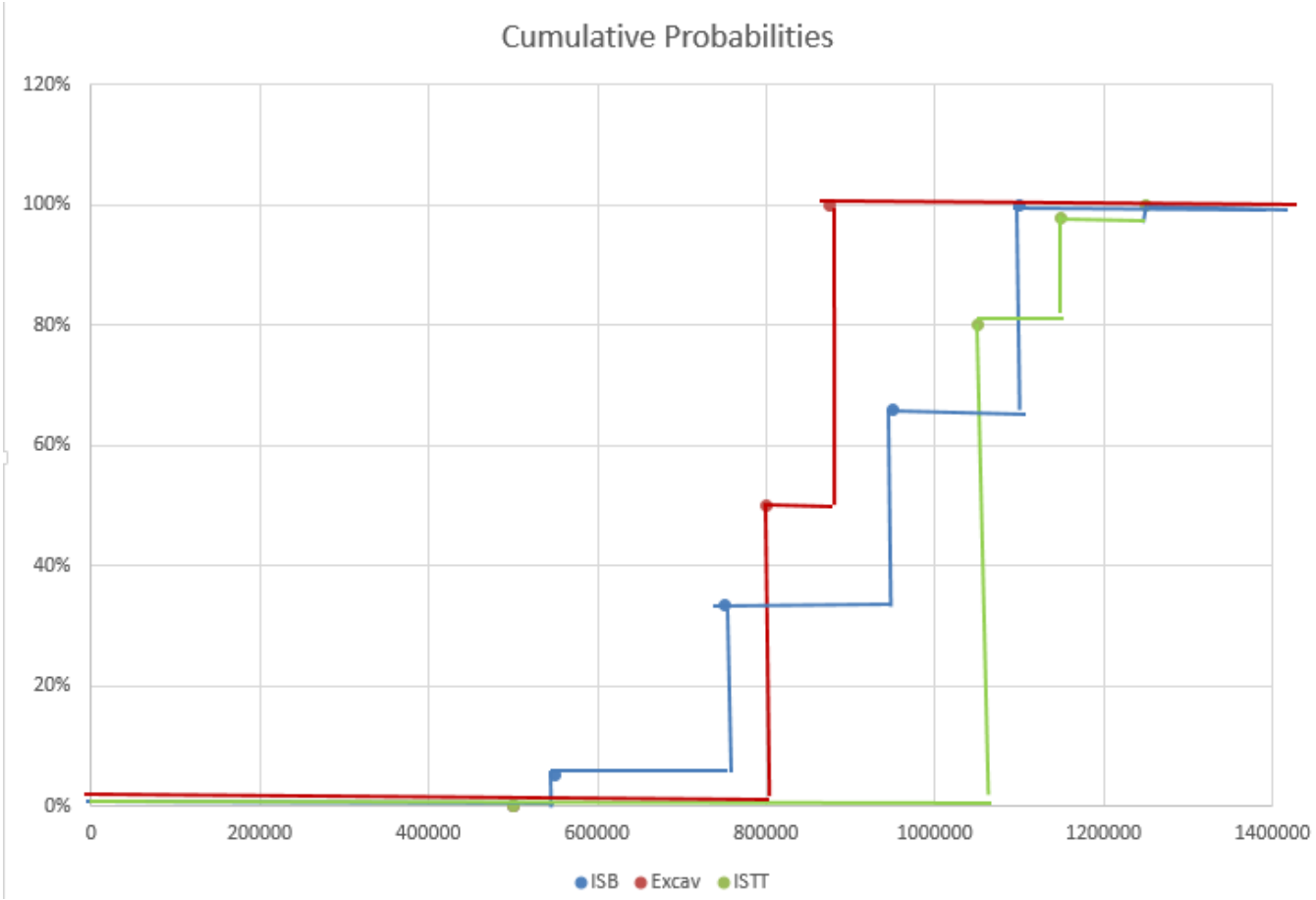


Work in the DPL Environment but can import spreadsheets

"Twisting the Arm" of MS Excel

Brute Force in Excel
(is not pretty, but workable for simple cases)

Cost	ISB	Excav	ISTT
500000	0%	0%	0%
550000	5%		
750000	34%		
800000		50%	
875000		100%	
950000	66%		
1050000			80%
1100000	100%		
1150000			98%
1250000			100%



Closing Thoughts and Key Take Away Points

- Decisions should be made on cost-ranges and probabilities
- Different options have different risk profiles
- Use of tools to identify uncertainties and plan for them
- Think of cleanup as a grouping of probabilities
  - not a straight line from start to finish
- MS Excel collapses thinking into one outcome
- Knowing risks (corners on the tree branch) highlights decision points in project life cycle
  - Creates planned decision points and requires action

Thank you!

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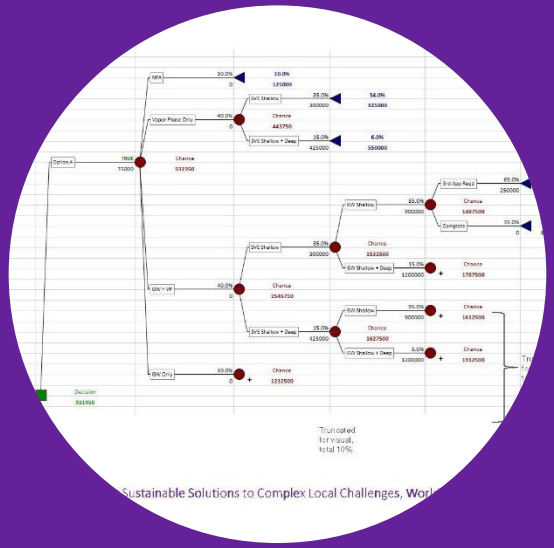

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