Practical Applications for Risk Quantification

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Agenda

- Why move beyond qualitative risk management ?
- Data characteristics and core risk quantification techniques
- Case studies: applications of risk quantification
- Live Monte Carlo simulation
- Integrating risk quantification into existing risk management and decision making processes

Why move beyond qualitative risk management ?

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Risk quantification is not new

- Doctors / pharmaceutical – risks tolerance and drug trials
- Treasurers – volatility of investment returns (Value at Risk)
- Corporate planning – “what if” sensitivity analysis, scenario planning
- Bank credit departments – risk return optimisation
- Feasibility studies – real option analysis
- Engineering design – safety, reliability, risk tolerance
- Insurers – price of risk reflected in premium; likelihood of claims
- Environment – regulation of emissions
- Weather – predictive reliability, global warming
- M&A – uncertainty as a basis of negotiation
- Options evaluation – boundaries of acceptable risk
- Decision making – risk analysis in exit strategies; cost benefit analysis

……

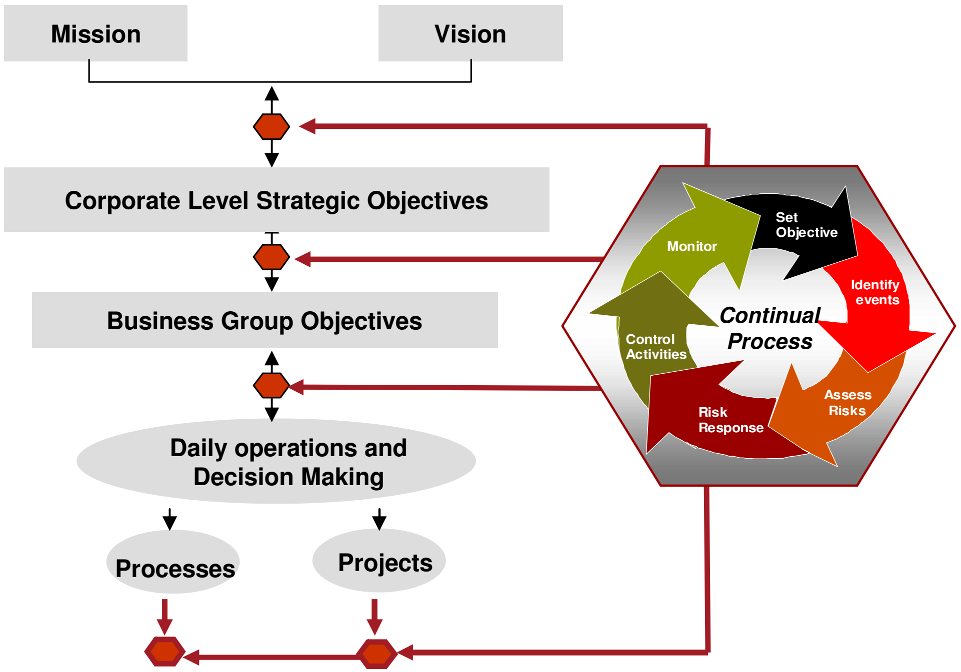
Risk quantification is performed for many reasons …

- To better understand one or more risks
- Source of competitive advantage – to allow more, well managed risk to be taken
- To make ‘risk adjusted’ decisions – particularly with large capital projects
- To better understand extreme events
- To measure cost / benefit of managing highest risks
- Calculate expected annual loss due to risk
- To be objective, transparent and rational
- To check on or manage expectation and perception (check on counter-intuitive risk)
- To establish risk appetite and tolerance
- To establish risk-based capital

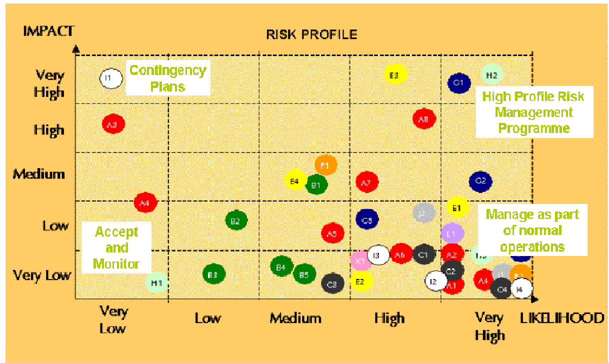
……when qualitative analysis is not enough

Enterprise risk management promotes building risk principles into key operating and decision making processes – most start with a qualitative approach

Risk assessment process is embedded into core processes and decision making activities



5x5 qualitative risk map



Risk matrix or risk register

For illustration purposes only

Objective : Increase market share of new product by 15% by Q4 2004

Risk	Risk Strategy	Risk Response	Residual Risk: Likelihood	Residual Risk: Impact	Action Plan	Target Completion Date	Risk Owner
Detailed description of risk	*Description of risk response*	*Description of existing response to risk*	Likelihood rating from 1 - 5	Impact rating from 1 - 5	*Action plan to mitigate risk to an acceptable level*	*Target completion date*	*Name of persons who are the risk owners*
Organisation has insufficient staff to provide adequate customer service	Reduce	• Establish manpower allocation policy • Establish appropriate human resource policy	3	2	• Implement the new manpower allocation policy • Conduct training to educate on roles and responsibilities • Prepare HR development plan	Q3 2004	• Planning Dept • Human Resources Dept

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Data characteristics and core risk quantification techniques

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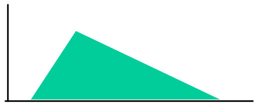
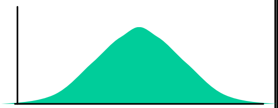
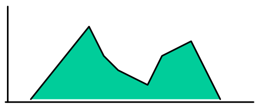
Understanding data - *frequency* (or likelihood) of events is measured in terms of units per period of time or per unit of something else

Frequency	Examples	Features
High Occurs hundreds, thousands or millions of times	❑ Credit defaults per year in a large bank ❑ Car accidents per year for taxi company ❑ Cable cuts for a power company per year ❑ Letters lost in the post per year	• Lot of data but sometimes hard to collect • Statistically significant 'volume' of data
Medium Occurs few times per year to once every 2 or 3 years	❑ Aircraft in near miss per year at major airport ❑ Loss or gain of a key account per year ❑ Major component failure in a factory per year	• Data often not collected • Reliant on record of investigations, memory or experience elsewhere • Statistically significant conclusions rare • Greater uncertainty
Low Occurs from once every few years to once in 100,000 years or more	❑ Dam failure - 20 times over past 100 years ❑ Nuclear power station melt down - two times in 50 years globally ❑ Project delayed 10 weeks due to late supplier delivery leads to loss of key customers	• Little data • Quantitative estimates based on experience of specialists, consensus in workshop, exploration of scenarios • Modelling limited to exploring possibilities

Understanding data – there are alternatives ways of expressing the loss or gain *(impact)* with increasing sophistication ….

• Point estimate	10 lives, $1m, 40 trees, 5 customers	increasing sophistication ↓
• Estimate plus contingency	$100k +10%	
• Range	NPV of project: Optimistic = + $30m Expected = + $10m Pessimistic = - $20m	
• Distributions	Capture complex uncertainty	

Characterising uncertainty with distributions

Name of distribution	Example of distribution	Defining characteristics	Use	Situations where suitable
Triangular		*Minimum, most probable, maximum* Continuous, bounded	Most commonly used distribution with no theoretical justification but simple and clear to use. It overestimates the size of tails at the expense of values close to the mean	Where distribution is not known and thought not to be a normal distribution because it is *bounded* or not symmetrical. Situations where a simple intuitive understanding is paramount and flexibility is a great advantage
Normal		*Mean, variance* Parametric, continuous, differentiable, unbounded	Frequently used distribution due in part to the central limit theorem which states that the mean of a set of values drawn independently from the same distribution will be normally described	. . .
Uniform distribution		*Maximum , minimum* Continuous, not differentiable, bounded	Used if the variable is bounded by a known maximum and minimum, and all values in between occur with equal likelihood	
General probability distribution		Continuous, not differentiable, bounded	Often used to represent subjective opinions of experts, particularly when formed using pairwise comparison	

\+ many others
- Binomial
- Poisson distribution
- Exponential
- Log normal
- Beta distribution
- Weibull
- StudentT
- Pareto
- etc

Special attention must be taken not to confuse the user with the language associated with statistics

Name of statistic	Definition	Use	Dangers
Mean (expected value)	Average of all generated outputs	Very useful and one of the most common statistics reported. Eg the average NPV of a transaction. It also has the property that if 2 or more variables are independent, then: Mean (a+b) = mean(a) + mean(b), and Mean (a*b) = mean (a) * mean (b)	Confusing the mean with the most probable (mode)
• **Standard deviation**			
• **Variance**			
• **Median**			
• **Value at risk**			
• **Percentiles**			
• **Expected loss**			
• **Unexpected loss**			
• **Skewness**			
• **Kurtosis etc**			

	Classification of distribution	Brief description
1	• Continuous	Smooth profile in which any value within the limits can occur
	• Discrete	Variable can only represent discrete values eg number of warehouses
2	• Bounded	Limited to possible values
	• Unbounded	Extends from minus infinity and/or plus infinity eg normal distributions
3	• Parametric	Theoretically derived distribution after making assumptions about the nature of the process that is being modelled eg exponential distribution
	• Non-parametric	Distributions that are artificially created eg triangular distributions

Examples of alternative risk quantification techniques

	Top-down	**Bottom-up**
Non-probabilistic	• Scenario analysis	• Stress test • Sensitivity analysis
Probabilistic	• Stock factor models • Income-based models (Earnings at Risk)	• Asset liability models • Market factor models (Value at Risk) • Actuarial models • Causal models (event trees, fault trees, event simulation)

Sensitivity analysis examines effect of different assumptions such as changed parameters or different distributions on an outcome.

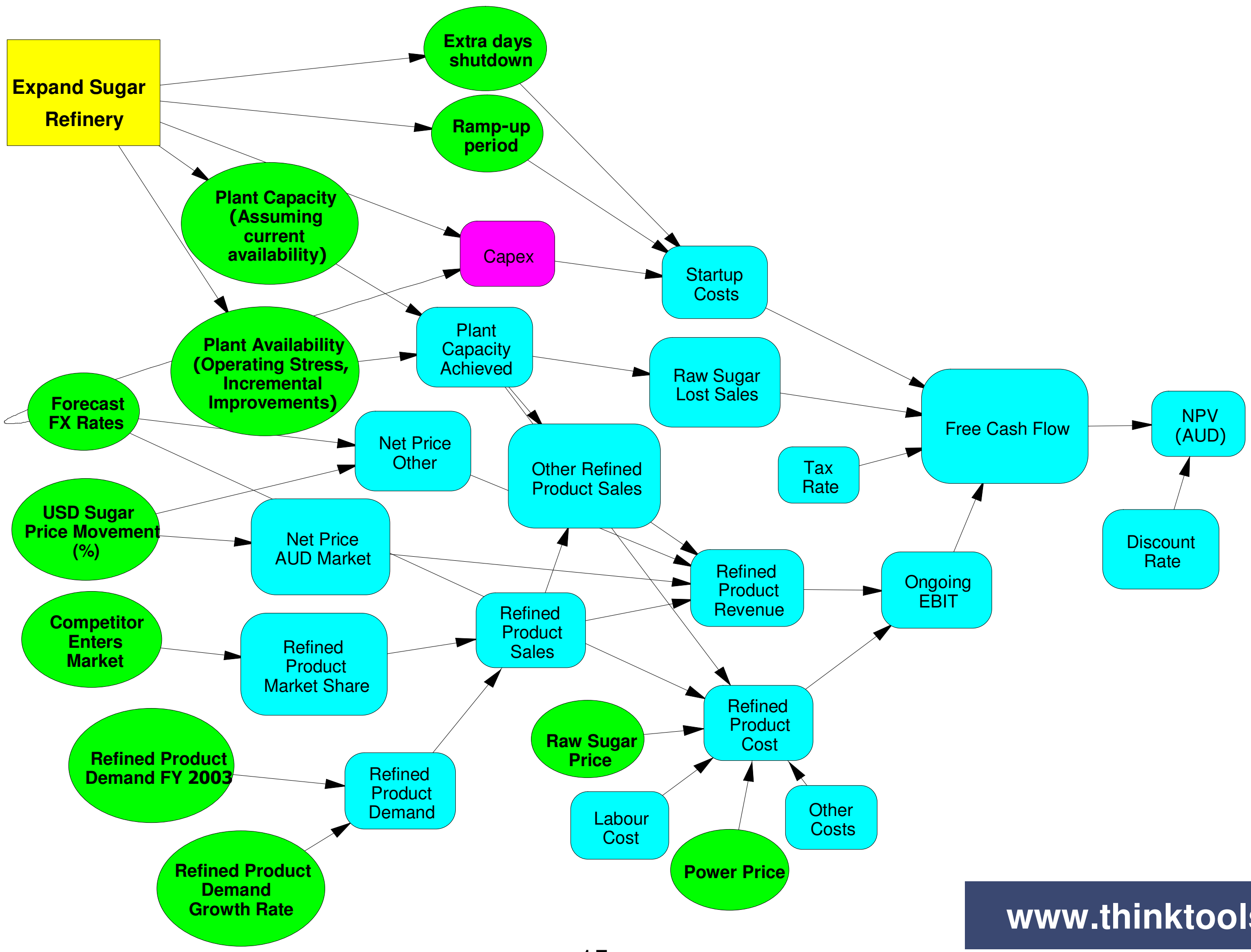
- “What if… ?” analysis
- What is the impact on our sales revenues if the Thai baht deteriorates by 10% against the US dollar ?
- In the context of a project, sensitivity analysis may examine how responsive a project’s Net Present Value (NPV) and Internal Rate of Return (IRR) is to a change in an input.

Scenario analysis - different scenarios describe a particular combination of internally consistent events that may occur in the future

	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Customer / Market	[High] Removal of ALL customer contact for Team A	[Medium] Removal of IN BOUND customer contact for Team A	[Low] Virtual layer between customer and Team A	[Low] Local only
Alliances & Partner	[High] Team A manages 'level 2 issue' collaboration across organisation	[Medium] Team A manages portfolio view	[Low] Team A manages portfolio view	[Low] Team A manages portfolio view
Management & Process	[High] Supplier/Customer relationship between Head Office and subs	[High] Additional manned layer	[Low] Impact not highly customer visible	[Low] No change
Organisation & People	[High] Re-organisation across the board	[Low] Additional resource in Corporate – no change for underlying business units	[Low] no change for underlying business units	[Low] No change
Systems & Infrastructure	[Medium] Significant interface integration	[Medium] Significant interface integration	[Medium] Significant interface integration	[Low] No further integration with Head Office

Level of Change **High** **Medium** **Low**

Influence diagrams are about mapping out the context for the risk at an appropriate level of detail



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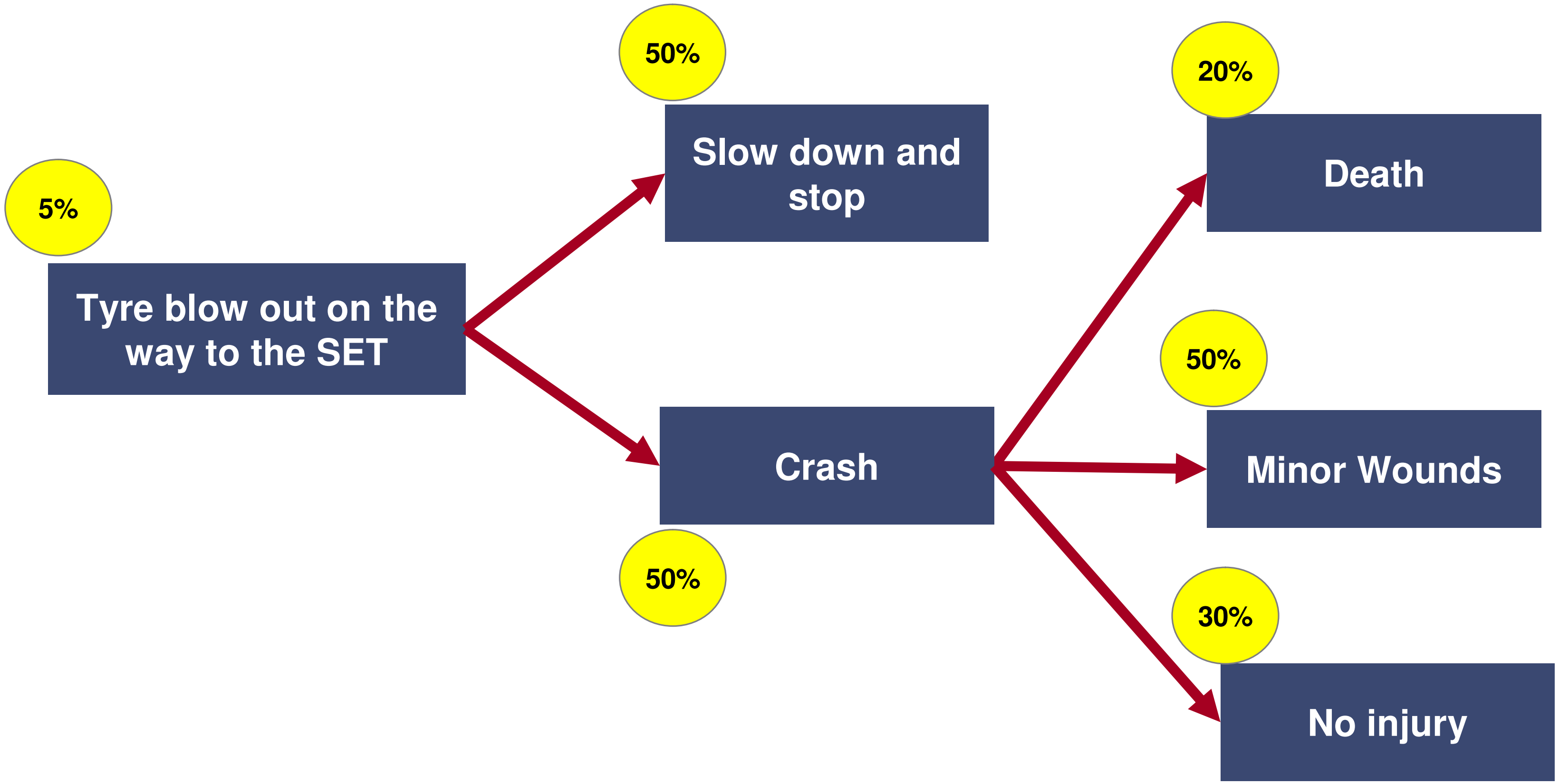
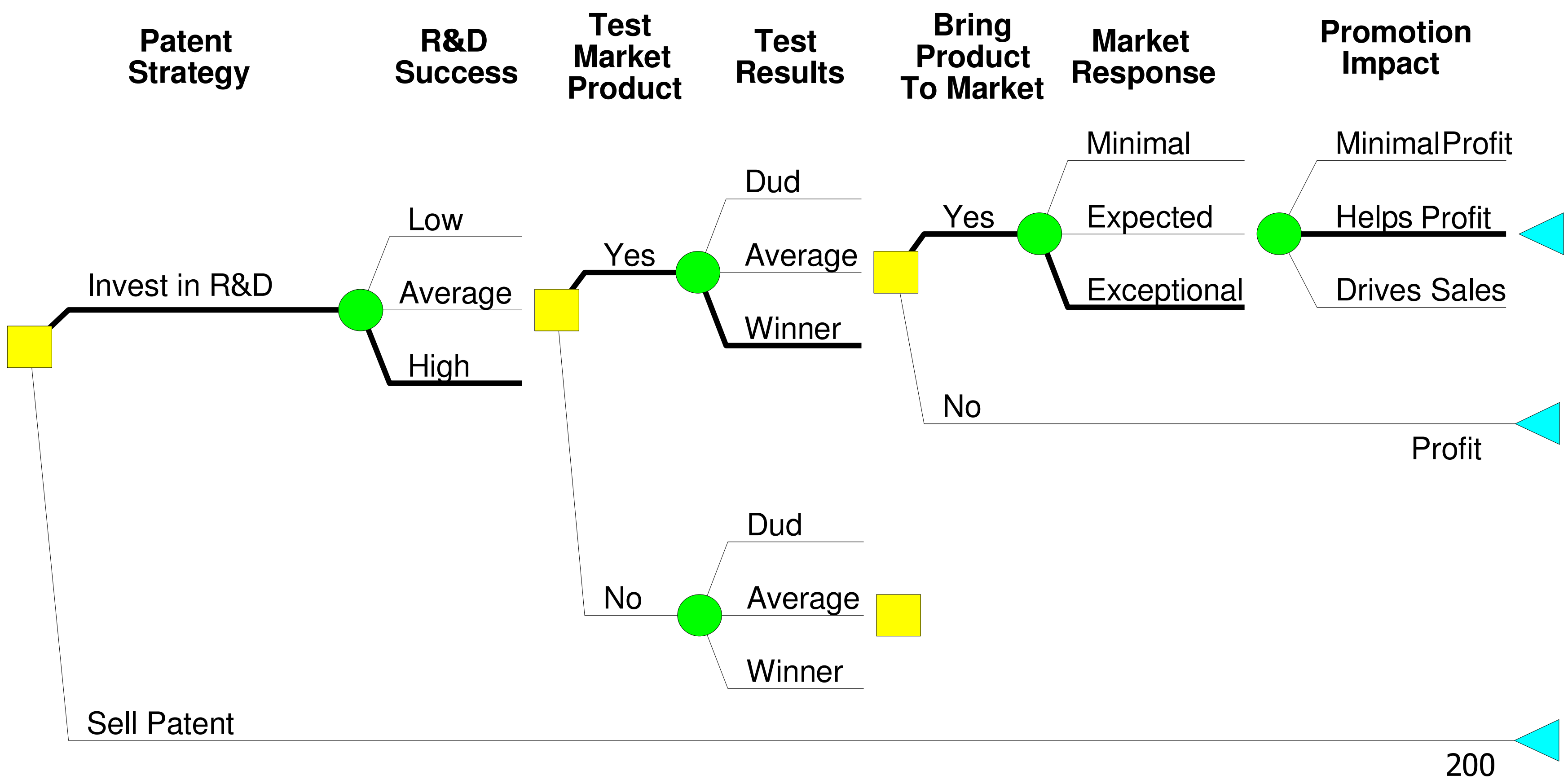
Event tree analysis



Chance of dying due to a crash following a blow out on the way to the SET is …

0.5% or 1:200

Risk identification and analysis should combine objectivity, logic and quantification



Simulating potential losses using techniques such as monte carlo analysis

Develop model → **Determine output based on random sample of inputs** → **Develop probability distribution of output**

Develop model

- specify inputs and outputs
- determine relationship between inputs and outputs
- develop distribution for each input

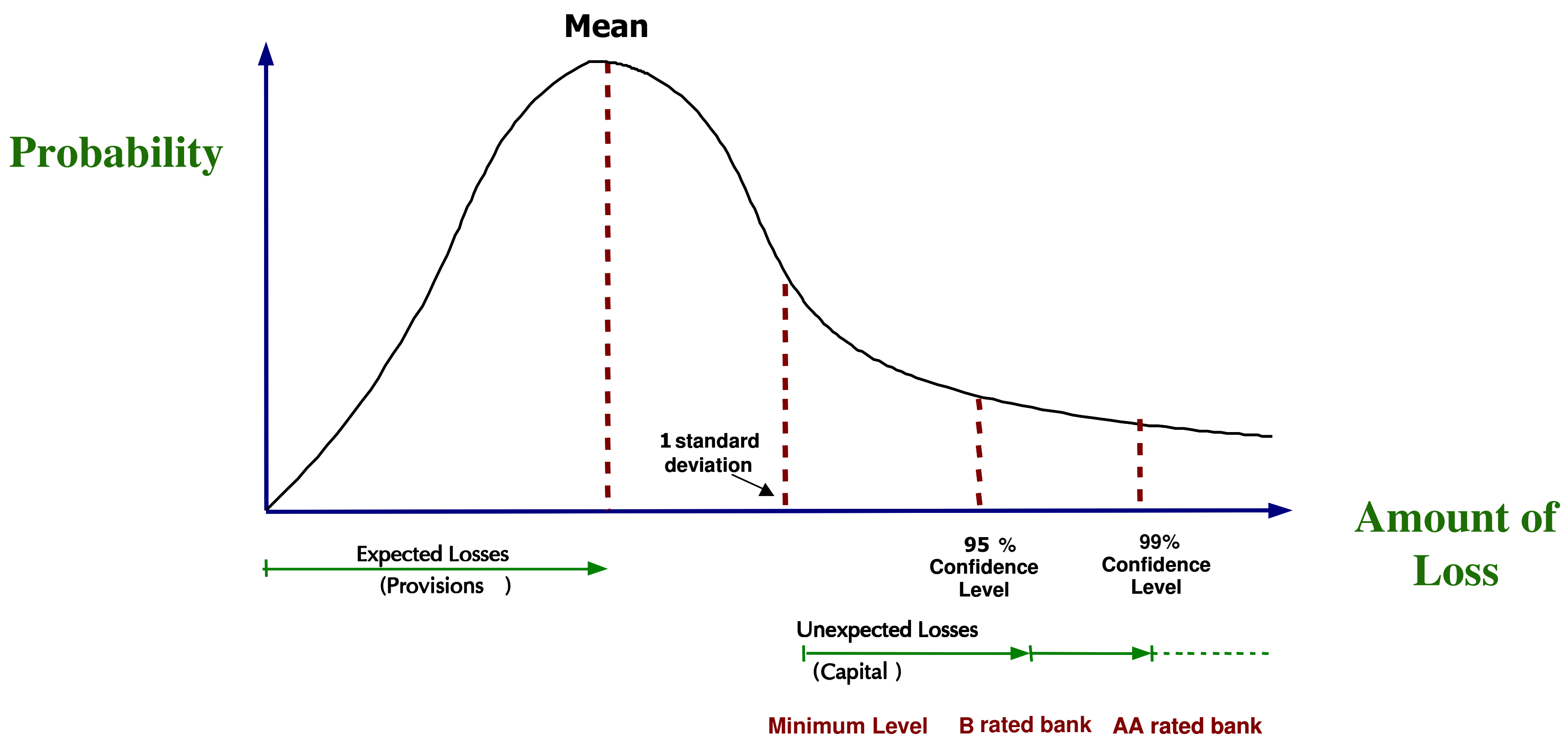
Determine output based on random sample of inputs

- pick a value from the distribution for each input
- calculate the output from the model using the sampled inputs
- save the output
- performed by software

Develop probability distribution of output

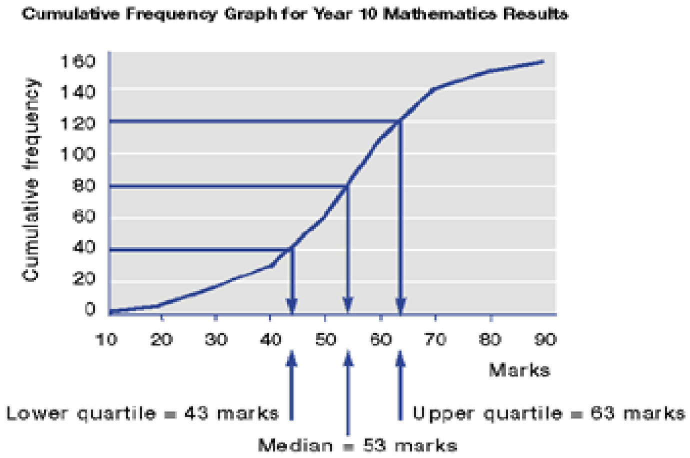
- repeat previous steps many times
- generates the probability distribution of the output shows the likelihood of occurrence of all modelled values of the output

A banking example –
How much capital does a bank require to cover possible losses from credit defaults ?

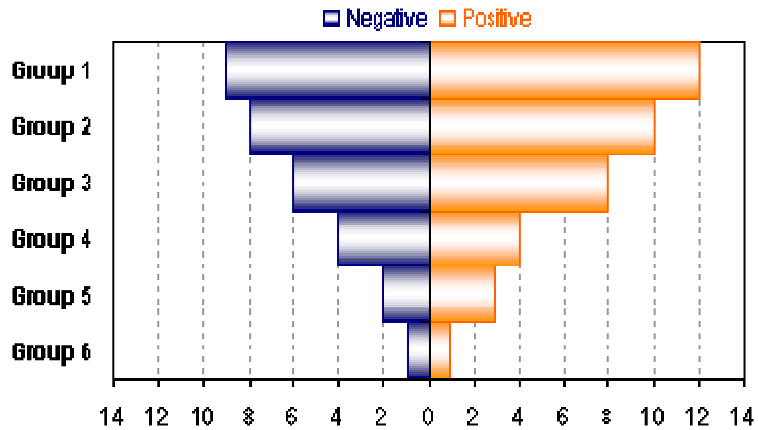


Sample outputs

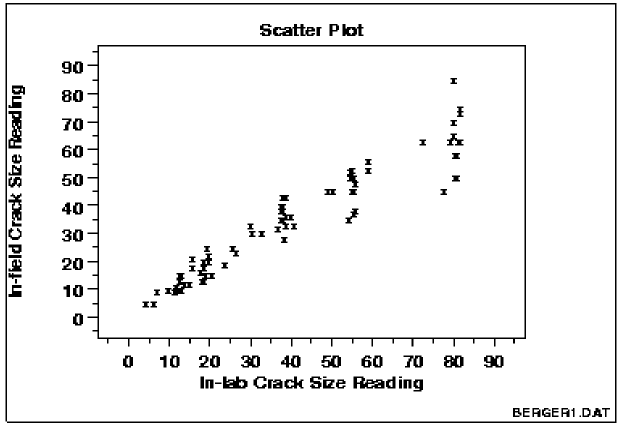
- Cumulative frequency chart



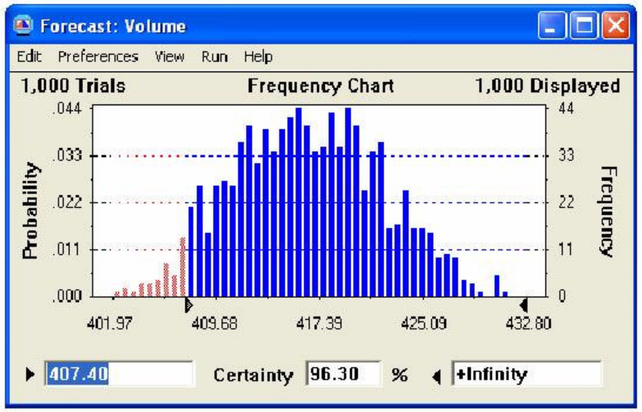
- Tornado chart



- Scatter diagram



- Histogram



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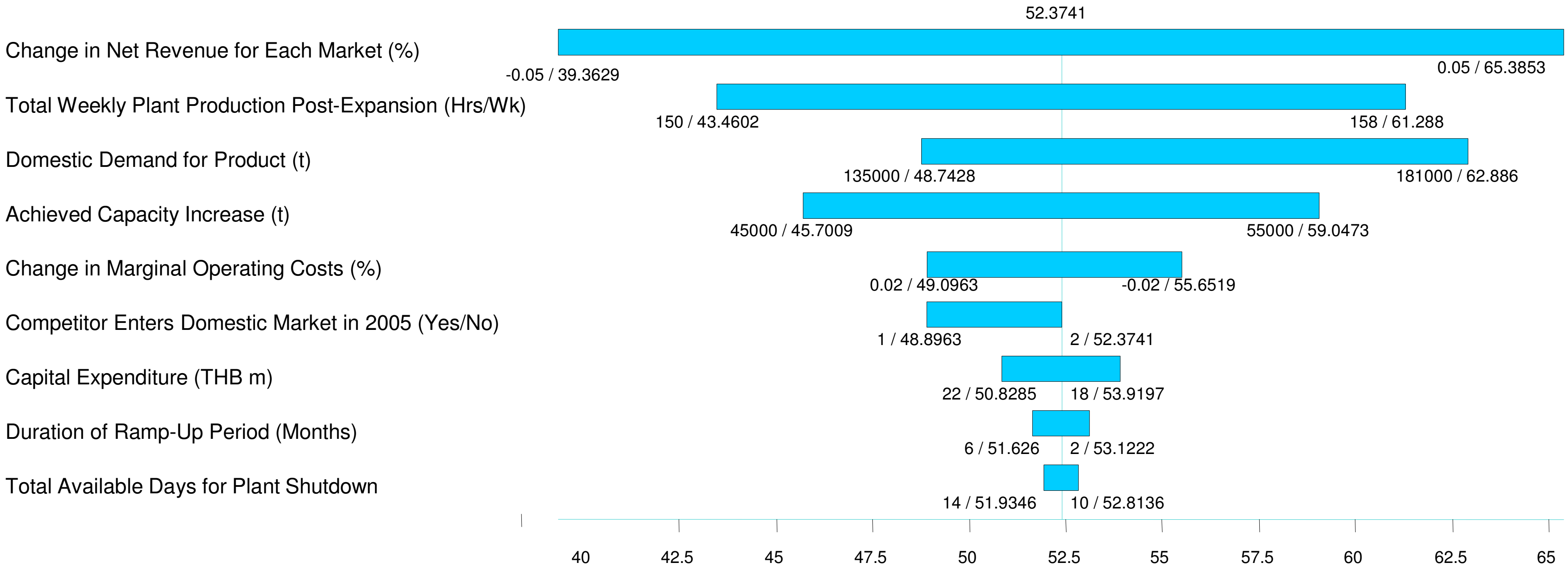
Tornado chart - understand the risk sensitivities



Net Present Value is sensitive to capacity, availability, demand and prices

Case studies:
Applications of risk quantification

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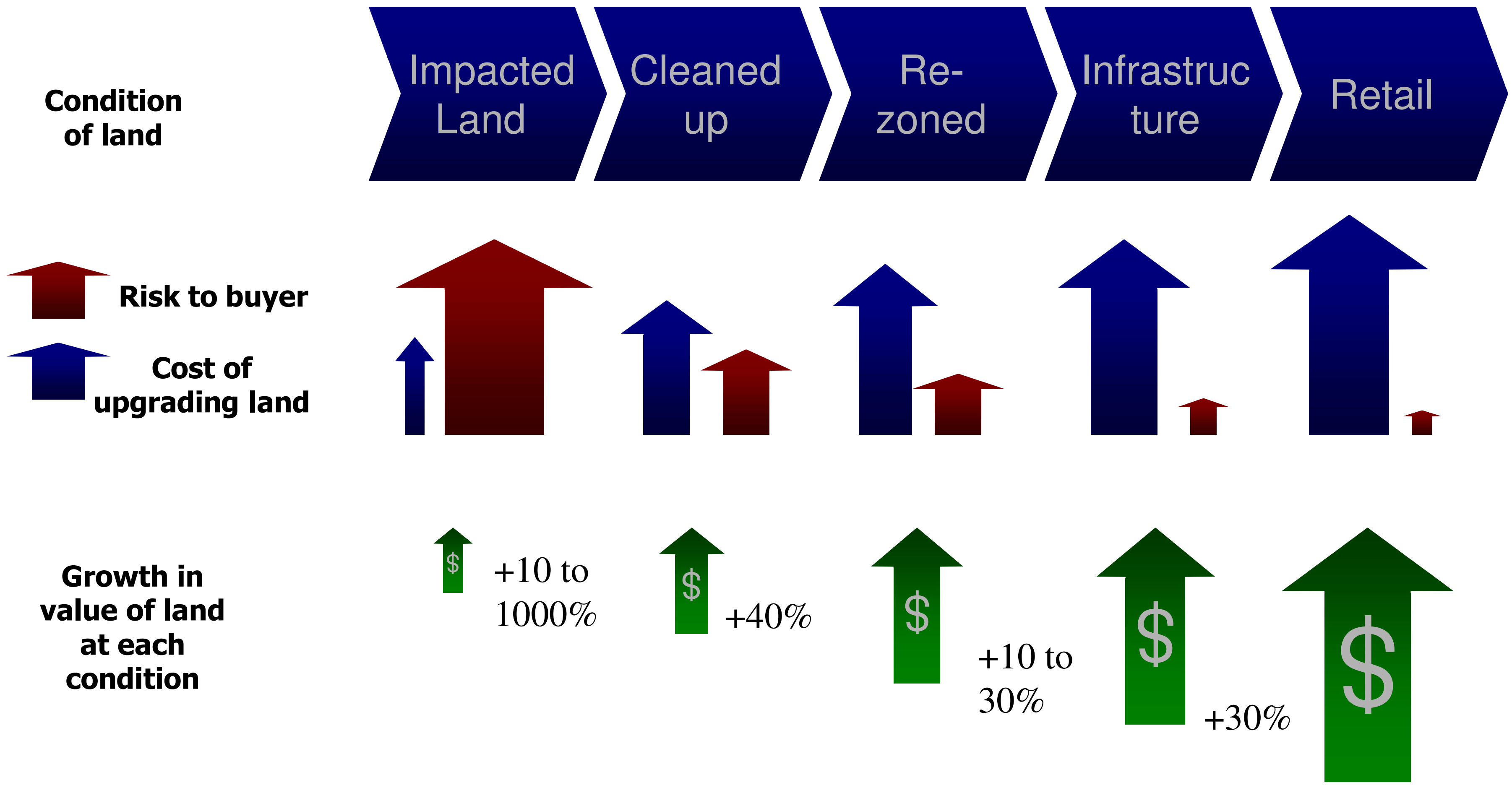
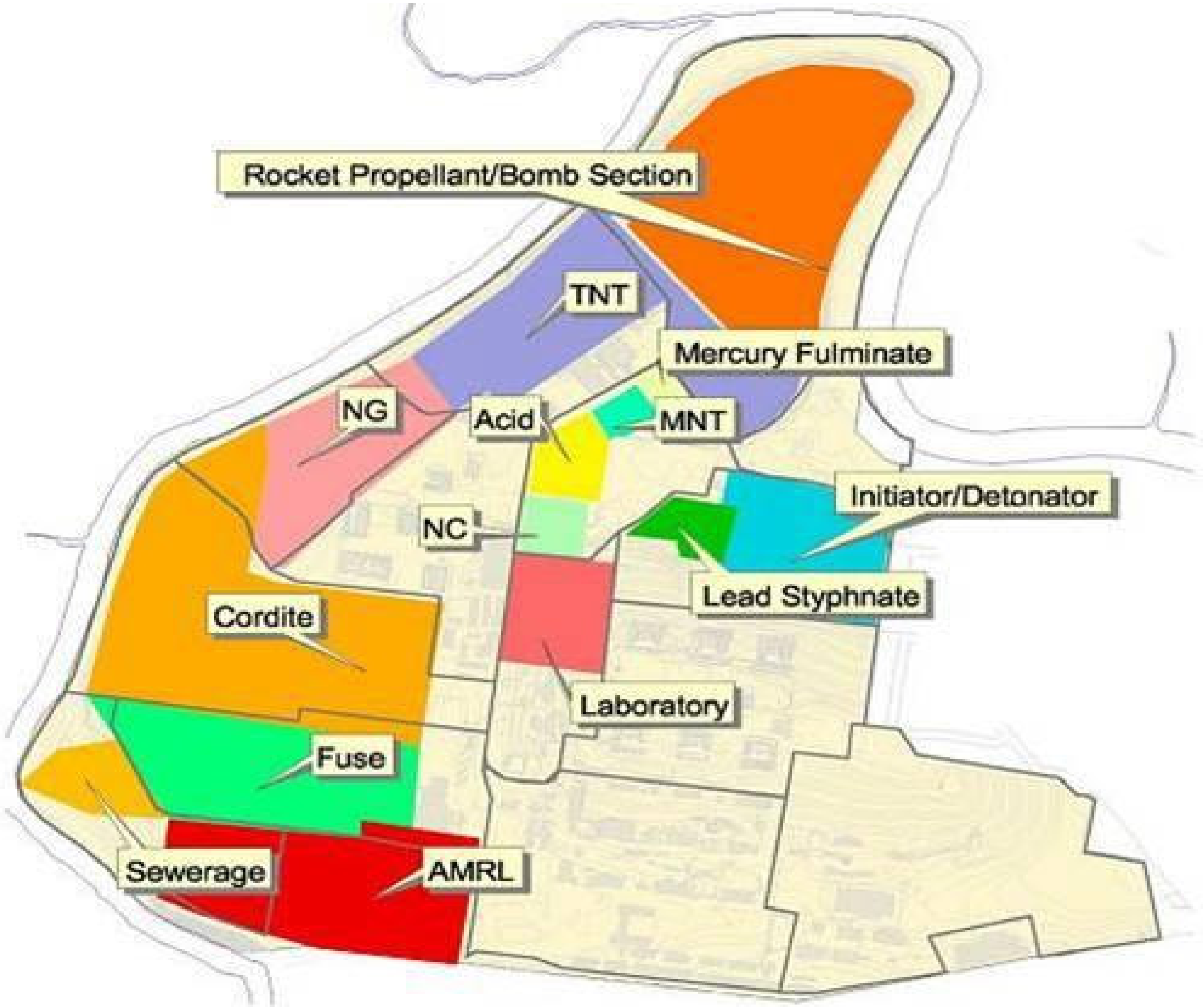
Case Study 1 – Value of uncertainty analysis

How much should the seller of 15 contaminated land plots spend to increase the value of the land ?



Case Study 1 – Value of uncertainty analysis



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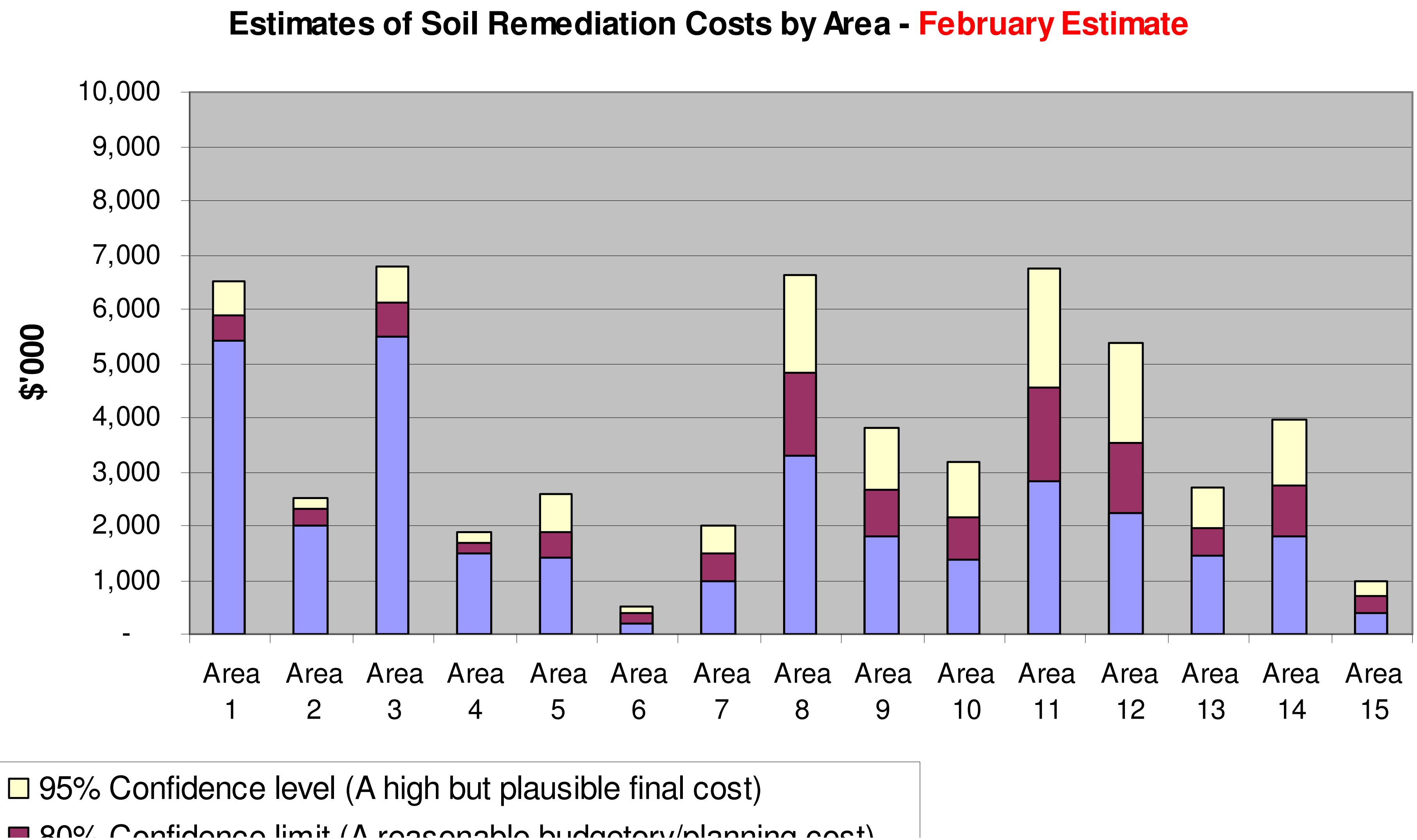

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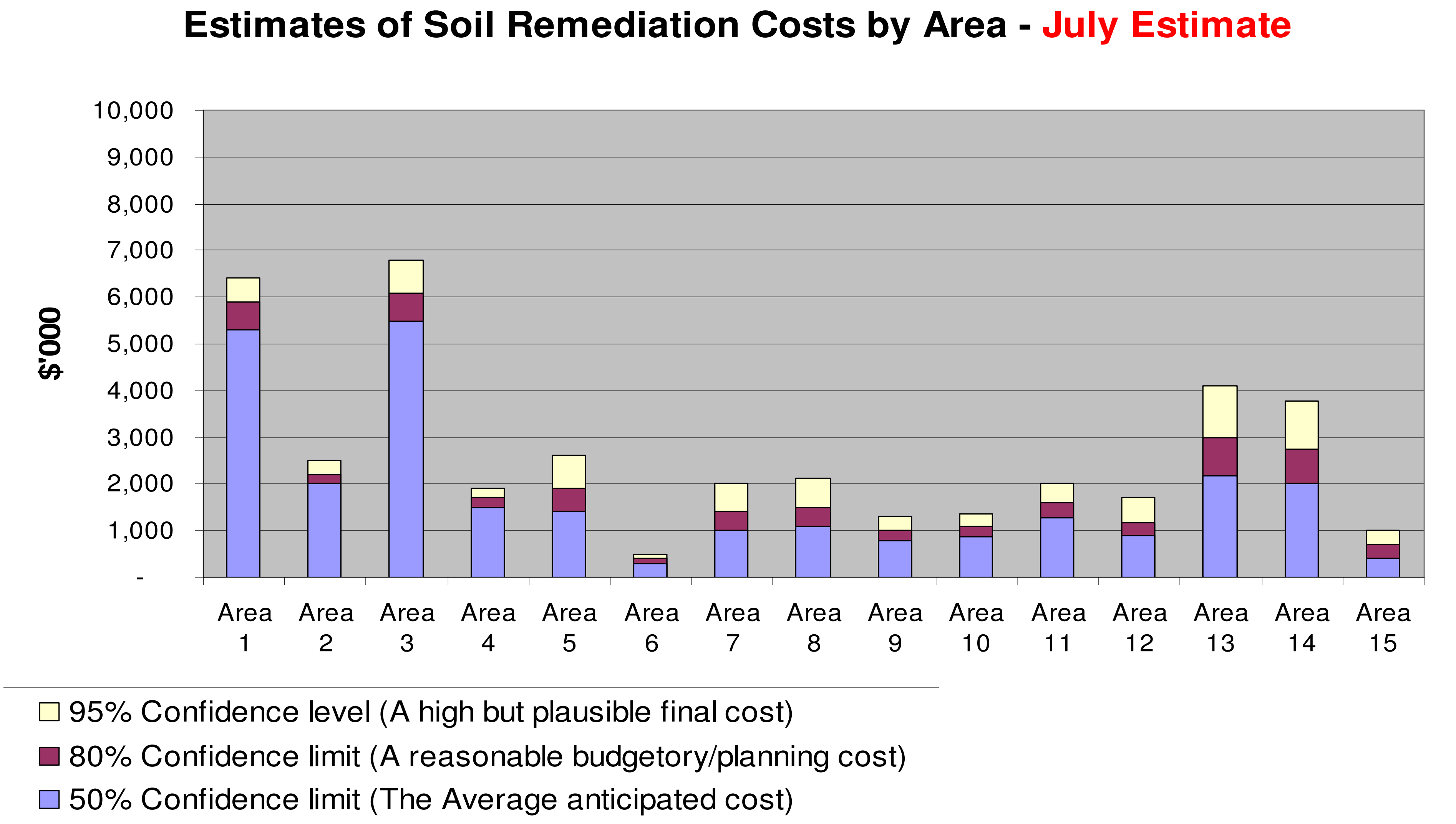
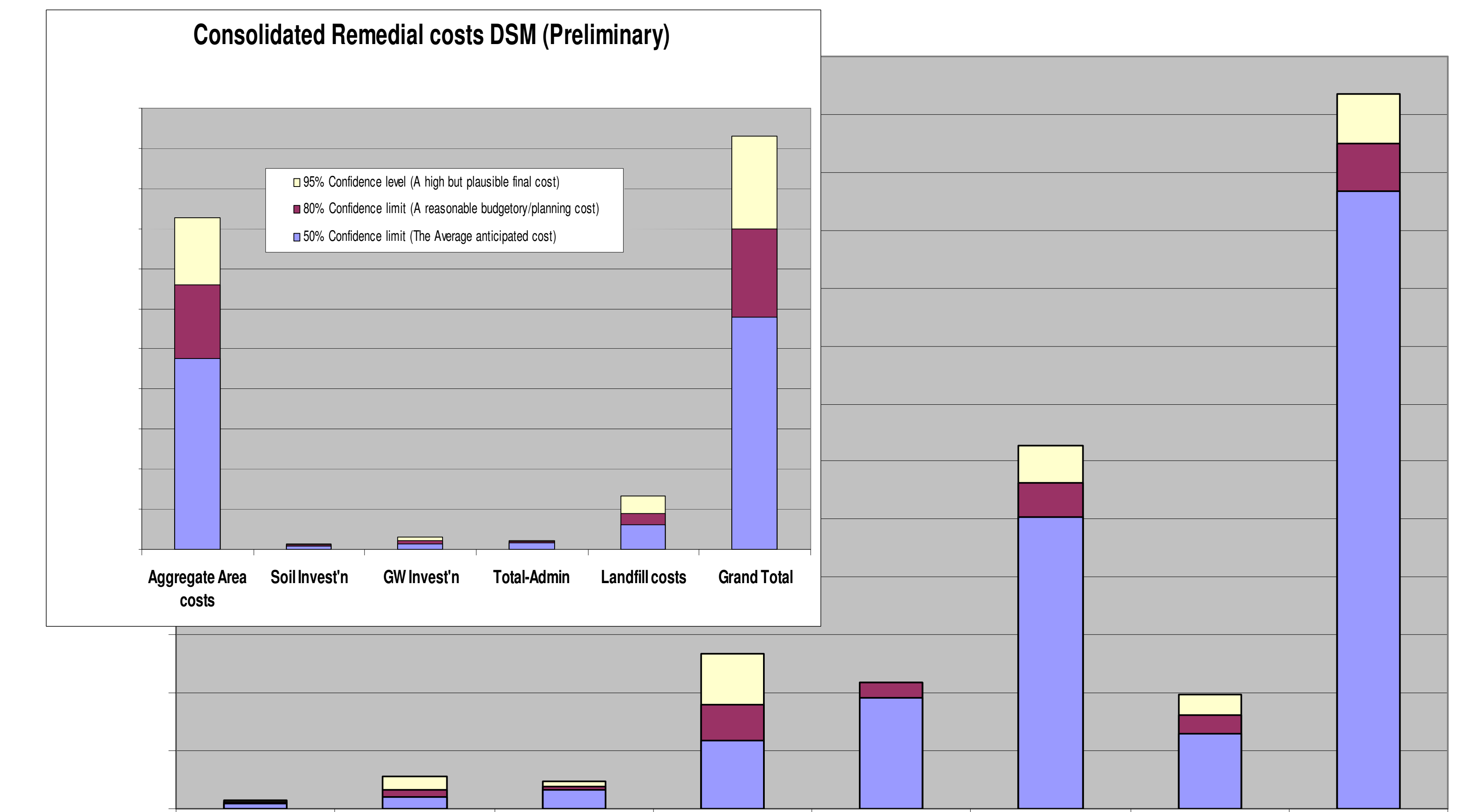


Case Study 1 – Value of uncertainty analysis

Consolidated Remedial costs (Sept 03 revision)



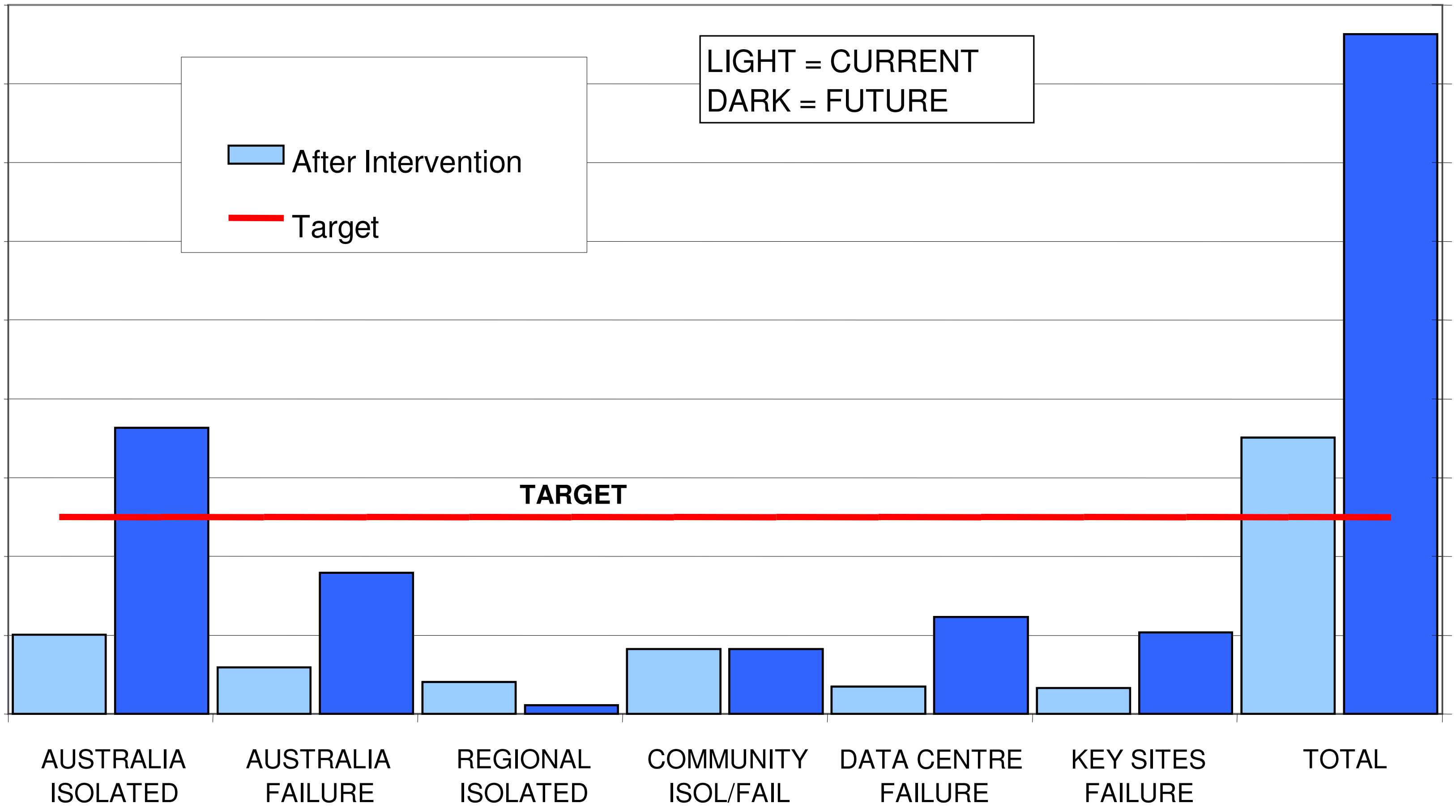
	Soil Invest'n	GW Invest'n	Total-Admin	Landfill costs	Demolition	Soil	Groundwater	Grand total
C95	704,000	2,781,000	2,331,085	13,471,544	10,972,168	31,390,964	9,925,406	61,756,515
C80	540,000	1,676,000	1,958,902	9,026,187	10,862,039	28,123,166	8,158,250	57,544,292
C50	418,000	1,065,000	1,674,921	5,873,552	9,568,149	25,156,408	6,503,839	53,428,141

Case Study 2 – Analysis of major risks

INITIATING EVENT	Annual Freq			INITIATING EVENT	Annual Freq	Outage Type	Prob	Impact	Prob	Impact	Prob	CONSEQUENCE
Cable Entry Failure				Cable entry failure	0.0051 2	**AUS ISOLATED**	.021257	Lost revenue	1			Direct revenue loss
Sabotage/Intervention	0.00001			Sat stations out	0.0051 2							
Software bug	0.005			Both core sites out	0.0212 1			Consequential claims	1	Consequential loss	0.9	Pay claims
Power feed	0.0001											
Equipment failure	0.00001							Reputation damage	0.9	Future business loss	0.9	Future revenue loss
Sat Stations Out												
Sabotage/Intervention	0.00001										0.9	PR and mktg recovery
Software bug	0.005											
Sun spots	0.000001									Credit rating drop	0.8	Increased funds cost
Power feed	0.0001											
Satellite failure	0.000001							Response	0.25	Overdesign	0.45	Solution costs
Both Core Sites Out												
Sabotage/Intervention	0.00001							Political Interference	0.25	Strengthen competitors	0.45	Lose mkt share
Software bug	0.02											
Power supply	0.001			Sabotage	0.0000	**AUS FAILURE**	.00101	Lost revenue	1			Direct revenue loss
Equipment failure	0.0001			Signalling Network	0.001							
Earthquake	0.00001							Consequential claims	1	Consequential loss	0.9	Pay claims
Fire	0.00001											
Operator error	0.0001							Reputation damage	0.9	Future business loss	0.9	Future revenue loss
Cable entry	0.000001											
												PR and mktg recovery
										Credit rating drop	0.8	Increased funds cost
								Response	0.5	Overdesign	0.9	Solution costs
								Political Interference	0.5	Strengthen competitors	0.9	Lose mkt share
				Sabotage	0.0000	**REGIONAL ISOL**	.008131	Lost revenue	1			Direct revenue loss
				Software bug	0.005							
				Power failure	0.001			Consequential claims	1	Consequential loss	0.9	Pay claims
				Equipment failure	0.001							
				Earthquake	0.0000			Reputation damage	0.9	Future business loss	0.5	Future revenue loss
				Fire	0.0000 1							
				Operator error	0.0001							
				System upgrade	0.001							
				Flood	0.0000							
				Natural Disasters	0.0000	**COMMUNITY I/F**	.20002	Lost revenue	1			Direct revenue loss
				Power, aircon	0.1							
				Vandalism	0.0000			Consequential claims	1	Consequential loss	0.9	Pay claims
				Quality failure	0.1							
				Building catastrophe	0.0000	**DATA CENTRES**	.00202	Lost revenue	1			Direct revenue loss
				Power, aircon	0.001							
				Vandalism	0.0000			Replace infrastructure	1			Capital exp
		2	4	3P Human Error	0.001							
				Building catastrophe	0.0000	**KEY SITES FAIL**	.01102	Lost revenue	1			Direct revenue loss
				Power, aircon	0.001							
				Vandalism	0.0000			Consequential claims	1	Consequential loss	0.9	Pay claims
		2	4	3P Human Error	0.01							
							5	Reputation damage	0.9	Future business loss	0.9	Future revenue loss
										Credit rating drop	0.04	Increased funds cost

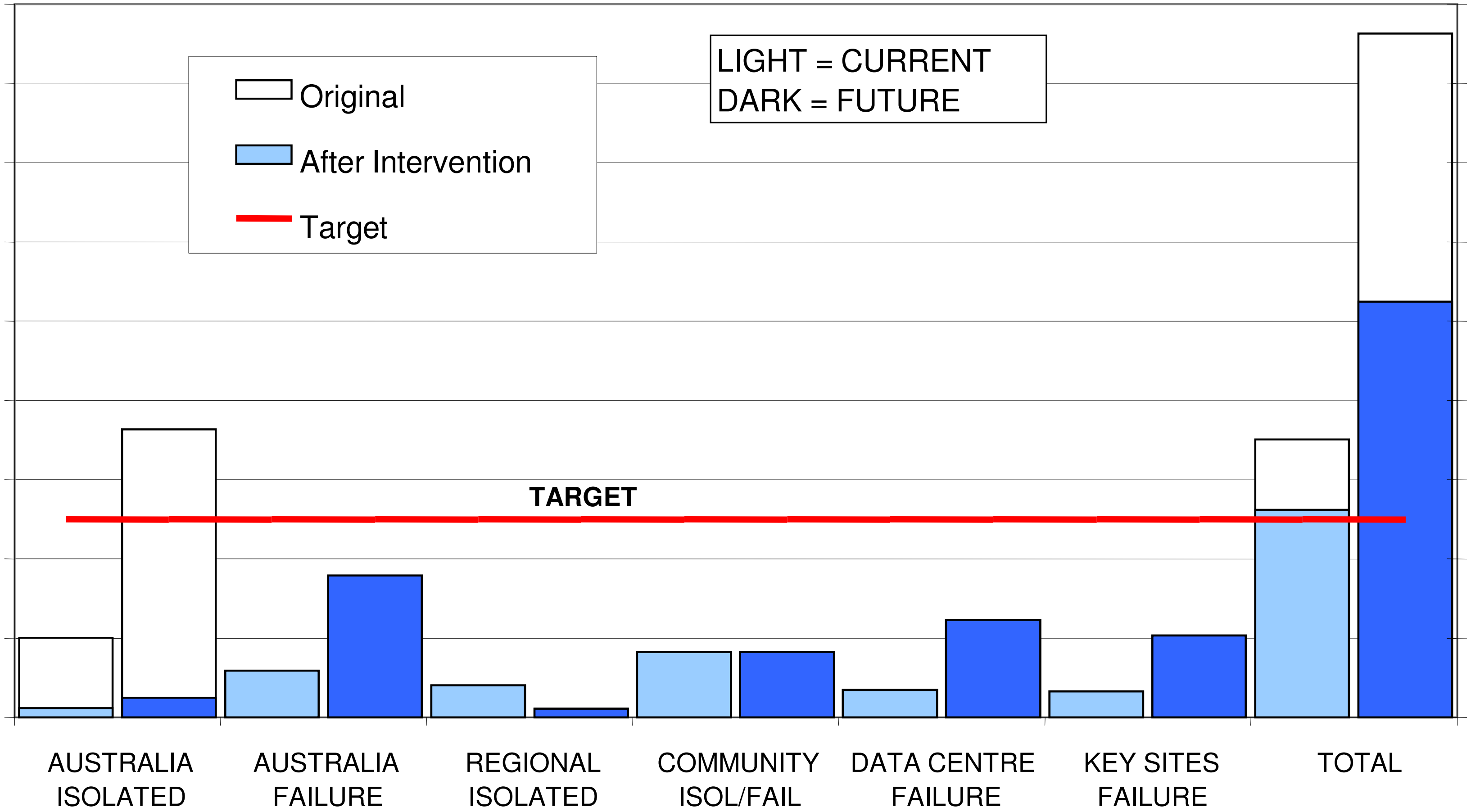
Case Study 2 – Analysis of major risks

Original position



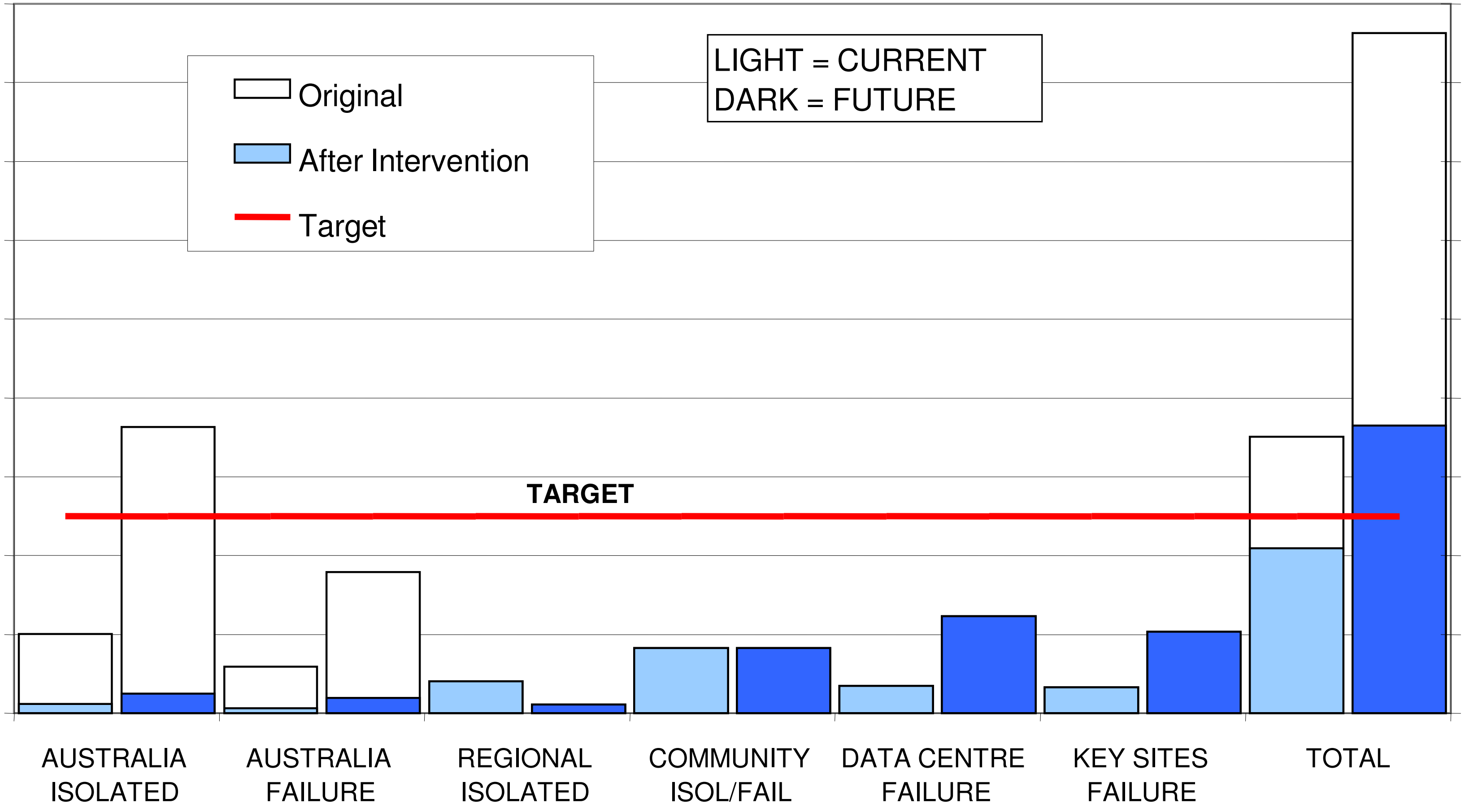
Case Study 2 – Analysis of major risks

Action 1 - New switch (Australia Isolation)



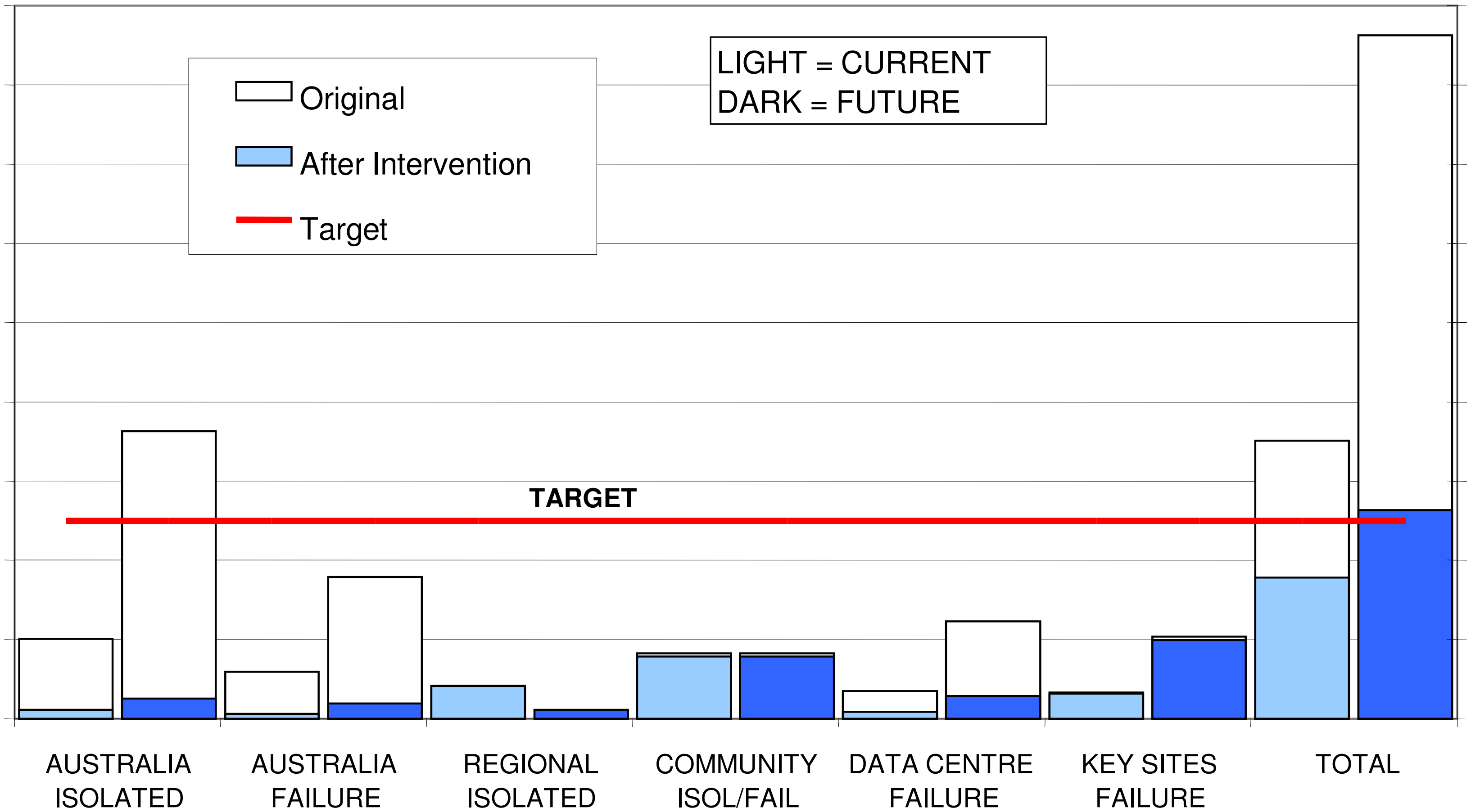
Case Study 2 – Analysis of major risks

Action 2 - Disaster recovery plan for Australia Failure



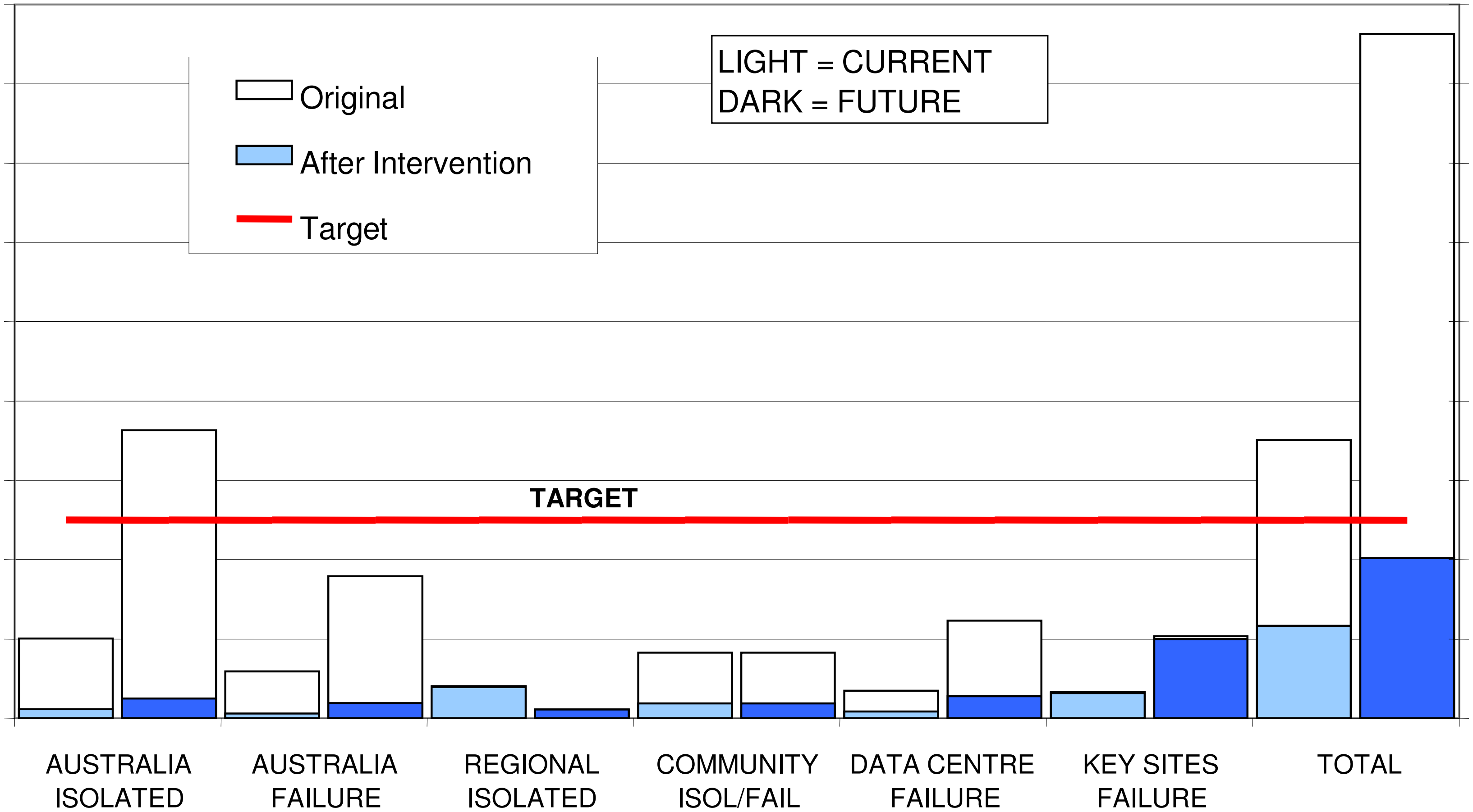
Case Study 2 – Analysis of major risks

Action 3 - Disaster recovery plan for Data Centres



Case Study 2 – Analysis of major risks

Action 4 - Improve customer relations plus disaster response plan for Community Isolation or Failure



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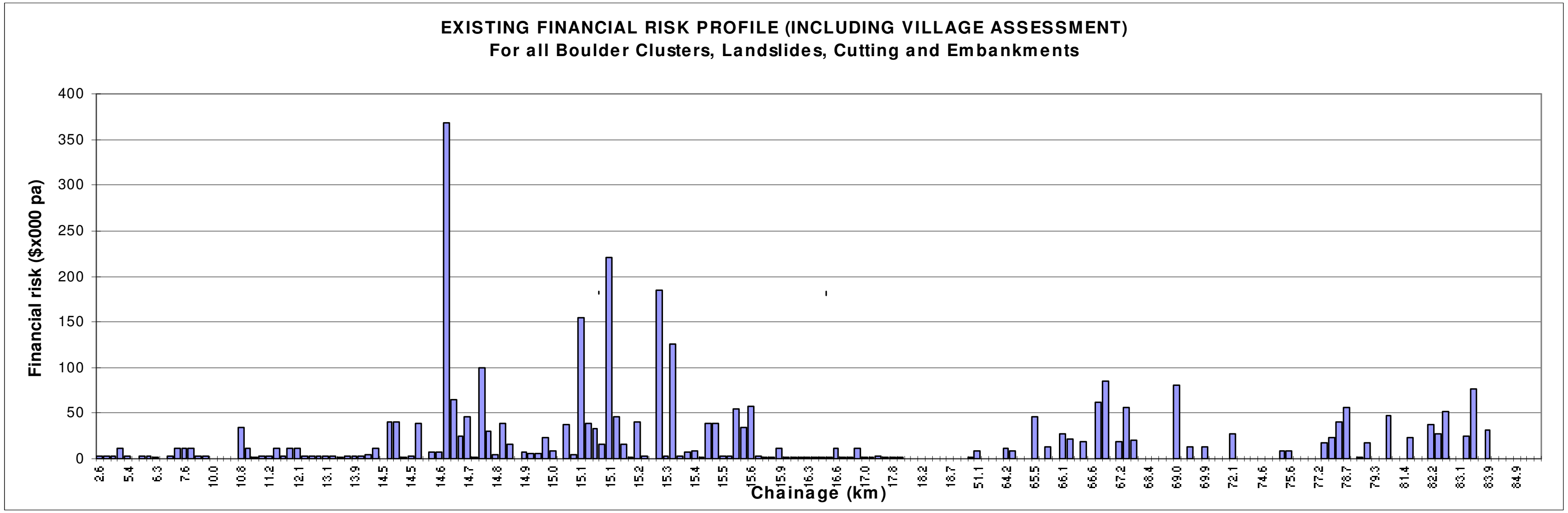
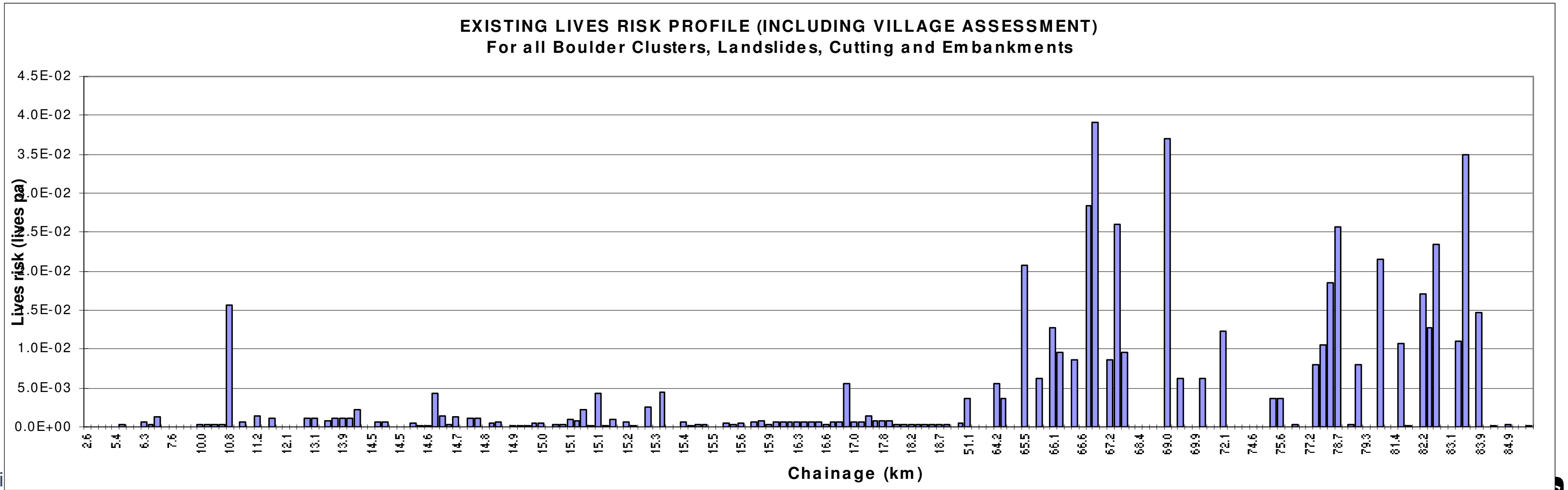
Case Study 3 – Practical decision making using risk analysis

Case Study 3 – Practical decision making using risk analysis





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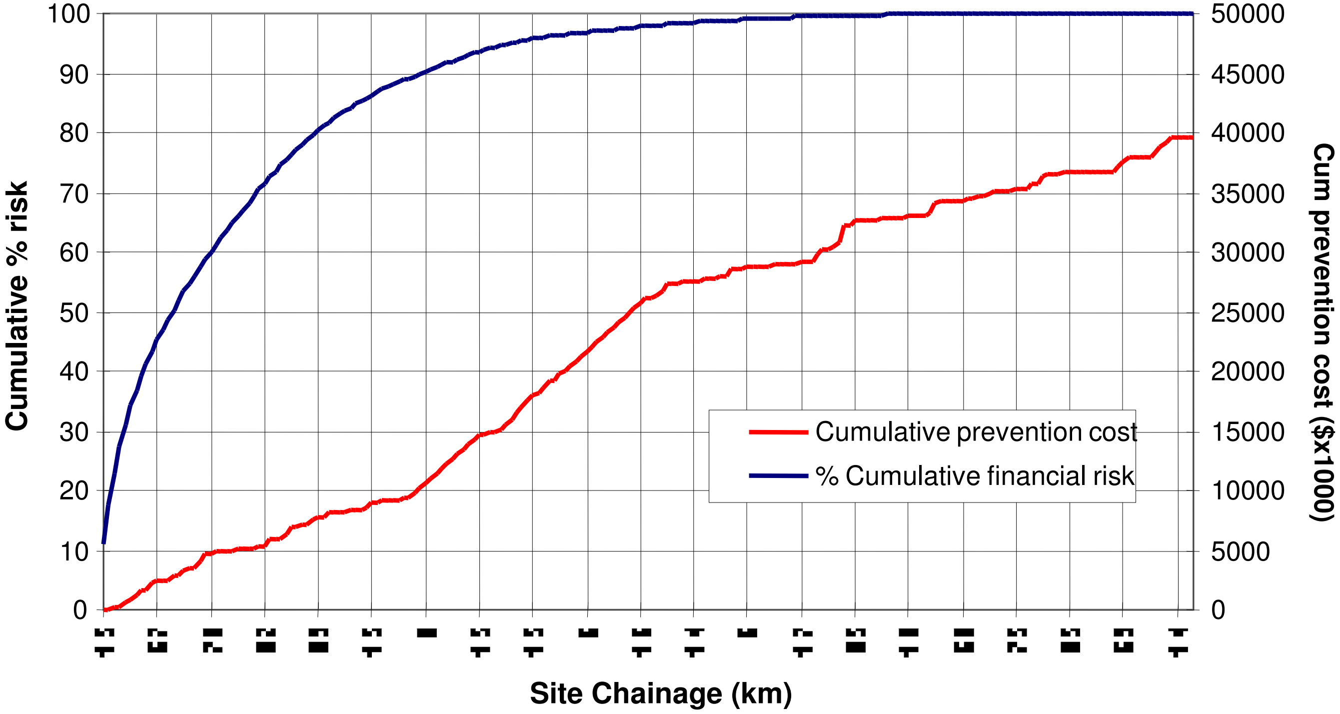
Case Study 3 – Practical decision making using risk analysis



Monte Carlo Simulation

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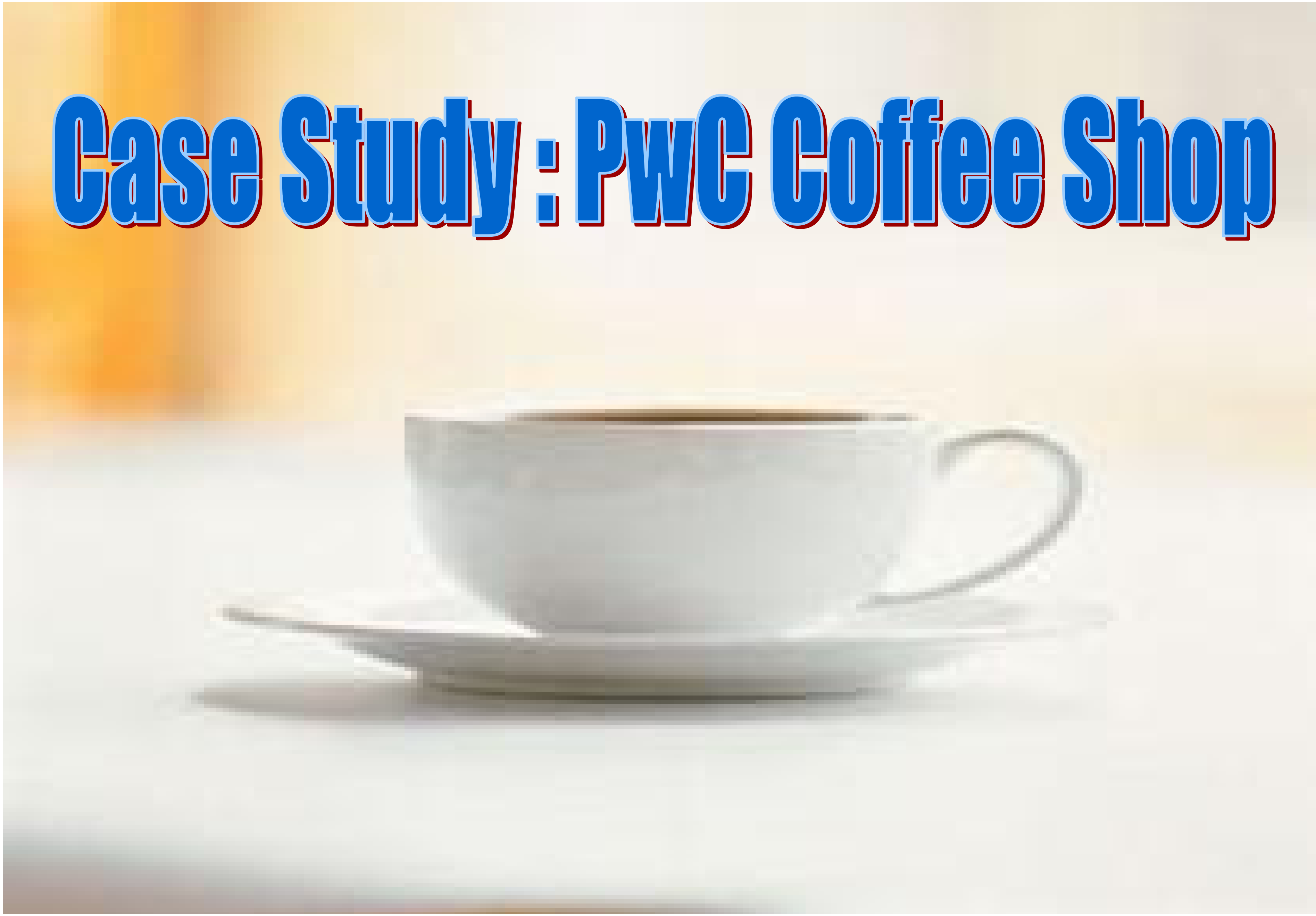
Case Study : PwC Coffee Shop



PwC Coffee Shop : Assumption

Number of coffee sold	45,000
Price per cup	$2.00
Total revenue	$90,000.00
Price of Coffee (per kg.)	$15.00
Grams of coffee per cup	0.034
Other costs	$50,000.00
Total cost	$72,950.00
Net	$17,050.00
Risk adjusted Net	$17,050.00

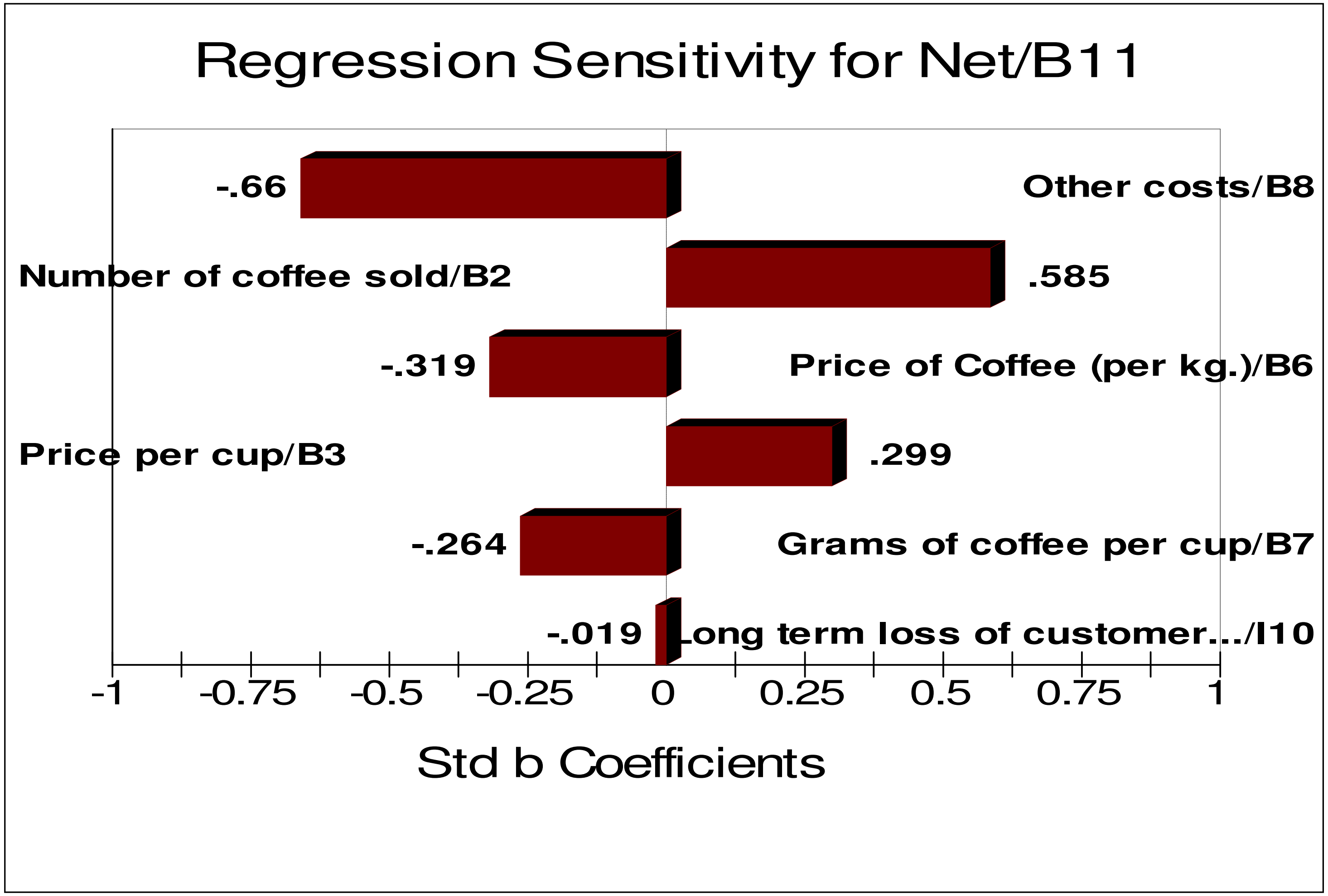
PwC Coffee Shop : Assumption

Prob.

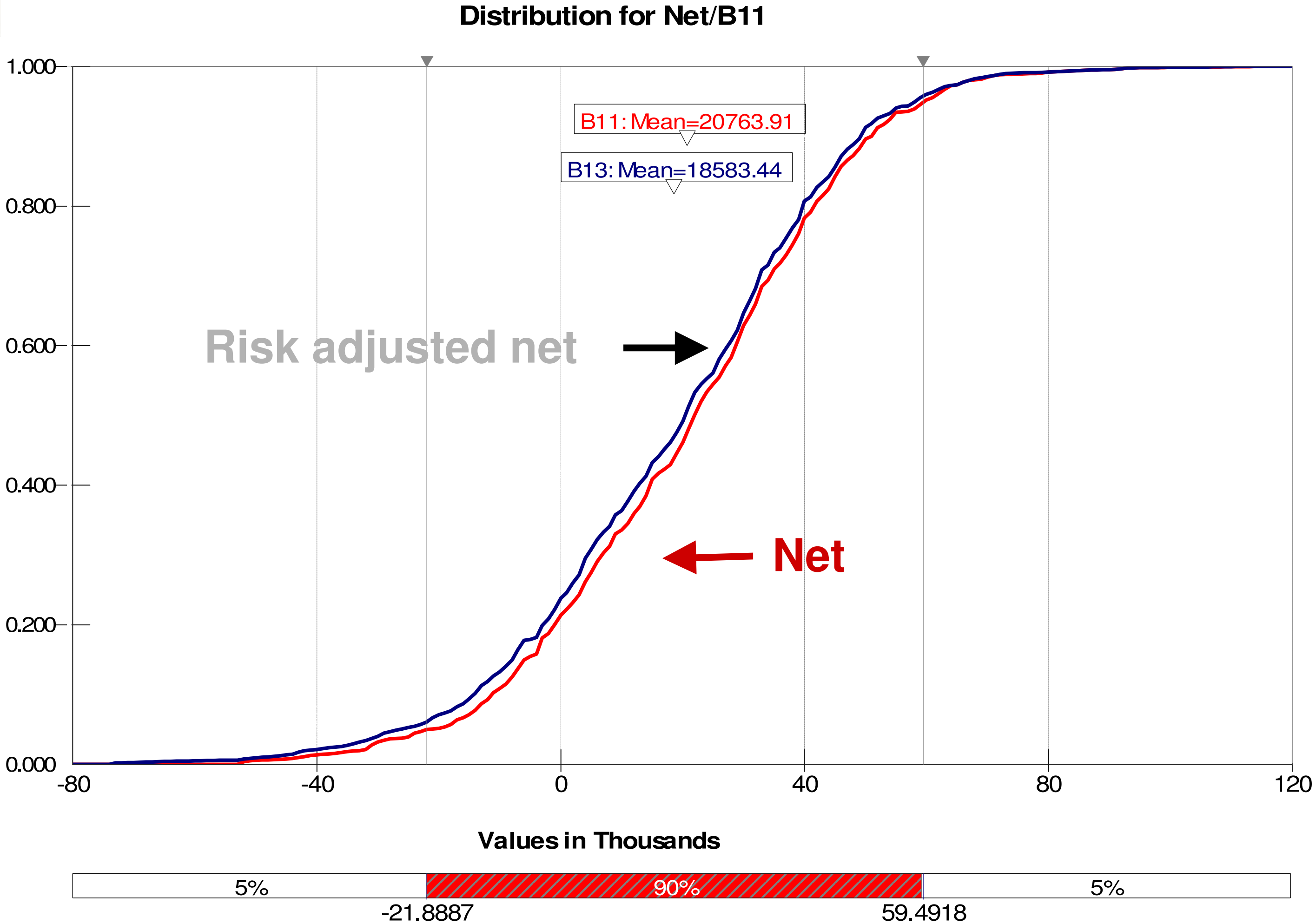
30%	Chance that coffee machine breaks down during the year
80%	Takes between 1 and 5 days to fix
24%	Net P

		CL50	CL95	Risk *CL50*Net P*
No Coffee Sale		$500	$2,500	$120
Repair cost		$8,000	$15,000	$1,920
Long term loss of customers		$100	$300	$24
Aggregate Risk				$2,064
	1	0		

PwC Coffee Shop : Tornado Graph - Net



PwC Coffee Shop : Compared Cumulative



Embedding quantification into risk assessment process

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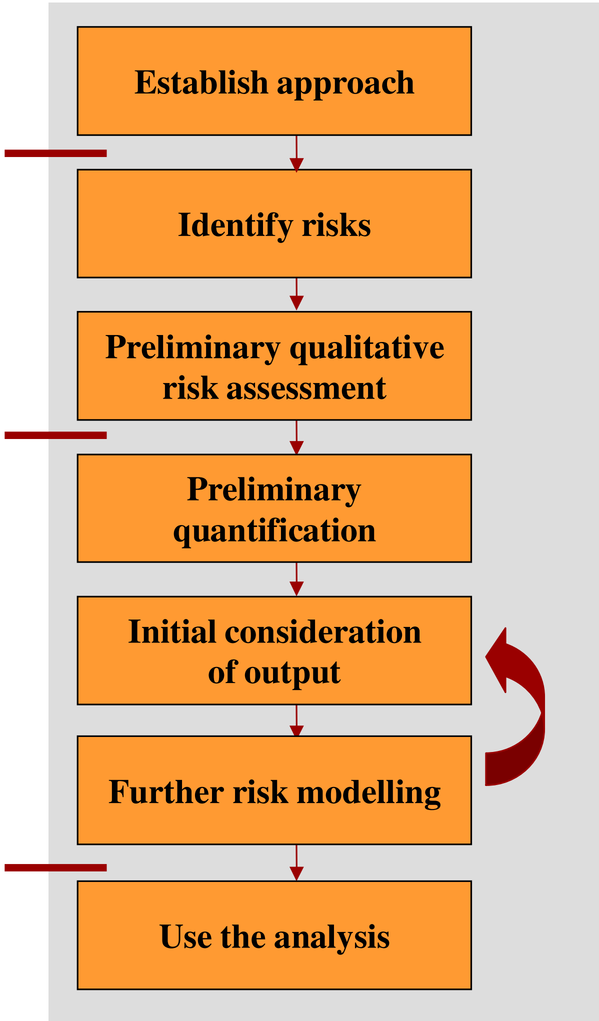
Typical phases in the risk assessment process

Phase 1 - Establish overall approach

Phase 2 - Qualitative assessment

Phase 3 - Gather data and model

Phase 4 - Use the data



What do we need to know ?

- What risks should be quantified ?
- What methodologies can be used to quantify risks and when is it appropriate to use each one ?
- What data should be gathered on risks and how can it be gathered
- Who should model the risks and be involved in reviewing the output ?
- What presentation techniques should be considered ?

Summary - Acknowledging and overcoming the challenges of a qualitative approach

The challenges

- 2 dimensional (single point) qualitative assessment of likelihood and impact can be too simple
- Practical difficulties in collecting reliable and relevant data and modelling risk
- Knowledge of risk quantification techniques is often very limited
- Gaining acceptance from business colleagues
- Risk quantification can be conceptually complex and may not be a quick fix

Overcoming the challenges

- Understand the alternative models through training
- Be flexible
- Focus on quality of thinking
- Move towards objective measures and systematic approach
- Focus on the critical risks
- Transparent, defensible and rational decision making
- Be prepared to get dirty !

Thank you

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