New guidance on quality and uncertainty in government analysis – and why calculating uncertainty is not enough

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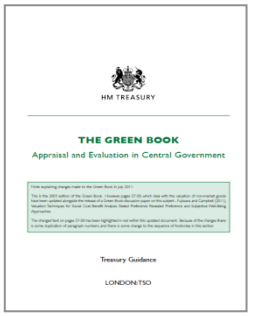
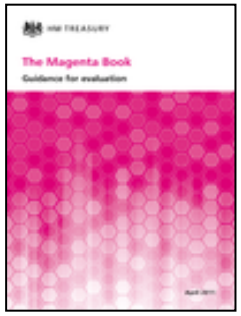
- John Paul Gosling, Leeds University

- …and others

The Aqua Book

- **Guidance on producing quality analysis for government**
- Aimed at all those conducting analysis and modelling to inform policy-making
- Intended as a companion to HM Treasury Green, Orange and Magenta books on policy evaluation and risk management
- To be published early 2015





Motivation – Macpherson report

Macpherson Recommendations

1: all business critical models …should have appropriate quality assurance

2: all business critical models … managed within a framework that ensures appropriately specialist staff are responsible …

3: Single Senior Responsible Owner for each model … … expert scrutiny and challenge … approve QA process

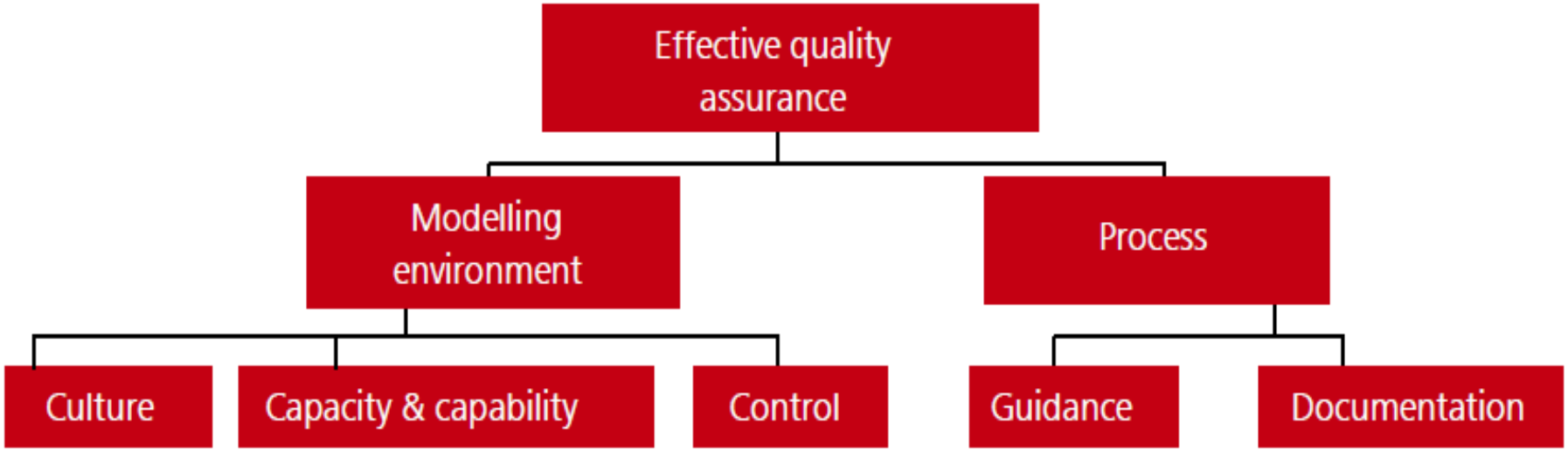
4: Departmental/ALB Accounting Officers' governance statements …to confirm appropriate QA framework used for all business critical models

7: **expert cross-departmental working group** to share best practice

➡ developed **Aqua Book**

Modelling Quality Assurance

- Changed environment for models in government
- Increased focus on assurance
- Applies to all



Aqua Book Overview

Part A – for those commissioning analysis:

- Decision-Making and Analysis
- Commissioning Analysis
- Quality Analysis and Quality Assurance
- The importance and implications of uncertainty

Part B – for those conducting analysis:

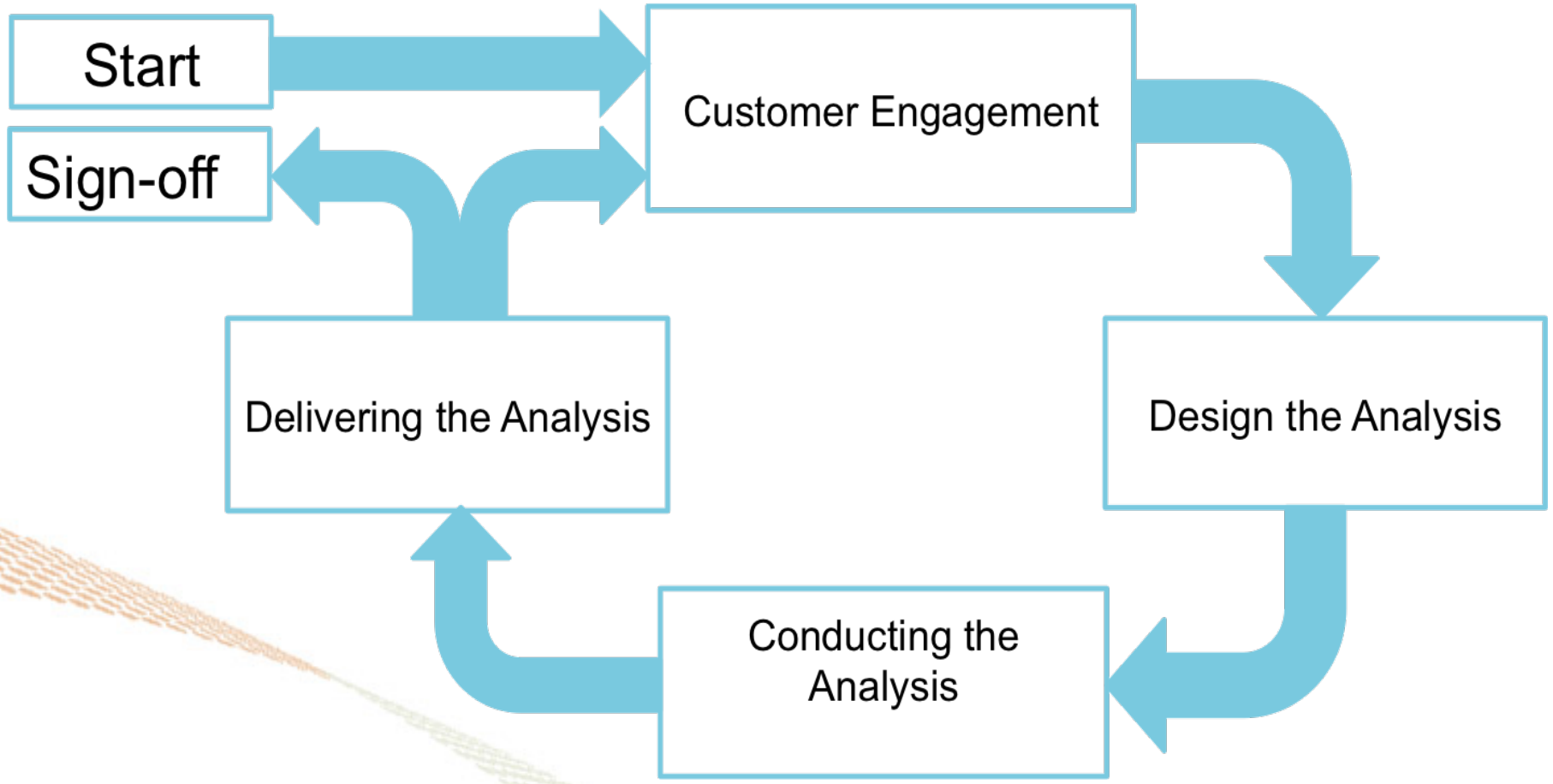
- Verification and Validation
- Analytical Assurance
- Analysing uncertainty

Part C – Aqua Book Resources

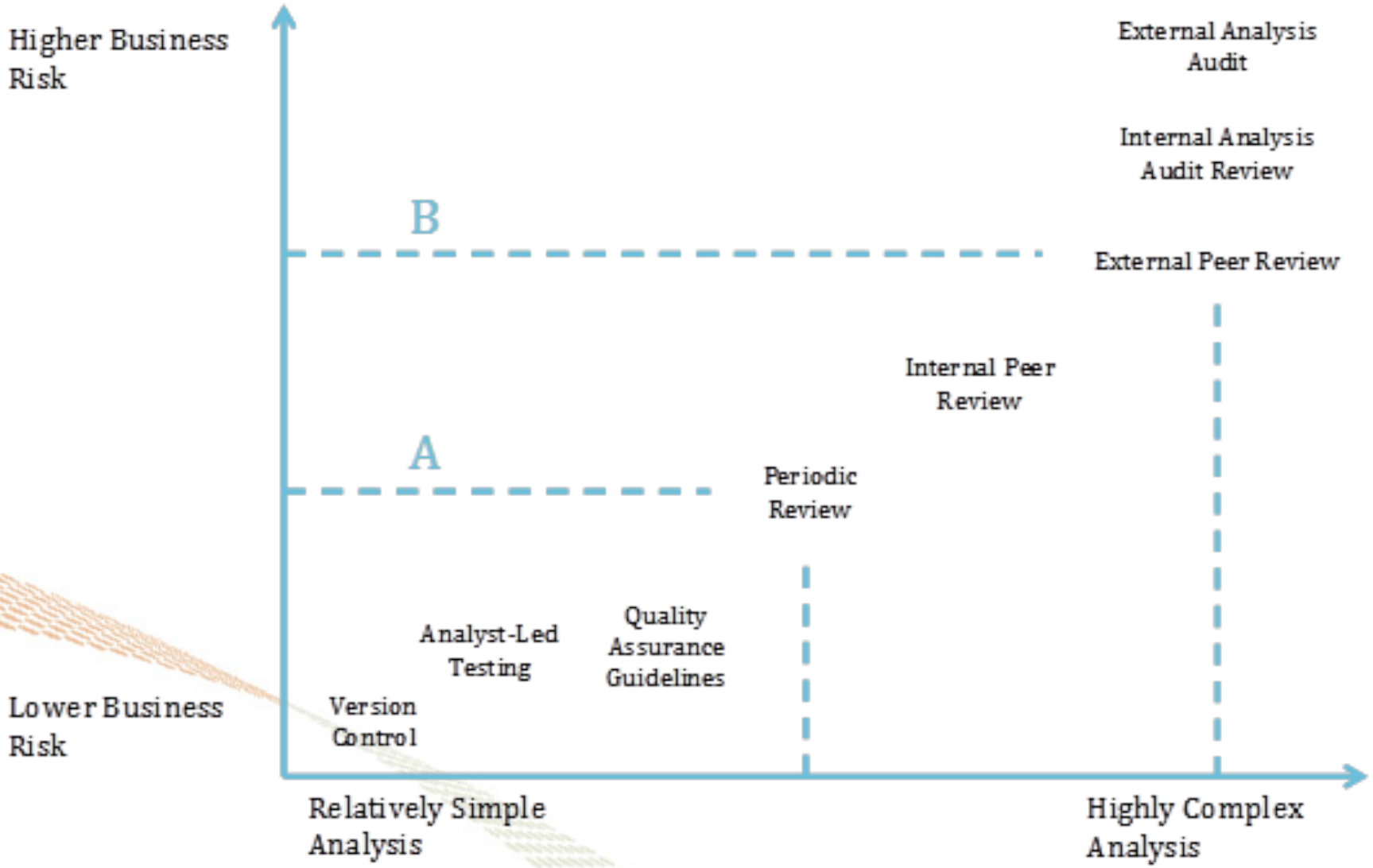
Aqua principles

1. Proportionality of response
2. Assurance throughout development
3. Verification and validation
4. Analysis with RIGOUR
   - Repeatable
   - Independent
   - Grounded in reality
   - Objective
   - understood and manage Uncertainty
   - address the initial question Robustly

Assurance throughout development

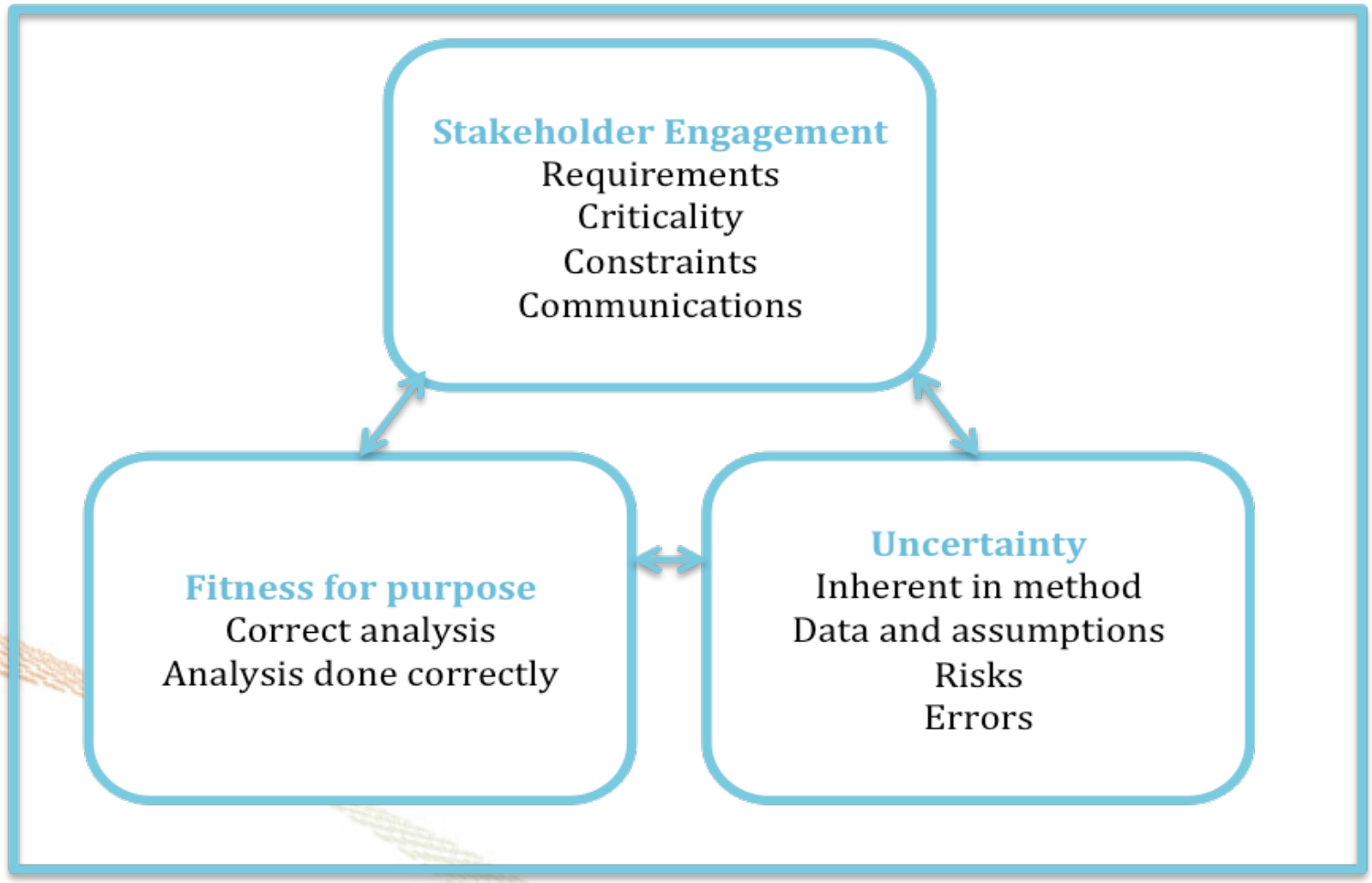


Proportionality of response



Requirements for quality analysis

Analytical Project



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Why deal with uncertainty?

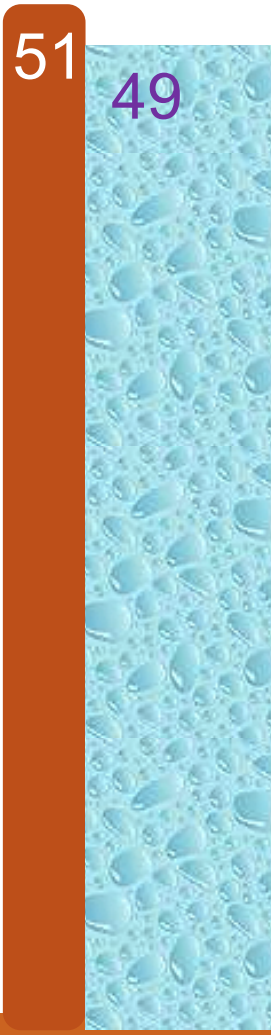
- Information on uncertainty is needed for decision-making

- ‘Credibility requires trust… trust requires openness…openness requires recognition of uncertainty’ (Phillips Report, 2000)

Why consider uncertainty?

Red River Flood, Grand Forks USA, 1997

- Levee height: **51 feet**
- River height *prediction*: **49 feet**



- Actual flood height: **54 feet**

After: Nate Silver, The Signal and the Noise, 2012

Why consider uncertainty?

Red River Flood, Grand Forks USA, 1997

- Estimated damages: **several $billion**

Why consider uncertainty?

Red River Flood, Grand Forks USA, 1997

- Levee height: **51 feet**
- River height *prediction*: **49 feet**
- Uncertainty: **±9 feet** (*not communicated*)

Information needed for risk management:

- *How much* higher might the river rise?
- *How likely* is it to exceed the levee height?

…taking account of *all identifiable uncertainties*

Implications for commissioners of analysis

- For each policy option, decision-makers need information on:
  - the range of possible outcomes
  - their likelihoods (preferably quantitative)
  - deep uncertainties (if present)
  - the reasons for the uncertainties
  - options for managing them

- Include these requirements in the commission
- If they are not provided, ask for them

Implications for analysts

Analysts need to:

- Identify sources of uncertainty
- Quantify them, if possible
- Assess their impact on outcomes

Identifying uncertainties

- Uncertainties affecting the policy outcome:
  - availability of resources
  - how the implementation unfolds
  - nature and magnitude of immediate impacts
  - wider or longer-term consequences
  - external risks & changes in policy context
- Uncertainties affecting the analysis of outcomes:
  - inputs: data, evidence, assumptions
  - how they are combined (models, logic)
  - factors omitted from the analysis
  - errors in the analysis (minimise by QA!)

Quantifying uncertainties

- Quantify the uncertainties:
  - alternative input values, or distributions
  - alternative equations or logic
  - including or excluding additional factors

- Based on analysis of data where possible
- Otherwise use expert knowledge
  - formal expert elicitation where appropriate

Propagating uncertainties

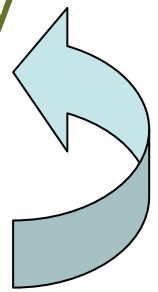
- Quantify the impact of the uncertainties on the analysis outcome
  - probabilistic modelling
  - formal sensitivity analysis
  - what-if calculations
  - expert judgement

- Highlight deep uncertainties you cannot quantify
  - say as much as you can about them

Proportionality

Refine the analysis only as far as is needed:

1. Start simply: list the uncertainties and estimate their impact by expert judgement
2. If needed, quantify the most important uncertainties by what-if calculations, sensitivity analysis or probabilistic modelling
3. Repeat step 2 until the analysis is sufficient to inform a decision



Requires consultation between analyst, commissioner and decision-maker

Calculating uncertainty is not enough

- Decision-makers need a complete account of the uncertainty that is identifiable by the analyst
- Calculations never include all identifiable uncertainty

→ **Need to evaluate the impact of uncertainties that are not quantified in the calculations**

- Identify and list the additional uncertainties
- Evaluate their individual impacts
- Evaluate their combined impact, taking account of dependencies between them

Ignoring additional uncertainties

- Not acceptable
- Exaggerates precision of estimate
- Leads to sub-optimal and sometimes catastrophic decisions

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Stating or implying that additional uncertainties are ‘negligible’

- Implies two complex judgements:
  - impact of uncertainties on estimate
  - consequences for decision-making

- Conflating these judgements
  - is not transparent
  - fails to make explicit what level of risk is being accepted
  - pre-empts role of decision-maker

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Describing additional uncertainties

- E.g. in discussion of analysis report
- Important but not enough

- Leaves decision-makers to judge the impact
  - they may have some specialist knowledge of the system being modelled
  - but will be less able to identify uncertainties associated with your model or judge their impact

→ sub-optimal and sometimes catastrophic decisions

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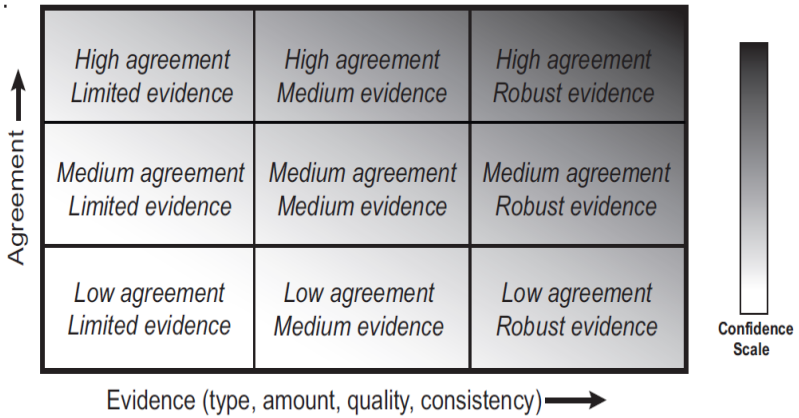
Qualitative evaluation of additional uncertainties

- E.g.: 49 feet with *'Moderate uncertainty'* or '*Medium confidence*'

e.g. IPCC confidence scale



- Ambiguous
- Leaves the decision-maker to interpret the range of possible outcomes & how likely they are

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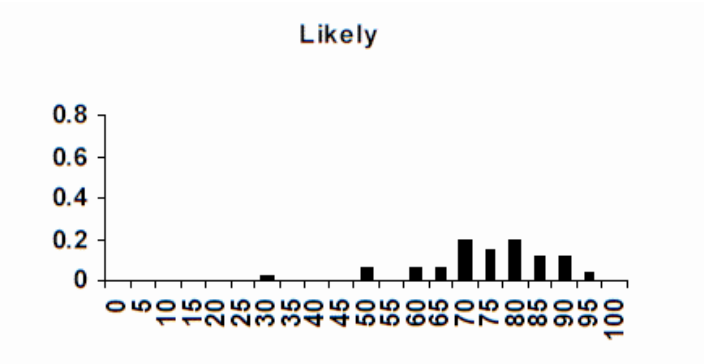
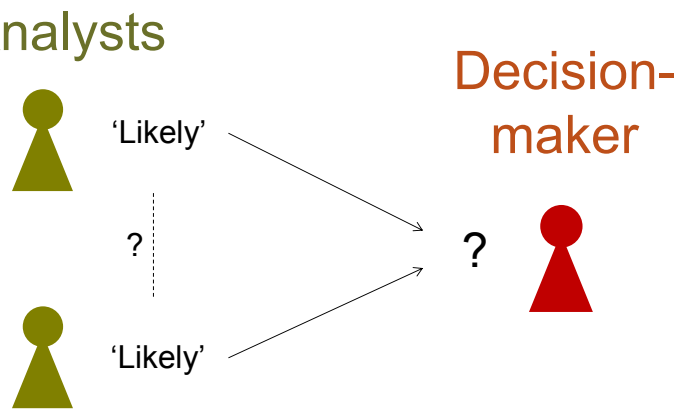
Qualitative evaluation of additional uncertainties

- Qualitative expression of likelihood of adverse outcomes, e.g. '*unlikely*', '*likely*'
- *Ambiguous*: the same word means different things to different people





- *Loaded*: tend to imply expectation of action

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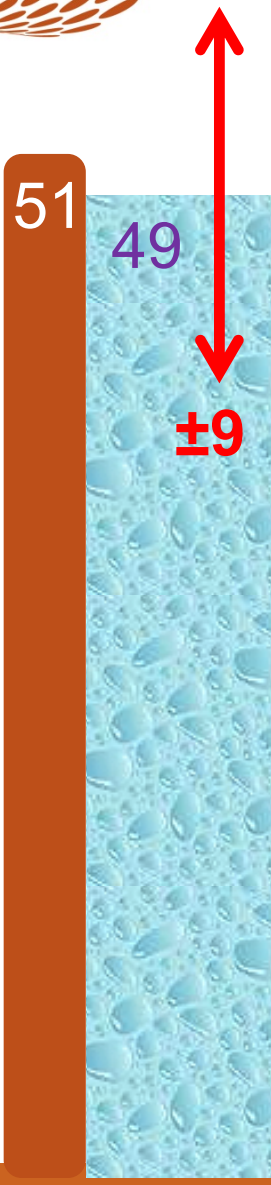
Subjective range for additional uncertainties

- e.g. 'Estimate 49 feet, *with uncertainty of ±9 feet*'

- Clearly expresses the analyst's assessment of the range of possible outcomes
  - *may* be sufficient if range excludes adverse outcomes
  - does not provide relative likelihoods for outcomes within the range



Subjective probabilities for additional uncertainties

- e.g. '*30% chance of exceeding 51 feet*'
- …or terms with defined meaning

e.g. IPCC likelihood scale

Term*	Likelihood of the Outcome
Virtually certain	99-100% probability
Very likely	90-100% probability
Likely	66-100% probability
About as likely as not	33 to 66% probability
Unlikely	0-33% probability
Very unlikely	0-10% probability
Exceptionally unlikely	0-1% probability

- Expresses the analyst's assessment of the *likelihood* of adverse outcomes
- Essential information for risk management

Avoiding judgements is not an option

- If the analyst won't make a judgement about the additional uncertainties, someone else will

- Decision-makers will either:
  - act *as if* the uncertainty is less than ±2 feet
  - act *as if* it is more than ±2 feet
  - act *as if* the uncertainty is unquantifiable

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Using judgement

- Human judgement is subject to cognitive heuristics and biases, including:
  - Over-confidence, incl. ‘law of small numbers’
  - Anchoring and adjustment
  - Availability
  - Range-frequency compromise
  - ‘Group-think’
- Use techniques from expert elicitation to guard against these biases
- Consider formal elicitation if the additional uncertainties appear critical to decision-making

When uncertainty really cannot be quantified

- Analyst *really* cannot say anything quantitative about the range or likelihoods
  → range could be infinite
  → probability could be anywhere from 0 to 1
- Qualitative expression would be misleading
- '**Deep uncertainty**'
  - essential info for decision-makers
  - major implications for types of strategy they should consider (e.g. precaution, resilience, flexibility, etc.)

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Implications of uncertainty for decision-making

- Consider the options for managing the uncertainty
- Choose options that reduce the chance of bad outcomes and increase the chance of good ones
- Appropriate balance between precaution and risk-taking
  - take account of other considerations: legal, economic, social, political

- Ask for more refined analysis if needed

Communication

- Layered approach:
  - concise summary: range and likelihood of outcomes, deep uncertainties, reasons, options
  - more detail for those who want it

- Acknowledge *outcomes* are uncertain
- Focus on communicating the *strategy*: how it addresses uncertainties, and the quality of analysis it is based on

Summary

- Look out for the AQUA book
- Calculating uncertainty is not enough
- Identify uncertainties not included in calculation
- Assess their combined impact
- Highlight any you cannot quantify