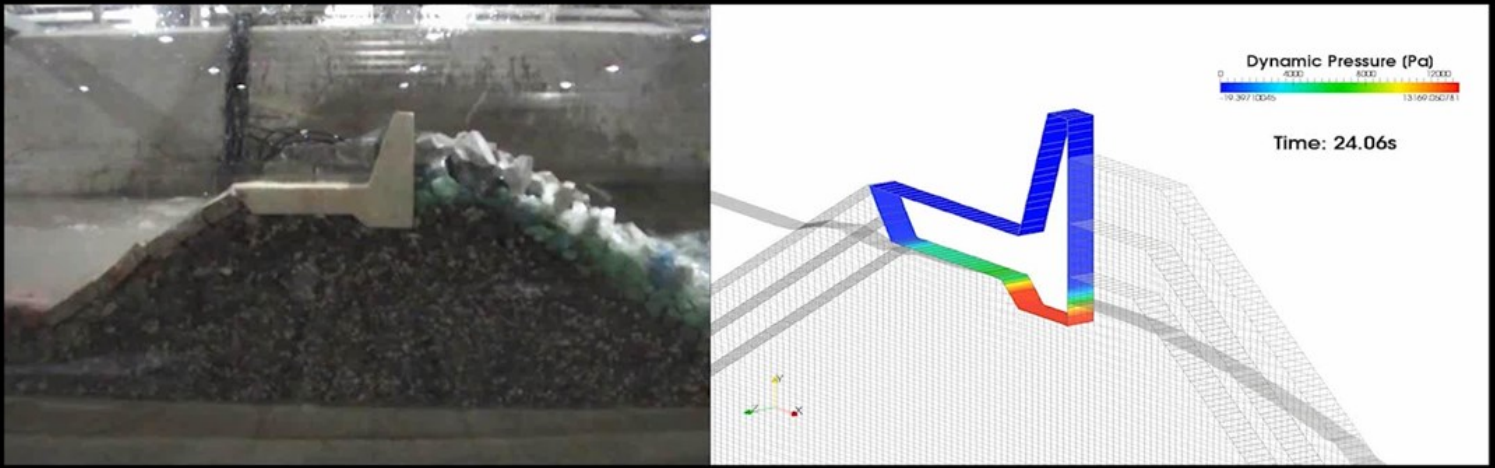


Coastal climate services at USACE & UK organisations (EA/ONR) – and some other thoughts!

Jonathan Simm, HR Wallingford

12 Nov 2019

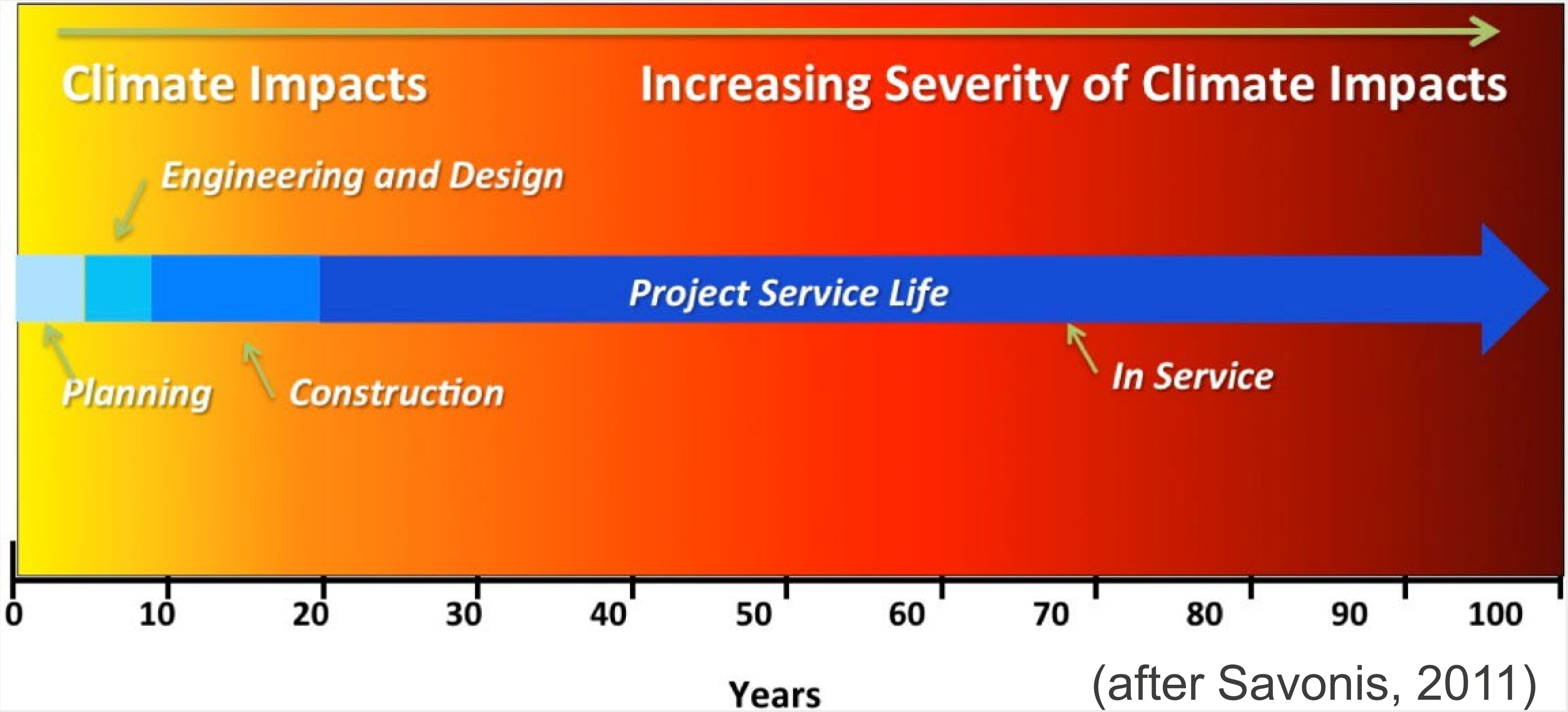
Workshop on WRCP Grand Challenge and Climate Services

USACE – Guidance

EP 1100-2-1 (2019) “Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation”

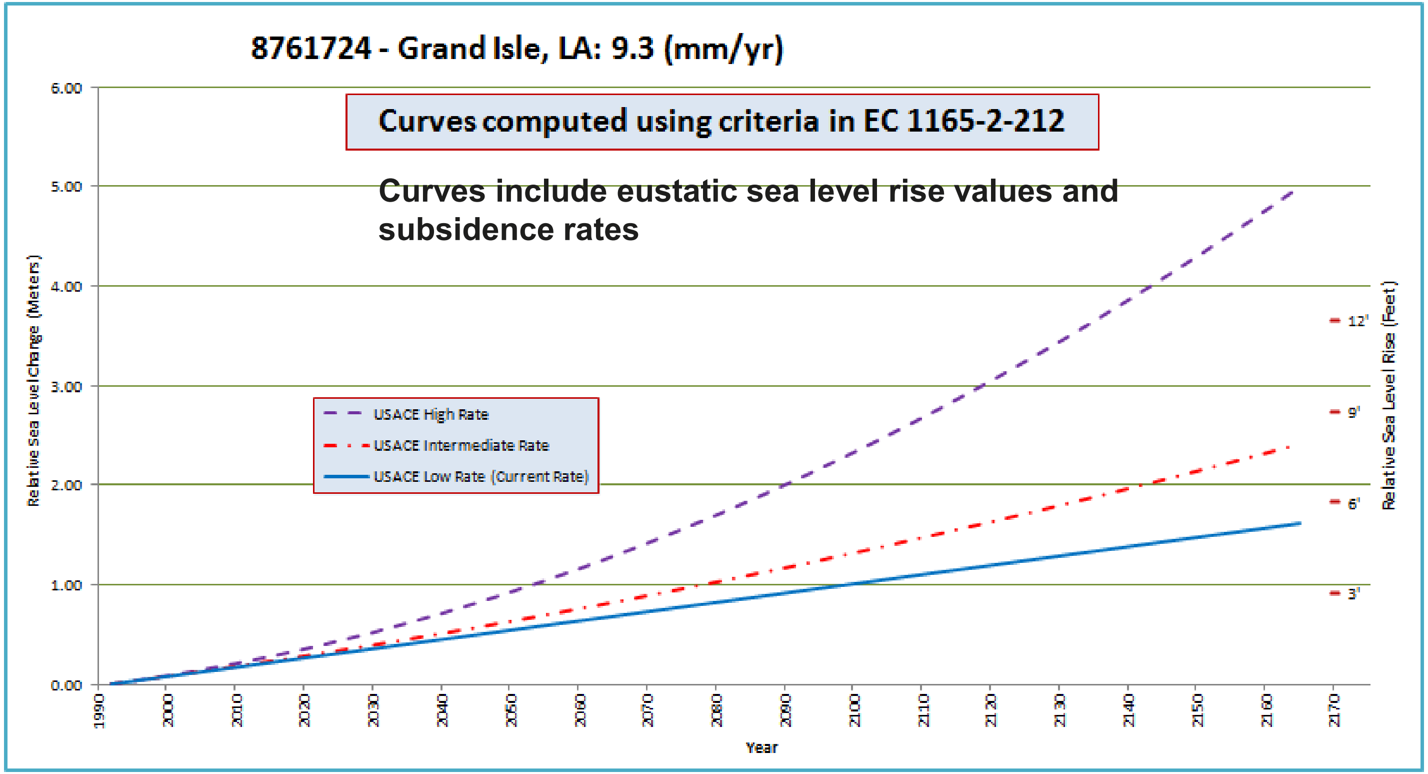
- Purpose and Key Concepts (USACE offices <u>must</u> use this guidance)
- Understanding and Estimating Sea Level Change
- Effect of Sea Level Change on U.S. Army Corps of Engineers (USACE) Decision-Making Processes
- Conclusions
- Appendices
  - References
  - Data Requirements and Development of Sea Level Change Curves
  - Mission area appendices for Navigation, Coastal Storm Damage Reduction, Flood Damage Reduction and Ecosystem Restoration Projects

Infrastructure time frames vs. climate impacts



(after Savonis, 2011)

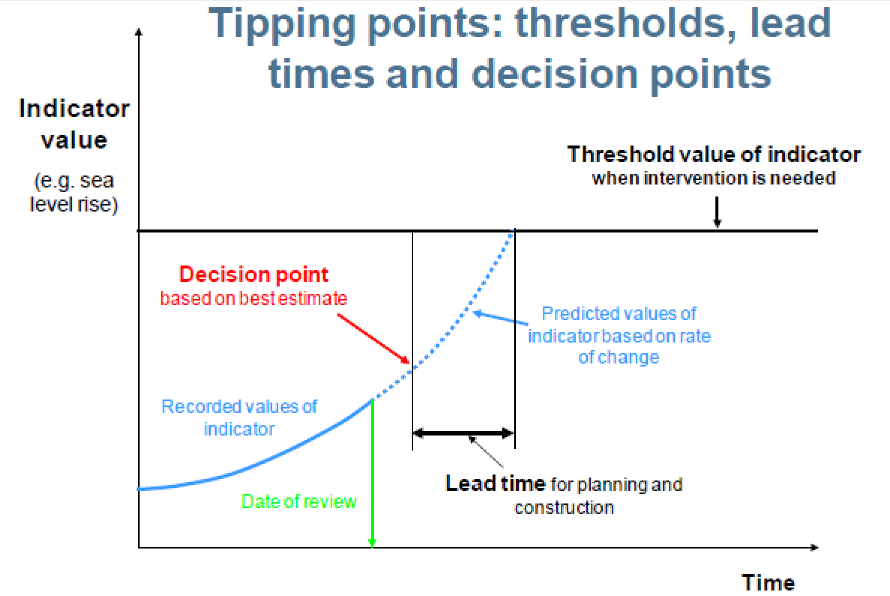
USACE SLC curves for Grand Isle, Louisiana

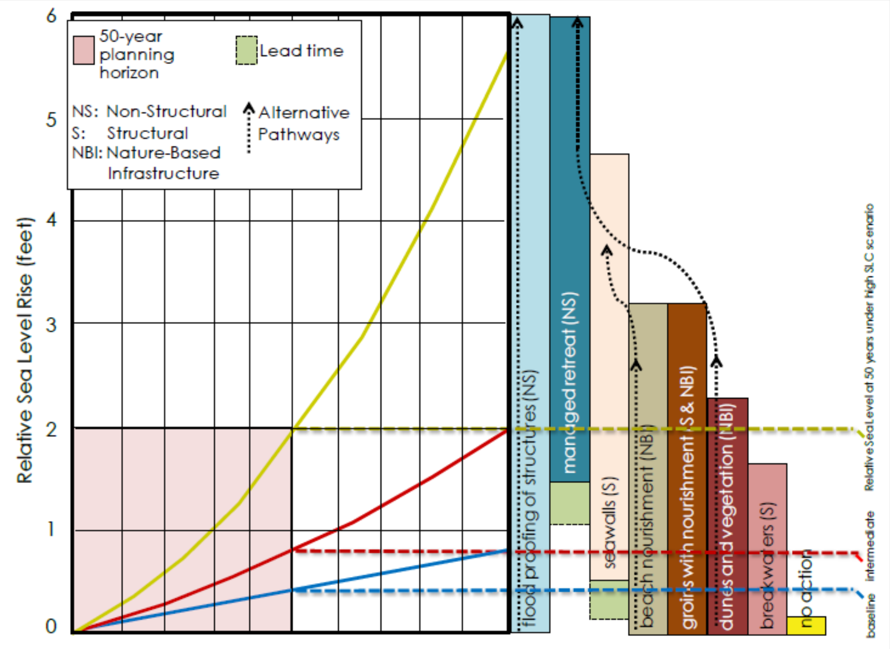


Range of responses suggested

Project Type	Protect	Accommodate	Retreat
Navigation	• Upgrade and strengthen existing primary structures • Expand design footprint and cross section of existing structures, including raising for clearance and access • Add secondary structures • Add structures to protect backshore Improve resilience of backshore facilities	• Upgrade drainage systems Increase maintenance and dredging • Adjust channel location and dimensions • Modify operational windows Flood proof interior infrastructure • Add sediment to shoreline or underwater morphology	• Relocate interior harbor infrastructure due to relative sea level rise or fall • Abandon harbor/port • Re-purpose project area
Coastal Storm Damage Reduction	• Upgrade and strengthen existing structures • Expand design footprint and cross section of existing structures • Add secondary structures • Dune/beach construction	• Increase maintenance of shoreline protection features • Sediment management • Beach nourishment/ vegetation • Upgrade drainage systems • Upgrade and modify infrastructure • Flood proof buildings Implement building setbacks • Modify building codes	• Relocate buildings and infrastructure • Land-use planning and hazard mapping • Modify land use

Decision pathways





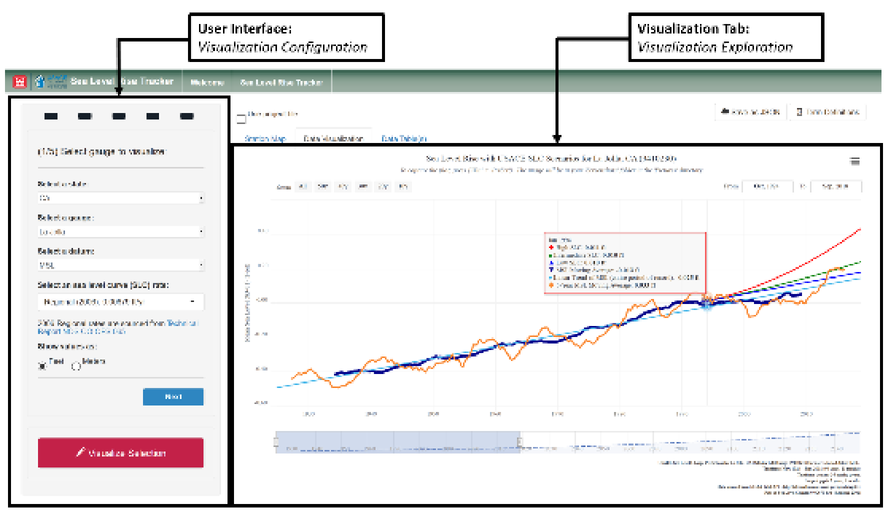
USACE Sea Level Tracker

The purpose of the Sea Level Tracker is twofold:

1. *Show actual sea level vs. the projected sea level change curves plainly and*
2. *Answer the question, "What rate of sea level change is currently being observed at the selected gauge?"*

Four main sections in Sea Level Tracker:

1. Data Entry Panel
2. Location Map.
3. Visualization Tab:
4. Data Table(s).



The tool does not predict future water levels. Rather, the tool offers smoothed analysis of historic sea level behaviour and the measured trends at a user selected gauge.

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EA earlier Climate Change guidance

Environment Agency

Table 5 Mean sea level allowance (compared to 1990 baseline, includes land movements)

Change to relative mean sea level	Sea level rise mm/yr up to 2025	Sea level rise mm/yr 2026 to 2050	Sea level rise mm/yr 2051 to 2080	Sea level rise mm/yr 2081 to 2115
H++ scenario	6	12.5	24	33
Upper end estimate	4	7	11	15
Change factor	Use UKCP09 relative sea level rise medium emission 95% projection for the project location available from the user interface.			
Lower end estimate	Use UKCP09 relative sea level rise low emission 50% projection for the project location available from the user interface.			

Erosion Risk Management Authorities

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Latest EA sea level rise allowance (mm/year)
(cumulative sea level rise for each epoch in brackets)

Area of England	1990 to 2025	2026 to 2055	2056 to 2085	2086 to 2115	Cumulative rise 1990 to 2115 / metres (m)
East, east midlands, London, south east	4 (140 mm)	8.5 (255 mm)	12 (360 mm)	15 (450 mm)	1.21 m
South West	3.5 (122.5 mm)	8 (240 mm)	11.5 (345 mm)	14.5 (435 mm)	1.14 m
North west, north east	2.5 (87.5 mm)	7 (210 mm)	10 (300 mm)	13 (390 mm)	0.99 m

Note: H^{++} allowances must be considered in critical cases – not yet updated

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The case of resilience of nuclear power plants
(c.f. Office for Nuclear Regulation/EA guidance)

Table 3: The use of RCPs, return periods, and sensitivity studies in climate change assessments – ONR and EA expectations.

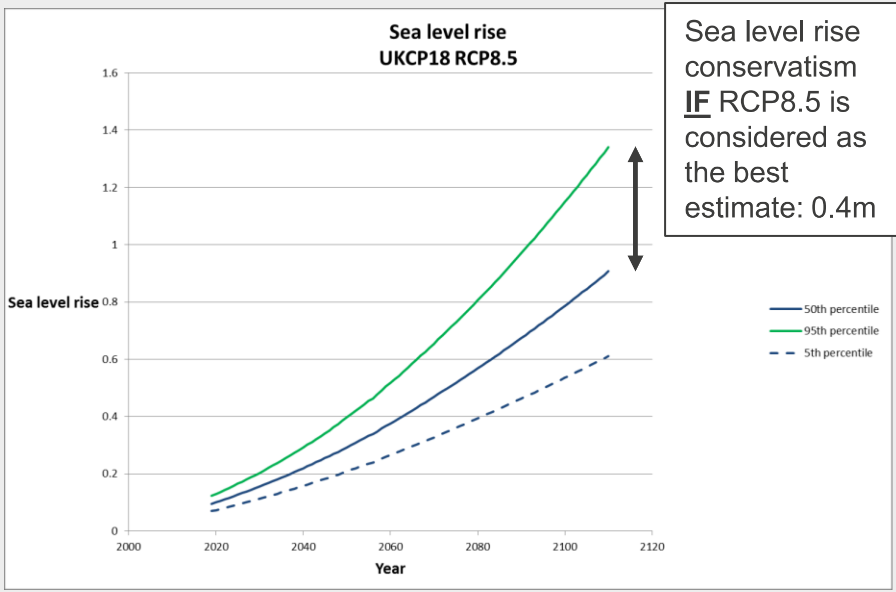
Expectation	ONR	EA
RCP to select	ONR does not prescribe the use of a particular RCP to define a design basis event[4]. The dutyholder will need to provide evidence that the RCP that they have selected is adequately conservative in line with ONR's Safety Assessment Principles (SAPs) and that uncertainty has been taken into account. ONR expects that there would not be a reduction in conservatism from the approaches that have been used in UKCP09 (ONR has generally accepted the UKCP09 medium emissions scenario at the 84th percentile as adequately conservative for defining a design basis (More information on this is available in Ref. 10)).	The Environment Agency flood risk and climate change guidance states a range of likely climate change scenarios should be assessed. Typically, this range of allowances is premised on scenarios across the medium and high emissions scenarios[5].The EA guidance is due to be updated in 2019 to reflect UKCP18 projections.

[4] In addition, dutyholders are expected to ensure that there is no disproportionate increase in risk for events more severe than the design basis. Dutyholders are also required to provide enhanced protection against even more severe events and provisions for recovery in the unlikely event that the protection capability is exceeded. Further information can be found in ONR's External Hazards SAPs (Ref. 12) and ONR's External Hazards TAG (Ref. 10 & 11).

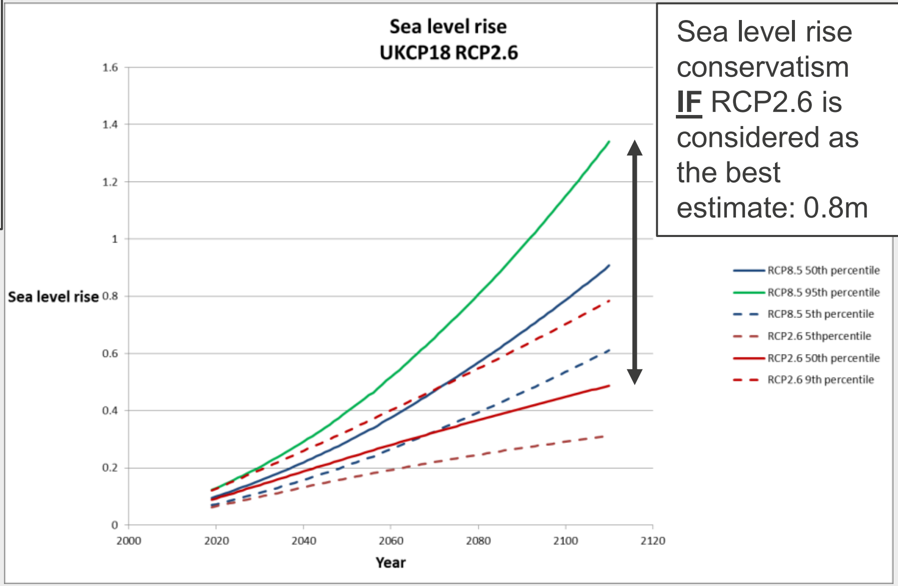
[5] Currently for sea level rise, a single figure allowance is provided in EA's climate change and flood risk guidance (Ref. 6). However, since publication of UKCP18, EA's interim preferred position is for developments sensitive to flood risk such as infrastructure projects (i.e. high impact should they flood) the 95th percentile for RCP8.5 should be assessed alongside the current single figure allowance.

A challenging case – nuclear power stations (precautionary approach needed)

Use of 95th percentile

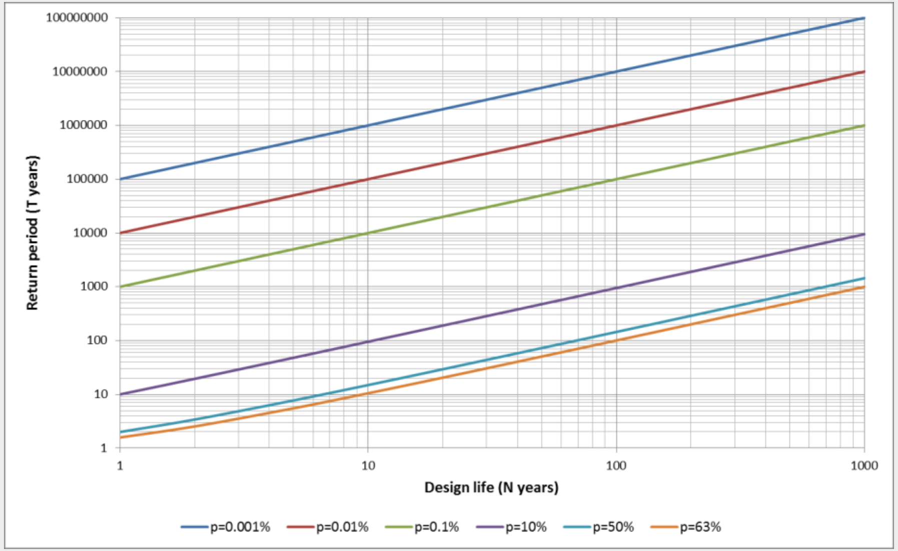


Sea level rise conservatism **IF** RCP8.5 is considered as the best estimate: 0.4m

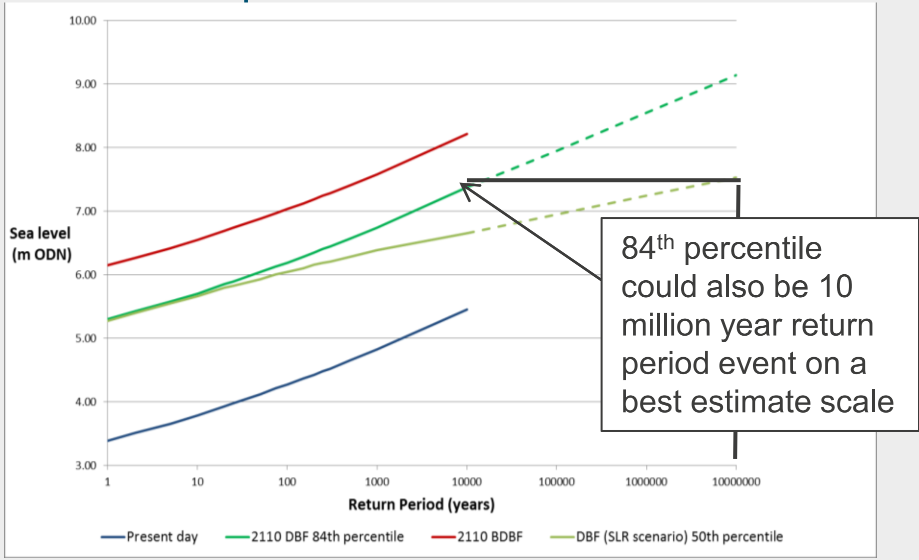


Sea level rise conservatism **IF** RCP2.6 is considered as the best estimate: 0.8m

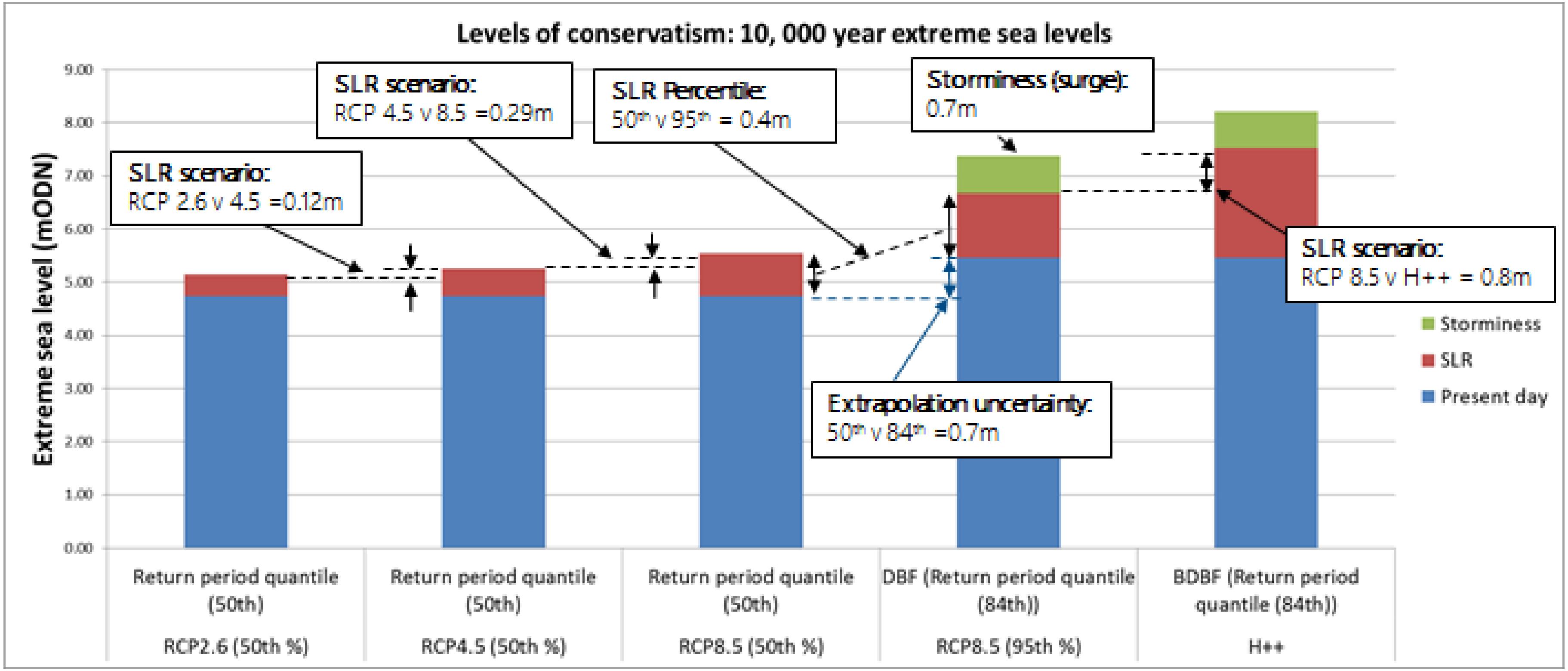
Return period conundrums
For Design Basis Event (DBE) and Beyond Design Basis Event (BDBE)



84th percentile estimates



Levels of conservatism for coastal nuclear projects



Beyond design basis

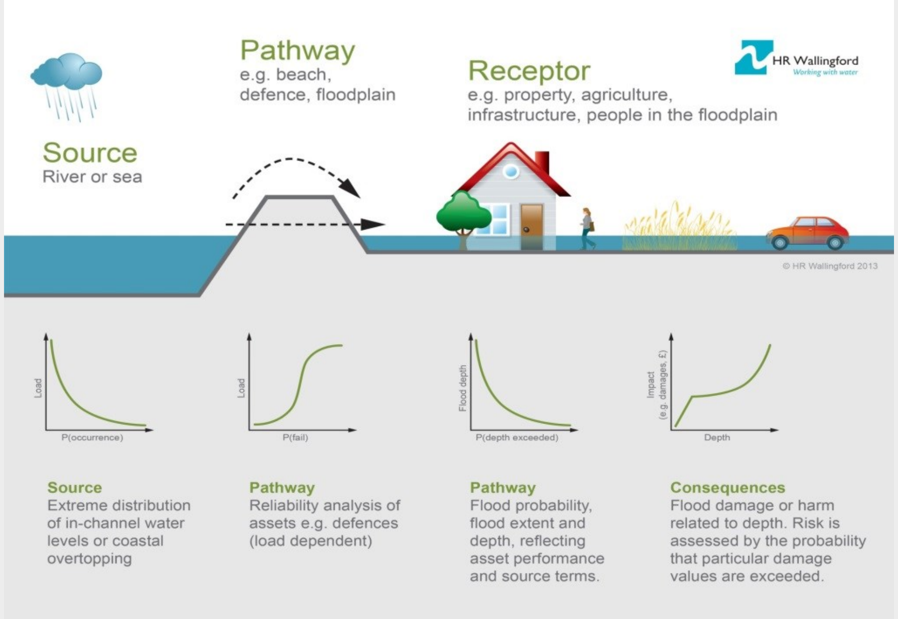
Engineering principles: external and internal hazards	Weather conditions	EHA.11
Facilities should be shown to withstand weather conditions that meet design basis event criteria. Weather conditions beyond the design basis that have the potential to lead to a severe accident should also be analysed.		

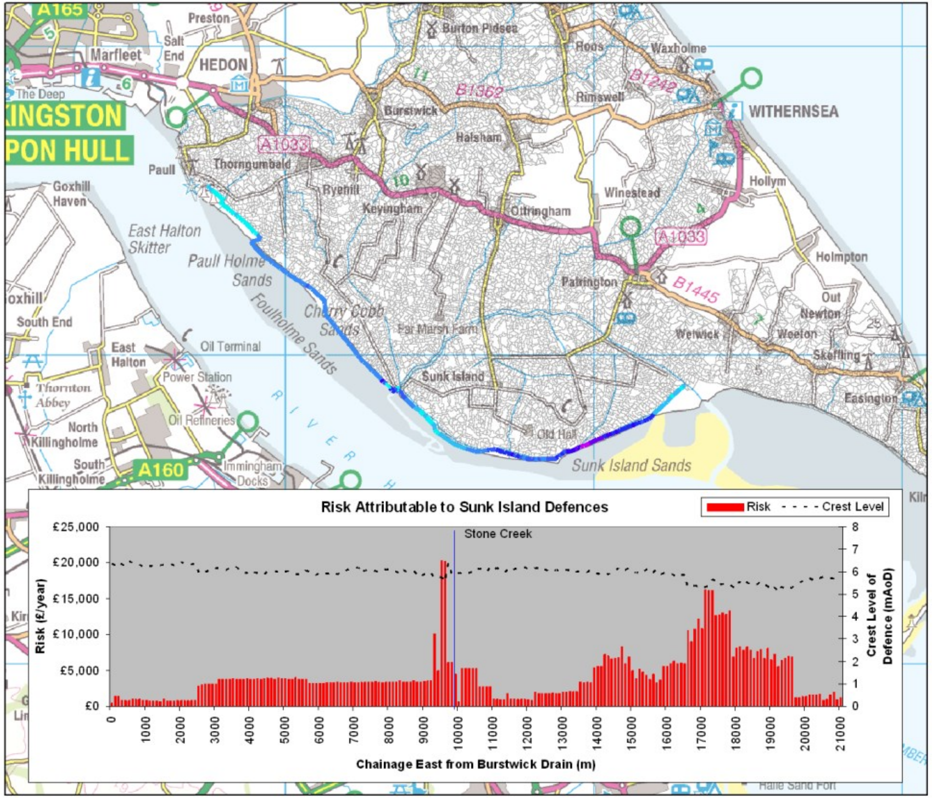
265. The consequences of the design basis flood being exceeded should be taken into account in the design of the facility, with particular attention paid to overtopping of defences and cliff edge effects. Severe beyond design basis and severe accident analysis (see paragraph 651 ff.) should be used as part of the design process.

110. BDBA for hazards should:

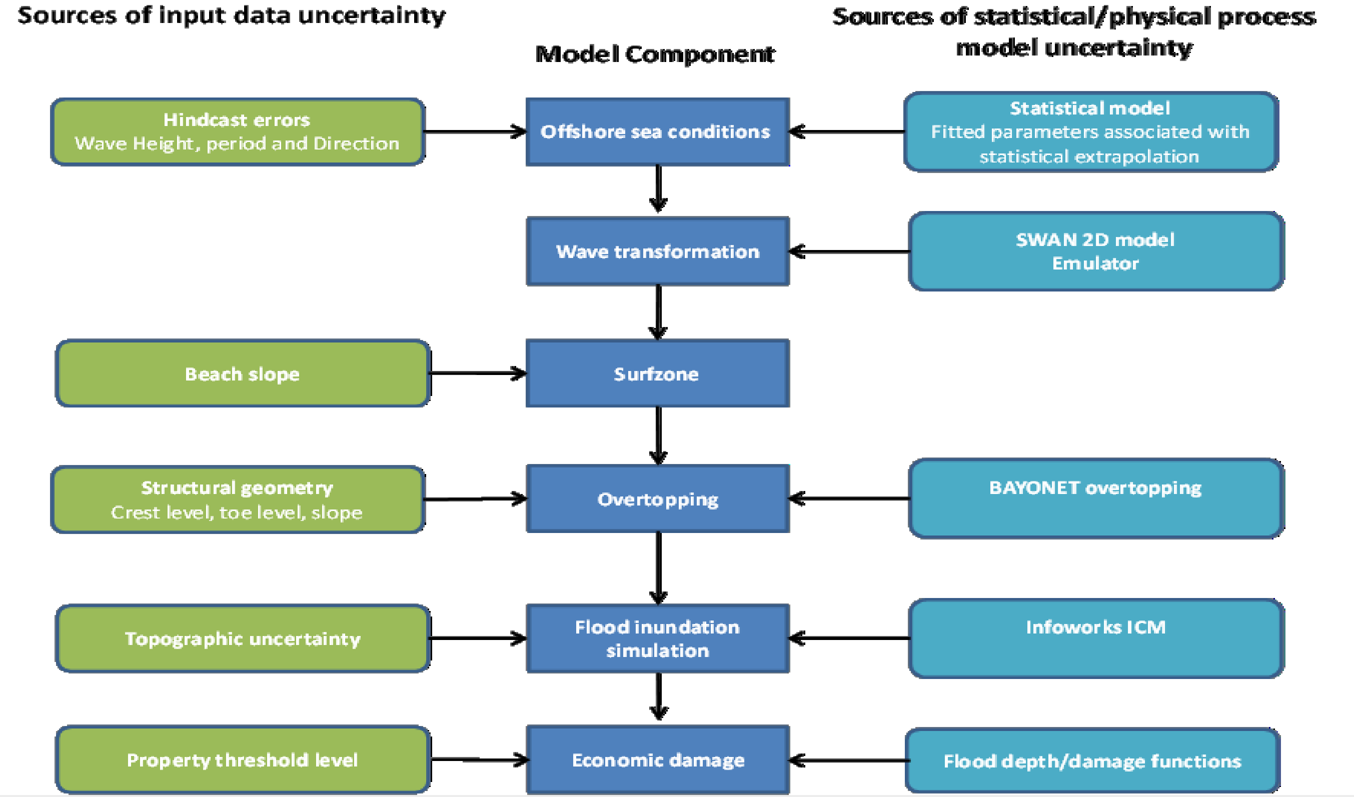
- Identify plant / SSC vulnerabilities and potential measures to improve robustness.
- Demonstrate sufficient margin to avoid cliff-edge effects just beyond the design basis (SAP EHA.7).
- For non-discrete hazards, identify the hazard level at which safety functions could be lost, in other words determine the BDB margin.

UK flood risk analysis approach

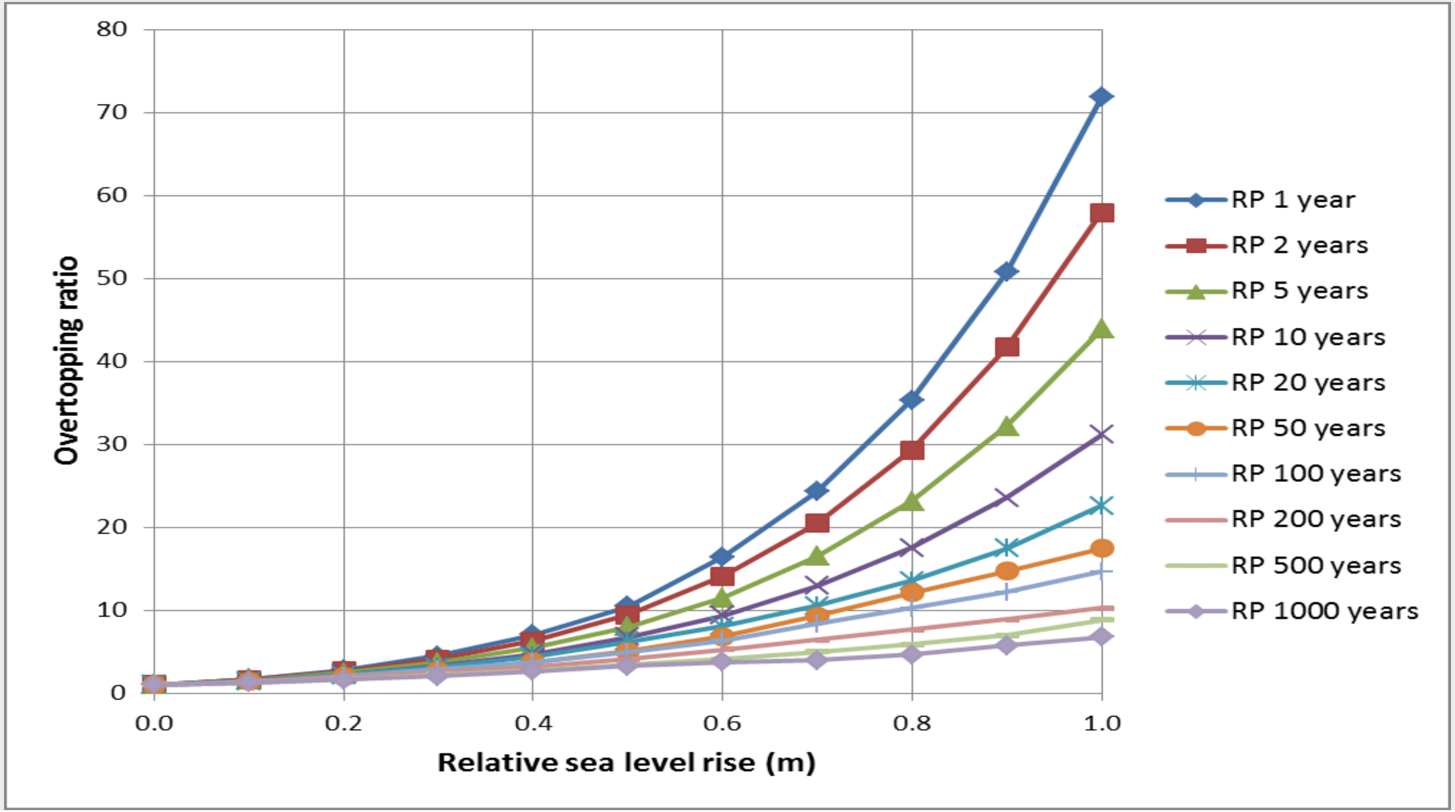




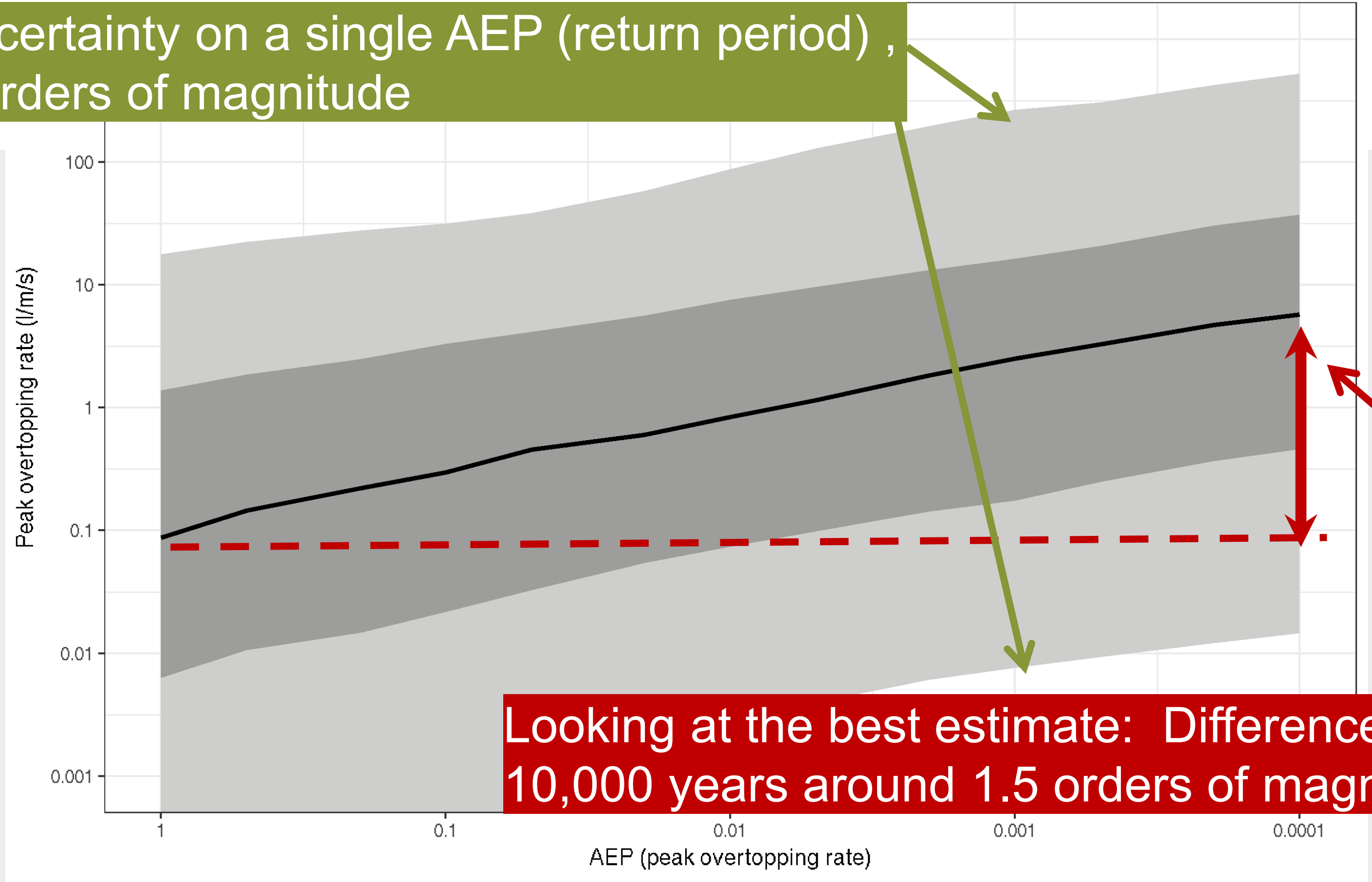
Uncertainty: Model chains



Increases in overtopping rates by 2080s
(all English defences)

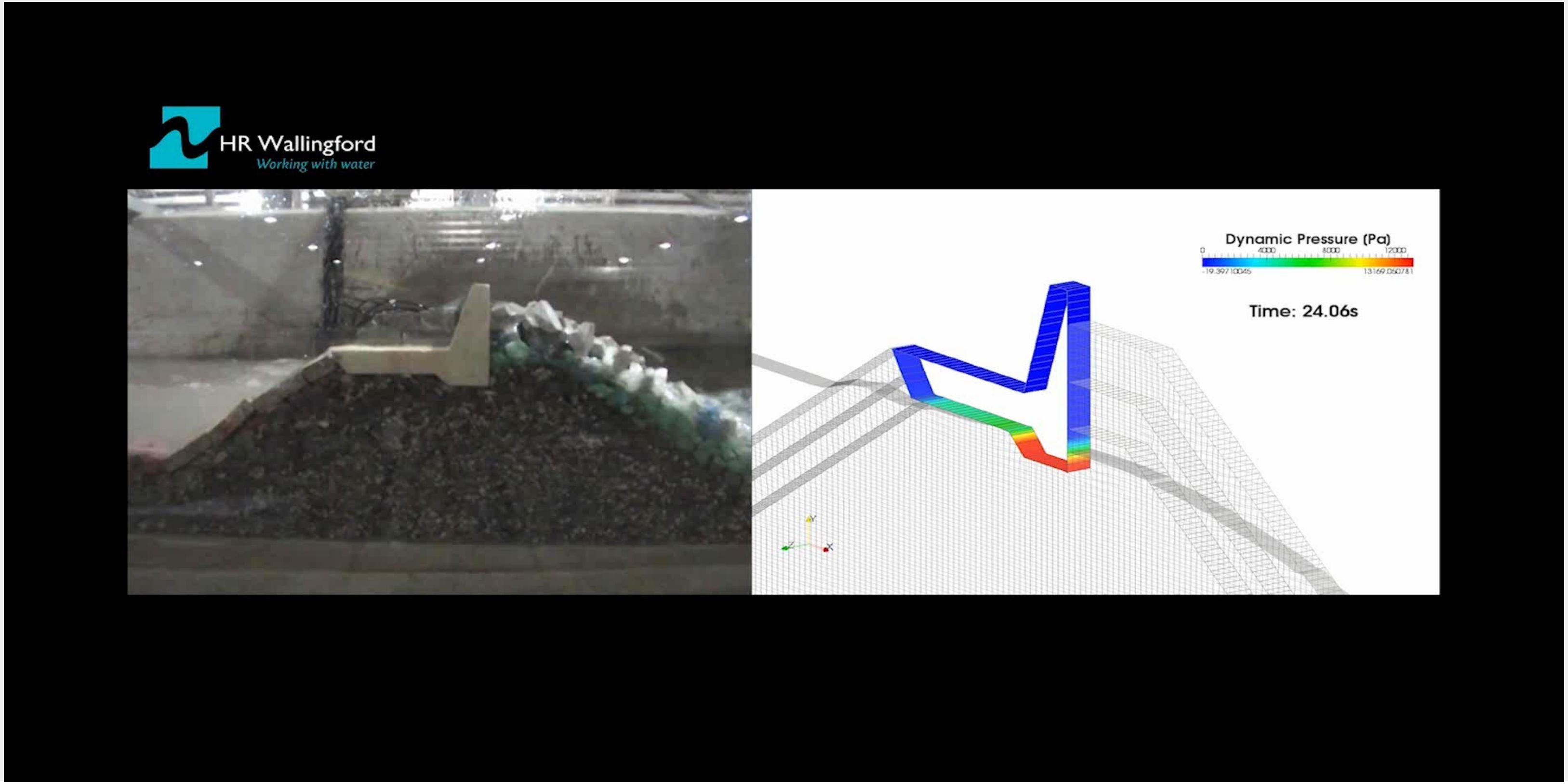


Uncertainty on a single AEP (return period) ,
4 orders of magnitude

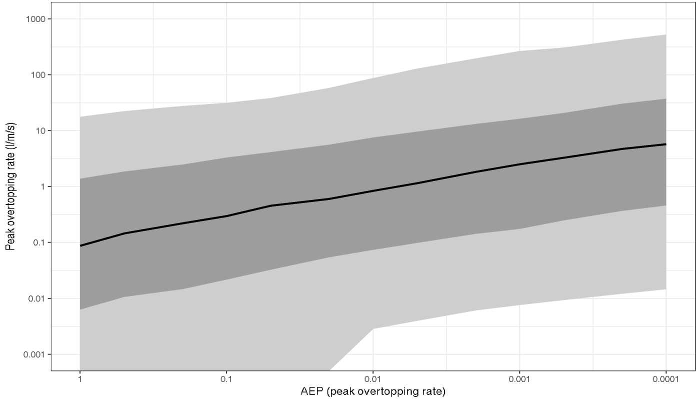


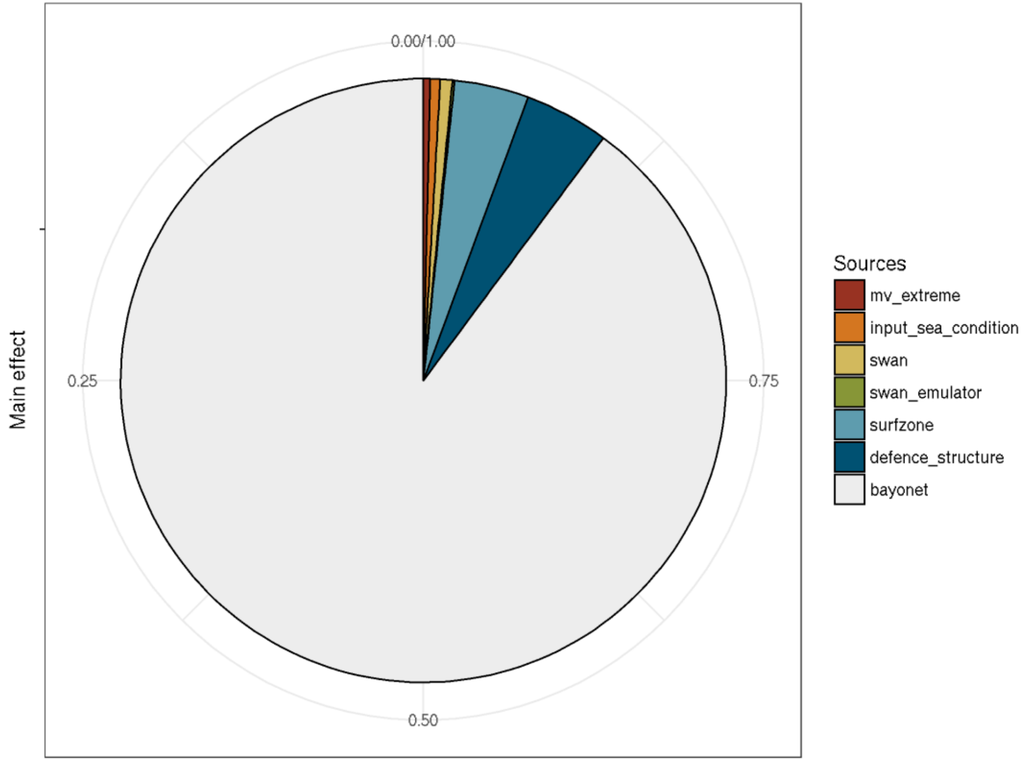
Looking at the best estimate: Difference between 1year and
10,000 years around 1.5 orders of magnitude

Overtopping – a highly uncertain process

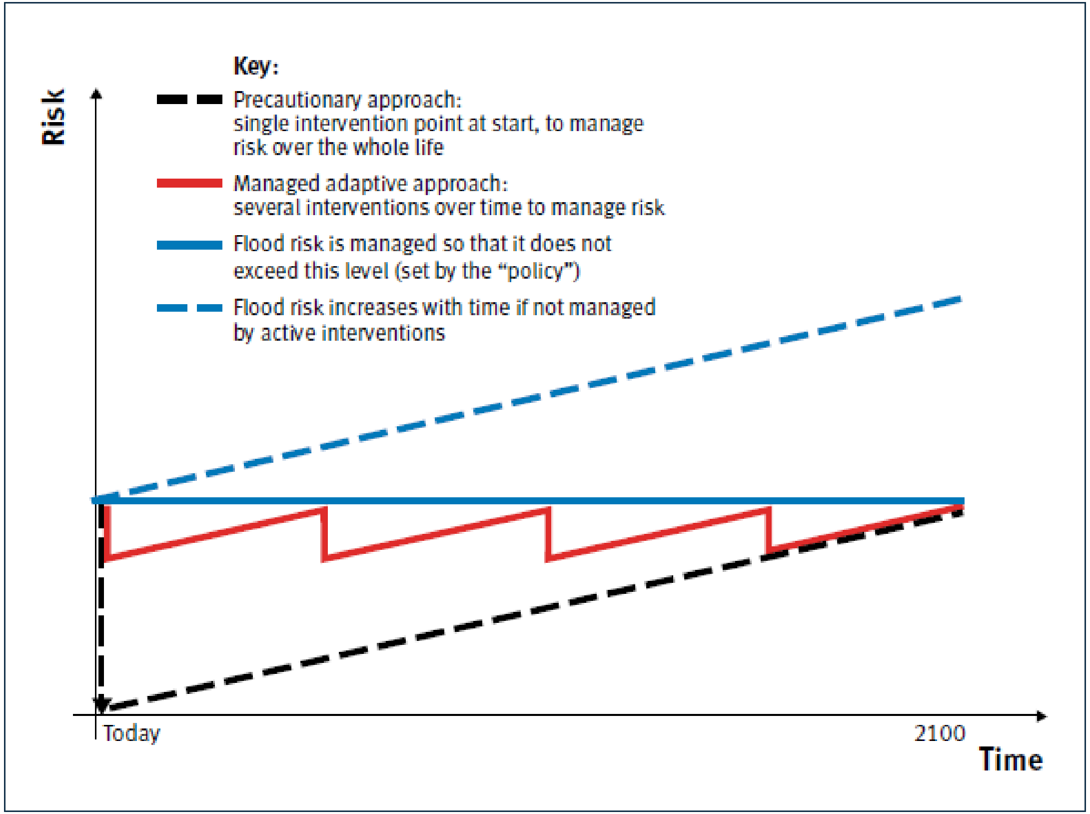


Results of sensitivity analysis of model chain

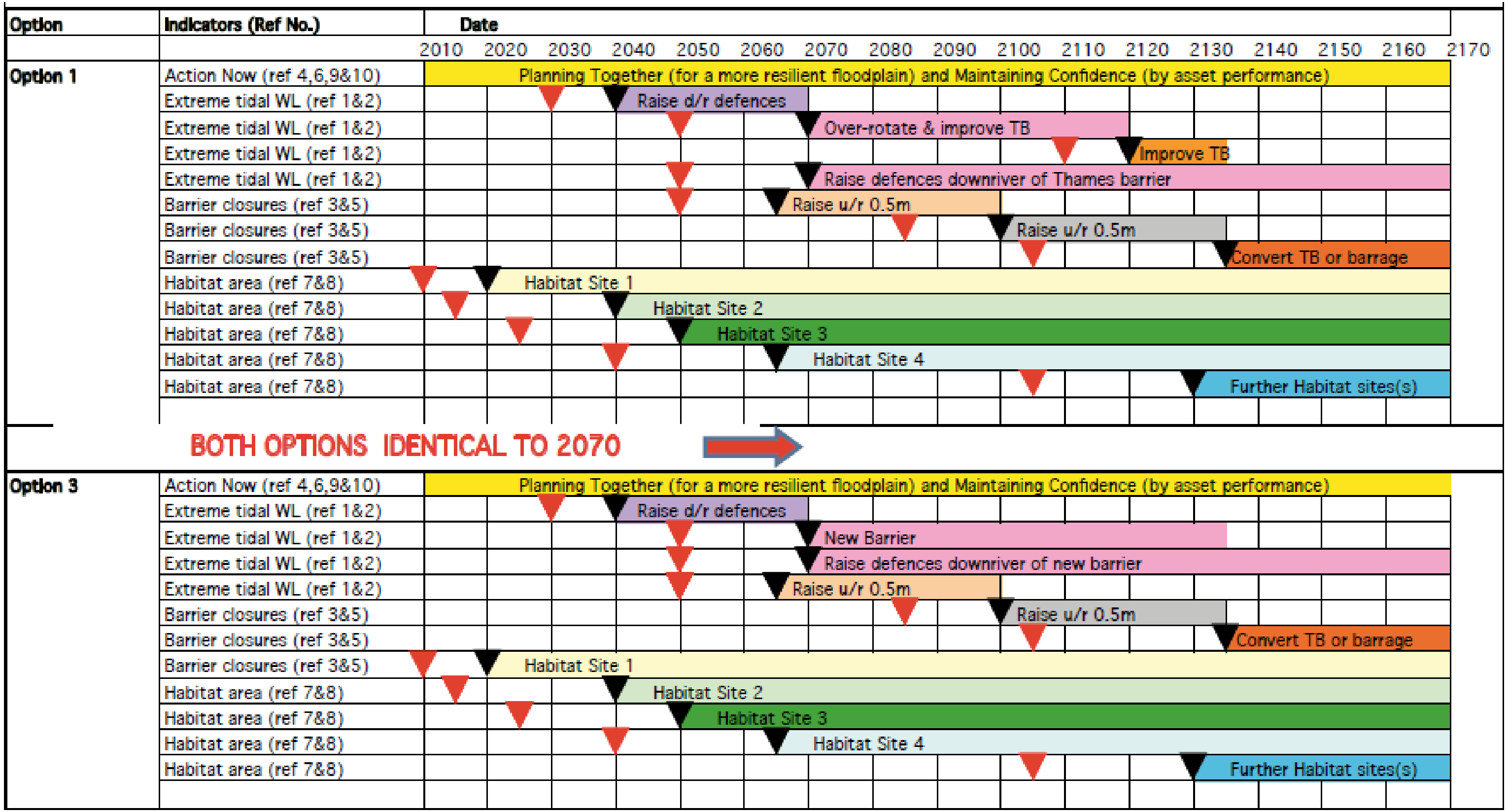




Managed adaptive approach for TE2100



TE2100 option timelines

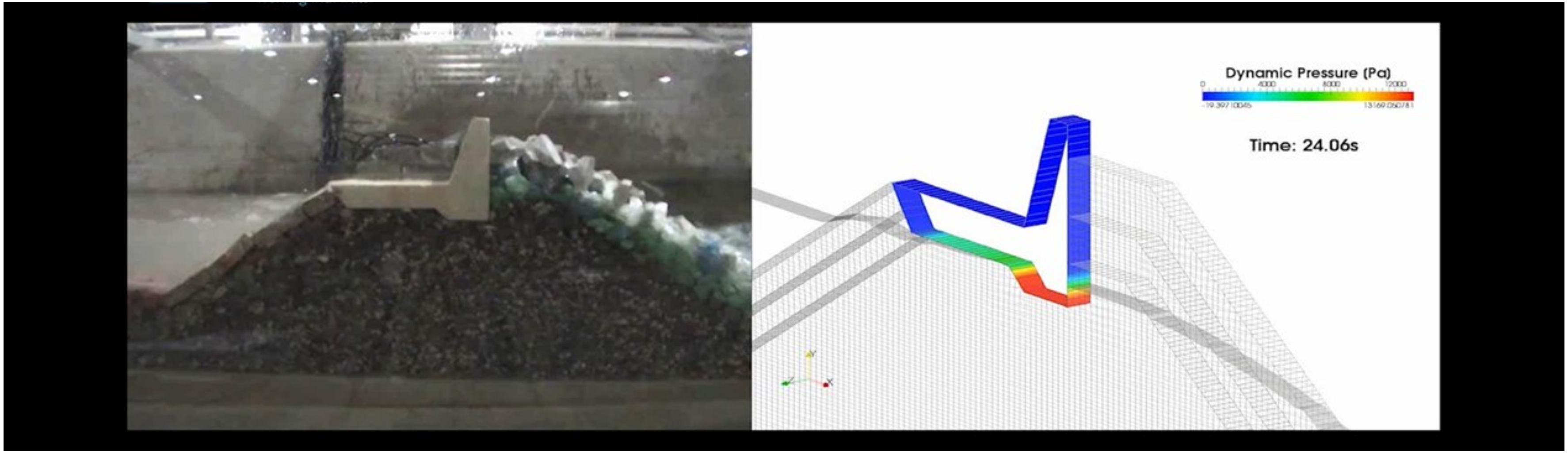


10 indicators for change in the Thames Estuary
(mean sea level change only one of 10 indicators)

1	Mean Sea Level	Mean sea level is the level which determines the number of times per year that a barrier must be closed. This also has a major impact on the area of intertidal habitat in the Estuary. Change in mean sea level also provides an indication of how the peak surge tide level may change.
2	Peak surge tide level	The extreme (but rare) tidal flood levels which will have to be managed. Peak surge tide level also determines the crest level of the defences including the Thames and other barriers.
3	Peak river (fluvial) flood flows	The combined tidal/fluvial flood risk in West London and where tributaries meet the estuary.
4	Condition of flood defence structures	To ensure that the flood defence system will function as required, our asset performance teams will inspect and monitor the defences and required improvements will be identified to ensure the integrity of the system. To optimise the repair and renewal of defences in order to achieve the best value for money in investment programmes whilst ensuring public safety.
5	Frequency of closure and reliability of the Thames/other barriers	To ensure that the annual probability of failure of these important structures does not exceed the level required to ensure that the flood risk management policies are achieved.
6	Developed area and value/type of development	People and property at risk. Key social and economic information for flood risk management planning.
7	Extent of erosion/deposition	To identify the extent of defences that are threatened by erosion. To determine the likely impacts of erosion and deposition on intertidal areas of erosion/deposition. This will be an important part of monitoring the cumulative effects on the environment of works carried out to the defence structures.
8	Intertidal habitat area including mudflat and saltmarsh	The extent of the intertidal habitat zone, and whether we are complying with EU habitats regulations.
9	Land use planning and development activities	A measure of how well flood risk (i.e. safer floodplains) and opportunities for sustainability (e.g. the creation of green corridors) are being factored into development. Also predicts future needs for society and economics.
10	Public/institutional attitudes to flood risk	Public (hence political) appetite for risk, and institutional preparedness to manage risk and to plan for/respond to emergencies.

Some issues/wishes from a practitioner perspective

- Likelihood of RCP scenarios – illusive goal but lack of information hampers risk-based decision making (for order 100 year lifetime investments). A big area of debate in USA.
- Estimates of very extreme events (e.g. UK H^{++}) are not always updated at the same time as general climate projections. Leads to out-of-phase thinking.
- Uncertainty analysis of the ultimate response (e.g. flooding) reveals there may be bigger coastal process uncertainties than SLC in many cases e.g. overtopping rates. We are also obliged to evaluate 'cliff edge' effects (if we know what they are!)
- Sea level rise and other coastal forcing changes are only one of many change drivers which we need to consider – see TE2100 list for example.
- We need concurrent time series data across a range of different forcings to facilitate analysis of dependencies and permit understanding of multiple source or compound flooding. We often have concurrent coastal data series but time series data to allow evaluation of dependencies between coastal forcing and fluvial events is limited.



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