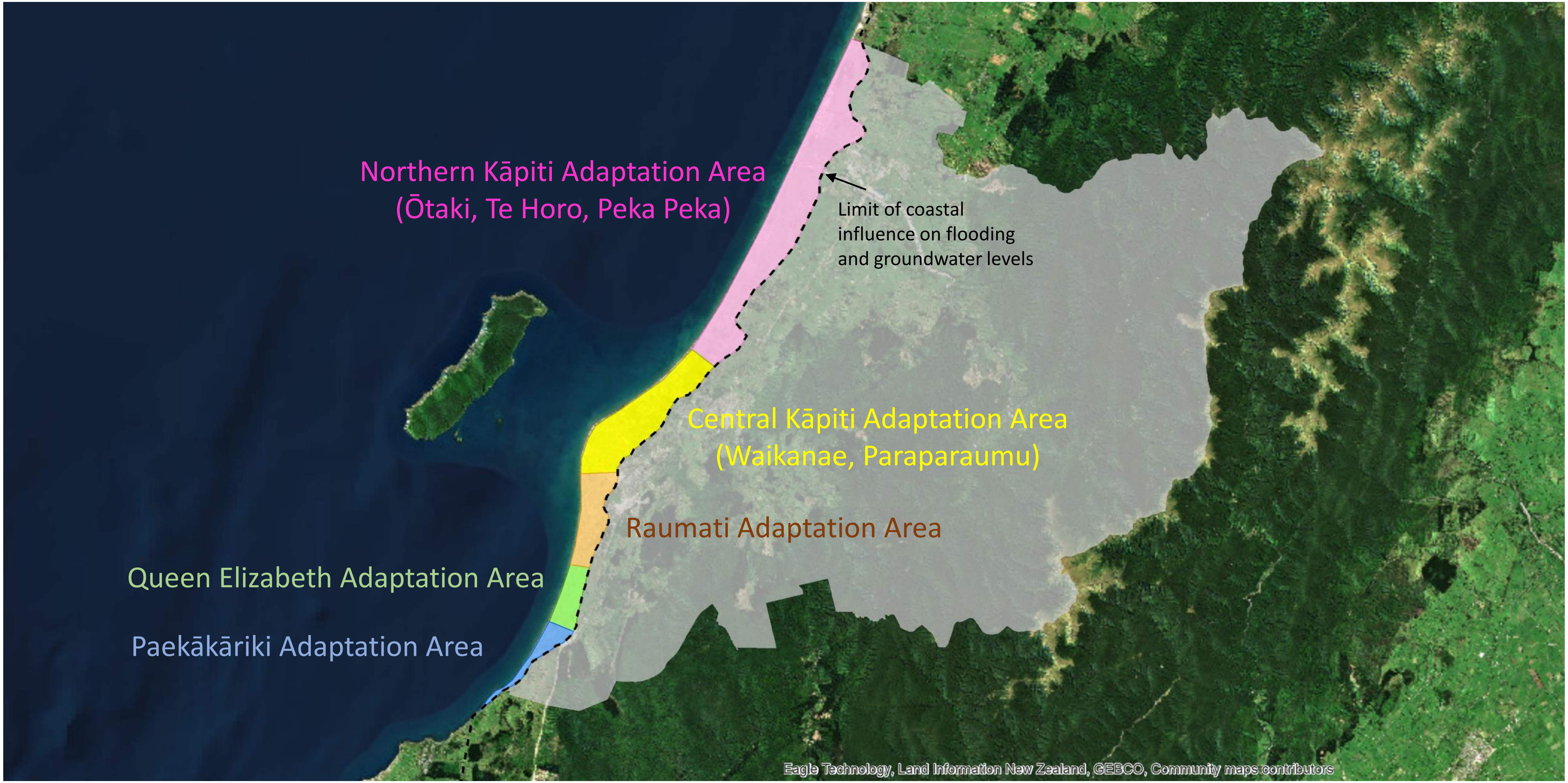
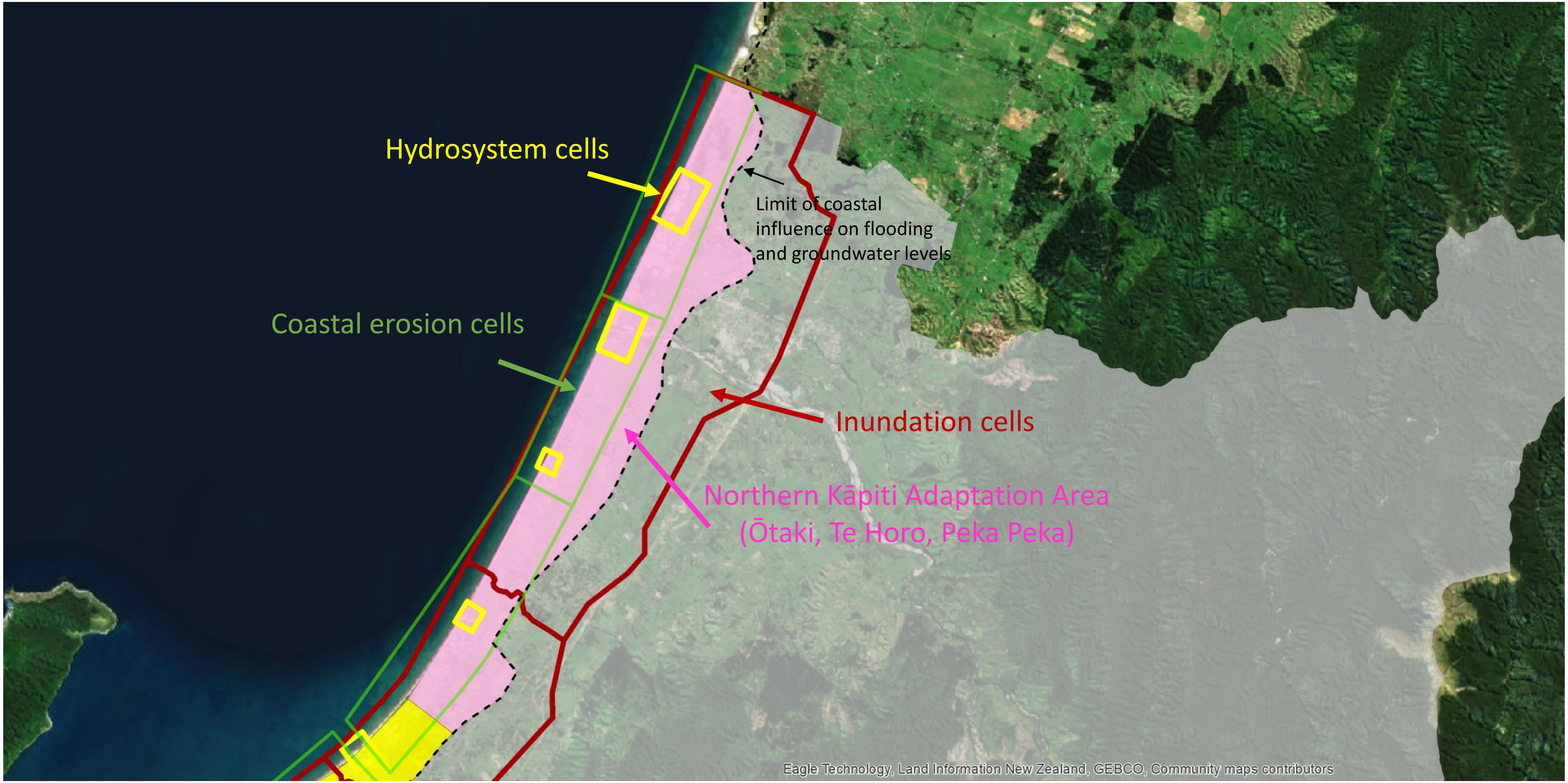
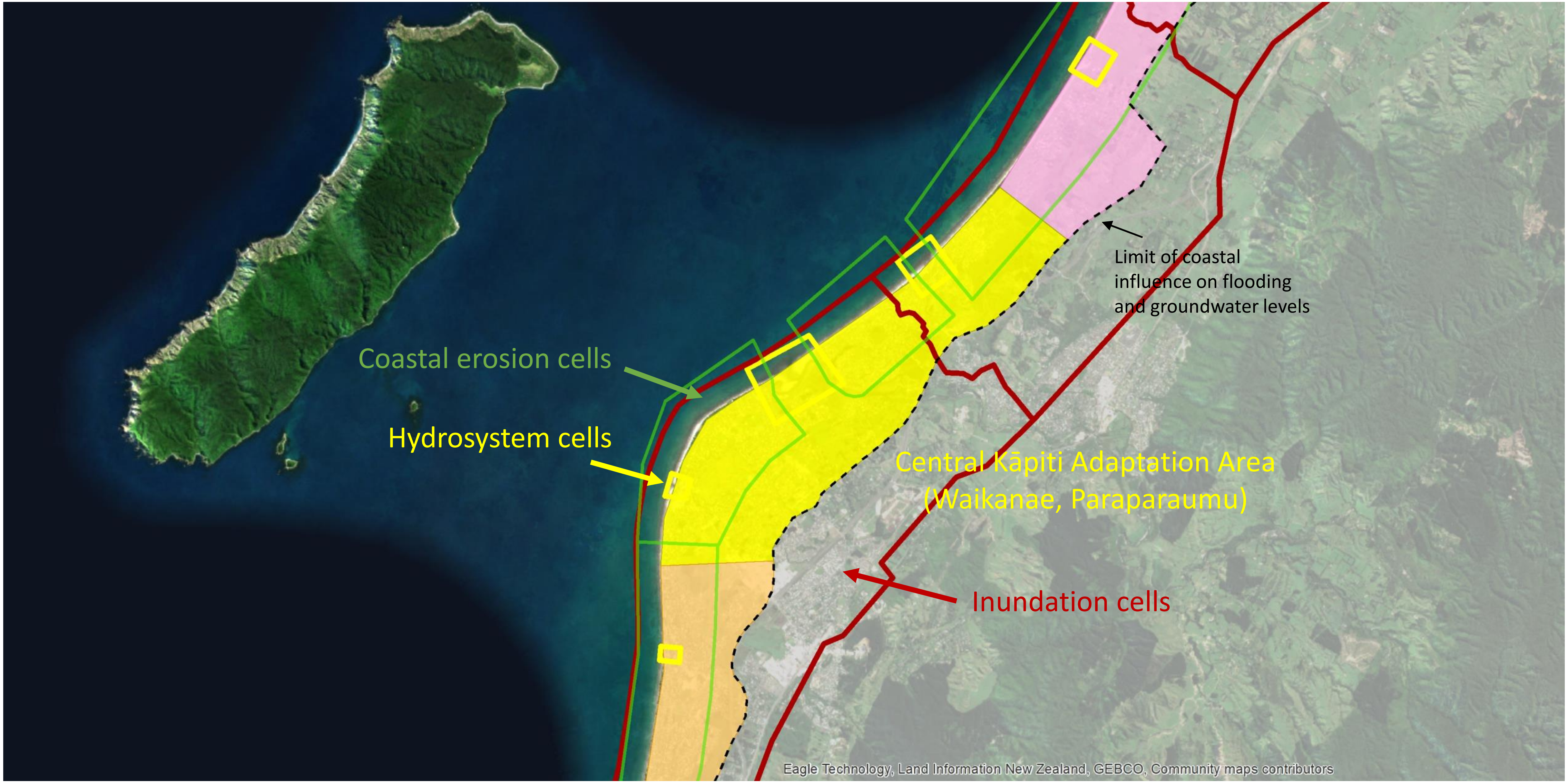
Proposed Adaptation Areas:



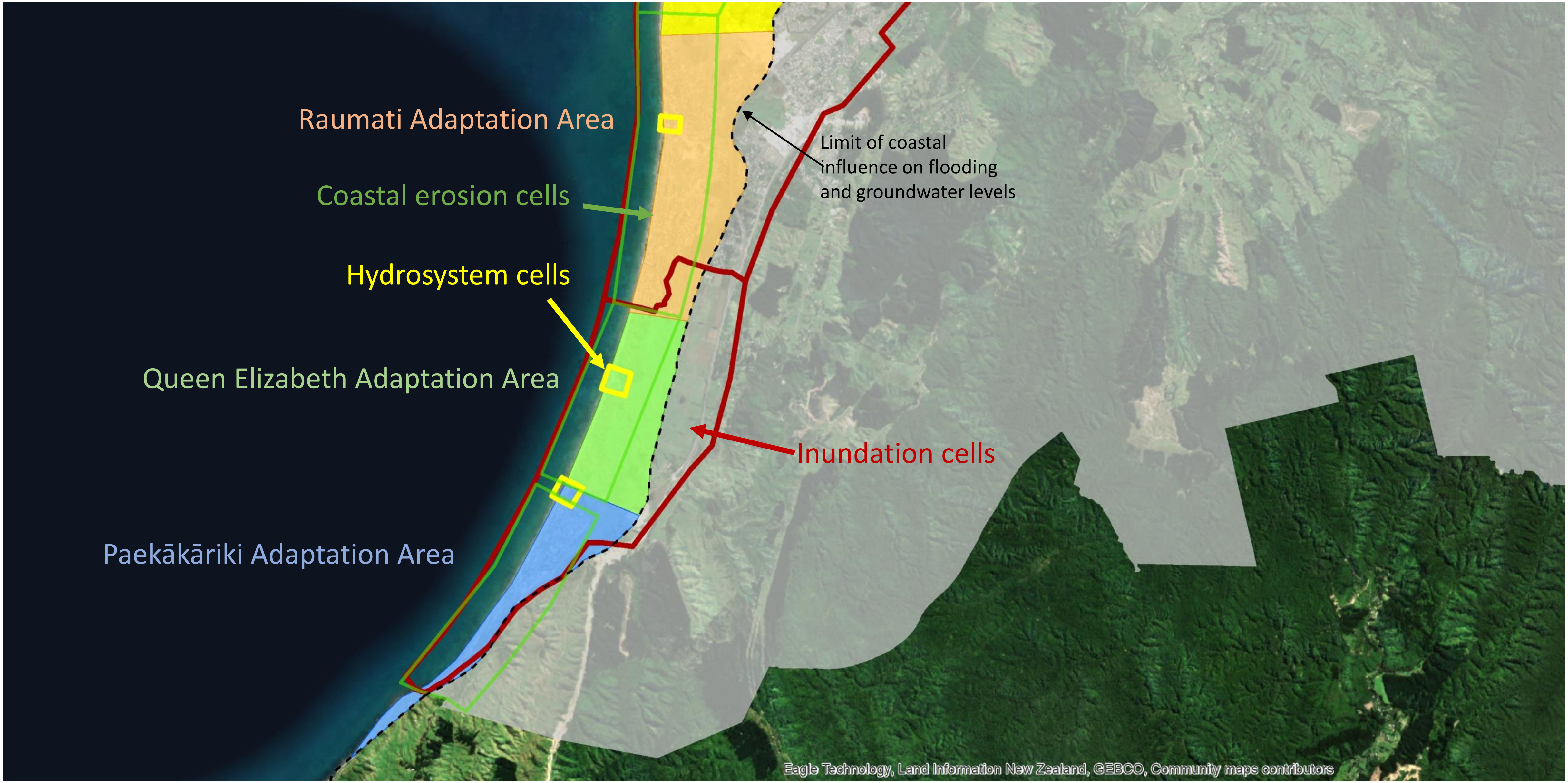
Comparison to Assessment Cells - North



Comparison to Assessment Cells - Central



Comparison to Assessment Cells - South



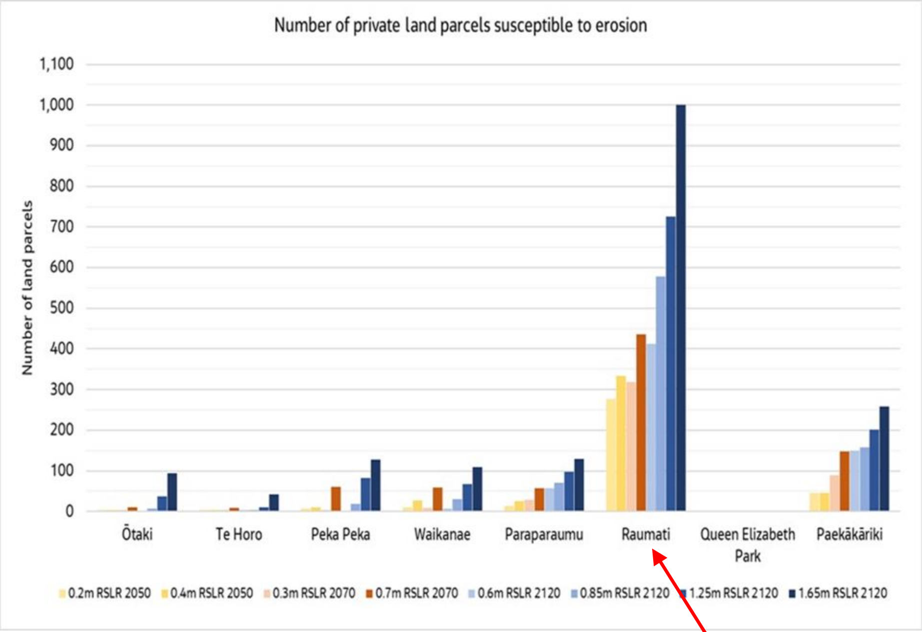
Prioritisation of Adaptation Areas

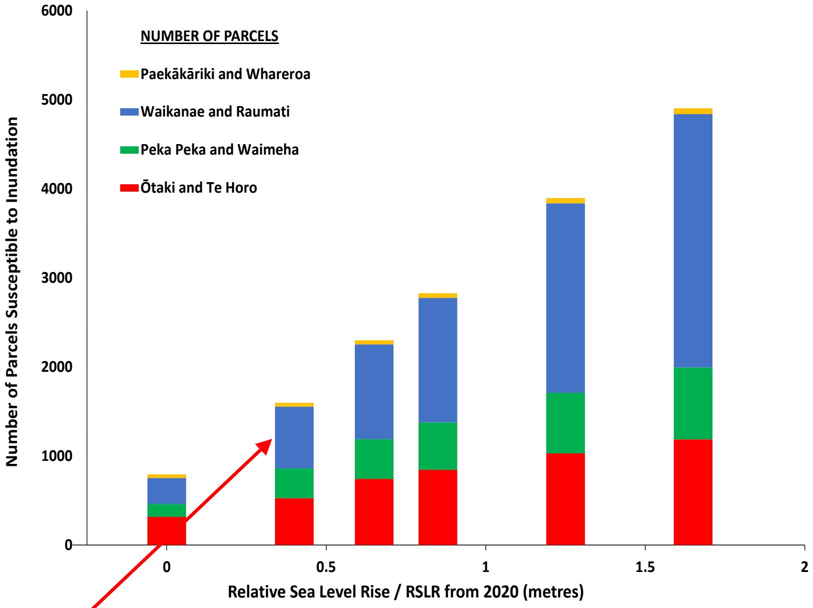
Did we need to Prioritise? Options for work-flow & engagement

1. **Prioritise – complete recommended strategy for one adaptation area before move to the next. Engagement and recommendation is staggered in time across adaptation areas**

   Possible Prioritisation Options:

   - **By Vulnerability**
   - **By Information**
   - **By Reverse Difficulty**



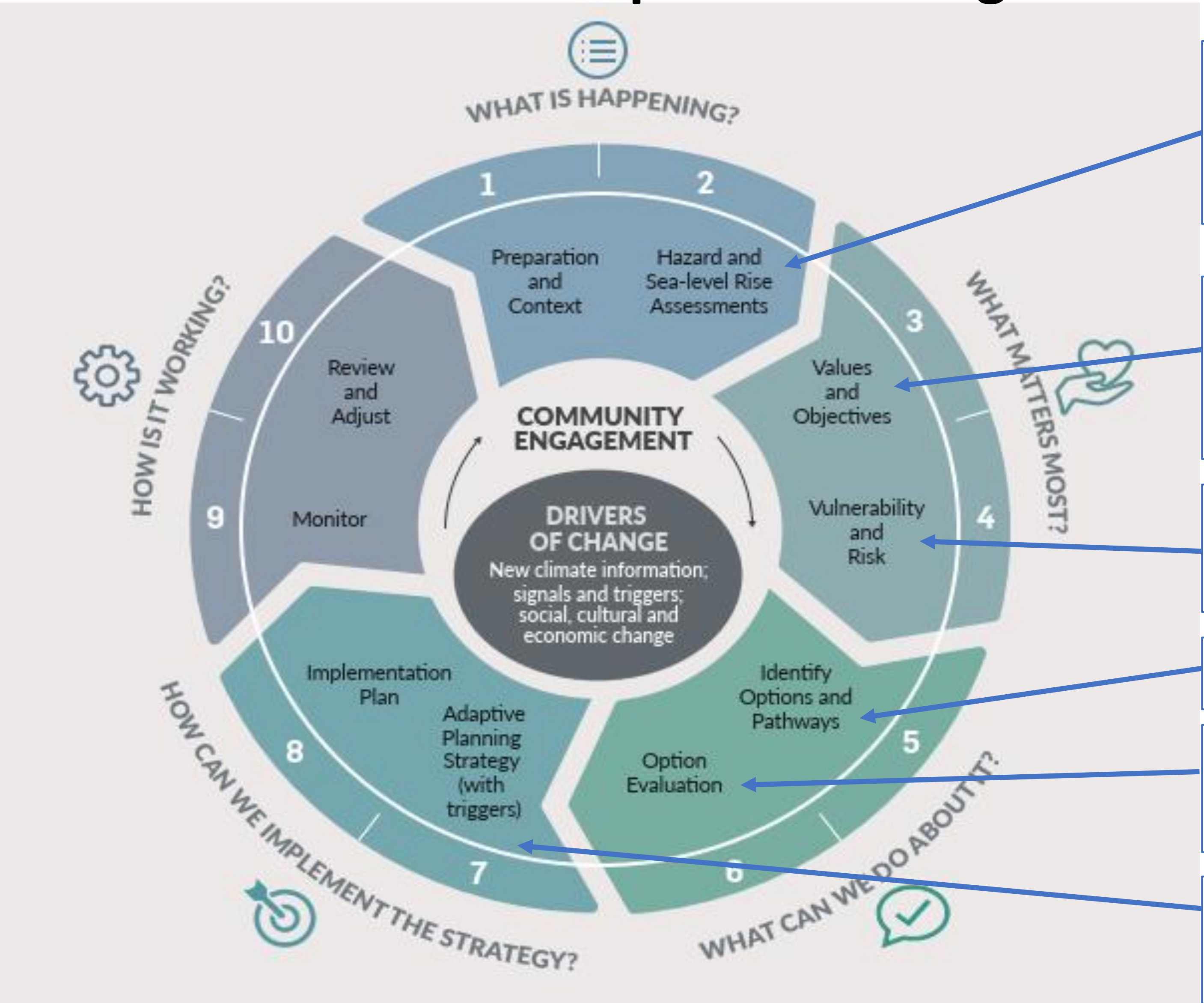


Most Vulnerable

2. **Don't Prioritise areas, work thru all areas in tandem, with engagement separated into adaptation areas/communities, but close in time.**

Based on Hawkes Bay experience, either option will require around a year of effort from now to arrive at recommended strategy

The DAPP Process: Adaptive Planning Framework (MfE, 2017):



Jacobs Hazards Susceptibility Assessment
GWRC Groundwater with SLR Assessment
AWA Surface Flooding Modelling

Maven Social Values Assessment
Boffa Natural Character Assessment
Cultural Assessment

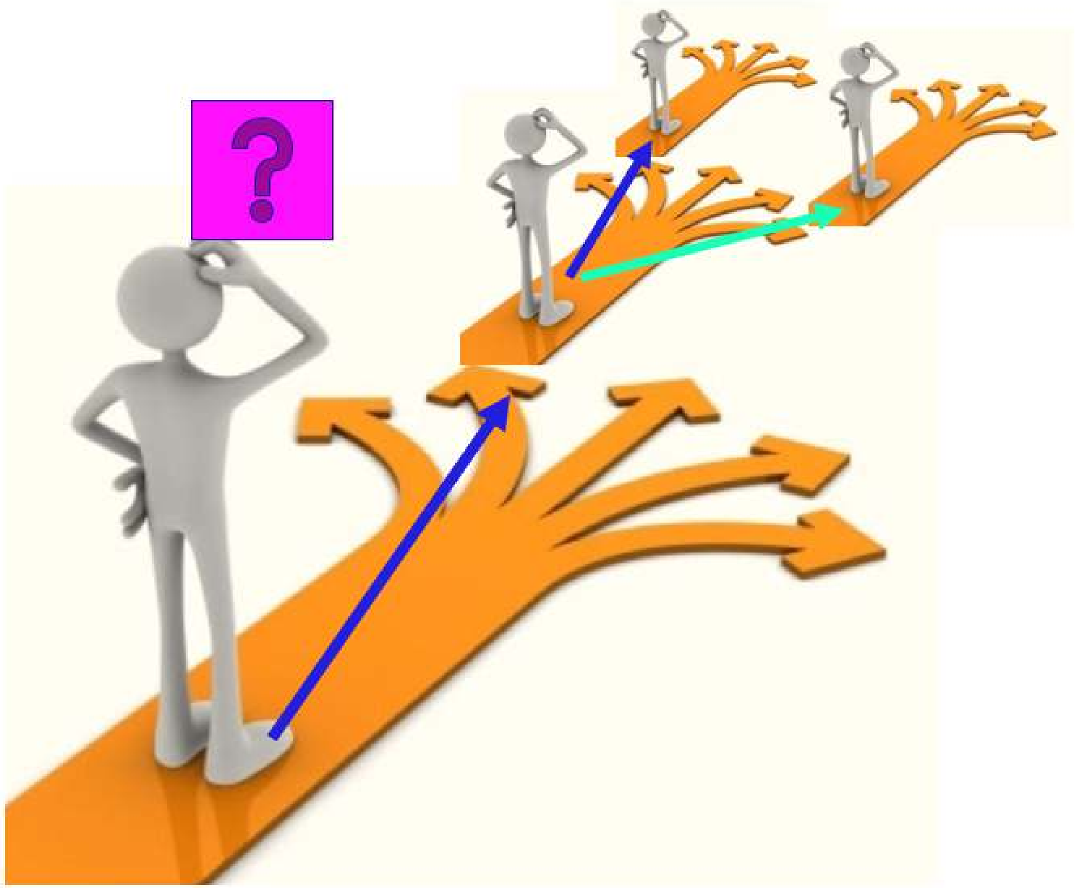
Jacobs Physical Vulnerability Assessment
Risk Based Planning Assessment

CAP Process – define possible pathways

Multi Criteria Decision Analysis (MCDA) – weighting up values and economics

CAP Recommended pathway
Council Decision on recommendations

Adaptation pathways -What are they?



- Coherent sequences of planned interventions to maintain the performance of systems over the long term to adapt to change and uncertainty
- Interventions maintain or improve the potential performance of systems as conditions evolve
- Aim is to develop adaptive capacity within assets and systems through embedding resilience and flexibility (= robustness)

Leading Questions in Starting the DAPP Process:

- What do you want your coast to look like in the future (natural, structures, developed)?
- What values do you wise to preserve (Protection, Environmental, Social, Cultural)?
- How far in the future do you want to have a strategy for?
- Where do we start (how do we prioritise areas)?

Steps in Developing an Adaptation Pathway

1. Define Long list of possible **Actions** (pro's and cons for each adaptation area)
2. Develop the possible Actions into a **Short list of potential pathways** for each Adaptation Area
3. Undertake a **MCDA** for the potential pathways (consideration of Protection, Environmental, Social, Cultural, Economic values/Risks)
4. Engage with community on the potential pathways for each Adaptation Area
5. Determine the **Preferred pathway** for each Adaptation Area
6. Determine the **signals and triggers** for moving between each Action in the Preferred pathway
7. Recommendation to Council on Preferred pathway for each Adaptation Area

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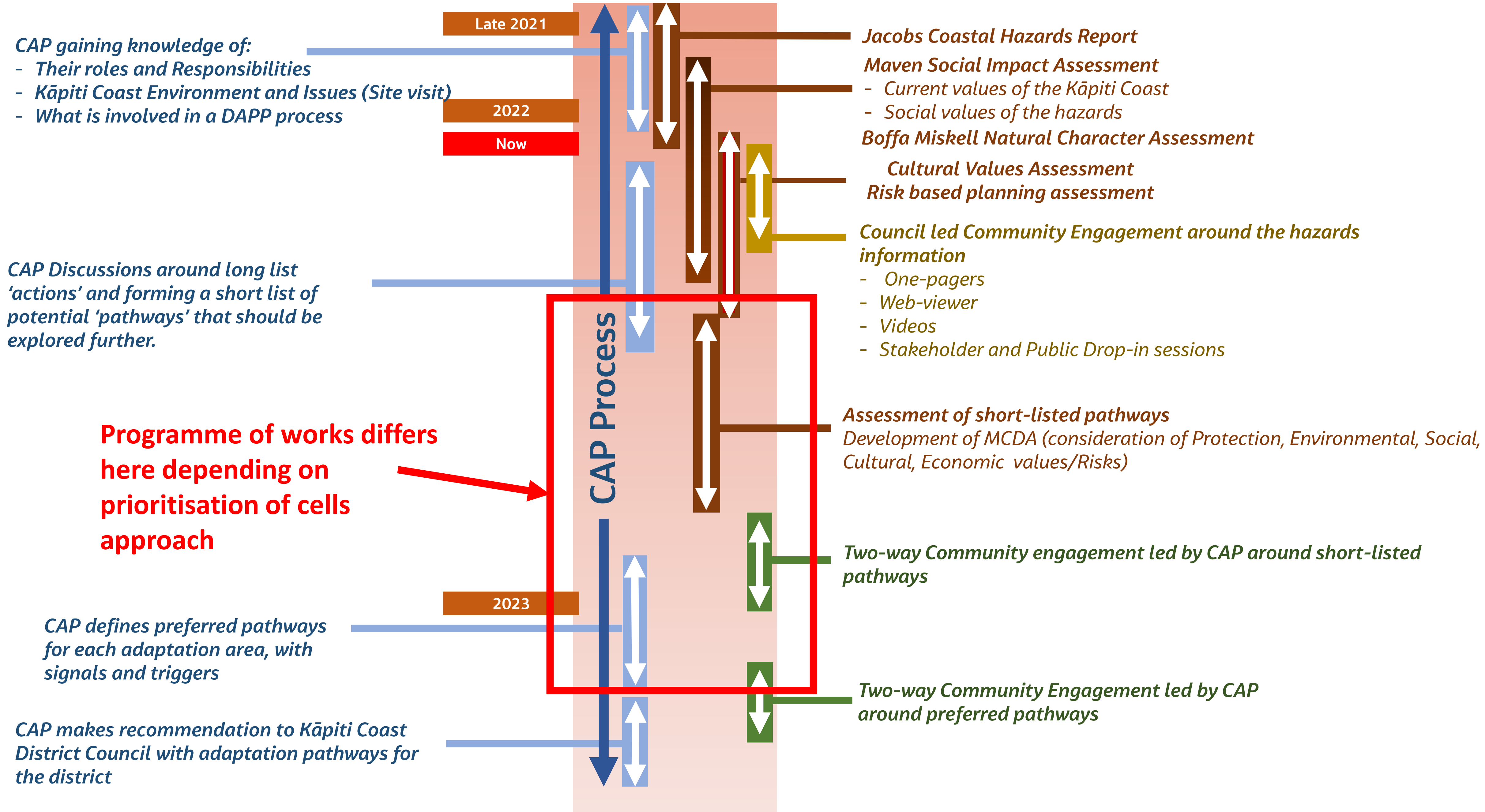
Takutai Kāpiti Indicative Timeframe



Potential Actions to be considered in an Adaptation Pathway

Maintain/Enhance resilience

- Maintaining what is already here
- Continuing community education
- Environmental monitoring
- Emergency management
- Controlling beach access
- Planting enhancement

Accommodate the hazard

- Flood proofing buildings and infrastructure
- Relocatable/ adaptable buildings
- Raising land levels
- Ground water and storm water management
- Relocation and resilience of infrastructure

Avoid the hazard

- Limiting further intensification
- Zoning and set back controls
- Trigger-based or time limited land use consents

Protect from the hazard

- Shoreline renourishment, beach scarping
- Hard engineering works (walls, revetments, groynes)
- Offshore wave reduction works (offshore breakwaters)
- Stopbanks, Storm surge barriers in inlets/river mouths

Retreat from the hazard

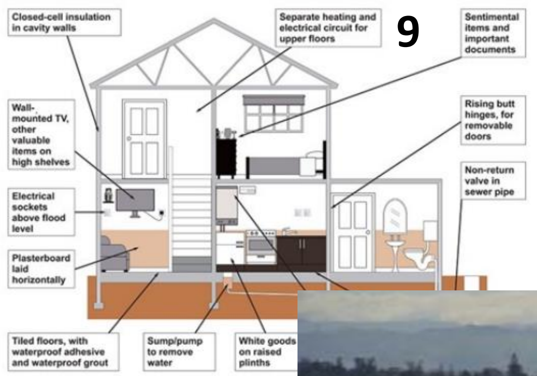
- Buy outs
- Land swaps
- Leasebacks
- Future interests
- Conservation easements
- Transferable development rights

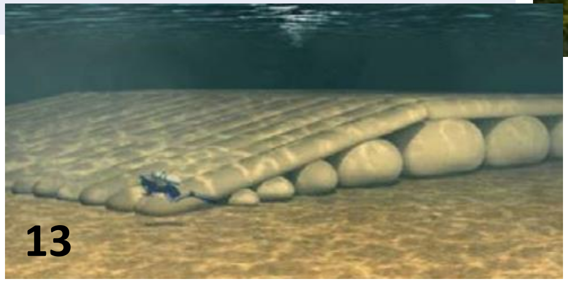
Long list Options – Hawkes Bay Example

	Method	Option	Description
1	**Maintain/ Enhance**	Status Quo	Maintain current coastal management approaches – i.e. do nothing new.
2	**Enhance**	Planting	Planting of beach crest areas to improve retention of material, reduce erosion and limit wave overtopping.
3	**Protect (soft engineering)**	Re-nourishment (sand)	Material placed offshore, using marine plant, and allowed to naturally migrate towards the beach raising foreshore levels. This helps to smooth out the beach profile and can help protect the beach by increasing wave energy dissipation.
4	**Protect (soft engineering)**	Beach Scraping	Redistribution of available sediments to maximise upper beach width and volume, hence increase the level of storm protection.
5	**Protect (soft engineering)**	Enhance Dune Crest	Raising of dune level at low elevations to reduce inundation risk
6	**Protect (soft engineering)**	Wetland or lagoon creation	Installing or enhancing coastal marshes and wetland areas to dissipate wave energy and reduce inundation risk.
7	**Protect (hard protection)**	Flood gate	Adjustable gates used to prevent storm surges from entering existing waterways, in turn preventing up-stream overtopping and flooding.

Long list Options – Hawkes Bay Example

	Method	Option	Description
8	**Maintain/ Enhance**	Install / enhance Inundation Protection	Increase existing / install new stop banks to provide greater protection from storm surge inundation
9	**Accommodate**	Inundation Accommodation	Implementation of policy to improve flood resilience of current and future properties
10	**Protect (hard engineering)**	Vertical Permeable Sill	A structure within the gravel beach that dissipates wave energy, reducing erosion losses through backwash and longshore drift and promotes the retention of gravel behind the structure. Existing examples at Te Awanga.
11	**Protect (hard engineering)**	Groynes and Nourishment	Limits the movement of sediment (gravels and sand) along the coast through longshore drift, thereby reducing localised losses to erosion. Nourishment is used to supply sand / gravel to the area protected by the groynes
12	**Protect (hard engineering)**	Breakwater	Shore parallel offshore breakwater (crest above MHWS). Structures break waves, promote the build up of sediment in the lee of the structure and reduce longshore drift.
13	**Protect (hard engineering)**	Offshore Reef	Shore parallel offshore reef (crest below MHWS). Structures break waves, promote the build up of sediment in the lee of the structure and reduce longshore drift





Long list Options – Hawkes Bay Example

	Method	Option	Description
14	**Protect**	Sea Wall	A large structure of rocks and/or concrete that absorbs/reflects wave energy and provides a physical barrier to erosion. Crest height of structure designed to limit overtopping and inundation.
15	**Retreat**	Retreat the Line	Primary defence line retreated inland providing a high standard of inundation protection to properties behind the new defence. (Situation unchanged for those in front)
16	**Retreat**	Managed Retreat	A strategic relocation of assets and people away from areas at risk, enabling restoration of those areas to their natural state

Example of Long-listing Exercise – Southshore, Christchurch

Assessing all options – their advantages, limitations and their applicability to the area

Natural shoreline enhancement

Type	Material	Description	Advantages	Limitations	Applicability for Southshore
Beach Nourishment	Sand	Build up natural beach with placement of introduced sand to a design slope.	• Natural beach is a good aesthetic outcome. • Provides good access to the estuary bed. • No adverse physical effects on estuary bed levels or salt marsh habitats. • Allows migration of estuary bed with future sea level rise.	• More sediment required than for pebbles and cobbles due to naturally flatter beach slopes as a result of smaller sediment size. • smaller sized material is more susceptible to transport away from the beach placement, hence question of durability without maintenance placements. • Greater placement and maintenance requirements would increase whole of life costs. • Usefulness limited to areas of natural beach above tide level and existing salt marsh. • Difficult to increase crest height above hinterland level and requires large footprint to do so.	• Not applicable on a section-by-section basis under Protection Strategy 1. • Applicability under Protection Strategy 2 is limited to existing areas of salt marsh. • Not as applicable as pebble or cobble renourishment due to questions on long-term stability.
	Pebbles	Build up natural beach with placement of introduced pebbles to a design slope.	• Due to larger sediment size than sand, is more resistant to wave transport so more stability of beach shape. • No adverse physical effects on estuary bed levels or salt marsh habitats. • Provides good access to the estuary bed. • While not a natural estuarine sediment, still has natural appearance. • Allows migration of estuary bed with future sea level rise.	• Is not a sediment size naturally found on estuary beaches. • Sediment could still to be transported from beach during high energy events. • Usefulness limited to areas of natural beach above tide level and existing salt marsh. • Difficult to increase crest height above hinterland level and requires large footprint to do so.	• Not applicable on a section-by-section basis under Protection Strategy 1. • Is applicable under Protection Strategy 2 in areas with a natural edge with some natural protection afforded by existing salt marsh. • However, is not as robust as cobble nourishments, therefore not considered to be applicable as using larger cobble sized material.
	Cobbles	Build up natural beach with placement of introduced cobbles to a design slope. This will be similar sized material as used in reno mattress and gabions.	• Due to larger sediment size than pebbles and sand, is more resistant to wave transport so more stability of beach shape. • No adverse physical effects on estuary bed levels or salt marsh habitats. • Is more flexible in slope and less site work required than reno mattress. • Smaller footprint for same height than sand or pebble renourishment due to steeper slopes. • Cobble sized material readily available from quarries. • Easy maintenance if required by topping up beach with more cobbles. • Provides access to the estuary bed. • While not a natural estuarine sediment, still has natural appearance. • Allows migration of estuary bed with future sea level rise.	• Is not a sediment size naturally found on estuary beaches. • Individual cobbles more mobile than in reno mattress, so need to design boulder size and slopes to ensure stability. • Requires large footprint to increase crest height above hinterland level. • Requires larger footprint than rock revetment. • Difficult to be adapted for longer-term protection with future SLR without consideration in initial design.	• Not applicable on a section-by-section basis under Protection Strategy 1. • Is applicable under Protection Strategy 2 in areas where there is limited water depth and required slopes to hinterland are not too steep and can be used in areas of existing salt marsh. • Can also be used to encapsulate existing rubble.

Example of Long-listing Exercise – Hawkes Bay

Discarding options from long list to form the short list – From the long list, what won't work here?

Table 8. Long List of Coastal Hazard Response Options

Option	Description	Representative Image
1: Status Quo	Maintain current coastal management approaches – i.e. do nothing new.	
2: Planting	Planting of beach crest areas to improve retention of material, reduce erosion and limit wave overtopping.	
3: Re-nourishment – Gravel	Renourishment of gravel on foreshore area to offset erosion losses, increase beach size and potentially crest height. Larger beach can dissipate more wave energy and reduce/prevent wave overtopping.	

Priority Unit	Options Discarded[23]	Rationale
Unit E1 (Ahuriri)	5. Beach face de-watering	Has not been proven to be reliably successful, and success has only been realised on sandy beaches. Not suitable for this coastline.
	8. Wetland or lagoon creation	Insufficient space to create additional wetland areas big enough to offer any coastal hazard mitigation benefit
	9. Flood gate	No waterways in this location suitable for this option
	10. Install / enhance inundation protection (stop banks)	Limited space to install
	12. Vertical permeable sill	High wave energy environment. Limited benefit. Benefits to sediment retention are not enough to substantially reduce risk
	17. Retreat the line	No practical location to move the line of defence to

Example of short list adaptive pathways – Hawkes Bay

- Where future options may be limited due to early-mid term decisions.
- More certainty around what actions will be undertaken in the future.
- Easier to plan for

1. Short list of pathways:

Table 10. Final Pathways to be assessed for each Priority Unit.

Priority Unit	Pathway	Short Term	→	Medium Term	→	Long Term
Unit E1 (Ahuriri)	Pathway 1	Status quo	→	Retreat the Line	→	Managed Retreat
	Pathway 2	Status quo	→	Retreat the Line	→	Sea wall
	Pathway 3	Status quo/ Renourishment	→	Renourishment + Control Structures	→	Managed Retreat
	Pathway 4	Status quo/ Renourishment	→	Renourishment + Control Structures	→	Sea wall
	Pathway 5	Status quo	→	Sea wall	→	Managed Retreat
	Pathway 6	Status quo	→	Sea wall	→	Sea wall

2. MCDA of short listed pathways:

Unit E1: Ahuriri												
Pathway	Short term	→	Medium term	→	Long term	MCDA Score	MCDA Ranking	Cost + Loss[1] ($m)	Cost + Loss[1] Ranking	VFM[2] ($'000/ point)	VFM[2] Ranking	Short Term build costs[3] ($m)
PW 1	Status quo	→	Retreat the Line	→	Managed Retreat	54	4	15.31	4	211	6	0.29 (0.02 / yr)
PW 2	Status quo	→	Retreat the Line	→	Sea wall	51	5	10.72	3	111	3	0.29 (0.02 / yr)
PW 3	Status quo/ Renourishment	→	Renourishment + Control Structures	→	Managed Retreat	58	3=	16.08	6	205	5	1.30 (0.08 / yr)
PW 4	Status quo/ Renourishment	→	Renourishment + Control Structures	→	Sea wall	58	3=	10.16	2	81	2	1.30 (0.08 / yr)
PW 5	Status quo	→	Sea wall	→	Managed Retreat	65	1	15.43	5	173	4	0.29 (0.02 / yr)
PW 6	Status quo	→	Sea wall	→	Sea wall	61	2	8.93	1	57	1	0.29 (0.02 / yr)

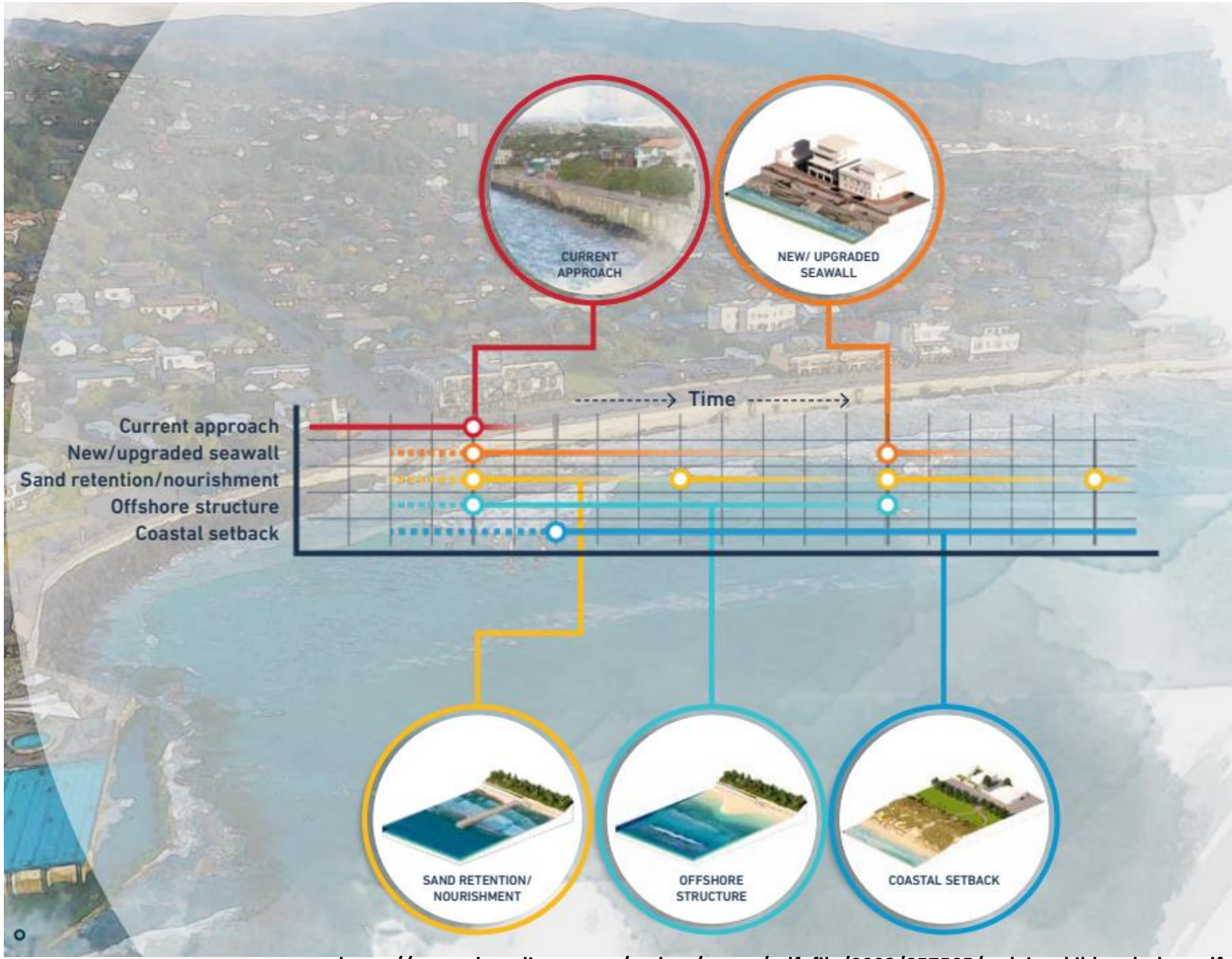
3. Recommendation on Pathway:

Table 12. Final Preferred Pathways – Northern Panel

UNIT E1: AHURIRI – PATHWAY 6				
Short term (0 – 20 years)	→	Medium term (20 – 50 years)	→	Long term (50 – 100 years)
Status quo	→	**Sea wall**	→	**Sea wall**

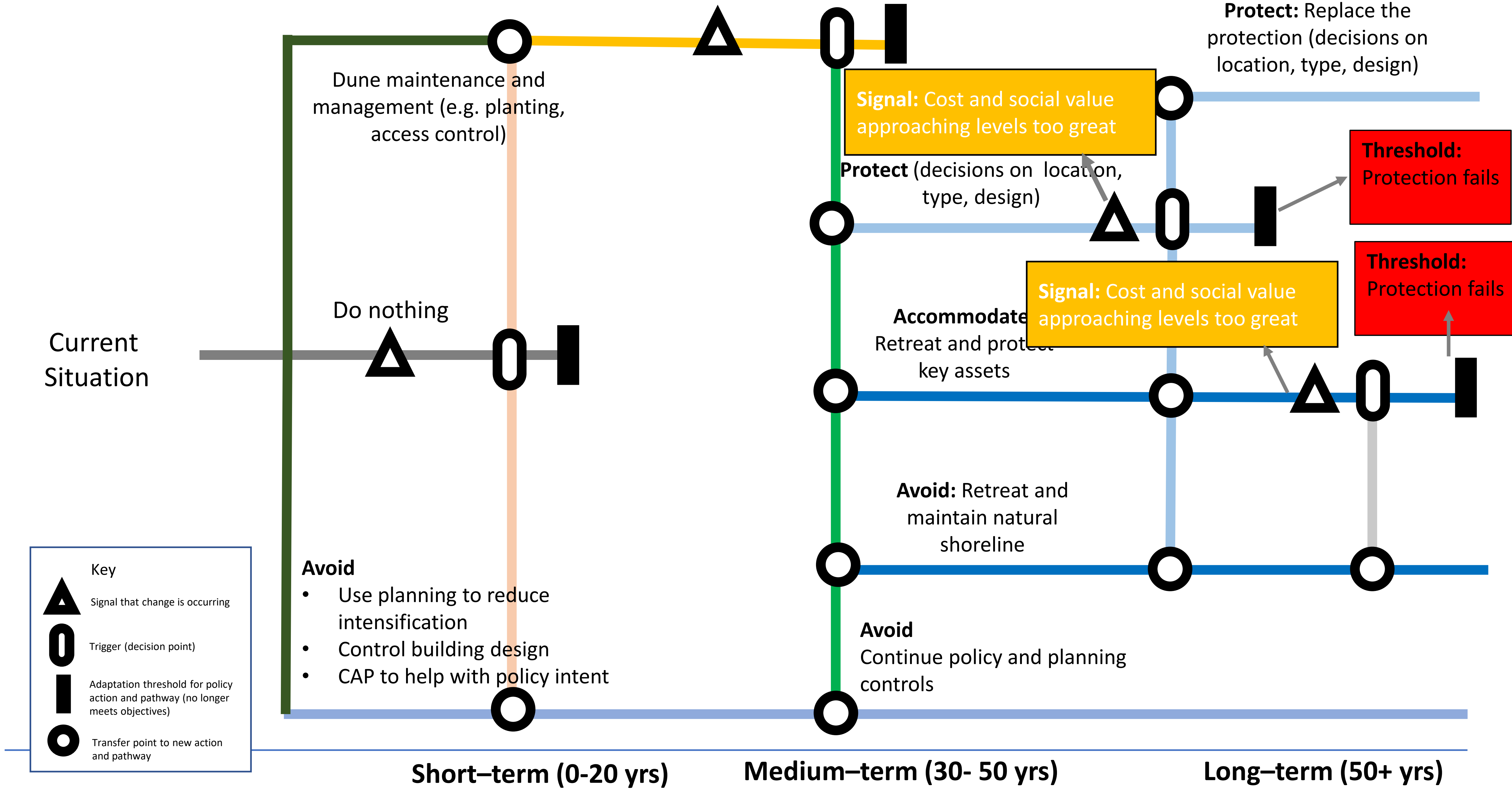
Example of adaptive pathway – St Clair to St Kilda, Dunedin

- When short-mid term options don't close off future options.
- More flexibility in the future, but less certainty about action over mid to long term.
- Harder to plan for, need to keep options open.



https://www.dunedin.govt.nz/__data/assets/pdf_file/0003/857505/stclair-stkilda-ctl-plan.pdf

Example of a possible adaptive pathway for Northern Kapiti Adaptation Area



Risk Based Planning for Coastal inundation hazard

- Considerations for planning:

1) Likelihood

what are the chances or probability it will occur?

can it “reasonably be expected to happen” ?

2) Consequence

what is the effect of inundation?

is it “significant”?

3) Change

The consequences and likelihoods of “coastal” inundation will change with time, mainly because of mean sea level rise (SLR):

> the consequences for a given likelihood will increase in the future

Or

> the likelihood of a given consequence will increase in the future

1) Likelihood of inundation

- Average Recurrence Interval (ARI)
  - On average, how often will it happen – every 10 years?, every 100 years?
- Annual Exceedance Probability (AEP)
  - What's the chance it will happen in any one year – 10%?, 1%?

POTENTIAL THRESHOLDS BASED ON LIKELIHOOD

	ARI	AEP	What's the chance it will happen during a period of…. 30 years?	60 years?	100 years?
"small flood"	5 years	20%	100%	100%	100%
↓	10 years	10%	96%	100%	100%
↓	20 years	5%	79%	95%	99%
↓	50 years	2%	45%	70%	87%
↓	100 years	1%	26%	45%	63%
"big flood"	200 years	0.5%	14%	26%	39%

"Very likely to happen" ??

"Reasonably be expected to happen" ??

2) Consequence of inundation

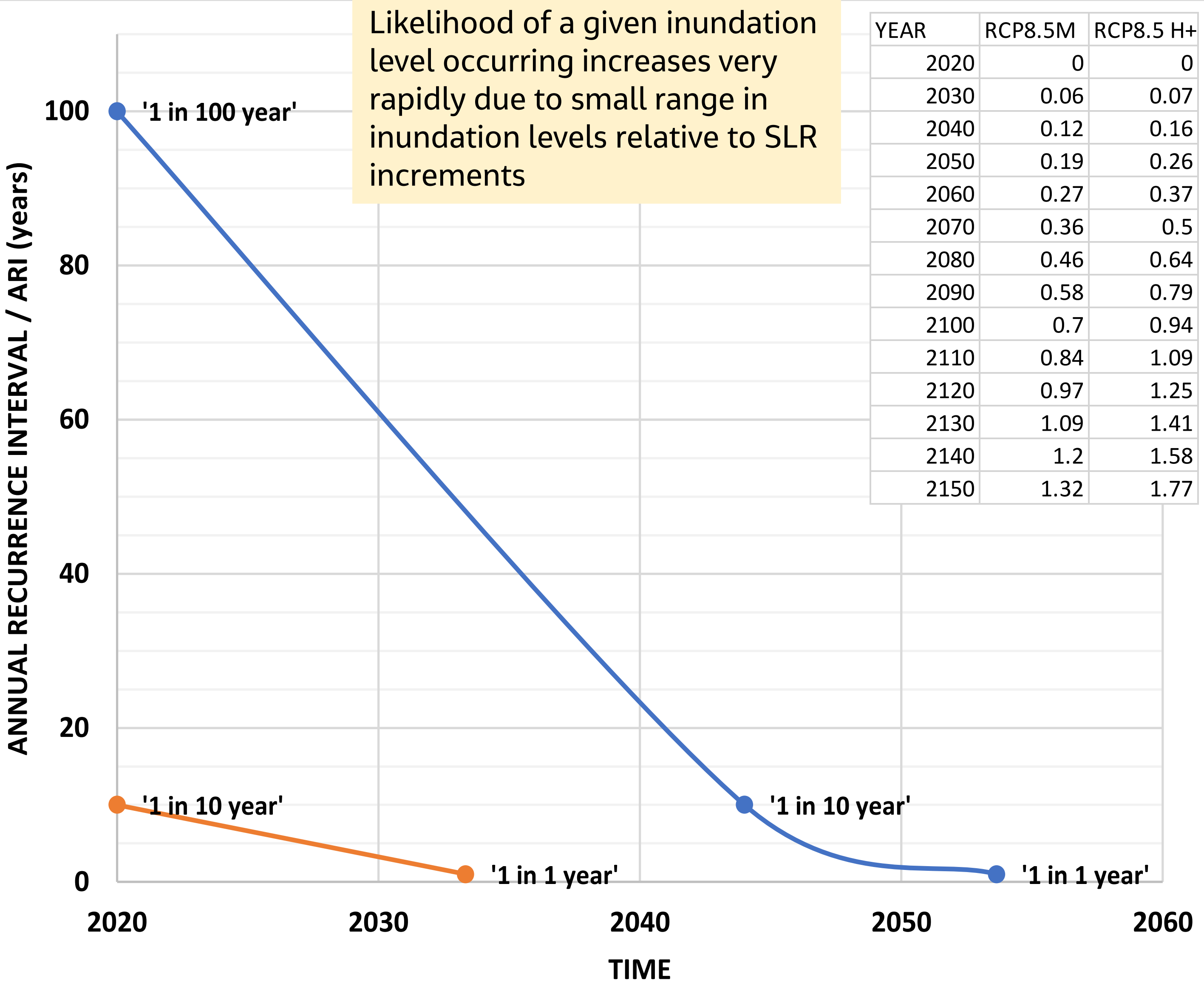
- Consequences
  - Injury to people or fatalities
  - Damage to or loss of buildings and infrastructure (direct and indirect consequences)
  - Damage to or loss of land and habitat
  - Damage to or loss of property (e.g. possessions, vehicles)
- Quantification
  - "Hazard rating"
    - ARR method
    - DEFRA/EA method
  - Still water depth, no velocity data

POTENTIAL HAZARD THRESHOLDS

AR&R		Still water depth	DEFRA/EA	Still water depth
H1	Generally safe	Less than 0.3 m	LOW Very low hazard	Less than 0.3 m
				0.3 m
H2	Unsafe for small vehicles	Over 0.3 m LOW	Danger for some (children, elderly, infirm)	Over 0.3 m MEDIUM
	0.5 m			0.5 m
H3	Unsafe for vehicles, children and the elderly	Over 0.5 m MEDIUM	Danger for most (general public)	Over 0.5 m HIGH
	1.2 m			
H4	Unsafe for vehicles and people	Over 1.2 m		
H5	Unsafe for vehicles and people, all buildings vulnerable to damage, some to failure	Over 2.0 m HIGH	Danger for all (including emergency services/civil defence)	Over 2.0 m

Change

- Example of change in probability of storm tide level (inundation level) with SLR



YEAR	RCP8.5M	RCP8.5 H+
2020	0	0
2030	0.06	0.07
2040	0.12	0.16
2050	0.19	0.26
2060	0.27	0.37
2070	0.36	0.5
2080	0.46	0.64
2090	0.58	0.79
2100	0.7	0.94
2110	0.84	1.09
2120	0.97	1.25
2130	1.09	1.41
2140	1.2	1.58
2150	1.32	1.77

Proposed thresholds and scenarios

- Three categories of coastal inundation hazard severity
  - “Low”
  - ”Medium”
  - ”High”
- Test two alternative methods for defining hazard:
  - Method 1

    Hazard severity defined by the maximum depth of flood water during a low frequency event
  - Method 2

    Hazard severity defined by the frequency of flooding, regardless of the depth of flood water

Proposed Erosion Thresholds/Scenarios

- For risk based approach to coastal erosion – consequence is away high (the land is gone and therefore will be unusable after a certain time), so key determination is likelihood, can be determined by:

  "*xxx* **probability** of that erosion will occur within *yyy* **timeframe** under *zzz* **SLR scenario**"

- In considering what the likely combinations of these factors are for defining high, medium and low erosion risk categories for district planning purposes, we need to consider the following:

1. The policy requirements of the relevant higher level planning instruments.
   Both the NZCPS and the RPS direct consideration of coastal erosion hazards to be over 100 year time frames, which dictates that this time frame needs to be the basis of at least one of the hazard risk zones. Both documents are silent on the SLR scenarios and probabilities.
2. If using a time frame of less than 100 years to define higher risk hazard zones, what is a reasonable time frame for potential land-uses within these zones?
3. Uncertainties in each of the factors, which links to how reasonable it is to use them in a planning context. As well as "Statistical Uncertainty" (Probability), this includes "Scenario Uncertainty" and "Modelling Uncertainty".

Hazard Category Definitions:

- **Method 1a** – Consistent time frame of 100 years across all hazard categories to be consistent with the NZCPS and RPS, and hazard categories being defined by different probability threshold.
  From the T&T assessment the proposed scenario is 2130 -1.2 m SLR.
- **Method 1b** - As above, but the timeframe for the low hazard category is extended out to beyond 100 years as per the recommendation in MfE (2017) (Table 10).
  From the T&T assessment this would be the 2150 - 2.0 m SLR scenario.

Hazard Category	Time Frame	SLR since 2020	Probability	Likelihood description (Statistical uncertainty)
High	2130	1.2 m	90%	Erosion very likely over whole zone
			66%	Erosion likely over whole zone
Medium	2130	1.2 m	66%	Erosion likely over whole zone
			33%	Greater erosion is unlikely
Low (1a)	2130	1.2 m	33%	Greater erosion is unlikely
			10%	Greater erosion is very unlikely
Low (1b)	2150	2.0 m	33%	Greater erosion is unlikely

RMA – Key Takeaways

- Direction in Part 2 –
  - Provide for health and safety.
  - Address significant risks, including those from climate change.
  - Must be reasonably foreseeable.

- Project Work must be usable for a Section 32 Process
  - Heavy focus on economic and employment impacts, i.e. impact of risk and risk management on urban development.

- NZCPS
  - Strong guidance on timeframes to be considered, language based on avoidance of risks