A TEMPLATE FOR MODELLING AND MANAGING SEA LEVEL RISE AND CLIMATE CHANGE

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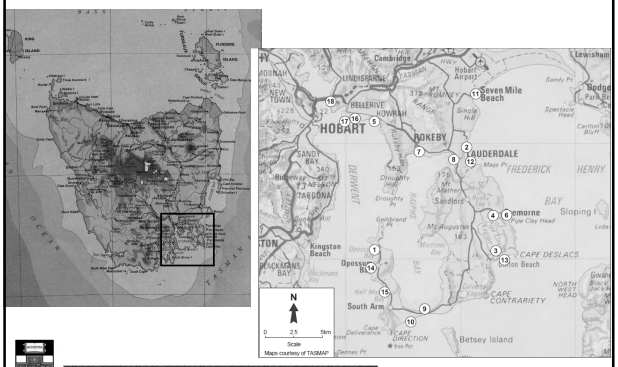
Phil Watson: Clarence City Council
Clive Attwater: SGS Economics and Planning

MANLY, MAY 1913

LOCATION OF EXAMPLE TEMPLATE



Clarence TAS Project Outline

Two main elements:

- Social and economic impact and response
  - SGS Economics & Planning
  - Myriad Research
  - Dr. Melissa Nursey-Bray
- Scientific/technical assessment of impacts
  - Water Research Laboratory, UNSW

SETTING

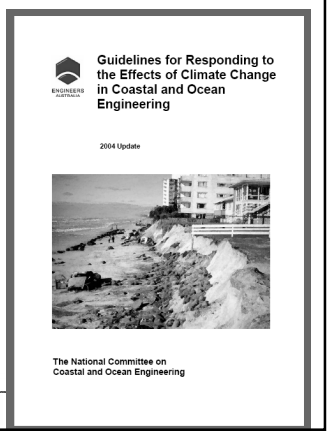
Social and economic assessment

- **Literature search** - experience elsewhere
- **Determine baseline attitudes** - community focus groups and survey
- **Implications** – issues, options identified by the technical and scientific assessment
- **Education strategy**

Community survey - focus groups

- People *like* living on or near the coast

NCCOE Template



Key Climate Change Variables

- NCCOE (2004) lists six key environmental variables applicable to coastal engineering, namely:

1. Mean Sea Level.
2. Ocean Currents and Temperature.
3. Wind Climate.
4. Wave Climate.
5. Rainfall/Runoff.
6. Air temperature.

Secondary Climate Change Variables

- NCCOE (2004) also lists 13 secondary or process variables applicable to coastal engineering, namely:

1. Local Sea Level
2. Local Currents.
3. Local Winds.
4. Local Waves.
5. Effects on Structures.
6. Groundwater.
7. Coastal Flooding.
8. Beach Response.
9. Foreshore Stability.
10. Sediment Transport.
11. Hydraulics of Estuaries.
12. Quality of Coastal Waters.
13. Ecology.

Matrix of Climate Change

Table 3.4
Interaction Matrix of Climate Change Variables for Potential Hospital Site

	Key Variable						
	Mean Sea Level	**Ocean Currents and Temp**	**Wind Climate**	**Wave Climate**	**Rainfall / Runoff**	**Air temperature**	**Ocean Acidity**
Local Sea Level	- assessed in detail	- not quantified - possible additional or seasonal changes to water level - managed through large ARI design event and freeboard	- quantified with sensitivity analysis - possible seasonal and extreme changes - managed through large ARI design event and freeboard	- quantified with sensitivity analysis - no wave setup due to foreshore depth - managed through large ARI design event and freeboard	- not quantified - rainfall changes similar for all sites - flood gradient expected to be minor in this part of estuary	- minor effect	- no effect
Local Winds	- no effect	- minor effect	- change not quantified - similar for all sites, but site is most exposed to SE - managed through large ARI design event and freeboard	- no effect	- no effect	- minor sea breeze effects	- no effect
Local Waves	- minor effect	- minor effect	- quantified with sensitivity analysis - managed through large ARI design event and freeboard	- assessed in detail - managed through large ARI design event and freeboard	- no effect	- no effect	- no effect
Effects on Structures	- effects on overtopping considered - it is assumed that port structures are maintained	- minor effect	- change not quantified - similar for all sites, but site is most exposed to SE - managed through large ARI design event and freeboard	- major effect if waves reach hospital site - it is assumed that port structures are maintained	- rainfall changes similar for all sites - runoff needs consideration at detailed design stage and can be managed	- no effect	- possible long term changes to durability of structures, but not assessed - it is assumed that port structures are maintained

Matrix of Climate Change

Table 3.4 (continued)

	Key Variable						
	Mean Sea Level	**Ocean Currents and Temp**	**Wind Climate**	**Wave Climate**	**Rainfall / Runoff**	**Air temperature**	**Ocean Acidity**
Groundwater	- some site data collected - assessed qualitatively	- minor indirect effect	- minor indirect effect	- minor effect	- some site data collected	- minor indirect effect	- may change groundwater pH
Coastal Flooding	- assessed in detail	- minor effect	- quantified with sensitivity analysis - managed through large ARI design event and freeboard	- change not quantified - managed through large ARI design event and freeboard	- rainfall changes similar for all sites - runoff needs consideration at detailed design stage and can be managed	- minor indirect effect	
Beach Response	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore
Foreshore Stability	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- possible long term changes to durability of structures - it is assumed that port structures will be maintained
Sediment Transport	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore	- n/a due to engineered shore
Hydraulics of Estuaries	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary
Quality of Coastal Waters	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary	- n/a due to setback from estuary
Ecology	- n/a due to built up nature of site	- n/a due to built up nature of site	- n/a due to built up nature of site	- n/a due to built up nature of site	- n/a due to built up nature of site	- n/a due to built up nature of site	- n/a due to built up nature of site

Technical assessment: Processes

- Tide and tidal anomalies - DATA
- Offshore extreme waves - DATA
- Swell wave penetration - SWAN
- Local wind waves - CEM
- Stormwater -QUALITATIVE
- Sea level rise - IPCC
- Tsunamis – COMMENT
- **LIDAR DATA ACQUIRED DURING STUDY**

Hazards

Hazards (generally 100 year ARI):

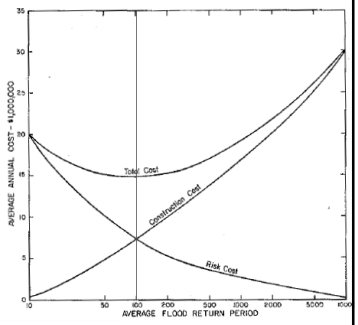
- Present day, 2050, 2100 – IPCC SLR
- Erosion - SBEACH
- Recession – BRUUN RULE
- Entrance stability - QUALITATIVE
- Wind blown sand – CEM,OBSERVATION
- Open coast inundation - MODELLING
- Lagoon/bay inundation - MODELLING
- Cliff/bluff stability - OTHER
- Seawater intrusion to groundwater - DESK

"Design Event"

BUILDING CODE OF AUSTRALIA (2007) For private house:
Wind load: 500 year ARI
Snow load: 150 year ARI

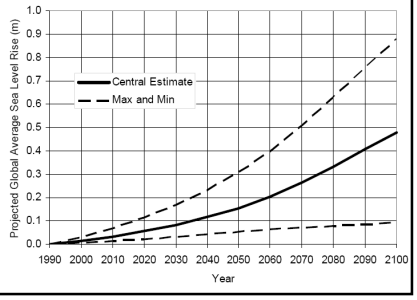
MOST FLOOD POLICIES AND COASTAL STRUCTURES in Australia and USA 100 year ARI plus freeboard of 0.5 m

NETHERLANDS COASTAL DEFENCES: 10,000 year ARI



IPCC (NCCOE, 2004) Sea level rise projections

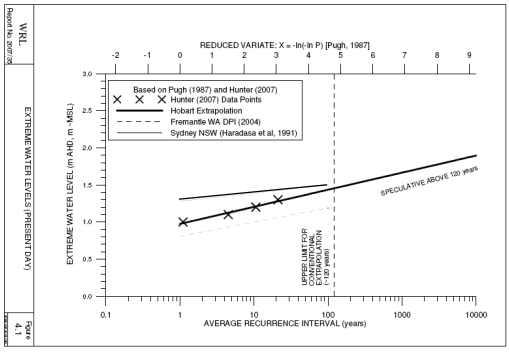
SEA LEVEL RISE for ~2100
0.9 m from NCCOE (2004) SLR curves based on IPCC (2001)
7 m IPCC (2007) for total melting of the Greenland ice sheet
70 m if all the world's ice sheets were to melt (GACGC, 2006)



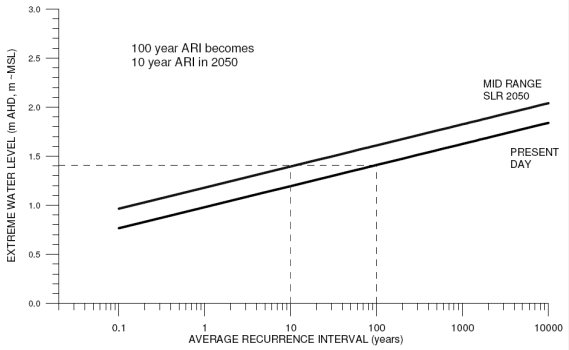
Sea level rise scenarios adopted

	Year and Sea Level Rise relative to 1990 (m)	
SLR Scenario	**2050**	**2100**
"Mid" range scenario	0.2	0.4
"High" range scenario	0.3	0.9

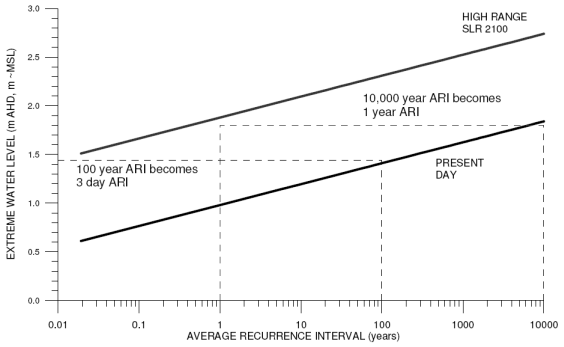
Present day water levels



Change in ARI

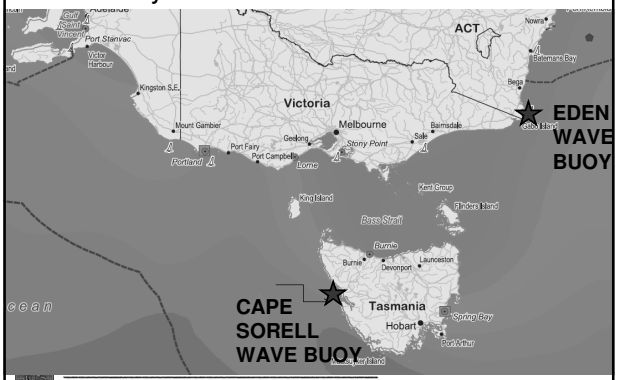


Change in ARI

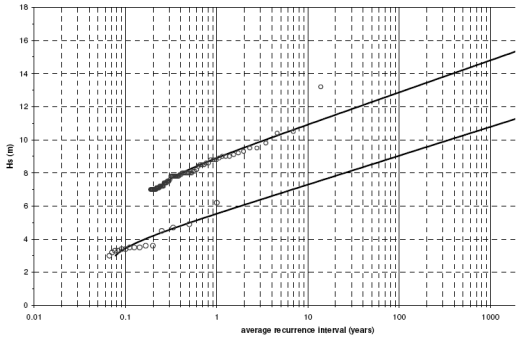


2100 HIGH RANGE SEA LEVEL RISE

Wave buoys

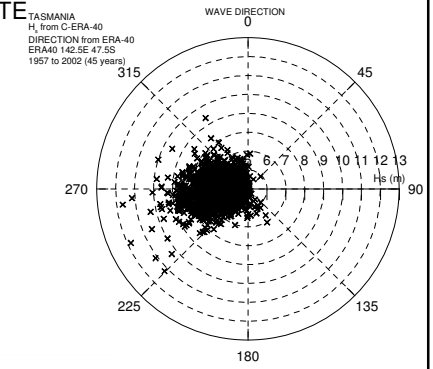


OCEAN WAVES – Cape Sorell TAS



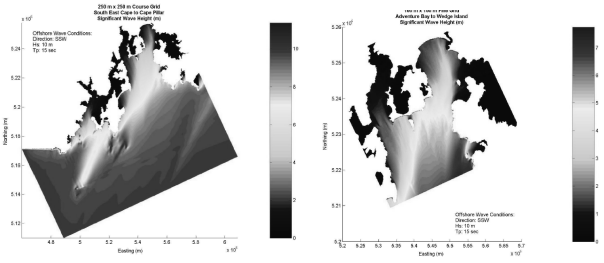
Analysis of Cape Sorell (top) and Wedge Island wave buoy data (Data source: BoM and CSIR

ERA-40 DIRECTIONAL WAVE CLIMATE

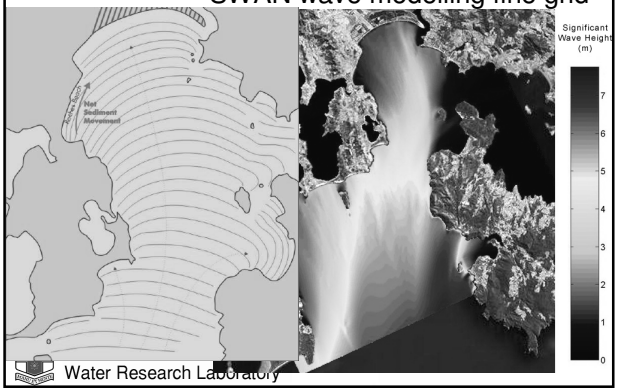


SWAN Wave Modelling

Ocean swell waves



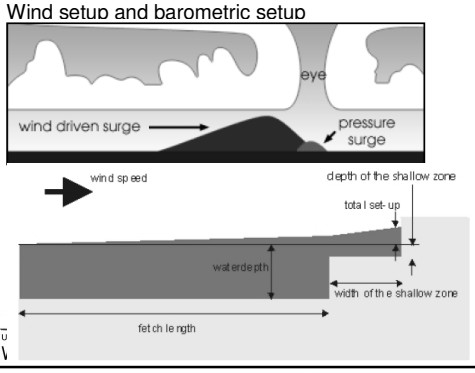
Technical assessment: SWAN wave modelling fine grid



SWAN output

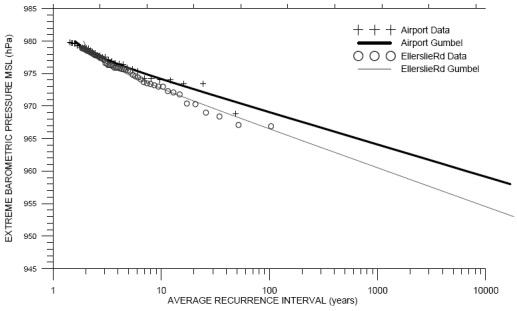
Barometric and Wind Setup

Wind setup and barometric setup

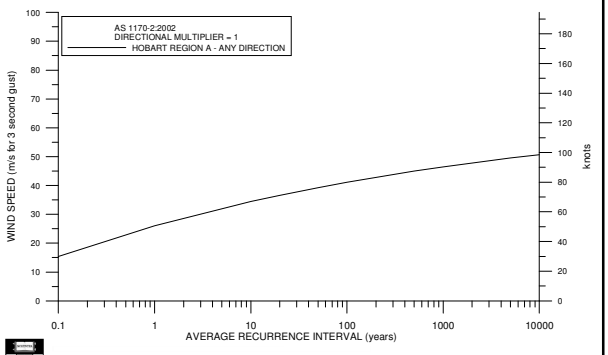


Barometric data

Barometric pressure >100 years of data

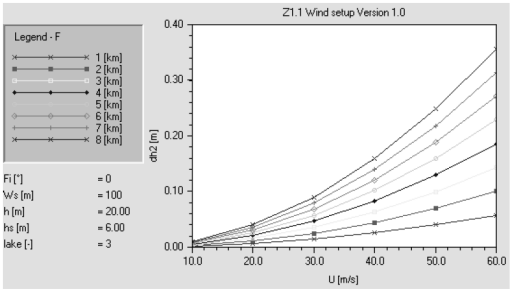


WIND SPEED

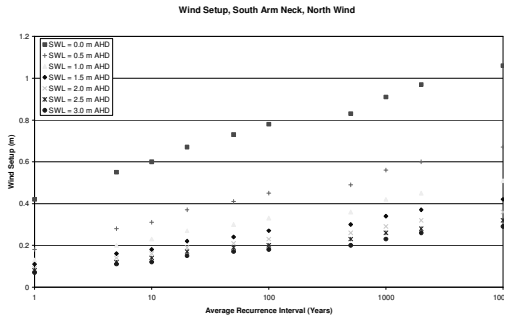


Wind Setup

Simple 1-D model

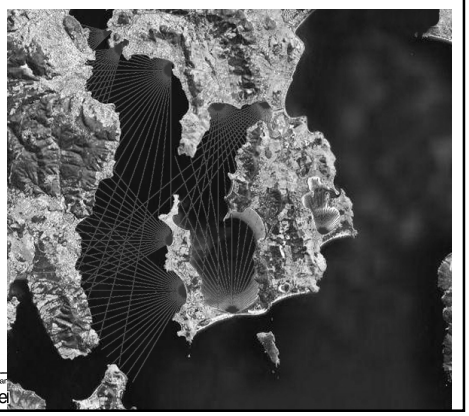


WIND SETUP
RALPHS BAY SOUTH ARM NECK

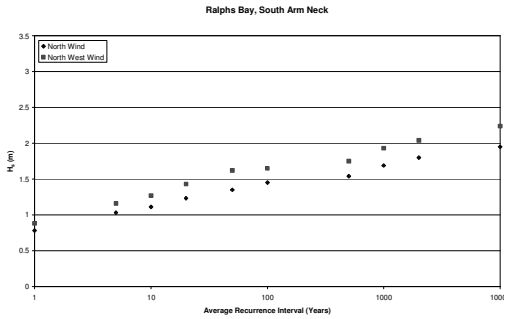


Wind waves

Wind waves

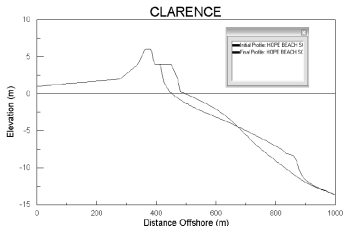


EXTREME WIND WAVES
RALPHS BAY SOUTH ARM NECK



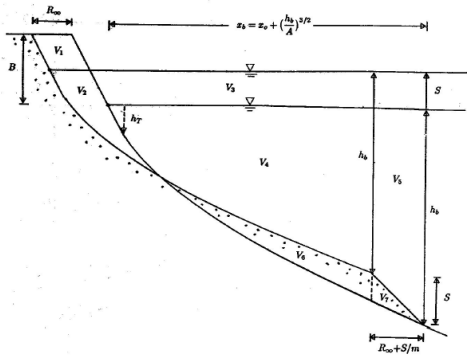
EROSION MODELLING

For locations where there is minimal historic data
Consideration of:
Carley and Cox (2003)
Nielsen and Adamantidis (2007)
WA Government (2005)



Model output (Hope Beach)

Bruun Rule – Closure depth



Bruun Rule

CLOSURE DEPTH METHODS
- Hallermeier inner
- Hallermeier outer
- SBEACH 100 year ARI
- Profile evidence

- BRUUN FACTOR
- Rule of thumb 50 to 100
- Range for Clarence (12 locations) 11 to 432

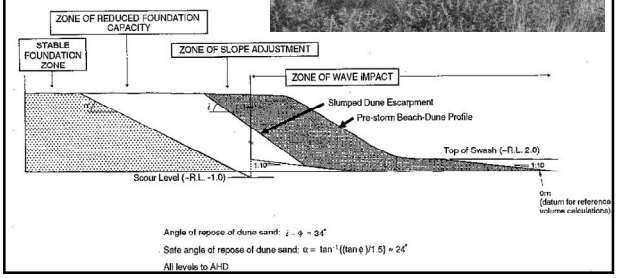
- ADOPTED BRUUN FACTOR
- 20, 50

Setback components

Setback components:

- S1: Allowance for storm erosion
- S2: Allowance for long term (underlying) recession
- S3: Allowance for beach rotation
- S4: Allowance for reduced foundation capacity (to Stable Foundation Zone)
- S5: Allowance for future recession (Bruun Rule)

DUNE STABILITY SCHEMA
after Nielsen et al (1992)

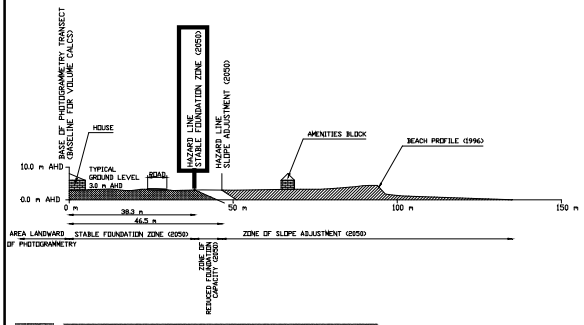


Angle of repose of dune sand: $\phi = 34°$

Safe angle of repose of dune sand: $\alpha = \tan^{-1}((\tan\phi)/1.5) \approx 24°$

All levels to AHD

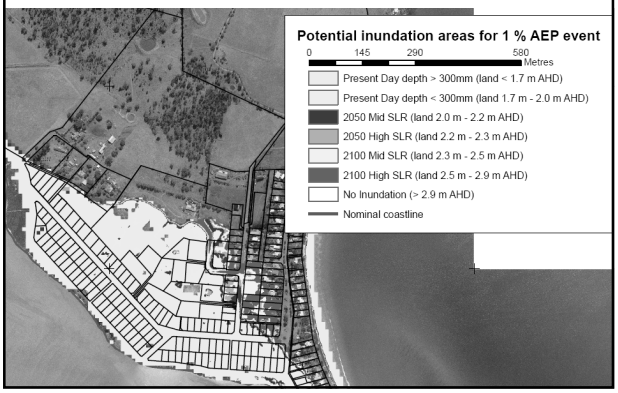
HAZARD LINES



HAZARD LINES FOR BUILDINGS - PRELIMINARY

Erosion (Wamberal 1978)

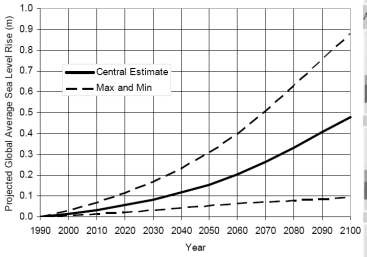
POTENTIAL INUNDATION using LIDAR data

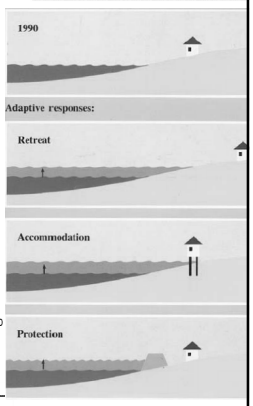


POTENTIAL INUNDATION LIDAR DATA AND DUNE BREACHES

ADAPTATION

PROJECTED SEA LEVEL RISE AND MANAGEMENT OPTIONS





Managed/adaptive approach

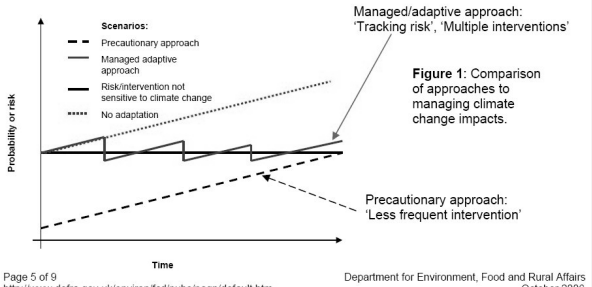


Figure 1: Comparison of approaches to managing climate change impacts.

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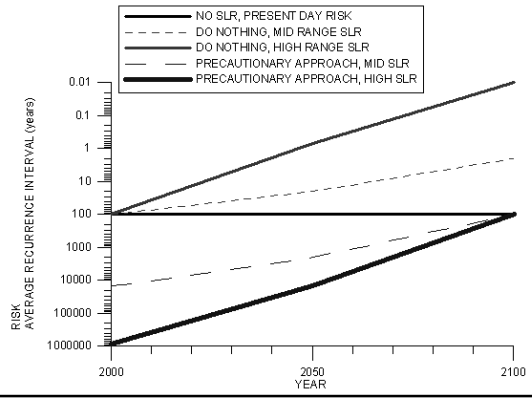
http://www.defra.gov.uk/environ/fcd/pubs/pagn/default.htm

Department for Environment, Food and Rural Affairs
October 2006

ARI for Managed/adaptive approach



Responses

Retreat options:

- Relocate structures beyond inundation and erosion
- Need to test community attitudes to preserving public foreshore access
- Repurchase of the seaward portion of allotments to maintain access

ADAPTIVE MANAGEMENT OPTIONS RETREAT, ACCOMODATE, PROTECT

- Planning controls, which must deal with:
  - Building setbacks.
  - Minimum floor levels.
  - Appropriate engineering assessments.
  - Appropriate construction techniques (eg piled buildings).
- Planning controls which may also consider a development freeze in some locations.
- Physical works such as seawalls, groynes, dune management or sand nourishment.
- Ongoing monitoring, analysis and review of findings.
- Additional data collection or studies.

ADAPTATION

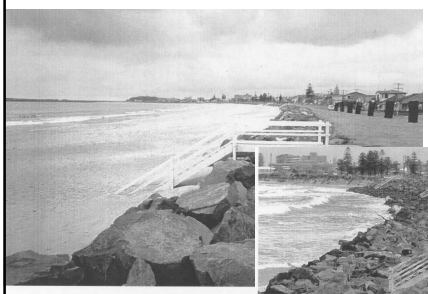
Accommodation

– ELEVATED HOUSES

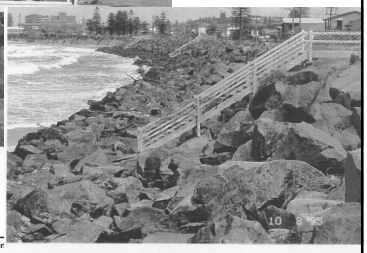
Geoff Mackley

GROYNES AND NOURISHMENT
LADY ROBINSONS BEACH

ADAPTATION – SEAWALLS



a) Typical Pre-Storm Conditions



b) Typical Post-Storm Conditions

ADAPTATION – SEAWALLS

Rock rubble - Santubong, Malaysia (designed by WRL)

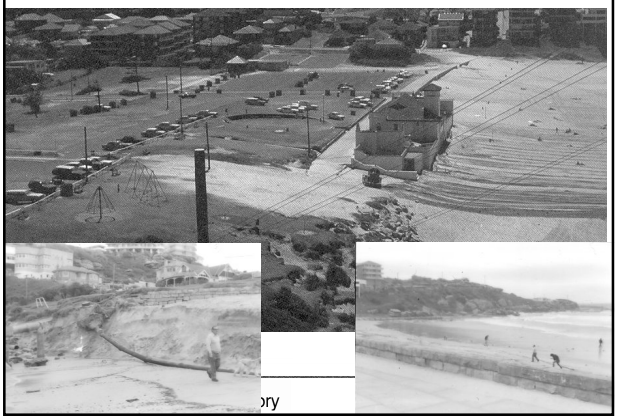
PROTECTION NOT ALWAYS POPULAR
PROPOSED SEAWALL
COLLAROY – NARRABEEN

1.1 km human line
in the sand
17/11/2002

KIRRA 1936

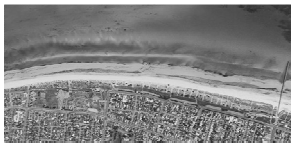
NOURISHMENT
KIRRA 17/07/2004

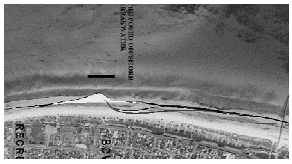
HARBORD/FRESHWATER 1978,
1974 (BOTTOM)

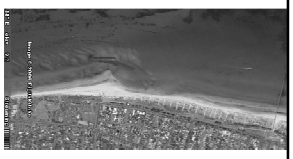


HARBORD/FRESHWATER 2004

OFFSHORE STRUCTURE







SUMMARY / CONCLUSIONS / DISCUSSION

- ~10 separate coastal processes and ~10 separate coastal hazards need consideration in coastal assessments
- The combination of major storm events with future sea level rise is the dominant factor to consider for planning
- Modelling of moderate complexity can answer many questions
- Technical output needs to be integrated into socio-economic framework

The end