Site evaluation for wetland restoration

Dr Nigel Pontee

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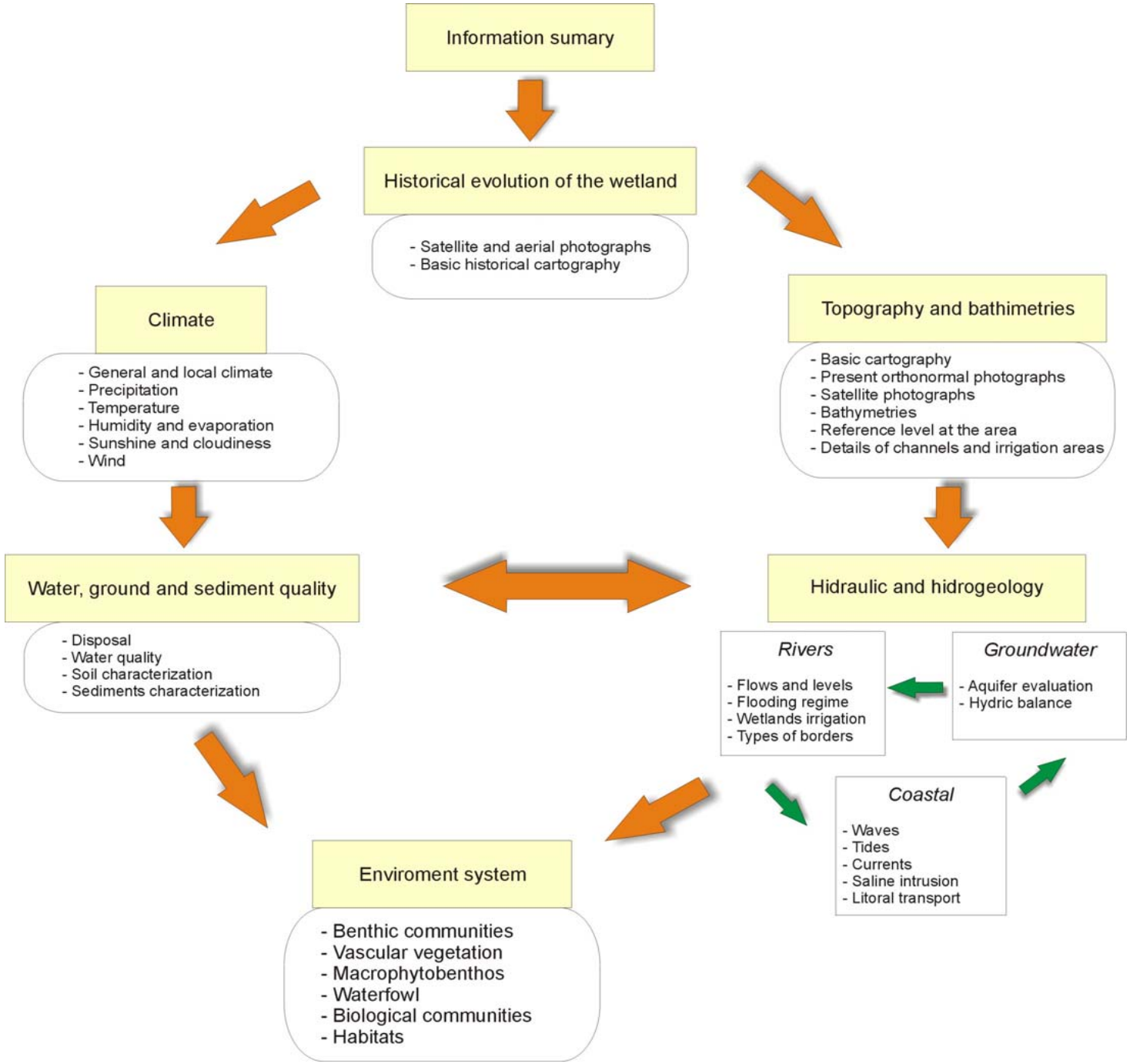
PIANC WG 7

Ecological engineering guidelines for wetlands restoration

1. Introduction
2. Background
3. Strategic plan
4. ☺ **<u>Site characterisation & evaluation</u>** ☺
5. Ecological function of wetland habitats & goal setting
6. Design of wetlands
7. Site construction
8. Site management
9. Final remarks
10. Case studies


Information sumary
Historical evolution of the wetland
- Satellite and aerial photographs
- Basic historical cartography
Climate
- General and local climate
- Precipitation
- Temperature
- Humidity and evaporation
- Sunshine and cloudiness
- Wind
Topography and bathimetries
- Basic cartography
- Present orthonormal photographs
- Satellite photographs
- Bathymetries
- Reference level at the area
- Details of channels and irrigation areas
Water, ground and sediment quality
- Disposal
- Water quality
- Soil characterization
- Sediments characterization
Hidraulic and hidrogeology
Rivers
- Flows and levels
- Flooding regime
- Wetlands irrigation
- Types of borders
Groundwater
- Aquifer evaluation
- Hydric balance
Coastal
- Waves
- Tides
- Currents
- Saline intrusion
- Litoral transport
Enviroment system
- Benthic communities
- Vascular vegetation
- Macrophytobenthos
- Waterfowl
- Biological communities
- Habitats

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Site evaluation

Why?

- Detailed site design
- Environmental impact assessment – before, during, after

How?

- Regional/estuary wide - choosing site
- Site specific - designing site

What do we need to know to design our wetland restoration scheme?

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Background

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© 1960 Engineers Testing Laboratories

". . . and we can save 700 lira by not taking soil tests."

Changing Management Outlook

Focus on species	⇨ Ecosystems
Single scale	⇨ Multiple scales
Short term response	⇨ Long term change
Humans outside system	⇨ Humans integral
Resource exploitation	⇨ Sustain productivity
Management intervention	⇨ Adaptation

source: Kenneth Sherman, NOAA

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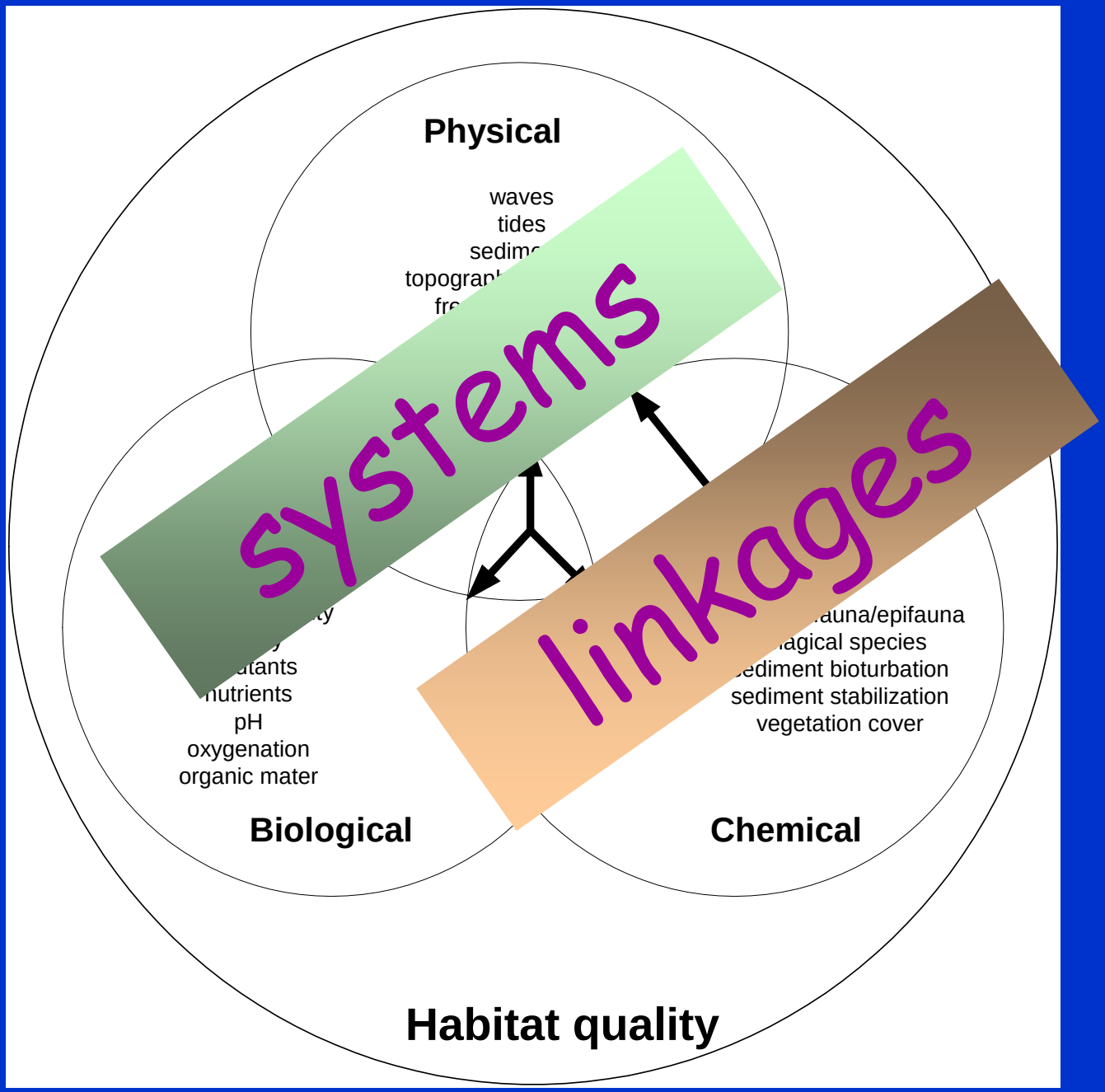
Design Requirements

Civil engineering design

- vast experience
- tried & tested methods
- key variables understood
- accepted risk evaluation

Habitat design

- limited experience
- solutions still being tested
- systems poorly understood
- perceived risk


Physical
waves
tides
systems
linkages
nutrients
pH
oxygenation
organic mater
Biological
sediment bioturbation
sediment stabilization
vegetation cover
Chemical
Habitat quality

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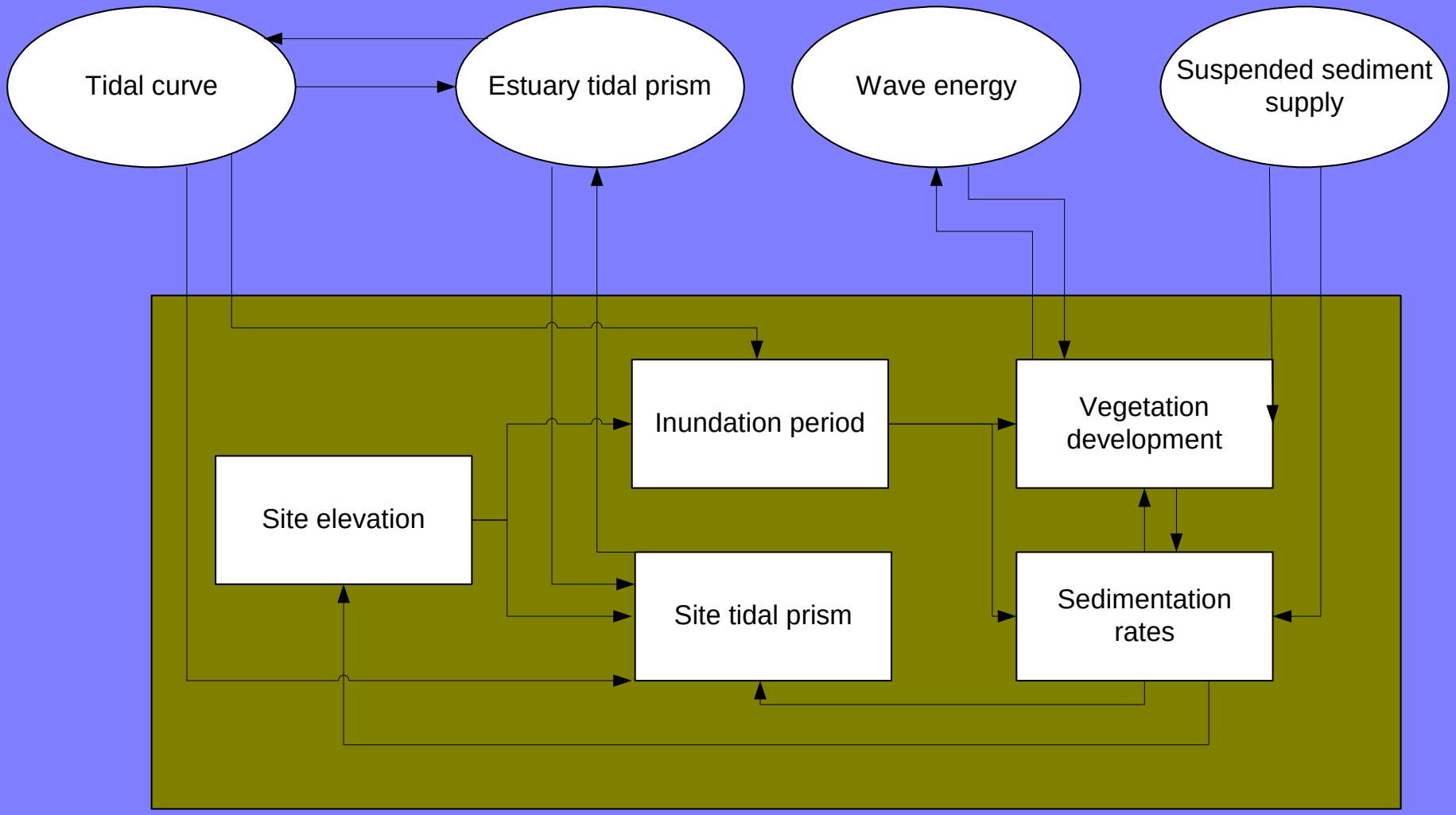
Linkages - estuary systems & managed realignment schemes



Regional/estuary wide considerations

systems

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Form Design

- Regime relationships
  - Prism-area (O'Brien)
  - Plan area (Renger & Partensky)
  - Flood-ebb dominance
    - (Dronkers, Pethick)
    - Friedrichs & Aubrey
  - Rollover (Allen, Pethick)
  - Entropy (Langbein, Townend)
- Mud shore profiles (Lee & Mehta, Kirby)
- 3-D parametric forms
- Modelling

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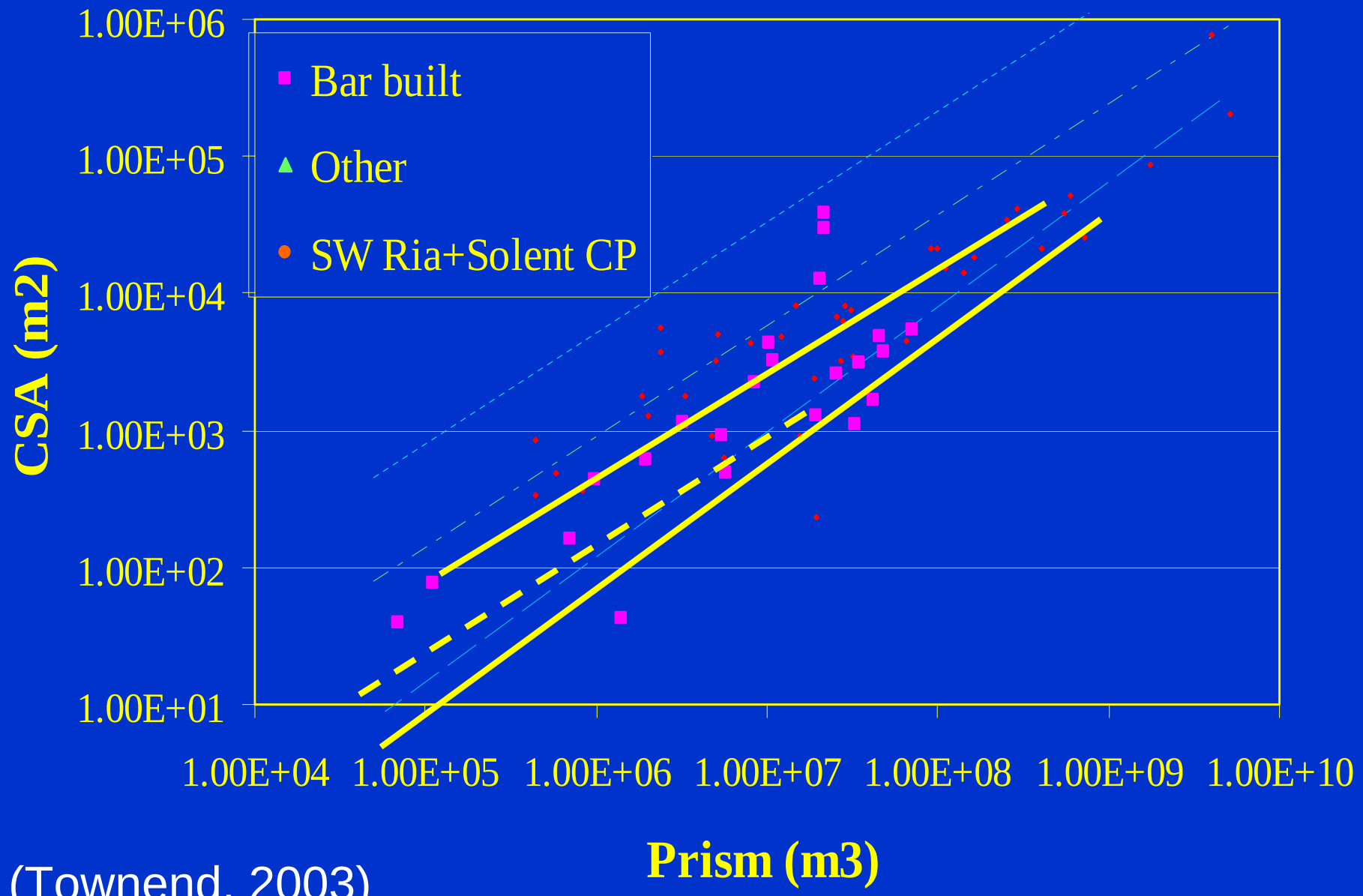
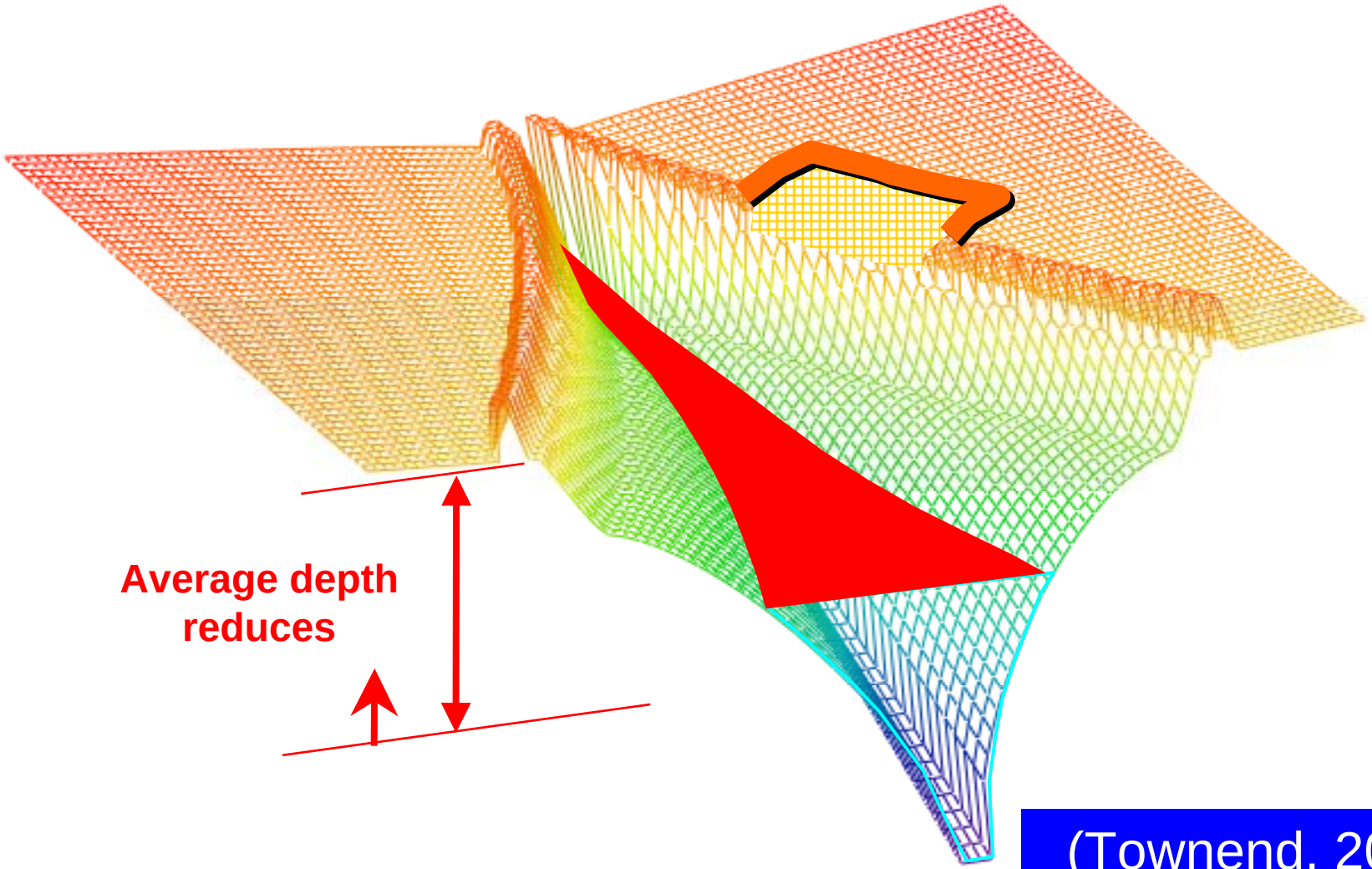
Estuary Status?



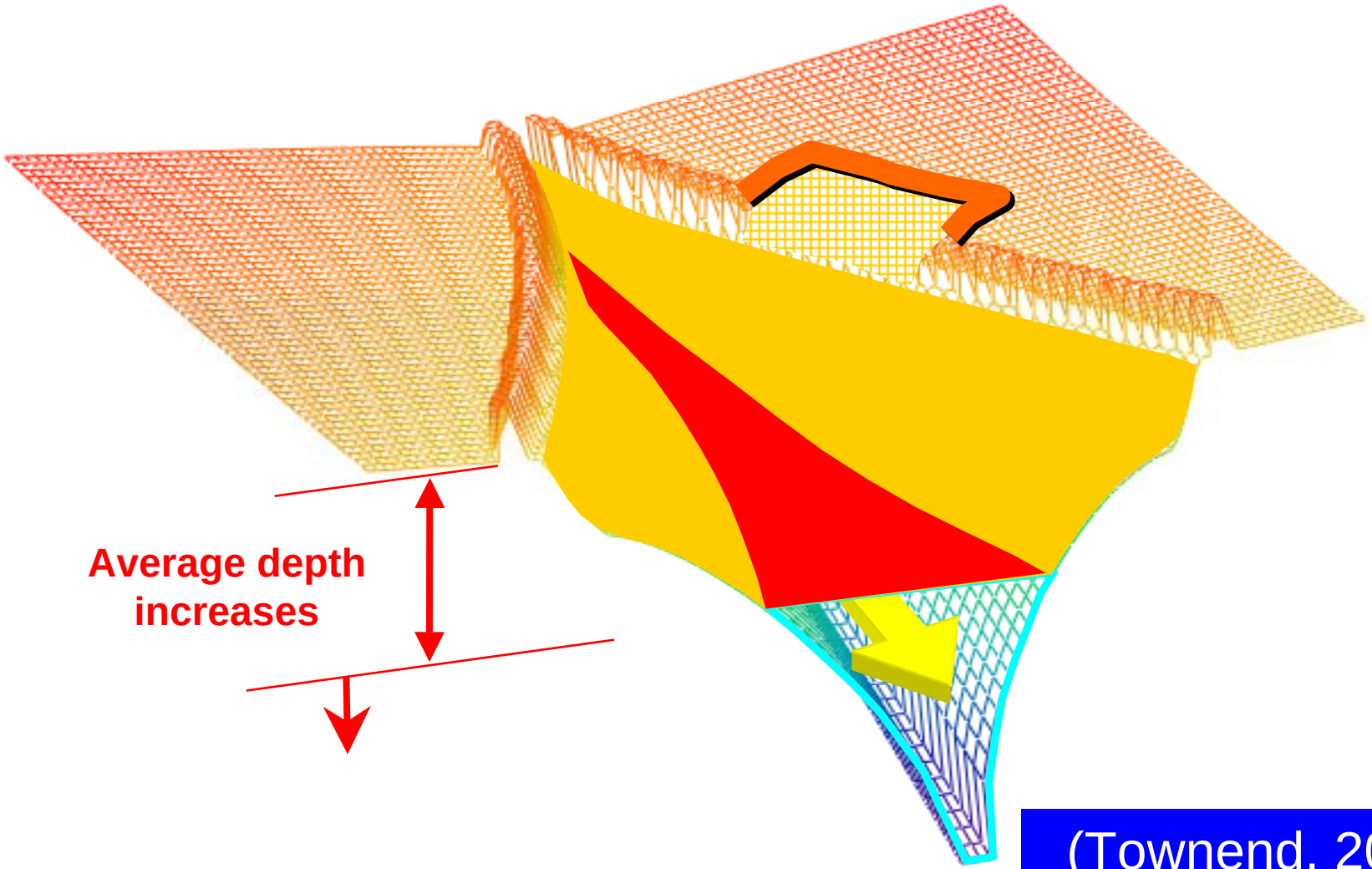
(Townend, 2003)

Introduce Set-back



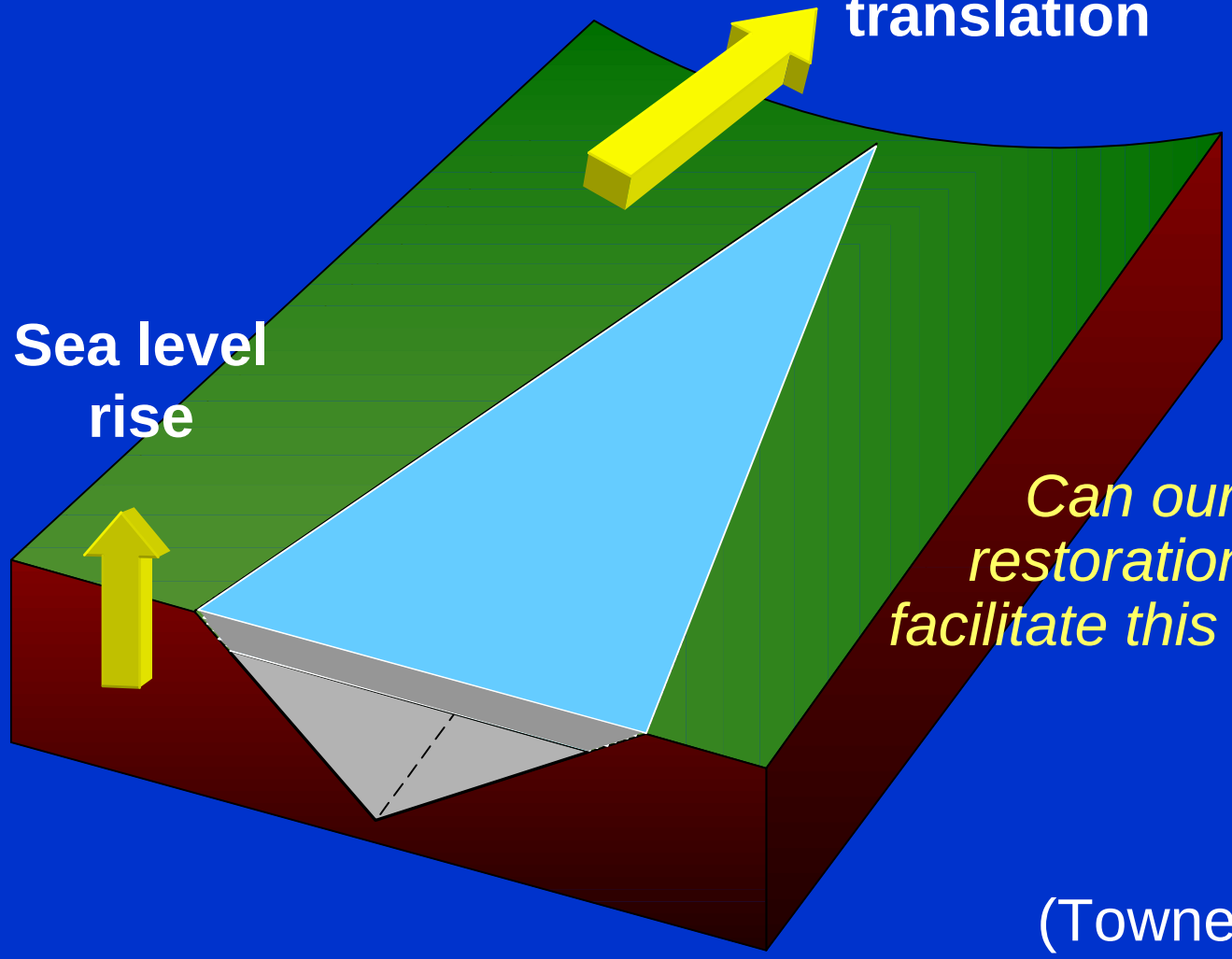
(Townend, 2000)

Channel Enlarges



(Townend, 2000)

Estuary Rollover



Can our wetland restoration scheme facilitate this process?

(Townend, 2002)

Ecological Considerations

- Seasonal – migration corridors birds
- Daily – diurnal feeding patterns
- Fish usage
- Nutrient sinks

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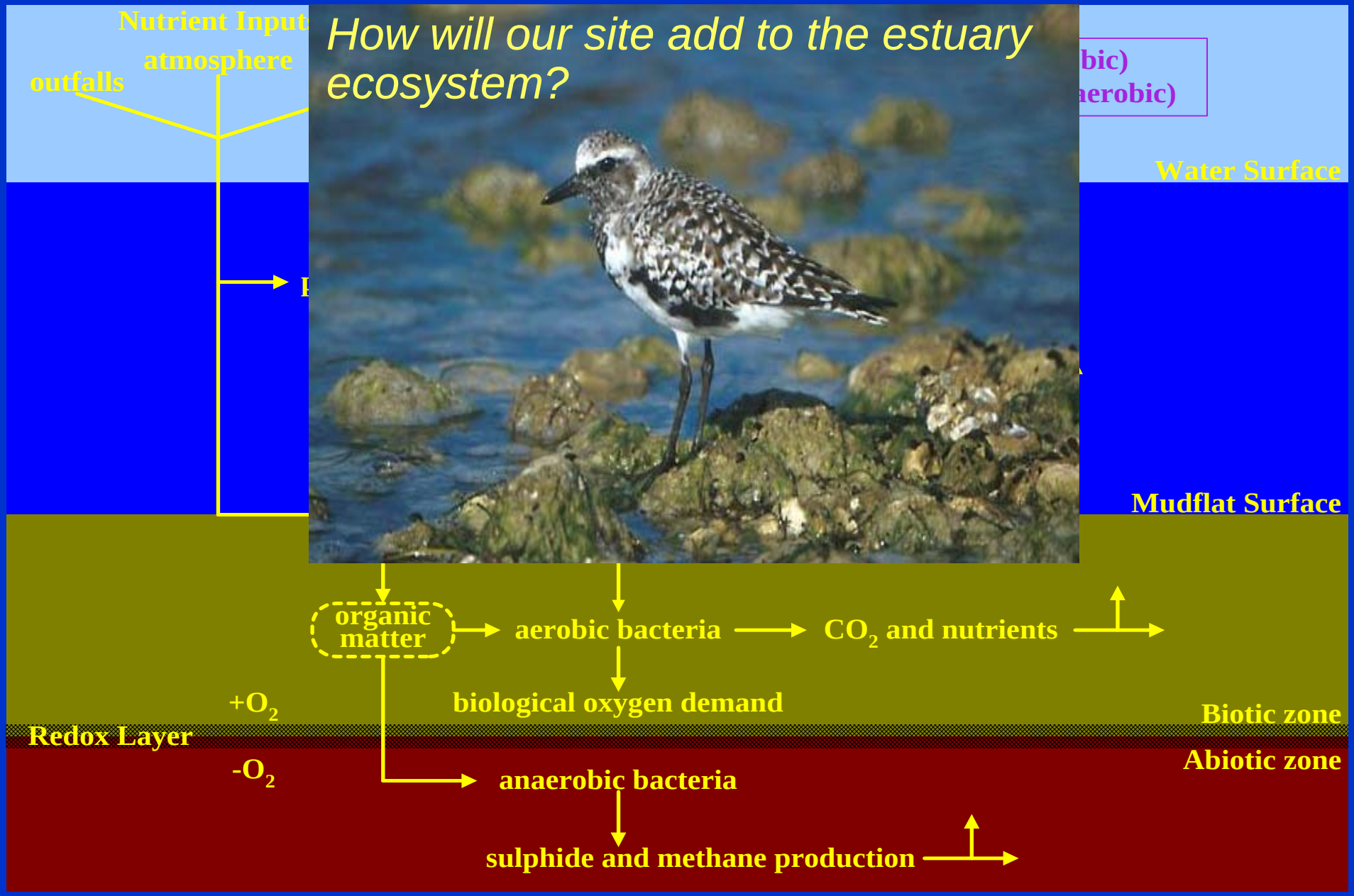
Ecosystem


How will our site add to the estuary ecosystem?
Nutrient Input
atmosphere
outfalls
bic)
erobic)
Water Surface
Mudflat Surface
organic matter
aerobic bacteria
CO_2 and nutrients
biological oxygen demand
$+O_2$
Biotic zone
Redox Layer
Abiotic zone
$-O_2$
anaerobic bacteria
sulphide and methane production

Humber Estuary

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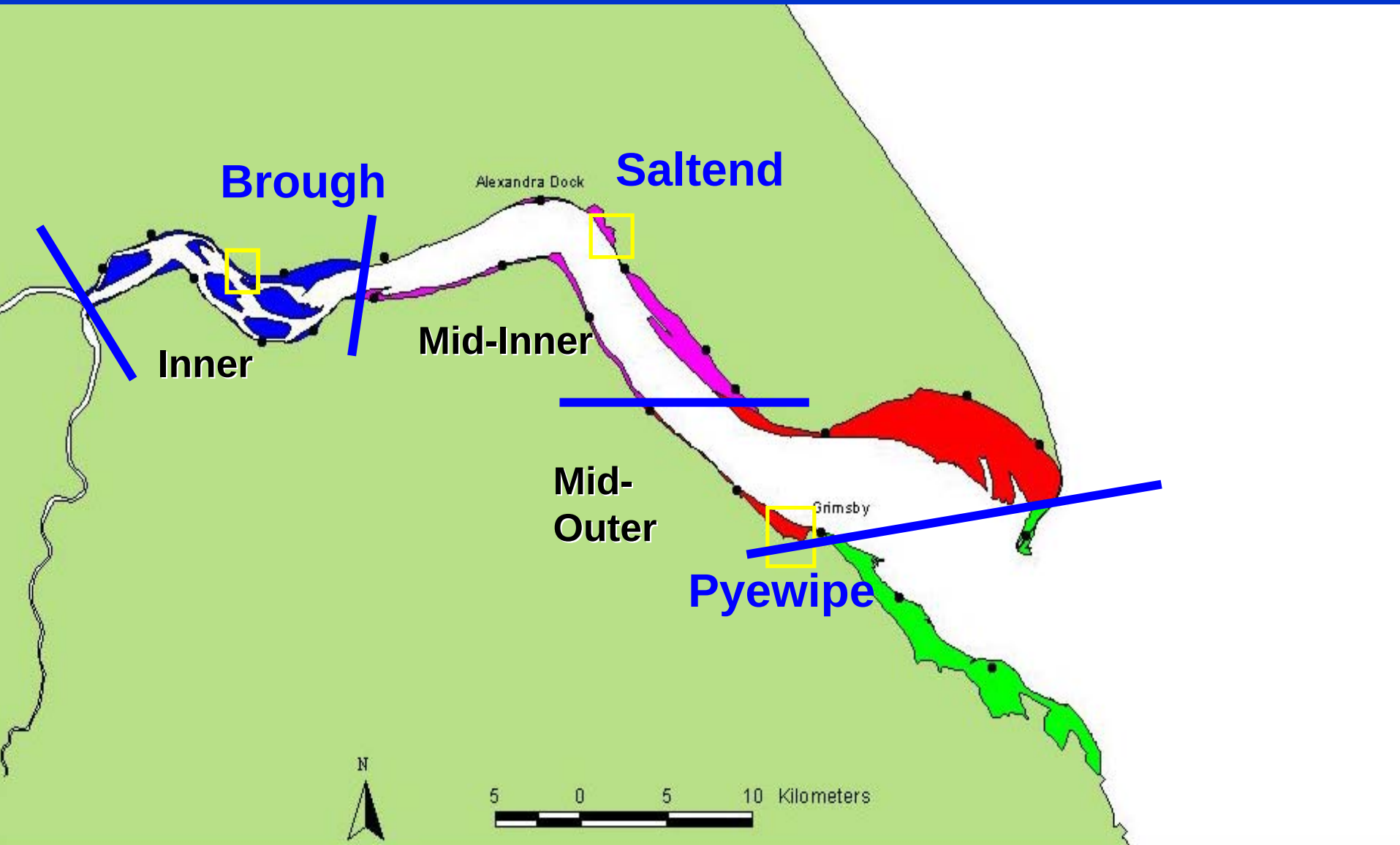
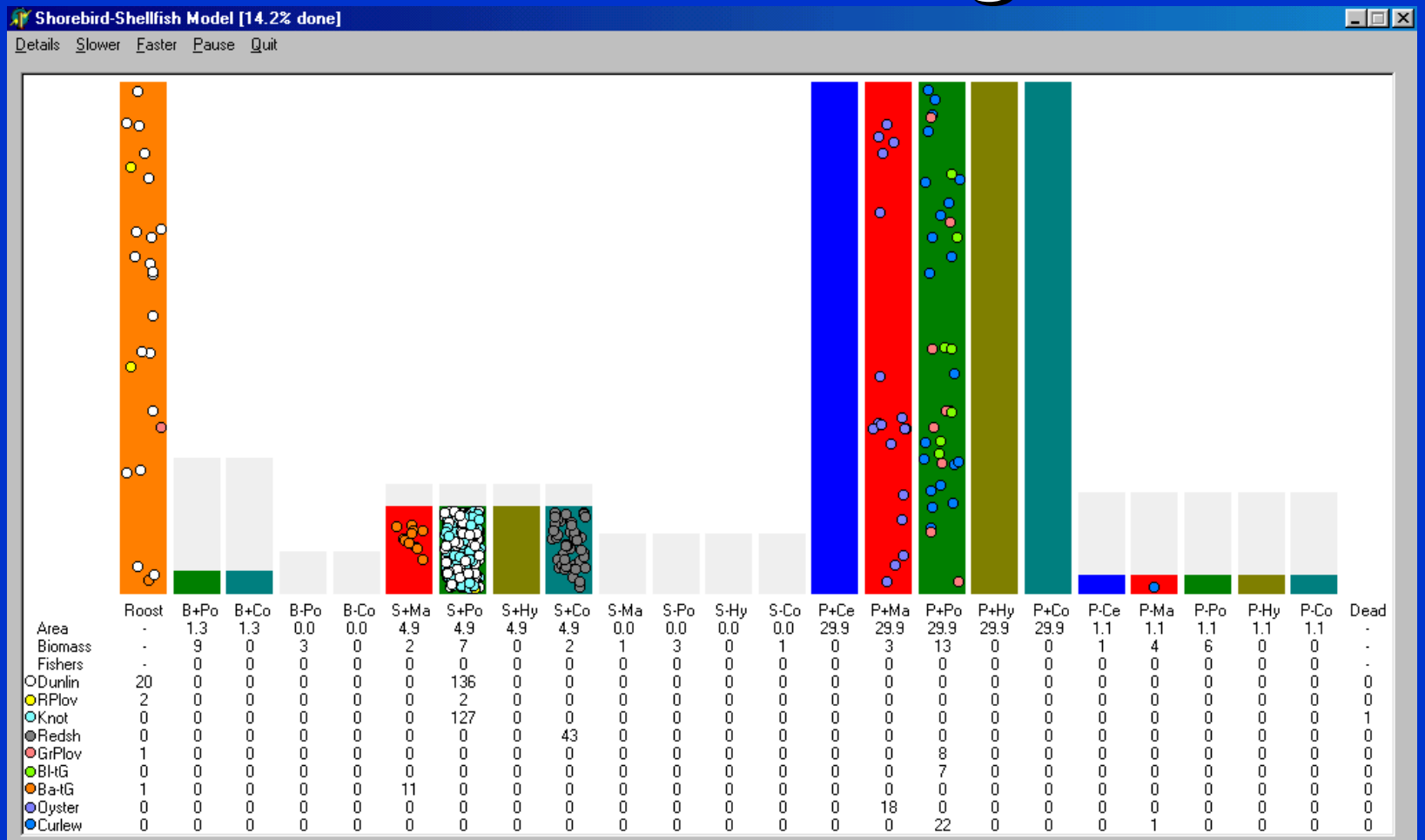
Humber Intertidal Macrobenthic Assemblages



Bird Modelling



Shorebird-Shellfish Model [14.2% done]

Details Slower Faster Pause Quit

	Roost	B+Po	B+Co	B-Po	B-Co	S+Ma	S+Po	S+Hy	S+Co	S-Ma	S-Po	S-Hy	S-Co	P+Ce	P+Ma	P+Po	P+Hy	P+Co	P-Ce	P-Ma	P-Po	P-Hy	P-Co	Dead
Area	-	1.3	1.3	0.0	0.0	4.9	4.9	4.9	4.9	0.0	0.0	0.0	0.0	29.9	29.9	29.9	29.9	29.9	1.1	1.1	1.1	1.1	1.1	-
Biomass	-	9	0	3	0	2	7	0	2	1	3	0	1	0	3	13	0	0	1	4	6	0	0	-
Fishers	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-
Dunlin	20	0	0	0	0	0	136	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
RPlov	2	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Knot	0	0	0	0	0	0	127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Redsh	0	0	0	0	0	0	0	0	43	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
GrPlov	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0	0	0	0
Bl-tG	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0
Ba-tG	1	0	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oyster	0	0	0	0	0	0	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	0
Curlew	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	0	0	0	1	0	0	0	0

Year: 1 (Winter) Period: 28 Sub-period: 3 Tidal stage: 3 Tidal range: 1.00

Day: 28 (Mon) Time: 9.25 Stage length: 2.00 Daylight: 2.00 Temperature: 12.69

Case 1

Site Selection multi criteria analysis

Design Objectives (1-4)								
Criteria (5-9)		**Weight**	**Site A**	**Site B**	**Site C**	**Site D**	**Site E**	**Site F**
1	Habitat, bird numbers and species (% of t	10	9.4	-9.1	-5.7	9.7	10.0	-14.2
2	No adverse impact on the geomorphology	10	6.8	6.1	-17.1	6.2	-11.8	4.9
3	No adverse impact on ecological function	3	3.2	0.4	-5.2	3.2	-2.4	0.4
4	Self-sustaining system	3	1.1	1.1	-6.8	1.1	1.1	1.1
5	Engineering Feasibility and costs	2	-0.7	1.2	-1.3	-2.8	0.4	3.5
6	Current standard of flood defence	2	-2.8	-1.0	-1.0	0.8	2.5	2.5
7	Preferred flood defence option.	2	-2.1	-2.1	1.6	1.6	1.6	1.6
8	No of owners	1	0.5	0.8	0.1	-2.2	0.1	0.5
9	Proximity	1	-0.3	-0.5	-0.1	0.0	-1.2	-0.1
	Totals		15.1	-3.0	-35.4	17.7	0.4	0.2
	Rank		2	6	7	1	4	5

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Site Specific Evaluation

Scientific background

UK case studies

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Specific design considerations

Physical

- tidal inundation
- wave climate
- sediment supply
- topography/bathymetry
- geology
- area (inc. buffer zones)
- water quality
- sediment quality

Ecological

- micro-benthic communities
- invertebrate fauna
- vegetation
- buffer zones
- disturbance factors
- ecological corridors

Requirements of primary colonisers

- intertidal morphology
- elevation
- exposure
- sediment composition
- rate of consolidation
- water quality
- hydrogeology
- existing flora & fauna

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UK Case studies

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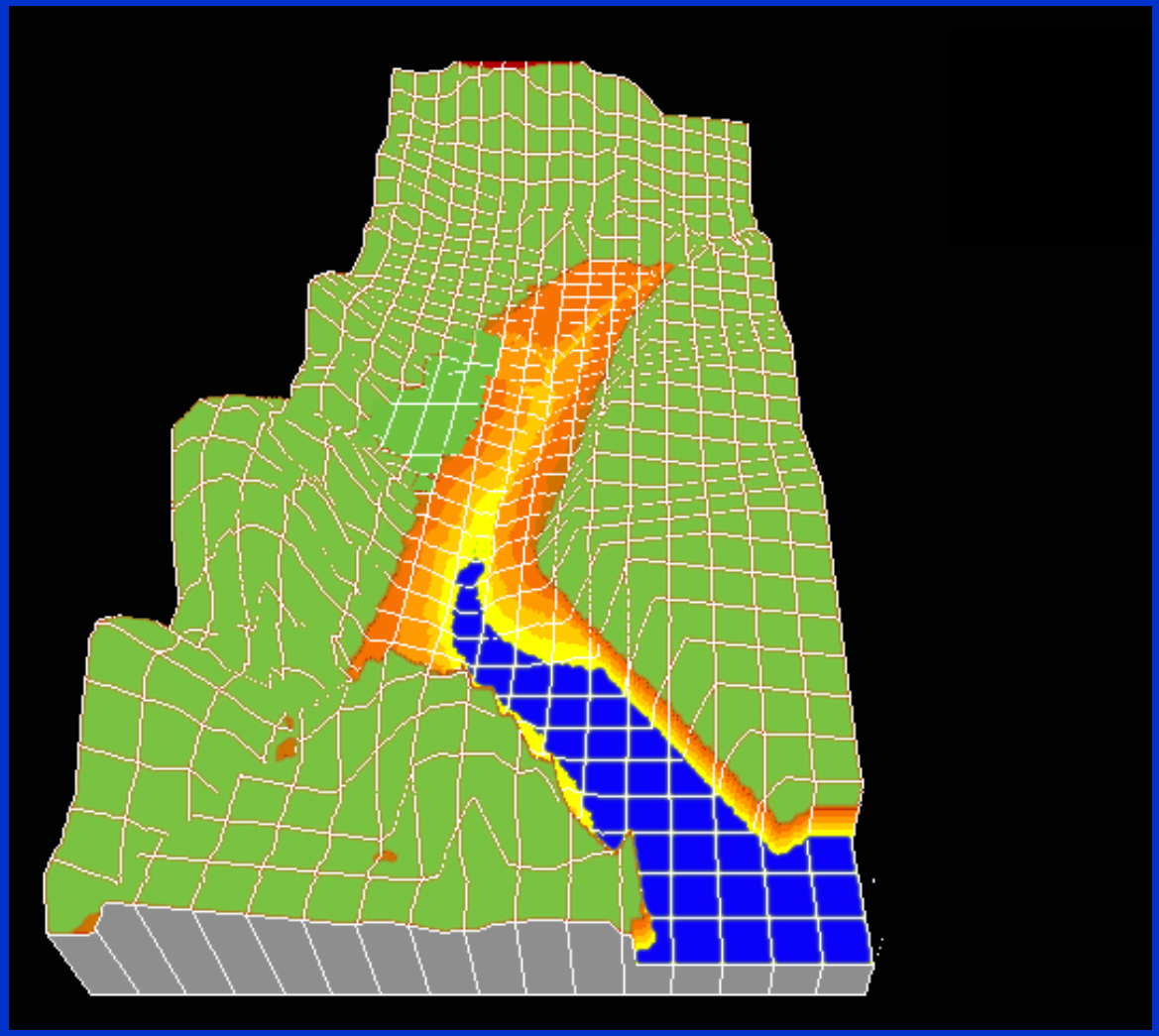
Proposed Terminal, S England, U.K

Dibden creek design required….



- Research into form, structure and function
- Detailed modelling of physical processes
- Exploration of physical-benthic interactions
- Investigation of bird use of creek habitat

- State of existing sea defences

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Chichester Harbour, S England, U.K.

Existing creek

networks

Breaching

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Chichester Harbour, S England, U.K.

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Chichester Harbour, S England, U.K.

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Orfordness, SE England, U.K

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Orfordness, SE England, U.K

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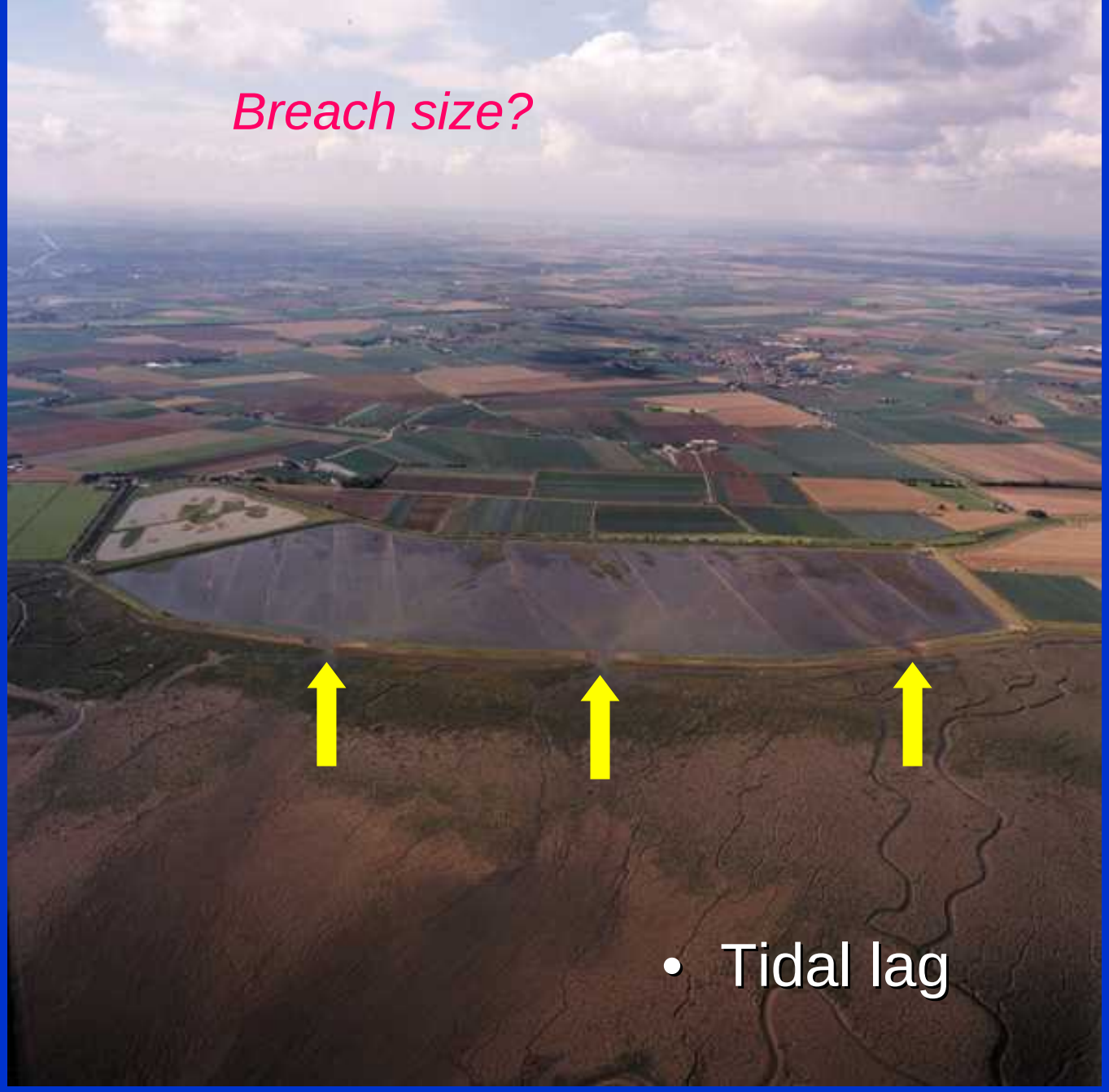
Orfordness, SE England, U.K



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Freiston, E England, U.K

- Breach erosion

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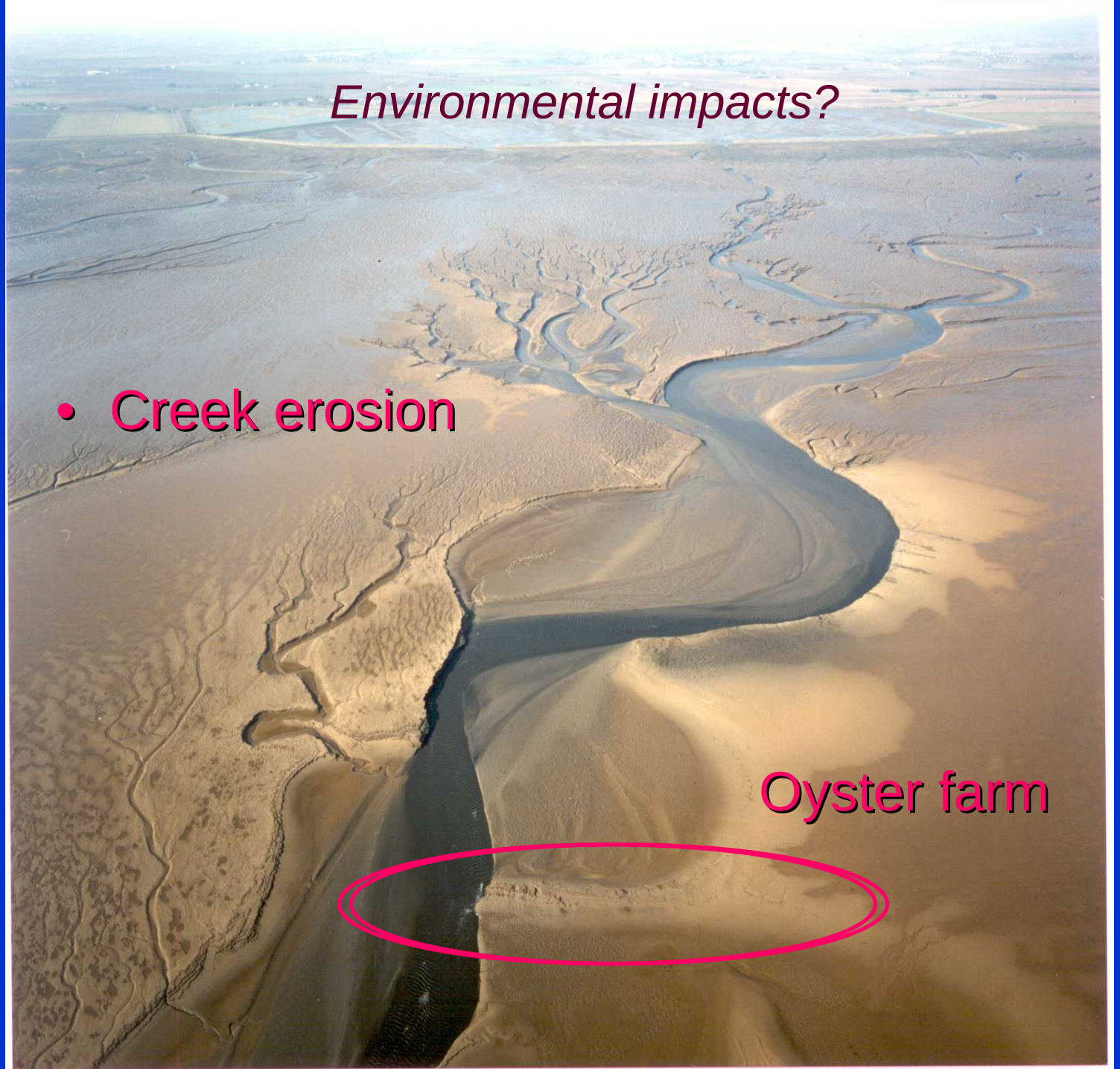
Freiston, E England, U.K

Environmental impacts?



- Creek erosion

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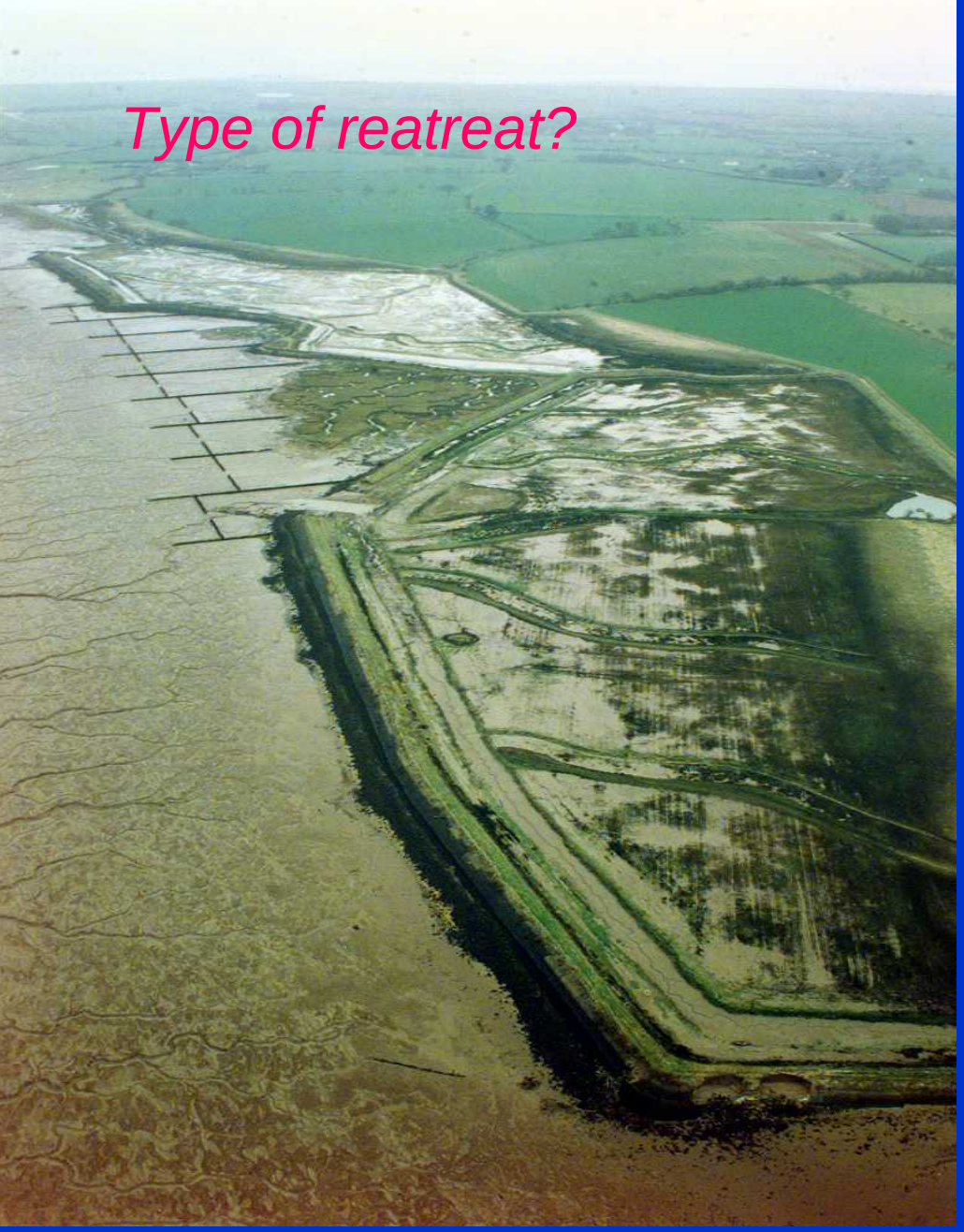

- Initial Breached realignment in 1993
- Eventual banked realignment?

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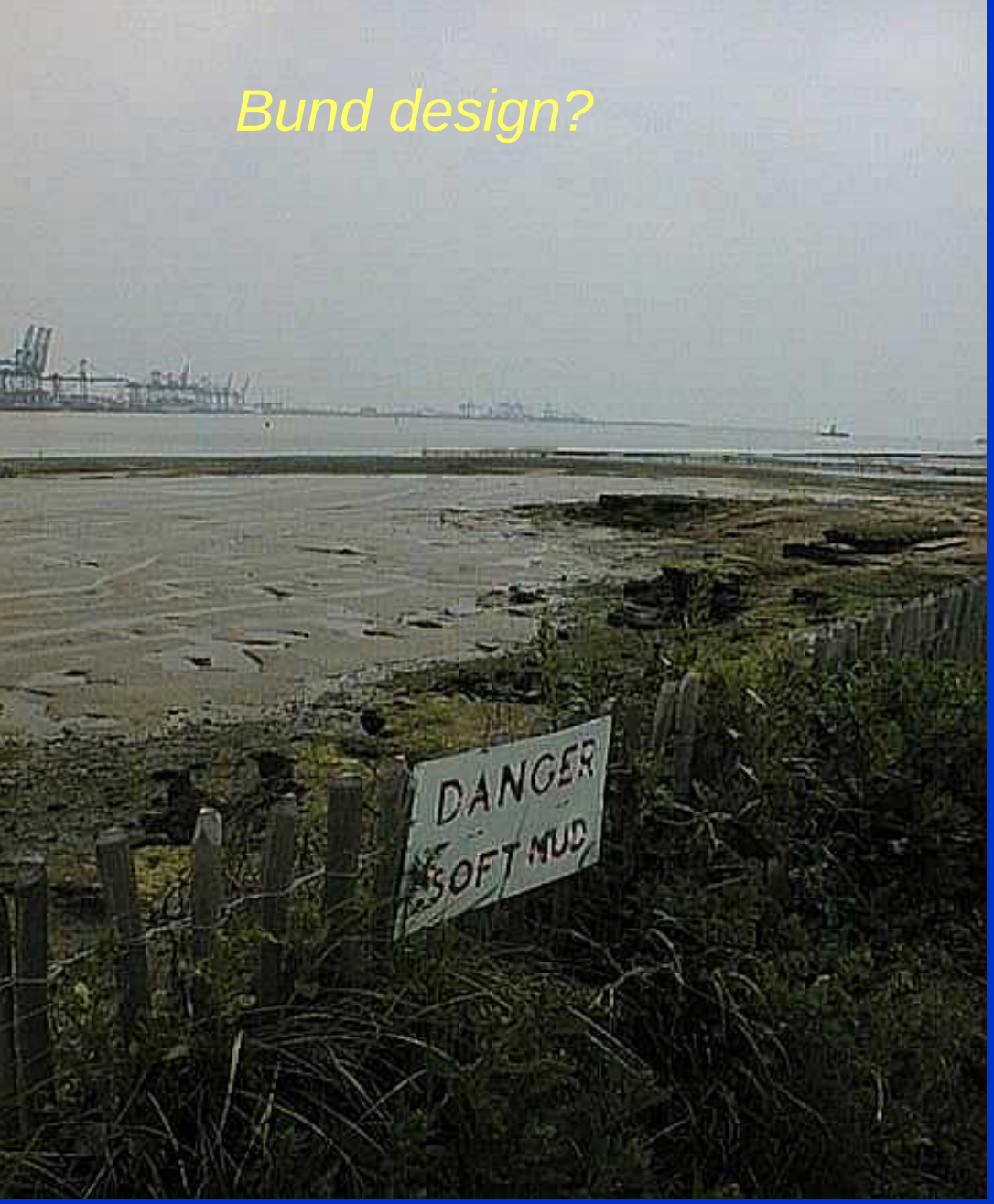
Orplands, SE England, U.K



- Foreshore recharge 1997
- Wave energy, bund roll-back & erosion

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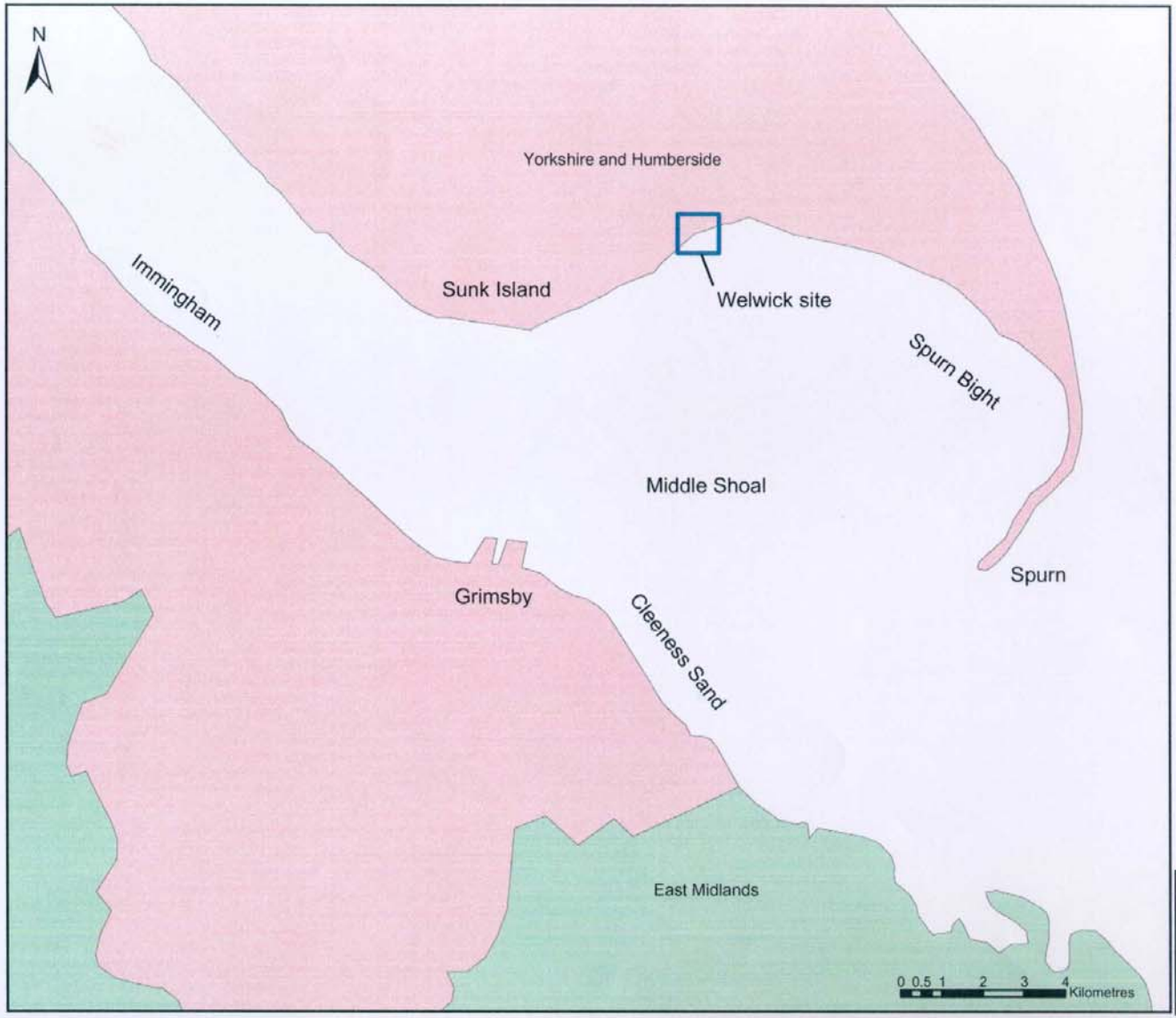
Shotley, SE England, U.K



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Location: R:\Projects\Gis_3233\welwick_locmap.mxd

ABP mer
marine environmental research

Location of the Welwick site in the Humber Estuary

Figure 1

Historical development

Elevations

Existing habitats

Modelling

Archeological survey

Ecological survey

Grain size and contamination survey

Geotechnical ground investigation

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Humber Estuary, NE England, U.K.

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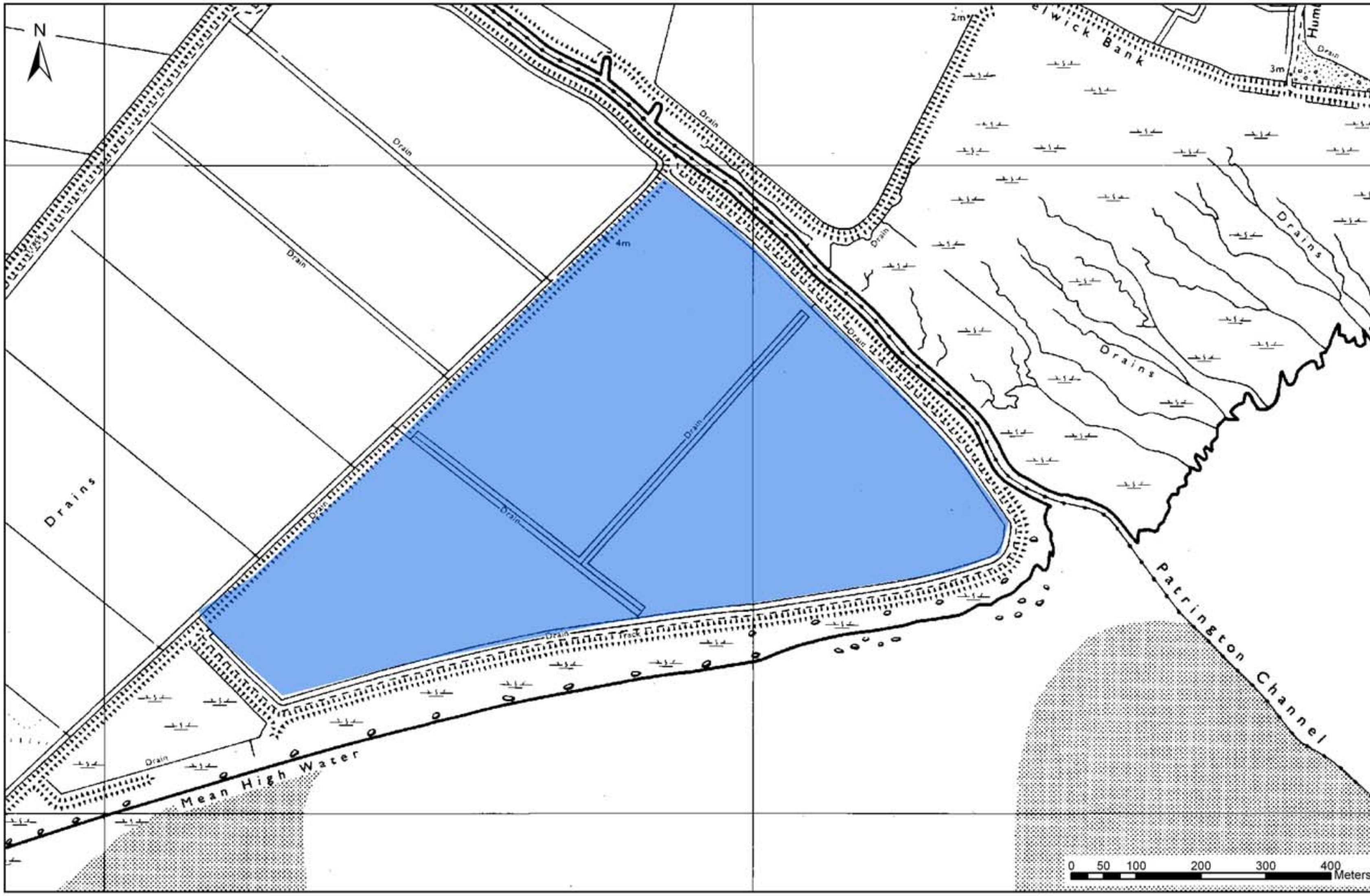

2000

Based upon the Ordnance Survey 1: 10 000 scale map, supplied by Envirocheck © 2000
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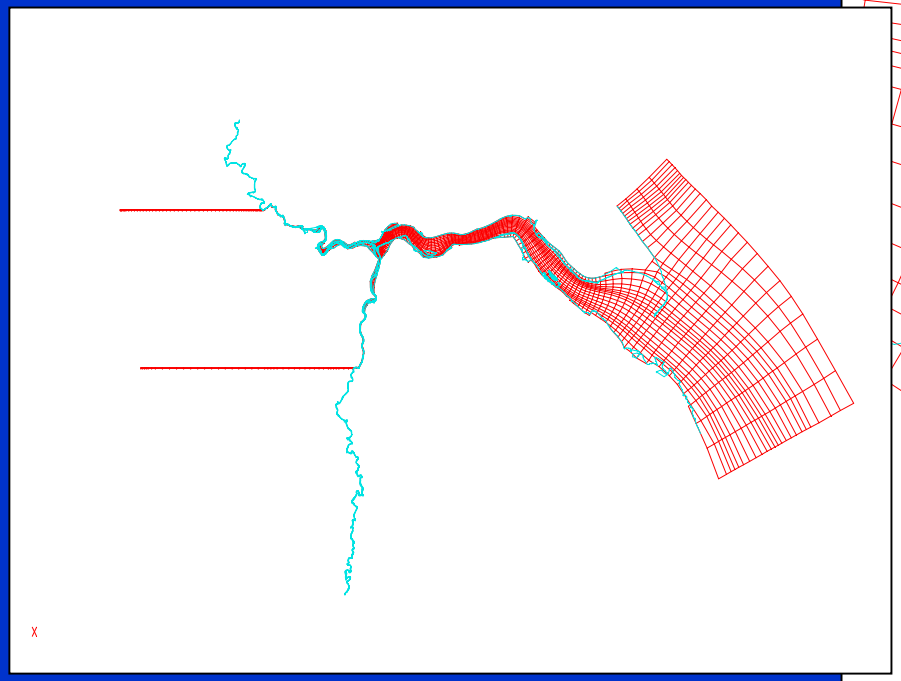
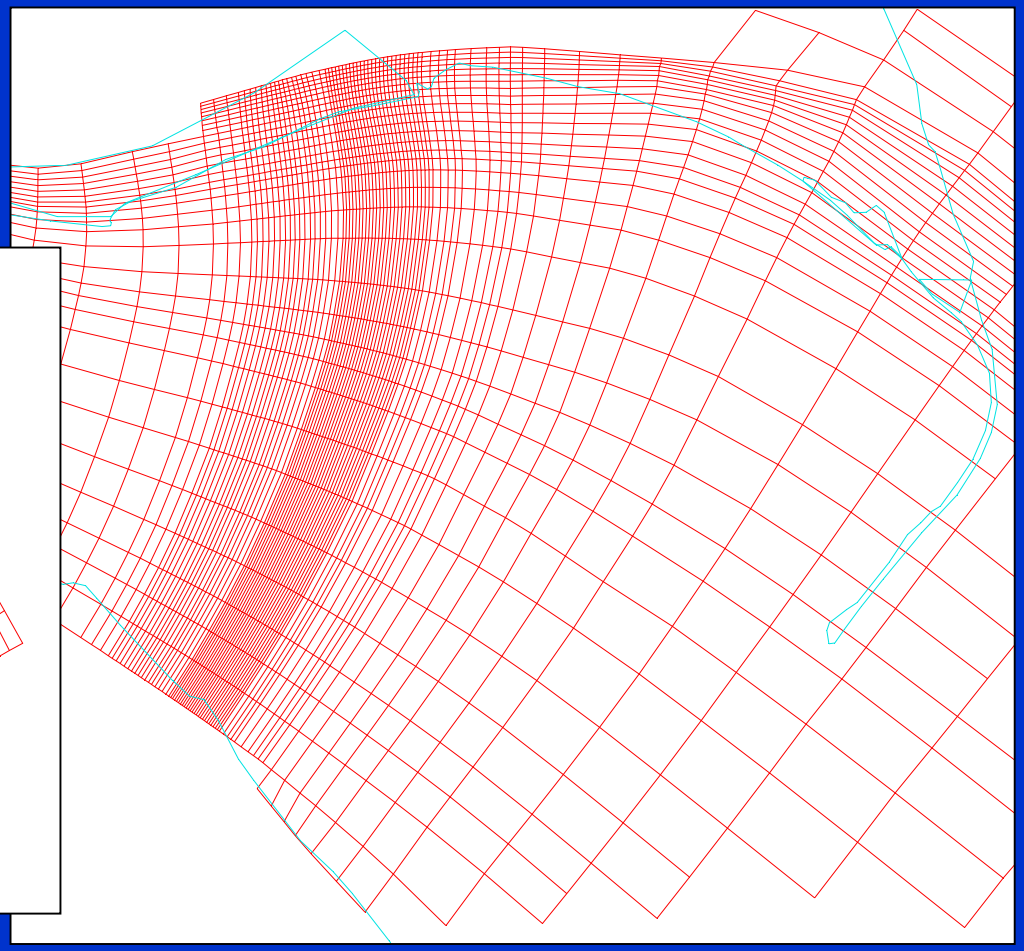
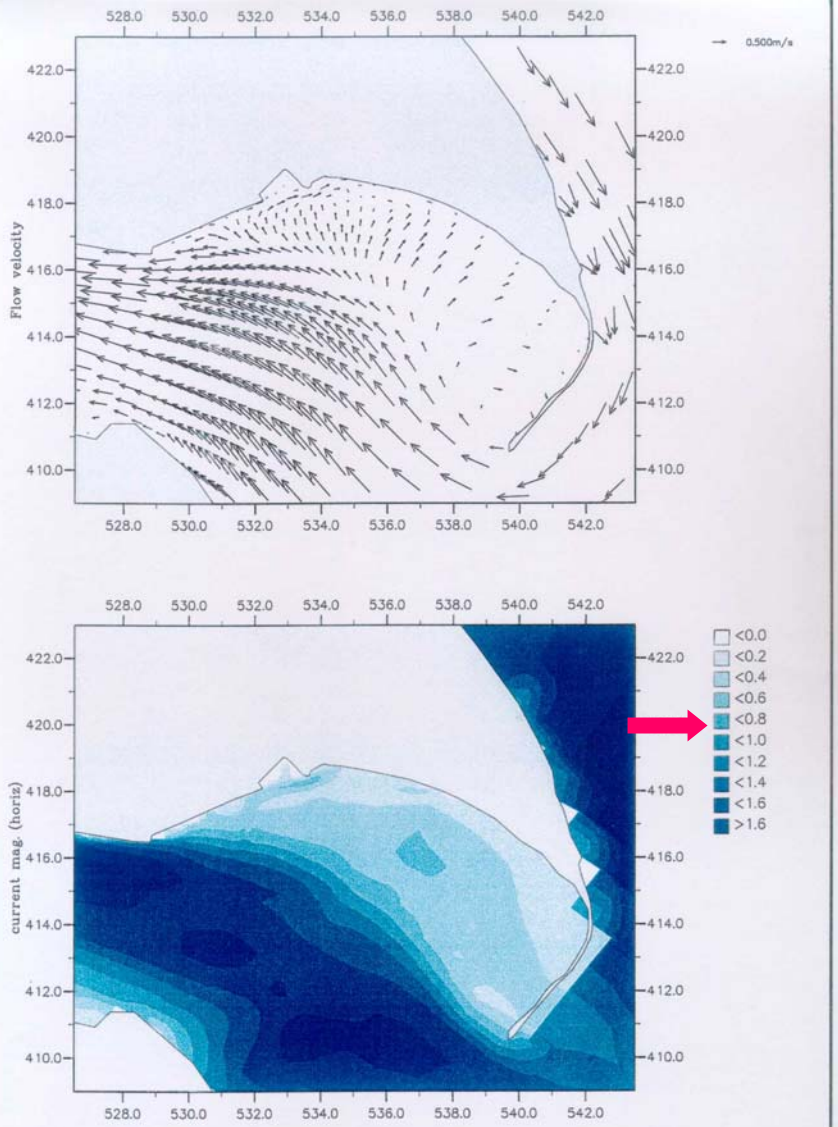
Modelling tides, waves, sedimentation







Top plot: Flow vectors during peak flood Bottom plot: Flow speed contours during peak flood	With scheme	
	Spring tide	
ABP Marine Environmental Research	Units in m/s	Figure 18

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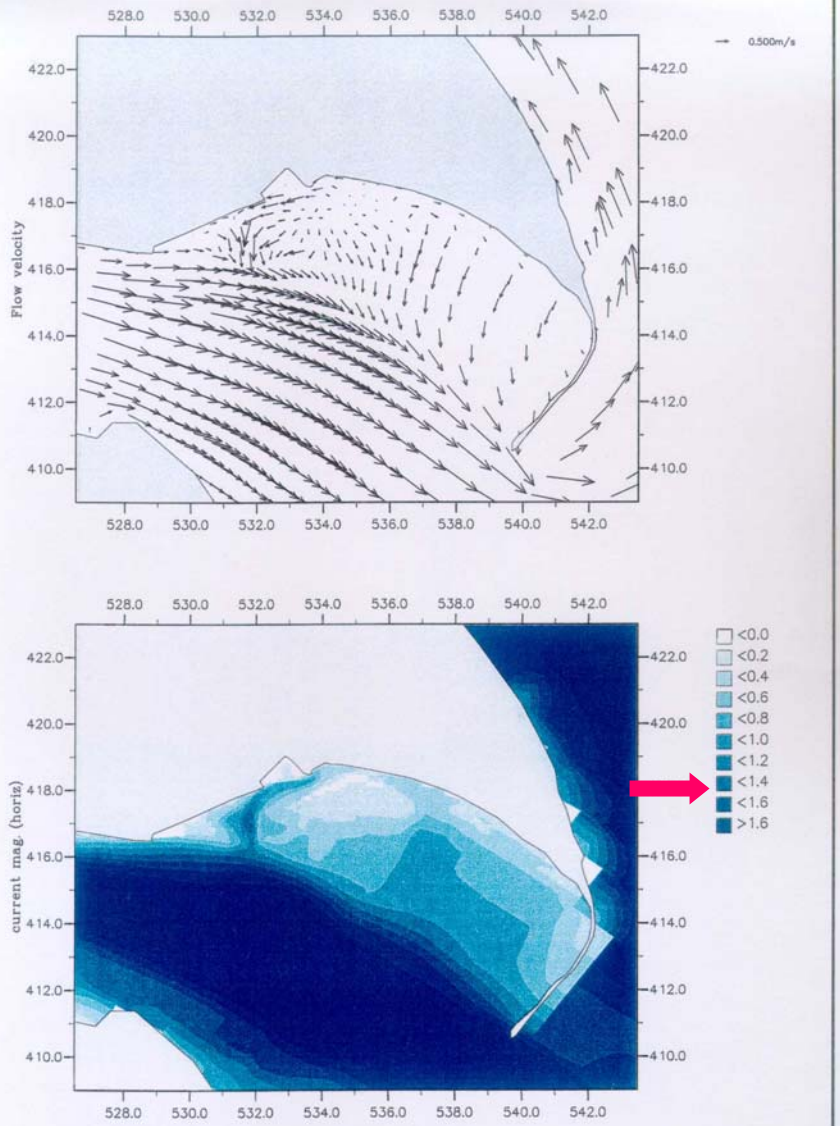

Top plot: Flow vectors during peak ebb Bottom plot: Flow speed contours during peak ebb	With scheme	
	Spring tide	
ABP Marine Environmental Research	Units in m/s	Figure 20

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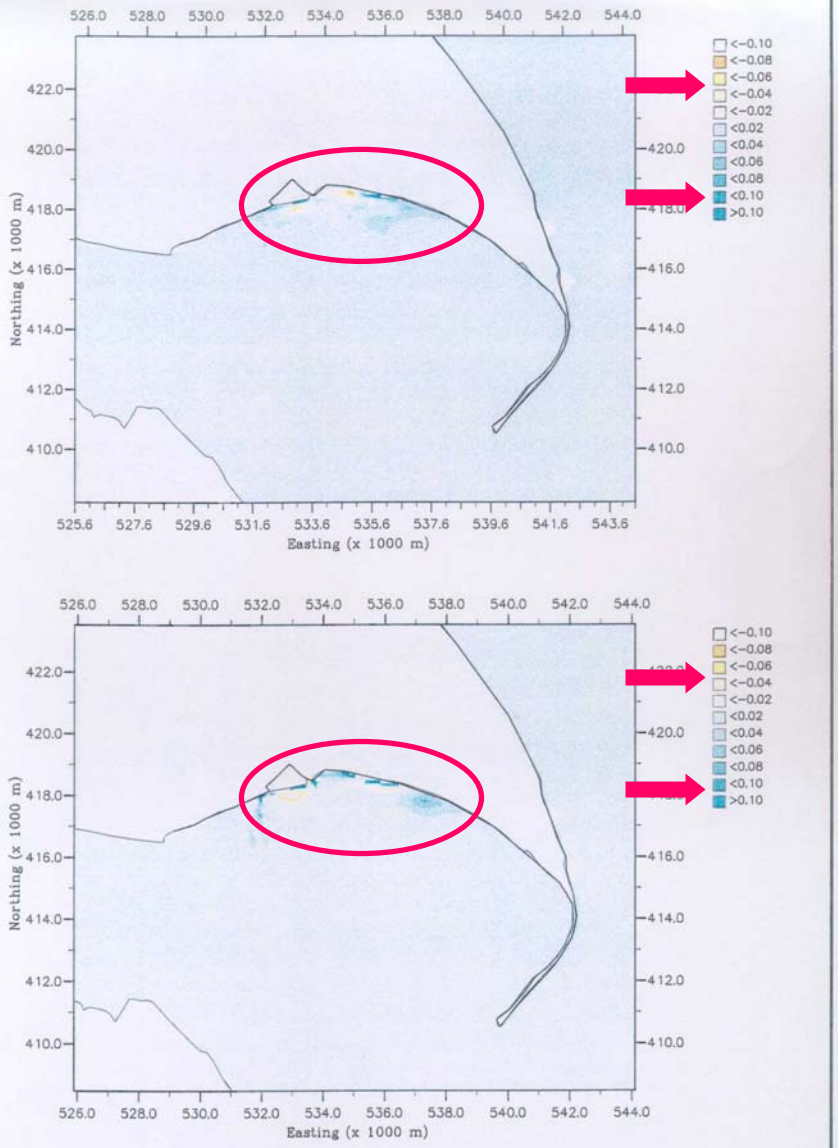

Top plot: Difference in flow speeds (peak flood)
Bottom plot: Difference in flow speeds (peak ebb)
NB: −ve change = reduction in speed

Spring tide

ABP Marine Environmental Research

Units in m/s

Figure 21

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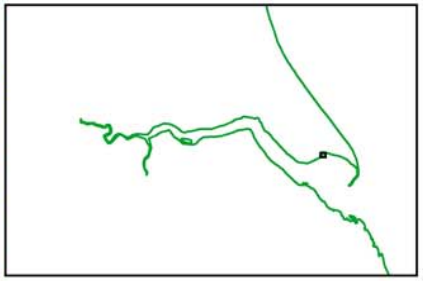

Vegetation

- Mudflat
- Pionner Saltmarsh
- Mid-Saltmarsh
- Upper Saltmarsh
- Brackish Saltmarsh
- Grassland

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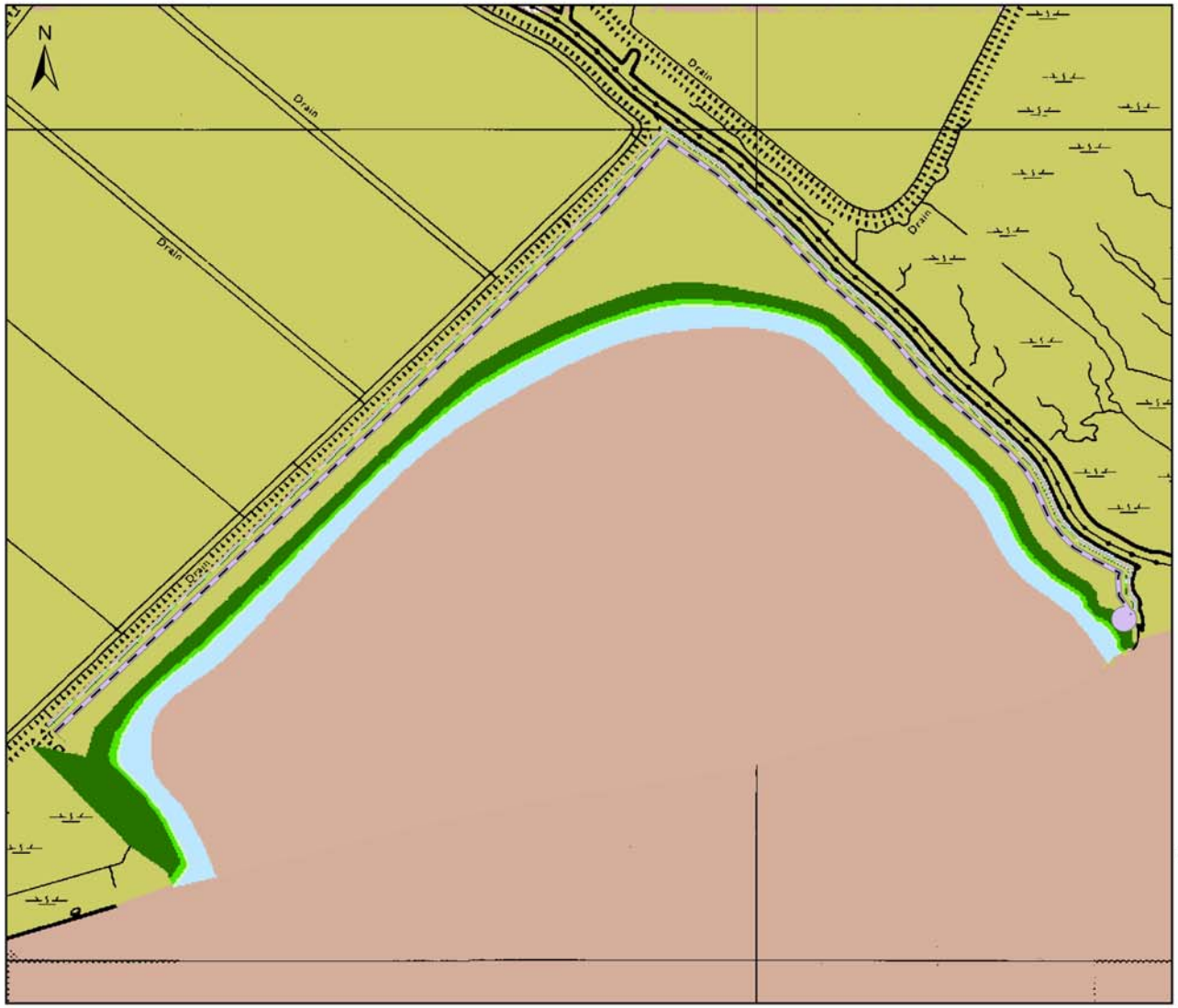
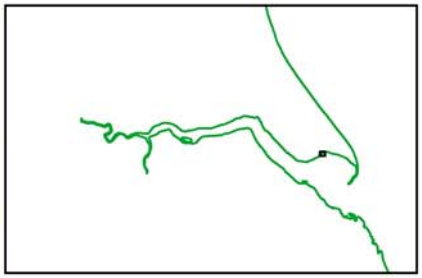
Predicted habitats for existing elevations

Figure 1





Proposed Footpath

Proposed Sea wall Crest

Vegetation

- Mudflat
- Pioneer Saltmarsh
- Mid-Saltmarsh
- Upper Saltmarsh
- Brackish Saltmarsh
- Grassland

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Location: R:\Projects\Gis_3233\welwick_new_C4.mxd

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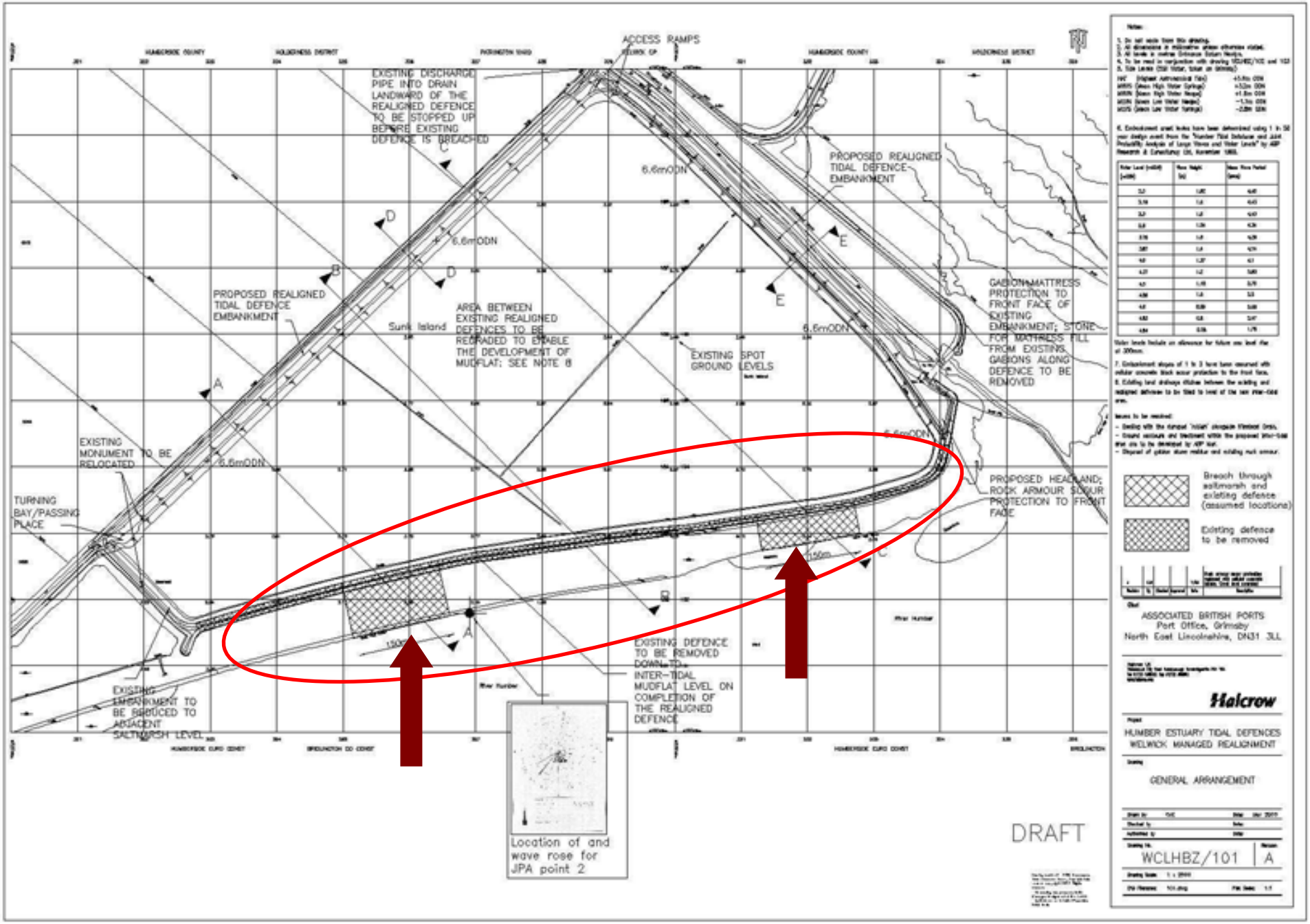
Welwick - Proposed scheme design showing removal of sea wall and predicted habitats

Figure 6


ACCESS RAMPS
EXISTING DISCHARGE PIPE INTO DRAIN LANDWARD OF THE REALIGNED DEFENCE TO BE STOPPED UP BEFORE EXISTING DEFENCE IS BREACHED
PROPOSED REALIGNED TIDAL DEFENCE EMBANKMENT
6.6mODN
PROPOSED REALIGNED TIDAL DEFENCE EMBANKMENT
Sunk Island
AREA BETWEEN EXISTING REALIGNED DEFENCES TO BE REGRADED TO ENABLE THE DEVELOPMENT OF MUDFLAT; SEE NOTE 8
EXISTING SPOT GROUND LEVELS
GABION/MATTRESS PROTECTION TO FRONT FACE OF EXISTING EMBANKMENT; STONE FOR MATTRESS FILL FROM EXISTING GABIONS ALONG DEFENCE TO BE REMOVED
EXISTING MONUMENT TO BE RELOCATED
TURNING BAY/PASSING PLACE
PROPOSED HEADLAND; ROCK ARMOUR SLOPE PROTECTION TO FRONT FACE
EXISTING EMBANKMENT TO BE REDUCED TO ADJACENT SALTMARSH LEVEL
EXISTING DEFENCE TO BE REMOVED DOWN TO INTER-TIDAL MUDFLAT LEVEL ON COMPLETION OF THE REALIGNED DEFENCE
Location of and wave rose for JPA point 2
Breach through saltmarsh and existing defence (assumed locations)
Existing defence to be removed
ASSOCIATED BRITISH PORTS
Port Office, Grimsby
North East Lincolnshire, DN31 3LL
Halcrow
HUMBER ESTUARY TIDAL DEFENCES
WELWICK MANAGED REALIGNMENT
GENERAL ARRANGEMENT
DRAFT
WCLHBZ/101
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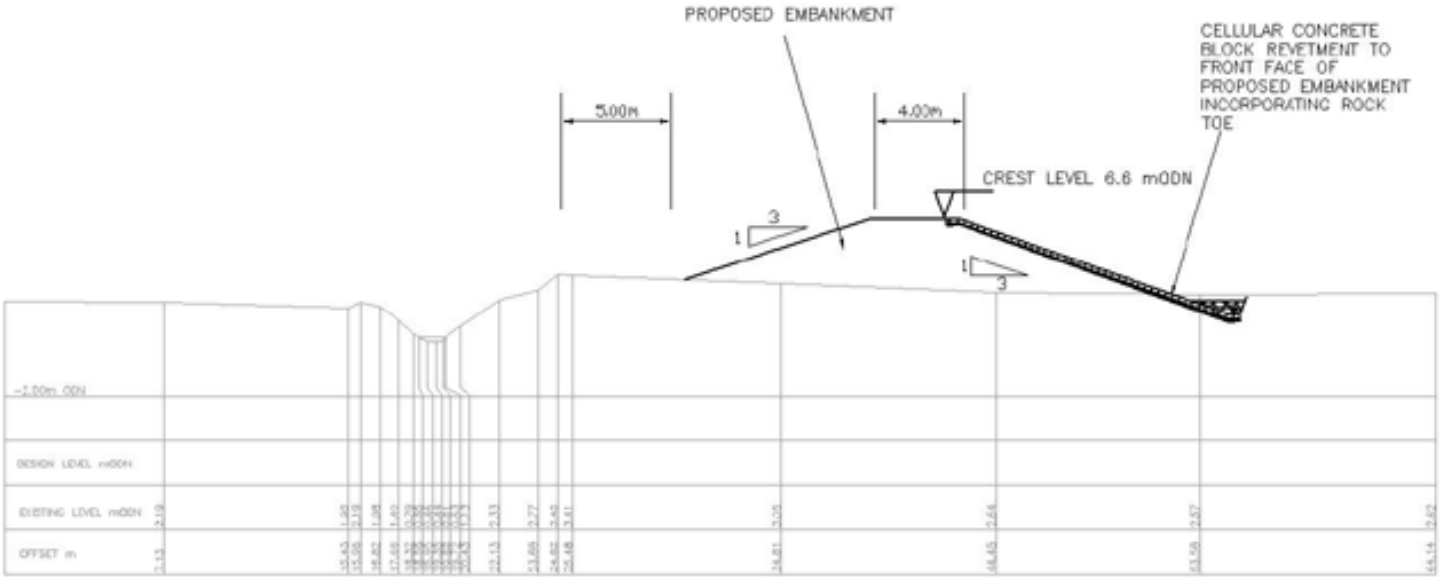

CROSS SECTION D – D

Conclusions

Site characterisation involves…..

- Systems & linkages
- Physical/biological/chemical factors
- Regional/estuary wide evaluation
- Multicriteria decision analysis
- Site specific evaluation

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