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COMEM

DEVELOPMENT OF A EUROPEAN SITE SELECTION TOOL FOR MANAGED REALIGNMENT

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Abstract

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By Onno Musch

Accelerating rising sea levels, aging coastal defences, and an ever increasing demand for land along the coast, require imminent, reactive, as well as long-term, anticipatory, adaptation by society. One such, relatively novel adaptation strategy, is managed realignment. Managed realignment site selection being non-standardised, this has, to date, necessitated the development of a site-specific selection process for most potential schemes. This status quo has attributed a perceived complexity to managed realignment strategy implementation.

This study explores the possibility of creating a site selection tool that may be applied to potential managed realignment sites throughout Europe. A representative range of 9 locations in 9 Western European countries (the Netherlands, Belgium, Germany, France, UK, Spain, Poland, Bulgaria and Italy) are looked at with regards to the current state of managed realignment as well as the potential drivers for managed realignment, constraints hindering the implementation of schemes and the site selection tools currently being employed. Through methods such as questionnaires, interviews and selective site visits, data is gathered for each study site. Key findings regarding managed realignment criteria and site selection processes are then collated into a Europe-wide applicable site selection tool.

This study finds that, although drivers for managed realignment schemes vary from site to site, a primary driver may be identified for any given managed realignment scheme. Also, current constraints to scheme implementation are seen to be dominated by financial and political factors. Further, this study finds that current site selection tools contain adequate detail in criteria, but assume pre-conceived drivers and possibilities for managed realignment that exclude the possibility of wider-spread use in other schemes. In addition, the lack of quantitative criteria analysis and the need for a 'filter' in the selection process are identified in this study.

Using the data gathered the European Site Selection Tool (ESST) is created and tested on a site selection case study along the Solent. The ESST is found to perform satisfactorily though further testing is recommended.

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List of Abbreviations and Acronyms

ABPmer	Associated British Port Marine Environmental Research
BAU	Business As Usual
BTB	'Berijd Te Betalen' (Willingness to Pay)
CBA	Cost Benefit Analysis
CWSS	Common Wadden Sea Secretariat
Defra	Department of Environment Food and Rural Affairs
EA	Environment Agency
EDG	Extended Deep Green
ESST	European Site Selection Tool
EU	European Union
FRM	Flood Risk Management
GIS	Geographic Information System
Ha	Hectare
HTL	Hold The Liine
MR	Managed Realignment
MO	Management Option
OMReG	the Online Managed Realignment Guide
Ramsar	Ramsar Convention on Wetlands
RSPB	the Royal Society for the Protection of Birds
RTE	Regulated Tidal Exchange
SLR	Sea Level Rise
SMP	Shoreline Management Plan
UK	United Kingdom

1.0 Introduction

Accelerating rising sea levels, aging coastal defences, and an ever increasing demand for land along the coast, require imminent, reactive, as well as long-term, anticipatory, adaptation by society. Coastal settlements have been subjected to changing environments since the beginning of time and adaptation to reduce vulnerability comes intuitively (STERR, 2008). A plethora of varying strategies have been developed over time to cope with the strains on the coastal areas worldwide. Historically the majority of these strategies comprised the use of hard defences however, with the apparent disappearance of natural coastal buffers exacerbating flood risk, new synergetic accommodation measures are being developed. One such, relatively novel strategy, with the first known scheme being implemented in the 1980's, is managed realignment (RUPP, 2010). Managed realignment involves setting back the line of actively maintained defences to inland of the original (BURD, 1995). This measure allows for the re-colonization, by ecological processes, of the previously defended land and the corresponding creation of a natural flood risk safeguard. Implementation may vary from a basic breaching of the defence line, allowing a fully natural formation of the scheme, to a very controlled Regulated Tidal Exchange (RTE) scheme where sluice gates manage water levels within the site carefully. Managed realignment (henceforth denoted as MR) schemes may be implemented for a variety of reasons, ranging from a nature compensation scheme to balance out consequences from land reclamation projects to the creation of a self-sustaining salt marsh that will act as a low-maintenance sea defence capable of adapting to sea level rise over time (FRENCH, 2001).

At present MR has been successfully implemented in 7 European countries (UK, Germany, the Netherlands, Belgium, Spain, France and Denmark) with the total number of schemes coming to 102 (ABPmer, 2010). Site selection being non-standardised, this has, to date, necessitated the development of a site-specific selection process for most potential MR schemes. This status quo has attributed a perceived complexity to MR strategy implementation (SHEPARD *et al,* 2007).

This study will explore the possibility of creating a site selection tool that may be applied to potential MR sites throughout Europe. A representative range of 9 locations in 9 Western European countries (the Netherlands, Belgium, Germany, France, UK, Spain, Poland, Bulgaria and Italy) will be looked at with regards to the current state of MR as well as the potential drivers for MR, constraints hindering the implementation of schemes and the site selection tools currently being employed.

2.0 Aims and Objectives

This dissertation aims to develop a user friendly, generic site selection tool which can be used for the identification of suitable managed realignment schemes throughout Europe. This tool will differ from extant tools by integrating MR procedures and practices of the different member states. In order to achieve this aim the following objectives had to be met:

- To investigate past, present and future trends in managed realignment throughout Europe and gain an understanding of the extent of managed realignment in the case study areas,
- To investigate the various tools currently available for site selection in Europe and determine which elements, if any, are universally applicable and may be incorporated into the new European tool,
- To gain an understanding of the similarities and differences with respect to drivers and constraints for managed realignment in different European countries using a sample of case study sites, and
- To create and test a new generic, user friendly, site selection tool, incorporating the findings of this dissertation and allowing for all the differences found amongst European countries.

In order to achieve the objectives stated above, the research draws upon the eight representative sites across Europe found within the Theseus Project. The following methodology is applied:

- A questionnaire to be completed by all study site champions,
- Interviews with all study site champions,
- Interviews with experts in the field of managed realignment at a European scale
- Site visits to the Plymouth and Scheldt site
- A test case of the tool using GIS modelling of a previously studied site

The results from this dissertation may:

- Facilitate international managed realignment scheme site selection
- Reduce complexity of procedures of MR for multi-national projects
- Improved knowledge of the state of MR throughout Europe
- Promote the use of MR and spread the implementation thereof (if desired)

3.0 Structure of Report

The dissertation is structured as follows:

Section 4 – Constitutes a literature review on managed realignment throughout Europe in general, the Theseus Project and project sites and non-generic site selection tools which have been used in the past.

Section 5 – Provides details of the methodology applied in this dissertation and discusses the limitations of the research methods.

Section 6 – Presents the results of the questionnaire surveys, the interviews and the site visits conducted for this dissertation.

Section 7 – Summarises the results obtained and discusses their significance towards the development of a European Site Selection Tool. Section 7 concludes with the presentation of the ESST.

Section 8 – Performs a rudimentary test of the ESST produced in Section 7 through GIS modelling of a previously studied site.

Section 9 – Provides a detailed discussion of the results obtained and contrasts and compares these with extant tools and literature.

Section 10 – Draws final conclusions from the data obtained and the site selection tool created. In addition recommendations for further work and research will be suggested.

4.0 Literature Review

4.1 Adaptation to coastal change in general

Sea levels are rising globally and significant impacts are being experienced in coastal areas around the world. This ranges from erosion of the cliffs in places such as the Isle of Wight to increased flood risk along extensive coastal stretches such as the Dutch coast (ENTER UK LTD, 2009; DELTA COMMISION, 2009). The United Nations Framework Convention on Climate Change (UNFCCC) has estimated a total additional cost of $4-11 billion/year for coastal engineering protection along the world's coasts assuming there is no adaptation deficit (MARTIN PARRY *et al,* 2009). Historically coastal engineering protection has taken the form of 'hard' engineering structures such as sea walls, groynes and breakwaters. However with the rising sea levels a phenomenon called 'coastal squeeze', caused by the extensive use of 'hard' engineering flood protection, is an issue along vast stretches of coast of the UK and other countries (TAYLOR *et al,* 2004). Figure 1, below illustrates the concept of 'coastal squeeze', where the saltmarshes and mudflats that would normally migrate to higher land with the rising sea levels, are 'squeezed' by the presence of sea walls and other 'hard' engineering solutions. Not only does this phenomenon eradicate valuable designated nature areas, it also weakens a sea wall's ability to protect the hinterland. In fact Dixon *et al,* found that as saltmarsh width decreases an almost linear increase in the height of the sea wall is necessitated to offer comparable protection, adding considerably to capital wall building and maintenance costs (DIXON *et al*., 1998; KING AND LESTER, 1995).

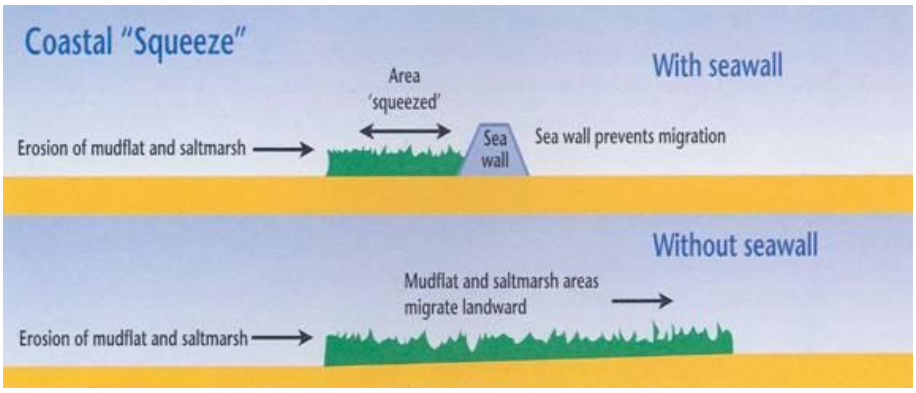


Figure 1: Illustration of the concept of 'coastal squeeze' (ELOISE, 2011: http://www.eloisegroup.org/themes/index.htm)

It has been suggested that under a 38cm sea level rise scenario, by the 2080's and bearing in mind existing trends of human destruction, global wetland losses could be as high as 70% from processes such as 'coastal squeeze', wetland erosion and land reclamation projects (NICHOLLS and HOOZEMANS, 2005). However, unlike the UK where Shoreline Management Plans are taking these new trends into consideration, many countries across Europe have no strategies to deal with the

rising sea levels (DEFRA, 2006a). The following list shows the current status of adaptation to sea level rise and climate change along the coasts of those European countries relevant to this study (TOL, *et al,* 2008):

- Bulgaria: very low awareness with no planned adaptation related to SLR
- Spain: low awareness with no planned adaptation related to SLR
- Poland: low awareness with a National coastal plan being developed
- Belgium: low awareness with no planned adaptation related to SLR
- France: medium awareness with no planned adaptation related to SLR
- Germany: high awareness with current regulations under reconsideration
- Netherlands: very high awareness with maintenance of current safety and service standards
- United Kingdom: very high awareness with accelerated SLR part of current design standards

Ecological drivers such as 'coastal squeeze' have led to the development of the field of 'soft' engineering solutions such as 'beach nourishment' (beach grade sand is placed on the beach to controll the effect of erosion) and 'managed realignment' (DEFRA, 2006a). 'soft' solutions are usually cheaper to construct and maintain and bring a certain degree of sustainability due to their ability to react and adapt to natural processes thus making them attractive from a financial and flood risk stand point (DEFRA, 2005b).

4.1.1 Cost-benefit-analysis of Managed Realignment

Due to the high value of coastal land there is often a conflict between sustaining socio-economic activity and ecological functioning of the coastal zones in Europe, in particular under current rising sea level trends (NICHOLLS, and DE LA VEGA-LEINERT, 2008). Thus, before any coastal land is planned to be realigned under a MR scheme it is important to look at the net gain of such a plan. However, due to the fact that many of the benefits of MR are not necessarily financial, performing an accurate cost-benefit-analysis becomes somewhat complicated.

When it comes to flood defence the monetary value of MR schemes is relatively straightforward: For example, the Environment Agency found in a report produced in 1996: "that where an 80m wide salt marsh is present, a 3-m-high seawall is required (£400/m), whereas with no salt marsh to dissipate the waves a 12-m-high seawall would be needed (£5000/m)" (EA, 1996). It is important to state that this relationship strongly depends on the local conditions of the site and is only meant to serve as an example of monetary valuation of MR schemes. For example, MOLLER *et al*. (2001), showed that

wave attenuation over saltmarsh was 50% higher than over sand flat, even under similar water depths, thus in an intertidal area with large areas of mudflat the financial gain would be significantly lower.

However, an important benefit of MR over 'hard' engineering solutions is also the ecological gain of the scheme. This can be measured in terms of 'how many endangered species may use the area' or 'how much people enjoy the nature area', but placing a financial figure on the ecological gain in order to perform a cost-benefit-analysis is necessary. This is an area of ongoing research with a variety of results currently available:

TURNER *et al*, (2006) suggests the following calculation for the Net Present Value of MR versus a Hold-the-Line (hard engineering) policy:

1- Managed Realignment: $C_t^{mr} = \sum_{t=0}^{T} \frac{1}{(1+r)^t} \left[l^{mr} \left(C_{k,t}^{mr} + C_{m,t}^{mr} \right) + a^{mr} \left(L_{agr,t}^{agr} - B_{e,t} \right) \right]$

2- Hold-the-line Defences: $C_t^{htl} = \sum_{t=0}^{T} \frac{1}{(1+r)^t} \left[l^{htl} \left(C_{r,t}^{htl} + C_{m,t}^{htl} \right) + C_{br,t}^{htl} \right]$

Where:

C_t^{mr} – Present value of total cost of MR at time t (£ million)

C_t^{htl} – Present value of total cost of HTL defences at time t (£ million)

r – Discount rate

l^{mr} – Length of MR defences (km)

l^{htl} – Length of HTL defences (km)

$C_{k,t}^{mr}$ – Capital cost of realignment at time t (£/km)

$C_{m,t}^{mr}$ – Maintenance cost at time t (£/km)

$C_{r,t}^{htl}$ – Replacement cost of the HTL defences at time t (£/km)

$C_{m,t}^{htl}$ – Maintenance cost of HTL defences at time t (£/km)

$C_{br,t}^{htl}$ – Cost of repairing breaches in HTL defences at time t (£/km)

a^{mr} – Area of intertidal habitat created by MR (ha)

$L_{agr,t}^{agr}$ – Forgone agricultural land value if MR takes place (£/ha)

$B_{e,t}$ – Environmental value gain associated with MR (£/ha)

3- Net Present Value: $NPV_t^{mr} = \sum_{t=0}^{t} (C_t^{mr} - C_t^{htl})$

Where:

NPV_t^{mr} – Net present value of managed realignment in comparison to hold-the-line for a given stretch of coastline (£ million)

This formula allows for the calculation of the comparative net present value of a MR scheme. However the $B_{e,t}$ value still needs to be determined in order to complete the calculation. RUPP, (2010) summarised the findings of SHEPARD *et al,* (2007) and COOMBES *et al,* (2004) as follows:

Table 1: Summary of economic wetland values

Item	Value of item at time of reference	Year value relates to	Value after adjustment to 2001/02 prices (in £)
Capital costs of realignment (realigning defences)	£811,893/km	2001-2002	811,893/km
Opportunity costs (Grade 1 & 2 land)	£2,110/ha	2001-2002	2,110/ha
Opportunity costs (Grade 3 land)	£2,382/ha	2001-2002	2,382/ha
Maintenance costs of realigned defences	£1,000/km/yr	1992	1,239/km/yr
Maintenance of non-realigned defences (max.)	£5,000/km/yr	2000	5,127/km/yr
Replacement costs	£618,000/km	2001	618,000/km
General habitat creation benefits	US$211-456/ha/yr	2003/1990	122(574)/ha/yr
Carbon sequestration benefits	£7/tonne CO_2	2000	7.18/t CO_2

A Ramsar technical report by DE GROOT *et al,* (2006), summarised the services provided by coastal wetlands to aid in the financial valuation of the areas. A possible method of putting a monetary value on cultural and recreational values of MR schemes is by looking at how much people are willing to pay for the project's benefits, also known as contingent valuation. This strategy was used in the Belgian research as shown in Figure 2, below (LIEKENS *et al*, 2010):

BTB = (a * pioniervegetatie + b * slikken en schorren + c * graslanden + d * bossen + e * open water, riet en moeras + f * heide en landduinen + g * omvang1 in hectare + h * soortenrijkdom - i * hoge soortenrijkdom * leeftijd + j * aanwezigheid wandel- en fietspaden – k * afstand in kilometer + l * natuurlijke omgeving + m * bebouwde omgeving – n * industriële omgeving + o * inkomen - p * % vrouwen + q * % lidmaatschap) * (r * omvang2 in hectare)

En BTB is groter of gelijk aan nul.

Figure 2: 'Willingness to pay' for different ecosystems in Belgium

Although the text is in Dutch, the concept of this 'willingness to pay' method can be seen from the Figure above: Each ecosystem type (slikken en schorren = mudflats and saltmarshes, bossen = forest etc.) is given a multiplication factor, as are certain important variables (eg: area in ha, industrial area, average income, % of women in population), where the multiplication factors have been found from extensive national surveys. The result is the amount of money the local population is willing to pay (BTB) for any particular site and thus a value can be attributed to any MR project site.

By using a valuation method such as the ones discussed above, it is possible to use the Net Present Value calculation of TURNER *et al,* (2006), to come to a financial comparison between a MR scheme and a Hold-The-Line policy where 'hard' engineering measures are used.

4.2 Managed Realignment

4.2.1 Current Situation

According to the OMReG database developed by ABPmer a total of 84 MR schemes have been implemented to this date (ABPmer, 2010). MR and Regulated Tidal Exchange (RTE) schemes can currently be found in Scotland, England, Belgium, Netherlands, Germany, Denmark, France and Spain.

However, the popularity of MR as a coastal management tool remains limited in most European countries. In Graveyron, France, for example, a survey was carried out and the results found that 62.5% of those surveyed were hostile to a de-polderisation scheme, which was explained by a strong attachment to the polder's heritage (GOELDER-GIANELLA, 2007). The same paper found that a lack of knowledge of the inter-tidal ecology and MR in general was of significant importance as "it was also those most hostile to the scheme who knew least about the polder environment" (GOELDER-GIANELLA, 2007). The study further found that the degree of human control in a MR scheme contributes to the public positive/negative perception where "opposition or indifference rises as human intervention drops and diminishes as the latter rises" (GOELDER-GIANELLA, 2007). The public of the UK may have the most positive attitude towards MR, which may be due to the large amount of publication of previous schemes, well documented coastal plans (in the form of Shoreline Management Plans (DEFRA, 2006a)) as well as a significant influence of the Royal Society for the Protection of Birds (RSPB) as was found in a survey carried out by CHADENAS, (2003).

A variety of both national as well as international programs have been introduced to promote MR schemes. In the UK the Countryside Stewardship scheme sets up an agreement with landowners that the land can be returned in 10 years' time (HALCROW *et al*, 2002). This scheme has had limited popularity due to the "relative irreversibility of the change" as it is perceived by many of the landowners (LEDOUX *et al,* 2004). In Germany the federal state of Mecklenburg Western Pomerania's 'grassland program' pays the local farmers €200/ha to extensively graze the coastal inundation strips and create salt grassland (FOCK, 2002). The idea of this scheme is to make MR economically 'on-par' with dike upkeep and intensive grazing. Finally a 'land exchange program' in Belgium, involves the government buying up suitable farm land in areas away from the Scheldt estuary for future exchange purposes with the aim of making it easier to acquire land for MR

schemes (RUPP, 2010). An international partnership such as the 'Three Wadden Sea states' has set agreements to extensive MR within the summer polders of the Netherlands and Germany and is directly geared towards promoting the use of MR as a coastal management tool (CWSS, 2001). RUPP, (2010) found: "…the application of these [MR] techniques seems to be accelerating in terms of both number and area of schemes, this trend can be expected to continue, as judged by the plethora of planned schemes found in many Western European countries."

In addition to public opposition, one of the limitations for MR scheme implementation is the complexity of procedures compared to a 'No-Acitve-Intervention' policy (LEDOUX *et al,* 2004). Currently a unique site selection procedure is being applied for almost every potential MR site throughout Europe and this lack of uniformity is increasing the complexity of MR projects and is thus an area that requires development. This literature review will compare and contrast the current site selection tools available to learn what this development should aim for.

4.3 Site Selection Tools

The following site selection tools were studied in this research:

1. 'Wallasea' site selection (SCOTT, 2003) for details see Appendix VIII
    - A 2 stage tool: Stage 1: Scoping, Stage 2: Selection of preferred sites
    - Includes a Multi-Criteria Analysis (MCA) where points are attributed for each set of criteria to form a ranking of the preferred sites. Points are given on a comparative basis between the preferred sites selected in Stage 2 (eg: for the criteria of site size, if 6 sites were selected in Stage 2, the largest potential site is attributed 6 points and the smallest potential site 1 point)
2. 'Solent' site selection (COPE, 2008) for details see Appendix IX
    - Four time epochs were identified: 0-19, 20-49, 50-100 and 100+
    - A matrix was designed where each site is ranked for each time epoch and within their potential management option (mo). (mo = re-align, private abandon, abandon, hold-the-line, naturally occurring and factored out)
3. 'Humber' site selection (TURNER *et al,* 2006) for details see Appendix V
    - A 3 stage tool: Stage 1: Scoping, Stage 2: Analysis, Stage 3: Evaluation
    - 5 possible management scenarios are identified: Hold-The-Line, Business As Usual, Policy Targets, Deep Green and Extended Deep Green
    - Criteria are set for each of the 5 scenarios, where, for example, the EDG scenario focuses for a large degree on the environment, certain criteria will carry greater weighting.

4. General guidelines provided by RUPP (2010), for details see Appendix VI
    - 2 stages are suggested: Basic screening and Detailed screening
    - Basic screening consists of an initial investigation of the site to ensure its suitability
    - Detailed screening is split into 4 categories: Habitat, Economic, Flood defence and Social/Political suitability
    - For each category a list of detailed criteria is suggested
    - These guideline have not been used or tested in the field
5. International case study by Comcoast (AHLHORN, 2007) for details see Appendix VII
    - 4 phases are suggested: Phase 1: Preparation, Phase 2: Involvement of Stakeholders, Phase 3: Detailed Investigation and Phase 4: Involvement of Stakeholders II.
    - Phase 1 produces a map of the conflict potential and opportunities for solution approaches
    - Phase 2 determines what detailed investigation is necessary
    - Phase 3 and 4 carry out the detailed investigation and assess the results
    - These guideline have not been used or tested in the field

The data required for the different site selection tools is summarized in Table 2.

Table 2: Summary of criteria of site selection tools

	Humber	Wallasea	Solent	Rupp	Comcoast
Site Size	■	■	■	■	■
Site Shape	■			■	■
Site Elevation	■	■	■	■	■
Proximity to existing habitat	■	■	■	■	■
infrastructure in area	■	■		■	■
Historical context	■		■	■	■
Present land use of the area	■	■	■	■	■
Area below the high spring tide level	■				
slope				■	
low energy exposure				■	■
No water logging				■	
not adjacent to major road				■	■
tidal creek present				■	
No/limited new defence needed		■	■	■	■
close to navigation channel				■	
Low value of fronting habitats				■	■
Low standard of existing defence		■	■	■	■
High wave attenuation potential				■	
Low impact on tidal prism		■	■	■	■
beneficial impact on water storage				■	
No public right of way			■	■	
Preferred management option is not Hold-The-Line		■		■	
Number of owners		■	■	■	■

Clearly the guidelines provided by RUPP (2010) takes the most complete list of criteria into consideration. Most of the criteria are shared by all site selection methods (EA – HESMP, 2000). Some criteria, such as ‘no water logging’, are important but are not included in most of the tools. On

the other hand, criteria such as 'Preferred management option is not Hold-The-Line' may be too limiting, where many European countries do not have a clear, overall, coastal management plan.

The Wallasea and Comcoast tools both attach weightings to the criteria in order to come to a ranking at the end of the tool. These ranking are very effective but also very specific seeing as the weighting/scoring of various criteria can vary depending on the main driver for site selection (mitigation/compensation, flood and coastal defence etc) and can therefore rule out the possibility of another MR project using the tool (PARKER *et al,* 2004). In addition "in many cases apart from elevation/tidal inundation the scores and thresholds are qualitative rather than quantitative (For example: BINNIE BLACK and VEATCH, 2000)" (PARKER *et al,* 2004). A more quantitative approach may give more reliable and easily standardised results.

Site selection criteria do not only vary for different objectives, they may also be dependent on the type of ecosystem on site. For salt marsh and mudflat creation, the key factors according to PARKER *et al,* (2004), were found to be:

- Proximity to similar habitats (indicating potential for successful creation);
- History of previous habitat at the site;
- Site elevation and tidal inundation;
- Site gradient;
- Drainage;
- Sediment supply and the ability to adjust to sea level rise;
- Salinity;
- Water quality

However, with regards to Eel grass a different set of criteria was found to dominate:

- Proximity to similar habitats (indicating potential for successful creation);
- Turbidity;
- Degree of exposure to waves and currents;
- Composition of the substrate;
- Site elevation and tidal inundation;
- Water quality;
- Competition from invasive species.

Thus, in order to keep the tool, being developed in this study, applicable for all of Europe's varied eco-systems, the tool must take into consideration those criteria applicable to all systems.

The Comcoast tool places a large emphasis on stakeholder involvement with meetings at various stages throughout the process. The Comcoast method is the only method that mentions the involvement of stakeholders in the process. This may be a crucial difference for site selection tools as MYATT *et al,* (2003a, 2003b) found in the UK, where those surveyed suggested that people be henceforth consulted "once the Environment Agency has selected a number of possible options…"

GIS modelling has been suggested in all the tools mentioned above and seems to be an effective method of site selection. In the critical comparison of selection tools produced by PARKER *et al,* (2004), he found GIS to the most comprehensive and clear medium for site selection:

> *"GIS can be applied as a tool to provide a rapid overview of potential sites for habitat creation within an estuary or coastline area. The GIS acts as a framework to bring together spatial data on different criteria relevant to site selection and then integrate them using the associated criteria thresholds to specify the sites that have characteristics that fit the requirements."* (PARKER *et al,* 2004)

For the development of a European Site Selection Tool, a combination of the tools produced to date may be applicable. Where the various criteria and possible rankings are critically studied and valid concepts (ie: stakeholder involvement from the Comcoast method) carried through into the new tool.

4.4 Drivers

The possible drivers for MR schemes have been studied in a variety of papers (for example: RUPP, 2010; LEGGETT *et al,* 2004; HALCROW *et al,* 2002) although most have focussed on the UK situation. The following 3 categories of drivers re-occur in all the documented literature:

1. Flood management
2. Environmental benefit
3. Financial benefit

In addition LEGGETT *et al* (2004) suggests legislation and navigation as two further driver categories and RUPP (2010) differentiates between compensation and nature conservation as two separate categories.

The three main categories can be seen as having the following benefits for coastal areas as collated from the available studies of this field (LEGGETT *et al, 2004; HALCROW et al,* 2002; PARKER *et al,* 2004; RUPP, 2010*)*:

1. Flood management
    a. Reduce the flood risk elsewhere in the system through changing of the hydrodynamic conditions.
    b. Improve the flood risk conditions in accordance with national legislation.
    c. Avoid uncontrolled abandonment of 'weak spots' in the dike.
    d. Manage the effects of sea level rise over time.
2. Environmental benefit
    a. Increase the diversity and ecological richness of the area.
    b. Increase or manage the existing ecosystems in accordance with local/international legislation.
    c. Compensate for engineering works or long term processes such as coastal squeeze in accordance with local/international legislation.
    d. Create areas with a high recreational value for eco-tourism.
    e. Provide nutrient and pollution sinks that purify the water.
3. Financial benefit
    a. Require smaller defences due to wave attenuation on salt marsh
    b. Create a sustainable flood defence that will provide safety for a longer period of time.
    c. Lower the maintenance cost of the flood defence system as a whole.

The drivers identified here will be carried forward and used in the questionnaires (see Section 5.1), where they will be rated on relative importance for the different study site. This study will also differentiate between compensation and nature conservation as two distinct categories.

4.5 Constraints

A large variety of possible constraints for MR has been identified in the research into this field. The following is a non-exhaustive list of examples from available studies (LEGGETT *et al, 2004; HALCROW et al,* 2002; PARKER *et al,* 2004; RUPP, 2010; DIXON *et al,* 1998):

1. Insufficient compensation for landowners
2. Potential loss of land with high economic value
3. High cost of MR
4. Lack of support from public
5. Potential loss of freshwater habitats
6. Flood risk management not apparent
7. Complexity involved in implementation

8. Legislation against MR
9. Immovable infrastructure
10. Population density
11. Inappropriate topography of area
12. Lack of technical knowledge
13. Lack of required data
14. Difficulty of re-creating diverse habitat
15. Time lag to full flood risk benefit as it takes time for the salt marshes to grow

Although there are still more, other, possible constraints to MR, the various studies were combined and the most frequently cited 11 constraints were taken forward into the questionnaire (Section 5.1).

4.6 Study Sites

The study sites selected for this project needed to be of a representative range for Europe as a whole. In addition it had to be possible within the short time frame to access people with knowledge of the area and an understanding of coastal management. Thus the Theseus Project sites were selected as the representative range. The EU run, Theseus Project aims to: – "examine the application of innovative combined coastal mitigation and adaptation technologies…" (THESEUS, 2010). The Theseus sites include: Plymouth, UK; Scheldt, Netherlands; Scheldt, Belgium; Elbe, Germany; Hel Peninsula, Poland; Santander, Spain; Gironde, France; Po River Delta, Italy; Varna, Bulgaria. They are located at well distributed sites throughout Europe as shown in Figure 3, below.

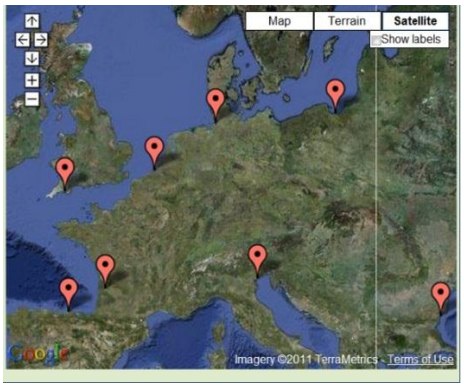


Figure 3: Map of Theseus project sites (http://www.theseusproject.eu/)

In addition there is a well-established line of communication between the sites and they were selected for having interesting coastal situations as is described below. (All the information shown here was obtained directly from the Theseus Project literature as collated by the site champions)

1. **Plymouth, UK;**

The 'Plymouth' case study area covers a very large area from the Plymouth estuary to the Exe. Some areas of particular interest were identified as:

- Exe estuary: including the Dawlish Warren spit, the estuary is experiencing significant erosion problems and with the spit currently at only 30m wide at its smallest point due to storm events during the winter of 2010. One area of potential MR has been identified in this area in the SMP (see Appendix X)
- Teignmouth estuary: damaged sea walls and the railway along the coast in this section, combined with existing mudflats and fisheries make this an interesting study area. Various potential MR schemes have been suggested in the SMP (see Appendix X)
- Slapton Ley: natural erosion of the shingle beach is threatening an important road as well as a fresh water ecosystem. The area has been identified as a potential MR scheme in the local SMP (see Appendix X)

The SMP prepared for this region by the South Devon and Dorset Coastal Advisory Group (SDADCAG) has collated data and suggests areas for MR. Due to this strategy investigation, data for GIS purposes is readily available for this area.

2. **Scheldt, Netherlands/Belgium;**

Maintenance of the shipping channel to the port of Antwerp has called for deepening of the main channels in the Scheldt estuary. This process has increased current velocities and the tidal amplitude which is also being increased by the funnelling effect of the shape of the estuary (3m at the mouth and more than 5m at the port of Antwerp). MR at this site could serve to dampen the tidal energy as well as providing compensation for the planned expansion of the port of Antwerp. Also, the creation of an artificially larger tidal prism could serve to flush the channels, thus allowing for reduced dredging operations. Much of the area around the estuary is at, or below, high water level, thus making MR possible. However, local opposition to MR is strong due to a historical attachment to the polders as well as a fear of increased salination of the ground amongst the local farming population.

The Scheldt is situated in both the Netherlands and Belgium, making it an international study site. Currently 5 large MR schemes exist along the Belgian Scheldt with 8 more schemes in the planning stages bringing the total to approximately 5000ha of MR projects. In contrast, there are no schemes at this moment along the Dutch Scheldt, though 3 schemes are currently being implemented.

Despite some MR plans along the Dutch Scheldt, the 6000ha that were reclaimed since the 1960's require much more extensive compensation in the future.

3. **Elbe, Germany;**

Due to extensive engineering works over the centuries, this estuary no longer 'meanders' and the flood tide comes in with more energy and thus increases the likelihood of flooding. Managed realignment in this area could dampen the tidal energy whilst also allowing for nature invigoration.

However, the present flood defence improvement program which started in 1990 will be finished in 2013 and will update all dikes along the estuary to the newest safety regulations. Tidal forelands are maintained by brushwood groynes in order to encourage siltation. This is mainly done to protect the green outer slopes of the sea dikes, but also works as compensation for works on the port of Hamburg. Up to 2010 the port expansions were exempt from Nature laws, however now this will have to be adjusted. In addition, all dike expansions towards the sea have to be compensated for and seeing as the entire stretch of the Elbe is embanked, compensation required is extensive. Interestingly for this area, flood risk data as well as land use data is only available when purchased from the Authority for land-registry and surveying.

4. **Hel Peninsula, Poland;**

Most of the coastline around the Hel Peninsula lies above the high tide water elevation, thus making a managed realignment scheme improbable. The peninsula itself is subject to strong erosion and is heavily developed, especially by tourist facilities. Tourism makes the land in this study area very valuable. In the rest of the Gulf of Gdansk some large areas are polder land with dikes at a mere 3m and in need of renovation. Large flooding events in 2001 clearly showed the poor dike maintenance in the area. Large nature reservations such as the Vistula Lagoon which is a Natura 2000 area, make the study area a valuable ecological asset.

5. **Santander, Spain;**

The bay of Santander has seen a large amount of anthropogenic pressure resulting in the land claim of large expanses of marsh area over the last century. Most of the areas around the bay are made up of cliffs and relatively steep beaches with limited areas appropriate for MR. However, current plans for further expansion of the port of Santander, will require compensation measures in the vicinity and plans are being developed for a MR site in the low-lying land on the East side of the bay. No effect of Sea Level Rise is taken into consideration in this study area as it is deemed to be insignificant.

6. **Gironde, France;**

The Gironde estuary experiences large tidal amplitudes due to the dredged navigation channels and the nature of the channel itself, where the tidal wave is amplified as it travels up the estuary. Managed realignment schemes along this estuary would serve to dampen the tidal energy and also improve environmental conditions in the area. Difficulties arise due to the sheer number of land-owners along the estuary (one stretch of 20km is owned by 400 different people). A survey taken in 2007 showed that 50% of dikes were in a good state of defence, 30% in a moderated state and 20% were in a bad state along the estuary.

A multitude of unmanaged realigned sites exist along the Gironde. 3 MR sites have also been identified in the area with nature creation to attract birds for hunting purposes as its main aim for two of those sites.

7. **Emilia Romagna, Italy;**

The Emilia Romagna site is experiencing significant erosional problems along the beach front. One area of particular significance for this study is the salt marsh expanse protected by a beach. This area is retreating at a rate of 11m per year due to storm activity overtopping the beach and entering the salt marsh area. This has led to the loss of about 75ha of coastal land in 24 years and is a continuous process.

Most of the rest of the study area is very densely populated with land having a high economic value along the coast. In addition to the erosion, subsidence of the land is also affecting the coastal area due to methane extraction with rates of to 10mm/year recorded in 2006.

8. **Varna, Bulgaria.**

Most of the coastline around Varna bay and surrounding area lies above the high tide water elevation mark with only 94ha below 10m elevation. The primary concern in this area is degradation due to coastal erosion from extreme weather events. The significant wave height is, on average, smaller than 1m and the tidal fluctuations are seen as ‘irrelevant’ (in the order of 0.08m). The site has some extensive nature areas coming to a total of about 13000ha. Most of these areas are Natura 2000 sites for the preservation of wild birds and consist of reed beds rather than the salt marshes we see in most other study sites.

The following tables show an overview of the relevant data for MR for the study sites. The red coloured boxes have a negative impact on the applicability of MR for the study site, the green boxes have a positive and the orange boxes have a neutral impact. Boxes that have no colour represent

data sets that were incomplete and insufficient to comment on. This data was assimilated from the data produced by the Theseus Project site champions.

Table 3: Summary of study site attributes and available data

site	Topographic suitability			Biological suitability		Economical suitability		Hydrologic suitability
	high ground retreat	sheltered coast	lowlying lands	marsh present	land elevation adequate	state of current flood defence	funds available for M.R.	tidal range
Gironde	possible	yes	extensive	extensive	unknown	50% good, 30% moderate, 20% bad	unknown	2-4.5m Le Verdon, 4-6m Bordeaux
Scheldt	unlikely	yes	extensive	extensive	unknown	excellent - updated and reviewed every 5 years in accordance with the Delta Plan	yes - compensation for loss due to dredging	3m Vlissingen (inlet), 5m Antwerp
Elbe	unlikely	yes	extensive	extensive	unknown	excellent - all dikes updated by 2013	no - federal funds only available if new defence line is shorter/same as old line	3m at inlet, 3.6m Hamburg (+0.7m at Spring)
Plymouth	possible	semi - sheltered	limited	limited	unknown	Exe Estuary and Slapton Ley erosional problems	yes - EA funds	3-4m
Santander	possible	yes	limited	limited	unknown	not relevant	yes - compensation for land reclaimation scheme	3-4m (+1m at Spring)
Emilia Romagna	possible	no	limited	limited	unknown	good but continuous erosional problems - 11m/yr	unknown	0.95m
Gdansk	possible	no	extensive	unknown	unknown - possibly too low for saltmarshes	unknown	unknown	insignificant - wind driven tide
Varna	possible	yes	no	none	unknown	not relevant	unknown	insignificant - wind driven tide

site	Political suitability			Data availability				Schemes present	
	pro M.R. policy	general M.R. acceptance	compensation schemes	land use maps	aerial photography	topographic maps	bathymetry maps	planned schemes	completed schemes
Gironde	yes - tide reducing areas planned	no - 62.5% surveyed hostile to de-polderisation (Gianella, 2007)	none	yes	yes	yes	unknown	unknown	Ile Nouvelle (270ha), Roseliere de Chenac (350ha), Reserve de Braud (120ha)
Scheldt	yes - compensation for loss due to dredging	no - extensive controll required	Belgium - buying up 'exchange' land (Rupp, 2010)	yes	yes	unkown	unknown	Plan Perkpolder, Het Zwin, Sigma Plan (8 sites)	Sigma Plan (5 sites)
Elbe	no - no depolderisation unless special requirement. HPA has concrete plans for dike realignment.	no - anti-de-polderisation sentiments	federal state pays €200/ha to extensively graze (Fock, 2002)	yes	unkown	unkown	unknown	unknown	Wrauster Bogen - Elbe
Plymouth	Yes - target of 140 ha/yr saltmarsh created	yes - RSPB influence	Countryside Stewardship Scheme for 10 years (Ledoux et al., 2004)	yes	yes	yes	yes	Exe Estuary -EA, River Tamar - National Trust, South Efford - EA	Saltram, Plym Estuary - EA, Pillmouth - River Torridge, Watertown Farm - River Yeo
Santander	yes - compensation for land reclaimation scheme	unkown	none	yes	yes	unkown	unknown	compensation scheme for harbour extension. Includes breaching spit.	none
Emilia Romagna	unknown	unkown	none	yes	yes	unkown	unknown	none	none
Gdansk	unknown	unkown	none	no	no	no	no	none	none
Varna	unknown	unkown	none	unkown	unkown	unkown	unknown	none	none

We can see from the table above that there is a significant lack of data in the 'Data Availability' section. This information is required for the GIS modelling of sites with regards to MR site selection in current tools and is thus of crucial importance. This section will be included in the questionnaires in Stage 2, where respondents will be asked to comment on the availability of the required data sets.

In addition we can see from the data currently available, that both the Gdansk site and Varna site are unlikely to be conducive to a successful MR implementation. However, further investigations into both sites were conducted in order to better understand why MR was not a valid solution.

'General MR Acceptance' as well as the 'State of Current Flood Defence' are clearly significant constraints to the implementation of MR schemes in this range of study sites.

The MR situation at present at the study sites is represented in Figure 4, below.

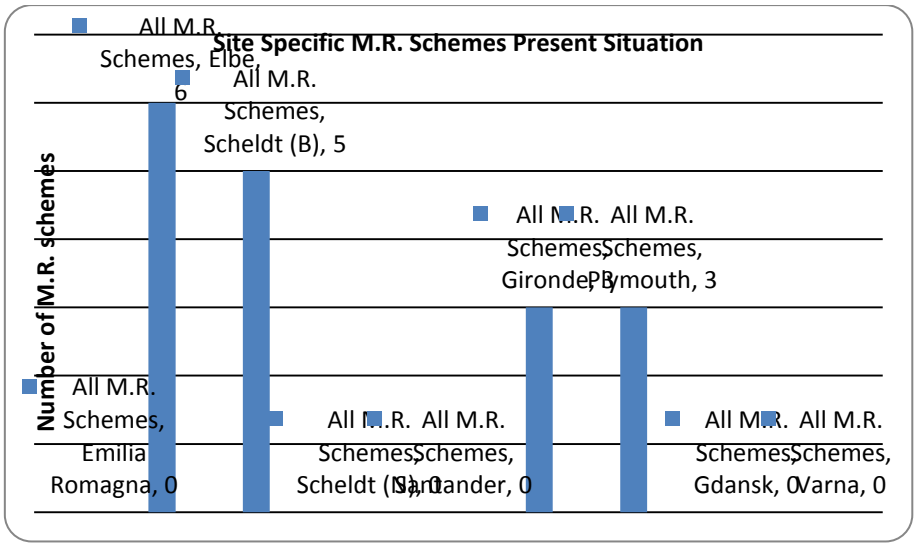


Figure 4: Current MR schemes at the study sites

Currently the most MR schemes are to be found in the Elbe site with the Belgian Scheldt, Gironde and Plymouth also showing MR activity. However, with regards to the actual habitat area created through MR at the Theseus sites, a different relationship becomes apparent. The following figure, Figure 5, shows the area of MR at the various sites as well as the average area of MR schemes for each site.

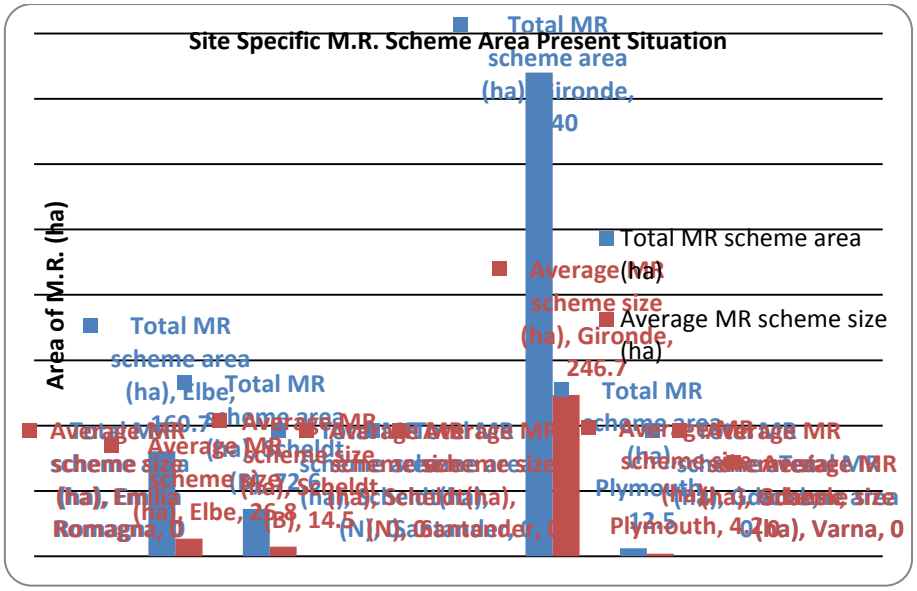


Figure 5: Area of current MR schemes at study sites

Here we can clearly see that the Gironde has, in fact, got the most MR to date.

A multitude of MR schemes are furthermore in the planning stages at the different study sites. The number of schemes and anticipated area to be created through these is shown in the following two figures, Figure 6 and 7.

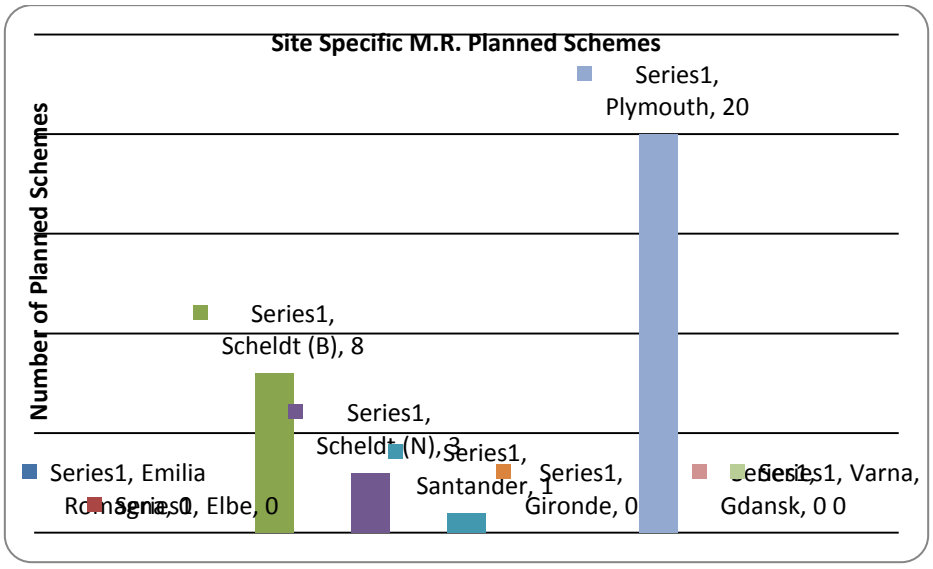


Figure 6: Planned MR schemes at the study sites

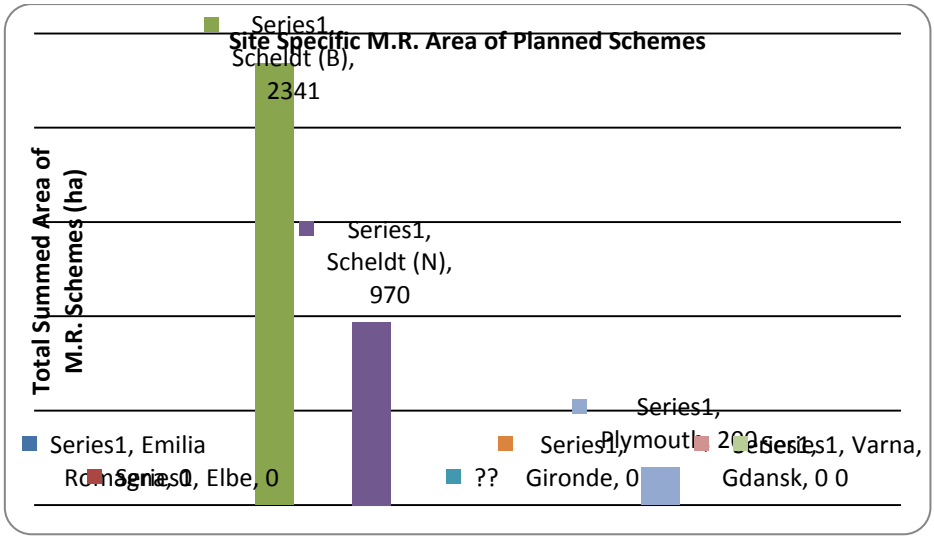


Figure 7: Proposed area of planned MR schemes at teh study sites

The Santander compensation site is in a very early planning stage and therefore the area of the proposed scheme could not yet be established. We can clearly see, however, that although the Plymouth site is planning many MR schemes (according to the SMP, see Appendix X), the size of these schemes is relatively small. The Belgian Scheldt, on the other hand, is planning only 8 new MR schemes but reaching an impressive 2341ha.

In conclusion, we can clearly see from this initial literature review that MR is a popular strategy in some of the study sites, whereas it is relatively unknown in others. This literature review has, however, found that MR could in theory be applied at all of the study sites, though to a lesser or greater extent. Thus the question of, why some sites have adopted MR and others have not, and how a European tool could influence this situation, must be looked at in the following sections.

5.0 Methodology

This section will describe the methodology used in this research and the different stages of the project. The following flow chart, Figure 8, shows an overview of the process and the various stages:

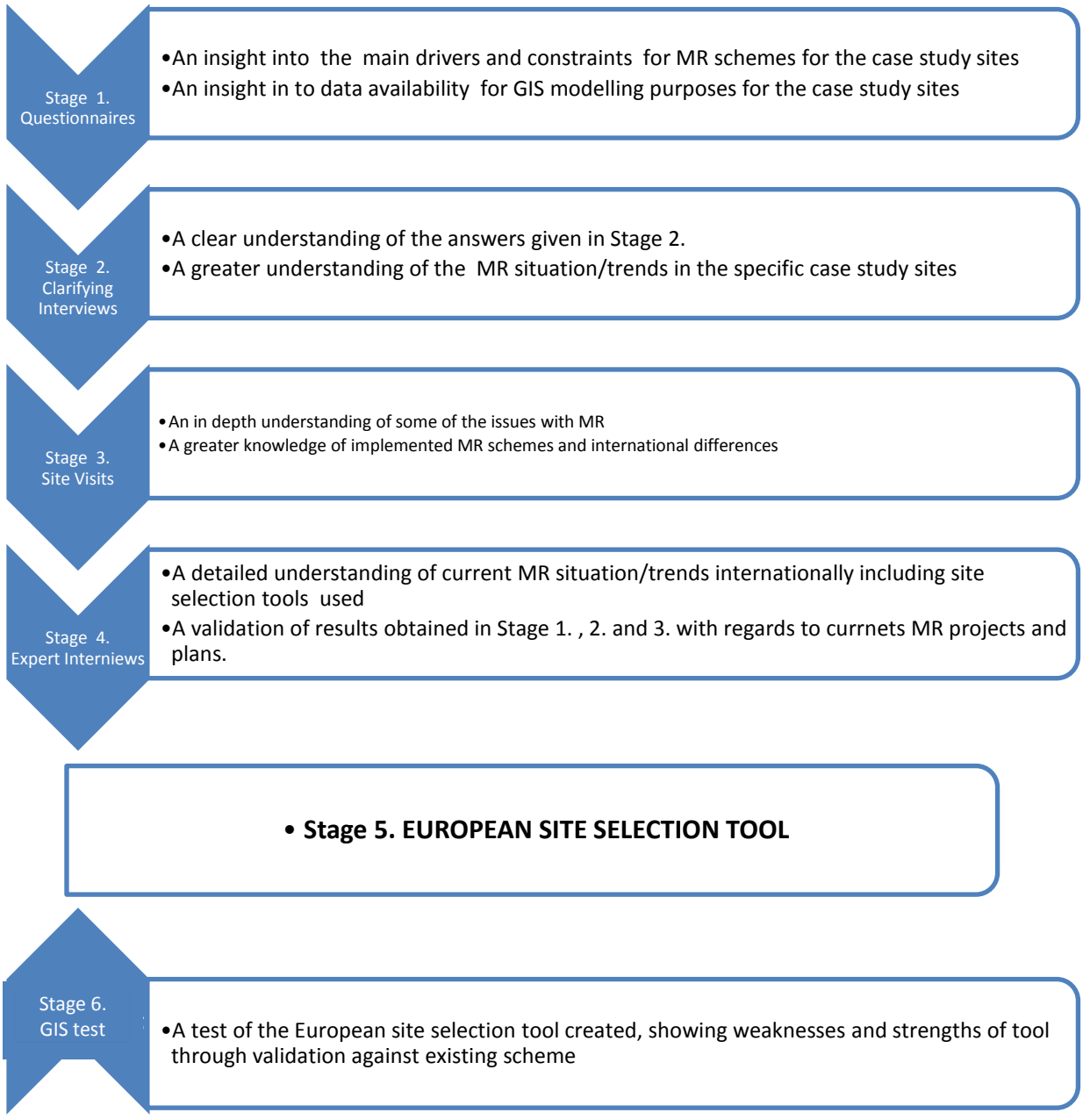


Figure 8: Flowchart of research stages used in this study

5.1 Stage 1. Questionnaires

5.1.1 Aims and design

Stage 1 consisted of a 'mixed-format' questionnaire (BERNARD, 2000). Mixed format indicates that a mixture of open and closed questions were included. It was determined that a mixed format questionnaire was most appropriate for this stage as it allowed the author to collect a wide range of data with minimum effort for the respondent. The closed questions, where the possible answers were suggested by the author, allowed for statistical analysis and thus showed international patterns as well as possible respondent bias for further detailed scrutiny in the following stages (CHOI *et al,* 2004). The open questions allowed for more varied and site-specific detailed responses. It was deemed important, at this early stage, to use the least time-consuming method in order to obtain maximum response rates.

The Stage 1 questionnaires were aimed at the site champions of the Theseus Project. Each site champion was sent an identical questionnaire (see Appendix I) with questions regarding:

1. Data availability for GIS modelling of sites
2. Drivers for MR schemes
3. Constraints for MR schemes

The aim of this stage was to get an initial insight into the main drivers, constraints and data availability (for GIS modelling purposes) for MR schemes for the specific case study sites selected as a representative range for Europe. These three question topics were identified through a preliminary literature review as areas where there were gaps in the current literature. As mentioned in GILL, 2001: "Identifying the incentives for MR and the constraints associated with it…and communicating these issues to stakeholders, landowners and the public will be an important component of the success of MR schemes." The detailed literature review of the study sites highlighted the same three areas where gaps in the data were apparent (See table 3 in Section 4.6). A decision was made to keep questions at a fairly high level for the following two reasons:

1. By keeping the questionnaire fairly short and relatively simple, it was hoped that a high response rate would be achieved.
2. Some of the Theseus site champions had limited experience with MR and thus in depth questions regarding the subject matter would fall outside the scope of the respondent's knowledge range.

In each section a list of possible answers was given and the respondent was asked to rate the answer on a five-point scale with the possible answers collated from a wide array of sources from literature. Although the risk of 'leading' towards an answer is increased in this manner of questionnaire design it was used because it requires less time from the respondent and thus increases chances of all questionnaires being returned and completed (BERNARD, 2000). In each section an answer of 'other' was also provided to allow for answers not present in the list of answers.

5.1.2 Limitations

The area of expertise of the different site champions was not the same as can be seen from the following list and thus bias was a clear issue:

- **Gdansk** – Expertise: near shore hydrodynamics and sediment transport
- **Scheldt (N)** – Expertise: salt marsh ecology (interaction between salt marshes and hydrodynamics)
- **Scheldt (B)** – Expertise: hydraulic engineering research
- **Santander** – Expertise: coastal engineering research
- **Gironde** – Expertise: hydrodynamics
- **Varna** – Expertise: digital modelling of hydrodynamics and morphodynamics
- **Plymouth** – Expertise: coastal engineering
- **Elbe** – Expertise: coastal engineering research
- **Emilia Romagna** – Expertise: hydrodynamics of coastal structures

For example, one of the site champions being an ecologist, his answers might 'lean' towards the nature oriented answers provided in the interview (CHOI *et al*, 2004). In addition, in this first round of interviews, only one respondent was available for each site. From a statistical point of view this is clearly insufficient data to allow for any meaningful results to be extrapolated, however MR is an area where in most European countries the general public have very little knowledge (BERNARD, 2000). Thus a large-scale quantitative survey was deemed impractical for this study and the site champions were taken as experts for their sites. This limited sample further increases the risk of bias in the results. To overcome this problem to a certain extent, Stage 2, Clarification Interviews, were undertaken to gain an improved understanding of the reasons for the answers provided in the questionnaire.

5.2 Stage 2. Clarification Interviews

5.2.1 Aims and design

Stage 2 consisted of detailed interviews. Interviews were considered appropriated at this stage, as it allowed the author to ask questions specific to the site including in-depth questions about answers

given in the questionnaire (stage 1). A 'Skype' interview format was selected due to the time constraints of the study.

In this stage the site champions of the case study sites were interviewed. The interview guide is provided in Appendix III. The questions were grouped under the following categories:

1. Profile questions
2. General MR questions
3. Questionnaire (Stage 1.) clarification questions

The profile questions were aimed at gaining a better understanding of the respondent and his/her area of expertise. This was necessary to assess whether some of the answers given may be subject to bias towards a respective field of expertise.

The general questions on the topic of MR were designed to gain insight into the respondent's understanding of the concept of MR as well as finding out about the view on MR in their area and undertake some 'forecasting' where respondents were asked to predict the future state of MR from current trends in their area (LOVERIDGE, 2002). These questions were aimed at gaining a greater understanding of the current state of MR and also get an idea of the possible trends going into the near future.

The questionnaire clarification questions were designed to reduce bias in the answers obtained in the first stage, questionnaires. Upon reflection of the answers from the questionnaires, any areas that required clarification were questioned in this interview stage. In addition, some direct questions regarding bias were asked to allow for some bias correction.

5.2.2 Limitations

The most prominent limitation of this stage was the accessibility of the respondents. Due to the time requirements of interviews, many of the site champions were likely not going to be able to respond within the time frame of this study. In an attempt to negate this issue, the questions of the interview were sent to respondents ahead of time to allow for prior preparation. However, a time requirement of at least one hour could not be avoided and this would remain a challenge.

Another limitation of this stage was the likely 'leading' nature of a phone interview (BERNARD, 2000). In order to minimise the effect of this issue, the interview questions that were sent out to the respondents were kept as general as possible without being vague. The prompts for some of the questions seen in the interview layout in Appendix III were not included in the sent out interview.

These were to be used by the author in case no answers came to mind for the respondent and suggestions could be used to prompt him/her.

5.3 Stage 3. Site Visits

5.3.1 Aims and design

The main aim of the site visit was for the author to gain a better understanding of the current issues and possibilities within the field of MR scheme realisation. Six schemes located in two Theseus sites were identified, through a review of the available literature, where varied projects were being realised or issues were particularly visible. The selected sites were:

1. Scheldt, Belgium/Netherlands – Hedwige site: Example of the importance of public support
2. Scheldt Belgium/Netherlands – Het Zwin: Example of difficulty of international MR project
3. Scheldt, Netherlands – Perkpolder site: Example of multi-purpose project for public support
4. Scheldt, Netherlands – Drowned Land of Saeftinghe: Not MR but good example of very mature and pristine inter-tidal area
5. Plymouth, UK – South Efford site: Example of conflict between losing designated land for MR
6. Plymouth, UK – Slapton Ley: Erosion issues affecting an important road may lead to inevitable MR with expensive consequences as well as large a designated area being affected

At each site an expert with knowledge of the particular area was available for a guided tour making it possible for clarifying questions to be answered on the spot.

5.3.2 Limitations

Due to time constraints and financial limitations for this study, a limited number of sites could be visited. However, due to a thorough literature review, the sites visited accurately portrayed some of the wider spread issues within MR throughout Europe.

The experts in the Netherlands, the UK and Belgium were all ecological experts and thus a bias was given to the natural aspects of MR rather than the engineering aspects.

5.4 Stage 4. Expert Interviews

5.4.1 Aims and design

The interviews in this stage were geared towards experts in the field of MR. Respondents with a wide range of experiences in national as well as international MR projects were approached with questions about the current situation in MR, future trends, and also specific site selection tool questions (see details of interviews in Appendix IV). Although stage 4, may suggest these interviews

were carried out near the end of the dissertation deadline, in reality, the timing of these interviews were driven by respondent availability and this stage ran throughout the entirety of the project.

The aim of this stage was to gain a more, in depth, knowledge of MR in the various European countries and some of the conflicts that have hindered MR in the past and will play a role in the future. In addition this stage was designed to validate some of the results obtained in Stage 1 to 3 as well as the literature review, by checking them against implemented MR schemes. Finally this stage was aimed towards improving the European site selection tool created as the conclusion of this study through discussions with the experts about gaps in current site selection tools and demands for the tool being developed.

5.4.2 Limitations

MR is a very site dependant discipline with issues and drivers often varying to a large extent from site to site. Thus information from an expert in the field of MR with no direct involvement in the sites of study may not necessarily disprove any conflicting data obtained in the other stages. However a certain degree of validation may be obtained from an expert's knowledge, when he/she has experience in the same country and under similar circumstances as the study site situation. Another limitation of this stage is the time limit of the study, making it difficult to approach many experts and organise an interview within the given time frame.

5.5 Stage 6. GIS Test

5.5.1 Aims and design

During this final stage, the developed generic European site selection tool created was tested. An area where a local, non-generic, site selection tool had previously been utilised to identify suitable MR sites, was chosen. The aim of this stage will be to see if, given the same information as the locally developed site selection tool had available, the new generic tool would select the same sites as were previously found.

This test will serve to validate the European site selection tool if it shows that it can be applied to a local case study and conclude with the same sites as were found in a detailed investigation. In addition the test will show the workability of the tool. Any drawbacks or issues with the tool may also be highlighted in this stage, thus allowing for further development suggestions for the tool.

5.5.2 Limitations

Due to the limited time available for this study, the tool was only tested on one site and without the input of local stakeholders, the tool can hence not be viewed as fully tested on a European scale.

6.0 Results

6.1 Stage 1 – Questionnaire

The questionnaire was filled out and returned by all site champions from the 8 Theseus Project sites. In total 10 questionnaires were completed. The two additional questionnaires were the results of the Dutch and Belgian part of the Scheldt site answering separately, as well as a double reply from the Santander site.

The data obtained from the questionnaires were assembled and analysed and the main results are presented here (for further information and detailed results see Appendix II).

6.1.1 Data Availability

The first part of the questionnaire queried perceived availability of data which is generally considered to be required for the purpose of MR site selection within a Geographic Information Systems (GIS) environment. All tools described in the literature review have, to date, included a GIS investigation aimed at determining the most appropriate site for MR and thus specific data is a requirement.

Figure 9, below shows the results from this study, where the blue columns represent the difficulty for each site to acquire the necessary data. The different data sets required for GIS modelling were rated out of a maximum of 5, where 1 denoted that it was very easy to acquire the data and 5 meant it was very difficult. The figure below shows the average data acquisition difficulty for each site.

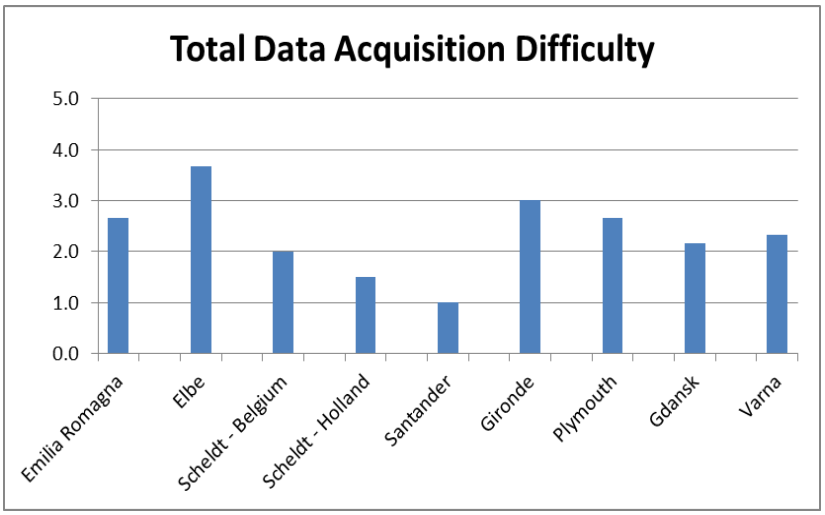


Figure 9: Summary of data availability results for study sites

All sites, with the exception of Santander, were found to have relatively extensive difficulties in finding some of the data sets. The Elbe and Gironde were found to have the least easy access to the required data, with both scoring high marks for 'Land ownership information'. Across all the sites 'Land ownership information' was regarded as the most difficult information set to get hold of as can be seen in the figure below, Figure 10.

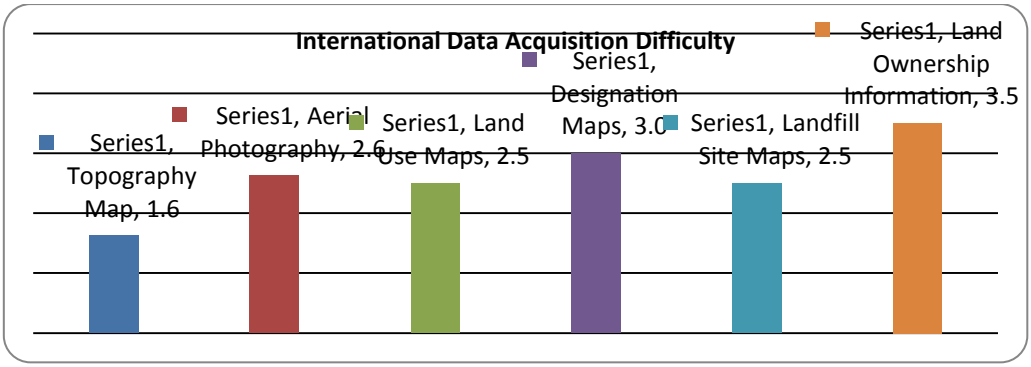


Figure 10: Summary of the difficulty of data acquisition per data set for the study sites

As may be expected, topography data was found to be one of the most easily accessible data sets. The high difficulty assigned to obtaining aerial photography data was not expected due to the wide range of publicly available online data such as 'Google Earth'.

6.1.2 Drivers

The second section of the questionnaire dealt with the drivers of the different sites for MR. The respondents were asked to rate the seven drivers, from 1 to 5, where 1 meant the driver was not important and 5 meant very important for that site. The results are summarized in Figure 11.

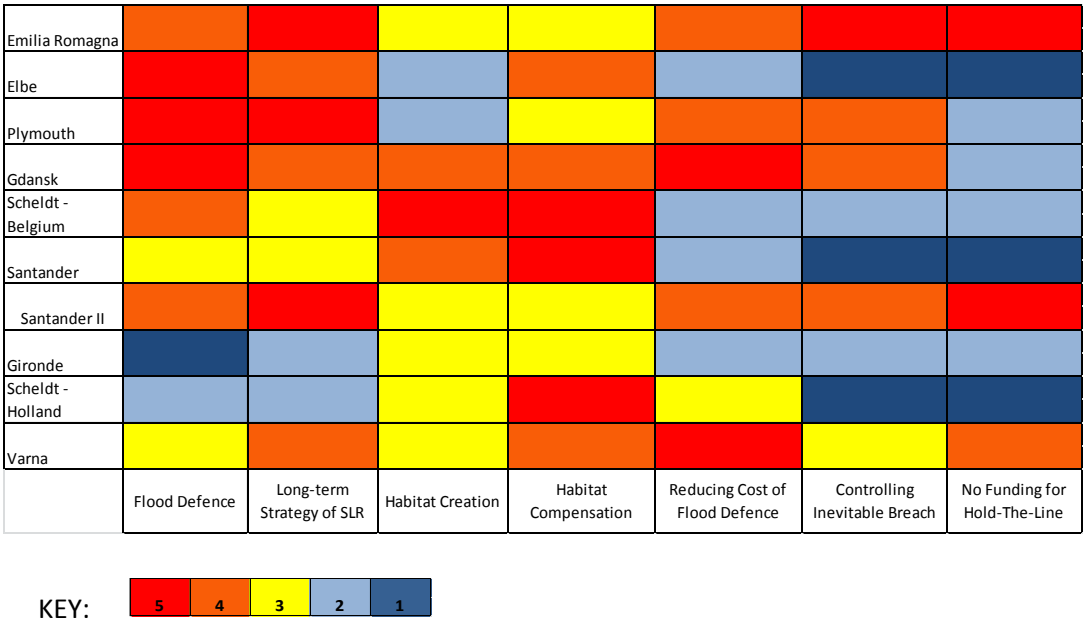


Figure 11: Summary of the driver importance for the study sites

The results show that the drivers for MR vary greatly between the sites. Another interesting results of this section is that the majority of the sites seem to have two drivers which feature as 'most important' in their area. Only the Dutch Scheldt has a very clear focus on one driver (habitat compensation) with the other drivers ranking low in terms of importance.

However, for the purposes of analysis we grouped the drivers into the following four categories as shown in Figure 12, below.

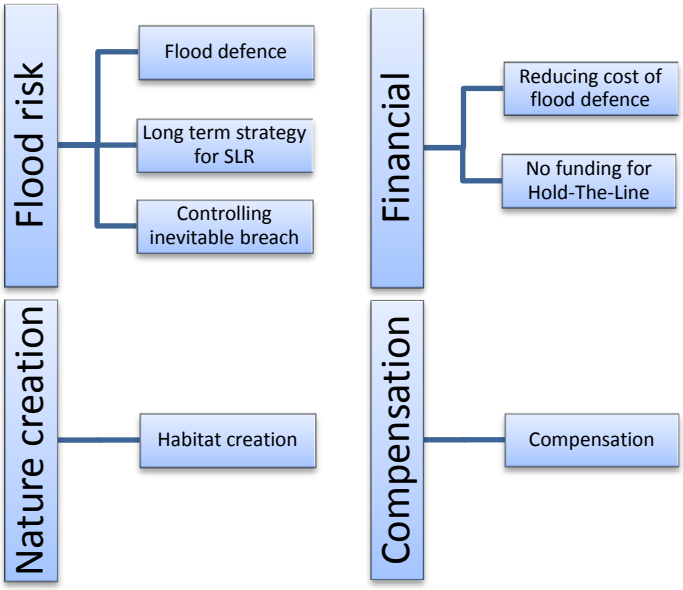


Figure 12: categorisation of possible drivers

The results from the questionnaire, with the categories as described in Figure 12, may now be summarised in the following figure, Figure 13.

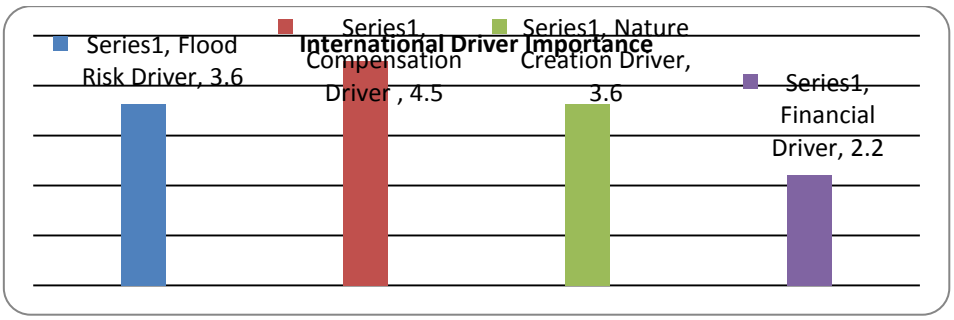


Figure 13: Summary of driver category results for the study sites

Compensation is the most popular primary objective for MR schemes throughout all case study sites with nature creation and flood risk sharing second. What we see when we group the drivers is that most sites now have a clear preference for one of the driver groups as shown in the figure below, Figure 14.

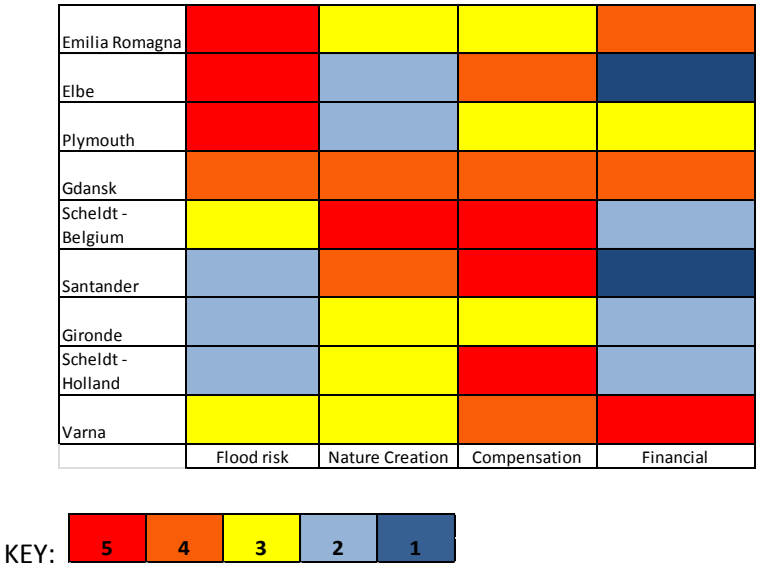


Figure 14: Summary of driver categories for the individual study sites

Only for the Gdansk site was there no clear primary driver for MR schemes. The Belgian Scheldt and Gironde have their interest spread over two drivers, but a clear focus on nature as both drivers involve nature invigoration.

6.1.3 Constraints

The final section of the questionnaire was the importance of various constraints for a MR scheme to be implemented. The constraints were grouped into 5 categories as shown in the following figure, Figure 15.

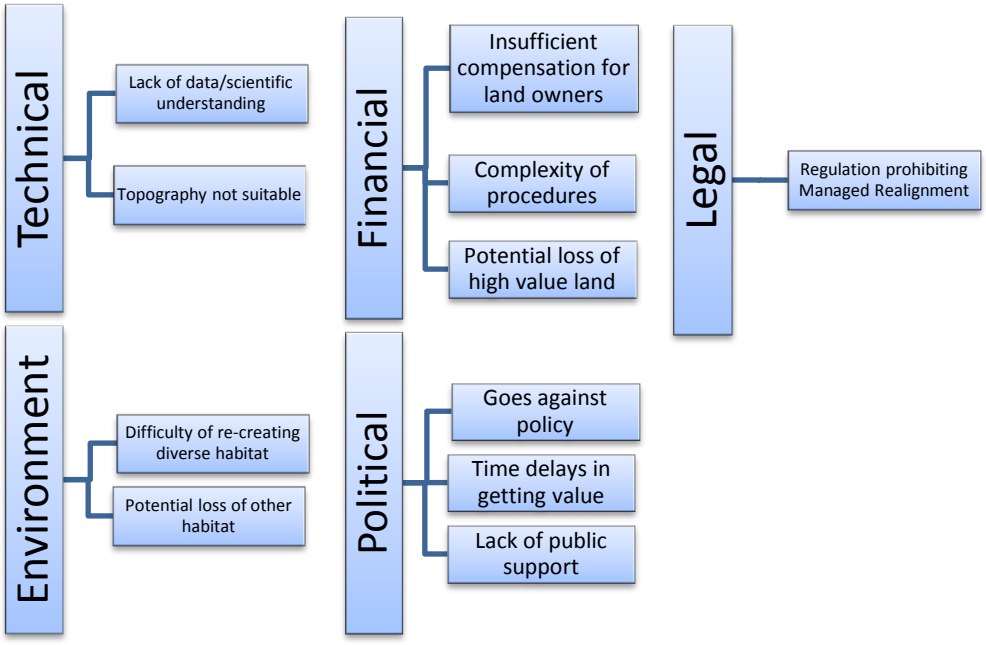


Figure 15: Categorisation of possible constraints

Upon analysis of the data the following results were obtained as shown in Figure 16, below.

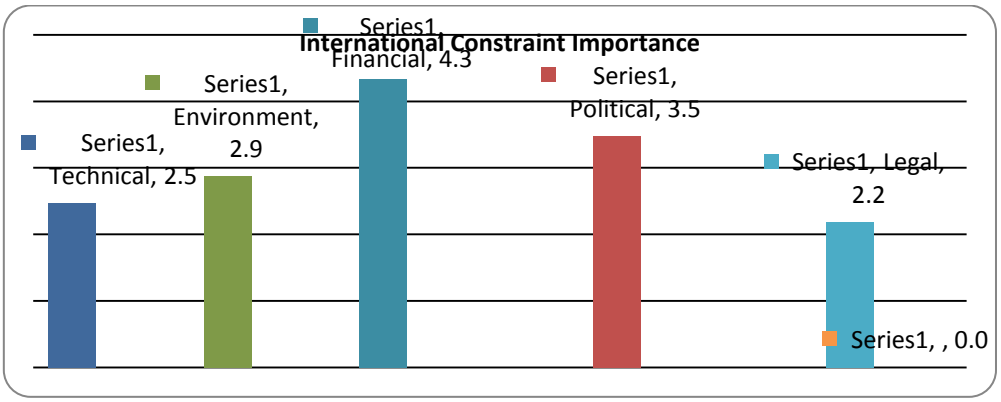


Figure 16: Summary of constraint categories for the study sites

Financial constraints dominate as a reason for not applying MR throughout Europe. In particular the 'potential loss of high value land' was seen as a major draw-back of MR. Political reasons are also seen as an important constraint for MR by many of the study sites with a 'lack of public support' ranking as the second highest constraint. The 'complexity of procedures' was rated third highest, showing that the current procedures for MR schemes in the different European countries are not stream-lined and form a significant obstacle.

6.2 Stage 2 – Clarifying Interviews

Non-responsiveness of respondents was a clear limiting factor in this phase. Out of the 8 site champions approached, only 3 were interviewed within the time frame of this study. The site champions interviewed were:

1. Hel Peninsula
2. Dutch Scheldt
3. Plymouth

For details on this phase and a full transcript of the interviews see Appendix III.

The main results obtained from this phase are now summarised:

1. Hel Peninsula:

- A study was undertaken by the Maritime Office in Hel Peninsula and found that retreat was an impossibility in the area
- All building along the coast, along the Hel Peninsula site, is regulated and no buildings can be placed in the danger zone. Therefore no compensation could be possible if retreat occurred.

- MR is a relatively unknown concept in Poland and neither respondent had dealt with the concept prior to this study.
- MR was seen as inappropriate for the Hel Peninsula site due to a lack of tidal fluctuations and very high economic value of the land due to tourism.

2. Dutch Scheldt:

- The land-ownership information is so difficult to obtain because it is not held by one body but many different organisations.
- The local farmers along the Scheldt are very strongly against MR mainly because of the salination of their land and a strong emotional bond to the polders.
- The local community around the planned Perkpolder MR project is mainly against the project because the large hotels and golf courses, included in the plans, do not fit in with the community, not because of the MR.
- MR is likely to increase along the Scheldt in the near future because of compensation laws and erosion of the salt marshes along the coast.

3. Plymouth:

- MR is particularly popular along this study site.
- MR is likely to increase in the near future because of increased evidence of coastal squeeze.
- The SMP plans should be seen as a guideline and not as set plans. Many of the MR schemes recommended in the SMP will not necessarily be realised.

6.3 Stage 3 – Site Visits

The site visits were mainly aimed towards seeing some of the issues with MR and visiting some of the potential sites. The visit to the Dutch Scheldt showed clearly the conflict with the local population and MR schemes. The following pictures, in Figure 17, were taken along the coastal area.

Figure 17: Anti-depolderisation signs along the Dutch Scheldt (picture taken May 2011)

The signs are written in Dutch and show slogans such as 'ONTPOLDEREN NEE!' (managed realignment no!) and 'STOP DE GROENE LEUGEN' (stop the green lie). Furthermore, upon visiting the Hedwige-Prosperpolder MR project, which is an international project between Belgium and the Netherlands, the contrast between the progress of the two countries was very interesting. The following photo, in Figure 18, shows this contrast.

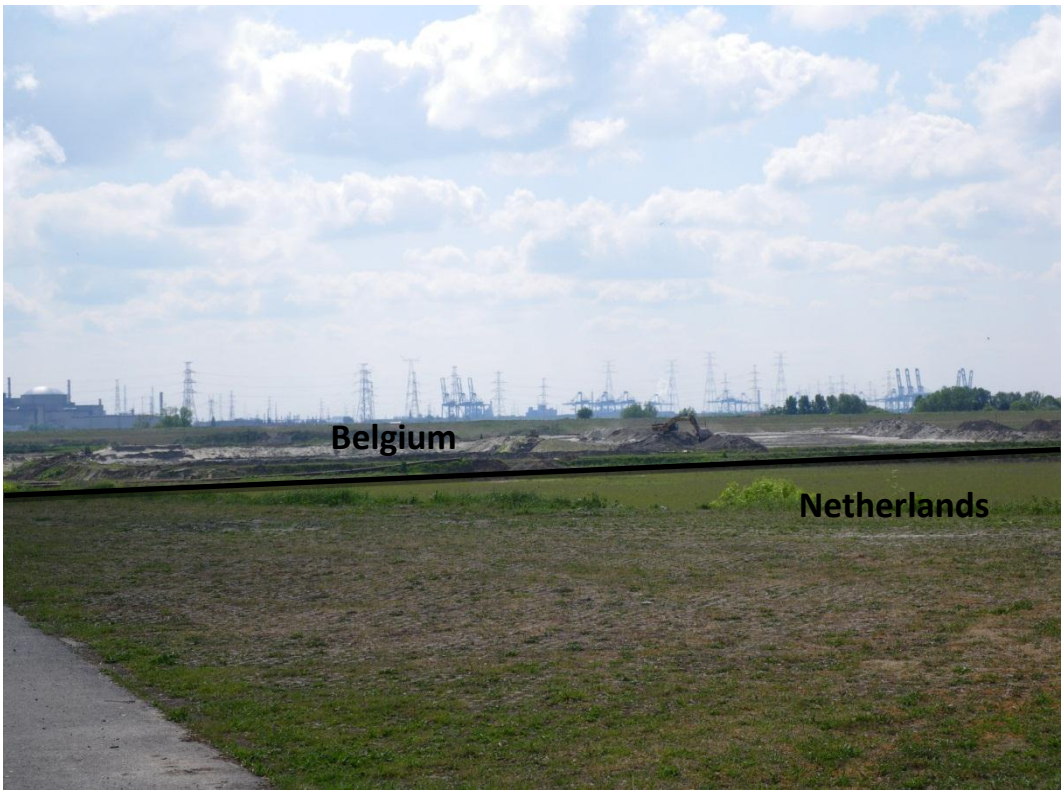


Figure 18: Contrast between the progress of MR works on the Belgian side of the border, and the lack of activity on the Dutch side (picture taken at the Hedwige site, May 2011)

The Belgian section of the MR is near completion, whereas on the Dutch side, site preparation works have yet to start. This is due to the fact that the discussions about this project with the local population have not yet come to a conclusion. In fact, the sign sporting the slogan 'STOP DE GROENE LEUGEN' (stop the green lie) was found on the edge of the project premises.

In the UK, both the Slapton Ley site and the South Efford site highlighted interesting MR conflicts. The Slapton Ley site has a designated brackish lake just behind the defence line as well as an important road running along the top of the shingle ridge. A breach here would have significant economical and also social repercussions. At the South Efford site fresh water grazing marsh is found within the potential MR site. The two sites are shown in the photos, in Figure 19, shown below.

Figure 19: Slapton Ley (left) and South Efford (right) potential MR sites. (picture taken May 2011)

The South Efford project is currently in progress, but the local population is not in agreement.

6.4 Stage 4 – Expert Interviews

Two experts were contacted in this phase. For a full transcript of the interviews for this phase see Appendix IV. An overview of the most important comments from this phase is given here:

- Now it is getting more difficult to acquire the land (in the UK) required for M.R. This is mainly due to the fact, in my opinion, that the price of the crops is going up.
- We(UK) are also seeing a real decline of popularity of M.R. in general as many people feel that they are giving away land and not seeing any real returns
- To the majority of the (Dutch) population M.R. is the same as giving up the fight against the sea.
- The most significant hindrance to M.R. is the lack of knowledge about it in most European countries.
- I believe the site selection is very similar in most countries where M.R. is practiced
- Our (UK) experience has generally shown that all sites have significant disadvantages which can generally be overcome by increasing costs, but the final site selection is likely to be based on a series of compromises.
- Involving the local population from the start of the project has yielded very positive results with regards to public support.
- The other area which has been difficult and will certainly be hard to reflect in a tool is around some of the intangible factors such as local community support or opposition.
- Your tool really needs to operate as a series of filters which will allow sites to be rejected as early as possible to keep costs down, but at the same time to provide a sufficiently robust defence of why sites end up being selected when others have been rejected.
- From the (UK) monitoring projects we have been running we are confident that M.R. is a very useful and successful measure.

7.0 Results Summary and European Site Selection Tool

From the results obtained in the literature review and stages 1 to 4, it is possible to draw some conclusions and possible guidelines for the creation of a European Site Selection Tool (ESST).

From previous tools we have found that GIS modelling is an effective method for site evaluation and comparison. However, data availability is an issue and the results obtained in the questionnaires regarding data availability (Section 6.2), show that all study sites have some difficulty in obtaining the data required for MR site selection. However, upon comparison of the data acquisition difficulty results and the known MR schemes implemented we see the following relationship in Figure 20.

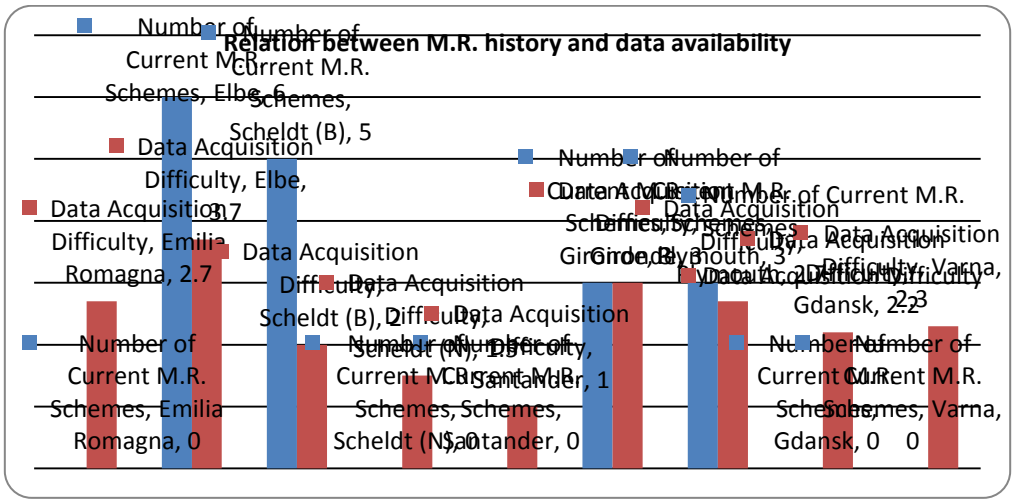


Figure 20: Graph showing the relationship between MR schemes implemented in an area and the difficulty of data acquisition

The vertical axis on this graph represents the number of schemes for the blue data set and the difficulty of data acquisition (out of a total of 5) for the red data set. This graph shows that the sites where the most MR sites have been realised in past, have also indicated the greatest difficulty in accessing the data required for site selection. Thus, although data collection is difficult for most sites, GIS modelling can still be used in a European tool as it is clearly not impeding MR scheme realisation.

In stage 1 to 4 the importance of local acceptance of MR plans was highlighted, as was demonstrated in the literature review, Section 4.2. This lack of knowledge about MR was very clear in some of the study sites and was confirmed in the interview with the Gdansk site champion (Stage 2). As was identified in the ComCoast methodology, the key to improved local support is by "improving and applying stakeholder engagement strategies with emphasis on public participation" (COMCOAST, 2007). Thus an ESST should include extensive stakeholder participation at various

distinct stages of the process. In particular an emphasis on the cost-benefit analysis should be performed in conjunction with the stakeholders where possible (LIEKENS *et al*, 2010).

Results from questionnaire regarding driver importance (see Section 6.2), showed that the different study sites throughout Europe had a wide variation of primary goals for a MR scheme. In addition, the local circumstances largely dictate the importance placed on the various site selection criteria, as we can see from the literature review on existing site selection tools (Section 4.3). Thus any set ranking of the criteria should be avoided in an ESST, and rather the ranking should form part of the tool and determined in conjunction with the local stakeholders.

A comparison of the tools currently available throughout Europe in the literature review (Section 4.3), indicates that the selection criteria used are comparable for most of the tools although some tools provide a more extensive list of criteria. The ESST can therefore use the same criteria as have been identified in previous MR studies.

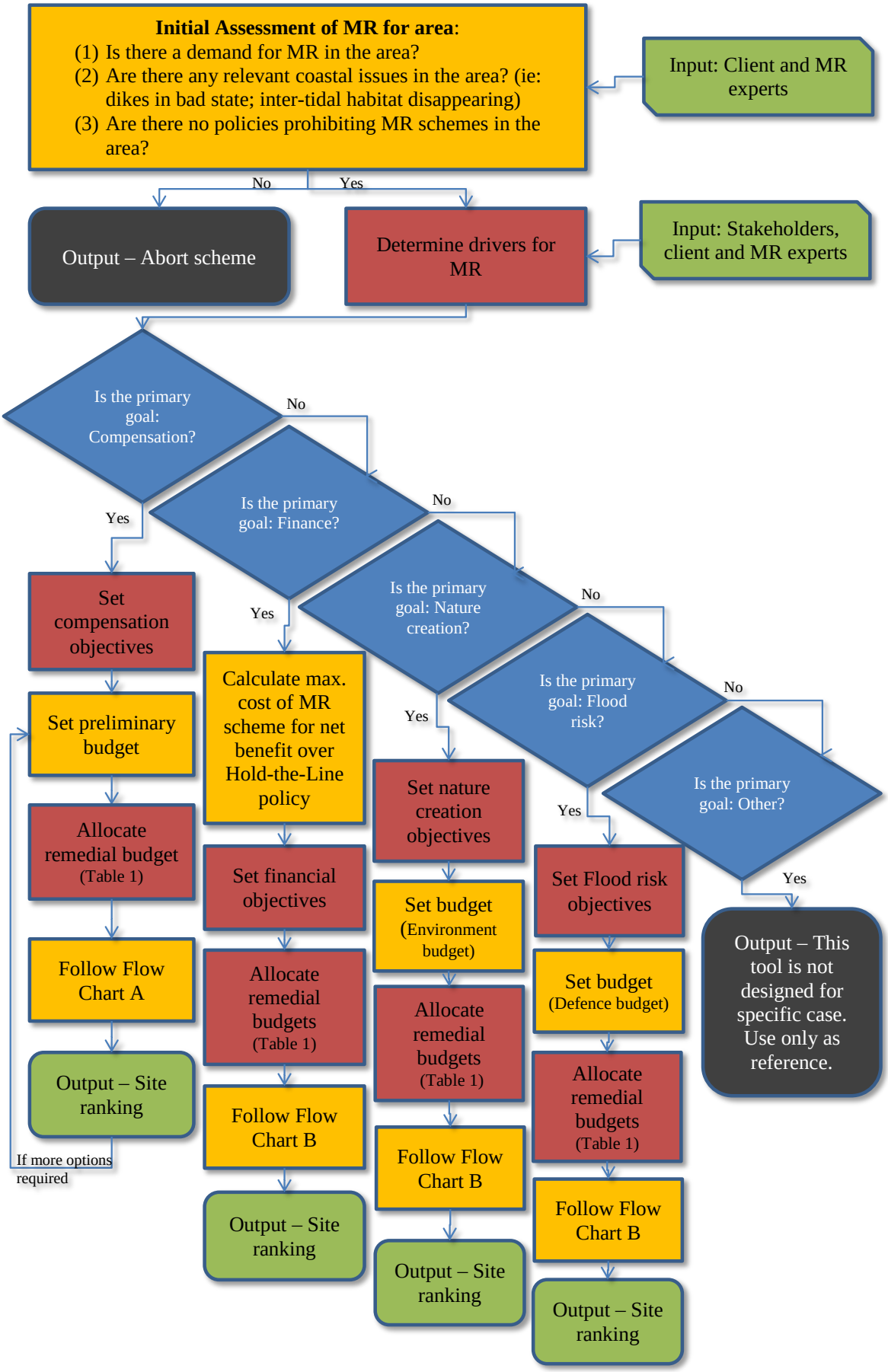
As mentioned in the interview with John Pygott (see Appendix IV), the tool needs to operate as a series of filters which will allow sites to be rejected as early as possible to keep costs down. Thus the option to abort site investigations should be available at various stages within the tool. However, as we have seen in literature review, Section 4.3, tools designed for compensation schemes focussed less on financial criteria and were inclined not to dismiss a site on the grounds of expensive remedial works.

From the results obtained in the questionnaire regarding constraint importance, financial constraints form a major hindrance to MR scheme realisation with the 'potential loss of high value land' being the greatest concern for sites throughout Europe. Thus the inclusion of a thorough remediation cost allocation with regards to a set acceptable budget is crucial for the ESST.

Some of the study sites contributing to this research clearly showed no interest in MR and/or had policies in place prohibiting MR in their area as seen in the interview with the Gdansk site champion (Stage 2). Thus a higher level initial assessment for MR applicability should be included in the ESST where MR drive and relevant policies and regulations are studied. Early abortion of MR scheme investigation must be a possibility in the ESST to avoid any time and money going to waste.

7.1 Stage 5 – European Site Selection Tool (ESST)

Using the results found in the literature review and stages 1 to 4, the following European Site Selection Tool (henceforth denoted as ESST) was designed. Red boxes indicate stakeholder involvement in decisions.

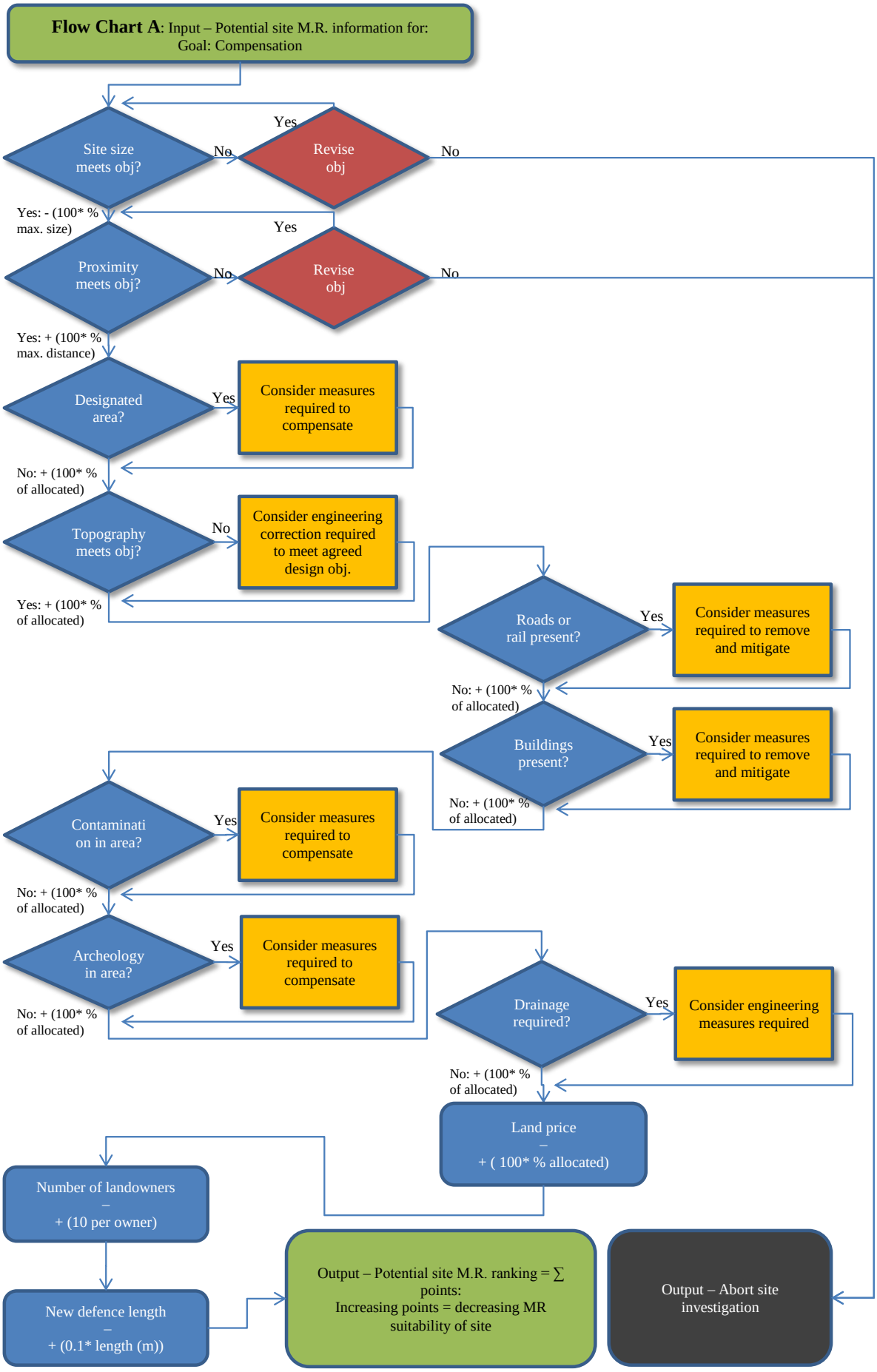

Initial Assessment of MR for area:
(1) Is there a demand for MR in the area?
(2) Are there any relevant coastal issues in the area? (ie: dikes in bad state; inter-tidal habitat disappearing)
(3) Are there no policies prohibiting MR schemes in the area?
Input: Client and MR experts
No
Yes
Output – Abort scheme
Determine drivers for MR
Input: Stakeholders, client and MR experts
Is the primary goal: Compensation?
No
Yes
Is the primary goal: Finance?
No
Yes
Is the primary goal: Nature creation?
No
Yes
Is the primary goal: Flood risk?
No
Yes
Is the primary goal: Other?
Yes
Set compensation objectives
Set preliminary budget
Allocate remedial budget (Table 1)
Follow Flow Chart A
Output – Site ranking
If more options required
Calculate max. cost of MR scheme for net benefit over Hold-the-Line policy
Set financial objectives
Allocate remedial budgets (Table 1)
Follow Flow Chart B
Output – Site ranking
Set nature creation objectives
Set budget (Environment budget)
Allocate remedial budgets (Table 1)
Follow Flow Chart B
Output – Site ranking
Set Flood risk objectives
Set budget (Defence budget)
Allocate remedial budgets (Table 1)
Follow Flow Chart B
Output – Site ranking
Output – This tool is not designed for specific case. Use only as reference.

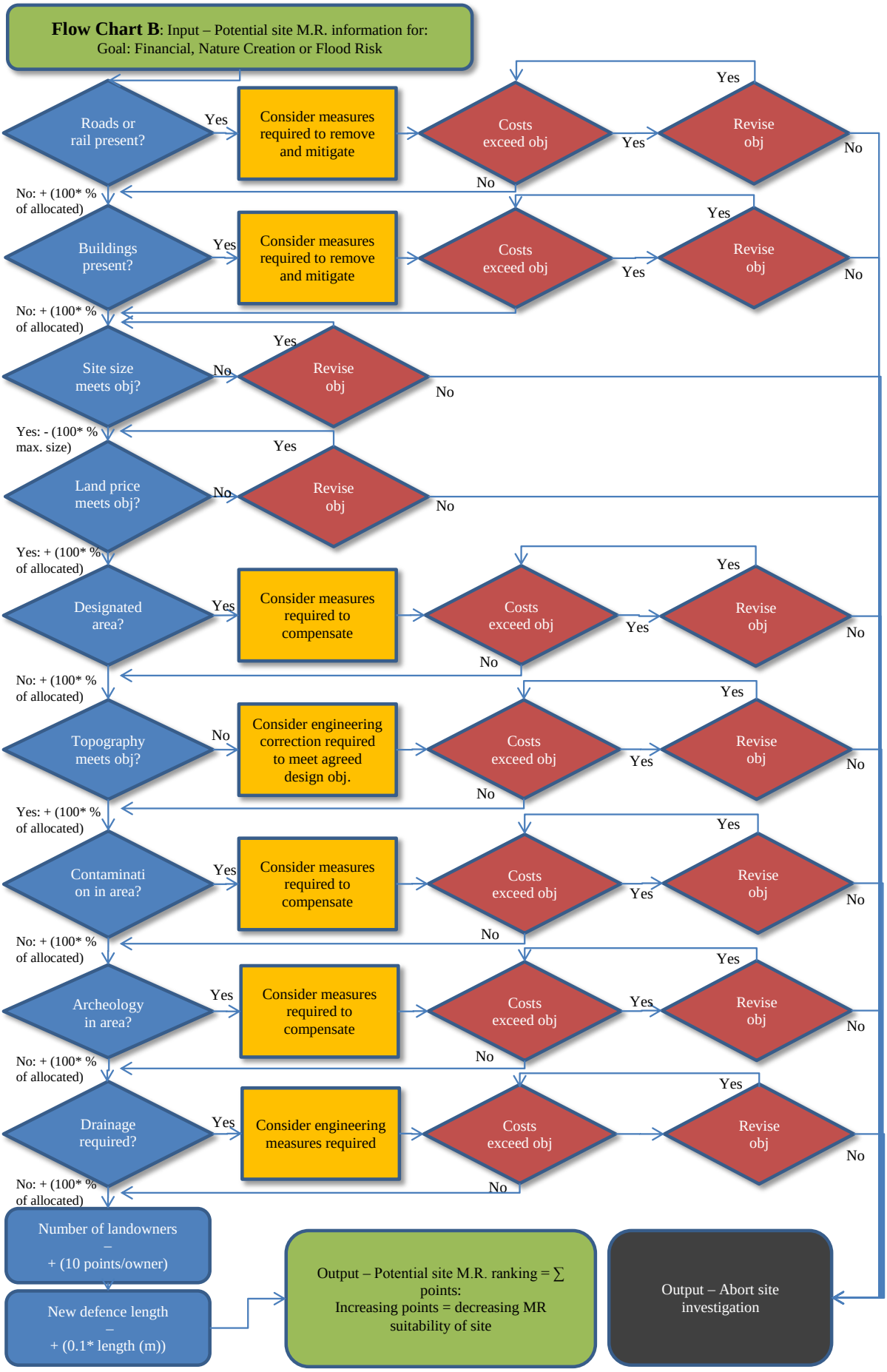
Set objectives (henceforth also denoted as obj.):

	Site size	Habitat balance	Proximity to engineering	State of current defences	Land Price
Compensation	✓	✓	✓		✓
Financial	✓	✓		✓	✓
Nature Creation	✓	✓			✓
Flood risk	✓	✓		✓	✓

Table 1 – Remedial work cost allocation:

Remedial work	% of remedial costs allocated	€ - allocated
Roads, paths and rail removal and mitigation		
Buildings removal and mitigation		
Designation compensation		
Elevation corrections		
Exposure corrections		
Archaeological mitigation		
Land drainage		
Contaminated land		


Flow Chart A: Input – Potential site M.R. information for:
Goal: Compensation
Site size meets obj?
No
Yes
Revise obj
No
Yes: - (100* % max. size)
Proximity meets obj?
No
Yes
Revise obj
No
Yes: + (100* % max. distance)
Designated area?
Yes
Consider measures required to compensate
No: + (100* % of allocated)
Topography meets obj?
No
Consider engineering correction required to meet agreed design obj.
Yes: + (100* % of allocated)
Roads or rail present?
Yes
Consider measures required to remove and mitigate
No: + (100* % of allocated)
Buildings present?
Yes
Consider measures required to remove and mitigate
No: + (100* % of allocated)
Contaminati on in area?
Yes
Consider measures required to compensate
No: + (100* % of allocated)
Archeology in area?
Yes
Consider measures required to compensate
No: + (100* % of allocated)
Drainage required?
Yes
Consider engineering measures required
No: + (100* % of allocated)
Land price
–
+ (100* % allocated)
Number of landowners
–
+ (10 per owner)
New defence length
–
+ (0.1* length (m))
Output – Potential site M.R. ranking = ∑ points:
Increasing points = decreasing MR suitability of site
Output – Abort site investigation


Flow Chart B: Input – Potential site M.R. information for:
Goal: Financial, Nature Creation or Flood Risk
Roads or rail present?
Yes
Consider measures required to remove and mitigate
Costs exceed obj
Yes
Revise obj
Yes
No
No
No: + (100* % of allocated)
Buildings present?
Yes
Consider measures required to remove and mitigate
Costs exceed obj
Yes
Revise obj
Yes
No
No
No: + (100* % of allocated)
Site size meets obj?
No
Revise obj
Yes
No
Yes: - (100* % max. size)
Land price meets obj?
No
Revise obj
Yes
No
Yes: + (100* % of allocated)
Designated area?
Yes
Consider measures required to compensate
Costs exceed obj
Yes
Revise obj
Yes
No
No
No: + (100* % of allocated)
Topography meets obj?
No
Consider engineering correction required to meet agreed design obj.
Costs exceed obj
Yes
Revise obj
Yes
No
No
Yes: + (100* % of allocated)
Contaminati on in area?
Yes
Consider measures required to compensate
Costs exceed obj
Yes
Revise obj
Yes
No
No
No: + (100* % of allocated)
Archeology in area?
Yes
Consider measures required to compensate
Costs exceed obj
Yes
Revise obj
Yes
No
No
No: + (100* % of allocated)
Drainage required?
Yes
Consider engineering measures required
Costs exceed obj
Yes
Revise obj
Yes
No
No
No: + (100* % of allocated)
Number of landowners
–
+ (10 points/owner)
New defence length
–
+ (0.1* length (m))
Output – Potential site M.R. ranking = ∑ points:
Increasing points = decreasing MR suitability of site
Output – Abort site investigation

8.0 Stage 6 – GIS tool test

In order to test the ESST developed in the previous section, it will be tested on a site where a detailed site selection process has previously been carried out. The chosen site for this test is the Solent and more specifically the area from Lymington to Hurst Spit.

The primary goal for this scheme was found to be 'Nature Creation' as was obtained from the detailed site selection investigation (COPE *et al,* 2008).

The objectives were set in accordance with the data obtained from COPE *et al,* 2008:

- Site size: min = 0.5ha, max = 300ha
- Habitat balance = max possible salt marsh creation
- Land price = no data available therefore a fictitious value of £5 million is adopted

A fictitious budget was set for the purposes of this test case at: £15 million

The remediation allocation was set, fictitiously, as shown in Table 4, with £10 million total available:

Table 4: Allocation of remedial budgets according to ESST

Remedial work	% of remedial costs allocated	£ - allocated
Roads, paths and rail removal and mitigation	10	£1 million
Buildings removal and mitigation	20	£2 million
Designation compensation	10	£1 million
Elevation corrections	15	£1.5 million
Exposure corrections	10	£1 million
Archaeological mitigation	0	£0
Land drainage	15	£1.5 million
Contaminated land	20	£2 million

The following 4 sites, shown in Figure 21, were investigated for the purpose of this test. They were selected in accordance with the 'Initial Assessment', being sites with a drive and possibility for MR site realisation.

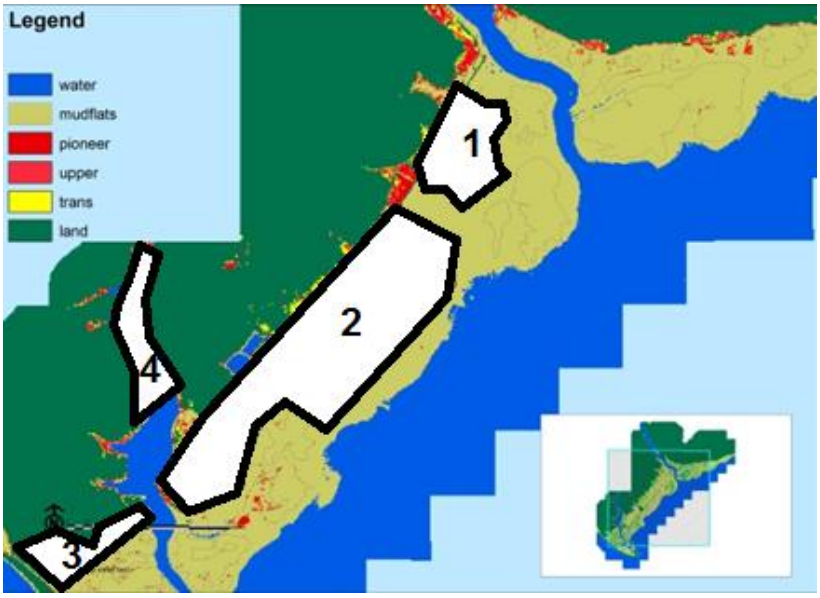


Figure 21: Potential MR sites in test area

The designation areas within the test site were found to be extensive. Figure 22, below gives an indication of those designations.

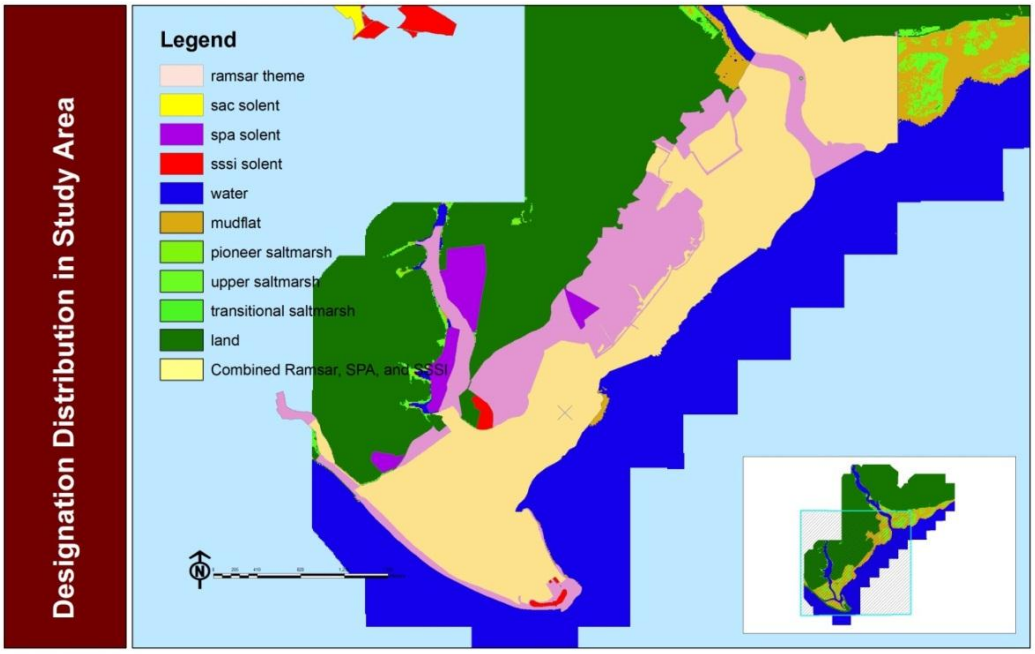


Figure 22: Designations in test area

The presence of buildings within the test area was also mapped on GIS. Figure 23 shows the towns in the area as well as the single buildings present.

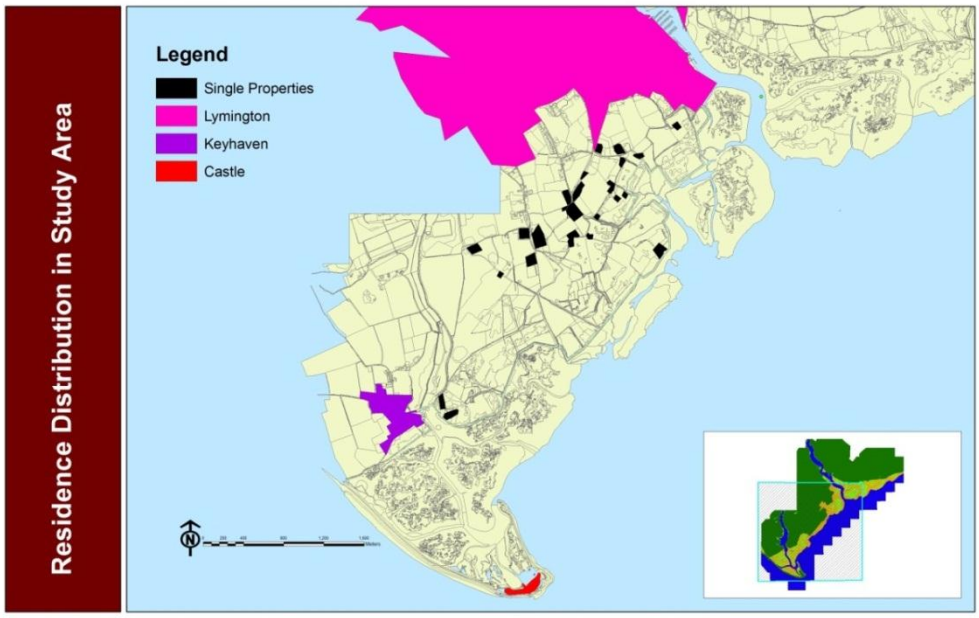


Figure 23: Residencies in test area

In order to estimate the elevation appropriateness of the potential sites, the defences were removed within the GIS model and the extent of salt marsh formation after 50 years of SLR was modelled. The results are shown in Figure 24, below.

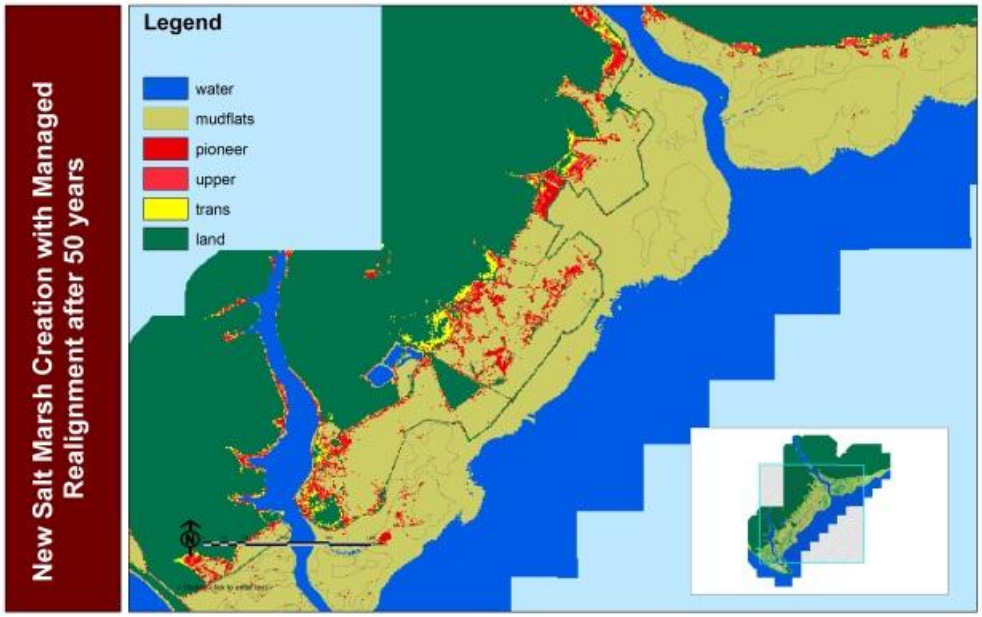


Figure 24: Potential salt marsh migration in 50 years in test area

Finally, the presence of landfill sites that would be affected by MR schemes, both current and old within the test area were mapped and displayed in Figure 25.

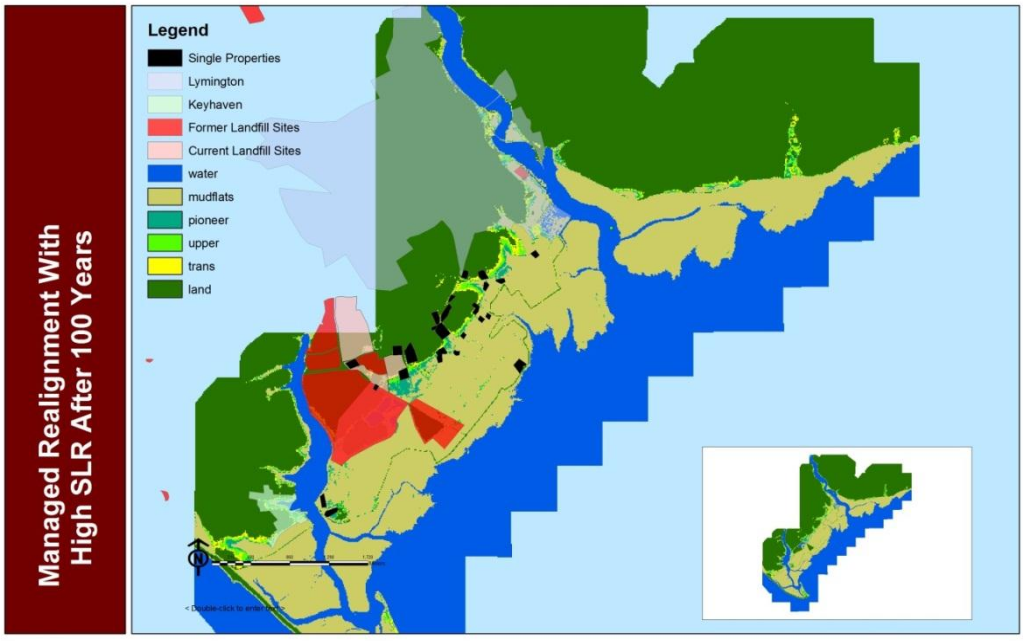


Figure 25: Landfill sites affected by MR schemes within 100 years in test area

Flow chart B was followed for all three test sites and the results are shown in Table 5, below:

Table 5: Results from ESST for test area

Site 1	Abort Site Investigation – Designation remediation costs exceed objective
Site 2	Abort Site Investigation – Buildings remediation costs exceed objective
Site 3	Potential MR site
Site 4	Abort Site Investigation – Contaminated land remediation costs exceed objective

Thus the site selected for further investigations was site 3. The tool was able to exclude site 2 very quickly due to the large amount of development inside the MR area. Sites 1 and 4 were also dropped before all criteria had to be investigated. This shows the efficiency of the tool.

The results of the detailed site selection process carried out for the same area by COLE *et al,* (2008), are shown in Figure 26, below.

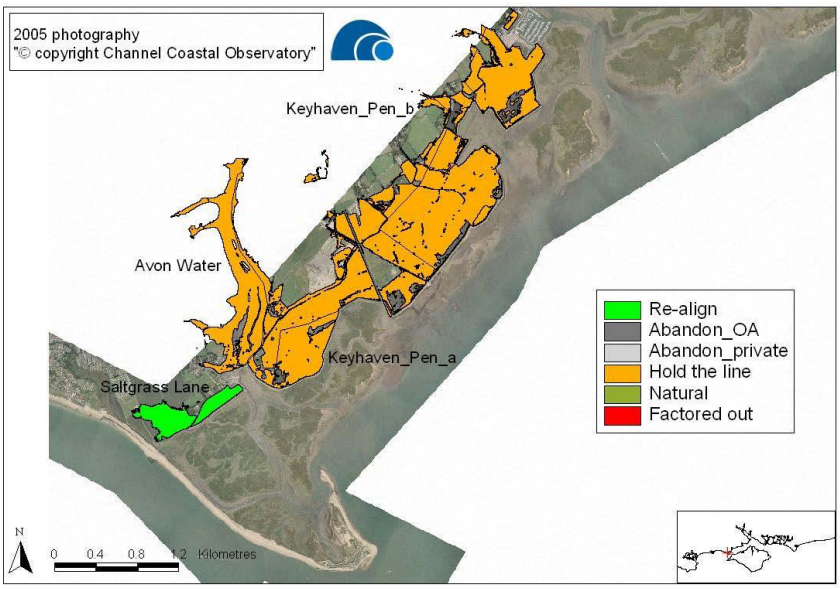


Figure 26: Result of previous site selection study for test area (COLE *et al,* 2008)

The results of the ESST concur with those found in the previous study.

This is a very rudimentary test of the tool, but it is able to show that the tool can potentially provide an efficient and accurate initial investigation for MR purposes.

9.0 Discussion

9.1 Drivers and Constraints

The results showed that the most important driver category for MR throughout Europe is compensation for areas of inter-tidal nature that has been lost. This result was also confirmed in the interviews with experts (see Section 6.4). However, upon critical analysis of the data found in the questionnaires, a tendency toward biased answers may be observed. Figure 27 shows the results for the driver rankings for the Santander site, completed by two different individuals with local expertise and authority. Santander I is an oceanographer, whereas Santander II is a coastal engineer.

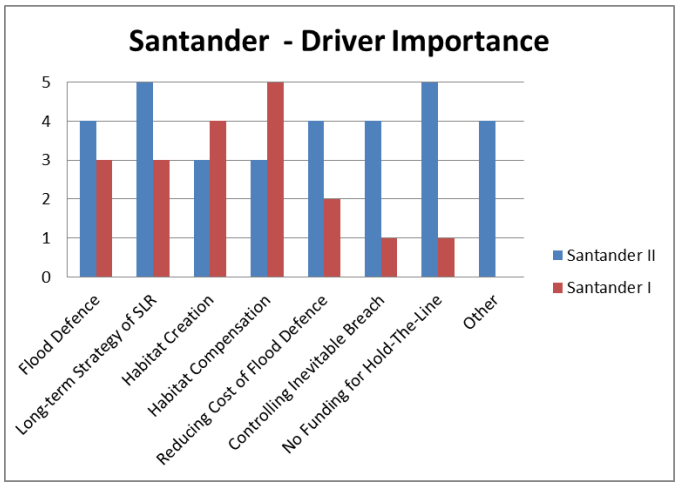


Figure 27: Graph showing the discrepancy between answers for the site but from different individuals

The results clearly reflect the differences in fields of interest and knowledge with Santander I claiming the main driver for MR to be compensation where Santander II finds flood risk management the primary goal.

Thus, due to the lack of quantitative results producing a high degree of possible bias, it is prudent to find validation from previous studies in the same subject matter. With regards to drivers, RUPP (2010) produced a research paper comparing the drivers for MR in Germany, the Netherlands and the UK. Figure 28, below, compares the results obtained in this study and those produced in RUPP (2010), showing a strong degree of variation between the two findings in terms of key drivers for the different countries.

Elbe				
Germany (RUPP, 2010)				
Plymouth				
UK (RUPP,2010)				
Scheldt - Holland				
Holland (RUPP,2010)				
	Flood risk	Nature Creation	Compensation	Financial

Figure 28: Comparison of driver data found in this study and in RUPP, 2010

However, where RUPP (2010) looked at country-wide MR statistics through quantitative surveys and data gathering, this study has focused on specific sites within those countries. Thus, the primary goal may vary to the national goal due to site-specific issues or constraints (ie: the growth of the port of Antwerp, coupled with significant erosion patterns in the Scheldt estuary requires compensation measures). This is confirmed by the following figure, Figure 29, from RUPP *et al* (2011), where current MR schemes along the Scheldt are clearly motivated by compensation measures.

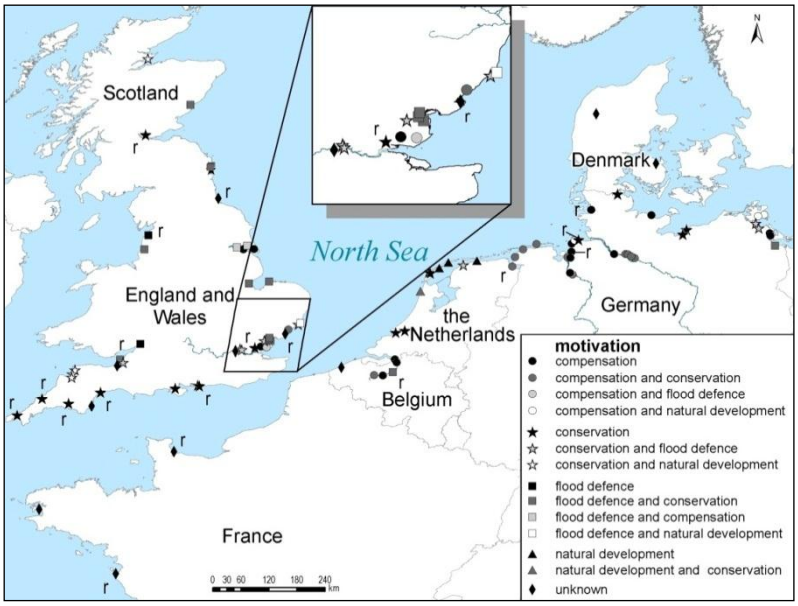


Figure 29: Motivation of MR schemes in Western Europe, 'r' depicts Regulated Tidal Exchange schemes (RUPPet al, 2011)

The result taken forward from the findings of this research, into the creation of the ESST, with regards to drivers for MR, is; the primary drivers vary greatly from site to site, but each site has a clear primary goal as well as one or more secondary goals for MR. This result is validated by the results obtained in RUPP (2010) as each country has a clear primary goal and all three countries have different goals.

The most important constraints were also found in RUPP (2010) and the results showed the following order of constraint importance for the three European countries:

- Germany – 1. Public opposition, 2. Costs, 3. No need/perceived benefit, 4. Complexity
- UK – 1. Lack of compensation, 2. Public opposition, 3. Costs, 4. Complexity, 5. Effects on protected habitats
- Netherlands – 1. Public opposition, 2. Costs, 3. Lack of compensation, 4. Population density

The results of this research found that financial constraints were the greatest constraint, followed by a lack of public support and complexity of MR. There is a very clear correlation between the data found in this study and those obtained by RUPP (2010).

Thus the idea, put forward in this study, that the ESST must address the two main constraints may be accepted as valid.

9.2 Financial Budget

The results from this research show clearly, that financial constraints such as the 'loss of high value land' and 'insufficient compensation for landowners' rank among the greatest constraints for most European countries. However, most tools to date avoid attributing costs to the various site selection criteria in order to minimise complications (see Section 4.3).

Thus, this study recommends a clear focus on the financial boundaries of each criterion with respect to a realistic and acceptable budget. This budget is set on a basis of the specific site requirements with regards to the primary goal of the project:

- Primary goal is compensation: A primary budget is set by the organisation/company carrying out the works requiring compensation. Due to the nature of a compensation scheme, being compulsory under law, this budget is increased if necessary to allow for full compensation.
- Primary goal is financial benefit: A cost-benefit analysis is performed, comparing the MR scheme to a Hold-The-Line policy. The budget is set where the MR scheme remains the more cost-effective solution.
- Primary goal is nature creation: The budget is set in accordance with the available budget for environmental projects under the local government. This may be calculated as in LIEKENS *et al,* (2010) in Section 4.2.
- Primary goal is flood risk: The budget is set in accordance with the available budget for flood risk management projects under the local government.

The result of such focus on financial criteria throughout the tool is that the financial constraints can be easily identified and sites that provide a financially acceptable solution for the specific goal are selected.

9.3 Public Opposition

The literature review and stages 1 to 4 all identified public opposition to MR as a key constraint. In particular the site visit to the Dutch Scheldt, clearly showed the impact public opposition to MR, can have on a potential scheme.

Previous studies have looked into the concept of public opposition and found that a distinct lack of knowledge was the main contributing factor: "…each of the five surveys demonstrated that the public possesses little knowledge of the marsh and polder environments." (GOELDNER-GIANELLA, 2007). GOELDNER (1999) and TUNSTALL (2000) also registered this gap in knowledge.

Stage 3: *Clarification Interviews*, carried out in this research, confirmed this lack of knowledge and showed, in addition, that the engineering and coastal experts in various European countries (ie: Poland) were not aware of the concept of MR.

In previous studies it was found that, for example: "Some respondents believed that managed realignment is only a short-term coastal defence option" (GOELDNER-GIANELLA, 2007). Also studies found that respondents' "…presence in the marsh was more contingent on their desire for contemplation and contact with nature than the will to actually observe the environment" (GOELDNER-GIANELLA and IMBERT, 2005). Such a lack of understanding of the subject of MR and the environment it is dealing with will likely lead to a lack of support from the local population due to underestimation of the importance of MR schemes both environmentally as well as in the field of safety. In addition, where local residents are not included in the decision making process, outright opposition to the finished product is a common occurrence:

> *"…it is essential that the local population have the possibility of taking part in the final decision and not suffer having the finished product imposed upon it, which in the UK has oft caused overt opposition to certain draft plans."* (EDWARDS *et al,* 1997)

Thus, this research suggests an inclusive approach for the ESST as was developed in the Comcoast site selection tool (Appendix VI). An exhaustive information campaign of letters to residents, information flyers, public workshops, newspaper articles, planning notices, as well as direct contact with stakeholders and inhabitants including guided tours of the MR areas, is suggested prior to the application of the ESST. A realisation that "scheme awareness does not necessarily equip respondents with sufficient knowledge to make informed decisions" requires an all-round information campaign that will properly equip all stakeholders (MYATT *et al,* 2003a). During the site selection process a continuous feedback approach is utilised to inform the stakeholders, as well as ensure that the final solution incorporates all interests represented. Finally, after site selection and

throughout the 'design-life' of the MR project, the stakeholders must be informed regularly of the progress of the site.

Such an exhaustive information campaign was adopted by the Royal Society for the Protection of Birds at the Freistone Shore MR site and found that "As a result of this relentless information campaign, the local RSPB have observed a massive culture change." (BADLEY, pers. comm.) Other studies have had similarly positive results from extensive stakeholder involvement: "…informing the population as well as their participation in the decision-making process and in the management of the de-polderised site largely helped the implementation of the projects" (GOELDNER-GIANELLA, 2007).

9.4 ESST Achievements

In addition to addressing the two major constraints to MR throughout Europe, mentioned above, the ESST aimed to address the following issues brought up in this research:

1. An assumption of the primary goal is made prior to the implementation of the tool
2. Stakeholders have limited/no involvement in the site selection process
3. An assumption that MR is desired and possible is made prior to the implementation of the tool
4. A 'ranking' of selection criteria in the tool that assumed a primary goal for the MR scheme
5. All sites are considered without a 'filter' to avoid excessive capital and time investments in non-eligible sites.
6. A lack of a clear budget to address financial constraints

Issues 1, 3 and 6 are addressed in the first stages of the ESST. Starting with the 'initial assessment' allows for a rapid realisation where MR is either not desired or not possible due to local policies. An identification of the primary objective of the scheme in conjunction with all relevant stakeholders, ensures that an accurate and site specific process can be used for site selection. In addition, the setting of a primary objective, leads to the allocation of a site-appropriate budget as discussed in detail in section 9.2, above. However, for compensation driven schemes, financial restrictions cannot be viewed in a similar manner as for the other 3 primary drivers. This is due to the fact that, where a compensation scheme is envisaged, the law states that the compensation measure must come to fruition no matter what cost. Thus a feedback loop is included in the compensation driver ESST where it is possible, if no adequate schemes are found, to increase the budget. In addition, excessive costs do not lead to site investigation termination under the compensation ESST, unlike the other 3 tools. Issue 2, discussed in detail in Section 9.3, above, is addressed through continuous feedback

loops at various stages throughout the path of the ESST flow charts. This includes the setting of objectives and allocation of remediation budgets for the various MR criteria in discussion with all stakeholders. The allocation of remediation budgets acts as a ranking method, where each MR criterion is allocated a percentage of the total budget available for remediation. For example, if designated areas within the proposed MR scheme are deemed unacceptable, the decision can be made, together with the stakeholders, to allocate a 0% remediation allocation to this particular issue. This will result in any area with designated space being rejected outright in the ESST flow chart. This method thus addresses issue 4. Finally issue 5 was introduced through the Stage 5. *Expert Interviews*, and was dealt with in the ESST through the additional output: abort scheme investigation. Where a critical criterion is not met within the tool, it is possible to opt out of further investigations at numerous stages of the ESST. This will allow the end user to carry out an efficient and purposeful initial site investigation.

9.5 ESST Limitations

One of the limitations identified in this research was the availability of data for the GIS modelling of sites in most countries studied. Although it was identified in Section 7 that MR scheme implementation was not necessarily related to the availability of data for GIS purposes, a lack of precise data will, likely, reduce the accuracy of the ESST results as well as diminish the efficiency of the tool. This research therefore recommends an in depth study into the accuracy of the data available for GIS purposes throughout Europe, as well as further research into data sources and availability to potential project implementers.

Due to the aim of this research to create a site selection tool that can be used on an international basis throughout Europe, the level of detail of the final tool may be limited. The individual flow chart process for the different primary goals, provides a satisfactory level of accuracy for preliminary purposes, but very local, site-specific issues may not be included in the tool (ie: the Reserve de Braud site in the Gironde had to ensure an adequate distance from populated areas due to the aim of using the site as hunting grounds). Thus it is recommended to use the ESST as a preliminary site selection tool, identifying sites with good site-specific MR potential, prior to a more in-depth site selection.

Finally, where the 'test case' modelling of the Solent region used to test the ESST did test the process of the model, it did not involve the stakeholders of the site and thus did not test one of the major aspects of the ESST. This research recommends an in-depth test of the ESST, including stakeholders, to get a better idea of the potential limitations of the tool as well as ease of use and possible areas of user confusion.

10.0 Conclusions

This dissertation aimed to develop a new preliminary site selection tool for managed realignment schemes throughout Europe. The idea of the new tool was to incorporate managed realignment procedures and practices of the different member states and unite them under a single, user-friendly, site selection tool. In order to achieve this aim the following objectives were met and the main findings of this research with regards to the set objectives were:

- **To investigate past, present and future trends in managed realignment throughout Europe and gain an understanding of the extent of managed realignment in the case study areas**,
    - Research indicates that there are currently 102 implemented MR schemes in Western Europe, spread over 7 countries: Denmark, Germany, the UK, the Netherlands, France, Spain and Belgium
    - Plans for future MR schemes exist in the Netherlands, Belgium, the UK and Germany
    - MR has been implemented at 4 of the case study areas: The Belgian Scheldt, the Gironde, Plymouth and the Elbe
    - MR is currently planned at 4 of the case study areas: The Belgian Scheldt, the Dutch Scheldt, Plymouth and Santander
    - MR is unlikely to be implemented at 2 of the case study areas: Varna and the Hel Peninsula (Gdansk)
- **To investigate the various tools currently available for site selection in Europe and determine which parts, if any, are universally applicable and may be incorporated into the new European tool**,
    - Most tools currently available are custom-designed for site-specific purposes
    - Rankings in current tools are specific to one pre-defined driver and not universally applicable
    - Most tools currently available use qualitative criteria selection
    - GIS modelling is used in all current tools and seems to be an effective method of site selection for the ESST
    - Extensive stakeholder involvement is suggested in the Comcoast study to improve public support for MR. This idea was used in the ESST
    - Current tools use similar criteria categories which were collated and used in the ESST
- **To gain an understanding of the similarities and differences in drivers and constraints for managed realignment in different European countries using a sample of case study sites,**
    - The drivers for MR throughout all study sites were found to be grouped under 4 categories: flood risk, compensation, nature creation and financial benefit

- Although compensation was found to be the most popular driver, the 9 study sites were fairly evenly spread over all 4 driver categories
- A primary driver could be identified for most study sites
- The main constraints were found to be financial and political with 'Potential loss of high-value land' and 'public opposition' being a constraint for all sites studied

- **To develop the new site selection tool, incorporating the findings of this dissertation and allowing for all the dissimilarities found amongst the participating countries, into a single, user friendly, tool.**
  - An initial assessment was included in the tool to check for MR drive and policies against a MR strategy
  - Stakeholder involvement was introduced at various stages of the tool to allow for greater participation and thus gain support as well as a more complete final solution
  - Driver-specific flow charts were produced to allow for differences in primary MR drivers between European countries
  - Clear overall budgets and remedial costs allocation were introduced into the tool to deal with financial constraints and allow for quantitative, standardised criteria analysis
  - Site investigation termination was included in the tool at various stages to provide a filtering effect for an efficient site selection process
  - A collation of site criteria was used from previous tools

The results from this study have produced a MR site selection tool that allows for an efficient and driver-specific preliminary selection process for all European countries. This new tool has the potential to facilitate international MR scheme site selection as well as reducing the complexity of procedures for multi-national MR projects. Through this study an improved awareness of the state of MR throughout Europe has been gained and the outcome may stimulate the spread of implementation of MR schemes.

10.1 Recommendations for Further Research

Further research recommended by this study includes:

1. An in depth study into the accuracy of the data available for GIS purposes throughout Europe, as well as further research into data sources and availability to potential project implementers.
2. An in depth test of the ESST, including stakeholders, to get a better idea of the potential limitations of the tool as well as ease of use and possible areas of user confusion.

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Appendix I – Questionnaires

EMILIA ROMAGNA - ITLAY

Dear Sir/Madam

The objective of this research questionnaire is to develop and test a site suitability method for the selection of potential managed realignment schemes at the 8 Theseus sites.

Managed realignment is a coastal management tool involving the setting back of the line of actively maintained defences to inland of the original (Burd, F.H., 1995. *Managed retreat: a practical guide*. English Nature, Campaign for a living coast series). The strategy allows for the breaching of previously defended land, with the possible aim of reducing 'coastal squeeze' through the creation of new saltmarsh areas and intertidal mudflats and simultaneously enhancing local flood defences.

In order to successfully implement a managed realignment scheme, the proposed site must fulfil a range of criteria: The site must lie within the tidal elevation fluctuations for saltmarshes to develop (ie: above MLWS and below MHWS). Topographic data is needed to establish fulfilment of this criterion. Furthermore, economically, socially and environmentally appropriate land must be available. For example; managed realignment schemes are normally not suitable if built up areas with high economic value are present within the site. Land use maps (including landfill sites), aerial photography data, environmental designation maps and land ownership information is required to assess the suitability of a site with regards to these criteria.

The site suitability method tested in this research was designed for selection of managed realignment sites in the UK. The questions of particular interest will be the applicability of the method on a European scale with the differences in data availability, motivations and constraints in different countries. Ultimately the insight acquired here should aid in determining where managed realignment may be an appropriate management method both at the Theseus Project sites and more generally in Europe. I would be most grateful for your cooperation in this questionnaire.

The research looks at the three limiting factors to the appropriateness of the site suitability method on a European scale: (1) data availability, (2) possible motivations, and (3) possible constrictions. (from here on managed realignment will be referred to as: M.R.)

1

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	1	**2**	3	4	5
Aerial photography	1	**2**	3	4	5
Land use maps	1	**2**	3	4	5
Designation maps	1	2	**3**	4	5
Landfill site maps	1	2	**3**	4	5
Land ownership information	1	2	3	**4**	5

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	3	**4**	5
Long-term strategy dealing with sea level rise	1	2	3	4	**5**
Habitat creation	1	2	**3**	4	5
Compensation (habitat regulation)	1	2	**3**	4	5
Reducing cost of flood defence	1	2	3	**4**	5
Controlling inevitable breach	1	2	3	4	**5**
Funding not available for hold-the-line	1	2	3	4	**5**
Other - please specify	1	2	3	4	5

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints

Lack of data and scientific understanding	1	**2**	3	4	5
Topography of area is not suitable for M.R.	1	2	3	**4**	5

Environmental Constraints

Difficultly of recreating a diverse habitat	1	**2**	3	4	5
Potential loss of terrestrial and fresh-water habitat	1	2	**3**	4	5

Financial Constraints

Insufficient compensation for affected landowners	1	2	3	**4**	5
Complexity of procedures compared to 'no intervention'	1	2	3	4	**5**
Potential loss of land with high economic value	1	2	3	4	**5**

Political Constraints

Goes against government strategy (policy)	1	2	**3**	4	5
Time delays in getting 'value' out of M.R.	1	2	**3**	4	5
Lack of public support for M.R.	1	2	3	4	**5**

Legal Constraints

Habitat regulations prohibit M.R. scheme	1	**2**	3	4	5

Other – please specifiy 1 2 3 4 5

1 Managed Realignment Site Suitability - Questionnaire

SANTANDER-SPAIN

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	X	2	3	4	5
Aerial photography	X	2	3	4	5
Land use maps	X	2	3	4	5
Designation maps	X	2	3	4	5
Landfill site maps	X	2	3	4	5
Land ownership information	X	2	3	4	5

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	X	4	5
Long-term strategy dealing with sea level rise	1	2	X	4	5
Habitat creation	1	2	3	X	5
Compensation (habitat regulation)	1	2	3	4	X
Reducing cost of flood defence	1	X	3	4	5
Controlling inevitable breach	X	2	3	4	5
Funding not available for hold-the-line	X	2	3	4	5
Other - please specify	1	2	3	4	5

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints

Lack of data and scientific understanding	1	X	3	4	5
Topography of area is not suitable for M.R.	X	2	3	4	5

Environmental Constraints

Difficultly of recreating a diverse habitat	1	X	3	4	5
Potential loss of terrestrial and fresh-water habitat	X	2	3	4	5

Financial Constraints

Insufficient compensation for affected landowners	1	2	3	X	X
Complexity of procedures compared to 'no intervention'	1	2	3	X	5
Potential loss of land with high economic value	1	2	X	4	5

Political Constraints

Goes against government strategy (policy)	1	X	3	4	5
Time delays in getting 'value' out of M.R.	X	2	3	4	5
Lack of public support for M.R.	1	2	3	X	X

Legal Constraints

Habitat regulations prohibit M.R. scheme	1	X	3	4	5

1 Managed Realignment Site Suitability - Questionnaire

UNIVERSITY OF Southampton

HEL PENINSULA - POLAND

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	X	2	3	4	5
Aerial photography	1	X	3	4	5
Land use maps	1	2	X	4	5
Designation maps	1	2	X	4	5
Landfill site maps	1	X	3	4	5
Land ownership information	1	X	3	4	5

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	3	4	X
Long-term strategy dealing with sea level rise	1	2	3	X	5
Habitat creation	1	2	3	X	5
Compensation (habitat regulation)	1	2	3	X	5
Reducing cost of flood defence	1	2	3	4	X
Controlling inevitable breach	1	2	3	X	5
Funding not available for hold-the-line	1	X	3	4	5
Other - please specify	1	2	3	X	5

The value of objects at risk from coastal flooding and erosion on Hel Peninsula is already quite high and is expected to rise in the future as a consequence of increasing attraction of the site (development of tourism).

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints					
Lack of data and scientific understanding	1	X	3	4	5
Topography of area is not suitable for M.R.	1	2	3	X	5
Environmental Constraints					
Difficultly of recreating a diverse habitat	1	2	X	4	5
Potential loss of terrestrial and fresh-water habitat	1	X	3	4	5
Financial Constraints					
Insufficient compensation for affected landowners	1	2	3	X	5
Complexity of procedures compared to 'no intervention'	1	2	3	X	5
Potential loss of land with high economic value	1	2	3	X	5
Political Constraints					
Goes against government strategy (policy)	1	2	3	X	5
Time delays in getting 'value' out of M.R.	1	X	3	4	5
Lack of public support for M.R.	1	2	3	X	5
Legal Constraints					
Habitat regulations prohibit M.R. scheme	1	2	3	X	5

Other – please specify	1	2	3	X	5

Hel Peninsula is very popular with tourists. It can be accessed by ferry from Gdynia and Gdansk during the summer. It is only 1-2 hours drive from the region of Gdańsk and Gdynia and a lot of visitors arrive by car.

Hel Peninsula is inhabited by about 10 000 people dealing with fishery and tourist services. The peninsula is visited every year by ca. 1 million tourists. At many locations, the railway and the road lie at a distance of 50-100 m from the shoreline. The peninsula width at the most narrow locations does not exceed 300 m, so there is no place to retreat.

GIRONDE - FRANCE

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	**1**	2	3	4	5
Aerial photography	1	2	3	**4**	5
Land use maps	1	**2**	3	4	5
Designation maps	1	2	**3**	4	5
Landfill site maps	1	2	3	**4**	5
Land ownership information	1	2	3	**4**	5

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	**1**	2	3	4	5
Long-term strategy dealing with sea level rise	1	**2**	3	4	5
Habitat creation	1	2	**3**	4	5
Compensation (habitat regulation)	1	2	**3**	4	5
Reducing cost of flood defence	1	**2**	3	4	5
Controlling inevitable breach	1	**2**	3	4	5
Funding not available for hold-the-line	1	**2**	3	4	5
	1	2	3	4	5
Other - please specify	1	2	3	4	5

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints

Lack of data and scientific understanding **1**

Topography of area is not suitable for M.R. **1**

Environmental Constraints

Difficultly of recreating a diverse habitat **2**

Potential loss of terrestrial and fresh-water habitat **2**

Financial Constraints

Insufficient compensation for affected landowners **4**

Complexity of procedures compared to 'no intervention **3**

Potential loss of land with high economic value **3**

Political Constraints

Goes against government strategy (policy) **2**

Time delays in getting 'value' out of M.R. **3**

Lack of public support for M.R. **3**

Legal Constraints

1 Managed Realignment Site Suitability - Questionnaire

ELBE - GERMANY

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	1	2	3	4	5
Aerial photography	1	2	3	4	5
Land use maps	1	2	3	4	5
Designation maps	1	2	3	4	5
Landfill site maps	1	2	3	4	5
Land ownership information	1	2	3	4	5

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	3	4	5
Long-term strategy dealing with sea level rise	1	2	3	4	5
Habitat creation	1	2	3	4	5
Compensation (habitat regulation)	1	2	3	4	5
Reducing cost of flood defence	1	2	3	4	5
Controlling inevitable breach	1	2	3	4	5
Funding not available for hold-the-line	1	2	3	4	5
Other - please specify	1	2	3	4	5

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints

Lack of data and scientific understanding	1	2	3	4	5
Topography of area is not suitable for M.R.	1	2	3	4	5

Environmental Constraints

Difficultly of recreating a diverse habitat	1	2	3	4	5
Potential loss of terrestrial and fresh-water habitat	1	2	3	4	5

Financial Constraints

Insufficient compensation for affected landowners	1	2	3	4	5
Complexity of procedures compared to 'no intervention'	1	2	3	4	5
Potential loss of land with high economic value	1	2	3	4	5

Political Constraints

Goes against government strategy (policy)	1	2	3	4	5
Time delays in getting 'value' out of M.R.	1	2	3	4	5
Lack of public support for M.R.	1	2	3	4	5

Legal Constraints

Habitat regulations prohibit M.R. scheme	1	2	3	4	5
Other – please specifiy	1	2	3	4	5

1 Managed Realignment Site Suitability - Questionnaire

PLYMOUTH - UK

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	1	(2)	3	4	5
Aerial photography	1	2	(3)	4	5
Land use maps	1	(2)	3	4	5
Designation maps	1	(2)	3	4	5
Landfill site maps	1	(2)	3	4	5
Land ownership information	1	2	3	4	(5)

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	3	4	(5)
Long-term strategy dealing with sea level rise	1	2	3	4	(5)
Habitat creation	1	(2)	3	4	5
Compensation (habitat regulation)	1	2	(3)	4	5
Reducing cost of flood defence	1	2	3	(4)	5
Controlling inevitable breach	1	2	3	(4)	5
Funding not available for hold-the-line	1	(2)	3	4	5
Other - please specify	1	2	3	4	5

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints

Lack of data and scientific understanding	1	2	(3)	(4)	5
Topography of area is not suitable for M.R.	1	2	(3)	4	5

Environmental Constraints

Difficultly of recreating a diverse habitat	1	(2)	(3)	4	5
Potential loss of terrestrial and fresh-water habitat	1	(2)	(3)	4	5

Financial Constraints

Insufficient compensation for affected landowners	1	2	3	(4)	5
Complexity of procedures compared to 'no intervention'	1	2	(3)	(4)	5
Potential loss of land with high economic value	1	2	3	4	(5)

Political Constraints

Goes against government strategy (policy)	1	(2)	3	4	5
Time delays in getting 'value' out of M.R.	1	(2)	3	4	5
Lack of public support for M.R.	1	2	3	(4)	5

Legal Constraints

Habitat regulations prohibit M.R. scheme	1	(2)	(3)	4	5
Other – please specifiy	1	2	3	4	5

1 Managed Realignment Site Suitability - Questionnaire

SCHELDT - NETHERLANDS

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	1	2	3	4	5
Aerial photography	1	2	3	4	5
Land use maps	1	2	3	4	5
Designation maps	1	2	3	4	5
Landfill site maps	1	2	3	4	5
Land ownership information	1	2	3	4	5

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	3	4	5
Long-term strategy dealing with sea level rise	1	2	3	4	5
Habitat creation	1	2	3	4	5
Compensation (habitat regulation)	1	2	3	4	5
Reducing cost of flood defence	1	2	3	4	5
Controlling inevitable breach	1	2	3	4	5
Funding not available for hold-the-line	1	2	3	4	5
Other - please specify	1	2	3	4	5

In the Western Scheldt (Dutch part) the answer will depend on who you ask: Population is likely to accept if needed to maintain safety of the below-sea level land; strong opposition against doing it for habitat creation. The latter is however what is required to compensate for habitat loss. Gives in the Netherlands serious political problems. Extremely sensitive topic

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints					
Lack of data and scientific understanding	1	2	3	4	5
Topography of area is not suitable for M.R.	1	2	3	4	5
Environmental Constraints					
Difficultly of recreating a diverse habitat	1	2	3	4	5
Potential loss of terrestrial and fresh-water habitat	1	2	3	4	5
Financial Constraints					
Insufficient compensation for affected landowners	1	2	3	4	5
Complexity of procedures compared to 'no intervention'	1	2	3	4	5
Potential loss of land with high economic value	1	2	3	4	5
Political Constraints					
Goes against government strategy (policy)	1	2	3	4	5
Time delays in getting 'value' out of M.R.	1	2	3	4	5
Lack of LOCAL public support for M.R.	1	2	3	4	5
Legal Constraints					
Habitat regulations prohibit M.R. scheme	1	2	3	4	5

Other – please specifiy	1	2	3	4	5

Please read up on the political turmoil this has given in the last few years both between Belgium and the Netherlands, as well as within the Netherlands. The old treaty which the Belgium's refer to, in order to oblige the Dutch to keep dredging the Western Scheldt, combined with the EU regulations requiring compensatory measures, and the huge resistant of the local population that has fought the sees for generations, make this a very c complex topic. And for some political parties, a political mine field

SCHELDT - BELGIUM

Note: the answers below are neither an official statement nor a personal opinion. It can probably be best described as a description on my perception on what lives around this issue and even then it cannot cover the diversity of opinions.

Jaak Monbaliu (March 30, 2011)

Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	1	**2**	3	4	5
Aerial photography	1	**2**	3	4	5
Land use maps	1	**2**	3	4	5
Designation maps	1	**2**	3	4	5
Landfill site maps	1	**2**	3	4	5
Land ownership information	1	**2**	3	4	5

Remark: there is a lot of information available, it is however not always clear and straightforward to access the data + not all data is freely available. I expect data collection to be relatively easy but time-consuming.

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. scheme at the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	3	**4**	5
Long-term strategy dealing with sea level rise	1	2	**3**	4	5
Habitat creation	1	2	3	4	**5**
Compensation (habitat regulation)	1	2	3	4	**5**
Reducing cost of flood defence	1	**2**	3	4	5
Controlling inevitable breach	1	**2**	3	4	5
Funding not available for hold-the-line	1	**2**	3	4	5
Other - please specify	1	2	3	4	5

Please not e that answers above are for M.R. plans already executed, in execution or at least in planning phase. For example M.R. (Hedwige Polder in the Netherlands) was part of the negotiation / compensation for deepening the fairway on the Scheldt river. Although I do not know all the details, this was often on the news and a tough political issue in the Netherlands.

Other examples: the reduced tidal inundation areas; controlled flooding areas; extension of the Zwin area (border Belgium/Netherlands) mainly to counteract sanding/silting up of intertidal domain.

It will politically be very difficult to designate more areas than there are already designated at this moment.

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraint and 1 is not a constraint at all at your site

Technical Feasibility Constraints					
Lack of data and scientific understanding	1	**2**	3	4	5
Topography of area is not suitable for M.R.	1	2	**3**	4	5
Environmental Constraints					
Difficultly of recreating a diverse habitat	1	2	**3**	4	5
Potential loss of terrestrial and fresh-water habitat	1	**2**	3	4	5
Financial Constraints					
Insufficient compensation for affected landowners	1	2	3	**4**	5
Complexity of procedures compared to 'no intervention'	1	2	3	**4**	5
Potential loss of land with high economic value	1	2	3	**4**	5
Political Constraints					
Goes against government strategy (policy)	1	2	3	4	**5**
Time delays in getting 'value' out of M.R.	1	2	**3**	4	5
Lack of public support for M.R.	1	2	3	**4**	5
Legal Constraints					
Habitat regulations prohibit M.R. scheme	1	2	3	4	5

Other – please specifiy	1	2	3	4	5

At least at the Belgian coast (is basically part of the larger Scheldt estuary) , the government has a hold the line policy. In fact there are ideas to push the line further seawards in the project Vlaamse Baaien (Flemish Bays). This idea came just a couple of years ago from a private initiative but has very recently (end of 2010) been taken over by the Flemish authorities who will order and supervise studies. The ideas are a set of projects to 1) defend the coastline 2) increase economic activity (harbours, tourism) and 3) increase diverse habitats.

Also on the Scheldt river there is the so called Sigma-plan (cf Dutch Delta-plan) in reaction to the 1953 flood.

1 Managed Realignment Site Suitability - Questionnaire

Varna - Data Availability:

The following data is required for the identification of suitable sites for M.R. schemes. Please indicate the ease of accessing each data set for your study area:

	Very easy				Very hard
Topography map	1	2	3	4	5
Aerial photography	1	2	3	4	5
Land use maps	1	2	3	4	5
Designation maps	1	2	3	4	5
Landfill site maps	1	2	3	4	5
Land ownership information	1	2	3	4	5

Possible Motivations

In order to use the model on a European scale, a comprehensive set of possible motivations for the implementation of a M.R. schemeat the 8 Theseus sites must be included. Please indicate the relative importance of the following drivers for your site, where 5 is a very important driver and 1 is not important at all:

Flood defence	1	2	3	4	5
Long-term strategy dealing with sea level rise	1	2	3	4	5
Habitat creation	1	2	3	4	5
Compensation (habitat regulation)	1	2	3	4	5
Reducing cost of flood defence	1	2	3	4	5
Controlling inevitable breach	1	2	3	4	5
Funding not available for hold-the-line	1	2	3	4	5
Other - please specify	1	2	3	4	5

Possible Constraints

If a model is to work on a European basis, it must take into consideration all the appropriate restrictions and constraints present in the various locations. This question attempts to understand the constraints that are relevant at the 8 Theseus Project sites. Please indicate the relative applicability of the following restrictions at your site, where 5 is a very strong constraintand 1 is not a constraint at all at your site

Technical Feasibility Constraints

Lack of data and scientific understanding	1	2	3	4	5
Topography of area is not suitable for M.R.	1	2	3	4	5

Environmental Constraints

Difficultly of recreating a diverse habitat	1	2	3	4	5
Potential loss of terrestrial and fresh-water habitat	1	2	3	4	5

Financial Constraints

Insufficient compensation for affected landowners	1	2	3	4	5
Complexity of procedures compared to 'no intervention'	1	2	3	4	5
Potential loss of land with high economic value	1	2	3	4	5

Political Constraints

Goes against government strategy (policy)	1	2	3	4	5
Time delays in getting 'value' out of M.R.	1	2	3	4	5
Lack of public support for M.R.	1	2	3	4	5

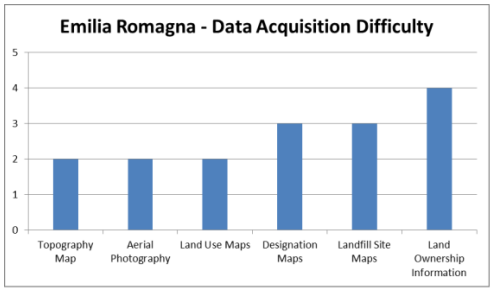
Legal Constraints

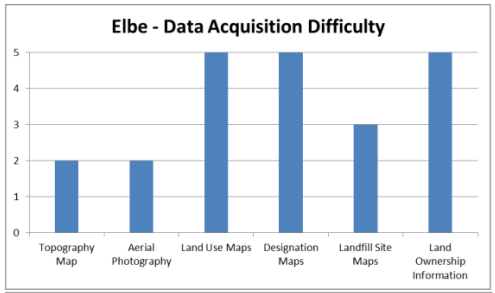
Habitat regulations prohibit M.R. scheme	1	2	3	4	5

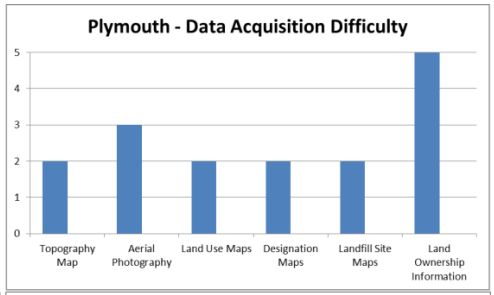
Other – please specifiy 1 2 3 4 5

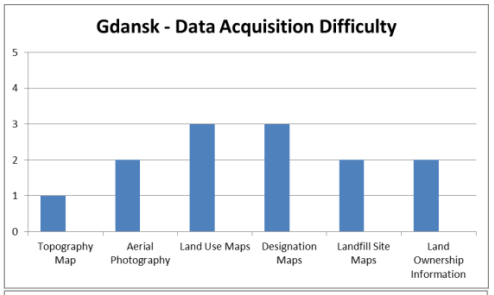
Appendix II – Questionnaire Results

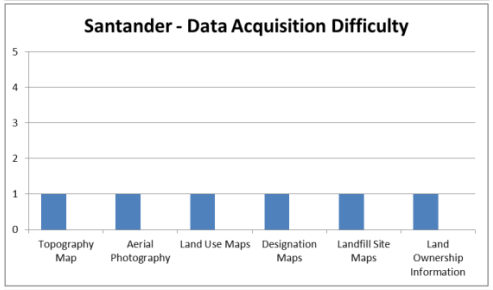
Site	Topography Map	Aerial Photography	Land Use Maps	Designation Maps	Landfill Site Maps	Land Ownership Information	Site Overall Data Acquisition Difficulty	Flood Defence	Long-term Strategy of SLR	Habitat Creation	Habitat Compensation	Reducing Cost of Flood Defence	Controlling Inevitable Breach	No Funding for Hold-The-Line	Other	Lack of Data/Scientific Understanding	Topography not Suitable	Difficulty of Recreating Diverse Habitat	Potential Loss of Other Habitat	Insufficient Compensation for Landowners	Complexity of Procedures	Potential Loss of High-Value Land	Goes Against Policy	Time Delays in Getting Value	Lack of Public Support	Regulation Prohibit
	Data Acquisition Difficulty							**Drivers**								**Constraints**										
																Technical		Environment		Financial			Political			Legal	Other
Emilia Romagna	2	2	2	3	3	4	2.7	4	5	3	3	4	5	5	0	2	4	2	3	4	5	5	3	3	5	2	0
																3.0		2.5		4.7			3.7			2.0	0.0
Elbe	2	2	5	5	3	5	3.7	5	4	2	4	2	1	1	0	2	2	4	4	2	2	5	3	4	2	3	0
																2.0		4.0		3.0			3.0			3.0	0.0
Scheldt - Belgium	2	2	2	2	2	2	2.0	4	3	5	5	2	2	2	0	2	3	3	2	4	4	4	5	3	4	0	0
																2.5		2.5		4.0			4.0			0.0	0.0
Scheldt - Holland	1	1	1	3	1	2	1.5	2	2	3	5	3	1	1	0	1	3	3	3	2	5	3	4	0	5	0	0
																2.0		3.0		3.3			3.0			0.0	0.0
Santander	1	1	1	1	1	1	1.0	3	3	4	5	2	1	1	0	2	1	2	1	4.5	4	3	2	1	4.5	2	0
																1.5		1.5		3.8			2.5			2.0	0.0
Gironde	1	4	2	3	4	4	3.0	1	2	3	3	2	2	2	0	1	1	2	2	4	3	3	2	3	3	1	0
																1.0		2.0		3.3			2.7			1.0	0.0
Plymouth	2	3	2	2	2	5	2.7	5	5	2	3	4	4	2	0	3.5	3	2.5	2.5	4	3.5	5	2	2	4	2.5	0
																3.3		2.5		4.2			2.7			2.5	0.0
Gdansk	1	2	3	3	2	2	2.2	5	4	4	4	5	4	2	4	2	4	3	2	4	4	4	4	2	4	4	0
																3.0		2.5		4.0			3.3			4.0	0.0
Varna	1	4	2	2	2	3	2.3	3	4	3	4	5	3	4	0	1	2	3	2	5	3	5	3	3	3	3	0
																1.5		2.5		4.3			3.0			3.0	0.0
Total Per Question	1.6	2.6	2.5	3.0	2.5	3.5		4.0	4.0	3.6	4.5	3.6	2.9	2.5	0.5	2.1	2.9	3.1	2.7	4.2	4.2	4.6	3.5	2.6	4.3	2.2	0.0
Importance of Constraint Sub-Section																2.5		2.9		4.3			3.5			2.2	0.0

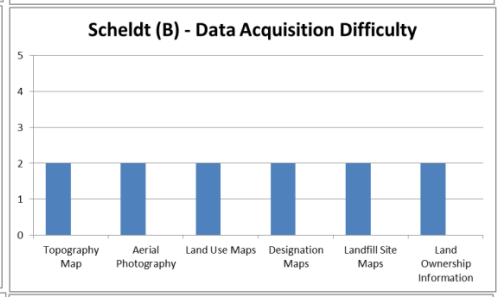

Emilia Romagna - Data Acquisition Difficulty
0
1
2
3
4
5
Topography Map
Aerial Photography
Land Use Maps
Designation Maps
Landfill Site Maps
Land Ownership Information

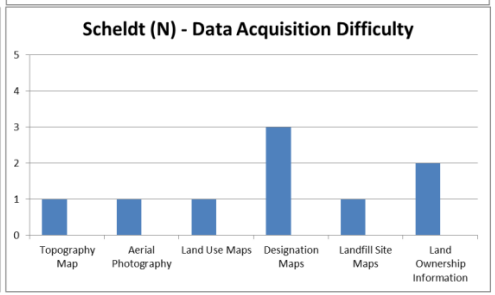

Elbe - Data Acquisition Difficulty
0
1
2
3
4
5
Topography Map
Aerial Photography
Land Use Maps
Designation Maps
Landfill Site Maps
Land Ownership Information


Plymouth - Data Acquisition Difficulty
0
1
2
3
4
5
Topography Map
Aerial Photography
Land Use Maps
Designation Maps
Landfill Site Maps
Land Ownership Information


Gdansk - Data Acquisition Difficulty
0
1
2
3
4
5
Topography Map
Aerial Photography
Land Use Maps
Designation Maps
Landfill Site Maps
Land Ownership Information


Santander - Data Acquisition Difficulty
0
1
2
3
4
5
Topography Map
Aerial Photography
Land Use Maps
Designation Maps
Landfill Site Maps
Land Ownership Information


Scheldt (B) - Data Acquisition Difficulty
0
1
2
3
4
5
Topography Map
Aerial Photography
Land Use Maps
Designation Maps
Landfill Site Maps
Land Ownership Information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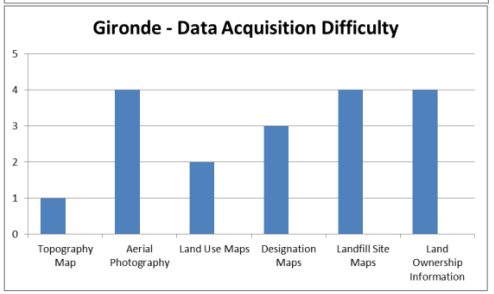
Aerial Photography
Land Use Maps
Designation Maps
Landfill Site Maps
Land Ownership Information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Designation Maps
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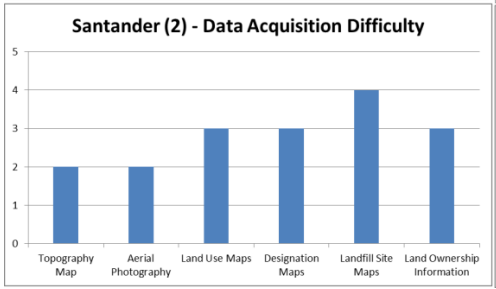
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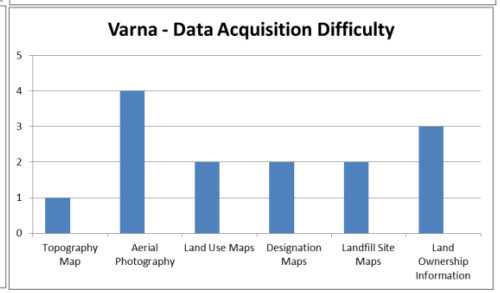
Varna - Data Acquisition Difficulty
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Designation Maps
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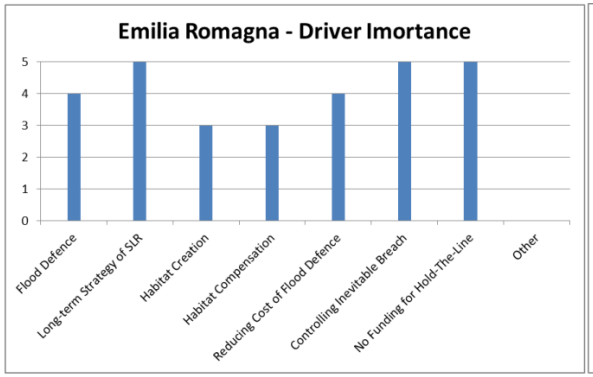
Land Ownership Information


Emilia Romagna - Driver Imortance
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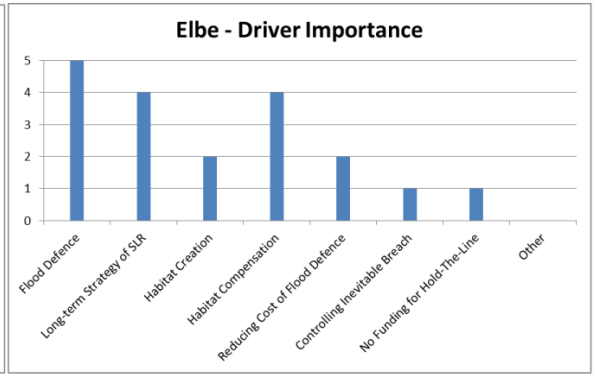
Long-term Strategy of SLR
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other


Elbe - Driver Importance
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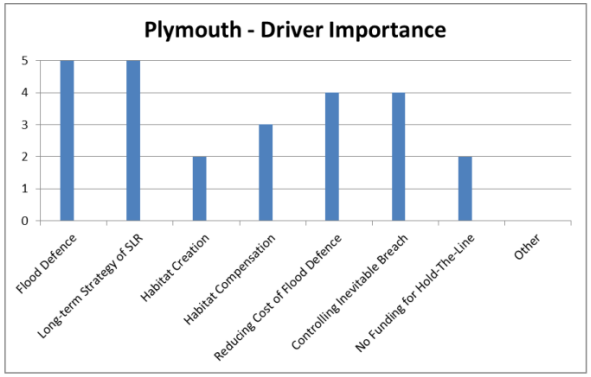
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other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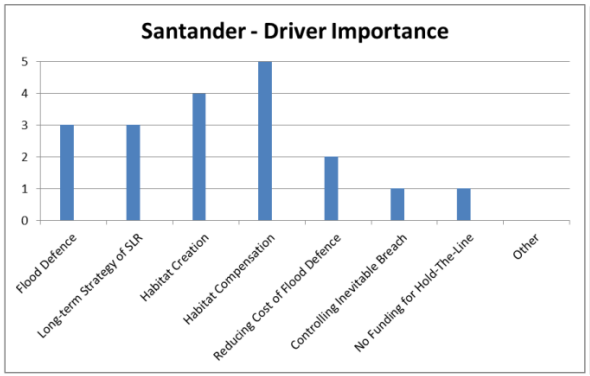
Long-term Strategy of SLR
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other


Santander - Driver Importance
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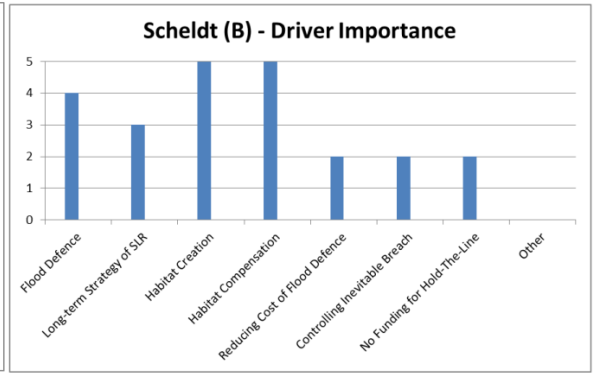
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other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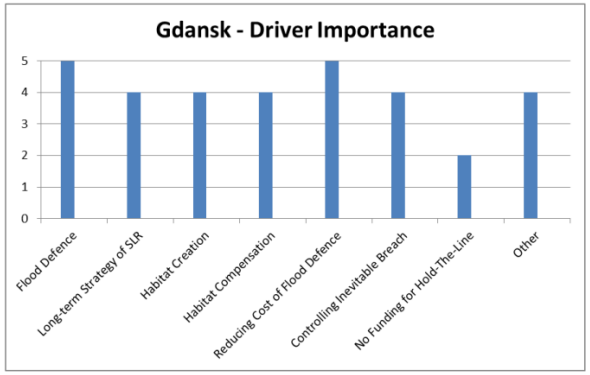
Long-term Strategy of SLR
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other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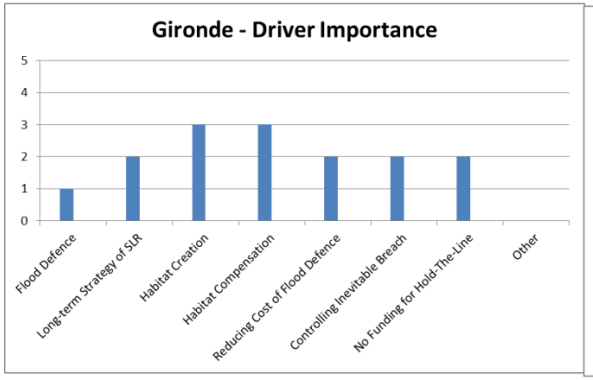
Long-term Strategy of SLR
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other


Gironde - Driver Importance
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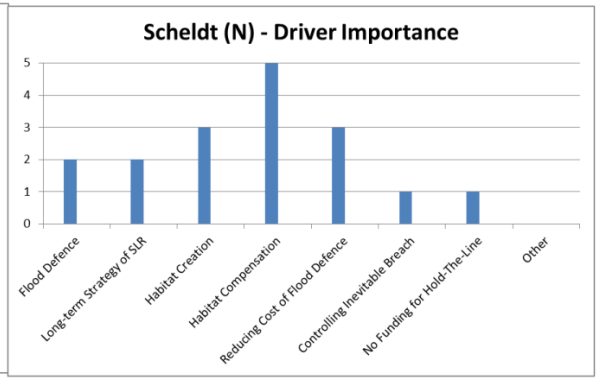
Long-term Strategy of SLR
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other


Scheldt (N) - Driver Importance
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Long-term Strategy of SLR
Habitat Creation
Habitat Compensation
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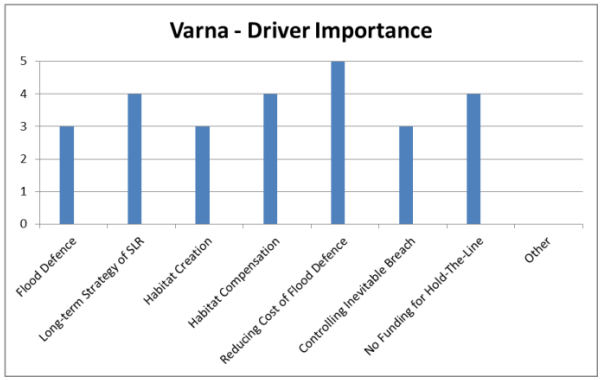
No Funding for Hold-The-Line
Other


Varna - Driver Importance
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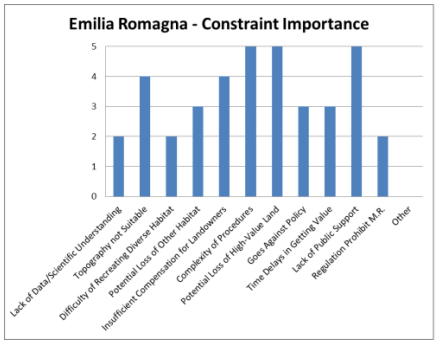
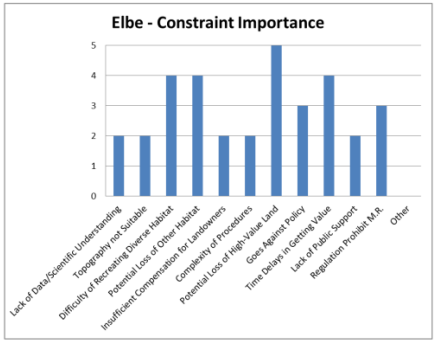
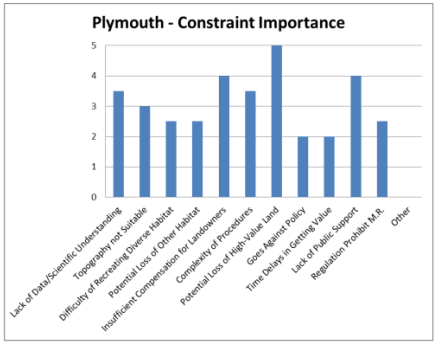
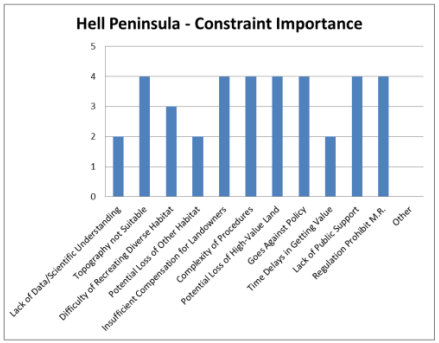
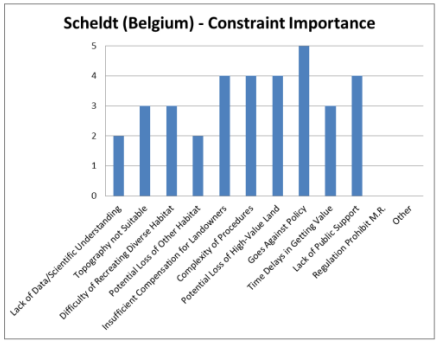
Long-term Strategy of SLR
Habitat Creation
Habitat Compensation
Reducing Cost of Flood Defence
Controlling Inevitable Breach
No Funding for Hold-The-Line
Other

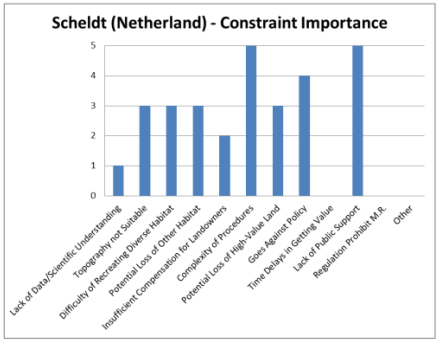

Emilia Romagna - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other

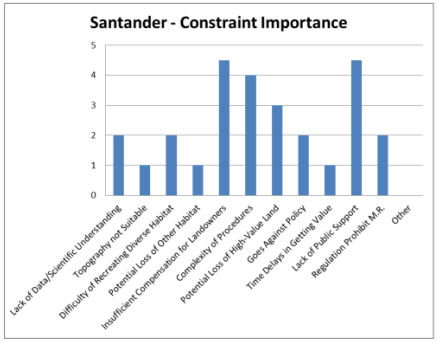

Elbe - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other


Plymouth - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other


Hell Peninsula - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other


Scheldt (Belgium) - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other


Scheldt (Netherland) - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other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Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
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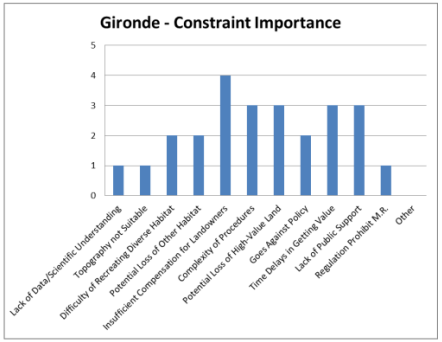
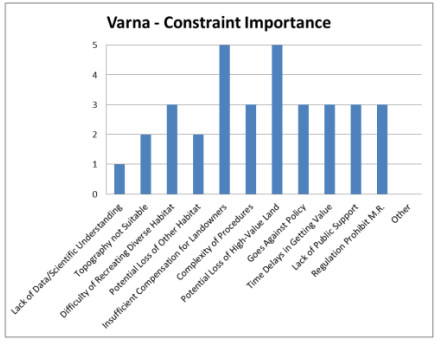
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other


Gironde - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other


Varna - Constraint Importance
Lack of Data/Scientific Understanding
Topography not Suitable
Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
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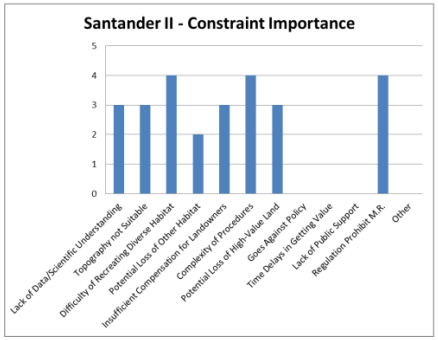
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other


Santander II - Constraint Importance
Lack of Data/Scientific Understanding
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Difficulty of Recreating Diverse Habitat
Potential Loss of Other Habitat
Insufficient Compensation for Landowners
Complexity of Procedures
Potential Loss of High-Value Land
Goes Against Policy
Time Delays in Getting Value
Lack of Public Support
Regulation Prohibit M.R.
Other

Appendix III – Clarifying Interviews

Example Interview:

Profile Questions

- What is your area of expertise?
- What previous experience have you had with Managed Realignment?

Managed Realignment (M.R.) Questions

- What do you understand by the term M.R.?
- Briefly, what do you think about M.R. in general?
- What is the general attitude towards M.R. in your area?
- Is "coastal squeeze" due to sea level rise seen as an issue in your area?
  - If yes, is compensation required for this process?
  - If no, why not?
- What general policy might support M.R. in your area, if any?
- What are the benefits of M.R. in your area, if any?
  - Examples: Cost related benefits, Social benefits, Legal benefits, Ecological benefits?
- What are the disadvantages of M.R. in your area, if any?
  - If there are no schemes, why are there no schemes currently?
  - Examples: Too much paperwork, a feeling of reduced safety, no need?
- What is the relation of public vs. private ownership in your area?
  - Who are the relevant landowners for M.R.?
  - Is the value of land rising in your area?
  - What government schemes, if any, are available for compensation for private owners?
- What planned M.R. is there in your area, if any?
  - Short term plans
  - Long term plans
- Do you expect an increase in M.R. in the near (0-20years)/far (20-100years) future?
  - No Action, Continue Present Rate, Increased Rate
  - Why do you expect this?

Questionnaire Specific Questions

Confidentiality

- Do I have permission to use the above answers in my research project?
- Are any parts of your answers above confidential and not to be used in the thesis write-up?

Hel Peninsula – Poland:

Profile Questions

- What is your area of expertise?

Rafal – Institute of hydro engineering (Leader)

- *Leader WT2.6, experience with dynamics and coastal protection*

Beata – IMGW: Maritime Office, forecast of sea level and warning system

- *Not officially involved in WT2.6 but Rafal feels they are combined site champions*

Managed Realignment (M.R.) Questions

- What do you understand by the term M.R.?
- Briefly, what do you think about M.R. in general?

R – Never met this term before I started with the Theseus Project, I feel it is more appropriate for tidal regions. MR is not for the Baltic Sea.

B – Never heard of MR either. But you can't compare the German Baltic coast because the Polish coast has even less tides. We really have no tides (less than 1 cm)

- What is the general attitude towards M.R. in your area?
- Is "coastal squeeze" due to sea level rise seen as an issue in your area?

R – Planning against sea level rise, we take into account SLR with all the coastal plans including storm surges = 30 cm SLR + 1.5m storm surge.

We do wonder if there will be enough space for nature to retreat but in Hel Peninsula there is no space for retreat, therefore we cannot focus on the nature problem

B – The general strategy for coastal defence is being reviewed. In accordance with the, now implemented EU Directives, we prefer to adopt soft measures for coastal problems.

- What general policy might support M.R. in your area, if any?

R – We are concerned about the maintenance of the coast with SLR, but there is simply no possibility to retreat. In accordance with the local directive the options for the Hel Peninsula area is beach nourishment and hard protection measures. The parliamentary law states that for this area retreat is not an option.

- What is the relation of public vs. private ownership in your area?

R – Private landowners must receive agreement from the Maritime Office to build near the coast.

R – All coastal water and land belongs to the government although there are private harbours, they are under supervision of the Maritime Office. In any danger area permission for building can only be given by the Maritime Office. Therefore there will not be buildings in an area where retreat might be possible.

R – There is no compensation scheme for possible retreat schemes because any retreat would not be managed and therefore seen as a 'disaster' for which compensation is not given.

- What planned M.R. is there in your area, if any?

none

- Do you expect an increase in M.R. in the near (0-20years)/far (20-100years) future?

none

Questionnaire Specific Questions

R – All data for the Hel Peninsula is held by the Maritime Office. It is not publicly available. The data is held by the Maritime Office for the Hel Peninsula because it is a problem area with regards to the coast processes happening there. Therefore a close eye must be kept on the area by the Maritime Office.

Appendix IV – Interview: John Pygott

14/04/2011 – Interview with John Pygott

Q1: **Why do you think there are so many M.R. schemes in the UK compared to comparable coast lines in other European countries?**

A1: In other countries, such as the Netherlands, it seems they have a different interpretation of the 'habitats directives'. As you know, in the UK we seem to have formulated the idea that we need to compensate for direct construction, but also for coastal squeeze. Coastal squeeze is seen in many other countries as a natural process and not needed to compensate for.

Q2: **In your experience is M.R. generally popular amongst the UK population?**

A2: M.R. used to be very easy to implement. Now it is getting more difficult to acquire the land required for M.R. This is mainly due to the fact, in my opinion, that the price of the crops is going up. Back in the early to late 1990's the price of crops was very low. As a matter of fact we used to get phone calls offering to sell land to us for M.R. purposes. Now, however, the agricultural land value is ever rising and it is becoming very difficult to buy the land.

Q2a: **But is M.R. still popular with the rest of the population?**

A2a: We are also seeing a real decline of popularity of M.R. in general as many people feel that they are giving away land and not seeing any real returns. In other European countries they link M.R. schemes to larger, flood related, schemes to show something at the end of the project. That is something we should learn to do more in the UK.

Q3a: **Is this a national problem or a local one, do you think?**

A3a: This seems to be a national problem with M.R. schemes, as everybody working in this field is experiencing similar issues now.

Q4: **How do you think M.R. schemes differ in the UK and the rest of Europe?**

A4: The main difference, I believe, from my work with other countries, is that they link their M.R. schemes with larger, more popular schemes. This means that the population gets behind the scheme and it is less difficult to get the scheme going.

Q4a: **What about in terms of site selection?**

A4a: I believe the site selection is very similar in most countries where M.R. is practiced. The only major difference being that the focus seems to be more on flood risk management. I have seen, however, some very significant opposition in, for example, a site in the Scheldt (Flanders), where it was clear that there was some very emotional issues of land reclamation heritage.

Q4b: What would be your advice for a European site selection tool?

A4b: I think the key challenge will be in terms of using the scores which will be derived from the various tests and combining them in a way which delivers the best result in terms of comparing sites. Our experience has generally shown that all sites have significant disadvantages which can generally be overcome by increasing costs, but the final site selection is likely to be based on a series of compromises.

As an example we have had situations where a site may be cheaper in land purchase terms but requires greater engineering intervention than a more expensive site because of factors such as contaminated land remediation. This means that the costs and benefits need to be looked at across all the potential scheme activities as early as possible.

This requires a fair amount of detailed information needing to be gathered to feed the process. This in itself can be costly if it requires ground investigation, detailed engineering design, planning of remediation for contamination etc. Your tool really needs to operate as a series of filters which will allow sites to be rejected as early as possible to keep costs down, but at the same time to provide a sufficiently robust defence of why sites end up being selected when others have been rejected.

The other area which has been difficult and will certainly be hard to reflect in a tool is around some of the intangible factors such as local community support or opposition. This could easily be the most significant factor but is hard to test and is prone to changing over time.

Q5: **Is M.R. proving to be a successful measure in your experience?**

A5: From the monitoring projects we have been running we are confident that M.R. is a very useful and successful measure. Although, maybe due to the lack of running time so far, or possibly simply the nature of M.R., we have not reached 100% compensation, we are very sure that M.R. is a good method for compensation and mitigation of engineering in this country.

Thank you very much

Appendix V – Tool 1

TURNER *et al,* 2006 - Humber

Figure 1: Decision support system for the Socio-Economic Analysis of coastal and flood defences

1. Scoping Stage

- Assessment of the environmental change process - Driving Forces–Pressure–Sate-Changes–Impacts–Responses (DP-S-I-R framework)
- Institutional and Stakeholder mapping and analysis

2. Analysis Stage

- Scenario setting and Management options analysis
- Data-collection and initial Monitoring (including Geographical Information Systems (GIS) data)
- Ecosystem functioning and valuation analysis

3. Evaluation Stage

- Cost-benefit modelling and valuation
- Multi-Criteria Assessment

Adapted from: OECD, 1993 and Turner *et al.*, 1998

The five scenarios are based on the following assumptions:

1. *Hold-the-line (HTL):* the existing defences are maintained to a satisfactory standard, but intertidal habitat will be lost due to continued development and coastal squeeze.
2. *Business-as-usual (BAU):* this option takes into account existing realignments; however compliance to the Habitats Directive is also lax, with continued economic development leading to an overall net loss of habitat due to coastal squeeze.
3. *Policy Targets (PT):* Economic growth is combined with environmental protection, with realignment undertaken to reduce flood defence expenditure and compensate for past and future intertidal habitat loss in compliance with the Habitats Directive.
4. *Deep Green (DG):* Environmental protection takes priority over economic growth, while development continues; the maximum feasible area of intertidal habitat is created.
5. *Extended Deep Green (EDG):* A greater emphasis is placed on habitat creation, with less restrictive criteria being used to identify suitable areas for realignment.

Figure 2: GIS – based realignment site location criteria

Criterion 1 – The Area below the High Spring Tide Level
The high spring tide level is the highest point at the coastline that is reached by the sea during a spring tide. The area below the high spring tide level illustrates the maximum area of intertidal habitat that could be created, before other factors are considered.
Criterion 2 – The Present Land Use of the Area
In all the managed realignment scenarios, i.e. BAU, PT, DG and EDG, it was not considered appropriate to carry out realignment where protected flora or fauna or historical/cultural assets would be put at risk. Therefore Sites of Special Scientific Interest (SSSI), Special Areas of Conservation (SAC) and other similarly protected areas together with historically significant buildings were excluded from the realignment areas.
Criterion 3 – The Infrastructure of the Area
For all of the scenarios, the transport network – including roads, railway lines and canals – were taken into account.
Criterion 4 – The Historical Context of the Area
The BAU, PT and DG scenarios considered the historical context of the potential areas for realignment. This constraint dropped for the EDG scenario.
Criterion 5 – The Spatial Context of the Areas
SIZE: The BAU, PT and DG scenarios considered that it would only be cost effective to realign areas that are greater than 5 ha in size (Pilcher *et al.*, 2002), while EDG scenario did not comply with this restriction, considering the creation of any intertidal habitat to be beneficial.
SHAPE: The BAU, PT and DG scenarios considered that the optimum shape for realignment areas can be considered as a trade-off between creating a wide intertidal area to maximise benefits, while ensuring that the length of realigned defences to protect the surrounding land is no greater than those which already exist (Pilcher *et al.*, 2002). This limitation was relaxed in the EDG scenario.
ELEVATION: All of the scenarios favoured retreat to an elevation above the high spring tide level where possible.
PROXIMITY TO EXISTING INTERTIDAL HABITATS: All of the scenarios considered that it is preferable to create intertidal habitats where they will fit in with the overall vegetation succession to facilitate the movement of species between habitats (Bergstrom *et al.*, 1996).

Appendix VI – Tool 2

RUPP, 2010 - International

Basic Screening:

Basic screening of the 8 selected sites will look for (as specified in S.Rupp, 2010):

- Appropriate elevation in the tidal frame;
- The exclusion of potential first order constraints; this could include: sites below a certain size, sites of certain elevation in the tidal frame, sites containing contaminated/landfill, sites containing major infrastructure, and steep sites.

What data is required: Topography map, tidal level data, appropriate exclusion layers (e.g. landfill)

Detailed Screening

Detailed screening comprises 4 sets of detailed site selection guidelines (as specified in S.Rupp, 2010), focussing on different parameters.

1. Suitability for habitat development (ease of flora and fauna establishment & sustainability)

- Slope of 1-3%; good slope (i.e. no future drainage problems);
- Close proximity to existing habitats;
- Appropriate site elevation;
- Low wave/tidal energy exposure;
- No water logging/aquaclude (due to arable site history);
- Remnant creek system/drainage;
- Not adjacent to major road/railway/airport (though some existing MRs are);
- Creates desired habitat/habitat mix.

What data is required: Topography map, bathymetry map, aerial photography, land use map, expert judgement

2. Economic suitability (cost of implementation)

- Low value land (e.g. low grade agriculture, low competition for land (ideal: in public ownership));
- No/short/low new defence needed;
- Low amount of engineering works needed (depending on a);
- Close to navigation channel (e.g. ease of affecting boat access for recharge);
- Low value/vulnerability of existing flora and fauna (i.e. designation/need for replacement
- habitat);
- Low value of fronting habitats;
- Low archaeological value.

What data is required: Topography map, bathymetry map, aerial photography, land use map, designation map, expert judgement.

3. Flood defence suitability (water level/cost reduction benefits)

- Low value/standard of existing defence (need for replacement);
- High wave attenuation potential (medium to long-term as saltmarshes develop);
- Low impact on estuary tidal prism;
- Beneficial impact on water levels (i.e. flood storage);

- Site's preferred management option is realignment/no active intervention (mostly applicable to countries with an SMP-type process which considers various options for each coastal management unit);
- Flood risk to adjacent properties is not increased/shorter line of defence than before.

What data is required: Topography map, bathymetry map, aerial photography, land use map, water level modelling, expert judgement.

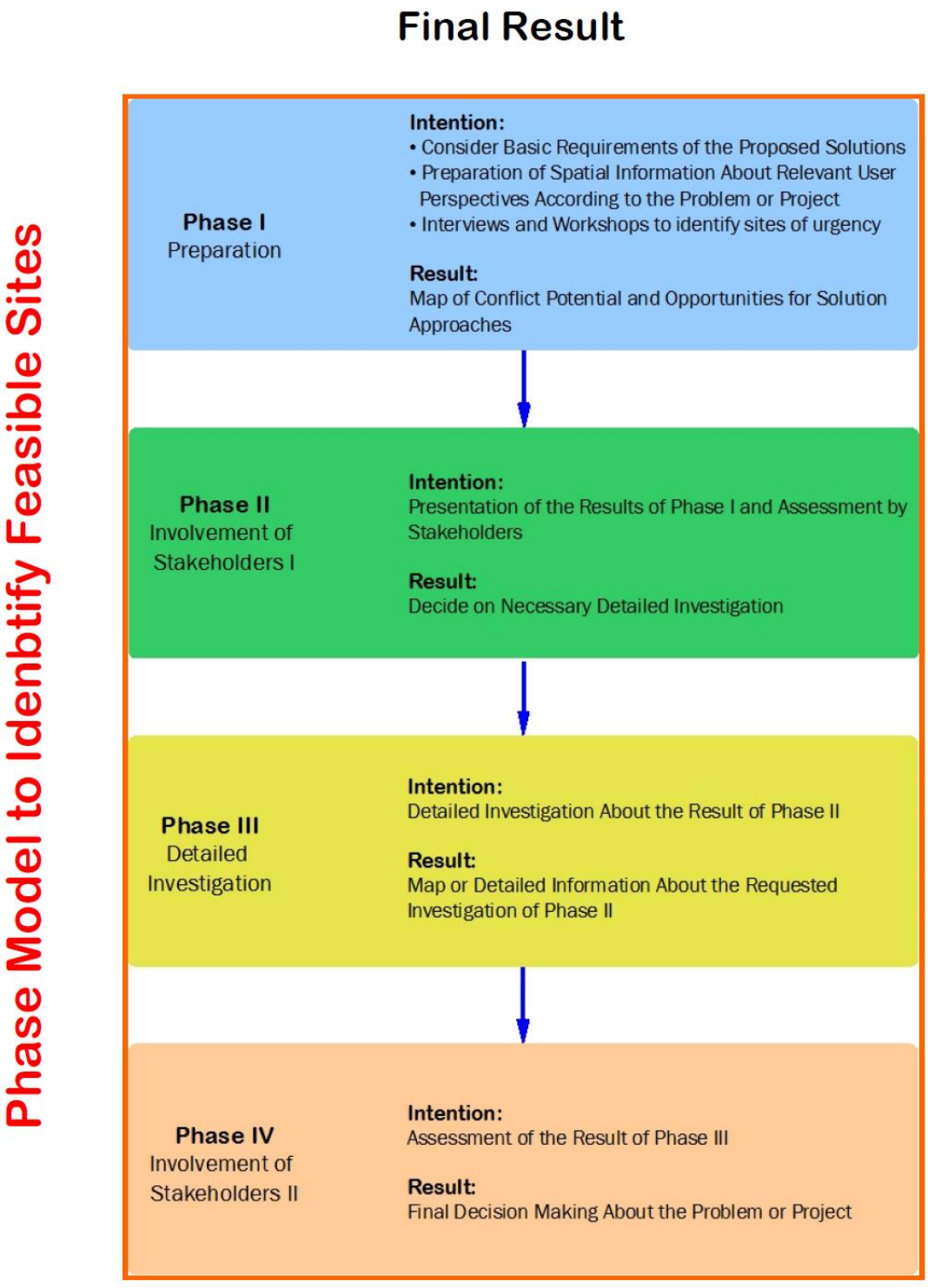
4. Social/political suitability (enforceability)

- Site has flood defence/safety function;
- Preferred management option is not hold the line;
- Site has no/low amenity value;
- Willing landowner, low amount of owners (ideal: public/NGO ownership);
- No public rights of way on site/seawall.

What data is required: land ownership/local knowledge, rights of way information.

Appendix VII – Tool 3

AHLHORN, 2007 - ComCoast



Appendix VIII – Tool 4

Wallasea

Site Selection Objectives

As a starting point for this review the original designed objectives for the proposed compensation measures were considered. These objectives were as follows:

(1) Provide habitat for the number and diversity of birds displaced by the loss of the two intertidal areas.
(2) Offset impacts to the integrity of the Medway and the Stour & Orwell Special Protection Areas (SPAs) caused by the two developments.
(3) Be self-sustaining, maintain bird populations for at least 50 years and not affect the integrity of the areas in which they are situated.
(4) Provide compensation measures for the loss of wetland functions (if any) which cannot be adequately replaced
(5) Be as close as possible to the original sites (i.e. Lappel Bank and Fagbury Flats) and ideally within the Greater Thames Estuary Natural Area (GTENA).
(6) Be at least 40ha in size.
(7) Not affect existing infrastructure.

Site Selection Process

The Stage 1 process involved the following key steps:

(1) Review of Flood Plain areas across North Kent, Essex and Suffolk

(2) Identification of urban and/or nature conservation constraints

(3) Identification of sites that are of a suitable size (i.e. larger than 40ha)

(4) Identification of sites likely to provide suitable mudflat habitat (more than 20ha)

(5) Comparison of the length of the required new counterwall (i.e. the new coastal defences to be created as part of the coastal realignment) with the length of the existing wall.

(6) Final selection of sites for Stage 2 review.

Stage 2 – Final Selection of Preferred Sites

Methods

Objective

The 43 potential sites identified in Stage 1 represent theoretical options that have the requisite outline characteristics but which require further studies to confirm that coastal realignment is achievable. The objective of the Stage 2 process is therefore, to compare these sites in terms of their value as compensation areas based on a range of geomorphological, ecological, engineering and socio-economic factors. In addition this stage seeks to select out those sites for which there may be significant obstacles, or 'constraints', to conducting a coastal realignment operation. Following this review the sites which are deemed to be most suitable for the coastal realignment work based on all considerations are identified and presented for further consideration by the PMG. To make this final selection of viable options the following steps were pursued: -

(1) Local EN teams and the EA were consulted to obtain relevant information about these sites.

(2) Any potentially significant constraints to realignment operations identified during the consultation process were highlighted.

(3) A Multi-Criteria Analysis (MCA) was applied to objectively compare all the sites using a suite of pre-determined criteria.

Table 3. MCA Criteria used for both the previous stage of the Phase 1 review and the present extended site selection process

No.	Key Criteria for Multi-criteria Analysis	Review of Nine Sites (ABPmer 2002)	Extended Site Selection Review (Present Study)	Scoring System Adopted for the Extended Site Selection Review MCA	Phase 1 Weighting	Additional Review Weighting
1	Total area of coastal setback	Modelling (by BTO/CEH) of likely bird numbers as % of target.	Extent of entire coastal set back area	0 – <40ha total area; 1– 40-100ha total area 2– 100-200ha total area 3 –200-400ha total area 4 –400-600ha total area 5 - >600ha total area	N/A	Highest (80-100)
2	Morphological functioning or 'Sustainability' of the site	% change in area at HW and Expert Judgement	Index = % change in tidal prism.	1 - Least unsustainable if Index relatively high (>500x10-5m3). 2 – Intermediate if Index between 1-5x10-3m3. 3 – Most Sustainable if Index 1 relatively small (<5x10-3m3).	High/Med (50-80)	High/Medium (60-80)
3	Indirect geomorphological impact on adjacent coastal and estuarine habitats	Not separately considered	Index = % distance upstream multiplied by % change in tidal prism and Expert Judgement	1 – Largest potential effect if Index >0.1 and Expert Judgement, 2 – Intermediate if Index is between 0.002-0.1, 3 - Smallest potential effect if Index <0.002.	High (60-80)	High/Medium (60-80)
4	Ecological Impact to terrestrial and freshwater habitats on site	Not considered	Likely occurrence of: Protected Species, Breeding birds and land subject to Environmentally Sensitive Area (ESA) agreement based on EN Questionnaire	0 – Largest potential effect if all 3 factors apply 1 – Intermediate high if 2 factors apply 2 – Intermediate low if only 1 factor apply 3 – Lowest potential effect if no factors apply	N/A	Medium/Low (30-60)
5	Engineering Feasibility and costs	Costing based on Bill of Quantities	Bill of Quantities for engineering works including mitigation measures required under CRoW act (estimate only)	1 – Highest Cost (more than £10m) 2 – Intermediate Cost (£5 to £10m) 3 – Intermediate Cost (£2 to £5m) 4 – Lowest Cost (< £2m)	Med/Low (30-60)	Low (20-40)
6	Current standard/condition of sea defences	Based on SMP or other relevant information available	Based on SMP or other relevant information available	1 - Very good 2 – Good 3 – Moderate 4 – Poor	Low (20 to 40)	Low (20-40)
7	Preferred flood defence option	SMP	SMP	0 – Hold the line 1 – Managed Retreat	Low (20 to 40)	Low (20-40)
8	No. of owners	Local Knowledge	Based on Local Knowledge and EN Questionnaire	0- More than 2 owners, unknown or not specified 1 - Two owners 2 - One owner only	Lowest (10 to 20)	Lowest (10-20)

	Average distance of site from Lappel and Fagbury	Average distance of site from Lappel and Fagbury	0 – Furthest (>60km) 1 – Intermediate high (50-60km) 2 – Intermediate Low (40-50km) 3 – Closest (<40km)	Lowest (10 to 20)	Lowest (10-20)

Appendix IX – Tool 5

Solent

A matrix was applied to rank the sites within each time epoch; this addressed more detailed issues such as land use, proximity of existing saltmarsh, licensed abstraction sites, historic buildings/scheduled monuments, archaeology, land ownership, rights of way and recreational use (see Appendix 3). Sites were ranked in each epoch and within their potential management option (i.e. – managed re-alignment, OA abandon, private abandon and hold the line), using the matrix (Table 5.3). Sites located at the top of epochs 0-19, 20-49, 50-100 and 100+ are technically most favourable for re-alignment or abandonment as;

- the land use is either unused or low grade agricultural land
- there is no or little cultural heritage
- there are no or few licensed abstraction sites
- there is low recreational usage
- there are no rights of way
- the land is owned by one statutory body rather than a number of individual private landowners
- the site is greater than 10 ha in area. Those sites greater than 40 ha were weighted.

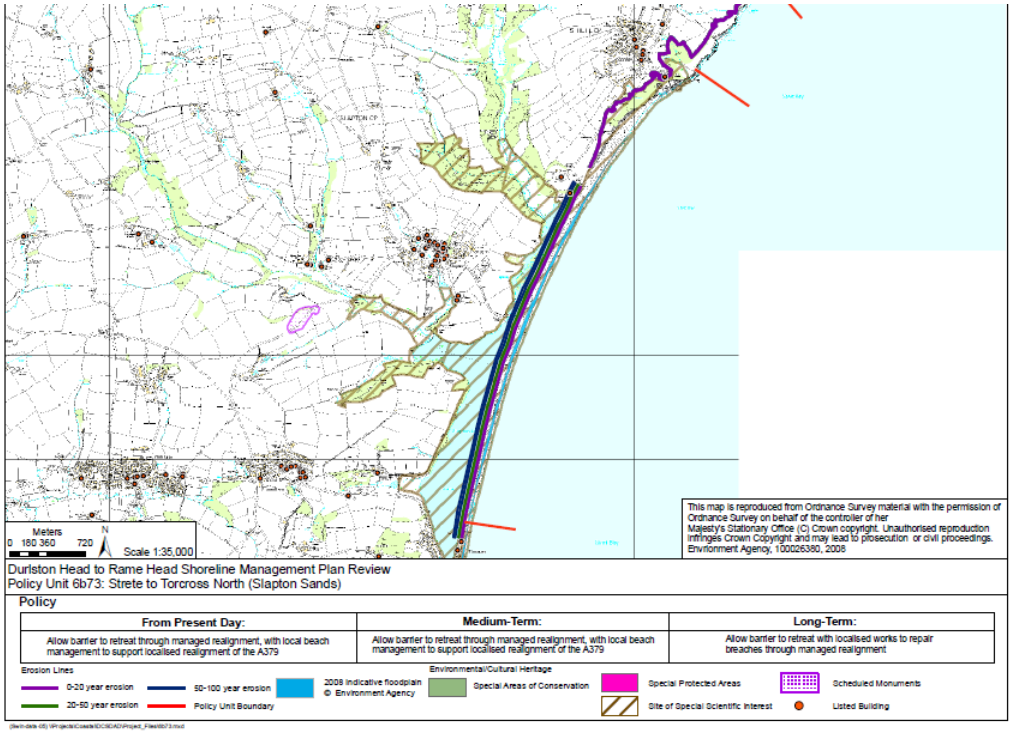
0-19	Ha	Score	20-49	Ha	Score	50-99	Ha	Score	100+	Ha	Score	Hold the line	Ha	Score	Naturally occurring	Factored out
West Northney	7	29	Pagham South	22.2	29	Stoke	4.6	28	Birdham	25	30	Southmoor	13.9	29	Beaulieu River_a	Alexandra Park
Medmerry	347	27	Thorney Island_c	11.9	24	Nutbourne	25.6	26				Prinstead	8.6	28	Beaulieu River_b	Alverstoke
Gillies	2.2	27	Itchenor	11.5	31	West Wittering	13.6	25				Appledram	10.7	27	Chaldock Point	Anchorage
Farlington Marshes	74	27	Tournerbury	44	29							Bremere and Pag Rife	196	27	Darkwater	Bakers Farm
North Common	4	26	Verner Common_b	2.4	28							Portchester Rec	8.1	26	Gutner Point	Bosham_a
Saltgrass Lane	15.9	24	Pounds Marsh	10.2	27							Fishbourne_b	9.8	26	Hamble_a	Bury Marshes
Lymington Reedbeds	35.6	24	Warren_Nore_b	44.3	27							Thorney Island_b	190	25	Hamble_b	Calshot
Conigar Point	4.1	30	Fishbourne_a	21.3	27							Keynor Rife	13.3	24	Hamble_c	Cams Hall A
Hook Lake	46	29	Beaulieu_Warren	193	27							Titchfield	170	23	Test Valley	Cams Hall B
Bosham_b	4.8	28	Warren_Nore_a	12.3	26							Key_Pen_b	101	23		Cams Hall D
Wicor	1	28	Newtown	1.6	25							Avon Water	40.7	23		Eastney
Thorney Island_a	63.3	28	East Chidham_a	4.7	24							Key_Pen_a	24	21		Fishbourne_d
Warblington	4.8	27														Fleetlands
Fleet	2.3	26														Frater
Church Norton	21.1	21														Gilkicker
Northney Farm	46	28														Great Salterns
Ella Nore	5.1	27														Hilsea
West Chidham_a+b	37	27														Horsea Island
Stanswood Valley	13.7	27														Hythe_b
Verner Common_a	6	26														Itchen Valley
Horse Pond	5.8	25														Lower Lym_b
Stansore Point	15.4	25														Lower Lym_c
Sidlesham	8	25														Lower Lym_d
East Chidham_c	4.7	24														Mengham
East Chidham_b	16.6	23														Pitts Deep
Selsmore	3.7	23														Plummers Water
																Ports Creek
																River Alver
																Salterns
																Sandy Point
																Sinah
																Sowley_a
																Sowley_b
																Westlands
																Woodcot

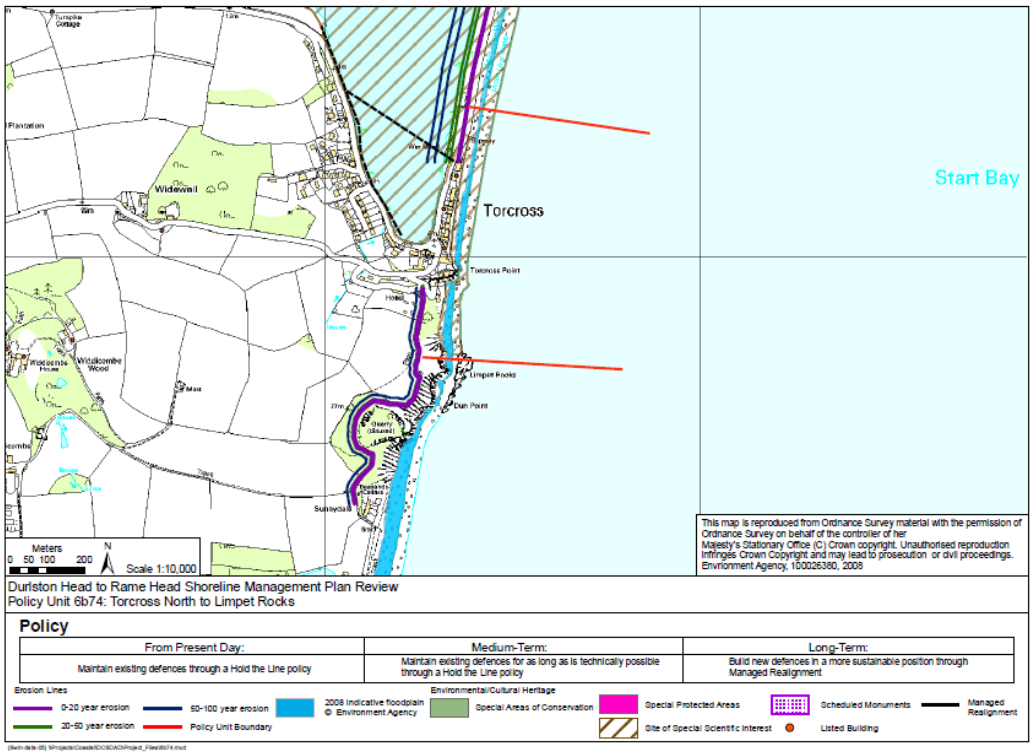
Re-align (OA)
Abandon (private)
Abandon (OA)
Hold the line (OA)
Naturally occurring
Factored out

Table 5.3: Epoch and ranking of potential habitat creation sites

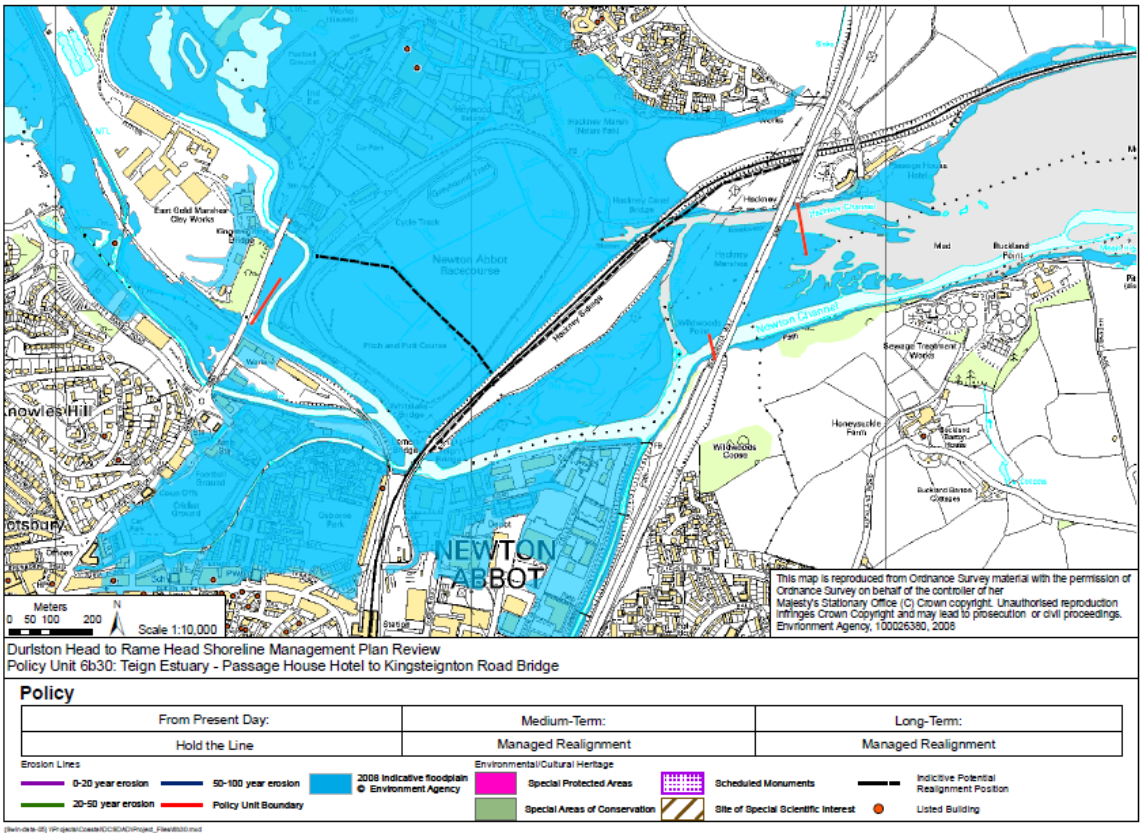
Appendix X – Durlston Head to Rame Head SMP2

Slapton Ley MR:

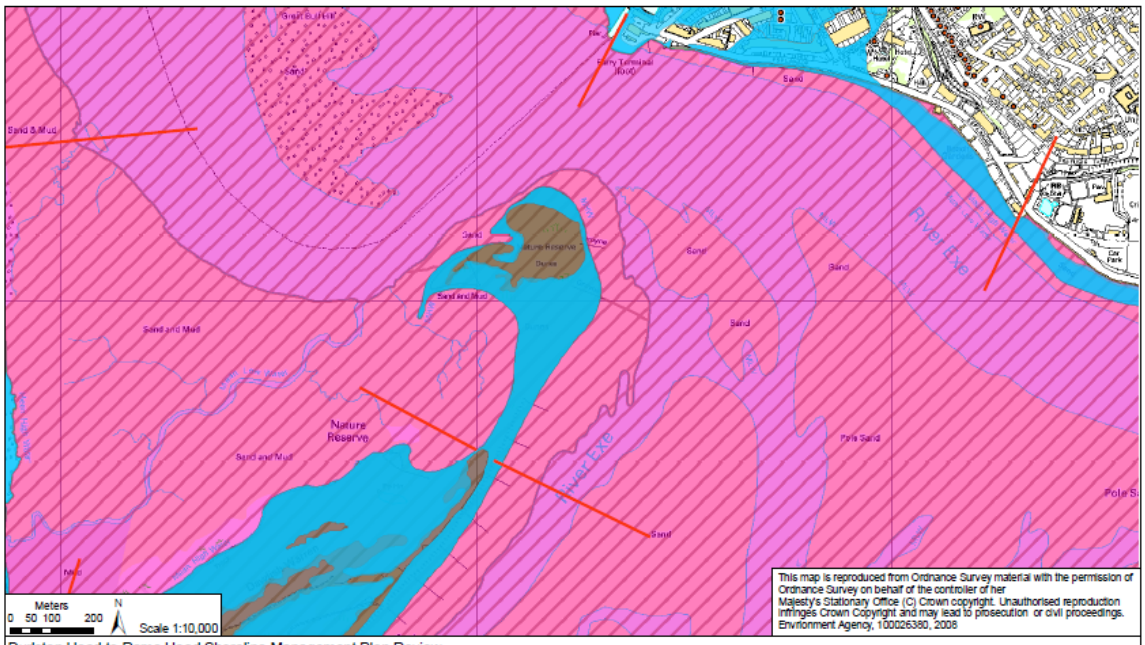




Teignmouth Estuary MR



Dawlish Warren designations:



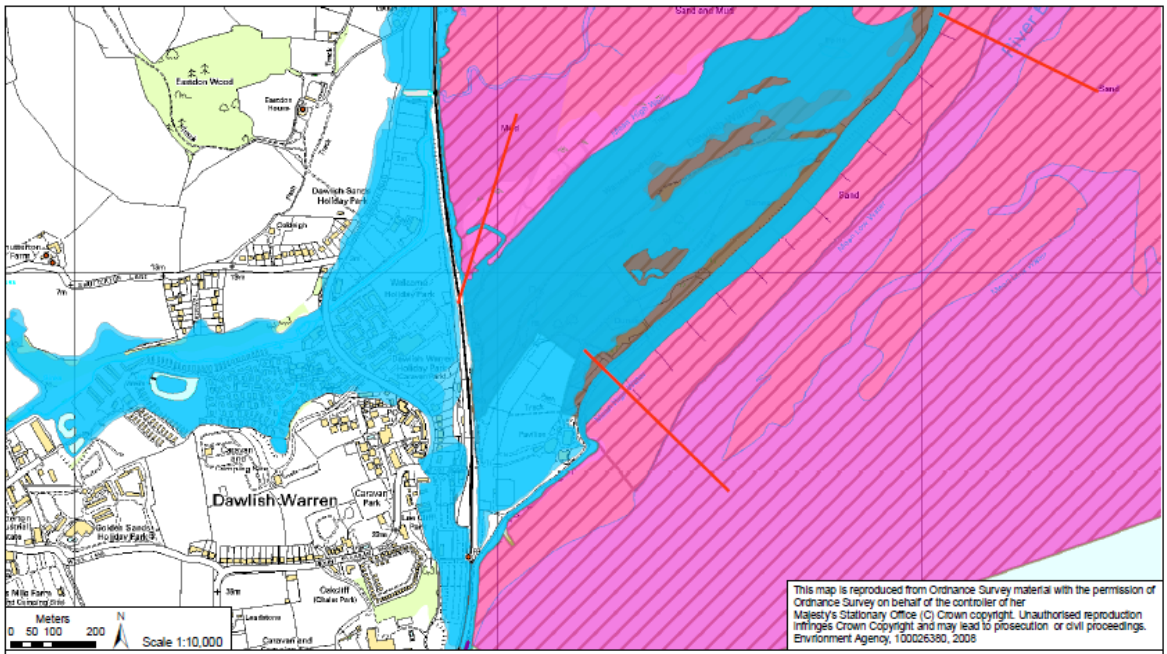
Durlston Head to Rame Head Shoreline Management Plan Review
Policy Unit 6b19: Dawlish Warren (East - distal end)

Policy

From Present Day:	Medium-Term:	Long-Term:
Hold the Line	Managed Realignment	Managed Realignment

Erosion Lines
0-20 year erosion | 50-100 year erosion | 2008 Indicative floodplain © Environment Agency
20-50 year erosion | Policy Unit Boundary

Environmental/Cultural Heritage
Special Protected Areas | Scheduled Monuments | Listed Building
Special Areas of Conservation | Site of Special Scientific Interest



Durlston Head to Rame Head Shoreline Management Plan Review
Policy Unit 6b20: Dawlish Warren (Central - gabion defences)

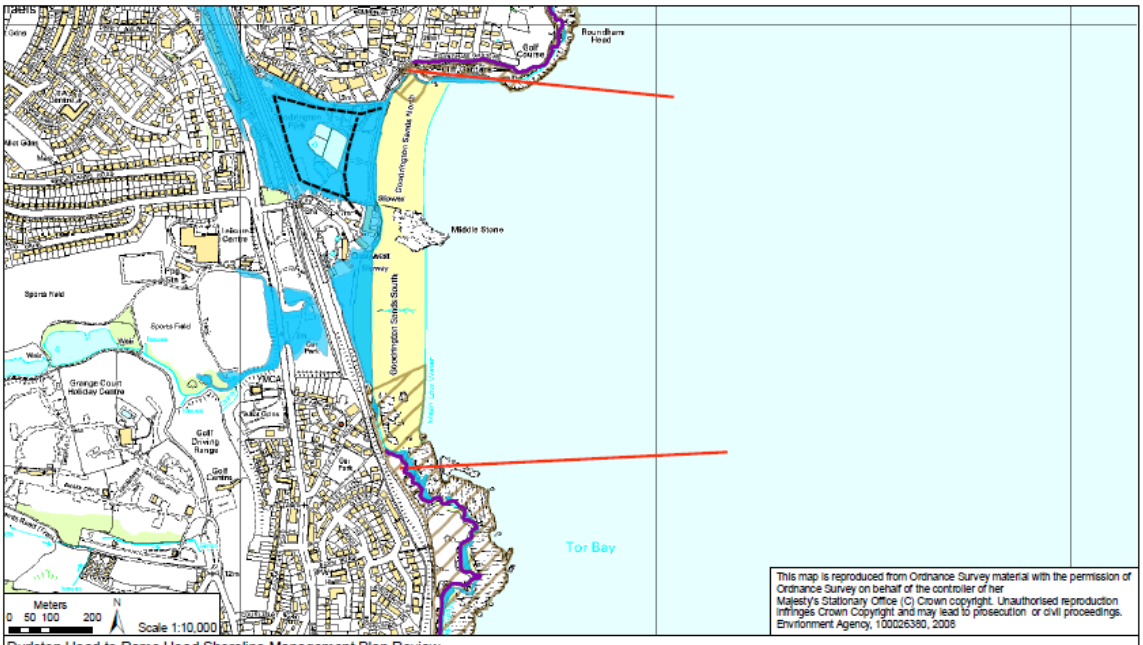
Policy

From Present Day:	Medium-Term:	Long-Term:
Hold the Line	Managed Realignment	Managed Realignment

Erosion Lines
0-20 year erosion | 50-100 year erosion | 2008 Indicative floodplain © Environment Agency
20-50 year erosion | Policy Unit Boundary

Environmental/Cultural Heritage
Special Protected Areas | Scheduled Monuments | Listed Building
Special Areas of Conservation | Site of Special Scientific Interest

Broadsands MR



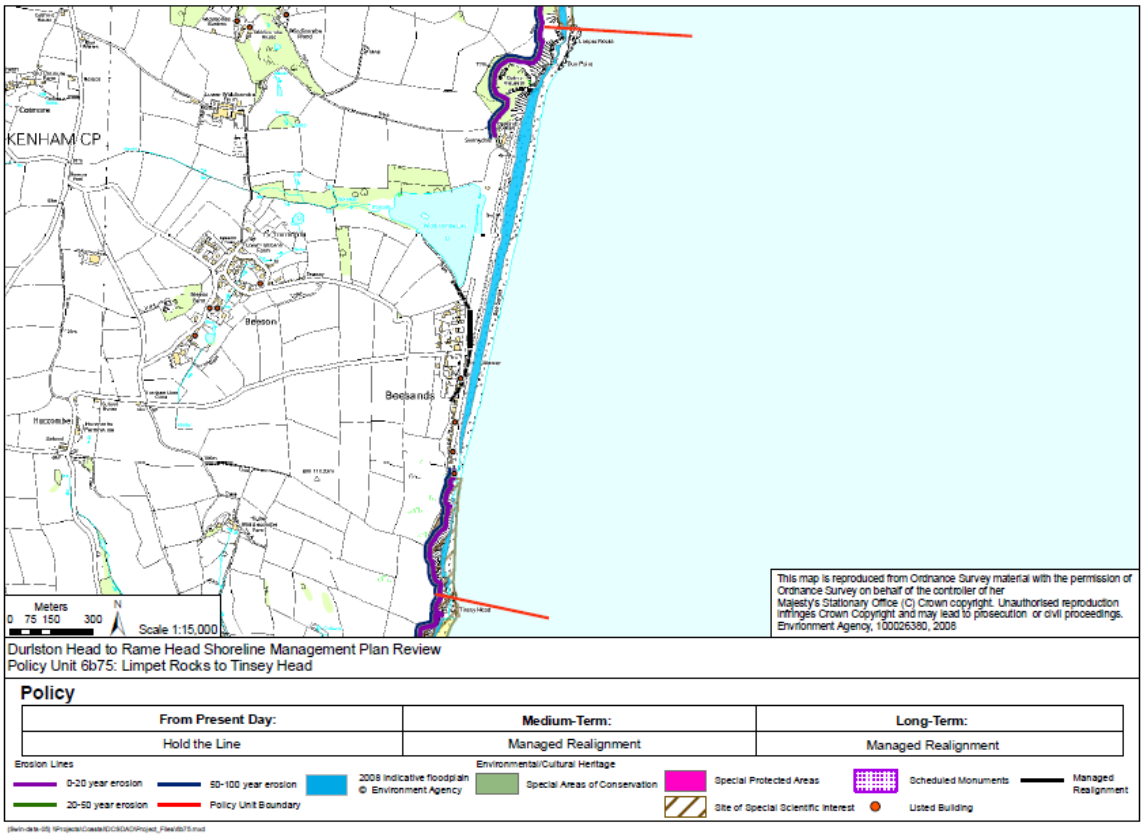
Durlston Head to Rame Head Shoreline Management Plan Review
Policy Unit 6b54: Goodrington Sands

Policy

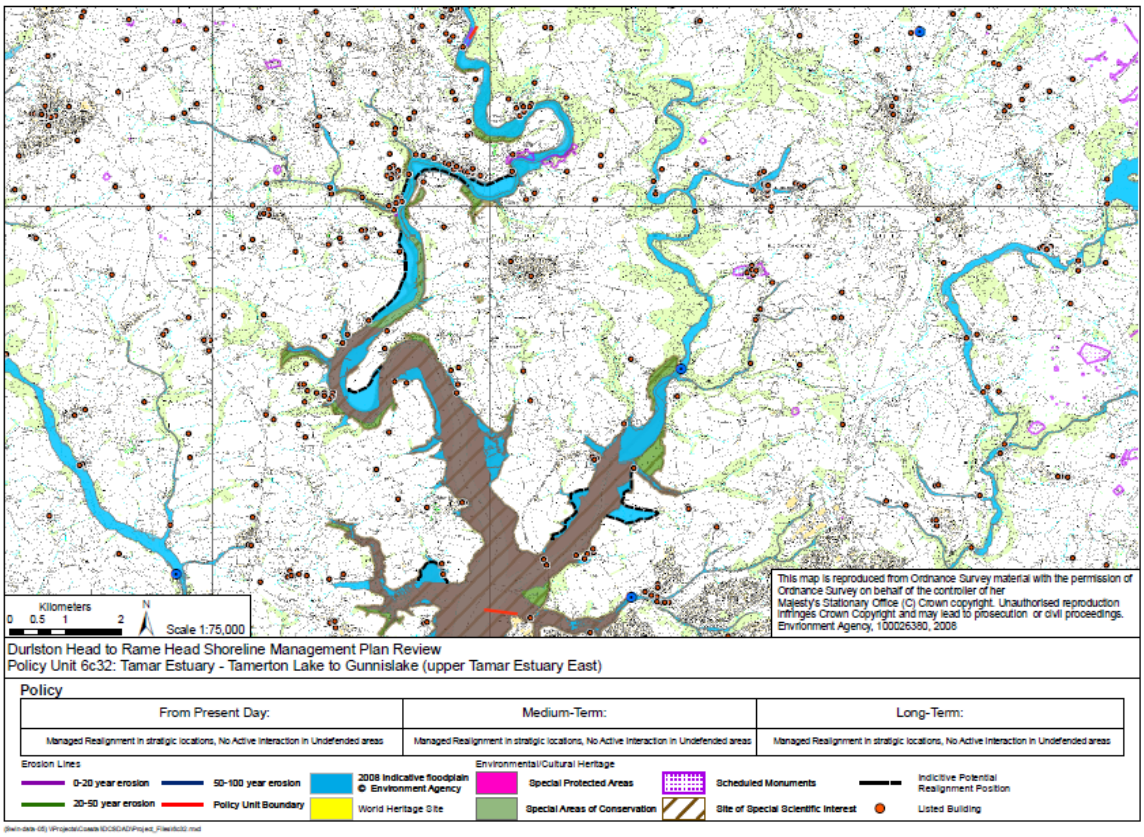
From Present Day:	Medium-Term:	Long-Term:
Hold the Line	Managed Realignment	Hold the Line

Erosion Lines
0-20 year erosion
20-50 year erosion
50-100 year erosion
Policy Unit Boundary
2008 Indicative floodplain © Environment Agency
Environmental/Cultural Heritage
Special Areas of Conservation
Special Protected Areas
Site of Special Scientific Interest
Scheduled Monuments
Listed Building
Managed Realignment

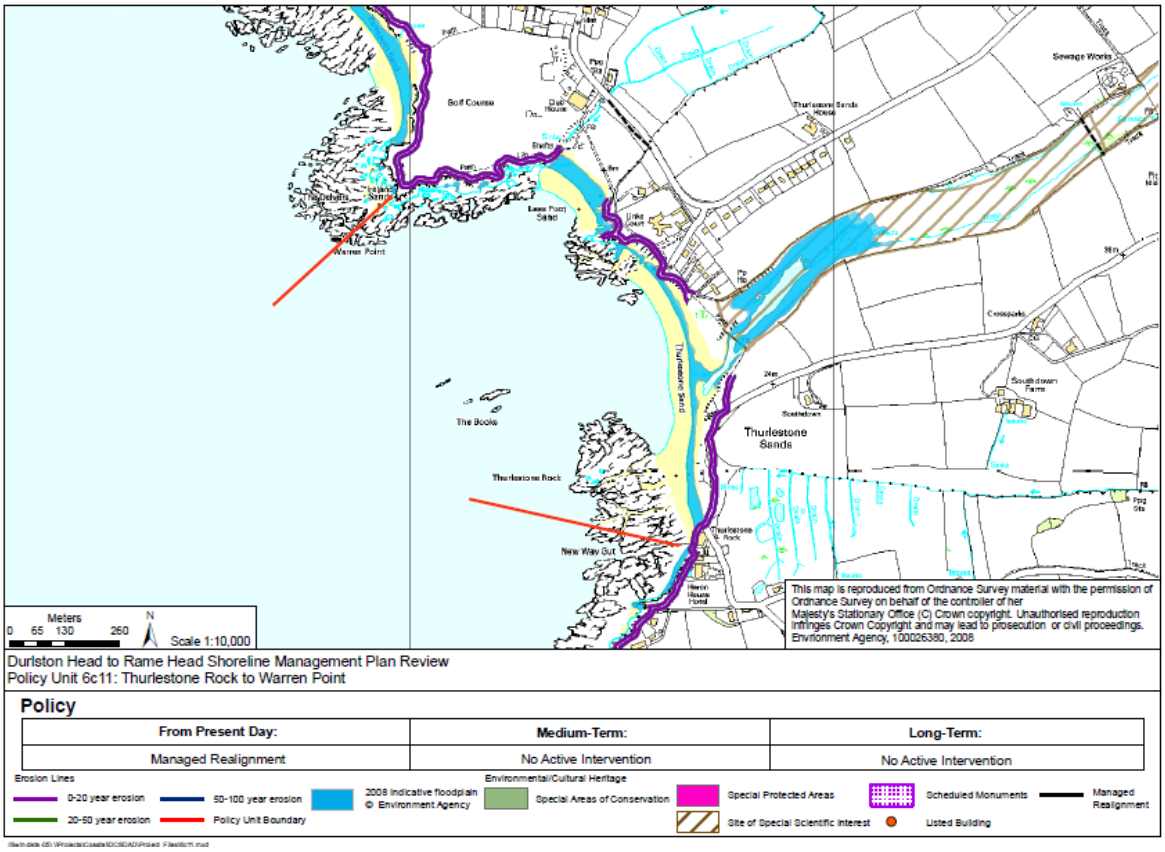
Limpet Rocks MR



Plymouth North West MR (including South Efford site)



Thurlestone Rock MR



Durlston Head to Rame Head Shoreline Management Plan Review
Policy Unit 6c11: Thurlestone Rock to Warren Point

Policy

From Present Day:	Medium-Term:	Long-Term:
Managed Realignment	No Active Intervention	No Active Intervention

Erosion Lines
0-20 year erosion
20-50 year erosion
50-100 year erosion
Policy Unit Boundary
2008 Indicative floodplain © Environment Agency
Environmental/Cultural Heritage
Special Areas of Conservation
Special Protected Areas
Site of Special Scientific Interest
Scheduled Monuments
Listed Building
Managed Realignment