THE DEVELOPMENT OF A FRAMEWORK FOR ESTUARY SHORELINE MANAGEMENT PLANS

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This document should be read in conjunction with the current Defra guidance for the integration of estuaries into SMPs (Appendix F, Defra, 2006).

Abstract

This paper describes an approach to estuary shoreline management planning (eSMP) based upon the shoreline management planning (SMP) approach, which has been used extensively around the UK coast.

The proposed method comprises two parallel strands, one following a functional approach and the other focussing on resources. Both approaches involve using a cause-consequence model to identify the temporal and spatial scale of any changes in the estuary system that may result. The estuary SMP process may be summarised as follows:

i) Identify functional requirements to develop "design" concept.
Evaluate the size, shape and location of the changes that are likely to result.
Assess the implications for **estuary resources.**

ii) Use resource interests to define an initial set of SCDO's.
Evaluate the size, shape and location of the changes that are likely to result.
Assess the implications for the **estuary system.**

iii) Compare the options against the management objectives and consult to identify preferred SCDO's.

iv) Map SCDO's as the management units for the estuary.

The proposed methodology provides a consistent procedure for defining SCDO's, that can be revisited as the science base advances, new data becomes available, or new infrastructure needs are identified. It therefore provides a sound framework on which to develop a long-term interactive management plan.

Introduction

This paper describes an attempt to adapt the coastal SMP process for use within an estuary. The resulting approach is referred to as an estuary shoreline management plan (eSMP). The aim of the eSMP is to provide a consistent procedure for defining SCDO's in estuaries, which can form the basis of a management plan over the medium to long-term. The first section of the paper describes the coastal SMP procedure. The next section describes the differences between estuaries and open coasts and the requirements of an eSMP. The recommended approach to eSMP development is then described in the final section.

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The SMP Process

MAFF (1995) divides the production of coastal SMPs into two stages:

1. Data collation, analysis and setting overall objectives.
2. Plan preparation.

The aim of Stage 1 is to gather and analyse information and identify all those with an interest in the area. This enables management units to be defined, and management objectives to be set for the shoreline. Stage 2 involves the definition of management units and appraisal strategic coastal defence options. The available Strategic Coastal Defence Options (SCDO's) for each management unit are:

i) Do nothing;
ii) Hold the existing defence line by maintaining or changing the standard of protection;
iii) Advance the existing defence line;
iv) Retreat the existing defence line.

Any SCDO studied must be sustainable and compatible with the preferred options identified for adjacent management units, as well as the processes at work within the sediment cell. Each option must also be evaluated in economic and engineering terms.

Within stage 2 the SMP process the definition of management units is of fundamental importance. MAFF (1995) defined a management unit as a length of shoreline with coherent characteristics, in terms both of natural coastal processes and land use. A number of different methods have been used to define management units and set SCDO's (see Townend *et al* 1996; Halcrow, 1991). However, a common problem in existing methods SCDO's is that management units tend to be controlled by resource issues on the developed coast, whilst on the undeveloped coast units are more likely to reflect the natural process and attendant geomorphological features. Thus the status quo tends to prevail.

A fuller description of the SMP process can be found in Purnell (1996) and a consideration of some of the technical issues involved in the preparation of SMP's is given by Townend *et al.* (1996), and Leafe *et al.* (1998).

Requirements for an Estuary SMP

Estuaries have a number of characteristics which distinguish them from open coasts and which are especially relevant to the adaptation of the SMP process (HR *et al.,* 1996). These include:

- The more complex water movement due to the enclosed channel morphology and the influence of freshwater and saline inputs.
- The greater degree of complexity in sediment transport pathways, which reflects both the complexity of water movements and the fact that sediment can be supplied from both marine and freshwater sources.
- The high degree of sediment reworking and the juxtaposition of erosional and depositional shores.
- The finer grades of sediment in transport, typically mud and sand, as compared to sand and gravel on coasts.

Within an estuary, form and process are inextricably linked, there are no obvious dependent and independent variables or clear cause-effect hierarchies. For example, although the size and shape of an estuarine channel is a response to tidal processes, the tidal discharge is itself dependent on the morphology of the estuarine channel since this determines the

overall tidal prism. This interaction results in the potential for small changes to have far reaching effects.

Whilst "process units" have been identified within a sub-cell on the open coast, for an eSMP, it is more appropriate to take the whole estuary as the basic "process unit". This demands a wider-scale, longer-term approach, driven by an understanding of physical processes. Developments within an estuary need to be considered in terms of both their local and estuary wide impacts.

The approach that needs to be adopted requires the investigation of the interactions between process and form, which give rise to the functional behaviour of the estuary system. Interventions, such as coastal defences, have the potential to alter estuarine form and/or processes, and in this way affect all parts of the estuary to some degree. Of critical importance is the need for the management framework to avoid focusing in on individual units, as tends to happen on the coast. Within the estuary there is a duality required, by which the manager considers not only local actions - within a management unit - which achieve a particular objective, but also whether there are actions that might be taken remotely that could equally achieve the objective. In all cases, it will be necessary to consider the impacts of a particular management action at all levels of the system. This leads to the concept of estuary “design” to meet the functional requirements of the users, whilst at the same time seeking to sustain the desired natural function of the system.

In an estuary the potential for small changes to have far reaching effects means there is a the need for a greater appreciation of the likely geomorphological impacts of any given defence strategy. Consequently, it is unlikely that the method of defining management units on the basis of resource and process units will be successful, due to the complexity of interaction within the estuary system. These interactions apply to both the needs of the estuary users as well as the physical processes operating. Thus in estuaries it is suggested that management units are best defined on the basis of unique SCDO’s.

The activities of users can interact directly with the estuary processes and indirectly with the flood defences or coast protection. To achieve sustainable use of the estuary, a plan for coastal defence needs to consider effects of navigation, nature conservation, urban areas, etc for the whole estuary. This requires an understanding of (i) how the estuary functions as a whole, (ii) the various user objectives within the estuary, (iii) the likely consequences of change, both natural and man-made.

Proposed Methodology

As for coastal SMP’s the whole process of the production of an eSMP can be split into two stages, each composed of a number of steps. The first stage of the procedure for an estuary, is virtually unchanged from coastal SMP’s. Stage 1 involves data collation, analysis and the setting overall objectives. It involves three main steps:

i) Identify all those with an interest in the area;
ii) Collate and analyse existing data on all the key issues;
iii) Set management objectives for the Plan area which form the basis for the appraisal and development of strategic coastal defence options.

Within an estuary, it is envisaged that there will be a set of broad objectives for the estuary as a whole. Some typical objectives drawn from MAFF guidance and previous SMP’s are summarised in Table 1. There may then be some localised objectives, not linked to management units (because they will not be defined *a priori*), but defined over lengths of shore for which there is some specific functional requirement.

Table 1. Possible management objectives

Type of Objective	Broad
Scope	For the estuary as a whole.
Examples	To adopt an estuary shoreline management plan (eSMP) consistent with the dominant processes and environmental constraints.
	To explore the opportunities to establish an estuary wide functional morphology, incorporating necessary human interventions and modifications.
	To ensure that the eSMP is based on sound economic and technical principles, which represent value for money.
	To identify opportunities for enhancement of landscape, amenity, conservation and the local economy.
	To inform the statutory planning process.
	To establish a programme and procedure for reviewing eSMP.
	To liase with and develop close working relationships with relevant authorities and organisations as necessary to work towards an integrated estuary management approach.
	To promote a greater public awareness and understanding of the estuary and how it influences local issues.
Type of Objective	Local
Scope	For lengths of shore which have some specific functional requirement, they therefore to highlight specific local needs
Examples	To protect such things as local habitats, historic sites and access routes - these can be viewed as preferences which may, if necessary, be over-ruled by the estuary wide objective
	To protect an urban conurbation - in this case the local objective may represent constraints on what can be achieved in terms of the estuary wide objectives.

Stage 2 involves the definition of management units and the choice of SCDO's. The process is broken down into two parallel approaches with a series of steps in each (Figure 1). The first approach starts with the concept of establishing an estuary wide design on the basis of a functional accommodation of the processes, fits suitable SCDO's into this framework, and then moderates these by a consideration of resource issues. Another way of expressing this approach would be to say "How will the estuary evolve and, in an ideal world, how can we accommodate this?". The second approach is resource based. It starts with a choice of SCDO's based solely on resource issues, and then moderates these by consideration of the physical processes operating in the estuary. Another way of expressing this would be to say, "In socio-economic terms, what would we like to do?".

It is apparent that the two approaches are effectively the converse of one another. Both take into account resource and process constraints, although the weightings given to each differ. Each approach produces a map of SCDO's around the estuary. The final step of the process is to try and reconcile the outcomes of the two approaches. The SCDO's require testing against the management objectives, taking due account of both process and resource implications. It is likely that this will make extensive use of consultation, in order that:

i) An improved understanding of the issues can be disseminated to as wide a group as possible; and,
ii) That this will, in turn, engender a better appreciation of the need for longer term planning, which is not unduly constrained by the status quo.

The aim of this final exercise should, of course, be to develop a broad based acceptance of the Plan.

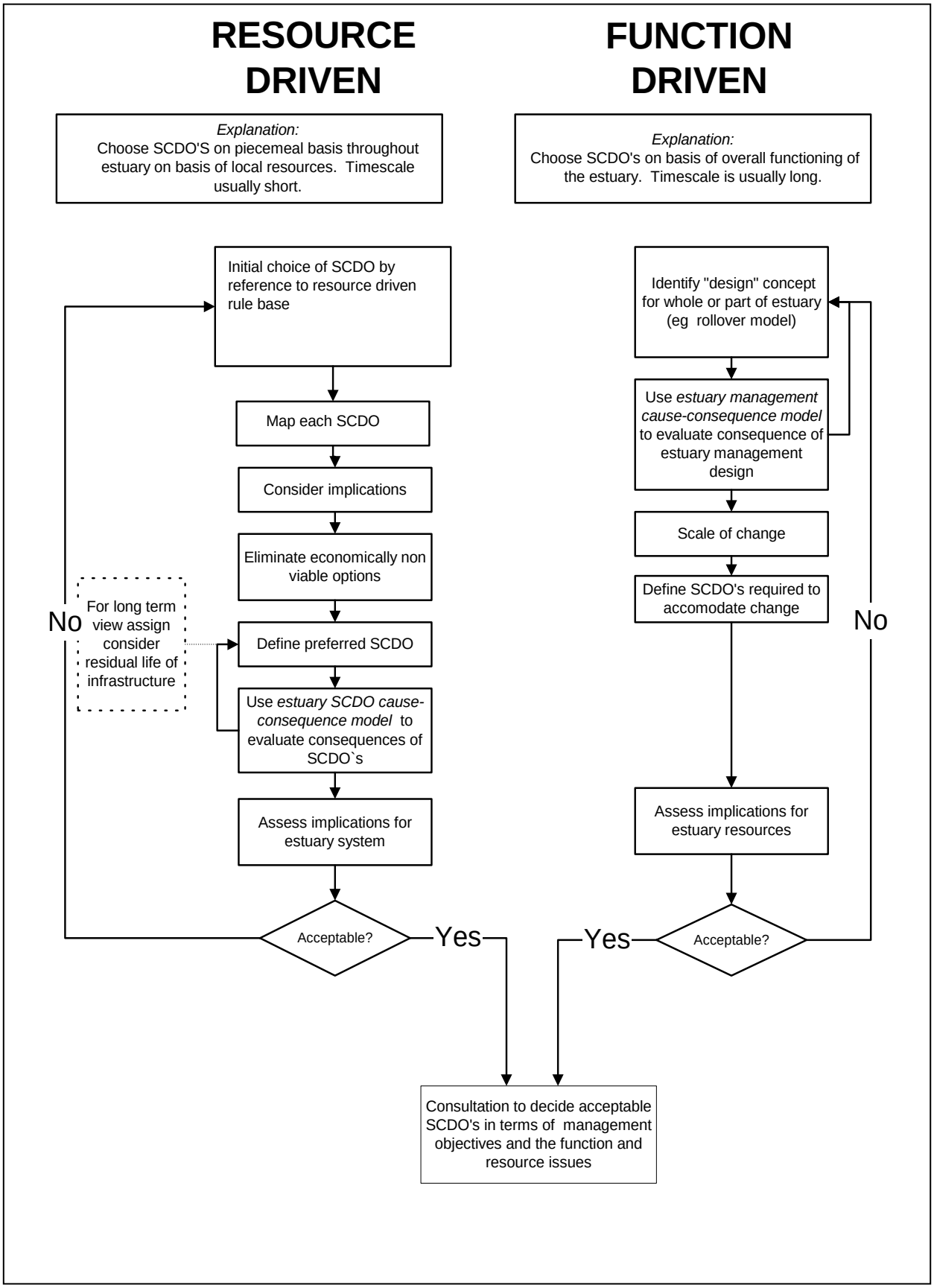

Figure 1. Flow diagram of process to define SCDO's for an estuary

(a) Function driven approach

This approach requires viable concepts to be identified and modelled to determine the spatial and temporal scales of change. This then provides a guide to where defences ought to be (or ought not to be!) and hence a set of SCDO's capable of delivering a particular estuary "design". The first step for the function driven approach, shown on the right side of Figure 1, is to refer to a conceptual design concept for the whole, or part of the estuary. One such design concept may be the rollover model for the landward transgression of the estuary proposed by Pethick (1996).

The next step is to evaluate how the system is likely to respond. This is explained conceptually through the *Estuary Management Cause-Consequence Model* (Figure 1) (Pontee and Townend, 1999). This model informs the user of the consequences of possible change in the estuary system, including energy, sediment and modifications to the estuary form through management actions. Each set of "causes" will have a spatial and a temporal scale as indicated in Figure 2. In combination these will invoke a response (or responses), the outcome of which may be at one or more spatial and temporal scales. An explanation of how the cause-consequence model and, in particular, the central response model is formulated, is given in a separate paper (Pontee and Townend, 1999).

It should be noted that under 'Management Actions' in Figure 2, sea defences represent a summary of the four SCDO's expressed in the *Estuary SCDO Cause-Consequence Model* (Figure 3). The model aims to inform the user of the scales of estuary change that will occur. Once the scale of change is known, SCDO's can be defined around the estuary, to accommodate these changes. It may well be that conflict arises here, since the function driven design concept may suggest SCDO's which are unacceptable on resource grounds. If this is the case, then it is necessary to return to the choice of SCDO's required to accommodate the design concept, or else reconsider the original design concept.

(b) Resource driven approach

For the resource driven approach, shown on the left side of Figure 1, the first step is to make an initial choice of SCDO's for the entire shoreline of the estuary, based upon a resource driven rule base (see Townend *et al.,* 1996). Once a range of SCDO`s has been defined in this way, it is necessary to consider the implications of these SCDO's and eliminate those that are not economically viable. This then leaves a preferred SCDO, based purely on resource issues, for each length of the estuary shoreline.

In an estuary although process units are both areal and temporal, coastal defences are relatively fixed and linear. The areas at risk from flooding and/or erosion determine the location and extent of defence requirements. In the main, these relate to a particular length of shoreline and so, as with the open coast, can be described by linear units which run along each bank. However, simply defining the length over which a defence is required is not sufficient to enable interactions with the estuary system to be evaluated. To assess the likely outcome of any change we need to know both the transverse location and lateral extent of the defences. This is what an SCDO provides, at least in a spatial rather than structural sense. Thus it is necessary to assign SCDO's to lengths of the estuary. To begin with these SCDO's are defined by landward resource interests, and take little or no account of natural processes.

Such a resource based definition of SCDO's then needs to be tested within a functional model of the estuary system, to identify the spatial and temporal scales of any impact. Here again, the cause-consequence model, described above, serves this purpose. An iterative process may be required to identify a set of SCDO's which result in acceptable local and system wide impacts.

In order to take account of process issues, which may mean that some of these SCDO's are unacceptable, it is necessary to use the *Estuary SCDO Cause-Consequence model* to evaluate the consequences on the estuary system (Figure 3). In some instances it may be necessary to specify the structural implementation of the chosen SCDO (e.g. linear structure, groynes etc.) in order to further define the cause.

However, in most cases within an estuary the majority of defences are likely to be linear structures. The cause-consequence model aims to inform the user of the consequences of each type of SCDO, and thereby integrates processes into the resource driven approach. If the chosen SCDO has seriously detrimental implications for the estuary system, then it is necessary to go back a stage and define a new preferred SCDO.

Resource driven approaches to SCDO's usually operate over short timescales being compatible with human planning needs. Estuary wide approaches would be expected to aim at longer timescales more compatible with estuarine evolution. However, the timescale of the resource driven approach can be extended by the introduction of residual life value for the infrastructure surrounding the estuary (see Townend *et al.,* 1996). In this way infrastructure which has exceeded a certain age is effectively removed from the resource considerations. Such a timescale may well be the design life, or the period after which there has been a desired return on capital investment. By removing elements from the infrastructure, they cease to be constraints and thus widen the number of SCDO's possible. These SCDO's can then be fed into the cause-consequence model as described above.

(c) Final selection of SCDO's

The final step of Stage 2, is to reconcile the chosen SCDO's from both the resource and the function driven approaches. In keeping with established SMP practice, the various options can be used as the basis for the consultation process that is an integral part of Stage 2. This consultation process needs to be approached with some care. It is likely that the SCDO's derived from the resource driven approach will favour the status quo (particularly if the analysis does not include the concept of removing life expired infrastructure). By contrast the SCDO's that accommodate a set of functional requirements may be unsuitable, particularly in the short-term. It will therefore be important to give a context to the proposed changes and stress the timescales involved.

Conclusions

Shoreline Management Plans seem set to play a key role in focussing the debate upon the choice between continuing to defend the coast or accommodating change, which sooner or later will need to be made. As might be expected this issue is particularly sensitive along the more developed lengths of coast, and is especially relevant to estuaries where there are large numbers of users and conflicts. The procedure suggested for eSMP's is more extensive than that used for coastal SMP's. The steps proposed to define SCDO's are as follows:

Stage 1

i) Identify all those with an interest in the area;
ii) Collate and analyse existing data on all the key issues;
iii) Set management objectives for the Plan area.

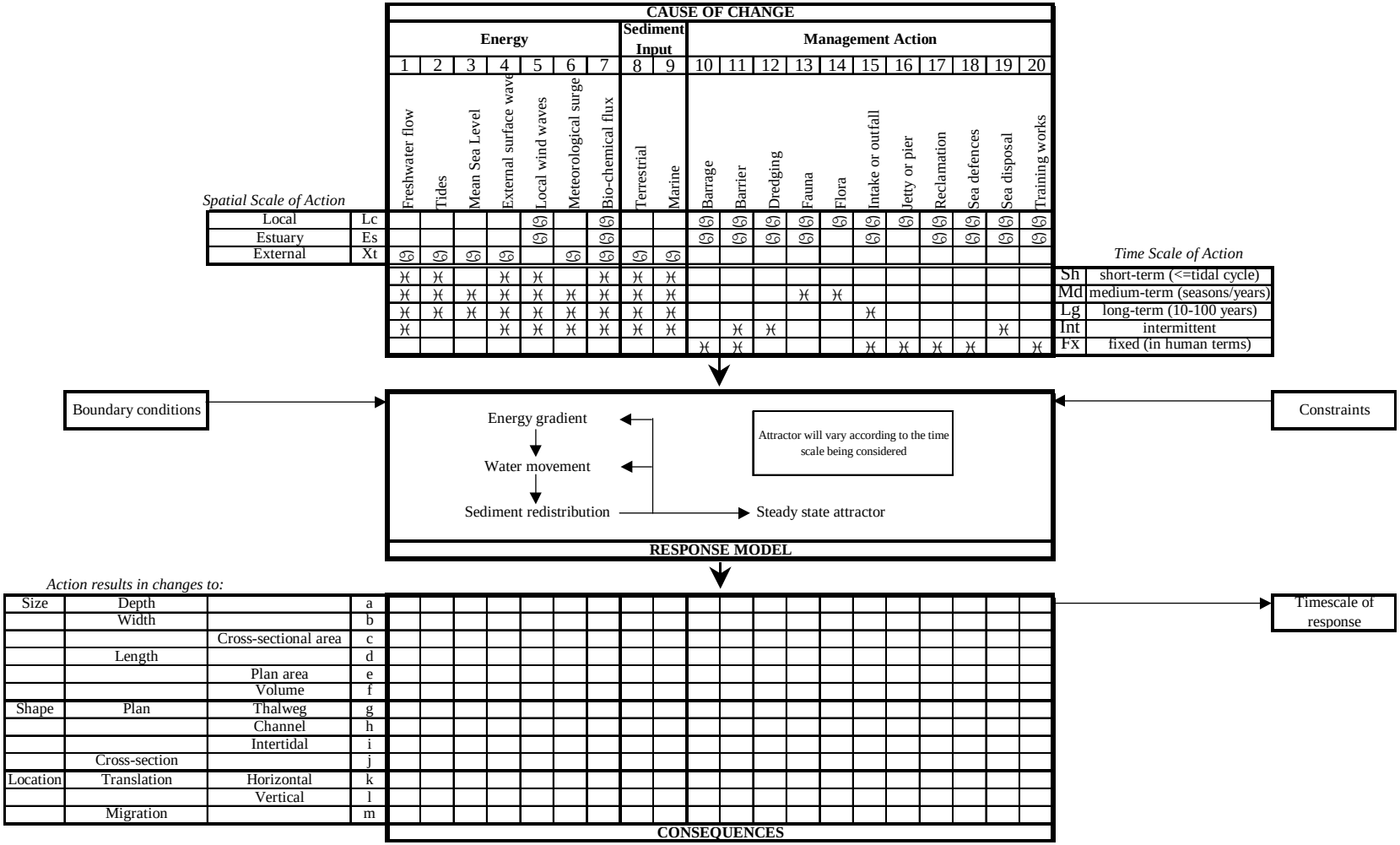

Figure 2. Estuary management cause-consequence model

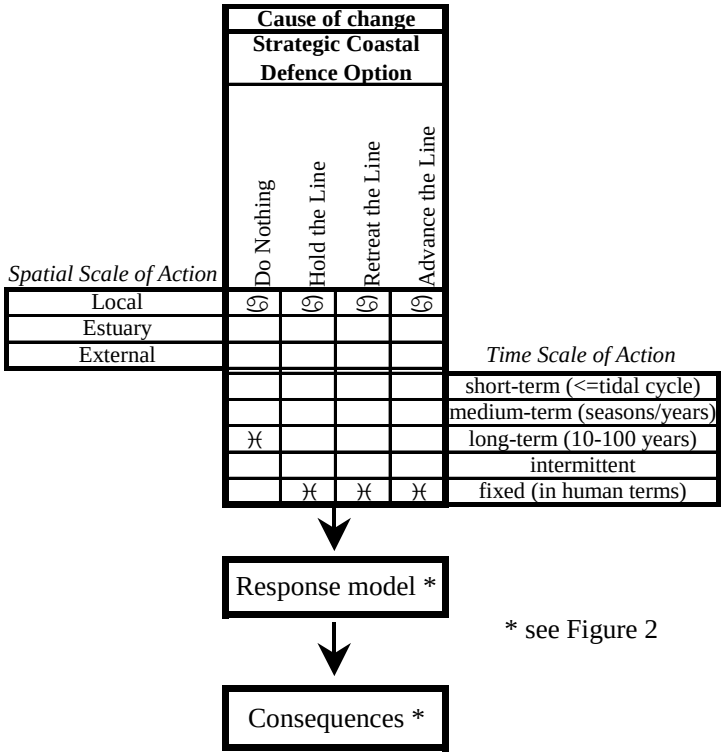

Figure 3. SCDO cause-consequence model

Stage 2

i) Identify functional requirements and develop "design" concept to accommodate these functions as far as possible;
Evaluate the size, shape and location of the changes that are likely to result;
Assess the implications for **estuary resources**.
ii) Use resource interests to define an initial set of SCDO's;
Evaluate the size, shape and location of the changes that are likely to result;
Assess implications for the **estuary system**.
iii) Compare the options against the management objectives and consult to identify preferred SCDO's.
iv) Map SCDO's as the management units for the estuary.

From previous experience the rule based analysis is straight forward and quick to apply (given the relevant data). The ability to apply the cause-consequence model is however dependent on the quality of the response model. An initial attempt to define this model is given in a separate paper (Pontee and Townend, 1999).

Importantly, the proposed methodology for the production of an eSMP establishes a consistent procedure for defining SCDO's, that can be revisited as the science base advances, new data becomes available, or new infrastructure needs are identified. Thus, although there will inevitably be some limits and caveats applied to the first attempt to define SCDO's, the analysis is repeatable and so the method proposed provides a sound framework on which to develop a long-term interactive management plan.

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