Oath to Burrowbridge Dredging and Associated Activities

Volume 3: Appendices Part 8 Section 3

2.1.1 Module 1 – Ecogeomorphic Attributes

A particular marine species tends to live within a certain environment; that is, it has a preference for a combination of environmental factors such as substrate type, temperature, salinity and hydrodynamic conditions. Figure 21 provides a conceptual framework which is founded on the concept that the landform is the principal integrator of hydromorphological pressures and ecological function.

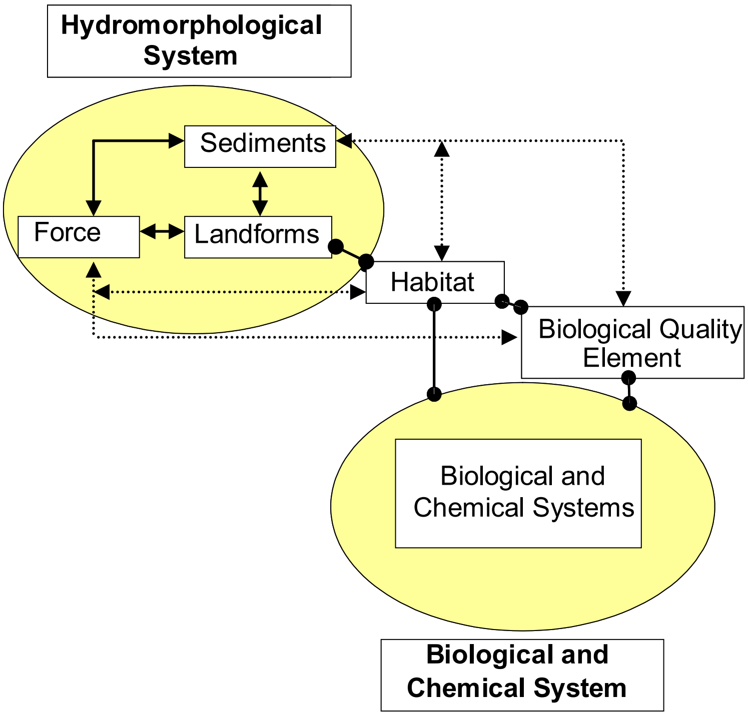

Figure 20 **The proposed conceptual framework (after Cooper *et al.* 2005).**

One of the fundamental assumptions underpinning the TraC-MImAS tool is that geomorphic processes and attributes provide a dynamic template that supports the structure and function of ecosystems (Little, 2000; Viles and Spencer, 1995). It follows, therefore, that if consideration is given to factors influencing both geomorphic and ecological functioning, it should be possible to select a suite of physical process and attributes that will provide a signal of impacts to ecosystem structure and function.

To help select a set of ecogeomorphic attributes, it was first necessary to identify a suitable suite of indicators of marine ecosystem health (**Box 1**). These indicators of ecosystem health were divided into two categories:

- Morphological and habitat attributes;
- Ecogeomorphic processes and disturbance patterns

Morphologic and Habitat Attributes

Attribute 1 - Substrate type
The type of substratum, mainly determined by the dynamics of water movement at the site, is highly important in structuring community composition, although salinity may become more critical in upper estuarine conditions. The rock or sediment type is significant in two respects as it affects the nature and extent of coastal features present in a given waterbody.

Attribute 2 - Natural range of flow and coastal features
Strong offshore currents affect many coasts and have a particularly marked influence on circalittoral communities, with lessening effects in shallow water and on the shore (where the influence of wave action predominates). However constricted sections of some inlets, particularly the narrows in sealochs, can have very strong currents which affect both the shallow subtidal and the lower shore zones, significantly increasing species richness. These, along with wave action, contribute to determining sediment grade and consequent community type.

Attribute 3 - Zonation: emersion/immersion on the shore
In beach and mudflat locations the degree of wetting and drying will have physiological consequences for the species inhabiting these environments. Along rocky coasts the intertidal communities are vertically zoned due to the variability and unpredictability in physical factors such as salinity, temperature and availability of food and nutrients which are related to tidal level and wave action.

Attribute 4 - Refuge habitat zones
Organisms frequently utilise seabed features that provide protection and shelter from disturbances or predation. These „refuge areas" are therefore critical components of functioning marine ecosystems e.g. rock crevices, rock pools and reefs.

Attribute 5 - Presence, abundance and distribution of macrophytes and macroalgae (e.g. seagrass, kelp beds and saltmarsh)
Macrophytes and macroalgae are integral components of a functional marine ecosystem. In addition to their intrinsic value, macrophytes and macroalgae provide natural coastal protection by the dissipation of wave energy and provide cover for other marine species where depth allows light penetration to the seabed.

Attribute 6 - Habitat connectivity
In addition to simple presence of habitats, a healthy functioning ecosystem requires that biota can migrate between habitat patches. These migrations may be linked to feeding or behavioral requirements, and/or changes in life stage requirement and/or recolonisation pathways, possibly after a disturbance. These can be interrupted by developments that fragment morphological zones and increase the fragmentation within inter-tidal zones (i.e. separating two areas of inter-tidal).

Ecogeomorphic Processes and Disturbance Patterns

Process 1 - Natural disturbance regime from astronomical and meterological driven forces
Changes in astronomically-driven (i.e. tidal) and meteorologically-driven (i.e. river flow) forces result in natural degrees of change in sediment depth, composition and structure within a functioning ecosystem. Natural disturbances can result from storm events which can create, alter or destroy morphological features, and redistribute biota. Shallow subtidal and intertidal sediments e.g. beach deposits reflect a high degree of wave disturbance.

Process 2 - Longitudinal sediment transport processes
Where waves break obliquely to the coast, a current is created in the surf zone which, when acting with the stirring action of the waves, results in the transport of material parallel to the shore. The rate and direction of such movements are influenced not only by the prevailing hydraulic processes, but also by the bathymetry and the physical characteristics of the beach and the threshold of movement of the sedimentary material. This "longshore current" or "Littoral drift" is a dominant influence in shaping the coastline and is the major cause of coastal erosion and/or accretion particularly where the dynamic equilibrium of the drift regime is altered in any way by natural changes or due to anthropogenic influences.

Process 3 – Lateral sediment transport processes
Reduced or increased sediment supply, or changes in the type of sediment supplied to a water body will ultimately result in morphological changes in the sub or inter-tidal morphology. Sediment input into the coastal zone arises from the erosion of cliffs and coastal slopes, material transported by littoral drift from adjacent water bodies, catchment derived input from fluvial sources and material transported from offshore sinks. Changes can be caused by natural changes (e.g. reductions in contemporary supply as sources have become exhausted throughout the Holocene) or human influences.

Process 4 – Chemical Processes
Communities living in intertidal zones are relatively tolerant of changes in salinity, temperature and turbidity. Salinity is an important community structuring factor in the upper reaches of estuaries and lagoons. Changes in salinity, nutrient enrichment, pH, oxygen, redox potential and drainage in the sediment column are important factors in determining community structure in sediments. These processes are strongly influenced by hydrodynamic factors such as changes in freshwater discharge. Organic enrichment can alter community structure and lead to increased numbers of opportunist species. Severe deoxygenation significantly reduces species richness. Shallow subtidal sediments reflect a high degree of temperature/salinity fluctuations, with increasingly more stable conditions with depth. The overall hydrographic regime and water quality characteristics of an area play an important role in determining community composition.

Process 5 – Biological processes
It is important not to ignore the biological interactions that operate in the marine environment such as competition and predation. There is a complex relationship between sediment characteristics and biological interactions that play an important role in determining community structures.

Box 1 Summary of indicators of ecosystem health for TraC Waters.

With reference to the information summarised in Box 1 and the full range of hydromorphological quality elements contained in Annex V of the WFD (**Table 17**), a set of ecogeomorphic attributes have been selected (**Tables 18, 19 and 20**). Each ecogeomorphic attribute has been chosen for its role in supporting the processes needed to create and maintain the physical environment on which biological quality elements exist (e.g. food webs or species interactions/competition). The attributes were selected to reflect the physical processes and attributes, biological and chemical processes/attributes have not been incorporated within TraC-MImAS. The tool does not require data for each ecogeomorphic attribute but uses this data to assess the relevance and sensitivity of each ecogeomorphic attribute to change. This core input data that the tool requires is pressure and water body type. The attributes are divided into the three dominant TraC zones:

- Hydrodynamics (**Table 18**) **-** Describes the influence of the tides, waves and freshwater inflow
- Intertidal (**Table 19**) - Describes the size and structure of the intertidal zone
- Subtidal (**Table 20**) - Describes the size and structure of the subtidal zone

<table>
<tr><th>Annex V 1.1.3.
Transitional Waters</th><th>Annex V 1.1.4.
Coastal Waters</th></tr>
<tr><td>Tidal Regime:
• Freshwater flow
• Wave exposure</td><td>Tidal Regime:
• Direction of dominant currents
• Wave exposure</td></tr>
<tr><td colspan="2">Morphological Conditions:
• Depth variation
• Quantity, structure and substrate of the seabed
• Structure of the intertidal and sub-tidal zones</td></tr>
</table>

Table 15 **Hydromorphological quality elements for TraC Waters in Annex V of the Directive.**

Ecogeomorphic Attributes	**Definition**	**Link to ecosystem attributes and processes**	
Hydrodynamics	*Describes the influence of the tides, waves and freshwater inflow etc, on TraC Waters*	Attributes	Processes
Tidal range	*The height that the sea rises and falls over a tidal cycle*	2,3	1,2,3
Currents	*Currents associated with the rise and fall of the tide*	2	1,2,3
Freshwater flow	*Riverine input into TraC Waters maybe modified by human interference of catchment hydrology*	2	1,2,3
Flushing/exchange	*The length of time it takes for a transitional water or sea loch to exchange its water*	2	1
Salinity/mixing/ stratification	*Occurs in transitional waters and sea lochs where freshwater input is important*	2	1
Waves	*Waves are important in driving sediment transport processes and can be altered or induced by morphological alterations*	2	1,2,3

Table 16 **Summary of ecogeomorphic attributes and links to indicators of ecosystem health - Hydrodynamics.**

Ecogeomorphic Attributes	Definition	Link to ecosystem attributes and processes	
Intertidal Zone	Describes the size and structure of the intertidal zone	Attributes	Processes
Geometry	Describes the spatial extent and form of the intertidal zone		
Planform	*Aerial view showing planar area of the intertidal zone (2D perspective). Describes the outline and spatial extent, or area of the intertidal zone which can change in response to prevailing coastal processes and/or realignment of the high water mark due to engineering activities (Masselink and Hughes, 2003).*	2,6	2,3
Profile	*Cross sectional form of an estuarine channel or gradient of the shoreline along a given line in a water body.*	1,2	1,2,3
Morphological features and substrate	Describes the shape and character of geomorphological features, and the size, structure and sorting of the intertidal sediments		
Nature and extent of coastal features	*Includes topographic, geomorphological and vegetation features of the coastal zone e.g. saltmarsh, seagrass, sand dunes, mudflats, sand bars, spits.*	2	1,2,3
Natural sediment size range	*Describes changes in sediment size distribution.*	1	1,2,3
Continuity and sediment supply	Assesses interruptions to coastal processes and sediment supply		
Longitudinal sediment transport processes	*Describes sediment mobilisation pathways i.e. transport of material by littoral drift from adjacent water bodies.*	1,2	2,3
Lateral sediment transport processes	*Includes land to sea connectivity and describes inputs and outputs of sediment from erosion of cliffs, catchment derived input from fluvial sources and material transported from offshore.*	1,2	2,3

Table 19 **Summary of ecogeomorphic attributes and links to indicators of ecosystem health - Intertidal Zone.**

Ecogeomorphic Attributes	Definition	Link to ecosystem attributes and processes	
Sub tidal Zone	**Describes the size and structure of the subtidal zone**	**Attributes**	**Processes**
Geometry	Describes the spatial pattern and form of the subtidal zone		
Planform	*Aerial view showing planar area of the subtidal zone (2D perspective). Describes the outline and spatial extent, or area of the subtidal zone which can change in response to prevailing coastal processes and/or engineering activities.*	1,2	1,2,3
Profile	*Cross sectional form of a channel or of the coastal zone perpendicular to the coastline*	1,2	1,2,3
Morphological features and substrate	Describes the shape and character of geomorphological features, and the size, structure and sorting of the intertidal sediments		
Nature and extent of coastal features	*Includes topographic, geomorphological and vegetation features of the subtidal zone e.g. seagrass, sand banks, ripples.*	1,2	2,3
Natural sediment size range	*Describes changes in sediment size distribution*	1,2	2,3
Continuity and sediment supply	Assesses interruptions to coastal processes and sediment supply		
Longitudinal sediment transport processes	*Describes sediment mobilization pathways i.e. transport of material by littoral drift from adjacent water bodies.*	1,2	2,3
Lateral sediment transport processes	*Includes land to sea connectivity and describes inputs and outputs of sediment from erosion of cliffs, catchment derived input from fluvial sources and material transported from offshore.*	1,2	2,3
Fish passage	*Describes pathways for fish passage – suggest this could either be incorporated into the 'Continuity' attribute, or could be moved to the hydrodynamic zone section*	6	5

Table 20 **Summary of ecogeomorphic attributes and links to indicators of ecosystem health - Subtidal Zone.**

2.1.2 Module 2 - TraC Typology

Overview

One of the most useful ways of classifying TraC waters is on morphology, tidal range, topography and the salinity distributions and flow characteristics (Dyer, 1997). Finkl (2004) presents an up to date and extremely comprehensive review of coastal classification schemes. However such classifications do not consider the interactions which occur within such environments between the morphology, hydrodynamics and ecological function.

The WFD requires all TraC waters to be assigned to ecologically distinct types, so that the ecological status of any given water body can be determined against „type-specific" reference conditions. The UK adopted System B in coastal and transitional waters and closely followed the guidance document produced by the EU CIS Working Group 2.4 (COAST) in deriving its final typology. The typology is a simplified representation of a complex suite of process and interactions and should not be considered as providing an accurate representation of all features present in a given water body. Whilst the typology groups on some of the important physical characteristics (e.g. exposure) which affect ecological function; it is broad scale and does not sufficiently account for the different physical conditions which apply across water bodies (e.g. substrate). The obligatory physical factors used to differentiate types included four common factors for coastal and transitional waters and two additional factors for transitional waters (Table 21).

The typology is an important element of TraC-MImAS, and provides the basis for developing a morphological and ecological sensitivity assessment. The typology reflects the presence and character of the attributes identified in the Attribute Module (Tables 16 to 18), their relative ability to absorb change (resistance), and their ability to recover from change (resilience). The typology is a very useful concept when looking at the likely ecological impacts of activities, in identifying monitoring requirements and, in the future, identifying more targeted remedies. UK and Irish TraC water bodies are represented by 12 coastal types and 6 transitional types. Table 22 presents a summary of the dominant hydromorphological characteristics of each of the transitional and coastal types recognised.

Physical Factor	Transitional	Coastal
Mixing Characteristics	•	•
Salinity	•	•
Mean Tidal Range	•	•
Wave exposure	•	•
Depth	•	
Substratum	•	

Table 21 **The physical factors used to differentiate types for TraC waters.**

TraC Type	General morphological characteristics and geographical distribution
Transitional Types	
TW1	*Partly mixed or stratified, meso or polyhaline, macrotidal, intertidal or shallow subtidal, predominantly sand and mud, e.g. Parrett Estuary, England.*
TW2	*Partly mixed or stratified, meso or polyhaline, mesotidal, intertidal or shallow subtidal, predominantly sand and mud, e.g. Tees and Dart Estuaries, England.*
TW3	*Fully mixed, polyhaline, macrotidal, sand or mud substratum, extensive intertidal areas, e.g. Humber and Thames Estuaries, England; Solway Estuary (transboundary).*
TW4	*Fully mixed, polyhaline, mesotidal, sand or mud substratum, extensive intertidal areas, e.g. Southampton Water and Plymouth Sound, England.*
TW5	*Transitional Sea Lochs, e.g. Gare Loch and Loch Linnhe, Scotland*
TW6	*Transitional Lagoons e.g. Fearn Lodge Lagoon, Dornoch Firth, Scotland.*
Coastal Types	
CW1	*Exposed, macro-tidal, e.g. Carmarthen Bay and South Pembrokeshire, South Wales.*
CW2	*Exposed, meso-tidal, e.g. West Atlantic Seaboard, Ireland and North Coast, Northern Ireland.*
CW3	*Exposed, micro-tidal.*
CW4	*Moderately exposed, macro-tidal, e.g. Kent and Sussex Coast, England.*
CW5	*Moderately exposed, meso-tidal, e.g. Northumberland Coast, England and Mourne Coast, Northern Ireland.*
CW6	*Moderately exposed, micro-tidal, e.g. Sound of Jura, Scotland and Brittas Bay Southwestern Irish Sea, Ireland.*
CW7	*Sheltered, macro-tidal, e.g. Bridgewater Bay, England.*
CW8	*Sheltered, meso-tidal, e.g. Firth of Forth, Scotland and Lough Foyle, Northern Ireland/ Ireland.*
CW9	*Sheltered, micro-tidal (none in the UK).*
CW10	*Coastal Lagoons, e.g. Dubh Loch, Loch Fyne, Scotland and Kinsale Marsh, Commoge, Ireland.*
CW11	*Shallow Sea Lochs, e.g. Loch Ryan, Scotland*
CW12	*Deep Sea Lochs, e.g. Loch Fyne, Scotland*

Table 17 **Overview of the physical characteristics of the UK and Irish TraC types.**

The formulation of TraC-MImAS required the development of a harmonised typological framework capable of capturing all „large" TraC water bodies (> 50 ha). Given the limited timeframe it was important to keep the tool as simple as possible and therefore a degree of aggregation has taken place. The proposed scheme is discussed further in the morphological and ecological sensitivity section.

The features present along a stretch of coast are not only dependent on tides, currents and wave exposure but are also dependent upon the underlying geology and bathymetry of the seabed and the underlying geology. All TraC water bodies have a mosaic of different habitat types from stable depositional mud to mobile sand to boulders to rock. To aid the assessment of morphological responses to alterations it became necessary to split the coastal typology into three sub types; coastal sedimentary (sheltered), coastal sedimentary (exposed) and coast bedrock (sheltered to exposed). These groupings will be subject to further review through validation and trialling.

The use of a solely physically based approach to assessing ecological impacts was an important issue raised during consultation with the technical panel. It is recognised that the typology is geomorphological and does not explicitly consider ecological drivers. The tool is not intended to provide a detailed assessment of ecological status rather the tool is intended to provide a means of identifying where ecological conditions are likely to be impaired through impacts to morphology. The simple differentiation on substrate proposed above provides the first step in making the assessment more ecologically relevant to those biological quality elements dependent upon the seabed (e.g. fish, macroalgae and invertebrates).

Linking morphological reference conditions, based on predominant sea bed characteristics, to EUNIS Level 3 habitats (http://eunis.eea.europa.eu/) provides a means of further developing the ecological approach. This tool does not have the ability to consider site specific conditions, for instance the presence of features of special interest. Proposals to modify areas of water bodies that have been identified as being particularly sensitive because of their important habitats and species will be subject to detailed assessment under existing regulations (e.g. Habitats Directive).

Assessment of relevance of ecogeomorphic attributes

Step 3 (Figure 5) in the development of the TraC-MImAS tool involved a process of elimination to resolve which ecogeomorphic indicators were relevant to which type. Two classes of relevance have been defined: not relevant and relevant (Table 23). For instance, stratification is unlikely to play an important behavioural role in coastal water bodies, and so that ecogeomorphic attribute is excluded from further consideration.

For future iterations of this tool, it is envisaged that the assessment of relevance would be refined using empirical data. This would potentially allow consideration of variations in the likely occurrence, or importance, of different ecogeomorphic indicators, or combination of ecogeomorphic indicators, between different types, thus promoting protection of those features and/or processes supporting ecosystem health.

Relevance	Description
Not Relevant	A disturbance acting on a particular ecogeomorphic attribute is not likely to affect the morphology and the intactness, integrity or naturalness of communities.
Relevant	A disturbance acting on a particular ecogeomorphic attribute is likely to affect the morphology and the intactness, integrity or naturalness of communities.

Table 18 **Summary of classes of relevance.**

2.1.3 Module 3 – Morphological and Ecological Sensitivity

Overview

A fundamental component of the MImAS approach is to assess the likelihood that an ecogeomorphic attribute will respond to a specified pressure, and by extension to consider the likely impacts on TraC ecology. The definition of sensitivity that was developed as part of the Review of Marine Nature Conservation (RMNC) is defined as follows (see Laffoley et al., 2000):

"*A very sensitive habitat or species is one that is very easily adversely affected by external factors arising from human activities and is expected to recover over a very long period or not at all. A sensitive habitat or species is one that is easily affected by a human activity, and is expected to only recover over a long period*."

MarLIN adopted the term intolerance for sensitivity, and used the rationale developed below to combine intolerance and recoverability into an overall sensitivity scale (Hiscock et al., 1999; Tyler-Walters et al., 2001). Therefore, intolerance was used for all prior instances of the term sensitivity including prior sensitivity assessments. The term sensitivity now refers to the combination of intolerance and recoverability.

The rationale uses the following definitions:

- „Intolerance" (was „sensitivity" sensu stricto) is the susceptibility of a habitat, community or species (i.e. the components of a biotope) to damage, or death, from an external factor. Intolerance must be assessed relative to change in a specific factor.
- „Recoverability" is the ability of a habitat, community or species (i.e. the components of a biotope) to return to a state close to that which existed before the activity or event caused change.
- „Sensitivity" is dependent on the intolerance of a species or habitat to damage from an external factor and the time taken for its subsequent recovery. For example, a highly sensitive. species or habitat is one that is very adversely affected by an external factor arising from human activities or natural events (killed / destroyed, .high. intolerance) and is expected to recover only over a very long period of time, (10 to 25 years, .low. recoverability). Intolerance, and hence sensitivity, must be assessed relative to a specified change in a specific environmental factor.

To allow assessment of the likelihood that a type (or ecogeomorphic attribute) would respond to an engineering activity, a simple method for assessing morphological and ecological sensitivity has been developed similar to that described above. River-MImAS utilised the general principles of resistance and resilience to change building on the conceptual framework of Grimm and Wissel (1997).

Within this resistance/resilience framework, types (or ecological communities) of increasing resistance and resilience are described as less sensitive to disturbances, whereas types (or ecology) of decreasing resistance or resilience are described as more sensitive. Although resistance and resilience would likely form a continuum of responses, three classes of resistance and resilience have been defined (low, moderate and high) (Tables 24 and 25).

Resistance class	Definition
Low	System/feature likely to respond to disturbance
Moderate	System/feature will potentially respond to disturbance
High	System/feature unlikely to respond to disturbance

Table 19 **Summary of resistance classes.**

Resilience class	Definition
Low	System/feature unlikely to recover to a pre-disturbance state or dynamic
Moderate	System/feature will potentially recover to a pre-disturbance state or dynamic
High	System/feature will likely recover to a pre-disturbance state or dynamic

Table 20 Summary of resilience classes.

Combining different resistance and resilience permutations generates nine total sensitivity combinations (Figure 22). The assessment of resistance and resilience is qualitative and many assumptions in assessing the likely sensitivities of different environments or systems have been made. Furthermore, this type of assessment cannot aim to accurately model complex physical or ecological responses. It is therefore important to recognise that the proposed sensitivity assessment is a high level exercise that has been developed to underpin a simple system for assessing the likely risk posed by an engineering activity. A more complete assessment of sensitivity would also have to consider a variety of additional factors that can only be assessed through a more detailed site specific analysis of TraC water bodies.

Morphological sensitivity assessment

This model of resistance/resilience was applied to the range of typical TraC Types listed in Table 6. This analysis was undertaken for two purposes:

(i) To group types into a smaller subset of types that will be used within MImAS
(ii) To allow assessment of variations in the sensitivity of the ecogeomorphic indicators between the grouped set of channel types.

To group different types, variations in the resilience and resistance to change of the hydrodynamics, intertidal and subtidal zones were qualitatively assessed and scored following the three class system outlined in Tables 8 and 9. The results of this grouping into the typology that underpins the tool are shown in Table 10. This assessment was based on an understanding of the boundary conditions and energy environments of each TraC type. The principal justification for combining types is that the reference condition ecology and morphological conditions are relatively consistent and it can be anticipated that overall there will be an equivalent response to anthropogenic pressures acting on equivalent ecogeomorphic attributes.

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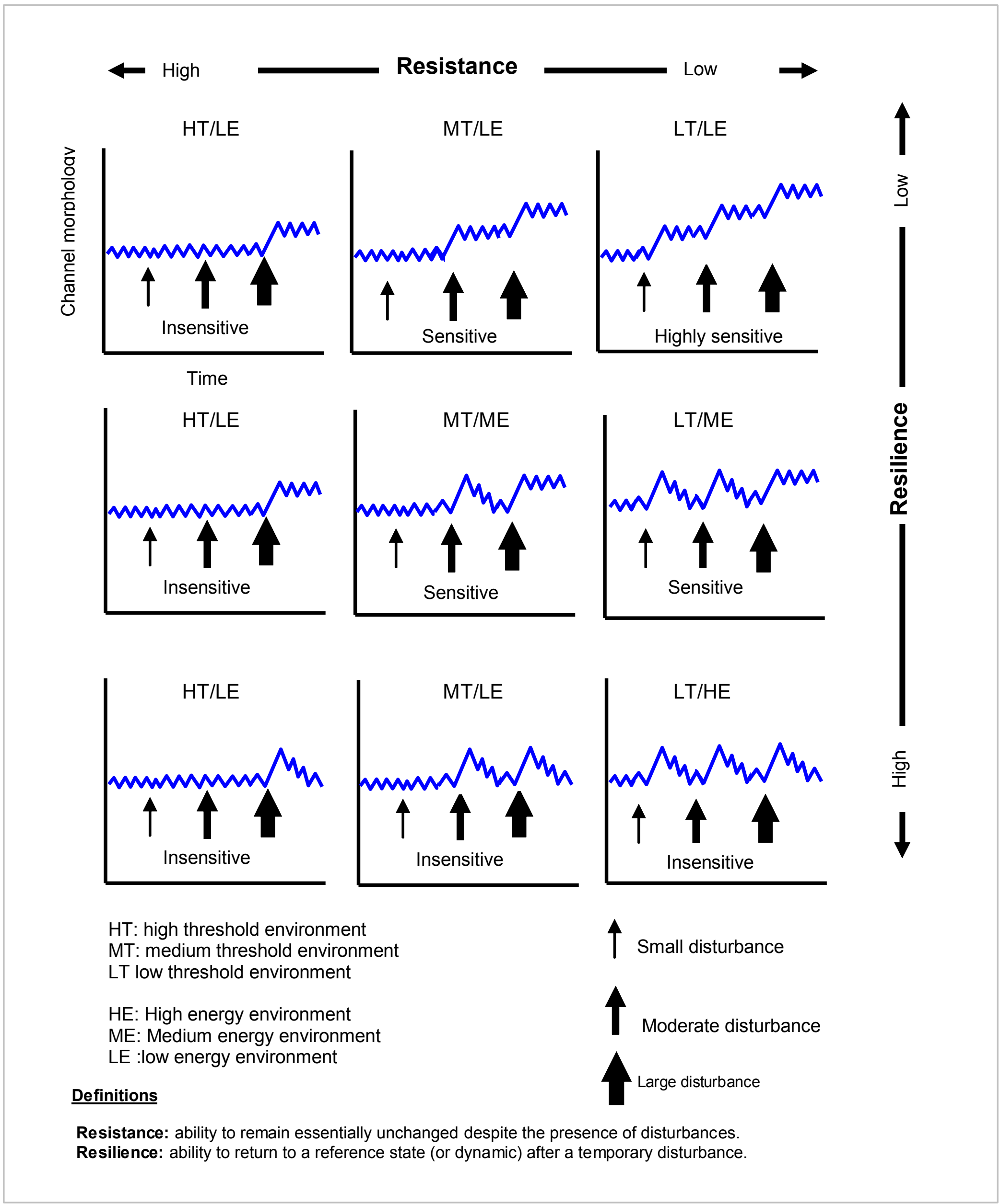

Figure 21 **Conceptual model of resistance, resilience and sensitivity**

To assess resistance, the boundary conditions of each TraC type were qualitatively assessed by the technical panel. Resilience to change was qualitatively assessed based on an understanding of variations in energy between channels and by considering the frequency of bed and bank sediment entrainment. The rationale was that TraC waters with higher energy and lower boundary resistance conditions are more active and are thus more likely to recover from system perturbations. The assessment was carried out for the three dominant TraC zones; hydrodynamics, intertidal and subtidal.

TraC Type	General morphological characteristics	Resistance/resilience classes	MImAS Code
CW1 to CW9	Sheltered to exposed, micro to macrotidal	Medium resistance, medium resilience (Hydrodynamics) High resistance, high resilience (Intertidal zone) Med resistance, high resilience (subtidal zone)	Coastal bedrock
CW1 to CW6	Moderately exposed, Macro-tidal. Sedimentary	Medium resistance, low resilience (Hydrodynamics) Low resistance, high resilience (Intertidal zone) Low resistance, high resilience (subtidal zone)	Moderately exposed to exposed coast, sedimentary
TW1 to TW4	Partially to fully mixed, mesotidal to macrotidal, intertidal or shallow subtidal, sand and mud.	Medium resistance, medium resilience (Hydrodynamics) Low resistance, high resilience (Intertidal zone) Low resistance, high resilience (subtidal zone)	Transitional meso to macrotidal
CW7 to CW9	Sheltered, micro-macrotidal. Sedimentary.	Medium resistance, medium resilience (Hydrodynamics) Medium resistance, medium resilience (Intertidal zone) Medium resistance, medium resilience (subtidal zone)	Sheltered coast, sedimentary
TW5, CW11 and CW12	TraC Sea Lochs.	Medium resistance, medium resilience (Hydrodynamics) Medium resistance, medium resilience (Intertidal zone) Medium resistance, low resilience (subtidal zone)	TraC sealochs
TW6, CW10	TraC Lagoons.	Medium resistance, Low resilience (Hydrodynamics) Low resistance, low resilience (Intertidal zone) Low resistance, low resilience (subtidal zone)	TraC lagoons

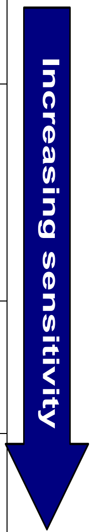

Table 21 **Grouping of TraC types based on the resistance and resilience framework.**

The sensitivity assessment described above was then extended to assess variations in the resistance and resilience of the ecogeomorphic indicators. Although this is a judgement-based and qualitative assessment, the assessment was undertaken in consideration of the theoretical principles underpinning the typology and with reference to information provided by the technical panel and steering group. As with other elements of the tool, the intention is for this assessment to be validated/refined using data generated from future research and the WFD monitoring programme.

When applying this sensitivity assessment within the scoring system that underpins the TraC MImAS, consideration was given to whether the activity would result in (i) a temporary destabilisation of a system (e.g. increased erosion) followed by re-stabilisation or (ii) a permanent destabilisation of a system. For those activities that would likely result in a temporary disturbance, the assessment of sensitivity considered both system resilience and resistance. However, for activities that would result in permanent features/disturbances, only system resistance was considered. Appendix 2 provides a summary of the sensitivity assessments.

Ecological sensitivity assessment

When considering ecological sensitivity the primary consideration is whether a degradation in the integrity, intactness or naturalness is likely to occur (SNIFFER Report WFD49 (2006) (River-MImAS). The assessment of resistance and resilience is qualitative and many assumptions in assessing the likely sensitivities of different environments or systems have been made. Furthermore this assessment cannot aim to accurately model complex physical or ecological relationships or specific biotopes. It is therefore important to recognise that a more complete assessment of sensitivity would also have to consider a variety of additional factors that can only be assessed through more detailed site specific analyses of TraC water body systems.

Given these limitations, only a rudimentary ecological sensitivity assessment is incorporated. The sensitivity assessment is a high level exercise developed to underpin a simple system for assessing the likely risk posed by an engineering activity. Ecological sensitivity can be either classed as sensitive or highly sensitive. The assessment simply considers a likely movement away from characteristics associated with reference conditions. The technical panel helped carried out an initial ecological sensitivity assessment with some input from the steering group (Table 27).

Sensitivity	Description
Sensitive	A moderate to large impact on an ecogeomorphic indicator of ecosystem health is likely to affect the intactness, integrity or naturalness of communities, or impact upon important organisms.
Highly Sensitive	A small impact on an ecogeomorphic indicator of ecosystem health is likely to affect the intactness, integrity or naturalness of communities, or impact upon important organisms.

Table 22 **Summary of classes of ecological sensitivity.**

2.1.4 Module 4 – Impact Assessment

Overview

Ecosystem response to anthropogenically induced change is a product of a number of complex physical, physiochemical and biological interactions. Morphological alterations affect TraC waters in a variety of ways and impacts can often propagate beyond the zone of activity. The duration and frequency and intensity of a particular activity are also important in determining the scale of impact. Land claim results in the direct loss of habitat and can result in changes to the physiographic character (e.g. planform and bathymetry) which in turn can alter hydrodynamic function. The presence of coastal defences and flow and sediment manipulation structures can result in changes to erosional and depositional patterns. These pressures can have a potential impact on habitat stability due to changes in currents or substrate availability causing a change in food supply and/or recruitment of colonising organisms. This can lead to acute or chronic impacts on the species and communities reliant on the ecosystem, ranging from macroalgae and benthos to birds and fish (Cascade Consulting, 2002).

This module comprises two components - (i) assessment of the likelihood that a morphological alteration will have an impact on an attribute (contained within the attribute module) and (ii) an assessment of whether impacts are likely to be contained within the vicinity of the pressure, or whether the impact will extend beyond the local vicinity of the pressure. The latter assessment is termed the „zone of impact".

Summary of engineering activities and morphological pressures

It would not be possible to develop a tool that can consider every engineering activity or design. To reduce the number of activities considered by TraC-MImAS, a suite of generic engineering activities that cover the full range of potential physical impacts on TraC waters have been defined. Rules have been developed that allow a wider range of morphological alterations to be mapped to this suite of generic pressures.

Fifteen generic pressures have been incorporated, they include shoreline pressures such as „hard" engineering for coastal defence, and pressures such as barrages and dredging. The Pressure Module is not type specific. The difference in response to the pressures between TraC water body types is captured by combining the Sensitivity Module with the Pressure Module. A detailed description of these generic pressures is provided in **Table 28**.

Specific pressures	Description
Land Claim	Historical (typically > 50 years) enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industry. The system may have partially recovered to a more "stable" natural condition since the land claim initially took place. Any new enclosure of intertidal or subtidal areas within impermeable banks followed by infilling for use by agriculture, housing, port or industrial use. The modification may destabilise the system.
Historic tidal river realignment	Historical (typically >50 years ago) alteration to course or planform of upper estuaries where the channel remains river-like. Includes straightening and removal of meanders to increase channel gradient and flow velocity (e.g. Ribble Estuary; See van der Wal et al., 2002; Fig 3.). This category can also include land claim.
New tidal river realignment	Any new alteration to course or planform of upper estuaries where the channel remains river-like.
Dredging (capital or maintenance)	Capital dredging for navigation purposes is the excavation of sediments to increase depths in an area, usually but not always for the first time, to accommodate the draft of vessels. May include maintenance dredging for the routine periodic removal of material in approach channels to port and harbour basins to maintain widths and depths in previously dredged areas to ensure the safe access for vessels.
High Voltage (HV) cables and Pipelines	The installation and subsequent protection of any cable (seabed) or pipeline (coastal to marine) for the transfer of electricity or discharge of effluent
Disposal of Dredgings (sea and intertidal)	The deposit of material dredged during maintenance and capital dredging campaigns into the marine environment or onto intertidal and subtidal areas for the purposes of disposal.

Impoundment	Impermeable barriers that extend either across the entire width of an estuary or embayment removing tidal influence (e.g. Cardiff Bay Barrage) or across coastal sounds and straits (e.g. South Ford Causeway, Outer Isles (Figure 10)). A structure that extends across a river channel that is used to impound, measure or alter flow (e.g. weirs, sluices).
Barrages	A semi-permeable impoundment that lets natural processes operate most of the time (e.g. barrage). Storm surge barriers may be built across estuaries in built up areas to reduce the risk of flooding during storm surges (e.g. Thames Barrier). Tidal barrages are constructed across estuaries with strong currents and large tidal range to harness tidal energy (Figure 11).
Flow and sediment manipulation structures	Hard engineering structures built to stabilise waterways for navigation and counter the effects of longshore drift. These include breakwaters, piers, groynes, flow deflectors, training walls etc. Ports, harbours and marinas are protected anchorage sites, often with extensive piers and breakwaters projecting into the adjacent water body (Figure 12).
Shoreline Reinforcement – Hard Engineering	The use of consolidated materials, e.g. rock armour, man made armour, revetments, retaining walls, gabion baskets, seawalls, wharves, quays, sheet piling etc. to protect vunerable coastlines or harbours from erosion (Figure 13).
Shoreline Reinforcement – Soft Engineering	Stabilisation of the shoreline using beach material to maintain beach levels and dimensions. May include synthetic materials (Figure 14).
Flood Defence Embankment	An artificial bank of earth or stone created to prevent inundation of estuarine and coastal floodplains.
Piled Structures	A range of structures raised on one or more foundation structures extending out into the adjacent water body e.g. bridge and pier supports. This category also includes wind turbine monopiles and outfalls (Figure 16).
Tidal devices	Any device which exploits the natural ebb and flow of coastal/marine tidal waters including horizontal axis turbines, cross axis turbines, oscillating hydrofoils and enclosed tips (venturi) energy extraction devices.
Other seabed uses	Any other pressures that could directly affect the bed morphology or substrate character.

Table 23 Definitions of generic categories of morphological alterations used in TraC-MImAS.

Assessment of likelihood of impact

The MImAS approach requires an assessment of the likelihood that any specified pressure will impact upon the established list of ecogeomorphic indicators. Three classes of likelihood of impact have been defined (Table 29).

Impact class	Definition
Likely	In most cases, this activity will result in an impact on a ecogeomorphic indicator
Possible	In some cases, this activity will result in an impact on a ecogeomorphic indicator
Unlikely	In most cases, this activity will not result in an impact on a ecogeomorphic indicator

Table 24 **Summary of classes of likelihood of impact.**

Defining the extents of impacts (zone of impact)

Engineering activities affect TraC systems in a variety of ways. Some of these impacts remain localised, but others can propagate extensively. To allow consideration of the extent of impacts resulting from different activities, a simple procedure for assessing the zone of impact from different activities has been developed. Three classes of impact extents are defined from „contained" to „pervasive" which will be expressed over the entire TraC system (Table 30). This assessment is independent of the water body typology.

Zone of impact	Description
Contained	Impacts likely to be localised and unlikely to extend beyond the local vicinity of the activity
Partly contained	Non-local impacts may occur and may propagate throughout the system
Pervasive	Non-local impacts likely to occur and impacts likely to propagate beyond the vicinity of the activity

Table 25 **Definitions of zone of impact classes.**

Although it is recognised that the extent of impacts resulting from morphological alterations may vary depending on the type of activity and the physical characteristics of a particular water body, for the purposes of assessing zones of impact, a non-type-specific assessment has been undertaken. Similarly, the approach does not consider how other activities in combination could affect the potential zone of impact. Finally, as with sensitivity, the extent or magnitude of impacts resulting from activities can be influenced by alteration out with the section being assessed. It has not been possible to incorporate these types of complex interactions within the current version of the TraC-MImAS tool.

2.1.5 Module 5 - The Scoring System

The scoring system combines the information contained in each module to calculate a numerical „impact rating". Each morphological alteration contained with the pressure module has its own impact score, which is specific to each TraC water body type. The impact score is calculated for each attribute in turn, and then averaged for attributes within the hydrodynamic, intertidal and subtidal zones. This value is then multiplied by the zone of impact to give an overall impact rating for each morphological alteration (pressure).

The equation used to calculate the impact rating can be summarised as:

Impact Rating	=	Relevance	X	Ecological Sensitivity	X	Morphological Sensitivity	X	Likelihood of Impact	X	Zone of Impact
		Output from typology module		Output from sensitivity module		Output from sensitivity module		Output from pressure module		Output from pressure module

To determine the percentage capacity used within a particular TraC water, the impact weightings are combined with the „alteration footprints" of all morphological alterations present within the section of estuarine or coastal water being assessed. An alteration footprint describes the type and extent of a morphological alteration. Different alterations will have different footprints, for instance, the footprint for shoreline reinforcement is the length over which the reinforcement occurs, whereas the footprint for dredging is the area over which dredging occurs. Summaries of the rules for calculating alteration footprints can be found in Section 2.2.2.

The formula used to calculate the capacity consumed by a single pressure, or combination of pressures within a predetermined assessment area/length, can be summarised as:

$$\text{Capacity Used (\%)} = \sum n \left(\frac{\text{Impact rating} \times \text{Footprint of morphological alteration}}{\text{Length/area of assessment unit}} \right) \times 100$$

* See Section 2.1.2 for a description of assessment units

Where n is the number of morphological alterations within the assessed length/area; and ∑ ( ) is the sum of results given by the equation specified in the parenthesis for each of the „n" alterations.

APPENDIX 2

Summary of datasets underpinning MImAS

Overview

The information in the tables was generated from expert opinion. In addition to consulting information in the literature, to assist in completing the tables the project team consulted the technical panel and steering group.

Ecogeomorphic attribute	Transitional	Coastal-transitional		Coastal		
	Transitional	Coastal-transitional		Sheltered	Mod Exp-Exposed	Sheltered-Exposed
	Micro-macro	Lagoon	Sea Loch	Sedimentary	Sedimentary	Bedrock
Hydrodynamics						
Open Water						
Tidal Range	1	1	1	1	1	1
Currents	1	1	1	1	1	1
Waves	1	1	1	1	1	1
Freshwater Influence						
Flushing/exchange	1	1	1	0	0	0
Salinity/mixing/stratification	1	1	1	1	1	1
Waves	1	1	1	1	1	1
Intertidal Zone						
Geometry						
Planform	1	1	1	1	1	1
Profile	1	1	1	1	1	1
Morphological features & substrate						
Nature and extent of coastal features	1	1	1	1	1	1
Natural sediment size range	1	1	1	1	1	0
Continuity and sediment supply						
Longitudinal sediment transport processes	1	0	1	1	1	0
Lateral sediment transport processes	1	1	1	1	1	0
Habitats						
Coastal sand dunes	1	0	0	0	1	0
Saltmarsh	1	1	1	1	0	0
Mudflat	1	1	1	1	0	0
Subtidal Zone						
Geometry						
Planform	1	1	1	1	1	1
Profile	1	1	1	1	1	1
Morphological features & substrate						
Nature and extent of coastal features	1	1	1	1	1	1
Natural sediment size range	1	1	1	1	1	0
Continuity and sediment supply						
Longitudinal sediment transport processes	1	0	1	1	1	0
Lateral sediment transport processes	1	1	1	1	1	0

Habitats						
Sabellaria spinulosa reefs	1	0	0	0	1	0
Modiolus beds	1	0	1	1	1	1
Seagrass beds	1	1	1	1	1	0
Maerl beds	1	0	0	1	0	0

Table 31 Relevance of ecogeomorphic indicators to the defined channel types. 1 - Relevant; 0 - Not Relevant.

Ecogeomorphic attribute	Transitional	Coastal-transitional		Coastal		
				Sheltered	Mod Exp-Exposed	Sheltered-Exposed
	Micro-macro	Lagoon	Sea Loch	Sedimentary	Sedimentary	Bedrock
Hydrodynamics						
Open Water						
Tidal Range	0.5	0.5	0.5	0.5	0.5	0.5
Currents	0.5	0.5	0.5	0.5	0.5	0.5
Waves	0.5	0.5	0.5	0.5	0.5	0.5
Freshwater Influence						
Flushing/exchange	0.5	0.5	0.5	0.5	0.5	0.5
Salinity/mixing/stratification	0.5	0.5	0.5	0.5	0.5	0.5
Waves	0.5	0.5	0.5	0.5	0.5	0.5
Intertidal Zone						
Geometry						
Planform	1.0	1.0	1.0	1.0	1.0	1.0
Profile	0.5	0.5	0.5	0.5	0.5	0.5
Morphological features & substrate						
Nature and extent of coastal features	1.0	1.0	1.0	1.0	1.0	1.0
Natural sediment size range	0.5	0.5	0.5	0.5	0.5	0.5
Continuity and sediment supply						
Longitudinal sediment transport processes	0.5	0.5	0.5	0.5	0.5	0.5
Lateral sediment transport processes	0.5	0.5	0.5	0.5	0.5	0.5
Habitats						
Coastal sand dunes	0.5	0.0	0.0	0.0	0.5	0
Saltmarsh	0.5	0.5	0.5	0.5	0	0
Mudflat	0.5	0.5	0.5	0.5	0	0
Subtidal Zone						
Geometry						
Planform	1.0	1.0	1.0	1.0	1.0	1.0
Profile	0.5	0.5	0.5	0.5	0.5	0.5
Morphological features & substrate						
Nature and extent of coastal features	1.0	1.0	1.0	1.0	1.0	1.0
Natural sediment size range	0.5	0.5	0.5	0.5	0.5	0.5
Continuity and sediment supply						
Longitudinal sediment transport processes	0.5	0.5	0.5	0.5	0.5	0.5
Lateral sediment transport processes	0.5	0.5	0.5	0.5	0.5	0.5

Habitats						
Sabellaria spinulosa reefs	0.5	0.0	0.0	0.0	0.5	0.0
Modiolus beds	1.0	0.0	1.0	1.0	1.0	1.0
Seagrass beds	0.5	0.5	0.5	0.5	0.5	0.0
Maerl beds	1.0	0.0	0.0	1.0	0.0	0.0

Table 32 Summary of sensitivity (based on resistance and resilience to change) of ecogeomorphic indicators within each grouping of channel types (0 - Insensitive; 0.5 - Sensitive; 1 – Highly Sensitive).

Ecogeomorphic attribute	Transitional	Coastal-transitional		Coastal		
				Sheltered	Mod Exp-Exposed	Sheltered-Exposed
	Micro-macro	Lagoon	Sea Loch	Sedimentary	Sedimentary	Bedrock
Hydrodynamics						
Open Water						
Tidal Range	0.5	0.5	0.5	0	0	0
Currents	0.5	0	0	0.5	0	0
Waves	0.5	0.5	0.5	0.5	0.5	0.5
Freshwater Influence						
Flushing/exchange	0.5	0.5	0.5	0	0	0
Salinity/mixing/stratification	0.5	0.5	0.5	0	0	0
Waves	0.5	0	0	0	0	0
Intertidal Zone						
Geometry						
Planform	1	0.5	0.5	0.5	0.5	0
Profile	0.5	0.5	0.5	0.5	0.5	0
Morphological features & substrate						
Nature and extent of coastal features	0.5	0.5	0.5	0.5	0.5	0.5
Natural sediment size range	0.5	0.5	0.5	0.5	0	0.5
Continuity and sediment supply						
Longitudinal sediment transport processes	0.5	0.5	0.5	0.5	0.5	0
Lateral sediment transport processes	0.5	0.5	0.5	0.5	0.5	0
Habitats						
Coastal sand dunes	1	0	0	0	1	0
Saltmarsh	0.5	0.5	0.5	0.5	0	0
Mudflat	0.5	1	1	0.5	0	0
Subtidal Zone						
Geometry						
Planform	1	0.5	0.5	0.5	0.5	0
Profile	0.5	0.5	0	0.5	0.5	0
Morphological features & substrate						
Nature and extent of coastal features	0.5	0.5	0.5	0.5	0	0.5
Natural sediment size range	0	0.5	0.5	0.5	0	0.5
Continuity and sediment supply						
Longitudinal sediment transport processes	0	0.5	0.5	1	0	0
Lateral sediment transport processes	0	0.5	0.5	0.5	0	0

Habitats						
Sabellaria spinulosa reefs	0.5	0	0	0	0.5	0
Modiolus beds	1	0	1	1	1	1
Seagrass beds	1	1	1	1	1	0
Maerl beds	1	0	0	1	0	0

Table 26 Summary of ecological sensitivity of defined channel type. 0 - Insensitive; 0.5 - Sensitive; 1 – Highly Sensitive.

HYDRODYNAMICS	Transitional	Transitional or coastal		Coastal		
				Sheltered	Mod-exposed	Shelt-exposed coast
Morphological Alteration	Meso-tidal	Lagoon	Sea loch	Sedimentary	Sedimentary	Bedrock
Land claim – high impact	0.38	0.38	0.38	0.19	0.19	0.19
Land claim – low impact	0.09	0.09	0.09	0.06	0.06	0.06
Historic tidal channel realignment – high impact	0.13	0.09	0.09	0.06	0.06	0.06
Historic tidal channel realignment – low impact	0.06	0.03	0.03	0.03	0.03	0.03
Recent tidal channel realignment – high impact	0.28	0.19	0.19	0.14	0.14	0.14
Recent tidal channel realignment – low impact	0.06	0.03	0.03	0.03	0.03	0.03
Dredging – high impact	0.13	0.13	0.13	0.09	0.09	0.09
Dredging – low impact	0.03	0.03	0.03	0.03	0.03	0.03
HV cable and pipelines – high impact	0.03	0.00	0.00	0.03	0.00	0.00
HV cable and pipelines – low impact	0.00	0.00	0.00	0.00	0.00	0.00
Use of dredged material – high impact	0.03	0.00	0.00	0.03	0.00	0.00
Use of dredged material – low impact	0.00	0.00	0.00	0.00	0.03	0.03
Impoundments – high impact	0.50	0.50	0.50	0.25	0.25	0.25
Impoundments – low impact	0.09	0.05	0.05	0.05	0.05	0.05
Barrages – high impact	0.50	0.50	0.50	0.25	0.25	0.25
Barrages – low impact	0.19	0.19	0.19	0.09	0.09	0.09
Flow and sediment manipulation, submerged – high impact	0.14	0.14	0.14	0.14	0.14	0.14
Flow and sediment manipulation, submerged – low impact	0.03	0.03	0.03	0.03	0.03	0.03
Shoreline reinforcement, hard engineering – high impact	0.19	0.19	0.19	0.09	0.09	0.09
Shoreline reinforcement, hard engineering – low impact	0.06	0.06	0.06	0.03	0.03	0.03
Shoreline reinforcement, soft engineering – high impact	0.03	0.03	0.03	0.03	0.03	0.03
Shoreline reinforcement, soft engineering – low impact	0.00	0.00	0.00	0.00	0.00	0.00
Flood defence embankment – high impact	0.19	0.19	0.19	0.05	0.05	0.05
Flood defence embankment – low impact	0.06	0.13	0.06	0.00	0.00	0.00
Piled structures – high impact	0.19	0.19	0.19	0.14	0.14	0.14
Piled structures – low impact	0.03	0.03	0.03	0.03	0.03	0.03
Tidal devices – high impact	0.03	0.03	0.03	0.03	0.03	0.03
Tidal devices – low impact	0.00	0.00	0.00	0.00	0.00	0.00
Other seabed uses	0.03	0.03	0.03	0.03	0.03	0.03

Table 27 Summary of impact ratings for morphological alterations- Hydrodynamic zone

INTERTIDAL ZONE	Transitional	Transitional or coastal		Coastal		
				Sheltered	Mod-exposed	Shelt-exposed coast
Morphological Alteration	Meso-tidal	Lagoon	Sea loch	Sedimentary	Sedimentary	Bedrock
Land claim – high impact	1.25	0.79	0.79	0.92	1.58	0.33
Land claim – low impact	0.33	0.21	0.21	0.25	0.42	0.08
Historic tidal channel realignment – high impact	0.38	0.23	0.25	0.25	0.46	0.08
Historic tidal channel realignment – low impact	0.22	0.13	0.16	0.16	0.28	0.06
Recent tidal channel realignment – high impact	0.88	0.56	0.56	0.63	1.13	0.25
Recent tidal channel realignment – low impact	0.44	0.28	0.28	0.31	0.56	0.13
Dredging – high impact	0.54	0.46	0.46	0.46	0.46	0.25
Dredging – low impact	0.08	0.08	0.08	0.08	0.08	0.04
HV cable and pipelines – high impact	0.08	0.08	0.08	0.08	0.08	0.04
HV cable and pipelines – low impact	0.02	0.02	0.02	0.02	0.02	0.00
Use of dredged material – high impact	0.41	0.28	0.28	0.28	0.28	0.13
Use of dredged material – low impact	0.19	0.13	0.13	0.13	0.13	0.06
Impoundments – high impact	1.33	0.83	0.83	1.00	1.67	0.33
Impoundments – low impact	0.22	0.13	0.16	0.16	0.28	0.06
Barrages – high impact	1.33	0.83	0.83	1.00	1.67	0.33
Barrages – low impact	0.50	0.31	0.31	0.38	0.63	0.13
Flow and sediment manipulation, submerged – high impact	0.63	0.38	0.41	0.44	0.75	0.13
Flow and sediment manipulation, submerged – low impact	0.17	0.10	0.13	0.13	0.21	0.04
Shoreline reinforcement, hard engineering – high impact	0.75	0.47	0.47	0.56	0.94	0.19
Shoreline reinforcement, hard engineering – low impact	0.17	0.10	0.10	0.13	0.21	0.04
Shoreline reinforcement, soft engineering – high impact	0.69	0.44	0.44	0.50	0.88	0.19
Shoreline reinforcement, soft engineering – low impact	0.17	0.10	0.10	0.13	0.21	0.04
Flood defence embankment – high impact	0.63	0.41	0.44	0.44	0.81	0.19
Flood defence embankment – low impact	0.15	0.27	0.10	0.10	0.19	0.04
Piled structures – high impact	0.75	0.47	0.47	0.56	0.94	0.19
Piled structures – low impact	0.29	0.19	0.19	0.21	0.38	0.08
Tidal devices – high impact	0.00	0.00	0.00	0.00	0.00	0.00
Tidal devices – low impact	0.00	0.00	0.00	0.00	0.00	0.00
Other seabed uses	0.00	0.00	0.00	0.00	0.00	0.00

Table 28 Summary of impact ratings for morphological alterations- Intertidal zone

SUBTIDAL ZONE	Transitional	Transitional or coastal		Coastal		
				Sheltered	Mod-exposed	Shelt-exposed coast
Morphological Alteration	Meso-tidal	Lagoon	Sea loch	Sedimentary	Sedimentary	Bedrock
Land claim – high impact	1.19	0.63	0.88	0.94	1.00	0.56
Land claim – low impact	0.25	0.29	0.29	0.33	0.42	0.08
Historic tidal channel realignment – high impact	0.38	0.20	0.28	0.31	0.38	0.19
Historic tidal channel realignment – low impact	0.13	0.06	0.09	0.09	0.09	0.06
Recent tidal channel realignment – high impact	0.89	0.47	0.70	0.75	0.89	0.52
Recent tidal channel realignment – low impact	0.13	0.00	0.13	0.13	0.13	0.13
Dredging – high impact	0.69	0.63	0.69	0.81	0.50	0.56
Dredging – low impact	0.22	0.17	0.20	0.25	0.16	0.19
HV cable and pipelines – high impact	0.28	0.16	0.25	0.34	0.19	0.22
HV cable and pipelines – low impact	0.19	0.08	0.14	0.22	0.13	0.13
Use of dredged material – high impact	0.47	0.28	0.42	0.47	0.28	0.28
Use of dredged material – low impact	0.23	0.12	0.21	0.23	0.14	0.14
Impoundments – high impact	1.50	0.88	1.13	1.25	1.50	0.75
Impoundments – low impact	0.13	0.06	0.09	0.09	0.09	0.06
Barrages – high impact	1.50	0.88	1.13	1.25	1.50	0.75
Barrages – low impact	0.38	0.22	0.28	0.31	0.38	0.19
Flow and sediment manipulation, submerged – high impact	0.56	0.33	0.47	0.52	0.61	0.38
Flow and sediment manipulation, submerged – low impact	0.20	0.13	0.17	0.20	0.23	0.16
Shoreline reinforcement, hard engineering – high impact	0.38	0.26	0.30	0.33	0.38	0.23
Shoreline reinforcement, hard engineering – low impact	0.06	0.06	0.06	0.06	0.06	0.06
Shoreline reinforcement, soft engineering – high impact	0.34	0.19	0.19	0.31	0.22	0.16
Shoreline reinforcement, soft engineering – low impact	0.13	0.06	0.06	0.13	0.06	0.00
Flood defence embankment – high impact	0.06	0.06	0.06	0.06	0.06	0.00
Flood defence embankment – low impact	0.00	0.00	0.00	0.00	0.00	0.00
Piled structures – high impact	0.56	0.30	0.40	0.52	0.52	0.28
Piled structures – low impact	0.19	0.08	0.11	0.19	0.16	0.09
Tidal devices – high impact	0.31	0.06	0.27	0.28	0.31	0.22
Tidal devices – low impact	0.13	0.03	0.13	0.13	0.13	0.13
Other seabed uses	0.16	0.06	0.13	0.13	0.16	0.09

Table 29 Summary of impact ratings for morphological alterations- Subtidal zone

Activity	Hydrodynamics	Intertidal	Subtidal
Land Claim - Low Impact	1	1	1
Land Claim - High Impact	2	2	2
Historic Tidal channel realignment (high)	1	1	1
Historic Tidal channel realignment (low)	1	1.5	1
Recent Tidal channel realignment (high)	1.5	1.5	1.5
Recent Tidal channel realignment (low)	1	1.5	1
Dredging - High Impact	1	2	2
Dredging - Low Impact	1	1	1
HV cable and pipelines (high)	1	1	1
HV cable and pipelines (low)	1	1	1
Sea disposal of dredgings (high)	1	1.5	1.5
Sea disposal of dredgings (low)	1	1.5	1.5
Impoundments (high)	2	2	2
Impoundments (low)	1.5	1.5	1
Barrages (high)	2	2	2
Barrages (low)	1.5	1.5	1
Flow & sediment manipulation- submerged (high)	1.5	1.5	1.5
Flow & sediment manipulation- submerged (low)	1	1	1
Shoreline reinforcement - hard engineering (high)	1.5	1.5	1.5
Shoreline reinforcement - hard engineering (low)	1	1	1
Shoreline reinforcement - soft engineering (high)	1	1.5	1
Shoreline reinforcement - soft engineering (low)	1	1	1
Flood defence embankment (high)	1.5	1.5	1
Flood defence embankment (low)	1	1	1
Piled Structures (high)	1.5	1.5	1.5
Piled Structures (low)	1	1	1
Tidal devices (high)	1	1	1
Tidal devices (low)	1	1	1
Other Sea-bed Uses	1	1	1

Table 30 Summary of zones of impact. 1 - impacts likely to be localised and unlikely to extend beyond the local vicinity of the activity; 1.5 - non-local impacts may occur and may propagate upstream and downstream through the system; 2 - non-local impacts likely to occur and impacts likely to propagate upstream and downstream through the system.

Appendix 3

Water Level Management Mitigation Measures

SOMERSET
DRAINAGE
BOARDS
CONSORTIUM

INCORPORATING THE AXE BRUE AND PARRETT DRAINAGE BOARDS

Area	Description	Type	Responsible Body	When	Comments
Aller Moor	Remedial Work at Beer Wall	Structures	EA	Autumn 2019	Not part of Sowy scheme mitigation but as completion of Beer Wall project.
	WLMP change – winter penning levels for Aller Moor	Operational protocols WLMP – at least 300mm of water in ditches at winter pen	EA/IDB	Winter 2020/21	Use EA structures Church Drove, Oxleaze Drove and IDB structure Stathe Drove to pen winter level. Operate IDB weirs Lucas Rhyne, Black Withies and Leazeway to hold water in winter. Maintain a 30 cm ditch water level.
	Operation of Langacre and Beer Wall	Operational Protocols	EA	Completion of beer wall 2019/20	Operate to effect ‘no change’ in winter months. (‘no change’ baseline - before the culverts were put under the road).
	Monitoring & WLMP update	Monitoring & WLMP update	IDB	2020 – 2022	Ecological and Monitoring plan.
King Sedgemoor (Non SSSI) Butleigh and Walton Moor, 18 ft rhyne	Telemetry to be installed at Nythe structure	Telemetry	IDB	Autumn 2019	Telemetry installed at Greylake.
	Monitor using telemetry at greylake and nythe structure	Monitoring	IDB	2020 – 2022	If effect seen then investigate operate Greylake sluice differently (environmental trigger). Or alternative option: purchase a piece of land and create new RWLA.
	Consider Operation of Greylake sluice Consider Nythe structure or other alternative.	Operating Protocols (Monitoring & Mitigation)	IDB	2022	If required and feasible, as informed by monitoring.

Area	Description	Type	Responsible Body	When	Comments
West Sedgemoor (SSSI)	Monitoring compliance of existing WLMPS	Operating Protocols (Monitoring & Mitigation)	EA	2020/21	Monitoring to trigger operational protocol of pumping stations.
Long Load (King's Moor and Witcombe Bottom)	Monitoring	Overwintering bird survey and existing data review	IDB	2019/20	
Long Load (King's Moor and Witcombe Bottom)	Operation of Long Load pumping station and syphon	Environmental Trigger points	2 year approach to affect.		Only if effect seen through monitoring? Operate to effect 'no change' in winter months. Retention of ecologically beneficial water.
Wet Moor (non SSSI)		Monitor		Effect after two years	Water levels, telemetry, levels and duration
Wet Moor (non SSSI)	Operate North barrier bank and sluice. Operate HEPs for the West	Environmental Trigger Points			Operate to effect 'no change' in winter months. Retention of ecologically beneficial water. Only if effect seen through monitoring?
West Moor (SSSI)	Replace RWLA structures	Structure	EA to install, IDB to operate	2020/21	Replace 4 stock structures, modification of 2 tilting weirs) approx. £100k Alternative Option: Possibility to extend the RWLA, re resilient wet grassland project.
West Moor (SSSI)	WLMP	WLMP review			

Area	Description	Type	Responsible Body	When	Comments
Huish Level	Assess potential WLM options.	Study	IDB/EA	2021	
Moorlinch RWLA	Refurbish the existing RWLA, Consider minor extension to the east	Construction/Appraisal	EA – Construction IDB – Future operation	2021 -2023	
King Sedgemoor SSSI	Monitor site conditions	Monitoring	IDB / EA	2020 ONWARDS	
Curry Moor SSSI	Monitor site conditions	Monitoring	IDB /EA	Continuation of existing	Monitoring already in place for Curry moor,

SOMERSET DRAINAGE BOARDS CONSORTIUM

INCORPORATING THE AXE BRUE AND PARRETT DRAINAGE BOARDS

WFD ASSESSMENT: OATH TO BURROWBRIDGE DREDGE

HAIRY CLICK BEETLE

ASSESSMENT AND MITIGATION PLAN

1. Introduction

This report has been completed to supplement the WFD Assessment for the proposed dredging of the River Parrett from Stathe to Burrowbridge, to be carried out by the Parrett Internal Drainage Board on behalf of the Somerset Rivers Authority (SRA).

Hairy Click Beetle Status and Protection

Hairy Click Beetles are a marginal terrestrial invertebrates known to be present on the banks of the Parrett transitional water body. The UK population of the hairy click-beetle is considered 'Endangered' under pre-1994 criteria defined by the International Union for Conservation of Nature (IUCN). They are classified as Schedule 41 species in the NERC 2006 Regulations. Schedule 41 is a list of habitats and species which are of principal importance for the conservation of biodiversity in England, identified through consultation with Natural England. The S41 list is intended to be used to guide decision-makers such as public bodies, in implementing their duty under section 40 of the Natural Environment and Rural Communities Act 2006, to have regard to the conservation of biodiversity when carrying out their normal functions. All recent records in Britain are from the River Parrett between Burrow Bridge and Oath, in Somerset. Old records are from the Severn catchment between Bristol and Tewkesbury, and on islands in the Thames. It is also found in central and southern Europe 7 datasets have provided data to the ABN Atlas.

All records of Hairy Click Beetle have been made in F2.1 – Swamp, marginal and inundation / Marginal and inundation / Marginal vegetation. However, within this broad habitat type the species is restricted to tall vegetation encompassing the probable larval food-plants, growing along rivers with brackish influence. All records of adult Hairy Click Beetle have been made in association with reed canary-grass Phalaris arundinacea and common reed Phragmites australis, which are present along the banks of the Parrett transitional water body (in particular at the landward end of the waterbody). Based on previous records, the potential range occupied by Hairy Click Beetle on the banks of the River Parrett extends over approximately 4.5 km between Oath (the upper tidal limit of the River Parrett) and Burrowbridge and the downstream section of the River Tone.

2018 Hairy Click Beetle Survey

Given the known presence of Hairy Click Beetle (as a NERC Schedule 41 species) on the banks of the water body in the vicinity of the proposed dredging operation, a further site specific and current survey of Hairy Click Beetle was required. This was carried out during the last week of May 2018 (when adults are active) by AEcol in-house entomologist, Dr James McGill, on three dates, 21st, 22nd and 23rd May 2018. Survey locations were agreed with the Environment Agency and Natural England prior to commissioning the survey.

The results and discussion was provided in the report entitled *Results of a Survey for Hairy Click-Beetle Synaptus Filiformis on the River Parrett, Somerset* (by AEcol, July 2018). In total, 26 adults were recorded from 21 locations along the River Parrett between 500m downstream of Oath Lock and 250 m downstream of Burrowbridge during the 2018 survey. The species was found to be associated with shallowly sloping tidal terraces, where dense stands of reed canary-grass are subject to flooding on the highest tides. Of an overall seven locations in which the species has historically occurred, it was recorded at three in 2018. Based on observations of habitat where hairy click beetles were recorded, and absent, it was possible to characterise typical habitat for adult hairy click beetle as gently sloping tidal terraces with dense, wide stands of reed canary-grass.

The proposed dredging area covers 2.1km of the River Parrett upstream of Burrowbridge. The survey therefore covered approximately double the area potentially affected by the works (4km of the River Parrett from Oath Lock to 250m downstream of the confluence at Burrowbridge and 250m upstream on the River Tone).

Two potential dredging scenarios were provided to AEcol for assessment of the potential impacts on Hairy Click Beetle populations in the area. Option 1 involves dredging of both sides of the bank to achieve the intended maximum flood conveyance of 5 cumecs. Option 2 represents a 'light' option, achieving only 2-3 cumecs but does not involve dredging on both sides of the bank. The final dredge proposal as provided in Appendix 1 of the WFD Assessment is somewhere between the two options.

2. Impacts

Habitat Loss Resulting from the Dredge

The 2018 survey report concluded the following:

- If unmitigated, option 1 would result in a temporary loss of 39% (1,320 m) of the habitat typical of that known to be exploited by the hairy click-beetle between Oath and Burrowbridge, at least for as long as it takes reed canary-grass to re-establish on the river bank. The maximum distance from the centre of the dredging zone to next available habitat typical of that exploited by hairy click-beetle would be 1,025 m.
- If unmitigated, option 2 resulted in a temporary loss of 28% (948m) of the habitat typical of that known to be exploited by the hairy click-beetle between Oath and Burrowbridge, at least for as long as it takes reed canary-grass to re-establish on the river bank. The maximum distance from the centre of the dredging zone to next available habitat typical of that exploited by hairy click-beetle would be 500 m.
- It can be assumed that the final dredge proposal is halfway between these two options based on the dredge design provided in Appendix 1 of the WFD Assessment. Consequently, approximately one third (34%) of the habitat would be temporarily lost as a result of the dredging operation.
- The remainder of the proposed dredging is either on the Burrowbridge bank, or the Stathe bank adjacent to War Moor. The impact on suitable habitat for hairy click-beetle here should be minor, as the vegetation and habitat structure here is not typical of most locations where the species was recorded.

Direct Mortality Resulting from the Dredge

- Of the known locations of Hairy Click Beetle from the 2018 survey, 2 locations will be directly affected by the proposed dredging. See Figure 1-4 at the end of this document for the right bank locations. The other 12 identified locations of Hairy Click Beetle within the study area will remain undredged.
- The dredging will take place in September and October; Adults will be in the transformation stages between larvae and adulthood and would emerge in the spring of the following year. The remaining members of the populations will be in the larval stages. All the beetles will therefore be within 20 cm of the ground surface around the succulent roots of reed canary-grass. Adult hairy click-beetles have wings but have only been observed to fly over 1-2 m.
- As a result, the dredging will take place when adults and larvae are vulnerable, although it is more likely that adults might find an alternative hibernation site in autumn or spring than winter, when temperatures are lower.

Summary Assessment

The dredging proposals do not represent a permanent loss of habitat for the species within the section from Stathe to Burrowbridge. Dredging experience further downstream on the same water body in 2014 and in 2015 found that reed canary grass regrowth (naturally) occurred within two years of full bank dredging, with full re-establishment by year 3. Factors that negatively affected the regrowth included grazing and shading by trees. The previous capital dredging operations included replanting as a mitigation (and consequently this is included in the mitigations discussed below). However, it was found that the main mechanism for restoring the vegetation along the dredged bank was natural regrowth and so this should be aided as much as possible in the mitigation programme (source: Somerset Drainage Boards Ecologist, 2018).

It is also clear that Hairy Click Beetle have previously re-established on these newly colonised stands of reed canary grass. For example, the 2018 survey identified adult hairy click beetles located on the banks of the lower Tone and Burrowbridge (both of which experienced excavation dredging of the banks in 2014). The new dredge profiles also result in an increase in available habitat area for reed canary grass due to the long sloping terrace included in the design profiles. This represents a potentially significant increase in potential habitat to be recolonised.

However, the limited mobility of the Hairy Click Beetle and the long larval stage of the species mean that those species located on the sections to be dredged are considered vulnerable to significant mortality. Despite evidence that recolonisation by the species is possible, the relative success of re-colonisation on all recovered banks is uncertain due to their limited mobility.

It is unclear whether the magnitude of potential impact on the Hairy Click Beetle as a result of the dredging would lead to a reduction in the status of WFD biological quality element at the water body scale. The recent survey between Oath and Burrowbridge identified a greater number of the species than any previous surveys. It is also possible that healthy Hairy Click Beetles have colonised other sections of the water body. However, the risk to the species is considered significant due to the status as an endangered Schedule 41 species. Therefore a risk to WFD compliance is identified if additional mitigation is not provided and its success monitored. It is also noted that without appropriate mitigation measures, any significant negative impact to the species would be in contravention with the responsibilities of the Somerset Drainage Boards Consortium and the Environment Agency for the protection and enhancement of the species under the NERC 2006 regulations.

The AEcol survey report concluded that without mitigation the bank reprofiling can be predicted to have a significant impact upon the species population. However, the report also went on to propose mitigation measures to ameliorate these effects and enable compliant dredging. It was noted that these mitigation methods are untested for the species. Therefore, a surveillance programme was also recommended to attempt to assess the effect of the dredging impacts on the species status in the longer term and explore the possibility of capturing larvae in baited traps.

3. Proposed mitigation measures

A series of measures are proposed as a mitigation programme to minimise the potential impact of the dredging from Stathe to Burrowbridge on the Hairy Click Beetle. These measures are also intended to help promote the growth of the species population by increasing available habitat and reducing some of the pressures on the population at this locality.

These mitigation proposals have been developed using the following sources:

- Recommendations in the report *Results of a Survey for Hairy Click-Beetle Synaptus Filiformis on the River Parrett, Somerset* (by AEcol, July 2018).
- Recommendations from The status of synaptus filiformis (.) (Coleoptera:Elateridae) in Somerset:Report of a survey in 19992” by Andrew Duff.
- Recommendations of the EA Biodiversity Officer and NE Officer (email communication June 2018)
- Professional experience from Somerset Drainage Boards Ecologist (October 2018).

The AEcol report identified two potential constraints to confidently defining effective mitigation, comprising that related to a lack of knowledge regarding both the need for intervention to aid recovery and also the efficacy of the mitigation actions. In particular, it was noted that there was a lack of information on how long the re-profiled banks take the re-vegetate and whether the soils left after re-profiling are in fact suitable for reed canary grass. It was flagged that there was uncertainty regarding the migration distances over which hairy click-beetles might travel to re-colonise habitat following recovery.

Local knowledge and expert opinion from the experiences of the Environment Agency and Somerset Drainage Boards from the 2014 and 2015 capital dredges along the Tone and Parrett suggest that the banks dredged using excavators were re-vegetated with reed canary-grass fairly rapidly (re-establishment in 2 years and full recovery within 3 years, as mentioned above).

The proposals below include measures to:

- Aid the recovery of the vegetation/habitat.
- Aid the migration of the species on to the newly dredged locations.
- Remove some of the pressures to the population at this locality.

See table 1 below.

Table 1. Hairy Click Beetle Mitigation Programme.

Mitigation Measure	Responsibility	Timescales of activities
1. Establish Suitable Habitat: Dredge Re-profiling and Re-seeding		
• The AEcol report suggests that based on observations of reed canary-grass and hairy click-beetle at the River Parrett, reprofiling should seek to create shallowly sloping tidal terraces, maximising the zone that is subject to flooding on the highest tides. • See dredge design profiles. The design profiles include a terrace at the point of low water height that slopes to the top of bank and effectively widens the overall channel size at maximum flow. The design profiles there creates habitat at varying depths of inundation. • The dredging will therefore retain a sloping upper bank subject to flooding at the highest flows/tides as required for hairy click beetles. • Strip and recover/replanting of reed rhizomes (Phalaris) will be applied.	• Somerset Drainage Boards Consortium. • Managed through dredge method statement and environmental mitigation programme. • Requirements included in contract documents (specification) to communicate contractor responsibilities. • Overseen/inspected by Environment Agency.	• Pre – works planning: present to autumn 2019. This includes dredge methods statements, environmental mitigation plan and specification documents. • Mitigation measures implemented during works: autumn 2019. • Environmental monitoring: during works autumn 2019 and following re-establishment of vegetation in spring 2020 (as specified in mitigation measure 6 below).
2. Limit Mortality and Re-Colonise: Excavation and Replacement		
• Where reed-sweet grass is removed, it is likely to contain live hairy click-beetle larvae and adults. Larvae recorded in the AEcol 2018 and Mendel 2003 study were within 20 cm of the ground surface. • Impacts to larvae can therefore be mitigated by digging out turves of vegetation at a depth of at least 50 cm. When depositing on the backs of banks, the turves can to be placed upright to maximise the likelihood that it may continue to grow in the new location and therefore support the larvae that depend upon it. Turves with reed canary-grass should not be buried beneath other dredgings. • Impacts to larvae can be further mitigated by following the above process and removing turves of vegetation at a depth of at least 50 cm – temporarily placing on the bank while carrying out bank reprofiling – replacing the turves at the top of the newly profiled bank (in the upper zone inundated at the highest flows/tides). This process will be carried out at specified locations, alternating along the length of the dredge location. It will be incorporated into the method statements/environmental mitigation programme. • To guard against frost penetration, the turves will be as large as possible with the equipment used and placed against each other in as large a mat as is practical.	• Somerset Drainage Boards Consortium. • Managed through dredge method statement and environmental mitigation programme. • Requirements included in contract documents (specification) to communicate contractor responsibilities. • Overseen/inspected by Environment Agency.	• Pre – works planning: present to autumn 2019. This includes dredge methods statements, environmental mitigation plan and specification documents. • Mitigation measures implemented during works: autumn 2019. • Environmental monitoring: during works autumn 2019 and following re-establishment of vegetation in spring 2020 (as specified in mitigation measure 6 below).

3. Limit Mortality and Re-Colonise: Pilot Larval Translocation		
• Soil sampling was found to be largely ineffective in the AEcol 2018 study and the Mendel 2003 study in the same location. However, the AEcol report suggests that a more efficient method could be developed to capture larvae and translocate (e.g. use of baited stocking or pitfall traps used in surveillance of other click beetle species in agricultural fields, Morales-Rodriguez *et al*. 2017). • It is proposed that a pilot study of trapping should be incorporated into the mitigation programme (to be completed prior to the dredge and moved to locations not proposed for dredging). • It is suggested that this approach should be applied at the two locations of known Hairy Click Beetles (from the 2018 survey) that are proposed to be dredged (see Figure 1-4). • If successful for live larvae, this mitigation measure could provide further opportunity to help strengthen the species population in the future.	• Somerset Drainage Boards Consortium to manage. In consultation with Environment Agency and Natural England. • Managed through environmental mitigation programme.	• Pre – works planning: present to autumn 2019. • Measures implemented prior to works: autumn 2019. • Environmental monitoring following implementation – see measure 6 below.
4. Remove Pressures: Livestock Fencing		
• Bank sections, deposited dredging spoil and excavated turves are to be fenced to keep cattle out during re-seeding/vegetation recovery (a minimum 12 month period). This will allow the substrate to remain undisturbed and the reed canary-grass has the best chance of re-establishing over the winter. • A programme to establish stock control in specific locations will be investigated and implemented in partnership with Natural England, the Environment Agency and any relevant landowners. • Any action for permanent fencing will need to consider Environment Agency planned works along the right bank for bank raising/maintenance in 2019-2020 (NCPMS project).	• Somerset Drainage Boards Consortium to manage temporary fencing in consultation with Environment Agency, Natural England and where relevant other landowners (notably, War Moor). • Managed through environmental mitigation programme.	• Pre – works planning: present to autumn 2019. • Measures implemented prior to works: autumn 2019. • Environmental monitoring following implementation – see measure 6 below.
5. Remove Pressures: Cutting		
• It is proposed that the bank vegetation cutting regime is altered on the Stathe bank between Burrowbridge and the Saltmoor road bridge (outside of the dredging area). There are recent records of hairy click-beetle on the bank directly opposite and downstream of the King Alfred Inn. As no dredging is planned on this section, it should be managed to maximise habitat suitability for hairy click-beetle and thereby provide a robust donor population for the dredged and reprofiled sections. • The vegetation maintenance regime should follow the prescription adopted on the River Tone upstream of the confluence with the River Parrett, where 2-3 m beside the channel is left uncut when the upper bank is mown.	• Somerset Drainage Boards Consortium to liaise with Environment Agency to agree and implement changes as required. • Managed through environmental mitigation programme.	• Agreed and implemented pre-dredging works; present to autumn 2019. • Environmental monitoring following implementation – see measure 6 below.

• The Environment Agency are in agreement that the vegetation maintenance regime should be adjusted as per recommendations for the benefit of the species.		
6. Future Proof: Data Collection and Monitoring Programme		
It is suggested in the AEcol report that the Stathe to Burrowbridge dredging programme provides an opportunity for data-collection to inform mitigation action for future flood protection works in Somerset, but also more widely in the UK and therefore provide an additional benefit to the species conservation. The suggestions in the report include: **1. Data-collection and review** Establish connection with the regulatory bodies responsible for managing riparian habitat of known Hairy Click Beetle across the UK, share information on existing practices. This process can should be managed by the Somerset Drainage Boards, the Environment Agency and Natural England in a partnership approach to the Hairy Click Beetle mitigation and conservation programme that has been described here. **2. Vegetation surveillance** A specified process has been detailed in the AEcol report, to be broadly followed, as detailed below. Four surveillance zones identified within the dredging reach: 1. Undisturbed banks where hairy click-beetle were recorded in 2018; 2. Undisturbed banks where hairy click-beetle were not recorded in 2018; 3. Dredged and reprofiled areas where hairy click-beetle were recorded in 2018; and 4. Dredged and reprofiled areas where hairy click-beetle were not recorded in 2018. Two replicates of each zone with as similar angles of slope as possible should be chosen and surveillance performed to record the following: - 1. Species composition of vegetation (using DAFOR); 2. Vegetation height; 3. Presence of livestock; and 4. Density (defined on two levels, comprising: a) thick (no bare ground visible through sward); and, b) thin (ground visible through sward).	• Somerset Drainage Boards Consortium to liaise with Environment Agency and Natural England. Partnership approach developed for step 1 data collection and review. Each regulatory body to contact their respective representative bodies in other locations. • Somerset Drainage Boards to manage vegetation and hairy click beetle surveillance of dredged location. In consultation with Environment Agency and Natural England. • Managed through environmental mitigation programme.	• Step 1 data collection and review prior to works starting; present to autumn 2019. • Vegetation and Surveillance monitoring: planning and any additional baseline surveys (beyond those presently completed) to be carried out between present and autumn 2019. • Vegetation surveillance starting from the spring following dredging (2020); carried out in spring and autumn as required thereafter. • Hairy click beetle surveillance, completed annually at the end of May each year as identified necessary.

Surveillance should continue for five years or until a reed canary-grass dominant sward with a thick density has been recorded in any un-grazed zone that was subject to dredging and reprofiling in autumn 2019. This vegetation surveillance should be carried out alongside other habitat/vegetation monitoring specified in the overall Environmental Mitigation Programme for the works. For example, using the fixed point vegetation survey completed by Johns Associates at the end of May 2018 as a baseline assessment of existing hairy click beetle habitat. **3. Hairy click-beetle surveillance** Hairy click-beetle surveillance is to be performed annually in all vegetation surveillance zones for five years, or until the species is encountered (whichever is sooner) to assess recolonisation by hairy click-beetle in reprofiled habitat at specified locations. Particular consideration should be given to how the migration distance of the species might be established. Should the surveillance proposed here show that Hairy Click Beetle have not re-established at the specified locations, a programme of pilot translocation will be investigated and developed as agreed by the partnership organisations.		

Figure 1 Location of Hairy Click Beetle (2018 survey) and proposed dredging location – Downstream section of dredge

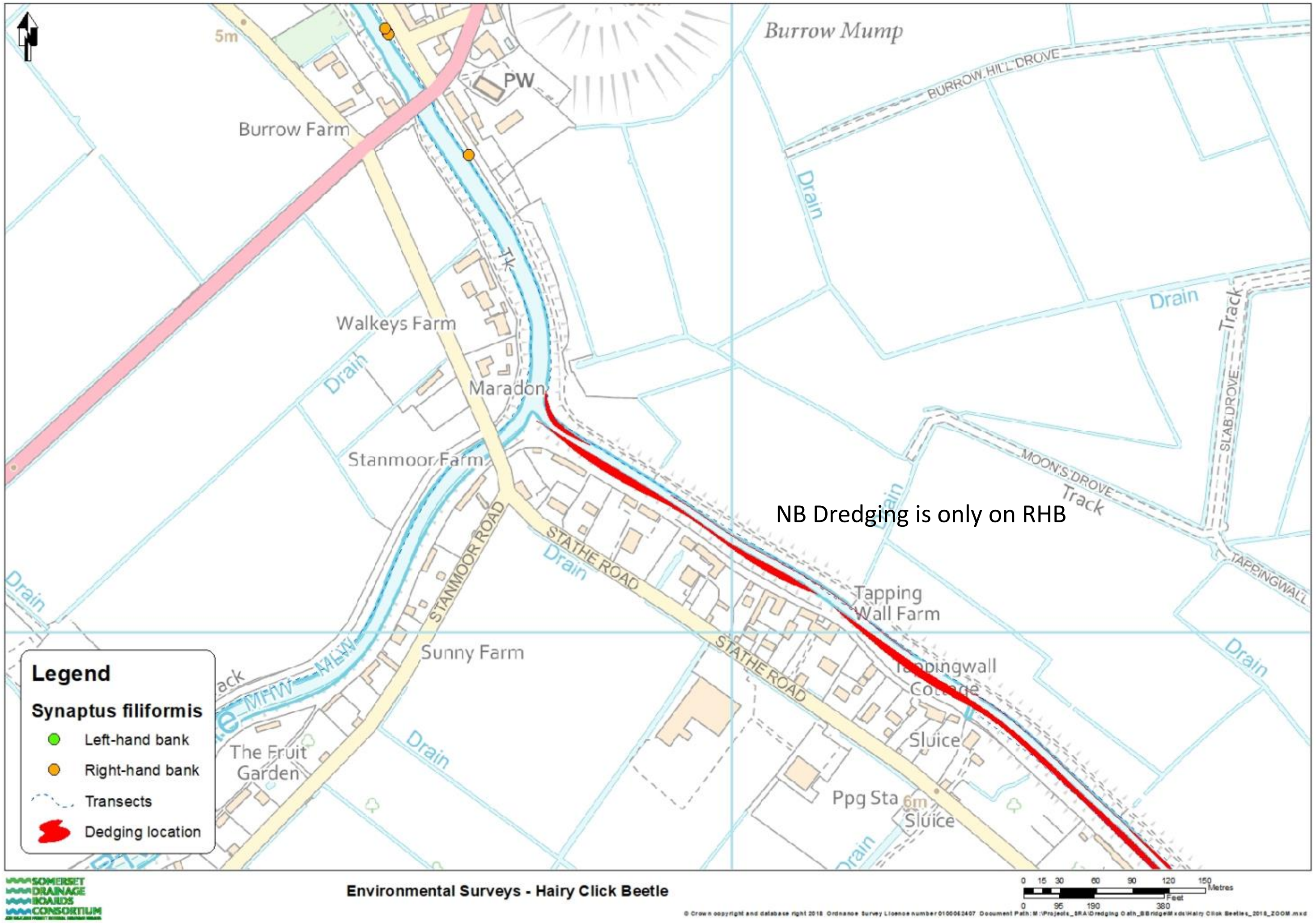

Figure 2 Location of Hairy Click Beetle (2018 survey) and proposed dredging location – Mid section of dredge

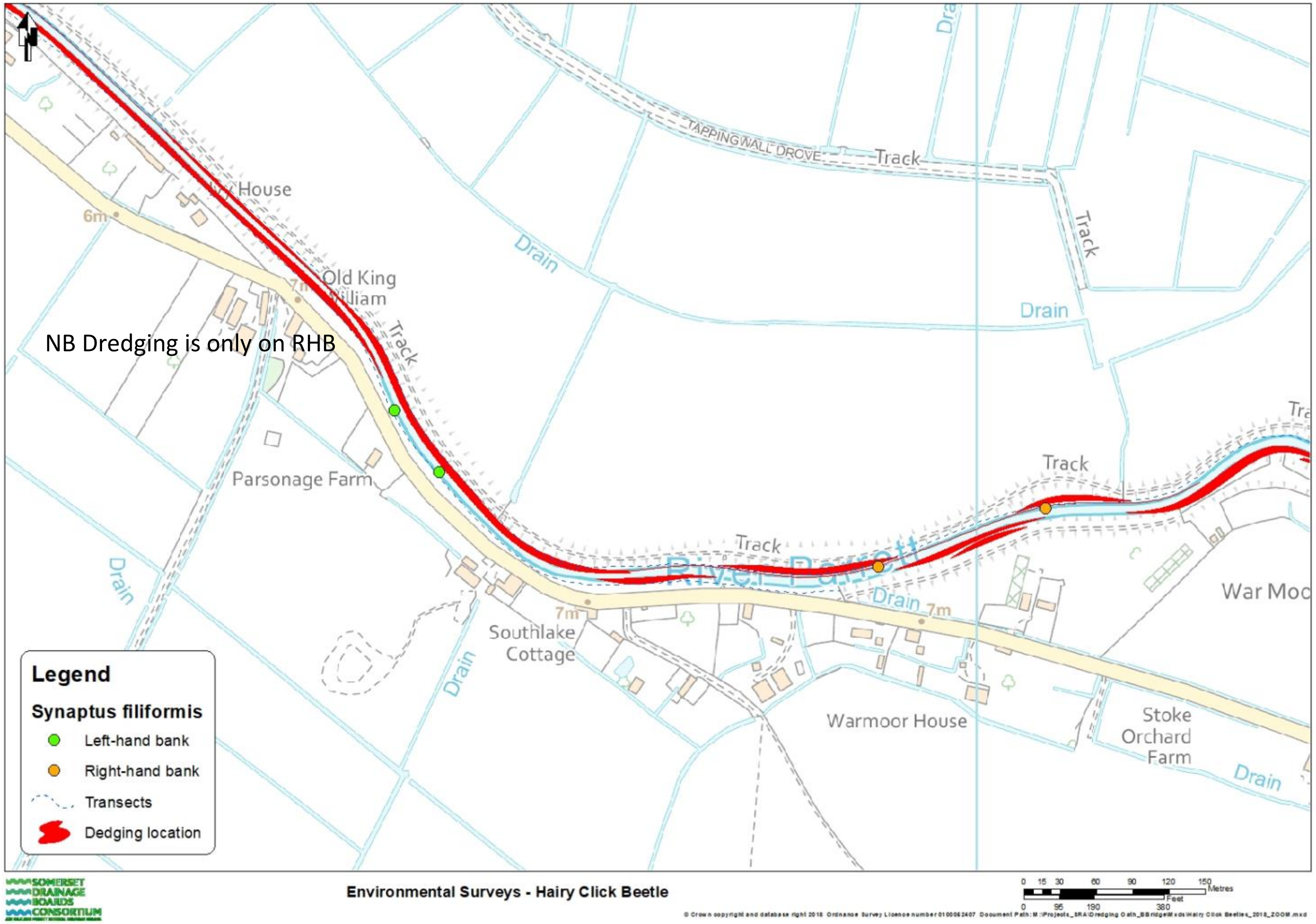

Figure 3 Location of Hairy Click Beetle (2018 survey) and proposed dredging location – Upstream section of dredge

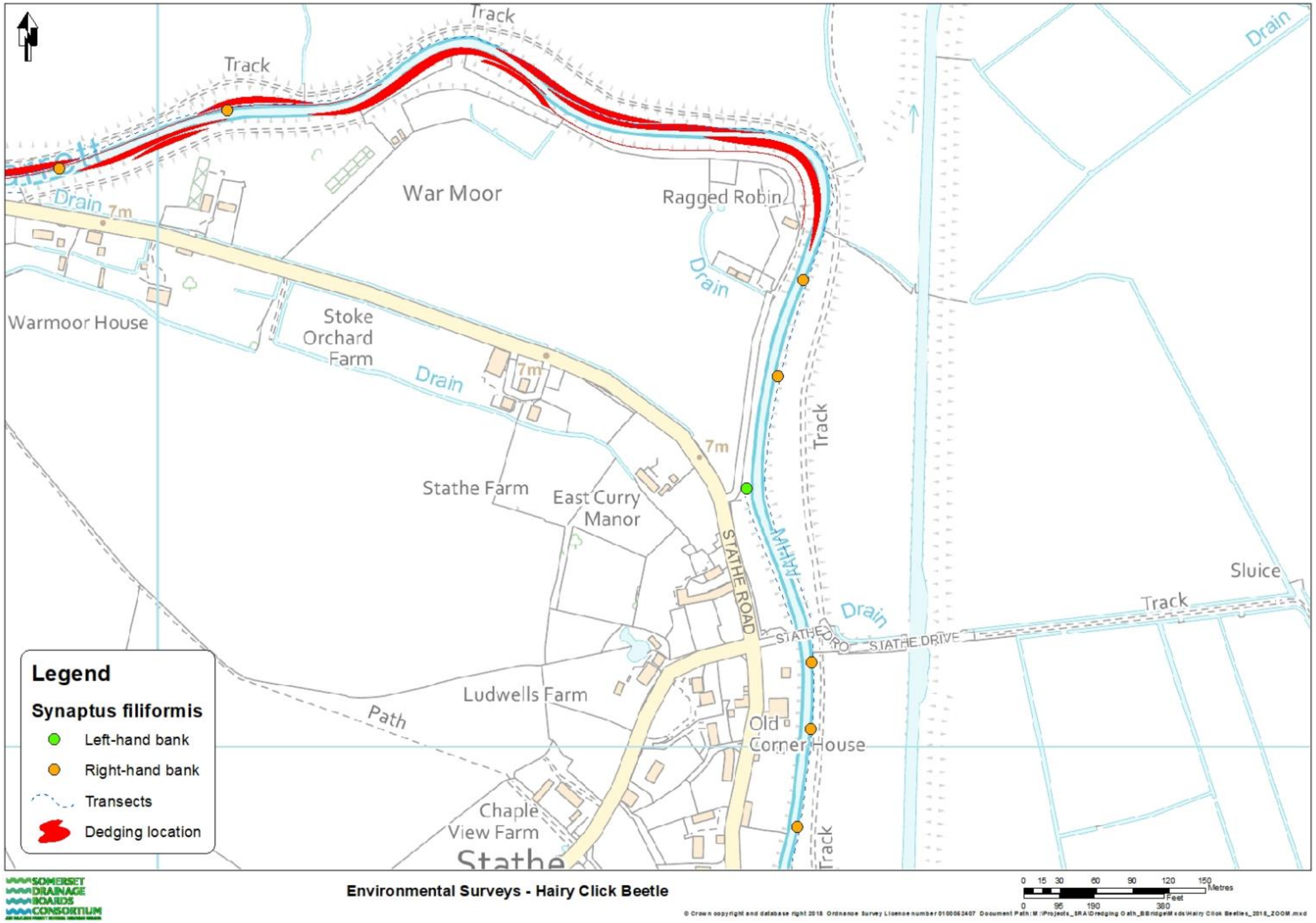

Figure 4 Location of Hairy Click Beetle (2018 survey) and proposed dredging location – Upstream of the proposed works