

Development and demonstration of systems-based estuary simulators

Technical Summary: FD2117

Joint Defra / EA Flood and Coastal Erosion Risk Management R&D programme

Background to R&D project

The project has investigated an alternative, yet complimentary, approach to help understand morphological behaviour in estuaries. This involves the application of a systems-based approach to estuary environments. One of the key aims of the approach developed is to provide a qualitative framework to understand and explain the behaviour of geomorphological features within estuaries, the linkages that exist between them and hence their response to change.

A system-based approach involves defining the individual components that make up a given environment and characterising how these components interact in order to understand the system organisation and define its behaviour. Systems-based thinking is a well-established conceptual framework in geomorphology, however methodologies for converting system diagrams into practical simulation tools have not previously been investigated.

EstSim has applied these systems-based concepts to estuaries to define and subsequently formalise the understanding of the system in a way that allows the qualitative prediction of long-term estuary morphological evolution and responses to environmental change (e.g. sea-level rise or sediment supply changes) or interventions (e.g. dredging or coastal protection). This research has been used to demonstrate the potential of such a systems-based approach.

The Project has been completed as part of the joint Defra / Environment Agency R&D Programme, and within Phase 2 of the Estuaries Research Programme. The project team comprised experts from ABPmer, University of Plymouth, Delft Hydraulics, University College London, Discovery Software and HR Wallingford.

Results of R&D project

The project involved providing a formal definition of estuary systems through mapping of the system components and providing an understanding of how these components interact (via the production of behavioural statements and systems diagrams). This definition of an estuary system maps a set of influences between the morphological and process components. This has been formalised using a Boolean network approach. The Boolean approach is mathematically straightforward, an estuary is conceptualised as a set of morphological features (inlet channels, tidal flats, saltmarshes, spits etc.) and processes (waves, tides, sediment supply etc.), which can be represented in the form of a network of interconnected components.



This Boolean formulation has been used to develop a *proof-of-concept* estuary system simulator. The prototype simulator incorporates linked sub-systems for inner and outer estuary zones, and for the interaction between the estuary and the open coast, and includes additional variables to represent engineering interventions (e.g. coastal groynes, seawalls, dredging). The prototype simulates the evolutionary trajectory in terms of the state of each of the components within the system.

This prototype simulator has been developed into a web-based interface. This provides full simulation functionality through an easy to use Graphical User Interface (GUI) and provides a means to promote systems based knowledge and understanding.

R&D Outputs and their Use

EstSim has been successful in providing exploratory level research into the systems-based approach for the simulation of estuary change. The research has been formalised and the resulting prototype simulator is beginning to reveal potential in this field, although it must be emphasised that at this stage this is still primarily an R&D tool. In addition, FD2117 has provided a valuable qualitative framework for the application of the systems based approach to estuaries.

The approach requires expert knowledge of estuary morphology in order to set up the model for specific estuaries. The present implementation of the model does not allow for the magnitude of an effect to be determined, but it does capture the characteristic behaviour of an estuary system. This approach can therefore be used to determine directions of change or tendency but cannot quantify this change.

At the present level of development, the prototype simulator is not designed as a universal tool to evaluate estuary management options. The Prototype can be used to explore geomorphological behaviour, provide a guide to other modelling studies and provide a means to promote systems based knowledge and understanding

This R&D Technical Summary relates to R&D Project FD2117 and the following R&D output:

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The above outputs may be downloaded from the Defra/EA Joint R&D FCERM Programme website (www.defra.gov.uk/environ/fcd/research).



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