

Research and Development

Final Project Report

(Not to be used for LINK projects)

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 Cromwell House, Dean Stanley Street, London, SW1P 3JH.
 An electronic version should be e-mailed to resreports@defra.gsi.gov.uk

Project title

BROAD SCALE MODELLING THEME LEADER

DEFRA project code

FD1809

Contractor organisation
and location

Halcrow Group Ltd
 Burderop Park
 Swindon
 Wilts SN4 0QD

Total DEFRA project costs

£ 99,000

Project start date

01/10/02

Project end date

31/08/03

Executive summary (maximum 2 sides A4)

Rationale for BSM

The key phrases defining the rationale of BSM are contained in the Penning-Rowcell Report (MAFF/EA 1997) which refers to the threat that **'...the huge investments made in the past may be under threat from climate change'** It goes on to highlight the **'... need to understand the frequency, extent and severity of coastal erosion and fluvial flooding likely in the future if we are to devise appropriate counteracting policies and schemes.'**, and concludes that **'...we need to develop models that facilitate this understanding at a strategic scale of the catchment and the coastal cell...'**

The BSM ROAME A statement

The rationale of BSM is set out in the ROAME A statement, from which the policy and scientific objectives are given below for convenience:

Policy Objective

The policy objective of BSM is to improve mathematical models in such a way that would:

1. enable Defra/EA to meet its policy aim of reducing risks to people and the developed and natural environment from flooding, through gaining an understanding of the large scale, medium to long term risks posed by such driving influences as climate change and cumulative anthropogenic change;
2. discourage inappropriate development in areas at risk of flooding or coastal erosion
3. inform Defra/EA as to the interaction between policies or strategies in such areas as planning, land use, agriculture, catchment management and flood defence itself, and flood risk.

Research Objectives

There are a number of objectives related to broad scale modelling that may be considered to be common and more generic to coastal, estuarine and fluvial areas. These are related to determining the large scale, medium to long-term consequences of natural change such as climate change or anthropogenic intervention.

Predictive tools that take into account the multi-faceted interactions between different physical processes and their feedback effects, as well as the ecological, biological and socio-economics are required to support policy formulation and the decision-making process as it relates to future planning. The scientific research objectives for this programme are to provide tools, methods and understanding which will allow Defra and EA to:

1. Determine large scale, medium to long-term natural evolution of river, estuarine and coastal systems and the influence that anthropogenic intervention may have on the process of flooding and flood and coastal defence, whether physical, biological or ecological, the consequential impact on management strategies and corresponding management response;
2. Determine the relative influence of climate change phenomena on these processes;
3. Understand the importance/ role of variability in climate influences on vegetation, sediment transport and morphological evolution;
4. Determine the regional and national socio-economic impacts leading to prioritisation of scheme development; optimisation of available resources; better informed planning policy and improved catchment management;
5. Similarly determine the broad scale regional and national impacts on ecological system integrity;
6. Provide tools to ensure the benefits of flood defence at one location do not lead to unacceptable consequences elsewhere or for other functions;
7. Provide tools to enable assessment of the impacts of alternative planning scenarios, catchment management practices and river engineering on the effectiveness of existing flood defences;
8. Provide tools to enable formulation of flood defence and flood plain zoning policy in relation to both structural and non-structural flood defence responses;
9. Provide tools to assist in the determination of acceptable locations and scales of new development (the particular effect of development in a specific location falls under other themes such as engineering).

BSM theme development

The theme has a number of strong integrative strands but can conveniently be broken down into three 'physical' topic areas plus a fourth cross-cutting group of topics which goes across all the three physical topic areas. This matches the disciplinary skill groupings among researchers while emphasising the need for integrated modelling of impacts on the human and natural systems. The topic areas are:

- Catchment modelling;
- Estuarial modelling;
- Coastal modelling;
- Cross-cutting topic areas – ecological and socio-economic modelling and decision support systems.

Research within these topic areas has been shaped by research plans commissioned in catchment, estuarial and ecological modelling under the previous BSM management contract, FD1802. During the contract period, procurement was in progress for a batch of three projects in this topic area and of phase 1 of the ecological modelling research plan. In addition planning work has been carried out on coastal BSM.

R&D Projects carried out during the contract period

Code	Title	Contractor	Start	End	Total cost £
FD2110	ERP Phase 1 Uptake	Posford Haskoning	Feb-02	Dec-02	172,500
FD2105	Improved methods for national spatial-temporal rainfall and evaporation modelling for BSM	Imperial College	Mar-02	Feb-05	683,250
FD2106	National river catchment flood frequency method using continuous simulation	CEH	Nov-01	Mar-05	436,026
FD2114	Review of impacts of rural land use and management on flood generation: short term improvement in modelling and research plan	Newcastle University	Jan-03	Mar-04	111,250

Scientific report (maximum 20 sides A4)

Introduction

This report sets out the planned and completed activities that have been carried out to develop and undertake R&D within the Broad Scale Modelling Theme of the Defra / Environment Agency Flood and Coastal Defence R&D programme. Key supporting documents are listed in the References.

Rationale for BSM

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Funding

The ROAME A recommends that Defra/EA should support this research because it will supply the scientific basis to ensure that best practice guidelines encourage the provision of sustainable defence measures that are technically and environmentally sound. Defra Flood Management division are aware of current international research and are confident that the research specified under this programme can not be obtained by buying-in existing information from other countries.

Evaluation criteria

The ROAME A recommends that the programme should be evaluated by asking the following questions:

1. What models have been developed that provide acceptable representations of large scale, medium to long-term evolution processes?
2. To what extent can these models be used to influence management response?
3. How have these models been developed and used to improve the understanding of climate change phenomena and seasonal variation effects?
4. Has the influence of anthropogenic intervention been assessed and quantified?
5. Are these models at a sufficiently reliable level to be used for assessing alternative broad scale planning scenarios and the cumulative effects of works on the surrounding environment?

Theme Organisation and structure

Structure of the overall programme

The Penning-Rowse Report (MAFF/EA 1997) proposed a number of priority research areas – risk and uncertainty; data and information; fluvial, estuarine and coastal processes; broad-scale models; climate change; economic and community impacts; performance evaluation; flood forecasting and warning; engineering; integration with environmental needs; preventive options; institutional change; biodiversity, conservation and sustainability, and community interface. This wide-ranging set of topics was condensed in the Implementation Report (MAFF/EA, 1999) into six "themes":

Defra - led

1. Fluvial, Estuarine and Coastal Processes
2. Policy Development
3. Broad-Scale Modelling

Environment Agency - led

4. Flood Forecasting and Warning
5. Risk Evaluation / Understanding of Uncertainty
6. Engineering

While themes 1, 3, 4 and 5 were carried through with their original scope, the smaller topics were grouped into themes 2 and 5.

Relationship between the themes

The Penning-Rowse proposals set out to reshape the research areas, which had formerly been defined by physical areas such as estuaries, and to make them more closely aligned with Defra and EA policy and business areas. The danger in this is that instead of research being fragmented in a policy sense it will be fragmented in relation to physical areas. Thus the new thematic grouping creates a challenge in managing programmes such as the Estuaries Research Programme (ERP). In order to overcome this discussions were held between the theme leaders and the programme coordinators and a matrix was drawn up expressing the relationships (Appendix B).

The success of the approach is now becoming apparent in the ERP Phase 2, with the ESTPROC project, run by the Processes theme, producing its outputs in the form of algorithms which can be used by the BSM estuarial projects which will commence in early 2004.

Theme advisory Group (TAG) membership

The membership of the BSM TAG includes representatives of the major stakeholders, Defra and EA, and leading experts covering the theme topics. They are shown in Table1, with their affiliations and topic areas.

Table 1 BSM TAG membership

Name	Affiliation	Topic area
Peter Allen-Williams	Defra	
Trevor Linfood	Environment Agency	
Prof. Howard Wheater	Imperial College London	Catchment modelling
Ian Townend	ABPMER	Coastal and estuarial modelling
Dr. Jon French	University College London	Coastal and estuarial geomorphology
Prof. Edmund Penning-Rowsell	Middlesex University Flood Hazard Research Centre	Social and economic impacts
Prof. Jacquie McGlade	University College London/ European Environment Agency	Ecological modelling
EP Evans	Visiting Professor Glasgow University	Theme Leader/ catchment planning and modelling

BSM topic areas

The theme has a number of strong integrative strands such as hybrid and probabilistic modelling, new mathematical methods, ecological and process modelling and decision support systems encompassing socio-economic impact modelling and GIS frameworks. However, it can conveniently be broken down into three ‘physical’ topic areas plus a fourth cross-cutting group of topics which goes across all the three physical topic areas. This matches the disciplinary skill groupings among researchers while emphasising the need for integrated modelling of impacts on the human and natural systems. The topic areas are:

- Catchment modelling;
- Estuarial modelling;
- Coastal modelling;
- Cross-cutting topic areas – ecological and socio-economic modelling and decision support systems.

Theme development

Basis of development

At the inception of the thematic programme BSM had available to it a number of relevant research planning documents:

- A catchment modelling scoping study (Naden et al 1997)
- A scoping study report for estuarial morphology research (HR Wallingford 1997). This was implemented via the Estuaries Research Programme (ERP) of which Phase 1 was completed in December 2000 (EMPHASYS Consortium 2000), and included among its outputs a long list of research priorities.

Development of the BSM work plan was initiated under FD1802 through a workshop in January 2001, in which experts and practitioners from a wide range of backgrounds participated. In addition BSM participated in Concerted Actions managed by the Processes theme on hydrology and coastal research.

It was decided that in order to produce a coherent programme of BSM research it was necessary to have prioritised and costed research plans, related to user needs and with outline project specifications in hydrology (Calver and Wheater 2002), ecosystem modelling (Cascade Consulting 2002) and estuaries (French, Reeve & Owen 2002). The latter was carried out in cooperation with the Processes and Engineering theme leaders and had the objective of producing a proper cross-theme programme from the very long list of potential topics identified by ERP Phase 1. BSM participated in the coastal Concerted Action noted above.

An account of each topic area follows.

Catchment modelling

The key table from the Hydrology Strategic Plan is shown below, updated with completed and ongoing projects shown in [blue](#).

Table 2: Components of the BSM Hydrology Strategic Programme with indicative cost levels and linkages in time (after Calver and Wheater Table 5.2)

HSP COMPONENT	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12	2002-07 budget £ m
C1 Definition of strategic agenda	FD2104 (completed)			** Stage 3		* Stage 4					0.1
C2 Maintenance of current practice	FD1913 (ongoing-Processes theme)			*	*				*	*	0.5
C3 National spatial-temporal rainfall modelling (1a)	FD2105 (ongoing)			**	**		*	*			1.0
C4 National continuous simulation runoff modelling (2a)	FD2106 (ongoing)			**	**		*	*			1.3
C5 Modelling impacts of land use and land management change (3a, 3b, 3c)	FD2114 (ongoing)		**	**				**	*		2.4
C6 Climate impact modelling (1b)	*							*			0.3
C7 Building a new modelling capability											
(a) generic modelling techniques						*		*		*	0.8
(b) data and data assimilation	*					***	*	*	*	*	1.0
(c) IT framework	*					***		*		*	0.8
C8 Software production		*	**	**	*	*	**	*	*	*	1.2

Estuarial modelling

The key table from the ERP2 Research Plan is shown below, updated projects are shown in **blue**.

Table 3: Proposed ERP2 core projects (1 - 8) and additional areas of basic research recommended for co-funding with Research Councils. (after French et al Table 4.1)

	Core R&D project title	R&D Theme	Status	Cost(k)
1	Uptake of ERP1 science	BSM/Risk	FD2110(completed)	172
2	Improved estuary data	Risk		450
3	Enhanced hybrid models	BSM	FD2107 (tender)	600
4	Estuary physical, sedimentary and biological processes	Process	FD1905 (ESTPROC, ongoing-Processes theme)	750
5	Enhanced top down models: 5a) Formalisation and interpretation of geomorphological concepts 5b) Behavioural modelling of estuarine systems	BSM	FD2116 (tender) FD2117 (tender)	275
6	Predictability of morphological systems	Process/BSM		120
7	Maintenance and dissemination of existing guidelines	Engineering		40
8	Delivery of ERP2 science	BSM/Risk		150
			Sub-total Defra/EA	2485
	Budget for research council co-funding			
i	Mathematical analysis of long term estuary behaviour	Process/BSM		Co-fund with EPSRC
ii	Evaluation of spatial landscape simulation for estuaries	Process/BSM		Co-fund with NERC
iii	Formal testing of critical scientific concepts	BSM/Process		Co-fund with NERC
			Sub-total co-funding	250
			Total	2735

The new starts being procured for 2003/04 represent a substantial contribution to advancing ERP Phase 2.

Coastal projects

The negative side of the good progress noted above in most topic areas only serves to highlight the lack of a coherent approach to coastal modelling, despite the Coastal Vision. The urgency of creating a good research programme in this topic area is confirmed by the emerging findings of the Foresight FCD project, which shows coastal risks as those with the greatest potential increase.

A table of priority projects is shown below based on an update of the Coastal Vision (Townend 2003), taking into account work at the Tyndall Centre and other factors.

Table 4: Priority projects in coastal research

No	Project/Sub-project	Priority
1 Decision support tools for strategic planning and asset management		
1.1	Demonstration projects applying latest guidelines to provide consistency in the structure and content of future SMPs. <i>This project will “come round again” as a platform for testing the new methods developed in the projects outlined below and feed into the 3rd round of SMPs</i>	Ongoing under SMP programme
1.2	National assessment of defence options to set up impact matrices for SMPs	High
1.3	National application of priority scoring to provide filter for next round of SMPs	High
1.4	Development of decision support tools (algorithms and “models”) for assessment of defence options, standards, vulnerability and thus flood/erosion risks, combining information from BSM and other themes. <i>This could make use of existing MDSF and RASP developments and also links to Tyndall Centre.</i>	Medium
1.5	National level assessment of defence standards and flood/erosion risks, based upon broad scale hydrodynamic modelling, introducing sensitivities to natural variability and climate change scenarios, with an improved economic assessment of assets at risk and investment needs. <i>Extends existing Asset Database and links to Tyndall Centre</i>	Low
2 Morphological modelling and coastal dynamics		
2.1	Development of sediment budgets for use in SMPs, with specific attention to routines to enable assessment of defence interactions. <i>(Links to Tyndall Centre)</i>	High
2.2	Develop behavioural models of geomorphological features that form components of the natural “defence” system. This is likely to be a mix of bottom-up, top-down and hybrid approaches to represent the behaviour of features such as barrier beaches, cliffs, sand dunes, shingle ridges, salt marshes, spits and banks. The overall framework is likely to be a systems approach with components including further development of: <ul style="list-style-type: none"> • The Futurecoast approach • The Tyndall Centre Coastal Simulator • Outputs from regional studies and monitoring • Ability to introduce impacts of anthropogenic intervention, e.g. structures, beach management, dredging. This project will need to link with 2.1 and 2.3.	High
2.3	Develop broad scale approaches to characterise the interactions between: <ul style="list-style-type: none"> • Exchanges between the beach face and the near shore • Coastline and tidal inlets/estuaries. 	Medium
2.4	Research into future evolutionary characteristics of morphological features (response to climate change scenarios, uncertainty of response to different parts of a system, e.g. bars, impacts of episodic events, influence of natural constraints).	Low
2.5	Application of novel analysis methods with particular reference to non-linear techniques	Low
3 Coastal climate		
3.1	National scale fine-grid hydrodynamic model of inshore wave transformations, with facility to calculate extremes and energy (for sediment transport)	Medium
3.2	National assessment of regional differences of the influence of climate change scenarios upon coastal forcing through the application of hydrodynamic models.	High
3.3	Potential for renewable energy devices to double as coastal defences	Medium

It is likely that projects 1.2 and 1.3 would be carried out under the SMP programme. The remaining High priority projects are therefore candidates for new starts in subsequent years.

Cross-cutting projects

BS ecosystem modelling

The key table from the scoping study, FD2108, is summarised below, updated with ongoing projects shown in blue.

Table 3: Proposed ecosystem model development projects (summarised from BSEIM scoping study report Table 5.1)

Ref. No.	Proposed Project
Short Term - within 2 years	
BSEIM 1 (FD2112-tender)	Development of Initial BSEIM Guidance: BSEIM Toolbox Phase 1 including training, user support and exploitation of R&D
BSEIM 2	Hydrological, Hydrodynamic and Geomorphological Model Development
BSEIM 3	Development of Ecosystem Impact Modelling Approach Phase 1
	a) Development of Ecosystem Baseline Descriptions.
	b) Interaction and Dynamic Evolution of Aquatic, Riparian and Wetland Ecosystems
	c) Development of Ecosystem Modelling Approaches
This project as with the others identified in the Table must recognise and integrate with work to support the Habitats and Water Framework Directives in order to ensure minimal duplication of effort and encourage development of consistent and inter-related assessment tools.	
Medium Term – 2 to 5 years	
BSEIM 4	Updating of BSEIM Guidance: BSEIM Toolbox Phase 2
BSEIM 6	Mid-Term Review of Progress
Long Term - Up to 10 years	
BSEIM 7	Ecosystem Impact Model Development – Phase 3
	a) Development of Suitable Ecosystem Baseline Description and Interactions of Aquatic, Riparian and Wetland Ecosystems
	b) Development of Ecosystem Modelling Approaches

Socio-economic modelling

Preparation was started for a BSM socio-economic modelling project in 2002-03, but this was subsumed within an ongoing Policy Development theme project. Ideas for new projects have been generated by the Foresight project and need to be considered.

Integrative projects

Project **W5C(03)01: Further development of the MDSF** is being prepared to start in 2004. This will bring in the defence reliability analysis developed under the RASP project and make MDSF applicable for coastal and estuarial tasks.

References

- Calver, A. & Wheeler, H.S. (2002) Scoping the broad scale modelling hydrology programme. Defra R&D project FD2104
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- HR Wallingford (1997) *Estuaries The case for research into morphology and processes*, Report SR 478.
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- Townend, I.H. (2003) *Coastal BSM Programme*. Personal communication