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Flood and Coastal Management Research and Development

Annual Report 2000–2002

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Department for Environment
Food and Rural Affairs

Flood and Coastal Management Research and Development

Annual Report 2000–2002

This report has been based on contributions from individual research contractors. The Department does not accept responsibility for opinions expressed, errors or omissions.

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Introduction

Government policy is to reduce and manage the risks to people and the developed and natural environment from flooding and coastal erosion. Since April 2001, Defra (previously MAFF) and the Environment Agency have jointly managed a user-oriented, thematic Research and Development Programme set up in line with the recommendations of the Advisory Committee on Flood and Coastal Defence R&D chaired by Professor Edmund Penning-Rowsell. The Joint Programme supports government policy by providing the science on which policy development and the next generation of tools and guidance for practitioners are based.

During the years 2000/2001 and 2001/2002, Defra contributed over £2.5m per annum to the Joint Programme – about 20 per cent more than in past years. This report, which as will be explained later, is to be the last report in this format, summarises the progress made during the last two years and provides references to publications where more detailed results can be found.

One major driver of recent government policy is an emphasis on development of 'e-delivery' of information and 'e-working'. This combined with Defra's commitments to 'accessibility' and 'accountability' has lead to an increasing use of electronic delivery of information both about R&D, as well as the actual outputs and results. Outputs from R&D projects in the Joint Programme are currently loaded onto an interim website hosted by the Environment Agency at (www.environment-agency.gov.uk/floodresearch).

Plans are being made to develop a joint government floodresearch website. The basis for these plans is the recommendations from a CIRIA run project "Improving The Implementation And Adoption Of R&D Results" (which can also be found on the floodresearch website and which includes a useful dissemination 'Route Map' for R&D). In future, rather than publish an Annual Report in a bound format, we will be listing projects completed in the year and providing links to the outputs which include a two page technical summary of each project. In addition to this Defra's Science Directorate also publishes project details and outputs from all Defra funded projects.

As in previous years the annual Defra Conference of River and Coastal Engineers continues to feature papers related directly to projects in the Joint Defra/Environment Agency programme. Full proceedings of the conference are available in bound form.

Also as in previous years, research contractors regularly run and contribute to other seminars and courses during the year, both on a self-financing basis and with sponsorship from the Joint Programme to help ensure effective dissemination of results and provision of opportunities for continuing Professional Development.

Within the Joint Programme there has been a considerable shift in the emphasis of research to reflect the development of six new themes of research following the recommendations of the Advisory Committee.

The Themes are:

- Fluvial, Estuarine and Coastal Processes
- Broad Scale Modelling
- Policy Development
- Flood Forecasting and Warning
- Risk Evaluation and Understanding Uncertainty
- Engineering

Each of the Themes has a Theme Leader who is supported by a small Theme Advisory Group (TAG) composed of a mix of users, researchers and experts.

In the early stages of development of the Joint Programme a series of 'Concerted Action' workshops brought together practitioners and researchers with particular areas of interest. The outputs from the workshops have been worked up and published as a series of 'Visions' for (available on the Interim website under 'cross-cutting') setting out a 5-10 year plan for research. I would like to express my appreciation to all who contributed to this process and ask you to convey that appreciation within your organisations where appropriate. It is through this tremendous support that we are able to develop a relevant and user-oriented programme.

If you should require further details of any particular project, then these may be obtained from the appropriate research institution or contractor whose addresses are at the back of this report. If you have any comment on the format of this report or the overall research programme, or would like to receive regular copies of our Newsletter, please contact Defra at the address on the front page.

I hope that, once again, you find this report useful.

Reg Purnell
Chief Engineer
Defra Flood Management Division

May 2003

Defra Project Number and Title:	FD 0404 Continuous Simulation Modelling For Flood Estimation
Research Contractor:	CEH-Wallingford
Objectives:	To develop modelling methods for river flood frequency estimation in continuous simulation mode: i.e. modelling whole time series as opposed to events. To establish model parameter values for hourly modelling for a sample of gauged catchments in Britain. To attempt to extend the method for flood frequency estimation at ungauged sites through the use of catchment property information.
Start Date/Finish Date:	April 1994 / November 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

This project has developed a new method for river **flood frequency estimation using continuous simulation**, that is, the modelling of catchment runoff response time series.

Rainfall-runoff models are used to derive continuous river flow time series. The method has been developed as a pilot system for ungauged as well as gauged sites, and designed for national application across Britain.

The overall principle is as follows. A generic rainfall-runoff model is used to convert rain falling over a catchment to the river flow at the outlet. For a group of catchments for which rainfall and river flow observations exist, the runoff model is calibrated. Spatial data which are more widely available across the country are also collated and, for the sample group of catchments, relationships are sought between runoff model parameters and spatial catchment property data. For ungauged locations, catchment properties can then be used to derive model parameters, in turn allowing the runoff models to be run to produce river flow time series from which flood (and other flow) statistics can be derived. By this means the method is regionalised or spatially generalised.

Long rainfall series are applied to the models with either locally-derived or spatially-generalised model parameters. Long river flow series are thus available, covering rarer, larger floods. The long rainfall time series can be observed or model-generated. It is in the application of rainfall series which drives the runoff models that changes in climate can be introduced to assess impacts of **climate change**.

Continuous simulation is also used for modelling and frequency estimation for features other than floods, for example, for low river flows. Furthermore, flood continuous simulation can apply to catchment-specific modelling, as well as to the countrywide generalised system developed here.

It is possible to view continuous simulation as a **next-generation methodology** for flood frequency estimation, following the Flood Studies Report and the Flood Estimation Handbook. It is anticipated that, with refinement of techniques and their application beyond test catchments, it will become apparent where particular strengths of continuous simulation are of most value.

The final project report details the runoff models and data issues, how spatial generalisation of the method to cover ungauged locations was achieved, and how extension to long time periods and rare events was achieved, including possible changes to climate. The way forward in terms of refinements to continuous simulation methodology is also indicated.

Outputs in the Year: Calver, A., Lamb, R., Kay, A.L. and Crewett, J. (2001). *"The continuous simulation method for river flood frequency estimation".* CEH Wallingford report to Defra.

Defra Project Number and Title:	FD 1004 Estuary Morphology – Survey And Modelling For Managed Set-Back Site
Research Contractor:	HR Wallingford Ltd.
Objectives:	To carry out measurements and modelling at the managed set-back site at Tollesbury in Essex, to allow continuing assessment of changes in the vicinity of the breach, and in Tollesbury Creek, following breaching which took place in August 1995.
Start Date/Finish Date:	April 1994 / November 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The project has been fully reported through the Tollesbury Group led by CEH Dorset. The project has had two phases: the first from 1994 to 1996 included assessment of the initial breach and flooding, while the second phase included the **post breach monitoring**. This second phase is outlined below.

The HR Wallingford contribution over the duration of the second phase of the project was to carry out measurements and modelling, and to assess **changes in the vicinity of the sea defence breach** and within Tollesbury Creek. The measurements were undertaken annually according to a pre-determined programme and comprised:

- Bathymetric surveys of Tollesbury Creek and Fleet out to Great Cobb Island;
- Aerial surveys of the breach and seaward portion of the set-back site;
- Section surveys of the breach.

These surveys were analysed to assess changes over time. **Measurable and significant changes were found within the Creek and Fleet**, but changes within the setback site near the breach were found to be less than the resolution of the measurement method. As a result reporting concentrated on the Creek changes.

In general, over the entire period June 1994 to November 2001 the whole bathymetric survey area deepened, particularly along Tollesbury Creek and in Tollesbury Fleet. This deepening has occurred in both subtidal and intertidal areas of the estuary. The subtidal and lower intertidal areas appear to be affected by the breach while the upper intertidal areas are affected by wave action. The most significant mechanism on the bed levels in the estuary as a whole appears to be the natural year on year variation in the wave climate. The estuary appears to have deepened as a whole over the period 1994-1996 and subsequently remained broadly stable. However, there is some suggestion that Old Hall Creek, to the north of Tollesbury Creek, has not yet stabilised since examination of point measurements and cross-section profiles suggests it appears to be accreting and gradually returning to the depths that existed before the breach occurred in 1994. At other locations within the estuary there appears to be no significant further deepening in the low water channel or on intertidal areas.

Outputs in the Year: Spearman, J.R. and Semmence, J. (2002). *"Tollesbury Creek Bathymetric Changes",* HR Wallingford Report TR126.

Defra Project Number and Title:	FD 1202 Causes Of Seasonal Sea Level Variations And Implications For Surge Predictions
Research Contractor:	Proudman Oceanographic Laboratory
Objectives:	To understand the processes causing variations in surge elevation which result in persistent errors in present surge forecasts and to improve surge models and prediction systems to account correctly for these variations.
Start Date/Finish Date:	January 1998 / July 2000 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The overall aim of this work was to understand **processes causing variations in surge elevation** which result in persistent errors in forecasts, seen as offsets between observed and forecast surges. With the understanding gained, surge models and prediction systems could be updated to account correctly for the variations in routine predictions.

Factors that could be responsible for such differences between observed and modelled surge heights were identified. These factors include: inconsistencies within the operational forecast scheme in the treatment of monthly to seasonal variations in water level; effects of long term variations in sea level in the Atlantic associated with processes beyond the shelf edge; the influence of surface wind waves; and effects of variations in water density resulting from changes in its temperature and/or salinity.

These processes were investigated in turn and on the basis of the results, **simple changes to operational procedures are proposed:**

i) For consistent treatment of seasonal variations, the harmonic tidal predictions used in the operational procedure should exclude the Sa (Solar annual) and Ssa (Solar semi-annual) constituents;
ii) Model surge forecasts should be improved by adding contributions due to sea level variations generated in the Atlantic and steric effects caused by varying water density.

As a consequence of i), operational tide predictions (excluding components that are primarily meteorological in origin) would differ from standard tide predictions (which simply explain on average as much of the observed variation in sea level as possible). The consequences of this distinction would need to be understood, accepted and approved by users. For ii), the simplest approach would add contributions, necessarily based on average conditions (and so dependent on the analysis period used), to all model grid points.

The effect of these changes was tested and found to be **effective in reducing errors**, differing significantly from the average conditions on which the corrections was based. Beyond this, further improvement would require substantial changes in forecast procedure to account directly for Atlantic and steric effects during the current year.

Finally, alternative approaches involving "post-processing" to correct predicted surges or sea levels on the basis of tide gauge observations over 2-3 days preceding a forecast, were noted. These methods may reduce errors caused by various mechanisms but require real-time observations, and so can benefit predictions only for tide gauge sites.

Outputs in the Year: Flather, R.A., Williams, J.A. and Blackman, D.L. (2000). *"Causes of seasonal sea level variations and implications for surge prediction".* Proudman Oceanographic Laboratory Internal Document No. 136.

Defra Project Number and Title:	FD 1203 Fine Grid Surge Model Evaluation
Research Contractor:	Proudman Oceanic Laboratory
Objectives:	To establish whether fine scale (fine grid) models of water body surges (generated by wind, atmospheric pressure, and tides) can improve forecast accuracy over the large-scale models currently used for national surge prediction.
Start Date/Finish Date:	January 2000 / December 2000 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The aim of this project was to establish whether fine grid surge-tide models could **improve forecast accuracy** as compared with CS3, the shelf scale (12km grid) model on which the present national surge predictions are based.

Surges affecting UK coasts are generated by wind and atmospheric pressure acting over the whole continental shelf, so **local and large-scale models must be used in combination**. Surges in local models have a large-scale component, introduced through open boundary conditions, and an internal component generated within the model domain. The fine grid models should improve the simulation of local variability, but cannot reduce errors in the external component, which may dominate. Therefore, in seeking to improve forecast accuracy, both local and large scale components must be considered.

Three regions: the central South Coast; the eastern Irish Sea; and the central East Coast were investigated. Each includes estuaries, embayments, and inter-tidal flats and channels that cannot be resolved properly by CS3.

Model results were compared with surges derived from tide gauges of the national "A" class network and from additional gauges run by the Environment Agency. The Agency gauges provided information on local surge variations.

The **main conclusions** were:

- Differences between surges computed from fine grid models and CS3 can be large in complex areas away from model open boundaries, and in rapidly changing storm situations. They are small near open boundaries of the local models and on open coasts, and generally when effects of local dynamics and forcing are less important.
- Comparison of model and observed surges for all coasts gave examples in which the fine grid model gave better results than CS3.
- Errors in the large-scale surge component affect both fine grid and CS3 surges, so when this component is large fine grid models cannot significantly improve surge forecast accuracy.
- To resolve surge variations in rapidly varying cases, model output and observations should be provided at intervals of no more than 15 minutes, and preferably less.
- Finer scale models (100-200m) nested within local (1km) models are required to resolve narrow channels through drying areas and smaller estuaries where some Agency gauges are located. These models could also account for effects of river flow on water levels, where this is significant.

Outputs in the Year: Flather, R.A., Williams, J.A., Blackman, D. and Carlin, L. (2001). *"Fine grid surge model evaluation",* POL Internal Document No. 141.

Defra Project Number and Title:	FD 1603 Appraisal Of The FEH Statistical Procedures For Flood Frequency Estimation
Research Contractor:	CEH-Wallingford.
Objectives:	To develop a comprehensive summary of flood frequency estimates using the Flood Estimation Handbook (FEH), thus anticipating difficulties that might arise when applying the FEH to different catchment types.
Start Date/Finish Date:	September 2000 / July 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The Flood Estimation Handbook (FEH) statistical method of flood frequency estimation comprises a series of procedures for estimating the flood peak of a specified return period at almost any site, gauged or ungauged, on the UK river network. The performance of the method has been appraised by automating its principal procedures, applying them for seven return periods at all locations throughout the river networks of England, Wales and part of southern Scotland, and analysing the results.

The return periods used in this project were selected to coincide with the requirements of the Environment Agency's programme of Catchment Flood Management Plan studies, namely 2, 5, 10, 25, 50, 100 and 200 years; this spans the full recommended range of capability of the FEH statistical method.

The effect of the **automation procedure was assessed at selected locations** by comparing the results with those produced by experienced users of the FEH statistical procedures. The performance of the method was assessed by searching for internal inconsistencies within the network-wide FEH estimates. No attempt was made to assess performance by comparing the estimates with those produced by other methods.

Numerous modifications were made to the procedures during the development of the automated method in order to avoid or reduce the spatial inconsistencies that would have been generated by adhering to the FEH guidelines. Many of **these changes are recommended for use** in any future versions of the FEH. They primarily affect the selection and weighting of donor and analogue gauges and the selection and weighting of pooling-group members.

Analysis of the results shows that, after the above modifications, **the FEH method performs well in most places** from the aspect of spatial coherence. Problems occur at a minority of confluences, usually where catchments of very different permeability converge or where there is a change in the set of donor gauges being used. The causes of the problems have been analysed and solutions are suggested.

The datasets of automatically produced estimates, created during this project, are not everywhere as reliable as those that could be made by an experienced manual user of the FEH, but they are still of value for a number of applications, particularly where estimates are required throughout a region. The report will discuss the limitations of these datasets and suggests how they might be improved.

Whilst this report will primarily be of interest to users of the FEH, no prior knowledge of the FEH has been assumed.

Outputs in the Year: None

Defra Project Number and Title:	FD 1901 Development Of Predictive Tools And Design Guidance For Mixed Beaches – Stage 2
Research Contractor:	HR Wallingford Ltd.
Objectives:	The overall aim of the research is to facilitate the development of Coastal Strategy Plans and Beach Management Plans by improving understanding of processes and responses for beaches with widely graded sediments; developing predictive tools for beach responses; and disseminating information and guidance to UK shoreline managers.
Start Date/Finish Date:	April 2000 / March 2003
Staff Input this Year:	No information provided.

Summary of Progress in the Year:

During the first year of this 3 year programme good progress has been made on all objectives. The project has received wide interest both nationally and internationally as it is recognised as an **important step forward towards improved shoreline management**. Work has benefited greatly from the association between HR Wallingford and Imperial College.

The following objectives have been completed:

- Literature review on mixed beach and graded sediment processes;
- Literature review on experimental research;
- Characterisation of UK mixed beaches;
- Field experiment at Seaford (20-24/03/01);
- Field experiment at Slapton Sands (02-06/04/01);
- Permeameter and preliminary threshold experiments;
- Preliminary swash zone velocity experiments;
- Planning of detailed threshold experiments;
- Planning and successful EU-TMR funding application for full scale wave flume research using the GWK facility in Hanover;
- Further development and validation of the OTTP cross-shore beach model.

Outputs in the Year: Blanco, B.L.S.R., Damgaard, J.S., Coates, T.T. and Homes, P. (2000). *"Management of mixed beaches",* 1st International Conference on Soft Shore Protection, Patras, Greece.

Defra Project Number and Title:	FD 1905 Estuaries Processes Research Project (EstProc)
Research Contractor:	Consortium led by HR Wallingford Ltd.
Objectives:	To develop further the understanding of hydrodynamic and sedimentary processes and biological sedimentary interactions within estuaries to build on work done in Estuaries Research Programme Phase I providing outputs for use by BSM Theme in developing improved Estuary Impact Assessment Systems.
Start Date/Finish Date:	December 2001 / November 2004
Staff Input this Year:	1.53 person years of scientific effort.

Summary of Progress in Year:

The main objective is to deliver research on **hydrodynamic and sediment processes in estuaries and the interactions between biology and sediments**. The fundamental new research will inform the further development of the management tools for estuary morphology, water quality and ecology assessed in Phase 1 of the Estuaries Research Programme.

The main research Objectives are:

- Task 1 – Improved understanding of Hydrodynamic Processes in estuaries
- Task 2 – Undertaking investigation into Sedimentary Processes in estuaries
- Task 3 – Investigating interactions between Biological and Sedimentary Processes in estuaries

A key activity was the **kick-off workshop** which was attended by the entire project Consortium and Funders' representatives to brainstorm the detailed make-up of the project. The workshop clarified linkages between research topics and data sources, as well as identifying external links to other process based and engineering research. Activities completed in this Stage of the project led to the production of the Inception Report detailing the conduct of the programme in Stages 2 and 3.

During Stage 2 of the programme all the technical work is planned for completion. The project team will participate in two workshops during this stage of the research at which the results will be presented and discussed. At these workshops progress will be facilitated by the secondary milestones defined in Stage 1 and by smaller technical meetings organised as required by the Task Leaders.

The main effort in Stage 3 will be on documenting the scientific results from the previous 30 months in an integrated fashion.

A project website (**www.estproc.net**) has also been developed.

Outputs in the Year: *Estuary Process Consortium. (2002). "Estuary Process Research Project (EstProc): Inception Report".* HR Wallingford Report TR129.

Defra Project Number and Title:	FD 1911 Freiston: Shore Managed Realignment
Research Contractor:	CEH-Dorset and Cambridge Coastal Research Unit (CCRU)
Objectives:	To ensure a comprehensive monitoring campaign is undertaken at the largest managed realignment scheme to be progressed in the UK at Freiston.
Start Date/Finish Date:	December 2001 / November 2007
Staff Input this Year:	No information provided.

Summary of Progress in Year:

Wave and tide monitoring

The wave and tide monitoring started in October 2001, with the installation of two non-directional wave and tide recorders, placed in the saltmarsh surface. The exact positions of the gauges have been measured using GPS positioning. The recorders are non-directional pressure gauges, measuring tidal height for 1 minute every 10 minutes and waves for a 20 minute period every 30 minutes.

Results have been delivered monthly to the Shoreline Management Group, and checked for format and completeness. Results are delivered as:

- Tidal heights every 10 minutes, compared to predicted tidal levels;
- Wave parameters: Significant wave height (H_s), Period (T_z), Wave amplitude (A_{max}, A_{min}), Maximum wave height (H_{max}) and Mean Depth (m).

A GIS layer showing the position of the gauges has been created as the first step in producing a digital data catalogue for the project.

Remote sensing

The LIDAR and CASI flights are being commissioned from the Agency's National Centre for Environmental Data and Surveillance at Twerton.

Non-technical progress

The Freiston site is the subject of a flood defence scheme and partnership European 5b funding initiatives, and is also an RSPB reserve. This Defra project has secured agreement with all parties that the monitoring of this site, for any purpose, is to be co-ordinated through the Monitoring Group steering this project. This has expanded the group to include additional experts and ensure a holistic approach is taken with this site. Additionally, lessons from the R&D projects at Tollesbury have been discussed and taken on board in planning this work.

Outputs in the Year: None.

Defra Project Number and Title:	FD 1912 Sandpit: Effects Of Offshore Dredging
Research Contractor:	Consortium Led by HR Wallingford Ltd.
Objectives:	To develop reliable guidelines and prediction techniques to better understand and predict the physical shore-face processes governing medium and long-term changes of the shore-face and coastal zone in response to the impact of human interference such as sand mining, aggregate dredging, sand dumping, and channels and pits for navigation, pipelines and cables.
Start Date/Finish Date:	November 2001 / April 2005
Staff Input this Year:	0.2 person years of scientific effort.

Summary of Progress in the Year:

The first 5 months of the project has been devoted to detailed planning both within UK and with the European project team, to preparing a collation of existing data to give a firm base on which to make the detailed plans, and to improving the SedFlux sediment predictor model.

Organisational

Exchange of information has been undertaken with CEFAS on Defra funded projects on ecological disturbances caused by gravel dredging. Information has also been exchanged with the EC EUMARSAND project (Southampton University).

The detailed planning of the project, including fieldwork and modelling, has been agreed and a methodology for meeting end-user requirements has been decided, to follow the successful pattern of previous MAFF project "Offshore Sand Banks".

Collation of existing data

Data and experiences from UK and world-wide have been located and digested. This review will form the basis of a more extended review including inputs from other partners in the overall EC project. This activity is being co-ordinated by Utrecht University. Results of CEFAS research have been absorbed, and have been copied to ecological partners in the EC project.

Improvements to SedFlux sediment transport predictor model

Several cases of non-intuitive behaviour of SedFlux have been identified, causes found, and are currently being fixed. A methodology for enhancements required for SANDPIT applications have been decided. These principally comprise inclusion of the effects of bed-slope on bedload and suspended transport of sand (relevant to side-slopes of pits), and modification to a non-equilibrium formulation suited to the TELEMAC-3D model (to account for the rapid changes in flow and bathymetry encountered within a mining pit). These will be implemented once the above-mentioned fixes have been proven.

Outputs in the Year: None.

Defra Project Number and Title:	FD 1913 Re-Vitalisation Of The FSR/FEH Rainfall-Runoff Method
Research Contractor:	CEH-Wallingford
Objectives:	To make improvements to antecedent soil moisture conditions, percentage runoff, design storm definition, and unit hydrograph definitions included in the Rainfall-Runoff method.
Start Date/Finish Date:	October 2001 / October 2003
Staff Input this Year:	No information provided.

Summary of Progress in the Year:

Activity has focussed on carrying out a **scoping study to determine data availability and consequences** for the research programme. The study concluded that flood event data collated for the Flood Studies Report, and supplementary studies, should form the basis of the analyses to be carried out in later phases of the project. However, since it was found that only 23% of the total number events held have a peak flow that exceeds the median annual flood, a proviso to this recommendation was that events of greater magnitude be acquired to improve existing data holdings.

The report recommended a pragmatic approach to acquiring new data. It is likely that the Environment Agency would have difficulty servicing a request for a large volume of data for a large number of catchments. Therefore, the primary source for new event data would be the hourly records of flow and catchment average rainfall assembled at CEH Wallingford as part of the Defra funded continuous flow modelling project (FD0404).

Outputs in the Year: Stewart, E.J., Bayliss, A.C., Marshall, D.C.W. and Packman, J.C. (2002). *"Revitalisation of the FSR/FEH Rainfall-Runoff Method: Data Scoping Study"*. CEH Wallingford report to Defra/Environment Agency.

Defra Project Number and Title:	FD 1914 Guidebook Of Applied Fluvial Geomorphology
Research Contractor:	Nottingham University
Objectives:	To produce a guidebook of applied fluvial geomorphology suited to the needs of end users wishing to adopt geomorphic principles, analyses and design approaches in river management and engineering.
Start Date/Finish Date:	December 2001 / August 2002
Staff Input this Year:	0.03 person years of scientific effort.

Summary of Progress in the Year:

To explain the scientific progress to date requires a short review of the circumstances that led to commissioning of the project by Defra.

For most of the twentieth century river management and inland flood alleviation in the UK was led by engineering interventions based on, at best, partial understanding of fluvial geomorphology. In the 1990s it was finally recognised that application of the principles of fluvial geomorphology not only produced schemes that were less environmentally disruptive, but also had the potential to **improve their effectiveness and long term sustainability**. During that decade, a series of R&D projects was commissioned by the NRA and its successor the Environment Agency, aimed at supplying river scientists, engineers and managers with the methodological basis and standard approaches necessary to gather and analyse the geomorphological information necessary to support sound decision making and project design in flood defence policy and operations.

Over a dozen R&D projects were funded and successfully completed, but the results of this considerable body of work were not disseminated properly and, consequently, uptake has been patchy. The result is that good geomorphological expertise may be found within British river management organisations, but it is held by a few individuals and is not easily accessible to operations staff. Unfortunately, the desire of flood defence engineers to adopt a geomorphic approach has been frustrated by the non-availability of appropriate geomorphological guidance.

This project will attempt to **synthesise methods, techniques and standard procedures** in applied fluvial geomorphology and compile them in a single document. The result will be a Guidebook that is better tailored to end-user needs than a text book, while avoiding the ‘cook book’ approach of a Handbook.

The limited resources available to support this project dictated that the underpinning science be drawn from the neglected R&D projects performed at the Universities of East Anglia, Newcastle, Nottingham, Portsmouth and Southampton during the 1990s. In the first part of the project the relevant NRA and Agency documents were procured and reviewed. In the second phase, the principal investigators revisited the synopsis of 1990s material and updated it in light of more recent work. The content of the book thus **reflects more up to date thinking**. It also benefits from experience gained through what application has taken place of the procedures and analyses developed during the 1990s.

Outputs in the Year: None.

Defra Project Number and Title:	FD 1705 Up-Dating And Modernising The 'Yellow/Blue/Red Manuals' For Appraising Coastal Defences And Flood Alleviation Works
Research Contractor:	Flood Hazard Research Centre
Objectives:	To evaluate the use of the Yellow and Red Manuals' results and procedures; to review the statistical/probabilistic approaches to evaluating the benefits of erosion control; to develop and enhance the databases on flood damages; to analyse the validity of different approaches to Contingent Valuation Methods (willingness to pay compared with value of enjoyment); and to revise the approaches and text contained within the Red, Blue and Yellow Manuals so as to be able to produce a "Multi-coloured Manual".
Start Date/Finish Date:	June 2000 / October 2002
Staff Input this Year:	0.9 person years of scientific effort.

Summary of Progress in the Year:

The end of financial year 2001/02 saw the completion of the discussion meetings with the owners of non-residential properties designed to obtain information on potential flood damages. The initial results, available as of March 2002, indicated a **substantial increase in flood damage potential owing to technological change and other factors**.

The end of the financial year also saw the completion of focus group meetings with those who had experienced flooding in their residential properties, and the beginning of the final analysis of flood damage potential in consultation with loss adjusters, salvage operators, etc. Again, these results, interim at that stage, indicated very considerable **increases in flood damage potential owing to increased affluence, technological change and building regulation alterations**.

In addition to these major areas of empirical investigation, good progress had been made in redrafting the results previously contained in the Blue, Red and Yellow FHRC Manuals.

In summary, the research results obtained from this project indicate significant increases in flood damage potential. Furthermore, information from Autumn 2000 floods has given more data on losses in all sectors and in particular showed an **increase in flood losses owing to emergency services costs**. The end of the financial year saw the beginnings of the finalisation of the draft report.

Outputs in the Year: Penning-Rowsell, E.C. and Green, C.H. (2000). *"New insights into the Appraisal of flood-alleviation benefits: (1) flood damage and flood loss information",* Journal of the Chartered Institution of Water and Environmental Management, Vol. 14.

Penning-Rowsell, E.C. and Green, C.H. (2000). *"New insights into the Appraisal of flood-alleviation benefits: (2) the broader context",* Journal of the Chartered Institution of Water and Environmental Management, Vol. 14.

Defra Project Number and Title:	FD 1805 Improving The Implementation And Adoption Of R&D Results
Research Contractor:	CIRIA
Objectives:	To identify, and recommend a plan for setting up, a user-oriented framework and related services for the effective implementation and adoption of R&D results and other related information from the joint Defra/Agency Flood and Coastal Defence R&D Programme.
Start Date/Finish Date:	February 2001 / September 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

With the setting up of the new Joint R&D Programme in Flood and Coastal Defence, a key management objective has been to focus on user needs and ensure that the intended benefits of the R&D projects are delivered. The Advisory Committee that recommended the new programme suggested that various management, organisational and cultural issues should be addressed in order to improve the implementation and adoption of research. A study (commonly referred to as the "Uptake Study") was carried out to investigate these and other issues that might need to be addressed. The aim was to confirm and/or recommend actions that would **contribute significantly to improving the uptake of results** from the new programme, and help to secure the intended benefits.

The study enabled a good understanding of the factors that may constrain the effective uptake of Flood and Coastal Defence R&D to be developed and of the actions that can help to overcome these. In summary, the constraints related to (a) R&D systems and culture; (b) organisational and institutional systems and culture across the Flood and Coastal Defence industry; and (c) individual learning and personal development issues – common to many other professional areas.

A series of recommendations to Defra and Agency management were then developed by the research team to improve the implementation and adoption of Flood and Coastal Defence R&D results. Overall, it was recommended that, in relative terms, more resources should be allocated to R&D uptake (i.e. the passive dissemination and active implementation of R&D results as distinct from the research itself). Some actions link into the wider issue of developing an improved Flood and Coastal Defence training programme.

The Technical Report describes the existing organisational and management structure relating to uptake, provides details of the gaps in the current approach, and sets out the recommended actions. Its purpose is to provide a **reference point for those involved in improving current practice**. The report does not provide detailed advice itself.

The CD-ROM **Route Map for R&D Project Managers** by contrast provides step by step guidance on the actions that can be followed on any R&D project. It is available as downloadable software and will run on Windows 2000.

Outputs in the Year: CIRIA. (2002). *"Improving the Implementation and Adoption of R&D Results",* R&D Technical Report W5G-003/TR

CIRIA. (2002). *"Route Map for R&D Project Managers",* CD-ROM.

Defra Project Number and Title:	FD 2002 Prediction Of Future Coastal Evolution For SMP Review
Research Contractor:	Halcrow Group Ltd.
Objectives:	To undertake a prediction or estimation of coastal evolution over the next 100 years (or longer, where appropriate); to assess the sensitivity of these predictions to a set of standard potential climate change scenarios as produced by UKCIP and to allow contemporary coastal processes and past, present and future management decisions to be placed within a longer term and wider scale framework which provides a vision for the coast and a scientific basis for considering the 'direction' for sustainable strategic management response.
Start Date/Finish Date:	October 2000 / March 2002
Staff Input this Year:	5 person years of scientific effort.

Summary of Progress in the Year:

The importance of establishing a comprehensive and auditable methodology for this project was established very early, therefore effort has concentrated on developing the methodology approach as part of Stage 1. This has included inputs, through a geomorphology workshop, of eminent geomorphologists as well as inputs from both the Client's Steering Group and the Internal Review Panel.

The expectations and requirements of the project from the viewpoint of the coastal authorities and other potential end-users have also been addressed through an **extensive consultation** exercise involving both a questionnaire and a series of regional seminars held at various locations around the country. A report summarising the responses has been drafted for circulation to the Coastal Groups. In general, the response to the research was very positive, with many recognising the need for such a national scale project. There was also useful discussion of local level issues to be addressed and the sources of information relating to these issues. There was however, a poor representation from planning divisions of local authorities. Continued contact is to be maintained with the Coastal Groups throughout the project, and it is hoped that the groups will assist in involving planners.

Stage 2 of the research involved the **data collation** exercise. Identification of possible data sources has been through both SMP review, knowledge of other studies and through consultation. An oblique aerial video has been shot for the whole coastline of England and Wales. The information provided by the video footage is of excellent quality and will assist the project in validating the data obtained from maps, previous studies etc., as well as providing visual access to every part of the coast, enabling the project team to further appraise existing conditions in areas of uncertainty. This data is now being analysed for Stage 3: the **assessment of coastal behaviour**.

Outputs in the Year: Burgess, K., Jay, H., Hutchison, J., Balson, P. and Ash, J. (2001). *"Futurecoast – Assessing Future Coastal Evolution".* Proc. 36th Defra Conf. River and Coastal Engineers.

Defra Project Number and Title:	FD 2003 Scheme Prioritisation System Review
Research Contractor:	Risk & Policy Analysts Ltd.
Objectives:	To provide a way of prioritising Government funding to support all possible flood and coastal defence schemes required at any given time.
Start Date/Finish Date:	August 2000 / July 2001 (project complete)
Staff Input this Year:	0.5 person years of scientific effort.

Summary of Project:

It is unlikely that there will ever be sufficient Government funding to support all possible flood and coastal defence schemes required at any given time. There is a need, therefore, for **a logical, transparent and fair system of prioritisation** to ensure that the funds that are available are invested in the most beneficial way. Under the current prioritisation system, potential projects are ranked by three criteria: priority, urgency and economic return. The problem with this approach is that many see this system as not focusing funds in areas with the greatest need and it may not, therefore, be delivering the most effective implementation of government policy.

This study involved: a review of recent submissions; a period of consultation based on the findings of this review; a workshop to develop key criteria; and a second consultation setting out two alternative revised systems.

The workshop provided an opportunity to discuss actual criteria and how they may be measured. It was agreed that as economic appraisal took account of many key aspects the benefit-cost ratio should form the core of any new system. However, it was recognised that in practice **a number of factors are often ignored in economic analysis** and many key criteria relating to risk, environmental and social aspects were suggested to take account of issues not necessarily included.

In order to incorporate the range of social and environmental parameters requested, there has had to be a trade-off between ease of use and comprehensiveness. However, to reduce form filling to a minimum, the new system proposes that information that should be readily available by the promoter of any project is input to a standard spreadsheet.

One of the difficulties in devising a fair system is the large range in value of projects put forward for grant aid. In a typical year this can range from a few thousand pounds to several million. During the development of the new system it became apparent that small schemes were not scoring at a level that reflected their contribution towards achieving policy aims. It was therefore decided to introduce a scaling factor to offset this anomaly. Two different methods were identified:

- Option 1 where each measure is related to the cost of the proposed works so that projects can be ranked according to these ratios so that all projects have equal weight.
- Option 2 where the scaling factor for different measures is achieved by the use of a log function.

A number of **test cases** were scored on both systems to allow detailed comparison and in addition, an overview of the two systems using a synthesised programme (based on the previous six years approved schemes) was provided by the Department to test the systems' effectiveness.

Outputs in the Year: Risk and Policy Analysts Ltd (2001). *"The review of the existing prioritisation system".*

Risk and Policy Analysts Ltd (2001). *"Scheme Prioritisation System – Consultation Document".*

Defra Project Number and Title:	FD 2004 Extension Of National Appraisal Of Assets At Risk From Flooding And Coastal Erosion
Research Contractor:	Halcrow Group Ltd.
Objectives:	To extend the recently completed National Appraisal of Assets (this provided information and a methodology for assessing economic impacts of flooding and coastal erosion) to Wales and to refine the earlier work (better information on standards of service, scenarios for climate change and assessing disbenefits of flooding to agriculture and road traffic).
Start Date/Finish Date:	October 2000 / November 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

This research has further developed preceding work to evaluate the **national economic impacts of flooding and coastal erosion** (FD1702).

The results of the research have been used by Defra to provide support to the spending review process, **helping to inform decisions taken regarding future budgetary provisions** for the funding of capital works and defence maintenance.

The conclusions from this research project were as follows:

- Approximately 10% of the population of England and Wales live within areas potentially at risk from flooding or coastal erosion, whilst approximately 12% of the agricultural land (including 61% of the country's Grade 1 agricultural land) is also located in these areas;
- Property worth over £220 billion and agricultural land worth approximately £7 billion is located within these areas potentially at risk;
- Without any flood and coastal defences, the annual average economic damage from flooding and coastal erosion in these areas would be over £3.5 billion/year;
- The capital works and maintenance investment needed to continue to provide and maintain present defence standards is in excess of £0.3 billion/year;
- Current standards of defence reduce annual average damages to approximately £0.8 billion/year;
- Continuing to invest at present levels of approximately £0.24 billion per year will result in increasing annual average damage possibly at the rate of some £10-15 million per year;
- Accommodating climate change is likely to require a further increase in investment of 10-20% over and above that required to meet indicative standards under present day conditions;
- Without allowance for accommodating the predicted impacts of climate change within defence provision the economic impacts associated with flooding could increase significantly, with annual average damages increasing in fluvial areas by approximately 50% and in excess of 200% on the coast by the year 2050.

This study has involved some broad-based assumptions and there is scope to further improve upon the accuracy of the analysis. However, there is sufficient confidence in the order of magnitude of the results to conclude that **there is a need to reappraise even the recently enhanced levels of funding** for flood and coastal defence. If investment is maintained at or around present levels, the results imply that effective protection can only be provided to selected areas of the country, i.e. a conscious decision might be required to abandon defences to some less populous areas.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2005 The Appraisal Of Human-Related Intangible Impacts Of Flooding
Research Contractor:	Risk & Policy Analysts Ltd.
Objectives:	To develop a robust, yet simple-to-use, methodology so that intangible impacts on human health and well being can be accounted for in assessing the benefits of flood alleviation measures.
Start Date/Finish Date:	January 2001 / December 2002
Staff Input this Year:	0.7 person years of scientific effort.

Summary of Progress in the Year:

Phase 1 of the study has involved the **development and validation of survey instruments**. The following tasks were set in order to achieve this: project scoping; literature review; develop survey instruments for health impacts and estimation of willingness to pay; and reporting.

The literature review aimed to assess the relevance of previous work and to identify possible approaches to measuring and valuing the intangible impacts of flooding. It was found that, whilst there were a number of studies concerning the health effects arising from flooding, there was no existing work on the valuation of such effects specifically relating to flooding. Therefore, economic studies on other causes of health impacts, such as air pollution, were considered. It was found that a number of valid health measures existed which could be used to measure both the physical and psychological health effects of flooding. Those taken forward for trialling were the Short-Form 12 (SF-12) for physical health; and the General Health Questionnaire 12 (GHQ-12), the Impact of Events Scale (IES) and the Post-Traumatic Stress Scale (PTSS) for psychological effects.

Two questionnaires were developed: one to cover the health impacts of those people who had experienced flooding within their house since January 1998, and the other to explore the willingness to pay of people to mitigate the given attributes of a flood event (e.g. depth of water, frequency of flooding, length of warning etc.). The questionnaires were trialled and discussed in a series of focus groups and interviews before a pilot survey was undertaken.

The health impacts questionnaire used a combination of checklists of symptoms, the GHQ-12, the SF-12 and the PTSS (in addition to questions on socio-economic data and the flood events experienced). The results to date indicate that **psychological health effects are more severe than physical effects** and that stress is a function of a wide range of factors. The results also show that the impacts are significantly more severe at the 'worst' time (generally up to three months after flooding).

With regard to the choice modelling questionnaire, lack of previous research required that the methodology be developed from first principles, with various approaches trialled. The results from the pilot surveys confirmed that **flooding did produce 'intangible' impacts** and that respondents were able to 'value' these impacts. Overall, this 'value' would appear to be of a similar order to that of the 'tangible' losses. Although values could be assigned to changes in the risk of flooding and, to a lesser extent, changes in warning time, values could not be assigned to changes in other characteristics. A key reason for this was that many respondents chose not to express a willingness to pay to prevent flooding on the grounds that other parties (notably the Government) should take the required action. As a result of this, it is felt that a robust valuation questionnaire has yet to be developed and will require further work.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2007 Community And Public Participation: Risk Communication And Improving Decision Making In Flood And Coastal Defence
Research Contractor:	Scott Wilson
Objectives:	The generic objective of this research project is to review current communication practices used in coastal and flood defence.
Start Date/Finish Date:	October 2001 / November 2002
Staff Input this Year:	1.1 person years of scientific effort.

Summary of Progress in the Year:

The generic objective of this research project is to review current communication practices used in coastal and flood defence. From this, suggestions on best practice approaches in risk communication and awareness raising are to supplied. These suggestions will then form the basis **of detailed recommendations on conflict resolution and awareness raising** when implementing flood and coastal defence measures.

Up to the end of March 2002, the project has achieved the following:

- The draft Stage 1 Scoping Report has been issued to the Steering Group;
- A draft Literature Review has been completed and issued to the Steering Group;
- Case Studies are progressed. These are located at Bewdley, Arun to Adur, Holderness and Uckfield. The 8 less-detailed case studies are Boston (Lincolnshire), Alconbury, Yolding, Wigan, Hunstanton, Worcester, Rea Valley and Hillfarance (Somerset);
- RPA and Scott Wilson have completed interviews with the Local Authorities, Environment Agency, etc. for 3 out of the 4 case studies.

The immediate tasks that the project aims to achieve are:

- Proceed with the 4 detailed case studies. The focus groups will be held and their results analysed. These case studies will provide information on the public's understanding of risk within different scenarios. All interviews with the Local Authorities, Environment Agency etc. will be completed;
- Proceed with the 8 less-detailed case studies. Questionnaires will be sent out and their results analysed;
- Organise the Stage One Workshop;
- Draft Stage 1 recommendations based on the findings of the 12 case studies.

Outputs in the Year: Scott Wilson and R.P.A. (2002). *"Community and Public Participation: Risk Communication and Improving Decision Making in Flood and Coastal Defence – Draft Scoping Report".*

Defra Project Number and Title:	FD 2008 Implementing Managed Retreat As A Strategic Flood And Coastal Defence Option
Research Contractor:	Halcrow Group Ltd.
Objectives:	To produce guidance and recommendations to enhance and increase the take up of managed realignment as a strategic flood and coastal defence policy option aimed at enhance flood and coastal defence sustainability and achieve environmental gains.
Start Date/Finish Date:	September 2001 / August 2002
Staff Input this Year:	0.46 person years of scientific effort.

Summary of Progress in the Year:

The research comprises a **review of experience**, both in England and Wales and overseas; conducting postal questionnaires and regional workshops to gather information and opinions; analysing in detail three case studies; and an examination of the implementation of present policy relating to Shoreline Management Planning, economic valuation, financial compensation, nature conservation and planning.

This research project sets out to answer the following six questions:

- Where has Managed Realignment been tried?
- What are the drivers (incentives) for Managed Realignment?
- What are the constraints (obstacles) to Managed Realignment?
- What can we learn from experience of Managed Realignment?
- What are the costs and benefits of Managed Realignment?
- How can we realise the benefits of Managed Realignment?

The main elements of the project have been **data gathering, regional workshops and case study workshops**.

Data gathering began with a review of shoreline management plans and river strategies to identify sites recommended for managed realignment. Results for coastal sites were good but there was a lack of information on river sites. Supplementary information on rivers was sought in a questionnaire sent mainly to Environment Agency staff. Plans of identified coastal and river sites with a defence policy of managed realignment were produced.

A separate review of **overseas experience of managed realignment** was undertaken. Information was obtained from 28 overseas contacts (8 in Netherlands, 5 in USA, 9 in Germany, 6 in Denmark, plus 1 in Scotland).

Plans were prepared for the case studies. Originally proposed for two sites at Thorngumbald (the Humber) and on the North Norfolk coast at the Salthouse, a third case study based on a river site was added (The River Yare, Norfolk Broads). Subsequently, owing to the sensitivity of the current state of negotiations concerning the implementation of the Salthouse scheme, it was replaced by a case study based around a project at Brancaster, Norfolk.

Outputs in the Year: Halcrow (2002). *"Stage 1 Project Report".*

Defra Project Number and Title:	FD 2009 Consistent Standards of Defence for Flood Cells
Research Contractor:	HR Wallingford Ltd.
Objectives:	To identify the key benefits and disadvantages of adopting consistent flood defence standards drawing on experience at selected sites where inconsistent standards have been reported as an issue.
Start Date/Finish Date:	January 2002 / January 2003
Staff Input this Year:	No information provided.

Summary of Progress in the Year:

No information provided.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2010 Flood Plain Management Manual (Phase 1)
Research Contractor:	HR Wallingford Ltd.
Objectives:	To provide preliminary guidance on the effective management of floodplains to river managers, local authorities (planning, amenity and other relevant functions), local communities, conservationists and developers leading to the provision of a Flood Plain manual that forms a common reference for all parties involved in floodplain management.
Start Date/Finish Date:	December 2001 / April 2002
Staff Input this Year:	No information provided.

Summary of Progress in the Year:

No information provided.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2012 Post Event Appraisal – Phase 1
Research Contractor:	Bullen Consultants
Objectives:	To examine the effectiveness of the monitoring and recording procedures currently employed by the Operating Authorities and Defra to collect data on events compared to best practice in other industries and the emergency services. To evaluate the usefulness of existing parameters being monitored compared to best practice in other industries and emergency services and by overseas flood management agencies. To prepare a best practice guide for recording event data in a consistent way for application throughout England and Wales.
Start Date/Finish Date:	September 2001 / August 2002
Staff Input this Year:	0.23 person years of scientific effort.

Summary of Progress in the Year:

The initial stage of the project is proceeding on two concurrent fronts:

1. A review of present practice and recent post flood reports based, in part, on the experiences of the project team;
2. Preparation of a questionnaire to go to practitioners in, and users of, post event monitoring and analysis, plus stakeholders in all other aspects flood management or its consequences. The questionnaire will also be used to elicit information from overseas flood management agencies and establish benchmarking with emergency services and other industries.

The work to date involves the **identification and subsequent review** of all relevant recent, on-going projects and initiatives. Only a few topics (mainly associated with data collection) are likely to require the development of new procedures. This project will therefore draw heavily on those initiatives. This study also needs to take account of these as they may require additional data or changes to reporting requirements.

The **questionnaire** has been designed to establish the extent of current monitoring, recording and appraisal, how any data and results are disseminated, perceived and actual shortfalls in current practice, requirements for additional data and analyses, and where ongoing research may address any shortfalls.

The list of proposed consultees is broad, but selected to enable canvassing of representatives of the full range of stakeholders and enable any identified shortcomings to be matched with stakeholder group needs.

The **initial review of recent reports and experiences** in appraising and recording the Easter and October 1998 and Autumn 2000 flood events has identified over 35 "headline topics". Headline topics are those on which data is relevant to post
event appraisal.

Outputs in the Year: Bullen (2002). *"Scoping and Preparatory Report".*

Defra Project Number and Title:	FD 0114 Catchment Management System – Phase 1: Hydraulics
Research Contractor:	HR Wallingford Ltd.
Objectives:	To build a Catchment Management System for the purpose of catchment management planning, with special reference to flood defence issues.
Start Date/Finish Date:	September 1997 / March 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The 'close-coupled' Whole Catchment Modelling approach led by CEH Wallingford has not developed as quickly as anticipated. The HR Wallingford work could therefore not be assimilated into the Whole Catchment Modelling system as had originally been intended. However, the ideas and framework for the project have been developed and pushed forward within several other initiatives.

Integrated Catchment Modelling was the focus of the **European EUROTAS project**. There was an agreed relationship between Defra-related studies and this project with a proportion of HR Wallingford's funding being used to develop approaches for the latter studies. The principal output of the EUROTAS research has been a prototype, integrated catchment modelling system that includes decision support procedures. The research has been disseminated through scientific papers, an end-of-project conference as well as implementation of the prototype integrated modelling framework.

EUROTAS has demonstrated the viability of **coarse-coupling of hydrological and hydrodynamic modelling for flood risk studies**. The implementation was demonstrated for UK conditions by HRW and CEH, as the 'Thames Catchment Study', with support from the Environment Agency Thames Region.

The Eurotas project website can be found at **www.hrwallingford.co.uk/projects/EUROTAS/**

Latest modelling for Catchment Flood Management Plans (CFMPs) under ongoing Environment Agency/Defra research is now putting the results of the above whole catchment modelling research into direct application within 2 years.

Outputs in the Year: EUROTAS (2000). *"Task T3 – Thames Catchment Study"*.
EUROTAS (2001). *"Task T1 – Design and initial implementation of Integrated Catchment Modelling (ICM) prototype"*.
EUROTAS (2001). "*Task T10 – Integration and dissemination".*

Defra Project Number and Title:	FD 0421 Catchment Management System – Phase 1: Framework and Demonstration
Research Contractor:	CEH-Wallingford
Objectives:	To build a prototype Catchment Management System for the purpose of catchment management planning, with special reference to flood defence issues.
Start Date/Finish Date:	April 1997 / March 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The objective of this project was to build a prototype Catchment Management System for the purpose of catchment management planning, with special reference to flood defence issues. In particular, the system will provide a direct linkage between hydrological and hydraulic models in order to provide an improved tool for the **assessment of flood risk within a catchment**. The system will enable a wider range of practical problems to be addressed than at present. It will allow catchment management practices, environmental (including climate) change together with land use and planning scenarios to be explicitly included in future flood risk assessments.

The Phase 1 study aimed to provide a **framework program together with demonstration applications**. These will serve to illustrate to practitioners the form of catchment management system envisaged and the need for support of its continued strategic development.

Whilst flood defence applications will feature predominantly in the demonstration system, the design will be such as to allow a wide range of water management issues to be addressed, extending from flood defence to environmental (water quality, ecology) management and economic aspects of these. The relevance to the production of Local Environment Agency Plans will be demonstrated.

The **Final Report** records the main outputs and achievements of the project. It is made up of four distinct parts complemented by an Executive Summary. Part 1, entitled "Whole catchment modelling: progress and prospects", serves to provide an overview of the project achievements. Part 2 comprises the Powerpoint Presentation produced for the 2002 Defra Conference. Part 3 entitled "Framework for Whole Catchment Modelling. Interim Report." is the Interim Report to the Project developed in the first year of the study. This contains important review material supporting the design of the framework program and the demonstrator case studies, together with an outline work programme for subsequent years.

Part 4 entitled "System Design: Specification of Data Structures which define a modelling problem." is the main technical output of the project and provides an incomplete draft specification of the data structures required to support the detailed coding of the framework. The detailed coding of the framework progressed significantly in prototype form. However, the complexity of the design arising from the requirements identified from the Scoping Study proved onerous to implement as code. This led to the final abandonment of the code development before a workable demonstrator framework was realised. The Final Report serves as a statement of the achievements of the project and contains material that may serve to guide a future development of a Catchment Management System.

Outputs in the Year: CEH Wallingford and HR Wallingford (2002). *"Catchment Management System. Phase 1: Framework & Demonstration"*. Final Contract Report to Defra, CEH Wallingford.

Defra Project Number and Title:	FD 1401 Estuary Research Programme Phase 1
Research Contractor:	Consortium Led by HR Wallingford Ltd.
Objectives:	To compile a new suite of tools for predicting morphology, water quality and ecology using existing methods, and make recommendations regarding reliability and the range of applicability.
Start Date/Finish Date:	December 1998 / December 2000 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

In December 1998 MAFF (now Defra), the Environment Agency and English Nature initiated Phase 1 of the Estuaries Research Programme. This 2-year project was carried out by the EMPHASYS consortium which comprised consulting engineers, research laboratories and university researchers.

Flood defence, navigation, water quality and conservation all influence, and in turn are influenced by, the shape (morphology) of an estuary. One of the challenges in predicting changes in the morphology is choosing a suitable prediction method. Three main approaches exist: Bottom-up methods represent detailed processes over short timescales; Top-down methods are based on conceptual ideas and operate at larger space and longer timescales and Hybrid methods combine the best features of both the above.

The EMPHASYS consortium investigated how **different predictive methods** can be used to evaluate different management strategies.

Six estuaries were selected for detailed work, i.e. collation of data, model testing and analysis. The selection was constrained by the availability of data related to long-term changes in form (i.e. bathymetry, intertidal profiles, topography). Without such data the realistic testing of predictive methods was not possible. It was also important that the chosen estuaries should represent contrasting and complementary classes of UK estuaries. For example, with and without industrialisation, both cohesive and non-cohesive sediments, macro and meso-tidal, and both constrained and unconstrained by hard geology.

Version 1B of the report "A guide to prediction of morphological change within estuarine systems" has been produced by the EMPHASYS Consortium during Phase 1 of the research. It provides information and **guidance for estuary managers**, stakeholders and interest groups on key questions that might arise with respect to estuary morphology and issues related to flood defence, navigation, water quality and nature conservation.

As well as publishing the best practice guide for predicting morphological change, the main achievements of the project are presented in a range of reports and papers, and as an **electronic database**.

Outputs in the Year: EMPHASYS Consortium. (2000). *"A Guide to Prediction of Morphological Change within Estuarine Systems."* Version 1B. Report TR 114.
EMPHASYS Consortium. (2000). *"Recommendations for Phase 2 of the Estuaries Research Programme"*. Final Report. Report TR 113.
EMPHASYS Consortium. (2000). *"Modelling Estuary Morphology and Processes"*. Final Report. Report TR 111.

Defra Project Number and Title:	FD 1604 Accommodating Uncertainty In Applying Broad-Scale Modelling For Flood Frequency Estimation
Research Contractor:	CEH-Wallingford Ltd.
Objectives:	To develop and apply methods for quantification of the uncertainty about parameters of broad-scale catchment hydrological models for use in estimating flood frequencies by continuous simulation.
Start Date/Finish Date:	October 1999 / July 2000 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The project 'Accommodating uncertainty in applying broad-scale modelling for flood frequency estimation' developed and applied methods for quantification of the uncertainty about parameters of broad-scale catchment hydrological models for use in estimating flood frequencies by continuous simulation. The **scientific achievements** were:

- Demonstration of a method for incorporating parameter uncertainty into the spatial estimation of model parameters on the basis of catchment properties;
- Application of the method to obtain model parameter distributions as a function of catchment properties, and hence to estimate uncertainties in modelled flood frequencies for the 'ungauged site' case.

There is growing interest in the application of conceptual rainfall-runoff models for flood frequency estimation, in a 'continuous simulation' framework, as an adjunct to event-based methods and statistical design methodology. This approach has advantages that stem from the **continuous water-balance accounting of the modelling approach**.

A conceptual rainfall-runoff model generally requires calibration, and one of the key challenges is therefore to develop ways of generalising models for use at ungauged sites. This project examined the uncertainty associated with generalisation of the parameters of the **'Probability Distributed Model'** (PDM), expressed as flood quantile confidence intervals at test sites that were treated as if ungauged. This was done by constructing regression relationships between hydrological model parameters and catchment properties so as to estimate the parameters as distribution functions. Flood flow outputs were then simulated from the parameter distributions and used to construct approximate confidence intervals.

Comparison with gauged data suggests that the generalised model could be tentatively accepted. Uncertainty in the modelled flood flows could appear large, but was often of a similar order to the uncertainty surrounding a more conventional statistical model, in this case a single-site Generalised Pareto distribution, fitted to the gauged data.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2103 Generation Of Spatially Consistent Rainfall Data – Refinement And Testing Of Simplified Models
Research Contractor:	Imperial College London and University College London
Objectives:	To provide a method for generating long-term temporal and spatially-consistent, rainfall series to support a new approach to flood estimation based on continuous rainfall-runoff simulation.
Start Date/Finish Date:	December 2000 / August 2001
Staff Input this Year:	0.8 person years of scientific effort.

Summary of Project:

In previous work, a range of modelling approaches for continuous simulation of spatial rainfall were developed and examined. A model for simulation of rainfall in continuous space and time was developed and tested using radar rainfall data, with promising performance. Alternative approaches were also developed, to be compatible with currently available raingauge data. Generalized Linear Models (GLMs) were shown to be a powerful tool for the representation of daily rainfall in space and time, and have the capability to represent both spatial and temporal non-stationarity. They can thus be used for analysis and simulation of, for example, topographic and other location effects on rainfall distribution and climate variability. However, for flood application, sub-daily spatial fields are needed. Hence the possibility of a **combined methodology** was considered.

In the present project, a combined methodology has been developed. It was envisaged that model application would be based on data from a network of daily raingauges, perhaps with one or two sub-daily gauges. The GLM can be fitted using the daily data, and used to interpolate missing data, define daily rainfall at additional locations, or extend the data series by simulation. Generation of long time-series was readily achieved. A simple multivariate model of hourly rainfall was used as the basis of the disaggregation procedure. This preserved the properties of the hourly spatial structure and was transformed to assimilate the daily values. A particular development has been the development of a scaling relationship, which holds for all intergauge distances, and relates the hourly to the daily cross-correlations. This can be used when the hourly cross-correlation structure is unknown.

Performance of the disaggregation scheme was tested for the Brue catchment, in south-west England, using the dense raingauge network established by the NERC HYREX programme, and for two contrasting areas of the Blackwater (south-east England) and north-east Lancashire. For the Brue, it was possible to test the scheme for the ideal situation in which the hourly cross-correlation structure is known. Results were generally good across a wide range of performance measures, although hourly cross-correlations for summer were less well represented than for winter. The results were then compared with the more realistic situation in which it was assumed that only two sub-daily gauges were available. Results were most encouraging, with very similar performance to the situation in which the full hourly cross-correlation structure was known.

Previous work with the GLM had shown some theoretical limitations in the representation of spatial dependence of rainfall (in particular difficulties in representing the spatial occurrence of wide-spread rainfall), and hence new theoretical developments were investigated and implemented, to overcome this. A **new dependence scheme was developed**, based on use of the Beta-Binomial family of distributions to represent rainfall occurrence. Comparisons of the observed and simulated distributions of numbers of wet sites were excellent both study areas, and it was concluded that the previously identified limitations have been satisfactorily resolved.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2104 Scoping Of Broad Scale Modelling Hydrology Programme
Research Contractor:	CEH-Wallingford
Objectives:	To develop the Broad Scale Modelling hydrological R&D programme.
Start Date/Finish Date:	August 2001 / March 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

This project presented a **strategic vision for the hydrological programme** of the Broad Scale Modelling Theme of the Defra/Environment Agency Flood Management Research Programme over a five to ten year time span.

The Final Report can be read in conjunction with the 'Hydrology Vision' statement (Calver and Anderson, 2002) which offers a succinct outline framework for hydrological flood management R&D across all Defra/Environment Agency Themes.

Chapter 1 sets the context and terms of reference for developing this hydrological research programme. Chapter 2 describes **user needs and the requirements** of the Broad Scale Modelling (BSM) hydrological research agenda. The scientific and technical background is presented in Chapter 3. Chapter 4 outlines research initiatives of other organisations of relevance to BSM hydrology.

Building on the information of Chapters 2 and 3, the BSM hydrological research strategic programme is presented in Chapter 5. Its eight major components are described, the relationships between them identified in terms of subject matter and of timing, and their five year indicative budget outlined. The components are identified as:

1. Definition of strategic agenda;
2. Maintenance of current practice;
3. National spatial-temporal rainfall modelling;
4. National continuous simulation runoff modelling;
5. Modelling impacts of land use and land management change;
6. Climate impact modelling;
7. Building a new modelling capability;
8. Software production.

It is estimated that an approximate budget of £9.4 million is required to meet the BSM objectives over a five year period, but that part of this could come from research partnerships with industry and the research councils.

The report concludes, in Chapter 6, with **recommendations for effective uptake** of the BSM strategic hydrological programme in the context of a continuing need for effective flood management research.

Appendices provide project outlines from the September 2001 BSM Targeted Programme, a note on the consultation process for this Strategic Programme and comment on research emphases.

Outputs in the Year: Calver, A. and Wheater, H. (2001). *"Scoping the Broad Scale Modelling Hydrology Programme"*, October 2001.

Defra Project Number and Title:	FD 2106 National River Catchment Flood Frequency Method Using Continuous Simulation
Research Contractor:	CEH-Wallingford Ltd.
Objectives:	To exploit advances in hydrological runoff modelling techniques for the advantages they offer design practice and planning through river flood frequency estimation.
Start Date/Finish Date:	December 2001 / November 2004
Staff Input this Year:	0.54 person years of scientific effort.

Summary of Progress in Year:

A preliminary selection of daily sites has been made, based on length of available record, catchment area, data quality (by cross-referencing with 'Hi-Flow' and 'Benchmark catchment' lists) and good spatial coverage. The **set of catchment properties has been reassessed**, so that all properties used in the new work will be readily available/calculable for any river catchment in Britain.

Progress has been made in resolving issues relating to the use of data at different time resolutions. Comparisons have been made using global parameter space searches between the parameterisations obtained for different model and data configurations. The aim has been to establish combinations of model configuration, data and objective function that provide consistent parameter estimates for different time step lengths.

Experiments with the model TATE indicate that when daily rainfall and flow data are brought into the generalisation procedure, the hydrological model should continue to be run with a shorter internal time step of one hour, but with the flow outputs being aggregated back to a daily average. It was found that a uniform distribution of the daily rainfall over 24 hours was sufficient.

Work on the **method of spatial generalisation to ungauged sites** has largely concerned important preparatory issues that have been addressed in readiness for application of modelling once the enhanced and updated project database is finalised.

Schemes for combining multiple objective functions in model calibration have been examined in some detail. A method was considered based on weighting objective functions so as to select those functions with lowest variance in the first derivative (least uncertainty about optima) and highest values of the second derivative (greatest 'sensitivity' of objective function). Although this proposal was statistically appealing, it was concluded that there would not be enough time to implement and test it. Instead, it has been decided to continue with the approach developed in project FD0404, using an objective function that is weighted towards peak flows, and a second function that gives greater weight to overall water balance. The functions will be applied within the sequential regression method for spatial generalisation

A **strategy has been developed for testing prototype methods**. The first stage is updating of the hourly database to cover the floods of winter 2000-2001. An information sheet on data requirements was prepared and forwarded to the Environment Agency Regions. Separate contact was established with SEPA.

Outputs in the Year: Calver, A., Lamb, R. Kay, A. L., Crooks, S., Jones, D. A. and Stewart, E. J. (2002). *"National river catchment flood frequency method using continuous simulation"*. Inception Report.

Defra Project Number and Title:	FD 2108 Broad Scale Ecosystem Impact Modelling – Scoping Study
Research Contractor:	Cascade Consulting
Objectives:	To provide an overview of the topic of Broad Scale Ecosystem Impact Modelling (BSEIM) and define an appropriate and cost-effective research programme.
Start Date/Finish Date:	January 2002 / December 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

There are a number of **policy and regulatory drivers** that have stimulated this research, linked to the requirement to better understand the impacts of policies and subsequent measures on the environment and thereby to protect and enhance supported ecosystems. The main drivers include the Strategy for Flood and Coastal Defence in England and Wales (Defra, 1999) and initiatives to plan flood and coastal management more sustainable, recognised through fluvial Catchment Flood Management Plans (CFMPs) and estuarine/coastal Shoreline Management Plans (SMPs). A wide range of other planning processes also interact, most notably the Water Framework and Habitats regulations, and the Planning Authorities development planning process.

Defra and the Environment Agency recognise the need to consider and cater for the needs of a wide range of users within the flood management process, ranging from governmental policy makers to the public as stakeholders. The study has therefore sought to develop an R&D programme that will allow production and dissemination of information at a number of levels appropriate for the intended end use. A workshop was convened to establish the technical user requirements and a number of case studies were used to identify existing operational methodologies and gaps that may need to be filled.

The outcome of the consultation was a clear call for a **more integrated approach to BSEIM**. A range of tools are required that can simulate ecosystem impacts at varying spatial and temporal resolutions, for both freshwater and estuarine/coastal systems. Users have also specified the development of a decision support system to help with collation and assessment of ecosystem data, and interpretation of modelling outputs.

The **recommended future modelling strategy** should be based on four key elements: the strategy will have to be flexible (in both scale and sub-model interaction), user friendly, operate at the lowest level of possible complexity and be capable of visualisation.

To achieve this end point, a number of R&D outputs are required that improve our understanding of the following: Ecosystem Model Input Data (Hydrological, hydrodynamic and geomorphological modelling and data inputs, Catchment/coastal cell ecosystem baseline descriptions, Processes contributing to the dynamic evolution of floodplain and estuarine/coastal ecosystems) and Ecosystem Modelling Tools (Quantitative modelling approach for river catchments, Quantitative modelling approach for estuarine and coastal cells and Decision support tools to aid users adopt models and interpret outputs)

The BSEIM R&D programme will be divided into short, medium and long-term elements. Seven projects are recommended, the first of which (BSEIM toolbox) should focus on compilation of existing information and methodologies suitable for immediate application in support of CFMP and SMP ecosystem assessments.

Outputs in the Year: Cascade Consulting (2002). *"Broad Scale Ecosystem Impact Modelling Tools: Scoping Study"*.

Defra Project Number and Title:	FD 2110 Estuaries Research Programme Phase 1 Uptake Project – Broad Scale Modelling, Data And Information Dissemination
Research Contractor:	Posford Haskoning
Objectives:	To set up a take up and training programme for the outputs of the Estuary Research Programme Phase 1.
Start Date/Finish Date:	February 2002 / November 2002
Staff Input this Year:	0.38 person years of scientific effort

Summary of Progress in Year:

Consultation with stakeholders of the Mersey and Blackwater Estuaries was carried out to establish the issues or concerns that could form a basis for demonstration projects. In Phase 1, meetings took place with local representatives from the Environment Agency and English Nature and the manager of the Estuary Strategy for each estuary and identified a number of broad issues. The product of these initial sessions was two Consultation Reports. In Phase 2, the Consultation Reports were sent to around 70 local stakeholders in each estuary with an invitation to attend one of two stakeholder workshops, to discuss and expand the range of issues. At each workshop a consensus was reached on the type of demonstration projects to be implemented. The Mersey Estuary workshop highlighted issues relating to changes in estuary dynamics that would occur if the training walls at the mouth of the estuary were altered. In the Blackwater Estuary, a suggestion to use the Abbot's Hall managed re-alignment methodologies as a basis for demonstration, appeared favourable to the attendees.

Part of the **Mersey Estuary demonstration** project will use research from an Oxford Brookes/HR Wallingford collaboration. This work has examined the reasons for historical change in the Mersey using a variety of modelling tools and thus will form the backbone of the demonstration, allowing the illustration of how modelling tools and data can be used to develop an understanding of an estuary system. This resource may be enhanced by further modelling of the short-term effects of the impact of changes to the training walls on tidal currents and sediment transport.

Part of the **Blackwater Estuary demonstration** will summarise the elements of the Abbot's Hall managed re-alignment project. The demonstration will cover the scoping of the project, the review of available data and collection of new data, and numerical modelling undertaken to build up a conceptual model of the area. Thereafter, the demonstration will show the results of the predictive testing (in this case the effects of the various breaches) and how the resulting information was further analysed to provide information on the impact of the scheme.

The database tasks have only recently started. The original EMPHASYS consortium partners have been asked to review the data that was supplied originally, and identify any new datasets that may be suitable for inclusion in the updated database.

Proprietary work has been carried out to achieve the aims with respect to the **end user training programme**, which will be run later in the project. An exhaustive list of possible trainees from a range of end users is being compiled, and the exact locations and format (including the appropriateness of the experimental interactive software package) of the workshops are presently being debated.

Outputs in the Year: Brew, D.S. (2002). *"Estuaries Research Programme Phase Uptake Project. Inception Report"*, Defra/Environment Agency Report.

Defra Project Number and Title:	FD 2115 ERP2 Research Plan
Research Contractor:	University College London
Objectives:	To present a five year Research Plan for Phase 2 of the Defra/Agency Estuaries Research Programme (ERP).
Start Date/Finish Date:	December 2001 / March 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The **Final Project Report** presented a five-year Research Plan for Phase 2 of the Defra/Agency Estuaries Research Programme (ERP). The Plan:

- Reviews and re-states the principal findings of ERP Phase 1;
- Prioritises the research projects recommended by ERP Phase 1;
- Investigates alternative approaches to estuary modelling, to take account of more recent research and other ideas developed outside of the ERP;
- Identifies other Defra/Agency R&D projects that ERP Phase 2 must link up with in delivering the tools for holistic estuary management;
- Proposes a coherent and costed programme of flood and coastal defence R&D for funding by Defra/Agency (3-5 year time frame);
- Identifies longer-term (5-10 year) fundamental research needs which should be funded (or co-funded) by UK Research Councils and other bodies;
- Integrates on-going operational and improvement activities and non-flood and coastal defence estuarine research needs into the same framework.

Section 2 of this report identifies the main user groups and presents a logical framework for the matching of estuarine research to their needs. In Section 3, the principal findings of ERP1 are summarised alongside a review of other recent research and alternative approaches to medium and long term prediction. **Recommendations for further research** are then prioritised, to take account of funding limitations and to ensure that projects carried forward are responsive to user needs and offer good value for public money.

Section 4 presents a 3-5 year programme of estuarine R&D. This includes **eight core projects**:

1. Uptake of ERP Phase 1; 2. Improved estuary data; 3. Enhanced hybrid models; 4. Physical, sedimentary and biological processes; 5. Enhanced top down models; 6. Understanding the predictability of morphological systems; 7. Maintenance / dissemination of existing R&D; and 8. Delivery of ERP Phase 2 (Programme Management).

Section 5 outlines the broader funding context, and lists priorities for longer term, more fundamental research, which lie within the remit of the UK Research Councils. Potential linkages with existing funding mechanisms and recently established networks (e.g. the EPSRC COZONE network) are considered. This part of the plan is intended to inform application and peer review procedures, such that the right kind of estuarine science is supported through the Research Councils.

Outputs in the Year: French, J., Reeve, D. and Owen, M. (2002). *"Estuary Research Programme Phase 2 Research Plan"*, April 2002.

Defra Project Number and Title:	FD 2201 Extreme Flood Recognition, Fluvial
Research Contractor:	University of Salford
Objectives:	To analyse historical extreme flood events, investigate and identify characteristics of meteorological conditions that can result in extreme floods in order to improve recognition of possible events in the future.
Start Date/Finish Date:	August 2001 / April 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The most extreme hydrometeorological events that are likely to be experienced in the United Kingdom have received only limited study from the point of view of underlying consistency and predictability. Practically all such rainfall and flood events that have occurred in the last 100 years or so have been described, and in some cases analysed in order to seek their causes. However, guidance to flood forecasters to help identify these events remains skeletal. It is vital that signals of the possibility of such events be recognised as early as possible, preferably 24 hours or more in advance.

In the project report, the results of a joint study carried out by the University of Salford and the Met. Office on behalf of the Defra are described. The research has investigated the nature of very extreme rainfall events and the meteorological situations leading to their occurrence, and also the susceptibility of river catchments to their spatial and temporal rainfall patterns. **Guidance on the recognition of extreme events is provided**. Given that such events are likely to have return periods of many thousands of years, the implications of the analysis for estimates of Probable Maximum Precipitation (PMP) have also been considered. It has been found that, whilst the estimates of PMP made using the Flood Studies Report procedure are inadequate, an extrapolation of the Flood Estimation Handbook statistics may provide estimates of PMP which are liable. However, further work to verify this conclusion is needed.

The recognition of the possibility of extreme flooding remains a major challenge for hyrometeorologists. In this project a **scoring system for river catchments** is described to provide an indication of extreme flood potential. By using the scoring system that identifies the contributions to a flood event from a variety of components it is possible to update and comprehend the likelihood of extreme flooding. The scheme is tested using published data of the consequences of extreme storms in England and Wales. The methodology is capable of formalising intelligence tables often developed by flood forecasting and warning teams in the Environment Agency using their local knowledge but on an ad hoc basis. Such a scoring scheme can be used as a decision support tool by practitioners.

Training datasets for a number of extreme events are provided in the form of rainfall time series and depth-area information.

Outputs in the Year: Collier, C.G., Fox, N.I. and Hand, W.H. (2002). *"Extreme Rainfall and Flood Event Recognition",* R&D Technical Report FD2201, August 2002.

Defra Project Number and Title:	FD 2207 Storm Scale Numerical Modelling
Research Contractor:	The Met. Office
Objectives:	To investigate the ability of a storm scale configuration of the Met. Office Numerical Weather Prediction (NWP) model to predict flood-producing rainfall up to 12 hours ahead and to develop appropriate tools to interpret and present the predictions in order to enhance operational flood prediction capabilities.
Start Date/Finish Date:	January 2001 / November 2004
Staff Input this Year:	0.2 person years of scientific effort.

Summary of Progress in the Year:

Identification of a **first case study**. The organised band of heavy rain that lead to flooding in parts of Kent and Sussex on 11th October 2001 was identified as the most appropriate meteorological event to use for initial high-resolution modelling experiments.

Setting up the first case study. Under the guidance of scientists at the Joint Centre for Mesoscale Meteorology (JCMM), Reading, tasks were set up at the Joint Centre for Hydro-Meteorological Research (JCHMR), Wallingford to allow the Met Office Unified Model with to be run with gridlengths of 12km and smaller. A forecast at 12 km gridlength of the 11th October case was run successfully. Precipitation fields were output and boundary conditions to allow a 4km gridlength simulation were produced. Initial difficulties in running the Unified Model at JCHMR have been overcome now that the computer system has been configured to allow direct access to disks at Met Office HQ, Bracknell and JCMM, Reading.

Monitoring the weather for new case studies has been ongoing. No good cases have been identified in the period of this report, however there are old events available. Work has been undertaken to classify the different types of case study that are required so that ultimately a balanced assessment of model performance can be obtained.

Work has been carried out at JCMM to produce diagnostics that are designed specifically for high-resolution Numerical Weather Prediction (NWP) output of precipitation. Some of these diagnostics will form the basis of **catchment-scale evaluation of high-resolution precipitation forecasts**. The way forward in using these products alongside statistical evaluation techniques has been an important consideration in planning the way ahead and is the subject of ongoing discussion with scientists at JCMM.

Outputs in the Year: None

Defra Project Number and Title:	FD 2206 Best Practice In Coastal Flood Forecasting
Research Contractor:	HR Wallingford Ltd.
Objectives:	To produce best practice guidelines within which future coastal flood forecasting should operate.
Start Date/Finish Date:	March 2002 / February 2003
Staff Input this Year:	0 person years of scientific effort.

Summary of Progress in the Year:

None.

Outputs in the Year: None.

Defra Project Number and Title:	CC 0337 Regional Climate Change Impact And Response Studies In East Anglia And North West England (REGIS)
Research Contractor:	Consortium led by Cranfield University
Objectives:	To evaluate the impacts of climate change, through an integrated methodology, on the agriculture, hydrology, biodiversity, and coastal areas of East Anglia and North West England.
Start Date/Finish Date:	November 1998 / October 2000 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The principal aim of RegIS was the development of a robust and transparent methodology for stakeholder-led, **regional assessment of climate change impacts** and cross-sectoral interactions between the major sectors driving landscape change. This methodology has been developed in the North West and East Anglia, and is believed to be transportable to other regions of the UK, thereby providing a framework for further assessments and studies.

Four national climate change scenarios have been developed on behalf of the United Kingdom Climate Impacts Programme (UKCIP), known as the UKCIP98 scenarios. The **socio-economic scenarios** used in the research have been developed within the RegIS project.

The main conclusions of the study are given in the **Final Project Report** for each region in relation to the socio-economic and climate change scenarios that were used to explore alternative futures. These points provide a qualitative description, or picture, of the two regions in terms of plausible changes and the potential for adaptation that have arisen from the RegIS study results.

Outputs in the Year: Holman, I.P., Loveland, P.J., Nicholls, R.J., Shackley, S., Berry, P.M., Rounsevell, M.D.A., Audsley, E., Harrison, P.A. & Wood, R. (2002). *"REGIS – Regional Climate Change Impact and Response Studies in East Anglia and North West England",* Summary Report, 2002.

Defra Project Number and Title:	FD 0206 Joint Probability Of Extreme Estuarine Water Levels
Research Contractor:	HR Wallingford Ltd.
Objectives:	To produce and demonstrate a robust methodology for determining extreme estuarine water levels due to the combined effects of tides, surges, flows and waves in a range of realistic situations. To disseminate joint probability research to the UK coastal engineering community.
Start Date/Finish Date:	April 1997 / July 2000
Staff Input this Year:	No information provided.

Summary of Progress in the Year:

This project has reviewed, developed and demonstrated **methods for determining extreme (design) water levels in estuaries**, taking account of the joint occurrence of tides, surges, flows and waves. Related research was undertaken within Project FD1704 (Joint probability: Dissemination, beta-testing and alternative applications).

During 2000/01, HR Wallingford undertook its final research efforts prior to production of a final report and concentrated on **refining, automating and validating various aspects of the data preparation**, analysis method, interpretation of results and assessment of uncertainties. At a late stage in the project, the opportunity arose to apply one of the new developments within the ongoing Thames Tidal Walls Strategy Study. This involved the use of joint probability analysis of wind speeds and water levels at Southend, from which varying water levels and wave conditions could be determined by hydraulic modelling throughout the study area.

During 2000/01, work at CEH-Wallingford was completed. Sensible trends, with **tentative meteorological explanations**, can be seen in the correlation results, including some time-lagged correlations and some noteworthy lacks of correlation.

Outputs in the Year: Svensson, C. and Jones, D. (2000). *"Dependence between extreme sea surge, river flow and precipitation: a study in eastern Britain",* CEH Project Report C01392, October 2000.

Defra Project Number and Title:	FD 1204 Integrated Effects Of Climate Change On Coastal Extreme Sea Levels
Research Contractor:	Proudman Oceanographic Laboratory
Objectives:	To derive guidance on changes/trends in extreme sea levels from existing information.
Start Date/Finish Date:	January 1999 / January 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

Contributions to any change in extreme sea levels, as observed at the coast, result from a number of inter-related components. The intention was to combine: global MSL change and observed regional trends; regional land movements; tidal changes due to increasing sea level; and changes in extreme storm surge elevations caused by changes in "storminess" with increasing levels of atmospheric CO_2.

The first stages in the work were to review the elements mentioned above and to assemble estimates (with uncertainties) for UK coasts. Observed trends in sea level were compared against contemporary estimates of the contributing components, providing an **indication of the reliability** of and uncertainty in estimates derived from combining these elements for past conditions.

Long term changes in sea level are monitored by POL using the UK national network of 45 tide gauges, and South Atlantic gauges which are the UK's contribution to the Global Sea Level Observing System (GLOSS). Several UK records are approximately 100 years long and show clear evidence for rising levels, implying 'absolute' sea level trends for the last century of about 1mm/year. Sea level changes also show a small 'sea level acceleration' component, as well as considerable inter-annual and inter-decadal variability.

Long term change in the observed mean sea level at any point is a combination of climate change related sea level variation, sometimes called the absolute sea level change, and the effect of land subsidence or uplift. Most land movements are due to long term geological processes such as glacial isostatic adjustment of the Earth following the last ice age or sediment compaction.

Changes in extreme sea level for 2075 were estimated from model projections by combining contributions from MSL, tide, storm surge and land movements. Extreme water levels generally occur as a combination of high water of a spring tide and a storm surge. An increase in mean sea level will, of course, affect extreme levels directly, but changes in the mean level and hence water depth can also influence the tide and surge components.

Changes in absolute and relative extreme sea level between 1990 and 2075 were calculated from the components. For relative values, estimates of the change are 20-60cm for UK coasts, depending on location. These can be compared with current guidance (Defra, 2000). Generally, the results agree well on the East Coast of England, but the estimated rates are lower on the South Coast and higher in the Irish Sea and Bristol Channel than currently recommended.

The distributions produced, like all similar estimates, are subject to large uncertainty and must be treated with caution. They are, however, indicative of the type of results that can be produced from model predictions.

Outputs in the Year: Flather, R.A., Baker, T.F., Woodworth, P.L., Vassie, J.M. and Blackman, D.L. (2001). *"Integrated effects of climate change on coastal extreme sea levels",* POL Internal Document No. 140, July 2001.

Defra Project Number and Title:	FD 1704 Joint Probability: Dissemination, Beta Testing And Alternative Applications
Research Contractor:	HR Wallingford Ltd.
Objectives:	To capitalise on the recently developed JOIN-SEA joint probability methods and software, both by industry dissemination and testing, and by finding new and alternative coastal and river engineering applications for them.
Start Date/Finish Date:	July 1999 / March 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

Both large waves and high water levels are important in **design and assessment of sea defences**. Defra has been funding work on joint probability for several years, focusing primarily on its applications to waves and water levels and to tides and surges. The methods have also been applied to wind-sea and swell as part of a program of research on bi-modal sea conditions. Similar methods have been demonstrated to be applicable to three partially dependent variables, namely water levels, waves and flows, during ongoing research on extreme total water levels in estuaries. The new JOIN-SEA methods have been in use in consultancy studies at HR Wallingford and other organisations over the last few years.

In principle, the JOIN-SEA methods and software developed jointly by HR Wallingford and Lancaster University can be applied to variables other than those for which they were developed, namely wave heights and water levels (with wave period treated as a secondary variable partially dependent upon wave height). The value of the research already completed would be increased by development of related program packages for alternative applications.

The objective of this project was to capitalise on the JOIN-SEA joint probability methods and software, both by **industry dissemination and testing**, and by finding new and alternative coastal and river engineering applications for them.

Prior to the briefing workshop in February 2000, some further developments were made to JOIN-SEA. These included minor updates to the programs, testing for use on a PC, parallel programs for the calculation of statistical uncertainty, creation of two 'blind' data sets to test the workshop delegates use of the programs, and a re-issue of the user manual and overall research report. During the subsequent feedback workshop in March 2001, the users' experience was shared and views collated about further development and dissemination.

New two-variable applications included waves and currents for seabed mobility and sediment transport applications, river flows and water levels for estuarine applications, and wind speed and water level in which wind speed is then used to predict waves in different parts of the study area.

A simplified but robust approach closely based on JOIN-SEA was developed and tested for application to any three partially dependent variables, and, in principle at least, to even more than three variables. This would potentially have much wider application in risk-based design and assessment methods for flood and coastal defences.

This project has helped to bring the **best available methods for analysis of the joint probability of waves and water levels** into wider use by the coastal engineering community.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2301 Absolute Fixing Of Tide Gauge Benchmarks Phase 2
Research Contractor:	Proudman Oceanographic Laboratory
Objectives:	To improve the monitoring of the vertical land movement component of changes in mean sea level using a combination of Continuously Operating GPS Receivers (COGRs) and episodic Global Positioning System (GPS) measurements around the coastline of Great Britain.
Start Date/Finish Date:	March 2000 / June 2003
Staff Input this Year:	3 person years of scientific effort.

Summary of Progress in the Year:

The 5 COGRs at Sheerness, Newlyn, Aberdeen, Liverpool and Lowestoft tide gauges have continued to operate, with GPS data automatically downloaded on a daily basis. Over the past year, all archived data from the 7 COGRs at tide gauges and a further 14 COGRs have been re-processed and re-analysed.

The **dual Continuous GPS station concept has been further investigated** and it has been found that relative vertical station velocities are not biased by periodic variations and are less dependent on the length of the time series. The possibility of combining these relative velocities with absolute gravity or geological estimates of land movement will be investigated during the next stage of the research.

In April 2002, the first episodic GPS measurements using a quasi-continuous approach were completed at Stornoway.

Absolute gravity (AG) measurements were made at Newlyn, Aberdeen and Lerwick. These have extended the time series of AG measurements by a further year. These AG measurements are the **best results at tide gauges that have been obtained worldwide**. A paper discussing these results was published in June 2001 and the results were presented at various national and international meetings.

The POL absolute gravimeter FG5-103 was taken to BIPM in Paris in July 2001 in order to take part in the 4-yearly intercomparison of absolute gravimeters (ICAG 2001). This is a regular intercomparison between the majority of absolute gravimeters available around the world and is organised by the International Bureau of Weights and Measures. The measurements with FG5-103 were within 1½gal of the mean of the other absolute gravimeters. This confirms that the POL AG **measurements continue to be consistent with the highest international standards**.

Outputs in the Year: Bingley, R.M,. Dodson, A.H., Teferle, F.N. and Baker, TF. (2001). *"GPS Monitoring of Changes in Ground Level for Flood and Coastal Defence.",* Proc. 36th Defra Conf. River and Coastal Engineers, Keele, June 2001.

Bingley, R.M,. Dodson, A.H., Penna, N.T., Teferle, F.N. and Baker, T.F. (2001). *"Monitoring the Vertical Land Movement Component of Changes in Mean Sea Level Using GPS: Results from Tide Gauges in the UK.",* J. Geospat. Eng., Vol 3, Number 1, June 2001.

Penna, N.T., Bingley, R.M,. and Dodson, A.H. (2002). *"Single Receiver Heighting using the Active Stations of the National GPS Network of Great Britain.",* Survey Review, Vol 36, Number 283, January 2002.

Defra Project Number and Title:	FD 2302 Risk And Uncertainty Review
Research Contractor:	HR Wallingford Ltd.
Objectives:	To develop standards to represent statistical uncertainty in parameters derived from field data and systematic uncertainties (incompleteness) associated with risk models and design methods.
Start Date/Finish Date:	November 2000 / April 2002
Staff Input this Year:	No information provided.

Summary of Progress in the Year:

The project is in its early stages and progress has been made in:

- Establishing a **common language of risk**;
- Review of projects completed since publication of HR Wallingford Report SR 483 'Application of risk methods in flood and coastal defence', in 1997, and their relevance to the 'Risk' theme;
- Initial concepts on the **framework for risk research** over the next 4-5 years.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2303 Coastal Defence Vulnerability 2075
Research Contractor:	HR Wallingford Ltd.
Objectives:	To assess the possible changes in coastal defence vulnerability (to overtopping or erosion) caused by global climate change over the next 75 years.
Start Date/Finish Date:	June 2000 / May 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

Three methods of estimating the changes in coastal defence vulnerability between now and 2075 were used. **The methods used present and future simulations** to calculate: coastal defence response to combined waves and water levels using numerical models; longshore drift rates, to compare annual mean drift rates and their variance; and statistical analysis of coastal defence response functions, derived from empirical equations.

The results were used to estimate changes in coastal defence vulnerability due to climate change at five test regions around the English and Welsh coastline. The results produced are not site specific but rather generic. Simplified bathymetries and typical structure types were used in an effort to provide results that were broadly representative of stretches of coastline, rather than specific locations.

Changes in wave climate around the UK were predicted to be small (less than 5% for wave height) and the increase in future extreme water levels will generally be within 20% of the increase in mean sea level. Sea level rise of 0.35m will cause average increases in overtopping volume of 50-150%, depending on structure type, location and modelling approach and if present day defences are unchanged in 2075. If the observed coastal steepening continues it will increase overtopping rates by a further 15%, approximately. The inclusion of sea level rise predictions in design calculations should account for the majority of the predicted change in wave impact on coastal structures.

In most cases the simulated future mean annual longshore drift rates were slightly greater than the present day rates, by an average of around 15%. The greater volumes of material that may need to be re-nourished would impact on the economic viability of beach nourishment and may necessitate a review of management options. However, as there is great uncertainty in the prediction of longshore transport, the work tends to show that future changes are unlikely to be greater than current levels of uncertainty and these should be considered in the normal course of sensitivity testing.

Qualitative and quantitative differences in future changes in vulnerability were found between the five sites examined around the coastline of England and Wales. This is because the sites have different tidal ranges, wave climates and surge levels. Moreover, the parameters have different joint probabilities at different sites. Thus results from one site cannot be transferred directly to other sites and individual assessments must be made for specific sites. Nonetheless, the **modelled scenarios give an indication of the general extent of changes** in coastal defence vulnerability that can be expected in the next 75 years.

Outputs in the Year: Sutherland, J. and Wolf, J. (2001). *"Coastal defence vulnerability 2075",* Proc. 36th Defra Conf. River and Coastal Engineers, Keele, UK. Paper 03–6.

Sutherland, J. and Wolf, J. (2002). *"Coastal defence vulnerability 2075",* HR Wallingford Report SR590.

Defra Project Number and Title:	FD 2304 To What Degree Can The October/November 2000 Flood Events Be Attributed To Climate Change?
Research Contractor:	CEH-Wallingford
Objectives:	To address the following key questions: "How unusual was the October/November 2000 flooding and rainfall in a historical context?" and "Can the October/November 2000 floods and rainfall be linked to climate change?"
Start Date/Finish Date:	December 2000 / June 2001 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

The research combined a primary data study with analysis of climate model outputs. There was **clear evidence** that the October/November 2000 floods and rainfall were unusual or unique in several ways:

- Rainfall for the September to November period (which included the build-up to the flooding) was the highest on record for those months;
- Rainfall for October/November 2000 was more than twice the long-term average for those two months over much of the country;
- Total river flows in five major basins (Thames, Trent, Severn, Wharfe and Dee) were greater than any time since the floods of 1947 for running totals over 10 days or more.

Viewed in a national context, the extent and duration of the flooding has few recorded parallels. It is **impossible to attribute a single weather event to climate change by looking only at that event**, i.e. it is not possible to attribute the 2000 flooding and rainfall in themselves to climate change.

What can be done is to ask whether there have been changes occurring in the frequency and magnitude of such events and to use climate models to see whether changes in extremes of potentially 'flood-producing' rainfall are predicted:

- There is evidence of increasing rainfall and river flow extremes in Britain in the last 30 to 40 years, especially for longer durations (e.g. 30 or 60 day running totals);
- Wider evidence also shows increases in winter season heavy rainfall events;
- This evidence is consistent with predictions of human-induced climate change. It has not been shown that observed changes in precipitation can be attributed to human activity;
- The changes predicted in extreme rainfall frequencies between 1860 and the present day are small compared to natural variability.

The project concluded that:

- **The events of October/November 2000 were extreme**, but cannot themselves be attributed to climate change. However, heavy rainfall and peak river flows of similar duration have been increasing in frequency and magnitude over the last 50 years;
- This pattern is consistent with model predictions of how human-induced climate change affects rainfall. However, it is not yet possible to say how far rainfall and flooding events such as those of October/November 2000 can be attributed to climate change, as opposed to natural variability.

Outputs in the Year: CEH-Wallingford and The Met. Office. (2001). *"To What Degree Can The October/November 2000 Flood Events Be Attributed To Climate Change?",* FD2304 Final Report, June 2001.

Defra Project Number and Title:	FD 2308 Joint Probability – Dependence Mapping And Best Practice
Research Contractor:	HR Wallingford Ltd.
Objectives:	To continue the process of dissemination and appropriate take-up of joint probability research which assesses environmental variables including waves, tides, surges, rainfall and wind through dependence mapping and development of test practice guidelines.
Start Date/Finish Date:	December 2001 / November 2004
Staff Input this Year:	0.28 person years of scientific effort.

Summary of Progress in the Year:

Data series on river flows, rainfall, tide, surge, water level, waves, wind-sea and swell-sea were purchased, collated, and where necessary shared between project team members.

An outline of the **best practice guide final report on use of joint probability methods** has been prepared.

A mailing was prepared outlining the project aims and methodology. A list of **consultees** was assembled.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2311 Environmental Change Indicators For Flood And Coastal Defence
Research Contractor:	CEH-Wallingford
Objectives:	To identify, define and select a range of climate change indicators relevant to flood and coastal defence and to develop mechanisms for monitoring, analysing and interpreting findings.
Start Date/Finish Date:	December 2001 / October 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

Environmental change is important to the flood defence industry because it may alter the flood risk and intended level of protection that is being given. Inevitably public concern focuses on changes that are expected to increase the flood risk on river floodplains or coastal flats. However, where change is giving a greater margin of safety over the design life of the protection works, there could be a lower risk if a downward environmental trend can be detected and quantified.

This project has sought to identify a wide range of possible **Environmental Change Indicators** (ECIs) for England and Wales related to floods, to locate data series over sufficiently long periods to make the ECI calculations valid, to produce a small number of pilot indicators, and to discuss their implications for future use and expansion.

The team assembled to carry out this work came from **senior levels in a range of research organisations** serving the industry. An initial open workshop tested ideas for ECIs; a narrower range of queries was then put to flood defence specialists by telephone questionnaire; a literature review was produced to avoid duplication of work; an interim paper was delivered to the September 2002 Keele River and Coastal Engineers conference; and then trial ECI series were completed to illustrate some of the proposed indicators and to enable this report to be presented.

Here the 'environment' being examined is that of river and sea level, being the most direct measure of flood risk. Some districts suffer the slower but persistent risk of groundwater flooding, so aquifer levels have also been considered, as have those catchment characteristics that change with time, such as forest cover and urban spread, and which may affect flood response to rainfall.

After examination of a large number of potential indicators, the following were recommended to be adopted as **headline indicators** to assist detection of possible environmental change impacts on flood risk:

- The frequency of daily rainfalls over 25mm for 5km grid squares representative of various parts of England and Wales. The Met Office maintains the gridded data;
- Time series of annual maximum and POT groundwater levels at selected sites having good quality long records;
- Time series of annual maximum and POT river levels at sites identified by Garrad;
- Time series and POT analysis of mean seal levels at the 5 benchmark sites monitored by POL.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2315 Concerted Action Performance Evaluation
Research Contractor:	HR Wallingford Ltd.
Objectives:	To review performance evaluation procedures, develop a risk-based framework and identify future R&D requirements for performance evaluation and manage the associated risks and uncertainties of flood defence structures. To produce a first draft of the FCD PAG6 guide on Post-Project evaluation.
Start Date/Finish Date:	March 2002 / March 2003
Staff Input this Year:	No information provided.

Summary of Progress in the Year:

No information provided..

Outputs in the Year: None.

Defra Project Number and Title:	FD 1302 Sand Dune Processes And Management For Flood And Coastal Defence
Research Contractor:	Royal Holloway University of London
Objectives:	To review the current methodologies and techniques available for the management of coastal dune systems. To evaluate the effects of climate change on dunes and associated beach systems and assess the likely effects of removing hard defences to recreate dynamic dune systems.
Start Date/Finish Date:	July 1999 / December 2002 (project complete)
Staff Input this Year:	3 person years of scientific effort.

Summary of Project:

Sand dunes are a vital component of coastal and flood defences in many parts of the world. On short timescales dune erosion during and after severe storms acts to naturally replenish beach and nearshore levels. On longer timescales, dune belts act as mobile flood defence barriers capable of altering position and form in response to varying wind/wave climate, sea level change and shoreline erosion and deposition. In addition, dunes have high conservation and recreational value and can assist in the maintenance of freshwater tables against saltwater intrusion.

Coastal **sand dunes are an important landform type and habitat around the coast of the British Isles**. In England and Wales they fringe approximately 9% of the total coastline representing 400km.

In recent years the need to develop a strategic management plan for sand dune systems in England and Wales has become ever more apparent, as competing pressures from various interests including flood defence, nature conservation, urban and recreational development have increased, and as European and national legislation relating to habitat conservation has been broadened and tightened.

The underlying premise of this work is that any national coastal dune management strategy with long-term vision must be based on adequate **knowledge of the geomorphology and dynamics of dunes**, their ecological and flood defence significance, and their value for other interests.

The results of the present study are summarised in **four separate volumes**:

- Volume 1 provides an overview of the geomorphology and management of the sand dunes in England and Wales, focusing on dune distribution, morphology, development history, sedimentology, process regime, current sand mobility and management status;
- Volume 2 provides a database summary of dunefield and dune attributes for each of the individual dune sites identified around the coast of England and Wales;
- Volume 3 provides a review of dune and dunefield management techniques, including practical methods for local scale sand dune control, dunefield-scale morphological and ecological landscaping and larger-scale strategic management;
- Volume 4 examines a number of case studies where present circumstances relating to coastal change require evaluation of a number of management options and development of a strategic framework for long-term sustainable management.

Outputs in the Year: Pye, K. and Saye, S.E. (2002). *"Overview of the Geomorphological and Management Status of Coastal Sand Dune Systems in England and Wales",* Defra Report, December 2002.

Defra Project Number and Title:	FD 2401 Coastal Rock Structures On Unprepared Foundations
Research Contractor:	HR Wallingford Ltd.
Objectives:	Undertake a scoping study into the viability of constructing rock coastal structures on unprepared foundations, including structure performance, constructability, maintenance requirements and environmental issues. Consider future research requirements.
Start Date/Finish Date:	May 2000 / September 2000 (project complete)
Staff Input this Year:	0.23 person years of scientific effort.

Summary of Project:

A **scoping study** into 'Coastal Rock Structures on Unprepared Foundations' was undertaken by HR Wallingford. The study methodology and findings are documented in the HR Wallingford report SR 577.

During the course of the study possible **advantages of constructions with limited layers or foundations** were identified and an Industry Workshop was held to discuss the issues concerned and ways forward. It was found that there is considerable scope for cost savings, more flexible structures and, in some cases, less environmental impacts if such structures are used at suitable locations.

Recommendations as to appropriate research to investigate the use of coastal rock structures with limited foundations or filter layers are provided within the report and some of the limitations in the guidance presently available are highlighted.

Two areas for immediate research are identified:

- Collation, appraisal and dissemination of existing experience;
- Descriptive numerical modelling of flows within rock structures.

On completion of these preliminary studies a more comprehensive research programme could be implemented.

Outputs in the Year: HR Wallingford (2002). *"Innovation in the use of coastal rock protection: Results of a research scoping study",* HR Report SR 577.

Defra Project Number and Title:	FD 2403 Soft Cliffs: Prediction Of Recession Rates And Erosion Control Techniques: Examples And Publication
Research Contractor:	High-Point Rendel
Objectives:	To develop an understanding of the processes of cliff stability and cliff recession with respect to managing cliffs.
Start Date/Finish Date:	March 2002 / August 2002 (project complete)
Staff Input this Year:	0.23 person years of scientific effort.

Summary of Project:

The project has been completed. The results have enabled a much **greater understanding of the processes of cliff stability and cliff recession** with respect to managing cliffs.

The work will enable practitioners in the field of coastal management to be better able to predict the probability of cliff failure and how to **evaluate the consequences** in terms of costs, benefits and remedial action.

Outputs in the Year: Clark, A.R. and Lee, E.M. (2002). *"Investigation and Management of Soft Rock Cliffs",* Thomas Telford ISBN 0727729853.

Defra Project Number and Title:	FD 2409 Performance Of Coastal Structures Phase 2
Research Contractor:	HR Wallingford Ltd.
Objectives:	To prepare practical guidance for the design and analysis of low cost structures for beach control and coast protection.
Start Date/Finish Date:	January 2002 / December 2002
Staff Input this Year:	0.45 person years of scientific effort.

Summary of Progress in the Year:

Good progress has been made in **identifying the performance requirements** for rock structures, defining present design guidance/practice and collecting scheme information.

Appropriate **case studies have been identified** and analysis has commenced. This is expected to provide a useful foundation from which the practical design guidance can be developed.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2410 Coastal Flooding Hazard By Wave Overtopping
Research Contractor:	HR Wallingford Ltd.
Objectives:	In collaboration with a number of European projects, to improve numerical models of wave overtopping of coastal defence structures and to develop design guidance as to which models are suitable for which circumstances.
Start Date/Finish Date:	January 2002 / March 2002 (project complete)
Staff Input this Year:	No information provided.

Summary of Project:

One of the principal concerns for practising coastal engineers is the accuracy and applicability of the range of methods available for **predicting peak and mean wave overtopping volumes and discharges** at coastal structures. Many of the methods are limited in the range and types of structure to which they may be applied, and common structure configurations exist around the UK coastline for which there are no reliable prediction methods. There is increasingly a need for more general methods that may be applied across the range of typical coastal structures that are to be found around the UK. This is especially important with regard to the expected sea level rise of 300mm over the next 50 years, and the increased confidence levels that are required on the overtopping performance of new and refurbished structures where public safety is concerned.

This research has partially focussed on obtaining new data sets for test structures that have not been tested previously, and on reproducing comparative data sets for existing empirical methods. These data have been collected for 2 and 3-dimensional structure configurations, for 2-dimensional partially armoured and rock mound structures, and will be used for a variety of analytical purposes. Originally conceived to **extend the range of predictive tools and provide good quality data to use for calibrating** and validating numerical models of wave overtopping, the research has developed beyond the original scientific objectives. Since this project was commissioned, a number of additional research projects have begun (see final paragraph of summary), and this has allowed the research team to significantly extend the scope of the original proposal.

The research has provided **new data that will enable existing design methods to be improved and updated.** These data will improve significantly the accuracy of existing prediction methods. Calibration of the wave conditions and the development of the test programme have provided data for use in validating and calibrating the numerical model ANEMONE OTT 1d.

Additional studies under FD2410 and the project extension FD2412 have been enhanced by support from the EU research project CLASH ("Crest level assessment of coastal structures by full scale monitoring, neural network prediction and hazard analysis on permissible wave overtopping"), and through collaborations with the German Coastal Research Station, Nordeney; Liverpool University; and Universities of Edinburgh & Sheffield (VOWS project). Elements of testing and analysis started under FD2410 have been extended and will now be reported under FD2412.

Outputs in the Year: Pullen, T., Bay, I & Napp, N. (2002). *"Three dimensional physical model studies of wave overtopping".* Report TR 128, HR Wallingford.
Pullen, T & Bay, I. (2002). *"Two dimensional physical model studies of wave overtopping",* Report TR 127, HR Wallingford.
Pullen, T & Clarke, S (2002). *"Numerical models of wave overtopping: a study on application and calibration",* Report SR 601, HR Wallingford.

Defra Project Number and Title:	FD 2411 Reducing The Risk Of Embankment Failure Under Extreme Conditions
Research Contractor:	HR Wallingford Ltd.
Objectives:	To enable operating authorities to understand and address critical issues related to the effective performance of flood and coastal defence embankments – particularly to develop a risk-based framework for their design, inspection and maintenance relating to potential mechanisms and consequences of failure (principally by breaching).
Start Date/Finish Date:	January 2002 / November 2004
Staff Input this Year:	0.3 person years of scientific effort.

Summary of Progress in the Year:

The scope of this project funding includes both research on **flood embankments** in the UK and support for the European IMPACT project.

For the UK embankments work, initial activity focuses on **identification of key players** (relating to flood defence embankments) and initiating a programme of consultation. This has been implemented as planned.

For the IMPACT project, time has been spent **co-ordinating the work programme** and initiating partner work in the various theme areas. Field testing, physical modelling and numerical modelling work are all scheduled for the next financial year.

Outputs in the Year: None.

Defra Project Number and Title:	FD 2412 Coastal Flooding Hazard By Wave Overtopping – Clash
Research Contractor:	HR Wallingford Ltd.
Objectives:	ITo develop new methods for engineers and managers to analyse/design defences against wave -induced flooding and overtopping hazards.
Start Date/Finish Date:	January 2002 / May 2005
Staff Input this Year:	0.4 person years of scientific effort.

Summary of Progress in the Year:

Under CLASH ("Crest Level assessment of coastal structures by full scale monitoring, neural network prediction and hazard analysis on permissible wave overtopping") and FD2412, HR Wallingford are committed to a **programme of full-scale measurements of overtopping** at Samphire Hoe, Kent, England, followed by a hydraulic model tests at small scale. Samphire Hoe is an area of reclaimed land, comprising 4.9M m3 of chalk excavated from the channel tunnel. Samphire Hoe has been landscaped and is used by the public as a recreational area. The site is owned by Eurotunnel Developments Ltd (EDL), and is run on their behalf by the White Cliffs Countryside Project (WCCP).

EDL and WCCP have agreed in principle to allow HR Wallingford to conduct full-scale measurements at Samphire Hoe, subject to conditions on access, risk assessments and liability. An initial site visit has been undertaken to determine how the full-scale measurements may be best achieved, and an area has been identified during discussions between HRW, EDL and WCCP as the most suitable location for deploying the full scale measuring equipment. The initial designs for the measuring equipment have been completed, and discussions are taking place with our European partners in CLASH to determine the final design. The next phase of the work involves the construction and calibration in the laboratory of the prototype measuring equipment.

Progress has also been made in the **identification of wave overtopping hazards**. Within CLASH and FD2412, HR Wallingford will contribute to the analysis and definition of hazards that arise from wave overtopping. Around the coastline of Europe and elsewhere, low-lying areas are often protected by a variety of coastal structure types that protect against flooding and/or erosion caused by waves and extreme surges. Under wave attack, such structures are liable to experience intense local wave impact pressures and may overtop severely. For most of these structures, the crest level and/or front face configuration are dimensioned to give acceptable levels of wave overtopping under specified extreme conditions. The processes of hazard generation by wave overtopping of seawalls are however not understood fully, particularly those that cause danger to people on or close behind the defence. The research undertaken so far under FD2412 into the analysis of overtopping hazards, has revealed that there are conditions where the type and severity or overtopping will change during the tidal cycle. The identification of the parameters for which these changes take place have already **improved our current understanding** on the identification, and description, of when hazardous overtopping events are likely to occur.

Outputs in the Year: Pullen, T. and Allsop, W. (2002). *"Proposal for Full Scale and Physical Model Measurements of Wave Overtopping at Samphire Hoe",* submitted to the CLASH consortium for the General Methodologies Report.

Allsop, W. and Alderson, J. (2002). *"Hazard Analysis",* submitted to the CLASH consortium for the General Methodologies Report.

Appendix A: Index by Subject

1. COASTAL ENGINEERING PROJECTS

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Appendix B: List of Defra Contacts at Research Institutions

Initials	Contractor	Defra Contact	Telephone/Fax/Email/Internet
BC	Bullen Consultants 11/12 Eldon Place Bradford West Yorkshire BD1 3AZ	Vic Horsley	Tel: 01274 370410 Fax: 01274 734447 E-mail: bradford@bullen.co.uk Web: www.bullen.co.uk
CAS	Cascade Consulting Enterprise House Manchester Science Park Lloyd Street North Manchester M15 6SE	Dr Kieran Conlan	Tel: 0161 227 9777 Fax: 0161 227 1777 E-mail: kieran.conlan@ cascadeconsulting.co.uk Web: www.cascadeconsulting.co.uk
CCRU	CCRU Department of Geography University of Cambridge Downing Place Cambridge CB2 3EN	Dr Tom Spencer	Tel: 01223 339775 Fax: 01223 355674 E-mail: tom.spencer@geog.cam.ac.uk Web: ccru.geog.cam.ac.uk
CEHD	CEH-Dorset Winfrith Technology Centre Winfrith Newburgh Dorchester Dorset DT2 8ZD	Prof Alan Gray	Tel: 01305 213500 Fax: 01305 213600 E-mail: ajg@ceh.ac.uk Web: www.ceh.ac.uk
CEHW	CEH-Wallingford Crowmarsh Gifford Wallingford Oxfordshire OX10 8BB	Dr Duncan Reed	Tel: 01491 838800 Fax: 01491 692424 E-mail: dwr@ceh.ac.uk Web: www.ceh-nerc.ac.uk
CIRIA	CIRIA 6 Storey's Gate, London SW1P 3AU	N/a	Tel: 020 7222 8891 Fax: 020 7222 1708 E-mail: N/a Web: www.ciria.org.uk
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Appendix B: List of Defra Contacts at Research Institutions

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Credits

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Further Information

Projects funded by Defra in the joint Defra/Environment Agency Programme are co-ordinated and administered by Defra's Science Directorate. For further information contact Beth Greenaway (beth.greenaway@defra.gsi.gov.uk).

The Defra Flood Management Research and Development Annual Report 2000-2002 can be found through www.defra.gov.uk/environ/fcd/research/

Further information on the projects outlined in this report can by found through www.defra.gov.uk/science/ and www.environment-agency.gov.uk/floodresearch

Information about the Joint Defra/Environment Agency flood and coastal risk management programme of research and development can be found through www.defra.gov.uk/environ/fcd/research/ or by email to info-fm@defra.gsi.gov.uk or by writing to the address below

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