R & D Project CO6(92)08

DISSEMINATION OF THE ANGLIAN SDMS

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GLOSSARY OF ABBREVIATIONS

BGS	British Geological Survey
BMT	British Maritime Research
HR	Hydraulics Research
SANDS	Shoreline and Nearshore Data System
SWHP Ltd	Sir William Halcrow and Partners Ltd
Imp College	Imperial College

EXECUTIVE SUMMARY

In 1987 the Anglian Regional Flood Defence committee approved expenditure on the first phase of the Sea Defence Management Study (SDMS). This was the first major exercise to be carried out along our coastline for flood defence and the study created the concept of Shoreline Management.

The SDMS took three years to complete for the 1500km of the Anglian coastline at an investment of £1.6 million, the work commenced by the study in Anglian Region continues today with a Regional monitoring programme keeping core data sets up to date and enabling on-going analysis of the ever changing coastline.

The SDMS generated a wealth of information on a broad range of topics. The reports cover from the inception to conclusion of the study, and represent a valuable reference library. The report outlines the reports produced under the study and provides a critique of their wider applicability.

GIS was found to be the best approach to handling data and as part of the study a review of proprietary GIS was undertaken. The conclusion that a modular system was more desirable than a fixed one was made. NRA Anglian Region did not develop a structured development path for GIS, instead development was driven by business needs to provide effective GIS meeting user and internal customer requirements. As new flood defence needs have been identified, the potentials of GIS have been realised and flexible development taken place. For the full potential to be recognised the system must remain flexible and be allowed to follow an evolutionary path. GIS can respond to change so long as SYSTEM review is an on-going process.

A need was also identified for a database system to hold coastal data at a district level. The result was a PC system, developed by Sir William Halcrow & Partners known as SANDS. SANDS provides a storage, retrieval and analysis medium for coastal data. Output from the system takes the form of graphical and text screen output, and report output to PC files. The system is probably more suitable to those with short sections of coastline. Available resourcing for lower level systems is questioned and unless the maintenance of systems such as SANDS is given a higher profile it is inevitable that they will fall into decay.

The prime purpose of the SDMS is to provide a sound basis for investment plans. The GIS and the monitoring programme, and the management strategy has a profound influence in the decades ahead on both coastal management and the move toward soft engineering solutions. Future needs for the system include the necessity for the authority to provide personnel and resources to enable the maintenance and promotion of understanding of the system throughout a wider audience.

Whilst significant advances were made during the Anglian Sea Defence Management Study, a number of gaps remain in the understanding of the consultants on coastal processes. Suggestions have been made in respect of coastal processes, the shoreline management system and the shoreline monitoring programme to redress the current situation with regards to

limitations or deficiencies in various aspects of the system.

The report examines lessons learnt from the SDMS and provides practical guidance on the approach to, methods utilised and conclusions drawn from the study. This will benefit the Regions carrying out Shoreline Management and improve the planning of Sea Defence work.

The implementation of a similar system in other regions has been examined, with two approaches looked at. Before any national implementation of the SMS it will be necessary to achieve agreement in employing the principles of management framework and also of the necessity to have a degree of standardisation in the data formats used within the system. The effectiveness of the application of this management technique will only be able to be evaluated in the medium and long term when the effects of feedback within the system can be seen to have had an influence on the components of the framework and what would be necessary to implement the management framework nationally.

KEYWORDS

Shoreline Management
Sea Defence Management Study
Geographical Information System (GIS)
Intergraph MGE software
Shoreline and Nearshore Data System (SANDS)
Shoreline Management System
Anglian Shoreline Monitoring Programme
Coastal Processes
Flood Defence

1 INTRODUCTION

In recent years there has been rapid development in the area of Shoreline Management and information required to carry out this task. The Sea Defence Management Study (SDMS) was the first major exercise to be carried out along our coastline for flood defence. This study created the concept of Shoreline Management and has provided many useful lessons in carrying out such studies and the way to achieve the best value from such projects. The work has continued in NRA Anglian Region and developed a team working on information capture, handling, and interpretation for flood defence.

The purpose of this report is to set out the lessons learnt from the SDMS and provide practical guidance on the approach to, methods utilised, and conclusions drawn from the study. This will benefit the Regions carrying out Shoreline Management and improve the planning of sea defence work. The approach to undertaking this task has been to collate the experiences of NRA Anglian Region staff and the consultants employed for the SDMS (Sir William Halcrow and Partners). This should provide a balanced and objective view of the study and its outputs. It will also provide a candid review of the study with the benefit of three years experience through the study and valuable hind-sight. The report is aimed at NRA regions but will also provide valuable insight for others embarking upon projects of this nature.

1.1 Background to SDMS

In 1987 the Anglian Regional Flood Defence committee approved expenditure on the first phase of the Sea Defence Management Study (SDMS). The commencement of this study was forward thinking for its time and many of the principles it established are now considered common knowledge. The approach to flood defence work of considering the coastal processes at work and their interaction with flood defence became known, through the study, as Shoreline Management.

Changes in staff over time had resulted in any specialist knowledge which had been assimilated in the past being effectively lost. There was no comprehensive management approach in place and therefore no continuing and uniform way of gathering information. With there being no central store of data the basic data held such as responsibilities, types of structures and defence length, was not readily available. As a result it was identified that the need for strategic planning was imperative:

- A management policy was required, to create a central database of information to store all data, and to facilitate a better understanding of coastal processes.

- It was recognised that if the potential of the SDMS was to meet long term commitments an investment was required in technology and expertise.

- The organisation of the products from the SDMS was acknowledged as needing to be directed from Headquarters, with widespread promotion of the system being important. Areas and District offices were recognised as important recipients of information and important contributors.

1.2 The Three Stages of the SDMS

The starting point for the SDMS was that the region held large amounts of data pertinent to flood defence work and coastal processes. The first stage was to combine this information with that available in published papers and data archives to develop an overview of our understanding and identify critical gaps in knowledge, information and data.

The second stage of development was to fill the critical gaps in knowledge, although it was not anticipated that this would encompass all the information necessary. In order to achieve this, supplementary studies were identified and specialists appointed to undertake primary or secondary research. Stage two also identified the need to access the information being gathered in relation to data type and geographical location. This involved the development of a referral database to provide the information handling technology.

The third stage of SDMS involved the development of the database system to a functional Geographical Information System (GIS). This involved the creation of a structured data model to effectively manage the data generated under stage one and two, and to be able to store, retrieve and analyze the information on a geographical basis.

The SDMS took three years to complete for the 1500km of the Anglian coastline at an investment of £1.6 million. A study on the scale of SDMS is unique in Europe and the management of and lessons from, such an exercise may provide useful pointers to others embarking upon such strategic work. For such a project to be successful there are many aspects to be considered to ensure that the maximum return is achieved from the investment.

The work commenced by the study in Anglian Region continues today with a Regional monitoring programme keeping core data sets up to date and enabling on-going analysis of the ever changing coastline. The programme also involves continued development of the GIS and internal skills to effectively mange the wealth of information within the system.

2 REVIEW OF SDMS REPORTS

2.1 Introduction

The SDMS generated a wealth of information on a broad range of topics. The reports of the study cover from the inception to conclusion of the study, and represent a valuable reference library. Although the studies were all carried out for the Anglian coast there are aspects of the work which provide fundamental information or methodology and, topics which are applicable irrespective of geographical location.

The following outlines the reports produced under the study and a critique of their wider applicability.

2.2 Stage I

2.2.1 Inception Report: September 1987, SWHP Ltd in association with BMT & HR

This report was the initial outline of the study in 1987. As an approach it represents a logical structure. That approach is to identify and evaluate the available information, plug the gaps, and develop a means of handling the information. The report itself has been superseded in terms of philosophy and information but it highlights the importance of having a strategy to approach the fundamental problem. The concepts that are presented at the inception stage will set the tone of the entire exercise. It effectively represents a work programme for the consultant and identifies key goals to be achieved (Figure 1). The remainder of direction is then fine tuning of particular aspects of the project.

The provision of an inception report with clear milestones, timing, and resource requirements should be a requirement of all projects. This report may provide some useful ideas to Regions and demonstrate the level of detail supplied at the outset of a project (to be compared to its conclusion).

It may be worthwhile to quickly review this document if embarking upon a study but later reports will provide better insight.

2.2.2 The Falling and Receding Foreshore in the Anglian Region: April 1987, SWHP Ltd in association with BMT and HR

This report provides extracts from study proposals and information upon the team to be working upon the project from the consultants side. It helps to define roles and responsibilities of the main consultant and the numerous sub-consultants. The definition of the approaches to be taken, methodology to be applied, expected outputs, and timescales supports the inception report from a more technical bias. It is critical that the client understands the technical implications of the project and the risks involved with proposals. It is then a management decision as to the level of risk versus the sophistication of output. This may require independent peer review if the client does not have sufficient skills or resources in-house.

Fig. 1 Programme of Works

Task No.	Activity	Month 1	2	3	4	5	6	7	8	9
1000	REFERRAL DATA BASE									
1010	Gather and screen references	—	- -	- -	- -	- -				
1020	Confirm Data sources	—	- -	- -	- -	- -				
1030	Input into data base	—	—							
2000	RELATIONAL DATA BASE									
2010	Set up software and base map	—	—							
2020	Historical change		—	—	—					
2030	Morphological Features			—	—					
2040	Tides		—							
2050	Extreme levels		—							
2060	Sediment Budget					—				
2070	Habitats			—						
2080	Pollutant levels				—					
2090	Coastal Usage					—				
2100	Gather Beach Profiles	—	—							
2110	Carry out interpretive analysis of data base					—	—			
3000	SUPPLEMENTARY STUDIES									
3010	Refine Nearshore wave climate	—	—	—	—					
3020	Examine current residuals		—	—						
3030	Beach profile analysis		—	—	—					
3040	Study climatic influences on sea levels				—	—				
3050	Geological history and techtonic movements	—	—	—						
3060	Review of International literature	- -	—	—	- -					
3070	Define Stage III Studies						—			
3080	Propose short term management policy						—			
4000	REPORTING									
4010	Prepare Atlas						—	—		
4020	Draft Report							—		
4030	Client Review								—	
4040	Finalise Report and Atlas									—
5000	PROJECT MANAGEMENT									
5010	Liason with Anglian Water	- -	- -	- -	- -	- -	- -	- -	- -	- -
5020	Co-ordination of inputs	- -	- -	- -	- -	- -	- -	- -	- -	- -

It may be worthwhile to quickly review this document if embarking upon a study but later reports will provide better insight.

2.3 Stage II

2.3.1 Study Report: November 1988, SWHP Ltd in association with BMT & HR

This provides a full description of the stage II projects, with focus on the development and application of the database systems and the ensuing results. This stage report is important in the management of the project to measure the inception promises against the real deliverables. This also provides a useful point to consider the next stage of the study and identify new opportunities or different approaches that may be taken. The report contains information on referral databases, relational databases, supplementary studies, the coastal atlas and a discussion of the results of the study to that point in time: The information on databases may provide useful background reading for those utilising IS in their studies or wishing to gain a basic insight to GIS; the supplementary study information may provide useful ideas of how to gather and interpret information such as wave, tidal, and shoreline change data; the section relating to the Atlas gives a brief description of the approach taken and discusses the value of this form of output; the discussion of results to date is largely applicable to the Anglian region but there are generic approaches outlined that could be applied to any coastline and provide inspiration for approaches to adopt in undertaking strategic studies.

An interesting and useful document for basic ideas. Contains historic data sets for Anglian Region which may be applicable to those Regions who abut it. Developments since 1988 have resulted in the report being superseded in many respects. The final study reports provide a summary of these studies but this is the original record.

2.3.2 Anglian Coastal Management Atlas: November 1988, SWHP Ltd

The Coastal Management Atlas provides interpretive maps with explanatory text for the Anglian coast (Appendix 1). The Atlas has proved a useful document to have for the first stages of any strategic planning. It provides a rapid overview of the Region against which prioritisation can begin. The layout and content of the Atlas may be useful to other Regions and if embarking upon such studies it should be considered as a deliverable at the outset. The limitation with the Atlas is that certain of the data in it is now out-dated and it requires revision. If information systems are being considered with the study then it is important to ensure that the ability to reproduce such documents in the future is built into the project. It was produced at the end of stage II, the subsequent data collection in stage III and the annual monitoring mean that many of the descriptions could be revised and updated and comparisons drawn between them.

The Atlas has also proved a valuable document for communicating information to lay-people. The compilation of data into such accessible form could be undertaken by all regions to provide a national overview of the basic parameters effecting and influencing the shape of the coastline. This could have a benefit to the NRA for external consultations and as a working document within the evolving coastal management scene.

The Atlas provides a snap-shot of data, and helps to identify some of the philosophy, from Stage II. The snap-shot limits it's usefulness for flood defence as it becomes older but is a useful reference document to compare the present with. The Atlas provides a useful summary of information which could usefully be repeated for all Regions.

2.3.3 Supplementary Studies Report: November 1988, SWHP Ltd in association with BMT & HR

This document provides write-ups of the work undertaken in Stage II of the SDMS. The main emphasis of the work is on the forces upon and responses of the foreshore with particular respect to their change in level:

- Wave Climate

  This section provides general information which may be helpful in identifying approaches to wave data collection and the identification of models to be used. It may assist in assessing utilisation of resources to optimise outputs;

- Residual Currents

  This section gives some background into tidal effects and the way to consider the motion of tidal water in respect of moving sediment. Some tidal formulae are outlined and the function of components of tidal flows;

- Beach Profile Analysis

  This considers the capture and storage of beach information in the Anglian Region and consideration of how to analyze such data. All historic information was collated with little or no survey work being carried out specifically for the report. The need for consistent approaches to beach surveys is also identified;

- Extreme Sea-Levels

  The North Sea has been subjected to many storm surges over the years and as such the extreme water levels produced by tide and surge conditions are particularly important. The section considers the data available and techniques for assessing the extreme values over time;

- Sea-level Change

  This provides an introduction to Holocene sea-level change and how sea-level change effects coastal processes including some general formulae. The information homes in to the east coast but will be of use to those regions adjoining Anglian;

- Literature Review

  This provides a description of how the review of literature relating to the Anglian Region was undertaken. This may be useful as a model to follow for other such studies but may require additional categories dependant upon the type of coastline in question.

This report provides useful background information and methodologies for the consideration of a variety of coastal processes effecting the shoreline. It would provide a useful starting point to obtain background understanding of the issues and enable informed development of a project. Some of the thinking in the report has been superseded more recently but it is none-the-less an interesting and informative report which is applicable to all regions.

2.3.4 Strategy Report and Addendum: November 1988, SWHP Ltd in association with BMT & HR

The Stage II Management Strategy Report was largely superseded by the Stage III strategy report. However it shows how the early thinking was developing and is a useful document to compare to the later reports. It also put forward recommendations for further studies to be undertaken which would improve understanding of certain physical processes operative within the study region. This is an important element of such interim reports to ensure that review and where necessary re-guidance of the project is undertaken.

The report shows the first thinking towards the shoreline management approach and provides a useful background to later developments. The philosophy of approach is pertinent to all Regions but some of the specific outputs do not represent the fuller picture developed by the end of stage III. The stage III strategy report has greater value for other regions to gain an insight to how the strategic thinking developed in the Anglian Region.

2.4 Stage III

2.4.1 GIS Review: July 1989, SWHP Ltd

After Stage II of the SDMS it was clear that a Geographic Information System (GIS) was the best way to handle the data. A review of the Geographical Information System (GIS) requirements for the coastal management system was undertaken and recommended the selection of the Intergraph MGE.

The report provides a useful comparison of systems in terms of targeted requirements for shoreline management. Many of the comparisons are still valid although all GIS have developed since the date of the report. This report may provide useful insight into what features to compare and contrast between systems.

2.4.2 Field Survey Reports: September 1990 SWHP Ltd (Sub-Contractor: BMT Ceemaid Ltd); July 1990, SWHP Ltd (Sub Contractor: BGS); May 1990, SWHP Ltd (Sub Contractor: GeoSea)

The Field Surveys identified as essential elements to be picked up under stage III are reported in a series of reports. The three main area are nearshore bathymetric survey, geological survey, and Humber Estuary sediment trends. These are in a series of reports and data sets:

- Nearshore Bathymetric Survey

  This exercise proved useful in two respects: It enabled definition of the nearshore zone, and, produced guidance on the extent of future survey work in a monitoring programme. The reports provide data to in-fill the critical gap between offshore admiralty survey and the on-shore beach profile surveys. The methodology of survey and profile establishment has been improved in subsequent NRA Anglian work.

  The report outlines the method, equipment, fixing positions, control, photographs, survey lines, reports etc used for this survey. These elements have been improved on and developed since SDMS into a tight specification which forms the basis of the existing Bathymetric Survey Programme. The project is useful as a style but there was no long-term view taken at the time.

- Nearshore Geological Survey

  This survey created geological corridors at 16 locations spanning the coastal strip and nearshore sea bed between Flamborough Head and Maplin Sands. The survey included the mobile and non-mobile geology giving an indication of the stability of sections of the coast and the potential for sediment movement in the nearshore and beach zones. This data set has proven very useful as a baseline data set which requires infrequent updating (Appendix 2). It is recognised that it would be worth extending this data set to provide complete coverage. This could be a progressive exercise, done to a standard format, when surveys are carried out in association with specific schemes as the need arises.

  The report on the Nearshore Geological Survey gives some useful background to the information but does not reflect the value of capturing this data as a set of information. The data relating to non-mobile geology may not need to be updated for some considerable time, and the information on mobile sediments provides a useful baseline that can be updated at anytime.

- Estuary Sediment Trends (Humber)

  This reports on studies of sediment transport in the Humber Estuary. The methodology used for this study may be useful to other regions to determine sources and sinks of sediments in estuaries. Other estuaries could be studied in a similar fashion to build up understanding of sediment movements in these locations.

  A good report which recognises erosion at Holderness and the need for the supply of sediment in Lincolnshire\The Wash to provide protection. The localised aspect makes the report directly applicable to the Anglian and Yorkshire regions, but the methodology is of interest to a wider audience.

2.4.3 Data Collection and Analysis Programme for the Anglian Shoreline Guidelines: May 1990, SWHP Ltd; January 1991, SWHP Ltd

These set out a programme of monitoring requirements for the shoreline (Fig. 2) which include details on the processes affecting shoreline behaviour, technical requirements of the monitoring system, operational requirements and consequential influences on the monitoring guidelines, programme costs, sensitivity appraisals, the system rationale and conclusions and recommendations. A definition of the long term monitoring requirements for the region.

A useful document in terms of reference, containing a review of the long-term monitoring requirements (locations, accuracy, density, frequency, presentation etc) which have been incorporated and improved on in the subsequent work of the Region. These documents would provide a valid start point for any region embarking upon a strategic monitoring programme.

2.4.4 Satellite Data Classification: September 1990, SWHP Ltd

A report to establish the extent to which Landsat Thematic Mapper (TM) data can be used in a monitoring programme of vegetation and/or sediment change in the Wash and Essex estuaries. The report will be of use to anyone considering using this technology but should be carefully interpreted. The increasing availability of data from the use of satellite images coupled with improved analysis techniques, suggests that it would be worth repeating this study for all regions with saltmarsh areas.

The report is useful, but it is questioned if the conclusions are correct. The report gives the impression that satellite imagery was not fine enough resolution to be used in monitoring vegetation/sediment in anything other than the long-term. This approach should be used to gain an overview of the situation rather than provide data suitable for comparable temporal analysis or suitably accurate quantitative values of such aspects as saltmarsh erosion rates.

2.4.5 Assessment of Beach Survey Techniques: September 1990, SWHP Ltd

This report reviewed the methods of undertaking survey work and their suitability for shoreline management. The report considers accuracy and frequency of beach surveys, the comparison between conventional and aerial surveys, information on the database software developed to store and analyze beach profiles (BDAS), and how beach profile data had been updated and reviewed.

The document contains some useful information but is open to challenges on a number of issues. Fuller consideration of this subject area is required.

2.4.6 Sediment Modelling: February 1991, SWHP Ltd (Sub-contractor: HR Wallingford & Imperial College)

This reports on the development of a numerical model of beach profile development through a sediment budget approach. It outlines the approaches taken and how the model reacted to test data sets. The model may have wider application to other regions but is not copyrighted by NRA. The report may provide some useful insight to modelling issues.

DATA ACQUISITION: SUMMARY TABLE I

Type	Description	Format	Frequency	Analysis	Storage	Archive	Use
A. FORCING:	Wind	. Strength . Direction (floppy disc or similar)	Hourly	Inshore wave climate Offshore storm climate	Head Office - analysis summaries to Areas	Head Office	Determination of typicality of exposure conditions and the impact energy against the shoreline for different level ranges.
	Still water level	- height ref. to datum (floppy disc or similar)	Quarter-hourly	Harmonic analysis Integration with inshore wave climate calculation	Head Office - analysis summaries to Areas	Head Office	Input to inshore wave climate and identification of differences between astronomic tidal prediction and actual water levels.
	Tidal Prism Assessment	Still water levels and currents strength and direction (hardcopy and magnetic tape)	Annual (with five to ten year cycle times for specific estuaries)	Tidal prism computation	Head Office and Areas	Areas	Determination of estuary change and correllation of such changes with saltmarsh integrity surveys.
B. RESPONSE:	Aerial Survey	Photographs (stereoscopic pairs)	Annual (extended to survey saltmarsh every five years)	Foreshore/Backshore levels (ref. Fig.4)	Head Office - level data in hardcopy to Areas	Head Office	Containing of Foreshore and Backshore features - monitoring of high water and low water mark movements - Production of beach profiles. Monitoring of saltmarsh areas.
	Land Survey	- (hardcopy numeric listings)	Biannual	Time series changes - correllation with impact energy at discrete level ranges.	Areas and Head Office	Areas	Ground truth for aerial survey and progression of time series profiles of longstanding.

	Hydrographic Survey	co-ordinated depths as spot heights and contours (hard copy and magnetic tape	Quinquennial	Time series changes - correllation with exposure conditions and their typicality	Head Office - hard copies of data to Areas	Head Office	Updating inshore wave climate transfer functions and thereby impact energy to the shoreline.
	Inspections	Manual records	Biannual	Time series changes from fixed-aspect photographs; dip records etc.	Head Office and Areas	Areas	Interpretation of results from other analyses - co-ordinating the various data against sea defence objectives
C. ADVICES:	Present status	Report	Biannual (with Autumn review of whole year)	Interpretation of results from forcing and response analyses	Head Office and Areas	Head Office and Areas	Planning of short-term operations and medium/long term investment requirements.
	Trends	Report	Biannual	Time series with forecasts - comparison with established 'thresholds'	Head Office and Areas	Head Office and Areas	Identification of timescales to critical conditions to assist planning of works - notification of long-term trends for strategic planning/studies etc.

The report highlights the limitations of modelling in the conclusions and the model itself is considered to need better validation. There is a lack of confidence in the modelling.

2.4.7 Tidal Circulation: February 1991, SWHP Ltd (Sub Contractor: UKAEA Harwell)

This report describes the calibration and verification of a hydrodynamic model developed to perform the calculation of current residuals. Quite often it is not practical to develop nearshore tidal currents on a project by project basis and so blanket coverage may provide the most cost effective solution. The report provides valuable information on the approach taken and the results of the analysis. The model could be developed in a number of ways, particularly to give finer resolution of information nearshore, in estuaries, and around geomorphological features. The data output from the model is frequently used in Anglian Region and provides a clear and consistent set of information (Appendix 3).

The study appears to be a good starting point. Currently, the report is slightly coarse and difficult to apply to detailed investigation/designs. Further development is required to increase the detail and content and to extend it into validated sediment transport. Extending the model developed under the SDMS to other regions would have similar benefits. Given that model development costs have been covered, this would be a cost effective way of establishing nearshore tidal currents within each region.

2.4.8 Offshore Banks (plus demo disk): February 1991, SWHP Ltd

This reports the variation in the configuration of sand banks off the East Anglian coast between Winterton and Benacre (Appendix 4). It is of direct relevance to the Anglian Region but does contain information on the methodology of analysis of the information. This approach could be applied to any mobile bank location.

The report is hard to follow and could have been presented in a much simpler form. The inclusion of a disk to show time series changes is very useful and is an effective way of communicating the information.

2.4.9 Impact of Sea Level Rise: February 1991, SWHP Ltd (Sub Contractor: University of Durham)

This examination looks at the potential impacts of projected sea-level rise on the Fenland and the coastline of the Wash. This used IPCC (1990) projections of sea-level rise to 2100 which were adapted to local conditions.

Nothing conclusive has been derived from this report and the report admits that data is not available to enable trends over more than 30-40 years to be considered. The report has local significance only.

2.4.10 Impact of Climate Change: February 1991, SWHP Ltd (Sub Contractor: UEA)

The report shows the results of research examining the history of storminess over the North Sea, the incidence of storm surges, and likely future patterns of storminess. The methodology adopted shows initiative and may well be a useful approach to apply to other sections of the coastline. The general conclusion that storminess has increased over the last decade, but this is not significantly different to the background, is very important.

The report pushes the data analysis and modelling to the limit. The results have great significance for the east coast but may also have wider applicability. The method of approach is worthy of consideration by other regions.

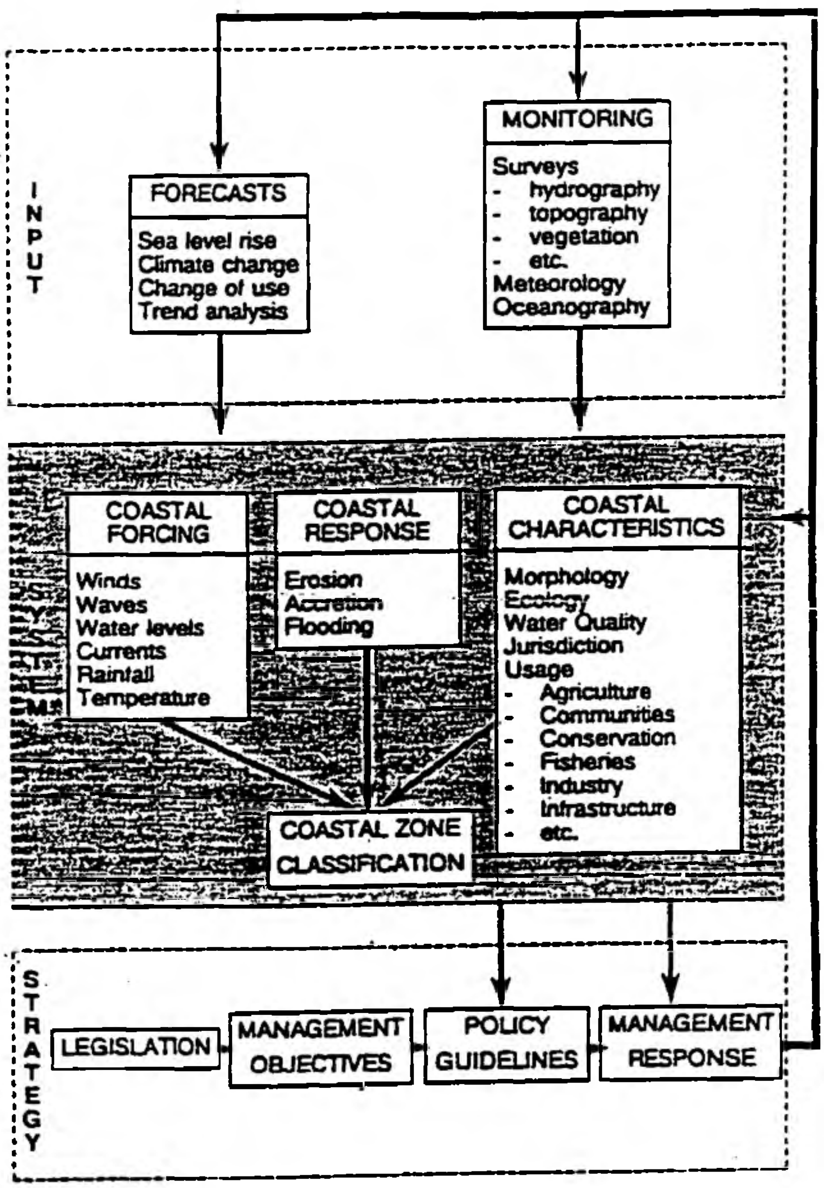


Figure 3 Responsive Management Framework

2.4.11 Review of Essex Saltings Programme: November 1990, SWHP Ltd

This considers the history, present conditions, and future developments of saltmarsh research in Essex. The report identified and focused attention on the problems associated with the Essex saltings and suggested development of the work onto a national platform.

The report has local significance regarding the Essex work but the programme of research it reports upon has a wider applicability. The report identifies the need for a coordinate national programme to be undertaken.

2.4.12 Stage III Study Report: April 1991, SWHP Ltd

This summary report describes all aspects of the project including, field work, detailed studies of specific processes, future monitoring requirements for the region and the continuing implementation of GIS to store and manipulate data. It deals with all the reports above and wider aspects of the SDMS. The future needs from the project were also considered.

As a review of the project the report is useful as everything is pulled together, giving a synopsis of all the other reports. Insight into the methodology and terms of reference used is also given. This report should be used as a starting point for information on the studies undertaken before referring to the detailed reports above. This report would be of value to anyone considering embarking upon strategic work as well as having information of local and wider importance.

The belief of the consultants is that the recommendations which were made relating to future needs in this report are still worthy of consideration.

2.4.13 The Future of Shoreline Management: October 1991, SWHP Ltd & NRA Anglian Region

This report was produced by NRA and SWHP staff for the launch of the SDMS in 1991. The report covers the key findings from the SDMS and is similar to the stage III study report. This report is in less depth than the Stage II report but deals with conceptual and general aspects of the project to a wider extent (Figure 3).

This report will be of value to all regions to gain an appreciation of the SDMS and to identify how it may be applicable to their region. It is also of value for specific information and methodologies which may be applicable to other regions.

	STUDY PLANNING	APPROACHES & METHODOLOGIES	GENERAL INFORMATION & KNOWLEDGE	LOCAL INFORMATION & KNOWLEDGE
STAGE I REPORTS				
INCEPTION REPORT	*			
THE FALLING & RECEEDING FORESHORE IN THE ANGLIAN REGION				*
STAGE II REPORTS				
STUDY REPORT	*	*		
ANGLIAN COASTAL MANAGEMENT ATLAS			*	
SUPPLEMENTARY STUDIES REPORT		*	*	
STRATEGY REPORT	*	*		
STAGE III REPORTS				
GIS REVIEW		*		
FIELD SURVEY REPORT			*	*
DATA COLLECTION & ANALYSIS PROGRAMME FOR THE ANGLIAN SHORELINE		*		
SATELLIE DATA CLASSIFICATION		*		*
ASSESSMENT OF BEACH SURVEY TECHNIQUES		*		
SEDIMENT MODELLING		*	*	
TIDAL CIRCULATION		*	*	
OFFSHORE BANKS		*		*
IMPACT OF SEA LEVEL RISE			*	
IMPACT OF CLIMATIC CHANGE			*	
REVIEW OF ESSEX SALTINGS PROGRAMME		*		*
STAGE III STUDY REPORT		*		
THE FUTURE OF SHORELINE MANAGEMENT CONFERENCE PAPERS		*		

Fig. 4 Summary of SDMS reports

3 GIS SYSTEM REVIEW

3.1 Introduction

One of the cornerstones of the SDMS was the use of GIS as the best approach to handling data. As part of the study a review of proprietary GIS was undertaken by both client and consultant. These reviews (GIS Review 1989) arrived at the same conclusion, a modular system was more desirable than a fixed one and that facilities to interface or integrate models should be available. From the available systems the Intergraph MGE provided the optimal combination of functionality and flexibility. This work has wider implications for the Region in terms of initiating GIS in the Anglian Region and providing a direction for development of an integrated system. This also has positive conclusions for any national approach to IT to produce compatible systems where use of developmental resources can be maximised on a national basis.

3.2 What is GIS?

A geographical information system, in common with other Information Systems, provides tools for data input, storage, manipulation and output.

It differs in that the tools have been developed to effectively handle the spatial attributes of data, i.e. their location and extent in space, as well as providing the functionality for descriptions, magnitudes, and classifications in the graphical environment.

GIS is a multinational, multi billion dollar industry which has had a very high profile over the last five years. GIS as a description is inadequate in that it covers a consortium of solutions to the spatial data handling needs of organisations and means different things to different people. The marketing of the main GIS suppliers and manufactures leads potential and current customers to have a feeling that only turn-key GIS is 'real' GIS and there is only <u>one</u> solution to our spatial data handling needs.

There are however, a number of options to meet the customers needs. The driving force behind final selection is the question that will be likely to need answering using the system (Figure 5).

3.3 SDMS Options Within GIS

The relative importance of the questions asked varies throughout the life of the system. The perception of their importance also determines the investment over time and the development direction of the system. These issues need some consideration at the outset of any project involving GIS. At the time of the study four options were available within the product range chosen by both NRA and the consultant. These were:

- PC Microstation with Dbase and/or Oracle;
- Workstation/UNIX Microstation with Informix;
- UNIX - Modular GIS Environment Base product;
- UNIX - MGE & MGA & MGGA.

EVOLUTIONARY DEVELOPMENT MODEL

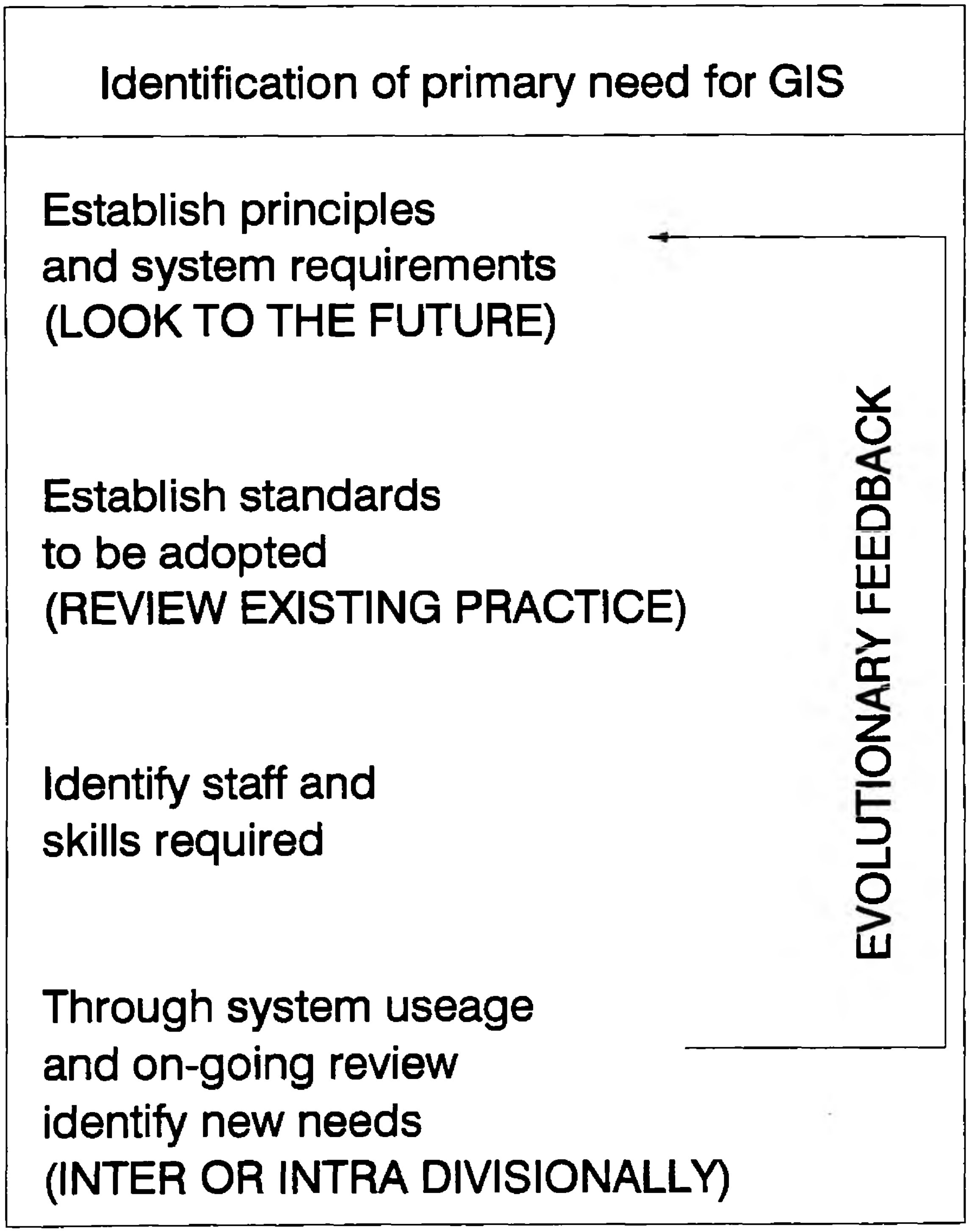


Fig. 5 Evolutionary Development Model

The fundamental needs of the project dictated that the selected option would have to be able to process large volumes of spatial data and generate a suitable summary of the nature of the coast. The system also had to be able to be applied to produce information to provide a consistent management approach for the shoreline.

Stage II of the SDMS aimed to understand the governing mechanisms of coastal processes along the Anglian coastline. This was to be facilitated by the provision of tools that gave the consultants the ability to analyze and assess existing sources of information. There was therefore a need to manipulate large volumes of information rapidly, see data geographically, see how each feature varied along the coastline, assess the interaction and inter-relationships geographically, and produce maps that could be readily interpreted by professionals in understanding the observed interactions. The fundamentals of this are processing power and clear graphical outputs.

3.4 System Development and Use

When commencing on a GIS route it is difficult to assess just what can be achieved. The initial impetus is to meet a specific need, which GIS is selected as the best option. With increasing demands upon computerised systems and personnel it is often the case that grand claims are made of a system. This leads those who don't understand GIS to believe it is a magic button and leaves those managing GIS seeking development to attain the perceived functionality.

The NRA Anglian Region, as with any organisation, had to face the decision of committing themselves to a major investment in GIS over a short timescale (ie the Big Bang approach) or to go for a phased implementation over a longer timescale. The system was developed with the gradual implementation of GIS with other functions in mind, however much of the system customisation is not practically available to other functions.

The business needs during the development of the system were the investigation of strategic systems for the Management of the Regions Sea Defence. This was agreed with the consultants where they recommended a detailed study would need to be made to consider issues of data maintenance, existing hardware capabilities and require capability identification of those operational groups within the Authority who would benefit from having some, or all, study data sets on-line and the provision of data access to bodies outside of the Authority. Trial implementation on a small scale would be the cost effective manner of identifying potential problems and benefits of such an attempt at data distribution. Data capture was therefore often tailored to very specific applications to ensure the cost effectiveness of the studies.

For example information from aerial photographs were captured in a digital form in a fairly crude manner. The same data was later required for further use in another study requiring extra expenditure. Much of the data has been captured in an unstructured format to allow graphical overlay of multiple datasets. The data may even have had some preliminary topological processing to intersect the linework. However to carry out fuller GIS analysis will require significant resources for some of the datasets.

Effort that would have been more cost-effective if carried out at the time of the initial data capture and prior to the need to produce results. Also, the classification of data may not be appropriate for all applications.

The cross functional development of GIS impacts on how the system will develop within Engineering. A major disadvantage is the increasing inter-dependence. For example, the Region recently embarked on a data capture exercise of over fifty themes of operational and environmental data for cross functional use. This project finished considerably late which caused major set backs for several GIS applications. Likewise there are major data resources which could and need to be integrated with the Engineering system to facilitate the change to Project Design based applications. These departments (eg: Conservation) are only just embarking on the GIS path.

In summary one of the main problems with the initial implementation is the belief that the system has all the answers - a common expectation of many information systems. The crude hype has to be converted into a more sophisticated user education. Access to the system can then be provided by the developers providing the right data and analyses in the first instance followed by giving Project Engineers 'viewing' access to the key data assets and functions they require.

3.4.1 Data and Information Standards

The main difficulty with the 'big bang' approach is the ability to satisfy all the users needs and to be able to specify up front the functionality and customisation that will be required. Users can be unaware of the potential facilities that could be available or they can be distracted from their core requirements by the more sophisticated functionality presented by vendors.

Model

The experiences of the NRA Anglian Region make it possible to present a model of evolution for GIS within divisionalised organisations (diagram). This simplified model has the starting point of a particular need for which the GIS approach is clearly justifiable and has been purchased nationally by the NRA to provide a common start point for data capture for all regions.

From the primary need it is possible to establish principles relating to the system. It is crucial to establish these principles at the outset to ensure the integrity of ownership of the system and the data within it. The starting point must be the immediate user requirements. This determines the sequencing of development and the key information sets required. At this stage it is also crucial to try to identify possible future requirements or alternative uses of the system by that junction.

The user requirements will also help to define the ownership of parts of the system and the data to be held within it. This enables responsibilities to be assigned and quality control measures to be established and effectively managed.

Having established the principles of how the system is to be created, the standards for information to feed the system must be established. This will address issues such as the structuring of data, the format of specific files, how information may be exchanged with other systems, and any standard approaches adopted by other sections or other organisations. This prevents repetition of development, divergence of approaches, and, maximises integration with existing practices.

Once the Specification for the system is established the necessary staff and skills need to be identified. This should consider the end users, who will provide technical support, any specialist skills required, and who will provide the overall management of the system and its usage. These appointments may well bring new skills into a department and require external assistance in identifying the "right person for the job". If the initial system development is to be external to the organisation it is essential to appoint the appropriate technical expertise at the beginning to ensure a smooth assimilation of the system into the organisation.

The usage of the system once within the organisation will help determine the customer needs. These needs require periodic review to ensure the customer is satisfied with functionality and procedure and to identify new areas of development that are required. These areas may involve a different division of the organisation or customer needs from the initial implementation. With the identification of a new need the development model feeds back upon itself to reconsider the principles, standards, and staff and skill requirements. Hence the system continues to evolve in conformity with the evolutionary model.

As the system continues to evolve it is an appropriate time for the Authority to undertake a review as to:

- whether the monitoring programme is effectively maintaining data currency;
- whether data sets outside the monitoring programme are being maintained.

The second of these reviews would initially involve assessing the extent to which different data sets were being used, and thereby establishing the relative merits in devoting resources to maintaining them. This prioritisation could then be coupled with a review programme for each of the data sets. Much of the information for drawing up such a programme could be based on the information within the data dictionary detailing the update and revision type for each of the data sets.

In its current form the Data Dictionary is separate to the GIS component of the management system . The consultant view is that integrating the two more fully would increase the users awareness of the utility in terms of use and maintenance requirements The dictionary would also benefit from the inclusion of more detailed information relating to data sources, reliability and functions of the data with respect to system utilities. There also is an immediate option to link the Management System to the Shoreline Monitoring Programme by porting data from SANDS directly into the SMS. There should also be scope for integrating other routine monitoring programmes undertaken by the Authority. Given recent work within the Water Quality department on similar systems potential for integration of water quality data within the existing management system should be reviewed.

The system is very extensive, containing a wide range of data for over 1500km of coast. During the analysis phase of the project, the ability to use and manipulate data for this purpose was thoroughly tested, where now it has been proven as a valuable management tool. A key aspect of the system is the need to keep it up to date and this is the role of the monitoring programme.

3.4.2 System Customisation

Initial GIS work was focused on simplistic geographical overlay and digital cartographic presentations. The initial use did allow the Region to gain insight, and focus the objectives, of fieldwork and numerical model studies.

It was recognised at any early stage of the study that a degree of software development would be necessary to meet the study system requirements. The review of GIS undertaken at the end of Stage II addressed this issue in terms of assessing the ease and degree of system customisation available with proprietary software packages.

Several major software suppliers were able to provide the tools to carry out the required tasks. The basic tools were customised to deliver a "management system" at the end of the contract. The development of the Shoreline Management System (SMS) however, was not to be seen as a stand alone system, but as one part of the corporate data requirements of the Region. Additional constraints/requirements existed in the need for central shared data resource, user ownership and quality control of data.

Within Stage III the use of GIS was envisaged to enable; retrieval of information for a specific site, provision of summary data for planning purposes, preparation of graphical displays for educational and public relations exercises, classification of coast into management zones and sensitivity testing of the classification system. Additionally there would be predictive modelling to determine projections of coastal change, impact of individual schemes, impacts from change of use and economic consequences (eg: sea level rise).

The standard GIS analysis facilities have been extended to meet the specific needs of shoreline management. The additional utilities include:

- x-y graph — allows various forms of graph to be generated
- chainage — enables changes along the coast to be analyzed
- photos — enables raster scanned photographs to be displayed
- graphical attributes — manipulates sketches and annotated cross-sections
- statistics — provides statistical analysis of user defined queries
- data dictionary — tools to document the data model
- display — allows the user to explore the different data sets, without any prior knowledge of the data structure
- graphs — graphical displays specific to particular type of data (eg: wind and wave roses, current vectors, etc.) (Appendix 5)
- reports — enable the user to select a location and produce a report (eg: all design information for a site or a summary of the data relevant to an environmental assessment)
- models — these include; a utility to manipulate the coastal zone classification data; mapping of a hazard zone based on projection of retreat rates; and computing overtopping of all sea defence for given storm conditions.

The base of GIS software was in its infancy. At the point where the Management System was delivered, the standard system software supplied by Intergraph itself was still undergoing speedy evolution.

The consultants now view this as being problematic for two main reasons in terms of system development:

1 A substantial amount of resources were devoted to developing system utilities which enhanced the systems base functionally. These included utilities which enabled functions such as fenced reporting, reference file attachment, access to database tables linked through relational joins and rapid data entry through use of look up tables.

Subsequent to delivery of the system to the Authority, all of the above utilities became unnecessary and redundant within a relatively short time period. This was due to the fact that as Integraph's base software evolved it incorporated the above functions as standard. The effect of this was to devalue the worth of these system customisations, whilst the overall functionality of the system remained unchanged. The support of system utility software through one source (Integraph) provides a consistent and sustainable approach to system development.

2 The rapid changes in the structure of the standard system software supplied by Integraph meant that post delivery as the Authority wished to upgrade the Integraph software it became necessary to rewrite the customised system utilities. The process was demanding of resource and expense and benefits were short lived as further development in the base system soon meant the upgraded utilities would require recompiling again.

The decision to use Integraph software was not based solely on its ability to be customised. Though the initially planned developments were achieved, this success is somewhat tempered by the fact that it was only sustainable for as long as the base system software remained unchanged.

The rapidity of proprietary system development is clearly an issue of concern. The experience of this development has led to the conclusion that source coding must be made available to NRA on software developments linked to other systems and that NRA must be able to modify code (or have it done on their behalf). If not there is a danger of being coded into one consultant to maintain and control the software.

It was recognised by the region that there may be difficulty in trading off the customisation of a proprietary GIS to very specific current business needs against allowing users to access functionality and develop skills which give true added value to our business information once the initial learning curve has been gone through.

Disadvantages were that the core resources necessary to succeed are only acquired gradually. It can be difficult to control a centralised approach to data management necessary for the sharing of information across functions. Initial applications also have to bear the burden of the start up costs, if pump priming funding is not provided.

3.4.3 System Development

In the consultants view optimisation of the system data usage would be aided by a wider distribution and availability. This is more readily achievable than in the past due to the portability of the system data between hardware platforms and software packages.

The system as initially delivered could only be run on Integraph UNIX platforms. Two major changes have taken place since. Firstly the cost of such hardware has fallen by a significant amount. Secondly the data sets and software utilities are now portable to DOS PC's. Both of these factors reduce the costs of making information more widely available. For example it would be relatively easy, by comparison to their original development, to transfer existing MDL utilities within SMS to run on PC's.

More significantly perhaps than the change in hardware dependence is the recent change in software dependence. Utilities now exist to efficiently transfer data from the existing Integraph system to a less sophisticated GIS, Map Info.

Shortfalls of the system are that it is tied to a policy. Software development is seen as being too much too soon with non-maximising benefit with development resulting in the need to upgrade the system. More pc's initially would have given greater value for money, with the data used seen as being simplistic, incomplete, not enough attention to what was core and what was 'superfluous', not good enough for design, requiring monitoring programme data and the required staff not in place.

Recent developments written in Microstation Development Language have proved relatively easy to upgrade compared with earlier developments in 'c', Micro CSL and I/FORMS. Of the original utilities delivered those relating to statistical analysis and graphing of variables should be considered for translation to MDL.

3.4.4 Training and Resources

GIS is an "end use" technology and at the outset there was not a clearly defined view of who the end users were going to be. Questions arose on who was going to run the technical day to day operations of the system, who were the end users of the information, how was the information to be provided, ie what was meaningful, and how many requests there would be and how quickly they need to be dealt with. The importance of such constraints cannot be under estimated.

GIS can provide the tools for presenting the information, but during the time of the study it was unclear what impact the final system would have on the regions work and what the potential of the system was.

In addition to this the consultants recommend that associated with wider system usage would be a requirement for further training, which would not only provide assistance for system users but would also generate a greater appreciation of the system data and capabilities. Once an awareness of these begins to grow, systems users should be encouraged to suggest further potential use for the management system. The argument that system development will best be driven once tangible benefits are recognised by those making use of the technology is a strong one and should not be overlooked by the Authority. Resources need to be made available to facilitate such an appreciation through training and internal promotion.

GIS is a labour intensive activity and places high demands on existing staff if it is to be successfully implemented. The Region only gradually had the resources to have staff working full-time on the system. Job descriptions had to be adapted to ensure that requests for information and analysis could be met. The first six months saw the installation of the system, high profile internal and external publicity and insufficient resources to operate the system on a day to day basis. The system could easily have fallen by the wayside and a considerable investment would have been wasted.

Management need to be aware of the human resource implications of GIS as well as capital level for hardware, software and data. Staff need to be in place at an early stage to ensure they can be involved in the design process and can accrue invaluable system and data handling experience.

There is also the need to define the relationships between the different users before commencing. This is important but not always possible as user awareness and enthusiasm will not necessarily be uniform across departments, leading to a reluctance to be involved in even a limited way. Anglian Region have therefore tried to develop an approach which tries to make the best of the prevailing organisational climate and the business needs of the NRA divisions. Applications are developed as the business needs are identified within an overall data and system framework. However, there has been no attempt to implement GIS organisation wide.

The support contract set up post delivery of the management system though useful could have provided more. Immediately after delivery of the system there was little communication between the Authority staff using the system and the system development team. This perhaps reflected the learning curve of the Authority staff who were first having to familiarise themselves with the system prior to putting it to operational use. Only once the data and utilities were sought to be employed with specific objectives did the Authority staff begin to make regular use of the support facility. Had greater resources been allocated to the system handover the time period between installation and use of the management system would have been shorter.

From interviews with engineering staff (D. Leggett) it would appear that the department is dissatisfied with the SMS' performance so far. The main criticisms seem to emanate from a lack of understanding of the system and the nature of information generated from the original study. Many of the queries raised by the Authority related to source an representation of system data, rather than its role in the SDMS. This would indicate a requirement for more detailed documentation of data source definition within the data dictionary.

The support contract was also the sole source of funding for system development and upgrades. This meant that the majority of the support budget was spent on software development as opposed to user support. The inclusion of further system development within discrete project budgets may be appropriate as a means for furthering the development of the SMS software, so separating the budgets for support and development. Proposals for restructuring the support contract have been put to the Authority which have more clearly defined the separate costs of user support, system upgrade and extension through development. This current review should allow the Authority to give further consideration to these proposals. To data the support contract has provided the sole budget for further system development. Were the SMS to be implemented at other NRA Regions there would be obvious benefits in sharing the burden of development costs between sites as well as wider user group who could direct system developments.

3.5 Conclusions

The NRA Anglian Region did not adopt a structured developmental path for GIS. Development has been driven by business needs to provide effective GIS services meeting user and internal customer requirements. The initial development of the SMS has followed an evolutionary path. The model of this evolution has been repeated as new flood defence needs have been identified and potentials of GIS realised. This approach has enabled a flexible development path which ensures that each need is met in the most effective way. This same model has been employed for other divisions of the NRA and they have a similar evolutionary feedback. Clearly the Primary Need and first phase of development bears the most cost and requires the deepest consideration. Further developments can build upon this basis and gain the benefit of experiences and skills acquired in the initial development.

GIS is not a magic button, but has proven itself already in the Anglian Region by becoming an integral part of divisional business. In order to realise the full potential of GIS it must remain flexible and be allowed to follow an evolutionary path. This enables GIS to respond to change and makes system review an on-going process. The Evolutionary Development Model allows this process to be at a scale and pace appropriate to organisational needs, while building the core infrastructure for handling geographic information.

4 SANDS SYSTEM REVIEW

4.1 Introduction

The Anglian Region NRA identified the need for a database system to hold coastal data at a district level. The system would hold data needed to make management decisions and provide backup data for apparent trends. For this reason an extension of the Geographical Information System (GIS) already held at Headquarters was not an option due to the knowledge required to use it. The cost of putting GIS into District Offices was also productively expensive. A PC system was decided upon which would be installed at District Offices giving staff instant access to the information held. Use of the system would rely on menus, making it straightforward to use.

Sir William Halcrow & Partners developed a system known as SANDS as part of the Sea Defence Management Study (SDMS). NRA contributed towards the development costs but Halcrows retain copyright of the software.

The SANDS system provides a storage, retrieval and analysis medium for coastal data. As a database system it's success naturally relies heavily on the quality of the data entered onto it.

Data collected through the Anglian Shoreline Monitoring Program can be easily stored, analyzed and viewed within SANDS. Output from the system takes the form of graphical and text screen output, and report output to files.

Information held in SANDS can be transferred to other pc databases, for example, those held internally in conservation and planning departments.

4.2 System Configuration and Customisation

SANDS is a pc based system requiring the following software and hardware to run:

- Minimum 2 megabytes of random access memory (RAM);
- One floppy disk drive and a hard disk;
- EGA or VGA colour monitor;
- Minimum 386 PC microcomputer;
- 387 maths co-processor;
- Microsoft mouse;
- Minimum 40 megabytes of free disk space;
- DOS 3.2 or above .

4.2.1 Installation

SANDS is supplied with run-time Informix software which is used to run the system. Installation of the system involves an automatic load routine which executes with a single command. During installation the user is given the choice of whether a password is required.

4.2.2 Customisation

Halcrows carried out the initial customisation of SANDS for the Anglian Region. This involved setting up locations within SANDS where shoreline inspections are to take place as directed by NRA, and setting up locations where time-series data is to be added, such as NRA Telemetry stations and Met Office wind data measuring sites. The Anglian Regions system is split into six areas corresponding to responsibilities of the District Offices along the coastline and this exercise was part of the customisation process.

Once the system has been customised the user is able to set up additional locations at any time using a routine set up outside SANDS. This is a straightforward procedure where the user is asked for a location name, national grid co-ordinates, a bearing for beach profiles and a priority code (which prioritises location name over-plotting on the map screen).

4.2.3 Functions

The configured coastline map and locations will be displayed when the user first enters SANDS. The user can zoom in on the map to show any area in greater detail, select a location to carry forward to another screen and select a name filter which restricts the data shown on the map and on subsequent screens. The user can then select to enter the diary, graphing or reporting functions.

The principal core function of the system is the Diary. This allows beach inspections, structure inspection, beach profiles and miscellaneous events to be recorded in a consistent manner and against a time reference. Supporting functions include a map to locate measurement sites and structures, and graphing facility to extract time series data such as winds, wave and tides as well as beach profiles. In addition there are various service utilities to deal with importing data, reporting and archiving (Townend & Leggett, 1992).

The graphing function allows the user to plot time series data such as winds and water levels as well as beach profiles. The graphing screen is set up so that up to three graphs can be displayed at any time (Appendix 7). Once displayed, graphs of the same data type can be rescaled to a selected graph on x or y or both axes to make comparing them easier. For example, if three graphs were displayed; water level data for 4 weeks, surge data for 1 week and predicted tide levels for two weeks the user could choose to rescale the y axes of the water level and predicted tide levels graphs to those of the surge data graph. These two graphs would then be redrawn using only the data for the dates selected for the surge data. All three graphs could then be effectively compared.

The reporting function allows the user to select various management and analytical reports which are then output to a file. The user is also able to view any DOS files without exiting out of SANDS by use of a view file function.

4.3 Data Collection

4.3.1 Anglian Regional Monitoring Program

The Regional Monitoring Program commenced in June 1991 with the with the aim of collecting data on a regional scale to determine how coastal processes effect our coastline. The focus of the monitoring programme is to capture information on both the forcing and the response. Forcing comprises data on winds, waves and water levels, whereas the response component includes beach change, spit development, cliff losses, vegetation change and, over the long term, changes in the nearshore bed. The data needs to be supplemented by a good record of the defence and of the shoreline condition and consequently, structure and beach inspections are also included within the monitoring programme (Townend and Leggett 1992). This latter grouping covers the shoreline survey work which includes Aerial Survey, Bathymetric Survey and Topographic Survey and Shoreline Inspections.

Aerial Survey

The aerial survey covers the open coast at 1:5000 scale, black and white, stereoscopic pairs of photographs. The estuary areas will be covered every five years.

Bathymetric and Topographic Survey

Permanent ground markers have been established every kilometre along the open coast. These have been tied into OD Newlyn for level and into OSGB 1936 national grid co-ordinate system. Transects are taken through the permanent markers at a pre-defined bearing. Each year 1/4 of the Region is being surveyed by a combination of bathymetric and topographic survey to a minimum of 2km offshore and to landward of the defence. The remainder of the Region is covered by topographic survey to yield transects from landward of defence to MLWS.

Scheme Specific Survey Work

Scheme specific surveys are bolted onto the existing Shoreline Monitoring Surveys, therefore providing data to a standard specification and a specific format.

Shoreline Inspections

In combination with the quantitative data above, it is essential to pick up local knowledge of changes and problems on the coast. NRA personnel regularly inspect the flood defence of the region to keep an eye on their condition and where repairs or new works are required. The monitoring programme also looks at the beaches to see if they are changing rapidly or to identify if their nature is changing. For example, a beach changing from sand to gravel may indicate greater energy effecting that particular location.

NRA Telemetry Stations

Water level data is collected at 15 min intervals at water level measuring sites around the Region. Data from these stations is supplied to the Shoreline Management group. It is intended that all NRA water level measuring stations will be put on the telemetry system.

External Data Purchase

Additional water level data has been purchased from Proudman Oceanographic Laboratory to give coverage of the coastline where there are insufficient NRA stations. Wind data and modelled offshore wind/wave data has been purchased from the Meteorological Office.

Certain data sets such as winds, are obtained centrally, processed and then distributed to the Districts. At the same time other data sets such as beach profiles, will be gathered on a local basis in each District, processed and stored for local use, whilst also being sent to the centre to ensure that a formal archive is maintained. One of the main objectives of the programme is to get fairly immediate feedback on shoreline behaviour and the structural integrity of the defence and the SANDS system is designed to capture, analyze and present the data in an appropriate format.

SANDS is a pc based system requiring the use of a computer mouse as well as the keyboard. No specific computer knowledge is necessary to use the system. Selecting the various screens/functions within SANDS is made easy by the use of pull-down menus (a one line header which, when selected, gives a list of options). Help messages are displayed whilst using SANDS and detailed help screens can be called on by pressing the F1 key.

There are no usage restrictions once SANDS is running. Any user can input, display, edit and output data.

4.4 Data Handling

4.4.1 Input

Data input to SANDS is either by keyboard entry for Beach & Structure Inspection Data or by direct transfer by disk for time-series data and beach profiles. Data can be input as and when required onto the main database at Headquarters or onto the District's databases and then exchange of data between the two. However, as there are no facilities for data export within SANDS and databases cannot be amalgamated, only copied over an existing database the exchange of data between databases will be limited.

The data entry screens for inspection data correspond to the proforma used by district staff when completing the inspections and data entry is basically a matter of completing an on-screen proforma (Appendix 6). Data import for certain fields is simplified by the use of a toggle function enabling the user to move through a series of choices by pressing the + or - keys. The choices for sea state for example are rough, smooth or calm. Although keyboard entry is a simple procedure, care must obviously be taken to ensure data is correctly input and we therefore carry out quality assurance checks.

Data import for time series data and beach profiles is achieved by use of a stand alone program run outside SANDS. After typing 'import' the user is given the choice of the following data types to import:

- Beach Profiles;
- Offshore Wave Data;
- Wind Data;
- Met Office Wind & Wave Data;
- Water Level Data;
- Tidal Constituents.

The user will then be asked to type in details of the location that the data is to be assigned to, except in the case of beach profiles where the location is taken from the data file.

The import formats for these data types are predefined and the user needs to ensure that he obtains digital data in the correct format. This is very restrictive as the user becomes reliant on the software developers to add new import formats (probably at extra cost). Additional import formats for beach profiles and water levels have been tailored by Halcrows to correspond to the Anglian Region's Regional Monitoring data and Telemetry data formats respectively.

4.4.2 Output

Diary

Beach and Structure Inspections and Beach Profiles can all be viewed directly. A function available whilst viewing a beach inspection entry is 'Stats'. This gives maximum, mean, minimum and actual plots using the selected profile as actual and using all other profiles for that location to calculate the maximum, minimum and mean (Appendix 7).

Graphs

Providing the relevant data is available graphs can be plotted for selected location and date range for any of the following data types:

- Beach Profile

  Chainage and level measurements (m) taken at a fixed point and going offshore at a fixed bearing;

- Storm

  An event defined by the period when offshore wave energy exceeds a pre-defined threshold level (wave energy measured in joules);

- Water Level

  Measured water levels;

- Tide - Predicted

  The tide level determined from harmonic tidal constituents (amplitude and phase of the set of harmonic components describing the variation of tide level at a given location);

- Surge

  Variations in observed tide level due to the prevailing meteorological conditions;

- Wave Inshore - Direction

  Mean propagation direction of waves;

- Wave Inshore - Height

  Significant wave height of inshore waves;

- Wave Inshore - Period

  Peak period of inshore waves;

- Wave Offshore - Direction

  Mean propagation direction of offshore waves;

- Wave Offshore - Height

  Significant wave height of offshore height;

- Wave Offshore - Period

  Peak period of offshore waves, or possibly zero crossing periods;

- Wind - Direction

  Wind direction as determined from wind measuring equipment;

- Wind - Speed

  Wind speed as determined from wind measuring equipment;

- On/Offshore Energy

  Energy delivered perpendicular to the beach as calculated from inshore waves;

- Longshore Energy

  Energy delivered parallel to the beach as calculated from inshore waves.

Reports

The following summarises the various reports available within SANDS. All output is written to a file chosen by the user who can then view and/or print out the file.

- Management Summary Report

  Direct output of data for any fields selected by the user, for one or all locations within specified date range. An example of usage would be to output a summary of structure states by reporting on four fields within structure inspection, location, structure state, comments and timescale (Appendix 6).

- Data Summary Report

  Lists for all data types, locations and dates for which data is held. Used in addition to the map screen to give an overview of which locations data is held for.

- Beach Profile Cross Section Report

  Reports on changes in the cross-sectional area of profiles for a location within a selected date range. Output shows the change in area from profile to profile broken down into chainage comparison 'zones' of 10m comparing only actual values. Used to monitor accretion/erosion of beach levels (Appendix 6).

- Storm Reports

  Storm description and storm typicality reports for selected location and date range. Storm description report returns information on individual storm details such as duration, intensity and energy data.

  Storm typicality reports returns 3 tables of results; Storm Typicality Energy Matrix which compares the actual number of storms in each energy category which occurred during the specified date range with the typical number of storms over the same time period from the complete time series available for that location; Storm Typicality Direction Matrix details the number of 'actual' and 'typical' storms within eight 45 direction sectors; and Storm Energy and Direction Distribution Matrix which presents a combination of the first two tables and as such may be used to assess variations in storm severity and direction simultaneously.

  Used to help monitor the effects of storm events on beach movement by highlighting the types and frequencies of storms.

- Shoreline Integrity Reports

  Information for Energy, Beach Response or Energy and response. Forcing: Energy Matrix - calculates and compares the amount of energy that different sections of the beach receive for both predicted and actual water levels. Also reviews the variation of actual energy levels from the long term average for a location. Response: Beach Profiles - calculates the maximum increase/decrease in beach profile height and grade (slope in degrees) both above and below Mean High Water and Mean Sea Levels. These changes can be compared with the long term changes computed using all the available profiles at a given location. Used to help understand beach response to the various forces affecting it.

4.5 Conclusion

SANDS fulfils the need for an easy to use database system capable of storing coastal data held by the Anglian Region. It provides a quick and easy route to analysing, storing and retrieving the data making it useful as a management tool, a central database and as a backup for District Office staff's on-site knowledge.

The reaction of District Office staff to the system has been varied. To one it is viewed favourably as a quick way of seeing how their beach levels are changing throughout a beach recharge scheme, whereas to another it is yet another computer system that has to be updated for headquarters benefit. It is important that all staff collecting the data for the system understand it's benefits. As more data is added to the system it will become more and more useful and hopefully this will be reflected by reactions to the system. Staff who frequently work on-site may not refer to the system much now as they can remember what happened last year but in five years time they should appreciate it more.

Release 1.0 of the system was first issued to the NRA in March '91. However this was not suitably developed to be used productively and it was not until December '92 that a version of the system was installed in District Offices, customised and ready for use. This delay could have been avoided if the project was undertaken in-house. Any future additions to the data import formats used by the system will have to be provided by Halcrows, a problem which would again be avoided if in-house staff had been used.

4.6 Recommendations

4.6.1 Database Access Levels

Unlike most database systems SANDS does not have access levels. Therefore data within the diary screen (beach & structure inspections, beach profiles and text entries) can be edited by any user. It may be worthwhile setting up a two-tier access system to avoid the possibility of data being mistakenly edited.

4.6.2 Installation

SANDS is automatically installed onto c:\. However it may be that the user wishes to install it onto another drive. The user should therefore be given the choice of which drive to install the system onto.

4.6.3 Data Exchange

Data exchange between district and headquarters databases is presently very limited. As data exchange is part of the concept of any database this issue needs attention. Data export functions need to be set up enabling the user to be able to select any data type, location(s) and date range and export all relevant data which could then be imported to another database, adding to or appending any existing records.

4.6.4 Data Input

Field Input

The inputting of data could be improved on given suitable portable data logging equipment enabling inspection data to be entered when collected therefore reducing considerably the possibility of data handling errors caused by typing up written notes. Also wet and windy weather makes recording of data onto paper proforma very difficult, a waterproof data logger such as the 'Husky Hunter' would improve data collection further.

Import Formats

Import formats for time series data and beach profile data are pre-defined. It is recommended that the user has the facility to define additional data formats. This need only be a simple program where the user is asked for the position (in terms of rows and columns) of the necessary data fields for the type of data to be imported.

4.6.5 Graphing Display

The graphing function within SANDS provides a powerful means of displaying and comparing data sets quickly highlighting any problems which can then be investigated further. However there are several improvements which could be made to this function. Axes are not displayed with the graphs. Presently a maximum and minimum value for each graph is shown alongside the graph which gives some idea of scale. Also the user is able to point the mouse arrow at a particular point on the graph screen to return the x and y values, this function would be more useful if the cursor position locked to the graph therefore giving actual values rather than the value of a 'blank' portion of the graph. However, despite these functions, the display of scaled axes would provide a more direct means of assessing the graphical output.

Another worthwhile improvement to the graphing function would be the ability to zoom in on a particular part of the displayed graph. Once a problem had been identified by viewing a selected beach profile, for example, the problem area could then be looked at in more detail within SANDS rather than having to use the hard copies of the profile.

4.6.6 Data Collection

The majority of the water level data input into SANDS so far comes from water level measuring stations collected on telemetry. However, some additional water level data has been purchased from the Met Office to provide coverage of the entire coastline. It is recommended therefore that locations where additional NRA water level measuring sites would eliminate the need to purchase further water level data are identified and established as water level measuring sites.

NRA measuring stations could also be set up to collect nearshore wind and wave data. This could then be compared to offshore data to improve the modelling capability.

4.7 Conclusions

The SANDS system provides a useful tool to store and view data relating to the main processes effecting the coastline. It is, however, limited in capability and probably more suitable to those with short sections of coastline. The need to hold information at a variety of levels within the NRA should be carefully reviewed to determine what staff want to have and what staff need to have to achieve their job. This question is inevitably linked to questions of available resourcing and unless the maintenance of systems such as SANDS is given a higher profile it is inevitable that they will fall into decay. A strategy for IT implementation should not just consider the potential of such systems but also the practical reality of usage and skills at the operational level. It may be a more efficient use of resources to provide only a centralised resource which catchment staff can call upon when needed. This approach in itself requires a commitment to effective communication and the identification of the need for the information that exists. This may require a change in traditional practise to improve the flood defence service provided and resources need to be allocated to management of such change.

5 SDMS USE AND PERCEPTIONS WITHIN THE ANGLIAN REGION

5.1 Benefits of the Study

To help with the writing of this document a team comprising NRA staff and the managing consultant of SDMS reviewed the project. This project was achieved through a number of organisations so that, together, a high level of technical excellence was brought to bear on the project.

The approach had advantages and disadvantages. The highly concentrated nature of the work programme meant that a concerted effort was made in a single direction. This led to some significant advances. It was also the case, however, that the rate of output was such that it was difficult to ensure adequate dissemination.

The prime purpose of the SDMS is to provide a sound basis for investment plans. To achieve this objective and to ensure that the management strategy is both technically sound and regionally coherent, a diverse and wide range of topics have been investigated. The GIS and the monitoring programme, and the management strategy has a profound influence in the decades ahead on both coastal management and the move towards soft engineering solutions.

A range of benefits have ensued from the study, the combining of these benefits (savings, effectiveness, information, investment, technical, political) provides a cost effective, competent, confident and professional service ensuring the achievement of objectives and an efficient business (Child & Leggett, 1991) (Figures 6 & 7).

5.2 Use of SDMS

The SMS has evolved over time to meet the needs and demands of flood defence and the Engineering Department. This has not been an unplanned evolution but more a stepwise development as new utilisation are identified and explored. It may not be the ideal path for development to take but represents the practical realities of IT usage within a large function. The result of internal evolution has been to progress the Shoreline Management System from a novel solution to an integral part of flood defence work inside three years. The flexibility of evolution allows adaption to new demands and prevents imposition of "the system" by identifying clearly internal needs and continually reviewing those needs (Leggett & Dowie, 1994).

The team is divided into two main sections, one half deals with the Shoreline Management Systems which is driven by a GIS specialist and assisted by an experienced technician, also using SANDS and other PC databases. The other half deals with the regional monitoring programme which includes contract management and liaison with engineers about monitoring and also checks and verifies data prior to entry into the Shoreline Management System or SANDS. The team is carefully structured to ensure the regular update and supply of data and advice to other engineering staff.

The usage of the system can be broken down into four main areas for illustrative purposes:

- Maps - Hard copy presenting a particular feature or analysis;
- Data Sets - Group of data on a theme (eg: Waves);
- Analyses - Integration of Information to develop understanding;
- Reports - Presentation of information and analysis with interpretation.

(Leggett & Dowie, 1994)

The system was initially developed as a management tool but has expanded its uses into four principle areas:

- Flood Defence Design and Maintenance

  The system provides an important source of data when assessing flood defence works. Customised functions within the Shoreline Management System for waves and tidal currents are used frequently. Data is supplied in map form and can be output to publication standard. Data can also be supplied in hard copy form or on disk to run with site-specific models or provide quantitative backup to specific queries.

- Strategic Planning

  The Authority is developing work undertaken in the Sea Defence Management Study to create a strategy to manage the coast into the future. This requires further development of the system, particularly to define the economics of schemes through the GIS. The Shoreline Management System has already been used to identify defence requiring work in the 1992/93 corporate plan and been used in relation to coastal planning issues.

- Information Management

  The Engineering Department hold information concerning defences including historic documents, diagrams and reports as well as CAD based engineering drawings. The system is beginning to be used to reference this data spatially and indicate who holds what information and where. The system has also been used to reference the aerial photography collected under the monitoring programme so that the relevant photography can be identified and thus located. This speeds retrieval of information not stored within the system itself.

- Site Specific Data

  Whilst the system has regionally consistent data, it is being used increasingly to store and manipulate site specific data. This is often at higher density or frequency that regional data and is often the product of detailed design work for an engineering scheme. By archiving this data it will be possible over time to develop a highly detailed mosaic of the Region, which will assist in interpretation of regional data as well as being an important archive facility for the future (Townend & Leggett, 1992).

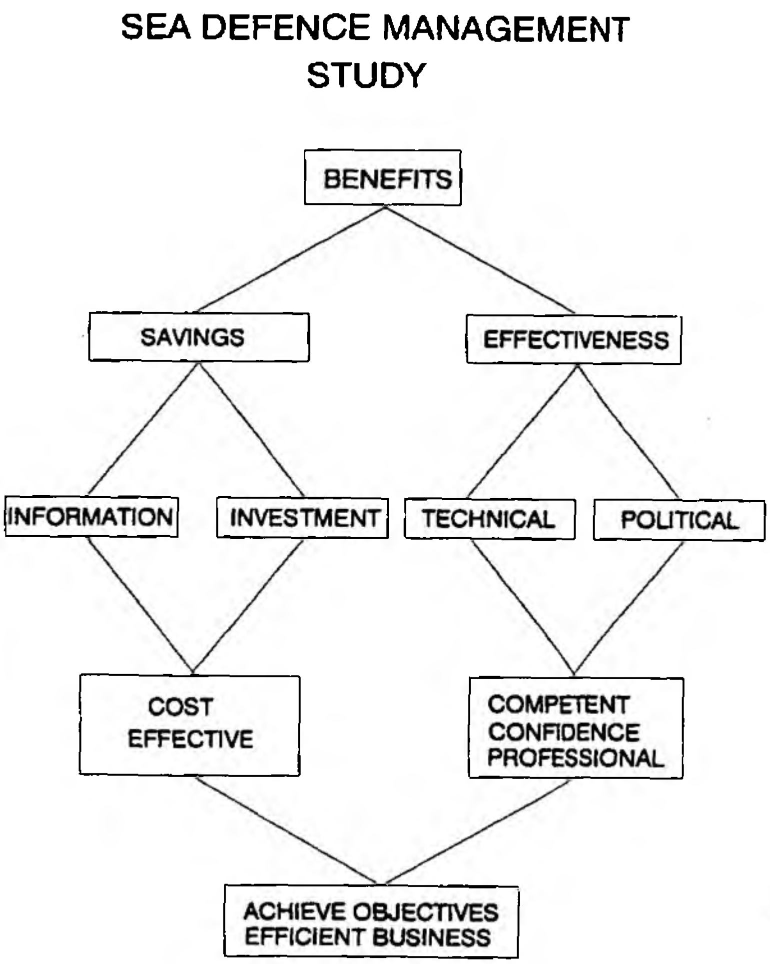


Fig. 6 Benefits of SDMS

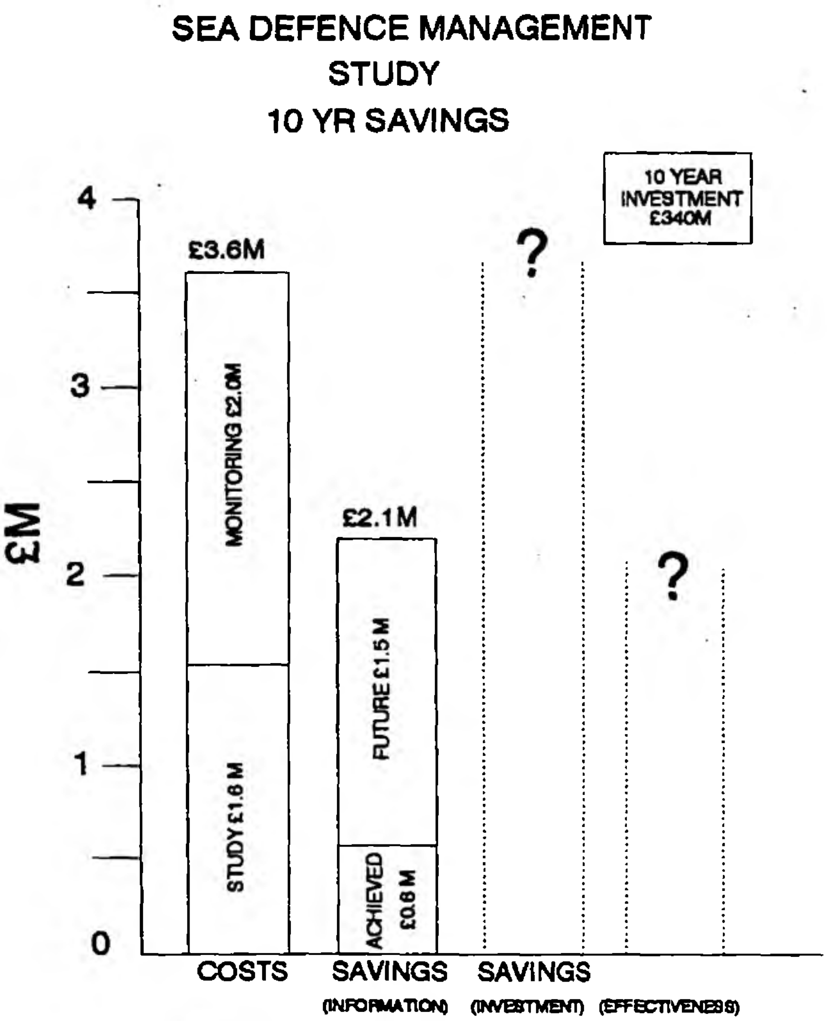


Fig. 7 Cost Savings of SDMS

5.3 **Perceptions of Shoreline Management** (D. Leggett)

At the outset it is a valid exercise to try and predict the future, or at least to leave enough scope to be able to adapt a system rather than re-invent it. It is also important not to build expectation of a system too high in order to justify its existence. The SMS was launched very carefully to demonstrate the power of the system and its complexity.

Another danger is to become too focused upon the technology. Training and understanding are essential both in terms of managing the GIS and utilising the information within it. Invariably systems become dependent upon a few individuals who understand the system and its contents. The dependency upon a few individuals enables dynamic and rapid development to take place and also enables a philosophical line to be developed which the system reflects. The problem with this reality is changes in personnel cause delays in development and targets to slip, in particular, when a new area is being addressed or critical philosophical development is taking place. In order to smooth this path it is important to address staffing at the outset and ensure there is a balance of routine ability and development flair, it may result in delayed development but ensures continued usage of the GIS. Understanding will also lead to requests to meet needs the system does not presently address and help shape development in line with departmental needs on an internally driven basis.

The system must be able to respond to the challenge and if the aim or objectives change, the organisational change also needs to be considered. Flexibility is achieved with an evolving system which remains in a state of flux, and it cannot be achieved with a system tied to limited software and developmental options. This is also an important consideration when using external resources.

Having a system that evolves with staff evolving around it (and leading it) provides the maximum flexibility to respond to new challenges or changes. The system still has vast untapped potential but as it evolves, these potentials are being realised. The rapid initial development by consultants was essential to set the Shoreline Management System in motion. It has been equally important to obtain in house control over the past 3 years, to develop GIS skills, and be able to plan development by combining the need of flood defence with knowledge of GIS. The control of the system means it is viable to use external resources because they can be directed in a well specified manner to achieve a task. The destiny of the system is dictated from internal needs not external expediency.

5.4 <u>Perceptions of Staff/Users</u>

The launch of the study in 1991 was identified by over half of respondents as a hindrance to the system. It was felt that the presentations to senior staff had not been repeated for the remainder of the department and dissemination from top down had not been forthcoming.

The original strategic nature of the SMS was only appreciated by those involved in the original study, however, all such respondents felt that the full potential for strategic work had not yet been realised. All respondents felt the system needed to be improved in some way to meet engineering project needs. It was perceived that the system had not lived up to the original expectations but that expectations had been too high.

5.4.1 Staff Interviews

Information

Generally, there was an unfamiliar feeling with the data and the information available from the system and as a result produced difficulties in including SMS in tender documents, such as knowing what questions to ask from Shoreline Management staff, and knowing what design information is available. Density and frequency of data from the original study was, sometimes, not suitable for design purposes but, data that had been used is recognised as valuable to engineering projects.

The coverage in estuaries, the frequency of wave data alongshore, the mapping of flood return periods, and sediment grading curves were all identified as data sets that required improving to meet project needs.

The system is not considered to have reached its full potential yet but an important contribution has been made to Engineering projects since July 1991. It is anticipated that demand on the system will increase in the future. This demand will require further system development and procedural development if the Shoreline Management team is to satisfy customer demands.

Staff at Lincoln office identified the need to be able to access information in their office. They did not feel that the SMS was a part of their department and felt that using information at a distance was problematic. Similar views were held by technical staff in Peterborough who wished to get hands on experience of the data. To access information at present SMS staff have to be approached. This in itself was not perceived as a difficulty but identifying the right member of the team was. Roles in the team were unclear to Engineering staff.

SMS Output

All respondents required hard copy output. Technical staff identified the need for digital output to store locally for model and analysis. This view was not shared by senior staff who considered that such analysis should be undertaken centrally.

Charging

22% of respondents felt that internal charging should be established, whilst 66% commented that external charging should be established. This charging was not seen to extend to Maritime Authorities although staff time should legitimately be recovered.

5.4.2 Analysis

From the interviews with Engineering staff it would appear that the department is dissatisfied with the Shoreline Management Systems' performance so far. The main criticisms of the system seem to emanate from alack of understanding of it and the nature of information generated from the original study.

The peak demand appears to come onto the SMS in the run up to April. This peak means that staff have infrequent contact with the system and are, therefore, not familiar with it. This peak also means a considerable burden on the team at this point in time to satisfy customer demands.

5.4.3 Recommendations

Training

The interviews with Engineering staff have exposed the need for training about accessing and understanding the Shoreline Management System and the information within it. It is proposed that SMS staff draw up a training programme for the department. Each training session would handle ten staff at a time and last less than a day. This would cover the background to the system, how it works, what information is in it, how to get at it, and, the relevance of the information to Engineering projects. This should be carried out in the first quarter of 1993 and be followed up with sessions for District Engineers and (separately) Maritime Authorities.

Project Management

It is considered that an appropriate Engineering Instruction should be issued relating to the usage of the SMS. The Instruction would incorporate the need to use the system as the first port of call for coastal project appraisals. The need to feed information generated from projects back into the system should also be highlighted. The Instruction would identify the Coastal Data Officer as the contact point for the group until training had been given to staff.

It is further recommended that all SMS information is channelled to consultants through Project Engineers rather than direct supply to the consultant. This would keep the Engineers informed of what their consultants were using and increase their familiarity with the SMS.

System Development

To fulfil the needs of the department the SMS requires further development to adjust it from a strategic basis to a project basis. This requires a developmental budget to address the data and analysis needs of the department. To calculate the costs it is recommended that an in-depth study be made of the developmental needs of the system over the next five years. This should consider the resources required including the financial implications. It is considered that this study should also identify the costs of maintaining the system so far and the financial and resource implications of developments that have been made to the SMS.

The nature of the SMS is of benefit nationally within the NRA and as such it may be appropriate to seek national funding. The developmental needs of the system should be considered as a national question. The expertise and experience of the Shoreline Management team is of benefit to flood defence personnel and as such the burden of costs should be distributed more evenly across the Regions.

In the short term additional terminals should be provided to satisfy the needs of technical staff and those staff based at Lincoln. The supply of access facilities to Lincoln should be a top priority.

Process Summaries

To fulfil the needs of the department, and place projects in context, project summaries should be produced by the Shoreline Management team. A summary should be produced for each District of the Region over the next six months. These summaries would utilise information from the SMS, the monitoring programme, and the expertise within the team. These reports will be of value to both Design and Operational staff.

To produce these reports information supply may need to be frozen or additional resources employed to maintain output. It is considered that these reports should be done in house to develop expertise and understanding of the region by NRA staff.

Strategic Work

To develop a strategy, for the Region's flood defence, elements of policy need to be clarified and a framework for a strategy defined. It is recommended this framework is defined. It is recommended this framework is defined by the Principal Engineers and developed using the SMS. Strategic work should be continued by the Shoreline Management team to help planning and programme definition for flood defence.

Annual Review

It is proposed that an annual review is undertaken of the system. This should be undertaken by a small working group established within the department. This group would be responsible for identifying deficiencies in the system and how best to overcome them in fulfilling the needs of the department. It is suggested this group include a Principal, an Assistant Engineer and a Technician as well as a member of the Shoreline Management team.

6 FURTHER REQUIREMENTS NEEDED FOR THE SYSTEM: CONSULTANTS VIEW

Foremost amongst the future needs was the necessity for the authority to provide personnel and resources to enable the maintenance of the system and the promotion of understanding of the system throughout a wider audience. In retrospect better understanding of the systems capabilities could have been gained initially by the secondment of a member of Halcrow's system development team at Halcrow to work with those responsible for systems maintenance for a period of one or two weeks. This would have improved staff familiarity with both the system and the data within it. It would also have given the development team a better understanding of the operational environment in which the system is being used.

Recommendations for specific studies were also put forward, relating to:

- river discharge and marsh condition;
- fine grid tidal modelling;
- nearshore wave climate;
- 3-D beach modelling;
- extended sediment path data;
- continued monitoring of international studies into climatic change impacting on sea level rise and flood risk.

Extension of the Shoreline Management System to provide summary reports and summary mapping was suggested. Implementation of such utilities is reliant on the authority defining specific operational requirements which could justify such developments.

Additional requirements for data sets were proposed relating to infrastructure and levels of service. These should be reviewed in the light of the pending Standards of Service contract.

Further development of the management system, in addition to system enhancements provided as part of the SDMS the authority have requested further developments following the initial delivery of the system. These included:

- wave rose plotting;
- current vector plotting;
- retreat model;
- and overtopping model.

Feedback from the Authority would indicate that these utilities are of operational value. Halcrow have applications, particularly for the retreat and overtopping utilities, on subsequent strategy and planning studies. Halcrow are continuing to develop similar tools to improve internal workflows and strongly recommend that the NRA consider a similar approach to the development of such utilities where clear benefit of automating workflows or types of repetitive analysis and reporting can be identified.

At the conclusion of stage II a number of recommendations were made relating to future needs to establish operational use of the management system, and improving the quality and scope of data maintained.

6.1 Coastal Process Studies

Further studies have been proposed to improve the understanding of specific aspects of coastal processes, with particular reference to the design or maintenance of the sea defence. Below is a summary of the tasks proposed by the consultants.

6.1.1 Sediment Audit

The task will involve a study to define a basis for being able to carry out sediment audits over selected lengths of coast. The initiation of a sediment audit for the East Coast would involve the assemblage of all published and unpublished data on the movement of sediment sources, sinks and pools. This would be supplemented with best predictions for future demand at the sinks due to such factors as sea level rise. The balance sheet for such an audit can be formalised using SMS. A substantial volume of information is already available for the sediments of the Anglian coastline and if collated in a structured way, this could provide the ability to carry out sediment audits.

6.1.2 Beach Modelling

Within the Anglian SDMS the 3-D Nearshore Profile model was developed to study beach behaviour. This could now be used to improve understanding of the clay downcutting process and long term beach movement. The downcutting process could be investigated by a rigorous validation of the model. The work would involve a field data collection programme involving the collection of detailed and repeatable measurements of beach and clay profiles over a period of 2-3 years. The data would be used to evaluate downcutting rates and determine how these relate to values presently assumed. The model would then be used to undertake sensitivity tests for the range of rates established.

The model can also be used to look at long term beach behaviour. Data collection of wind, wave and water level and current over 1 year would be required. This information, obtained from an intensive programme, would then be used to validate the model and carry out a range of sensitivity tests on long term beach movement. The model could also be applied to a number of locations around the coast to examine volatility, critical beach thresholds and net sediment budgets. These studies will provide the information needed to improve design methods on both sand beaches and those with a clay sub-base.

6.1.3 Sediment Trends

A study needs to be undertaken to improve the definition of sediment circulation for the Yarmouth Banks. Samples of sediment have been collected for the southern part of the banks system, off Great Yarmouth as a part of a study for Waveney DC. Extending the coverage to as far north as Winterton Ness would complete the coverage of the Yarmouth Bank system. Existing sediment trends could then be reworked so the overall circulation patterns can be identified with greater certainty. Knowledge of any circulation is crucial, both to planning works on the coast, and for any other activities, such as dredging. The current interest in nearshore dredging for beach recharge is a particular relevance in this respect.

6.1.4 Wave Climate

The study will aim to extend the existing modelling capability so as to provide a better estimate of the wave climate in and around the estuaries. Within Stage II of the SDMS, nearshore wave climate was computed using a wave refraction model to transfer the offshore time series to each inshore location. The processes is treated as linear and accounts for the way in which waves from deep water propagate in to the shore. Losses, such as local winds, bed friction, wave breaking, etc. are effectively accounted for by using what is known as the 'TMA' spectra which is depth dependant. In more sheltered areas the amount of energy arriving from offshore is limited. Consequently the value of the hindcast procedure would be greatly improved for these sites by inclusion of the locally generated waves. A hindcast model such as PHEW could be set up to compute local wind-generated waves, this data will need to be merged with information obtained from the wave refraction model. The software could then be installed as part of SMS. The information will benefit in feasibility and design studies requiring wave climate as one of the design parameters.

6.1.5 Tidal Modelling

A tidal model for the southern North Sea has been established within the SDMS to compute currents, and in particular current residuals near to the shore. This model can be run to provide an understanding of storm impact on the movement of nearshore sediments and provide data to a finer resolution for design purposes.

The model was run on a coarse grid but was also tested on a fine grid. Running on the fine grid would provide better resolution, which is of higher value for design studies. The model was also developed to include the influence of wind stress, therefore it can be run to reproduce (in 2-D) the influence of particular storm events or to examine the sensitivity to given wind fields. Use of this will examine the way in which tidal residuals are influenced by storm events and also study the local impact of currents during the passage of a storm, leading to a better understanding of the magnitude of currents in the nearshore during storm events.

6.1.6 Update Atlas

There is the need to revise the Anglian Coastal Management Atlas to incorporate the extensive new data sets that have been collected since it was published in 1988. This may also serve to define the process units for the ACAG forum.

6.2 Shoreline Management System

The ongoing maintenance of the Shoreline Management System is covered by a support agreement. Further developments to the system have been considered by the consultants, with particular emphasis on:

- improved efficiency of operation; and
- tools that extend the use of the system and so increase the overall benefit to the Authority.

6.2.1 Customised Reports

A number of standard formatted reports on topics that are routinely requested could be established using RIS Report Writer, this could provide such things as; a summary of design parameters for a site, a map plus text report on environmental consideration for a site and a summary of assets in a flood protection zone. Standard reports would significantly speed-up and ease data access making information within the system more available to users.

6.2.2 Time Series Data in SMS

To be able to access time series data from within SMS it would be appropriate to adopt the SANDS design and generate tidal levels from constituents when required, and inshore wave data from the offshore data set using appropriate refraction coefficients. To do this it will be necessary to port the existing SANDS database tables to SMS, associated computational routines will also have to incorporated within SMS. As part of this development there is also a requirement to simplify and control the porting of data between SMS and SANDS. This could be implemented through a form driven user interface with a built in set of quality checks for each data type.

6.2.3 SMS Workflow

In order that full use is made of SMS, it is important that the workflow is properly tailored to give maximum productivity on tasks that have to undertaken on a routine basis. This would involve producing a summary of SMS usage, detailing staff inputs and the steps involved in carrying out frequently requested activities. From this the workflow can be analyzed and the scope identified for; re-ordering the workflow, using alternative techniques, introducing utilities to improve the workflow and preparing standard reports or forms to improve control over particular activities. Specific action can then be taken to implement the revised workflow. Automating procedures and providing standard reports/forms can provide significant improvements in productivity.

6.2.4 Standards of Service/Cost Benefit Analysis

It is appropriate to carry out a preliminary scoping study, so that the analysis procedures are properly defined and specific limits can be set on data requirements. The requirements for standards of service have been established as part of a national R & D programme. As there is likely to be overlap between these type of analyses, it is appropriate that the two are looked at together to avoid duplication. Some of the required information may already be available but inevitably, a data exercise will be needed to extend and complete the database, which may have to include field work.

To implement procedures within SMS, standard reports and routines to undertake specific analyses will have to be developed. Some work currently underway clearly demonstrates the scope for applying this technique within a GIS. With much of the base information already in place, additional functions can be added cost effectively. As the range of functions increases, greater use can be made of the system, so improving return on initial investment.

6.2.5 Retreat Model

The current retreat model within SMS simply extrapolates historical shoreline movement rates normal to the coastline giving rise to unrealistic results. By using one-line theory to represent shoreline movement, and the concept of influence functions to describe sources and sinks along the shore, limitations can be overcome so as to accommodate alongshore movement and so provide more realistic forward projections. In order to apply the model within the SMS, integral lengths of coast would have to be defined. For each of these lengths the relevant calibration parameters would be defined using historic data. This work would link closely with *sediment audit*, giving a potentially powerful predictive capability for evaluating management options.

6.2.6 Extend Overtopping Routine

The existing overtopping module is designed to examine overtopping on a regional basis. It uses the definition of each defence and design conditions that are provided by the database. For individual defence, an alternative would be to extract this information from the database into a form such that the user could modify any parameter and then compute overtopping rates. This requires a relatively modest development of the existing routine and would provide a design similar to that provided by SWALLOW from HR or the consultants own SEAWALL software.

6.2.7 Statistics

The existing utility provides basis statistics for univariate and bivariate data sets. To be able to investigate correlations between several datasets there is a need to use multi-variate methods. This will be achieved by extending the statistical analysis utility to include routines for principle component analysis, cluster analysis and factor analysis.

6.2.8 Data Dictionary and Data Audit

The existing data dictionary is written in Informix and is not therefore accessible from within MGE. Easy access to this facility will help ensure that database documentation is properly maintained. The addition of a data audit facility will also aid the task of database maintenance by providing the tools to investigate missing and incomplete data. This will be achieved by converting the existing data dictionary to use RIS and work from the microstation environment and adding a utility to run audits on the contents of the database.

6.2.9 Change Database to Oracle

If the NRA wishes to adopt Oracle as the standard database, the underlying database for the GIS will need to be changed. To make this change it will be necessary to unload the data from the existing Informix tables, mount Oracle and then reload the tables. All existing SMS tables should work without change as they are written to use the RIS interface.

6.2.10 New Data Sets

Additional data sets could be added to extend the range of information available and to fill some of the current gaps.

6.3 Shoreline Monitoring Programme

The shoreline monitoring programme has been established throughout the region and the key requirement is to carry the implementation through to the point where it is an accepted and routine operational task. As such the following proposals focus on aspects which will improve confidence and help sustain staff commitment to the programme as a whole.

6.3.1 Improve Wave Climate

The aim is provide an improved description of inshore wave climate, particularly within estuaries. To do this the task on *wave climate* needs to be implemented. The improve data could then be made available within SANDS. The result would be to provide those areas with predominantly esturial coast more realistic data for use in studying shoreline response.

6.3.2 SANDS on Oracle

If the NRA wishes to standardize on the use of Oracle, the underlying database for SANDS will need to be changed. To do this a version of SANDS needs to be customised to run on Oracle instead of Informix. The result would be a standardisation of databases within the Authority.

6.3.3 SANDS Input Using a Hand Held Computer

A handheld computer would enable the direct input of data as beach and structure inspections are being carried out. The data needs to be captured on a Psion/Husky type machine, where the information can then be down-loaded onto the office pc, where quality checks are carried out and the user can verify and edit the data. Finally the data is loaded into SANDS.

6.3.4 Annual Review

Each area office is to be visited on an annual basis where a review of the years data is to be carried out, producing a summary report. This will help to develop confidence and a better appreciation of the value of the Shoreline Monitoring Programme.

6.4 Conclusions and Recommendations

Whilst significant advances were made during the Anglian Sea Defence Management Study, a number of gaps remain in the understanding of the consultants on the coastal processes which prevail on the Anglian Coast. Suggestion have been made in respect of coastal processes, the shoreline management system and the shoreline monitoring programme to readdress the current situation with regards to limitations or deficiencies in various aspects of the system.

Clearly continued development will entail a significant expenditure on an annual basis. It is therefore recommended that the Authority make provision for an appropriate budget, to support the continued development of the Shoreline Management Programme as a whole.

7 STRATEGY FOR IMPLEMENTATION OF A SIMILAR SYSTEM IN OTHER REGIONS

7.1 System Design

There would appear to be two approaches to extending the SMS to provide national coverage. Either to implement and administrate a single central system, or a number of regionally controlled systems. The benefits associated with a single central system are related more to initial cost than operational efficiency. It would be possible to invest in a single data storage and analysis system which would significantly reduce the level of investment in hardware and software necessary for a national implementation. Also the degree of staff resources and training would be minimised.

Operationally the system would be remote from its users. The task of maintaining currency within the data would be less likely to be effectively performed. Given that the investment in this data would outweigh the investment in hardware and software the worth of the system would be devalued by any deterioration in its integrity. Further the divorce of data users of the system would limit the potential for user lead system development.

The preferred option would be to promote the use of the SMS within each NRA Region. Having established acceptance of the principle of the Responsive Management Framework and a routine monitoring programme a means of installing the central GIS Management System should be pursued. Each region has adopted independent strategies for IT implementations, and there may be an understandable reluctance to invest in additional hardware and software to support the SMS. If the methods for applying the common data structures and analytical techniques as in the SDMS could be formally defined as procedure than each region could at least access the potential for translation of these methodologies to their own operational environments.

If existing hardware within the NRA Regions could support the SMS then the cost of system set-up as per the Anglian Region would be dependant on software licence costs. Were a point to be reached where the NRA undertook to implement the SMS on a nationwide basis within each region then a national licence agreement could be negotiated as has been the case with the data dictionary, with the inclusion of an annual maintenance contract for user support and system development.

As previously noted the base system software is now less hardware dependant than at the time of initial implementation. The current situation is that though the data and MDL utilities under the SMS can be ported to PC the analysis performed at the conclusion of stage III was one so using utilities currently only supported on Integraph workstations. If methods of reproducing these techniques on PC can be found then existing hardware could possibility support the implementation of the SMS within each region. Future developments planned by Intergraph to support their products on platforms running the Windows NT operating system may also mean that existing hardware would be capable of supporting the SMS.

7.2 Project Management Brief and Consultant Role

Before any national implementation of the SMS it will be necessary to achieve agreement in employing the principles of management framework and also of the necessity to have a degree of standardisation in the data formats used within the system.

The effectiveness of the application of this management technique will only be able to be evaluated in the medium and long term when the effects of feedback within the system can be seen to have had an influence on the components of the framework and what would be necessary to implement the management framework nationally.

Overall, the way the project was structured and managed, coupled with the fact that it was the first of its kind, meant the Authority got exceptional value for money. In this context it is unlikely that, overall, the client would have got better value by, for instance, sub-dividing the work and going to competitive tender on each component. This would have simply reduced the perceived value of the project and hence the level of goodwill that went with any involvement.

Inevitably, the standard achieved in the various components of the study varied significantly. The nature of the project organisation meant that these were nevertheless integrated to achieve the desired standard overall. One of the areas of greatest variability was with work allocated to the Universities. Generally this was commissioned through a recognised specialist in his/her field, where consequently research assistants were employed to carry out the work. Thus resulting in the standard varying according to their ability. Whilst the benefit of University based commissions is that specialist work can be advanced relatively cost effectively, the ability to control the quality of the work is greatly reduced, introducing a higher degree of risk into the project.

The other aspect which could of been done more cost effectively was the field survey, the geological survey work was very successful and produced high quality results to the planned programme, whilst the bathymetry survey was frustrated by extensive down-time due to a summer of Easterly winds. Following this the delivery of the completed work was delayed. In hindsight, it would seem that the nearshore bathymetric survey contract was too large an undertaking for the type of organisation doing the work. A better return would, therefore, be achieved by going out to tender on a series of smaller contracts. On-going survey work that forms part of the annual monitoring programme has subsequently proved this way of working.

Many aims were associated with the implementation of the management system which fell outside the scope of works specific to the SDMS and development of the Shoreline Management System. A data model definition relating to Conservation and Ecology information was produced (Fig. 8) in consultation with the authorities conservation department, with the idea that this data would be collated and entered by the Authority, though not within the time frame of the SDMS. The consultants comment that had this information been available at the time it would of allowed more detailed analysis to be undertaken which may have influenced the studies conclusions and recommendations. More detailed information on land use, and land management strategy analysis, particularly the definition of policy guidelines would have been of direct value for cost benefit analysis.

7.3 Resource Requirements

The study as carried out by the Anglian Region NRA initially comprised a review of existing data and an identification of gaps within that database. Much of the work that followed involved the processing of existing data into the system plus the commission of Supporting Studies to complete the availability of data required to fulfil the study aims.

There are overheads associated with this data capture which could be ameliorated in compiling a national data set. By identifying those data sets used in the analysis phase of Stage II and those required by the monitoring programme a core data set can be established. Resources could then be focused on obtaining these data sets nationally, avoiding unnecessary capture of potentially redundant information.Following the methodology employed on the SDMS an investigation would need to be undertaken to establish to what extent core data sets existed nationally and how accessible it would be to the Authority. Further data would need to be commissioned to generated data which proved unavailable. Such an exercise would no doubt incur substantial expense, but with the benefit of the experience gained with the SMS data collection could be better managed and costs reduced.

A greater awareness of graphic file structure and data model design, data capture extended to a national study can be better specified, reducing the amount of post capture data processing. To this end standardisation of data formats within the NRA could significantly contribute towards the portability of information between regions and applications.

Internally within the Anglian Region this has been addressed by the use of SANDS. The adaptation of such a system on a national basis would have similar benefits. Also the data model for the SMS has been purchased by NRA HQ to enable the regions to work with common data structure. It lies with the NRA to promote awareness of this model in order that it may be evaluated and referred to those responsible for carrying out related work nationally and regionally.

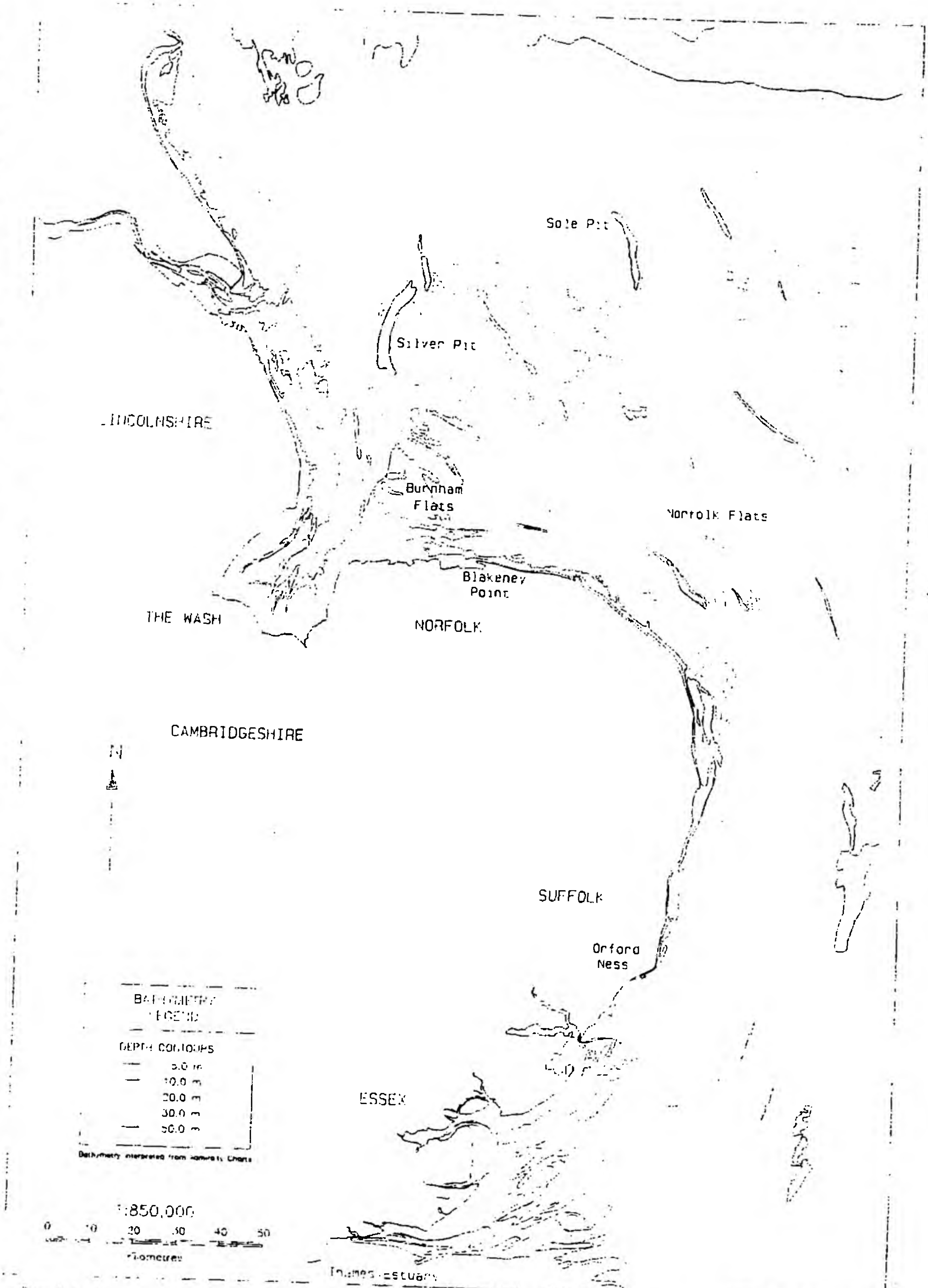
Index Name: ce_ecology

Category	Index level	Definition
bird_counts	4	count points of bird communities from national archives incl BTO and WWT
bird_feeding_areas	5	area survey data of prefered feeding sites
coastal_flora	2	cliff, saltmarsh, dune and shingle ridge vegetation from NCC and NRA data
conservation_sites	1	site parcels based on NCC data
fisheries	6	spawning grounds and fishery areas from MAFF and NRA
sea_banks	3	tidal embankment management plans

Fig. 8 Data Model : Categories Report for Ecology and Conservation

APPENDIX 1

Examples from the Anglian Shoreline Management Atlas



The Sea Defence Management Study for the Anglian Region

Sir William Halcrow & Partners Ltd

BATHYMETRY

Date: 30 Nov 88

1.5 BATHYMETRY

This map shows the variations in seabed depths immediately offshore of the Anglian coast. Contour information was interpreted from Admiralty Charts prepared by the Hydrographer of the Navy.The southern North Sea is made up of a northern basin, a southern basin and a trans-basin divide running between North Norfolk and the Dutch coast. Lincoln and Norfolk are therefore situated on the relatively shallow trans-basin divide, Suffolk lies along the southern basin and Essex is largely within the estuary regime of the Thames.

The major seabed features include:

-- the deep pits which lead off the trans-basin divide into the northern basin; notably Sole Pit and Silver Pit

-- the extensive shallows of Burnham Flats at the entrance to the Wash.

-- the system of linear banks running from north-west to south east and situated to the north-east of the Norfolk coast

-- the comparatively narrow width of the nearshore (5 and 10 metre contours) from Blakeney Point south to Orford Ness

-- the numerous (and highly mobile) sand banks within the Thames estuary.

Note: Data extracted from British Admiralty Charts 1190, 1183, 1503, 109, 108, 1504, and 1610 in Crown Copyright and is reproduced with the permission of the Comptroller of Her Majesty's Stationary Office.

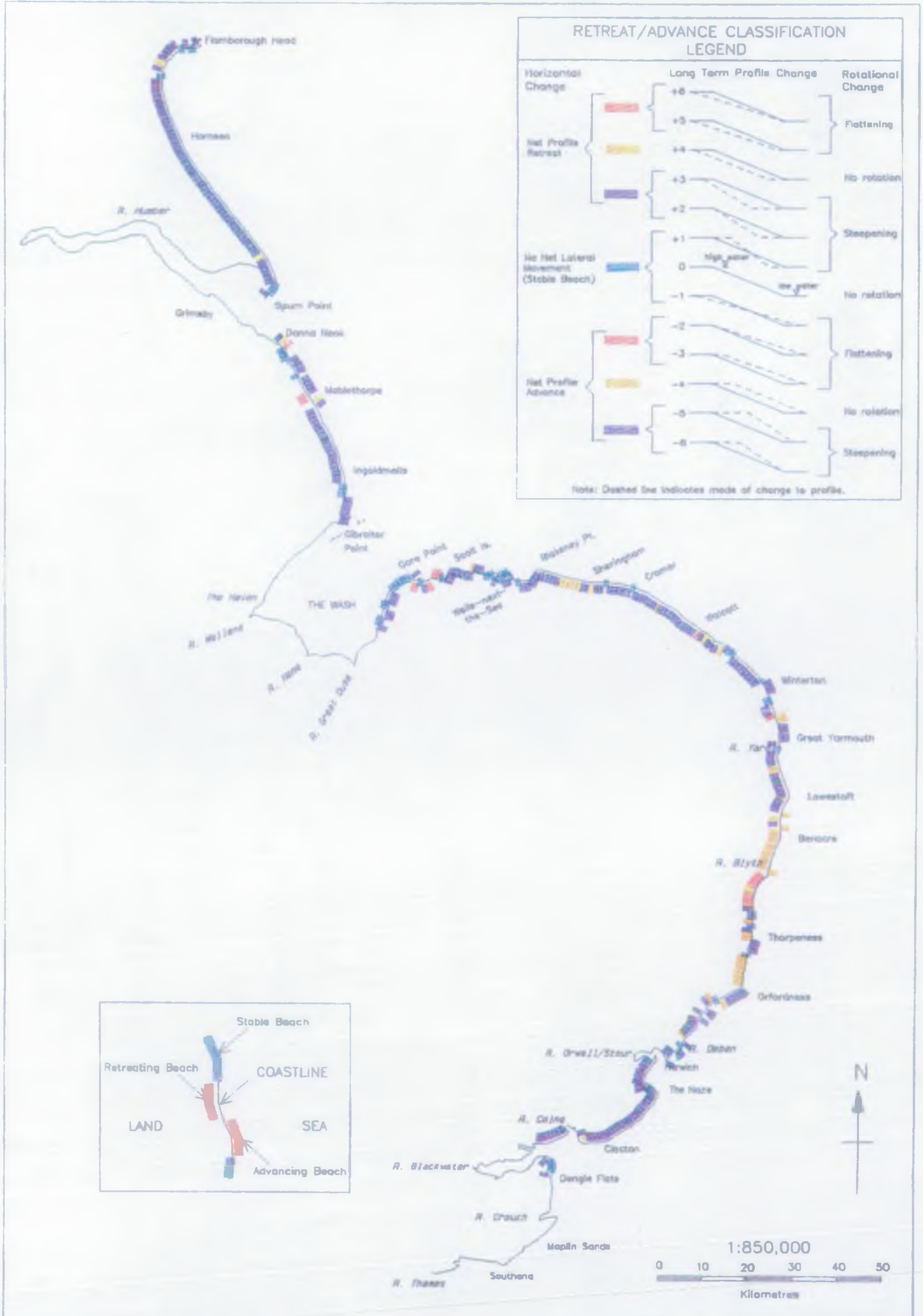
The Sea Defence Management Study for the Anglian Region Sir William Halcrow & Partners Ltd	BATHYMETRY

Date: 30 Nov 88

4.4 LONG TERM RETREAT / ADVANCE CLASSIFICATION

In previous sections retreat of high and low water has been mapped, as has the differential retreat. These each reveal the magnitude of individual aspects of beach movement but do not describe the overall mode of change. To overcome this, a retreat/advance classification system was developed to characterise the different types of beach movement. Rates of high and low water movement are combined to define horizontal and rotational movements which describe the net profile change. In all, 13 combinations have been defined and these are illustrated in the legend opposite.

This map highlights the fact that much of both the retreating and advancing coast is steepening (78% of the coast in all). The consistency of certain lengths and the order of change from one classification to another provide both valuable guidance for interpretation and the definition of individual "coastal units".



The Sea Defence Management Study for the Anglian Region Sir William Halcrow & Partners Ltd	LONG TERM RETREAT/ADVANCE CLASSIFICATION

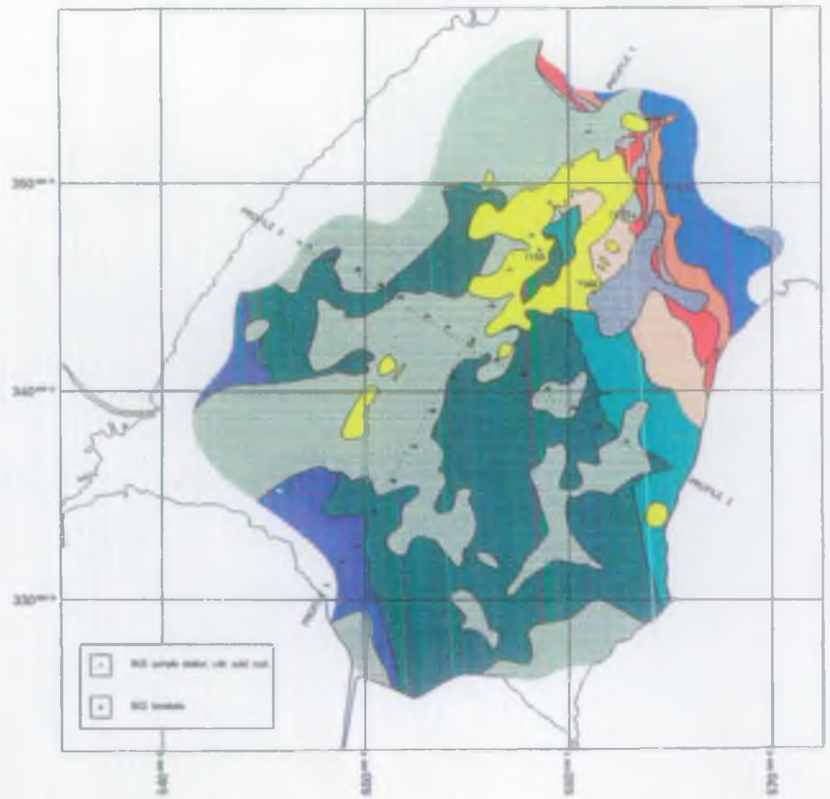
Date: 30 Nov 88

APPENDIX 2

Output from the Nearshore Geological Survey

- **Geology: Exclusive of Mobile Sediments**

Geology: Exclusive of Mobile Sediments



NRA
National Rivers Authority
Anglian Region

SHORELINE MANAGEMENT SYSTEM

EXPLANATION TO GEOLOGY: EXCLUSIVE OF MOBILE SEDIMENTS AND PROFILES

HOLOCENE — Sand and gravel of Holocene age

PLEISTOCENE

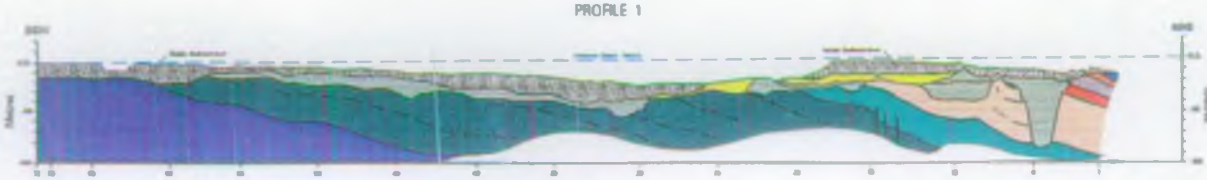
UPPER CRETACEOUS

LOWER CRETACEOUS

UPPER JURASSIC

Profiles

PROFILE 1



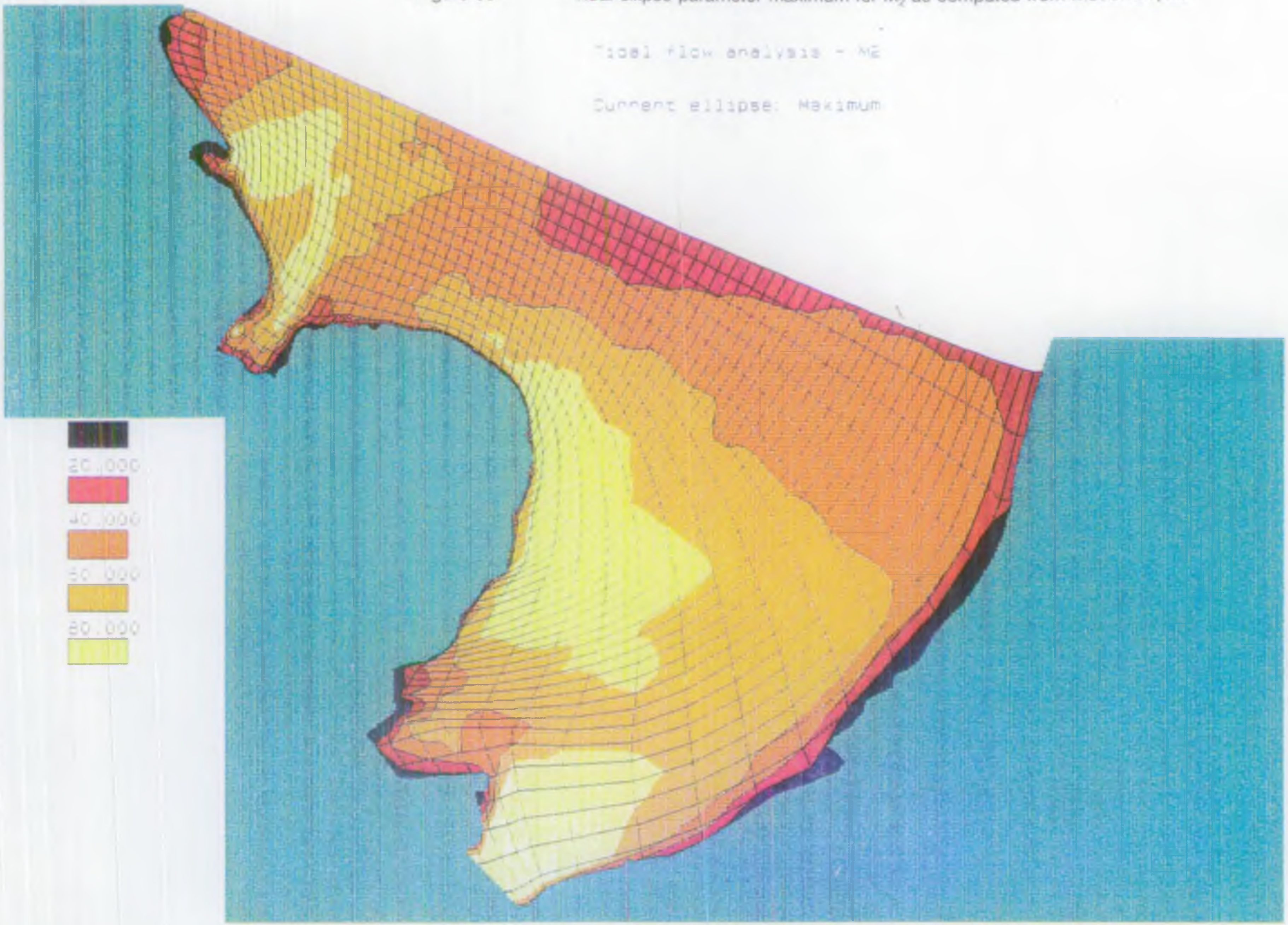
PROFILE 2

APPENDIX 3

Output from 'Tidal Circulation Study Task Report'

- **Tidal ellipse parameter maximum M2 as computed from model output**

Figure 36 Tidal ellipse parameter maximum for M_2 as computed from model output.



APPENDIX 4

Output from 'Offshore Banks Study Task Report'

- **Contour plots of the interpolated sand bank data**

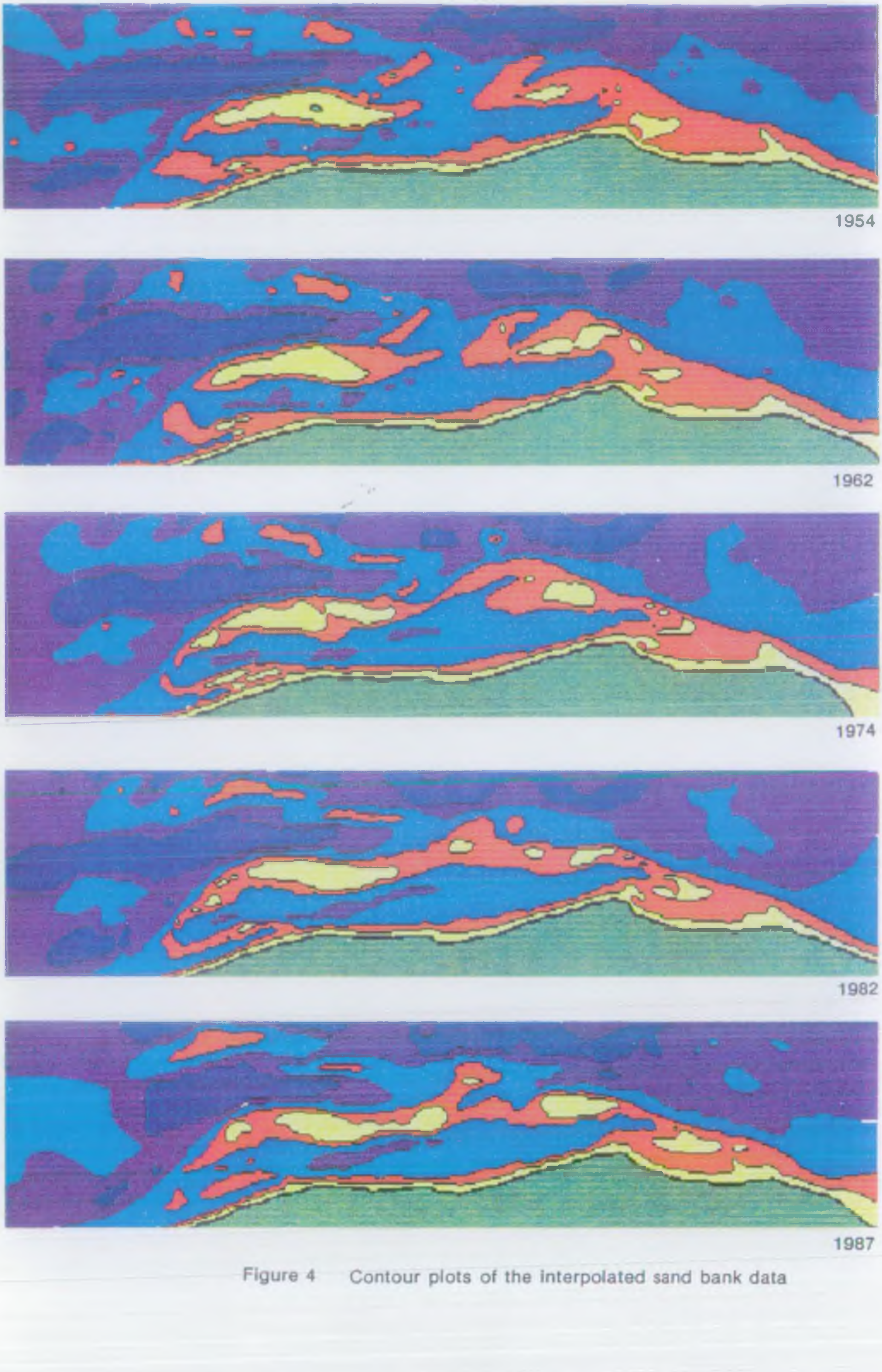
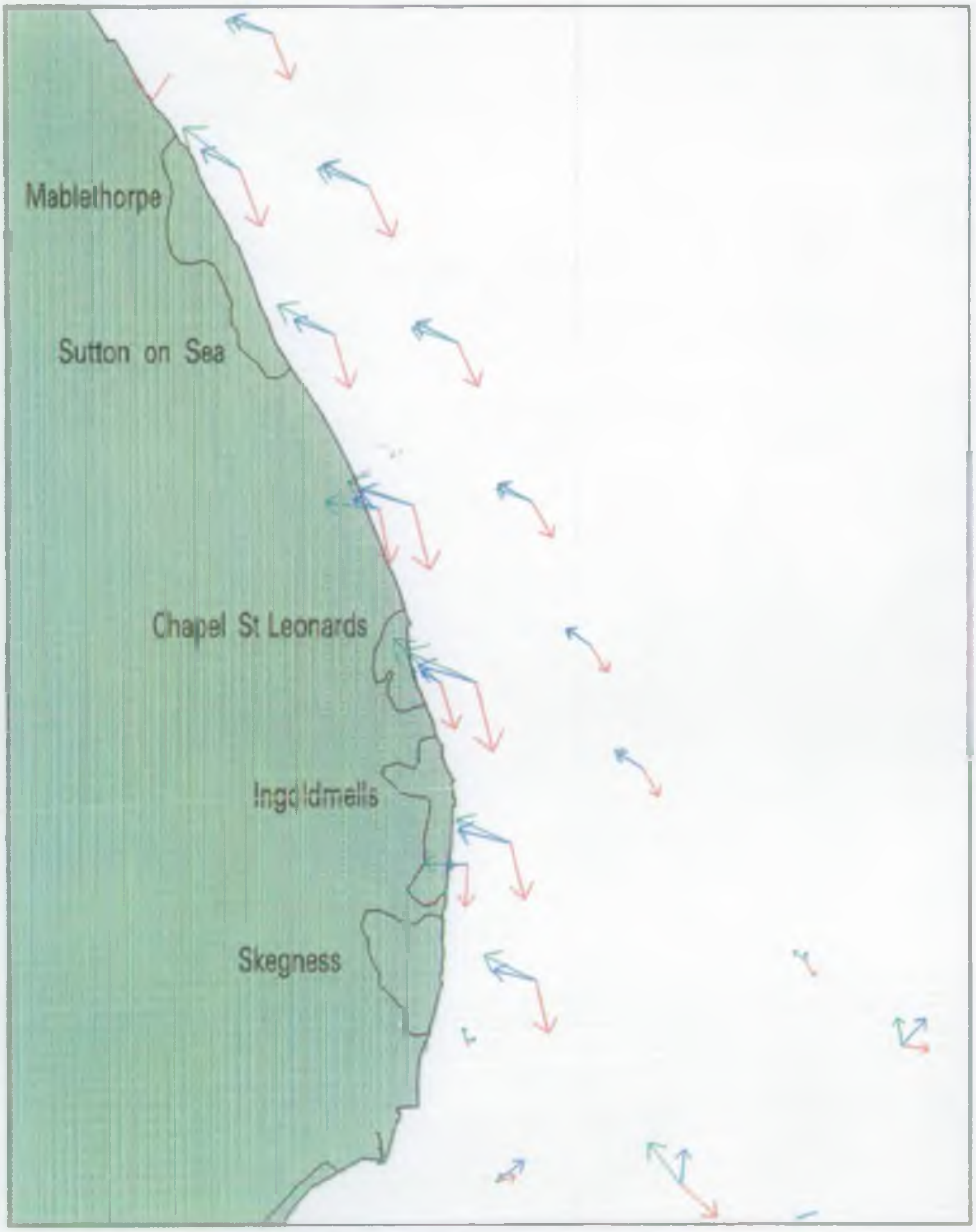


Figure 4 Contour plots of the interpolated sand bank data

APPENDIX 5

Examples of output from customised Shoreline Management System

- **Tidal Sediment Transportation**
- **Wave Roses for the Lincolnshire Coast**



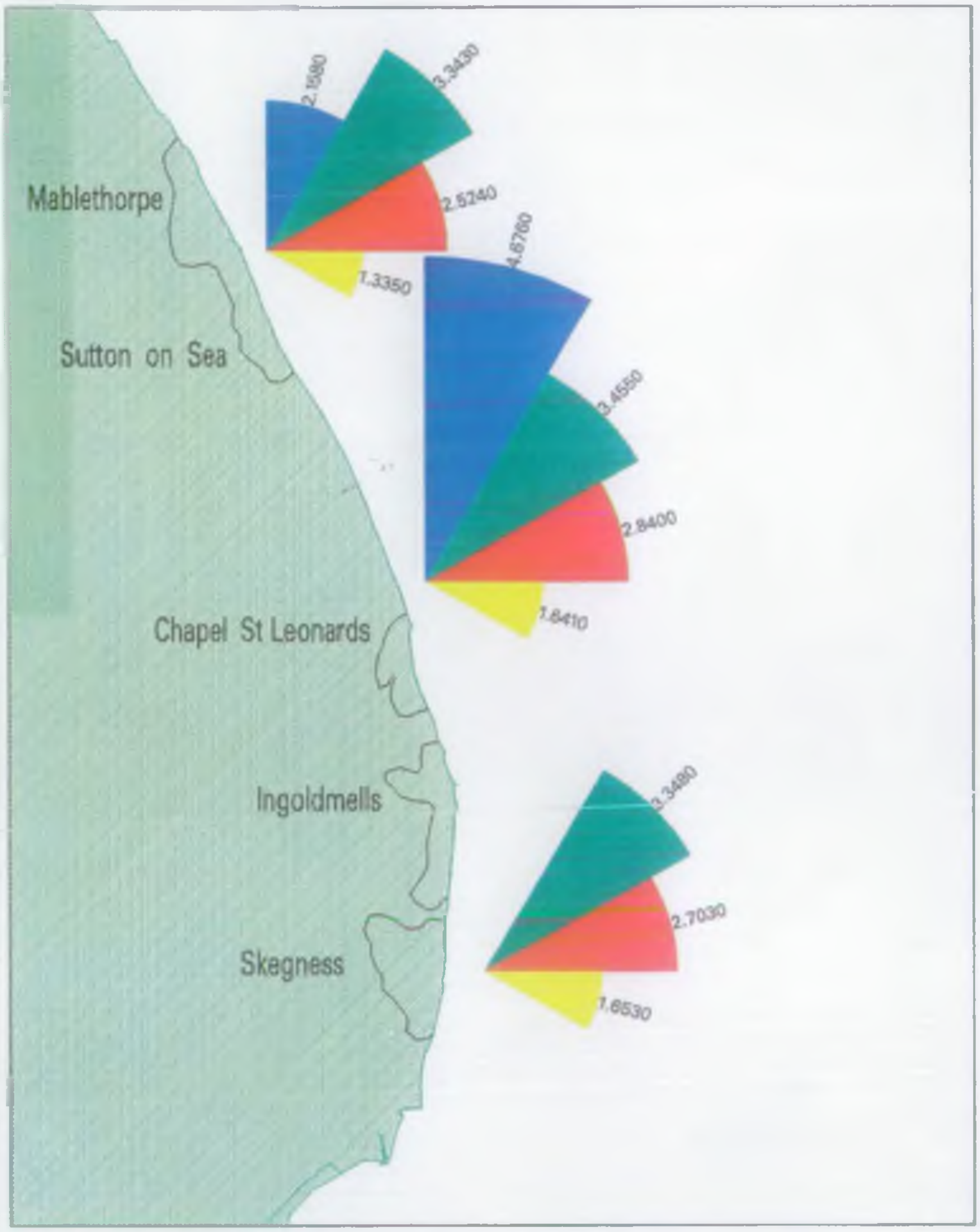
Tidal sediment transport

NRA
National Rivers Authority
Anglian Region

SHORELINE MANAGEMENT SYSTEM

KEY:

Net
Suspended
Bedload



Wave roses for the Lincolnshire coast

NRA
National Rivers Authority
Anglian Region

SHORELINE MANAGEMENT SYSTEM

KEY:

0°
30°
60°
90°
120°

km

Scale

APPENDIX 6

Sands Data Collection Proformas

- Beach Inspection Detail Sheet
- Structure Inspection Report Sheet
- Day Details

BEACH INSPECTION DETAIL SHEET

Sands Beach Inspection Name:

Location Description:
Chainage/Co-ordinates:-
Profile Marker Ref:-

Summary:
Summary to Diary (39 characters)

Full Summary (94 characters)

Film No.	Frame No.	Details

Dip	Position	Dip(m)	Comments
1.			
2.			
3.			
4.			
5.			
6.			

Beach Sediments:
Position:
(36 characters max)

Time

Upper Beach:
Material: Absent / Sand & Gravel / Sand & Mud / Rock / Sand / Mud / Gravel / Till
Slope 1: degrees
Littoral Drift? Yes No
Comments (58 characters max)

Mid Beach:
Material: Absent / Sand & Gravel / Sand & Mud / Rock / Sand / Mud / Gravel / Till
Slope 1: degrees
Littoral Drift? Yes No
Comments (58 characters max)

Lower Beach:
Material: Absent / Sand & Gravel / Sand & Mud / Rock / Sand / Mud / Gravel / Till
Slope 1: degrees
Littoral Drift? Yes No
Comments (58 characters max)

STRUCTURE INSPECTION REPORT SHEET

Sands Location: [ ]

Location Description:

Chainage/Co-ordinates:-

Profile Marker Ref:-

Summary: Summary to Diary (39 characters)

Inspection Time: [ ] hrs

Position:		Structure State:		Beach State:	
[ ]	Nearshore	[ ]	Good	[ ]	Accreting
[ ]	Foreshore	[ ]	Fair	[ ]	Stable
[ ]	Backshore	[ ]	Moderate	[ ]	Eroding slowly
[ ]	Hinterland	[ ]	Poor	[ ]	Eroding rapidly
[ ]	Offshore	[ ]	Bad	[ ]	Volatile

Action Levels Structure Dip [ ] m (ODN)

STRUCTURE INSPECTION

Comments : (9 lines, 80 characters per line maximum)

SANDS INSPECTION - DAY DETAILS

Date	Time	Inspector
Level at Low Tide m	Time of Low Tide hrs	Tidal Station Ref:

Wind: Light / Moderate / Strong	Seastate: Calm / Moderate / Rough	Visibility: Calm / Moderate / Rough	Rain: Yes / No

APPENDIX 7

Examples of output screens from SANDS

- Beach Profile Screen
- Graphing Function

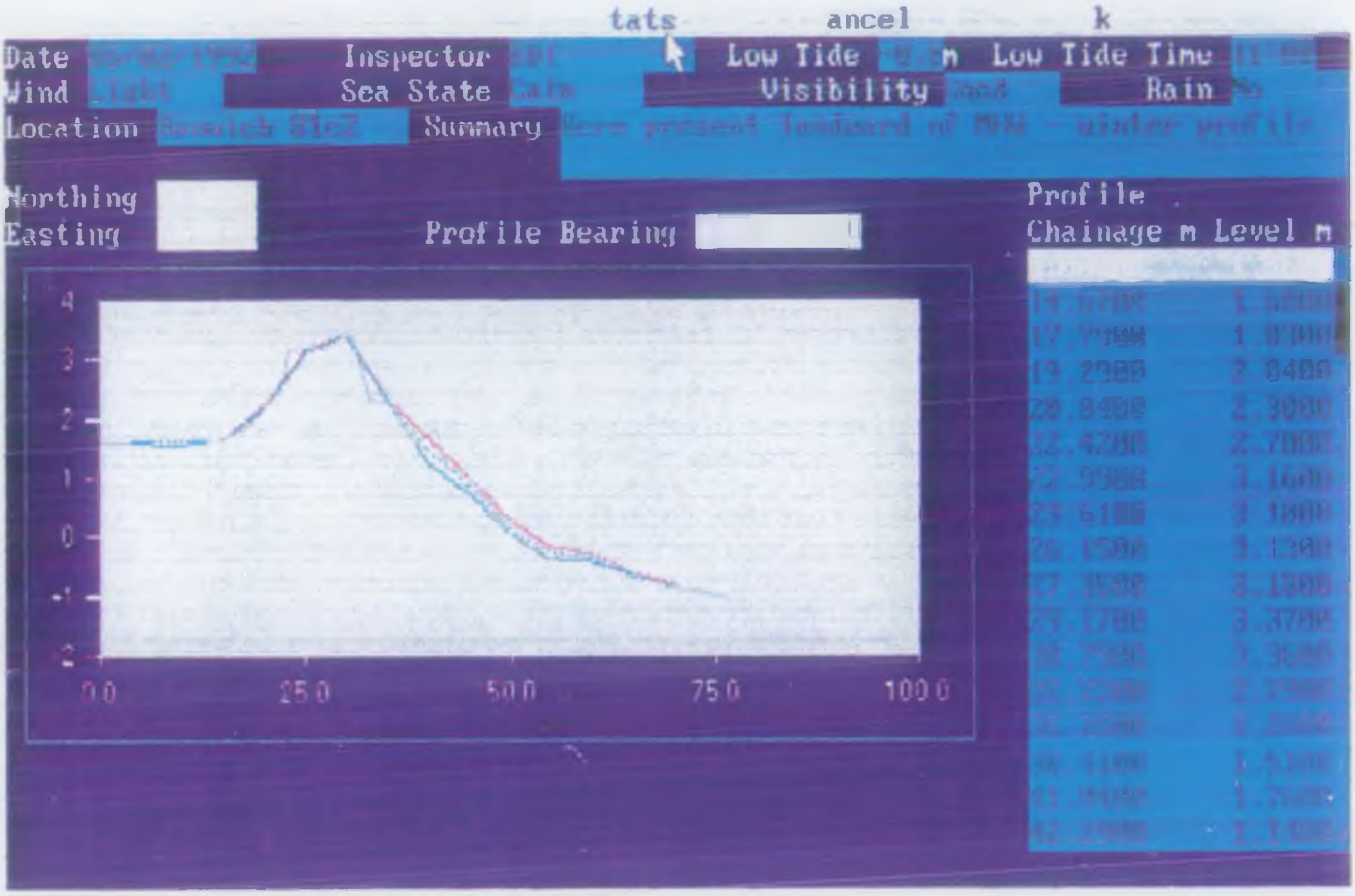


Figure 5.5 Beach Profile Screen Showing Statistical Analysis

6.3 Figures

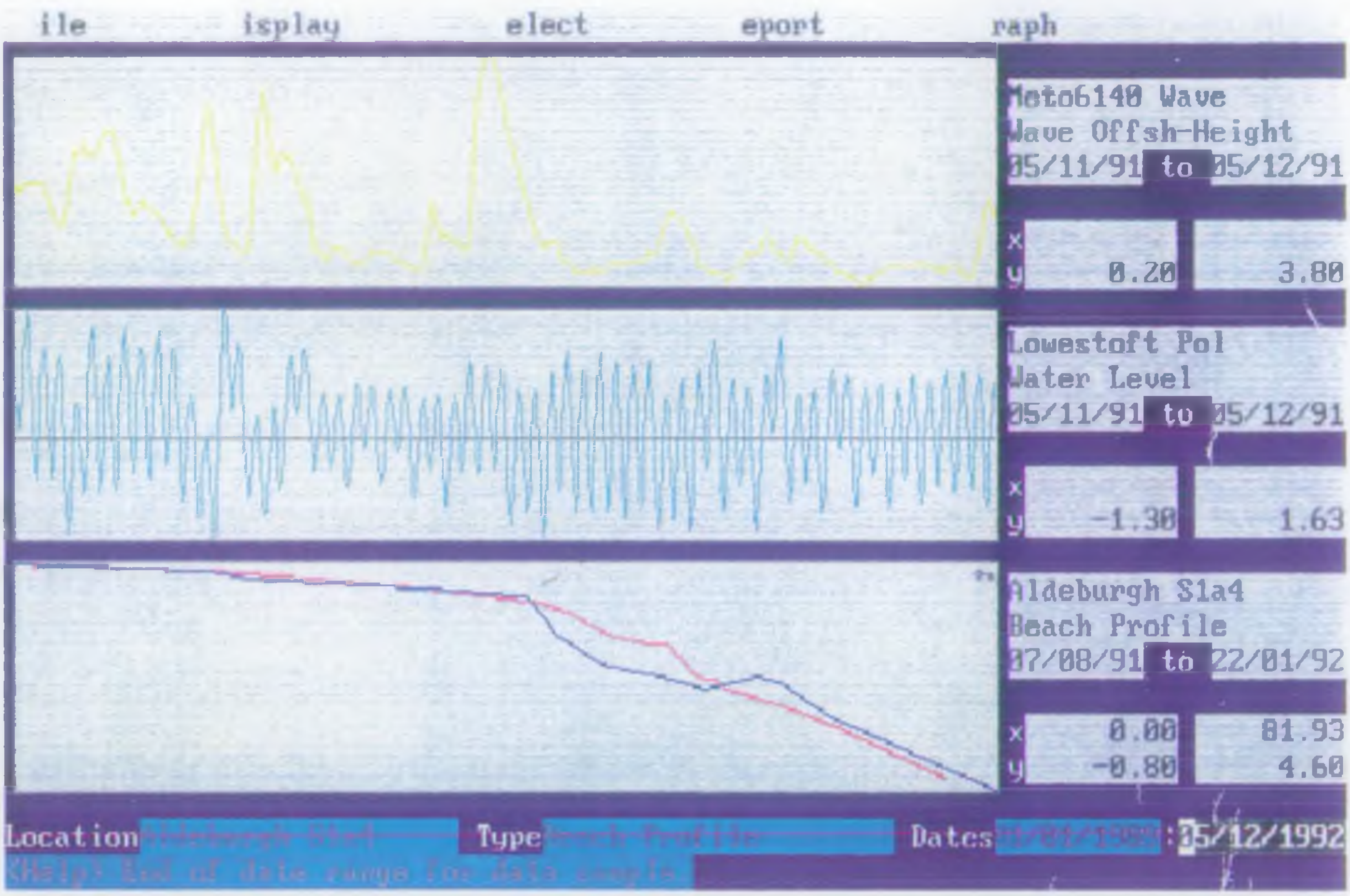


Figure 6.1 Example Graph Screen

SANDS Management Summary Report.

Report Dates : 01/01/00 to 31/12/99 Location Name : ALL LOCATIONS

STRUCTURE INSPECTIONS

DATE	LOCATION	SUMMARY
03/02/88	Cromer	Cracks are evident in the concrete

WORKS ID	POSITION	STRUCTURE CONDITION	BEACH CONDITION
	Hinterland	Moderate	Eroding Rapidly

COMMENTS
Some measure of priority is needed for this area as beaches appear to be steepening and eroding.
31/08/95
31/08/95

DATE	LOCATION	SUMMARY
01/02/90	Saltfleet	Groyne field descriptions.

WORKS ID	POSITION	STRUCTURE CONDITION	BEACH CONDITION
3021	Foreshore	Poor	Eroding Slowly

COMMENTS
The majority of the timber groynes adjacent to this location are in too poor a condition to be refurbished or improved. Pile timbers have been eroded to such an extent that there would be no means of securing the planking necessary to raise beach levels. The few groynes which do have reasonably substantial piles would probably not withstand the additional stress of removal and re-driving. These groynes could however be made more effective by the provision of more planking to raise levels and more particularly to close any gaps in their profiles or at the junction with the sea walls.

DATE	LOCATION	SUMMARY
01/02/90	Leigh on Sea	Polder for marsh regeneration

WORKS ID	POSITION	STRUCTURE CONDITION	BEACH CONDITION
2032	Nearshore	Fair	Accreting

COMMENTS
Vertical timber fencing was erected in order to stabilise marsh sediments in th area and so promote marsh regeneration thus preventing erosion. At low tide, it can be seen that vegetation (Spartina) is establishing itself within the polder but careful monitoring of the fencing should be carried out, particularly after storms.
Accretion of marsh sediments is noted (due to a reduction in tidal energy thus allowing finer material to be deposited).

DATE	LOCATION	SUMMARY
02/02/90	Winterton	Sheet piles are being uncovered.

WORKS ID	POSITION	STRUCTURE CONDITION	BEACH CONDITION
3065	Hinterland	Fair	Eroding Slowly

COMMENTS
The recent sea wall construction here is of a most substantial form and although the concrete elements towards the bottom of the slope have suffered some abrasion by sea-borne shingle, these are reinforced and there is no cause for concern at present.
Both the masonry and concrete forms of sea wall are in generally sound conditio with their foundations covered by beach material. Where beach levels are low, the concrete wall has suffered abrasion to reveal steel reinforcement which has been severely abraded itself.
11/11/93

Beach profile cross-section changes at A Place : 31/12/1899 to 31/12/1999

From	To	0.0m 8.0m	8.0m 16.1m	16.1m 24.1m	24.1m 32.2m	32.2m 40.2m	40.2m 48.2m	48.2m 56.3m	56.3m 64.3m	64.3m 72.4m	72.4m 80.4m	Gains	Losses	Net
31/12/1899	19/08/1978	-0.2	-6.7	-0.5	1.8	0.1	-0.2	0.5	1.4	0.7		4.5	7.5	-3.0
19/08/1978	25/06/1979	-0.1	-0.1	-0.1	-2.3	0.6	5.4	2.1				8.1	2.6	+5.5
25/06/1979	01/06/1980	0.2	6.8	0.6	0.5	-0.7	-5.2	-2.7	-0.1	-0.7		8.1	9.3	-1.2
01/06/1980	12/07/1983	1.9	-3.1	-3.1	0.4	3.4	0.5	-1.9	-2.7	-2.6		6.2	13.4	-7.2
12/07/1983	16/07/1984	2.8	-0.0	-1.5	-0.0	-2.2	-1.2	-2.2	-1.5			2.8	8.7	-5.9
16/07/1984	03/08/1985	-0.6	-8.5	-1.4	-4.6	-3.8	1.4	5.2	5.7	6.2		18.4	18.9	-0.5
03/08/1985	08/09/1986	-0.3	2.9	-5.3	6.3	-0.2	-3.4	-4.9	-6.4			9.2	20.5	-11.3
08/09/1986	24/04/1987	4.7	3.7	2.8	-3.8	-3.8	-4.5	-3.0	-2.2			11.2	17.2	-6.0
24/04/1987	14/05/1988	-2.3	-6.2	-0.7	-5.4	-1.7	-1.4	-1.4	-0.8			0.0	19.9	-19.9
14/05/1988	01/03/1989	0.8	-1.6	-4.6	-4.9	-1.3	2.4	3.4	5.9			12.6	12.4	+0.3
01/03/1989	05/04/1990	-9.6	-5.9	2.3	-1.0	-1.9	-6.2	-6.9				2.3	31.4	-29.1
Min area change		-9.6	-8.5	-5.3	-5.4	-3.8	-6.2	-6.9	-6.4	-2.6	0.0	7.5	4.5	-7.2
Max area change		4.7	6.8	2.8	6.3	3.4	5.4	5.2	5.9	6.2	0.0	18.9	18.4	-0.5
Mean area change		-0.2	-1.7	-1.0	-1.2	-1.0	-1.1	-1.1	-0.1	0.9	0.0	12.3	9.3	-3.0
Std Dev area change		3.6	4.9	2.6	3.5	2.0	3.5	3.6	4.0	3.8	0.0	5.1	6.3	+3.0
Min change rate		-8.8	-8.1	-5.7	-6.1	-6.1	-7.1	-6.3	-5.8	-0.8	0.0	0.0	0.0	-8.8
Max change rate		7.5	7.2	4.5	5.8	1.1	6.3	4.9	7.4	5.9	0.0	8.8	7.5	+7.5
Mean change rate		0.0	-0.6	-0.7	-1.7	-1.5	-1.2	-1.0	0.0	1.2	0.0	2.6	2.7	-0.8
Std Dev change rate		3.8	4.7	2.8	3.6	2.0	4.0	3.7	4.1	3.2	0.0	2.4	2.6	+3.6
Trend (sq.m./yr)		0.4	-0.9	-1.2	-1.0	-1.0	-1.1	-0.9	-0.7	-0.7	0.0			

Profiles judged too short to use for the statistics on Gain, Loss & Net change at the bottom right of the report are marked with "*"

Note on comparison of different length profiles.
For short profiles changes of cross section are reported where the data is available. Comparisons past the end of the profile are deferred till a long enough profile is analysed.
Eg. if profiles 1 & 3 are longer than profile 2, and the cross section increases 1.0 sq m at each chainage interval, the report looks like :

```
Change from profile 1 to 2    1.0   1.0   1.0   1.0   1.0
Change from profile 2 to 3    1.0   1.0   1.0   1.0   1.0   2.0   2.0   2.0   2.0   2.0
                              ^   These are 3 vs 2    ^     ^    These are 3 vs 1     ^
```