1997/031

TENDER
FOR
INTEGRATED DATA MANAGEMENT
AND
ENQUIRY SYSTEM
(EDMS)

SCOPING AND DEMONSTRATION PROJECT

11 July, 1997

Contents

1. INTRODUCTION

This proposal has been prepared in response to the Environment Agency's (the Agency) invitation to tender for "Integrated data management and enquiry system (EDMS): Scoping and demonstration project", dated 30 June, 1997, referenced FIN/P/PIP/CAF.

It is a joint submission prepared by the Natural Environment Research Council (NERC) and Tessella Ltd, led by NERC.

2. REQUIREMENT

In the section that follows, we have set out our understanding of the requirement. It is based on the information in the invitation document together with additional clarifying information provided during the tender process.

2.1 Overview

The Agency's National Centre for Environmental Data and Surveillance (EDS) is responsible for the custody, maintenance, enhancement and interpretation of the Agency's environmental databases on behalf of the Environmental Strategy Directorate. These databases cover disparate subjects and contain many forms of data. In combination with data sets generated outside the Agency, they represent a powerful tool for providing information on the state of the environment.

The inherited systems of the previous National Centre at Twerton have been designed primarily around coastal data sets and are composed of multiple databases and software packages. They do not represent an integrated system that is capable of efficiently supporting investigations into processes and problems that span many different environmental media.

The Agency's brief is wider than its predecessor's. Consequently, there is a need to receive, store, analyse and disseminate new types of data. These data will be sourced and received by organisations both within and without the Agency. Establishing the relationships and tools that will allow the smooth and speedy interchange of data will be important and is stressed in the Agency's paper "View Points on the Environment".

Given the complexity of the environment and the speed of technical development, it is not possible to forecast either the nature of future problems nor the types of data that will be available to aid their resolution. The Agency's data systems therefore need to be generic in order to maximise the chance that they can accommodate new data types and minimise the need for changes to the core database design.

A generic database design is also a key requirement for the development of the type of query facilities that will allow the exploration of relationships between

different data types regardless of their subject matter.

2.2 Objectives

The objective of this proposal is first to identify the data handling requirements of the EDS. Having agreed the requirement, a market survey of "off the shelf tools", a conceptual model, a functional specification and a demonstrator will be prepared to allow the EDS to consider the options for proceeding with the development of an operational system.

2.2.1 Review of customer needs and Agency strategy

In close liason with the EDS, we will define a "user specification" for the EDMS system. This will take into account the Agency's emerging strategy on data management and GIS as well as the "convergence" strategy and year 2000 issues.

2.2.2 Trade review of available GIS/database systems

In the light of work package one, we will perform a trade review of "off the shelf" GIS and database systems that are candidates for the EDMS.

2.2.3 Conceptual model design

Given the user specification and a decision as to the GIS/database system to be used, we will design a conceptual data model. This may be based on previously existing models. It is recognised by the Agency that the model will represent the system at the time of conception and will have to evolve throughout the project as a whole.

2.2.4 System design

As a result of work packages one to three, the information to produce a system specification and to define the hardware platform will have been established. The Agency consider that a "rapid prototyping" approach for the final implementation will give the build phase the maximum chance of adapting to changing user needs. With this in mind the system specification will only identify the key system components, their functions and the order in which they should be written in the rapid prototyping exercise.

2.2.5 Demonstration system

Once the EDMS core GIS and database systems have been established, they will be procured independently of this contract.

A demonstration exercise is then required showing how the EDMS system may be linked dynamically to an external database and hence enable the EDS staff to access or download the external data for use in their work. The purpose is to enable the EDS to a) identify problem areas and b), subject to a), enable the EDS to identify the remaining work necessary to complete the system.

The demonstrator will be written in close collaboration with the EDS. Subject to the proposal being feasible, the demonstration will show:

- how a request may be initiated
- the transmission of the request to an external system
- the external system either
    * granting access permissions
      or
    * retrieving the data, dispatching them to EDMS and initiating a load process on the EDMS
- the EDMS displaying the data.

The demonstrator will not have analytical capabilities.

3. APPROACH

3.1 Overview

Our approach will be to form a small and experienced team of NERC and Tessella staff whose collective experience spans all aspects of the design, development and operation of database systems for environmental data. NERC and Tessella have worked together successfully for ten years. Tessella have been involved with the development of the Water Information System since 1989. Nearly all the original team are still with the company and remain in regular contact. Appendices 3 to 5 summarise our respective experience with respect to the design of environmental database systems.

We have made provision for the team to have access to the staff of the various NERC data centres, should detailed information about particular data types or systems be required.

It is our intention that the team should work closely with the nominated staff of the EDS. Provision has been made for travel to Bath and Bristol and for electronic communication.

We are aware of the importance of good project management. A project manager will be appointed who will be responsible for reporting progress weekly to the Agency.

Our work analysis and cost estimates have been based on a directly comparable study which we undertook prior to our current commission for the Malaysian Government. To arrive at our costing and plans, we broke the project down into approximately 100 tasks, each with a clear output contributing to one of the five deliverables (see Appendix 1).

3.1.1 Review of customer needs and Agency strategy

After obtaining and assimilating existing documentation on Agency strategy and requirements, it is envisaged that one or two members of the team will meet with the EDS staff in Bath and Bristol for a total of 3 or 4 days spread over two visits.

The objective will be to identify, in user terms, the types of data that the system should be able to handle and the functionality required of the system.

We have assumed that lists of the main classes of data (terrestrial, freshwater, atmospheric and marine) will be available, together with descriptions of the data within each class in sufficient detail to enable us to decide whether the generic data model to be proposed later, will be able to handle these data.

For estimation purposes, we have assumed that the functionality of the system will be defined in relation to a list of topics along the following lines: input, editing, validation[1], storage, selection, analysis, presentation, export, user interface, metadata catalogue, ease of direct access to database, access by remote users, access to remote databases, performance, access control, audit trail, software supplier independence, hardware independence, multi-user access, and resilience.

With this information to hand, a user requirements specification will be prepared in draft. During the preparation period, we will expect to be in regular contact with the EDS, clarifying points of detail. On completion, we will present the result to the EDS at a meeting. Any required minor modifications will be made and the final report then submitted for acceptance. It is anticipated that the length of the finished report will be in the region of 10 pages.

3.1.2 Trade review of available GIS/database systems

As soon as the EDS requirements become clear, we will establish the key GIS / database properties that the survey should ascertain. A list of systems and their producers will be compiled and the required information obtained and tabulated. Each system will be evaluated against the user requirement and the Agency's IS policy if that is relevant. A short list of acceptable systems will be prepared.

The results will be submitted in the form of a short report, probably three to four pages long.

3.1.3 Conceptual model design

The development of generic structures for handling data and all that goes with them usually takes many man years of effort spread over many elapsed years. New models frequently demand processing speeds, storage volumes and disk access times in advance of the capabilities of current hardware.

Consequently, we consider that it is unwise to anticipate developing a new model within the two month time frame of this scoping study. Unless the requirements study reveal data types of which we are currently unaware and which our current model cannot handle, we will propose either the current WIS version 1.8 or the WIS version 3.0 data model, usually referred to as the

[1] Quality control.

WIS Cube. The two models are identical in principle. However, the 1.8 model has the advantage of being operational and its strengths and weaknesses being well understood. The 3.0 model handles a greatly extended range of data types and can be implemented on a much wider range of relational database systems. However, it is still under development, the first working prototype being due for testing in late 1997.

The Water Information System (WIS) is the successor to the Water Archive System[2] which has been used by the Agency and its predecessors since 1974. Both systems see the world as composed of features or objects described by the values of their attributes. A feature might be a gauging station, a discharge to air or an Agency vessel or plane. Their attributes might include site name, site photo, geographical location, atmospheric chemical concentrations, rating equation constants and so on. Grids, such as land cover or CASI images, can be treated as attributes of maps or other objects. All data may vary over time.

Briefly, the WIS Cube provides a simple conceptual framework within which the user can visualise many disparate data types as being held and against which selective requests for data can be framed. The three axes of the cube represent attributes (what), features (where) and time (when). Thus a particular cell within the cube contains the value for a particular attribute at a given place and time, for example, the nitrate concentration in the Avon at Bath on 06/07/97 at 11:30 AM.

In the light of the requirements study, we will recommend the use of one or other versions of the WIS conceptual data model, modified if necessary. We will also provide a description of the model and identify any important considerations in relation to its physical implementation of which we are aware.

The report will not include a description of the physical data model which we understand is not required at this point.

NERC will wish to retain all copyright and IPR relating to the Cube, but will grant to the Agency the right to use the conceptual model for its own internal purposes without further charge.

3.1.4 System design

Under this work package, a high level system design will be prepared specifying the major components of the system in terms of their functionality.

Where critical, suggestions will be included as to the method by which a component should be implemented.

Key interfaces between components will be identified, so that they can be defined early in the prototyping exercise.

[2] Often referred to within the Agency as the Water Quality Archive.

The order of development will be set out to guide the rapid prototyping team.

Hardware constraints will be listed.

3.1.5 Demonstration system

The purpose of the demonstration is to understand the problems of exploiting data in external systems.

To this end, in conjunction with the EDS staff, two systems will be identified, one to act as a surrogate for the future EDMS and the other to represent the external system. Our estimates are based on using the LOIS CD-ROM viewer (see Appendix 3), a PC-based cut-down version of WIS 3.0, to represent the EDMS and an ArcView or ArcInfo database to represent the external supplier.

We will then investigate options for establishing communication between the systems. An obvious example is Dynamic Data Exchange (DDE), which represents one possibility for reaching an ArcInfo database. However, DDE is being replaced by Object Link Embedding (OLE). Alternatives will need to be considered for UNIX based systems. Open Database Connectivity (ODBC) provides a route for linking SQL databases.

Ideally, a generic solution is required that, once communication is established, will enable EDMS to interrogate and extract data from any system. The demonstration design phase will investigate such a solution. However, it is believed that such a solution is several years away and that a hardwired solution for each external database will be required for sometime. It is also probable that for sometime and for many external data sets, it will be necessary to download them into the EDMS, rather than merely access them on the external database as and when required.

It is our experience that linking systems together for the first time is often a long and difficult process. We would strongly recommend that the level of expectation in relation to the results of this work package be set at a realistically low level.

4. DELIVERABLES

The project deliverables are:

- a user specification for the EDMS
- recommended options for GIS/database systems that fulfil the needs of the EDMS
- a conceptual model
- a functional specification, build stages and hardware dependencies
- a functional demonstrator

5. PROGRAMME OF WORK

The invitation to tender requires the work to be completed within two months and suggests intermediate dates for the delivery of reports. We have identified the tasks necessary to produce the deliverables (see Appendix 1) and sized the team so that they can be achieved within the time available.

The resulting programme is summarised in the Gantt chart in Appendix 2.

We are concerned that it is a very tight timetable for a potentially complex system. There is no slack in the programme to allow for contingencies or delays, i.e. any delay moves the end date. Given that the work is taking place over the summer period, we think it would be more realistic to anticipate a three to four month project.

6. RISK ANALYSIS

In preparing this proposal we have endeavoured to identify areas where problems could arise. The table below lists the perceived risks and how we have sought to contain them.

Risk	**Preventive measures**
Requirement specified at high level - potential for different interpretations as to the range of data types to be handled and functionality required of the system.	Define the anticipated data types. Define the anticipated functionality.
There is no slack in the programme to allow for contingencies.	Bringing in more staff would be unlikely to shorten the time scale - warn the Agency that a problem exists.
Linking systems together for the first time is usually a difficult process where little help is available from the suppliers.	Limit expectation.

7. PROJECT MANAGEMENT

Project management will be the responsibility of Tessella who will appoint a project manager to oversee the work and report to the Agency.

He will maintain the project task list and monitor its completion.

Reports will be made verbally to the Agency once a week and in writing once a month.

There will be a number of meetings between team members and the EDS staff.

The project manager will attend these should matters arise that cannot be resolved by phone, fax or Email.

In the event that a problem cannot be resolved after ten days, it will be referred to the line managers of the nominated officers on both sides. If they are unable to resolve the matter within a month, then the disputes procedure in the contract will be followed.

8. STAFFING

The project team will comprise four named key staff, a project manager and two supporting programmers:

Roger Moore	NERC, Institute of Hydrology
A project manager	Tessella
Isabella Tindall	NERC, Institute of Hydrology
Kevin Morris	NERC, Plymouth Marine Laboratory
David Hill	NERC, Institute of Hydrology
Programmer	Tessella
Programmer	NERC

Advice will be available from:

The British Oceanographic Data Centre at Bidston
The Environmental Information Data Centre at Monks Wood
The British Geological Survey Data Centre at Keyworth

Details of individual roles are given in Appendix 7 and CV's in Appendix 6.

9. COSTS

The table below summaries total costs per work package excluding travel and subsistence.

Project start up	£1,021.50
Work Package 1- User specification	£6,342.25
Work Package 2 - Options for GIS/Database system	£2,180.00
Work Package 3 - Conceptual model	£3209.00
Work Package 4 - System design	£6718.19
Work Package 5 - Demonstrator	£14,788.00
Scientific advice	£735.00
Project management	£2,150.00
Total	**£37,143.94**

APPENDIX 1 Detailed programme of work

Set out on the following pages is the detailed programme of work for the five work packages. The programme shows the individual tasks within each work package, as well as their duration, the dates between which they will be undertaken and the team member responsible for each task.

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Initials
1	**Project start up**	**1d**	**14/07/97**	**15/07/97**		
2	Get project number	0.5d	14/07/97	14/07/97		CIT
3	Briefing meeting	0.5d	14/07/97	15/07/97	2	RVM,PM,ANOT1,DRH,KM,CIT
4	**Work Package 1- User specification**	**14.59d**	**15/07/97**	**01/08/97**		
5	Identify exdsting documents	1d	15/07/97	16/07/97	3	RS
6	Copy and disseminate to team	0.25d	18/07/97	18/07/97	5	CIT
7	Prepare contents list for specification	0.25d	18/07/97	21/07/97	6	DRH
8	1st meeting with EA	3d	15/07/97	17/07/97	3	RVM,CIT
9	2nd meeting with EA	1d	18/07/97	21/07/97	8	RVM,CIT
10	Prepare draft report	2d	21/07/97	23/07/97	9	RVM,CIT
11	Present draft report	2d	28/07/97	30/07/97	10	RVM,CIT
12	Modify draft	1d	30/07/97	31/07/97	11	RVM,CIT
13	Print and submit final report	1d	31/07/97	01/08/97	12	ANOL1
14	**Work Package 2 - Options for GIS/Database system**	**8d**	**25/07/97**	**05/08/97**		
15	Identify key system properties	0.5d	25/07/97	25/07/97	3,9	ANOT1,RVM
16	Identify systems and suppliers	1d	25/07/97	28/07/97	15	ANOT1
17	Obtain data	1.5d	28/07/97	30/07/97	16	ANOT1
18	Evaluate and prepare recommendations	1d	30/07/97	31/07/97	17	ANOT1
19	Prepare draft report	2d	31/07/97	04/08/97	18	ANOT1
20	Present draft report	1d	04/08/97	04/08/97	19	ANOT1
21	Print and submit final report	1d	04/08/97	05/08/97	20	ANOT1
22	**Work Package 3 - Conceptual model**	**22.47d**	**25/07/97**	**22/08/97**		
23	Identify model objectives	0.5d	11/08/97	11/08/97	3,9	RVM
24	List and describe data types in user terms	1d	25/07/97	28/07/97	3,9	CIT
25	Develop conceptual data model	1d	25/07/97	28/07/97	3,9	RVM
26	Check model against user data	1d	01/08/97	04/08/97	25,24	RVM
27	Identify potential physical implementation problem are	1d	04/08/97	05/08/97	26	RVM
28	Prepare draft report	2d	05/08/97	07/08/97	27	RVM

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Initials
29	Present draft report	1d	08/08/97	11/08/97	28	RVM
30	Print and submit final report	1d	11/08/97	12/08/97	29	ANOL1
31	**Work Package 4 - System design**	**16.56d**	**01/08/97**	**22/08/97**		
32	Prepare contents list	0.25d	01/08/97	01/08/97	3,9	RVM
33	**Prepare report sections with EA**	**8.81d**	**01/08/97**	**13/08/97**		
34	**Data**	**3d**	**01/08/97**	**06/08/97**		
35	Types	2d	01/08/97	05/08/97	32,9	CIT
36	Volumes	1d	05/08/97	06/08/97	32,9	CIT
37	Input	0.5d	11/08/97	12/08/97	32,9	RVM
38	Editing	0.5d	12/08/97	12/08/97	32,9	RVM
39	Validation	0.5d	12/08/97	13/08/97	32,9	RVM
40	Storage	0.5d	01/08/97	04/08/97	32,9	DRH
41	Selection	0.5d	01/08/97	04/08/97	32,9	PM
42	Analysis and processing	0.5d	01/08/97	04/08/97	32,9	KM
43	Presentation	0.5d	04/08/97	04/08/97	32,9	KM
44	Export	0.5d	13/08/97	13/08/97	32,9	RVM
45	User interface	0.5d	04/08/97	05/08/97	32,9	KM
46	Meta data catalogue	0.5d	04/08/97	04/08/97	32,9	DRH
47	Ease of direct access to data by users	0.2d	05/08/97	06/08/97	32,9	PM
48	Access by remote users	0.5d	05/08/97	06/08/97	32,9	ANOT1
49	Access to remote databases	0.5d	06/08/97	06/08/97	32,9	ANOT1
50	Performance	0.25d	05/08/97	05/08/97	32,9	PM
51	Access control	0.5d	04/08/97	04/08/97	32,9	PM
52	Audit trail	0.5d	04/08/97	05/08/97	32,9	PM
53	Software supplier independence	0.25d	04/08/97	04/08/97	32,9	DRH
54	Hardware supplier independence	0.25d	04/08/97	05/08/97	32,9	DRH
55	Multi-user access	0.25d	05/08/97	05/08/97	32,9	PM
56	Resilience	0.25d	05/08/97	05/08/97	32,9	PM

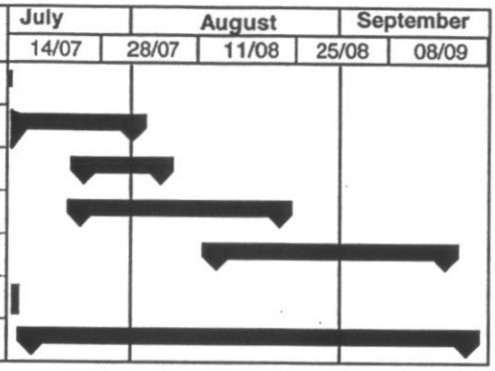
ID	Task Name	Duration	Start	Finish	Predecessors	Resource Initials
57	Referential integrity	0.25d	13/08/97	13/08/97	32,9	RVM
58	Rapid Prototype development stages	1d	15/08/97	18/08/97	33	RVM
59	Assemble draft report	2d	13/08/97	15/08/97	35,36,37,38,39,40,41,42,43,44,45,46,47,	ANOL1
60	Present draft report	1d	19/08/97	20/08/97	59	RVM,DRH
61	Modify draft	2d	20/08/97	21/08/97	60	RVM,DRH
62	Print and submit final report	1d	21/08/97	22/08/97	61	ANOL1
63	**Work Package 5 - Demonstrator**	**25.28d**	**13/08/97**	**16/09/97**		
64	Identify objective	0.5d	13/08/97	14/08/97	3,9	RVM,KM,DRH
65	Design demonstration system	3d	14/08/97	19/08/97	64	DRH,KM
66	**Produce demonstration system**	**17d**	**19/08/97**	**09/09/97**		
67	Assemble hardware	1d	08/09/97	09/09/97	65	DRH
68	Assemble software	1d	19/08/97	20/08/97	65	KM
69	Assemble data	5d	19/08/97	25/08/97	65	CIT
70	Write code	10d	21/08/97	04/09/97	65	DRH,KM,ANOT1
71	Test	3d	04/09/97	08/09/97	70	DRH,KM,ANOT1
72	**Prepare presentation**	**4.78d**	**09/09/97**	**16/09/97**		
73	Plan	0.5d	09/09/97	10/09/97	65	DRH,KM
74	Prepare supporting material	1d	10/09/97	11/09/97	73	CIT
75	Rehearse	1d	12/09/97	15/09/97	74,71	DRH,KM,RVM
76	Present	1d	15/09/97	16/09/97	75	DRH,KM,RVM
77	Scientific advice	1d	15/07/97	15/07/97	3	RL,HG,RW
78	**Project management**	**49.15d**	**18/07/97**	**19/09/97**		
79	**Weekly report**	**49.15d**	**18/07/97**	**19/09/97**		
80	Weekly report 1	0.5d	18/07/97	18/07/97		PM
81	Weekly report 2	0.5d	25/07/97	25/07/97		PM
82	Weekly report 3	0.5d	01/08/97	01/08/97		PM
83	Weekly report 4	0.5d	08/08/97	08/08/97		PM
84	Weekly report 5	0.5d	15/08/97	15/08/97		PM

ID	Task Name	Duration	Start	Finish	Predecessors	Resource Initials
85	Weekly report 6	0.5d	22/08/97	22/08/97		PM
86	Weekly report 7	0.5d	29/08/97	29/08/97		PM
87	Weekly report 8	0.5d	05/09/97	05/09/97		PM
88	Weekly report 9	0.5d	12/09/97	12/09/97		PM
89	Weekly report 10	0.5d	19/09/97	19/09/97		PM

APPENDIX 2 Gantt chart

Shown below is a summary chart indicating when the work packages will be undertaken. The programme has been prepared to meet the schedule suggested in the invitation to tender. This starts on 14th July (mid-July) and ends on 19th September (mid-September). It also honours the intermediate dates by which the deliverables for individual work packages are required.

ID	Task Name
1	**Project start up**
4	**Work Package 1- User specification**
14	**Work Package 2 - Options for GIS/Database system**
22	**Work Package 3 - Conceptual model**
63	**Work Package 5 - Demonstrator**
77	Scientific advice
78	**Project management**



APPENDIX 3 Relevant knowledge and experience - NERC

Set out below is a brief history of the Natural Environment Research Council's (NERC) involvement in the design and operation of environmental database systems, which we hope demonstrates that we have the knowledge and experience requested in the invitation to tender.

The Water Archive System (WAS) was conceived shortly after the 1973 Water Act which sought, for the first time, to manage all aspects of the water cycle as an integrated whole. In keeping with the spirit of the time, the aim of the Water Archive was to provide a single system capable of holding all data required by the water industry; its object being to facilitate the understanding of cause and effect relationships. The novel features of its design were that all the referencing systems were based on geography and not administration, all data were geographically referenced, it was dictionary driven and, in today's terminology, it was object orientated. It also included query facilities that could search both in time and space. The water archive was conceived in an age when most people were not computer literate and the concept of generic systems capable of holding data on anything from cars to clouds had not taken root. Consequently, the Water Archive was primarily used for water quality data and many of its generic features have lain un-exploited. However, it is now twenty three years old and is still widely used.

One of the features of the Water Archive was the ability to perform upstream/downstream searches. Pre-dating digital mapping, this was achieved by use of Hydrological References, a hierarchical river numbering system based on river distance. Its implementation required the measurement of every river stretch, the capture of its end grid references and the recording of its connectivity to the adjacent stretches. Although most of the work was undertaken manually, attention was soon given to automation. Digitising was the obvious solution. However, at that time, interactive systems for capture, validation, editing and processes such as node matching did not exist, neither could the systems of the time cope with the long sinuous lines generated by rivers. It was therefore necessary to design and write systems from scratch. Despite the advances in GIS, contractors still, 20 years later, find it remarkably difficult to produce fully connected, error free river network data. Nevertheless, the NERC has now achieved full coverage of the UK and is the only organisation to have done so.

It took three years to produce the maps for the 1975 River Quality Survey (RQS). Although many of the data were computerised, the final map production was still a manual effort. However, it was apparent that, theoretically at least, their production should be capable of automation. A small research exercise was mounted and by 1980 it was demonstrable that all the data for the RQS could be held in the Water Archive and the entire set of maps produced in less than a day. Much had been learnt about generic design by then and the same system could also produce the Fish Directive maps.

In parallel with these developments, the NERC was undertaking the Flood Studies Report. In this, the statistics of river flow were correlated with catchment

characteristics obtainable from maps in order to allow the estimation of floods at ungauged sites. Deriving these characteristics by hand using square counting and planimeters was a large task. Digitising was again looked to as a way of automating an otherwise overwhelming task. Here, however, the techniques explored were raster based rather than vector based.

During the 1980's, there were many attempts to replace WAS. Though it had become the largest and most widely used system in the water industry, it was visibly ageing. None of the attempts passed the drawing board stage, but one NERC design, the Great Ouse Database, formed an important stepping stone on the way to our present systems. A frustration of the time was that each spatial and time-series data type was held in a separate and different database.. Exploring relationships between different data types was difficult and often impossible. The Great Ouse Database provided the first formal opportunity to design from scratch a 4-D database.

Although the Ouse database was never implemented, born out of frustration with the system, an impulse decision was made 'to do something'. A very small prototype PC system called HAGIS (a Hydrologically Appropriate GIS) was built in three weeks to demonstrate the ideas of combining temporal and spatial data within one database. HAGIS was seen by International Computers Ltd (ICL) who saw that the formation of the National Rivers Authority would create a commercial opportunity, if they could provide a replacement for the Water Archive. HAGIS contained the embryo of what they wanted.

In 1989, a collaboration was formed between NERC's Institute of Hydrology (IH) and ICL to produce the Water Information System (WIS). IH's contributions were its experience and data and ICL's were financial resources and project management. IH conceived and designed the system. Tessella was commissioned to write it.

The objectives remained the same as for the Water Archive; a single system that could hold anything. Paradoxically, simplifying the WAS design achieved a system capable of handling many more data types. An extremely simple conceptual model was developed to enable users to visualise their data, the WIS Cube. The original concepts of features and attributes were retained, but the range of data types increased from the usual numbers and characters to include spatial properties, grids, arrays, images, sound, documents and etc.. All data were allowed to vary with time. Thus it became possible to trace the movements of research vessels and planes or the changing positions and geometry of rivers.

Although the development resources for WIS were large by research standards, they were not infinite. Ideally, the database should have been written from scratch, but time did not permit. A relational database was therefore used as the vehicle upon which to implement the WIS Cube. Contrary to popular opinion, relational databases are extremely effective at holding spatial data. They can recover large amounts very quickly. The time dimension presents a greater challenge. Despite this, the reliability and resilience of good relational databases amply outweigh their costs and disadvantages.

WIS version 1 is currently used by National Power and version 2 is under development in Malaysia. Whereas version 1 is Unix workstation based, version 2 has PC clients and uses ODBC to link to any compatible SQL database. Version 2, while retaining the Cube unchanged, explores using ArcInfo as the storage device for spatial attributes. This will obviate the need to design a new map interface.

The major implementation of WIS version 1 is at the Land Ocean Interaction Study (LOIS) Rivers Data Centre, where a multi Gbyte database has been established containing a wide range of data. LOIS is a £30M research project studying coastal zone processes, with the emphasis on processes that span environmental component boundaries. An integrated database is therefore vital. The LOIS study area covers the East coast from the Tweed to Lowestoft spanning three Agency regions. With the help of the Agency, all their water quality data for rivers, sewage and trade effluents, together with data on abstraction licences, consents and biology have been assembled. As each region uses different systems, the data have had to be harmonised to a set of common standards to create a single seamless database for the LOIS region. This has been a major undertaking and although there will undoubtedly be errors in the attempts at matching regional terminology, it has nevertheless created a large and valuable database for analytical purposes. LOIS will be succeeded by other programmes and the database is currently being extended to include all North West's data for the NERC Environmental Diagnostics thematic programme.

WIS, like WAS, is a generic dictionary driven system. These dictionaries contain the definitions of the data stored within the system both in user and system terms. Their primary purpose is to allow the user to define the types of data to be held. However, it has emerged that they are powerful tools in the establishment of standards and most of the existing dictionaries used by the Agency were originally written or commissioned by NERC staff. These include:

The Chemical Determinand Dictionary
The Biological Determinand Dictionary
The Hydrological Determinand dictionary
The Microbiological Determinand dictionary
The Sewage Determinand dictionary
The Dictionary of British Freshwater Algae
The Dictionary of Macrophytes.
The Dictionary of Freshwater Invertebrates

Two new dictionaries have been commissioned for LOIS. Of these the LOIS Chemical Determinand Dictionary additionally cross references LOIS determinands with the names, codes and units used in the EA regions of the LOIS area.

The main end product of LOIS is to be a set of CD-ROM's containing the LOIS data from all the different components of the project: rivers, coasts, marine, atmosphere and earth sciences. A viewer is required to enable users to visualise and extract data sets of interest. This is currently under development and will use the WIS 3 database design, implemented on an Access database. So that the CD's can be given away without incurring royalty and licence charges, the viewer will have its own map

interface. The assembly of the data and the production of the viewer will all be undertaken by staff who have been proposed for the EDMS project.

The volume of data requests during LOIS is in danger of exceeding the LOIS Data Centres' ability to respond. More to the point, users want to access data directly, not through an intermediary. They want to link their models directly to the databases, not download data with all the concomitant problems implied. The automated generation of meta data catalogues and their display on the WWW has therefore been explored. However, this is an interim solution. The user really wants to browse the database as it is now, not as it was last week. Therefore, down-loadable Java aplets that will give the user the direct access he requires are being considered.

The LOIS data requirements have necessitated obtaining data from many sources and in many formats. To date, separate conversion programs have had to be written for each format. An assessment of the cost of developing and maintaining these conversion programs has led NERC to consider the development of a program that can read any format and map it to the WIS Cube. A design study has been commissioned demonstrating that such a program is feasible, though the first versions will be slow and ponderous.

The description of NERC experience set out above is not in any sense exhaustive. Important systems such as those at the British Oceanographic Data Centre, the Environmental Information Centre and British Geological Survey have not been mentioned and nor have major data exercises such as the IH DTM and the Land Cover data sets. However, we hope that sufficient has been said to show that NERC has hands on experience of virtually every aspect of designing, building and operating environmental databases and has sustained it over a long period.

APPENDIX 4 Relevant knowledge and experience - Tessella

Tessella is a software services company that specialises in developing software for scientific and engineering companies, and has completed many projects for the Institute of Hydrology (IH) and companies within the water industry.

The main strengths that Tessella will bring to this project are as follows:

- The project will require strong project management by someone who is familiar with the technical aspects of the work. Our proposed Project Manager, Jon Tilbury, has considerable experience in this area having been Tessella's senior developer on IH's Water Information System. Jon's understanding will facilitate the design of a modular system which will provide the maximum flexibility.

- Tessella's TickIT accredited certification to the international standard for quality, BS EN ISO 9001, means that the software we develop is properly designed, documented, commented and is written to pre-defined coding standards. This in turn means that future maintenance and enhancement of the Tessella code will be straightforward, whether carried out by Tessella staff or by other developers.

- We believe that close contact with the customer is essential at all stages of a software development project, and will therefore establish a number of ways, formal and informal, of reporting progress to EA. This means that at every stage of the project, EA will know what Tessella is doing and will be able to request changes if our interpretation of the Specification is not correct.

- We have a broad skill base within the company upon which to draw. As well as the proposed project staff, we can call on the services of experts in other technical areas if the need arises.

APPENDIX 5 Previous projects

Listed below are some of the projects through which NERC and Tessella have gained their experience in the design and implementation of environmental database software.

NATURAL ENVIRONMENT RESEARCH COUNCIL

HYDATA - A complete hydrological database package for PC's, originally designed by the Institute of Hydrology for its own staff and now used by governments and consultants throughout the world.

Water Information System - A major collaborative development between IH, ICL and Tessella to produce an information system for environmental data capable of handling spatial and temporal data.

The IH Digital Terrain Model -.A 50 x 50m grid of heights for the UK together with other supporting grids to allow the automated determination of catchment boundaries and other catchment characteristics.

Water resource management software - The development of applications around HYDATA for the British Waterways Board

HYQUAL - A PC based water quality database developed by IH and used by the British Airports Authority

SWIPS - A PC based database for soil moisture data developed by IH.

National Water Archive - The centre responsible for assembling and publishing the national records of river flow.

LOIS - The Land Ocean Interaction Study - NERC's largest research programme to date. It has five data centres to assemble, manage and disseminate the required data and is exploring the use of WIS for the creation of a single integrated database containing all the LOIS data.

Malaysian Hydrological Information System - A joint exercise with Syed Mohammad, Hooi dan Binnie (SMHB) and the Technical University of Malaysia to develop a new hydrological information system for the Department of Irrigation and Drainage based on the WIS design but using Informix, ArcInfo and ArcView as the underpinning software packages.

Environmental Diagnostics - A NERC thematic programme which will use WIS for managing many of its data holdings.

EASIER - A joint research project between the Institutes of Hydrology, Terrestrial Ecology and Freshwater Ecology to develop a common linked framework that

facilitates hydrological and catchment modelling approaches - i.e. deals with the problem of interfacing models and databases.

TESSELLA

Water Information System - Tessella has a long history of working with the Institute of Hydrology. We provided the development team who were largely responsible for the implementation of IH's Water Information System. Much of the experience gained on this 5 year project has been retained within Tessella. Our senior programmer on the WIS team, Jon Tilbury, is proposed as the Tessella Project Manager for the EA's project.

Visualization and Modelling for the NRA - Tessella has developed a system for NRA Wessex to provide data visualization facilities for the output from NRA Wessex's point source discharge models for both river and estuary simulations. Based on the programming environment PV-WAVE, Tessella's application can visualise large volumes of data including vector and contour data on the screen. The application uses an advanced animation facility developed by Tessella to show tide cycles, and the NRA aims to use the system to optimise the dispersion of authorised discharges and provide the basis of licences for new outflows.

Leigh Barrier Flood Prediction Model - Tessella has helped NRA Southern to develop and enhance its Leigh Barrier Model. This is a flood prediction model which operates by using average rainfall data from all or any of six rain gauges located around the catchment area. Tessella has implemented the model on a VAX system and has made several enhancements to the data collection and entry interface.

GIS Development - Tessella has developed a GIS front-end to Golden River's telemetry systems using the desktop mapping tool MapInfo. Tessella's application allows users to view detectors in their geographical context, to contact the roadside detectors via the geographical interface and to perform some geographical analysis of the data collected.

Image Processing - RTZ Mining have a suite of image processing applications collectively called RTZIPS. They are used to process satellite images for mineral exploration. These are DOS FORTRAN applications and are command line driven. Although there are more modern, Windows based applications for image processing of satellite data, the RTZIPS functions are still valuable and help RTZ to keep their competitive edge. In order to prolong their life and possibly widen their use within the company, RTZ wanted a Windows user interface adding to RTZIPS. Tessella have developed a Visual Basic front end which prompts the user for the necessary parameters (providing input data checking and help information) and runs the existing FORTRAN executables. This approach means that RTZ retain their confidence in the existing code without the need for the exhaustive testing which would be required if the processing modules were re-written from scratch.

SANDCALC - Hydraulics Research is the leading authority in many areas of hydraulic engineering. One of their outputs is a technical manual on sand dynamics

near beaches of different types. This information is of critical importance to engineers when designing structures that will stand on the sea bed near the coast.

Tessella has developed a Windows program called SANDCALC that implements all the algorithms described in the HR manual in software. This software is now distributed with the manual, and is used by engineers to calculate parameters that are applicable to their particular environment.

The algorithms are implemented in FORTRAN DLLs, and the graphical user interface was developed using Visual Basic for Windows.

PIPELINE - British Gas use a FORTRAN program called WOMODPC to model the stresses in high pressure gas pipes used to transport gas around the UK. The input data for the model describes the geometry of the pipe to be modelled, the soil above and beneath the pipe, and any other known information, such as location of point loads etc. These input data are currently passed to the model via an ASCII input file.

British Gas wish to distribute the model to British Gas Transco, the company that is responsible for the pipeline network. In order to do this they must make the program more user friendly. Tessella have achieved this by writing a graphical user interface in Visual Basic. The GUI assists users to enter and validate input data, and has some graphical capabilities to allow them to display graphs of the results.

APPENDIX 6 Curriculum Vitae

Set out on the following pages are the Curriculum Vitae of the team members.

CVs of Proposed NERC Project Staff

At NERC staff availability changes on a daily basis so staff will only be formally allocated to this project once EA's order has been confirmed. However, the following team is proposed, subject to availability:

Roger Moore	Project Manager	PSO	Billing rate £424/day
Isabella Tindall	Analyst Programmer	HSO	Billing rate £245/day
Kevin Morris	E.I.S. Programmer	HSO	Billing rate £245/day
David Hill	E.I.S. Programmer	SO	Billing rate £208/day
A.N.Other	E.I.S. Programmer	SO	Billing rate £208/day

Curriculum Vitae

Institute of Hydrology

Roger Vernon MOORE

Nationality:	British
Date of birth:	23 November 1945
Profession:	Hydrologist
Position in firm:	Principal Scientific Officer
Specialisation in firm:	Design of geographic information systems for the water industry, including digital mapping
Years with firm:	Joined 1982 - permanent full-time staff member

Key Qualifications

1982 to date

Head of the Environmental Information System Section, Institute of Hydrology.
Member of the LOIS Steering Committee.
Chairman of the LOIS Data Committee.
Manager of the IH LOIS Rivers Data Centre.
Member of the Environmental Diagnostics Committee in Data and Quality Assurance
Referee for NERC Grants Committee

Responsible for:

* designing environmental information systems capable of integrated spatial and time series data management.
* establishing a national agreement on a UK. river network digitising specification
* directing the digitising of the U.K. river network
* designing interactive mapping systems for water authorities

1974 - 1982

Responsible within the Department of the Environment for the management and technical design of the national Water Archive System Project.

Organised the 1975 UK River Pollution Survey.
Prepared the U.K. River Flow maps.

1971 - 1974

Water resources engineer with Rofe, Kennard and Lapworth responsible for reservoir yield studies in relation to water supplies for the North West of England together with various flood studies. Developed a water resource modelling system and an optimisation procedure for reservoir operation.

1972 - 1973

Seconded to Water Resources Board to work on catchment models.

1969 - 1970

Regional Hydrological Officer - Northern and Luapala Provinces, Zambia, in charge of all hydrological field work.

Education

Civil Engineering Trust Scholar, 1965-1969.
Bachelor of Science (Civil Engineering) Honours, Edinburgh, 1969.
Master of Science (Hydrology), Imperial College, 1972.
Diploma of Science, Imperial College, 1972.
Member of the Institution of Water and Environmental Management.

Experience

1982 to date

Natural Environmental Research Council, Institute of Hydrology.
Responsible within Information Hydrology Division for a section which:

* chairs the LOIS Data Committee
* manages the IH LOIS Data Centre
* researches and promotes digital resources and asset mapping techniques relevant to the water industry.
* specifies the standard to which U.K. rivers should be digitised and obtains national agreement.
* organises the digitising of the U.K. river network through joint ventures with the WRA, government and the Ordnance Survey.
* designs a geographic information system (now known as the Water Information System) which has attracted co-funding by ICL and pilot site development in the North West region of the National Rivers Authority.

Liaison officer between the Institute's UK Surface Water Archive team and the Southern Water Authority and the Clyde, Forth and Tay River Purification Boards.

1974 - 1982

Department of the Environment, Water Data Unit.
Responsible for:

* the design and implementation of the Water Archive System - a major project that co-ordinated the scientific data of the Water Industry.
* chairing most W.A.S. working groups, as Technical Secretary of the W.A.S. project's policy committee.
* co-ordinating the establishment of standards for water data, and for related publications, e.g.:
  The Chemical Determinand Directory
  The Microbiological Determinand Dictionary
  The Biological Determinand Dictionary
  The Hydrological Determinand Dictionary.
* research into digital mapping.

In addition:

* carried out with others the design and production of the River Flow maps of England and Wales.
* advised the Australian Government on the design of a Water Quality Data System which was subsequently implemented.
* advising the Danish Government on Hydrological Referencing.

1971 - 1974

Rofe, Kennard & Lapworth, Consulting Engineers.

Responsible (in a three firm team) for the hydrological aspects of the Lake District Conjunctive Use Study. This assessed the yield of the major lakes used together to supply the North West of England. A large simulation model was developed to study alternative strategies. Dynamic programming algorithms were devised to derive optimal reservoir operating policies.

Similar studies were undertaken for the Burnley area, and other work included flood studies for the proposed Channel Tunnel approaches and for Kidderminster.

1972 - 1973 Water Resources Board

Worked on the development of catchment models for real time forecasting of river flow.

1969 - 1970 Hydrological Survey, Government of the Republic of Zambia.

Reopened and ran the Hydrological Survey of Zambia's office for Northern and Luapala Provinces. Established a network of gauging stations. Instituted a regular flow gauging programme. Trained Zambian counterpart staff. Construction management of all necessary structures. Employed and administered all necessary staff.

Publications

Publications at Rofe, Kennard and Lapworth

Rofe, Kennard and Lapworth, Binnie & Partners, T.H. Hawksley & Partners, 1974, Report on the Conjunctive Use of the Lakeland Sources to Manchester Corporation.

Rofe, Kennard and Lapworth, 1974, Burnley Sources - A Feasibility Study. North West Water Authority.

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The Determinand Dictionaries - a DOE series in which R.V.Moore was the principal author. Subjects:

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Microbiology
Biology
Sewage
Hydrology

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2 The WIS Data Model and Data Dictionaries
3 The Dictionary and Structure Editors
4 Data Editors
5 Bulk Data Transfers
6 Common Facilities (The User Interface and Mapping)
7 Reporting and Graphing
8 What, Where and When Lists
9 Catchment Characteristic Derivation
10 Low Flow Estimation
11 Flood Estimation
12 Flow Processing
13 River Quality Survey Mapping
14 Consent Compliance Reporting
15 System Administration Software
16 Data Sets Required by Applications
17 Supporting Services
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1.0	Early 1991
1.1	Early 1991
1.2A	6 December 1991
1.2B	24 January 1992
1.2C	28 April 1992
1.2D	5 June 1992
1.2E	17 June 1992
1.3A	24 July 1992
1.3B	25 August 1992
1.3C	18 September 1992
1.3C2	15 October 1992
1.3D	23 November 1992
1.3E	25 January 1993
1.3F	5 March 1993 (NTF-WIS) only
1.35	29 April 1993
1.4	April 1994
1.5	1 November 1994
1.6	1 October 1995
1.7	1 June 1996
1.8	1 March 1997

Data

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1981 South West. Institute of Hydrology, Wallingford.
1983 Yorkshire. Institute of Hydrology, Wallingford.
1984 Thames. Institute of Hydrology, Wallingford.
1984 Anglia. Institute of Hydrology, Wallingford.
1985 Severn Trent. Institute of Hydrology, Wallingford.
1989 Clyde and Borders. Institute of Hydrology, Wallingford.
1989 Northumbria. Institute of Hydrology, Wallingford.
1989 Southern. Institute of Hydrology, Wallingford.
1989 Wales. Institute of Hydrology, Wallingford.
1994 The 1:25000 digitised river centre line network for North West. Institute of Hydrology. Wallingford.

Other Interests

Vernon Moore Designs - a private venture involved in furniture manufacture and the design of computer controlled machines.

Set design for plays and musicals.

Language Capability

	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent

Signature Date

Curriculum Vitae

Institute of Hydrology

Claire Isabella TINDALL

Nationality:	British
Date of birth:	25 November 1967
Profession:	Environmental Scientist
Position in firm:	Higher Scientific Officer
Specialisation in firm:	Information Technology (Water Environment)
Years with firm:	5½

Key Qualifications

1991 to date Higher Scientific Officer in the Environmental Systems Section.
Experience includes:

* Setting up and management of the NERC Land Ocean Interaction Study (LOIS) Rivers Data Centre at IH.
* Project management for a contract for the NW region of the National Rivers Authority, to create a digital rivers network.
* Design, writing and maintenance of the technical and user documentation for the environmental information system, WIS, which the Institute has developed with ICL (UK) Ltd.

1991

* Scientific Officer on temporary contract, Institute of Terrestrial Ecology, Monks Wood.

Member of the British Hydrological Society.

Education

1987 - 1990 BSc Honours Degree (Class 2i) in Environmental Biology and Cartography, Oxford Brookes University, including a final year project on fruit feeding butterflies of Sierra Leone, West Africa (including overseas field work).

1990 - 1991 MSc Degree in Environmental Resources, University of Salford, including a project, in conjunction with ITE, on the integration of ecological data in an Oracle database with the Laser-Scan HORIZON GIS.

Awards

British Cartographic Society Laser-Scan Award 1992 for best thesis.

Experience

1993 to date Setting up and management of the IH LOIS Rivers Data Centre. This involves identifying user requirements, defining data dictionaries and standards, acquiring the data from external organisations, developing the WIS database and updating it with newly researched data and ensuring that all LOIS researchers receive the information they require from their Data Centre.

1996 Consultancy for the Institute of Terrestrial Ecology, Banchory on a contract to identify & assess possible release sites for beavers in Scotland. This involved analysing hydrological data at a number of sites for a report to Scottish Natural Heritage.

1992 - 1994 Project management for a contract to re-digitise the watercourses and water bodies for the NRA-NW region (the extent of the data is from the 1:50 000 scale maps but the detail is taken from the 1: 25 000 scale maps).

1991 to date Responsible for the design, drafting, production and maintenance of the technical and user documentation for WIS. This has so far included the following documents:

a) What is WIS?	30 pages
b) WIS Technical Notes 1 - 18	3/4 pages each
c) WIS User Guide	340 pages
e) WIS-PCA User Guide	30 pages
f) WIS System Administration Guide	70 pages

1991 to date Responsible for overseeing the design, setup and maintenance of standard WIS demonstrations. The demonstrations including scripts, are prepared in readiness for visits by IH visitors, prospective customers and other interested parties. Also responsible for taking WIS to other locations for demonstrations at promotional events or sales campaigns.

1991 to date Responsible for training users in the concepts and detail of the different modules within WIS. Delivered the Introduction to WIS course to IH staff responsible for the Plynlimon datasets, to staff involved in the real-time flood forecasting project in Hong Kong and to LOIS project personnel.

1991 - 1994 Consultancy for the National River Watch project based at the University of Hertfordshire analysing and presenting their data both to the National Power sponsored steering committee and through its newsletter.

1991 Institute of Terrestrial Ecology, Monks Wood.
Environmental applications of GIS including some land cover data comparisons from alternative sources.

1991 Research student working under the supervision of Mr Nigel J. Brown on the Integration of the Biological Records Centre data in an Oracle database with the HORIZON GIS.

Other responsibilities

Member of IH Sports and Social Club Committee (1992 - date).
Appointed staff representative on Restaurant User Group Committee (1992 - date).

Publications

R.V. MOORE & C.I. TINDALL 1992. What is WIS? IH/ICL Report pp 30.

R.V. MOORE & C.I. TINDALL 1992. WIS Technical Notes 1-18. IH/ICL Report pp 3/4 each.

C.I. TINDALL 1993. WIS User Guide. IH/ICL Report pp 340.

C.I. TINDALL 1993. WIS-PCA User Guide. IH/ICL Report pp 30.

R.V. MOORE & C.I. TINDALL (Eds) 1993. WIS System Administration Guide. IH/ICL Report pp 70.

R.V. MOORE, C.I. TINDALL & N.J. BONVOISIN (1993). The use of GIS techniques to assess discharge consents and abstraction licences. Proc. BHS Cardiff Symposium Sept 1993 3.21.-3.27.

TINDALL, C.I. 1994. River Network Error Validation Report for NW National Rivers Authority.

TINDALL, C.I. Land Ocean Interaction Study. A New Approach to Managing Time Series and Spatial Data for a Larger Interdisciplinary Research Project. Proc. Hydro GIS '96: International Conference an Application of Geographic Information Systems in Hydrology and Water Resource Management. Vienna, Austria 16-19 April 1996. (Submitted to Editors).

TINDALL, C.I. LOIS Chemical Determinand Dictionary Report for LOIS DATA Committee, May 1995 (approx. 100 pages).

TINDALL, C.I. & MOORE, R.V. 1997. Data management for the Land Ocean Interaction Study Programme. Science of the Total Environment - Special Issue.

C. I. TINDALL C.V. sheet 4

Language Capability

	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent
French	Fair	Fair	-

Signature Date

Curriculum Vitae

Kevin Morris

Nationality:	British
Date of birth:	2 November 1963
Profession:	Remote Sensing Scientist
Position:	HSO, Plymouth Marine Laboratory
Specialisation in firm:	LOIS - Remote sensing and GIS

Experience

1995-present Higher Scientific Officer, Plymouth Marine Laboratory. LOIS - Remote sensing and GIS.

1992-1995 Manager, NERC Remote Sensing and GIS Unit, University of Plymouth.

1989-1994 University College, London, Research Assistant and Ph.D. (part-time). Mapping 3D geological features from remotely sensed images and digital elevation data.

1986-1988 Remote sensing scientist, JARIC, RAF Brampton.

Research Interests:

Remote sensing and GIS applications in the coastal zone. Multi-dimensional visualisation of coastal processes. Development of coastal zone management expert system. Mapping 3D geological structures from remote sensing.

Education

1981-1984 B.Sc. University of Leicester. Mining Geology and Mineral Exploration

1985-1986 M.Sc. Silsoe College. Applied Remote Sensing.

1989-1994 Ph.D. University College, London. Remote Sensing.

Publications

BARNSLEY, M.J., MORRIS, K.P. 1990a. Analysis of Ground-level Directional Radiance Spectra, Proceedings of the 16th Annual Conference of the Remote Sensing Society, Remote Sensing and Global Change, University College of Swansea, 19-21 September, 175-185.

BARNSLEY, M.J., MORRIS, K.P. 1990b. Correction of the Sensor View Angle Effect in Multispectral Imagery, Proceedings of the 16th Annual Conference of the Remote Sensing Society, Remote Sensing and Global Change, University College of Swansea, 19-21 September, 186-197.

BARNSLEY, M.J., STRAHLER, A.H., MORRIS, K.P., MULLER, J-P. 1994. Sampling the Surface Bidirectional Reflectance Distribution Function (BRDF): 1. Evaluation of Current and Future Satellite Sensors. Remote Sensing Reviews, 8, 271-311.

MORRIS, K.P., BARNSLEY, M.J. 1989. An Assessment of Various Procedures for the Radiometric Correction of the Sensor View Angle Effect, Proceedings of the 15th Annual Conference of the Remote Sensing Society - Remote Sensing for Operational Applications, University of Bristol, 13-15 September, 283-290.

MORRIS, K.P. 1990. The automatic detection of three-dimensional features from remotely-sensed imagery and digital terrain models, In: Remote Sensing: An operational technology for the mining and petroleum industries, London, Institute of Mining and Metallurgy, 59-74.

MORRIS, K.P. 1991. Using Knowledge-Base Rules to Map the Three-Dimensional Nature of Geological Features, Photogramm. Engng. and Remote Sensing, 57, 1209-1216. Also presented at the Eighth Thematic Conference on Geologic Remote Sensing at Denver where it was awarded the BEST of SESSION poster paper.

MORRIS, K.P., REID, A. 1992. Report on the Derivation of Maps for Alexander Island, antarctica from Landsat Thematic Mapper Imagery, Internal Report RSU001, Remote Sensing Unit, Department of Geography, University College London.

MORRIS, K.P. 1993. Mapping Geological Structures from Airborne Imagery and Digital Elevation Data, Proceedings of the NERC Symposium on Airborne Remote Sensing - 1993, University of Dundee, 20-21 December, 180-190.

VAN SCOY, K.A., MORRIS, K.P., ROBERTSON, J.E., WATSON, A.J. 1995. Thermal Skin Effect and the Air/Sea Flux of Carbon Dioxide: A Seasonal High Resolution Estimate, Global Geochemical Cycles, In press.

MORRIS, K.P. 1995. Mapping Three-dimensional Geological Structures from Remotely Sensed Images and Digital Elevation Data, PhD. Thesis, University College London.

MORRIS, K.P., YOUNGS, K., MURPHY, R.J. 1995. Remote Sensing in LOIS, The application of remotely sensed data to monitoring coastal processes, Dundee Centre for Coastal Zones Research, 19-20th December.

MORRIS, K.P. 1995. GIS - RACS(C) Second Annual Workshop, Burwalls, Bristol, September, 27-29.

HILL, D., MORRIS, K.P. 1996. Data Integration, Proc. LOIS First Annual Meeting, Plymouth, March. 26-28, 99.

MORRIS, K.P., LAVENDER, S.H., MURPHY, R.J., ROBINSON, M-C. YOUNGS, K.J. 1996. Integration of CASI data and sea-truth measurements in the coastal zone, Proc. 2nd Int. Airborne Remote Sensing Conf., 24-27 June, San Francisco, 1-74.

YOUNGS, K.J., MORRIS, K.P. 1996. Airborne Remote Sensing of the Sediment Fluxes within the Humber Estuary, Proc. 2nd Int. Airborne Remote Sensing Conf., 24-27 June, San Francisco.

MURPHY, R.J., MOORE, G., WILSON, A., YOUNGS, K.J., MORRIS, K.P. 1996. Remote Sensing of Coasts and Estuaries as part of LOIS, SeaWIFS Technical Report Series, Volume 33, Proc. First SeaWiFS Exploitation Initiative (SEI) Team Meeting, G.F. Moore and S.B. Hooker (Eds) NASA Tech. Memo. 104566, 33.

Language Capability

	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent

Signature: Date:

Curriculum Vitae

Institute of Hydrology

David Richard HILL

Nationality:	British
Date of birth:	20 May 1973
Profession:	Environmental Information Systems Programmer
Position:	Scientific Officer
Specialisation in firm:	General systems design, programming and database administration
Years with firm:	2 years

Key Qualifications

Computing skills include, a good knowledge of C, Fortran 77 and Visual Basic programming, Oracle 7 RDBMS including Pro-Fortran, SQL, SQL Forms, SQL Text Retrieval, SSADM, general data communications and networking knowledge. Structured and event driven programming techniques have been acquired and implemented in a multi tasking windowing environment. During my final year studies have included; Advanced networking, software management and measurement, information retrieval, integrated text retrieval systems, multi-media and applications, graphics, information society and database applications development.

Additional skills include a comprehensive knowledge of many Windows/DOS applications and UNIX operating systems.

Education

1984 - 1989 Lipson Community College, Plymouth

GCSE - Art and Design (A), Chemistry (A), Design Technology (B), English (C), French (D), Geography (B), History (B), Maths (C), Media Studies (C),Physics (A).

1989 - 1991 Lipson Community College, Plymouth
GCE 'A' Levels - Art and Design (B), Design Technology (A).

1991 - 1995 University of Plymouth.

Four year sandwich course. BSc (Hons) Computing and Informatics.
Degree classification 2:1

Experience

Aug. 1993- Aug. 1994 The Institute of Hydrology, Oxfordshire - Programmer/IT support

Main duties include:

* Software development for the LOIS (Land, Ocean, Interface Study) Date Centre.
* Production of data dictionaries, construction of the database using Oracle 6/7 RDBMS and the Institutes Water Information System.
* Management of the Institutes meteorological site.

Nov. 1994- July 1995 Lipson Community College - Evening class teacher.

Part-time job teaching RSA computer literacy and information technology. The RSA scheme involved teaching basic computing skills and then progressing to three specific areas. These areas include word processing, Desktop publishing, spreadsheets, databases and computer art. Additional work has also included the invigilation of various examinations.

Aug. 1995 - Present The Institute of Hydrology, Oxfordshire - Environmental Information Systems - Programmer.

Main duties include:

* Providing programming support for the LOIS Data Centre.
* Loading data sets from internal and external sources.
* Promotion of the LOIS project via the Internet, incorporating an automatic metadata cataloguing system.
* Design and prototyping of advanced remote data access methods based on Java and Internet technologies.
* Analysis of current software and management issues relating to the operation of the LOIS Data Centre.
* Development of a quality assurance system to include both data and software systems.
* Design and prototyping for the WIS-2 system (Water Information System). Prototyping work involves the use of Microsoft Access, Microsoft Visual Basic 4/5 (Remote database access), Microsoft Excel, ODBC and ORACLE 7.

Publications

HILL, D.R. 1995. Multi-media Dartmoor Information System.

HILL, D.R., BELLAMY, S.P. 1996. Search mechanisms for querying the time dimension in 4-D GIS. 1st International Conference on GeoComputation, Leeds, UK, 1996, University of Leeds, Vol 1, Pages 405 - 420.

HILL, D.R. 1997. Distributing Geographical Information Systems and Data using Java and the Internet. 2nd International Conference on GeoComputation, Dunedin, New Zealand, 1997 (In press)

Language Capability

	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent

Signature: Date:

CVs of Proposed Tessella Project Staff

At Tessella staff availability changes on a daily basis so staff will only be formally allocated to this project once EA's order has been confirmed. However, the following team is proposed, subject to availability:

Jon Tilbury	Project Manager	Scale 8	Billing rate £56.00/hour
Stephen Fullerton	Analyst Programmer	Scale 3	Billing rate £31.50/hour

The CVs for both staff are provided on the following pages. Alternative or additional staff of equivalent experience can be made available during the course of this project should they be required.

Curriculum Vitae

Name : Jonathan Tilbury

Date of Birth : 22/3/63

Position : Technical Manager

Qualifications :

3 'A' Levels: Mathematics (A), Physics (A), Chemistry (A)

BA (Upper Second with Honours)
Metallurgy and Material Science
University of Oxford

Project Management Module (Pass with Merit),
Open University

Employment :

Start	**End**	**Employer**
Jun 1983	Sep 1983	Mount Isa Mines, Queensland
Jun 1984	Sep 1984	MIT, USA
Jan 1986	Present	Tessella

Machine Experience :

SUN, SGI
IBM PC
IBM Mainframe
CRAY

Software Experience:

System Software	**Languages**	**Packages**
UNIX-Solaris	FORTRAN	Oracle
MS Windows	C	GKS
MVS	SQL	PV-WAVE
UNICOS	MapBasic	MapInfo
UNIX-IRIX	Shell Scripts	LabWindows
		AVS
		MS Project

Experience

May 1996 - Present

Skills: Project Management

Jon has just completed managing the production of a Bio-Informatics product at a customer site. The product is important for the future of the company but the development project had run into problems and was running one year late. Jon was brought in to take control of the project and to manage the completion of the product.

The project team was 14 strong and comprised both Tessella and customer staff. Effort on the project totalled 1600 man days. There was considerable pressure to deliver from the sales team as they had already pre-sold 525 copies. However the internal users kept adding functionality and compromising the development schedule. Jon's primary task at the start of the project was to establish a way of formally defining the product and to manage any changes that were requested. This was largely successful.

The team then moved into the detailed design and production phase. This has required motivating and disciplining the team so they work effectively together, and continuous monitoring of progress. The team had considerably mixed abilities and this required sensitive handling. Also the problems of managing staff from different organisations cannot be underestimated. Jon played special attention to communication within the team, with senior management, and with the sales and customer support departments to ensure no misunderstandings built up.

The product is currently being beta tested. The completion date was 1 week later than that predicted at the start of the production phase 6 months earlier. This is a considerable achievement given the changing requirements and reflected a continuous and effective trade off between functionality and delivery date. The skills Jon acquired on the Open University 'Project Management' module played a large part in its success.

March 1996 - Present

Skills: Project Management, Visualisation Techniques

Jon is the Project Manager and architect for an ambitious research project into ways of efficiently visualising vast scientific data sets. This project is a collaboration between Tessella and companies in France and Italy and will run over a two and a half year period. It is half funded by the European Commission under the Esprit programme. Tessella's component of the system is a GUI for producing 3D visualisations of the compressed and

reduced data. Jon has a fixed budget and must come up with the best product possible in the time available.

October 1995 - June 1996

Skills: C, LabWindows, Data Acquisition, MS Windows

Jon was the project manager and chief designer for a data acquisition and processing systems for the DRA. This 'restricted' project uses LabWindows running under MS Windows to acquire and present the data and C to process it. Jon developed a prototype which proved to the customer and the MOD that the principle was workable and then developed this into a formal design. An applications programmer has now developed the software with Jon as the Project Manager. Despite its complexity and the lack of experience of the project team in this technical area, the project was delivered ahead of schedule and well within budget.

One important aspect of the project is the software quality. The system will be used in a real time situation to support a very expensive piece of hardware and must thus be built to the highest standards. A hybrid set of procedures has been devised using the most appropriate of Tessella's and the DRA's quality systems and the project is extensively documented and tested.

October 1994 - March 1995

Skills: Project Management, Object Oriented Systems

Since October 1994, Jon has been Project Manager of the development and support of a multipurpose object oriented simulation environment developed for marine engagement simulations for the DRA. This system uses AVS/Express to provide the glue to link a number of simulation objects developed in C++. It also includes a simulation engine (C++) and a repository manager (SCCS, C, Motif). The first version of this system was delivered in May 1995 and since then a number of enhancements have improved performance and usability. The development team grew to 6 staff and the support team varies from 2-3. Project control was made more complex by the tight time scales and high complexity of the solution..

September 1994 - November 1994

Skills: Project Management, Oracle, PV WAVE

Jon was the project manager and chief architect of a borehole database developed to hold time series of pressure and temperature. This generated very high quantities of data (about 2.5 Gb) that needed organising within an Oracle database. A front end was written using PV WAVE. Jon's experience with C-Oracle interface was invaluable in optimising the solution.

September 1994 - Present

Skills: Resource Management, Staff management and Development

Since September 1994 Jon's responsibility had expanded to include managing Tessella's UNIX Unit. This comprises approximately 15 staff working on various UNIX developments as well as a few cross platform MS Windows projects. Jon is responsible for staff development and motivation, recommending recruitment of appropriate staff and the system administration of the Tessella UNIX Unit network.

Jon is also the senior project manager for the unit. In addition to the larger projects mentioned here, he has managed a large number of smaller projects including the delivery of training courses in UNIX, the development of PV-WAVE prototypes for the oil industry, MapInfo prototype front ends to data acquisition systems and many other projects.

As part of his management responsibility, Jon has been a member of the Tessella Quality Steering Committee since 1992. This committee has overall responsibility for the initial and continued development of Tessella's BS EN ISO 9000 Quality Management System. Jon has also written some of the procedures, including System Design.

February 1994 - April 1995

Skills: Project Management, MapInfo, Systems Analysis

Jon was Project Managing for the development of a complex modelling system. This confidential project involves a large project team made up of 2 Tessella staff and 3 customer staff. Jon has the task of ensuring delivery is on time and to budget as well as acting as overall design authority.

January 1991 - September 1994

Skills: Project and Resource Management, System Design

At the start of 1991 Jon was promoted to Business Manager within Tessella. This post involves business responsibility for Tessella's work in the water industry. It has included the analysis of customer requirements, the writing of project proposals, and the project management and resourcing of projects.

Amongst the projects Jon has managed are systems to convert water quality data from WQ15 format into National Transfer Format (NTF), packages to provide data visualization software to the National Rivers Authority and an extension to an Asset Management model to run using the full memory of a PC.

April 1989 - January 1994

Skills: FORTRAN, C, SQL, UNIX, Oracle, MS Windows, System Analysis and Design

Jon worked on the Water Information System at the Institute of Hydrology. This large database and graphics system is written in FORTRAN, uses GKS Graphics and accesses Oracle via embedded SQL. Jon has worked as a part of the small development team since it's inception and has developed a number of key features. These include a digital mapping system including a map editor, the database SQL interface library, and various data loading facilities. In all cases he has been involved in all stages of development, from design to implementation, testing and user support. He is now one of the senior designers of the system and is involved in the design of all new modules added to the system.

The Water Information System is implemented on SUN workstations. Jon has gained a great deal of expertise in UNIX and has been acting as System Manager for the development network. He has also worked as the database administrator for the networked Oracle database.

March 1993

Skills: Oracle, SQL, UNIX, FORTRAN

Jon installed a Real Time Flood Forecasting system at Binnies in Hong Kong. This system, written by the Institute of Hydrology for the Land Drainage Department of the Hong Kong Government, runs on a WIS 1.2E database. Jon installed the database in Hong Kong and tuned the system to optimise performance.

June 1991 - April 1992

Skills: Requirements Analysis, Advanced graphics, Relational Databases

Jon completed a consultancy project for HR Wallingford. This involved a study for HR's customer the Civil Engineering Department of the Hong Kong Government on a complete graphical visualization system and database for their field data measurement and WHAMO hydraulic modelling data. The Hong Kong government have decided to act on Tessella's recommendations and have recently awarded a contract for the implementation work.

January 1986 - April 1989

Skills: FORTRAN, UNIX, VMS, UNICOS

Jon's first three years work for Tessella was centred on the development and maintenance of the Monte Carlo code MCBEND. This large FORTRAN code was constantly evolving as new features and time-saving methods were included. As this code was developed over a number of years by several people, this work involved familiarisation with many different programming styles and methods. He has also written many auxiliary codes that carry out nuclear data preparation and post-run analysis, all in FORTRAN. His last project was the development of a diffusion code using finite difference techniques.

This development work was carried out on the IBM Mainframe. He also developed and ran two codes on the CRAY supercomputer using both COS and UNICOS operating systems. Much of the later work was transferred to a local area network of SUN workstations which demanded a knowledge of UNIX shell programming and skill in the efficient use of many features of the UNIX operating system. He has written a short code on a DEC PDP-11 and has some experience in the use of DEC VAX and micro VAX computers.

He has spent some time in the use of MCBEND and associated codes such as FENDER and SNAPSH to carry out shielding calculations. These have included a detailed safety review of a nuclear power station and a very accurate survey of the use of oil well logging tools.

January 1981 - June 1985

Skills: FORTRAN

While at Oxford Jon spent some time researching into aspects of the lead smelting process including the use of process control software. This was in 1983 with a company called Mount Isa Mines, Australia as a Research Assistant. In 1984 he carried out some research into the microscopic composition of steel including theoretical calculations of optimum machine performance using FORTRAN programs, at Massachusetts Institute of Technology, USA as a Research Assistant.

Curriculum Vitae

Name : Stephen Fullerton

Date of Birth : 18/04/69

Position : Associate Analyst Programmer

Qualifications : 5 'A' Levels: Mathematics (A), Further Mathematics (B), Physics (B), Chemistry (C), General Studies (D)

BSc II(i) Physics with Astrophysics
University of Birmingham, 1990

PhD Astronomy and Physics
University of Glasgow, 1993

Employment :

	Start	**End**	**Employer**
Tessella	Nov 96	Present	
University of Durham	Feb 94	Sept 96	

Machine Experience :

IBM PC
IBM 3090
DEC Alpha

Software Experience :

System Software	**Languages**	**Packages**
VAX/VMS	FORTRAN	
SUNOS	C	
UNIX	Visual Basic	
Windows		

Experience

February 1997 - Present

Skills: Visual Basic 4.0, MapInfo

Stephen is currently working on a project at WRc in Swindon. The work involves the development of WRc's WATNET optimisation system for water networks. The development is being done using Visual Basic and uses MapInfo's VB mapping control to provide a map based user interface.

January 1997

Skills: Visual Basic 4.0, Access, SQL, ODBC

Stephen completed a short contract helping to develop an electronic ordering system using client/server technology. The system has been developed in Visual Basic using an Access database in a Windows 95 environment. Stephen has been writing VB code concerning the Graphical User Interface and to query and update the client's Access database, as well as developing a protocol and code to enable the client and server to communicate.

November - December 1996

Skills: Visual Basic

Since joining Tessella Stephen has been involved in two high profile Visual Basic developments. The first was to implement a number of modifications to an application that Tessella had previously developed for a customer in the oil and gas industry. The customer requested these changes shortly before releasing the application to its users, and the successful uptake of the software depended on the modifications being implemented and the application fully tested in a very short time frame. Stephen made an excellent start to his career with Tessella on this project and earned the praise and thanks of the customer at the end of a very successful training course accompanying the software's release.

The second project was to develop a demonstration application using Visual Basic to support a proposal submitted to a mining company. Due to the deadlines imposed by the customer, this project was also carried out under severe time constraints. However, based on the quality and completeness of the demonstration Tessella was awarded the contract to develop the full system.

February 1994 - September 1996

Skills: FORTRAN

Stephen's research work at the University of Durham has involved observations, data analysis and computational/mathematical modelling of polarized light scattering by dust grains in proto-plantary nebulae. He has written codes in FORTRAN to compute Mie scattering calculations to predict polarization levels resulting from scattering by grains of various constituents. A Monte Carlo approach was taken to estimate the resulting polarization from multiple scattering in an optically thick circumstellar disk. Results have supported the view that core-mantle grains are responsible for high polarization levels in the observed objects, and have been written up in peer reviewed journals.

APPENDIX 7 Project team details

Name	:	Roger V. Moore
Role	:	Design
Organisation	:	NERC, Institute of Hydrology
Address	:	Wallingford, Oxon. OX10 8BB UK
Phone	:	+44 (0)1491 838800
Fax	:	+44 (0)1491 692424
Email	:	rvm@ua.nwl.ac.uk or rvm@ioh.ac.uk

Name	:	To be assigned on award of contract
Role	:	Project manager (and database design advice)
Organisation	:	Tessella
Address	:	3 Vinyard Chambers, Abingdon. Oxon OX14 3PX UK
Phone	:	+44 (0)1235 555511
Fax	:	+44 (0)1235 553301
Email	:	?@tessella.co.uk

Name	:	Isabella Tindall
Role	:	Data Centre Operation, Dictionaries and Interchange
Organisation	:	NERC, Institute of Hydrology
Address	:	Wallingford, Oxon. OX10 8BB UK
Phone	:	+44 (0)1491 838800
Fax	:	+44 (0)1491 692424
Email	:	cit@ua.nwl.ac.uk or cit@ioh.ac.uk

Name	:	Dr Kevin Morris
Role	:	User interface, remote sensing and GIS
Organisation	:	NERC, Plymouth Marine Laboratory
Address	:	Prospect Place, Plymouth PL1 3DH UK
Phone	:	+44 (0)1752 633100
Fax	:	+44 (0)1752 633101
Email	:	kpm@pml.ac.uk

Name	:	David Hill
Role	:	Environmental Information Systems programmer
Organisation	:	NERC, Institute of Hydrology
Address	:	Wallingford, Oxon. OX10 8BB UK
Phone	:	+44 (0)1491 838800
Fax	:	+44 (0)1491 692424
Email	:	drh@ua.nwl.ac.uk or drh@ioh.ac.uk

Name	:	To be assigned on award of contract
Role	:	GIS market survey
Organisation	:	Tessella
Address	:	3 Vinyard Chambers, Abingdon. Oxon OX14 3PX UK
Phone	:	+44 (0)1235 555511
Fax	:	+44 (0)1235 553301
Email	:	?@tessella.co.uk

Name	:	To be assigned on award of contract
Role	:	Programmer
Organisation	:	NERC
Address	:	
Phone	:	+44 (0)
Fax	:	+44 (0)
Email	: