Reducing Uncertainty in River Flood Conveyance - Phase 2

Inception Report

Report SR 596
April 2002
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Report SR 596
April 2002
Contract - Research

This report describes work funded by DEFRA/Environment Agency under contract number R&D Project W5A – 057. This report was coordinated by Manuela Escaramelía and the Technical Director for this study was Dr Paul Samuels. The HR Wallingford job number was MJS 0223.

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Summary

Reducing uncertainty in river flood conveyance - Phase 2

Inception Report

Report SR 596
April 2002

Under their joint R&D programme for Flood and Coastal Defence, DEFRA/Environment Agency are funding a Targeted Programme of research aimed at obtaining better predictions of flood water levels. In order to achieve this, advances in knowledge and understanding made over the past three or four decades in the estimation of river conveyance will need to be introduced into engineering practice.

The project relates particularly to water level estimation, leading to a reduction of flood risk and better targeting of expenditure. It is expected that the application of this knowledge from UK engineering research will have an international impact through improving the methods available to consultants.

The above objectives will be achieved through two core components of the new Conveyance Estimation System (CES) that will be developed: the Conveyance Generator and the Roughness Advisor. The CES is to be designed so that new knowledge from a parallel Strategic Programme of research can be integrated into the CES in due course.

This report is the Inception Report for the project and covers:

- Background to the project;
- Progress of work carried out in the first three months of the project related to Components T1 (Data mining), T2 (Conveyance methods review) and T4 (Roughness review);
- Outline definition of the functional specifications for the software components of the project;
- Project Management and Quality Plans;
- Development and delivery of software;
- Dissemination and publicity of the project.
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the report)
1. INTRODUCTION

1.1 Background
Under their joint R&D programme for Flood and Coastal Defence, DEFRA/Environment Agency are funding a Targeted Programme of research aimed at obtaining better predictions of flood water levels. In order to achieve this, advances in knowledge and understanding made over the past three or four decades in the estimation of river conveyance will need to be introduced into engineering practice.

HR Wallingford, in association with academic experts and river flood practitioners was commissioned in 2001 to carry out a Scoping Study to define targeted and strategic programmes for research ("Reducing Uncertainty in River Flood Conveyance, Phase 1 - Scoping Study").

A proposal for the Targeted Programme of research on reducing uncertainty in the estimation of river flood levels was submitted to DEFRA/EA in December 2002 by a team led by HR Wallingford. The proposal was accepted and the project commenced in January 2002. The project ("Reducing Uncertainty in River Flood Conveyance, Phase 2 – Production of Conveyance estimation Toolkit", R&D Project W5A-057) is being undertaken under the Framework Agreement between HR Wallingford and the Environment Agency for research services.

This report is the Inception Report for the project. At the project Start-up Meeting no major changes/amendments were suggested by the Agency Project Manager regarding the proposed work and other information contained in the Offer of Professional Services dated 3 December 2001. A summary of the additional actions (or of the emphasis on particular aspects of the work) from that meeting can be found in Section 2.4.1. The information contained in the offer of services therefore remains valid.

The present report contains the following information. After the Introduction in Chapter 1, the progress of work carried out in the first two months of the project is summarised in Chapter 2. This covers work related to Components T1 (Data mining), T2 (Conveyance methods review) and T4 (Roughness review), and the meetings carried out during this period. Chapter 3 describes the work on the outline definition of the functional specifications for the software components of the project. Work on the dissemination and publicity of the project is covered separately in Chapter 7. The Project Management Plan and the Project Quality Plan are given in Chapters 4 and 5, respectively. Chapter 6 deals with issues related with the development and delivery of software, and dissemination of the project is covered in Chapter 7.

1.2 Objectives
The objective of the project is to draw together best engineering practice and implement the results of nearly two decades of research into river flood conveyance in order to produce a significant advance in the practice of river flood management in the UK. The past research has been mainly funded by EPSRC and centred around the Flood Channel Facility at Wallingford. The project relates particularly to water level estimation, leading to a reduction of flood risk and better targeting of expenditure. It is expected that the application of this knowledge from UK engineering research will have an international impact through improving the methods available to consultants.

The above objectives will be achieved through two core components of the new Conveyance Estimation System (CES) that will be developed: the Conveyance Generator and the Roughness Advisor.

The CES is to be designed so that new knowledge from a parallel Strategic Programme of research can be integrated into the CES in due course.
1.3 Project Team

The team assembled for the project includes HRW staff and non-HRW staff and can be divided in the following categories (see Figure 1):

**Project Management**

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project Director</td>
<td>Dr Keith Powell</td>
</tr>
<tr>
<td>Project Manager</td>
<td>Manuela Escarameia</td>
</tr>
<tr>
<td>Software Project Manager</td>
<td>Andrew Nex</td>
</tr>
</tbody>
</table>

In the absence of the Project Manager the Deputy Project Manager is Dr Christine Lauchlan.

**Technical development**

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Directors</td>
<td>Dr Paul Samuels</td>
</tr>
<tr>
<td></td>
<td>Edward Evans</td>
</tr>
<tr>
<td>Technical Director for Software</td>
<td>David Fortune</td>
</tr>
<tr>
<td>Conveyance research fellow</td>
<td>Caroline McGahey</td>
</tr>
<tr>
<td>Software research fellow</td>
<td>Dr Wiktoria Daniels</td>
</tr>
<tr>
<td>River roughness advisors</td>
<td>Karen Fisher</td>
</tr>
<tr>
<td></td>
<td>Dr Hugh Dawson</td>
</tr>
</tbody>
</table>

**External Expert Panel**

<table>
<thead>
<tr>
<th>Role</th>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prof. Donald Knight</td>
<td></td>
<td>University of Birmingham</td>
</tr>
<tr>
<td>Prof. Garry Pender</td>
<td></td>
<td>Heriot-Watt University</td>
</tr>
<tr>
<td>Prof. Alan Ervine</td>
<td></td>
<td>University of Glasgow</td>
</tr>
<tr>
<td>Dr Chris Whittle</td>
<td></td>
<td>Eden Vale Modelling Services</td>
</tr>
</tbody>
</table>

The project will be monitored by a Project Board appointed by the Agency. The membership of the Agency Project Board includes representatives of the following areas of work: Flood forecasting (Rahman Khatibi), Regional river Modelling (Peter Spencer) and Design (David Keiller). Corresponding members have also been invited from the work area of Maintenance and to represent Scotland and Northern Ireland interests.

Close contact with model users at key stages in the development of the CES and its user interface is essential for the success of the project. The information being sought at this stage will require a more detailed knowledge of model use than would be the day-to-day experience of most members of the Project Board. Thus a Consultative Group is currently being identified with the Project Board to liaise with the software developers in looking at:

- the likely modes of the use of the CES by different users,
- its need to interact with common data sets and sources,
- the linkages to other software systems,
- model management and process control,
- “look and feel” of the user interface,
- common tasks etc.

It is important that the members of the consultative group are actively involved in the use of 1-D models or using results of conveyance estimation. Their role will be to assist with ensuring the CES becomes a practical working tool within the Agency offices and those of its consultants. Thus the interaction with the User Consultative Group will shape the final interface which is delivered around the CES to maximise the
“user” acceptance of the new approach. The underlying philosophy will be to support the users in performing their functions including modelling tasks by structuring the CES in the most appropriate way.

The User Consultative Group includes representatives of the following areas of work: Maintenance (John Ulyatt and/or Dave Gillett of EA Anglian Regional Office), Flood Forecasting (Lance Dawkins, EA Anglian Regional Office), Food Risk Mapping Consultants (Tony Green of JBA), Design (Mr Jon Bartlett or Mr Tim Palmer of BBV), Hydrometry (to be nominated), RHS (Mr Jim Walker, EA Warrington Office), Local Authorities and other consultants (Rob Cheetham of HR Wallingford, Jon Wicks), IDBs (Mr David Sisson, Alford Drainage Board). Most of these representatives have links to the members of the Agency Project Board.

Project team members will go to the offices of the Consultative Group to seek their views on the issues listed above. This is expected to occur on average three times during the 24 months of the project and the discussions will last half a day.

A link will also be established between the Consultative Group and the EPSRC network, since a key part of acceptance will be the usability of the CES for University MSc and other courses.

1.4 Project Tasks
The project tasks were described in the HR Offer of Professional Services of 3 December 2001 and are presented in Appendix 1.
2. PROGRESS ON WORK

2.1 Data Mining (Component T1)

The primary objective of the data mining task is to assemble topographic and hydrometric data sets for testing the flood conveyance estimation methods. This process includes three phases:

1. Screening the existing data for coverage, quality and suitability as test data
2. Assembling the selected data sets for the development and testing of the conveyance methods covering all typical river/floodplain morphologies
3. Making the data available through the Network website.

Quality data for a variety of flow conditions is essential for developing, testing and validating the conveyance estimation system such that it receives broad acceptance and can be implemented with confidence.

Phase 1

The data that is required for the calibration of the conveyance generator should comprise both field and experimental measurements. A maximum of fifteen data sets should be selected with a preferred ratio between the field and laboratory data sets of 2:1.

Field data

The field data provides the real river scenario including: the actual flood events that have occurred; the resistance of in situ sediment types and natural vegetation; the irregular cross-sectional and plan form geometries that occur in undeveloped areas; and seasonal variations in flow rates. The nature and quality of the data sets typically vary according to:

1. The period over which the measurements have been recorded
2. The type of measuring devices e.g. hydrometric gauges, maximum level recorders
3. The lengths of the river reach along which the measurements have been taken
4. The number of flood events for which data is available
5. Availability of existing ISIS, HECRAS or MIKE 11 models containing geometrical data
6. The effects of downstream controls e.g. hydraulic structures, tidal influence.

Dr Chris Whitlow has prepared a report entitled “Data mining exercise to identify field scale datasets in England and Wales to support research into floodplain conveyance”. This will be presented in Interim Report 1 (datasets). Various organisations and individuals were contacted within the UK hydraulic modelling community and a list was assembled of available datasets for rivers located in the Midlands, Thames, Anglian, Southern, South West and North East Regions. These were ranked with the primary criteria being the availability of the data and the feasibility of obtaining a long section profile either locally or over a longer distance. This report provided the initial selection of river data sets. This process is not, however, limited to this Wales and England data. The River Main in Northern Ireland and the River Blackwater in Scotland are being investigated for available and reliable data sets.

The top fifteen ranked data sets are currently being assessed and screened to assemble a combination of rivers that cover a range of flow rates, longitudinal gradients, river reach lengths, sinuosities, sediment and vegetation resistance, cross-sectional geometries, plan forms as well as both in and out of bank flow cases. This variety is essential in testing the conveyance generator against all possible flow conditions. The fifteen rivers are listed in Table 1:
Table 1  Top Fifteen Ranked Rivers (after Chris Whitlow 2002)

<table>
<thead>
<tr>
<th>Rank</th>
<th>River</th>
<th>Region</th>
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<tbody>
<tr>
<td>1</td>
<td>Blackwater</td>
<td>Thames</td>
</tr>
<tr>
<td>2</td>
<td>Severn</td>
<td>Midlands</td>
</tr>
<tr>
<td>3</td>
<td>Thames</td>
<td>Thames</td>
</tr>
<tr>
<td>4</td>
<td>Teme</td>
<td>Midlands</td>
</tr>
<tr>
<td>5</td>
<td>Cherwell</td>
<td>Thames</td>
</tr>
<tr>
<td>6</td>
<td>Trent</td>
<td>Midlands</td>
</tr>
<tr>
<td>7</td>
<td>Wye</td>
<td>Midlands</td>
</tr>
<tr>
<td>8</td>
<td>Medway</td>
<td>Southern</td>
</tr>
<tr>
<td>9</td>
<td>Cam</td>
<td>Anglian</td>
</tr>
<tr>
<td>10</td>
<td>Alconbury Brook</td>
<td>Anglian</td>
</tr>
<tr>
<td>11</td>
<td>Tone</td>
<td>South West</td>
</tr>
<tr>
<td>12</td>
<td>Longford</td>
<td>Thames</td>
</tr>
<tr>
<td>13</td>
<td>Salwarpe</td>
<td>Midlands</td>
</tr>
<tr>
<td>14</td>
<td>Ouse</td>
<td>North East</td>
</tr>
<tr>
<td>15</td>
<td>Sence</td>
<td>Midlands</td>
</tr>
</tbody>
</table>

**Experimental Data**

Experimental set-ups are a controlled means of obtaining data for specific cases. They provide useful velocity, shear stress and turbulence data, while precise meander patterns and floodplain resistance conditions can also be created. This is essential in validating empirically based equations and determining parameter estimation for turbulence closure difficulties. However, these physical models create ideal flow conditions that do not generally occur in nature and they are further subject to scaling effects.

Dr Alan Ervine presented a paper in the scoping report entitled “The role of experimental and field data”, which describes the available data sets with reference to the quality and accuracy of the data. Three data categories are identified:

1. Small-scale model data (i.e. flumes 5-25m long, 0.5-2m wide)
2. Large-scale model data (i.e. flumes 30-60m long, 5-10m wide)
3. Field data

The small-scale model data sets, typically from universities, include some fairly meticulous results. Of the large-scale data sets, the Flood Channel Facility data is considered the highest quality. The River Blackwater 1/5 scale model is recommended in particular as it provides a doubly sinuous compound channel flow case and it would provide a good comparison to the field data.

This experimental data is currently being screened for five representative flow cases with high quality measurements.
Phase 2
Various individuals within the UK hydraulic modelling community have been contacted for river data corresponding to the top fifteen ranked rivers of Chris Whitlow’s report. The Environment Agency is in the process of distributing letters to the various consultants to permit them to make this river data available to HR Wallingford. Once obtained, the nature of this data will dictate how it is assembled and hence made available for use in the testing/calibration of the conveyance generator.

Phase 3
Once all the data sets are selected and assembled they will be made available on the Network website.

2.2 Conveyance Methods Review (Component T2)
This section outlines the conveyance estimation review process, covering the previous approaches to computing discharge and the more recent work that has been undertaken. This process follows on from the expert paper by Donald Knight, which formed part of the Annex to the Scoping Study Report. Knight identified various methods of calculating conveyance and the associated limitations of these methods and their implementation. These typically include assumptions made in the derivations such as quasi-straight channel reaches and negligible lateral momentum transfer for the early divided channel methods (DCMs) that many 1D river modelling packages are based on.

The Scoping Study Report drew out some of the key messages from Knight’s paper in the Scoping Study Report as:

- The improved DCM methods may perform well in given circumstances, however, they are not based on rigorous physics and cannot be broadly accepted.
- The coherence method (COHM) of Ackers requires an idealised trapezium section and is therefore not readily applicable to natural channels.
- The lateral distribution method (LDM) ignores the secondary flow terms and simplifies the diffusion process through the use of a single ‘catch-all’ parameter.

The Shiono & Knight method (SKM) extends the physical basis of the LDM method, and despite the difficulty of estimating the three calibration coefficients, the physical basis of this method provides much promise, albeit for straight prismatic channels only.

Professor Knight’s expert paper makes the distinction between ‘global’, ‘zonal’ and ‘local’ roughness coefficients which refer to the whole cross-section, the sub-area of a cross-section or the ‘unit strip’ of boundary respectively. As a result, the scale of the conveyance calculation should be considered. Two of the approaches currently under consideration include the conveyance as representative of a river section or alternatively as the sub-reach scale e.g. the computational ‘cell’ between two consecutive cross-sections or the average properties of larger aggregations of sections covering a physio-graphic unit such as a meander.

Meandering channels
In general, the straight channel methods reviewed by Knight are not applicable to the meandering channels found in nature. Meandering channels provide a further degree of complexity as the effects of helical secondary currents, bends, expansions and contractions as the water flows between the main channel and the floodplains, increased turbulence, varying degrees of sinuosity and the cross-stream variation in water level should be considered. Previous approaches to determining the discharge in meandering channels were largely developed for inbank flow and are not generally applicable to two-stage channels. More recently, work has been undertaken to develop a conveyance estimation method that is applicable to a range of flows including two-stage meandering flow with varying vegetation across the section. These methods include the extension of the original work by Shiono & Knight (1991) and the methods of Bousmar & Zech (1999), Shiono et al (1999) and Ervine et al (2000).
The older historic approaches to estimating conveyance capacity are not strictly physics based and are therefore not suited to a wide range of channels. The two approaches that are currently under investigation are based either on the division of the section into physically identifiable units and flow mechanisms and their associated energy losses, or a simplification of the Reynolds Averaged Navier Stokes Equations (RANSE). These approaches have been assessed in terms of the following criteria:

- Theoretical and physical basis of the method
- Consideration of all energy losses and the energy loss hierarchy
- Previous testing of methods against existing laboratory and/or field data
- Reliable and readily available coefficients
- Ease of implementation from a simple straight channel to a meandering compound case
- Primary output: water level for a given flow rate
- Secondary outputs: lateral velocity and/or shear stress distributions
- Spatially averaged roughness coefficients
- Small number of roughness values

(i) Shiono et al (1999)

Shiono et al (1999) extended the original Ervine & Ellis (1987) approach to flow in meandering channels of analysing the energy losses in the various flow zones in a channel division method. This method considers the various energy loss contributions from the flow processes occurring within each zone i.e. the inbank main channel flow, the out of bank flow within the meander belt and the out of bank flow beyond the meander belt. The equation essentially assumes that all losses depend upon the square of the local flow velocity and are of the form:

$$\sum_{i=1}^{n} K_i \frac{v^2}{2g} = \frac{S_o}{s}$$

where

- \(v\) = velocity of the flow zone/section (m/s)
- \(S_o\) = bedslope
- \(g\) = gravitational acceleration (m²/s)
- \(s\) = sinuosity
- \(K_i\) = coefficient that accounts for the loss mechanisms in a zone

The coefficient \(K\) assumes different values to account for the various loss mechanisms. The losses in the inbank region include boundary friction, secondary flows and streamwise turbulent shear stresses. The zone within the meander belt width incorporates losses due to boundary friction, expansion and contraction of flow and turbulent shear forces over the meander wavelength. The zone beyond the meander belt includes losses due to boundary friction only. The advantages of this model are that it:

- is physically based
- identifies the flow zones and flow structures
- incorporates the losses due to secondary currents, bed friction, streamwise turbulent shear stresses, turbulent shear forces over the meander wavelength and flow expansions and contractions
- is easy to apply and understand

The implementation of this model would, however, require further consideration of the following issues:

- Can the principle of superposition be applied to the energy loss contributions or are there interactions which would prevent this?
- Variation in water depth results in different contributions of the various loss mechanisms. How is this to be incorporated in the model?
- The loss coefficients are derived from laboratory data. Are these coefficients suitable for the change in scale to real rivers?
• The losses are determined over a meander reach. Can these be converted to a cross-sectional reference framework for input into a 1D river model?
• The current method applies to an idealised section. Can the method be adapted to handle real world sectional geometries and irregular meander patterns?


Ervine et al (2000) proposed an adaptation of the original SKM depth-averaged approach to meandering channels. This is illustrated in the following equation:

\[
\rho g S_o - \frac{1}{8} \rho f U_d^2 \left(1 + \frac{1}{s^2}\right)^{\frac{1}{2}} + \partial \left( \rho \lambda H \left(\frac{f}{8}\right) U_d \frac{d U_d}{dy} \right) = \frac{d}{dy} \{ H \left( \rho \bar{U} \right) \}
\]

which includes a term that describes the horizontal shear layer, the mass exchange in and out of the main channel as well as the expansion and contraction losses in a meandering channel. A coefficient \( K \), which relates the effects of the secondary currents to the depth mean velocity, is introduced such that:

\[
\bar{U} \bar{V} = K U_d^2
\]

Applying this factor to the original SKM equation and expressing the velocity in terms of the cross-stream variation of the unit flow, \( q \). (since this has strong continuity properties) yields:

\[
g H^3 \frac{\partial H}{\partial x} - \frac{f}{8} q^2 \left(1 + \frac{1}{s^2}\right)^{\frac{1}{2}} + \partial \left( \lambda H \left(\frac{f}{8}\right) \frac{q}{H} \frac{q}{H} \right) - H^2 \frac{d}{dy} \left( \frac{K q^2}{H^2} \right) = 0
\]

where the bedslope \( S_o \) has been replaced by the change in surface water level in the streamwise direction, since for a natural river the local bed slope can be highly irregular. It is important to note that the friction factor \( f \) may depend upon both the local value of unit flow and on depth. In this equation:

• the first term I refers to the variation in hydrostatic pressure along the reach,
• the second term II accounts for the effects of boundary friction,
• the third term III describes the turbulence due to shearing between the vertical slices and
• the fourth term IV incorporates the turbulence due to secondary currents.

The advantages of this model are that it:

• is physically based
• considers the momentum effects in all three directions
• provides a lateral velocity and shear stress distribution
• incorporates losses due to secondary currents, bed friction and turbulent shear stresses
• is potentially implementable in natural channels using numerical integration across the cross-section

The implementation of this model would require further consideration of certain issues:

• Finding closure to the system of equations. Would this require tedious parameter estimation and on what would these parameters be based?
• The streamwise velocity vector changes direction at bankfull level in a meandering river, as it follows a path parallel to the floodplains. How would this variation be characterised?
• Should a curvilinear or cartesian co-ordinate system be used, or a combination e.g. curvilinear for inbank flow and cartesian for out of bank flow?

**Work in progress**
A review of the existing research into conveyance estimation has reduced the possible approaches to the two outlined above. Although these are the preferred methods, a number of issues have been identified for further consideration. This has resulted in the following objectives:

1. Revisit the depth integration of the three-dimensional Navier-Stokes equations with respect to the various energy loss terms and the parameter estimation that emerges as a result of the closure problem. Relate these equations to conveyance.

2. Consider a possible combination of the energy loss approach (Shiono *et al* 1999) and the RANSE approach (Ervine *et al* 2000). The energy loss approach could be included to simplify the loss mechanisms in the depth-averaged equations. Something similar to the simple relative path length concept in ISIS might be used to capture the different flow patterns on the flood plain and in the main channel.

3. Consider the hierarchy of secondary flow mechanisms that are present in the various flow zones as relative depth and sinuosity increase. Can this be incorporated in the estimation of the \( K \) parameter?

4. Is conveyance independent of water surface slope? Variation of conveyance with surface slope may need to be passed through to the 1-D modelling systems, which will imply modification of these models.

These objectives constitute the current work in progress.

### 2.3 Roughness Review (Component T4)

Work began in January 2002 on the Roughness Review, component T4. The activities in the first three months of the project are to:

- Review information identified in the expert paper in the Scoping Study (Fisher and Dawson, 2001)
- Review other existing data sets for sites with significant vegetation and physical features
- Identify morpho-type groups using the RHS database and include sub-strata characteristics

A review of information identified in Fisher and Dawson (2001) has begun along with other papers, not mentioned in the expert review. These additional papers have either been published or have been sourced by the authors since the expert paper was written. There are other papers of which the authors were aware which were not referenced in the expert paper. Due to space constraints, only the most relevant information was included in the expert paper. The roughness review will include papers which may not ultimately be used but they will be considered and then the reasons for not using the information will be given.

The data from the papers is being entered into a table so that it can be easily compared and extracted. The format and an example of this is shown in Appendix 2, tables 1 and 2. Many of the papers under review have little hydraulic data published and the information is more descriptive. There are some key references where the hydraulic data is extensive. These papers have been identified and it is anticipated that the data will form the backbone of the information in the roughness review. Some of the data sets have associated vegetation data and these will be used alongside the data from important reviewed papers to determine the hydraulic roughness of vegetated channels. The sites where there is no vegetation will be used in the roughness review and advisor to build a database of sites of different types and from different rivers. The data from these sites will give a sound basis for prediction of hydraulic roughness in a variety of situations.
The authors also have some data from their own research and other sources such as the Environment Agency, EPSRC and MAFF funded research and PHABSIM sites. Some of the data from these sites has been documented and the sites are listed below. There are still some sites where data is available and this is being sourced from the required parties. These sites include data from: the River Blackwater in Hampshire, the Mill Stream, a side channel of the River Frome in Dorset together with the main course; and several other tributaries in the Piddle and Frome catchment.

It is likely that the literature review will point out gaps in the existing data and acquisition of new data may therefore be required. The data collection exercise will be targeted to fill those gaps and it is not anticipated to cover large rivers, where wading is not possible.

The morpho-type groups have been identified from the RHS database, as shown in Appendix 2, figure 1 and classification of substrate characteristics is underway.

In addition, NERC-CEH has funded equivalent amount of work on analysis and preparation of existing data for scientific output utilising basic studies. This has, so far, overviewed vegetation distribution by RHS morpho-type and an analysis of potential vegetation types for inclusion has also begun. The work has already improved the ability to extract data on speciation and abundance from the plant database, and has started extraction of existing data on vegetative hydraulic resistance from field books available at CEH in Dorset.

2.4 Meetings

2.4.1 Start-up Meeting

The project Start-up Meeting took place on 3 January 2002, at the Environment Agency Head Office in Bristol. As well as discussing some aspects of the HRW Offer of Professional Services for the present study, the meeting also covered issues related to the formulation of a new Framework Agreement between HRW and the Environment Agency for research work. The Agenda and Notes of the meeting are presented in Appendix 3. In relation to the work proposed in the Offer of Services, the main points covered were:

- Management progress meetings – to be normally conducted at HRW to coincide with technical team meetings or alternatively to be conducted by video conferencing.
- Functional specifications for the various work components – to agree on requirements for functional specifications prior to the Inception Meeting.
- Open code – to discuss with Prof. Donald Knight and Dr. Chris Whitlow availability of program code that has been developed under EPSRC funding for possible inclusion of different conveyance calculation methods into “open” version of ISIS.
- Inception Meeting - particular emphasis to be given to securing optimum membership of the Agency Project Board and User Consultative Group.
- Publicity – to identify and produce a listing of potential publicity outlets for the project and to produce articles, papers and project flyers.

2.4.2 Inception Meeting

The Inception Meeting took place on 8 January 2002, at HR Wallingford. This meeting involved the Agency Project Manager, a few members of the Agency Project Board, all members of the management and technical project team, and all members of the External Expert Panel. A full briefing on the project was given at the meeting, concentrating particularly on the Work Plan and on the critical nature of some of the tasks, both in terms of time and technical importance. The majority of the discussions centred on the outlining of the requirements of the functional specifications for the various software components of the project. The membership of the Agency Project Board and of the User Consultative Group was also discussed but not finalised at the meeting. Appendix 4 shows the agenda and the notes of the meeting.
2.4.3 Inception Workshop
The Inception Workshop took place on 12 April, at HR Wallingford and involved the members of the Agency Project Board and members of the User Consultative Group representing a wide range of user interests. At this meeting an introduction was given on the project objectives and on work already carried out on the development of conveyance methods, on roughness estimation and on data to be used in the future testing of the conveyance generator. The expected roles of the APB and UCG were discussed. Appendix 5 shows the agenda and the notes of the meeting.

2.4.4 Other meetings
A number of other, smaller, meetings have taken place in the first two months of the project, some involving the HR technical and management project team and some the external experts contracted for the project. These have been arranged to discuss and review progress on the following topics:

- Identification and assessment of conveyance methods
- Assembly of data from rivers and from laboratory tests
- Roughness review
- Outline of functional specifications of Conveyance Generator, of Roughness, Conveyance Estimation System, and of ISIS implementation of CES. In addition to these, work has also been carried out on the function specification for the InfoWorks RS implementation.
- Interface with Wallingford Software regarding implementation of study outputs.
3. FUNCTIONAL SPECIFICATIONS

3.1 Introduction
This is the initial Function Specification for the software components of the Targeted Research Programme.

The main users of the system were identified in the Scoping Study and the Inception Meeting, and are listed in the beginning of this section. There follows a summary of the expected areas of application and the tools used in those areas. A set of Use Cases is then developed, which defines and illustrates the various ways in which users will interact with the software components, considered as a whole, to achieve their goals. This leads to an outline specification of the functions of each software component in turn. Some performance requirements are then identified, and finally there is a consideration of the information flow between the system components and the interaction with other software, both within Wallingford Software’s suite of products and outside.

USERS:

Organisations
The intended users of the system, as identified in the Scoping Study and Inception Meeting, fall into the following organisation categories (see Figure 2):

- The Environment Agency
- Local authorities
- Internal drainage boards
- Developers
- Contractors
- Engineering consultants
- Environmental consultants
- Insurers

Associated organisations
The following organisation categories are not classed as end users of the system in the practical sense, but their needs must be engaged for delivery of the benefits of the Programme:

- Academic community
- Software developers

Application areas
The Scoping Study identified that Conveyance was relevant to the organisations identified in the following application areas:

- strategic land-use planning for the effects of future development, land-use change and climate change impacts together with any flood defence works through the Catchment Flood Management Planning initiative.
- the identification of the flood plain (as in the Section 105 surveys)
- design of flood defence works (e.g. in the delivery of the NCP)
- assessing the effects of maintenance activities
- the extension of rating curves at gauging stations
- real-time flood forecasting of the areas of inundation.

The scale of the problem under consideration varies both within each of the application areas and between them. For example, the extension of rating curves at gauging stations may require the assessment of
conveyance at a local (section or computational cell) scale, whereas reach-scale assessments may be more relevant to strategic land-use planning.

**Summary of tools used**

The tools used in the various application areas may be summarised as follows.

<table>
<thead>
<tr>
<th>Planning</th>
<th>Dev. control and design</th>
<th>River works design</th>
<th>Maintenance</th>
<th>Hydrometry</th>
<th>Flood mapping</th>
<th>Forecasting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrodynamic models</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Routing models</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Backwater models</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Rating surfaces</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Rating curves</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Single flow/level values</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

### 3.2 User Goals

**Summary of factors affecting conveyance**

Some of the factors affecting conveyance are identified in the table below. For each of the application areas listed in Section 3.1, the table shows which factors are likely to be of interest.

<table>
<thead>
<tr>
<th>Planning</th>
<th>Dev. control and design</th>
<th>River works design</th>
<th>Maintenance</th>
<th>Hydrometry</th>
<th>Flood mapping</th>
<th>Forecasting</th>
</tr>
</thead>
<tbody>
<tr>
<td>High flows</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Low flows (e.g. for water quality)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Season</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Maintenance regime</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vegetation type and maturity</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>River bed material</td>
<td></td>
<td>✓</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Floodplain land use</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floodplain physical features</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Channel geometry</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**System use summaries**

It is useful to identify typical scenarios in which the system will be used before moving on to more detailed consideration of the individual tasks within those scenarios. Typical scenarios are described below.

**Stand-alone use**

One or more river cross-sections are obtained, either by detailed survey or by estimation. Information on vegetation, bed material, soil types and maintenance practices is also collected. The user enters the data into the system and obtains estimates of conveyance and uncertainty for the section or reach. The user may calibrate the calculation by adjusting calibration parameters to match the calculated conveyance with values obtained from observations. The user then adjusts the parameters to reflect proposed or actual changes and obtains new estimates of conveyance.

**Model development**

A survey of the river and floodplain is carried out, producing a combination of high-density points along cross-sections and more sparse ground survey data covering the entire area of interest. Information on vegetation, bed material, soil types and maintenance practices is also collected in database, geographical (i.e. map), photographic, text and verbal forms. Calibration data in terms of flow and level time series and peaks are also collected. Hydrological data are obtained.

Modellers input the data into a modelling system. The modelling system obtains initial values of conveyance parameters and uncertainty estimates from the input data and built-in knowledge. As the model is built, simulations are carried out and adjustments to the schematisation which require re-estimation of conveyance parameters are made.

**Model calibration**

Modellers use calibration factors to adjust the conveyance within the uncertainty bands to achieve an acceptable fit to historical data. (They also adjust structure coefficients, hydrological parameters etc.) This is undertaken using either discrete events or continuous simulation. It should not be necessary to adjust the schematisation or the conveyance model at this stage. The calibrated model is validated by running a further historical event or long time series.

**Interactive model runs**

The calibrated model is used in the simulation of events or a continuous time series. Conveyance may change during the course of the model runs due to seasonal and long term changes in vegetation, bed material or plan form. These factors are driven both:

- by the input data, where, for example, the modeller defines how vegetation varies by season, and
- by model results, where, for example, severe flooding may result in a change in vegetation following the next growth season.

The changes in conveyance are taken into account inside the modelling system without further interaction with the modeller. Results are produced in terms of flows, levels, velocities, flooded outlines, depth contours and uncertainty bands.

**Model updates for planning, design and model maintenance**

Modellers update the input data to represent changes such as floodplain development or channel improvements, for example. These changes may be designs of proposed development, or they may be incorporated as part of the continuous process of updating the model to reflect reality. The modelling system obtains new values of conveyance parameters as appropriate. The calibration factors derived during the calibration phase are applied to the new conveyance parameters, and model runs are carried out using the updated model.
Automatic model runs

Model runs are commonly carried out automatically in a flood forecasting system. Conveyance changes during the course of these continuous simulations in the same way as in interactive model runs, and again there is no interaction with the user in incorporating these changes.

Use cases

A use case is a convenient way to describe the system’s behaviour under various conditions as it responds to requests from users. In each use case, a “user” has a “goal” in mind and initiates an interaction with the system to accomplish that goal. It is hoped that the use cases will benefit the project by:

- clarifying the requirements of the system to its designers and end users at an early stage in the project;
- identifying issues requiring further specification or discussion;
- feeding the development of the functional specification;
- guiding the testing of the completed system.

The following is described in a manner appropriate for software development, which may be somewhat unfamiliar to some hydraulic engineers and other users. However, the proposed work will be further illustrated by screenshots as the project develops.

From a user point of view, the goals for this software project and their use cases can be divided into three levels. The levels conveniently correspond to the distribution of the corresponding functions amongst the software components.

- **Low-level** goals concern the estimation of roughness. These are achieved within the scope of the **Roughness Advisor**. These goals are low-level in the sense that they are usually not the ultimate goal of the person using the system, but rather a sub-goal towards achieving a higher level modelling or conveyance goal.

- **Mid-level** goals concern the estimation of conveyance and uncertainty. These are achieved within the scope of the **Conveyance Estimation System**. They are mid-level in that they will sometimes arise from a higher level goal concerning water levels, flows etc and also make use of lower level goals. However, they are often important goals in their own right; an example is a person planning a channel maintenance programme or a river works designer wishing to determine a rating curve for a cross-section.

- **High-level** goals concern the estimation of water levels, flows, velocities, flooded outlines and flood depth contours. These are achieved within the scope of **ISIS** and **InfoWorks RS** (and in other 1-D modelling packages). Geographical outputs such as flooded outlines and depths will not be available directly in ISIS, though most major consultancies have GIS-based tools to do this. The high-level goals usually require the satisfaction of one or more mid-level and low-level goals.

Each goal is identified with one or more Users, sometimes called the “Primary Actor”, who interacts with the system to achieve the stated goal. Since most of the external (i.e. human) users of the system share most of the goals, they are generically identified as the “System user” in the use cases below. In many cases, however, the User is not a person but another component of the system, itself working to attain some other goal. For example, the CES in working to calculate conveyance for a particular reach “uses” the Roughness Advisor to calculate the roughness of the reach, and is therefore identified as a User of the Roughness Advisor for that particular use case.

Underlined portions of the use cases represent delegation to another use case at an equal or lower level. In electronic versions of the text, clicking on the underlined text will activate a hyperlink to the relevant secondary use case.

Non-modelling applications are expected to demand a subset of these goals, but some of the low-level and mid-level goals will become high-level.
It should be noted that the Conveyance Generator software component does not appear in any of the user goals, since it is not a software deliverable from the project and therefore does not have any interaction with the users of the system identified in Section 1. Its only interaction is with the project team during the development phase of the project.

**Definitions**

For the purposes of the use cases, the following terms are defined.

**Line**

A line is a series of (x,y) (and possibly z) points on the ground. The line may have additional attributes, such as roughness parameters, which do not vary along the line. A line may include some or all of the river channel and some or all of the floodplain.

**Polygon**

A polygon is a series of (x,y) (and possibly z) points enclosing an area on the ground. The enclosed area may have additional attributes, such as roughness parameters, which do not vary within the polygon.

**Cross-section**

A cross-section is contiguous collection of lines. Each line forming the cross-section may have additional attributes, such as roughness parameters. These attributes may vary along the cross-section.

**Low-level goals – the Roughness Advisor**

**Estimate roughness parameters for line**

User: CES, ISIS, IW-RS (or other 1-D models)

- The user inputs geometric details of the line.
- The user selects salient features from vegetation databases etc.
- The system derives roughness parameters for the line.

**Estimate roughness parameters for polygon**

User: System user, CES, ISIS, IW-RS (or other 1-D models)

- The user inputs geometric details of the polygon.
- The user selects salient features from vegetation databases, bed material databases, photographs, soil type databases and any other resources available.
- The system derives roughness parameters for the polygon.

**Estimate roughness parameters for cross-section**

User: System user, CES, ISIS, IW-RS (or other 1-D models)

- The user inputs geometric details of the cross-section.
- The user selects salient features from vegetation databases, bed material databases, photographs, soil type databases and any other resources available.
- The system derives roughness parameters for the lines forming the cross-section.

**Estimate roughness parameters for lines from polygon inputs**

User: System user, CES, ISIS, IW-RS (or other 1-D models)

- The user inputs geometric details of the line.
- The system estimates roughness parameters for as many polygons as required.
- The system derives roughness parameters for the line from the roughness parameters from the individual polygons, dividing the line as required so that each line has a single set of parameters.
Estimate roughness parameters for cross-section from polygon inputs
User: System user, CES, ISIS, IW-RS (or other 1-D models)
- The user inputs geometric details of the cross-section.
- The system estimates roughness parameters for as many lines as required.
- The system derives roughness parameters for the cross-section from the roughness parameters from the individual lines.

Estimate roughness uncertainty for polygon/cross-section/parts of cross-section
User: System user, CES, ISIS, IW-RS (or other 1-D models)
- The system derives uncertainty parameters for the polygon/cross-section using databases etc.

Estimate seasonal variation in roughness
User: System user, CES, ISIS, IW-RS (or other 1-D models)
- The system estimates roughness parameters for the polygon/cross-section.
- The system derives uncertainty parameters for the polygon/cross-section using databases etc.

Estimate long-term variation in roughness
User: System user, CES, ISIS, IW-RS (or other 1-D models)
- The system derives long-term variation factor curves for the polygon/cross-section using databases etc.

Estimate effect of maintenance on roughness
User: System user, CES, ISIS, IW-RS (or other 1-D models)
- The system derives maintenance variation factor curves for the polygon/cross-section using databases etc.

Estimate variation in roughness with flow, water level or velocity
User: System user, CES, ISIS, IW-RS
- The system derives flow/water level variation factor curves for the polygon/cross-section using databases etc.

Estimate roughness and uncertainty parameters for given date /maintenance standard/flow/level/velocity
User: System user (NB not ISIS or IW-RS)
- The system estimates roughness parameters for the polygon/cross-section.
- The user inputs a date/maintenance standard/flow/level
- The system estimates the variation in roughness with season/long-term/maintenance/flow/water level/velocity.
- The system uses the variation factor curves to estimate the roughness parameters for the given data/maintenance standard/flow/water level/velocity.

Mid-level goals – the Conveyance Estimation System

Estimate conveyance of cross-section
User: System user, ISIS, IW-RS (or other 1-D models)
- The user inputs geometric details of the cross-section
- The user sets any other required parameters
- The Roughness Advisor estimates roughness parameters for the cross-section
- The system carries out the appropriate conveyance calculation for the section.
- The system outputs the conveyance function – this may be a lookup table or a set of equations.

Estimate conveyance of reach
User: System user, ISIS, IW-RS (or other 1-D models)

- The user inputs geometric details of the reach, including survey cross-sections, centre line and other linear features.
- The Roughness Advisor estimates roughness parameters for the reach as either polygons or cross-sections, depending on which method is used.
- The system carries out the appropriate conveyance calculation for the reach, which may involve carrying out conveyance calculations for the individual sections.
- The system outputs conveyance functions for each of the cross-sections – these may be lookup tables or sets of equations depending on which method is used.
- The system may output an overall conveyance function of the reach, if this is available given the method used.

Estimate effects of roughness uncertainty on uncertainty of conveyance
User: System user, ISIS, IW-RS (or other 1-D models)

- The Roughness Advisor estimates the roughness uncertainty.
- The system estimates the conveyance of the cross-section/reach for the appropriate range of roughness parameters given the estimated roughness uncertainty.
- The system calculates the uncertainty as upper/lower bounds, or statistical distribution, etc.

Estimate seasonal variation in conveyance
User: System user, ISIS, IW-RS (or other 1-D models)

- The Roughness Advisor estimates the seasonal variation in roughness.
- The system estimates the conveyance of the cross-section/reach for the appropriate range of roughness parameters given the seasonal variation in roughness. The variation may be expressed as a series of multiplicative factors or a set of conveyance curves etc.

Estimate long-term variation in conveyance
User: System user, ISIS, IW-RS (or other 1-D models)

- The Roughness Advisor estimates the long-term variation in roughness.
- The system estimates the conveyance of the cross-section/reach for the appropriate range of roughness parameters given the long-term variation in roughness.

Estimate effect of maintenance on conveyance
User: System user, ISIS, IW-RS (or other 1-D models)

- The Roughness Advisor estimates the variation in roughness with maintenance regime.
- The system estimates the conveyance of the cross-section/reach for the appropriate range of roughness parameters given the variation in roughness with maintenance regime.

Estimate variation in conveyance with flow, water level or velocity
User: System user, ISIS, IW-RS (or other 1-D models)

- The Roughness Advisor estimates the variation in roughness with flow, water level or velocity.
- The system estimates the conveyance of the cross-section/reach for the appropriate range of roughness parameters given the variation in roughness with water level.
Estimate velocity distribution at cross-section
User: System user, ISIS, IW-RS (or other 1-D models)
- The system estimates the conveyance of the cross-section/reach.
- The Roughness Estimator estimates the roughness parameters for parts of the cross-section.
- The system uses the individual roughness values and the geometry of the section to estimate how velocity varies across the section, and possibly how it varies with flow/depth, depending on the conveyance method used.

Estimate effects of conveyance uncertainty on uncertainty of velocity distribution
User: System user, ISIS, IW-RS (or other 1-D models)
- The system estimates the uncertainty of the conveyance at the cross-section.
- The system uses the individual roughness values and the geometry of the section to estimate the uncertainty in the variation of the velocity across the section.

Estimate rating curve at cross-section
User: System user
- The system estimates the conveyance of the cross-section.
- The user inputs the required range of flows or levels and the channel slope.
- The system calculates a rating curve.

Estimate effects of conveyance uncertainty on uncertainty of rating curve
User: System user
- The system estimates the uncertainty of the conveyance of the cross-section.
- The system calculates the uncertainty of the rating curve given the uncertainty in the conveyance.

Estimate seasonal variation of rating curve
User: System user
- The system estimates the seasonal variation of the conveyance.
- The system calculates the seasonal variation of the rating curve given the seasonal variation of the conveyance.

Estimate long-term variation of rating curve
User: System user
- The system estimates the long-term variation of the conveyance.
- The system calculates the long-term variation of the rating curve given the seasonal variation of the conveyance.

Estimate effect of maintenance on rating curve
User: System user
- The system estimates the variation in the conveyance with maintenance regime.
- The system calculates the variation in the rating curve with maintenance given the variation in the conveyance.
High-level goals – ISIS and InfoWorks RS

Estimate water level at cross-section
User: System user, ISIS, IW-RS
- The user builds a model including the cross-section.
- The system estimates the conveyance of the cross-sections in the model.
- The system carries out a simulation using the model and the calculated conveyances.
- The system calculates the resulting water levels at the cross-section.

Estimate velocities at cross-section
User: System user
- The system estimates the velocity distribution at the cross-section.

Depending on the methods developed, either
- The user provides a time series of flows and water levels at the cross-section, probably by carrying out a model simulation.
- The system calculates the velocities distributed over the cross-section.

or
- The system calculates a time series of velocities distributed over the cross-section by carrying out a model simulation.

Estimate effects of conveyance uncertainty on uncertainty of water levels
User: System user, IW-RS
- The system estimates the uncertainty in conveyance at the cross-sections.
- The system re-estimates water levels using different values of conveyance, chosen appropriately according to the estimated uncertainty in conveyance.
- The system calculates the uncertainty of water levels from the various estimates.

Estimate effects of conveyance uncertainty on uncertainty of velocities
User: System user
- The system estimates the uncertainty of the velocity distribution at the cross-section.
- The system calculates the uncertainty in the velocities given the uncertainty in the velocity distribution.

Estimate water levels taking into account seasonal variation in conveyance
User: System user, IW-RS
- The system estimates the seasonal variation in conveyance.
- The system estimates water levels using a time-varying form of the conveyance taking into account the seasonal variation.

Estimate velocities taking into account seasonal variation in conveyance
User: System user
- The system estimates the seasonal variation in conveyance at the cross-sections.
- The system re-estimates water levels using different values of conveyance, chosen appropriately according to the estimated seasonal variation in conveyance.
- The system calculates the velocities distributed over the cross-section.
Estimate water levels taking into account long-term variation in conveyance
User: System user, IW-RS

- The system estimates the long-term variation in conveyance.
- The system estimates water levels using a time-varying form of the conveyance taking into account the long-term variation.

Estimate velocities taking into account long-term variation in conveyance
User: System user

- The system estimates the long-term variation in conveyance at the cross-sections.
- The system re-estimates water levels using different values of conveyance, chosen appropriately according to the estimated long-term variation in conveyance.
- The system calculates the velocities distributed over the cross-section.

Estimate water levels taking into account the effect of maintenance
User: System user, IW-RS

- The system estimates the variation in conveyance with maintenance regime.
- The system estimates water levels using a time-varying form of the conveyance taking into account the variation with maintenance regime.

Estimate velocities taking into account the effect of maintenance
User: System user

- The system estimates the long-term variation in conveyance at the cross-sections.
- The system re-estimates water levels using different values of conveyance, chosen appropriately according to the estimated long-term variation in conveyance.
- The system calculates the velocities distributed over the cross-section.

Calibrate hydraulic model on levels or flows
User: System user

- The user adjusts conveyance factors for one or more sections and for a specified range of water levels.
- The system re-estimates water levels, adjusting the conveyance according to the specified factors.

High-level goals – InfoWorks RS and MDSF
The following high-level goals may be met by the InfoWorks RS implementation and by other systems such as MDSF and proprietary modelling systems which fall outside the scope of the Project.

Estimate flooded outlines or depth contours
User: System user

- The system estimates water levels at all sections.
- The system combines the estimated water levels with a ground model and calculates flooded outlines or depth contours.

Estimate effects of conveyance uncertainty on uncertainty of flooded outlines or depth contours
User: System user

- The system estimates the uncertainty of water levels at all sections.
- The system combines the representative water level estimates with a ground model and calculates flooded outlines or depths.
**Estimate seasonal variation of flooded outlines or depth contours**
User: System user
- The system estimates the seasonal variation of water levels at all sections.
- The system combines the representative water level estimates with a ground model and calculates flooded outlines or depths.

**Estimate long-term variation of flooded outlines or depth contours**
User: System user
- The system estimates the long-term variation of water levels at all sections.
- The system combines the representative water level estimates with a ground model and calculates flooded outlines or depths.

**Estimate effect of maintenance on flooded outlines or depth contours**
User: System user
- The system estimates the variation with maintenance regime of water levels at all sections.
- The system combines the representative water level estimates with a ground model and calculates flooded outlines or depths.

### 3.3 Software functions

The project requires the development of four software components:

- The Roughness Advisor (RA)
- The Conveyance Generator (CG)
- Conveyance Estimation System and Uncertainty Estimator (CES)
- The ISIS implementation

In addition, a fifth component may be developed during or after the completion of the project:

- InfoWorks RS implementation

The CES and ISIS implementation are deliverables from the project. The Roughness Advisor will initially be developed as a stand-alone tool, but will eventually be integrated within the CES. The Conveyance Generator will be used as a research tool for deriving and assessing conveyance functions.

The functions of the five systems are outlined below.

#### 3.3.1 Roughness Advisor

**Objectives**
- Facilitate access to expert knowledge and information on the roughness of UK rivers and flood plains for conveyance estimation

**Data inputs**
The Roughness Advisor should address the needs of users with a wide range of requirements. Two main categories can be determined in terms of data availability:

Category A  No data, very limited data or descriptive data, to
Category B  Comprehensive data.
For Category A users if a grid reference is available, links with RHS database will enable planform, substrate and morpho-types to be inferred.

Data available from Category B users may include:

- grid reference
- width
- depth
- slope
- discharge
- information on maintenance (e.g. time of maintenance, percentage of channel maintained, previous knowledge, methods used)
- information on whether it is a backwater case
- GIS data

Common to both user categories:

- Databases (e.g. UK River Habitat Survey (RHS), UK Vegetation Database, Roughness Characteristics of New Zealand Rivers)
- Qualitative appraisal of photographs.

**Methods**
The methods will be determined during the Roughness Review task (T4). They will be dependent on the level of data input and may include calculation and descriptive rules. When more than one method is used, there will be no discontinuities between them. The advice on roughness will be based on Manning’s n or on a variation on it. Indication of uncertainty on levels, discharge and storage areas will be given.

**Data storage**
Data will be stored using standard file-based technology provided by whatever development tools are used.

**Data outputs**
It is expected that the outputs from the roughness advisor will include:

- A base roughness parameter
- Upper and lower bounds for base roughness parameter, or similar
- Seasonal variation factor curve, or similar
- Long term variation factor curve (e.g. vegetation maturity, channel degradation, climate change), or similar
- Maintenance standard variation factor curve, or similar
- Flow and/or depth variation factor curve, or similar
- Velocity variation factor curve, or similar

These outputs should be available in terms of

- Polygons— i.e. the above outputs defined for plan areas, where parameters do not vary within each polygon
- Lines – i.e. the above outputs defined for plan lines, where parameters do not vary along each line
- Cross-sections – i.e. the above outputs generalised or averaged over a cross-section
- Reaches – i.e. the above outputs generalised or averaged over a length of river/floodplain

**Other aspects**
For users with limited data (Category A) advice will be given to collect more data if the uncertainty bands around the data are too wide.
Issues

- Need to ensure simplicity of the method
- Some morpho-types have better data than others; this can be overcome by limited data collection to improve data sets
- The roughness advisor should provide links with other software packages, for example the RHS, but should not require them to be present, nor incorporate them in whole or in part. It must be capable of functioning as a stand-alone product.
- In determining uncertainty the accuracy and applicability of the methods will need to be reviewed carefully.
- The roughness advisor should not make unnecessary assumptions about the modelling process – for example, it should be able to estimate roughness parameters for areas as well as section lines, even though hydraulic models such as ISIS currently only work with section lines.
- Further knowledge will be required particularly on the use that non-modellers will make of the roughness advisor and this will influence the calculation and delivery of results.

3.3.2 Conveyance Generator

Objectives
The purpose of the Conveyance Generator is to take the topographic representation of a river section (or reach) and the characterisation of the boundary roughness to produce the conveyance (flow carrying capacity) with information on the band of uncertainty about the “best” estimate. The method should not require significantly more data input above that of current 1-D modelling systems and ideally should only require the users to estimate parameters which fall within their general experience (i.e. channel and flood plain resistance).

Data inputs
- Essential data
  - River cross-section coordinates
  - Roughness description across the section
  - Sinuosity measure
  - Range of levels (or flows) of interest
  - Surface slope

- Optional data
  - DEM of channel and flood plain
  - Channel banks or centreline in GIS
  - Method specific parameters (which may be input by an expert or related by default to other data)

Methods
- The methods will be based either on the division of the section into physically identifiable units and flow mechanisms or a simplification of the Reynolds Averaged Navier Stokes Equations (RANSE) will be used.
- The methods to be examined will include Ervine et al (2000), Bousmar & Zech (1999), Shiono et al (1999) and Shiono & Knight (1991). These methods may include “secondary” parameters which account for other processes apart from the local bed resistance.
- The models of the RANSE will be rewritten in terms of the cross-stream variation of the unit flow value (depth integral of streamwise and lateral velocity components) since this has strong continuity properties.
- The numerical approximations for the RANSE will be generated from the Finite Element Method.
- The uncertainty in the conveyance estimates will be illustrated taking account of
  - uncertainty information passed from the roughness advisor,
- the degree of local calibration
- the nature of the local topography and its influence on “secondary” method parameters

**Data Storage**
Topographic, conveyance and roughness data will be stored using standard file-based technology provided by the development tools used.

**Data Outputs**
- Tabulation of conveyance with stage
- Values of variation of conveyance with slope (if appropriate)
- Uncertainty bands or distribution
- Graph of conveyance with stage

**Issues**
- How reach average information is to be handled, e.g. estimate of sinuosity, small-scale section irregularity, mean surface or bed gradient
- Theoretical methods for conveyance estimation are derived using the uniform flow assumption with bed and surface slopes coincident which is rarely the case for a natural channel
- Whether roughness and geometry are fixed or allowed to show a seasonal variation (growth and decay of vegetation), cycles of deposition and erosion, resistance depending upon the hydraulic conditions (especially velocity)
- how should uncertainty be expressed for the user – as an upper and lower band or as a probability function – need to include this in the user consultation
- The degree of expert intervention enabled in the selection of “secondary” method parameters (e.g. “eddy” viscosity if used)
- Should the Conveyance Generator work in reverse to calibrate model parameters (roughness, secondary parameters) to match observed rating curves?
- Is conveyance independent of water surface slope? (This is not guaranteed in general for models based on the RANSE). The variation of conveyance with surface slope may need to be passed through to the 1-D modelling systems, which will imply modification of these models.
- How frequently should the tabulation of conveyance be – at the level of each survey point (as in ISIS) or at regular vertical intervals, or a combination of the above.
- Should the Conveyance Generator also include a function to show the implied cross-stream variation of unit flow or the derived depth average velocity
- Should cross-stream variation of water level be allowed? (Strictly this violates the 1-D modelling assumption)

3.3.3 Conveyance Estimation System (CES)

**Objectives**
- Integrate conveyance generator functions and roughness advisor functions as a stand-alone tool
- Provide a realistic range for conveyance estimates

Only the conveyance estimation parts of the CES are considered in this section. The roughness advisor will be incorporated in the CES, but its inputs, outputs and functions are considered elsewhere in this document.

**Data inputs**
Inputs to the CES will be via datafiles and user interaction in a spreadsheet-style or dialog-based user interface. Some of these inputs will be provided by the roughness advisor part of the CES.

- Essential data
  - River cross-sections as offset-level pairs (alternatively georeferenced sections may be provided)
  - Roughness parameters across sections (unless roughness polygons are provided)
- Range of water levels/depths or flows of interest

- **Optional data**
  - Georeferenced river cross-sections
  - Cross-sections extending over floodplain
  - Georeferenced cross-sections extending over floodplain
  - River centre line defined by a sequence of (x,y) pairs
  - Other linear features (banks, hedges, roads) defined by sequences of (x,y) pairs
  - Roughness polygons defined by sequences of (x,y) pairs
  - Channel slopes at cross-sections
  - Floodplain slopes at cross-sections
  - For each roughness polygon:
    1. Roughness category
    2. Calibration factor
    3. Maintenance standard time series
  - For each roughness category:
    1. Base roughness parameter
    2. Base roughness lower bound
    3. Base roughness upper bound
    4. Seasonal variation curve (a multiplicative factor)
    5. Long-term variation curve (e.g. vegetation maturity, channel degradation, climate change – a multiplicative factor)
    6. Maintenance standard variation curve (a multiplicative factor)
    7. Flow and/or depth variation curve (a multiplicative factor)
    8. Calibration factor
  - Times and dates of start and end of period of interest
  - Output timestep
  - Range of levels/flows to be calculated
  - Conveyance calibration factors

**Methods**
The methods are to be determined during the Conveyance Generator task (T2).

**Data storage**
Conveyance and roughness data will be stored using standard file-based technology provided by whatever development tools are used.

**Data outputs**
Outputs will be provided to users graphically and by tabulation on the screen, as well as through files for export to spreadsheets and other systems. Output to ISIS will be through machine-readable files.

Outputs will be:
- Base rating curve for each section
- Base conveyance curve for each section
- Uncertainty bands for the base rating curve and conveyance curve
- Some representation of the variations in rating and conveyance with season, maintenance, long-term, levels, velocity
- Some representation of velocity distribution across sections
- Conveyance calibration factors
- Geometrical details of cross-sections (required for results viewing in ISIS)

**Open code**
The CES will be implemented as open code. The input and output data formats will be published, so that third party software suppliers will be able to provide facilities for reading the new conveyance functions into other modelling packages.
**Issues**

- How do we represent the conveyance function? For example, it might be a look-up table or an algorithm which is executed during timestepping or steady flow computation.

- How do we represent variations in rating and conveyance with season, maintenance regime, velocity etc in the output? For example, is it
  1. a time series of multiplicative factors?
  2. a set of conveyance functions with a time series of weights, the final conveyance function being a linear combination of the functions?

- The impact of the various factors affecting conveyance should as far as possible be treated as independent, so that users carrying out model studies can select any combination of specific season, maintenance regime etc for simulation without returning to the CES and RA.

- How do we represent velocity distribution in the output? In general the CES should not output velocities themselves, because they depend on flow, water level, season etc. Therefore some representation of the variation of velocity across the section and also with flow, water level etc is required.

- The impact of maintenance on conveyance is complex, in that the conveyance at any given time may depend on the maintenance regime over the previous year or more. This may be difficult to represent functionally.

- The seasonal and long-term variation in roughness may depend on flows over a long period. For example, a particularly wet autumn may affect the vegetation growth in the following spring. The system should be capable of representing and simulating these effects in a long-term hydraulic model simulation without repeated runs of the CES.

- Most hydrological models incorporate some representation of the travel time of runoff water in streams across open land in the catchment being modelled. This travel time is likely to be affected by variations in roughness of those streams and land caused by changes in vegetation or land surface cover. Taking account of these effects is outside the immediate scope of this project, but they will be considered where necessary.

**3.3.4 ISIS Implementation**

**Objectives**

- Interface outputs from the above with the ISIS simulation engine

From a user’s perspective, the CES and ISIS will be integrated as far as possible to provide a seamless working environment. However, the ISIS user interface is not suitable for major additions in functionality of a geographical nature, and the development of such geographical functionality within the ISIS user interface is outside the scope of this project. The user interface for the CES supplied within ISIS will therefore be based around the stand-alone CES, with user-friendly links between the CES and the ISIS UI. This will also have the advantage of minimising the amount of duplication of CES user interface functionality in ISIS.

**Data inputs**

The inputs to ISIS will be machine-readable files containing some of the outputs from the CES and a selection from the following additional information:

- Base conveyance curve for each section
- Some representation of the variations in conveyance
- Some representation of velocity distribution across sections
- Geometrical details of cross-sections (not used in the engine, but necessary for output to UI)

The inputs will be confined to the time-varying aspects of conveyance. All other factors, such as calibration adjustments and uncertainty bands, will be taken into account outside the ISIS simulation engine.
Methods
The conveyance function will be used in the hydraulic simulation engine and in the calculation of wavespeed/attenuation curves for use in routing models. No consideration of uncertainty will be made in the simulation engine; uncertainty will be estimated by running several simulations with using different conveyance curves or wavespeed/attenuation curves.

The ISIS units which will use the new conveyance function are:
- River section – St Venant equations
- Floodplain section – Conveyance equations with normal depth assumption
- VPMC section – Variable Parameter Muskingum-Cunge equations based on conveyance equations with normal depth assumption

Data storage
The ISIS implementation will have no data storage. Data will be read by the engine at the start of the simulation and held in memory throughout the simulation.

Data outputs
- Flow at each cross-section
- Water level at each cross-section
- Average velocity at each cross-section
- Velocity across each cross-section – this will either be a direct output from the simulation or a post-processing step. The exact approach will be determined during the detailed design of the software.
- Geometrical details of cross-sections, for results viewing purposes

3.3.5 InfoWorks RS Implementation
The InfoWorks RS hydraulic simulation engine is identical to the ISIS simulation engine, but in addition InfoWorks RS provides full management of the modelling process and GIS functionality for constructing models and displaying model data and results. These tools facilitate closer integration with the CES than is possible in ISIS. For example, it is likely that certain aspects of the preferred conveyance method will require parameters relating to the river plan form. In the ISIS implementation of the CES, users will be required to digitise these from maps. InfoWorks RS, however, holds plan form data in its GIS components and could extract these data digitally. The basic data will be maintained in the InfoWorks RS version-controlled geographic database.

An example screenshot of the InfoWorks RS GeoPlan is shown in Figure 3. The display shows river cross-sections and centreline overlaid on a digital ground model and a satellite image of the surrounding area. Polygons or zones sharing a common type of vegetation could be displayed as shaded areas similar to the blue areas shown, here representing flood storage areas. Clicking on the shaded area might bring up a property sheet showing details of the roughness parameters and conveyance factors, with a link back to the Roughness Advisor.

A further example of the benefits of integration in InfoWorks RS is the estimation of uncertainty in flooded outlines caused by uncertainties in the roughness parameters. ISIS users would have to work through several simulations using different sets of conveyance parameters, and then manually compare the results. It may be possible to automate this procedure to some extent using the InfoWorks RS Simulation Controller.

Objectives
Integrate conveyance estimation system and uncertainty estimator into InfoWorks RS

Data inputs
- River and floodplain cross-sections on the GeoPlan
- River centre line on the GeoPlan
- Other linear features on the GeoPlan (banks, hedges, roads)
- Roughness polygons on the GeoPlan
- For each roughness polygon:
  - Roughness category
  - Calibration factor
  - Maintenance standard time series
- For each roughness category:
  - Base roughness parameter
  - Base roughness lower bound
  - Base roughness upper bound
  - Seasonal variation curve (a multiplicative factor)
  - Long-term variation curve (e.g. vegetation maturity, channel degradation, climate change – a multiplicative factor)
  - Maintenance standard variation curve (a multiplicative factor)
  - Flow and/or depth variation curve (a multiplicative factor)
  - Calibration factor
- Times and dates of start and end of simulation

Methods
The methods used in the CES will be applied in InfoWorks RS. The user will be guided in the use of multiple simulations to estimate how uncertainty in conveyance is reflected in water levels and flooded outlines.

Data storage
Data storage will be in the standard InfoWorks RS version controlled GIS database. This database allows multiple users to build and maintain models, and is coupled to a geographically-based user interface.

Data outputs
- Flow at each cross-section
- Water level at each cross-section
- Average velocity at each cross-section
- Velocity distribution over each cross-section
- Flooded outlines
- Flood depth contours
- Uncertainty bands showing the impact of uncertainty in conveyance on flow at each cross-section
- Uncertainty bands showing the impact of uncertainty in conveyance on water level at each cross-section
- Uncertainty bands showing the impact of uncertainty in conveyance on velocity distribution over each cross-section
- Uncertainty bands showing the impact of uncertainty in conveyance on flooded outlines

3.4 Performance requirements
The following performance requirements for the system as a whole have been identified:

1. Conveyance methods must not have a significant adverse effect on ISIS (or other 1-D models) simulation times.
2. It should not be necessary to apply the Roughness Advisor and CES repeatedly in order to carry out a single long-term hydraulic simulation. The hydraulic simulation engine must be able to take account of the effects of variation in conveyance during a long simulation without further reference to the other software components.
3. Links with third party software must not be too slow.
4. Conveyance methods must allow long time-series simulations as well as single event simulations.
3.5 Information Flow
Figure 4 shows the information flow between the deliverable software components of the project. The dashed lines indicate that it is not clear at this stage whether the velocity distribution would be used by the simulation engine to calculate velocities, or whether this would be a post-processing step accessed through the user interface. Figure 5 shows the information flow in the InfoWorks RS implementation of the project software. Note the simpler data flow, the use of uncertainty estimates in the simulation process, and the single entry point for geometrical data into the process.

3.6 Interaction with other software

Roughness databases
The Roughness Advisor will provide links with suitable databases and knowledge bases, such as the River Habitat Survey. Such links may take the form of occasional downloads, although live links may be provided in some cases. The applications will be kept separate, however; there will be no merging of source code, and the RA will not assume the presence of any third party software.

Flood forecasting
InfoWorks RS models can be exported for use in real-time flood forecasting systems, such as the FloodWorks system produced by Wallingford Software. FloodWorks uses the same ISIS hydraulic simulation engine as InfoWorks RS and ISIS, and it will be possible to incorporate the modifications made to the ISIS engine under this project in the hydraulic simulation component of FloodWorks. Consideration of the suitability of the conveyance formulations for real-time use should therefore be made during this project.

Sediment simulation
River bed material and shape are factors in sediment simulation. ISIS and InfoWorks RS provide facilities for sediment modelling through:

- a mobile bed module coupled to the hydraulic simulation
- a water quality module which simulates the retention of pollutants in the cohesive material on the river bed.

The mobile bed module provides several methods for updating the river bed, ranging from simple vertical adjustment of the entire cross-section to water depth-dependent deposition and erosion. The conveyance methods developed in the project will affect the hydraulics of the mobile bed module only if the simplest form of bed updating is applied.

The possible interaction between sediment deposition/erosion and roughness will not be addressed in the present project, but may be suitable for further research and development.

The water quality module does not update the river bed, and so is only affected by variations in conveyance indirectly through the hydraulic model results. The possible impact of changes in the deposited cohesive sediment or the pollutants trapped in the pore water in that sediment will not be addressed in the present study.
4. MANAGEMENT PLAN

4.1 Work Plan

The Work Plan was slightly revised since the Offer of Services was produced to better reflect the interaction between the various components of the project. It also reflects a better understanding of the various tasks within the work components that have already commenced, but the overall work programme remains unchanged. In the website version of this report the Work Plan (Figure 6) was much simplified.

The Work Plan is subject to further revision during the project within the parameters and requirements of the study. In particular, work during Year 2 of the study is dependent on progress in the first year and its detailed planning may therefore require further adjustments.

The following table gives the key milestone dates within the Work Plan that will enable the Agency and DEFRA to check major control dates and payment milestones (these latter are also given in Table 5):

Table 2  Project Milestones

<table>
<thead>
<tr>
<th>Key Milestone Dates</th>
<th>Milestone</th>
<th>Progress Control Date</th>
<th>Payment Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Month 1</td>
<td>Inception Meeting</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Month 3 (end of)</td>
<td>Inception Report</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Month 3 (end of)</td>
<td>Interim Report 1 (Datasets)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Month 4</td>
<td>Inception Workshop</td>
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<td>✗</td>
</tr>
<tr>
<td>Month 6 (middle)</td>
<td>Development of conveyance and roughness spreadsheets</td>
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<td>✓</td>
</tr>
<tr>
<td>Month 9 (end of)</td>
<td>End of roughness data acquisition</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Month 10 (end of)</td>
<td>Interim Report 2 (Conveyance Methods)</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Month 10 (end of)</td>
<td>End of roughness data analysis</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Month 12 (middle of)</td>
<td>Presentation Workshop (presentation of work during Year 1)</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Month 12 (end of)</td>
<td>Roughness Report, Demonstration of Roughness Advisor</td>
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<td>✓</td>
</tr>
<tr>
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<td>Interim Report 3 (Method testing)</td>
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<tr>
<td>Month 15 (end of)</td>
<td>Development of ISIS code</td>
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<td>ISIS integration</td>
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<td>✓</td>
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<td>Month 21 (end of)</td>
<td>Demonstration of CES</td>
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<td>✓</td>
</tr>
<tr>
<td>Month 22 (end of)</td>
<td>Training day for Pilot testers</td>
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<td>✓</td>
</tr>
<tr>
<td>Month 24 (middle of)</td>
<td>Launch Workshop (launching of CES)</td>
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<td>✗</td>
</tr>
<tr>
<td>Month 24 (end of)</td>
<td>Conveyance Manual (final), Pilot Testing, Initial Training Material and Revised CES</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

4.2 Risk Assessment

A table itemising about 40 different risk issues for this project was produced at the proposal stage and included in the proposal document. The main purpose of the Risk Assessment Table is to indicate the most important issues that need to be monitored during the project to ensure that: 1. the project objectives are met, and 2. any new issues are promptly identified and dealt appropriately.

The risk identification and mitigation strategy has been further refined in the inception stage of the project and the table has therefore been updated to include more risk issues (see Table 3) A new column was included to indicate which parties should be involved in addressing the various risk issues.
<table>
<thead>
<tr>
<th>H 5</th>
<th>Technical Directors to review with academic team members</th>
<th>TD</th>
<th>M</th>
<th>H</th>
<th>4</th>
<th>Interim reports</th>
</tr>
</thead>
<tbody>
<tr>
<td>H 3</td>
<td>Technical Directors to review with academic team members</td>
<td>TD</td>
<td>L</td>
<td>M</td>
<td>2</td>
<td>Interim reports</td>
</tr>
<tr>
<td>H 5</td>
<td>Technical Directors to review with academic team members</td>
<td>TD</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>Interim reports</td>
</tr>
<tr>
<td>H 3</td>
<td>Consult authors (some are academic team members)</td>
<td>TD</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>Interim reports</td>
</tr>
<tr>
<td>H 5</td>
<td>Technical Directors to review with academic team members</td>
<td>TD</td>
<td>M</td>
<td>H</td>
<td>4</td>
<td>Interim reports</td>
</tr>
<tr>
<td>H 3</td>
<td>Technical Directors to review with academic team members</td>
<td>TD</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>Interim reports</td>
</tr>
<tr>
<td>M 4</td>
<td>Technical Directors, team and experts to review at workshops</td>
<td>TD</td>
<td>M</td>
<td>M</td>
<td>3</td>
<td>Interim reports</td>
</tr>
<tr>
<td>L 2</td>
<td>None possible if weather related; reschedule data collection and supplementary review; link with RHS upgrade.</td>
<td>TD</td>
<td>M</td>
<td>L</td>
<td>2</td>
<td>Progress report; letter to Agency</td>
</tr>
<tr>
<td>M 2</td>
<td>None</td>
<td>TD</td>
<td>L</td>
<td>M</td>
<td>2</td>
<td>Interim reports</td>
</tr>
<tr>
<td>M 2</td>
<td>Pre-contract review commissioned from Dr C D Whitlow</td>
<td>TD</td>
<td>L</td>
<td>M</td>
<td>2</td>
<td>Report by C D Whitlow</td>
</tr>
<tr>
<td>L 2</td>
<td>Pre-contract review by Dr C D Whitlow; possible survey requirement</td>
<td>APM</td>
<td>M</td>
<td>L</td>
<td>2</td>
<td>Report by C D Whitlow</td>
</tr>
<tr>
<td>H 4</td>
<td>Request the Agency to re-survey site topography; check gauged flows</td>
<td>APM</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>Meeting notes; Subcontract specifications</td>
</tr>
<tr>
<td>H 4</td>
<td>Regular team briefing; subcontract services well specified</td>
<td>TD</td>
<td>M</td>
<td>M</td>
<td>3</td>
<td>Interim reports; Guidance Document; “Help” file</td>
</tr>
<tr>
<td>M 4</td>
<td>Technical Directors, team and experts to review at workshops</td>
<td>PD</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>HR staff and project management procedures</td>
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<tr>
<td>H 3</td>
<td>Consult on CES output formats</td>
<td>PD</td>
<td>L</td>
<td>M</td>
<td>2</td>
<td>Interim reports</td>
</tr>
<tr>
<td>M 3</td>
<td>Technical Directors to review with academic team members</td>
<td>TD</td>
<td>L</td>
<td>M</td>
<td>2</td>
<td>Interim reports</td>
</tr>
<tr>
<td>H 3</td>
<td>Use established working relationships</td>
<td>PM</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>Subcontract specification</td>
</tr>
<tr>
<td>H 4</td>
<td>Scoping study carried out; review of work at bid stage; additional resources applied</td>
<td>PD</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>Scoping study report; Proposal</td>
</tr>
<tr>
<td>H 5</td>
<td>Use HR project management system to monitor progress; Functional specification; Additional resources applied</td>
<td>PM</td>
<td>M</td>
<td>H</td>
<td>4</td>
<td>HR Project management records; Inception report</td>
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<tr>
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<td>HR Project management; Project Board reviews</td>
<td>PM</td>
<td>L</td>
<td>M</td>
<td>2</td>
<td>Scoping study; Proposal; Progress reports</td>
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<td>M 3</td>
<td>Team building and motivation; reserve staff identified</td>
<td>PD</td>
<td>L</td>
<td>M</td>
<td>3</td>
<td>Proposal</td>
</tr>
<tr>
<td>M 3</td>
<td>Reserve staff identified; Redundancy of expertise in team; Good working conditions</td>
<td>PD</td>
<td>L</td>
<td>M</td>
<td>3</td>
<td>Proposal; HR H&amp;S manual</td>
</tr>
<tr>
<td>H 4</td>
<td>Project Manager to give respond-by dates and chase decisions</td>
<td>APM</td>
<td>L</td>
<td>H</td>
<td>3</td>
<td>Correspondence between PM &amp; APM</td>
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<td>H 4</td>
<td>Project Manager liaises with Agency Project Manager; APM gives advance warnings to pilot testers; Pilot testers work included in their contract specifications</td>
<td>APM</td>
<td>M</td>
<td>H</td>
<td>4</td>
<td>Progress reports; Agency contract specifications with pilot testing organisations</td>
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<td>Priority</td>
<td>Activity Description</td>
<td>Responsible</td>
<td>Type</td>
<td>Risk Measure</td>
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<td>H 3</td>
<td>Use experienced editor; revise draft after pilot testing</td>
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<td>TD L H 3</td>
<td>Draft Guidance Document</td>
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<tr>
<td>M 3</td>
<td>Recommend additional research to EPSRC / NERC / Agency</td>
<td>TD M M 3</td>
<td>M M 3</td>
<td>Roughness review</td>
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<td>Iterative prototyping with consultative group</td>
<td>TD L H 3</td>
<td>TD L H 3</td>
<td>Functional specifications; prototypes</td>
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<td>L 3</td>
<td>Method design; define defaults when possible; couple to map-based GIS</td>
<td>TD M L 2</td>
<td>TD M L 2</td>
<td>Guidance document; “Help” file</td>
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<tr>
<td>H 3</td>
<td>Iterative prototyping with consultative group</td>
<td>TD L H 3</td>
<td>TD L H 3</td>
<td>Guidance document; “Help” file</td>
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<td>M 2</td>
<td>Contract specification</td>
<td>PD L M 2</td>
<td>PD L M 2</td>
<td>Proposal</td>
<td></td>
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<tr>
<td>H 3</td>
<td>Pilot testing using ISIS</td>
<td>PD L H 3</td>
<td>PD L H 3</td>
<td>Pilot testing report</td>
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<td>M 3</td>
<td>Inform other providers of CES formats; Agency to require CES with other models</td>
<td>APM M M 3</td>
<td>APM M M 3</td>
<td>Guidance document</td>
<td></td>
<td></td>
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<tr>
<td>H 3</td>
<td>Regular project board meetings and progress reviews; HR Quality Assurance plan</td>
<td>PD L H 3</td>
<td>PD L H 3</td>
<td>Progress reports; Scoping Study Report;QA documentation</td>
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<td></td>
</tr>
<tr>
<td>H 5</td>
<td>Define data delivery requirements in the Inception Report; Agency Project Manager to monitor timely delivery</td>
<td>APM L H 3</td>
<td>APM L H 3</td>
<td>Inception report</td>
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<tr>
<td>M 2</td>
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<td>APM L M 2</td>
<td>APM L M 2</td>
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<tr>
<td>M 3</td>
<td>Regular project board meetings and progress reviews</td>
<td>APM L M 2</td>
<td>APM L M 2</td>
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<td></td>
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<tr>
<td>H 4</td>
<td>Agency Project Manager to promote concept within Agency</td>
<td>APM L M 2</td>
<td>APM L M 2</td>
<td>New Agency Contract Specification</td>
<td></td>
<td></td>
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<tr>
<td>M 4</td>
<td>Agency to require use of the CES in all flood studies</td>
<td>APM L M 2</td>
<td>APM L M 2</td>
<td>New Agency modelling contract specification</td>
<td></td>
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</tr>
<tr>
<td>M 3</td>
<td>Develop training material; Agency to require CPD for modellers</td>
<td>APM L M 2</td>
<td>APM L M 2</td>
<td>Project output</td>
<td></td>
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<tr>
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<td>Inform other providers of CES formats; Agency to inform PM and TD of relevant changes in Agency CIS strategy</td>
<td>APM L L 1</td>
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<td>APM L M 2</td>
<td>APM L M 2</td>
<td>Interim reports</td>
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</table>

- Risk measure (HH = 5, HM = 4, HL = 3, MM = 3, ML = 2, LL = 1)
- EEP = External Expert Panel, EO = External Organisations
- TD = HR Technical Director, APM = Agency Project Manager
4.3 Invoicing

This section is not included in the website version of the report.
5. PROJECT QUALITY PLAN

A Quality System has been produced covering HR Wallingford’s activities in the investigation of civil engineering hydraulics. The Quality System is based on ISO 9001 (BS 5750: Part 1:1987) and is a project based system in which individual projects are planned and controlled through a Quality Plan to ensure that the services provided meet the requirements of the client. The Quality System comprises two documents: the Quality Manual and the Quality Procedures. The Quality Manual sets out a statement of Company policy and outlines how conformance of the Company’s Quality Policy to the requirements of ISO 9001 is to be achieved. The Quality Procedures Manual sets out the detailed procedures designed to meet the requirements of ISO 9001.

The Quality System that has been implemented for this project will contribute to the management of risk during the project as it will help identify potential problem areas and take prompt adequate action to minimise any impact on the overall expected performance.

The HR Wallingford Quality System for all projects is summarised below. The Quality Plan comprises:

- The Project Activity Schedule, which includes activity responsibilities, checking and signing off procedures (see Appendix 6);
- A Checklist of Actions to be carried out by the HR project manager, which includes aspects such as organisation of the project, implementation, outputs and project closure (see Appendix 6);
- Procedures for recording project information.

These documents will be kept, checked and updated as required throughout the duration of the project and are available to the Environment Agency Project Manager for inspection.
6. SOFTWARE DEVELOPMENT AND DELIVERY

6.1 Scope of delivery

Three main software deliveries are identified in the contract:

- The roughness advisor
- The conveyance generator
- Implementation of improved conveyance calculation in the Isis simulation.

The roughness advisor and conveyance generator together form the conveyance estimation system (CES). The CES will be delivered in two forms - the first as open code to facilitate further modification for research or further implementation purposes. In this way it would not be automatically supported after the project. The second, for the stand-alone user (e.g. maintenance operators), will be supported. The implementation with Isis may include both new, stand-alone modules and modifications to Isis itself.

In addition, at the inception stage, it has been identified that the software team should advise on implementation of improved conveyance calculations in two further systems: MDSF (Modelling and Decision Support Framework) and InfoWorks.

The Agency has invested in MDSF as a methodology for developing procedures and tools for calculating flood risk. It is likely to be extended as a development system in the future. It exchanges data with Isis and Isis simulations can be a part of the methodology. The Agency needs to know that these two projects in which it is investing – Improved conveyance and MDSF – are being coordinated.

Wallingford Software has developed InfoWorks to provide an integrated, multi-user modelling environment to provide a choice of simulation engines, including both Isis and PDM (both extensively used by the Agency). InfoWorks now includes some of the MDSF functionality and is likely to include more in the future. The Agency has expressed an interest in using InfoWorks as a modelling environment, so needs to know how the improved conveyance calculation would be incorporated.

This project will deliver a range of software plus advice on further implementation with MDSF and in InfoWorks.

There are other river simulation systems in use, or potentially in use, by the Agency, including HEC RAS. The aim is that the stand-alone roughness advisor and conveyance generator should allow improved conveyance calculations where possible. However, modifications to simulation software, such as HEC RAS, are outside the scope of this project.

6.2 Type and language of software

It has been anticipated that the roughness advisor would incorporate some sort of programmed spreadsheet. However, no firm decisions have been made on the type and language of software that is delivered (or upon which advice is given – eg for MDSF and InfoWorks). This is as it should be, because these decisions should be taken as part of technical specification, following the requirements analysis and functional design. Decisions will probably be made in Autumn 2002. Consideration will be given to using appropriate languages at each stage, and trying to maximise the amount of software re-use.

However, it is fairly certain that a range of software languages will be involved. The programmed spreadsheet would probably be done using Basic. Isis uses both Delphi and Fortran. InfoWorks uses Visual C++ and Fortran. MDSF uses Avenue plus other languages.

This sounds confusing, but modular design should mean that conveyance-related data can pass between systems that use different languages. It is possible that some functionality will be coded-up more than
once, in different languages, across these systems. This is not a problem in itself, but care will be taken that the same results are obtained in each option.

6.3 Performance, ease of use and level of functionality

It has been identified that this project should improve the way that the Agency calculates and applies conveyance. Previous attempts to do this have tended to increase complexity and decrease performance for the users of software systems, to such an extent that what seem to be improvements become liabilities and the new methods were rejected.

So this project must achieve a suitable balance between performance, ease of use and level of functionality. It is likely that very different systems are suitable for three user groups (for example): the stand-alone users who may require a subset of answers and who value ease of use above all; the experimental researcher who needs flexibility and control of calculations above all; and the contract modeller who needs an approved answer, speed and integration with the modelling system.

The roughness and conveyance calculations should be identical within whichever system they appear. However, some systems have a more advanced range of user interface and data management functions than do other systems. This is because the Agency can take advantage of previous investment of time and money in existing systems, for example with GIS user interfaces. As a guide, the hierarchy of sophistication of user interface and data management (from lowest to highest) is likely to be:

- Experimental versions of the roughness advisor and conveyance generator
- Stand-alone versions of the roughness advisor and conveyance generator
- Isis
- MDSF
- InfoWorks

The matrix of user requirements and levels of system sophistication available will be sorted out during functional design, with the overriding aim of genuinely changing and improving the way each of the user groups calculates conveyance in their usual work.

6.4 Open architecture and open source

There is much debate about the merits or otherwise of various degrees of openness. At one extreme, fully open source is very flexible, but is difficult to control and maintain. Closed code does not have the flexibility, but is easier to control and maintain.

Open architectures allow flexibility in that modules from different sources can be used, but data management and performance can become overwhelming issues. In general, river modelling systems will become more open, particularly in response to the needs of the Water Framework Directive for more extensive integrated catchment modelling involving a wide range of simulation and data types. However, fully open architectures, models and adapters that have no performance or data management limitations are not yet available. This is an area of continued research and development in which HR Wallingford and Wallingford Software are at the forefront.

There is no overall right or wrong answer that suits every user and circumstance. This project will pick a solution for each user type and for each of the systems mentioned above. So, for example, the research users are likely to get a good proportion of open source, but they will have to support what they do with it themselves.
7. DISSEMINATION AND UPTAKE

Ensuring that appropriate tools are delivered to all the users concerned is one of the primary objectives of the study. Dissemination and uptake within the user groups are therefore very important aspects of the project. A number of workshops have been planned involving representatives of the different types of user to engage them in the study and raise early awareness (e.g. Inception Workshop in the first months of the project, Presentation Workshop at the end of the first year of the project). A Launch Workshop is also scheduled for the end of the study. To help ensure a good uptake of the results of the project, initial training will be provided under this contract and further training is also being considered after 2003.

It is also the intention of the Project Team to publicise the Conveyance project extensively and a number of dissemination initiatives have already been carried out. These are summarised in the following table together with initiatives which have been identified for the future, and more items will be added to it as further opportunities arise.

Table 6  Publicity for the Conveyance Project

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<th>Type of event</th>
<th>Venue</th>
<th>Completion status</th>
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<th>Type</th>
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<td>Various</td>
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<tr>
<td>Management”</td>
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<td>on Fluvial Hydraulics</td>
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*TBD – to be decided
8. KEY REFERENCES


Figures
Figure 1 Team members and roles

Agency Project Board

Agency Project Manager  Mervyn Bramley
Planning/Dev Control/Risk Mapping
Flood Forecasting  Design (Maintenance/Conservation)
Other (e.g. Scotland, Northern Ireland)

Technical Development

Roughness  Conveyance
Hugh Dawson  Paul Samuels
Karen Fisher  Caroline McGahey

Technical Direction

Paul Samuels
Edward Evans
David Fortune (Software)

Software Production
Wallingford Software

Project Management

Project Director  Keith Powell
Project Manager  Manuela Escarameia
Project Manager (Softw)  Andrew Nex

User Consultative Group

Agency Project Manager  Mervyn Bramley
Planning/Dev Control/Risk Mapping
Flood Forecasting  Design: Hydrometry;
Other (e.g. Local Authorities)
Figure 2 Conveyance support system

Note: hatched boxes indicate components external but related to CES
Figure 3  Example screenshot of the InfoWorks RS GeoPlan
Figure 4  Information flow between the deliverable software components of the project

Figure 5  Information flow in the InfoWorks RS implementation of the project software
| TASK | Jan 02 | Feb 02 | Mar 02 | Apr 02 | May 02 | Jun 02 | Jul 02 | Aug 02 | Sept 02 | Oct 02 | Nov 02 | Dec 02 | Jan 03 | Feb 03 | Mar 03 | Apr 03 | May 03 | Jun 03 | Jul 03 | Aug 03 | Sept 03 | Oct 03 | Nov 03 | Dec 03 |
|------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| T-0  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Project Management | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-1  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Data Mining and Assembly | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-2  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Conveyance Estimator | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-3  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Testing of Preferred Meth. in 1D model | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-4  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Roughness Review | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-5  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Roughness Advisor | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-6  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Conveyance Est. Syst (CES) | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-7  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Conveyance Manual | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-8  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Pilot Testing & Finalisation | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T-9  |        |        |        |        |        |        |        |        |         |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| Initial Training Material | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Figure 6 Work plan**
Appendices
Appendix 1

Project components
Appendix 1  Project components

Tables:  Components of Targeted Programme

<table>
<thead>
<tr>
<th>Component T0</th>
<th>Project Planning, Management and Integration</th>
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<tr>
<td><strong>Objective</strong></td>
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<td>To deliver the project to specification, on programme and within budget</td>
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<tr>
<td><strong>Scope</strong></td>
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<tr>
<td>• Risk identification and management</td>
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</tr>
<tr>
<td>• Progress review internally and with the Agency</td>
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</tr>
<tr>
<td>• Planning and overall co-ordination of the Programme tasks and sub-tasks</td>
<td></td>
</tr>
<tr>
<td>• Software development planning and control including:</td>
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<td>- Functional specification of the Roughness Advisor</td>
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<td>- Functional specification of the Conveyance Estimation System and Uncertainty Estimator</td>
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<td>- Pilot (beta) testing</td>
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</tr>
<tr>
<td>• Cost control</td>
<td></td>
</tr>
<tr>
<td>• Quality control</td>
<td></td>
</tr>
<tr>
<td>• Staff resourcing and team integration</td>
<td></td>
</tr>
<tr>
<td><strong>Key Steps</strong></td>
<td></td>
</tr>
<tr>
<td>• Establish and implement project management system (See Section 7.1)</td>
<td></td>
</tr>
<tr>
<td>• Establish and implement project quality plan (see Section 7.2)</td>
<td></td>
</tr>
<tr>
<td>• Undertake regular reviews with Technical Directors and Academic Experts</td>
<td></td>
</tr>
<tr>
<td>• Prepare Agency monthly progress reports</td>
<td></td>
</tr>
<tr>
<td>• Liase with Agency Project Manager and the Agency Project Board (See Section 6.2)</td>
<td></td>
</tr>
<tr>
<td>• Liase with Consultative Group and Pilot Testing organisations (See Section 6.3)</td>
<td></td>
</tr>
<tr>
<td>• Submit Inception and Interim reports</td>
<td></td>
</tr>
<tr>
<td><strong>Key Risks</strong></td>
<td></td>
</tr>
<tr>
<td>Time over-runs for development and testing</td>
<td></td>
</tr>
<tr>
<td>See other risks in the project risk assessment table</td>
<td></td>
</tr>
<tr>
<td><strong>Linkages</strong></td>
<td></td>
</tr>
<tr>
<td>All project components</td>
<td></td>
</tr>
<tr>
<td><strong>Deliverables</strong></td>
<td></td>
</tr>
<tr>
<td>Inception Report containing detailed functional specification, breakdown and scheduling of each task</td>
<td></td>
</tr>
<tr>
<td>Regular monthly project progress summaries to Agency Project Manager (See Section 7.1)</td>
<td></td>
</tr>
<tr>
<td>Component T1</td>
<td>Data Mining and Assembly</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
<td>Assemble topographic and hydrometric data sets for testing the conveyance methods</td>
</tr>
</tbody>
</table>
| **Scope** | • River survey data  
• Laboratory experimental data  
• Previously assembled river model data sets |
| **Key Steps** | • Section 105 model data set review  
• Flood Defence Project data set review  
• Experimental data set review  
• Obtain data sets  
• Make data sets available for publication on the EPSRC Network internet site |
| **Key Risks** | Insufficient data sets for real river identified which are suitable for the testing  
See Project Risk Assessment Table |
| **Linkages** | Provides information to components T2, T3, T4, T5, T6 and T9 |
| **Deliverables** | Publication of data sets on the website of the EPSRC Network on flood conveyance  
Interim Report 1 “Data sets” |
**Component T2 Conveyance Generator**

**Objective**
To identify, test and code methods for conveyance estimation suitable for in bank and out-of-bank flow in all UK rivers

**Scope**
Review, select, code and test appropriate 1-D conveyance estimation methods for natural and engineered river and flood plain systems.

**Key Steps**
- Select methods from the reviews undertaken in the scoping study
- Code methods in spreadsheet form (potentially based upon the Birmingham MSc project)
- Compare methods with experimental and field data
- Select at most 4 methods to cover range of real river conditions
- Code methods in appropriate language as open code
- Produce user spreadsheet interface to preferred method(s)
- Document methods and test results
- Document algorithms as “open” code
- Define data exchange formats for other model providers to implement
- Interact with the EPSRC network through presentation of methodology at a network meeting

**Key Risks**
Methods give conflicting results
Methods do not give a smooth transition with changes in geometry
New methods require additional and unfamiliar data
See Project Risk Assessment Table

**Linkages**
Input from T1 and T4
Provides information to T3, T6 and T7

**Deliverables**
### Component T3  
**Testing of Preferred Method in 1-D model**

#### Objective
To demonstrate that the recommended method is robust for application to river modelling  
To be able to advise users as to what difference the new method will make to stage-discharge curves and to overall steady unsteady modelling results

#### Scope
The demonstration of robustness will only involve the ISIS model and will be done using approximately 5 recent cases drawn from the Environment Agency and its Framework Consultants

#### Key Steps
- Implement preferred conveyance estimation method in ISIS (financed by HR Wallingford)  
- Test against at least 5 cases  
- Review results  
- Undertake additional tests for up to 3 sites as required  
- Document results

#### Key Risks
Lack of data for test cases  
See Project Risk Assessment Table

#### Linkages
Input from T1 and T2  
Provides information to T6 and T7  
Development of a link between the CES and ISIS by HR Wallingford and Wallingford Software in parallel with the CES R&D Project

#### Deliverables
Interim Report 3: “Testing of preferred method in 1D model”

---

*HR Wallingford*
<table>
<thead>
<tr>
<th>Component T4</th>
<th>Roughness review</th>
</tr>
</thead>
</table>

**Objective**

To gather, validate and catalogue knowledge on the boundary roughness of UK rivers

**Scope**

Initially the data collection will be restricted to England and Wales, information gathered will include water level, flow rate, topographic survey, photographs, density and species of flora. The sites review will include the Agency River Habitat Survey site database

**Key Steps**

- Review information identified in the expert paper in the scoping study and any other recent relevant material
- Review and collate other existing data for the whole of the UK, including Scotland and Northern Ireland
- Characterise typical river types based upon physio-geographic indices
- Identify morpho-type groups using RHS database
- Identify gaps in data coverage
- Specify and undertake additional strategic data collection; this will cover England and Wales and will include in-bank vegetation and substrata impacts on hydraulic roughness.
- Identify need for further data collection programme to be carried out under the Strategic Research Programme
- Provide probability distributions for vegetation roughness to assist in the estimation of uncertainties within the Conveyance Estimation System
- Review options for river maintenance for control of riverine vegetation and produce guidance on effect of maintenance procedures on vegetation roughness
- Analyse collated and newly collected data, including seasonality effects, for incorporation in the Roughness Manual and Roughness Estimator
- Produce a guidance manual on the roughness of UK rivers
- Review findings with project experts advisors and the EPSRC network

**Key Risks**

Methods and data sets conflict
Adverse weather or flow conditions precludes data collection on time
Priority is not given by the Environment Agency to provide access to existing data sets or sites for data collection
See Project Risk Assessment Table

**Linkages**

Input from RHS and T1
Supporting science base work by Dr H Dawson at CEH (Dorset)
Provides information to T2 and T5

**Deliverables**

Scientific documentation of the Roughness Review (to Final Draft standard)
<table>
<thead>
<tr>
<th>Component T5</th>
<th>Roughness Advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To facilitate access to expert knowledge and information on the roughness of UK rivers and flood plains for conveyance estimation</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Develop a structured view of the information, site data and photographs from the roughness review for rivers in England and Wales</td>
</tr>
<tr>
<td><strong>Key Steps</strong></td>
<td></td>
</tr>
<tr>
<td>• Establish a database of photographs of vegetation and substrate for different morpho-types</td>
<td></td>
</tr>
<tr>
<td>• Devise a classification system based upon easily measurable or observable parameters</td>
<td></td>
</tr>
<tr>
<td>• Categorise components of overall roughness from unit values and section geometry</td>
<td></td>
</tr>
<tr>
<td>• Provide access to estimates of roughness and potential range (i.e. uncertainty) for each type</td>
<td></td>
</tr>
<tr>
<td>• Compound unit roughness values into overall figure for cross-section components</td>
<td></td>
</tr>
<tr>
<td>• Produce a computer-based implementation of this knowledge as an “expert” system</td>
<td></td>
</tr>
<tr>
<td><strong>Key Risks</strong></td>
<td>Insufficient site data available for complete characterisation</td>
</tr>
<tr>
<td></td>
<td>See Project Risk Assessment Table</td>
</tr>
<tr>
<td><strong>Linkages</strong></td>
<td>Input from T4</td>
</tr>
<tr>
<td></td>
<td>Provides information to T3, T6 and T7</td>
</tr>
<tr>
<td><strong>Deliverables</strong></td>
<td>Alpha version of the Roughness Advisor for inclusion in the CES</td>
</tr>
</tbody>
</table>
### Component T6

**Conveyance Estimation System and Uncertainty Estimator**

<table>
<thead>
<tr>
<th><strong>Objective</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>To integrate the Conveyance Generator and the Roughness Advisor onto a stand-alone tool and provide a realistic uncertainty range for the conveyance estimates</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Scope</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop a unified user interface to the project software tools and electronic form of the guidance manual and provide a framework for estimating uncertainty in conveyance values.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Key Steps</strong></th>
</tr>
</thead>
</table>
| • Produce functional specifications of the Conveyance Estimation System (including Uncertainty Estimator)  
• Iterative prototypes evaluated with the User Consultative Group  
• Develop framework for uncertainty estimation  
• Test uncertainty estimator  
• Integrate project software components in a unified “wrapper” |

<table>
<thead>
<tr>
<th><strong>Key Risks</strong></th>
</tr>
</thead>
</table>
| Users do not appreciate how the CES will influence their working methods (which impacts upon the design of the CES)  
See Project Risk Assessment Table |

<table>
<thead>
<tr>
<th><strong>Linkages</strong></th>
</tr>
</thead>
</table>
| Input from T2, T3, T4, T5 and T7  
Provides information to T8 and T9 |

<table>
<thead>
<tr>
<th><strong>Deliverables</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpha version of the CES, including Uncertainty Estimator</td>
</tr>
<tr>
<td>Component T7</td>
</tr>
<tr>
<td>--------------</td>
</tr>
<tr>
<td><strong>Objective</strong></td>
</tr>
<tr>
<td><strong>Scope</strong></td>
</tr>
</tbody>
</table>
| **Key Steps** | - Draft manual from components of the interim reports.  
  - Devise examples and flow charts.  
  - Develop hypertext form to include with CES.  
  - Review and revise text. |
| **Key Risks** | Guidance document is difficult to follow (see Risk Assessment table). |
| **Linkages** | Takes input from T2, T3, T4, T5, and T6. Provides information for T6, T8, and T9. |
| **Deliverables** | Conveyance Manual (paper-based).  
  Conveyance Manual (hypertext version). |
### Component T8: Pilot Testing

#### Objective
To demonstrate the feasibility of using the CES in real situations, obtain operational feedback and develop initial user-base to assist with CES roll-out.

#### Scope
Up to four organisations will be identified by the Agency as Pilot testers, each on one or more current Agency flood defence projects.

#### Key Steps
- Identify Pilot Test Organisations and projects (operations, capital programme, planning, etc)
- Deliver CES, spreadsheets and Guidance to Pilot Testers (as appropriate)
- Train Pilot Testers
- Support Pilot testers
- Monitor and evaluate pilot test experience and results
- Modify CES and spreadsheets where appropriate

#### Key Risks
Pilot Testing organisations over-run time allowed
See Project Risk Assessment Table

#### Linkages
Takes information from T3, T6 and T7
Potentially leads to modification of T6, T7 and T9

#### Deliverables
Conveyance Estimation System (CES) available as a spreadsheet-style stand-alone system
Conveyance Estimation System (CES) implemented in ISIS
<table>
<thead>
<tr>
<th><strong>Component T9</strong></th>
<th><strong>Initial Training Material</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Objective</strong></td>
<td>To develop initial set of CPD material to train users of the CES and Conveyance Generator</td>
</tr>
<tr>
<td><strong>Scope</strong></td>
<td>Development of PowerPoint presentations and exercises with the CES for 1-day intensive training course</td>
</tr>
<tr>
<td><strong>Key Steps</strong></td>
<td></td>
</tr>
</tbody>
</table>
| • Extract information from the guidance document  
• Develop 1 day training programme and agree with Agency  
• Write PowerPoint presentations  
• Develop case study material for exercises  
• Deliver 1 day training to Pilot Test Organisations  
• Evaluate training material and modify as necessary  
• Participate in two one-day briefing seminars for Agency staff and framework consultants (one in the North and one in the South) |
| **Key Risks**    | Users unfamiliar with conveyance concepts and 1-day insufficient  

See Project Risk Assessment Table |
| **Linkages**     | Input from T3, T6 and T7 |
| **Deliverables** | Training day for Pilot Testers: power point presentation, notes, exercises  
Participation in two briefing seminars to be organised by the Agency. |
Appendix 2

Roughness review
Figure 1. The distribution of channel vegetation types a) liverworts, mosses or lichens, b) emergent broad-leaved herbs, c) emergent reeds, sedges or rushes, d) rooted floating-leaved, e) free-floating, f) amphibious, g) submerged broad-leaved, h) submerged fine-leaved and i) filamentous algae in the UK [based on Dawson, F.H., Raven, P.J. & Gravelle, M.J. (1999) Distribution of the morphological groups of aquatic plants for rivers in the U.K. Hydrobiologia 415, 123-130. (Key: present –1-32% - small solid circles; ≥ 33% extensive - large solid circles)
Table A2.1 Sample of form for recording data

Reference: Bakry MF, Gates TK and Khattab AF, 1992

General

<table>
<thead>
<tr>
<th>Country</th>
<th>Exp or field data</th>
<th>Catchment area</th>
<th>Length of reach</th>
<th>Distance from source</th>
<th>Ht above sea level</th>
<th>Plan form</th>
<th>Features</th>
<th>Times in year of data collection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egypt</td>
<td>Field</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Feb-Oct</td>
</tr>
</tbody>
</table>

Hydraulic (First row is bankside vegetation, second is submerged)

<table>
<thead>
<tr>
<th>Discharge</th>
<th>Depth</th>
<th>Velocity</th>
<th>Area</th>
<th>Wetted Parameter</th>
<th>Hydraulic radius</th>
<th>Slope</th>
<th>Channel shape</th>
<th>Number of cross-sections</th>
<th>Roughness “n”</th>
<th>Reynold’s number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vegetation

<table>
<thead>
<tr>
<th>Type</th>
<th>Spacing</th>
<th>Density</th>
<th>Cutting regime</th>
<th>Times of cutting</th>
<th>Length</th>
<th>Flexibility</th>
<th>Stiffness</th>
<th>Coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bankside</td>
<td></td>
<td>0.06-0.36</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>submerged</td>
<td></td>
<td>0.06-0.25</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary

No clear trend for relationship between n and VR for canals with ditch-bank vegetation.
Deflection of vegetation due to increased velocity has little impact on resistance for cases where vegetation is confined to canal banks.
For canals with emergent bankside vegetation, n values similar to those suggested in Chow (1959)
For submerged vegetation n was greater than predicted in Chow.
For channels with submerged vegetation n is related to vegetation density and VR.
For fully turbulent flows n can be considered to be a constant??, independent of flow characteristics but where bed and banks are thickly covered in vegetation considerable part of the flow takes place through vegetation, causing a reduction in R below the turbulent range therefore n will depend on VR.
General trend for n to decrease logarithmically with increasing VR, submerged vegetation. (Gwinn and Ree, 1980)
<table>
<thead>
<tr>
<th>River and site</th>
<th>Individual readings or over a season</th>
<th>Source of data</th>
<th>Vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>River Severn, Bewdley</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Derwent</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Trent</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Avon</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Ilam at Manifold</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Tanat</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Vrynwy</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Severn, Montford</td>
<td>One day</td>
<td>HR Wallingford/EA</td>
<td>None present</td>
</tr>
<tr>
<td>River Cole, near Swindon</td>
<td>Two seasons</td>
<td>HR/MAFF/RRP</td>
<td>Yes data available</td>
</tr>
<tr>
<td>River Cole, Birmingham; Two sites</td>
<td>Two/three seasons</td>
<td>EPSRC funded research</td>
<td>Yes data available</td>
</tr>
<tr>
<td>Candover Brook, Hampshire</td>
<td>One season</td>
<td>HR/MAFF</td>
<td>Yes data available</td>
</tr>
<tr>
<td>River Tame, Sandwell Valley</td>
<td>Several days in a season</td>
<td>Yes data available</td>
<td>Yes data available</td>
</tr>
<tr>
<td>River Tame, Hampstead Road</td>
<td>Several days in a season</td>
<td>Yes data available</td>
<td>Yes data available</td>
</tr>
<tr>
<td>River Tame, Perry Park</td>
<td>Several days in a season</td>
<td>Yes data available</td>
<td>Yes data available</td>
</tr>
<tr>
<td>River Tame, Brookvale Road</td>
<td>Several days in a season</td>
<td>Yes data available</td>
<td>Yes data available</td>
</tr>
<tr>
<td>River Tame, Thompson Drive</td>
<td>Several days in a season</td>
<td>Yes data available</td>
<td>Yes data available</td>
</tr>
<tr>
<td>Bawn’s Burn, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Abels bridge, River Blackwater, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Lisdoart Mill, River Blackwater, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Lisdoart Bridge, River Blackwater, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Forthill Bridge, River Blackwater, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Caledon Bridge, River Blackwater, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Omagh Road, River Blackwater, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Burn’s Bridge, River Blackwater, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Oona River, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>River Fury, NI</td>
<td>One/two seasons</td>
<td>University of Ulster/ MAFF funded</td>
<td>None present</td>
</tr>
<tr>
<td>Livery Hill, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>?</td>
</tr>
<tr>
<td>Location</td>
<td>Duration</td>
<td>Institution</td>
<td>Data Present</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------</td>
<td>----------------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>Conagher Bridge, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>None present</td>
</tr>
<tr>
<td>Stranocum Bridge, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>None present</td>
</tr>
<tr>
<td>Clontyfinnan, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>None present</td>
</tr>
<tr>
<td>Stracam, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>None present</td>
</tr>
<tr>
<td>Moss side, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>None present</td>
</tr>
<tr>
<td>Doughery Water, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>None present</td>
</tr>
<tr>
<td>River Noe, River Bush, NI</td>
<td>One/two seasons</td>
<td>University of Ulster</td>
<td>None present</td>
</tr>
<tr>
<td>River Itchen</td>
<td>Several flow conditions</td>
<td>CEH Wallingford PHABSIM data</td>
<td>?</td>
</tr>
<tr>
<td>River Allen</td>
<td>Several flow conditions</td>
<td>CEH Wallingford PHABSIM data</td>
<td>?</td>
</tr>
<tr>
<td>River Lambourne</td>
<td>Several flow conditions</td>
<td>CEH Wallingford PHABSIM data</td>
<td>?</td>
</tr>
<tr>
<td>River Piddle</td>
<td>Several flow conditions</td>
<td>CEH Wallingford PHABSIM data</td>
<td>?</td>
</tr>
<tr>
<td>River Wey</td>
<td>Several flow conditions</td>
<td>CEH Wallingford PHABSIM data</td>
<td>?</td>
</tr>
<tr>
<td>Upper Derwent</td>
<td>Several flow conditions</td>
<td>University College Worcester/EA PHABSIM data</td>
<td>None present</td>
</tr>
<tr>
<td>River Tavy</td>
<td>Several flow conditions</td>
<td>University College Worcester/EA PHABSIM data</td>
<td>None present</td>
</tr>
</tbody>
</table>
Appendix 3

Start-up Meeting, Agenda and Notes
Appendix 3  Start-up Meeting Agenda and Notes

START-UP MEETING
Reducing Uncertainty in Conveyance Estimation

Thursday, 3 January 2002

Venue:  Room 2, Rio House, Aztec West

Agenda (provisional)

10:00 - 10:15  Coffee

1.  Framework Agreement

   Refer to Framework Agreement Rev E and EA R&D Conditions of Contract

   - Clarification of final point – MB email to SH
   - DEFRA comments during approval
   - Signing
   - Procedure for awarding “packages” under the Agreement

2.  Conveyance Project

   Refer to offer of Professional Services (3/12/01 – HRW Proposal P1471)

   - Finalization of Agreement for the package
   - Project Management and Contractual Arrangements
     (brief summary by PS and MB, followed by agreement of any outstanding points)
   - Organisation Structures – roles and responsibilities
   - Management Issues to be covered in Inception Report
   - Inception Meeting
   - Publicity
   - Involvement of Scotland and NI

3.  Modelling Strategy

4.  AOB

Lunch in Canteen

Attendance:
Stephen Huntington, Paul Samuels, Manuela Escarameia, Edward Evans,
Mervyn Bramley, Mark Roddan, Gill Davies
Reducing Uncertainty in Conveyance Estimation

Note on Start-Up Meeting – 3rd January 2002, Bristol

Present:

Stephen Huntington - HR Wallingford, Managing Director
Paul Samuels - HR Wallingford, Project Technical Director
Manuela Escarameia - HR Wallingford, Project Manager
Edward Evans - Consultant, Joint Technical Director
Mervyn Bramley - Environment Agency, Project Manager
Mark Roddan - Environment Agency, Procurement Manager

The meeting was delayed due to MB’s indisposition – the following points were covered by other attendees in the pre-meeting:

Others to add relevant points

1. Framework Agreement

MB to write to DEFRA seeking to ensure that DEFRA aligns its conditions of engagement under its Commission with HRW as closely as possible to the Agency Framework Agreement. In doing this, MB would:

- Cover the specific points he had explained to Graham Bacon of DEFRA Research Policy and International Division justifying the Framework Agreement with DEFRA, including the rationale for accepting limited liability (MB hereby confirms DEFRA name).
- Emphasise the benefits of procurement of R&D from External Centres of Expertise having the same basic rationale irrespective of whether the project is procured through DEFRA or the EA.
- Confirm the view of HRW and the EA that best value and quality of resourcing is achieved by ensuring that total relevant activity (for DEFRA and EA) is identified prior to the start of each fiscal year (the joint schedule).

MB to forward to HRW (SH) copies of:

- July 01 version of note on “Development of Work Programmes with External Centres of Expertise”. (This is the high level note that sets out the principal of “total relevant activity”, along with the basic generic criteria and procedures for procurement of any project through a National Centre of Expertise.
- Revision E to Framework Agreement (amended to explain that the limit on liability relates to HRW)
- Background information from OST on Foresight 3 (restricted).

ME to confirm current version of EA conditions of contract to be attached to the Framework Agreement (MR has confirmed Issue No. 2 – 03.04.00)
MB/SH to clarify the most up to date “Schedule of 2001/02 R&D and related projects in Framework Agreement” (MB confirms that SoD (Scheme of Delegation – Form C) approval was given to EA projects in Schedule Rev. A, dated 26.10.01, totalling £790k total value).

MB/MR to produce a short note explaining to (a) officers under DEFRA/EA Joint Programme, and (b) other business groups in EA, the procedure for awarding packages under the Framework Agreement. This must cover:

- Rationale/criteria for inclusion of projects in the Annual Schedule.
- Steps/criteria for adding projects to the Framework Agreement during the course of the year – this would include “black square justification” and need to raise additional Form C (SoD approval for Single Tender Action).
- Procedure for annual review of rates and costs of ongoing projects.

MR to produce bound-up version of Framework Agreement, plus supporting Conditions of Contract and Schedule. MR to arrange for Procurement Officer signature, plus (possibly) HR Finance Director. MB to check how/whether Geoff Mance wishes to sign. (MB confirms that GM will be asked to sign).

MB to confirm the projects in the Annual Schedule that are covered by the EA Form C approval.

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modelling and Decision Support Framework for CFMPs</td>
<td>£270k</td>
</tr>
<tr>
<td>Risk Assessment of FD Systems for strategic planning</td>
<td>£250k</td>
</tr>
<tr>
<td>Performance and reliability of F&amp;CD structures</td>
<td>£50k</td>
</tr>
<tr>
<td>Reducing uncertainty in river flood conveyance</td>
<td>£490k</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>£970k</strong></td>
</tr>
</tbody>
</table>

MB and SH to arrange joint press release on Framework Agreement. This should also be linked in with Conveyance Project start-up.

2. Conveyance Project

MB to get Gill Davies to send Purchase Order to HRW for Conveyance Project in sum of £498k asap.

Gill Davies, ME and MB to achieve quicker payment of HRW invoices than in the Scoping Study. (GD to check general approach with MR).

MB to promote synergy between Project Board and User Consultative Group.

Gill Davies to send HRW copies of:

- EA R&D Project Management Manual
- EA R&D Report Production Guide (with additional sections being added to accommodate DEFRA/EA joint programme)

Agreed that management progress meetings between ME and MB might be by video conference, but would normally be face to face at HRW. Latter should preferably coincide with team meetings so that MB can take part in significant decisions. Try to avoid isolating the project management meetings from...
technical staff. (Note MB would expect to dovetail these meetings with other management meetings at HRW). ME to draw up timetable of Conveyance Project meetings.

At Inception Meeting, particular emphasis to be given to:

- Optimum membership/representation on Project Board and User Consultative Group (MB will involve Peter Spencer in this process). MB to confirm tasks of Project Board (as per EA R&D Manual).
- Explaining the steps in the overall project from completion of the Conveyance Estimation System through to delivery of software for ISIS.
- Risk assessment and mitigation actions (including checks by project board/project managers).
- Level of acceptance checking by Project Board members generally (as distinct from checking by designated user representatives).

Noted it was important to resolve basic understanding of requirements for functional specification prior to Inception Meeting.

**PS/MB** to add/develop appropriate Headline Targets – mindful of need to illustrate benefits of efficiency gain (cost savings) and reduction in uncertainty (flood level; flow capacity).

**PS** to talk to Donald Knight and Chris Whitlow before Inception Meeting to determine whether CW intends to be protective of his program code for bolting different conveyance calculation methods into “open” version of ISIS. If he is, then MB to talk (progressively) with Donald Knight and Peter Hedges, and to clarify need for all “players” in FD modelling development to accept basic premise of openness at the research/development level (as distinct from commercial development).

**ME** to produce listing of all potential outlets for publicity for conveyance project. ME to check/ensure production of a project flyer for the CIWEM meeting (London zoo - 25th January).

Draft A, MB 4/1/02
Appendix 4

Inception Meeting (Agenda and Notes)
Appendix 4 Inception Meeting (Agenda and Notes)

Inception Meeting
Reducing Uncertainty in Conveyance Estimation
Tuesday, 8 January 2002

Venue: HR Wallingford, Blackstone Room
Howbery Park
Wallingford
Oxfordshire OX10 8BA

Agenda

10:00 - 10:30  ASSEMBLE and COFFEE

10:30 – 10:35  Welcome  Keith Powell

10:35 – 10:45  Meeting Overview and Introductions  Paul Samuels

10:45 – 11:00  The Project Context  Mervyn Bramley

11:00 – 11.15  The Project Vision  Edward Evans

11:15 – 11:45  Integrating and managing the Project  M Escarameia
Project scope, team, roles, timetable, project management requirements, Inception Report

11:45– 12:10  Delivering the CES  Paul Samuels
Deliverables, Risk mitigation and management

12:10 – 12:45  Report on progress on T1 Data Mining and Assembly  Chris Whitlow

12:45 – 13:30  LUNCH BREAK

13:30 – 14:00  Functional Specifications – what’s involved?  David Fortune

14:00 - 15:15  Group work on Functional Specifications  All
- Conveyance Generator
- Roughness Advisor
- Conveyance Estimation System (CES)

15:15 – 15:30  TEA

15:30 – 16:00  Administrative and contractual matters  M Escarameia

16:00 - 16:20  Summary of Actions  M Escarameia

16:20 – 16:30  Other issues and business

16:30  DISPERSE
Notes on the Team Inception Meeting
Reducing Uncertainty in Conveyance Estimation
Tuesday, 8 January 2002

Venue: HR Wallingford, Blackstone Room
Howbery Park
Wallingford
Oxfordshire OX10 8BA

Attendees:
Mervyn Bramley* Environment Agency
Peter Spencer* Environment Agency
Keith Powell HR Wallingford, Director
Paul Samuels HR Wallingford
Edward Evans Independent Consultant
Manuela Escarameia HR Wallingford
David Fortune HR Wallingford, Wallingford Software
Andrew Nex HR Wallingford, Wallingford Software
Christine Lauchlan HR Wallingford
Caroline McGahey HR Wallingford
Chris Whitlow Eden Vale Modelling Services
Alan Ervine University of Glasgow
Donald Knight University of Birmingham
Garry Pender Heriot-Watt University
Karen Fisher University of Birmingham
Hugh Dawson CEH Dorset
Peter Clark* NEECA Consultants

* Members of the Agency Project Board attending

Agenda items

Note: The following are notes on the main aspects discussed during the inception meeting and are therefore not comprehensive minutes.

1. Meeting Overview – Paul Samuels

Challenge: to bring about a major technical and cultural change in the basis of river hydraulics by delivering to the users an easy to use package.

2. The Project Context – Mervyn Bramley

Need to be open to other initiatives and research developments currently being undertaken (and proposed) in fields with potential impact on the Conveyance project.

3. The Project Vision – Edward Evans

4. Integrating and Managing the Project – Manuela Escarameia

Need to identify members of Agency Project Board and User Consultative Group, to allow early involvement in the project and participation in the Inception Workshop, scheduled for March.
5. Delivering the CES – Paul Samuels

Comments/suggestions on the above presentations

- After implementation of the CES will the existing ISIS methods remain available (for example to allow comparisons and re-visits of earlier modelling jobs? This needs to be discussed with the Agency Project Board.
- An overarching strategy for dissemination of this project is required – see item B) of these notes.
- Government Foresight initiative to raise the profile of flood and coastal defence may provide some impetus for addressing user inertia.
- Consideration should be given to conservation groups, as these groups tend to lead the objectors to various flood defence projects.
- At a publicity level – are conservation officers aware of this project?
- There is also an international dimension to the project as there is a need for this type of system across the world. Perhaps there is a need for a simple version (in textbooks, for example) that can be marketed internationally?
- Maintaining both open and packaged versions requires co-ordination and long term commitment.

6. Report on progress on T1 Data Mining and Assembly – Chris Whitlow

The initial screening of real river data has been completed.

Comments:

- For each data set a rank should be presented which represents an assessment of the data quality.
- Is there enough variation in channel types? Steep rivers are not well represented in the data sets. Information should be obtained for rivers outside the England and Wales data sets, e.g. the River Blackwater.
- Requirements of the programme are for 8 test cases/sets of field data.
- Hugh and Karen’s datasets should be included. This would allow matching of roughness types and data sets.
- Academic datasets – what is available? Garry Pender to check Scottish river datasets and make data on the River Severn available.

7. Functional Specifications – David Fortune

Main points to be covered in functional specifications are presented in Annex 1.

8. Group discussion on Functional Specifications

Several ideas were put forward during the group discussion, which are presented in Annex 2 without attempting to order them according to the Functional Specification they relate to. This will be carried out in the development of the Functional Specifications for the River Capacity Management (the overall system of users/applications defined in the Scoping Study), the Conveyance and Uncertainty Estimator, the Roughness Advisor and the CES.

9. Upcoming Meeting Dates

- 7 February (pm) - Team Expert Review: GP, AE, DK, MME, PGS, EPE, MEB (to be confirmed at end of January)
- 8 February 2002 - EPSRC Network at HR Wallingford
• Inception Workshop – Involving Agency Project Board and User Consultative Group

Possible dates:
5,6 12,13 March 2002

2) Non Agenda items

• Users

Users of the CES will be working in the following areas of work:

- Maintenance
- Planning/Development Control/Risk Mapping
- Flood Forecasting
- Design
- Hydrometry.

Non-Agency Users

Local Authorities/Agency Liaison – MB
[Birmingham City (HR to investigate)]
ADA – technical committee: David Sissons (computational group) or Keith Walters

• Possible Members of Project Board and User Consultative Group

<table>
<thead>
<tr>
<th>Area of work</th>
<th>Agency Project Board</th>
<th>User Consultative Group</th>
<th>Action by</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maintenance</td>
<td>Dave Denness</td>
<td>Named by Dave Denness</td>
<td>Mervyn Bramley</td>
</tr>
<tr>
<td>Planning/Dev.</td>
<td>Peter Spencer</td>
<td>-Agency staff</td>
<td>Peter Spencer</td>
</tr>
<tr>
<td>Control/Risk Mapping</td>
<td></td>
<td>-Consultant (MMP – Andrew Kirby?)</td>
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<tr>
<td>Flood Forecasting</td>
<td>Rahman Khatibi</td>
<td>Agency nominee</td>
<td>Mervyn Bramley/Rahman Khatibi</td>
</tr>
<tr>
<td>Design</td>
<td>NCPM Consultant</td>
<td>NCPM Consultant</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(David Keiller/Peter Clark)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydrometry</td>
<td>Rob Furnell to nominate</td>
<td>Rob Furnell to nominate</td>
<td>Mervyn Bramley</td>
</tr>
<tr>
<td>River Habitat Survey</td>
<td>Hugh Dawson to nominate (Paul Raven?)</td>
<td>-</td>
<td>Hugh Dawson</td>
</tr>
<tr>
<td>Conservation</td>
<td>Mervyn Bramley to nominate</td>
<td>-</td>
<td>Mervyn Bramley</td>
</tr>
<tr>
<td>Other (e.g ADA, Local Authorities)</td>
<td>Mervyn Bramley to nominate</td>
<td>David Sissons (or Keith Walters) or nominee</td>
<td>Paul Samuels</td>
</tr>
</tbody>
</table>
• Stakeholders for the Project Team to Inform

English Nature
EPSRC Network
CCW (Countryside Council Wales)
Scottish National Heritage
WWF
RDC
River Restoration Centre
Scottish Executive
DANI
OPW (Office of Public Works, Dublin)
ADA (technical committee)
LGA-EA Link
Dr Robert Sellin
Scottish LA Group
Association of Municipal Engineers (Scotland)

• Publicity

It is intended to publicise the Conveyance Project well and a table of dissemination activities has been produced. This table is provisional and more items may be added to it as further opportunities arise.

Table  Publicity for the Conveyance Project

<table>
<thead>
<tr>
<th>Type of event</th>
<th>Venue</th>
<th>Action by</th>
<th>Date</th>
<th>Type</th>
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<tr>
<td><strong>Press releases</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Press release for Conveyance Project</td>
<td>-</td>
<td>HRW/SWH</td>
<td>TBD*</td>
<td>Various</td>
</tr>
<tr>
<td>Joint press release for Framework Agreement and Conveyance Project</td>
<td>-</td>
<td>SWH/MB</td>
<td>TBD*</td>
<td>Various</td>
</tr>
<tr>
<td><strong>Conferences</strong></td>
<td></td>
<td></td>
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<tr>
<td>River Flow 2002, International Conference on Fluvial Hydraulics</td>
<td>Louvain-la-Neuve, Belgium</td>
<td>PGS</td>
<td>Paper submission 15/01/02 September 4-6, 2002</td>
<td>Paper presented by Paul Samuels</td>
</tr>
<tr>
<td>DEFRA Conf.2002</td>
<td>Keele University</td>
<td>PGS</td>
<td>16-17 September 2002</td>
<td>Paper</td>
</tr>
<tr>
<td>XXX IAHR Biennial Congress, 2003</td>
<td>Thessaloniki, Greece</td>
<td>PGS/MME</td>
<td>August 24-28 2003</td>
<td>Paper(s)</td>
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</table>
Table  Publicity for the Conveyance Project (continued)

<table>
<thead>
<tr>
<th>Articles</th>
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</thead>
<tbody>
<tr>
<td>Research Focus</td>
</tr>
<tr>
<td>Environment Action</td>
</tr>
<tr>
<td>NCE – investigate possibility of article in special edition on floods</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Brochures/fliers</th>
</tr>
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<tbody>
<tr>
<td>Project Data Sheet</td>
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<table>
<thead>
<tr>
<th>Internet</th>
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</thead>
<tbody>
<tr>
<td>EPSRC Network on Conveyance web site</td>
</tr>
<tr>
<td>Development of separate web site to be discussed</td>
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</tbody>
</table>

*TBD – to be decided
Annex 1

Functional Specification:
- Identify the types of user
- Identify tasks undertaken
- Identify how software will support the user
- Identify key performance requirements (outputs, tabular, graphical, etc…)
- Identify data available
- Characterise data (survey, model parameter, accuracy, uncertainty…)
- Identify data storage
- Identify information flow
- Identify interaction with other software
- Identify security

Annex 2

*Issues for the Functional Specifications:*

Characteristics of System Performance:
- More reliable
- More accurate
  - Achieved through uncertainty estimator
- A reduction in the band of uncertainty
- Graphical
- Significantly quicker to incorporate level of detail
- Ease of use
- CES should be able to access information from a variety of sources
- Information and data transfer easily from one form to another
- Information and data flow between CES and ISIS
  Two-way links to Agency’s modelling strategy
- Range of river types (slope, section, vegetation etc)
- To apply over a range of stages (not only maximum)
- Ideally one method for many mechanisms
- No discontinuities
- No choices presented to user that they are unable to answer
- Promote understanding of processes
- Identify important processes, parameters, mechanisms
- Online linking to knowledge base and support (needs to be intuitive)
  - Roughness review acts as scientific justification/back up for roughness values adopted
- Effect of change e.g. vegetation over time, seasonal change, dredging
- Impact and effects of different management procedures
- Include the effect of bedforms
- Vertical slice methods
- Promote cultural change in analysis of rivers
- Velocity distribution as an output
- Confidence on out of range use e.g. extremes
- Covering all different boundary types
- ‘Roughness’ scale – unit (local) scale and global scale values
- Division of reaches of similar morphology
• Expert and amateur users – specialist can intervene in specific parameters e.g. bedforms, vegetation, and possible modify them
• Fast computation in ISIS

**Roughness Advisor**
Roughness for high and low flows
Forecasting requires a range of roughness values (related to flow depths)
Central values as well as upper and lower bounds
How does calibration effect uncertainty?

**Input values:**
- Observed hydrographs, photographs
- Categories of vegetation
- Gauging records, rating curves, river habitat survey database
- Topographical sections
- Records of recent management
- Photographs at a variety of times of year
- Bed materials (observations and samples)
- Rules and guides to the choice of value/data
Assuming no data or minimal data, building in information you have and quantifying uncertainty

**Others**
Use of CES for model audit
Include a section “Understanding your results” which includes classic examples of UK rivers, simple examples of expected behaviour (i.e. stage-discharge curves)
option to input data directly, i.e. CSV format
Appendix 5

Inception Workshop (Agenda and Notes)
Appendix 5 Inception Workshop (Agenda and Notes)

Reducing Uncertainty in River Flood Conveyance
Inception Workshop for Targeted Research Programme
Friday, 12 April 2002

Venue: HR Wallingford, De Morney Room
Howbery Park
Wallingford
Oxfordshire OX10 8BA

Chairman: Mervyn Bramley

Agenda

09:45 - 10:00 ASSEMBLE and COFFEE

10:00 – 10:35 Introduction and Background

Business context (5 min) Mervyn Bramley
Business Interests (10 min) Attendees
Structure of Targeted Programme (10 min) Paul Samuels
Project timetable (10 min) Manuela Escarameia

10:35 – 12:00 Presentation of the Inception Report

Conveyance methods (30 min) Caroline McGahey
Data mining (10 min) Caroline McGahey
Roughness Review (20 min) ManuelaEscarameia & Hugh Dawson
Functional specifications (25min) Andrew Nex/David Fortune

Each presentation to be followed by Q/As of clarification

12:00 – 12:30 LUNCH BREAK

12:30 – 12:45 Related Research Issues Donald Knight

12:45 – 12:55 User Consultative Programme Edward Evans

12:55 – 13:30 Open discussion on Inception Report

13:30 – 13:45 AOB and Closure Mervyn Bramley

Note: The meeting can carry on further into the afternoon if necessary.
Participants

- **Agency Project Board**
  Mervyn Bramley  
  Environment Agency, Head Office
  Rahman Khatibi  
  Environment Agency, Flood Forecasting
  Peter Spencer  
  Environment Agency, Regional River Modelling
  David Keiller  
  NEECA Consultants, Design

- **User Consultative Group**
  Lance Dawkins  
  EA Anglian Office, Flood Forecasting
  Tony Green  
  JBA, Flood Risk Mapping Consultants
  Tim Palmer  
  BBV, Design
  David Price  
  EA Anglian Office, Hydrometric
  John Ulyatt  
  EA Manby Office, Flood Defence Operations Team Leader
  Jim Walker  
  EA Preston Office, River Habitat Survey
  David Sisson  
  IDB, Alford Drainage Board
  Rob Cheetham  
  HR Wallingford, EA and Local Authorities client
  John Wicks  
  Halcrow

- **HR Team**
  Paul Samuels  
  HR Wallingford
  Edward Evans  
  Independent Consultant
  Donald Knight  
  University of Birmingham
  Hugh Dawson  
  CEH Dorset
  Chris Whitlow  
  Eden Vale Modelling Services
  Manuela Escarameia  
  HR Wallingford
  David Fortune  
  Wallingford Software
  Andrew Nex  
  Wallingford Software
  Caroline McGahey  
  HR Wallingford

**Corresponding members**

Dave Gillett  
EA Ely Office, Flood Defence Operations Team Leader
Notes on the Inception Workshop
Reducing Uncertainty in River Flood Conveyance
Friday, 12 April 2002

Venue: HR Wallingford, De Morney Room
Howbery Park
Wallingford
Oxfordshire OX10 8BA

Chairman: Mervyn Bramley

Attendees:
Mervyn Bramley* Environment Agency
Peter Spencer* Environment Agency
Rahman Khatibi* Environment Agency
David Keiller* NEECA Consultants, Design
Paul Samuels** HR Wallingford
Edward Evans** Independent Consultant
Manuela Escarameia** HR Wallingford
Caroline McGahey** HR Wallingford
David Fortune** HR Wallingford, Wallingford Software
Andrew Nex** HR Wallingford, Wallingford Software
Rob Millington HR Wallingford, Wallingford Software
Donald Knight** University of Birmingham
Hugh Dawson** CEH Dorset
Tony Green*** JBA, Flood Risk Mapping Consultants
Tim Palmer*** BBV, Design
John Ulyatt*** EA Manby Office, Flood Defence Operations Team Leader
Jim Walker*** EA North West, Warrington, River Habitat Survey
Rob Cheetham*** HR Wallingford, EA and Local Authorities client
Jon Wicks*** Halcrow

Apologies:
Lance Dawkins*** EA Anglian Office, Flood Forecasting
David Price*** EA Anglian Office, Hydrometric
David Sisson*** IDB, Alford Drainage Board
Karen Fisher** University of Birmingham
Chris Whitlow** Eden Vale Modelling Services

* Members of the Agency Project Board
** Members of the Project Team
*** Members of the User Consultative Group

A) Agenda items

Note: The following are notes on the main aspects discussed during the inception meeting and are therefore not comprehensive minutes.
1. Introduction and background

The conveyance project has also been endorsed by the relevant authorities in Scotland and Northern Ireland and the project team will take the necessary actions to meet their requirements.

2. Presentation of the Inception Report

Comments and issues raised

The comments or questions are given and where appropriate followed by

the project team’s response as necessary an indented paragraph below

Conveyance estimation

Should representatives of HEC-RAS and MIKE11 be invited to participate in these meetings?

The view of the team is that the conveyance estimation system will be produced as open code and such organisations will therefore have the opportunity to update their software.

How will the conveyance system incorporate backwater effects?

This will be done in the context of the hydraulic models which use the CES for conveyance estimates.

Will the effect of obstructions on flood plains be taken into account by the new conveyance method?

The effect of obstructions (e.g. hedges, walls, urban areas) is recognised to a certain extent in this project and by the current “Afflux at Bridges” project being carried out by Jeremy Benn Associates. However, these will be fully addressed by the parallel strategic research to be funded in the future by EPSRC and other sources.

With the currently proposed conveyance methods the roughness value is a “pure” (local) roughness value associated only with roughness effects (as opposed to roughness plus velocity distribution effects, turbulence, etc). In order to know the corresponding conventional Manning’s n some processing back into a Manning’s equation will be necessary. This could be incorporated in the CES interface.

If existing river models need to be extended in the future, will the new conveyance system require that the whole model be set-up again?

This aspect will be considered and it is possible that hybrid models are the answer.

It would be useful to see existing calibration information when using the new conveyance system; this can in principle be done by plotting on a stage –discharge graph the calibration point and the line for the estimator.

Data mining

The data selected for the testing of the conveyance method should cover a wide range of river and flood plain sizes.

A report by John Pirt gives details of high quality data from a single section, Severn at Montford, which is a straight section (contact: Donald Knight).
It was suggested to start a database of the existing good quality river and laboratory data, including data held by Birmingham University.

This would need to be done outside the CES project and suitable funding would need to be sought.

Roughness review

The effect on roughness of seasonality of vegetation in relation to seasonality of flows may need to be considered (represented by the Christmas tree effect where resistance increases in the summer, drops following floods but does not necessarily go back to original level).

These issues will be included in the roughness review, but the extent of guidance which will be given is currently uncertain.

Vegetation changes due to climate change will not be considered under this project.

If the roughness in the new conveyance estimation is not based on the traditional Manning’s n (but rather on a “pure” version to account only for friction effects, it would be useful for the software to display an equivalent Manning’s n so that users can set the value being given by the CES in context of their experience.

The River Habitat Survey (RHS) covers more than 15 000 sites nationally (7500km of watercourse length) and includes information on: in channel vegetation, channel shape and sinuosity, bed form variation and size, presence of artificial /natural bed features, flood plain land use on 50m either side of the river channel. This information is available on CD.

The Roughness Advisor needs to include out-of-bank roughness (e.g. woodlands) to enable simulation of flood depths.

Need to consider the drag on individual trees or groups of tress in assessing flood plain resistance.

Velocity on flood plains can reach 1m/s.

Need to maintain links to other work being done on river roughness e.g. the FLOBAR2 project being led by University of Cambridge.

Functional Specifications

The Roughness Advisor and the Conveyance Generator can be combined into one single tool, if required.

How will calibration information be taken into account in roughness estimation?

If possible, when running river models, the calibration process will be done within ISIS, rather than requiring it to be done separately.

There should also be a sensitivity analysis and followed by feedback to the Roughness Advisor and Conveyance Generator, moving outside the error bands given.

In InfoWorks RS the distribution of roughness could be given in plan.

Examples of prototype screens will be available in the Autumn.

For the stand-alone tool it is important to note that dredging may be done at the same time as vegetation maintenance and this will affect the roughness values in the watercourse. Also, maintenance may be carried out on one bank only rather than on both.
3. Related research issues
(Professor Donald Knight – The University of Birmingham)

Donald Knight is producing a book with Professor Nezu consolidating the UK and Japanese advances on the understanding and science of compound channel flows. This will be a valuable resource for all working in this area.

A new EPSRC research grant has been awarded on the effects of channel shape and heterogeneous roughness to Donald Knight and Nigel Wright (Nottingham).

Future EPSRC funded work may include (subject to good grant applications):
- Flood plain modelling (numerical)
- Remote sensing
- Flood plain roughness (inc. patchiness)
- Spreadsheet development for analytical solutions.

The EPSRC Teaching Company Schemes could provide additional research and development resources in this area.

A meeting will be held on 29 April 2002 on the Foresight Programme.

*The environment is a key aspect in future EU funding.*

(In the forthcoming sixth framework programme this is covered in the theme on global change and biodiversity)

4. User Consultative Programme

It would be useful if JBA could liaise internally with other S105 consultants.

The expected involvement of the User Consultative Group (UCG) will consist of:

a) Individual meetings/discussions between the project team and the members of the UCG (half day meetings)
   These are expected to occur on average 3 times during the 24 month duration of the project.
   The first of these meetings will involve users concerned with maintenance (see Actions). Other meetings will be arranged on a one-to-one basis in the summer months.

b) Proposed group meetings at HR Wallingford.
   - User Consultation meeting
     Main objective: to present examples of prototype screens
     Proposed date: Late September 2002
   - Presentation Workshop
     Main objective: Overview of the first year work on the proposed the Conveyance Estimation System
     Proposed date: December 2002
   - Initial training for pilot testers (one day)
     Proposed date: September/October 2003
- Pilot testing of the CES  
  Date: October to December 2003.

- Launch Workshop  
  Main objective: Launch of the CES to EA/DFRA and other users.  
  Proposed date: December 2003

6. List of deliverables from the project

The project will produce a number of deliverables, some paper-based some computer-based.

Paper-based deliverables:
• Inception report
• Interim Report 1 – Data sets
• Interim Report 2 – Review of methods for estimating conveyance
• Interim Report 3 – Testing of preferred method in 1D model
• Roughness Manual.
• Conveyance Manual (paper version)
• Notes for the 1-day training course for Pilot Testers (as PowerPoint presentation files).

Software deliverables:
• Publication of data sets on the project website (and of the EPSRC Network on flood conveyance).
• Conveyance Manual (hypertext version)
• Conveyance Estimation System (CES) available as open code and
• CES implemented in ISIS.

7. Actions

Comments on Chapter 3.3 (up to page 28) of the draft Inception Report to be received from members of Agency Project Board and User Consultative Group. Comments received by 19 April will be incorporated in the Inception Report, due at the end of April; comments received later are also welcome and will be taken into account.

Action: Members of APB and UCG

The project team will meet with Dave Denness / Fola Ogunyoye / John Ulyatt / David Sisson to discuss maintenance-related issues and involvement/requirements of the Internal Drainage Boards / ADA. Provisional date: end April / beginning of May.

Action: Paul Samuels

Rob Furnell (EA Warrington) will be contacted to nominate a representative for hydrometry in the UCG.

Action: Mervyn Bramley / Peter Spencer

Outputs from the project are currently being published in the EPSRC Network web site (public access) run by Prof. Ervine of Glasgow University. Actions will be carried out towards setting up a project web site with restricted access within HR Wallingford’s web site containing data and other documents used or developed during the project.

Action: Manuela Escarameia / Caroline McGahey

HR Wallingford, 27 April 2002
Appendix 6

Quality Plan Documents (not included in the website version of the report)
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