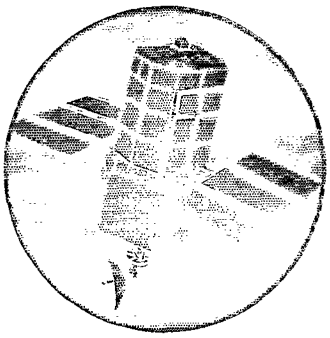
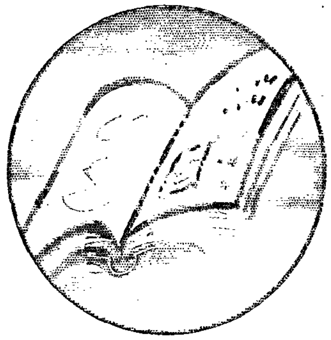
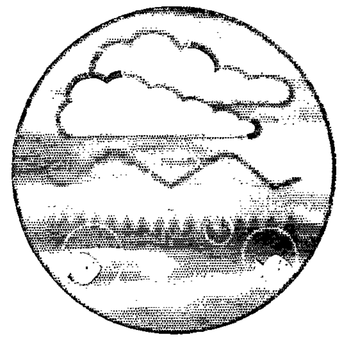
Evaluating the Benefits of Hydrometric Networks

Research and Development

Project Record
W6/005/13

Sniffer
SCOTLAND & NORTHERN IRELAND FORUM FOR ENVIRONMENTAL RESEARCH

ENVIRONMENT AGENCY

Evaluating the Benefits of Hydrometric Networks

R & D Project Record W6/005/13

A R Black, A M Bennett, N D Hanley, C L Nevin and M E Steel

Research Contractor:
University of Dundee
In collaboration with University of Stirling *and* Scotia Water Services

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Statement of use
This report is a Project Record from Project W6-005. It contains raw data and background material gathered as part of the project, and complements the R&D Technical Report (W146) issues as the main outputs of the project. Recipients of the report are to pass on comments to the Environment Agency Project Manager.

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Environment Agency Project Leader
The Environment Agency's Project Leader for R&D Project W6-005 was:
Mr W D Rylands, Environment Agency, Thames Region

OVERVIEW

This Project Record presents raw data and background information gathered during the work of Environment Agency National R&D Project W6/005 *Evaluating the Benefits of Hydrometric Networks*. It complements the Technical Report of the same title issued in 1999. In addition, it has been intended from the inception of the project that a user manual will be produced in due course, to aid implementation of the methods presented in the Technical Report. As of June 1999, this work had not yet begun.

The scope of this Project record is as indicated in the Contents below; its purpose is to collate raw data generated by the project and make it available to benefit any user for whom the details of the Technical Report prove insufficient.

CONTENTS

I PROGRESS REPORTS

Twelve Progress Reports were produced within the work of the project, and are reproduced here in full. Dates and numbers are as follows:

Progress Report W6/005/1	August 1996
Progress Report W6/005/2	September 1996
Progress Report W6/005/3	October 1996
Progress Report W6/005/4	November 1996
Progress Report W6/005/5	December 1996
Progress Report W6/005/6	January 1997 (mid-way review document)
Progress Report W6/005/7	February 1997
Progress Report W6/005/8	March 1997
Progress Report W6/005/9	April/May 1997
Progress Report W6/005/10	June 1997
Progress Report W6/005/11	December 1997
Progress Report W6/005/12	April 1998

Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

August 1996

R&D Progress Report W6/005/1

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

A R Black, A M Bennett and N D Hanley

Research Contractor:
University of Dundee
in collaboration with University of Stirling *and* Scotia Water Services

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R&D Progress Report W6/005/1

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Statement of use
This report is the first monthly Progress Report from Project W6/005. It describes the work carried out since the contract was awarded in July 1996, along with some initial findings. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

Research contractor
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Environment Agency's Project Leader
The Environment Agency's Project Leader for R&D Project W6/005 is:
Mr W D Rylands (Thames Region)

R&D Progress Report W6/005/1

1. INTRODUCTION

Notification was received from the Environment Agency in a letter dated 18 July 1996 that the contract had been awarded.

As set out in the tender, the contract is being undertaken by a team of three principal investigators: Dr A R Black (University of Dundee), Dr N D Hanley (University of Stirling) and Dr A M Bennett (Scotia Water Services), with each making a broadly equal input. Therefore, although the Agency has entered into a contract with the University of Dundee which, in turn, will have sub-contracts with the other two parties, at a functional level the work is being undertaken on a collaborative basis by three equal partners. In addition, Professor A Werritty (University of Dundee) is acting in a consultative role to the project, and Research Assistants (RAs) at the two universities will contribute to the work in a supportive capacity.

This Progress Report details work done, and all significant events associated with the project, from the date of award until the end of August. With an agreed project start date of 1 August, it is the first such monthly report produced under this project.

2. PROJECT INCEPTION MEETING

Following notification of the award of contract, an inception meeting was arranged for the earliest possible opportunity, fixed at 25 July 1996 in Reading. Present were:

Environment Agency	Contractors
Nigel Fawthrop, Project Proposer	Andrew Black, Project Manager
David Rylands, Project Leader	Tony Bennett, Hydrologist
Meg Postle, EA Environmental Economist	Nick Hanley, Environmental Economist
John Waterworth, SNIFFER Representative	Alan Werritty, Mentor
Nicky Bailey, Project R&D Co-ordinator	

It was of particular use to the contractors to have a detailed explanation given covering the background to the project, and the particular needs which its outputs should satisfy. In addition several helpful ideas were developed, regarding the choice of regions and catchments to be used in the development and testing of methods for assessing benefits. Some pertinent sources of literature were identified. Full minutes of the meeting were subsequently produced and circulated by WDR.

3. STAFFING

As noted above, Research Assistants are to be used to support the work in Dundee and Stirling. To date, Michael Steel has been confirmed as the Dundee RA (following approval by WDR) and will be issued with an appropriate contract of employment. Approval is awaited for Ceara Nevin to work in a similar role at Stirling.

Michael Steel has already begun work on the literature review; a September/October start-date is envisaged for the Stirling RA to fit in with the scheduled development of methods for assessing benefits.

4. BENEFIT DATA COLLECTION

4.1 National Hydrometric Group meeting

A crucial element to the success of the project is the collection of information from regions of the various UK environmental agencies, regarding the value which users place on the hydrometric data being collected. It was therefore very fortunate that a meeting of the Environment Agency National Hydrometric Group was scheduled for 8 August, only a matter of days after the start of the project.

Tony Bennett was able to attend this meeting, and was invited to speak to Regional Representatives about the project. We considered it important that the originators of hydrometric data were informed at an early stage about the project, since ultimately it is intended to contribute directly to their activities and, in the interim, we will need their co-operation. Tony's presentation drew a considerable amount of interest. Information was gathered regarding the extent to which data use had been addressed in different Regions, and provided useful guidance on which Regions to approach regarding potential fact-finding visits.

Following this meeting, telephone contact has been made with Anglia, Midlands, North East and South West Regions of the EA, and East and West Regions of SEPA.

4.2 Regional visits

A visit was made to the East Kilbride office of SEPA West Region on 27 August. Interviews were held with representatives of the Hydrology, Pollution Control, Biology, Chemistry and Marine Science sections. We were encouraged by the willingness of the SEPA staff to co-operate with our work, and felt that the range of responses received from our questions indicated that there were important differences in the value of data for different functions. Some appeared to lend themselves much more readily to quantification than others, and it was especially useful for Nick Hanley to be able to put economically-driven questions direct to data users. Table 4.1 provides a summary of the most useful observations made.

Table 4.1 Main observations from visit to SEPA West Region

Hydrology/Water Resources

- In water resources, the importance of characterization of flow regimes should not be under-estimated
- Q95 derivation for discharge consent-setting is one of the most important functions supported by hydrometric data
- It was felt important that gauges should continue to operate in support of the maintenance of a national monitoring network, and to support national research programmes such as those for flood or low flow estimation
- New data uses had been emerging over the last few years, e.g. flood warning systems, water quality modelling, insurance needs re flood damage
- Telemetry is useful in planning the effective deployment of hydrology and biology staff

Pollution Control

- Pollution control is only as good as the data available to it, so a high level of importance attached to quantity and accuracy of flow measurement
- Increasing financial awareness amongst water users places an increasing responsibility on regulatory authorities to be accurate and to be able to justify decisions, e.g. through quality assurance schemes
- Moves towards variable discharge consents will place increasing demands on hydrometric data
- Background monitoring essential in order to interpret water quality variations
- Increasing pressure on regulators to 'prove it' - e.g. fishermen complaining that rivers never stay high as long as they once did - need for flow data
- Gauging station huts provide potentially valuable housing for new instruments - e.g. continuous water quality monitoring

Biology

- Biological modelling (e.g. RIVPACS) often requires flow inputs, but can reasonably be done on the basis of estimates; the same applies to loch phosphorous loading models
- Flow data are useful in the interpretation of biological survey results, but need not relate to the sampled site or river; indeed rainfall data may often suffice

Chemistry

- Main data requirement is in the computation of loadings to tidal waters, e.g. for Red List work, OSPARCOM, but these are subject to 'huge' error - so accuracy of hydrometric data not critical
- Requirements also on a case study basis, e.g. river pollutant movement studies
- General impression of only general needs for hydrometric data

Marine Science

- Estuary inflows are needed to say 5% accuracy for modelling water quality - especially important in summer months
- If flow data were not available, marine scientists would find it necessary to take their own measurements
- Occasional other needs relate to developments such as sea-loch fish farms, and require only approximate flow data

Visits have now been arranged for Midlands Region of the EA on 6 September and for North East Region on a date still to be agreed. As with the SEPA visit, the aim will be to gather information on the different needs and perceptions of users across all sections. By the end of the third visit, it will be possible to draw up a data request for widespread distribution, which will allow a comprehensive view to be developed on each of those issues which will allow progress to be made in quantifying benefits.

5. LITERATURE REVIEW

Work on the literature review has begun, and so far more than 30 potentially useful references have been found using on-line and CD-ROM bibliographic search tools. Some directly relevant works already obtained include a World Meteorological Organisation report, papers presented by Nigel Fawthrop at a recent conference in Iceland and some work from Australia reporting on an assessment of hydrometric network data there. The approach in the latter work seems especially useful, in that the first step is to examine benefits coming from networks as a whole (rather than single sites). It may prove advantageous to start in a similar direction in this study.

Nick Hanley has contributed to the scope of the search from an economic perspective, and all this work should be written up by the end of October.

6. APPROACHES TO EVALUATING BENEFITS

Discussion after the East Kilbride visit, and reflection on the Project Inception Meeting, revealed the view that the project is being drawn strongly towards just one approach to evaluating benefits of hydrometric networks, namely cost-benefit analysis. Within this general approach, there are a number of variants which could be adopted:

- Quantification of all benefits
- Quantification of selected benefits where justified
- Do not attempt quantification (on the basis of recognized inherent problems); instead develop some more indirect method

    - and in each case recognizing that methods for assessing one type of benefit cannot be equally applied to other types of benefit

Alternatives such as cost-effectiveness analysis, risk-benefit analysis and multi-criteria analysis are not presently under consideration. We would like to discuss with the Agency whether this is their express wish (and, if so, then why), or whether some consideration could be given to such alternatives.

7. FINANCE

Sub-contracts have been drawn up and offered to the Scotia Water Services and the University of Stirling. The University of Dundee has agreed the invoicing arrangements proposed at the Project Inception Meeting.

The first invoice will fall due at the end of October, following completion of Task 1 of the 6 identified in Table 1 of the Financial Cost Statement.

8. WORK PLAN - MONTH 2

1. Literature review to continue
2. Visits to EA Midlands and North East Regions
3. Development and circulation of benefit data request to Regions
4. Discussion regarding development of methods

Evaluating the Benefits of Hydrometric Networks

University of Dundee
Scotia Water Services
University of Stirling

September 1996

R&D Progress Report W6/005/2

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT
PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

A R Black, A M Bennett and N D Hanley

Research Contractor:
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Environment Agency's Project Leader
The Environment Agency's Project Leader for R&D Project W6/005 is:
Mr W D Rylands (Thames Region)

R&D Progress Report W6/005/2

1. INTRODUCTION

This report describes progress made on the project during September 1996. The main areas of activity have been the literature review, and visits to Environment Agency offices targeted at enhancing understanding of the diverse uses of hydrometric data. No problems have been encountered in any contractual or administrative aspects of the project, and the principal investigators are now well engaged with the key concepts of the project.

2. LITERATURE REVIEW

Good progress has been made during the month through the efforts of Michael Steel (Research Assistant) at Dundee. Approximately 50 technical papers have been consulted, and a draft literature review now exists, based on all the material read to date. A small number of papers are still outstanding from the Inter-Library Loan system, and will be used to provide additions to the review where useful. Main headings covered are:

- History and background
- European context/funding
- Hydrometric data and other reviews
- Network efficiency and operation
- Cost-benefit analysis and hydrometry
  - reservoirs and storage
  - low flows
  - flood protection
  - pollution control
  - groundwater resources
- Whole network evaluation

The draft is due for circulation amongst team members shortly, following which the Project Leader will be provided with a draft for comment. Further outstanding references will be pursued before submission of the final review at the end of October. Following the meetings described below, Environment Agency staff have been of assistance by forwarding copies of relevant papers for this review.

3. BENEFIT DATA COLLECTION

Following the visit to SEPA West in August, two further visits were made by AMB and ARB in September to Environment Agency offices:

Friday 6 September	Midlands Regional HQ, Solihull
Tuesday 10 September	North East Region, Ridings Area Office, Leeds

In both cases, local hydrometric managers had arranged a full day of interviews with colleagues from all other relevant functions in their respective offices, and excellent cooperation was received in both cases. Notes following the two visits, and summarising the most interesting points to arise, are appended to this report. New ideas and opinions were found in each of the three visits while, with each successive visit, some common threads were strengthened. It was felt that the full round of visits had placed the team in a good position to proceed to generating a data request/ questionnaire for large-scale distribution to regional and area staff. It should be noted at this stage that both Environment Agency visits produced a strong impression of intense network-wide data use, particularly in the fields of flood defence and pollution control.

A meeting of the three principal investigators was held in Stirling on 24 September to discuss how best to proceed with the collection of benefit information. We now propose to issue a number of brief questionnaires to Environment Agency/SEPA/ DoE(NI)/DANI staff in order to directly survey data use and perceived benefits from a large proportion of the user base - in line with our tender document proposals. External data users (eg consultants, Institute of Hydrology) will also be included in this process. Draft questionnaires will be passed to the Project Leader for comment and approval before any is issued.

Much of the approach for this exercise was developed by AMB and NDH (ARB was delayed in attending this meeting); the general approach has been agreed and can be summarised as follows:

- The data request should be comprehensive in scope, such that the results will indicate the total benefits being derived from hydrometric data from users - a list of all uses will be produced.

- Once the benefits have been identified, they can be ranked in order of importance. This may be partly intuitive, but objective bases will be sought in the responses, and will be combined with the collective experience of the principal investigators.

- Depending on the nature of a review which might be carried out for some given area (ie network, catchment, river or station), the list will then be used to assess benefits. Network reviews will be expected to concentrate on data uses at the top of the list, while catchment reviews may include items from lower ranks. NDH takes the view that it may not be possible to carry out an economic assessment at the station-scale because information relates not only to a single site but to a river reach or stage; it may be necessary therefore to use more hydrological approach similar to that employed by the Institute of Hydrology review of the Northern Ireland gauging network.

Contact will be made with the Project Leader in the near future on this general topic.

4. STAFFING

Michael Steel has begun work as a Research Assistant in Dundee. Ceara Nevin has been approved by the Agency to work as a Research Assistant in Stirling, and is due to begin work on October 1.

5. FINANCE

University of Dundee sub-contracts have now been signed and returned both by the University of Stirling and by Scotia Water Services.

The first invoice will fall due at the end of October, following completion of Task 1 of the 6 identified in Table 1 of the Financial Cost Statement, ie the literature review.

6. WORK PLAN

Priority will be given in the coming month (October) to the rapid production and distribution of data request sheets to regional and area offices. The approach employed will be to ask straightforward questions, in the hope that responses will be numerous and prompt. Analysis of responses should at least be begun by the end of October, if not being well advanced.

With the imminent involvement in the project of Ceara Nevin in Stirling, further progress is expected with NDH on the approaches to evaluating benefits. It is likely that some further literature will be accessed, in collaboration with Michael Steel.

The literature review is due for completion at the end of October.

APPENDIX

Main new ideas from Environment Agency visits to Birmingham and Leeds

Midland

Data uses:

User	Use
Hydrometry	Design of new river gauging stations
	Real-time coordination of gauging activity (day-to-day; times of stress)
	Identification of station malfunctions - eg telemetry defects
Water Resources	To keep models as up-to-date as possible - for flood warning, pollution (use max amount of data available)
	Development/calibration of models - flood warning, etc
	License setting and monitoring of abstractions (eg stop abstraction X when flow falls below threshold at gauging station Y)
	Water resource situation reporting (only some stations required)
	Groundwater monitoring - eg to detect overabstraction
Flood Defence	Monitoring of flood hydraulics - so that if channel changes, understanding of river behaviour is up-to-date
	Level monitoring in estuaries required in case trend in peaks
Water Quality	Catchment WQ modelling
	Statutory reporting (calc of loadings)
Fish/Rec/Cons/Navig	Demonstration of no change in flows for public (eg anglers)
	Case study modelling - eg L Severn saline mixing problems
	Fishline service for anglers: 40,000 calls/yr
	Navigation purposes

Price elasticity re external data requests - 50% increase in requests once data became free.

Atkins Report (NRA-ST) - £3m average annual potential flood damage across Region

R Blythe (Solihull) - looked at quantification of benefits of WQ maintenance/improvement

Statutory WQ objectives (part of Catchment Mgt Plan) - Regional study on Worcs Stour, included CBA.

Leeds

Data Uses:

User	Use
Water Resources	Internal feedback purposes - is stn operating properly; can performance be improved? Resource monitoring - inform licensing staff if flows getting low. Used as basis of routine dialogue with reservoir operators - how much release to support river flows? Resource modelling work - what if rain only 20% of average over next month; what if compensation flows reduced? Data for STW operators - what is happening in river (flow, WQ) - how should treatment process be adjusted? Support interpretation of potentially inaccurate data from other sites. New licensing will be based on real-time flow at gauging stations, so data will have benefit to water users (estimates would need to be conservative).
Licensing	Hydrometric data needed for license setting (along with info from the applicant), and perhaps real-time if prescribed flow involved (see above).
Flood Defence	Archived event data used for design purposes (incl PE, ppt etc). Data required for Flood Warning System (esp now that EA gives warning direct!).
Fisheries	Case-based work eg WQ impact on fish populations. Flow regime required, often in design context - whether for channel restoration, species re-introductions.
Env'l Modelling	Non-routine impact assessments of consent applications. On-going monitoring is needed despite historical archives, because historic WQ data is not generally available and is collected specifically for the project.
Environ Protection	Flows needed to assess dilution for discharges (need Q_{95}) Historic data may be OK (so might be good estimates), but what if behaviour of river changes (trend in Q_{95} or perhaps a big drought) - best to keep monitoring.

In past, investments in the hydrometric network have been shared between Water Resources (40%), Flood Defence (40%) and Others (20%) (say 15% from Water Quality and 5% from Fisheries if available).

Charging for abstractions - based on previous year's Water Resources costs + loss factor + season factor + cost of supporting flows.

Water supply plc is largest external user in NE Region - well worth covering at some stage
RFFS in Yorkshire - A Akhandi not aware of any CVA done at time of commissioning.

ENVIRONMENT AGENCY

Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

October 1996

R&D Progress Report W6/005/3

RESEARCH AND DEVELOPMENT
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R&D Progress Report W6/005/3

CONTENTS

A *literature review* is included separately with this Progress Report.

1. INTRODUCTION

This report describes progress made on the project during October 1996. Work has been advancing in a number of key areas:

- The literature review has now been completed at Dundee by Mike Steel (MES) under the guidance of ARB, and with inputs from Stirling;
- Tony Bennett (AMB) has been following up visits to agency offices, by investigating the demands of external data users; and
- Caera Nevin (CN) has been appointed as a Research Assistant from October 1st at Stirling University, and has been investigating the feasibility of various approaches to quantifying the befits of hydrometric data under the guidance of Nick Hanley (NDH).

2. LITERATURE REVIEW

A comprehensive literature review has now been completed and is enclosed with copies of this Progress Report. Approximately 100 references have now been consulted, identified on the basis of CD-Rom and on-line bibliographic searches, following up references in the papers read, and using papers supplied by Environment Agency staff and others.

Surprisingly large amounts of literature have been generated within the last 10 years, principally in the USA, Australia, the Nordic countries and the UK. This is indicative of a high level of interest in the subject of quantifying the benefits of data, and provides a rich starting point for this study to consider methods which might be applied in a UK context.

Studies have employed a number of different approaches to quantifying benefits, and have been conducted in a small number of scenarios, e.g. flood defence, reservoir design, bridge/culvert design data uses. Benefit cost ratios have often exceeded unity, but not in all cases. Typically, the methods used in obtaining benefit assessments have been complex, and thought will have to be given to the practicalities of implementing any of these methods in the context of this study. In some cases, it has been stated that benefits are not quantifiable, but several researchers have based their work on minimum benefit cost ratios, i.e. those calculated on the basis of those individual component benefits which can reasonably be quantified.

It is anticipated that, despite exhaustive searching, further relevant literature will be found during the remaining months of this project. The team therefore wishes to retain the option to add to the review now presented, subject to any additions being approved by the Environment Agency Project Leader. The reader is directed to the review itself for full details of the literature surveyed.

3. BENEFIT DATA COLLECTION

3.1 Information requests

A set of eight Information Requests was developed for distribution to offices of the Environment Agency, SEPA and the Northern Ireland authorities, each Request being directed to a specific function of an individual office.. These were sent out during week commencing 21 October, and requested to be returned by 8 November 1996. In England and Wales, most Requests were sent to Area offices, with only Water Resources directed to Regional offices in the first instance. In Scotland, the principal offices of the seven former RPBs were used in all cases as the main centres of activity while, in Northern Ireland, telephone calls identified appropriate DoE(NI) and DANI contacts who were willing to copy Requests to other relevant colleagues, For all functions, the aim was to obtain a comprehensive picture of data use - see Progress Report W6/005/2.

Copies of the eight Information Requests are included as Appendix I. Discussions with the Project Leader produced several useful suggestions which were taken on board before producing final versions of the Requests. At the date of writing (6 November), 68 responses had been received, and a message had been received from DoE(NI) that there would be a one-week delay in the return of information from that organisation.

3.2 External data users/uses (AMB)

A visit had been made to Yorkshire Water Services in Bradford, following discussions in North East Region of the Environment Agency about the importance of water plcs as data users. Contact had also been made with all three EA/SEPA offices where visits had taken place (see Progress Report W6/005/2) to follow up with details of external data users. Full notes for all this activity are given in Appendix II.

3.3 Informal talks at Institute of Hydrology

Informal discussions were held on a recent visit to the Institute of Hydrology with Martin Lees and Terry Marsh of the National Water Archive. Both identified the national importance of baseline monitoring, where accurate data could be obtained from index catchments (preferably at sites with already long records). Climate change was identified as an important reason for maintaining monitoring programmes at sites where arguably the flow regime has already been well characterised by good, long records. Further discussions may be held with IH personnel on specific points.

4. METHODS OF EVALUATING BENEFITS

Caera Nevin has been appointed as a Research Assistant to the project at Stirling University from 1st October. In her first month, she has been working with the literature relevant to economic methods and beginning an assessment of the value of each to the project at hand. Progress to date is summarised in the notes included as Appendix III; these are to be regarded as working notes and report simply on findings and thoughts to date. This work has been undertaken under the general guidance of NDH, but Caera has also visited Dundee in order to discuss relevant literature and approached with ARB and MES.

CN has been in touch with Meg Postle, who was keen that Caera should pay a visit to Norwich to discuss relevant work with her there. However, Meg has become heavily involved with a public inquiry, and is not now likely to be available until late November. NDH has spent a short period in the USA and has now returned, and will be able to be more involved in Caera's work meantime.

5. LIAISON

ARB has been in contact with David Rylands (Project Leader) during the month, principally on the subject of the detail of the Information Requests. With these now despatched, attention turned to the proposed progress meeting provisionally scheduled for 13th November. Various members of the Project Board would have had difficulty in attending this meeting, and ARB suggested that a meeting in December might have more to usefully discuss. The option for this meeting remains open.

A weighty set of papers was received from Nigel Fawthrop (Project Proposer) during the month, and was found to be of considerable benefit to the literature review.

6. STAFFING

As reported above, Caera Nevin began work as a Research Assistant on the project at Stirling University on 1 October. Mike Steel officially ended employment on the project at the end of the month.

7. FINANCE

The first invoice due under the main contract is now due, and will now be submitted following production of the literature review.

Two monthly invoices have now been received from Scotia Water Services and have been forwarded for payment by the Dundee University Finance Office.

8. WORK PLAN

In the month of November, work should advance on two fronts:

- Analysis of Information Request returns, and
- Development of methods for assessing data benefits.

The former item should be expedited quickly in order to inform the latter as soon as possible. It is important for team members to note that an absolute deadline exists for the development of methods by the end of December, with a preferred approach to emerge also by then or within the early part of January.

Contact with Project Board members may be useful in helping the development of methods, perhaps in the context of a meeting.

9. OTHER

ARB was given the opportunity to review a World Meteorological Organisation report relevant to the subject of this report, for *Circulation*, the newsletter of the British Hydrological Society. The opportunity was used to produce a short article which raises in a 'public' forum some of the issues central to this project. It was felt inappropriate to refer to this R&D project in the review, but it is hoped that the piece will be generally constructive in raising awareness of relevant issues. The review is included as Appendix IV.

APPENDIX I: INFORMATION REOUEST FORMS

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

How are the hydrometric data used?

Would any further hydrometric data be used if the network were extended?

If hydrometric data collection were to cease, would you:
a) use theoretical estimates? YES/NO
b) commission you own flow measurement programme? YES/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

What % of the consents in your area are linked to flow in the receiving watercourse?

Do you issue variable-rate consents based on available dilution?

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

If not, are there plans to do so in your area?

....

Name: Telephone:

Position: Region/Area:

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

How are the hydrometric data used?

Would any further hydrometric data be used if the network were extended?

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/NO

b) commission you own flow measurement programme? YES/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

Do you use real-time data at all? If so, how?

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

....

Name: Telephone:

Position: Region/Area:

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)?

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

How are hydrometric data used for flood warning models?

a) As levels/As flows/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐
Using real-time data to inform duty flood warning officer ☐
Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/NO
Would it use data from more stations if the network were extended? YES/NO

Name: Telephone:

Position: Region/Area:

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

- Historic only (eg data up to 1 year ago) ☐
- Mix of historic and recent ☐

How are hydrometric data used?

How would flood defence functions be attempted in the absence of any historic hydrometric data?

Would Flood Defence use data from more stations if the network were extended?

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

What hydrometric data do you require for channel maintenance and weed-clearing work?

....

Name: Telephone:

Position: Region/Area:

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Freshwater chemistry

What hydrometric data are needed in your function (type of data, approx number of stations)?

How are they used?

Are any stations used more than others; if so, which and why?

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

Would you use hydrometric data from more stations if the network were extended?

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

....

Name: Telephone:

Position: Region/Area:

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

How are they used?

Are any stations used more than others; if so, which and why?

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

Would you use hydrometric data from more stations if the network were extended?

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

....

Name: Telephone:

Position: Region/Area:

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Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

How are they used?

Are any stations used more than others; if so, which and why?

Would you use hydrometric data from more stations if the network were extended?

Do you operate a Riverline telephone service?

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

....

Name: Telephone:

Position: Region/Area:

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

How are the data used?

Do you have any requirements regarding the accuracy of hydrometric data?

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

Would you use hydrometric data from more stations if the network were extended?

Name: Telephone:

Position: Region/Area:

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ......

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

APPENDIX II: EXTERNAL DATA USES - NOTES ON PROGRESS

NOTES FROM VISIT TO YORKSHIRE WATER SERVICES

Ian Stevens - Water Supply

Direct abstraction sites:

* YWS have, at present, 8 major river intakes, and at all of these the abstraction rate is directly related to the flow in the river;
* YWS have access to the Agency telemetry network (he thinks it is shared at these 8 sites?) and will typically access the system three times a day;
* At present, all controls are manually operated and the operatives access the flows directly from the Agency;
* At all intakes the weir is the property of the Agency and, given legislative requirements, he cannot see how the Agency would be allowed to control these 8 stations.
* The Agency also have one measuring weir for compensation flows from a headwater reservoir; flows are not continually read at this site, only manual observations are taken for regulatory purposes.

Water Resource Modelling

* Use both historical ADFs from archived data, and real time data for updating models that are currently in use on a daily time scale;
* Data are obtained from Richard Maxted and Mike Low;
* The general Resource Model is updated on a very course interval, say 6-monthly, and looks at the Region as a whole as well as individual catchments;
* The Emphasis is on modelling the system as a whole as a management tool for yield assessment;
* Some historic data are also used for FDC generation etc; and for spell duration events;
* If no data were available, would have to rely on synthesised data derived from rainfall records;
* At the weekly timescale they have to report on resource availability, current stocks, flows, recharge rates etc;
* The planning model is then run to determine the next week's operation, taking into account likely flows and demand;

* Only a small number of Agency sites are used for this weekly assessment - say 6 or so;
* In total, 12 or so stations are essential to YWS for their routine work in supply management;
* During times of stress there is increased co-operation with the Agency and data are taken from a greater number of sites.

Ed Bramley, Environmental Quality

Have no routine data requirements from the Agency, though they do work in collaboration on specific projects relating to waste water quality and policy. Recent examples include:

* UPM studies - one in Sheffield and 1 in York - data requirements are:
* Fishery surveys - flows needed to put survey results into perspective;
* Ditto for biological surveys;
* Time of travel studies of contaminants to potable supplies - almost 40 studies have been carried out in recent years at different flow rates, all require extensive use of Agency data;
* Greater use has been made of the data during the recent dry spell.

In general, when YWS require flow data for water quality studies they will need intensive, accurate data from the Agency stations, together with less intensive and less accurate data from intermediate sites. If the Agency are unable to assist with this they have to commission outside contractors to collect the data for them, often using the Agency for advice.

A WIDER ASSESSMENT OF EXTERNAL DATA USERS

It has been recognised that significant use is made of hydrometric data by external organisations or individuals. In order to ensure that this is fully accounted for we have approached the three Regions that were visited during the questionnaire development phase.

The data requested/received is as follows:

Midland Region
Summary data requests have been obtained for the past hydrological year; this timescale was chosen as it was felt that the requests often came in pulses associated with the winter and summer extremes. Amongst other details the forms list date of request, name and address of requester, time taken to fulfil request and the category of user (Internal/External/STW). A total of over 1000 requests were made during the year. We

are currently categorising the requests in order to assess the relative demands of the external users; one useful bonus is that it will also be possible for us to breakdown the internal users and quantify their demands on the data.

North East Region
Ridings Area of North East Region have been able to provide us with a summary of data requests for the period January 1995 to October 1996. The totals are as follows:

Internal users	172 requests
External traders	461 requests
Students	40 requests

This demonstrates the extensive use of data that is made by external users. A more detailed analysis has been carried out on the requests made since March 1996. The top ten are as follows:

Yorkshire Water	21
Calderdale MBC	5
Yorks Wildlife Trust	5
IoH	5
Bradford MBC	4
Mott MacDonalds	4
Binnie & Co	4
Alter Power	3
Aspinwalls	3
Acer Environmental	3

From this it is clear that one of the main groups of external users are the major engineering consultancies. We are thus now beginning to focus on these in order to try and assess the different uses and benefits that they derive from the hydrometric data. For this we have decided to work closer to home, drawing on the users of SEPA West.

SEPA WEST
We have requested the past 6 months data request forms from the SEPA West office in East Kilbride. These forms, of which there is one for each data request, will provide details of the data user, address and contact name, data requested, the use to which it was to be put, the data which was supplied and any supporting analysis or information. We intend to select a sample of these requests and then approach the major users to obtain their perspective on the benefits that they derive from the hydrometric data. We hope to start the visits during the later part of November.

AMB 041196

APPENDIX III
ECONOMIC METHODS - REVIEW OF METHODOLOGIES

Some working notes to promote discussion.

Part 1 - The Use of CBA Methodologies to Evaluate the Worth of Hydrometric Data

The value of streamflow data according to Cloke and Cordery is seen 'in the reduction of expected losses as a result of better decisions' (Cloke & Cordery, 1993); decisions, outlined in the review in relation to flood warning advice, the implementation of flood mitigation measures, and the prevention of water pollution through the alleviation of low flows and better understanding of flow patterns.

The difficulty in quantifying the benefits of data collection stem from the indirect and thus 'invisible' nature of these benefits. Part 1 discusses the alternative approaches within CBA to evaluate data, and in examining their advantages and shortcomings outlines the most appropriate option under the indirect benefits of:

1.1. Flood Alleviation/Mitigation Benefits

- The calculation of damages averted with consideration of urban/rural catchment differences.
- The use of hedonic price methods to determine the benefits of flood alleviation measures on housing prices within the affected catchment.
- The use of contingent valuation [CVM] to directly question floodplain residents on their willingness to pay for the reduced risk of inundation. Also the use of CVM in the context of putting a value on both use and non use benefits of increased recreation facilities in terms of fishing days to fishermen, and other bankside recreationalists.
- The application of the travel cost approach is also discussed in relation to such recreational benefits.

1.2. Water Quality Improvement

- in terms of potable supplies [from surface and groundwater improvement], the impact of improved water quality on quality and quantity of fish stocks, instream recreation uses such as swimming and other water sports, and other non use.

1.3. Improvements in the availability of water supplies to floodplain residents

The Relevant Population for Accrual of Data Collection Benefits: In the discussion of data benefits our population of interest throughout is described as the general public.

1.4. The Transferability of Benefits from Hydrometric Data Collection

1.5. Allocating Use and Non-use Benefits to Data Collection Within CBA

This paragraph suggests in theory the role of the data user mail questionnaires in allocating the benefits of flood alleviation etc. to data collection, and the possibility of utilising responses within a sensitivity analysis.

Summary

Due to the fact that the value of data overall is reflected in the reduction of expected losses from better decisions (Cloke & Cordery, 1993), the review in part 2 focuses specifically on economic approaches adopted to value reduction of uncertainty in parallel with, or in place of CBA.

Part 2 - The Existence of Risk and Uncertainty with Respect to Environmental Decision Making and the Role of Hydrometric Data

2.1. A Distinction Between Risk and Uncertainty

In respect to the environment, decision making according to Faucheux and Froger will always be in the context of complexity, irreversibility and uncertainty (Faucheux & Froger, 1995). Krzystofowicz appears to be in agreement specifically highlighting forecasts concerning hydrometeorologic phenomena as 'inherently uncertain' (Krzytstofowicz, 1983). Dasgupta and Pearce, in project evaluation also classify uncertainty in terms of its source in an attempt to emphasise the need for modification to the standard methodologies of CBA in order to incorporate this (Dasgupta & Pearce, 1972).

In adopting a suitable economic approach to evaluate the worth of hydrometric data however, it is important to distinguish between the terms risk and uncertainty. If probabilities can be assigned to specific outcomes the situation is deemed risky, and if consequences cannot be identified with any likelihood the situation is one of uncertainty (Dasgupta & Pearce, 1972). Fauchaux and Froger identify all the interactions between the economic system and the environment as being under strong uncertainty, described as a distribution of 'non-additive probabilities and/or by a plurality of probability distributions which are not fully reliable.' (Fauchaux & Froger, 1995).

2.2. Dealing With Environmental Uncertainty Within an Economic Framework

Traditionally, several approaches have been adopted in dealing with uncertainty, summarised by Zerbe and Dively (Zerbe & Dively, 1994):

1. Ignore uncertainty. This is appropriate where it is small, time span of importance is short or where CBA is only a rough estimate.

2. Reduce it to levels where it can be ignored. This may be achieved by gathering additional data or more accurate information.
3. Recognise uncertainty and factor it into analysis, i.e. with the introduction of sensitivity analysis, simulation or decision trees.

The second point of the above is of particular interest. While not ensuring its elimination the collection of hydrometric data does reduce the level of uncertainty.

In suggesting an approach which provides a more clear evaluation of the worth of hydrometric data in this respect one should be able to identify the cases where it is cost effective to invest the resources necessary to get a more precise picture of river flows, and the other cases where in fact it may be better to utilise existing data and address remaining uncertainty through modelling etc.

2.3. The Use of Bayesian Decision Theory

Freeze et al. support risk reduction as the principal function of environmental data collection in the proposition that data worth be assessed by comparing the cost of data collection against the expected value of risk reduction relating to a specific project. This they propose can be carried out using Bayesian decision theory (Freeze et al. 1992). In Simpson's 1987 review of methodologies for estimating the value of streamflow data, Bayesian decision theory, in providing a method to 'pool or update' information is also deemed superior to earlier methods, such as generating synthetic records through identifying statistical distributions (Simpson et al. 1987).

2.3.1. The Suitability of Bayesian Decision Theory Within an Environmental Decision Making Framework

On closer examination of the nature of both Bayesian methods and environmental decision making it becomes apparent that, despite widespread application, they may be somewhat incompatible for our framework.

A Bayesian approach requires three important ingredients to be effective:
1. A set of project specific design alternatives
2. Specific performance criterion/criteria
3. Parameter uncertainty.

Project specific design alternatives are compared, before collecting new data in a prior analysis, and after collecting new data in a posterior analysis. Data worth is calculated as the increase in the expected value of an objective 'goal' function [formulated in the knowledge of probable outcomes] due to the availability of proposed additional measurements (Freeze et al. 1992).

The ingredients outlined imply that the assignment of probabilities to established outcomes is justified, implying in turn, the existence of a risky situation, and not one representative of environmental uncertainty, as discussed (Dasgupta & Pearce, 1972). Bayesian theory is a traditional probability theory based on substantive rationality, yet

Machina suggests that such traditional theories of decision making may need to be reversed, with the occurrence of different forms of uncertainty (Machina, 1987); perhaps one of those forms being environmental uncertainty.

Aspects within reservoir storage design and flood frequency prediction inhibiting the assignment of outcome probabilities, which may thus inhibit the use of Bayes are outlined (Klemes, 1977 & Davey, 1989).

2.4. Evaluating Additional Data Through its Relationship with Error Reduction

In response to McMahon and Cronin 'marginal economic analysis' which I outline, however, Adeloye has commented that it is not correct to assume the error relating to reservoir capacity design could be made equal to that of any one streamflow parameter which determines it, since these are larger in comparison to the sampling errors of the parameters themselves (Adeloye, 1990). This stems from Adeloye's finding that when the length of data record was increased fourfold, the temporal error was only reduced by 50%, and with an eight fold increase the error was reduced by a factor of 2.8.

As early as 1965 Linsley also identified that cost savings could not be related in a linear fashion to data accuracy.

Overall Cloke and Cordery in 1993 found that the benefit cost ratio in relation to reservoir storage design depended on a number of factors:

1. The amount of existing data
2. The number of sites at which data are to be collected
3. The adopted discount rate.

The only methodological solution to deal with such uncertainty was deemed by Adeloye to be the use of Monte Carlo simulation (Adeloye, 1990) involving the production of a large number of 'equally likely' synthetic time series of streamflow data and the analysis of each flow parameter to determine 'its distribution and other statistical' parameters.

2.5. Alternative Methods to CBA for Evaluating the Worth of Hydrometric Data

- Multiattribute Utility Theory
- Qualitative Multicriteria Evaluation

I am currently waiting for material [expected early next week] relating to what will be a short discussion of the advantages/disadvantages of these alternative approaches, as suggested by Meg Postle.

3.0. Data Collection, Uncertainty and the Appropriate Discount Rate

This includes a paragraph of discussion of the issues surrounding whether within CBA and hydrometric data the discount rate should be adjusted in an attempt to account for uncertainty. NDH to contribute.

CN 011196

APPENDIX IV REVIEW FOR *CIRCULATION*

W O Thomas, Jr (1994) **An overview of selected techniques for analysing surface-water data networks**. *WMO Operational Hydrology Report No 41*, WMO-No 806, 30p.

The issue of this WMO report is timely for hydrometricians in the UK. It describes and reviews methods for assessing surface-water gauging networks in terms of assessing station locations, data type and frequency, and optimum record length. In a climate of increasing emphasis on the justification of resource expenditure, it therefore provides useful reading.

An early chapter focuses on data requirements - who wants what data, why, to what accuracy, how often, how long for and when? A point-rating scheme is presented which allows the network manager to assess the value of data being generated at any site, although this is subjective. One thoughtful inclusion is an assessment of the economic value of water in a watercourse, which feeds through into an assessment of the value of the data.

Some alternative methods of providing streamflow data are considered, extending beyond normal UK practices, eg crest-stage 'stations' maintained only in order to measure the stage of the annual maximum flood. Flow-routing, regression techniques and catchment models are all discussed as options which should always be explored as alternatives to the costly process of collecting data in the field. For networks which are considered to be appropriate for future needs, a 'travelling hydrographer' program is described. This allows the available gauging effort to be directed at minimising uncertainty in the network data, using uncertainty functions, travel and station running costs.

By far the most rigorous chapter is 'Analysing the regional hydrology network'. Using examples from Canada and the US, and drawing on his own experience, the author considers the lengths of record necessary to define at-station flow parameters to a given accuracy, and the regional gauging densities necessary to limit sampling errors in relation to future information needs at ungauged sites. By introducing station operation costs in a mathematical framework, the value of individual sites in reducing sampling error, over given planning horizons, can be assessed.

The report makes the important distinction between stations operated for water resource management purposes and those operated as part of a regional information-gathering system. In practice this distinction is often blurred but, nonetheless, network managers must strive to maximise the information value of their monitoring activities. The report provides some useful tools to aid that process, particularly in devising gauging strategies and assessing the theoretical sampling error-reduction benefit of continued station operation. However, it is of limited value for application to networks where real-time or recent data are drawn from many stations, often for a range of resource management functions. It also fails to recognise the importance of ongoing data collection where climate or land-use change may markedly alter future streamflow characteristics.

Andrew Black
University of Dundee

Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

November 1996

R&D Progress Report W6/005/4

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

A R Black, N D Hanley and A M Bennett

Research Contractor:
University of Dundee
in collaboration with Scotia Water Services *and* University of Stirling

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R&D Progress Report W6/005/4

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This report is the result of work jointly funded by the Environment Agency and the Scotland and Northern Ireland Forum for Environmental Research (Sniffer).

Dissemination status
Internal: Restricted
External: Restricted

Statement of use
This report is the fourth monthly Progress Report from Project W6/005. It describes work carried out during November 1996 and indicates immediate priorities for December 1996. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

Research contractor
This document was produced under R&D Project W6/005 by:

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in collaboration with: University of Stirling *and* Scotia Water Services
Tel/fax: 01786 467480/467469 01659 74487/74470

Environment Agency's Project Leader
The Environment Agency's Project Leader for R&D Project W6/005 is:
Mr W D Rylands (Thames Region)

R&D Progress Report W6/005/4

1. INTRODUCTION

This report describes progress made on the project during November 1996. Four main activities are to be reported:

- Analysis of information request responses by Ceara Nevin (CN) at Stirling University
- An assessment by CN of approaches to environmental decision-making, data collection and cost benefit analyses in relation to this project, under guidance of Nick Hanley (NDH)
- Information-gathering by Tony Bennett (AMB) at Scotia Water Services, in relation to benefits accrued by external data-users
- A meeting of all project staff to discuss approaches to assessing benefits

2. INFORMATION REQUEST RESPONSES

Approximately 100 responses have now been received from the respective agencies for England & Wales, Scotland and Northern Ireland. In individual data-user categories, the numbers of responses varied from 7 to 17: consensus responses were therefore possible (though not always found) for each question from each category of user.

Analysis has been performed by producing coding sheets for each category of request (ARB and AMB). These sheets listed the main categories of response for each question, based on the responses received by early November. All responses were then passed to CN at Stirling, who then entered the information received into spreadsheet files for each category of response. Frequency counts and cross-tabulations have been produced for all categories of response, and late receipts (after the given deadline of 8 November) have also been added to the database.

Several of the questions asked were common to several (if not all) of the categories of data request, eg "What data types do you use", "How do you use hydrometric data". Wherever possible, data from these questions have been merged in order to produce a broader view of the relative levels of use in different functions and for different types of data.

It was also noticeable that, despite asking questions directed specifically at the activities of individual functions of the various agencies, responses often overlapped in terms of describing the activities which used hydrometric data. Perhaps this should have been expected; it does provide some useful feedback in terms of what are the main data-using functions at least in terms broadly of the amount of staff effort expended in each. Again, responses have been merged in order to give an overview of overall frequency with which various functions use hydrometric data.

One disappointing aspect of the responses was that very little information was forthcoming regarding economic benefits of using hydrometric data. One useful piece was information was received from Anglian Region regarding the value of water in storage for supply purposes and the benefits of having available accurate streamflow data. However, no other response at the time of writing was so specific. This will have a limiting effect on using the responses in the development of methods for assessing data benefit.

Notwithstanding the above, it is felt that the numbers of responses received does allow a comprehensive picture of hydrometric data use to be established. Full results of the analysis of these responses will be provided in the December Progress Report.

With what is presumed to be the great majority of responses now received, this seems to be the appropriate time to acknowledge the staff of the UK environmental agencies. Many staff went out of their way to provide information beyond the direct requirements of the questions, and this has all been found to be useful in building towards a comprehensive picture of hydrometric data use in the UK.

3. EXTERNAL DATA USAGE

AMB has been pursuing this aspect of the study with personnel in the three environmental agency offices visited in the early stages of the project (Environment Agency Midlands Region, Ridings Area and SEPA West Region). To date, preliminary analysis has been done for data received from Midlands Region, and work is in hand to undertake detailed analysis for all three. From all three sources, information is being supplied regarding the total volume of hydrometric data requests, and the sources of those requests. A basic breakdown of the Midlands data is as follows:

Internal requests	**Number**	**% of total**
Total (inc rainfall)	519	46
Total (excl rainfall)	425	48
External requests		
Total (inc rainfall)	606	54
Total (excl rainfall)	456	52

Midland Region hydrometric data requests August 1995 - September 1996

Breaking down the external non-rainfall requests, the following frequencies have been found for six main categories:

Category	**Number**	**% of total**
Schools/Universities	172	38
Consultancies	153	34
Severn Trent Water	37	8
Other companies (insurance, planning etc)	31	7
Institute of Hydrology	11	2
Others	52	11

Origin of external non-rainfall requests

It should be noted that some internal data requests are likely to be for the benefit of external users, so external data usage may account for more than the 54% of total requests identified in the upper table. Note also that this analysis makes no distinction between large and small data requests. Results of these analyses are being passed direct to Stirling University.

4. METHODS OF EVALUATING BENEFITS - ECONOMICS

CN has spent much of the past month engaged in a review of approaches to environmental decision making, data collection and cost-benefit analysis which are relevant to the objectives of this study. This has resulted in an extensive document being produced, and this is now with NDH for the purposes of some fine-tuning.

The review complements the more hydrologically-driven literature review completed at Dundee by Mike Steel, and is now informing work being carried out on detailing the methods which could be used to evaluate the benefits of hydrometric data. With the lack of economic data emerging from the information requests to environmental agency offices, the ultimate challenge of the project remains difficult, but some progress is being made regarding approaches to this. NDH is currently working on this aspect of the project, using those empirical bases which can viably be identified, and is in regular contact with ARB to maintain dialogue on this critical aspect. The December Progress Report will outline in detail the methods of evaluating benefits which can be used, and the January (6-month) Progress Report will bring together all aspects of the report which have been reported to date, and indicate the preferred approach to be adopted.

5. METHODS OF EVALUATING BENEFITS - STRATEGIES

A team meeting was held in Stirling on 13 November to discuss progress made in various parts of the programme, and to identify routes to explore further. A consensus emerged that different treatments of the subject of assessing benefit were appropriate at different scales. Where the gauging density over a wide area was in question, it would be appropriate to take an economic viewpoint and consider all the main aspects of data benefit; these could then be related to data costs over the same area. However, at a local scale, the consensus was that hydrological considerations should prevail, in terms of the capture of information. How much information does any one gauge which is not available (in essence) from another? While these ideas are expressed only broadly, they may form the basis of a preferred approach as our deliberations continue.

6. LIAISON

A meeting on Bed mobility in flooded river systems (AM) and River flow measurement (PM) was organised by IAHR to be held in Wallingford on 3 December. AMB expects to attend this meeting and engage in discussion with some of the speakers in the afternoon session.

7. STAFFING

Ceara Nevin's contract is due to expire on 14 December, by which time much of the work on formulating concepts for evaluating data benefits should be complete.

8. FINANCE

An invoice for the first quarter's work on the project was due to be issued by Dundee University to the Environment Agency on 2 December. Invoices have been received from Stirling University and Scotia Water Services and have been authorised for payment.

9. WORK PLAN

The working month of December will be short, on account of the Christmas break. Nonetheless, it is hoped that by the end of the month, it will be possible to report the views of the team on how the benefits of hydrometric data might best be expressed. A meeting has been scheduled for December 13 in Stirling to discuss this, allowing time for reporting activities before month-end. The December Progress report will also include the results of the review described above in Section 4.

Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

December 1996

R&D Progress Report W6/005/5

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

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Statement of use
This report is the fifth monthly Progress Report from Project W6/005. It describes work carried out during December 1996 and indicates immediate priorities for January 1997. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

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R&D Progress Report W6/005/5

1. INTRODUCTION

With the submission of this Progress Report, three important reports have been completed and the project has now moved much closer to its mid-way stage. The three reports are included as appendices:

Appendix I: Analysis and interpretation of hydrometric data questionnaires;
Appendix II: Benefit estimation methods for hydrometric data;
Appendix III: Alternative methodological approaches to representing the economic benefits of hydrometric data.

Appendix I reports on the range of applications of hydrometric data in the environment agencies, attitudes towards assessing their value by agency staff, and key items of information which offer potential in the development of methods for benefit assessment (and see Section 2). In Appendix II (summarised in Section 4.1), a review of existing methods for estimating benefits is presented, extending the scope of the original literature review. This then allows the development of a more fundamental review (Appendix III and see Section 4.2), which identifies three broad approaches to evaluating hydrometric data benefits. A preference for an approximate cost-benefit analysis approach is expressed.

In Section 3, some comments on benefit assessment from consulting engineers are reported. Work continues in this area but, as yet, little usable data has become available.

The work completed to date now gives a much more complete picture of the possibilities for evaluating benefits than was available a month ago. A preferred approach has been identified from a range of three viable possibilities, and gives an indication of how an operational method of benefit assessment might be developed. However, there have been some disappointments. The questionnaire survey of agency personnel has produced an encouraging volume of response, with considerable breadth in the range of data benefits, but surprisingly little quantitative benefit information which could be used in the development of general models. Also, the literature, despite a burgeoning of interest in the application of economic ideas to this general subject, lacks any attempt to provide a framework in which overall assessments of benefit might be made. This Progress Report presents the results of a considerable amount of recent effort on the project, and gives our latest assessment on how such a framework might be produced to satisfy the requirements in the UK for this type of information. The six-month Progress Report due at the end of January 1997 will be used to develop these ideas further, prior to the Project Board meeting.

2. INFORMATION REQUESTS

Analysis of the completed information requests (referred to elsewhere as questionnaires) is now complete. One hundred and forty-one completed requests were received in time for analysis, and a full report on this is included as Appendix I to this report.

Some early comments on the responses to the various questions were presented in Progress Report W6/005/4 (Section 2). While Appendix I presents a detailed analysis of the responses under a number of related headings, a broad summary of findings is given here, addressing specifically the question of how these findings aid the formulation of a method for evaluating the benefits of hydrometric data collection.

Key findings from Appendix I: Analysis and Interpretation of Hydrometric Data Questionnaires

The role of hydrometric data varies considerably from one agency function to another. In some, it appears to be a primary input to the function, eg in the operation of flood warning systems, Riverline telephone services and in the operation of variable abstraction licenses. None of these functions could operate without the provision of appropriate hydrometric data. In other functions, however, the role of hydrometric data is much less clear in the overall exercise of the function. For example, in the design of flood defences, river flow or level records will be used according to availability. Practically any additional data would be of value to the design process, but the design will be undertaken no matter how much or how little the available data. Another example is in pollution control (say for the assessment of a consent application) - hydrometric data will be used whenever available and fit for the purpose but, in the absence of any data, estimation techniques will be used as an alternative, and the hydrometric data are only one part of the function. The responses indicate that the valuation of hydrometric data benefits is limited by an imprecise understanding of the relationship between the provision of data and the execution of the various agency functions, irrespective of any difficulties in quantifying the economic value of the functions themselves.

The responses indicate that agency functions may result in multiple benefits, each of which may be related to an economic benefit. Figure 1 in Appendix I provides an example relating to abstraction licensing, for which the provision of data was linked by respondents to benefits in terms of:
habitat improvement scheme planning,
alleviation of low flows,
drought monitoring,
(more) accurate estimation of future flows, and
managing water transfer schemes.
Note that this list is not exhaustive, but specifies only those benefits identified in responses.

Respondents indicated that some stations were used for more purposes that others, Table 6 of Appendix 1 giving details for Fisheries & Conservation, Freshwater Biology/Chemistry and Marine/Estuary Science. Interviews with pollution control and abstraction licensing staff, however, indicated that data use could be expected from all stations in a network. In an overall assessment of benefit, these variations in the level of data use add to the complexities of variations in benefit associated with different functions which, in turn, vary on a geographical basis.

Some aspects of the responses do point to the possibility of quantitative economic benefit assessments. Respondents indicated in many cases that where hydrometric data were not available, licensing and consent applications must be restrictive, and this will have economic ramifications for the industrial, commercial or agricultural activities in question. No general rules can be expected to offer accurate valuations, but there may be scope for the development of some guidelines. Applicability will be limited by the lack of licensing legislation in Scotland.

Some estimates of benefit value were available for flood warning, though these were provided only from three Regions in England and showed a considerable range. Of all the agency functions, this currently offers the best (most direct) prospect of quantitatively assessing benefits, although the distinction between value of function and value of data remains to be addressed. Flood warning responses suggest that a reduction of data availability would impact sharply on benefits, though perhaps not least in terms of the effort required to modify warning systems to operate without given data streams.

Two final observations from the responses are that most functions would value the availability of more data, and that data 'requirements' (in an optimum sense) in terms of data accuracy and periods of record are highly variable: they depend on the characteristics of individual projects.

The analysis of responses promotes the view that there are limited opportunities for quantitative benefit assessment. A framework approach is recommended - see Appendix 2 to this Progress Report. While there does appear to be scope for using economic data in the case of flood warning systems, possibilities are much more limited in respect of other functions. Specially commissioned studies would be required to provide empirical economic data by which procedures might be formulated for the routine assessment of benefits from single monitoring sites or networks. Progress in identifying methods for assessing benefits is reported in Appendix 3.

Summary of benefits identified

One of the objectives of the information request survey was to assess the diversity of benefits identified by officers in various agency functions. Appendix 1 refers to the overlap of responses from various functions. It is hoped to produce a summary table indicating the main groupings, and all identified uses within each, from the questionnaire results. At the time of writing, however, some difficulty was being experienced in condensing the available information; this will be held over until Progress Report W6/005/6.

3. EXTERNAL DATA USAGE

Tony Bennett continues work in this aspect of the project. Discussions have been held with two major data users. In both cases, the view was expressed that it is virtually *impossible* to value data within the context of major (engineering) projects. This might in part reflect a feeling that, from the point of view of a consultant, adequate resources could never be justified to assess the value of data: the priority is always to achieve the aims of the project. However, the view was also expressed that the level of data availability was important in "increasing confidence" in design estimates, though an element of risk would always be present, and the reduction of risk was not quantified by these practitioners.

Tony will persist with this line of enquiry by discussing matters with directors and high-level managers within these consultancies and others in Glasgow, typically discussing drainage, road and bridge schemes. The hope is that at higher levels of management and with more experienced personnel, at least some approximate estimates of value may be obtained; ideally this may involve an assessment of the benefit of changes in design resulting from improved data availability. It is encouraging that one senior consultant has suggested that if an evaluation of data benefits were to be included at the outset, as part of the brief for a design exercise, it may then be possible to produce some well-reasoned values.

4. METHODS OF EVALUATING BENEFITS

Two major pieces of work on methods of evaluating benefits have been completed this month. The first is a literature-based review of economic methods for quantifying benefits, and the second builds on the first and outlines a series of alternative approaches to representing benefits - ie a broader conceptual treatment.

4.1 Benefit Estimation Methods For Hydrometric Data - Appendix II

This is an extensive review of the various economic methods which have been used in attempting quantification of benefits. It is based on a large body of literature (a long reference list is included) and, to some extent, abstracts from and builds onto the earlier, hydrologically-based literature review included with Progress Report W6/005/3.

Three parts deal respectively with *Detailed approaches to CBA*, *General approaches to CBA*, and *Valuing the hydrometric data collection network.* In the detailed and general approaches to CBA, problems arise in relation to project-specific valuations, thus precluding the possibility of develop general methods in this study. Benefit transfer offers a means of overcoming this difficulty, although approximations for various benefits will be required. The part dealing with valuation approaches includes a less economically rigorous approach, which could be pursued if some of the difficulties relating to the more formal economic methods were deemed to be insurmountable.

This review provides an authoritative statement on the various methods which can be used to assess benefits, and has been used - along with Appendix I - as the basis for an assessment of the merits of using various approaches to evaluating benefits. This assessment is presented here as Appendix III and is discussed immediately below.

4.2 Alternative Methodological Approaches to Representing the Economic Benefits of Hydrometric Data - Appendix III

This review, by Nick Hanley, sets out concisely a position on the pivotal question of how benefits are to be assessed. At its heart, three approaches are considered:
An approximate CBA approach
A scoring approach
A multi-criteria analysis approach
- note that this list differs from the three sections of Appendix II. An approximate CBA approach is identified as the preferred option. All three options are considered to be viable, but only the first offers the opportunity to assess benefit in full economic terms - a goal which is central to the purpose of the project. While the other approaches would allow assessments of relative worth to be made, only this approximate CBA approach can truly approach the goal of being able to generate benefit data which could then be compared with data generation costs.

However, in order to be able to do this, a number of obstacles must be overcome. These are detailed in Section 5 of Appendix III but, despite these, the preferred approach is to make a commitment to this approach (on the basis of its superior potential) and see how best the identified difficulties can be addressed in the context of two case studies. No guarantee can be made regarding the outcome of this process but, if the primary objective is to generate economic benefits, then this path must be followed. This choice must clearly be discussed in the scheduled February Project Board meeting, and agreement be reached with the Board regarding how the second phase of the project is to be undertaken.

If an approximate CBA approach is to be developed, there will be a need for some empirical benefit data for a number of benefits. Appendix III indicates the need to derive base values and length-of-record and local weightings, and it is proposed that special exploratory work would be required in order to obtain these. The preferred context is to focus on two selected catchment areas, and obtain empirical benefit data for these.

Neither the literature nor the results of the questionnaire survey have been able to provide a suitable foundation for making general benefit assessments, although reported approaches to case-specific assessments have been numerous. Such work would therefore require an additional input of effort above that outlined at the tender stage: this would have financial implications and would probably require some modest lengthening of the original timetable, perhaps by a month. An initial estimate would be that two months' time of a research assistant would be required, under the supervision of Nick Hanley.

5. STAFFING

Ceara Nevin completed work on the project at Stirling University on 14 December, and has been thanked for excellent work in relation to the methods of assessing benefits and analysis of the information request responses.

6. WORK PLAN

For the end of January, a 6-month Progress Report will be produced, consolidating all work carried out in the first phase of the project, and incorporating all outputs produced thus far. A complete statement will be made to indicate how the team believes work should progress in the second phase, thus providing the basis for discussions with the Project Board. There will also be provided the format and contents of an R&D Note, this to be the responsibility of ARB in consultation with both collaborators.

APPENDIX I

Analysis and Interpretation of Hydrometric Data Questionnaires

Development of questionnaires, rationale and sampling technique
In order to define the nature of current hydrometric data collection activities by the environment agency within the UK a postal self completion questionnaire was developed and sent to key environment agency personnel in the functions shown in Table 1.

Sample Size and Response Rate: In total a sample of 241 questionnaires were despatched tailored to ascertain the situation with regard to nine agency functions, actual numbers to each function outlined in table 1. One hundred and thirty eight responses were received in time for analysis. This response rate of 58% is particularly high for a postal questionnaire, responses using this technique generally averaging under 10%.

Table 1: Breakdown of Agency Functions to Which Questionnaires were Sent

Agency function	*Sample no.*	*No. of respondents*
Abstraction Licensing	26	18
Fisheries & Conservation	33	19
Flood Warning	33	19
Flood Defence	26	17
Freshwater Biology	33	14
Freshwater Chemistry	33	7
Marine/Estuary Studies	33	10
Pollution Control	33	19
Water Resource Management	17	18*

* the higher response rate is a result of a request by us that questionnaires be copied within the agency to personnel who may not have received their own.

The following brief report outlines questionnaire responses received overall and specifically in relation to function area. Essentially discussion focuses on a number of issues referred to during the literature review and CBA methodology report:

1. The specific uses of data and associated benefits [as identified/unidentified in the literature review] of hydrometric data collection according to EA personnel.
2. The potential benefits if any in extending the network.
3. The difficulties in defining an approach to linking data types with data use benefits.
4. The importance of real-time data collection in addition to historic data.
5. The predicted effects of extending or reducing the hydrometric data network.
6. The current awareness of EA personnel of the economic value of hydrometric data.
7. The contribution of questionnaire responses to the development of an economic framework similar to that of Davar & Brimley in the CBA methods section for hydrometric data evaluation within the UK

Section 1 - Specific Data Types Required by Agency Functions and Relevant Uses

1.1. Data Types Required

The two principal categories of data collected were those on river flows and water levels, the percentage within each function using these indicated in table 2.

The largest proportion of cases within any one function using averaged daily flow was 57% within freshwater chemistry, pollution control also exhibiting a substantial amount, at 42%.

6/C05/5

Percentile measures (Pctl) are also required in many situations for pollution control, in addition to abstraction licensing functions which also showed the greatest proportion of cases demanding instantaneous flows (AIF). These possibly indicate the more precise nature of information required in the determination and enforcement of abstraction licences and pollution consents. This is in contrast to water resources management where 67% of cases specified only mean annual flows (MAF), 80% overall referring to general flows (Uns.), with the specific need for daily flows referred to by only 16%. With regard to flood warning 84% of cases referred to only general flows.

Table 2: Percentage of cases under each function stating a requirement for specific data set

Function Type	*River Flows*						*Tide/Water Levels & Climate*				
	ADF	*MAF*	*AIF*	*FDC*	*Pctl*	*Uns.*	*Wtr.*	*Rain*	*GW*	*Tide*	*Mcs.*
Abstraction Licensing	22	6	39	16	22	50	72	61	39	6	11
Fisheries & Conservation	11	5	5	5	0	58	53	16	11	0	0
Flood Warning	0	0	0	0	0	84	89	47	0	21	5
Flood Defence	0	0	0	0	0	0	0	0	0	0	0
Freshwater Biology	7	29	21	0	7	50	21	0	0	0	0
Freshwater Chemistry	57	57	14	0	14	43	29	29	0	0	0
Marine/Estuary Studies	20	10	10	0	0	70	10	50	0	10	0
Pollution Control	42	26	5	16	37	37	11	26	0	0	0
Water Resources Mgmt.	13	67	13	0	7	80	73	73	60	13	33

As could be expected the measurement of both river (Wtr.) and rainfall (rain) levels is cited as essential to flood warning. Water resources management, abstraction licensing and fisheries and conservation also appeared from responses to rely on such data. Groundwater data (GW) is less essential overall, however in relation to water resource management and abstraction, is considered necessary in 60% and 39% of cases respectively.

1.2. Use of Data Types by Function

To facilitate the examination of data use tables 3.1-3.3 break down individual uses into sections.

Hydrometric data appears to have a key role across the functions in relation to the monitoring of low flow situations (oplw/risk/drgt), a role particularly emphasised with regard to water resources management and freshwater chemistry. In relation to estuarine/marine management data is used in only 20%, 20% and 10% of cases for determining currents within the estuary (estc), ecological conditions (estec), and salinity (estsl) respectively. This perhaps signifies the low level use of hydrometric data for this function overall. Where pollution related uses of data are considered the determination of pollution loadings (load) is most widespread.

W6/005/5

APPENDIX I: ANNEXE I

Abbreviations Within Tables Which Require Further Explanation

Table 2: Percentage of cases under each function stating a requirement for specific data set

ADF	Average Daily Flow
MAF	Mean Annual Flow
AIF	Instantaneous Flow
FDC	Flow Duration Curve
Pctl	Percentile measures i.e. Q_{95}, Q_5
Uns.	Unspecified Flows
Wtr.	Water levels
Rain	Rainfall levels
GW	Ground Water levels
Tide	Tides
Mcs.	Climate data / data for Morecs

Table 3.1: Percentage of cases under each function specifying data uses

oplw.	Monitoring of low flows
Risk	Assessment of low/high flow risks
drgt.	Drought monitoring / operations planning
estc.	Estuary current determination
Estec.	Determination of ecological conditions
Estsl.	Determination of salinity
Cons.	Determination and enforcement of consents
Nut	Determination of nutrient budgets
load	Calculation of pollution loading
trade	Analysis of trade effluents
trav.	Determination of pollutant travel times

Table 3.2: Percentage of cases under each function specifying data uses

fldef	Flood defence
fldwn	Flood warning
rtpr	Report purposes
tmpk	Flood time to peak estimation
mdl	Modelling
ablc	Abstraction licensing and enforcement
Flfh	Determination of suitable flows for fish migration
pldil	Calculation of dilution factors for pollutants
ecim	Ecological impact assessment
fhsv	Fish surveys
chnl	Channel bank work

Table 3.3: Percentage of cases under each function specifying certain general data uses

Bckg	Provision of background information
inqrs	Resolution of issues at inquiries
desn	Design of new stations
pbinf	Provision of information to the public
Plan	Planning of fieldwork
trend	Analysis of trends
Qlsm	Specific water quality sampling

Table 3.3: Percentage of cases under each function specifying certain general data uses

Function Type	*GeneralUses*						
	Bckg	*inqrs*	*desn*	*pbinf*	*Plan*	*trend*	*Qlsm*
Abstraction Licensing	6	17	0	0	11	0	0
Fisheries & Conservation	0	0	0	16	11	5	0
Flood Warning	0	0	0	0	0	0	0
Flood Defence	18	0	29	0	0	0	0
Freshwater Biology	14	0	0	0	29	0	36
Freshwater Chemistry	0	0	0	14	29	14	43
Marine/Estuary Studies	10	20	0	0	0	10	0
Pollution Control	5	5	0	0	0	5	0
Water Resources Mgmt.	40	0	0	27	33	7	0

What could be considered the more general uses of data, see list of abbreviations (Annex 1), illustrated in table 3.3 are most common in relation to water resource management functions. Among these uses however the utilisation of data in the provision of background information, for reporting purposes and in planning fieldwork in-stream was identified for several areas.

The results in tables 2 & 3.1-3.3. highlight early in the analysis potentially what is a great difficulty in *linking* the monetary value of data use benefits to the collection of particular data sets. For example, in table 2 average daily flow data is recorded as necessary in relation to seven different Environment Agency functions in total, and in table 3.1. up to six different functions make use of data in relation to pollution. We are informed thus that data is necessary and in use but how important or necessary one data type is to one function relative to any other can only be estimated in a qualitative manner. The common use of data across functions has further implications should there be a rationalisation of the network, a point discussed in detail in section 3. The removal of collection facilities for just one data type would have effects across many Environment Agency functions.

Section 2 - The Value of Real-time and Historic Data

Environment Agency specialists for each function were questioned with respect to their use of both real-time (real) and historic (Hist) hydrometric data. The responses in this section have potential relevance in the future if rationalisation of the network were to be considered and decisions continued on the basis of simulation using historic data only. For example, if pollution control benefits could equally be expected with the sole use of historic hydrometric data (Hist), the costs of real-time data collection could be avoided and in turn a greater benefit cost ratio produced.

Table 4: The nature of data collected for Certain Agency Functions

Functions	*Nature of Data*			*Simulation*			
	Both	*Real*	*Hist.*	*nofut*	*general*	*real + hist*	*historic*
Flood defence	100	0	0	0	0	0	0
Freshwater biology	71	14	7	7	14	36	29
Water resource mgmt.	13	0	73	0	0	29	14

Across these three functions real-time data alone (real), and in conjunction with historic data appears to play the greatest role currently, only a small proportion of cases with respect to freshwater biology operating on historic data alone 14%.

W6/005/5

The use of both real-time and historic data in simulation was examined in relation to freshwater biology and chemistry in table 4 and where it was carried out most often took advantage of both real-time and historic data, i.e. in 36% and 29% of cases, historical data alone accounting for simulation in 29% and 14% respectively.

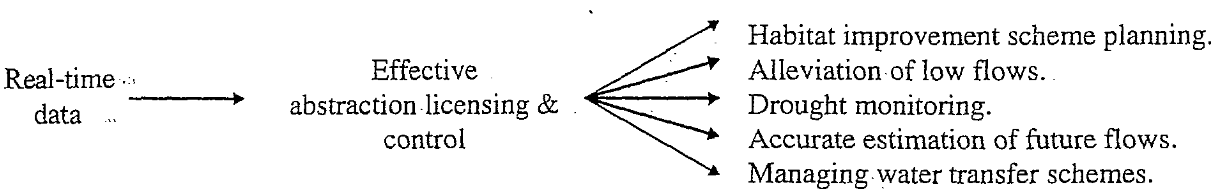
Table 5: The use of realtime data in flood warning

Function	*Realtime Data*		
	model+ officer	*officer*	*dont know*
Flood Warning	58	37	5

Where the responsibility is flood warning, in the majority of cases i.e. 58%, real-time data has a dual purpose, in modelling (model) and to inform flood warning officers (officer). In relation to abstraction licensing, in only one situation was it specified that real data was not used. The specific aspects to which it contributed varied among abstraction licence determination and enforcement, drought and low flow monitoring, and estimating future flows.

It is the widespread nature of real-time data use which is important as it confirms its contribution to a number of benefits, e.g. within just one agency function, figure 1.

Figure 1: Contribution of real-time data within abstraction licensing



Section 3 - The possible effect on existing benefits of reducing/extending the network

In both the literature review (included with Progress report W6/005/3) and the report on CBA methodologies (Appendix II to this Progress Report), benefits have been considered with the assumption of an existing or 'complete' network. There is a possibility however that changes may occur within the network, reducing or extending activities. Considering this possibility the questionnaires set out to examine the qualitative effect of such changes on existing benefits, if any. If for example a reduced network had no effect on benefits, then a reduction could be advised ensuring lower costs, stable benefits and in turn a higher benefit cost ratio.

Table 6: Current network situation in relation to fisheries & conservation, freshwater biology, freshwater chemistry and marine/estuary management

Function	*Use of Stations*	
	Certain	*Reasons*
Fisheries & Conservation	74	Riverline Prevent poaching Location of stn e.g. downstream from releases. Assess fishing conditions.

		Where fish is counted. At main abstraction points. Areas of heavy floodplain use.
Freshwater Biology	29	Assessment of metals load. Ecologically acceptable flow assessment. Rivers susceptible to low flows. Stations used for biological monitoring. Representative sites.
Freshwater Chemistry	43	At bottom of catchment/proximity to estuary.
Marine/estuary	0	n/a

3.1. The Current Situation

Under the functions of fisheries & conservation, freshwater biology and freshwater chemistry certain stations were cited as being used more than others (certain) in 74, 29 and 43 % of cases respectively, reasons for this given in table 6. Given the fact that in fisheries & conservation certain stations only are used due to a small number of reasons in 74% of regions, there may be potential here for weighting the importance of stations for this function within the network on the basis of these factors.

Examining the current situation with regard to marine and estuary management the hydrometric network was only considered by Agency officers to satisfy 40% of needs, a reduction in this case clearly having potentially very negative effects on relevant benefits.

3.2. The Effects of Reducing the Existing Network

The potential effects of reducing the existing network were largely examined in relation to abstraction licensing, flood warning, flood defence, and pollution control.

Table 7.1: Percentage of cases affected by reduction in network

Function Type	*When Data absent*				*Effect of removal on licences/consents.*			
	com	*estim*	*both*	*other*	*no*	*poss*	*varies*	*yes*
Abstraction Licensing	11	6	83	0	22	11	11	39
Flood Warning	0	0	0	0	0	0	0	0
Flood Defence	0	76	0	12	0	0	0	0
Pollution Control	11	16	74	0	21	0	37	32

Officers responsible for abstraction and pollution control were questioned as to what measures would be taken in the event of data being absent, and how this would in turn affect licences and consents. The majority of cases in each function stated that in such a situation both outside help would be consulted (com) and estimating procedures (estim) would be carried out, 83% and 74% respectively.

39% and 32% of those responsible for abstraction and pollution control responded that due to the lack of certainty which would result licences and consents would in turn be more restrictive or as was agreed in several cases a more precautionary approach would be advised. A significant proportion of pollution control respondents stated however that it would vary with specific events.

Percentage differences suggested in abstraction control were between 15-20%, and those in relation to pollution consents 10-25%. It should be noted however that almost half the pollution control officers stated they did not know what the difference would be, almost 30% of abstraction licensing officers stating the difference was too variable to specify.

Table 7.2: Servicing needs with a reduced network

Function Type	*Servicing needs with a reduced network*					
	badly	*dont know*	*pressure*	*reduce effec.*	*Same*	*Soso*
Flood warning	58	16	0	11	5	11
Freshwater biology	29	14	21	0	0	36
Freshwater chemistry	29	0	14	0	14	43

Flood warning, freshwater biology and freshwater chemistry functions were asked specifically how existing needs would be satisfied with a reduced network, table 7.2 exhibiting that flood warning functions primarily would be badly affected (badly), while with the remaining functions slightly more respondents stated that some needs would suffer but others would remain adequately serviced (Soso). This would imply that flood warning is somewhat more sensitive; a reduction in costs of for example 10% possibly resulting in a proportionately greater reduction in benefits.

Reducing data collection concerning freshwater biology and chemistry functions would according to 21% and 14% of respondents have indirect effects, in that there would be increased pressure placed upon other areas (pressure)e.g. estimating, possibly causing these other areas to operate less efficiently.

3.3. Effects of Extending the Existing Network

All Agency functions with the exception of water resource management were questioned as to whether an extended network would be useful for operations, responses given in table 8.

Table 8: Would data from an extended network be useful?

Function Type	*Would extended data be useful*				
	dont know	*no/prob no*	*yes/probyes*	*possibly*	*depends*
Abstraction Licensing	0	6	89	6	0
Fisheries & Conservation	0	26	42	5	16
Flood Warning	0	5	89	0	0
Flood Defence	0	6	71	12	6
Freshwater Biology	0	29	71	0	0
Freshwater Chemistry	0	29	57	14	0
Marine/Estuary Studies	0	50	40	10	0
Pollution Control	21	16	63	0	0

Apart from marine/estuary management the majority of personnel across functions responded that they would utilise an increased amount of data if available (yes/probyes). This reflects the picture throughout for marine/estuary management in that overall data appears to play less of a role than with other functions. It may also be considered to indicate that increased investment in the current network would lead to an increase in benefits. Agency officers who responded yes also qualified their answers, outlined in table 9.

Table 9: Increased uses from an extended network

Function	*Relevant uses*
Abstraction Licensing	Allow data to be received closer to site of interest Judgement of headwaters extractions To satisfy enforcement requirements Decrease limitations on licensing and consents Improved evaluation of impacts on smaller watercourses
Fisheries & Conservation	Increased coverage of areas lower down the river
Flood Defence	Research purposes Increase level of data, hence confidence Reduce the number of gaps in the network Improvement of modelling accuracy
Freshwater Biology	Refinement of rivpacs inputs Existing gaps in data cause difficulty Enhance biological surveying Ensure a more reliable analysis
Freshwater Chemistry	Improve on existing lack of accuracy
Marine/Estuary Studies	Better estimate flushing rates To assess impact of fish farms Existing gauging stations are too far inland
Pollution Control	Ensure more accurate data Allow more emphasis away from large catchments only Present sites not always close enough to sewage works

An interesting issue, if somewhat tangential in terms of economic values, which this question raised within fisheries & conservation, and which would seem relevant to all functions is that of whether hydrometric data is currently being utilised to its full potential. It was suggested that if more guidance was given to current users, then perhaps the existing network could be better utilised and in some cases there may not be a requirement for *extended* activities.

Section 4 - Accuracy and Hydrometric Data

Within certain approaches to economic valuation of data, there is an assumption (outlined in the literature review) that the benefits from increased hydrological information are related to the % standard error affecting the hydrological parameter, and in turn that the cost of decreasing the standard error can be estimated on the basis of increased frequency of measurement, increased number of stations in the study area, additional number of years in operation and better interpolation techniques.

On the basis of this theory it was useful to examine in this research what levels of accuracy are currently required relating to data functions. If required accuracy levels are known, specific stations could possibly be evaluated on the basis of how actual accuracy levels compare, with the implication that the closer those levels, the more benefits would accrue to that station.

Table 10: Level of Accuracy Required

Function Type	*% Accuracy required*						
	as accurate as possible	*specified levels of accuracy*	*dont know*	*estimates + observation required.*	*estimates suffice*	low/ none	*variable*
Flood Defence	12	65	12	0	0	0	12
Freshwater Biology	14	0	7	14	29	0	21
Freshwater Chemistry	29	0	0	29	29	0	0
Marine/Estuary Studies	10	10	0	0	0	20	0

Unfortunately the majority of officers across functions questioned, apart from flood defence, did not feel able to specify accuracy levels in a quantitative way (despite our request). On further questioning however it may be possible to more accurately define these. It is interesting to note however that the smallest error level possible is not automatically the most desirable, several respondents referring to the need for balance, accuracy levels specified for flood defence outlined in table 11.

Table 11: Accuracy levels specified within flood defence

Flood Defence Data	*Accuracy Level*
Data on flows	+/-5% - 10%
Flood levels	50-300mm
Flood warning	50mm

In relation to flood defence it was also inquired as to what the effects of lower accuracy were. Again answers were qualitative in nature, almost half of cases referring to a reduction in existing operations; reduced effectiveness, reduced/impaired service, reduced confidence, or less accuracy. Thirty percent of respondents said however that effects would have greater significance beyond the direct effect than a mere reduction in services.

Specific levels of accuracy for low/medium and high flow measurement were quantified to some extent with regard to water resource management, results given in table 12.

Table 12: Specific levels of accuracy required in water resource management

Function Type	*% Error allowed in flow measurement*								
	Zero	*two*	*five*	*seven*	*ten*	*fifteen*	*twenty*	low/ none	*variable.*
Low flow measures	7	0	66	0	0	0	0	0	0
Medium flow measures	7	7	47	7	27	0	0	0	0
High flow measures	7	0	20	0	40	7	20	0	0

It appears that overall, high flow measurement in this context requires slightly lower levels of accuracy than is the case with either low or medium flows, which in the majority of cases allow an error no higher than 5%.

Within flood warning a requirement which may be paralleled with accuracy levels is the minimum record length required for estimation, the assumption being that accurate estimations rely upon the existence of past records. Considering responses however this varies considerably, for example almost equal numbers of respondents saying five years, two years, twenty years, and that it depends on the situation in question. In view of such differing opinions, these responses would be of little use in defining an acceptable approach to weighting.

Section 5 - Quantifying the economic value of hydrometric data

In terms of specific cost benefit analyses carried out to date or the quantification of data benefits in a monetary way, there are it seems a number of studies accessible to 82% of flood defence managers. Despite this however only 41% attempted to define the % of such benefits attributable to hydrometric data only. Estimates given ranged from 1 - 100%, with little agreement between managers. Useful comments included those that equated hydrometric data benefits to averted flood damages, and that *relatively,* benefits could range from being high in urban areas to nil for remote areas.

Possible existing economic values for data were also sought in relation to flood warning. Again these ranged considerably from region to region, actual values given in table 13.

Table 13: Average economic saving to the community from flood warning systems

Region	*Monetary saving per yr.*
Anglian [central area-a]	£260,000
Region	*Monetary saving per yr.*
Anglian [central area-b]	£80,000
Midlands	£1,000,000
North West	£150,000

The CBA methods section discussed the project specific nature of many approaches to determine the economic value of hydrometric data. The range of questionnaire responses to requests for estimates of value reinforces the rationale of such approaches, and in turn the difficulty of defining a standard methodology to quantify benefits in this study. Again a framework approach as proposed in the methodology section appears more appropriate.

APPENDIX I: ANNEXE I

Abbreviations Within Tables Which Require Further Explanation

Table 2: Percentage of cases under each function stating a requirement for specific data set

ADF	Average Daily Flow
MAF	Mean Annual Flow
AIF	Instantaneous Flow
FDC	Flow Duration Curve
Pctl	Percentile measures i.e. Q_{95}, Q_5
Uns.	Unspecified Flows
Wtr.	Water levels
Rain	Rainfall levels
GW	Ground Water levels
Tide	Tides
Mcs.	Climate data / data for Morecs

Table 3.1: Percentage of cases under each function specifying data uses

oplw.	Monitoring of low flows
Risk	Assessment of low/high flow risks
drgt.	Drought monitoring / operations planning
estc.	Estuary current determination
Estec.	Determination of ecological conditions
Estsl.	Determination of salinity
Cons.	Determination and enforcement of consents
Nut	Determination of nutrient budgets
load	Calculation of pollution loading
trade	Analysis of trade effluents
trav.	Determination of pollutant travel times

Table 3.2: Percentage of cases under each function specifying data uses

fldef	Flood defence
fldwn	Flood warning
rtpr	Report purposes
tmpk	Flood time to peak estimation
mdl	Modelling
ablc	Abstraction licensing and enforcement
Flfh	Determination of suitable flows for fish migration
pldil	Calculation of dilution factors for pollutants
ecim	Ecological impact assessment
fhsv	Fish surveys
chnl	Channel bank work

Table 3.3: Percentage of cases under each function specifying certain general data uses

Bckg	Provision of background information
inqrs	Resolution of issues at inquiries
desn	Design of new stations
pbinf	Provision of information to the public
Plan	Planning of fieldwork
trend	Analysis of trends
Qlsm	Specific water quality sampling

Table 4: The nature of data collected for Certain Agency Functions

Both	Collection of both real and historic data
Real	Collection of realtime data only
Historic	Collection of historic data only
nofut	No simulation currently carried out, may do so in the future
general	General 'smulation' cited as being carried out
real + hist	Simulation using both real and historic data carried out
historic	Simulation using historic data only carried out

Table 5: The use of realtime data in flood warning

model + officer	Realtime data used in modelling and to inform flood warning officer
officer	Realtime data used to inform flood warning officer
dont know	Dont know how realtime data is used

Table 6: Current network situation in relation to freshwater biology, freshwater chemistry and marine/estuary management

Certain	The % of Agency personnel specifying that certain stations were used more than others
Reasons	Specific reasons stated why certain stations were used more than others

Table 7.1: Percentage of cases affected by reduction in network

com	External research would be commissioned
estim	Estimation techniques would be used
both	Both outside help and estimation techniques would be utilised
other	Other
no	No effect on issuing licences / consents
poss	Possibly an effect on issuing licences / consents
varies	Effect on licence / consents issue would be variable (situation dependent)
yes	Reduction of network would affect licence / consent issue

Table 7.2: Servicing needs with a reduced network

badly	Needs would be badly serviced
dont know	Dont know
pressure	A reduced network would increase pressure on other resources
reduce effec.	Needs would be serviced less effectively
Same	Needs would be serviced in the same way
Soso	Some needs would be affected

Table 8: Would data from an extended network be useful?

dont know	Dont know
no/prob no	An extended network would not/probably not be useful
yes/probyes	An extended network would/probably would be useful
possibly	An extended network possibly be useful
depends	It depends on the situation

APPENDIX II
Title: Benefit Estimation Methods for Hydrometric Data
By: Ceara Nevin

<u>Introduction</u> - Environmental Decision Making, Data Collection and Cost Benefit Analysis
The environment is composed of a number of complex interacting systems. A symptom of this complexity is that it can take a long time to obtain enough information to develop an understanding. One response is to design [and maintain] a network of sites where measurements are made, 'in order to encourage understanding and provide an indication of future change' (Burt, 1994). This proposal, in addition to the comment in the Government's 1990 white paper on the environment - that without good monitoring activities 'environmental policy decisions cannot be based on the best of scientific and technological analysis' (H.M.S.O. 1990) - appears to support the continuation of environmental data collection.

When evaluating any project concerning the environment, such as the structuring of a data collection network, financial costs however must be assessed and compared with environmental benefits obtained.

This estimation of costs and 'monetary' benefits of an environmental improvement can justify project expenditure or exhibit to decision makers that the project is not worthwhile (Ramchandani, 1989).

Cost Benefit Analysis, a quantitative analytical method, was originally developed for performing economic evaluations of alternative US federal water supplies. As a consequence of its capacity to assign monetary values in a non-market situation, it has been accepted by government in both project and policy decision making.

There are several approaches to the use of cost benefit analysis in the evaluation of hydrometric data, a combination of which are examined in this report:

- ***Detailed*** - data from one or several specific observing stations is related to a specific project or to a set of similar water resources projects e.g. flood protection schemes.
- ***General*** - Overall data from a country/region/network of stations is assessed in relation to a data use [not necessarily project specific].

<u>Part 1</u> - Detailed Approaches to Cost Benefit Analysis

Part one involves the identification of indirect benefits of data collection as outlined in the literature review and the discussion of how these may best be valued using cost benefit analysis. For clarity, the discussion has been structured in sections. While each section represents an individual benefit, in order to provide a comprehensive approach and exhibit the links between benefits, some overlap exists.

1. Indirect Benefit: Water Quality Improvement

<u>1.1.</u> <u>Benefit Category</u>: Water quality improvement in terms of an improvement in both surface and groundwater[1] abstracted for <u>potable supply</u>.

<u>1.2.</u> <u>Relationship of Benefit to Data Collection</u>: The collection of hydrometric data encourages more accurate estimation of a river's assimilative capacity and in turn the more efficient issue of pollution consents to industry through avoiding the risk of over/under provision of water treatment capacity (Crabtree et al, 1996. Black et al, 1994).

1.3. Economic Valuation of Water Quality Improvement for Potable Supply

1.3.1. Avoidance Costs/Averting Expenditure Actions

Theoretical explanations of this approach are based on the production function theory of consumer behaviour. It is suggested that costs incurred by households, firms or Government to avoid exposure to a water contaminant, can be used as an empirical measure of the pollution costs imposed on society (Courant & Porter, 1981).

In addition to actual expenditure Abdulla et al included an evaluation of the amount of time required for averting actions, based on the estimated wage of the respondent (Abdulla et al. 1992). In that study total 'averting actions' were defined as including; increased bottled water purchases for individuals buying it prior to pollution, bottled water purchases by new buyers, installing home water treatment systems, hauling water from alternate sources, and boiling water. A key assumption however within the averted expenditure approach is that averting actions *perfectly* substitute for reduction in pollution (Courant & Porter, 1981).

The construction of regression models with this method is useful to identify household and contaminant factors influencing expenditure. Raucher attributed influence to the contaminant's health risk, the extent of the public's awareness, type of water supply and presence of children (Raucher, 1986).

Averted expenditure studies by organisations (e.g. firms and Government/local authorities) have generally focused on the capital and operating cost associated with water treatment. Care must be taken however in the event of considering costs to both firms and households in the same CBA study that double-counting does not occur, as households, in addition to firms, can benefit from a firm's water treatment activities.

The averting expenditure method provides a lower bound estimate of total costs imposed by pollution. The divergence arises as some consequences of water pollution cannot be averted entirely through expenditure (Courant & Porter, 1981). In an attempt to address this properties of the utility function in addition to those of the household's production function should be examined. Despite this limitation however, and the failure to consider non-use values the approach has been used effectively on its own and as an 'anchor' for *willing to pay* values within contingent valuation (Abdulla, 1994).

Benefit Transfer: Benefit transfer may reduce the financial cost and time of carrying out a cost benefit analysis, in reducing the primary research involved. It has been defined as 'the process of taking a value or benefit estimate developed for a previous project or policy decision and transferring it to the proposed project or policy decision' (Postle & Moore, 1995). Several concerns have been highlighted however in relation to the validity of this approach and as a result its use is limited, according to Postle and Moore, to the estimation of orders of magnitude

The site specific and household factor influences upon averted expenditures, as related to Raucher in the discussion, may imply that benefit transfer is difficult (Raucher, 1986).

1.3.2. Contingent Valuation

The gross monetary value of any market good or service has two components: financial value and consumer surplus. Averted expenditure approaches concentrate on the averted *financial cost* of goods through a focus on consumer's *actual* expenditure. The amount which consumers are *willing to pay* may be greater, this difference being known as consumer surplus. The contingent valuation (CVM) approach to CBA attempts to capture both this consumer surplus and financial value to reflect the total utility derived from improved drinking water quality.

Contingent valuation involves the structuring of artificial markets, designed to directly elicit measures of consumer surplus through individuals' WTP[2] (Bergstrom et al, 1990). Such a market, for improved drinking water quality, with relevant payment mechanisms could be applied either within a controlled setting, or in the field. Artificial markets are divided into two broad categories: those that involve actual monetary payments for non-market goods, and those that do not (Bergstrom et al, 1990).

Jordan and Elnagheeb used a CVM study to estimate total WTP for improvement in drinking water quality in Georgia (Jordan & Elnagheeb, 1993), while Desvouges et al have looked specifically at the option value relating to water resources (Desvouges et al, 1987). Stevens et al [although not referring directly to water resources] argue that ignoring the non-use values in CBA can underestimate the total value from such an environmental resource by up to 75% (Stevens et al. 1993).

<u>1.3.2.1.</u> Limitations of CVM: Gregory et al believe that CVM, as applied to measuring improvements in drinking water quality and recreation uses (Gregory et al, 1993), are fundamentally flawed for a number of reasons:

1. Assigning monetary values imposes unrealistic cognitive demands upon respondents, as one is dealing in an artificial market situation.
2. The observed disparity between WTP and WTA, as discussed below.

Kahnemann and Knetsch also found that when individuals assign a monetary value in an artificial market situation, they seemed unable to distinguish between the relevant 'good', and their 'sense of moral satisfaction' associated with contributing to a good cause, e.g. the improvement of water quality for society (Kahnemann & Knetsch, 1992).

Bowers expressed concern that the use of WTP within contingent valuation [as a consequence of WTP being a function of income and wealth] implied the acceptance of the pattern of WTP as given by society's existing distribution of income, even if inequitable (Bowers, 1993). The use of WTA compensation as an alternative has been found however to elicit much higher responses (Hanley & Spash, 1994).

The payment mechanism may also influence results. The choice of water rates for the measure of willingness to pay for water quality improvement, for example, will encourage responses which reflect peoples' attitudes towards the role of public investment or private water company profits, and not the importance of improved drinking water quality (Green & Turnstall, 1991).

Support for the reliability of contingent valuation in estimating water quality benefits comes from Loomis' study however, where test-retest results for willingness to pay to preserve Mono Lake in California, over a nine month period, remained relatively stable (Loomis, 1989).

<u>1.3.3.</u> Hedonic Pricing Method

The Hedonic pricing method uses surrogate measures e.g. variation in house prices, as an indication of the value of a change in water quality.

Garrod and Willis (1992) found that the proximity of open water to a property increased its value by 5%. However, this also highlighted several bases for concern with this method including that:

1. House prices represent a unique *combination* of characteristics, yet HPM centers on an individuals ability to isolate and estimate the value of particular attributes independently. To aid this valuation economists also require a great deal of regionally and nationally adjusted data.
2. The HPM will only reflect household's marginal WTP for a particular attribute if the *measured* level of the attribute corresponds to the *perceived* level by the consuming household.

Ramchandani has commented that this method tends to be inaccurate for valuing water quality improvements, and is more suitable for air or traffic quality changes (Ramchandani, 1989).

2. Indirect Benefit: Enhanced Recreation from Water Quality Improvement

2.1. Benefit Category: An improvement in water quality relating to improved recreational uses[3]. Green et al believe that the benefits of water quality improvement in the UK will mainly arise from increases in the amenity and recreational value of rivers, rather than from the abstraction of water for potable supply (Green et al, 1989). In this context improved water quality leads to:

a) a reduction in incidences of low dissolved oxygen resulting from the bacterial degradation of organic materials and heavy sediment loads, which make it difficult for fish to live (Kneese, 1984). This reduction leads to increases in the total availability i.e. *quantity*, of recreational freshwater fishing. Clean water also leads to an increase in *quality* of fishing, ensuring the presence of more game fish such as trout (Patrick, 1991).
b) an upgrade in the status of a river's quality e.g, from fishable to swimmable, thus opening up other in-stream uses (Feenberg & Mills, 1980).

2.2. Relationship of Benefits to Data Collection: The relationship of water quality improvement to data collection is explained in paragraph 1.2.

2.3. Economic Approaches to Evaluating Recreation Benefits

2.3.1. Travel Cost Method

The Travel Cost Method is argued by some to be the most appropriate approach within CBA to value *user* benefits from recreation (Ramchandani, 1989). Similar to CVM it is a non-market valuation technique, but here travelling expenses [financial costs + time spent] are used as a proxy for the price of visiting outdoor recreational sites (Hanley et al, 1997). These costs are then used in formulating the recreation demand equation which is used in turn to estimate consumer surplus for visits.

The process initially involves the collection of economic and demographic data through visitor surveys which is incorporated in the estimation of a statistical relationship between visits and the cost of visits.

Opinions tend to differ between authors on how precisely demand for recreation should be defined, the variables which should be included in the evaluation, and how (Davis & O'Neill, 1991). Gautam and Steinback identified the historical daily average catch rate as an important explanatory variable for 'quality of fishing experience' in their valuation of recreational fishing in North East America (Gautam & Steinback, 1996).

In Davis and O'Neill's evaluation of recreational angling using the TCM in N. Ireland, the mode of transport used was considered, in addition to the extent to which recreational activities other than angling were pursued during the trip (Davis & O'Neill, 1991). This is a useful approach as it permits an estimation of the *proportion* of the cost of the trip attributable to angling in isolation to other uses to be estimated.

It was argued by Green and Turnstall that an increase in water quality would attract new visitors away from *other* substitute sites (Green & Turnstall, 1991). Cesario and Knetsch included a factor reflecting 'competing opportunities' provided by all other sites in their zonal travel cost model (Cesario & Knetsch, 1976).

The TCM generally leads to an underestimation of water quality / flood alleviation benefits as total recreational benefits only represent the additional value to existing users (Brookshire & Smith, 1987).
The overall validity of the travel cost approach has been recently questioned however in a paper by Green. It showed that the fundamental assumption underlying the validity of TCM is not always the case, this assumption being that the value of visits undertaken from distant origins is greater than for origins nearer the site, because the travelling costs are greater (Green, 1990).

<u>2.3.1.1.</u> **Hedonic Travel Cost Method**: This involves the estimation of benefits from enhanced recreation from water quality improvements on a 'per recreation/fishing day' basis (Bockstael et al, 1987), through the regressing of individuals 'total cost [Cmij] of visiting a site [j] on the characteristics of the site [bj]:

$$Cmij = f^i\ [bj]$$

It is assumed here that the costs of visiting a particular site and the characteristics of the site are similar, for all individuals living within the same area, the variation stemming from the *different* sites visited by people from the same area. The distinction therefore, between this and the standard TCM model, is that here recreational benefits relating to improved water quality are estimated from the demand for site characteristics, and not that for recreation trips (Dasgupta & Pearce, 1977).

<u>2.3.1.2.</u> **Random Utility Model:** The appeal of this model to value enhanced recreation relates to the collection of travel cost and characteristics data for a number of substitute sites in an area. The probability that an individual will visit site i rather than j is then calculated, depending on the costs of visiting each site and their characteristics, relative to the characteristics in the individual's set of alternatives offering maximum utility. The welfare effects of changing a characteristic can then be calculated (Braden & Kolstad, 1991).

<u>Benefit Transfer</u>: In adopting a travel cost approach Gautam and Steinback assumed that sites within the same region were likely to be fairly homogenous in terms of catch rates, travel costs and distances to sites (Gautam & Steinback, 1996), possibility facilitating benefit transfer. Radford adopted an homogenous functional forum for all rivers in a region as differences in observed mean per capita values across rivers in a similar area were found not to be significant (Radford, 1991).

<u>2.3.2.</u> Contingent Valuation

Similar to TCM, contingent valuation employs an economic and demographic survey. In contrast however, it facilitates the estimation of nonuser benefits in relation to an improvement in recreation.

It has been suggested that the values expressed by respondents who do not engage in in-stream recreation should be almost purely intrinsic in nature, implying that calculating the average WTP amount for them allows an approximation of the intrinsic benefits accruing to all individuals from the enhanced availability and quality of recreational use. Adopting this assumption Kneese subtracted nonrecreationalists' WTP from recreationalists' WTP [deemed

equal to total user values] and concluded that intrinsic value, apart from constituting 100% of non-user value, constitutes 45% of this total user value (Kneese, 1984).
Green et al sampled *three* groups of respondents in their contingent valuation study of water quality improvements: river corridor users, households adjacent to the river corridor and households located at least two miles from an accessible river corridor, with the total value then estimated as (Green et al, 1989):

[No. of visits * value of increased pleasure per visit] + non-use value of improvement

Earlier in this paper Gregory et al commented that requiring respondents to assign a monetary value within the non-market CVM placed excessive cognitive demands upon the respondent (Gregory et al, 1993). Kneese has proposed a solution to another cognitive difficulty for individuals in this context, i.e. to be aware of the *existing* water quality, and the water quality improvement *needed* for specific recreational uses (Kneese, 1984). He proposed that these levels be described in words and depicted graphically by means of a 'water quality ladder', which can also ensure that different people perceive existing and required levels in a similar way.

Benefit Transfer: In the Water Foundation's water quality manual a CVM survey was especially commissioned to develop 'standardised' values for the benefits to anglers associated with water quality improvements, a summary of which is given below (W.R.F, 1995).

Table 1: Summary of monetary benefits attributed to an increase in water quality for angling

Angler Type	*Value (£ per person per trip)*	*From**	*To***	*Method*
Coarse	3.86	No fishing	C3	CVM
	4.07	No fishing	C2	CVM
	6.21	No fishing	C1	CVM
	6.51	No fishing	T3	estimate
	7.58	No fishing	T2	estimate
	11.86	No fishing	T1	CVM
	15.83	No fishing	S1	CVM
Non-migratory salmon	7.16	No fishing	C1	CVM
	8.92	No fishing	T3	CVM
	10.39	No fishing	T2	CVM
	16.28	No fishing	T1	CVM
	22.65	No fishing	S1	CVM
Migratory salmon	11.58	No fishing	C1	CVM
	11.95	No fishing	T2	estimate
	18.70	No fishing	T1	CVM
	25.66	No fishing	S1	CVM

* Water quality where fishing is cannot be carried out.
** Improved water quality level.
Source: Adapted from W.R.F. 1995.

3. Indirect Benefit: The Generation of Hydroelectric Power

3.1. Benefit category: The generation of hydroelectric power contributes to 10% of the energy requirements of Scotland alone (SEF, 1996). The development capacity of hydroelectric power can be assigned a monetary value on the basis of £ per MW.

3.2. Relationship of benefit to data collection: This may be explained through the importance of forecasting seasonal flow changes on the effective operation of a hydroelectric plant as highlighted by Monokrovich (Monokrovich, 1990). At such plants throughflow is increased leading up to an expected surge of water or flood with a view to releasing some of the reservoir's capacity so that it can hold this water. If such forecasts are inaccurate or absent the throughflow regimen is calculated using the average high water inflow volume. If the actual inflow is greater, the lost production due to excess water discharged must be compensated by energy generated using fossil fuel.

3.3. Economic Approaches to Valuing Benefits from Hydroelectric Power Generation

3.3.1. Opportunity Cost Approach

Monokrovich calculated data value on the basis of the increased energy output from more accurate data. Assuming accuracy levels of 80-85% the lost production opportunity was calculated where:

$$R = U^* \, Wdis$$

R = Lost production
U = Difference in cost price of thermal station electricity and hydropower electricity
Wdis = Energy lost, being a function of volume discharged and the pressure head at which power is produced.

Monokrovich found that with this assumption of 80-85% accuracy a further increase of 5% gave an additional energy output of 1.4-1.9%, which could be equated to MW, and in turn valued at the market rate, resulting in an annual benefit of 100,000-140,000 roubles. The overall value of data was considered dependent on the actual capacity of the hydroelectric scheme.

4. Indirect Benefit: Enhanced Flood Protection

4.1. Benefit Category: The benefits from avoided losses due to flood protection. Flood damages can be either direct or indirect, depending or whether the damage is the result of direct contact with the flood waters or whether the losses result from disruption of economic activity as a consequence of flooding i.e. indirect flooding.

Benefits are further subdivided into tangible and intangible. Tangible benefits are measurable in monetary terms, while intangible are more difficult to attribute a monetary evaluation to e.g. greater security against loss of life, and enhancing environmental quality (Kuiper, 1971), or costs of dislocation to family life (Thampapillai & Musgrave, 1985).

4.2. Relationship of Benefits to Data Collection: Decisions concerning the implementation of flood mitigation schemes, according to Cordery and Cloke, are dependent on the accuracy of avoidable information. As the data length increases 'the inherent uncertainty of the characteristics of the stream flows decreases and confidence in estimates of the size and frequency of expected flood increases' (Cordery & Cloke, 1994).

4.3. Economic Approaches to Evaluating the Benefits of Flood Protection/Flood Warning Systems

4.3.1. Hedonic Price Method

Penning-Rowsell et al examined several US applications of HPM to flood alleviation benefit assessment and found little consistency in terms of explanatory variables included (Penning-Rowsell et al, 1992). This casts doubt on its validity.

Miyata and Abe applied this technique to valuing flood control benefits for the Chitose basin in Hokkaido, Japan (Miyata & Abe, 1994). A reduction in the variable, annual expected depth of flood water (AEDFW), was used to represent the resultant improvement in regional safety. This variable, in addition to a number of other variables was incorporated into two land price functions for suburban and urban areas:

$AEDFWi = \int_0^{\infty} P(Q) * Di(Q)dQ$	AEDFWi = annual expected depth of flood water in square I [1km grid squares] P(Q) = probability of occurrence of volume of discharge Q Di(Q) = expected depth of flood water in square i associated with volume discharge Q
Urban $\ln LP_1 = 4.9231 - 0.0041X_1 + 0.0035X_2 + 0.0001X_3 + 0.1069AEDFW - 0.5952D_1 + 1.0988D_2 + 0.1424D_3 + 0.3520D_5$ Suburban $\ln LP_2 = 3.7401 - 0.0116X_1 + 0.0003X_3 - 0.2010AEDFW + 0.4032D_4$	LP_i = land price per $1m^2$, X_1 = travel time between the nearest railway station to Sapporo station[the capital], X_2 = number of workers in a square, X_3 = population within a square, AEDFW = annual expected depth of flood water, D_1 = dummy for expected residential area, D_2 = dummy for commercial area, D_3 = dummy for gas supply, D_4 = dummy for water supply, D_3 = dummy for drainage availability, ln = natural logarithm.

The annual average cost considered was defined as:

$$c = \left(i + \frac{i}{(1+i)^n - 1}\right) * I$$

where c = annual average cost, i = interest rate (4.5%), n = number of years, and I = total investment for the project.

The increase in land prices found with a reduction in AEDFW represented the benefit of a flood control project. The largest benefit cost ratio was that found for Eniwa city at 1.99, which when limited to the consideration of direct damage avoided, in order to avoid the possibility of double counting, fell to .74. The overall benefit in suburban areas was greater than in urban areas due to a greater flood area, however the urban unit benefit was much greater i.e. 44 times that of suburban units. Table 2 exhibits the similarities across Japan in terms of the % of overall damage accounted for by annual average expected damage types.

Table 2: Reduction in the annual average expected damage type estimated as a % of overall damage

Damage Type	*Ebetsu*	*Chi-tose*	*Eniwa*	*Hiro-shima*	*Nanp-oro*	*Naga-numa*	*Total*
Property-	**13.7**	**25.6**	**12.6**	**16.9**	**27.1**	**38.3**	**14.6**
Houses	4.4	5	4.6	2.1	4.1	4.1	4.5
Furniture	3.3	3.4	2.3	1.6	2.5	2.3	2.3
Agricultural capital stocks	0.1	0.3	0.1	0.1	0.49	0.9	0.6
Agricultural inventory stocks	0	0.06	0.02	0.02	0.08	0.2	0.03
Other industrial capital stocks	2.1	0.85	2.9	5.5	1.3	0.3	2.8
Other industrial inventory stocks	1.4	0.2	1.5	1.5	1	0.3	1.4
Rice	2	6	1	4.9	17.2	28.7	3
Dry fieldcrops	0.44	9.9	0.16	1.2	0.4	1.6	0.4
Public Facilities-	**22.5**	**19.4**	**22.9**	**21.7**	**19**	**16.1**	**22.3**
Roads and bridges	2.7	2.3	2.7	2.6	3.9	3.3	
Agricultural facilities	11.5	9.9	11.7	11.1	9.8	8.3	2.8
Agricultural land	0.08	0.06	0.09	0.08	0.06	0.05	11.4
Railways	1.96	1.7	1.99	1.9	-	-	0.09
Urban facilities	0.8	3.3	3.85	3.7	3.2	2.7	
Telecommunication facilities	0.34	0.3	0.34	0.3	0.28	0.2	1.8 -
Power facilities	2.1	1.8	2.1	2	1.8	1.5	3.8 0.33 2.1
Indirect Damage-	**63.7**	**55**	**64.5**	**61.3**	**53.9**	**45.6**	**63.1**
Cost of emergency measures	2.1	1.8	2.2	2.0	1.8	1.5	
Reduction in production	19.7	17.4	19.9	18.9	16.7	14.1	2.1
Repercussive effects on production.	15.6	13.52	15.9	15.1	13.2	11.2	19.5
Cost of traffic suspension	6.1	5.3	6.2.	5.9	5.2	4.4	15.5
Increase in living costs	10.7	9.2	10.8	10.3	9.0	7.6	6.1
Others	9.4	8.1	9.5	9.02	7.9	6.7	10.6 9.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Adapted from figures as reported by Miyata & Abe (1994).

Contrary to Penning-Rowsell's findings the above tables shows similarities across cities in % of total damages accounted for by each category. Examining benefit by type of damage, across cities indirect benefits were found on average to be 1.4 times direct benefits.

4.3.2. Avoided Damages Method

Potential damages avoided due to a flood protection scheme which Hueting attributed a monetary value to included loss of agricultural protection, damage to urban areas, temporary reduction in economic activities, costs of clean up, annual expenditures relating to emergency measures and health effects (Hueting, 1992). Cordery and Cloke similarly identified losses as the sum of items such as damage to property and infrastructure and disruption to businesses and transport routes (Cordery & Cloke, 1994).

4.3.2.1. Evaluating Agricultural Benefits i.e. avoided damages: This is on the basis of a farm survey (Penning-Rowsell et al, 1992) within the benefit area determining land use, soil type, and flood experience of the land. An assessment is then made of the change in the value of output using adjusted[4] product prices.

4.3.2.2. Evaluating Urban Flood Protection Benefit: The unit loss method, developed initially by Penning-Rowsell and Chatterton was adopted by Parker et al to provide standard/average or site survey loss data for residences, businesses, and general utility loss (Parker et al, 1987). Accurate loss data can be derived initially from detailed studies of 'representative' samples of land uses and activities. On completion of this stage, only outline survey data is then needed in each project area rather than a complete modelling exercise. An advantage of this unit loss method is that losses can be built up or aggregated initially from individuals, to regions, and nationally. The suitability of this method is limited however to estimating direct losses and not changes which are likely to occur throughout the economy.

4.3.2.3. Evaluating intangible flood protection benefits i.e. intangible losses avoided
Qualitative Evaluation: This is the description of intangible benefits and costs comprehensively and clearly without attempting to assign a monetary value.

Bootstrapping: Bootstrapping is a method of deriving equivalent monetary values for unquantified losses, based on an extensive interview survey with flood victims (Green et al, 1989. Penning-Rowsell et al, 1992). A schedule for such surveys has been developed by Middlesex university and validated through 2000 interviews with flooded households.

Green's approach is illustrated in a number of steps:

1. Respondents were asked about the financial value of their losses and to rate the overall severity of the flood in terms of its impact on household life, and the relative severity of each of individual impacts. Scores on a scale of 1-10 are illustrated in table 3, 10 representing very severe damage and 1, least severe.
2. Table 3's subjective severity judgements for one of the two direct damages (i.e. fabrc of the house, and its contents) were regressed[5] on a number of independent variables including financial magnitude of direct damage.

Table 3: Relative severity of different impacts or flooding as assessed by those who reported experiencing each impact

Damage	*Swalefcliffe*	*Uphill*	*Southgate*
Damage to house structure	5.0	5.0	3.0
Damage to replaceable contents.	9.0	7.0	0
Loss of memorabilia.	10.0	7.0	-
Health effects.	7.5	5.0	2.0
Stress of the flood itself.	10.0	n/a	6.5
Evacuation.	10.0	6.0	-
Disruption.	10.0	10.0	6.0

[n/a = not asked. - = no household suffered impact]
Source: Adapted from Green et al, 1989.

3. Monetary equivalent values for unquantified impacts were derived though:
    - an equation invented to express subjective severity in terms of pounds, see below.
    - insertion of subjective severity judgements for each of the unquantified impacts into equation.

$$\text{Log(subjective severity)} = 0.30\log(\pounds) + 0.01$$
$$(r = 0.75;\ F = 74.90;\ p <= 0.001)$$

4.3.2.4. Evaluating Environmental Benefits i.e. environmental flood losses avoided

The benefits from saving environmental functions can be estimated through a 'collective political decision' by experts as referred to by Hueting (Hueting, 1992), contingent valuation or shadow prices.

With the shadow prices approach the potential loss avoided is estimated as the cost of creating or recreating exactly the same ecosystem elsewhere, e.g. the loss of an area of marshland would be valued as the cost of buying the same area and type of land elsewhere, and then establishing the same ecosystem (Penning-Rowsell et al, 1992). Indirect environmental benefits have been found to be well in excess of direct benefits, in this case, approximately double direct damages.

5. Indirect Benefit: Enhanced Flood Warning Systems

5.1. Benefit Category: Flood damages are a function of water depth and warning time, defined by Day in the equation (Day et al, 1969):

$$E(D) = \Sigma^{n}_{i-1} PiDi$$

Pi = probability of a flood within the 'steps'/recurrence intervals i and i - 1
Di = community damage associated with flood level at top of step i, a function of the warning time, type
of action and response to the warning.
E(D) = expected annual loss
n = number of contour steps to approach floodplain limit, also representing the recurrence interval

Damage losses may be avoided through improved flood warning systems.

5.2. Relationship of Benefit to Data Collection: Increased length or accuracy of data leads to more precise flood warning schemes.

5.3. Economic Approaches to Evaluating the Benefits of Enhanced Flood Warnings

The approach adopted by Walsh and Noonan to assessing the contribution of weather data to flood warning may also be applied in relation to directly evaluating that of hydrometric data (Walsh & Noonan, 1990). The steps involved in this approach are outlined below, the assumptions upon which it was based including that:

- the weather radar network was operational 95% of the time.
- there would be a 70% response rate by occupants to warnings. Weather/flood warnings are of no value without good communications to the public.
- the availability of suitable flood forecasting/warning models, using radar (or in our case hydrometric data) as an input.
- benefits only relate to flood damage reduction.

1. Identification of sites where radars could provide greatest flood warning benefit. All flood data was collected on property at risk within England and Wales, flood damage assessment based on Penning-Rowsell and Chatterton's methods.
2. Classification of risk to property in terms of three categories of frequency of occurrence (1 in 10 yrs, 1 in 10 - 1 in 50 yrs, 1 in 50 yrs) plus catchment response times.
3. Conversion of single flood event data (from step 1) to average annual benefit using factors derived from derived from assumptions damage levels for differing flood events, see annexe 1and table 4 below.

Table 4: Factors to multiply single event damage reduction to give average annual benefits.

Category	*Event*	*Multiplying factor*
A	Flooding more frequent than 1 in 10 years	0.25
B	Flooding frequency between 1 in 10 and 1 in 50 years	0.07
C	Flooding less frequent than 1 in 50 years	0.02

Source: Adapted from Walsh & Noonan. (1990).

4. Derivation of weighting factors based on catchment response time of 4 hours. When response times were between 6 and 9 hrs radar was assumed to be of some value, and to be very useful for response times between 3 and 6 hrs, table 5.

Table 5: Weighting factors to give benefit due to radar

	No existing F/W scheme				*With existing F/W scheme*			
Times of response (Hrs)	0-3	3-6	6-9	>9	0-3	3-6	6-9	>9
Without 'Frontiers'*	0	0.8	1.0	1.0	1.0	0.6	0.2	0.05
With 'Frontiers'	1.0	1.0	1.0	1.0	0.9	0.75	0.2	0.05

* radar operating in conjunction with additional rain forecasting system.
Source: Adapted from Walsh & Noonan. (1990).

The most updated figures available using Walsh and Noonan's method calculate benefits, on the basis of giving a 4 hr. warning, to be £1.56m per yr, rising to £3.84m when data is combined with 'frontiers' data, implying benefit cost ratios of 3 and 5 respectively.

Benefit Transfer: The extent to which both standard and average data are available for flood damage has facilitated the transfer of flood alleviation benefits.
The term standard depth damage is reserved for data assembled from secondary sources. Average data is used to denote data derived from previous site surveys, averaged to give a generalised indication of flood damages for property types. UK damage data to residences/commercial units is frequently updated in the Flair report, by Middlesex University. Table 6 outlines different types of currently available data.

Table 6: Different types of flood damage data available and their characteristics

Types of Data	*Examples*
Standard Data • Based on specified simplifying assumptions regarding flood characteristics, e.g. velocity effects are minimal. • Based on specified costing approach e.g. use of average remaining values.	Direct depth damage data for residences

• Based on a synthesis of data from multiple primary and secondary sources including loss adjustments. • Assumed to be transferable throughout U.K.; may incorporate national secondary data sources based on sample surveys. • Available where damage characteristics are likely to be very similar because properties or services are similar.	Emergency Services cost data
Average Data • Based on assessments of flood loss potential from a large number of cases/properties using e.g. business site survey interview schedule. • Based on specified costing approach but also relies on property manager's estimated. • devised where there is relatively high variability between damage sensitivity of properties and where standard data cannot be devised. • transferable within the UK but cannot be expected to take full account of uniqueness of properties.	Direct depth damage data for industry Manufacturing flood loss data
Site Survey Data • Loss data collected by 'one-off' site surveys using, e.g. business site survey interview schedule. • Most reliable where properties or locations have unique damage characteristics.	

Source: Adapted from Parker et al. (1987).

6. Indirect Benefit: Recreation Benefits from Enhanced Flood Protection/Flood Warning Systems

6.1. Benefit Category: In addition to improved water quality, recreational benefits also accrue to more effective flood warning / flood alleviation measures. The difference lies in that in the case of water quality improvement, benefits relate more to an increase in the quality *and* quantity of recreational uses, while the latter concentrates on the benefits stemming from increased amenity land saved from flooding, through flood warning systems and better design of flood mitigation measures.

6.2. Relationships of Benefits to Data Collection: As hydrometric data increases, 'the inherent uncertainty of the characteristics of the stream flows decreases and confidence which aids the design of flood mitigation measures and issue of flood warnings increases (Cordery & Cloke, 1994). More effective flood warning procedures avoid the loss of amenity land through flooding.

6.3. Economic Approaches to Evaluating Recreation Benefits from Enhanced Flood Protection/Flood Warning

6.3.1. Travel Cost Method

Section 2 offered a discussion of this method in relation to improved water quality. Penning-Rowsell et al in their evaluation of coastal flood protection proposed that in addition to the loss of enjoyment that may follow due to flooding, the possibility that users will decide to transfer their visits to an alternative site should also be taken into account, in total economic loss, illustrated in figure 1.

Figure 1: Estimating total economic loss in terms of recreation from flooding

1. $B_1 = Eo - E_1$

2. $B_2 = (Eo - Ea) + (Ca - Co)$

Eo = Value of enjoyment of today's visit/a visit in current conditions
E_1 = Value of enjoyment per visit after flood
Ea = Value of enjoyment per visit at the alternative site visited after flooding
Ca = Cost incurred in visiting the alternative site after flooding
Co = Cost incurred in visiting the present site.
B_1 = Benefit when economic loss is measured by the loss in enjoyment only
B_2 = Benefit when economic loss is measured by the difference between enjoyment at the site plus any increase in cost involved in visiting the alternative site.

Source: Penning-Rowsell et al. (1992).

Similarly to the case with water quality, the travel cost method generally leads to an underestimation of flood alleviation benefits (Brookshire & Smith, 1987). While Green et al however questioned the validity of the approach in relation to water quality improvement benefits, Penning-Rowsell et al propose TCM as a 'sound basis' for the use of CVM in relation to recreational benefits of flood alleviation (Penning-Rowsell et al, 1992).

6.3.1.1. Hedonic Travel Cost Method: This method, described in section 2, may also be appropriate in valuing the recreational benefits from more effective flood alleviation.

Benefit Transfer: The 'per recreation day' standard values as attributed with the hedonic travel cost model, may be suitable for equating with days lost due to flooding in similar catchments.

Part 2 - General Approaches to Cost Benefit Analysis

The aim of this report is to consider economic approaches which provide a clear evaluation of the worth of hydrometric data. This has been attempted essentially in a piecemeal fashion by valuing the indirect benefits of data collection, as outlined, and proposing that they then be apportioned to hydrometric data in a quantitative way. In parallel to this it may be useful to consider a more general approach which examines the relationship between data collection and risk reduction.

Evaluating the Collection of Hydrometric Data Directly Through its Relationship to Risk/Uncertainty Reduction

Introduction - A Distinction Between Risk and Uncertainty

Environmental decision making, according to Faucheux and Froger, will always be in the context of uncertainty in addition to complexity (Faucheux & Froger, 1995). Forecasts which concern hydrometeorologic phenomena were highlighted by Krzystofowicz as 'inherently uncertain'. This uncertainty he categorised as: 'natural uncertainty' which stems from the nature of hydrological systems and 'forecast uncertainty' stemming from the processes involving the interpretation of this data (Krzytstofowicz, 1983).

Dasgupta and Pearce also classify uncertainty in project evaluation in terms of its source in an attempt to emphasise the need to modify the standard methodologies of CBA, as discussed in part one, to incorporate this (Dasgupta & Pearce, 1972).

In adopting a suitable economic approach to evaluate the worth of hydrometric data however, it is important to distinguish between the terms *risk* and *uncertainty*. The crucial factor for Dasgupta and Pearce rests on the availability of information. If probabilities can be assigned to specific outcomes the situation is defined as risky, and if consequences cannot be identified with any likelihood the situation is deemed one of uncertainty (Dasgupta & Pearce, 1972). Similarly Vercelli refers to risk as being based on 'a reliable classification of possible events' with uncertainty referring to 'events whose probability distribution does not exist or is not fully definable for lack of reliable classification criteria' (Vercelli, 1991).

Finally, Fauchaux and Froger identify all the interactions between the economic system and the environment as being under *strong uncertainty*, on a scale of certainty to ignorance. This is described as a distribution of 'non-additive probabilities and/or by a plurality of probability distributions which are not fully reliable.' (Fauchaux & Froger, 1995).

1. Dealing With Environmental Uncertainty Within an Economic Framework

Traditionally, several approaches have been adopted in dealing with uncertainty, summarised by Zerbe and Dively (Zerbe & Dively, 1994):

1. Ignore uncertainty, appropriate where it is small, time span of importance is short or where CBA is only a rough estimate.
2. Reduce it to levels where it can be ignored by gathering additional data or more accurate information.
3. Recognise uncertainty and factor it into analysis with the introduction of sensitivity analysis, simulation or decision trees.
4. Adding a risk premium to the discount rate (Parker et al, 1987).

Adding a risk premium to the test discount rate is an unsatisfactory method as increasing it also reduces the effective time horizon for the scheme i.e. the higher the discount rate the closer is the date when benefits or costs accruing will be zero. The most preferred method for coping with uncertainty, according to Parker et al is sensitivity analysis which may be relevant in our case for the apportionment of indirect benefits to data collection.
The following general approaches rely on the second method above, the collection of additional data and its relation to error (equated to risk) reduction.

1.1. Data Collection and its Relationship to Error Reduction

This is based on the assumption that the benefits from increased hydrological information [Bh] are related to the % standard error [Eh] affecting the hydrological parameter:

$$Bh = f[Eh]$$

It is proposed that the *cost* of decreasing the standard error ΔC_{eh} by ΔEh, can be estimated in terms of the variables:

1. Increased frequency of measurement [ΔNm]
2. Increased number of stations in the study area [ΔNs]
3. Additional number of years in operation [ΔNt]
4. Better interpolation technique [ΔCi]

Precise relationships are illustrated in the box 1.

Box 1: Relationship of data collection to error reduction

Cost of decreasing error: $\Delta C_{eh} = f(\Delta Nm, \Delta Ns, \Delta Ne, \Delta Ci)$
Marginal benefit of decreasing error: $\Delta Bh / \Delta Eh = f(Eh - \Delta Eh) - f(Eh)/\Delta Eh$
Marginal cost of decreasing error: $\Delta C_{\Delta eh} / \Delta Eh = f(\Delta Nm, \Delta Ns, \Delta Ne, \Delta Ci) / \Delta Eh$

Source: Adapted from McMahon & Cronin. (1980).

This method is generally applied to data evaluation on planned water resource projects in respect to a particular region or network.

Edgar et al. suggested early on that the adequacy of hydrologic data [i.e. which encompasses hydrometric data] in economic terms, centred upon the marginal cost associated with improving the data being just equal to the marginal benefit resulting from the improvement in information relating to potential flood damages for example, and reduction in error implied as a result (Edgar et al. 1973).

McMahon and Cronin's marginal economic analysis approach focused on developing statistical relationships of increasing/reducing uncertainty(exhibited through differing errors) to the construction costs of dams/reservoirs, culverts/bridges, regulation measures, and hydropower operations and examining which had the greater influence (McMahon & Cronin, 1980). It supported the continuation of data collection in that the disbenefit of a 20% reduction in the Canadian data collection network was greater than the relative benefit in continuing data collection activities.

1.2. Non-Bayesian Decision Theory

An appropriate way to assess the value of data collection is to estimate the value of the next data sample. This involves:

1. The definition of a benefit/error function, similar to the error reduction approach
2. Translation of benefit/error function to a benefit/length of record function
   a. Simulation of long period of record
   b. Splitting this into sections [Ts]
3. The separate use of each section for designing the project and benefits calculated [Bs]
   a. Bs is compared with benefits from using a long period of record [Bl].
   b. The difference [ΔBs = Bl - Bs] can then be attributed to the additional period of record [ΔTs = Tl - Ts].

In assessing the value of data to flood mitigation planning, Cordery and Cloke divided available streamflow data for N.S.W into small sample sizes [10 years] to estimate design flood levels which were then used to develop damage frequency relations (Cordery & Cloke, 1992). Levee construction costs to each sample's design level were calculated, which allowed the difference in benefits between different design levels to be estimated. This allowed the value of 10 extra years of data given that 20 years are available, for example to represent the difference in overall benefits. The situation was simulated using data from an existing monitoring station for which a long record was available. Assuming that flood mitigation protection measure planning was the only use, benefits were up to eighty times the cost of annual data collection at the site.

In 1993 the value of streamflow data for flood estimation for minor structures was assessed by examining the improvement in design flood estimation during the period 1958 to 1987 (Cloke et al, 1993). It was assumed that design floods estimated in 1987 incorporating the most recent methodology, and longest record length 'would be the closest to the intended or true design value'. Hence benefits were related to the avoidance of additional costs resulting from underdesign/overdesign, variables considered including flood damage cost, flood durations, average number of vehicles affected [annual average daily traffic values], detour distances [assuming that traffic affected would choose to detour], traffic detour costs [allowing for occupants' time, and vehicle depreciation, maintenance and fuel costs and frequency of overlapping. Relevant costs were those from collecting streamflow data.

As early as 1965 Linsley also identified that cost savings could not be related in a linear fashion to data accuracy (Linsley, 1965), while Cordery and Cloke, in 1993 found a similar nonlinear relationship with regard to reservoir storage design, i.e. that the present worth of collecting the 'next' sample of data is much smaller than the present worth of collecting the 'previous' sample of data (Cloke & Cordery, 1993).

Overall Cloke and Cordery concluded that benefit cost ratio depended on the amount of existing *and* additional data, and the number of sites at which data are to be collected.

Table 7: Formulae for use in benefit cost study for minor waterway construction

Underdesign Cost Estimation $C_u = (R_u.N.C_{fd}) + C_t$ $C_t = R_u.N.E_u.T_u.[(D.C_v) + (O.C_p.D/S)]$ C_u = total costs resulting from underdesign during design life \$. C_{fd} = average flood damage costs per structure during design life \$ C_t = costs resulting from traffic disruption 4 C_v = vehicular costs, \$/km D = average detour distance, km S = average vehicle speed, km/hr O = average vehicle occupancy T_u = average no. of vehicles delayed, in addition to design intention by underdesign E_u = extra flood overlappings during design life N = no. of structures in region R_u = ratio of underdesigned structures to total sampled	***Underdesign Savings*** $S_u = R_u.N.S_w$ S_u = total savings resulting from underdesign S_w = average savings per structure from reduced capital expenditure for structures underdesigned, \$
Overdesign Costs $C_o = R_o.N.C_a$ C_o = total costs resulting from overdesign, \$ C_a = average cost per structure of unnecessary capital expenditure due to overdesign of structure, \$ R_o = ratio of overdesigned structures to total sampled.	***Overdesign savings*** $S_o = (R_o.N.S_a) + S_t$ $S_t = R_o.N.E_o.T_o.[(D.C_v) + (O.C_p.D/S)]$ S_o = total savings resulting from overdesign during design life, \$ S_a = average savings in flood damage during design live per structure from reduced overlappings, \$ S_t = savings resulting from reduced traffic disruption, \$ E_o = reduction in flood overlappings during design life T_o = average reduction in vehicles delayed due to overdesign

Source: Cloke et al. (1993).

Benefit cost ratios for a programme of data collection relating to minor waterway crossing design were estimated as 120, 21, 4.4 and -0.25, for discount rates of 0, 4,7 and 10% respectively. These could be considered conservative estimates however, taking all program costs into account but relating benefits to just one use. Equivalent monetary benefits ranged from $3900m to $350m with 0 to 7% discount rates.

Similar to Cloke et al's 1993 study, Ramirez et al examined the effect of additional information on better flood alleviation designs in Rushford Minnesota, by examining the *ex-post* value of information (Ramirez et al, 1988). The value of information concept (VOI) used in these two approaches was ex post in the sense that the information was on hand when its value was determined. This contrasts with bayesian approaches where the exact information to be received is unknown at the time its potential value is assessed. New estimates with 28 years additional data showed a reduction in avoided damages from $30,750 to $21,420, and as a consequence a reduced b/c ratio of .87

The value of increased data collection at two observation stations on the Lapuanjoke river in Finland was calculated by the value of land which could be used due to decreased uncertainty on the area at risk from flooding i.e. an extra 80ha, see table 8 (Laitinen & Puupoponen, 1996). It was found however that benefits stabilised after 40 years.

Table 8: Uncertainties of HQ150* and benefits of data

Period (yrs)	*HQ 1/50 Station 1. (m_3/s)*	*Station 2. (m_3/s)*	*Benefits (million FIM)*
10	210-500	96-228	0
20	240-430	109-196	4,8
30	290-410	132-187	6,4
40	290-400	132-182	8,0
50	295-395	134-180	8,0
60	310-395	141-180	8,0

* lowest limit of elevation permitted for construction on floodplain.
Source: Laitinen & Puupponen. (1996).

Benefit Transfer: Hydrometric data are used very differently for specific investment project. Cordery and Cloke found also that even for similar project types, from site to site benefits varied depending on size of basin upstream, of the site, local topography, flooding frequency and the number and damage susceptibility of the properties to be protected (Cordery & Cloke, 1991).

1.3. The Use of Bayesian Decision Theory

The application of decision theory to evaluating the worth of data involves a number of steps:

1. A set of initial existing data e.g. time series/probability distribution], known as the 'prior' is used to design the water resource project in question e.g. flood control.
2. The times series/probability distribution is modified over time with new data, known as the 'posterior'
   a. the 'prior' estimates are revised using bayes' theorem, improving information and reducing error, illustrated in box 2:

Bayes rule/theorem

$$P(ai/c) = \frac{P(ai)\ P(c/ai}{Ei\ P(ai)\ P(c/ai)}$$

ai = a priori probability estimates
c = new information

3. Calculation of the expected opportunity loss [EOL], which is represented by the difference between additional benefits due to better design and additional costs due to acquisition of additional information. The optimal design is that which minimises XOL. XOL, however, cannot be calculated until all possible outcomes for additional measurements and corresponding posteriors are examined.

In Simpson's 1987 review of methodologies for estimating the value of streamflow data, bayesian decision theory, in providing a method to 'pool or update' information was deemed superior to earlier methods, such as generating synthetic records through identifying statistical distributions (Simpson et al. 1987).
Davis, Kiesel and Duckstein's early paper also illustrated the application of bayesian decision theory in assessing the value of additional data by incorporating it into engineering decisions on flood levee design on the Rillito Creek floodplain (Davis et al. 1971).
Adeloye suggested a bayesian approach to evaluating the worth of hydrometric data for reservoir capacity in examining the 'dependent' relationship which exists between reduction in uncertainty (equated to temporal error, see figure 2) and costs of reservoir over/under design (Adeloye, 1995). Due to the complexity however in defining such a relationship for each error type, Adeloye proposes the use of Monte Carlo simulation.

Figure 2: Breakdown of Total Data Error

$$e = \sqrt{(e^2_g + e^2_t + e^2_s + e^2_m)}$$

e^2_g = Gauging error due to flow measurement
e^2_t = Temporal error due to short data record length
e^2_s = Spatial error due to data transferred from a measurement location to the location of the project
e^2_m = Model error due to assumptions concerning the nature of the random hydrological process.

Source: Adapted from Adeloye 1995.

Adeloye found that when the length of data record was increased fourfold, the temporal error was only reduced by 50%, and with an eight fold increase the error was reduced by a factor of 2.8.

1.3.1. The Suitability of Bayesian Decision Theory Within an Environmental Decision Making Framework

On closer examination of the nature of both bayesian methods and environmental decision making it becomes apparent however that, despite widespread application, they may be somewhat incompatible:

1. The process of developing equations to reflect all possible interactions among variables, and assigning different probabilities of outcome is very time consuming (Zerbe & Dively, 1994), and expensive. This also implies that the assignment of objective probabilities to established outcomes is justified, implying in turn, the existence of a risky situation, and not one representative of environmental uncertainty, as defined (Dasgupta & Pearce, 1972).
2. This is essentially a project specific approach relying on the availability of detailed project specific costs.

In 1977 Klemes highlighted that when using hydrometric data as a decision basis in reservoir design one must remain aware that one is dealing with a 'complete random process' (Klemes, 1977), while Davey believes that while historical extreme flood events give a useful guide to the possible size of maximum floods, the fact that several recorded floods have exceeded maximums set highlights the potential extreme responses. Machina suggests that such traditional theories of decision making, as bayesian may need to be reversed with the occurrence of different forms of uncertainty (Machina, 1987).
If bayesian decision theory was to be adopted its use would be dependent on a large number of simplifying assumptions (Cloke & Cordery, 1993).

Part 3 - Valuing The Hydrometric Data Collection *Network*

1. Network Approach to Data Evaluation

Mawdsley et al examined the value of data for the design of flood protection schemes with respect to a gauge network in NE England.
Historic data was used to assess the effects of obtaining further data rather than expectations based on all possible future flows.

The general principle behind this approach was the assessment of the opportunity loss of making a wrong decision given imperfect data. According to Mawdsley the value of existing data is represented by the difference between the opportunity loss of decision making in the design of a flood protection works without any data, and that with hydrometric data[6] (Mawdsley et al. 1990):

$$\text{Data Value} = EOL_{yo} - EOL_y$$

Yo = data available in the absence of a gauge. In the absence of data other information would be used to make the decision e.g. rainfall information, or simulated data.
Y = data available with the gauge

To assess the expected opportunity loss for a given level of data, an opportunity loss function was obtained which is a function of the error in the estimate of the design parameter (e), and a probability distribution of the error p(e) is also required, which was then combined to obtain:

$$EOL_y = \int_{-\infty}^{\infty} OL(e)p(e)de$$

By considering all contributing errors in the data, the probability distribution of the error in the design was estimated, the errors being classified into four groups i.e. gauging, temporal, spatial and model.
With application of this method to three network case studies, see table 9, Mawdsley found data value increased at a diminishing rate, whereas annual costs varied relatively little after installation.

Table 9: Value of hydrological data for flood protection only in three case studies

Values/Scheme	*Morpeth*	*Stokesley*	*Croft*
No. of gauges	1	2	3
Station years of data	10	24	54
Cost of scheme	£172,000	£325,000	£90,000
EOL [base level]	£10,650	£14,950	£1,100
Value of gauge data	£7,910	£12,350	£3,980
Cost of data for station year	£ 758	£1,378	£1,378
Value of data per station year	£791	£515	£74
Values as % of scheme cost	5	4	5
Benefit/cost ratio	1.0	0.37	0.05

Source: Adapted from Mawdsley et al. (1990).

The value of data was shown to be 4-5% of construction costs of the flood protection scheme for the lengths of data available considering flood protection as the only application of the data. The relatively low benefit/cost ratio for the flood protection schemes may have been caused by their small sizes. If a bigger scheme was undertaken and the 4-5% value was still correct, then the benefit/cost ratio would increase.

2. The Audit Approach

The audit approach, developed by Davar and Brimley, has been used to identify areas where improved network performance could be achieved without any additional resources, and to provide a guide by which to assess the impacts of any decision (Davar & Brimley, 1990).

Contrary to cost benefit analysis however, no monetary value is assigned to benefits. Instead the total set of existing and proposed stations are prioritised or ranked in order of performance on a number of considerations:

1. A survey identifies users' needs
2. Uses are rated on the basis of % benefit attributable to data
3. A set of priority considerations/criteria is outlined i.e. site characteristics; identified client needs [in terms of hydrology and operational] and a region's importance for water resources.
4. Individual gauging stations, organised on a catchment basis are assessed, by a number of water resource experts and managers, in terms of the extent to which they reflect priority considerations, see table 10.
5. The higher the total station audit points accumulated by a particular station, the higher the relative value of benefits derived from that station.

Table 10: Example of network evaluation audit for New Brunswick

Priority Consideration - Site Characteristics	*Available Points*	*Maximum Score Possible*	*Rationale for Score*
Mean annual flow		6	Large drainages provide more representative samples for province as a whole.
• less than $25m^3/s$	2		
• $25 - 125m^3/s$	4		
• greater than $125m^3/s$	6		
Water level only		3	These stations provide less info. than flow stations.
Quality of record		15	The better the quality of record the greater the information value.
Period of record (years)		10	Short records need to be extended to establish a record. Once record is established it is of decreasing value, with exception of very long records, which become valuable for index purposes.
• 0 - 5	7		
• 6 - 10	5		
• 11 - 15	3		
• 16 - 25	7		
• 26 - 40	10		
• greater than 40			
Proximity to climate station		5	Stations whose record may be readily related to comparative meteorological data have added information value.

Source: Adapted from Davar and Brimley. (1990).

The audit approach offers an approach also to identifying redundancy in gauging stations, in assessing stations on the basis of such criteria, as outlined above, in addition to marginal costs. The priority considerations for site characteristics could also be based on responses from user surveys.

Review Conclusion

The above review examines potential approaches to valuing hydrometric data in three parts:

1. Detailed approach to cost benefit analysis
2. General approach to cost benefit analysis
3. Valuing the hydrometric data collection network

A two step procedure was suggested in relation to part 1, where indirect data collection benefits e.g. flood protection, could first be quantified and then apportioned to actual hydrometric data. For comprehensive coverage of these indirect benefits, both tangible and intangible (para 4.3.2.3.), a combination of primary survey techniques would be required implying considerable investment in time and money. In an attempt to avoid this, benefit transfer was also discussed, as useful in approximating values, if reliant on the availability of existing updated values.

General approaches value the worth of hydrometric data through its relationship to risk/uncertainty reduction. Such approaches, as outlined in part 2, have been used extensively in recent years with regard to investment planning. The difficulty in applying these techniques for our purposes however stems from their project specific nature which prevents the transfer of benefits, possible in part 1.

Finally, part 3 proposes a more holistic approach, focusing on the valuation of the data collection network, with the potential to then narrow down specific stations. The audit approach (part 3, section 2) in particular is highlighted as offering a possible 'user friendly' solution to the valuation issues faced by Environment Agency and S.E.P.A officers across functions, however its effectiveness, as will be discussed in Hanley's forthcoming paper, may rely on its use in association with further statistical techniques to develop an efficient *framework* for economic valuation.

Annexe 1

Determination of multiplication factors to convert benefits of floodwarning from single events to average annual benefits

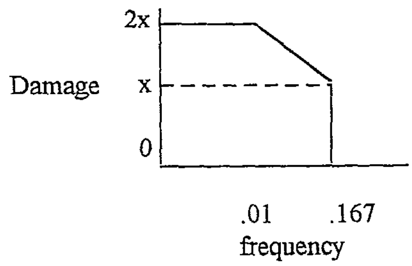
A) Flooding more frequent than 1 in 10 yrs:

In this category of flood risk zones it was assumed that protection was given up to approx. 1 in 6 year frequency, with damage doubled for a 1 in 100 year and less frequent events.

- assume single event damage reduction = £x
- average annual benefit (area under curve)

$= 2x * .01 + \frac{2x + x}{2} (.167 - .01)$

$= 0.255x$, i.e. .25 = 'frequency factor'



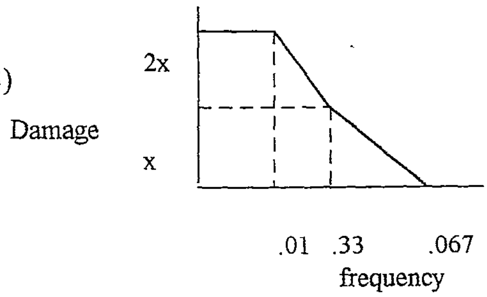
B) Flooding frequency between 1 in 10 and 1 in 50 yrs.

Assume average flood frequency to be 1 in 30 years with flood damage doubled for a 1 in 100 year and less frequent events and with damage reduced to zero for a 1 in 15 year event.

- assume single event damage reduction = £x
- average annual benefit (area under curve)

$= 2x * .01 + \frac{(2x + x)}{2} (.033 - .01) + \frac{x}{2} (.067 - .033)$

$= .00715x$, i.e. .07 = 'frequency factor'



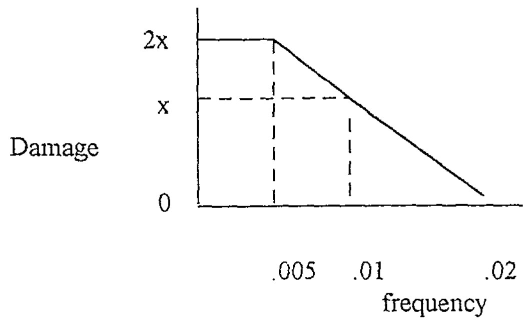
C) Flooding frequency less than 1 in 50 yrs

Assume average flood frequency to be 1 in 100 years with flood damage doubled at 1 in 200 years and less frequent events and with damage reduced to zero at a frequency of 1 in 50 years.

- assume single event damage reduction = £x
- average annual benefit

$= 2x * .055 + \frac{(2x + x)}{2} (.01 - .005) + \frac{x}{2} (.02 - .01)$

$= 0.022x$, i.e. .02 = 'frequency factor'



[1] Benefits from groundwater quality improvement are included due to its importance in catchment management, for public and private water supply and for providing base-flow for many surface water systems (Newson, 1995).

[2] Total willingness to pay may be sought from individuals, or alternatively broken down into its components; current personal use values [current use values], possible future use values [option values], future generation use values [bequest values], non-use values [existence/intrinsic values].

[3] The majority of the 38,000km of watercourse in Britain, are too narrow and shallow ever to support activities in addition to recreational activity (Green & Turnstall, 1991).

[4] Adjustment factors published by the Ministry of agriculture, fisheries and food, 1985.

[5] Assumptions made included that impacts are independent, and that an acceptable regression equation could be obtained.

[6] This implies that Mawdsley believes there remains a level of inherent uncertainty even after the collection of hydrometric data.

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APPENDIX III

Evaluating the Benefits of Hydrometric Networks

Paper to the Environment Agency by University of Dundee, University of Stirling and Scotia Water Services

ALTERNATIVE METHODOLOGICAL APPROACHES TO REPRESENTING THE ECONOMIC BENEFITS OF HYDROMETRIC DATA

version #2

author: Nick Hanley

1. The objectives

This project is concerned with estimating the benefits of hydrometric data. Three possible motives for doing this are the abilities to be able to:

(i) rank gauging stations in terms of their relative economic benefits
(ii) conduct marginal cost-benefit analysis of whether an additional station should be added to network, or whether an existing station should be shut down, and
(iii) assess the public value of a gauging network in terms of its total economic value.

In case (ii) above, information on the (marginal) costs of data collection is needed; in cases (i) and (iii) it is not, although in case (iii) total economic value could be compared with total system costs. Expressing benefits in monetary units allows them to be compared with costs.

2. The problems

Essentially, these can be summarised as the following:

(i) the benefits of any given gauging *network* are many and varied, as shown by our interview responses, and by our questionnaire survey
(ii) operationally, it seems unlikely that sufficient funds and/or experience would be available to carry out original empirical work on benefit estimation in all cases, except perhaps for major network reviews
(iii) the implication is therefore that "standard" benefit figures should be made available, in an attempt at benefit transfer. However, there are very considerable problems with such benefits transfers.
(iv) in any case, it is well known that the standard errors on estimates for non-market benefits (such as improvements in water quality) are typically wide
(v) finally, the benefits of continuing to collect data from a given station are known to depend partly on the length of record already existing for that station: whilst station benefits are also dependent on how unique that station is in terms of representing varying catchment characteristics and/or the spatial location of economic activity (such as rural vs. urban).

The above problems make it unlikely that a simple application of Cost Benefit Analysis (CBA) is possible, but also that funds/expertise are unlikely to be available for a more sophisticated CBA except in the case of very major changes to the monitoring network. However, objectives (ii) and (to a lesser extent) (iii) above imply some sort of quasi-formal CBA framework.

3. Economic value estimation and the benefits of hydrometric data

The economic benefits of collecting hydrometric data are, in principle, similar to the benefits of collecting any other kind of information regarding uncertain outcomes, such as weather forecasting or forecasts of the rate of inflation. This is that such collection enables either an increase in economic benefits or a decrease in economic costs, often in a planning context. Given uncertainty, these costs and benefits may be expressed in terms of expected values[1] or certainty equivalents. What is more, the economic criterion for how much information to collect is the same in all these situations: namely, that if the right amount of information is collected, then the marginal cost of collecting one more (or one less) "unit" of information be equal to the marginal benefits. This criterion could also be applied to decisions over whether to add or subtract one more information gathering unit. Aside from planning-type applications (where "planning" is interpreted in the broadest sense), the other major category of benefit is in real-time uses of data, in flood warning and abstraction control.

Two problems thus arise in the context of hydrometric data: these are (i) what to count as economic benefits, and how to value them; and (ii) how to define the "information generating unit". For many classes of benefit we have identified (see Nevin (1996) (Appendix II), and the report on the questionnaire data (Appendix I)), the benefits of collecting data for the purposes of, for instance, flood warning, would seem to be applicable more to the catchment, or a river (ie some concept of a network) than to any one station. If this is true on the whole, then it makes more sense to consider either the river or the catchment as the information generating unit, for which economic benefits will be measured. In this case, the question of whether to add or remove one more station to the network becomes a hydrometric question, concerned with the increase in predictive performance for the system as a whole.

Nevin (1996) reviews the techniques which could be applied to a large range of potential benefits for hydrometric networks, and actual experience with these methods. Summarising, benefits can be classified as those affecting market-valued resources (such as housing or bridges) and those affecting non-market resources, such as water quality. Very few of these benefits are likely to be "captured" by the data gatherer, either due to the non-market nature of the benefits, or the public nature of the data. A complementary classification is to recognise:

- benefits of real-time data (eg flood warning, abstraction control): these benefits can potentially be market-valued;
- benefits relating to investment planning (eg new bridges, dams, reservoirs, housing): these benefits can also potentially be market-valued;

[1] Although the use of expected values implies we know (i) the complete range of possible outcomes (states of the world) and (ii) the probability distribution of these outcomes. This is unlikely to describe all situations.

- benefits relating to water quality planning (e.g.setting of pollution constraints and abstraction/return flows). These benefits are unlikely to be market-valued.

In these three cases, benefits are, in general terms, given by:

- avoided damages (flood warning)
- avoided costs of over- or under-investment. The maximum Willingness To Pay (WTP) of users of information for these purposes (eg construction companies) would indicate its value here: however, such maximal WTP amounts are not revealed by the current process of giving out such information. Freeing up the market for hydrometric data would produce prices closer to this desired signal, and reveal something about the price elasticity of demand for information.
- through a production function, where information is one input (along with abatement expenditure and flows) to increasing water quality. More information as an input can allow for less spending on abatement, or better management of return/abstraction flows, to produce a given level of water quality.

In all these cases, however, it is crucial to separate out the marginal effect of providing more information from the value of the resource or service flow concerned. For example, not all of the value of water quality improvements could be attributed to providing information if additional abatement expenditure occurs. What we must aim to do is estimate the marginal value (marginal value product, in the case of the production function approach) of information.

4. Possible methodologies for analysing the economic benefits of hydrometric data

Here we outline three possible approaches to incorporating the economic benefits of hydrometric data into a decision-making framework.

4.1 An approximate CBA approach

In what follows, we assume that, either through original empirical work, or through some benefit transfer process, economic values have been arrived at for all possible categories of benefit (not forgetting, though, the considerable empirical difficulties involved here, as noted in Nevin, 1996). These economic values might be expressed in terms of £ per £ spent on data collection gleaned from previous case studies. Expenditure could thus be used as a measure of the quantity of information. Alternatively, benefits could be expressed per measuring station (ie total benefits divided by the total number of stations), again from case studies, and again with the purpose of relating benefits to the amount of effort input, and the quantity of data. These benefit figures will be referred to as "base values": see Table 1. We know that the length of existing data records is important in determining the value of additional data; so these base values would then be weighted to take account of this. Finally, special local circumstances might exist, making the benefits in any one category larger than average, so weights could be attached here too, based for example on the spatial characteristics of the catchment (we do not discuss how to arrive at these weights yet: for data length, we need to estimate the functional form of an equation relating data usefulness-eg predictive power- to length of record). Then, for any system, the relevant benefit categories are entered, and weighted average scores computed for each benefit category. Summing these gives either the total benefit per £ spent on the network, or per station. In the former case, multiplying by actual system costs and then comparing with these costs gives an approximate equivalent to CBA . In the latter case, multiplying by the number of stations and then comparing with system cost again gives a CBA-type comparison. **It should be noted, however, that since (i) benefit transfer and (ii) weighting is used in this method, this does not replicate a formal CBA.**

If the operational question of interest is whether to add more stations, or take some away, then the above procedure could be repeated on different groupings of stations and the results compared. This would involve re-running the economic model with adjusted inputs in terms of benefits, to produce approximate cost-benefit results for different groups of stations.

If a ranking of individual stations or groups of stations is desired, then the above procedure could be repeated and the results used to produce a ranking. However, it would be very important to consider the smallest data generating network used to produce the base values, since otherwise we are extrapolating beyond the range of our observations.

In principle, this method could be presented as a simple spread-sheet type computer model.

4.2 A scoring approach

This could be implemented using the same framework as that described above, but replacing economic benefit base values with importance scores, arrived at through expert judgement (eg through some sort of DELPHI process). Davar and Brimley (1990) report the use of such a system in New Brunswick. However, whilst the method could be used to rank stations or groups of stations, it could not be used in any cost comparison, including decisions on whether to add or subtract stations.

4.3 A multi-criteria analysis approach

This could be accomplished with a goal-programming method. This would involve, for each benefit category, identifying acceptable or target scores (eg minimum hours warning time for the flood warning category). A matrix would then be built up to show how any network could contribute to achieving these goals, some of which will be complementary and some of which would be conflicting with each other. Cost could be included as one objective/constraint set. A mathematical programming routine would then be run on this matrix and objective set, with the goal of minimising the sum of differences between goals and achievements. This would give an "optimal" design of the system. Alternative system designs could be run through the model to compare their performance on the "achievements versus targets" criterion. However, the approach could not be used to assess the economic efficiency of a network. In addition, the method is very data intensive, is critically dependent on specification of targets, and would not be easy to present in a user-friendly format.

5. Recommended method

We therefore recommend that the project goes forward using the approximate CBA approach as the basis for assessing economic benefits, since it seems to have one important advantage over the other two methods considered, namely that it can address the issue of economic efficiency, as well as ranking and analysis of decisions over adding and/or subtracting stations. Three big problem areas are though, obvious:

* how to compute base values
* how to compute weightings for length of record
* how to compute local weights

The method could, of course, be used without weights being used, but this would lose much content. Some of the answers to these questions can be found in the literature review, interviews and survey results. However, it is felt that most learning will occur in trying to apply this method to two case study data networks in the next phase of the project. Of course, findings based on two case studies will be of limited generalisability; however, this limitation would only be adressed by devoting significantly more resources to the project. We also note that, due to the paucity of previous research in this area, we anticipate that un-filled "holes" will exist in the economic model based on Table One at the end of the project.

The approximate CBA approach provides an economic criterion for managers of networks to use. We would suggest that this should be supplemented with a criterion based on hydrology itself. This could address, for example, the issues of station redundancy and network representativeness, and could also be expanded into a scoring system along the lines suggested by Davar and Brimley. Thus two criteria would be used in assessing hydrometric networks: economic, and hydrological. This would provide more information than one criterion alone.

benefit categories	flood warning	road and bridge construction	flood planning: housing	low flows: abstraction	low flows: return flows	hydro power	storage
base values (£ per £k system cost)	b1	b2	b3	b4	b5	b6	b7
length of record weight	w11	w12	w13	w14	w15	w16	w17
local conditions weight	w21	w22	w23	w24	w25	w26	w27
applicable to network X?	yes	no	yes	no	yes	no	yes
score for network X	s1=(b1*w11*w21)	s2=(b2*w12*w22)=0	s3=(b3*w13*w23)	s4=(b4*w14*w24)=0	s5=(b5*w15*w25)	s6=(b6*w16*w26)=0	s7=(b7*w17*w27)

Total Weighted Benefits (can be compared to total costs of network X of £C): [(b1+b3+b5+b7)*C] = £B

Table One: approximate CBA method applied to network X

For some of these benefits categories (eg water quality) it seems likely that no estimates of the value of data per se will be found in the literature. Thus we propose to test the "production function" approach suggested above, to estimate the marginal value of data. This might work as follows. Suppose data is available on some indicator of water quality Q_t over time for a given river (this might be a weighted average of values q_{it} at i monitoring points). Suppose data is also available on abatement expenditure A_t , flow rates F_t and the quantity of data collected D_t . Our argument is that collecting data on flows enables better water quality to be achieved for given investments in abatement. Then we could estimate:

$$Q_t = f(A_t , F_t , D_t)$$

and find the partial derivative $\delta Q_t / \delta D_t$. Given the cumulative effects of both data collection and abatement spending, we would need to experiment with alternative lag structures for D and A. But if such a partial relationship can be found (which is statistically significant and reasonably robust) than a base value for hydrometric data collection's value to water quality improvements could be derived. We propose to test this procedure in the case study part of the project.

REFERENCES

CNS (1991) "The benefit cost of hydrometric data: river flow gauging" Report to Dept of the Environment FR/D 0004.

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Nevin C (1996) "Benefit estimation methods for hydrometric data" Appendix II to this Progress Report - W6/005/5

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Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

January 1997

R&D Progress Report W6/005/6

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

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Statement of use
This report is the sixth monthly Progress Report from Project W6/005. Its production marks the half-way stage of work on the project, and it provides an overview of findings to date and the views of the project team on the means by which to proceed to completion. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

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R&D Progress Report W6/005/6

Questionnaire responses

FLOOD DEFENCE

1. INTRODUCTION

This report is the sixth Progress Report of R&D Project W6/005. It marks the half-way stage of the project and, unlike previous reports which have summarized work over each successive month, it summarizes all work completed thus far and takes stock of the position reached. It then considers the course to be taken in the second phase of the project. New material is presented under headings 2.2 and 2.3, providing a condensed summary of all data uses reported in the questionnaire survey, and updating reports on discussions with external data users.

Four of the most important appendices attached to earlier Progress Reports are included again with this report, providing details of key phases of the background work completed to date. These are given at Appendices A-D. A new Appendix E contains a comprehensive account of work with external data users, including some earlier reports of progress.

2. BACKGROUND WORK COMPLETED TO DATE

2.1 Literature reviews

Two major reviews have been presented with Progress Reports preceding this one:

1. a hydrologically-based review of reported benefit assessment methods by M Steel presented with Report W6/005/3, and
2. an economics literature-based review by C Nevin considering the economic methods which have been (or could be) applied to quantifying the benefits, included as Appendix II to Report W6/005/5.

For the sake of completeness, these reviews are included also with this report as Appendix A and Appendix B respectively. In the interests of presenting a coherent overview of the main findings of the project to date, however, a new summary of these reviews is presented here.

2.1.1 Hydrologically-based review of methods of quantifying benefits

This initial review drew on approximately 100 published papers and reports, and identified that substantial interest was currently being shown in the subject of this study by hydrometric authorities and researchers in the USA, Australia, the Nordic countries and the UK. Reported studies are of many types: some consider single specified uses of hydrometric data while others aim to address all uses; some are specific to individual water-related projects or gauging stations while others address whole networks.

When data are obtained for the ongoing costs of hydrometric monitoring, benefit-cost ratios range widely from 0.05:1 to 92:1. In other cases however, monetary benefits of data collection re not obtained, but instead points are allocated to recognize the relative strengths and weaknesses of single sites in relation to a list of criteria, in order that decisions can be made regarding network changes.

The review also refers to a recognition that some benefits are not readily or realistically quantified, such that benefit assessment may sometimes refer to minimum benefit levels, ie excluding some difficult components. One difficulty common to all approaches is that future benefit assessments can only ever be based on a historic information base. Therefore, it is difficult to quantify the information value of continued gauging which might capture the hydrological effects of unprecedented climatic, land use or water utilization changes.

2.1.2 Economics literature-based review of methods of quantifying benefits

This review was structured in three parts.

1. Detailed approaches could be applied to the assessment of benefit in six identified benefit areas (Water quality improvement; Enhanced recreation; Hydropower generation; Enhanced flood protection; Enhanced flood warning; Reduced recreational losses). Many studies were reported which give details of the application of various methods to each of the six benefit areas. This is an area

which could be developed further for the purposes of this project and, with the identification of preferred methods for assessing benefit in each of these areas, it may be possible in some cases to allow the transfer of benefit assessments from the literature to new catchment areas.

2. General approaches to benefit assessment can be applied on the basis of reducing uncertainty or risk for planning or operational purposes. However, such an approach can only be specific to individual projects: no benefit transfer is possible. Therefore general approaches are excluded from further consideration.

3. Valuation of the data collection network was considered, particularly using an audit approach. By means of point-allocation, hydrometric stations can be ranked in order of importance for decision-making purposes, but no monetary quantification of benefits is involved. This approach is therefore excluded from further consideration also, since it fails to allow the core aim of this project to be realized.

The detailed approach to benefit assessment ((1) above) therefore emerges at a clear advantage over the other two methods considered. Further comment on the relative strengths of these methods, and the direction for future development, is offered below.

2.2 Information requests to agency staff

A questionnaire survey was undertaken, directing questions at staff in all functions of the sponsoring agencies. Nine separate questionnaires were developed for identified groups of data users, and copies distributed throughout all regions. A total of 138 responses were received in time for analysis, 58% of the number of requested responses, but including multiple responses from within some regions/areas.

The objects of this exercise were firstly to conduct a comprehensive survey of data uses, to ensure that all areas of data benefit were identified, and secondly to gather information on the value placed by users on benefits of one type or another. Success was considerable in the first of these, but limited in the second. Table 1 provides a new summary of all data uses identified by the questionnaire, arranged according to the nine functions identified for questionnaire survey. It should be noted that some responses were received from more than one function, in which case such responses have been listed only under the one function in which a response was most frequent. It should be noted also that because an open questionnaire approach was employed, this list is not exhaustive: other data uses may not have been specified.

Many of the main data uses (those most frequently cited) are well known to all agency staff across the functions, eg flow data requirements for discharge consent determinations, abstraction licensing, flood warning system operation, calculation of marine loadings. However, others must be less well known, or can easily be overlooked. Fisheries, Recreation, Conservation & Navigation Officers are reported to value flow data in the design of environmental enhancements for conservation and recreational purposes (eg canoeing) - a far cry from the oft-quoted dams, bridges and culverts for which flow data are more often required for design purposes. Flow data

Hydrological Network Data Uses

[key: SUBJECT
n main data uses in order of frequency
- other cited data uses]

POLLUTION

1. consent determination/review
2. calculation and modelling of mass balance/pollutant loads
3. assessing and managing pollution events
- design of surface-water treatment
- sewerage modelling
- timing of engineering work
- risk assessment for pollution prevention

ABSTRACTION

1. abstraction licences; determining new levels and altering existing ones
2. investigating derogation complaints
3. enforcing residual and compensation flow licences
- catchment model construction and evaluation
- estimation of dry weather flows in ungauged catchments
- setting 'hands off' flows
- compensation

CHEMICAL

1. calculating chemical loads to North Sea for PARCOM/Red List/Harmonized Monitoring Scheme/Global Environmental Monitoring
2. modelling catchment water quality and quantity (including SIMCAT modelling)
- information about time of sampling for result interpretation
- studying effects of low flows on water quality
- compliance with Drought Orders
- planning fieldwork

BIOLOGICAL

1. input into RIVPACS
2. determining whether conditions are suitable and safe for sampling
3. calculating dilution available for effluent for sampling/cost recovery
4. loading models (solute loadings and loch retention) and water quality models (loch eutrophication/phosphorus concentration)
5. interpreting survey results
- to 'trigger' surveys on low flow effects/drying/recovery
- Base Flow Index input to SERCON conservation assessment scheme

FISHERIES/CONSERVATION/RECREATION/NAVIGATION

1. relating flow/discharge with run-times and the suitability/utilization of various habitats
2. targeting vulnerable areas for monitoring/improving/restoring habitat
3. operational use; survey information, critical levels, enforcement, fish rescue

- access; canoeing only at high flows
- low flow research projects
- design of channels (environmental enhancement) and fish passes
- maintenance of navigation and power generation purposes

FLOOD WARNING

1. flood warning system development
2. flood warning system calibration
3. flood warning system operation

- level to level correlation
- extended use of radar
- flood forecasting modelling

FLOOD DEFENCE

1. assessing return periods (flood frequencies)
2. assessing particular flooding events (post flood analysis)
3. design of new works; flood alleviation schemes
4. calibration of design models for schemes/investigations
5. management of infrastructure (maintenance work)

- checking design tolerances
- improving Flood Studies estimates
- development of control purposes eg building above sea level

MARINE/ESTUARINE

1. river loads and freshwater inputs for water quality modelling

- estuarine salinity and current studies
- calibrating models/predictive simulation
- marine survey evaluation
- design purposes

WATER RESOURCES MANAGEMENT

Data uses encompass a number of uses cited above, from most subjects;

- water resources planning and monitoring
- low flows and abstraction issues
- flood risk and warning
- insurance/legal purposes
- research projects

Table 1 *Summary of hydrometric data uses, listed by function* are not only required for the operation of flood warning systems, but are also necessary for their design and for ongoing validation: if some change in the hydrological behaviour of a catchment occurs, or one in its channel hydraulics, then information is required in order that a warning system can be modified and perhaps also for the purposes of adjusting risk assessments. Field scientists in freshwater biology, freshwater chemistry and marine science functions all referred to the value of real-time telemetry data in being able to plan effective fieldwork.

On the assessment of data benefits by agency users, only a small number of responses yielded directly useful information. Where the potential was thought to exist, users were asked to refer us to quantitative estimates of benefit. So when Flood Defence Managers were asked if the results of cost-benefit analyses for flood defence schemes were available, responses were generally positive, yet when Flood Warning Managers were asked to indicate the value of savings accruing from operation of their area systems, only two (out of 16) were able to indicate values: £150k for NW Area of EA-NW Region, and £1m for EA-Midlands Region. A minority of other responses indicated potential sources of data, and if pursued, these further sources (often at a Regional level) may come to have rather greater value than the information thus far received.

In some further questions, users were asked to indicate the effect of reductions in data availability on their functions, allowing some indirect assessment of data benefit to be made. For example, Pollution Control Managers were asked to assess the likely difference between consents based on estimated flow data and those based on measured streamflows. Most were unable to give a response, several commenting that this was an "impossible task". Four of the 17 respondents did offer estimates, varying between 10% and 25% of the consent. While groups of responses of this sort can be of help in confirming some existing suppositions (direction of effects), they offer limited further value in relation to the quantification of benefits.

Further economic perspectives are included in the full analysis of the responses, which was presented initially with the December Progress report W6/005/5 and is also included with this report as Appendix C.

One final specific aspect of the responses to note is the importance of real-time data. With the widespread advent of telemetry, new uses have developed and become established in several areas of agency operations, eg model-based flood warning systems, pollution dispersion models, RiverLine telephone services for anglers and information for field staff when planning daily work schedules. Here a technological development has greatly increased the data utility of existing networks and, in some instances, has underpinned the justification of new stations for flood warning or low flow monitoring.

2.3 Interviews with external data users

When starting the Project we were aware that external organisations or individuals use hydrometric data for a variety of purposes. Despite this it became apparent during the early stages of the research that, even if they are not the major users of the data in all cases, they may well derive some of the largest benefits from the data. Given this we approached three Regions to try and establish a breakdown of the data use, both between external and internal users, and between different classifications of external data users. The results from this are included in Appendix E, which also includes details of interviews held with some of the external data users.

From the responses we received it would appear that the majority of *information requests* are received from external data users. However, it must also be noted that we suspect that there may be many internal users who do not formally request the data, or who are able to extract it directly from the computer systems themselves. It was also noticeable that there is a significant difference in the split between SEPA and the Environment Agency, with the Environment Agency recording many more requests from external users. This may be due to the Environment Agency's predecessor organisation having a much higher profile, along with the fact that the data is available free of charge from the Environment Agency where as a charge is made by SEPA.

As the extent of external data use was so large it was decided to try and classify it for the two Environment Agency Regions visited. Three main user types emerged - the water companies (the second largest single user in the Ridings Area, possibly due to the well publicised problems Yorkshire Water were having with the drought, and the third in Midlands Region), external consultancies (second in Midlands and third in Ridings) and students/schools/colleges, primarily for project work, who were the highest single user for both the Midlands Region and Ridings Area. Whilst it could be argued that the data supplied to the students has both a short and long term benefit, we felt that it was unwise to spend time trying to evaluate these rather spurious benefits. Instead, efforts were concentrated on the water companies and external consultants - a visit was made to Yorkshire Water Services and a number of Scottish Consultancies.

The findings from these visits are included in Appendix E. It would appear that the water companies rely heavily on a few stations for their day to day activities of resource management, but also use data from the wider network when the system is under stress. However, both the departments that were interviewed were unable to assign a benefit value to the data that they use, other than stating that in the case of abstraction sites they felt the Environment Agency would be prevented from closing the relevant gauging station by the legislation.

Initial enquiries with external consultancies were not promising, with almost all the companies we contacted replying that they derived benefit from hydrometric data but were unable to give a value for this benefit. Further questioning, followed up by a number of visits, has resulted in more useful results, with some companies actually being able to quote typical figures for some of the benefits they derive from the data. We shall also be trying to obtain details of a recent publication which details the reduction in uncertainty for hydro-power design offered by hydrometric data. It is felt that, with even more persistent work, it may be possible to gain a greater feel for the benefits which these users derive from the data. Given the potential size of these benefits this is clearly important as it will significantly increase the benefit:cost ratio for some networks.

Finally, it is perhaps worth noting one difference we have found between users of the data from SEPA and the Environment Agency. When interviewing Flood Defence staff within the Environment Agency, the general feeling was that, whilst hydrometric data were useful if not essential in some cases, the engineers felt that they could rely on theoretical methods if they had to. Flood defence works have traditionally been carried out by external consultants in Scotland, and it was interesting to note that they assigned a much greater importance (and associated benefit) to the availability of hydrometric data, stating that project costs would significantly rise and confidence decrease if the data were not available. Without wishing to become involved in any apparent Environment Agency 'internal politics', it would appear that some internal users might underestimate the actual benefit of the data which is so readily available to them whilst those who have to formally seek the data from outside the organisation consider it to be more valuable.

3. PROPOSED METHODOLOGIES AND PREFERENCE

Nick Hanley's paper on alternative methodological approaches (included with December Progress Report W6/005/5 and again with this Report at Appendix D) builds on the results of the background work reported in Section 2 above. The reader is referred to its contents for a full but succinct discussion of the viable methodologies available to the project. However, for the purposes of continuity, some of the most salient points are extracted here.

Much of the paper builds on the detailed approaches to benefit assessment identified in 2.1.2 (1) above. By this route, standard values would be produced for separate areas of data benefit, and would be the subject of benefit transfer methods. Such benefits could then be summed. There must be no avoiding the fact that such standard benefit values are difficult to derive. One reason is that it does not appear viable to specifically include all elements of total benefit which might apply in a given river. Another, perhaps more importantly, is that standard error margins on estimates of the value of non-market goods (such as hydrometric benefits) are known to be wide. In addition, it should be remembered that benefits of ongoing data collection have been identified with monitoring the unexpected: when the effects of new climatic, land use or water management changes are recorded, these can yield unexpected benefits (enhanced utility of data sets) and can provide the basis of currently unforeseen data uses. Comments on telemetry in Section 2.2 are of direct relevance here. Past strategic decisions have, in time, shown themselves to yield strategic value.

In addition to considering what benefits should be quantified in a given river situation and how these should be quantified, the paper also identifies the question of how to define the information-generating unit. This becomes a hydrological question. By virtue of the contribution of flows from upper to lower stream reaches, measurements at one point are inherently linked to those which could be taken at another within some catchment. It is therefore proposed that benefit evaluation should be undertaken on a catchment basis, to allow benefits and costs to be compared at that scale. Where management decisions are then to be taken as a result of such comparisons - ie closure of existing or establishment of new stations - it would then become a hydrological question as to the sites where changes would take place.

A hydrologist might wish to consider such factors as:

- the information gain or loss associated with given network changes
- the location relative to gauging stations of water functions in a catchment which (would) benefit from adjacent data availability
- the hydrometric performance of a station across the range of expected flows
- the physical and meteorological characteristics of a catchment when compared with others in the drainage basin or administrative area
- the relative running costs of various possible new stations
- the suitability of sites for telemetry connection

One final general issue to consider is the contribution of hydrometric data to some of the benefits discussed. While it is clear that each of the benefits identified (eg flood warning, pollution control, etc) is a result of the use of hydrometric data, what is far less clear is how to divide benefits between the availability of data and the interpretation of agency officers using the data. Thus far it has generally been assumed that benefits accruing from the use of hydrometric data can be attributed wholly to their provision. But an awkward corollary of this approach might then be that the efforts of staff in such functions as flood warning, pollution control etc are associated with no additional benefit beyond that which would arise simply from the provision of hydrometric data - clearly a nonesense. This issue remains to be resolved.

The Hanley 'alternative approaches' paper identifies three viable methods by which benefits could be assessed. These do not follow directly from the three parts of the Appendix B economics review by Nevin, but rather build on them. Again, the strongest approach is a detailed benefit assessment approach, now termed an approximate CBA approach. This approach recognizes the strength of identifying individual benefit components for any given river area and summing these, and - by 'approximate' - also the weaknesses involved in benefit transfer (error margins) and in the possible omission of locally significant benefits. In particular, this approach allows benefits to be estimated in economic terms and thus allows the direct comparison of benefits with costs. By reference to published papers and reports, it is proposed that base benefit values be determined for as many types of benefit as possible, and that weightings can then be derived to take account of length of existing record and local conditions (see Table One - Appendix D).

The other two methods identified are a scoring approach, and a multi-criteria analysis approach. Neither allows economic assessment of benefits or, therefore, a direct comparison of benefits with costs. On this important consideration alone, the approximate CBA approach is therefore identified as a preferred option. It also provides the opportunity for development into a spreadsheet model, offering potential for the dissemination of a management tool. Further details of all three approaches are provided in Appendix D.

Assuming that an approximate CBA approach is adopted, a number of steps can be identified for the fulfillment of the project objectives, and these are outlined in Section 7.

4. PROPOSAL FOR EXTRA WORK

In the preceding paragraphs and in the December progress report to the EA (Appendix D to this Report), we outlined a methodology for benefits assessment which we referred to as an "approximate CBA method". There are a number of steps which need to be taken to develop this method before proceeding to the case study testing phase, which need to be carried out over the next two months. The objectives of this additional part of the project are to:

1. search the literature, and other sources, for examples of the "base values" referred to in Table One (Appendix D);
2. search the literature, and other sources, for examples of the weights used in Table One (Appendix D);
3. carry out inquiries with data users (eg consulting engineers) to try to fill any of the gaps left over after steps (1) and (2); and
4. preparatory work on the regression method suggested in the December report, to set up and test the model to be used, prior to the case studies being undertaken.

The proposal is that Stirling University carry out steps 1 2, and 4, and Scotia Water Services carry out step 3, and then relay the information to Stirling. This work was not budgeted for in the original proposal, so below we outline the extra costs implied.

Why is this work important?

- because otherwise it will be impossible to generate general base values for the methodology proposed;
- because, whilst the case studies will generate values for some of these entries, these values will be specific to the conditions encountered in the two case studies. We could therefore not put such values forward as general base values to be used by the sponsor agencies in applying our suggested methodology throughout the UK; and
- if base values are not found, then all that can be delivered is a framework for analysis, without the data necessary to carry it out. The EA/SNIFFER could, however, decide to provide this data internally if either so wished (that is, carry out the work we are suggesting be carried out by the project team).

What extra resources are required?

Most additional work will be done by Ceara Nevin, whose objective will be to assemble a spreadsheet representing Table One in the Appendix D, with values inserted for as many of the cells as possible. This will entail detailed literature searches, analysis and compilation. Thus we are asking for funds to employ her for a further 2 months. Nick Hanley would have an input in supervising this additional work, equal to 2 days. Tony Bennett would supply an extra 2 days above his present allocation, making further contact with consulting engineers, and perhaps including some interviews. The total costs are:

1	Ceara Nevin	£2424
2	Nick Hanley	£400
3	Stirling support costs - library loans, etc	£150
4	Overheads on (1) to (3)	£1190
5	Stirling Subtotal	£4164
6	Scotia Water Services (staff time + costs)	£600
	Total	**£4764**

5. INFORMATION GATHERED ON COSTS

By pursuing an approach which uses a cost-benefit analysis at its heart, it is implicit that data generation costs must be quantifiable. The Specification within the invitation to tender indicates this to be the case, and the submitted Tender assumes that such data can be made available.

Data generation costs are assessed on a Regional basis, and must be seen to be the product of the calculation methods used. The main components are field costs (eg gauging, instrument maintenance), data capture and processing costs, and overhead costs. It is understood that cost assessment in the UK is generally done as part of the ongoing management of networks, and that (in the Environment Agency) total system costs are included in annual discussions between data providers and users for the determination of Service Level Agreements.

Some average cost information has been received in a recently-completed review for the Nordic Coordinating Committee for Hydrology (Puupponen, 1996). Average data generation costs per station-year are presented for each of the Nordic countries. The lowest cost, ECU 2492 for Denmark, is arguably most typical of UK conditions from a catchment/terrain perspective, although labour costs may differ.

It is anticipated that detailed methods of assessing data generation costs will differ from one region or agency to another. It is proposed that one study areas have been identified, discussions begin with local staff in order to determine whether catchment or station data costs can be made available.

6. CONTENT OF FUTURE R&D NOTE

One required output from the project is a specification of the format and content of a future R&D Note in the form of a manual, which would make the practical benefits of the project available to agency staff. While this specification is not due until month 10, current thinking colours the likely content of that manual, and it seems sensible to take this opportunity to consider these implications. Six broad areas would need addressed if the project follows current thinking:

1. **Cost assessment methods** - it would be necessary to ensure some standard approach to expressing the full economic cost of data generation.

2. **Initial benefit survey** - an introduction for the hydrometric manager in which to obtain some 'ground truth' regarding the full extent and relative importance of individual benefit components. This may be based on a survey of water utilization patterns, or on an analysis of data request information (routine collection would be necessary for this).

3. **Benefit assessment procedures** - for each type of benefit to be quantified. This would involve the use of base values and the application of appropriate weights at a catchment/area scale, and would be implemented by computer software.

4. **Assessment of non-quantified benefits** - it would be necessary to develop recommendations for the treatment of those benefits not quantified under (3) above.

5. **Approximate cost-benefit analysis** - comparison of costs with benefits.

6. **Information value of individual gauging stations** - based on hydrometric considerations: data quality, catchment characteristics, location relative to resource management activities.

Consideration of the format of the manual seems premature at present.

7. WORK PLAN

Table 2 indicates the steps which would be necessary to bring the project to a successful conclusion, assuming that an approximate CBA approach is agreed upon. For the purposes of recognizing that this is in itself a matter for discussion (and not wishing to preclude other outcomes), that decision is included as step 1 in the table.

Step	Task	Personnel	Week No
1	Adopt approximate CBA approach for development	Board	0
2	Agree list of benefits to be included in method, or delegate decision to project team on basis of findings in 3-6 below	NDH, Board	0/4
3	Search literature to derive base values	NDH, CN	1-4
4	Gather ancillary data with benefit estimates to estimate weighting values + functional form of relationships with predictor variables	NDH, CN	1-4
5	Obtain information from consulting engineers to add to (3)+(4) above	AMB	1-4
6	Develop form of equation(s) to combine base values, record length and local conditions weights, in order that total benefits can be estimated	NDH, AMB, CN	5-7
7	Identify and agree areas for case studies: 2 catchments	ARB, AMB, NDH, Board	~3
8	Obtain from sponsor agencies cost data for case study areas	agencies via Board	3-5
9	Develop framework within which hydrological criteria can be combined to assess relative information utility of individual gauging sites	ARB, AMB	2-5
10	Formalise procedures in PC environment	AMB, CN, NDH, ARB	7-8
11	Test all methods, refine and report	AMB, CN, NDH, ARB	7-12

Table 2 Proposed timetable to include additional work for approximate CBA approach
(Week 0 = w/e 21 February, ie week of Project Board meeting)

The table includes tasks shown within the original project timetable, as well as those tasks following on from Section 4, specifically required to implement the approximate CBA approach. Because of the extra proposed work, it is requested that the overall timetable should be moved back by one month, with the final target dates becoming:

Test draft procedures	end month 10 (31 May)
Draft R&D Note and Project Record circulated	end month 11 (30 June)
Complete Final R&D Note and Project Record	end month 13 (31 August)

8. SUMMARY

A large amount of effort has been expended in the collection of infromation regarding reported methods of hydrometric data benefit assessment, and the benefits of data use by UK environment agencies. From this work, three viable methods of benefit assessment have been identified: an approximate cost-benefit analysis approach; a scoring approach and a multi-criteria analysis approach. The project team present the approximate CBA approach as their firm preference on the basis of its advantages, but while recognising its limitations, as indicated in Table 3.

Advantages

- Benefits are identified in economic terms, allowing direct comparison with data generation costs. Only this method allows this direct comparison to be made.
- The approach lends itself well to implementation via PC spreadsheet.

Disadvanatges

- Not all benefits might lend themselves to quantification by this approach.
- Benefit estimates are expected to be subject to wide errors.

Table 3 *Principal advanatges and disadvantages of approximate CBA method*

It is proposed that benefits would be assessed on a catchment or local area scale, from networks of stations, for the purposes of comparison with cost estimates. Where network management decisions were then to be takem, these would be based on hydrometric and hydrological considerations, eg station performance/accuracy, location relative to resource management activities, etc.

While there is some uncertainty regarding the number of benefit types for which base values and appropriate weightings can be derived, the ongoing discussions with consulting engineers give grounds for optimism regarding the quantification of major economic benefits (see Appendix E).

The value of adopting this preferred approach, and the various issues concerned with putting it into effect, will form the focus of the forthcoming Project Board meeting in Reading on February 19th.

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6|                                              +------------G/L Codes------------+
 |5|                                            |        1-S-525300003/****        |
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Perth City

Year End 9798	LY Actuals (Accruals)	LY Revised Budget	Variance
Opn Bal	0.00	0.00	0.00
April	8897.76	0.00	(8897.76)
May	8773.16	0.00	(8773.16)
June	48954.65	0.00	(48954.65)
July	40350.55	0.00	(40350.55)
August	51582.11	0.00	(51582.11)
September	38047.08	0.00	(38047.08)
October	27203.19	0.00	(27203.19)
November	41704.35	0.00	(41704.35)
December	30397.06	0.00	(30397.06)
January	26209.34	0.00	(26209.34)
February	38985.10	0.00	(38985.10)
March	64275.58	0.00	(64275.58)
	425379.93	0.00	(425379.93)

Period(s): 08 through) Data (1,2,3,4) or <CR> for all:

This tallies with sum of totals on attached pages

Secondary Treatment, Activated Sludge

Hydrometric Data

Numerous studies such as those by Scott (1987), Black et al. (1994) and Black and Cranston (1995) have demonstrated the broad range of uses of hydrometric data, the latter describing the evolution of data usage in Scotland and highlighting new and anticipated uses of data being produced by the existing network. In the 1994 review of the Northern Ireland hydrometric network, Black et al. identified 13 distinct data uses from interviews with the Department of the Environment for Northern Ireland's Environment Service and the Department of Agriculture for Northern Ireland (Black et al., 1994, p17):

1. residual/prescribed flows/levels
2. river regulation/transfer schemes
3. abstraction point spillage protection
4. catchment yield assessment
5. flood forecasting
6. flood design studies
7. water sampling to meet PARis COMmission guidelines
8. assimilative capacity
9. consent standards
10. transmission of data to National River Flow Archive
11. ecological studies/recreational monitoring
12. benchmark monitoring
13. hydrological studies

Of these uses only one station (the station nearest Belfast) could claim 11 uses for its data, and those stations whose data had the most uses were generally the lowest gauges on major catchments. Stations whose data had few uses were often level-only stations. Scotland's data usage, although similar (Black and Cranston employed the same 13 data use categories), has been strongly influenced by the development of HEP - much of Captain W. N. McClean's early gauging was aimed at assessing HEP potential. Water quality assessment then became a driving force for the opening of new stations in the late 1950s/early 1960s, followed by research projects (forestry - Balquidder; acidification - Loch Dee) and more recently the development of telemetry-based flood warning schemes. New technology has enabled more remote stations to be opened and can allow data to be collected at only one extreme of the flow duration curve to meet specific needs. Although both these reviews noted the lack of representation of smaller catchments, the potential of Scottish historical flow data with respect to climate change impacts was considered valuable and the increasing multifunctionality of the network praised.

Network efficiency and operation

It is becoming ever more important that networks are efficient in their collection of hydrometric data, and are able to justify the levels of expenditure spent on them. This issue influences network design, operation and can bring about the contraction of a network. There are many approaches to network design (for example Moss, 1987; comparison of specific technologies by Moss and Tasker, 1991; entropy approach of Yang and Burn, 1994) but inevitably maximum information can only be achieved by a dense expensive network. As a less dense network leads to a loss of information, the best solution is found if the sum of information loss and network costs shows a minimum (Van der Made, 1990). In terms of network rationalisation, Burn and Goulter (1991) described a methodology to reduce a network and increase its effectiveness by searching for redundant information. They used a hierarchical clustering algorithm to identify groupings of stations and then selected one station from each group to be retained as a member of the reduced network (incorporating station specific information such as the user's judgement and experience).

There is also a variety of work concerning the operation of a network to maximise the quality of the data and minimise the time and expenditure required to collect it. Pelletier (1988) documented the main uncertainties in the determination of river discharge and Mades et al. (1990) presented a technique for assessing instrumentation systems in terms of cost effectiveness. Kitandis et al. (1984a) considered the cost effectiveness of direct discharge measurements as a means of increasing the accuracy of data, and also studied (1984b) the effects of visitation frequency and instrument reliability on data accuracy. On a more practical note, Pelletier and Simonovic (1988) and Simonovic et al. (1988) tackled the problem of optimal field operation of a hydrometric network using a travelling salesman algorithm modified to solve the `Travelling Hydrometric Technician Problem'. They produced an algorithm compatible with the capabilities of personal computers which could be used to:

1. compare stations according to their relative importance
2. plan emergency network operation
3. determine the cost effectiveness of a particular stream gauging programme.

Cost benefit analysis and hydrometry

It has been recognised that more than just a qualitative valuation of the benefits of streamflow gauging is required to justify its significant cost to countries worldwide. Studies have therefore considered either the value of hydrometric data from a network generally, or for a specific purpose (see below). A cost benefit approach has also been used to assess the planning of networks and the ability to improve data quality from a network. Wilson (1972) evaluated the relative value of three broad categories of hydrometric data: mean discharge, flow dependability and flood data. By considering the effects of network intensification/development he highlighted the latter two categories as producing the largest portion of benefits. Watt and Wilson (1973) were able to identify a parabolic relation between cost savings (such as costs of hydraulic structures or future damages avoided) and data accuracy suggesting that data improvement beyond a certain point would no longer be economically attractive. Estimates of the costs and benefits of data with respect to specific uses are inherently more accurate, and this approach has provided the basis of Service Level Agreements between NRA (now Environment Agency) data providers and internal customers since 1993, to provide a framework to link costs, benefits, quality assurance and network reviews (Fawthrop and Streeter, 1996). A number of authors have produced the following cost benefit estimates for specific data uses.

1. *Reservoirs/storage*

Increased hydrometric data reduces the uncertainty involved in estimating required storage. Uncertainty leads to either underdesign (frequent water shortages occur) or overdesign (capital unnecessarily tied up), so the availability of long records is desirable. However, although this uncertainty decreases as the record length increases, the coefficient of variation (CV) of annual flows represents the most significant streamflow parameter determining reservoir design storage (Adeloye, 1995; 1996), because an increased annual CV either reduces the mean flow (thus increasing storage requirement) or increases the standard deviation (thus requiring more storage to deal with the ensuing large fluctuations in streamflow). Nevertheless, the length of streamflow data record has an enormous influence on the accuracy of reservoir capacity estimates especially for record lengths of 20 years or less, and Adeloye (1990) was able to demonstrate that this relationship approximately obeys the inverse-square-root law. Longer data records are also valuable as they are more likely to include critical periods which cannot be synthetically generated from shorter records (Barlishen et al., 1989).

The ratio of benefits to costs will depend on the amount of data already in hand, the length of the extra sample of data to be collated and the number of sites at which data are to be collected (Cloke and Cordery, 1993). It is clear though, that 'even for those streams which occur in the relatively stable hydrological regimes of Europe, large sampling errors are associated with reservoir capacity estimates obtained from short streamflow data records' (Adeloye, 1990, p234). This means that a 6-year data record implies 30% error in capacity estimates and even a 20-year record implies 15%, so financially the cost of under- or overdesign will depend on the size of the storage. By determining storage sizes from a range of record lengths, Cordery and Cloke (1990) were able to estimate the variation in capital cost of the designed structures. Further work (Cloke and Cordery, 1993) subsequently demonstrated that if data collected from all 500 stations in New South Wales was to be used for no purpose other than storage design the benefits and costs would become about equal once records had been collected for about 80 years. It also noted that other data uses would ensure a benefit cost ratio greater than one for the foreseeable future even if the network was greatly expanded. Even after reservoir design is complete, hydrometric data is extremely valuable; in reservoir operation it was found that policies that employed more complete hydrological information performed significantly better (Tejadaguibert et al., 1995).

2. *Low flows*

There is little work regarding the value of flow data in dealing with low flows. Willis and Garrod (1995) evaluated a low flow alleviation scheme on the River Darent in Kent, and identified five principal benefits of alleviating low flows as recreational, commercial, educational, amenity value to residents, and passive values to non-residents. With £7.2 million spent on capital works, £5 million on a pipeline and £1 million on riverside boreholes in this catchment (the latter two both to augment water in the Darent), the percentage error associated with a short record could amount to a significant sum financially. The economic value of water in a watercourse could also be re;lated indirectly to data value, and studies such as Bilsby et al., Postle and Moore, and Gautam and Steinback (all 1996) have considered the value of recreational fisheries, linking changes inenvironmental quality to recreation gains and losses. However, the value attributable to the use of hydrometric data in these situations in difficult to define.

3. *Flood protection*

The use of hydrometric data is most obviously valuable now that online data can be used in flood warning systems enabling the organisation of emergency services, closure of road and rail links, issuing of warnings to public services and companies and the issuing of warnings to the population at large including the possibility of evacuation (Roche, 1990).

In terms of the design and construction of flood protection schemes, Mawdsley et al. (1990) studied three small schemes in England, and estimated the data value to be approximately 4-5% of construction costs. This produced benefit cost ratios of 1.0, 0.37 and 0.05; in only one case were the data considered worth collecting if this application was the only use of the data. Cordery and Cloke (1994) used streamflow records, a damage-height relationship and a height of protection-cost relationship for three sites in Australia, and devised a flood mitigation strategy from a sample of the record. This was then compared to a strategy devised from the same data plus data from the following years to produce firm conclusions:
(a) that gauging stations should be installed *now* in regions where there is likely to be a demand for flood protection works in the future;
(b) that collected data are so valuable for project planning that there is a need for considerable public investment in installation and operation of stream gauging stations to collect and archive high quality data.

4. *Pollution*
Quantification of the value of streamflow data for water pollution control was worked towards by Adeloye and Mawdsley (1990) but no clear result was achieved as the authors were wary of ignoring intangible benefits and producing low data value estimates. Nevertheless, 'the indication from the error characteristics presented...is that the data are likely to have value in the application' (p407).

5. *Bridges*
Cordery and Cloke (1990) considered the design of crossings of small streams and in their evaluation included the following;
(a) capital loss/saving due to overdesign/underdesign
(b) cost/saving of damage to structure due to overdesign/underdesign
(c) cost/saving of delays and extra travel distance when the road is closed.
This produced a benefit cost ratio of 92 for the years between 1958 and 1987 which would fall to 22 if the cost of all data collection were included.

6. *Groundwater*
Despite a lack of quantitative work on the value of groundwater data, monitoring has been intensified in recent years due to an increase in problems such as contamination, overabstraction and their environmental consequences (Zhou, 1996). The high cost of groundwater data collection must be justified by the fact that all processes of interaction between the groundwater system and the environment can be observed only by a monitoring network, allowing applications such as detecting the impacts of climate changes and human activities on groundwater quantity and quality.

Moss (1996) provides a useful overview of worth of data studies such as those described above. On a methodological basis, he identifies three approaches which have been employed:

- *Hypothetical studies* use synthetic data series and theoretical approaches to the worth of data to assess how benefits vary with length of record available;

- *Ex post facto studies* explore the worth of real streamflow data after they have been collected; and
- *Preposterior studies* attempt to estimate the worth of data before collection, by using Bayesian Decision Theory, but require simulations to overcome otherwise insurmountable computing demands.

The relative merits of these approaches will be discussed in the final section of this review.

Network evaluation

Whilst the above case studies cover specific data uses, there are a few cases of broader network evaluation worthy of comment. Studies by Cordery and Cloke have already been mentioned, but their work on Australian gauging went beyond the quantification of benefits of data per usage to estimating the benefits of the whole data collection programme for New South Wales. Their 1990 paper relied on assessing what were considered to be the two most significant uses of data; the design of crossings over small streams and the design of storages. From these two data uses it was estimated that the benefit cost ratio for the network considered was at least 27 and probably greater than 30. A more complete evaluation was conducted by the same authors in 1992 (Cordery and Cloke, 1992a; 1992b), where the cost in each data usage case was taken as the cost of collecting and archiving data from the complete network of stations, and related to benefits in a range of categories. The following results were produced (1992a, p275):

data use	estimated benefit/cost ratio
crossing of minor waterways	0.8
flood mitigation	0.1
sizing of water storages	1.7
major structures	2.0
urban drainage	>4
others	>0
minimum total benefit/cost ratio	9

An evaluation of the U. S. Geological Survey stream gauging programme (Thomas Jr et al., 1990) used nine categories of data use: regional hydrology (3227 stations), hydrological systems (3564), legal obligations (238) planning and design (938), project operation (2447), hydrological forecasts (2437), water quality monitoring (2307), research (603) and other uses (609). It calculated that the data from each gauging station had an average of 2.6 uses, and of the 1252 stations with only a single data use it identified 60 as not having sufficient justification to continue their operation. A further 69 stations being operated for short term special projects were identified as not having sufficient justified data uses beyond completion of their respective studies; in all about 2% of stations were recommended for discontinuation. Analysis found the network to be cost effective and concluded that (a) the standard error of the streamflow records could not be significantly reduced by changing operating practices given the present budget and (b) the present budget could not be significantly reduced and still maintain the current level of accuracy of streamflow records.

A more subjective, qualitative audit approach was used to evaluate the hydrometric network of New Brunswick in Canada by Davar and Brimley (1990). They modified the priority considerations of Wahl and Crippen (1984) to produce these four groupings for each station to be scored under:
(a) site characteristics
(b) identified client needs - regional hydrology
(c) identified client needs - operational hydrology
(d) regional importance of water resources

A scoring structure from 0 to 10 was developed so that the higher the total station audit points accumulated by a particular station, the higher is the relative value of benefits derived from that station. Therefore the scoring was only an ordering of relative worth and no economic value attributed to stations. Although the framework was subjective, it was found to be a useful integrating tool, and the provision of objective guidelines for the assessment procedure helped prevent the subjectivity being too detrimental. However, as in most of these evaluations, current values are all that are used in the decision making process as the future worth of data is difficult to predict. There is also the issue of comparing different data uses, as some might be considered more important than others, whilst some tasks which use hydrological data might be achievable without it by other means.

A growing importance in the value of water as a potentially sustainable resource has not been enough to maintain hydrological networks and the services that operate them in many countries. Worldwide hydrometric observation is deteriorating, especially when compared to global meteorological data, at a time when the global demand for water is accelerating (Rodda et al., 1993).

Future technologies
Hydrometric data collection may in the future become less reliant on ground-based measurements. The growth of remote sensing in hydrology has seen the introduction of remotely-sensed data being used in precipitation estimates, soil moisture measurements, snow water equivalent and snow extent assessments, seasonal and short term snowmelt runoff forecasts, and surface water inventories. In the next decade these might be joined by remote measurements of land cover, sediment loads, erosion, groundwater and areal inputs into hydrological models (Rango, 1994). The impact of remote sensing is also likely to be great because of its ability to provide spatial rather than point data, on a global scale and even for remote and inaccessible regions of the Earth (Engman, 1996). The transmission of hydrological data by satellite is also a valuable cost effective and reliable method of data collection, and for areas where no hydrological data are available there is the chance to estimate runoff (for example two techniques described by Kruger et al., 1982). However, progress in these fields has been hindered by the lack of dedicated hydrological satellites (Barrett and Herschy, 1989). Presently sensors with good resolution in space (Landsat, SPOT) are able to provide information on slow hydrological processes such as snowmelt, ice, land use, and model parameters, and those with good resolution in time (GOES, Meteosat, GMS) cover dynamic processes such as rainfall, runoff and floods (but not in detail as spatial resolution is poor). It is evident that what hydrologists need is good resolution in space *and* time (Schultz, 1988).

Discussion

This review has illustrated a considerable amount of interest in the subject of assessing hydrometric data benefits. More than 50 papers are cited, and more than 90 have been consulted. The great majority of this literature (85%) has been published since 1986, notwithstanding the fact that some useful principles had been established in the 1970s. This could be interopreted as an indicator of the importance now being attached to assessing the justification for expenditure on hydrometric monitoring - a trend found in many other fields of activity around the world.

The case studies above have reported a wide range of values for hydrometric data. In single-application assessments, Mawdsley et al. (1990) reported a benefit cost ratio of only 0.05:1for one small flood defence project (ie benefit<<cost) while, at the other extreme, Cordery and Cloke (1990) have found a benefit cost ratio as high as 92:1 for the collection of data and their application to flood estimation in small crossing design methodologies in New South Wales for a 30-year period. Even a more conservative assessment in the latter studyproduced a ratio of 22:1. Cordery and Cloke (1992a) have also been active in the field of assessing benefits for all types of data use. They stress that some benefits are not quantifiable but, on the basis of adding benefits for all those uses which can be lent to such treatment, a minimum ratio of 9:1 can be justified. Earlier work for the UK by CNS Scientific & Engineering Services (1991) found that ratios in the range 1.2:1 to 7:1 were appropriate for that country, depending on methods used.

It can be seen therefore that a significant range of values have been attached to hydrometric data, depending on the type of application, characteristics of the study in question and assessment of existing data - amongst others. The useful overview by Moss (1996) cited above reminds the reader that different approaches can be employed in a given situation, and each of these has its own inherent assumptions. Not least amongst these are the assumptions that past streamflow observations can be used to estimate statistical properties of future distributions of values within given levels of uncertianty, notwithstanding increasing signs of vulnerability of flow behaviour to changes in climate, and the constant possibilities of land use change impacts. Also, it is regularly observed in the literature that no study can quantify all the benefits accruing from the collection of data, e.g. what is the conservation benefit of operating a gauging station which allows flow to be maintained to provide a safe habitat for a rare ecosystem?

The risk of inconsistencies between one approach and another, coupled with the recognition that some benefits cannot be quantified, has led some workers to prefer qualitative or subjective methods in the assessment of benefits. One example is the work of Davar and Brimley (1990) in Canada, where points are awarded under a number of headings in order to produce an expression of relative worth. If unquantifiables were to be regarded as as important in a given area, or serious reservations were held regarding methods of quantification, this might be an appropriate approach for some studies.

This review has set out the main areas of work reported on assessing the value of hydrometric data. In the context of the wider Environment Agency/SNIFFER-sponsored study in which it arises, results of a survey of data users, and further work on assessing alternative approaches to quantification, are now awaited before proceeding further.

3 CATCHMENTS FOR TESTING

During the course of the month, proposals arrived through the Project Leader that three catchments might be considered for the purposes of testing the methodologies. In addition to the Bollin and Foyle proposals made at the Project Board meeting, the Little Ouse in Anglian Region was offered as a third possibility. The project team takes the view that within the time limitations of the project, the number of test areas should be restricted to two. This is particularly important in regard to the time required to identify sources and obtain all relevant data.

The question therefore arose as to which of the available options should be pursued - a decision left to the project team. The purpose of testing is to evaluate the methods developed, and to offer the opportunity for changes to be made. Two differing areas were therefore sought, in terms of the uses and benefits associated with local hydrometric data. The Foyle catchment was idfentified immediately as a rural area with little development pressure on its water resources, and therefore representing a test area where perhaps few of the benefits of hydrometric data could be quantified. By contrast, the other catchment to be chosen ideally needed to include a large range of benefit areas in order that some extensive testing could be carried out. Available information concerning the two candidate areas is presented in Table 1.

Bollin	Little Ouse
• 3 gauging stations	• 9 gauging stations
• Direct supply headwater reservoirs	• Groundwater scheme - augmentation
• Plans for further gauging sites	• Transfers to Essex via cutoff channel
• Dunham Massey gauge proposed for upgrading	• Flood diversion
• Compensation releases and Drought Order	• Fenland SSSI affected by borehole abstraction
• Water quality issues - Manchester Airport 2nd runway	
• Abstraction pressures due to agriculture	
• Designated fishery	
• Scope for future low-head HEP scheme	

Table 1 Characteristics of two candidate test catchments

It was considered that the Bollin catchment was more complex than the Little Ouse in terms of the applications of hydrometric data and so, on this basis, it was selected to complement the Foyle as a test catchment. Ceara Nevin has been in touch with local staff in both areas with a view to obtaining water use information, *eg* lists of consented discharges, and further data collection regarding data use is planned.

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APPENDIX B
BENEFIT ESTIMATION METHODS FOR HYDROMETRIC DATA

By Ceara Nevin

<u>Introduction</u> - Environmental Decision Making, Data Collection and Cost Benefit Analysis

The environment is composed of a number of complex interacting systems. A symptom of this complexity is that it can take a long time to obtain enough information to develop an understanding. One response is to design [and maintain] a network of sites where measurements are made, 'in order to encourage understanding and provide an indication of future change' (Burt, 1994). This proposal, in addition to the comment in the Government's 1990 white paper on the environment - that without good monitoring activities 'environmental policy decisions cannot be based on the best of scientific and technological analysis' (H.M.S.O. 1990) - appears to support the continuation of environmental data collection.

When evaluating any project concerning the environment, such as the structuring of a data collection network, financial costs however must be assessed and compared with environmental benefits obtained.

This estimation of costs and 'monetary' benefits of an environmental improvement can justify project expenditure or exhibit to decision makers that the project is not worthwhile (Ramchandani, 1989).

Cost Benefit Analysis, a quantitative analytical method, was originally developed for performing economic evaluations of alternative US federal water supplies. As a consequence of its capacity to assign monetary values in a non-market situation, it has been accepted by government in both project and policy decision making.

There are several approaches to the use of cost benefit analysis in the evaluation of hydrometric data, a combination of which are examined in this report:

- *Detailed* - data from one or several specific observing stations is related to a specific project or to a set of similar water resources projects e.g. flood protection schemes.
- *General* - Overall data from a country/region/network of stations is assessed in relation to a data use [not necessarily project specific].

<u>Part 1</u> - Detailed Approaches to Cost Benefit Analysis

Part one involves the identification of indirect benefits of data collection as outlined in the literature review and the discussion of how these may best be valued using cost benefit analysis. For clarity, the discussion has been structured in sections. While each section represents an individual benefit, in order to provide a comprehensive approach and exhibit the links between benefits, some overlap exists.

1. Indirect Benefit: Water Quality Improvement

<u>1.1.</u> <u>Benefit Category:</u> Water quality improvement in terms of an improvement in both surface and groundwater[1] abstracted for <u>potable supply</u>.

1.2. Relationship of Benefit to Data Collection: The collection of hydrometric data encourages more accurate estimation of a river's assimilative capacity and in turn the more efficient issue of pollution consents to industry through avoiding the risk of over/under provision of water treatment capacity (Crabtree et al, 1996. Black et al, 1994).

1.3. Economic Valuation of Water Quality Improvement for Potable Supply

1.3.1. Avoidance Costs/Averting Expenditure Actions

Theoretical explanations of this approach are based on the production function theory of consumer behaviour. It is suggested that costs incurred by households, firms or Government to avoid exposure to a water contaminant, can be used as an empirical measure of the pollution costs imposed on society (Courant & Porter, 1981).

In addition to actual expenditure Abdulla et al included an evaluation of the amount of time required for averting actions, based on the estimated wage of the respondent (Abdulla et al. 1992). In that study total 'averting actions' were defined as including; increased bottled water purchases for individuals buying it prior to pollution, bottled water purchases by new buyers, installing home water treatment systems, hauling water from alternate sources, and boiling water. A key assumption however within the averted expenditure approach is that averting actions *perfectly* substitute for reduction in pollution (Courant & Porter, 1981).

The construction of regression models with this method is useful to identify household and contaminant factors influencing expenditure. Raucher attributed influence to the contaminant's health risk, the extent of the public's awareness, type of water supply and presence of children (Raucher, 1986).

Averted expenditure studies by organisations (e.g. firms and Government/local authorities) have generally focused on the capital and operating cost associated with water treatment. Care must be taken however in the event of considering costs to both firms and households in the same CBA study that double-counting does not occur, as households, in addition to firms, can benefit from a firm's water treatment activities.

The averting expenditure method provides a lower bound estimate of total costs imposed by pollution. The divergence arises as some consequences of water pollution cannot be averted entirely through expenditure (Courant & Porter, 1981). In an attempt to address this properties of the utility function in addition to those of the household's production function should be examined. Despite this limitation however, and the failure to consider non-use values the approach has been used effectively on its own and as an 'anchor' for *willing to pay* values within contingent valuation (Abdulla, 1994).

Benefit Transfer: Benefit transfer may reduce the financial cost and time of carrying out a cost benefit analysis, in reducing the primary research involved. It has been defined as 'the process of taking a value or benefit estimate developed for a previous project or policy decision and transferring it to the proposed project or policy decision' (Postle & Moore, 1995). Several concerns have been highlighted however in relation to the validity of this approach and as a result its use is limited, according to Postle and Moore, to the estimation of orders of magnitude

The site specific and household factor influences upon averted expenditures, as related to Raucher in the discussion, may imply that benefit transfer is difficult (Raucher, 1986).

1.3.2. Contingent Valuation

The gross monetary value of any market good or service has two components: financial value and consumer surplus. Averted expenditure approaches concentrate on the averted *financial* *cost* of goods through a focus on consumer's *actual* expenditure. The amount which consumers are *willing to pay* may be greater, this difference being known as consumer surplus. The contingent valuation (CVM) approach to CBA attempts to capture both this consumer surplus and financial value to reflect the total utility derived from improved drinking water quality.

Contingent valuation involves the structuring of artificial markets, designed to directly elicit measures of consumer surplus through individuals' WTP[2] (Bergstrom et al, 1990). Such a market, for improved drinking water quality, with relevant payment mechanisms could be applied either within a controlled setting, or in the field. Artificial markets are divided into two broad categories: those that involve actual monetary payments for non-market goods, and those that do not (Bergstrom et al, 1990).

Jordan and Elnagheeb used a CVM study to estimate total WTP for improvement in drinking water quality in Georgia (Jordan & Elnagheeb, 1993), while Desvouges et al have looked specifically at the option value relating to water resources (Desvouges et al, 1987). Stevens et al [although not referring directly to water resources] argue that ignoring the non-use values in CBA can underestimate the total value from such an environmental resource by up to 75% (Stevens et al. 1993).

1.3.2.1. Limitations of CVM: Gregory et al believe that CVM, as applied to measuring improvements in drinking water quality and recreation uses (Gregory et al, 1993), are fundamentally flawed for a number of reasons:

1. Assigning monetary values imposes unrealistic cognitive demands upon respondents, as one is dealing in an artificial market situation.
2. The observed disparity between WTP and WTA, as discussed below.

Kahnemann and Knetsch also found that when individuals assign a monetary value in an artificial market situation, they seemed unable to distinguish between the relevant 'good'; and their 'sense of moral satisfaction' associated with contributing to a good cause, e.g. the improvement of water quality for society (Kahnemann & Knetsch, 1992).

Bowers expressed concern that the use of WTP within contingent valuation [as a consequence of WTP being a function of income and wealth] implied the acceptance of the pattern of WTP as given by society's existing distribution of income, even if inequitable (Bowers, 1993). The use of WTA compensation as an alternative has been found however to elicit much higher responses (Hanley & Spash, 1994).

The payment mechanism may also influence results. The choice of water rates for the measure of willingness to pay for water quality improvement, for example, will encourage responses which reflect peoples' attitudes towards the role of public investment or private water company profits, and not the importance of improved drinking water quality (Green & Turnstall, 1991).

Support for the reliability of contingent valuation in estimating water quality benefits comes from Loomis' study however, where test-retest results for willingness to pay to preserve Mono Lake in California, over a nine month period, remained relatively stable (Loomis, 1989).

1.3.3. Hedonic Pricing Method

The Hedonic pricing method uses surrogate measures e.g. variation in house prices, as an indication of the value of a change in water quality.

Garrod and Willis (1992) found that the proximity of open water to a property increased its value by 5%. However, this also highlighted several bases for concern with this method including that:

1. House prices represent a unique *combination* of characteristics, yet HPM centres on an individuals ability to isolate and estimate the value of particular attributes independently. To aid this valuation economists also require a great deal of regionally and nationally adjusted data.
2. The HPM will only reflect household's marginal WTP for a particular attribute if the *measured* level of the attribute corresponds to the *perceived* level by the consuming household.

Ramchandani has commented that this method tends to be inaccurate for valuing water quality improvements, and is more suitable for air or traffic quality changes (Ramchandani, 1989).

2. Indirect Benefit: Enhanced Recreation from Water Quality Improvement

2.1. Benefit Category: An improvement in water quality relating to improved recreational uses[3]. Green et al believe that the benefits of water quality improvement in the UK will mainly arise from increases in the amenity and recreational value of rivers, rather than from the abstraction of water for potable supply (Green et al, 1989). In this context improved water quality leads to:

a) a reduction in incidences of low dissolved oxygen resulting from the bacterial degradation of organic materials and heavy sediment loads, which make it difficult for fish to live (Kneese, 1984). This reduction leads to increases in the total availability i.e. *quantity*, of recreational freshwater fishing. Clean water also leads to an increase in *quality* of fishing, ensuring the presence of more game fish such as trout (Patrick, 1991).
b) an upgrade in the status of a river's quality e.g, from fishable to swimmable, thus opening up other in-stream uses (Feenberg & Mills, 1980).

2.2. Relationship of Benefits to Data Collection: The relationship of water quality improvement to data collection is explained in paragraph 1.2.

2.3. Economic Approaches to Evaluating Recreation Benefits

2.3.1. Travel Cost Method

The Travel Cost Method is argued by some to be the most appropriate approach within CBA to value *user* benefits from recreation (Ramchandani, 1989). Similar to CVM it is a non-market valuation technique, but here travelling expenses [financial costs + time spent] are used as a proxy for the price of visiting outdoor recreational sites (Hanley et al, 1997). These costs are then used in formulating the recreation demand equation which is used in turn to estimate consumer surplus for visits.

The process initially involves the collection of economic and demographic data through visitor surveys which is incorporated in the estimation of a statistical relationship between visits and the cost of visits.

Opinions tend to differ between authors on how precisely demand for recreation should be defined, the variables which should be included in the evaluation, and how (Davis & O'Neill, 1991). Gautam and Steinback identified the historical daily average catch rate as an important explanatory variable for 'quality of fishing experience' in their valuation of recreational fishing in North East America (Gautam & Steinback, 1996).

In Davis and O'Neill's evaluation of recreational angling using the TCM in N. Ireland, the mode of transport used was considered, in addition to the extent to which recreational activities other than angling were pursued during the trip (Davis & O'Neill, 1991). This is a useful approach as it permits an estimation of the *proportion* of the cost of the trip attributable to angling in isolation to other uses to be estimated.

It was argued by Green and Turnstall that an increase in water quality would attract new visitors away from *other* substitute sites (Green & Turnstall, 1991). Cesario and Knetsch included a factor reflecting 'competing opportunities' provided by all other sites in their zonal travel cost model (Cesario & Knetsch, 1976).

The TCM generally leads to an underestimation of water quality / flood alleviation benefits as total recreational benefits only represent the additional value to existing users (Brookshire & Smith, 1987).
The overall validity of the travel cost approach has been recently questioned however in a paper by Green. It showed that the fundamental assumption underlying the validity of TCM is not always the case, this assumption being that the value of visits undertaken from distant origins is greater than for origins nearer the site, because the travelling costs are greater (Green, 1990).

2.3.1.1. Hedonic Travel Cost Method: This involves the estimation of benefits from enhanced recreation from water quality improvements on a 'per recreation/fishing day' basis (Bockstael et al, 1987), through the regressing of individuals 'total cost [Cmij] of visiting a site [j] on the characteristics of the site [bj]:

$$\text{Cmij} = f^{i}\ [\text{bj}]$$

It is assumed here that the costs of visiting a particular site and the characteristics of the site are similar, for all individuals living within the same area, the variation stemming from the *different* sites visited by people from the same area. The distinction therefore, between this and the standard TCM model, is that here recreational benefits relating to improved water quality are estimated from the demand for site characteristics, and not that for recreation trips (Dasgupta & Pearce, 1977).

2.3.1.2. Random Utility Model: The appeal of this model to value enhanced recreation relates to the collection of travel cost and characteristics data for a number of substitute sites in an area. The probability that an individual will visit site i rather than j is then calculated, depending on the costs of visiting each site and their characteristics, relative to the characteristics in the individual's set of alternatives offering maximum utility. The welfare effects of changing a characteristic can then be calculated (Braden & Kolstad, 1991).

Benefit Transfer: In adopting a travel cost approach Gautam and Steinback assumed that sites within the same region were likely to be fairly homogenous in terms of catch rates, travel costs and distances to sites (Gautam & Steinback, 1996), possibility facilitating benefit transfer. Radford adopted an homogenous functional forum for all rivers in a region as differences in observed mean per capita values across rivers in a similar area were found not to be significant (Radford, 1991).

2.3.2. Contingent Valuation
Similar to TCM, contingent valuation employs an economic and demographic survey. In contrast however, it facilitates the estimation of nonuser benefits in relation to an improvement in recreation.

It has been suggested that the values expressed by respondents who do not engage in in-stream recreation should be almost purely intrinsic in nature, implying that calculating the average WTP amount for them allows an approximation of the intrinsic benefits accruing to

all individuals from the enhanced availability and quality of recreational use. Adopting this assumption Kneese subtracted non-recreationalists' WTP from recreationalists' WTP [deemed equal to total user values] and concluded that intrinsic value, apart from constituting 100% of non-user value, constitutes 45% of this total user value (Kneese, 1984).
Green et al sampled *three* groups of respondents in their contingent valuation study of water quality improvements: river corridor users, households adjacent to the river corridor and households located at least two miles from an accessible river corridor, with the total value then estimated as (Green et al, 1989):

[No. of visits * value of increased pleasure per visit] + non-use value of improvement

Earlier in this paper Gregory et al commented that requiring respondents to assign a monetary value within the non-market CVM placed excessive cognitive demands upon the respondent (Gregory et al, 1993). Kneese has proposed a solution to another cognitive difficulty for individuals in this context, i.e. to be aware of the *existing* water quality, and the water quality improvement *needed* for specific recreational uses (Kneese, 1984). He proposed that these levels be described in words and depicted graphically by means of a 'water quality ladder', which can also ensure that different people perceive existing and required levels in a similar way.

Benefit Transfer: In the FWR water quality manual a CVM survey was especially commissioned to develop 'standardised' values for the benefits to anglers associated with water quality improvements, a summary of which is given below (FWR, 1996).

Table 1: Summary of monetary benefits attributed to an increase in water quality for angling

Angler Type	*Value (£ per person per trip)*	*From**	*To***	*Method*
Coarse	3.86	No fishing	C3	CVM
	4.07	No fishing	C2	CVM
	6.21	No fishing	C1	CVM
	6.51	No fishing	T3	estimate
	7.58	No fishing	T2	estimate
	11.86	No fishing	T1	CVM
	15.83	No fishing	S1	CVM
Non-migratory salmon	7.16	No fishing	C1	CVM
	8.92	No fishing	T3	CVM
	10.39	No fishing	T2	CVM
	16.28	No fishing	T1	CVM
	22.65	No fishing	S1	CVM
Migratory salmon	11.58	No fishing	C1	CVM
	11.95	No fishing	T2	estimate
	18.70	No fishing	T1	CVM
	25.66	No fishing	S1	CVM

* Water quality where fishing cannot be carried out.
** Improved water quality level.
Source: Adapted from FWR (1996).

3. *Indirect Benefit: The Generation of Hydroelectric Power*

3.1. Benefit category: The generation of hydroelectric power contributes to 10% of the energy requirements of Scotland alone (SEF, 1996). The development capacity of hydroelectric power can be assigned a monetary value on the basis of £ per MW.

3.2. Relationship of benefit to data collection: This may be explained through the importance of forecasting seasonal flow changes on the effective operation of a hydroelectric plant as highlighted by Monokrovich (Monokrovich, 1990). At such plants throughflow is increased leading up to an expected surge of water or flood with a view to releasing some of the reservoir's capacity so that it can hold this water. If such forecasts are inaccurate or absent the throughflow regimen is calculated using the average high water inflow volume. If the actual inflow is greater, the lost production due to excess water discharged must be compensated by energy generated using fossil fuel.

3.3. Economic Approaches to Valuing Benefits from Hydroelectric Power Generation
3.3.1. Opportunity Cost Approach
Monokrovich calculated data value on the basis of the increased energy output from more accurate data. Assuming accuracy levels of 80-85% the lost production opportunity was calculated where:

$$R = U^* \, Wdis$$

R = Lost production
U = Difference in cost price of thermal station electricity and hydropower electricity
Wdis = Energy lost, being a function of volume discharged and the pressure head at which power is produced.

Monokrovich found that with this assumption of 80-85% accuracy a further increase of 5% gave an additional energy output of 1.4-1.9%, which could be equated to MW, and in turn valued at the market rate, resulting in an annual benefit of 100,000-140,000 roubles. The overall value of data was considered dependent on the actual capacity of the hydroelectric scheme.

4. *Indirect Benefit: Enhanced Flood Protection*

4.1. Benefit Category: The benefits from avoided losses due to flood protection. Flood damages can be either direct or indirect, depending or whether the damage is the result of direct contact with the flood waters or whether the losses result from disruption of economic activity as a consequence of flooding i.e. indirect flooding.

Benefits are further subdivided into tangible and intangible. Tangible benefits are measurable in monetary terms, while intangible are more difficult to attribute a monetary evaluation to e.g. greater security against loss of life, and enhancing environmental quality (Kuiper, 1971), or costs of dislocation to family life (Thampapillai & Musgrave, 1985).

4.2. Relationship of Benefits to Data Collection: Decisions concerning the implementation of flood mitigation schemes, according to Cordery and Cloke, are dependent on the accuracy of avoidable information. As the data length increases 'the inherent uncertainty of the characteristics of the stream flows decreases and confidence in estimates of the size and frequency of expected flood increases' (Cordery & Cloke, 1994).

4.3. Economic Approaches to Evaluating the Benefits of Flood Protection/Flood Warning Systems

4.3.1. Hedonic Price Method

Penning-Rowsell et al examined several US applications of HPM to flood alleviation benefit assessment and found little consistency in terms of explanatory variables included (Penning-Rowsell et al, 1992). This casts doubt on its validity.

Miyata and Abe applied this technique to valuing flood control benefits for the Chitose basin in Hokkaido, Japan (Miyata & Abe, 1994). A reduction in the variable, annual expected depth of flood water (AEDFW), was used to represent the resultant improvement in regional safety. This variable, in addition to a number of other variables was incorporated into two land price functions for suburban and urban areas:

$AEDFWi = \int_0^{\infty} P(Q) * Di(Q)dQ$	AEDFWi = annual expected depth of flood water in square I [1km grid squares] P(Q) = probability of occurrence of volume of discharge Q Di(Q) = expected depth of flood water in square i associated with volume discharge Q
Urban $\ln LP_1 = 4.9231 - 0.0041X_1 + 0.0035X_2 + 0.0001X_3 + 0.1069AEDFW - 0.5952D_1 + 1.0988D_2 + 0.1424D_3 + 0.3520D_5$ Suburban $\ln LP_2 = 3.7401 - 0.0116X_1 + 0.0003X_3 - 0.2010AEDFW + 0.4032D_4$	LP_i = land price per $1m^2$, X_1 = travel time between the nearest railway station to Sapporo station[the capital], X_2 = number of workers in a square, X_3 = population within a square, AEDFW = annual expected depth of flood water, D_1 = dummy for expected residential area, D_2 = dummy for commercial area, D_3 = dummy for gas supply, D_4 = dummy for water supply, D_3 = dummy for drainage availability, ln = natural logarithm.

The annual average cost considered was defined as:

$$c = \left(i + \frac{i}{(1+i)^n - 1}\right) * I$$

where c = annual average cost, i = interest rate (4.5%), n = number of years, and I = total investment for the project.

The increase in land prices found with a reduction in AEDFW represented the benefit of a flood control project. The largest benefit cost ratio was that found for Eniwa city at 1.99, which when limited to the consideration of direct damage avoided, in order to avoid the possibility of double counting, fell to .74. The overall benefit in suburban areas was greater than in urban areas due to a greater flood area, however the urban unit benefit was much greater i.e. 44 times that of suburban units. Table 2 exhibits the similarities across Japan in terms of the % of overall damage accounted for by annual average expected damage types.

Table 2: Reduction in the annual average expected damage type estimated as a % of overall damage

Damage Type	*Ebetsu*	*Chi-tose*	*Eniwa*	*Hiro-shima*	*Nanp-oro*	*Naga-numa*	*Total*
Property-	**13.7**	**25.6**	**12.6**	**16.9**	**27.1**	**38.3**	**14.6**
Houses	4.4	5	4.6	2.1	4.1	4.1	4.5
Furniture	3.3	3.4	2.3	1.6	2.5	2.3	2.3
Agricultural capital stocks	0.1	0.3	0.1	0.1	0.49	0.9	0.6
Agricultural inventory stocks	0	0.06	0.02	0.02	0.08	0.2	0.03
Other industrial capital stocks	2.1	0.85	2.9	5.5	1.3	0.3	2.8
Other industrial inventory stocks	1.4	0.2	1.5	1.5	1	0.3	1.4
Rice	2	6	1	4.9	17.2	28.7	3
Dry fieldcrops	0.44	9.9	0.16	1.2	0.4	1.6	0.4
Public Facilities-	**22.5**	**19.4**	**22.9**	**21.7**	**19**	**16.1**	**22.3**
Roads and bridges	2.7	2.3	2.7	2.6	3.9	3.3	2.8
Agricultural facilities	11.5	9.9	11.7	11.1	9.8	8.3	11.4
Agricultural land	0.08	0.06	0.09	0.08	0.06	0.05	0.09
Railways	1.96	1.7	1.99	1.9	-	-	1.8
Urban facilities	0.8	3.3	3.85	3.7	3.2	2.7	3.8
Telecommunication facilities	0.34	0.3	0.34	0.3	0.28	0.2	0.33
Power facilities	2.1	1.8	2.1	2	1.8	1.5	2.1
Indirect Damage-	**63.7**	**55**	**64.5**	**61.3**	**53.9**	**45.6**	**63.1**
Cost of emergency measures	2.1	1.8	2.2	2.0	1.8	1.5	2.1
Reduction in production	19.7	17.4	19.9	18.9	16.7	14.1	19.5
Repercussive effects on production.	15.6	13.52	15.9	15.1	13.2	11.2	15.5
Cost of traffic suspension	6.1	5.3	6.2	5.9	5.2	4.4	6.1
Increase in living costs	10.7	9.2	10.8	10.3	9.0	7.6	10.6
Others	9.4	8.1	9.5	9.02	7.9	6.7	9.3
Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Source: Adapted from figures as reported by Miyata & Abe (1994).

Contrary to Penning-Rowsell's findings the above tables shows similarities across cities in % of total damages accounted for by each category. Examining benefit by type of damage, across cities indirect benefits were found on average to be 1.4 times direct benefits.

4.3.2. Avoided Damages Method

Potential damages avoided due to a flood protection scheme which Hueting attributed a monetary value to included loss of agricultural protection, damage to urban areas, temporary reduction in economic activities, costs of clean up, annual expenditures relating to emergency measures and health effects (Hueting, 1992). Cordery and Cloke similarly identified losses as the sum of items such as damage to property and infrastructure and disruption to businesses and transport routes (Cordery & Cloke, 1994).

4.3.2.1. Evaluating Agricultural Benefits i.e. avoided damages: This is on the basis of a farm survey (Penning-Rowsell et.al, 1992) within the benefit area determining land use, soil type, and flood experience of the land. An assessment is then made of the change in the value of output using adjusted[4] product prices.

4.3.2.2. Evaluating Urban Flood Protection Benefit: The unit loss method, developed initially by Penning-Rowsell and Chatterton was adopted by Parker et al to provide standard/average or site survey loss data for residences, businesses, and general utility loss (Parker et al, 1987). Accurate loss data can be derived initially from detailed studies of 'representative' samples of land uses and activities. On completion of this stage, only outline survey data is then needed in each project area rather than a complete modelling exercise. An advantage of this unit loss method is that losses can be built up or aggregated initially from individuals, to regions, and nationally. The suitability of this method is limited however to estimating direct losses and not changes which are likely to occur throughout the economy.

4.3.2.3. Evaluating intangible flood protection benefits i.e. intangible losses avoided
Qualitative Evaluation: This is the description of intangible benefits and costs comprehensively and clearly without attempting to assign a monetary value.

Bootstrapping: Bootstrapping is a method of deriving equivalent monetary values for unquantified losses, based on an extensive interview survey with flood victims (Green et al, 1989. Penning-Rowsell et al, 1992). A schedule for such surveys has been developed by Middlesex university and validated through 2000 interviews with flooded households.

Green's approach is illustrated in a number of steps:

1. Respondents were asked about the financial value of their losses and to rate the overall severity of the flood in terms of its impact on household life, and the relative severity of each of individual impacts. Scores on a scale of 1-10 are illustrated in table 3, 10 representing very severe damage and 1, least severe.
2. Table 3's subjective severity judgements for one of the two direct damages (i.e. fabric of the house, and its contents) were regressed[5] on a number of independent variables including financial magnitude of direct damage.

Table 3: Relative severity of different impacts or flooding as assessed by those who reported experiencing each impact

Damage	*Swalefcliffe*	*Uphill*	*Southgate*
Damage to house structure	5.0	5.0	3.0
Damage to replaceable contents.	9.0	7.0	0
Loss of memorabilia.	10.0	7.0	-
Health effects.	7.5	5.0	2.0
Stress of the flood itself.	10.0	n/a	6.5
Evacuation.	10.0	6.0	-
Disruption.	10.0	10.0	6.0

[n/a = not asked. - = no household suffered impact]
Source: Adapted from Green et al, 1989.

3. Monetary equivalent values for unquantified impacts were derived though:
    - an equation invented to express subjective severity in terms of pounds, see below.
    - insertion of subjective severity judgements for each of the unquantified impacts into equation.

$$\text{Log(subjective severity)} = 0.30\log(\pounds) + 0.01$$

$(r = 0.75; F = 74.90; p <= 0.001)$

4.3.2.4. Evaluating Environmental Benefits i.e. environmental flood losses avoided
The benefits from saving environmental functions can be estimated through a 'collective political decision' by experts as referred to by Hueting (Hueting, 1992), contingent valuation or shadow prices.

With the shadow prices approach the potential loss avoided is estimated as the cost of creating or recreating exactly the same ecosystem elsewhere, e.g. the loss of an area of marshland would be valued as the cost of buying the same area and type of land elsewhere, and then establishing the same ecosystem (Penning-Rowsell et al, 1992). Indirect environmental benefits have been found to be well in excess of direct benefits, in this case, approximately double direct damages.

5. Indirect Benefit: Enhanced Flood Warning Systems

5.1. Benefit Category: Flood damages are a function of water depth and warning time, defined by Day in the equation (Day et al, 1969):

$$E(D) = \sum_{i-1}^{n} PiDi$$

Pi = probability of a flood within the 'steps'/recurrence intervals i and i - 1
Di = community damage associated with flood level at top of step i, a function of the warning time, type of action and response to the warning.
E(D) = expected annual loss
n = number of contour steps to approach floodplain limit, also representing the recurrence interval

Damage losses may be avoided through improved flood warning systems.

5.2. Relationship of Benefit to Data Collection: Increased length or accuracy of data leads to more precise flood warning schemes.

5.3. Economic Approaches to Evaluating the Benefits of Enhanced Flood Warnings
The approach adopted by Walsh and Noonan to assessing the contribution of weather data to flood warning may also be applied in relation to directly evaluating that of hydrometric data (Walsh & Noonan, 1990). The steps involved in this approach are outlined below, the assumptions upon which it was based including that:
- the weather radar network was operational 95% of the time.
- there would be a 70% response rate by occupants to warnings. Weather/flood warnings are of no value without good communications to the public.
- the availability of suitable flood forecasting/warning models, using radar (or in our case hydrometric data) as an input.
- benefits only relate to flood damage reduction.

1. Identification of sites where radars could provide greatest flood warning benefit. All flood data was collected on property at risk within England and Wales, flood damage assessment based on Penning-Rowsell and Chatterton's methods.
2. Classification of risk to property in terms of three categories of frequency of occurrence (1 in 10 yrs, 1 in 10 - 1 in 50 yrs, 1 in 50 yrs) plus catchment response times.
3. Conversion of single flood event data (from step 1) to average annual benefit using factors derived from derived from assumptions damage levels for differing flood events, see annexe 1and table 4 below.

Table 4: Factors to multiply single event damage reduction to give average annual benefits.

Category	*Event*	*Multiplying factor*
A	Flooding more frequent than 1 in 10 years	0.25
B	Flooding frequency between 1 in 10 and 1 in 50 years	0.07
C	Flooding less frequent than 1 in 50 years	0.02

Source: Adapted from Walsh & Noonan. (1990).

4. Derivation of weighting factors based on catchment response time of 4 hours. When response times were between 6 and 9 hrs radar was assumed to be of some value, and to be very useful for response times between 3 and 6 hrs, table 5.

Table 5: Weighting factors to give benefit due to radar

	No existing F/W scheme				*With existing F/W scheme*			
Times of response (Hrs)	0-3	3-6	6-9	>9	0-3	3-6	6-9	>9
Without 'Frontiers'*	0	0.8	1.0	1.0	1.0	0.6	0.2	0.05
With 'Frontiers'	1.0	1.0	1.0	1.0	0.9	0.75	0.2	0.05

* radar operating in conjunction with additional rain forecasting system.
Source: Adapted from Walsh & Noonan. (1990).

The most updated figures available using Walsh and Noonan's method calculate benefits, on the basis of giving a 4 hr. warning, to be £1.56m per yr, rising to £3.84m when data is combined with 'frontiers' data, implying benefit cost ratios of 3 and 5 respectively.

Benefit Transfer: The extent to which both standard and average data are available for flood damage has facilitated the transfer of flood alleviation benefits.
The term standard depth damage is reserved for data assembled from secondary sources. Average data is used to denote data derived from previous site surveys, averaged to give a generalised indication of flood damages for property types. UK damage data to residences/commercial units is frequently updated in the Flair report, by Middlesex University. Table 6 outlines different types of currently available data.

Table 6: Different types of flood damage data available and their characteristics.

Types of Data	*Examples*
Standard Data • Based on specified simplifying assumptions regarding flood characteristics, e.g. velocity effects are minimal. • Based on specified costing approach e.g. use of average remaining values. • Based on a synthesis of data from multiple primary and secondary sources including loss adjustments. • Assumed to be transferable throughout U.K.; may incorporate national secondary data sources based on sample surveys. • Available where damage characteristics are likely to be very similar because properties or services are similar.	Direct depth damage data for residences Emergency Services cost data
Average Data • Based on assessments of flood loss potential from a large number of cases/properties using e.g. business site survey interview schedule. • Based on specified costing approach but also relies on property manager's estimated. • devised where there is relatively high variability between damage sensitivity of properties and where standard data cannot be devised. • transferable within the UK but cannot be expected to take full account of uniqueness of properties.	Direct depth damage data for industry Manufacturing flood loss data
Site Survey Data • Loss data collected by 'one-off' site surveys using, e.g. business site survey interview schedule. • Most reliable where properties or locations have unique damage characteristics.	

Source: Adapted from Parker et al. (1987).

6. Indirect Benefit: Recreation Benefits from Enhanced Flood Protection/Flood Warning Systems

6.1. Benefit Category: In addition to improved water quality, recreational benefits also accrue to more effective flood warning / flood alleviation measures. The difference lies in that in the case of water quality improvement, benefits relate more to an increase in the quality *and* quantity of recreational uses, while the latter concentrates on the benefits stemming from increased amenity land saved from flooding, through flood warning systems and better design of flood mitigation measures.

6.2. Relationships of Benefits to Data Collection: As hydrometric data increases, 'the inherent uncertainty of the characteristics of the stream flows decreases and confidence which aids the design of flood mitigation measures and issue of flood warnings increases (Cordery & Cloke, 1994). More effective flood warning procedures avoid the loss of amenity land through flooding.

6.3. Economic Approaches to Evaluating Recreation Benefits from Enhanced Flood Protection/Flood Warning

6.3.1. Travel Cost Method

Section 2 offered a discussion of this method in relation to improved water quality. Penning-Rowsell et al in their evaluation of coastal flood protection proposed that in addition to the loss of enjoyment that may follow due to flooding, the possibility that users will decide to transfer their visits to an alternative site should also be taken into account, in total economic loss, illustrated in figure 1.

Figure 1: Estimating total economic loss in terms of recreation from flooding

1. $B_1 = Eo - E_1$

2. $B_2 = (Eo - Ea) + (Ca - Co)$

Eo = Value of enjoyment of today's visit/a visit in current conditions
E_1 = Value of enjoyment per visit after flood
Ea = Value of enjoyment per visit at the alternative site visited after flooding
Ca = Cost incurred in visiting the alternative site after flooding
Co = Cost incurred in visiting the present site.
B_1 = Benefit when economic loss is measured by the loss in enjoyment only
B_2 = Benefit when economic loss is measured by the difference between enjoyment at the site plus any increase in cost involved in visiting the alternative site.

Source: Penning-Rowsell et al. (1992).

Similarly to the case with water quality, the travel cost method generally leads to an underestimation of flood alleviation benefits (Brookshire & Smith, 1987). While Green et al however questioned the validity of the approach in relation to water quality improvement benefits, Penning-Rowsell et al propose TCM as a 'sound basis' for the use of CVM in relation to recreational benefits of flood alleviation (Penning-Rowsell et al, 1992).

6.3.1.1. Hedonic Travel Cost Method: This method, described in section 2, may also be appropriate in valuing the recreational benefits from more effective flood alleviation.

Benefit Transfer: The 'per recreation day' standard values as attributed with the hedonic travel cost model, may be suitable for equating with days lost due to flooding in similar catchments.

Part 2 - General Approaches to Cost Benefit Analysis

The aim of this report is to consider economic approaches which provide a clear evaluation of the worth of hydrometric data. This has been attempted essentially in a piecemeal fashion by valuing the indirect benefits of data collection, as outlined, and proposing that they then be apportioned to hydrometric data in a quantitative way. In parallel to this it may be useful to consider a more general approach which examines the relationship between data collection and risk reduction.

Evaluating the Collection of Hydrometric Data Directly Through its Relationship to Risk/Uncertainty Reduction

Introduction - A Distinction Between Risk and Uncertainty

Environmental decision making, according to Faucheux and Froger, will always be in the context of uncertainty in addition to complexity (Faucheux & Froger, 1995). Forecasts which concern hydrometeorologic phenomena were highlighted by Krzystofowicz as 'inherently uncertain'. This uncertainty he categorised as: 'natural uncertainty' which stems from the nature of hydrological systems and 'forecast uncertainty' stemming from the processes involving the interpretation of this data (Krzytstofowicz, 1983).

Dasgupta and Pearce also classify uncertainty in project evaluation in terms of its source in an attempt to emphasise the need to modify the standard methodologies of CBA, as discussed in part one, to incorporate this (Dasgupta & Pearce, 1972).

In adopting a suitable economic approach to evaluate the worth of hydrometric data however, it is important to distinguish between the terms *risk* and *uncertainty*. The crucial factor for Dasgupta and Pearce rests on the availability of information. If probabilities can be assigned to specific outcomes the situation is defined as risky, and if consequences cannot be identified with any likelihood the situation is deemed one of uncertainty (Dasgupta & Pearce, 1972). Similarly Vercelli refers to risk as being based on 'a reliable classification of possible events' with uncertainty referring to 'events whose probability distribution does not exist or is not fully definable for lack of reliable classification criteria' (Vercelli, 1991).

Finally, Fauchaux and Froger identify all the interactions between the economic system and the environment as being under *strong uncertainty*, on a scale of certainty to ignorance. This is described as a distribution of 'non-additive probabilities and/or by a plurality of probability distributions which are not fully reliable.' (Fauchaux & Froger, 1995).

1. Dealing With Environmental Uncertainty Within an Economic Framework

Traditionally, several approaches have been adopted in dealing with uncertainty, summarised by Zerbe and Dively (Zerbe & Dively, 1994):

1. Ignore uncertainty, appropriate where it is small, time span of importance is short or where CBA is only a rough estimate.
2. Reduce it to levels where it can be ignored by gathering additional data or more accurate information.
3. Recognise uncertainty and factor it into analysis with the introduction of sensitivity analysis, simulation or decision trees.
4. Adding a risk premium to the discount rate (Parker et al, 1987).

Adding a risk premium to the test discount rate is an unsatisfactory method as increasing it also reduces the effective time horizon for the scheme i.e. the higher the discount rate the closer is the date when benefits or costs accruing will be zero. The most preferred method for coping with uncertainty, according to Parker et al is sensitivity analysis which may be relevant in our case for the apportionment of indirect benefits to data collection.
The following general approaches rely on the second method above, the collection of additional data and its relation to error (equated to risk) reduction.

1.1. Data Collection and its Relationship to Error Reduction

This is based on the assumption that the benefits from increased hydrological information [Bh] are related to the % standard error [Eh] affecting the hydrological parameter:

$$Bh = f[Eh]$$

It is proposed that the *cost* of decreasing the standard error ΔC_{eh} by ΔEh, can be estimated in terms of the variables:

1. Increased frequency of measurement [ΔNm]
2. Increased number of stations in the study area [ΔNs]
3. Additional number of years in operation [ΔNt]
4. Better interpolation technique [ΔCi]

Precise relationships are illustrated in the box 1.

Box 1: Relationship of data collection to error reduction

Cost of decreasing error: $\Delta C_{eh} = f(\Delta Nm, \Delta Ns, \Delta Ne, \Delta Ci)$

Marginal benefit of decreasing error: $\Delta Bh/\Delta Eh = f(Eh - \Delta Eh) - f(Eh)/\Delta Eh$

Marginal cost of decreasing error: $\Delta C_{\Delta eh}/\Delta Eh = f(\Delta Nm, \Delta Ns, \Delta Ne, \Delta Ci)/\Delta Eh$

Source: Adapted from McMahon & Cronin (1980).

This method is generally applied to data evaluation on planned water resource projects in respect to a particular region or network.

Edgar et al. suggested early on that the adequacy of hydrologic data [i.e. which encompasses hydrometric data] in economic terms, centred upon the marginal cost associated with improving the data being just equal to the marginal benefit resulting from the improvement in information relating to potential flood damages for example, and reduction in error implied as a result (Edgar et al. 1973).

McMahon and Cronin's marginal economic analysis approach focused on developing statistical relationships of increasing/reducing uncertainty(exhibited through differing errors) to the construction costs of dams/reservoirs, culverts/bridges, regulation measures, and hydropower operations and examining which had the greater influence (McMahon & Cronin, 1980). It supported the continuation of data collection in that the disbenefit of a 20% reduction in the Canadian data collection network was greater than the relative benefit in continuing data collection activities.

1.2. Non-Bayesian Decision Theory

An appropriate way to assess the value of data collection is to estimate the value of the next data sample. This involves:

1. The definition of a benefit/error function, similar to the error reduction approach
2. Translation of benefit/error function to a benefit/length of record function
   a. Simulation of long period of record
   b. Splitting this into sections [Ts]
3. The separate use of each section for designing the project and benefits calculated [Bs]
   a. Bs is compared with benefits from using a long period of record [Bl].
   b. The difference [$\Delta Bs = Bl - Bs$] can then be attributed to the additional period of record [$\Delta Ts = Tl - Ts$].

In assessing the value of data to flood mitigation planning, Cordery and Cloke divided available streamflow data for N.S.W into small sample sizes [10 years] to estimate design flood levels which were then used to develop damage frequency relations (Cordery & Cloke, 1992). Levee construction costs to each sample's design level were calculated, which allowed the difference in benefits between different design levels to be estimated. This allowed the value of 10 extra years of data given that 20 years are available, for example to represent the difference in overall benefits. The situation was simulated using data from an existing monitoring station for which a long record was available. Assuming that flood mitigation protection measure planning was the only use, benefits were up to eighty times the cost of annual data collection at the site.

In 1993 the value of streamflow data for flood estimation for minor structures was assessed by examining the improvement in design flood estimation during the period 1958 to 1987 (Cloke et al, 1993). It was assumed that design floods estimated in 1987 incorporating the most recent methodology, and longest record length 'would be the closest to the intended or true design value'. Hence benefits were related to the avoidance of additional costs resulting from underdesign/overdesign, variables considered including flood damage cost, flood durations, average number of vehicles affected [annual average daily traffic values], detour distances [assuming that traffic affected would choose to detour], traffic detour costs [allowing for occupants' time, and vehicle depreciation, maintenance and fuel costs and frequency of overlapping. Relevant costs were those from collecting streamflow data.

As early as 1965 Linsley also identified that cost savings could not be related in a linear fashion to data accuracy (Linsley, 1965), while Cordery and Cloke, in 1993 found a similar nonlinear relationship with regard to reservoir storage design, i.e. that the present worth of collecting the 'next' sample of data is much smaller than the present worth of collecting the 'previous' sample of data (Cloke & Cordery, 1993).

Overall Cloke and Cordery concluded that benefit cost ratio depended on the amount of existing *and* additional data, and the number of sites at which data are to be collected.

Table 7: Formulae for use in benefit cost study for minor waterway construction

Underdesign Cost Estimation	*Underdesign Savings*
$C_u = (R_u.N.C_{fd}) + C_r$ $C_t = R_u.N.E_u.T_u.[(D.C_v) + (O.C_p.D/S)]$ C_u = total costs resulting from underdesign during design life $. C_{fd} = average flood damage costs per structure during design life $ C_t = costs resulting from traffic disruption 4 C_v = vehicular costs, $/km D = average detour distance, km S = average vehicle speed, km/hr O = average vehicle occupancy T_u = average no. of vehicles delayed, in addition to design intention by underdesign E_u = extra flood overlappings during design life N = no. of structures in region R_u = ratio of underdesigned structures to total sampled	$S_u = R_u.N.S_w$ S_u = total savings resulting from underdesign S_w = average savings per structure from reduced capital expenditure for structures underdesigned, $
Overdesign Costs	*Overdesign savings*
$C_o = R_o.N.C_a$ C_o = total costs resulting from overdesign, $ C_a = average cost per structure of unnecessary capital expenditure due to overdesign of structure, $ R_o = ratio of overdesigned structures to total sampled.	$S_o = (R_o.N.S_a) + S_t$ $S_t = R_o.N.E_o.T_o.[(D.C_v) + (O.C_p.D/S)]$ S_o = total savings resulting from overdesign during design life, $ S_a = average savings in flood damage during design live per structure from reduced overlappings, $ S_t = savings resulting from reduced traffic disruption, $ E_o = reduction in flood overlappings during design life T_o = average reduction in vehicles delayed due to overdesign

Source: Cloke et al. (1993).

Benefit cost ratios for a programme of data collection relating to minor waterway crossing design were estimated as 120, 21, 4.4 and -0.25, for discount rates of 0, 4,7 and 10% respectively. These could be considered conservative estimates however, taking all program costs into account but relating benefits to just one use. Equivalent monetary benefits ranged from $3900m to $350m with 0 to 7% discount rates.

Similar to Cloke et al's 1993 study, Ramirez et al examined the effect of additional information on better flood alleviation designs in Rushford Minnesota, by examining the *ex-post* value of information (Ramirez et al, 1988). The value of information concept (VOI) used in these two approaches was ex post in the sense that the information was on hand when its value was determined. This contrasts with bayesian approaches where the exact information to be received is unknown at the time its potential value is assessed. New estimates with 28 years additional data showed a reduction in avoided damages from $30,750 to $21,420, and as a consequence a reduced b/c ratio of .87

The value of increased data collection at two observation stations on the Lapuanjoke river in Finland was calculated by the value of land which could be used due to decreased uncertainty on the area at risk from flooding i.e. an extra 80ha, see table 8 (Laitinen & Puupponen, 1996). It was found however that benefits stabilised after 40 years.

Table 8: Uncertainties of HQ150* and benefits of data

Period (yrs)	*HQ 1/50 Station 1. (m_3/s)*	*Station 2. (m_3/s)*	*Benefits (million FIM)*
10	210-500	96-228	0
20	240-430	109-196	4,8
30	290-410	132-187	6,4
40	290-400	132-182	8,0
50	295-395	134-180	8,0
60	310-395	141-180	8,0

* lowest limit of elevation permitted for construction on floodplain.
Source: Laitinen & Puupponen. (1996).

Benefit Transfer: Hydrometric data are used very differently for specific investment project. Cordery and Cloke found also that even for similar project types, from site to site benefits varied depending on size of basin upstream, of the site, local topography, flooding frequency and the number and damage susceptibility of the properties to be protected (Cordery & Cloke, 1991).

1.3. The Use of Bayesian Decision Theory

The application of decision theory to evaluating the worth of data involves a number of steps:

1. A set of initial existing data e.g. time series/probability distribution], known as the 'prior' is used to design the water resource project in question e.g. flood control.
2. The times series/probability distribution is modified over time with new data, known as the 'posterior'
   a. the 'prior' estimates are revised using Bayes' theorem, improving information and reducing error, illustrated in box 2:

Bayes rule/theorem

$$P(ai/c) = \frac{P(ai)\ P(c/ai}{Ei\ P(ai)\ P(c/ai)}$$

ai = a priori probability estimates
c = new information

3. Calculation of the expected opportunity loss [EOL], which is represented by the difference between additional benefits due to better design and additional costs due to acquisition of additional information. The optimal design is that which minimises XOL. XOL, however, cannot be calculated until all possible outcomes for additional measurements and corresponding posteriors are examined.

In Simpson's 1987 review of methodologies for estimating the value of streamflow data, bayesian decision theory, in providing a method to 'pool or update' information was deemed superior to earlier methods, such as generating synthetic records through identifying statistical distributions (Simpson et al. 1987).
Davis, Kiesel and Duckstein's early paper also illustrated the application of bayesian decision theory in assessing the value of additional data by incorporating it into engineering decisions on flood levee design on the Rillito Creek floodplain (Davis et al. 1971).

Adeloye suggested a bayesian approach to evaluating the worth of hydrometric data for reservoir capacity in examining the 'dependent' relationship which exists between reduction in uncertainty (equated to temporal error, see figure 2) and costs of reservoir over/under design (Adeloye, 1995). Due to the complexity however in defining such a relationship for each error type, Adeloye proposes the use of Monte Carlo simulation.

Figure 2: Breakdown of Total Data Error

$$e = \sqrt{(e^2_g + e^2_t + e^2_s + e^2_m)}$$

e^2_g = Gauging error due to flow measurement
e^2_t = Temporal error due to short data record length
e^2_s = Spatial error due to data transferred from a measurement location to the location of the project
e^2_m = Model error due to assumptions concerning the nature of the random hydrological process.

Source: Adapted from Adeloye 1995.

Adeloye found that when the length of data record was increased fourfold, the temporal error was only reduced by 50%, and with an eight fold increase the error was reduced by a factor of 2.8.

1.3.1. The Suitability of Bayesian Decision Theory Within an Environmental Decision Making Framework

On closer examination of the nature of both bayesian methods and environmental decision making it becomes apparent however that, despite widespread application, they may be somewhat incompatible:

1. The process of developing equations to reflect all possible interactions among variables, and assigning different probabilities of outcome is very time consuming (Zerbe & Dively, 1994), and expensive. This also implies that the assignment of objective probabilities to established outcomes is justified, implying in turn, the existence of a risky situation, and not one representative of environmental uncertainty, as defined (Dasgupta & Pearce, 1972).
2. This is essentially a project specific approach relying on the availability of detailed project specific costs.

In 1977 Klemes highlighted that when using hydrometric data as a decision basis in reservoir design one must remain aware that one is dealing with a 'complete random process' (Klemes, 1977), while Davey believes that while historical extreme flood events give a useful guide to the possible size of maximum floods, the fact that several recorded floods have exceeded maximums set highlights the potential extreme responses. Machina suggests that such traditional theories of decision making, as bayesian may need to be reversed with the occurrence of different forms of uncertainty (Machina, 1987).
If bayesian decision theory was to be adopted its use would be dependent on a large number of simplifying assumptions (Cloke & Cordery, 1993).

Part 3 - Valuing The Hydrometric Data Collection *Network*

1. Network Approach to Data Evaluation

Mawdsley et al examined the value of data for the design of flood protection schemes with respect to a gauge network in NE England.
Historic data was used to assess the effects of obtaining further data rather than expectations based on all possible future flows.

The general principle behind this approach was the assessment of the opportunity loss of making a wrong decision given imperfect data. According to Mawdsley the value of existing data is represented by the difference between the opportunity loss of decision making in the design of a flood protection works without any data, and that with hydrometric data[6] (Mawdsley et al. 1990):

$$\text{Data Value} = EOL_{yo} - EOL_{y}$$

Yo = data available in the absence of a gauge. In the absence of data other information would be used to make the decision e.g. rainfall information, or simulated data.
Y = data available with the gauge

To assess the expected opportunity loss for a given level of data, an opportunity loss function was obtained which is a function of the error in the estimate of the design parameter (e), and a probability distribution of the error p(e) is also required, which was then combined to obtain:

$$EOL_{y} = \int_{-\infty}^{\infty} OL(e)p(e)de$$

By considering all contributing errors in the data, the probability distribution of the error in the design was estimated, the errors being classified into four groups i.e. gauging, temporal, spatial and model.
With application of this method to three network case studies, see table 9, Mawdsley found data value increased at a diminishing rate, whereas annual costs varied relatively little after installation.

Table 9: Value of hydrological data for flood protection only in three case studies

Values/Scheme	*Morpeth*	*Stokesley*	*Croft*
No. of gauges	1	2	3
Station years of data	10	24	54
Cost of scheme	£172,000	£325,000	£90,000
EOL [base level]	£10,650	£14,950	£1,100
Value of gauge data	£7,910	£12,350	£3,980
Cost of data for station year	£ 758	£1,378	£1,378
Value of data per station year	£791	£515	£74
Values as % of scheme cost	5	4	5
Benefit/cost ratio	1.0	0.37	0.05

Source: Adapted from Mawdsley et al. (1990).

The value of data was shown to be 4-5% of construction costs of the flood protection scheme for the lengths of data available considering flood protection as the only application of the data. The relatively low benefit/cost ratio for the flood protection schemes may have been caused by their small sizes. If a bigger scheme was undertaken and the 4-5% value was still correct, then the benefit/cost ratio would increase.

2. The Audit Approach

The audit approach, developed by Davar and Brimley, has been used to identify areas where improved network performance could be achieved without any additional resources, and to provide a guide by which to assess the impacts of any decision (Davar & Brimley, 1990).

Contrary to cost benefit analysis however, no monetary value is assigned to benefits. Instead the total set of existing and proposed stations are prioritised or ranked in order of performance on a number of considerations:

1. A survey identifies users' needs
2. Uses are rated on the basis of % benefit attributable to data
3. A set of priority considerations/criteria is outlined i.e. site characteristics, identified client needs [in terms of hydrology and operational] and a region's importance for water resources.
4. Individual gauging stations, organised on a catchment basis are assessed, by a number of water resource experts and managers, in terms of the extent to which they reflect priority considerations, see table 10.
5. The higher the total station audit points accumulated by a particular station, the higher the relative value of benefits derived from that station.

Table 10: Example of network evaluation audit for New Brunswick

Priority Consideration - Site Characteristics	*Available Points*	*Maximum Score Possible*	*Rationale for Score*
Mean annual flow • less than $25m^3/s$ • $25 - 125m^3/s$ • greater than $125m^3/s$	 2 4 6	6	Large drainages provide more representative samples for province as a whole.
Water level only		3	These stations provide less info. than flow stations.
Quality of record		15	The better the quality of record the greater the information value.
Period of record (years) • 0 - 5 • 6 - 10 • 11 - 15 • 16 - 25 • 26 - 40 • greater than 40	 7 5 3 7 10	10	Short records need to be extended to establish a record. Once record is established it is of decreasing value, with exception of very long records, which become valuable for index purposes.
Proximity to climate station		5	Stations whose record may be readily related to comparative meteorological data have added information value.

Source: Adapted from Davar and Brimley. (1990).

The audit approach offers an approach also to identifying redundancy in gauging stations, in assessing stations on the basis of such criteria, as outlined above, in addition to marginal costs. The priority considerations for site characteristics could also be based on responses from user surveys.

Review Conclusion

The above review examines potential approaches to valuing hydrometric data in three parts:
1. Detailed approach to cost benefit analysis
2. General approach to cost benefit analysis
3. Valuing the hydrometric data collection network

A two step procedure was suggested in relation to part 1, where indirect data collection benefits e.g. flood protection, could first be quantified and then apportioned to actual hydrometric data. For comprehensive coverage of these indirect benefits, both tangible and intangible (para 4.3.2.3.), a combination of primary survey techniques would be required implying considerable investment in time and money. In an attempt to avoid this, benefit transfer was also discussed, as useful in approximating values, if reliant on the availability of existing updated values.

General approaches value the worth of hydrometric data through its relationship to risk/uncertainty reduction. Such approaches, as outlined in part 2, have been used extensively in recent years with regard to investment planning. The difficulty in applying these techniques for our purposes however stems from their project specific nature which prevents the transfer of benefits, possible in part 1.

Finally, part 3 proposes a more holistic approach, focusing on the valuation of the data collection network, with the potential to then narrow down specific stations. The audit approach (part 3, section 2) in particular is highlighted as offering a possible 'user friendly' solution to the valuation issues faced by Environment Agency and S.E.P.A officers across functions, however its effectiveness, as will be discussed in Hanley's forthcoming paper, may rely on its use in association with further statistical techniques to develop an efficient *framework* for economic valuation.

Annexe 1

Determination of multiplication factors to convert benefits of flood warning from single events to average annual benefits

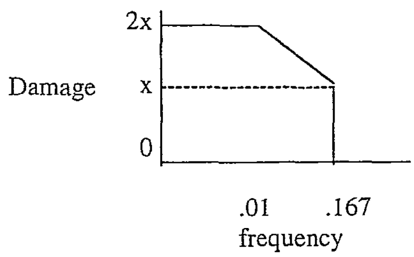
A) Flooding more frequent than 1 in 10 yrs:

In this category of flood risk zones it was assumed that protection was given up to approx. 1 in 6 year frequency, with damage doubled for a 1 in 100 year and less frequent events.

- assume single event damage reduction = £x
- average annual benefit (area under curve)

$$= 2x * .01 + \frac{2x + x}{2} (.167 - .01)$$

$= 0.255x$, i.e. .25 = 'frequency factor'



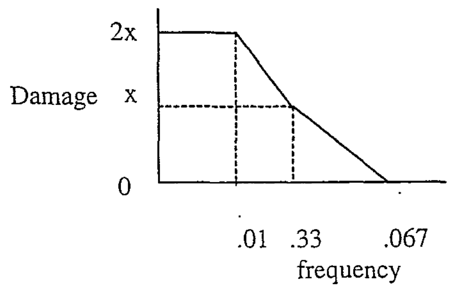
B) Flooding frequency between 1 in 10 and 1 in 50 yrs.

Assume average flood frequency to be 1 in 30 years with flood damage doubled for a 1 in 100 year and less frequent events and with damage reduced to zero for a 1 in 15 year event.

- assume single event damage reduction = £x
- average annual benefit (area under curve)

$$= 2x * .01 + \frac{(2x + x)}{2} (.033 - .01) + \frac{x}{2} (.067 - .033)$$

$= .00715x$, i.e. .07 = 'frequency factor'



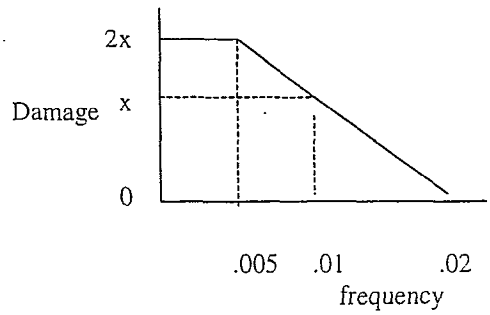
C) Flooding frequency less than 1 in 50 yrs

Assume average flood frequency to be 1 in 100 years with flood damage doubled at 1 in 200 years and less frequent events and with damage reduced to zero at a frequency of 1 in 50 years.

- assume single event damage reduction = £x
- average annual benefit

$$= 2x * .055 + \frac{(2x + x)}{2} (.01 - .005) + \frac{x}{2} (.02 - .01)$$

$= 0.022x$, i.e. .02 = 'frequency factor'



[1] Benefits from groundwater quality improvement are included due to its importance in catchment management, for public and private water supply and for providing base-flow for many surface water systems (Newson, 1995).

[2] Total willingness to pay may be sought from individuals, or alternatively broken down into its components;. current personal use values [current use values], possible future use values [option values], future generation use values [bequest values], non-use values [existence/intrinsic values].

[3] The majority of the 38,000km of watercourse in Britain, are too narrow and shallow ever to support activities in addition to recreational activity (Green & Turnstall, 1991).

[4] Adjustment factors published by the Ministry of agriculture, fisheries and food, 1985.

[5] Assumptions made included that impacts are independent, and that an acceptable regression equation could be obtained.

[6] This implies that Mawdsley believes there remains a level of inherent uncertainty even after the collection of hydrometric data.

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APPENDIX C

Analysis and Interpretation of Hydrometric Data Questionnaires

Development of questionnaires, rationale and sampling technique
In order to define the nature of current hydrometric data collection activities by the environment agency within the UK a postal self completion questionnaire was developed and sent to key environment agency personnel in the functions shown in Table 1.

Sample Size and Response Rate: In total a sample of 241 questionnaires were despatched tailored to ascertain the situation with regard to nine agency functions, actual numbers to each function outlined in Table 1. One hundred and thirty eight responses were received in time for analysis. This response rate of 58% is particularly high for a postal questionnaire, responses using this technique generally averaging under 10%.

Table 1: Breakdown of Agency Functions to Which Questionnaires were Sent

Agency function	*Sample no.*	*No. of respondents*
Abstraction Licensing	26	18
Fisheries & Conservation	33	19
Flood Warning	33	19
Flood Defence	26	17
Freshwater Biology	33	14
Freshwater Chemistry	33	7
Marine/Estuary Studies	33	10
Pollution Control	33	19
Water Resource Management	17	18*

*the higher response rate is a result of a request by us that questionnaires be copied within the agency to personnel who may not have received their own.

The following brief report outlines questionnaire responses received overall and specifically in relation to function area. Essentially discussion focuses on a number of issues referred to during the literature review and CBA methodology report.

1. The specific uses of data and associated benefits [as identified/unidentified in the literature review] of hydrometric data collection according to EA personnel.
2. The potential benefits if any in extending the network.
3. The difficulties in defining an approach to linking data types with data use benefits.
4. The importance of real-time data collection in addition to historic data.
5. The predicted effects of extending or reducing the hydrometric data network.
6. The current awareness of EA personnel of the economic value of hydrometric data.
7. The contribution of questionnaire responses to the development of an economic framework similar to that of Davar & Brimley in the CBA methods section for hydrometric data evaluation within the UK.

Section 1 – Specific Data types Required by Agency Functions and Relevant Uses

1.1 Data Types Required

The two principal categories of data collected were those on river flows and water levels, the percentage within each function using these indicated in Table 2.

The largest proportion of cases within any one function using averaged daily flow was 57% within freshwater chemistry, pollution control also exhibiting a substantial amount, at 42%.

Percentile measures (Pctl) are also required in many situations for pollution control, in addition to abstraction licensing functions which also showed the greatest proportion of cases demanding instantaneous flows (AIF). These possibly indicate the more precise nature of information required in the determination and enforcement of abstraction licences and pollution consents. This is in contrast to water resources management where 67% of cases specified only mean annual flows (MAF), 80% overall referring to general flows (Uns.), with the specific need for daily flows referred to by only 16%. With regard to flood warning 84% of cases referred to only general flows.

Table 2: Percentage of cases under each function stating a requirement for specific data set

Function Type	*River flows*						*Tide/Water Levels & Climate*				
	ADF	*MAF*	*AIF*	*FDC*	*Pctl*	*Uns.*	*Wtr.*	*Rain*	*GW*	*Tide*	*Mcs.*
Abstraction Licensing	22	6	39	16	22	50	72	61	39	6	11
Fisheries & Conservation	11	5	5	5	0	58	53	16	11	0	0
Flood Warning	0	0	0	0	0	84	89	47	0	21	5
Flood Defence	0	0	0	0	0	0	0	0	0	0	0
Freshwater Biology	7	29	21	0	7	50	21	0	0	0	0
Freshwater Chemistry	57	57	14	0	14	43	29	29	0	0	0
Marine/Estuary Studies	20	10	10	0	0	70	10	50	0	10	0
Pollution Control	42	26	5	16	37	37	11	26	0	0	0
Water Resource Mgmt.	13	67	13	0	7	80	73	73	60	13	33

As could be expected the measurement of both river (Wtr.) and rainfall (rain) level is cited as essential to flood warning. Water resources management, abstraction licensing and fisheries and conservation also appeared from responses to rely on such data. Groundwater data (GW) is less essential overall, however in relation to water resource management and abstraction, is considered necessary in 60% and 39% of cases respectively.

1.2 Use of Data Types by Function

To facilitate the examination of data use Tables 3.1-3.3 break down individual uses into sections.

Hydrometric data appears to have a key role across the functions in relation to the monitoring of low flow situations (oplw/risk/drgt), a role particularly emphasised with regard to water resources management and freshwater chemistry. In relation to estuarine/marine management data is used in only 20%, 20% and 10% of cases for determining currents within the estuary (estc), ecological conditions (estec), and salinity (estsl) respectively. This perhaps signifies the low level use of hydrometric data for this function overall. Where pollution related uses of data are considered the determination of pollution loadings (load) is most widespread.

Table 3.1: Percentage of cases under each function specifying data uses

Function Type	*Flow Risk*			*Estuarine Uses*			*Pollution Related Uses*				
	oplw	*risk*	*drgt*	*estc*	*estec*	*estsl.*	*Cons*	*nut*	*load*	*trade*	*trav*
Abstraction Licensing	39	39	0	0	0	0	22	5	5	5	0
Fisheries & Conservation	42	0	11	0	0	0	0	0	0	0	0
Flood Warning	0	0	0	0	0	0	0	0	0	0	0
Flood Defence	12	18	0	0	0	0	6	0	0	0	0
Freshwater Biology	21	21	8	0	0	0	7	14	7	0	0
Freshwater Chemistry	43	14	0	0	0	0	14	29	71	0	29
Marine/Estuary Studies	0	0	0	20	20	10	0	50	60	20	0
Pollution Control	0	0	0	0	0	0	89	11	47	11	16
Water Resource Mgmt.	73	33	33	0	0	0	47	13	13	0	0

Table 3.3 Percentage of cases under each function specifying data uses

Function Type	*Flood Related Uses*			*modelling/ abst.*		*Ecological Uses*					
	fldef	*fldwn*	*rtpr*	*tmpk*	*mdl.*	*ablc.*	*Flfh*	*pldil*	*ecim*	*fhsv*	*chnl*
Abstraction Licensing	11	6	0	0	5	100	0	0	0	6	0
Fisheries & Conservation	0	0	0	0	16	10	58	16	37	79	32
Flood Warning	0	100	0	5	24	0	0	0	0	0	0
Flood Defence	51	53	65	47	21	0	0	0	0	0	0
Freshwater Biology	0	0	0	0	43	7	0	0	0	0	0
Freshwater Chemistry	0	0	0	0	0	0	0	0	0	14	0
Marine/Estuary Studies	0	0	10	10	20	0	0	0	0	0	0
Pollution Control	0	0	5	0	58	0	0	0	0	0	0
Water Resource Mgmt.	0	20	13	13	53	53	0	0	0	0	0

Flood defence, from results, seems to rely more on data specifically on flood related factors and generally than flood warning, with the exception of modelling techniques (mdl) which are practised by both. The actual modelling system most commonly cited was rivpacs. The difficulty in apportioning a monetary value here would be that, like with many uses, data is just one input within modelling and an accurate estimation of its value would rely on its isolation from the remaining inputs.

Primarily within fisheries & conservation data has considerable use for ecological purposes, predominantly for fish surveys (fhsv), and in informing agency functions on flow conditions for migrating fish (flfh). While not emphasised in the literature review, a further benefit emphasised in the questionnaires is that of data as a major input in the riverline telephone service to river users a data use cited by 11% of fisheries & conservation respondents.

Table 3.3 Percentage of cases under each function specifying certain general data uses

Function Type	*General Uses*						
	Bckg	*inqrs*	*desn*	*pbinf*	*Plan*	*trend*	*Qlsm*
Abstraction Licensing	6	17	0	0	11	0	0
Fisheries & Conservation	0	0	0	16	11	5	0
Flood Warning	0	0	0	0	0	0	0
Flood Defence	18	0	29	0	0	0	0
Freshwater Biology	14	0	0	0	29	0	36
Freshwater Chemistry	0	0	0	14	29	14	43
Marine/Estuary Studies	10	20	0	0	0	10	0
Pollution Control	5	5	0	0	0	5	0
Water Resource Mgmt.	40	0	0	27	33	7	0

What could be considered the more general uses of data, see list of abbreviations (Annex 1), illustrated in table 3.3 are most common in relation to water resource management functions. Among these uses however the utilisation of data in the provision of background information, for reporting purposes and in planning fieldwork in-stream was identified for several areas.

The results in tables 2 & 3.1-3.3 highlight early in the analysis potentially what is a great difficulty in *linking* the monetary value of data use benefits to the collection of particular data sets. For example, in table 2 average daily flow data is recorded as necessary in relation to seven different Environment Agency functions in total, and in table 3.1 up to six different functions make use of data in relation to pollution. We are informed thus that data is necessary and in use but how important or necessary one data type is to one function relative to any other can only be estimated in a qualitative manner. The common use of data across functions has further implications should there be a rationalisation of the network, a point discussed in detail in section 3. The removal of collection facilities for just one data type would have effects across many Environment Agency functions.

Section 2 - The Value of Real-time and Historic Data

Environment Agency specialists for each function were questioned with respect to their use of both real-time (Real) and historic (Hist) hydrometric data. The responses in this section have potential relevance in the future if rationalisation of the network were to be considered and decisions continued on the basis of simulation using historic data only. For example, if pollution control benefits could equally be expected with the sole use of historic hydrometric data (Hist), the costs of real-time data collection could be avoided and in turn a greater benefit cost ratio produced.

Table 4: The nature of data collected for Certain Agency Functions

Functions	*Nature of Data*			*Simulation*			
	Both	*Real*	*Hist*	*nofut*	*general*	*real + hist*	*historic*
Flood defence	100	0	0	0	0	0	0
Freshwater biology	71	14	7	7	14	36	29
Water resource mgmt.	13	0	73	0	0	29	14

Across these three functions real-time data alone (Real), and in conjunction with historic data appears to play the greatest role currently, only a small proportion of cases with respect to freshwater biology operating on historic data alone 14%.

The use of both real-time and historic data in simulation was examined in relation to freshwater biology and chemistry in table 4 and where it was carried out most often took advantage of both real-time and historic data, i.e. in 36% and 29% of cases, historical data alone accounting for simulation in 29% and 14% respectively.

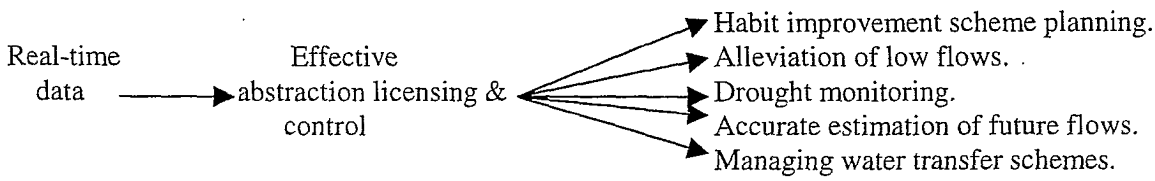
Table 5: The use of realtime data in flood warning

Function	*Realtime Data*		
	model+officer	*officer*	*don't know*
Flood Warning	58	37	5

Where the responsibility is flood warning, in the majority of cases i.e. 58%, real-time data has a dual purpose, in modelling (model) and to inform flood warning officers (officer). In relation to abstraction licensing, in only one situation was it specified that real data was not used. The specific aspects to which it contributed varied among abstraction licence determination and enforcement, drought and low flow monitoring, and estimating future flows.

It is the widespread nature of real-time data use which is important as it confirms its contribution to a number of benefits, e.g. within just one agency function, figure 1.

Figure 1: Contribution of real-time data within abstraction licensing



Section 3 - The possible effect on existing benefits of reducing/extending the network

In both the literature review (included with Progress Report W6/005/3) and the report on CBA methodologies (Appendix II to this Progress Report), benefits have been considered with the assumption of an existing or 'complete' network. There is a possibility however that changes may occur within the network, reducing or extending activities. Considering this possibility the questionnaires set out to examine the qualitative effect of such changes on existing benefits, if any. If for example a reduced network had no effect on benefits, then a reduction could be advised ensuring lower costs, stable benefits and in turn a higher benefit cost ratio.

Table 6: Current network situation in relation to fisheries & conservation, freshwater biology, freshwater chemistry and marine/estuary management

Function	***Use of Stations***	
	Certain	*Reasons*
Fisheries & Conservation	74	Riverline Prevent poaching Location of st e.g. downstream from releases. Assess fishing conditions. Where fish is counted. At main abstraction points. Areas of heavy floodplain use.
Freshwater Biology	29	Assessment of metals load. Ecologically acceptable flow assessment. Rivers susceptible to low flows. Stations used for biological monitoring. Representative sites.
Freshwater Chemistry	43	At bottom of catchment/proximity to estuary.
Marine/estuary	0	n/a

3.1. The Current Situation

Under the functions of fisheries & conservation, freshwater biology and freshwater chemistry certain stations were cited as being used more than others (certain) in 74, 29 and 43% of cases respectively, reasons for this given in table 6. Given the fact that in fisheries & conservation certain stations only are used due to a small number of reasons in 74% of regions, there may be potential here for weighting the importance of stations for this function within the network on the basis of these factors.

Examining the current situation with regard to marine and estuary management the hydrometric network was only considered by Agency officers to satisfy 40% of needs, a reduction in this case clearly having potentially very negative effects on relevant benefits.

3.2. The Effects of Reducing the Existing Network

The potential effects of reducing the existing network were largely examined in relation to abstraction licensing, flood warning, flood defence, and pollution control.

Table 7.1: Percentage of cases affected by reduction in network

Function Type	***When Data absent***				***Effect of removal on licences/consents***			
	com	*Estim*	*both*	*other*	*no*	*poss*	*varies*	*yes*
Abstraction Licensing	11	6	83	0	22	11	11	39
Flood Warning	0	0	0	0	0	0	0	0
Flood Defence	0	76	0	12	0	0	0	0
Pollution Control	11	16	74	0	21	0	37	32

Officers responsible for abstraction and pollution control were questioned as to what measures would be taken in the event of data being absent, and how this would in turn affect licences and consents. The majority of cases in each function stated that in such a situation both outside help would be consulted (com) and estimating procedures (estim) would be carried out, 83% and 74% respectively.

39% and 32% of those responsible for abstraction and pollution control responded that due to the lack of certainty which would result licences and consents would in turn be more restrictive or as was agreed in several cases a more precautionary approach would be advised. A significant proportion of pollution control respondents stated however that it would vary with specific events.

Percentage differences suggested in abstraction control were between 15-20%, and those in relation to pollution consents 10-25%. It should be noted however that almost half the pollution control officers stated they did not know what the difference would be, almost 30% of abstraction licensing officers stating the difference was too variable to specify.

Table 7.2: Servicing needs with a reduced network

Function Type	*Servicing needs with a reduced network*					
	Badly	*don't know*	*pressure*	*reduce effec.*	*Same*	*Soso*
Flood warning	58	16	0	11	5	11
Freshwater biology	29	14	21	0	0	36
Freshwater chemistry	29	0	14	0	14	43

Flood warning, freshwater biology and freshwater chemistry functions were asked specifically how existing needs would be satisfied with a reduced network, table 7.2 exhibiting that flood warning functions primarily would be badly affected (Badly), while with the remaining functions slightly more respondents stated that some needs would suffer but others would remain adequately serviced (Soso). This would imply that flood warning is somewhat more sensitive; a reduction in costs of for example 10% possibly resulting in a proportionately greater reduction in benefits.

Reducing data collection concerning freshwater biology and chemistry functions would according to 21% and 14% of respondents have indirect effects, in that there would be increased pressure placed upon other areas (pressure) e.g. estimating, possibly causing these other areas to operate less efficiently.

3.3. Effects of Extending the Existing Network

All Agency functions with the exception of water resource management were questioned as to whether an extended network would be useful for operations, responses given in table 8.

Table 8: Would data from an extended network be useful?

Function Type	*Would extended data be useful*				
	don't know	*no/prob no*	*yes/prob yes*	*possibly*	*depends*
Abstraction Licensing	0	6	89	6	0
Fisheries & Conservation	0	26	42	5	16
Flood Warning	0	5	89	0	0
Flood Defence	0	6	71	12	6
Freshwater Biology	0	29	71	0	0
Freshwater Chemistry	0	29	57	14	0
Marine/Estuary Studies	0	50	40	10	0
Pollution Control	21	16	63	0	0

Apart from marine/estuary management the majority of personnel across functions responded that they would utilise an increased amount of data if available (yes/prob yes). This reflects the picture throughout for marine/estuary management in that overall data appears to play less of a role than with other functions. It may also be considered to indicate that increased investment in the current network would lead to an increase in benefits. Agency officers who responded yes also qualified their answers, outlined in table 9.

Table 9: Increased uses from an extended network

Function	***Relevant uses***
Abstraction Licensing	Allow data to be received closer to site of interest Judgement of headwaters extractions To satisfy enforcement requirements Decrease limitations on licensing and consents Improved evaluation of impacts on smaller watercourses
Fisheries & Conservation	Increased coverage of areas lower down the river
Flood Defence	Research purposes Increase level of data, hence confidence Reduce the number of gaps in the network Improvement of modelling accuracy
Freshwater Biology	Refinement of rivpacs inputs Existing gaps in data cause difficulty Enhance biological surveying Ensure a more reliable analysis
Freshwater Chemistry	Improve on existing lack of accuracy
Marine/Estuary Studies	Better estimate flushing rates To assess impact of fish farms Existing gauging stations are too far inland
Pollution Control	Ensure more accurate data Allow more emphasis away from large catchments only Present sites not always close enough to sewage works

An interesting issue, if somewhat tangential in terms of economic values, which this question raised within fisheries & conservation, and which would seem relevant to all functions is that of whether hydrometric data is currently being utilised to its full potential. It was suggested that if more guidance was given to current users, then perhaps the existing network could be better utilised and in some cases there may not be a requirement for *extended* activities.

Section 4 - Accuracy and Hydrometric Data

Within certain approaches to economic valuation of data, there is an assumption (outline in the literature review) that the benefits from increased hydrological information are related to the % standard error affecting the hydrological parameter, and in turn that the cost of decreasing the standard error can be estimated on the basis of increased frequency of measurement, increased number of stations in the study area, additional number of years in operation and better interpolation techniques.

On the basis of this theory it was useful to examine in this research what levels of accuracy are currently required relating to data functions. If required accuracy levels are known, specific stations could possibly be evaluated on the basis of how actual accuracy levels compare, with the implication that the closer those levels, the more benefits would accrue to that station.

Table 10: Level of Accuracy Required

Function Type	*% Accuracy required*						
	as accurate as possible	*specified levels of accuracy*	*don't know*	*estimates + observation required*	*estimates suffice*	*low/ none*	*variable*
Flood Defence	12	65	12	0	0	0	12
Freshwater Biology	14	0	7	14	29	0	21
Freshwater Chemistry	29	0	0	29	29	0	0
Marine/Estuary Studies	10	10	0	0	0	20	0

Unfortunately the majority of officers across functions questioned, apart from flood defence, did not feel able to specify accuracy levels in a quantitative way (despite our request). On further questioning however it may be possible to more accurately define these. It is interesting to note however that the smallest error level possible is not automatically the most desirable, several respondents referring to the need for balance, accuracy levels specified for flood defence outlined in table 11.

Table 11: Accuracy levels specified within flood defence

Flood Defence Data	*Accuracy Level*
Data on flows	+/-5%-10%
Flood levels	50-300mm
Flood warning	50mm

In relation to flood defence it was also inquired as to what the effects of lower accuracy were. Again answers were qualitative in nature, almost half of cases referring to a reduction in existing operations; reduced effectiveness, reduced/impaired service, reduced confidence, or less accuracy. Thirty percent of respondents said however that effects would have greater significance beyond the direct effect than a mere reduction in services.

Specific levels of accuracy for low/medium and high flow measurement were quantified to some extent with regard to water resource management, results given in table 12.

Table 12: Specific levels of accuracy required in water resource management

Function Type	*% Error allowed in flow measurement*								
	Zero	*two*	*five*	*seven*	*ten*	*fifteen*	*twenty*	*low/ none*	*variable*
Low flow measures	7	0	66	0	0	0	0	0	0
Medium flow measures	7	7	47	7	27	0	0	0	0
High flow measures	7	0	20	0	40	7	20	0	0

It appears that overall, high flow measurement in this context requires slightly lower levels of accuracy than is the case with either low or medium flows, which in the majority of cases allow an error no higher than 5%.

Within flood warning a requirement which may be paralleled with accuracy levels is the minimum record length required for estimation, the assumption being that accurate estimations rely upon the existence of past records. Considering responses however this varies considerably, for example almost equal numbers of respondents saying five years, two years, twenty years, and that it depends on the situation in question. In view of such differing opinions, these responses would be of little use in defining an acceptable approach to weighting.

Section 5 - Quantifying the economic value of hydrometric data

In terms of specific cost benefit analyses carried out to date or the quantification of data benefits in a monetary way, there are it seems a number of studies accessible to 82% of flood defence managers. Despite this however only 41% attempted to define the % of such benefits attributable to hydrometric data only. Estimates given ranged from 1 - 100%, with little agreement between managers. Useful comments included those that equated hydrometric data benefits to averted flood damages, and that *relatively*, benefits could range from being high in urban areas to nil for remote areas.

Possibly existing economic values for data were also sought in relation to flood warning. Again these ranged considerably from region to region, actual values given in table 13.

Table 13: Average economic saving to the community from flood warning systems

Region	*Monetary saving per yr.*
Anglian [central area-a]	£260,000
Region	*Monetary saving per yr.*
Anglian [central area-b]	£80,000
Midlands	£1,000,000
North West	£150,000

The CBA methods section discussed the project specific nature of many approaches to determine the economic value of hydrometric data. The range of questionnaire responses to requests for estimates of value reinforces the rationale of such approaches, and in turn the difficulty of defining a standard methodology to quantify benefits in this study. Again a framework approach as proposed in the methodology section appears more appropriate.

ANNEXE I

Abbreviations Within Tables Which Require Further Explanation

Table 2: Percentage of cases under each function stating a requirement for specific data set

ADF	Average Daily Flow
MAF	Mean Annual Flow
AIF	Instantaneous Flow
FDC	Flow Duration Centre
Pctl	Percentile measures i.e. Q_{95}, Q_5
Uns.	Unspecified Flows
Wtr.	Water levels
Rain	Rainfall levels
TW	Ground Water levels
Tide	Tides
Mcs.	Climate data / data for Morecs

Table 3.1: Percentage of cases under each function specifying data uses

oplw.	Monitoring of low flows
Risk	Assessment of low/high flow risks
drgt.	Drought monitoring / operations planning
estc.	Estuary current determination
Estec.	Determination of ecological conditions
Estsl.	Determination of salinity
Cons.	Determination and enforcement of consents
Nut	Determination of nutrient budgets
load	Calculation of pollution loading
trade	Analysis of trade effluents
trav.	Determination of pollutant travel times

Table 3.2: Percentage of cases under each function specifying data uses

fldef	Flood defence
fldwn	Flood warning
rtpr	Report purposes
tmpk	Flood time to peak estimation
mdl	Modelling
ablc	Abstraction licensing and enforcement
Flfh	Determination of suitable flows for fish migration
pldil	Calculation of dilution factors for pollutants
ecim	Ecological impact assessment
fhsv	Fish surveys
chnl	Channel bank work

Table 3.3: Percentage of cases under each function specifying certain general data uses

Bckg	Provision of background information
inqrs	Resolution of issues at inquiries
desn	Design of new stations
pbinf	Provision of information to the public
Plan	Planning of fieldwork
trend	Analysis of trends
Qlsm	Specific water quality sampling

Table 4: The nature of data collected for Certain Agency Functions

Both	Collection of both real and historic data
Real	Collection of realtime data only
Historic	Collection of historic data only
nofut	No simulation currently carried out, may do so in the future
general	General 'simulation' cited as being carried out
real + hist	Simulation using both real and historic data carried out
historic	Simulation using historic data only carried out

Table 5: The use of realtime data in flood warning

model + officer	Realtime data used in modelling and to inform flood warning officer
officer	Realtime data used to inform flood warning officer
don't know	Don't know how realtime data is used

Table 6: Current network situation in relation to freshwater biology, freshwater chemistry and marine/estuary management

Certain	Type % of Agency personnel specifying that certain stations were used more than others
Reasons	Specific reasons stated why certain stations were used more than others

Table 7.1: Percentage of cases affected by reduction in network

com	External research would be commissioned
estim	Estimation techniques would be used
both	Both outside help and estimation techniques would be utilised
other	Other
no	No effect on issuing licences / consents
poss	Possibly an effect on issuing licences / consents
varies	Effect on licence / consents issue would be variable (situation dependent)
yes	Reduction of network would affect licence / consent issue

Table 7.2: Servicing needs with a reduced network

badly	Needs would be badly serviced
don't know	Don't know
pressure	A reduced network would increase pressure on other resources
reduce effec.	Needs would be serviced less effectively
Same	Needs would be serviced in the same way
Soso	Some needs would be affected

Table 8: Would data from an extended network be useful?

don't know	Don't know
no/prob no	An extended network would not/probably not be useful
yes/prob yes	An extended network would/probably would be useful
possibly	An extended network would possibly be useful
depends	It depends on the situation

APPENDIX B

ALTERNATIVE METHODOLOGICAL APPROACHES TO REPRESENTING THE ECONOMIC BENEFITS OF HYDROMETRIC DATA

version #2

author: Nick Hanley

1. The objectives

This project is concerned with estimating the benefits of hydrometric data. Three possible motives for doing this are the abilities to be able to:

(i) rank gauging stations in terms of their relative economic benefits
(ii) conduct marginal cost-benefit analysis of whether an additional station should be added to network, or whether an existing station should be shut down, and
(iii) assess the public value of a gauging network in terms of its total economic value.

In case (ii) above, information on the (marginal) costs of data collection is needed; in cases (i) and (iii) it is not, although in case (iii) total economic value could be compared with total system costs. Expressing benefits in monetary units allows them to be compared with costs.

2. The problems

Essentially, these can be summarised as the following:

(i) the benefits of any given gauging *network* are many and varied, as shown by our interview responses, and by our questionnaire survey
(ii) operationally, it seems unlikely that sufficient funds and/or experience would be available to carry out original empirical work on benefit estimation in all cases, except perhaps for major network reviews
(iii) the implication is therefore that "standard" benefit figures should be made available, in an attempt at benefit transfer. However, there are very considerable problems with such benefits transfers.
(iv) in any case, it is well known that the standard errors on estimates for non-market benefits (such as improvements in water quality) are typically wide
(v) finally, the benefits of continuing to collect data from a given station are known to depend partly on the length of record already existing for that station: whilst station benefits are also dependent on how unique that station is in terms of representing varying catchment characteristics and/or the spatial location of economic activity (such as rural vs. urban).

The above problems make it unlikely that a simple application of Cost Benefit Analysis (CBA) is possible, but also that funds/expertise are unlikely to be available for a more sophisticated CBA except in the case of very major changes to the monitoring network. However, objectives (ii) and (to a lesser extent) (iii) above imply some sort of quasi-formal CBA framework.

3. Economic value estimation and the benefits of hydrometric data

The economic benefits of collecting hydrometric data are, in principle, similar to the benefits of collecting any other kind of information regarding uncertain outcomes, such as weather forecasting or forecasts of the rate of inflation. This is that such collection enables either an increase in economic benefits or a decrease in economic costs, often in a planning context. Given uncertainty, these costs and benefits may be expressed in terms of expected values[1] or certainty equivalents. What is more, the economic criterion for how much information to collect is the same in all these situations: namely, that if the right amount of information is collected, then the marginal cost of collecting one more (or one less) "unit" of information be equal to the marginal benefits. This criterion could also be applied to decisions over whether to add or subtract one more information gathering unit. Aside from planning-type applications (where "planning" is interpreted in the broadest sense), the other major category of benefit is in real-time uses of data, in flood warning and abstraction control.

Two problems thus arise in the context of hydrometric data: these are (i) what to count as economic benefits, and how to value them; and (ii) how to define the "information generating unit". For many classes of benefit we have identified (see Nevin (1996) (Appendix II), and the report on the questionnaire data (Appendix I)), the benefits of collecting data for the purposes of, for instance, flood warning, would seem to be applicable more to the catchment, or a river (ie some concept of a network) than to any one station. If this is true on the whole, then it makes more sense to consider either the river or the catchment as the information generating unit, for which economic benefits will be measured. In this case, the question of whether to add or remove one more station to the network becomes a hydrometric question, concerned with the increase in predictive performance for the system as a whole.

Nevin (1996) reviews the techniques which could be applied to a large range of potential benefits for hydrometric networks, and actual experience with these methods. Summarising, benefits can be classified as those affecting market-valued resources (such as housing or bridges) and those affecting non-market resources, such as water quality. Very few of these benefits are likely to be "captured" by the data gatherer, either due to the non-market nature of the benefits, or the public nature of the data. A complementary classification is to recognise:

- benefits of real-time data (eg flood warning, abstraction control): these benefits can potentially be market-valued;
- benefits relating to investment planning (eg new bridges, dams, reservoirs, housing): these benefits can also potentially be market-valued;

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[1] Although the use of expected values implies we know (i) the complete range of possible outcomes (states of the world) and (ii) the probability distribution of these outcomes. This is unlikely to describe all situations.

- benefits relating to water quality planning (e.g.setting of pollution constraints and abstraction/return flows). These benefits are unlikely to be market-valued.

In these three cases, benefits are, in general terms, given by:

- avoided damages (flood warning)
- avoided costs of over- or under-investment. The maximum Willingness To Pay (WTP) of users of information for these purposes (eg construction companies) would indicate its value here: however, such maximal WTP amounts are not revealed by the current process of giving out such information. Freeing up the market for hydrometric data would produce prices closer to this desired signal, and reveal something about the price elasticity of demand for information.
- through a production function, where information is one input (along with abatement expenditure and flows) to increasing water quality. More information as an input can allow for less spending on abatement, or better management of return/abstraction flows, to produce a given level of water quality.

In all these cases, however, it is crucial to separate out the marginal effect of providing more information from the value of the resource or service flow concerned. For example, not all of the value of water quality improvements could be attributed to providing information if additional abatement expenditure occurs. What we must aim to do is estimate the marginal value (marginal value product, in the case of the production function approach) of information.

4. Possible methodologies for analysing the economic benefits of hydrometric data

Here we outline three possible approaches to incorporating the economic benefits of hydrometric data into a decision-making framework.

4.1 An approximate CBA approach

In what follows, we assume that, either through original empirical work, or through some benefit transfer process, economic values have been arrived at for all possible categories of benefit (not forgetting, though, the considerable empirical difficulties involved here, as noted in Nevin, 1996). These economic values might be expressed in terms of £ per £ spent on data collection gleaned from previous case studies. Expenditure could thus be used as a measure of the quantity of information. Alternatively, benefits could be expressed per measuring station (ie total benefits divided by the total number of stations), again from case studies, and again with the purpose of relating benefits to the amount of effort input, and the quantity of data. These benefit figures will be referred to as "base values": see Table 1. We know that the length of existing data records is important in determining the value of additional data; so these base values would then be weighted to take account of this. Finally, special local circumstances might exist, making the benefits in any one category larger than average, so weights could be attached here too, based for example on the spatial characteristics of the catchment (we do not discuss how to arrive at these weights yet: for data length, we need to estimate the functional form of an equation relating data usefulness-eg predictive power- to length of record). Then, for any system, the relevant benefit categories are entered, and weighted average scores computed for each benefit category. Summing these gives either the total benefit per £ spent on the network, or per station. In the former case, multiplying by actual system costs and then comparing with these costs gives an approximate equivalent to CBA . In the latter case, multiplying by the number of stations and then comparing with system cost again gives a CBA-type comparison. **It should be noted, however, that since (i) benefit transfer and (ii) weighting is used in this method, this does not replicate a formal CBA.**

If the operational question of interest is whether to add more stations, or take some away, then the above procedure could be repeated on different groupings of stations and the results compared. This would involve re-running the economic model with adjusted inputs in terms of benefits, to produce approximate cost-benefit results for different groups of stations.

If a ranking of individual stations or groups of stations is desired, then the above procedure could be repeated and the results used to produce a ranking. However, it would be very important to consider the smallest data generating network used to produce the base values, since otherwise we are extrapolating beyond the range of our observations.

In principle, this method could be presented as a simple spread-sheet type computer model.

4.2 A scoring approach

This could be implemented using the same framework as that described above, but replacing economic benefit base values with importance scores, arrived at through expert judgement (eg through some sort of DELPHI process). Davar and Brimley (1990) report the use of such a system in New Brunswick. However, whilst the method could be used to rank stations or groups of stations, it could not be used in any cost comparison, including decisions on whether to add or subtract stations.

4.3 A multi-criteria analysis approach

This could be accomplished with a goal-programming method. This would involve, for each benefit category, identifying acceptable or target scores (eg minimum hours warning time for the flood warning category). A matrix would then be built up to show how any network could contribute to achieving these goals, some of which will be complementary and some of which would be conflicting with each other. Cost could be included as one objective/constraint set. A mathematical programming routine would then be run on this matrix and objective set, with the goal of minimising the sum of differences between goals and achievements. This would give an "optimal" design of the system. Alternative system designs could be run through the model to compare their performance on the "achievements versus targets" criterion. However, the approach could not be used to assess the economic efficiency of a network. In addition, the method is very data intensive, is critically dependent on specification of targets, and would not be easy to present in a user-friendly format.

5. Recommended method

We therefore recommend that the project goes forward using the approximate CBA approach as the basis for assessing economic benefits, since it seems to have one important advantage over the other two methods considered, namely that it can address the issue of economic efficiency, as well as ranking and analysis of decisions over adding and/or subtracting stations. Three big problem areas are though, obvious:

* how to compute base values
* how to compute weightings for length of record
* how to compute local weights

The method could, of course, be used without weights being used, but this would lose much content. Some of the answers to these questions can be found in the literature review, interviews and survey results. However, it is felt that most learning will occur in trying to apply this method to two case study data networks in the next phase of the project. Of course, findings based on two case studies will be of limited generalisability; however, this limitation would only be adressed by devoting significantly more resources to the project. We also note that, due to the paucity of previous research in this area, we anticipate that un-filled "holes" will exist in the economic model based on Table One at the end of the project.

The approximate CBA approach provides an economic criterion for managers of networks to use. We would suggest that this should be supplemented with a criterion based on hydrology itself. This could address, for example, the issues of station redundancy and network representativeness, and could also be expanded into a scoring system along the lines suggested by Davar and Brimley. Thus two criteria would be used in assessing hydrometric networks: economic, and hydrological. This would provide more information than one criterion alone.

benefit categories	flood warning	road and bridge construction	flood planning: housing	low flows: abstraction	low flows: return flows	hydro power	storage
base values (£ per £k system cost)	b1	b2	b3	b4	b5	b6	b7
length of record weight	w11	w12	w13	w14	w15	w16	w17
local conditions weight	w21	w22	w23	w24	w25	w26	w27
applicable to network X?	yes	no	yes	no	yes	no	yes
score for network X	s1=(b1*w11*w21)	s2=(b2*w12*w22)=0	s3=(b3*w13*w23)	s4=(b4*w14*w24)=0	s5=(b5*w15*w25)	s6=(b6*w16*w26)=0	s7=(b7*w17*w27)

Total Weighted Benefits (can be compared to total costs of network X of £C): [(s1+s3+s5+s7)*C] = £B

Table One: approximate CBA method applied to network X

For some of these benefits categories (eg water quality) it seems likely that no estimates of the value of data per se will be found in the literature. Thus we propose to test the "production function" approach suggested above, to estimate the marginal value of data. This might work as follows. Suppose data is available on some indicator of water quality Q_t over time for a given river (this might be a weighted average of values q_{it} at i monitoring points). Suppose data is also available on abatement expenditure A_t, flow rates F_t and the quantity of data collected D_t. Our argument is that collecting data on flows enables better water quality to be achieved for given investments in abatement. Then we could estimate:

$$Q_t = f(A_t, F_t, D_t)$$

and find the partial derivative $\delta Q_t / \delta D_t$. Given the cumulative effects of both data collection and abatement spending, we would need to experiment with alternative lag structures for D and A. But if such a partial relationship can be found (which is statistically significant and reasonably robust) than a base value for hydrometric data collection's value to water quality improvements could be derived. We propose to test this procedure in the case study part of the project.

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APPENDIX E

EXTERNAL DATA USERS

A wider assessment of external data users

It has been recognised that significant use is made of hydrometric data by external organisations or individuals. In order to ensure that this is fully accounted for we have approached the three Regions that were visited during the questionnaire development phase. The data requested/received is as follows:

Midlands Region
Summary data requests have been obtained for the past hydrological year; this timescale was chosen as it was felt that the requests often came in pulses associated with the winter and summer extremes. Amongst other details, the forms list date of request, name and address of requester, time taken to fulfill request and the category of user (Internal/External/STW). A total of over 1000 requests were made during the year. We are currently categorising the requests in order to assess the relative demands of the external users; one useful bonus is that it will also be possible for us to break down the internal users and quantify their demands on the data.

North East Region
Ridings Area of North East Region have been able to provide us with a summary of data requests for the period January 1995 to October 1996. The totals are as follows:

Internal users	172 requests
External traders	461 requests
Students	40 requests

This demonstrates the extensive use of data that is made by external users. A more detailed analysis has been carried out on the requests made since March 1996. The top ten are as follows:

Yorkshire Water	21
Calderdale MBC	5
Yorks Wildlife Trust	5
IoH	5
Bradford MBC	4
Mott MacDonalds	4
Binnie & Co	4
Alter Power	3
Aspinwalls	3
Acer Environmental	3

From this it is clear that one of the main groups of external users is the major engineering consultancies. We are thus now beginning to focus on these in order to try and assess the different uses and benefits that they derive from the hydrometric data. For this we have decided to work closer to home, drawing on the users of SEPA West.

SEPA WEST

We have requested the past 6 months data request forms from the SEPA West office in East Kilbride. These forms, of which there is one for each data request, will provide details of the data user, address and contact name, data requested, the use to which it was to be put, the data which was supplied and any supporting analysis or information. We intend to select a sample of these requests and then approach the major users to obtain their perspective on the benefits that they derive from the hydrometric data. We hope to start the visits during the later part of November.

NOTES FROM VISIT TO YORKSHIRE WATER SERVICES

Ian Stevens - Water Supply

Direct abstraction sites:

- YWS have, at present, 8 major river intakes, and at all of these the abstraction rate is directly related to the flow in the river;
- YWS have access to the Agency telemetry network (he thinks it is shared at these 8 sites?) and will typically access the system three times a day;
- At present, all controls are manually operated and the operatives access the flows directly from the Agency;
- At all intakes the weir is the property of the Agency and, given legislative requirements, he cannot see how the Agency would be allowed to control these 8 stations.

- The Agency also have one measuring weir for compensation flows from a headwater reservoir; flows are not continually read at this site, only manual observations are taken for regulatory purposes.

Water Resource Modelling

- Use both historical ADFs from archived data, and real time data for updating models that are currently in use on a daily time scale;
- Data are obtained from Richard Maxted and Mike Low;
- The general Resource Model is updated on a very coarse interval, say 6-monthly, and looks at the Region as a whole as well as individual catchments;
- The emphasis is on modelling the system as a whole as a management tool for yield assessment;
- Some historic data are also used for FDC generation etc, and for spell duration events;
- If no data were available, would have to rely on synthesised data derived from rainfall records;
- At the weekly timescale they have to report on resource availability, current stocks, flows, recharge rates etc;
- The planning model is then run to determine the next week's operation, taking into account likely flows and demand;
- Only a small number of Agency sites are used for this weekly assessment - say 6 or so;

- In total, 12 or so stations are essential to YWS for their routine work in supply management;
- During times of stress there is increased co-operation with the Agency and data are taken from a greater number of sites.

Ed Bramley, Environmental Quality

Have no routine data requirements from the Agency, though they do work in collaboration on specific projects relating to waste water quality and policy. Recent examples include:

- UPM studies - one in Sheffield and one in York - data requirements are;
- Fishery surveys - flows needed to put survey results into perspective;
- Ditto for biological surveys;
- Time of travel studies of contaminants to potable supplies - almost 40 studies have been carried out in recent years at different flow rates, all require extensive use of Agency data;
- Greater use has been made of the data during the recent dry spell.

In general, when YWS require flow data for water quality studies they will need intensive, accurate data from the Agency stations, together with less intensive and less accurate data from intermediate sites. If the Agency are unable to assist with this they have to commission outside contractors to collect the data for them, often using the Agency for advice.

EXTERNAL CONSULTANCIES

A number of external consultancies have been contacted to try and identify the benefits that they derive from hydrometric data and, perhaps more importantly, the value of these benefits. All the offices that were contacted were very keen to declare the importance of the data but, on initial interview, were unable (or unwilling) to either give details or try and estimate the value of the benefits that they derive on behalf of their clients. Following this rather unhelpful start a very brief presentation was made at a meeting of the ICE Scottish Hydrological Group, outlining the project and requesting assistance from some of the firms. Further discussions, in some cases with the same personnel, have yielded more promising results in two areas:

Hydro-electric schemes
There is at present a significant growth in small scale hydro-electric power schemes as a result of a number of initiatives promoted by the Government. In Scotland two of the firms undertaking the feasibility and design work for the major developers are Dougall Baillie Associates (DBA) of East Kilbride and Edinburgh Hydro Systems Consult (EHS).

Interviews were held with one of the two senior partners at DBA who feels most strongly that hydrometric data *is an essential component* in their design work, allowing them to calculate both the magnitude and seasonality of the primary resource. The network data are often used to place short term flow/rainfall records (6 months - 3 years) into a longer context; they commission these flow surveys for each scheme as necessary at a typical cost of £3-6,000 per year for each catchment. The availability of the data allows them to reduce the uncertainty in deriving the design flows for the turbines - in some cases they need to be able to predict the annual average flow to within 1% over a long term record. However, they were unable to quantify the magnitude of this benefit, either in terms of cost or reduced uncertainty.

EHS have recently completed a research project funded by the Energy Technology Support Unit (ETSU) looking specifically at the errors associated with estimating flow regimes on a theoretical basis rather than basing the analysis on neighbouring catchments which have a long-term record. Part of this work was subcontracted to the Institute of Hydrology. At present we have been unable to obtain permission to refer to the report as it has yet to be published, but we have been told that there is a significant reduction in the uncertainty if reliable hydrometric data from a neighbouring catchment are available. If we are able to derive this reduction in uncertainty it may then be possible to assign a benefit value to the data used for the feasibility study.

Engineering works

The Babtie Group are one of the largest engineering consultancies in the UK, and their Scottish office contains a group who specialise in work relating to rivers. A meeting was held with the three senior managers in this group to discuss the uses that they have for the hydrometric data:

Drainage Studies

These are generally undertaken at a small scale within individual catchments, and involve the integration of surface and sub-surface drainage with the natural hydrological systems. They would typically look for approximately 5 'events' to calibrate their hydraulic models, with a minimum of six weeks field study being necessary. Wherever possible they would use data from hydrometric networks in their studies as they have far greater confidence in this than data derived in such a short timescale. A major benefit of the hydrometric data is that it allows them to put their study into a long term perspective using the Flood Studies Report. Babties are often asked to re-evaluate their studies after major flooding events (such as that which occurred in Strathclyde in 1994) and *it is essential* that they have hydrometric data to allow them to do this, and that the data continue to be collected.

Flood Studies

Individual studies involve a number of different components:

1. Risk assessment - involves putting observed or theoretical events into a longer term perspective. Long-term station records are far superior to those from stations which may be closer to the site in question but have not run for as long. Extreme events are often cross-calibrated with rainfall data to confirm their return period. The view was expressed that it is important to ensure that long term records from strategic sites are maintained;
2. Hydrograph derivation - where a site is not close to a representative gauging station Babties will derive a hydrograph from *other stations within the network*, both up and downstream. Clearly, the greater the number of stations the greater the confidence that they have in the derived flows;
3. Model Calibration - *it is essential* to have base station data from u/s and d/s of the study site to be able to calibrate a detailed hydraulic model of a site; all model calibrations need gauging station data. The cost of defences is directly related to water level; if they have no recorded data it may be necessary to design defences up to 1.5 - 2 metres higher than would be determined with reliable data. If no calibration data are available it is necessary to undertake a more extensive sensitivity analysis to try and minimise uncertainty - this adds significantly to the project costs.

BENEFITS OF HYDROMETRIC NETWORKS

Q	Answer based on River Modelling Group requirements	Other Comments with relevance to Flood Defence generally
1	A mix of historic and recent data is required. The types of data required includes: • peak levels and flows for flood events (either as annual maxima or POT) • flow/level hydrographs for flood events • rainfall amounts • hyetographs for storms associated with flood events • flow duration curves	
2	Calibration and verification of hydrologic, hydraulic and sediment transport models. Assessment of simple hydraulic calculations	Also, used for: flood warning purposes, assessing working conditions within river channel, simple hydraulic calculations
3	Rely entirely on Flood Studies Report methodology (which itself is based on historic data) or similiar.	
4	Yes, depending on relevance of location and accuracy of flows during flood events	Yes
5	~~Better than ± 10 mm for levels (or ± 5 2% for flows). Accuracy of estimated flood levels depends on use.~~	
6	Less robust or more conservative design - leading to increased construction or maintenance costs	
7	*No, held by Project Engineering Group at Warrington*	
8	*Not known to River Modelling Group*	
9	*Not applicable to River Modelling Group*	Both high and 'normal' flow data are required to assess the benefits in agricultural areas as there is a land drainage benefit often.

Tim Palmer
Asst. Engineer (River Modelling)
Environment Agency - NW
Nov 1996

(5) Ideally better than ± 5mm for levels (± 10mm probably acceptable; better than ± 5% (2-3% preferred) for flows. Both levels and flows relate to true values in river at the peak. Note 'in river' - accuracy of measurement in stilling well is only part of the story!
Flood levels hence generally ± 10mm. PSS

Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

February 1997

R&D Progress Report W6/005/7

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

A R Black, A M Bennett and N D Hanley

Research Contractor:
University of Dundee
in collaboration with University of Stirling *and* Scotia Water Services

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R&D Progress Report W6/005/7

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This report is the result of work jointly funded by the Environment Agency and the Scotland and Northern Ireland Forum for Environmental Research (Sniffer).

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Statement of use
This report is the seventh monthly Progress Report from Project W6/005. It describes activities at the mid-way stage of the project, including and following a major meeting with the Project Board. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

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Environment Agency's Project Leader
The Environment Agency's Project Leader for R&D Project W6/005 is:
Mr W D Rylands (Thames Region)

R&D Progress Report W6/005/7

1. INTRODUCTION

This report describes activities on project W6/005 during February 1997. The main event of the month was a meeting between Project Board and the team carrying out the work, held in Reading on 19 February. The purpose of the meeting was to review the work carried out in the first six months, particularly the methods identified for assessing benefits, and the preference expressed, as detailed in Progress Report W6/005/6. The meeting was an integral part of the Specification produced in the original Invitation to Tender for the project.

2. MEETING WITH PROJECT BOARD

Appendix I to this report is a set of minutes by David Rylands, Project Leader, summarizing the meeting with the Project Board on 19 February 1997. Discussion at the meeting was often vigorous and wide-ranging, and always constructive. The meeting shared the view that some of the issues at the centre of this project are difficult, and that perfect solutions to recognized problems may not always be possible.

At the conclusion of the meeting, the approximate CBA approach to benefit assessment had been agreed , with the qualification that unquantifiable benefits should also be recognized by the approved method in the interests of completeness. Only in this way can fully-informed decision-making take place.

The agenda for the meeting was constructed principally of those issues for which the project team wished some guidance from the Board, and the minutes (Appendix I) indicate the results of discussion on each. As a further record of the discussion, and for reference by members of the team, some additional points made at the meeting are included as Appendix II to this report.

One query arises from reflection after the meeting: the consultation of technical experts, suggested to improve the recognition and evaluation of benefits, may not differ greatly from some of the consultation undertaken as part of the questionnaire exercise. Care will be needed to ensure that useful products follow from this activity.

The project team was encouraged by the positive response of the Board to their work and proposals in the first six months, and wish to place on record their thanks for such considerable and constructive feedback.

3. POST-MEETING DEVELOPMENTS

3.1 Catchments for testing

The catchments discussed at the Project Board meeting are the Foyle in Northern Ireland, and the Bollin within the Environment Agency's North West Region. The Foyle offers the advantage of a small basin with several gauges, and having been included within the Institute of Hydrology 1994 network review. The Bollin, though having only three established primary gauging stations, has several contrasting resource management issues, each with hydrometric data demands, and has been identified for use on the merit of these features.

Subject to any other suggestions being made and accepted by the Board, these two catchments will be used for testing purposes. Care will need to be taken to define the catchments in terms of data generation and uses.

3.2 Paper for British Hydrological Society 1997 symposium

An abstract has been submitted for the above symposium. Despite late submission, it is hoped that it may still be possible to make an oral presentation at the symposium. It is intended that the paper will focus on questions central to this project, and on approaches to assessing benefits.

A possible paper to the 1998 British Hydrological Society first international symposium could then report some of the main outputs from the project. Both papers would achieve useful exposure for the work of the project, an aim endorsed at the Project Board meeting. An abstract for the 1998 meeting needs to be produced for 1 April 1997.

3.3 Derivation of quantitative data and models

Because of the difficulties of starting the additional work, and the logistical difficulties of ARB being away from Dundee, this work will be reported on in the next Progress Report.

4. FINANCE

Prior to the Project Board meeting, one invoice for £13,061 had been issued for the first quarter of the main contract and paid by the Environment Agency. A second quarterly invoice had recently been issued. In order to conform to the fixed-price arrangements for each of six items identified in the tendering process, it was agreed prior to the meeting that the University of Dundee should issue a further invoice, in order that payments were made within the 1996/97 financial year for the first three items of work which culminated in production of Progress Report W6/005/6. At the meeting, it was reported that these arrangements were in hand - an invoice for approximately £23,845 was being generated .

A request had been made in Progress Report W6/005/6 for additional funding to cover extra work not originally envisaged at the tendering stage. This had been agreed in principle at the Project Board meeting, but subject to the necessary authorizations being made. This has been a matter of some urgency, because it was proposed that the additional work should be started w/c 3 March 1997 and, because an extra Research Assistant contract of employment is involved, these authorizations are required before work can get under way. In early March, some delay was being encountered, but it was hoped that this would soon be overcome.

5. PERSONNEL AND CONTRACTUAL

Once advice is received that the additional work can be undertaken, a contract will be made with Ceara Nevin for an additional two months' employment at Stirling University. Contractual arrangements will be made between Dundee University and both Stirling University and Scotia Water Services to accommodate the additional payments due to each, as per Section 4 of report W6/005/6.

6. WORK PLAN

Work should now proceed as per the work plan in report W6/005/6, and based on the agreed two-month extension to the original project completion date. Main areas of work for March are:

Stirling	Base values, weights, etc
AMB	Further information from consulting engineers
ARB/AMB	Develop criteria for complementary hydrometric assessment of data value

APPENDIX I MINUTES OF TEAM MEETING WITH PROJECT BOARD, READING, 19/2/1997

NOTES OF THE MEETING OF THE PROJECT STEERING GROUP AND THE DUNDEE UNIVERSITY TEAM TO DISCUSS THE R&D PROJECT 'ECONOMIC BENEFITS OF HYDROMETRIC NETWORKS'

HELD IN THE BOARD ROOM, 3rd FLOOR, KINGS MEADOW HOUSE, READING AT 11.00 ON WEDNESDAY 19 FEBRUARY 1997

Attendance:
Giles Phillips, Thames, Project Executive to 14.50
John Adams, North West, Topic Leader
David Rylands, Thames, Project Leader
Angela Wallis, Anglian
Meg Postle, EA Environmental Economist
John Waterworth, SNIFFER Representative
Nicky Bailey, Assistant R&D Co-ordinator, Thames
Andrew Black, Dundee
Nick Hanley, Stirling
Tony Bennett, Scotia Water Services

1 Alan Werrity was unable to attend. Angela Wallis was welcomed to the Board to take over from Nigel Fawthrop, who now keeps an eye on proceedings from Business Planning. Giles Phillips met the project team for the first time.

2 AB, NH and TB gave a resume of the report and associated issues

3 Discussion ranged over the points suggested in the agenda, though not in the order specified. The numbering of the notes follows the that of the agenda.

3.1 The Board felt that if the approximate CBA approach were to be used alone there would be a danger of eliminating the benefits that were extremely difficult or impossible to translate into economic terms. Therefore the team was asked to develop the approximate CBA method within an overall framework with other appropriate methods alongside.

3.2a AB asked if any particular issues had to be fully quantified. JA was keen that water resources aspects should be fully dealt with, but anything that could be quantified should be.

3.2b The issue of confusing the benefits of the thing being measured with the benefits of the measurement was discussed. It is a difficult problem, but it will be dealt with.

3.2c Estimation of the weightings in the approximate CBA table would be based on very few data points, and so there would be room for improvement. It was felt that even if there were uncertainties in the estimation of the figures, the exercise would focus attention on all potential benefits of the data and improve the assessment of the worth of data.

3.2d It was agreed that a catchment-based assessment of benefits would be preferable to single site assessment.

3.3 The further work identified in the report was agreed in principle, and it was agreed that additional time to carry out this work and the work on the example catchments would be required. An additional two months was agreed.

3.6 Case study areas: JW and JA both had suggestions for catchments from their own areas with several different measurement needs. Northern Ireland has the advantage of having had the hydrometric review carried out recently by IH, which should be complementary to this project. Further suggestions were invited. It was recognised that some input would be required from the operators and users of these networks.

3.7 Various documents (including work by Atkins and at Silsoe) were suggested as possible sources of data.

MP mused on the benefits of data for flood defence schemes - is the disbenefit of poor data the capital cost of having to build higher defences to account for uncertainty, or the consequences of having a lower level of protection. The need for data collection for post project appraisal was noted.

GP suggested a meeting of technical experts who were users of hydrometric data to try and improve the recognition and evaluation of benefits.

3.8 It was felt that Section 8(???) of the report provided a good overview of the issues that would need to be covered in the manual and it was agreed that it was much too early to have any firm views on the exact layout and contents. The ultimate aim was to have a document that was usable by and useful to the hydrometric manager trying to use it

5 Copies of the 6 month report will be sent to Leeds and SEPA east.

It was suggested that papers should be written on the project. Two at least. BHS symposia might be useful venues for presentation.

6 Actions

1	Project team to develop approximate CBA approach alongside other appropriate techniques to pick up benefits that cannot be assigned economic benefits	AB et al
2	Suggestions for suitable catchments for case study areas with details and reasons for using them to DR by 14/3/97	Board
3	Sort out extra funding and additional time - Form G	DR/NB
4	AB/DR to discuss possibility of meeting with technical experts who are users of hydrometric data to develop ideas on benefits of data. Suggestions for useful 'experts' needed.	AB/DR All
5	MP/NB to supply useful documents to the Team	MP/NB
6	AB to contact BHS symposia oranisers about papers	AB

7	Arrange next meeting	AB/DR

7 Date of next meeting: TBA

j:\floodmod\r&d\meetings\drmn9702.doc

APPENDIX II ADDITIONAL NOTES FROM TEAM MEETING WITH PROJECT BOARD, READING, 19/2/1997

Points made in addition to those included in the minutes (Appendix I)
References are to Progress Report W6/005/6

- Benefit assessment should recognise availability of real-time data
- JA: no internal charging for data. It would be advantageous if external data users could identify the uses to which data are put.
- JW: data gathering now outsourced in Northern Ireland to DANI which, from April, will be developing costing systems. EA North East Region Field Data Services also has available cost information.
- P71 foot, first bullet: benefits to the environment of flow alteration cannot be quantified, but it is possible to quantify the cost of providing water from another source (NDH).
- Distinction between value of data and value of an agency function: this at least needs to be referred to, even if it is not possible to invoke some mathematical relationship between the two.
- GP: methods developed must be sensitive to changing a network by one station; this information is definitely required.
- JA: project team needs to be aware that networks have been expanding over the last 5 years, and that justifications exist for such changes. By adopting a network-based approach to benefit assessment, it should be possible to identify the changes in benefit which would result from further changes.
- JA wished to know if the methods would allow planned network expansions to be identified as justifying customer needs. GP suggested that if some benefits can be shown, then a manager is then in a position to argue for changes over and above those justified by benefit quantification, *ie* reference to tangible and intangible benefits.
- MP suggested that past work concerned with assessing benefits of changes in water quality class (ie x pence/km/class) would not be appropriate to the needs of this project.

- ARB wondered about valuing units of information, eg £ benefit/unit uncertainty reduction in Q_{95}.

- GP suggested that the benefits of the project may in no small part lie in learning about the dangers and difficulties of these evaluations and how to deal with them, *cf* answers *per se*.

- The initial benefit survey suggested in Section 6 of the Progress Report W6/005/6 was agreed as a useful device, to be considered as a checklist which could be completed before cost-benefit ratios are considered. The extent of numerical data could then be compared with the checklist.

- GP reminded the team that they are not asked to go beyond what is required in terms of the specification of a manual.

- AMB wondered how big a job the Board thought a review would be for a network of say 20 stations. GP suggested that 3-5 days' effort would be ideal, but perhaps optimistic. JA raised the relevance of current work in Thames, NW and Anglian re data needs. DR suggested that a structured questionnaire to users would help a network manager to place the results of an approximate CBA exercise in context.

- JW felt that the PC implementation of a method should be sufficiently transparent that users could add extra data if non-standard benefits were to be quantified for a given network.

ENVIRONMENT AGENCY

Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

March 1997

R&D Progress Report W6/005/8

RESEARCH AND DEVELOPMENT PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

A R Black, C L Nevin, N D Hanley and A M Bennett

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University of Dundee
in collaboration with University of Stirling *and* Scotia Water Services

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This report is the eighth monthly Progress Report from Project W6/005. It describes activities during a two-month period of extra work mid-way through the project. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

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Environment Agency's Project Leader
The Environment Agency's Project Leader for R&D Project W6/005 is:
Mr W D Rylands (Thames Region)

R&D Progress Report W6/005/8

1 INTRODUCTION

The contents of this report cover March and early April 1997. The work in progress is essentially in relation to the 2-month extension to cover derivation of base benefit values and weights, with some activity directed towards method testing and the assessment of unquantifiable benefits.

2 DERIVATION OF BASE VALUES AND WEIGHTS

This is currently the main area of activity on the project. Ceara Nevin has again been working as a Research Assistant in Stirling University, having started work in early March and expecting to complete her programme on 2 May. She has mainatined regular contact with Nick Hanley and Andrew Black. The work aims to gather information from case studies of hydrometric data benefit in several benefit areas and, with hydrological guidance, to go about identifying the factors which will determine the variation in values from one site to another. Beyond this it is intended that for each type of benefit, some form of functional relationship can be derived so that base values and weights can be recommended for application in any particular situation.

A list of nine benefit areas has been drawn up and, for each of these, determinants of benefit value and ranges of values have been identified from the literature. A working document showing current information on each of these is included as Appendix I. One important feature to note is that as this information is developed and moved towards a deliverable stage, many of the benefit assessments will allow a choice of approaches to evaluating an individual benefit. On the one hand, this reflects a range of approaches being reported in the literature but, more poignantly, it also allows a range of approaches in application, which will be important when considering that relevant input data are rarely as abundant as may be desired.

Further sources of reference material are being pursued in order to strengthen the empirical basis on which the benefit assessment methods are being developed. In particular, Environment Agency Regional Offices have been approached for copies of flood warning and flood defence reports in which benefit assessment data may be included.

As this work proceeds, it is clear that further thought is required in order to quantify the effectiveness of individual gauging sites in generating data benefits. The essence of this task lies in being able to assess the information content associated with each site, and to be able to recognise duplication where it occurs. Factors such as hydrometric performance (eg accuracy) and sensitivity to location will be important in this context. ARB and AMB are detailed to undertake this element of the work.

3 CATCHMENTS FOR TESTING

During the course of the month, proposals arrived through the Project Leader that three catchments might be considered for the purposes of testing the methodologies. In addition to the Bollin and Foyle proposals made at the Project Board meeting, the Little Ouse in Anglian Region was offered as a third possibility. The project team takes the view that within the time limitations of the project, the number of test areas should be restricted to two. This is particularly important in regard to the time required to identify sources and obtain all relevant data.

The question therefore arose as to which of the available options should be pursued - a decision left to the project team. The purpose of testing is to evaluate the methods developed, and to offer the opportunity for changes to be made. Two differing areas were therefore sought, in terms of the uses and benefits associated with local hydrometric data. The Foyle catchment was idfentified immediately as a rural area with little development pressure on its water resources, and therefore representing a test area where perhaps few of the benefits of hydrometric data could be quantified. By contrast, the other catchment to be chosen ideally needed to include a large range of benefit areas in order that some extensive testing could be carried out. Available information concerning the two candidate areas is presented in Table 1.

Bollin	**Little Ouse**
• 3 gauging stations	• 9 gauging stations
• Direct supply headwater reservoirs	• Groundwater scheme - augmentation
• Plans for further gauging sites	• Transfers to Essex via cutoff channel
• Dunham Massey gauge proposed for upgrading	• Flood diversion
• Compensation releases and Drought Order	• Fenland SSSI affected by borehole abstraction
• Water quality issues - Manchester Airport 2nd runway	
• Abstraction pressures due to agriculture	
• Designated fishery	
• Scope for future low-head HEP scheme	

Table 1 Characteristics of two candidate test catchments

It was considered that the Bollin catchment was more complex than the Little Ouse in terms of the applications of hydrometric data and so, on this basis, it was selected to complement the Foyle as a test catchment. Ceara Nevin has been in touch with local staff in both areas with a view to obtaining water use information, *eg* lists of consented discharges, and further data collection regarding data use is planned.

4 NON-QUANTITATIVE APPROACHES

It was agreed at the February Project Board meeting that a checklist would be developed as part of the preferred methodology, such that at the start of a network review, a brief structured assessment of the water resources, data generation and data uses would be carried out. This would then provide the context within which a quantitative assessment of benefits could be undertaken. Some draft notes concerning the possible form of such a checklist are appended at Appendix II for comment. Development will continue.

As this activity continues, it is planned to include questions in the checklist which will assist in the quantitative benefit assessment procedures. For example, benefits accruing from the operation of a flood warning system will be contingent partly on the number of gauging sites contributing data, and their displacement relative to the town being warned. Information-gathering in the checklist stage of review could then be useful in the later, more quantitative stages, or equally in any qualitative benefit assessments.

It should also be recorded at this stage that some work has been done on bringing the Davar and Brimley qualitative/point-scoring methods (see Progress Report W6/005/6 p22) within reach of qualitative stages of this project. At this stage, it is uncertain whether this will be incorporated into the checklist procedures, or whether it might lead to some benefit assessment in parallel with the quantitative methods.

5 MISCELLANEOUS

5.1 British Hydrological Society Symposia

The abstract submitted for the BHS 1997 symposium has now been accepted and a paper is due for submission by 16 May 1997. Andrew Black is to take the lead in its production, consulting and collaborating with other memebrs of the team and Project Board as required. Tony Bennett will be able to present the paper at the symposium in September; Andrew Black is unable to attend because of a prior engagement. The abstract of the paper is included as Appendix III to this report.

No abstract has been submitted for the 1998 BHS international symposium. While this might have offered a useful forum for dissemination of some of the results of the project, none of the sessions offered the opportunity of including the paper under a relevant theme.

5.2 Meeting with SEPA personnel

SEPA East Region is undertaking a fundamental review of its hydrology function. Recognising the relevance of this project, Mark McCabe (Corporate Services) and

John Anderson (East Region Hydrology) visited Andrew Black on 8th April to learn more about the project and the approaches identified for benefit assessment.

6 FINANCE

A letter dated April 10 1997 has been received from the Environment Agency authorising extension of the project budget as per Progress Report W6/005/6 Section 4. The necessary arrangements regarding subcontracts with the University of Stirling and Scotia Water Services are now being put in hand.

Benefit Values for Hydrometric Data Collection

No	Indirect Benefit	Determinants of Benefit Value	Range of Values
1.	*Improved design and operation of reservoirs*	Actual benefit values vary depending on: a) the amount of data already in hand b) the length of the extra sample of data to be collected. c) the number of sites at which data are to be collected.	• The value of streamflow data may be estimated as 4% of the total cost (construction & operation) of the scheme which the data services, according to Adeloye & Mawdsley. • Black et al suggested benefit cost ratios of between 7.6 and 15.2 for river flow gauging in respect to reservoir storage determination, dams and weir construction and operation, 7.6 recommended as the lower bound. • Cordery & Cloke estimated the value of data for the design of water supply storages only with the b/c ratio of 1.7 when 40 years data is already held, and the ratio of 5.3 when 20 years data are already in hand (Cordery & Cloke, 1991). • Alternatively depending on the no. of years records in hand it may range from 0.4% (4yrs) to 3.8% (50yrs) of reservoir construction costs, according to Adeloye & Mawdsley.
2.	*More efficient generation of hydroelectric power*	Actual benefit values vary depending on: a) the nominal capacity of the hydro station. b) its sensitivity to changing hydrological conditions. c) and the volume of the regulation reservoir.	• The benefit of data collection for the operation and design of hydro plants may be equated to the cost of flow surveys currently commissioned by consultants for each scheme i.e. £3,000 - £6,000 per year (to be clarified by Tony Bennett). • The WTP for hydrological and weather radar data has already been demonstrated by Scottish Hydro as £25,000 per year (to be clarified by me). In the construction of hydro electric storage schemes as opposed to run of river schemes, where data is considered of less value overall, it has been suggested that the value of data is equivalent to a maximum of 5% of total costs. • Zhidikov suggested in 1982 that the benefit of hydrometric data in forecasting for hydro electric generation is equal to the increase in power production of 2% on average. • Acres suggested in 1977 that 65% of the initial investment in hydro electric power development is sensitive to hydrometric data, and that 5% of this latter investment represents the value of the benefits from this data. This may allow us to provide a lower bound to Scottish Hydro's estimates.
3.	*Improved design of bridges, culverts etc.*	Actual benefit values vary depending on: a) the size of the project in question b) flood recurrence interval.	• Cloke et al in 1993, estimated that the benefit cost ratio attributable to minor bridge construction has a lower bound of .8, increasing to a b/c ratio of 2 for major structures (Cloke et al, 1993).

		The potential for saving funds from having accurate streamflow data may be fairly high large according to Cordery & Cloke, for construction projects but their small number means their contribution to the overall benefits attributable to hydrometric data may not be that great.	• Acres suggested in 1977 that 10% of the initial investment in road and bridge construction is sensitive to hydrometric data, and that 10% of this latter investment represents the value of the benefits from this data, allowing us to provide a lower bound to the above estimates.
4.	*Improved flood warning systems*	Actual benefit values vary depending on: a) the predictive accuracy of the warning b) how effectively the flood warning is disseminated to the public c) the potential response of the public once the warning is received d) the greater the value of expected flood losses prevented. An expansion of the radius of warning to include additional communities will also result in an increase. For example, in the case of agriculture, the exact benefit depends on the number of farms within the floodplain at risk. The benefits attributed to a flood warning system thus, may best be estimated therefore by a linear function taking into account, total flood damages potentially avoided, dissemination of warning, response rate, and accuracy of the warning itself. I. Calculation of avoided damages II. Multiplication by factor related to flooding frequency III. Multiplication by % of public to which warning is effectively disseminated, % accuracy of warning and % of public who respond to warning. Benefits are generally greatest for the floodplains of mature unregulated rivers without land drainage works.	• Total annual benefits from flood warnings to domestic properties in the UK have been estimated as £3.2m (1989). Another assumption is that the benefit attributable to flood warning is equal to 9% of the capital value of domestic properties in the area. • The % relating to hydrometric data defined as 33% by CNS. The benefits in turn must be multiplied by the probability of the occurrence of a flood such as given below, according to Walsh and Noonan, and the response rate e.g. 70%. *Probability of occurrence of flooding* — **Factor* More frequent than 1 in 10yrs — .25 Frequency 1 in 10yrs - 1 in 50yrs — .07 Less frequent than 1 in 50yrs — .02 • While warnings were issued in the Severn Trent area, effective dissemination was only to 58% of the population. Average accuracy of warnings in both Severn and Trent areas was estimated to be 74% (with reliability decreasing in areas less subject to flooding). Whether the community responds to a flood situation depends upon both the issuing of a warning and if flooding has occurred in the past, according to Severn Trent survey figures: — *Take Action* — *No Action* *Potential response given by those never flooded* — 76% — 24% *Potential response from those flooded in the past* — 80% — 20% *Actual response with flood warning to those before flood* — 63% — 37% *Actual response from those not receiving flood warning* — 38% — 62% In the Severn Trent area minimum damage reduction directly attributed to flood warnings was found to be 17% per annum. • It may be possible to adapt this approach to the estimation of benefits to

			agriculture. • An international US-Canada joint commission study defined the benefit cost ratio for flood control as 4.26 (Reynolds, 1982), however this was based on high flooding frequency and in turn the avoidance of very high flood damages. A more accurate estimation for our purposes may be this study's <u>b/c ratio of 1.23</u>, in relation to a situation where flood forecasting, warning and proofing where evident.
5.	*Pollution Control*	Actual benefit values vary depending on: a) the number of pollution permits in place and industry pollution control strategies.	
6.	*Improved flood protection*	Actual benefit values vary depending on: a) the size of the basin upstream of the site b) the local topography c) the frequency of flooding d) the number and damage susceptibility of properties to be protected.	• The value of streamflow data may be estimated as <u>4% to 5% flood protection scheme cost</u> (annual expenditure of flood alleviation schemes in the UK being approximately £58m, with data available for 50% of schemes), according to Mawdsley et al in 1990.
7.	*Improved determination of abstraction in low flow periods.*	In this situation benefits may range from site to site depending upon a) the existing risk and occurrence of low flows b) the current uses and level of use of the water resource, e.g. recreational uses such as canoeing, agricultural land area irrigated etc. Accurate information in relation to river flows, in a low flow period would facilitates the restriction of abstractions, in turn avoiding the environmental damages which would otherwise occur: Net benefit = value of avoided environmental damage - value of water to its next best use i.e. agricultural irrigation, private water supply.	• Benefits may be based on Garrod and Willis' figures for mean WTP received for maintenance and improvement of flows for the River Darent of <u>£2.87 - £7.06 per household per year</u>, considering all river uses including recreation. (not attrib. .directly to data). • If one was to equate the collection of data to increasing the reliability of water supply management, and thus avoidance of drought, Howe and Smith suggest figures of the public's <u>WTP of $4-6 per household per month</u>, however these figures relate to the willingness to pay where the situation is one of the most severe actual hydrologic events on record, so are considered somewhat high and unrepresentative for our purposes. • Where agricultural irrigation is the main concern the value of streamflow data in low flow alleviation may be based on the averted costs of drilling a borehole and abstracting supplies from groundwater, these <u>costs ranging from £1.1 - £5.1 per mm irrigation /ha/yr</u> (not attrib. .directly to data)
8.	*The detection of change in the future*	Since actual changes cannot be foreseen, it is not possible to evaluate actual benefits. What has been proposed however is that if a gauging network were abandoned and a change was subsequently suspected to have occurred then probably at a *minimum* a local network may have to be installed.	• The range of benefits in this respect may be equal to <u>the range of construction costs of a local network</u> in the future. • In relation to potential reservoir construction, Black et al suggest that in practical terms if there is already a good naturalised flow record for an existing reservoir in an adjacent valley, it is unlikely that the additional knowledge by a

			further measurement of the one hydrological regime could be justified.
9.	*Abstraction*	Actual benefit values depending on: a) the scale of abstractions for augmenting storage reservoirs b) the degree of local reliance on groundwater.	• Where the main concern is the determination of abstractions for augmenting storage reservoirs <u>a benefit cost ratio of 7 is suggested</u>, the actual ratio depending upon e) and f) of the determinants outlined.

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APPENDIX II
DRAFT/NOTES FOR INTRODUCTORY CHECKLIST

SURFACE WATER GAUGING NETWORK REVIEW
ASSESSMENT OF BENEFITS GENERATED BY MONITORING

Catchment review for ________________________________ (area)

INTRODUCTORY CHECKLIST

Purpose
The purpose of this checklist is to preface the mechanistic elements of the review with a systematic and qualitative survey of the water resources[1] and monitoring network of the catchment being reviewed. Answers to the questions below will allow results from the later, more mechanistic, parts of the review to be placed into a broader context. This is particularly important in relation to those benefits which do not lend themselves readily to quantification. Nonetheless, in giving a general overview, the checklist will address all areas of potential benefit.

A The resource
A1 Catchment characteristics

For the area under review
Size of area (km^2)
Mean annual rainfall (mm) - overall
- for driest gauged catchment
- for wettest gauged catchment

Mean annual actual evaporation - overall (mm)
What % of the area lie within the 20m AOD contour?
Give the altitudes of the three highest hills/mountains in the area
Describe the geology of the area:
Mostly impermeable/Mostly permeable/Mixture
Mostly acidic/mostly alkaline/mixture

A2 Uses of water

What is the primary use of water in the catchment?

Are abstractions made for public water supply schemes?
(a) - from surface sources
(b) - from groundwater

---

[1] groundwater, rainfall, air might all be substituted here. Separate checklists would need to be developed for each medium.

Are surface reservoirs used for storage purposes?
Are surface reservoirs used for HEP?
Are there run-of-river HEP schemes; if so where?

Over approximately what % of the area are there agricultural abstractions?
(a) - from surface sources
(b) - from groundwater

Is the agriculture in these areas water-intensive?

How many sewage treatment works discharging to watercourses are there in the area?
0
1-5
6-15
16-30
30+

Describe the level of urban development in the area: Essentially rural
Some urban development
Major urban centres

What and where are the main industrial users of water?
(Indicate source of supplies, annual demand as far as practicable)

Is there any flow regulation scheme(s) in the area; if so where?

B Uses of data

If possible, information for this section should be extracted from data request log sheets. Take account (again where possible) of any access to your data holdings which by-passes the logging system.

Indicate which of the following uses are made of the data collected in the area:

Flood warning

Flood design work - flood defences
- other structures (major, minor?)

Storage design

Low flows - abstractions
- return flows

HEP operational

Water resources - operational management

Consent determination/review

Calculation/modelling of mass balance/pollutant loads

Assessing/managing pollution events

License determination/review

Enforcement of licences, derogation investigations

Real-time data use with variable licences

Scientific support - interpretation of chemical/biological field data
- calculation of loadings and discharges to sea
- model development
- others

Fieldwork planning - agency staff

Recreational - fisheries/RiverLine
- amenity management, eg canoeing

Following sections to be developed

C Potential future uses of data

D Locational factors - how well suited is network to needs?

(think also accuracy, availability of telemetry...)

APPENDIX III
ABSTRACT OF PAPER ACCEPTED FOR 1997 BHS SYMPOSIUM

New approaches to the evaluation of hydrometric monitoring data

J R W Adams[1], A M Bennett[2], A R Black[3], N D Hanley[4] and W D Rylands[5]

[1] Environment Agency, North West Region
[2] Scotia Water Services
[3] Geography Department, University of Dundee
[4] Economics Department, University of Stirling
[5] Environment Agency, Thames Region

This paper reports some new approaches to a long-recognised problem in hydrometry - namely the assessment of benefits arising from hydrometric data collection. Because of increasing pressures to justify expenditure, a considerable literature has built up on a range of methods for assessing benefits. Site-specific and network-orientated studies have been developed, covering either single uses or limited numbers of data use types. However, no single framework is known which could be used to fully evaluate the benefits accruing from specific groups or single stations. This is a reflection of the difficulties associated with quantifying some types of benefit - eg the value of maintaining a healthy aquatic flora and fauna or providing recreational opportunities through flow regulation. Because of these difficulties, progress has been slow in developing any comprehensive benefit assessment framework.

The paper reports some of the methodological progress being made in providing methods for assessing benefits in both quantitative and qualitative ways. Established economic approaches are drawn on where appropriate (eg in assessing the damages avoided through flood defence or flood warning), and are complemented by more broadly-based assessments of non-quantifiable benefits. The evolving framework will provide environment agencies in the UK with a tool for reviewing monitoring activities in any area, including the assessment of proposed new sites. It is hoped that the presentation of these ideas to the BHS, including the application of basic economic principles to a review of specific gauging stations and their uses, will provide for a stimulating discussion on the most appropriate means of evaluating monitoring activities.

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ENVIRONMENT AGENCY

Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

April/May 1997

R&D Progress Report W6/005/9

RESEARCH AND DEVELOPMENT
PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

A R Black, C L Nevin, N D Hanley and A M Bennett

Research Contractor:
University of Dundee
in collaboration with University of Stirling *and* Scotia Water Services

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R&D Progress Report W6/005/9

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Dissemination status
Internal: Restricted
External: Restricted

Statement of use
This report is the ninth monthly Progress Report from Project W6/005. It describes activities during a two-month period of extra work mid-way through the project. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

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Environment Agency's Project Leader
The Environment Agency's Project Leader for R&D Project W6/005 is:
Mr W D Rylands (Thames Region)

R&D Progress Report W6/005/9

1 INTRODUCTION

The contents of this report cover late April and May 1997. During this period, the remainder of the additional work for deriving base values and weights has been completed, and discussions have taken place regarding the next stages of the work.

2 BASE VALUES, WEIGHTS AND TESTING

Ceara Nevin has completed this section of the work. Appendix I is a substantial table which encapsulates all of this work. Eight areas of benefit are identified, and against each there are now direct means by which benefit values can be quantified.

In the testing stage of the project, data will be gathered for each of the methods, wherever available and practicable, in order to identify the types of value which can be produced, and the differences between results obtained with different approaches. It is intended that the testing process will reveal the suitability and limitations of the various available procedures, such that recommendations can be made regarding those to be used in application.

The testing process will also allow further developments to take place regarding the sensitivity of benefit assessments to the hydrometric stations being operated in different scenarios. It is felt that using real benefit information and real gauging networks is the best means of allowing the methods to evolve, in order that they may reflect as usefully as possible the sensitivity of benefits to networks.

Contact has been made with agency staff in the two test areas, and some data have already been collected regarding consents to discharge in the Bollin catchment.

3 PROJECT TEAM MEETING

A meeting of the project team took place on 22nd May to discuss the results of the additional phase of the work. Much of the discussion centred on sources of information required by the various methods identified in Appendix I. It was recognised that the availability of information would often present practical limitations to those methods which could be used in practice.

Another important area of discussion was how to ensure that the hydrometric performance of the data-gathering network was reflected in the benefit assessment. ARB suggested that it might be best if data benefit values could accurately and directly reflect the performance of gauging stations in relation to identified benefit areas. However, after discussion it was felt that this was over-ambitious, and that it would be better to include in the final methodology a separate hydrological/hydrometric assessment of the data generating stations for each network review. This was part of the originally agreed methodology. ARB is therefore to concentrate on this aspect.

The checklist element of the methodology, as discussed at the February Project Board meeting, was also identified for further development. Such a checklist should provide a framework into which other elements can be integrated.

4 BHS PAPER

A paper with the revised title 'Towards new approaches to the evaluation of hydrometric monitoring data' had been submitted to convenor of the British Hydrological Society 1997 Symposium committee. Consultation had taken place with D Rylands and J Adams as co-authors, and a copy of the submitted version had been sent to J Waterworth for comment. No response has yet been received from the convenor.

5 TIMETABLE

Other commitments have made interaction between members of the project team somewhat slow over the past month, and the project is currently running a few weeks behind schedule. It is hoped that this can be remedied in the coming weeks and, meantime, ARB hopes to maintain contact with D Rylands as Project Leader.

Benefit Values for Hydrometric Data Collection

No	Indirect Benefit	Determinants of Benefit Value	Value Base	Range of Values
1.	*Improved design and operation of reservoirs*	Actual benefit values vary depending on: a) the amount of data already in hand b) the length of the extra sample of data to be collected. c) the number of sites at which data are to be collected. d) the adopted discount rate.	I. Construction costs II. Construction costs III. Cost of data collection IV. Construction costs	I. The value of streamflow data may be estimated as <u>4% of the total cost</u> (construction & operation) of the scheme which the data services (Adeloye & Mawdsley, 1988). II. Alternatively depending on the no. of years records in hand it may range from <u>0.4% (4yrs) to 3.8% (50yrs) of reservoir construction costs</u> (Adeloye & Mawdsley, 1988). III. Cordery & Cloke estimated the value of data for the design of water supply storages only with the <u>b/c ratio of 1.7</u> when 40 years data is already held, and <u>the ratio of 5.3</u> when 20 years data are already in hand (Cordery & Cloke, 1991). IV. An estimation may also be made on Adeloye's estimtes for overdesign costs in relation to reservoir storage capacity (Adeloye, 1990). With 6 yrs data in hand these are 33% of construction costs, and with 20 yrs data these costs equal 13% of construction costs.
2.	*More efficient generation of hydroelectric power*	Actual benefit values vary depending on: a) and the volume of the regulation reservoir. b) the nominal capacity of the hydro station.	I. Cost of flow surveys II. Construction costs III. Cost and market price of power produced. IV. Construction costs	I. The benefit of data collection for the operation and design of hydro plants may be equated to the cost of flow surveys currently commissioned by consultants for each scheme i.e. <u>£3,000 - £6,000 per year</u> (Tony Bennett). II. In the construction of hydro electric storage schemes as opposed to run of river schemes, where data is considered of less value overall, it has been suggested that the value of data is equivalent to a maximum of <u>5% of total scheme construction costs</u> (Scottish Hydro). III. Zhidikov suggested in 1982 that the benefit of hydrometric data in forecasting for hydro electric generation is equal to the <u>increase in power production of a maximum of 2%</u>. According to Scottish Hydro's figures the average annual capacity of a hep plant is 47.8 gega watts with the average price received 1.5p per kilo watt hr/£15 per megawatt hr (Urquart, 1997). IV. Acres suggested in 1977 that 65% of the initial investment in hydro electric power development is sensitive to hydrometric data, and that <u>5% of this latter investment</u> represents the value of the benefits from this data. This may allow us to provide a lower bound to Scottish Hydro's estimates.
3.	*Improved design of bridges, culverts etc.*	Actual benefit values vary depending on:	I. Data collection costs	I. Cloke et al estimated that the benefit cost ratio attributable to culvert/bridge construction has a <u>lower bound of .8</u> for minor waterway

		a) the size of the project in question b) flood recurrence interval. The potential for saving funds from having accurate streamflow data may be fairly high large according to Cordery & Cloke, for construction projects but their small number means their contribution to the overall benefits attributable to hydrometric data may not be that great.	II. Construction costs	crossings, increasing to a b/c of 2 for major structures (Cloke et al. 1993). II. Acres suggested in 1977 that 10% of the initial investment in road and bridge construction is sensitive to hydrometric data, and that 10% of this latter investment represents the value of the benefits from this data, allowing us to provide a lower bound to the above estimates.
4.	*Improved flood warning systems*	Actual benefit values vary depending on: a) the predictive accuracy of the warning b) how effectively the flood warning is disseminated to the public c) the potential response of the public once the warning is received d) the greater the value of expected flood losses prevented. An expansion of the radius of warning to include additional communities will also result in an increase. For example, in the case of agriculture, the exact benefit depends on the number of farms within the floodplain at risk. The benefits attributed to a flood warning system thus, may best be estimated by a linear function taking into account, total flood damages potentially avoided, dissemination of warning, response rate, and accuracy of the warning itself. I. Calculation of avoided damages II. Multiplication by factor related to	I. Capital value of domestic properties. II. Linear relationship III. Linear relationship	I. Total annual benefits from flood warnings to domestic properties in the UK have been estimated as £3.2m (1989 prices). Another assumption is that the benefit attributable to flood warning is equal to 9% of the capital value of domestic properties in the area (CNS, 1991). II. The % relating to hydrometric data defined as 33% by CNS. The benefits in turn must be multiplied by the probability of the occurrence of a flood such as given below, according to Walsh and Noonan, and the response rate e.g. 70%. *Probability of occurrence of flooding* — **Factor* More frequent than 1 in 10yrs — .25 Frequency 1 in 10yrs - 1 in 50yrs — .07 Less frequent than 1 in 50yrs — .02 III. While warnings were issued in the Severn Trent area, effective dissemination was only to 58% of the population. Average accuracy of warnings in both Severn and Trent areas was estimated to be 74% (with reliability decreasing in areas less subject to flooding). Whether the community responds to a flood situation depends upon both the issuing of a warning and if flooding has occurred in the past, according to Severn Trent survey figures: — *Take Action* — *No Action* *Potential response given by those never flooded* — 76% — 24% *Potential response from those flooded in the past* — 80% — 20% *Actual response with flood*

		flooding frequency III. Multiplication by % of public to which warning is effectively disseminated, % accuracy of warning and % of public who respond to warning. Benefits are generally greatest for the floodplains of mature unregulated rivers without land drainage works.		*warning to those before flood* 63% 37% *Actual response from those not receiving flood warning* 38% 62% In the Severn Trent area minimum damage reduction directly attributed to flood warnings was found to be 17% per annum. It may be possible to adapt this approach to the estimation of benefits to agriculture.
			IV. Linear relationship	IV. Alternatively, WS Atkins model may be adapted with avoided flood damages adapted from the NRA's North West region, however it was recognised that each catchment is unique and requires an independent assessment capable of judging the specific needs. Data were prepared in order to assess the relative costs and benefits. a) Initially it was assumed that on average 35% of system costs could be attributed to flood warning. b) Average annual damage figures were estimated as shown in table 2.1. c) To calculate actual benefits attributed to flood warning a number of factors are included within a linear equation: FDA = PFA * R * PRA * PHR * PHE FDA......actual flood damage avoided PFA.......potential flood damage avoided R...........reliability of the flood warning process (ie the proportion of the population at risk which is warned with sufficient lead time to take action) PRA......proportion of residents available to respond to a warning PHR......proportion of households able to respond to a warning PHE......proportion of households who respond effectively. d) The resultant figure for the NRA 'North West' region was estimated as (1995 figures). 75% of this figure can be attributed to the actual flood warning system, the remaining 25% attributed to dissemination, public education and post flood appraisal.
			V. Data collection costs	V. Finally, Day in 1973 estimated b/c ratios for a flood forecasting system from 3:2 to 7:3, based on damage to residential properties and the assumption of a 100% response rate (Day, 1973).

5.	*Pollution Control*	Actual benefit values vary depending on: a) the number of pollution permits in place and industry pollution control strategies.	I. Pollution abatement costs.	I. Based on responses from EA personnel, that in the absence of data a more conservative approach by approximately 20% is taken to the determination of pollution discharge consents, the benefit of data in this regard may be estimated through the avoided cost of over-abatement by firms in the achievement of consent standards: a) determine the firms pollution control costs (examining both fixed and variable). b) apply a factor of .2 to the variable costs, given that fixed costs with a 20% reduction in standards may not be likely to change. While not as exact as benefit estimation methods in other sections this approach provides a guideline on values.
6	*Improved flood protection*	Actual benefit values vary depending on: a) the size of the basin upstream of the site b) the local topography c) the frequency of flooding d) the number and damage susceptibility of properties to be protected.	I. Construction costs II. Data collection costs III. Data collection costs	I. The value of streamflow data may be estimated as 4% to 5% flood protection scheme cost (annual expenditure of flood alleviation schemes in the UK being approximately £58m, with data available for 50% of schemes (CNS, 1991)), according to Adeloye and Mawdsley. II. An international US-Canada joint commission study defined the benefit cost ratio for flood control as 4.26 (Reynolds, 1982), however this was based on high flooding frequency and in turn the avoidance of very high flood damages. A more accurate estimation for our purposes may be this study's b/c ratio of 1.23, in relation to a situation where flood forecasting, warning and proofing were evident. III. A b/c ratio of 1.99 was calculated by Miyata & Abe, with a lower bound of .74 for flood defences when indirect damage avoided is excluded to avoid double counting (Miyata & Abe, 1994).
7.	*Improved determination of abstraction for public, private and agricultural use/alleviation of low flows*	In this situation benefits may range from site to site depending upon: a) the existing risk and occurrence of low flows b) the current uses and level of use of the water resource, e.g. recreational uses such as canoeing, agricultural land area irrigated etc.	I. WTP measure II. WTP measure III. Averted costs of	I. Benefits may be based on Garrod and Willis' figures for mean WTP received for maintenance and improvement of flows for the River Darent of £2.87 - per household per year (Willis & Garrod, 1993), considering all river uses including recreation. This still needs to be attributed to data however. II. If one was to equate the collection of data on river flows to increasing the reliability of water supply management, and thus avoidance of drought, Howe and Smith suggest figures of the public's WTP of $4-6 per household per month, however these figures relate to the willingness to pay where the situation is one of the most severe actual hydrologic events on record, so are considered somewhat high and unrepresentative for our purposes. III. The benefit of streamflow data in low flow alleviation also relate to

			irrigation	agricultural irrigation. This benefit may be estimated on the averted costs of drilling a borehole and abstracting supplies from groundwater due to inadequate surface water supplies, these costs ranging from £1.1 - £5.1 per mm irrigation /ha/yr (not attrib. directly to data) (CNS, 1991).
			IV. Cost of developing water supplies.	IV. The benefit accruing to the use of data to accurately determine abstraction across uses may also be equated to the cost of developing new water resources for public supply, i.e. £1m per megalitre of yield (Smith 1997).
			V. Data collection costs	V. A b/c ratio of 8-10 has been estimated by CNS, 7 being the conservative estimate. This ratio of 7 was derived through multiplying the figure for the benefits of three gauging stations by the ratio of total abstraction for water supply from surface waters in the UK, to that from the sources covered by three gauging stations (CNS, 1991).
8.	*The detection of change in the future*	Since actual changes cannot be foreseen, it is not possible to evaluate actual benefits. What has been proposed however is that if a gauging network were abandoned and a change was subsequently suspected to have occurred then probably at a *minimum* a local network may have to be installed.	I. Construction costs	I. The range of benefits in this respect may be equal to the range of construction costs of a local network in the future. II. In relation to potential reservoir construction, Black et al suggest that in practical terms if there is already a good naturalised flow record for an existing reservoir in an adjacent valley, it is unlikely that the additional knowledge by a further measurement of the one hydrological regime could be justified (Black et al, 1995).

Table 2.1: Annual average damage figures for flood warning benefit estimation in NRA's North West area

Tp	average annual damage - no warning	average annual benefit - warning 2 hrs	4 hrs	6 hrs	8 hrs
< 3 hrs	£3,368,179	£758,263	£1,106,294	£1,305,271	£1,497,383
3 to 9 hrs	£1,514,058	£350,023	£504,930	£597,175	£687,463
> 9 hrs	£1,991,869	£475,580	£681,688	£807,363	£931,917
Total	£6,874,105	£1,583,865	£2,292,913	£2,709,809	£3,116,794
Urban A band	£4,550,263	£1,124,891	£1,599,548	£1,899,056	£2,200,144

Table 2.2: Results - Opportunity benefits resulting from improvements to NRA flood warning capability and benefits of the existing system in place by area

Region	*Opportunity benefits £000s*	*Existing system benefits £000s*	*Incremental benefits £000s*
Anglian	7,251	2,825	4,696
North & Yorks	967	346	621
North West	676	268	407
Severn Trent	2,996	992	2,004
Southern	372	185	187
South Western	493	195	298
Thames	544	245	298
Welsh	1587	642	945
Total	15,155	5,699	9,456

25% of this total equals the benefits attributed to dissemination, public education, and post flood appraisal.

Table 2.3: Mean wtp for the prevention of low flows (NRA, 1994)

Mean Wtp	Residents	Visitors
Maintaining current flow levels in *all 40 rivers*.	15.00	12.28
Improving current flow levels in *all 40 rivers*.	9.61	7.64
Maintaining current flow levels in *River Darent* only.	7.06	4.51
Improving current flow levels in *River Darent* only.	4.34	2.87

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Evaluating the Benefits of Hydrometric Networks

University of Dundee
University of Stirling
Scotia Water Services

June 1997

R&D Progress Report W6/005/10

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT
PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

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R&D Progress Report W6/005/10

1 INTRODUCTION

This report builds on the methods of deriving economic benefit values as outlined in the previous Progress Report for this project, W6/005/9. At present, it is of a provisional nature as the contents have not been discussed among all members of the project team. It is presented as a means of stimulating discussion, and the contents can be revised after further discussions among members of the project team, and after discussions with members of the Project Board.

2 BENEFIT VALUES AND HYDROMETRIC NETWORKS

This issue is at the very heart of the project and, with all of the preparatory work of the project complete, the stage is now reached where a final operational methodology must be fully explained and agreed upon. Such a stage is reached only now, because although there has been much discussion with the Project Board regarding how the aims of the project should be achieved, it is only when the work is done that the importance of possible obstacles becomes apparent. Similarly, the task of translating objectives into reality constitutes the acid test of whether concepts are viable in their intended context.

The bulk of the previous Progress Report, W6/005/9, demonstrated how estimates of benefit could be arrived at by reference to the various factors controlling benefit in a wide range of types. In many cases, a number of different routes have been provided to give benefit assessments for the same benefit type, e.g. for the improved design of bridges, culverts, etc.; values may be estimated either by application of a minimum data benefit/cost ratio as obtained from other studies, or by reference to the capital cost of the possible works in question. With the case studies adopted in this project, it will be possible to give advice regarding which of the various approaches should be applied.

For the purposes of this project, it is important that such values are sensitive to the hydrometric data which result in such benefits being accrued. The means of doing this are now addressed. Two alternatives can be identified.

1. A qualitative assessment of hydrometric data accuracy and utility is made in parallel with the economic assessment of benefit values, and is then used subjectively by those undertaking a network review.

2. Direct means are found to enable benefit values to reflect relevant aspects of the data underpinning each benefit. Primary aspects would be:

- The accuracy of the data at flow rates appropriate to the benefit (e.g. accuracy of high flow estimates/measurements for design studies; accuracy at low flows for abstraction license determinations)

- The proximity of data-generating sites to points of application (e.g. how useful are data gathered at gauging station X to an economically valuable use of the data at town Y?).

  Some precedents may be adopted to help address the first point, but the spatial locating of points of benefit poses distinct problems with the second.

Detailed information is presented for each of these, to allow a full consideration of which approach is the most appropriate to the needs of hydrometry in the UK.

2.1 Qualitative hydrometric network assessment

The Institute of Hydrology (IH) report '*A review of the Northern Ireland hydrometric network*' (Black et al., 1995) presented a broadly-based methodology for assessing the efficacy of the then network in Northern Ireland in relation to the demands being made of it. It did not make extensive reference to economic methods, but concentrated on relating data uses to the information-generating properties of the network as a whole, and the utility of individual gauging sites in relation to the data uses serviced by those sites. As such, it provides some very useful background to this part of the study, and the Institute's intellectual property rights in that work must be recognised. However, because the thrust of this work is to consider the economic benefits arising from hydrometric data, the IH work must only be seen as relevant background, and the development of qualitative methods for assessing hydrometric networks must be focused specifically on the economic benefit assessments which have been developed within this project.

Table 1 presents a list of benefit areas and the aspects of hydrometric data which affect the magnitude of the benefits which are derived, the content being based on the results of the questionnaire survey and interviews with agency staff.

Benefit area	**Hydrometric factors affecting benefit**					
	1	**2**	**3**	**4**	**5**	**6**
Design of storages	√	√	(√)	√		√
Design of bridges, culverts, etc.			√	√		√
Flood warning system design and operation			√	√	√	√
Flood defence			√	√		√
Pollution control	√	√		√	√	√
Abstraction licensing	√	√		√	√	√

Table 1 Aspects of hydrometric network performance affecting benefit values

Hydrometric factors affecting benefit:
1. Accuracy of low flow measurement
2. Accuracy of intermediate flow measurement

3. Accuracy of high flow measurement
4. Representativeness of measured flows to point(s) of application
5. Availability and reliability of telemetry
6. Reliability of recording

Accuracy in items 1-3 refers simply to the precision of recorded data in relation to actual flows through the range experienced at a site. A large body of literature exists on the sources of hydrometric error and the practicalities of maintaining accuracy (see Herschy, 1985); similar considerations apply in the measurement of other environmental parameters, e.g. rainfall.

Assessing the representativeness of measured flows (4) recognises that flow measurement occurs only rarely at precisely the point where data are required. Two aspects of this are important: the geographical distribution of gauges when related to the distribution of points of data application (and benefit), and the appropriateness of gauged catchment types (in relation to catchment size, geology, water utilisation, etc) when compared with the characteristics of catchments and rivers where data are required.

The concept of representativeness is advanced as a catch-all means of assessing whether gauging sites are likely to serve the needs demanded of them, with respect to geographical distribution and catchment characteristic considerations. The concept is well developed in the IH Northern Ireland report, where the whole of the Northern Ireland drainage network was characterised in terms of the physical characteristics of every conceivable catchment (these generated with Micro Low Flows), and then comparisons made with the catchment characteristics of all gauged catchments. If agreement were reached over the desirability of including such an exercise in the recommended approach to assessing networks, this concept could be developed into a checklist-driven procedure for agency staff, which would be simpler and quicker to implement than the more sophisticated IH approach.

The availability and reliability of telemetry (5) is listed as being important to those functions which require real-time data: flood warning, pollution control (in the case of monitoring flows in relation to a pollution incident) and abstraction licensing (where this is tied to flow levels in a river - a feature which might become more common if climatic influences lead to increasingly variable flows in future).

Finally, reliability of recording (6) is seen to be important for all of the benefit areas listed. Simply put, the benefits of recording flow will quickly diminish if gaps or periods of uncertain data quality arise in the record: benefits of recording can only arise from the use of data which are representative at least of conditions at the point of measurement.

In a hydrometric network benefit assessment, it is proposed that this information could be combined with economic assessments of benefit as shown in Table 2.

Benefit area	Estimated benefit	Hydrometric factors affecting benefit						Network performance						Outcome
		1	2	3	4	5	6	1	2	3	4	5	6	
A_1	B_1	√	√	√	√		√	H	H	H	H		H	Value B_1 confirmed
A_2	B_2			√	√		√			H	H		M	Value B_2 compromised - technical remedy recommended
A_3	B_3			√	√	√	√			H	H	M	H	Value B_3 compromised - technical remedy recommended
A_4	B_4			√	√		√			H	M		H	Value B_4 compromised - network redesign needed to secure improvement
A_5	B_5	√	√		√	√	√	L	H		H	H	H	Value B_5 severely compromised - technical remedy recommended
A_6	B_6	√	√		√	√	√	H	H		M	H	M	Value B_5 severely compromised - technical remedies and network redesign recommended

Table 2 Proposed qualitative methodology for relating benefit assessments to hydrometric network performance

Hydrometric factors as proposed in Table 1; performance indicated by H=High, M=Medium, L=Low. Compromised/severely compromised benefit values are those where the numerical value resulting from approximate CBA is substantially affected by hydrometric factor(s).

Perhaps the most difficult aspect of applying this method is to make the performance assessments for the entire network in question, since the benefit values are assessed on this basis. However, it is suggested that this should be done with reference to those sites or areas of greatest importance in relation to the realisation of benefits, e.g. headwater areas from storage design, major towns/cities for flood defence, etc.

At the end of this process, a network manager or review team should have available for the network under review:

- costs of the network
- an assessment of benefit values for each relevant type of benefit (to be regarded as potential benefits)

- an assessment of the performance of the hydrometric network in terms of delivering these potential benefits, for each type of benefit

An informed assessment could then be arrived at, as to whether the current network was delivering good value for money. This type of analysis could then be moved forward to consider the effects of perturbing the network, with respect to the location and specification (technical capabilities) of gauging stations. So for example, if a network were seen to offer a ratio of potential benefits to costs substantially greater than unity, but with some benefit types compromised say by technical weaknesses or by the representativeness of the current network, then it would be possible to demonstrate the value of a network expansion in strengthening its performance.

2.2 Direct hydrometric network assessment

It was suggested above that two main aspects of assessing directly the impact of hydrometric performance on network data value were data accuracy and proximity of gauging stations to points at which data benefits accrue. To develop this approach, methods are therefore needed to translate the economic benefit values generated from the base values and weights to values which accurately reflect the performance of a gauging network. This requires consideration with respect to each benefit type, since each may have its own sensitivity to hydrometric data quality.

The design of storages is considered as an example. Benefits of hydrometric data application in the design of storages are have been assessed as a fraction of scheme capital cost. If the collected data were subject to some error, this may cause either overdesign or underdesign. A similarity may be seen with the reduction of uncertainty which accompanies increases in record length. Adeloye (1990) has suggested that overdesign associated with 6 years record in hand may cost as much as 33% of construction costs, falling to only 13% when 20 years data are held. However, difficulty arises in assessing the magnitude of sensitivity to data accuracy, since this is sure to be scheme-specific. It may be possible to obtain typical assessments from actual schemes, but the wisdom of such an approach is questionable.

The economic benefit of hydrometric data for this purpose is derived from literature-based assessment of benefit expressed as a fraction of scheme cost. In application to any one network of gauges, the value of scheme costs is often likely to be a nominal figure since, in many cases, these schemes will not be current but only possible in some future scenario. To then apply some further adjustment, on the basis of reported experience elsewhere, to reflect the possible effect of measurement uncertainty on benefit, would be to widen the uncertainty associated with the resultant expression of benefit. Also, a further adjustment would need to be made in order to reflect the likely reduction in benefit caused by transferring information from a gauge site to the point of data application, and again further uncertainty would result. Compounding the uncertainties associated with each of these seems, subjectively, to offer the possibility of uncontrolled error in the resultant values and, on that basis, appears inadvisable. Also, such an approach might be seen to implicitly suggest a higher accuracy in the results of the approximate CBA than is intended, and is again therefore felt to be inappropriate.

A second example can be considered and, for the sake of variety, will concern flood flows - specifically, design flood work concerned with *flood defence*. Here, hydrometric errors are well known, arising from the difficulties involved in calibrating gauging stations for high flows. Data from gauging stations are used for flood defence work and, because such works rarely relate to the immediate vicinity of gauging sites, recorded levels must be translated into flows so that information can be transferred to sites of interest. As with storage design, an error in a design flow can lead to costs of overdesign or underdesign. In this case, because again a design question has been chosen, the above arguments regarding compounding of uncertainties can be seen to apply.

Flood warning is chosen as a third example. Here, warning schemes are often based on gauging station levels (and recorded rainfalls and other non-river information), and so the problems of calibration are lost. Difficulties in level recording are much less common than the occasional problem of telemetry unavailability, which is often caused by extreme adverse weather conditions. Proximity of gauging sites tends not to be problematic, because schemes usually involve stations from as many sites as are necessary in order to give warnings of a required reliability and lead-time, with new stations being constructed if necessary.

The main question arising here then may be how to assess the benefit impact of telemetry reliability. A simple approach may be to arrive at a representative failure rate for telemetry lines, and to assume that a warning would not be given in the event of such a failure. However, this gives an unduly pessimistic assessment. Flood warning schemes as a rule are based on alarm generation being possible from a number of data sources, and often draw on the experience of the hydrologist in the event of equipment failure (as well as more generally). Perhaps a more realistic approach would be to suggest that a telemetry failure could result in a delay to the issue of a warning, such that damage avoidance was less than would otherwise be the case. Data could be produced to describe this effect, but again this would need to be done on a location-specific basis to take into account the amount of property at risk and the usual length of warnings possible.

The themes emerging from this discussion are that attempts at direct benefit impact assessments may tend to substantial uncertainty and subjectivity, or may require local detailed studies in order to be effective.

2.3 Summary

It is suggested that a qualitative assessment of the impact of hydrometric performance on benefit is to be preferred over attempts to derive direct impact values in terms of economic benefits.

Advantages of this approach are:

- Simplicity of application
- Avoidance of potentially unacceptable uncertainties
- Avoidance of the need for detailed studies to underpin a network review (unless specifically warranted)

It could be argued that an important disadvantages of adopting this approach would be the loss of opportunity to express benefits precisely. However, it has never been suggested that such values can be expressed with great precision: rather, the approach is one of *approximate* cost-benefit analysis.

The views of the Project Board on this preference will be sought.

3 CHECKLIST

Further development of the checklist approach has taken place since initial presentation in Progress report W6/005/8. The previously separate sections B and D on uses of data and suitability of network to needs respectively have been brought together and extended, and are currently held as a check-list in spreadsheet format. A section C 'Potential future uses of data' has also been expanded, though this remains in simple form owing to the difficulty of knowing how to identify possible future demands of networks. The current version of the full checklist is appended at Appendix I.

The spreadsheet format of part of the checklist is seen as useful progress towards providing the prototype of an interactive management tool. On the left of the list of data uses is a column of boxes which can be used to identify those data uses of importance to a given network. Through a system of formulas and cell protections, it should be possible to guide the user through a system of questions/boxes such that only relevant choices need to be made but, conversely, ensuring that all required information is asked of the user. In practice, translation of this type of template to a database program such as Microsoft Access, which features a forms interface, may allow this to be expedited most effectively.

Recent experience with page design and programming for world wide web pages suggests that it should be possible to construct pages on a web server, designed to ask for and store this information. At an operational level, this may offer distinct advantages: revisions to the software could be made centrally on the basis of operational experience, and access could be readily available to any user with access to the appropriate web server (e.g. by password access to an Environment Agency web server).

The case study catchments will allow the appropriateness of the current version of the checklist to evaluated. The views of the Project Board on the content and method of delivery of this checklist are sought.

4 CASE STUDIES

Contact has been made with both North West Region of the Environment Agency and the Environment and Heritage Service for Northern Ireland, and a visit has been made to Belfast, during which the Foyle case study was discussed. We initially asked for a list of contacts within each Region to enable direct requests to be made regarding the different uses of hydrometric data. Both regions felt that it would be simplest to make a single request through one contact, and that this contact then collates the various pieces of information from the different sources. A request has thus been made to both regions for the identified data. Once this has been received the data will be used to evaluate the economic assessment proposed in Progress report W6/005/9. Following this, there will be a second stage to the evaluation, based on hydrological criteria (as per Section 2 above). It may be necessary to complete a further request for this part of the evaluation.

5 BHS PAPER

The paper submitted for the Salford 1997 symposium has been accepted for presentation and publication in the proceedings, subject to minor modifications which are in hand.

6 NEXT REPORT

Again, this Progress Report has been submitted behind schedule. Recent enquiries by the Environment Agency's Project Leader have served as a catalyst to further progress, and it is regretted that this has become necessary. It is hoped that the content of this report will serve to stimulate discussion among all involved and help stimulate an improved rate of progress. It is very much hoped that the next Progress Report will give a full account of the work on the rest catchments, in time to allow use of that material in the oral presentation at the Salford symposium.

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DRAFT INTRODUCTORY CHECKLIST

SURFACE WATER GAUGING NETWORK REVIEW
ASSESSMENT OF BENEFITS GENERATED BY MONITORING

Catchment review for ____________________________________ (area)

INTRODUCTORY CHECKLIST

Purpose
The purpose of this checklist is to preface the mechanistic elements of the review with a systematic and qualitative survey of the water resources[1] *and monitoring network of the catchment being reviewed. Answers to the questions below will allow results from the later, more mechanistic, parts of the review to be placed into a broader context. This is particularly important in relation to those benefits which do not lend themselves readily to quantification. Nonetheless, in giving a general overview, the checklist will address all areas of potential benefit.*

A The resource
A1 Catchment characteristics

For the area under review
Size of area (km^2)
Mean annual rainfall (mm) - overall
- for driest gauged catchment
- for wettest gauged catchment

Mean annual actual evaporation - overall (mm)
What % of the area lie within the 20m AOD contour?
Give the altitudes of the three highest hills/mountains in the area
Describe the geology of the area:

Mostly impermeable/Mostly permeable/Mixture
Mostly acidic/mostly alkaline/mixture

[1] groundwater, rainfall, air might all be substituted here. Separate checklists would need to be developed for each medium.

A2 Uses of water

What is the primary use of water in the catchment?

Are abstractions made for public water supply schemes?
(a) - from surface sources
(b) - from groundwater

Are surface reservoirs used for storage purposes?
Are surface reservoirs used for HEP?
Are there run-of-river HEP schemes; if so where?

Over approximately what % of the area are there agricultural abstractions?
(a) - from surface sources
(b) - from groundwater

Is the agriculture in these areas water-intensive?

How many sewage treatment works discharging to watercourses are there in the area?
0
1-5
6-15
16-30
30+

Describe the level of urban development in the area: Essentially rural
Some urban development
Major urban centres

What and where are the main industrial users of water?
(Indicate source of supplies, annual demand as far as practicable)

Is there any flow regulation scheme(s) in the area; if so where?

B Uses of data

If possible, information for this section should be extracted from data request log sheets. Take account (again where possible) of any access to your data holdings which by-passes the logging system.

Use the left column to indicate which of the following uses are made of the data collected in the area
For each data use ticked, use the right columns to indicate the specific requirements of each data use in the area

Data use — TICK		Telemetry			Low-flow accuracy required			Limit of high flows required					Comments
		Essential	Desirable	Not required	High	Standard	Not required	Q50	Q10	Q1	Mean Ann Flood	Max flood	Any apparent abundance or shortage of stations, or station location issues
☐ Flood warning													
☐ Flood design work	- flood defences												
☐	- other structures (specify:________________)												
☐ Storage design													
☐ Low flows	- abstractions												
☐	- return flows												
☐ HEP operational													
☐ Water resources - operational management													
☐ Consent determination/review													
☐ Calculation/modelling of mass balance/pollutant loads													
☐ Assessing/managing pollution events													
☐ License determination/review													
☐ Enforcement of licences, derogation investigations													
☐ Real-time data use with variable licences													
☐ Scientific support	- interpretation of chemical/biological field data												
☐	- calculation of loadings and discharges to sea												
☐	- model development												
☐	- others												
☐ Fieldwork planning	- agency staff												
☐ Recreational	- fisheries/RiverLine												
☐	- amenity management, eg canoeing												

C Potential future uses of data

With reference to the list of data uses in B above, list the following:
a) any uses which are not expected to require data collection in the long-term

b) any uses where a given length of data will be sufficient to satisfy the need (give length)

c) any uses where data from a greater number of stations may be required in future (give reasons),

AND
d) any new types of data use expected to arise.

Evaluating the Benefits of Hydrometric Networks

University of Dundee
Scotia Water Services
University of Stirling

December 1997

R&D Progress Report W6/005/11

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT
PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

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R&D Progress Report W6/005/11

1 INTRODUCTION

This report provides an update on work for the test catchment part of the project. It has been compiled to show the state of progress in preparation for a meeting to be held in Reading with members of the Project Board on Friday 5th December 1997. Most of the report consists of benefit assessments for given benefit types. Most relate to the Bollin catchment, which was identified as having the potential for a relatively large number of separate benefit assessments (given the size of catchment, approx 250 km^2). The only relevant data obtained for the Foyle catchment (to date) are for the costs of bridge and culvert repairs. A final view has to be taken as to whether there are any other benefit types which can be quantified for the Foyle catchment. Having a lack of case study data for a flood defence scheme in either of the test catchments, knowledge of, and access to information on the Perth flood defence scheme has been used to furthe rillustrate methods which can be employed.

Because of the difficulties of bringing together members of the project team while data has been slowly converging, this work has not been fully discussed among members of the team. In particular, the timing of this report (relative to the arrival of information), has made it difficult to represent fully the input of NDH in this report. However, further input from him will be made in the meeting of 5 December.

2 EXTERNAL SOURCES OF DATA

Several sets of data have been necessary to make the assessments presented. These are:

Bollin catchment
Gauging station performance data
Assessment of likely characteristics of hydro-power plant
Rule-of-thumb guide to relationship between HEP power output and scheme cost
Population of catchment
Sewage works discharging into catchment
Rule-of-thumb guide to relationship between STW population equivalent and annual variable running cost
Construction cost for A34 road project
Annual budget for Cheshire County Council maintenance of structures

Tay catchment
Perth flood defence scheme capital cost

3 APPROACHES TO BENEFIT SCALING

In each benefit assessment, three headings have been provided for the scaling of benefits: data accuracy, data applicability and period of benefit. Comments regarding the former two types were provided in Progress report W6/005/10 and these ideas have now been modified, after discussions involving M Postle, D Rylands and members of the project team in order that numerical values are retained throughout the process of qualifying potential benefits.

Previously, it had been suggested that a descriptive qualifier should be used with the output from a benefit assessment, but now tables of scaling values have been produced and are included as an Appendix. It must be stressed that these values have been arrived at on an intuitive basis only - drawing on the hydrological and hydrometric experience of AMB and ARB. To derive such values on a more empirical basis would be impractical, and it is hoped that the values provided do describe the form of relationships which would be anticipated by data users. Certainly, they provide a basis on which the effects of altering gauging networks may be assessed - a key aspect of the project.

Period of benefit scalings have been presented for large capital projects, in order that occasional benefits are not included misleadingly in overall benefit assessments which are then compared with annual running costs. In the examples given, the benefits of such major projects have been distributed across a five-year period. This time period was chosen for a number of reasons, principally:

- Agency staff are likely to be familiar with projects within this time scale - if the period is lengthened, there is an increasing probability that familiarity will decrease;

- Familiarity will also be important in relation to other organisations - local/national government, or contractors. Again, over longer time periods, the reliability of information can be expected to deteriorate;

- It is considered that inflation-linked changes to the capital cost of these projects will fall within the error bands/confidence limits of the methodology. If the time base is lengthened then there will be an increasing need to allow for inflation in the approach, further complicating the methodology;

- Many of the projects (i.e. their construction) will last for periods of this length. If a shorter time period was chosen, there would be difficulties associated with attributing the benefit to a single year;

- Finally, as the time period is reduced the methodology will become more sensitive to benefits arising from major projects of this type. By averaging the benefits over a five-year period it is felt that a sensible balance is met between the benefits arising from the current network and typical projects which benefit from the data provided by this network.

A more satisfactory approach may be to find ways of distributing benefits over the entire period to which they apply, requiring discount rates, design life length, etc. The views of the Project Board will be sought on this issue, along with views on the more general matter of whether benefits should be spread among years at all, rather than counted only for the years in which the projects were constructed.

4 ACKNOWLEDGEMENTS

We are grateful to all the organisations which have assisted with the provision of data for this part of the study. Particular thanks go to United Utilities (North West Water) for assistance with annual STW running costs - the data provided are commercially sensitive and are not to be attributed to them (but instead to 'an English Water Company') in any results reports, manuals etc arising from this project. Similar thanks go to the anonymous consultancy providing help with estimating the cost of hydro-electric scheme capital works.

APPENDIX

Hydrometric data component benefit assessment proforma

Test catchment
Bollin

Benefit
Avoidance of costs of inappropriate hydro-power investment

Basis of benefit assessment
Use of hydrometric records has allowed an assessment of the viability of a hydro-power scheme to be made, and has indicated that the scheme could be of low/non-profitability or non-viable. On this basis it has been decided that the investment should not be made. The value of the data is thus equivalent to the avoided losses.

Calculation of potential benefit
This is rather more complicated than many of the other case studies. Where possible, costs have been linked to capacity of the scheme to allow the approach to be used elsewhere.

Suggested installed capacity for Bollin site is 240 kW
Scheme capital cost = £1,000 * power (kW) = £240,000

Annual costs for scheme to be viable (various sources)	
10% payback of capital expenditure	£24,000
10% return on capital investment	£24,000
Rent to landowners/water charges at £10,000 per MW	£ 2,400
Rates at £10,000 per MW	£ 2,400
Insurance at £5,500 per MW	£ 1,320
Wages/operational costs at £5-6,000 minimum per site	£ 5,500
Admin and scheme management costs at £6,000 per site	£ 6,000
TOTAL annual income to break even	£65,620

Maximum annual revenue @ 4.2p per unit determined by:
kW capacity x unit charge x 24 hours x 365 days
= 240 x 0.042 x 24 x 365
= £88,300

This assumes that scheme can operate for 100% of time.

Run of river schemes typically operate for 45% of time at full power equivalent based on flow duration curve (derived from 25% at full power, and the remainder at lower power). To ensure that a conservative estimate is derived, it is suggested that 50% is used.

This equates to an annual revenue of 0.5 x £88,300 = £44,150
Annual avoided loss thus equivalent to £66,620 - £44,150 = £22,470 = potential benefit

Scaling for data accuracy
The project requires data which are accurate in the central portion of the flow duration curve, Q_{80} - Q_{10}.
The data for the River Bollin are of a high accuracy throughout this range.
No scaling (reduction) is required on account of this factor.

Scaling for data applicability
Gauging station data for the project was derived from two gauging sites (on the main stem and its main tributary to Bollin), measuring flow for more than 90% of the area draining to the site of interest. This represents a high degree of applicability, and no scaling (reduction) is required on account of this factor. It is of fundamental importance that the benefit arises from use of observed data, these being inherently superior to use of theoretically derived flow duration curves.

Scaling for period of benefit
Annual data - no scaling required.

Component benefit assessment
No scaling of potential benefit, therefore component benefit = £22,470 pa.

Hydrometric data component benefit assessment proforma

Test catchment
Bollin

Benefit
Improved design of bridges and culverts - (1) A34 by-pass project

Basis of benefit assessment
Hydrometric data provide for the avoidance of over-design and under-design costs by reducing uncertainty, as reported in literature

Calculation of potential benefit
Construction cost of project obtained as £60 million (excluding indirect costs of construction, such as planning costs, land purchase).
Literature indicates that 10% of construction costs are sensitive to hydrometric data (i.e. £6 million of the cost is variable subject to hydrometric data).
The benefit of the hydrometric data is given as 10% of the hydrometric data-sensitive element above, i.e. £600,000.

Scaling for data accuracy
The high (flood) flow elements of the time series collected at the Bollin (Wilmslow) and Dean (Stanneylands) gauging stations are of principal interest in this application. A scaling scheme has been devised (see Appendix) for representing flood data accuracy and can be applied to the two gauging sites. Results are:
Wilmslow: 20%) i.e. very poor flood flow measurement
Stanneylands: 20%)

Because the two stations are of equal importance in this project, equal weighting is given to the two scaling factors, i.e. the hydrometric data benefit must be scaled by 20% to represent this factor.

Scaling for data applicability
Benefits arise from application of hydrometric data to the construction of both major and minor river crossings. A simple measure which can be obtained by the hydrologist is the fraction of a capital project which is located within a catchment of interest. In this case, some 70% of the route length of the project lies within the catchment of the Bollin and its tributaries. The remainder lies within the Mersey catchment to the north.

The benefit assessment should be scaled by 70% to reflect this factor.

(Incidentally, the two major river crossings of the A34 by-pass are almost immediately adjacent to gauging stations on the River Bolin and its main tributary the River Dean. However, no information is available locally for the smaller watercourses of the area.)

Scaling for period of benefit

Like the hydro-power application for the Bollin, this benefit may be regarded as a one-off/occasional benefit rather than an annual benefit. Other comparable road (or rail) projects will almost certainly occur in the future within the Bollin catchment. A comprehensive approach to assessing benefits of this type may be to assess the annual cost of major transport infrastructure works in the catchment, and subject each project to the types of assessment detailed above.

A more practical approach may be to attempt to identify all such projects within say a 5-year period. This type of initial query ought to be reasonably well answered by the appropriate local authorities. In the case of the Bollin, the major projects are this A34 road project and the Manchester Airport Runway 2 project now in progress. The benefits of all projects over the 5 years would then be distributed over that period, i.e. annual benefits will be 20% of the totals assessed.

A scaling of 20% is therefore proposed to account for period of benefit.

Component benefit assessment

Assessed as £60,000 * 20% * 70% * 20% = £1680 pa.

Hydrometric data component benefit assessment proforma

Test catchment
Bollin

Benefit
Improved design of bridges and culverts - (2) Cheshire County Council maintenance of structures

Basis of benefit assessment
Hydrometric data provide for the avoidance of over-design and under-design costs by reducing uncertainty, as reported in literature

Calculation of potential benefit
CCC annual budget (typically) £600k for maintenance of structures; about 15% of this applies to Bollin catchment (based on sizes of catchment and county) = £90k. Application of above procedures gives annual potential of 1% of £90k = £900.

Scaling for data accuracy
Flood flow data of primary relevance. The two upstream gauging stations in the catchment score 20% scalings, and Dunham Massey has an unknown score due to (a) channel control problems and (b) a reported highest gauged flow of 5% greater than the highest recorded flow. However, relevance of data applicability is also important.

Scaling for data applicability
Data uses and therefore benefits are distributed widely throughout the catchment and must vary from year to year. Considering this and the already low potential benefit, it is not deemed worthwhile to attempt any scaling. Indeed, the accuracy scaling also suggests that this benefit estimate should not be developed further. However, in some case where larger potential benefits may be identified, treatment of individual benefits may be warranted.

Scaling for period of benefit
Annual benefit data used.

Component benefit assessment
Negligible.

Hydrometric data component benefit assessment proforma

Test catchment
Bollin

Benefit
Improved design of bridges and culverts - (3) Manchester Airport Runway 2

Basis of benefit assessment
Hydrometric data provide for the avoidance of over-design and under-design costs by reducing uncertainty, as reported in literature

Calculation of potential benefit
The large scale of this project and the consequently sensitive nature of its costings make detailed data difficult to obtain for this project. However, a total construction cost of £172 million (1993 Q3 prices) has been provided, and it is known that because a major river crossing for the runway is involved in the project, then real benefits should be expected to accrue from the use of hydrometric data.
As above, potential benefit can be assessed as 1% of scheme construction costs, i.e. £1.72 million.

Scaling for data accuracy
The two gauges of most benefit for this application are Wilmslow and Stanneylands, each noted above as scoring a 20% scaling for data accuracy. This figure is therefore to be applied to the potential benefit.

Scaling for data applicability
The site is a short distance downstream of the Bollin/Dean confluence, and a short distance downstream of the 2 gauging stations on those watercourses respectively. Taking the two gauges as a combined catchment area, the ratio of this area to that draining to the site gives a ratio of 89%.

Scaling for period of benefit
For the same reasons as for other major capital projects, it is proposed to distribute this benefit over 5 years. A scaling of 20% is therefore proposed to account for period of benefit.

Component benefit assessment
Assessed as £1,720,000 * 20% * 89% * 20% = £61,232 pa.

Hydrometric data component benefit assessment proforma

Test catchment
Bollin

Benefit
Avoidance of excess pollution control costs

Basis of benefit assessment
Hydrometric data are necessary for the accurate setting of consent standards for discharges. In the absence of such data, questionnaire survey indicates that consent setting would be more cautious. Consents are reviewed on a regular basis as a means of responding to changing catchment and regulatory conditions. It therefore follows that the collection of hydrometric data results in a benefit through the avoidance of those excess pollution control costs which would otherwise be borne if standards were higher (as a result of a lack of data). Benefits to be assessed as 20% of variable costs of treatment.

Calculation of potential benefit
Population equivalent values for the major sewage works in the Bollin catchment were obtained, and related to estimated treatment costs (obtained from a curve based on data supplied by an English Water Company). Results for the five works are given in the table:

Works	Population equiv	Est annual cost (£)	Est benefit (@20%) (£)
Hale	15,200	50,920	10,184
Alderley Edge	14,100	52,875	10,575
Knutsford	12,800	51,200	10,240
Bowdon	4,700	44,650	8,930
Mobberley	3,600	36,000	7,200

Summing the right-hand column, the total potential benefit arising from data application at these works is £57,779.

Scaling for data accuracy
As for alleviation of low flows, this benefit type is based on low flow measurement, and the requirement for accuracy must reflect this. Stations in the Bollin catchment generally appear to have been gauged frequently at low flows, although EA information for Dunham Massey GS at the catchment outfall describes "severe weedgrowth and [site] has no stable control; flow measurement is therefore poor ...". Reference to the Appendix shows that an accuracy scaling would normally be based on the annual frequency of low flow gaugings but, in this case, it appears that site problems would suggest that these are over-estimates. A nominal 50% benefit scaling is proposed for Dunham Massey, with 90% scalings being appropriate to the other two (upstream) gauging stations.

Scaling for data applicability
It is proposed that to scale potential benefits according to the location of gauging stations relative to data benefit points, a ratio of catchment areas should be used. Where the river passing a point of data application (e.g. a STW) drains an area essentially the same as a nearby gauging station, a benefit scaling of approximately 100% will apply (an upper bound of 100% will need to be imposed) while, where a gauge measures only a small fraction of a catchment draining to a works, the benefit scaling will be reduced accordingly. Conversely, where the nearest/most appropriate gauge is at a point draining an area much larger than that at the point of interest, again the applicability scaling should be low. The Appendix describes a system for deriving scaling values on the basis of catchment areas, and this has been applied below:

Hale	Bollin u/s of confluence with major tributary	70%
Alderley Edge	on Mobberley Brook (ungauged)	5%
Knutsford	on Birkin Brook (ungauged)	12%
Bowdon	Bollin u/s of confluence with major tributary	70%
Mobberley	on Mobberley Brook (ungauged)	10%

Scaling for period of benefit
These are annual data, and no scaling in this respect is therefore required.

Component benefit assessment

Works	**Potential benefit (@20%) (£)**	**Scaling and result**
Hale	10,184	* 50% accuracy scaling * 70% applicability scaling = £3,564
Alderley Edge	10,575	* 50% accuracy scaling * 5% applicability scaling = £264
Knutsford	10,240	* 50% accuracy scaling * 12% applicability scaling = £614
Bowdon	8,930	* 50% accuracy scaling * 70% applicability scaling = £3,126
Mobberley	7,200	* 50% accuracy scaling * 10% applicability scaling = £360

TOTAL BENEFIT = £7,928 pa (attributable to Dunham Massey alone)

Note that substantial scope may exist for siting a new gauge within the Mobberley Brook catchment - benefits accruing from accurate consent setting for just one STW (e.g. Alderley Edge, Mobberley) with a ~100% accuracy scaling and a high applicability scaling could more than justify the annual running costs of a new station.

Note

The above example illustrates a conceptual difficulty with the present 'scaling for data applicability' methodology that is proposed. Much of the UK hydrometric network is based on obtaining data from representative areas, and applying this to catchments which are not gauged but have similar catchment characteristics. Whilst neither the Mobberley or Birkin Brook catchments contain a gauging station, their outflows are part of the flow gauged at Dunham Massey. However, the fraction of runoff they contribute to Dunham Massey is small, and the applicability scaling values are therefore very small (5-12%), i.e. a major benefit reduction is proposed. Whether the scaling by area ratio is the most desirable/applicable method must be a matter for conjecture, and the views of the Project Board are welcomed. The adopted approach must be robust, and must be sensitive to the addition of a new gauging station within an ungauged catchment.

Hydrometric data component benefit assessment proforma

Test catchment
Bollin

Benefit
Improved determination of abstraction licenses/avoidance of low flow problems

Basis of benefit assessment
Willingness to pay for the maintenance and improvement of flow regime has been studied for the Darent catchment as one of the ex-NRA's 40 low-flow rivers of England & Wales. Summary findings for truncated mean values from the study data set are:

Group	Willingness to pay (£/household/year)
Residents	4.34
Visitors	2.87
Non-users	1.70

Information from the Environment Agency (North West Region) indicates that because of summer agricultural abstractions, there is a low flow risk and the abstractions have to be managed carefully to avoid this situation. On this basis, results of the Darent study are considered to be transferable to the Bollin. However, for direct applicability to be justified, it would need to be assumed that the environmental characteristics of the Bollin were the same as those of the Darent, and similarly that the population characteristics of those willing to pay (e.g. income, age distribution, interests) were the same in both cases. This is unlikely to be true, but nonetheless, it is hoped that these data will be of good indicative value.

This basis would not be applicable to a catchment where no serious risk of low flows was likely.

Calculation of potential benefit
A lower bound to the willingness to pay may be obtained from the resident population of the catchment, estimated to be equivalent to 55,000 households.
With a WTP of £4.34/household pa, this gives a potential benefit of £238,700 pa.

However, this assumes that all of the benefit derives only from application of the hydrometric data, counting nothing for the abstraction determination/licensing and enforcement functions of the Environment Agency. A hydrometric data benefit of 10% of the total assessed from WTP is considered to be a conservative value, and is proposed as an approach to be applied consistently in assessment of this type. Potential benefit therefore becomes £23,870.

Scaling for data accuracy
Low flow data, at around the Q_{95} flow, are central to the derivation of this benefit. Abstractions are located throughout the catchment, and so data from all three gauging stations in the catchment are necessary to the pursuit of this benefit.

Scaling factors are obtained for each station as follows:

Dunham Massey:	50%	(see Bollin pollution control cost assessment)
Wilmslow:	90%	)
Stanneylands:	90%	) - assumed

A simple average is taken to provide an overall scaling for this factor of 77%.

As with some other test applications, this example reveals a possible shortfall in the proposed approach. Whilst it is meaningful to assess the accuracy of the low flow data provided by the three gauging stations within the catchment, the approach may initially result in lower benefits if a new gauging station were to be built. This is because it will take a number of years/low flow events to develop/confirm the rating and, during this period, the accuracy is likely to result in a lower accuracy scaling factor than that of the three existing stations. Consequently, the overall accuracy scaling factor will be lower. However, the change in the final benefit assessment will depend not only on accuracy scaling but also on applicability scaling, for which there should be an increase.

Scaling for data applicability
Abstractions occur in all parts of the catchment, and it could be considered that the current disposition of 3 gauging stations is broadly appropriate to abstraction licensing needs in the catchment. However, it could equally be argued that the establishment of more stations would improve data applicability, and that the converse would apply with fewer stations. A means is required to cope with the distributed nature of the abstractions around the catchment. It is proposed that a method be developed which would use the largest *n* abstractions in the catchment, and for each assess the applicability of available hydrometric data. This has not yet been possible within the process of testing in this catchment and, for the sake of illustration only, it is assumed that a scaling of 50% should be applied to reflect a wide distribution of abstractions in relation to gauging sites.

Scaling for period of benefit
The data provided are annual rates - no further scaling is required for this factor.

Component benefit assessment
Product of the above = £23,870 * 77% *50% = £9,190
(A major benefit in comparison with others)

Hydrometric data component benefit assessment proforma

Test catchment
Tay at Perth

Benefit
Improved design of flood protection works

Basis of benefit assessment
Specialist literature indicates that the value of streamflow data may be estimated as 4-5% of flood protection scheme cost.

Calculation of potential benefit
4.5% of reported scheme cost of £22 million = £1 million

Scaling for data accuracy
Highest gauging at Ballathie gauging station is marginally in excess of mean annual flood: Appendix suggests scaling of 80%.

Scaling for data applicability
One major tributary (Almond) enters Tay downstream of Ballathie GS and upstream of Perth. Ratio of catchment areas gives scaling of 95%.

Scaling for period of benefit
As with the A34 infrastructure investment, it is proposed to distribute this benefit over 5 years, i.e. scale by 20%.

Component benefit assessment
Product of the above = £152,000. This is based on data from one gauging station only. An increase in benefit could be achieved with sole reference to a site more immediately upstream of the point of investment/benefit (Perth).

APPENDIX - SCALING VALUES

In order to ensure that the baseline benefits are applied to individual case studies in a meaningful and defensible manner it is necessary to scale them down to reflect imperfections arising from the spatial coverage of the network, data quality and length of record. This will, in turn, reward 'good quality' networks by ensuring that their net benefits are closer to the baseline values than those derived from networks where the data is less suitable. One particular area of concern is that of data quality/accuracy throughout the entire flow range.

The project team are aware that the Environment Agency has developed its own methodology of classification based on the Q_{95}, Average Daily Flow and Mean Annual Flood as indicators of low, medium and high flows. This methodology is not used by any of the SNIFFER organisations. Whilst it was tempting to develop the scaling factors from the Agency classification system, we are also aware that this system is regarded as having serious deficiencies by many Agency personnel, particularly those who have to try and meet the targets it sets. We have thus proposed an alternative method for scaling for data accuracy which, we feel is more sensitive This has not been finalised in any way, but we hope that it will form the focus for debate with the Project Board as to whether or not the approach should be refined further, or the Agency system adopted.

Scaling for data accuracy - low flows

Q_{95} is assumed to be the parameter of interest in the great majority of low flow analyses. Scalings have been proposed on the basis of annual frequency of gauging at below the Q_{90} flow, and assume that where higher frequencies are involved, some gaugings will be near or below the Q_{95} flow. Scaling factors are given below for gauging stations of both velocity-area and structural control types.

Number of gaugings per year at flows of Q_{90} or less	Velocity-area station	Structural control
<0.5	0%	10%
0.5-0.9	50%	60%
1.0-1.9	75%	90%
2.0-3.9	90%	100%
>=4.0	100%	100%

Scaling for data accuracy - flood flows

Here the ratio of the highest ever gauging at the site to the highest ever recorded flow at the site is taken as a measure of accuracy. Ratios are likely to vary considerably on a regional basis, but this is considered to reflect the difficulty of flood flow measurement, in a way similar to the variation of the ratio. Proposed scaling factors are as follows:

Highest gauging equal to or greater than	Flood accuracy scaling
90% of maximum recorded flow	100%
Average of mean annual flood and max recorded	90%
Mean annual flood	80%
0.75 * mean annual flood	65%
0.5 * mean annual flood	50%
Mean flow	20%
None of the above	0%

It is assumed that hydrologists applying this method will take into account material factors which would affect results, such as a change in the flood control of a site mid-way through a period of record. In such a situation, it may be assumed that only gaugings after the change would contribute to the accuracy of the station.

Scaling for data accuracy - mid-range flows

The approach proposed for assessing mid-range accuracy is comparable to that above for low flow accuracy, i.e. a basis of gauging frequency with differentiation according to control type. However, to ensure that gaugings are taken in both the higher and the lower parts of the mid-flow range, the proposed procedure involves summing scaling factors for the upper and lower parts of the mid-flow range.

Number of gaugings per year at flows between Q_{10} and Q_{50}	Velocity-area station	Structural control
<0.5	0%	5%
0.5-0.9	25%	30%
1.0-1.9	37.5%	45%
2.0-3.9	45%	50%
>=4.0	50%	50%

Number of gaugings per year at flows between Q_{50} and Q_{90}	Velocity-area station	Structural control
<0.5	0%	5%
0.5-0.9	25%	30%
1.0-1.9	37.5%	45%
2.0-3.9	45%	50%
>=4.0	50%	50%

SCALING FACTOR OBTAINED BY ADDING TOGETHER ONE VALUE FROM EACH TABLE.

Scaling for data applicability

It is proposed that this scaling is undertaken on the basis of the ratio of catchment areas between a point of data application/benefit and a gauging station used to deliver benefit for that point. In the case where a gauging station is upstream of a point of data application ("target point") the ratio *gauged catchment area: target point catchment area* could be used. As the gauging station measures flow for successively smaller areas, so the scaling drops.

Conversely, where the gauge to be used is downstream of the target point, the scaling should be close to unity where drained areas are the same, and it should reduce as the target point catchment becomes a successively smaller fraction of the gauged area, i.e. use the ratio *target point catchment area : gauged catchment area*. It is hoped that the physical basis of the scaling may commend this approach. However, this is only a working proposal, and the project team would welcome comments regarding its suitability or any modifications or alternatives.

In the case of the A34 project, distributed over a length of some kilometres, it has seemed prudent to scale the benefit according to the fraction of the project lying in the Bollin catchment - see notes for that project. Some choice of approaches must be made available to cope with situations such as this, along with guidance as to when each approach is most appropriate.

Evaluating the Benefits of Hydrometric Networks

University of Dundee
Scotia Water Services
University of Stirling

April 1998

R&D Progress Report W6/005/12

ENVIRONMENT AGENCY

RESEARCH AND DEVELOPMENT
PROGRESS REPORT

Evaluating the Benefits of Hydrometric Networks

Research Contractor:
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in collaboration with University of Stirling *and* Scotia Water Services

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Dissemination status
Internal: Restricted
External: Restricted

Statement of use
This report is the twelfth monthly Progress Report from Project W6/005. It provides a link between discussions at the December 1997 Board meeting and the recently-issued Draft Technical Report. It is to be used for information as to the progress to date and proposed work programme. Recipients of the report are to pass on comments to the Environment Agency Project Leader.

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R&D Progress Report W6/005/12

1. INTRODUCTION

Following the December Project Board meeting in Reading, the research team was tasked with addressing a number of outstanding issues before issuing a Draft Technical Report. This final Progress Report details the ways in which these matters have been addressed, and aims to provide members of the Project Board with a logical link between Progress Report W6/005/11 and the Draft Technical Report which has recently been issued.

This report addresses three areas of development since the December meeting:

- Additional benefit type - costs avoided in pumping operations
- Foyle testing
- Scaling - development of proposed methodology

It is anticipated that any further developments of the methodology/research output will form the basis of dialogue between the research team and the Project Board, and will be reflected in revisions to the final Technical Report.

2. ADDITIONAL BENEFIT TYPE - COSTS AVOIDED IN PUMPING OPERATIONS

At the December 1997 Project Board meeting in Reading, Angela Wallis commented that it would be useful if the methodology being developed could include some means of assessing the benefits of using hydrometric data in avoiding excess costs in pumping operations. Subsequently, Angela has obtained summary data relating to pumping costs in two catchments within Anglian Region. These vary from £12 per megalitre (Ely to Stour) to £20 per megalitre (Ely to Blackwater). Costs differ due to the amount and length of pumping, and the different heads that are involved.

Data use is intensive, with flow data being used above the point of abstraction, in the channel/pipe carrying the pumped water and in the receiving watercourse. However, it quickly became apparent that whilst the potential benefits may be significant, there is a considerable amount of data that is needed before this can be assessed in a quantitative way. For example, it is considered that any case study will require the following information to be collected:

- The costs of the pumping the water, both at individual stages and throughout the whole scheme.
- How these costs might alter if no hydrometric data were available.
- What costs the availability of data allow the Environment Agency and Water Company to avoid, and the sensitivity of these costs to data availability. For example, will reduced availability of data necessarily result in an increase in costs, or is there a critical point?
- What the potential outcomes are of not having or using hydrometric data, and the costs associated with this - e.g., additional process costs, costs to the consumer, pollution/low flow impact costs etc. How are these costs separated from benefits that are already to be quantified as part of the methodology, e.g. pollution abatement costs?

Following discussions with Angela it is considered that the development of a methodology for this particular benefit type is beyond the scope of this project, particularly given the limited application of this potential benefit (primarily to three Agency Regions on differing scales). As no published material has been discovered relating to this, it would be necessary to use one Region's situation to develop a methodology and then confirm this with a case study in a second Region.

Consequently we intend to include reference to this in the Technical Report, and outline what data might be needed and how these may then be used to derive a benefit, based on some of the other benefit types. It will then be necessary for the practitioner to collate the available data and then work with this in a structured manner. The depth of analysis will depend on the reason why the review is being carried out - it may be that the issue is as simple as the removal/addition of a single gauge, in which case efforts can be focused on this rather than the whole system.

A similar approach will also be required to assess the benefits arising from the use of hydrometric data in the management of navigable waterways, and possibly for fisheries management. However, it should also be remembered that this final benefit type was not identified as a significant user of the data by the environment agencies during the earlier stages of the project.

3. FURTHER CASE STUDIES RELATING TO THE FOYLE CATCHMENT

At the December Project Board meeting it was agreed that, if possible, case studies should be completed for the Foyle catchment. The data received from the authorities responsible for the management of the catchment were as follows:

1. A summary list of all reservoir storage within the catchment extending back to schemes constructed in 1839 (none are present within the Foyle catchment).
2. Confirmation of no hydro-electric schemes, either existing or planned.
3. Confirmation that no formal flood warning system exists within the catchment.
4. Details of bridge/culvert design works undertaken during the last two years.
5. Confirmation that only four STWs discharge directly to the Foyle, but no details of discharge volumes, population served etc.
6. A listing of industrial discharge consents in the catchment, together with physical parameter constraints and details where applicable.

Of these different data use types, there is only sufficient detail to enable an initial assessment to be undertaken for category 4 as listed above. Accepting this, it must also be considered that, despite repeated requests, we have not received any supporting information on the quality and applicability of the hydrometric data that are collected within the catchment other than the period of record (all five stations were commissioned in the 1970s).

Hydrometric data component benefit assessment proforma

Test catchment
Foyle

Benefit
Improved design of bridges and culverts

Basis of benefit assessment

Hydrometric data provide for the avoidance of over-design and under-design costs by reducing uncertainty, as reported in the literature.

Calculation of potential benefit
Construction costs of projects undertaken over two years between 1995-1997 are as follows:

Catchment	Title/Bridge	Client/Consultant	Est. Cost
Roe	Limavady By-pass Curly Bridge	DOE Roads	£500k
Roe Faughan	Repairs to Roe Bridge Repairs to Faughan Bridge	Translink/ Ferguson McIlveen Ferguson McIlveen	£250k
Fairywater	Bridge re-decking	DOE Roads	£55k
Camowen	Footbridge	Community Assoc.	£40k
Foyle	Community platform millennium project	3rd millennium bridge company	£100k
Roe	Disabled anglers' footbridge	Community Assoc.	£50k
Fairywater	Moorfield Bridge	DOE Roads	£50k
Burndennet	Burndennet Bridge	DOE Roads	£300k
TOTAL			£1,345k

It can thus be seen that the total construction costs are estimated to be £1.345 million. The literature indicates that 10% of these costs are likely to be sensitive to hydrometric data, and that in turn 10% of this equates to the typical benefit. Consequently, potential benefit is calculated to be £13.45k.

Scaling for data accuracy
No scaling factors can be derived at this time

Scaling for data representativeness
Unlike the Bollin case studies, the above costs relate exclusively to the structures themselves rather than a larger scheme which includes a river crossing. As all of the structures are within a gauged catchment there is no need to scale the benefit assessment in this case.

Scaling for period of record
Again, no data are available, but individual factors could be obtained

Scaling for the period of benefit
As the data apply to a two year period, a scaling of 0.5 is applied.

Component benefit assessment
Assessed as £13.45k * $?_1$ * 100% * $?_2$ * 50% = £? pa.
Note that this compares to an estimated total operating cost of £1,900 per annum for the network of five stations covering the above catchments - it seems likely that benefits may exceed costs.

For the reasons identified above, no further quantitative benefit assessment has proved possible. However, it should be noted that the magnitude of benefit quantified is very small when compared to some of the component benefit values identified for the Bollin catchment. Moreover, it is expected that, in a rural area supporting only a low population density, and no large-scale infrastructure warranting the extensive use of hydrometric data, the approximate indication of benefit given here may allow some sort of first-order approximation of total quantifiable benefit.

4. SCALING OF BENEFIT VALUES

At the December Project Board meeting, the principal issue to arise in relation to scaling concerned the handling of inherently annual benefit values and those relating to investment decisions. It was a recognised target of the methods that annual benefit values should be produced, but difficulties existed over the best means of translating (often large) benefit values associated with (occasional) investment decisions into an annual form. Two principal routes were identified through extended discussions after the meeting:

1. obtain annualised values for each investment decision benefit, using an annual equivalent factor formula; or
2. use a simple averaging approach for a short length of years, assessing all benefits occurring in that period.

The first approach is theoretically attractive in that the time value of money is accounted for explicitly. It would be implemented on the basis that annual benefit values would be obtained for every year from the implementation of a capital scheme until the end of the design life. However, this creates the problem that, for the overall assessment of benefit to be representative, data need to be gathered for all capital projects in the catchment area which are still within their design lives. Obtaining information for such projects would clearly pose substantial problems, and pose the risk of generating unrepresentative outputs.

The second approach is proposed for adoption using a 5-year window up to the time of benefit assessment (i.e. the current year). This makes no direct allowance for the time value of money, but does attempt to give a representative indication of typical annual benefit through the use of 5-year annual averaging. However, use of this method does pose the risk of generating overestimates, where a large benefit of locally unusual magnitude occurs during the 5-year period.

In the draft Progress Report, the second method is recommended for general application, because the risk of consistently underestimating benefit from investment decisions is judged to be less helpful that running the risk of substantial overestimates on some occasions. Furthermore, the use of annual equivalent factors is recommended for situations where a single benefit dominates the overall assessment of benefit for a catchment.

This issue is dealt with at length in Section 7.4 of the Draft Technical Report.

One further point to note, on the subject of scaling, is that other scaling factors have been the subject of further development since the December meeting. In particular, accuracy scaling methods have been developed further, linking to the 1995 NRA Gauging Station Classification system. Also, scalings of >100% have been introduced where considered appropriate. Chapter 7 of the Draft Technical Report details the up-to-date evolution of methods for all aspects of scaling.

5. STAFFING

Members of the Project Board may wish to note that, since the last Progress Report, Nick Hanley has been appointed Professor of Natural Resource Economics in the Institute of Ecology and Resource Management, University of Edinburgh. He continues to be fully involved with the research, and Ceara Nevin (who acted as a research assistant to this project in its earlier stages and is now studying under his supervision in Edinburgh) also remains interested in the core issues of the research.

6. FINANCE

Invoices for all outstanding sums were submitted to the Environment Agency in March, prior to the end of the 1997/98 financial year. While the work of the project as a whole remains to be completed, now awaiting feedback to the Draft Technical Report, this will allow payments to be made as soon as the remaining project milestones are passed.

The survey should also consider that the existing hydrometric network may not be sufficiently extensive. Changing customer demands for data, changes in the Agency's work and climatic change all dictate that data collection must reflect changing demands.

Questionnaire responses

FRESHWATER CHEMISTRY

INFORMATION REQUEST: Freshwater chemistry

What hydrometric data are needed in your function (type of data, approx number of stations)? Flow figures. (PARCOM) monthly.
Mean daily flow figures for specific dates at 10 most downstream sites, and one upland site. (ECN)

How are they used?
They are used to calculate the loadings of a range of parameters to Convention waters.

Are any stations used more than others; if so, which and why?
No. All stations are monitored monthly.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?
If the lowest means most downstream then the 10 stations are satisfied. The one upland station should not be changed.

Would you use hydrometric data from more stations if the network were extended?

Not at present.

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

To look at trend analysis.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

± 30%
Estimates would be acceptable in some places.

Name: Carol Maguire   Telephone: 254824

Position: H.S.O.   Region/Area: N. Ireland

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Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Freshwater chemistry

What hydrometric data are needed in your function (type of data, approx number of stations)?

RIVER FLOWS MAINLY PARTICULARLY 95% LOW FLOWS + MEAN FLOWS – APPROX. ONE STATION PER RIVER.

How are they used?

TO CHECK ON COMPENSATION FL[illegible]W RELEASES FROM WATER SUPPLY / CANAL FEEDER RESERVOIRS; TO ~~CALCULATE~~ CONSENT TO DISCHARGE CONDITIONS TO BUILD COMPUTER MODELS SIMULATING QUALITY + QUANTITY IN A CATCHMENT

Are any stations used ~~more~~ more than others; if so, which and why?

NO

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs? IT WOULD REDUCE THE RELEVANCE OF THE FLOW INFORMATION FOR THE HIGHER PARTS OF THE CATCHMENT RESULTING IN MORE SPOT GUAGING REQUESTS.

Would you use hydrometric data ~~from more stations if the network~~ were extended?

BALANCE BETWEEN PROVIDING PERMANENT RIVER GUAGING STATIONS + USING SPOT GAUGING HAS TO BE MADE → Yes, but spots [illegible]

Do you use hydrometric data for simulation purposes, either in real time or with historic data? ↳ SEE ANSWER TO QUESTION 2 – SIMCAT MODEL BUILT – USED HISTORIC DATA.

"TIME OF TRAVEL" GRAPHS USED BASED ON HISTORIC DATA TO PREDICT POLLUTION SLUGS FLOW PAST POTABLE ABSTRACTION POINTS ON RIVERS – [illegible] TUNED DURING A POLLUTION EVENT WITH REAL TIME DATA

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

CATCHMENT RUNOFF ESTIMATES SUFFICE IN SOME PLACES

– MAJOR DISCHARGE CONSENT SETTING REQUIRES MORE ACCURATE DATA – AS ACCURATE AS CAN PRACTICABLY BE PROVIDED!

Name: S.M. BOWEN Telephone: 01543 444141 EXT 4800

Position: SENIOR POLLUTION CONTROL OFFICER Region/Area: MIDLAND / UPPER TRENT

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(17)

INFORMATION REQUEST: Freshwater chemistry

What hydrometric data are needed in your function (type of data, approx number of stations)?

Flow (20 stations)

Rainfall (regional network to estimate average)

How are they used?

Calculation of loads of chemical parameters discharged to North Sea

Likely effect of low flows on water quality

Harmonised Monitoring scheme. Data returns to D.E.

Are any stations used more than others; if so, which and why?

Teddington Weir is used because at the bottom end of the Thames catchment and above the estuary. Used for load calculations and effect of low flows on water quality in the estuary.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

This network would serve virtually all our needs for load calculations some (about 10) may still be required for harmonised monitoring

Would you use hydrometric data from more stations if the network were extended?

Rarely. Probably no.

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

No

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

As accurate as possible to show trends in loads discharged to the North Sea. Estimates sometimes have to be used where there is no gauging station at the very bottom end of a river discharging to the estuary. This is a problem.

Name: Tony Place Telephone: 01734 535423

Position: Senior Scientist Region/Area: PPC Department, Thames region

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INFORMATION REQUEST: Freshwater chemistry

(18)

What hydrometric data are needed in your function (type of data, approx number of stations)?

GENERAL FLOW INFO. LEVELS AND DILUTIONS.
CAN INCLUDE ALL CURRENT STATIONS

How are they used?

REAL TIME HYDROGRAPHS FOR GENERAL INFORMATION AT TIME OF SAMPLING. DAILY FLOWS + LEVELS FOR HARMONISED MONITORING AND CLOSED ENVIRONMENTAL MONITORING STATIONS

Are any stations used more than others; if so, which and why?

TWEED AT BOLESIDE — WHITEADDER AT HUTTON GAUGE
TWEED AT NORHAM — EYE AT EYEMOUTH GAUGE
Gi bottom catchments

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

OKAY FOR GENERAL NEEDS BUT WOULD NOT GIVE THE DETAIL WE REQUIRE AT PRESENT.

Would you use hydrometric data from more stations if the network were extended?

MORE THAN LIKELY

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

NO

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

ESTIMATES WOULD SUFFICE FOR A GREAT DEAL.

Name: A. RINGROSE   Telephone: 01896 75 2425

Position: PRINCIPAL CHEMIST   Region/Area: EAST

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Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Freshwater chemistry
+ Freshwater Biology.

What hydrometric data are needed in your function (type of data, approx number of stations)? Area wide info on river flows, water levels rainfall

How are they used? Information for public, river fishery surveys, planning fieldwork.

Are any stations used more than others; if so, which and why?

No.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

Poorly.

Would you use hydrometric data from more stations if the network were extended?

Yes.

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

No.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?
For fisheries surveys, +/- 2-5% is preferable
For other uses, estimates are acceptable.

Name: Simon Hughes Telephone: 01734 533358.

Position: Area Fisheries Officer Region/Area: Thames (West).

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INFORMATION REQUEST: Freshwater chemistry

What hydrometric data are needed in your function (type of data, approx number of stations)? Annual mean flow, Daily mean flow, Summer and winter mean flows, 5 %ile low flows.

How are they used? Reporting for: Harmonised monitoring, Red List/Parcom, where loadings are required. SIMCAT MODELLING of catchments to assess discharge quality standards, SWQO's, RQOs. Judging compliance with Drought Order.

Are any stations used more than others; if so, which and why?

All stations are used for the above purposes, although only specific ones are used for Harmonised monitoring. ie those at bottom | catchments

---

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs? All stations are used for catchment modelling purposes so the lowest station in each major catchment would not suffice. Stations in catchments are limited already and estimates which are not very accurate have to be used.

Would you use hydrometric data from more stations if the network were extended?

Yes, to improve on existing lack of accuracy.

Do you use hydrometric data for simulation purposes, either in real time or with historic data? Yes, for catchment modelling. Both real time and historic.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

We already have to use estimates which could be 20-50% out because of the lack of stations. Gauged flows of 5-10% error are used for reporting of Harmonised Monitoring and Red List/PARcom. Ideally more accuracy and more fixed gauging stations are needed. Our Microflow Study is not applicable to chalk streams (e.g. Test, Itchen, Meon, etc), so more stations would be welcome.

Name: [signature] Telephone: 01903 820692 Ext 2167

Position: Senior Pollution Control Officer Region/~~Area~~: SOUTHERN

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Questionnaire responses

FRESHWATER BIOLOGY

(19)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

MEAN ANNUAL FLOWS FOR EACH RIVER REACH WITHIN THE RIVER QUALITY SAMPLING NETWORK.

How are they used?

TO PREDICT BIOLOGICAL RIVER QUALITY USING RIVPACS III

Are any stations used more than others; if so, which and why?

UNKNOWN.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

NO. Didn't answer question [illegible]

Would you use hydrometric data from more stations if the network were extended?

YES

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

YES

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

ESTIMATES WOULD GENERALLY SUFFICE

Name: DR G.P. GREEN Telephone: 01258 456080 EXT 3335

Position: REGIONAL BIOLOGY CONTACT Region/Area: SOUTH WEST REGION

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Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

YOU MAY RECEIVE ADDITIONAL COMMENTS FROM MY COLLEAGUES (SEN BIOLOGISTS) IN NORTH WESSEX, DEVON AND CORNWALL

(2)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

Type - River Flows & water levels most relevant to biology.
No. stations - as many as practicable, especially for upper reaches of watercourses susceptible to low flows and smaller tributaries (representative selection.)

How are they used?

At present used mostly for background information. Use should be extended eg to trigger surveys of low flow effects/recovery, but inadequate biology staffing to do so at present. Stations which demonstrate critically low flow or drying would provide particularly relevant info re. potential ecological damage, but will depend sensitivity of river reaches concern.

Are any stations used more than others; if so, which and why?

Yes - Low Flow (ALF) rivers stations - due to greater emphasis of importance of river flows in these rivers and our ability to justify monitoring the effects of flow upon biota.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

No. It would run counter to what we need

Would you use hydrometric data from more stations if the network were extended?

Yes, hopefully.

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

Not at present - but future may hold this possibility if good historic data on flows and biology are available to construct useful models.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

Not known. However, observed data is necessary eg. to monitor low flows/drying. Tendency for models to be well off the mark?
Extreme events are of interest to biology eg peak flows and minimum flows (including length of drying for example), since each can produce significant ecological effects, which may be undesirable if unnatural.

Name: Dave Leeming Telephone: 01992 645093

Position: Biologist Region/Area: Thames - Waltham Cross Laboratory. (covers NE area & part of SE area of region).

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Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Re. use of hydrometric data

The flows in the R. Thames over Teddington Weir are used to 'trigger' biological surveys in the tidal section downstream. The frequency of sampling increases when the target flow ~~on the~~ over the weir falls below a critical level. This arrangement has existed for a number of years (for further info contact Clare Dale at this office) in order to ensure that abstraction from the freshwater Thames above Teddington is not causing ecological damage to the tidal section downstream.

6

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

Very little really only help to decide height of rivers for sampling

How are they used?

Are any stations used more than others; if so, which and why?

NO

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

IT WOULD NOT SERVE THEM.

Would you use hydrometric data from more stations if the network were extended?

Yes

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

No

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

Fairly accurate esp. larger rivers

Name: A George Telephone: 01743 272828 3439

Position: Area Biologist Region/Area: MIDLAND w/s

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You could have included SAC.

(4)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)? We use a measure of "discharge category" in our predictive model RIVPACS – this discharge category on a scale of 1 to 10 is generally taken from a historic data set or issued from water quality planning. It is not updated

How are they used? on a daily basis.

Are any stations used more than others; if so, which and why? No

---

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs? Probably wouldn't affect biology

Would you use hydrometric data from more stations if the network were extended?

probably not – although our "discharge category" data may be more accurate if more stations used

---

Do you use hydrometric data for simulation purposes, either in real time or with historic data? historic data

---

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

Estimates OK

Name: S. Ralph

Telephone: 01222 770088 ext 2175

Position: Appraisal Officer – Biology Region/Area: Welsh SE [redacted] AREA

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(3)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)? WE HAVE VERY LITTLE NEED FOR HYDROLOGY DATA ROUTINELY.

– OCCASIONALLY WE NEED FLOW THROUGH A LOCH eg FOR MODELLING INCREASES IN PHOSPHORUS CONCENTRATION DUE TO FISH FARMS

How are they used?

– THE MAIN USE OF FLOW DATA WOULD BE TO WORK OUT DILUTION AVAILABLE FOR EFFLUENTS & LIKELY CONCENTRATIONS IN RIVERS

Are any stations used more than others; if so, which and why?

DONT OFTEN USE DATA FROM A PARTICULAR STATION

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?
THIS WOULD BE ADEQUATE FOR BIOLOGY

Would you use hydrometric data from more stations if the network were extended?

NO

Do you use hydrometric data for simulation purposes, either in real time or with historic data? NO

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data? ESTIMATES WOULD BE ADEQUATE FOR MOST PURPOSES

Name: J Hunter Telephone: 01349 862021

Position: Biologist Region/Area: SEPA NORTH DINGWALL

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Any further comments? - please use reverse of form and tick here .... ☐

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(2)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?
(1) Instantaneous flows for major rivers ~~etc~~ (c 10 sites)
(2) Mean annual flows – as required.

How are they used?
(1) To decide if its safe to visit rivers.
(2) For water quality modelling of specific areas eg loch eutrophication projects.

Are any stations used more than others; if so, which and why?

No

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

OK for (1) above but not for (2)

Would you use hydrometric data from more stations if the network were extended?

Yes

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

Yes – (2) above

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

(1) requires observed data.
(2) – varies according to project.

Name: Brian Clelland Telephone: 01738 - 627989

Position: Principal Biologist · Region/Area: East (Perth)

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Any further comments? - please use reverse of form and tick here ☐

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(P)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)? 1/ Discharge category for RIVPACs

2/ flow info on day of sampling

3/ Special projects i/ne. water transfer ii/ catchment stud

How are they used? 1/ RIVPACs

2/ Saftey - to avoid travelling to a distant river which is in flood

Are any stations used more than others; if so, which and why? 3/ i/ Yes, those on the R. Wear for the Ecologically Acceptable Flow

ii yes, for information on the R. Nent for assessment of metals load

---

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

Badly. For detail in special projects we need a good network

Would you use hydrometric data from more stations if the network were extended?

Yes we would refine the RIVPACs input and use it for our special projects

---

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

Yes (projects I am involved with or interested in do)

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

Variable. discharge cat. fine for rivpacs but greater precision required for (for instance) calculating loads. IFE would be the best people to give %age accuracy required for rivpac

Name: Anne Lewis Telephone: 0191 2034120

Position: Senior Ecologist Region/Area: North East \ Northumbria

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

MEAN DAILY FLOWS / MONTHLY RAINFALL

How are they used?

CALCULATIONS OF SOLUTE LOADINGS + FLOW MODELLING

Are any stations used more than others; if so, which and why? YES – SOME ARE THOUGHT TO BE MORE ACCURATE THAN OTHERS.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs? THIS WOULD BE UNACCEPTABLE – ACCURATE EXTRAPOLATION FROM SINGLE STATIONS IS THOUGHT TO BE OF LIMITED VALUE + SUBJECT TO CONSIDERABLE ERROR

Would you use hydrometric data from more stations if the network were extended?

YES – MORE STATIONS ARE NEEDED FOR EG ON THE NENE BETWEEN NORTHAMPTON + WANSFORD

Do you use hydrometric data for simulation purposes, either in real time or with historic data? YES – SOME SIMULATION IS CARRIED OUT BOTH IN REAL TIME + ON HISTORICAL DATA

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

ACCURACY IS VITAL WHEN CALCULATING LOADS IN LARGER RIVERS ESTIMATES SERIOUSLY COMPROMISE THE VALUE OF LOAD CALCULATIONS

Name: DR CHRIS EXTENCE Telephone: 01775 – 762123

Position: SENIOR BIOLOGIST Region/Area: ANGLIAN / NORTHERN

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(4)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

microlowflows simulation flow catagories

How are they used?

As a parameter for RIVPACS (River Invertebrate Prediction and Classification System)

Are any stations used more than others; if so, which and why?

No

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

Depends on the needs of microlowflows simulation

Would you use hydrometric data from more stations if the network were extended?

No

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

Yes, as above.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

→

Name: Trevor Renals Telephone: 01208 78301

Position: Senior Biologist Region/Area: SW / Cornwall

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Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(a)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type ~~of data,~~ ~~approx~~ number of stations)? River flows - generally for Water Quality classified stretches but also for other watercourses for investigational work.

How are they used?
Discharge category is a requirement for the use of RIVPACS (IFE prediction package for macroinvertebrates - contact me if you need more info.)

Are any stations used more than others; if so, which and why?
Dependent on number of water quality problems - no obvious pattern to this.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?
We would have to guess the rest! → Chuck [illegible]

Would you use hydrometric data from more stations if the network were extended?
Southern network seems very sparse - we had to use MicroLowFlow & guesswork for the 1995 GQA Biological Survey.

Do you use hydrometric data for simulation purposes, either in real time or with historic data? No.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?
Discharge categories - mean annual flow (cumecs)

1	< 0.31	6	5.00 - 10.00
2	0.31 - 0.62	7	10.00 - 20.00
3	0.62 - 1.25	8	20.00 - 40.00
4	1.25 - 2.50	9	40.00 - 80.00
5	2.50 - 5.00	10	> 80.00

Name: Bob Dines   Telephone: 7-23-2174

Position: Regional Biologist   Region/~~Area~~: Southern.

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(11)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)? Poor access and lack of resources restrict our useage of hydrometric data.

How are they used? At present we use very simplified discharge data for RIVPACS modelling - derived from map. It was hoped to use micro flow data but this was never made available.

Are any stations used more than others; if so, which and why?

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?
This would be as good as useless if we were to want to use the data.

Would you use hydrometric data from more stations if the network were extended?
More reliable widespread flow & level data would be useful for analysis of biological data esp. in respect of low flows.

Do you use hydrometric data for simulation purposes, either in real time or with historic data? use of discharge data for RIVPACS ANALYSIS of Biological data.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

Until more work is done to evaluate the use of hydrometric data in biological analytical modules I cannot give a figure for accuracy. I rely on expertise of our hydrometric staff to advise.

Name: Brian Hemsley Flint Telephone: 0113 2312184.

Position: Senior Ecologist Region/Area: North East Region / Ridings Area.

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(17)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)? CURRENT RIVER LEVELS, LEVELS AT THE TIME OF SAMPLING AND THE CALCULATED DILUTION OF DISCHARGES. ABOUT 20 STATIONS

How are they used? TO DETERMINE IF SURVEY WORK CAN BE SAFELY UNDERTAKEN, TO DETERMINE THE AVAILABLE DILUTION OF DISCHARGES.

Are any stations used more than others; if so, which and why?
A SMALL NUMBER WHERE THE RELATIONSHIP BETWEEN LEVEL AND SAFE ACCESS IS WELL UNDERSTOOD. THESE MAY BE COMPARED TO OTHER LESS FAMILIAR SITES TO ASSESS SAFETY IMPLICATIONS OF SAMPLIN

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs? ON LARGE RIVERS WITH MAJOR TRIBUTARIES SEVERAL STATIONS ARE NECESSARY. SOME RIVERS SAMPLED HAVE NO STATION AND THEREFORE INFORMED GUESSES REGARDI. SAFE SAMPLING ON THESE RIVERS ARE SOMETIMES NECESSARY. ONLY 4 STATIONS ARE NOT OF INTEREST.

Would you use hydrometric data from more stations if the network were extended?

YES

Do you use hydrometric data for simulation purposes, either in real time or with historic data? YES RIVPACS III, SERCON etc

---

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

FOR H&S PURPOSES A HIGH DEGREE OF PRECISION IS REQUIRED PARTICULARLY IF LEVELS ARE MARGINAL

Name: JOHN CLAYTON Telephone: 01896 752425

Position: BIOLOGIST Region/Area: SEPA EAST, GALASHIELS

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INFORMATION REQUEST: Freshwater Biology (13)

What hydrometric data are needed in your function (type of data, approx number of effective stations)? (a) Current flows from telemetry stations - for safe sampling.
(b) Average flows, for RIVPACS predictions.
(c) Flows at particular times or over particular time periods, for inclusion in reports.

How are they used?

See above

Are any stations used more than others; if so, which and why?
For (a) above, some sites are a good guide to other watercourse, so these sites are consulted often.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?
This would reduce the usefulness of the data

Would you use hydrometric data from more stations if the network were extended?
Yes

Do you use hydrometric data for simulation purposes, either in real time or with historic data?
Yes - RIVPACS [illegible]

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

Estimates can suffice for some purposes, although real observation are required for (a) above.

Name: Dr David Rendall Telephone: 01387 720 502

Position: Principal Biologist. Region/Area: SEPA West, South division.

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INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

i) Discharge Categories for 320 stations (River Flows)
2) Extent of low-flow conditions, affecting wetted area of river bed & dilution for effluents.

How are they used?
i) Used in Rivpacs Model for predicting biological expectations for a particular site
2) To explain poor biological results for particular site

Are any stations used more than others; if so, which and why?

No

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

i) The figures for our model have all been derived. ie a one-off need 2) Probably wouldn't serve this need.

Would you use hydrometric data from more stations if the network were extended?

Not necessarily

Do you use hydrometric data for simulation purposes, either in real time or with historic data? as above

Model Can be used historically but discharge categories not thought to have changed significantly

---

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

i) Estimates.

2) Probably need observed data.

Name: G. [illegible] Telephone: 01543 444141

Position: Area biologist Region/Area: Midlands. Upper Trent

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(2)

INFORMATION REQUEST: Freshwater Biology

What hydrometric data are needed in your function (type of data, approx number of stations)?

INSTANTANEOUS FLOWS, DAILY MEAN FLOWS, MEAN ANNUAL FLOWS, Q95S, BASE FLOW INDEX

THE MORE STATIONS THE BETTER.

How are they used? BASE FLOW INDEX - INPUT TO SERCON (CONSERVATION ASSESSMENT SCHEME)

INSTANEOUS - LEVELS OBTAINED BY TELEMETRY USED TO ASSESS WHETHER FLOWS ARE LOW ENOUGH TO ALLOW SAMPLING.

DAILY MEANS - MAY BE OBTAINED FOR SAMPLING DATE + DAYS PRECEDING WHEN INTERPRETING SURVEY RESULTS.

MEAN ANNUALS - INPUTS TO RIVPACS + SERCON, CALCULATION OF LOCH RETENTION TIMES FOR LOADING MODELS, CRITICAL LOADS.

Q95 - CALCULATING DILUTION RECEIVED BY DISCHARGES IN ORDER TO PRIORITISE FOR SAMPLING / COST RECOVERY.

Are any stations used more than others; if so, which and why?

ALL STATIONS ON RIVERS WHICH HAVE BIOLOGICAL MONITORING ARE USED TO SOME EXTENT, BUT OBVIOUSLY ONLY THOSE WITH TELEMETRY LINK CAN BE USED TO DETERMINE SAFE LEVELS FOR SAMPLING.

If the hydrometric network in your area were reduced to the lowest station in each major catchment, how would this network serve your needs?

WOULD STILL PROVIDE USEFUL DATA BUT WOULD CLEARLY PLACE GREATER DEMANDS ON HYDROLOGY SECTION SINCE DATA WOULD NEED TO BE EXTRAPOLATED FOR UPSTREAM SITES MORE OFTEN

Would you use hydrometric data from more stations if the network were extended?

CERTAINLY - LACK OF DATA FROM ISLANDS AND PARTS OF MAINLAND ARGYLL CAN CAUSE DIFFICULTIES.

Do you use hydrometric data for simulation purposes, either in real time or with historic data?

NO.

What % accuracy is required in the data for your purposes; would estimates suffice in some places or do some uses demand observed data?

ESTIMATES SUFFICE FOR MOST PURPOSES.

Name: ROSS DOUGHTY Telephone: 01355 238181

Position: HEAD OF BIOLOGY Region/Area: WEST

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Questionnaire responses

ESTUARY/MARINE SURVEY

FORMATION REQUEST: Marine/estuary survey

(34) (34)

What hydrometric data do you use (data type, approx number of stations)?

River gauging fixed stations - 4
Rain fall gauges - 3
Ground water data ~ 2

How are the data used?

Nutrient budgets for lakes,
Relationship between flow & pH in acid stressed rivers.
Pollutant loads entering estuaries.
Flushing rates for lakes.

Do you have any requirements regarding the accuracy of hydrometric data?

accuracy of available hydrometric data is no general the limiting factor, this tends to be the accuracy of chemical analysis or the errors introduced by discontinuous sampling.
NB we are interested in the flux of pollutants more than just river flow.

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

Would you use hydrometric data from more stations if the network were extended?

Yes. eg. 1) currently no gauging on the Manchester Ship Canal, Sankey Brook, etc. ie. minor tribs of the Mersey estuary;

2) A better understanding of ground water flow in the area of the Cheshire Mers would allow us better estimate the flushing rates of these still waters.

Name: Andrew Hartland Telephone: 01925 653999 x 2658

Position: Scientific Officer Region/Area: North West / Regional

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Any further comments? - please use reverse of form and tick here .... ☑

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b2W

11. 11.96.

1) Sorry this is late but I didn't receive it until the 11.11.96.

2) Though a marine section - we are also responsible for a no. of fresh water stations. These stations are associated with flow measurement installations run by hydrometry, we have also used non-fixed gauging equipment on the inlets to lakes to examine nutrient budgets.

3) We carry out flow measurements in estuaries using equipment owned by the marine section ie a Broad Band Acoustic Doppler Current Profiler (ADCP). I have assumed that this work is outside of the interest of this study

4) We have also been involved in the use of the ADCP in river gauging. Again I have assumed you are not interested in this work

AH.

(48)

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

On occasions I would request rainfall data at approximately 2-3 stations per year.
Quantity of rainfall and duration of rainfall event.

How are the data used?

The data are used as part of the Bathing Waters Monitoring Programme usually in investigation into failures - i.e. were there abnormal weather conditions on the day of the failure.

Do you have any requirements regarding the accuracy of hydrometric data?

yes.

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

on occasions the nearest rainfall station has been a considerable distance from the bathing water site.

Would you use hydrometric data from more stations if the network were extended?

yes.

Name: CLAIRE VINCENT Telephone: 01232 254823

Position: HSO MARINE MONITORING Region/Area: ENVIRONMENT + HERITAGE SERVICE, DOE (N.

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b2W

(35)

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

RIVER FLOWS TO THE SEA WITH SUFFICIENT FREQUENCY TO RESOLVE FLOW PEAKS + TROUGHS

How are the data used?

IN RELATION TO ESTUARINE SALINITY AND ESTUARINE CURRENTS

Do you have any requirements regarding the accuracy of hydrometric data?

NONE BEYOND EXISTING

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

NONE BEYOND EXISTING

Would you use hydrometric data from more stations if the network were extended?

Name: A. EDWARDS Telephone: 0131 449 7296

Position: TIDAL WATERS Region/Area: SEPA EAST

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b2W

(36)

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

SELDOM USE HYDROMETRIC DATA.

HYDROMETRIC DATA COULD BE USEFUL AS INPUT TO MATHEMATICAL MODELS OF FIRTHS OR ESTUARIES. MOST OF THIS WORK IS DONE BY CONSULTANTS RATHER THAN SEPA

How are the data used?

Do you have any requirements regarding the accuracy of hydrometric data? No

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)? No

THERE WILL BE INCREASING NEED FOR CURRENT MEASUREMENT IN SEA LOCHS AROUND MARINE FISH FARMS.

Would you use hydrometric data from more stations if the network were extended?

FRESHWATER FLOW COULD BE USED IN MODELLING RETENTION TIME OF SEALOCHS FOR ASSESMENT OF IMPACT OF FISH FARMS. IN MOST CASES THERE WOULD BE NO DATA ON INFLOWING RIVERS - WOULD HAVE TO WORK FROM CATCHMENT AREA & RAINFALL.

Name: J Hunter Telephone: 01349 862021 SEPA

Position: Biologist & Marine Survey Officer Region/Area: NORTH - DINGWALL

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

(138) C37

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

River flows as daily or seasonal means. Percentile values also used.

How are the data used?

Data used in estuary and coastal flow modelling firstly to calibrate models; secondly to set up predictive simulations for particular flow events. Data also used to determine river loadings to water quality models.

Do you have any requirements regarding the accuracy of hydrometric data?

The hydrometric data is generally more accurate than other environment data used for modelling studies.

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

More problems have been encountered with flow measurement at sewage works and industrial plant than for rivers. Does this count as hydrometric?

Would you use hydrometric data from more stations if the network were extended?

Not likely. Generally the most downstream station is suitable for modelling purposes and coverage in areas of interest is good (in my personal experience).

Name: N. Sickie   Telephone: 01355

Position: Hydrographer/Modeller.   Region/Area: South West, East Kilbride

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52W

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

(a) Current information.
(b) Freshwater inputs to estuaries

How are the data used?

In reports

Do you have any requirements regarding the accuracy of hydrometric data?

No special requirements

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

No

Would you use hydrometric data from more stations if the network were extended?

Not for these purposes

Name: Dr David Rendall Telephone: 01387 720502

Position: Principal Biologist Region/Area: SEPA West, South division

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Any further comments? - please use reverse of form and tick here .... [ ]

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b2W

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

We have no marine/estuary gauging stations in the Region. Directional flow and speed data are collected but as part of specific projects for discharge consent applications made to the Region. Rain gauge data is collected.

How are the data used?

Not used by Pollution Control.

Do you have any requirements regarding the accuracy of hydrometric data?

Not applicable.

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

Not applicable.

Would you use hydrometric data from more stations if the network were extended?

Possibly but unlikely.

Name: M. Berone, Telephone: 01903 820692 Ext 2167.

Position: Senior Pollution Control Officer Region/~~Area:~~ SOUTHERN

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b2W

(6)

SW Region - Not Devon Area

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

Rainfall (50 stations in SW Region) - Daily totals - instantaneous if available

River Flow (All rivers are relevant, but only required on as-needed basis, eg 8-10 per year).

Daily Flows, Q_{95}, Q_{50}, Q_5 etc

How are the data used?

Rainfall is used in determining causes of non-compliance with bathing waters directive. (ECBWD)

Rainfall used to assist with sewer model audit.

Rainfall useful for specific marine surveys.

River Flow - required in determining causes of non-compliance with ECBWD.

River Flow - required for design purposes - effluent dilutions etc.

River Flow - useful for marine survey evaluation

Do you have any requirements regarding the accuracy of hydrometric data?

In general, our accuracy requirements are less than the accuracies quoted by the data providers, particularly river flow

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

Coverage.

Would you use hydrometric data from more stations if the network were extended?

Yes

Name: Norman Babbedge Telephone: 01392-444000 x 2636

Position: Senior Scientist (Scheme Development) Region/~~Area~~: SW Region

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

(4L)

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

RIVER FLOWS
RAINFALL

How are the data used?

CALCULATION OF LOADINGS ENTERING ESTUARIES
RAINFALL DATA LINKED TO BATHING WATER DIRECTIVE SAMPLING. (IE. IF A FAILURE, RAINFALL DATA USED TO CONSIDER SEVERITY OF STORM EVENT), RAINFALL DATA ALSO USED TO ASSESS SPILL FREQUENCY DATA FROM SEWER OVERFLOWS.

Do you have any requirements regarding the accuracy of hydrometric data?

FOR REPORTING POSSIBLE DIRECTIVE FAILURES CONNECTED TO RAINFALL EVENTS, DATA MUST BE AS ACCURATE AS POSSIBLE TO ALLOW CROSS COMPARISON TO OTHER NETWORKS (± 10% ?)

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

—

Would you use hydrometric data from more stations if the network were extended?

—

Name: M TUCKER   Telephone: [illegible]

Position: [illegible] OFFICER   Region/Area: SOUTH WEST / SOUTH WESSEX

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b2W

(42)

INFORMATION REQUEST: Marine/estuary survey

What hydrometric data do you use (data type, approx number of stations)?

Flows from freshwater tributary to tidal system (one station pre-estuary, at lowest point)

How are the data used?

For calculating loads and freshwater inputs

Do you have any requirements regarding the accuracy of hydrometric data?

Only in so much as more accurate flow data leads to more accurate load estimates.

Do you ever have hydrometric data needs which cannot be met by the hydrometric network (if so, please elaborate)?

Yes - gauging stations on most rivers are too far inland to facilitate above uses with confidence/accuracy.

Would you use hydrometric data from more stations if the network were extended?

Essentially no; use would be shifted to more appropriate stations, but I can envisage situations with multiple flows to tidal sections where extra stations would be of benefit.

Name: B. BARNETT Telephone: 01522 513100

Position: Marine Scientist Region/Area: Anglian/Northern

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Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

Sorry for missing your deadline - things are a bit hectic here at present!

Questionnaire responses

WATER RESOURCE MANAGEMENT

(29)

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year RIVER FLOWS & LEVELS.
TYPICAL YEAR - 95% of stations used.

How are the hydrometric data used within your function?
PROVISION OF INFORMATION - SERVICE TO POLLUTION PREVENTION FUNCTIO OTHER SCIENCE FUNCTIONS

MONITORING OF COMPENSATION AGREEMENTS.
ABSTRACTION CONTROL - POLICING OF CONTROL AREAS.

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	32	%
Catchment outfall stations	30	%
Mid-catchment/major tributary stations	38	%

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☑

(tick one)

Do you require specific levels of accuracy in flow measurement?
THESE DEPEND ON STATION USE - MOST STATIONS ARE MULTI FUNCTIONA

Low flows	+/- 5%.	*Express values as +/- x% of flow*
Medium flows	+/- 10%	*or other unit (specify)*
High flows/floods	+/- 10%.	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so please indicate:
NO ECONOMIC INFORMATION AVAILABLE.

Name: MARK HALLARD. Telephone: 0131- 449 - 7296.

Position: SENIOR HYDROLOGIST Region/Area: SEPA EAST REGION (EDINBURGH

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Any further comments? - please use reverse of form and tick here .... ☑

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SEE ATTACHED REVIEW OF GAUGING STATION USE - CARRIED OUT RECENTLY FOR THE WHOLE OF SEPA EAST REGION.

36

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year RAINFALL / EVAPORATION DATA
CURRENTLY NETWORK USED LESS THAN 40%

How are the hydrometric data used within your function?
WEATHER DETAILS FOR MONTHLY REPORTS, FLOODING INCIDENTS, ETC
RAINFALL EVAPORATION LOW FLOW DATA FOR YIELD ESTIMATION FOR STRATEGY PROGRAMME (ONE-OFF EXERCISE 1992.)
RAINFALL DATA FOR LARGE SOURCES eg MOURNES.

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	80 %
Catchment outfall stations	10 %
Mid-catchment/major tributary stations	10 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- ☐ Historic data adequate alone once record length exceeds threshold
- ☑ Ongoing data collection is required only at 40 % of current network stations
- ☐ Ongoing data collection is required at all stations in hydrometric network

(tick one)

Do you require specific levels of accuracy in flow measurement? ___

Low flows	___	*Express values as +/- x% of flow*
Medium flows	___	*or other unit (specify)*
High flows/floods	___	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:
NO

Name: TOM HARLAN Telephone: (01232) 354765

Position: SPTO Region/Area: N. IRELAND

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

FOR THE PURPOSES OF REVIEWING THE WATER RESOURCE STRATEGY ON A REGULAR BASIS IT WILL BE NECESSARY FOR MORE INFORMATION FROM THE NETWORK BEING REQUIRED.

(28)

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year

Data types – Rainfall, Climate, River flow, Groundwater levels.
% Network/year – 50% 50% 100% 90%

How are the hydrometric data used within your function?

The data are used for water resource management, planning and monitoring droughts. ~~The~~

Please indicate distribution of your data use - allocate scores to add to 100% – This varies considerably between Areas.

	%	Kent	Sussex	Hampshire
Headwater stations	____%	4%	25%	60%
Catchment outfall stations	____%	4%	18%	20%
Mid-catchment/major tributary stations	____%	92%	57%	20%

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☑

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows ± 5%
Medium flows ± 7%
High flows/floods ± 10%

Express values as +/- x% of flow or other unit (specify)

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

No – none

Name: Scott Ferguson
Telephone: 01903 832226

Position: Senior Hydrometric Officer Region/~~Area~~: Southern.

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Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(22)

INFORMATION REQUEST: Water Resource Management/Planning

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year daily mean flows
15 min / data
flow

How are the hydrometric data used within your function?
Operating Agreements
Abstraction Licence enforcement
Alleviation of Low Flows studies

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	50 %
Catchment outfall stations	25 %
Mid-catchment/major tributary stations	25 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility? Yes

- Historic data adequate alone once record length exceeds threshold ☒ No
- Ongoing data collection is required only at 70 % of current network stations ☑
- Ongoing data collection is required at all stations in hydrometric network ☐ not necessarily

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	±5%	*Express values as +/- x% of flow*
Medium flows	± 5%	*or other unit (specify)*
High flows/floods	± 20%.	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

No

Name: Alan Worton Telephone:

Position: Principal Officer Region/~~Area~~: SOUTH WEST

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Any further comments? - please use reverse of form and tick here ☐

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INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year

ALL

How are the hydrometric data used within your function?

licence enforcement, licence determination, drought monitoring, drought order/drought permit determination WR situation assessment, derogation/impact enquiry resolution, etc.

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	33 %
Catchment outfall stations	34 %
Mid-catchment/major tributary stations	33 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☑

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	± 2%	*Express values as +/- x% of flow*
Medium flows	± 2%	*or other unit (specify)*
High flows/floods	± 5%	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

Impossible to do job without hydrometric data. i) Claims for derogation could be millions of pounds in case of water companies, major users. ii) Alternative is that major WR developments may be refused due to lack of hydrometric data †

Name: DN TUBB Telephone: 01392 - 444000 Ex 2367

Position: P.O. Resource Management Region/Area: SOUTH WEST

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Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(† value/cost of major WR schemes = £1 million per 1Ml/d of yield

(35)

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year River/loch/sea levels, river flows, groundwater level (limited), rainfall. 100% used

How are the hydrometric data used within your function?
1) Calculation of flow statistics for discharge consents
2) Use as analogue stations for ungauged catchments
3) Flood warning purposes/flood risk assessments
4) Issue to external individuals/institutions for further use

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	43 %
Catchment outfall stations	36 %
Mid-catchment/major tributary stations	21 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

Historic data adequate alone once record length exceeds threshold ☐
Ongoing data collection is required only at ___% of current network stations ☐
Ongoing data collection is required at all stations in hydrometric network ☒
(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	5 – 10%	*Express values as +/- x% of flow*
Medium flows	–	*or other unit (specify)*
High flows/floods	–	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

NO

Name: RICHARD BROWN Telephone: 01349 862021

Position: HEAD OF HYDROLOGY Region/Area: SEPA NORTH

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Any further comments? - please use reverse of form and tick here ☒

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Please note:

1) Comments ~~relate~~ only to former HRPB area and questions on former NERPB area of SEPA north should be addressed to Nigel Goody.

2) I am not particularly happy that the answers overleaf reflect the situation in this area and suggest that you might consider carrying out face to face interviews.

R C Brown
12/11/96

33

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year Telemetered rainfall — 100% Daily Rainfall Sites – (10%) Telemetered Reservoir level (100%) Telemetered River Level — 50% Observation B/hole – 20% Telemetered R-Flow — 80% Telemetered River Abstractions (100%) Spot Gaugings — 70%

How are the hydrometric data used within your function?
(1) For Water Situation Reporting (2) For setting licence restrictions
(3) For assessing merits of Drought Order/Permit Applications
(4) For yield analysis (5) To develop long term "naturalised" flow records.
(6) To make Operational/River Regulation Decisions (continued overpage)

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	30 %
Catchment outfall stations	30 %
Mid-catchment/major tributary stations	40 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

Historic data adequate alone once record length exceeds threshold	☐
Ongoing data collection is required only at 70 % of current network stations	☑
Ongoing data collection is required at all stations in hydrometric network	☐

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	±5%	*Express values as +/- x% of flow*
Medium flows	±5%	*or other unit (specify)*
High flows/floods	±5%	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

NO

Name: T. HARRISON Telephone: 0121 711 5807

Position: Senior Hydrologist Region/Area: Midland Region – Headquarters

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Any further comments? - please use reverse of form and tick here .... ☑

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Use of Data (continued)

(7) To monitor Agency/Water Company compliance with licence conditions and operating Agreements.

(8) For one off water resource/modelling studies

(9) For long term water resource planning/modelling.

(10) For long term data archiving, to support all functions, and to support data requests from the public etc.

(11) To support river habitat field & modelling studies.

(12) To support pollution travel time prediction field and modelling studies (to protect intakes).

Comments:

I have completed this from a Water Resource Management point of view, and in this function I have NO information whatsoever on the economic value of hydrometric data.

The only information on economic value that I have relates to Flood Forecasting & Warning, and this was passed to Andrew Black/Tony Bennett during their visit to Solihull earlier in the year.

Tim Harrison

(2x)

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year Rainfall and river flow. Rainfall is often area or region average - uses 10-20 gauges. River flow perhaps - 20 locations. Some MORECS data.

How are the hydrometric data used within your function?

Drought monitoring, reporting to advisory committees. Analysis for water resources modelling.

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	20 %
Catchment outfall stations	40 %
Mid-catchment/major tributary stations	40 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at 70 % of current network stations ☑
- Ongoing data collection is required at all stations in hydrometric network ☐

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	3-5%	*Express values as +/- x% of flow*
Medium flows	3-5%	*or other unit (specify)*
High flows/floods	20%	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

No.

Name: John Mawdsley Telephone: 0113 231 2492

Position: WR. Coordinator Region/~~Area:~~ North East

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Any further comments? - please use reverse of form and tick here ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Although I say we need on going data from 70% of the stations, it is not necessarily the same 70% each year.

The answers are to give a broad idea of our use of data – there are of course specific detailed studies relating to the data from one or two gauges, often the longest records.

(29)

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year Flow, level, rainfall, GW level, climate: 100% of stations

How are the hydrometric data used within your function?
WR Planning, licensing, operational investigations, yield studies, applied hydrology, S188 surveys, LEAPs ...

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	10 %
Catchment outfall stations	60 %
Mid-catchment/major tributary stations	30 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☑

(but historic data are also important). *(tick one)*

Do you require specific levels of accuracy in flow measurement?

Low flows	1-5 %	*Express values as +/- x% of flow*
Medium flows	1-5 %	*or other unit (specify)*
High flows/floods	5-10 %	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:
The value of data increases with accessibility, QA, transferability. Value is proportional to location, length of record and what one is using it for.

Name: IAN BARKER Telephone: 01222 770088

Position: Reg. WR Manager Region/Area: WELSH - REGIONAL OFFICE

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Any further comments? - please use reverse of form and tick here .... ☑

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The survey should also consider that the existing hydrometric network may not be sufficiently extensive. Changing customer demands for data, changes in the Agency's work and climatic change all dictate that data collection must reflect changing demands.

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year: Flows - mainly daily mean flow, - 65-85%
Reservoir/lake levels (daily mostly) - 100%
Rainfall (daily, monthly, intensity) - not sure what is termed "network stations"

How are the hydrometric data used within your function?
Many types of hydrological analyses including - water resource planning,
- water resources/drought monitoring
- modelling of systems / catchments
- low flow estimates for many functions
- range of hydrological information for internal / external customers for a wide range of needs.
- development and improvement of hydrological models / techniques

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	20 %
Catchment outfall stations	60 %
Mid-catchment/major tributary stations	20 %

* see over 1

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☑ * see over 2

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	____	*Express values as +/- x% of flow*
Medium flows	____	*or other unit (specify)*
High flows/floods	____	

* see over

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

Name: Meg Owens Telephone: 01925 653999 ext 2748

Position: Catchment Modeller (Hydrology) Region/Area: North West Region

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Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

*1 The need for flows at headwater sites and sites with mainly natural flow is becoming increasingly important for many requirements. Also adequate data to enable flow naturalization at other sites is important.

*2 Any potential redundancy in the network would need to be rigorously proved for all needs and all flow conditions. There may be stations we haven't used for a while but will they be the site of hydrological interest in the future? This is often hard to predict. A long term record at a site can suddenly become very valuable.

*3 Generally if flows are more accurate, then hydrological analysis will be more accurate, and the decisions made using that hydrological information will be better decisions.

Accuracy required will be dependent on the site and the use of that data, but generally for water resources the mid and lower flows are likely to be more important.

Generally, an accuracy of about 5% is probably desirable.

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year RIVER FLOW/LEVEL, COASTAL WATER LEVEL RAINFALL, EFFLUENT FLOW AND ONE BOREHOLE.

How are the hydrometric data used within your function? ROUTINE Q95 TYPE ASSESSMENTS etc, RESOURCE ESTIMATE FLOOD RISK/FLOW ESTIMATIONS, INPUT DATA FOR MODELS.

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	CA 10 %
Catchment outfall stations	CA 30 %
Mid-catchment/major tributary stations	CA 60 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility? NOT STRICTLY, BUT AT TIMES OF CHANGING RAINFALL/RUNOFF PATTERNS ONGOING DATA COLL. IS ESSENTIAL

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☑

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows +/- 7% approx
Medium flows +/- 10%
High flows/floods +/- 15%, however in practice flood flows have significant error bands well above +/-

Express values as +/- x% of flow or other unit (specify)

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

I AM NOT AWARE OF ANY SPECIFIC DATA/DOCUMENTS OUTLINING THE ECONOMIC BENEFITS OF HYDROMETRIC DATA COLLECTION

Name: MARC BECKER Telephone: 01355 238181

Position: HYDROLOGIST Region/Area: WEST

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Any further comments? - please use reverse of form and tick here ....

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(21)

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year

RIVERFLOW RECORDS | RAINFALL DATA | GROUNDWATER LEVEL DATA

100% OF NETWORK

How are the hydrometric data used within your function?

- X FLOOD WARNING.
- X FLOOD RISK ASSESSMENTS
- ✓ RESEARCH PROJECTS - LOW FLOW STUDIES.
- ✓ COMPENSATION FLOW MONITORING

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	24 %
Catchment outfall stations	60 %
Mid-catchment/major tributary stations	16 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

Historic data adequate alone once record length exceeds threshold	☐	A
Ongoing data collection is required only at ___% of current network stations	☐	B
Ongoing data collection is required at all stations in hydrometric network	☑	C

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	100	→ 0
Medium flows	98	→ ±2%
High flows/floods	95	

Express values as +/- x% of flow or other unit (specify)

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

NO

Name: D. McLEAN Telephone: 01896 754797

Position: HYDROLOGIST Region/Area: SEPA (EAST)

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Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(5) DANI RIVERS AGENCY DOES NOT HAVE ANY WATER RESOURCE RESPONSIBILITIES TO DATE.

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year

How are the hydrometric data used within your function?

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	____%
Catchment outfall stations	____%
Mid-catchment/major tributary stations	____%

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☐

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	____	*Express values as +/- x% of flow or other unit (specify)*
Medium flows	____	
High flows/floods	____	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

DAWSON

Name: [signature] Telephone: 01232 253372

Position: SENIOR ENG HYDROMETRICS Region/Area: N. IRELAND NI

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Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(117)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

Flows + Rainfall, dry weather flows, 95°
Groundwater dip levels.
Approximately 65 stations

How are the hydrometric data used?

Scope for using main river data - impractical for small streams.

Would any further hydrometric data be used if the network were extended?

The low flow data is used to assess the availability of resources for new licence applications + to determine the need for restrictions on the licences

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? (YES)/NO

b) commission you own flow measurement programme? (YES)/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

No - use theoretical data.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

Implementing restrictions.
Controlling public water supply licences.

Do you use real-time data at all? If so, how?

as above.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

We have a duty to maintain Minimum Acceptable Flows under the Water Resources Act 1991 even if they have not been set.

Name: Anne Plowmer Telephone: 01684 850951

Position: Asst Water Resources Officer Region/Area: Midlands / Lower Severn

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Any further comments? - please use reverse of form and tick here .... [ ]

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

(2)

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year Data Type - river flows, river levels, rainfall
Operate 45 flow measurement stations and 15 river level station

How are the hydrometric data used within your function?
Spray Irrigation licensing; discharge consent information; flood risk assessm
flood warning; statistical information to consultants for design:
insurance and legal purposes

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	22 %
Catchment outfall stations	20 %
Mid-catchment/major tributary stations	58 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at ___% of current network stations ☐
- Ongoing data collection is required at all stations in hydrometric network ☑

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	5 %	*Express values as +/- x% of flow*
Medium flows	5 %	*or other unit (specify)*
High flows/floods	10 %	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

Name: JOHN ANDERSON Telephone: 01738 627989

Position: PRINCIPAL HYDROLOGIST Region/Area: SEPA: EAST (formerly Tay R.P.B)

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

20

INFORMATION REQUEST: Water Resource Management

What hydrometric data do you use? - type of data and approx fraction of network stations used in typical year

50 to 70%

How are the hydrometric data used within your function?

Abstraction licensing - resource availability prescribed flows
Flow stats for discharge consents
Strategic water resources planning - data for modelling resource systems
Design flood hydrograph & flood modelling.
Assesment of drought severity

Please indicate distribution of your data use - allocate scores to add to 100%

Headwater stations	20 %
Catchment outfall stations	60 %
Mid-catchment/major tributary stations	20 %

Does your function require a programme of ongoing data collection, or are historic data generally of equivalent utility?

- Historic data adequate alone once record length exceeds threshold ☐
- Ongoing data collection is required only at 90% of current network stations ☑
- Ongoing data collection is required at all stations in hydrometric network ☐

(tick one)

Do you require specific levels of accuracy in flow measurement?

Low flows	± 10%	*Express values as +/- x% of flow or other unit (specify)*
Medium flows	± 10%	
High flows/floods	± 10%	

Do you have any assessment of the (economic) value of hydrometric data to your activities (eg uncertainty reductions and attendant benefits); if so pleease indicate:

No.

Name: G. P. Davies Telephone: 0121-711-2324 x 3040

Position: Regional Water Resources Planner. Region/Area: Midlands

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Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Questionnaire responses

ABSTRACTION LICENSING

(18)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

Flow data for rivers across Cumbria. No idea how many stations, but potentially all of them.

How are the hydrometric data used?

Used to assess abstraction licence applications, and also to review current specified flow requirements on major licences.

Would any further hydrometric data be used if the network were extended?

Yes - always useful to get data close to the site of interest.

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? (YES) NO — limited

b) commission you own flow measurement programme? (YES) NO — Would have to check theoretical values.

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

Possibly have to be more conservative.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

15-20%

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

Allows compensation + prescribed flows to be reviewed with regard to what is acceptable. Allow improvements to be instigated.

Do you use real-time data at all? If so, how?

In drought/low flow situations, need to know current levels so that actions can be taken - eg open sluices, check NWW comp. flows -

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

Allow us to carry out our duties under WRA with respect to determining licence applications.

Name: Pete Kerr Telephone: 01228 25151

Position: Area Water Resources M Region/Area: NW N Area.

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

(108)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

FLOW GAUGINGS (SPOT GAUGINGS + DATA FROM GAUGING STATIONS). 50 STATIONS.
GROUNDWATER LEVELS. 85 STATIONS.
RAINFALL DATA.

How are the hydrometric data used?

ASSESSING IMPACT OF SURFACE AND GROUNDWATER ABSTRACTION LICENCE APPLICATIONS.
SETTING LICENCE CONDITIONS
COMPILING FLOW DURATION CURVES & HYDROGRAPHS.

Would any further hydrometric data be used if the network were extended?

YES

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~ SUBJECT TO BUDGET LIMITATIONS.

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

NOT NECESSARILY. WE WOULD NORMALLY RELY ON THEORETICAL DATA.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

USEFUL FOR ENFORCEMENT STAFF.

Do you use real-time data at all? If so, how?

NOT GENERALLY USED BY LICENSING STAFF. AGAIN USED BY ENFORCEMENT STAFF.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

AGAIN USED BY ENFORCEMENT STAFF TO ENSURE COMPLIANCE WITH LICENCE CONDITIONS.

Name: T.G. FOLLAND / N. PRALL   Telephone: 01302 44 2049 / 01302 44 2048

Position: ABSTRACTION LICENSING OFFICERS.   Region/Area: SOUTH WEST REGION - DEVON AREA.

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

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b2W

(107)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

River flow data and raingauge data from throughout the North Wessex area. (Ap. 45 river stations)

How are the hydrometric data used?

To determine flow statistics, such as, Q95 and winter Q95.

Would any further hydrometric data be used if the network were extended?

A good coverage is essential as applications for licences can appear at any location throughout the area.

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

Possibly.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

One based on estimates would always be confirmed with several spot measurements

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

—

Do you use real-time data at all? If so, how?

When flow at a gauging station is compared to extended borehole pump tests

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

Very important to meeting our legislative requirements in abstraction licensing.

Name: Telephone:

Position: Region/Area:

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b2W

(106)

INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations
All data streams, approx 40 full rate gauging stations
400+ boreholes 200 raingauges 4 Climate Stns

How are the hydrometric data used?
Licensing, Resources planning, Flood Defence, Resource Assessment, Fish Migration Service
Water Quality consents, pollution investigation

Would any further hydrometric data be used if the network were extended?
Network may extend with the provision of flood forecasting models
more telemetry Rainfall and tidal gauges

If hydrometric data collection were to cease altogether, would you:
a) use theoretical estimates? ~~YES~~/NO
b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?
If there isn't any data how can one judge whether the licence is more restrictive? We would certainly be conservative, but normally ask for an extension and capture the data in that period.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).
This depends on cases - using Micro low flows for estimates on chalk geology the difference can be vast.

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?
Drought/Flood management - instant view of catchments health - monitoring large water company abstractions. Ability to react to PR stories
Ability to monitor sluice management

Do you use real-time data at all? If so, how?
Rainfall - floodwarning Groundwater - flood warning
River flows - MRF conditions Low flows - lock positions showing drawdown of po

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? Used for MRF condition compliance
Land drainage statutory duties. Groundwater leachate monitoring support dont WQ survey - national data provision of flows for dilution purposes.

Name: SIMON TAYLOR Telephone: 01903 215835

Position: RESOURCES MANAGER ~~Region~~/Area: SUSSEX

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

(105)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

Low flow gauging -> DWF
groundwater levels -> available g/w resources.

How are the hydrometric data used?

In abst= licence determination

Would any further hydrometric data be used if the network were extended?

No.

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/NO Both!

b) commission you own flow measurement programme? YES/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

If no data available - would use theoretical and/or back up with several one-off gauging

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

N/A.

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

Day to day data essential in regulation of R Severn and Shropshire g/w Scheme, and the restriction of certain abst= licences.

Do you use real-time data at all? If so, how?

To restrict those licences where abst= is dependent on flow being above a certain level.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? - don't understand question

Name: JEAN PAYN Telephone: 01743-272828

Position: Senior Water Resources Officer Region/Area: Upper Severn Area - Midland Reg

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

103

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

SPOT GAUGINGS + 38 GAUGING STATIONS

How are the hydrometric data used?

TO CONSTRUCT + EVALUATE CATCHMENT MODELS
TO ENFORCE RESIDUAL FLOW/COMPENSATION FLOWS ON LICENCE

Would any further hydrometric data be used if the network were extended?

YES - DESPERATE LACK OF SPRING GAUGES

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/NO (YES circled)

b) commission you own flow measurement programme? YES/NO (YES circled)

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

NO - LACK OF [illegible] ACTUAL DATA COULD GO EITHER WAY/ E.G MORE OR LESS RESTRICTIVE

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

NIL - ACTUAL DATA IS USUALLY USED TO EVALUATE THE ACCURACY OF ESTIMATES FOR AN UNGAUGED STRETCH

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

ENFORCEMENT OF ABSTRACTION LICENCES
(presume "Water Resources" aspects being covered by Regional Response)

Do you use real-time data at all? If so, how?

DROUGHT
LOW FLOWS
ABSTRACTION LICENCE DETERMINATION

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? Not clear what is required.

Name: CAROL VALVONA Telephone: 01208 78301

Position: LICENSING INSPECTOR Region/Area: SOUTH WESTERN / CORNWALL

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

102

INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

34 GAUGING STATIONS - DTS LOGGERS (15 MINUTE RIVER LEVEL)

How are the hydrometric data used?

FLOW DURATION CURVES ETC USED FOR ESTIMATION OF DRY WEATHER FLOWS ON UNGAUGED CATCHMENTS OR OTHER PARTS OF GAUGED CATCHMENT.

Would any further hydrometric data be used if the network were extended?

YES. IMPROVED EVALUATION OF IMPACT ON SMALLER WATERCOURSES.

If hydrometric data collection were to cease altogether, would you:
a) use theoretical estimates? YES/NO
b) commission you own flow measurement programme? YES/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

NOT NECESSARILY - ALTHOUGH IF THERE WAS UNCERTAINTY OVER AVAILABLE WATER THERE MAY BE MORE REFUSED LICENCES OR TIME LIMITED LICENCES.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

DATA HELPS IN THE DETERMINATION OF LICENCES. ALSO IN THE MANAGEMENT OF "CUT OFF" FLOW CONDITIONS + REGULATION SCHEMES.

Do you use real-time data at all? If so, how?

MANAGEMENT OF RIVER REGULATION SCHEMES

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? SOME GAUGING STATIONS FORM PART OF RIVER REGULATION SCHEMES.

Name: D.F. ANDERSON Telephone: 01437 760081

Position: HYDROLOGIST (WATER RESOURCES) Region/Area: WELSH REGION (SW AREA

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b2W

+ all other water resources / hydrology matters involving X border [illegible]

(1)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

Flow 40; level 40, groundwater 50, rainfall 130, climate 20.

How are the hydrometric data used?

According to the problem or requirement - sometimes simple, sometimes complicated

Would any further hydrometric data be used if the network were extended?

yes

Hydrometric network is extended (optimal) / rationalised to give adequate coverage for all uses

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? ~~YES~~/NO (circled) absolutely not - need ratios.

b) commission you own flow measurement programme? YES/NO (circled)

How would that be done? - especially when many hydrological problems require immediate and long term accurate data.

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available? No. With an adequate network data can be confidently transferred. Licensing and other work often involves temp. installations to relate to permanent stations.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

—

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits? Resources rivers for which we are directly responsible (eg Dee) require immediate data access.

Do you use real-time data at all? If so, how?

Yes above (flood warning)

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? All up to legislative req. and standards.

Name: W. V. Hughes Telephone: 01244 670?? ~~[illegible]~~

Position: Area Water Resources Manager Region/Area: N. Area Welsh Region.

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b2W

\160

INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations.

350 sites where flow is measured regularly by current meter
90 flow sites
50 level sites and 350 borehole sites..

How are the hydrometric data used?

Estimation of available resource and necessary licence controls

Would any further hydrometric data be used if the network were extended?

Yes.

If hydrometric data collection were to cease altogether, would you:
a) use theoretical estimates? YES/~~NO~~
b) commission you own flow measurement programme? YES/~~NO~~ subject to resources.

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

Precautionary principles would be adopted

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

Cannot answer, subjective judgement made.

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

Yes - to transfer schemes and aquifer management (f). Also licence control (c) trigger levels and spray irrigation bans. (g) (g)

Do you use real-time data at all? If so, how?

Yes for above purposes

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? Statutory minimum flows d/s of Reservoir sites. Large PWS licences refer to control flow at named site.

Name: D HENDRIKZ Telephone: OX 4595 01522 513100

Position: AREA LICENSING OFFICER LINCOLN Region/Area: NORTHERN ANGLIAN

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

Flow Gauging Records – 75 gauging stations
– 150 routine current metering stations.
Rainfall records – 200 stations ; Ground water levels – in excess of 150 observation boreholes
20-25 Tide level recorders.

How are the hydrometric data used?

Determination of applications for new abstraction licences and increases in existing licences.
Investigation of complaints of derogation – including low water levels in wells, reduced river flows and adverse impacts on wetland sites, arising from the issue of licences.

Would any further hydrometric data be used if the network were extended?

Yes – we would use all that was available.

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? Yes in limited circumstances but generally no. YES/NO

b) commission you own flow measurement programme? ✓ YES/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

– almost certainly yes.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

Almost impossible to generalise – depends greatly on location of abstraction point and type, size and sensitivity of river and whether winter or summer (although no new summer surface abstraction licences are issued in Eastern Area). Say 30% reduction for winter surface water licence.

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

Yes, abstraction licences relating to both rivers and boreholes frequently contain flow and/or level cessation conditions which rely on the availability of hydrometric data for their implementation. The imposition of Section 57 restrictions during periods of drought also rely on the availability of this data

Do you use real-time data at all? If so, how?

See above

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

Name: A.W. HOCKADAY Telephone: 01473 727 712

Position: Area Licensing Officer Region/Area: Anglian Region, Eastern Area

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Any further comments? - please use reverse of form and tick here .... ☐

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INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations
Full hydrometric services - flow hydrograph, flow statistics (ADF, Q95 MDF) Telemetrically linked, chart stations, spot gaugings, low flows.
How are the hydrometric data used? - All stations in S.Wessex area.

compilation of flow statistics to assess impact of proposed abstraction and discharges of effluent to controlled waters, linking flow conditions for MPF calculations

Would any further hydrometric data be used if the network were extended?
Yes. Frequency assessments for licensing and consenting are data limited.

If hydrometric data collection were to cease altogether, would you:
a) use theoretical estimates? YES/~~NO~~
b) commission you own flow measurement programme? YES/~~NO~~
c) get applicant to invest in additional data gathering which will need auditing

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?
Possibly - also may involve using other stretches or tributaries, increasing risk of inappropriate determination

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction):
Site specific depending upon other variables.

Does the availability of data offer any benefit in the day-to-day management of river systems and the resource? If so, what are these benefits?
- all abstractors to continue to abstract linked to prescribed flows

Do you use real-time data at all? If so, how?
No.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

Name: Adam Dam[illegible] Telephone: 01258 456080

Position: Authorisations officer ~~Region/Area~~: Area.

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b2W

Exeter ~~Devon~~

(116)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

Rainfall data = 122 Sites Spot flow gauges - 3 climate stations
Flow data = 37 stations Level data = 75 sites groundwater levels ≈ 259.

How are the hydrometric data used?

Determining licences, setting licensing policies for catchment. Resolving derogation issues, compensation and hands off flows.

Would any further hydrometric data be used if the network were extended?

yes,

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/NO

b) commission you own flow measurement programme? YES/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available? We would carry out a spot flow gaugings at the end of summer to determine the licence, this could be unrepresentative and would lead to a more restrictive licence than if a long term flow data was used.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

N/a

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

yes, the monitoring of prescribed flows and the enforcement of licence conditions.

Do you use real-time data at all? If so, how?

as above.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? Licensing laws (Water Resources Act), Statutory Instruments for compensation Releases from reservoirs. Statutory maintained flows into tidal for dilution

Name: MAGGIE BULLET / Isabel Cunningham Telephone: (0113) 2312073 / 2312074

Position: AREA LICENSING OFFICER Region/Area: NORTH EAST - RIDINGS AREA

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

(117)

INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations
Rainfall, Evapotranspiration, Percolation/Runoff, River Flow

How are the hydrometric data used?
- Assessing available resources
- Setting 'hands off' flows
- Enforcing Licence Conditions

Would any further hydrometric data be used if the network were extended? Yes

---

If hydrometric data collection were to cease altogether, would you:
a) use theoretical estimates? YES/NO (YES circled)
b) commission you own flow measurement programme? YES/NO (YES circled)

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available? Yes, probably

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction). Impossible to say without knowing difference between 'real' and estimated data. Licence conditions would be on precautionary side.

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?
- close to 'real-time' monitoring of licence conditions
- assessment of resource availability
- assessment of impact of existing abstraction.

Do you use real-time data at all? If so, how?
- monitoring licence conditions
- investigating 'low flow' situations

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? Requirements of WR Act '91 to manage water resources.

Name: NIGEL HAWKES Telephone: (0118) 953 5392

Position: SNR WATER RES. OFFICER Region/~~Area:~~ THAMES.

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Any further comments? - please use reverse of form and tick here .... ☑

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b2W

NB Abstraction Licensing is a Regionally based function in Thames Region. Two of our three Areas passed the questionaire to me.

ENVIRONMENT
AND HERITAGE
SERVICE

Dr. A R Black
Geography Department
University of Dundee
DUNDEE
DD1 4HN

26 November 1996

Dear Andrew,

BENEFITS OF HYDROMETRIC NETWORKS: INFORMATION REQUEST

I enclose completed survey forms in relation to the above section of the SNIFFER project. I realise that the returns are later than your stated date , but this was unavoidable since the forms had to be issued to three different sections within the Department.

In the case of the form relating to 'Abstraction', a reply has been provided by assuming the role (for which we have statutory provision but which has never been enacted). If this is not suitable please regard it as a nil return on this issue.

I trust that the replies will prove informative and useful and wish you success with the project.

Yours sincerely,

JOHN WATERWORTH
Water Quality Unit

T132_LEE.DOC

INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

Instantaneous + mean daily flows from approx 20 stations, daily. Also spot gaugings + groundwater data from a number of sites.

How are the hydrometric data used?

(i) Monitoring licence conditions relating to min. prescribed flows.
(ii) Investigating incidents of low flows/illegal abstraction, including stream support schemes.
(iii) Commenting on licence applications.

Would any further hydrometric data be used if the network were extended?

Yes, network is never extensive enough. Indeed enforcement requirements have led to extending hydrometric network.

If hydrometric data collection were to cease altogether, would you:
a) use theoretical estimates? YES/~~NO~~
b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

See Adam Davis response

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

— " —

Does the availability of data offer any benefit in the day-to-day management of river systems and the resource? If so, what are these benefits?

Ensuring licence conditions are met protects rivers from low flows & in stream support schemes ensures continuous flow.

Do you use real-time data at all? If so, how?

Yes — for daily monitoring of condition both mean daily flows + instantaneous flows are used, via telemetry, to estimate future flows.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?

Relates very well as most recent 70's + 80's g/water development took place after or coincident with network development ∴ licences are tied to gauging station flows.

Name: C. HARDWICK Telephone: 01258-456080

Position: WATER RESOURCES MANAGER Region/Area: SOUTH WESSEX, SOUTH WEST

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Any further comments? - please use reverse of form and tick here .... ☑

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2W

Exeter Devon

I've answered the questions as best I can from a licence enforcement perspective. The structure in South Wales is such that Licence Enforcement comes under myself the Area Water Resources Manager, whilst licence determination, issuing of licences comes under Adam Davis the Authorisations Officer — see his answers attached.

Whilst we liaise closely on a number of issues we've tried to answer the questions from our particular standpoint.

Structure:

Area WR Manager → Licence Inspections Enforcement.

Authorisations Officer → Licence Determination.

NI ... we not ...
But this is how it could impinge in theory
J. Waterworth

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations
FLOWS — MDF & Q95 ≃ 20 STATIONS WOULD COVER MAIN/POTENTIAL ABS.
& RAINFALL

How are the hydrometric data used? PROPOSED ABSTRACTIONS WOULD BE CONSIDERED AGAINST CURRENT WATER USAGE, AND THE REQUIRED DILUTION FLOWS, AND THE FLOW INDICIES: WOULD DICTATE AVAILABILITY FOR HIGH OR LOW LOSS USES. CONTINU RECORDS WOULD FACILITATE

Would any further hydrometric data be used if the network were extended? UPLAND SITES COULD BE USED FOR HEADWATERS ABSTRACTIONS.

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/~~NO~~ BASED ON HISTORI DATA

b) commission you own flow measurement programme? YES/~~NO~~ SUMMER PROGRAM OF INTENSE GAUGING

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available? YES. ANY FLOW ESTIMI WOULD BE TREATED AS APPROXIMATE, AND AVAILABLE WATER/YIELD FACTORED DOWN ACCCORDINGLY

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

≃ 20% less (≃ scope for error based on CC estimate

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits? YES — QUALITY INFO ON FLOW NOT ONLY ALLOWS THE PROPER SETTING OF LIMITS, BUT ALSO PERMITS A CONTINUOUS MONITORING OF THE EFFECT, IF ANY, OF AN ABS. ON A RIVER REGIME.

Do you use real-time data at all? If so, how? VIA TELEMETRY — REAL TIME DATA CAN PROVIDE A CURRENT 'SNAP SHOT' OF RIVER BEHAVIOUR UNDER CONSENTED CONDITIONS — PARTICULARLY AT TIMES OF STRESS ON RESOURCE (eg DRY SUMMER

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? ESSENTIAL IN FULFILLING STATUTORY POWERS ESTABLISHED UNDER THE WATER ACT (N.I. ORDER) 1972 (REVISED 1996)

Name: J. Waterworth Telephone: 01232 254860

Position: SECTION HEAD - WATER ENG. Region/Area: N. IRELAND

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b2W

(1) The ENVIRONMENT & HERITAGE SERVICE is a 'Next Steps' Agency of the DOE (N.I.). which commenced in April 1996

(2) Although Abstractions are not licenced by EHS, the power to do so has existed since the original Water Act of 1972. Currently there are proposals to carry out this function and possibly introduce charging.

(3) Data has been used to monitor the effect of an abs. on downstream water quality via consents to discharge + dilution standards, and advice has been provided on the viability of small schemes.

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations

46 River gauging stations 500 Groundwater stations
80 Rain gauges

How are the hydrometric data used?

Licence application determination
Licence enforcement
Water resources planning
Flood warnings
Flood alleviation schemes
FRC schemes SWQO's SSSI's
Discharge consents

Would any further hydrometric data be used if the network were extended?

Yes - climatological

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?

Yes - using the "precautionary principle."

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).

20 % ??

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?

Real-time drought management, flood warning + licence enforcement, pollution incidents, fish rescues

Do you use real-time data at all? If so, how?

Abstraction licensing, discharge consenting, habitat improvement schemes, flood defence schemes, fishing surveys, advice to owners

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? Water Resources Act 1991: consideration of river flow and enhancement of conservation (also Environment Act 1995) in abstraction licensing and water resources planning.

Name: R. MURCHIE Telephone: 4839

Position: AREA RESOURCES MANAGER Region/Area: SOUTHERN / HAMPSHIRE - ISLE OF WIGHT

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b2W

Hydrometric data underpins most water management activities, and is applied to a wide range of external customers: local authorities, consultants, water companies, academics, students etc.

Without good hydrometric networks and properly validated data it is hard to see how water resources could be managed effectively, as well as major flood defence schemes.

RM

INFORMATION REQUEST
Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations
Instantaneous + mean daily flows from approx 20 stations, daily. Also spot gaugings + groundwater data from a number of sites.

How are the hydrometric data used?
(i) Monitoring licence conditions relating to min. prescribed flows.
(ii) Investigating incidents of low flows/illegal abstraction including stream support scheme.
(iii) Commenting on licence applications.

Would any further hydrometric data be used if the network were extended?
Yes, network is never extensive enough. Indeed enforcement requirements have led to extending hydrometric network.

If hydrometric data collection were to cease altogether, would you:
a) use theoretical estimates? YES/~~NO~~
b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?
See Adam Davis response

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).
— " —

Does the availability of data offer any benefit in the day-to-day management of river systems and the resource? If so, what are these benefits?
Ensuring licence conditions are met protects rivers from low flows & in stream support schemes ensures continuous flow.

Do you use real-time data at all? If so, how?
Yes — for daily monitoring of condition both mean daily flows + instantaneous flows are used, via telemetry, to estimate future flows.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements?
Relates very well as most recent 70's & 80's g/water development took place after or coincident with network development ∴ Licences are tied to gauging station flows

Name: C. HARDWICK Telephone: 01258-456080
Position: WATER RESOURCES MANAGER Region/Area: South Wessex, South West
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b2W

Exeter Devon

I've answered the questions as best I can from a licence enforcement perspective. The structure in South Wales is such that Licence Enforcement comes under myself the Area Water Resources Manager, whilst licence determination, issuing of licences comes under Adam Davis the Authorisations Officer — see his answers attached.

Whilst we liaise closely on a number of issues we've tried to answer the questions from our particular standpoint

Structure:

Area WR Manager → Licence Inspections Enforcement.

Authorisations Officer → Licence Determination.

NO4)

INFORMATION REQUEST

Abstractions and return flows (licensing and water orders)

What hydrometric data do you use - type of data and approx number of stations
Gauging station records - particularly derived Q95. Mean Daily Flow Data. Minimum recorded flows. Spot gaugings. Flow duration curves

How are the hydrometric data used?
Mainly for licence determination - setting "Hands Off" conditions. Assessing abstraction proposals at pre-application stage

Would any further hydrometric data be used if the network were extended?
Yes-

If hydrometric data collection were to cease altogether, would you:

a) use theoretical estimates? YES/NO (YES circled)

b) commission you own flow measurement programme? YES/NO (YES circled)

If no flow data were available for a given reach of river, would you have to issue a more restrictive licence than if flow data were locally available?
Not necessarily - may use other appropriate stations or flow estimates.

If so, please indicate the typical % difference likely between a licence based on observed data and one based on estimates (eg 25% reduction).
Varies - flow estimates often provide lower flow figu in upper reaches of the catchment than measured flow

---

Does the availability of data offer any benefit in the day-to-day management of river systems and the reource? If so, what are these benefits?
Yes - helps to target areas for enforcement in low flow periods.

Do you use real-time data at all? If so, how?
Telemetry - for instantaneous flow reading. Not common practice in NW region yet but seen as beneficial in the longer term.

How do you consider the flow monitoring network in your area to relate to any relevant legislative requirements? Only relates in respect to the Agency general duties to secure the proper use of water through water resources (and other functions) management.

Name: PAUL CRANE Telephone: 0161-973-2237 x3014

Position: SNR. LICENSING OFFICER Region/Area: N.W. REGION (SALE OFFICE

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b2W

In terms of licence enforcement. As more licences have conditions attached relating to 'hands off' flows at gauging stations - we need a policy regarding responsibility for monitoring this i.e. do the Agency monitor & inform licence holder or should it be the licence holders responsibility to interrogate the gauging station for data. Need an operational system that is effective in practice.

Questionnaire responses

POLLUTION CONTROL

(25)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

Statistical breakdown of flows for discharge consent models. Number varies (probably @ 10 sites per year).

How are the hydrometric data used?

Discharge consent modelling

Would any further hydrometric data be used if the network were extended?

Yes. Present sites are not always close enough to sewage works to be applicable

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/NO (YES circled)

b) commission you own flow measurement programme? YES/NO (YES circled) - but rarely.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

Depends on accuracy of theoretical data i.e. accuracy of micro low flows method of calculation

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

Depends on accuracy - see above.

What % of the consents in your area are linked to flow in the receiving watercourse?

None - i.e. no ~~consent~~ discharge conditions linked directly to flows. <1% are seasonal - these are calculated using "winter" and "summer" flows - either calculated using data or theory - as applicable.

Do you issue variable-rate consents based on available dilution?

No - unless you count seasonally based consents.

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

None

If not, are there plans to do so in your area?

No.

Name: Sean McKay Telephone: 7-24-2607

Position: Senior Scientist (QC) Region/Area: South West (PPC)

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We use ADF and Q95 to calculate river needs consents. If real data is available we use that, otherwise the micro low flows package is used to calculate theoretical flows.

To ~~our~~ my knowledge, we have no consent that is related directly to the flow in the receiving water, although we do have Seasonal consents.

Seasonal consents are calulated using ADF's ~~for~~ and Q95's for ~~defined~~ clearly defined "winter" and "summer" periods. Again, we use real data if applicable.

Sean McKay

Q4

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

~35 instantaneous flow data

How are the hydrometric data used?

To calculate loadings for 'North Sea and Harmonised Monitoring commitments. Also now required for Environmental Change Network monitoring and reporting for two sites in South West.

Would any further hydrometric data be used if the network were extended?

No I don't think so.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/NO (NO circled)

b) commission you own flow measurement programme? YES/NO (YES circled)

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

What % of the consents in your area are linked to flow in the receiving watercourse?

Do you issue variable-rate consents based on available dilution?

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

If not, are there plans to do so in your area?

Name: Rosanne Broome Telephone: x 2622 Exeter

Position: Senior Scientist (Region) Region/Area: EA SW Region

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INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations
LOW FLOW (Q95) AND MEAN DAILY FLOW (Q50). DATA PRODUCED FROM GUAGED STATIONS AND CATCHEMENT CHARACTERISTI.

How are the hydrometric data used?
IN FORMULATING DISCHARGE CONSENTS

Would any further hydrometric data be used if the network were extended?

I DON'T BELIEVE SO.

If hydrometric data collection were to cease, would you:
a) use theoretical estimates? YES/~~NO~~
b) commission you own flow measurement programme? YES/~~NO~~

THE MAIN CONSIDERATION WOULD BE THE SENSIVITY OF THE DISCHARGE I DILN

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?
WOULD USE THEORETICAL ESTIMATE UNLESS AVAILABLE DIL^N. WAS CRITRAL FACTOR

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

What % of the consents in your area are linked to flow in the receiving watercourse?
MAJORITY OF CONSENTS BASED ON Q95.

Do you issue variable-rate consents based on available dilution? VERY RARELY

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution? < 1%. REAL TIME DATA WOULD BE USED

If not, are there plans to do so in your area?

Name: G. NELSON Telephone: 01232 - 254831

Position: SECTION HEAD ~~INDUSTRIAL~~ CONSENTS Region/Area: N.IRELAND

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(40) (xx)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

1. River flows - Q95 and Q50. 20 stations
2. Rainfall - intensity, duration and return period. 5 stations
3. River levels - 1 station.

How are the hydrometric data used?

1. Used in consent calculations eg. Warn Brew, Qualsoc
2. Used in surface water run-off treatment design + consenting and in sewerage modelling.
3. Used to regulate a trade effluent discharge

Would any further hydrometric data be used if the network were extended?

No.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~ if necess.

We would ask our Hydrology department to advise us. Probably use historic data to provide theoretical estimates.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

We would use theoretical estimate of flow data which would incl. a safety margin which would vary in size depending on the situation. Usually at least one gauging is undertaken.

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

This will vary. There is no typical difference.

What % of the consents in your area are linked to flow in the receiving watercourse?

Approx. 30% in as much as river flow data are used to calculate the consent conditions.

Do you issue variable-rate consents based on available dilution?

No. A few summer/winter consents exist where the quality limits are different. Flow rates are the sa

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution? 0

If not, are there plans to do so in your area? No. It is not often that effl. flow rates can be controlled to suit river flows. Effluent quality standards can differ but usually no more than two standards.

Name: DH Williams Telephone: 01222 770088 2106

Position: District Poll^n Control Manager Region/Area: Welsh / SE

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(107) (87)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

BASIC STAT'S DERIVED FROM IN SITU RIVERINE AND TREATMENT PLANT MONITORING (27 RIVERINE GAUGING STATIONS FOR FLOW)

How are the hydrometric data used?

i) MASS-BALANCE BASED COMPUTER PROGRAMS FOR CONSENT CONDITION SETT
ii) MODELLING OF WATERCOURSE POLLUTANT LOADS
iii) NATIONAL LOAD MONITORING. eg. PARCOM, REDLIST, HARMONISED MONITORI

Would any further hydrometric data be used if the network were extended?

PROBABLY YES, HOWEVER SERVICE IS QUITE EXTENSIVE AND ADDITIONAL GAUGING IS LIKELY TO BE UNECONOMIC

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/NO

FLOW MEASUREMENT IS CONDUCTED BY ANOTHER DEPARTMENT ON A CLIENT/CONTRACTOR BASIS AND FUNDED BY OUR DEPARTMENT (WATER RESOURCES & QU

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

NOT STRICTLY SPEAKING AS FLOW DATA EXISTS FOR THOSE SIGNIFICANT WATERCO. LARGE DISCHARGES WOULD NOT BE PERMITTED TO SMALLER WATERCOURSES AND SMALL DISCHARGES WOULD TEND TO BE DESCRIPTIVE RATHER THAN NUMERIC & MONITORED ACCORDI

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

What % of the consents in your area are linked to flow in the receiving watercourse?

ALL CONSENTS ARE SET DEPENDANT UPON AVAILABLE DILUTION HOWEVE APPROXIMATELY 20% OF NEW CONSENTS USE A QUANTITATIVE APPROACH

Do you issue variable-rate consents based on available dilution?

VERY RARELY, ONLY ONE EXISTS FOR CONTINUOUS PLL DISCHARGES (…

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

NONE

If not, are there plans to do so in your area?

NO

Name: BRIAN LILLIE Telephone: 0191 203 4000 EXT 4121

Position: WATER QUALITY OFFICER Region/Area: NORTH EAST REGION (NORTHUMBRIA AR

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INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations
Rainfall & Flow Gauging Stations ≥ 50.

How are the hydrometric data used? Consent setting, River Load Calculations, Trends in Classification. Possibly due to long term increase in average flows, Modelling.

Would any further hydrometric data be used if the network were extended?
Yes, especially in catchments where no hard data is available

---

If hydrometric data collection were to cease, would you:
a) use theoretical estimates? YES/~~NO~~
b) commission you own flow measurement programme? YES/~~NO~~
This would depend on scale of proposal we would be assessing for discharge consent purposes - etc

---

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?
Not necessarily.

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).
?

What % of the consents in your area are linked to flow in the receiving watercourse?
Very few

Do you issue variable-rate consents based on available dilution? Yes

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution? Very small percentage ; Yes real time data is used

If not, are there plans to do so in your area?

Name: Robert Kerr Telephone: 01355 238181

Position: Discharge Consents Region/~~Area~~ West SEPA

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INFORMATION REQUEST: Pollution control/discharge consents

(63) (78)

What hydrometric data do you use - type of data and approx number of stations

Continuous flow data from strategic monitoring stations. Approx 10 in a[rea] For consent determinations invariably have to rely on theoretical flow mean, 95%ile exceed, mode

How are the hydrometric data used?

Used for River Needs modelling purposes.

Would any further hydrometric data be used if the network were extended?

Obviously the more accurate the data the better. Actual guaged data would replace theoreticals if greater availability.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? already do. (YES)/NO

b) commission you own flow measurement programme? already (YES)/NO do for more sensitive determinations.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

We have found that theoretical flows (95%ile exceed) tend to be more restrictive than actual, but we do attempt to get confirmed flows.

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

probably between 10-20% difference.

What % of the consents in your area are linked to flow in the receiving watercourse?

All - whether they are actual or theoretical.

Do you issue variable-rate consents based on available dilution?

No - tend to work on worst case scenario.

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

If not, are there plans to do so in your area? Yes - we have been looking into this - but applicants are not forthcoming with discharge hydrograph type information - when pushed they often prefer to accept worst case rather than undertake studies.

Name: [illegible] Telephone: 0161 973 2237 ext 5038

Position: Tech. Support Manager Region/Area: North West - South.

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INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations
Rainfall, flow

How are the hydrometric data used? Rainfall eg pollution may results from [illegible] either into rivers or the sea, "act of God" defence may be cited by farmers defence if slurry spread to land enters watercourse. Flow eg dilution are for consented discharges, needed to calculate loads eg pollution spill

Would any further hydrometric data be used if the network were extended?

If hydrometric data collection were to cease, would you:
a) use theoretical estimates? YES/NO (YES circled)
b) commission you own flow measurement programme? YES/NO (YES circled)
I don't hold a budget! will depend on sites

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?
In some cases, yes

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).
Impossible to say.

What % of the consents in your area are linked to flow in the receiving watercourse?
All water company STWs and large private STWs

Do you issue variable-rate consents based on available dilution?
The rate doesn't change but some have relaxed winter quality conditions

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

If not, are there plans to do so in your area?

Name: KATHRYN NELSON Telephone: 7-23-3310

Position: WATER QUALITY OFFICER (DATA) Region/Area: SOUTHERN / SUSSEX

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INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

mostly low and median flow data, rainfall data. 44 flow / 17 rain gauges / 152 level observation bore hole

How are the hydrometric data used?

1 consent calculation and
2 estimation of mass balance loads.
3 pollution events.

Would any further hydrometric data be used if the network were extended?

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

No do a theoretical calculation, if it all a commissioned study

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

What % of the consents in your area are linked to flow in the receiving watercourse?

70% approx

Do you issue variable-rate consents based on available dilution? Yes

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution? 1% real-time data is used

If not, are there plans to do so in your area?

Name: J. C. DOLBY Telephone: 0115 945 5722

Position: Area Water Quality Manager Region/Area: Midlands | Lower Trent.

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(147)

(84)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

I expect hydrometric data to be processed to provide practical low flow statistics. Little raw hydrometric data used by PPC staff

How are the hydrometric data used?

Mean daily flow statistical distribution parameters used in simple mass balance calculations and combined frequency analysis

Would any further hydrometric data be used if the network were extended?

There is a lack of flow measurement on SMALL representative stream types. Too much reliance on hydrometric data from large catchments

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available? Does the IH Low Flow Estimation technique give optimistic or pessimistic estimates?

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

How good is the IH estimate?

What % of the consents in your area are linked to flow in the receiving watercourse?

100% of all consented discharges to freshwater streams

Do you issue variable-rate consents based on available dilution? No.

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

Not applicable

If not, are there plans to do so in your area?

No

Name: Tom Inglis Telephone: 01349 862021

Position: DIVISIONAL MANAGER Region/Area: NORTH / WEST DIVISION

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(82)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

Minimum flow estimates, 95%ile flow estimates for derivation of all consents. Use travel times (in mins) for arranging timing of certain "dirty" instream works

How are the hydrometric data used?

Calculation of consents
Timing of engineering works to protect D/S interests

Would any further hydrometric data be used if the network were extended?

Network probably adequate in Borders Area.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~ only where necessary.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

Only if necessarily to maintain water quality + ensure compliance with EQS's.

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

Unable to answer this hypothetical question - Hydrometric data gives good coverage in Borders.

What % of the consents in your area are linked to flow in the receiving watercourse?

≈ 10 - 15% of monitored discharges

Do you issue variable-rate consents based on available dilution?

Yes

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

Only in 1 case

If not, are there plans to do so in your area?

All consents are to be reviewed within next 12 months to 95%ile 2 Tier type in preparation for the UWWTD. Compliance will be statistically based + minimum (or 95%ile) min flows will be used. No real time data will be used in the future.

Name: ALLAN VIRTUE Telephone: 01896 752425

Position: TEAM LEADER Region/Area: EAST / BORDERS SEPA

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... [ ]

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(158) (83)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

ESTIMATES OF MEAN AND LOW FLOWS (95% EXCEEDENCE).
FLOW DURATION STATISTICS, TIME OF TRAVEL INFORMATION.

How are the hydrometric data used?

DILUTION ASSESSMENT.
CONSENT SETTING MODELS - SIMPLE 'COMBINED DISTRIBUTION' MODELLING
& MORE COMPLEX CATCHMENT MODELS.

Would any further hydrometric data be used if the network were extended?

YES, ESTIMATES OF FLOWS AT ~~UN~~ CURRENTLY UNGAUGED SITES COULD BE IMP.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~

BOTH - AS AT PRESENT.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

IT DEPENDS ON RISK ASSESSMENT OF INDIVIDUAL CASE. POSSIBLY.

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction). +/- 20%.

What % of the consents in your area are linked to flow in the receiving watercourse?

100%.

Do you issue variable-rate consents based on available dilution? SOME SEASONALLY BASED CONSENTS.

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution? <1%

NO REAL TIME DILUTION ASSESSMENT

If not, are there plans to do so in your area?

NO.

Name: MARK HALLARD (FOR BRIAN HEALEY). Telephone: 0131-449-7296

Position: DIVISIONAL MANAGER Region/Area: SEPA EAST REGION, EDINBURGH

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... [ ]

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

HYDROLOGIES HAVE THE POOR QUALITY COPY. — ORIGINALS CAN BE OBTAINED IF DESIRED FROM JOHN ANDERSON - SEPA EAST, PERTH OFFICE.

APPENDIX I

[illegible] STATIONS IN SEPA EAST REGION

Ref no	GAUGING STATION	Watercourse	Catchment area (sqkms)	Classification	Flood warning	Records from	Average no. of gaugings per month			Cableway	Electricity	Telephone	Instrument	Rain gauge	Air temp	Diss oxygen	Control structure
							1991-1993	1997	1994 1995								
1	Luther Br	Luther Water	136	Primary	?	1963	0.56	1.25	1.08	Y		Y	TG1150				
2	Prosen Br	Prosen Water	104	Primary	Y	1984		1.00	1.00	Y		Y	TG1150				
3	Kirkton Mill	Lunan Water	124	Primary		1981	7.36	1.83	0.92	Y		Y	Turtle				
4	Logie Mill	R North Esk	732	Primary	?	1993	1.03	0.67	0.64	Y		Y	TG1150				compound crump weir
5	Brechin	R South Esk	488	Primary	Y	1983	1.47	3.75	0.75	Y	Y	Y	TG1150				
6	Dalhousie Br	West Water	127	Primary	?	1985		1.68	0.89	Y		Y	TG1150				
7	Arbroath	Brothock Water	60	Primary	Y	1969			0.67	Y	Y	Y	TG1150				
8	Stella Br	R South Esk	130	Primary	Y	1991			0.92	Y		Y	TG1150	Y	Y		
9	Guthrie	Lunan Water	33.8	Secondary		1996			0.96				Waterman				
10	Colliston	Colliston Burn	6.4	Secondary	Y	1994			0.92			Y	TG1150	Y	Y		kerb control
11	Kemback	R Eden	307	Primary		1968	2.47	2.42	1.75	Y		Y	TG1150			Y	
12	Balmossie	Dighty Water	127	Primary		1970	3.33	2.83	1.08	Y	Y	Y	Turtle				
13	St Michaels	Motray Water	60	Secondary		1984		2.25	1.21			Y	Waterman				
14	Craigmill	Craigmill Burn	29	Secondary		1987		1.09	1.21			Y	Turtle				
15	Strathmiglo	R Eden	26	Secondary		1990			1.59				Chart				
16	Kilmany	Motray Water	33	Secondary		1990			1.42				Chart				kerb control
17	Caputh	R Tay	3210	Primary	Y	1948	0.92	0.58	0.92	Y		Y	TG1150				
18	Ballathie	R Tay	4590	Primary	Y	1953	0.58	0.50	0.79	Y		Y	TG1150				
19	Pitnacree	R Tay	1150	Primary	Y	1958	3.89	0.75	0.89	Y		Y	TG1150				
20	Cookston	Dean Water	177	Secondary		1959	3.56	2.08	1.63	Y			Chart				
21	Wester Cardean	R Isla	367	Primary	Y	1972	2.83	3.25	1.54	Y		Y	TG1150				
22	Comrie Br	R Lyon	391	Primary	Y	1973	1.33	0.92	1.25	Y		Y	TG1150				
23	Pitlochry	R Tummel	1670	Primary	Y	1979	0.81	0.08	0.67	Y		Y	TG1150				
24	Almondbank	R Almond	175	Primary	Y	1973	2.14	1.08	1.17	Y	Y	Y	TG1150				
25	Kindrogan	R Ardle	103	Secondary	Y	1985		1.33	0.92			Y	TG1150	Y			
26	Newton Br	R Almond	84	Primary	Y	1981	2.47	2.17	1.29	Y		Y	TG1150				
27	Kenmore	R Tay	601	Primary	Y	1975	0.94	0.67	0.92	Y		Y	TG1150				
28	Millbank	Lunan Burn	94	Secondary		1984	0.92	1.67	1.42				Chart				
29	Hermitage	R Braan	210	Primary	Y	1982	1.92	2.00	0.83	Y		Y	TG1150				
30	Killin	R Dochart	239	Primary	Y	1983	2.16	1.17	1.17	Y		Y	TG1150	Y			
31	Gleneagles	R Earn	432	Primary	Y	1985	0.06	1.08	0.79	Y		Y	TG1150				
32	Lochmill	Garry Burn	20	Secondary		1997		1.08	1.63				Chart				sleeper control
33	Luncarty	Ordie Burn	54	Secondary		1995		0.58	1.29	Y		Y	Turtle				
34	Pitcrockie	Alyth Burn	32	Secondary		1991			1.36								
35	Dean Br	Dean Water	230	Primary	Y	1990			1.08	Y		Y	TG1150				
36	Jackstone	Ordie Burn	20	Secondary		1990			1.71				Chart				
37	Killiecrankie	R Garry	745	Primary	Y	1991			1.13	Y		Y	TG1150				
38	Kinloch Rannoch	R Tummel	647	Primary	Y	1991			0.13	Y		Y	TG1150				
39	Br of Gaur	R Gaur	247	Primary	Y	1992			0.13	Y		Y	TG1150				
40	Marble Lodge	R Tilt	155	Primary	Y	1992			0.75	Y		Y	TG1150				
41	Camusvrachan	R Lyon	237	Primary	Y	1992			0.96	Y		Y	TG1150				
42	Gollybanks	Golly Burn	4.2	Secondary		1995			0.29				Post reading				kerb control
43	Kinkell Br	R Earn	591	Primary	Y	1950	3.17	2.58	1.63	Y	Y	Y	TG1150	Y			
44	Cultybraggan	Ruchill Water	100	Primary	Y	1971	1.83	1.83	1.26	Y		Y	TG1150				
45	Forteviot Br	R Earn	782	Primary	Y	1973	1.19	0.67	0.67	Y		Y	TG1150				
46	Aberuthven	Ruthven Water	50	Primary	Y	1990			1.30	Y		Y	TG1150				
[illegible]	Luffness	Peffer Burn	26.2	Primary		1969	na	0.50	0.08			Y	TG1150				flume – crump weir
[illegible]	Musselburgh	R Esk	330	Primary	Y	1952	na	2.17	1.08	Y	Y	Y	TG1150				
[illegible]	Craigiehall	R Almond	369	Primary	Y	1957	na	0.33	0.25	Y		Y	TG1150				
[illegible]	Murrayfield	Water of Leith	107	Primary	Y	1963	na	1.33	0.46	Y	Y	Y	TG1150				
51	Almondell	R Almond	229	Primary	Y	1963	na	0.92	0.50	Y		Y	TG1150				flat V weir
52	East Linton	R Tyne	307	Primary	Y	1961	na	1.00	0.96	Y	Y	Y	TG1150				
53	Spilmersford	Tyne Water	161	Primary	Y	1965	na	0.92	0.88	Y	Y	Y	TG1150				broad crested weir
54	Saltoun Hall	Birns Water	93	Primary		1955	na	1.02	0.83				Chart				compound broad crested weir
55	Belton House	Biel Water	51.8	Primary		1973	na	1.25	0.98			Y	TG1150				gabion basket control
56	Dalmore Weir	R Esk	81.6	Primary	Y	1960	na	0.75	0.46			Y	TG1150				ogee weir
57	Lennoxlove	Gifford Water	64	Primary	Y	1973	na	1.00	0.98	Y		Y	TG1150				
58	Almond Weir	R Almond	43.8	Primary		1962	na	1.75	0.50				Chart				broad crested weir
59	Liberton	Braid Burn	16.2	Primary	Y	1959	na	0.42	0.17			Y	TG1150				compound crump weir

HIGHLIGHTED STATIONS = OLD FORTH. RPB. STATIONS.

Ref no.	GAUGING STATION	Watercourse	Catchment area (sqkms)	Classification	Flood warning	Records from	Average no. of gaugings per month			Cableway	Electricity	Telephone	Instrument	Rain gauge	Air temp	Diss oxygen	Control structure
							1961-1993	1997	1994-1996								
[redacted]	Cobbinshaw	Bog Burn	8.5	Primary		1963	na						Chart				flume
61	Dalkeith Palace	North Esk	137	Primary		1963	na	1.00	0.67	Y			Arx				
62	Almondell	Union Canal feeder	na	Secondary		1963	na						Chart				sharp crested weir
63	Colinton	Water of Leith	72	Primary	Y	1976	na					Y	TG1150				flat V weir
64	Whitburn	R Almond	30.3	Primary	Y	1978	na	2.00	0.50		Y	Y	TG1150				broad crested weir
65	Turnhouse	Gogar Burn	36.8	Primary		1977	na	1.75	0.29	Y			Chart				kerb control
66	Polmonthill	R Avon	195	Primary	Y	1972	na	1.67	0.58	Y		Y	TG1150	Independent			broad crested weir
67	Bonnybridge	Bonny Water	50.5	Primary		1972	na	1.50	0.42	Y		Y	TG1150				
68	Headswood	R Carron	122.3	Primary		1969	na	2.92	0.08	Y		Y	TG1150				flat V weir
69	Bridge of Teith	R Teith	517.7	Primary	Y	1957	na	0.17	0.21	Y		Y	TG1150				
70	Anie	R Lany	190	Primary	Y	1974	na	0.92	0.42	Y		Y	TG1150				
[illegible]	Bridge of Allan	Allan Water	210	Primary		1972	na	1.08	0.68	Y		Y	TG1150				
[illegible]	Kinbuck	Allan Water	161	Primary		1959	na	0.83	0.33	Y		Y	TG1150				gabion basket control
73	Glenochil	R Devon	181	Primary		1959	na	0.92	1.21			Y	TG1150				
74	Gargunnock	R Forth	397	Primary		1977	na	0.83	0.54	Y		Y	TG1150				
75	Leven	R Leven	424	Primary		1970	na	1.00	0.50	Y		Y	TG1150				gabion basket control
76	Balfour Mains	R Ore	162	Primary		1973	na	1.25	0.54	Y		Y	TG1150				
77	Fairfield Mill	Black Devon	56.2	Primary		1977	na	0.50	0.04				Chart				broad crested weir
78	Castlecary	Red Burn	22	Primary		1977	na	1.17	0.54	Y			Chart				
79	Bannockburn	Bannock Burn	23.7	Primary		1979	na	1.25	0.33			Y	TG1150				gabion basket control
80	Loch Venachar	Eas Gobhain	202	Secondary	Y	1979	na		0.08			Y	TG1150				sharp crested weir
81	Whinnyhall	Lochty Burn	14	Primary		1980	na	0.75	0.13			Y	TG1150				flat V weir
82	Craigforth	R Forth	1036	Primary		1982	na	0.33	0.21	Y		Y	TG1150				
83	Cashmore	Kelty Water	2.7	Primary		1982	na						Chart				flume
[illegible]	Lathro	North Queich	23.1	Primary		1984	na	0.92	0.54			Y	TG1150				
85	Kinross	South Queich	33.6	Primary		1985	na	0.92	0.58				Chart				
[illegible]	Duchry	Loch Ard Burn 10	0.85	Primary		1986	na						Chart				flume + crump weir
[illegible]	Elrig	Loch Ard Burn 11	1.45	Primary		1985	na						Chart				flume + crump weir
[illegible]	Langhill Weir	R Carron	77.7	Closed		1985	na						Chart				flume + broad crested weir
[illegible]	Cowbridge	South Esk	44.5	Primary		1990	na	0.92	0.54	Y			Chart				
[illegible]	Milton	R Forth	70.2	Primary		1989	na		0.25				Chart				
[illegible]	Lochend House	Goodie Water	19.2	Closed		1989	na						Chart				kerb control
[illegible]	Castlehill Res	R Devon	66	Primary		1991	na						Chart				thin plate + broad crested weir
[illegible]	Loch Katrine	Achray Water		Secondary	Y	1993	na					Y	TG1150	Y			sharp crested weir
94	Damleys Cottage	Greens Burn	14.1	Primary		1994	na					Y	TG1150				crump weir
95	Janefield	Peffer East		Primary		1993	na						Chart				flume
96	Kingledores	R Tweed	139	Primary	Y	1961	2.96	2.08	1.92	Y		Y	TG1150	Y			
97	Cademuir	Manor Water	61.8	Primary	Y	1968	2.67	1.58	1.92	Y		Y	TG1150				
98	Lyne Ford	R Tweed	373	Primary	Y	1961	2.72	2.25	1.75	Y		Y	TG1150				
99	Peebles	R Tweed	694	Primary	Y	1950	1.31	1.50	1.42	Y		Y	TG1150				
100	Brockhoperig	Ettrick Water	37.5	Primary	Y	1965	3.14	1.92	1.79	Y		Y	TG1150	Y			
101	Deephope	Tima Water	31	Primary	Y	1973	3.69	3.00	1.75	Y		Y	TG1150				
102	Hundleland	Megget Water	56.2	Primary	Y	1958	2.47	0.58	1.04	Y		Y	TG1150				
103	Craig Douglas	Yarrow Water	118	Primary	Y	1968	0.94	0.33	0.00			Y	TG1150				trapezoidal flume
104	Gordon Arms	Yarrow Water	156	Primary	Y	1967	2.28	2.33	1.92	Y		Y	TG1150	Y			
105	Philiphaugh	Yarrow Water	231	Primary	Y	1982	2.67	1.42	1.63	Y		Y	TG1150				
106	Lindean	Ettrick Water	499	Primary	Y	1961	3.11	2.25	1.88	Y		Y	TG1150				
107	Lyne Station	Lyne Water	175	Primary	Y	1961	2.56	2.08	1.96	Y		Y	TG1150				
108	Galashiels	Gala Water	207	Primary	Y	1963	2.00	2.17	2.13	Y		Y	TG1150				
109	Earlston	Leader Water	239	Primary	Y	1966	2.83	2.42	1.92	Y		Y	TG1150				
110	Hawick	R.Teviot	323	Primary	Y	1960	2.11	2.58	2.00	Y		Y	TG1150				
111	Jedburgh	Jed Water	139	Primary	Y	1971	2.67	2.58	2.29	Y		Y	TG1150				
112	Ancrum	Ale Water	174	Primary	Y	1972	2.53	2.33	2.13	Y		Y	TG1150				
113	Ormiston Mill	R Teviot	1110	Primary	Y	1960	3.42	2.67	2.33	Y		Y	TG1150	Y		Y	
114	Boleside	R Tweed	1500	Primary	Y	1961	1.58	2.67	2.04	Y	Y	Y	TG1150			Y	
115	Sprouston	R Tweed	3330	Primary	Y	1969	3.00	2.50	2.54	Y		Y	TG1150				
116	Norham	R Tweed	4390	Primary	Y	1969	2.53	1.75	2.33	Y		Y	TG1150			Y	
117	Coldstream	Leet Water	113	Primary	N	1970	3.92	1.33	1.08	Y		Y	TG1150				flume (low flow)
118	Eyemouth Mill	Eye Water	119	Primary	Y	1967	2.83	1.50	2.08	Y		Y	TG1150				
119	Mouth Bridge	Blackadder Water	159	Primary	Y	1973	2.17	1.33	1.96	Y		Y	TG1150	Y			
120	Hutton Castle	Whiteadder Water	503	Primary	Y	1969	0.00	0.00	0.00			Y	TG1150				compound crump weir

Scottish Environment Protection Agency, East Region.

APPENDIX III

[redacted]

Ref no.	GAUGING STATION	Water resources					Water quality			Floods		Other data uses			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Luther Br	*				*	*	*		*	*	*			
2	Prosen Br						*	*		*	*	*			
3	Kirkton Mill					*	*	*		*		*		*	*
4	Logie Mill						*	*	*	*	*	*		*	*
5	Brechin			*			*	*	*	*	*	*		*	
6	Dalhousie Br						*	*		*	*	*		*	
7	Arbroath						*	*		*	*	*			
8	Gella Br						*	*		*	*	*		*	
9	Guthrie						*	*		*				*	*
10	Colliston						*	*		*	*	*			
11	Kemback					*	*	*	*	*	*	*	*	*	*
12	Balmossie						*	*	*	*	*	*			
13	St Michaels	*				*	*	*		*		*	*		
14	Craigmill	*				*	*	*		*	*	*			
15	Strathmiglo					*	*	*		*	*	*			*
16	Kilmany					*	*	*		*		*			
17	Caputh	*					*	*		*	*	*		*	*
18	Ballathie	*					*	*	*	*	*	*		*	*
19	Pitnacree	*					*	*		*	*	*		*	
20	Cookston					*	*	*		*		*	*	*	
21	Wester Cardean	*					*	*		*	*	*		*	
22	Comrie Br	*		*			*	*		*	*	*		*	
23	Pitlochry	*	*		*		*	*		*	*	*		*	*
24	Almondbank	*					*	*	*	*	*	*		*	
25	Kindrogan						*	*		*	*	*		*	*
26	Newton Br	*					*	*		*	*	*			
27	Kenmore	*					*	*		*	*	*		*	
28	Millbank						*	*		*		*		*	
29	Hermitage						*	*		*	*	*		*	
30	Killin						*	*		*	*	*			
31	Craighall	*					*	*		*	*	*		*	
32	Loakmill	*				*	*	*		*		*			
33	Luncarty	*				*	*	*		*	*	*			
34	Pitcrocknie						*	*		*					
35	Dean Br					*	*	*		*	*	*			
36	Jackstone	*				*	*	*		*		*			
37	Killiecrankie		*				*	*		*	*	*			
38	Kinloch Rannoch	*	*				*	*		*	*	*		*	
39	Br of Gaur	*	*				*	*		*	*	*			
40	Marble Lodge						*	*		*	*	*			
41	Camusvrachan	*		*			*	*		*	*	*			
42	Gaillybanks	*				*	*	*							
43	Kinkell Br	*		*		*	*	*		*	*	*		*	
44	Cultybraggan	*					*	*		*	*	*			*
45	Forteviot Br	*					*	*	*	*	*	*		*	
46	Aberuthven						*	*		*	*	*			
[redacted]	Luffness	*				*	*		*			*	*		*
[redacted]	Musselburgh						*		*	*	*	*			
[redacted]	Craigiehall						*	*	*	*	*	*			
[redacted]	Murrayfield	*		*			*		*	*	*	*			
[redacted]	Almondell			*		*	*	*	*	*	*	*			
[redacted]	East Linton					*	*		*	*	*	*			
[redacted]	Spilmersford					*	*		*	*	*	*			
[redacted]	Saltoun Hall						*		*			*			
[redacted]	Salton House						*		*	*	*	*			
[redacted]	Dalmore Weir	*					*		*	*	*				
[redacted]	Lennoxlove						*		*	*	*				
[redacted]	Almond Weir						*	*	*	*		*			
[redacted]	Liberton						*		*	*	*	*			

CATEGORIES

1. Yield assessment
2. Reservoir safety
3. Operational resource monitoring
4. *Compensation flow monitoring*
5. Other abstraction monitoring
6. *Water quality/assimilative capacity studies*
7. Pollution control/consent standard monitoring
8. *PARCOM harmonised monitoring*
9. Design studies
10. Flood warning
12. Land drainage ← Baseline monitoring
13. Ecological/recreational studies
14. Research needs

Pitcrocknie discontinued in 1995

+5 -

Ref no.	GAUGING STATION	Water resources					Water quality			Floods		Other data uses			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14
[illegible]															
60	Cobbinshaw	•		•	•	•	•		•			•			
61	Dalkeith Palace	•					•		•	•		•			
62	Almondell			•	•	•	•					•			
63	Colinton	•		•	•		•		•	•	•	•			
64	Whitburn						•	•	•	•	•	•			
65	Turnhouse						•	•	•	•	•	•			
66	Polmonthill						•		•	•	•	•			
67	Bonnybridge						•	•	•	•	•	•	•		•
68	Headswood	•			•		•	•	•	•	•	•			•
69	Bridge of Teith	•		•			•		•	•	•	•			
70	Anie	•					•		•	•	•	•			•
71	Bridge of Allan	•					•		•	•	•	•			
72	Kinbuck						•		•	•	•	•	•		
73	Glenochil	•					•		•	•		•			
74	Gargunnock	•					•		•	•		•			
75	Leven	•					•		•	•		•		•	
76	Balfour Mains	•					•		•	•		•			
77	Fauld Mill	•				•	•	•	•	•		•			
78	Castlecary						•	•	•	•		•	•		•
79	Bannockburn	•					•		•	•		•			
80	Loch Venachar	•			•		•			•	•	•			
81	Whinnyhall						•	•	•			•			
82	Craigforth	•					•		•	•	•	•		•	
83	Clashmore	•					•		•				•	•	•
84	Lathro	•					•		•	•		•	•	•	•
85	Kinross	•					•		•	•		•	•	•	•
86	Duchry	•					•						•	•	•
87	Elrig	•					•						•	•	•
88	Langhill Weir	•		•	•		•								
89	Cowbridge	•					•		•	•		•			
90	Milton	•					•		•			•		•	•
91	Lochend House	•				•	•							•	•
92	Castlehill Res.	•		•	•		•					•			
[illegible]	Nungate						•			•	•	•			
[illegible]	Loch Katrine	•		•	•		•				•	•			
[illegible]	Callander	•					•			•	•	•			
[illegible]	Damleys Cottage	•					•	•	•			•	•	•	•
[illegible]	Janefield	•				•	•					•	•	•	
[illegible]	Riverside									•					•
96	Kingledores	•		•	•		•				•	•		•	•
97	Cademuir	•					•				•	•			
98	Lyne Ford			•	•	•	•				•	•			
99	Peebles				•		•	•		•	•	•		•	•
100	Brookhoperig	•					•				•	•		•	•
101	Deephope	•					•				•	•		•	
102	Henderland			•	•		•				•	•			
103	Craig Douglas	•		•	•		•				•	•			
104	Gordon Arms			•	•	•	•	•			•	•			
105	Philiphaugh			•	•		•				•	•			
106	Lindean			•	•	•	•	•			•	•			•
107	Lyne Station			•	•		•				•	•			
108	Galashiels					•	•	•		•	•	•			
109	Earlston						•				•	•			
110	Hawick						•	•			•	•			•
111	Jedburgh						•	•			•	•			
112	Ancrum			•	•		•				•	•			
113	Ormiston Mill				•		•				•	•			•
114	Boleside				•		•				•	•			•
115	Sprouston				•		•	•		•	•	•			•
116	Norham				•		•		•		•	•			•
117	Coldstream						•					•	•		
118	Eyemouth Mill					•	•		•		•	•			
119	Mouth Bridge					•	•	•			•	•			
120	Hutton Castle			•	•		•		•		•	•			•

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

95%ile, M.D.D.

How are the hydrometric data used?

To calculate consent conditions.

Would any further hydrometric data be used if the network were extended?

Maybe - not sure

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? ~~YES~~/NO

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

PROBABLY

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

at least 25%

What % of the consents in your area are linked to flow in the receiving watercourse?

Do you issue variable-rate consents based on available dilution? YES

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution? less than 1%

If not, are there plans to do so in your area? [illegible]

Name: B. GLOAK Telephone: 01738 627989

Position: POLL. CONT. MANAGER Region/Area: PERTH / TAY CATCHMENT

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here [ ]

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

How are the hydrometric data used? MAIN USES:- (1) TIME OF TRAVEL DATA - TO HELP MANAGE POLLUTION INCIDENTS - AS MOST OF MY RIVERS HAVE IMPORTANT POTABLE WATER ABSTRACTIONS IN THEIR LOWER REACHES. (2). DISCHARGE CONSENT DERIVATION.

Would any further hydrometric data be used if the network were extended?

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? **(YES)**/NO

b) commission you own flow measurement programme? YE**(S)**/NO

UNLIKELY - WATER RESOURCES WILL ~~[illegible]~~ RESPOND POSITIVELY TO OCCASIONAL REQUESTS TO PROVIDE ADDITIONAL DATA

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available? POSSIBLY SLIGHTLY MORE RESTRICTIVE, BUT IN PRACTICE THIS IS NOW RARELY AN ISSUE WITH THE "MOST RELAXED" CONSENTS NOW TYPICALLY "60:40" STANDARD

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

SAY 10%

What % of the consents in your area are linked to flow in the receiving watercourse? NO FIRM FIGURE READILY AVAILABLE - A HIGH % OF SMALL STW CONSENTS ARE NOT LINKED TO FLOW

Do you issue variable-rate consents based on available dilution? - YES FISH FARM CONSENTS & 1 PIC TISSUE

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution? ONLY 2/3 IN AREA

If not, are there plans to do so in your area?

Name: R MERRIMAN Telephone: 01437 760081

Position: DPCM Region/Area: WELSH

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Any further comments? - please use reverse of form and tick here .... [ ]

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(73) (58)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

FIELD FLOW GAUGINGS
DATA COLLECTED FROM GAUGING STATIONS

How are the hydrometric data used?

DETERMINATION OF DISCHARGE CONSENT APPLICATIONS, REVIEW OF EXISTING CONSENTS

Would any further hydrometric data be used if the network were extended?

YES

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~ RELUCTANTLY
b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

POSSIBLY

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

IMPOSSIBLE TO SAY

What % of the consents in your area are linked to flow in the receiving watercourse?

5 - 10% (WHERE CONDITIONS CALCULATED USING HYDROMETRIC DATA)

Do you issue variable-rate consents based on available dilution?

RARELY

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

< 1% YES

If not, are there plans to do so in your area?

Name: T.C. HAMBLY Telephone: 01208 78301 x 5053

Position: DISCHARGE CONSENTS OFFICE Region/Area: SOUTH WEST REGION - CORNWAL

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Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

95%ile Low flow (Q95) and Average Daily Flow determined from long term flow hydrograph.

How are the hydrometric data used?

For calculating effluent quality standards using Monte Carlo mass-balance modelling.

Would any further hydrometric data be used if the network were extended?

The flow statistics required are rarely available for the watercourse

---

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? currently used most of the time. (YES)/NO

b) commission you own flow measurement programme? YES/(NO)

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available? POSSIBLY

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

What % of the consents in your area are linked to flow in the receiving watercourse?

< 1% (ABOUT 11)

Do you issue variable-rate consents based on available dilution? NO

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

If not, are there plans to do so in your area? NO

Name: RICHARD DEAN Telephone: 7 23 3124

Position: ASST. WQ PLANNER Region/Area: SOUTHERN / KENT

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INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

Data from 37 fixed surface water gauging stations, and also from various gaugings undertaken for specific 'cases'. Principal data required is mean & 95%iles

How are the hydrometric data used?

The data is required for modelling purposes – for the derivation of standards for consents (to discharge).

Would any further hydrometric data be used if the network were extended?

Yes.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~

Theoretical estimates are currently used for proposals in catchments where data is not available.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available? Not usually.

An estimate of flow would need to be used; a conservative estimate of flow would mean a more restrictive consent be applied

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

—

What % of the consents in your area are linked to flow in the receiving watercourse?

None that are directly linked. There are a number of "seasonal" consents which allow a relaxation of standards during the winter months when flows are higher. (<5

Do you issue variable-rate consents based on available dilution?

No.

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

—

If not, are there plans to do so in your area?

No

Name: J D NUTTER Telephone: 01278 457333

Position: AUTHORISATIONS OFFICER Region/Area: SOUTH WEST – NORTH WESSEX AREA

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Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(11)

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

Mean flow, Q95 flow: approx 12 stations.

How are the hydrometric data used?

Consent calculations
Risk assessments for pollution preventions.

Would any further hydrometric data be used if the network were extended?

yes

If hydrometric data collection were to cease, would you:
a) use theoretical estimates? - only as last resort. ~~YES~~/NO
b) commission you own flow measurement programme? YES/~~NO~~

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

Consent is based on best available info. If no data available need to commission measurement programme

ASIANTAETH YR AMGYLCHEDD
ENVIRONMENT AGENCY

with compliments

The Environment Agency
Chester Road, Buckley, Flintshire CH7 3AJ
Tel 01244 550124 Fax 01244 550144

Position: Area - Consents Officer Region/Area: Welsh N. Area

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Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Pollution control/discharge consents

What hydrometric data do you use - type of data and approx number of stations

Approx 60 river flow gauging stations in the Area. 16 provide river levels only. The rest measure levels and flows every 15 minutes. We use the annual & seasonal statistics - means, 95%ile exceedence flows. Also flow duration curves occasionally

How are the hydrometric data used?

Usually input mean/95%ile into mathematical models when calculating consent standards. For certain catchments (sensitive) data is being used to calculate both point source and diffuse nutrient loadings.

Would any further hydrometric data be used if the network were extended?

Yes. Would benefit from more stations, particularly u/s of all significant STWs.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~

b) commission you own flow measurement programme? YES/~~NO~~

We already use theoretical estimates and 'spot' gaugings i) where no flow station exists and ii) where flow station exists but interested in location further u/s or d/s.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

Yes - although if discharge was significant would at least try to get a "low flow" upstream spot gauging done.

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

Difficult to quantify. Consent std would be based on low-flow worst case flow rather than on the whole river flow distribution.

What % of the consents in your area are linked to flow in the receiving watercourse?

Apart from small septic tank discharges, all will be linked to) 80% ?

Do you issue variable-rate consents based on available dilution?

No - but some consents to tidal waters only allow discharges to occur around high water.

If so, what % of the consents in your area are of this type; are real-time data used to assess available dilution?

Very few - 1%

If not, are there plans to do so in your area?

No

Paul Simmons

pp Name: LAURENCE RANKIN Telephone: 01772 339882

Position: WATER QUALITY AREA MNGR Region/Area: NW/CENTRAL

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(23)

INFORMATION REQUEST: Pollution control/discharge consents

..t hydrometric data do you use - type of data and approx number of stations

Hydrometric Staff supply data based on Microflow Software qualified by spot gaugings where available. River flow.

How are the hydrometric data used?

As data inputs to water quality models

Would any further hydrometric data be used if the network were extended?

Soil Moisture Deficits might be of some use i.e. application of farm waste to land and likely runoff.

If hydrometric data collection were to cease, would you:

a) use theoretical estimates? YES/~~NO~~ Would have to.

b) commission you own flow measurement programme? YES/~~NO~~

Necessary / Vital to certain things.

If no flow data were available for a given reach of river, would you have to issue a more restrictive consent than if flow data were locally available?

No, unfair to use a pessimistic assumption if we don't bother to gather data, WSC likely to appeal.

If so, please indicate the typical % difference likely between a consent based on observed data and one based on estimates (eg 25% reduction).

...of the consents in your area are linked to flow in the receiving watercourse?

70% = all based on defining flow distribution from 5%ile low flow to mean flow.

Do you issue variable-rate consents based on available dilution? NO.

If so, what % o.. ..e consents in your area are of this type; are real-time data used to assess availab... ..ilution?

If not, are ther... ...s to do so in your area?

Name: R. MOORE Telephone: 01543 444144 EXT 4800

Position: AREA WATER QUALITY PLANNER Region/Area: MIDLANDS UT AREA.

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Any further comments? - please use reverse of form and tick here ...

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Questionnaire responses

FLOOD WARNING

(i)

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)? Currently we use the following telemetry sites :— 54 Rainfall, 28 flow, 28 level & 9 tide. The system will be expanded as part of ARTS See note 1

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

4 or 5 flood events of 1yr return & above - these could occur in one winter period.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

Yes

How are hydrometric data used for flood warning models?

a) ~~As levels/As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

See Note 1 re ARTS

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

No sensitivity analysis has been carried out. Certainly removal of 25% or more of current gauging network would seriously affect the warning system.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: JOHN EAST Telephone: 01522 513100 Ex 4569

Position: AREA HYDROLOGIST Region/Area: ANGLIAN / NORTHERN AREA

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Any further comments? - please use reverse of form and tick here ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

The telemetry monitoring of level and flow and forecasting capability will be expanded via the Anglian Region Telemetry System Project. Project documents contain details of benefits from flood warning. Nigel Fawthrop will have appropriate documents.

73

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data; approx number of stations)? River Level } - 170
River Flow }
Rainfall - 110
Some sites are combined sites.

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? 5 YEARS -- MINIMUM. - BUT, OF COURSE, FLOOD WARNING IS INTERESTED IN EXTREMES AND THESE DO NOT ALWAYS FALL TIDILY INTO A MINIMUM DURATION OF YEARS.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? STATIONS HAVE BEEN ADDED PERMANENTLY TO PROVIDE DATA TO ISSUE WARNINGS - THIS IS INEVITABLE. MODELS MAY SUBSEQUENTLY BE DEVELOPED. DO YOU DEFINE THE HYDROMETRIC NETWORK ~~TOTAL~~ AS ALL SITES ~~THAT~~ AT WHICH WATER LEVEL/FLOW IS MEASURED - OR JUST THAT PART OF NETWORK MAINTAINED BY HYDROMETRIC SECTION.

How are hydrometric data used for flood warning models?

a) ~~As levels~~/~~As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) PLEASE REFER TO "AN ASSESSMENT OF THE COSTS + BENEFITS OF FLUVIAL FLOOD FORECASTING" NRA R+D NOTE 463 - AVAILABLE FROM ENVIRONMENT AGENCY HEAD OFFICE. - this is latest R+D project + will have the latest figures.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?). FLOOD WARNINGS ARE SITE SPECIFIC + USE INFORMATION FROM SPECIFIC STATIONS, THEREFORE PERCENTAGE REDUCTIONS DO NOT DEAL WITH THE ISSUE. IF THE 25% BEING REMOVED ARE THOSE USED BY FW THEN IT IS SENSITIVE.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? [redacted]/NO

Would it use data from more stations if the network were extended? YES/[redacted]

Name: Telephone:

Position: Region/Area:

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Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(8) (X)

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)?
30 TELEMETRY RAINGAUGES
30 TELEMETRY RIVER FLOW SITES
22 TELEMETRY RIVER LEVEL SITES
TO PROVIDE WARNING for 8,500 km² Catchment

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? THE MINIMUM IS A 6 MONTH PERIOD IN THE WINTER SEASON IN WHICH FLOOD FLOWS ARE NEARLY OUT OF BANK IN THE FLOOD RISK LOCATION AT LEAST ONCE. IN SOME AREAS THIS MAY NOT HAPPEN FOR 3 YEARS IN OTH AREAS IT MAY HAPPEN IN THE FIRST Y

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

YES AT LEAST AT 2 SITES – BUT THE EQUIPMENT WAS UPGRADED FOR BETTER ACCURACY

How are hydrometric data used for flood warning models?

a) ~~As levels/As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐
Using real-time data to inform duty flood warning officer ☑
Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) Two specific schemes in Central Area that rely on a flood warning system operating have benefits of approx £260,000 and £80,000.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

There is a 100% reliance on each gauge providing the warning. Consequently removing them would mean a need to send a person out in a flood to monitor level

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~
Would it use data from more stations if the network were extended? YES/~~NO~~

Name: T.M. ETTRICK + CHRIS CONVINE Telephone: XT 4933

Position: HYDROLOGIST + ASSISTANT ENGINEER DESIGN Region/Area: ANGLIAN (BRAMPTON OFFICE CENTRAL AREA)

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Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

IF YOU REQUIRE ANY FURTHER INFORMATION FROM ANGLIAN REGION, CENTRAL AREA ON FLOOD WARNING

Please Contact : BRYONY C. MAY

EMERGENCY PLANNING OFFICER, CENTRAL AREA,

ENVIRONMENT AGENCY, ANGLIAN REGION,
CENTRAL AREA,
BROMHOLME LANE,
BRAMPTON,
HUNTINGDON,
CAMBS., PE18 8NE.

Telephone :- 01733 464972
Fax :- 01480 413381

(5)

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)?

River Level, flow, calibrated gauges to OD(N). c. 50 sites.

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

guess... 5-10 yrs.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

No.

How are hydrometric data used for flood warning models?

a) A~~s levels/As flow~~s/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

– Visual Reporting via Radio-link from what we call "Flood Patrols."

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) No details.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

No details.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/NO

Would it use data from more stations if the network were extended? YES/NO

Name: JOHN DORA Telephone: 01734 533381

Position: OPERATIONS MANAGER Region/Area: THAMES - WEST

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Any further comments? - please use reverse of form and tick here .... ☑

[redacted] return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

pleased to help – did my degree at Dundee (Civil Eng!) in 1981!
JD.

Please note Thames Region manages Flood Warning not from the Area's but as a Regional service based at Waltham Cross under Chris. Haggett.

I assist in providing info. based on field observation and limited telemetred sites, in deciding upon the issuing of warnings.

[signature] 29.10.96

(X4)

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)? River levels & flows
Loch and reservoir levels 48
Sea levels Rainfall intensity

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? We do not yet operate any FW models

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? NO

How are hydrometric data used for flood warning models?

a) As levels/As flows/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐
Using real-time data to inform duty flood warning officer ☒
Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) Not quantified in any of the 7 FW schemes

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?). 12 stations are not normally used in a FW context. Removal of either 25 or 50% would render schemes inoperable unless some were sacrificed for others

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: RICHARD BROWN Telephone: 01349 862021

Position: HEAD OF HYDROLOGY Region/Area: SEPA NORTH REGION

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Any further comments? - please use reverse of form and tick here .... ☒

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Please note :-

Same comments as for attached sheet.

RS

12/11/96

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)? Data type: River flow, river level, rainfall, air temperature. 43 Stations + link to Scottish Hydro Electric Clunie control room for 15 parameters on loch levels, spillways, turbines & ground sluices.

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? Record not essential. Models can be used when a record is not available*. Data will improve the quality of the flood warning model.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? Yes, 7.

How are hydrometric data used for flood warning models?

a) ~~As levels/As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

See Babtie Shaw & Morton and Ove Arup reports on Tay Floods 1990 & 19[illegible]

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?). Reliability of system and quality of decision making would be substantially reduced if stations removed.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: JOHN ANDERSON Telephone: 01738 627989

Position: PRINCIPAL HYDROLOGIST Region/Area: SEPA EAST (formerly Tay R.P.B)

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Initial alarm thresholds on new stations have been set after flood estimation and hydraulic modelling exercise.

INFORMATION REQUEST: Flood warning (161)

What data are needed for flood warning purposes (type of data, approx number of stations)? RAINFALL, RIVER LEVEL, SNOW DATA
TIDAL LEVELS
50

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

DEPENDS ON QUALITY

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? YES

How are hydrometric data used for flood warning models?

a) As levels/~~As flows/Both~~ *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: PAUL DODDS Telephone: 0191 203 4000

Position: AEC Region/Area: NORTH EAST

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

This is possibly the worst questionaire I have ever had the misfortune to have to complete

...CURRENTLY WE ONLY OPERATE 1 FLOOD WARNING SYSTEM. WE ARE INVESTIGATING A FURTHER 2 FLUVIAL WARNING + 1

INFORMATION REQUEST: Flood warning

COASTAL SYSTEM

What data are needed for flood warning purposes (type of data, approx number of stations)? 6 LEVEL + 4 RAINFALL (WHITE CART)

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? LITTLE RECORD REQUIRED IF BASED ON MODELLING STUDIES, ALTHOUGH A PERIOD OF VALIDATION IS REQUIRED (SAY ONE WINTER SEASON ??)

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? YES, STATIONS HAVE BEEN CREATED FOR FLOOD WARNING, AND THEY HAVE BEEN ADDED TO NETWORK.

How are hydrometric data used for flood warning models?

a) As ~~levels/As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

I SUSPECT BY REMOVING UP TO 50% OF THE FLOOD WARNING LEVEL GAUGES WOULD ONLY HAVE RELATIVELY MINOR IMPACT, THIS IS DUE TO MODELLING INPUT. HOWEVER THESE STATIONS ARE USEFUL FOR STAT... S... IN HO... PROGR... OF FL...

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: MARC BECKER Telephone: 01355 238181

Position: HYDROLOGIST Region/Area: SEPA WEST

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(50)

INFORMATION REQUEST : Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)? North Area, North West Region.
30No. real time level outputs with known stage discharge curves.

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? 10 years.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?
No but they may be in the future

How are hydrometric data used for flood warning models?

a) As levels/As flows/Both (circled: Both) *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑
Using real-time data to inform duty flood warning officer ☑
Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) Ask RFH at Warrington for reports.
Say #50K savings each year.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).
We would be 'stum' without 25% or 50% of the network.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~
Would it use data from more stations if the network were extended? YES/~~NO~~

Name: Andrew Chraser Telephone: 01228 - 25151.

Position: Technical Manager Region/Area: North West Region / North West Area

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....

Please return to Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(5)

INFORMATION REQUEST: Flood warning

PLEASE NOTE THAT FLOOD WARNING STATIONS WITHIN THE AGENCY ARE USED SOLELY FOR THE INITIATION OF EMERGENCY PROCEDURES WITHIN THE AGENCY AND NOT USED TO WARN THE GENERAL PUBL[IC]

What data are needed for flood warning purposes (type of data, approx number of stations)? ONLY 3 STATIONS (OUT OF 100 TOTAL) USED FOR FLOOD WARNING PURPOSES.
2 NO. AT OMAGH, CO. TYRONE — R. CAMOWEN - 201013 & R. DRUMRAGH - 201014
WATER LEVEL INFORMATION AVAILABLE TO AREA OFFICE VIA TELEMETRY (B.T. LINES).
1 NO AT LOWER BANN RIVER @ LOUGHAN ISLAND NEAR COLERAINE - 203301

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

COULD BE OF IMMEDIATE USE

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

NO

How are hydrometric data used for flood warning models?

a) As levels/~~As flows/Both~~ *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐
Using real-time data to inform duty flood warning officer ☑
Other (please specify) AREA OFFICE HAS ACCESS TO STATIONS VIA TELEMETRY BUT THERE IS NO AUTOMATIC WARNING SYSTEM

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) NOT KNOWN

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

NOT REALLY APPLICABLE DUE TO SMALL NUMBER OF RELATED STATIONS

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? ~~YES~~/NO

Name: [signature] Telephone: 01232 253372

Position: SENIOR ENG, HYDROMETRICS Region/Area: N. IRELAND

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Lct

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)? Data must be real-time, and available at short notice - eg. every 15mins. At present we have around 25 flood zones, served by just under 30 raingauges and 70 river level sites. However, the number of flood zones is set to increase dramatically, with consequent data need increases

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

Absolute minimum would be 2 or 3 events. But several years of data is best, inorder to produce an accurate and robust model

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

Yes, Yes.

How are hydrometric data used for flood warning models?

a) ~~As levels~~/~~As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

Subject to current R+D, by Peter Borrows.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

It would be extremely difficult, if not impossible to provide a flood warning system with any reduction in gauges.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: OWEN WEDGWOOD Telephone: 01925-653999

Position: Assistant Hydrologist. Region/Area: North West.

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ..... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood warning (30)

What data are needed for flood warning purposes (type of data, approx number of stations)?
RIVER FLOWS, RIVER LEVELS, LOCH LEVELS, RAINFALL, SNOWCOVER, GENERAL MET. CONDITIONS, REAL TIME DATA ACQUISITION.

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

CAN BE OF IMMEDIATE USE.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

YES.

How are hydrometric data used for flood warning models?

a) ~~As levels~~/~~As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) NO INFORMATION. PERHAPS LOCAL EMERGENCY PLANNING OFFICERS ??

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).
FLOOD WARNING SCHEMES ARE OPERATED WITH A BARE MINIMUM OF STATIONS AT THE MOMENT. - COULDNT OPERATE WITH ANY LESS.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? (YES)/NO

Would it use data from more stations if the network were extended? (YES)/NO

Name: MARK HALLARD Telephone: 0131-449 7296

Position: SENIOR HYDROLOGIST Region/Area: SEPA. EAST REGION (EDINBURGH)

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

SEE ATTACHED REVIEW OF GAUGING STATION USE.

(15)

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)? LEVEL, FLOW, RAINFALL/SNOWFALL, S.M.D., TIME. DON'T KNOW HOW MANY STATIONS NEEDED BUT THERE WILL NEVER BE ENOUGH.

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? D/K.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? DON'T KNOW.

How are hydrometric data used for flood warning models?

a) ~~As levels~~/~~As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐
Using real-time data to inform duty flood warning officer ☑
Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) D/K.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?). AT A GUESS REMOVING 25% OF NETWORK WOULD REDUCE EFFECTIVENESS BY 50%+. LOW FLOW STNS ARE NOT V.USEFUL FOR FLOOD WARNING.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~
Would it use data from more stations if the network were extended? YES/~~NO~~

Name: M.A.S. STEEN Telephone: 01473 -727712

Position: EMERGENCY PLANNER Region/Area: ANGLIAN REGION / EASTERN AREA

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)?

Flow monitoring, level monitoring, rainfall monitoring

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

Yes and Yes

How are hydrometric data used for flood warning models?

a) As levels/As flows/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐

Using real-time data to inform duty flood warning officer ☐

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

1) Essential
2) Severe impact on Flood Warning ability
3) —

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/NO (YES circled)

Would it use data from more stations if the network were extended? YES/NO (YES circled)

Name: Brian Garbett Telephone: 01543 444141

Position: Flood Emergencies Officer Region/Area: Midlands Region, Upper Trent Area

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood ~~warning~~

What data are needed for flood warning purposes (type of data, approx number of stations)? FLOOD PEAK DATA OVER AS LONG A PERIOD AS POSSIBLE FOR STATIONS LOCAL TO TARGET OF WARNINGS + FOR UPSTREAM STATIONS.

What is the minimum record length required for a station to be useful in the setting-up of a flood ~~warning~~ forecasting model? 5YRS.

Have new stations ever been established in your area purely for the creation of a flood ~~warning~~ forecasting model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? YES.

How are hydrometric data used for flood warning models?

a) ~~As levels~~/~~As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood ~~warning~~ forecasting model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) SEE N.R.A. BUSINESS CASE FOR NATIONAL FLOOD WARNING PROJECT.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?). THE NETWORK INCLUDES THE WHOLE HYDROMETRIC NETWORK. A NUMBER OF STATIONS USED SOLELY FOR LOW FLOW MEASUREMENT COULD BE REMOVED – SAY 10% WITHOUT PROBLEM

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: E.G.F. ING Telephone: 01 743 272 828

Position: SEN. ENG. Region/Area: MIDLANDS, UPPER SEVERN,

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

(16)

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)?

RIVER LEVEL } REAL TIME N° 6
TIDE LEVEL } REAL TIME N° 60 approx.
RAINFALL } REAL TIME N° 10-15

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? 1 or 2 years.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? Yes.

How are hydrometric data used for flood warning models?

a) As levels/As flows/Both BOTH *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) Don't know but will be significant.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

A significant effect, g/s data forms a major part of Flood Warning.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/NO SOME BUT NOT ALL

Would it use data from more stations if the network were extended? YES/[redacted]

Name: BRYAN NELSON Telephone: 01325 480849

Position: AREA EMERGENCY CO-ORD Region/Area: NE REGION | DALES AREA. = YORK?

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood warning

(60)

What data are needed for flood warning purposes (type of data, approx number of stations)?

RIVER LEVELS AND RAINFALL - 41 STATIONS

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

10

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network?

YES (8)

How are hydrometric data used for flood warning models?

a) As levels/~~As flows/Both~~ *(delete as appropriate)*

b) Using real-time data in a flood warning model ☐

Using real-time data to inform duty flood warning officer ☑

Other (please specify)

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!)

RECENTLY - MINIMAL

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?).

EXTREMELY SENSITIVE

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: D. McRAW Telephone: 01896 754797

Position: HYDROLOGIST Region/Area: SEPA EAST

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood warning

What data are needed for flood warning purposes (type of data, approx number of stations)? VARIES

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model?

MODEL DEVELOPMENT UNDERTAKEN BY REGIONAL HEAD OFFICE FLOOD WARNING TEAM.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? YES NEW STATIONS HAVE BEEN ESTABLISHED FOR FLOOD WARNING PURPOSES AND THESE HAVE BEEN ADDED TO THE PERMANENT HYDROMETRIC NETWORK.

How are hydrometric data used for flood warning models?

a) ~~As levels~~/~~As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify) USING HISTORICAL INFORMATION FOR MODEL DEVELOPMENT PURPOSES.

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) JUSTIFICATION OF FLOOD WARNING SYSTEMS IS UNDERTAKEN BY REGIONAL HEAD OFFICE FLOODWARNING TEAM.

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?). THE MAJORITY OF THE FLOODWARNING SYSTEM RELIES ON REAL-TIME DATA TO ANALYSE TRENDS AND MAKE MANUAL PREDICTIONS. ANY LOSS OF THE NETWORK WOULD THEREFORE LEAVE A GAP IN INFORMATION AND A LOSS OF FLOODWARNING COVERAGE.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~ BY NECESSITY.

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: RICHARD MACILWAINE Telephone: 0161 973 2237

Position: TECHNICAL MANAGER Region/Area: NORTH WEST / SOUTH AREA.

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Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood warning (2)

What data are needed for flood warning purposes (type of data, approx number of stations)? Data for F.W. Purposes - Level/Flow at each warning location is ideal. Trent catchment approx. 46 Interrogable raingauges and 60 gauging stations.

What is the minimum record length required for a station to be useful in the setting-up of a flood warning model? Minimum of 3 to 4 flood events typically for yellow warnings - maybe a minimum 2/3 years records - ideally much longer.

Have new stations ever been established in your area purely for the creation of a flood warning model and, if so, have any of these stations subsequently been added permanently to your hydrometric network? No. Maybe in the future as a result of Catment Management Plans (now Local Environment Agency Plans) and the extension of the existing system.

How are hydrometric data used for flood warning models?

a) ~~As levels~~/~~As flows~~/Both *(delete as appropriate)*

b) Using real-time data in a flood warning model ☑

Using real-time data to inform duty flood warning officer ☑

Other (please specify) Level to level correlation. Extended use of Radar.

What is the average annual economic saving to the community which is thought to accrue from operation of the flood warning system(s) in your area? (If there are any reports on this subject which you could send/lend us, these would be gratefully received; 1-2 per area maximum!) £1 M per year (Region).

How sensitive is your warning system(s) to gauging station data? For example, what would be the outcome of removing 25% or 50% of the network? If any sensitivity analysis has been undertaken, please comment on the relative importance of individual stations (eg are some superfluous to model performance?). Depends on which stations. Generally very sensitive. Optimum coverage at present. Reduction in coverage would produce direct reduction in Standards of Service.

If the hydrometry function were to be removed, would the flood warning function wish to assume responsibility for all current flood warning stations? YES/~~NO~~

Would it use data from more stations if the network were extended? YES/~~NO~~

Name: R. C. Ledhams Telephone: (0115) 9455772

Position: Senior Engineer (Emergencies and Systems) Region/Area: Midlands / Lower Trent Area.

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Please return to. Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Questionnaire responses

FLOOD DEFENCE

63

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

- Historic only (eg data up to 1 year ago) ☑
- Mix of historic and recent ☑

How are hydrometric data used? Assessing flood return periods

How would flood defence functions be attempted in the absence of any historic hydrometric data? FSR mainly, level gauges.
(FSR = Flood Studies Report. AB)

Would Flood Defence use data from more stations if the network were extended?

Not routinely

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

± 50mm would be nice

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Any greater than ± 0.1m not worth having on tidal section

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

Not directly - most Sussex stations cannot gauge flood flows.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

?

What hydrometric data do you require for channel maintenance and weed-clearing work? Data is not used for maintenance purposes generally. Useful for consent purposes re temp works.

Name: Adrian Biggs Telephone: 01903 - 215835

Position: Area FDM Region/Area: Sussex Area

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[illegible]

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☐

Mix of historic and recent ☑
& real time.

How are hydrometric data used? Development Control (identification of flood plains), Investigation of flooding problems / programming of maintenance & improvement works (including design), Flood Warning & emergency planning, Information on flood risk for insurance, house purchase etc.

How would flood defence functions be attempted in the absence of any historic hydrometric data? On site 'by eye' assessments of flood risk, use of Flood Studies for flow data. But the above functions would all be subject to question & considerable errors would occur.

Would Flood Defence use data from more stations if the network were extended?
Yes. We can never have too much data.

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? Flows → need to be accurate to ± 10% for use in model design & calibration.
Levels to nearest 0.01m for all purposes.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?
Regulatory function is seriously hampered by lack of real data in defining flood plains and assessing flood risk. Legal actions & planning inquiries/planning appeals hinge on reliable data. Design – uncertainty can lead to overdesign for safety, or errors.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available? All FD Capital works & 80% of Revenue works are justified by C/B analysis based on flood losses. Flood Plain mapping in Region was justified by cost of using emergency services / development control appeals. Also a B/C of Flood Warning used in Alscot Park G.S. refurbishment. Copies in Region/Area.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?
This is so subjective I do not believe it is a valid question and any answer given would be at best misleading.

What hydrometric data do you require for channel maintenance and weed-clearing work? Flows, levels ie stage/discharge relationship. Long term statistics for return period analysis. Details sufficient for construction & calibration of hydraulic models.

Name: J.D. Crabbe / J.D. Banks Telephone: 01684 850951

Position: Senior Eng (Tech Team) / Asst. Eng (Works) Region/Area: Midlands / Lower Severn.

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Hydrometric provision is managed Regionally & the requirements across the Region have been assessed. There are shortfalls in the current provision of stations and specific site gaugings i.e. inadequate range of measurements, shortage of length of records & 'gaps' in network so rivers/reaches not adequately covered.

Calibration of models is particularly problematical.

Estimation of long return period floods is unreliable/inaccurate for many sites.

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☐

Mix of historic and recent ☑

DATA FROM APPROX. 80 STATIONS OUT OF 100 TOTAL USED FOR FLOOD DEFENCE PURPOSES.

How are hydrometric data used? SHORT TERM – DETERMINING TIME TO PEAK FOR ESTIMATION OF Q bar.
LONG TERM – DEVELOPMENT OF RATINGS AND ESTIMATION OF FULL RANGE OF FLOWS/ RETURN PERIODS AND RIVER LEVELS. DATA ALSO USED IN RESEARCH eg F.E.H.

How would flood defence functions be attempted in the absence of any historic hydrometric data?

CATCHMENT CHARACTERISTIC METHODS OF FLOOD ESTIMATION

Would Flood Defence use data from more stations if the network were extended?
NETWORK HAS BEEN EXTENDED RECENTLY FOR FLOOD STUDIES RELATED TO SPECIFIC AREAS AND FOR RESEARCH PURPOSES

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? USUAL MEASUREMENT ACCURACY = ± 5mm
REQUIRED FLOOD LEVEL ACCURACY WOULD BE RIVER-DEPENDENT AS WITH SOME RIVERS A SMALL RISE IN LEVEL GIVES A LARGE RISE IN RETURN PERIOD, AND VICE-VERSA. BENEFITS AVAILABLE FROM FLOOD ALLEVIATION WOULD PROBABLY BE LEVEL DEPENDENT.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?
MAY DEPEND ON INDIVIDUAL FLOODED AREA BUT LOWER ACCURACY MAY HAVE SIGNIFICANT EFFECT ON BENEFITS

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

YES

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

NOT KNOWN

What hydrometric data do you require for channel maintenance and weed-clearing work?

LITTLE OR NO ASSESSMENT OF DATA DONE FOR MAINTENANCE PURPOSES.

Name: [signature] Telephone: 01232 253372

Position: SENIOR ENG. HYDROMETRICS Region/Area: N. IRELAND

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INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☐

Mix of historic and recent ☑

(X2)

How are hydrometric data used? DESIGN CRITERIA, MAINTENANCE WORKS, OPERATIONAL CONTROL, ENVIRONMENTAL SCHEMI MODEL CALIBRATION, WATER BALANCES etc...

How would flood defence functions be attempted in the absence of any historic hydrometric data? less accurately, less assured, poorer standards or too high standards hence increased costs and /or decreased benefits. lack of Planning Control info.

Would Flood Defence use data from more stations if the network were extended?

YES

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? ± 10% ± 50 mm or ± 100 mm depending of scale, sensitivity etc...

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

YES

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

YES & YES

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

? How do you measure. Operationally up to £500,000

What hydrometric data do you require for channel maintenance and weed-clearing work? Stage / discharge information. levels - real time compared to predetermined alarm / threshold levels ± 10 mm

Name: D.P. VAN BEESTEN Telephone: 01932 789833 Ext 3430

Position: OPERATIONS MANAGER Region/Area: THAMES South East Area.

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If it would help I would be delighted to attend an interview. I have been in the industry for 25 years and been involved in:-

1. Flood Defence Capital Works - Feasibility, Design & Construct
2. Project Management
3. Land Drainage Schemes
4. Environmental Enhancements
5. Reservoir Design
6. Development Control
7. Flood Defence Maintenance Programmes
8. Land Drainage Consents
9. Navigation on the Thames, Kennet and Avon Canal, & River Wey
10. Operation of Flood Defence Assets.

David
4/11/96

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

- Historic only (eg data up to 1 year ago) ☑
- Mix of historic and recent ☑

How are hydrometric data used? Assessing flood return periods

How would flood defence functions be attempted in the absence of any historic hydrometric data? FSR mainly, level gauges.
(FSR = Flood Studies Report. AGB)

Would Flood Defence use data from more stations if the network were extended?

Not routinely

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

± 50mm would be nice.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Any greater than ± 0.1m not worth having on tidal section

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

Not directly - most Sussex stations cannot gauge flood flows.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

?

What hydrometric data do you require for channel maintenance and weed-clearing work? Data is not used for maintenance purposes generally. Useful for consent purposes re temp works.

Name: Adrian Biggs Telephone: 01903 - 215835

Position: Area FDM Region/Area: Sussex Area

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FAX to Caela Nevin, Stirling Univ. 1 page only. 30/10/96.
Another late-comer! Andrew.

INFORMATION REQUEST: Flood defence

(37)

What data are required for flood defence purposes?

- Historic only (eg data up to 1 year ago) ☐
- Mix of historic and recent ☑

How are hydrometric data used? FLOOD FORECASTING/ANALYSIS. ESTIMATION OF FLOOD RISK; DESIGN OF FLOOD ALLEVIATION SCHEMES

How would flood defence functions be attempted in the absence of any historic hydrometric data?

APPLICATION OF THEORETICAL TECHNIQUES DRAWN FROM THE FLOOD STUDIES REPORT.

Would Flood Defence use data from more stations if the network were extended?

POSSIBLY

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

i) data – flows ± 10%

ii) levels – ± 0.1 m. for damage records

(iii) ± 0.01m for flow gauging?

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Vulnerability to sensitivity analysis, therefore reduced/impaired justification. Can't quantify degree of loss.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

Yes, but few recent schemes have been promoted in-house. Could be an issue with Consultants' intellectual copyright.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

100% or don't know – sorry, can't interpret question to provide an unambiguous answer!

What hydrometric data do you require for channel maintenance and weed-clearing work? x-year return period flows and stages for design standard floods.

Name: I. W. HART Telephone: 01733 46 4925

Position: Flood Defence Mgr. Region/Area: ANGLIAN/CENTRAL

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Any further comments? - please use reverse of form and tick here .... ☐

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INFORMATION REQUEST: Flood defence

(2)

What data are required for flood defence purposes?

- Historic only (eg data up to 1 year ago) ☑
- Mix of historic and recent ☑

How are hydrometric data used? - TO DETERMINE CATCHMENT FLOW FIGURES SET AGAINST RETURN PERIODS (FLUVIAL)

How would flood defence functions be attempted in the absence of any historic hydrometric data?
USE DATA FROM ADJACENT CATCHMENTS - USE FLOOD STUDIES CATCHMENT CHARACTERISTIC'S METHOD OR SIMILAR

Would Flood Defence use data from more stations if the network were extended?
YES - THIS WOULD IMPROVE LEVELS OF CONFIDENCE IN CATCHMENT HYDROLOGY

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? -
FLOOD LEVELS ± 50MM - HYDROMETRIC DATA BEST POSSIBLE AVAILABLE

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?
LACK OF DATA CONFIDENCE - COULD UNDER ESTIMATE FLOWS - REDUCE SCHEME JUSTIFICATIONS

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available? word is benefit/cost
Yes - we have several which would be available upon request.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?
Do not understand this question - The benefits are those from flooding ie £1m per annum hydrometric data as such, may have a cost value to obtain, but this is not a benefit as such in many terms

What hydrometric data do you require for channel maintenance and weed-clearing work? FLOWS - VELOCITIES - LEVELS - MANNING COEFFICIENTS FOR CHANNELS - BACKWATERING CALCULATIONS

Name: MIKE POMFRETT Telephone: 01992- 645041

Position: PROJECT MANAGER Region/Area: THAMES REGION - NORTH EAST AREA

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Any further comments? - please use reverse of form and tick here ☐

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INFORMATION REQUEST: Flood defence

(23)

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☑

Mix of historic and recent ☑

How are hydrometric data used? Flood Forecasting, flood warning dissemination, flood records and post flood analysis.

How would flood defence functions be attempted in the absence of any historic hydrometric data? Reliance upon current staff experience and live data of flood event.

Would Flood Defence use data from more stations if the network were extended?

Yes.

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

a) 2 places of decimals.
b) ± 50mm

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Poorer flood forecasting, poorer flood warning quality. Less accurate cost/benefit analyses

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

Yes. Yes.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

Difficult one – I would guess. 10% (max).

What hydrometric data do you require for channel maintenance and weed-clearing work? Only at weed-raking screens or automatic weed-screens.

Name: R.W. FRANCIS Telephone: 01732 875587

Position: Area Engineer Region/Area: Southern / Kent

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Any further comments? - please use reverse of form and tick here ☐

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INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☑

Mix of historic and recent ☑

How are hydrometric data used?

FLOOD WARNING / CAPITAL SCHEMES / CONSENTS MAINTENANCE / DEV CON.

How would flood defence functions be attempted in the absence of any historic hydrometric data?

N/A

Would Flood Defence use data from more stations if the network were extended?

YES

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

What hydrometric data do you require for channel maintenance and weed-clearing work?

Name: Paul Dodds Telephone: 0191 203 4000

Position: AEC Region/Area: NE

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Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

ENVIRONMENT AGENCY - NORTH EAST REGION
RIDINGS AREA

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☑

Mix of historic and recent ☑

How are hydrometric data used?

NON REAL TIME - i) as basis of design of flood alleviation schemes
ii) for development control purposes (eg building only permitted above max. rec. flood level)
REAL TIME - as basis for flood forecasting + warning

How would flood defence functions be attempted in the absence of any historic hydrometric data? Virtually impossible. (Assuming this definition covers all data i.e. river flow, level, sea level etc.

Would Flood Defence use data from more stations if the network were extended?

Potentially - YES. Generally aim to collect data to support the business/function - not the other way round!

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

Generally ± 15mm is likely to be OK - given the use of the data for engineering schemes + flood warning.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Possible errors in scheme design, advice to local planning authorities.
Possible errors in flood forecasting and therefore missed or false warnings issued.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

YES.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

Assuming definition covers all data collected - very close to 100%, i.e. the function could not operate without hydrometric data.

What hydrometric data do you require for channel maintenance and weed-clearing work? None to drive work required, but
a) real time data can indicate need for debris clearance at weedscreens
b) " " " " " conditions are suitable for maintenance work to be carried out (or not).

Name: MARK TINNION Telephone: 0113 2312031

Position: FLOOD DEFENCE SYSTEMS ENGINEER Region/Area: NORTH EAST / RIDINGS AREA

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INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☐

Mix of historic and recent ☑

58

How are hydrometric data used?

As basic information and as a check for information derived from modelling.

How would flood defence functions be attempted in the absence of any historic hydrometric data?

Only theoretical values could be used - this would lead to uneconomic or unreliable design

Would Flood Defence use data from more stations if the network were extended?

YES - all available data would be used

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

only to about ±5% - it is not worth while trying for more accuracy

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Little - more data is more important than more accuracy

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

- For schemes

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

5%

What hydrometric data do you require for channel maintenance and weed-clearing work? we would benefit from more data - and analysis at present we don't use this for maintenance and would find it difficult without new systems and/or staff

Name: TIM KERMODE Telephone: 01962 - ~~84~~4700 76 (Sunbury 4700)

Position: AREA F.D. MANAGER Region/Area: SOUTHERN / HANTS & IOW

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Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

INFORMATION REQUEST: Flood defence

(4)

What data are required for flood defence purposes?

- Historic only (eg data up to 1 year ago) ☐
- Mix of historic and recent ☑

How are hydrometric data used? Calibration of models for hydraulics for schemes and investigations. Real time information for Flood warning and Operations.

How would flood defence functions be attempted in the absence of any historic hydrometric data? All based on empirical methods, or localised calibration. Operations & Warning by luck only.

Would Flood Defence use data from more stations if the network were extended?

Yes

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? Varies depending on river type. 50 -> 300 mm.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)? Reduction in service, especially where highly managed.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available? Yes, copies from Richard Eales & Dave Pilkington, Exeter Office

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?
Couldn't put a value on this without more research

What hydrometric data do you require for channel maintenance and weed-clearing work? Monitoring effect for justification.

Name: KEN TATEM Telephone: 01278 457333

Position: AREA FLOOD DEFENCE MANAGER Region/Area: SOUTH WEST/NORTH WESSEX

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Any further comments? - please use reverse of form and tick here .... ☐

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46

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) [ ]

Mix of historic and recent [✓]

How are hydrometric data used? Real time flood forecasting and calibration (historic) To prove design models, estimate flood frequencies and Improve Flood Studies Estimates.

How would flood defence functions be attempted in the absence of any historic hydrometric data? Flood Warning - with no ongoing calibration

Flood Defence works - By Flood Studies Report and mathematical modelling

Would Flood Defence use data from more stations if the network were extended?

Yes, where forecasts could be improved - need long enough dataset to calibrate against. Would improve mathematical modelling accuracy.

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? As accurate as possible > 90%. Some historic data (non-hydrometric sources) can be unreliable and misleading, which can be worse than no data.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Flood Warning - limited where model forecasts are accurate and need no realtime validation/updating. Otherwise model deterioration and unreliability.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

No

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

Crystal Ball job! maybe 30%.

What hydrometric data do you require for channel maintenance and weed-clearing work? Levels and flows

Name: Roy Ladhams Telephone: (0115) 9455722

Position: Senior Engineer (Emergencies and Systems) Region/Area: Midlands/Lower Trent Area

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Any further comments? - please use reverse of form and tick here .... [ ]

Please return to. Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Filled in for J.R. Outram - Area Flood Defence Manager.

INFORMATION REQUEST: Flood defence

(49) What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) + well beyond ☑

Mix of historic and recent ☑

How are hydrometric data used? Assessment of flow/rainfall V return period. Assessment of particular flood flows during extreme events.

How would flood defence functions be attempted in the absence of any historic hydrometric data? – Flood Studies methods + other empirical formulae.

Would Flood Defence use data from more stations if the network were extended?

Probably

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? As accurate as possible.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

Possible design failure. Excessive freeboard may need to be built into defence levels.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available? – Yes – please direct your request to the Engineering Section, E. Agency, Richard Fairclough House, Knutsford Road, Warrington WA4 1HG.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

None – benefits are related to physical flood damage aversion. They are not a product of the design parameters. (A rather odd question – have I misunderstood the rear.)

What hydrometric data do you require for channel maintenance and weed-clearing work? V. little. These are traditional practices and carried out to pre-determined levels of service

Name: [illegible] Telephone: 01772 339882

Position: Flood Defence Manager Region/Area: Central – Lancashire

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Any further comments? - please use reverse of form and tick here .... ☐

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(5)

/FORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

- Historic only (eg data up to 1 year ago) ☐
- Mix of historic and recent ☑

How are hydrometric data used?

Check design tolerances of Flood Defence Schemes. Indentify flood flow return periods. Maintain data on maintenance efficiency. W.R Section 105 works.

How would flood defence functions be attempted in the absence of any historic hydrometric data?

With great difficulty

Would Flood Defence use data from more stations if the network were extended?

Yes

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

Accurate for Section 105 purposes / Design purposes. Say to 0.2m

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

In a limited 'urban rich' Area of the Env. Agency then data is required to justify both maintenance and Capital works.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

a) Lots for Cap. Schemes. b) For Revenue new Flood Defence Management System will be available from April 1997.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

1% approximately.

What hydrometric data do you require for channel maintenance and weed-clearing work?

None, just by observation.

Name: Andrew Crass. Telephone: 01228-25151.

Position: Technical Manager. Region/Area: North West Region / North West Area

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Any further comments? - please use reverse of form and tick here .... ☐

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INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☐

Mix of historic and recent ☑

How are hydrometric data used?

In the management of existing river infrastructure, flooding events and design of new works.

How would flood defence functions be attempted in the absence of any historic hydrometric data?

Via information collected following events, observation of events, studies of physical features on the ground.

Would Flood Defence use data from more stations if the network were extended?

Yes, since these would refine existing and generally increase level of data information.

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

This is dependant on physical use of Catchment, urban areas require information of a high accuracy whereas rural areas can be more coarse.

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

For flood protection in urban areas low value data can result in over design due to lack of confidence in data.

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

Available information via the Region.

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

High for urban areas to nil for remote rural area.

What hydrometric data do you require for channel maintenance and weed-clearing work?

None

Name: John Hesp Telephone: (01473) 727712

Position: Area Flood Defence Manager Region/Area: Anglian Region, Eastern Area

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Rod - Andrew Black's Hydrometric Network Request
Pete 19/11/96

INFORMATION REQUEST: Flood defence

① What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☑

Mix of historic and recent ☑

② How are hydrometric data used?

③ How would flood defence functions be attempted in the absence of any historic hydrometric data?

④ Would Flood Defence use data from more stations if the network were extended?

Yes, depending on relevance of location and accuracy of flows at/over flood events

⑤ How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

Say, no worse than ± 10 mm at peak, allowing for all effects (i.e. of river level, not level in well). Depends on use!

⑥ What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

less robust, or more conservative design.

⑦ Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

—

⑧ If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

⑨ What hydrometric data do you require for channel maintenance and weed-clearing work?

Name: R. SPENCER Telephone: 01925-653999

Position: HYDRAULIC MODELLING MANAGER Region/Area: NW

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

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BENEFITS OF HYDROMETRIC NETWORKS

Q	Answer based on River Modelling Group requirements	Other Comments with relevance to Flood Defence generally
1	A mix of historic and recent data is required. The types of data required includes: • peak levels and flows for flood events (either as annual maxima or POT) • flow/level hydrographs for flood events • rainfall amounts • hyetographs for storms associated with flood events • flow duration curves	
2	Calibration and verification of hydrologic, hydraulic and sediment transport models. Assessment of simple hydraulic calculations	Also, used for: flood warning purposes, assessing working conditions within river channel, simple hydraulic calculations
3	Rely entirely on Flood Studies Report methodology (which itself is based on historic data) or similiar.	
4	Yes, depending on relevance of location and accuracy of flows during flood events	Yes
5	~~Better than ± 10 mm for levels (or ± 5 2% for flows). Accuracy of estimated flood levels depends on use.~~	
6	Less robust or more conservative design - leading to increased construction or maintenance costs	
7	*No, held by Project Engineering Group at Warrington*	
8	*Not known to River Modelling Group*	
9	*Not applicable to River Modelling Group*	Both high and 'normal' flow data are required to assess the benefits in agricultural areas as there is a land drainage benefit often.

Tim Palmer
Asst. Engineer (River Modelling)
Environment Agency - NW
Nov 1996

(5) Ideally better than ± 5mm for levels (± 10mm probably acceptable; better than ± 5% (2-3% preferred) for flows. Both levels and flows relate to true values in river at the peak. Note 'in river' - accuracy of measurement in stilling well is only part of the story!
Flood levels hence generally ± 10mm. PSS

(45)

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☐

Mix of historic and recent ☑

How are hydrometric data used? FLOOD WARNING, FLOOD EVALUATION, DESIGN OF NEW WORKS, CALIBRATION OF MODELS.

How would flood defence functions be attempted in the absence of any historic hydrometric data? BY INDIRECT MEANS ONLY – (BUT THESE ARE BASED ON HISTORIC DATA!)

Would Flood Defence use data from more stations if the network were extended?

DEPENDS ON LOCATION AND PURPOSE (LOW FLOWS?)

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be? CANNOT GENERALISE

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

LESS CONFIDENCE = HIGHER RISKS

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

YES, YES (SUBJECT TO LOCAL ARRANGEMENT)

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

THIS COMPARISON CANNOT BE MADE IN THIS WAY.

What hydrometric data do you require for channel maintenance and weed-clearing work? FLOW AND LEVEL.

Name: R. Horrocks Telephone: (01392) 444000 x 2436

Position: REGIONAL FLOOD DEFENCE MANAGER Region/Area: SOUTH WEST

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☑

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

1. IMPORTANT TO RECOGNIZE NEED FOR EXTREME <u>AND</u> CONTINUOUS (HIGH FREQUENCY) DATA.

2. EVEN BEST INDIRECT METHODS DEPEND UPON DATA — HENCE NEED TO CONTINUE TO COLLECT LONG RECORDS

3. MANY SITES GIVE POOR HIGH FLOW ACCURACY — (PRIMARY PURPOSE IS WATER RESOURCE / LOW FLOW) BUT IMPORTANT THAT AT LEAST LEVEL RECORDED TO 100 YR + STANDARD.

Note In South West Region Areas only use hydrometric data for operational purposes usually during flood events. If you have not done already you should consult Linda Aucott and R. Eales at Manley Ho Exeter.

INFORMATION REQUEST: Flood defence

What data are required for flood defence purposes?

Historic only (eg data up to 1 year ago) ☐

Mix of historic and recent ☑ (4)

My reply hence relates just to operational use

How are hydrometric data used?

Hydrometric data is used to supplement flood warning and operational telemetry during flooding events

How would flood defence functions be attempted in the absence of any historic hydrometric data?

—

Would Flood Defence use data from more stations if the network were extended?

Probably, yes but dependant of location

How accurate do hydrometric data need to be for flood defence purposes, and how accurate do estimated flood levels need to be?

± 50mm for both * estimated flood levels is Flood Warning *

What are the effects of lower accuracy hydrometric data (ie a cost/lost benefit)?

—

Do you have any examples of cost-benefit analysis reports completed for flood defence programmes and, if so, are copies available?

L of S project is underway in South West Region for Telemetry, liaise with L Aucott

If the benefit of flood defence measures in your area were assessed as a nominal £1m pa on average, what % of this would you attribute to hydrometric data inputs?

—

What hydrometric data do you require for channel maintenance and weed-clearing work? Use of hydrometric data would only be possible in close proximity to gauging stations. The steepness of catchments make scope for use in Cornwall very limited

Name: G. Trapmore Telephone: 01208 78301

Position: AFDM Region/Area: S.W Cornwall

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Any further comments? - please use reverse of form and tick here .... ☐

* Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

Questionnaire responses

FISHERIES & CONSERVATION

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

(12)

What hydrometric data do you use (type of data, approx number of stations)?

RARELY, EXCEPT FOR SPECIFIC PROJECTS OR PROGRAMS

How are they used?

IN RELATION TO FISH POPULATION DENSITIES

Are any stations used more than others; if so, which and why?

—

Would you use hydrometric data from more stations if the network were extended?

NOT GENERALLY BUT SOME AREAS POORLY SERVED

Do you operate a Riverline telephone service?

—

If so, please provide details of usage levels, call charges, revenue (if possible).

—

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

NONE

Name: R SEDGWICK Telephone: 01543 444141

Position: FISH SCIENTIST Region/Area: MIDLANDS / U. TRENT

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

RIVER FLOWS / RIVER LEVELS / RAINFALL

A WIDE RANGE OF THE HYDROMETRIC SITES IN THE AREA IS ACCESSED PERIODICALLY

How are they used?

ANALYSIS TO ASSIST THE INTERPRETATION OF FISH CATCH DATA & FISH MOVEMENT INFO
ASSESSMENT OF APPROPRIATE SAFEGUARDS TO PLACE ON ABSTRACTION LICENCES.
DETAILED ANALYSIS OF DROUGHT ISSUES.
MEASUREMENT OF REGULATED FLOWS.

Are any stations used more than others; if so, which and why?

NEWBY BRIDGE R. LEVEN IS USED FREQUENTLY IN DRY WEATHER TO ENABLE FLOWS TO BE REGULATED.
SITES ON SIGNIFICANT SALMON AND SEA TROUT RIVERS TO INTERPRET FISH MOVEMENT AND CATCH INFORMATION.

Would you use hydrometric data from more stations if the network were extended?

MORE USE WOULD BE MADE BUT THE EXTENT WOULD DEPEND ON LOCATION AND CURRENT ISSUES.
AT THE MOMENT EXPANSION IN THE LEVEN AND EAMONT CATCHMENTS IS UNDERWAY. THIS WILL HELP WITH REGULATION AND DROUGHT MANAGEMENT

Do you operate a Riverline telephone service?

YES. RIVERCALL ON 0891 500 999

If so, please provide details of usage levels, call charges, revenue (if possible).

THE SYSTEM USES A PREMIUM RATE NUMBER AND THE PROFITS GO TO THE AGENCY.

FOR FURTHER INFORMATION CONTACT MIKE KNOWLES, POLICY AND DEVELOPMENT MANAGER FOR THE AGENCY IN WARRINGTON.

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement?

CANOEISTS USE THE SYSTEM BUT THERE IS NO LEGISLATIVE BACKGROUND FOR THIS IN THE REGION.

Name: N. C. DURIE.   Telephone: 01228 25151

Position: AREA FCR MANAGER   Region/Area: NORTH WEST REGION | NORTH AREA

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Any further comments? - please use reverse of form and tick here ....☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

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INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

River flows 39 fixed stations + numerous spots: low flow + flow duration curves
Water levels at pumping stations. (Telemetry @ fixed gauging stations + pump stations
Rainfall measurement.

How are they used?

Assessing fisheries habitat. Impacts on fisheries. Checking management
Work planning checking suitability of river conditions for site visits
surveys (using telemetry). Incident progress (using telemetry)

Are any stations used more than others; if so, which and why?

According to fisheries status of watercourse

Would you use hydrometric data from more stations if the network were extended?

Yes

Do you operate a Riverline telephone service?

No

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

N.A.

Name: F. FARR-COX Telephone: (01278) 457333 x 4604

Position: Snr Fish. Tech Region/Area: S.W. NORTH WESSEX

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Any further comments? - please use reverse of form and tick here .... ☐

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›2W

(124)

INFORMATION REQUEST

Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

RIVER FLOW; & MINIMUM/DRY WEATHER FLOW, RIVER LEVEL INFO. (MAINLY).

How are they used?

INTERPRETATION OF FISHERY SURVEY DATA/RESULTS.
" OF SALMON CATCH (ROD & COMMERCIAL RESULTS) & SALMON etc MIGRATION PATTERNS.
IN RELATION TO REQUESTS FOR ADVICE RE eg NEW POOLS, FISH FARMS, &

Are any stations used more than others; if so, which and why?

MAINLY THOSE RELEVANT TO ABSTRACTION LICENCE CONTROLS (TO SAFEGUARD FISHERY INTERESTS)

Would you use hydrometric data from more stations if the network were extended?

YES

Do you operate a Riverline telephone service? YES, OPERATED REGIONALLY FROM SAPPHIRE EAST. (SEE ATTACHED)

If so, please provide details of usage levels, call charges, revenue (if possible).

DETAILS FROM CHRIS MARSH.
AT SAPPHIRE EAST (MIDLANDS REGION HQ
FAX 0121 711 5824
? PROBABLY ALREADY SUPPLIED

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement? —NO

AGREEMENT WITH LOWER & UPPER NAVIGATION TRUSTS WHO OPERATE HAZARD WARNING SIGNS (SEE P4 OF ENCLOSED BOOKLET) IN RELATION TO WARWICK GUAGE.

Name: ALAN STARKIE Telephone: 01684 850951

Position: FISH SCIENTIST Region/Area: MIDLANDS REGION, LOWER SEVERN AREA.

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Any further comments? - please use reverse of form and tick here ....

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

12/11/96

FRCN questionnaire attached. There does not appear to be a Freshwater Chemist as such in this region

ENVIRONMENT AGENCY

with compliments Alan S

The Environment Agency
Riversmeet House, Newtown Industrial Estate, Northway Lane, Tewkesbury, Gloucester GL20 7TG
Tel 01684 850951 Fax 01684 293599

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.egion has an experienced
inspectors who are able to
ge of fisheries management
entific principles and will
and syndicates to get the
voiding many pitfalls and
: the Environment Agency
ils.

In any activity where you run the risk of falling into the river such as canoeing, rafting and sailing you should wear a good quality lifejacket or buoyancy aid. Rough water canoeists are also advised to wear a helmet.

Take note of warning signs and follow their instructions. A network of Navigation Hazard Warning Signs operates on the River Avon which advise against navigation when the river rises above a safe level. Always follow this advice. The majority of these are manually operated flap board type where the message is changed at times when navigation is considered hazardous. A few are of an automatic, self-reading design. Examples of both designs are illustrated in the back of this handbook. Information on river levels can be obtained at all times by phoning the appropriate "Riverline" number (see page 8).

The governing body of each sport will have compiled a set of rules and safety recommendations. Follow these at all times. In addition a Natural Water Sports code has been published by the Central Council of Physical Recreation jointly with the Sports Council.

Even if all the rules are followed, the occasional accident can happen and it is important that you learn the basic skills in rescue, resuscitation and first aid. There are many courses and publications available to teach you these skills.

Children should always be accompanied by an adult when on or near water and they should be taught the dangers and safe practices.

(117)

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

Very little

Flow gauging stations are rarely used

How are they used? - In commenting on drought orders

- Groundwater levels are used to explain low water levels in ponds

- Chart recorders used to monitor compliance with water levels set in WLMP's

Are any stations used more than others; if so, which and why?

Currently chart recorders on Amberley Wildbrooks

Hardham on W. Rother

Would you use hydrometric data from more stations if the network were extended?

Maybe, it would be useful if more guidance was given on potential uses of hydrometric data as we probably underuse the system

Do you operate a Riverline telephone service?

No

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement?

L. MACDOUGALL

Name: pp P. GRIFFITHS Telephone: 01903 - 215835

Position: AREA C+R OFFICER Region/Area: Southern / Sussex

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

120

INFORMATION REQUEST

Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

Very little hydrometric data are currently used by the fisheries function in Sussex. Applications where hydrometric data are being used or are likely to be used in the future are i) for the analysis of sea trout movements in the Rivers (western) Rother and Ouse in relation to flow / discharge and ii) PHABSIM/IFIM investigations of habitat availability under different flow regimes in the Ouse.

How are they used?

i) Flow/discharge related to run-timing of sea trout.

ii) Flow related to utilisation of various habitat types by juvenile trout and adult trout

Are any stations used more than others; if so, which and why?

Hardham - Rother } Main abstraction points and monitoring points for sea trout
Barcombe - Ouse } Fish passes present at both sites + counters.

Would you use hydrometric data from more stations if the network were extended?

Probably.

Do you operate a Riverline telephone service?

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement?

Name: S. BETTS Telephone: 01903 - 215835

Position: AREA FISHERIES OFFICER Region/Area: Southern / Sussex

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Any further comments? - please use reverse of form and tick here .... ☐

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Cut

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

Q90/95; Flow duration curves; mean daily flow figures rainfall

How are they used?

To assist in interpretation of monitoring results.
To target areas for monitoring or improvements (habitat)
To assist in determining whether river conditions are suitable for biological sampling.

Are any stations used more than others; if so, which and why?

Varies dependent on conditions and reasons eg. drought situation on affected rivers.
Monitoring - to see if conditions OK for survey work (river specific) H & S requirements

Would you use hydrometric data from more stations if the network were extended?

Probably but do not consider extension necessary for our purposes.

Do you operate a Riverline telephone service? Yes. (Angling flow line - Floodcall separate

If so, please provide details of usage levels, call charges, revenue (if possible).

approx 4,500 calls. revenues 25p/min (approx 24p per call)
revenues approx £1000.

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

Name: BILL WALKER Telephone: 01904 692296

Position: REGIONAL OFFICER - FISHERIES Region/Area: NORTH EAST - DALES

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

Recreation (109)

INFORMATION REQUEST

Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

CANOEISTS ARE ENCOURAGED TO CHECK RIVER LEVELS ON THE INFORMATION

How are they used? SERVICE PROVIDED FOR ALL RIVERS.

SOME ACCESS AGREEMENTS ONLY ALLOW CANOEING ~~ABOVE~~ AT HIGHER FLOWS.

Are any stations used more than others; if so, which and why? ie Riverline

Would you use hydrometric data from more stations if the network were extended?

Do you operate a Riverline telephone service? YES.

If so, please provide details of usage levels, call charges, revenue (if possible).

SEE LEEDS.

If a navigation function is served: NONE

What data do you use for navigation purposes; is their provision a legislative requirement? NONE.

Name: Barbara Pike Telephone: 4141

Position: Recreation Region/Area: Northumbria

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

Fisheries Enforcement (110)

INFORMATION REQUEST

Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

Data is supplied by the Hydrometric Dept. on request from both main river and tributary stations - The enforcement section can not access this themselves - although it would be beneficial if it could be arranged

How are they used?

The information is used to determine if certain areas are vulnerable or if there is the potential for fish to be 'running' at certain locations

Are any stations used more than others; if so, which and why?

mostly stations in watercourses where there is a Salmonid population that has suffered at the hands of the poacher.

Would you use hydrometric data from more stations if the network were extended?

The stations we get information from are sufficient at the moment

---

Do you operate a Riverline telephone service?

N/A

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement?

N/A.

Name:

Telephone:

Position: –

Region/Area:

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

Fisheries Science (111)

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

FLOW LEVELS & HEIGHTS

4 STATIONS

How are they used?

FISH COUNTS PLOTTED AGAINST FLOW.
FLOW/HEIGHT USED TO ASSESS IF WORK IN RIVER CAN BE DONE
EG. ELECTRIC FISHING

Are any stations used more than others; if so, which and why? downstream stns
SUNDERLAND BRIDGE, RIDING MILL, MORWICK.
FOR COUNTER INFORMATION - FISH MOVEMENTS VS FLOW RATES (MONTHLY).

Would you use hydrometric data from more stations if the network were extended?

POSSIBLY ALTHOUGH UNLIKELY

Do you operate a Riverline telephone service?

NO

If so, please provide details of usage levels, call charges, revenue (if possible).

NO

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

NO

Name: P. R[signature] Telephone: 0191 2034149

Position: ECOLOGIST FISH Region/Area: NORTH EAST / NORTHUMBRIA

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(112)

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

1 - FLOW DATA - KIELDER RELEASES.
2 - FLOW DATA RIVER WEAR

How are they used?

INFORMATION FOR WATER TRANSFER SCHEME
ASSESSMENT OF ECOLOGICAL IMPACT
ASSESSMENT OF DILUTION FACTOR OF POLLUTANTS
ASSESSMENT OF FLOW/DEPTH FOR SAFETY IN TAKING BIOLOGICAL SAMPLES.

2 - ASSESMENT OF MACROPHYTE COMMUNITIES FOR UWWTD PURPOSES.

Are any stations used more than others; if so, which and why?

UGLY DUB - TO VIEW ANNUAL RELEASE PATTERN (ASSESSMENT OF ECOLOGICAL IMPACT) - KIELDER
R. DERWENT
S. TYNE - METAL CONCENTRATIONS

Would you use hydrometric data from more stations if the network were extended?

Do you operate a Riverline telephone service?

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

Name: VICKI WARREN / GD CLERK Telephone: 4174 / 4081 (EXT.)

Position: FRESHWATER ECOLOGIST Region/Area: NORTHUMBRIA AREA 0191 203 4000

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Any further comments? - please use reverse of form and tick here .... ☐

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b2W

(113)

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?
Flow data on rivers Lune, Wyre, Ribble and tribs.
Approx 5 station regularly

How are they used?

5 regularly. Others on incident or needs basis
perhaps max 6 others per year.

Are any stations used more than others; if so, which and why?
Main river for flows, fishing conditions.

Would you use hydrometric data from more stations if the network were extended?

Can't say depends on location & need.

Do you operate a Riverline telephone service?
Yes but a regional service.

If so, please provide details of usage levels, call charges, revenue (if possible).
"Not my monkey."

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement? No navigation responsibilities

Name: [signature] Telephone: 01772 339882.

Position: FRCN Manager Region/Area: NW Central

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Any further comments? - please use reverse of form and tick here .... ☐

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114

INFORMATION REQUEST

Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

INTERROGATION OF FISH COUNTERS. LOGGED NUMBERS OF SALMON. Only One Station in USE.

How are they used?

DURING THE SALMON SPAWNING SEASON, THEY ARE USED TO GIVE AN IDEA OF WHEN THE MAIN RUNS OCCUR, ALSO TO GIVE AN IDEA OF NOS OF FISH MAY BE SPAWNING.

Are any stations used more than others; if so, which and why?

YES, OUR STATION AT LLANYBLODWEL, THE OTHER COUNTERS HAVE BEEN DAMAGED AND CURRENTLY OUT OF USE.

Would you use hydrometric data from more stations if the network were extended?

NOT NECESSARILY

Do you operate a Riverline telephone service? WE HAVE DONE IN THE PAST.

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement?

Name: CHRIS BAINGER. Telephone: 01743 272828 EXT 3477.

Position: FISHERIES TECHNICIAN Region/Area: MIDLANDS UPPER SEVERN.

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Any further comments? - please use reverse of form and tick here ....☐

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?W

115

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

FLOW MEASUREMENT

How are they used? OPERATIONAL USE – SURVEY INFORMATION CRITICAL LEVELS ETC

Are any stations used more than others; if so, which and why?

NO. USED AD HOC

Would you use hydrometric data from more stations if the network were extended?

YES

Do you operate a Riverline telephone service?

YES

If so, please provide details of usage levels, call charges, revenue (if possible).

UNKNOWN. (REGIONAL SYSTEM)

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

NONE

Name: A. R Lee Telephone: 0161 973 2237 EXT 3056

Position: AREA FRCB Mgr Region/Area: SOUTH AREA N. W. REGION

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

(116)

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

How are they used?
TO LINK WITH FISH MOVEMENTS AND FOR TRIGGERING POSSIBLE RELEASES OF WATER BANK.

Are any stations used more than others; if so, which and why?
THOSE ON DROUGHT-AFFECTED / LOW FLOW RIVERS OR THOSE WHICH HAVE A FISH COUNTER.

Would you use hydrometric data from more stations if the network were extended?
PROBABLY.

Do you operate a Riverline telephone service?
NO.

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?
NO.

Name: MARTIN WILLIAMS Telephone: 01208 78301 EXT 5052

Position: FRC MANAGER Region/Area: CORNWALL

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

NONE

How are they used?

N/A

Are any stations used more than others; if so, which and why?

N/A

Would you use hydrometric data from more stations if the network were extended?

N/A

Do you operate a Riverline telephone service?

NO

If so, please provide details of usage levels, call charges, revenue (if possible).

/

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

/

Name: C. BEARDALL Telephone: 01473 727712 x 4020

Position: FRCN MANAGER Region/Area: EASTERN / ANGLIAN

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

River flows from about [illegible] stations and groundwater levels from small number of sites commonly used.

How are they used?

Instantaneous flows + monthly means used to assess habitat suitability for fish - particularly salmonids and guide operational work, eg enforcement, restocking etc.
Also in research projects with respect to low flows.

Are any stations used more than others; if so, which and why?

Stations on chalk streams affected by abstraction particularly heavily used - for conditions with regard to migration upriver and habitat suitability in river + guiding enforcement action

Would you use hydrometric data from more stations if the network were extended?

Most impacted area already covered - extended network would be of longer term value.

Do you operate a Riverline telephone service?

No

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

Name: [illegible] Telephone: 01258 456080

Position: Area FRC Mgr Region/Area: South Wessex

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

(118)

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

Various when undertaking environmental enhancement works.

How are they used?

For design of channels – capacity etc

Are any stations used more than others; if so, which and why?

No – depends on site of project

Would you use hydrometric data from more stations if the network were extended?

As above. Depends if it is relevant to project site.

Do you operate a Riverline telephone service? NO
(We do have emergency phones).

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement? Monitor retention levels (via telemetry)
[illegible]
[illegible] data used.

Name: MICHAEL EVANS Telephone: 01480 414581 – (ex 4940)

Position: FRCN MANAGER Region/Area: ANGLIAN / CENTRAL

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here ....☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

(121)

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

WATER LEVEL & FLOW DATA ON RIVERS AND WATER LEVEL DATA ON LOUGH NEAGH AND LOUGH ERNE SYSTEMS.

APPROX. NO. OF STATIONS = 12

How are they used?

LOUGH NEAGH / LOWER BANN RIVER STATIONS MONITORED TO ADJUST WATER LEVELS WITHIN STATUTORY RANGE. A PRIMARY USE OF DATA IS FOR MAINTENANCE OF NAVIGATION. LOUGH ERNE STATIONS MONITORED FOR NAVIGATION AND POWER GENERATION PURPOSES. (GENERATION DONE BY E.S.B.I. IN SOUTHERN IRELAND)

Are any stations used more than others; if so, which and why?

LOUGH NEAGH (2 NO) / LOWER BANN (7 NO) USED EXTENSIVELY. CATCHMENT FORMS 42% OF N.I. LAND SURFACE. RIVERS AGENCY HAS STATUTORY DUTIES IN RELATION TO MAINTENANCE OF LEVELS. FISHERY & COMMERCIAL INTERESTS ARE CONSIDERABLE

Would you use hydrometric data from more stations if the network were extended?

No

Do you operate a Riverline telephone service?

No

If so, please provide details of usage levels, call charges, revenue (if possible).

—

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement?

WATER LEVELS MONITORED ON L. NEAGH / LOWER BANN RIVER AND L. ERNE.

LEVEL MONITORING IS CARRIED OUT FOR STATUTORY PURPOSES

Name: [signature] Telephone: 01232 253372

Position: SENIOR EX. HYDROMETRICS Region/Area: N. IRELAND

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

127 Came with several other (MARINE)

INFORMATION REQUEST FRCNs from I. Shell - copy FRCN Marine NE
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

1 station - ~~Wylam~~ Bywell river flows (cumecs)

How are they used?

To compare with estuarine trawl data, to see if it has a significant effect on population distribution

Are any stations used more than others; if so, which and why?

Require lowest stations nearest to estuary

Would you use hydrometric data from more stations if the network were extended?

Yes - if these were lower down the river.
Occassional use only.

Do you operate a Riverline telephone service?

No

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:
What data do you use for navigation purposes; is their provision a legislative requirement?

None

Name: S. PEATY Telephone: 0191 203 4140

Position: MARINE SCIENTIST Region/Area: NORTH-EAST - NORTHUMBRIA

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

INFORMATION REQUEST
Fisheries, Conservation, Recreation and Navigation

What hydrometric data do you use (type of data, approx number of stations)?

MONTHLY HYDROLOGICAL SUMMARY. } Stations appropriate to use.
RAINFALL DATA
MEAN FLOW DATA

How are they used?

Compilation of FISHERIES SURVEYS.
Fish Pass Design
Habitat restoration

Are any stations used more than others; if so, which and why?

NO.

Would you use hydrometric data from more stations if the network were extended?

YES

Do you operate a Riverline telephone service? NO

If so, please provide details of usage levels, call charges, revenue (if possible).

If a navigation function is served:

What data do you use for navigation purposes; is their provision a legislative requirement?

NONE

Name: M. EXETER Telephone: 01992 645049

Position: AREA FISHERIES OFFICER Region/Area: THAMES / NORTH EAST.

Kindly pass copies to any colleagues who may not have received a copy of this request

Any further comments? - please use reverse of form and tick here .... ☐

Please return to: Mike Steel, Geography Department, University of Dundee, DUNDEE, DD1 4HN by 8/11/96

b2W

III KEY CORRESPONDENCE

Correspondence is reproduced in the following pages regarding the following key areas of data collection:

A Scottish Water Authority

Environment Agency (NW Region) re River Bollin) - Data requests
Rivers Agency (Northern Ireland) re River Foyle)

On other factual matters for which no correspondence is produced, information was gathered either through the questionnaires (Part II of this Project Record), verbally, from published papers, or from recognised sources (see Technical Report text).

Alastair Stewart
17/11/97 12:14

To: Joyce Grieve/NOSWA, Kevin Moran/NOSWA
cc:
Subject: Wastewater Treatment Plants at Perth, Forfar, Brechin and ~~Crieff~~. Coupar Angus

Joyce and Kevin

A researcher at University of Dundee (Andrew Black Tel 01382 344433 Fax 01382 344434) is undertaking research work for EA, SEPA and DOE NI on hydrometric data for river flow monitoring. He is also seeking correlation between flow data consent for discharges. I said we could help here.

Joyce - can you abstract for 1996/97 global running costs (excluding loan charges and consequential capital depreciation etc.) in respect of each of the four works named above? am assuming that we have single cost centres for these large works. So running costs encompass power, labour, consumables,plant,etc. If Crieff is not stand alone, is there another works from which it would be easy to obtain running costs? You choose, but let Kevin know of any change to the list.

Kevin - can you let me have a note of the design equivalent populations of each of the four works and the degree of treatment, in simple terms, primary, secondary or tertiary?

I would like this information no later than Thursday to enable me to reply to Andrew for Friday this week.

Thanks

Alastair

Overheads / Indirect Costs

GME Costs
Lab Costs
Re-charges
Sludge Removal Costs
Pumping R&M
System (chokes & blockages)
Fabric of sewer
Septic Tanks

Joyce Grieve
17/11/97 14:40

To: Alastair Stewart/NOSWA
cc:
Subject: Re: WTP Data

Alastair,

Design populations and costs with Morna. Please treat costs with caution; there are accruals for income on both Brechin and Coupar Angus. I have also given you a list of other costs which may be charged elsewhere.

regards

Joyce

Table 3.2	Design Population	Theoretical Annual Flow (m^3) (calculated)	Average Annual Flow (m^3)
Auchterarder	2900	232,870	356,041
Blairgowrie	6524	523,877	677,078
Brechin	7535	605,060	749,611
Crieff	5500	441,650	1,292,976
Forfar	22000	1,766,600	1,535,803
Kinross	6000	481,800	1,261,440
Kirriemuir	5500	441,650	1,103,760
Perth	44000	3,533,200	11,163,744
Pitlochry	11650	935,495	625,359
Scone	4135	332,040	643,334
	115744	9,294,242	19,409,146

3.5.7 The sample of ten plants covers approximately 73% of treated wastewater. Using total costs found of £5,497,717, 100% costs projection would be £7,531,119. The total revenue expenditure on items included in 1994-95 was just over £9M, but this included costs which would not be rechargeable, e.g. treatment unrelated to trade effluent.

3.6 Income from Charges

3.6.1 In principle, Trade Effluent charges should be based on the estimated average cost of dealing with one cubic metre of combined wastewater (i.e. domestic plus trade effluent) and surface water draining to treatment plants through the Department's sewers. The charge must take into account all expenditure involved in providing, maintaining and operating the Department's sewerage system. The current charge for trade effluent is 22p per cubic metre.

3.6.2 Income is difficult to estimate and often varies from budget throughout the course of the year. Environmental factors such as companies going out of business, or introducing stringent pre-treatment measures to minimise the pollutant loading and decrease charges are outwith the control of the Authority.

3.6.3 Insufficient attempt is presently made to forecast accurately trade effluent revenues, resulting in unrealistic budget predictions. Following a recent internal audit review, it has been recommended that a budget for income should be set on the basis of number of consents in each area along with an estimate of the volumes being discharged. This information has now been provided to budget-holders by Trade Effluent staff for their future use.

3.6.4 Trade Effluent income amounted to £527,105.00 in 1993/94 and £664,206.00 in 1994/95, a shortfall of £6,866,913 in that year using projected costs. It is recognised that not all costs can be targeted at individual traders, and that the Department has a statutory role in

Perth City

6 |
| 5 |
| | 4 | Budget Enquiry
| | | 01 Actual v Budget
| | | | 2 | Current Year V Last Year
| | | | | 03 **Last year**

G/L Codes
1-S-525300003/****
to
1-S-525300003/****

Year End 9798	**LY Actuals (Accruals)**	**LY Revised Budget**	**Variance**
Opn Bal	0.00	0.00	0.00
April	8897.76	0.00	(8897.76)
May	8773.16	0.00	(8773.16)
June	48954.65	0.00	(48954.65)
July	40350.55	0.00	(40350.55)
August	51582.11	0.00	(51582.11)
September	38047.08	0.00	(38047.08)
October	27203.19	0.00	(27203.19)
November	41704.35	0.00	(41704.35)
December	30397.06	0.00	(30397.06)
January	26209.34	0.00	(26209.34)
February	38985.10	0.00	(38985.10)
March	64275.58	0.00	(64275.58)
	425379.93	0.00	(425379.93)

Period(s): **08** through) Data (1,2,3,4) or <CR> for all:

This tallies with sum of totals on attached pages

Secondary Treatment, Activated Sludge

	General Ledger Code		LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525300003/1101	Rates	170940.92	0.00	(170940.92)
2	1-S-525300003/1102	Water Charges	15232.59	0.00	(15232.59)
3	1-S-525300003/1104		0.00	0.00	0.00
4	1-S-525300003/1202		0.00	0.00	0.00
5	1-S-525300003/1203		0.00	0.00	0.00
6	1-S-525300003/1401	Rep & Maint	144.00	0.00	(144.00)
7	1-S-525300003/1402		0.00	0.00	0.00
8	1-S-525300003/1403		0.00	0.00	0.00
9	1-S-525300003/2101	Equip - Gen	10514.95	0.00	(10514.95)
10	1-S-525300003/2201	Materials	4907.09	0.00	(4907.09)
11	1-S-525300003/2202	Stores	2981.31	0.00	(2981.31)
12	1-S-525300003/2203	Chemicals - Other	183.20	0.00	(183.20)
13	1-S-525300003/2204	E & M	523.47	0.00	(523.47)
14	1-S-525300003/2289		0.00	0.00	0.00
15	1-S-525300003/2308	Clothing & Uniforms	464.74	0.00	(464.74)
16	1-S-525300003/2309	Laundry	38.34	0.00	(38.34)
17	1-S-525300003/2391	SEPA	1721.92	0.00	(1721.92)
18	1-S-525300003/2392	"	0.00	0.00	0.00
19	1-S-525300003/2400	Incineration	744.00	0.00	(744.00)
20	1-S-525300003/2903		0.00	0.00	0.00
			208397		

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

	General Ledger Code		LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525300003/2907		0.00	0.00	0.00
2	1-S-525300003/3209	Electricity	76078.30	0.00	(76078.30)
3	1-S-525300003/3251	E&M Rep & Maint	38520.03	0.00	(38520.03)
4	1-S-525300003/3301	Hire of Veh.	152.07	0.00	(152.07)
5	1-S-525300003/3302	Hire of Plant	4496.34	0.00	(4496.34)
6	1-S-525300003/3901	Veh. Re-charges	4244.82	0.00	(4244.82)
7	1-S-525300003/3902	Plant Recharges	1020.00	0.00	(1020.00)
8	1-S-525300003/4201	Tel - Rent	437.19	0.00	(437.19)
9	1-S-525300003/4202	" - Calls	263.29	0.00	(263.29)
10	1-S-525300003/C111	Sal & Wages	14790.41	0.00	(14790.41)
11	1-S-525300003/D111		75324.37	0.00	(75324.37)
12	1-S-525300003/D122		0.00	0.00	0.00
13	1-S-525300003/D141		0.00	0.00	0.00
14	1-S-525300003/D151		0.00	0.00	0.00
15	1-S-525300003/T111		1368.23	0.00	(1368.23)
16	1-S-525300003/T122		31.31	0.00	(31.31)
17	1-S-525300003/T141		108.35	0.00	(108.35)
18	1-S-525300003/T151		135.01	0.00	(135.01)
19	1-S-525300003/T161		13.68	0.00	(13.68)

ARR 216,982

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

6 | 5 | 4 | Budget Enquiry
01 **Actual v Budget**
2 | Current Year V Last Year
03 **Last year**

G/L Codes
1-S-525400003/****
to
1-S-525400003/****

total

Year End 9798	**LY Actuals (Accruals)**	**LY Revised Budget**	**Variance**
Opn Bal	0.00	0.00	0.00
April	2586.04	0.00	(2586.04)
May	3020.40	0.00	(3020.40)
June	24390.66	0.00	(24390.66)
July	5125.22	0.00	(5125.22)
August	16332.99	0.00	(16332.99)
September	10112.63	0.00	(10112.63)
October	14586.71	0.00	(14586.71)
November	12374.54	0.00	(12374.54)
December	7995.06	0.00	(7995.06)
January	11205.19	0.00	(11205.19)
February	8464.13	0.00	(8464.13)
March	16936.69	0.00	(16936.69)
	133130.26	0.00	(133130.26)

Period(s): 08 through Data (1,2,3,4) or <CR> for all:

Secondary Treatment Biological Filters

	General Ledger Code	LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525400003/1101	46197.60	0.00	(46197.60)
2	1-S-525400003/1102	3474.44	0.00	(3474.44)
3	1-S-525400003/1203	0.00	0.00	0.00
4	1-S-525400003/1401	245.00	0.00	(245.00)
5	1-S-525400003/1402	367.14	0.00	(367.14)
6	1-S-525400003/1403	0.00	0.00	0.00
7	1-S-525400003/2101	136.13	0.00	(136.13)
8	1-S-525400003/2201	3351.52	0.00	(3351.52)
9	1-S-525400003/2202	331.54	0.00	(331.54)
10	1-S-525400003/2203	1297.33	0.00	(1297.33)
11	1-S-525400003/2204	218.16	0.00	(218.16)
12	1-S-525400003/2289	5.09	0.00	(5.09)
13	1-S-525400003/2305	0.00	0.00	0.00
14	1-S-525400003/2308	101.87	0.00	(101.87)
15	1-S-525400003/2309	90.54	0.00	(90.54)
16	1-S-525400003/2391	7728.56	0.00	(7728.56)
17	1-S-525400003/2392	0.00	0.00	0.00
18	1-S-525400003/2397	0.00	0.00	0.00
19	1-S-525400003/2500	0.00	0.00	0.00
20	1-S-525400003/2907	0.00	0.00	0.00

63,546

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

	General Ledger Code	LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525400003/3204	98.72	0.00	(98.72)
2	1-S-525400003/3209	29175.06	0.00	(29175.06)
3	1-S-525400003/3251	7817.86	0.00	(7817.86)
4	1-S-525400003/3302	830.50	0.00	(830.50)
5	1-S-525400003/3901	1456.56	0.00	(1456.56)
6	1-S-525400003/3902	390.00	0.00	(390.00)
7	1-S-525400003/C111	7489.05	0.00	(7489.05)
8	1-S-525400003/D111	22327.59	0.00	(22327.59)
9	1-S-525400003/D122	0.00	0.00	0.00
10	1-S-525400003/D141	0.00	0.00	0.00
11	1-S-525400003/D151	0.00	0.00	0.00

69586

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

6|
|5|
| |4| Budget Enquiry
| |01 **Actual v Budget**
| |2| Current Year V Last Year
| |03 **Last year**

Coupar Angus

G/L Codes
1-S-525300002/****
to
1-S-525300002/****

Year End 9798	**LY Actuals (Accruals)**	**LY Revised Budget**	**Variance**
Opn Bal	0.00	0.00	0.00
April	1451.28	0.00	(1451.28)
May	4938.11	0.00	(4938.11)
June	8523.12	0.00	(8523.12)
July	27435.52	0.00	(27435.52)
August	16909.80	0.00	(16909.80)
September	(2864.13)	0.00	2864.13
October	(1073.15)	0.00	1073.15
November	13193.40	0.00	(13193.40)
December	5849.30	0.00	(5849.30)
January	10073.40	0.00	(10073.40)
February	11000.15	0.00	(11000.15)
March	(85207.68)	0.00	85207.68
	10229.12	0.00	(10229.12)

Period(s): **08** through   Data (1,2,3,4) or <CR> for all:

Secondary Treatment Delegated Budget

	General Ledger Code	LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525300002/1101	61034.24	0.00	(61034.24)
2	1-S-525300002/1102	1713.65	0.00	(1713.65)
3	1-S-525300002/1203	0.00	0.00	0.00
4	1-S-525300002/1401	0.00	0.00	0.00
5	1-S-525300002/1402	0.00	0.00	0.00
6	1-S-525300002/2101	37389.97	0.00	(37389.97)
7	1-S-525300002/2201	0.00	0.00	0.00
8	1-S-525300002/2202	4.31	0.00	(4.31)
9	1-S-525300002/2203	11124.66	0.00	(11124.66)
10	1-S-525300002/2204	0.00	0.00	0.00
11	1-S-525300002/2907	0.00	0.00	0.00
12	1-S-525300002/3209	27462.28	0.00	(27462.28)
13	1-S-525300002/3251	3483.18	0.00	(3483.18)
14	1-S-525300002/3901	1357.88	0.00	(1357.88)
15	1-S-525300002/4201	157.85	0.00	(157.85)
16	1-S-525300002/4202	34.76	0.00	(34.76)
17	1-S-525300002/7392	(146565.16)	0.00	146565.16
18	1-S-525300002/C111	2718.03	0.00	(2718.03)
19	1-S-525300002/D111	9485.81	0.00	(9485.81)
20	1-S-525300002/D122	0.00	0.00	0.00

Accrual for Income

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

	General Ledger Code	LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525300002/D141	0.00	0.00	0.00
2	1-S-525300002/D151	0.00	0.00	0.00
3	1-S-525300002/T111	684.11	0.00	(684.11)
4	1-S-525300002/T122	15.15	0.00	(15.15)
5	1-S-525300002/T141	54.13	0.00	(54.13)
6	1-S-525300002/T151	67.45	0.00	(67.45)
7	1-S-525300002/T161	6.82	0.00	(6.82)

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

Brechin

6|
|5|
| |4| Budget Enquiry
| |01 **Actual v Budget**
| |2| Current Year V Last Year
| |03 **Last year**

G/L Codes
1-S-525400002/****
to
1-S-525400002/****

Year End 9798	**LY Actuals (Accruals)**	**LY Revised Budget**	**Variance**
Opn Bal	0.00	0.00	0.00
April	3165.24	0.00	(3165.24)
May	6734.68	0.00	(6734.68)
June	20795.10	0.00	(20795.10)
July	9968.34	0.00	(9968.34)
August	11673.59	0.00	(11673.59)
September	20207.75	0.00	(20207.75)
October	6022.28	0.00	(6022.28)
November	8171.52	0.00	(8171.52)
December	(701.94)	0.00	701.94
January	20618.13	0.00	(20618.13)
February	7741.27	0.00	(7741.27)
March	(16202.30)	0.00	16202.30
	98193.66	0.00	(98193.66)

Period(s): **08** through Data (1,2,3,4) or <CR> for all:

Secondary Treatment, Biological Filters.

	General Ledger Code	LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525400002/1101	22538.15	0.00	(22538.15)
2	1-S-525400002/1102	1906.09	0.00	(1906.09)
3	1-S-525400002/1107	0.00	0.00	0.00
4	1-S-525400002/1203	0.00	0.00	0.00
5	1-S-525400002/1401	11315.49	0.00	(11315.49)
6	1-S-525400002/1402	982.41	0.00	(982.41)
7	1-S-525400002/2101	18169.31	0.00	(18169.31)
8	1-S-525400002/2201	1683.04	0.00	(1683.04)
9	1-S-525400002/2202	189.29	0.00	(189.29)
10	1-S-525400002/2203	4694.23	0.00	(4694.23)
11	1-S-525400002/2204	190.74	0.00	(190.74)
12	1-S-525400002/2308	205.44	0.00	(205.44)
13	1-S-525400002/2309	198.33	0.00	(198.33)
14	1-S-525400002/2391	2026.48	0.00	(2026.48)
15	1-S-525400002/2392	0.00	0.00	0.00
16	1-S-525400002/2397	0.00	0.00	0.00
17	1-S-525400002/2903	0.00	0.00	0.00
18	1-S-525400002/2907	0.00	0.00	0.00
19	1-S-525400002/3204	273.27	0.00	(273.27)
20	1-S-525400002/3209	21226.15	0.00	(21226.15)

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

	General Ledger Code	LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525400002/3251	14849.76	0.00	(14849.76)
2	1-S-525400002/3301	91.80	0.00	(91.80)
3	1-S-525400002/3302	6392.56	0.00	(6392.56)
4	1-S-525400002/3901	3062.32	0.00	(3062.32)
5	1-S-525400002/3902	1440.00	0.00	(1440.00)
6	1-S-525400002/4201	486.91	0.00	(486.91)
7	1-S-525400002/4202	160.53	0.00	(160.53)
8	1-S-525400002/7392	(55000.00)	0.00	55000.00
9	1-S-525400002/C111	16266.40	0.00	(16266.40)
10	1-S-525400002/D111	24844.96	0.00	(24844.96)
11	1-S-525400002/D122	0.00	0.00	0.00
12	1-S-525400002/D141	0.00	0.00	0.00
13	1-S-525400002/D151	0.00	0.00	0.00

Accrual for Income

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

	General Ledger Code	LY Actuals (Accruals)	LY Revised Budget	Variance
1	1-S-525400002/3251	14849.76	0.00	(14849.76)
2	1-S-525400002/3301	91.80	0.00	(91.80)
3	1-S-525400002/3302	6392.56	0.00	(6392.56)
4	1-S-525400002/3901	3062.32	0.00	(3062.32)
5	1-S-525400002/3902	1440.00	0.00	(1440.00)
6	1-S-525400002/4201	486.91	0.00	(486.91)
7	1-S-525400002/4202	160.53	0.00	(160.53)
8	1-S-525400002/7392	(55000.00)	0.00	55000.00
9	1-S-525400002/C111	16266.40	0.00	(16266.40)
10	1-S-525400002/D111	24844.96	0.00	(24844.96)
11	1-S-525400002/D122	0.00	0.00	0.00
12	1-S-525400002/D141	0.00	0.00	0.00
13	1-S-525400002/D151	0.00	0.00	0.00

GL Code Line __ (1-20 or Next/Prev Page) Transaction/Source T/S

ENVIRONMENT AGENCY

Our Ref: SO1410.2708.ams
Your Ref:

Date: 27 August 1997

A M Bennett
Scotia Water Services
Belton House
Wanlockhead
Biggar
ML12 6UR

Dear Sirs

PUBLIC REGISTER AND ENVIRONMENTAL INFORMATION REQUEST
Re: River Bollin

Further to our letter of 28 July 1997 and your telephone conversation of 27 August 1997, please find enclosed the responses we have received so far, the remainder will follow as soon after they have come into our office.

FLOOD DEFENCE

Unfortunately this Agency does not keep specific records on the costs of design and construction of culverts/bridges undertaken by outside Authorities or companies.

Major construction works on the River Bollin include the recent completion of the A34 Wilmslow-Handforth Bypass by AMEC/Mc Alpine Joint Venture for Cheshire County Council and the commencement of the construction of Manchester Airport second runway by AMEC/Tarmac Joint Venture for Manchester Airport Plc.

Generally this Agency requires that any proposed new culverts/bridges over "main river" watercourses such as the River Bollin, are designed to pass the theoretical 1 in 100 year flood flow with at least 600 mm freeboard. The onus is on the developer/promoter of scheme to undertake the necessary hyrological and hydraulic investigations, to the satisfaction of this Agency's Flood Defence section and to ensure that any existing flooding problems are not aggravated or new ones created.

HYDROELECTRIC GENERATION

The only scheme within the Bollin Catchment is at Quarry Bank Mill at Styal Museum. This is not strictly hydroelectric but the river is used to power a water wheel for display purposes and ultimately to provide water power to drive museum machinery.

As far as we are aware, no data from this scheme has been used in neighbouring catchments.

The abstraction is direct from the River Bollin at National Grid Reference (NGR) SJ 833 828 via a sluice gate feeding a mill race.

We have no knowledge as to the construction costs of the scheme but as this was a high profile project undertaken by National Trust, we assume that they may have figures available.

The scheme capacity details are:

The licence currently authorises abstraction at a rate not to exceed 0.546 Megalitres per hour, 3.27 Megalitres per day and 1064 Megalitres per year. These quantities were effective from 1993 when the authorised volumes were reduced. The licence was originally issued for 4.54 Megalitres per hour, 31.82 Megalitres per day and 8728 Megalitres per year which was approximately fifty percent of what had been applied for.

We were contacted in 1994 concerning the proposal to install a low head water turbine at the site as part of the Non Fossil Fuel Obligation Contracts (NFFO) but have not heard anything since.

We were also contacted in 1994/1995 concerning a water turbine installation at the site of Warburton Corn Mills further down the Bollin at NGR SJ 703 888 again as part of NFFO Contracts but again, we have not heard anything since.

ABSTRACTIONS

Please find enclosed a listing which gives details of all known licensed abstractions within the vicinity of the site. Whilst every effort is made to ensure the information provided is as accurate as possible, please note that this data if based on current licensed abstraction within the specified area. It is possible that unlicensed abstractions also exist, particularly for domestic and/or agricultural use, which are not included on the list. Further information regarding these abstractions, if any, may be obtained from the appropriate Environmental Health Department who are required to keep records for sources used for private water consumption.

This Agency does not hold any information of the number of households served by any abstraction schemes originating within the catchment, this information may be held by the water undertaker North West Water plc.

There are no current gauging stations within the catchment operated by the Agency linked to public water supply schemes.

ECOLOGY

Our Ecology section are not sure that they could provide any conservation/biology data that would be useful to this project in assessing the direct benefits that arise from hydrometric gauging. They can see indirect benefits, for example, hydrometric information is useful when planning river restoration works, in determining the existing hydrological characteristics of the catchment and helping determine an appropriate channel design for the restored river.

The information provided is based on that currently available to the Agency. The Agency and its officers accept no liability whatsoever for any loss or damage arising from the interpretation or use of the information.

As discussed in our telephone conversation, you may wish to come down to our office and talk to the consultees concerned who have given the responses. Your best initial point of contact would be Paul Crane who I believe has been briefed by John Adams before his departure. Paul on extension 3014.

I hope this information proves useful to you and if you should require any further information, please do not hesitate to contact me at the address below.

Yours faithfully

pp Anne-Marie Shepherd

ANITA COGDELL
Customer Services Officer

This matter is being dealt with by Anne-Marie Shepherd on extension 3628.

HW35

RIVERS Agency

Headquarters
Hydebank
1 Hospital Road
BELFAST
BT8 8JP

Telephone: 01232-253355
Fax: 01232-253455

Your Ref:

Our Ref: HYDR/142

Mr Tony Bennett
Scotia Water Services
Belton House
Wanlockhead
Biggar, ML12 6UR
Scotland

30 September 1997

Dear Tony

SNIFFER PROJECT - COST BENEFIT OF HYDROMETRIC NETWORKS

I would apologise for the time taken to reply to your request for information but I had to refer to another Government Department which delayed matters.

Reference Items 1 Reservoirs & 2 Hydro-electric Generation

Not Applicable.

Reference Item 3 Bridge/Culvert Design

From our Design Units' records for the Foyle catchment over the past 2 years, there have been 9 requests for river flows to facilitate bridge/culvert related works. The Scheme details are as below. The majority are bridge upgrades or repairs and I have received no costs for related road schemes.

River	Title/Bridge	Client/Consultant	Est Cost
Roe	Limavady By-pass Curly Bridge	DOE Roads Service	£500k
Roe	Repairs to Roe Bridge	Translink/ Ferguson McIlveen	)) £250k
Faughan	Repairs to Faughan Bridge	Ferguson McIlveen	)
Fairywater	Bridge Re-decking Mullanatmoog	DOE Roads Service	£55k
Camowen	Footbridge	Hospital Rd Community Assoc	£40k
Foyle	Community Platform Millennium Project	3rd Millennium Bridge Co./ Montgomery, Cleary	£100k
Roe	Disabled Anglers' Footbridge	Burnfoot Community Devel Assoc.	£50k
Fairywater	Moorfield Bdge, Drumquin	DOE Roads Service	£50k
Burndennet	Burndennet Bridge	DOE Roads Service	£300k
TOTAL			£1,345K

I estimate the data collection costs as follows:-

Staff Time = 10 PTO days per year for all 5 of the Gauging Stations (ie 2 days per annum per Station) which equates to approx £1,100/Year.

Travel equates to approx £900/Year for all 5 Stations.

Total costs are therefore in the order of £400/Station/Year.

Station opening dates:-

Fairywater	Nov 71
Camowen	Apr 72
Roe	Jan 75
Faughan	Aug 76
Burndennet	May 75

(Note:- R. Foyle is ungauged and tidal)

Reference 4 Flood Warning Systems

Only 2 Stations within the Foyle Catchment (and indeed within N. Ireland) relate to Flood Warning. These Stations are Camowen @ Lisboy and Drumragh @ Drumshanly. They are 'level only' Stations (ie no gauging done at sites) and can be accessed via telemetry by Area Operational Staff to determine the state of these rivers which flow into the R. Strule above the town of Omagh. The Stations are not connected to any form of automated warning system.

I hope that this provides you with some useful information for the SNIFFER Project. If you need further information or clarification, please contact me.

Yours sincerely

STEPHEN DAWSON
Senior Hydrometric Engineer
Hydrometric Section

cc. Mr John Waterworth

Mr T Bennett
Belton House
Wonlockhead
BIGGAR
Scotland
ML12 6UR

Hydrometric Networks **SNIFFER/EA Research Project**

As discussed please find attached details of the major Water Service dams with information on year of commission, height, etc.

I hope this information is of use in your research.

Tom Hagan
Water Service
Northland House
3 Frederick Street
BELFAST
BT1 2NR

Tel: (01232 354765)

16 September 1997

OE (NI) - WATER SERVICE

DAMS - ALL DIVISIONS
BASED ON 1992 AMP DATABASE (NOT UPDATED)

(NOTE ALL THE INFORMATION PROVIDED IS CONFIDENCE GRADED BUT NOT SHOWN HERE)

Report Ref D101/DAM2 WK4

Type of Dam
Ear - Earth
Roc - Rockfill
Gra - Concrete/Masonry gravity dam
Arc - Concrete/Masonry arch dam
But - Concrete/Masonry buttress dam
Oth - Other

Div Code	Sub-Div Code	Asset Code	Name of Dam	Irish Grid Reference	Type of Dam	Capacity in ML	Compen-sation Flow ML/D	Year of Commis-sioning	Year of Refurb-ishment	Height of Dam in M	Condition Grade of Dam	Year of Panel Eng Inspection	Name of Outlet Stream
E	A	1	BALLYSALLAGH LOWER RESERVOIR	J457787	EAR	568	0.25	1909		7	2	1995	CRAWFORD'S BURN
E	A	2	BALLYSALLAGH UPPER RESERVOIR	J447775	EAR	750	0.35	1954		12	2	1995	CRAWFORD'S BURN
E	A	3	CONLIG LOWER RESERVOIR	J500787	EAR	77	0	1884		4	3	1995	MILL RACE
E	A	4	CONLIG UPPER RESERVOIR	J499783	EAR	127	0	1900		7	3	1995	MILL RACE
E	A	5	PORTAVO RESERVOIR	J563829	EAR	268	0	1935		7	1	1995	ORLOCK
E	A	6	LOUGH COWEY	J598546	GRA	970		1955		2	3	1995	UNNAMED STREAM
E	A	23	CREIGHTONS GREEN RES	J430788	EAR	545	0	1956	1983	10	1	1995	UN-NAMED RIVER
E	A	24	(HOLYWOOD EAST) CHURCH RD UPPER	J414773	EAR	145	0	1922	1973	8	2	1995	UNNAMED STREAM
E	B	20	DORISLAND RES	J389875	EAR	302	0	1878	1982	13	2	1995	WOODBURN RIVER
E	B	26	KNOCKBRACKEN (SR) RESERVOIR	J363665	EAR	445	0	1892		20	2	1998	PURDY'SBURN
E	D	8	TANNAGHMORE	J391445	EAR		0	1940	1980	3	2	1995	UNNAMED STREAM
E	D	11	SILENT VALLEY	J309204	EAR	13276	0	1932	1983	24	1	1995	KILKEEL RIVER
E	D	12	BEN CROM	J309204	GRA	7721	0	1957		38	1	1995	MILL RIVER TO SILENT VALLEY
E	L	10	BOOMER'S RESERVOIR	J254664	EAR	270		1897	1977	12	2	1995	OLDPARK BURN
E	L	14	STONEYFORD	J217702	EAR	3688	0.012	1887		12	2	1995	STONEYFORD RIVER
E	L	15	LEATHEMSTOWN RES	J214723	EAR	452	0.012	1891	1979	19	2	1995	GLENAVY RIVER
E	N	16	WOODBURN NORTH RESERVOIR	J371911	EAR	372	0	1878	1979	13	2	1995	WOODBURN RIVER
E	N	17	WOODBURN LOWER SOUTH RESERVOIR	J377894	EAR	487	0	1865	1979	19	2	1995	SOUTH WOODBURN RIVER
E	N	18	WOODBURN MIDDLE SOUTH RESERVOIR	J373895	EAR	2135	0	1868	1979	26	2	1995	LOWER SOUTH RES
E	N	19	WOODBURN UPPER SOUTH RESERVOIR	J373895	EAR	1669	0	1874	1977	22	2	1995	DISCHARGES TO WOODBURN MIC
E	N	21	LOUGH MOURNE	J429921	EAR	2621	0	1879	1979	4	2	1995	PLUCK STREAM
E	N	22	COPELAND RES	J429921	EAR	607	0	1879	1979	19	2	1995	COPELAND WATER
E	S	13	LOUGH ISLAND REAVY	J290333	EAR	9091	0.013	1840	1981	13	2	1997	MUDDOCK RIVER
N	A	1	KILLYLANE	J285985	EAR	1363	0	1960	1960	16	1	1996	KILLYLANE BURN
N	A	2	BALLYBOLEY	D377035	EAR	39	0	1899	1984	7	2	1996	NONE
N	A	3	POTTERSWALLS	J161908	EAR	82	0	1937	1937	4	2	1996	NONE
N	B	4	QUOLIE UPPER	D188137	EAR	240	0	1949	1980	15	1	1996	QUOLIE WATER
N	B	5	QUOLIE LOWER	D180130	EAR	182	0	1887	1980	12	1	1996	QUOLIE WATER
N	B	6	DUNGONNELL	D193172	ROC	1090	0.0005	1970		16	1	1996	BALLSALLAGH WATER
N	C	7	ALTNAHINCH	D121234	EAR	1270	0.037	1965	1965	23	1	1996	RIVER BUSH

Type of Dam
Ear - Earth
Roc - Rockfill
Gra - Concrete/Masonry gravity dam
Arc - Concrete/Masonry arch dam
But - Concrete/Masonry buttress dam
Oth - Other

DAMS - ALL DIVISIONS
BASED ON 1992 AMP DATABASE (NOT UPDATED)

(NOTE ALL THE INFORMATION PROVIDED IS CONFIDENCE GRADED BUT NOT SHOWN HERE)

Report Ref D101/DAM2.WK4

Div Code	Sub-Div Code	Asset Code	Name of Dam	Irish Grid Reference	Type of Dam	Capacity in ML	Compensation Flow ML/D	Year of Commissioning	Year of Refurbishment	Height of Dam in M	Condition Grade of Dam	Year of Panel Eng. Inspection	Name of Outlet Stream
N	C	8	BALLYVERSAL	C893347	EAR	18	0	1911		3	2	1996	NONE
N	C	9	BALLYWILLAN	C873384	EAR	80	0	1900	1900	11	2	1996	NONE
N	C	10	CRAIGAHULLIAR	C879387	EAR	150	0	1909	1981	8	2	1996	NO NAME
N	C	11	DUNALIS	C804308	EAR	141	0	1934	1949	7	2	1996	NO NAME
N	C	12	ALTIKEERAGH	C748320	EAR	127	0	1953	1953	9	1	1996	NONE
N	C	13	BALLINREES	C797297	EAR	1210	0	1955	1955	15	1	1996	NONE
S	A	1	SEAGAHAN	H895383	EAR	2396	0.0017	1959	1982	26	2	1997	BUTTERWATER
S	A	2	CLAY LAKE	H832326	ROC	1764	0.0021	1840	1984	4	2	1997	NO NAME
S	A	200	CAPPAGH.	H685676	EAR	59	0	1878	1980	6	2	1997	TORRENT
S	A	201	ALTMORE	H685676	EAR	175	0	1962	1962	16	2	1997	TORRENT
S	N	400	FOFANNY	J284293	EAR	409	0	1909	1978	16	2	1997	SHIMNA RIVER
S	N	401	SPELGA	J267274	ARC	3327	0.026	1957	1970	31	2	1997	RIVER BANN
S	N	402	LOUGH ISLAND REAVY	J305343	EAR	9091		1839	1991	13	2	1997	
W	E	3	KILLYFOYLE	H470313	GRA	732	0.005	1968	1968	1	2	1995	FINN RIVER
W	E	7	BALLYDOOLAGH	H283485	EAR	700	0	1870	1982	2	2	1995	BALLYDOOLAGH
W	L	1	ALTNAHEGLISH	C696041	GRA	2270	0	1934	1987	42	1	1997	ALTNAHEGLISH RN
W	L	8	KILLEA	C387163	EAR	468	0	1904	1935	12	1	1995	LIBERTY BURN
W	O	2	GLENHORDIAL	H482752	EAR	64	0	1877	1968	7	2	1996	KILLYCLOGHER RN
W	O	4	CURLEY HILL	H352982	EAR	33	0	1908		6	4	1995	KNOCKAVOE BURN
W	O	5	FINGREAN	H576776	EAR	746	0	1971		3	1	1995	
W	O	6	LOUGH BRADEN	H259712	EAR	626	0	1952	1965		2	1996	BLACK WATER

IV Project Personnel

Project Board members:

John Adams (Midlands Region (ex-NW); former R&D Topic Leader)
Scott Ferguson (Southern Region; R&D Topic Leader)
David Rylands (Thames Region; Project Leader)
Giles Phillips (HQ; Project Executive)
Meg Postle (EA Environmental Economist)
Nicky Bailey (Thames Region; R&D Management Support Officer)
John Waterworth (Environment & Heritage Service Northern Ireland; SNIFFER rep.)
Angela Wallis (Anglian Region; Board Member)
Nigel Fawthrop (Anglian Region; Project Proposer)

Research team members and contact details:

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Geography Department, University of Dundee, DUNDEE, DD1 4HN
Tel 01382 344433; fax 01382 344434; email a.z.black@dundee.ac.uk

Tony Bennett
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Nick Hanley
formerly Reader in Environmental Economics, University of Stirling
now Professor of Natural Resource Economics, Institute of Ecology and Resource Management, Kings Buildings, University of Edinburgh, EH9 3JG
phone 0131 535 4111; fax 0131 667 2601

Ceara Nevin
formerly Research Assistant at University of Stirling
now Research Student at University of Edinburgh; contact details as per Nick Hanley

Mike Steel
Research Assistant at University of Dundee; contact details as per Andrew Black

V Published Paper

The following paper was presented orally at the Sixth British Hydrological Society National Hydrology Symposium, held at Salford University in September 1997, and published in the proceedings of that meeting.

Publication details:
Black, A R, Bennett, A M, Hanley, N D, Nevin, C L, Steel, M E, Rylands, W D and Adams, J R W (1997) Towards new approaches to the evaluation of hydrometric monitoring data. *Proceedings of Sixth National Hydrology Symposium*, Salford, September 1997, Wallingford: British Hydrological Society, 1.29-1.38.

Towards new approaches to the evaluation of hydrometric monitoring data

A.R. Black, A.M. Bennett, N.D. Hanley, C.L. Nevin, M.E. Steel, W.D. Rylands and J.R.W. Adams

Abstract

This paper reports progress in a research project which is developing methods of assessing the benefits of hydrometric monitoring data. Because of the complexity or non-market nature of many of the benefits arising from hydrometric data collection, such assessments have not routinely been made. However, with the availability of data for the costs of monitoring, and the need to ensure and demonstrate wise deployment of resources, the development of such methods allows monitoring agencies to assess the benefits of their activities. Where economic benefits can be related to costs, ratios can be calculated. The paper presents a review of those economic methods which have been applied to benefit assessment, and the results of a complementary survey of data users within and outside the UK hydrometric agencies. The development of an approximate cost-benefit assessment approach is explained as the basis of the method for assessing benefits, drawing on recent advances in non-market valuation techniques. Mechanisms for recognising the importance of intangible benefits are also described, in the interests of promoting broadly-based benefit assessments. The paper concludes with a discussion of how the application of these methods will contribute to the periodic review of monitoring networks.

Introduction

Hydrometric monitoring in the United Kingdom encompasses the routine observation of rainfall, water levels in rivers and lakes, river flows, groundwater levels and, less commonly, the collection of other relevant data such as snow accumulation and climate parameters. Monitoring is undertaken in England and Wales by the Environment Agency, in Scotland by the Scottish Environment Protection Agency and in Northern Ireland by the Environment and Heritage Service and the Department of Agriculture for Northern Ireland. Each of these bodies has a duty to monitor water and other resources on a regional basis, within its area of jurisdiction, in the course of promoting the wise use of these resources. Other bodies, such as water supply undertakings, undertake independent monitoring activities for their own purposes.

The history of hydrometry in the UK is a long one, with the earliest monitoring of rainfall dating from the seventeenth century. However, this paper will consider surface water monitoring only. The earliest continuous records of river level and flow are from the River Lee at Feildes Weir in 1879 (Lees, 1987), but occasional observations are known from as long ago as 1740 for the city of Edinburgh (F. M. Law, *pers. comm.*). These earliest measurements were concerned with quantifying water resources for supply purposes. However, the subsequent expansion of monitoring in the UK, principally from the late 1940s, was concerned also with land drainage, fisheries and pollution prevention. Today, the statutory authorities operate some 1600 gauging stations from which data are used for a wide range of purposes.

With the growth of monitoring by public authorities, there has been an increased need to ensure that expenditure is being directed towards appropriate activities and at an appropriate scale. Therefore, efforts have been directed towards assessing the economic value derived from hydrometric data collection programmes. Often, such studies have focused on the benefits accruing from one particular application of data, although occasionally more general assessments have been undertaken.

With reorganisation affecting the whole of environmental regulation in the UK, principally as a result of the 1995 Environment Act, the new agencies are keen to have a methodology with which to evaluate the benefits of hydrometric data.

collection activities. This is important within the context of the Act requiring the England & Wales and Scotland agencies to take account of the costs and benefit of their activities. Such a methodology will allow future decisions, regarding monitoring network changes, to be undertaken in full knowledge of the benefits accruing from the various strategies available. A study was commissioned by the Environment Agency and the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) in 1996 to develop the methodologies required, and forms the basis of this paper. It follows work by the Environment Agency, reported by Fawthrop and Streeter (1996a, b), which considered the efficiency and value-for-money with which hydrometric services are being provided . In the following sections, we will describe the history of assessing hydrometric data benefits, provide an overview of current data uses in the UK and their associated benefits, and then explain how a new approach is being developed which will provide for the fullest possible assessment of benefits in the future.

Literature review

Formal benefit quantification was not applied in the earliest advances into hydrometry: the various interests involved required hydrometric data sufficiently strongly to justify the necessary expenditure. However, since the growth in recognition of cost-benefit analysis as a useful tool for appraising resource allocation decisions in water projects since the 1960s, benefit assessments in hydrometry have become increasingly common. The products of these reviews have been reported in the hydrological and economics literature. Many studies have concentrated on single uses of data, or the uses of data from specific gauges or groups of gauges, with a small minority addressing whole networks in a general manner. At the same time, there has been a history of methods which do not attempt to fully quantify benefits in economic terms, but which set out criteria to guide the review of an existing network.

Economic benefit assessments

A number of economic approaches are employed to assess the benefits arising from the use of hydrometric data.

1 Benefits of applying real-time data to reduce damages - e.g. by the issue of flood warnings based on hydrometric data.

2 Benefits of applying real-time data in resource management - costs can be avoided, e.g. in a drought situation, if real-time information allows actions to be taken to avoid likely costs, such as pumping to maintain river flows or to provide supply from distant sources.

3 Benefits relating to investment planning - costs are associated with under-design and over-design and so, where data can be used to reduce uncertainty in the design process, a benefit arises. Examples include bridge and dam design, and major commercial or residential developments.

4 Benefits assessed within the context of a production function - hydrometric data can be treated as an input in the production of a desired level of water quality, e.g. more information as an input can allow for less expenditure in abatement costs.

Each of these approaches has been applied in the selected economic case studies summarised below, covering five main areas of benefit (the list is not exhaustive).

Storage reservoir design
The design of a reservoir is based on the delivery of a required yield and, in order for the reservoir to deliver this in practice, a knowledge of the behaviour of the inflow streams is desirable. Synthetic data are regarded as a less valuable alternative. Adeloye (1995; 1996) indicates that the coefficient of variation of annual inflows is the most important streamflow parameter for design purposes, and that capacity estimates are highly sensitive to record length. He also illustrates (1990) that a six-year record implies a 30% error in required capacity estimate, while even 20 years still result in a 15% error. Longer records are of particular importance because of their increased likelihood of including critical periods (e.g. droughts) which cannot be synthetically generated from shorter records (Barlishen *et al.*, 1989). In New South Wales, Cordery and Cloke (1990) were able to assess the sensitivity of reservoir capital costs to record lengths, identifying savings in over-design and under-design as data benefits. They developed this work to show that if data from the 500 gauging stations in New South Wales were applied only to this type of work, data collection benefits would remain in excess of costs until record lengths reached approximately 80 years. Such an analysis excludes other benefits from consideration, not least the benefits of reservoir operating strategies which employ comprehensive hydrological data (Tejadaguibert *et al.*, 1995).

Design of bridges
Cordery and Cloke (1990) also present benefit-cost ratios for data used in New South Wales for the design of small stream crossings. Design guidelines have been issued in Australia in 1958, 1977 and 1987, based on successively larger amounts of streamflow data (Institution of Engineers, Australia, 1987). Each revision of the guidelines is associated with changes in the costs and benefits accruing from the design of new crossings, namely:

(a) capital loss/saving due to overdesign/ underdesign,
(b) cost/saving of damage to structure due to

underdesign/overdesign, and

(c) cost/saving of delays, extra travel distance, etc. (Cordery and Cloke, 1990, p222).

A benefit-cost ratio based on data collection costs and benefits relating to this data use only, between the years of 1958 and 1987, produces a ratio of 92:1. Even when all data collection costs in the state are considered over the period, a substantial ratio of 22:1 is found. Benefits accruing from the application of data to other design work were additional to the reported analyses.

Flood protection

Uncertainty reduction is important within the design of flood defences. Mawdsley *et al.* (1990) report a study in England, relating the benefits of data in this context to the costs of collection. Benefits were given as approximately 4-5% of construction costs, giving benefit-cost ratios of 1.0, 0.37 and 0.05 in the three examples studied. By contrast, however, Cordery and Cloke (1994) produce benefit-cost ratios of up to 80:1, and suggest that there should be a general expectation that data benefits will outweigh collection costs whenever flood protection works are contemplated. On this basis, they recommend that whenever data are scarce and a future need of this sort is likely, instrumentation programmes should commence immediately.

Flood warning systems

Hydrometric data are needed for both the design and operation of flood warning systems. Benefits of flood warning are assessed by reference to damages avoided: flood-threatened residents and businesses can move possessions or stock and equipment to avoid the effects of inundation. The most significant UK effort in assessing flood damages and the possible avoidance of costs by structural and flood warning measures has been undertaken by the Middlesex University Flood Hazard Research Centre. Recent research for the National Rivers Authority (Heijne *et al.*, 1996), following these methods, has indicated that tangible benefits from fluvial flood warning in England and Wales could amount to some £15 million annually. Current research for the Environment Agency (1996) indicates that in some circumstances, tangible losses may be reduced by as much as 50% as a result of warnings. However, little work has been done on relating the possible benefits of schemes to the costs of providing data.

Water quality maintenance and improvement

Some progress towards valuing water quality maintenance and improvements has been made in the UK by Adeloye and Mawdsley (1990). However, they report low data values, and consider it important to stress intangible benefits. The difficulties here relate to the problem of water quality not being a marketed good. However, data benefits can be arrived at by the application of a production function (see above). Benefits may also accrue from being able to avoid costly actions in order to maintain quality standards. Sections below will discuss how this approach may be used in this study.

Recreational benefits are often associated with water quality management. Green *et al.* (1989) suggest that improvements in water quality due, for example, to the avoidance of low flow episodes, will lead to benefits in terms both of increased quality and quantity of fishing, and may allow other benefits such as swimming or other clean-water sports. Progress in quantifying these benefits is difficult: benefits are not as clearly identifiable as with flood defence projects, for example. Nonetheless, economic principles can be invoked to quantify some benefits, and a recent F.W.R. (1996) manual gives monetary benefits of up to £25.66 per angler-visit resulting from water quality improvements. Methods used to assess benefit include assessment of demand and the willingness of anglers to pay for recreational benefits, e.g. by reference to travel costs over different journey lengths. However, it is not the concern of these methods to identify that fraction of recreational benefit which is directly attributable to data collection (see below).

Many more studies are known than those reported here, but the selection serves to illustrate the range of circumstances in which data benefit assessment has been attempted. In some examples, differences in benefit assessment are reported for similar applications of data. Part of the explanation for this must lie in the circumstances of a specific project, e.g. the costs of a proposed investment project, the local costs of data collection. However, it must also be possible that different approaches could be taken to appraising the benefits arising in one given project. Reference to the means by which data collection costs are assigned to individual benefits gives one illustration of this.

Non-economic benefit assessments

Non-economic benefit assessment methods have been developed where comparative data-generating values have been required as part of the review of a gauging network: Although numerical scores are used, these do not purport to represent the economic value of the data being generated. One example comes from Canada where Davar and Brimley (1990) report the application of a general approach by Wahl and Crippen (1984). In it, scores were accumulated under each of four headings:

(a) site characteristics,
(b) identified client needs - regional hydrology,
(c) identified client needs - operational hydrology, and
(d) regional importance of water resources.

This allows an objective basis for discriminating amongst stations, but offers no direct potential for assessing the economic benefits of data and is therefore discounted from application in this study.

Network reviews

Perhaps as an indication of the increasing emphasis being placed on accounting for public expenditure, the literature search for this study indicated a substantial growth in data-benefit-cost papers since the mid-1980s. One particularly important study for the UK is the broad-based benefit-cost assessment undertaken for the whole UK flow gauging network by C. N. S. Scientific & Engineering Services (1991). At *c.*1987 prices, total UK costs for flow gauging were estimated at £9 million, with benefits being quantified in five main areas:

(a) the risk of climatic change or other factors causing a significant change of river flow (assuming that the gauging network had been abandoned);
(b) water authority operations, including the supply of potable water;
(c) irrigation;
(d) flood alleviation;
(e) flood warning.
(C.N.S., 1991; p.1)

Perhaps surprisingly, the study reported only "small benefits" being quantifiable from flood warning, and none from consents to discharge effluent, although the latter was seen to be important nonetheless. The final benefit values ranged from £11 million to £60 million, representing benefit-cost ratios of 1.2:1 to 7:1, with a best estimate of 2.3:1. This indicated that UK expenditure on gauging was producing cost-effective returns, but the report did not provide a methodology for the assessment of local networks. It is noticeable that the range of ratios is large, reflecting the importance of the methods used for assessing benefit. It is recognised that costs can be quantified with much greater confidence.

Through the Nordic Coordinating Committee for Hydrology, the Nordic countries have been undertaking a review of their hydrometric monitoring programmes (Puupponen, 1996). Their assessment of benefits has so far been limited to the classification of the networks with respect to the utilisation of data, using three broad categories:

- hydrological analysis and process studies,
- water resources management, and
- environmental monitoring.

The importance of each site for each function was assessed by local hydrometric staff, rather than by data users.

The review considered the economic properties of hydrological data and hydrological network operation, concluding that "the economic characteristics of hydrologic data and acquisition and hydrologic data as a commodity show that the conditions for a comparative market are not met, so economically efficient conditions for the production and exchange of hydrologic data will not be established" (Puupponen, 1996). Such findings accord well with those of this project.

Survey of data uses and benefits

As part of the process of developing methods to assess benefits, it was decided that contact should be made with data users. This would allow applications of data, and the benefits arising from them, to be identified.

A series of questionnaires was developed for distribution to regional and area offices of all the UK hydrometric agencies. Questionnaires were drawn up specifically for each of the following agency functions:

- Freshwater chemistry
- Freshwater biology
- Estuary/marine survey
- Water resource management
- Abstraction licensing
- Pollution control
- Flood warning
- Flood defence
- Fisheries & conservation

Table 1 lists the main uses identified for each of these functions. Many of the main uses are familiar to all associated with the work of the agencies, e.g. discharge consent determinations, flood warning system operations, calculation of marine loadings. But others are less well known, e.g. application in the design of environmental enhancements for recreational activities such as canoeing, a far cry from the oft-quoted dams, bridges and culverts, and this illustrates the diversity of activities undertaken by environment agencies and the breadth of utility of their hydrometric data.

Elucidating information regarding the benefits of data was much more difficult than identifying uses. Most Pollution Control Officers, in responding to their questionnaire, were unable to quantify the likely effects of a shift from setting consent standards with flow data available to relying only on flow estimates. Similarly, most Flood Warning Officers found it difficult to provide information on the benefits accruing from operation of their systems, despite the economic nature of the direct benefits. The exercise therefore had its main benefit in identifying the breadth of data use, rather than in quantifying benefits.

Interviews were held with a number of external data users, recognising that their uses are in addition to those identified by the questionnaire survey. Some uses, such as those pertaining to water supply, may yield some of the largest benefits accruing from data use. Data request-logging systems in the Midlands Region and Dales Area of the Environment Agency allowed an overview of the frequency of requests from different types of user. In both, schools and

Table 1 **Summary of hydrometric data uses cited in questionnaire responses, listed by function**

Hydrological Network Data Uses

[key: SUBJECT
n main data uses in order of frequency
- other cited data uses]

Pollution

1. consent determination/review
2. calculation and modelling of mass balance/pollutant loads
3. assessing and managing pollution events
- design of surface-water treatment
- sewerage modelling
- timing of engineering work
- risk assessment for pollution prevention

Abstraction

1. abstraction licences; determining new levels and altering existing ones
2. investigating derogation complaints
3. enforcing residual and compensation flow licences
- catchment model construction and evaluation
- estimation of dry weather flows in ungauged catchments
- setting 'hands off' flows
- compensation

Chemical

1. calculating chemical loads to North Sea for PARCOM/Red List/Harmonized Monitoring Scheme/Global Environmental Monitoring
2. modelling catchment water quality and quantity (including SIMCAT modelling)
- information about time of sampling for result interpretation
- studying effects of low flows on water quality
- compliance with Drought Orders
- planning fieldwork

Biological

1. input into RIVPACS
2. determining whether conditions are suitable and safe for sampling
3. calculating dilution available for effluent for sampling/cost recovery
4. loading models (solute loadings and loch retention) and water quality models (loch eutrophication/ phosphorus concentration)
5. interpreting survey results
- to 'trigger' surveys on low flow effects/drying/recovery
- Base Flow Index input to SERCON conservation assessment scheme

Fisheries/Conservation/Recreation/Navigation

1. relating flow/discharge with run-times and the suitability/utilization of various habitats
2. targeting vulnerable areas for monitoring/improving/restoring habitat
3. operational use; survey information, critical levels, enforcement, fish rescue
- access; canoeing only at high flows
- low flow research projects
- design of channels (environmental enhancement) and fish passes
- maintenance of navigation and power generation purposes

Flood Warning

1. flood warning system development
2. flood warning system calibration

3. flood warning system operation
- level to level correlation
- extended use of radar
- flood forecasting modelling

Flood defence

1. assessing return periods (flood frequencies)
2. assessing particular flooding events (post flood analysis)
3. design of new works; flood alleviation schemes
4. calibration of design models for schemes/investigations
5. management of infrastructure (maintenance work)
- checking design tolerances
- improving Flood Studies estimates
- development of control purposes *e.g.* building above sea level

Marine/Estuarine

1. river loads and freshwater inputs for water quality modelling
- estuarine salinity and current studies
- calibrating models/predictive simulation
- marine survey evaluation
- design purposes

Water Resources Management

Data uses encompass a number of uses cited above, from most subjects;
- water resources planning and monitoring
- low flows and abstraction issues
- flood risk and warning
- insurance/legal purposes
- research projects

universities/colleges formed the single largest group, with the water supply companies and consultants being second or third in each. For users external to the data collection agency, their maximum willingness to pay for data would be an indication of the economic value of those data. However, current charges for data supply (typically only handling charges) fall well short of these maximal amounts, so charges could not be used as a measure of benefit.

An interview with one supply company indicated that most of their usage derived from eight sites, with direct access to data three times a day; but in periods of drought, data from a much larger area are requested. Visits were also made to a number of consulting engineers. Here, some progress was achieved in identifying the sensitivity of flood defence design data uncertainties in design flood, and also the relationship between design and cost. In one example studied, a 20% cost increase in a £20 million scheme was a realistic scenario if no suitable data were available. A secondary point is that even after a period of data collection at a site, benefits continue to grow as a result of reducing parameter uncertainty, though at a changing rate (see Thomas, 1994). This is particularly important in relation to the estimation of rare floods, especially if climatic shifts may occur.

Problems of benefit identification

A number of difficulties facing the development of a method for assessing hydrometric data benefits were identified above. Difficulties arise in the assessment of some benefits where no satisfactory basis can be found for quantification. Such benefits are referred to as intangible benefits and include, for example, the reduction or avoidance of stress and illness associated with flooding, and the recreational benefits of maintaining or improving water quality. Benefits are real, but are hard to value, although recent advances in non-market valuation techniques mean that "ball-park" benefit figures can be arrived at (Hanley and Spash, 1994).

Relationships between benefits and their determinants can be difficult to define. Estimates of benefit arising from flood warnings are dependent on assumptions made regarding the effectiveness of warnings issued, the value of movable property and the future frequency of floods across a range of magnitudes. The possible 20% overdesign cost for a flood defence scheme mentioned earlier is an indicative figure and, in a given case study, will similarly depend on several factors.

Finally, a distinction should ideally be made between the benefit arising from some agency function (e.g.

flood warning) and the benefit directly attributable to the use of data in performing that function. In practice, it seems likely that assumptions will need to be made as a means of addressing this point, since there is no recognised basis of making such a distinction.

These difficulties are generally indicative of the obstacles which confront attempts to quantify the benefits of hydrometric monitoring data, and have been recognised by past attempts to make progress in this area. In developing methods to quantify benefits, assumptions must be made as necessary, and limitations to the methods be recognised as appropriate.

Development of a reliable method of benefit assessment

With these comments as a starting-point, a two-part approach can be advanced, dealing with both quantifiable and intangible benefits respectively.

Assessment of quantifiable benefits: an Approximate Cost-Benefit Analysis approach

An Approximate Cost-Benefit Analysis (ACBA) approach is proposed as the most valuable means of assessing the quantifiable benefits of any given hydrometric data collection activity. We have already identified that benefits arise in a range of data applications, with a corresponding range of methods of quantification available. These benefits can therefore be added to produce an overall benefit for all data uses where quantification is possible.

It is proposed that this method can be developed through the following steps (see Table 2):

1. Base values are obtained from published sources or detailed interviews for each type of benefit. These should represent benefits applying to a typical or nominal situation in which the benefit arises. The review should also identify the range of benefit values occurring, and the factors responsible for the observed variation.

2. A weighting system is developed to reflect the effect of key factors on the benefit arising in any given situation. These weights can then be applied to the base value. For most types of benefit, a weighting will be applied to reflect the value of the record length; others will be specific to benefit types.

3. Following the use of base values and weights for each benefit type appropriate to a given situation, the various component benefits can be summed to arrive at a total benefit.

4. A benefit-cost ratio can then be obtained by comparison of this benefit figure with the total costs associated with generation of the data in question. It is recommended that the method be applied to groups of data-generating stations, e.g. on a catchment basis, as a means of recognising the interdependence of stations in relation to the information value of their data.

Table 2 **Approximate CBA method applied to a network X**

benefit categories	flood warning	road and bridge construction	flood planning: housing	low flows: abstraction	low flows: return flows	hydro power	storage
base values (£ per £k system cost)	b1	b2	b3	b4	b5	b6	b7
length of record weight	w11	w12	w13	w14	w15	w16	w17
local conditions weight	w21	w22	w23	w24	w25	w26	w27
applicable to network X?	yes	no	yes	no	yes	no	yes
score for network X	s1=(b1*w11*w21)	s2=(b2*w12*w22)=0	s3=(b3*w13*w23)	s4=(b4*w14*w24)=0	s5=(b5*w15*w25)	s6=(b6*w16*w26)=0	s7=(b7*w17*w27)

Total Weighted Benefits (can be compared to total costs of network X of £C): [(b1+b3+b5+b7)*C] = £B

The method is referred to as 'approximate' in recognition of the fact that not all benefits can be quantified, and also because the derivation of component values is approximate: the base values and weights are not intended to give precise values. Nonetheless, their use does provide a basis on which a review can compare the costs and benefits of data generation in a given area. Other approaches, such as the point-scoring method of Davar and Brimley (1990), cannot yield data suitable for this purpose.

Assessment of intangible benefits: a checklist approach

Ample comment has been made in preceding sections reflecting the inability of quantitative methods to represent all benefits of data in a given area. However, decision-making in the context of a review of hydrometric activities should always be made on as informed a basis as possible. When developing methods for assessing data benefit, it must therefore be important to provide for the representation of intangible benefits.

The development of a checklist is advanced as a useful means of servicing this need. The purpose is to set the economic benefit assessment into a broader context, and one which will aid decision-making. The checklist should therefore include the following aspects, focused on the area in question:

1. *Qualitative description of the water resources* - rain and snowfall amounts, evaporative demand, seasonality of these, hydrological response of rivers to precipitation, groundwater, storages, water quality aspects.

2. *Qualitative description of water use* - number, type, location and size of major water uses, timing of demand, return flows, information regarding economic value of water as a resource

3. *Proximity of gauging stations to information demand centres* - an opportunity to comment informally on the relative displacement of stations to those points where information is needed, *e.g.* needs of flood warning system well served throughout the catchment, but flow data deficient in relation to assessing pollutant loadings to North Sea.
4. *Possible future demands for hydrometric data* - an opportunity to indicate how contemporary benefit assessments might change in the future.

This checklist approach should be undertaken at the onset of any review, by staff with a good knowledge of the subject area. The results can then be compared with those of the ACBA, and any anomalies explored. Such a dual approach therefore allows checks to be made and adds robustness rather than placing reliance on one set of methods only. In a final consideration of a hydrometric network, decision-makers are therefore able to take a well-informed view of the benefits being generated. It should be noted that both elements of this procedure are intended to be flexible and transparent, so that specific local considerations can be accommodated.

Assessment of the methods

The methods described constitute a new approach to assessing the benefits of hydrometric data collection, and represent the current stage of work in an ongoing research programme. The next phase is to apply the methods as a means of testing them in a real situation. For this purpose, two contrasting areas have been selected: the Lough Foyle catchment in County Londonderry and the River Bollin catchment in Cheshire. The Foyle catchment is essentially rural, with only a number of small towns. The water resources are plentiful on account of an annual rainfall of some 1300 mm, and the patterns of resource utilisation reflect the rural land use. By contrast, there are several important resource issues in the Bollin catchment, including the implications of a new airport runway, abstraction pressures from spray irrigation and the possibility of a low-head HEP plant, and the applications of hydrometric data differ accordingly.

It is intended to assess benefits and benefit-cost ratios for a number of scenarios in each catchment area. One immediately available scenario will be the present situation, to obtain an assessment of the value of data being generated with the current networks. Other scenarios should consider both higher and lower gauging densities. The use of a number of scenarios should indicate the network with which a maximum benefit-cost ratio can be achieved. It will be instructive for both researchers and local agency staff to consider the implications of a network producing this maximum ratio, not least the funding which might be required, and also the implications of implementing other scenarios. It will be important to compare the results of economic benefit assessments with the outputs from the checklist approach described above, and also with the professional opinion of local staff.

PC-based spreadsheets will be used as far as possible, to allow flexibility in application, and also easy dissemination at the close of the development phase. Such an approach should be in the interests of transparent operation by the user, and will also allow for updating of stored base values and weights.

Discussion and conclusions

The value of the methods reported in this paper lies in their ability to offer an effective aid to hydrometric decision-making, and in particular to provide an economic assessment of the ratio of benefits to costs for a given set of stations. The ability of the method to indicate whether or not benefits exceed data generation costs is particularly important. At the same time, it is recognised that any decisions regarding possible changes in monitoring networks must still be made within existing resource-allocating frameworks. A case for network expansion based on an increased benefit-cost ratio is unlikely to guarantee the availability of the additional funding required, primarily because the agency which would meet such additional costs would not gain in hard currency the benefits in prospect.

With or without these methods, decision-making regarding hydrometric networks must always be done with the maximum available information. The methods reported here increase the availability of that information, through both the ACBA and checklist approaches. In some catchments, the economic benefit assessment may reflect most of the benefits of data generation while in others, such as rural catchments with little resource development, the opposite may apply. The use of a checklist should allow the user to identify which situation applies, by comparing the outputs of both approaches. Such comparisons will be especially useful until such time as a large body of experience is gained in the application of the methods. In the future, it is hoped that the general approaches adopted here will allow application to other environmental monitoring networks, e.g. assessment of air quality monitoring networks.

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