



defra

SID 5 Research Project Final Report

- **Note**

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- This form is in Word format and the boxes may be expanded or reduced, as appropriate.

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Project identification

1. Defra Project code
2. Project title
3. Contractor organisation(s)
4. Total Defra project costs (agreed fixed price)
5. Project: start date
end date

6. It is Defra's intention to publish this form.
Please confirm your agreement to do so..... YES NO

(a) When preparing SID 5s contractors should bear in mind that Defra intends that they be made public. They should be written in a clear and concise manner and represent a full account of the research project which someone not closely associated with the project can follow.

Defra recognises that in a small minority of cases there may be information, such as intellectual property or commercially confidential data, used in or generated by the research project, which should not be disclosed. In these cases, such information should be detailed in a separate annex (not to be published) so that the SID 5 can be placed in the public domain. Where it is impossible to complete the Final Report without including references to any sensitive or confidential data, the information should be included and section (b) completed. NB: only in exceptional circumstances will Defra expect contractors to give a "No" answer.

In all cases, reasons for withholding information must be fully in line with exemptions under the Environmental Information Regulations or the Freedom of Information Act 2000.

(b) If you have answered NO, please explain why the Final report should not be released into public domain

Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Probabilistic flood forecasts reflect the uncertainties arising from measurement errors, model calibration and initial conditions, as well as other factors, such as rainfall forecasts.

The introduction of Probabilistic Flood Forecasting into Environment Agency operational practice will be a major system development over the next few years, which should provide stakeholders such as local authorities, the emergency services, and Environment Agency staff with better information for managing flood events as they develop. This will allow a more risk-based approach to decision making; for example, on the need to evacuate properties, operate flow control structures, or close rail or road links.

The aim of this project was to assess the current state of knowledge and direction of developments in probabilistic flood forecasting in consultation with external researchers, and to discuss business needs with end-users in order to identify and scope a 5-10 year development for the introduction of probabilistic forecasting into operational use within the Environment Agency.

The project started with a review of studies already underway in some other flood forecasting and warning services worldwide, and international research on techniques for generating probabilistic forecasts and using the outputs to make better operational decisions. The topics considered included both fluvial and coastal forecasting, and related areas (e.g. pluvial forecasting in urban areas), including operational implications for training, systems, presentation of information etc (with a key aim being to identify research needs and other follow-on projects). Some applications in other areas were also considered, such as weather forecasting, hurricane warning, and climate change modelling.

In parallel with this review, an extensive consultation exercise was carried out with more than 40 Environment Agency staff at national, regional and area level, ending with a Project Workshop in February 2007 to discuss the main findings. The topics considered included current approaches within the Environment Agency to assessing uncertainty in flood forecasts, views on priorities for implementation of a probabilistic approach, research needs, and various questions, concerns or issues that people might have with introducing a probabilistic approach.

The technical report from the project summarises the outcome from the review and consultation phase, and represents both a technical review of possible ways ahead, and a summary of questions, issues and constraints arising from the consultations and the review work for input to the strategy phase of the project. In general terms, the report considers the following questions about probabilistic flood forecasting:

- What are some of the reasons for adopting probabilistic flood forecasting?
- What is the current approach to flood forecasting in the Environment Agency, and what uncertainties are there in the process?
- What is possible technically in Detection and Forecasting, Warning and Response, and in other (non-flooding) applications?
- What consultation and other findings will be taken forwards in developing the strategy?

The main topics considered in the report are:

- Experience gained by other organisations which are considering using (or have implemented) probabilistic information in operational forecasts
- Various related research studies within the Environment Agency, the Floodsite, FREE and FRMRC programmes, and internationally
- The outcome from an extensive consultation exercise in the period November 2006 to March 2007 with national, Regional and Area Environment Agency staff, and research organisations in the UK and overseas
- The main findings from the project workshop on 13 February 2007 which discussed various issues and questions from the consultation exercise
- Some current and emerging research themes in the area of probabilistic flood forecasting

Short proposal forms are also included for several priority research topics. This report, and the associated strategy document, will help to inform Defra and the Environment Agency in developing a plan for bringing this important development into operational use over the next few years.

Project Report to Defra

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
- the scientific objectives as set out in the contract;
 - the extent to which the objectives set out in the contract have been met;
 - details of methods used and the results obtained, including statistical analysis (if appropriate);
 - a discussion of the results and their reliability;
 - the main implications of the findings;
 - possible future work; and
 - any action resulting from the research (e.g. IP, Knowledge Transfer).

The Scientific Objectives as set out in the contract

The main objectives of this scoping project were to identify the likely size, specification and cost for the main longer term development programme to introduce probabilistic forecasting into the Environment Agency. The key objectives were to:

1. Assess the current state of knowledge and direction of developments
2. Assess end-user needs and operational implications
3. Prepare draft technical report
4. Prepare draft Project Initiation Document (PID)
5. Issue Final Technical Report and Project Initiation Document (PID)

The project was overseen by a Project Board including representatives from the Environment Agency, Met Office, and WL/Delft Hydraulics.

The extent to which the objectives set out in the contract have been met

The review and consultation phase was completed in February 2007 with issue of the draft technical report and presentation of the findings at a project workshop on 13 February 2007.

Regarding Task 4, at the Project Board meeting on 1 March 2007 (Item 2.4 of minutes) it was agreed that a Project Initiation Document (PID) including costs would be too specific for recommendations on a collection (portfolio) of projects to be implemented over the next 5-10 years, and that a Strategy report should be issued instead providing a 'vision' or roadmap for the development of probabilistic flood forecasting within the Environment Agency. The resulting strategy report (which is an internal Environment Agency document) was accepted by the Project Board at the final project meeting on 29 June 2007.

Details of methods used and results obtained, including statistical analysis (if appropriate)

The project included an extensive consultation phase, with consultees including Environment Agency staff, the Project Board, researchers, and operational staff in other flood forecasting services. The main techniques used on the project were:

- Literature reviews, with more than 100 recent references cited in the Technical Report
- Consultations with more than 40 Environment Agency staff at national, regional and area level at some 15 locations around the UK
- Consultations with researchers working in this area at several UK and international universities/research organisations
- Consultations with operational staff trialling probabilistic flood forecasting techniques in several countries
- Presentations (and feedback) on the main findings and project reports at 5 one-day Project Board meetings
- Presentations (and feedback) on the project findings at 3 workshops (the workshop for this project, and the workshops for two related projects)
- Presentation of the main project findings to the Incident Management and Community Engagement (IMC) TAG meeting on 27 June 2007
- Consideration of written comments received from the Project Board on the main project reports

No statistical analyses were required or used on the project

A discussion of the results and their reliability

The main outputs from the project are the Technical Report, and an initial strategy document which will be used by the Environment Agency to help in developing the policy and processes required for this important operational development. As with all such strategic studies, the results represent a 'snapshot' based on current understanding, and will require regular reviews and updates as policy develops and new information becomes available (e.g. from research studies and operational testing). The Technical Report also presents more than 80 findings from the consultation and review exercise, although views may change over time as operational experience is gained in use of probabilistic flood forecasting techniques.

The main implications of the findings

The main findings from this project consider research needs, system development requirements, and process and policy implications. The next steps will be for key stakeholders to translate the findings into specific tasks with associated budgets and timescales, and to consider the overall policy and process implications which are highlighted. A programme of regular review and updating of the strategy will also need to be implemented.

Possible future work

In addition to the proposals in the strategy document, the Technical Report proposes six priority research and development projects as follows:

Title	Main Objectives
Communication of Probabilistic Flood Forecasts	To review best practice in communication of probabilistic information in flood warning and elsewhere (e.g. weather forecasting), and to make recommendations on the improvements to systems, operational procedures, staff training and public awareness needed before probabilistic flood forecasts are used operationally.
Decision Support Systems for Probabilistic Flood Forecasting– Scoping Study	To review research and operational applications of Decision Support Systems which use probabilistic forecasts, both in flood forecasting, and in related fields such as hydropower generation. Also, to review the main sources of measurement, input and modelling uncertainty in the flood forecasting and warning process. Based on these reviews, to scope out the detailed design for a Decision Support System to assist Flood Warning and Forecasting Duty Officers in decision making for some key applications (selected based on an analysis of potential benefits).
Probabilistic Flood Forecasting using Integrated Catchment Models	To evaluate the impact of adopting probabilistic flood forecasting operationally for fluvial integrated catchment flood forecasting models combining hydraulic models with hydrological inputs, and to recommend practical ways of reducing model runtime and an operational statistical framework for processing multiple model runs with probabilistic inputs. This work will complement existing research which is focussing on the hydrological modelling components (i.e. Project T46 “Hydrological Modelling with Convective Scale Rainfall”), with a spin-off benefit of developing best practice guidelines for converting existing flood risk mapping and scheme design hydrodynamic models to real time use for implementation on NFFS
Performance Monitoring for Probabilistic Flood Forecasts	To develop a range of techniques for performance monitoring, verification, and skill assessment for use with probabilistic/ensemble fluvial and coastal flood forecasts. Also to recommend approaches to be adopted for operational implementation.
Threshold Setting for Probabilistic Flood Forecasts	To develop a range of techniques for flood warning threshold setting for use with probabilistic/ensemble fluvial and coastal flood forecasts. Also to recommend approaches to be adopted for operational implementation.
Assessing the Financial and other Benefits of Probabilistic Flood Forecasts	To develop a methodology (or range of techniques) by which the financial, operational and intangible (non-monetary) benefits arising from probabilistic flood forecasts can be estimated for a range of typical forecasting problems, including fluvial, pluvial and coastal flood forecasting, and to derive a first assessment of the benefits at a national level.

Any action arising from the research (e.g. IP, Knowledge Transfer)

None

References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

Sene, K.J., Whitfield, D., Huband, M., Chen, Y., 2007. Abstract/poster presentation at the 3rd HEPEX Hydrological Ensemble Prediction Experiment workshop, 27-29 June, Stresa, Italy.

Defra Flood and Coastal Erosion Risk Management R&D. Article. Page 15, Issue No. 12, July 2007