

## **R&D Technical Report FD0206**

# **Joint probability of extreme estuarine water levels**

### **Background to R&D project**

MAFF (now Defra) has been funding joint probability research for several years, focusing previously on large waves and high sea levels, astronomical tides and surges, and confluence flows. The present project extends the joint probability theme to determination of extreme water levels in estuaries. This situation has an additional complication compared to similar predictions on the coast, in that river flows and their joint occurrence with high sea conditions (due to astronomical tides, surges and waves) may need to be considered.

Astronomical tides can be predicted reliably around most of the UK, and associated tidal levels can be forecast many years ahead. There is some information on surges, flows and waves around most of the UK, but forecasts can be made at best only a few days ahead, and predictions of extremes at nearshore and inland locations are usually done on a site-by-site basis as the need arises. Risk and uncertainty in flood prediction has been studied in several recent research projects, (e.g. Defra / Environment Agency, 2002) and is a continuing theme in Defra's research priorities.

The present project followed on from several years work on joint probability analysis methods aimed at refining predictions of extreme sea conditions at the coast. These methods have now come into routine use in HR Wallingford's coastal studies, and have been disseminated for use by other UK coastal engineering consultants. Further development of the methods to the more complex situation of overall water levels in estuaries was a natural continuation of the joint probability theme, funded by MAFF (now Defra) over a 3-year period beginning in Summer 1997.

The intention of the present project was to combine the best of the existing approaches into a new generally applicable methodology for assessment of overall extreme water levels in estuaries and tidal rivers.

### **Results of R&D project**

Joint probability methods developed for the combined action of large waves and high sea levels on sea defences were adapted to the potentially more complex problem of the combined action of river flows, sea levels and waves in estuaries and rivers. No new hydraulic modelling techniques were developed, but the statistical methods developed, tested and validated should allow better estimation of the frequency of occurrence of extreme conditions driven by two or more of the primary input variables.

These joint probability developments are not intended to replace better established methods for flood studies, but rather to assist in selecting appropriate combinations of inputs, and to refine the corresponding prediction of overall return periods.

Joint probability analysis is relevant only in estimating the likelihood of occurrence of flood risk scenarios dependent on more than one loading variable, and in this situation, it is hard to see how a study could be undertaken without joint probability analysis. If flood risk depends solely on one variable, then there is no need to carry out a joint probability analysis.

Defra/EA project FD2308 continues the process of dissemination and appropriate take-up of joint probability research which assesses environmental variables including waves, tides, surges, rainfall and wind. This is achieved through dependence mapping and the development of test practice guidelines. It

should enable engineers and other direct users to better utilise joint probability methods, leading to more effectively designed defences.

## **R&D Outputs and their Use**

This document provides information for Defra and Environment Agency Staff about the prediction of extreme water levels in estuaries and rivers using joint probability methods.

The overall water level in estuaries and rivers may be dependent upon river flow, astronomical tide, surge, waves and wind. For situations where two or more of these variables are important, this report addresses the issue of how those variables should be combined, before input to hydraulic models or design methods. It would be relatively easy to deal with the combination of either independent or fully dependent variables, but in practice the variables are usually slightly correlated to an extent best determined from site-specific data.

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This R&D Technical Summary relates to R&D Project FD0206 and the following R&D outputs:

- **R&D Technical Report FD0206 - Extreme water levels in estuaries and rivers: The combined influence of tides, river flows and waves.** December 2003.

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The above outputs are available under the Risk Theme on the Environment Agency website [www.environment-agency.gov.uk/floodresearch](http://www.environment-agency.gov.uk/floodresearch) or the Defra website ([http://www2.defra.gov.uk/research/Project\\_Data](http://www2.defra.gov.uk/research/Project_Data)).

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