EARLY WARNING SYSTEM – FEASIBILITY FOR APPLICATION TO DUBLIN RIVERS

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ABSTRACT

The Dublin Coastal Flooding Protection Project started in May 2003 and resulted in among others a detailed analysis of flood risk to Dublin and of measures that can be undertaken to alleviate and reduce the risk. One of the measures that have come forward is the use of an Early Warning System for coastal flooding. This system has been implemented in May 2005 and is currently undergoing a year of being fine-tuned and tested.

Subsequent to this a feasibility study was carried out to further investigate the use of an Early Warning System for the Dublin Rivers and the required steps for integration with the coastal Early Warning System. This study was undertaken between March and August 2005. Specifically the study describes the basic requirements for a fluvial flood warning system. Subsequently the rivers Liffey, Tolka and Dodder were briefly assessed in order to prioritize further development. The River Liffey was selected as a pilot for making a basic design for an early warning system (data requirements, models, intelligence, triggers, output). Based on this steps for integration of fluvial and coastal flood warning systems were identified and briefly costed and a general programme was defined.

Keywords: Dublin Coastal Flooding Protection Project (DCFPP), Early Warning Systems, lead-time

1 INTRODUCTION

Recent flood events in Europe, including the 1993 and 1995 events in the Rhine and Meuse basins, the summer floods of 1997 and 2002 in the Oder, Elbe and Danube basins and the UK floods of 2000/2001 have raised interest in the provision of flood warning in an effort to reduce losses of property and life due to large floods. In Ireland, the February 2002 coastal floods in particular too have resulted in various steps to address flood risk, among which the Dublin Coastal Flooding Protection Project (DCFPP), which commenced in 2003.

The ability to provide timely warnings to minimize risk to lives and properties of imminent flooding, so that simple yet effective measures can be taken, is one of the main objectives of the development of early warning systems (EWS). Such systems would typically consist of the following components: monitoring, forecasting, warning, response, evaluation and improvement.

One of the main aims of the DCFPP was the design of a coastal flood forecasting system, including a user-interface named TRITON. This system consists of the components monitoring, forecasting and warning and provides forecasts every 12 hours for water levels in time for up to 36 hours in advance.

At present TRITON has been implemented and is currently undergoing a phase of testing as well as fine-tuning of trigger levels for the issuing of warnings. As TRITON addresses coastal flood risk only, Dublin City Council have decided to also investigate the steps needed to arrive at a fluvial EWS and ultimately an integrated coastal and fluvial early warning system.

Royal Haskoning, as the consultants of the DCFPP, together with Trinity College, have carried out this feasibility study for extending the current EWS to also include a fluvial EWS for the rivers Liffey, Tolka and Dodder. The main objectives of this study were fourfold:

- To assess the suitability of a fluvial EWS application
- to arrive at a concept design of a fluvial EWS
- to identify steps to integrate the coastal and fluvial EWS
- to arrive at an overall programme for further development

2 The components of an Early Warning System

As mentioned, the typical components of an EWS are:

- *Monitoring* involves the collection of meteorological data and hydrological data, e.g. real-time and historic water level measurements.
- *Forecasting* entails utilising monitored data to model future situations and thus give a forecast, e.g. where and when will certain water levels occur.
- *Warning* incorporates receiving flood forecasts, interpretation of the data and subsequent issuing of warnings based on preset trigger criteria.
- *Response* involves informing the public, coordination of emergency response activities e.g. Major Emergency Plan (MEP) for Dublin and response measures such as placing of demountable flood defences.
- *Evaluation* assesses the overall performance of the aforementioned components individually as well as combined (e.g. carry out hindcasts, carry out flood emergency exercises) and results in feedback regarding the *Improvement* of the EWS. As such Evaluation and Improvement are often considered separately.

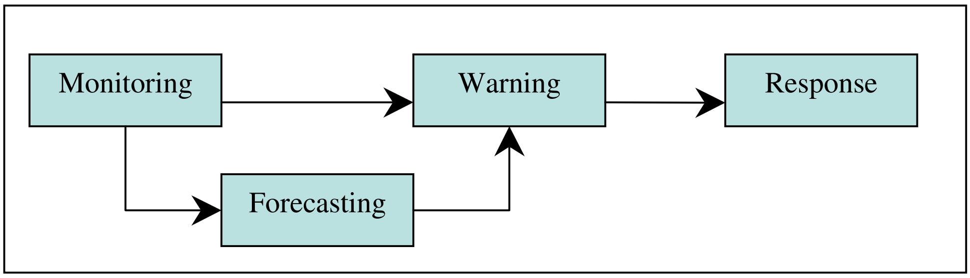

Figure 1: Main components of an early warning system

Within the scope of the project, the focus was aimed at mainly the components monitoring and forecasting.

3 FACTORS FOR SUCCESS

An EWS can only perform successfully if each of the individual components as well as the system as a whole functions properly. Based on a review of international best practice, several factors were found to be key in arriving at a state of the art EWS.
In the following several key success factors are given:

- An extensive telemetric network of rain and flow/level recorders within the catchment to be considered for accurate forecasts and to produce longer lead-times.
- The onset of improved global observation systems such as radar has increased the lead-time of forecasts. In particular links to real-time rainfall measurements can significantly improve insight in run-off.
- Models running frequently (on a daily or sub-daily basis), with the frequency increased (to hourly forecasts) pending a flood event.
- A vital component of a successful EWS is the existence of a central agency to make decisions and issue clear warnings in times of floods. Due to the complexity of such situations, additional tools have been developed to aid authorities during emergency events.
- Modern telecommunication systems to reach all the public. The development of new information technologies and the rapid spread of global communications have considerably increased the availability of information and early warnings about flooding.

- Early warning systems also must be comprehensible and accessible to all users.
- The need for common assessment to review the performance of an early warning system and which can identify any operational problems with the system.
- Substantial capital investment to develop a EWS. For example in the U.K approximately £15 million was injected into a National Flood Forecasting system with coverage of most of the Regions Rivers.

4 FRAMEWORK TO ASSESS FEASIBILITY

The main driver to assess the feasibility of implementing an EWS for the Dublin rivers is to prioritise development. A more detailed assessment of the feasibility will be provided in future phases of the project, once more insight is obtained into the costs and benefits. However it is likely that social considerations and not so much economics may prevail in deciding whether or not to develop and implement an EWS: the inhabitants will demand being informed of any potential flood event beforehand.

In general terms physical, technical, social and economic factors will determine the boundary conditions as well as need for the EWS.

The performance of the EWS can be assessed via performance parameters such as timeliness, accuracy, reliability, user friendliness, flexibility and costs & benefits. Within the scope of this study, the focus has been on the first three parameters and result in an analysis of the following:

- lead-time, i.e. time to respond;
- adequacy of data.

In later phases of the development, the focus will shift to user friendliness, flexibility and costs & benefits.

5 ASSESSMENT OF DUBLIN RIVERS

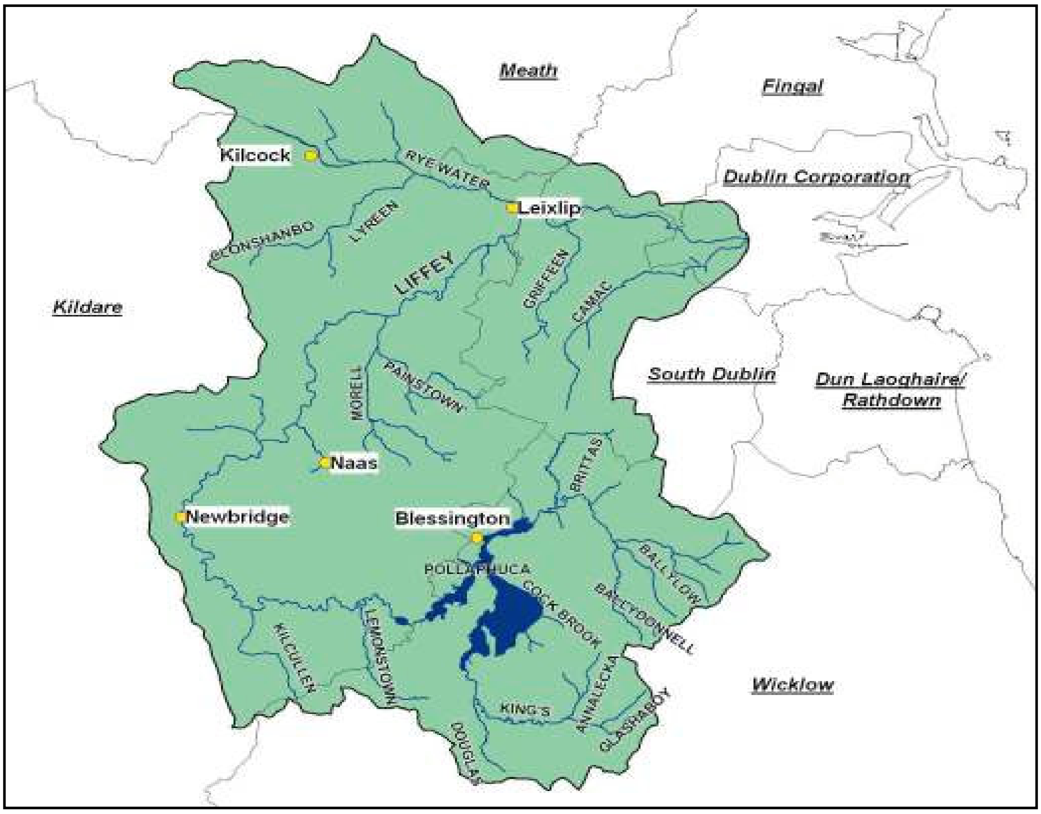

Figure 2: Liffey Catchment

RIVER LIFFEY

The River Liffey is the largest of the Dublin rivers with a length of 138 km and a total catchment area of 1300 km^2. The upper stretches are heavily dominated by the Pollaphouca and Golden Falls

reservoirs which provide substantial opportunity to contain floods. The lower stretches are far less controlled. The total lead-time is in the order of 15 hours.
At present limited infrastructure is in place regarding monitoring (rainfall, water levels) and no models are currently available to carry out hydrological forecasts. There are however weirs and reservoirs that could aid in improving lead-times. The size of the catchment also may provide opportunities for new measures to be implemented to increase lead-times.

The Electricity Supply Board (ESB) do however have considerable operational infrastructure in place in order to operate the Pollaphouca, Golden Falls and Leixlip reservoirs. Their control centre at Turlough Hill makes use of among others radar from Met Éireann and rain gauge measurements in the Lee catchment in Cork to predict conditions in the Liffey catchment. Operational decisions are taken based on expert judgement and experience.

Obviously the Liffey is the largest river which flows through the heart of Dublin.
Flooding would potentially affect large areas and a substantial part of the Dublin population. As such the social need for an EWS is substantial.

RIVER TOLKA

The Tolka is the second largest river, however substantially smaller than the Liffey with a total length of 33 km and catchment area of 152 km^2. The Lead-time is in the order of 5 to 6 hours.

Also for the Tolka, at present limited infrastructure is in place regarding monitoring (rainfall, water levels). Models to carry out hydrological forecasts are however available (GDSDS, 2005). There are limited measures currently in place that could aid in improving lead-times. At present it is unknown whether measures could be put into place to improve lead-times.

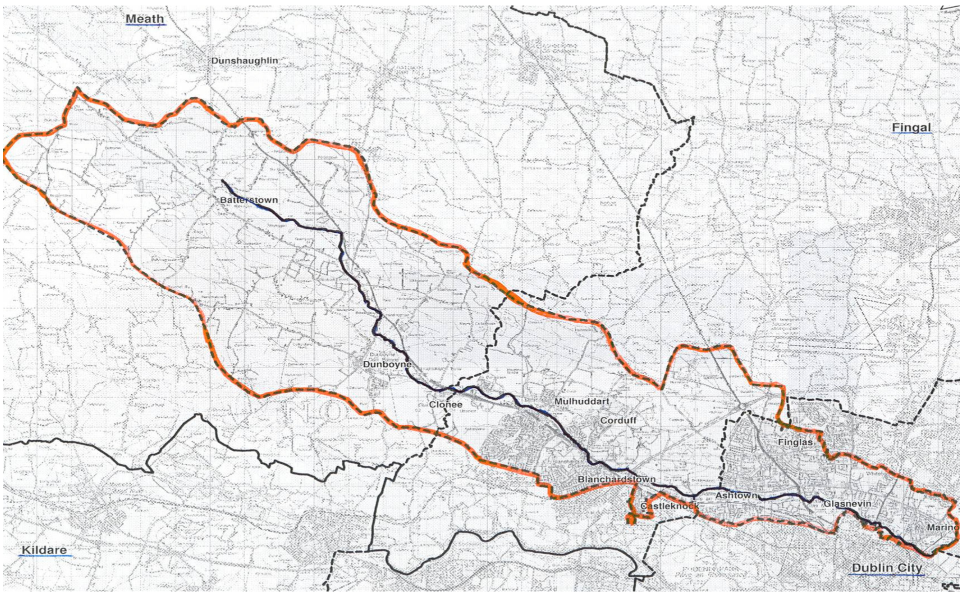

Figure 3: Tolka Catchment

The Tolka too flows through a substantial area of Dublin. Flooding can affect large areas and a substantial part of the Dublin population. As such the need for a EWS from a social perspective is substantial.

RIVER DODDER

The Dodder is the flashiest of the three rivers. Its total length is 27 km and its catchment area is 113 km^2. The lead-time is in the order of 2 to 3 hours only.

Also for the Dodder, at present limited infrastructure is in place regarding monitoring (rainfall, water levels) and models.

It is questionable whether meteorological forecast (use of radar) can help improve lead times, as experience has proven radar to be less effective for the relative small catchment area that lies in the "shadow" of the Wicklow Mountains. There are however a number of measures in place (e.g. reservoirs) that could aid in improving lead times. Furthermore, it is expected that other measures could be put into place to this end.

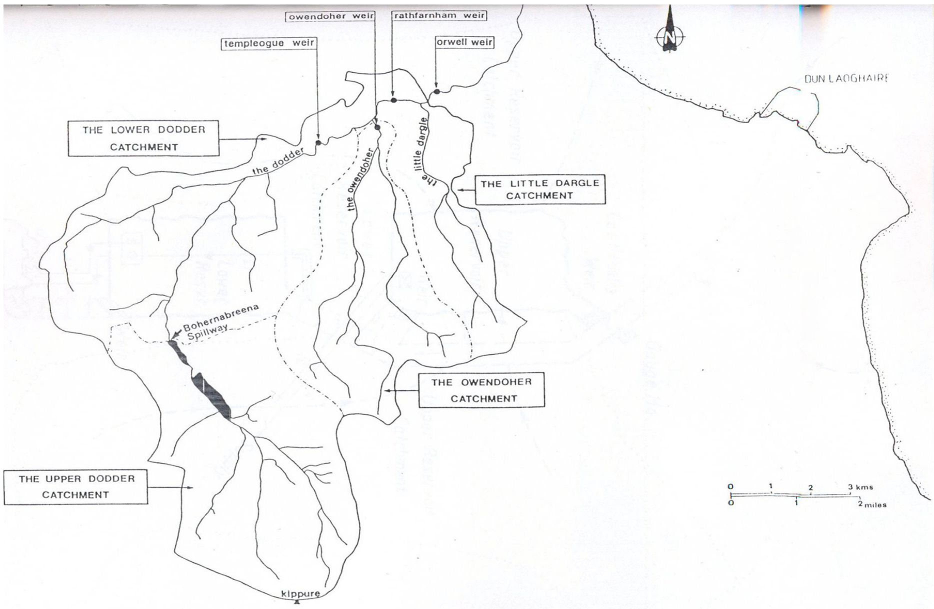

Figure 4: Dodder Catchment

The Dodder also flows through a substantial area of Dublin. Flooding would potentially affect large areas and a substantial part of the Dublin population. As such the need for an EWS is substantial.

SELECTION OF PILOT

It is difficult to assess the potential economic benefits of an EWS, in particular when compared to carrying out tangible measures within the catchment. Too little information is available at this point to assess the cost-benefits associated with the implementation of an EWS in comparison to other measures. Generally the need from a social point of view will be present in all three cases.

Based on the infrastructure (e.g. at ESB) that is currently in place and the availability of data, it was decided to further investigate the River Liffey within this study to arrive at a concept design.

6 SYSTEM BEHAVIOUR

The most recent flood events of note on the Liffey Catchment were November 2000 and June 1993. Both were analysed in more depth in order to develop a better understanding of how the flood was managed within the catchment. The return period of the selected events was 60 years for Pollaphouca for November 2000 event and 3 years for the June 1993 event. For Leixlip Reservoir the return periods were 22 and 45 years, respectively.

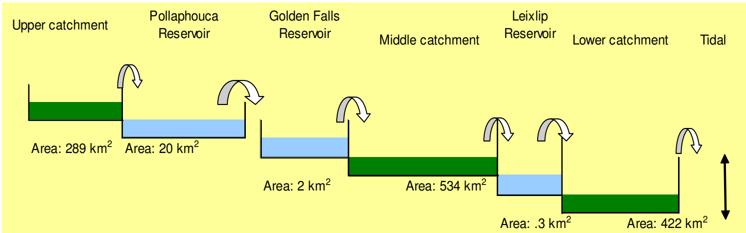

Figure 5: General schematisation of the Liffey catchment

Based on the analysis, it was more than evident that Pollaphouca acts as a flood relief reservoir for the middle and lower catchments. In the absence of the dam at Pollaphouca extensive flooding would have occurred in the Middle and Lower catchments. With the reservoir downstream reaches are practically insensitive to any major flooding in upstream reaches. Golden Falls reservoir further reduces flood risk.

The main consideration for the operation of Pollaphouca and Golden Falls reservoir is to time releases to minimize flood risk based on events that do directly impact on the middle and lower stretches of the Liffey. This is also one of the main operational objectives for the ESB control centre at Turlough Hill.

The focus on flood risk and thus early warning systems therefore would need to shift to the middle and lower Liffey stretches. This obviously would need to accommodate all the operational infrastructure now in place at Turlough Hill.

The option of an additional reservoir located in the Middle catchment would reduce the flood peak by decreasing the natural inflow into the Leixlip. It would create the additional benefits of water supply and recreation. The generation of power would be subject to an additional study regarding the feasibility for power generation at this location. A number of disadvantages are immediately raised regarding cost, location and practicality.

This area is becoming highly developed both commercially and residentially due to its proximity to Dublin. The task of finding a suitable location could prove very difficult and costly.

It is obvious that there will be some degree of negativity with each option proposed to alleviate flooding. Following the above discussions the construction of new defences may be needed in the Middle and lower catchments. This can be flood containment options (walls, embankments etc.), demountable rigid or floating defences etc.

7 BASIC CONCEPT DESIGN

Within the study the focus of the functional design for the River Liffey has been on mainly the monitoring and forecasting components. For each of the components an analysis has been made of minimum requirements.

For example: For operational purposes it is essential to have hourly recorded rainfall data, that can be transmitted and used real-time. At present there are only 2 such recorders within the Liffey catchment. Various theories have been developed to determine the minimum number of gauges. The US National Weather Guideline would suggest a relationship as given below.

Using this, this would imply that the Liffey would require as many as 11 gauges. Comparison with general practice in the Netherlands as well as in Germany confirms this to be reasonable.

Based on the analysis of minimum requirements, the following basic concept design for the Liffey was derived. See Figure 7. Regarding the colour coding: white shading represents no relevance, green shading represents relevant and already available and yellow represents relevant and not yet available.

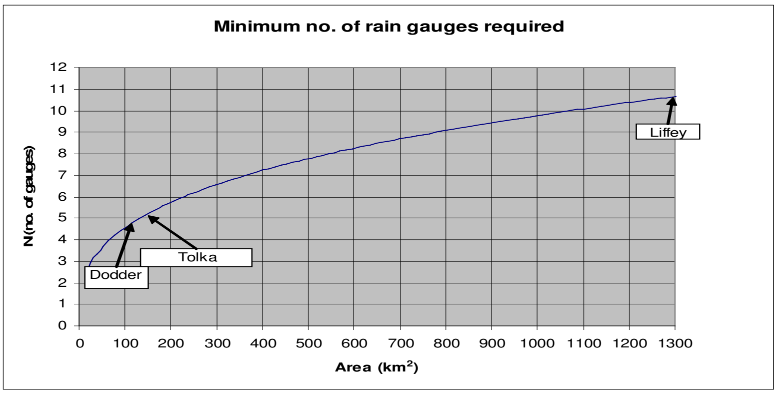

Figure 6: National Weather Guideline for minimum number of gauges.

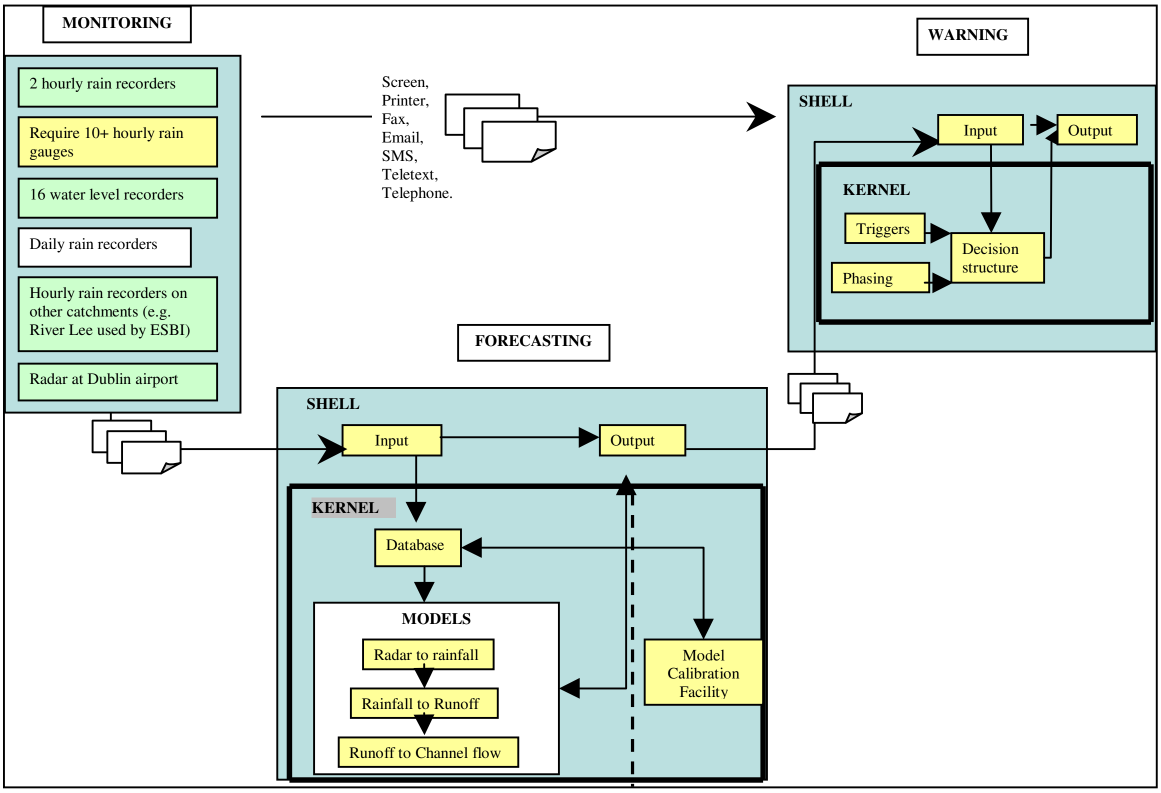

Figure 7: Basic concept design for monitoring, forecasting and warning

Further requirements among others are:

- The upper catchment (near to river source), middle catchment and lower catchments all require at least 3 hourly automatic rainfall recorder and preferably measurements of evaporation potential.
- There is a need to develop a rainfall to runoff algorithm or model. Data requirements would include knowledge on soil and vegetation types, drainage networks, impermeable areas etc.
- The installation of at least 3 reliable flow recorders along the stretches of the Liffey from its source to the Pollaphouca reservoir, Golden Falls to Leixlip and Leixlip to Islandbridge. It

would be more practicable if both the water level recorders and the rainfall recorders were operated by the same company/organisation.

- It would be very beneficial to ESB regarding the operation of the dams to have a rainfall recorder in the proximity of the Ryewater catchment. This would allow the ESB to anticipate the quantity of flow expected at the confluence of the Ryewater and the Liffey and hence the rate of discharge from Leixlip.
- It would be beneficial to translate the experience and expert judgement used currently for the operation of the dams into programmed logic. In initial stages this then can provide decision support for operations, in later stages this could even be automated.
- The weir upstream of Islandbridge is the last point of measurement before tidal influence becomes dominant. However, at present there is no water level recorder or rating curve to measure flow. It would be beneficial to install a flow recorder at this location in the near future.
- Tidal gauges are presently being installed in the estuary and will be hugely beneficial in forecasting the combined effects of high tides and large flood events on the Liffey.

8 INTEGRATION OF THE COASTAL AND FLUVIAL EWS

As regards the coastal EWS (TRITON), this system is currently being implemented and tested at Met Eireann as well as at Dublin City Council. This system at present does not automatically calculate the Liffey river discharge at Islandbridge. Currently, this is manually inputted into the model to provide forecasts for the tidal reaches of the river. Therefore, the combined functional design for the coastal and fluvial EWS will need produce an estimation of river discharge that can then be used automatically for all stretches of the Liffey.

DEVELOPMENT PHASES			PROGRESS	
COASTAL	FLUVIAL		COASTAL	FLUVIAL
	1. Initial feasibility study			In progress
	2a Monitoring (increased data)	2b. Development of models		To be completed
1. Functional design	3. Redefine the functional design		completed	To be completed
2. Technical design	4 Technical Design		completed	To be completed
3. Implement./ Testing	5. Implementation / Testing		In progress	To be completed
6. Functional Design combined			To be completed	
7. Technical Design combined			To be completed	
8. implementation / testing			To be completed	
9. Commissioning			To be completed	
10. Evaluation			To be completed	
11. Improvements			To be completed	

Figure 8: Development phases

As present, the coastal EWS can be used to forecast events. Further development regarding defining trigger values for automatically issuing warnings and subsequent response should be finalised by the end of 2006. It is expected, in particular as substantial improvements on data monitoring and modelling are required, that development and implementation of an integrated early warning system would require another 4 to 5 years.

The total costs involved with the design, implementation, testing and commissioning of a full fledged early warning system (coastal & fluvial, linked to response systems) would be in the order of €2million excluding VAT. These costs would be incurred mainly over the period 2006 to 2011.

9 CONCLUSIONS

One of the main deliverables of the Dublin Coastal Flooding Protection Project is an interim coastal flood forecasting system. This system has been installed at Met Eireann and Dublin City Council and is currently being tested and fine-tuned.

Further to this first steps have been undertaken to investigate possibilities of applying early warning systems to the Dublin rivers and subsequently integrate this into one comprehensive Early Warning System. Such systems would complement infrastructural measures.

Each of the Dublin rivers, i.e. the Liffey, the Tolka and the Dodder, have been briefly assessed with respect to physical, technical, social and economic characteristics.
Based on this the Liffey was selected as a pilot to assess the requirements for an early warning system.

For the Liffey in particular investments will be required with respect to improving data collection of rainfall, modelling and warning. Furthermore operations of the dams could be supported by decision support systems, not only allowing a more robust approach but potentially also allowing further optimisation.

It is expected that the development, implementation, testing and commissioning of an integrated system would require a further five to six years of time. The total development costs would be in the order of € 2 million excluding VAT.

It is difficult to assess the benefits of such a system. A major consideration however is that the inhabitants of the catchments more and more will demand to be informed of any potential flooding, however short the notice may be, in order to take preventive measures.