Methodology for Decision Support Systems for Flood Event Management

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<table>
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<th>Title</th>
<th>Methodology for Decision Support Systems for Flood Event Management</th>
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<tbody>
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<tr>
<th>Date</th>
<th>Revision</th>
<th>Prepared by</th>
<th>Organisation</th>
<th>Approved by</th>
<th>Notes</th>
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SUMMARY

This report describes the methodology for Decision Support Systems for Flood Event Management. An overall approach is presented. For three pilot areas this general approach is applied to specific parts of flood event management. The pilot areas are the Thames (UK), Schelde (NL) and urban flash floods in France. For each of the pilots the design of a prototype Decision Support System is described.
CONTENTS

Document Information iii
Document History iii
Acknowledgement iii
Disclaimer iii
Summary iv
Contents vii

1. Introduction ..................................................................................................................1
   1.1 Objectives ........................................................................................................1
   1.2 Approach .........................................................................................................1
   1.3 Overview of the report .....................................................................................1
   1.4 Links with other tasks ...................................................................................1
   1.5 Lessons learned from previous projects ............................................................1

2. DSS methodology ........................................................................................................3
   2.1 Methodological framework ..............................................................................3
   2.2 Flood Event Management tasks and their application ........................................6
   2.3 Risk based decision support ............................................................................7

3. DSS Design ..................................................................................................................8
   3.1 Thames ............................................................................................................8
   3.2 Schelde ............................................................................................................8
   3.3 Urban flash floods ..........................................................................................16

4. References .................................................................................................................17
1. Introduction

1.1 Objectives
The objective of task 19 of the FLOODsite programme is to link knowledge and models from FLOODsite themes 1 and 2 in a Decision Support System (DSS) in support of emergency management planning and practice. The DSS aims to provide the relevant authorities with support in deciding on the evacuation procedure to follow. The EU Flood Directive will make the preparation for flood event management imperative. Efforts within the FLOODsite programme to develop decision support can help the relevant authorities with the implementation of the Flood Directive.

1.2 Approach
As a first step, a review has been made of existing DSSs for flood event management within the EU (Maaten et al, 2007). The main conclusion of this report is that there is not a lot of experience with using DSSs for flood event management, as opposed to the much wider experience of using DSSs for long term flood risk management. In the same report, an assessment of the requirements of the end-users is presented. The end-users have been identified as the authorities responsible for flood event management. For evacuation this is mostly the municipal or provincial authority. Specialised institutions play an important role as well, such as the Environment Agency in the United Kingdom and regional water authorities in the Netherlands. The main user requirements focus on availability of information regarding the extent of flooding expected, the consequences for the transport network and the time required for evacuation.

1.3 Overview of the report
This report presents the next step towards the development of DSSs for flood event management. Chapter 2 presents a methodological framework for flood event management DSSs. This comprehensive framework is used to develop the design of prototype DSSs for pilot studies, as described in Chapter 3. These prototype DSSs will be implemented and presented to the end-users. These results will be presented in the final report of FLOODsite task 19. The lessons learned from the design, implementation, application and presentation of the prototype DSSs will be delivered to Theme 5 of FLOODsite to be included in the best practice guidelines for flood risk analysis and management and related training activities.

1.4 Links with other tasks
A clear link exists with FLOODsite task 18, which focuses on the development of a DSS for long-term flood risk management. The review of existing DSSs and the formulation of a methodology have been developed in close cooperation with task 18. However, due to the different tasks of the DSSs to be developed, no overlap is expected in the development of prototype applications of the DSSs.

The DSS for flood event management links knowledge from different tasks within FLOODsite theme 1 and 2, such as:

- Modelling breach initiation and growth (task 6);
- Reliability analysis of flood defence structures and systems (task 7);
- Flood inundation modelling / methodologies (task 8);
- Real-time guidance for flash-flood risk management (task 16); and
- Emergency flood management - evacuation planning (task 17).

1.5 Lessons learned from previous projects
OSIRIS (Operational Solutions for the management of Inundation Risks in the Information Society) was originally a 5th EU FP project under the IST (Information Society Technology) programme (Erlich, 2006). Its goal consisted in improvement of the dissemination, using Information and Communication Technologies (ITC), of information on flood risk to citizens for better prevention or crisis management. In the framework of OSIRIS a prototype of a tool called “OSIRIS-Inondation” has been developed to provide operational solutions to local managers of the Loire River basin. The main
objective consisted in provision of a tool, which can help the local stakeholders to make use of the official forecasts and to link them to other documents: flood prevention plans, rescue organisation plans, which since French law of 2004 become a part of a regulatory document called Community Safeguard Plan (PCS). The “OSIRIS-Inondation” prototype was specified, tested and validated by the different groups of stakeholders represented by an active OSIRIS partner and committed end-user Etablissement Public Loire (EPLoire).

An important part of the work consisted in the validation of the demonstrators, which was carried on as part of the OSIRIS project activities. It consisted in confirmation (or information) that the prepared demonstrators do indeed reflect the needs and expectations of users, as articulated during the design phase. As part of this appraisal, the content of the individual tools was revised, and improvements to the software were identified as well as improvements to the user interface, suggested by the stakeholders responsible for the testing off the software.

Tests of the usefulness and suitability of the demonstrators being built in the project were conducted with many appraisal groups associated with flood damage mitigation, as well as with inhabitants at risk for flooding. This latter group, as well as local- and county-level crisis managers, was the most frequently used appraisal group. Practically all partners responsible for building and testing of demonstrators conducted appraisals with these groups.

For the two demonstrators being built in France, test participants also included representatives of: technical municipal and department services, elected representatives and local government institutions (EP Loire) or institutions responsible for flood safety (DIREN).

As a consequence of the positive feedback received from different stakeholders in the Loire River basin the French authorities decided to pursue a validated approach and the Centre d’Etudes Technique Maritime et Fluvial (CETMEF), a service of the French Ministry of Infrastructure, is now in charge of the further development of OSIRIS-Inundation and of its distribution. Detailed information is available at the following address: http://www.ist-osiris.org/indexOsiris.html.

The OSIRIS experience (both during the project and the post-project industrialisation phase of the “OSIRIS-inondation”) was integrated in the Tasks 17 (Asselman et al, 2007) and 19 (Maaten et al, 2007). The results of the OSIRIS project formed a major input for the assessment of the users’ requirements and the review of flood event management decision support.

In Task 19, the principal benefit lies in integration in the DSS design phase the appropriate sources of information related to prevention plans.
2. DSS methodology

2.1 Methodological framework

The methodological approach is based on terminology presented in the FLOODsite report *Language of Risk* (Gouldby et al, 2004). The aim is to support relevant authorities in flood event management. This support can be during the preparation for flood event management or during the actual flood event. The support should lead to risk based decision making based on a comparison of the risk resulting from different management options. Management options in flood event management can be divided into four categories:

- Operational flood prevention;
- Operational flood management;
- Evacuation; and
- Rescue.

Operational flood prevention consists of flood prevention measures that can be taken in the time between the forecast of a flood event and the actual event. Examples of these measures are operation of barriers and retention areas and the temporary raising of dikes with sand bags. Long term flood prevention measures, such as lowering of the floodplain are not incorporated.

In the case of operational flood management the aim is not to prevent the flooding event itself, but to influence the way the flooding proceeds. This can be done by, for example, opening or closing sluice gates that influence the flooding pattern.

A very important management option in flood event management is decision whether or not to evacuate. Evacuation deals with the relocation of humans, livestock and capital goods from an area threatened by flooding to a safe place. During the preparation phase evacuation plans should be prepared to enable evacuation during a flood event.

Management options in rescue determine the amount of resources used for rescue and the way they are deployed. An important question to be solved in flash flood areas is the state of the transport network to be used by rescue services.

Flood event management starts with a forecast of a flood event provided by a flood early warning system.

The scheme below presents the methodological framework for flood event management DSSs. The framework consists of several modules. The external driver module describes the existing situation prior to the flood and the boundary conditions for the flood event. The tools module consists of the tools used in the other modules. The management response module describes the management options available to the decision maker. The analysis is described in the modules in the central column.
Figure 1: Methodological framework

**Exposure module**
- Inhabitants (spatial distribution, age, shelter)
- Livestock (spatial distribution, shelter)
- Property and utilities (spatial distribution, shelter)
- Actual capacity of transport network (under flood conditions)

**Vulnerability module**
- Relation between flood characteristics and damage (value lost, people injured, casualties) for individual objects in the different categories

**Consequence module**
- Damage to inhabitants (affected people, exposed people, casualties)
- Damage to livestock, property and utilities (expressed in the value lost)

**Risk module**
- Expected damage for a forecasted water level summed over the different breach locations expressed in euros or number of people

**Hazard module**
- Fluvial / tidal water levels at different locations
- Breach locations and growth
- Flood characteristics (depth, velocity, extent)

**Tools module**
- Flood Early Warning Systems
- Reliability analysis of flood defence system
- Hydrodynamic model

**External driver module**
- Discharge
- Water level
- Precipitation
- Wind
- Tide
- Topography
- Drainage system

- Data on people and livestock
- Time of the day of the expected flood event
- Property and utilities at risk and part of this that is moveable
- Transport network

**Management response module**
- Operational flood prevention (sand bags, retention areas, temporary barriers, storm surge barriers)
- Operational flood management (closure of gates)

**Evacuation, rescue and warning**

**Provision of Information to Decision Makers**
The boundary conditions of the flood event are forecast fluvial / tidal water levels that will come from a flood forecasting system. This forms the input of the hazard module. Based on an analysis of the reliability of the flood defence system, the most likely locations of failure of the defence system are selected. For each location a failure probability is established. For dikes, a breach growth model can be applied to describe the growth of the breach over time and its final dimensions. The information on water level and breach location and growth can be combined in a hydrodynamic inundation model to calculate the flood characteristics for each possible failure location. At the level of the hazard module, the decision maker can influence the flood characteristics by operational flood prevention measures and operational flood management measures, as described in section 2.1.

The exposure module compares the information on the flood characteristics with static information on the distribution of the receptors such as inhabitants, livestock, property, utilities and the transport network. This defines the exposure to the flood event. The exposure can be influenced by execution of an evacuation or by a rescue operation.

The vulnerability module defines the relation between flood characteristics and damage. This relation is different for different types of humans and goods, depending on their characteristics (such as age) and their shelter (such as the type of building they are in). The input to the vulnerability module consists of reference damage functions established theoretically or empirically based on flood damage data or for example loss of life or injury functions for people exposed to floodwaters.

In the consequence module a damage and casualties model combines the exposure and the vulnerability and calculates the damage to inhabitants, livestock, property and utilities. Damage to inhabitants can be expressed as number of people affected, exposed or injured and the number of casualties to be expected. Damage to livestock property and utilities is expressed as value lost. The damage calculation is executed for each possible breach location. If the accumulated effect of combined breaches can be expected to differ from the sum of the effects, calculations for the combined situation should be carried out as well. If management options such as evacuation have been selected, their influence will be incorporated through the resulting effect in the exposure.

The risk module combines the results of the consequence module for the different breach locations. Combination takes place by summation for each location the probability of failure times the resulting damage. The combined risk is expressed as the expected damage of a forecast flood event under the selected management option. Again damage can be expressed as value lost, number of people affected, exposed or injured and the number of casualties.

### 2.2 Flood Event Management tasks and their application

The methodological framework for a flood event management DSS presented above allows for different tasks to be accomplished:

- Flood early warning;
- Operational flood prevention;
- Operational flood management;
- Preparation of evacuation plans;
- Preparation of rescue plans;
- Evacuation during a flood event; and
- Rescue after a flood event.

The content of the tasks can differ slightly between different natural systems, such as:

- Low lying areas with a flat topography and large polders with a large area that can be flooded. The distance to safe places will typically be of the order of tens of kilometres. The source of flooding can be fluvial and/or tidal;
FLOODsite Project Report
Contract No: GOCE-CT-2004-505420

- Sloping areas with an undulating topography where only the river valley can be flooded. The distance to safe places will typically be of the order of hundreds of metres. The source of flooding will be mostly fluvial; and
- Hilly and mountainous areas with a steep sloping topography where flash floods can occur. The distance to safe places will typically be in the order of hundreds of metres. The source of flooding is fluvial.

Flood forecasting forms the basis for all flood event management: without a proper forecast of a flood no event management can take place. Different types of systems have very different lead times for flood early warning. In low land areas flooding from a river, the lead time will be typically in the order of several days. The lead time for flooding from sea in low land areas and for fluvial flooding in sloping areas will be much shorter (in the order of one day). Flash floods are the most difficult to predict and their lead time will be in the order of hours.

Operational flood prevention and operational flood management are most relevant for low land areas. In the other systems fewer opportunities exist to influence the probability of flooding and the flood pattern by management actions.

Evacuation and rescue can be important in all of the systems. The general problem is that the lead time might not be enough to complete an evacuation. Owing to the fact that in low land and sloping areas people are mostly much better protected during a flood event when in their houses than when on the road, the decision whether or not to evacuate will be very important for decision support. An important issue for both evacuation and rescue is the availability of the transport network under flooding conditions. Traffic management therefore also forms an important part of the decision support.

2.3 Risk based decision support

The aim of the above outlined methodology is to allow the decision maker to take better informed decisions. This can be done by supplying in a structured way all relevant information. An important step is to integrate the information into one measure for decision making: the risk. Risk in flood event management is defined slightly different from risk in flood risk management. In flood risk management the risk is defined as the product of the probability of a flood event and the associated consequence (damage) summed over all possible flood events for a certain location. In this way flood risk maps can be produced and desirable management options can be selected by comparing the flood risk for different (combinations of) options.

In flood event management, the time horizon is much shorter and the probability of the flood event is much higher (otherwise there would be no flood event to manage). Therefore, the consequence and the risk in flood event management are much closer. The main uncertainty in the period between the forecast and the actual flood is the flood pattern, as determined by the breach locations for low land areas and by the exact location of the rainfall for flash floods. If this uncertainty is significant, it can be taken into account by assigning a probability to each flood pattern. The consequence of this flood pattern is then calculated and the consequences for all possible flood patterns are summed to derive the risk. In this way, decision making can be supported by comparing the risk of different management options, just as in the case of flood risk management.
3. **DSS Design**

The above outlined principles will be applied in three pilot areas to prepare prototype DSSs. None of the applications will produce a prototype DSS for all aspects of flood event management. Each of the prototype DSSs will focus on a part of the methodological framework. The selection which part to focus on has been made in consultation with the end-user.

### 3.1 Thames

The aim of the research is to produce a prototype DSS for the Thames that will be implemented in two embayments in the Thames Estuary, Thamesmead and Canvey Island. There is a strong link with Task 17 and the results of the evacuation and loss of life models piloted in Task 17 will be incorporated with the prototype DSS. It is expected that the following methods will be implemented in the prototype DSS:

- The ‘Flood Risk To People’ methodology developed as part of a previous Environment Agency Research and Development project will be implemented within the DSS. This will allow the estimated loss of life and injuries to people to be estimated for a number of forecast flood scenarios;
- The ‘Flood Risk To People’ methodology will be extended to take into account the possible location of people at different times of the day. For example this may incorporate a number of ‘time slices’ during Monday to Friday and the weekend to distribute the people at risk (e.g. at 1 am 90% of people may be in bed). The possibility of incorporating a ‘seasonal’ aspect to this for places such as seaside towns where the population is much higher in the summer than the winter will be investigated;
- The closure of road networks and its impact on the emergency services will be investigated. Research work undertaken by the Australian organisations that relates the mass of a vehicle, the floodwater velocity and depth to the chance of a vehicle being overturned will be implemented within the DSS. Using the available DTMs and results of 2D hydrodynamic models will allow decision makers to be told at what time in a forecast flood event roads should be closed and whether large emergency vehicles could still safely pass them;
- The architecture of the prototype DSS will allow results from a variety of loss of life and evacuation models to be imported and viewed for various scenarios;
- Depending on the availability of the methodology the Dutch Evacuation Calculator (EC) will be implemented within the DSS. The EC will allow estimates of the time that it takes people to evacuate based on the number of people and the road capacity to be made;
- The use of freely available open source routing methods and the production of a simple evacuation model embedded within the prototype DSS will be investigated and if possible implemented.

### 3.2 Schelde

**Introduction**

The Westerschelde estuary as focused on in this pilot is a lowland system with polders, protected from the sea by embankments. Critical water levels are formed by a severe storm in combination with spring tide. Early warning for this is provided by the national climate institute. As soon as critical water levels are expected, the Schelde DSS becomes useful. In the previous section possible management options are described. For the current system these options are restricted to evacuation and rescue. As operational flood prevention just sand bags can be placed and this is expected to save some time but is not seen as a preventive measure.

The methodological framework as shown in chapter 2 is used as a start for the decision support system of the Schelde pilot. This framework is a general set up for all kind of systems, which means some parts can be left out depending on the purpose.
The following sections describe the system characteristics of the Westerschelde estuary, the purpose of the DSS, the background of the data that are included in the DSS and finally the functionality of the prototype.

**Overview of the pilot area**

The Schelde catchment consists of the Schelde river, the Westerschelde Estuary and its flood-prone area. The Schelde river flows from France through Belgium into the Westerschelde in the Netherlands; a wide estuary connected to the North Sea (see figure 3.1). The average discharge of the Schelde river near the Dutch-Belgium border is 127 m$^3$/s. The water levels in the Schelde River and Westerschelde are influenced by the tides. The tidal difference in the Westerschelde increases from west (3.86 m) to east (4.83 m) and it increases further on the Schelde River (ARCADIS *et al.*, 2004). Critical water levels for the Schelde Estuary occur when severe storm surges coincide with high tides.

This case study includes only the North part of the Westerschelde flood-prone area, bounded at the north by the Oosterschelde water body. This flood-prone area mainly consists of low-lying polders. It is divided into different dike rings by connected embankments or higher areas. The three dike ring areas are called Walcheren, Zuid-Beveland-West and Zuid-Beveland-Oost (see figure 3.1). Ancient secondary embankments are present in the flood-prone area which may significantly affect the flood extent and flood depths in the dike rings. The land use functions of the flood-prone area are residential area, industries, transport, agriculture and nature, tourism and fisheries.

In 1953 a storm at the North Sea combined with high tides caused a lot of damage and casualties in the Netherlands, and some damage in Belgium. This flood triggered the development of the Delta Plan which includes amongst others the raising of embankments along the Westerschelde in order to make them able to withstand a design water level with a probability of 1/4000 per year.

In the province Zeeland, the actual strength of embankments is not known. Most embankments have a long history and information on characteristics is not present. For these embankments the probability of breaching as a result of high water levels can be higher or lower than expected. If a dike breaches, water levels could reach knee height within an hour. Forecasts for extreme weather conditions will be available about 12 hours beforehand. This might be enough to evacuate some areas and save lives.

For more information on the Westerschelde characteristics, reference is made to Task 14 (*Klijn et all*, unpublished).
Aim of Schelde DSS and user requirements

The purpose of the Schelde Decision Support System is two-sided:

- Support policymakers in making evacuation plans;
- Support decision makers at time of a flood event: ‘shall we evacuate or not…’.

The first one is typically risk-based. There is no danger yet and consequences can be evaluated without time pressure. In this case risk is expressed as the number of exposed people and the expected casualties. Different evacuation plans can be developed and compared.

The second purpose deals with decisions under high time pressure. Extremely high water levels are forecasted within about 12 hours. A fast decision has to be made whether people need to be evacuated or not. Maybe it is enough to direct the most vulnerable persons to a shelter place. Maybe there are hospitals or other susceptible objects in the area expected to be flooded.

An other important issue for evacuation management is the availability of the transport network under flooding conditions. This kind of information should be added to the DSS.

Based on the summary of requirements in the Task 19 review, a DSS for evacuation management should include the following maps:

1. Flooding characteristics (pattern, maximum water depth, maximum flow velocity and extent);
2. Location, number and vulnerability of people at risk;
3. Location and type of buildings at risk;
4. Available infrastructure and available time to evacuate;
5. Available shelter locations;
Number 4 will be included in close cooperation with task 17.

**Model schematization and choice of breach locations**

The effect of extreme sea conditions is modelled with a Sobek1D2D model, in cooperation with Task 14. This model contains both the Westerschelde and the flood-prone areas. The Westerschelde is schematized as a quasi-2D by simulating flow through the main channels and interlink those by 1D branches. The flood-prone area is schematized by a 2D grid containing cells of 1 ha, showing the average elevation. Boundary conditions for this model are the tide at Vlissingen and the upstream inflow from the Schelde River. The model simulates the flood pattern and the resulting maximum water depths. The model is discussed in more detail in the appendix of Task 14.

High water levels in the Schelde Estuary are caused by combinations of storm surges and high tides. Relevant variables to consider when describing relevant sea conditions for flooding are thus astronomic tiding, storm surges at the North Sea, wind directions and wind speeds and the interaction between these variables. Of these variables the maximum, duration and time profile needs to be understood. IMDC (2005) did a statistical analysis on these variables in order to combine them into sets of variables with a certain probability. To study the flood consequences of an extreme event the conditions with probability of 1/10000 have been used. Difference with conditions of 1/4000 is in the order of a few centimeters. It has a small effect on the resulting water levels. It is assumed that the dike will breach when a water level with probability 1/4000 is reached. In case of a 1/10000 event, this means the dike breaches just before the peak water level is reached.

![Figure 3.2 Extreme water levels for different return periods, arrow denotes the time of breach](image-url)

It is uncertain where embankments will break, at what moment they will break and how many breaches will occur during extreme conditions. Since breaching is unsure until the last moment, a number of breach locations have been simulated. For our study area 12 locations were chosen more or less randomly from available simulations in task 14. Embankments are assumed to fail when the water level reaches the 1/4000 year water level. If an embankment
fails the breach is assumed to grow to a width of 200 m with a grow rate according to the formula of Van der Knaap (see task 14).

Next to all failure locations in the outside embankments, there is also a possibility that the sluices in the Canal of Walcheren fail which may be followed by a breach in the embankments of that Canal. Secondary embankments are expected to stay in tact.

The water depth maps resulting from the Sobek1D2D model are combined with the population spread map provided by the province. This results in maps with affected people. The number of exposed people is dependent on the evacuation plan. If no evacuation is carried out the number of exposed people equals the number of affected people.

Later on these maps could be further specified by including information on the time of day. During a regular working day most people are in school or at work, while during the night people are usually at home. Depending on the timing of the event, exposure maps could be different.

**Functionality of the Schelde DSS**

The prototype DSS for the Schelde pilot, called Evacuation Support System (ESS), has been built following the general framework as introduced in chapter 2. As the purpose of the ESS is evacuation management, some modules of the framework can be left out or reduced. Figure 3.3 shows a screen dump of the ESS as it appears on the screen after installing the software. On the left some of the modules as explained in the framework can be found. Below the modules are explained in more detail. The risk module is not added, because it contains the same information as the consequence module. The management response module only contains evacuation measures.

In the upper left corner, a drop down menu is present from which a ‘scenario’ can be chosen. Each scenario represents a breach location or a set of breach locations. All available breach locations and their labels are presented on the overview map.
Figure 3.3 Screendump of Schelde ESS at start-up

**External driver module**

- External driver
- Current weather conditions

All flood event management starts with a forecast of a flood event provided by a flood early warning system. The external drivers of the Schelde consist of weather conditions and resulting water levels. In the current module a link is made with renown internet sites that show weather conditions and current measured water levels at Vlissingen.

**Hazard module**

- Hazard
  - Maps
    - Water depth
    - Maximum flow velocity
    - Time of inundation
  - Animation

For each breach scenario three maps are available with the following information per grid cell of 1 ha:
- maximum water depth;
- maximum velocity;
- time of inundation.

When clicking on one of the grid cells, the grid value is shown in the upper right corner of the screen.

The second functionality in the module ‘hazard’ is a simulation of the chosen flood scenario as a function of time.

**Exposure module**
For each breach scenario four maps are available with the location and number of inhabitants, livestock and infrastructure. Also a map with shelters is available. Tall and stable buildings and high areas are shown. Shelters could be used to evacuate people to.

**Consequence module**

For each breach scenario three maps are available with an estimation of casualties, affected people and building collapse. Both are derived from the velocity and water depth maps. The options ‘graphs’ and ‘tables’ are available to compare consequences of different breach scenarios.

In future versions there will be a map with objects at risk (buildings that are likely to collapse, hospitals, etc.). When clicking on one of the objects, the user will obtain information for this object (name/id, information on consequences such as max. water depth and time of inundation).

**Management response module**

Several evacuation plans can be read, applied and compared. The consequences can be found in maps again. In a later stadium it will be possible to create evacuation plans in this ESS. Input from task 17 is needed.
Example of a breach scenario
In the current example the breach location ‘Rilland’ has been selected. The location is shown by a red dot with a name tag (figure 3.4, left). The background map shows a topographical map of a part of Zeeland. Figure 3.4 (right) shows the maximum water depth map on top of the topographical map. Close to the breach location the maximum water depth is the highest. Figure 3.5 shows the time of inundation. The red area gets flooded within 2 hours after breach initiation.
3.3 Urban flash floods

The aim of the research will be validation on the available examples of applications of TELEMAC 2D System (www.telemacsystem.com) in order to derive the pragmatic approach to attribution of flood risk in urban areas using 2D hydrodynamics including issues relative to crisis management. This will enable identification of the critical points in terms related to the representation of the complex topography, geometry of buildings, roads, sewers etc. to be taken into account for an appropriate urban flooding case studies so that they can be targeted for improvement in view of applying 2D modelling in crisis management (determination of evacuation path, vulnerable zones, etc.). The study will be conducted on existing 2D model set-up for one of the urban areas situated in the southern France submitted to frequent flash floods due to intense concentrated precipitation.

This part of work will allow to derive a general set of recommendations for any 2D hazard assessment tool.

The study will assess the existing regulations in some EU member states (France, UK, Germany) with respect to urban flood risk prevention and in particular the link between 2D modelling approach and Flood Crisis Management plans for urban areas will be assessed and appropriate lessons related to methodological guidelines and specification of additional tools in order to cope with existing regulations in France (Community Safeguard Plans) will be drawn. This part of work will contribute to Management Response module.

The urban flash flood site will be an undisclosed city in the southern France. It will represent a borough situated in a densely urbanized area, where exist significant risks of flash flooding. Cooperation has been sought with appropriate municipal and county authorities of a mid-size urban area in southern France to use existing data and to make results of research available. An agreement on this issue is expected in the beginning of March 2007, but guarantees exist at this moment. The sensitivity of the problem makes it extremely delicate during the local election period, which will take place before summer 2007. If such agreement will not be established a "dematerialised" example, without reference to any particular city, will form the base for the application.
4. References


