Are flood models used?

A method for assessing the use of flood models in the operational phase of flood calamity management

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Nelen & Schuurmans

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Summary

In flood calamity management three phases are distinguished: the preparatory phase, the operational phase and the post calamity phase. This research focuses on the operational phase, lasting from three days before an event right until the event occurs. In this phase, actions taken are reactive to the situation. Currently, flood models are used in the preparatory phase of flood calamity management. However, in the operational phase flood models are barely used (Leskens & Brugnach, 2012).

The last few years the 3Di consortium has worked on a powerful tool that may be usable in the operational phase of flood calamity management. However, it is still unsure if this tool will effectively improve the decision making process and there is currently no method available to assess this. This thesis focuses on developing such a method. The objective of this research is to develop a method to assess the use of flood models in the operational phase of flood calamity management by establishing a set of specific and measureable indicators which together can be used to assess this.

To reach this objective, first the decision making context of flood calamity management in the use of technical information is explored. This is done by analyzing flood calamity plans and observing participants at a workshop organized by the 3Di consortium. Second, encountered practical constraints in the use of technical information are collected. This is done by analyzing evaluation reports and observing participants at another workshop organized by the 3Di consortium. Third, the constraints are represented in specific and measurable indicators. This is done by interviewing a wide range of professionals from water boards. Fourth, the representativeness of the indicators for a real flood calamity is verified. This is done by observing participants at the national flood calamity exercise at Hoogheemraadschap of Delfland on 14 November, 2012.

The decision making context of flood calamity management in use of technical information is determined. The topics of decision making can roughly be divided into three groups: measures against the causes of floods, measures against the effects of floods and organizational decisions. The network of teams cooperating in the operational phase of flood calamity management can be found in figure 3-1 on page 14. The process of making a decision is usually structured using a predefined decision making structure. Technical information is considered as an external influence on the decision making process. Experts have a limited role, although information managers seem to be of increasing importance.

Constraints in use of technical information encountered during flood calamities or exercises are determined. Policy questions determine the technical information required, which is preferred as an advice what decision to make. Currently, flood model calculations are barely made during the operational phase of flood calamity management. Instead, mostly precalculated scenarios are used. Communication of information is a key concern regarding the use of technical information. This is supported by the increasing use of netcentric systems. Topics of constraints encountered are, lack of overview, reliability of information, model expectations and pressure of time.

The method for assessing the use of flood models in the operational phase of flood calamity management consists of twenty indicators. These indicators are grouped in six categories, based on the structure of Covello and Merkhofer (1994): Logical soundness, Completeness, Accuracy, Acceptability, Practicability and Effectiveness. The indicators can be found in table 3-2 on page 19.

Two types of possible relations between two indicators are recognized, ranking by importance and trade-offs between two indicators. To value an indicator, one or more questions are suggested that need to be answered affirmatively. Each question can be answered using one of three types of measurement methods, objective measurement, expert elicitation and user interviews. The questions can be found in table 3-4 on page 32.

The representativeness of the indicators for a real flood calamity is verified at the flood calamity exercise at Hoogheemraadschap Delfland on the 14 November, 2012. The use of the 3Di flood model to support decision making is assessed by the model users based on the indicators.

In conclusion, it is important to also consider use of flood models in addition to internal model properties, since a model should fit the organizational context and appeal model users. The twenty indicators identified can be used to assess the use of flood models in the operational phase of flood calamity management. This can be done by answering the presented questions using three types of measurement methods. The indicators appeared to be of variable importance and satisfying two indicators may reveal a trade-off between these indicators. The set of indicators are verified to be representative for a real flood calamity.

Preface

This thesis is the result of five months of research and is the final piece of my education in Water Engineering and Management. From the first year of the bachelor programme Civil Engineering, I was particularly interested in the different perspectives of technical experts and governmental policy makers. The different perspectives lead to failure of great technical solutions in real world problems and is not particularly unknown in integrated water management.

My interest in this has led to the subject of this thesis, in which a very specific context is considered. By explicitly stating requirements for flood model use in flood calamity decision making, I hope to bring the perspectives of technical experts and decision makers slightly closer together.

I am grateful for the opportunity given by Nelen & Schuurmans to conduct this research within their facilities. Due to the encouraging environment, I found myself mostly at the office in Utrecht working on my research. Everyone there made sure I could get familiar with the company, got all the means necessary for my research and they provided the supportive and collegial atmosphere.

I would like to thank my supervisors Anne Leskens and Maarten Krol for their guidance and support. As head of the committee Maarten Krol gave much in depth feedback throughout the research. Special thanks go out to Anne Leskens, who not only combined the intensive roles of both the daily supervisor and external supervisor, but also ensured that I could easily integrate in the company.

All involved employees of the water boards are gratefully acknowledged for their contribution. Without the supplied documents, made observations, held interviews and questionnaires taken, this research would not be possible. Finally, I am thankful to all friends and family for their support, especially my girlfriend Yasmin on the long days I was in Utrecht.

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1 Introduction

This chapter introduces the research and explains its relevance. The first paragraph of this chapter describes the research object. The second paragraph describes the general scientific context. The scientific context is related to the research object in the third paragraph. This leads to the research objective presented in the fourth paragraph. The research questions to reach this objective are introduced in the fifth paragraph. The framework for the research is described in paragraph six and the seventh paragraph describes the research strategy.

1.1 Research object

The Netherlands have a rich history in water safety, since large parts are situated below sea level. Large populations and high economic value are located in polders and are protected by a system of dikes, canal rings and pumping stations or sluices. Even though the necessity of safety, recent inspection of safety levels of primary dikes showed that almost one third was insufficient. This implies that more than 1200 kilometres of dunes, dikes and levees are considered to be unsafe (Inspectie Verkeer en Waterstaat, 2011).

Fortunately, life threatening floods have not occurred in the Netherlands since the North Sea flood of 1953. However, the risks seem to be significant. In the summer of 2003 everyone was surprised by an unexpected failure of the dike at the village of Wilnis. One of the dikes of the ring canal collapsed by a formerly unknown failure mechanism (Onderzoekscommissie Wilnis, 2004). Also, with assumed climate change discharges of the main rivers are expected to increasingly impose problems. In 1995 high discharges led to large scale evacuations of the Dutch river area. More recently, at the beginning of 2012 apparent failure of the dike at Woltersum due to severe piping led to a situation in which even emergency services fled the location (Veiligheidsregio Groningen, 2012).

These examples make clear that water safety should not merely focus on prevention of floods. An important concept that addresses this insight is the multi-layer safety policy (Kolen & Kok, 2011). Herein, three layers of safety are distinguished: prevention of floods, reduction of damages by smart spatial planning and flood calamity management. In flood calamity management multiple phases can be identified. For the purpose of this research, three phases are distinguished. The first phase is the preparatory phase, chosen to last until three days before an event, such as a dike breach. In the preparatory phase there is no short term threat and actions are proactive. The second phase is the operational phase, lasting from three days before an event right until the event occurs. In this phase actions taken are reactive to the situation. The third phase is the post calamity phase, starting on the moment the event occurs. It considers the relief efforts in the affected area.

Currently all kinds of models are used in water safety policy. For example, in the first layer models are used to calculate normative water levels to determine the required dike height. In the second layer, flood models are used to adapt spatial planning to possible flood risks. In the third layer, flood models are used in the preparatory phase of flood calamity management. However, in the operational phase of flood calamity management flood models are barely used (Leskens & Brugnach, 2012).

Over the last few years, the 3Di project has worked on a powerful tool that may be usable in the operational phase of flood calamity management. A prototype is tested for making calculations during the national flood calamity exercise the 14th of November. However, it is still unsure if this tool will effectively improve the decision making process. This research focuses on the use of flood models in the operational phase of flood calamity management. Currently, no assessment method is available to the assess use of flood models in the operational phase of flood calamity management. This thesis focuses on the possibilities to develop such a method.

1.2 Scientific context

1.2.1 Model users

In integrated water management model users are often divided in two groups: experts and decision makers. The experts are considered water engineers that try to fully understand the complex system and its uncertainties. The decision makers are considered to have less expert knowledge and have the main goal of making careful decisions. Both groups of users have a different perception of the use of models in decision making processes. Experts see the model as the centre of technical information, while decision makers see a model as just one of many sources of information (Borowski & Hare, 2007).This different perception is also supported by the observation of Brugnach et al. (2007). They address that decision makers have no need for complex model output and just asked for "one answer, one model" solutions for their problem.

1.2.2 Role of models

Models can have different roles in integrated water management. According to Brugnach et al. (2008), four different types of roles can be distinguished: prediction, exploratory analysis, communication and learning. The role may affect the position the model has in the decision making process.

The predictive role could be considered as the classic role in which the system is partly represented by mathematical equations. The model is used to make quantitative predictions about possible events and measures to support the decision making process with quantified data. In this role the model has an advisory purpose and is positioned outside the decision making process. In the exploratory role a model is used to discover unexpected behaviour of complex systems. Earlier unrecognized properties of a system can be exposed to learn about the problem and the solution space. In the communicative role a model is used as a communication tool. A model can make things clear in a way which other communication methods may not. In the learning role a model can contribute to a process of social learning. The modeller and the decision maker can together create mutual understanding. As a result the model is situated in the centre of the decision making process.

1.2.3 Uncertainty framework

Uncertainties strongly influence the use of models in water management and therefore it is important to consider the topic. Brugnach et al. (2008) have introduced a framework of two dimensions to characterize uncertainties: cause of uncertainties and manifestation of uncertainties. The two dimensions can be found in table 1-1 and are elaborated below.

Table 1-1: Causes and manifestations of uncertainty (Brugnach et al., 2008).

Causes of uncertainty	**Manifestation of uncertainty**
Error in empirical observations	Data, parameter values
Complex dynamics	Structure
Ambiguity and conflicting knowledge	Framing
Ignorance	
Values and beliefs	

The first dimension is the cause of uncertainties. Brugnach et al. (2008) identify five causes of uncertainties. The first cause of uncertainty, error in empirical observations, is a commonly understood cause of uncertainty. It represents a deviation between the real value and the approximation that is used in the model, for example, the deviation between a measured value and a real value due to a measurement error. Errors in empirical observations can also be caused by failures of techniques, procedures or instruments. The second cause of uncertainties is complex dynamics. Many natural systems are complex, because they contain chaotic or nonlinear behaviour. Also, natural systems continually evolve and adapt. The dynamic and complex nature of natural systems is thus one of the causes of uncertainty in models that represent them. The third cause of uncertainty is ambiguity and conflicting knowledge. Ambiguity represents uncertainty caused by different interpretations of the facts, which can originate from a linguistic difference or different disciplinary backgrounds. Also, facts can sometimes be explained in multiple ways. This way conflicting knowledge can be a cause of uncertainty. The fourth cause of uncertainty is ignorance, in which the extreme case is that you do not know what you do not know. Ignorance indicates that certain aspects of the system are not known or ignored, i.e. recognised and total ignorance (Walker et al., 2003). The fifth and last cause of uncertainty is values and beliefs. This is a variation due to subjectivity. Where information cannot always be fully objectively valuated, subjectivity of the modeller can be a cause of uncertainty and variation.

The second dimension of uncertainty distinguished by Brugnach et al. (2008) is manifestation or the location of uncertainties. The authors identify three locations where uncertainty manifests. The first location where uncertainty can manifest is data and parameter values. The uncertainty is clearly attributable to concrete input data or specific parameters and it is uncertainty that is mostly recognised by modellers and model users. The second location where uncertainties manifest is the structure of the model itself. A model consists of elements that interact with each other and the structure of connections can contain uncertainties. These uncertainties show lack of understanding of how the system works and can indicate flaws in underlying theories on which the model is built. The third location of uncertainties is in the framing of the modelling process. Modelled reality is always framed through a perspective of values, beliefs, interests and experience of the modeller. This subjectivity in the modelling process can be the first moment when uncertainties begin to arise.

1.3 Scientific context applied to operational phase of flood calamity management

1.3.1 Model users in flood calamity management

In flood calamity management also experts and decision makers can be recognized as model users (Leskens & Brugnach, 2012; McCarthy et al., 2007). McCarthy et al. (2007) also state that roles and responsibilities of professionals mean that they have different communication needs. The same problems between the experts and the decision makers as in general integrated water are to be expected.

1.3.2 Role of flood models in flood calamity management

In the operational phase of flood calamity management, one may suggest that the predictive role is the most important role of a flood model. The model is then used to quantify effects of the calamity event and is used to assess possible measures. The exploratory and learning role of a model is limited during flood calamities, since the available time is limited. The communicative role however, may play an important role. The situation during a flood calamity can be complex and model representations could contribute to a comprehensible overview of the situation.

The predictive role of flood models in flood calamity management influences the position of the model in the calamity organization. The modellers are a supporting team to the decision makers, next to other advisory stakeholders, such as emergency services and municipal services.

1.3.3 Functionalities

The functions and properties of a model are important for its usability in a practical situation. According to Leskens and Brugnach (2012), inflexible use of flood models is one of the main reasons they are not used in flood calamities. They state that calculation times up to two hours are too large for flood models to be of use during flood calamities. For example, in a flood calamity exercise held by Hoogheemraadschap Hollands Noorderkwartier intervals between meetings were at a maximum of one hour (Vinck et al., 2011). Model run time can sometimes be reduced by increasing computational power. However, this not always possible. Innovative or smart design of the computational framework can also decrease model run times. For example, the 3Di flood model can estimate the required spatial calculation grid to decrease model run time (3Di Waterbeheer, 2012).

1.3.4 Coping with uncertainties in flood calamity management

The presence of uncertainties is unavoidable. Therefore it is important to have a strategy to cope with them. Experts try to determine all model uncertainties and possibly quantify them by using uncertainty and sensitivity analysis. In the last decade increased computational power led to increased use of ensemble calculations. This is a method to calculate model output uncertainty based on propagation of uncertainties in model parameters. In recent literature, this is suggested as a promising technique for assessing uncertainties (Leskens & Brugnach, 2012; McCarthy et al., 2007).

Decision makers often request confidence intervals or bandwidths in order to cope with uncertainties in model results (Brugnach et al., 2007; Leskens & Brugnach, 2012; McCarthy et al., 2007). This has showed to be of great importance to decision makers (Leskens, 2012). However, an overview of uncertainties can easily become complex. McCarthy et al. (2007) observed that the Environmental Agency decision makers had no need for widely diverging results from ensemble calculations, but only asked for the likelihood of near future floods of specific areas. In addition, Borowski and Hare (2007) observed that experts process the model results and translate them into comprehensible information for decision makers. This process involves simplification of information and interpretation of uncertainties.

As a result complex information about uncertainties is simplified, for example to one statistical range. This may give the false impression that all uncertainties are quantitatively known. There is probably always a loss of information in this process and whether the resulting uncertainty levels are meaningful depends on the decency of the procedure. However, Brugnach et al. (2007) state that the uncertainties should be transparent to decision makers for information to be of value. Also recent research by Van Loenen et al. (2012) confirms the importance of communication of uncertainties, but points out that explicit uncertainties can cause confusion when there is a lack of expert knowledge on the topic.

This suggests there is a duality in this topic. On one hand, decision makers demand straightforward information suitable for a simple assessment directly supporting the decision making process. On the other hand, model results are mostly complex and demand a careful interpretation by experts. This tension appears to remain and is important considering who deals with the uncertainties in the model.

Although both groups of model users are usually familiar with the fact that uncertainties are present in flood models, it is important to consider who has to cope with them. McCarthy et al. (2007) state that in current flood calamity decision making processes decision makers always depend on the experts' own technically informed judgments or predictions. Decision makers can therefore definitely benefit from understanding model uncertainties.

1.4 Research objective

The objective of this research is to develop a method to assess the use of flood models in the operational phase of flood calamity management by establishing a set of specific and measureable indicators which together can be used to assess this.

1.5 Research questions

The research is structured by four key questions. These research questions provide the basis for the research strategy and the individual paragraphs in the chapters Methods and Results.

- What is the decision making context of flood calamity management in use of technical information?
- What constraints in the use of technical information are encountered in practice?
- How can the constraints be represented in specific and measureable indicators?
- How can the representativeness of the indicators for a real flood calamity be verified?

1.6 Research framework

The research is structured using a research framework. The indicators for assessing the use of model based tools in the operational phase of flood calamity management are categorized based on the structure of Covello and Merkhofer (1994). The structure contains three internal and three external criteria respectively: Logical soundness, Completeness and Accuracy; and Acceptability, Practicability and Effectiveness. An interpretation of the structure is made to fit the purpose of the research. The interpretation of the six categories is described below.

1.6.1 Logical soundness

Logical soundness comprises the internal consistency. It considers if the model is justified by theory and legitimacy of fundamental assumptions. A logically sound model uses valid procedures to fulfil its purpose in modelling a system. In this research Logical soundness is interpreted as the correct representation of the relevant part of reality. So also more practical aspects can be classified in this category. The second dimension of uncertainties classified by Brugnach et al. (2008), the location of uncertainties, is used to divide uncertainties under the framework of Covello and Merkhofer (1994). Uncertainties located in the model structure are mainly considered in the category Logical soundness.

1.6.2 Completeness

Completeness is considered in two directions: depth and broadness. The first direction describes whether parts that are present in the model are completely described. This different from Accuracy, because Completeness describes whether elements are present and Accuracy the accurateness of the present parts. The second direction describes whether sufficient parts are present in the model so that is complete.

1.6.3 Accuracy

Accuracy describes if the facts that are presented are precise. Also uncertainties are reviewed under this category, because of the overlap between uncertainties and inaccuracies. This is limited to quantitative aspects, since qualitative aspects are considered as external criteria. The reason for this is that qualitative aspects of accuracy appear mostly through Acceptability and Effectiveness of flood models. Uncertainties classified by Brugnach et al. (2008) that are located in data and parameter values are mainly in this category.

1.6.4 Acceptability

Acceptability is acceptance of flood models as a source of information for decision making by model users, who are both experts and decision makers as recognized by Leskens and Brugnach (2012) and McCarthy et al. (2007). The category can contain a wide range of aspects, for example understandability and model users' perspectives and prior experiences. The aspects in this category contribute to the acceptance of the use of the flood model and its results.

1.6.5 Practicability

Practicability is the usefulness of the flood model in a practical environment as perceived by model users, who are both experts and decision makers as recognized by Leskens and Brugnach (2012) and McCarthy et al. (2007). It reviews that the flood model is to be used in a realistic, practical environment and not a perfected laboratory setup. This covers the inflexibility issues in functionality as addressed by Leskens and Brugnach (2012). As part of these functionalities, limitations in time and resources are an important topic in this category.

1.6.6 Effectiveness

Effectiveness describes the effect of flood model usage by model users, who are both experts and decision makers as recognized by Leskens and Brugnach (2012) and McCarthy et al. (2007), on the decision making process. Effectiveness reviews both the effect of the model output on the decision made and the effect of the usage of the flood model on the process. Uncertainties as classified by Brugnach et al. (2008) that are located in framing are mainly in this category.

1.7 Research strategy

This paragraph describes the research strategy used, which is represented by the diagram in figure 1-2. The research consists of five phases: defining context, acquiring data, generating results, verification and conclusions. Each phase is a process consisting of activities represented by blue description boxes.

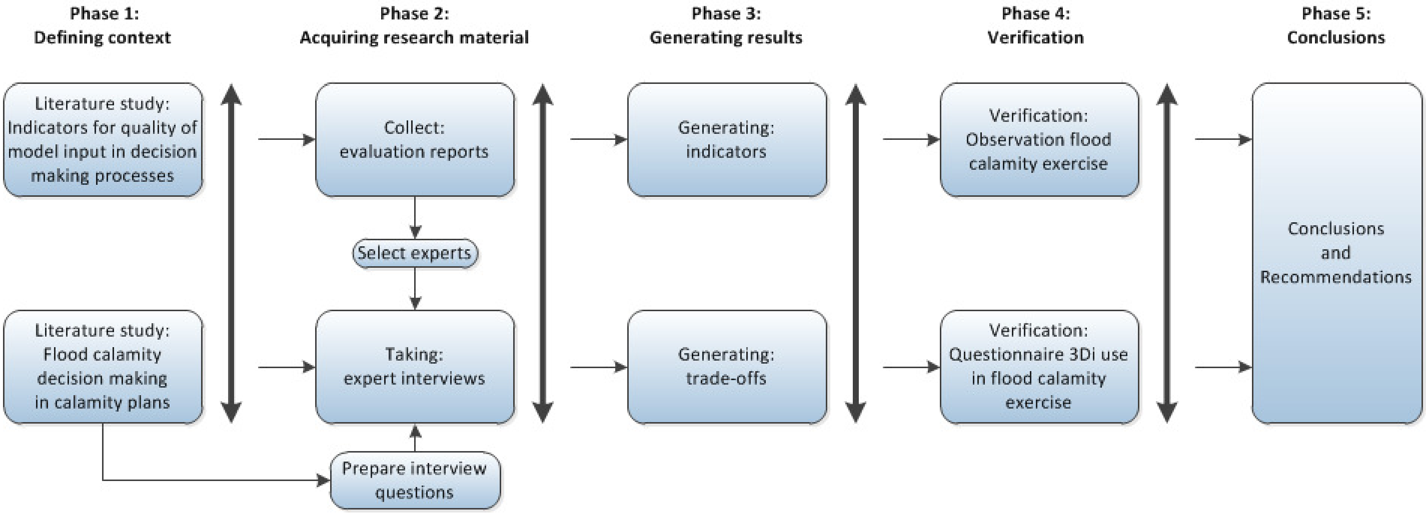


Figure 1-2: The research strategy used for this research.

2 Methods

This chapter explains the research methods used. For each research question an individual research method is used. Each method describes the activities done and how that contributed to answering the research question. Paragraph one to four describes the methods for research question one to four.

2.1 What is the decision making context of flood calamity management in use of technical information?

2.1.1 Approach

Research question one is answered by using two research methods in methodological triangulation (Denzin, 2006). The first research method is analyzing flood calamity plans that describe the calamity organization in the operational phase of flood calamity management. The second research is observing participants of the workshop ‘Beslissing Centraal’ at Waternet on 28 June, 2012. The approach to both research methods is described below.

Analyzing flood calamity plans

In preparation for possible flood calamities, most water boards have flood calamity plans that describe a wide range of protocols for the operational phase of flood calamity management. Some water boards do not have calamity plans specific for flood calamities, but use general calamity plans describing the calamity organization in the operational phase. In case no flood calamity plans were available, general calamity plans were used to describe decision making context.

Some flood calamity plans are publicly available on the websites of the water boards. Otherwise contacts at the water boards were approached to request the flood calamity plans. The content of the documents is interpreted and summarized on one page maximum, based on the sub questions presented below.

Observing participants of workshop ‘Beslissing Centraal’

The workshop was organized by Nelen & Schuurmans on behalf of the 3Di consortium and was held at Waternet on 28 June, 2012. The goal of the workshop was to identify necessary technological developments of the 3Di flood model to fit the needs of the potential users of flood models. An additional goal was to identify possible improvements in the decision making process required use the 3Di flood model.

The goal of making observations at the workshop is to acquire knowledge to help answering research question one. This research method has therefore a more exploratory character compared to analyzing flood calamity plans. During the workshop the participants are observed and notes are made, based on the sub questions below.

2.1.2 Sub questions

To answer the research question, four sub questions have been defined. The answers to the four sub questions form the answer to research question one. The four sub questions are presented below.

- What decisions are made in the operational phase of flood calamity management?
- What is the decision making network in the operational phase of flood calamity management?
- What is the structure of the decision making process in the operational phase of flood calamity management?
- What is the position of technical information in the operational phase of flood calamity management?

2.1.3 Expected results

The result is a descriptive paragraph that answers research question one, thus describing the decision making context of flood calamity management in use of technical information. The paragraph consists of four subparagraphs, containing the answers to the four sub questions.

2.2 What constraints in the use of technical information are encountered in practice?

2.2.1 Approach

Research question two is answered by using two research methods in methodological triangulation (Denzin, 2006). The first research method is analyzing evaluation reports that evaluate exercises or real flood calamities. The second research method is observing participants of the workshop 'Vervolg Case study 3Di Waternet' at Waternet on 25 September, 2012. The approach to both research methods is described below.

Analyzing evaluation reports

The water boards evaluate every calamity that occurs. Also, all held exercises regarding flood calamities are evaluated. These evaluation reports describe the encountered constraints in the use of technical information.

Most evaluation reports are for internal use and were not publicly available. Contacts at the water boards were approached to request the evaluation reports. The content of the documents is interpreted and summarized on one page maximum, based on the sub questions presented below.

Observing participants of workshop 'Vervolg Case study 3Di Waternet'

The workshop was organized by Nelen & Schuurmans on behalf of the 3Di consortium and was held at Waternet on 25 September, 2012. The goal of the workshop was to identify the necessary analyzes for decision making in the operational phase of flood calamity management.

The goal of making observations at the workshop is to acquire knowledge to help answering research question two. This research method has therefore a more exploratory character compared to analyzing evaluation reports. During the workshop the participants are observed and notes are made, based on the sub questions below.

2.2.2 Sub questions

To answer the research question, three sub questions have been defined. The answers to the three sub questions form the answer to research question two. The three sub questions are presented below.

- What technical information is used in the operational phase of flood calamity management?
- How is technical information used in the operational phase of flood calamity management?
- What constraints are encountered in the use of technical information in the operational phase of flood calamity management?

2.2.3 Expected results

The result is a descriptive paragraph that answers research question two, thus describing the use of flood models in the operational phase of flood calamity management and the practical constraints encountered. The paragraph consists of three subparagraphs, containing of the answers to the three sub questions.

2.3 How can the constraints be represented in specific and measureable indicators?

2.3.1 Approach

Research question three is answered by conducting semi structured interviews. The approach to the interviews is elaborated below.

Conducting semi structured interviews

Due to the exploratory character of the research, semi structured interviews are assumed suitable to gather expert knowledge. A limited set of base questions allows flexibility to introduce new questions based on the answers given. The structure of the interviews is described by an interview schedule. Videos and pictures of flood models and its results are presented as examples to discuss. The base questions for the interviews are presented below.

- What are the most important requirements of technical information from flood models?
- What are the most important strengths and weaknesses of the examples of flood model information presented?
- What are the trade-offs that need to be made between requirements of flood models?
- How do you value the presented trade-off?
- Can ideal information from flood models change the structure of the calamity organization?

These questions are further elaborated into the interview schedule presented in appendix I, along with the examples of flood models. The recorded interviews are analyzed and interpreted, based on the sub questions presented below.

Selection of participants

The evaluation reports contain names of key employees of water boards regarding flood calamity management. They were approached as possible interview candidates, but also consulted for other appropriate interview participants.

Participants were selected from three groups of professionals. The first group are the experts who directly deal with the technical information during a flood calamity. The second group are decision makers that are involved in the decision making process on a high level. The third group are process coordinators that are not part of the decision making process, but have a good overview of the process. A maximum of three interviews per water board is held to ensure diversity of participants.

Filter questions

Four filter questions are formed to verify the relevance of the answers given by the interview participants. If an interview participant mentioned an important aspect, the filter questions were used to determine if it was relevant, considering the purpose of this research. The four filter questions and the correct answers are presented below.

- What technical information is considered?
  correct answer: flood inundation
- Which phase of flood calamity management is considered?
  correct answer: operational phase
- Where does the information come from?
  correct answer: flood models
- Which team requests flood model information and which teams supplies this?
  correct answer: supplied by WOT and requested by WBT or ROT

2.3.2 Sub questions

To answer the research question, three sub questions have been defined. The answers to the three sub questions form the answer to research question three. The three sub questions are presented below.

- What are indicators for assessing the use of flood models in the operational phase of flood calamity management?
- How are the indicators related to each other?
- How do the indicators together form a method for assessing the use of flood models in the operational phase of flood calamity management?

2.3.3 Expected result

The result is a descriptive paragraph that answers research question three, thus describing indicators for assessing the use of flood models in the operational phase of flood calamity management. The paragraph consists of three subparagraphs, containing of the answers to the three sub questions.

2.4 How can the representativeness of the indicators for a real flood calamity be verified?

2.4.1 Approach

Research question four is answered during a national flood calamity exercise. During the exercise on the 14 November, 2012 at Hoogheemraadschap of Delfland, the 3Di flood model is used for information about effects of possible breaches. The verification is conducted within this exercise and consists of observations and a test case. The approach to both is elaborated below.

Observing participants flood calamity exercise

Observations were be made of the group participants that had contact with the modellers of the 3Di flood model. The focus was the communication within the group participants and communication with the modellers. The goal of the observations was to recognize both the identified indicators and trade-offs.

The comments made by the group participants were interpreted to fill in a checklist with the identified indicators. In this checklist a difference is made if a participant mentions an indicator implicit, explicit or as a bottleneck in the decision making process. The indicator checklist used can be found in appendix II. The comments were also used to fill in a cross table, representing all possible trade-offs between the identified indicators. The trade-off checklist can be found in appendix III.

Test case evaluation 3Di flood model use

An evaluation was scheduled at the end of the flood calamity exercise. During this evaluation a test case of the assessment method is held. In this test case the indicators are used to let participants evaluate the use of the 3Di flood model during the flood calamity exercise and verify the trade-offs made.

The test case was done using a questionnaire, which was handed out to the group that was directly involved in the use of the 3Di flood model. The first part of the questionnaire contained a test case for the indicators. The participants were asked to evaluate the use of the 3Di flood model during the calamity exercise. The second part of the questionnaire was used to verify the trade-offs made by the interview participants. A case similar to the flood calamity exercise was presented and respondents were asked to make the trade-offs presented. The full questionnaire can be found in appendix IV.

2.4.2 Sub questions

To answer the research question, four sub questions have been defined. The answers to the four sub questions form the answer to research question four. The four sub questions are presented below.

- What indicators are observed during the flood calamity exercise?
- What trade-offs are observed during the flood calamity exercise?
- How are indicators valued by the participants of the flood calamity exercises?
- How are trade-offs made by the participants of the flood calamity exercise?

2.4.3 Expected result

The result of the observations is a diagram indicating the amount of times an indicator is mentioned by a participant and an overview of the trade-offs recognized during the flood calamity exercise. The result of the test case is an evaluation of the use of the 3Di flood model during the flood calamity exercise by the participants. The test case also shows which of the two indicators in the four identified trade-offs are considered to be most important by the participants of the flood calamity exercise.

3 Results

This chapter contains the answers to the four research questions. They are the results of the activities described in the previous chapter. The results of research question one to four can be found in respectively paragraph one to four.

3.1 What is the decision making context of flood calamity management in use of technical information?

This paragraph contains the result of research question one, describing the decision making context of flood calamity management in use of technical information. It is a summary of the results of the analyzes of the calamity plans. The full results can be found in appendix V. The workshop ‘Beslissing Centraal’ appeared to be less directly applicable. A summary of this workshop can be found in appendix VI. The research question is answered by answering four sub questions, each discussed in individual subparagraphs.

- What decisions are made in the operational phase of flood calamity management?
- What is the decision making network in the operational phase of flood calamity management?
- What is the structure of the decision making process in the operational phase of flood calamity management?
- What is the position of technical information in the operational phase of flood calamity management?

3.1.1 Topics of decisions

During a flood calamity many decisions need to be made. An important topic is measures against the cause of the flood, so that water no longer flows into the affected area. Examples are repairing dikes or closing off the water supply to the breach. A similar but significantly different topic is measures against the effect of floods. Examples include closure of compartments in a polder or creating artificial breaches so water does not accumulate in high value areas. Another decision that may need to be made during a flood calamity is whether to evacuate certain areas and when. Also organizational decisions need to be made, for example to scale up or not, or to initiate specific organizational protocols.

3.1.2 The decision making network

During the operational phase of flood calamity management decisions are made by multiple teams in the decision making network. This subparagraph describes the network of decision makers and their responsibilities.

The main structure of the decision making network is presented in figure 3-1. In the network two parallel chains can be identified, the functional chain and the general chain. It is important to notice that information generally flows up the hierarchy, while the chain of command is top-down. In water related issues the water board is the leading authority. However, when public safety is at risk, the leading authority is at the general chain.

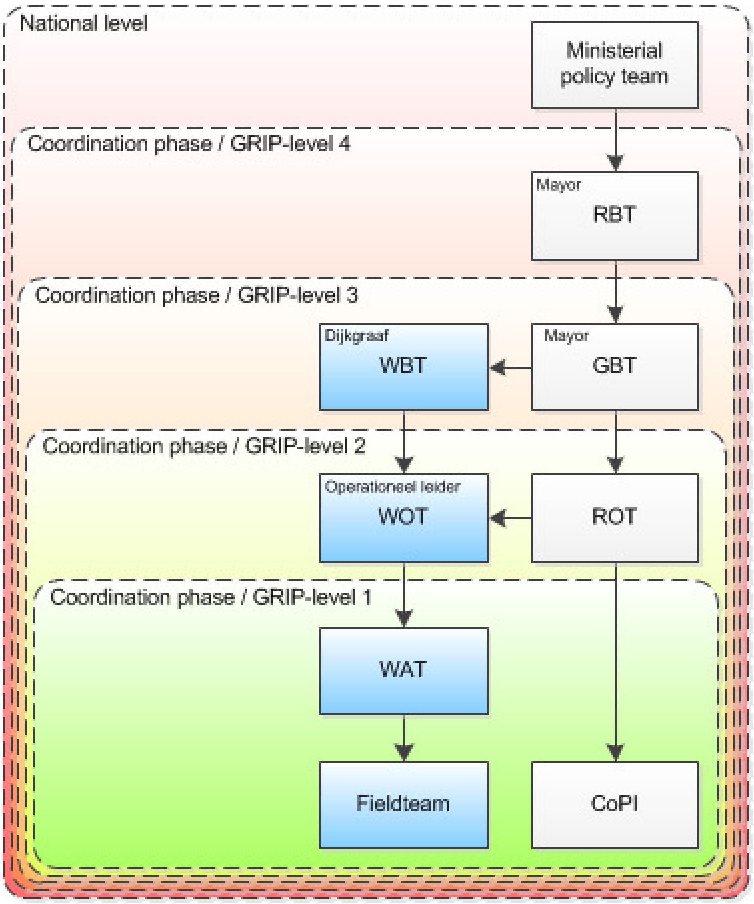


Figure 3-1: The decision making network during the operational phase of flood calamity management regarding the functional and general chain.

The functional chain contains governmental actors that are related to water concerning issues, in case of flood calamities the water board. Starting at the bottom of the chain there is the Water board Action Team (WAT), or sometimes called Water board Action Centre (WAC) (Hoogheemraadschap De Stichtse Rijnlanden, 2010). This team consists of members that fulfil practical actions or coordinate field teams. Members of this team can be modellers or other experts. Therefore, new information about a situation is mostly acquired by the WAT, such as field data or model results. In a more urgent situation operational coordination may be required. Then, the Water board Operational Team (WOT) is formed to make operational decisions in coordinating one or more WATs. The WOT is lead by an Operational Leader (OL). Large calamities require strategically support and for this the Water board Policy Team (WBT) is activated. The OL also takes place in the WBT and is an important link between the WBT and the WOT. The head of the WBT is the dijkgraaf. In a calamity on a national scale the dijkgraaf reports to the Minister of Infrastructure and Environment.

The general chain contains governmental organizations unrelated to water management, but that are involved in public safety. In water related issues they are not involved unless public safety is at risk. In that case, the general chain is the leading authority over the functional chain. At the end of the chain is the Command Incident Location (CoPI), which coordinates all emergency services, such police and fire department. In case of a calamity the actions of the CoPI are coordinated on a regional scale by the Regional Operational Team (ROT), which has a function similar to the WOT. When decision making on a strategic scale is necessary, the Municipal Policy Team (GBT) is activated as a leading authority. If multiple municipalities are affected, one Regional Policy Team (RBT) has the lead, similar to the WBT in the functional chain. On a larger scale the RBT hands over the authority to the ministerial policy team. When a calamity is of national scale, multiple extra teams can become active (Taskforce Management Overstromingen, 2009b).

Scaling is a procedure in the decision making process that greatly influences the structure of the decision making network. Scaling is the procedure in which the calamity organization is enlarged or diminished. In calamity plans it is addressed as one of the most important aspects, because it is essential for good functioning of calamity management. The general chain uses GRIP-levels as a uniform procedure of scaling. They contain concrete demands for each level and further instructions how to operate. Water boards use coordination phases as procedures for scaling, which are similar to the GRIP-levels. With each increased GRIP-level an additional leading authority is added to the calamity organization. Scaling up occurs when additional command or authority is required. The decision to scale up is made based on the available information about the situation, for example regarding risks, (financial) consequences or media attention (Advies Commissie Crisisbeheersing, 2012).

In reality, the decision making network can be dynamic and more complex, depending on the calamity at hand. This was also confirmed by multiple participants at the workshop (see appendix VI). Case specific characteristics can ask for the involvement of specific participants. Also, there are a lot of external actors that are woven into main organization, for example contractors and press, but also the daily organization of the institutions involved. Independent of the additional network participants, the structure of general chain and functional chain remains intact.

3.1.3 Structure of the decision making process

The decision making process is a social and organic process. Structuring the process is hard, since calamity management is no daily business for the participants and each case is unique. The pressure in the process is high, because the consequence of decisions is high, the amount of time available is limited and the uncertainty in available information is large.

To ensure an efficient decision making process, its structure is prescribed in the calamity plans. The procedures describe who has authority on which topics and how decisions should be made, although there is not always uniformity in the advised procedure. In some local cases a three-step procedure of perception, assessment and decision (BOB-structure), or a four-step variation, process, perception, assessment and decision (PBOB-structure) (Vinck et al., 2011) for decision making is prescribed. For decision making on national level a custom five-step process for decision making is advised (Taskforce Management Overstromingen, 2009b).

3.1.4 The position of technical information

This subparagraph describes the position of technical information in the decision making process during the operational phase of flood calamity management. The calamity plans are written from an organizational perspective and do not extensively elaborate on the technical information required. The technical information is considered as merely one of the inputs in the decision making process. Models and other technical information are considered as an external influence in the decision making process. However, it can be possible that technical information are incentives for further actions, for example, scaling up the organization at certain water levels (Waterschap De Dommel, 2008). In all cases the technical information has a role in which it supports decisions.

Not many experts are present in the teams. Only a limited amount of persons are responsible for the input of technical information in the decision making process. In the WAT for example, usually one person is present that daily work with flood models. In operational teams, such as WOT, experts are less present. An information manager can be present in the operational team that is familiar with technical information delivered. Multiple teams contain a plotter who visualizes the technical information. These visualizations give other members of the team an overview of available information. The hierarchy of the decision making network implies that information is processed multiple times before it reaches the leading authority, including inevitable simplification of technical information. Higher up the hierarchy the information is usually bundled, possibly visual, in situation reports (sitraps) generated by subordinate teams.

3.2 What constraints in the use of technical information are encountered in practice?

This paragraph contains the results of research question two, describing the constraints in the use of technical information encountered in practice. It is a summary of the full results analyses of the evaluation reports, which can be found in appendix VII. The workshop ‘Vervolg case study 3Di Waternet’ appeared to be less applicable. A summary of this workshop can be found in appendix VIII. The research question is answered by answering three sub questions, each discussed in individual subparagraphs.

- What technical information is used in the decision making process in the operational phase of flood calamity management?
- How is technical information used in the operational phase of flood calamity management?
- What constraints are encountered in the use of technical information in the operational phase of flood calamity management?

3.2.1 The technical information used

The technical information required differs per situation, but the basic information mainly consists of water levels and flow speeds. Decision makers are more interested in interpretation of the basic information as predicted events over a timeline, for example, maps with arrival times of the water front. The technical information used is determined by the specific policy question considering the actual state of the calamity.

3.2.2 Use of technical information in practice

In multiple evaluation reports decision makers address that they prefer scenarios as the form of technical information. In practice scenarios are frequently used in various ways. One way scenarios are used is to overview possible consequences of a breach. Multiple flood models are made to predict a wide range of flood events. Scenarios are also used in calamity plans to create decision trees in advance. For creating the decision trees, flood models are used to analyze the system and identify critical water levels. In many cases extensive preparatory calculations are made to be used in the decision making process in the operational phase of flood calamity management. The aim is to minimize the calculations required during the calamity.

Information management seems to have a prominent role in the use of technical information in decision making processes. Multiple water boards mention the use of information management systems to manage all information. There is an increasing use of netcentric systems at the water boards, influenced by the implementation of these systems at all public safety districts. The system Cedric is commonly known, although also other systems are used. See for more information about netcentric systems Reitsma et al. (2011).

Another aspect that appears to be important is the communication of information. As previously addressed, the decision making network is complex and it is important that information is uniform to all network participants. However, there is a difference between information for internal communication and external communication. Internal communication serves the purpose of informing network participants, where external information is for informing the public. It is addressed as important that the information communicated should fit both the receiver and his goal. Therefore, it is important that all network participants have the same information available, but that it is clear what is relevant for them and what not.

3.2.3 Constraints encountered in the use of technical information

The evaluation reports give an impression of constraints in the use of technical information encountered during practical situations. An important constraint is the lack of overview of available information. This appears from an overflow of information and getting lost in details. The constraint is tried to overcome by using information management systems.

Another recurring theme is that decision makers are unsure if the information is reliable and whether they should make decisions based on the information. This appears from the request for higher accuracy and more details. Uncertainty levels may also be important to indicate if information is reliable, but only if decision makers know how to interpret the uncertainty levels.

Also, decision makers do not always know what is realistic to expect of flood models in terms of accurateness and computational speed. Sometimes the expectations are unrealistic. In one exercise it was remarked that a model should be a tool for making assessments and that also social and economic aspects should be included for the model to be complete (Vinck et al., 2011).

The form and use of technical information covers all kinds of encountered constraints. Miscommunication and lack in consensus can sometimes be problematic. For example, during an exercise it was hard to address the urgency of the situation through the technical information (Vinck et al., 2011).

Most decision makers consider there is no time to make calculations or create new scenarios during a calamity. Decisions are made based on the information that is directly available. For this reason preparatory calculations need to be extensive. However, trying to achieve perfect preparations for calamities may be unrealistic.

3.3 How can the constraints be represented in specific and measureable indicators?

This paragraph contains the result of research question three, describing the indicators for assessing the use of flood models in the operational phase of flood calamity management. The results are based on analyses of the recorded interviews. The research question is answered by answering three sub questions, each discussed in individual subparagraphs.

- What are indicators for assessing the use of flood models in the operational phase of flood calamity management?
- How are the indicators related to each other?
- How do the indicators together form a method for assessing the use of flood models in the operational phase of flood calamity management?

3.3.1 Indicators for assessment of flood model use in the operational phase of flood calamity management

This subparagraph contains the results of the iterative process of determining the indicators. Ideas for indicators came from Covello and Merkhofer (1994) and were transformed in a preliminary set of indicators based on the results of the first two research questions. During the interviews the set of indicators was continuously improved and the number of interview participants that mentioned an indicator was counted. In table 3-2 a summary can be found of the amount of participants who addressed a specific indicator as important.

Three types of measurement methods for measurement of the indicators are distinguished. The first type is objective measurement, usable for indicators that can be objectively measured. These indicators can be assessed by measuring a concrete value, which can be compared to the required value. The second type of methods is expert elicitation. A group of experts assess an indicator and aim to reach consensus, possibly by using a combination of both quantitative and qualitative methods, such as the NUSAP method (Van Der Sluijs et al., 2005). This type of methods is suitable for indicators that cannot be objectively measured or have an unknown required level. Expert elicitation can be used to determine if the indicator is sufficiently met. The third group of methods are user interviews. Some indicators relate to whether the model user is satisfied with the flood model. By consulting (future) model users the indicator can be assessed and can be determined if an indicator is sufficiently met.

Each indicator is separately described in this subparagraph. First, the indicator is conceptually described. Second, the opinions of the interview participants about the importance of the indicator are presented. Third, suggestions are made for measuring the indicator.

Actuality

Actuality considers the recentness of the flood model input data. It is about error in data caused by outdated information. In flood models breach information can change rapidly and has large influence on model results. Other examples of information that needs to be recent in flood models are bottom height and friction coefficients. The term Actuality is derived by the author as a demerger from Validity. It comes from interview participants who addressed that information needs to be up-to-date.

Five out of seventeen interview participants addressed Actuality explicitly as important. They addressed is as important, because outdated input data may make a flood model useless. For example Kers stated that, “the model is not usable if it is too outdated” (Interview with W. Kers) and Van Dijk stated that, “It is very important that the model is updated with the most recent events in the field.” (Interview with W. van Dijk). Other interview participants addressed that it differs whether Actuality is important. For example Gooijer stated that, “the recentness of the information is very important in an area with ground settlement” (Interview with J. Gooijer) and Van Loon stated, “if the deviation is water level is only a few millimetres, it probably doesn’t matter.” (Interview with A. van Loon).

The first type of objective measurement methods is limited applicable. A method for estimating if information is outdated is to determine how old the information is. As Dragt confirms, “If information may be outdated, it is necessary to have at least an indication how old the information is.” (Interview with J. Dragt). However, determining how old the information is may not directly tell if the information is outdated. Actuality depends on the effect of outdated data on the flood model result. To measure this it is necessary to know to what extent the information differs from reality, which is in most cases not possible. Therefore, an expert elicitation method can be used to decide if the data is sufficiently recent to be useful.

Table 3-2: The final set of indicators resulting from the held interviews, grouped in the six categories. In the second column the amount of interview participants from a total of seventeen that mentioned an indicator as important is presented.

Indicator	Number participants
Logical soundness	
Actuality	5 / 17
Validity	7 / 17
Completeness	
Completeness of elements	4 / 17
Completeness of components **	9 / 17
Scenarios	7 / 17
Accuracy	
Level of detail	6 / 17
Acceptability	
External consistency	1 / 17
Understanding of model structure	4 / 17
Understanding of model uncertainties **	8 / 17
Confidence in model operators	7 / 17
Credit	4 / 17
Practicability	
Required time *	11 / 17
Functionalities	7 / 17
Pre-processing	4 / 17
Post-processing **	8 / 17
Effectiveness	
Uniform framing	6 / 17
Understanding of model result *	11 / 17
Decision clarification **	9 / 17
Customizability presentation model result	4 / 17
Suitable for decision making culture	3 / 17

Validity

Validity describes the extent to which the flood model correctly represents a certain part of reality. Some interviews participants simply stated that, "the model should be correct." (For example, interview with G. Verbraak). A valid flood model produces results that are supported by a scientific basis. The term Validity is an interpretation of the example operational validity of Logical soundness presented by Covello and Merkhofer (1994).

Seven out of seventeen interview participants addressed Validity explicitly as important. Some interview participants addressed that they perceived a minimum level of Validity necessary for a flood model to be useful in decision making. As Verbraak stated, “If reality appears to be significantly different than the model results, this frustrates future decisions based on the model.” (Interview with G. Verbraak).

To objectively measure Validity it is important to determine the deviation in the flood model results from reality. Although determining ‘real’ values may be impossible, this can be covered by using other techniques and control calculations to validate the model. Another suggestion for determining Validity is use expert elicitation to assess the possibility for unknown uncertainties. If it is clear which parts of the flood model are valid and which are not, it will be better possible to determine flood model Validity. As Haddink referred, “It is important to describe what you do know and what you don’t know.” (Interview with E. Haddink). Due to the nature of unknown uncertainties, it will always be unsure whether a flood model is sufficient valid, “It is always important to consider it is just a model”. (Interview with J. Gooijer).

Completeness of elements

Completeness of elements considers whether all location specific individual elements are present in the flood model. Regarding flood models examples of these could be culverts or closures. The absence of these may have large influences on the model results, depending on the specific case that is evaluated. The term Completeness of elements is derived by the author from the category Completeness in the framework of Covello and Merkhofer (1994). It originates from the interviews, in which interview participants addressed that all elements should be present.

Four out of seventeen interview participants addressed the Completeness of elements as important. It appears it is only important until a certain point. Kers stated, “you want a model to be complete as possible.” (Interview with W. Kers). This suggests that a perfectly complete flood model is assumed to be unrealistic. Rietman pointed out the relativity of Completeness, by stating that, “completeness in not that important, because you will always need to act from the assumption that there is plenty you don’t know.” (Interview with B. Rietman). Wijnstra related the limited importance of Completeness of elements to the problem of focussing too much on details. He stated that, “completeness is important, but one should not focus too much on individual elements. It is important that the total overview of the situation is simple and clear.” (Interview with A. Wijnstra).

Objective measurement methods are limited applicable, since it requires that is known which elements are present and which are not. In practical situations this limitation appears to be recognized by model users. As stated by Rietman, “One should always assume that not all elements are present in the model”. (Interview with B. Rietman). As a solution Gooijer stated, “there is always a risk of missing information, but this is in current practise covered by using multiple possible scenarios.” (Interview with J. Gooijer). An objective measurement method might be to perform a sensitivity analysis for identifying the influence of possible missing elements. The order of magnitude of the effect of missing elements could indicate the Completeness of elements. So far it is possible to know if all elements are present, an expert elicitation can be used to decide if necessary elements are present.

Completeness of components

Completeness of components in a flood model reviews whether sufficient components or modules are present in the model. A component can model a certain aspect of flood calamity. The interview participants mentioned all kinds of examples, “economical damages" (Interview with R. Weijs and C. Van Ackooij), "evacuation times and routes" (Interview with B. Rietman) and "hospitals or dangerous chemicals" (Interview with G. Verbraak) as important during a calamity. Other examples could be one or two dimensional flow and water quality. The term Completeness of components is derived by the author from the category Completeness in the framework of Covello and Merkhofer (1994). It originates from the interviews, in which interview participants addressed that all necessary model components should be present in the flood model.

Nine of out seventeen interview participants addressed the importance of Completeness of components. In general the importance of Completeness was widely recognized. As Van Dijk addressed, "for the water board it is of most importance to have an as complete as possible overview of the situation." (Interview with W. van Dijk). However, there appears to be ambiguity about the tasks and responsibilities the water board has. As Kers mentioned, they "were corrected by the public safety district to only focus at their core business in delivering flow predictions". (Interview with W. Kers). By contrast, Leijen recalled they had a societal obligation "look beyond their primary scope". (Interview with J. Leijen).

The components present can easily be objectively measured. However, to know which components are required, it needs to be clear which tasks and responsibilities should be considered. Otherwise there is no criterion what is to be considered complete. The policy questions that could arise during a flood calamity may indicate the components that should be present in the flood model. As Dragt stated, "without the right information the model results are useless." (Interview with J. Dragt). Therefore, user interviews can be used to identify if the components required for the tasks and responsibilities of the model user are present in the model.

Scenarios

Scenarios are different variants of model setups that are assessed at the same moment. This can be used to account for uncertainties, allowing multiple possible situations to be assessed. Scenarios can also be used to compare the effects of different possible strategies. The term Scenarios originates from multiple interview participants who addressed that scenarios are important.

Seven out of seventeen interview participants addressed the use of Scenarios as important. Most interview participants addressed the importance of Scenarios based on the crucial role Scenarios have in current flood calamity management. In relation to this, Verbraak stated that, "precalculated scenarios have the main advantage is that there is more time to develop, calculate and assess them." (Interview with G. Verbraak). Van Dijk even stated that, "It is important to assess scenarios in advance, since there is no time to assess them during a calamity."

Measuring the use of Scenarios could be divided in the quantity and the quality of the scenarios. The quality of a single scenario can be assessed by the other indicators, so does not need to be further discussed. The amount of scenarios should be sufficient and can be objectively measured. The amount of scenarios necessary depends on the case and the preferences of the decision maker. The preferred amount of scenarios may increase when uncertainties about possible events rises, but may decrease when scenarios become more complex. Rietman stated, "A limited set of possible scenarios can be explicitly asked for by the public safety district." (Interview with B. Rietman). Ketelaars mentioned the recent use of three scenarios, "least worst, most probable and worst case scenarios" (Interview with J. Ketelaars) as preferable by decision makers. In other cases, user interviews can indicate whether the amount of scenarios is satisfactory for decision making.

Level of detail

The Level of detail is interpreted as the required spatial and temporal grid. However, the spatial and temporal grid are inseparable from the significance and uncertainty levels in the model result. Therefore, this indicator also covers the known quantified uncertainty levels. This choice is supported by several interview participants who used multiple terms in replaceable context, for example, precise, accurate, uncertainty and detail. The term Level of detail is derived by the author, because the word detail seemed to suit most interview participants.

Six out of seventeen interview participants addressed the Level of detail as important. However, although most interview participants agreed that there is minimal level of required detail, some addressed there could also be too much detail. Wijnstra stated that "too much detail can have a negative influence on the decision making process." (Interview with A. Wijnstra). Leijen supports this, who recalled that, "there is a minimal level of required detail, but the amount of detail must have added value". (Interview with J. Leijen). The opinions about quantified uncertainty levels were also divided. Some addressed that decision makers only benefit from uncertainty levels that they fully understand. For example, Weijs and Van Ackooij addressed that, "they could cause a false sense of certainty." (Interview with Weijs and Van Ackooij). However, others addressed that decision makers regularly ask for quantified uncertainty levels, as Kers stated, "decision makers explicitly ask for quantified uncertainty levels." (Interview with W. Kers).

Spatial and temporal grids are objectively measureable in their natural units. The required detail strongly depends on the specific policy question and may possibly be determined by a combination of both expert elicitation and user interviews. For example, regarding the spatial grid, Gooijer mentioned, "a polder that was about to flood, due to a dike that was about to collapse. In that polder there were a few farms of which we suspected to be on higher ground. However, the spatial grid of the flood model was too large, so the bottom height around the farm was averaged to a scale in which the farms would flood. Only later it appeared that the farm actually did lie on higher ground." (Interview with J. Gooijer). Considering the temporal grid, one could suggest the temporal grid should fit the order of minutes in which flooding of an area may occur. However, it should also be possible to make calculations for a larger period of time. It might take a few days for water to fully spread in large areas. Regarding quantified uncertainty levels, it may necessary to explore the interpretation of these in flood calamity exercises for them to be of use to decision makers.

External consistency

External consistency is the similarity of the model results to results of other similar techniques available. A new flood model may give significantly different results than the one previously used, which can cause the model users to distrust the flood model. The term External consistency is an interpretation by the author of the example of Acceptability "compatibility with existing institutions and processes" given by Covello and Merkhofer (1994).

Only one of the seventeen interview participants explicitly addressed the importance of External consistency. Haddink stated that, "the decision making process is frustrated when advice based on new insights strongly differ from previous advice." (Interview with E. Haddink). Although only one interview participant explicitly mentioned this, there are also other signs this could be an important indicator. For example, during the second workshop observed, one of the policy makers in spatial planning stated that it would be unacceptable if fresh insights would cause a different advice regarding the decision to make.

The amount of deviation required for model users to distrust the flood model is to be considered subjective. The method of user interviews is suitable to determine the accepted deviation, combined with the possibility to increase Acceptability by explaining differences. Possibly regular exercises in which the flood model is a positive contribution may gradually increase the acceptance of lack of External consistency.

Understanding of model structure

Understanding of model structure is the knowledge model users have about the underlying relations in the flood model used to represent reality. It covers both the knowledge of which relations are present as the understanding how these relations influence the model result. Model users that have understanding of the model structure are considered to better accept model results as basis for decision making. The term Understanding of model structure is derived by the author, the importance of model structure and the term itself is based on work of Brugnach et al. (2008).

Four out of seventeen interview participants addressed Understanding of model structure as important. The number of interview participants who addressed Understanding of model structure as important is limited, since most addressed only understanding of model result as important. However, some clearly stated the importance of knowledge of the system. As Van Dijk states, “understanding of the complex reality is a real challenge, especially for non-experts. Models can support in this.” (Interview with W. Van Dijk). Others addressed that it is probably unrealistic to expect non-experts to have extensive model knowledge.

To measure Understanding of model structure the method of user interviews can be used. One way may be to use questions to verify whether the message is understood. This is also suggested by Van der Leij, “returning questions to the decision makers is an important technique to verify if information is understood.” (Interview with H. van der Leij). Important is to consider whether model users have technical knowledge about the topic in reality, since this increases the ability to understand the model structure. Whether participatory processes are used to increase Understanding of model structure can be objectively measured. As Van der Leij mentions, “The system should be understood in advance, which can be obtained by long and intensive cooperation.” (Interview with H. van der Leij). Also Kers supported this, who stated that “currently much attention is paid to training and exercises, to give non-experts knowledge about the system.” (Interview with W. Kers).

Understanding of model uncertainties

Understanding of model uncertainties implies the possibility of model users to qualitatively assess the uncertainties possibly present in the flood model. It covers knowledge of model users concerning which uncertainties may be present and in what order of magnitude their effect is. Understanding of model uncertainties is important for making decisions based on uncertain information. The term Understanding of model uncertainties is in literature widely addressed as important for model use in policy questions, see for example Brugnach et al. (2007) or Walker et al. (2003).

Eight out of seventeen interview participants addressed the Understanding of model uncertainties as important. It is addressed by multiple interview participants that qualitative Understanding of model uncertainties is more important than quantifying them in for example statistical bandwidths. Gooijer states that, “it is in first place important to identify what uncertainties may be present” (Interview with J. Gooijer) and Verbraak mentions that, “always should be considered the possibilities of uncertainties that remain completely unknown”. (Interview with G. Verbraak).

Similar to Understanding of model structure, Understanding of model uncertainties can be measured by the method of user interviews. Questions to model users can be used to verify if uncertainties are understood. A first step could be to consider if the model users know which uncertainties might be present in the model. It is also important determine if model users know the order of magnitude of the uncertainties. Most important is the handling of uncertainties in real situations. Van Loon stated that in current practice, “when there is any uncertainty presented to decision makers, the decision made will be on the safe side.” (Interview with A. van Loon). Expert elicitation can be used to evaluate decisions to decide if uncertainties are correctly assessed by decision makers.

Confidence in model operators

Confidence in model operators describes whether non-expert model users and decision makers have confidence in the expertise of the model operators. If the decision maker trusts the model operators, the model results will be faster accepted in the decision making process. The term Confidence in model operators is derived by the author, based on multiple interview participants who addressed that it is necessary to blindly trust model operators during a flood calamity.

Seven out of seventeen interview participants addressed the Confidence in model operators as important. Although this is quite unusual in integrated water management, multiple interview participants addressed that during a calamity there needs to be a high level of trust between the professionals. Dragt even stated that, “advices of technical experts are mostly directly followed in the decision making process.” (Interview with J. Dragt). This is confirmed by Verbraak, who stated that, “during flood calamities it is vital for fast decision making that advices from model operators can be blindly trusted by the decision makers.”(Interview with G. Verbraak).

To measure Confidence in model operators it is important to consider the trust of the decision maker in following up advice from the model operator. A method of user interviews may be suitable to determine this. A considerable factor in confidence is the training and experience of the model operator. Proper training and regular exercises, involving both the model operators and the decision makers, can be assumed necessary and can be objectively measured. By doing this, the positive experiences by the decision maker with the model operator increases.

Credit

Credit is the strength of the reputation a flood model has built up by earlier successful uses. For decision makers to accept a flood model it is important that the model has proven itself in other similar applications. The term Credit is derived by the author from the example of Acceptability “User confidence, familiarity and experience with the method” by Covello and Merkhofer (1994), based on interview results.

Four out of seventeen addressed Credit as an important indicator. As Siebring confirms, “current models are quickly accepted in practical situations, but users are suspicious about newly introduced models.” (Interview with A. Siebring). When a flood model has little Credit, little has to go wrong for confidence to disappear. For example, Dragt mentioned that, “an IT system that appears to react slowly on crucial moments can really frustrate the decision making process.” (Interview with J. Dragt).

User interviews can be used to determine if model users have positive experiences with the flood model. Distrust in a model probably appears quickly through the personal opinion of the decision maker. Also, in exercises the Credit can be measured by user interviews, since the decision maker’s response to advice of model results may indicate the Credit of the model. It is important to consider that new models need to prove they are suitable, especially when they differ strongly from older models. It seems inevitable that this requires time and practice.

Required time

The Required time describes the amount of time required to use the flood model. This is usually considered to mostly consist of model run time. However, this appeared to be misstated. As multiple interview participants stated, it is the total time that matters. As Van Loon summarizes, “Not only the calculation time, but also the time to process new input for the model and to process the model output is important.” (Interview with A. van Loon). In addition, Rietman mentioned that, “for complex information, there should also be time reserved to interpret the model results, so it is too late to hand them over at the start of a meeting.” (Interview with B. Rietman). The term Required time is based on the example of Covello for Practicality, “Time required to apply technique” (Covello & Merkhofer, 1994).

Eleven out of seventeen interview participants addressed the Required time as important. All the interview participants recalled that the available amount of time is fixed during a calamity, so this indicator could be considered as a boundary condition. Leijen addressed that, “the available amount of time depended on the agreed meeting schedule.” (Interview with J. Leijen). Some interview participants emphasized the Required time for post processing. Post processing time appears to be underestimated, while information that is not fully processed on time is simply not used. Wijnstra mentioned an example, “in which the printer was still running on the moment the information was required in a meeting, making all effort useless.” (Interview with A. Wijnstra).

Objective measurement of Required time is possible, since time can directly be measured in seconds. The meeting schedules could possibly indicate the time in which a flood model could be used. In determining required and available time, one should consider that all actions in the use of models should fit in these. Although the meeting schedule may vary, one could say the allowed time is in the order of magnitude of ten to thirty minutes. However, Van Dijk mentions that, “there is a good chance that during a real calamity the decision maker does not allow time for calculations, but directly wants to make the decision based on the available information at hand.” (Interview with W. van Dijk). This is confirmed by the statements of other interview participants, that in decision making processes during the operational phase of flood calamity management decisions are easily made based on common sense instead of model information. Therefore, it is advised to also conduct user interviews to verify if the available time to use the model is accepted to be used.

Functionalities

Functionality considers the possibilities in changing flood model parameters, regarding both the amount of parameters that actually can be changed and the ease of doing this. Examples of this could be parameters of breaches, dikes, weirs or friction coefficients. It differs from the Completeness of components that it considers adaptability of already present model components. The term Functionalities is derived by the author, based on interview participants who addressed the importance of adjustability of a flood model.

Seven out of seventeen interview participants addressed Functionalities as important. Suggestions indicate that this might related to specific parts of a model that not could be modified on crucial moments. Also, as Van Loon addressed, “models should always be adaptable for corrections in components that appear to function wrong.” (Interview with A. Van Loon). Siebring also indicated the importance of adjustable parameters, but also addressed that, “many functionalities for overriding stock parameters may complicate the usage and interpretation of the model.” (Interview with A. Siebring). It seems assumable that the increase in Functionalities leads to a complication in model operation. Van Dijk also recognizes this problem and addressed as a solution that, “integration of calamity systems into the daily activities, would significantly improve the use of them in flood calamity management.” (Interview with W. Van Dijk).

To measure Functionalities, one should explore which are required in the first place. A method regarding user interviews may provide a good start and the possible policy questions during a flood calamity may give insight in this. Also, one can argue it is important that model operation does not become too complex. Regular testing of the model during development might show whether the model operation becomes too complex and expert elicitation may be well suitable for this. The argument by Van Dijk that model operating activities should be similar to daily activities seems an effort worth to try and can be objectively measured.

Pre-processing

Pre-processing contains all necessary operations on data and information before it can be used in the flood model. Examples of this could be, incorporating new field measurements in the model or loading a new bottom height map in the model. The term Pre-processing is derived by the author, based on a comment of a participant of the workshop ‘Beslissing Centraal’ (see appendix VI), who addressed the importance of both Pre-processing and Post-processing in flood model use in policy questions.

Four out of seventeen interview participants addressed Pre-processing as important. Most of them addressed a specific function to be important. For example, Dragt mentioned that, “telemetrically acquired real-time water levels should be included automatically.” (Interview with J. Dragt). Leijen however mentioned that, “The model should be able to use the format of our data files.” (Interview with J. Leijen). Van der Leij had another point of view and addressed the importance of, “the inclusion of meteorological predictions” (Interview with H. Van der Leij).

To measure the Pre-processing it is first important to consider which data and information should be included easy in the flood model. Probably the components of the model and the specific policy questions will determine the demand for Pre-processing. Some model information may be expected to be updated real-time, such as field measurements. Other information is probably not expected to be changed during model use, such as physical relations between 1D and 2D components. Expert elicitation can be used as a method to determine which Pre-processing is necessary. As addressed earlier, the Required time is an important indicator. Objectively measuring whether the Pre-processing is sufficient might be done based on the time required. As Wijnstra stated, “when extensive activities are required to use new information in a model, this may take too long to be useful in the fixed available amount of time in the decision making process.” (Interview with A. Wijnstra).

Post-processing

Post-processing are all activities that are necessary to transform raw flood model output data to information that is usable in the decision making process. This concerns data processing, but also interpretation of data and filtering of information. The indicator assess whether post-processing is sufficiently incorporated in the model, so information is directly usable. The term Post-processing is derived by the author, based on the same comment as Pre-processing of a participant of the workshop ‘Beslissing Centraal’ (see appendix VI), who addressed the importance.

Eight out of seventeen interview participants addressed the Post-processing as important. They also stated the risk of determining what is relevant from raw data. As confirmed by Van Loon, “transforming data to information requires interpretation and possibly a first step in decision what is relevant and what not." (Interview with A. Van Loon). The difficulty of this is confirmed by Leijen, who states that, "sometimes it appears only halfway in the decision making process which information is required." (Interview with J. Leijen).

Measuring Post-processing should consider how the information should look like when used in the decision making process and should be in a form that is preferable by decision makers. Therefore, the method of user interviews can be used to assess the indicator. Also, it may be generally assumed that the necessary operations after model Post-processing should be minimal. In model results is visual representation an important aspect. As Gooijer indicates, "the visual representation does not have to be fancy, but it should be very clear and understandable." (Interview with J. Gooijer). Also, the information should easily be combined with other sources of information. For example GIS specialists are currently used to create combined overview visualisations. Since a possible lack of knowledge of model users may make user interviews unsuitable for this aspect, expert elicitation may provide further possibilities for assessment.

Uniform framing

Uniform framing considers whether all related participants have the same overview of the situation and the available information. Uniformity in framing of the problem is important for constructively thinking about possible solutions. The term Uniform framing is derived by the author from the general term framing used in water management, see for example Janssen et al. (2010).

Six out of seventeen interview participants addressed Uniform framing as important. The general opinion was that it is vital to have the same overview of the situation at hand. As Van Loon mentioned, "the model result should be a uniform, direct applicable package of information that leaves no discussion of interpretation."(Interview with A. van Loon). Also Dragt confirmed the importance of Uniform framing, "The WAT is too busy to overview the complete situation, although it is important that they have the same overview of information as the other teams." (Interview with J. Dragt).

Since framing cannot be objectively measured and regards the view of models users, the method of user interviews is probably best suitable for assessment. Some symptoms contribute to the risk of non-uniform framing. For example, the use of technical jargon may be a barrier for non-experts. As Van Loon addressed, "the use of jargon is very tempting for experts, but disrupts the uniformity in understanding of the situation."(Interview with A. van Loon). User interviews are necessary to measure this. Currently, the uniformity of framing is being improved by the use of netcentric systems. It is important that all model users have the same information available and this can be objectively measured.

Understanding of model result

Understanding of flood model result implies a clear and unambiguous model result that requires no expert interpretation. The ideal situation is that model output can be directly used by non-experts in the decision making process, without any possible discussion about interpretation of the results.

Eleven out of seventeen interview participants explicitly addressed the understanding of the model result as important. All of the interview participants addressed that flood model information is useless if it not understandable what it means. They also mentioned a clear division of roles between the water board and the public safety district. For example, Van Loon stated that, "the water board has the expert role to assess the complex and complete situation, to summarize it into a clear and understandable overview for the public safety district." (Interview A. van Loon).

As with understanding of model structure and uncertainties, Understanding of model result can be measured by user interviews. The form of the model result should fit the preferences of the model user. A criterion could be that non-expert should understand the information. Currently, the large amount of information available appears often to be a bottleneck. Expert elicitation could be used to decide if the information is sufficiently concise. For example, Verbraak mentioned that, “information overflow is an important reason for lack of understanding.” (Interview with G. Verbraak). Importance of concision is confirmed by Wijnstekers, who addressed that, “a point wise summary is mostly sufficient” (Interview with G. Wijnstekers). However, multiple interview participants mentioned that is probably unrealistic to have a totally unambiguous model result. As Kers stated, “there is always an explanation required for the information provided to decision makers.” (Interview with W. Kers). Some interview participants stated that a single image and a short verbal explanation is the ideal form for understandable information.

Decision clarification

Decision clarification implies that there is no room for discussion about which decisions need to be made based on the flood model results. The ideal situation is that the model result makes unmistakably clear which decisions need to be made. The term Decision clarification is derived by the author, based on an example of Covello and Merkhofer (1994), “Usefulness of results”, and comments by interview participants that a flood model’s main purpose is to make clear which decision needs to be made.

Nine out of seventeen interview participants addressed Decision clarification as important. Although it seems trivial that model results should make clear which decisions need to be made, multiple interview participants addressed that in many cases technical information causes more questions than answers. Siebring stated that, “decision makers only want a single normative water level, so they can compare it to the water levels appointed in scripts and know what decisions to take.” (Interview with A. Siebring). This is also suggested by Gooijer, who mentioned that, “non-experts of the public safety district tending to ask ‘Can you guarantee the safety for hundred percent?’ to the experts of the water board.” (Interview with J. Gooijer).

The clarity of the decision to take strongly depends on the balancing of priorities of the decision maker, making user interviews the most suitable measurement method. Although it is important that there is a uniform priority distribution among decision makers, in reality this will mostly not be the case. Therefore, it should be important that multiple criteria could be tested using the model result. Expert elicitation can be used to determine if the model result can be used for integrated assessment. This also suggested by Weijs and Van Ackooij, who stated that “model results should provide a wide ranging cost benefit analysis, directly usable for decision makers.” (Interview with Weijs and Van Ackooij). User interviews can be used to indicate if it is clear what decisions need to be made.

Customizability presentation model result

Customizability of presentation of model result covers to possibility to adjust the presentation of the flood model result to the preferences of individual teams, since each network participants can have different preferences for information. The term is derived by the author, based on suggestions by interview participants that different roles of teams may lead to different requirements for information.

Four out of seventeen interview participants addressed the Customizability of presentation of model information as information. Weijs and Van Ackooij stated that, “each team has different responsibilities and thus different emphasis.” (Interview with Weijs and Van

Ackooij). To further specify this, Rietman stated that, “in principle, specialist can handle for details and nuances.” (Interview with B. Rietman).

Measuring Customizability of presentation of model results depends on the individuals and the policy question at hand. Therefore, user interviews are probably the most suitable measurement method. Model results could be customized for field teams, operational teams and strategic teams. As Gooijer stated, “the same information may be required in a different form in a team that operates on a field-, operational or strategic level.” (Interview with J. Gooijer). Case specific requirements of presentation of model results may be further identifiable through exercises.

Suitable for decision making culture

Suitable for decision making culture considers if the flood model fits in the culture of the decision making process. An example could be the use of model to answer a strategic question with an answer on a strategic level, and not with extensive technical model information. The term is derived by the author, based on suggestions by interview participants that the flood model is subordinate to the decision making process.

Three out of seventeen interview participants addressed the indicator as important. For example, Dragt stated that, “The WBT asks a general questions, such as ‘What is the status of the dikes?’ while the experts consider the situation more specific.” (Interview with J. Dragt). Another example is mentioned by Gooijer, who stated that, “The public safety district thinks from an absolute perspective, while experts at the water board more consider nuances of the system.” (Interview with J. Gooijer).

To determine if a flood model suits the decision making culture, knowledge about the calamity organization is required. The method of user interviews is probably the most suitable method to determine this, considering the decision making culture is mostly determined by the personal preferences of the decision makers. Probably practical situations are required to expose this. Flood calamity exercises in which realistic policy questions arise may learn about the suitability of the flood model for the decision making culture.

3.3.2 Relations between indicators

During the interviews two types of possible relations between indicators are recognized. The first type of relation is ranking, caused by a difference in importance between indicators. The second type of relation is a restriction between two specific indicators, called a trade-off.

Ranking of indicators by importance

During the interviews suggestions appeared that some indicators are more important than others. The indicators are divided into three groups, based on the number of participants that addressed a specific indicator as important. The three groups are boundary conditions, high priority indicators and low priority indicators and are described in this subsection.

The first group of indicators are the boundary conditions, consisting of the indicators Required time and Understanding of model result. Both indicators were addressed as important by eleven out of seventeen interview participants, making them the most frequently mentioned indicators. They seemed to act as boundary conditions on flood model use. The Required time is fully confined by the time available. For example, when a meeting is scheduled in thirty minutes, this is a fixed boundary condition for use of the flood model. In a single specific case, it will be probably possible to exactly determine the time available. Understanding of model result also appeared to be a boundary condition. If a decision maker does not understand the model result presented, it will not be used in the decision making process.

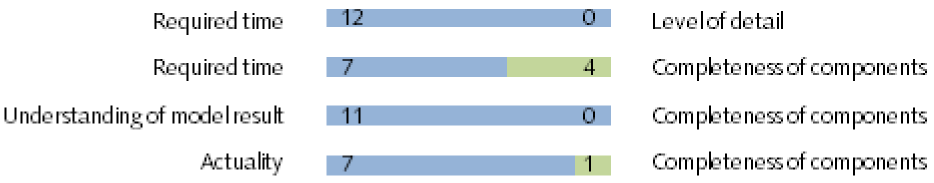
The second group of indicators are the high priority indicators. These are, Completeness of components, Decision clarification, Post-processing and Understanding of model uncertainties. Each indicator was addressed by eight or nine interview participants as important. The indicators have in common that they should be met on a high level for a flood model be of use in the decision making process. Without high quality presence of these indicators, the model would have little added value in the decision making process. The flood model and the results would be there, but probably wouldn't be used to make decisions based on.

The third group are low priority indicators and contains the other fourteen indicators. These are, Validity, Scenarios, Confidence in model operators, Functionalities, Actuality, Level of detail, Uniform framing, External consistency, Suitable for decision making culture, Completeness of elements, Understanding of model structure, Credit and Pre-processing. They are addressed by seven or less interview participants as important. Although they are marked as low priority indicators, it is important to consider that these are still important indicators for flood model use. Each of these indicators contributes to the use of flood models in operational phase of flood calamity management. However, in contrast with the high priority indicators, an individual low priority indicator is not vital for the use of flood models. For example, Validity is important, but of limited importance for model use. Parts of the flood model may not be valid, but especially when it is known what is valid and what is not, this does not have to exclude the model from the decision making process. Another example is the Level of detail. In many cases there is probably no high Level of detail necessary, but will an estimation of the order of magnitude of the effect satisfy.

Trade-offs between two indicators

During the interviews restrictions between indicators were recognized. These are called trade-offs. Four concrete trade-offs were recognized. There are two conditions recognized for a trade-off to exist between two indicators. The first condition is high ranking of the indicators. Three of the four identified trade-offs have at least one indicator marked as boundary condition, while the remaining trade-off contains a high priority indicator. High ranking of indicators implies they are very important for flood model use in the operational phase of flood calamity management. Little compromises can be made regarding these indicators. The second condition is that both indicators are inversely proportional. Satisfying one indicator naturally causes restrictions on the other indicator. For example, more components integrated in a model inevitably causes the time required to increase.

Four recurring conflicts are identified as concrete trade-offs between two indicators. From the moment a concrete trade-off was identified, the interview participants of the next interviews were asked to choose which of the two indicators they found more important. These results are summarized in figure 3-3, each concrete trade-off is explained below.



3-3: The concrete trade-offs between indicators identified in the interviews. The number indicates the amount of interview participants that chose a specific indicator as most important.

Required time – Level of detail

Level of detail is strongly connected to the Required time. A higher Level of detail requires more calculations and thus more computational time. The indicator Required time can be identified as a boundary condition. All participants addressed that the available amount of time during a flood calamity is fixed, due to meeting schedules predefined in flood calamity plans. The Level of detail depends on the time available to make a model run. Also, most participants mentioned they would prefer a quick and dirty calculation over a detailed assessment in most situations.

Required time – Completeness of components

An increased number of components of a flood model increases the computational time of the model, since simply more calculations need to be made. The respondents had diverged opinions concerning this trade-off. Most respondents mentioned that the Required time also in this situation acted as a boundary condition. However, the Completeness of components in the model was also mentioned as crucial. They mentioned that components necessary to answer specific questions should be present, otherwise the model would be useless. As some interview participants mentioned, one could consider the Completeness of components also as a high priority indicator.

Understanding of model result – Completeness of components

The more components a flood model consists of, the more complex and harder to understand the result of the model becomes. All interview participants addressed the importance of both understanding the model result and the Completeness of components of the flood model. They mentioned it is a hard choice since both are very important. However, all participants eventually choose for understanding the model result as most important. Multiple interview respondents mentioned a difference for this trade-off within the calamity organization. They identified understanding of the model result as most important indicator for the general chain in this trade-off, since they need to make decisions while they have no expert knowledge. On the other hand, the functional chain has an advisory role for the general chain and needs to consider the calamity in its complete complexity. For the functional chain the Completeness of components is addressed as the most important indicator in this trade-off.

Actuality – Completeness of components

More components in flood models implies that more input data is required to run the model. The more information is required to run a model, the more information needs to kept up-to-date. This trade-off was for some participants hard to make. The problem is the usability of the flood model when it is not up-to-date or complete. Both are considered as important, but it is the effect on the model result which determines which indicator is most important in this trade-off. Most interview participants reasoned that outdated data is unusable and thus chose for Actuality as the most important indicator in this trade-off.

3.3.3 Method for assessment of flood model use

A method for assessing flood model use in the operational phase of flood calamity management is made, based on the indicators and suggestions for measurement methods in sub paragraph 3.3.1. The result is a list containing one or more questions for each indicator that need to be answered affirmatively to satisfy the indicator. The required measurement method for each question is marked. The list can be found in table 3-4.

Table 3-4: List for assessing the use of flood models in the operational phase of flood calamity management. Each indicator can be assessed by answering the questions presented. For each question a measurement method is suggested.

Indicators	**Objective measurement**	**Expert elicitation**	**User interviews**	
Logical soundness				
Actuality	X			› Is known how old the data is?
		X		› Is the data sufficiently recent to be useful?
Validity	X			› Can the model be validated by control calculations?
		X		› Is it assumable that most uncertainties in the model are known?
Completeness				
Completeness of elements	X			› Is the model insensitive to possibly missing elements?
		X		› Are the necessary elements present in the model?
Completeness of components			X	› Are the components required for the tasks and responsibilities of the model user present in the model?
Scenarios			X	› Is the amount of scenarios satisfactory for decision making?
Accuracy				
Level of detail		X		› Have both the spatial grid and the temporal grid enough detail to base conclusions on?
			X	› Is the amount of detail in the spatial grid and the temporal grid satisfactory for decision making?
Acceptability				
External consistency			X	› Do model users accept deviations in model results compared to other techniques?
Understanding of model structure ›	X			› Did both experts and model users participate in model development and training for model usage?
			X	› Do model users understand the relations in the model to represent reality?
Understanding of model uncertainties		X		› Do decisions made during exercises indicate that model users correctly assess uncertainties?
			X	› Do the model users understand which uncertainties are present in the model and their order of magnitude?
Confidence in model operators	X			› Have the model users positive experiences with the model operators?

	X			› Are the model operators qualified and regularly trained?
			X	› Do the decision makers blindly trust the advice of model operators?
Credit			X	› Have the model users positive experiences with the model?
Practicability				
Required time	X			› Is the total time required to use the model sufficiently small to fit the meeting schedules of the calamity organization?
			X	› Do the model users accept the time required to use the model?
Functionalities	X			› Are model operating activities similar to daily activities?
		X		› Is model operation not too complex?
			X	› Are functionalities necessary to answer the relevant policy questions present in the model?
Pre-processing	X			› Can the model automatically be updated with field measurements?
		X		› Can newly available input data in little time be inserted in the model?
Post-processing		X		› Gives the model result a comprehensible overview of relevant information?
			X	› Are no operations necessary to use the model result after post-processing?
			X	› Is the form of the model result preferred by decision makers?
Effectiveness				
Uniform framing	X			› Is the same information available to all model users?
			X	› Do all model users interpret the model results the same?
			X	› Is there no incomprehensible technical jargon used?
Understanding of model result		X		› Is the model result concise and is there no risk of information overflow?
			X	› Do the model users understand the model result?
Decision clarification		X		› Can the model result be used for integrated assessment?
			X	› Is the model result for decision makers clear in the decisions need to be made?
Customizability presentation model result			X	› Can the presentation of the model result be customized to the model users' preferences?
Suitable for decision making culture			X	› Is the approach the model uses to support decision making suitable for the decision making culture?

3.4 How can the representativeness of the indicators for a real flood calamity be verified?

This paragraph contains the result of research question four, describing the summary of results from the observation and questionnaire during the flood calamity exercise. The research question is answered by answering four sub questions, each discussed in individual subparagraphs.

- Which of the identified indicators are observed during the flood calamity exercise?
- What trade-offs between indicators are observed during the flood calamity exercise?
- How do the participants of the flood calamity exercise valuate the 3Di flood model use using the identified set of indicators?
- How do the participants of the flood calamity exercise valuate the four identified trade-offs?

3.4.1 Observed indicators during flood calamity exercise

During the flood calamity exercise observations are made to recognize the twenty indicators in a realistic case. The results of this observation are presented in figure 3-5. The red bar indicates the amount of people that addressed an indicator. The green bar adds the amount of people who addressed an indicator as a bottleneck in the decision making process. The blue bar indicates the total absolute number of remarks made about an indicator.

All indicators where recognized during the flood calamity exercise, except for Actuality. During the exercise no one asked if the information was possibly outdated. A possible explanation for this may be that the confidence decision makers had in the model operators made them trust the model data not to be outdated.

Another notable observation is the emphasis on Scenarios. This can be explained by the form in which model information is preferred by decision makers. In the practical situation of operational flood calamity management constantly is thought about possible scenarios. The fact that scenarios play a fundamental role in the required form of information may the reason Scenarios are strongly emphasized.

Functionalities were also considered to be very important by the exercise participants. This is probably due to the fact it was the first time the flood model was used in a flood calamity exercise. Therefore, the possibilities where not clear, which repeatedly raised questions.

The importance of Pre-processing may also be related to this. Multiple times questions rose which new information could be implemented in the model. The cooperation between the model information and other information seemed to be important. An example that was frequently mentioned was the inclusion of precipitation data.

Remarkable was the importance of Uniform framing. In the first stage of the flood calamity exercise there was much attention for generating an overview image of the situation. Therefore, there was a lot of effort put into generating an Uniform framing using different sources of information.

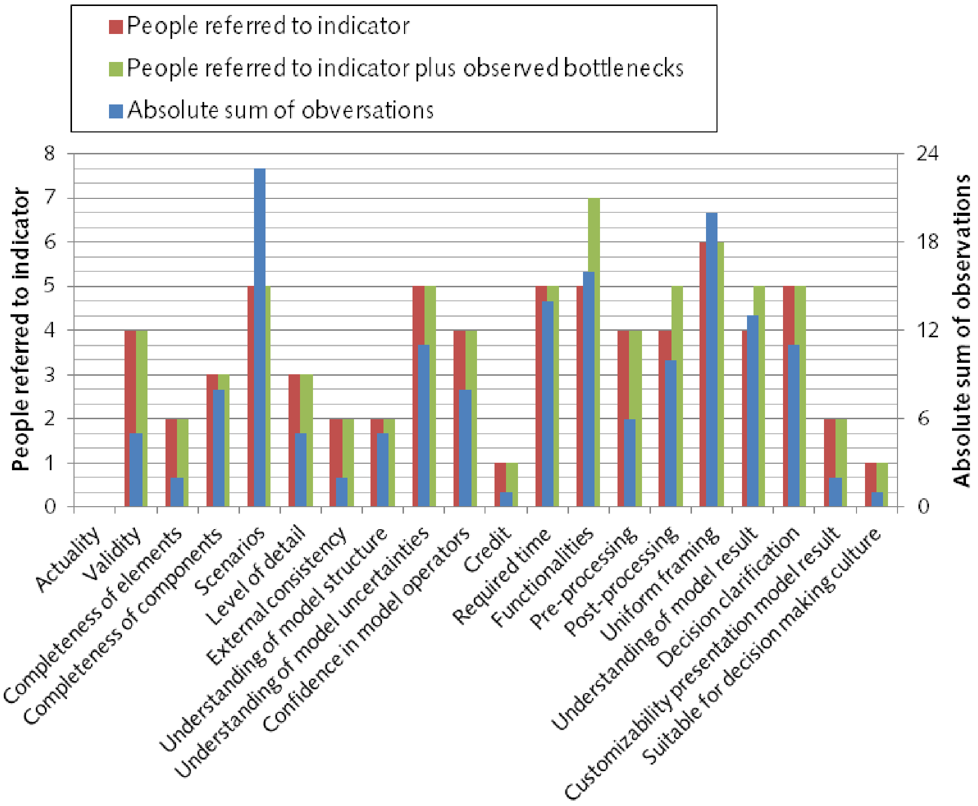


Figure 3-5: The indicators observed during the flood calamity exercise on 14 November 2012.

3.4.2 Observed trade-offs during flood calamity exercise

During the flood calamity exercise also trade-offs were observed. The trade-offs were not explicitly mentioned, so it required interpretation by the observer to recognize the trade-off. Each trade-off was only discussed once. This is because they appeared during short discussions between two or more persons, which then found a pragmatic solution so the trade-off would not appear again. The trade-offs recognized are presented in table 3-6. The indicator in the left column got the highest priority assigned.

Table 3-6: The trade-offs between indicators observed during the flood calamity exercise on 14 November 2012.

Highest priority indicator		**Lowest priority indicator**
Required time	–	Scenarios
Required time	–	Functionalities
Required time	–	Post-processing
Functionalities	–	Completeness of elements
Functionalities	–	Completeness of components
Functionalities	–	Post-processing
Understanding of model result	–	Completeness of components
Understanding of model result	–	Level of detail

More trade-offs were identified during the verification than during the interviews held. A reason for this could be that the indicators were not known during the interviews, so trade-offs were harder to identify. Another reason could be that the trade-offs arise from practical situations. For example, the Required time puts constraints on the Functionalities that could be used to generate the preferable model result.

It is remarkable that seven out of eight trade-offs contain one or two indicators from the six indicators that are qualified as boundary conditions or high priority indicators. This can be explained by the fact the boundary conditions and high priority indicators are considered to be very important and therefore can minimally be compromised. Two of those indicators that conflict may form directly an impasse, while low priority indicators might more easily be neglected.

3.4.3 Valuation of indicators by participants of the flood calamity exercise

After the flood calamity exercise participants were asked to value each indicator based on the use of the 3Di flood model during the flood calamity. This provided a test case in which indicators are used to assess the use of model based tools during the operational phase of flood calamity management. The results of this can be found in table 3-7.

The test case showed that the flood calamity exercise participants are overall content with the use of the flood model. Many indicators are by many participants valued with grade eight. However, a few marks stand out.

A few individuals marked an indicator as insufficient. One individual marked the Understanding of model uncertainties with a four. This might be explainable, due to the fact uncertainties were not explicitly discussed. However, since only one person addressed Understanding of model uncertainties is insufficient, this is assumed to be insignificant to base conclusions on. Two out of six interview participants that graded the Decision clarification marked it unsatisfactory, with respectively a three and a five. This implies that they suggest the model result didn't made clear which decisions need to be made. A comment that was made stated that the influence of the flood model on the decision making process was not recognizable.

Remarkable was seven indicators were not valued at all by at least the half of the people who made the questionnaire. Although it is hard the base conclusions on this, one could say there is little conscious of aspects regarding the use of a flood model. This makes clear that the results from the questionnaire should be interpreted with caution.

Table 3-7: The results of the questionnaire held at the end of the flood calamity exercise. The valuation of indicators regarding the use of the 3Di flood model in the flood calamity exercise by the participants. The participants A to H gave a score from 1 to 10 for each indicator, or no score when they could not valuate the indicator.

Indicator	Ave.	Std.	A	B	C	D	E	F	G	H
Actuality	7,8	0,41	8	8	8		8	7	8	
Validity	7,6	0,79	8	8	8	8	6		8	7
Completeness of elements	7,4	0,89	8		8	8	6			7
Completeness of components	7,5	0,71		8		7				
Scenarios	8	1,15	7	8	8	7		7	9	10
Level of detail	8,4	1,51	6		9	8	10	7	9	10
External consistency	7,8	0,5		8	8	8		7		
Understanding of model structure	7	1	7	8			6			
Understanding of model uncertainties	6,5	1,91		8		8	6	4		
Confidence in operators	9,1	0,99	8	10	8	10	10	8	9	10
Credit	8,2	0,45		8	8	8			8	9
Required time	7,9	0,64	7	8	8	9	8	7	8	8
Functionalities	7,4	0,89		7	8		8		8	6
Pre-processing	7,5	1,29				8	7	6		9
Post-processing	7	1		8		8	6	7	6	
Uniform framing	8	0,82		8		8			7	9
Understanding of result	8	0,53	7	8	8	9	8	8	8	8
Decision clarification	6,8	2,4	7			9	8	3	5	9
Customizability presentation result	7	0					7		7	7
Suitable for decision making culture	7,7	0,82	7			9	8	7	7	8

3.4.4 Valuation of trade-offs by participants of the flood calamity exercise

The respondents to the questionnaire were also asked to chose between the two indicators from the four identified trade-offs in the interview. For this purpose, a case was created similar to the flood calamity exercise. A concrete example of the use of a flood model in case of a possible dike breach was presented as a reference. The respondents were asked to choose which of the indicators is most necessary to be improved in further development of the flood model. The results can be found in figure 3-8.

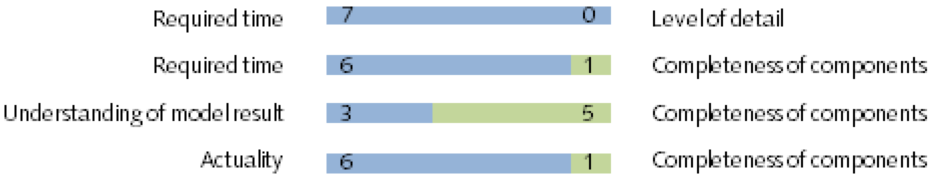


Figure 3-8: Results of questionnaire held at the end of the flood calamity exercise. Valuation of the four trade-offs by participants of flood calamity exercise. The numbers indicate the amount of participants that chose one of the two conflicting indicators.

Three of the trade-offs were made the same as during the interview. However, the trade-off between understanding of model result and Completeness of components was made differently. This is probably a case specific result. One might suggest that the 3Di flood model result was apparently quite understandable in the way it is used during the flood calamity exercise. Otherwise it is also possible that the Completeness of components of the model seriously flawed.

4 Discussion

This chapter contains the discussion of the research. It reviews the meaning of the research and its results in a broader context. The first paragraph discusses the chosen scope of the research. The second paragraph discusses the framework that is used. The third paragraph discusses the research methods used for each of the research questions.

4.1 Research scope

4.1.1 Decision making process

The scope of the research regarding the decision making process in the operational phase of flood calamity management is narrowed to the technical advisory role of the Water board Operational Team to decisions made in Water boar Policy Team and Regional Operational Team. One could argue widening the scope to include decision making processes in all teams of the calamity organization (see figure 3-1). Another possibility is to narrow the scope to one team in the calamity organization or one specific decision making topic.

The chosen scope regarding the decision making process fits the available time and resources for this master thesis. Also, exploring the decision making process during the operational phase of flood calamity management is an objective in this research. To focus on the WOT appeared to be a good choice, since it is the team that most frequently translates the technical information for use by non-technical decision makers.

4.1.2 Perspective of the water board

The research is conducted from the perspective of the water boards. The analyzed calamity plans and evaluation reports are written by professionals of the water board, the interview participants are employees of water boards and the national flood calamity exercise is attended at Hoogheemraadschap Delfland. The public safety district also has an important role during flood calamities, because they are the leading authority. Research from the perspective of the public safety district may give different results, possibly because of their limited specific technical knowledge. It is also possible they focus more on the use of the model results in the decision making process than the flood model itself.

Including the perspective of the public safety district would not fit the available time and resources for this master thesis. Also, in the perspective of the public safety district the flood models would still be operated by experts from the water board. Since the experts from the water board currently have trouble using flood models in the operational phase of flood calamity management, the perspective of the water board is more suitable for this research.

4.1.3 Generic approach

In general, other case specific characteristics may influence the requirements for flood model information. For example, the decision making process is different when considering a dike breach of a small ring canal or a large river. Other examples, such as the Amsterdam Internet Exchange in the Watergraafsmeer, could concern important infrastructure at risk.

The goal of this study is to create generally applicable indicators, not specific for one case. This may limit the direct applicability of the method in a specific case.

4.2 Research framework

The framework of Covello and Merkhofer (1994) is used to structure this research. This has led to a clearer and complete result, but may also have led to a bias in the results.

The framework is useful for revealing indicators that otherwise may have remained undiscovered. For example, the indicator Actuality was only mentioned by a few interview participants. However, many interview participants confirmed the importance of Actuality in the trade-off with Completeness of components. The framework may have limited the scope in the search for indicators, possibly resulting in exclusion of indicators. However, the framework is mostly used to concretize discovered aspects into indicators. Therefore, the influence on the actual content is considered to be minimal. Also, no severe mismatches or limitations in using the framework of Covello and Merkhofer (1994) have appeared throughout the research.

The framework has also proven to be of use in unravelling the aspects, since some encountered aspects were vague or ambiguous. An example of this is the term confidence, which appeared numerous times in the research. The term confidence is reviewed from the perspective of each of the categories. The meaning of confidence for a specific category is then represented into one or more indicators. Thus, confidence is ensured by one or more indicators in multiple categories. Using other categories may have led to other indicators. Still, there were no terms that could not be properly divided into the six categories of Covello and Merkhofer (1994).

The distribution of the indicators among the categories seems balanced, although it is noticeable that fourteen out of twenty indicators are in the three external categories. A possible explanation could be the method of interviewing experts in model usage. External categories are focused on model application, so they are likely to be more emphasized by model users. Research focussed on model developers would have a more rational character and may stronger emphasize internal indicators.

4.3 Research method

4.3.1 What is the decision making context of flood calamity management in use of technical information?

To answer the first research question, relevant aspects are characterised regarding the use of technical information in the decision making process. This is based on the decision making process as described in flood calamity plans and by observations made at the workshop ‘Beslissing Centraal’.

The suitability of the calamity plans as research material for this purpose can be discussed. It is imaginable that the decision making process in a chaotic calamitous situation is different than planned. Also, describing the process based on literature also requires an interpretation of the researcher, possibly biasing the result. For example, to decide the extent of the decision making network. During a flood calamity on national scale there is also a National Operational Coordination Centre. On a small scale, it is arguable to include local contractors in the decision making network. Another example is the position of technical information in the flood calamity organization. This is interpreted based on the role descriptions of the participants in the teams.

Since it is not possible to observe the decision making process in reality, analyzing the calamity plans is a meaningful effort. This is confirmed by the contacted experts at the multiple water boards. Also, by using two research methods for methodological triangulation (Denzin, 2006), the bias in the result is assumed to be reduced.

4.3.2 What constraints in the use of technical information are encountered in practice?

In the second research question, practical constraints in the use of technical information are identified, based on the documented experiences in evaluation reports and observations made during the workshop ‘Vervolg Case study 3Di Waternet’.

Possibly not all encountered constraints are documented, which could have multiple reasons. For example, the complexity or political sensitivity of constraints could cause constraints to be omitted from reports. The lack of documented constraints is also suggested by the little attention for technical aspects in evaluation reports in the first place. The analyzed reports contained little reflection on the specific use of technical information. As in research question one, the method is sensitive to the interpretation by the researcher. This influences the subjects addressed as relevant. For example, evaluation reports emphasize the importance of communication of information. As a result the researcher identifies this as a relevant aspect. Otherwise, the validity the technical information is little considered in the evaluation reports. The researcher interprets that validity of technical information is probably no issue during the operational phase of flood management.

As argued in the previous subparagraph, it is not possible to make extensive observations of the decision making process. Therefore, analyzing the evaluation reports is a good effort to answer the research question. As in the case with the first research question, a second research method is used for methodological triangulation (Denzin, 2006), assumed to sufficiently reduce biasing of the results.

4.3.3 How can the constraints be represented in specific and measureable indicators?

To answer the third research question, a selection of seventeen professionals involved in the use of flood models in calamity management is interviewed. Since the selection is limited, they should sufficiently represent the total group of professionals. A wide range of participants is selected, from both technical and organizational backgrounds, in different positions in the calamity organization and with little and extensive experience. Therefore, the selection is diverse and is considered to be representative.

The selection of interviewed professionals did not contain any water board’s political spokesmen. This choice is supported by the interviewed professionals. They stated that the political spokesmen fully trust the advice of their highest officials for making operational decisions, since the spokesmen have no technical knowledge. It is not uncommon that they ask for full guaranteed safety. In many cases this is probably unrealistic and may imply that decisions are actually made by the officials who assess model information.

The selected professionals are a small fraction of all professionals that could be interviewed. Therefore, caution is required when interpreting the results. For example, if one out of seventeen interview participants makes a statement, this result may be insignificant and no conclusions should be based on the result. In that case, additional interviews are required to be able to draw conclusions considering the statement.

A part of the interviews contained implicit answers to the questions, which required interpretation by the researcher. Due to this, the results are influenced by the researcher’s own perspective. By using the framework of Covello and Merkhofer (1994) as a reference in the interpretation of the results, the influence of the researcher’s own perspective is considered to be reduced as much as possible.

Flood models are currently not used in the operational phase of flood calamity management, so the interview questions presented to the interview participants may be hypothetical. As a result, the interview participants tend to think about current model usage, which is in the preparatory phase. Therefore, there was not always a clear distinction between the use of flood models in the preparatory phase and the operational phase. The researcher had to critically analyze the context of the interview participants' answers.

The exploratory character of the interviews caused the style of the interviews to change throughout the research. The last interviews may be influenced by answers from the first interviews. This creates risk of steering answers of interview participants by the framing of the questions. This effect is considered negligible, since the base questions for the semi-structured interviews remained the same and no steering of answers was recognized when analyzing recorded interviews.

4.3.4 How can the representativeness of the indicators for a real flood calamity be verified?

In the fourth research question, the representativeness of the indicators for a real flood calamity is verified by observations made during the national flood calamity exercise the 14th of November at Hoogheemraadschap Delfland.

This method makes the results subjective to the personal interpretation of the researcher. The indicators were verified using a checklist with the identified indicators. Therefore, possible indicators that were not recognized in the interviews are not considered. For example, one of the participants of the calamity exercise mentioned in the questionnaire "technically linking to weather prediction models to the flood model" as an important necessary improvement to be made. Technical connections to other models is not included as an indicator, but the implications can be translated to the indicators Pre-processing and Post-processing, Completeness of components and Functionalities.

The purpose of the verification was to confirm the relevance of the indicators, not discovering new indicators. By concretely defining the indicators to be verified in advance, this was an executable exercise.

5 Conclusions and recommendations

This chapter contains the conclusions and recommendations based on the results of this research. The first paragraph contains the conclusions and the second paragraph contains the recommendations.

5.1 Conclusions

5.1.1 What is the decision making context of flood calamity management in use of technical information?

Operational decisions are made about measures against the causes of floods or measures against the effects of floods. Organizational decisions are made about the extent of the calamity organization.

Currently, there are differences in the calamity organization between the water boards. The Advies Commissie Crisisbeheersing (2012) aims to create a uniform decision making network for each water board. In the decision making network each team has its own tasks and responsibilities, and thus requirements for technical information.

The functional chain consists of teams of employees of the water board. The severity of the calamity determines scaling of the organization, structured by coordination phases in which the decision making network is increased with teams of higher officials. In a full scale calamity the hierarchy top-down consists of WBT, WOT, WAT and field teams.

The general chain operates parallel to the functional chain and consists of teams of general officials. The structure of the decision making network is similar to functional chain and scaling is structured by GRIP-levels. During a full scale calamity the general chain consists top-down of RBT or GBT, ROT and CoPI. In a calamity the general chain is the leading authority.

The decision making process is structured in the calamity plans. Water boards, public safety districts and national teams use different structures. Examples are BOB, PBOB or a custom 5-step structure (Taskforce Management Overstromingen, 2009b).

The calamity plans are written from an organizational perspective. Therefore, there is little attention for technical information. The organization of the use of technical information described in the plans is focused on the communication of information. There is little attention for the content of technical information. The plans describe a few experts in each team. The information manager has large influence on the use of technical information in the decision making process.

5.1.2 What constraints in the use of technical information are encountered in practice?

The basic information used in advices about decisions consists of water levels and flow speeds. These are used to makes predictions about possible events over time.

Currently a wide range of precalculated scenarios is used to predict the consequences of possible dike breaches. At some water boards scripts based on water levels are also used to make decisions about which measures to take. There is an increase in the use of netcentric information management systems. This is in conjunction with the emerging role of information manager, who manages the system. An important distinction is the difference between information for internal use, to inform network partners, and information for external use, for informing the public. Requirements of internal information differs per team.

A practical constraint in the use of technical information that is encountered is lack of overview of available information. This can be caused by an information overflow or because decision makers get lost in details. Another constraint is the strict time limit, because there is no time to create new scenarios and make calculations. Another constraint is the reliability of the information for making decisions. Decision makers request sufficient accuracy, detail and want uncertainties to be small and known.

However, decision makers often have trouble assessing uncertainties and do not know when to accept them. In general, they do not know what performances to expect from models. Another constraint encountered in practice is lack of uniformity of information. Decision makers also prefer to assess the entire policy question at hand, which requires integration of all kinds social and economic aspects in the flood model.

5.1.3 How can the constraints be represented in specific and measureable indicators?

The interviews with professionals from the water boards related to flood model usage has resulted in twenty indicators: six internal indicators and fourteen external indicators based on the framework of Covello and Merkhofer (1994). The overemphasis of external indicators is explainable, since in general the model users are more concerned with direct usefulness to ensure quick decision making. Experts tend to address every nuance and uncertainty in the model results to make a careful interpretation. Especially during a flood calamity, there is the necessity to both act quickly and take careful decisions. Together, the indicators provide a method for assessing the use of flood models in the operational phase in flood calamity management. The indicators are presented in table 5-1.

Concrete trade-offs between indicators were hardly ever recognized. The pairs of indicators that were identified as trade-offs during the interviews are presented below.

Some indicators are more important than others. Based on the results from the interviews the indicators are grouped in three categories: boundary conditions, high priority indicators and low priority indicators. The research indicated no relation between the importance of the indicator and the ability to measure them. The two indicators Required time and Understanding of model result are distinguished as boundary conditions, because it is absolutely necessary that they are achieved. The four indicators Completeness of components, Decision clarification, Post-processing and Understanding of model uncertainties are distinguished as high priority indicators. They need to be met on a high level for a flood model to be of value in decision making processes.

Table 5-1: Indicators for assessing the use of flood models in the operational phase of flood calamity management. * are indicators marked as boundary conditions. ** are indicators marked as high priority indicators.

Internal indicators	**External indicators**
Logical soundness	***Acceptability***
Actuality	External consistency
Validity	Understanding of model structure
Completeness	Understanding of model uncertainties **
Completeness of elements	Confidence in model operators
Completeness of components **	Credit
Scenarios	***Practicability***
Accuracy	Required time *
Level of detail	Functionalities
	Pre-processing
	Post-processing **
	Effectiveness
	Uniform framing
	Understanding of model result *
	Decision clarification **
	Customizability presentation model result
	Suitable for decision making culture

Table 5-2 Verified concrete trade-offs between two indicators recognized during the interviews.

Indicator 1		**Indicator 2**
Required time	–	Level of detail
Required time	–	Completeness of components
Understanding of model result	–	Completeness of components
Actuality	–	Completeness of components

5.1.4 How can the representativeness of the indicators for a real flood calamity be verified?

The verification supports the representativeness of the indicators for assessing the use of flood models in the operational phase of flood calamity management. The few differences in emphasis are most probably explained by the different contexts, since the verification was done during a realistic flood calamity exercise and the primary research in interviews was performed when there was no exercise.

The observed trade-offs partly match the identified trade-offs. The difference can be explained because the trade-offs observed during the flood calamity exercise mainly arose from practical constraints, concerning the possibilities of the specific flood model. Seven out of eight trade-offs identified during the flood calamity exercise contained boundary conditions or high priority indicators.

After the use of the 3Di flood model during the flood calamity exercise the involved professionals have completed a questionnaire to value the model usage. The only significant negative feedback concerned Decision clarification, indicating a perceived lack of flood model contribution to the decision making process. Assessing model use appeared difficult, since at least half of the respondents were not able to assess seven of the indicators.

The same professionals were asked to choose one of the indicators in the identified trade-offs. In three trade-offs the same important indicator was chosen as in the interviews. The trade-off between understanding of model result and Completeness of components was made different. As opposed to the primary research, in the verification the indicator Understanding of model result was addressed more importantly than Completeness of components.

5.2 Recommendations

- Use participatory processes in flood model development to fit the model to the organizational context and possible model users. It is not to be expected that the calamity organization adapts to a flood model, since the organization is based on the tasks and responsibilities during a calamity. Also, a significant amount of encountered constraints in use of technical information is caused by the organizational context. Furthermore, the importance of external aspects is suggested by the indicators. Not only are fourteen of the twenty indicators in an external category, also five of the six indicators that are marked as boundary condition or high priority indicator are in an external category.
- Use the indicators to assess flood model use in the operational phase of flood calamity management. The list with questions and corresponding types of measurement methods can be used to value each indicator. The indicators are based on the opinions of a wide range of experts, suggesting a complete coverage of both internal and external aspects. The developed method especially highlights external aspects that may be obscured when conventional model validation or verification techniques are used. Also, the identified indicators are verified to be representative for a real flood calamity during a national flood calamity exercise.
- If the available time or resources are limited, use only the six indicators marked as boundary conditions or high priority indicator to assess flood model use. Most interview participants addressed these indicators as important. Five of these six indicators are in external categories. Therefore, using these six indicators to assess flood model use can be a useful addition to a model that is considered to be internally sufficient.

5.2.1 Recommendations for further research

- Additional research to the restrictions between indicators is recommended. The restrictions recognized between two indicators, called trade-offs, are a first step identify restrictions in fulfilling indicators. Additional case studies may provide more knowledge on restrictions between indicators and possibilities to cope with them.
- Additional research on how to measure indicators is recommended. Three types of measurement methods are already suggested. However, to actually measure an indicator in a specific case a more concrete measurement plan is needed. Additional case studies may provide more detailed measurement plans for indicators.

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Glossary

Term	Description
BOB	Perception, Assessment, Decision
BOS	Decision Support System
CoPI	Command Incident Location
EDO	Worst Imaginable Flood (scenario)
GBT	Municipal Policy Team
LCMS	National Calamity Management System
LOCC	National Operational Coordination Centre
OL	Operational Leader
PBOB	Process, Perception, Assessment, Decision
RBT	Regional Policy Team
ROT	Regional Operational Team
Sitrap	Situation report
WAC	Water board Action Centre
WAT	Water board Action Team
WBT	Water board Policy Team
WOG	Water board Operational Support Team
WOT	Water board Operational Team

I INTERVIEW SCHEDULE

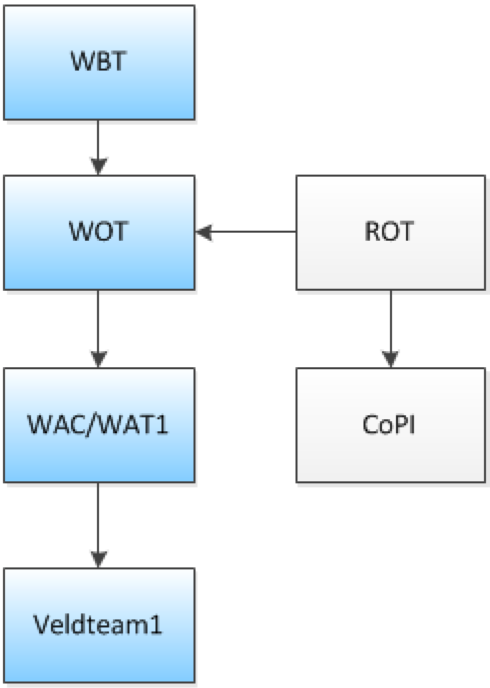
Duur: 1 uur

Het doel van het interview is de eisen te achterhalen die allerlei gebruikers van technische informatie in het besluitvormingsproces hieraan stellen en hoe ze trade-offs in deze eisen afwegen.

Opening
[Introductie van mijzelf en het onderzoek]

In kaart brengen persoon:

- Leeftijd: ……
- Opleiding: ………
- Functie (dagelijks): ……………………………………………………………………………………………………..
- Functie (calamiteit) : ……………………………………………………………………………………………………
- Relevante ervaring: ………………………………………………………………………………………..................
- Locatie in organisatie en rol beleid/techniek:



Deel 1: Eisen aan technische informatie

Vraag 1. *Volledig open vraag*

> ***"Wat zijn volgens u de belangrijkste eisen aan deze technische informatie?"***
> - Welke voorbeelden zijn er?
> - Waaruit blijkt dat?
> - Waarom is het niet anders?

Vraag 2: Voorbeeld door case en eisen [Hoogwater januari 2012]

> *"Welke* ***positieve punten*** *ervaart u en welke* ***negatieve punten*** *ervaart u?"*
> *"en welke zijn het belangrijkst om besluiten te kunnen nemen?"*
>
> Wat betreft de aspecten:
> - Volledigheid overzichtsbeeld
> - Begrijpbaarheid overzichtsbeeld
> - Detailniveau en accuraatheid
> - Rekensnelheid
> - Explicietheid onzekerheid
> - Besliszekerheid
> - Gebruiksgemak
> - Flexibiliteit
> - Uitgebreidheid
> - Beheersbaarheid database

NB1.: Bij vragen over inhoud van besluiten: Evacueren, afsluiten watergangen, compartimenteren
NB2.: In het geval van vooraf vastgestelde scenario's, wat is vooraf al besloten?

Deel 2: Identificeren trade-offs en beoordelen

Vraag 3: Welke trade-offs zijn er?

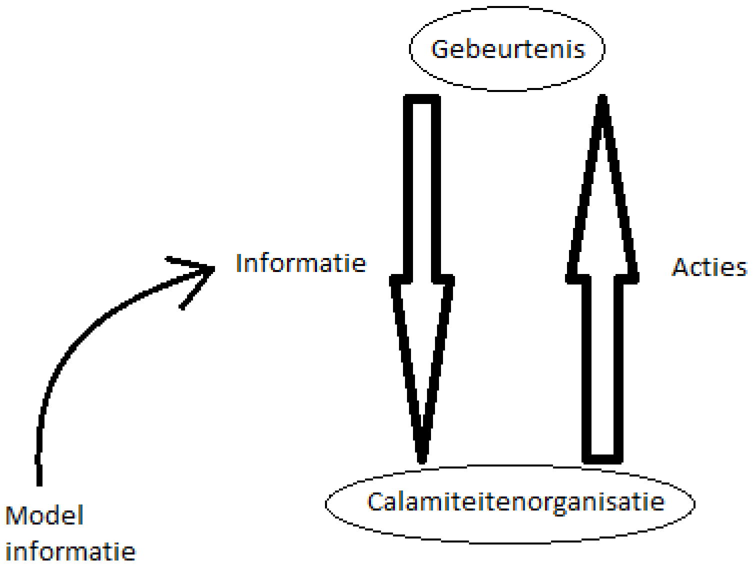
Vraag 4: Maken van trade-offs

1. Rekensnelheid ←→ Detail
2. Volledigheid ←→ Begrijpbaarheid
3. Volledigheid ←→ Actualiteit
4. Begrijpbaarheid ←→ Expliciteit onzekerheid
5. Rekensnelheid ←→ Expliciteit onzekerheid
6. Uitgebreidheid ←→ Overview
7. Rekensnelheid ←→ Volledigheid

Deel 3: Organisatorisch trade-off

Model	Gebeurtenis	Calamiteitenorganisatie
Gesimplificeerd	Complex	Gestructureerd
Tijd varieert in model	Chaotisch	Structuur star
Rationeel	Onvoorspelbaar	Rollen vastgelegd
	Real-time	Menselijk gedrag
	Uniek	

Vraag 4: *Welke trade-offs zijn er tussen: Eigenschappen organisatie ←→Eigenschappen technische informatie*



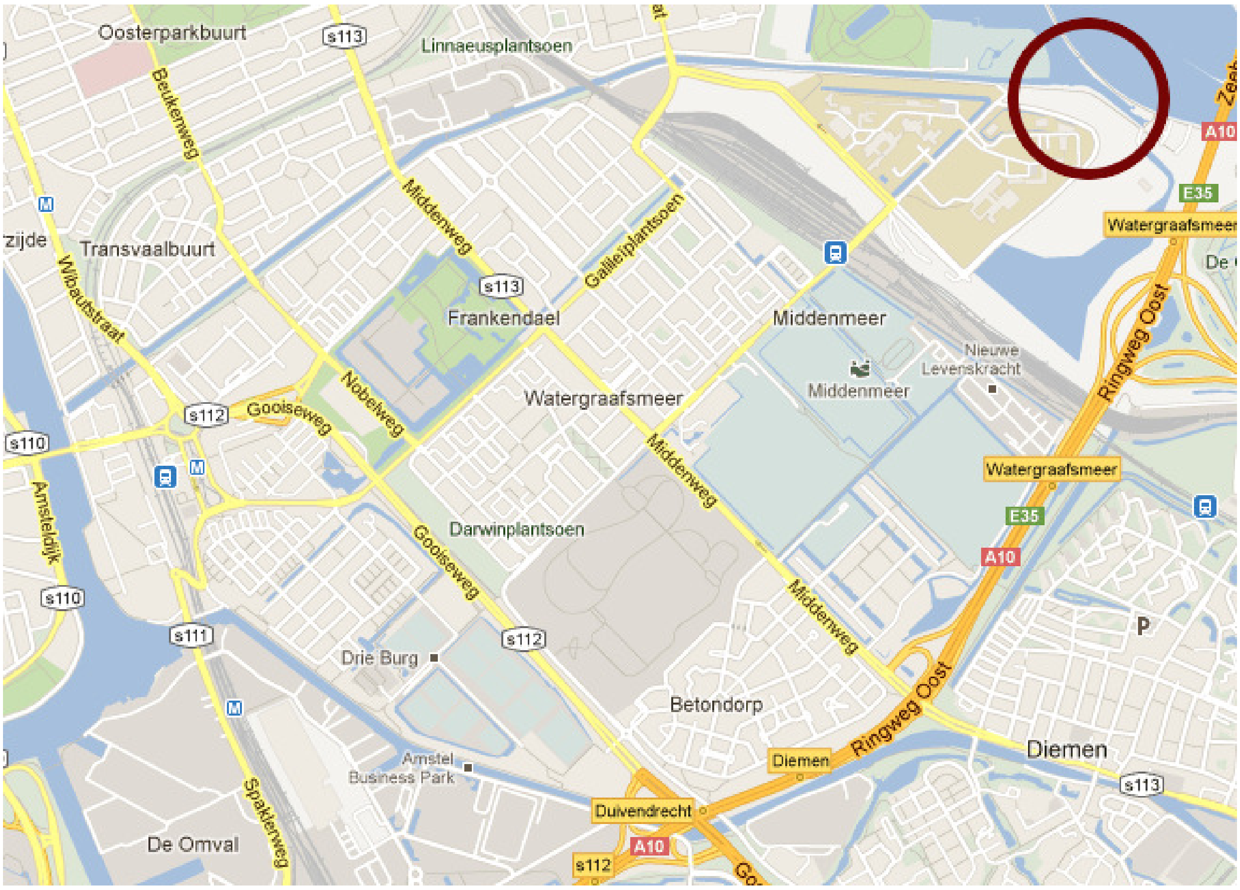
Vraag 5: *Aan welke eisen moet een 'Supermodel' voldoen?*
Vraag 6: *Veranderd dat dan de calamiteitenorganisatie en hoe?*
[gedreven door betere infovoorziening]

Optie 1: Geen verandering
Optie 2: Zelfde structuur, maar een enkele schakel verdwijnt
Optie 3: Ronde tafel idee
Optie 4: Samenvoegen met veiligheidsregio

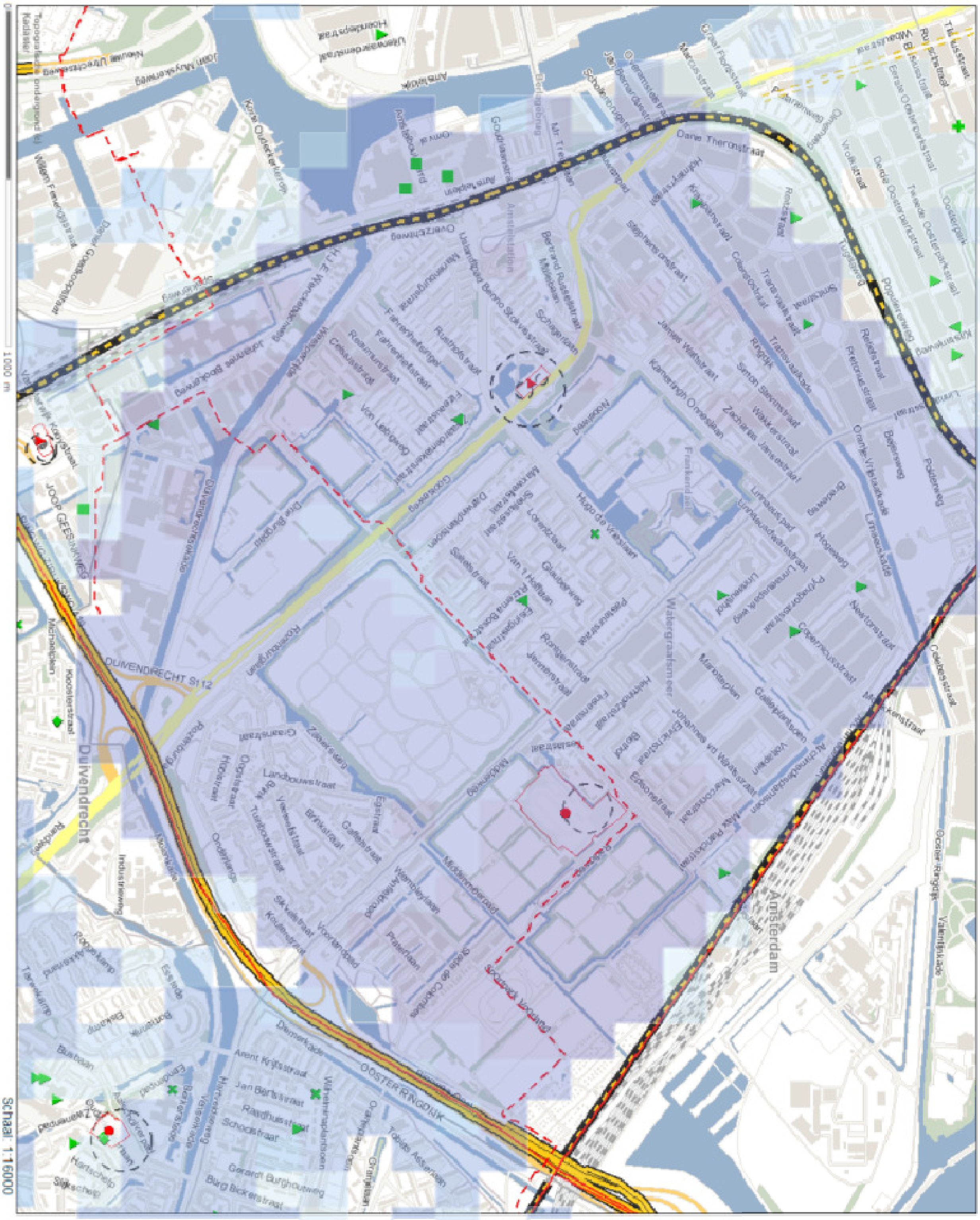
Interessant voorbeeld: Door netcentrisch werken veranderen de rollen van de mensen in de teams. Er wordt echter ook aangegeven dat de structuur van organisatie zelf (WBT, WOT, WAT) niet veranderd, omdat de taken en verantwoordelijkheden hetzelfde blijven.

a. Case: overzichtkaart watergraafsmeer

Watergraafsmeerpolder met dijkdoorbraak vanuit Nieuwe Diep



b. Statische overzichtskaart



Veiligheidsafstanden

☑ Risicocontour 10-6/jr

Ongevallen gevaarlijke stoffen

☑ ▲ LPG

☑ ● Ammoniak

Transport

☑ Weg

☑ Spoorweg

☑ Waterweg

☑ Buisleiding

☑ Ongeval op land

Hogesnelheidslijn

Intercitylijn

Autosnelweg

(Provinciale) autoweg

Kwetsbare objecten

☑ ▼ Woonverblijf

☑ ▲ Onderwijsinstelling

☑ ✕ Tehuis

☑ ■ Kantoor/ bedrijf

☑ ★ Ander object

Natuurrampen

Overstroming

☑ Overstromingsdiepte

minder dan 0,2 m

0,2 - 0,5 m

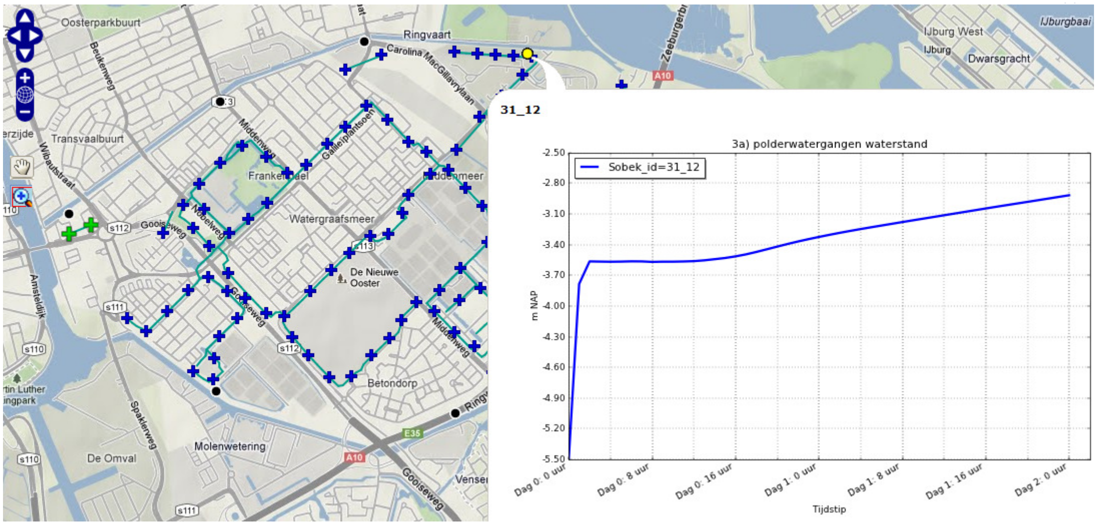
0,5 - 0,8 m

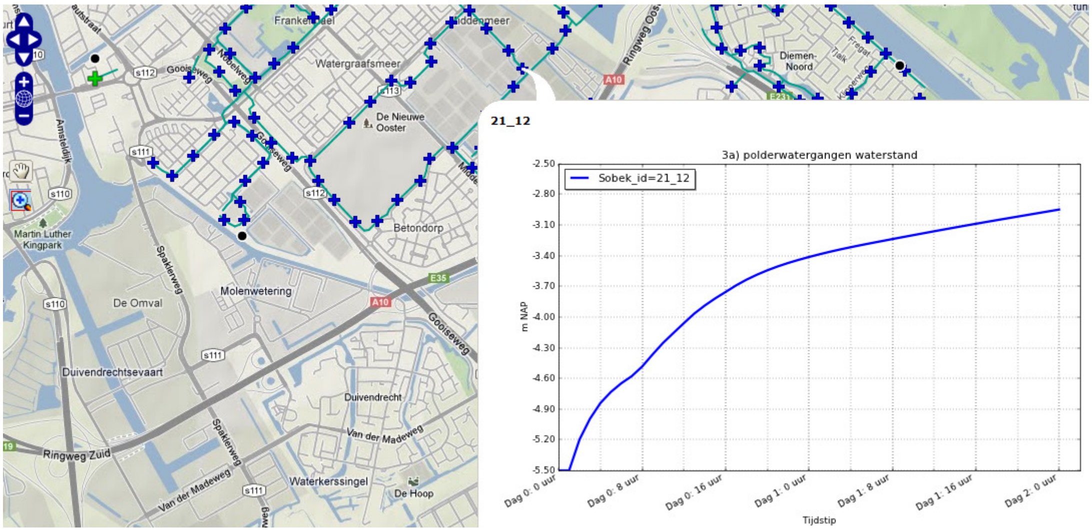
0,8 - 2,0 m

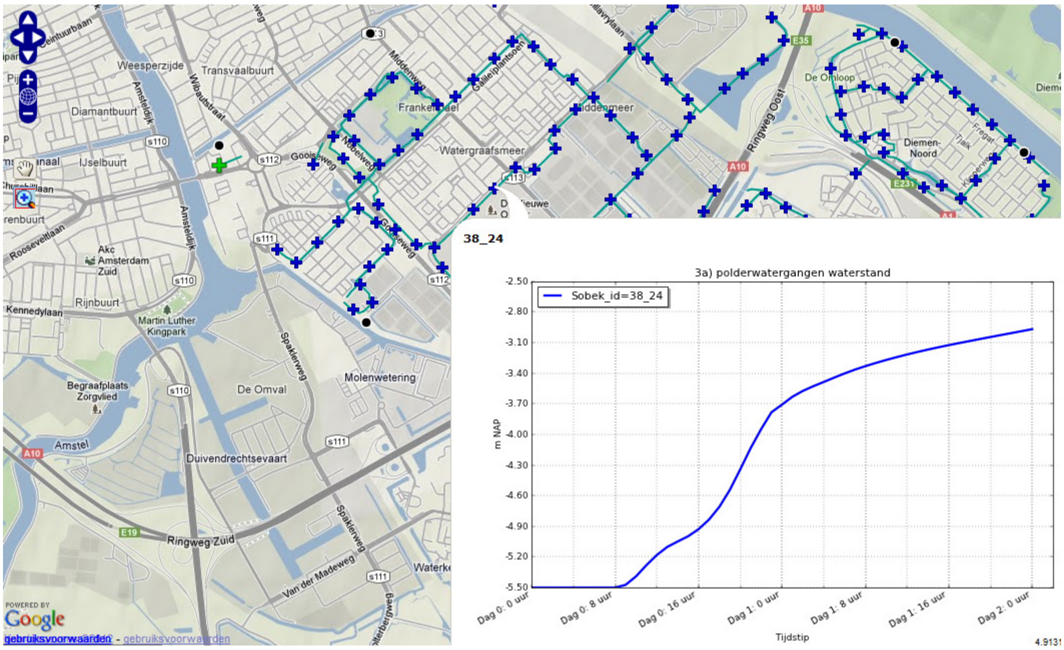
2,0 - 5,0 m

meer dan 5,0 m

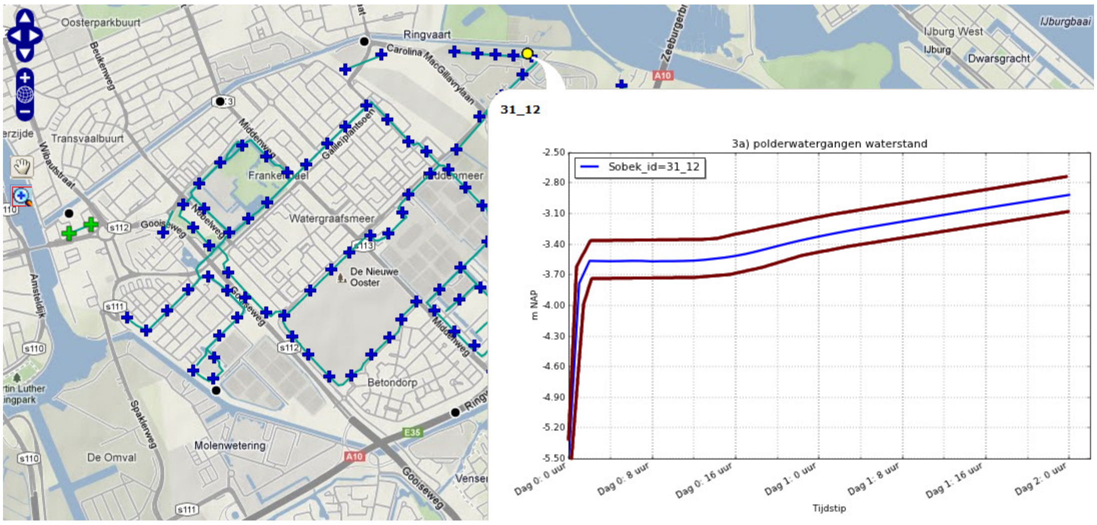
c. Grafiek verwachte waterstand

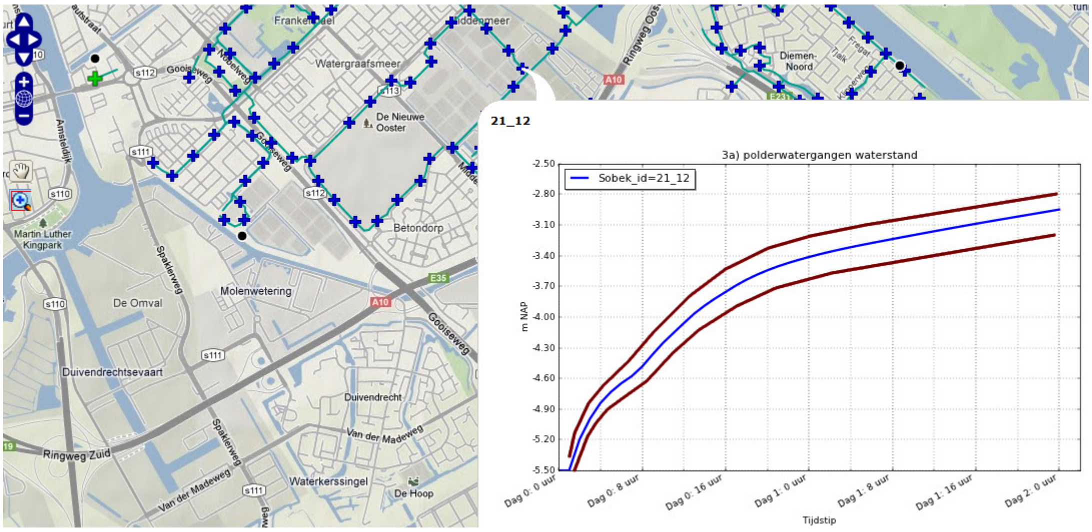


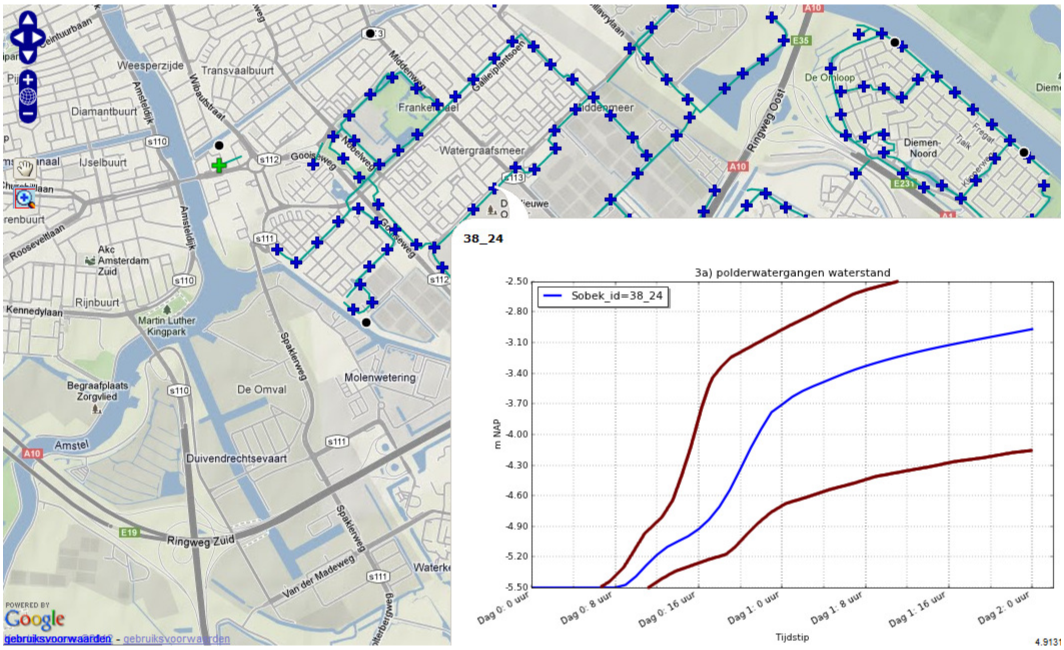




d. Grafiek verwachte waterstand met onzekerheid







e. Video’s werking Lizard

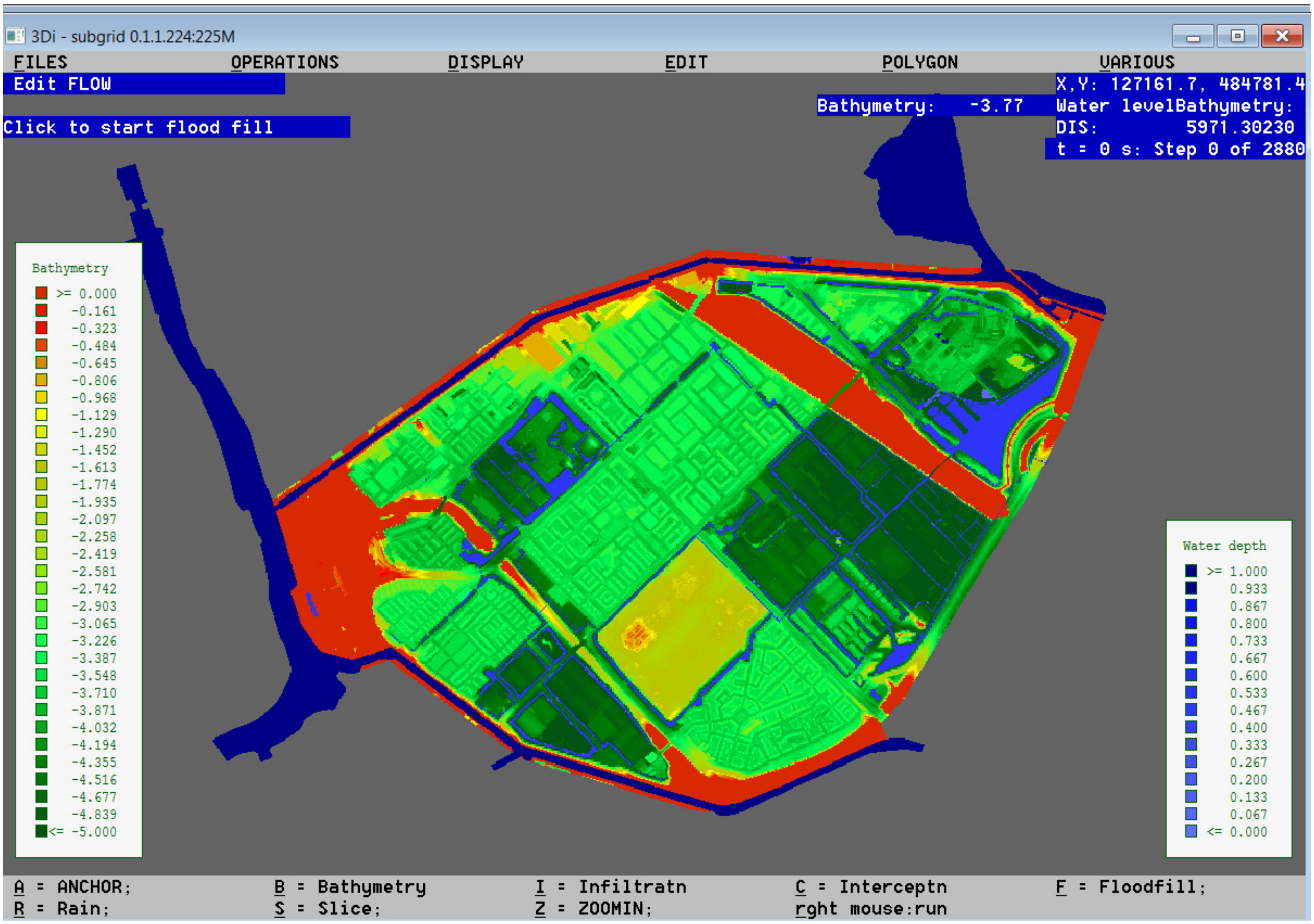
a. diepte en stroomsnelheid
zie video: ‘4a. Werking Lizard diepte stroomsnelheid.wmv’

b. schade en slachtoffers
zie video: ‘4b. Werking Lizard schade slachtoffers.wmv’

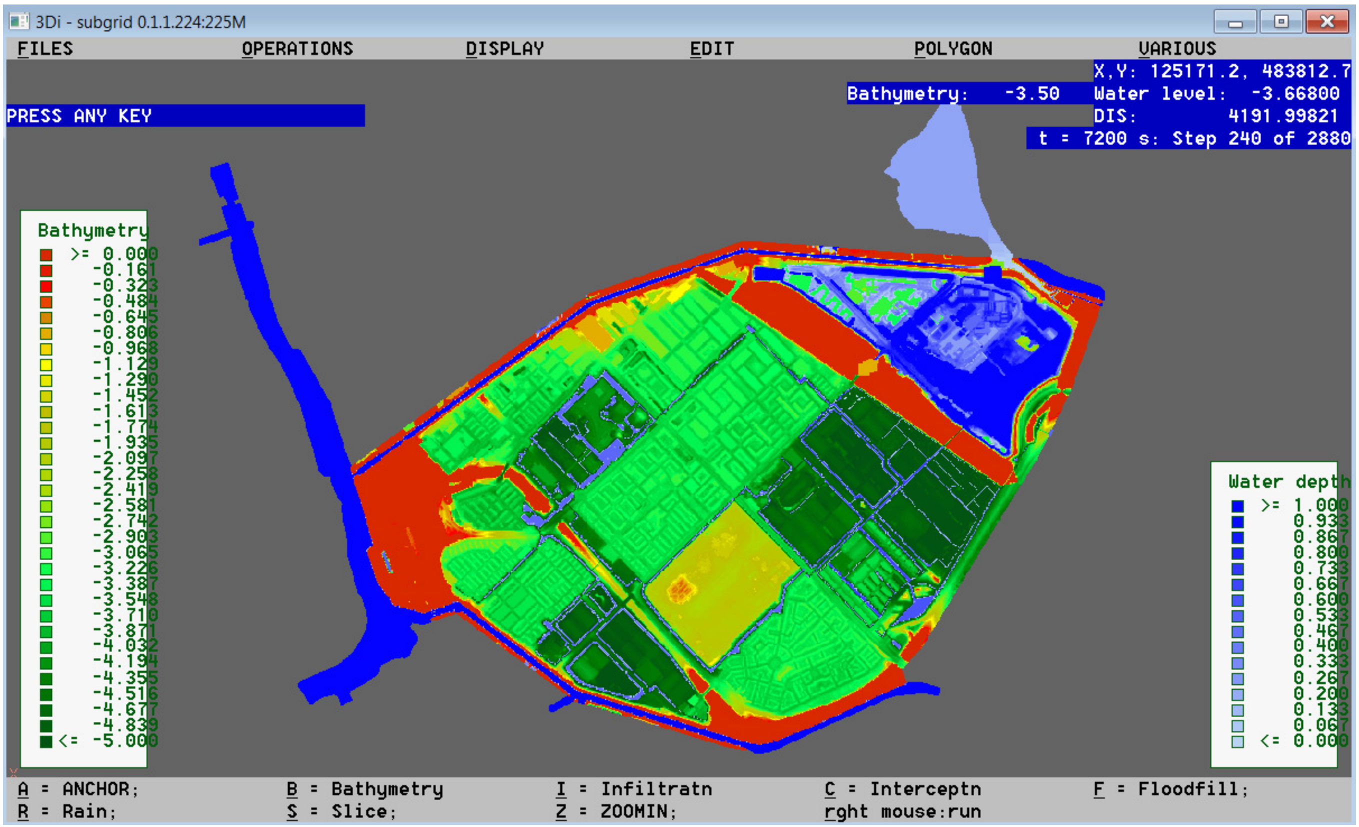
f. 3Di resultaten

a. 3D visualisatie van overstroming in 3Di
zie video: ‘5a. 3Di 3d animatie overstroming Watergraafsmeer.wmv’

b. 3Di hoogtekaart gebied



c. Simulatie overstroming Watergraafsmeer in bovenaanzicht



```
PRESS ANY KEY
Bathymetry:     -3.50
X,Y: 125171.2, 483812.7
Water level:   -3.66800
DIS:          4191.99821
t = 7200 s: Step 240 of 2880
```

g. Gebruik 3Di

a. Video Watergraafsmeer: ‘6a. 3Di gebruik watergraafsmeer.mp4’

b. Video de Purmer: ‘6b. 3Di demo De Purmer.avi’

II INDICATOR CHECKLIST VERIFICATION OBSERVATIONS

Verificatie: Observatieformulier voor genoemde eisen tijdens calamiteitenoefening

Codering:	eis impliciet genoemd	~~///~~
	eis expliciet genoemd	~~0000~~
	eis blijkt een knelpunt	~~XXXX~~

Logical soundness							
Actualiteit							
Validiteit							
Completeness							
Volledigheid van elementen							
Volledigheid van componenten							
Scenario's							
Accuracy							
Detailniveau							
Acceptability							
Externe consistentie							
Begrip van modelstructuur							
Begrip van onzekerheden in model							
Vertrouwen in mensen							
Credit							
Practicability							
Benodigde tijd							
Functionaliteiten							
Voorbewerking							
Nabewerking							
Effectiveness							
Eenduidige framing							
Begrijpbaarheid van het modelresultaat							
Beslisduidelijkheid							
Aanpasbaarheid resultaat							
Passend in besluitvormingscultuur							

....

....

....

III TRADE-OFF CHECKLIST VERIFICATION OBSERVATIONS

Verificatie: Observatieformulier voor gemaakte trade-offs tijdens calamiteitenoefening	Actualiteit	Validiteit	Volledigheid van elementen	Volledigheid van componenten	Scenario’s	Detailniveau	Externe consistentie	Begrip van modelstructuur	Begrip van onzekerheden in	Vertrouwen in mensen	Credit	Benodigde tijd	Functionaliteiten	Voorbewerking	Nabewerking	Eenduidige framing	Begrijpbaarheid van het modelresultaat	Beslisduidelijkheid	Aanpasbaarheid resultaat	Passend in besluitvormingscultu
Actualiteit	■																			
Validiteit		■																		
Volledigheid van elementen			■																	
Volledigheid van componenten				■																
Scenario’s					■															
Detailniveau						■														
Externe consistentie							■													
Begrip van modelstructuur								■												
Begrip van onzekerheden in model									■											
Vertrouwen in mensen										■										
Credit											■									
Benodigde tijd												■								
Functionaliteiten													■							
Voorbewerking														■						
Nabewerking															■					
Eenduidige framing																■				
Begrijpbaarheid van het modelresultaat																	■			
Beslisduidelijkheid																		■		
Aanpasbaarheid resultaat																			■	
Passend in besluitvormingscultuur																				■

……

……

IV QUESTIONNAIRE 3DI FLOOD MODEL USE

15 november 2012

Evaluatie vragenlijst 3Di calamiteitenoefening

In de calamiteitenoefening is op 14 november een 3Di model gebruikt om stroming te modelleren. Het doel van deze vragenlijst is verifiëren of het model voldeed aan de informatievraag die ontstond in het besluitvormingsproces.
Geef uw waardering voor elk model aspect weer met een cijfer 1 tot en met 10 door het desbetreffende bolletje in te kleuren.

Kwaliteit model

1. Hoe waardeerde u de actualiteit van het model?
Actualiteit betekent hier hoe recent de informatie is, die is ingevoerd in het model.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

2. Hoe waardeerde u de validiteit van het model?
Met validiteit wordt bedoeld dat de realiteit goed gerepresenteerd werd door het model.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

3. Hoe waardeerde u de volledigheid van aanwezige elementen in het model?
Hiermee worden elementen als doorgangen, tunnels, afsluitingen, etc. bedoeld.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

4. Hoe waardeerde u de volledigheid van het model met betrekking tot aanwezige componenten?
Waren er voldoende componenten aanwezig, zoals riool, water kwaliteit, dijk stabiliteit, etc.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

5. Hoe waardeerde u de scenario's in het model?
Hiermee wordt bedoeld, de variëteit van de beschikbare set scenario's.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

6. Hoe waardeerde u het detailniveau in het model?
Oftewel, was het detail in ruimte en tijd voldoende om besluitvorming te ondersteunen.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

Vertrouwen in het model

7. Hoe waardeerde u de verandering in het 3Di modelresultaat t.o.v. de oude SOBEK resultaten?
Dit heeft betrekking tot de acceptatie van veranderingen in het modelresultaat.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

8. Hoe waardeerde u de begrijpbaarheid van de achterliggende modelstructuur?
Dit heeft betrekking op het gevoel van begrijpbaarheid wat er achter de schermen gebeurd.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

9. Hoe waardeerde u de begrijpbaarheid van onzekerheden?
Hiermee wordt bedoeld of het model bijdroeg aan ‘gevoel’ voor aanwezige onzekerheid.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

10. Hoe waardeerde u het vertrouwen in de operators van het model?
Met andere woorden, had u vertrouwen in de expertise van de personen die het model bedienden.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

11. Hoe waardeerde u de reputatie van het model?
Dit omvat het vertrouwen in het model doordat het eerder succesvol is toegepast.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

Gebruik van het model

12. Hoe waardeerde u de tijd benodigd om het model te gebruiken?
Oftewel, de snelheid van het model om bruikbaar te zijn tijdens calamiteiten.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

13. Hoe waardeerde u de functionaliteiten van het model?
Hiermee wordt bedoeld of voldoende onderdelen in het model aan te passen zijn via de user interface.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ……………………………………………………………………………………………

……

14. Hoe waardeerde u de voorbewerking van data voor het model?
Dit omvat de mogelijkheden om operationeel nieuwe data in het model op te nemen.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ………………………………………………………………………………………………………

………

15. Hoe waardeerde u de nabewerking van het modelresultaat?
Met nabewerking wordt bedoeld of gegeneerde data wordt omgezet naar bruikbare informatie.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ………………………………………………………………………………………………………

………

16. Hoe waardeerde u de eenduidigheid van de beeldvorming gegenereerd door het model?
Hiermee wordt bedoeld, eenzelfde beeld van de situatie voor alle betrokkenen.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ………………………………………………………………………………………………………

………

17. Hoe waardeerde u de begrijpbaarheid van het model resultaat?
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ………………………………………………………………………………………………………

………

18. Hoe waardeerde u de beslisduidelijkheid van het modelresultaat?
Dit betekent dat het modelresultaat duidelijk maakt welke beslissing genomen moet worden.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ………………………………………………………………………………………………………

………

19. Hoe waardeerde u de aanpasbaarheid van de presentatie van de modelresultaten?
Dit omvat de aanpasbaarheid aan de wensen van de eindgebruiker.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ………………………………………………………………………………………………………

………

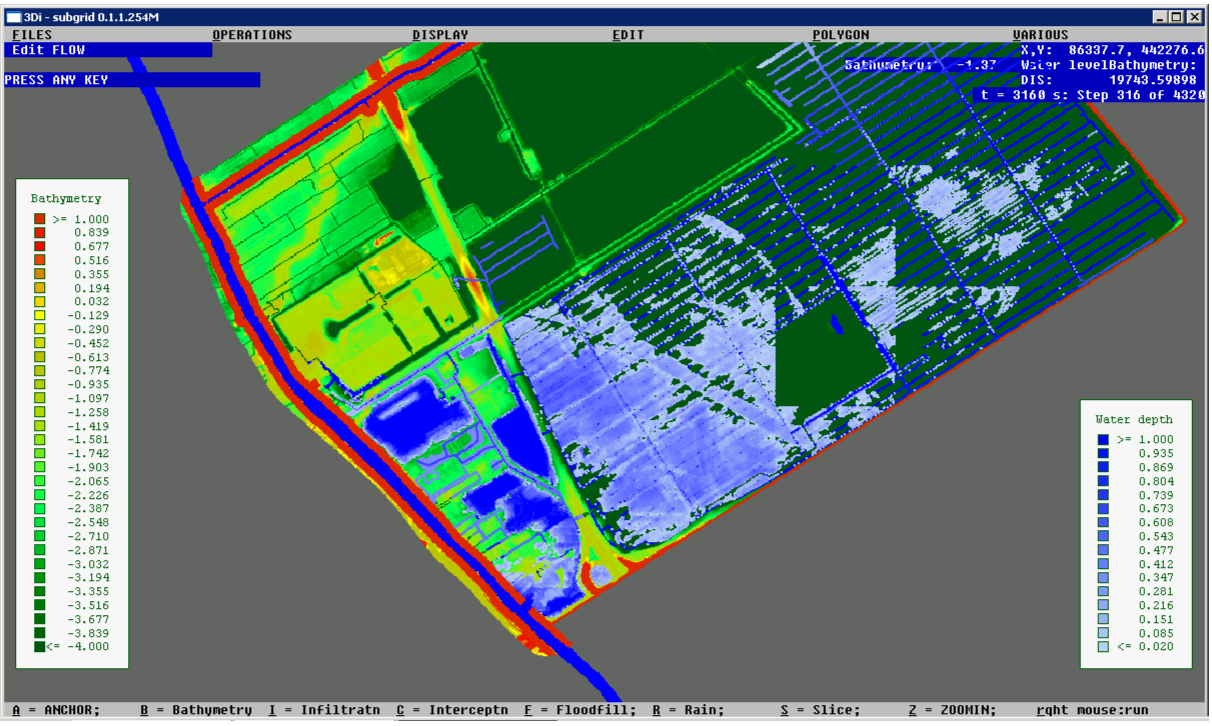
20. Hoe waardeerde u het model in de besluitvormingsstructuur?
Met andere woorden, paste de werkwijze van het model in de huidige besluitvormingsstructuur van de calamiteiten organisatie.
○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ 6 ○ 7 ○ 8 ○ 9 ○ 10 ○ Geen idee

Eventuele toelichting: ………………………………………………………………………………………………………

………

Afwegingen

Het 3Di model bood tijdens de calamiteitenoefening de mogelijkheid om real-time te modelleren. Het was het een bron van informatie die ondersteuning gaf bij het maken van operationele beslissingen. In een calamiteuze situatie worden hoge eisen gesteld aan zo'n model, bijvoorbeeld met betrekking tot de aspecten uit het eerste deel van deze vragenlijst.
In dit deel van de vragenlijst wordt u gevraagd een keuze te maken tussen twee van deze aspecten.



Case:
Voor deze vraag nemen we een dreiginggeval die had kunnen voorkomen tijdens de oefening. Het betreft een boezemdijk om een polder die mogelijk zou kunnen bezwijken tijdens een hoogwater situatie. In de bovenstaande afbeelding ziet u een modellering van stroming ten gevolge van een doorbraak van deze boezemdijk. Aan de hand van dergelijke ervaringen tijdens de calamiteitenoefening willen we het model verbeteren.

In de onderstaande tabel zijn zeven afwegingen tussen twee verbeterpunten opgesteld. Geef per afweging aan welke eis volgens u de hoogste prioriteit moet hebben bij toepassing van het 3Di model tijdens de calamiteitenoefening. Geef uw keuze aan door het desbetreffende vakje te kleuren. Wanneer het onmogelijk is een keuze te maken, kunt u 'geen keuze' selecteren.

Optie 1				Optie 2	Geen keuze
Benodigde tijd voor een modelrun	○	←→	○	Detail in ruimte en tijd	○
Volledigheid van aanwezige elementen, zoals tunnels	○	←→	○	Begrijpbaarheid modelresultaat	○
Volledigheid van componenten, zoals kwaliteit, dijk stabiliteit	○	←→	○	Recentheid van de informatie in het model	○
Duidelijkheid welke beslissing te nemen	○	←→	○	Begrip van aanwezige onzekerheden	○
Benodigde tijd voor een modelrun	○	←→	○	Begrip van aanwezige onzekerheden	○
Benodigde tijd voor een modelrun	○	←→	○	Volledigheid van componenten zoals riool, dijkstabiliteit	○
Volledigheid van componenten zoals riool, dijk stabiliteit	○	←→	○	Benodigd voorbewerking	○

Eventuele opmerkingen: ……

……

……

……

……

……

……

Hartelijk dank voor het invullen van de vragenlijst! Wilt u op de hoogte blijven van de resultaten? Laat dan uw contactinformatie achter:

Naam: ………

E-mailadres: ………

V

RESULTS ANALYSIS OF FLOOD CALAMITY PLANS

Calamity plan Hoogheemraadschap De Stichtse Rijnlanden 2010-2013
(Hoogheemraadschap De Stichtse Rijnlanden, 2010)

Introduction

The calamity plan maintains the guideline for calamities within the water board. It structures the process of calamity management and contain multiple procedures.

Relevant characteristic aspects of decision making process during flood calamities

The calamity organization consists of the WBT, WOT and the WAC. The WAC performs actions that need to be taken, such as the implementation of measurements or gathering field data. The WAC communicates with the WOT that coordinates these actions. WOT makes operational decisions based on field data and other technical information. WBT makes decisions on a tactical level and coordinates the WOT. At the same time, they receive information from WOT that forms the basis for the decisions.

Next to the main organization, a supportive group can be active for wide support all three teams. They do not provide technical information. Also, a wide range of executing units can be active, depending on the nature of the calamity.

An important aspect of calamity organization is scaling up or down. Small problems are usually solved by the WAC. When a problems turns in or appears to be a calamity, the WOT is called together to coordinate the actions. With increasing severity the WBT is engaged to take tactical decisions. It is also possible that large scale calamities are so large, that other parties take over organization. From that moment, coordination of the calamity management is not in control of the water board anymore. After a calamity is solved, a similar procedure of downscaling is followed.

The process of up scaling makes communication complex. During urgent calamities good communication is essential for the functioning of the organization. Therefore, it is important that technical information is efficiently available.

Use of technical information

The plan is mainly focused on the organizational side of calamity management and gives no clear description of how technical information should be used. It does state who is responsible for technical information. In the WBT there is a plotter who arranges visual representations of information. The WOT also has a plotter, but in addition also an information manager who collects and sorts all necessary information. The WAC has multiple experts available that directly put technical knowledge inside the process. This technical information is communicated to the WOT by the writer of the sitrap.

Calamity plan Waterschap Hunze en Aa’s 2011 (Waterschap Hunze en Aa's, 2011)

Introduction

The calamity plans of water board Hunze en Aa’s organises the structure of crisis management. It contains multiple procedures.

Relevant characteristic aspects of decision making process during flood calamities

An important aspect present in de document is the dynamic nature of the responsibility during a flood calamity. Depending on the case at issue, different stakeholders can be responsible for calamity management. Examples given are the water board, public safety district and the municipality or major. Another important point is the varying selection of external partners. The network of partners during a calamity depends strongly on the nature and development of the calamity. Different actors demand different information, where internal information is separated from external information.

Use of technical information

The exact form of technical information is not mentioned in the plans. It is stated that there is an expert in WOT who is responsible for technical information. The exact procedures how to use technical information is not described, but it is clear that a distinctive advice is desirable. This requires a simplification step of the technical information by the expert. It appears that decision makers have no desire for complicated technical information in the decision making process.

The decision to scale up is made based on the expected water levels. A decision support system is used to do this. This is possibly a flow model that uses precipitation data to predict water levels.

Calamity plan Hoogheemraadschap De Stichtse Rijnlanden 2012-2015

(Hoogheemraadschap De Stichtse Rijnlanden, 2012a)

Introduction

This version is a complete revision of the version from 2010-2013. New insights and better use of modern techniques should make this a more effective calamity plan.

Relevant characteristic aspects of decision making process during flood calamities

The concept of scaling up and down is again emphasized and addressed as an important factor for increased complexity. In addition to this it is addressed that there is a shifting responsibility when there the calamity organization is scaled up. In the first instance, responsibility is addressed at the municipality, although water related issues are directly the responsibility of the water board. Increasing urgency of calamities can make it a regional issue, where the public safety district is the leading authority. In rare cases, a calamity can organized on a national level. Another perspective of hierarchy is the duality between the hierarchy of the water board and the main hierarchy. Here, the WOT advices the ROT. The main point of concern in the calamity plans is managing information and communication. The information needs to be custom made and suit the requirements of the receiver.

Use of technical information

The calamity plan addresses predefined scenarios as the source of information about expected water levels, flow speeds and arrival times. The scenarios vary in settings and situations, for example, there is scenario where the Maeslantkering fails to close. The criteria used for making decisions are based on water levels, for example evacuation if water levels exceed a specific level.

Operationeel basisplan (dreigende) overstroming friesland (Provincie Fryslan, 2008)

Introduction

The plan is not official yet, it is a concept version aimed on feedback and further development. The main purposes are to continue the development of flood calamity plan and test the robustness of scenario development. However, it does contain some useful information about decision making during flood calamities and the use of technical information.

Relevant characteristic aspects of decision making process during flood calamities

The document addresses that calamity management is essentially different compared to day to day business. The concept calamity plan is based on multiple pillars, of which the decision making process pillar and the information management pillar describe the process. Another important aspect is responsibility and involvement of stakeholders due to multiple laws. It shows that large calamities can connected to many different laws, which makes decision making and responsibilities complicated. In the structure of organization two columns are identified. The first column is the general column in which the municipality is represented. The second column is the functional column, in which the water board is represented. In case of a life threatening calamity, the functional column acts as support for the functional column.

Scaling up the organization is similar to other calamity plans. Clear is that the water board scales up based on 'coordination phases' and the public safety district based on 'GRIP-levels'. Another important point made is that decision makers always have to make hard decisions. There are no win-win situations and the author even talks about lose-lose situations. Due to this, balancing interests is one of the main tasks of decision makers. This problem is even larger due to the fact that decisions made can be very uncertain and consequences extremely large. Some components of these cases are extremely unpredictable (weather) and assessment takes too much time due to the complexity of the problem.

Use of technical information

The calamity plan is based on a few specific technical indicators. These indicators are gathered in scenarios. More specific these indicators are, flood levels, area overviews, timelines and effects. Model information is used to raise awareness of the situation. This does not always work, in particularly for civilians.

Expected water levels and timelines are based on Worst Imaginable Flood (EDO) scenarios, which are compared to actual measured water levels. However, it is recognized that high quality information is necessary for good decision making. A list of required technical information is giving in the report:

- Water level information, models and maps
- Meteorological predictions
- Geographic, infrastructural and demographic information
- Infrastructure, capacities and services

One of the most important types of technical information required are time depended expected water levels.

Calamity plan Water board Zuiderzeeland (Waterschap Zuiderzeeland, 2011)

Introduction

The calamity plan of Water board Zuiderzeeland describes organization of calamity management. It is not specified and is the general document for calamities related to water management.

Relevant characteristic aspects of decision making process during flood calamities

Tasks of the WBT are summarized as strategic, for example, policy development, administrative coordination, long term effects, etc. Tasks of the WOT are summarized as tactical decisions, for example, operational coordination, global approach, coordination with other agencies, etc. The WOG supports the WOT, although in the situation may justify support of Water Board Operational Support Team (WOG) for the WAC. The tasks of the WAC contains coordination of actual measures.

Scaling plays a role both the general column and the water column. The GRIP-levels of the general column are linked to the coordination phases of the water column. Both columns can initiate up- or downscaling in both columns. The initiation of the involved teams, such as the RBT or WBT, is directly linked to the GRIP-levels or coordination level active. The OL is the head of WOT, but also participates in the WBT and is therefore a key figure in information management.

The calamity plans also suggests that Rijkswaterstaat also can initiate a policy and operational team.

Use of technical information

Information is normally collected and processed by members of the WAT. This can be field data, collected by members of the WAT or fieldworkers. Also it is addressed that this information can come from available information systems, that possibly could be model information. However, technical information can also be supplied by WOG.

Bestrijdingsplan hoog water en dijkdoorbraak (Waterschap Zuiderzeeland, 2010)

Introduction

The script 'Hoog water en dijkdoorbraak' is part of the overall calamity plan. It describes instructions, procedures and responsibilities in case of high water levels or failure of a levee.

Relevant characteristic aspects of decision making process during flood calamities

It is addressed that calamity management is no day to day activity for most of the people involved. The decisions that need to be made during a flood calamity are, reducing effects of the flooding, controlling the cause of the flooding, scaling of the organization and evacuations. However, it is not possible to close a gap in a levee until water levels at both sides are equal. Also, it is addressed that it is hard to effectively evacuate residents once flooding has started.

The organizational structure at the water board is based on WBT, WOT and one or multiple WACs. Each team is flexible in its composition, but it is obvious that specialists participate in a WAC. The frequency of meetings varies, but is about once per two hours.

For communication a difference is recognized between internal and external communication. Under external communication is considered the public and the press. Internal communication is own personnel and contractors. Network partners can be considered as both internal and external communication.

Use of technical information

Organizational decision making is based on (expected) water levels. There an alarm level of the water level that triggers the calamity organization and scaling occurs based on expected near future water levels. Flood models are used to create scenarios with expected water levels at time intervals after a breach. These scenarios are used to make decisions about measures. Technical information is a lot of cases transferred to others teams by sitraps.

VI WORKSHOP ‘BESLISSING CENTRAAL’

Introduction

The workshop was organized by Nelen & Schuurmans on behalf of the 3Di consortium. The goal of the workshop was to identify necessary technologic developments of the 3Di platform to fit the needs of the potential users of the model. An additional goal was to identify steps that need to be made in process to be able to use the 3Di model. The workshop was led by Nelen & Schuurmans employees Anne Leskens and Martijn Siemerink.

The workshop is used to gain additional knowledge for the thesis. It is part of the expert knowledge gained in phase of the research one to learn about the decision making process. The personal goal in the workshop is to identify stakeholders and learn about their perspective on use of models during flood calamities. Two questions are tried to be answered:

- Who are the stakeholders in flood calamity management?
- What is their perspective on the use of model in flood calamity management?

Participants

In an introduction round of the workshop, each participant introduced him- or herself. This identifies the stakeholders present at the workshop and they represent different organizations:

- Waternet
- Science Park Amsterdam
- Deltares
- Municipality of Amsterdam
- Ingenieursbureau Amsterdam
- University of Amsterdam
- Public safety district
- Water board
- Inhabitants

The introduction round ends with a short discussion about the use of flood models. In this discussion a few topics have been discussed. One of the first mentioned topics is the duality between integration and over-complexity in which a balance usually needs to be sought. In model results visual representation of results is important. The participants would like to see al visual representation of the flow speed and water depth.

More specific about the 3Di model, the participants want the model to be fast and detailed. Communication is addressed as an important function, which needs to be detailed and clear. Moreover, they want the model to create a common understanding of the system and its situation.

It is observed that the model user is not uniform. Multiple persons with multiple functions are going the use the model, so the ‘model user’ has many perspectives, goals and levels of knowledge.

Presentations of four workgroups

In the next part of the workshop the group was divided in four smaller groups. The first group was labelled ‘policy’ and contained stakeholders active in governmental institutions regarding policy making. The second group was labelled ‘crisis’ and contained stakeholders active in organizations regarding the operational phase of crisis management. The third group was spatial planning and contained policy makers regarding spatial planning. The fourth group contained model makers of Waternet. Each group was asked which problems they deal with, what they do to contribute to the problem and what constraints they encounter. An overview of points addressed by each group is given below.

Policy group

The policy group stated that climate change is important aspect in policy making. Also, they try to integrate the problem of water safety with water hindrance. Last, they try to make sure vital infrastructure in protected during a flood calamity.

The constraints they identify are summarized as consistency and integration of components and support of continually evolving insights. Important aspects mentioned are listed below.

- Information provision
- Scenarios
- Limited budget
- Interaction between scales
- Interaction between disciplines
- Addressing urgency to directors
  - Content
  - Costs
  - Risks and uncertainties
  - Social aspects
- Perception of situation

Crisis group

The group crisis contained stakeholders of the public safety district and Waternet. They try to reduce effects of water hindrance and floods. The group identifies both a preparatory phase, which contains planning, and an operational phase of incident control. Waternet designs countermeasures and gives advice about further technical measurements. The public safety district deals with crisis control of municipal processes and crisis communication. On 13, 14 and 15 November a large exercise will be held by the public safety district.

Constraints in the crisis group can be summarized as a lack of sense of urgency at the public safety district, the policy makers and the inhabitants. Other important aspects are listed below.

- Clearly distinction between the municipal organizations and the water organizations
- Public safety district has insufficient knowledge of problems
- Experiences as Wilnis are quickly forgotten
- Which critical functions are at risk?
    - Electricity
    - Gas
    - Water
    - Telecom
- Available time for decisions
- Risk communication: Waternet to public safety district to Inhabitants and emergency services

Spatial planning group

The spatial planning group aims to develop a long term policy for spatial planning in which all relevant aspects are balanced. The spatial planning group summarizes the important aspects into one topic, integration. It is stated that integration is hard in practice, not always optimal and not always desired. Other mentioned aspects are listed below.

- Integration
- Cost optimization
- Insight in low and subsurface infrastructure
- Integration is not always wanted (requires time and money)
- Presentation of information (positive or negative)
- Integration confined by separated budgets
- In theory integration is not new, but in practice it is really new

Model makers group

The model makers are experts from Waternet who create and operate models. They assess risks on water hindrance, sewerage, surface water and the entire water system. Their tasks are to give advice decision makers on adapting the water related infrastructure.

Constraints they identified are summarized in finding balance between integration and level of detail. Important was the possibility to make the model suitable for full scale cost-benefit analysis in which all kinds of aspects are assessed. Other topics are summarized below.

- Quality of data
    - Is the data recent and actual?
- Level of detail
- Economic value versus costs
- Clear norms, but also sustainable for future developments
    - Especially for integrated water management
- Sense of urgency by clear indication of economic value
    - Advices are not always used due to lack of persuasion
- Legal liabilities

Demonstration prototype 3Di Touch Table

In the last part of the workshop the prototype 3Di Touch Table was demonstrated. The 3Di model computational core is situated at a central location and the model is accessible through an internet connection. In this case, a large touch screen was connected for controlling the model. Two flood simulations were demonstrated in the model. This led to a few comments, attractive aspects and elements that were not as desired.

The strong visual aspect made a lot clear for the participants and was considered as an improvement. Also, the computational power was perceived with great positivity and the smart definition of grid cells was conceived a positive point. However, some participants would like to see an option to quickly determine the quantity of water, for example, flowing through a street. Another function that appears to miss is to quickly compare different scenarios or references cases. The prototype has a raw interface for control so this was also mentioned as a point for improvement. The last thing mentioned was lack in pre-processing and post-processing. Comprehensive pre- and post-processing leads to the fact that only experts can use the model. Another remark is that integration of aspects, level of detail and use suitable for non-expert requires an extensive database management system to manage all information. Also reliability of the model is addressed as an important factor, next possibilities to link the system to other models or modules.

Conclusions

The workshop has led to insights about the decision making context. However, the main theme of the workshop was not the operational phase of flood calamity management, but moreover the use of the 3Di model. Therefore, both research questions could not fully be answered. A few meaningful observations have been made although.

Stakeholders cannot always be clearly identified. Some people have multiple functions and some organizations, for example the public safety district, has a complex organizational structure itself. For a full understanding of the decision making context, it is important to map out the entire decision making network in high detail.

From scientific literature, the model user is seen as one uniform entity. However, during the workshop it became clear that most of the participants were potential model users. So, the model user is far from uniform.

During the workshop, a lot of recognizable themes appeared, such as integration, completeness and requirements of experts for usage. During the discussions, it appeared however that a lot of these themes are complex. Not every user of the model has the same demands and a lot of them conflict with each other.

VII RESULTS ANALYSIS OF EVALUATION REPORTS

Evaluatieverslag van regionale oefening Noord-Holland nat (Hoekstra, 2008)

Introduction

The evaluation report contains a review of the regional exercise ‘Noord-Holland Nat’ held in the public safety district Noord-Holland Noord. The exercise contained a fictional flood scenario on a regional scale. The main goals of the exercise were cooperation and communication. The evaluation report contains an overview of the individual evaluation reports based on these two goals.

Relevant characteristic aspects of decision making process during flood calamities

The main participants of the exercise were the RBT, ROT and eight municipal calamity teams. The RBT makes strategic decisions and the ROT the operational decisions. The RBT usually consists of representatives of different institutions and other supportive participants. Where they operate on the highest level, the receive basic information from the ROT. The ROT coordinates actions based on the decision by the RBT. They maintain most of the technical information. In this case, the technical information was used as HIS-information supplied by the Water Board. The municipal crisis teams consists of municipal services and actually performs the actions taken by the ROT.

Other actors mentioned in the evaluation report are the GBT and the Ministerial Policy Team. The role of the GBT is not clear, excepted they make decision on a municipal scale. The size of the calamity increased during the exercise and the situation was scaled up. From this moment the Ministerial Policy Team was the highest decision making authority. They communicate decisions to the RBT.

Important seems the fact that there is a lot of communication, where in most of problems arise. Due to problems in communication of technical information, not all participants had to information they were supposed to have. Also, not all information was uniform.

Constraints in use of technical information

The technical information supplied by the Water Board was not in all cases distributed to all relevant actors. This is an external aspect and relates to the effectiveness in the use of models.

Also two different maps were used and there was no consensus about which one to use. The acceptance of models clearly plays a role in this case. However, the cause of this is the duality of two models, which on itself would probably relate to effectivity.

Evaluatieverslag FloodEx HHNK (Hoogheemraadschap Hollands Noorderkwartier, 2009)

Introduction

FloodEx is an exercise with the focus on international assistance during a flood calamity. The scenario of the exercise is a levee breach and flooding of large parts of HHNK as a result. An EDO-scenario forms the basis for this setting. The exercise itself is focused on international help from pumping teams abroad.

Relevant characteristic aspects of decision making process during flood calamities

The foreign pumping teams were presented to assist pumping activities. They received orders coordinated by the WAC. These actions are coordinated by the ROT, which receives technical information in the form of water images from the water board. The ROT communicates with the National Operational Coordination Centre (LOCC) which is the overhead decision maker during the exercise.

For the collection of information the system ‘Cedric’ is used. It is a platform to collect basic information about calamities. For integration of information in meetings of the WAC scenarios are used as a basis. It is stated throughout the exercise that information needs to be clearly communicated.

Constraints in use of technical information

The ROT has needs for specific information about the flooding. Their demand consists of scenarios with water depths, flow speeds, etc. They want detailed and accurate information which clearly states whether measures should be taken or not, for example an evacuation. The problem stated is that this demand is probably not realistic. This demand can be placed under the categories of Completeness and Accuracy. When one states that the technical information is presented by the water board to the ROT and they need to have confidence in de information, it is mostly a case of Acceptability of technical information.

The WAC has stated the need of an overview map, which combines all relevant information. This is about the completeness of the technical information.

Evaluatieverslag hoogwater januari 2011

(Hoogheemraadschap De Stichtse Rijnlanden, 2011b)

Introduction

The report evaluates period of excessive high water in the region of the water board in the period January 2011. In that period water levels reached critical levels and calamity procedures were engaged. Fortunately, no calamity has really taken place. However, it gives some view on the process when a real calamity takes place.

Relevant characteristic aspects of decision making process during flood calamities

An analysis has been performed of the network of actors which was active during the period. Besides regular parties, the network appears to be very complex. This implies that a real situation always has more actors than expected and more cross connections arise during the calamity. This makes communication and the distribution of the right information to the right people hard.

Important for the decision making process is that all parties have the same overview of the situation. Due to the complexity of the situation, this not always appeared to be the case. Visual representation can be support this. Also, external communication is commented as poor. Information is collected, organized and presented in the system 'CAW'. As a third party developed tool, it collects information from for example multiple water boards and Rijkswaterstaat and weather data, which can be consulted by all relevant stakeholders.

Constraints in use of technical information

It was commented that during the period that by using all modern techniques, decision support became very depended on them. People were worried that loss of power or communication lines would leave them helpless. This is related to the practicality of a model. Another constraint was the quality of technical information. The speed in which predictions were made was addressed as unpractical and accurateness of the results was addressed as insufficient. Also, it appeared that predictions changed over time, which resulted in a lack of confidence and thus acceptability of model results.

Evaluatie oefening Hofpoort (Hoogheemraadschap De Stichtse Rijnlanden, 2011a)

Introduction

The exercise is held by Hoogheemraadschap De Stichtse Rijnlanden and is focused specific on the organization within the WBT, WOT and WAT. The setting is failure of a levee and each team held an extensive meeting in which the decision making process is practiced.

Relevant characteristic aspects of decision making process during flood calamities

Practical information was collected by the WAT and communicated to WOT. The WAT is the first point where information enters the organization. They discussed the content and create a situation report. This situation report is discussed in the WOT. The WOT makes an interpretation of the information and transforms it, so it is suitable for WBT. It states that was chosen to use maps to give an overview of the situation to WBT.

Constraints in use of technical information

There was room for improvement in the process of collecting information and forming an image of the situation. Participants of the exercise noticed that this process could be executed more structured with increased speed as a result. In relation to the categories, it is not the model itself that is discussed and therefore it is hard to relate to that. If possible at all, it would be the category of effectiveness.

Draaiboek oefening De Geer (Hoogheemraadschap De Stichtse Rijnlanden, 2012b)

Introduction

At the water board a scenario based exercise is held. The scenario is a damaged levee, which fails during the first WAT meeting. The WBT, WOT and WAT are the main participants in the exercise.

Relevant characteristic aspects of decision making process during flood calamities

The internal organization is classic top-down, from WBT to WOT to WAT. The WOT makes decision on a operational level, where the WBT makes decisions on a tactical level. The scale of the event increased during the exercise, which has led to an organizational up scaling. The coordination of activities is transported from the WBT to the public safety district.

In all three teams there is a sitrap-responsible and a plotter present. The first collects and summarizes all information and the second creates visual representations of information. However, some participants addressed it was still hard to keep an overview of the situation. The form is the technical information is not mentioned in the evaluation report.

Constraints in use of technical information

Some participants address the problem to create an overview of the problem. This could relate to the completeness of a model. However, most of the information is usually present somewhere, but poorly managed or presented. This relates to the effectiveness of a model. In addition to this it was hard to create a combined overview of relevant old information and new information.

Evaluatie hoogwater januari 2012 (Waterschap Hunze en Aa's, 2012)

Introduction

Due to high precipitation in January regional water levels were above average. Wind caused higher water levels at sea resulting in limited possibilities for releasing water on the Waddenzee. With no sign of improvement on the short term, a calamity was identified.

Relevant characteristic aspects of decision making process during flood calamities

An operational team makes decisions about operational issues and a policy team makes decisions on a tactical levels. In this situation, there were two hierarchies. The water board has two teams, the WBT and the WOT, and the public safety district also has two teams, RBT and ROT. Both hierarchies operate mainly next to each other, where the water board is only responsible for water related issues and the region is responsible for a wide range of public services. This complicates the network and increases the need for clear information transfer. Technical information is supplied by the WOT. The implies that WOT collects, managed and summarizes the technical data.

Water levels are calculated using Decision Support System (BOS) for high water, which is used both by the ROT and the WOT. Information is gathered and shared through the National Calamity Management System (LCMS). The daily board of the water board addressed that they would like to receive the full WOT reports.

Constraints in use of technical information

It appeared that predictions made by the model were insufficient. An improvement of the model results was necessary. The first hours after the prediction showed a deviation too large. However, it is unsure if the predicted water levels matched the eventually reached water levels. Other sub elements also appeared to give a insufficient result. The main point of the constraint appeared to be the accuracy of the model, although this appears through the acceptability of a model.

Evaluatierapport oefening laag Holland (Vinck et al., 2011)

Introduction

The in communication specialized consultancy firm Trimension has organized the exercise for Hoogheemraadschap Hollands Noorderkwartier. Participants were the teams WBT, WOT and WAC. The scenario executed was composed of two elements, high water levels in the entire region and failure of a specific levee. The two main goals of the exercise was to practice procedures in each team and train cooperation between the teams.

Relevant characteristic aspects of decision making process during flood calamities

An important aspect is that the people involved in the decision making process during the calamity do not work in calamity management in their day to day activities. Therefore it is addressed as important that a clear PBOB structure is followed in the decision making process. An efficient decision making process is essential. Also it is necessary to address that urgency and taking fast actions are important requirements in decision making and there is frequently feedback between the teams. From the schedule it appeared that there is approximately once or twice per hour a meeting.

In the use of information a clear distinction is made in information for internal communication and for external communication. In each team there is responsible for information management and there is a plotter for the visual representation. However, it is not clear what the precise role of the information manager is. In the WOT for example, this is the same person as the secretary. Field observations reaches the decision maker through multiple intermediaries, which increases the risk of distortion of information.

Technical information used includes GIS and a high water prediction information system. The visual presentation of information is addressed as an important aspect and the plotter is responsible for mapping technical information. The evaluation report states more or less states that information is the core of communication, so it is important to customize information according to the perceived goal and receiver. The presentation, visualization of technical information and how it is documented is decisive for decision making.

Constraints in use of technical information

Participants of the exercise address that there is a lack integration of economic and social aspects in the decision making process. This complies to the completeness category. The information was not well structured and it was advised to use PBOB and the presentation of information is almost as important as the content. This relates to the category effectiveness. A main theme addressed was finding a balanced between global information and details, or intuitive and rational decisions. The same duality appears in a loss of overview when working on details. This constraints related to practicability or effectiveness. Another constraint is the acceptation of uncertainty. Decision makers did not know how much uncertainty to accept in making decisions. Possibly this relates to logical soundness, since it is about understanding uncertainties. It was also addressed the technical information was not effective in convincing about the urgency of the situation.

Deelrapport planvorming (Taskforce Management Overstromingen, 2009b)

Introduction

The report describes an exercise in which the national planning aspect in the (short) period that a calamity may introduce. It is a summary of the results of multiple three-day exercises held. The focus is on organization of the calamity management. Due to the uncertainty of actual calamities, the document describes strategies, more the concrete procedures for operations.

Relevant characteristic aspects of decision making process during flood calamities

The organization on a national level introduces roles for the National Operational Staff, LOCC and Staff Large Scale Evacuation, that are directly linked to each other. the National Operational Staff integrates regional plans, while taking special attention to local priorities. Staff Large Scale Evacuation arranges large scale evacuation processes.

Another important aspect related to flood calamities on a national scale is that there is too little times to create scenarios or make any significant calculations on the situation. The report also concludes that there is a strong need to structure the decision making process. The operational decision making process on a national scale is structured according to five steps. The first step is determining the goal of the process, the second step is evaluation of related factors, the third step is evaluation of the situation, the fourth step is to explore and assess possibilities and the fifth step is to make a decision.

In relation to scaling up the organization it is addressed that it is sometimes necessary to scale up multiple level at once.

Attention is also paid to the transfer of information. It is addressed that correct is communication of information to all related actors, both vertically as horizontally and internal and external is vital for success of calamity management.

Constraints in use of technical information

An important aspect of management of technical information is that the required information should be available and accessible. They refer to practical cases where information appeared to be available, but when needed it was not. Also, technical information can be required in different situations and levels in the organization. The management of technical information in the operational phase of flood calamities is complex. A list of concerns is presented in the document:

- What minimal information in each process necessary?
- Who is the owner of the information?
- What agreements are made regarding used terms?
- Is the information organized by postal code?
- In what form is the information delivered?
- How fast can be the information be delivered?
- Which medium is used for storage of the information?
- Is there a dashboard for presentation of real-time information?

Deelrapport first impression (Taskforce Management Overstromingen, 2009a)

Introduction

The document is a short evaluation (first impression) of the actual main exercise of Waterproef. This note on the evaluation report is short due to the overlap with the previous note.

Relevant characteristic aspects of decision making process during flood calamities

It is noticed that in certain scenarios scaling between the water column and the general column are not linked, although it is usually advised to synchronize scaling. This can have advantages in the time available for decision making.

One of the general remarks concerning the exercise is that the calamity organization is complicated. Even for an expert involved in calamity management it can be hard to fully understand the organization. It is addressed that it is fruitful to use a central system to manage information, but that it is essential that is correctly used by everyone involved.

Constraints in use of technical information

A main problem was the information flows between decision making on the regional and the national level. Also, it was addressed that there were occasionally moment of information overflow. This was mostly the case for decision makers, they need information that is concise, clear and unambiguous.

Bestuurlijke samenvatting inhoudelijke evaluatie neerslag 14/15 juli 2011

(Hoogheemraadschap Delfland, 2011)

Introduction

The document is a short evaluation of the calamity management due to the high precipitation on the 14th and the 15th of July 2011. The evaluation is written from an organizational perspective.

Relevant characteristic aspects of decision making process during flood calamities

The decision making process is structured, so only global decisions need to be made when a calamity occurs. Based on observations a decision is made what protocol is followed. In each protocol a script describes actions to take. It is noticed that there are many scenarios that make the process of decision making complex.

Use of technical information

Decisions are made based on expected precipitation. Predefined scenarios are used to estimate effects of expected precipitation. The scenarios are made beforehand using flow models. After the calamity some sort of evaluation takes places whether the scenarios accurately described the situation. These evaluations also shows that a lot of questions during the calamity remain unanswered.

De dijkafschuiving in Wilnis op 26 augustus 2003, evaluatie van het functioneren van de calamiteitenorganisatie (Van der Bruggen et al., 2004)

Introduction

In August 2003 there was a levee failure near the town of Wilnis. No warnings signs were witnessed and it occurred in the middle of the night, which made the event completely unsuspected. The evaluation report is written from an organizational point of view. However, some useful information is present.

What technical information is used in the decision making process?

No flow information is used in the decision making process. This is caused by the short duration of the flood event of only a few hours. Groundwater level is of importance after the flooding. The rise of groundwater levels damages all kinds of infrastructure and constructions.

How is technical information used?

The decision to close-off the water ways the stop the flooding is made by people from the WAT on the moment they arrived at the breach location. External advisors are involved to give advice about stability of landmass bodies and to conduct monitoring. They are connected to the WOT. The ROT makes a request at the water board to deliver a person that can supply them with technical information. However, this results only in telephonic communication between the ROT and the water board. The WBT has no direct contact with technical information, there are informed by other network participants. The recommendations of the report address that there is room for improvement concerning the responsibility regarding specific information. A more clear and more formal distribution of tasks and responsibilities improves the quality of information lines. The advices is to pay more attention to defining formal information flows.

What constraints are encountered in the use of technical information?

The report does not go into details about technical information. Some considerations have been made, but the report does not mention what they are or what the constraint is.

VIII WORKSHOP 'VERVOLG CASE STUDY 3DI WATERNET'

Introduction

The workshop was organized by Nelen & Schuurmans on behalf of the 3Di consortium. The goal of the workshop is to learn about possibilities for improvement of complex decision making processes, by playing an interactive game. The result is an overview of the required analyzes for proper decision making. The workshop was led by Nelen & Schuurmans employees Anne Leskens and Martijn Siemerink.

The workshop is used to gain additional knowledge for this research. It is part of the expert knowledge gained in research question two to learn about use of technical information in the decision making process and the constraints encountered. The goal is to get familiar with the way technical information is used in the operational phase of flood calamity management and identify constraints in the use of technical information. Two questions are tried to be answered:

- How is technical information used in flood calamity management?
- What constraints are encountered in the use of technical information?

3D visualisation

In the first part of the workshop the case area is explored by using a 3D visualisation. Two scenarios are presented, flooding of the area due to a levee breach and water hindrance due to extreme precipitation.

Flooding due to levee breach

A scenario is visualized in which the Watergraafsmeer polder gradually floods. Participants see added value of the 3D visualization with respect to classic visualisations, but also suggestions for improvement are made.

- Adding extra data points by extra measurements
- Use existing information about building dimensions

It appears that workshop participants link irregularities in visualisation directly to possible flaws in the model itself, while this actually does not have to be the case.

Hindrance due to extreme precipitation

A scenario is visualized in which large amounts of water remain in the streets due to extreme precipitation. This case makes clear there is a demand for a single 'end' situation, so the size of the problem is clear. A dynamic event over time create confusion about the essence of the problem. The small scale in the model raises doubt about validity of the model. Improvements of the model are suggested by using:

- Line shapes
- Technical drawings of spatial planning
- Infiltration areas

The participants summarize that data and information used to create the model should correctly represent reality.

Game

During the game participants were asked to design solutions to both problems, hindrance and flooding, in both a selection of the Watergraafsmeer polder and a selection. The objective was to integrate all stakes and develop one master plan for both issues.

On a small the processes differs strongly in the two groups. The first group thought lightly about possible measures. They first brainstormed about possible measures, then explored effects of possible measures and finally chose the measures best supported by the participants of the group. In contrary the second group first recognized that measures for water hindrance are more easy to consider, so they mainly focus on these. The second groups struggles in exploring measures and finds problems considering different priorities and legal aspects.

Important aspects that become visible during the game was the need to quickly assess possible measures. In addition is should be possible to use technical information to quickly bring different opinions together for one decision. Last, it is considered to be of importance that civilians understand the importance of decisions taken, so they are widely publicly supported.

The process regarding decision making on larger spatial scale was similar, although there were a few differences. The increased area appeared have more opportunities for measures. However, small scale problems should be viewed on a small scale map. The participants seem to be more aware about possible uncertainties and want to design measures that are robust for deviations in design standards.

Evaluation of the game

A point wise summary is made of the evaluation.

- There is a need for quick assessment of measures, so quick filtering of useless measures is possible.
- In a design process an iterative process is preferred, with increasing detail or accuracy in each step.
- Water management is increasing in complexity, normative assessment is becoming decreasingly adequate.
- During floods there is a demand for clear and simple information, such as the amount time available or expected economic damages.
- Understanding of urgency is important for being able to implement measures.

Interactive modelling

Possible measures are modelled in the group. The interactive way of modelling quickly learns all participants about properties of the system. All participants create a sense of feeling about the considered water system, which appear to improve the quality and the speed of the decision making process.

Conclusions

The experiences of the workshop are summarized in three points.

- By interactive modelling all people involved get feeling about the system.
- Interactive modelling is very suitable for use in spatial planning policy issues.
- Interactive modelling increases the ability for integrated assessment of a set of possible measures. For future assessment, normative assessment probably no longer satisfies.

The participants of the workshop were not specific about use of technical information in the operational phase of flood calamity management. Therefore, the results are limited applicable. However, observing the workshop however has contributed greatly to the author’s knowledge about decision makers values and beliefs.