

1. Application of 3Di in Trial 1

1.1 Introduction

The hydrodynamic model 3Di supports decision-making in crisis management situations. The 3Di instrument is accurate, fast and visible. With these abilities 3Di provides flood simulations that can instantly help to get a better Common Operational Picture and raise situational awareness among all stakeholders (including non-experts). Furthermore, 3Di provides the possibility to alter the model instantly to calculate other possible scenarios. For instance to see and measure the effects of possible measures.

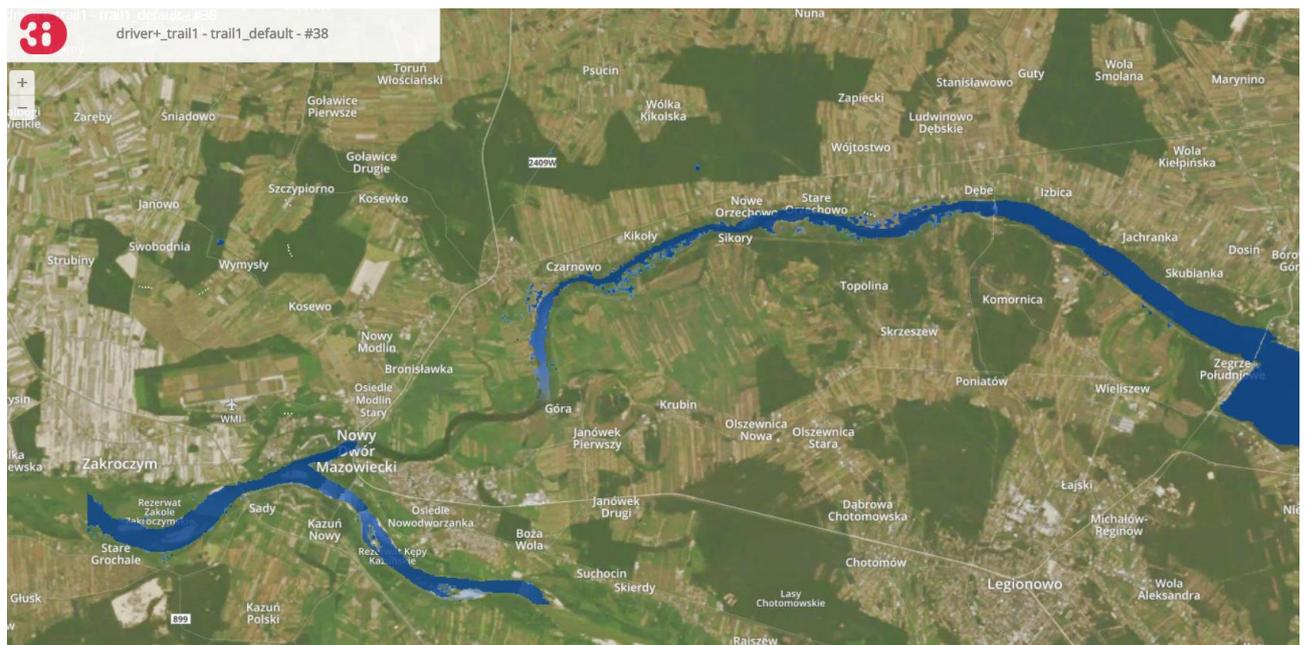


Figure 1-1 User interface of the 3Di livesite.

In Trial 1 the 3Di instrument was tested as a solution to improve both the COP and the situational awareness in flood simulations. To test the added value in Trial 1 two teams had the assignment to make a priority list for the evacuation of designated buildings in the area, following a scenario of a toxic flood originating from a breach in a storage of toxic mud located at Zegrzynski lake. One team had the possibility to use the 3Di model. The other team received static information as their source of information. The team with 3Di had the possibility to use the model interactively for optimal insight into the flood pattern, arrival times and the effect of potential measures on the disaster. To execute a valid test of the added value of 3Di in the Driver+ program several preparations were carried out. In the next paragraph these steps are described. The third paragraph describes how 3Di was used during the Trial.

1.2 Activities in the preparation of Trial 1

In the preparation of Trial 1, 3Di was prepared in three ways:

1. The technical integration of 3Di with the Testbed and Socrates
2. Building a 3Di model for the selected area of interest
3. Configure the 3Di model to be ready-to-use during the Trial

In the next paragraphs each of the preparation steps are described. Here, the activities for the application of 3Di in general and the activities that were done particularly for the Trial are distinguished.

1.2.1 Technical integration of 3Di in Driver+ (Testbed and Socrates)

The 3Di instrument consists of several technical components which make it possible to use 3Di operationally during crisis management. The figure on the right shows three important elements that are available to use 3Di live from every location with an internet connection.

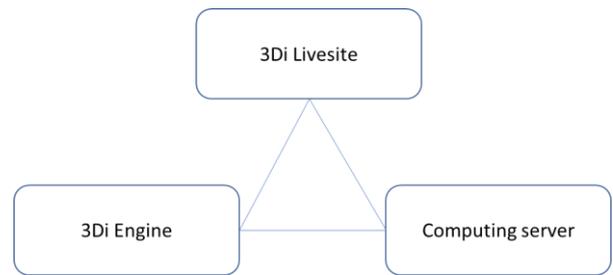


Figure 1-2 General architecture 3Di instrument making it possible to calculate in the cloud.

The 3Di engine entails the code to compute water flow in 1D and 2D for flooding, drainage and other water management studies. The engine is based on state-of-the-art numerical schemes. The engine makes use of a so-called subgrid method. This technique includes high resolution information in coarse resolution computations. This guarantees both accuracy and efficiency. The 3Di engine includes a whole range of processes, including surface run-off, 1D and 2D surface water and groundwater flow. Moreover, it can deal with 1D sewer flow and structures like pumps, weirs and culverts. 3Di deals with numerous external forcings, like precipitation from radar images and wind.¹

The 3Di Livesite is the user interface to run a 3Di model and allows users to interact with the model during a simulations. On the livesite users are able to interactively influence the simulation by changing the rainfall, wind force and model components like cross-sections, breaches and pump capacities. Through the livesite connections are available with **computing servers**. The computing server delivers the computation power that is needed to run the model. This connection makes it possible to use 3Di models from every place with an internet connection. The only recommended software to be installed before using the 3Di livesite is the Google Chrome Browser.

In Trial 1 the 3Di Livesite was the user interface available for practitioners. The use case for integration of the Testbed and with Socrates was about sharing information for situational awareness during the crisis management situations and sharing information about the effect and design of measures to mitigate the consequences of a flood.

The 3Di Livesite provides the option to export [store] results of a model run. The results of a model run are stored in a NetCDF-file. The NetCDF is written according to the CF conventions.² Through the 3Di – API it is possible to download the NetCDF-file. For the GIS software QGIS a 3Di plugin is developed to read and use the NetCDF file.

The most used possibility to store and visualize the results of a model run is through the information platform Lizard and its API. Within this route the NetCDF with raw data is made available in the user interface of Lizard.³ From Lizard and its API it is

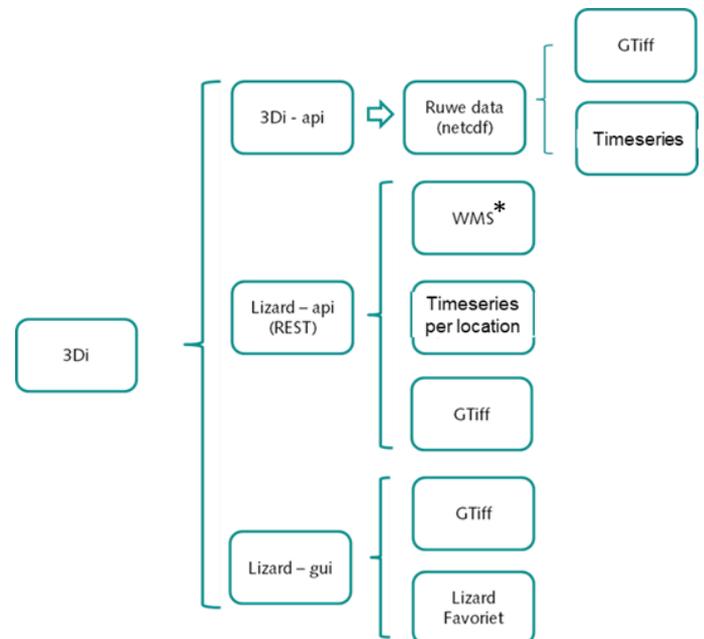


Figure 1-3 Possibilities to export 3Di results.

¹ The 3Di engine is developed by Prof. dr. ir. G. S. Stelling, who worked on the subgrid technique in close collaboration with Prof. dr. ir. V. Casulli. Most of the techniques used within the 3Di engine are published in scientific papers.

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possible to export data in different formats. The WMS is under development and was not available for the Trial.

The ambition for Trial 1 was to integrate 3Di into the Test-bed and to make the 3Di results available in Socrates. During Dry Run 1 a first design of the architecture was available (see figure 2-3). During Dry Run 1 and in the weeks after a special GeoServer was set up to make the transfer of GeoTIFF files with 3Di results possible. The aim was to send the GeoTIFF file with the maximum water depth levels of a model run on an decisive moment. See the workflow below of the designed process.

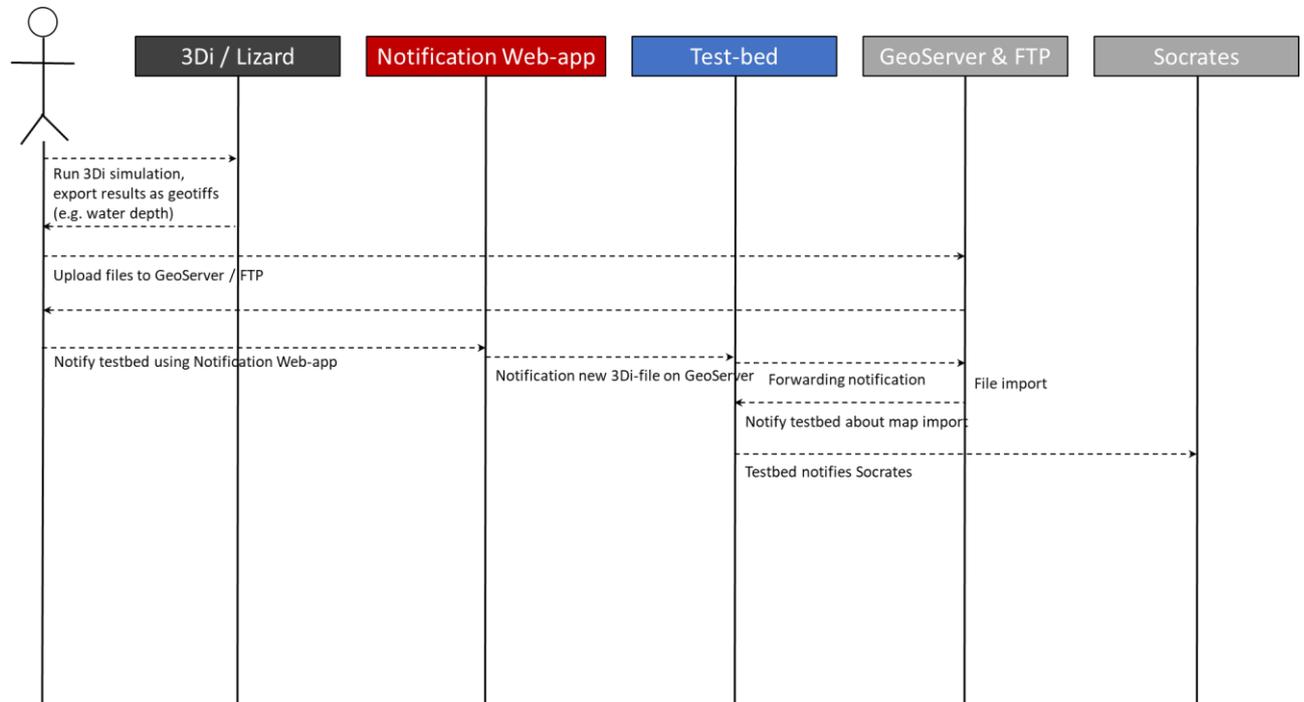


Figure 1-4 Workflow design integration 3Di, Testbed and Socrates

During Dry Run 2 the connections were functioning as designed. However, the time of uploading of the large GeoTIFF files was much longer than expected. Therefore the decision was made to leave the transfer of GeoTIFF files out of the test-Trial and the Trial. It was at this point and within this timeframe not possible to develop a better connection. It is possible that the WMS export format, which is in development, will make this a lot easier.

During the test-Trial the information flow between 3Di/Lizard and the Notification Web-app, Test-bed and Socrates was a message to send when the practitioners finished a model run worth to share. The practitioners with 3Di available had the task to decide whether the information from 3Di was helpful to share to increase the COP of all stakeholders. During the test-Trial in DryRun2 this workflow was successfully tested.

Unfortunately, was it not possible to test this infrastructure during Trial 1. The Test-bed and associated functions were out of order at the moment that 3Di was tested.

1.2.2 Building the 3Di model for the area of interest

To make use of the 3Di instrument a model needs to be available of the area of interest. The very first step in the preparation of the Trial was to build a 3Di hydrodynamic model of the area of interest. In figure 4-5 the workflow to build a 3Di model is visualized. Here, it is presented as a straight while in reality constant iterations are made to test and improve the model.

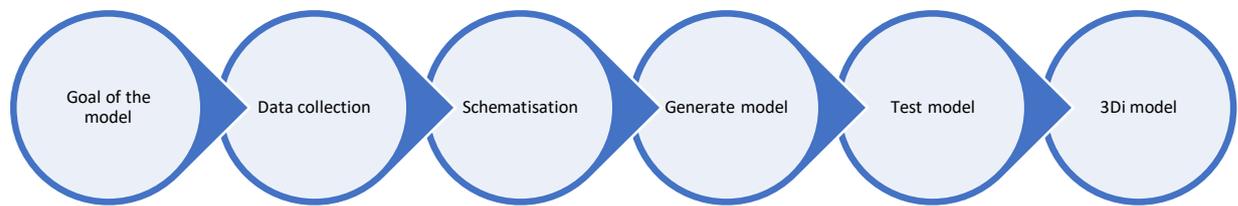


Figure 1-5 Steps to take to build a 3Di model

The first step to determine the goal of the model is an important step. The goal of the model determines the functions that are used and determine the critical data requirements. For Trial 1 the goal was to test the usability of 3Di during decision-making. Therefore, it was important that the model gives a good impression of the flood zones and the model is fast enough to use it interactively. In case of this flooding model, a sewerage system for example can be left out of the model since it will not make a difference on river floods.

Most of the data required to build a 3Di model is geo information (e.g. raster data, 1D elements). For the collection of data and the schematisation GIS knowledge and software is needed. The mostly used GIS package that is used to build 3Di models is open software QGIS. In QGIS an especially designed 3Di plugin is available for support.

Within a 3Di flood model the resolution of the Digital Elevation Model determines for an important part the accuracy of the model. Since this was a test case it was decided to use the already available ASTER Global-DEM with a 30 by 30 meter resolution, which is available worldwide. In order to improve the results of the model this DEM was interpolated into a 5 by 5 meter resolution. Furthermore, the schematisation was used to make the results as realistic as possible. Before Dry Run 1 the following components were added in the 3Di model:

- creating a fictive dam in the river Narev at Debe
- creating a fictive dam between the river Narev and the river Wisla at Nowy Dwór Mazowiecki
- creating levees alongside the river Narev
- creating an initial water level in the river Narev

During Dry Run 1 the model was demonstrated and tested. In regular modelling building practices the goal of the model is evaluated and local knowledge on the area is used to improve the model. In this case the ones responsible to make the crisis scenarios during Trial 1, the Trial organisation, set the starting points and assumptions for the model. The following adjustments were made in the model after Dry Run 1:

- adjusting geographic extent model
- adjustment DEM interpolated to 5x5m
- adjusting friction within the riverbed to 0.035 (to simulate mud-like fluid)
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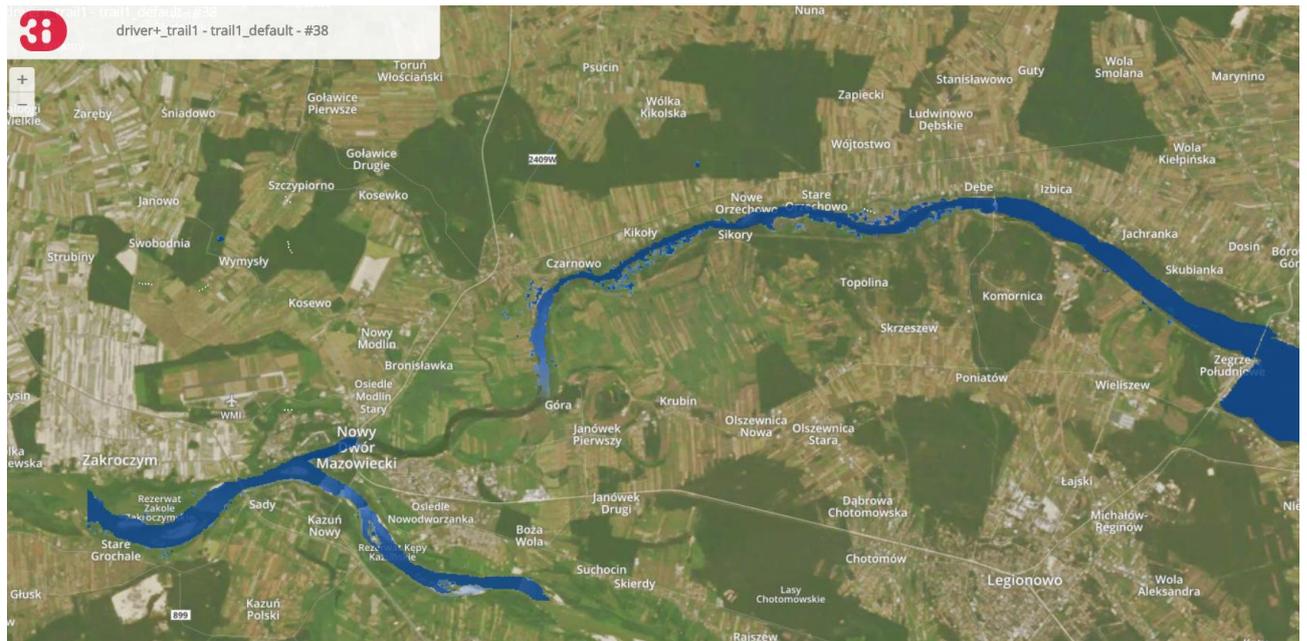


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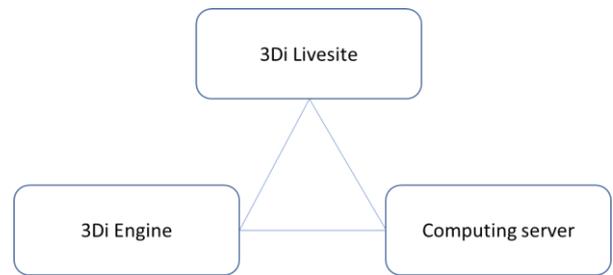


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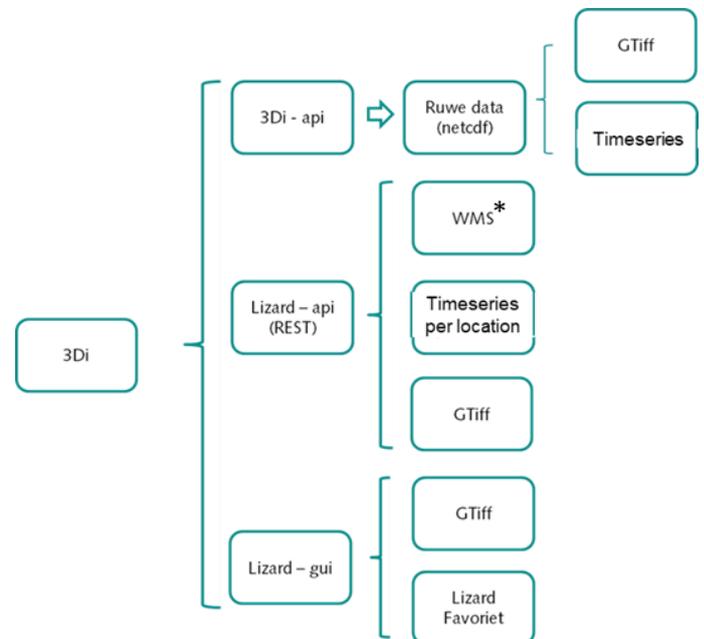


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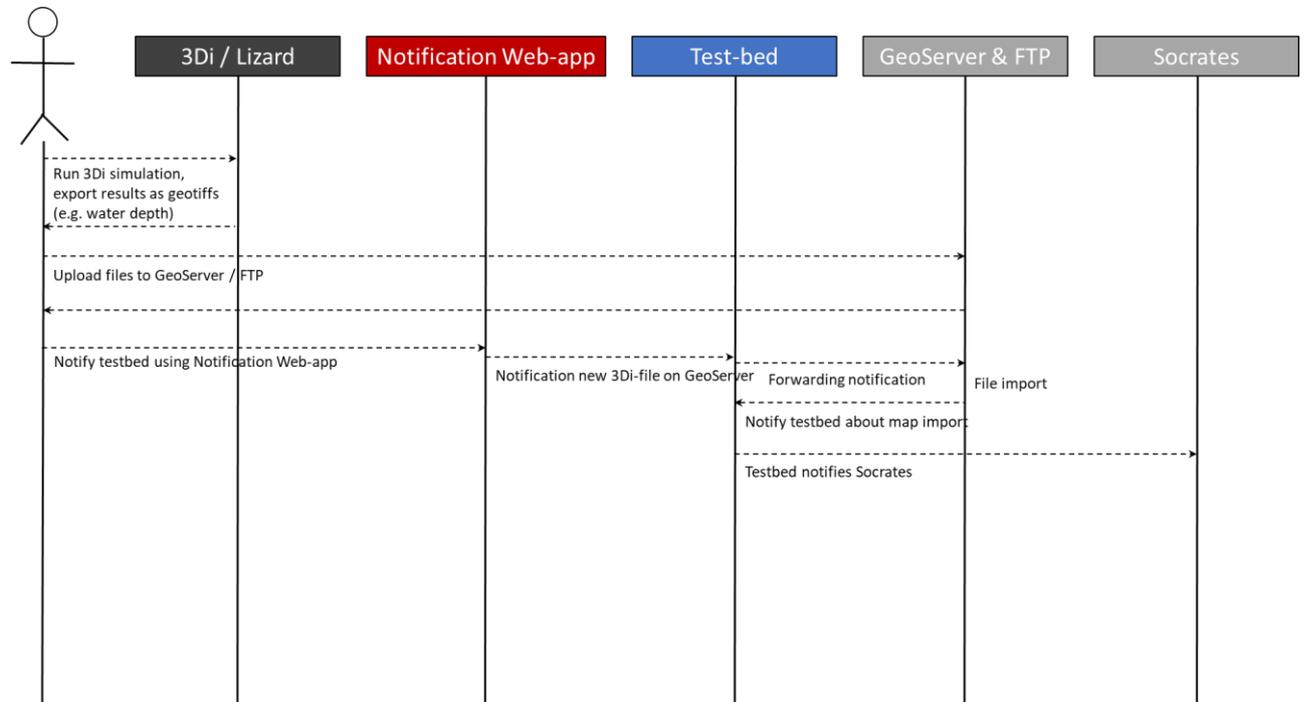


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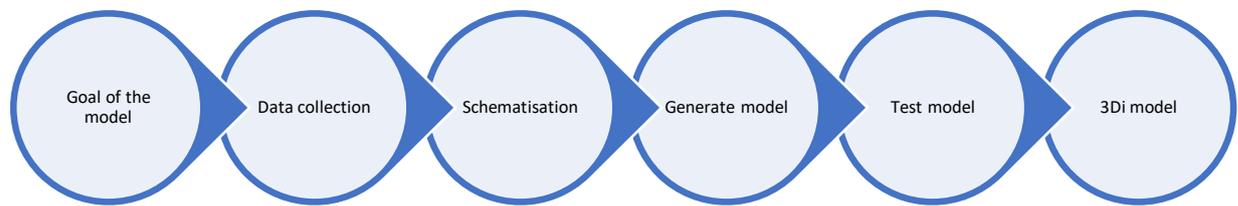


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2.2.3 Scenario configurations

3Di offers a range of possibilities to alter and configure the 3Di model to calculate the result of specific scenarios. This is both possible in the settings of the model and possible on the live site. Several options are available to configure particular scenarios within the 3Di model. In the screenshots below two options are given: how to adjust forcing on the model (rain, a positive or negative discharge point and wind) and how to open and close breach locations. The latter was mainly used during Trial 1.



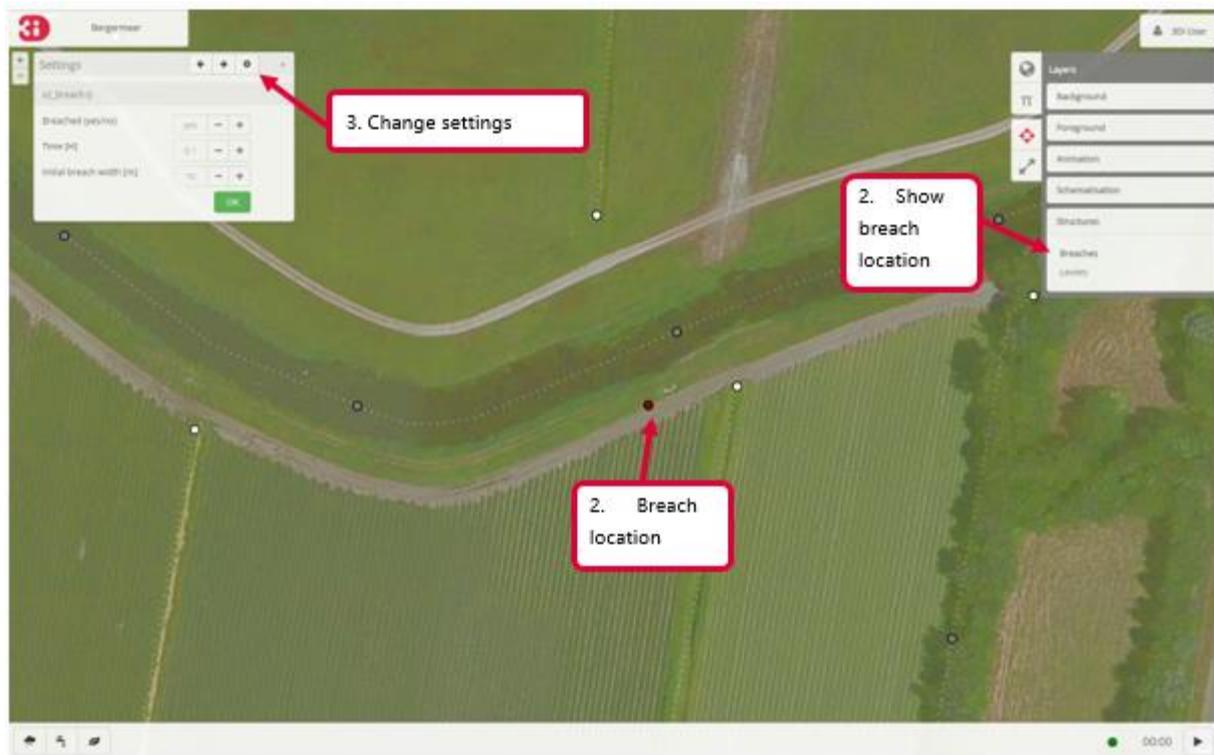


Figure 2-6 Two print screens of the user interface of the 3Di live site, where is shown how to adjust forcing on the model and how to work with breaches in the model.

In order to support the scenario of Trial 1 and to make it possible to test 3Di in the given timeframe of the Trial we configured the model on the scenario. The most important adjustments were adding particular breach locations after Dry Run 1. After testing the scenario story and the model in Dry Run 2, an extra breach location was added to the model. Furthermore, in between Dry Run 1 and Dry Run 2, two instances of the model were created. One model where the flood started with a breach in the dam and one instance where the flood already reached nearby the town Gora. In this way the practitioners had more time for analysis and fulfilling their task to determine the order of evacuation and testing the added value of dynamic flood information from 3Di.

2.3 Solution usage in Trial 1

During Trial 1 3Di was used to get an overview of the flood pattern of the chemical spill. One team of practitioners had 3Di available to decide on the evacuation order of selected buildings while the other team did not have 3Di available. The aim of the Trial was to test the operational use of 3Di during a crisis management situation, and whether 3Di could support the crisis managers in their decision making process on evacuation. In this Trial 3Di was used as an independent operating system. The connection with Socrates and the Testbed were not tested during Trial 1.

The team which had access to 3Di worked along a two-step strategy to determine which buildings had to be evacuated and in which order:

1. Determine the priority in terms of risk of the designated buildings
2. Determine the order of evacuation by priority and expected arrival time of the water

Step 1: Risk of designated buildings

The team used a standardized method to determine the risk for each of the designated buildings. For each of the buildings the team weighed the risk following the formula:

$$\text{Risk} = \text{Height} * \text{Exposure} * \text{Vulnerability}$$

Height = height difference between highest water level in proximity of building and elevation of building, or time of first arrival of water

Exposure = number of persons present

Vulnerability = mobility of affected persons and/or vulnerability or importance of building

3Di was used as an information source to determine the Height. The team simulated about half a day of the flood and processed those results to Lizard, in which they located all the buildings and determined the height difference between the highest water level in the proximity of the building and the elevation of the building (Height) per location. In the determination of the Height, the team took into account that models are always an approximation of reality, meaning that the actual water level might be higher or lower.

The number of persons present per building (Exposure) was not provided in the Trial. Depending on the time of day and the use of the building, the team assumed whether people would be present in the building or not. For example: people will only be present in a school during school hours and not at night, while a hospital will always contain people. Therefore, if the water reaches a school during night time, it will not need evacuation since no persons will be present at that time. The time needed to evacuate a specific building or the availability of vehicles were not considered in this Trial.

In the Vulnerability both the mobility of the people present and the vulnerability or importance of the building were taken into account by the team. For example: the team assumed that people in a church will be able to evacuate themselves if given a long enough notice, while people in a hospital will always require assistance. Furthermore, some buildings are important to protect, especially when they have a high economic value.

Using all three variables the team determined the priority in terms of risk for all buildings, focusing on the buildings in the proximity of or in the flooded area.



Figure 2-7 The team working on determination of the risk in Trial 1

Step 2: Order of evacuation

The team determined the order of evacuation by combining the risk of designated buildings as determined in step 1 with the arrival times of water as present in Lizard after processing of the 3Di results. First the flooded areas were considered, taking water arrival times and speed of water depth increase into account, second the buildings close to flooded areas were considered. Using both those steps the team decided on which buildings to evacuate and in which order.

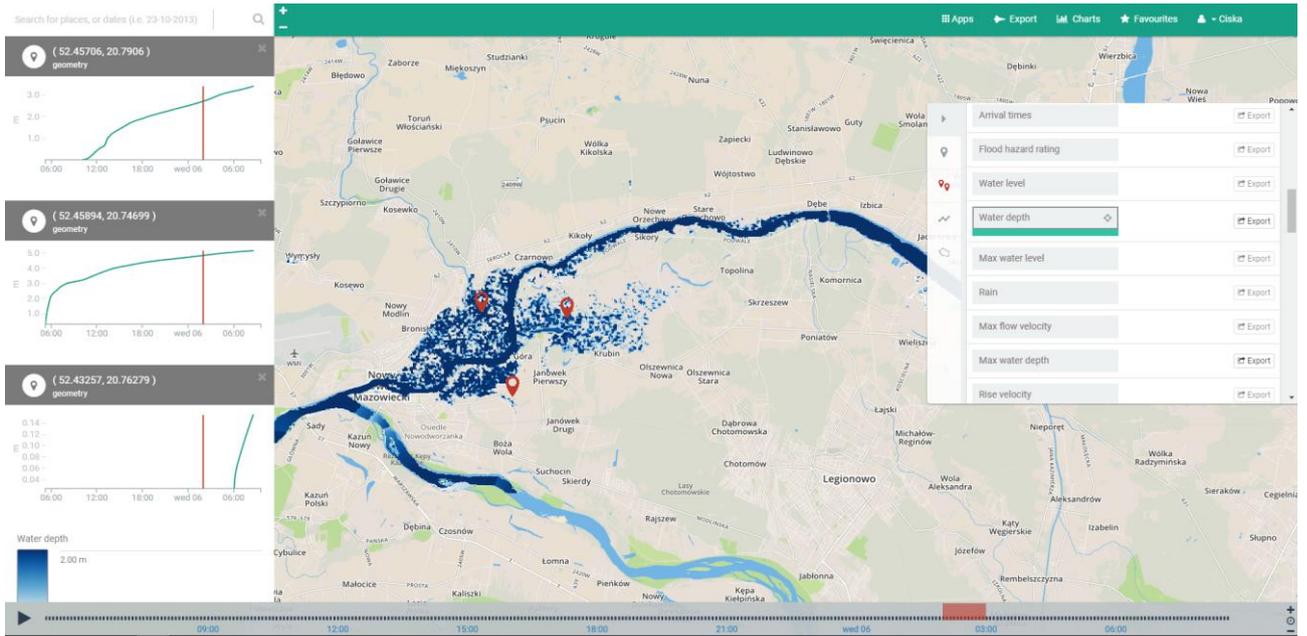


Figure 2-8 Water depth as shown in Lizard after processing of 3Di results, with three marked locations