Manual - Oil Spill Model to Model Oil Spills During Flooding Events in a Freshwater Environment

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Link to Model: https://github.com/Ch-Brun/Oil-Spill-Model

Content

Structure

The developed oil model is a combination of the modelling of the flooding event in HEC-RAS 5.0.6 and the further processing of the results in QGIS3. The results of the HEC-RAS model serve as input parameters for the oil spill model in QGIS3. In particular, the calculations of the flow depths, the x and y components of the flow velocities on the different nodes and the created mesh of the flooding areas are used for the further processing in QGIS.
The final oil spill model is composed of two different models which are linked to each other (see Figure 1). Model 1 simulates the first step of an oil spill during a flooding event. It is responsible to generate the oil spill elements and simulate the way of the elements from the leakage of the oil tank inside the building to the outside of the building, where the heating oil floats on the water surface and is entrained by the currents. The output of the first model then serves as starting input for the second model. The second model simulates the behaviour of an oil spill outside of the building, moving away from its source while floating on top of the water surface and getting entrained by the currents. The second model is looped over all the selected timesteps until the desired end time or until all or most of the elements have been deposited.

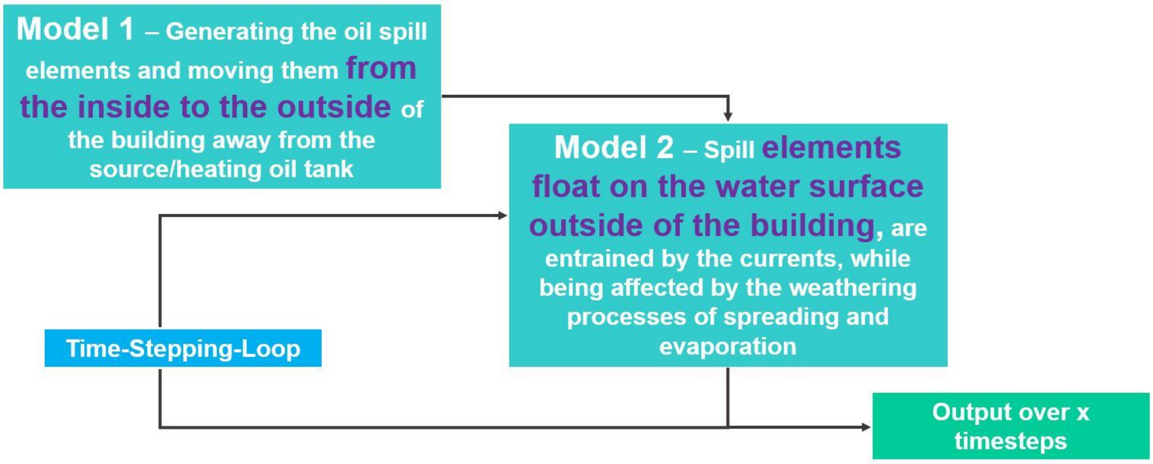


Figure 1: Relationship between Model 1 and Model 2 (see Relationbetweenthemodel1&2.jpg for a higher resolution of the picture, https://github.com/Ch-Brun/Oil-Spill-Model/blob/master/Relationbetweenthemodel1%262.JPG).

Both models generally follow the subsequent structure:

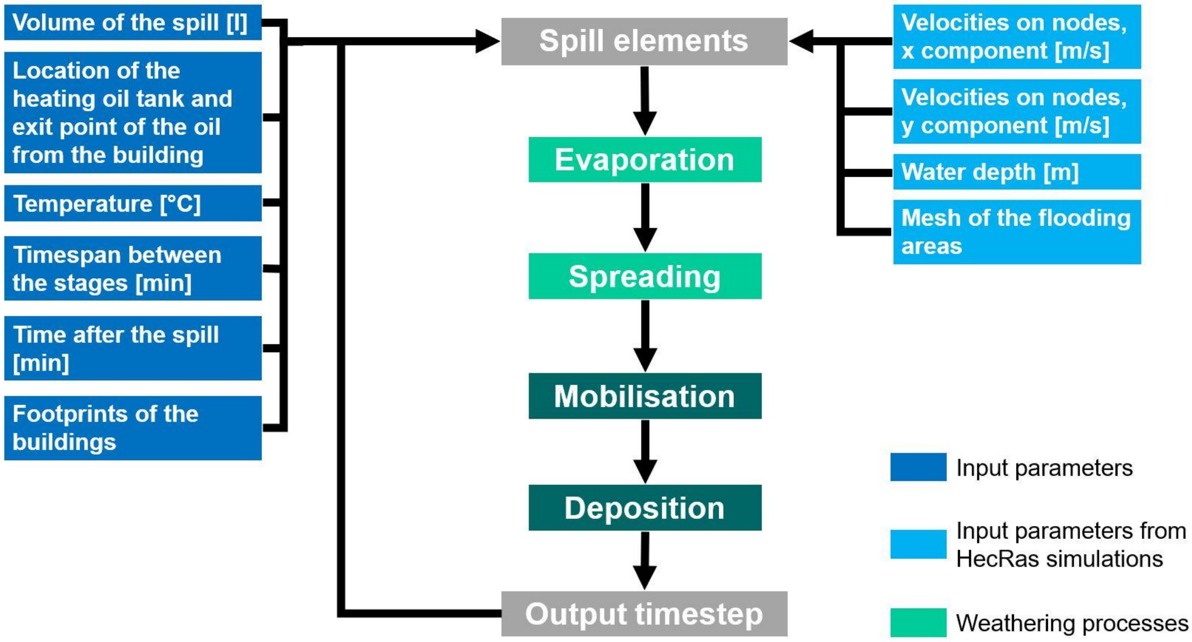


Figure 2: General structure of the Model (see Generalstructure.jpg for a higher resolution of the picture, https://github.com/Ch-Brun/Oil-Spill-Model/blob/master/Generalstructure.JPG).

Detailed structure of Model 1 with the respective functions in QGIS3

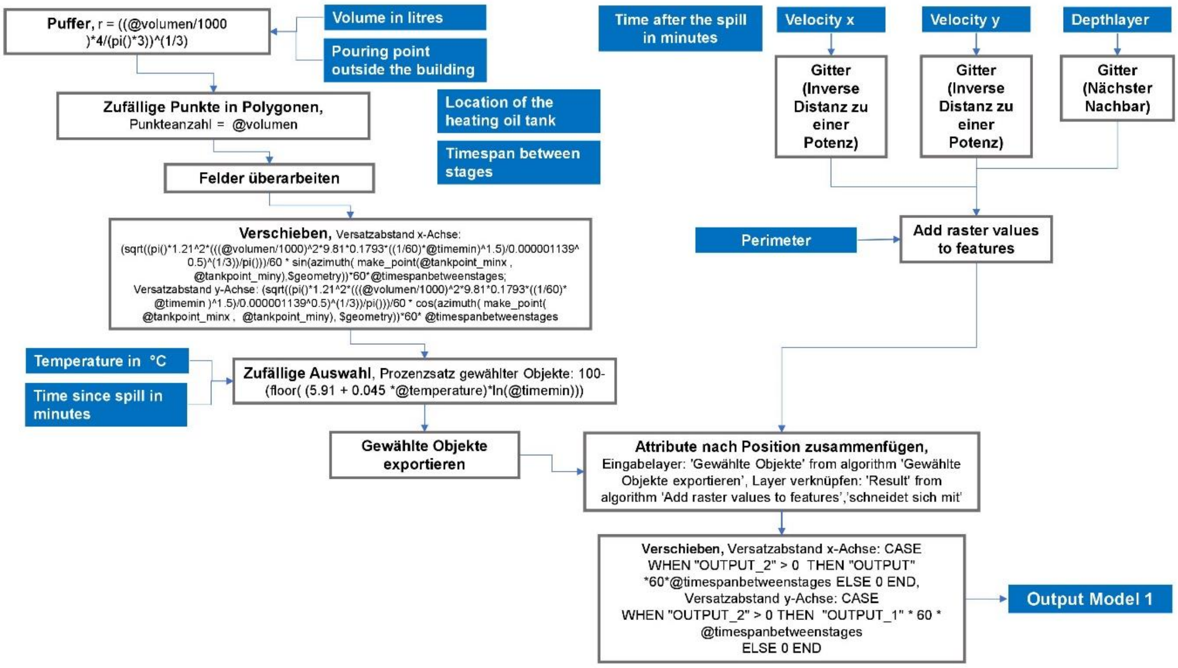


Figure 3: Detailed structure of Model 1 (see Model1QGIS,jpg for a higher resolution of the picture, https://github.com/Ch-Brun/Oil-Spill-Model/blob/master/Model1QGIS.jpg).

Detailed structure of Model 2 with the respective functions in QGIS3

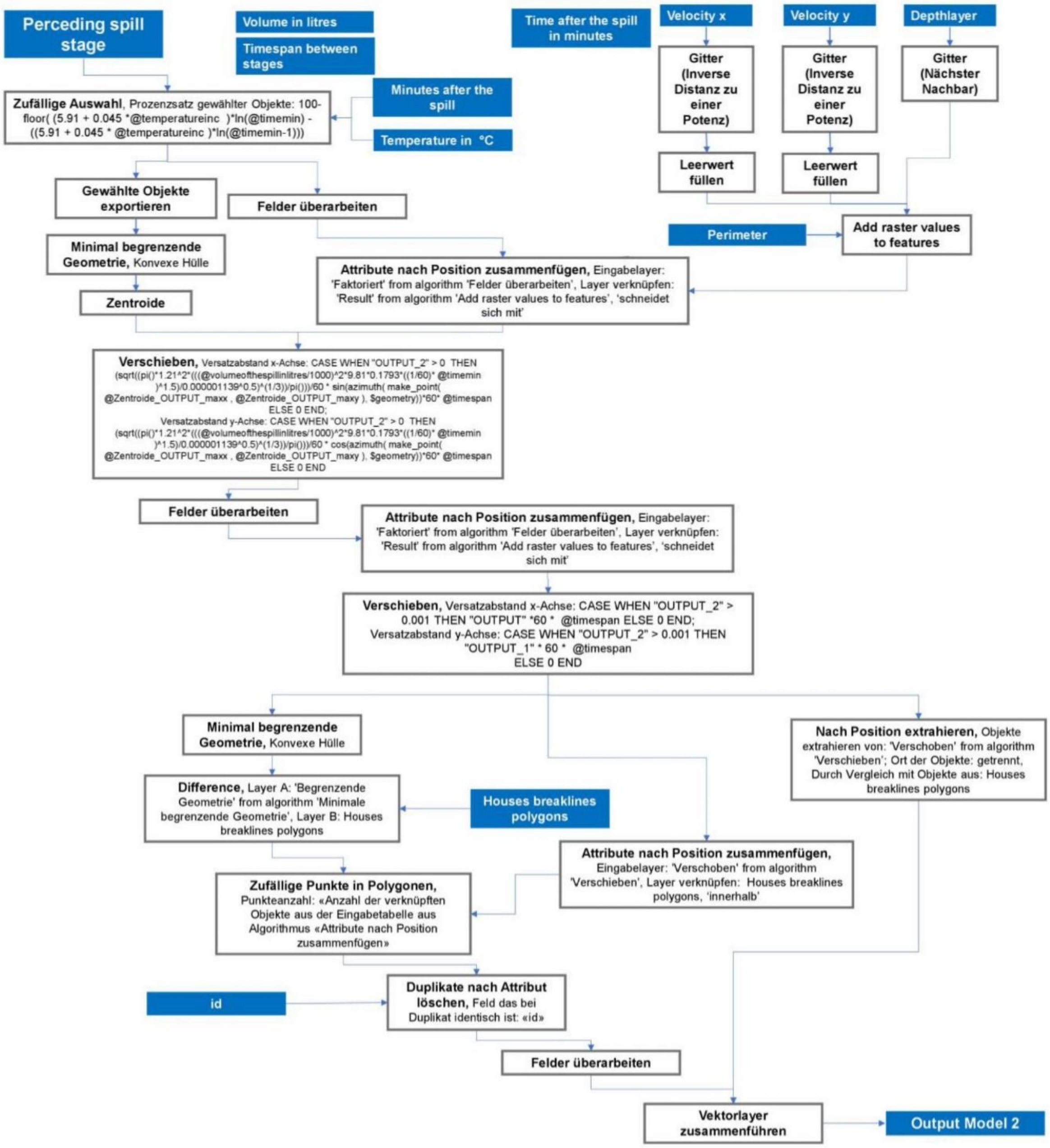
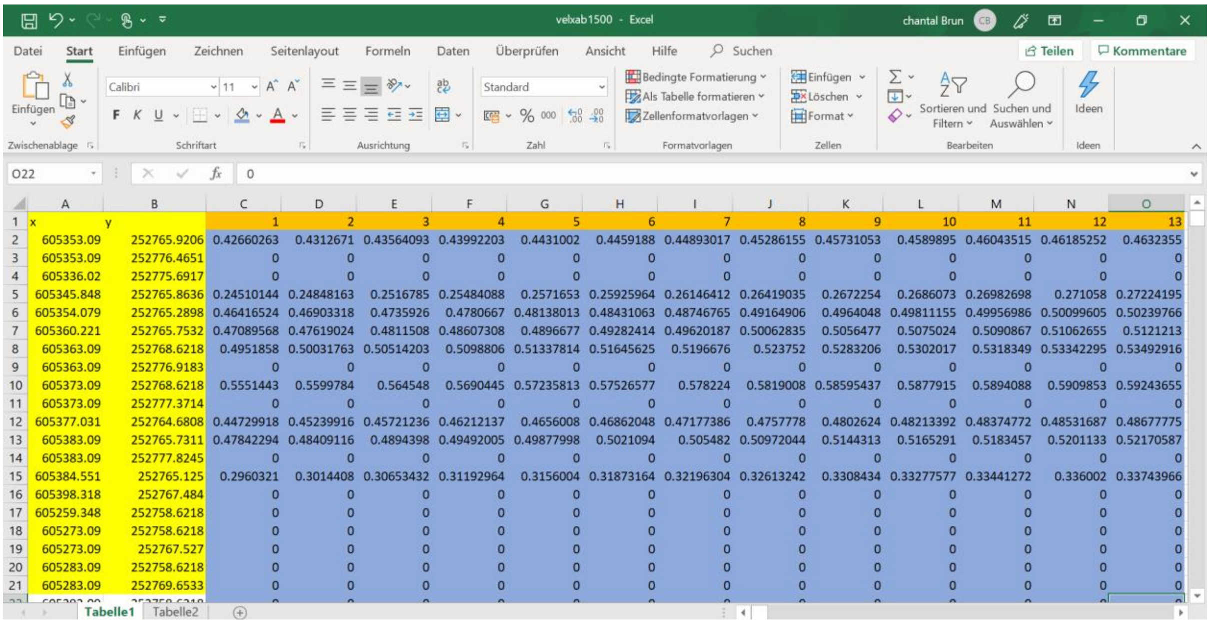


Figure 4: Detailed structure of Model 2 (see Model2QGIS.jpg for a higher resolution of the picture, https://github.com/Ch-Brun/Oil-Spill-Model/blob/master/Model2QGIS.jpg).

Instructions

1) Open Hdf5 file from HEC-RAS simulation
2) Export and save as text file coordinates for all the nodes for all the flow areas
   a. Geometry/2D Flow Areas/»Name of the flow area»/FacePoints coordinates
3) Export and save as text file x and y component of the velocities on the nodes
   a. Results/Unsteady/Output/Output Blocks/Base Output/Unsteady Time Series/2D Flow Areas/»Name of the flow area»/Node X Vel respective Node Y Vel
4) Export and save as text file x and y component of the velocities on the nodes
   a. Results/Unsteady/Output/Output Blocks/Base Output/Unsteady Time Series/2D Flow Areas/»Name of the flow area»/Depth
5) Import velocity, depth and coordinates text files in excel
6) Select the predefined timesteps of the x and y component for the velocities as well as the depth dataset for the modelling, transpose data (see part of the table of the print screen coloured in blue) and add the x and y coordinates of the nodes in front of the data (see part of the table of the print screen coloured in yellow)
7) The timesteps of the velocities and depth dataset must be renamed, each timestep has to be added the time information of how much time (in minutes) has passed since the oil was spilt (see part of the table of the print screen coloured in orange)
8) The tables should now look like the following print screen:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	x	y	1	2	3	4	5	6	7	8	9	10	11	12	13
2	605353.09	252765.9206	0.42660263	0.4312671	0.43564093	0.43992203	0.4431002	0.4459188	0.44893017	0.45286155	0.45731053	0.4589895	0.46043515	0.46185252	0.4632355
3	605353.09	252776.4651	0	0	0	0	0	0	0	0	0	0	0	0	0
4	605336.02	252775.6917	0	0	0	0	0	0	0	0	0	0	0	0	0
5	605345.848	252765.8636	0.24510144	0.24848163	0.2516785	0.25484088	0.2571653	0.25925964	0.26146412	0.26419035	0.2672254	0.2686073	0.26982698	0.271058	0.27224195
6	605354.079	252765.2898	0.46416524	0.46903318	0.4735926	0.4780667	0.48138013	0.48431063	0.48746765	0.49164906	0.4964048	0.49811155	0.49956986	0.50099605	0.50239766
7	605360.221	252765.7532	0.47089568	0.47619024	0.4811508	0.48607308	0.4896677	0.49282414	0.49620187	0.50062835	0.5056477	0.5075024	0.5090867	0.51062655	0.5121213
8	605363.09	252768.6218	0.4951858	0.50031763	0.50514203	0.5098806	0.51337814	0.51645625	0.5196676	0.523752	0.5283206	0.5302017	0.5318349	0.53342295	0.53492916
9	605363.09	252776.9183	0	0	0	0	0	0	0	0	0	0	0	0	0
10	605373.09	252768.6218	0.5551443	0.5599784	0.564548	0.5690445	0.57235813	0.57526577	0.578224	0.5819008	0.58595437	0.5877915	0.5894088	0.5909853	0.59243655
11	605373.09	252777.3714	0	0	0	0	0	0	0	0	0	0	0	0	0
12	605377.031	252764.6808	0.44729918	0.45239916	0.45721236	0.46212137	0.4656008	0.46862048	0.47177386	0.4757778	0.4802624	0.48213392	0.48374772	0.48531687	0.48677775
13	605383.09	252765.7311	0.47842294	0.48409116	0.4894398	0.49492005	0.49877998	0.5021094	0.505482	0.50972044	0.5144313	0.5165291	0.5183457	0.5201133	0.52170587
14	605383.09	252777.8245	0	0	0	0	0	0	0	0	0	0	0	0	0
15	605384.551	252765.125	0.2960321	0.3014408	0.30653432	0.31192964	0.3156004	0.31873164	0.32196304	0.32613242	0.3308434	0.33277577	0.33441272	0.336002	0.33743966
16	605398.318	252767.484	0	0	0	0	0	0	0	0	0	0	0	0	0
17	605259.348	252758.6218	0	0	0	0	0	0	0	0	0	0	0	0	0
18	605273.09	252758.6218	0	0	0	0	0	0	0	0	0	0	0	0	0
19	605273.09	252767.527	0	0	0	0	0	0	0	0	0	0	0	0	0
20	605283.09	252758.6218	0	0	0	0	0	0	0	0	0	0	0	0	0
21	605283.09	252769.6533	0	0	0	0	0	0	0	0	0	0	0	0	0

9) Save excel files (x component and y component of velocities and depth) and import both files in QGIS3
10) Directly extract the created mesh from the HEC-RAS simulation as shapefile and import in QGIS3
    a. Go to Geometry in RAS Mapper, go to 2D flow areas, right-hand click on “Perimeters”, select “Export Layer”, select “Save Features to Shapefile”
11) Extract the houses polygons of the Break Lines from the HEC-RAS simulation as a polygon shapefile
    a. Go to Geometry in RAS Mapper, go to 2D flow areas, right-hand click on “Break Lines”, select “Export Layer”, select “Save Features to Shapefile”
12) Define and create a point shapefile of the location of the heating oil tank

13) Define and create a point shapefile of where the oil is supposed to have exited the building

14) Download script (Model1script.py) or modelbuilder file (firststagemodel_CB.model3) of Model 1 from: https://github.com/Ch-Brun/Oil-Spill-Model

15) Execute Model 1 once

16) Download script (Model2script.py) or modelbuilder file (secondstagemodel_CB.model3) of Model 2 from: https://github.com/Ch-Brun/Oil-Spill-Model

17) Execute Model 2 with input from the Model 1 over desired end of time

18) Results can be best viewed or extracted to video with TimeManager (link to download: https://plugins.qgis.org/plugins/timemanager/) in QGIS3

➔ Testdata can be downloaded as well on: https://github.com/Ch-Brun/Oil-Spill-Model, see text files “velocitiesxnodes”, “velocitiesynodes”, “depth”, “meshLaufen” and “breaklinesLaufen”

➔ The test data is based on the event of the 8th/9th of August in 2007 for the city of Laufen, Basel-Country, Switzerland.

About Model 1

Setup in QGIS3

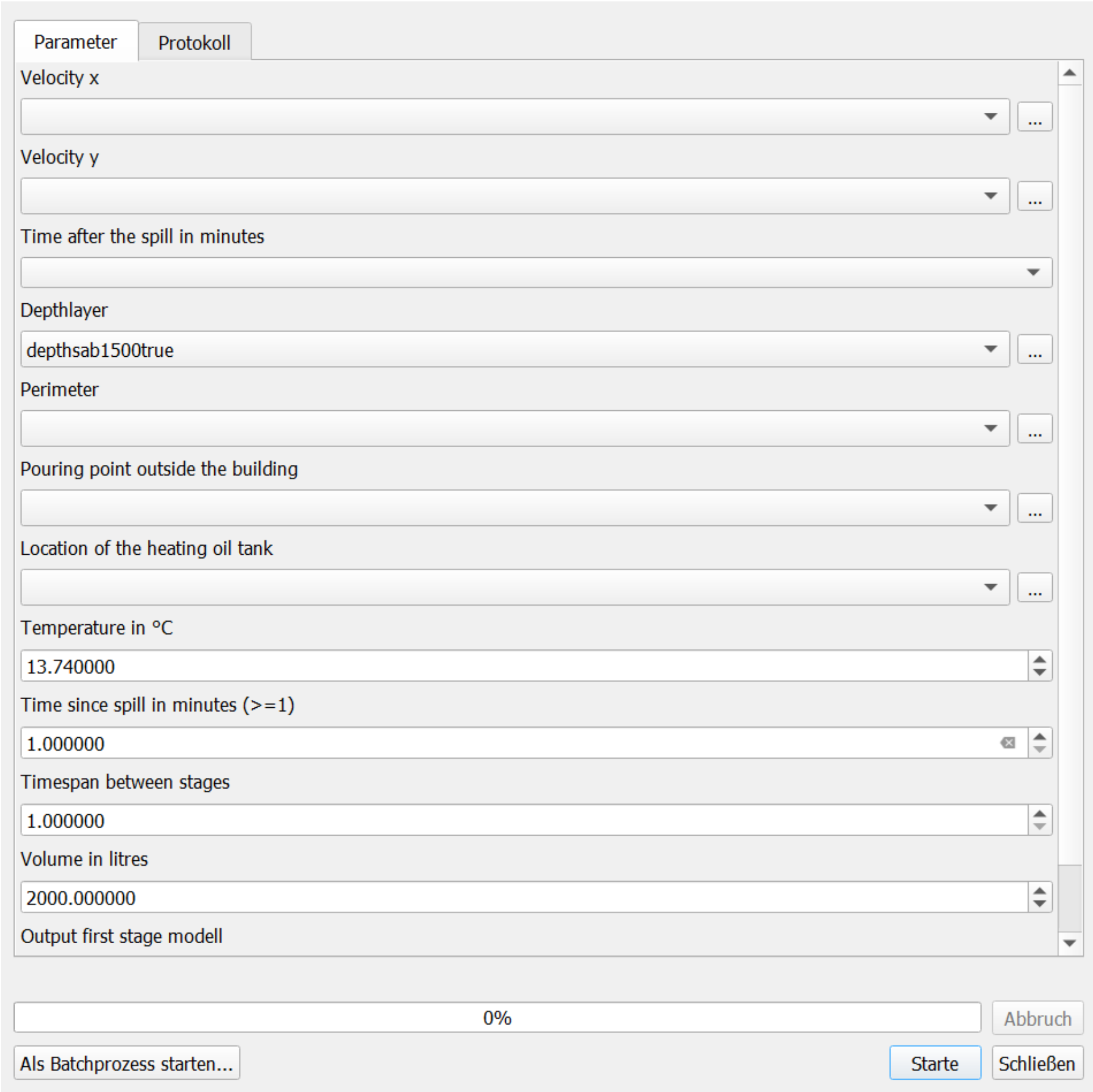


Figure 5: Setup of Model 1 in QGIS3.

Variables

- **Velocity X**: Input file of the x component of the modelled velocities (file format: point shapefile)
- **Velocity Y**: Input file of the y component of the modelled velocities (file format: point shapefile)
- **Time after the spill in minutes**: Select the timestep in minutes (based on Velocity X file)
- **Depthlayer**: Input file of the modelled water depths (file format: point shapefile)

- **Perimeter**: Input file of the mesh created in HEC-RAS (file format: polygon shapefile)
- **Pouring point outside of the building**: Coordinates of the point where the oil is supposed to have exited the building (file format: point shapefile)
- **Location of the heating oil tank**: Coordinates of the heating oil tank (file format: point shapefile)
- **Temperature in °C**: Insert temperature information at the selected timestep (file format: number)
- **Time since spill in minutes**: Choose the selected timestep (Minimum: 1 minute, maxima: 1440 minutes)
- **Timespan between the stages**: Select the timespan in minutes between the modelled timesteps (Minimum: 1 minute, maxima: 100 minutes)
- **Volume in litres**: Volume of the oil spill in litres (file format: number)

About Model 2

Setup in QGIS3

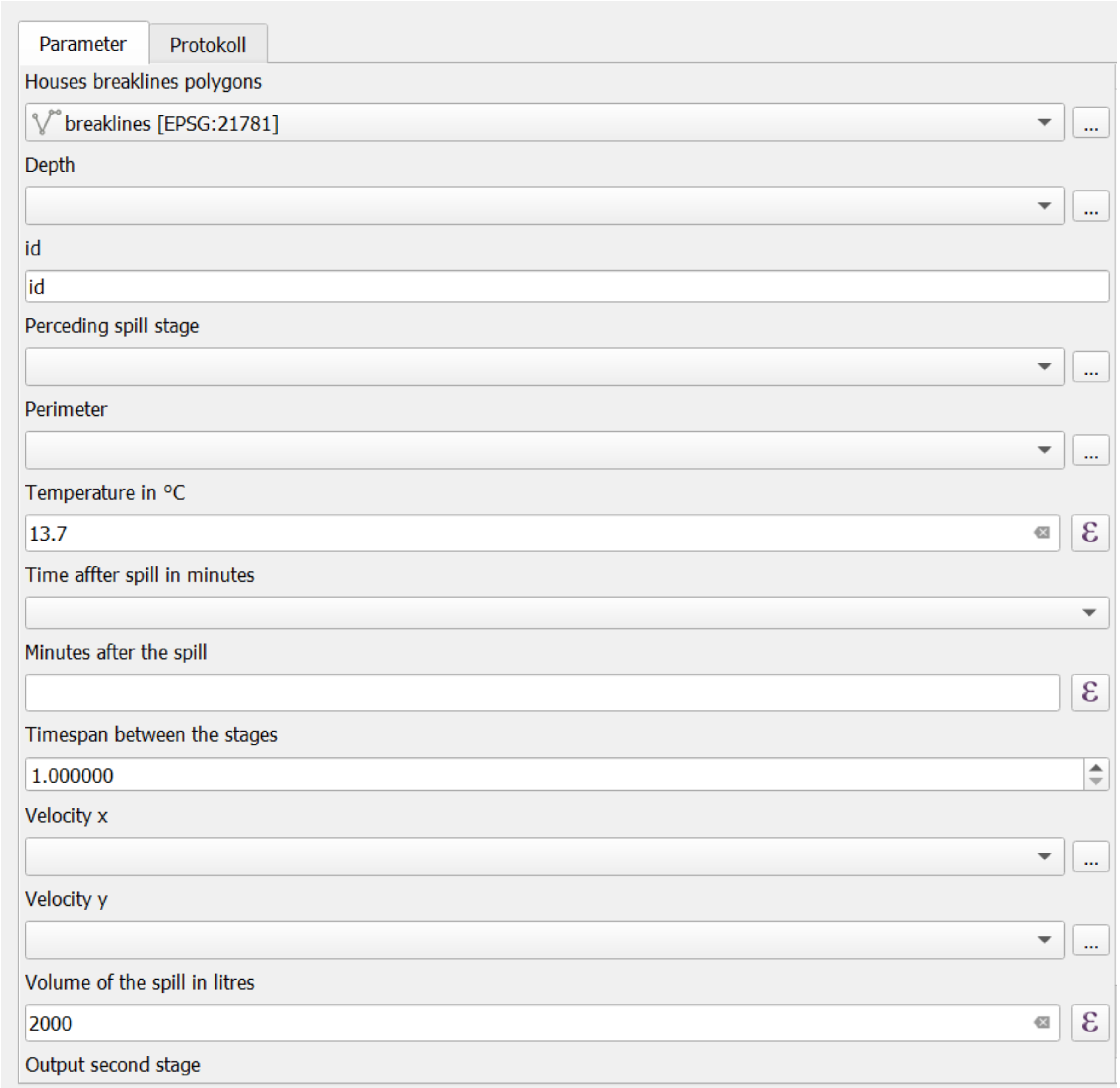


Figure 6: Setup of Model 2 in QGIS3.

Variables

- **Houses breaklines polygons**: Input file of the polygons for the houses in the perimeter from the HEC-RAS simulations (file format: polygon shapefile)
- **Depthlayer**: Input file of the modelled water depths (file format: point shapefile)
- **Id**: leave field unchanged
- **Preceding spill stage**: Output of Model 1 in the first step or the results of preceding spill stage (file format: point shapefile)
- **Perimeter**: Input file of the mesh created in HEC-RAS (file format: polygon shapefile)

- **Temperature in °C**: Insert temperature information at the selected timestep (file format: number)
- **Time after the spill in minutes**: Select the timestep in minutes (based on Velocity X file)
- **Minutes after the spill**: Insert number of minutes after the spill for the respective timestep (file format: number)
- **Timespan between the stages**: Select the timespan in minutes between the modelled timesteps (Minimum: 1 minute, maxima: 100 minutes)
- **Velocity X**: Input file of the x component of the modelled velocities (file format: point shapefile)
- **Velocity Y**: Input file of the y component of the modelled velocities (file format: point shapefile)
- **Volume in litres**: Volume of the oil spill in litres (file format: number)