Title of the project:
Automatic generalisation of 2D model results for 1D model emulation.

Assignment no.: 2.18	**Internal / external:** Internal
Head graduation committee: Prof S.J.M.H. Hulscher	**Daily advisor:** Robert-Jan den Haan (DPM) Koen Berends (WEM / Deltares) Jord Warmink (WEM)
Name(s) of participating companies or institutes: Deltares, UT/DPM	**Start of the project:** *a.s.a.p.*

Required courses:
Mathematical Physics
River Dynamics
Data Analysis

Short description of the research:
To build a metamodel of hydraulic effects for the Virtual River serious gaming environment.

As part of the RiverCare research programme, we are developing a serious gaming environment with the (work) title Virtual River. In this game, players play a specific role, i.e. the water manager, nature manager or provincial manager. Each role pursues their own goals, some are aligned with others, some are not. Players first, collectively, negotiate and decide how to arrange the riverine area, a river stretch of around 10 river kilometres, including the floodplains. For each floodplain section, players can apply pre-defined spatial measures, one in each floodplain section, or decide to not apply to any measures. The collective decision on which measures to apply is the basis for a scenario.

After measures have been decided, players have to, individually, manage their units; land that they control. This management is performed in turns, with each turn representing time steps of 3 or 5 years (to be determined later). Depending on management decisions, there can be changes in each unit from one turn to another, representing temporal developments (i.e. vegetation growth/succession). As a consequence, the conveyance of each unit in relation to the normative discharge (in order to comply with flood safety norms) also changes. Furthermore, a change in conveyance of one unit may affect ... ate ar... .

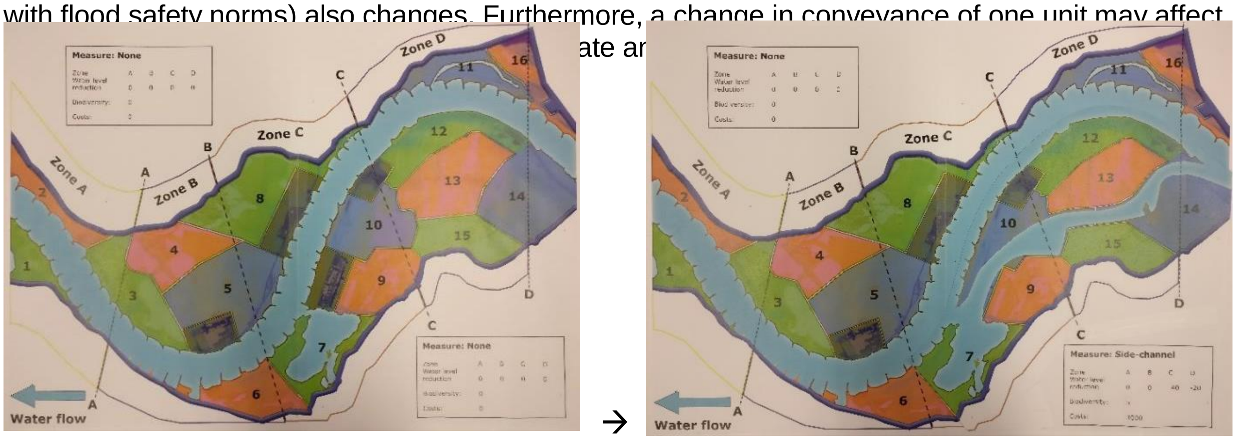

Figure 1. Paper prototype of the game with the starting situation (left) and applied side-channel as a spatial measure (right)

In order to show the effect of different management, an hydraulic metamodel needs to be developed that describes how changes in units affect each other and the water levels in general. Goal of the research is to develop this metamodel. This metamodel only relates to hydraulics following different roughness values and sedimentation values (if applicable to the unit) as input, not to including processes such as vegetation succession.

Terminology

Unit: Section of the floodplain that can be individually managed by the player. There are 20 units. Not all units may be active at all time.
Variable: Each unit has two potential variables: roughness *R* and sedimentation *S*. Units [1-16] have only roughness. Units [17-20] have both.
Scenario: A possible outcome of the design phase, e.g. doing nothing, building a sidechannel, relocating dikes etc.
Hydromodel: A numerical model of a river. We will use Delft3D Flexible Mesh
Metamodel: A statistical model emulating the results of the hydromodel

What will you do?

This research contains the following steps:

1. Build a hydromodel that models the game area plus several km downstream to account for boundary effects. The model will calculate the steady state solution for a given design discharge.
2. For each unit, make a roughness definition and distribution (minimum roughness, maximum roughness, roughness formula)
3. For each unit for which erosion/sedimentation is important, generate digital elevation maps
4. Apply a uniform distribution on all variables and generate a sample of *m* hydromodels
5. Run the sample and extract output water levels on all control points (A, B, C, D)
6. Train the metamodel given all input variables, which gives the waterlevel on the control points as output

Metamodel description
The metamodel describes the relationship between the water level at the nodes [A, B, …] given the input variables:

$$\begin{bmatrix} A \\ B \\ \vdots \\ D \end{bmatrix} = f(\theta), \quad \theta = (R_1, R_2, \ldots, R_{20}, S_{17}, \ldots, S_{20})$$

Given that the model is high dimensional and should be able to account for covariance between all input parameters, given only limited input samples, we propose a metamodel in the form of a (multidimensional) Gaussian Process. The possibility to construct a single metamodel per scenario (that will output waterlevels at all points) will be studied. However, a fall-back option is to generate a metamodel for each individual output point [A, B, C, …] and each individual scenario.

Computational time

The first step is to generate a metamodel for a single output location [e.g., A] and a single scenario [e.g., doing nothing], starting with a *m=500* hydromodel sample. From there, we either increase *m*, if insufficient, or move to other output points and scenarios.