Methodology for Modelling Natural Based Solutions in HEC-RAS

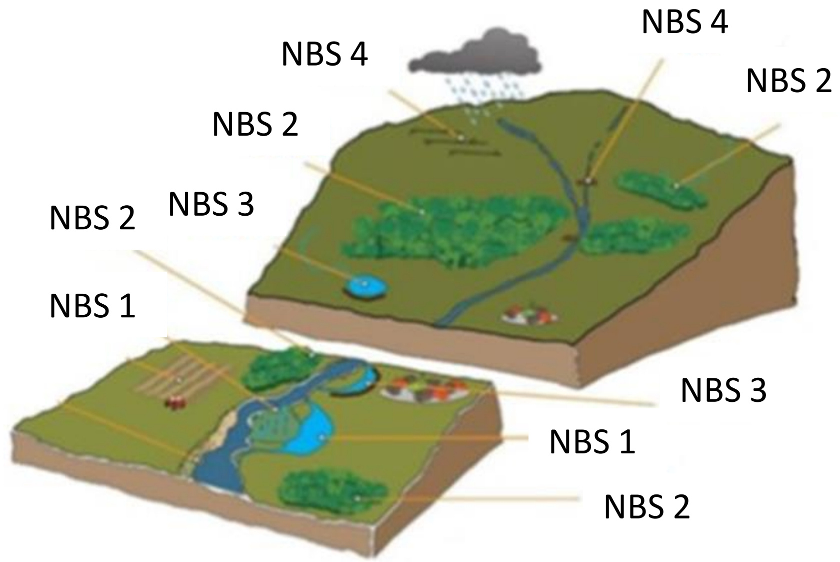
Prof. Anastasios Stamou – Giorgos Mitsopoulos Phd Candidate
Laboratory
of Applied Hydraulics
of National and Technical University of Athens

1. Introduction

Natural Flood Management (NFM):‘Natural flood management involves techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters. These techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defense engineering that works against or disrupts these natural processes’.

According to literature the main Natural Based Solutions (NBS) are:

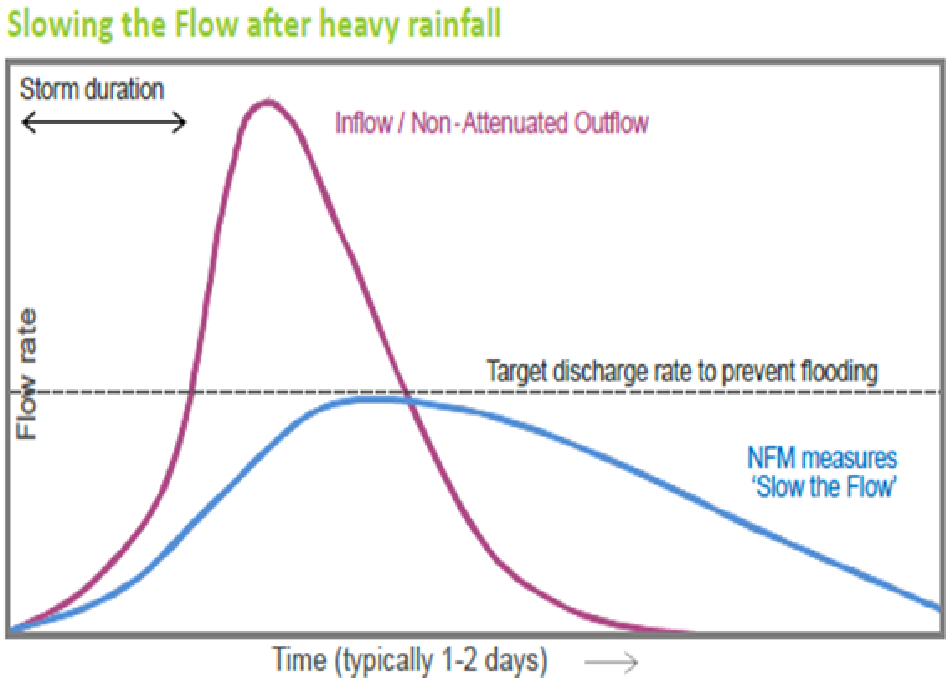
1. river restoration and flood plain reconnection (NBS 1),
2. reforestation and afforestation (NBS 2),
3. retention ponds – detention ponds (NBS 3) and
4. leaky barriers (NBS 4).



2. Objectives of NFM – Retention Pond

The Objectives of the NFM and especially of the retention pond are:

- ❖ Reduce the downstream maximum height of a flood (the flood peak)thus reducing the scale and impact of the flood
- ❖ Delay the arrival of the flood peak downstream, thus increasing the time available to prepare.



3. HEC-RAS Application Methodology

Step1: Creation of the terrain, where the application will take place.

Step2: Create the HEC-RAS river model (River axis, Cross Sections), apply boundary conditions and run the model to obtain initial conditions.

Step3: Give boundary conditions and run the model to obtain initial conditions.

Step4: Add lateral structures at the overbank of the river next to the retention pond.

Step5: Create the 2D mesh at the area of the retention pond and connect it to the lateral structure.

Step6: Create gates at the lateral structures with it boundary conditions to reduce the discharge inside the river.

Step7: Compare the results before and after the use of the retention pond to see if further calibration is needed.

4. Step 1: Terrain

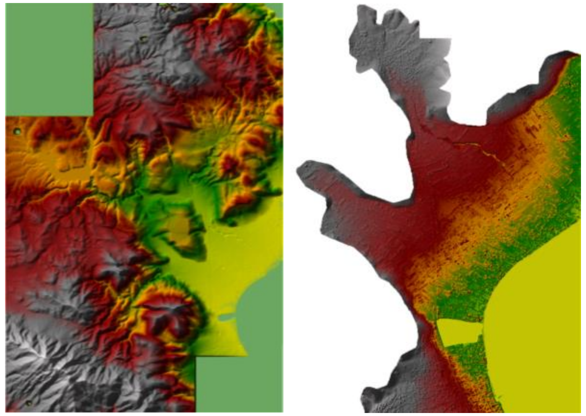
Method 1

GIS SOFTWARE → ELEVATION POINT MAP → TIN SURFACE → TIFF IMAGE

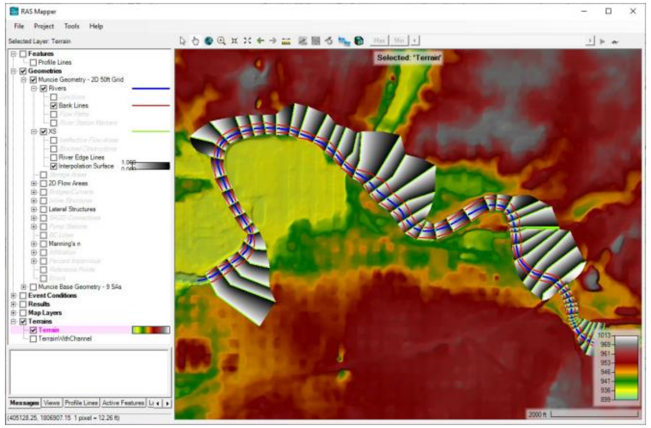
OR

Method 2

RAS MAPPER → CREATION OF RIVER WITH CS AT THE AREA OF THE RETENTION POND → ADD THE RETANTION POND ELEVATION IN THE CSs → CREATE CS INTERPOLATION SURFACE



DEM or DSM

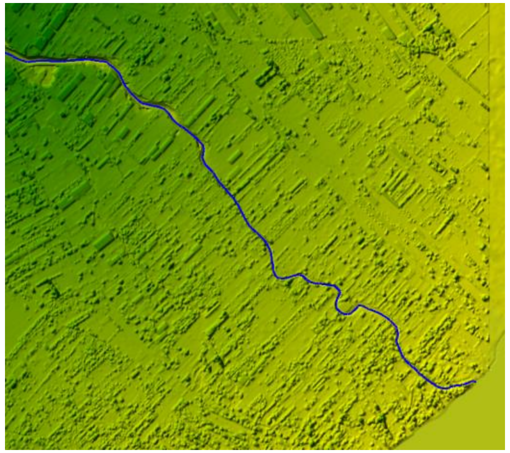


Cross Section Interpolation Surface

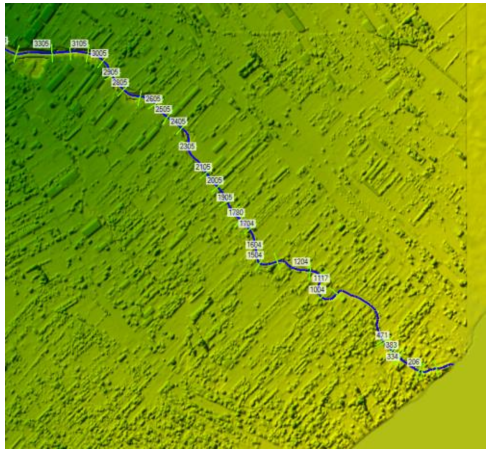
Procedure:

- We enter RAS-Mapper
- We load the correct coordinate system
- We create RAS-Terrain by using a) DEM or DSM and b) Tiff Image from Method

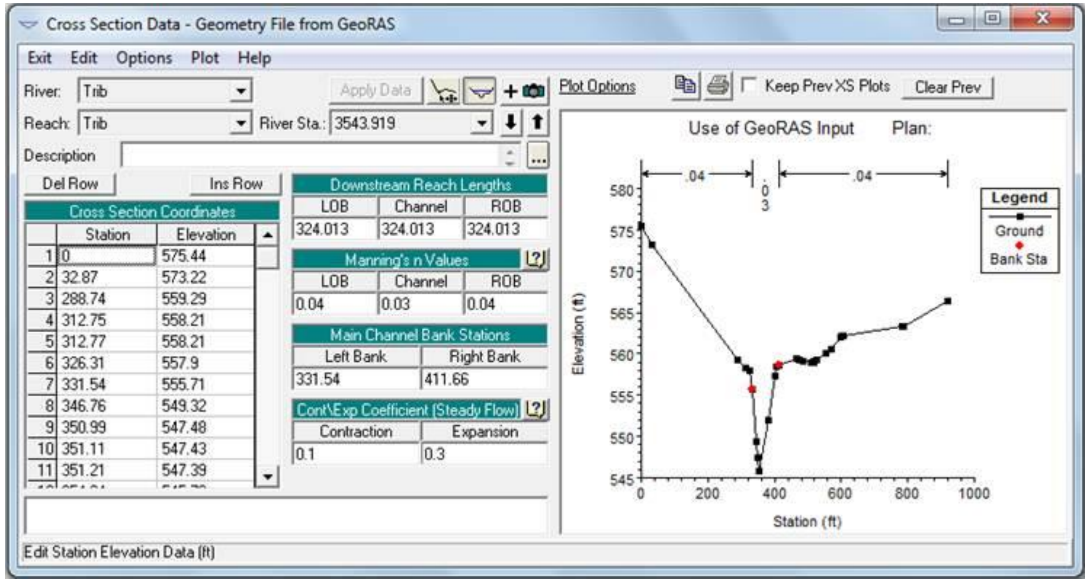
5. Step 2: River Model



Draw the Stream Centerline

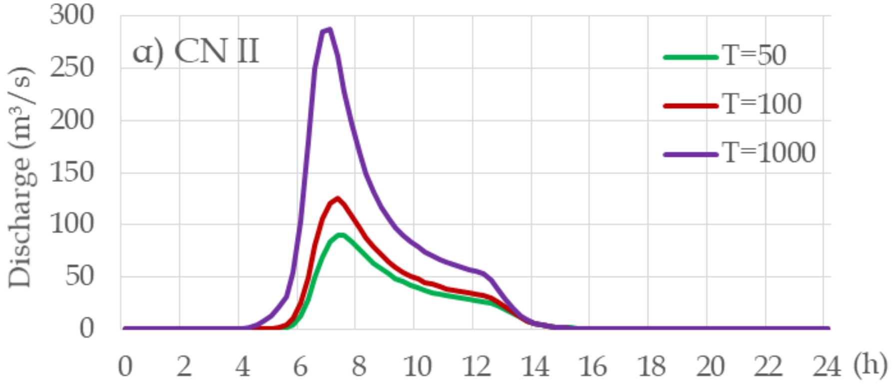


Create the cross section line perpendicular to the streamline

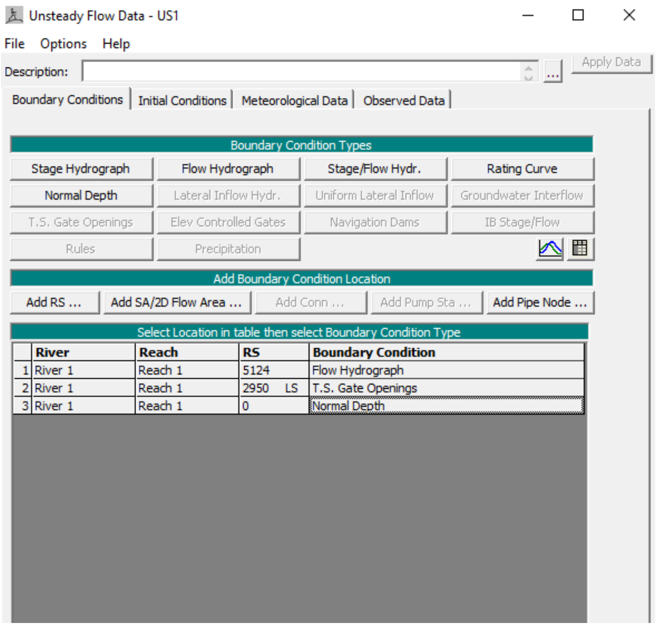


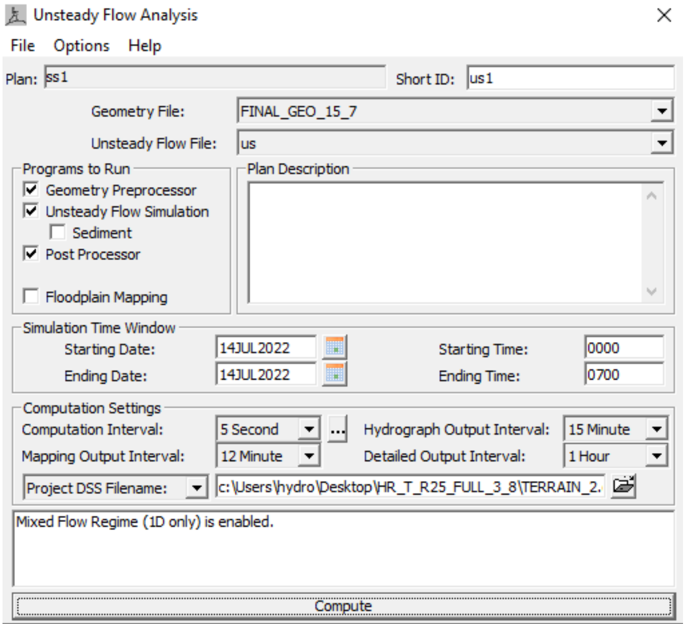
Give cross section coordinates, roughness, reach lengths, contraction/expansion coefficients and define where the banks are.

6. Step 3: Boundary Conditions



Flow Hydrograph





Possible Boundary Conditions

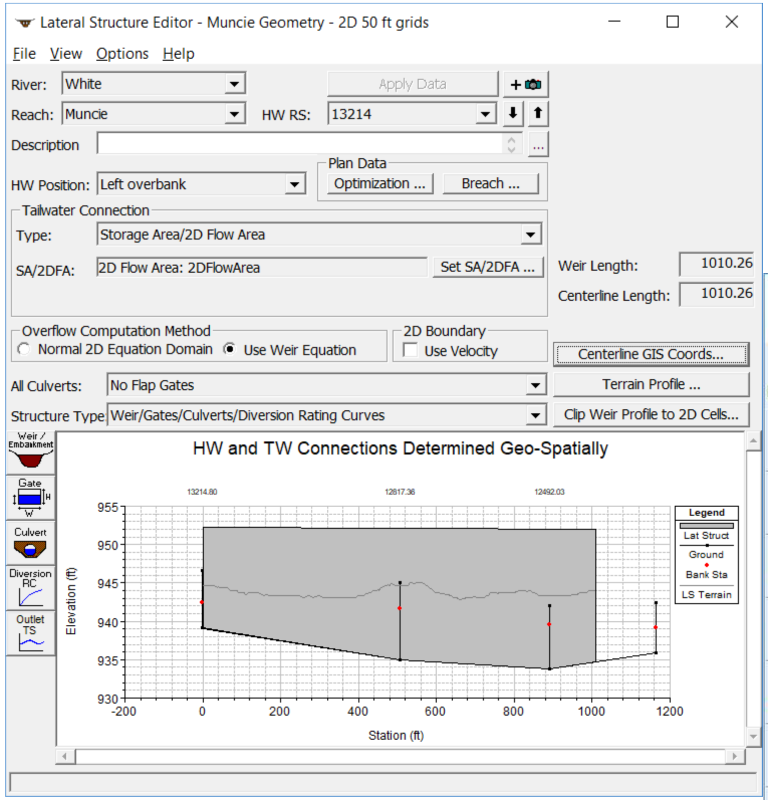
1. Inlet Boundary conditions
   - Stage or flow hydrograph
   - Rating Curve
2. Outflow Boundary conditions
   - Normal Depth
   - Rating Curve

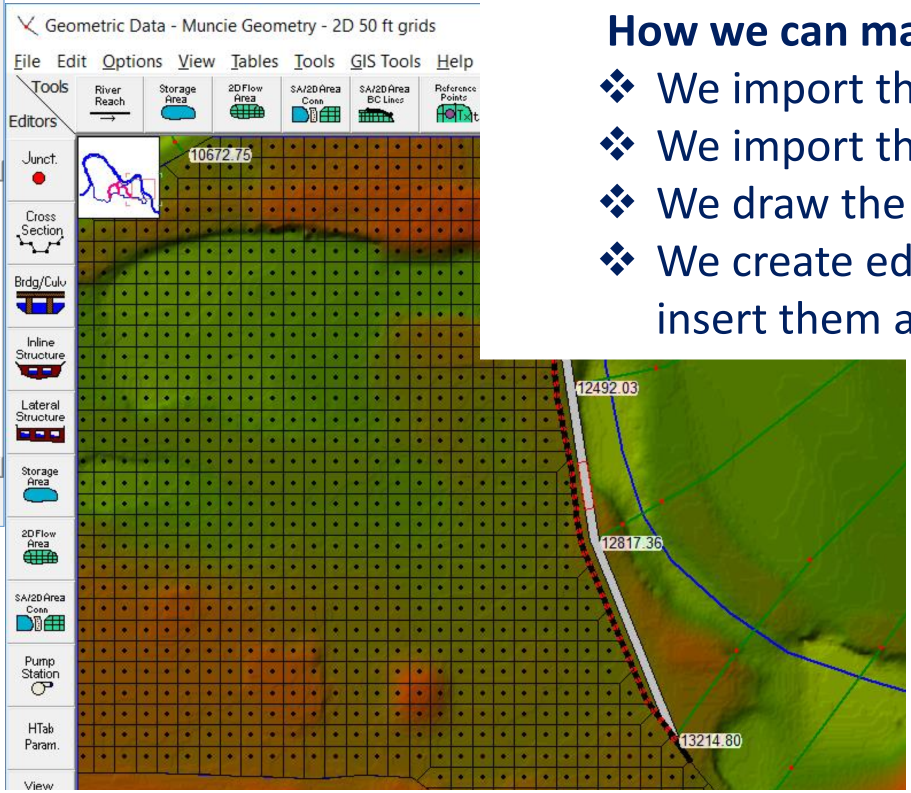
Important Note to avoid instabilities!!

In unsteady flow analysis check

1. Which solver option is appropriate (FDM, FVM)
2. The time step (Courant criteria)
3. Relaxation factors

7. Step 4: Lateral structures





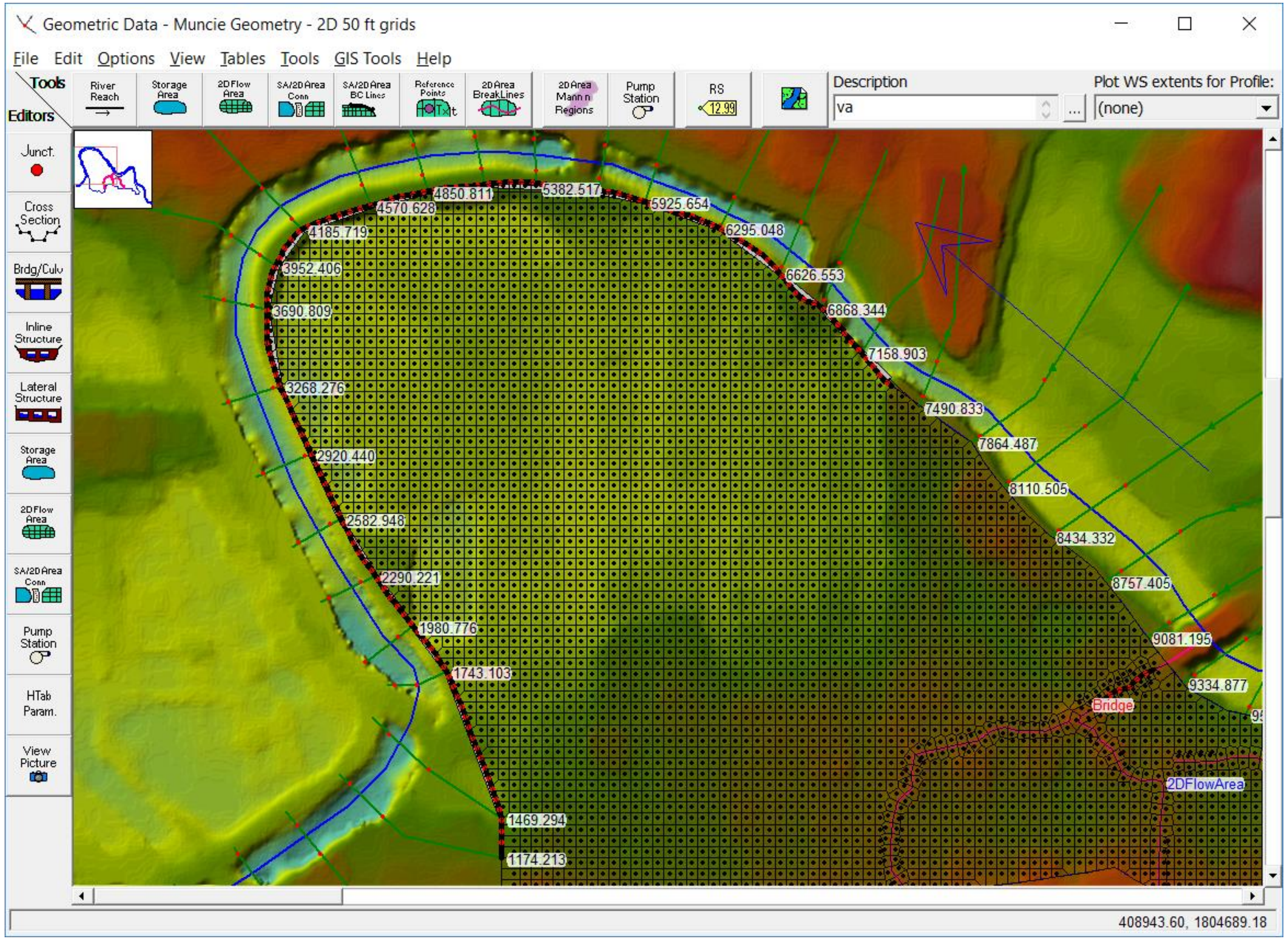
What are they and how we use them ?

- Lateral structures are levees that combine 1D river with 2D retention pond
- They use the weir equation to give boundary conditions (Q) to the 2D areas by using the Water surface elevation of the 1D river.

How we can make them in HEC-RAS?

- We import them from GIS in shape files
- We import them with coordinates
- We draw the inside HEC-RAS (not accurate)
- We create edge lines from CSs inside RAS-Mapper and insert them again as shape files.

8. Step 5: 2D Area – Retention Pond



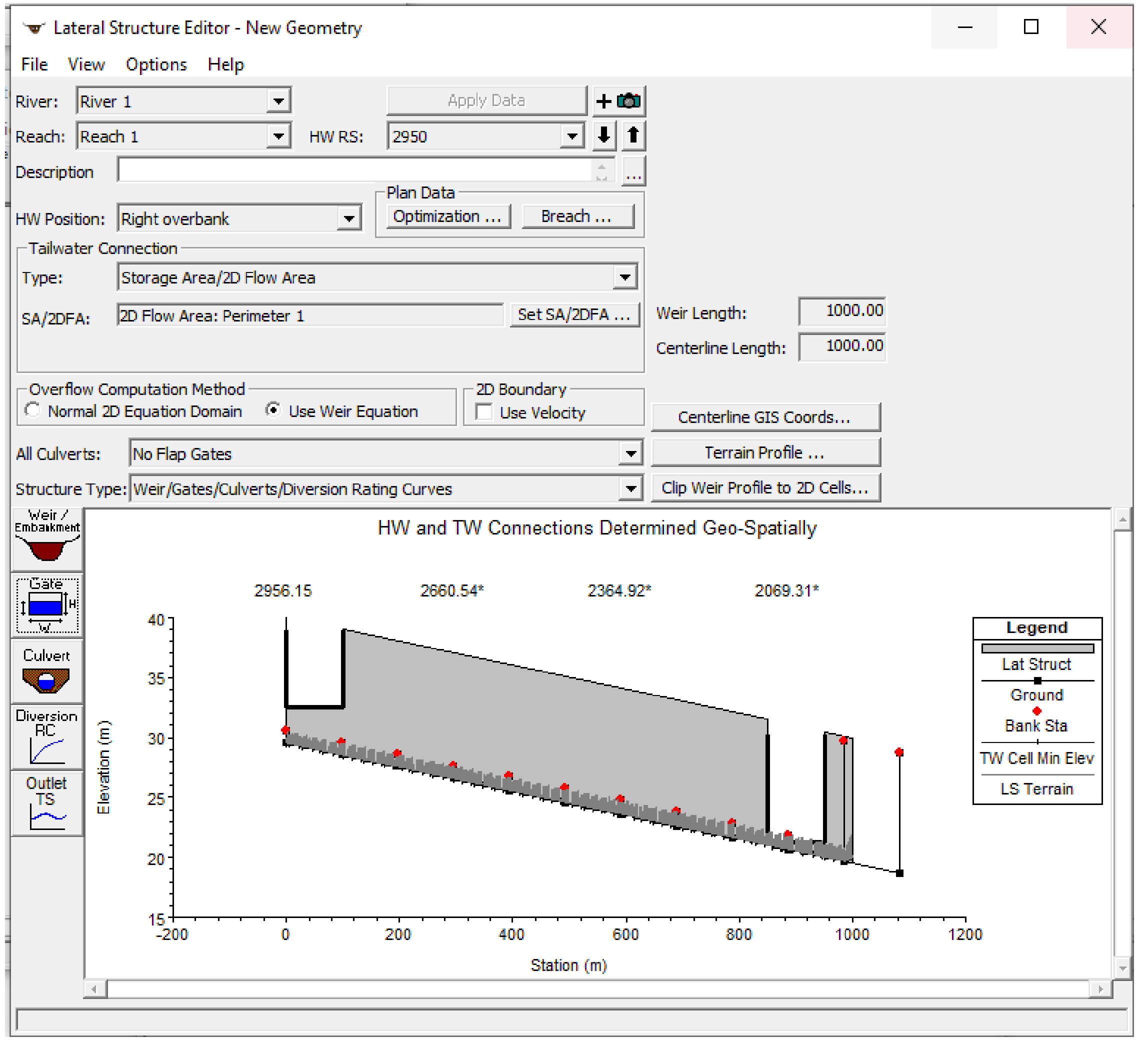
- 2D area is the area of the retention pond
- Flow is 2-Dimensional
- The equations are solved on a mainly orthogonal grid
- Dimensions of the grid are defined by the user (ex. 20x20 m)
- Roughness coefficient is required
- The terrain elevation is stored on the grid nodes. The finer grid has a better representation of the terrain.

How we can make them in HEC-RAS?

- We import them from GIS in shape files
- We import them with coordinates
- We draw the inside HEC-RAS (not accurate)

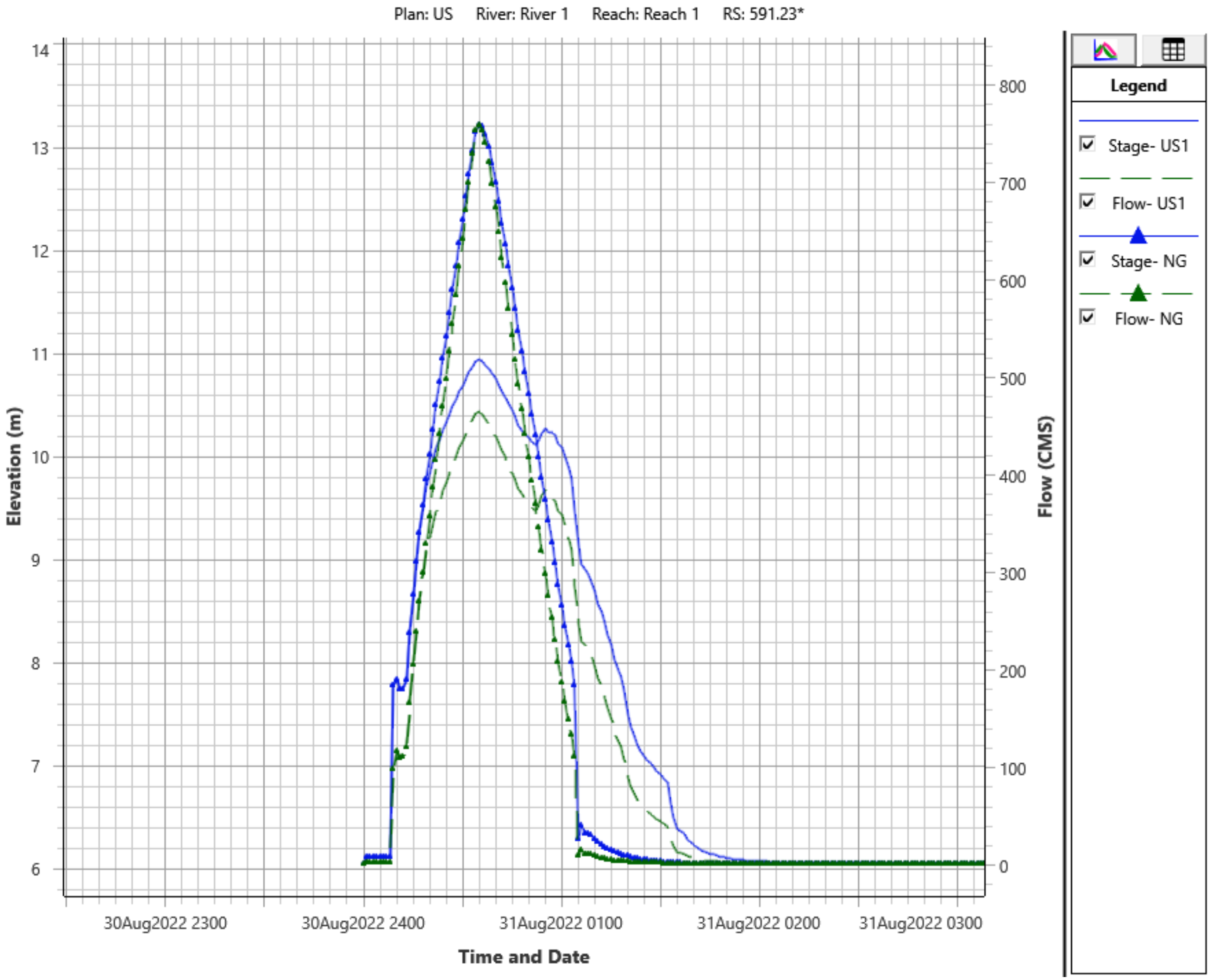
Important Note!!
The perimeter of the 2D area must match the Lateral Structure Centerline.

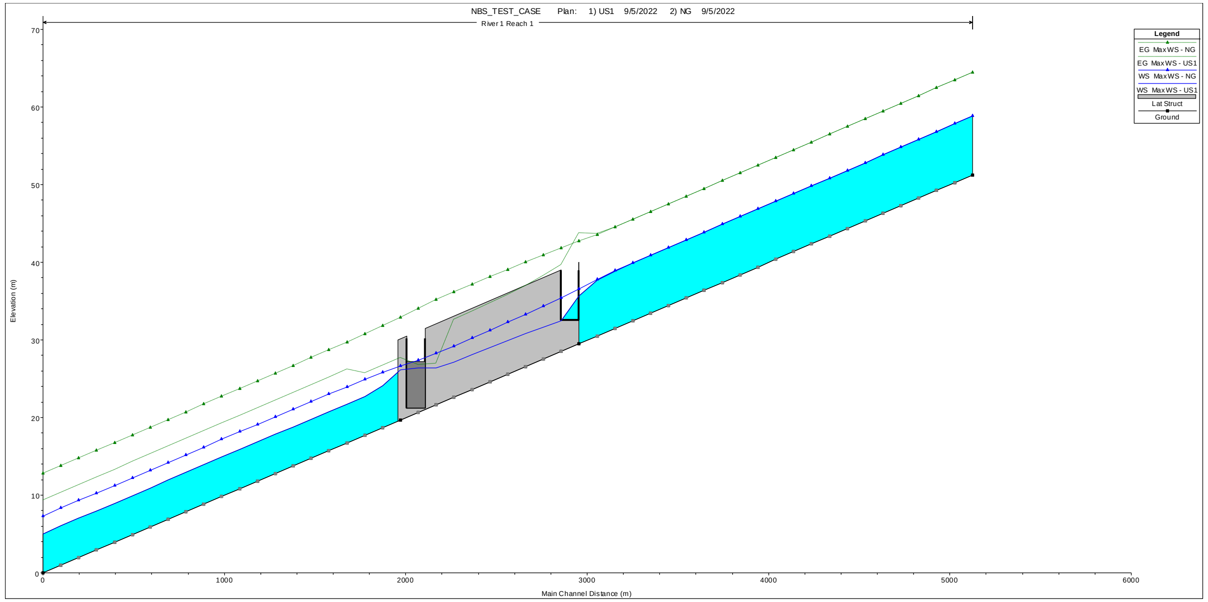
9. Step 6: Gates at Lateral Structures



- Gates are essential in the design to let the water in and out of the retention pond.
- The are mainly designed as broad-crested weirs.
- They need geometrical characteristics.
- In boundary condition table we can assign when they open and close.
- Gates are the most important design parameter of the optimized retention pond system.

10. Step 7: Results and Calibration





1. Check the results in specific cross sections
   - ❖ No change is expected until we reach the area of the retention pond.
   - ❖ Only flow discharge must be reduced in the area of the pond.
   - ❖ Both flow discharge and stage must reduce after the retention pond and the descending part of the hydrograph must be delayed.
2. Check the new water surface elevation to see if it meets the new design criteria.

11. Comprehension

Participants need to hand in a technical report where they are going to present the results from the hands on tutorial in groups of 2 or 3 people.

In the report the following must be addressed:

1. Introduction – Scope of the present work
2. Methodology and mathematical background
3. Creation and application of the model
4. Results and Discussion

ANY QUESTIONS ?

THANK YOU VERY MUCH FOR YOUR ATTENTION!