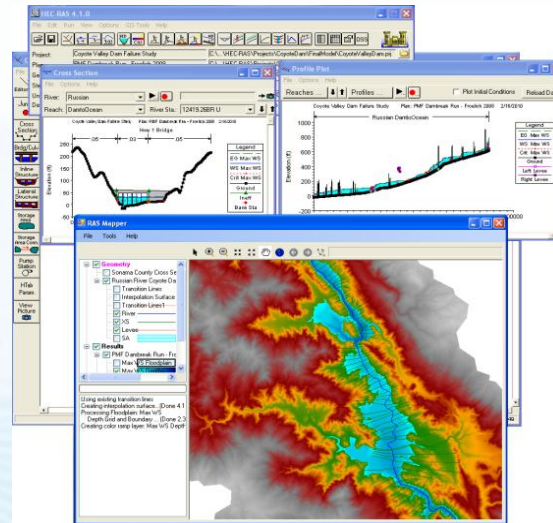


Common borders. Common solutions.

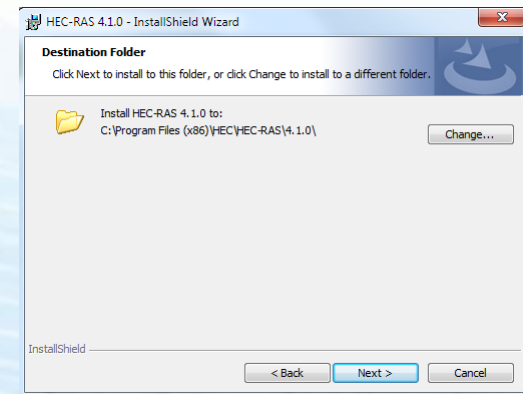
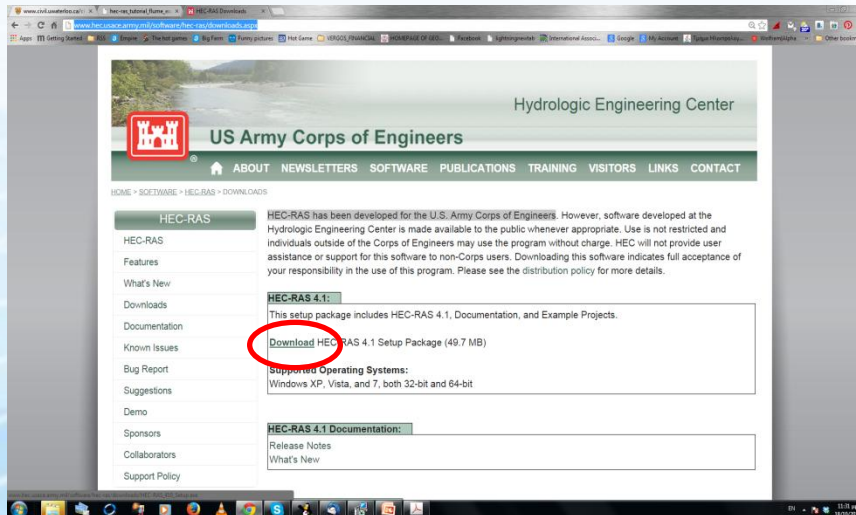
HEC RAS..... step by step



Dr Eleni A. Tzanou

Common borders. Common solutions.

- HEC-RAS has been developed for the U.S. Army Corps of Engineers.
- Download from <http://www.hec.usace.army.mil/software/hecras/downloads.aspx> and follow installation instructions



Common borders. Common solutions.

Hydraulic Analysis

- **HEC-RAS** performs one-dimensional hydraulic calculations for a full network of natural and constructed channels

Capabilities of **HEC-RAS**:

- Hydraulic Analysis
- Data Storage and Management
- Graphics and Reporting
- RAS Mapper
- HEC-RAS 4.1 (among others...new Mapper and Sediment Transport Model)

This software is free, widely used and scientifically accepted
Large documentation on its use and technical background

Common borders. Common solutions.

HEC-RAS. How to.....

Structure of HEC-RAS

- Creates and saves project files(.prj file)

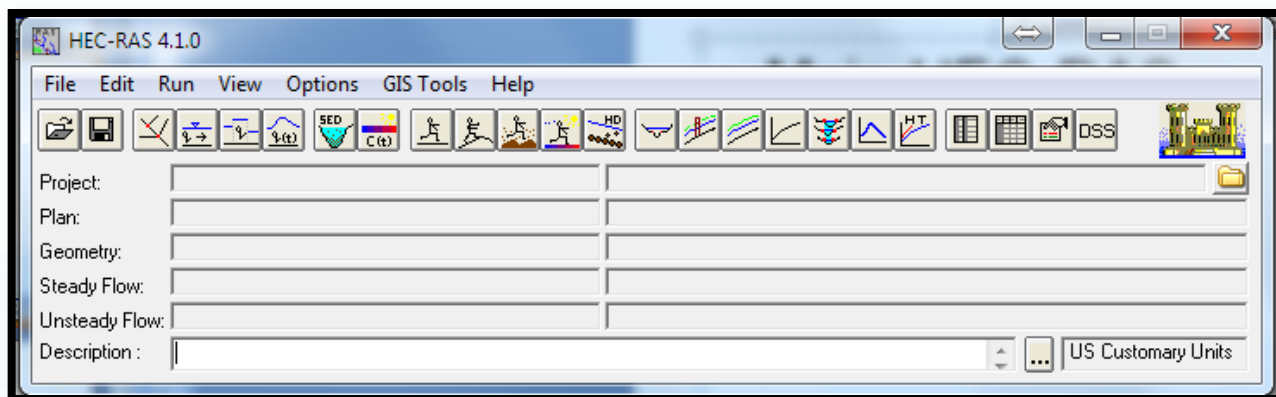
Each project includes:

1. Unit system (SI/US customary)
2. Geometry (XS, bridges, weirs, etc.) (.g file)
3. Flow Data (steady, unsteady) (.f file)
4. Plan data(combination of flow/geometry to use for the analysis) (.p file)

Many files of geometry flow and plan data can be created!!!!!!

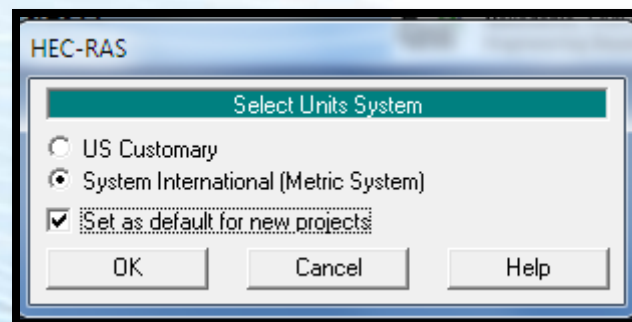
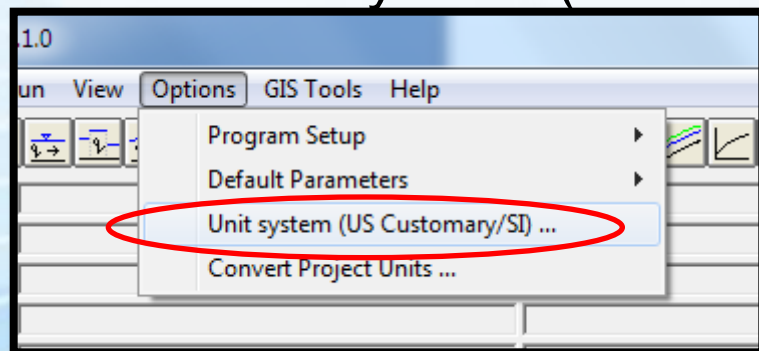
Common borders. Common solutions.

- Main HEC-RAS Window....start from scratch



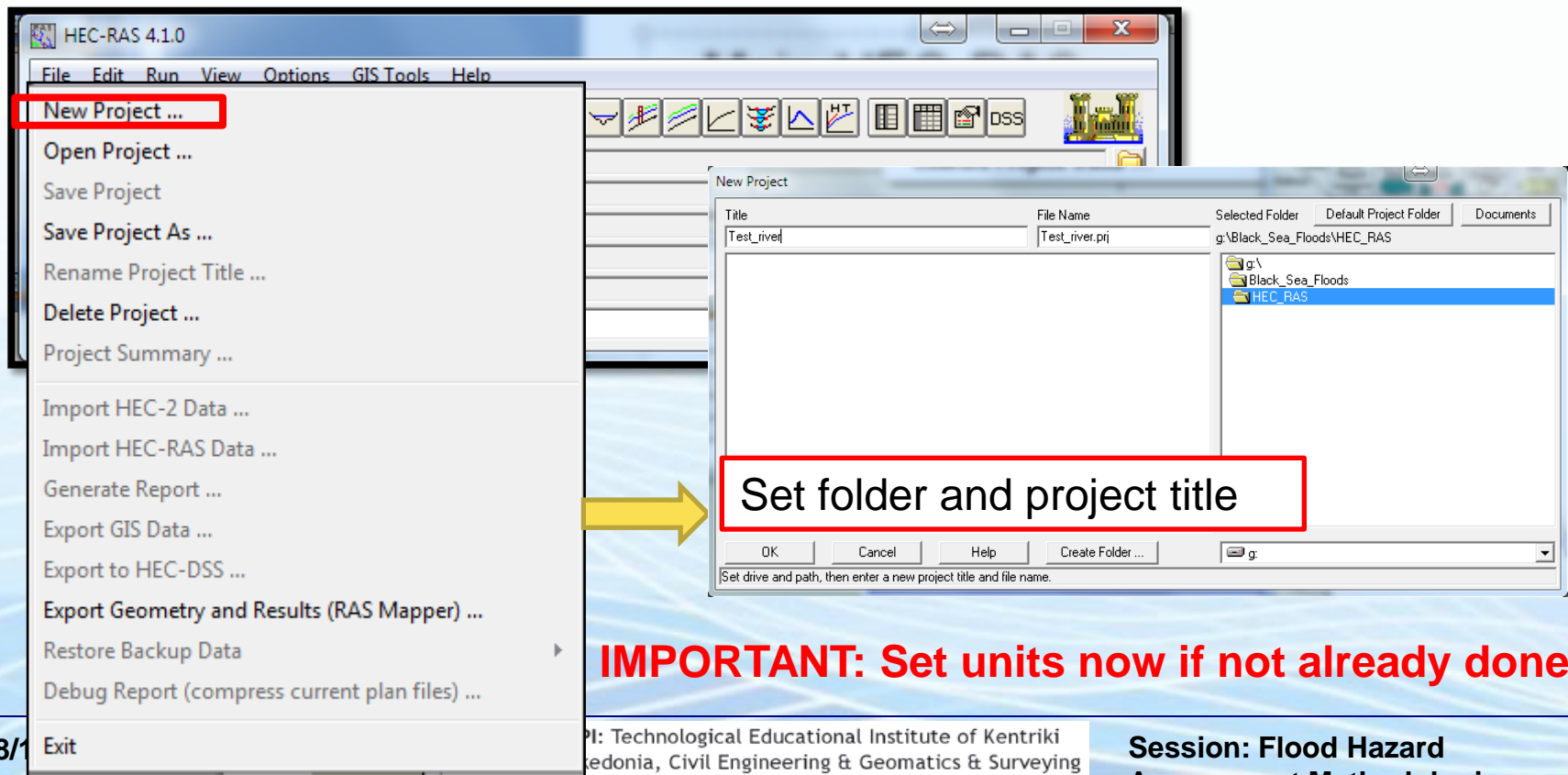
All main functions
are accessed
from this menu

- Set Unit System (can be done later too)



Common borders. Common solutions.

How to Create and Save a New Project (.prj) (can always be done later on too). Go to **File** and select **New Project**.



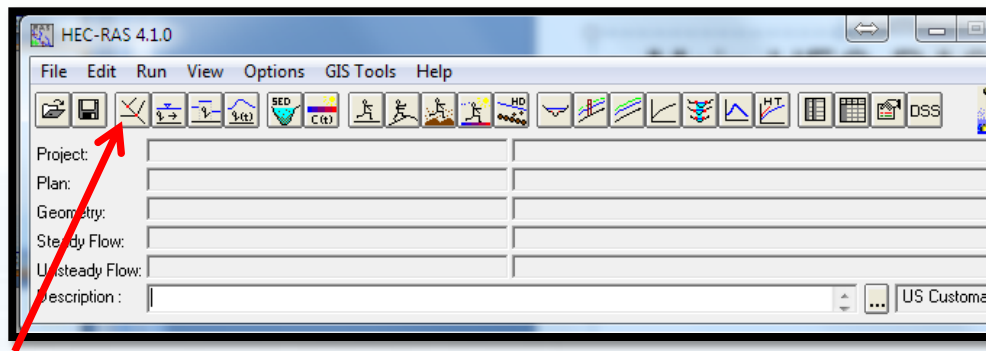
The screenshot shows the HEC-RAS 4.1.0 application window. The 'File' menu is open, and 'New Project ...' is highlighted with a red box. A yellow arrow points from this menu item to the 'New Project' dialog box. In the dialog box, the 'Title' field contains 'Test_river' and the 'File Name' field contains 'Test_river.prj'. The 'Selected Folder' is 'g:\Black_Sea_Floods\HEC_RAS', which is also highlighted with a red box. The dialog box has buttons for 'OK', 'Cancel', 'Help', and 'Create Folder ...'. Below the dialog box, the text 'Set folder and project title' is written in a red box. At the bottom of the slide, there is a red text box that says 'IMPORTANT: Set units now if not already done!!!!'.

Set folder and project title

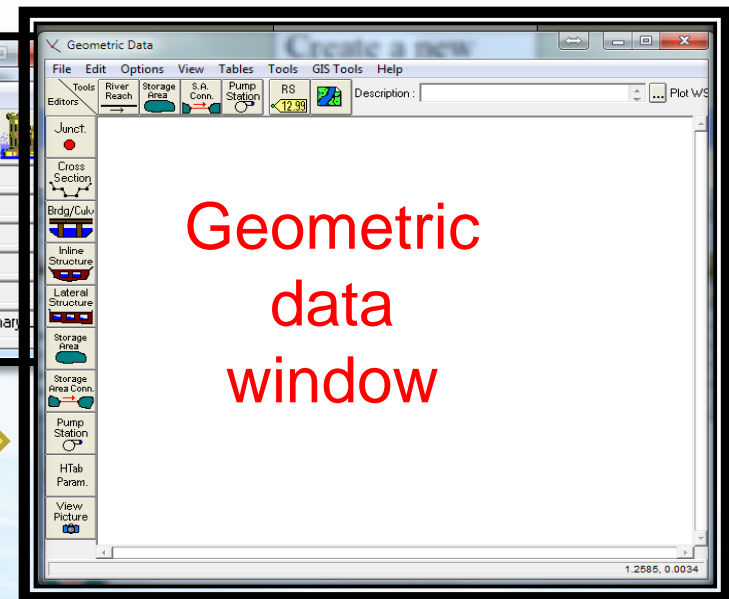
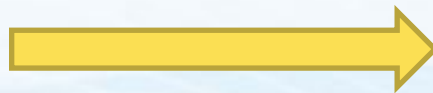
IMPORTANT: Set units now if not already done!!!!

Common borders. Common solutions.

How to create and work with Geometry Files (.g)



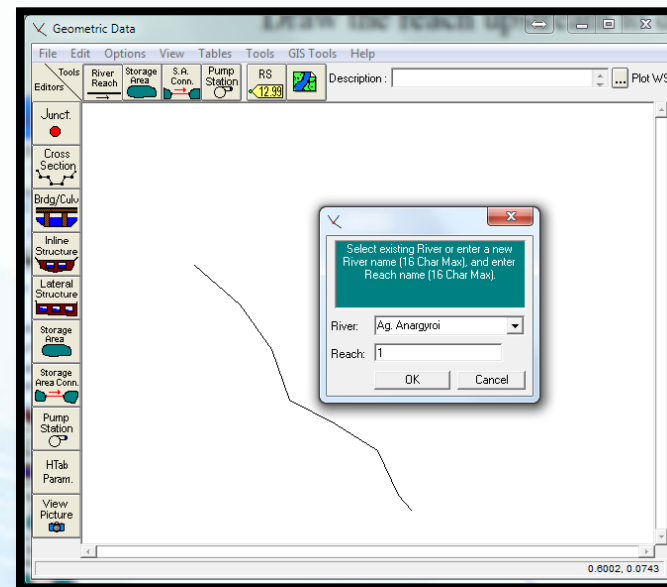
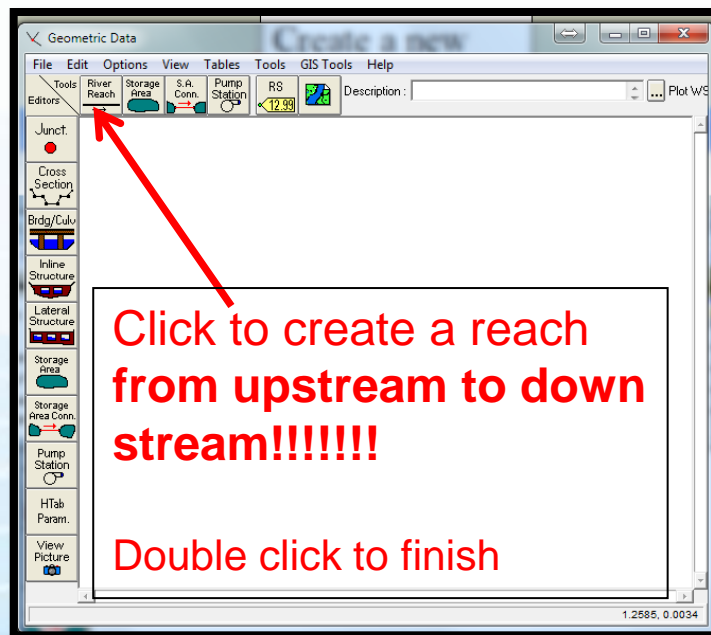
Click to open geometric
data editor window



All geometric data and edits are inserted here and must be
SAVED....

Common borders. Common solutions.

- The first thing in geometry is to create a reach (...one or more intersecting reaches)



Then insert river and reach
name and click ok

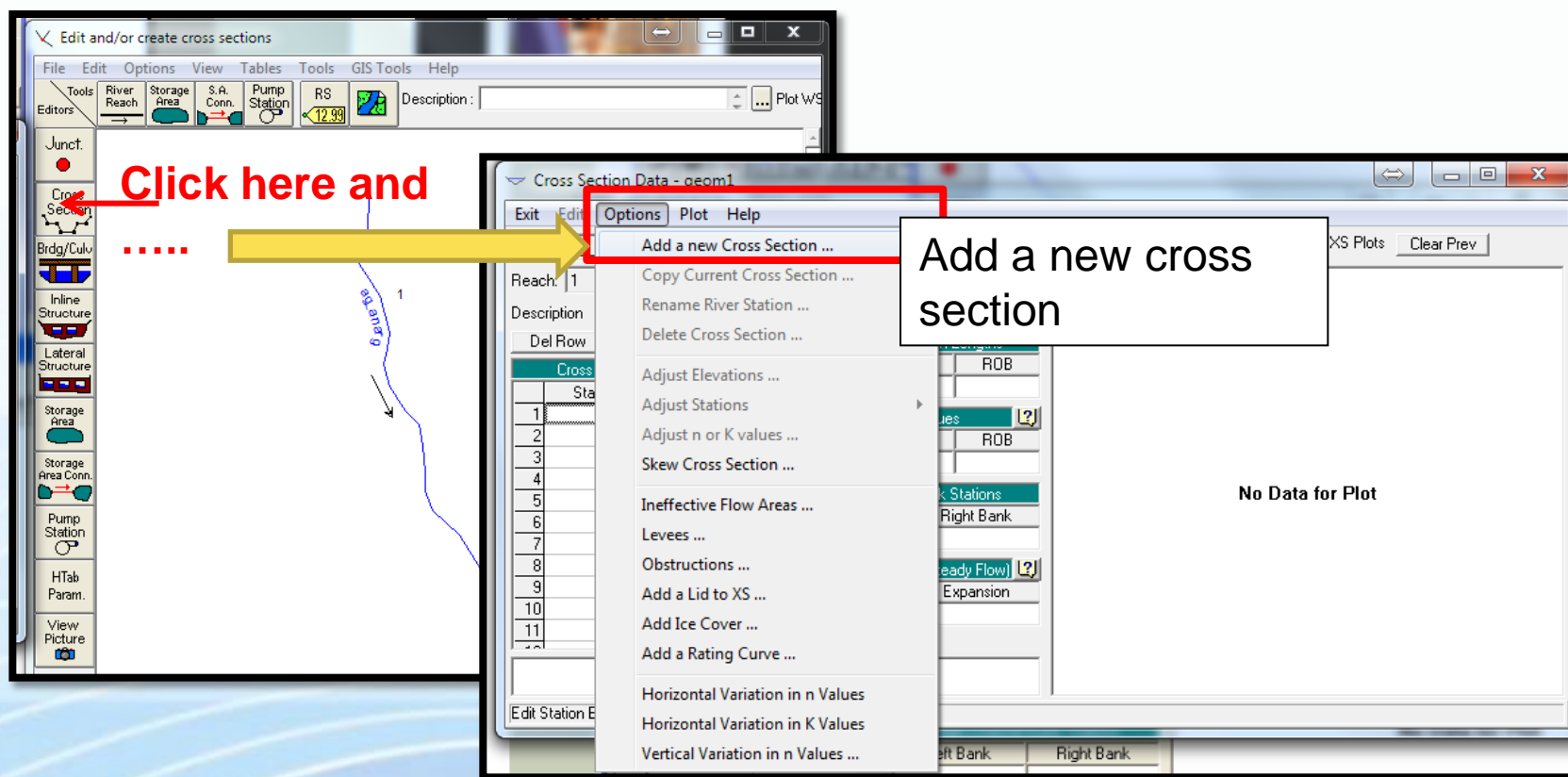
Dealing with geometry and Cross Sections

Common borders. Common solutions.

- Cross sections define the channel geometry
- Cross sections are defined by Station(x) and Elevation (y)
- Cross sections (among other parameters) define the channel slope
- Overbank stations differentiate channel and floodplain characteristics
- Manning n coefficients define resistance to flow
- Expansion and contraction coefficients define energy losses associated with velocity head changes between cross sections
- Ineffective flow areas can store but not convey water downstream
- Obstruction areas block flow completely
- Levee elevations confine flow to channel until the levees are overtopped

Common borders. Common solutions.

- Cross Section data input.



Click here and

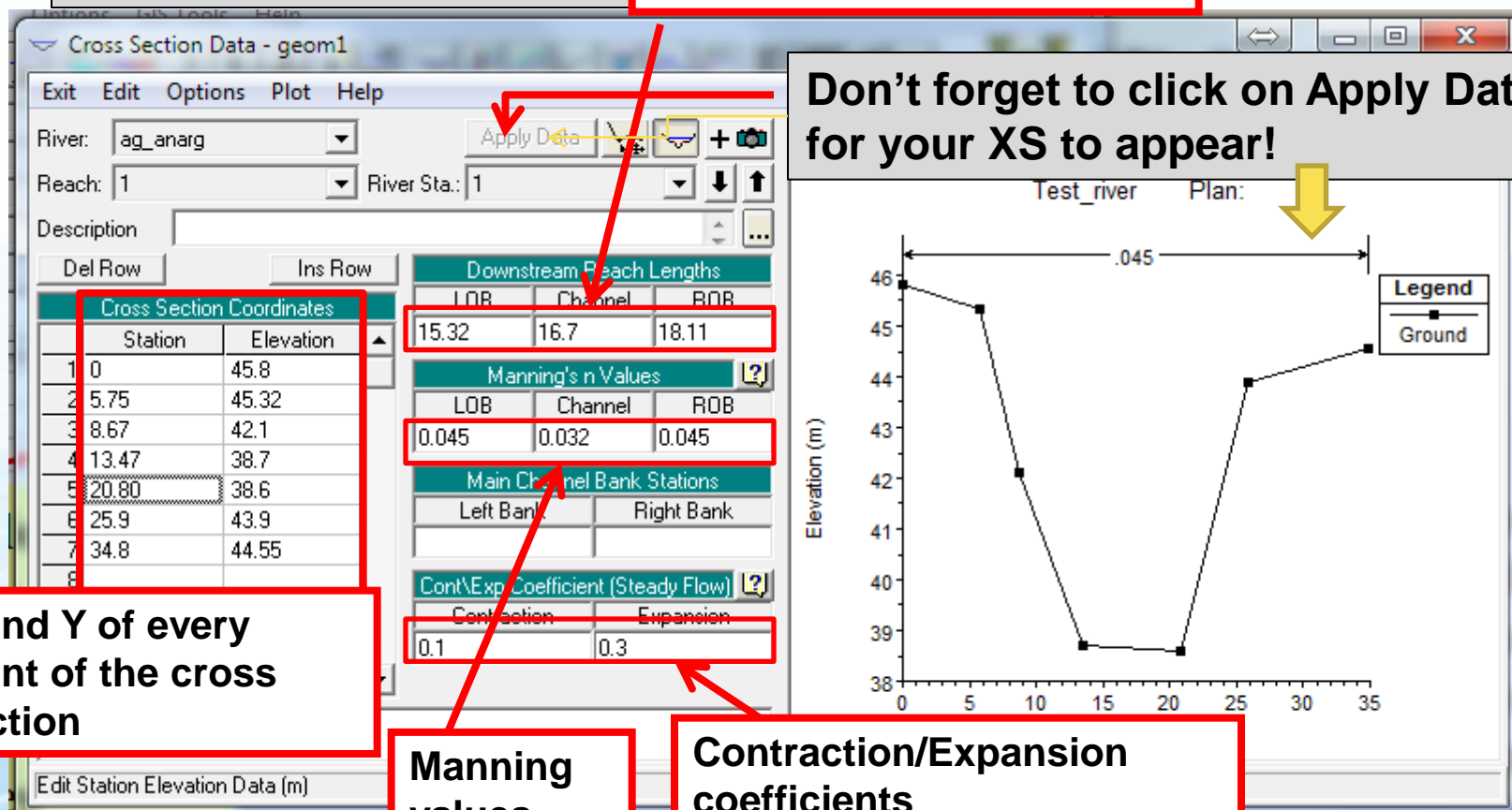
Add a new cross section

No Data for Plot

Cross-sectional data are
set from left to right
looking **downstream**

Distance to next
downstream cross section

Don't forget to click on Apply Data
for your XS to appear!



X and Y of every
point of the cross
section

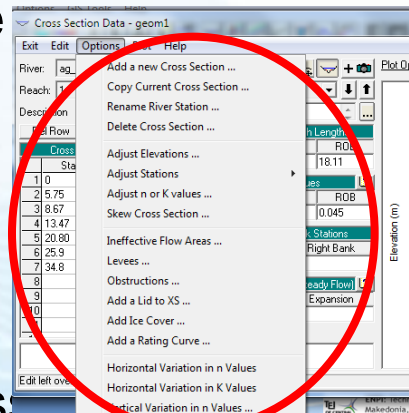
Manning
values

Contraction/Expansion
coefficients

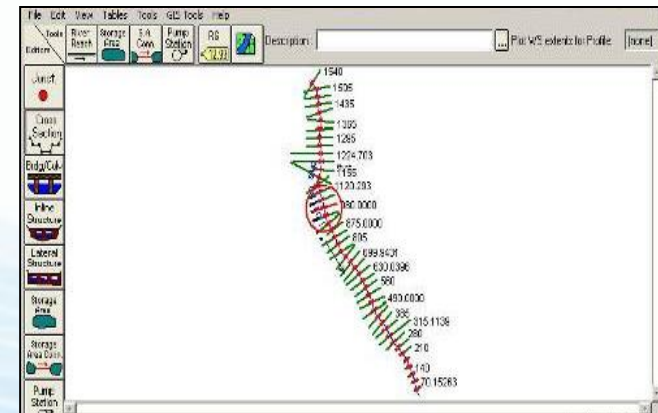
Common borders. Common solutions.

- Follow the same steps to create all cross sections.
- The geometry in rivers (not culverts) is not uniform so one needs to define all cross sections' characteristics every time manually. If uniform geometry occurs though (i.e. structured channels, culverts) cross sections can be copied.

Once a cross section is defined all the options become available.



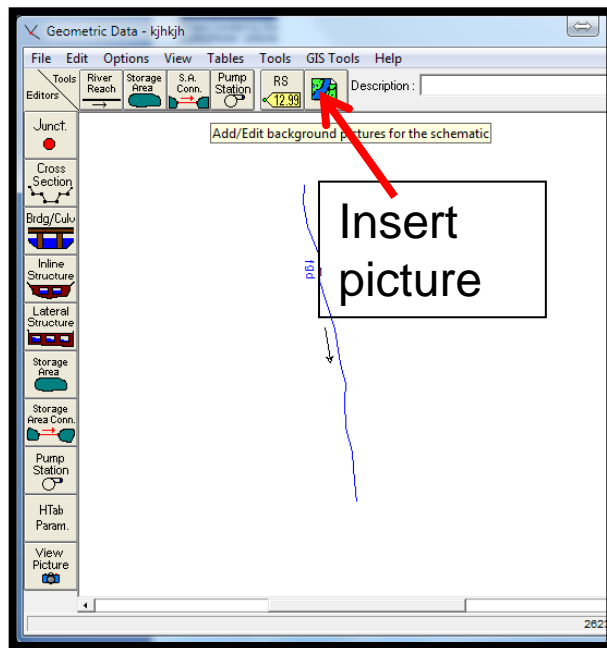
When finished exit cross section Editor and save geometry data.



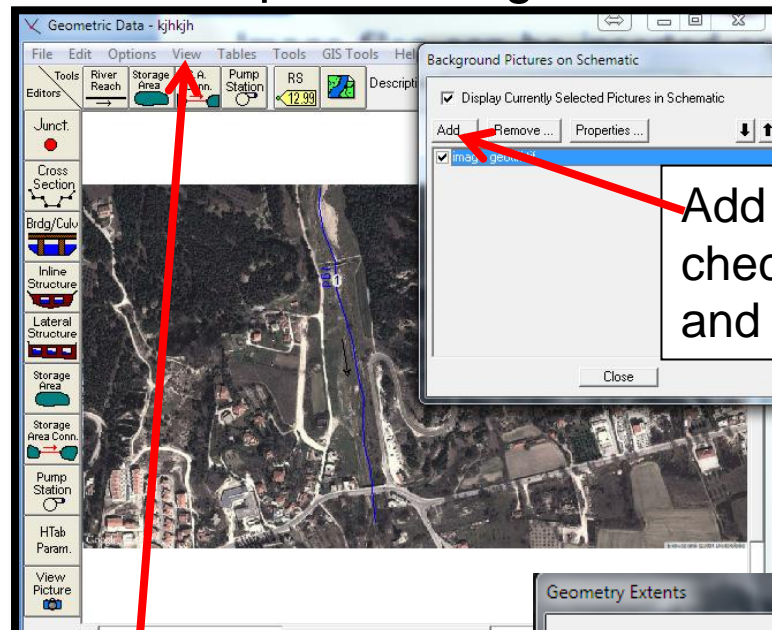
This is how the geometry data looks with many cross sections added



Image files can be inserted only as background (but already georeferenced!!) in HEC-RAS so as to overcome the problem of coordinates (the software does not “accept” or recognize coordinates as a geographic or spatial feature).

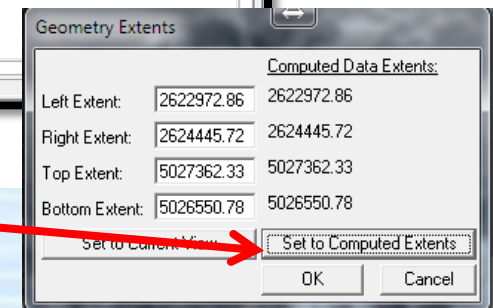


Cross sections may be also added through a .csv file format



Add image file, check image file and close

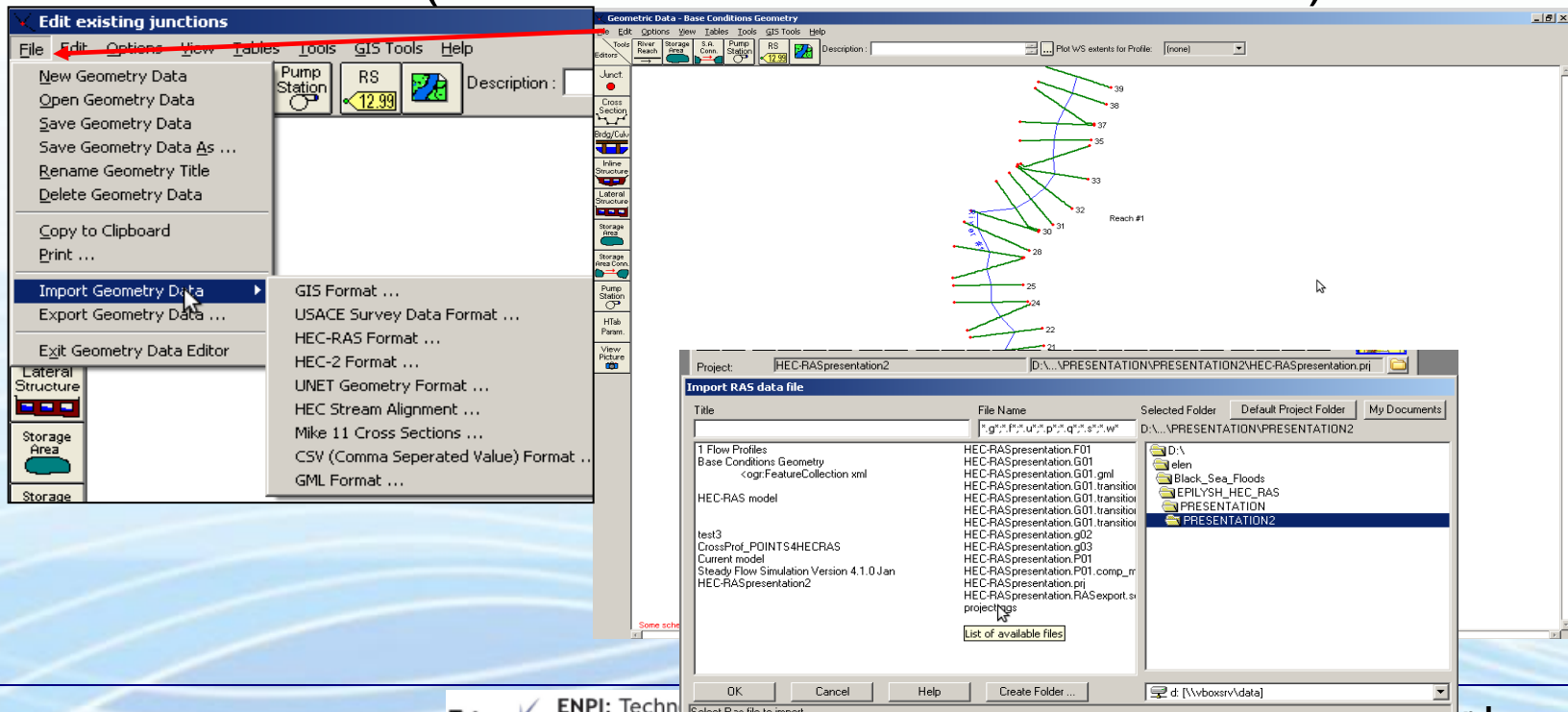
If the image is not visible set image computed extends from schematic plot extend in view menu



CREATE GEOMETRY

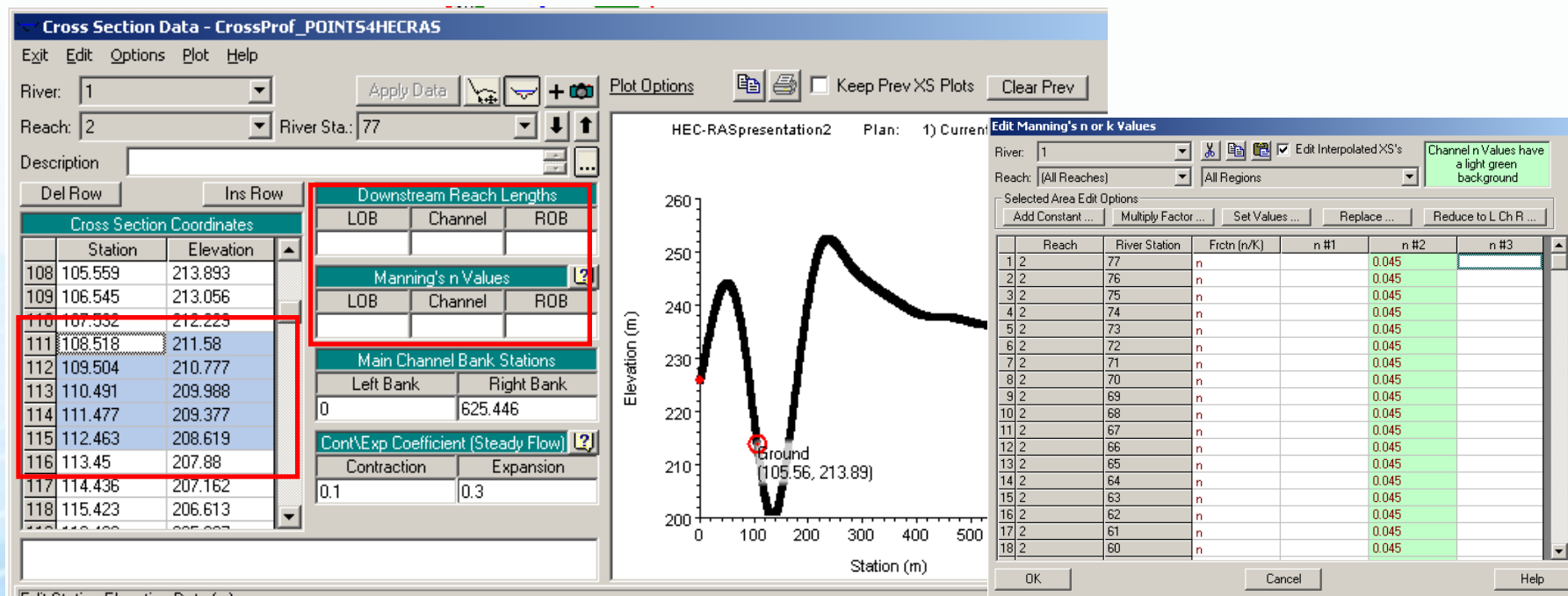
Common borders. Common solutions.

- Or....import the XS geometry exported from QGIS.
- Or.... use Plugin QGIS2RAS
- Or....csv file (see format in HEC-RAS manual)



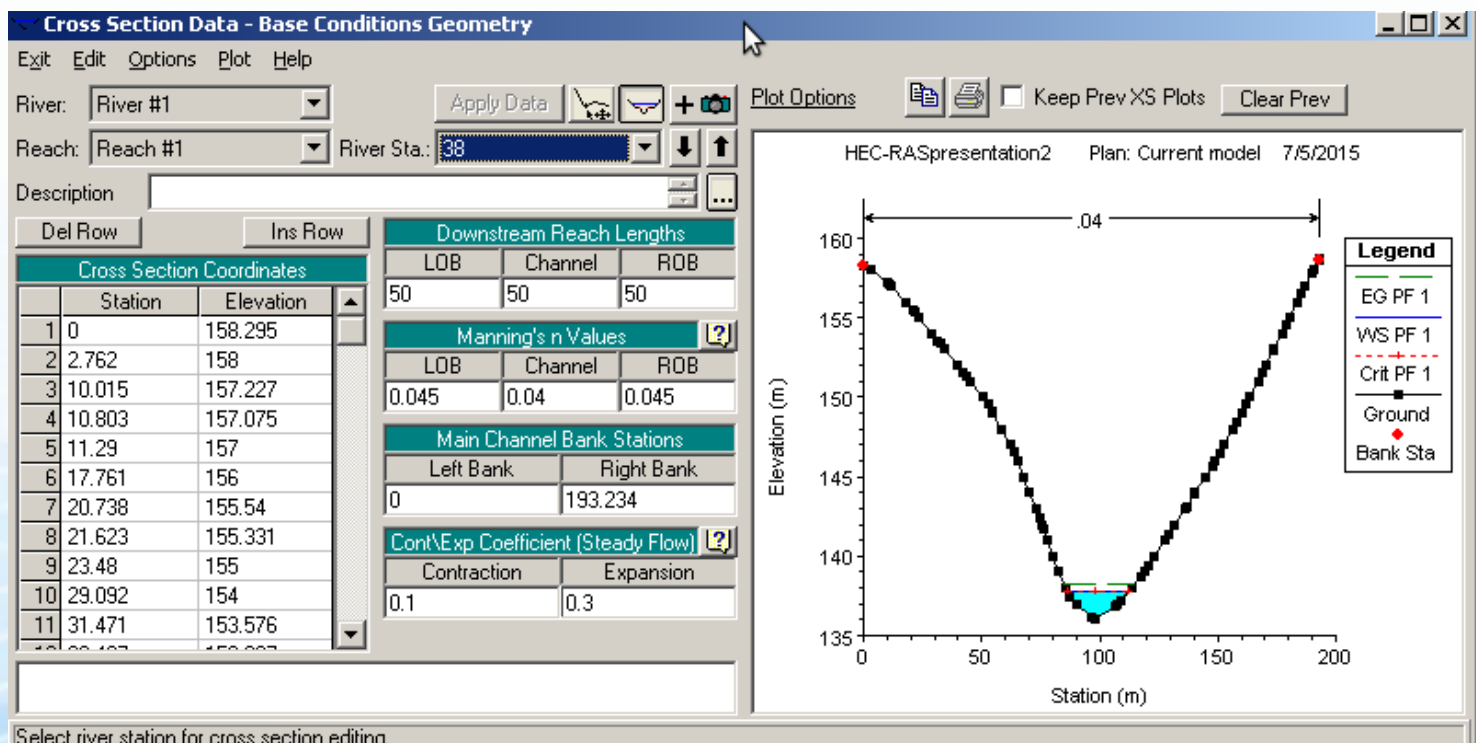
Common borders. Common solutions.

- Pay attention to....**blank data** and **number of XS stations**.



Common borders. Common solutions.

- Check geometry and save the correct file



Common borders. Common solutions.

How to work with Flow data

- Flow data are the .f files
- HEC-RAS can compute the following:

Steady flow (constant with time)

Unsteady flow (varies with time)

Quasi-unsteady flow

- Regimes (supercritical, subcritical, mixed)

Boundary conditions:

1. Supercritical-upstream
2. Subcritical-downstream
3. Mixed-both

FLOW DATA

Common borders. Common solutions.

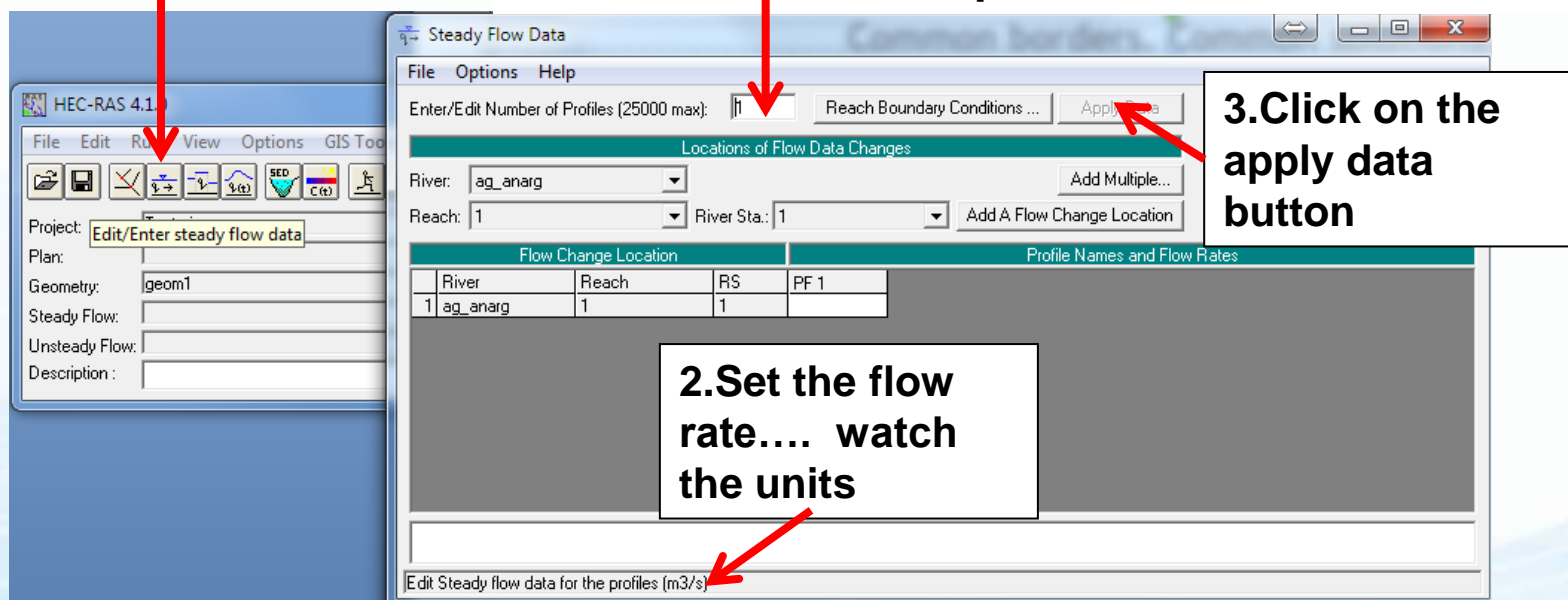
- Flow data is obtained from appropriate precipitation data collection for each region and the creation of a Unit Hydrograph.
- Flow measurement data
- Rainfall Intensity Duration Frequency Curves,
- STEEL equation,
- Peak Stormwater Runoff Rate Equations
- In our case ...

	<u>10y</u>	<u>50y</u>	<u>100y</u>
<u>Flow Discharge (m³/s)</u>	<u>64.50</u>	<u>117.46</u>	<u>240.85</u>
<u>Sediment Discharge(m³/s)</u>	<u>14.15</u>	<u>25.77</u>	<u>52.84</u>

Common borders. Common solutions.

Click here to open the steady flow data menu

1. Set the number of profiles...for different flow rates



HEC-RAS 4.1.0

File Edit Reach View Options GIS Tools

Project: **Edit/Enter steady flow data**

Plan:

Geometry: geom1

Steady Flow:

Unsteady Flow:

Description:

Steady Flow Data

File Options Help

Enter/Edit Number of Profiles (25000 max): **1** Reach Boundary Conditions ... Apply

Locations of Flow Data Changes

River: ag_anarg Add Multiple...

Reach: 1 River Sta.: 1 Add A Flow Change Location

Flow Change Location				Profile Names and Flow Rates	
River	Reach	RS	PF		
1	ag_anarg	1	1		

2. Set the flow rate.... watch the units

3. Click on the apply data button

Edit Steady flow data for the profiles (m3/s)

Common borders. Common solutions.

Decide on and set the boundary conditions...assume if no other way the condition of flow upstream or downstream

Save the flow Data, (the first time use the "save as" option

The screenshot shows the 'Steady Flow Data' dialog box with the 'Reach Boundary Conditions ...' button circled in red. Below it, the 'Steady Flow Boundary Conditions' dialog box is open, showing the 'Set boundary for all profiles' option selected. The 'Available External Boundary Condition Types' section includes 'Known W.S.', 'Critical Depth', 'Normal Depth', 'Rating Curve', and 'Delete'. The 'Selected Boundary Condition Locations and Types' table is as follows:

River	Reach	Profile	Upstream	Downstream
ag_anarg	1	all		

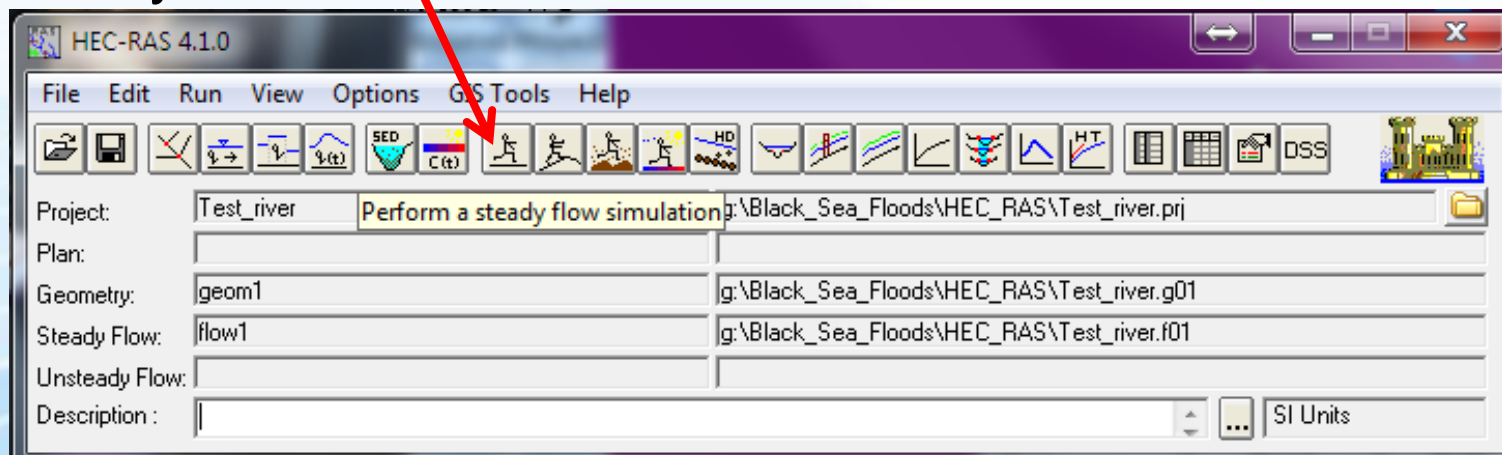
At the bottom of the dialog, there are buttons for 'OK', 'Cancel', and 'Help', and a note: 'Select boundary condition for the upstream side of selected reach.'

From the main HEC-RAS menu a plan may be saved...but not necessary.

Common borders. Common solutions.

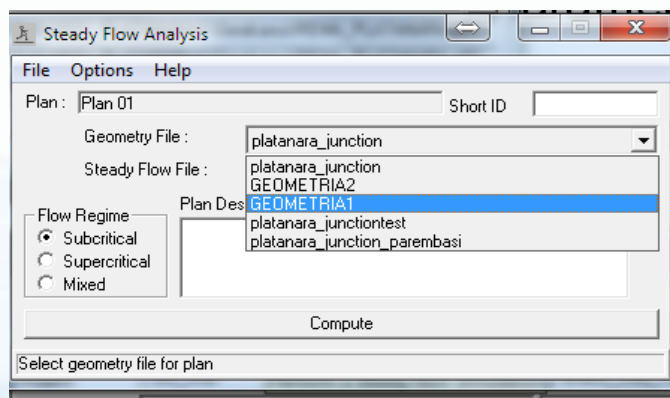
- Following the last steps unsteady and quasi-steady data can be created and saved.
- Now all the necessary parameters have been created for a successful run.

Click on this button to perform the analysis-simulation for steady flow.



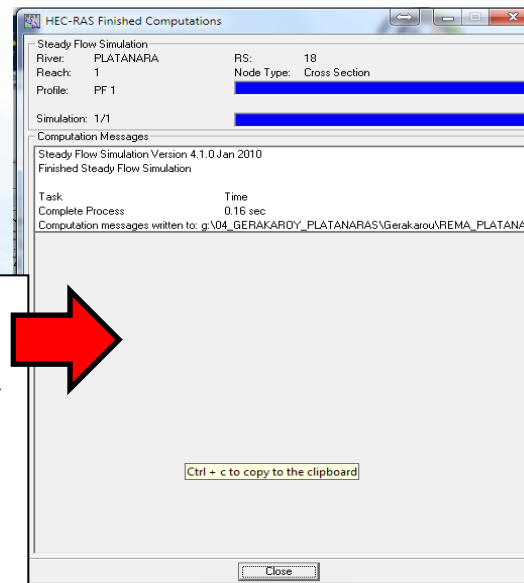
Common borders. Common solutions.

On the Analysis menu different .g files, flow rates and regimes may be chosen. Once they are set click **Compute** to run the simulation



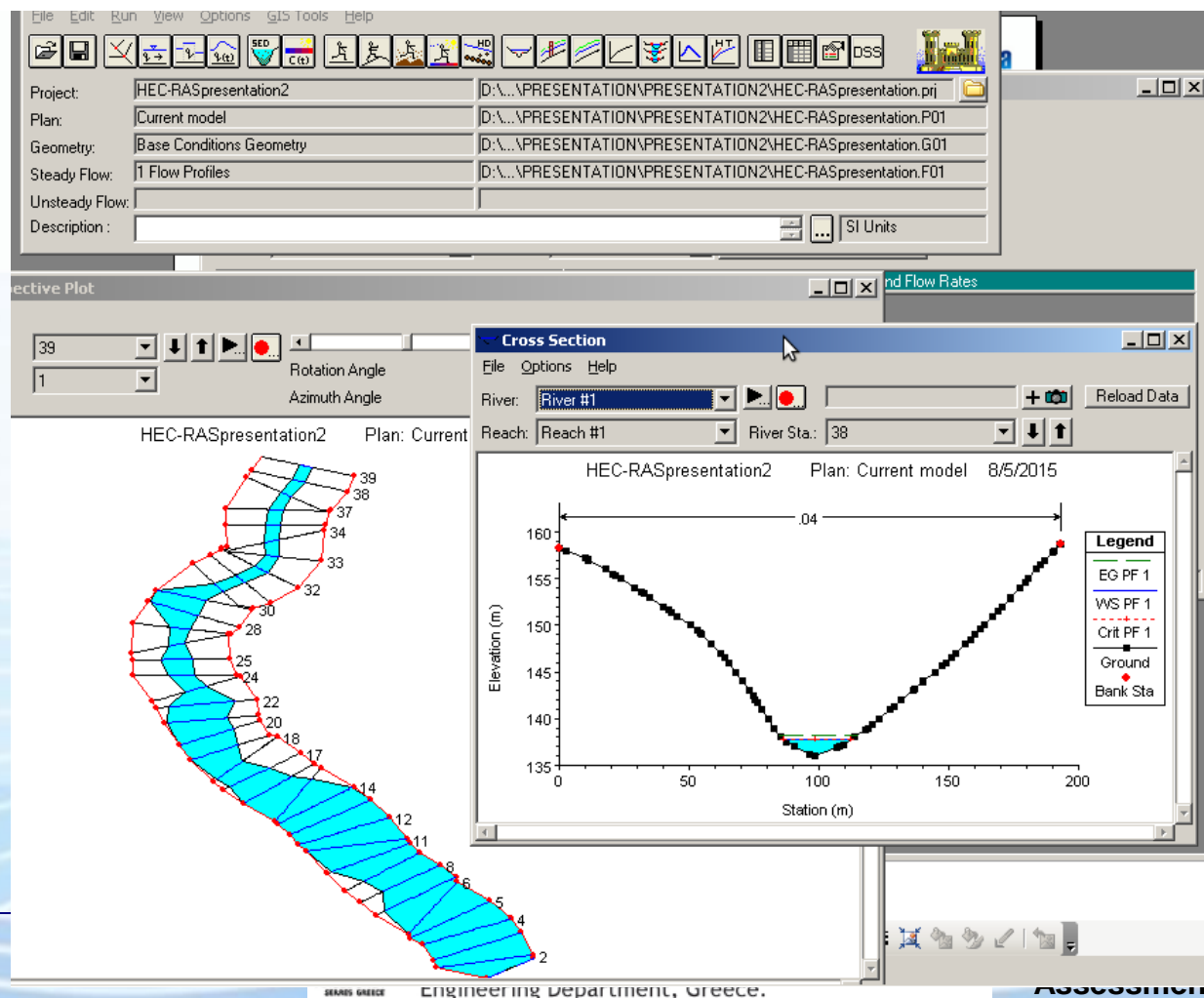
If computations are successful the following window appears, otherwise...

Congrats ,
you did it!

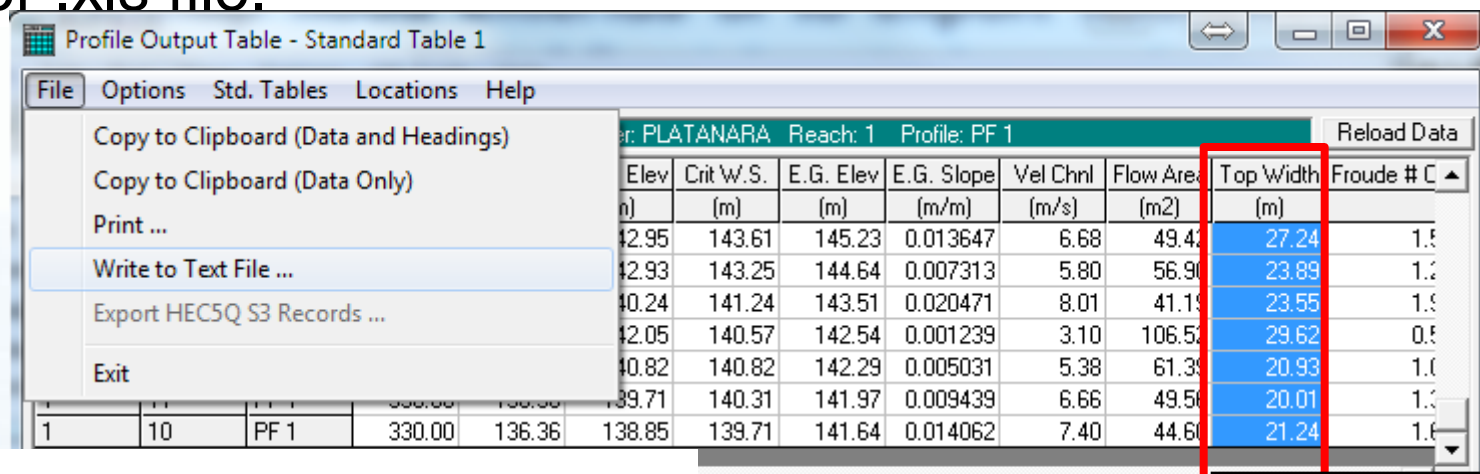


Errors and problems' reports appear in this area and everything should be corrected... then run the simulation again

This is how the simulation results appear in cross sections, profile plots and tables.



- To map flood extends or to export floodplain results table data (top width of flow) has to be copied in a text editor or .xls file.



Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

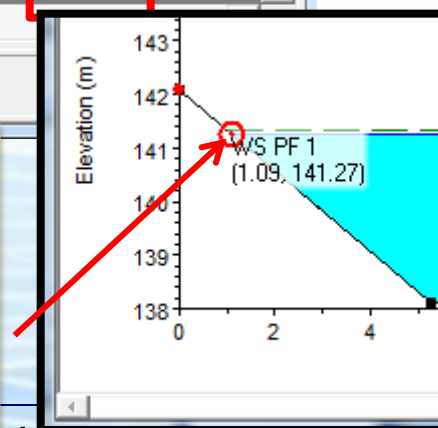
Copy to Clipboard (Data and Headings)
Copy to Clipboard (Data Only)
Print ...
Write to Text File ...
Export HEC5Q S3 Records ...
Exit

Location: PLATANARA Reach: 1 Profile: PF 1 Reload Data

Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m ²)	Top Width (m)	Froude # C
142.95	143.61	145.23	0.013647	6.68	49.4	27.24	1.5
142.93	143.25	144.64	0.007313	5.80	56.9	23.89	1.2
140.24	141.24	143.51	0.020471	8.01	41.1	23.55	1.5
142.05	140.57	142.54	0.001239	3.10	106.5	29.62	0.5
140.82	140.82	142.29	0.005031	5.38	61.3	20.93	1.0
139.71	140.31	141.97	0.009439	6.66	49.5	20.01	1.5
138.85	139.71	141.64	0.014062	7.40	44.6	21.24	1.6

- The top width of flow has to be related to the first station of the cross section. That is easy to do from geometry data.

By clicking on the water surface line the distance from the first station is given.

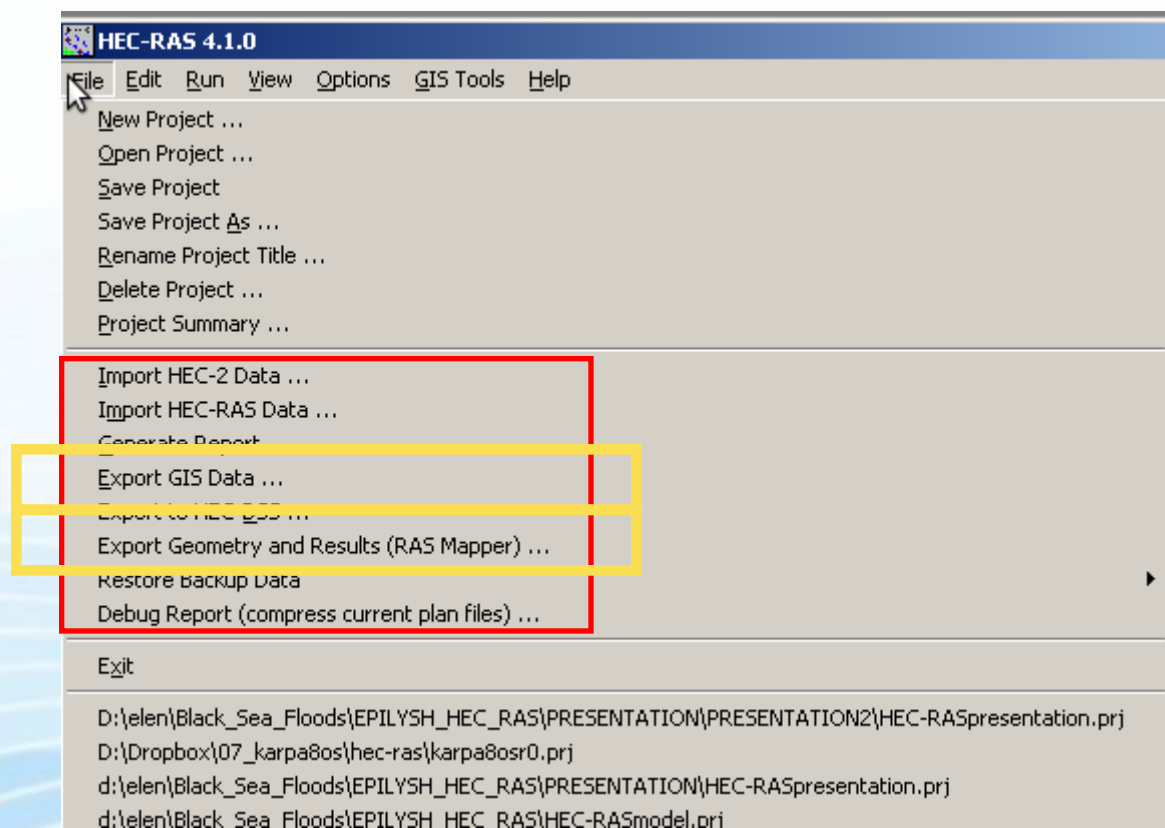


Common borders. Common solutions.

- Finally, we need to save the project file we have been working on....and continue in QGIS for floodplain mapping.

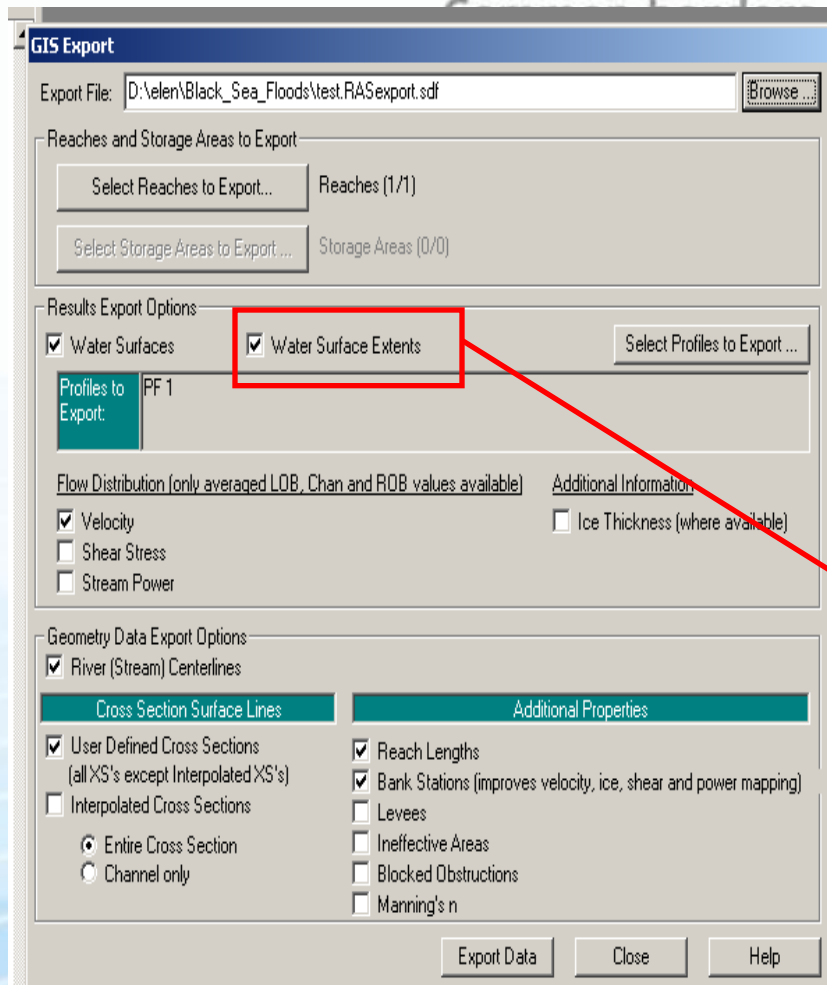
Common borders. Common solutions.

- **How to Export HEC-RAS to QGIS**



Common solutions.

- The .sdf file is for ArcGIS only....but contains all information needed !!!
(open with notepad)



GIS Export

Export File: D:\elen\Black_Sea_Floods\test.RASexport.sdf Browse...

Reaches and Storage Areas to Export

Select Reaches to Export... Reaches (1/1)

Select Storage Areas to Export... Storage Areas (0/0)

Results Export Options

☒ Water Surfaces ☒ Water Surface Extents Select Profiles to Export...

Profiles to Export: PF 1

Flow Distribution (only averaged LOB, Chan and ROB values available) Additional Information

☒ Velocity ☐ Ice Thickness (where available)

☐ Shear Stress

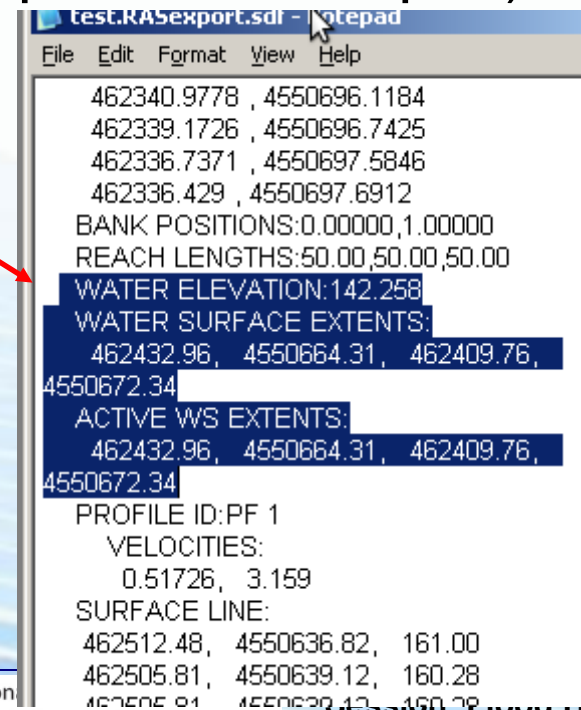
☐ Stream Power

Geometry Data Export Options

☒ River (Stream) Centerlines

Cross Section Surface Lines	Additional Properties
<input checked="" type="checkbox"/> User Defined Cross Sections (all XS's except Interpolated XS's)	<input checked="" type="checkbox"/> Reach Lengths
<input type="checkbox"/> Interpolated Cross Sections	<input checked="" type="checkbox"/> Bank Stations (improves velocity, ice, shear and power mapping)
<input type="checkbox"/> Entire Cross Section	<input type="checkbox"/> Levees
<input type="checkbox"/> Channel only	<input type="checkbox"/> Ineffective Areas
	<input type="checkbox"/> Blocked Obstructions
	<input type="checkbox"/> Manning's n

Export Data Close Help

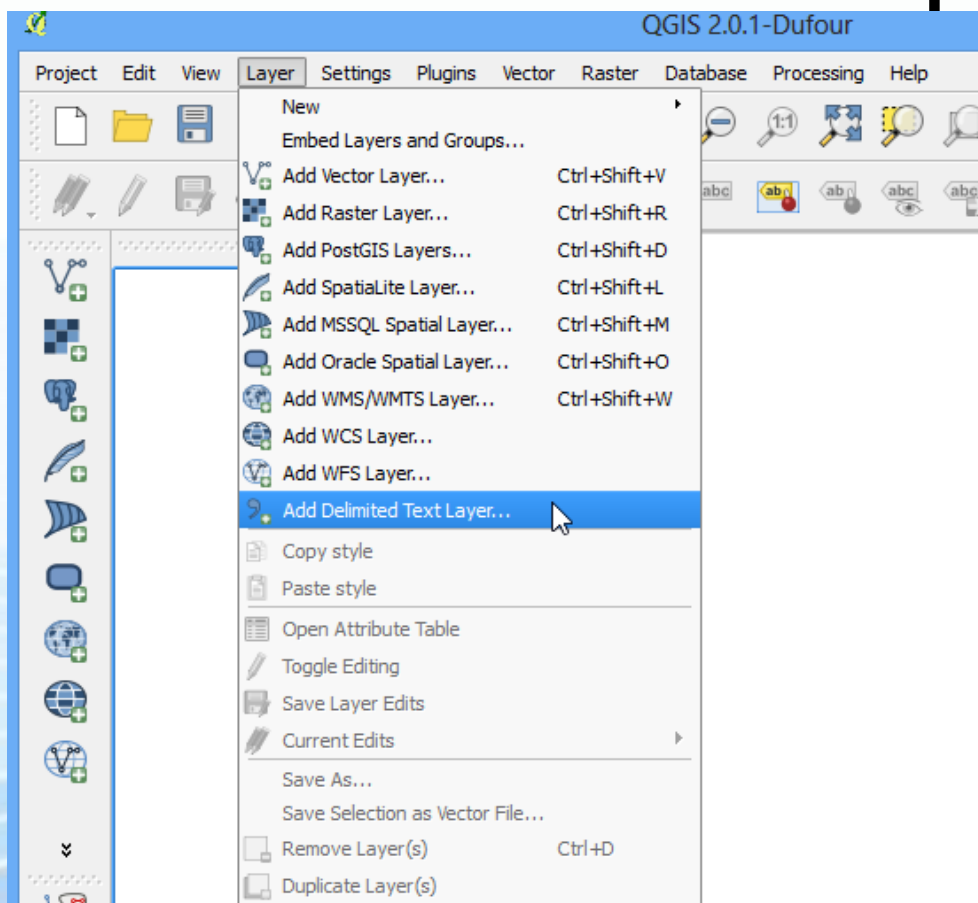


```

File Edit Format View Help
462340.9778 , 4550696.1184
462339.1726 , 4550696.7425
462336.7371 , 4550697.5846
462336.429 , 4550697.6912
BANK POSITIONS:0.00000,1.00000
REACH LENGTHS:50.00,50.00,50.00
WATER ELEVATION:142.258
WATER SURFACE EXTENTS:
462432.96, 4550664.31, 462409.76,
4550672.34
ACTIVE WS EXTENTS:
462432.96, 4550664.31, 462409.76,
4550672.34
PROFILE ID:PF 1
VELOCITIES:
0.51726, 3.159
SURFACE LINE:
462512.48, 4550636.82, 161.00
462505.81, 4550639.12, 160.28
462505.81, 4550639.12, 160.28
  
```

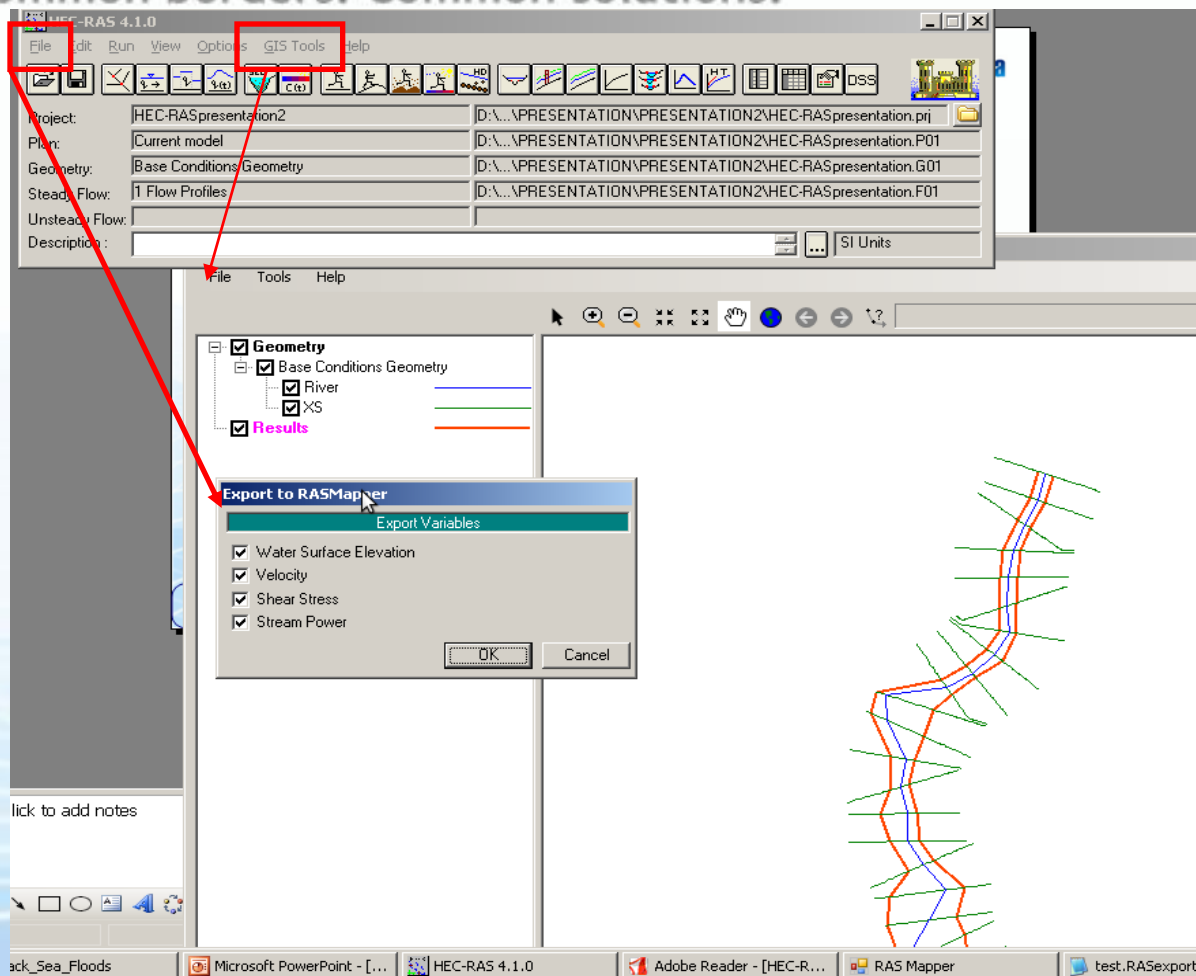
Common borders. Common solutions.

- **Prepare a .csv or .txt file and import to QGIS**



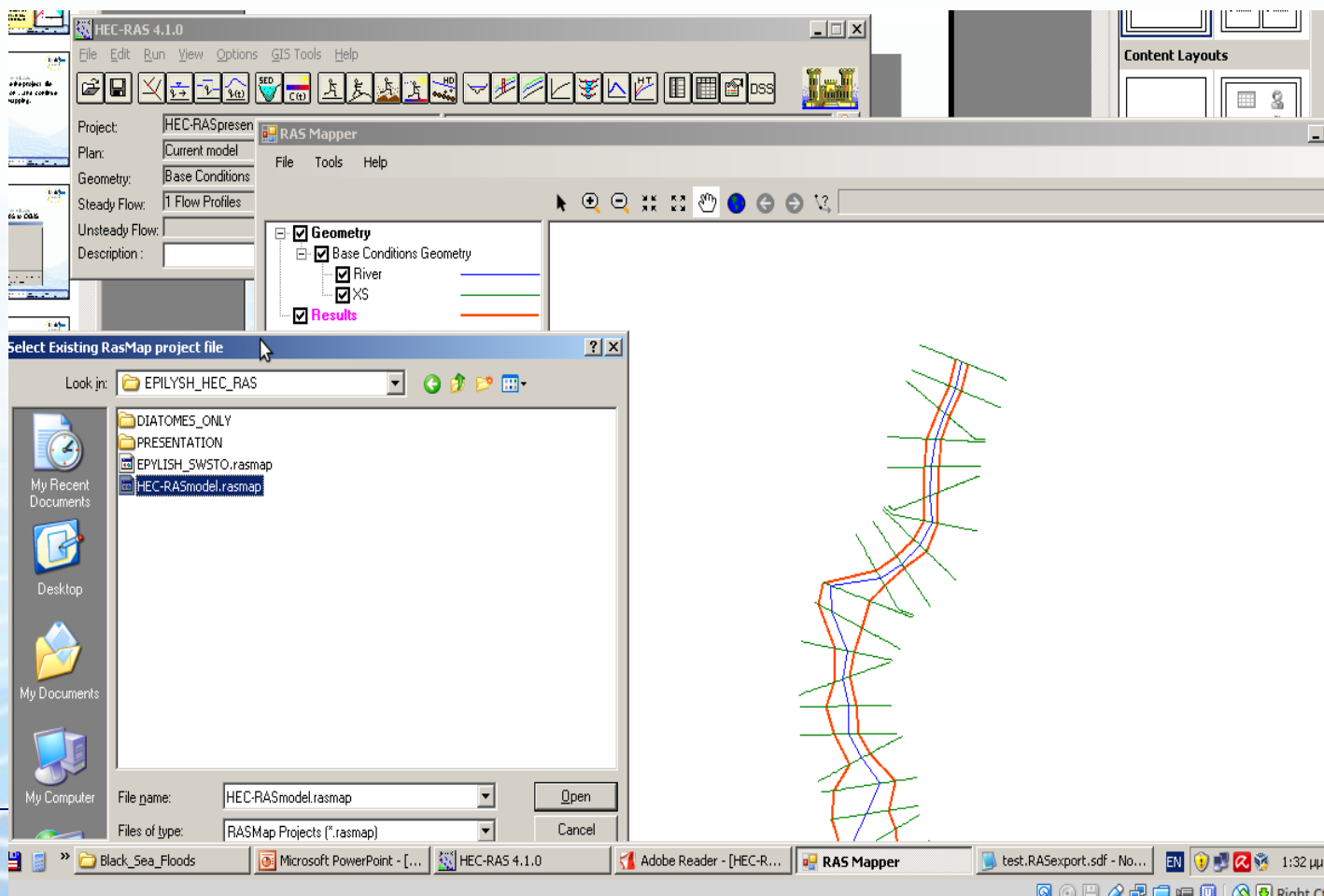
Common borders. Common solutions.

- **RAS Mapper**

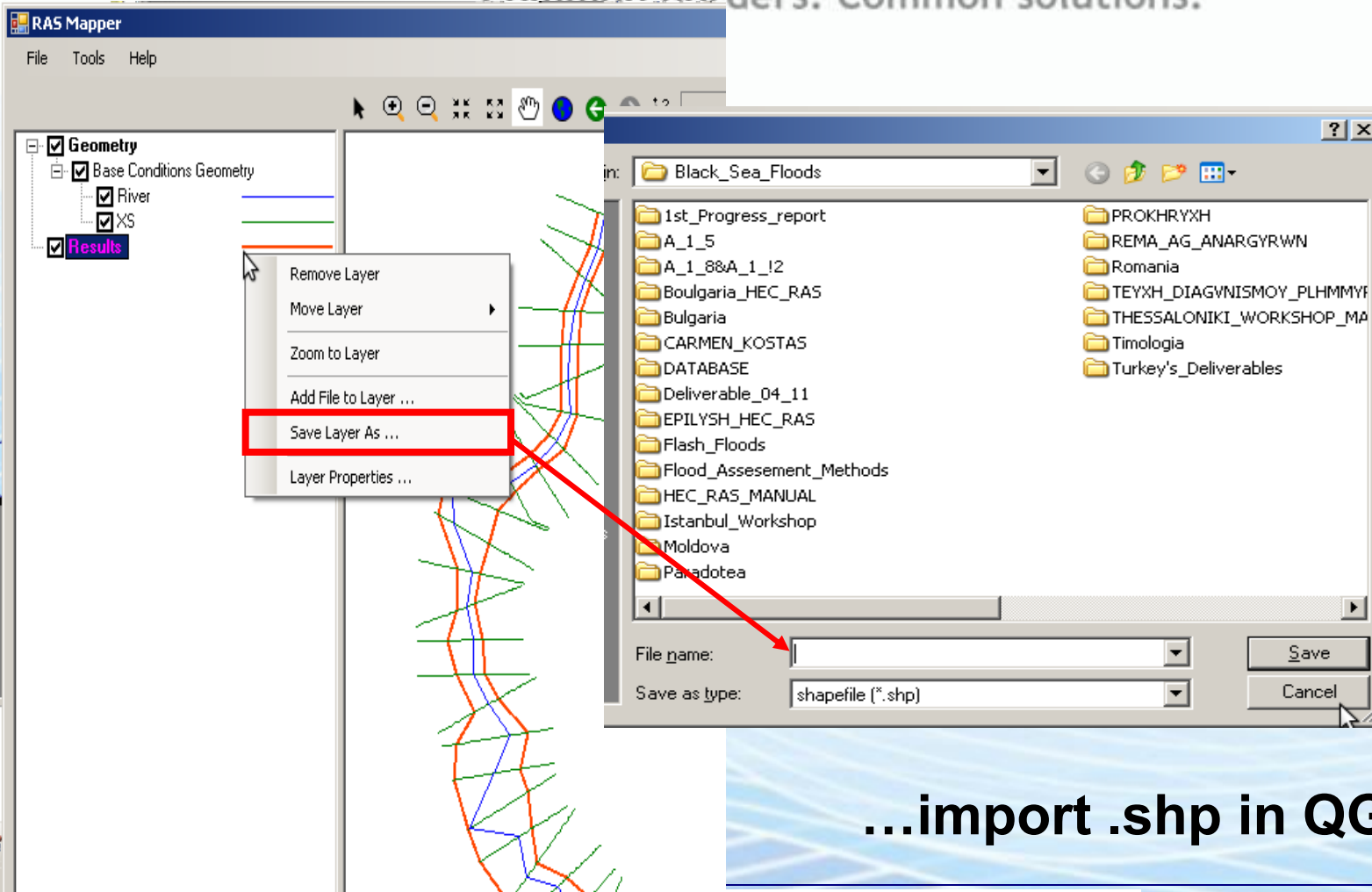


Common borders. Common solutions.

Create a .rasmap file and import it to RAS Mapper



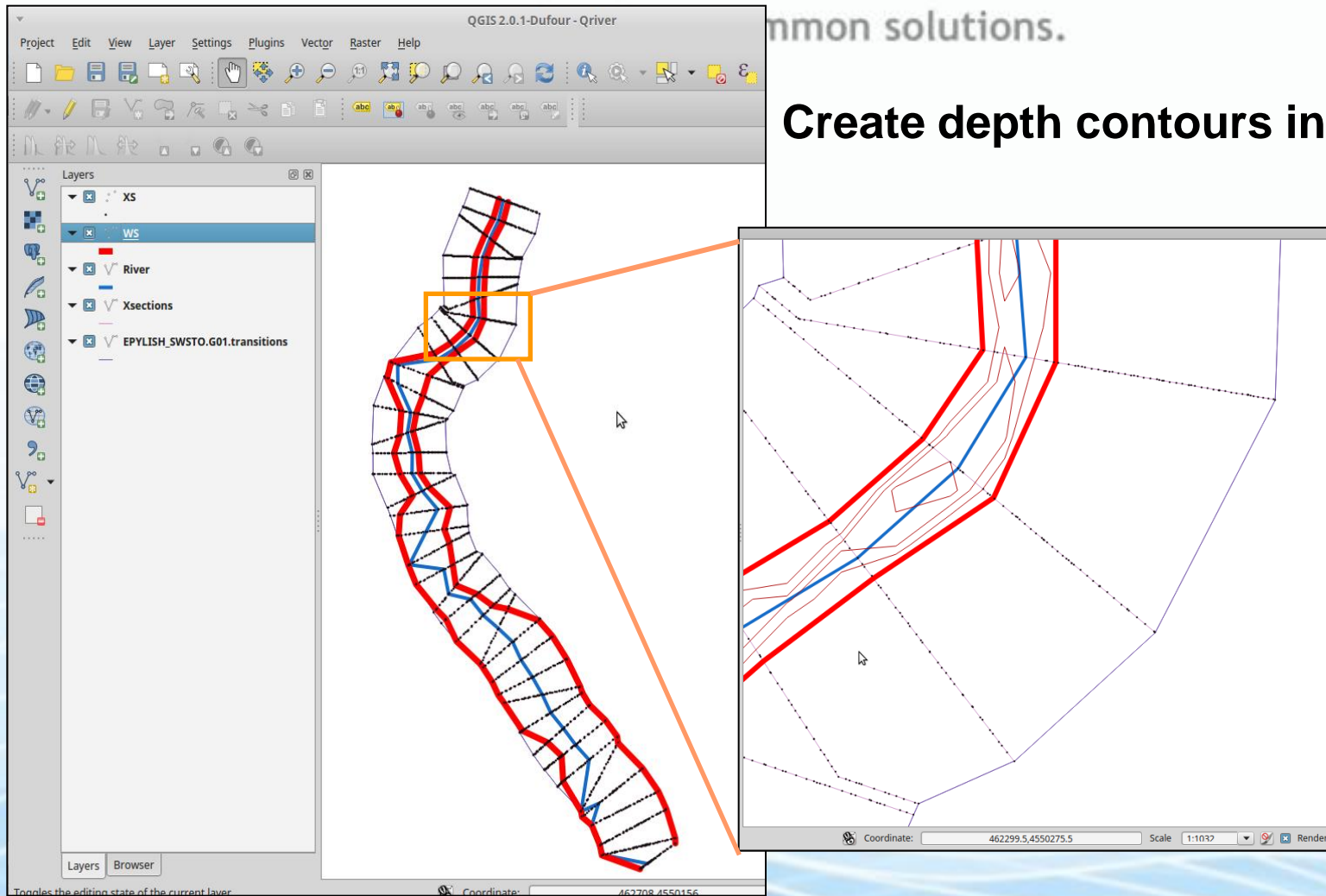
Common borders. Common solutions.



...import .shp in QGIS....

Common solutions.

Create depth contours in GIS



Alternative method to create results in QGIS

Common borders. Common solutions.

- Another way to create results...
- Copy as image the XYZ Perspective Plot from HEC-RAS save it as png, or another image format.
- In QGIS go to Raster Georeferencer and georeference the image.
- Import the image and use the tools to georeference by matching the cross sections of the image to the ones created and extracted at the beginning of the process from QGIS.
- More time-consuming method that needs to add elevation data for each point...but it works too.

Common borders. Common solutions.

Thank you!

Acknowledgments:

The research was partially funded by the EU within the context of the **Black Sea Basin Joint Operational Programme 2007-2013** and partially by **National funds**