

Common borders. Common solutions.

# Earthquake, Landslide and Flood Disaster Prevention: the **SciNetNatHaz** project

## A step-by-step guide to **HEC-RAS**

**E. Tzanou**

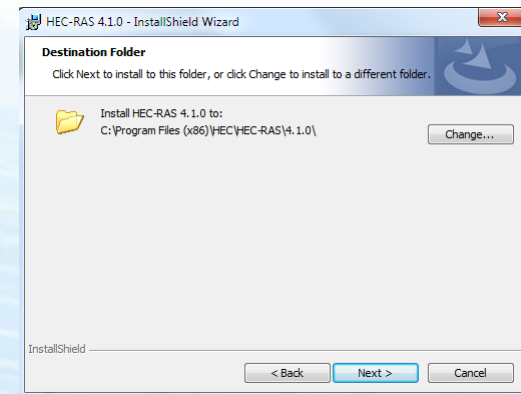
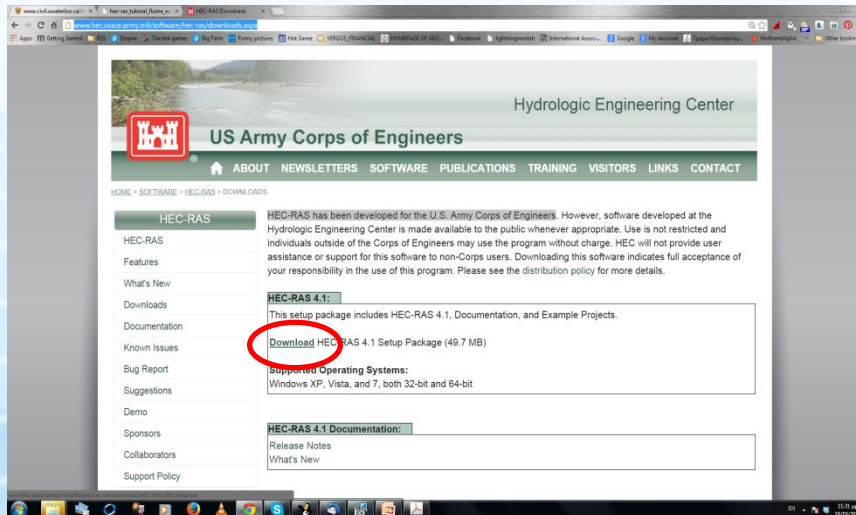
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**Ευχαριστίες:**

Το Ερευνητικό Έργο **SciNetNatHaz** χρηματοδοτείται από  
πόρους της **ΕΥ** μέσω του Προγράμματος **Black Sea  
Basin Joint Operational Programme 2007-2013**  
και από **Εθνικούς πόρους (ΕΣΠΑ)**

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- 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



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# 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**



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# HEC-RAS Structure

## Structure of HEC-RAS

- Creates and saves project files(.prj file)

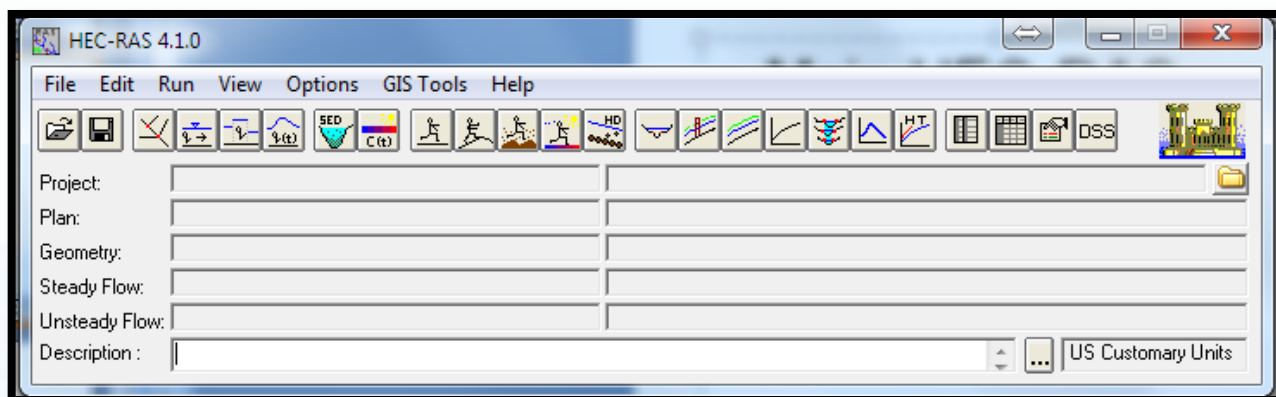
Each project includes:

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!!!!!!**

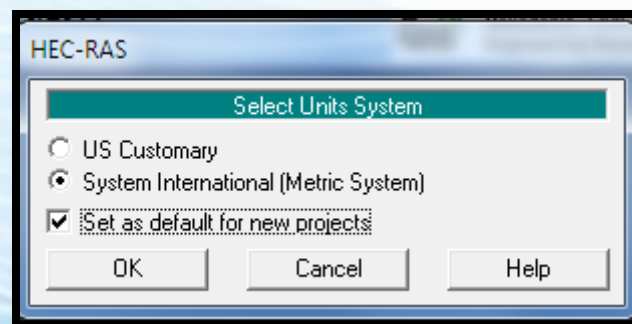
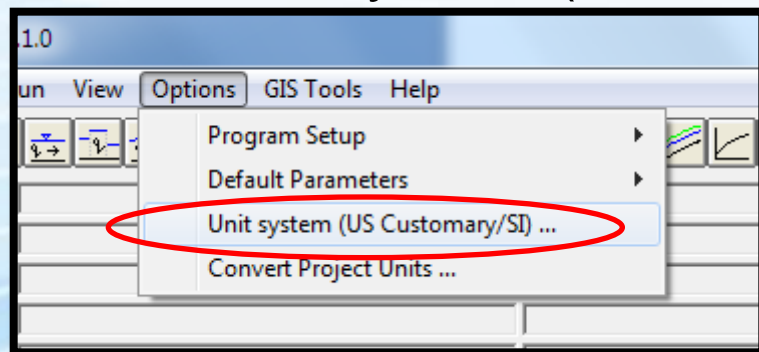
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- Main HEC-RAS Window....start from scratch



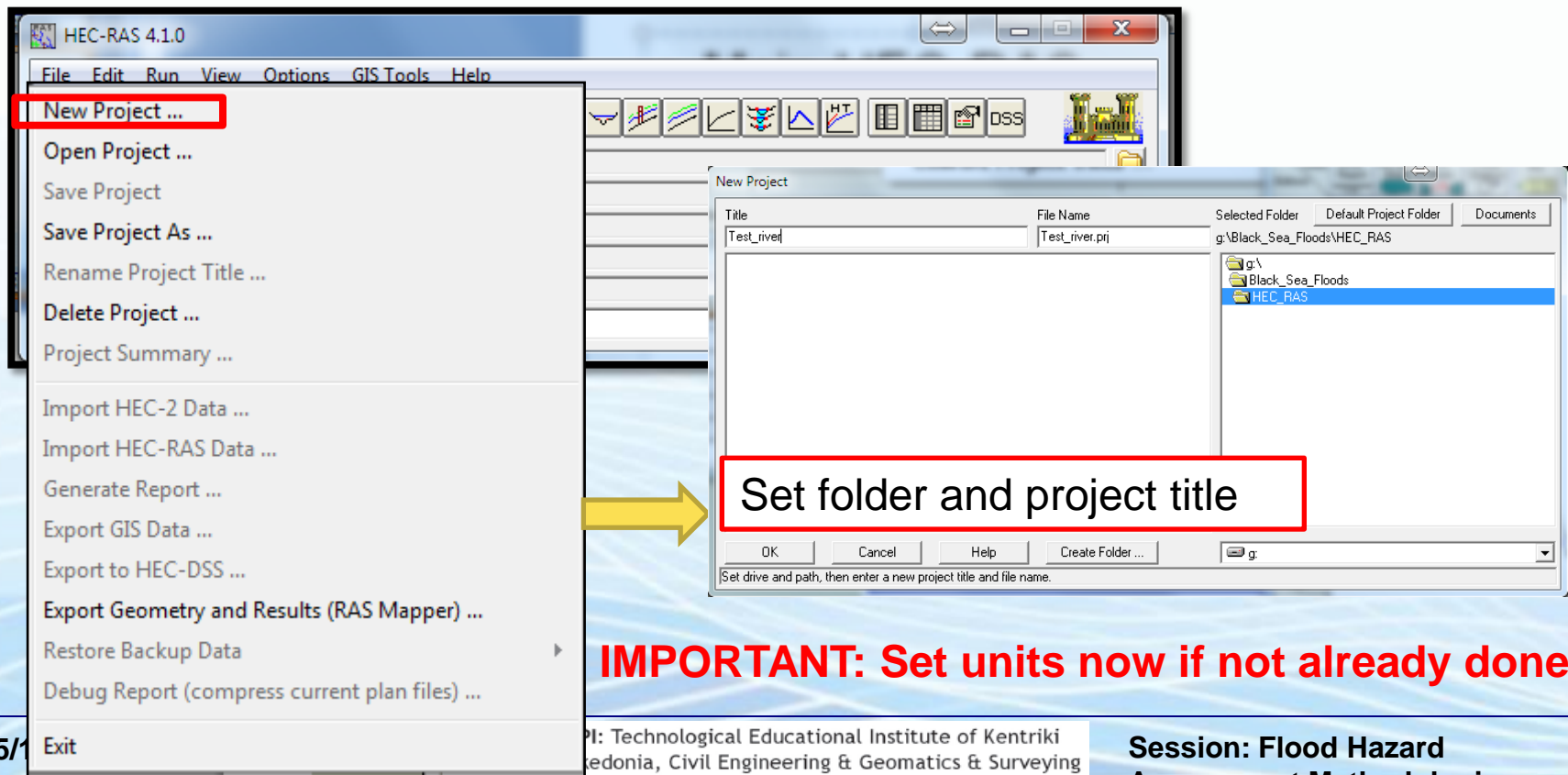
All main functions  
are accessed  
from this menu

- Set Unit System (can be done later too)



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**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!!!!'.

HEC-RAS 4.1.0

File Edit Run View Options GIS Tools Help

New Project ...

Open Project ...

Save Project

Save Project As ...

Rename Project Title ...

Delete Project ...

Project Summary ...

Import HEC-2 Data ...

Import HEC-RAS Data ...

Generate Report ...

Export GIS Data ...

Export to HEC-DSS ...

Export Geometry and Results (RAS Mapper) ...

Restore Backup Data

Debug Report (compress current plan files) ...

Exit

New Project

Title: Test\_river

File Name: Test\_river.prj

Selected Folder: g:\Black\_Sea\_Floods\HEC\_RAS

Default Project Folder: g:\Black\_Sea\_Floods\HEC\_RAS

Documents: g:\Black\_Sea\_Floods\HEC\_RAS

Set folder and project title

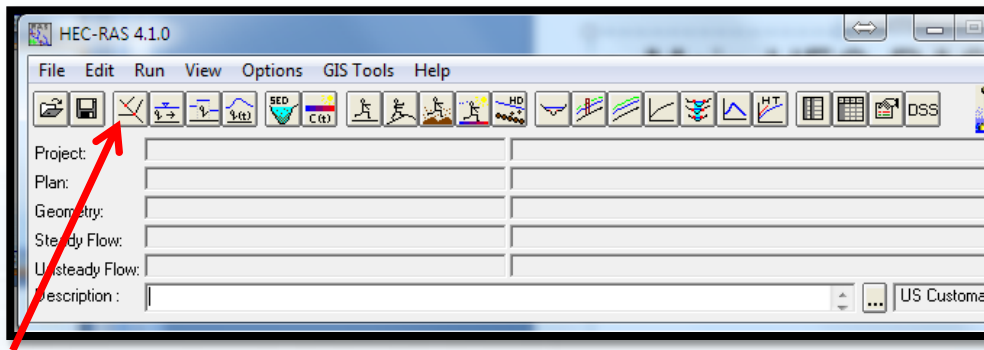
OK Cancel Help Create Folder ...

Set drive and path, then enter a new project title and file name.

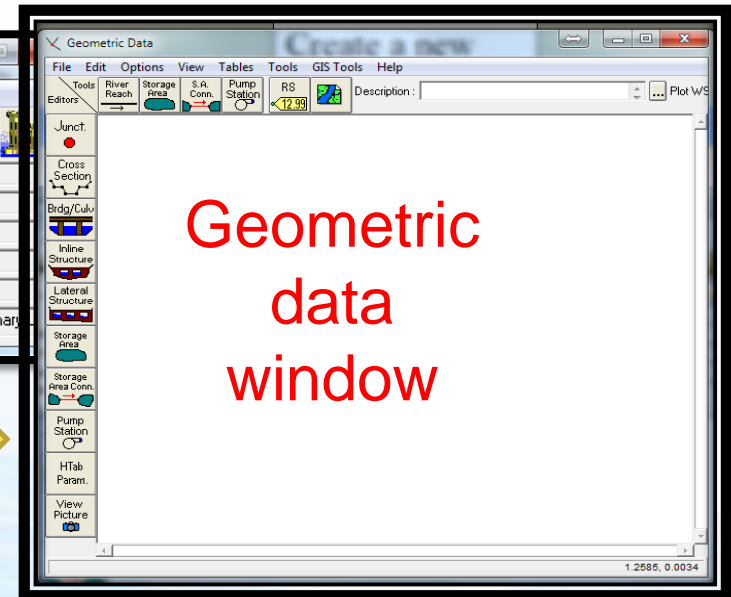
**IMPORTANT: Set units now if not already done!!!!**

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



Click to open geometric  
data editor window

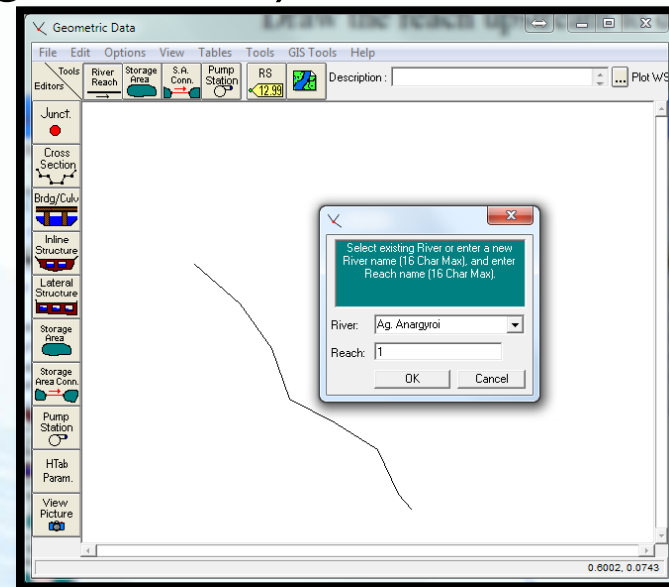
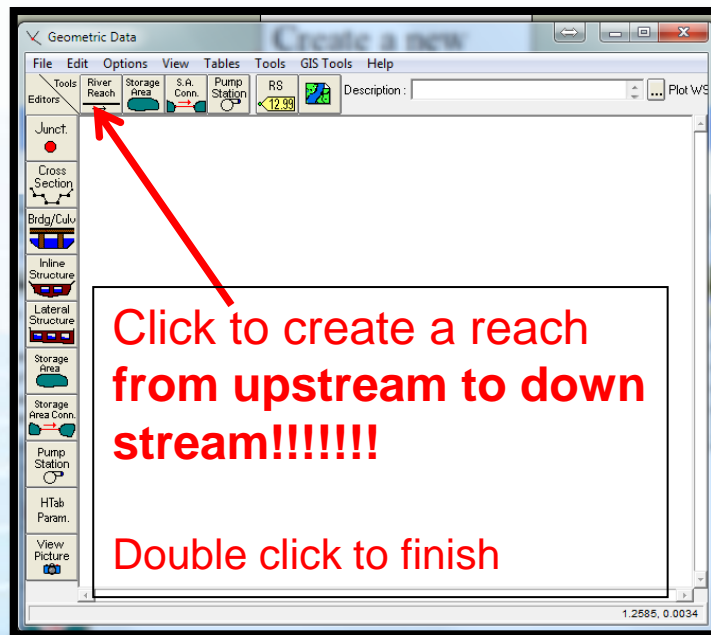


All geometric data and edits are inserted here and must be  
**SAVED**....



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



Then insert river and reach  
name and click ok



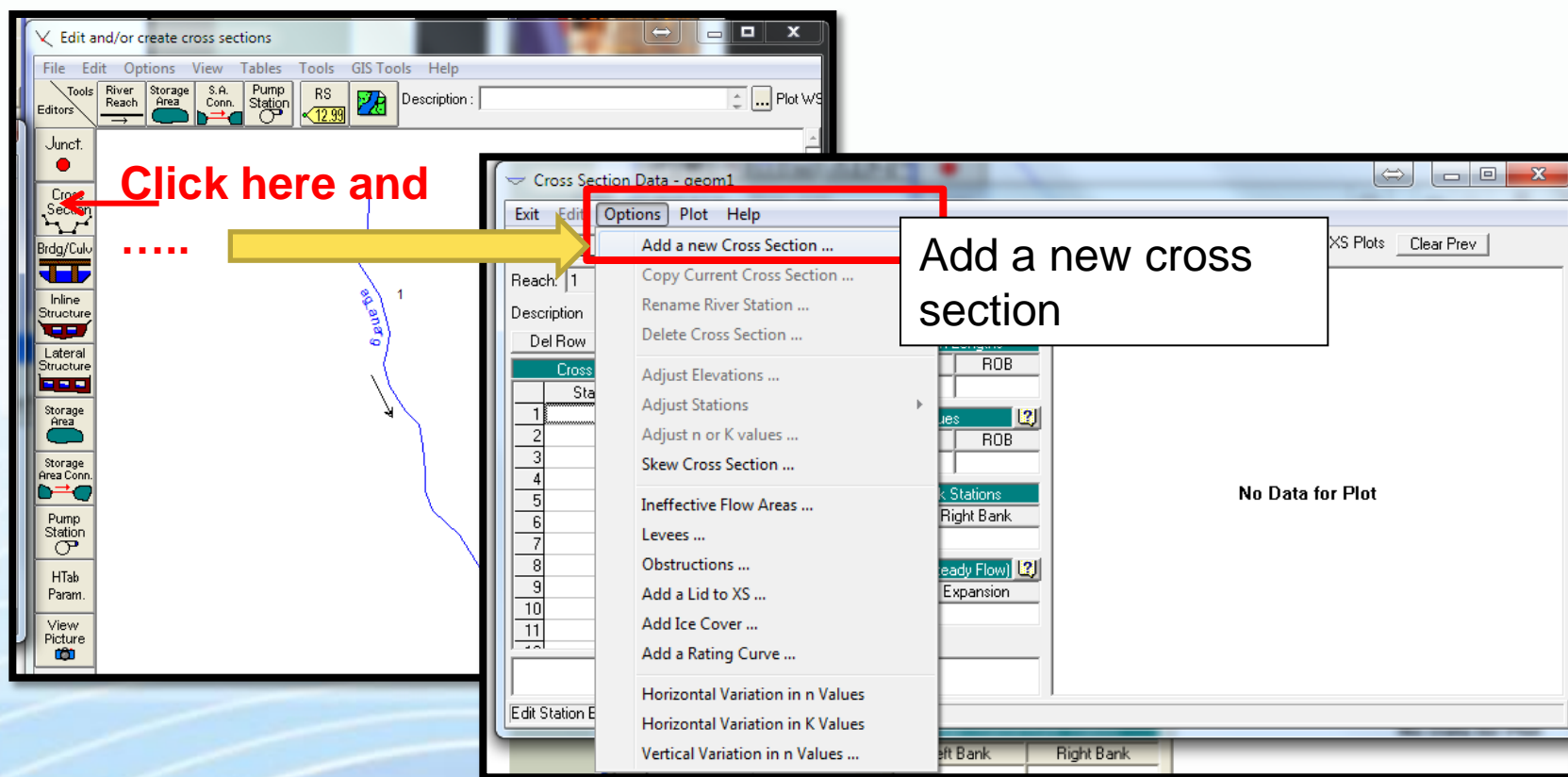
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## Dealing with geometry and Cross Sections

- **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

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# Cross Section data input



Click here and .....

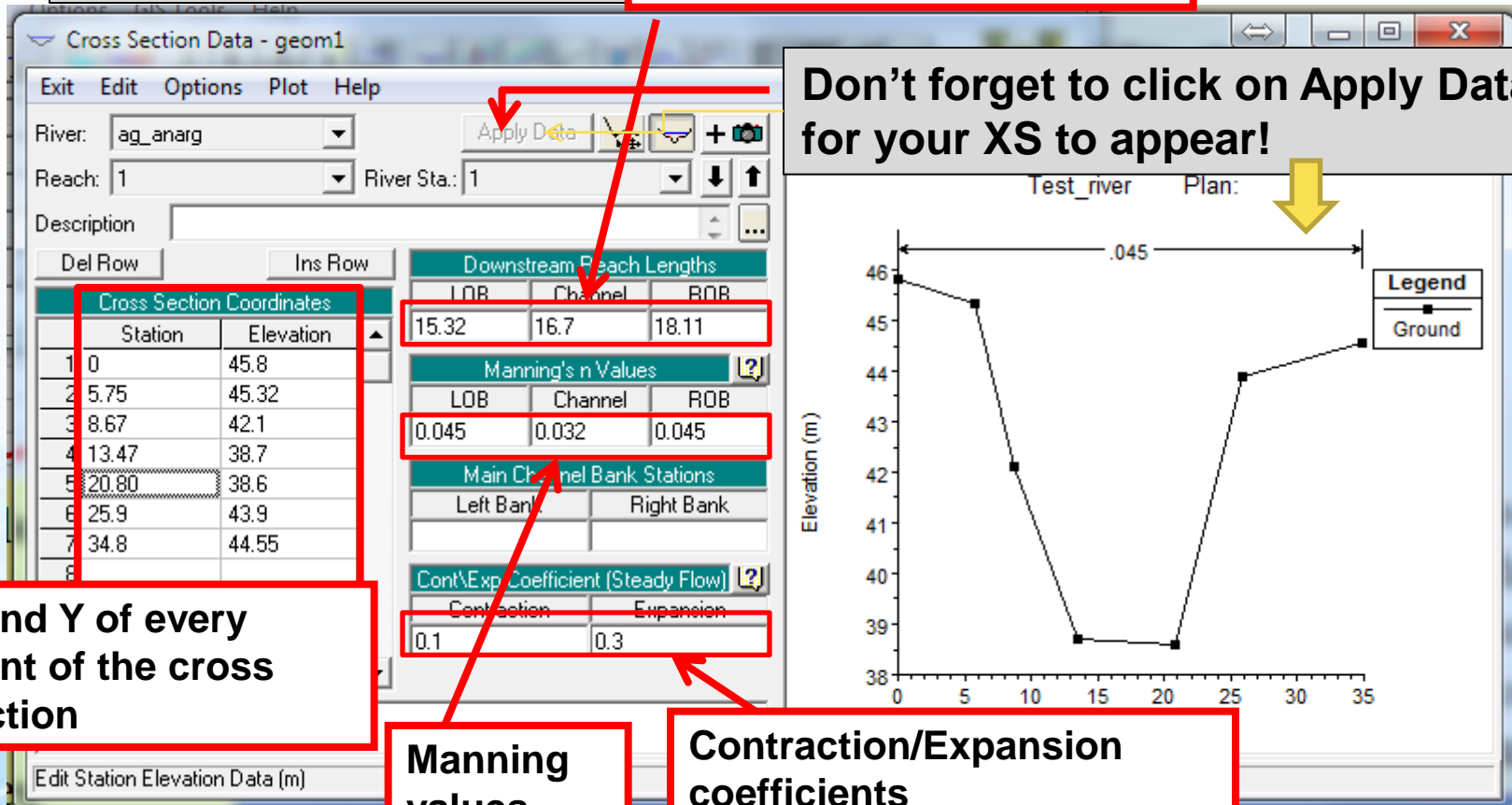
Add a new cross section

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

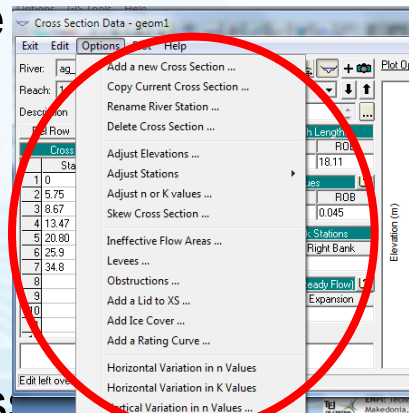
Manning  
values

Contraction/Expansion  
coefficients

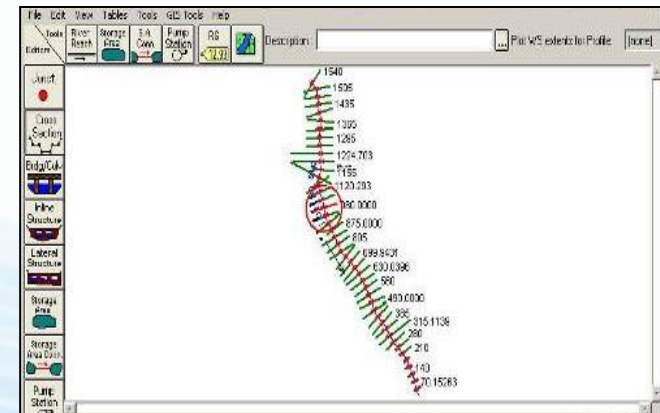
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- Follow the same steps to create all cross sections.
- The geometry in rivers (not culverts) is not uniform so one needs to define all cross sections' characteristics every time manually. If uniform geometry occurs though (i.e. structured channels,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

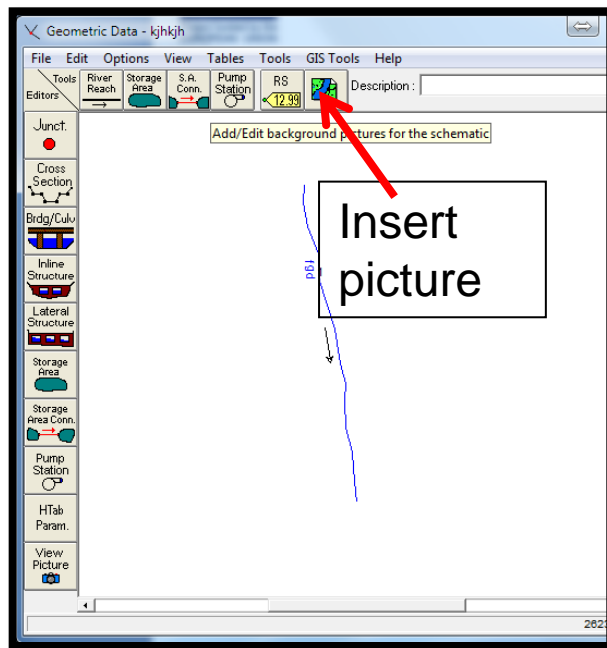


This is how the geometry data looks with many cross sections added

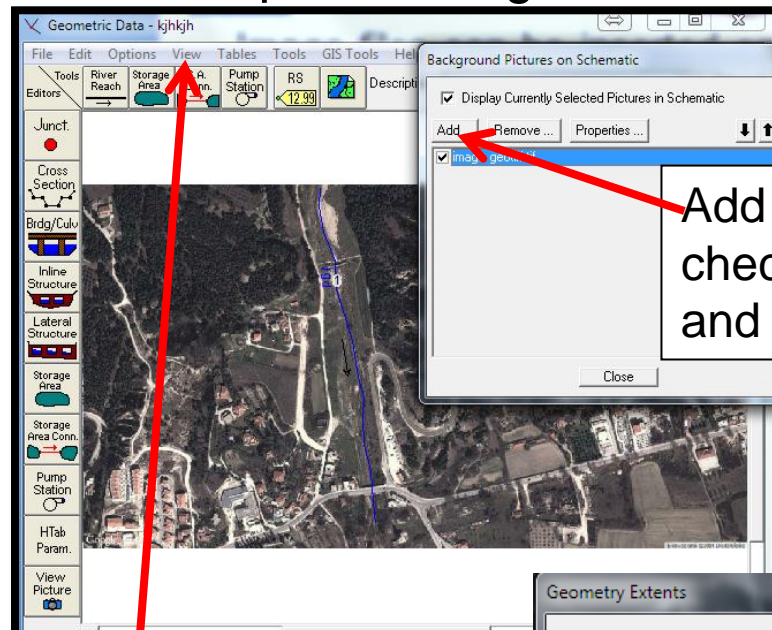




Image files can be inserted only as background (but already georeferenced!!) in HEC-RAS so as to overcome the problem of coordinates (the software does not “accept” or recognize coordinates as a geographic or spatial feature).

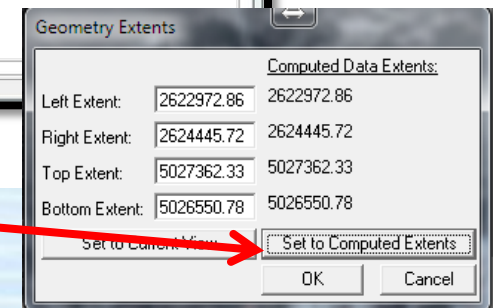


Cross sections may be also added through a .csv file format



Add image file, check image file and close

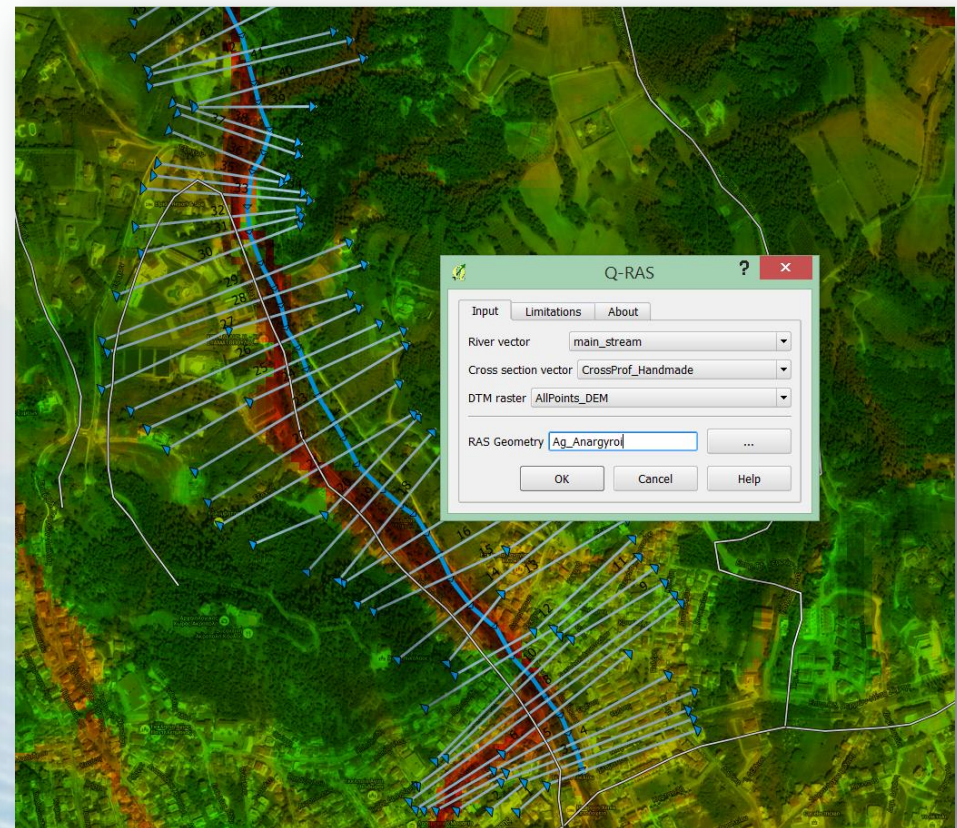
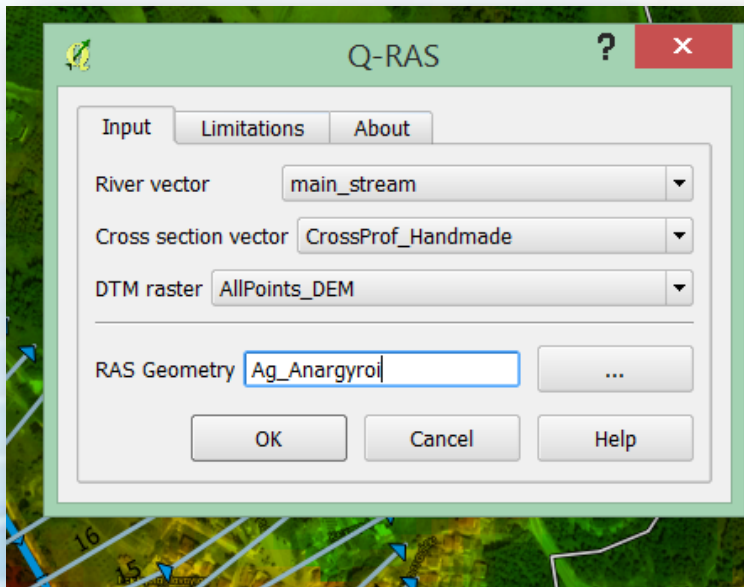
If the image is not visible set image computed extends from schematic plot extend in view menu



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## Create or Import GEOMETRY

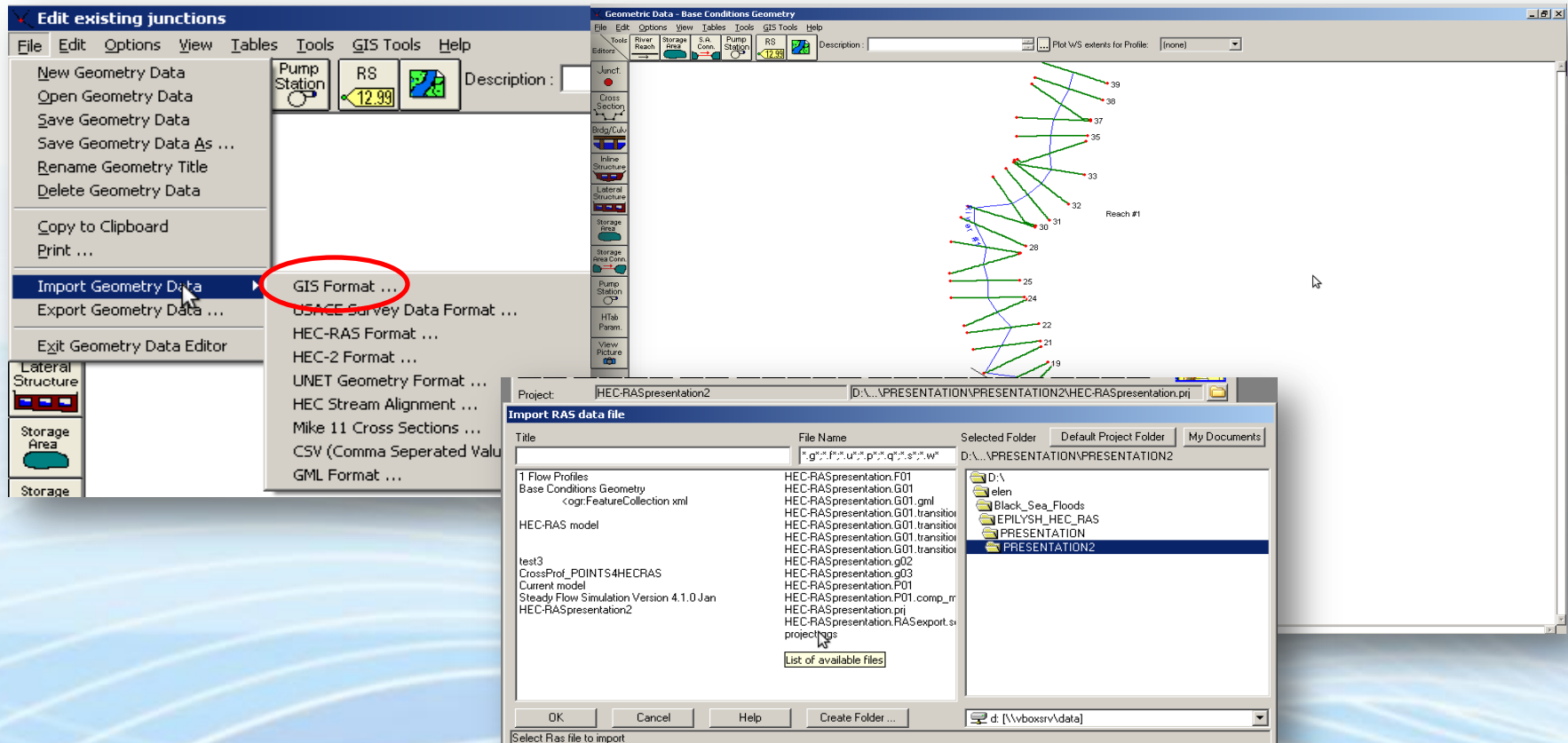
Or....import the XS geometry  
exported from QGIS using the  
**Q-RAS** plugin





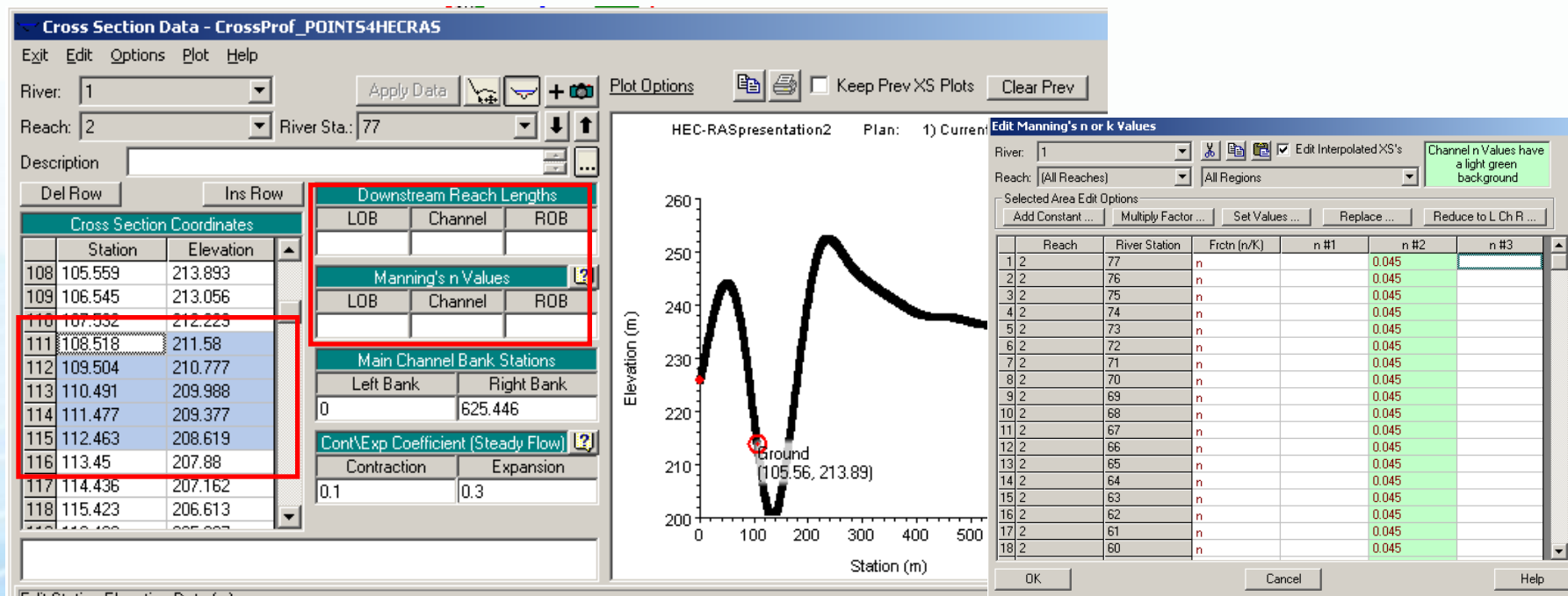
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# Geometry (calculated from Cross Sections)



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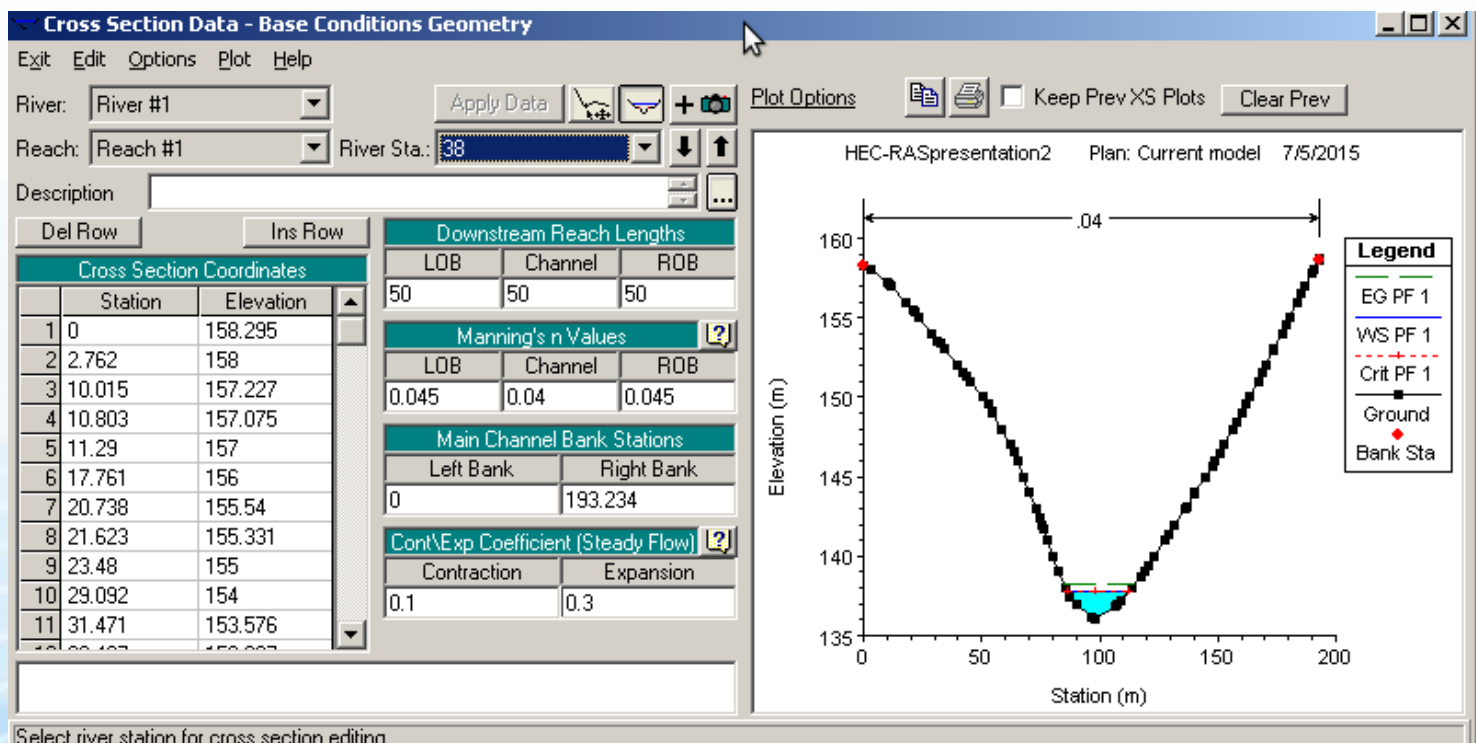
- Pay attention to....**blank data** and **number of XS stations.**





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# Check geometry and save the corrected file



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## 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

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## FLOW DATA

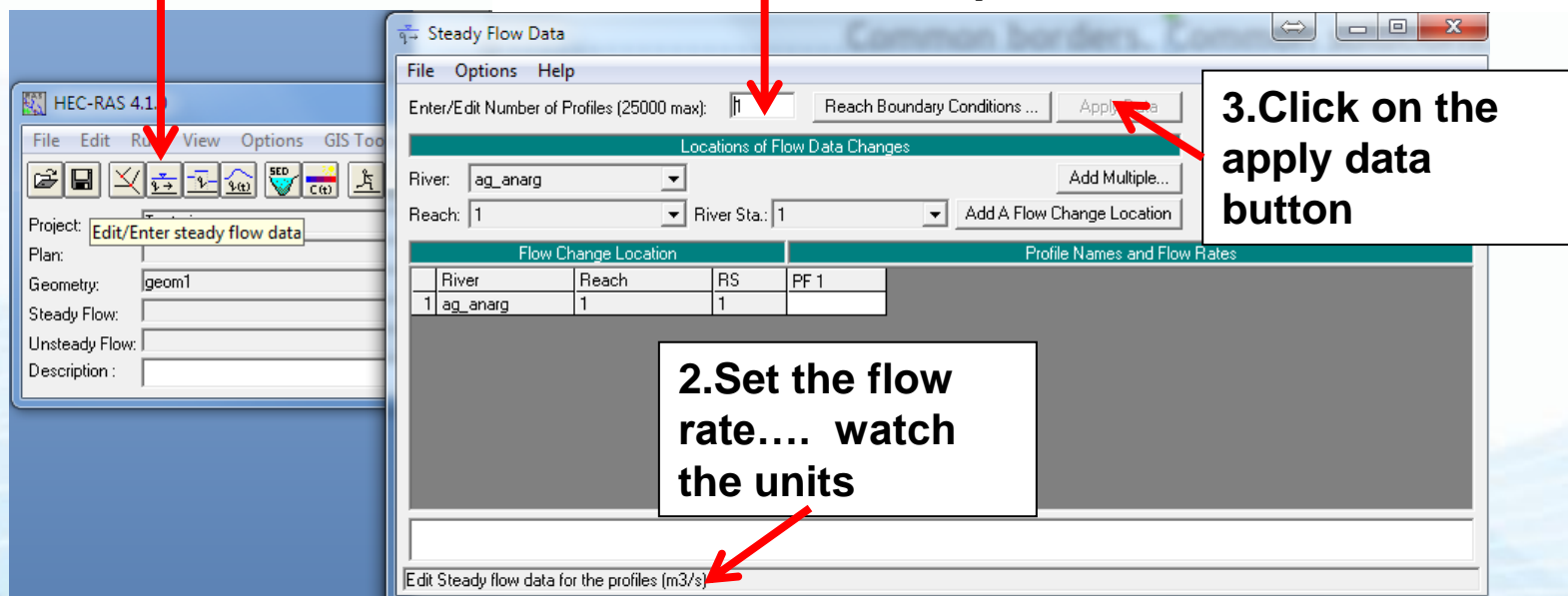
- Flow data is obtained from appropriate precipitation data collection for each region and the creation of a Unit Hydrograph.
- Flow measurement data
- Rainfall Intensity Duration Frequency Curves,
- STEEL equation,
- Peak Stormwater Runoff Rate Equations
- In our case ...

|  | <u>10y</u>   | <u>50y</u>    | <u>100y</u>   |
|--|--------------|---------------|---------------|
| <u>Flow Discharge (m<sup>3</sup>/s)</u>    | <u>64.50</u> | <u>117.46</u> | <u>240.85</u> |
| <u>Sediment Discharge(m<sup>3</sup>/s)</u> | <u>14.15</u> | <u>25.77</u>  | <u>52.84</u>  |

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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 Run 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

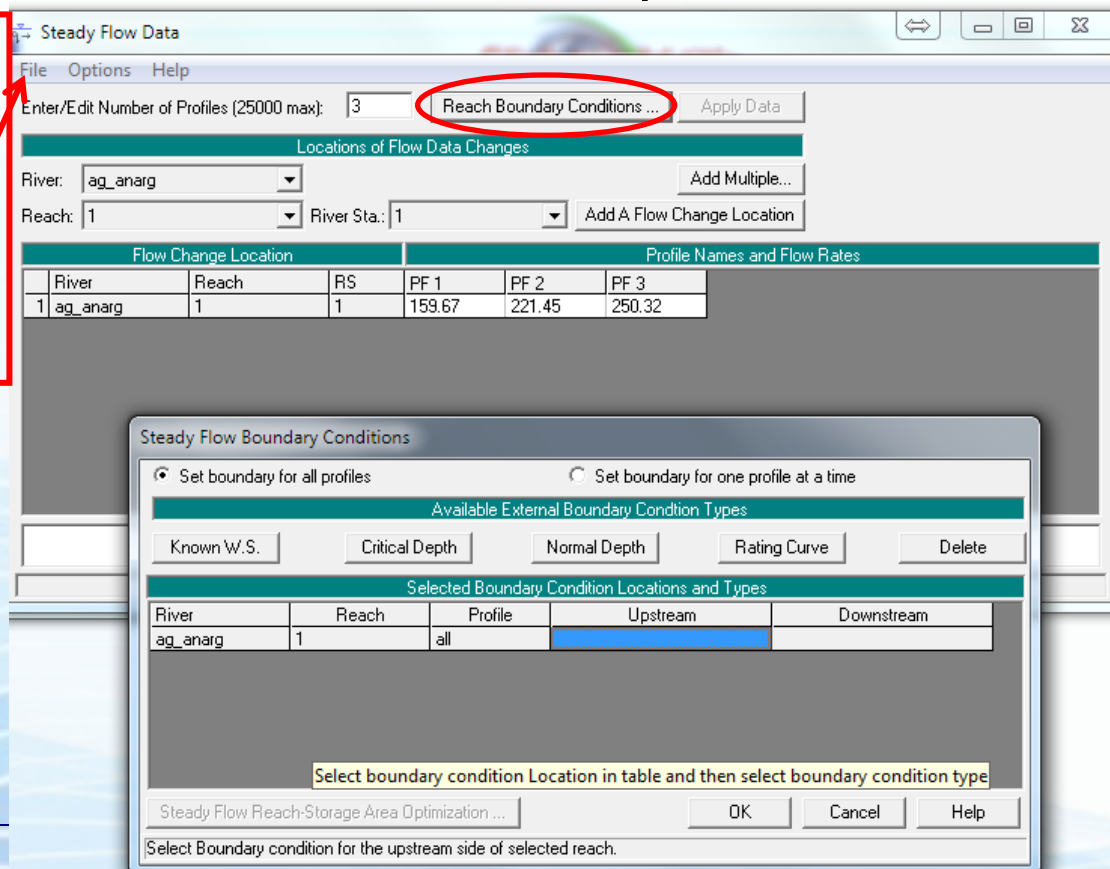
Edit Steady flow data for the profiles (m3/s)



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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 HEC-RAS software interface. The 'Steady Flow Data' dialog box is open, showing the 'Reach Boundary Conditions ...' button circled in red. Below it, the 'Locations of Flow Data Changes' section shows 'River: ag\_anarg' and 'Reach: 1'. The 'Flow Change Location' table is as follows:

| Flow Change Location |       |    | Profile Names and Flow Rates |        |        |
|----------------------|-------|----|------------------------------|--------|--------|
| River                | Reach | RS | PF 1                         | PF 2   | PF 3   |
| 1 ag_anarg           | 1     | 1  | 159.67                       | 221.45 | 250.32 |

The 'Steady Flow Boundary Conditions' dialog box is also open, showing the 'Set boundary for all profiles' radio button 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     |          |            |

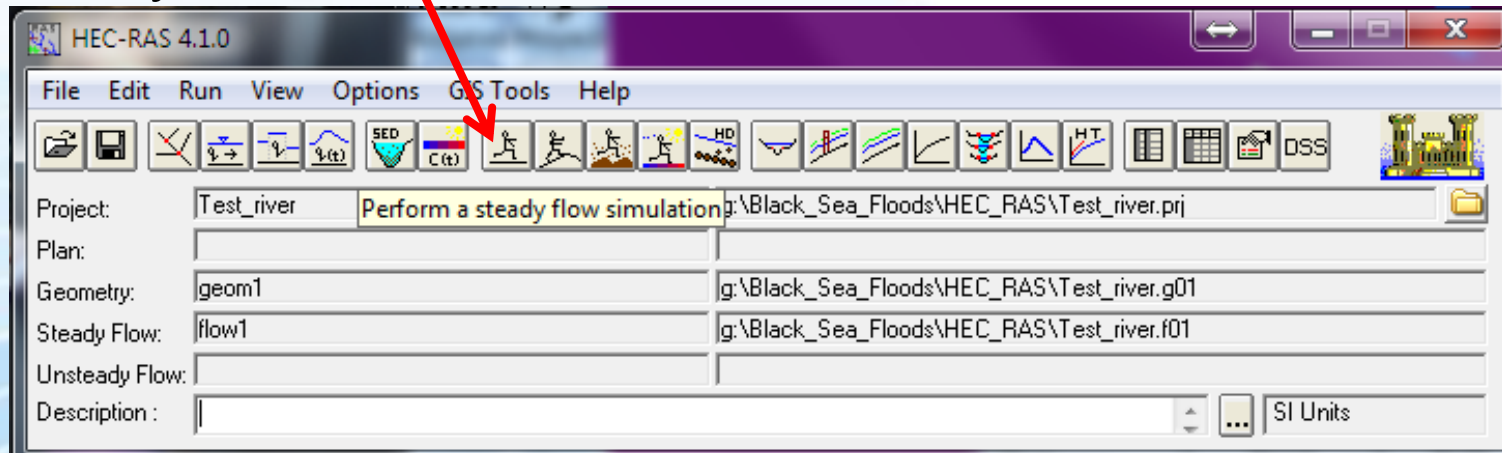
The 'Steady Flow Reach-Storage Area Optimization ...' button is visible at the bottom of the dialog box.

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

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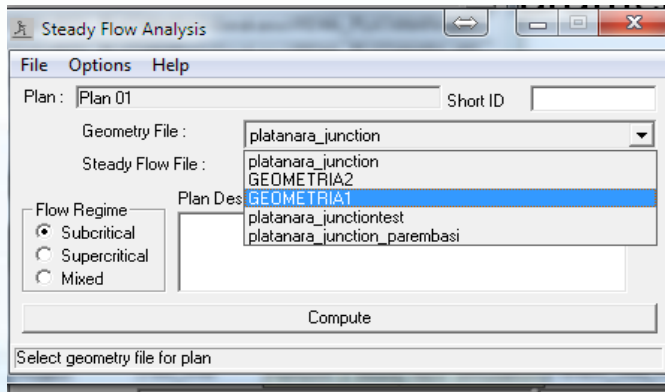
- Following the last steps unsteady and quasi-steady data can be created and saved.
- Now all the necessary parameters have been created for a successful run.

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



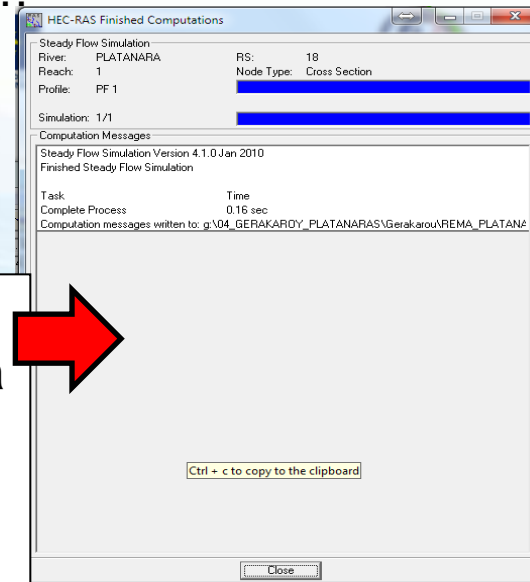
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On the Analysis menu different .g files, flow rates and regimes may be chosen. Once they are set click **Compute** to run the simulation



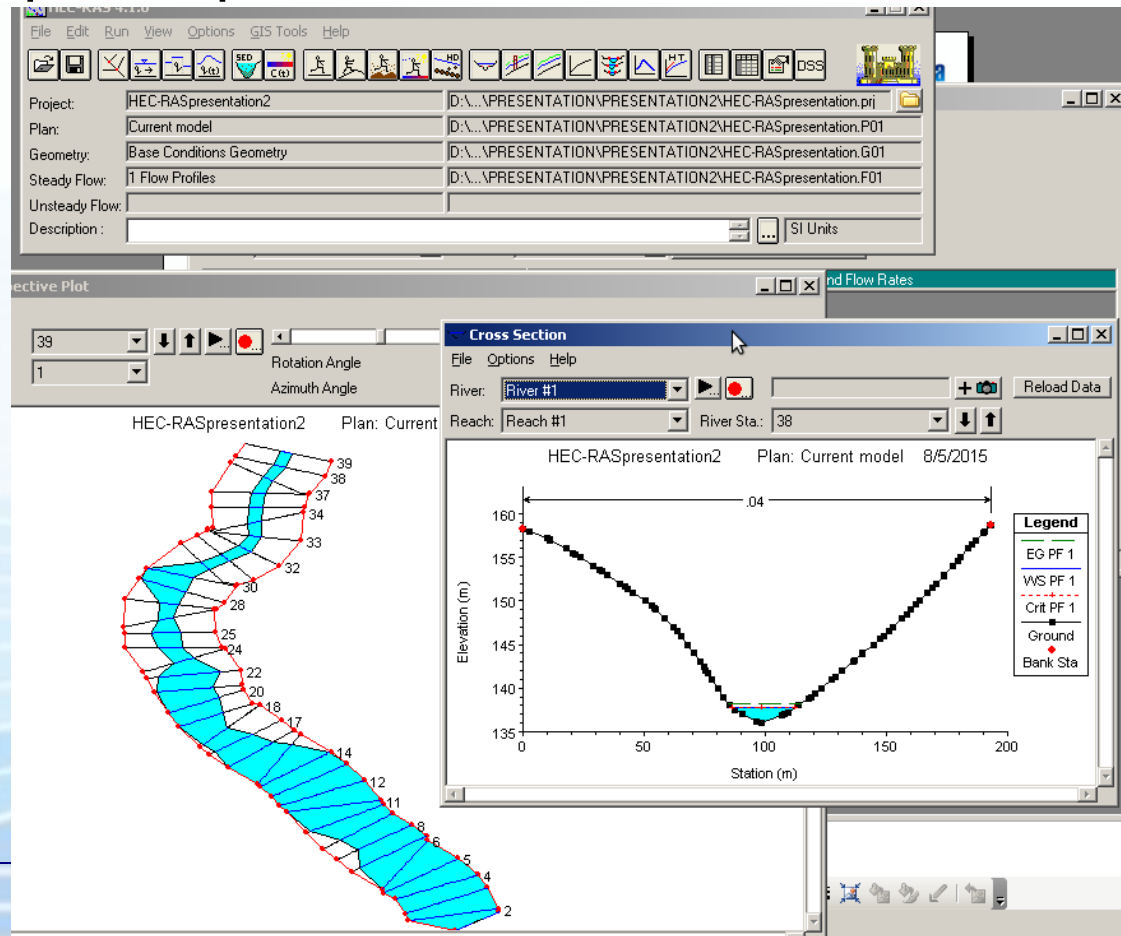
If computations are successful the following window appears, otherwise...

Congrats ,  
you did it!



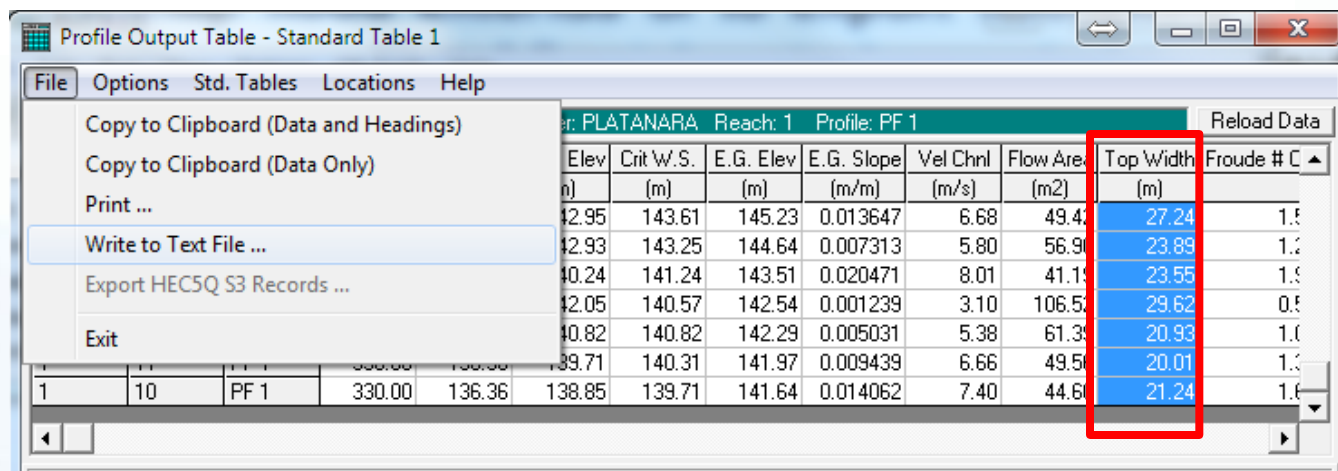
Errors and problems' reports appear in this area and everything should be corrected... then run the simulation again

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





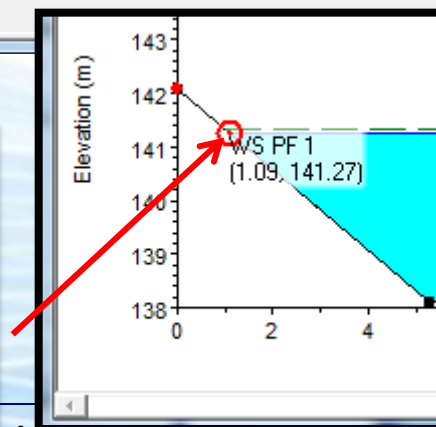
- To map flood extends or to export floodplain results table data (top width of flow) has to be copied in a text editor or .xls file.



| Elev<br>(m) | Crit W.S.<br>(m) | E.G. Elev<br>(m) | E.G. Slope<br>(m/m) | Vel Chnl<br>(m/s) | Flow Area<br>(m <sup>2</sup> ) | Top Width<br>(m) | Froude # C |
|-------------|------------------|------------------|---------------------|-------------------|--------------------------------|------------------|------------|
| 142.95      | 143.61           | 145.23           | 0.013647            | 6.68              | 49.47                          | 27.24            | 1.5        |
| 142.93      | 143.25           | 144.64           | 0.007313            | 5.80              | 56.90                          | 23.89            | 1.2        |
| 140.24      | 141.24           | 143.51           | 0.020471            | 8.01              | 41.15                          | 23.55            | 1.9        |
| 142.05      | 140.57           | 142.54           | 0.001239            | 3.10              | 106.57                         | 29.62            | 0.9        |
| 140.82      | 140.82           | 142.29           | 0.005031            | 5.38              | 61.35                          | 20.93            | 1.0        |
| 139.71      | 140.31           | 141.97           | 0.009439            | 6.66              | 49.50                          | 20.01            | 1.3        |
| 138.85      | 139.71           | 141.64           | 0.014062            | 7.40              | 44.60                          | 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.

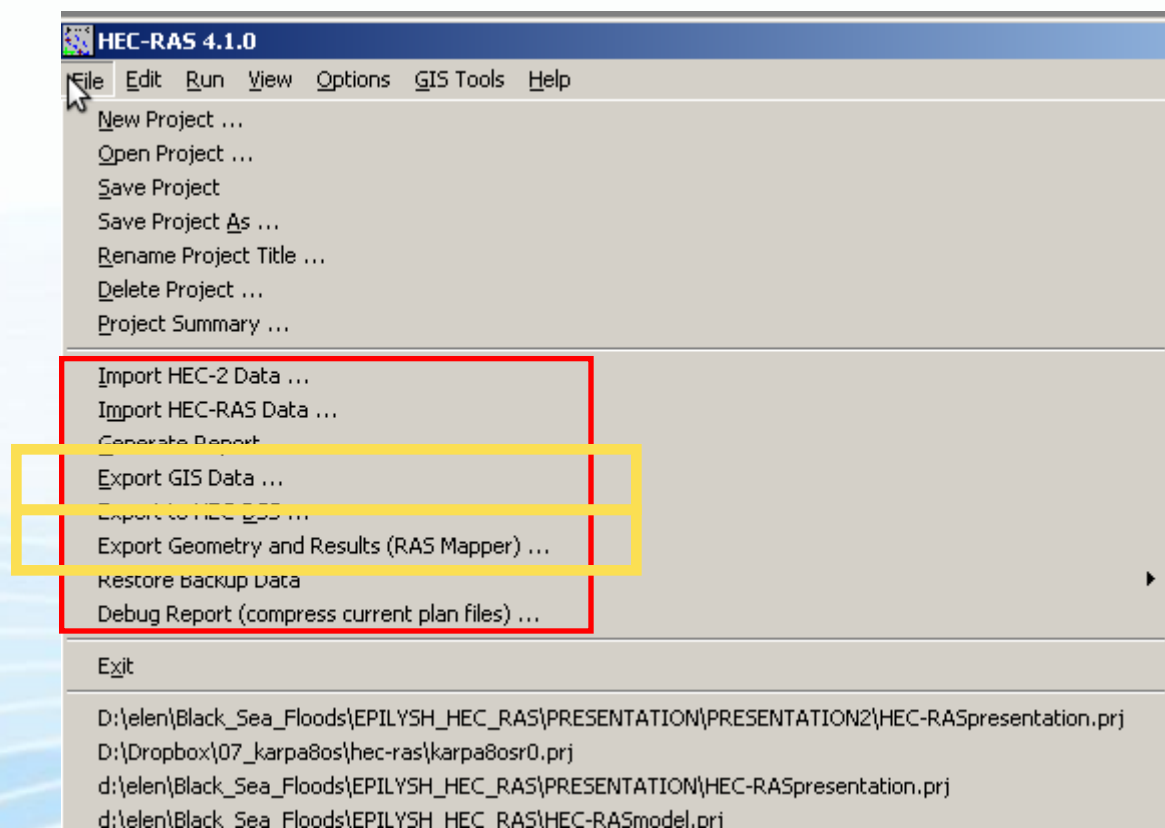


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- Finally, we need to save the project file we have been working on....and continue in QGIS for floodplain mapping.

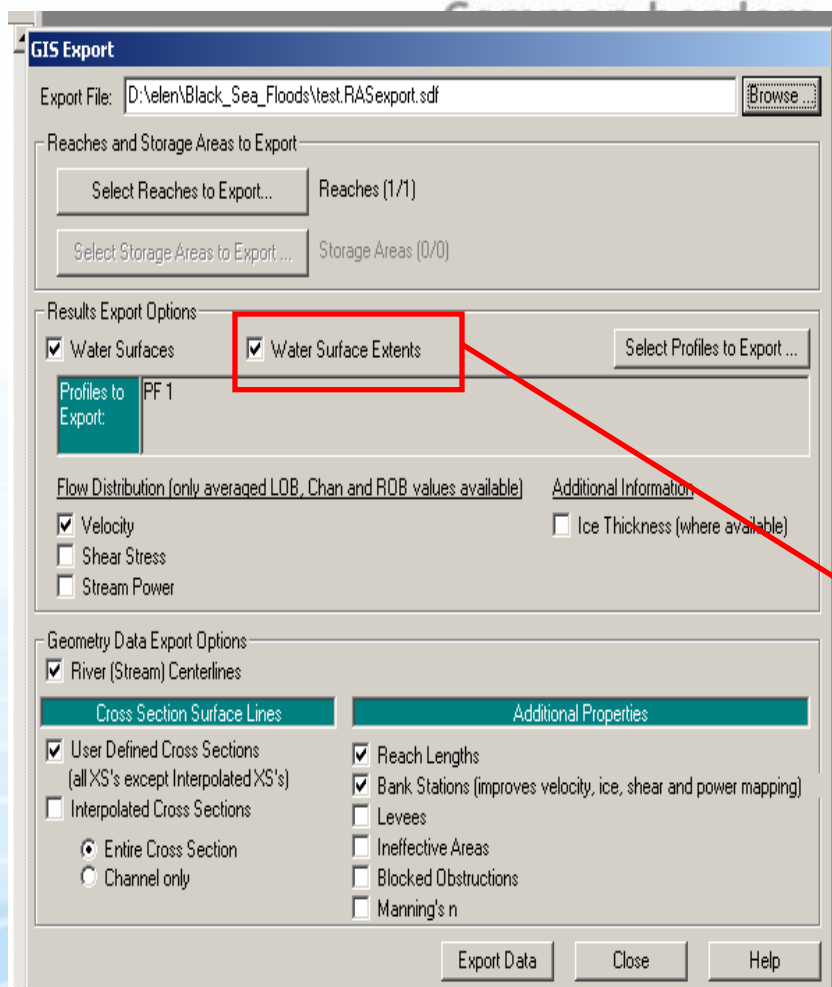
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- **How to Export HEC-RAS to QGIS**



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

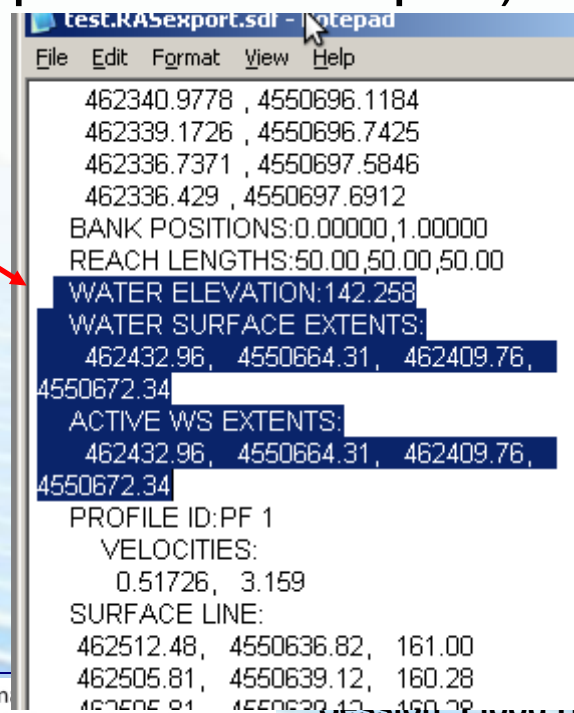
☐ Stream Power

Geometry Data Export Options

☒ River (Stream) Centerlines

| Cross Section Surface Lines  | Additional Properties   |
|--|---|
| <input checked="" type="checkbox"/> User Defined Cross Sections<br>(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



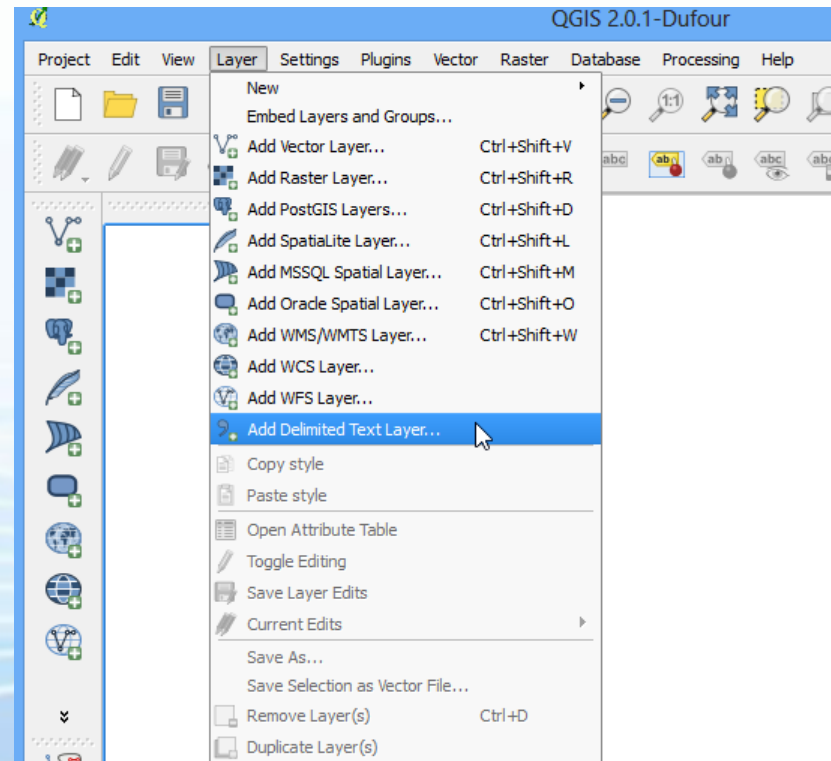
```

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
  
```



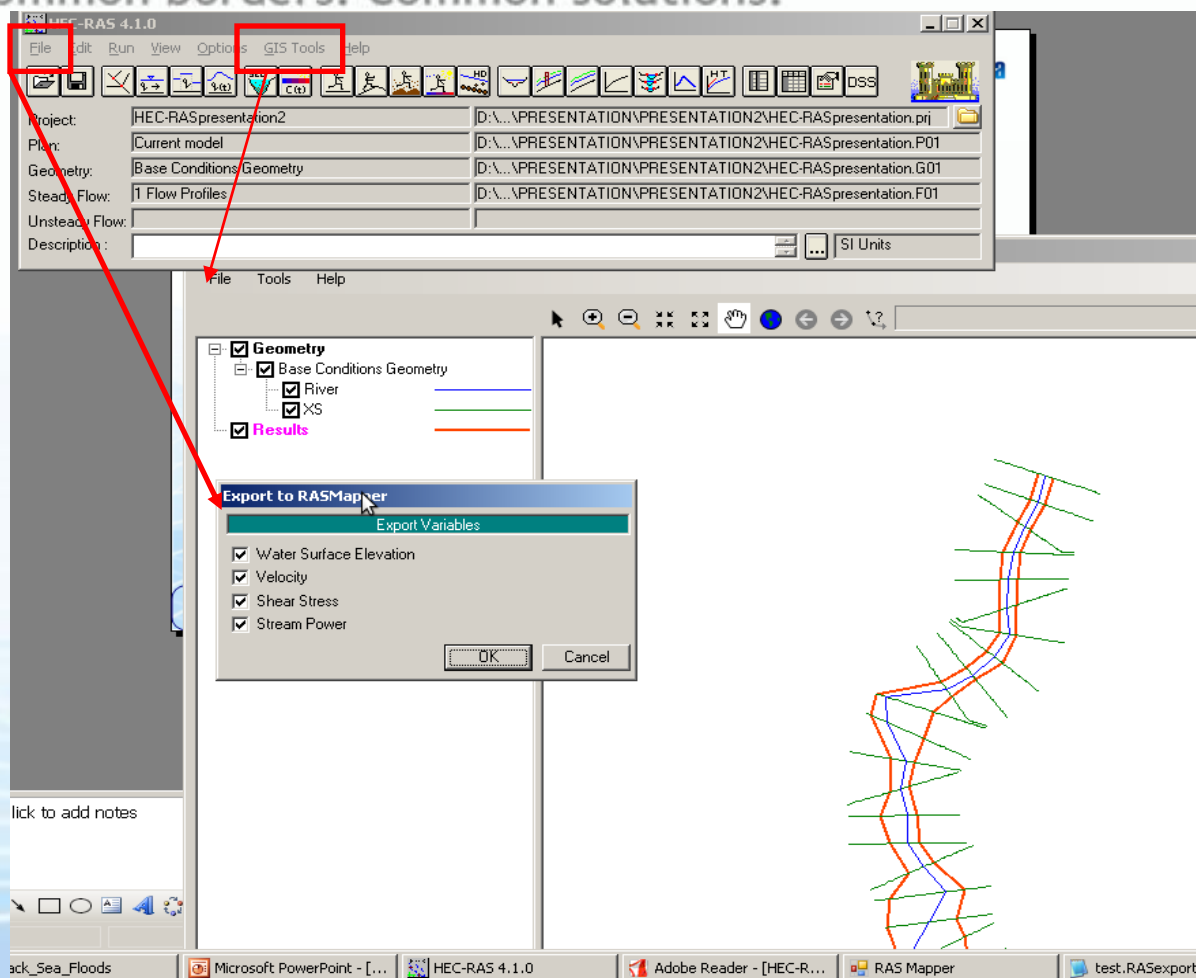
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- Prepare a .csv or .txt file and import to QGIS



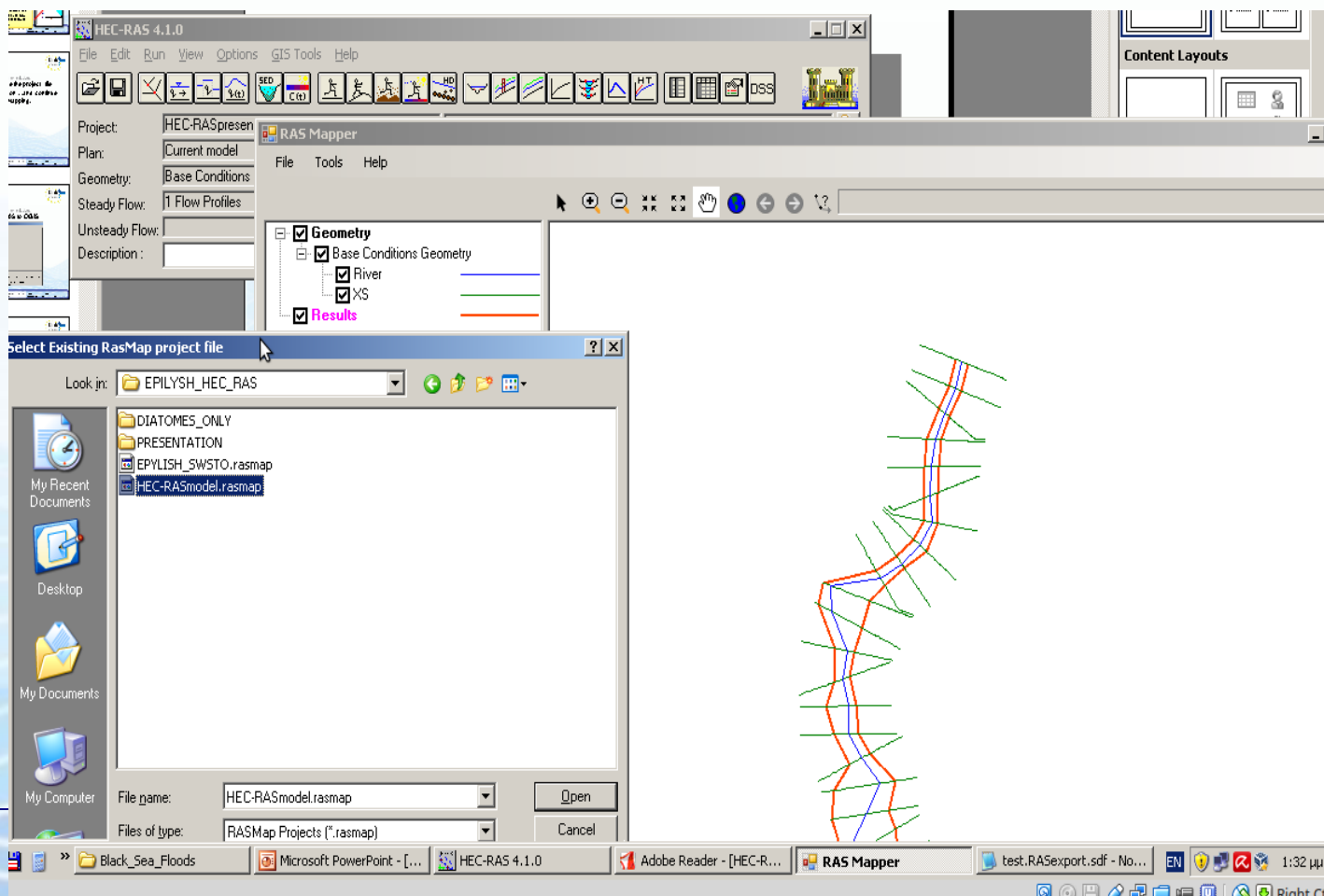
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- **RAS Mapper**



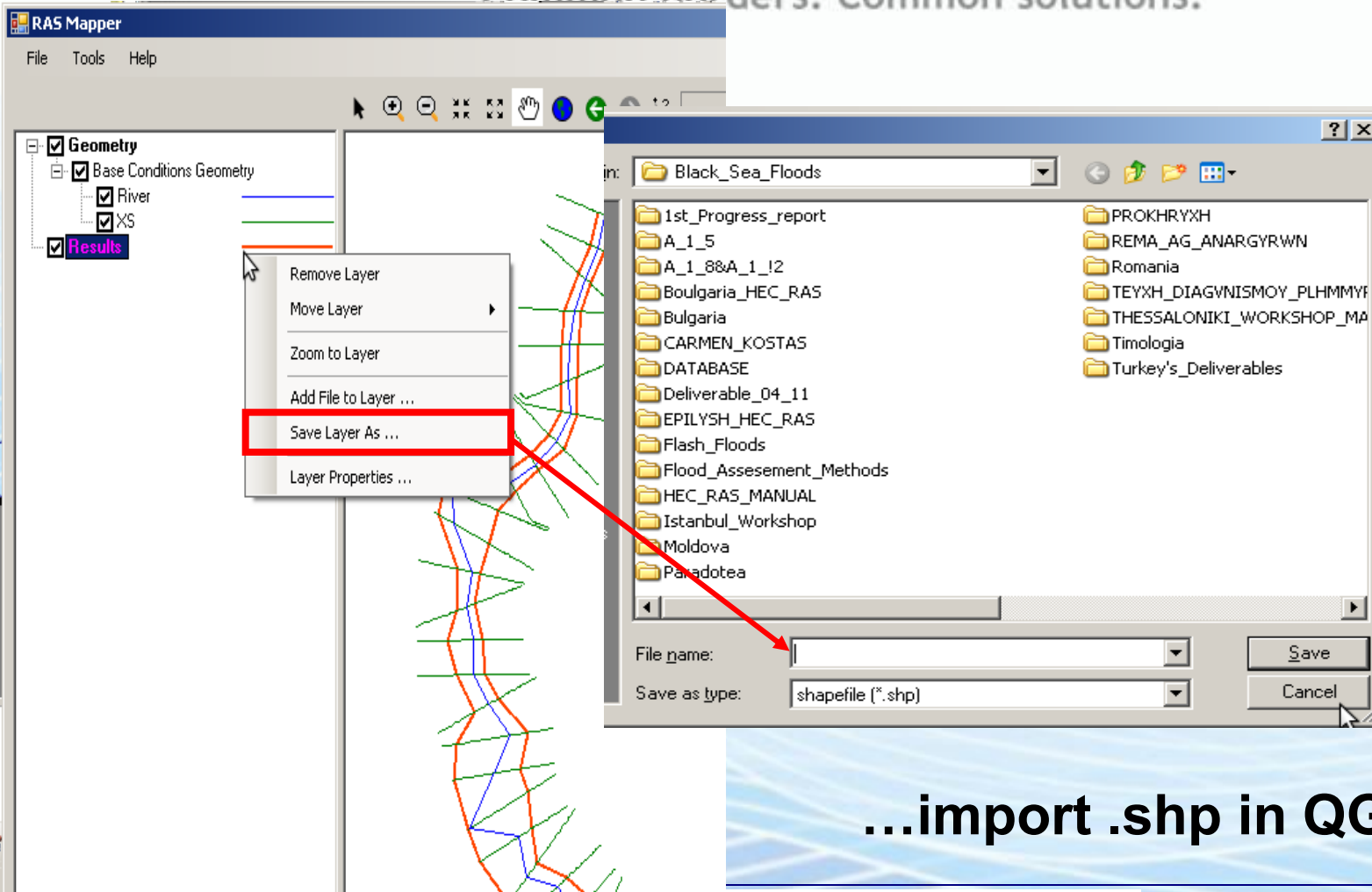
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## Create a .rasmap file and import it to RAS Mapper



The screenshot displays the HEC-RAS 4.1.0 software interface. The main window shows the 'RAS Mapper' tab, which includes a 'Geometry' section with checkboxes for 'Base Conditions Geometry', 'River', 'XS', and 'Results'. The 'River' checkbox is selected. Below this, a 'Select Existing RasMap project file' dialog box is open, showing a list of files in the 'EPILYSH\_HEC\_RAS' folder. The file 'HEC-RASmodel.rasmap' is selected. The 'File name' field is set to 'HEC-RASmodel.rasmap' and the 'Files of type' is set to 'RASMap Projects (\*.rasmap)'. The 'Open' button is visible. In the background, a map of a river channel is visible, showing a winding path with green lines representing the river banks and a blue line representing the river channel. The taskbar at the bottom shows several open applications: 'Black\_Sea\_Floods', 'Microsoft PowerPoint - [...]', 'HEC-RAS 4.1.0', 'Adobe Reader - [HEC-R...', 'RAS Mapper', and 'test.RASexport.sdf - No...'. The system clock shows '1:32 μμ'.

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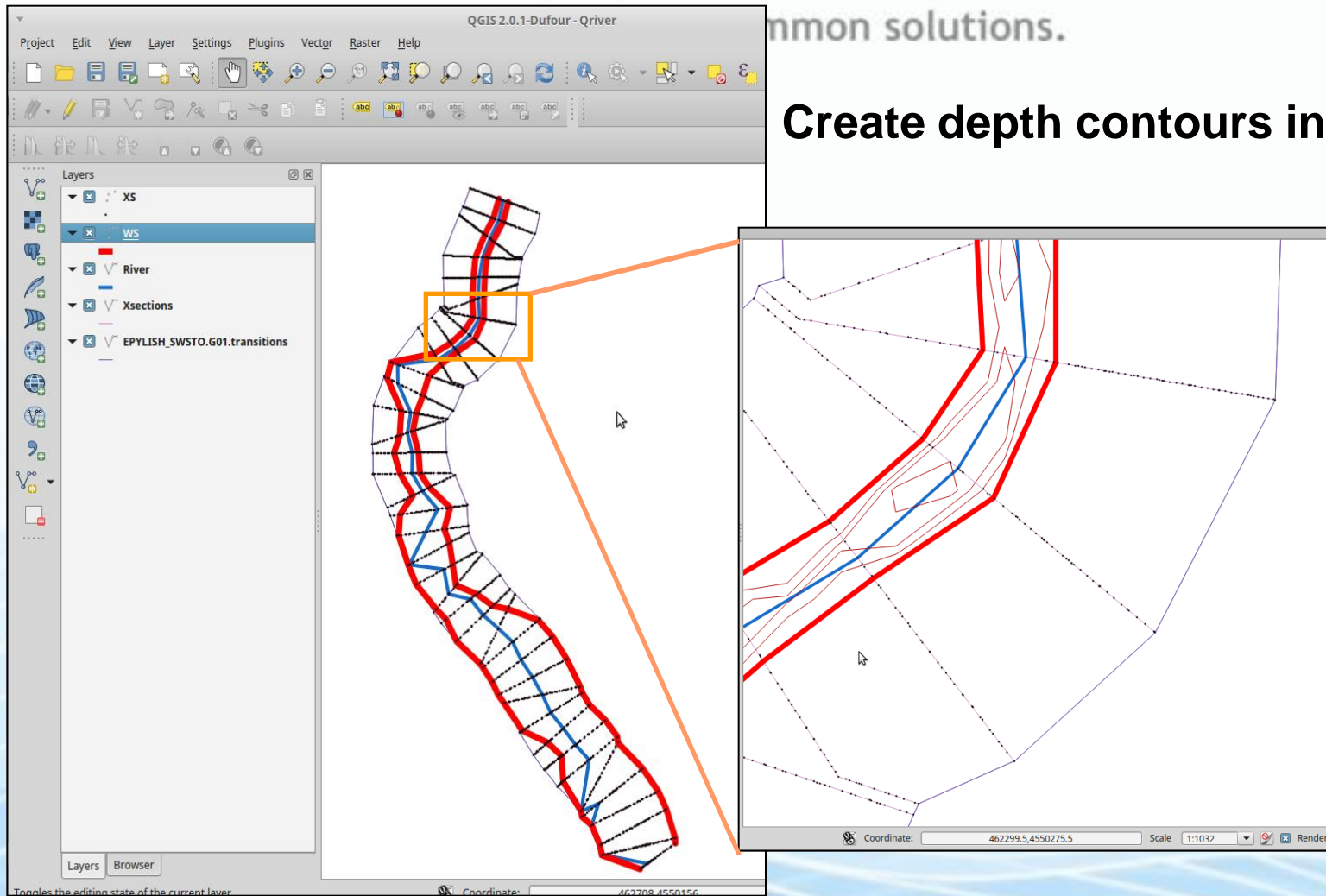


...import .shp in QGIS....



Common solutions.

## Create depth contours in GIS



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## Alternative method to create results in QGIS

- 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.

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# 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**