

HEC-RAS



A Tutorial (Model Development of a Small Flume)

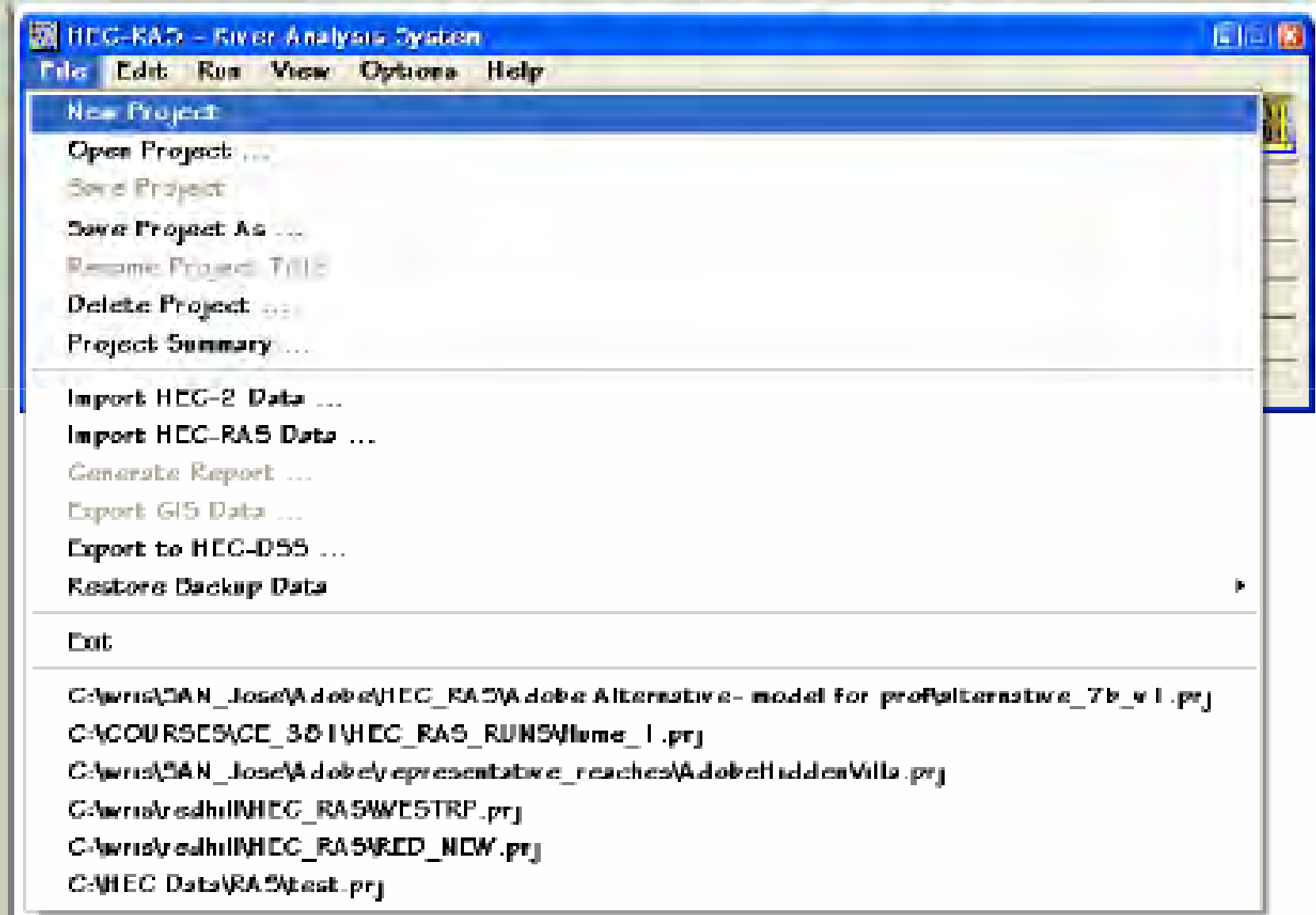
HEC-RAS

- Hydraulic Engineering Center: River Analysis System
- 1-D step backwater model
- Utilizes energy equation to compute water surface elevation for a given discharge, geometry, and resistance

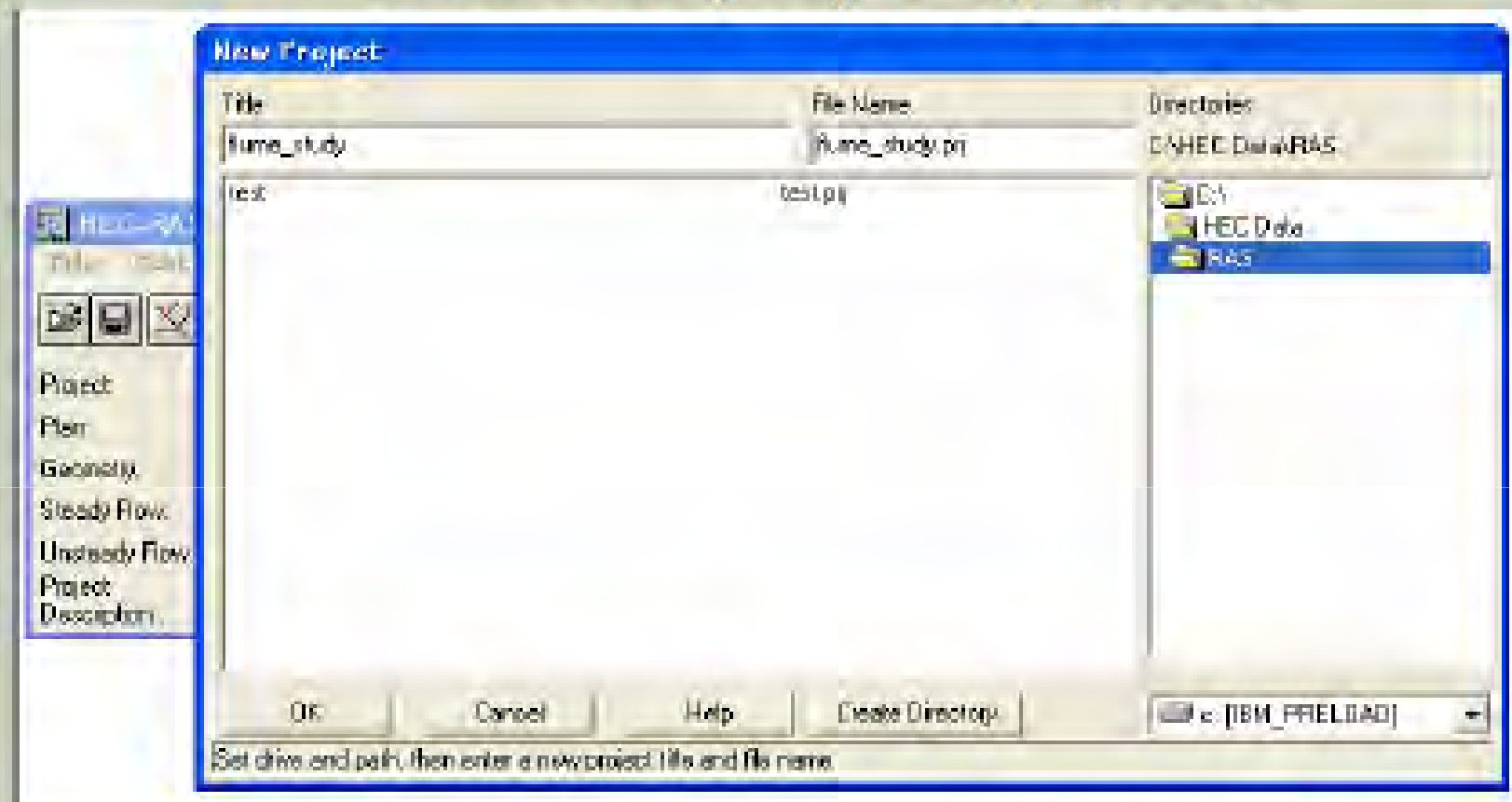
Organizational Structure

- Open project –creates (.prj file)
- 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(what combination of flow/geometry to use for the analysis) (.p file)

Open a new project

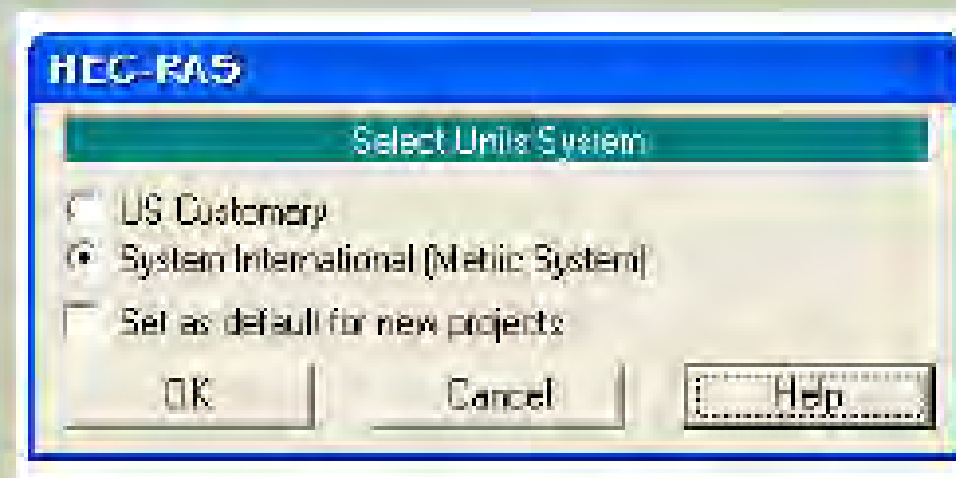
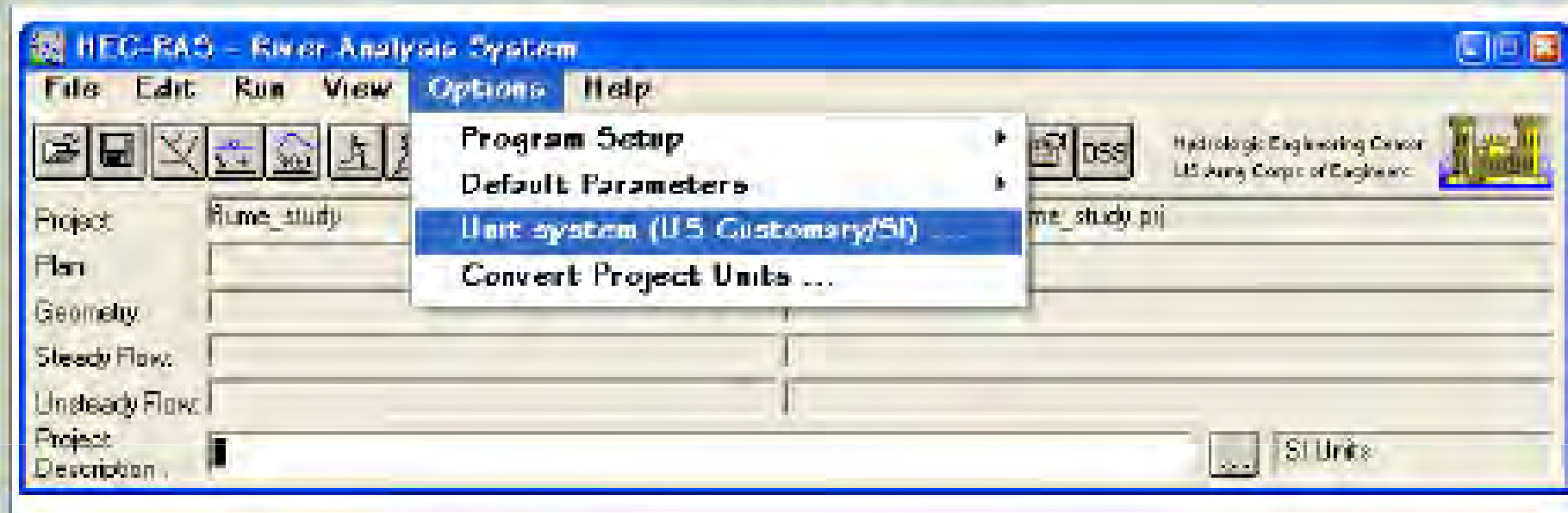


Name the project (.prj file)



After you have entered the above, click O.K. and O.K. again

Select SI units



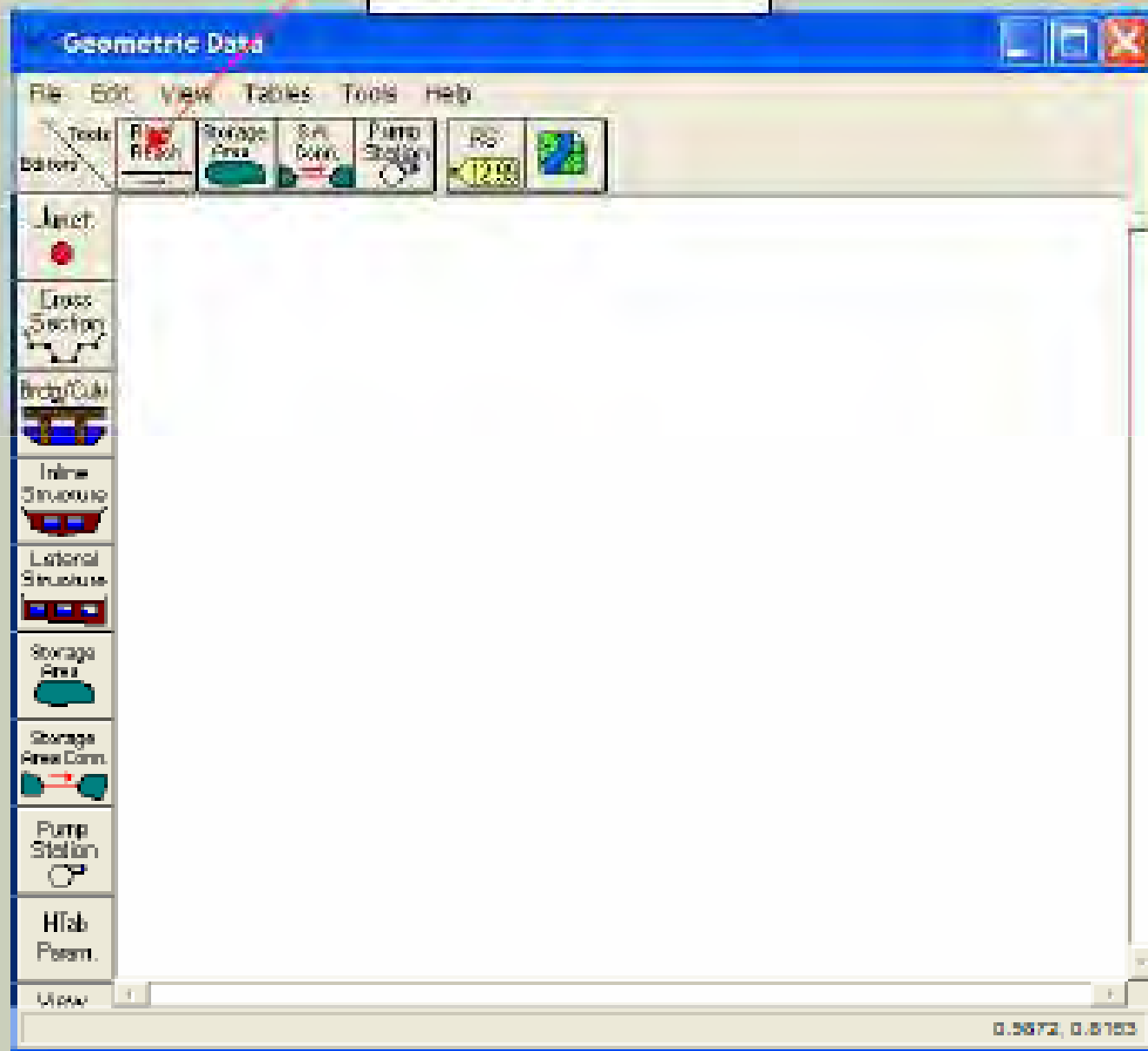
Geometry Files (.g)

- Create a reach- single or dendritic

Click here

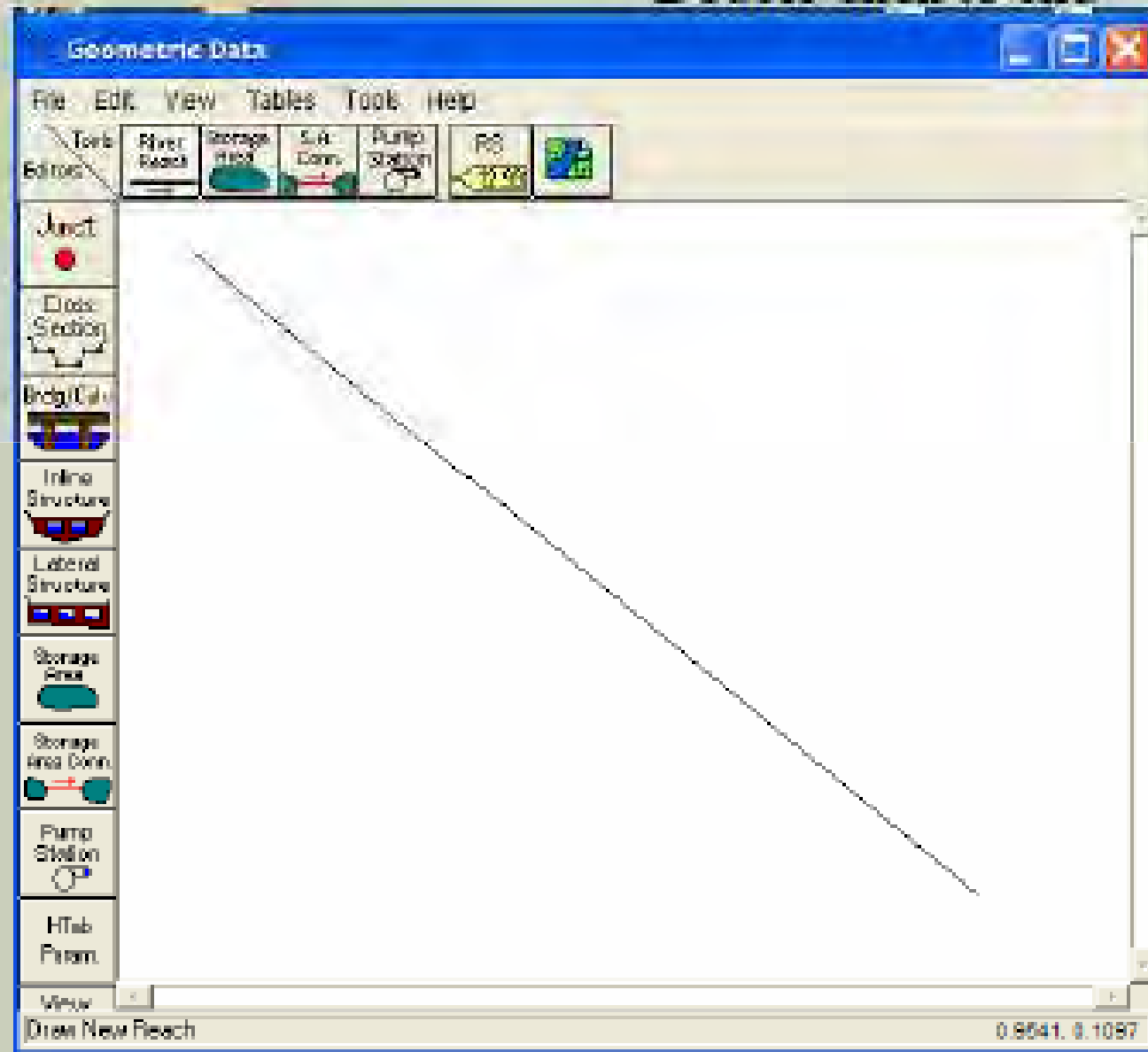


Create a new
river reach

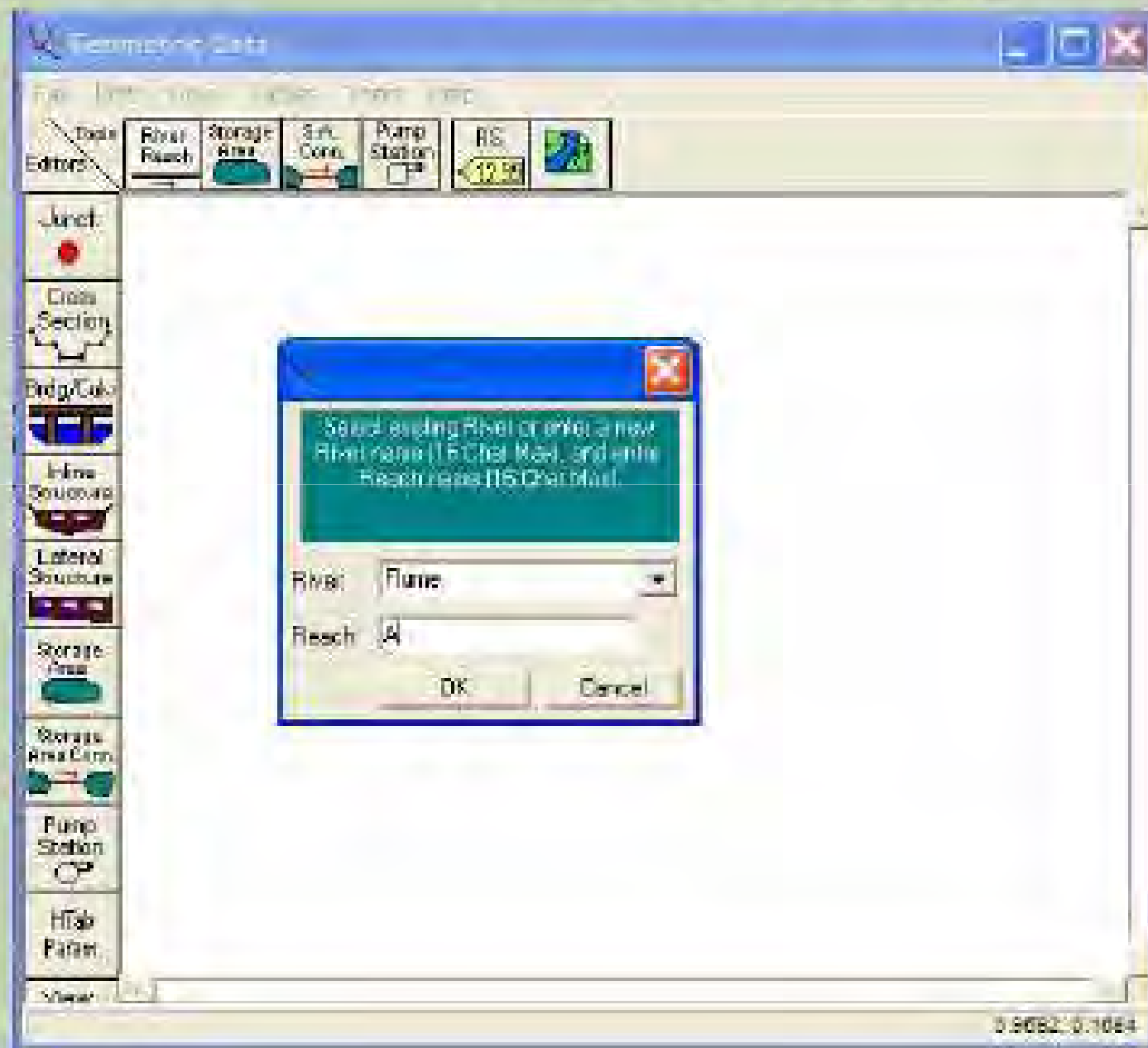


Draw the reach upstream to downstream

Double click to end



Name the river and reach



Geometry

- Cross sections define the channel/flume geometry
- Cross sections are defined by Station(x) and elevation (y) in the plane of the cross section perpendicular to the flow
- River station, downstream reach length and cross section thalweg elevation define the channel slope
- Overbank stations differentiate channel and floodplain characteristics
- Resistance to flow is defined by Manning n coefficients for both the channel and floodplain
- Expansion and contraction coefficients define energy losses associated with velocity head changes between cross sections
- Ineffective flow areas are can store but not convey water downstream
- Obstruction areas block flow completely
- Levee elevations confine flow to channel until the levees are overtopped

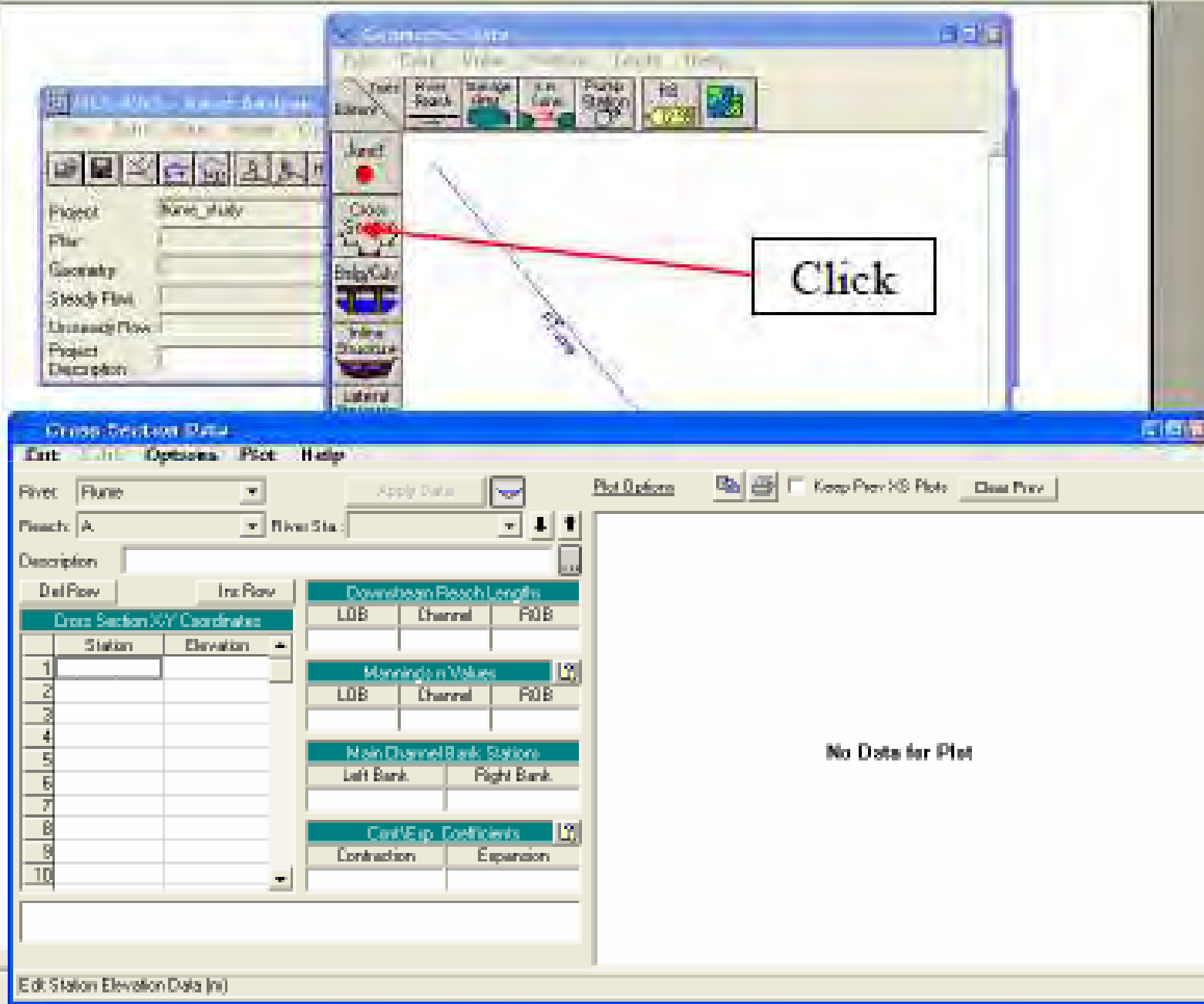
More geometry

- Junctions define where two reaches are connected
- Bridges and culverts
- Inline weirs/gates
- Off channel storage
- Pumping stations
- All can be modeled with a reasonable amount of detail (can be covered at a later date)

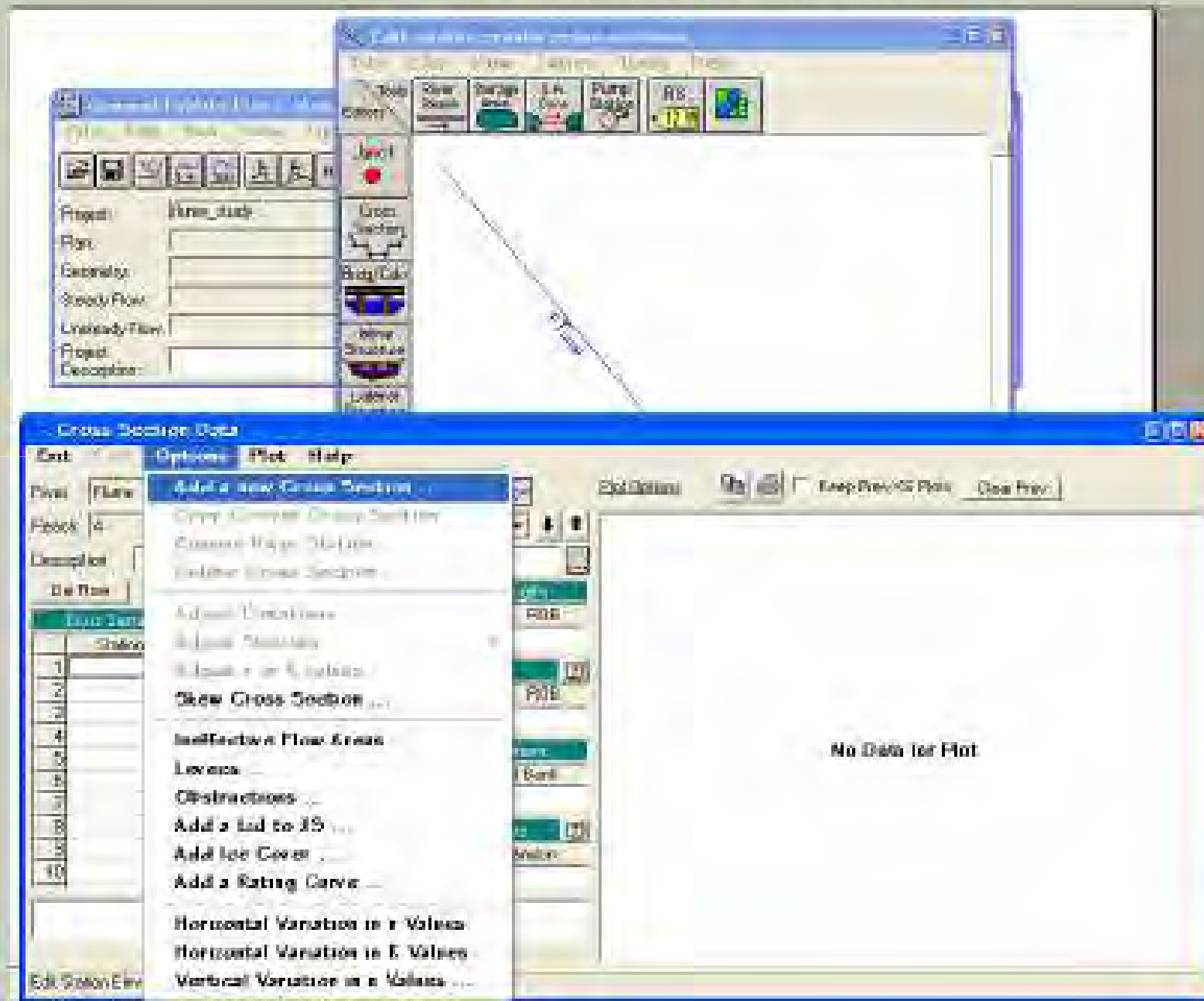
Flume example

- Width- 7.57 cm (0.0757 m)
- Wall height- 12 cm (0.12 m)
- Flume Length- 182 cm (1.82 m)
- Slope-none , horizontal
- Roughness- Plexiglass ($n \sim 0.0085$)
- Discharge- 1.5 l/s (0.0015 m³/s)
- Cross section spacing –10 cm (0.1 m)
- Downstream boundary condition (critical depth at outlet, free overfall)

Enter cross section data

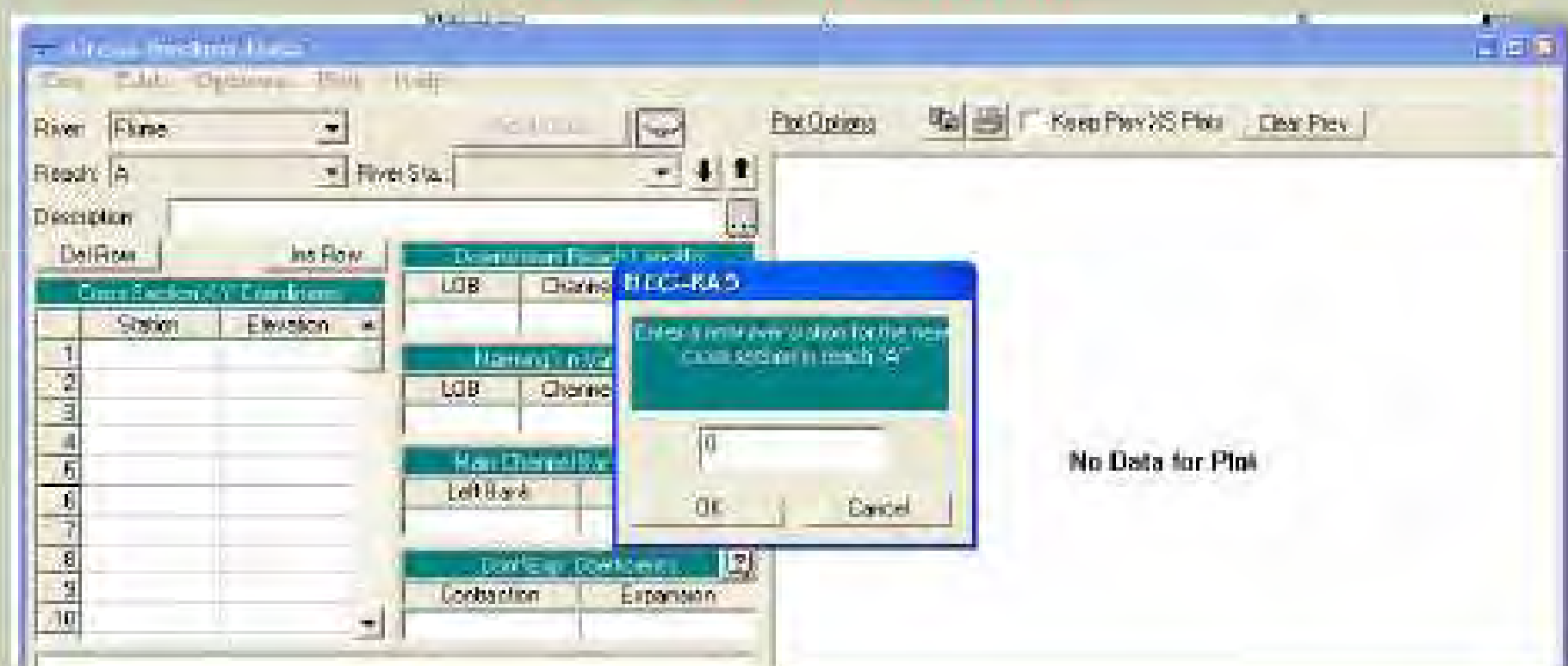


Add a new cross section



Start at downstream river station 0.00 m

(HEC RAS ESTABLISHES THE DOWN STREAM END AS ZERO FOR A STARTING DISTANCE AND PROGRESSIVELY WORKS UP STREAM IN CHAINAGE)



Enter and apply data assuming an arbitrary datum of 100.00 m, notice the downstream reach length is zero since we are at the furthest downstream extent of the model

Cross-sectional data

- Entered from left to right looking down stream

Enter desired description of the cross section

No Data for Plot

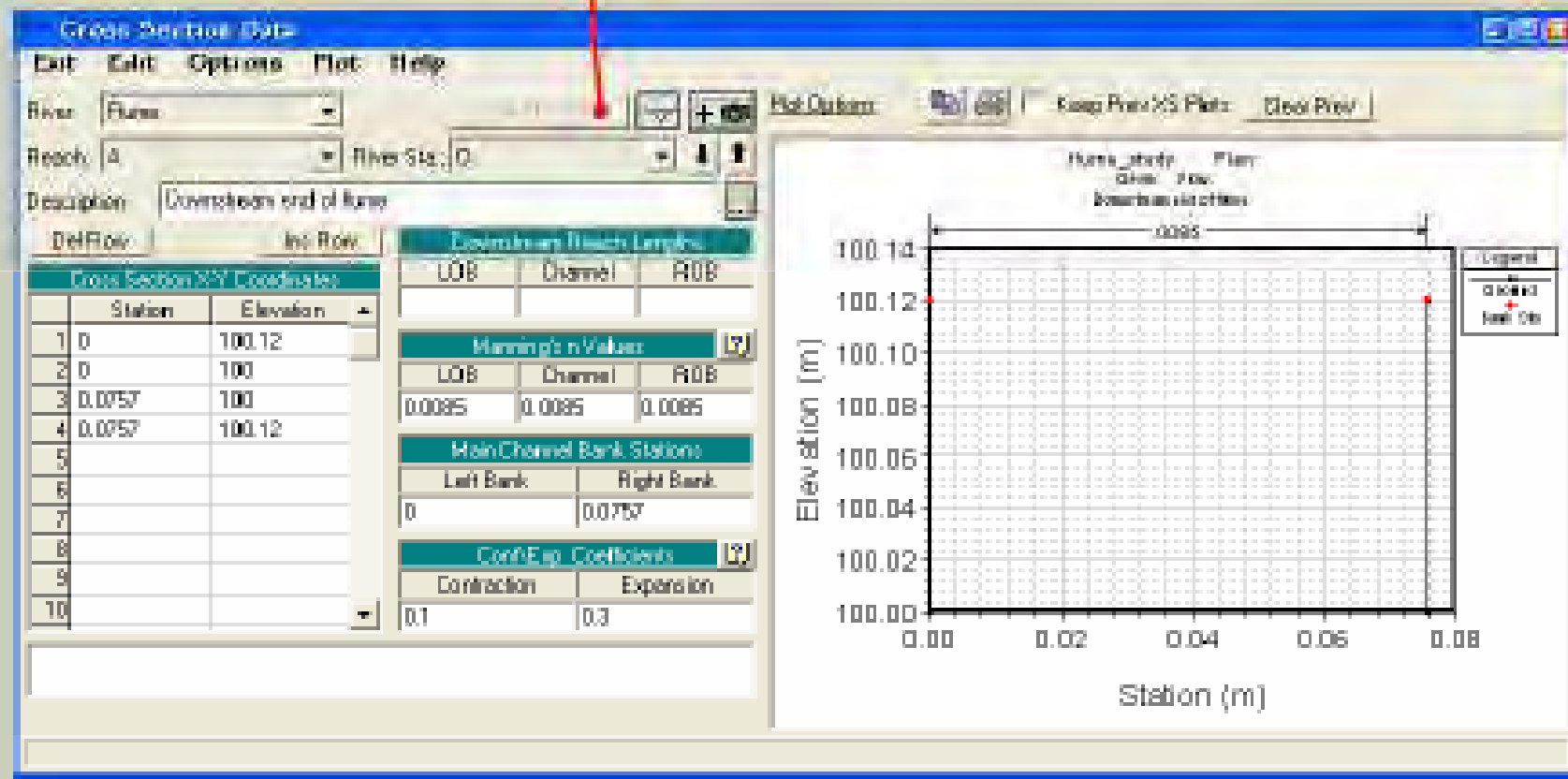
You also have to enter the locations where a flood plain would start if there was one, for this model we will assume the top of the flume is where the flood plain would start (hence at LOB=0m, ROB=0.0757m).

If there were flood plains, this box defines the horizontal right and left limits of the chainages of the main channel (see page after next for example)

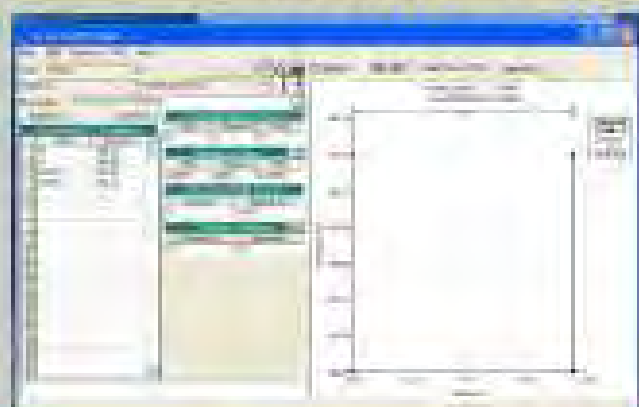
Mannings n values

LOB & ROB would be the left and right flood plains respectively

Click on "Apply Data" to add the cross-section to the model and to view the section

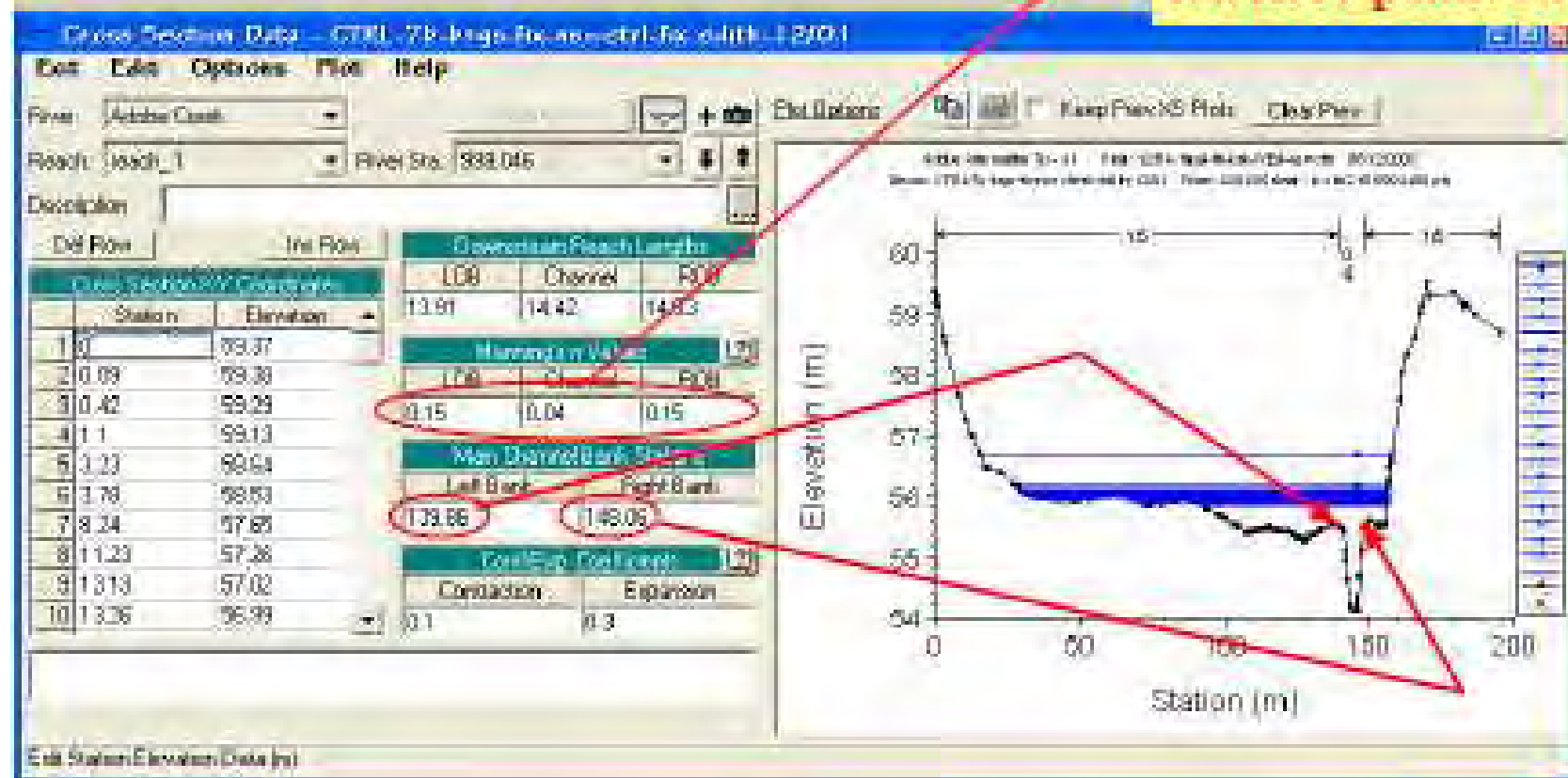


Main Channel Chainage Definition



Flume Example

Note the different Manning's n values in the channel and on the right and left flood plains for a river.



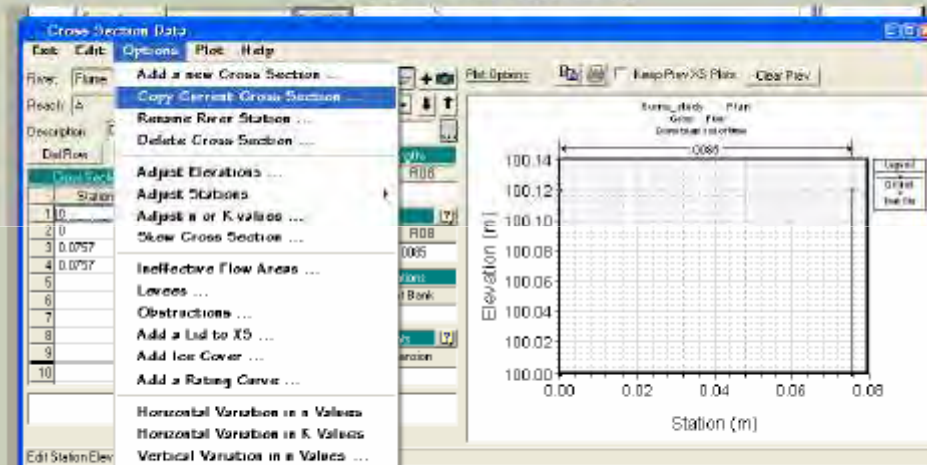
Adobe Creek Example

Since the geometry is uniform from the upstream to downstream extent, we can make use of the cross section interpolation tool to compute the geometry with the specified cross section spacing

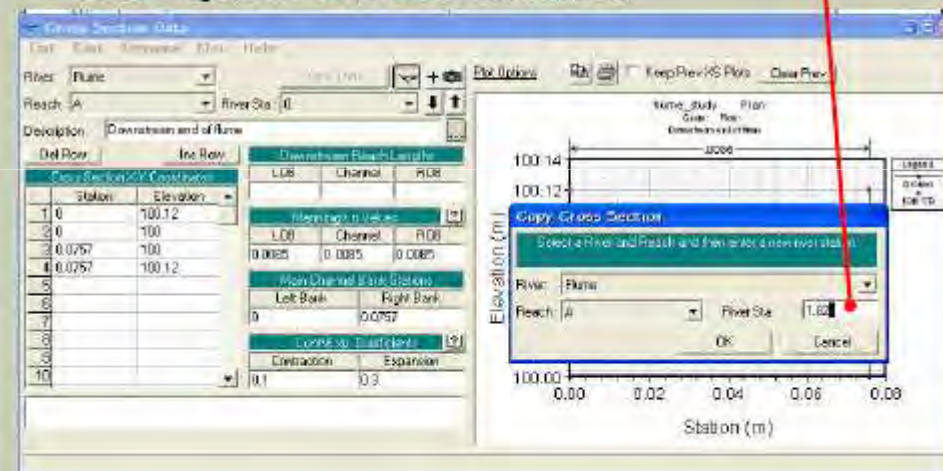
This will take

a few steps....

Add a new cross section at the upstream end river station 1.82 m
 (Since we have the same geometry we are going to make use of the
 copy section function)



Enter the station chainage at the upstream end of the flume
(for the flume the upstream end will be located at 1.82m)
Otherwise, if the geometry was different, you would
Click – options / add a new cross section

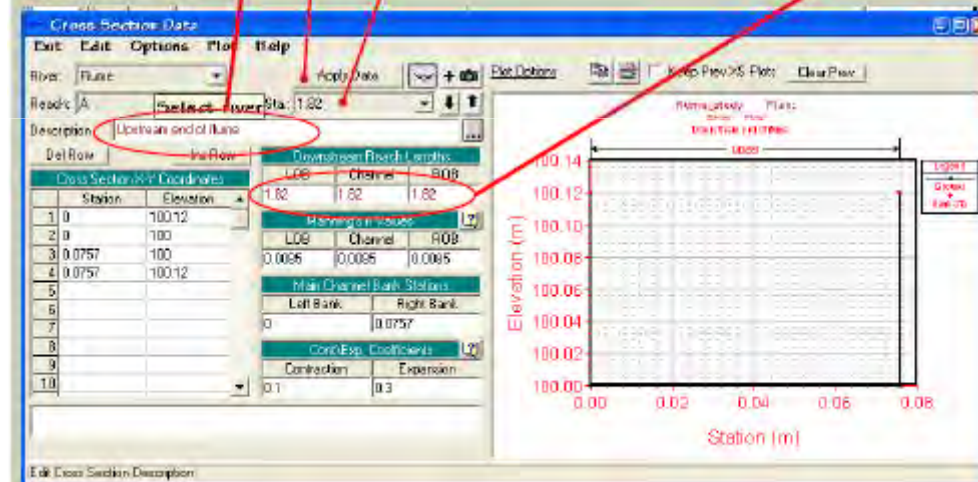


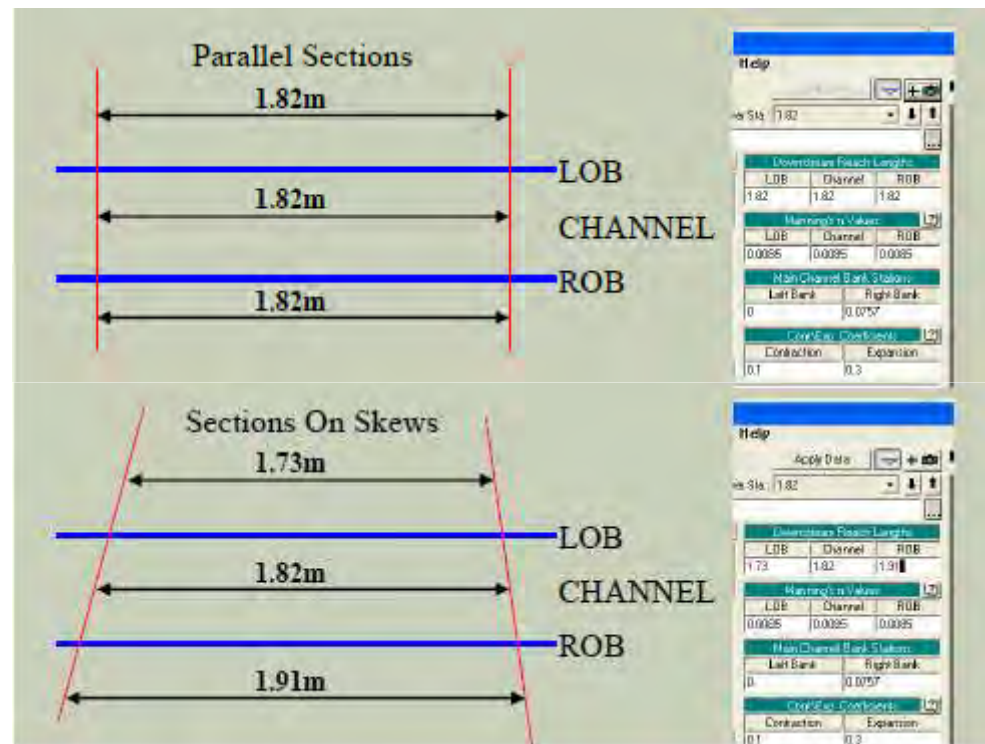
Remember to click "apply data" after you have entered the geometry

Remember to change the description to reflect the upstream cross-section

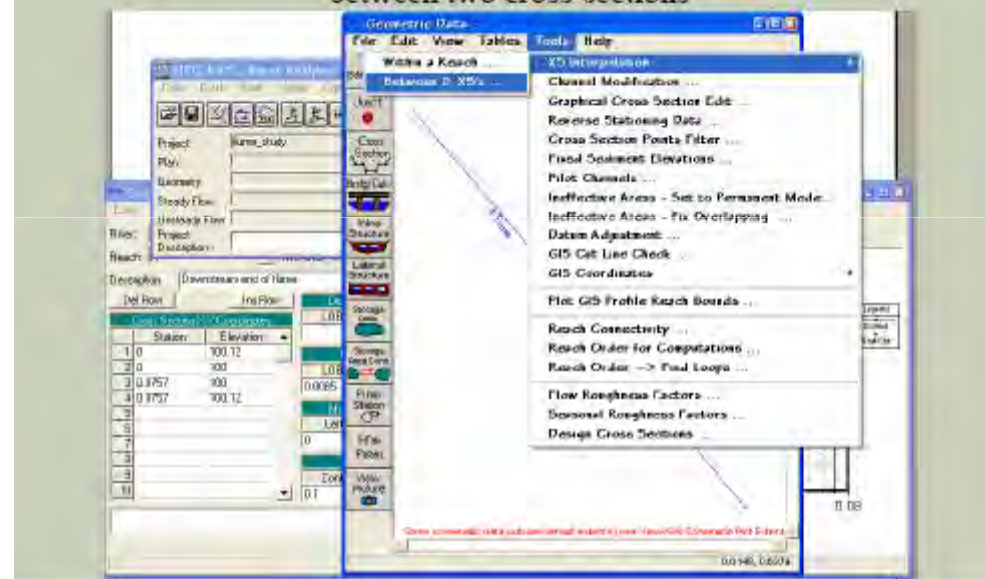
The station identifier you just entered

The LOB, Channel & ROB distances between sections need to be answered since the sections are parallel, then all three distance are the same (1.82m)

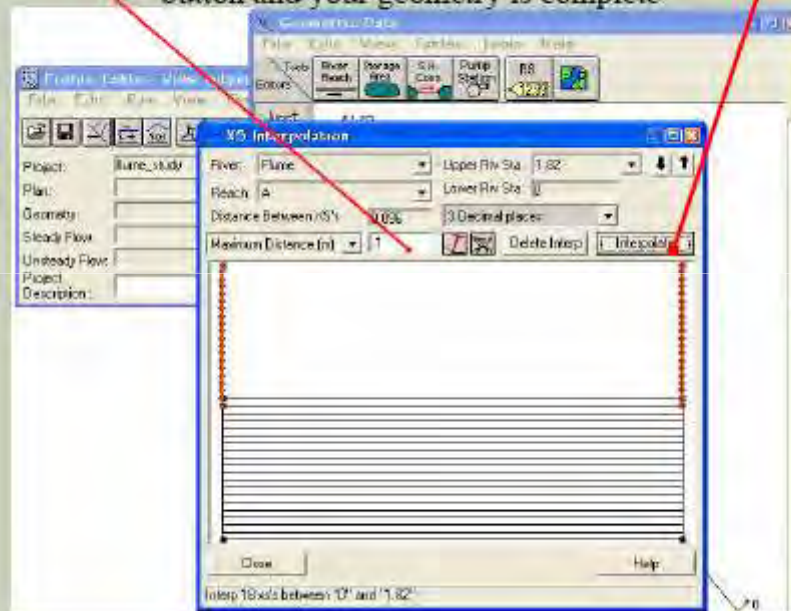




Now it's time to interpolate cross sections...In the main geometry menu click on tools/XS interpolation and select between two cross-sections

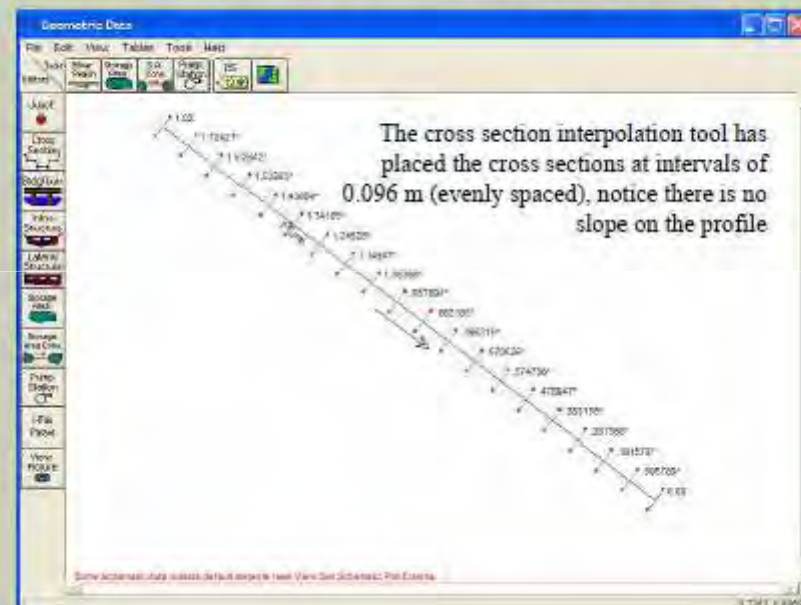


Enter 0.1 m as the max distance between XS's, then hit the interpolate button and your geometry is complete



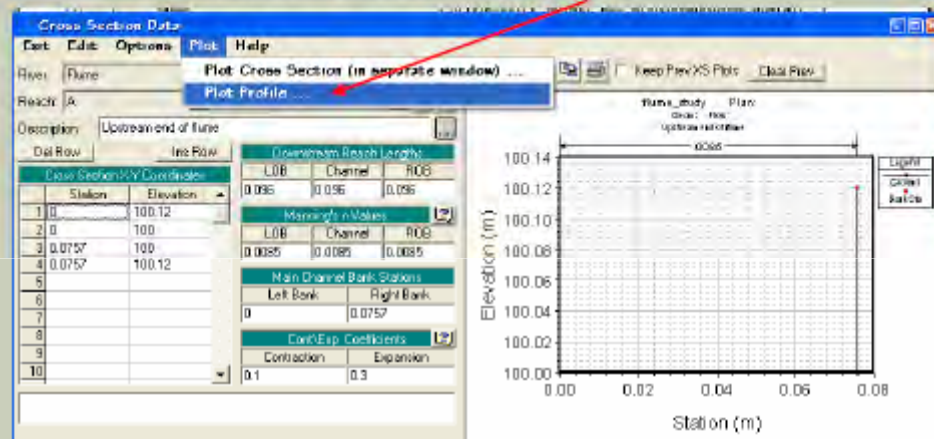
If you continued to have different cross sectional geometry at each cross-section, you would continue to add new cross-sections and enter the distances between each section.

Your main geometry menu should now look like this



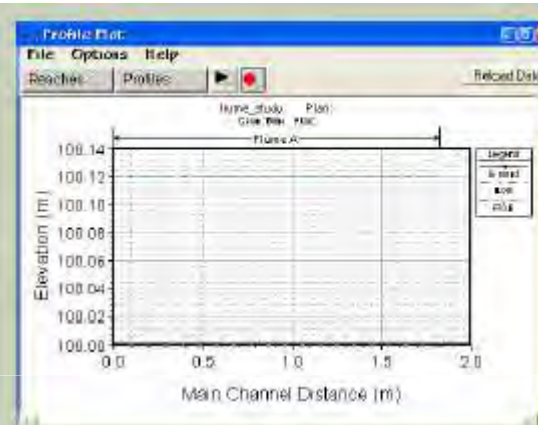
Let's look at the profile for our model, click on the cross section data menu tab, then plot/profile

The screenshot shows the 'Cross Section Data' software window. The 'Plot' menu is open, and the 'Plot Profile' option is selected. The 'Cross Section X/Y Coordinates' table is visible, showing stations and elevations. The graph on the right displays the profile of the cross-section, with elevation on the y-axis (ranging from 100.00 to 100.14) and station on the x-axis (ranging from 0.00 to 0.08).



If your plot does not look like this:

- go to "options" on the Cross section data window
- go to "scaling"
- change y axis min to 100.0
- change y axis max to 100.14
- change y axis increment to 0.02
- click OK
- go to "options / variables"
- click on the first two that are un checked (left main channel bank elevation & right main channel bank elevation), click O.K.
- click "options / grid" and make sure that "thick border, major and minor tick grids" are all on.



Now let's put some water in this flume...

Flow data (.f files)

- Steady (constant with time)
- Unsteady (varies with time)
- Regimes(supercritical, subcritical, mixed)
- Boundary conditions:
 1. Supercritical-upstream
 2. Subcritical-downstream
 3. Mixed-both

Flow data continued

- Boundary condition types:
 1. Known water surface elevation
 2. Critical depth- free overfall or weir
 3. Normal depth- downstream energy slope required
 4. Rating curve (WSE as a function of discharge)

Now open the steady flow data menu

Click

The screenshot shows the HEC-RAS software interface. On the left is the Project Explorer pane with a tree view containing 'Project', 'Plan', 'Geometry', 'Steady Flow', 'Unsteady Flow', and 'Description'. The 'Steady Flow' item is selected. A red arrow points from a 'Click' label to the 'Steady Flow' icon in the Project Explorer. On the right is the 'Steady Flow Data' dialog box. It has a title bar 'Steady Flow Data' and a menu bar 'File Options Help'. Below the menu bar are two input fields: 'Enter/Edit Number of Profiles (2000 max)' with a value of '1' and 'Reach Boundary Conditions' with a value of 'Supply Water'. Below these is a section titled 'Locations of Flow Data Changes' with a table. The table has two columns: 'Flow Change Location' and 'Profile Names and Flow Rates'. The table contains one row with the following data:

	River	Reach	R5	PF 1
1	Flume	A	1.82	

Below the table is a large empty text area. At the bottom of the dialog box is a status bar that reads 'Edit Steady flow data for the profiles (m3/s)'.

Let's consider 3 flows 0.5, 1.0, and 5 liter/s

Enter and apply the data

HEC-RAS - Steady Flow Data

File Options Help

Enter/Edit Number of Profiles (2000 max): 3 Reach Boundary Conditions: Apply Data

Locations of Flow Data Changes

River: Flume Reach: A River Sta.: 1.82 Add A Flow Change Location

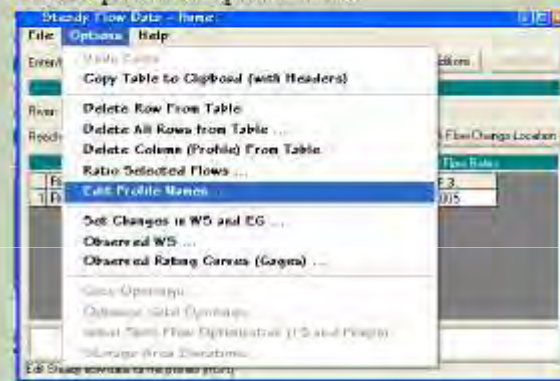
Flow Change Location			Profile Names and Flow Rates		
River	Reach	RS	PF 1	PF 2	PF 3
1	Flume	1.82	0.0005	0.001	0.005

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

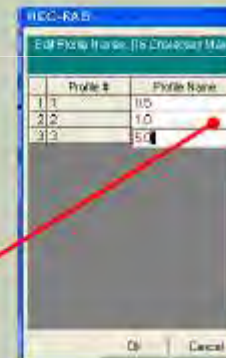
Now we are going to change the profile names (from PF 1, PF2, PF3)

-On the "steady flow data window"

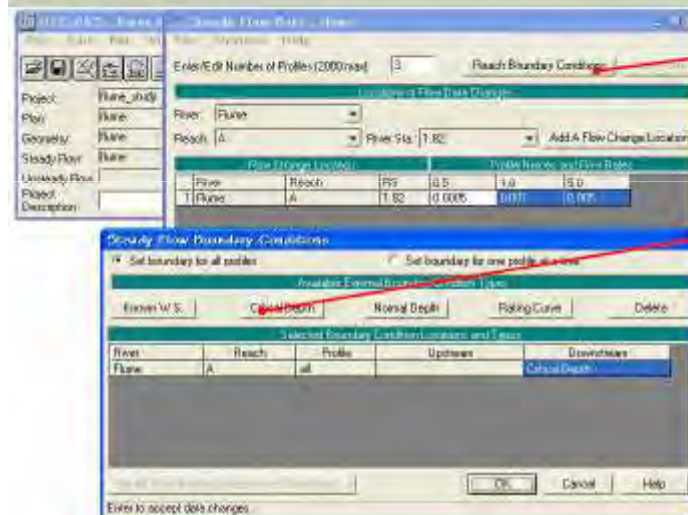
- Chose options / edit profile names



Double click each box on the right of the window to what you see in the HEC-RAS box, and then click O.K.



Now we need to specify the boundary condition,
let's assume subcritical flow and critical depth at
the overfall therefore a downstream boundary
condition and a H2 profile



Select Reach
Boundary
conditions
from the
steady flow
menu,

then select
critical depth
in the
boundary
conditions
menu

Easy enough now save the
data to your directory, this
creates a .f file. Since this is
the first time saving the flow
data use the "SAVE FLOW
DATA AS" option

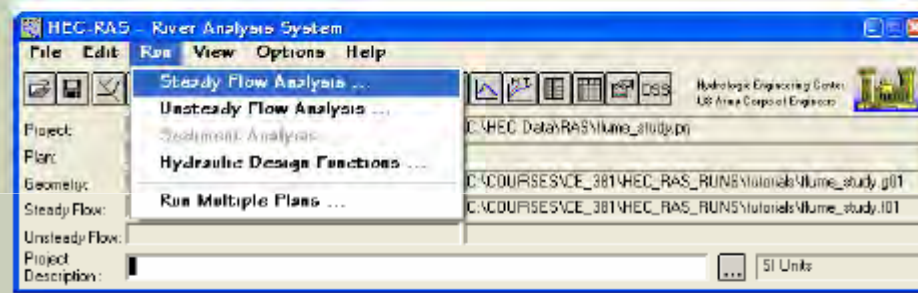
Your main HEC-RAS interface should show the following now

MAKE SURE THAT ALL OF YOUR FILES ARE STORED IN THE SAME DIRECTORY (what ever that directory may be) OR, THE SIMULATION WILL NOT WORK

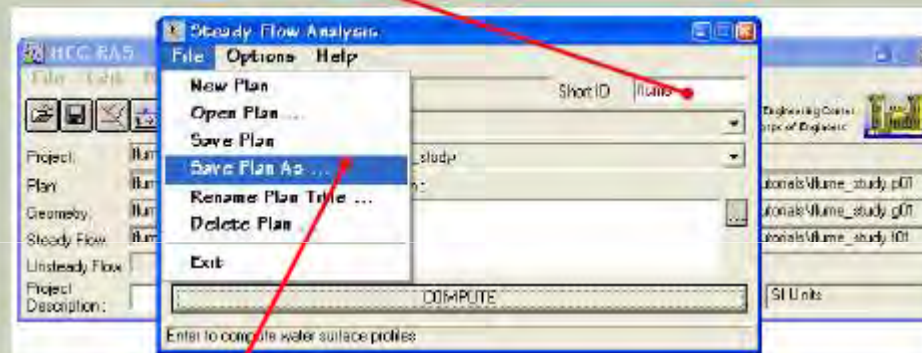


One last step before we run the simulation, we must couple the geometry and flow with the plan (.p file)

On the main Hec-Ras interface select Run
and steady flow analysis



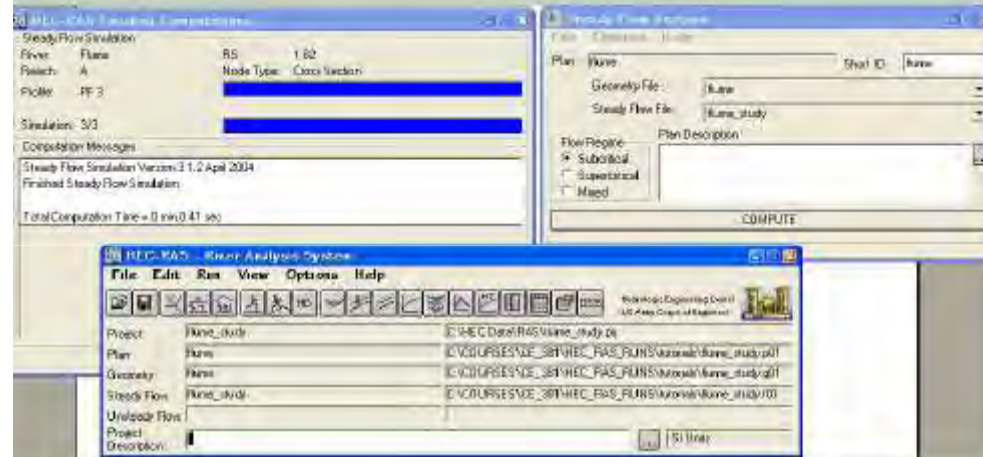
Go ahead and name the plan and save it in the working directory and give a short ID, maybe "flume", use the same name in the station identifier box



Now we can go ahead and save a plan with the existing geometry and flow data

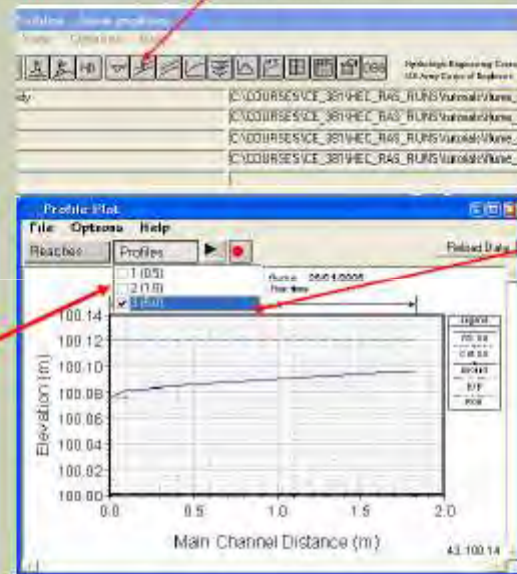
Now we are ready to Run our simulation, hit the "compute" button when ready

When the following screens are visible the simulation has been run



Close the computation screen and congratulations you just ran a HEC-RAS model!

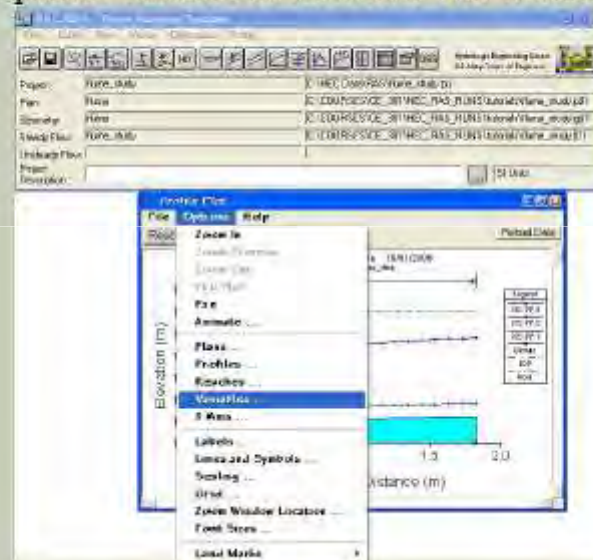
Let's look at the water surface profile generated for the 5.0 L/s flow, click on the view profiles tab on the main interface



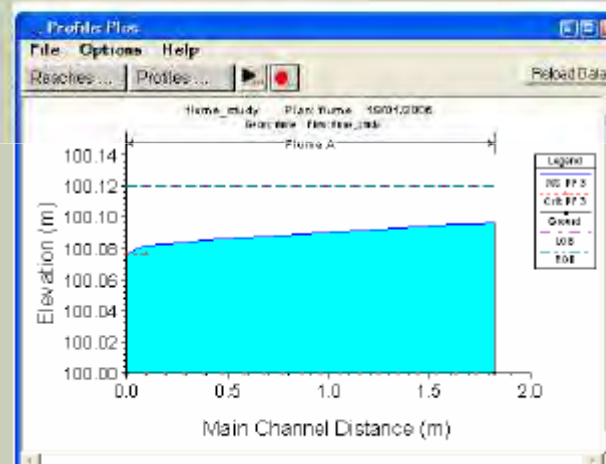
Make sure the other profiles are unchecked

Lets add the critical flow depth....

Navigate to options / variables on the Profile Plot Window



- Make sure that the following are checked on:
- Left main channel bank elevations
 - Right main channel bank elevations
 - Filled in water surface
 - Critical depth elevation

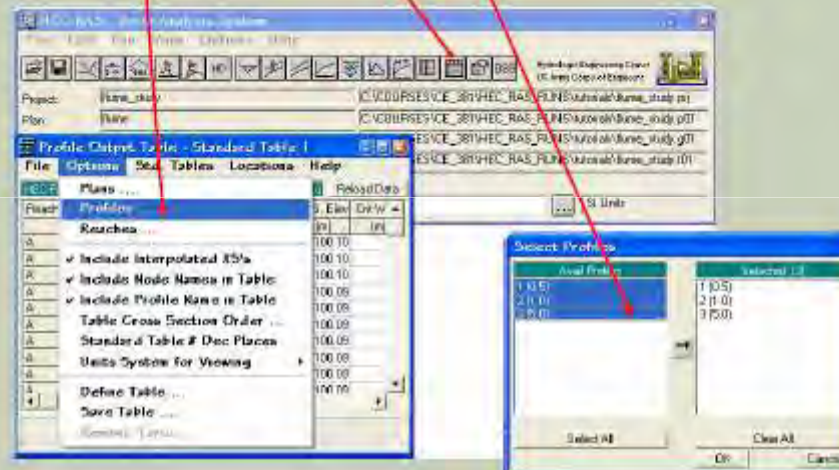


SELECT MODELS

- ☒ Water Surface
- ☐ Energy Grade Elevation
- ☒ Observed Water Surface
- ☐ Ice Cover
- ☒ Reach Labels
- ☒ Left Level
- ☒ Right Level
- ☐ Pilot Channel
- ☒ Sediment Elev
- ☒ Left Side Lateral Structures
- ☒ Right Side Lateral Structures

OK Cancel

Click on the tables tab of the main menu interface. Select options/profiles, select all three flows and click the O.K. button.



The standard output of HEC RAS lists variables with several different levels of precision, which is dependent upon the particular variable. Since the flume is a very small representation of a "river reach", we need to increase the level of precision on the output to properly capture the scale of the flume.

On the "PROFILE OUTPUT TABLE", click on **OPTIONS / STANDARD TABLE & DEC. PLACES**.

Variable	Units	Number of Decimals
0 Total		4
1 Min Ch El		4
2 W/S Elev		4
3 Ch W/S		4
4 E.G. Elev		6
5 E.G. Slope		4
6 Vel Chnl		4
7 Flow Area		4
8 Top Width		4
9 Froude # Ch		4

Change any # Dec. values less than 4 to 4 decimal places.

Variable	Units	Number of Decimals
0 Total		4
1 Min Ch El		4
2 W/S Elev		4
3 Ch W/S		4
4 E.G. Elev		6
5 E.G. Slope		4
6 Vel Chnl		4
7 Flow Area		4
8 Top Width		4
9 Froude # Ch		4

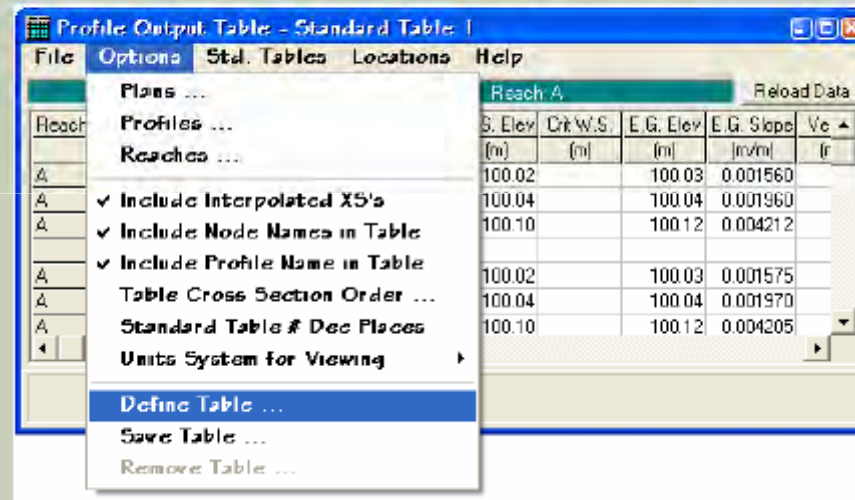
You can export the data from the Profile Output Table to any application

Profile Output Table - Standard Table 1											
File Options Std. Tables Location Help											
Copy to Clipboard (Data and Headings)											
Copy to Clipboard (Data Only)											
Print ...											
Write to Text File ...											
Export ASCII (Data Only)											
Exit											
LET-RAS Plot Dump: River Name: Reach: 0											
Stn	Gr/W.S.	E.G. Elev.	E.G. Slope	Vel Dvl	Flow Area	Top Width	Flowd # Ch				
	Int	Int	Int/ft	Int/ft	Int ²	Int					
42	100.0281	0.001560	0.2732	0.0018	0.0756	0.5736					
51	100.0428	0.001860	0.3637	0.0027	0.0756	0.6113					
62	100.1204	0.004212	0.6894	0.0073	0.0756	0.7086					
80	100.0280	0.001575	0.2801	0.0018	0.0759	0.5773					
A	1.72421*	0.0010	100.0000	100.0359	100.0426	0.001870	0.3644	0.0027	0.0759	0.6144	
A	1.72421*	5.0	0.0050	100.0000	100.0999	100.1200	0.004205	0.6896	0.0073	0.7113	
A	1.62842*	0.5	0.0005	100.0000	100.0239	100.0278	0.001615	0.2836	0.0018	0.0759	0.5851
B	1.62842*	1.0	0.0010	100.0000	100.0356	100.0424	0.002010	0.3671	0.0027	0.0759	0.6214
G	1.62842*	5.0	0.0050	100.0000	100.0991	100.1197	0.004273	0.6943	0.0072	0.0759	0.7186
A	1.53263*	0.5	0.0005	100.0000	100.0236	100.0277	0.001657	0.2862	0.0018	0.0759	0.5891
A	1.53263*	1.0	0.0010	100.0000	100.0353	100.0423	0.002054	0.3700	0.0027	0.0759	0.6267
A	1.53263*	5.0	0.0050	100.0000	100.0945	100.1194	0.004344	0.6991	0.0072	0.0759	0.7261
A	1.43684*	0.5	0.0005	100.0000	100.0233	100.0276	0.001702	0.2879	0.0018	0.0759	0.6016
A	1.43684*	1.0	0.0010	100.0000	100.0350	100.0421	0.002099	0.3731	0.0027	0.0759	0.6365
A	1.43684*	5.0	0.0050	100.0000	100.0938	100.1190	0.004419	0.7041	0.0071	0.0759	0.7338
A	1.34105*	0.5	0.0005	100.0000	100.0231	100.0274	0.001751	0.2908	0.0018	0.0759	0.6107
A	1.34105*	1.0	0.0010	100.0000	100.0347	100.0419	0.002148	0.3763	0.0026	0.0759	0.6447
A	1.34105*	5.0	0.0050	100.0000	100.0931	100.1187	0.004497	0.7093	0.0071	0.0759	0.7421
A	1.24525*	0.5	0.0005	100.0000	100.0229	100.0273	0.001804	0.2939	0.0017	0.0759	0.6205
A	1.24525*	1.0	0.0010	100.0000	100.0344	100.0417	0.002200	0.3796	0.0026	0.0759	0.6534
A	1.24525*	5.0	0.0050	100.0000	100.0924	100.1184	0.004581	0.7148	0.0070	0.0759	0.7507
A	1.14947*	0.5	0.0005	100.0000	100.0226	100.0271	0.001863	0.2972	0.0017	0.0759	0.6312
A	1.14947*	1.0	0.0010	100.0000	100.0341	100.0416	0.002258	0.3833	0.0026	0.0759	0.6628
A	1.14947*	5.0	0.0050	100.0000	100.0917	100.1181	0.004669	0.7206	0.0070	0.0759	0.7587
A	1.05368*	0.5	0.0005	100.0000	100.0223	100.0269	0.001928	0.3009	0.0017	0.0759	0.6427
A	1.05368*	1.0	0.0010	100.0000	100.0333	100.0414	0.002316	0.3871	0.0026	0.0759	0.6757

And paste the data into excel or any other applicable application

[illegible]

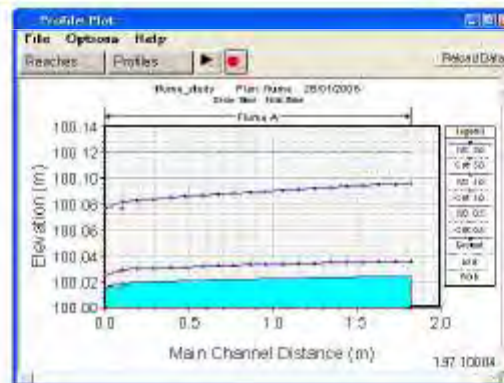
This table provides water surface elevation, velocity, Froude number, area, width, energy grade line etc. Many more options are available under options/define table



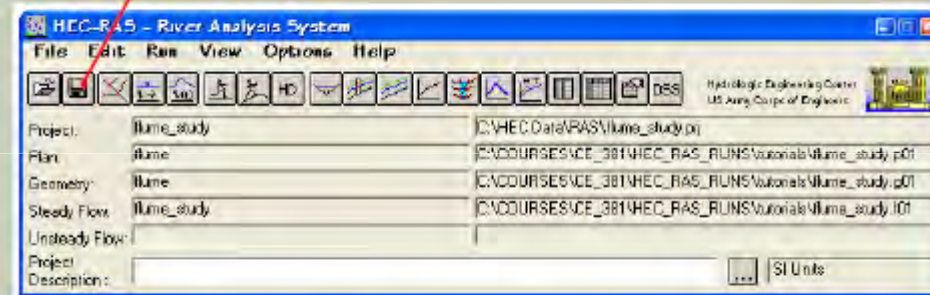
Double click any parameter (in the Available Variables) to add it to your table.



Now that we have selected all three flows, we can go back to the main menu and the plot profile tab to compare the three flows.



One last step let's go ahead and save the .prj or project file we have been working on.



*Nice work, you now know how to
run HEC-RAS.*

When you attempt to calibrate your results to observed data, there are only three things you can vary:

- A. the Manning's n coefficient (within a reasonable range)
- B. flow range (examine the min, max and mean flow ranges that you observed)
- C. the exact location of the critical depth location

Observed and simulated 1.137 L/S flow
(1.82m long x 0.757m wide flume)

