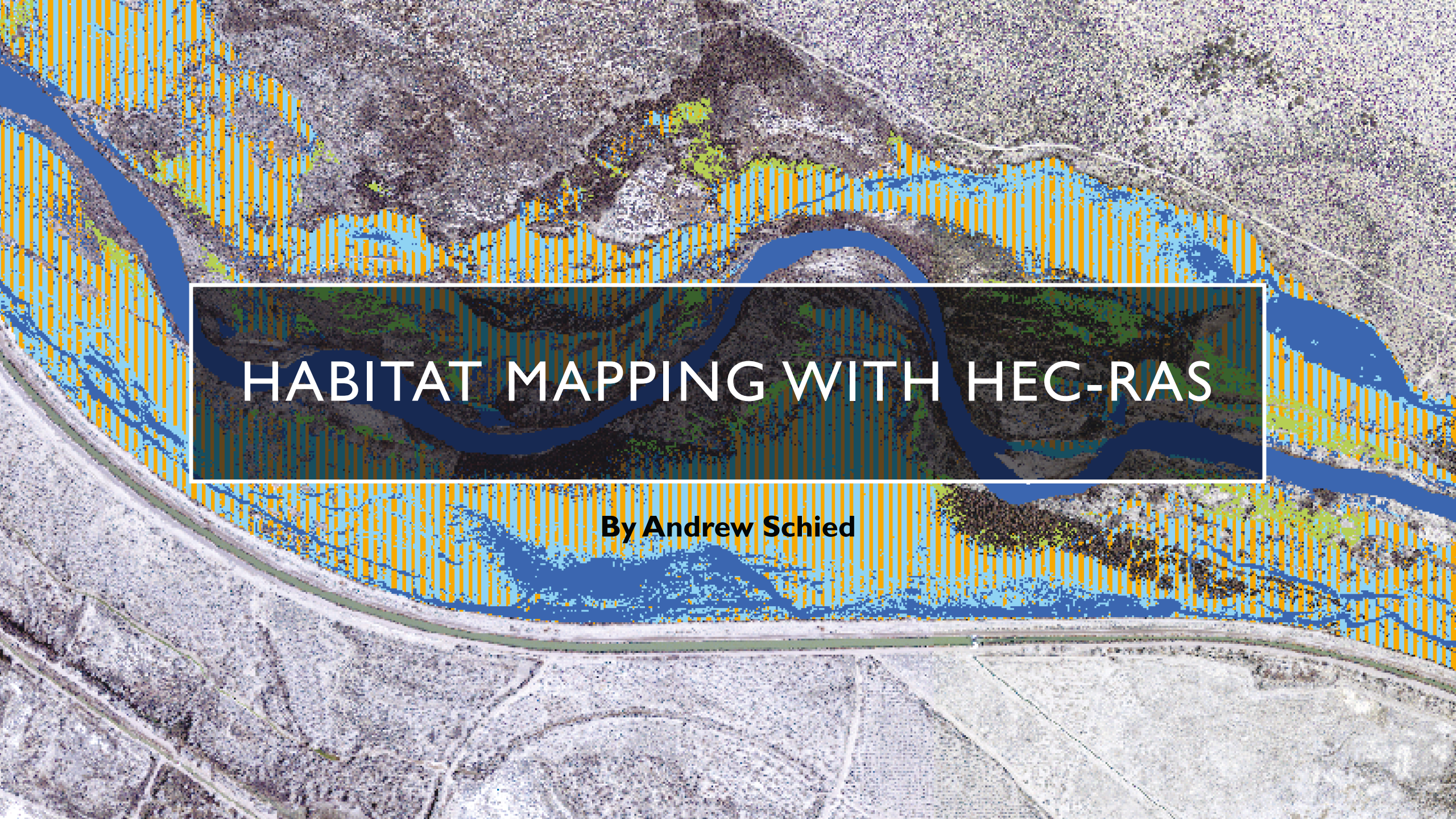


HABITAT MAPPING WITH HEC-RAS

By Andrew Schied

OVERVIEW

- My research focusses on the Middle Rio Grande river in Albuquerque, NM.
- Utilized modeling to relate hydraulic conditions to suitable available silvery minnow habitat.
- 1) Introduction to HEC-RAS
- 2) How to set up HEC-RAS
- 3) Demonstration of how HEC-RAS works

WHAT IS HEC-RAS

- Stands for Hydrologic Engineering Centers River Analysis System (HEC-RAS)
- Publicly available software create by the US Army Corps of Engineers

WHAT IS HEC-RAS CAPABLE OF?

- One-dimensional steady flow
- One and two-dimensional unsteady flow calculations
- Sediment transport/mobile bed computations
- Water temperature/water quality modeling

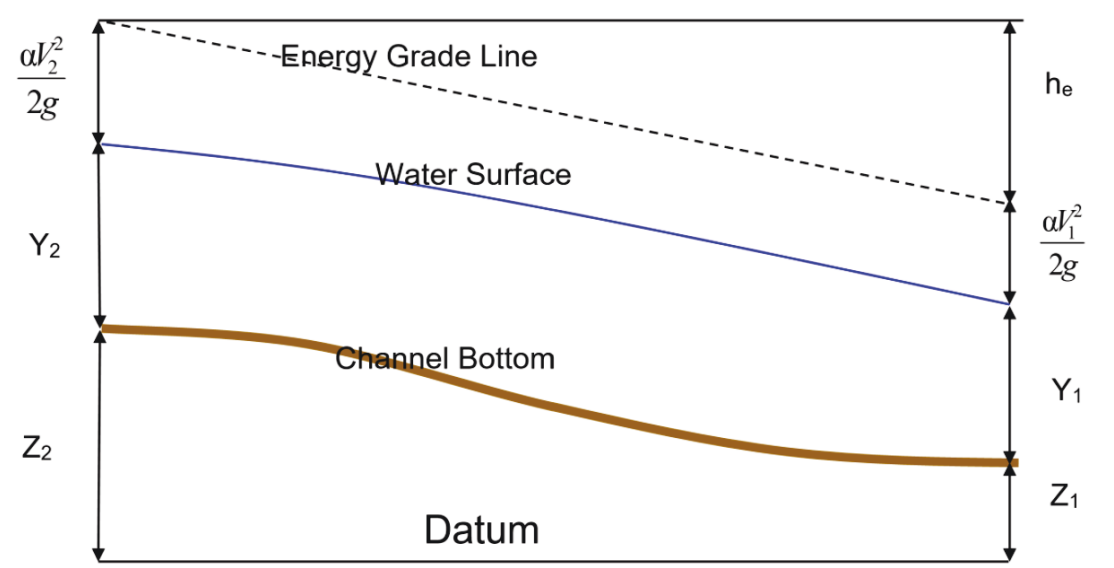
HOW DOES IT WORK?

Water surface profiles are computed from one cross section to the next by solving the Energy equation with an iterative procedure called the standard step method.

- **One Dimensional Energy Equation**

$$z_2 + y_2 + \alpha_2 \frac{{v_2}^2}{2g} = z_1 + y_1 + \alpha_1 \frac{{v_1}^2}{2g} + h_e$$

- Z= elevation of channel inverts
- Y= depth of water
- v= average velocity
- g= gravitational acceleration
- α= velocity weighting coefficients
- h_e= energy head loss



Representation of Terms in the Energy Equation

HOW DOES IT WORK?

The energy head loss (he) between two cross sections is comprised of friction losses and contraction or expansion losses. $h_e = L\bar{S_f} + C\left|\frac{\alpha_1 {v_1}^2}{2g} - \frac{\alpha_2 {v_2}^2}{2g}\right|$

- **Energy Loss Due to Expansion and Contraction**

$$h_{Ce} = C\left|\frac{\alpha_1 {v_1}^2}{2g} - \frac{\alpha_2 {v_2}^2}{2g}\right|$$

L = discharge weighted reach length

S_f = representative friction slope between two sections

C = contraction/expansion coefficient

- **Energy Loss Due to Friction from Manning's Equation**

$$S_f = \left(\frac{Q}{K}\right)^2$$

$$K = \frac{1}{n} {R_h}^{2/3} A$$

n = Manning's coefficient

A = cross sectional area

R_h = hydraulic radius

S_f = friction slope

HOW DOES IT WORK?

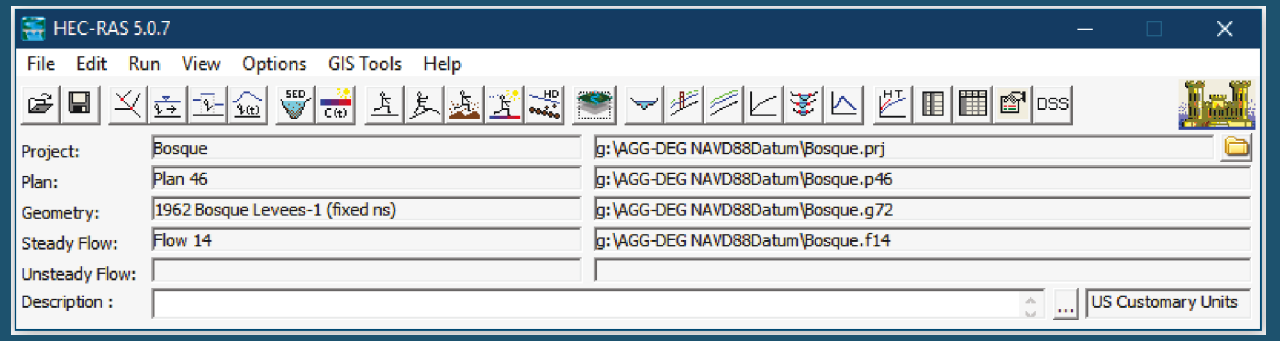
Computational Procedure

1) **Assume a water surface elevation at the upstream or downstream cross sections.**
2) **Based on the assumed water surface elevation, determine the corresponding total conveyance and velocity head.**
3) **Compute S_f and solve for losses h_e**
4) **Solve the energy equation for the water surface.**
5) **Compare the computed value of depth with the assumed value and iterate until the values agree within 0.01 feet.**

SETTING UP HEC-RAS

Required Information

- Surveyed cross sections (STA and ELEV)
- Average reach slope for boundary conditions
- LiDAR topographical data (if using RAS Mapper)

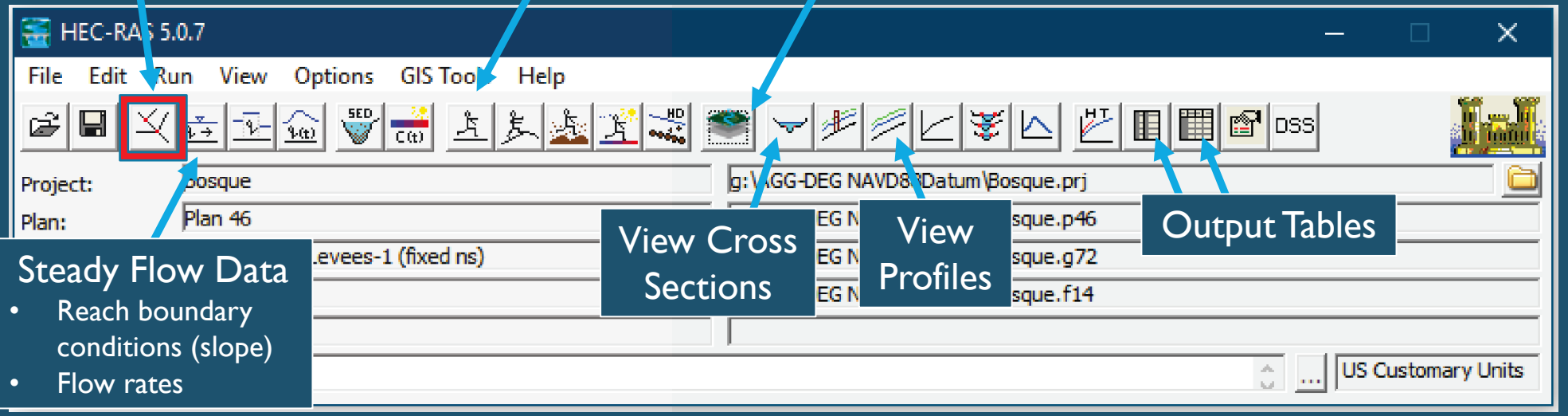


SETTING UP HEC-RAS

Geometry Editor

Run Steady Flow Analysis
- Flow Regime (Sub/super/crit)
- Flow Distribution

RAS Mapper
- View maps and data spatially



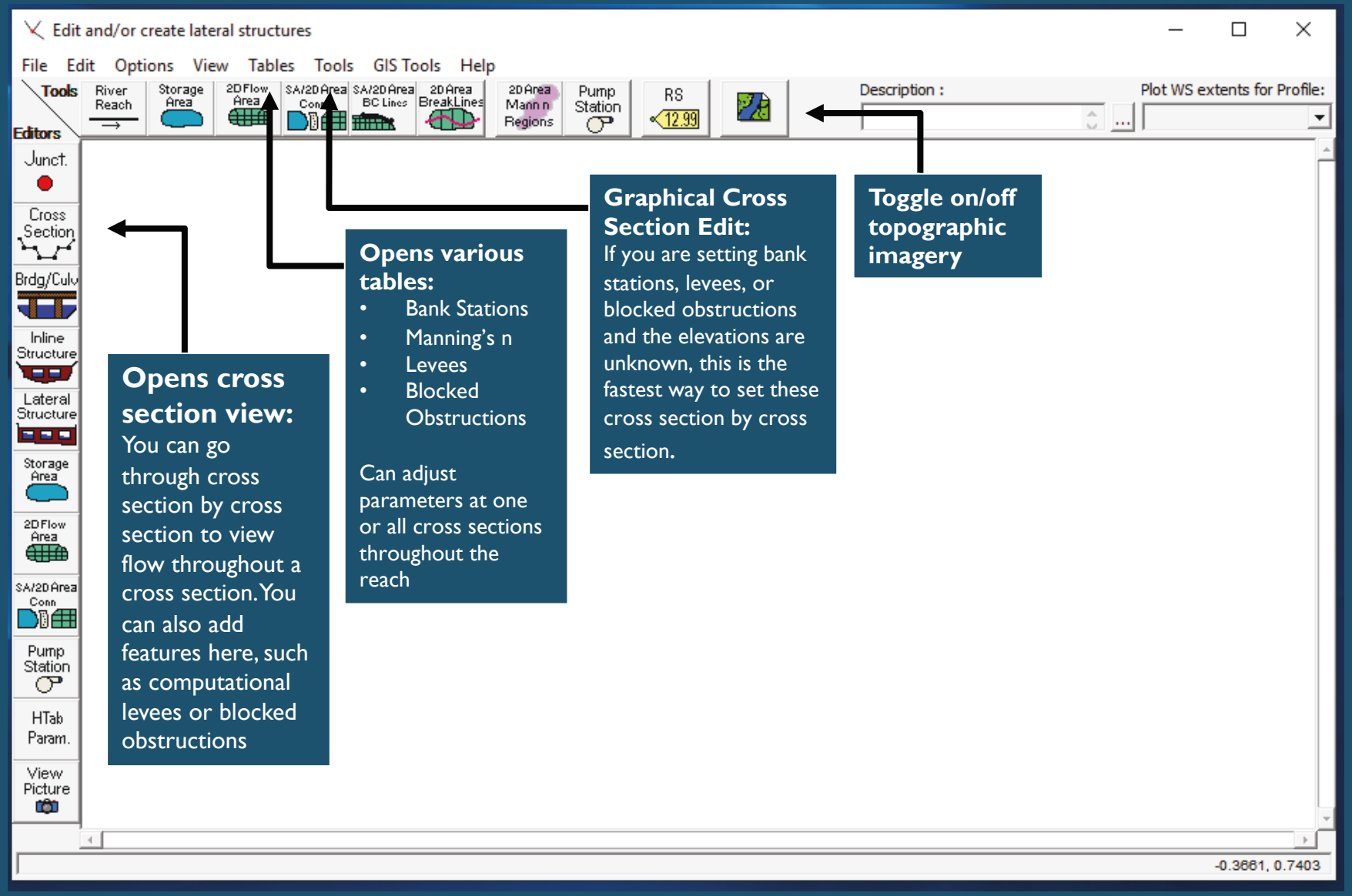
Steady Flow Data
- Reach boundary conditions (slope)
- Flow rates

View Cross Sections

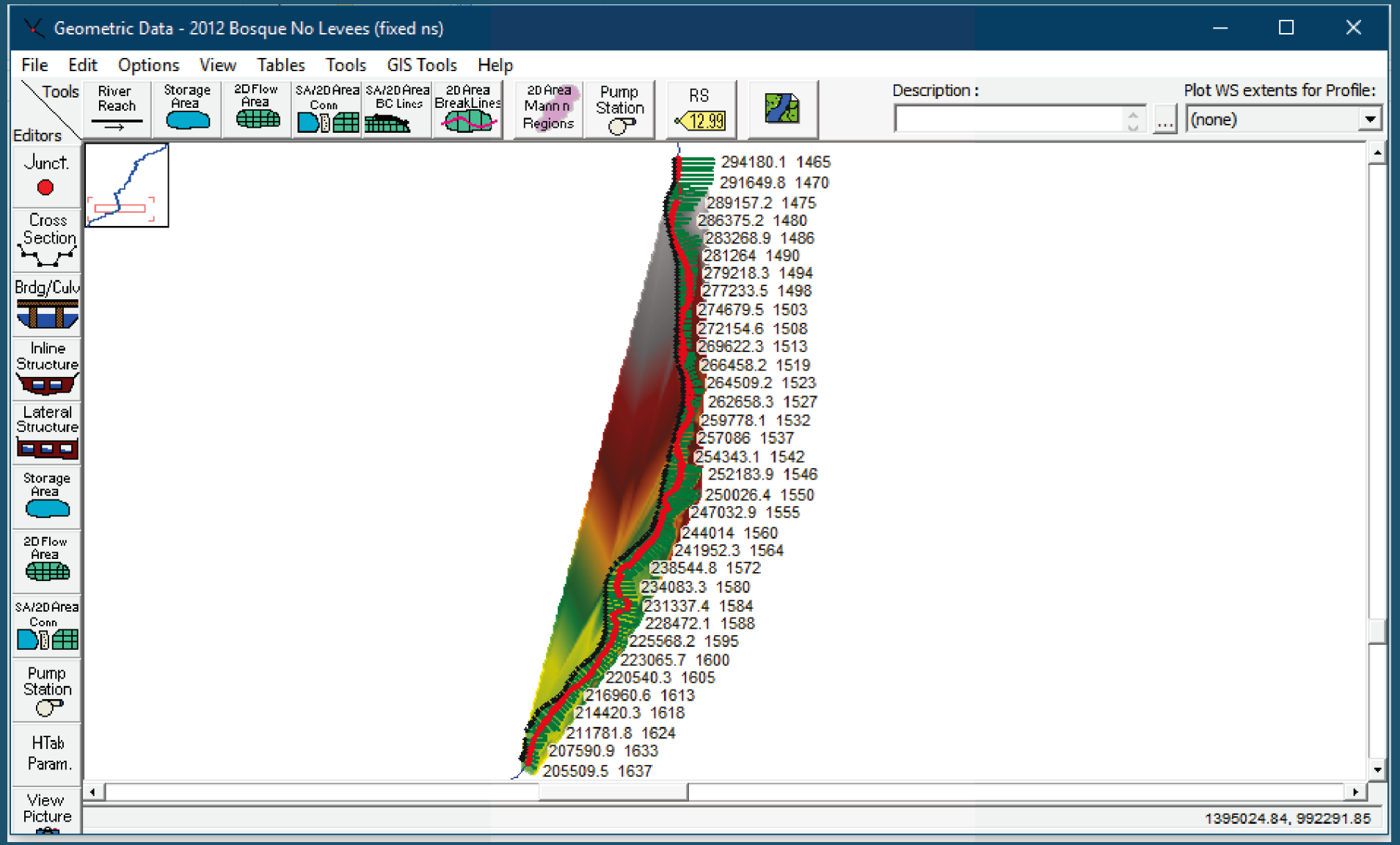
View Profiles

Output Tables

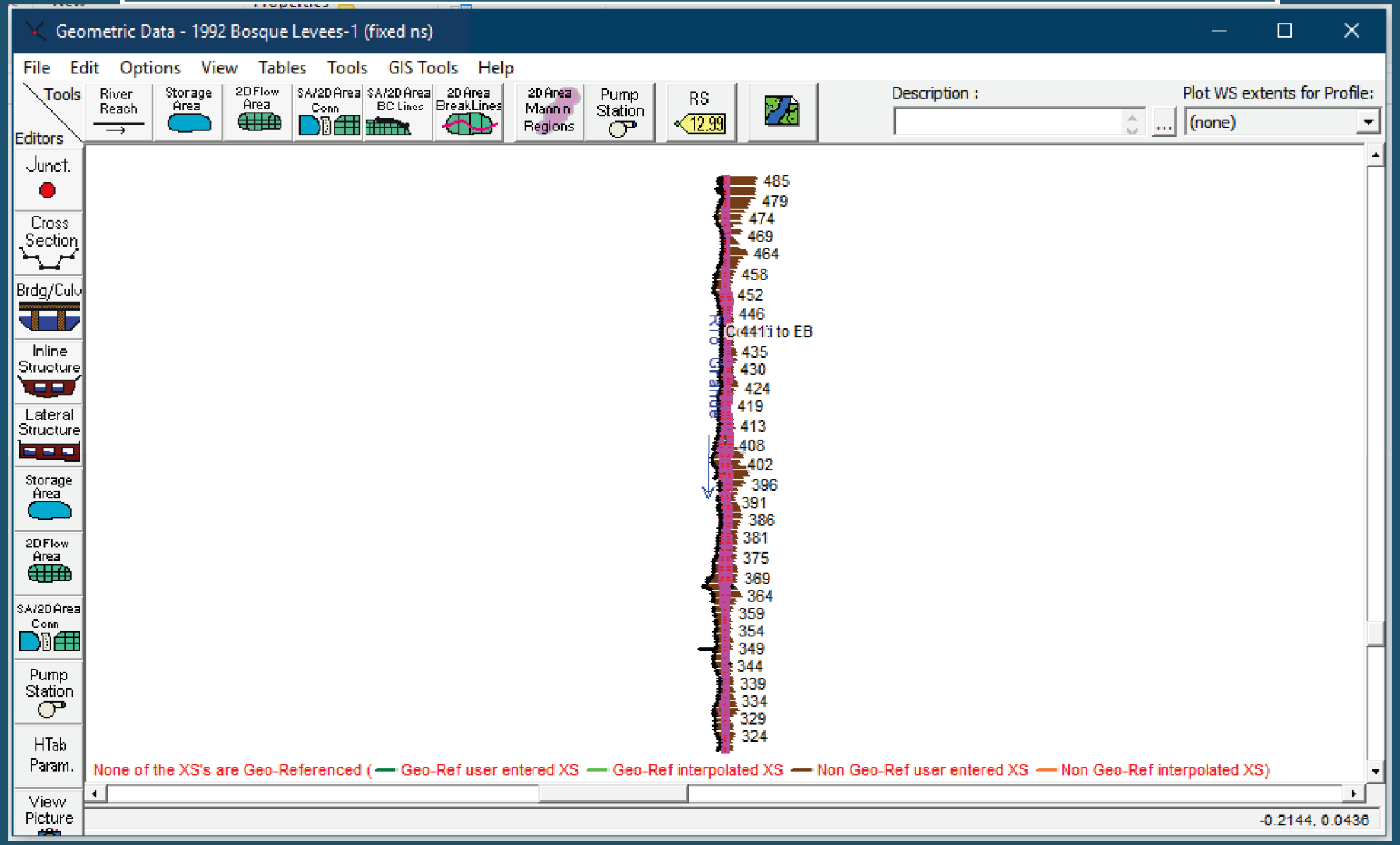
SETTING UP HEC-RAS



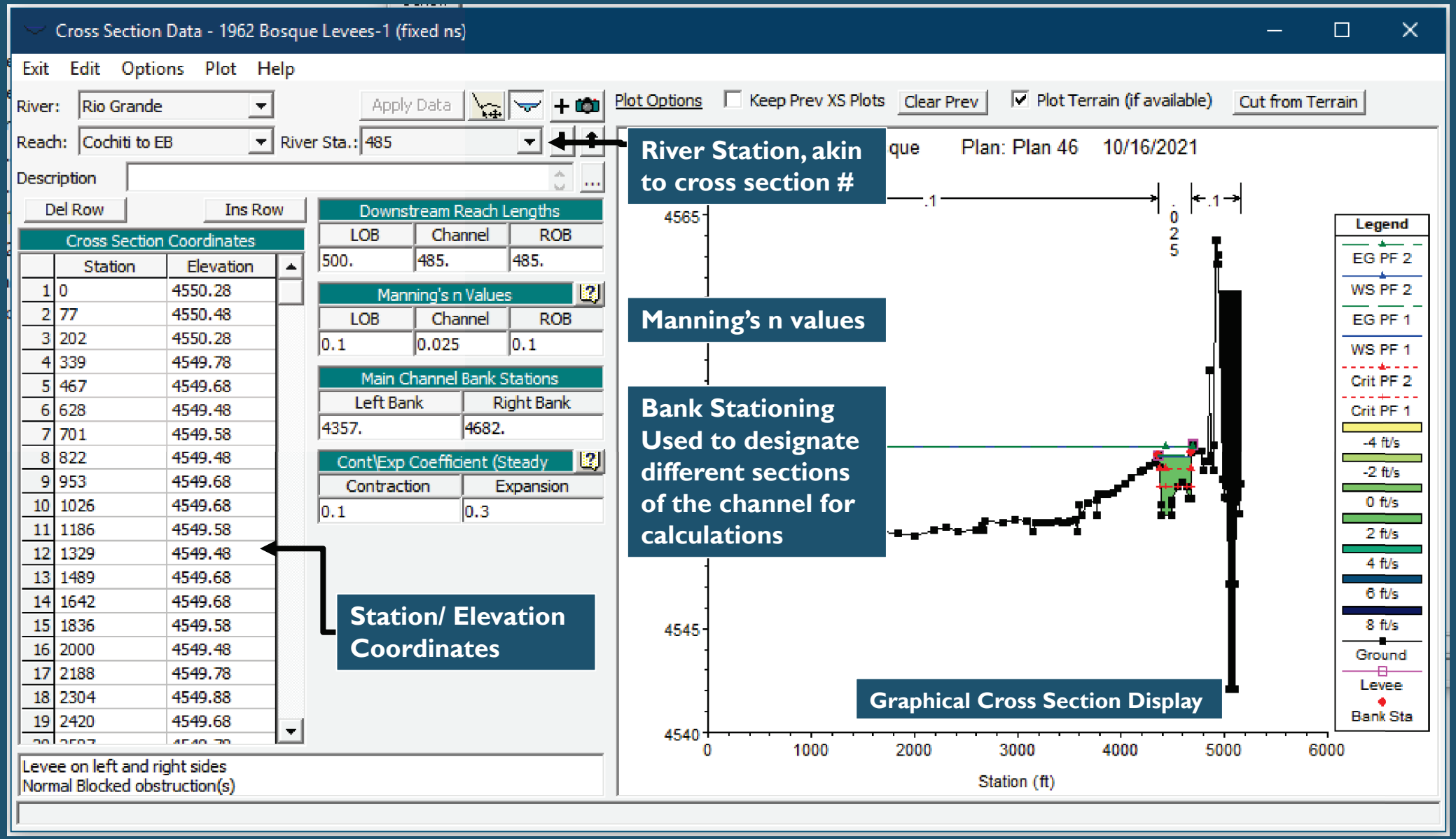
SETTING UP HEC-RAS



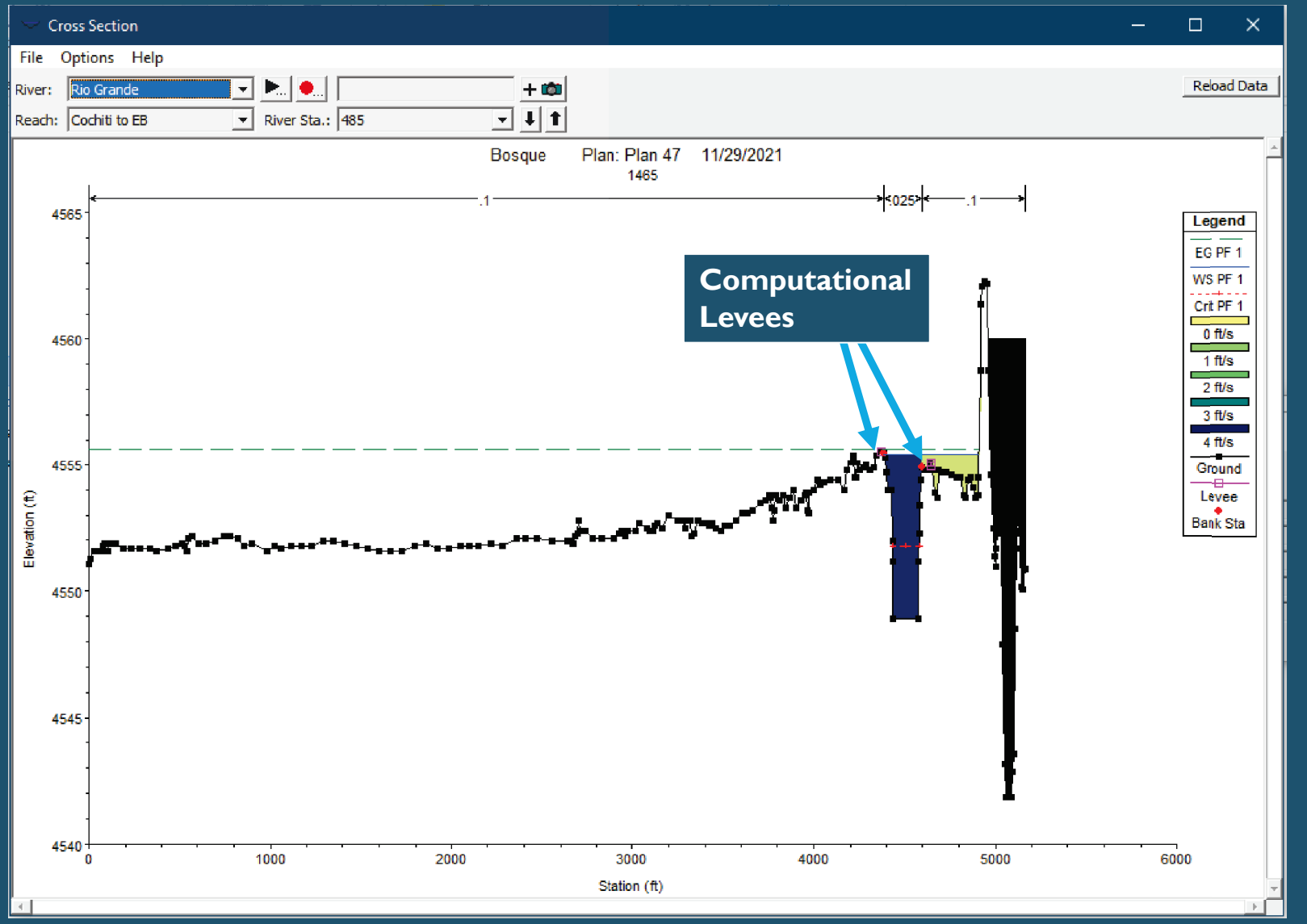
SETTING UP HEC-RAS



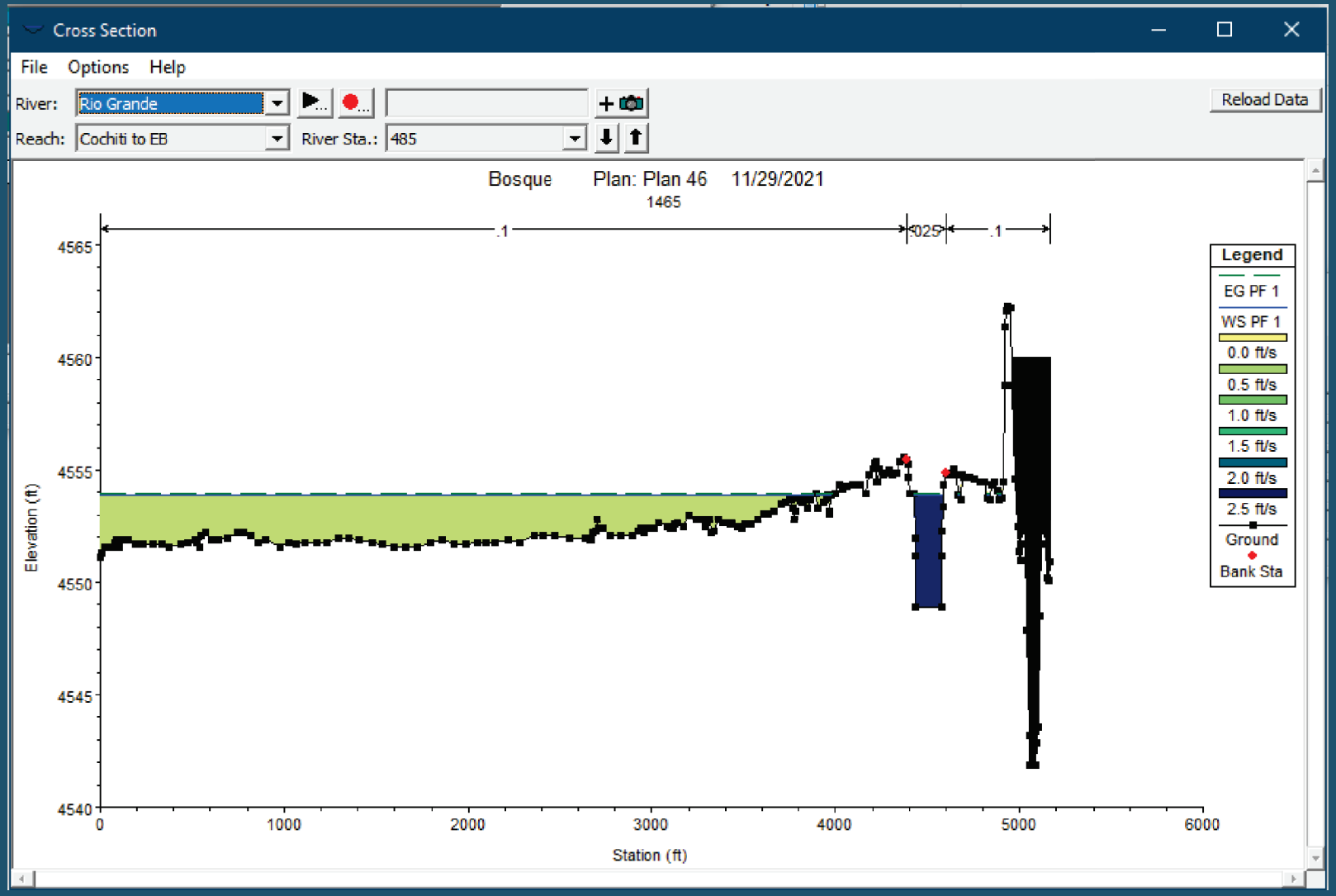
SETTING UP HEC-RAS



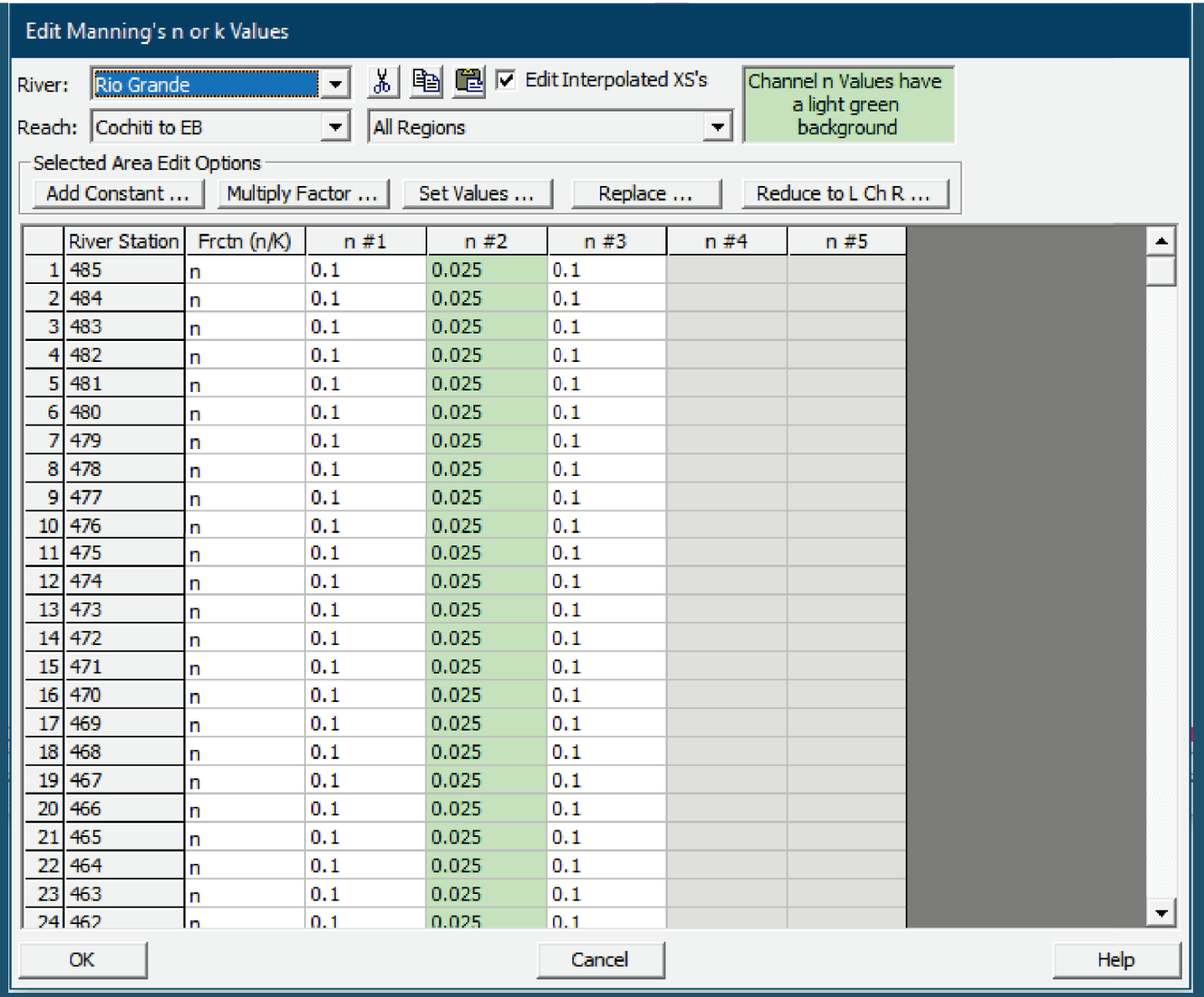
SETTING UP HEC-RAS



SETTING UP HEC-RAS



SETTING UP HEC-RAS



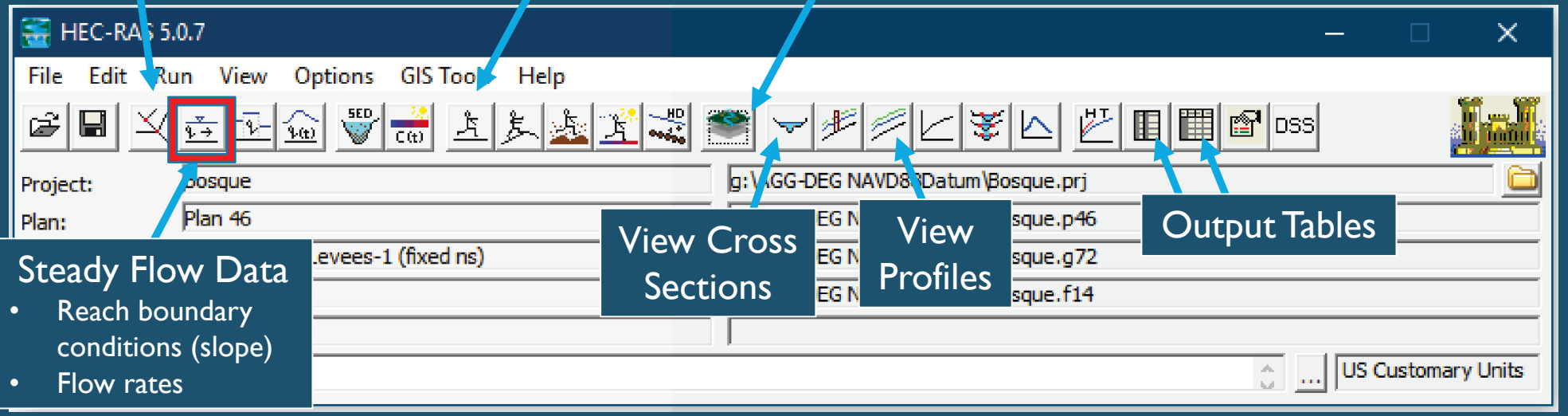
	River Station	Frctn (n/K)	n #1	n #2	n #3	n #4	n #5
1	485	n	0.1	0.025	0.1		
2	484	n	0.1	0.025	0.1		
3	483	n	0.1	0.025	0.1		
4	482	n	0.1	0.025	0.1		
5	481	n	0.1	0.025	0.1		
6	480	n	0.1	0.025	0.1		
7	479	n	0.1	0.025	0.1		
8	478	n	0.1	0.025	0.1		
9	477	n	0.1	0.025	0.1		
10	476	n	0.1	0.025	0.1		
11	475	n	0.1	0.025	0.1		
12	474	n	0.1	0.025	0.1		
13	473	n	0.1	0.025	0.1		
14	472	n	0.1	0.025	0.1		
15	471	n	0.1	0.025	0.1		
16	470	n	0.1	0.025	0.1		
17	469	n	0.1	0.025	0.1		
18	468	n	0.1	0.025	0.1		
19	467	n	0.1	0.025	0.1		
20	466	n	0.1	0.025	0.1		
21	465	n	0.1	0.025	0.1		
22	464	n	0.1	0.025	0.1		
23	463	n	0.1	0.025	0.1		
24	462	n	0.1	0.025	0.1		

SETTING UP HEC-RAS

Geometry Editor

Run Steady Flow Analysis
- Flow Regime (Sub/super/crit)
- Flow Distribution

RAS Mapper
- View maps and data spatially



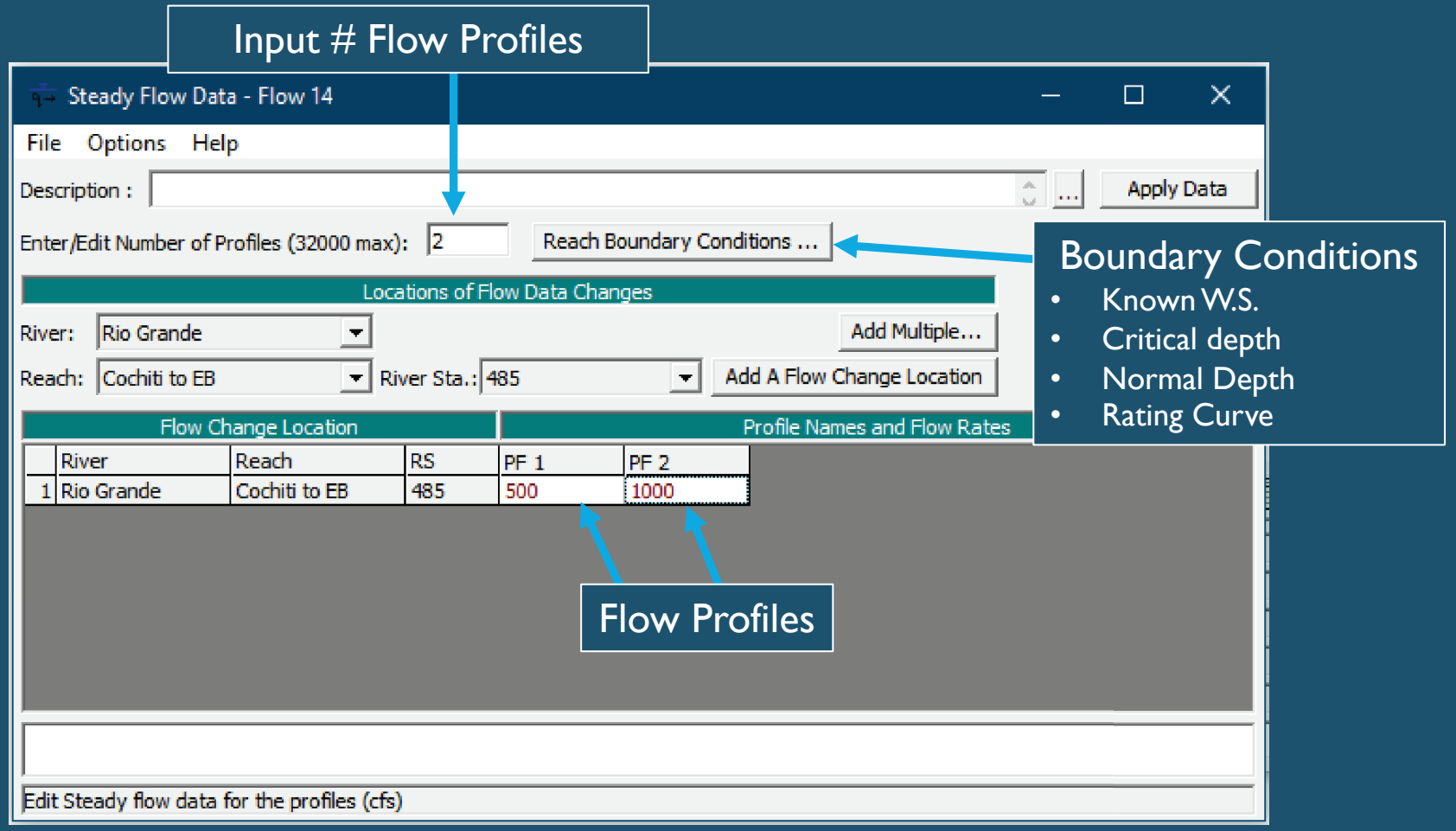
Steady Flow Data
- Reach boundary conditions (slope)
- Flow rates

View Cross Sections

View Profiles

Output Tables

SETTING UP HEC-RAS

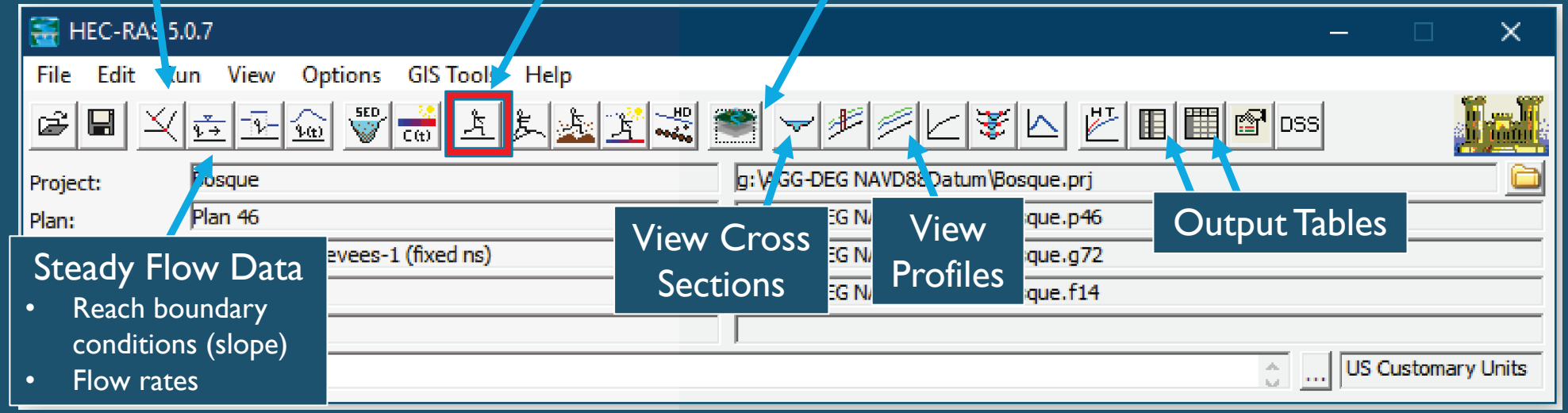


SETTING UP HEC-RAS

Geometry Editor

Run Steady Flow Analysis
- Flow Regime (Sub/super/crit)
- Flow Distribution

RAS Mapper
- View maps and data spatially



Steady Flow Data
- Reach boundary conditions (slope)
- Flow rates

View Cross Sections

View Profiles

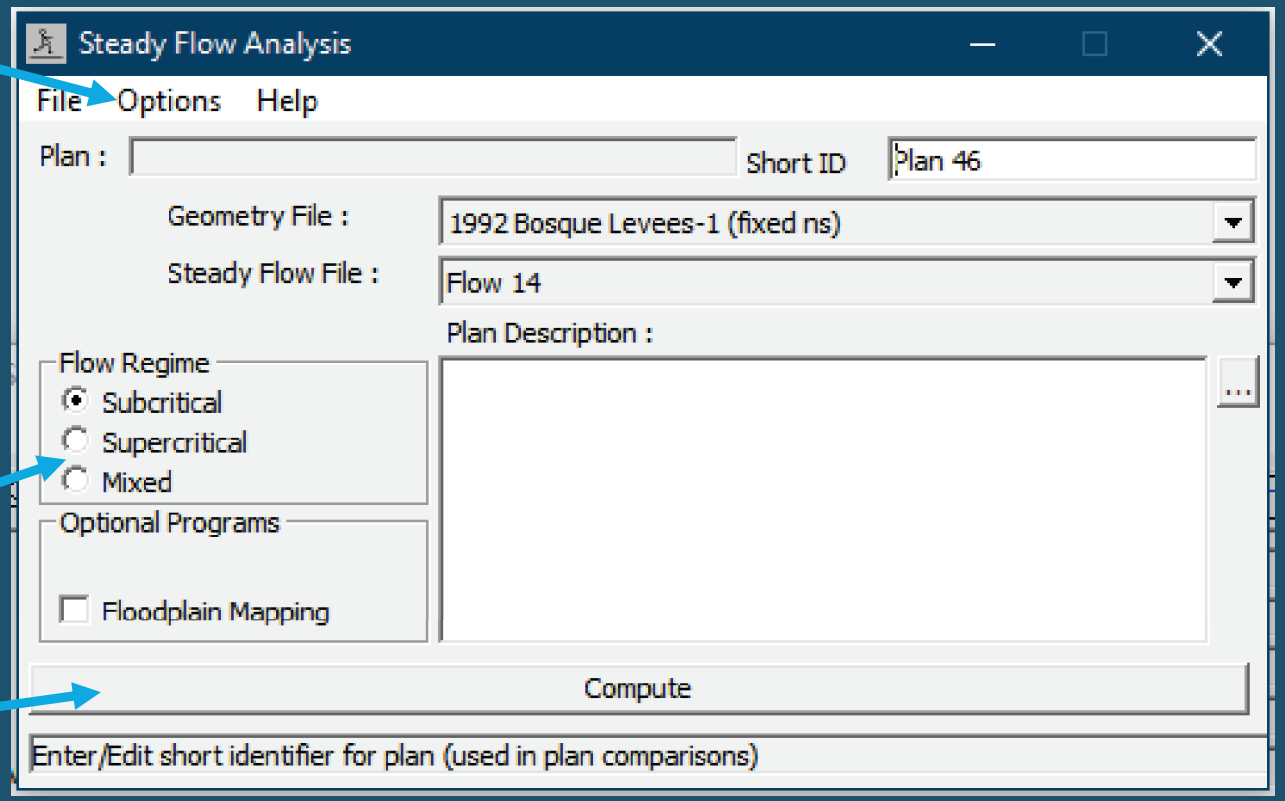
Output Tables

SETTING UP HEC-RAS

Options
- Flow Distribution Locations

Flow Regimes
- Subcritical
- Supercritical
- Mixed

Run!



SETTING UP HEC-RAS

Flow Distributions

- By default HEC-RAS will use 3 flow distributions (left floodplain, main channel, right floodplain)
- Can define a greater resolution, up to 45 slices.
- In this case, I wanted to most resolution possible for the floodplains.

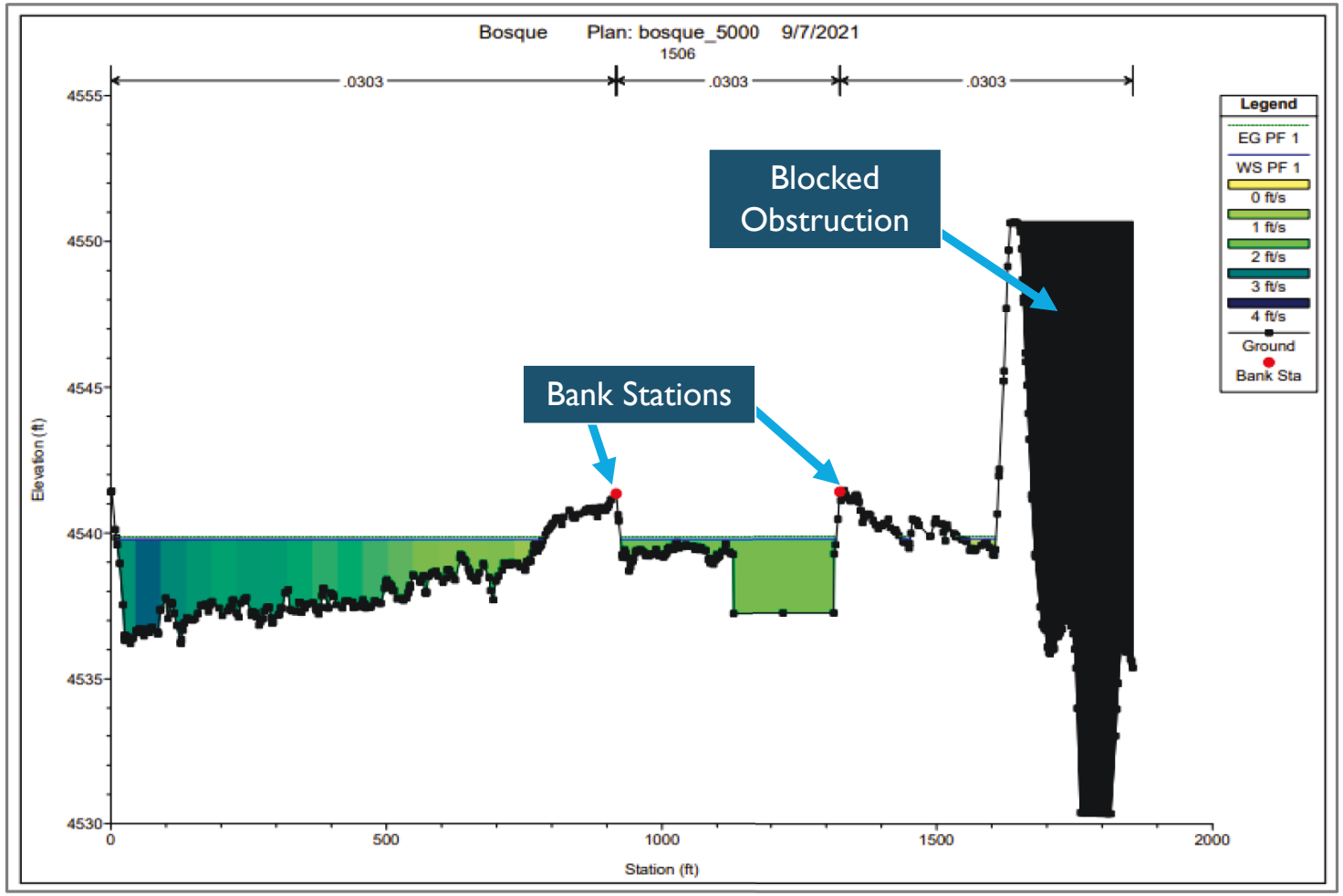
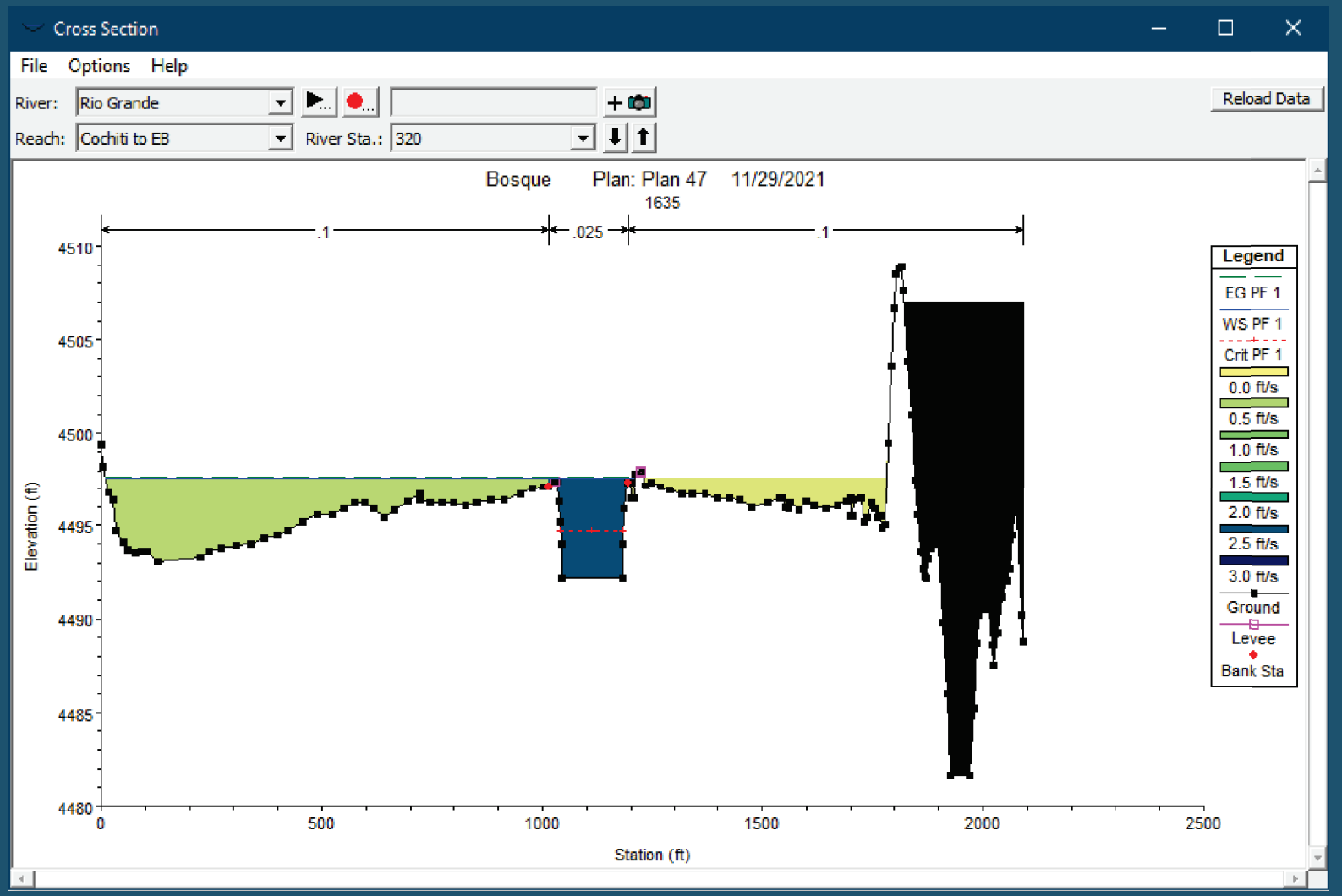


Figure 63 Cross-section with flow distribution from HEC-RAS with 20 vertical slices in the floodplains and 5 vertical slices in the main channel. The blue and green slices are small enough that the discrete color changes look more like a gradient.

SETTING UP HEC-RAS

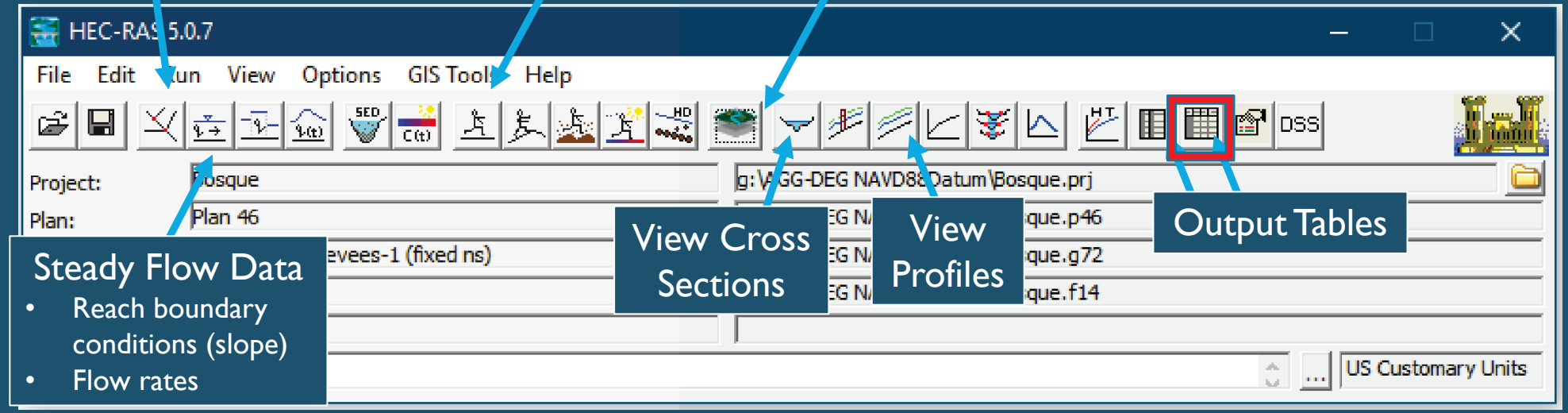


VIEWING THE RESULTS

Geometry Editor

Run Steady Flow Analysis
- Flow Regime (Sub/super/crit)
- Flow Distribution

RAS Mapper
- View maps and data spatially



Steady Flow Data
- Reach boundary conditions (slope)
- Flow rates

View Cross Sections

View Profiles

Output Tables

VIEWING THE RESULTS

Options allows you to further define output values

Profile Output Table - Standard Table 1

File Options Std. Tables User Tables Locations Help

HEC-RAS Plan: Plan 46 River: Rio Grande Reach: Cochiti to EB Profile: PF 1 Reload Data

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Cochiti to EB	485	PF 1	4000.00	4548.88	4553.91		4553.95	0.000208	2.35	7849.31	4186.62	0.19
Cochiti to EB	484	PF 1	4000.00	4548.97	4553.77		4553.83	0.000303	2.75	6962.96	4271.02	0.23
Cochiti to EB	483	PF 1	4000.00	4548.77	4553.63		4553.68	0.000281	2.63	7119.76	4243.68	0.22
Cochiti to EB	482	PF 1	4000.00	4548.37	4553.47		4553.53	0.000326	2.92	6586.51	4239.68	0.24
Cochiti to EB	481	PF 1	4000.00	4547.27	4553.29		4553.38	0.000275	2.92	5589.86	3707.17	0.22
Cochiti to EB	480	PF 1	4000.00	4546.87	4553.12		4553.23	0.000314	3.29	5119.97	3535.26	0.24
Cochiti to EB	479	PF 1	4000.00	4546.76	4552.79		4552.97	0.000766	3.78	2972.16	2822.65	0.35
Cochiti to EB	478	PF 1	4000.00	4546.66	4552.13		4552.51	0.001169	5.34	1942.22	1695.46	0.45
Cochiti to EB	477	PF 1	4000.00	4546.56	4552.04		4552.15	0.000364	2.90	2952.82	1832.05	0.25
Cochiti to EB	476	PF 1	4000.00	4546.56	4551.84		4551.96	0.000459	3.09	2595.49	1955.26	0.28
Cochiti to EB	475	PF 1	4000.00	4546.26	4551.33		4551.54	0.001103	4.29	1986.26	915.83	0.42
Cochiti to EB	474	PF 1	4000.00	4546.25	4550.87		4551.05	0.000617	3.86	2900.62	1971.64	0.33
Cochiti to EB	473	PF 1	4000.00	4546.15	4550.64		4550.75	0.000518	3.33	4266.36	2815.24	0.30
Cochiti to EB	472	PF 1	4000.00	4545.65	4550.36		4550.46	0.000614	3.11	3910.37	2527.76	0.31
Cochiti to EB	471	PF 1	4000.00	4545.75	4550.08		4550.18	0.000468	2.95	3501.97	1852.25	0.28
Cochiti to EB	470	PF 1	4000.00	4545.55	4549.82		4549.91	0.000495	2.62	3207.31	1931.79	0.28
Cochiti to EB	469	PF 1	4000.00	4545.34	4549.59		4549.69	0.000399	2.72	2721.42	1566.22	0.26
Cochiti to EB	468	PF 1	4000.00	4544.64	4549.25		4549.43	0.000696	3.68	2041.52	1198.11	0.34
Cochiti to EB	467	PF 1	4000.00	4544.44	4548.98		4549.08	0.000569	3.33	3444.72	1641.47	0.31
Cochiti to EB	466	PF 1	4000.00	4544.34	4548.46		4548.67	0.001307	4.62	2732.31	1903.74	0.46
Cochiti to EB	465	PF 1	4000.00	4544.44	4547.85		4548.03	0.001429	4.60	2717.54	1635.96	0.47
Cochiti to EB	464	PF 1	4000.00	4543.33	4547.23		4547.39	0.001114	4.00	2673.44	1601.64	0.41
Cochiti to EB	463	PF 1	4000.00	4543.93	4546.92		4546.96	0.000564	2.72	5117.70	2838.38	0.29
Cochiti to EB	462	PF 1	4000.00	4542.83	4546.70		4546.74	0.000315	2.43	5565.64	2761.69	0.23
Cochiti to EB	461	PF 1	4000.00	4543.03	4546.55		4546.58	0.000314	1.96	5675.34	2566.40	0.22
Cochiti to EB	460	PF 1	4000.00	4542.23	4546.37		4546.42	0.000409	2.30	4821.52	2400.48	0.25
Cochiti to EB	459	PF 1	4000.00	4542.33	4546.16		4546.22	0.000426	2.58	4278.39	2300.57	0.26
Cochiti to EB	458	PF 1	4000.00	4541.83	4545.77		4545.94	0.000698	3.69	2872.97	2344.23	0.34

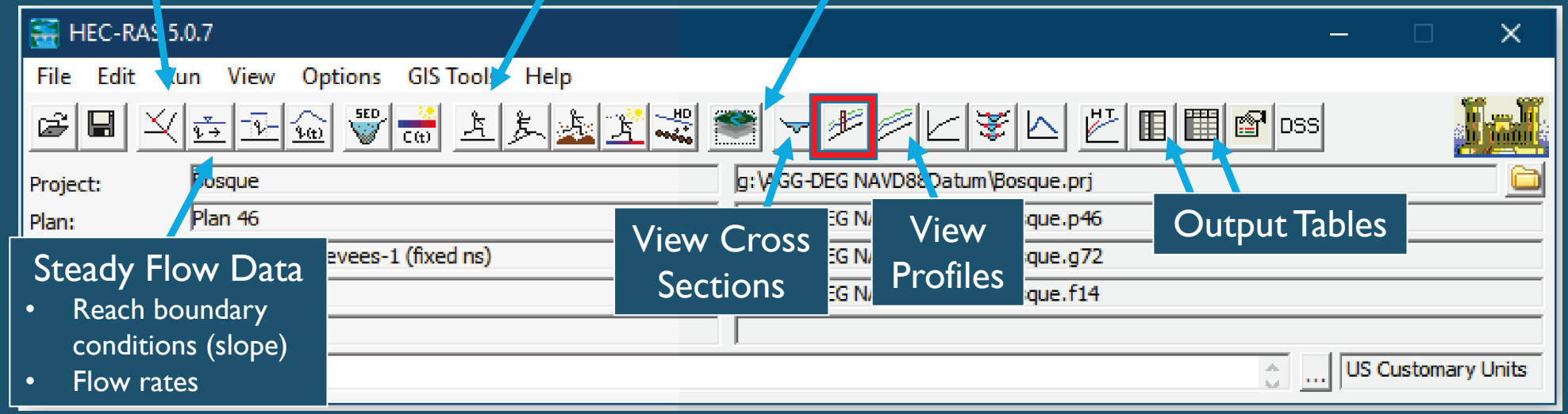
Total flow in cross section.

VIEWING THE RESULTS

Geometry Editor

Run Steady Flow Analysis
- Flow Regime (Sub/super/crit)
- Flow Distribution

RAS Mapper
- View maps and data spatially



Steady Flow Data
- Reach boundary conditions (slope)
- Flow rates

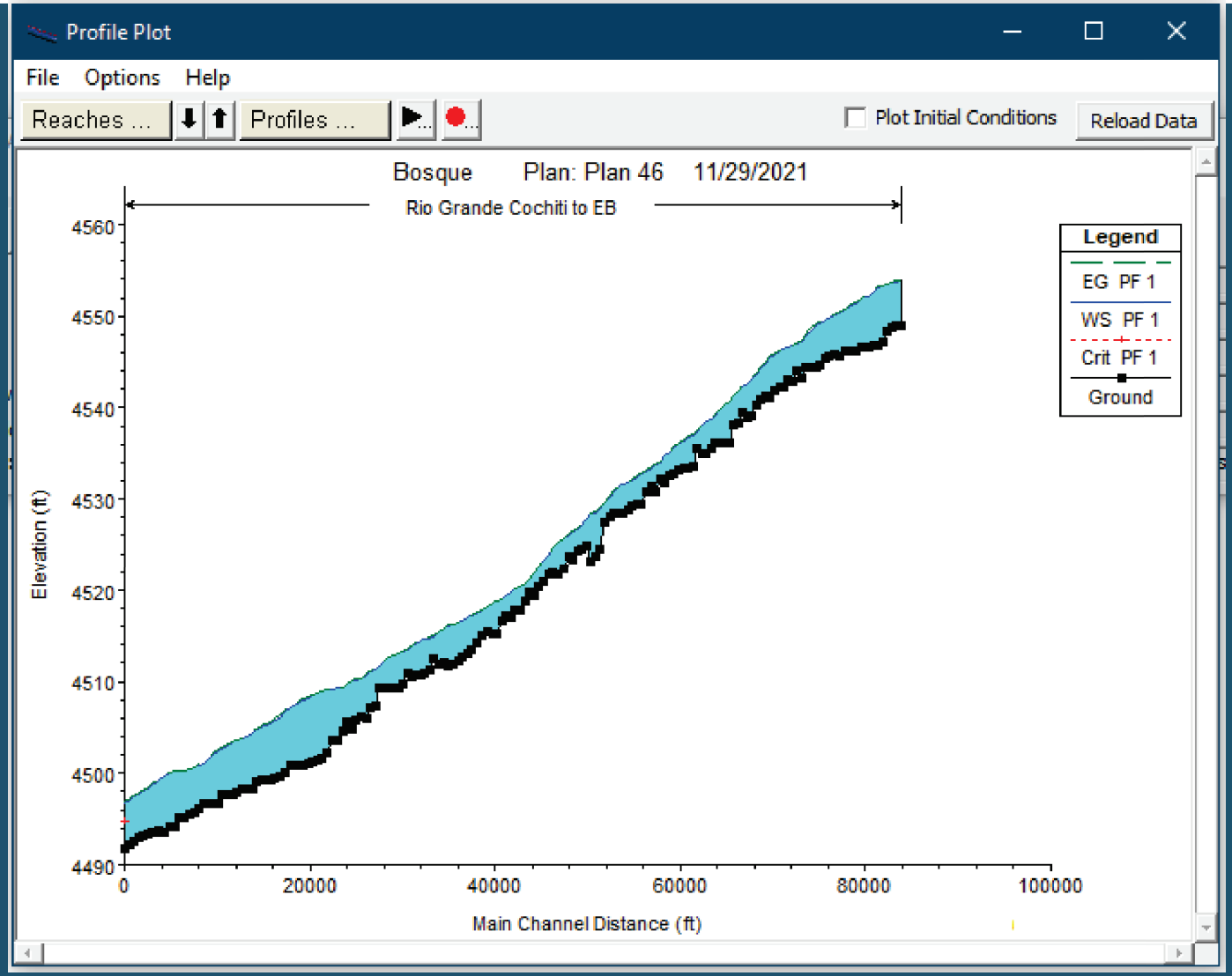
View Cross Sections

View Profiles

Output Tables

VIEWING THE RESULTS

Flow profile

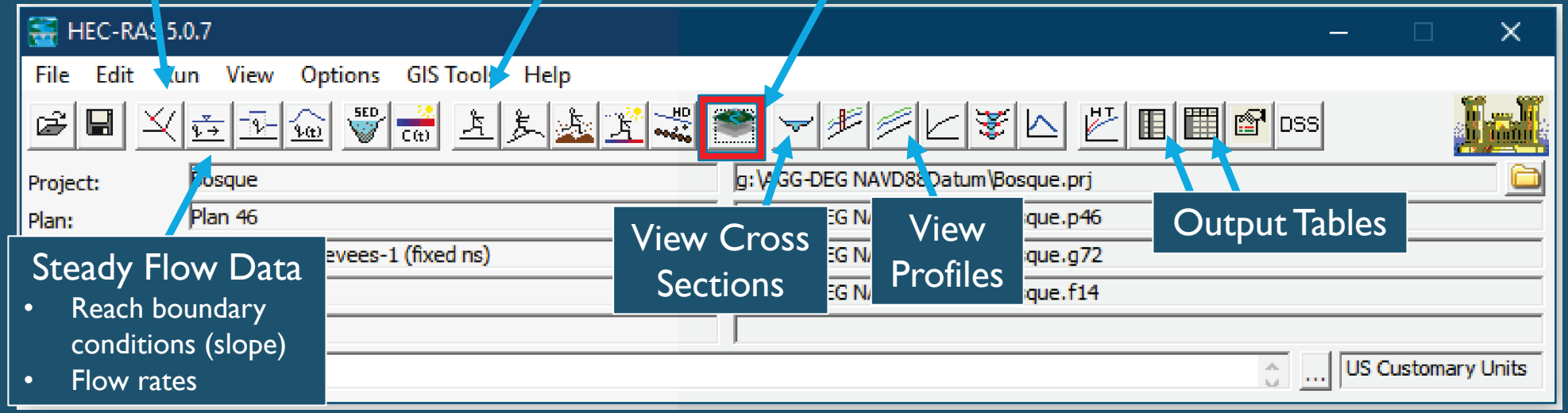


RAS MAPPER

Geometry Editor

Run Steady Flow Analysis
- Flow Regime (Sub/super/crit)
- Flow Distribution

RAS Mapper
- View maps and data spatially



Steady Flow Data
- Reach boundary conditions (slope)
- Flow rates

View Cross Sections

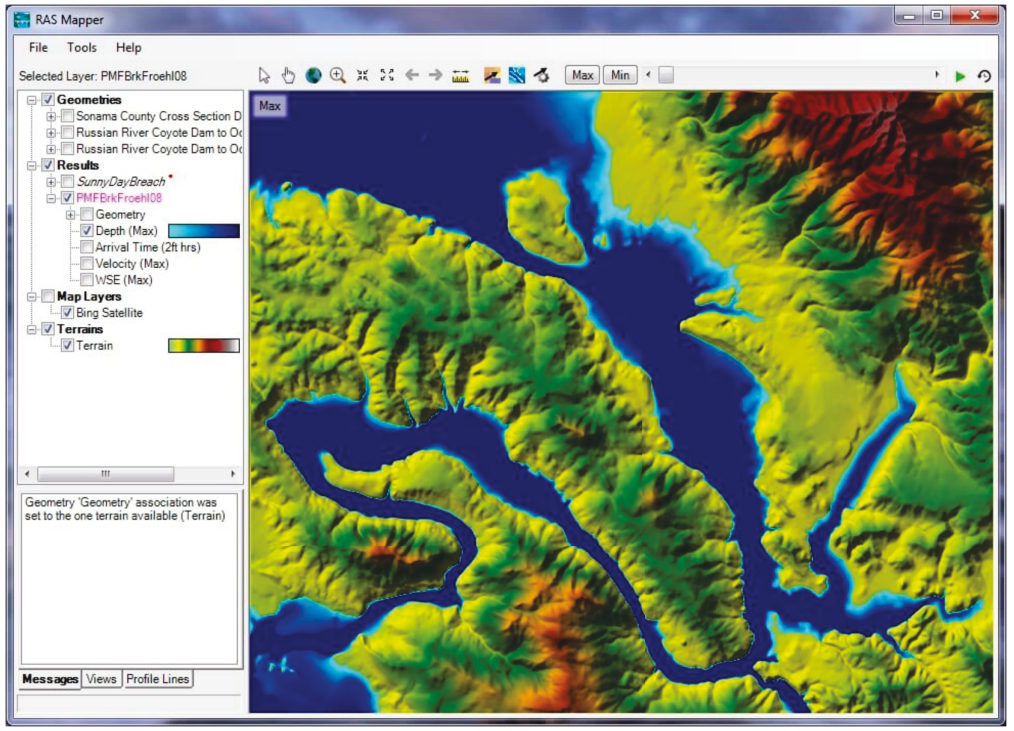
View Profiles

Output Tables

RAS MAPPER

What is RAS Mapper?

- HEC-RAS has the capability to perform inundation mapping of water surface profile results directly from HEC-RAS.
- Visualizes 1D model results.
- Various types of map layer results can be generated,
  - depth of water
  - water surface elevations;
  - velocity
  - inundation boundary (shapefile)
  - flow (1D only right now)
  - depth times velocity
  - depth times velocity^2

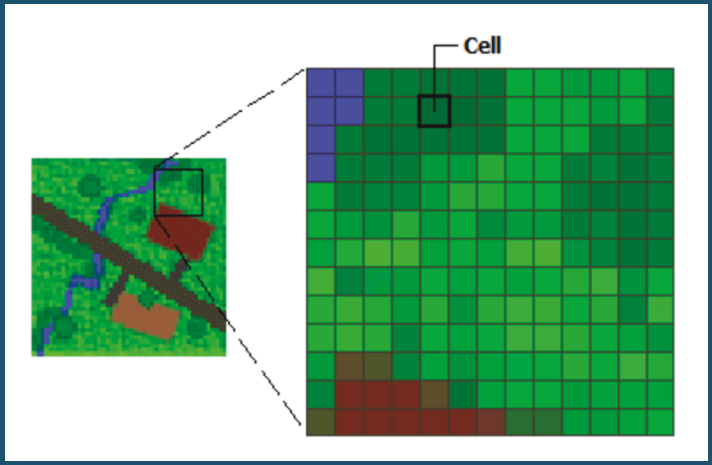


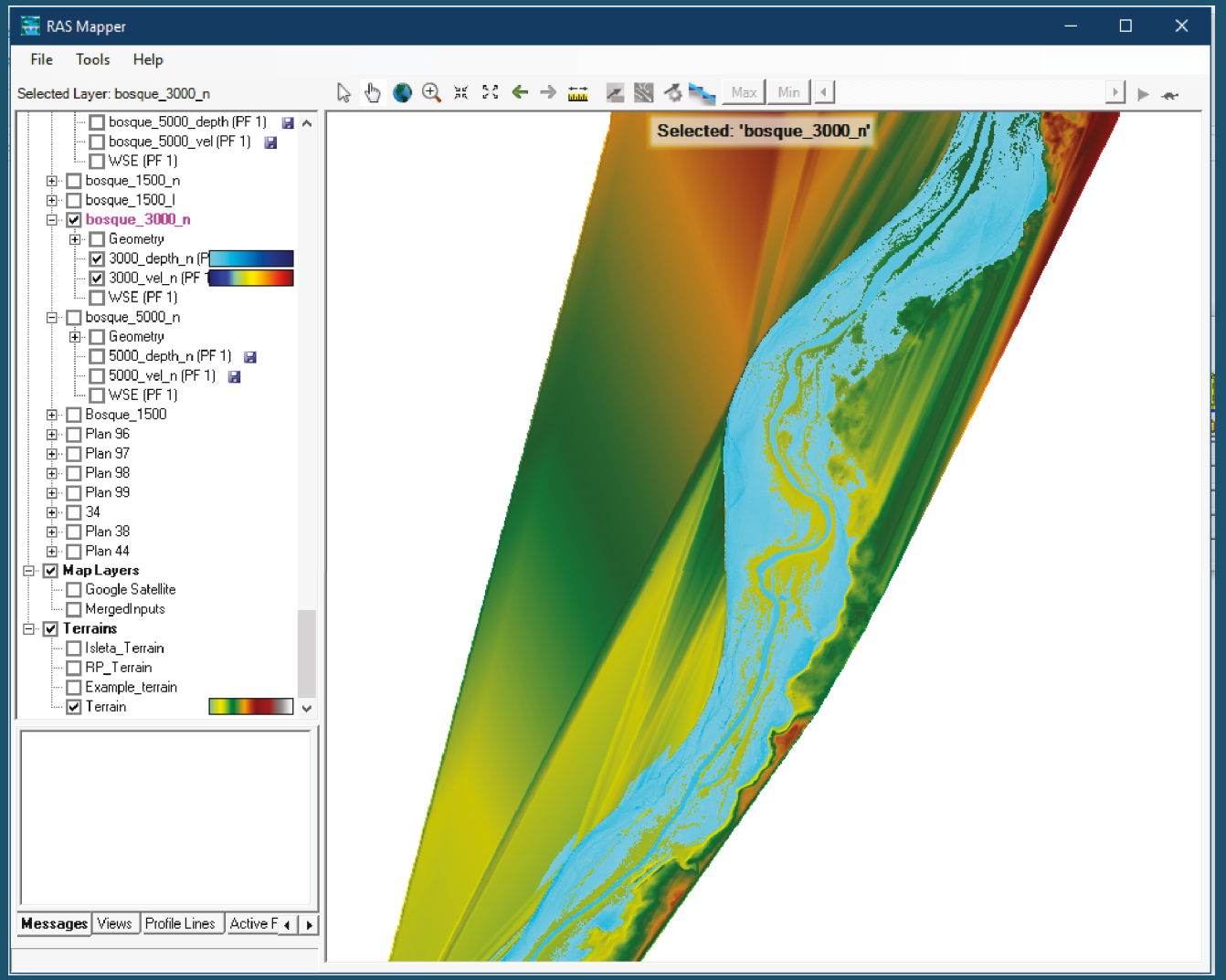
RAS MAPPER

- Allows for the exportation of raster files. (.tif and .vrt)

What is a Raster File?

- A raster consists of a matrix of cells (or pixels) organized into rows and columns (or a grid) where each cell contains a value representing information, such as depth.



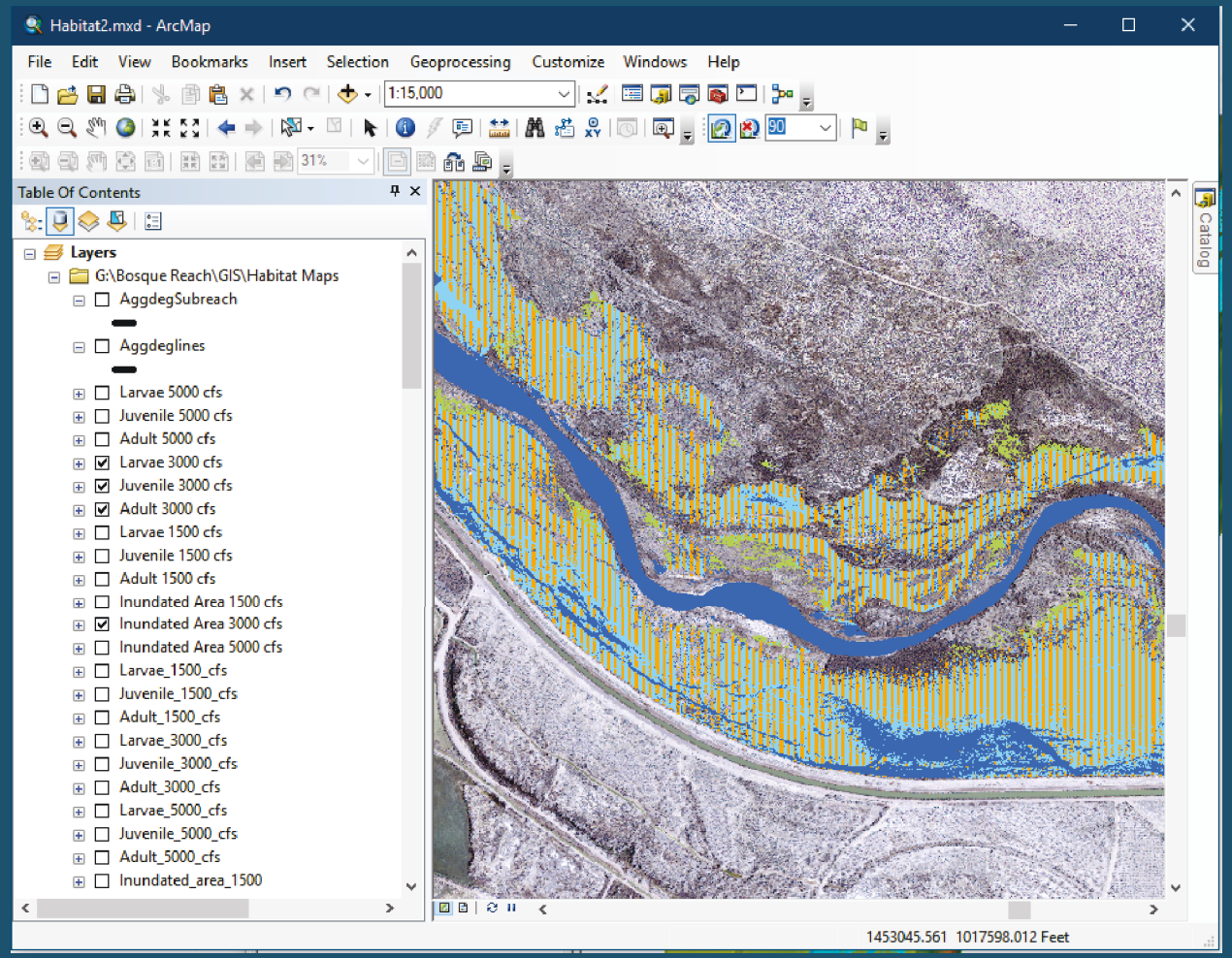


RAS MAPPER+ARCMAP

Table 5 Rio Grande Silvery Minnow habitat velocity and depth range requirements (from Mortensen et al., 2019)

	Velocity (cm/s)	Depth (cm)
Adult Habitat	<40	>5 and <60
Juvenile Habitat	<30	>1 and <50
Larvae Habitat	<5	<15

- ArcMap is a mapping software developed by ESRI.
- Using a tool called "ModelBuilder" the raster can be split up based on the depth and velocity requirements for each life stage of the Silvery Minnow.



RAS MAPPER+ARCMAP