A SURFACE WATER MODEL OF THE MIAMI RIVER

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- HEC-RAS
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- Model's Assumptions
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BACKGROUND

Miami River:

- Estuary
- Navigation and storm drainage relief
- 5.5 miles long
- Tamiami Canal
- Comfort Canal

PROJECT OBJECTIVE

- Predict surface profiles
  - Average flow conditions from 1986 to 1999
  - HEC-RAS
- Hydrologic Engineering Center River Analysis Software
- One-dimensional steady flow analysis

HEC-RAS

- Applicable to steady gradually varied flow
  - Natural channels
  - Constructed channels
- Supercritical, subcritical, and mixed flow regimes
- Energy or Momentum equations

HEC-RAS (Cont.)

Software limitations:

1. Flow must be steady
2. Flow must be gradually varied
3. Flow must be one-dimensional
4. River/channel must have small slopes
5. Channel must have a fixed bed
6. Energy losses must be definable by the energy head loss equation

ENERGY EQUATION

Standard Step Method

$$Y_2 + Z_2 + \left({\alpha_2 V_2^2} \middle/ {2g} \right) = Y_1 + Z_1 + \left({\alpha_1 V_1^2} \middle/ {2g} \right) + h_e$$

$$h_e = L S_f + C \left| {\alpha_2 V_2^2} \middle/ {2g} - {\alpha_1 V_1^2} \middle/ {2g} \right|$$

$$S_f = (Q / K)^2$$

CRITICAL DEPTH

Calculated:

1. Supercritical flow regime

2. Requested by the user

3. User entered boundary condition

CRITICAL DEPTH (Cont.)

4. Flow regime identification

5. Program cannot balance the energy equation

CRITICAL DEPTH (Cont.)

Found through iterations of the total energy equation:

$$H = WS + \alpha V^2 / 2g$$

MOMENTUM EQUATION

Applicable when:

- Water surface at critical depth
- Rapidly varying flow

HEC-RAS applies the momentum equation for the following:

- Hydraulic jumps
- Stream junctions
- Flow obstructions

STREAM JUNCTIONS

- Analyzed by HEC-RAS using energy or momentum equations
- Cross sections placed close to the stream junction
- Cross sections perpendicular to the flow before and after the junction

STREAM JUNCTIONS

- Momentum vs. Energy
- Six different possible flow conditions
- Flow combining, subcritical flow

STREAM JUNCTIONS

Energy equation at a stream junction

$$WS_0 + \frac{\alpha_0 V_0^2}{2g} = WS_1 + \frac{\alpha_1 V_1^2}{2g} + L_{0,1} S_{f\,0,1} + C \left| \frac{\alpha_1 V_1^2}{2g} - \frac{\alpha_0 V_0^2}{2g} \right|$$

Momentum equation at a stream junction

$$SF_0 = SF_1 \cos\theta_1 - F_{f\,1,0} + W_{x1,0} + SF_2 \cos\theta_2 - F_{f\,2,1} + W_{x2,1}$$

STREAM JUNCTIONS (Cont.)

Friction force equation at a stream junction

$$F_{f\,0,1} = S_{f\,0,1}\frac{L_{0,1}}{2}A_0\cos\theta_1 + S_{f\,0,1}\frac{L_{0,1}}{2}A_1\frac{Q_1}{Q_0}$$

Weight force equation at a stream junction

$$W_{x0,1} = S_{o0,1}\frac{L_{0,1}}{2}A_0\cos\theta_1 + S_{o1,0}\frac{L_{0,1}}{2}A_1\frac{Q_1}{Q_0}$$

MODEL ASSUMPTIONS

Data	Assumption
• **Average flow data**	• No tidal flow contributions
• Cross sectional data	• Five foot freeboard for the river

MODEL ASSUMPTIONS

MODEL ASSUMPTIONS

Data

- No cross sections for the South Fork

Assumption

- Comfort connects directly to the River

MODEL ASSUMPTIONS (Cont.)

Data	Assumption
• No cross sections for areas with marinas	• River does not have any marinas

MODEL ASSUMPTIONS (Cont.)

Data

- No cross sections for bridge crossings

Assumption

- River does not have any bridges

MODEL ASSUMPTIONS

MODEL ASSUMPTIONS (Cont.)

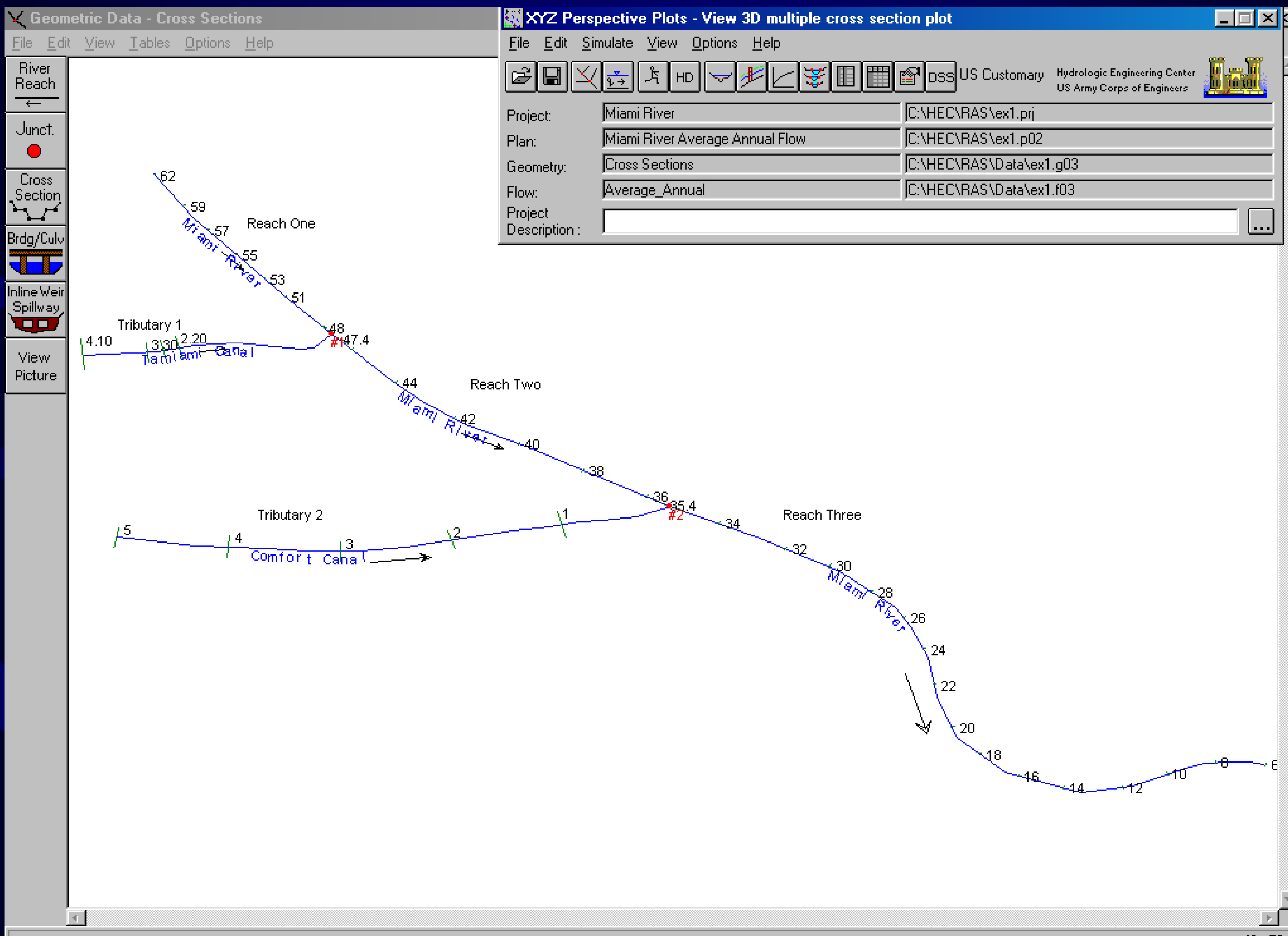
Assumption

- Manning's value of 0.07

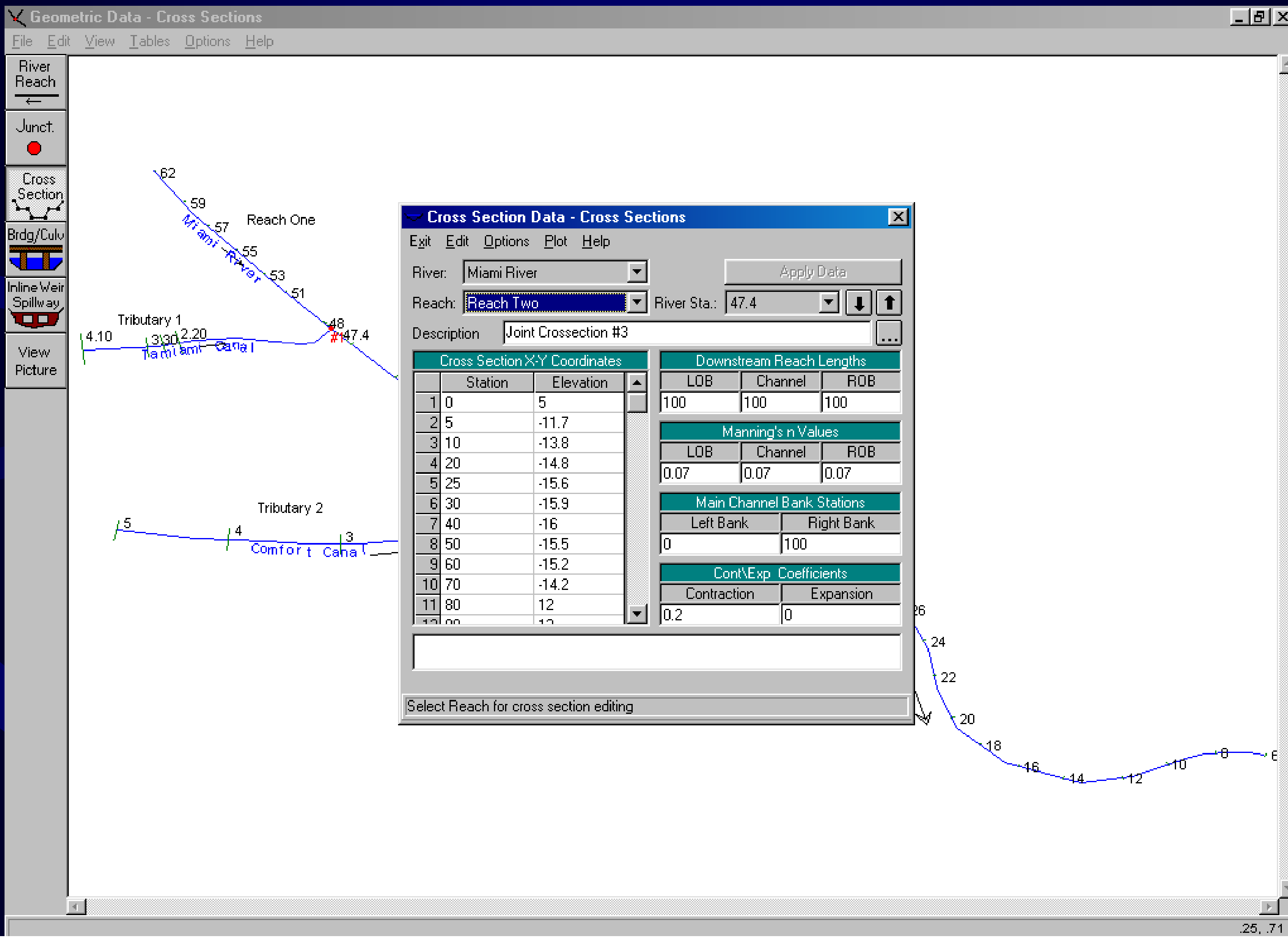
MODEL ASSUMPTIONS (Cont.)

- River's flow = S-26 + S25B + S25
  - Drainage basins were not considered
- Assumed water surface elevation at last cross section: -0.6 ft NGVD

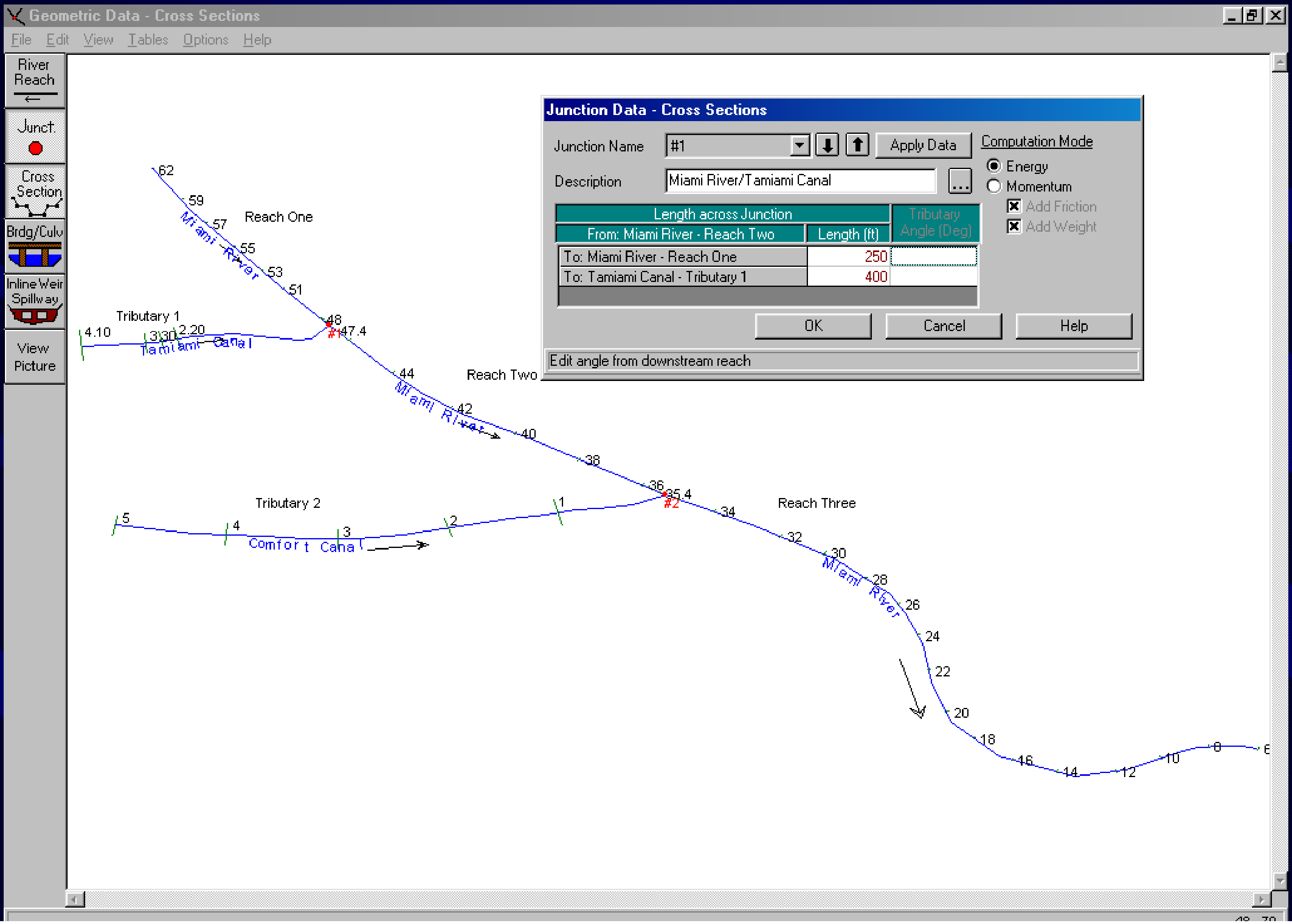
METHODOLOGY



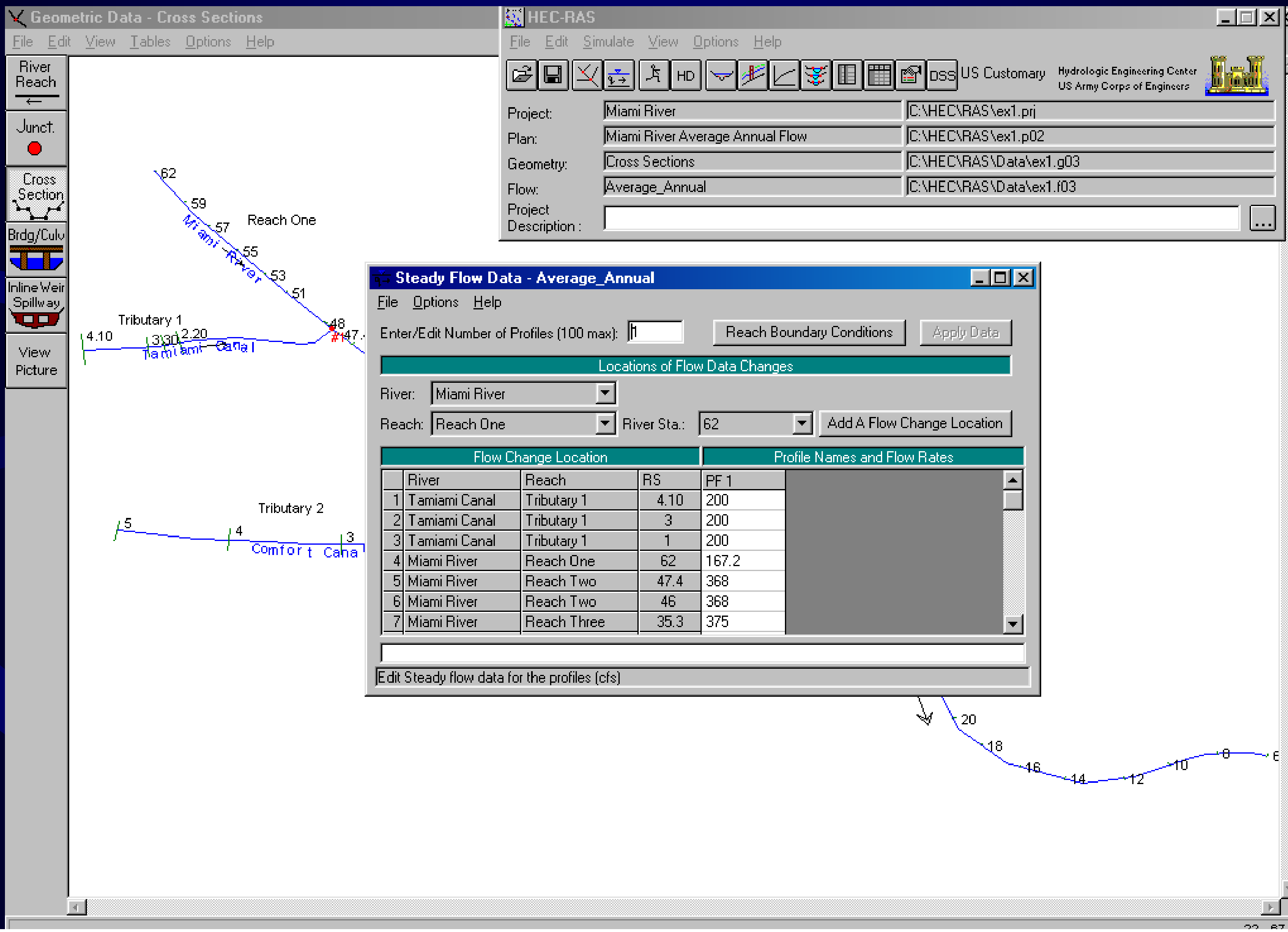
METHODOLOGY



METHODOLOGY



METHODOLOGY (Cont.)



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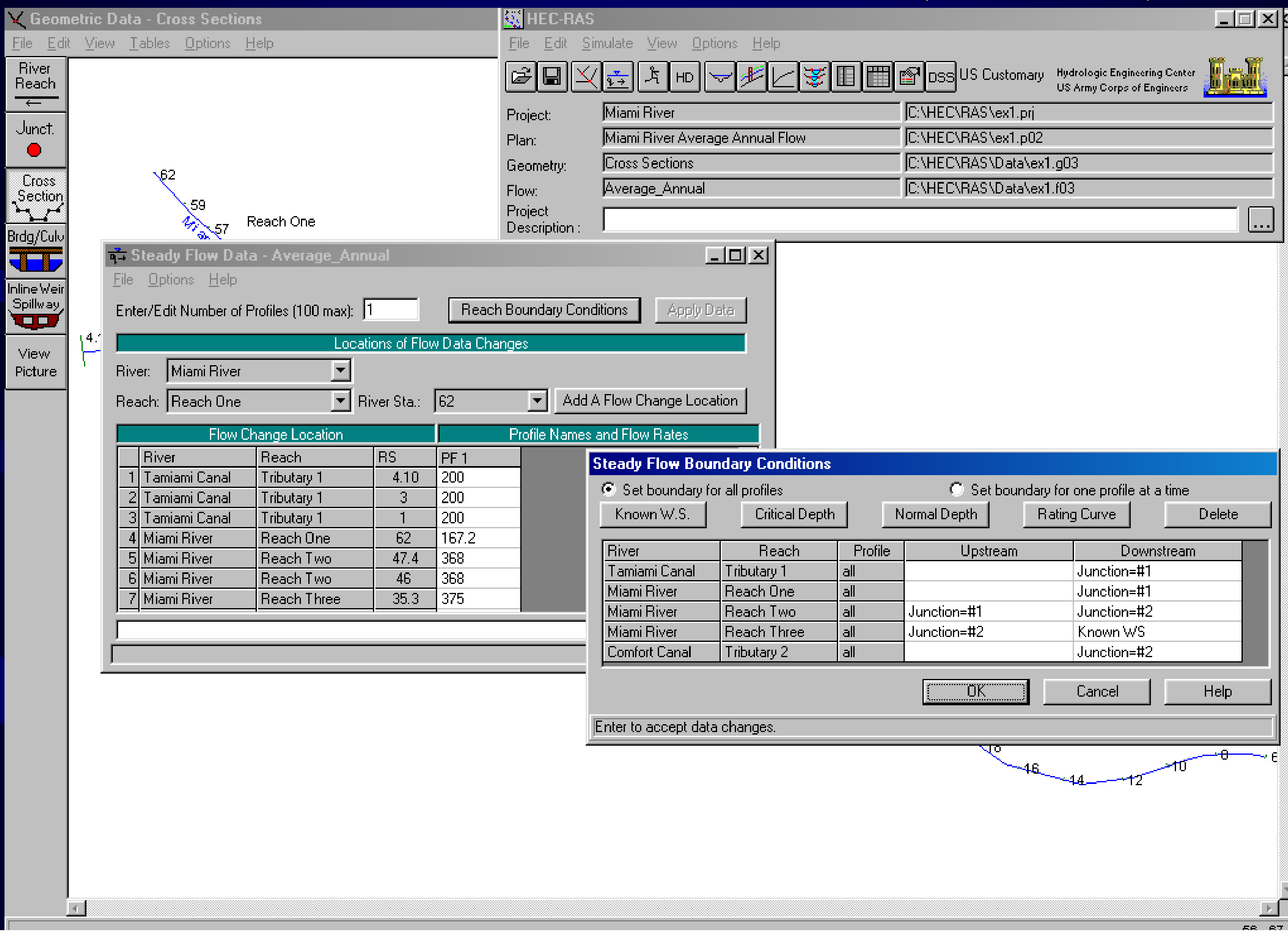

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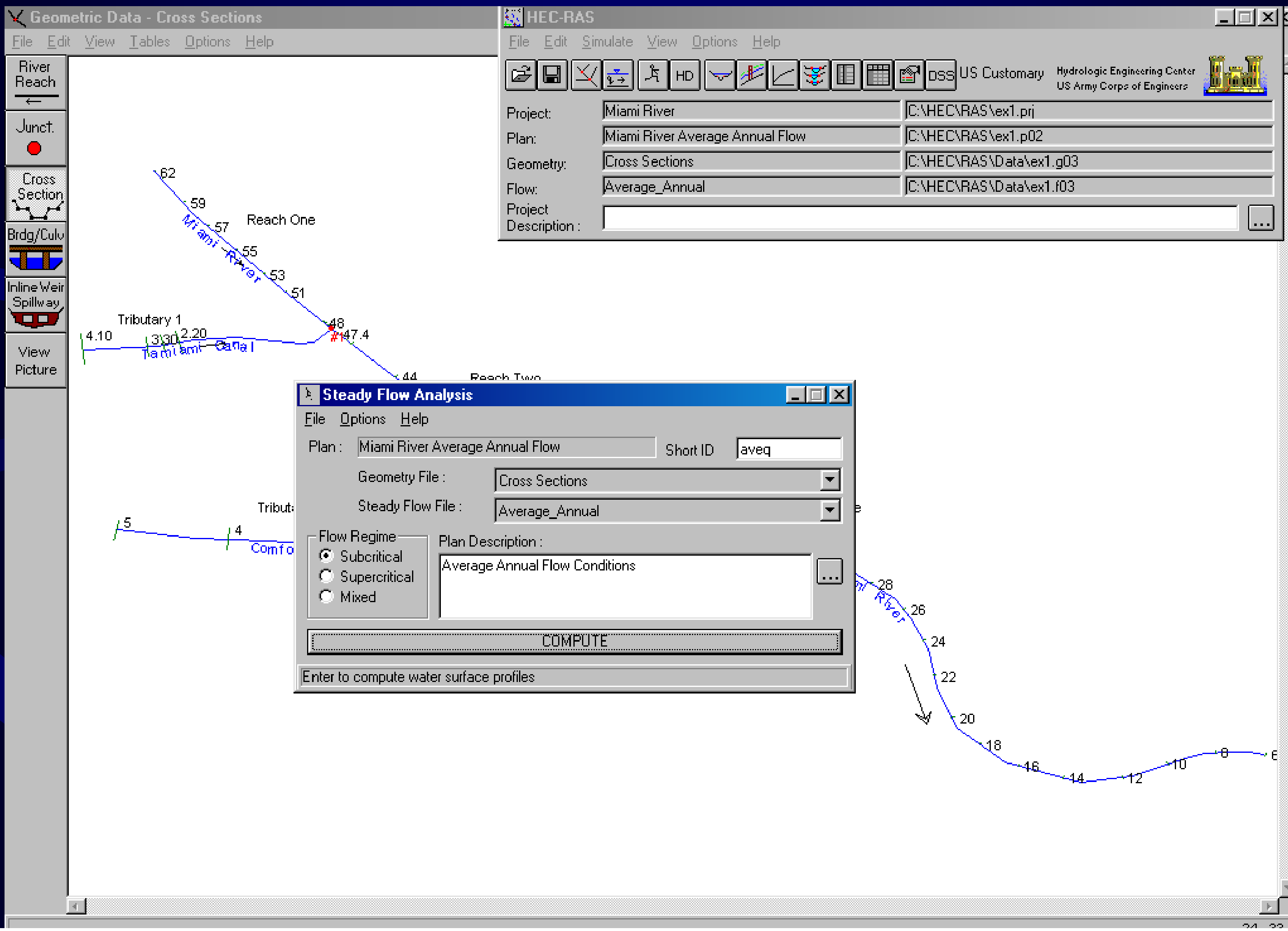


MODEL'S RESULTS

Tabular Results

Profile Output Table - Standard Table 1

File Options Std. Tables Help

HEC-RAS Plan: aveq

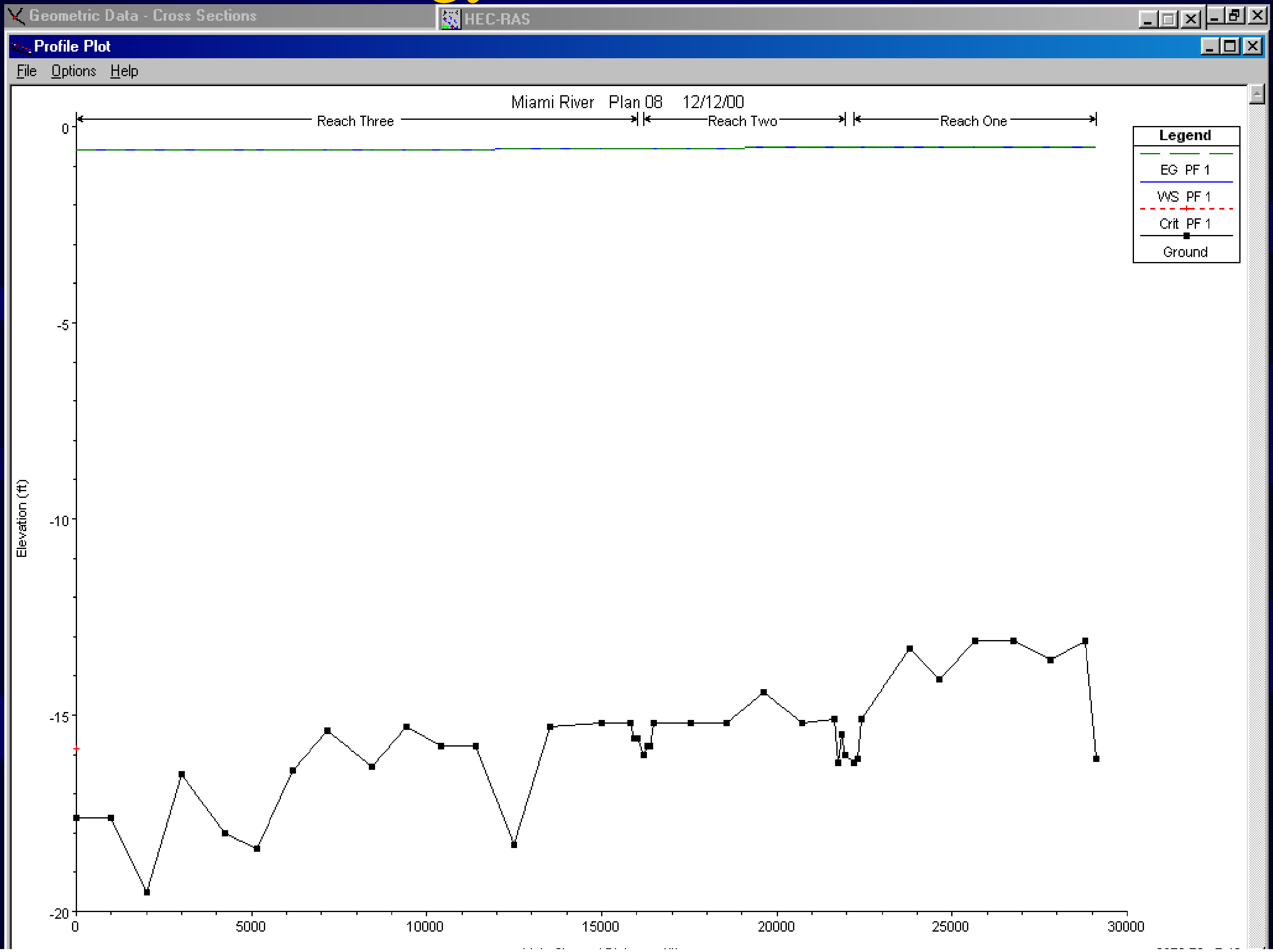
Reload Data

Reach	River Sta	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
Reach One	62	168.00	-16.10	-0.51		-0.51	0.000002	0.15	1129.34	107.10	0.01
Reach One	61	168.00	-13.10	-0.51		-0.51	0.000004	0.18	956.30	100.92	0.01
Reach One	59	168.00	-13.60	-0.51		-0.51	0.000002	0.12	1395.63	155.58	0.01
Reach One	57	168.00	-13.10	-0.52		-0.51	0.000005	0.17	1005.95	136.15	0.01
Reach One	55	168.00	-13.10	-0.52		-0.52	0.000003	0.14	1198.84	145.72	0.01
Reach One	53	168.00	-14.10	-0.52		-0.52	0.000001	0.12	1409.33	120.32	0.01
Reach One	51	168.00	-13.30	-0.52		-0.52	0.000002	0.14	1193.12	112.52	0.01
Reach One	48	168.00	-15.10	-0.52		-0.52	0.000001	0.09	1897.05	149.38	0.00
Reach One	47.5	168.00	-16.10	-0.52		-0.52	0.000001	0.13	1309.52	96.47	0.01
Reach One	47.4	168.00	-16.20	-0.52		-0.52	0.000002	0.13	1285.80	96.11	0.01
Reach Two	47.4	368.00	-16.00	-0.53		-0.53	0.000013	0.37	999.06	73.56	0.02
Reach Two	47.3	368.00	-15.50	-0.53		-0.53	0.000008	0.29	1249.15	95.50	0.01
Reach Two	47.2	368.00	-16.20	-0.53		-0.53	0.000009	0.31	1187.19	94.91	0.02
Reach Two	46	368.00	-15.10	-0.53		-0.53	0.000005	0.22	1641.41	148.39	0.01
Reach Two	44	368.00	-15.20	-0.53		-0.53	0.000005	0.23	1596.69	129.86	0.01
Reach Two	42	368.00	-14.40	-0.54		-0.54	0.000005	0.23	1603.35	136.89	0.01
Reach Two	40	368.00	-15.20	-0.54		-0.54	0.000004	0.21	1789.61	166.80	0.01
Reach Two	38	368.00	-15.20	-0.55		-0.55	0.000004	0.21	1745.92	159.54	0.01
Reach Two	36	368.00	-15.20	-0.55		-0.55	0.000004	0.21	1786.70	172.74	0.01
Reach Two	35.6	368.00	-15.80	-0.55		-0.55	0.000008	0.29	1276.27	100.29	0.01
Reach Two	35.5	368.00	-15.80	-0.55		-0.55	0.000008	0.29	1276.19	100.29	0.01
Reach Two	35.4	368.00	-16.00	-0.56		-0.55	0.000007	0.26	1392.04	120.02	0.01
Reach Three	35.3	375.00	-15.60	-0.56		-0.56	0.000006	0.25	1483.15	120.13	0.01
Reach Three	35.2	375.00	-15.60	-0.56		-0.56	0.000006	0.25	1486.55	120.23	0.01
Reach Three	35.1	375.00	-15.20	-0.56		-0.56	0.000010	0.30	1264.33	119.74	0.02
Reach Three	34	375.00	-15.20	-0.56		-0.56	0.000003	0.17	2147.40	209.60	0.01
Reach Three	32	375.00	-15.30	-0.57		-0.57	0.000003	0.16	2394.40	263.29	0.01
Reach Three	30	375.00	-18.30	-0.57		-0.57	0.000003	0.15	2524.77	277.98	0.01
Reach Three	28	375.00	-15.80	-0.57		-0.57	0.000003	0.18	2126.22	181.70	0.01
Reach Three	26	375.00	-15.80	-0.58		-0.58	0.000003	0.18	2114.47	184.31	0.01
Reach Three	24	375.00	-15.30	-0.58		-0.58	0.000004	0.20	1872.35	163.71	0.01
Reach Three	22	375.00	-16.30	-0.58		-0.58	0.000003	0.18	2074.38	167.58	0.01
Reach Three	20	375.00	-15.40	-0.59		-0.59	0.000003	0.18	2033.53	171.94	0.01
Reach Three	18	375.00	-16.40	-0.59		-0.59	0.000004	0.20	1883.12	165.21	0.01
Reach Three	16	375.00	-18.40	-0.59		-0.59	0.000002	0.15	2501.90	188.08	0.01
Reach Three	14	375.00	-18.00	-0.59		-0.59	0.000002	0.17	2252.10	189.97	0.01
Reach Three	12	375.00	-16.50	-0.60		-0.60	0.000001	0.14	2764.43	206.94	0.01
Reach Three	10	375.00	-19.50	-0.60		-0.60	0.000001	0.11	3425.18	237.35	0.01

Total flow in cross section.

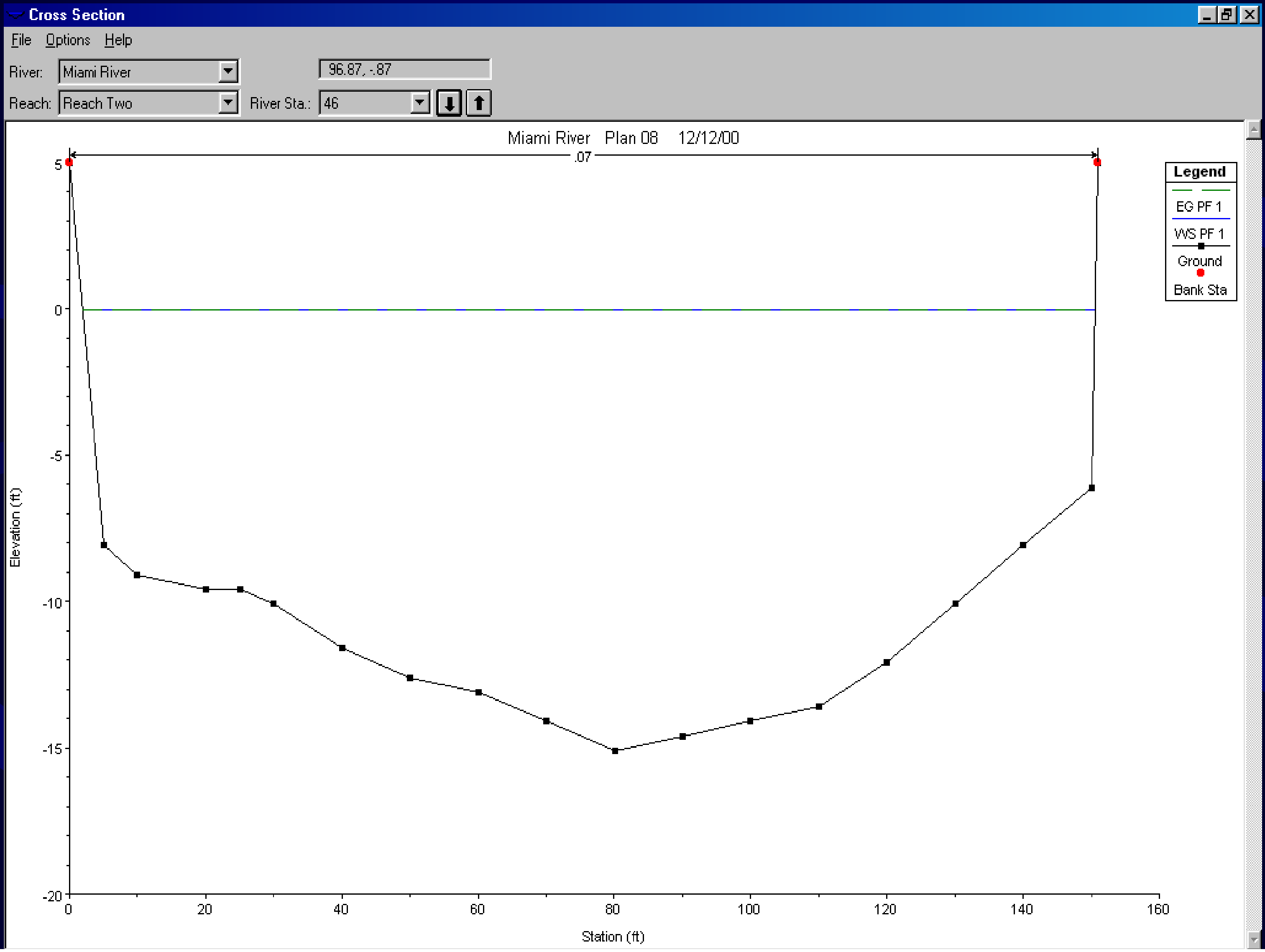
MODEL'S RESULTS (Cont.)

Energy Method Results



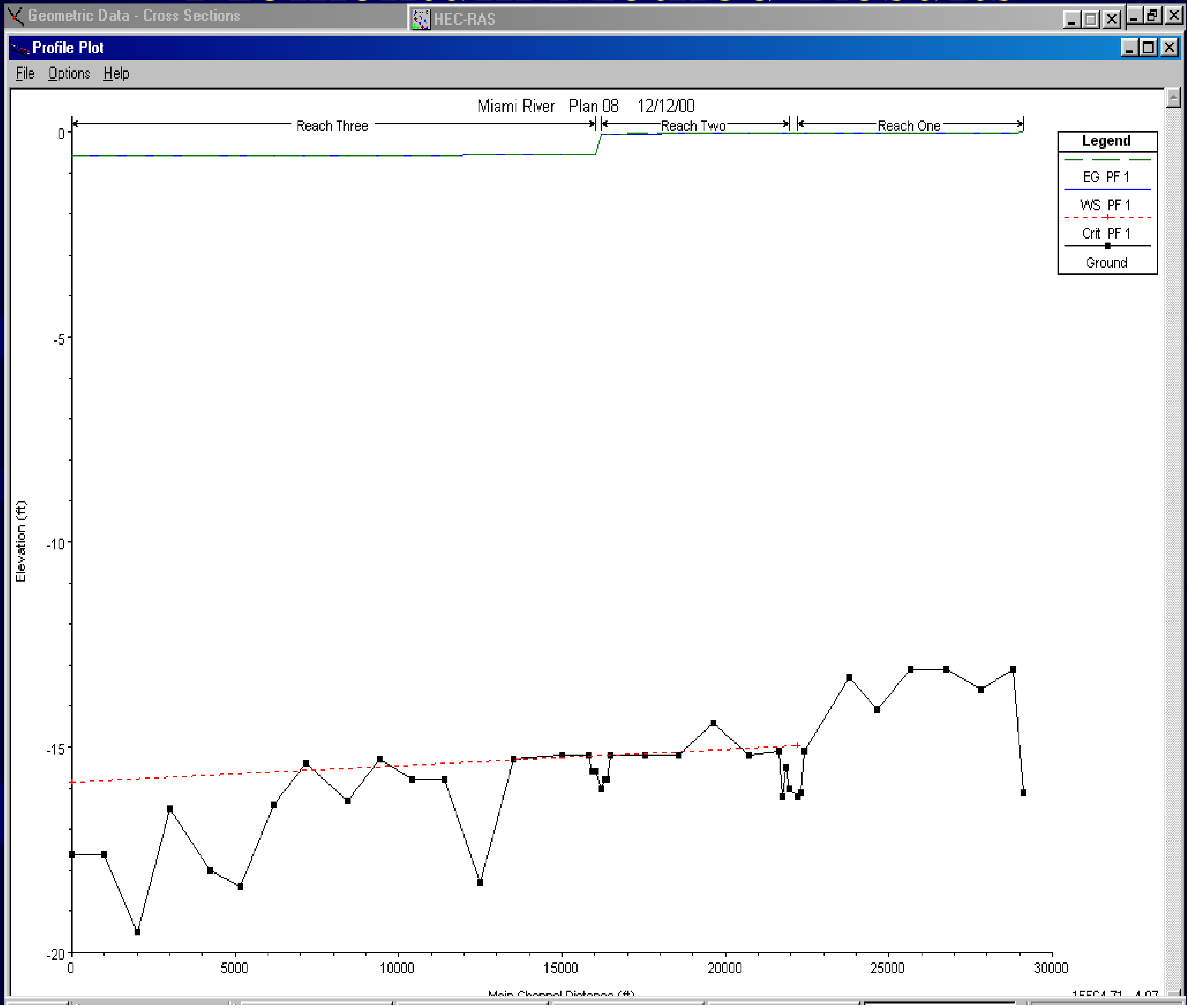
MODEL'S RESULTS (Cont.)

Energy Method Results



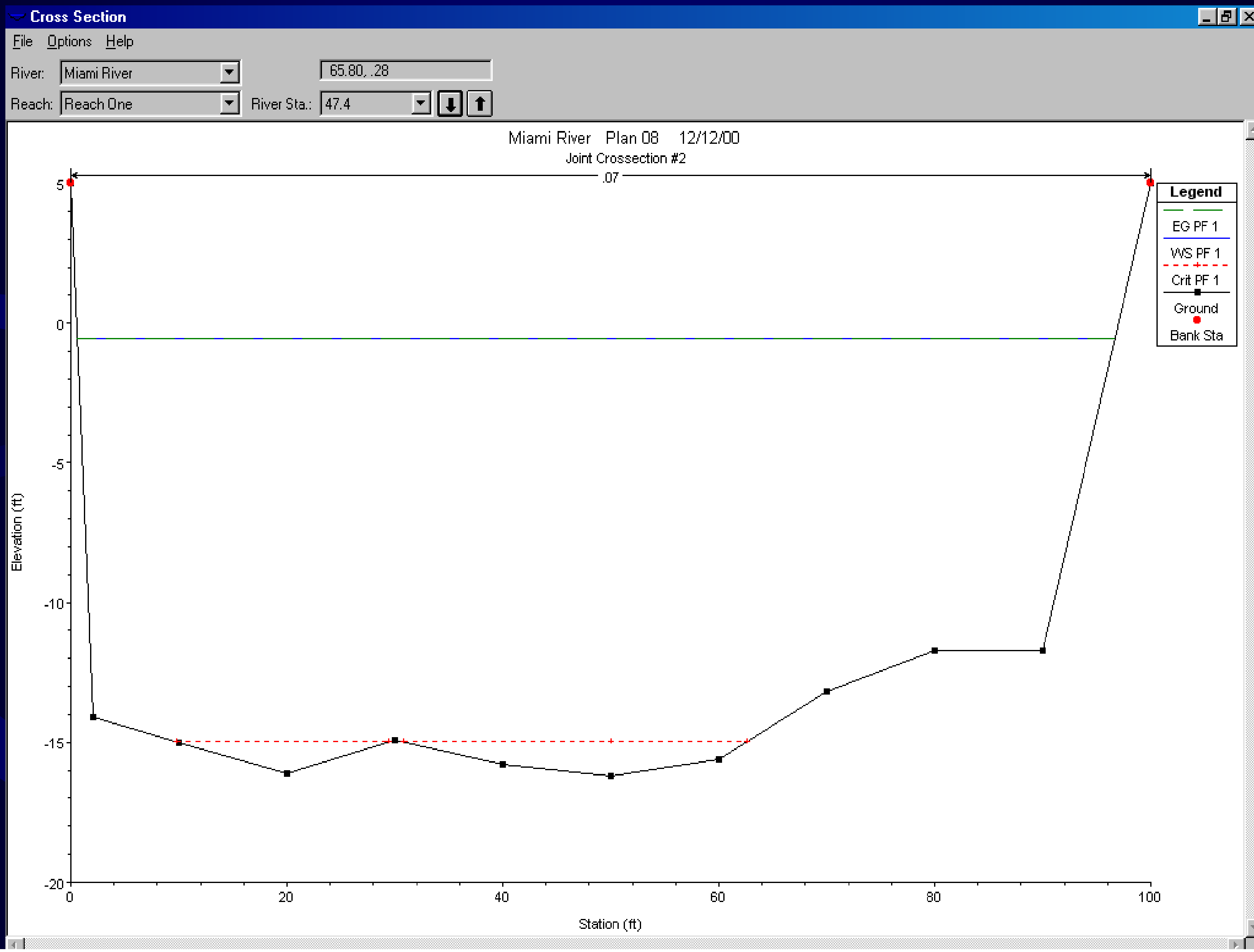
MODEL'S RESULTS (Cont.)

Momentum Method Results



MODEL'S RESULTS

Momentum Method Results

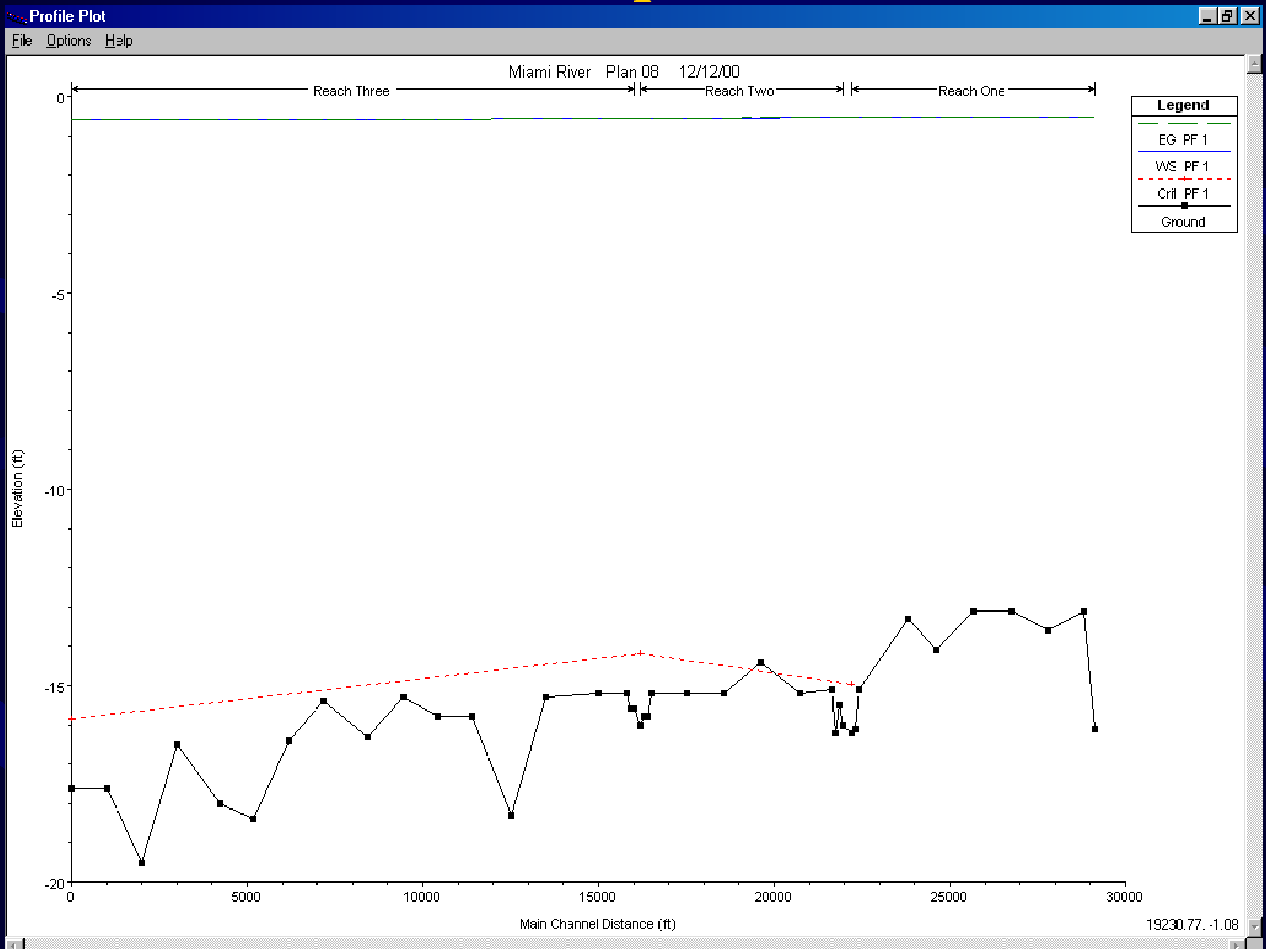


MODEL'S RESULTS (Cont.)

- Test cross section added downstream of Comfort
- Steady flow analysis was performed

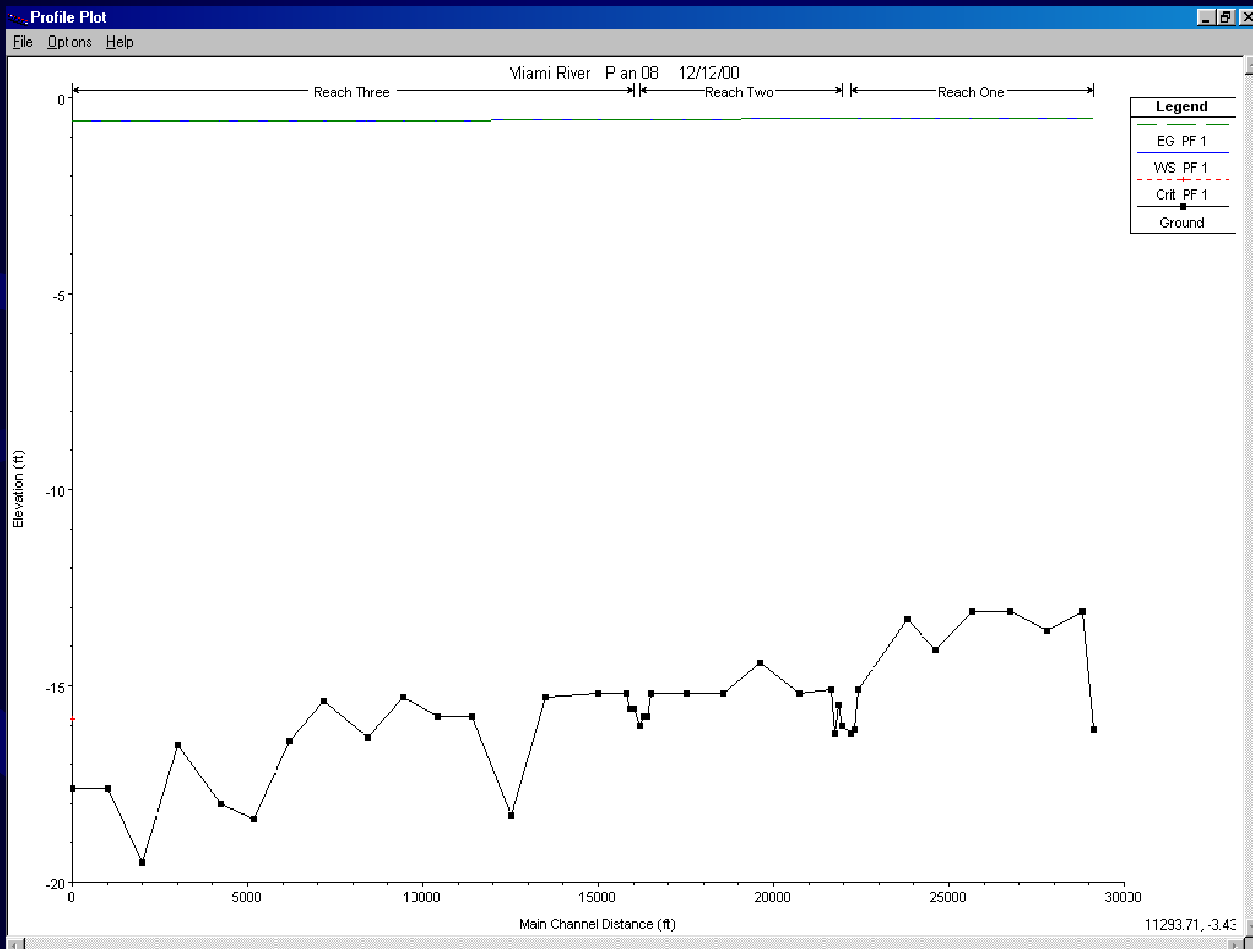
MODEL'S RESULTS (Cont.)

Momentum Equation Results



MODEL'S RESULTS (Cont.)

Energy Equation Results



CONCLUSION

- Results obtained were expected
- Reach Three similar to the mean low water elevations
- Depth, slope, and bed roughness changed by sediments

RECOMMENDATIONS

- Match model to existing conditions
  - Flow data and corresponding water surface elevations
  - Sensitivity analysis
- Inclusion of the flow from drainage basins

RECOMMENDATIONS (Cont.)

- More recent cross sectional data
  - Marinas and bridges
- Operation of control structures S-26, S-25, and S-25B

REFERENCES

Fernandez, Nahum D. *A Basic Study on the Hydraulics of the Miami River, Miami-Dade County , Florida.* Miami: Florida International University, August 2000.

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US Army Corps of Engineers. *HEC-RAS River Analysis System: User Manual, Version 2.2.* Davis: US Army Corps of Engineers, September 1998.

US Army Corps of Engineers. *HEC-RAS River Analysis System: Hydraulic Reference Manual, Version 2.2.* Davis: US Army Corps of Engineers, August 1998.

THE END

ANY QUESTIONS?