# CALIBRATING A HEC-RAS MODEL
# OF THE
# MISSOURI RIVER
# FOR
# FEMA FLOODWAY DEVELOPMENT

## AN ALTENATIVE METHOD

# OUTLINE

1. General scope of the project

2. Available Data

3. Challenges

4. Streamlined approach

5. Techniques

6. Results to date.

7. Outstanding issues.

# SCOPE OF THE PROJECT

The Kansas City and Omaha Districts are working with FEMA Region VII to Compute a floodway for the Missouri River from Mile 811 to the mouth.

The Kansas City District is responsible for the reach from Mile 498 to the Mouth

- Modeling is based on the Upper Mississippi River System Flow Frequency Study (UMRSFFS) one percent probability flood profile.
- Geometry data from the UMRSFFS UNET model was used to build a RAS model for the River
- The RAS model is being calibrated to the UMRSFFS Profile.

# DELIVERABLES TO FEMA

- Existing Conditions RAS Model
- HEC-RAS data set
- Geo-referenced project files
- RAS floodway runs
- Profile Plots
- Data must meet DFIRM Data Capture Standards

# AVAILABLE DATA

- UMRSFFS geometry files, flow data and profiles
- A digital terrain model from bluff to bluff
- A rough RAS geometry file based on the UMRSFFS work

# CHALLENGES

Refining cross sections for 498 miles of river

Calibrating to within one half foot of the UNET profile which was the basis of the UMRSFFS model

Coordination between NWO, NWK and FEMA

Today we focus on the second challenge – Calibration of 498 miles of river

# TECHNICAL APPROACH

Dr. Robert Barkau developed a program in Visual Basic to streamline calibration

Output files from the Visual Basic program feed directly into the RAS model

# Input Geometry

The original UMRSFFS simulations were performed in UNET.

UNET geometry was imported into RAS.

Therefore, calibration can be run from UNET geometry.

EXCEL algorithm utilizes UNET property tables.

# Very Fast Excel Backwater Algorithm

For calibration, about 30 times faster than RAS.

Missouri River from Rulo to St. Charles can be calibrated in less than a day.

Produces results in close agreement with RAS.

Calibrated “n” values can be imported into RAS.

# Calibration on One Screen

- The target profile, calibrated profile and departure between the two are visible on one screen
- Only one key stroke is required to re-run the simulation and view the changes to the profile
- Can complete a new run in 5 to 10 seconds

# A major technical consideration
# The Missouri River Reclaims its Overbank During the 1% Flood

Missouri River agricultural levees provide protection up to approximately the 25 year event.

During larger events, the levees overtop and degrade and the Missouri River reclaims the floodplain.

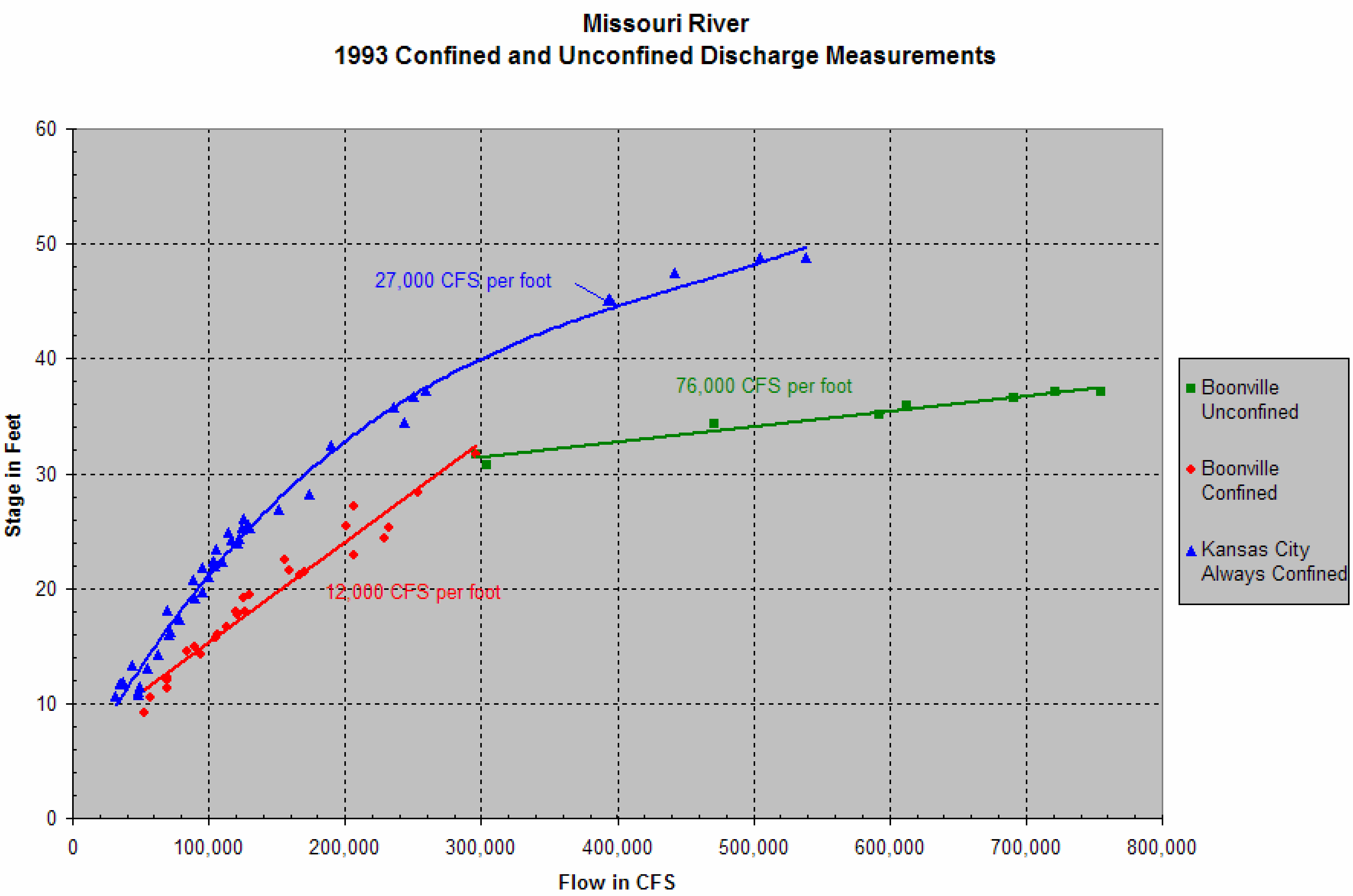
Observed at Rulo, St. Joseph, Waverly, Boonville, and Hermann by USGS flow measurements and the destruction of the floodplain during the 1993 flood.

# Calibration Strategy

The UNET simulation assumed that, after levee failures, the Missouri River overbank conveyed water from bluff to bluff.

Therefore, RAS calibration assumed that Missouri River conveyed water from bluff to bluff.

# 1993 Flood at Boonville



Missouri River
1993 Confined and Unconfined Discharge Measurements
Stage in Feet
Flow in CFS
0
10
20
30
40
50
60
0
100,000
200,000
300,000
400,000
500,000
600,000
700,000
800,000
27,000 CFS per foot
76,000 CFS per foot
12,000 CFS per foot
Boonville Unconfined
Boonville Confined
Kansas City Always Confined

The Visual Basic model uses the energy equation to compute stage in a similar way as does HEC-RAS.

# Energy Equation

$$Z_1 = Z_2 + \left(\frac{\alpha_2 V_2^2}{2g}\right) + S_f \, \Delta x_E + c \left|\frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g}\right| - \left(\frac{\alpha_1 V_1^2}{2g}\right)$$

Where:

$\alpha$ = the Velocity Distribution Coefficient,

and

$\Delta x_E$ = Conveyance Weighted Travel Distance of the Flow

# These two factors distort the energy equation

$$\alpha = \frac{A_{LOB}\left(\frac{K_{LOB}}{A_{LOB}}\right)^3 + A_{Ch}\left(\frac{K_{Ch}}{A_{Ch}}\right)^3 + A_{ROB}\left(\frac{K_{ROB}}{A_{ROB}}\right)^3}{A\left(\frac{K}{A}\right)^3}$$

$$\Delta x_E = \frac{K_{LOB}\,\Delta x_{LOB} + K_{Ch}\,\Delta x_{Ch} + K_{ROB}\,\Delta x_{ROB}}{K}$$

# Conveyance Factors

$$F_{Ch} = \frac{K_{Ch\ New}}{K_{Ch\ Old}}$$

$$F_V = \frac{K_{OB\ New}}{K_{OB\ Old}}$$

Microsoft Excel - Backwater3.xls

J24 = -0.3414306640625

| | Index | River Mile | Flow | Elevation | Channel Factor | Overbank Factor | Iterations | Error | 100 Year Profile | Error | Channel "n" | Overbank "n" | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 12 | 138.62 | 586000 | 553.98 | 1.500 | 1.100 | 2 | 0.000 | 553.72 | 0.26 | 0.020 | 0.073 | 9361 | 0.000 | 0.073 |
| 14 | 13 | 138.10 | 591000 | 553.82 | 1.500 | 1.100 | 2 | 0.000 | 553.57 | 0.25 | 0.020 | 0.073 | 9229 | 0.000 | 0.073 |
| 15 | 14 | 137.24 | 591000 | 553.26 | 1.500 | 1.100 | 2 | 0.000 | 552.99 | 0.27 | 0.020 | 0.072 | 11512 | 0.000 | 0.073 |
| 16 | 15 | 136.61 | 591000 | 553.03 | 1.100 | 1.100 | 2 | 0.000 | 552.79 | 0.23 | 0.027 | 0.073 | 9732 | 0.000 | 0.073 |
| 17 | 16 | 136.10 | 591000 | 552.47 | 1.100 | 0.900 | 1 | -0.003 | 552.67 | -0.20 | 0.027 | 0.089 | 9462 | 0.000 | 0.089 |
| 18 | 17 | 135.61 | 591000 | 552.02 | 1.100 | 0.900 | 2 | 0.000 | 552.09 | -0.07 | 0.027 | 0.089 | 9697 | 0.000 | 0.089 |
| 19 | 18 | 134.89 | 591000 | 551.24 | 1.100 | 0.900 | 2 | 0.000 | 551.34 | -0.09 | 0.027 | 0.088 | 9973 | 0.000 | 0.089 |
| 20 | 19 | 134.25 | 591000 | 551.14 | 1.100 | 0.900 | 2 | 0.000 | 551.02 | 0.12 | 0.027 | 0.088 | 14069 | 0.000 | 0.089 |
| 21 | 20 | 133.66 | 591000 | 550.87 | 1.100 | 0.900 | 2 | 0.000 | 550.65 | 0.22 | 0.027 | 0.087 | 13501 | 0.000 | 0.089 |
| 22 | 21 | 133.12 | 591000 | 550.22 | 1.000 | 0.900 | 2 | 0.000 | 550.38 | -0.16 | 0.030 | 0.086 | 13251 | 0.000 | 0.089 |
| 23 | 22 | 132.47 | 591000 | 549.62 | 1.000 | 0.900 | 2 | 0.000 | 549.84 | -0.23 | 0.030 | 0.083 | 12583 | 0.000 | 0.089 |
| 24 | 23 | 131.84 | 591000 | 548.89 | 1.000 | 0.900 | 2 | 0.000 | 549.23 | -0.34 | 0.030 | 0.073 | 11212 | 0.000 | 0.089 |
| 25 | 24 | 131.19 | 591000 | 548.30 | 1.000 | 0.900 | 2 | 0.000 | 548.58 | -0.28 | 0.030 | 0.081 | 10744 | 0.000 | 0.089 |
| 26 | 25 | 130.37 | 591000 | 547.78 | 1.000 | 0.900 | 2 | 0.000 | 547.75 | 0.03 | 0.030 | 0.074 | 10979 | 0.000 | 0.089 |
| 27 | 26 | 129.90 | 665000 | 546.96 | 1.100 | 0.900 | 2 | 0.000 | 547.01 | -0.05 | 0.027 | 0.089 | 10073 | 0.000 | 0.089 |
| 28 | 27 | 129.29 | 665000 | 546.05 | 1.100 | 0.900 | 1 | 0.003 | 546.13 | -0.07 | 0.027 | 0.089 | 10236 | 0.000 | 0.089 |
| 29 | 28 | 128.76 | 665000 | 545.49 | 1.100 | 0.900 | 1 | -0.005 | 545.49 | -0.01 | 0.028 | 0.089 | 11055 | 0.000 | 0.089 |
| 30 | 29 | 127.98 | 665000 | 544.78 | 1.150 | 1.000 | 2 | 0.000 | 544.60 | 0.18 | 0.026 | 0.080 | 9918 | 0.000 | 0.080 |
| 31 | 30 | 127.37 | 665000 | 544.38 | 1.150 | 1.000 | 2 | 0.000 | 544.21 | 0.17 | 0.026 | 0.080 | 10138 | 0.000 | 0.080 |
| 32 | 31 | 126.83 | 665000 | 543.94 | 1.200 | 1.000 | 2 | 0.000 | 543.63 | 0.30 | 0.025 | 0.080 | 12492 | 0.000 | 0.080 |
| 33 | 32 | 126.04 | 665000 | 543.48 | 1.200 | 1.000 | 1 | 0.005 | 543.31 | 0.17 | 0.025 | 0.080 | 9789 | 0.000 | 0.080 |
| 34 | 33 | 125.12 | 665000 | 542.97 | 1.150 | 1.000 | 2 | 0.000 | 542.86 | 0.11 | 0.026 | 0.079 | 9209 | 0.000 | 0.080 |
| 35 | 34 | 124.47 | 665000 | 542.11 | 1.150 | 1.000 | 2 | 0.000 | 541.98 | 0.13 | 0.026 | 0.080 | 10862 | 0.000 | 0.080 |
| 36 | 35 | 123.84 | 665000 | 541.64 | 1.100 | 1.000 | 1 | -0.003 | 541.69 | -0.04 | 0.027 | 0.080 | 9293 | 0.000 | 0.080 |
| 37 | 36 | 122.97 | 665000 | 540.93 | 1.100 | 0.900 | 0 | -0.004 | 540.98 | -0.05 | 0.027 | 0.089 | 10315 | 0.000 | 0.089 |
| 38 | 37 | 122.09 | 665000 | 540.30 | 1.100 | 0.900 | 2 | 0.000 | 540.28 | 0.01 | 0.027 | 0.089 | 12271 | 0.000 | 0.089 |
| 39 | 38 | 121.46 | 665000 | 539.82 | 1.100 | 0.900 | 2 | 0.000 | 539.82 | 0.00 | 0.027 | 0.089 | 11057 | 0.000 | 0.089 |
| 40 | 39 | 120.56 | 666000 | 538.85 | 1.100 | 0.900 | 2 | 0.000 | 539.05 | -0.20 | 0.028 | 0.089 | 11608 | 0.000 | 0.089 |
| 41 | 40 | 119.93 | 666000 | 538.19 | 1.100 | 0.900 | 2 | 0.000 | 538.16 | 0.03 | 0.027 | 0.089 | 12670 | 0.000 | 0.089 |
| 42 | 41 | 119.25 | 666000 | 537.66 | 1.150 | 0.900 | 2 | 0.000 | 537.65 | 0.01 | 0.026 | 0.089 | 13215 | 0.000 | 0.089 |
| 43 | 42 | 118.58 | 666000 | 537.17 | 1.150 | 0.900 | 2 | 0.000 | 537.09 | 0.08 | 0.026 | 0.089 | 13752 | 0.000 | 0.089 |
| 44 | 43 | 117.70 | 666000 | 536.43 | 1.150 | 0.900 | 2 | 0.000 | 536.26 | 0.17 | 0.026 | 0.085 | 13927 | 0.000 | 0.089 |
| 45 | 44 | 116.95 | 666000 | 535.76 | 1.150 | 0.900 | 2 | 0.000 | 535.44 | 0.31 | 0.026 | 0.085 | 12791 | 0.000 | 0.089 |
| 46 | 45 | 116.02 | 666000 | 534.81 | 1.150 | 0.900 | 2 | 0.000 | 534.78 | 0.03 | 0.026 | 0.088 | 12676 | 0.000 | 0.089 |
| 47 | 46 | 115.39 | 666000 | 534.27 | 1.150 | 0.900 | 2 | 0.000 | 534.36 | -0.09 | 0.026 | 0.089 | 11478 | 0.000 | 0.089 |
| 48 | 47 | 114.96 | 666000 | 534.05 | 1.150 | 0.900 | 2 | 0.000 | 534.10 | -0.05 | 0.026 | 0.089 | 11405 | 0.000 | 0.089 |
| 49 | 48 | 114.45 | 666000 | 533.75 | 1.150 | 0.900 | 2 | 0.000 | 533.80 | -0.05 | 0.026 | 0.089 | 11177 | 0.000 | 0.089 |
| 50 | 49 | 113.65 | 666000 | 532.84 | 1.150 | 0.900 | 2 | 0.000 | 533.08 | -0.24 | 0.026 | 0.089 | 12533 | 0.000 | 0.089 |

RAS and EXCEL Plot / RAS / Profile Details / Check Calib Profile / With Levees Departure Plot (2) / Calib Profile / FFS Elev / DA Plot / FFS Flow

Ready

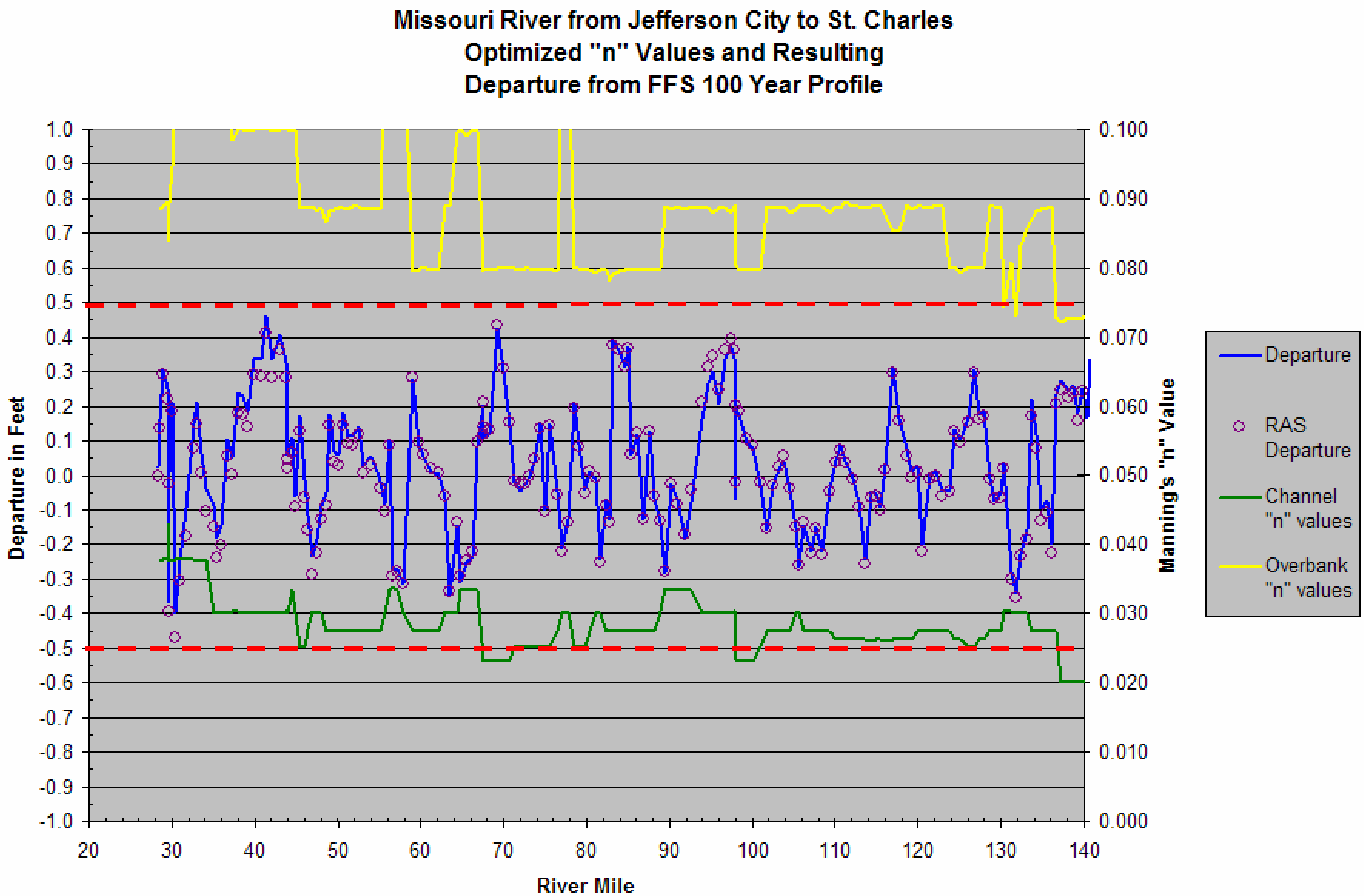
Microsoft Excel - Backwater3.xls

E24 = 0.93

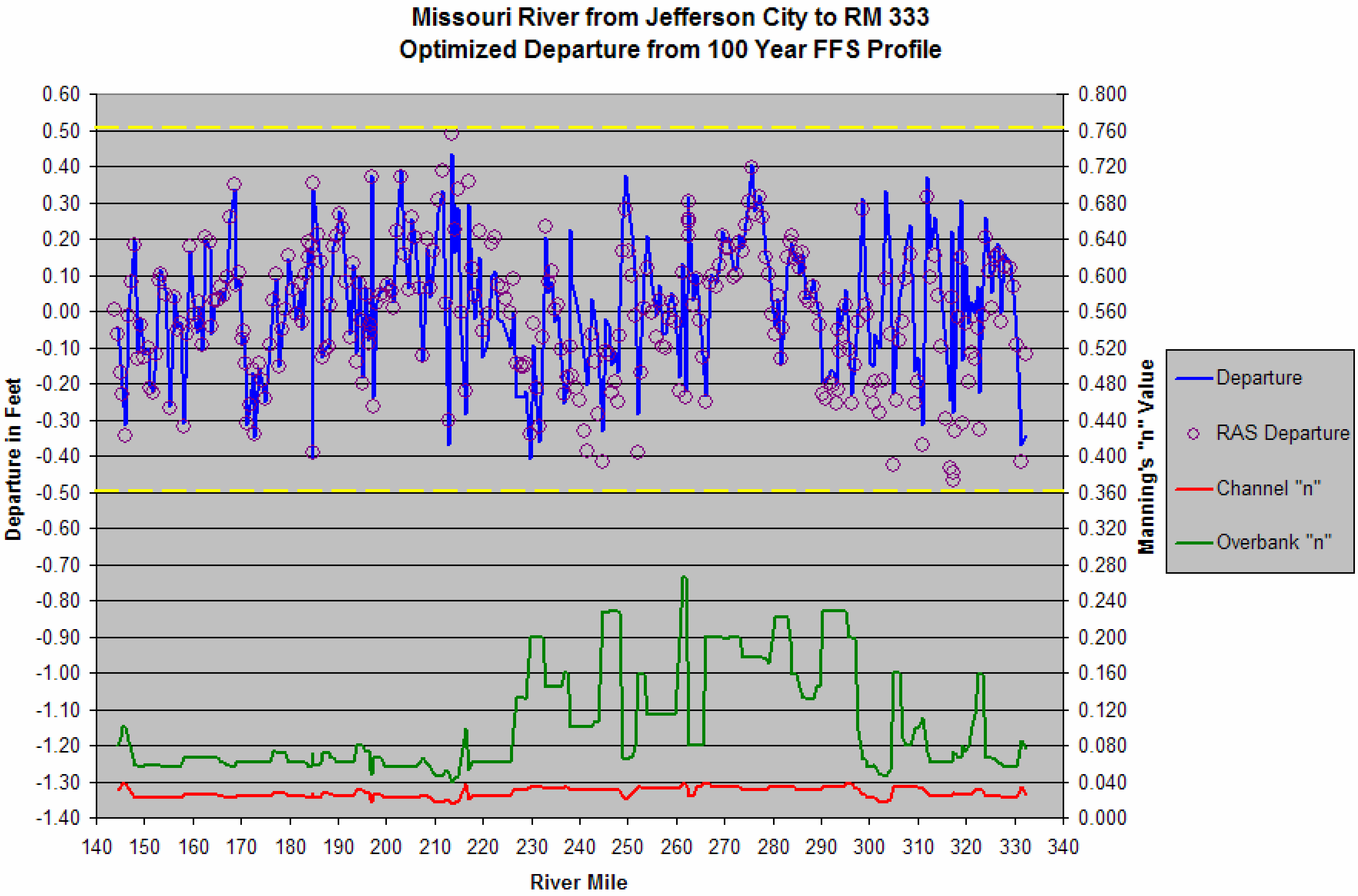
| | Index | River Mile | Flow | Elevation | Channel Factor | Overbank Factor | Iterations | Error | 100 Year Profile | Error | Channel "n" | Overbank "n" | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 12 | 138.62 | 586000 | 554.05 | 1.500 | 1.100 | 2 | 0.000 | 553.72 | 0.32 | 0.020 | 0.073 | 9362 | 0.000 | 0.073 |
| 14 | 13 | 138.10 | 591000 | 553.88 | 1.500 | 1.100 | 2 | 0.000 | 553.57 | 0.31 | 0.020 | 0.073 | 9229 | 0.000 | 0.073 |
| 15 | 14 | 137.24 | 591000 | 553.33 | 1.500 | 1.100 | 2 | 0.000 | 552.99 | 0.34 | 0.020 | 0.072 | 11515 | 0.000 | 0.073 |
| 16 | 15 | 136.61 | 591000 | 553.10 | 1.100 | 1.100 | 2 | 0.000 | 552.79 | 0.31 | 0.027 | 0.073 | 9732 | 0.000 | 0.073 |
| 17 | 16 | 136.10 | 591000 | 552.55 | 1.100 | 0.900 | 1 | -0.002 | 552.67 | -0.12 | 0.027 | 0.089 | 9462 | 0.000 | 0.089 |
| 18 | 17 | 135.61 | 591000 | 552.10 | 1.100 | 0.900 | 2 | 0.000 | 552.09 | 0.01 | 0.027 | 0.089 | 9698 | 0.000 | 0.089 |
| 19 | 18 | 134.89 | 591000 | 551.34 | 1.100 | 0.900 | 2 | 0.000 | 551.34 | 0.00 | 0.027 | 0.088 | 9973 | 0.000 | 0.089 |
| 20 | 19 | 134.25 | 591000 | 551.24 | 1.100 | 0.900 | 2 | 0.000 | 551.02 | 0.21 | 0.027 | 0.088 | 14072 | 0.000 | 0.089 |
| 21 | 20 | 133.66 | 591000 | 550.96 | 1.100 | 0.900 | 2 | 0.000 | 550.65 | 0.32 | 0.027 | 0.087 | 13503 | 0.000 | 0.089 |
| 22 | 21 | 133.12 | 591000 | 550.33 | 1.000 | 0.900 | 2 | 0.000 | 550.38 | -0.05 | 0.030 | 0.086 | 13259 | 0.000 | 0.089 |
| 23 | 22 | 132.47 | 591000 | 549.73 | 1.000 | 0.900 | 2 | 0.000 | 549.84 | -0.11 | 0.030 | 0.083 | 12599 | 0.000 | 0.089 |
| 24 | 23 | 131.84 | 591000 | 549.05 | 0.930 | 0.900 | 2 | 0.000 | 549.23 | -0.19 | 0.032 | 0.073 | 11292 | 0.000 | 0.089 |
| 25 | 24 | 131.19 | 591000 | 548.38 | 0.900 | 0.900 | 2 | 0.000 | 548.58 | -0.20 | 0.034 | 0.081 | 10770 | 0.000 | 0.089 |
| 26 | 25 | 130.37 | 591000 | 547.78 | 1.000 | 0.900 | 2 | 0.000 | 547.75 | 0.03 | 0.030 | 0.074 | 10979 | 0.000 | 0.089 |
| 27 | 26 | 129.90 | 665000 | 546.96 | 1.100 | 0.900 | 2 | 0.000 | 547.01 | -0.05 | 0.027 | 0.089 | 10073 | 0.000 | 0.089 |
| 28 | 27 | 129.29 | 665000 | 546.05 | 1.100 | 0.900 | 1 | 0.003 | 546.13 | -0.07 | 0.027 | 0.089 | 10236 | 0.000 | 0.089 |
| 29 | 28 | 128.76 | 665000 | 545.49 | 1.100 | 0.900 | 1 | -0.005 | 545.49 | -0.01 | 0.028 | 0.089 | 11055 | 0.000 | 0.089 |
| 30 | 29 | 127.98 | 665000 | 544.78 | 1.150 | 1.000 | 2 | 0.000 | 544.60 | 0.18 | 0.026 | 0.080 | 9918 | 0.000 | 0.080 |
| 31 | 30 | 127.37 | 665000 | 544.38 | 1.150 | 1.000 | 2 | 0.000 | 544.21 | 0.17 | 0.026 | 0.080 | 10138 | 0.000 | 0.080 |
| 32 | 31 | 126.83 | 665000 | 543.94 | 1.200 | 1.000 | 2 | 0.000 | 543.63 | 0.30 | 0.025 | 0.080 | 12492 | 0.000 | 0.080 |
| 33 | 32 | 126.04 | 665000 | 543.48 | 1.200 | 1.000 | 1 | 0.005 | 543.31 | 0.17 | 0.025 | 0.080 | 9789 | 0.000 | 0.080 |
| 34 | 33 | 125.12 | 665000 | 542.97 | 1.150 | 1.000 | 2 | 0.000 | 542.86 | 0.11 | 0.026 | 0.079 | 9209 | 0.000 | 0.080 |
| 35 | 34 | 124.47 | 665000 | 542.11 | 1.150 | 1.000 | 2 | 0.000 | 541.98 | 0.13 | 0.026 | 0.080 | 10862 | 0.000 | 0.080 |
| 36 | 35 | 123.84 | 665000 | 541.64 | 1.100 | 1.000 | 1 | -0.003 | 541.69 | -0.04 | 0.027 | 0.080 | 9293 | 0.000 | 0.080 |
| 37 | 36 | 122.97 | 665000 | 540.93 | 1.100 | 0.900 | 0 | -0.004 | 540.98 | -0.05 | 0.027 | 0.089 | 10315 | 0.000 | 0.089 |
| 38 | 37 | 122.09 | 665000 | 540.30 | 1.100 | 0.900 | 2 | 0.000 | 540.28 | 0.01 | 0.027 | 0.089 | 12271 | 0.000 | 0.089 |
| 39 | 38 | 121.46 | 665000 | 539.82 | 1.100 | 0.900 | 2 | 0.000 | 539.82 | 0.00 | 0.027 | 0.089 | 11057 | 0.000 | 0.089 |
| 40 | 39 | 120.56 | 666000 | 538.85 | 1.100 | 0.900 | 2 | 0.000 | 539.05 | -0.20 | 0.028 | 0.089 | 11608 | 0.000 | 0.089 |
| 41 | 40 | 119.93 | 666000 | 538.19 | 1.100 | 0.900 | 2 | 0.000 | 538.16 | 0.03 | 0.027 | 0.089 | 12670 | 0.000 | 0.089 |
| 42 | 41 | 119.25 | 666000 | 537.66 | 1.150 | 0.900 | 2 | 0.000 | 537.65 | 0.01 | 0.026 | 0.089 | 13215 | 0.000 | 0.089 |
| 43 | 42 | 118.58 | 666000 | 537.17 | 1.150 | 0.900 | 2 | 0.000 | 537.09 | 0.08 | 0.026 | 0.089 | 13752 | 0.000 | 0.089 |
| 44 | 43 | 117.70 | 666000 | 536.43 | 1.150 | 0.900 | 2 | 0.000 | 536.26 | 0.17 | 0.026 | 0.085 | 13927 | 0.000 | 0.089 |
| 45 | 44 | 116.95 | 666000 | 535.76 | 1.150 | 0.900 | 2 | 0.000 | 535.44 | 0.31 | 0.026 | 0.085 | 12791 | 0.000 | 0.089 |
| 46 | 45 | 116.02 | 666000 | 534.81 | 1.150 | 0.900 | 2 | 0.000 | 534.78 | 0.03 | 0.026 | 0.088 | 12676 | 0.000 | 0.089 |
| 47 | 46 | 115.39 | 666000 | 534.27 | 1.150 | 0.900 | 2 | 0.000 | 534.36 | -0.09 | 0.026 | 0.089 | 11478 | 0.000 | 0.089 |
| 48 | 47 | 114.96 | 666000 | 534.05 | 1.150 | 0.900 | 2 | 0.000 | 534.10 | -0.05 | 0.026 | 0.089 | 11405 | 0.000 | 0.089 |
| 49 | 48 | 114.45 | 666000 | 533.75 | 1.150 | 0.900 | 2 | 0.000 | 533.80 | -0.05 | 0.026 | 0.089 | 11177 | 0.000 | 0.089 |
| 50 | 49 | 113.65 | 666000 | 532.84 | 1.150 | 0.900 | 2 | 0.000 | 533.08 | -0.24 | 0.026 | 0.089 | 12533 | 0.000 | 0.089 |
| 51 | 50 | 112.88 | 666000 | 532.47 | 1.150 | 0.900 | 2 | 0.000 | 532.55 | -0.08 | 0.026 | 0.089 | 12817 | 0.000 | 0.089 |

RAS and EXCEL Plot / RAS / Profile Details / Check Calib Profile / With Levees Departure Plot (2) / **Calib Profile** / FFS Elev / DA Plot / FFS Flow

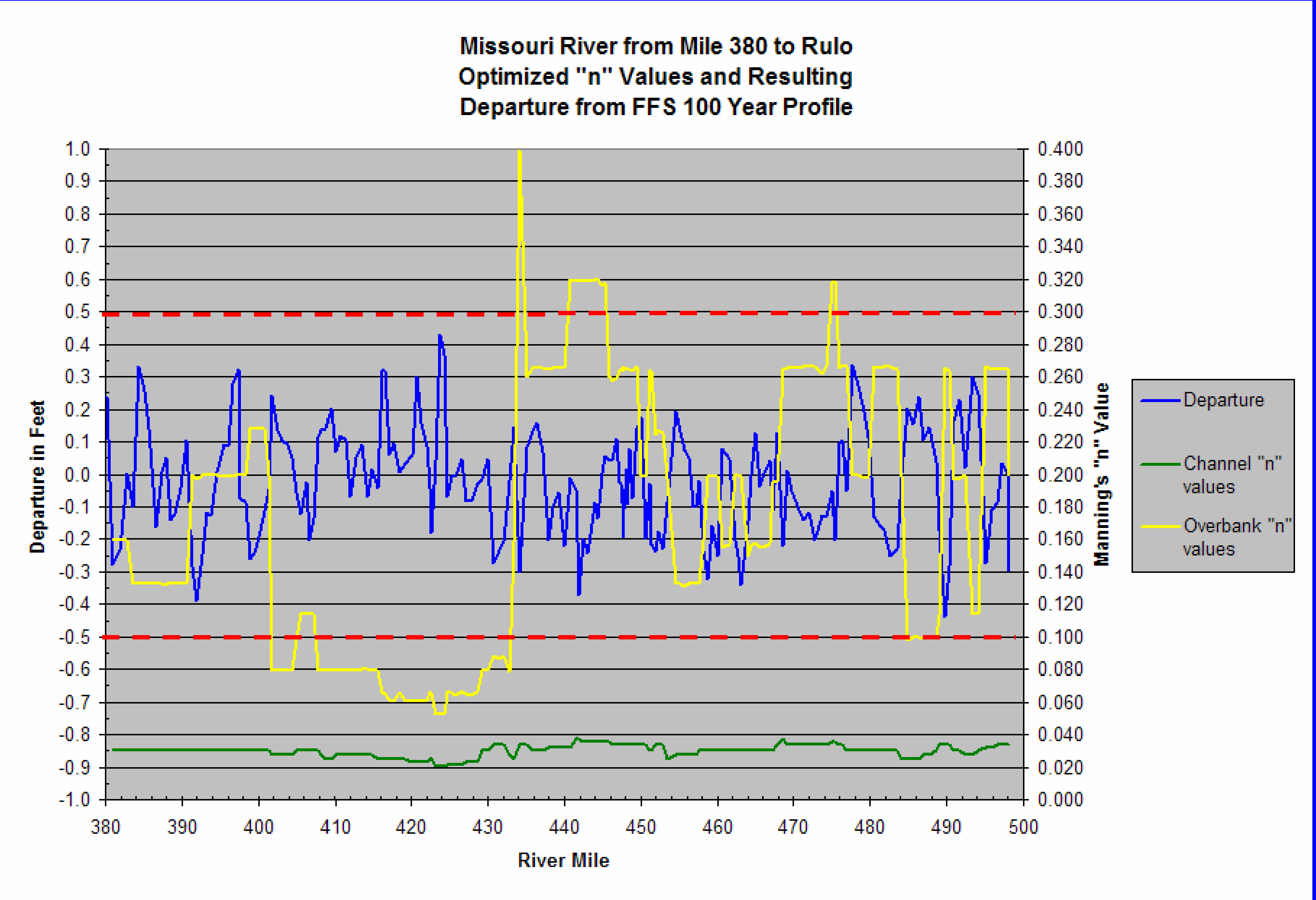
Ready



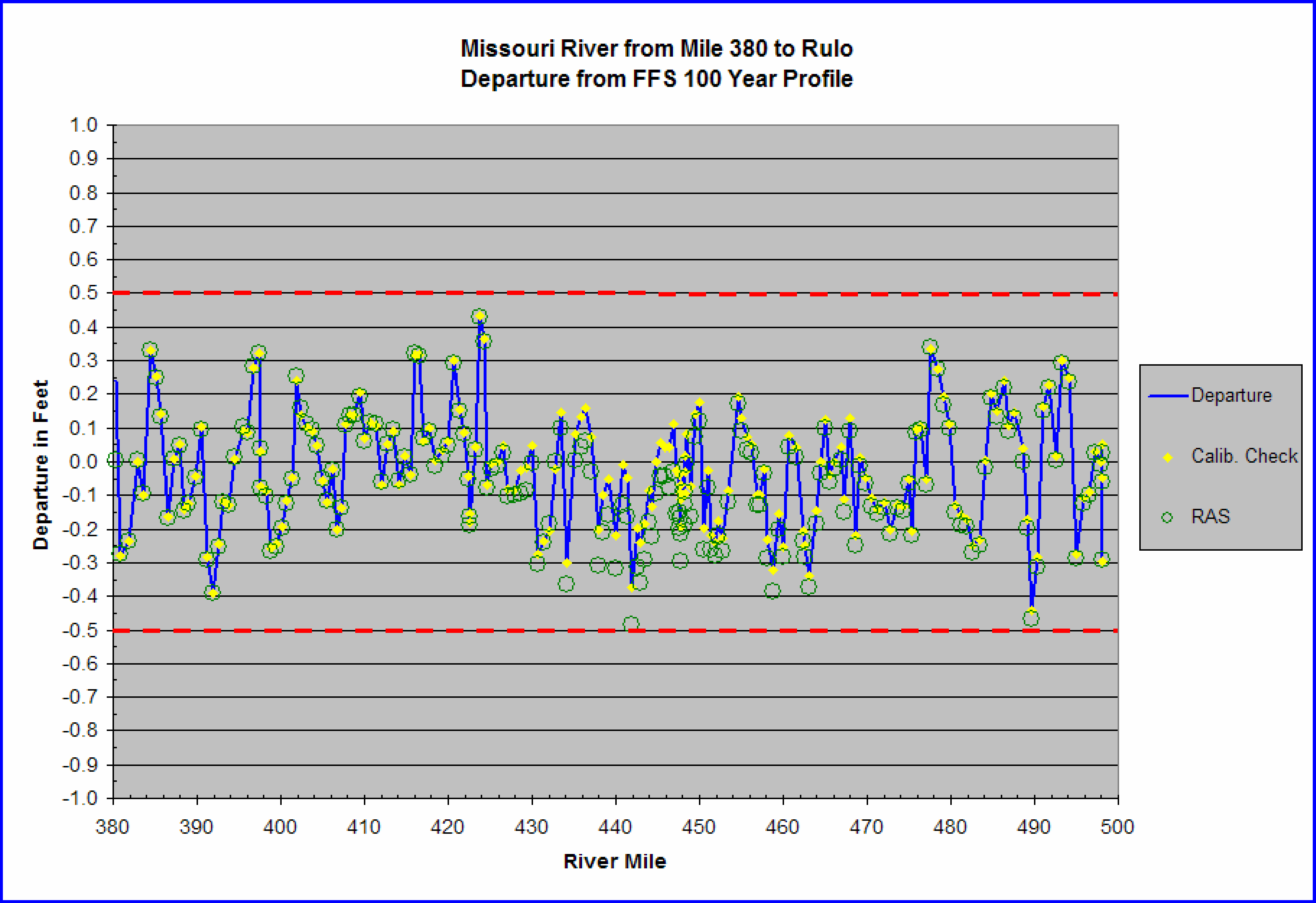
Missouri River from Jefferson City to St. Charles
Optimized "n" Values and Resulting
Departure from FFS 100 Year Profile
Departure in Feet
Manning's "n" Value
River Mile
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
0.100
0.090
0.080
0.070
0.060
0.050
0.040
0.030
0.020
0.010
0.000
20
30
40
50
60
70
80
90
100
110
120
130
140
Departure
RAS Departure
Channel "n" values
Overbank "n" values



Missouri River from Jefferson City to RM 333
Optimized Departure from 100 Year FFS Profile
Departure in Feet
Manning's "n" Value
River Mile
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
-0.70
-0.80
-0.90
-1.00
-1.10
-1.20
-1.30
-1.40
0.800
0.760
0.720
0.680
0.640
0.600
0.560
0.520
0.480
0.440
0.400
0.360
0.320
0.280
0.240
0.200
0.160
0.120
0.080
0.040
0.000
140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340
Departure
RAS Departure
Channel "n"
Overbank "n"



Missouri River from Mile 380 to Rulo
Optimized "n" Values and Resulting
Departure from FFS 100 Year Profile
Departure in Feet
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
Manning's "n" Value
0.400
0.380
0.360
0.340
0.320
0.300
0.280
0.260
0.240
0.220
0.200
0.180
0.160
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
380
390
400
410
420
430
440
450
460
470
480
490
500
River Mile
Departure
Channel "n" values
Overbank "n" values


Missouri River from Mile 380 to Rulo
Departure from FFS 100 Year Profile
Departure in Feet
River Mile
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
-0.6
-0.7
-0.8
-0.9
-1.0
380
390
400
410
420
430
440
450
460
470
480
490
500
Departure
Calib. Check
RAS

# Outstanding issues

ITR and Resolution of Comments

Coordination with FEMA

# DISCUSSION