Adaptive Hydraulics (ADH) Modeling
User Group Workshop
January 12, 2010

NUMERICAL MODELING OF LOWER MISSISSIPPI RIVER

Erol Karadogan and Clint Willson

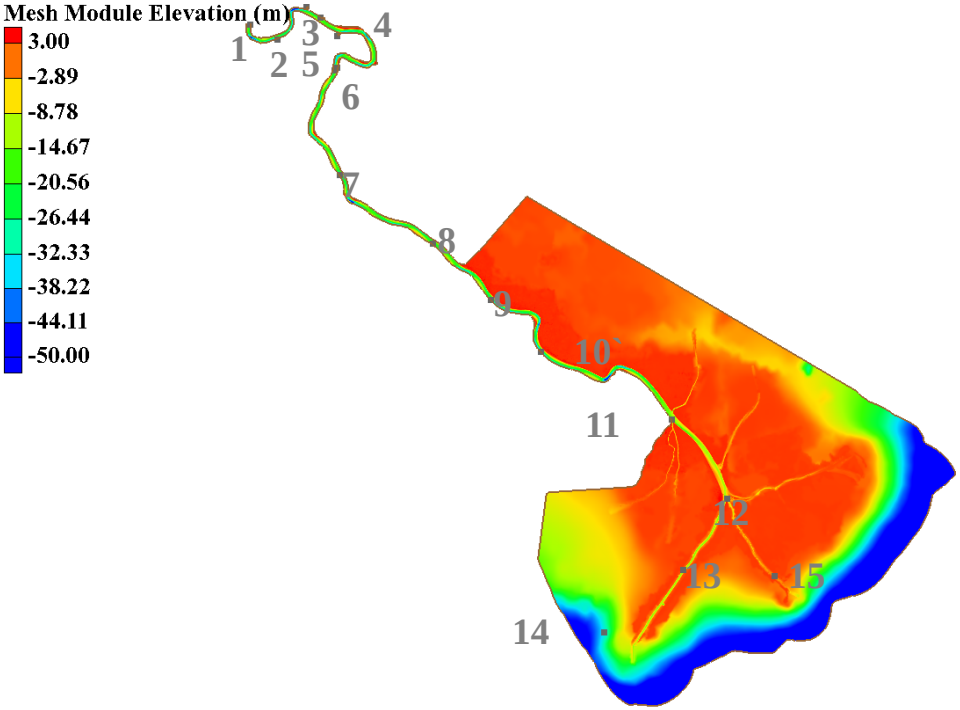
Acknowledgements

- Louisiana Office of Coastal Protection and Restoration (OCPR)
- Coastal and Hydraulics Laboratory at the USACE Engineer Research and Development Center (CHL, USACE)
- Louisiana State University Center for Computation and Technology (LSU, CCT)
- The Louisiana Optical Network Initiative (LONI)
- Coastal Environmental Modeling Laboratory (LSU, CEML)

Outline

- Conceptual Model
- HPC Usage
- Validation Efforts
- Simulating Certain Events
- Investigating Effect of a Diversion
- ADH Features
- Conclusions

Hydrodynamic Modeling of Lower Mississippi River Delta



Gage #	River Mile	Location
1	102.8	Carrollton
2	98.3	Harvey Lock
3	92.7	IHNCL
4	91	Chalmette
5	88.3	Algiers Lock
6	76.6	Near Braithwaite
7	62.5	Alliance,
8	48.7	West Pointe A La Hache,
9	39.3	Port Sulpher,
10	29.5	Empire,
11	10.7	Venice,
12	-0.6	Head Of Passes,
13	-8.5	Southwest Pass At Mile 9.2
14	-17.4	(Southwest Pass) At East Jetty
15	-10.4	South Pass At Port Eads

Number of Nodes: **214,515**
Number of Elements: **424,207**
Total Mesh Area: **1.53×10^9 mi^2**
Resolution is down to: **30 m**

High Performance Computing

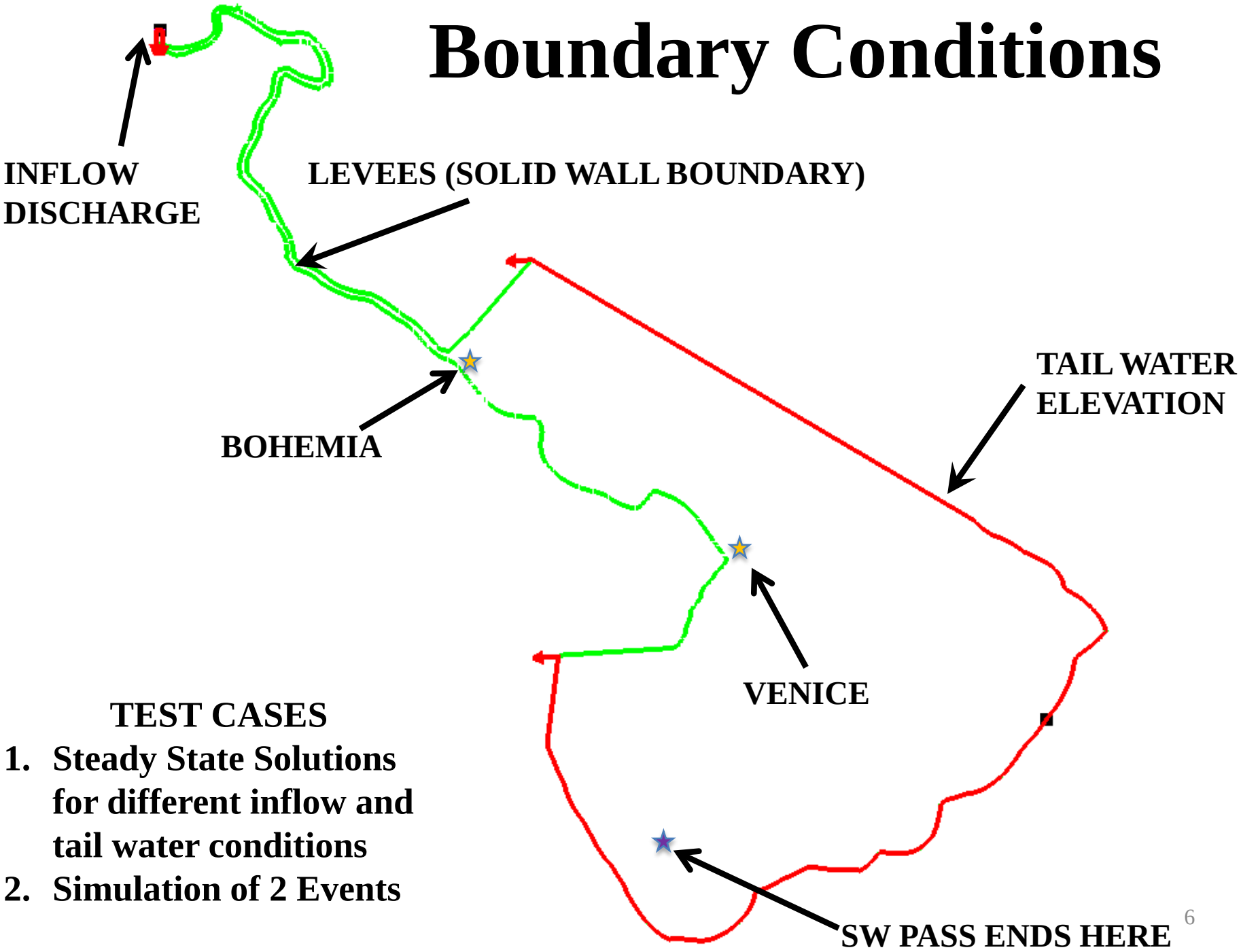
LSU
CENTER FOR COMPUTATION & TECHNOLOGY

- **Peak Performance**
  - **50. Tflops (Queenbee)**
  - **15.3 Tflops (Tezpur)**
- **Number of nodes**
  - **680 (Queenbee)**
  - **360 (Tezpur)**
  - **70 (Mangal)**

Systems

- **Tezpur (CCT)**
- **Queenbee (LONI)**
- **Mangal (SCE)**

Boundary Conditions



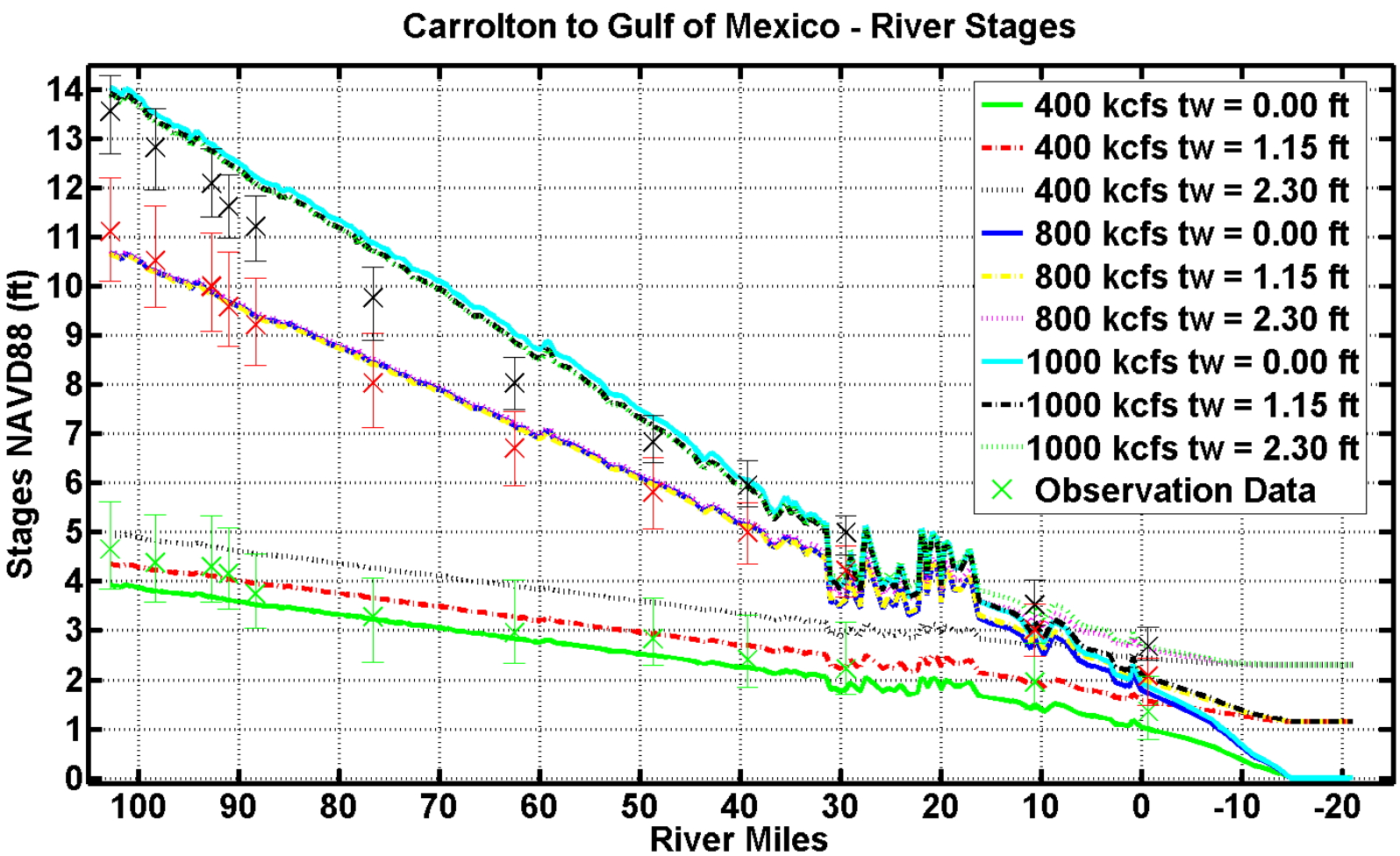
TEST CASES

1. **Steady State Solutions for different inflow and tail water conditions**
2. **Simulation of 2 Events**

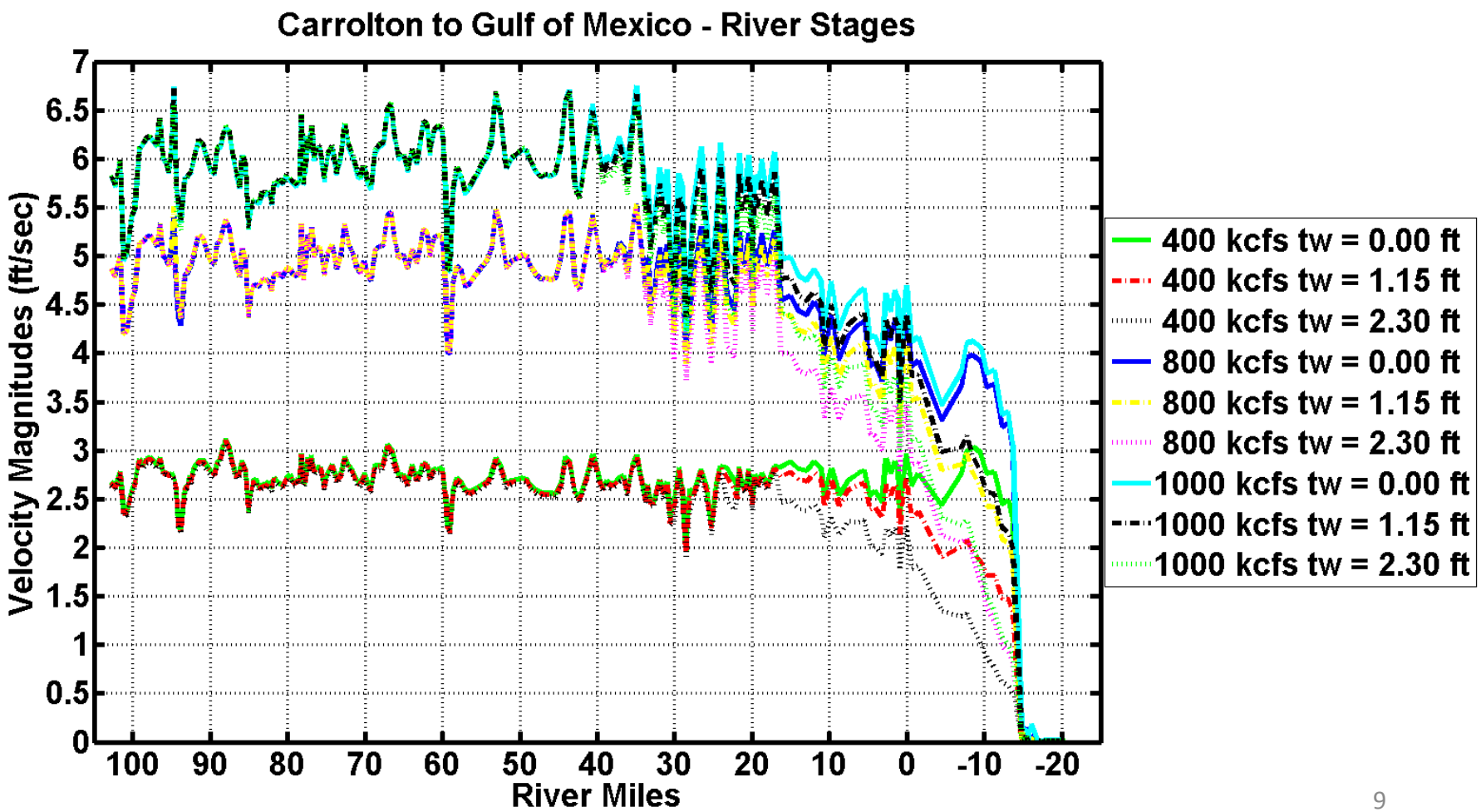
Steady State Solutions

- Stage hydrographs at gages are obtained for the water years between 1987 and 2009 after excluding extreme values and non-physical outlier
- Constant Inflow Discharge and Constant Tailwater Elevation
- 3 Flow Rates
  - 400,000 cfs (Low Flow)
  - 800,000 cfs (Medium Flow)
  - 1,000,000 cfs (High Flow)
- 3 Tailwater Elevations
  - 0.00 ft
  - 1.15 ft
  - 2.30 ft
- “Steady State” option is invoked.
- Manning’s n = 0.020

Steady State Solutions
Water Surface Elevations



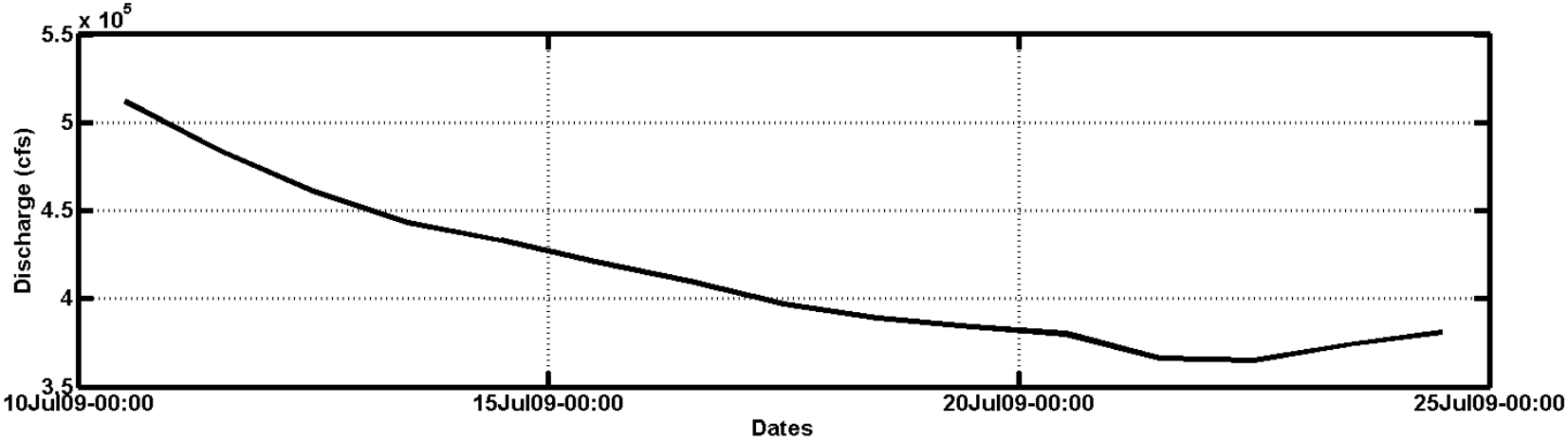
Steady State Solutions
Velocity Magnitudes

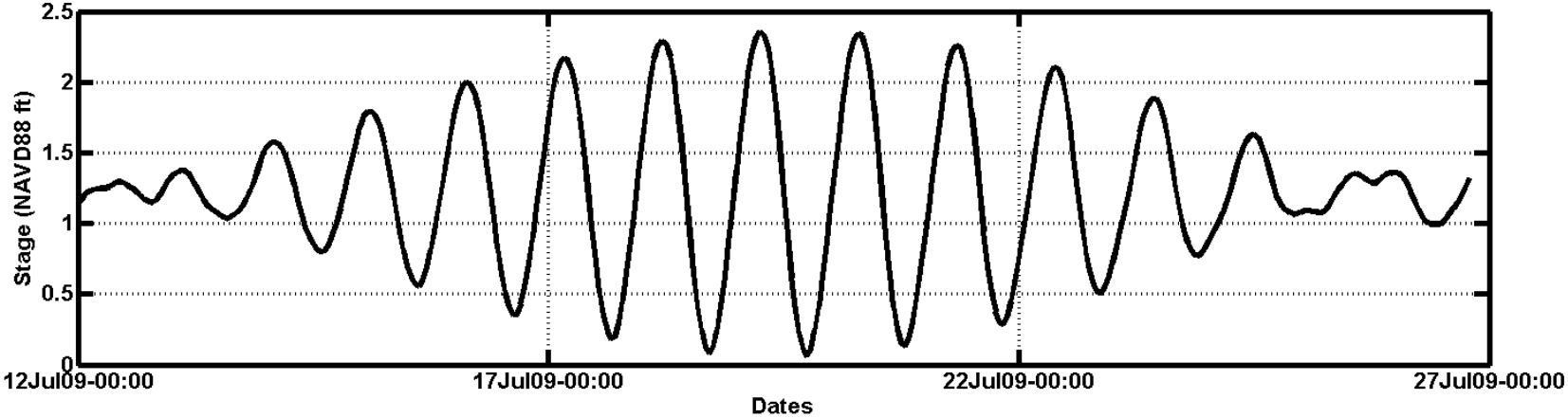


Simulating Certain Events

- Inflow Discharge: Tarbert Landing Discharge Data (2 Days Lagged)
- Outflow Tailwater Elevations: ADCIRC Tidal Base and T_Tide Toolbox
- 2 Events
  - July 12th – July 27th 2009 (Q~400,000 cfs)
  - April 21st – May 5th 2009 (Q~800,000 cfs)

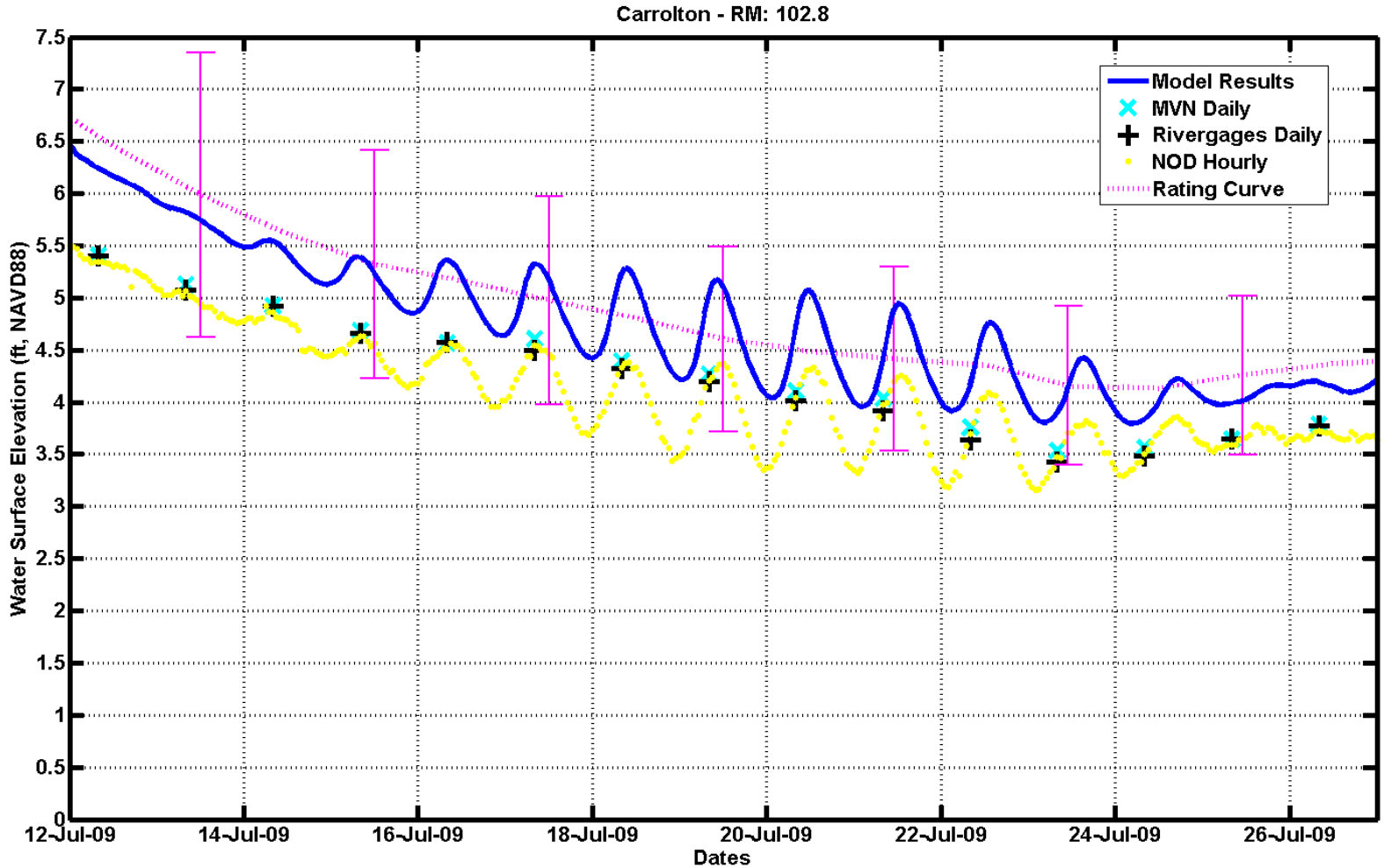
July 12th – July 27th 2009 Boundary Conditions

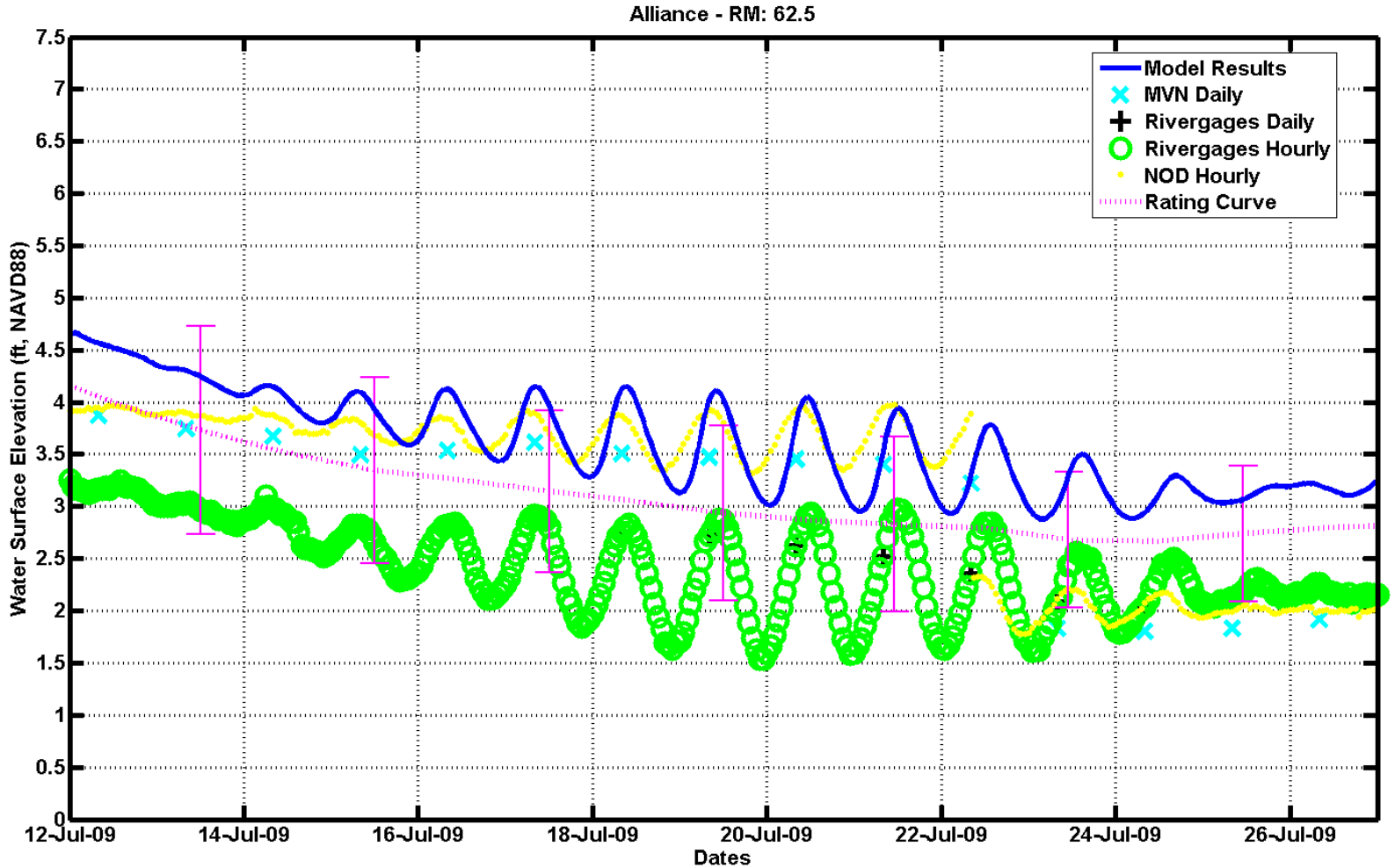


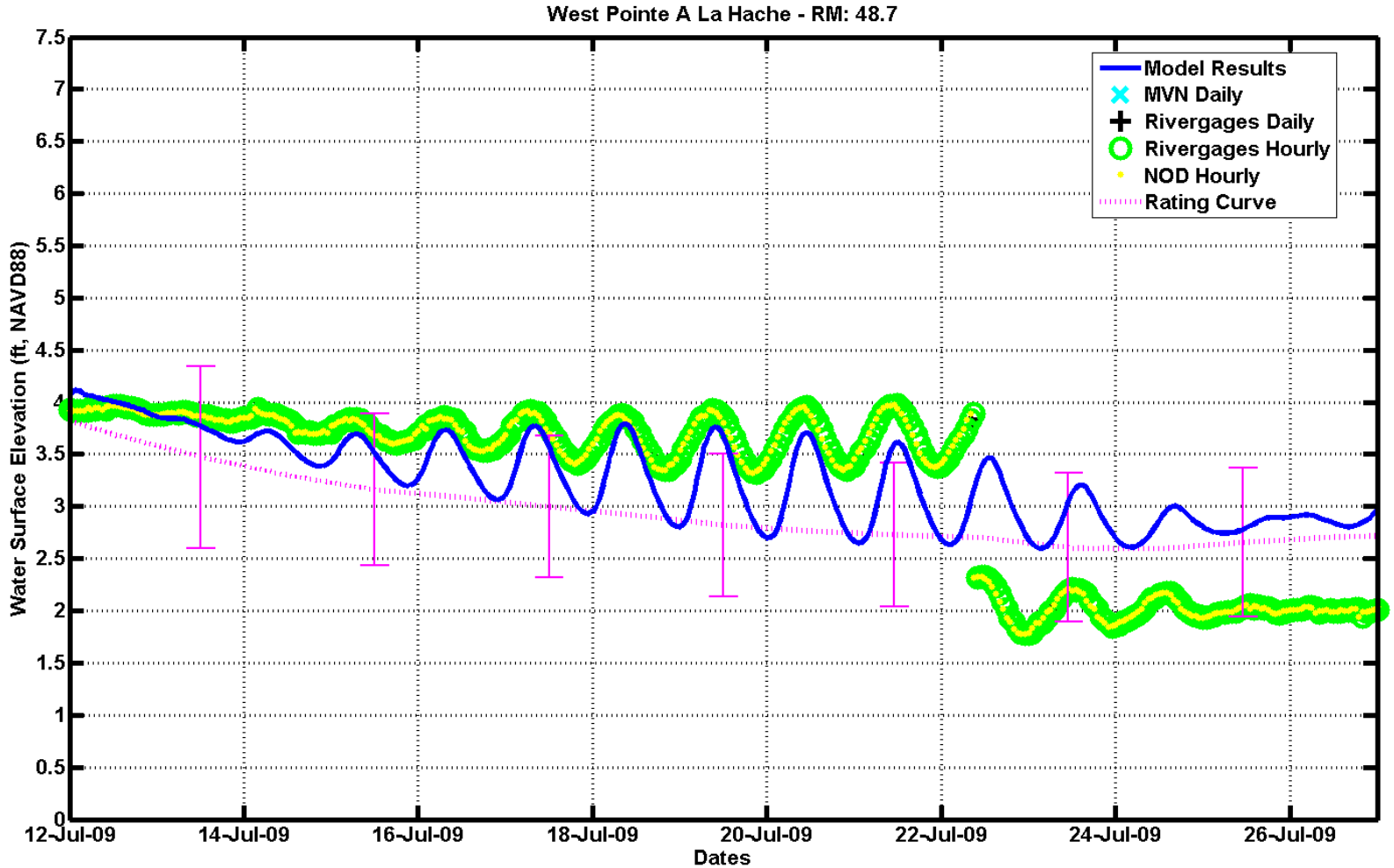


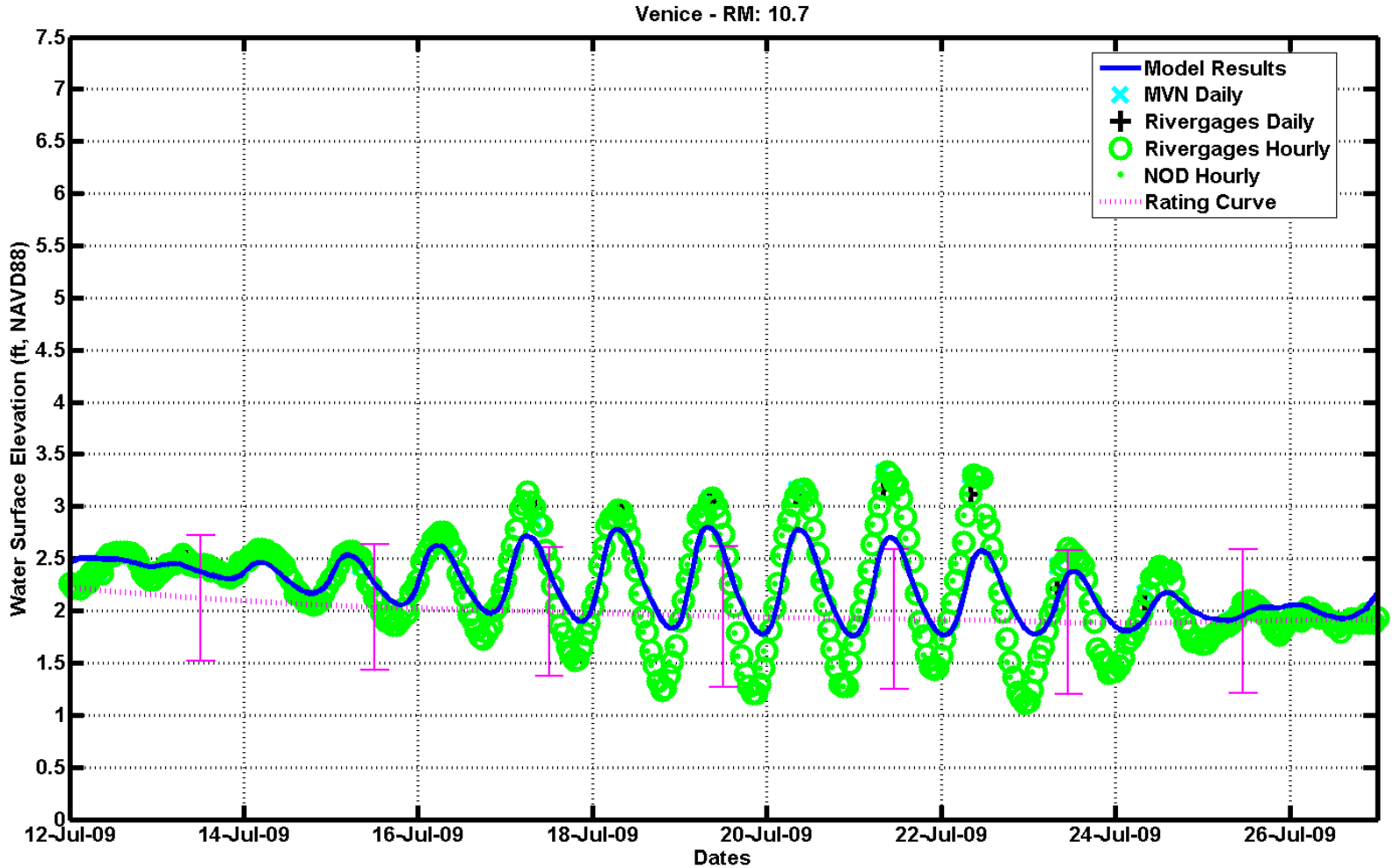
July 12th – July 27th 2009

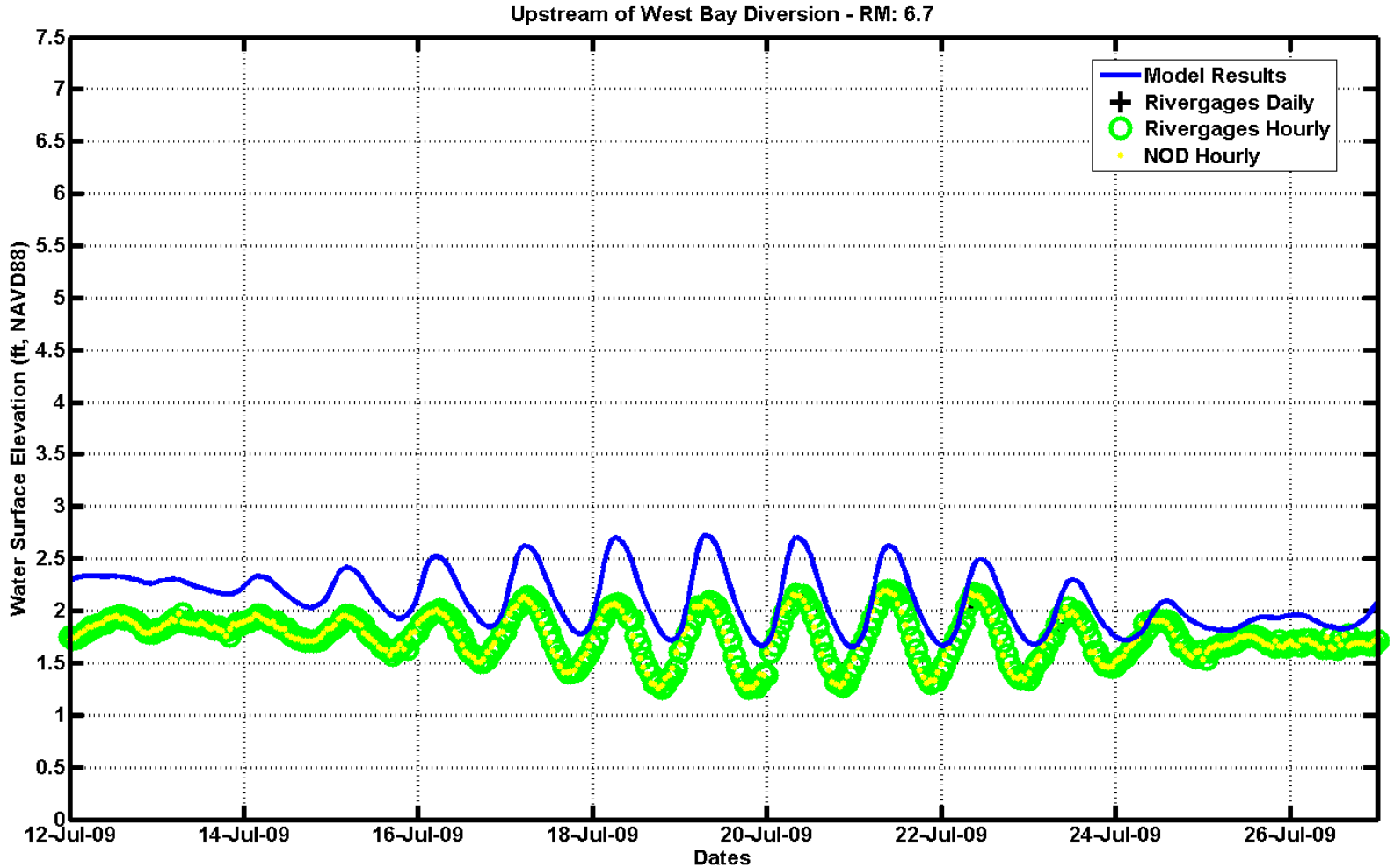
WATER SURFACE ELEVATION TIME SERIES AT SELECTED GAGE LOCATIONS

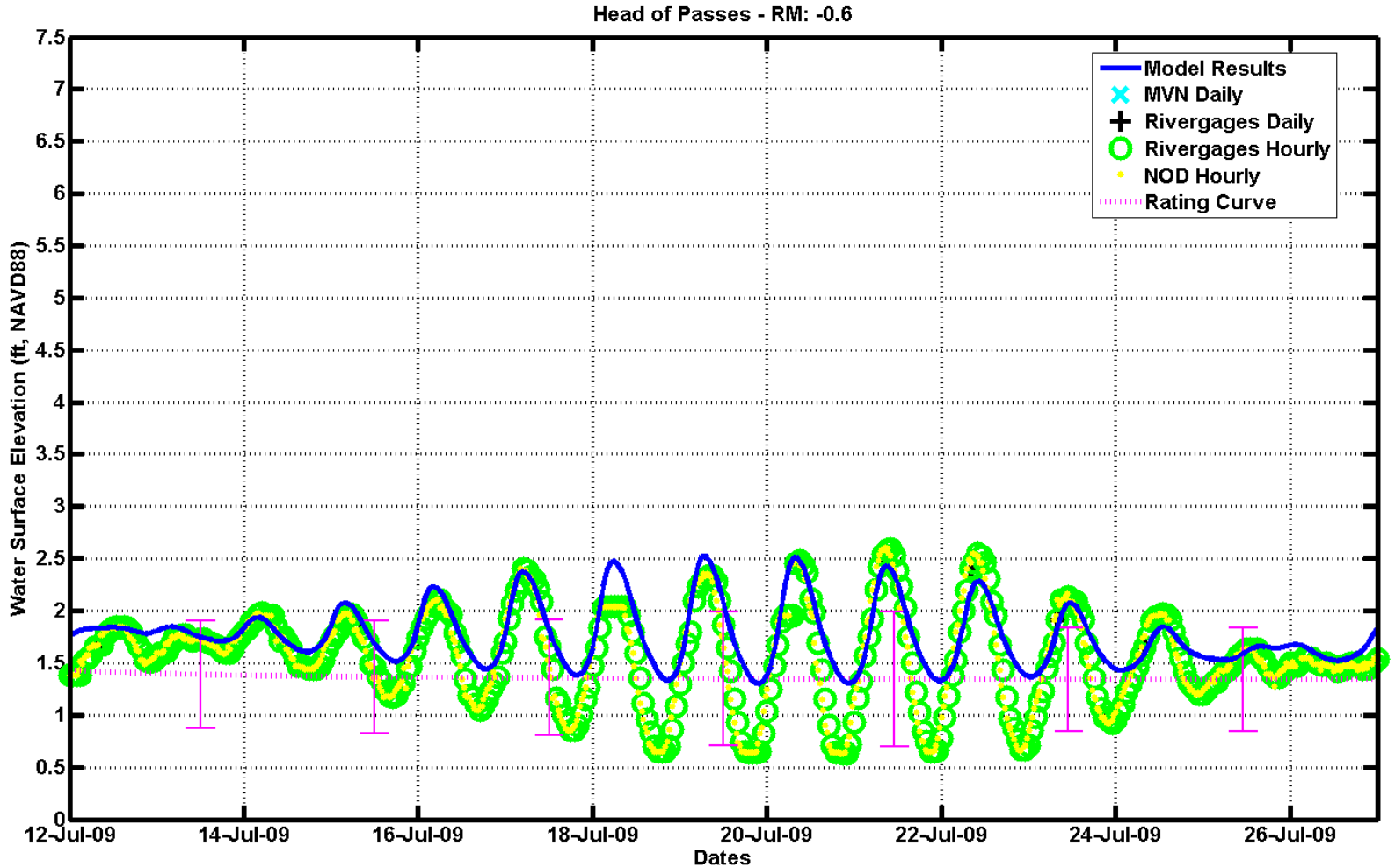

Carrolton - RM: 102.8
Model Results
MVN Daily
Rivergages Daily
NOD Hourly
Rating Curve
Water Surface Elevation (ft, NAVD88)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09
Dates

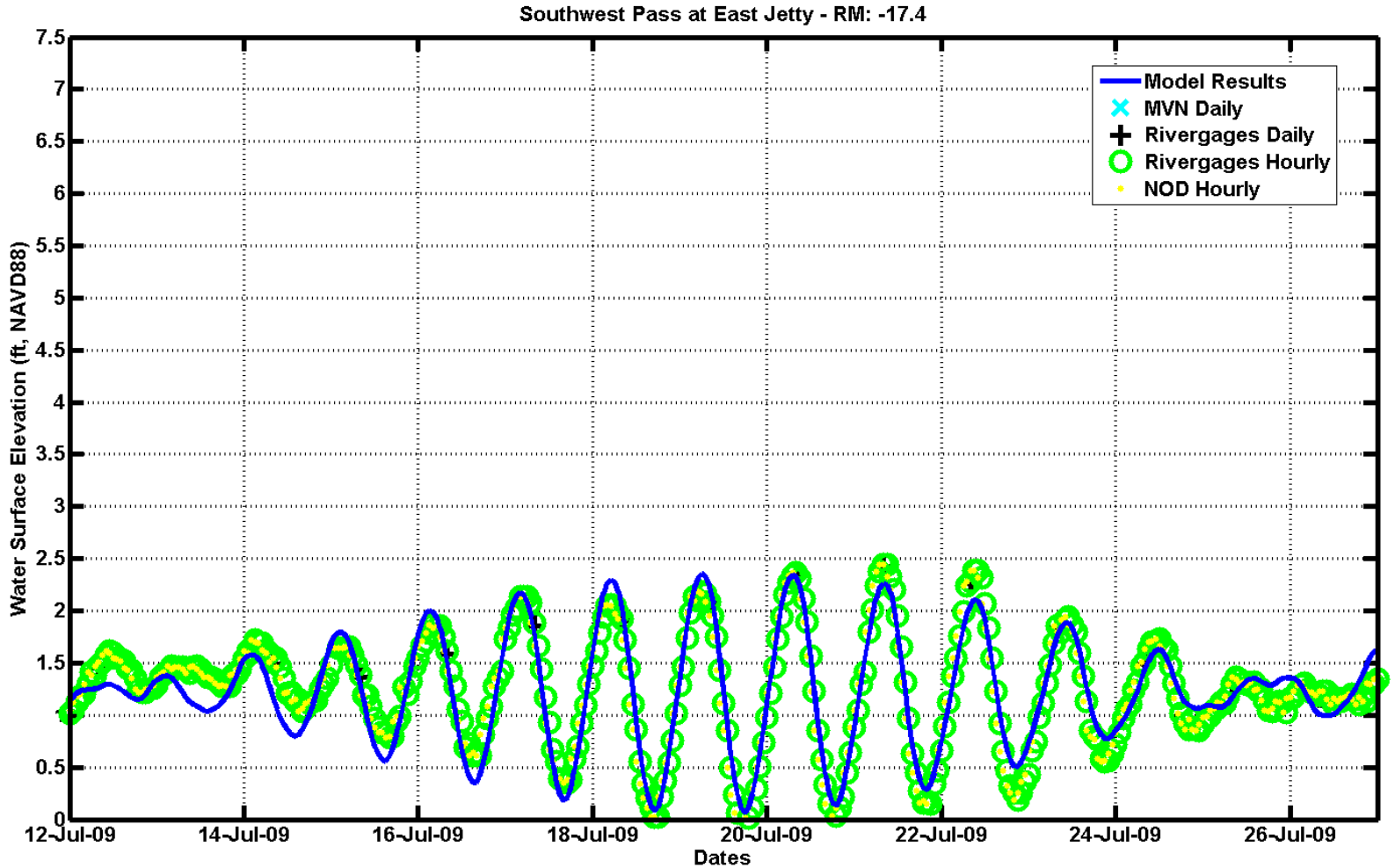

Alliance - RM: 62.5
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve
Water Surface Elevation (ft, NAVD88)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09
Dates

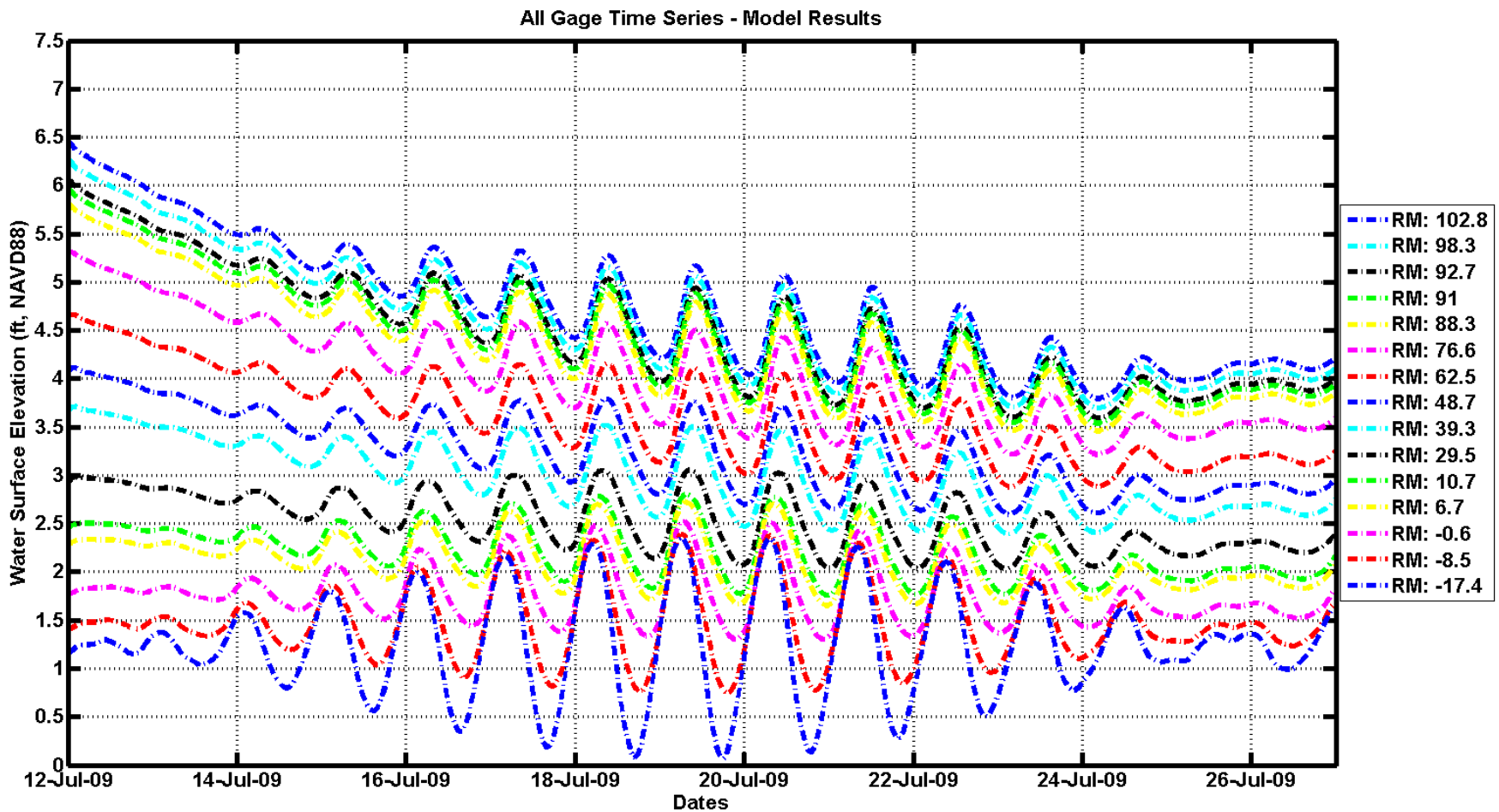

West Pointe A La Hache - RM: 48.7
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve
Water Surface Elevation (ft, NAVD88)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09
Dates


Venice - RM: 10.7
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve
Water Surface Elevation (ft, NAVD88)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09
Dates


Upstream of West Bay Diversion - RM: 6.7
Model Results
Rivergages Daily
Rivergages Hourly
NOD Hourly
Water Surface Elevation (ft, NAVD88)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09
Dates

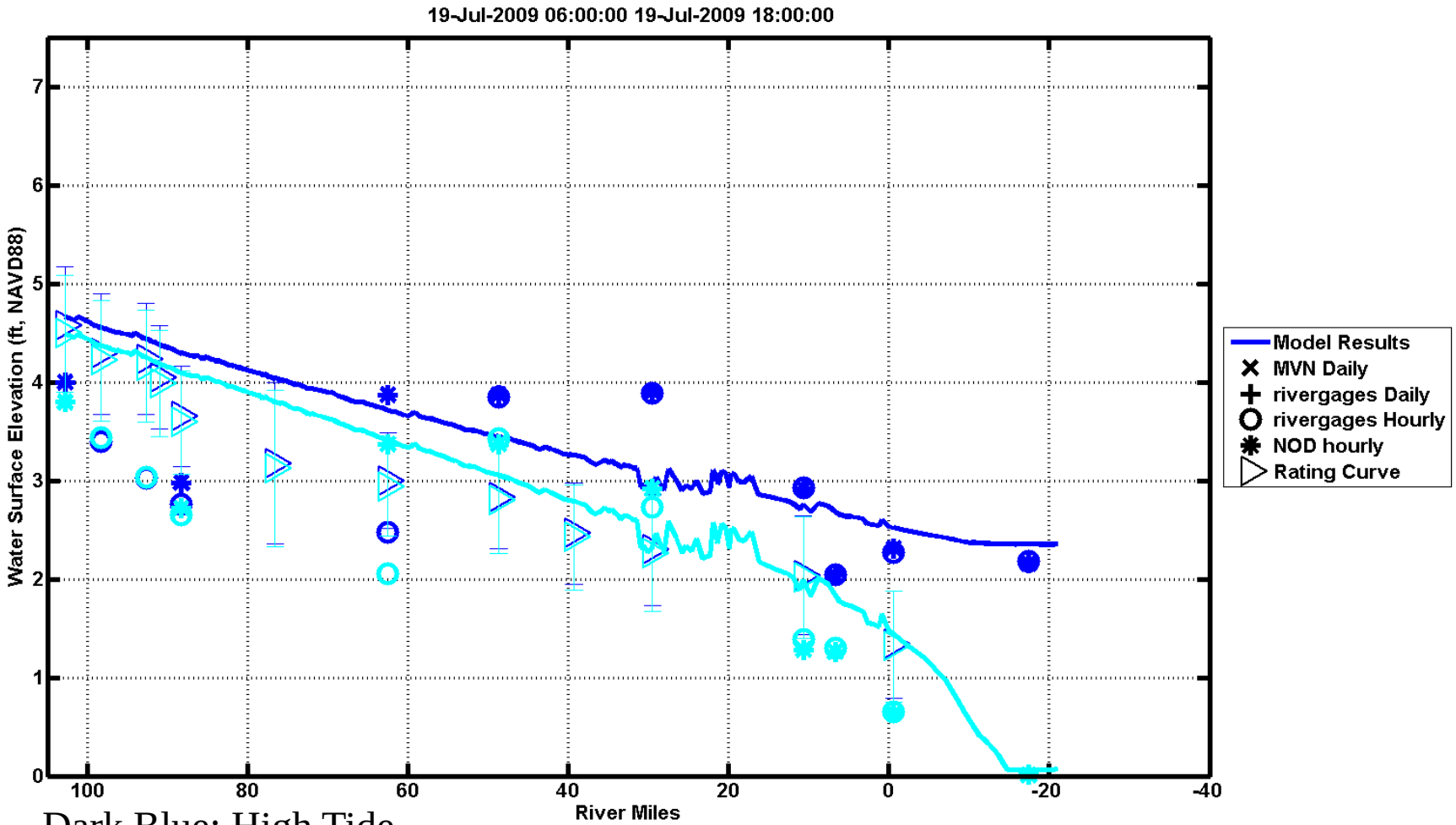

Head of Passes - RM: -0.6
Water Surface Elevation (ft, NAVD88)
Dates
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09


Southwest Pass at East Jetty - RM: -17.4
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Water Surface Elevation (ft, NAVD88)
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09
Dates


All Gage Time Series - Model Results
Water Surface Elevation (ft, NAVD88)
Dates
7.5
7
6.5
6
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
12-Jul-09
14-Jul-09
16-Jul-09
18-Jul-09
20-Jul-09
22-Jul-09
24-Jul-09
26-Jul-09
RM: 102.8
RM: 98.3
RM: 92.7
RM: 91
RM: 88.3
RM: 76.6
RM: 62.5
RM: 48.7
RM: 39.3
RM: 29.5
RM: 10.7
RM: 6.7
RM: -0.6
RM: -8.5
RM: -17.4

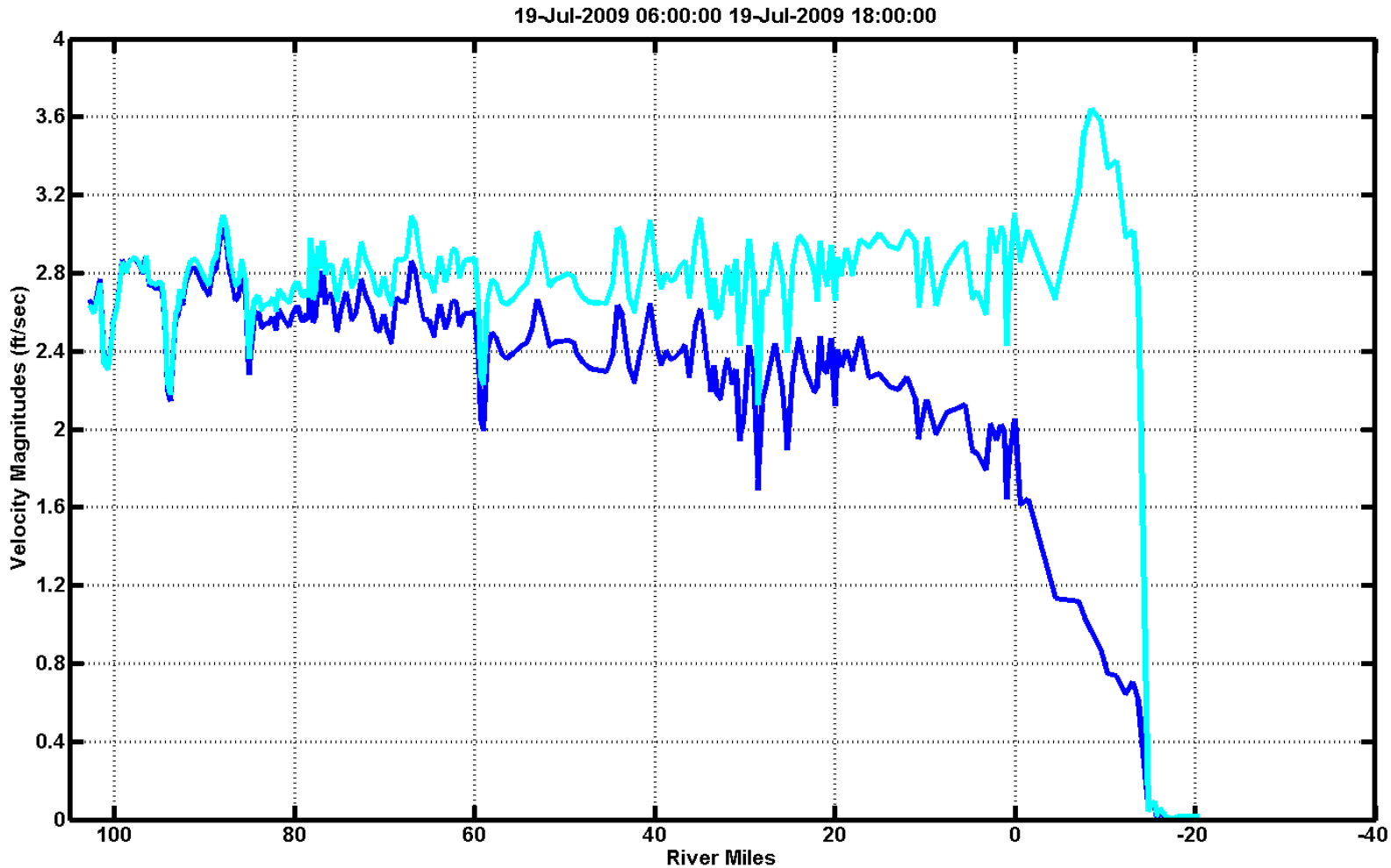
July 12th – July 27th 2009

HIGH TIDE VS. LOW TIDE



Dark Blue: High Tide
Light Blue: Low Tide

- River discharge is almost constant (400,000 cfs)
- Tidal variation is maximum between the two times that are shown.



Dark Blue: High Tide
Light Blue: Low Tide

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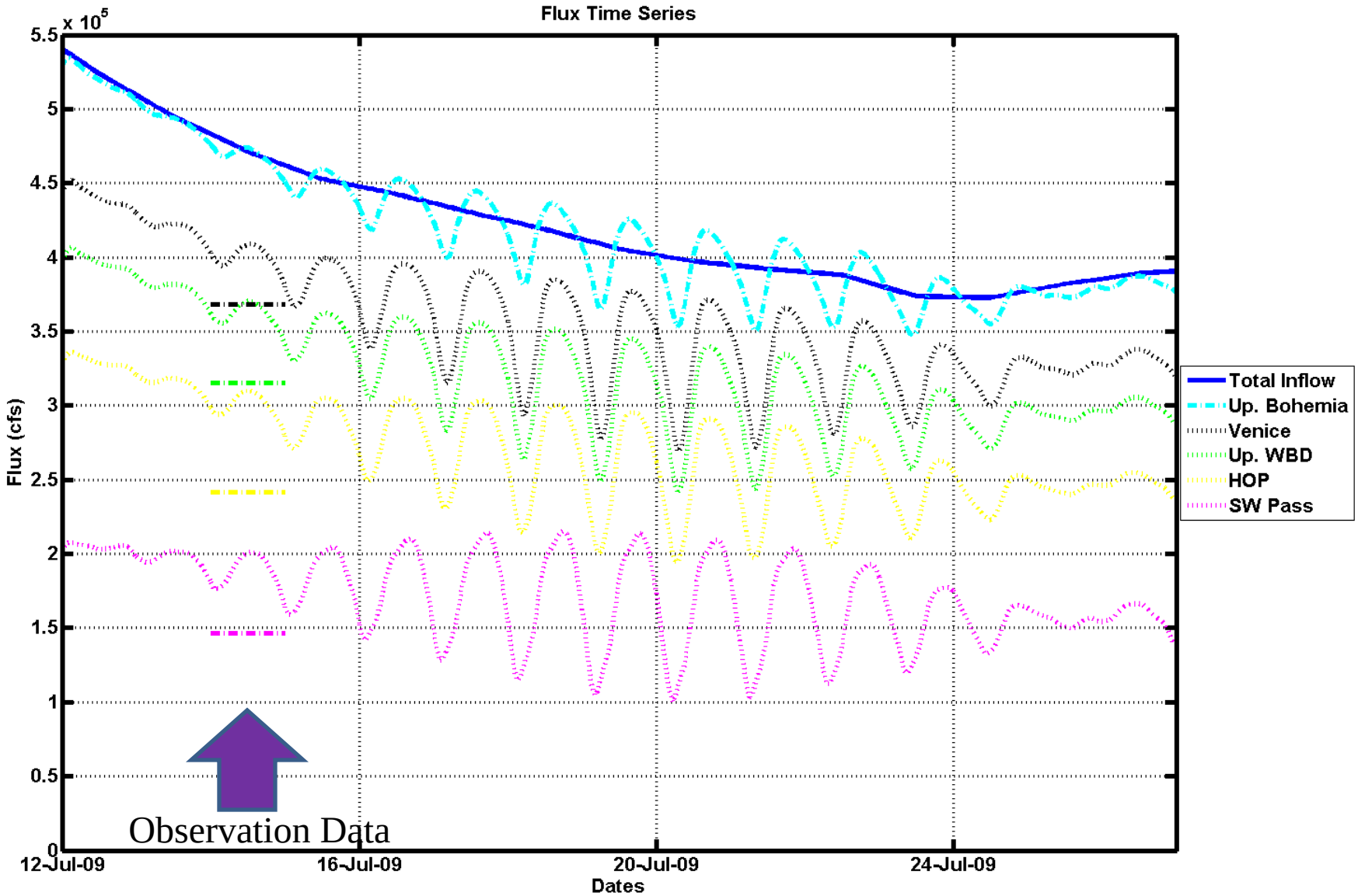
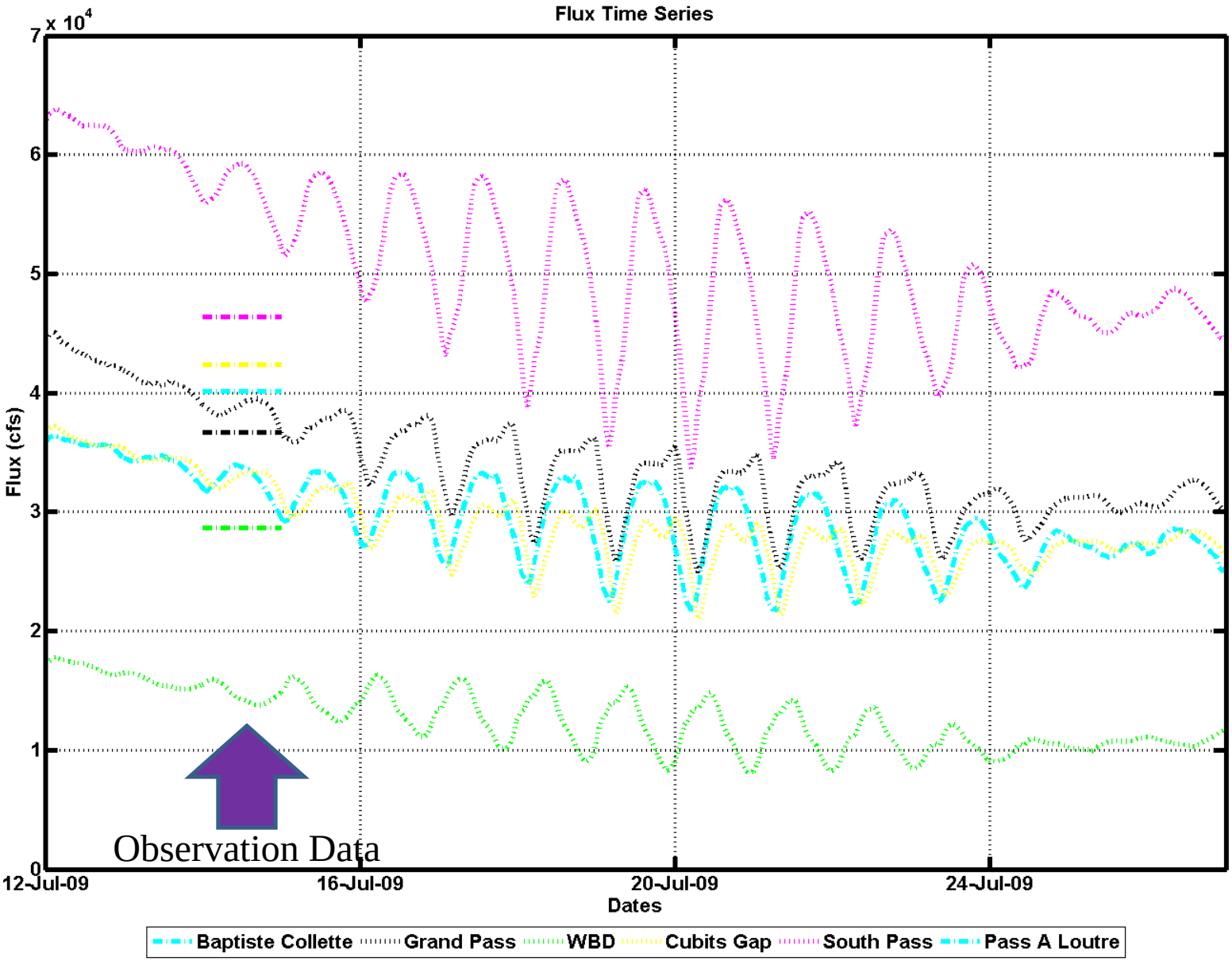
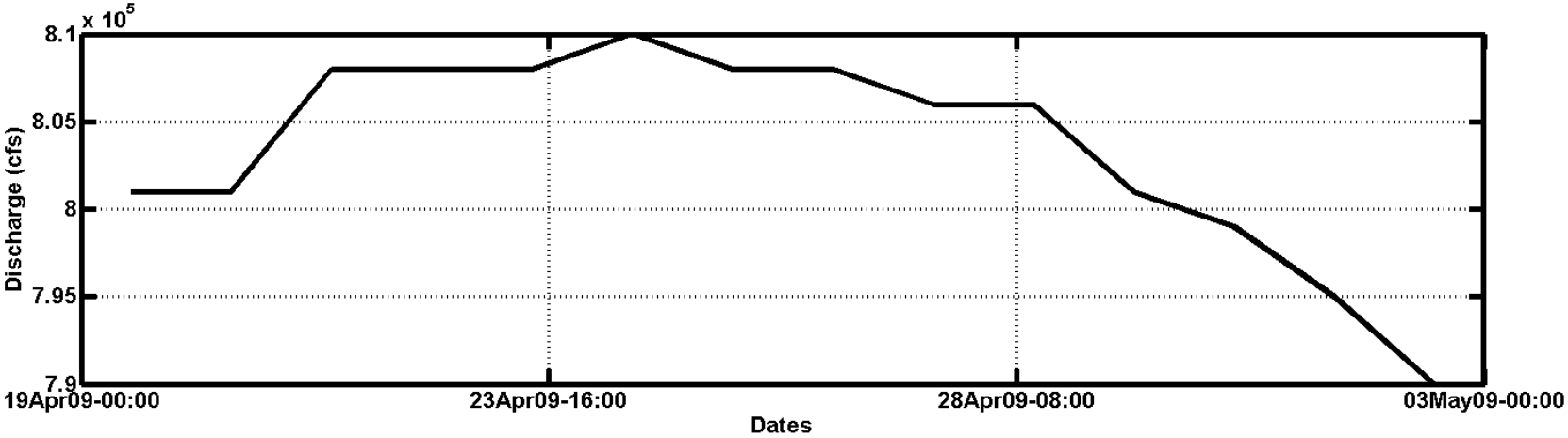
July 12th – July 27th 2009

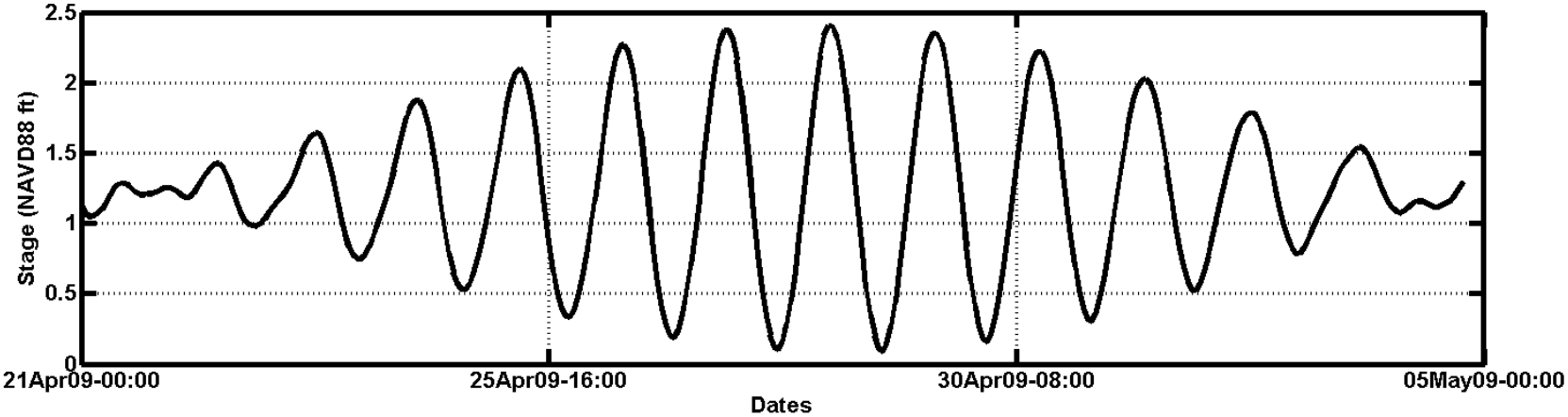
TIME SERIES FOR FLUXES ACROSS DIFFERENT RIVER X-SECTIONS AND PASSES


Flux Time Series
x 10^5
5.5
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flux (cfs)
12-Jul-09
16-Jul-09
20-Jul-09
24-Jul-09
Dates
Total Inflow
Up. Bohemia
Venice
Up. WBD
HOP
SW Pass
Observation Data


Flux Time Series
x 10^4
7
6
5
4
3
2
1
0
Flux (cfs)
12-Jul-09
16-Jul-09
20-Jul-09
24-Jul-09
Dates
Observation Data
Baptiste Collette
Grand Pass
WBD
Cubits Gap
South Pass
Pass A Loutre

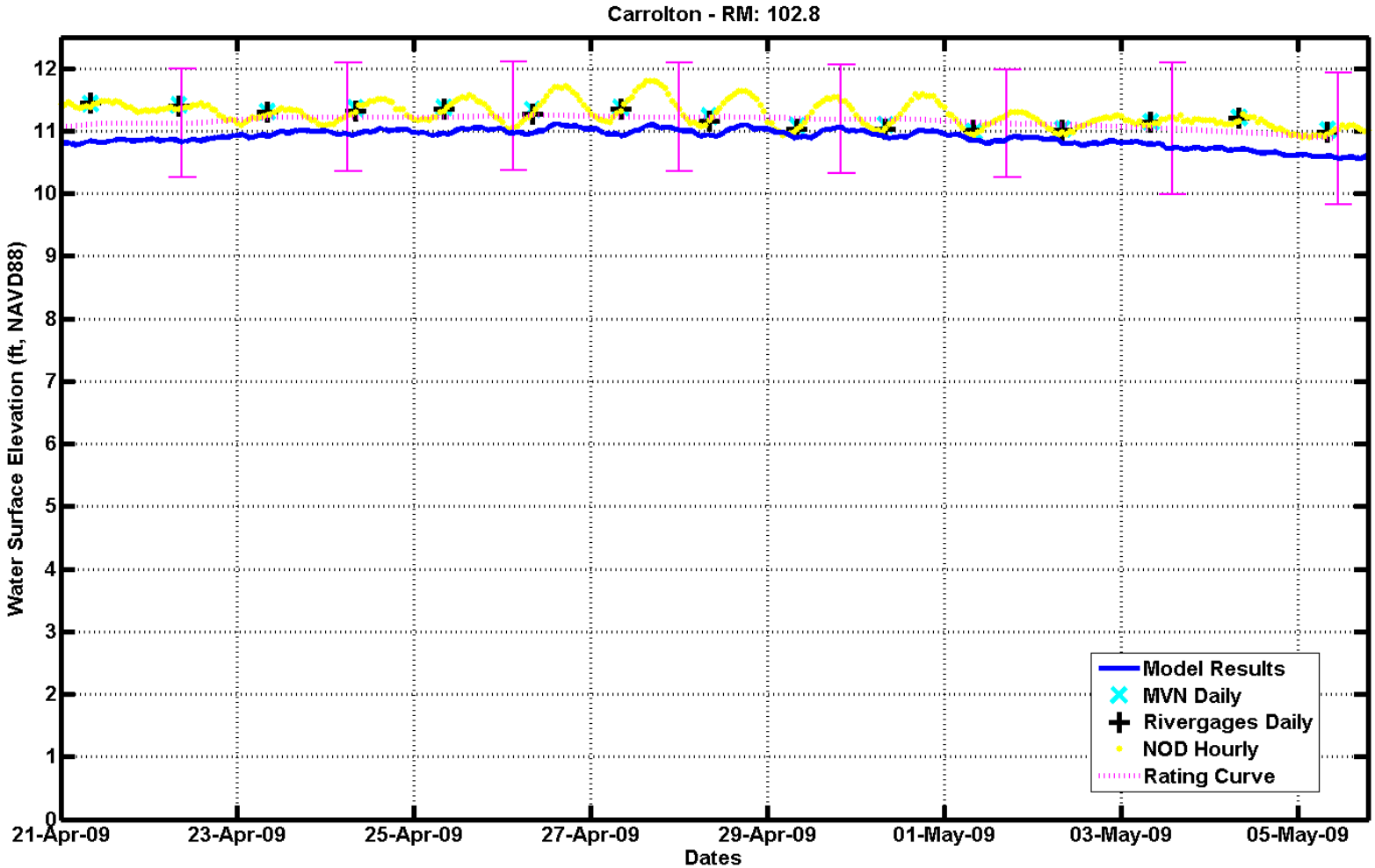
April 21st – May 5th 2009 Boundary Conditions

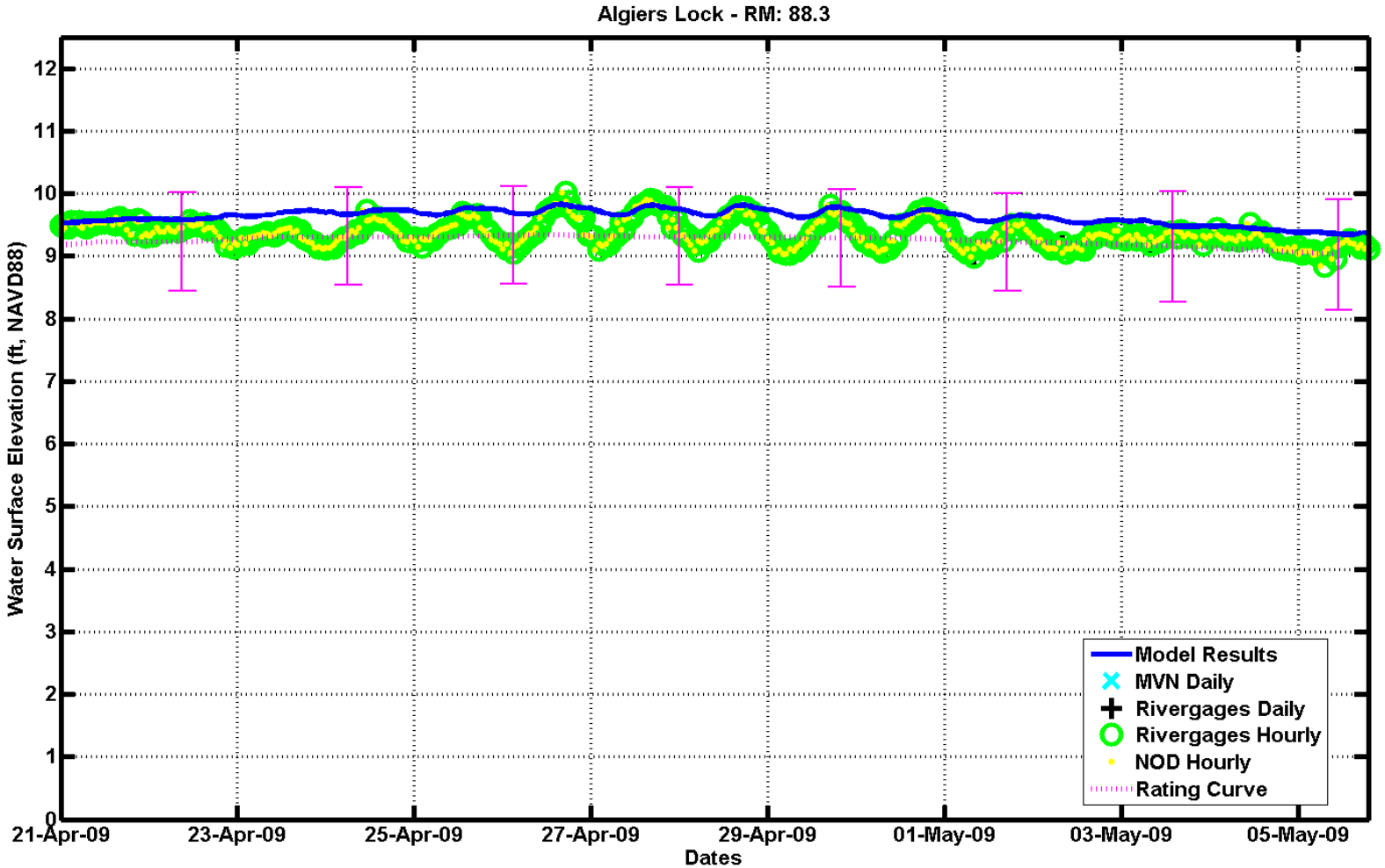


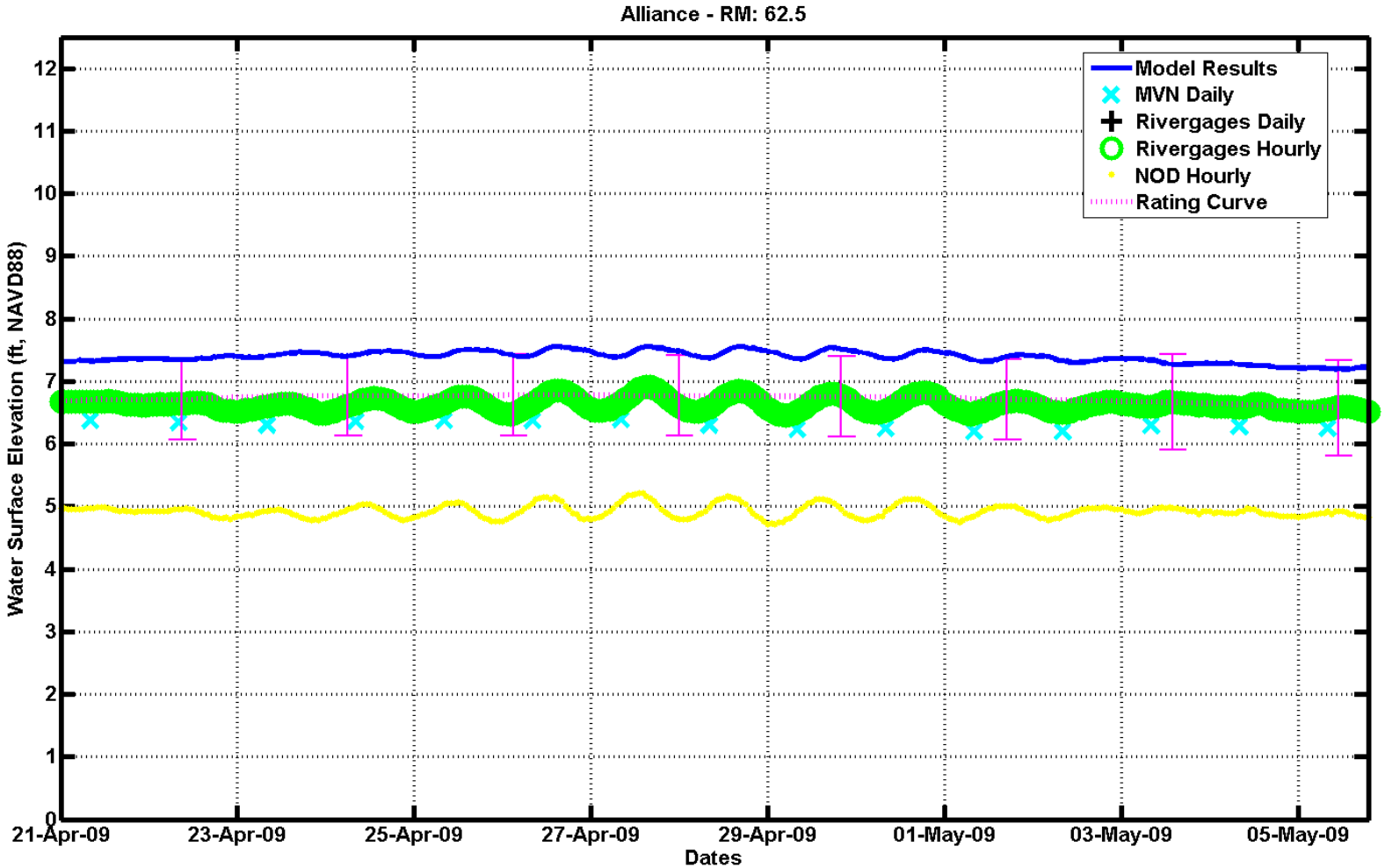


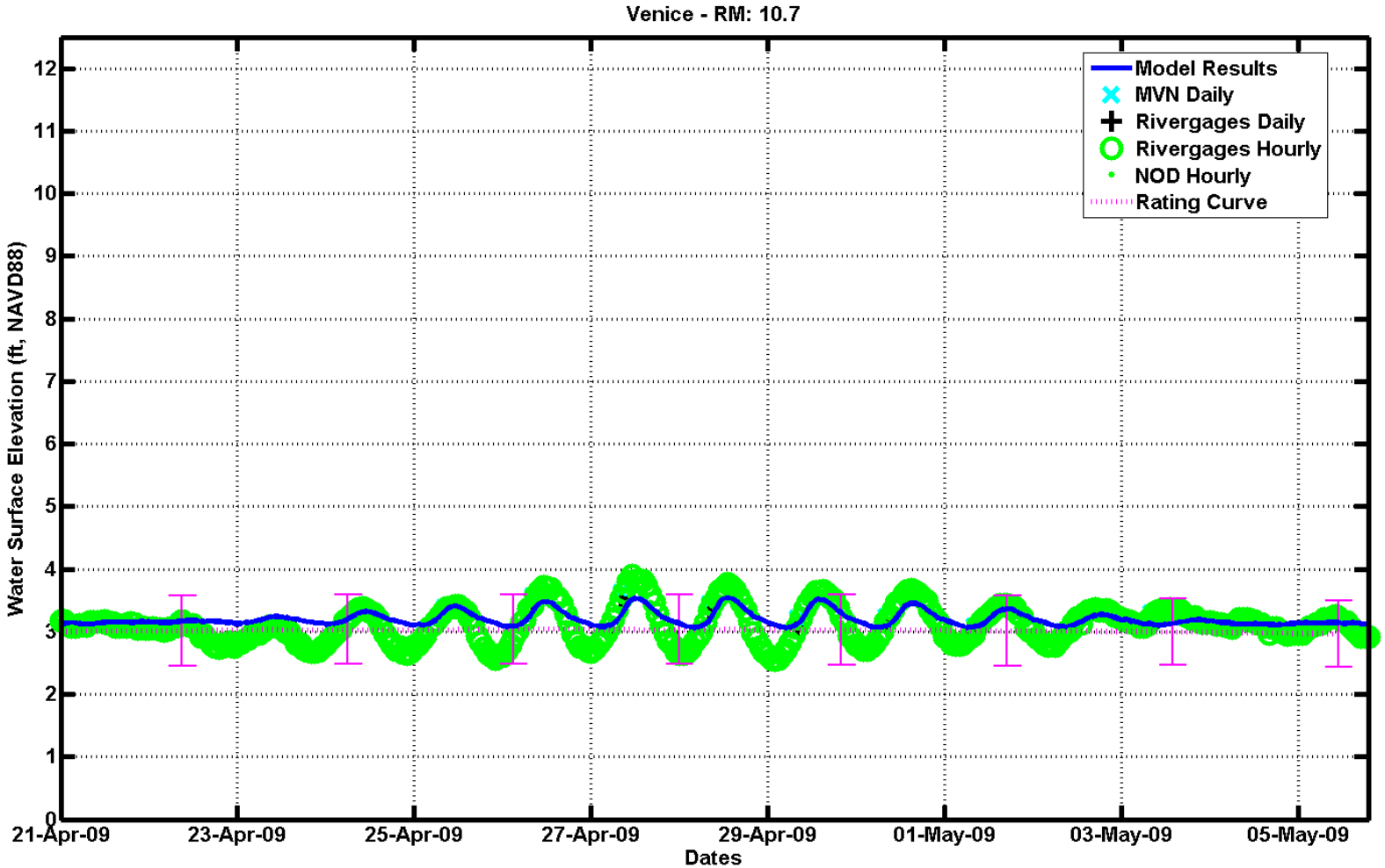
April 21st – May 5th 2009

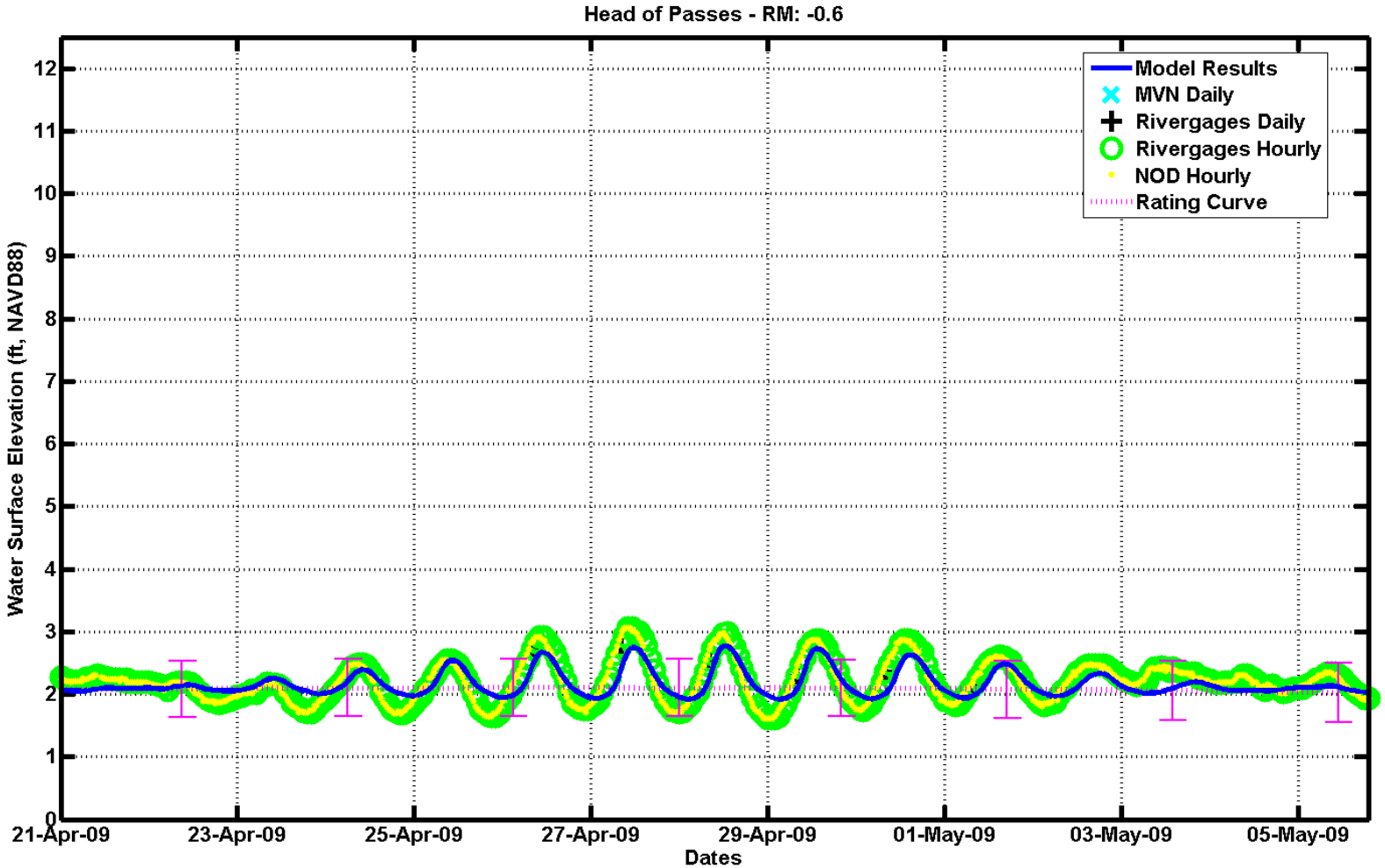
WATER SURFACE ELEVATION TIME SERIES AT SELECTED GAGE LOCATIONS

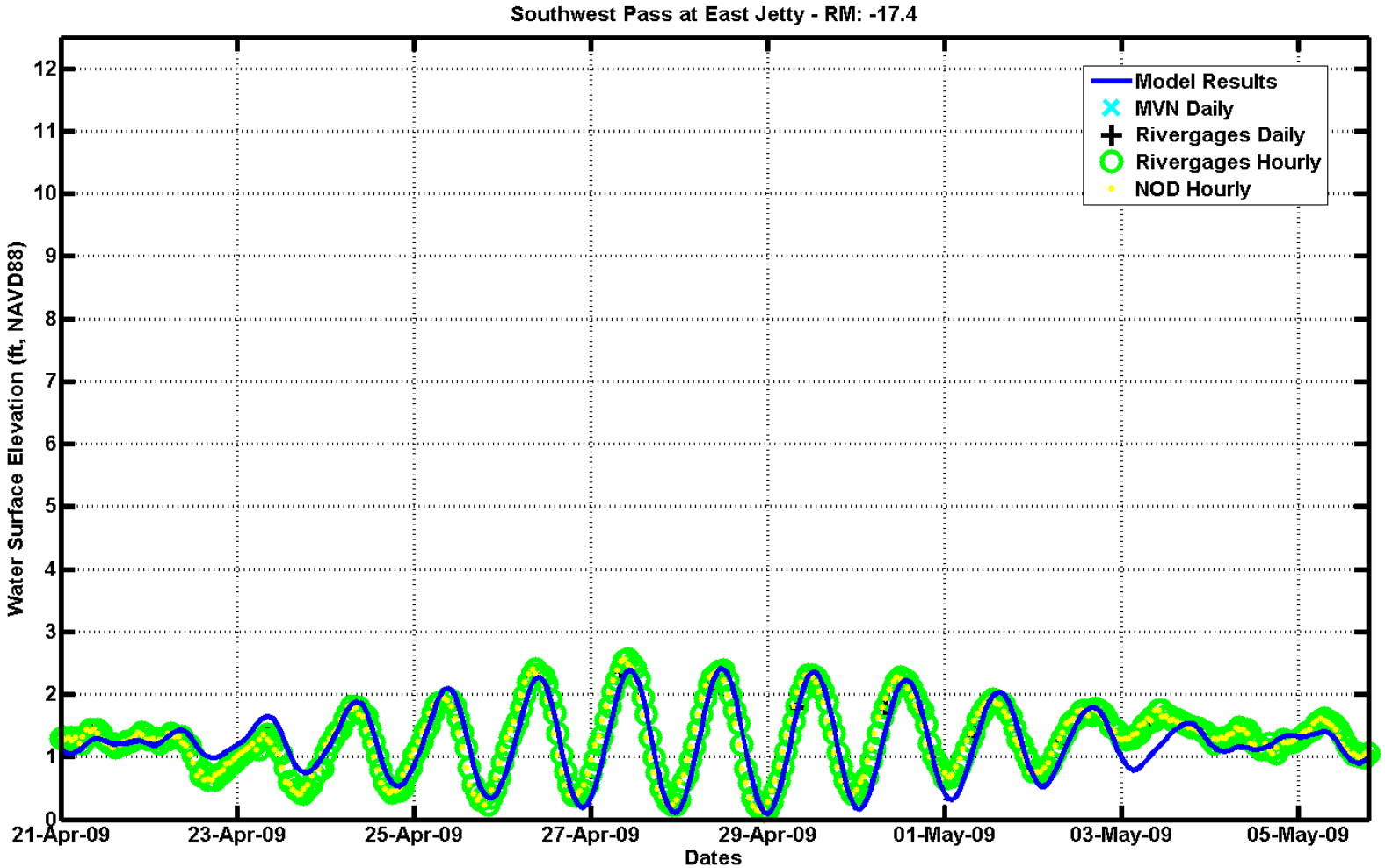

Carrolton - RM: 102.8
Water Surface Elevation (ft, NAVD88)
0
1
2
3
4
5
6
7
8
9
10
11
12
21-Apr-09
23-Apr-09
25-Apr-09
27-Apr-09
29-Apr-09
01-May-09
03-May-09
05-May-09
Dates
Model Results
MVN Daily
Rivergages Daily
NOD Hourly
Rating Curve


Algiers Lock - RM: 88.3
Water Surface Elevation (ft, NAVD88)
12
11
10
9
8
7
6
5
4
3
2
1
0
21-Apr-09
23-Apr-09
25-Apr-09
27-Apr-09
29-Apr-09
01-May-09
03-May-09
05-May-09
Dates
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve


Alliance - RM: 62.5
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve
Water Surface Elevation (ft, NAVD88)
0
1
2
3
4
5
6
7
8
9
10
11
12
21-Apr-09
23-Apr-09
25-Apr-09
27-Apr-09
29-Apr-09
01-May-09
03-May-09
05-May-09
Dates

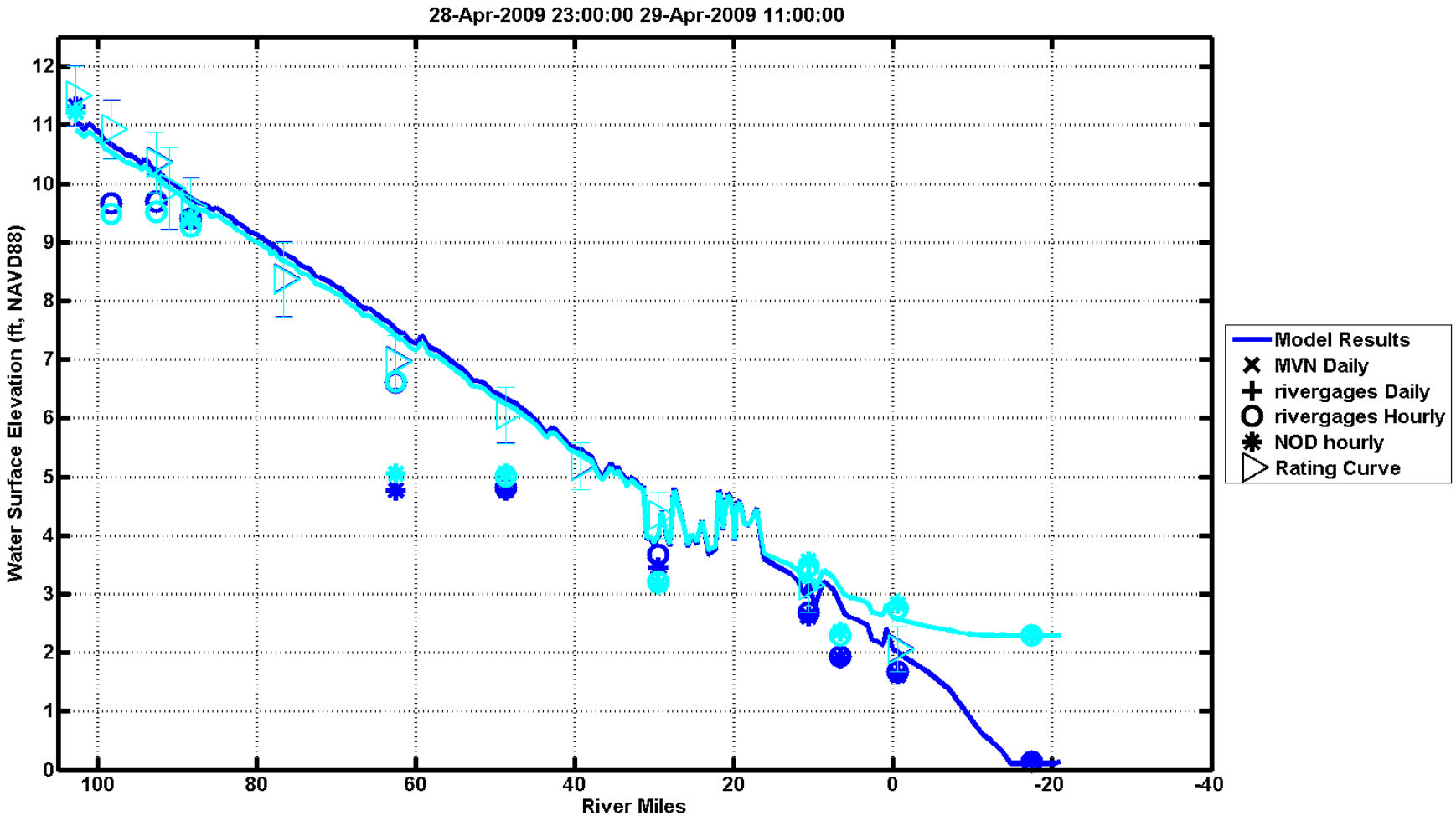

Venice - RM: 10.7
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve
Water Surface Elevation (ft, NAVD88)
0
1
2
3
4
5
6
7
8
9
10
11
12
21-Apr-09
23-Apr-09
25-Apr-09
27-Apr-09
29-Apr-09
01-May-09
03-May-09
05-May-09
Dates


Head of Passes - RM: -0.6
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Rating Curve
Water Surface Elevation (ft, NAVD88)
0
1
2
3
4
5
6
7
8
9
10
11
12
21-Apr-09
23-Apr-09
25-Apr-09
27-Apr-09
29-Apr-09
01-May-09
03-May-09
05-May-09
Dates


Southwest Pass at East Jetty - RM: -17.4
Model Results
MVN Daily
Rivergages Daily
Rivergages Hourly
NOD Hourly
Water Surface Elevation (ft, NAVD88)
0
1
2
3
4
5
6
7
8
9
10
11
12
21-Apr-09
23-Apr-09
25-Apr-09
27-Apr-09
29-Apr-09
01-May-09
03-May-09
05-May-09
Dates

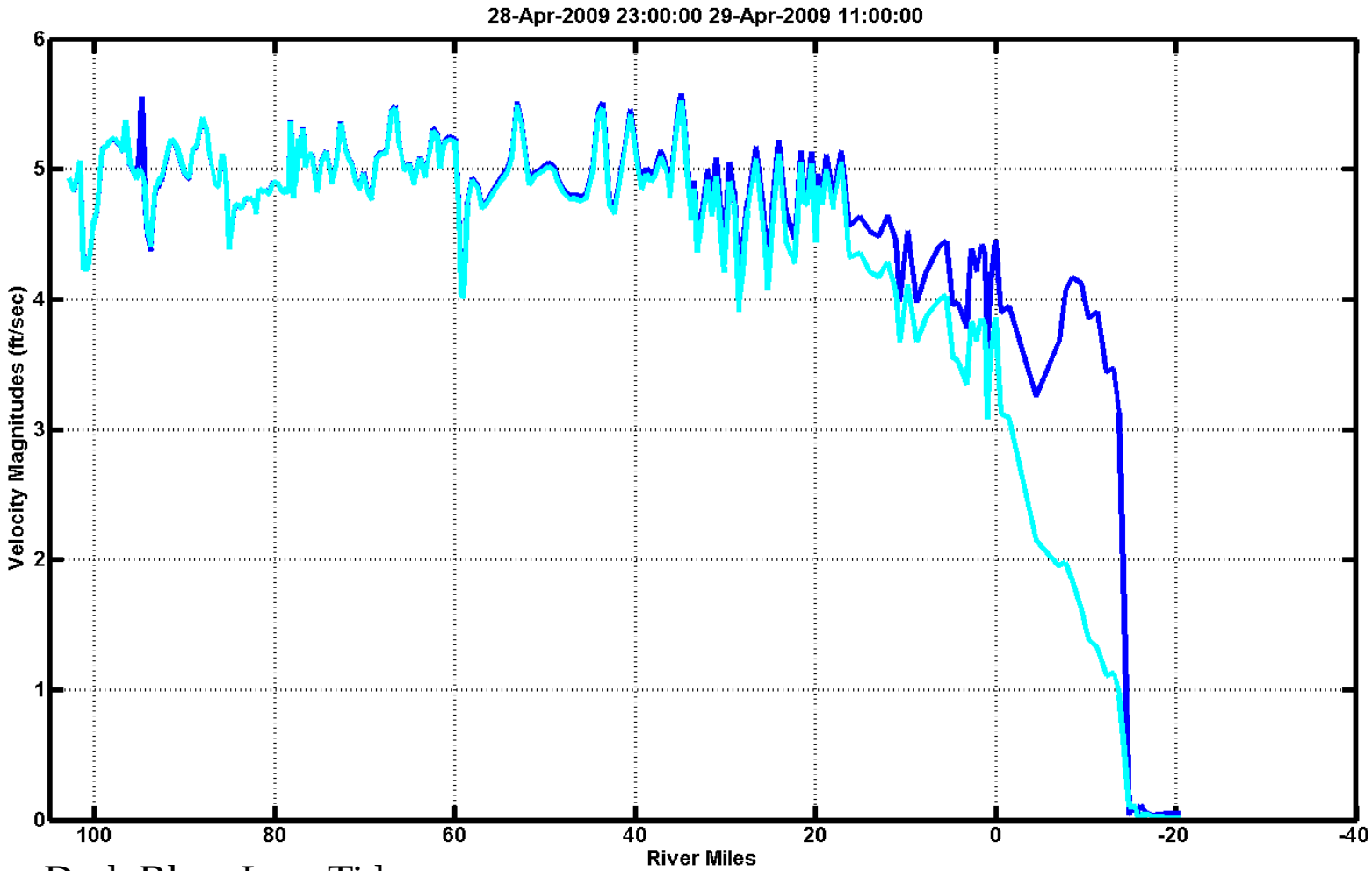
April 21st – May 5th 2009

HIGH TIDE VS. LOW TIDE



Dark Blue: Low Tide
Light Blue: High Tide

- River discharge is almost constant (800,000 cfs)
- Tidal variation is maximum between the two times that are shown.



Dark Blue: Low Tide
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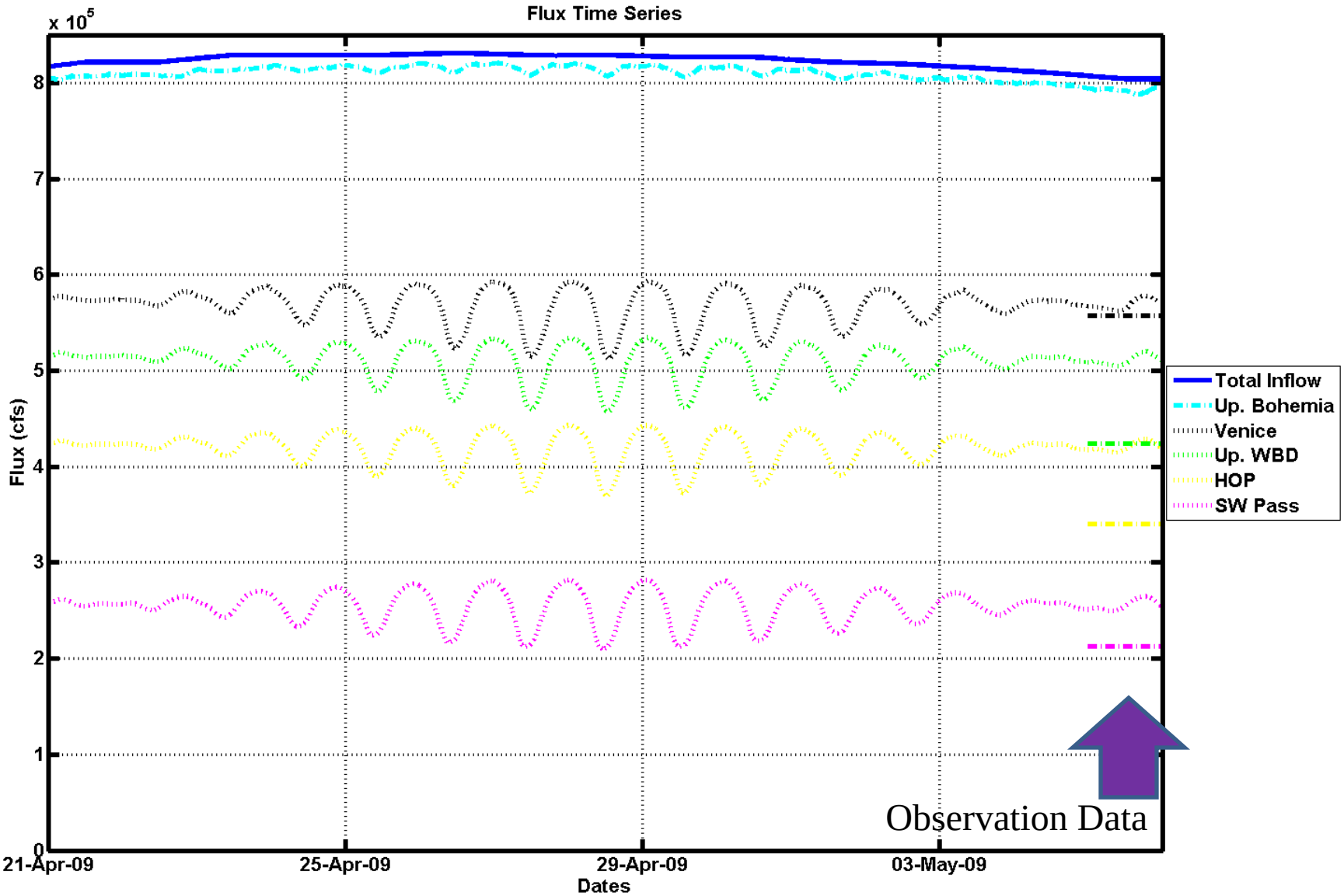
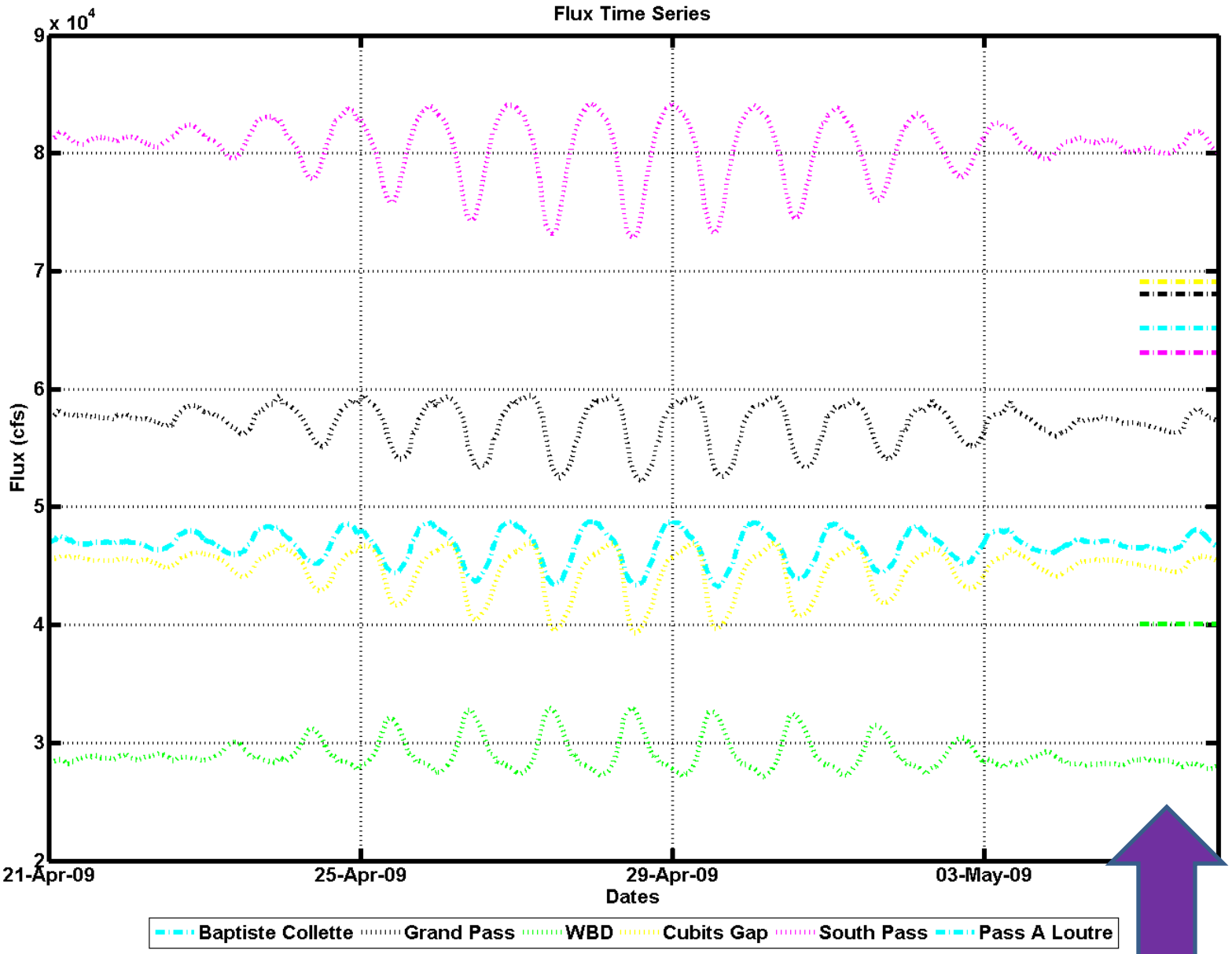
April 21st – May 5th 2009

TIME SERIES FOR FLUXES ACROSS DIFFERENT RIVER X-SECTIONS AND PASSES

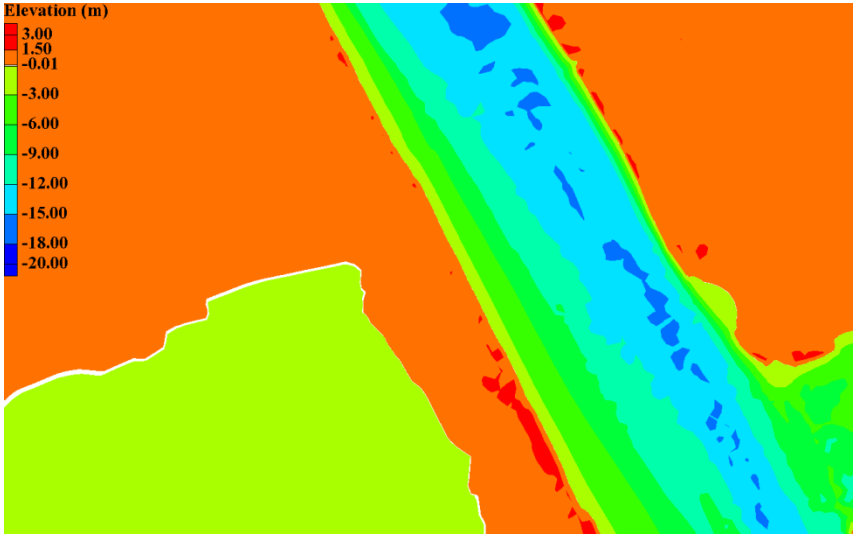

Flux Time Series
x 10^5
8
7
6
5
4
3
2
1
0
Flux (cfs)
21-Apr-09
25-Apr-09
29-Apr-09
03-May-09
Dates
Total Inflow
Up. Bohemia
Venice
Up. WBD
HOP
SW Pass
Observation Data



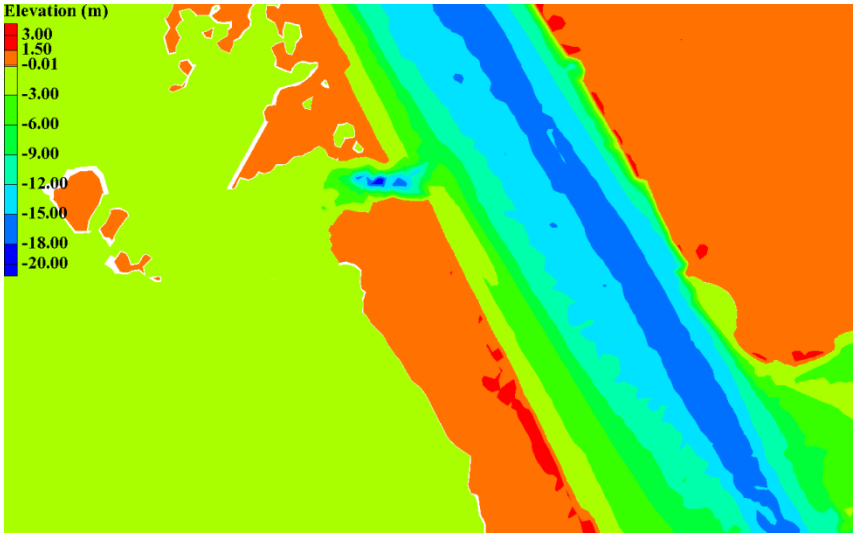
Observation Data

West Bay Diversion

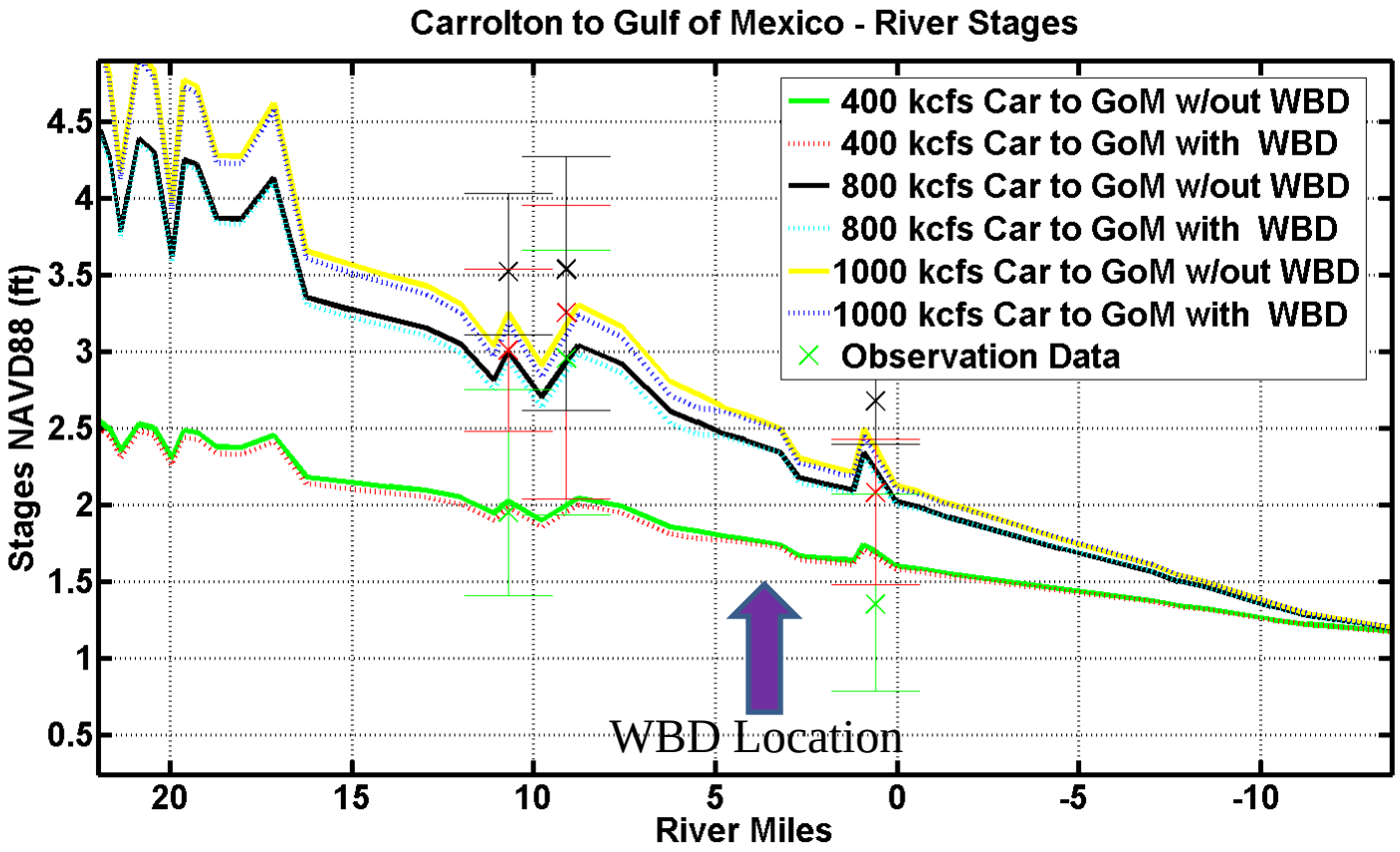
Without WBD



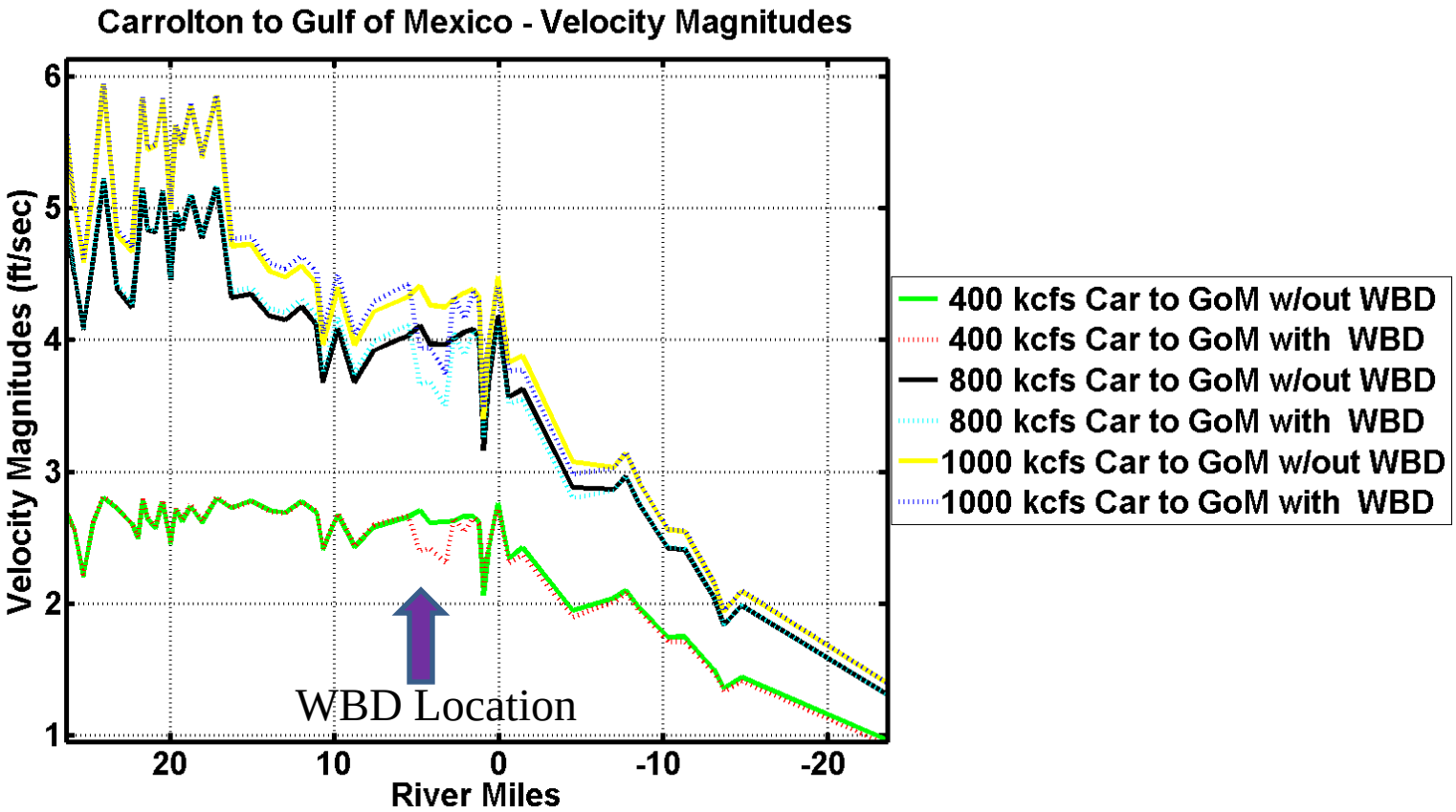
With WBD



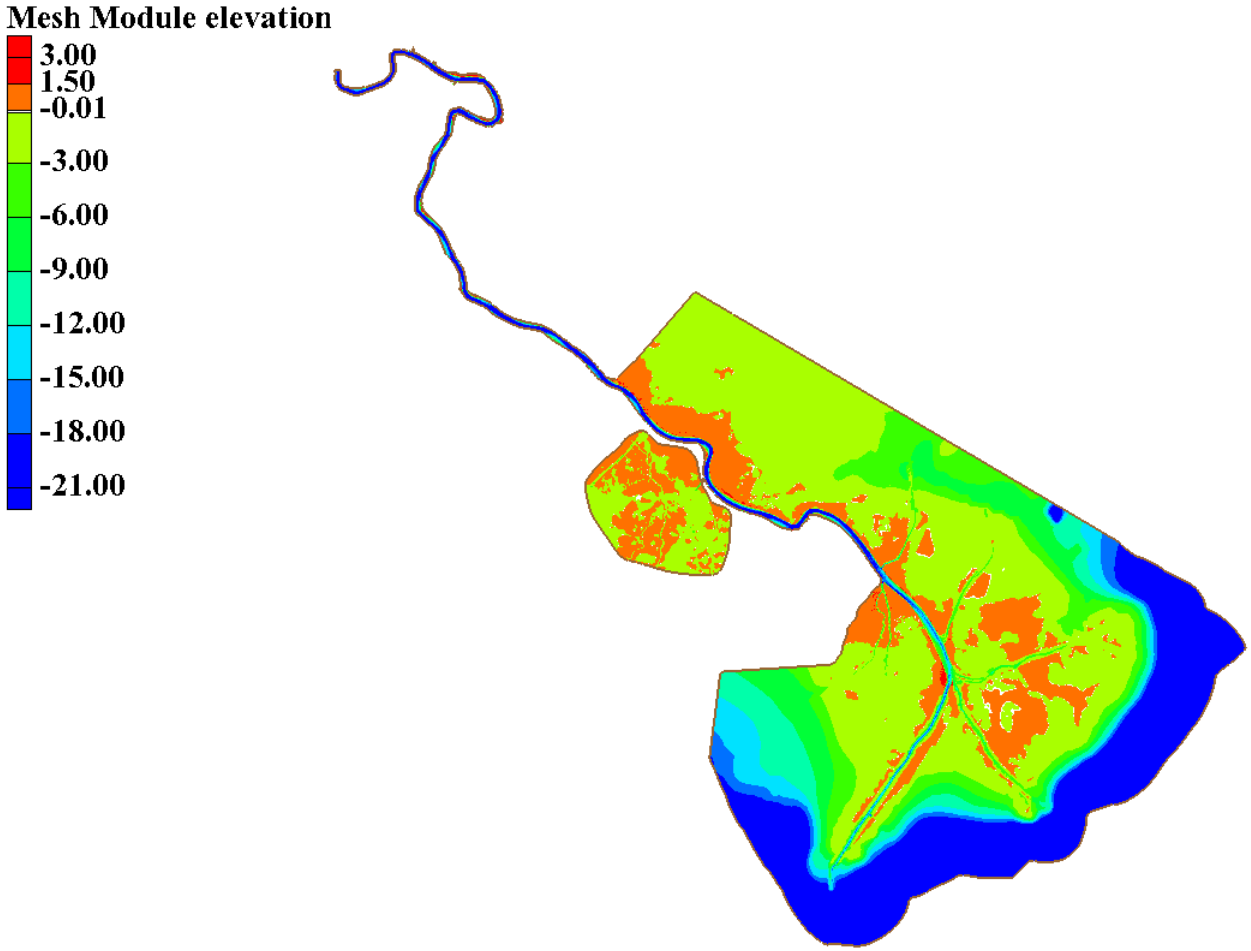
West Bay Diversion - WSE



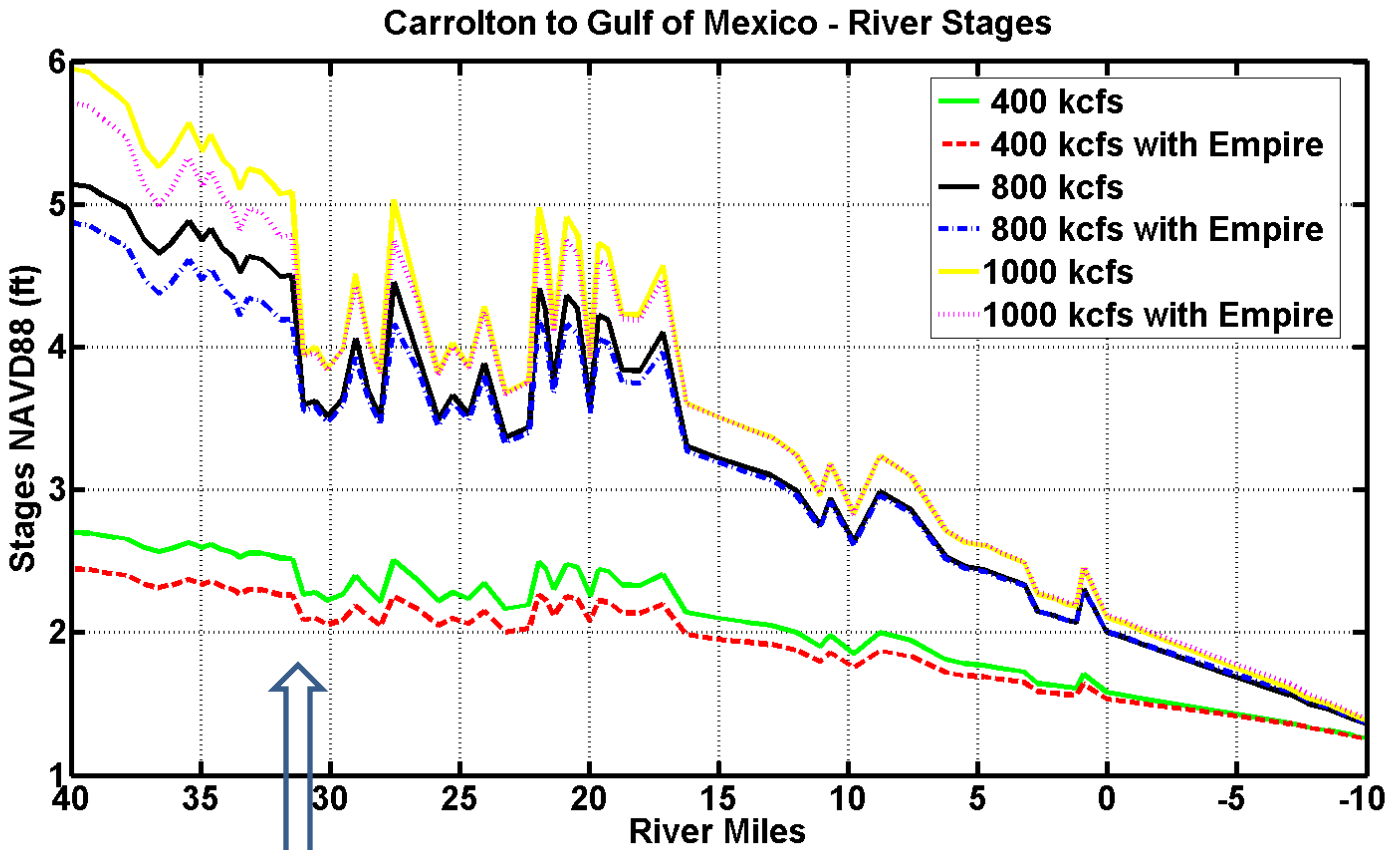
West Bay Diversion Velocity Magnitudes



Current Mesh with Empire Area

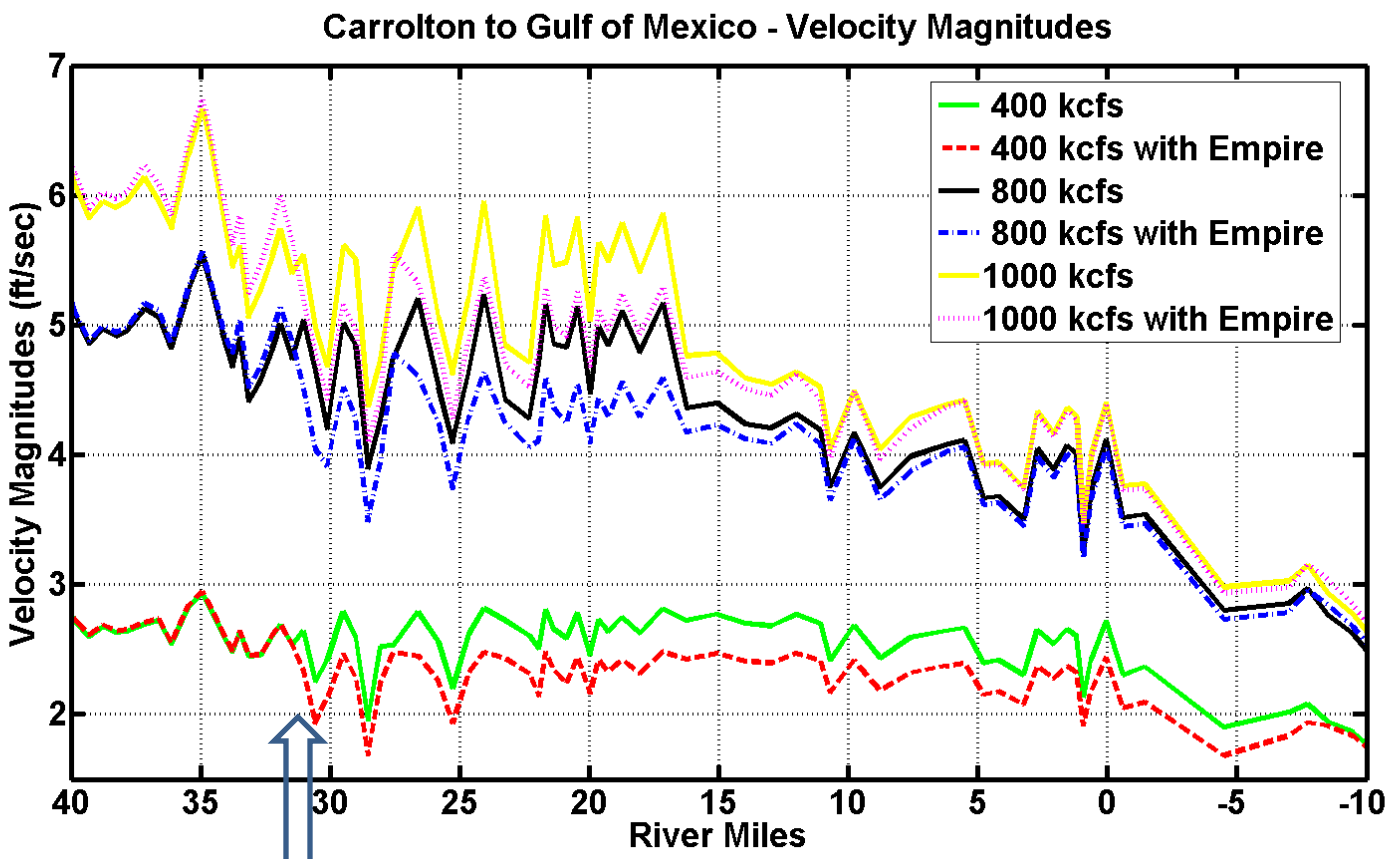


River Stages vs. River Miles Around Empire Area



Hypothetical Diversion

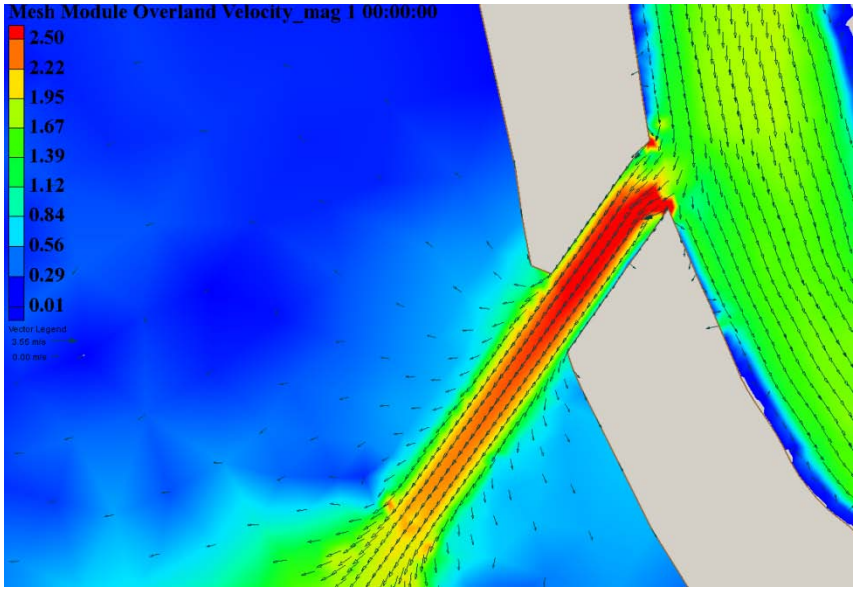
Velocity Magnitudes vs. River Miles Around Empire Area



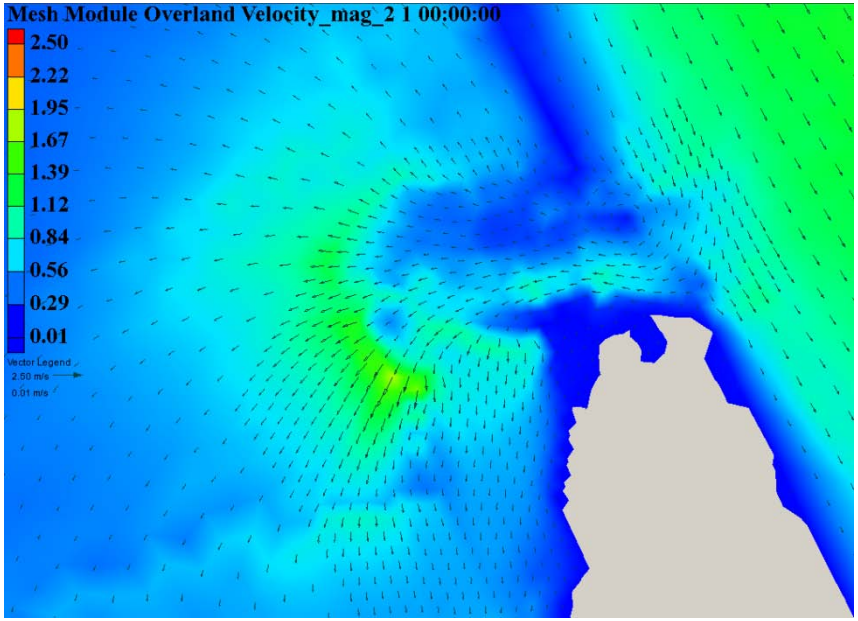
Hypothetical Diversion

Different Diversion Entrances

Empire Diversion



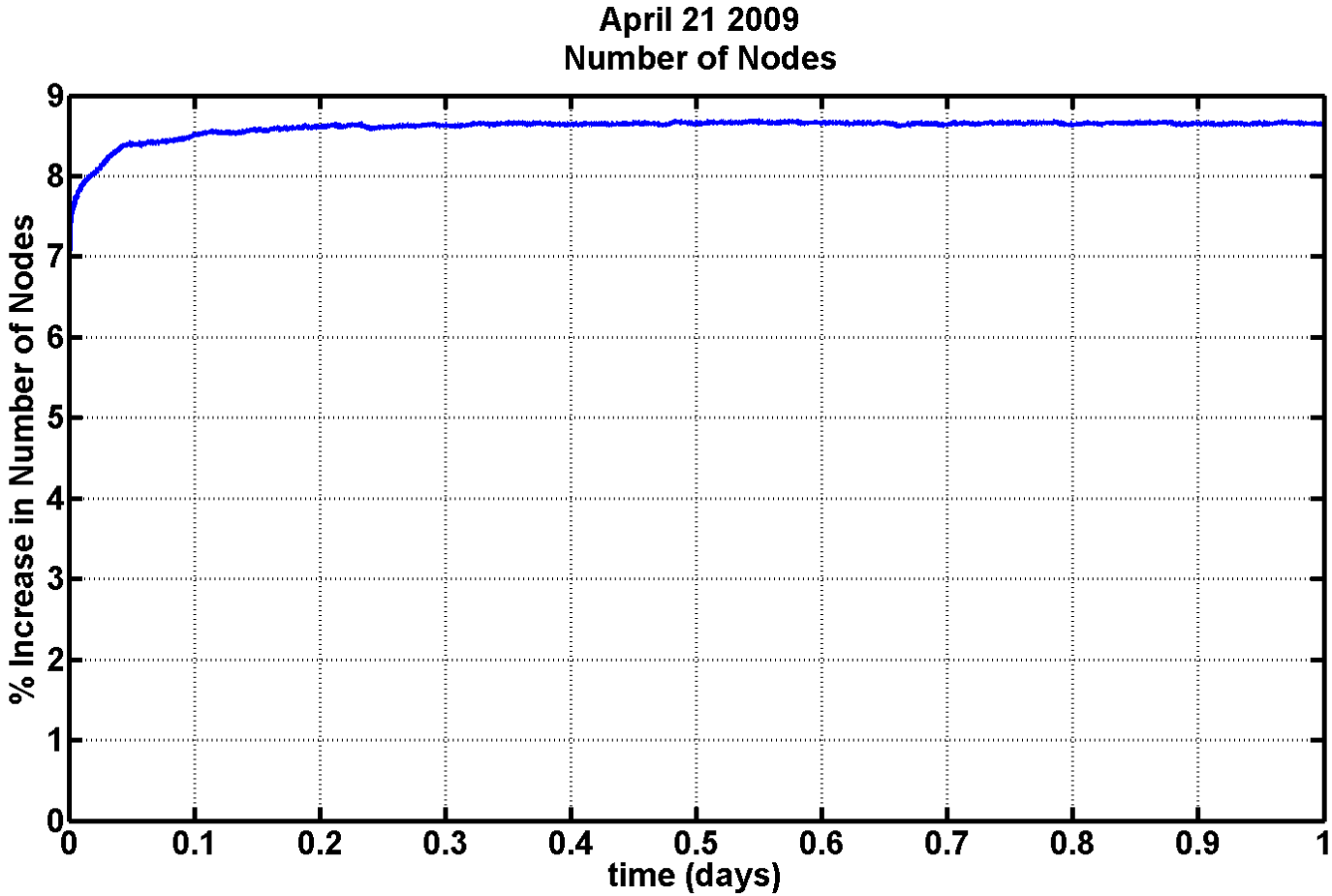
West Bay Diversion



10 m deep
244 m wide
Better Shape and Angle

ADAPTION ON VS. ADAPTION OFF

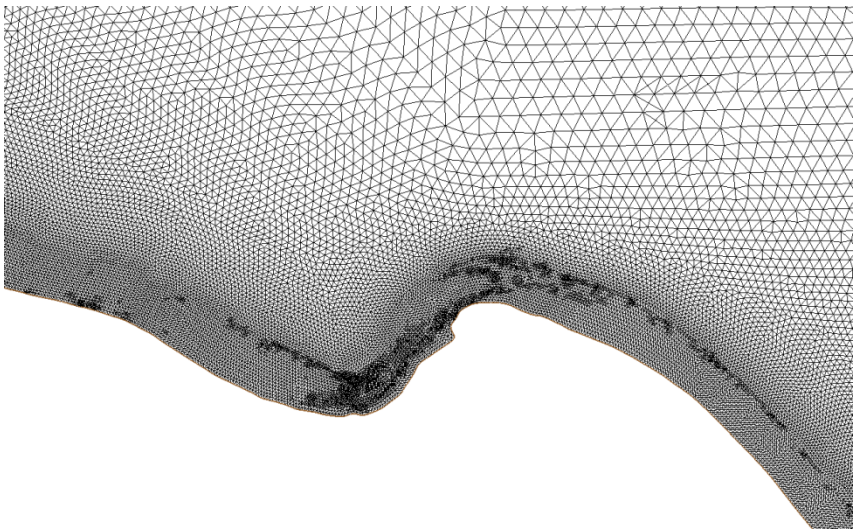
Change in # of Nodes



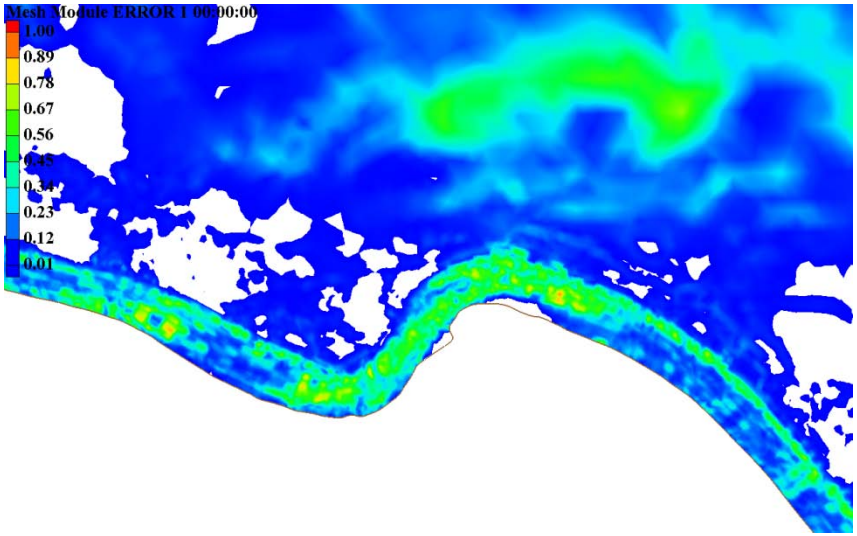
With adaption on, the elapsed time was 3.6 times of the run with adaption off.

MP ML 1 3
MP SRT 1 50

Adapted Mesh at 86400 sec

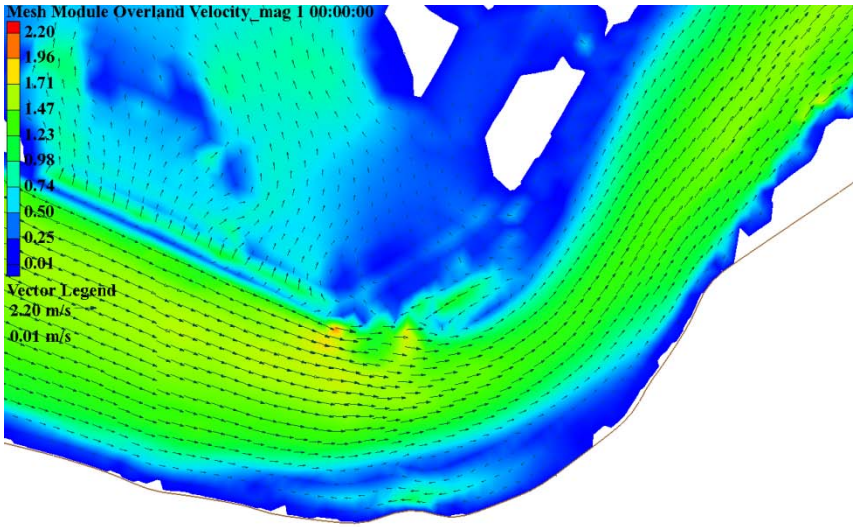


Error Values at 86400 sec

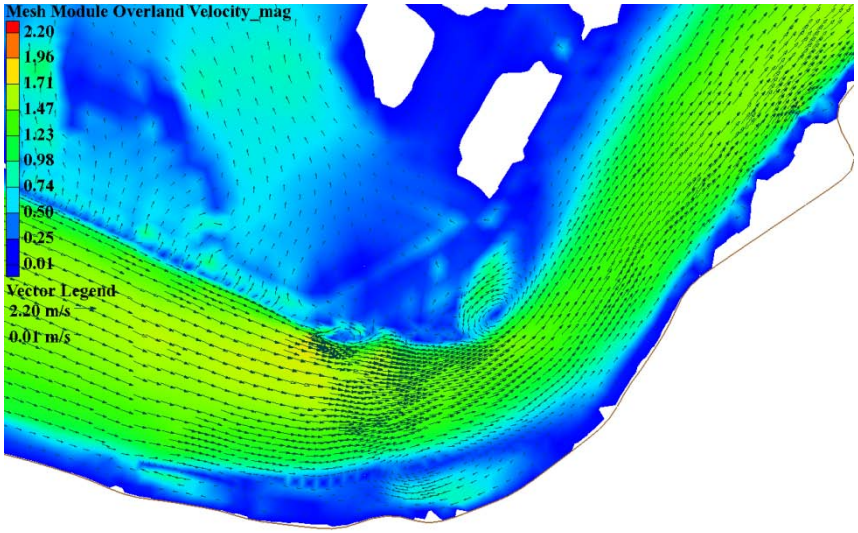


Velocity Contours

Adaption Off



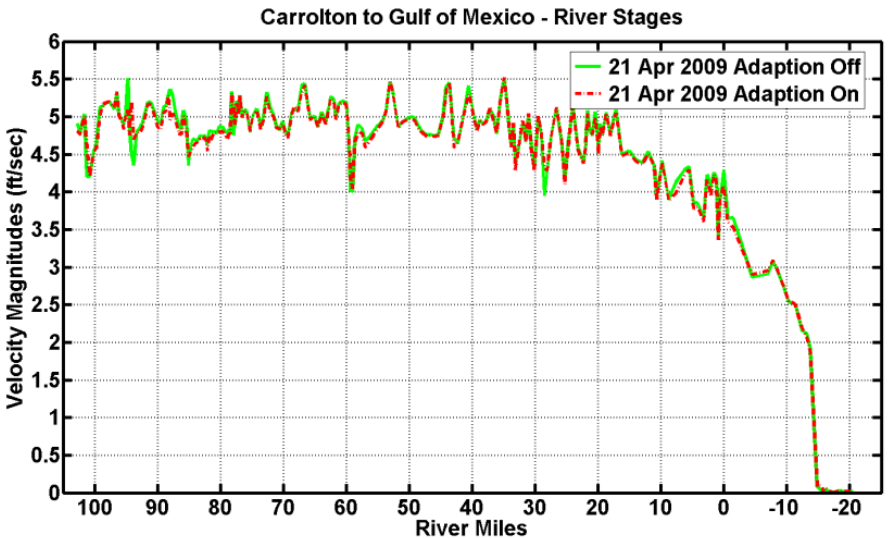
Adaption On



Comparison Along Main Channel

Water Surface Elevation

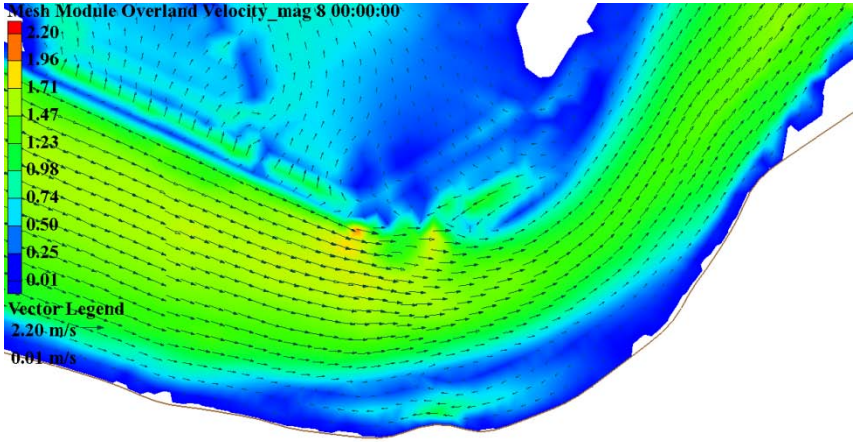
Velocity Magnitudes



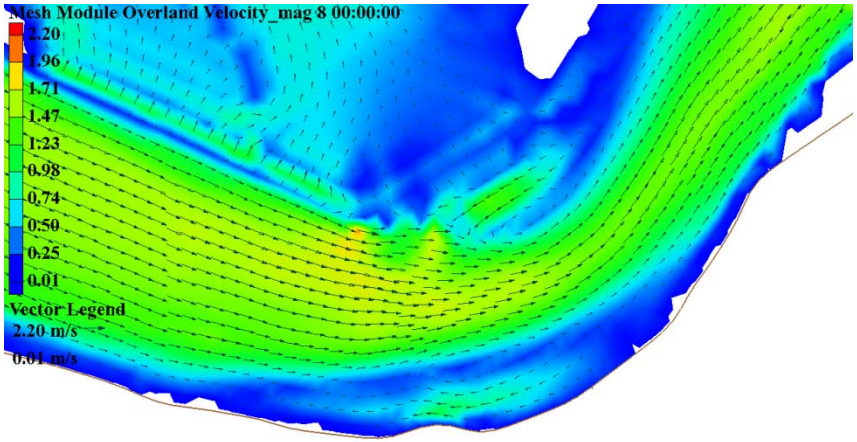
VORTICITY ON VS. VORTICITY OFF

Velocity Contours

Vorticity Off

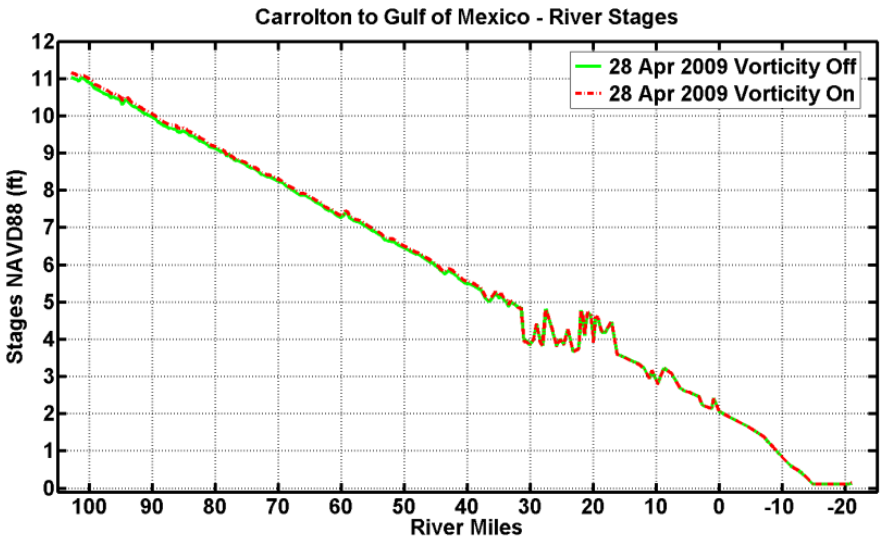


Vorticity On



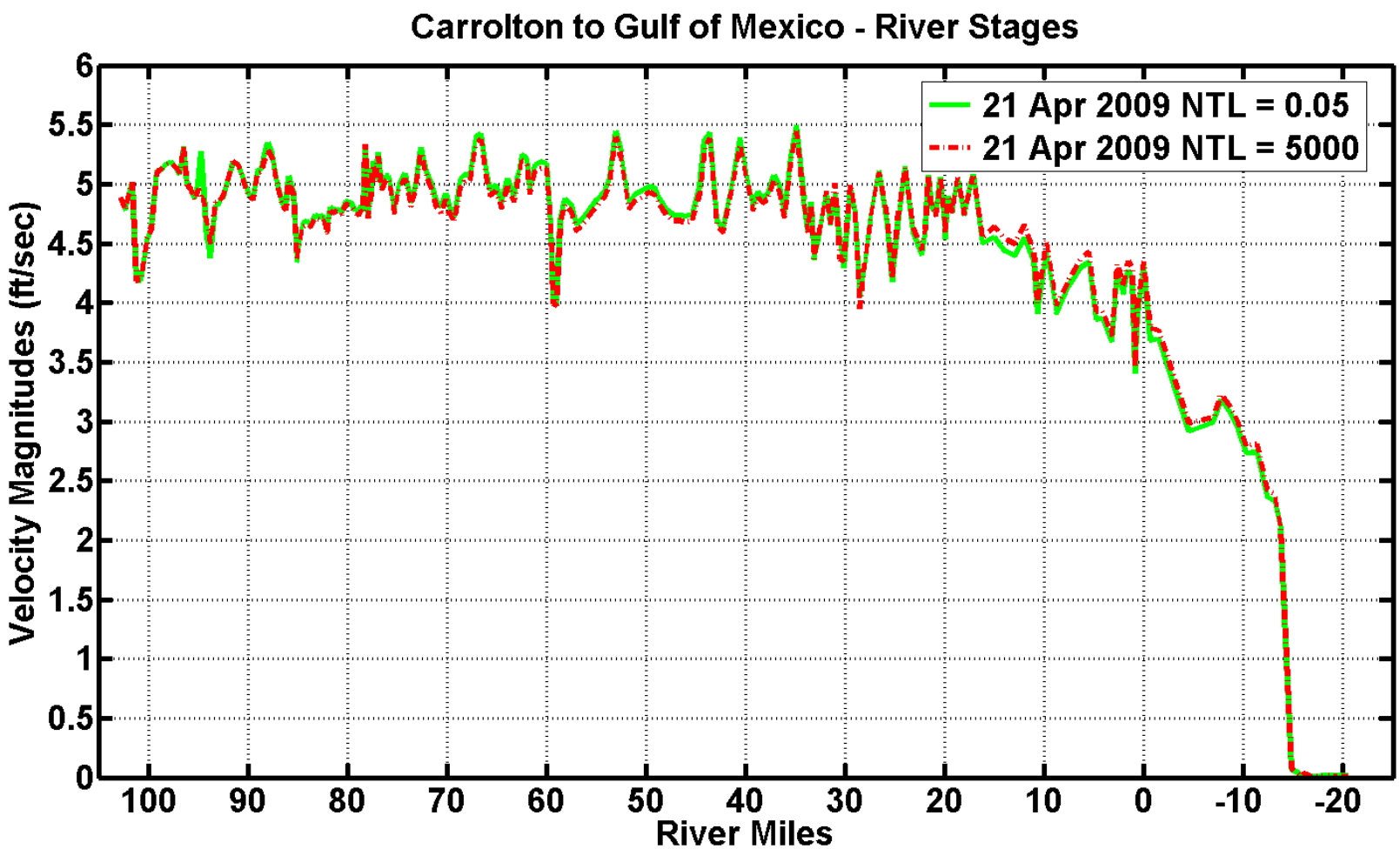
Comparison Along Main Channel

Water Surface Elevation



Velocity Magnitudes

TOLERANCE FOR NON-LINEAR EQUATIONS



With a lower NTL value, the elapsed time was ~16 times of the run with a higher NTL value.

Conclusions

- Simulated river stages by the model match with existing conditions except for the stretch of the river between RM 90 and 70.
- A reasonable agreement is achieved between model results and observation data for the distribution of flow at several River cross sections and through Lower River Passes.
- Tail water elevation has a more significant effect on the upstream stages at low flow rates while there is still a little effect at the medium and high flow rate.
- Higher tail water elevations increase the overflowing around Empire, Fort Jackson and downstream of Venice.
- The model results for simulating certain events is promising for the future although it under estimates flow through some of the passes and over estimates river stages upstream of River Mile 50.
- According to the model results, the impacts of West Bay and hypothetical Empire Diversion openings are not significant on the river stages.
- Those structures decreased the velocity magnitudes along a small stretch of the river around their neighboring areas.
- Further understanding is needed for the selection of tolerance value for non-linear iterations.
- In the current mesh conditions, adaption and bendway correction do not improve results.