# Appendices

Appendix A – SWMM Model Documentation

Appendix B – CSO Diagrams and Coordinates

Appendix C - Water Quality Model Documentation

Appendix D – Basis for Cost Estimates

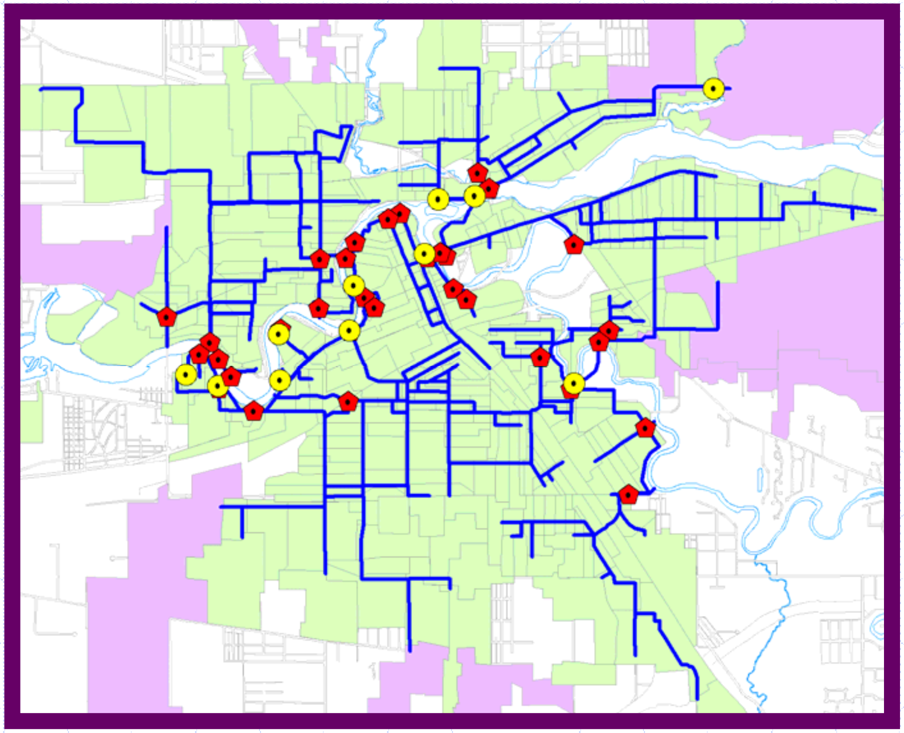
Appendix E – Public Participation Documentation

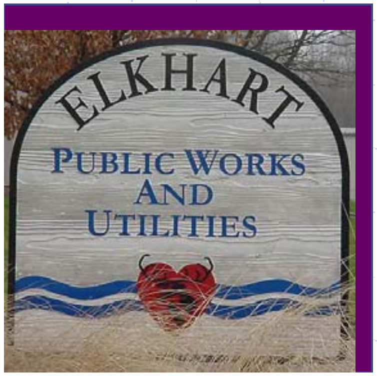
# Appendix A

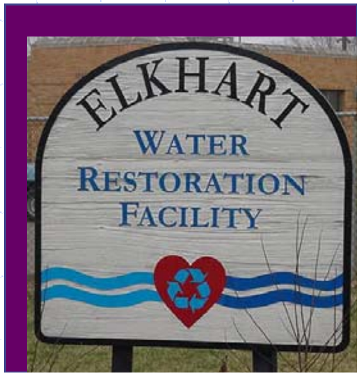
## SWMM Model Documentation

# City of Elkhart

## Combined Sewer System (CSS) - Model Development and Calibration



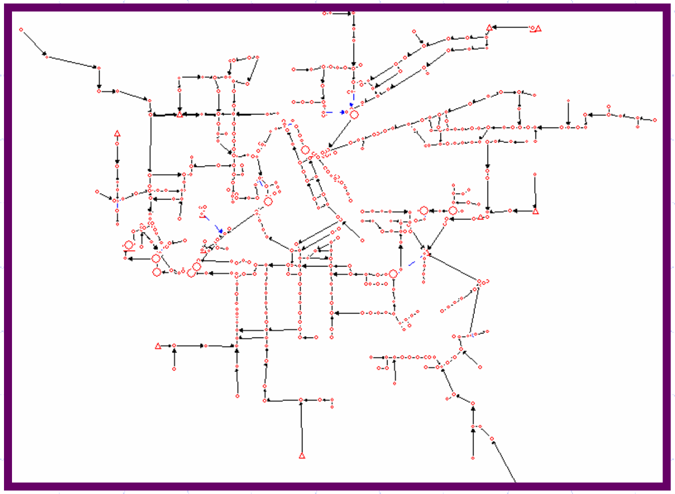



April 12, 2006

# Agenda

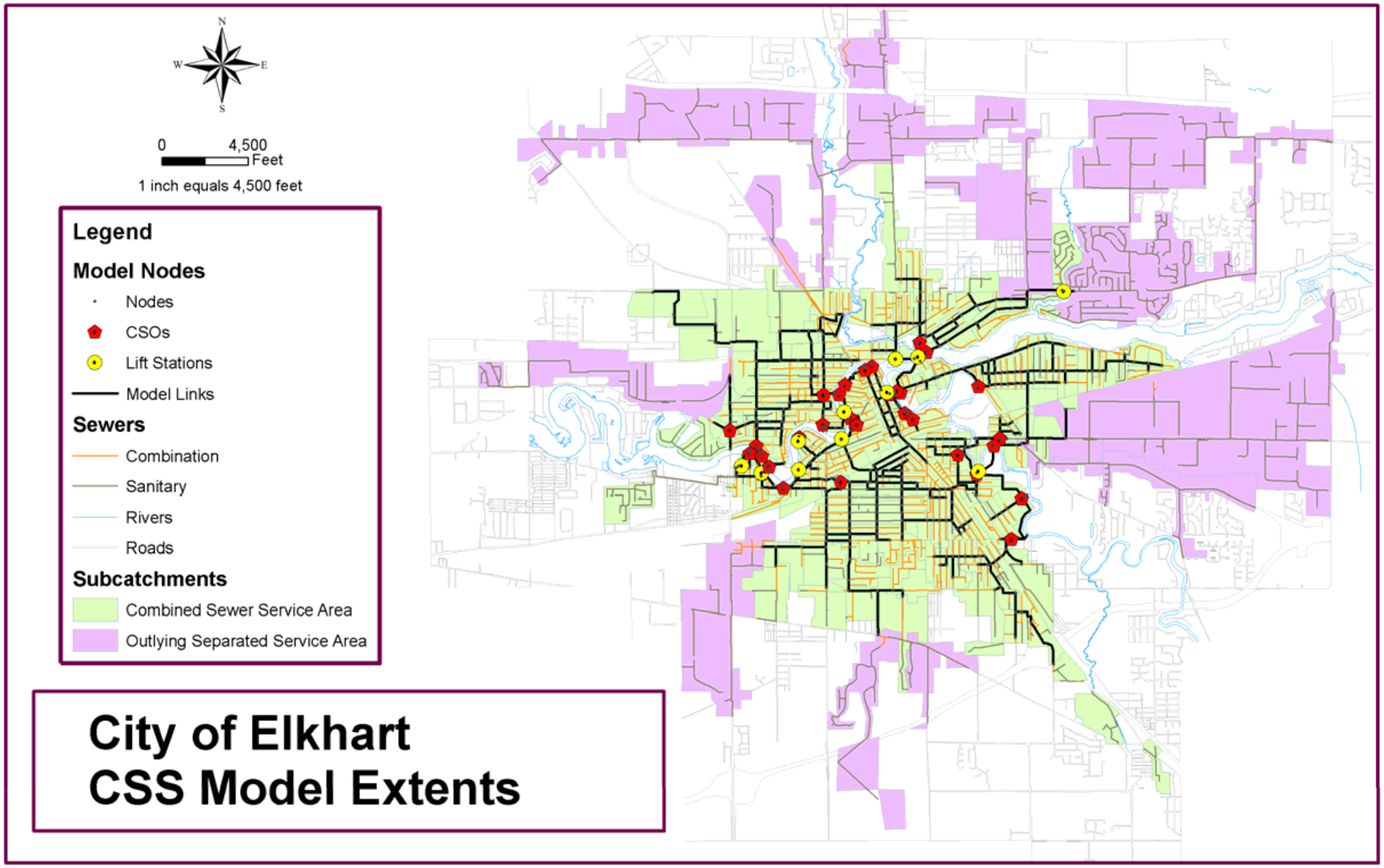
1. Model Development
   - CSS Model History
   - Collection System Network
   - Collection System Drainage Areas
2. Collection System Monitoring
3. Model Calibration
   - Dry Weather (DW)
   - Wet Weather (WW)



# CSS Model Refinements

1. 1991/1994: Base model developed
2. 2001: Converted to XP-SWMM v. 6.02 with initial comparisons to data.
3. 2003: Upgraded to XP-SWMM v. 8.52 and began system-wide model calibration.
4. 2006: Completed LTCP model calibration.

# Collection System Network - Extents



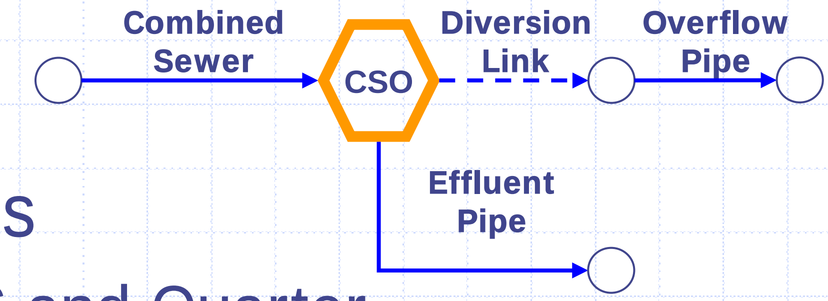
# Collection System Network - Extents

| Summary Parameters | Combined Sewer System | CSS Model |
|---|---|---|
| Length of Sewers (ft) | ~1,385,000 | ~295,000 |
| Pipe Diameter Range (in) | 3 - 80 | 6 - 78 |
| Number of Active Combined Sewer Overflows (CSOs) | 33[1] | 34[1] |
| Number of Lift Stations (LSs) | 60 | 11 |

Notes

1. CSO#2 was recently removed from the CSS, but it was still active during the 2004-05 monitoring program.

# Collection System Network - CSOs




1. Information Sources
   - Rim elevation – GIS and Quarter Section Drawings
   - Pipe sizes, invert elevations, and overflow elevations - 2000 field survey data
   - Available as-built drawings
   - Current system knowledge

# Collection System Network - Lift Stations

1. LS Representation Enhancements
   - Upgraded 5 key LSs to “dynamic head” pumps.
   - Updated modeled pumping rates for all LSs based on design points and available 2004-05 discharge flow monitoring data.

# Collection System Network - Influent Screw Pumps

1. Refined WWTP representation to limit influent flows.
   - Maximum Flow: 44 mgd
2. Influent screw pumps often surcharge the 54-inch Laramie St Interceptor during/after “good steady” rainfall.

# Collection System Drainage Areas - Extents

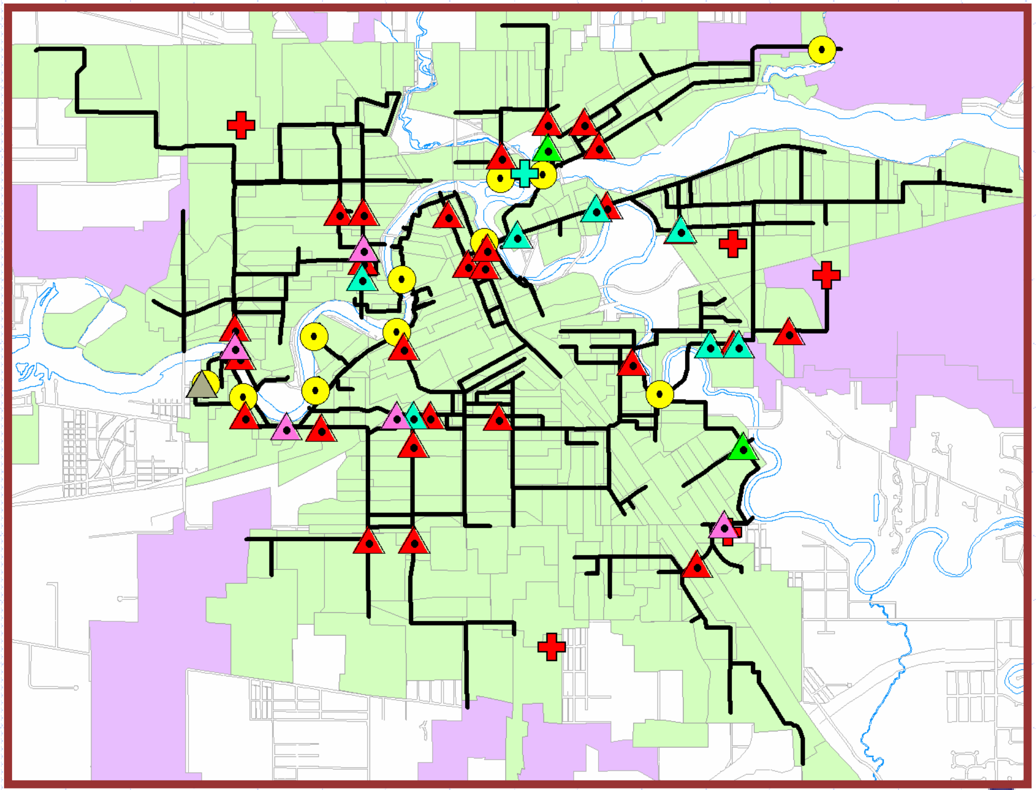
| Summary Parameters | CSS Model |
|---|---|
| Total Tributary Area (acs) | 14,883 |
| Outlying Separated Service Area (acs) | 7,836 |
| Combined Sewer Service Area (acs) | 7,047 |
| Number of Subcatchments | 399 |
| Average Size (acs) | ~37 |
| Size Range (acs) | 0.25 – 1,945 |

# Collection System Drainage Areas: Hydrology Refinements

| Service Area Type | Percent Of Total Service Area | Wet Weather Response Type |
|---|---|---|
| Outlying Separated Service Area | 53% | Rainfall-derived I/I |
| Combined Service Areas | 28% | Typical rapid surface runoff |
| Combined Service Areas with local separation | 19% | Lower magnitude rapid surface runoff |

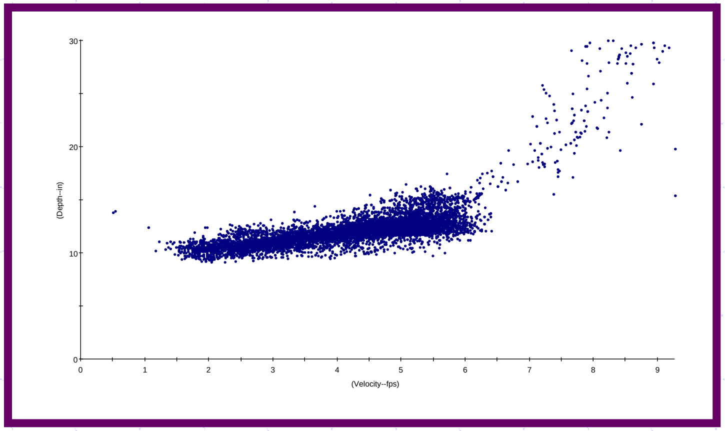
# Collection System Monitoring – Summary

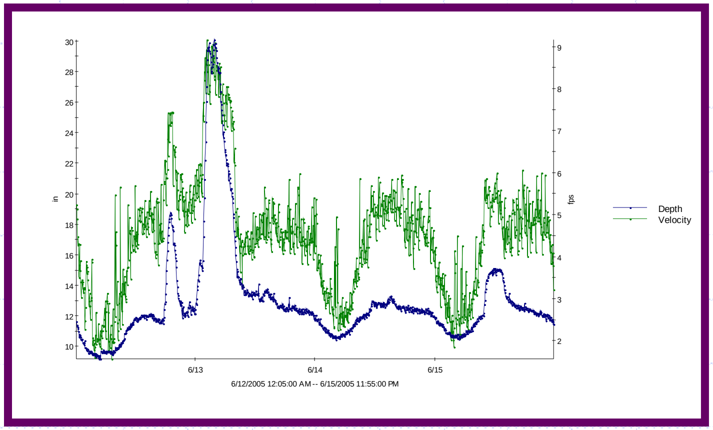
1. 1999: Initial data comparisons
2. 2002-04: LTCP field monitoring initiated
3. 2003: CSO outfall metering
4. 2004-05
   - 25 meters
   - 5 gauges
   - 11 LSs
   - 5 CSOs
   - WWTP



# Collection System Monitoring – QA/QC Tasks

1. Depth, velocity, and flow hydrographs
2. Depth-velocity scatter plots
3. Flow calculations verified using the continuity equation
4. Dry weather flow balance
5. Peak flow comparisons



# Collection System Monitoring – Data Available for Calibration

*See schematic handout.*

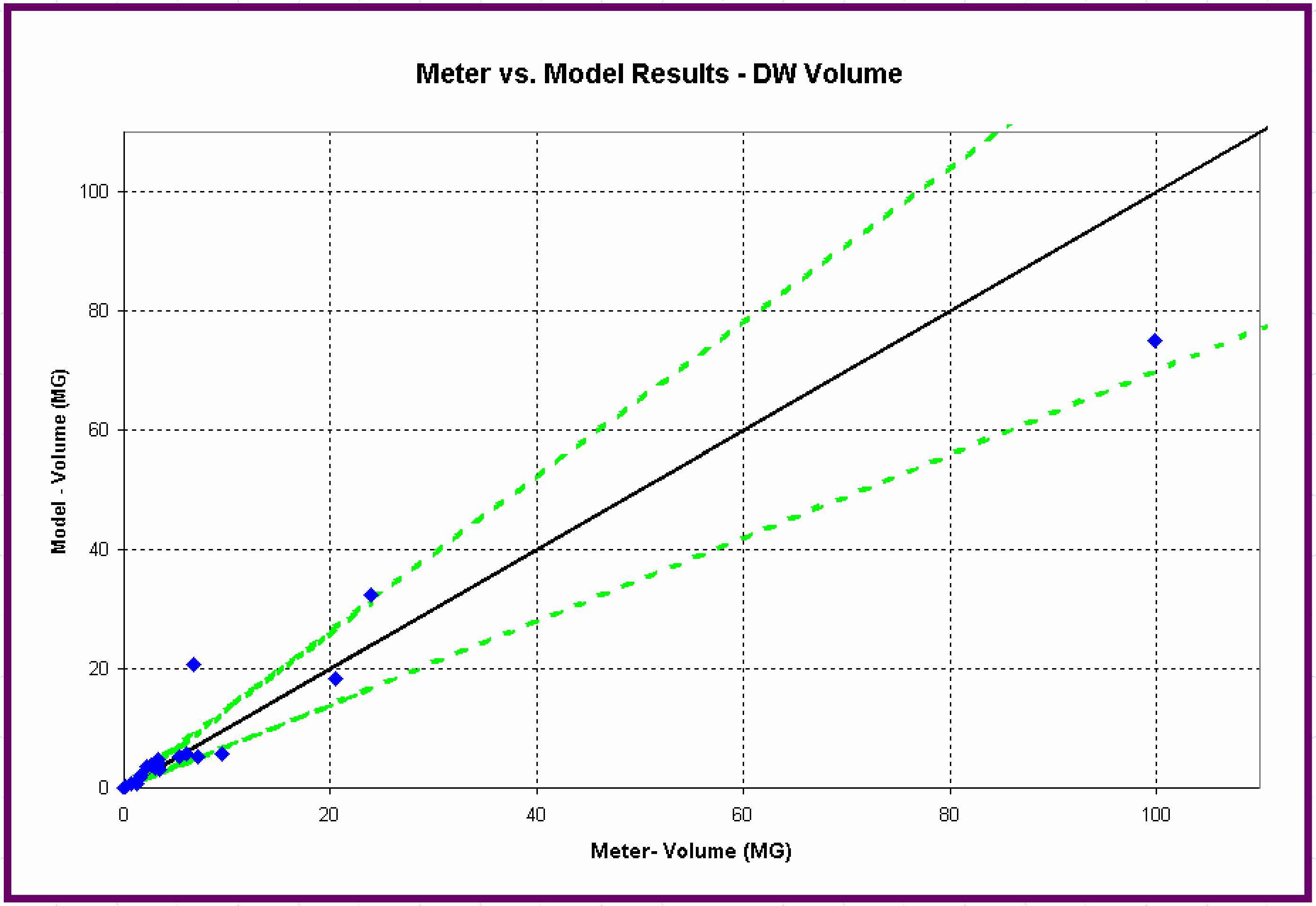
# Model Calibration

1. Calibration consists of adjusting model parameters within reasonable ranges to obtain simulated results that closely replicate field-monitored flows and depths.
2. Calibration Measures: Hydrograph shape, total volume, and peak flow.
3. Calibration Goals: + or -30%, for flow meters with acceptable data.
   - Within typical range for planning level models

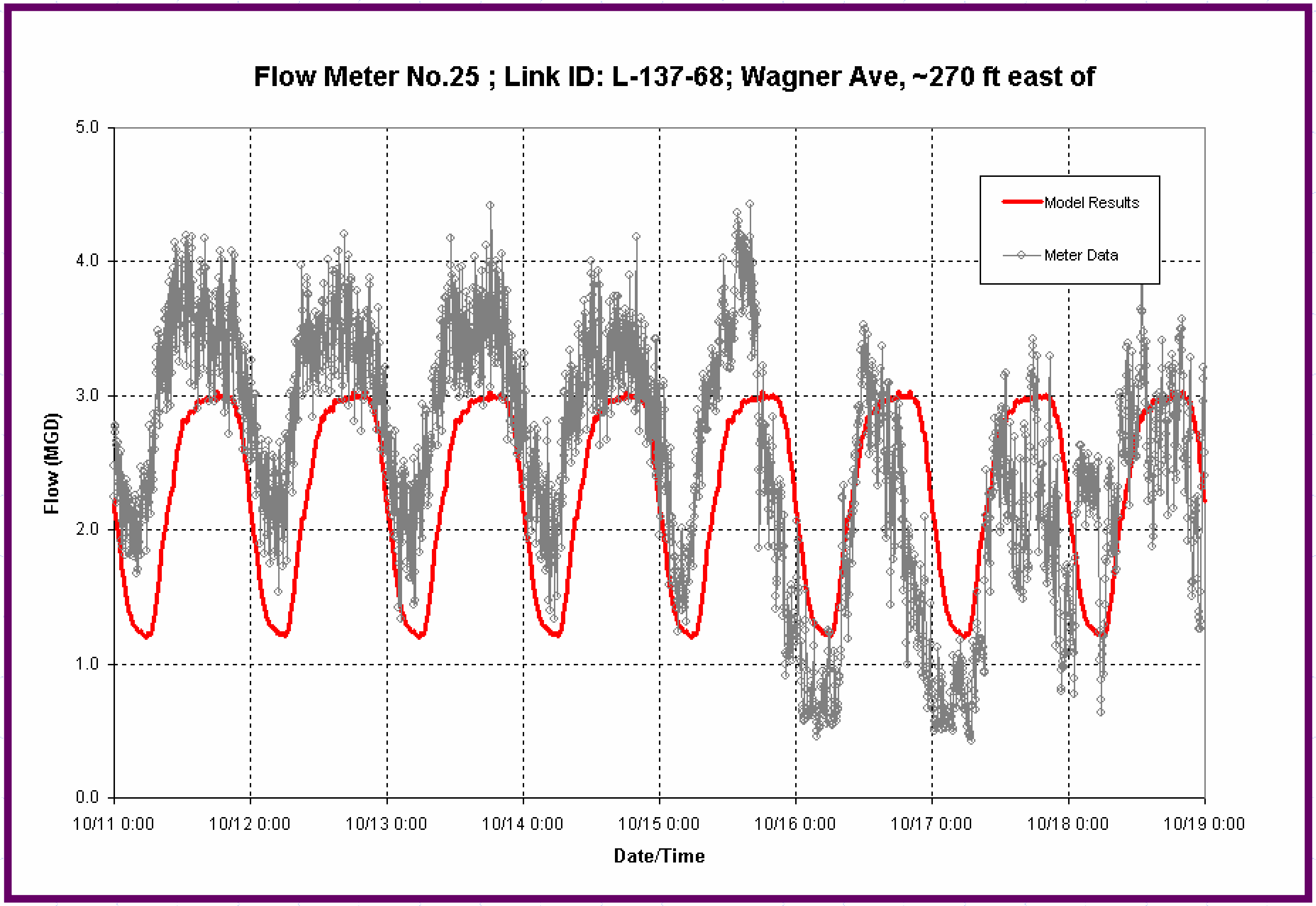
# Model Calibration – Dry Weather

1. Purpose:
   - Check hydraulic model for connectivity issues
   - Provide accurate baseline for wet weather simulations
2. Calibration Approach
   - Primary Data: In-system flow meter and WWTP influent flow data from Oct. 11-22nd and Nov.13-14, 2004
   - Supplementary Data: LS discharge volumes from Nov. 2004.

# Model Calibration – DW Calibration Results



# Model Calibration – DW Calibration Results

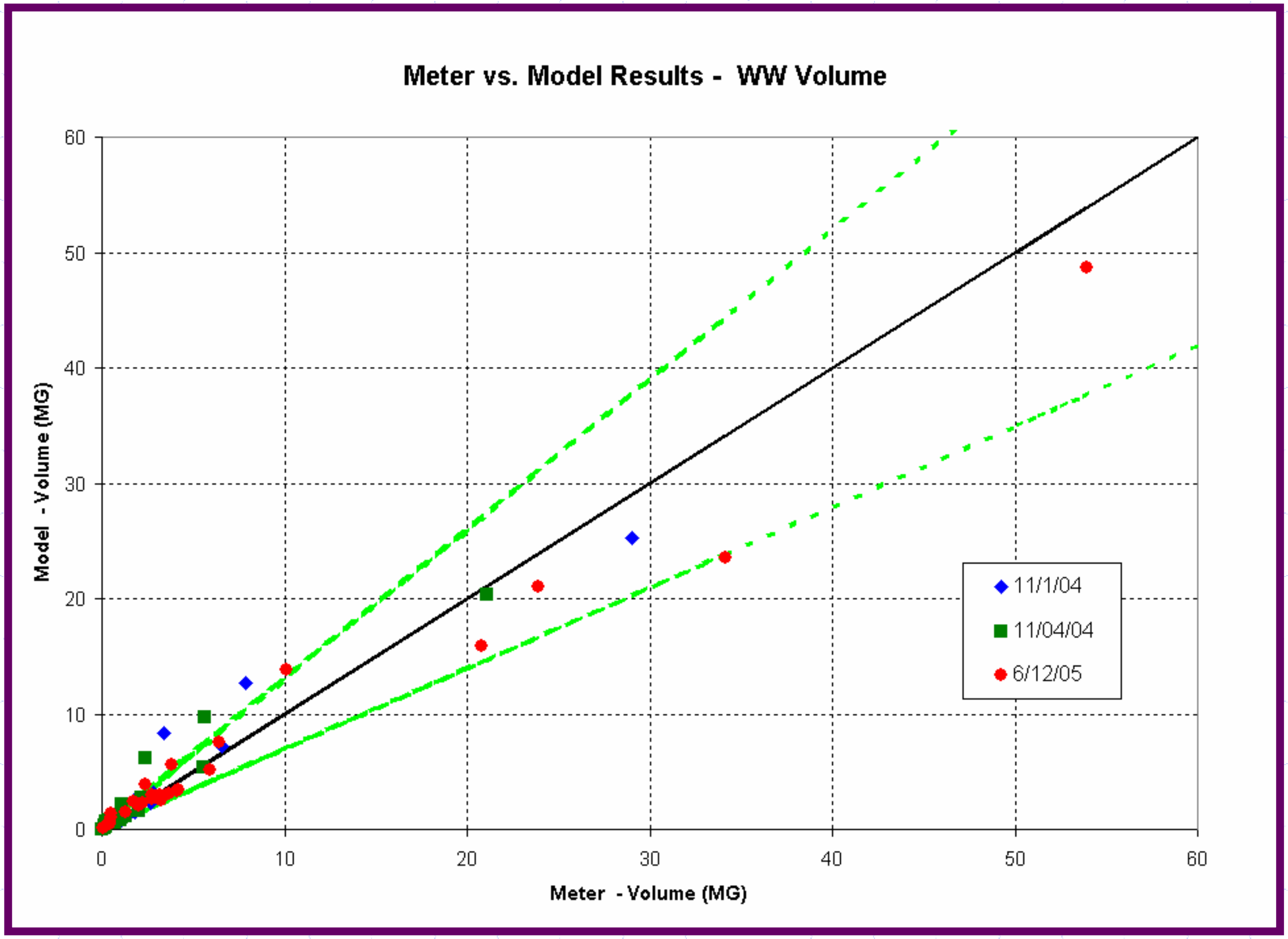


# Model Calibration – Wet Weather

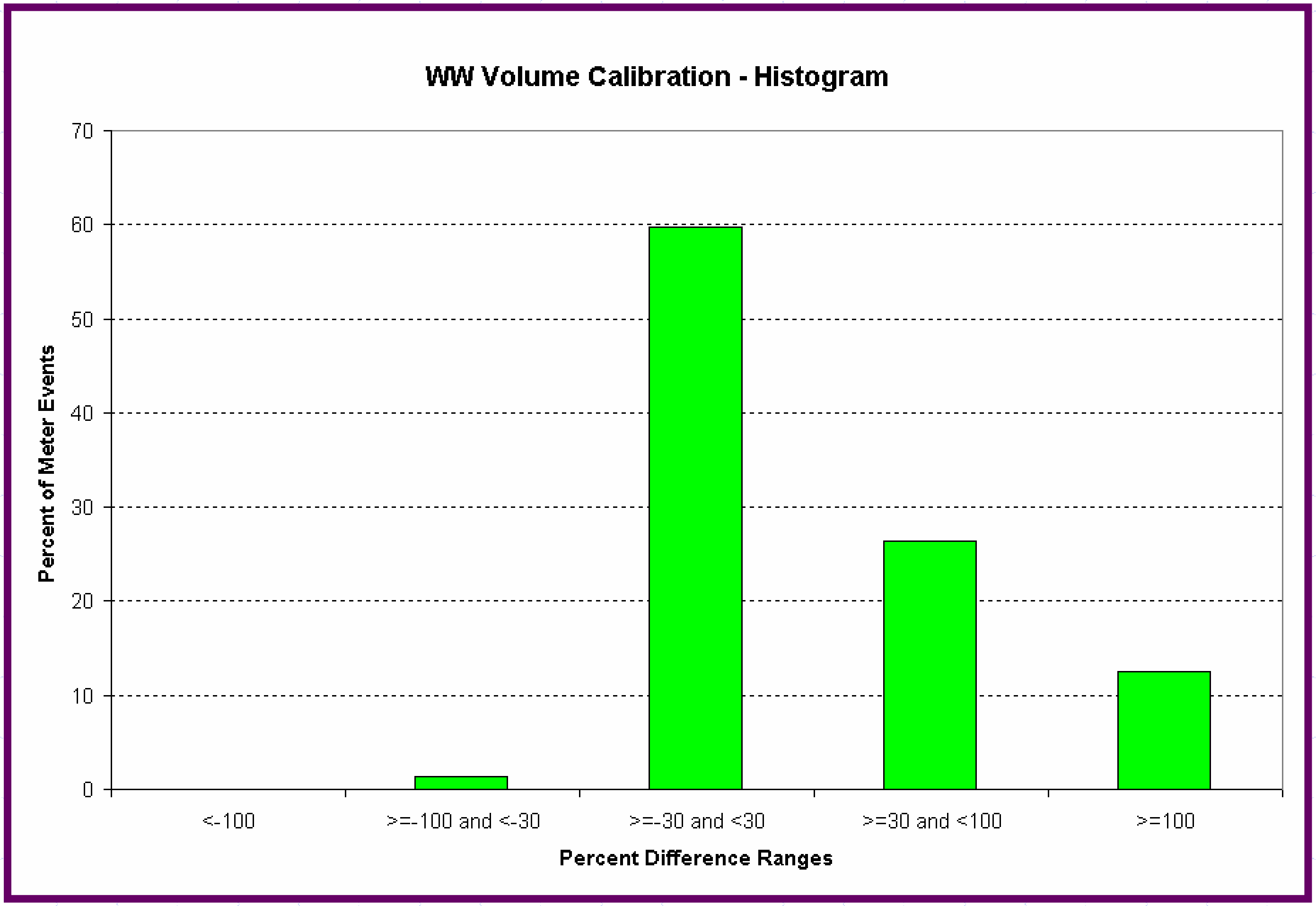
1. Purpose: Adjust model parameters to reasonably predict CSS flows caused by precipitation events, while maintaining realistic parameter values.

| Event Date | Duration (hrs) | Rainfall Total (in) | Peak 5-Min Intensity (in/hr) | Return Period |
|---|---|---|---|---|
| 11/1/04 | 11.6 | 0.70 | 0.72 | < 2 months |
| 11/4/04 | 12.8 | 0.54 | 0.60 | < 2 months |
| 6/12/05 | 15.5 | 1.90 | 1.20 | ~9 months |

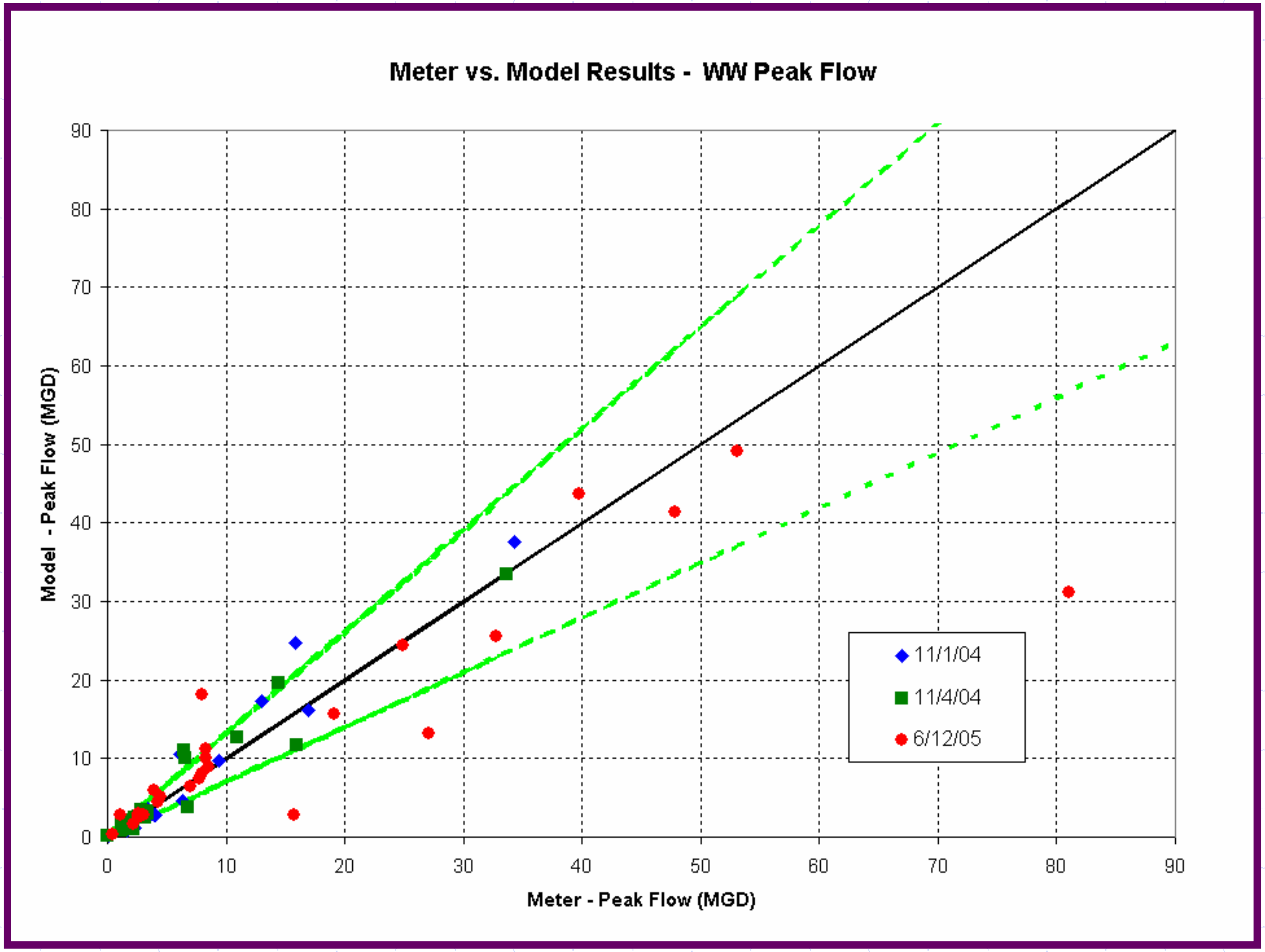
# Model Calibration – WW Calibration Results



# Model Calibration – WW Calibration Results



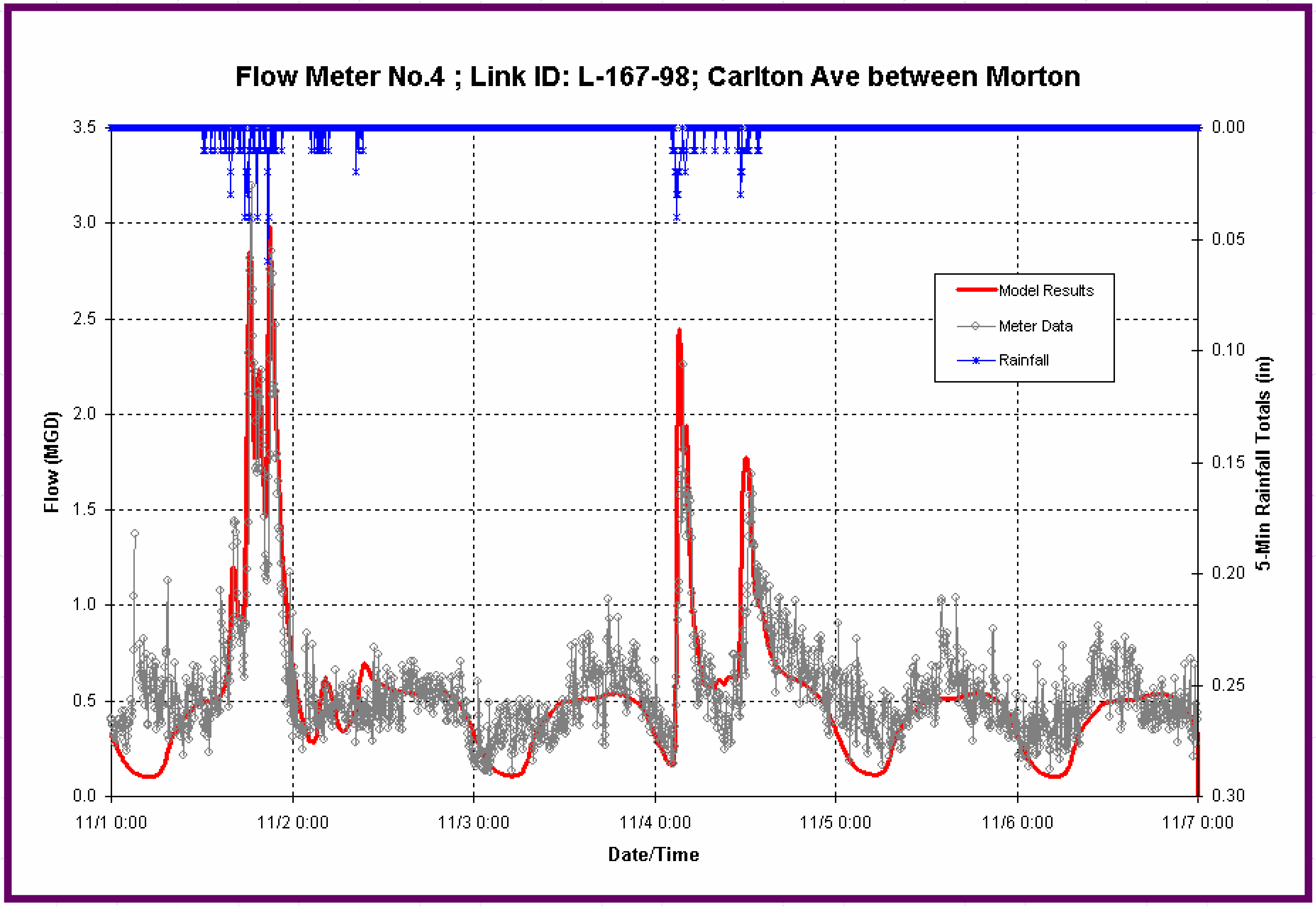
# Model Calibration – WW Calibration Results



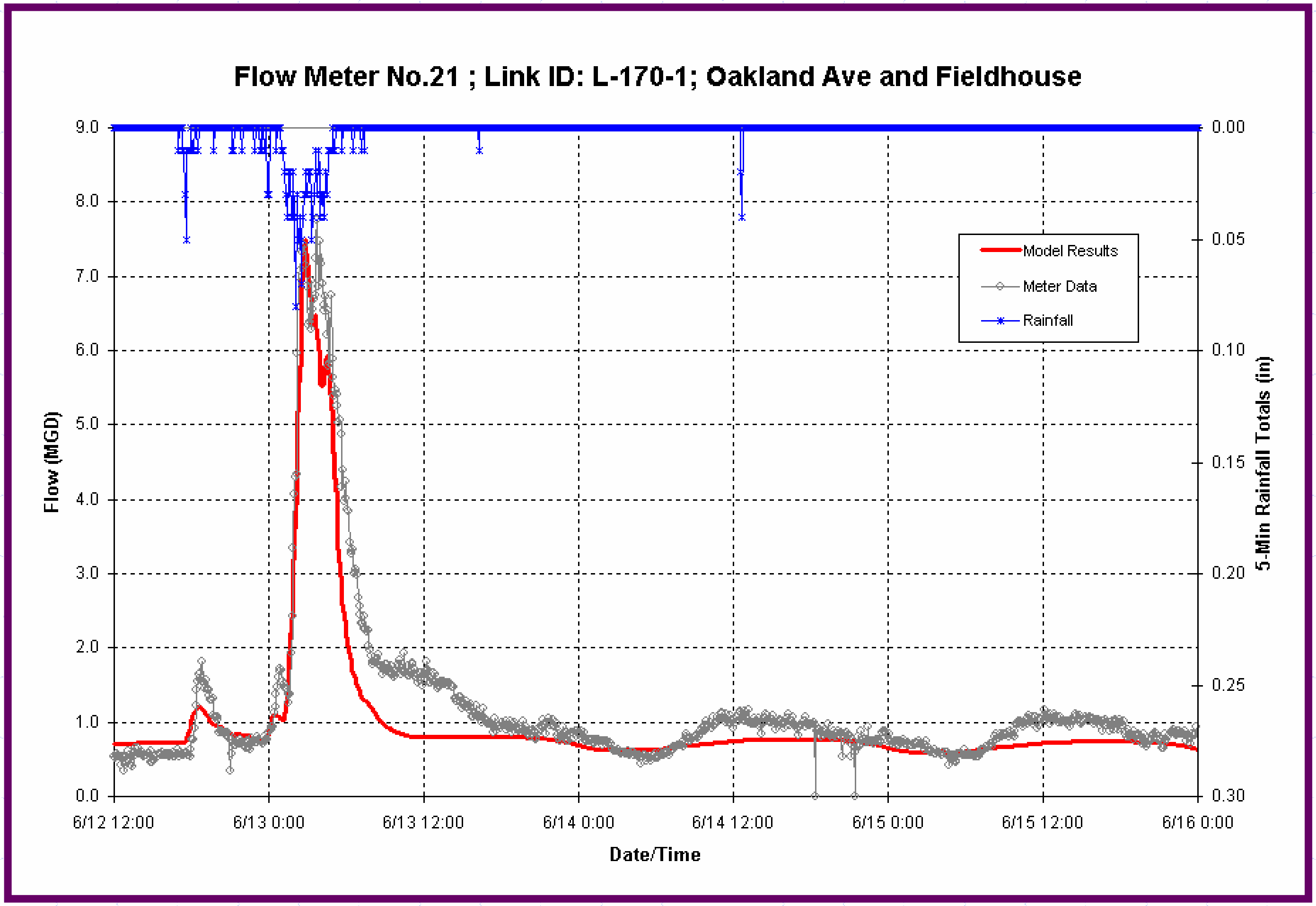
# Model Calibration – WW Calibration Results

1. Volume: ~60% of meters within calibration goals with another ~25% conservatively overpredicting.
2. Peak flow: Model within calibration goals for ~67% of meters.
3. In cases where comparisons fall outside goals, the data set and model results were investigated further to confirm acceptability.

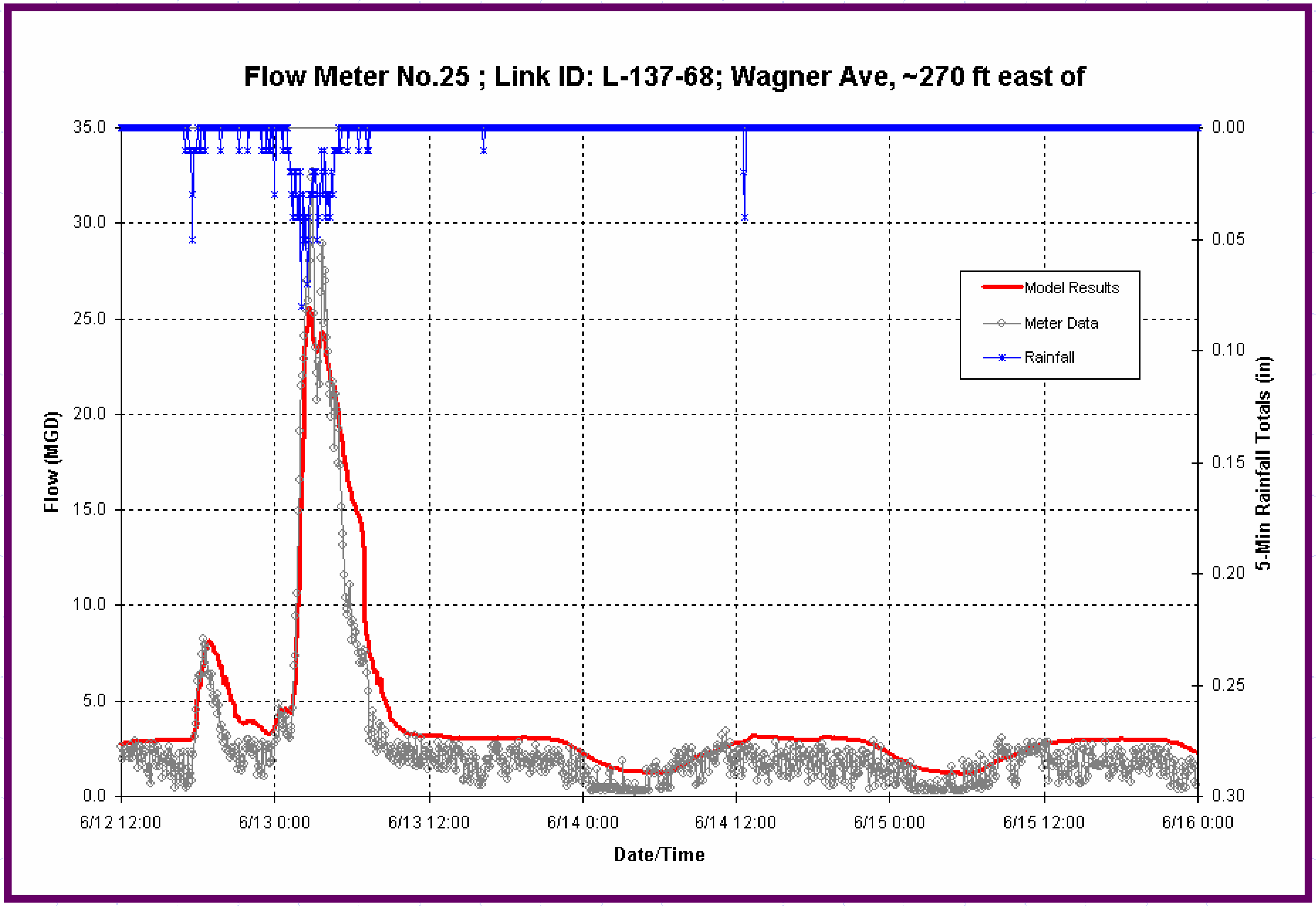
# Model Calibration – WW Calibration Results



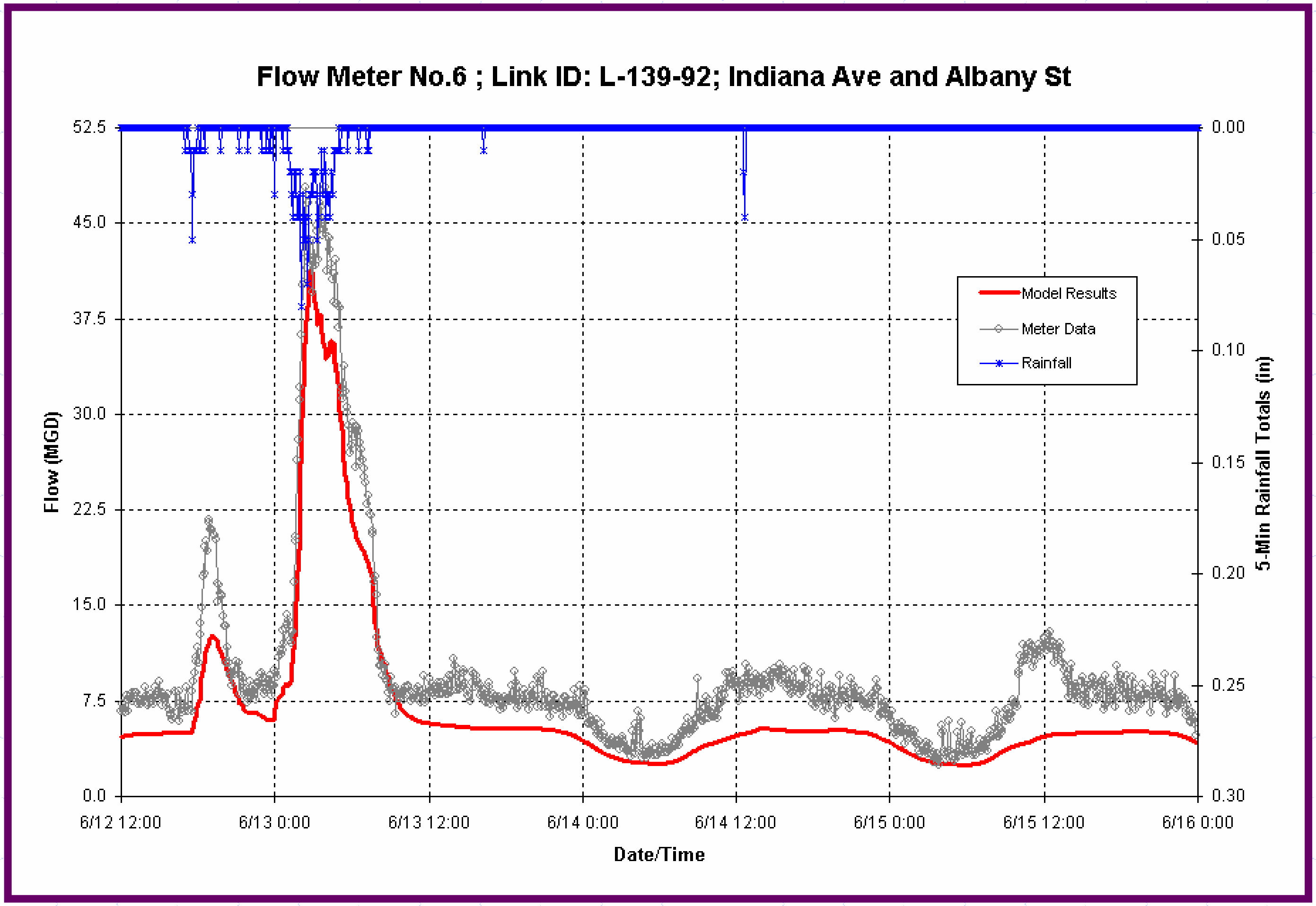
# Model Calibration – WW Calibration Results



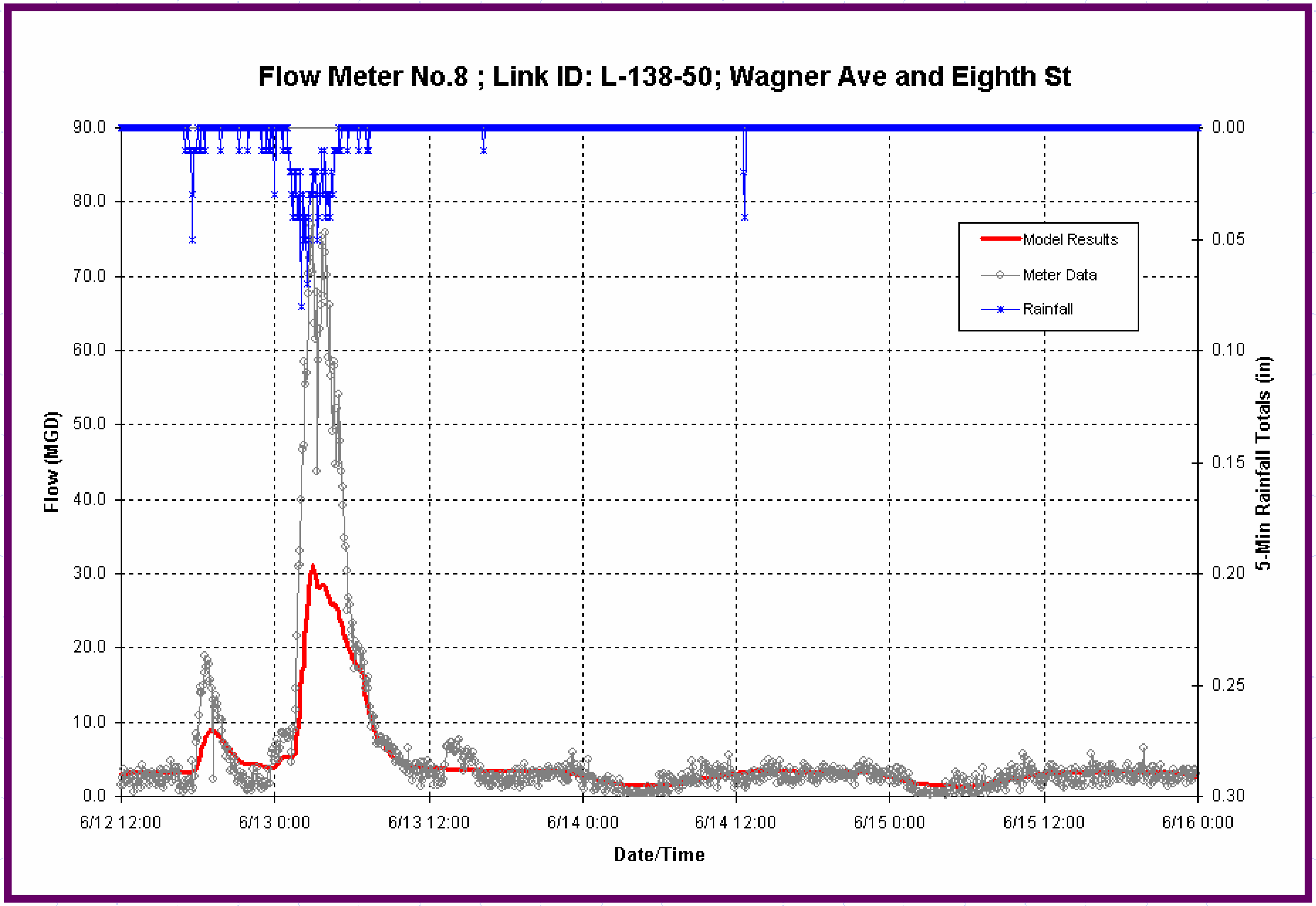
# Model Calibration – WW Calibration Results



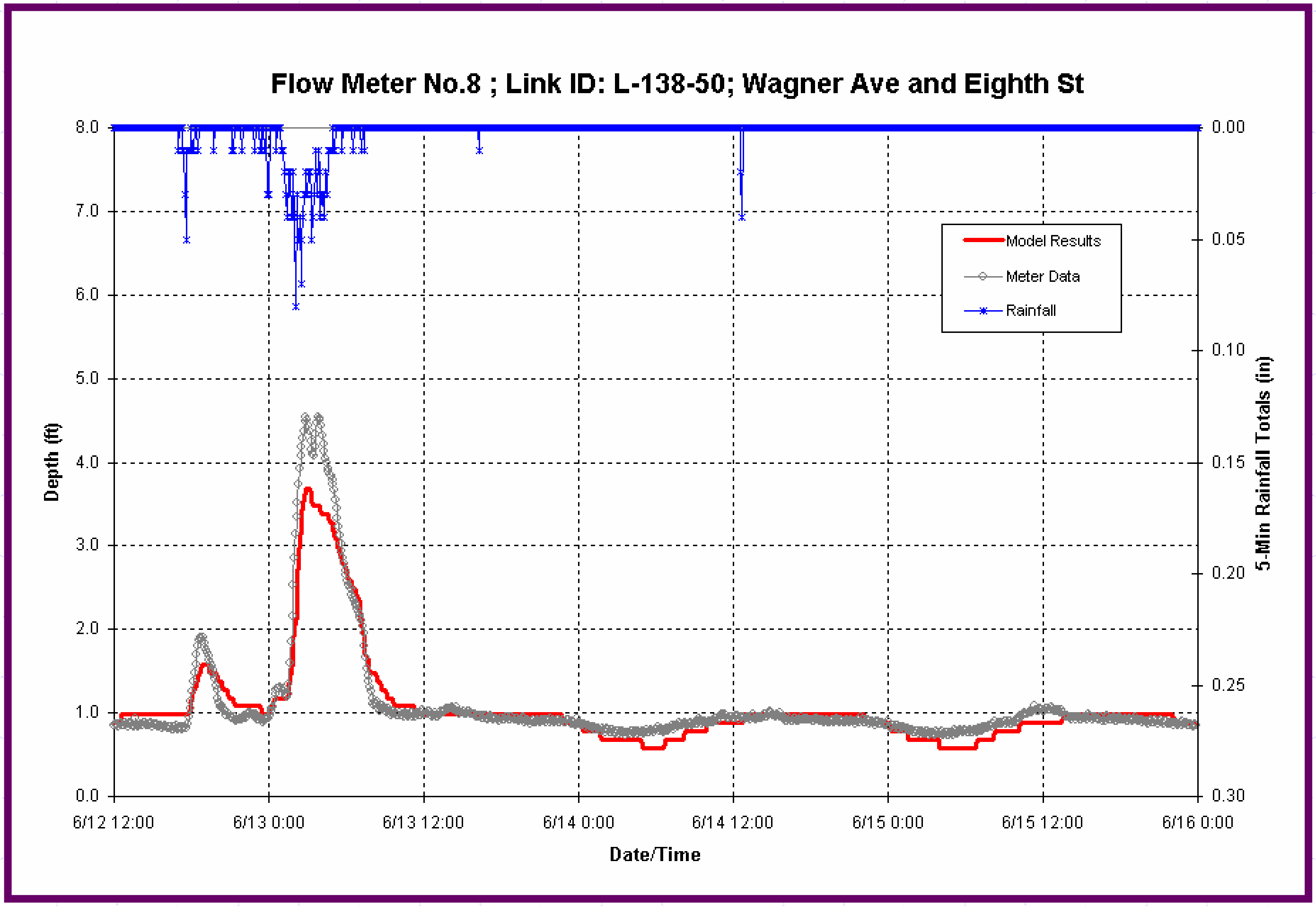
# Model Calibration – WW Calibration Results



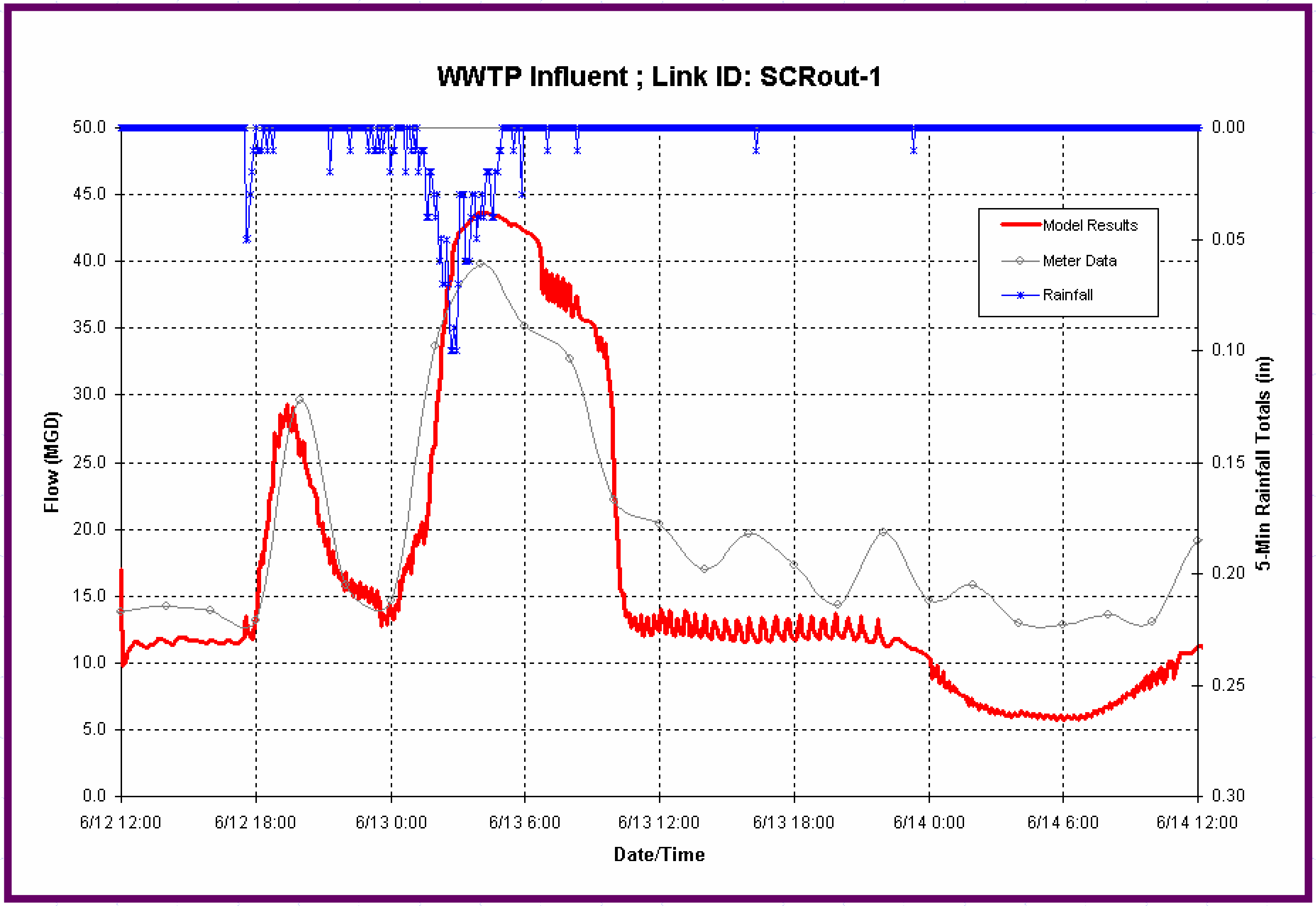
# Model Calibration – WW Calibration Results



# Model Calibration – WW Calibration Results



# Model Calibration – WW Calibration Results



# Model Calibration – WW Results

1. Given the calibration goals assessment and the visual match between the simulated results and the observed response, the City's model suitably predicts WW flows within the system for LTCP development purposes.

ELKHART, INDIANA
PUBLIC WORKS AND UTILITIES
LONG TERM CONTROL PLAN

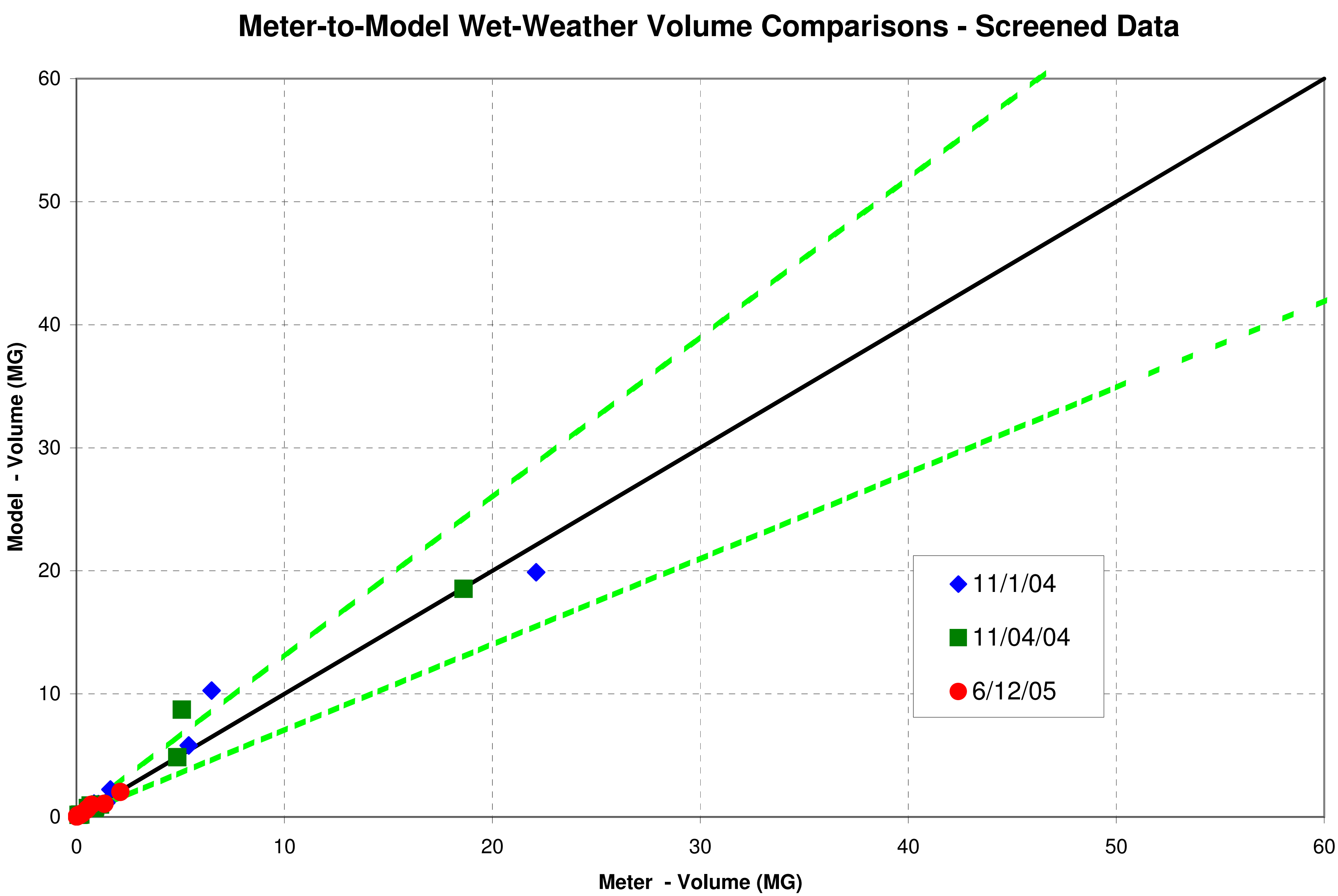
# Combined Sewer System (CSS) Model Calibration

Greeley and Hansen/Malcolm Pirnie
May 1, 2006

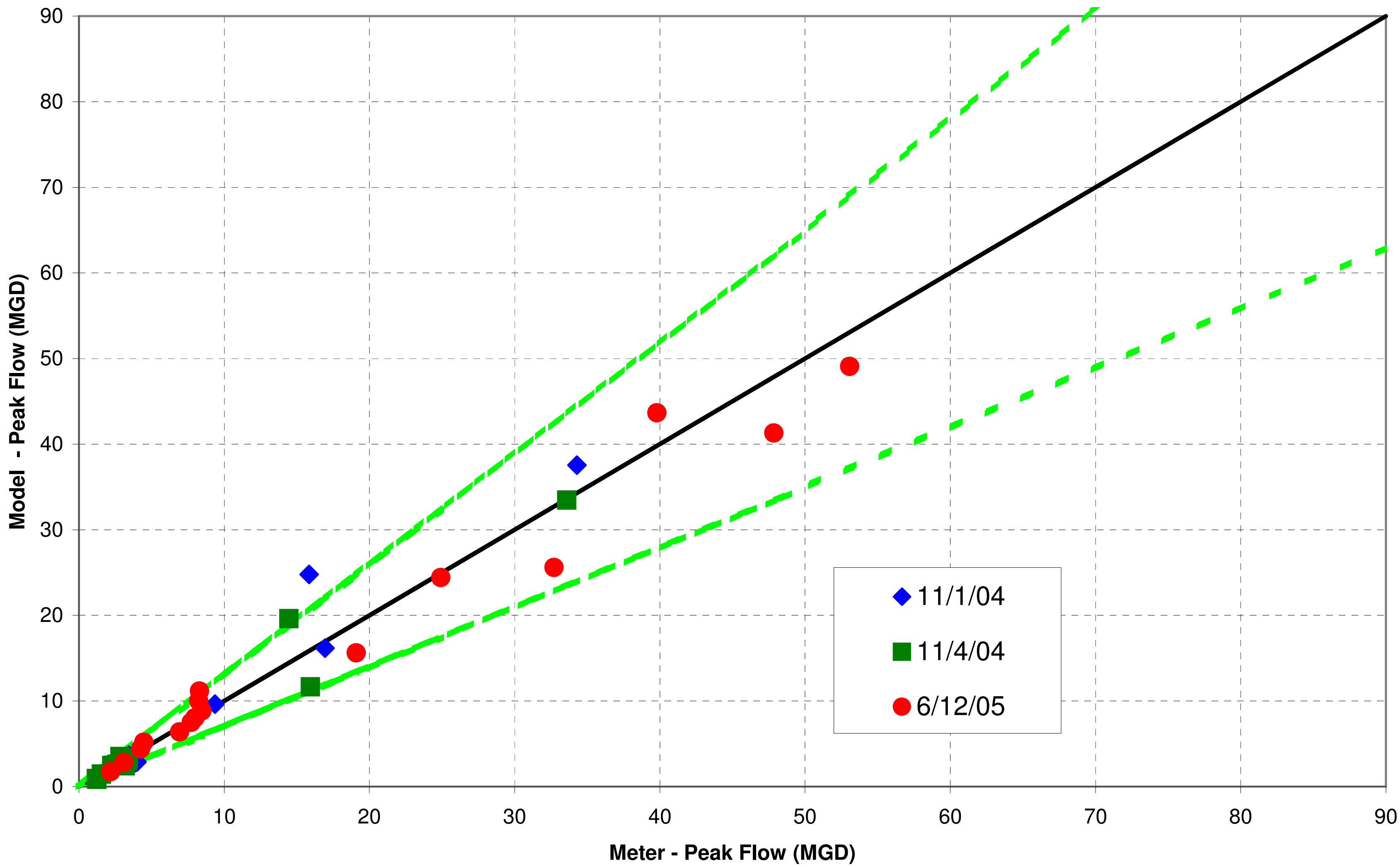
This memorandum briefly describes the information package (tables, graphs, and written summaries) documenting calibration of the City's CSS model. Table 1 lists the items provided. It should be noted that the overall calibration comparisons, the first four items in Table 1, are based upon the final data screening. This data screening eliminated meter events with documented data issues, which would otherwise unfairly compromise the calibration comparisons. However, hydrograph comparisons are provided for all meter events (depth for overflow locations), since hydrograph comparisons provide many indicators of model performance, including subjective ones such as "goodness of fit." Where data is suspect or, where additional explanation is warranted, the meter-to-model graphs are annotated.

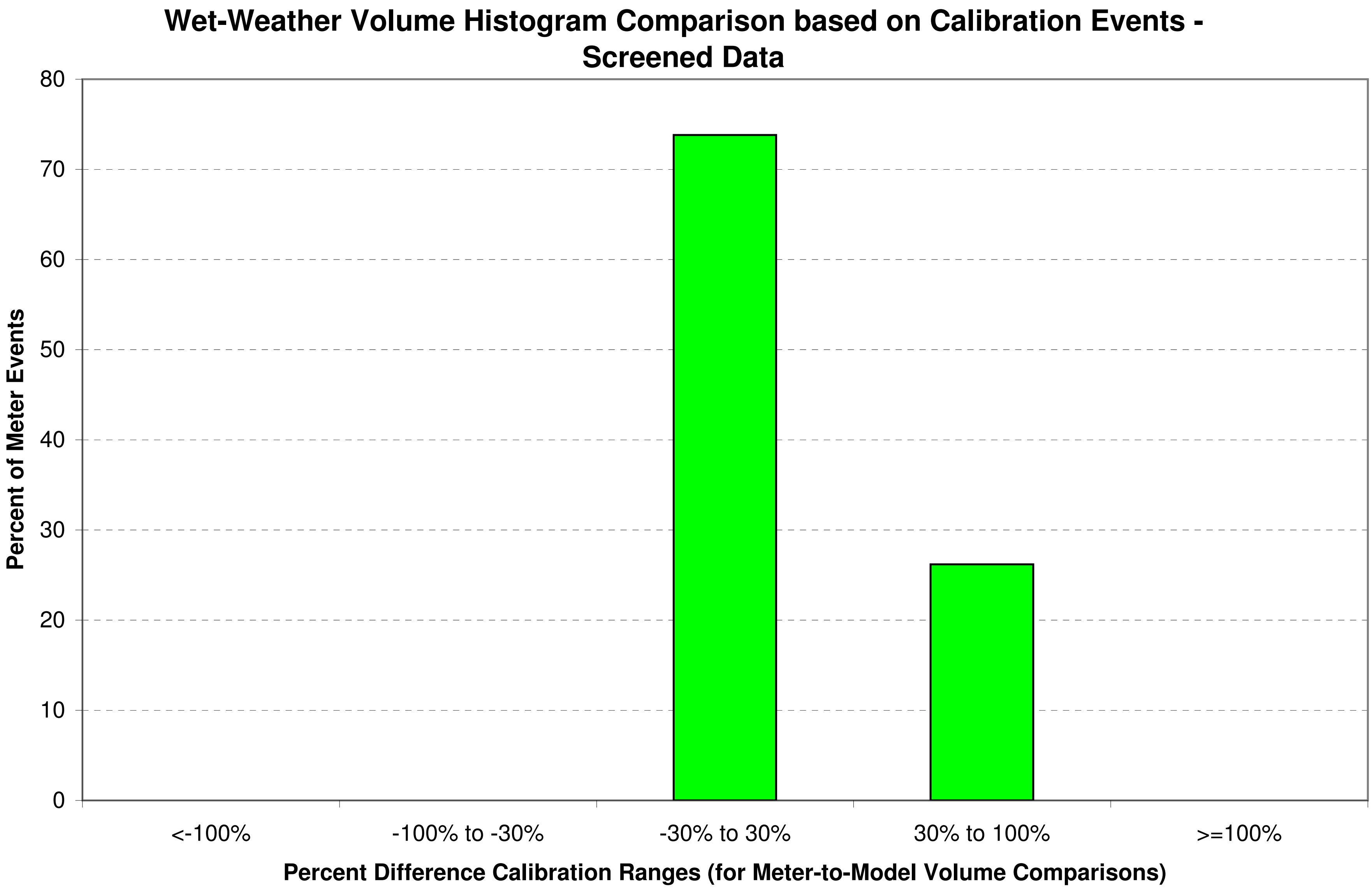
**Table 1**
**Calibration Support Files**

| Information Description | Filename (Click to View Document) |
|---|---|
| Meter-to-model wet-weather volume comparisons (graph) | Meter_to_Model_Screened_Volume_Comparisons.pdf |
| Meter-to-model wet-weather peak flow comparisons (graph) | Meter_to_Model_Screened_Peak_Flow_Comparisons.pdf |
| Meter-to-model wet-weather volume histogram comparison (graph) | Meter_to_Model_Screened_Volume_Histogram.pdf |
| Meter data screening summary and meter-to-model wet-weather volume and peak flow comparisons (table) | Data_Screening_and_Meter_to_Model_Tabular_ Comparisons.pdf |
| November 1, 2004 and November 4, 2004 calibration event hydrographs showing model results and measured data (graphs) | Nov04_Calibration_Event_Hydrographs.pdf |
| June 12, 2005 calibration event hydrographs showing model results and measured data (graphs) | June05_Calibration_Event_Hydrographs.pdf |
| Summary of sensitivity analysis | Sensitivity Analysis.pdf |
| Summary of initial and final hydrology parameters for each model subcatchment (tables) | Hydrology_Parameters_Combined_Subcatchments.pdf<br>Hydrology_Parameters_Outlying_Separate_ Sanitary_Subcatchments.pdf<br>Infiltration_Parameter_Summary_All_Subcatchments.pdf |


Meter-to-Model Wet-Weather Volume Comparisons - Screened Data
Model - Volume (MG)
Meter - Volume (MG)
0
10
20
30
40
50
60
11/1/04
11/04/04
6/12/05

# Meter-to-Model Wet-Weather Peak Flow Comparisons - Screened Data





Wet-Weather Volume Histogram Comparison based on Calibration Events - Screened Data
Percent of Meter Events
0
10
20
30
40
50
60
70
80
<-100%
-100% to -30%
-30% to 30%
30% to 100%
>=100%
Percent Difference Calibration Ranges (for Meter-to-Model Volume Comparisons)

## Tabular Summary of Data Screening and Meter-to-Model Volume and Peak Flow Comparisons

| Flow Meter | General Data Categorization for Calibration Events | | | Screened Comparisons for 11/1/2004 Calibration Event | | | | | | Screened Comparisons for 11/4/2004 Calibration Event | | | | | | Screened Comparisons for 6/12/2005 Calibration Event | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Volume (MG) | | | Peak Flow (MGD) | | | Volume (MG) | | | Peak Flow (MGD) | | | Volume (MG) | | | Peak Flow (MGD) | | |
| | 11/1/2004 | 11/4/2004 | 6/12/2005 | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) |
| 1 | G | DS | G | 1.64 | 2.23 | 35.9 | 9.37 | 9.64 | 2.9 | | | | | | | 5.23 | 6.06 | 15.9 | 53.08 | 49.07 | -7.6 |
| 2 | DS | OK | DS | | | | | | | 0.19 | 0.19 | -1.2 | 1.20 | 0.93 | -22.5 | | | | | | |
| 3 | DS | DS | ND | | | | | | | | | | | | | | | | | | |
| 4 | G | G | OK | 0.85 | 0.92 | 8.6 | 3.20 | 2.98 | -6.8 | 0.72 | 0.75 | 4.7 | 2.26 | 2.45 | 8.4 | 0.84 | 1.32 | 56.5 | 6.94 | 6.37 | -8.2 |
| 5 | OK | OK | DS | 0.77 | 0.83 | 8.6 | 3.54 | 2.71 | -23.6 | 0.85 | 0.77 | -9.8 | 3.36 | 3.04 | -9.4 | | | | | | |
| 6 | OK | OK | G | 6.50 | 10.28 | 58.1 | 15.85 | 24.77 | 56.3 | 5.07 | 8.71 | 71.6 | 14.46 | 19.61 | 35.6 | 14.43 | 11.40 | -20.9 | 47.85 | 41.30 | -13.7 |
| 7 | G | G | G | 0.84 | 1.08 | 28.0 | 2.79 | 2.91 | 4.4 | 0.69 | 0.91 | 32.1 | 2.41 | 2.47 | 2.5 | 1.56 | 1.50 | -3.6 | 7.99 | 8.02 | 0.4 |
| 8 | DS | DS | DS | | | | | | | | | | | | | | | | | | |
| 9 | G | G | G | 0.62 | 0.85 | 38.8 | 3.43 | 3.65 | 6.2 | 0.55 | 0.72 | 30.1 | 2.82 | 3.49 | 23.7 | 1.08 | 1.50 | 38.8 | 8.26 | 10.00 | 21.1 |
| 10 | DS | DS | DS | | | | | | | | | | | | | | | | | | |
| 11 | G | G | OK | 1.15 | 0.89 | -22.8 | 3.99 | 2.88 | -28.0 | 0.89 | 0.82 | -7.7 | 3.42 | 3.29 | -3.8 | 1.86 | 1.92 | 3.0 | 8.31 | 11.16 | 34.3 |
| 12 | DS | DS | G | | | | | | | | | | | | | 0.96 | 1.23 | 28.5 | 8.48 | 8.84 | 4.2 |
| 13 | DS | DS | OK | | | | | | | | | | | | | 7.76 | 10.51 | 35.5 | 24.92 | 24.43 | -2.0 |
| 14 | G | G | OK | 1.05 | 1.04 | -1.2 | 3.46 | 2.69 | -22.3 | 0.91 | 0.90 | -0.4 | 2.61 | 2.61 | 0.0 | 1.24 | 1.24 | 0.4 | 4.25 | 4.40 | 3.6 |
| 15 | OK | OK | G | | | | | | | | | | | | | 2.96 | 2.89 | -2.5 | 19.11 | 15.62 | -18.2 |
| 16 | DS | DS | ND | | | | | | | | | | | | | | | | | | |
| 17 | OK | OK | DS | 0.14 | 0.21 | 51.6 | 1.24 | 1.00 | -19.2 | 0.11 | 0.16 | 45.5 | 1.24 | 0.82 | -33.6 | | | | | | |
| 18 | DS | DS | ND | | | | | | | | | | | | | | | | | | |
| 19 | DS | DS | G | | | | | | | | | | | | | 0.71 | 0.70 | -1.6 | 3.10 | 2.83 | -8.6 |
| 20 | DS | DS | G | | | | | | | | | | | | | 1.11 | 1.07 | -3.1 | 4.47 | 5.17 | 15.8 |

Data Code Legend

| Data Code | Explanation |
|---|---|
| G | Good data |
| OK | Data shows evidence of undefined anomalies, but comparisons are possible |
| DS | Data suspect |
| ND | No data |

Coloring Legend

Not included in screened data comparisons for volume and peak flow

Data appears suspect, but detailed reviews do not reveal sufficient justification to exclude data from volume and peak flow comparisons

## Tabular Summary of Data Screening and Meter-to-Model Volume and Peak Flow Comparisons (continued)

| Flow Meter | General Data Categorization for Calibration Events | | | Screened Comparisons for 11/1/2004 Calibration Event | | | | | | Screened Comparisons for 11/4/2004 Calibration Event | | | | | | Screened Comparisons for 6/12/2005 Calibration Event | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Volume (MG) | | | Peak Flow (MGD) | | | Volume (MG) | | | Peak Flow (MGD) | | | Volume (MG) | | | Peak Flow (MGD) | | |
| | 11/1/2004 | 11/4/2004 | 6/12/2005 | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) |
| 21 | G | G | G | 1.44 | 1.16 | -19.1 | 3.88 | 2.79 | -28.1 | 1.13 | 1.01 | -10.7 | 3.19 | 2.43 | -23.9 | 1.87 | 1.51 | -19.3 | 7.75 | 7.48 | -3.4 |
| 22 | DS | DS | DS | | | | | | | | | | | | | | | | | | |
| 23 | OK | OK | DS | 0.98 | 0.81 | -17.0 | 2.24 | 1.77 | -20.8 | 0.88 | 0.71 | -19.3 | 1.55 | 1.46 | -5.6 | | | | | | |
| 24 | DS | DS | DS | | | | | | | | | | | | | | | | | | |
| 25 | G | G | G | 5.41 | 5.81 | 7.4 | 16.94 | 16.18 | -4.5 | 4.86 | 4.84 | -0.4 | 15.94 | 11.65 | -26.9 | 5.77 | 6.89 | 19.4 | 32.72 | 25.59 | -21.8 |
| 26 | ND | ND | DS | | | | | | | | | | | | | | | | | | |
| 27 | ND | ND | G | | | | | | | | | | | | | 0.23 | 0.28 | 20.5 | 2.18 | 1.73 | -20.8 |
| 28 | ND | ND | DS | | | | | | | | | | | | | | | | | | |
| WWTP Influent | G | G | G | 22.11 | 19.89 | -10.0 | 34.30 | 37.55 | 9.5 | 18.62 | 18.54 | -0.4 | 33.60 | 33.45 | -0.4 | 22.59 | 21.69 | -4.0 | 39.80 | 43.65 | 9.7 |

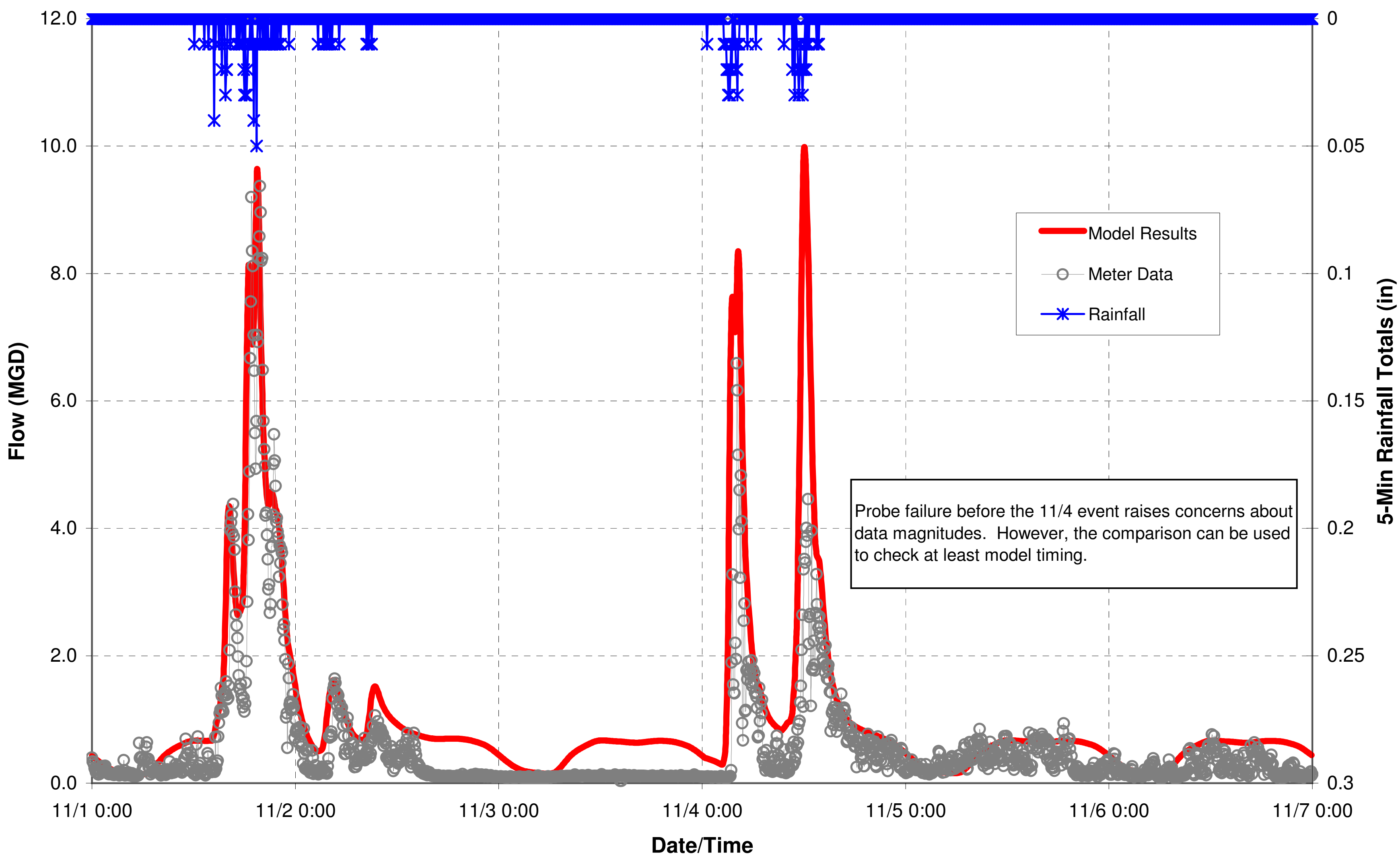
Data Code Legend

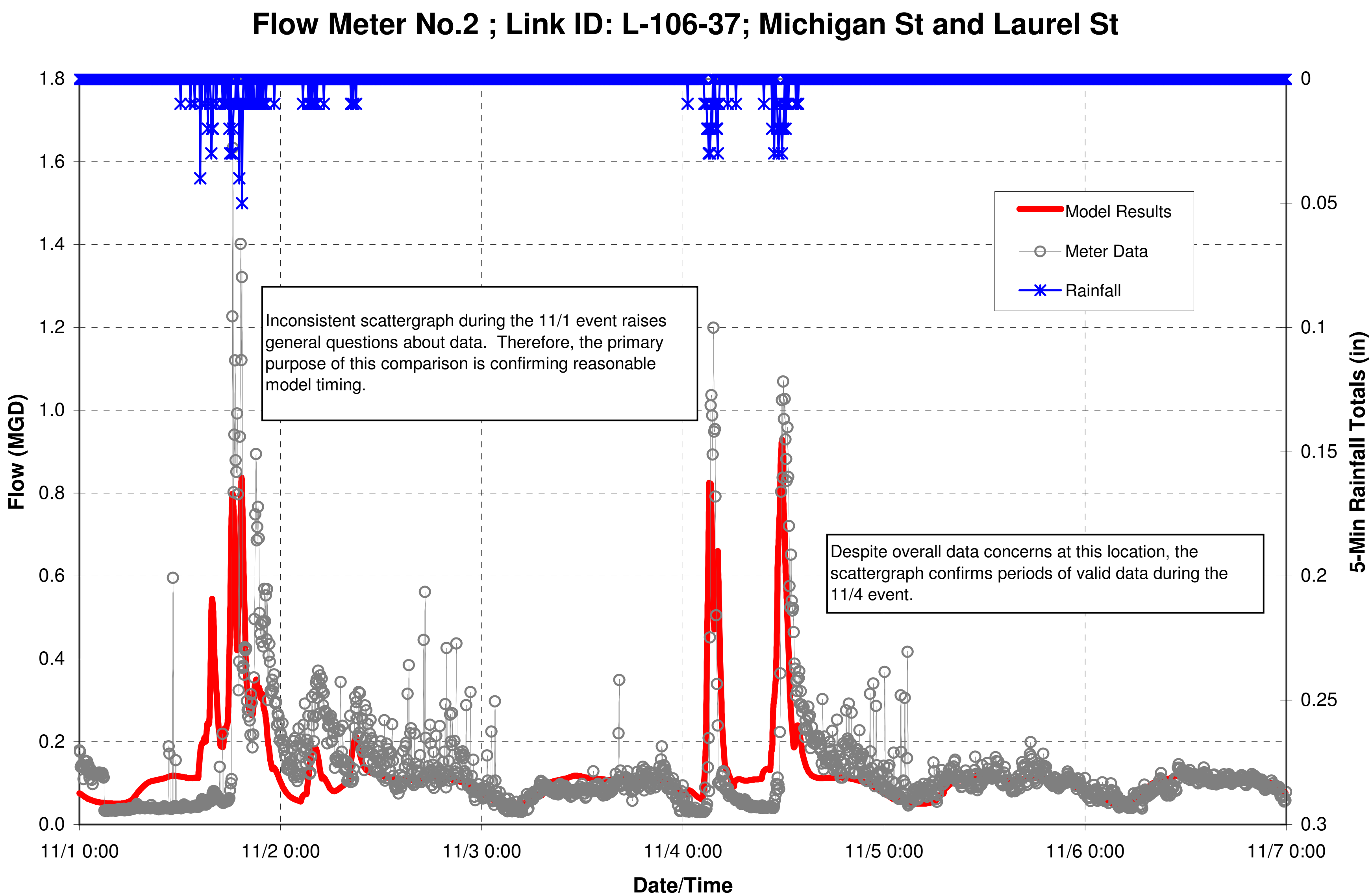
| Data Code | Explanation |
|---|---|
| G | Good data |
| OK | Data shows evidence of undefined anomalies, but comparisons are possible |
| DS | Data suspect |
| ND | No data |

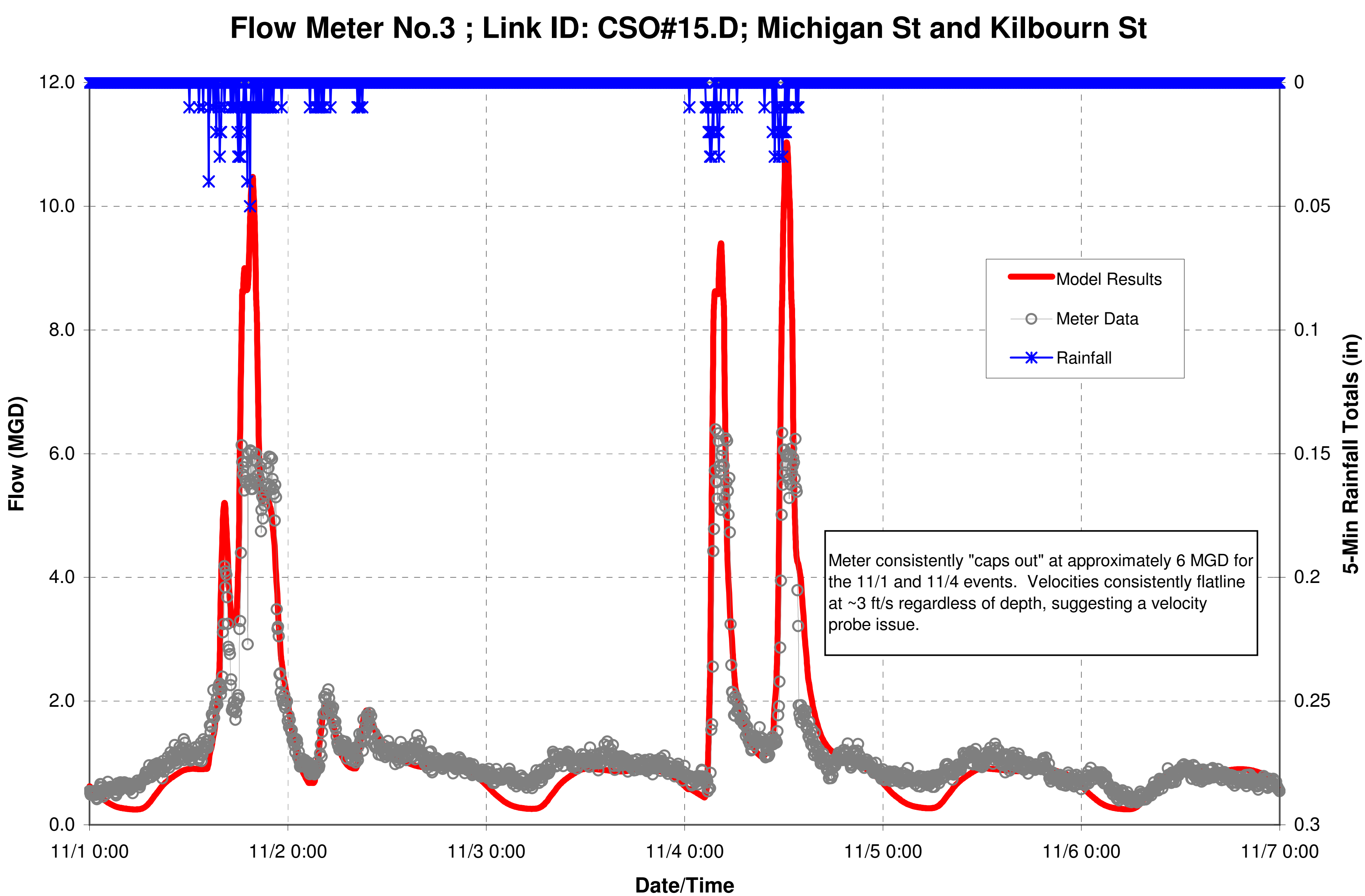
Coloring Legend

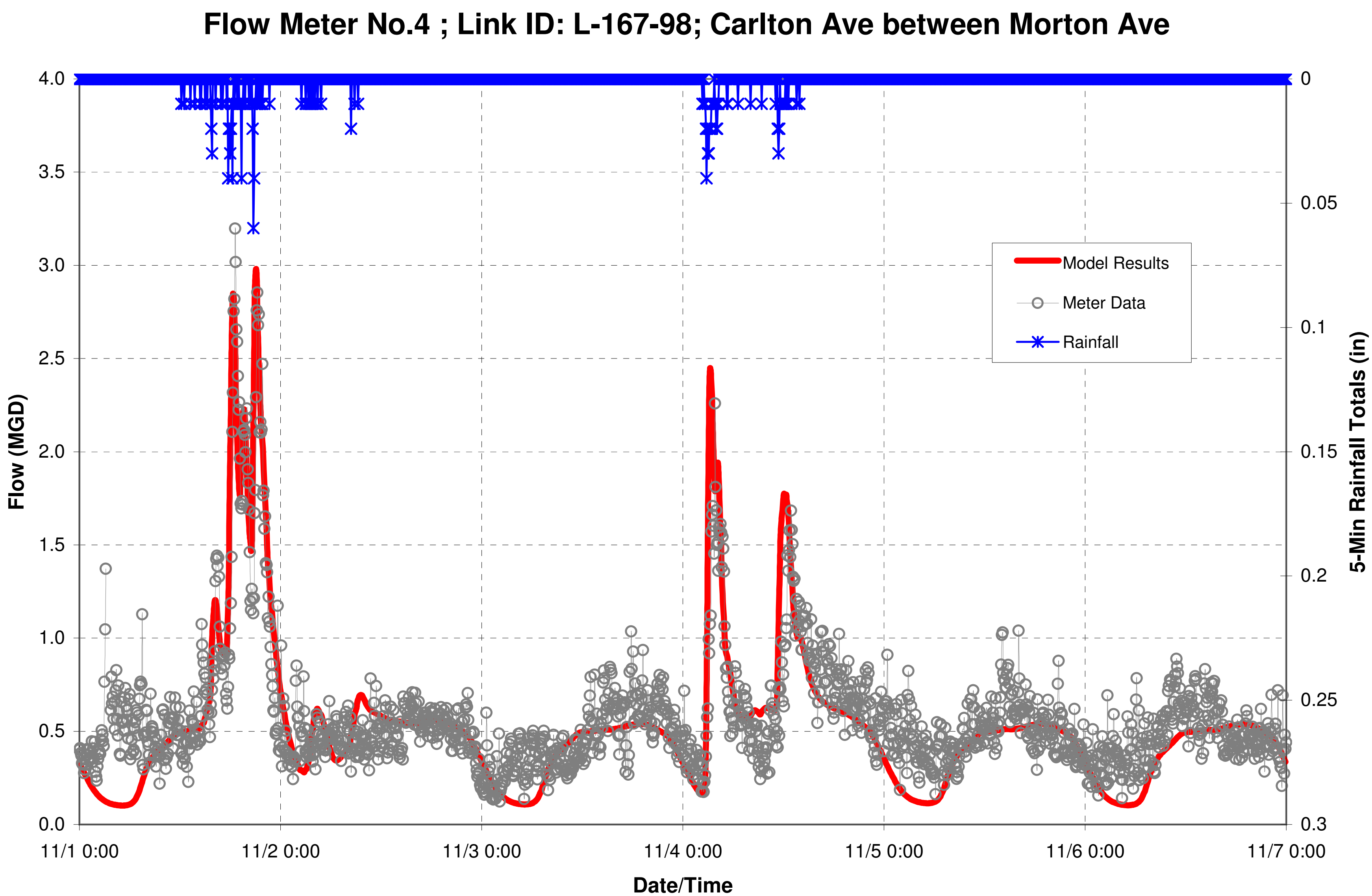
| | |
|---|---|
| Pink | Not included in screened data comparisons for volume and peak flow |
| Green | Data appears suspect, but detailed reviews do not reveal sufficient justification to exclude data from volume and peak flow comparisons |

# Flow Meter No.1 ; Link ID: L-107-32; Plum St and Laurel St

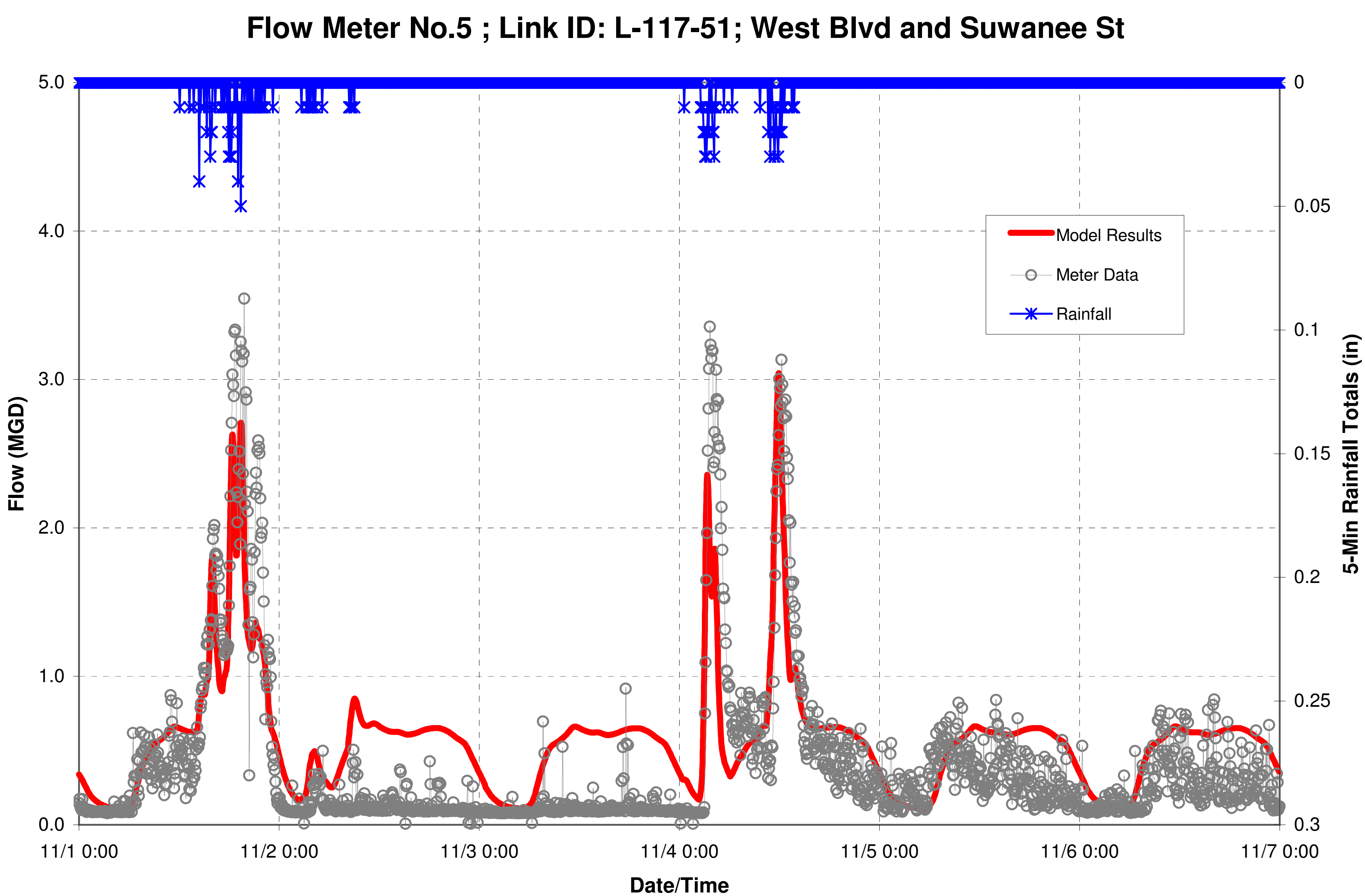



Flow Meter No.2 ; Link ID: L-106-37; Michigan St and Laurel St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
Inconsistent scattergraph during the 11/1 event raises general questions about data. Therefore, the primary purpose of this comparison is confirming reasonable model timing.
Despite overall data concerns at this location, the scattergraph confirms periods of valid data during the 11/4 event.
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00

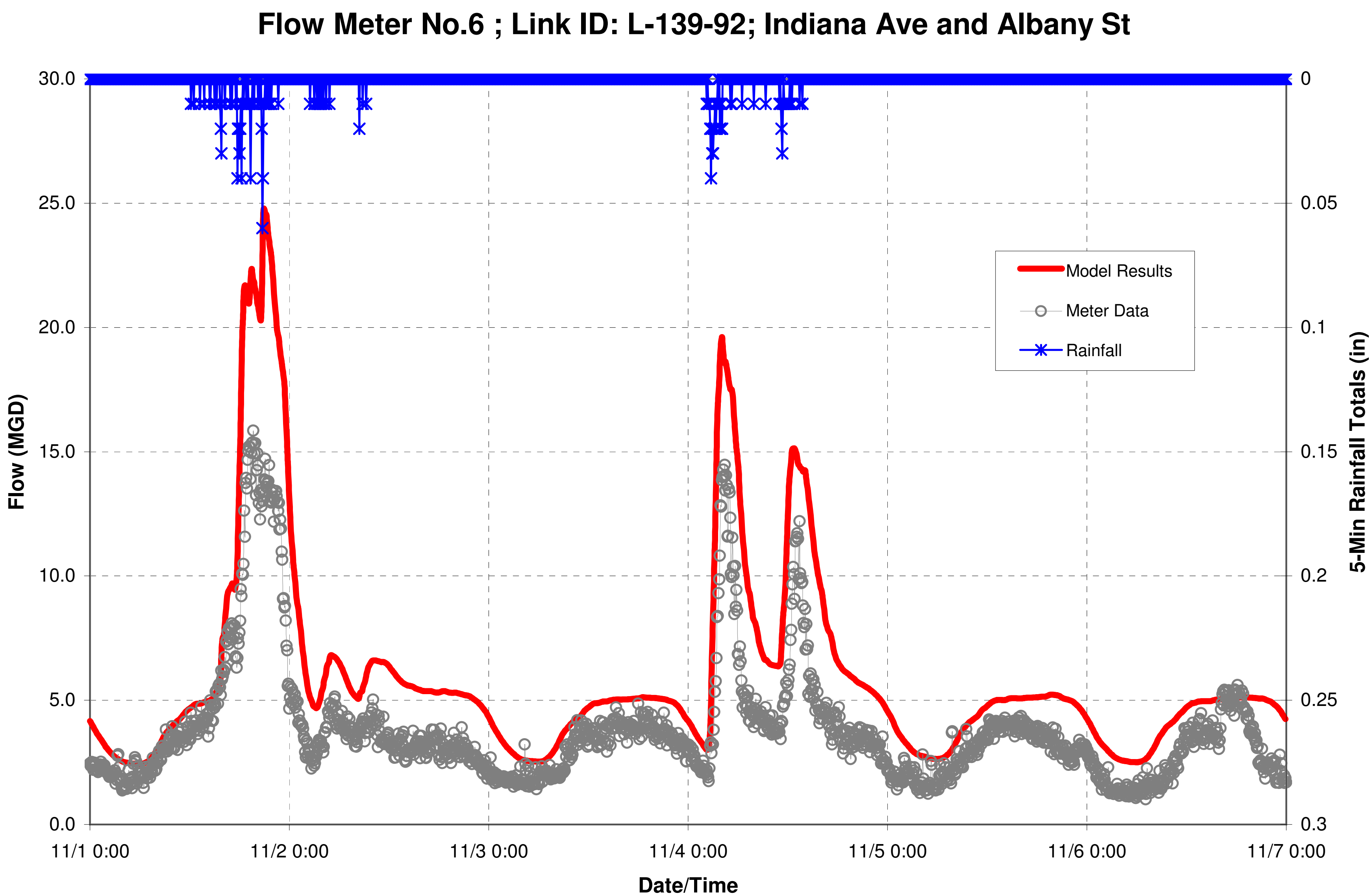

Flow Meter No.3 ; Link ID: CSO#15.D; Michigan St and Kilbourn St
Flow (MGD)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Rainfall
Meter consistently "caps out" at approximately 6 MGD for the 11/1 and 11/4 events. Velocities consistently flatline at ~3 ft/s regardless of depth, suggesting a velocity probe issue.



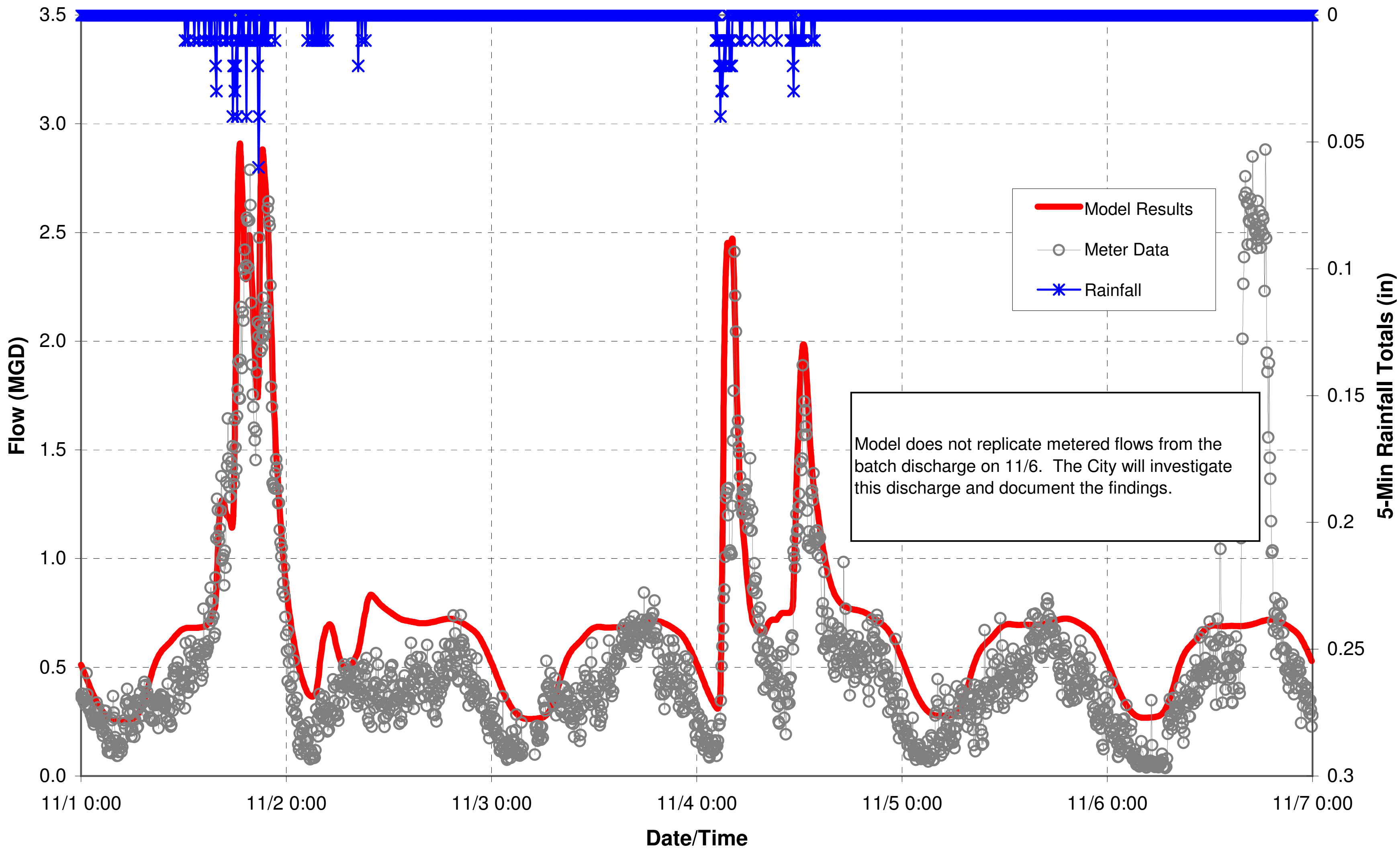
Flow Meter No.4 ; Link ID: L-167-98; Carlton Ave between Morton Ave
Flow (MGD)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Model Results
Meter Data
Rainfall
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time

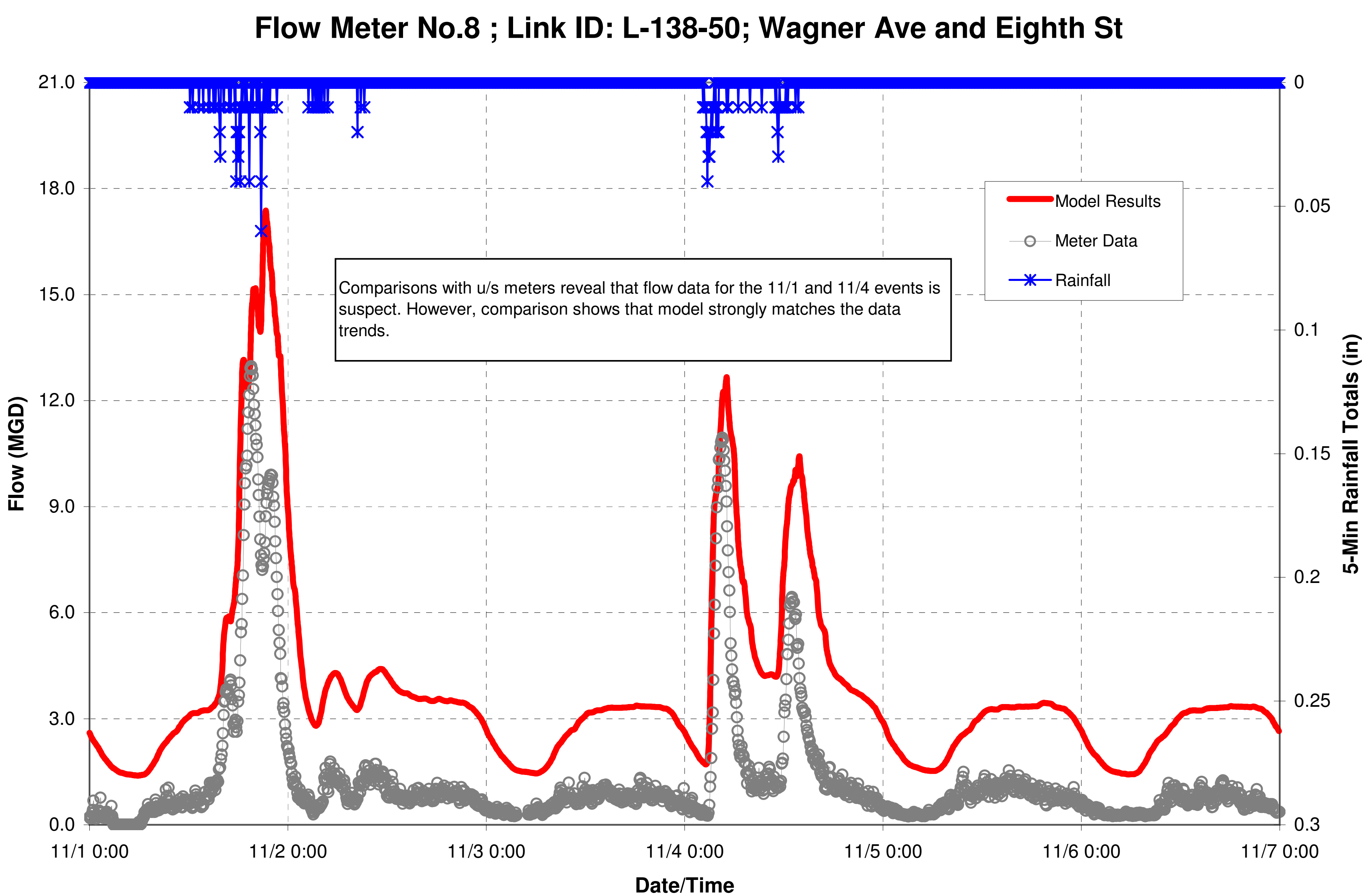


Flow Meter No.5 ; Link ID: L-117-51; West Blvd and Suwanee St
Flow (MGD)
5.0
4.0
3.0
2.0
1.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Rainfall


Flow Meter No.6 ; Link ID: L-139-92; Indiana Ave and Albany St
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Flow (MGD)
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Rainfall

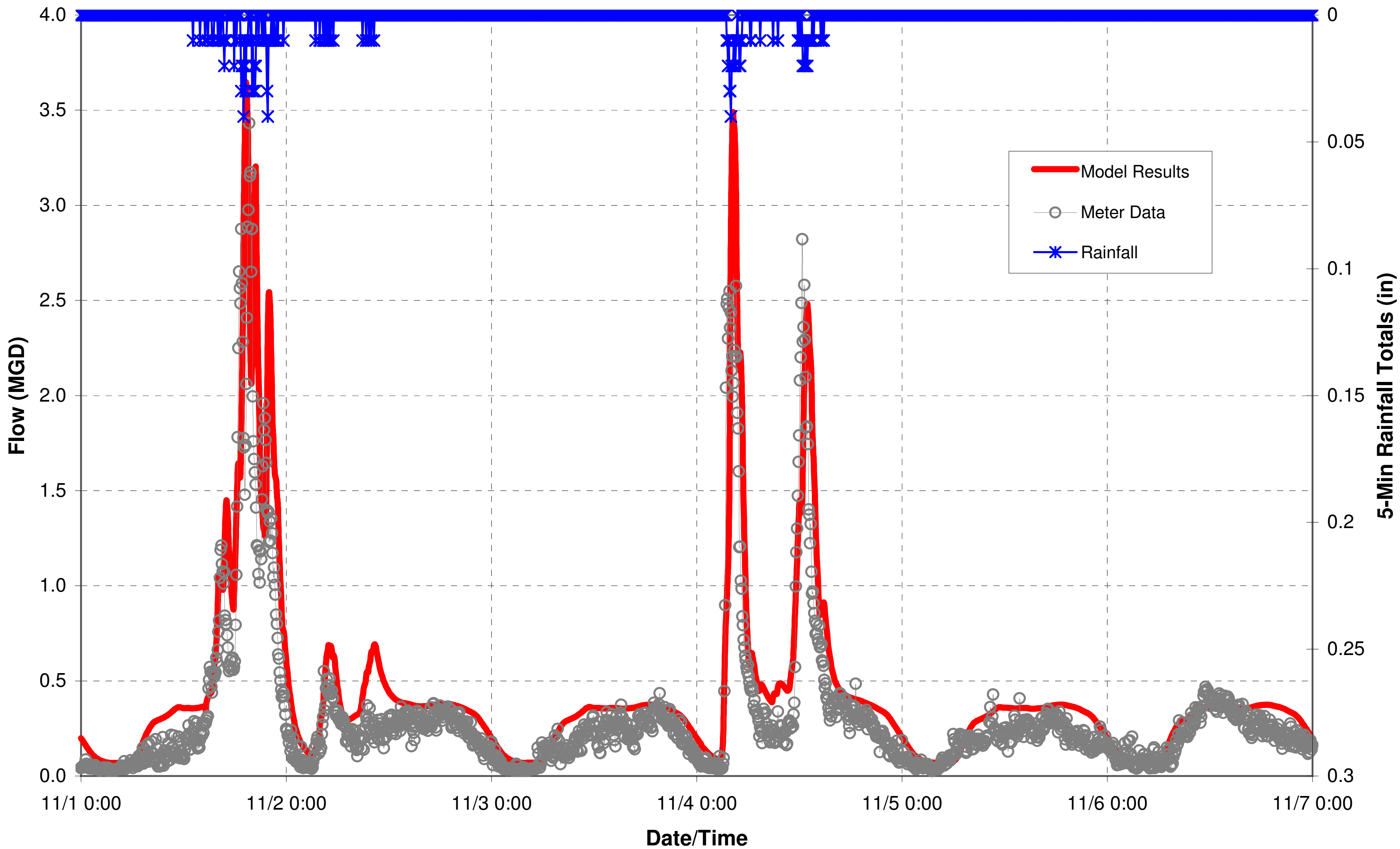
# Flow Meter No.7 ; Link ID: L-151-56; Ninth St and Garfield Ave



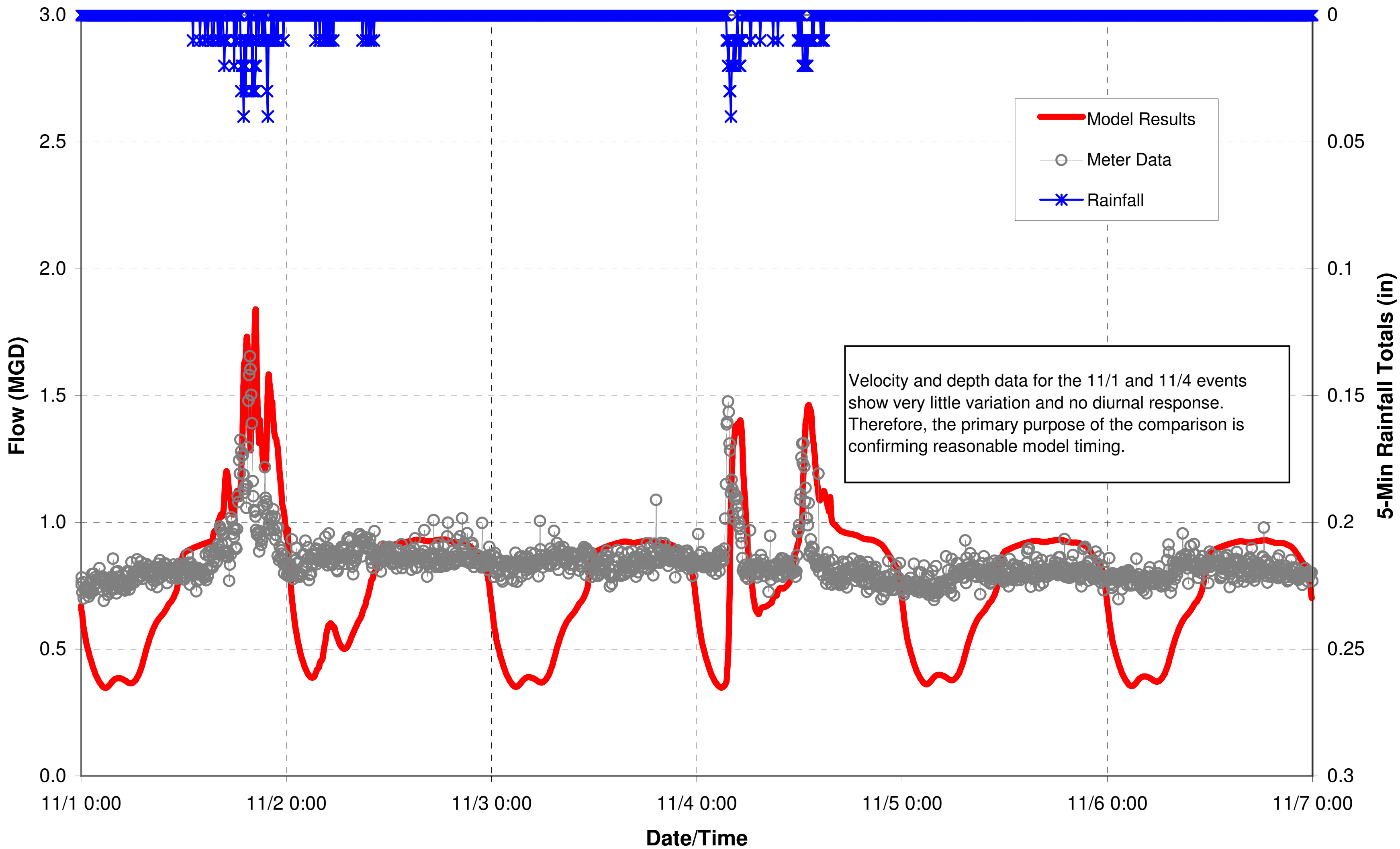


Flow Meter No.8 ; Link ID: L-138-50; Wagner Ave and Eighth St
Comparisons with u/s meters reveal that flow data for the 11/1 and 11/4 events is suspect. However, comparison shows that model strongly matches the data trends.
Model Results
Meter Data
Rainfall
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
0.0
3.0
6.0
9.0
12.0
15.0
18.0
21.0
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00

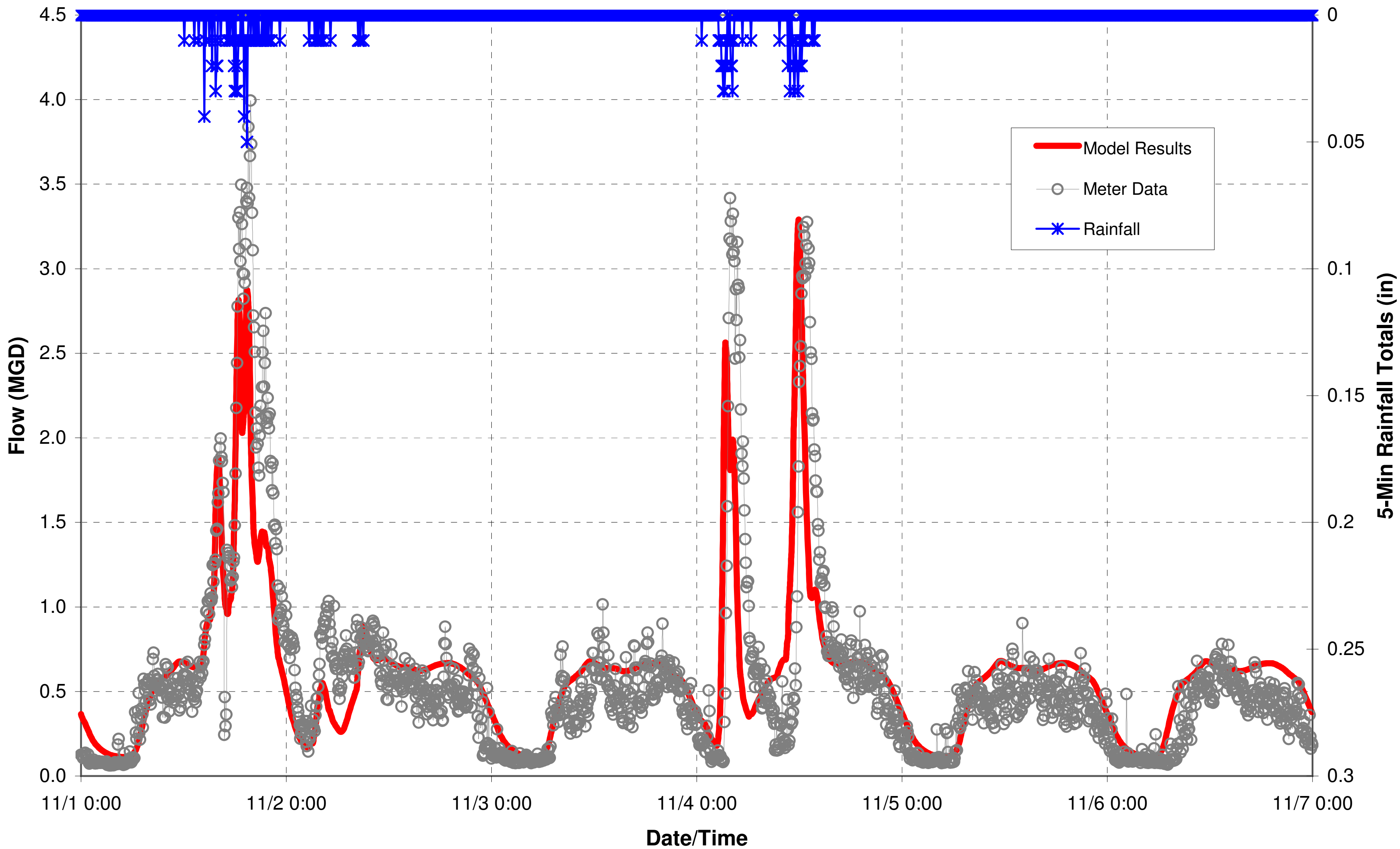
# Flow Meter No.9 ; Link ID: L-88-85; Cone St and McPherson St



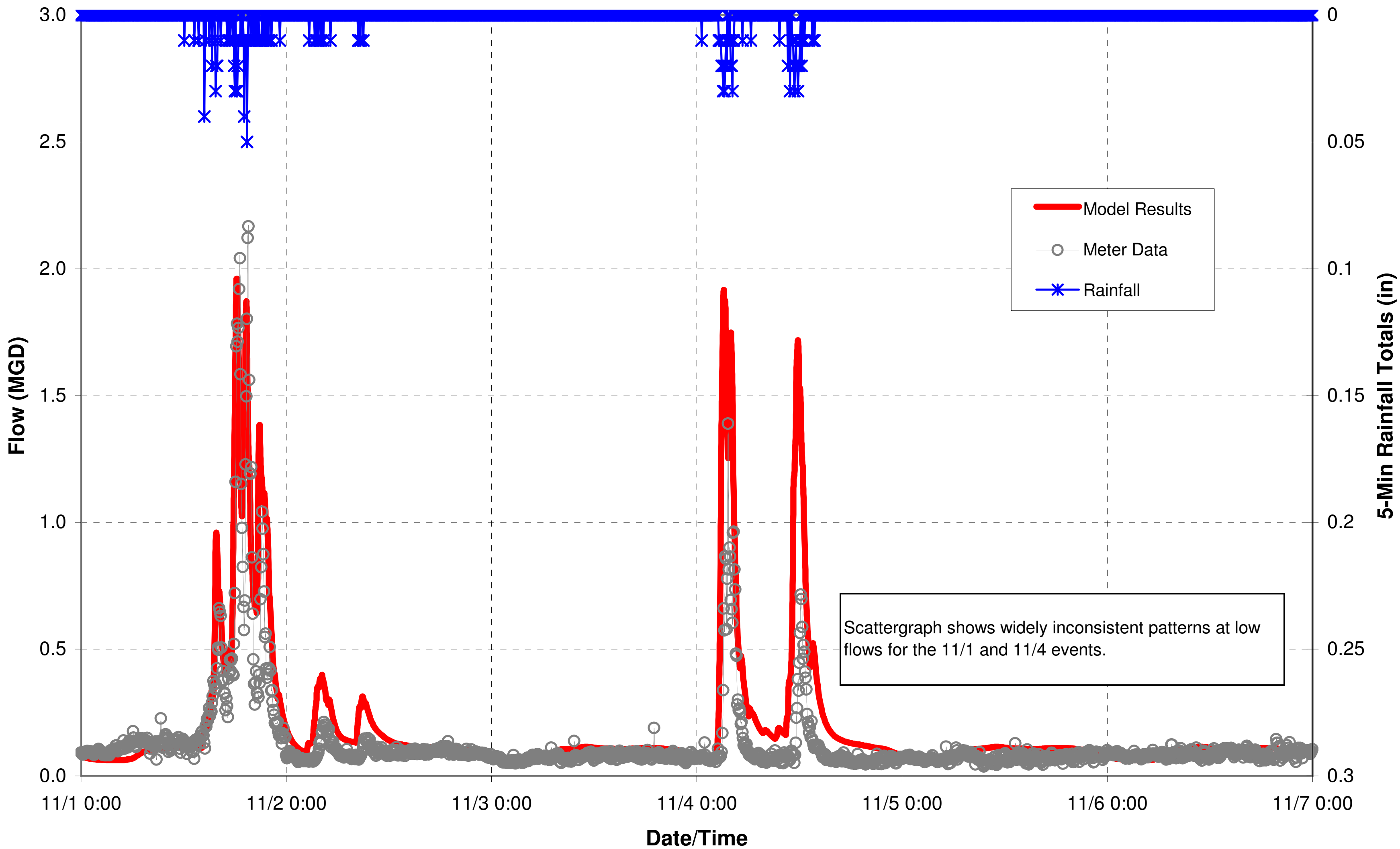
## Flow Meter No.10 ; Link ID: L-89-33; Beardsley Ave and Dearborn St

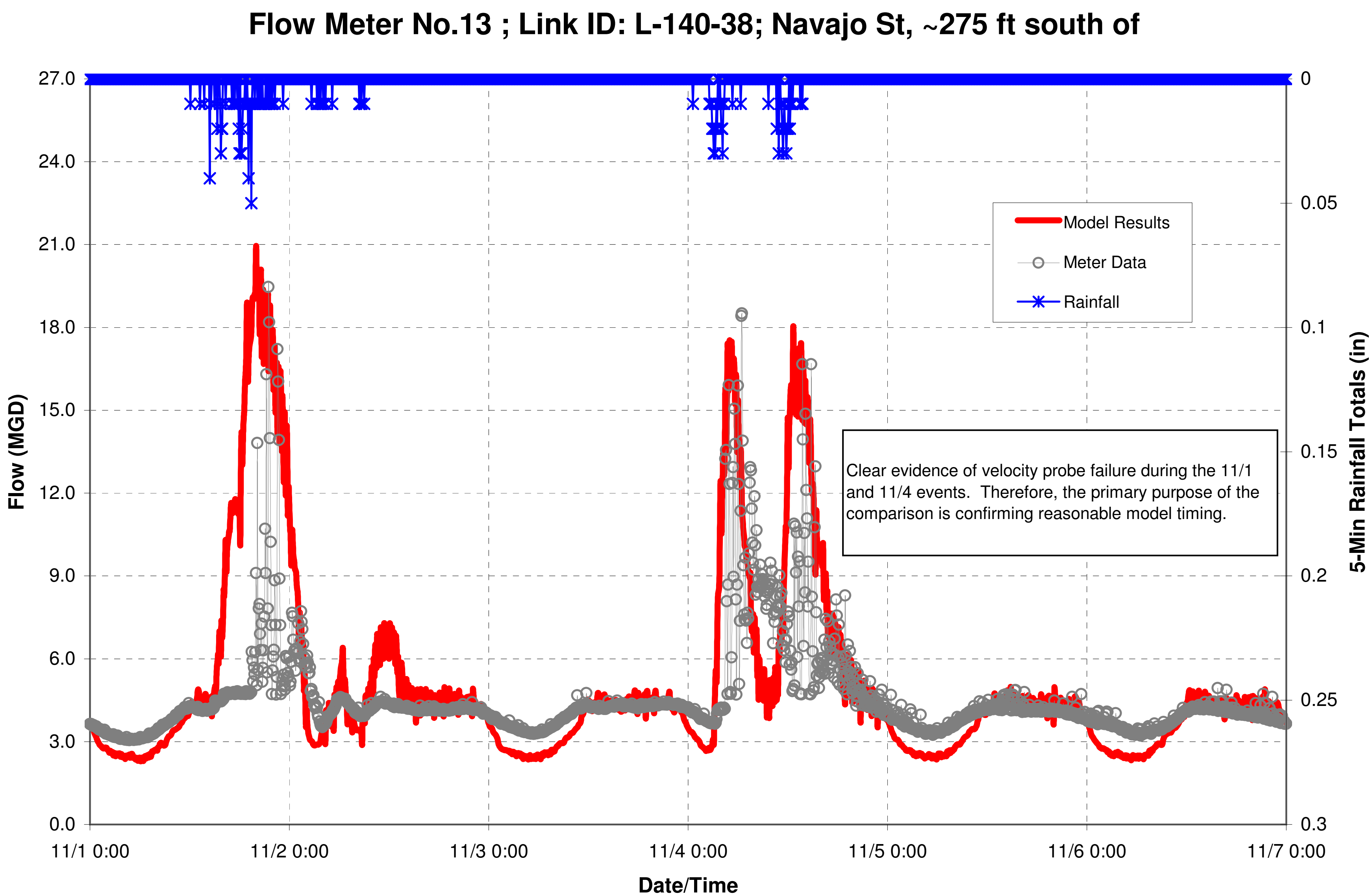


## Flow Meter No.11 ; Link ID: CSO#17.D; McNaughton Park, between

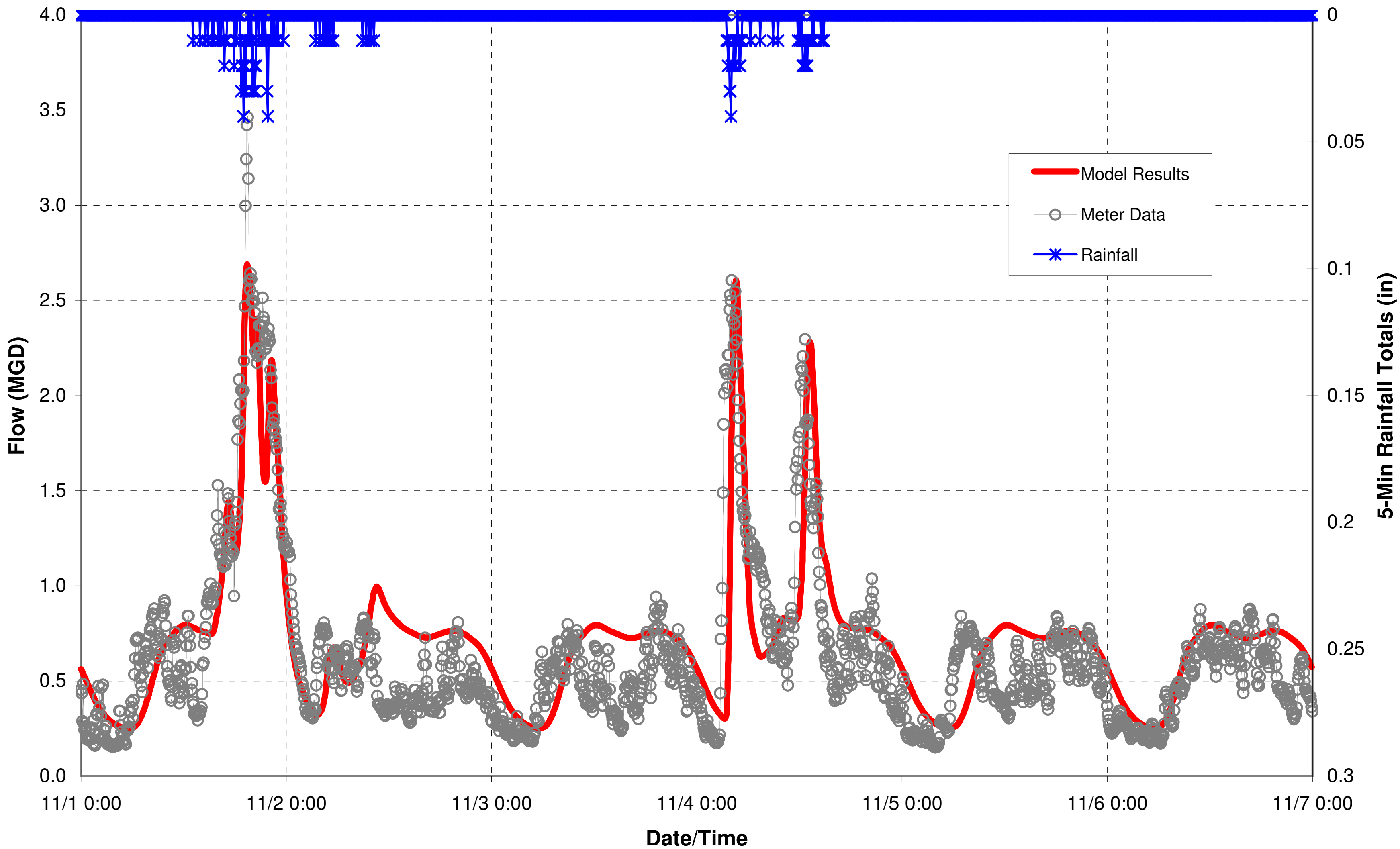


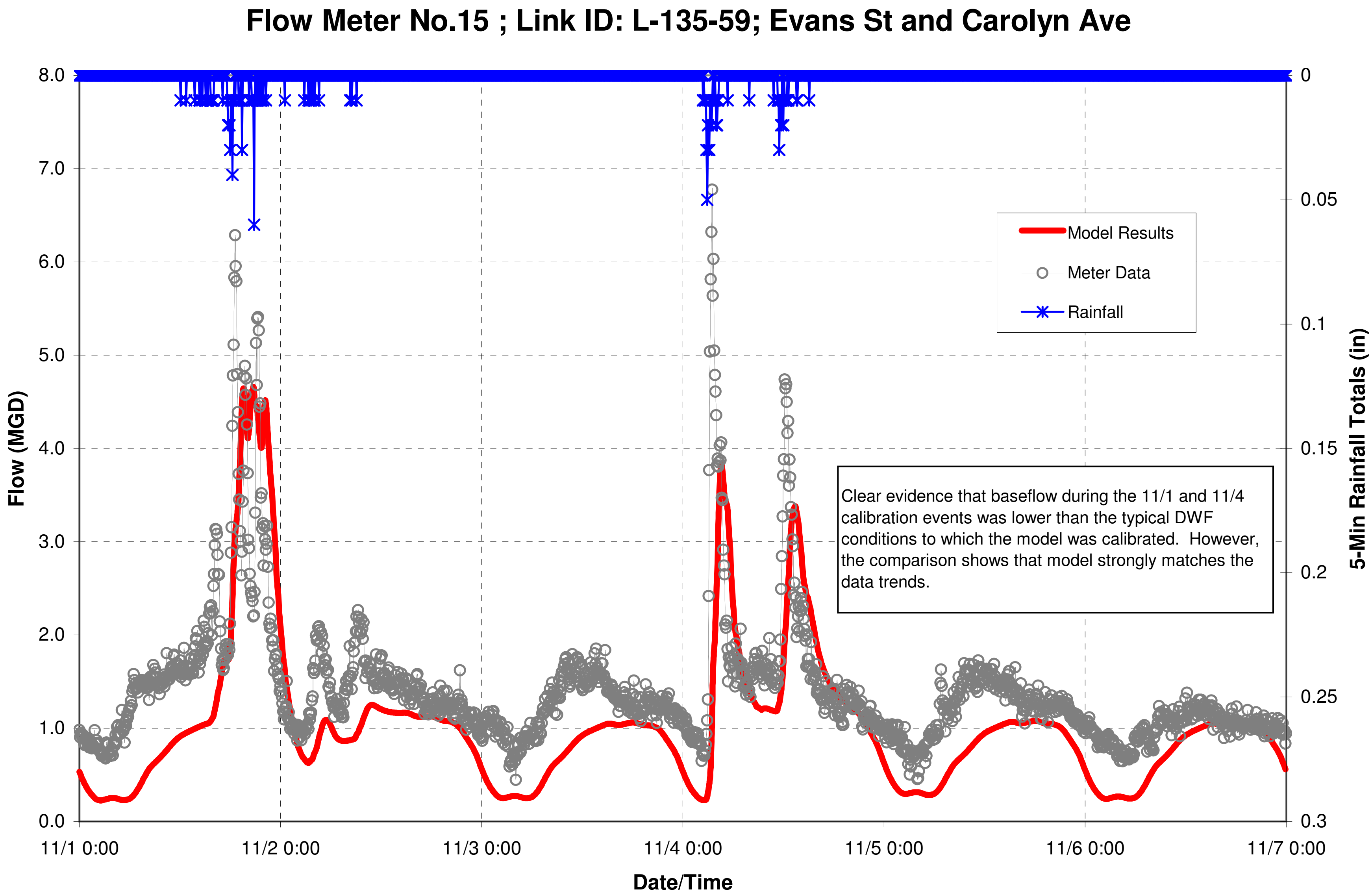
## Flow Meter No.12 ; Link ID: L-138-25; Eighth St and Marion St

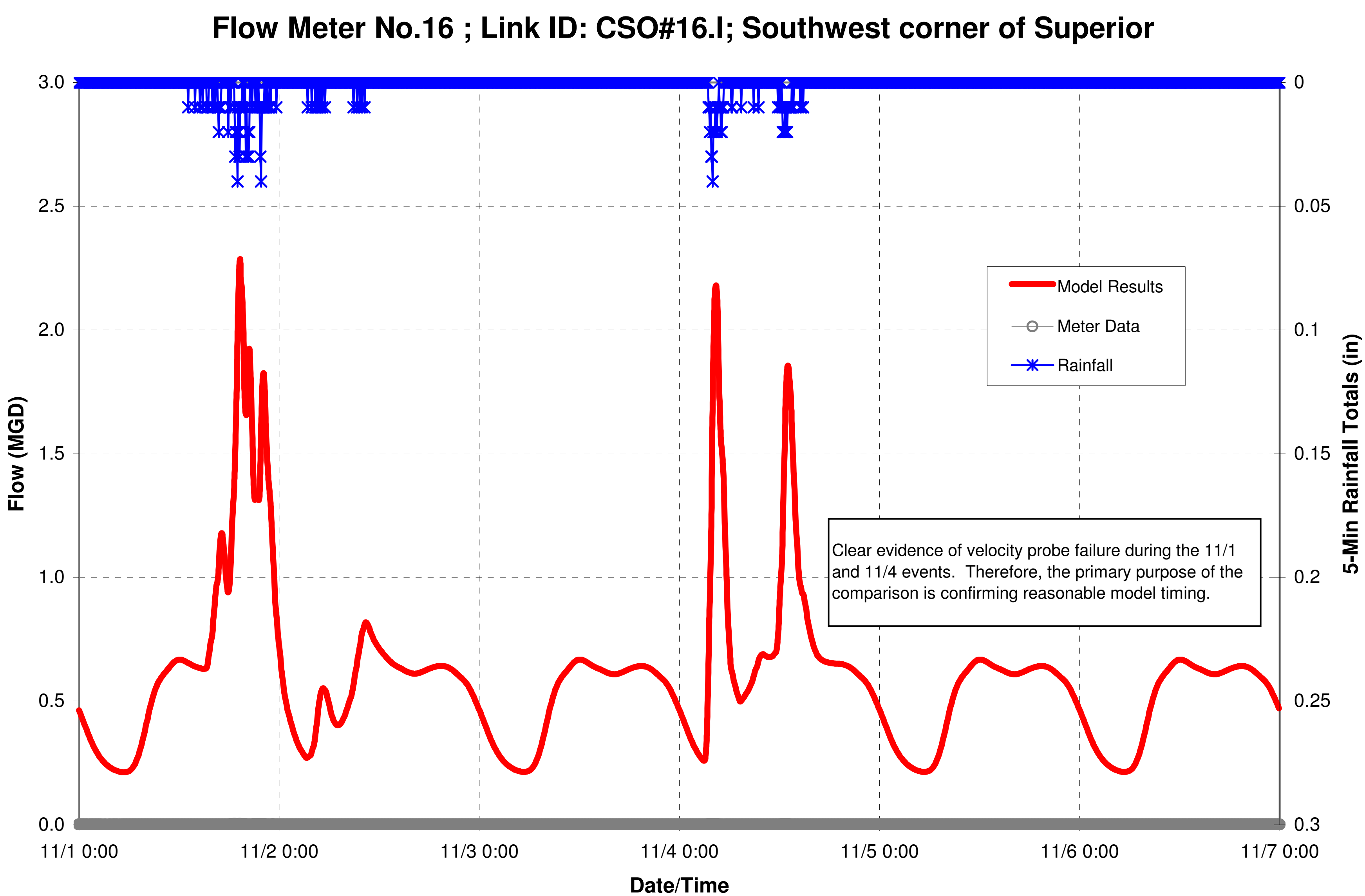



Flow Meter No.13 ; Link ID: L-140-38; Navajo St, ~275 ft south of
Model Results
Meter Data
Rainfall
Clear evidence of velocity probe failure during the 11/1 and 11/4 events. Therefore, the primary purpose of the comparison is confirming reasonable model timing.
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
27.0
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00

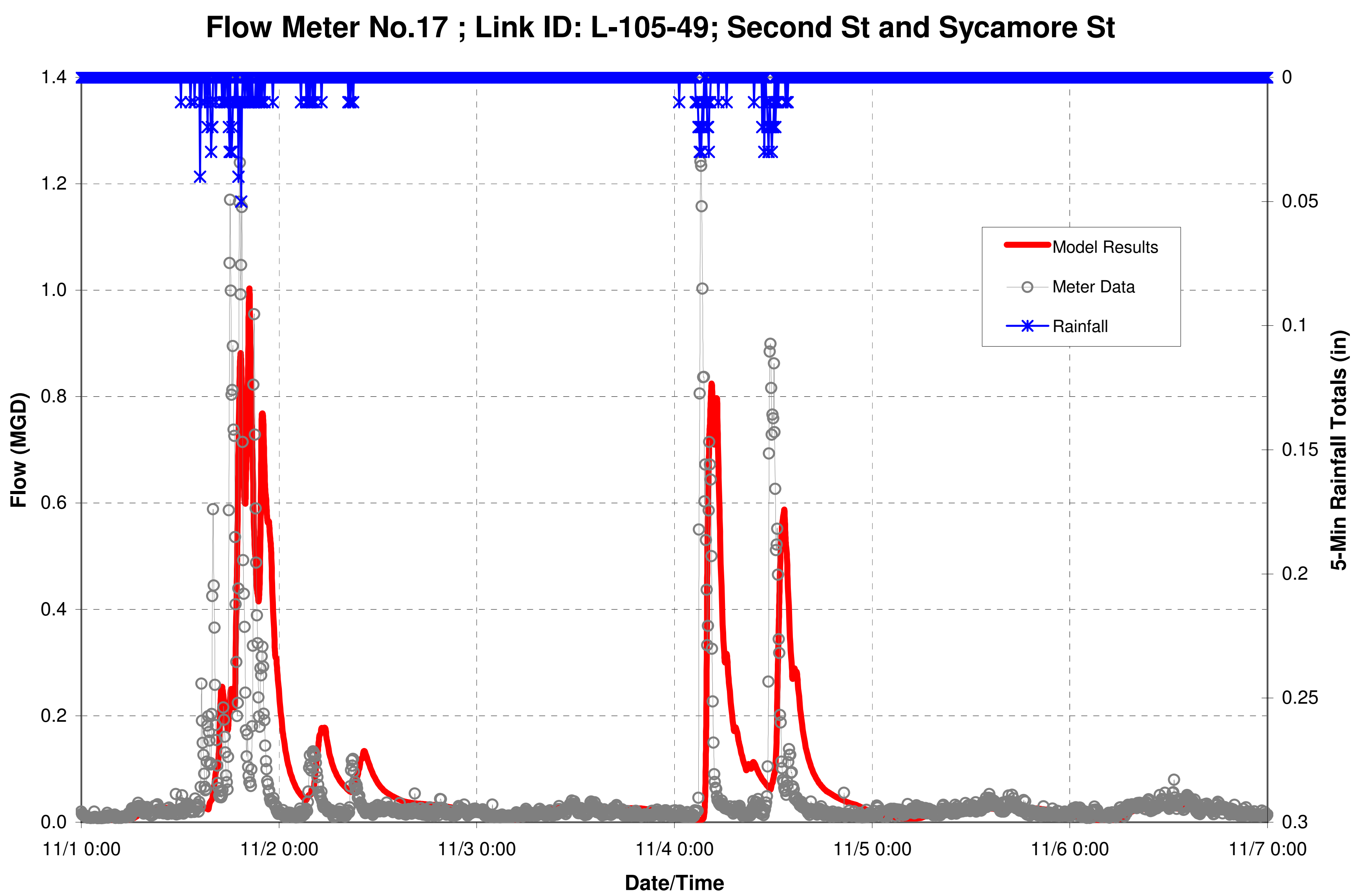
## Flow Meter No.14 ; Link ID: L-104-28; Jackson Blvd and Marine St



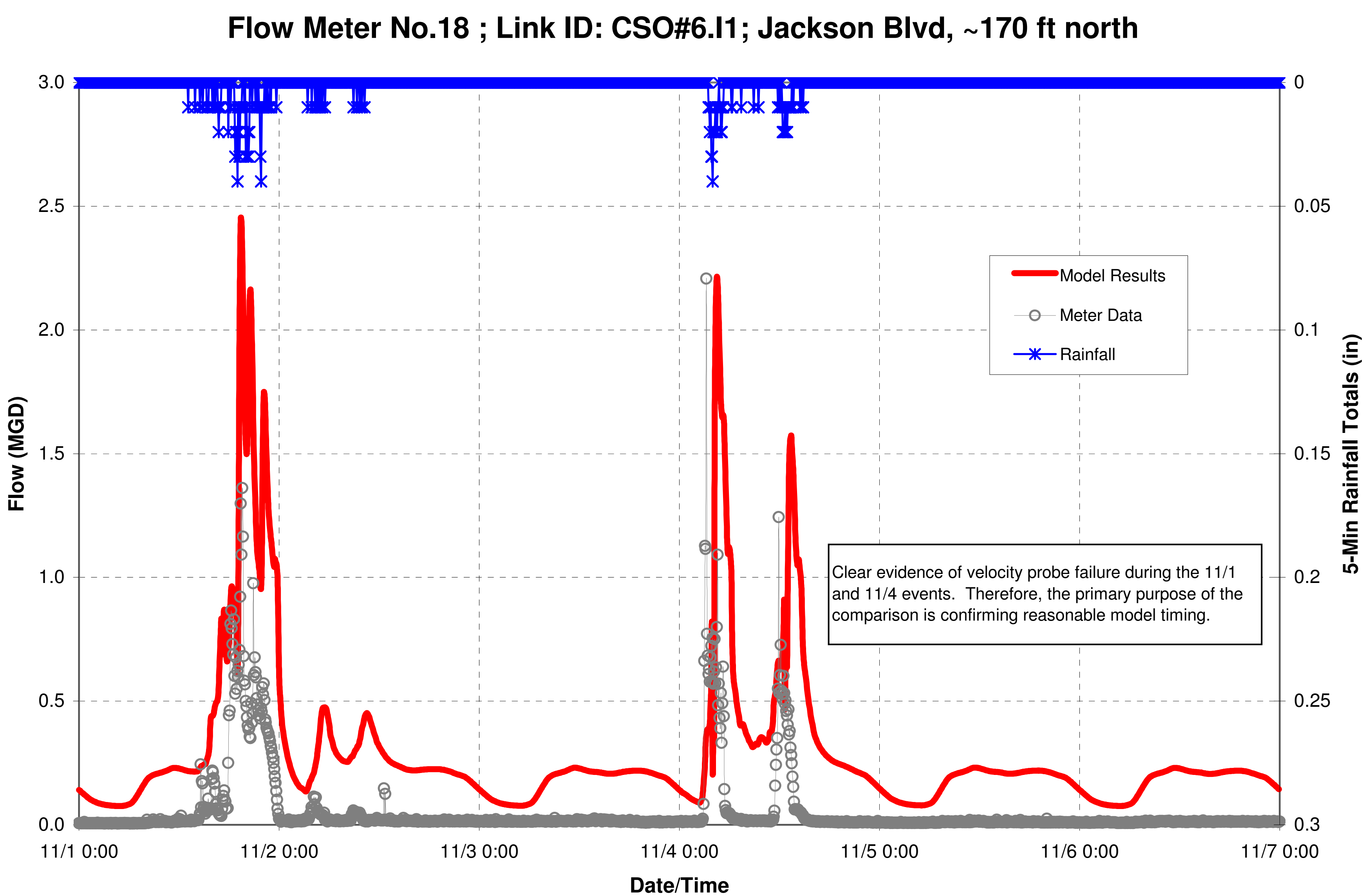

Flow Meter No.15 ; Link ID: L-135-59; Evans St and Carolyn Ave
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Model Results
Meter Data
Rainfall
Clear evidence that baseflow during the 11/1 and 11/4 calibration events was lower than the typical DWF conditions to which the model was calibrated. However, the comparison shows that model strongly matches the data trends.



Flow Meter No.16 ; Link ID: CSO#16.I; Southwest corner of Superior
Flow (MGD)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Rainfall
Clear evidence of velocity probe failure during the 11/1 and 11/4 events. Therefore, the primary purpose of the comparison is confirming reasonable model timing.

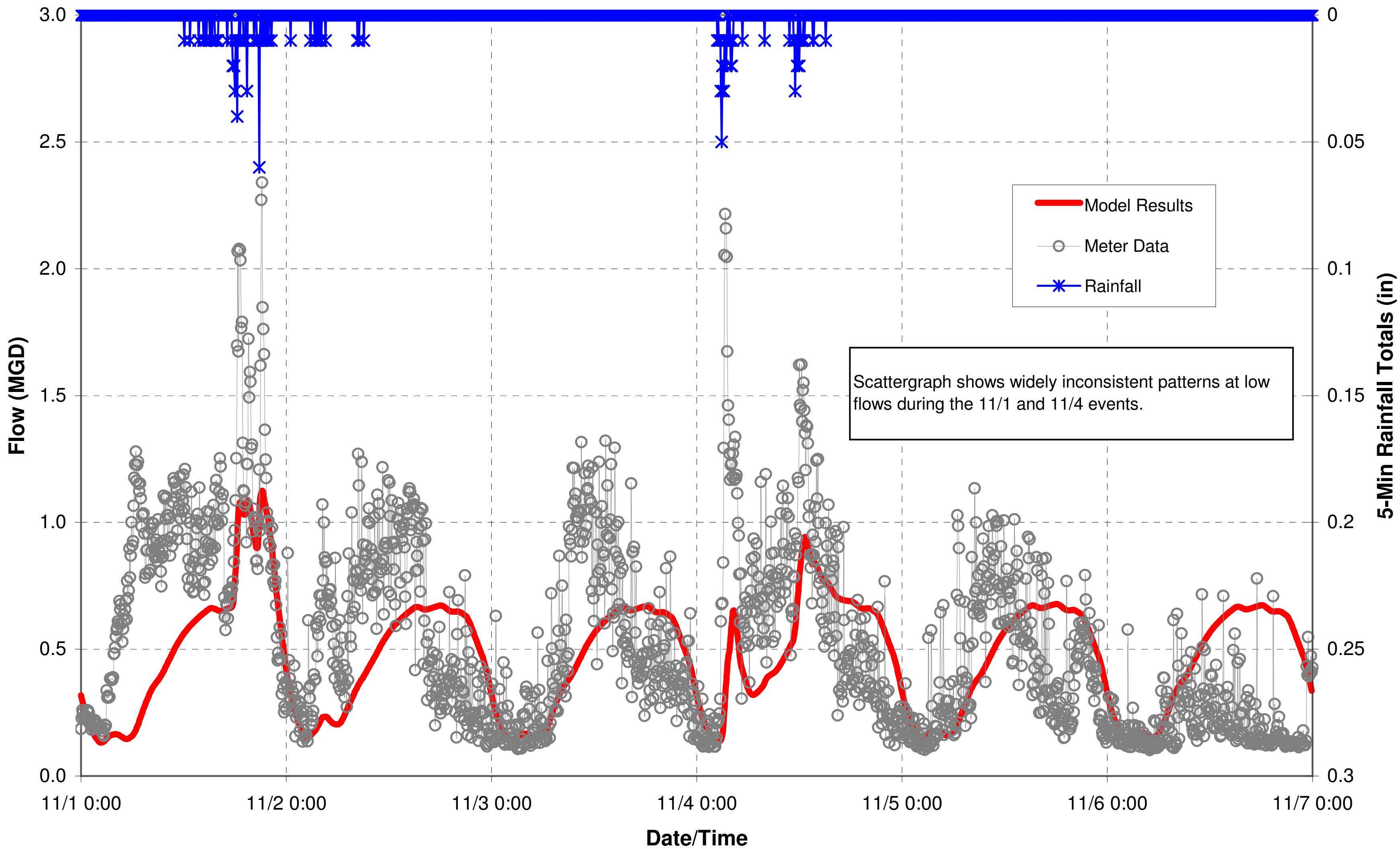


Flow Meter No.17 ; Link ID: L-105-49; Second St and Sycamore St
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
Flow (MGD)
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Rainfall

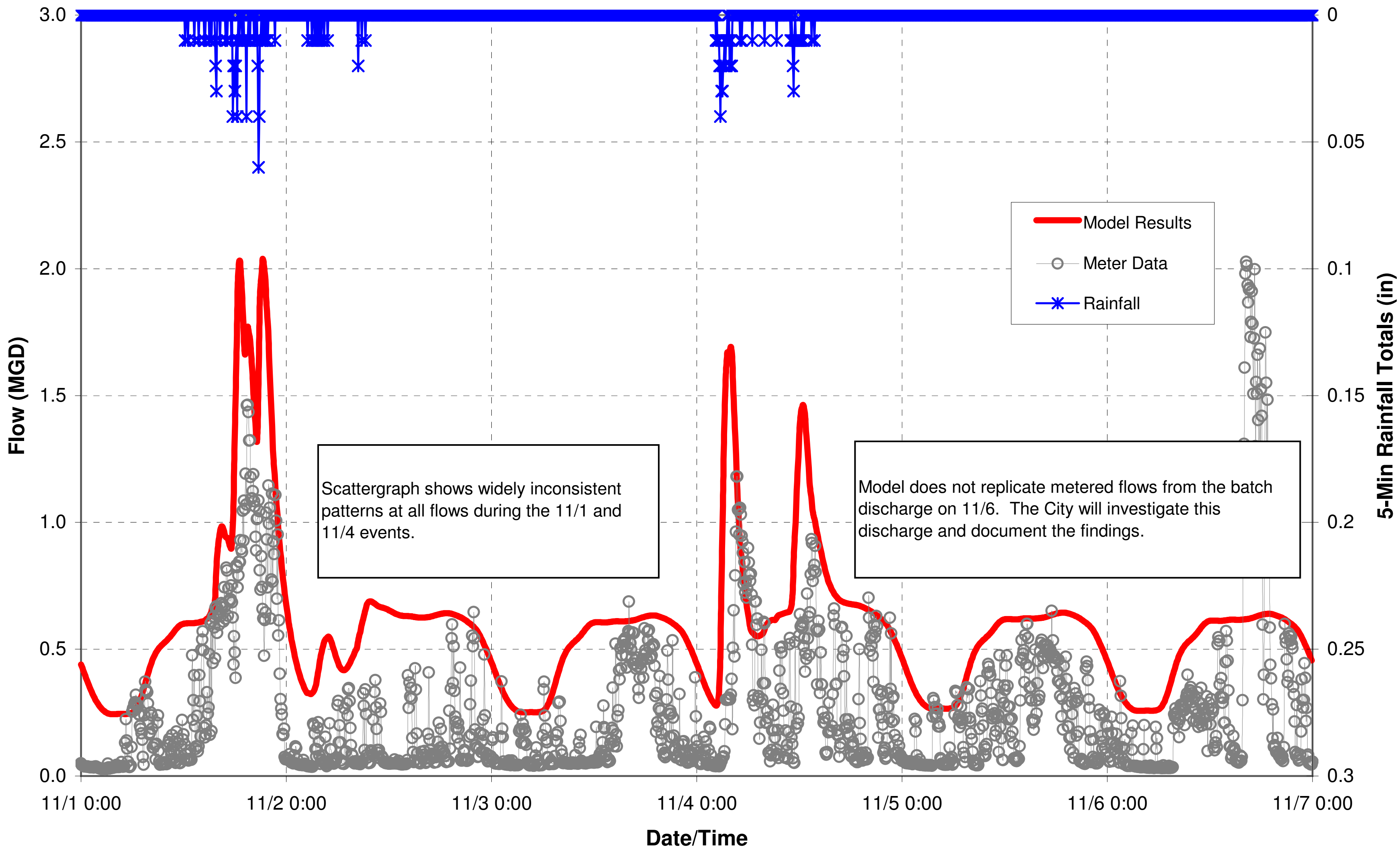


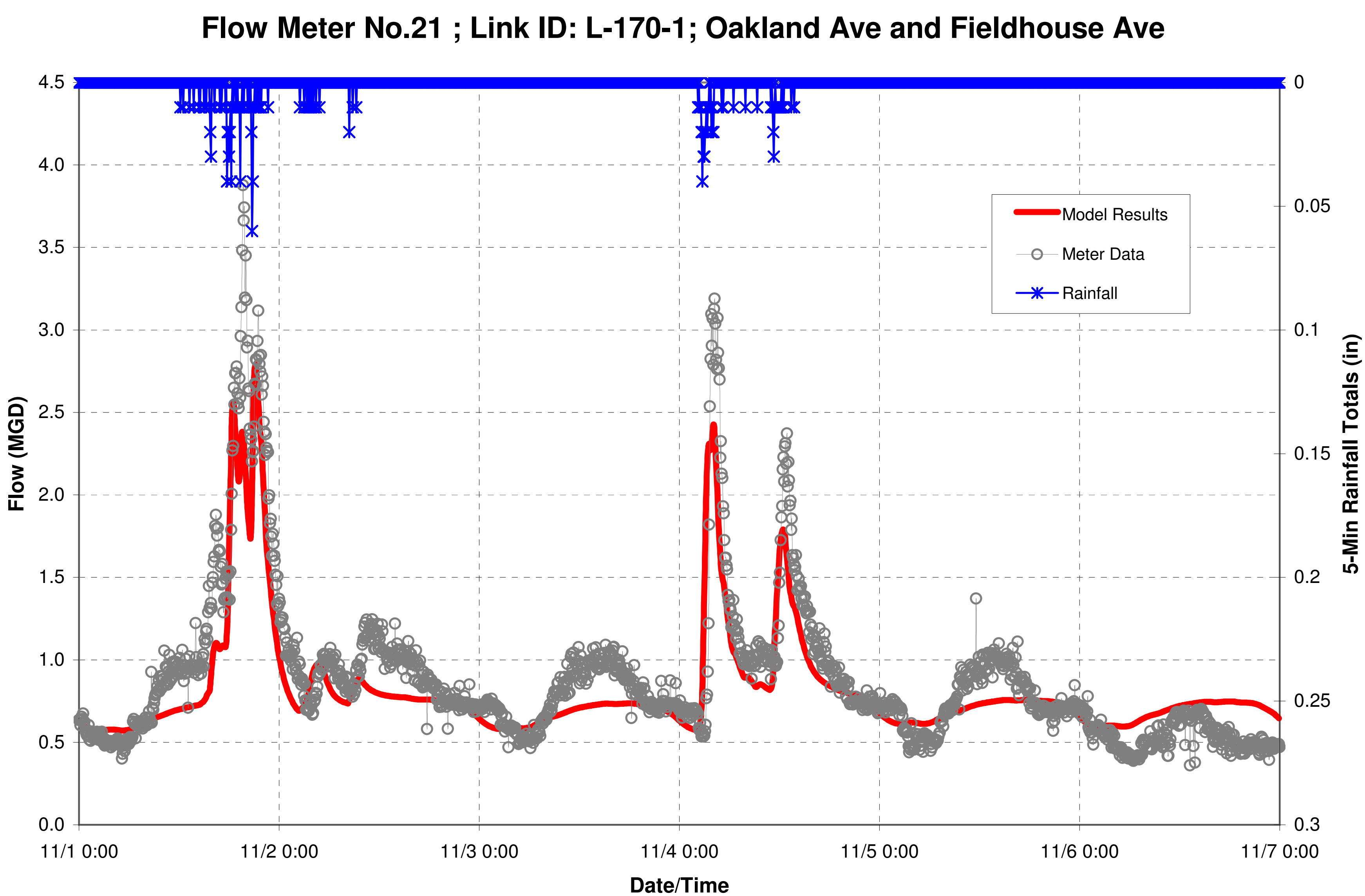
Flow Meter No.18 ; Link ID: CSO#6.I1; Jackson Blvd, ~170 ft north
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Model Results
Meter Data
Rainfall
Clear evidence of velocity probe failure during the 11/1 and 11/4 events. Therefore, the primary purpose of the comparison is confirming reasonable model timing.

# Flow Meter No.19 ; Link ID: L-123-13; Middlebury St and Denver St



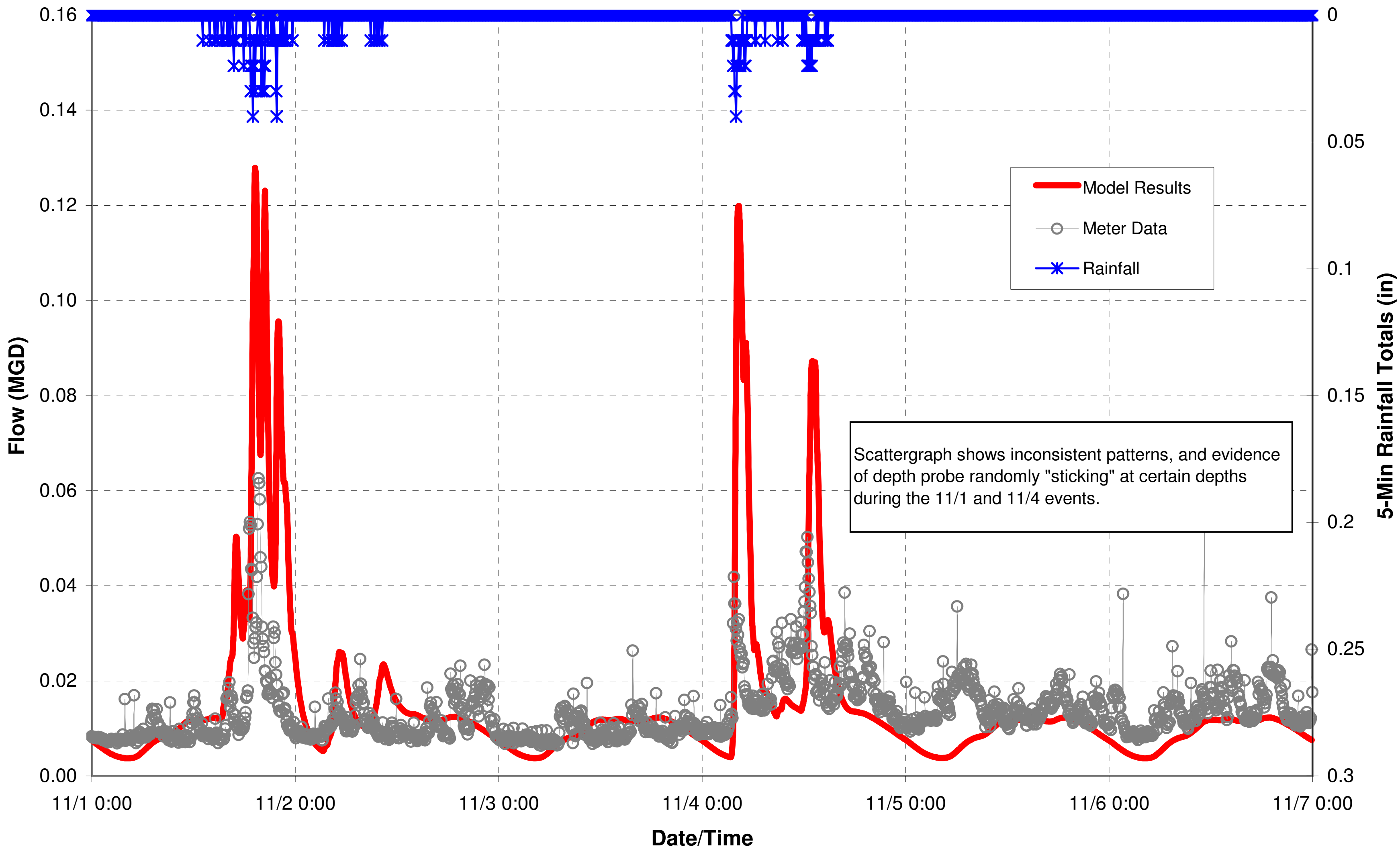
# Flow Meter No.20 ; Link ID: L-170-29; Ninth St and Fieldhouse Ave



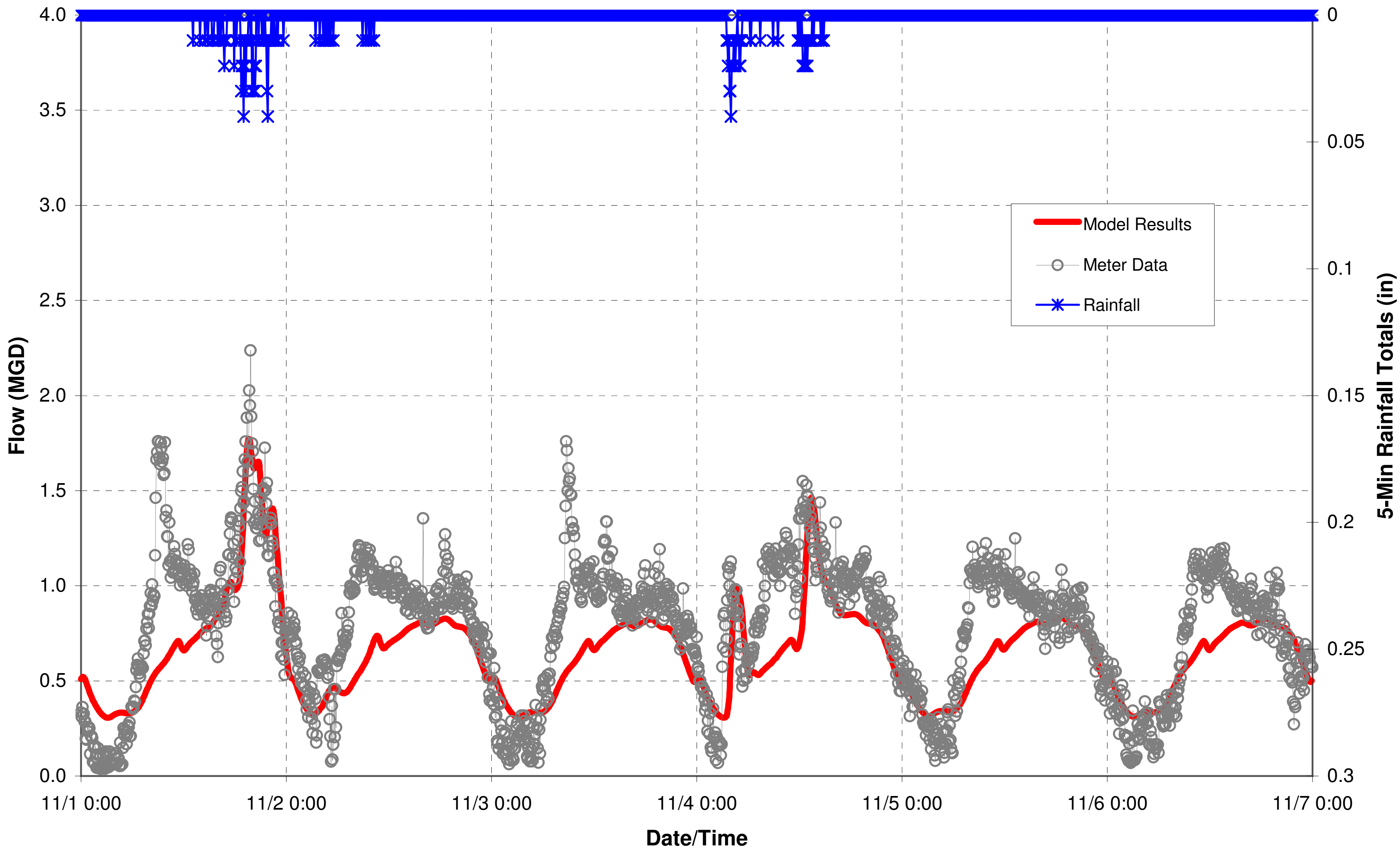


Flow Meter No.21 ; Link ID: L-170-1; Oakland Ave and Fieldhouse Ave
Flow (MGD)
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Model Results
Meter Data
Rainfall
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time

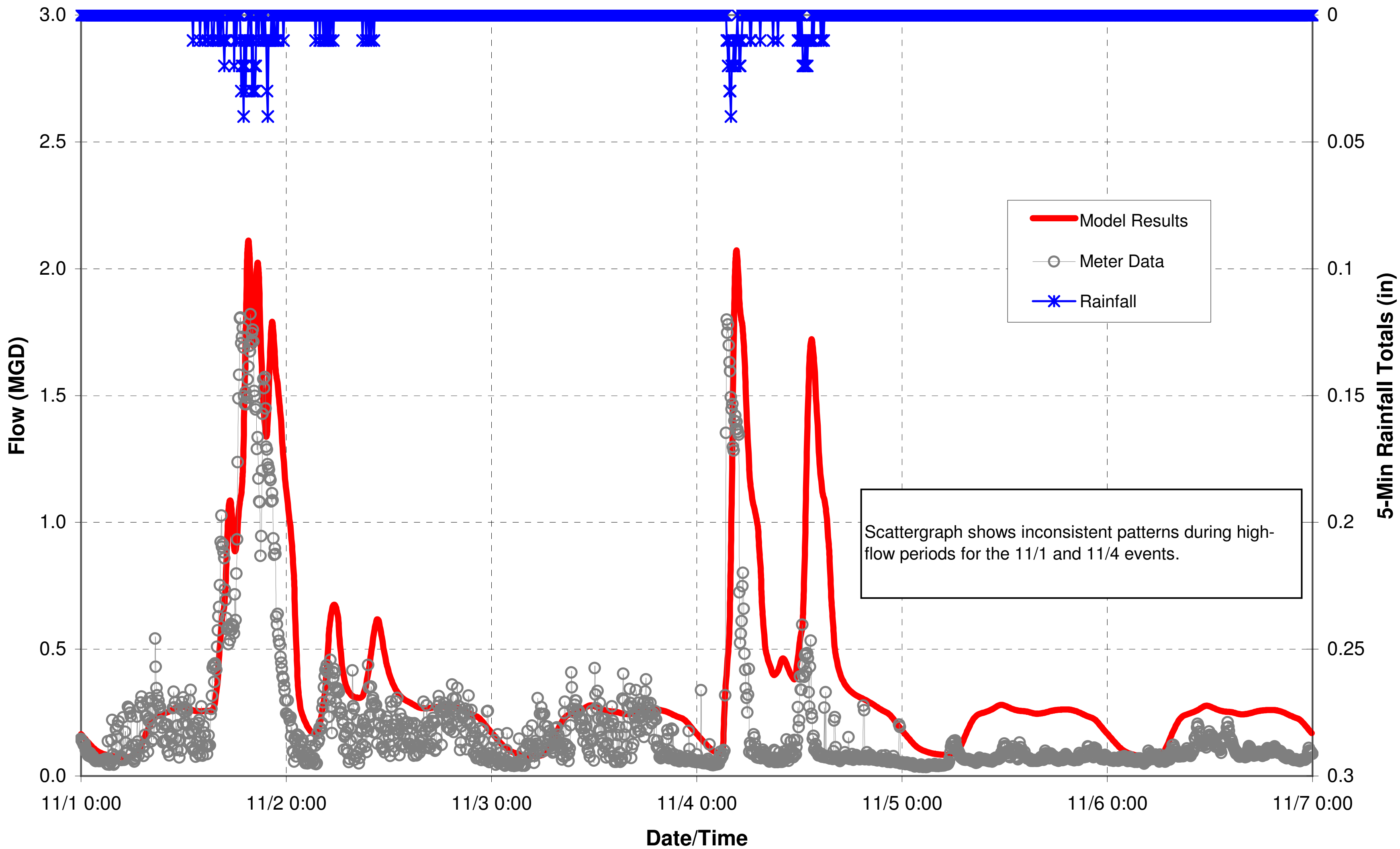
## Flow Meter No.22 ; Link ID: L-88-37; Cassopolis St and Russell Ct

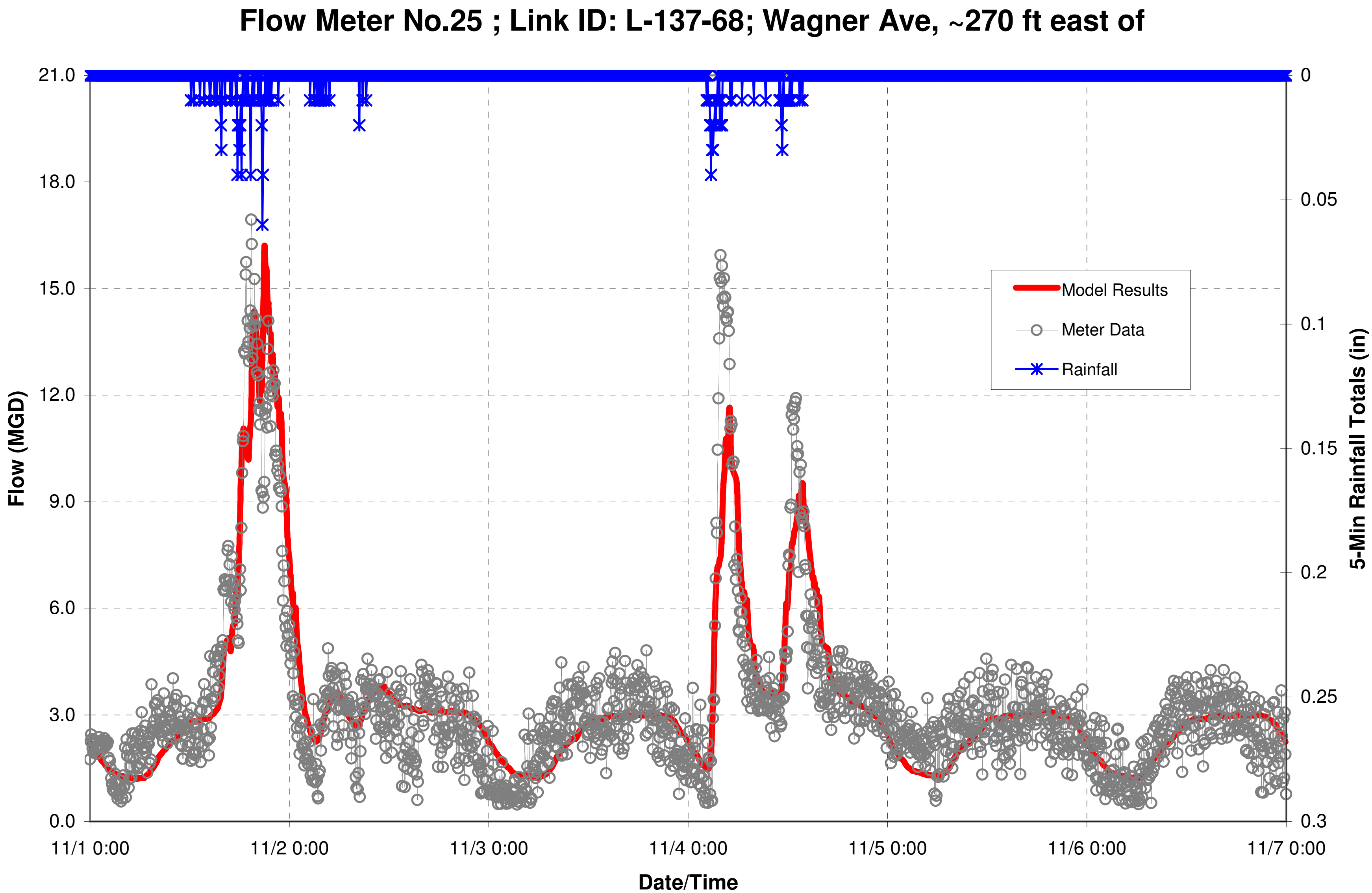


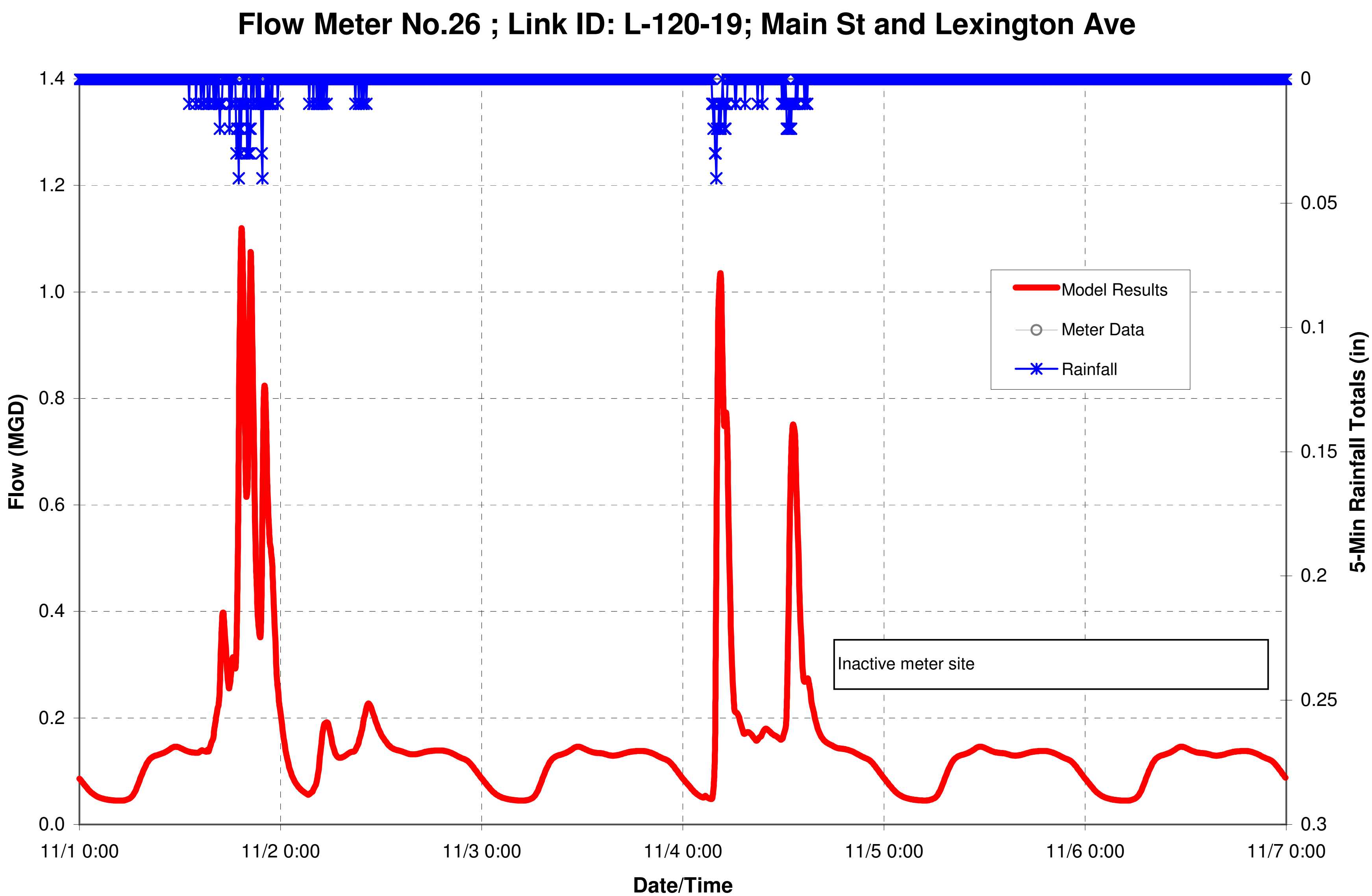
# Flow Meter No.23 ; Link ID: L-89-16; Grant St and Dearborn St



# Flow Meter No.24 ; Link ID: L-136-98; Tipton St and Charles St

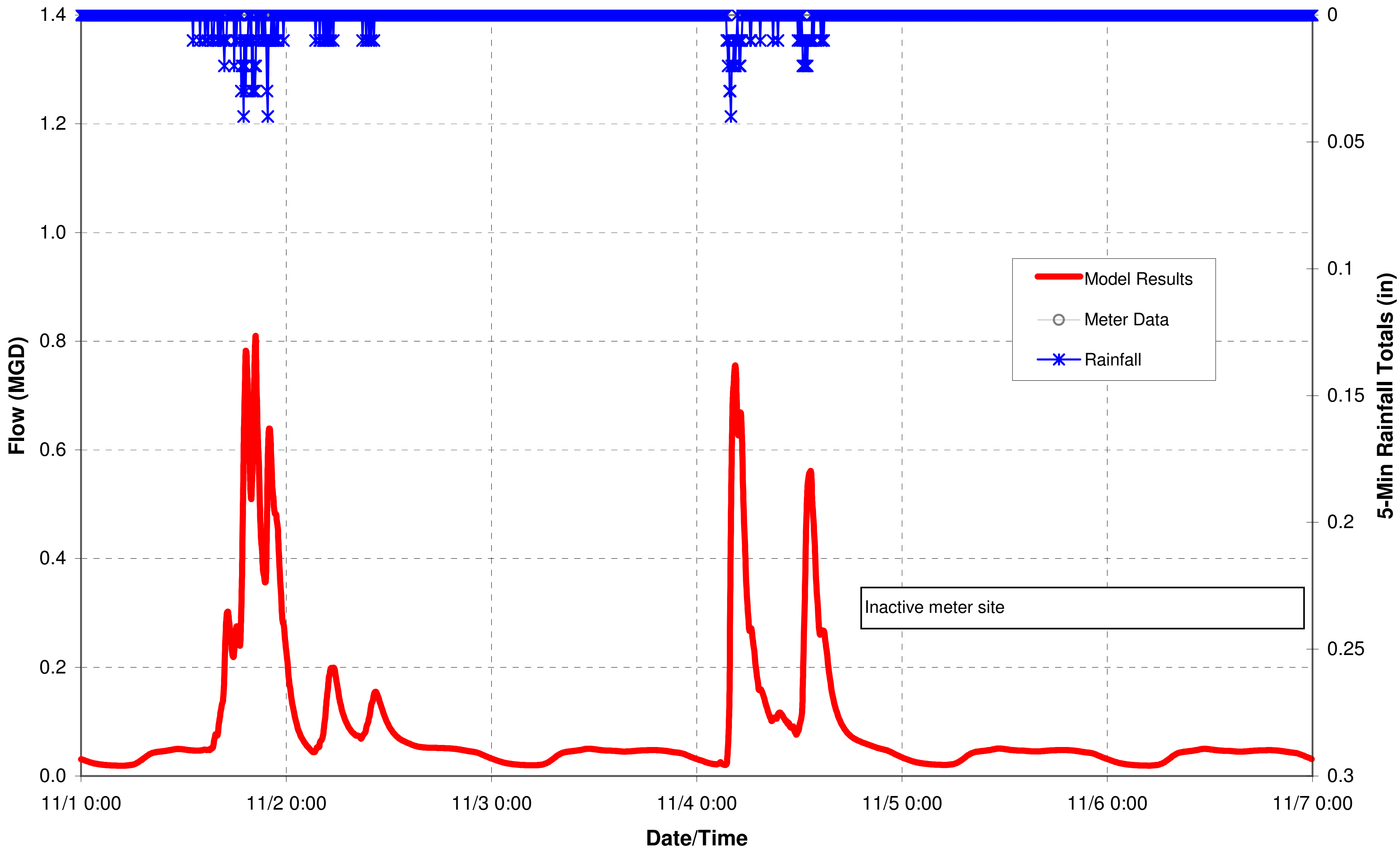


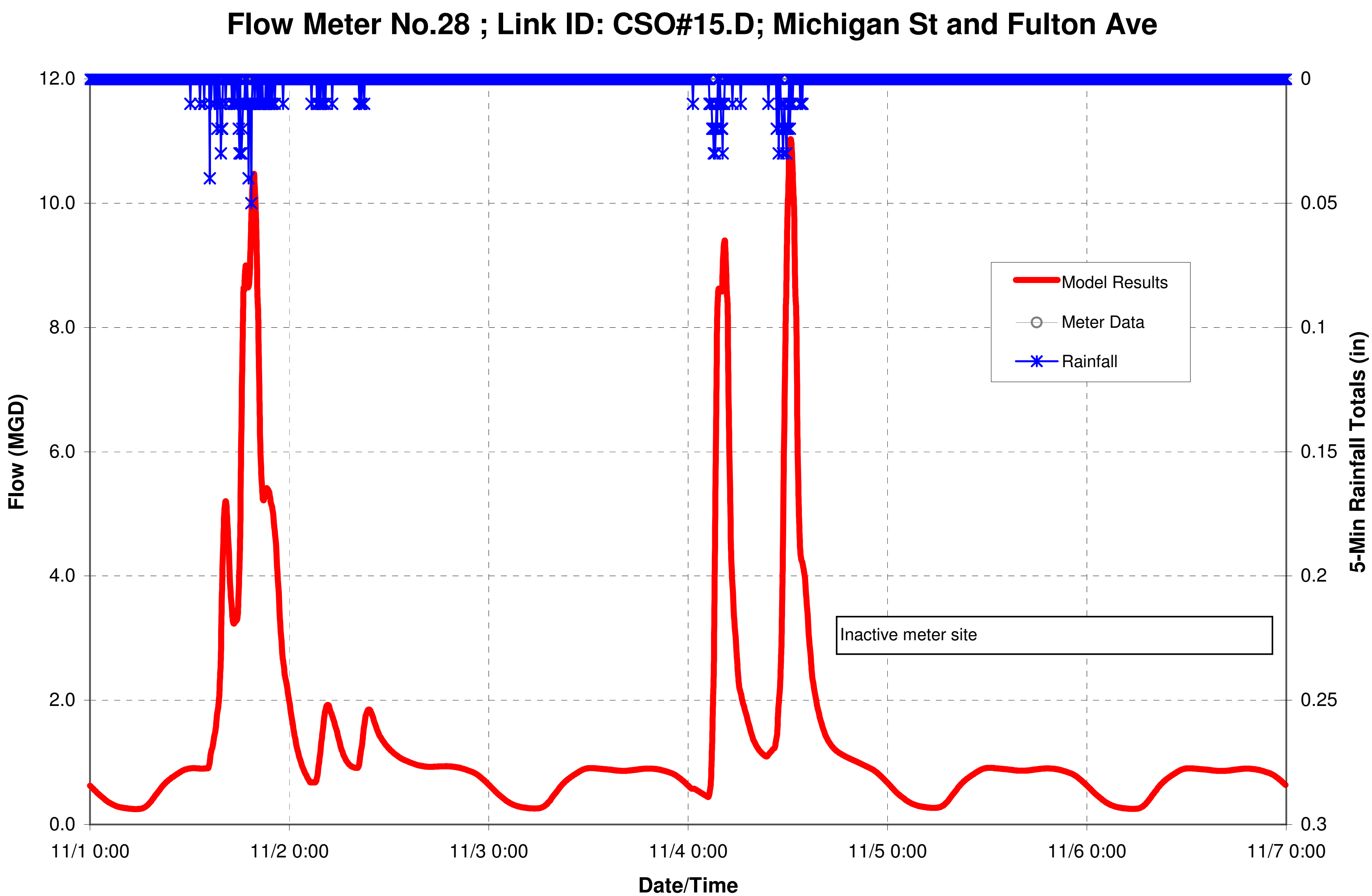

Flow Meter No.25 ; Link ID: L-137-68; Wagner Ave, ~270 ft east of
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
Flow (MGD)
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Rainfall



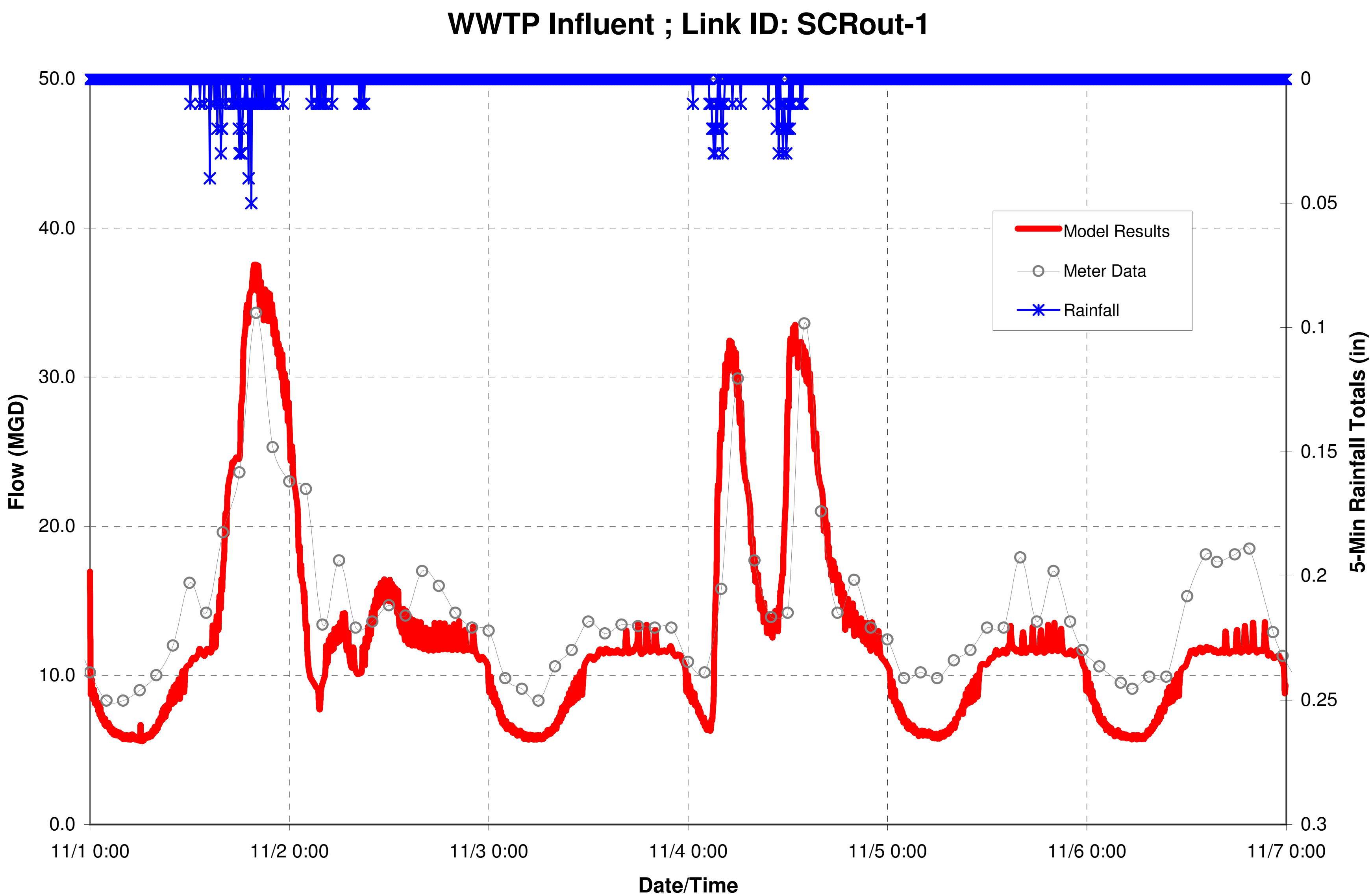
Flow Meter No.26 ; Link ID: L-120-19; Main St and Lexington Ave
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Model Results
Meter Data
Rainfall
Inactive meter site

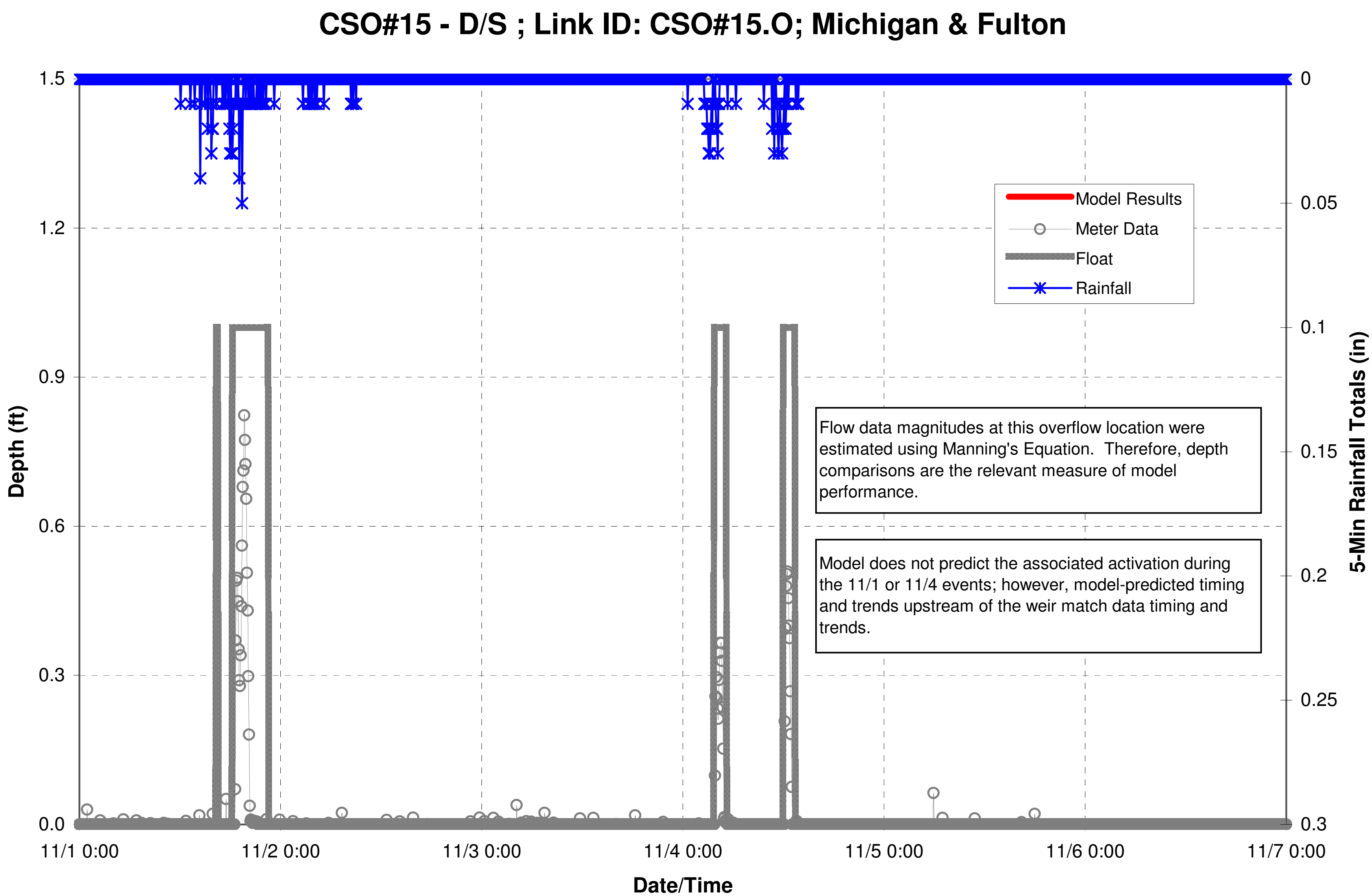
## Flow Meter No.27 ; Link ID: L-120-130; Second St between Lexington

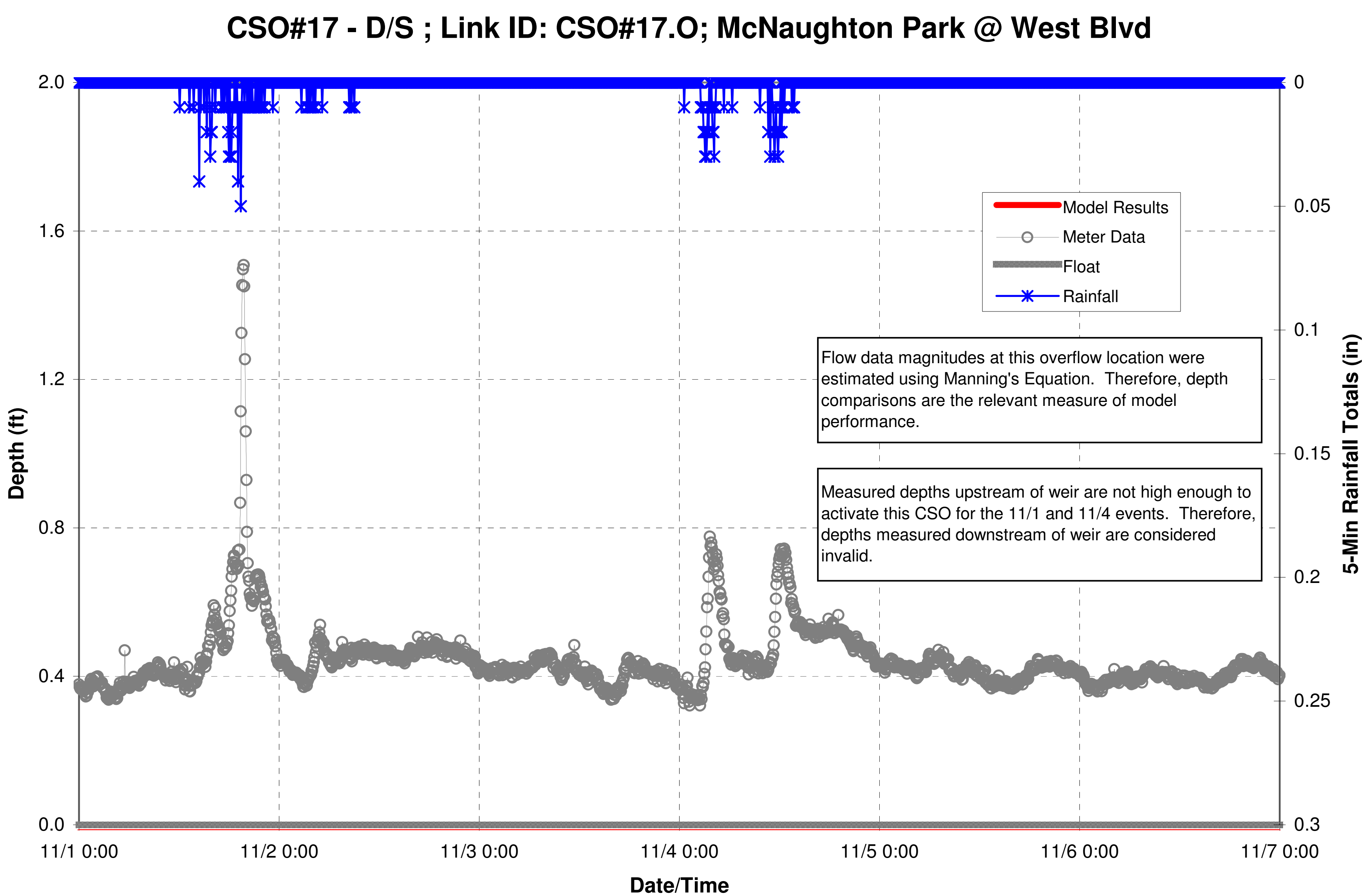


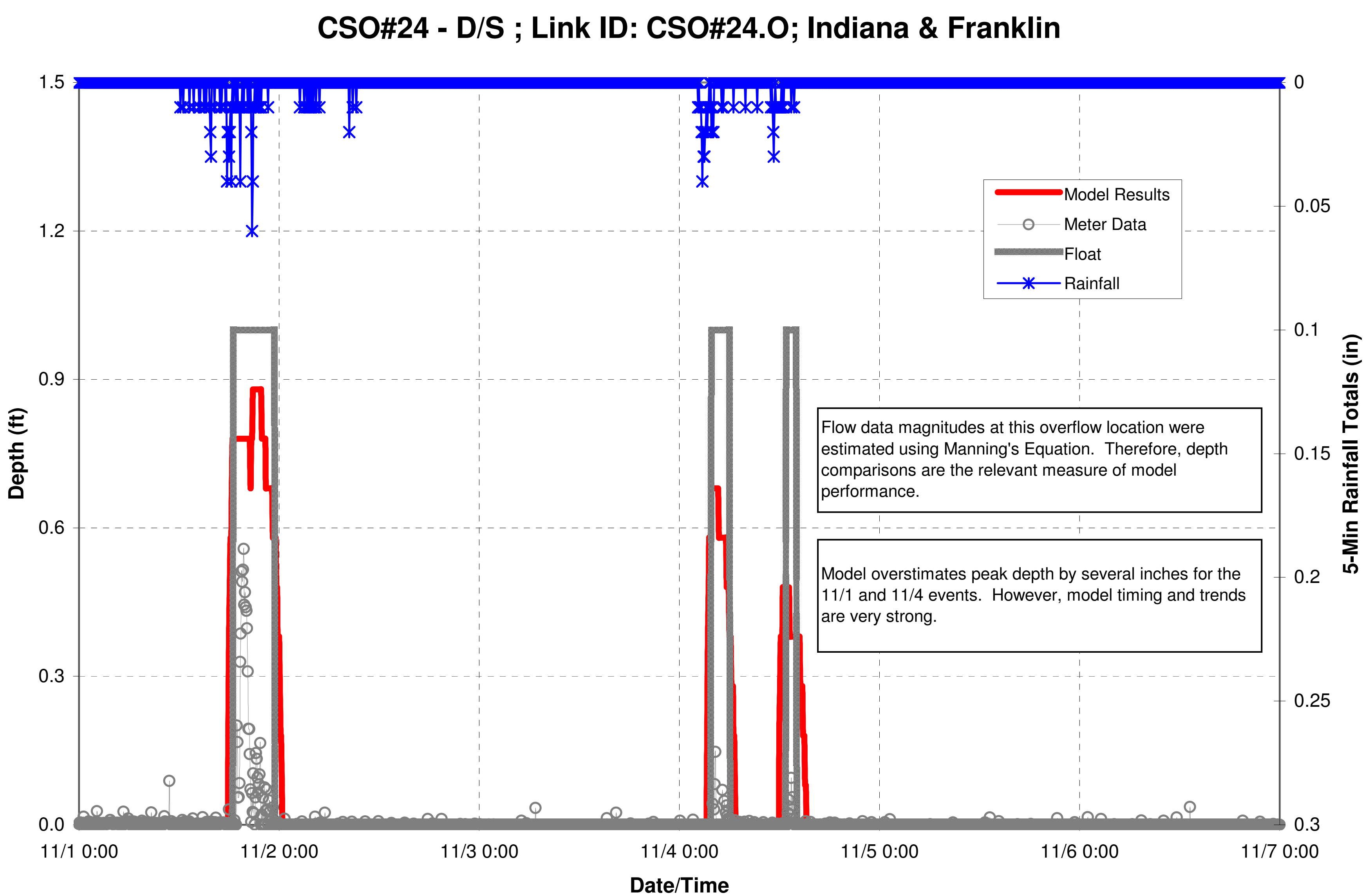


Flow Meter No.28 ; Link ID: CSO#15.D; Michigan St and Fulton Ave
Flow (MGD)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Rainfall
Inactive meter site

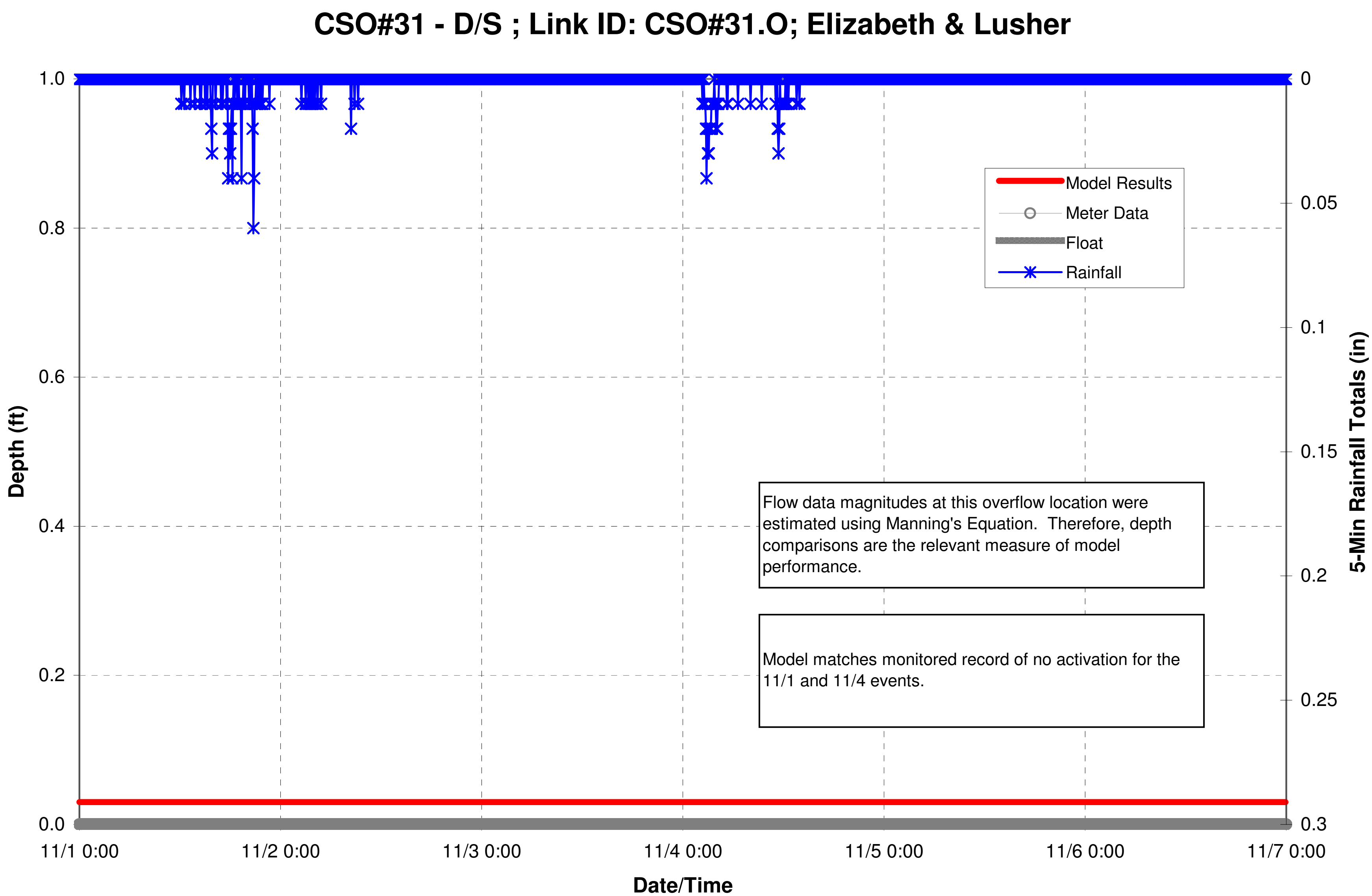

WWTP Influent ; Link ID: SCRout-1
Model Results
Meter Data
Rainfall
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
50.0
40.0
30.0
20.0
10.0
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00

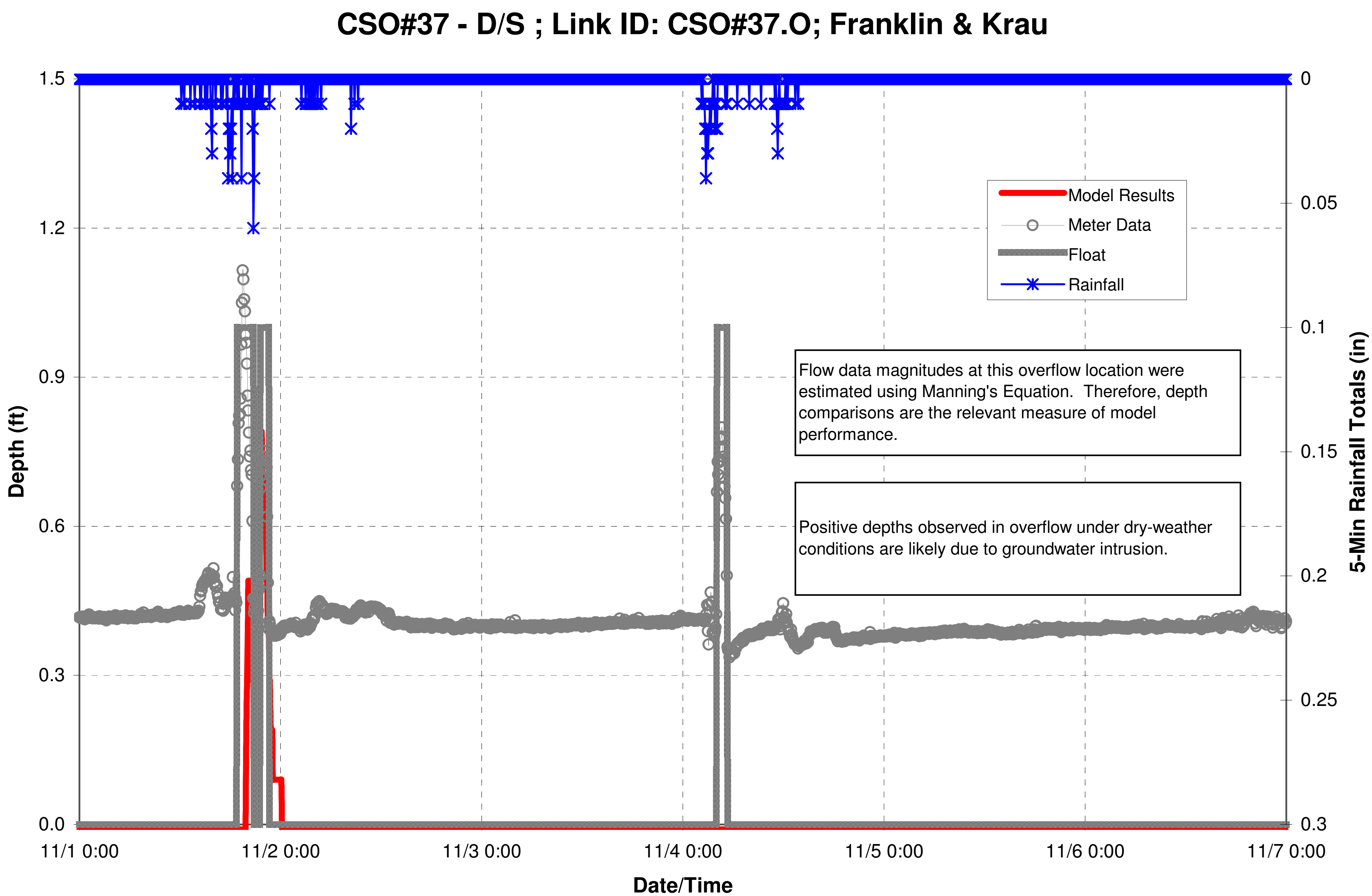

CSO#15 - D/S ; Link ID: CSO#15.O; Michigan & Fulton
Depth (ft)
1.5
1.2
0.9
0.6
0.3
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons are the relevant measure of model performance.
Model does not predict the associated activation during the 11/1 or 11/4 events; however, model-predicted timing and trends upstream of the weir match data timing and trends.


CSO#17 - D/S ; Link ID: CSO#17.O; McNaughton Park @ West Blvd
2.0
1.6
1.2
0.8
0.4
0.0
Depth (ft)
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons are the relevant measure of model performance.
Measured depths upstream of weir are not high enough to activate this CSO for the 11/1 and 11/4 events. Therefore, depths measured downstream of weir are considered invalid.



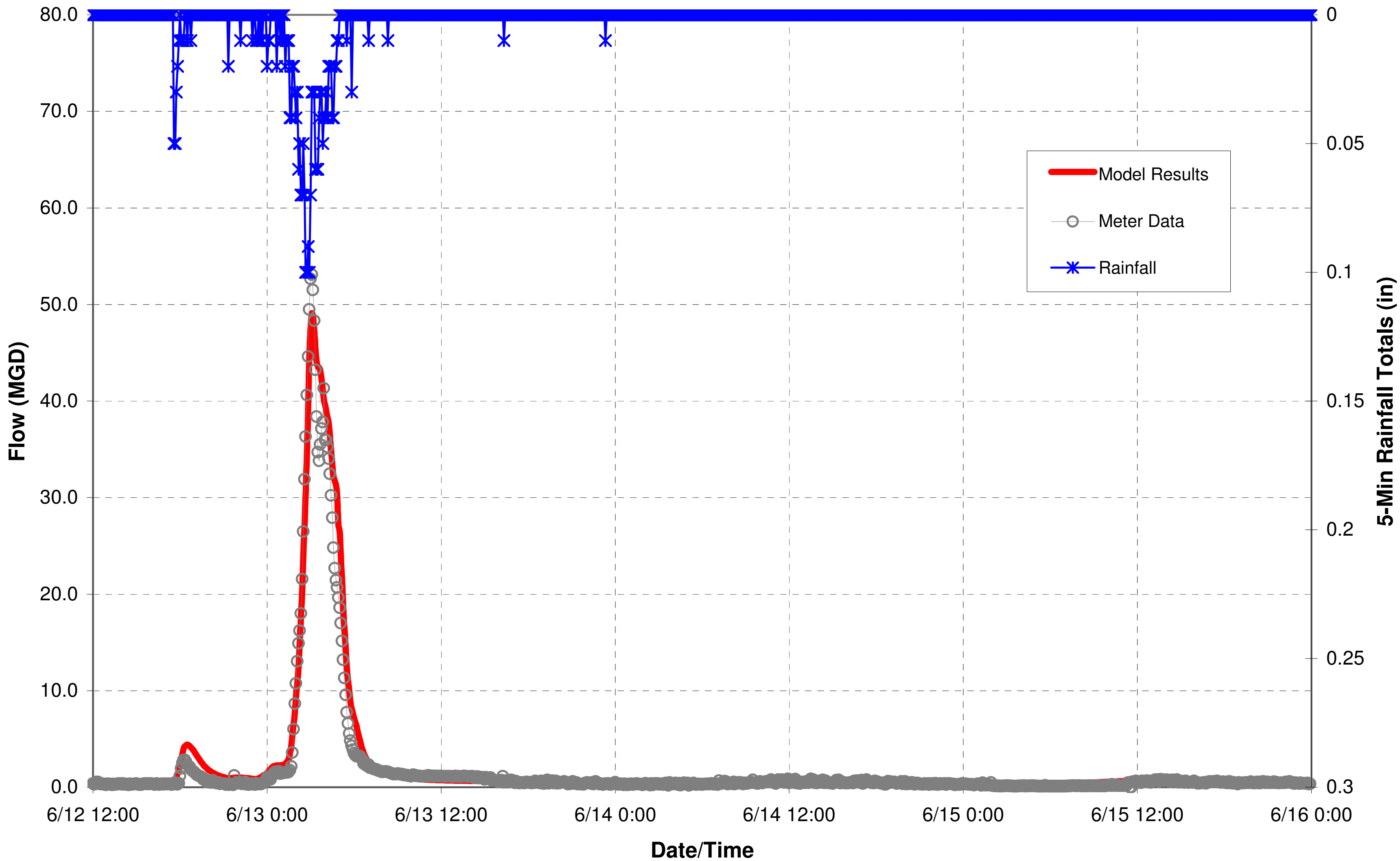
CSO#24 - D/S ; Link ID: CSO#24.O; Indiana & Franklin
Depth (ft)
1.5
1.2
0.9
0.6
0.3
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons are the relevant measure of model performance.
Model overstimates peak depth by several inches for the 11/1 and 11/4 events. However, model timing and trends are very strong.

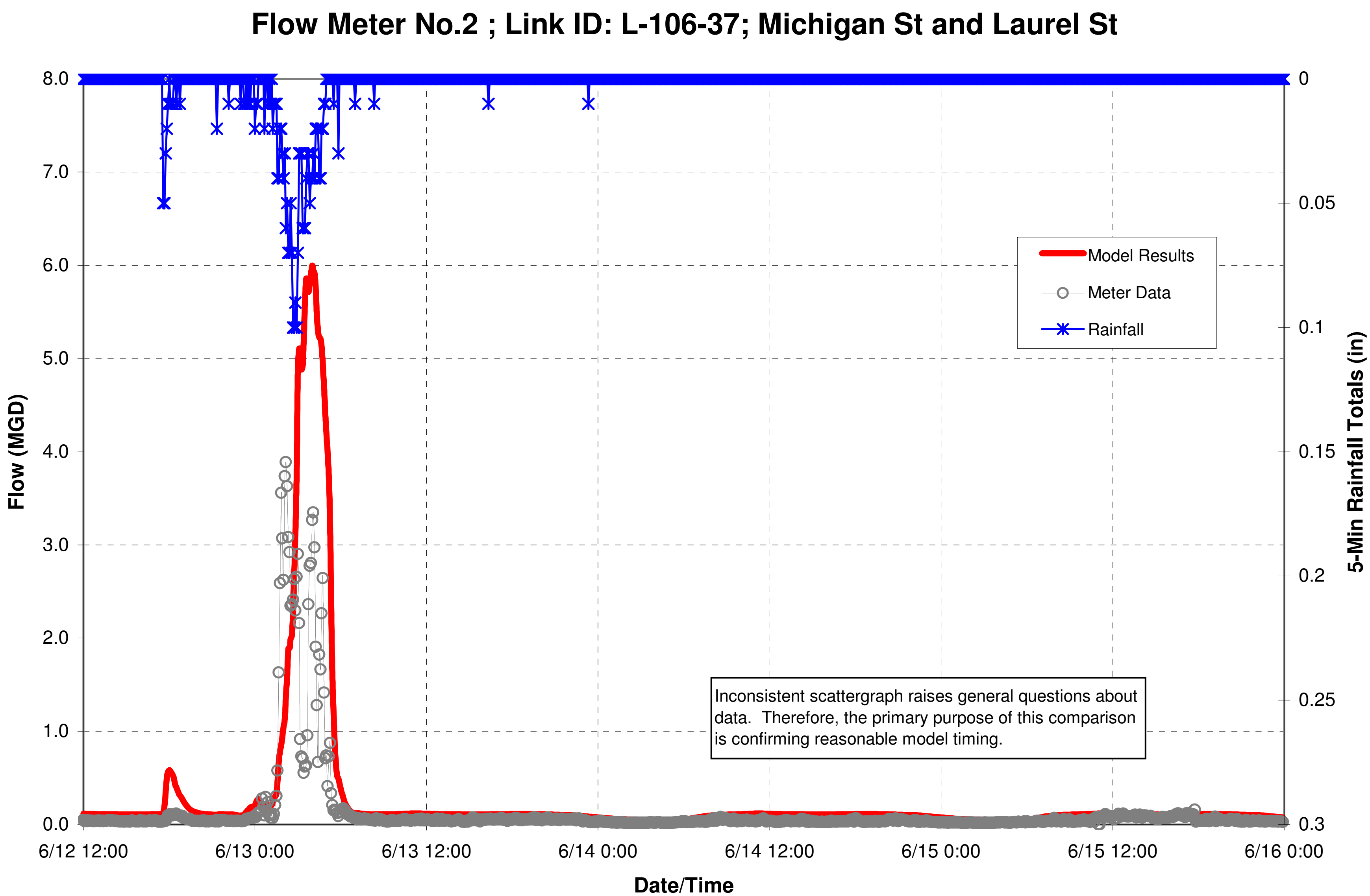

CSO#31 - D/S ; Link ID: CSO#31.O; Elizabeth & Lusher
1.0
0.8
0.6
0.4
0.2
0.0
Depth (ft)
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Date/Time
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons are the relevant measure of model performance.
Model matches monitored record of no activation for the 11/1 and 11/4 events.



CSO#37 - D/S ; Link ID: CSO#37.O; Franklin & Krau
Depth (ft)
5-Min Rainfall Totals (in)
Date/Time
1.5
1.2
0.9
0.6
0.3
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
11/1 0:00
11/2 0:00
11/3 0:00
11/4 0:00
11/5 0:00
11/6 0:00
11/7 0:00
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons are the relevant measure of model performance.
Positive depths observed in overflow under dry-weather conditions are likely due to groundwater intrusion.

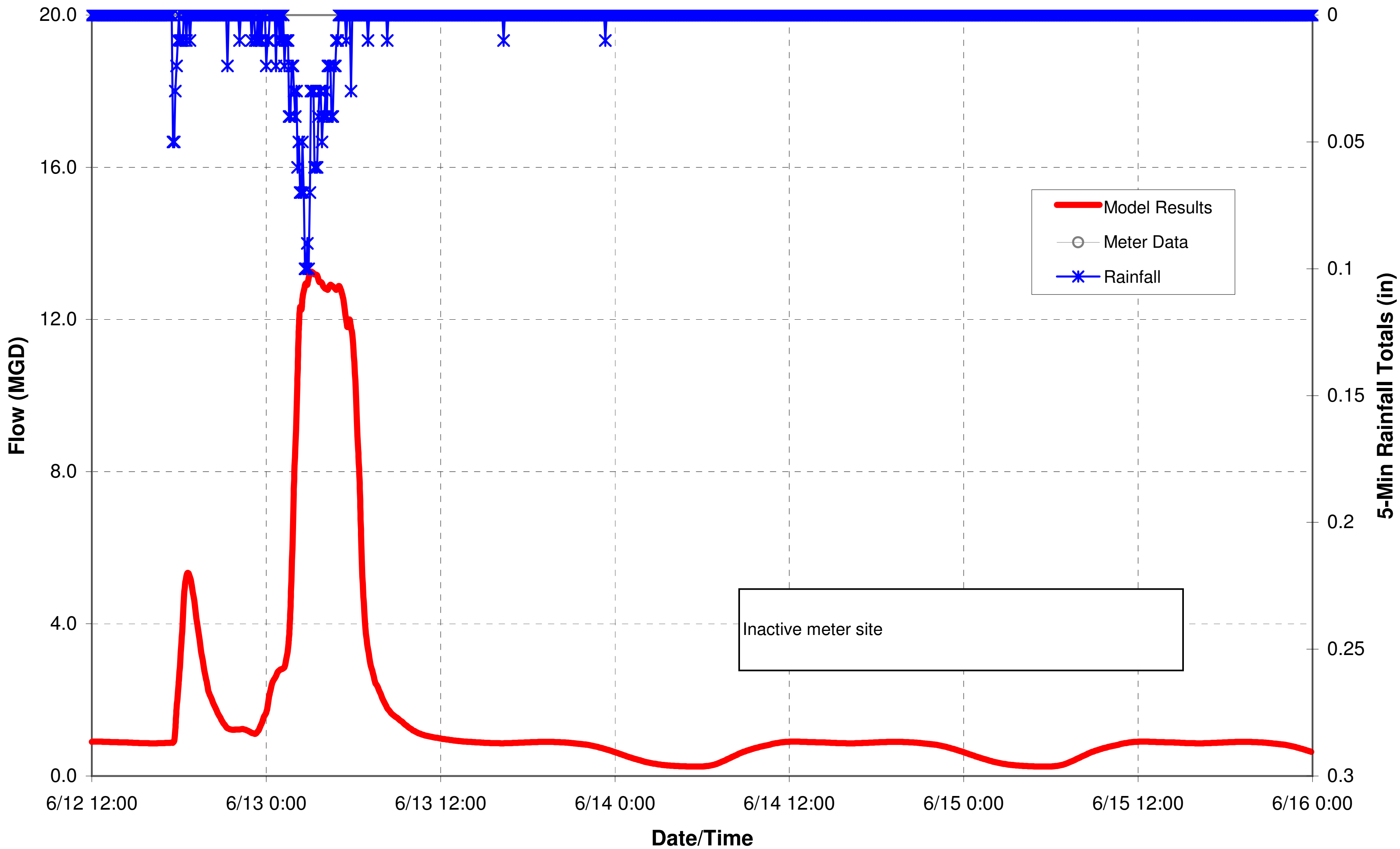
## Flow Meter No.1 ; Link ID: L-107-32; Plum St and Laurel St



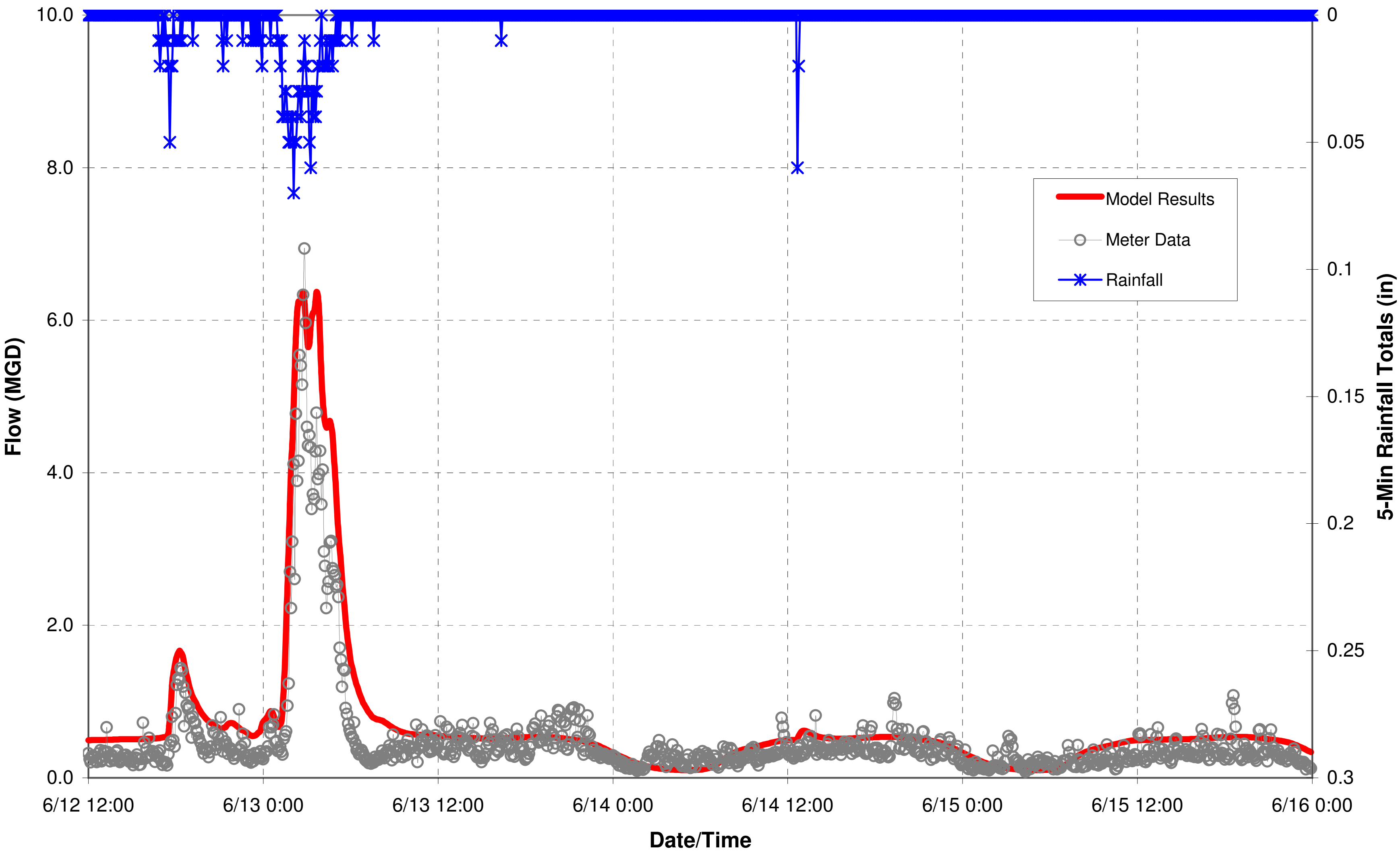


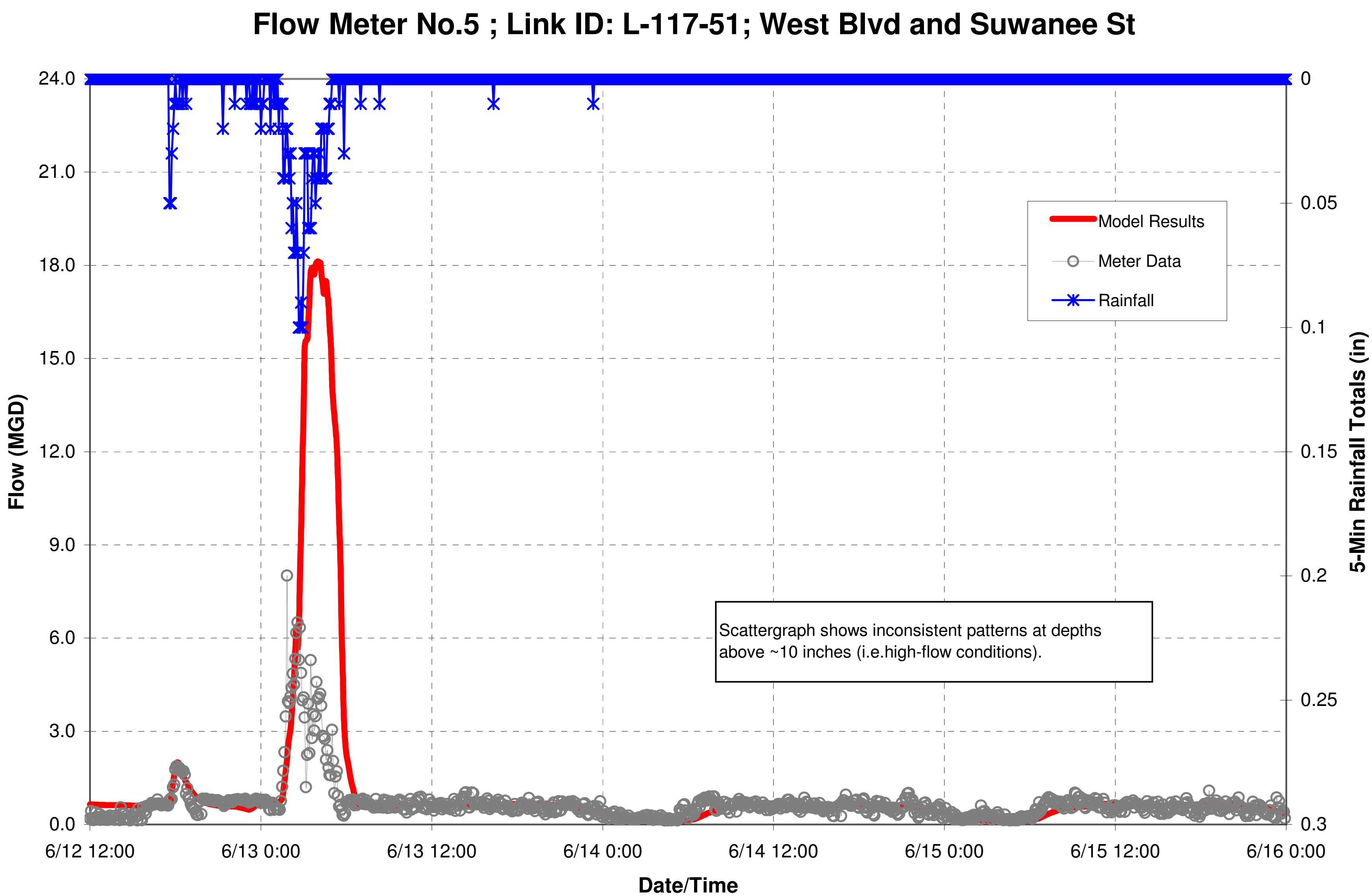
Flow Meter No.2 ; Link ID: L-106-37; Michigan St and Laurel St
Flow (MGD)
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Date/Time
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Model Results
Meter Data
Rainfall
Inconsistent scattergraph raises general questions about data. Therefore, the primary purpose of this comparison is confirming reasonable model timing.

## Flow Meter No.3 ; Link ID: CSO#15.D; Michigan St and Kilbourn St

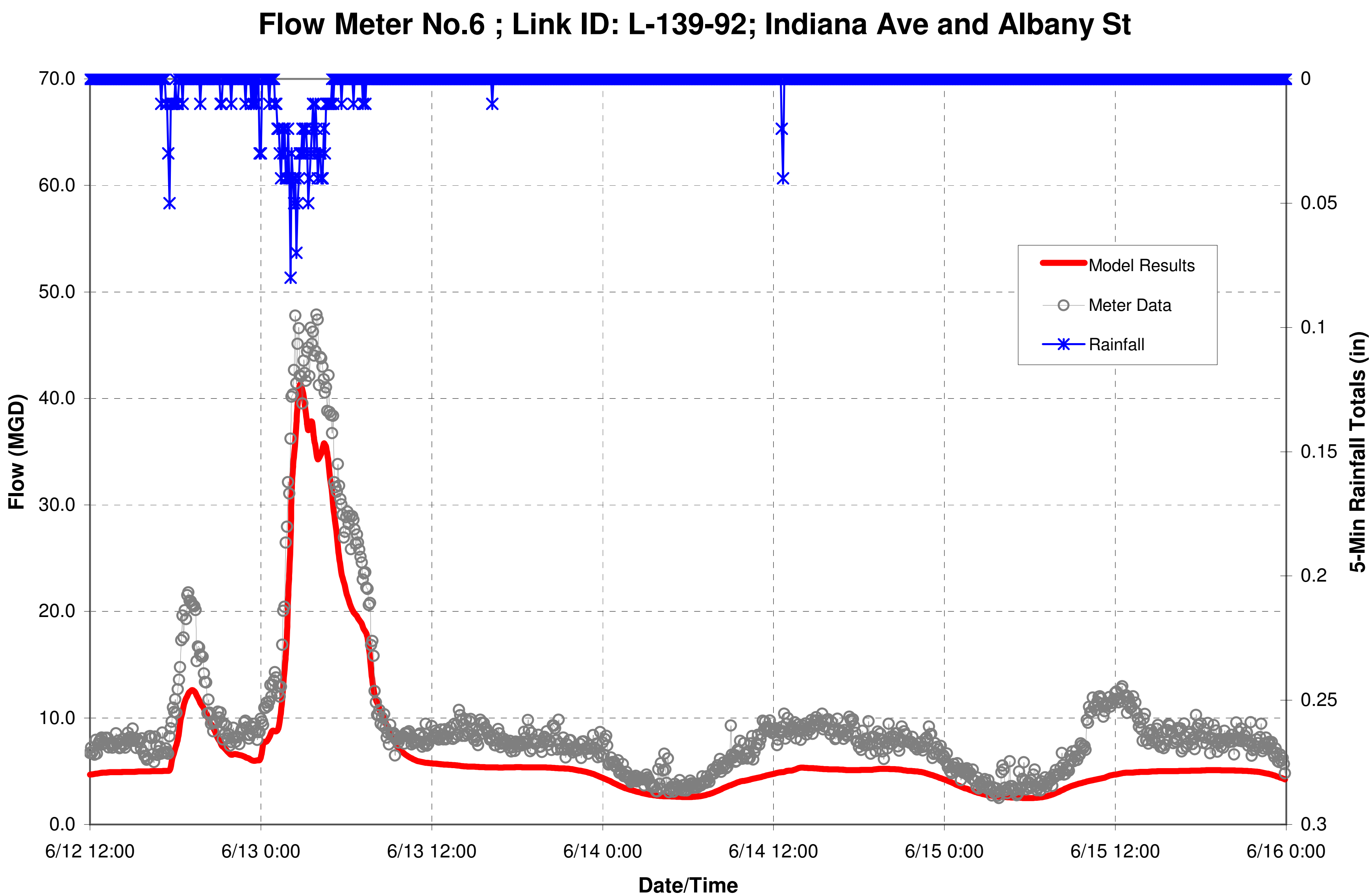


## Flow Meter No.4 ; Link ID: L-167-98; Carlton Ave between Morton Ave

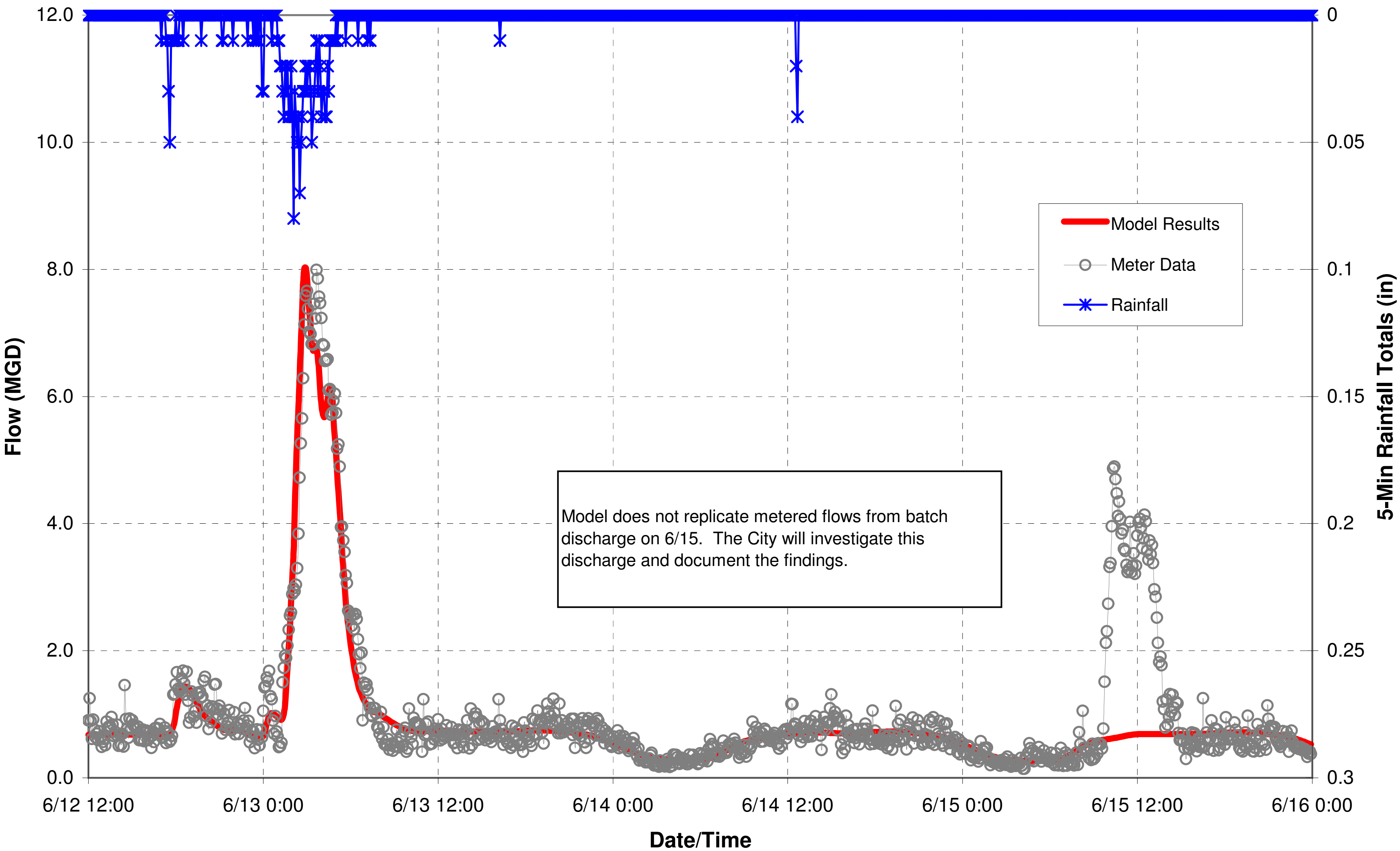


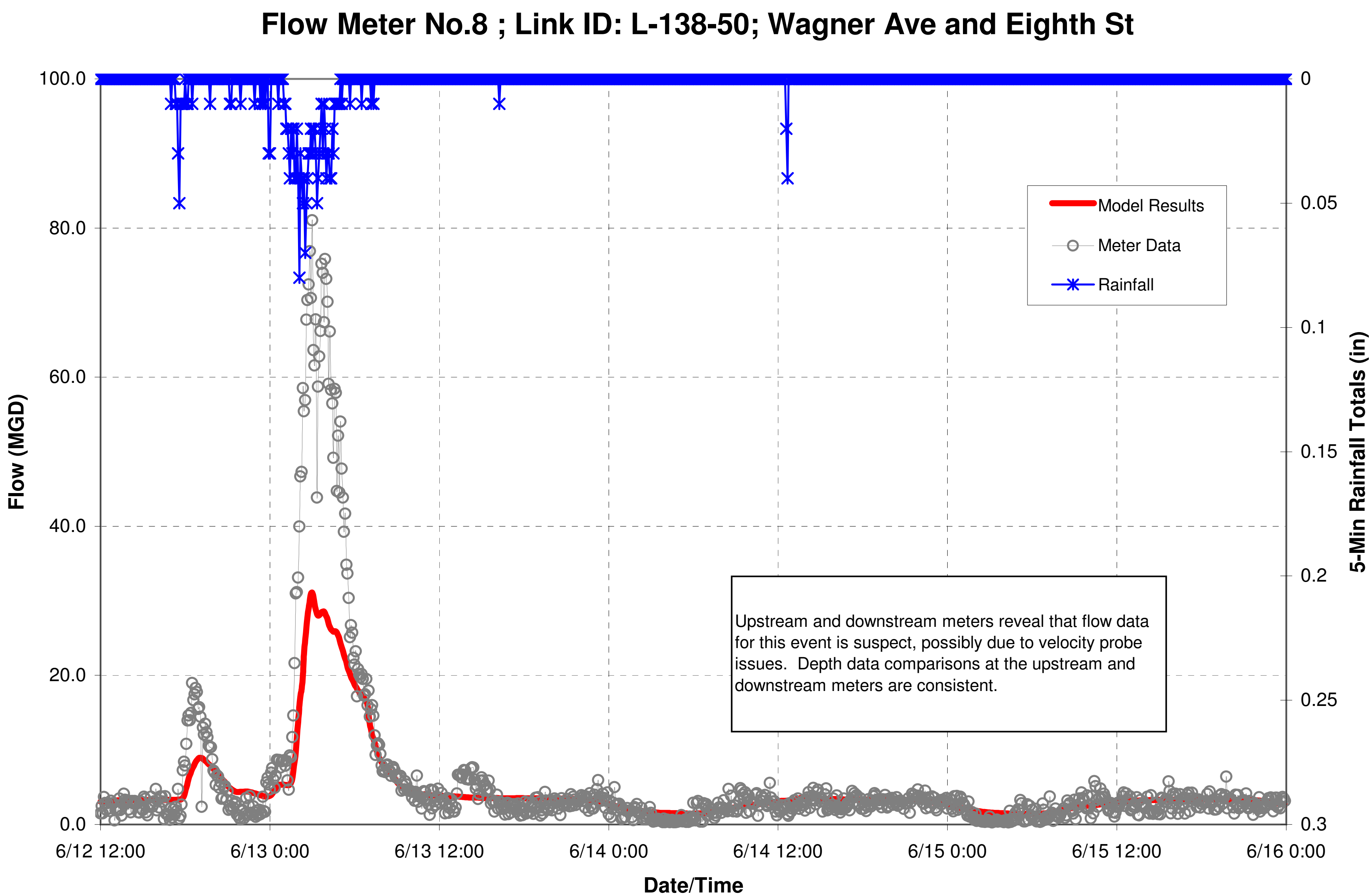


Flow Meter No.5 ; Link ID: L-117-51; West Blvd and Suwanee St
Flow (MGD)
24.0
21.0
18.0
15.0
12.0
9.0
6.0
3.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Rainfall
Scattergraph shows inconsistent patterns at depths above ~10 inches (i.e.high-flow conditions).

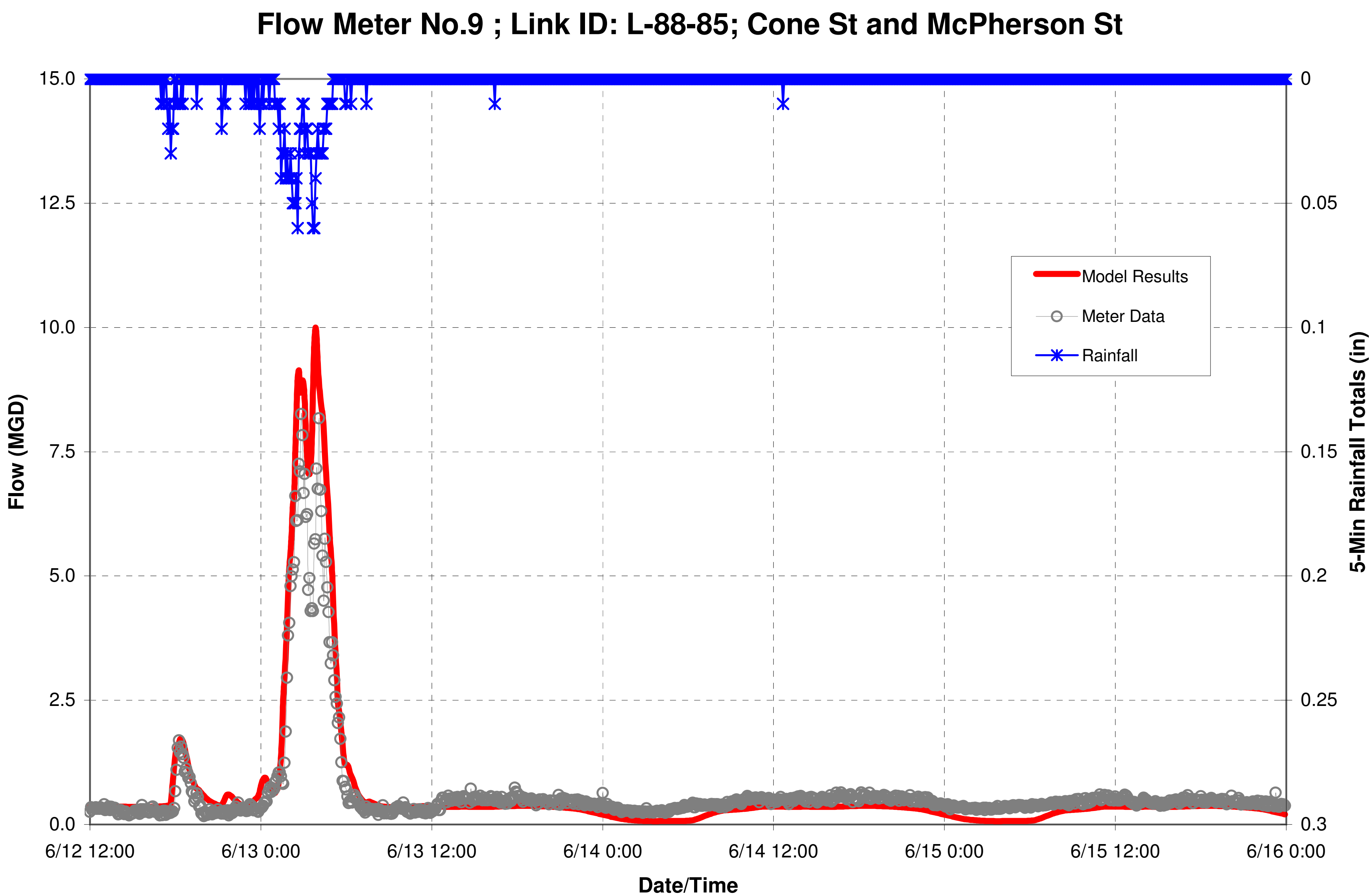

Flow Meter No.6 ; Link ID: L-139-92; Indiana Ave and Albany St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00

# Flow Meter No.7 ; Link ID: L-151-56; Ninth St and Garfield Ave

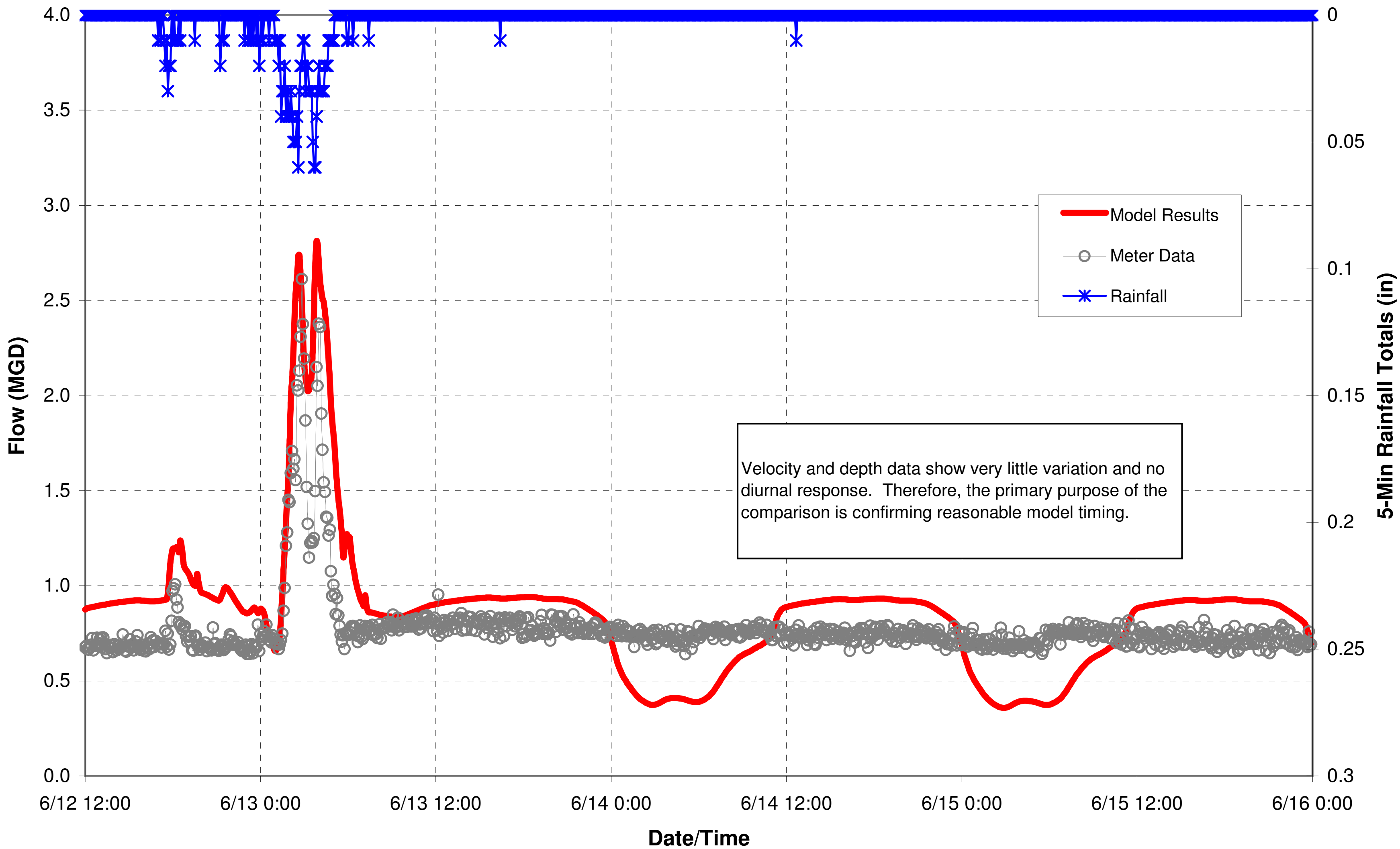




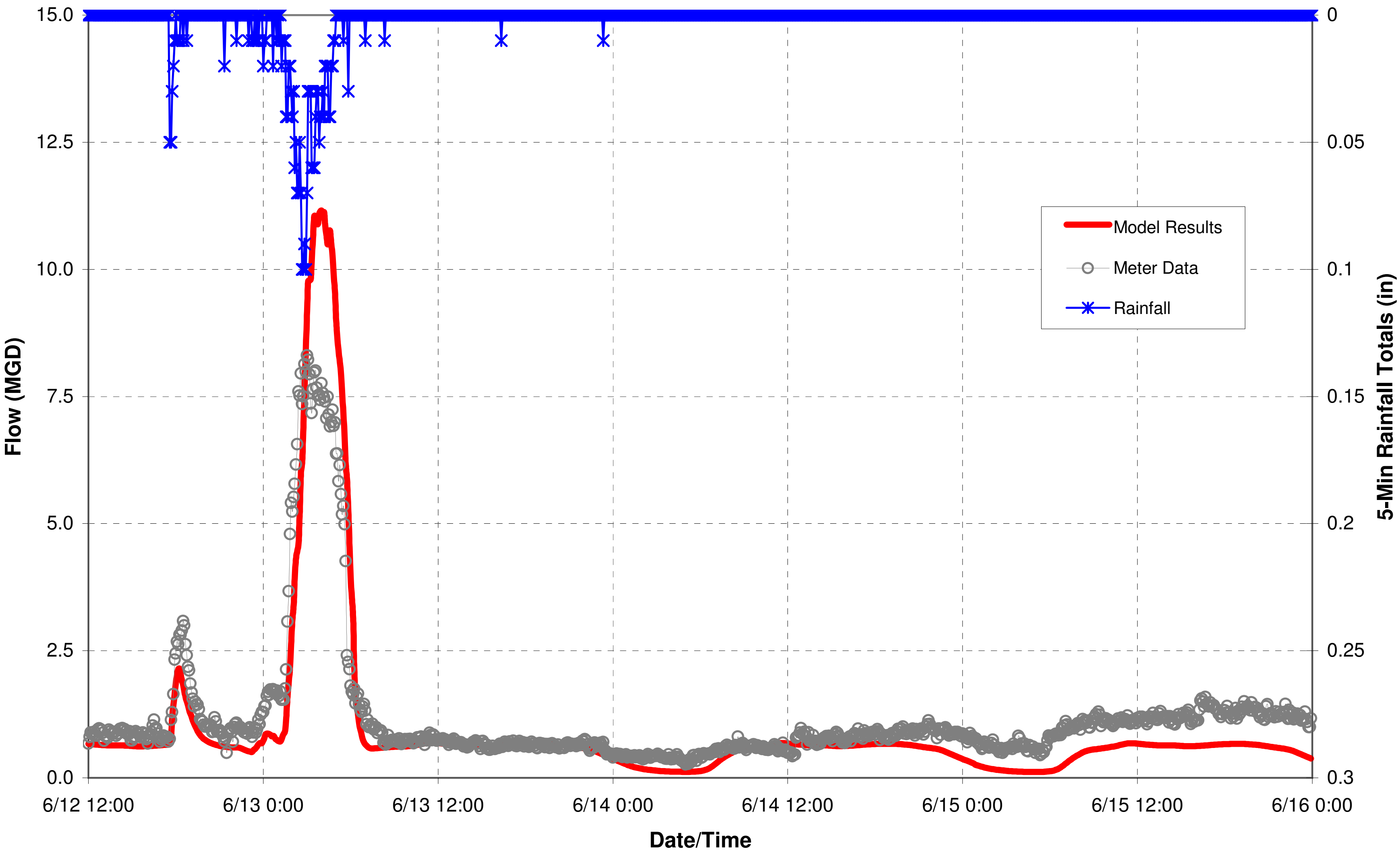
Flow Meter No.8 ; Link ID: L-138-50; Wagner Ave and Eighth St
Flow (MGD)
100.0
80.0
60.0
40.0
20.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Rainfall
Upstream and downstream meters reveal that flow data for this event is suspect, possibly due to velocity probe issues. Depth data comparisons at the upstream and downstream meters are consistent.

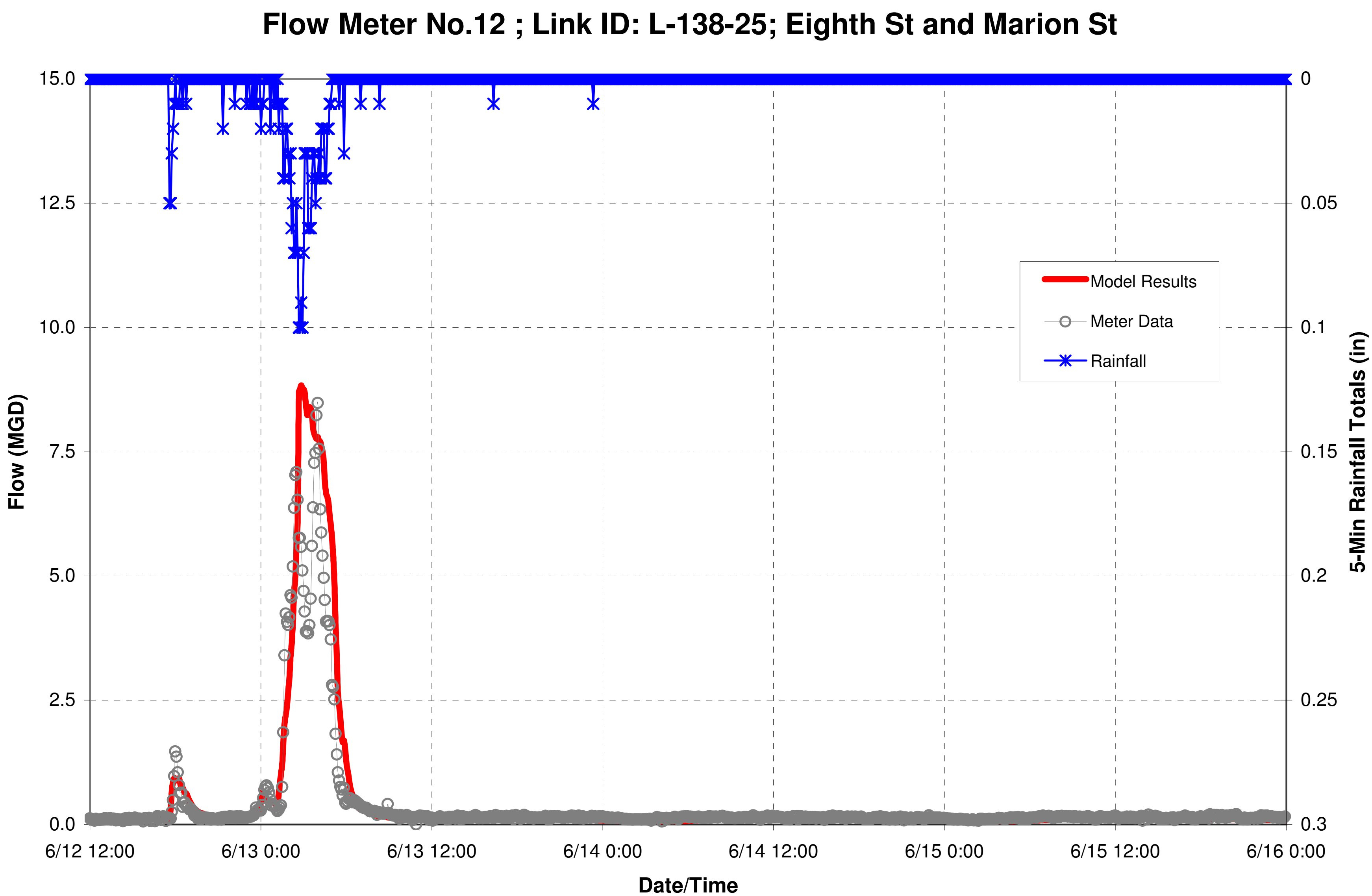

Flow Meter No.9 ; Link ID: L-88-85; Cone St and McPherson St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
15.0
12.5
10.0
7.5
5.0
2.5
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00

# Flow Meter No.10 ; Link ID: L-89-33; Beardsley Ave and Dearborn St



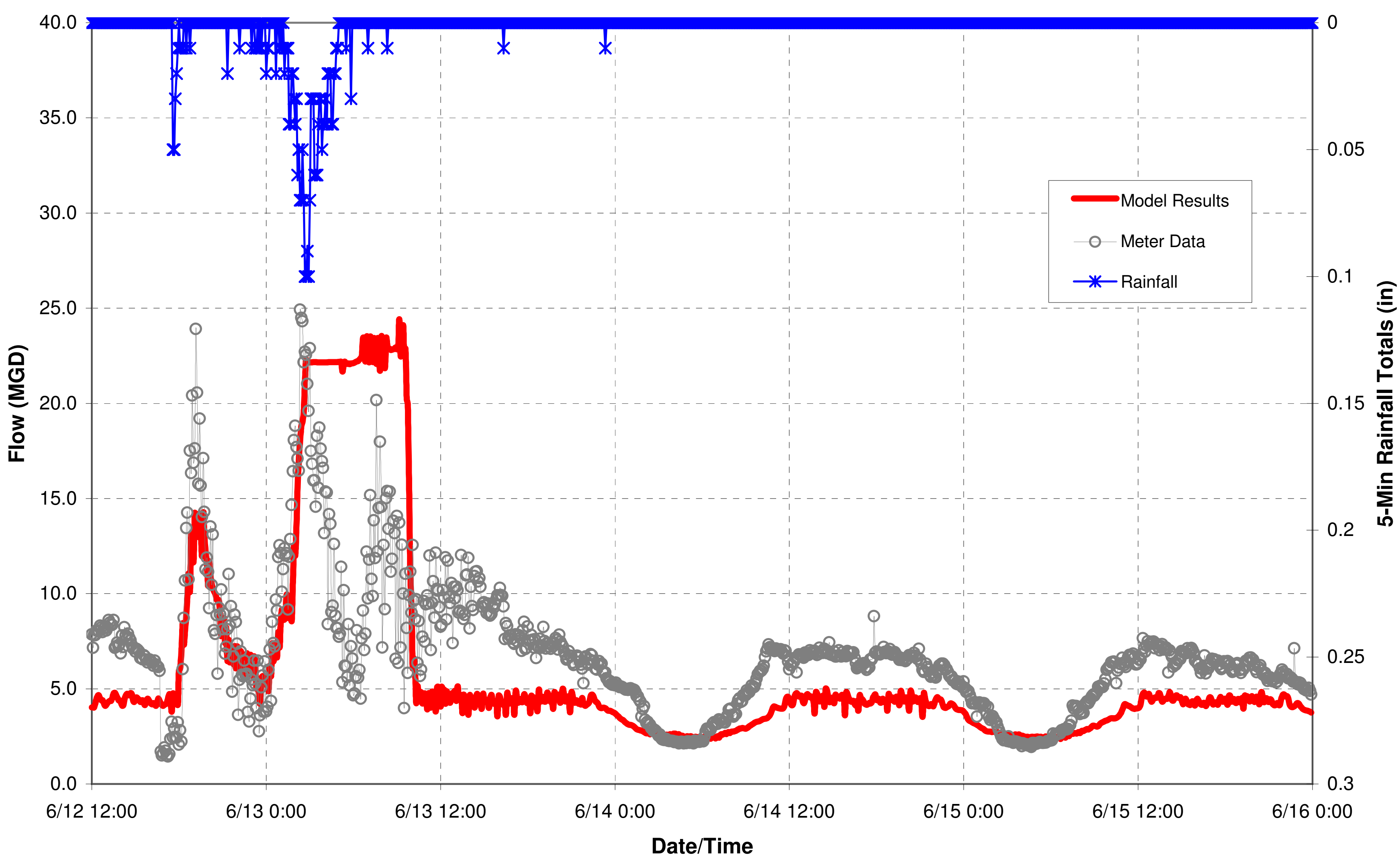
## Flow Meter No.11 ; Link ID: CSO#17.D; McNaughton Park, between

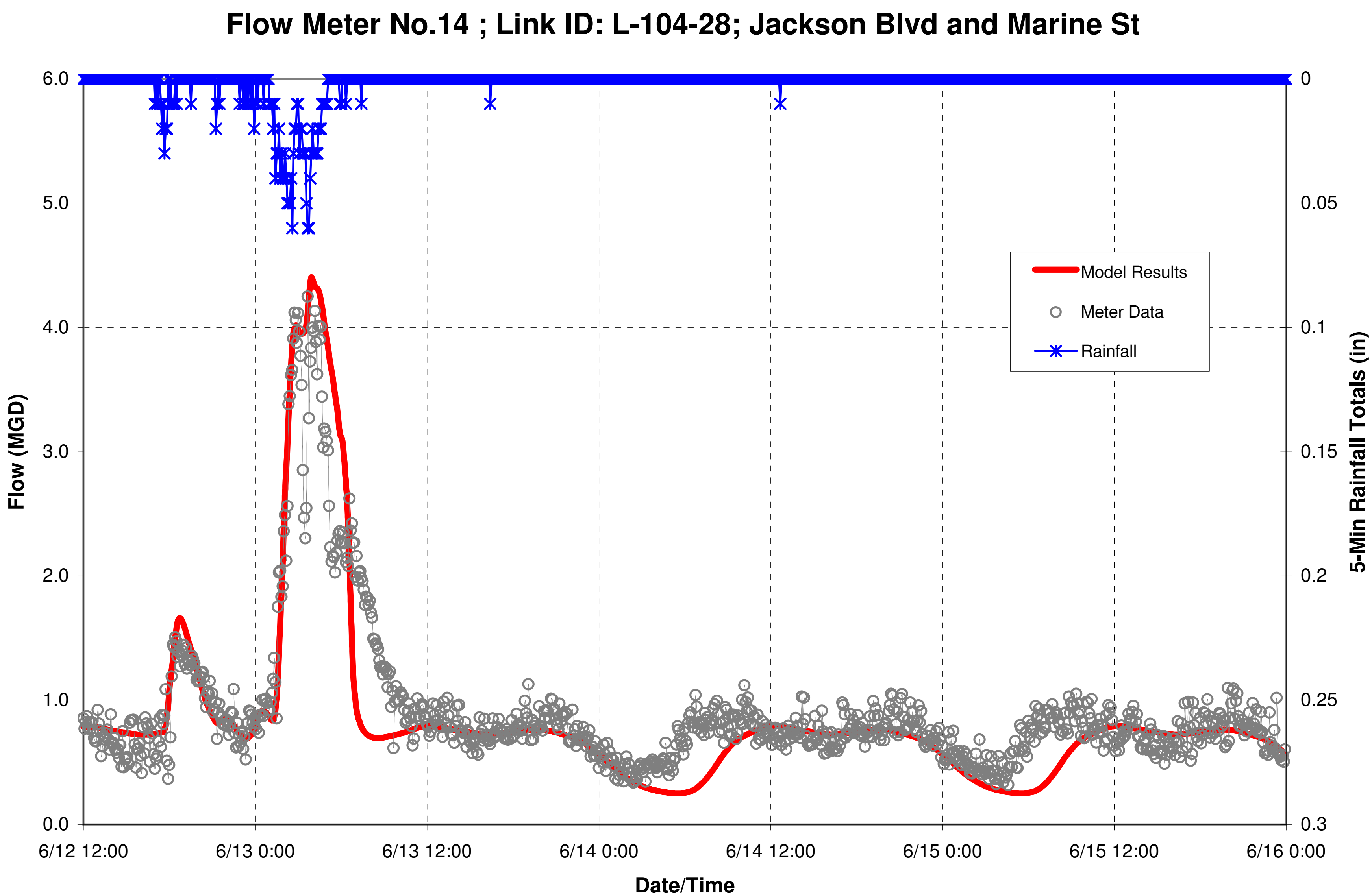




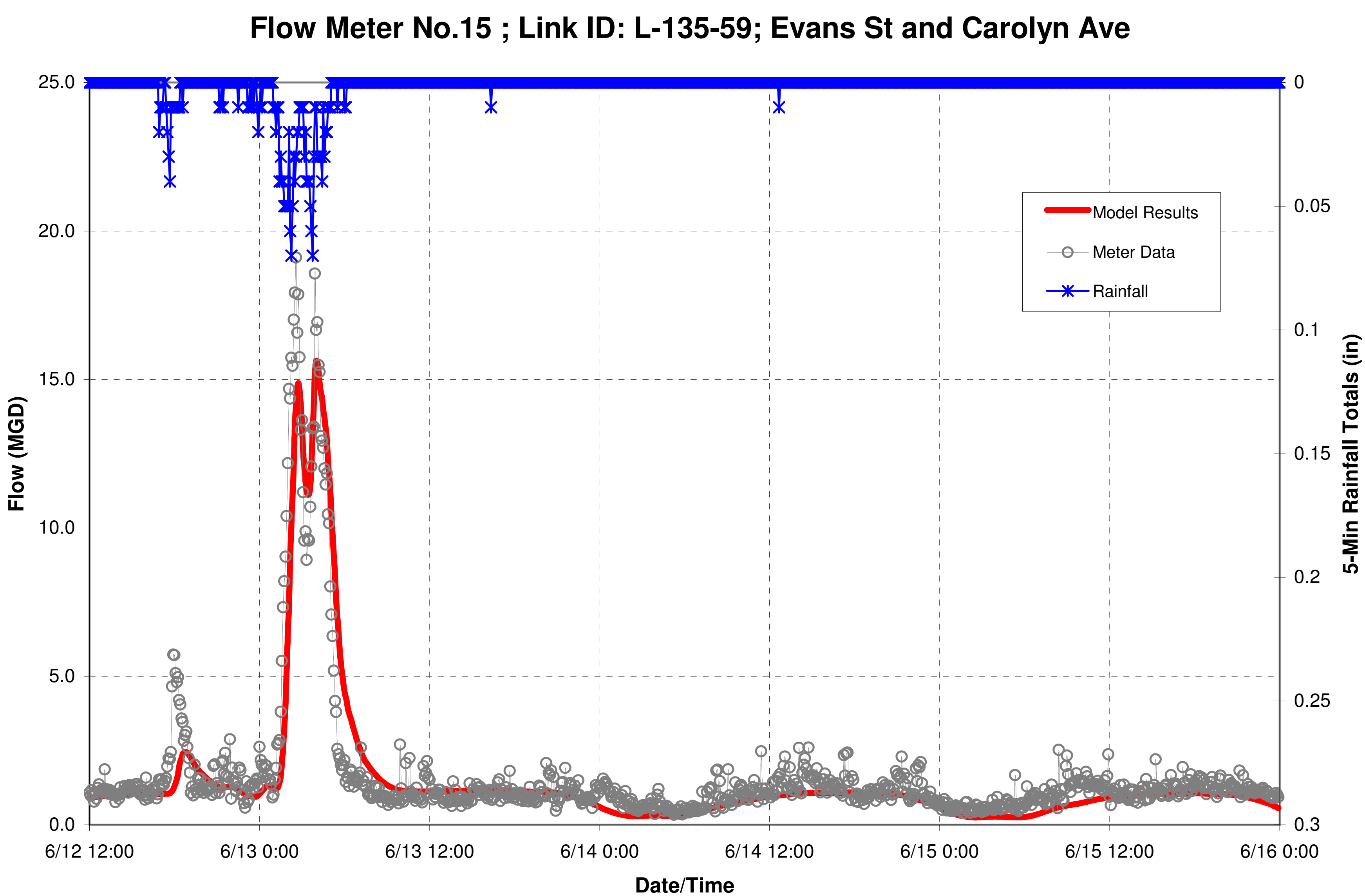
Flow Meter No.12 ; Link ID: L-138-25; Eighth St and Marion St
15.0
12.5
10.0
7.5
5.0
2.5
0.0
Flow (MGD)
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
Model Results
Meter Data
Rainfall
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time

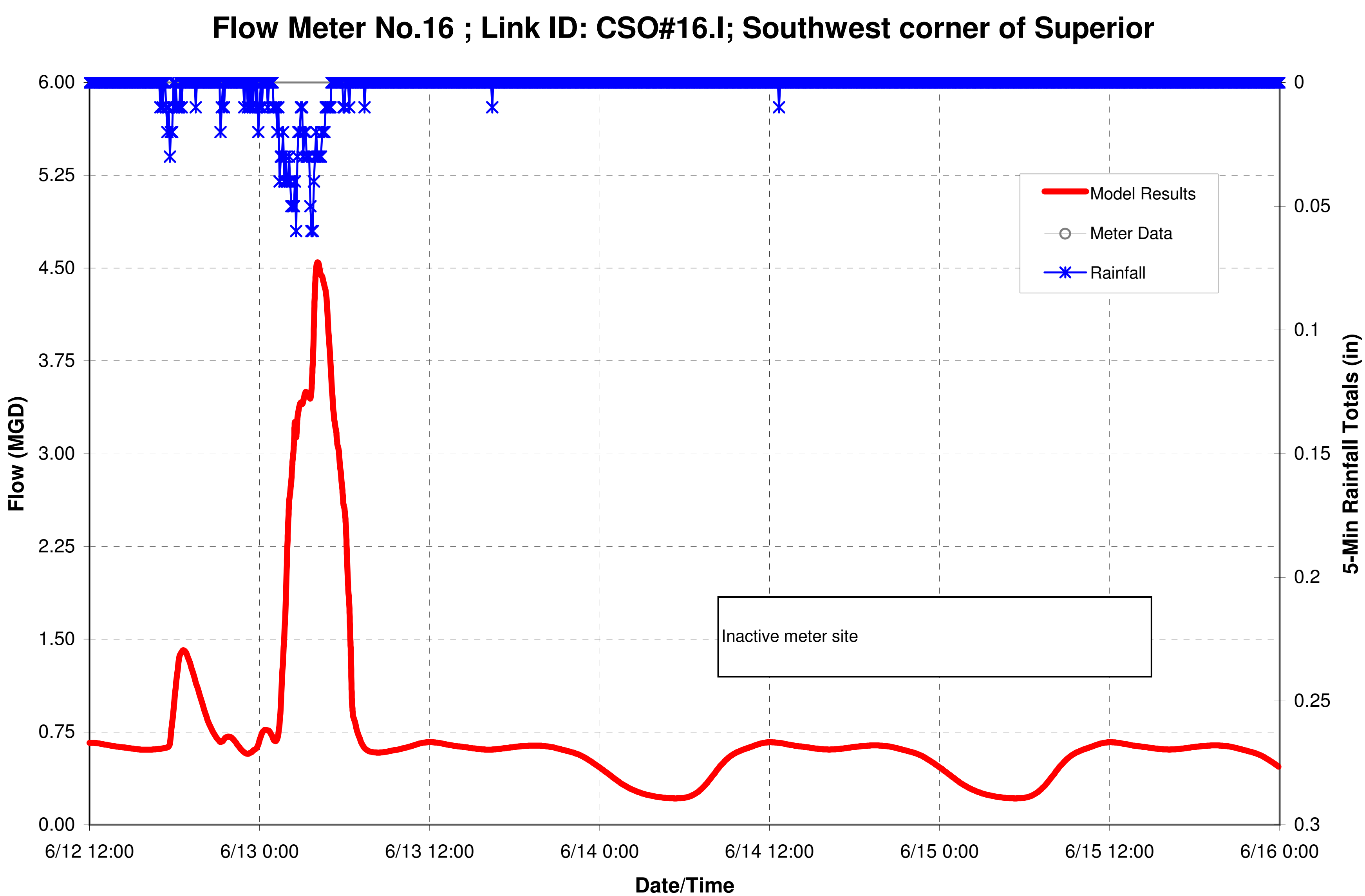
# Flow Meter No.13 ; Link ID: L-140-38; Navajo St, ~275 ft south of



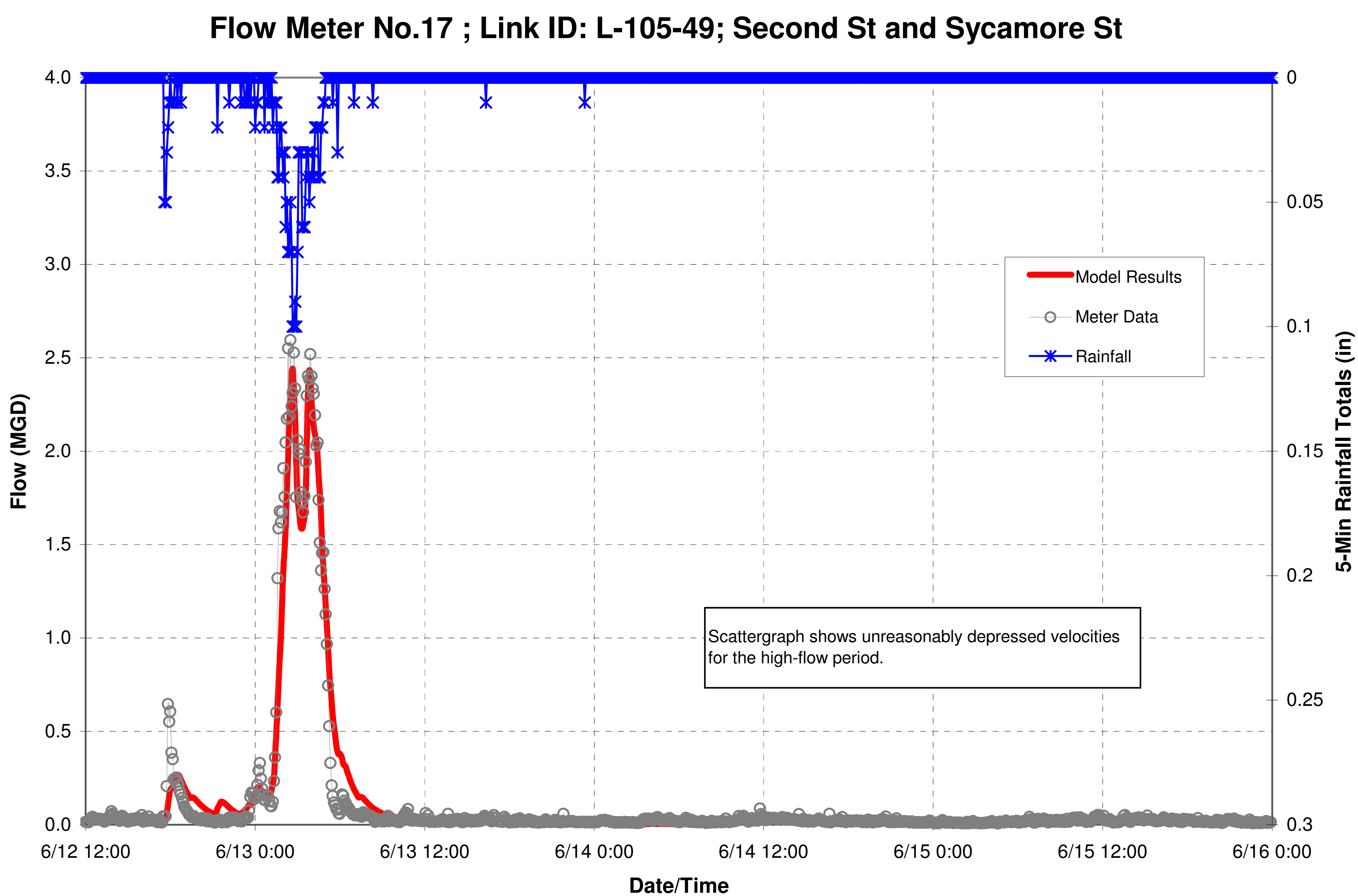


Flow Meter No.14 ; Link ID: L-104-28; Jackson Blvd and Marine St
Model Results
Meter Data
Rainfall
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00

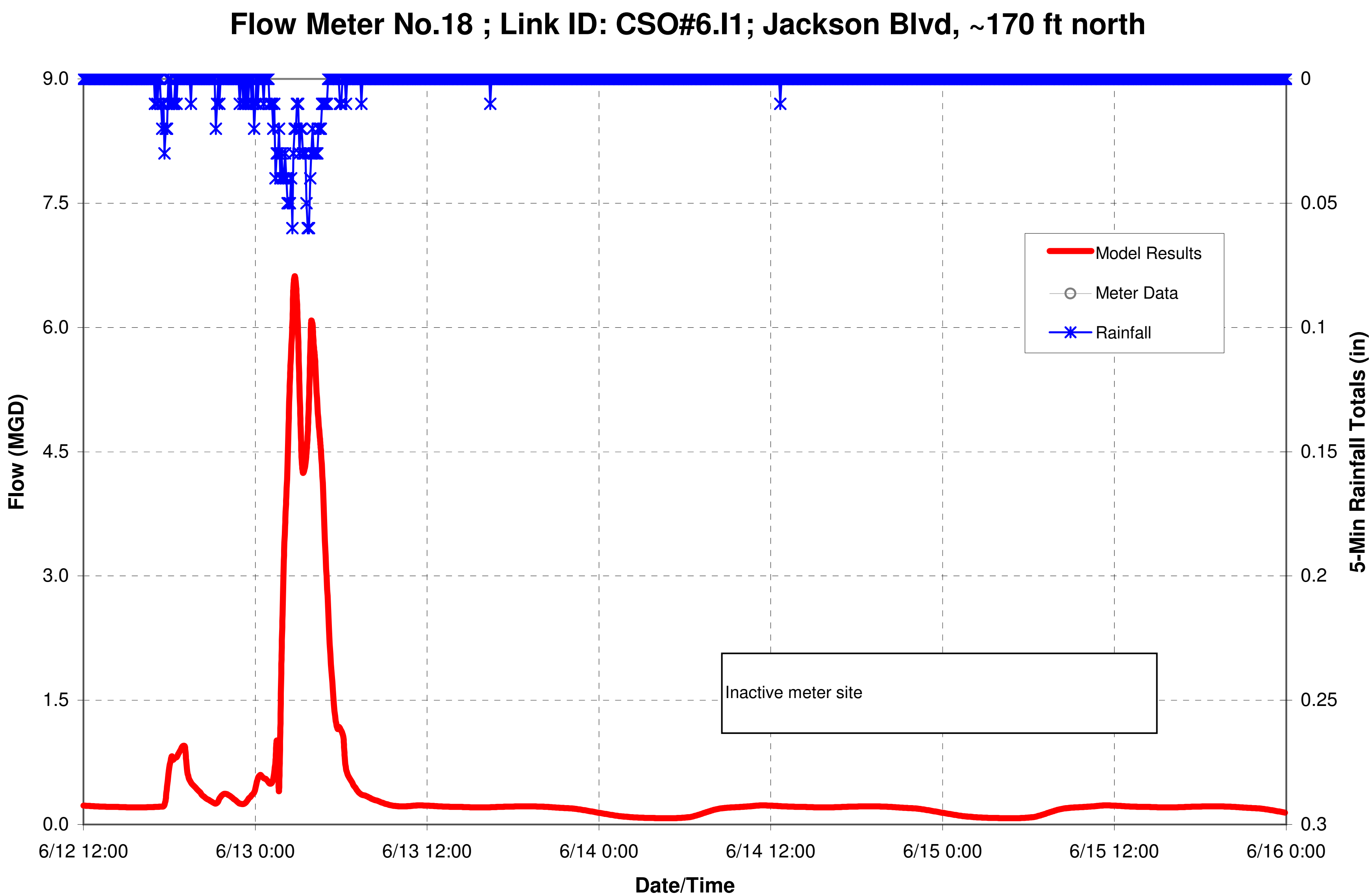

Flow Meter No.15 ; Link ID: L-135-59; Evans St and Carolyn Ave
Flow (MGD)
25.0
20.0
15.0
10.0
5.0
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Rainfall



Flow Meter No.16 ; Link ID: CSO#16.I; Southwest corner of Superior
6.00
5.25
4.50
3.75
3.00
2.25
1.50
0.75
0.00
Flow (MGD)
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Rainfall
Inactive meter site

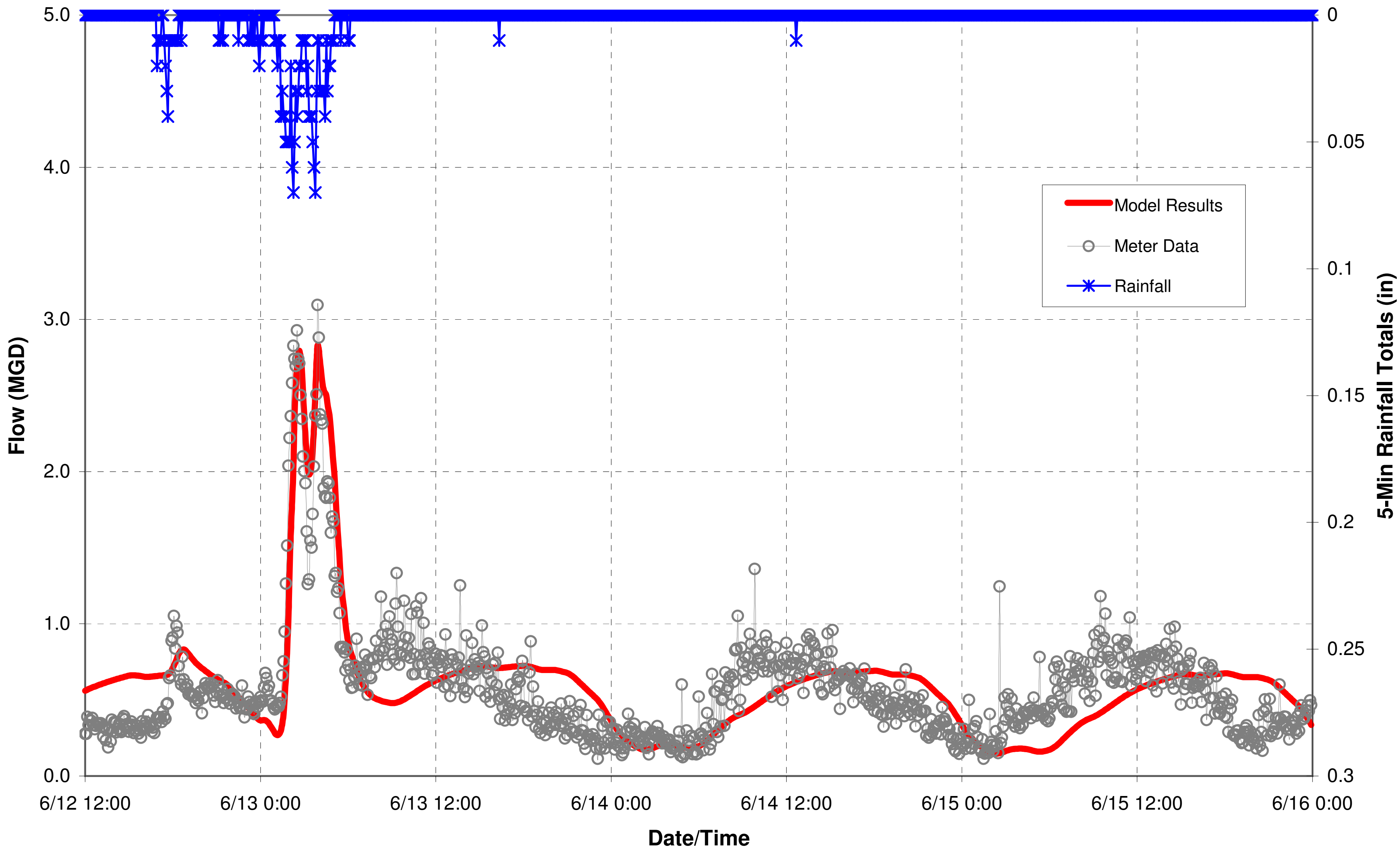


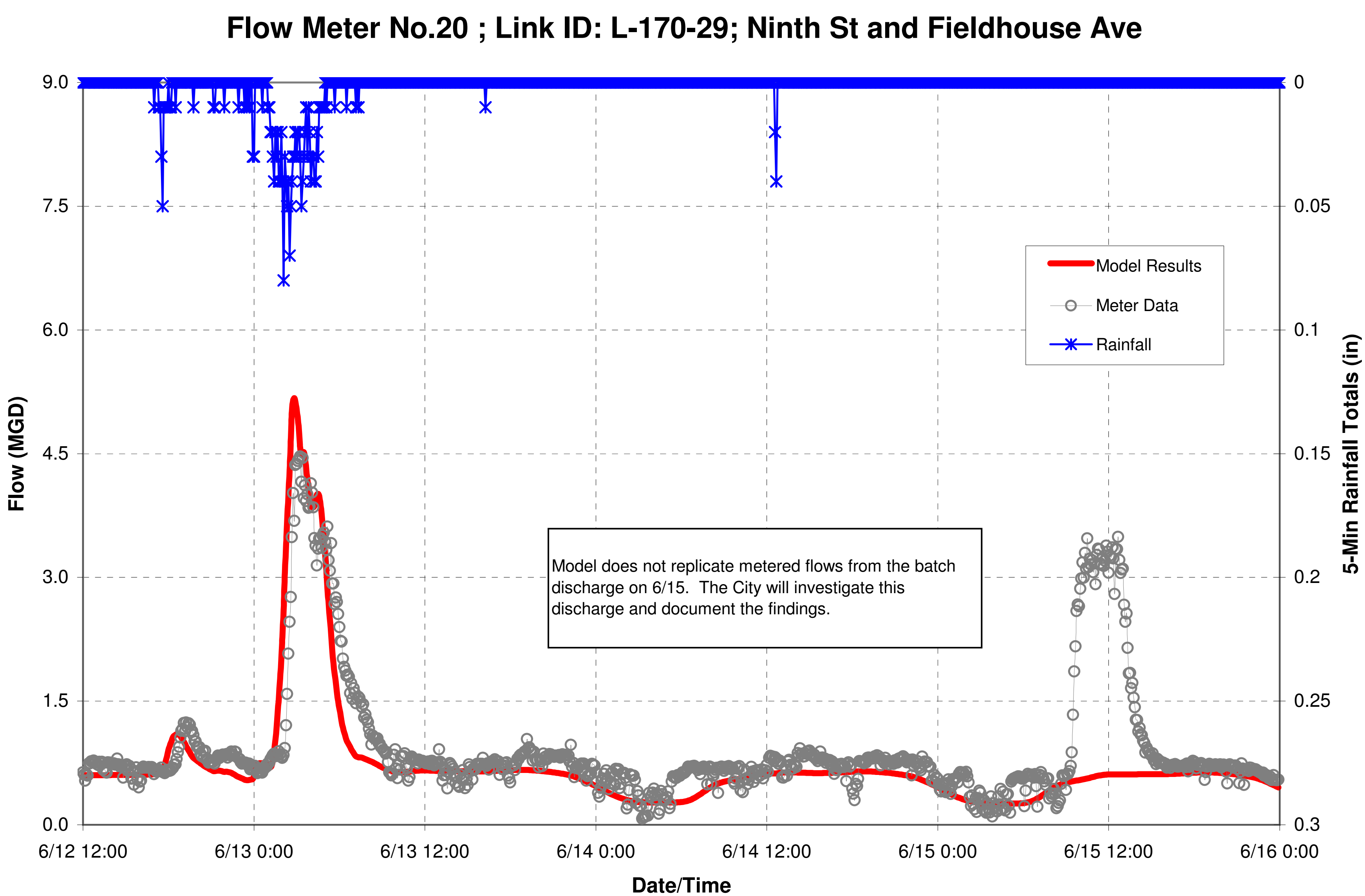
Flow Meter No.17 ; Link ID: L-105-49; Second St and Sycamore St
Flow (MGD)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Model Results
Meter Data
Rainfall
Scattergraph shows unreasonably depressed velocities for the high-flow period.
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time



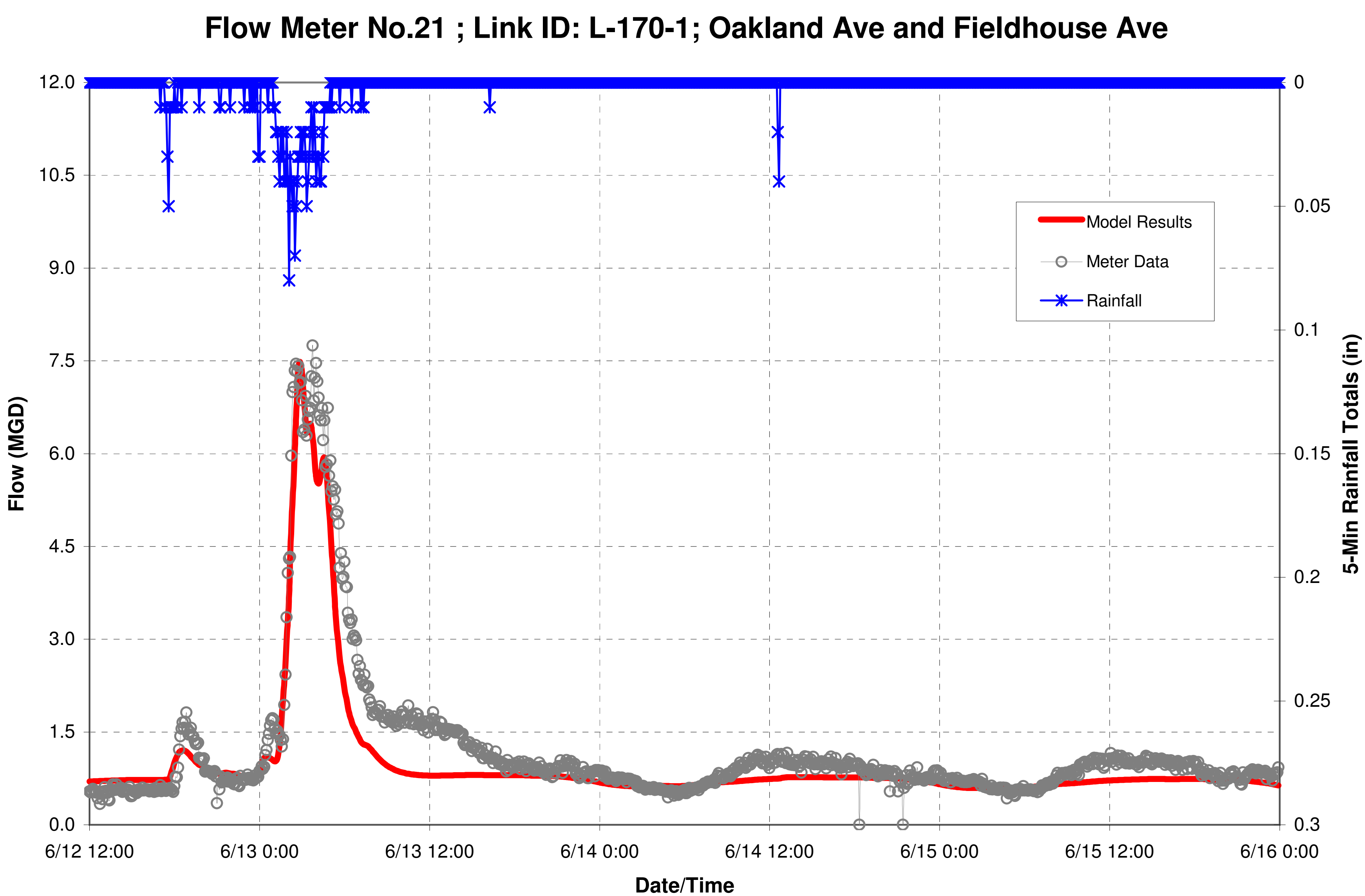
Flow Meter No.18 ; Link ID: CSO#6.I1; Jackson Blvd, ~170 ft north
Flow (MGD)
9.0
7.5
6.0
4.5
3.0
1.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Model Results
Meter Data
Rainfall
Inactive meter site
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time

# Flow Meter No.19 ; Link ID: L-123-13; Middlebury St and Denver St

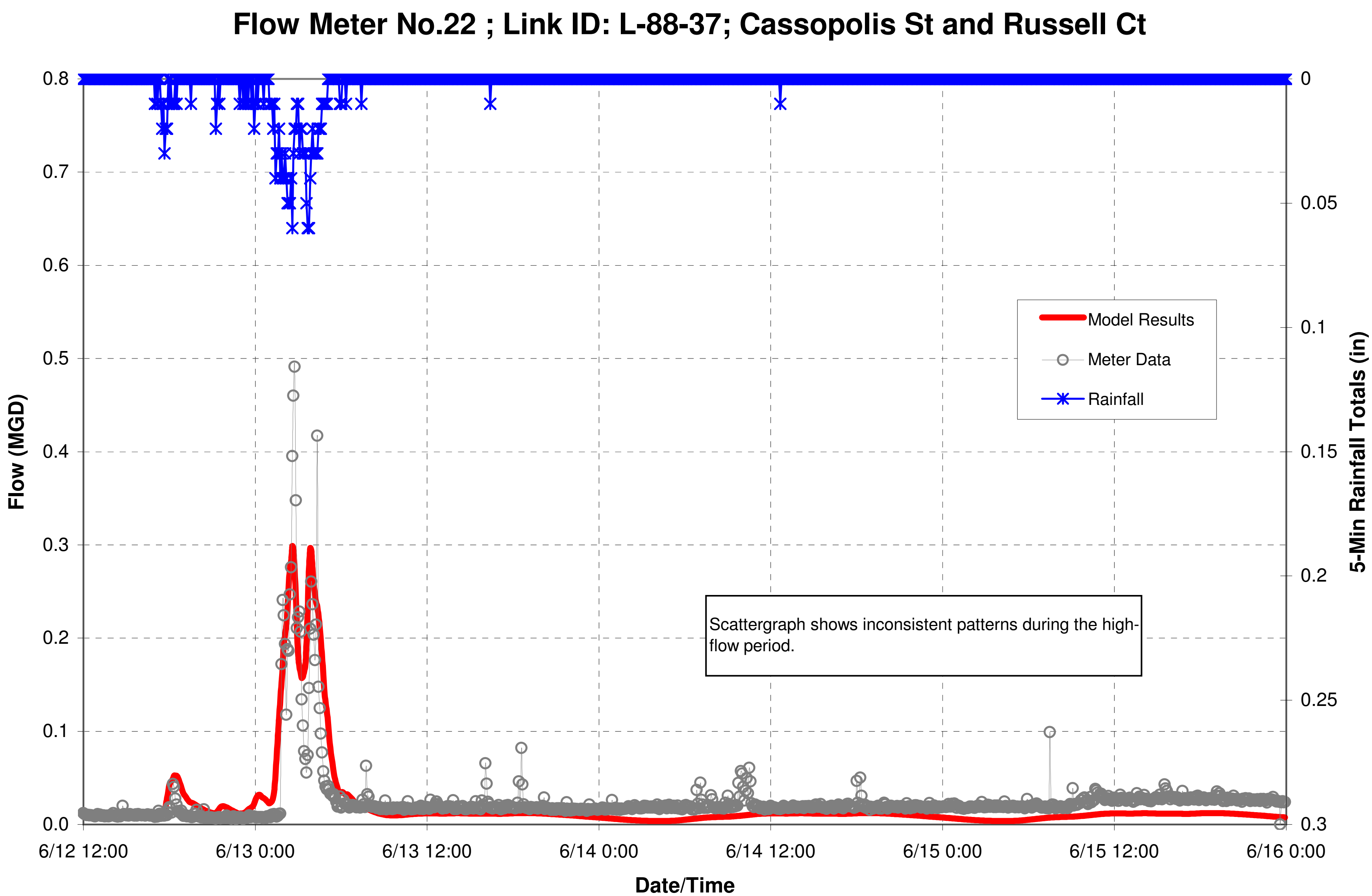




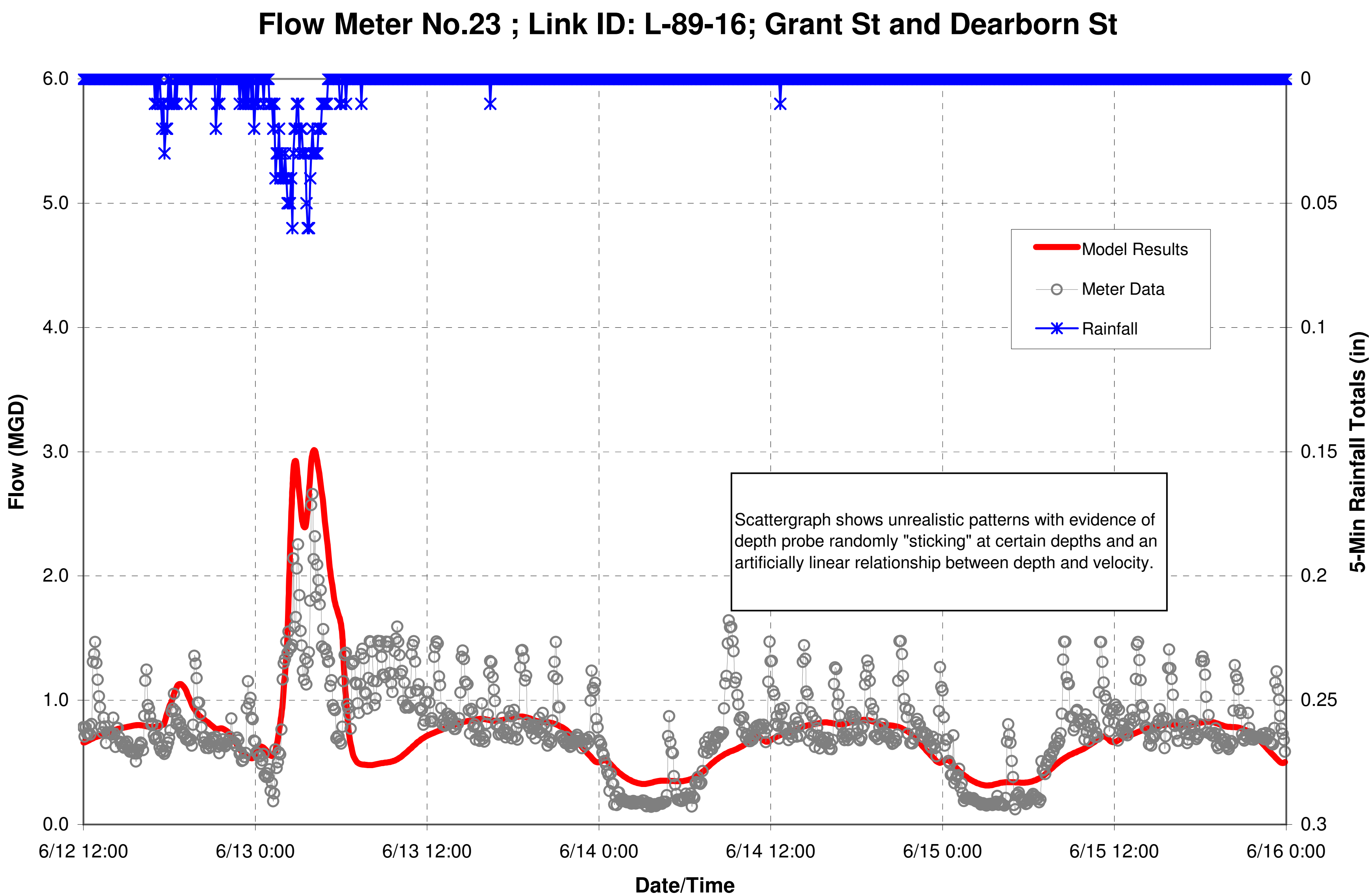
Flow Meter No.20 ; Link ID: L-170-29; Ninth St and Fieldhouse Ave
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
9.0
7.5
6.0
4.5
3.0
1.5
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Model Results
Meter Data
Rainfall
Model does not replicate metered flows from the batch discharge on 6/15. The City will investigate this discharge and document the findings.



Flow Meter No.21 ; Link ID: L-170-1; Oakland Ave and Fieldhouse Ave
Flow (MGD)
12.0
10.5
9.0
7.5
6.0
4.5
3.0
1.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Model Results
Meter Data
Rainfall
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time

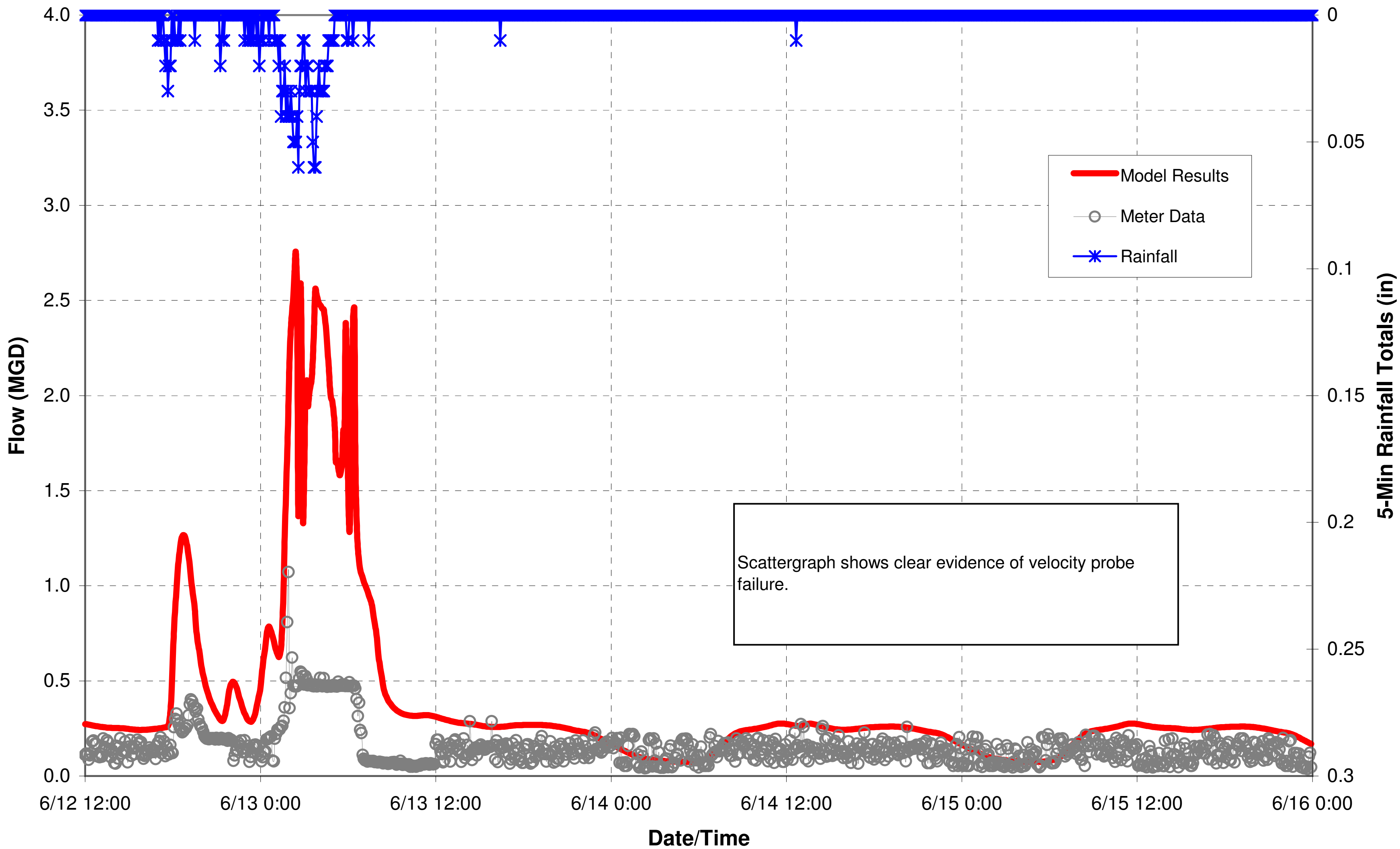


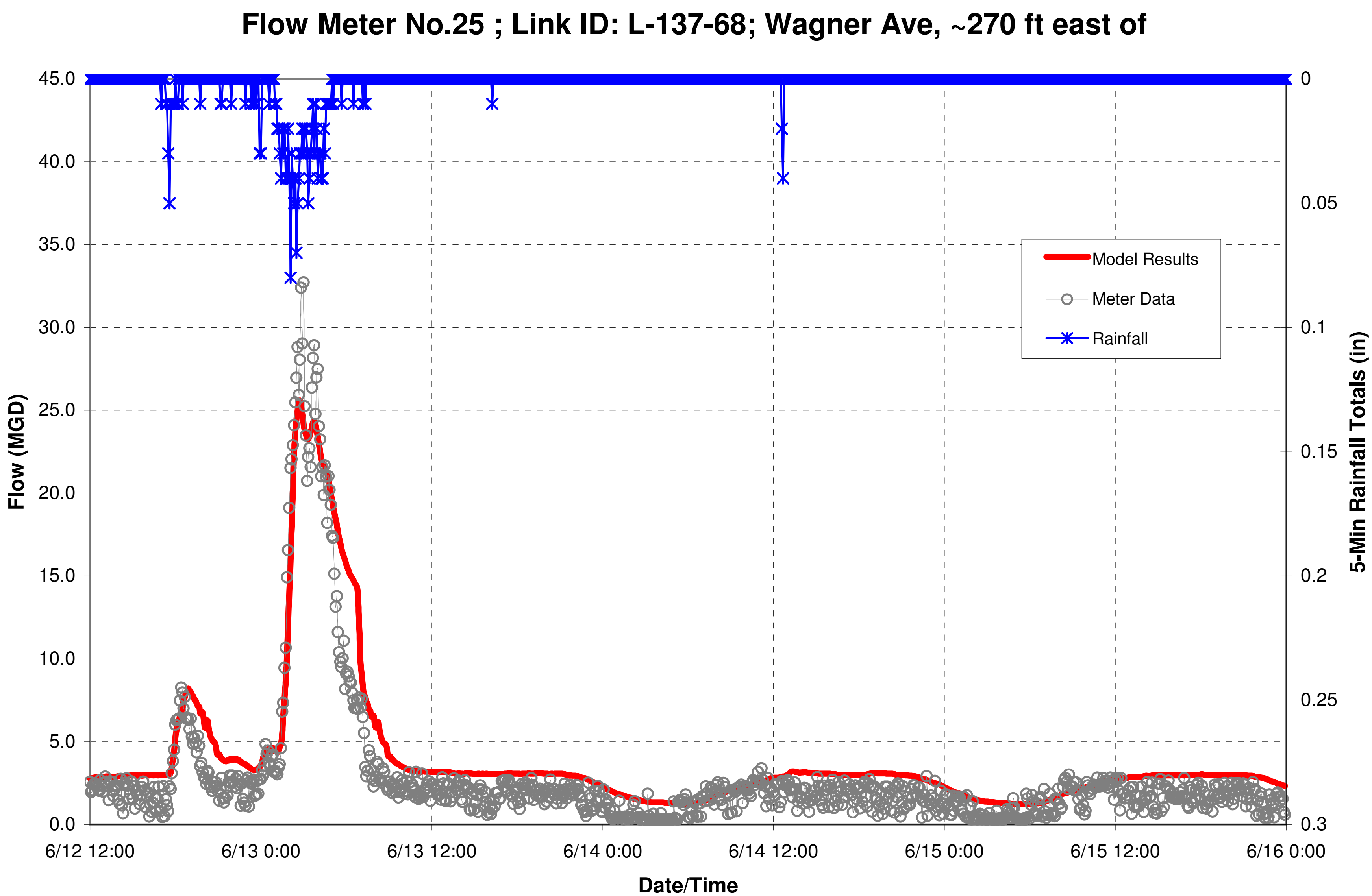
Flow Meter No.22 ; Link ID: L-88-37; Cassopolis St and Russell Ct
Flow (MGD)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Rainfall
Scattergraph shows inconsistent patterns during the high-flow period.



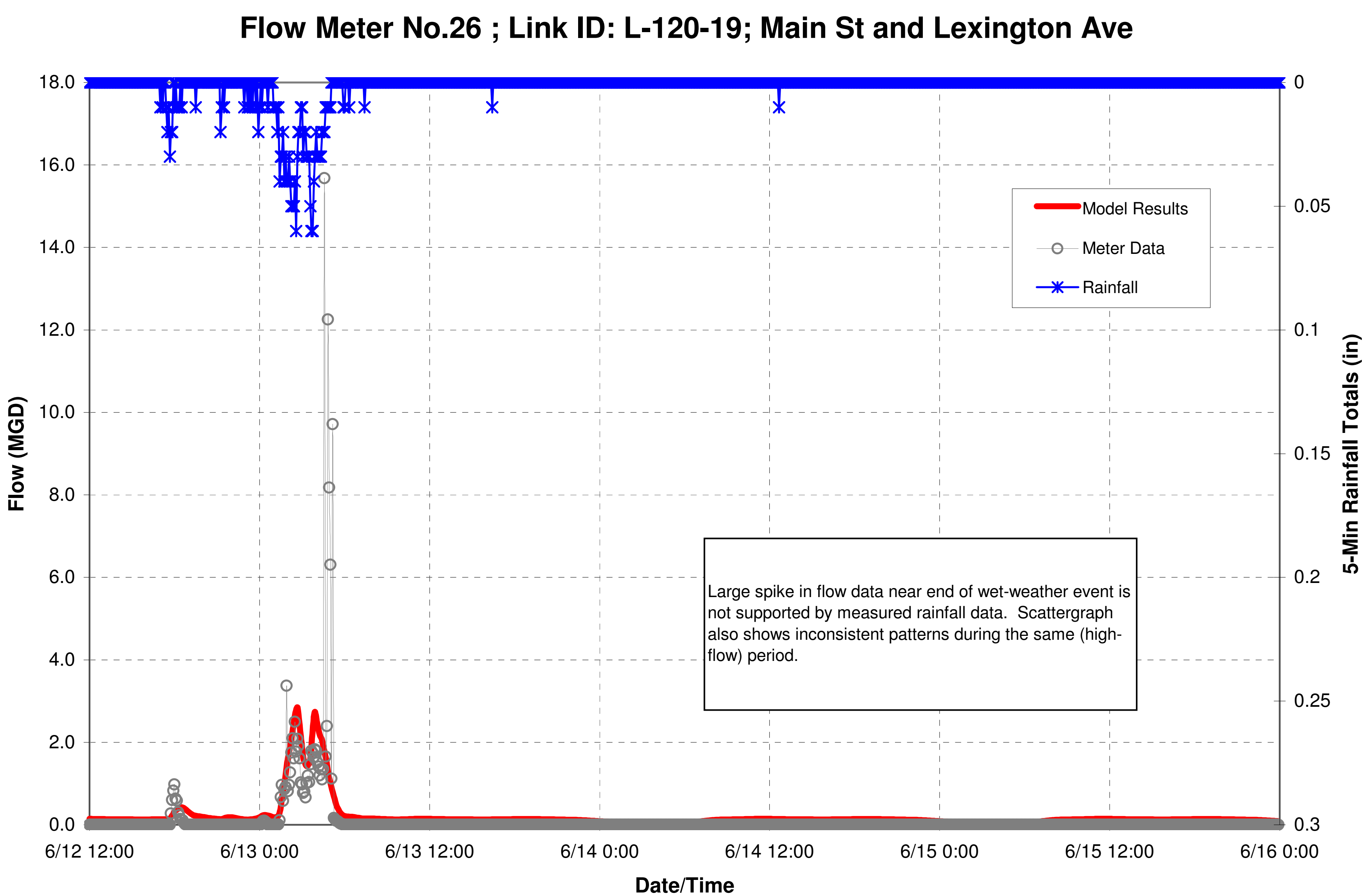
Flow Meter No.23 ; Link ID: L-89-16; Grant St and Dearborn St
Flow (MGD)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Rainfall
Scattergraph shows unrealistic patterns with evidence of depth probe randomly "sticking" at certain depths and an artificially linear relationship between depth and velocity.

## Flow Meter No.24 ; Link ID: L-136-98; Tipton St and Charles St



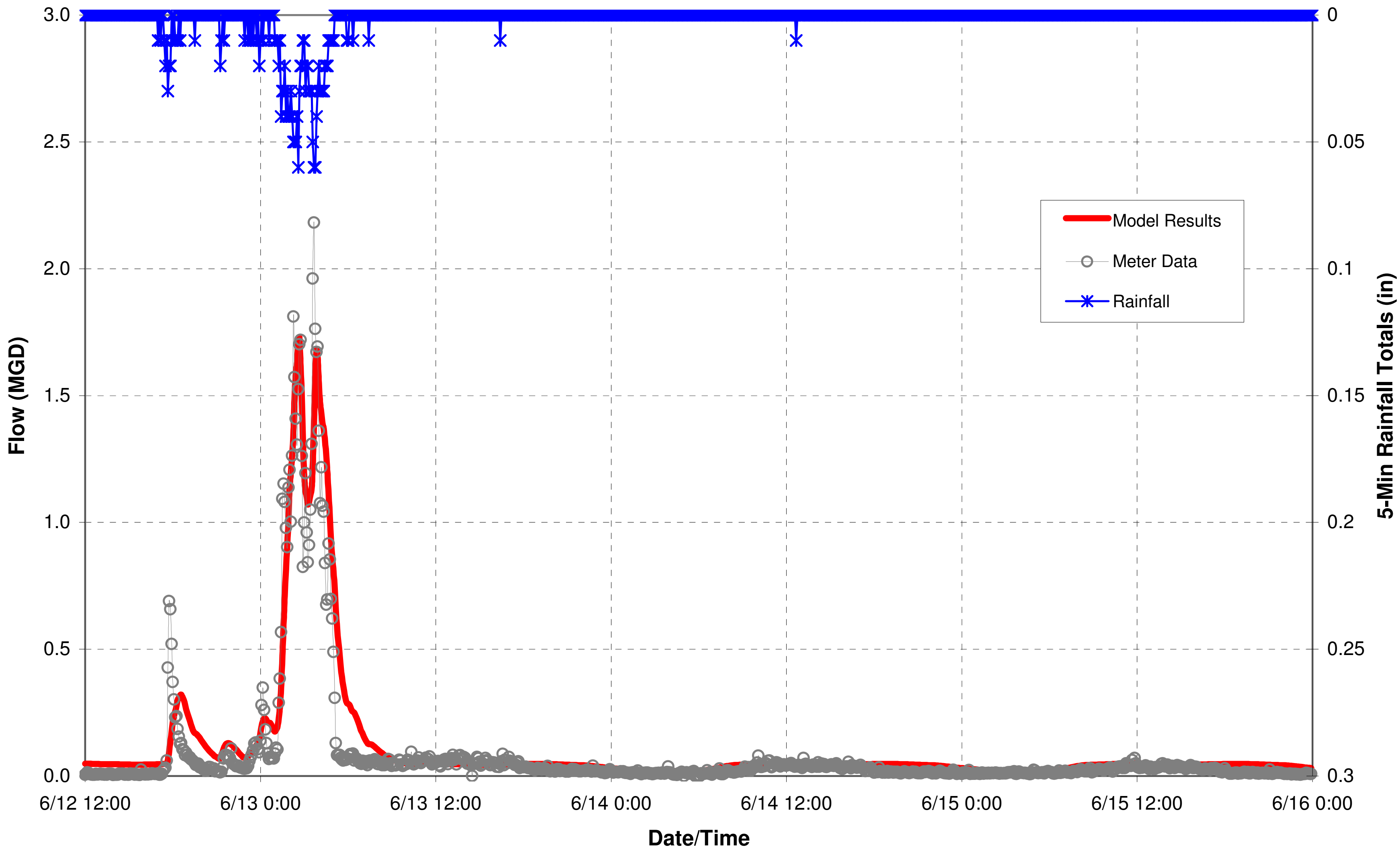


Flow Meter No.25 ; Link ID: L-137-68; Wagner Ave, ~270 ft east of
Flow (MGD)
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Model Results
Meter Data
Rainfall
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time

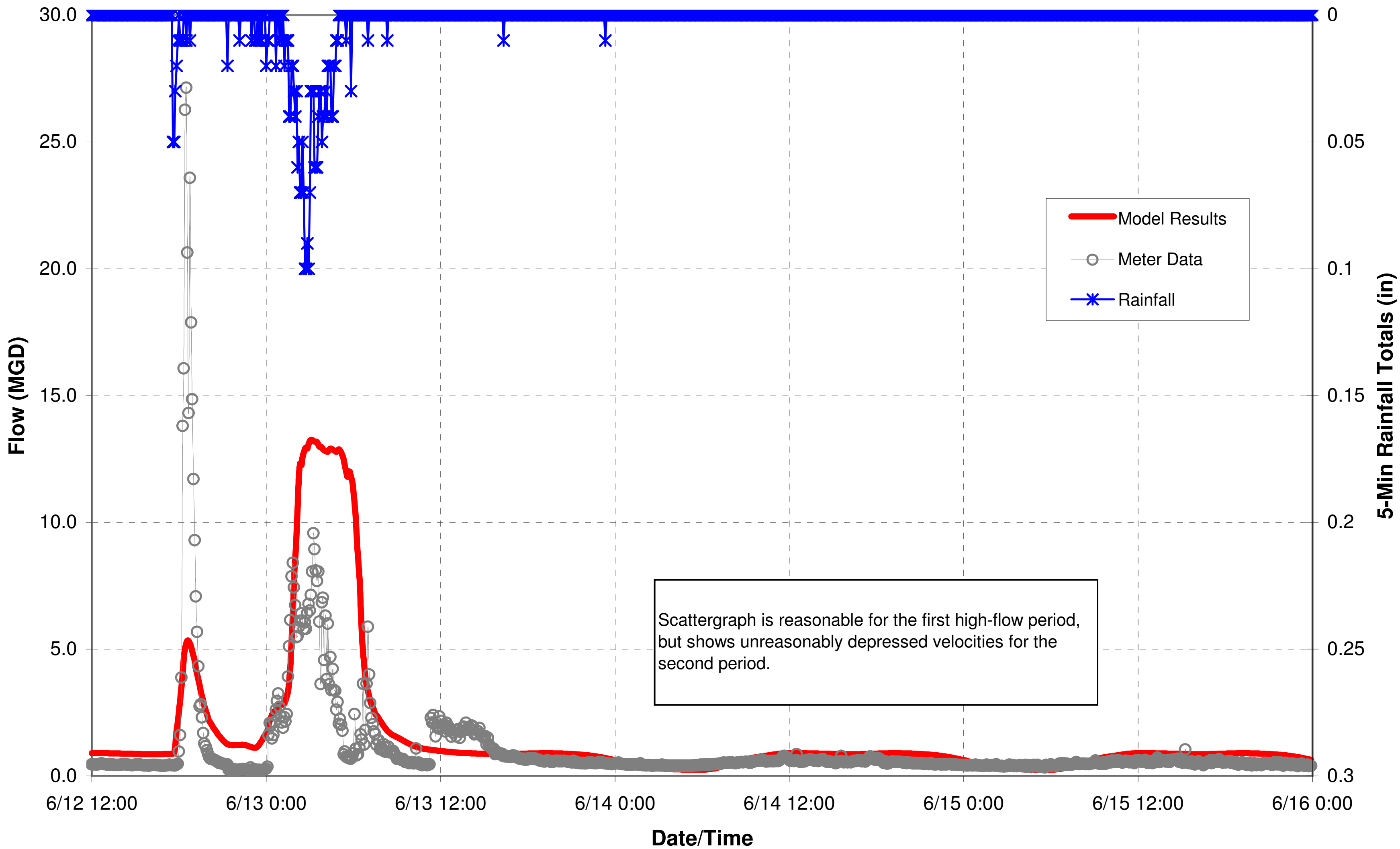


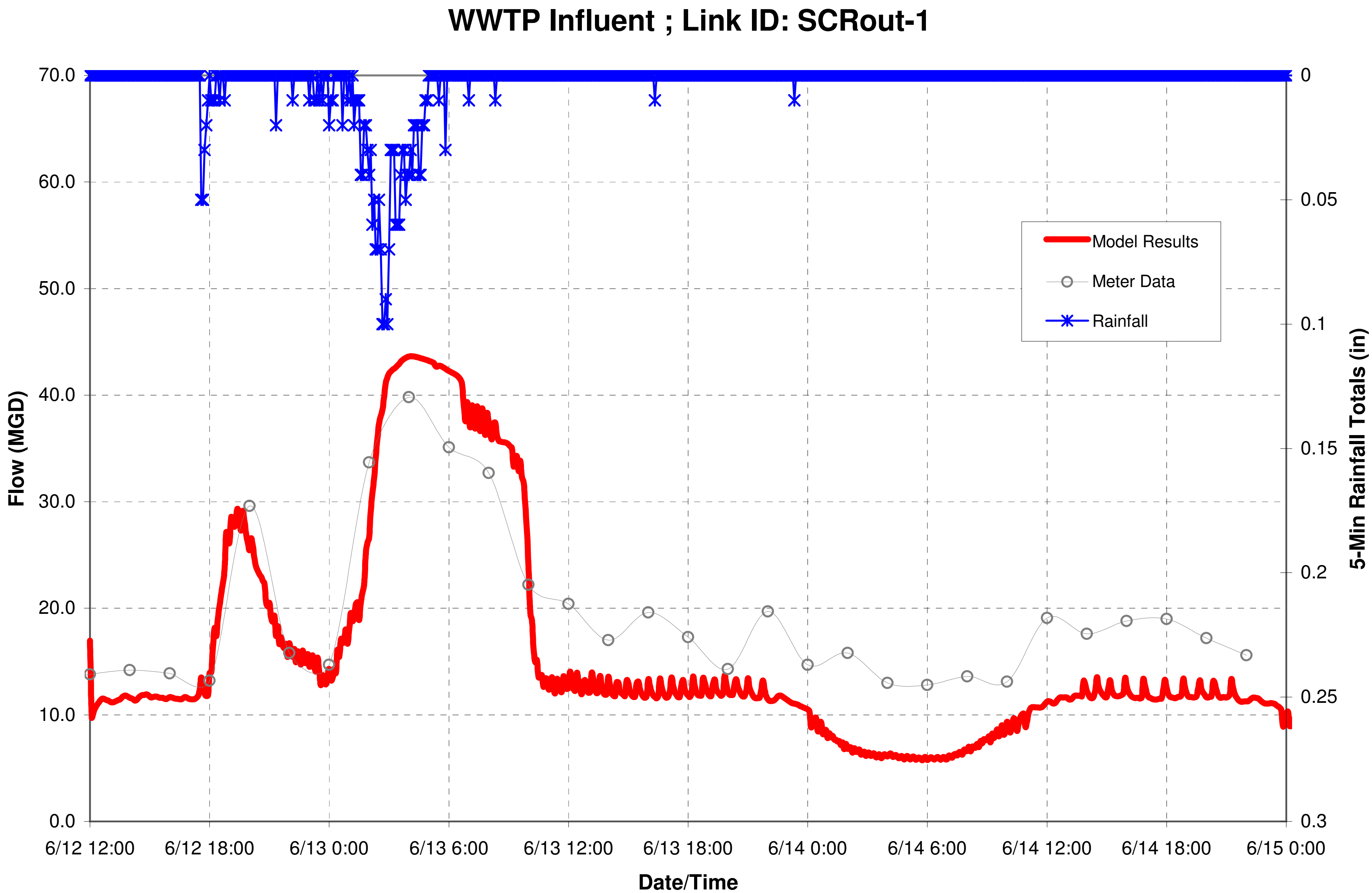
Flow Meter No.26 ; Link ID: L-120-19; Main St and Lexington Ave
Flow (MGD)
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Rainfall
Large spike in flow data near end of wet-weather event is not supported by measured rainfall data. Scattergraph also shows inconsistent patterns during the same (high-flow) period.

# Flow Meter No.27 ; Link ID: L-120-130; Second St between Lexington

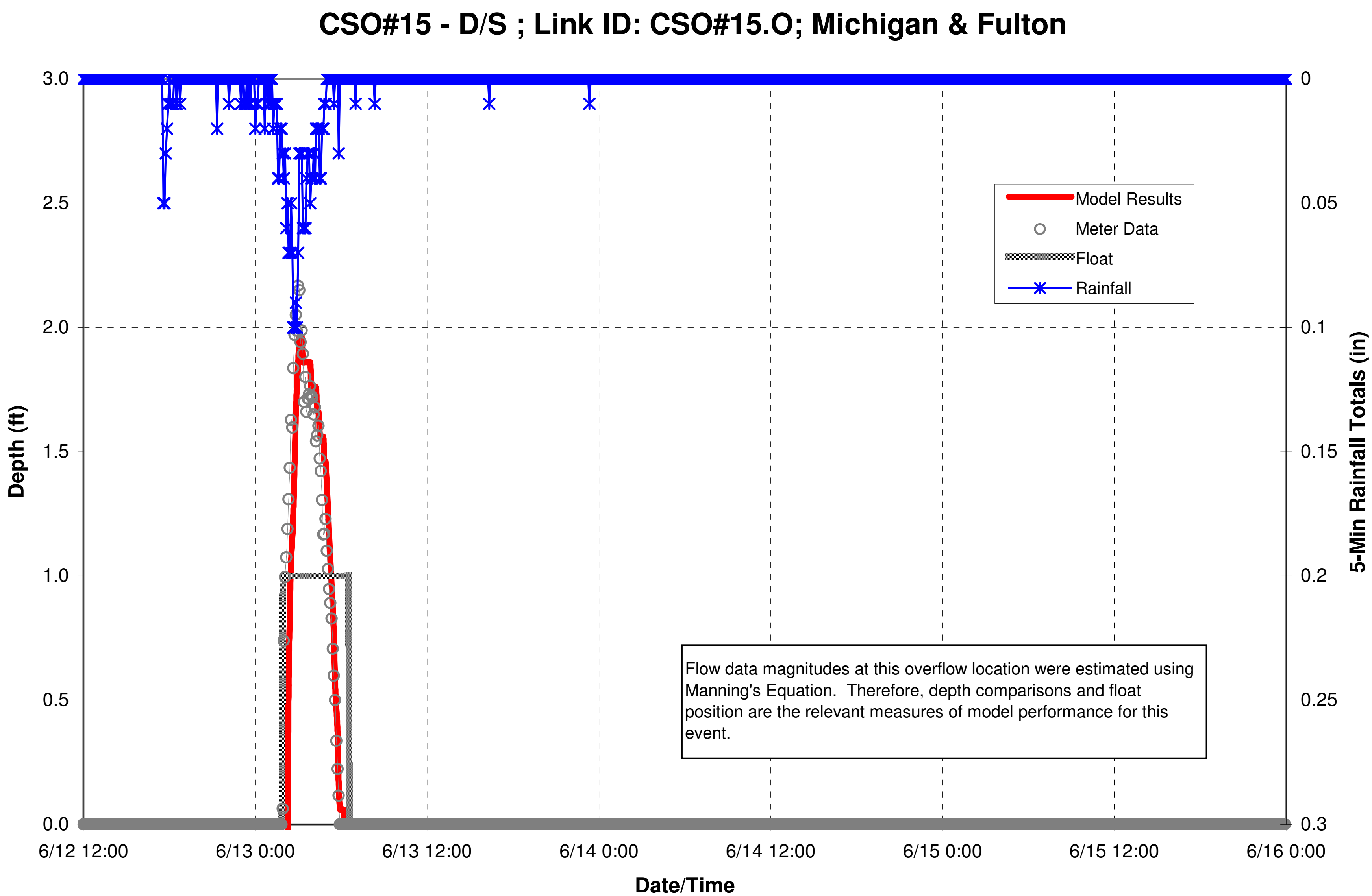


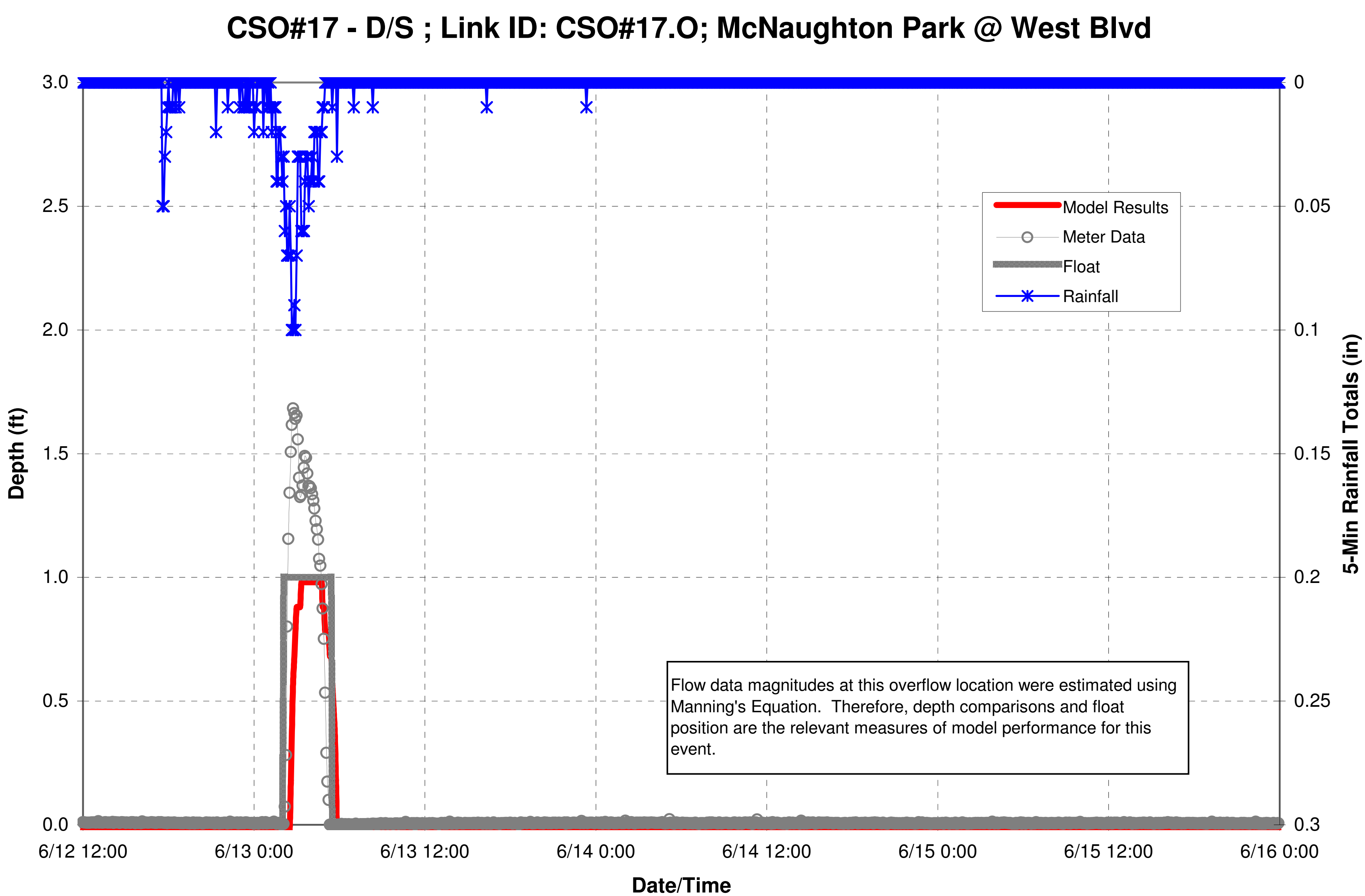
## Flow Meter No.28 ; Link ID: CSO#15.D; Michigan St and Fulton Ave



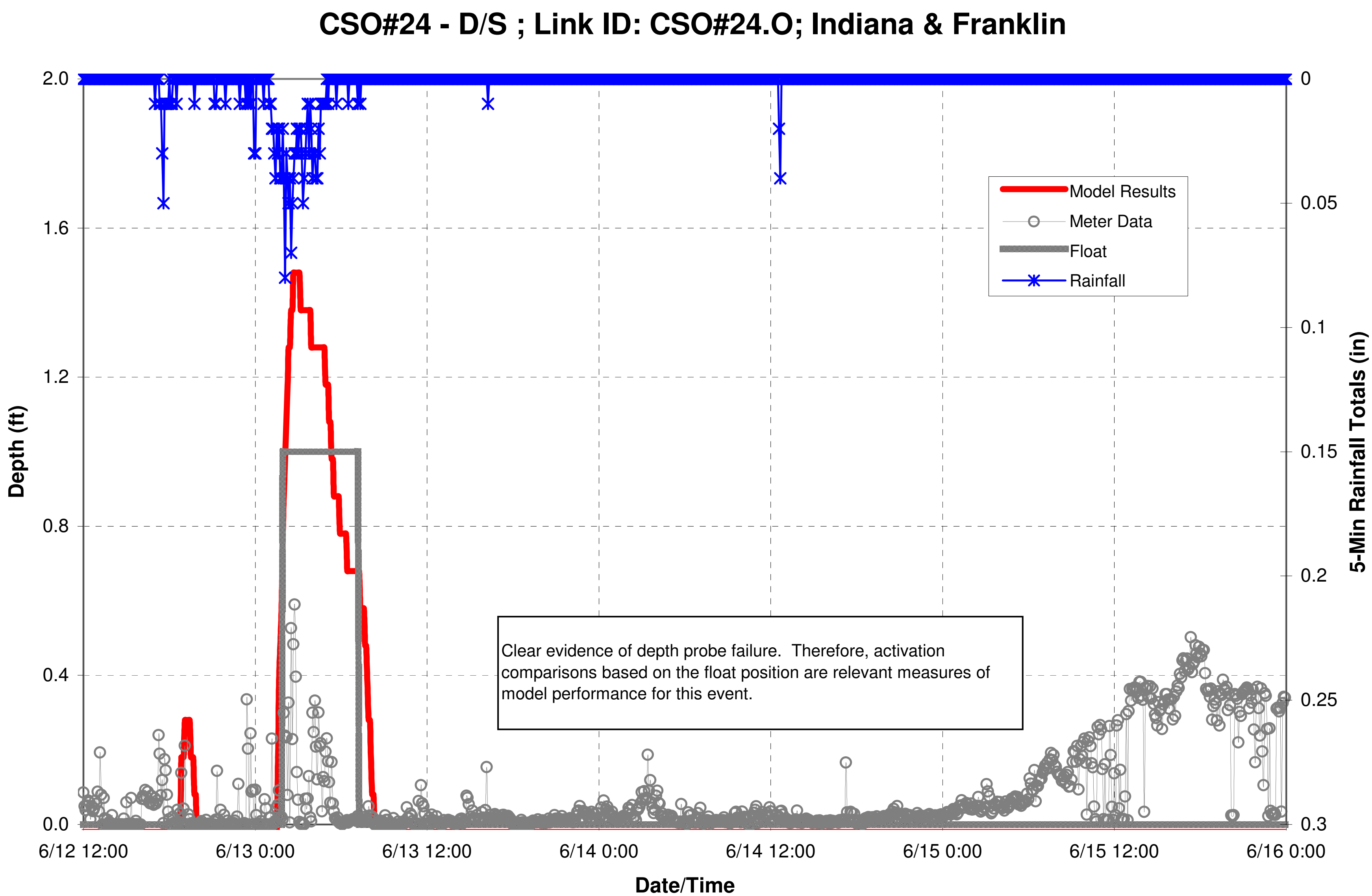


WWTP Influent ; Link ID: SCRout-1
Flow (MGD)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
Model Results
Meter Data
Rainfall
6/12 12:00
6/12 18:00
6/13 0:00
6/13 6:00
6/13 12:00
6/13 18:00
6/14 0:00
6/14 6:00
6/14 12:00
6/14 18:00
6/15 0:00
Date/Time


CSO#15 - D/S ; Link ID: CSO#15.O; Michigan & Fulton
Depth (ft)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons and float position are the relevant measures of model performance for this event.

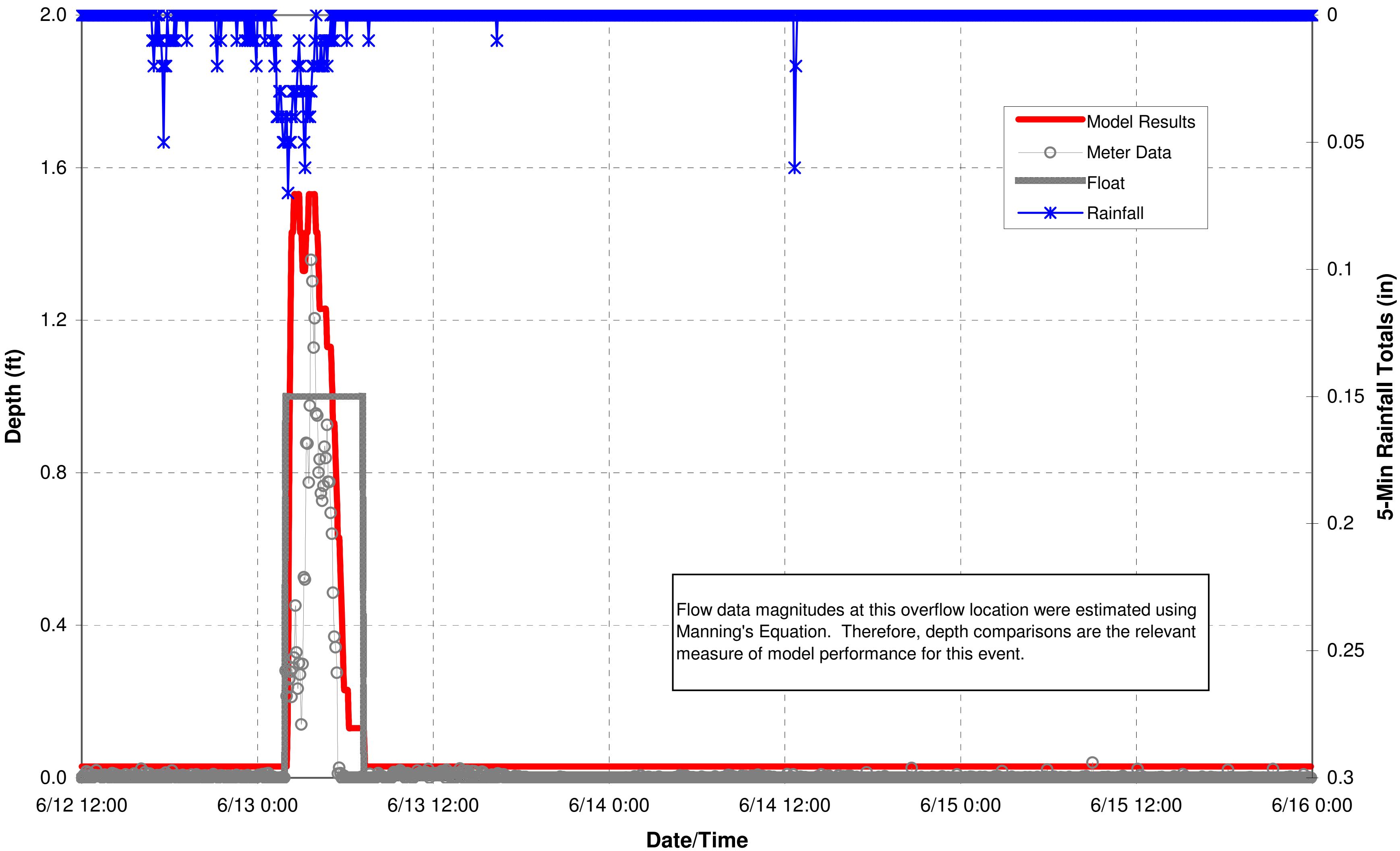


CSO#17 - D/S ; Link ID: CSO#17.O; McNaughton Park @ West Blvd
Depth (ft)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0
0.05
0.1
0.15
0.2
0.25
0.3
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons and float position are the relevant measures of model performance for this event.

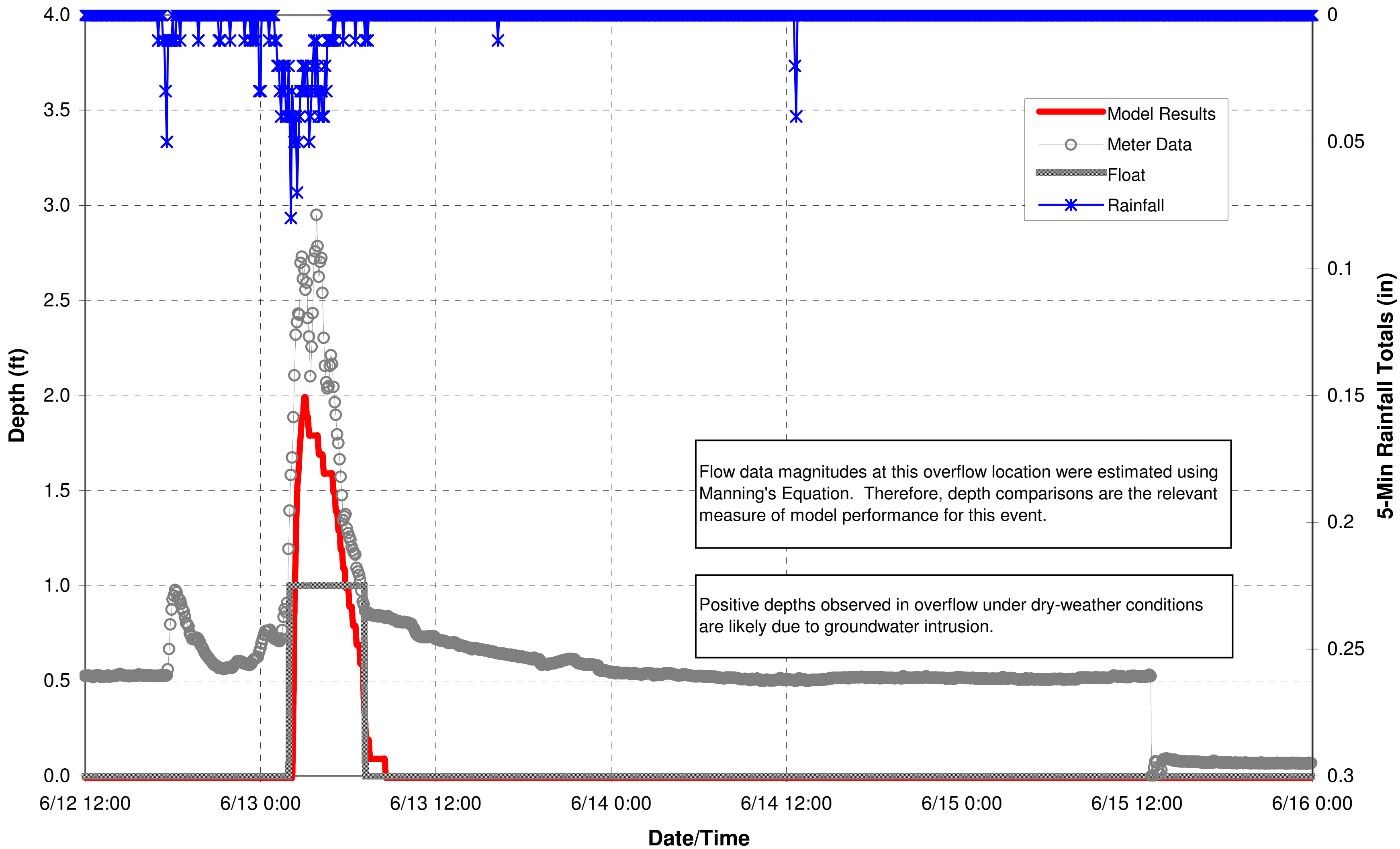


CSO#24 - D/S ; Link ID: CSO#24.O; Indiana & Franklin
Depth (ft)
2.0
1.6
1.2
0.8
0.4
0.0
0
0.05
0.1
0.15
0.2
0.25
0.3
5-Min Rainfall Totals (in)
6/12 12:00
6/13 0:00
6/13 12:00
6/14 0:00
6/14 12:00
6/15 0:00
6/15 12:00
6/16 0:00
Date/Time
Model Results
Meter Data
Float
Rainfall
Clear evidence of depth probe failure. Therefore, activation comparisons based on the float position are relevant measures of model performance for this event.

## CSO#31 - D/S ; Link ID: CSO#31.O; Elizabeth & Lusher



# CSO#37 - D/S ; Link ID: CSO#37.O; Franklin & Krau



## Sensitivity Analysis

*Introduction*

The purpose of a model sensitivity analysis is to determine which input parameters have the greatest impact on model predictions. This information helps guide the calibration process, as it identifies the subset of key parameters that largely control how the model responds under the conditions of interest. For an XP-SWMM collection system model applied to the LTCP development process, the condition of interest is wet weather, with the goal being to obtain credible model predictions of system response to precipitation events.

The important measures of system response for a wet-weather LTCP analysis are as follows:

- Wet-weather volume, an overall metric of wet-weather response and critical to storage schemes included in abatement options.
- Wet-weather peak flow, a short-term measure of the wet-weather response and key to both capacity investigations and treatment schemes included in abatement options.
- Hydrograph shape, a measure integrally related to volume and peak flow, but important in its own right in understanding the transient nature of wet-weather flow events.

Given that these three measures are key for an LTCP development effort, the goal of any sensitivity analysis should be to identify the calibration parameters that have the greatest impact on model predictions for these measures.

It is worth noting that a fourth measure, wet-weather peak depth, is also important to represent properly for LTCP purposes, but it is not independent of the three measures listed above. That is, if volume, peak flow, and hydrograph shape are represented properly, then peak depth will typically be well defined.

*Process and Results*

Many models, including XP-SWMM, now have an "automated" sensitivity analysis feature. These automatic features are useful, but they are not inherently intelligent, nor do they replace the need for the modeling team to have a sound understanding of the fundamental hydrologic processes that the model is representing. Rather than rely on automated features, the City's consultant modeling team, with a combined 40 years of experience in wet-weather collection system modeling, used the early stages of the calibration process to identify the following sensitivity relationship between the important measures of system response (identified above) and model input parameters.

| Important Response Measure | VERY SENSITIVE Primary Calibration Parameters | LESS SENSITIVE Secondary Calibration Parameters |
|---|---|---|
| **Wet-Weather Volume** | Subbasin area | Depression storage |
| | Percent impervious | Soil infiltration parameters |
| **Wet-Weather Peak Flow** | Percent impervious | Overland flow slope |
| | Subbasin width | Overland flow N |
| **Hydrograph shape** | Subbasin width | Overland flow slope |
| | | Overland flow N |

*Conclusions*

Based on the sensitivity analysis, the modeling team applied the following rules to the calibration process:

- The primary calibration parameter for wet-weather volume was percent impervious. While predicted volume is also very sensitive to subbasin area, the area parameter is measurable and well defined, and hence not subject to change for calibration purposes.
- The primary calibration parameter for wet-weather peak flow was subbasin width. With percent impervious typically established through the volume calibration, subbasin width was used to adjust peak flows.
- The primary calibration parameter for hydrograph shape was subbasin width; however, with width already adjusted to define peak flow, a reasonable representation of hydrograph shape was typically achieved through calibration to the first two measures. Any remaining adjustments to shape deemed necessary were obtained with the secondary timing parameters (overland flow slope and overland flow N).

## Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments

| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 100-20 | Combined | 24.05 | 24.05 | 28.4 | 183.1 | 0.5360 | RG1 | Elkh1 | 24.05 | 5.7 | 274.6 | 0.5360 | RG1Spr05 | Elkh1 |
| 100-6 | Combined | 31.45 | 31.45 | 33.9 | 150.0 | 0.6500 | RG1 | Elkh1 | 31.45 | 6.8 | 225.0 | 0.6500 | RG1Spr05 | Elkh1 |
| 101-20 | Combined | 12.71 | 12.71 | 27.5 | 178.7 | 0.6500 | RG1 | Elkh1 | 12.71 | 5.5 | 268.0 | 0.6500 | RG1Spr05 | Elkh1 |
| 101-6 | Combined | 36.58 | 36.58 | 27.5 | 125.0 | 0.6500 | RG1 | Elkh1 | 36.58 | 5.5 | 187.5 | 0.6500 | RG1Spr05 | Elkh1 |
| 102-13 | Combined | 15.58 | 15.58 | 27.5 | 488.9 | 0.5200 | RG4 | Elkh1 | 15.58 | 5.5 | 733.3 | 0.5200 | RG4Spr05 | Elkh1 |
| 102-23 | Combined | 13.08 | 13.08 | 28.7 | 129.6 | 0.5200 | RG4 | Elkh1 | 13.08 | 5.7 | 194.3 | 0.5200 | RG4Spr05 | Elkh1 |
| 102-26 | Combined | 4.61 | 4.61 | 59.2 | 115.7 | 0.2180 | RG4 | Elkh1 | 4.61 | 59.2 | 173.6 | 0.2620 | RG4Spr05 | Elkh1 |
| 102-33 | Combined | 24.09 | 24.09 | 41.0 | 125.0 | 0.2180 | RG4 | Elkh1 | 24.09 | 41.0 | 187.5 | 0.2620 | RG4Spr05 | Elkh1 |
| 102-36 | Combined | 12.89 | 12.89 | 42.2 | 163.3 | 0.2180 | RG1 | Elkh1 | 12.89 | 42.2 | 244.9 | 0.2620 | RG1Spr05 | Elkh1 |
| 102-38 | Combined | 10.55 | 10.55 | 50.9 | 107.3 | 0.2180 | RG1 | Elkh1 | 10.55 | 50.9 | 160.9 | 0.2620 | RG1Spr05 | Elkh1 |
| 102-40 | Combined | 13.92 | 13.92 | 28.0 | 130.8 | 0.2180 | RG4 | Elkh1 | 13.92 | 5.6 | 196.2 | 0.2180 | RG4Spr05 | Elkh1 |
| 102-41 | Combined | 12.40 | 12.40 | 27.5 | 143.5 | 0.2180 | RG4 | Elkh1 | 12.40 | 5.5 | 215.3 | 0.2180 | RG4Spr05 | Elkh1 |
| 102-42 | Combined | 5.52 | 5.52 | 27.5 | 84.6 | 0.2180 | RG1 | Elkh1 | 5.52 | 5.5 | 126.9 | 0.2180 | RG1Spr05 | Elkh1 |
| 102-43 | Combined | 10.73 | 10.73 | 27.5 | 112.9 | 0.2180 | RG1 | Elkh1 | 10.73 | 5.5 | 169.4 | 0.2180 | RG1Spr05 | Elkh1 |
| 102-44 | Combined | 27.35 | 27.35 | 27.5 | 180.7 | 0.2180 | RG1 | Elkh1 | 27.35 | 5.5 | 271.1 | 0.2180 | RG1Spr05 | Elkh1 |
| 102-57 | Combined | 4.57 | 4.57 | 27.5 | 74.5 | 0.5200 | RG4 | Elkh1 | 4.57 | 5.5 | 111.8 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-1 | Combined | 7.11 | 7.11 | 27.5 | 87.9 | 0.5200 | RG4 | Elkh1 | 7.11 | 5.5 | 105.4 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-13 | Combined | 5.73 | 5.73 | 27.5 | 87.1 | 0.2180 | RG4 | Elkh1 | 5.73 | 5.5 | 130.7 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-14 | Combined | 6.11 | 6.11 | 27.5 | 87.9 | 0.2180 | RG4 | Elkh1 | 6.11 | 5.5 | 131.9 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-15 | Combined | 5.59 | 5.59 | 27.5 | 82.5 | 0.2180 | RG4 | Elkh1 | 5.59 | 5.5 | 123.8 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-16 | Combined | 7.98 | 7.98 | 27.5 | 94.4 | 0.2180 | RG4 | Elkh1 | 7.98 | 5.5 | 141.6 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-17 | Combined | 5.57 | 5.57 | 27.5 | 83.5 | 0.2180 | RG4 | Elkh1 | 5.57 | 5.5 | 125.2 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-18 | Combined | 6.42 | 6.42 | 30.9 | 90.5 | 0.2180 | RG4 | Elkh1 | 6.42 | 6.2 | 135.7 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-19 | Combined | 19.86 | 19.86 | 27.6 | 428.8 | 0.2180 | RG4 | Elkh1 | 19.86 | 5.5 | 514.5 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-30 | Combined | 3.56 | 3.56 | 27.5 | 81.3 | 0.5200 | RG4 | Elkh1 | 3.56 | 5.5 | 97.6 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-35 | Combined | 3.90 | 3.90 | 27.5 | 62.2 | 0.2180 | RG4 | Elkh1 | 3.90 | 5.5 | 93.3 | 0.2180 | RG4Spr05 | Elkh1 |
| 103-41 | Combined | 5.97 | 5.97 | 27.5 | 88.3 | 0.5200 | RG4 | Elkh1 | 5.97 | 5.5 | 132.5 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-47 | Combined | 9.81 | 9.81 | 27.5 | 106.2 | 0.5200 | RG4 | Elkh1 | 9.81 | 5.5 | 159.4 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-51 | Combined | 12.17 | 12.17 | 28.0 | 176.6 | 0.5200 | RG4 | Elkh1 | 12.17 | 5.6 | 211.9 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-54 | Combined | 7.76 | 7.76 | 27.5 | 98.1 | 0.5200 | RG4 | Elkh1 | 7.76 | 5.5 | 147.1 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-6 | Combined | 2.41 | 2.41 | 27.5 | 55.0 | 0.5200 | RG4 | Elkh1 | 2.41 | 5.5 | 66.0 | 0.5200 | RG4Spr05 | Elkh1 |
| 103-61 | Combined | 3.90 | 3.90 | 29.6 | 64.1 | 0.1900 | RG4 | Elkh1 | 3.90 | 5.9 | 96.1 | 0.1900 | RG4Spr05 | Elkh1 |
| 103-8 | Combined | 9.17 | 9.17 | 27.5 | 96.1 | 0.2180 | RG4 | Elkh1 | 9.17 | 5.5 | 144.2 | 0.2180 | RG4Spr05 | Elkh1 |
| 104-14 | Combined | 10.87 | 10.87 | 27.9 | 117.5 | 0.2400 | RG4 | Elkh1 | 10.87 | 5.6 | 141.0 | 0.2400 | RG4Spr05 | Elkh1 |
| 104-15 | Combined | 6.70 | 6.70 | 38.1 | 92.6 | 0.9350 | RG4 | Elkh1 | 6.70 | 7.6 | 111.1 | 0.9350 | RG4Spr05 | Elkh1 |
| 104-26 | Combined | 8.08 | 8.08 | 36.5 | 110.7 | 0.2400 | RG4 | Elkh1 | 8.08 | 7.3 | 132.8 | 0.2400 | RG4Spr05 | Elkh1 |
| 104-28 | Combined | 3.55 | 3.55 | 33.5 | 57.4 | 0.2400 | RG4 | Elkh1 | 3.55 | 6.7 | 68.9 | 0.2400 | RG4Spr05 | Elkh1 |
| 104-4 | Combined | 20.11 | 20.11 | 69.8 | 88.3 | 0.9350 | RG4 | Elkh1 | 20.11 | 14.0 | 106.0 | 0.9350 | RG4Spr05 | Elkh1 |
| 104-9 | Combined | 8.51 | 8.51 | 50.9 | 112.1 | 0.2400 | RG4 | Elkh1 | 8.51 | 10.2 | 134.6 | 0.2400 | RG4Spr05 | Elkh1 |
| 105-103 | Combined | 14.57 | 14.57 | 53.9 | 150.5 | 0.6150 | RG4 | Elkh1 | 14.57 | 10.8 | 180.6 | 0.6150 | RG4Spr05 | Elkh1 |
| 105-11 | Combined | 9.03 | 9.03 | 28.5 | 152.9 | 1.5030 | RG2 | Elkh1 | 9.03 | 5.7 | 183.4 | 1.5000 | RG2Spr05 | Elkh1 |
| 105-2 | Combined | 5.92 | 5.92 | 27.5 | 76.0 | 1.5030 | RG2 | Elkh1 | 5.92 | 5.5 | 91.2 | 1.5000 | RG2Spr05 | Elkh1 |
| 105-34 | Combined | 5.00 | 5.00 | 63.9 | 87.7 | 0.5560 | RG4 | Elkh1 | 5.00 | 12.8 | 105.2 | 0.5560 | RG4Spr05 | Elkh1 |
| 105-36 | Combined | 3.04 | 3.04 | 65.9 | 55.1 | 0.7400 | RG2 | Elkh1 | 3.04 | 13.2 | 66.2 | 0.7400 | RG2Spr05 | Elkh1 |
| 105-45 | Combined | 4.66 | 4.66 | 72.5 | 80.3 | 0.7400 | RG2 | Elkh1 | 4.66 | 14.5 | 96.3 | 0.7400 | RG2Spr05 | Elkh1 |
| 105-49 | Combined | 12.27 | 12.27 | 65.9 | 88.7 | 0.7400 | RG2 | Elkh1 | 12.27 | 65.9 | 133.1 | 0.8880 | RG4Spr05 | Elkh1 |
| 105-55 | Combined | 2.90 | 2.90 | 75.0 | 61.6 | 0.7400 | RG4 | Elkh1 | 2.90 | 15.0 | 73.9 | 0.7000 | RG4Spr05 | Elkh1 |
| 105-58 | Combined | 26.03 | 26.03 | 50.3 | 160.9 | 0.2400 | RG4 | Elkh1 | 26.03 | 10.1 | 193.1 | 0.2400 | RG4Spr05 | Elkh1 |
| 105-6 | Combined | 4.82 | 4.82 | 27.5 | 120.1 | 1.5030 | RG2 | Elkh1 | 4.82 | 5.5 | 144.1 | 1.5000 | RG2Spr05 | Elkh1 |
| 105-73 | Combined | 7.33 | 7.33 | 51.2 | 63.3 | 0.2400 | RG4 | Elkh1 | 7.33 | 10.2 | 75.9 | 0.2000 | RG4Spr05 | Elkh1 |
| 105-78 | Combined | 3.09 | 3.09 | 75.0 | 61.6 | 0.2400 | RG4 | Elkh1 | 3.09 | 15.0 | 73.9 | 0.2400 | RG4Spr05 | Elkh1 |
| 105-79 | Combined | 5.03 | 5.03 | 71.4 | 74.8 | 0.2400 | RG4 | Elkh1 | 5.03 | 14.3 | 89.8 | 0.2400 | RG4Spr05 | Elkh1 |
| 106-26 | Combined | 23.82 | 23.82 | 27.7 | 171.8 | 3.9560 | RG2 | Elkh1 | 23.82 | 6.9 | 343.5 | 3.9600 | RG2Spr05 | Elkh1 |
| 106-36 | Combined | 15.18 | 15.18 | 29.9 | 148.6 | 0.6380 | RG2 | Elkh1 | 15.18 | 7.5 | 297.2 | 0.6380 | RG2Spr05 | Elkh1 |
| 106-37 | Combined | 9.38 | 9.38 | 27.9 | 117.1 | 0.6380 | RG2 | Elkh1 | 9.38 | 7.0 | 234.3 | 0.6380 | RG2Spr05 | Elkh1 |
| 106-42 | Combined | 5.99 | 5.99 | 28.2 | 134.0 | 0.6380 | RG2 | Elkh1 | 5.99 | 9.9 | 160.8 | 0.6380 | RG2Spr05 | Elkh1 |
| 106-46 | Combined | 4.26 | 4.26 | 42.6 | 71.9 | 0.6380 | RG2 | Elkh1 | 4.26 | 14.9 | 86.3 | 0.6380 | RG2Spr05 | Elkh1 |
| 106-53 | Combined | 1.35 | 1.35 | 28.3 | 46.7 | 0.7400 | RG2 | Elkh1 | 1.35 | 5.7 | 56.0 | 0.7400 | RG2Spr05 | Elkh1 |
| 106-58 | Combined | 8.50 | 8.50 | 28.4 | 40.1 | 0.7400 | RG2 | Elkh1 | 8.50 | 5.7 | 48.1 | 0.7400 | RG2Spr05 | Elkh1 |
| 106-64 | Combined | 6.72 | 6.72 | 28.8 | 93.8 | 0.7400 | RG2 | Elkh1 | 6.72 | 5.8 | 112.5 | 0.7400 | RG2Spr05 | Elkh1 |
| 106-7 | Combined | 11.54 | 11.54 | 58.8 | 128.7 | 0.6380 | RG2 | Elkh1 | 11.54 | 14.7 | 257.4 | 0.6380 | RG2Spr05 | Elkh1 |

## Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued)

| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 107-17 | Combined | 11.96 | 11.96 | 65.2 | 206.3 | 0.7900 | RG2 | Elkh1 | 11.96 | 24.1 | 247.6 | 0.7900 | RG2Spr05 | Elkh1 |
| 107-32 | Combined | 16.53 | 16.53 | 43.1 | 231.3 | 0.7880 | RG2 | Elkh1 | 16.53 | 16.0 | 277.6 | 0.7880 | RG2Spr05 | Elkh1 |
| 107-33 | Combined | 35.90 | 35.90 | 65.6 | 206.3 | 0.7880 | RG2 | Elkh1 | 35.90 | 24.3 | 247.6 | 0.7880 | RG2Spr05 | Elkh1 |
| 107-38 | Combined | 27.95 | 27.95 | 64.8 | 184.7 | 0.7880 | RG2 | Elkh1 | 27.95 | 24.0 | 221.6 | 0.7880 | RG2Spr05 | Elkh1 |
| 107-47 | Combined | 6.71 | 6.71 | 31.6 | 82.0 | 0.5430 | RG2 | Elkh1 | 6.71 | 11.1 | 98.4 | 0.5430 | RG2Spr05 | Elkh1 |
| 107-50 | Combined | 42.92 | 42.92 | 32.3 | 524.5 | 0.5430 | RG2 | Elkh1 | 42.92 | 11.3 | 629.4 | 0.5430 | RG2Spr05 | Elkh1 |
| 107-70 | Combined | 27.80 | 27.80 | 29.1 | 116.2 | 0.5430 | RG2 | Elkh1 | 27.80 | 10.2 | 139.4 | 0.5430 | RG2Spr05 | Elkh1 |
| 108-18 | Combined | 74.27 | 74.27 | 58.1 | 277.3 | 0.7880 | RG2 | Elkh1 | 74.27 | 21.5 | 332.8 | 0.7880 | RG2Spr05 | Elkh1 |
| 116-16 | Combined | 102.75 | 102.75 | 31.1 | 176.9 | 0.2030 | RG2 | Elkh1 | 102.75 | 4.7 | 707.7 | 0.2030 | RG2Spr05 | Elkh1 |
| 116-24 | Combined | 11.54 | 11.54 | 38.9 | 115.7 | 0.1860 | RG2 | Elkh1 | 11.54 | 5.8 | 462.7 | 0.1860 | RG2Spr05 | Elkh1 |
| 117-38 | Combined | 11.10 | 11.10 | 27.5 | 117.0 | 0.1860 | RG2 | Elkh1 | 11.10 | 4.1 | 467.9 | 0.1860 | RG2Spr05 | Elkh1 |
| 117-43 | Combined | 7.19 | 7.19 | 39.6 | 95.5 | 0.1860 | RG2 | Elkh1 | 7.19 | 5.9 | 381.9 | 0.1860 | RG2Spr05 | Elkh1 |
| 117-5 | Combined | 38.89 | 38.89 | 27.9 | 150.0 | 0.1860 | RG2 | Elkh1 | 38.89 | 4.2 | 600.0 | 0.1860 | RG2Spr05 | Elkh1 |
| 117-51 | Combined | 13.17 | 13.17 | 29.4 | 215.7 | 0.1860 | RG2 | Elkh1 | 13.17 | 4.4 | 862.7 | 0.1860 | RG2Spr05 | Elkh1 |
| 117-54 | Combined | 7.58 | 7.58 | 27.5 | 97.6 | 0.4760 | RG2 | Elkh1 | 7.58 | 4.1 | 390.2 | 0.4760 | RG2Spr05 | Elkh1 |
| 118-15 | Combined | 1.13 | 1.13 | 32.6 | 40.3 | 0.3780 | RG2 | Elkh1 | 1.13 | 11.4 | 48.3 | 0.3780 | RG2Spr05 | Elkh1 |
| 118-2 | Combined | 54.96 | 54.96 | 29.2 | 140.0 | 0.5430 | RG2 | Elkh1 | 54.96 | 4.4 | 560.0 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-27 | Combined | 19.95 | 19.95 | 27.5 | 139.2 | 0.5430 | RG2 | Elkh1 | 19.95 | 4.1 | 556.8 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-33 | Combined | 1.24 | 1.24 | 27.5 | 35.9 | 0.5430 | RG2 | Elkh1 | 1.24 | 4.1 | 143.4 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-37 | Combined | 2.90 | 2.90 | 27.5 | 61.6 | 0.3780 | RG2 | Elkh1 | 2.90 | 5.5 | 73.9 | 0.3780 | RG2Spr05 | Elkh1 |
| 118-38 | Combined | 8.95 | 8.95 | 29.0 | 106.8 | 0.3780 | RG2 | Elkh1 | 8.95 | 5.8 | 128.2 | 0.3780 | RG2Spr05 | Elkh1 |
| 118-46 | Combined | 15.83 | 15.83 | 27.5 | 130.7 | 0.5430 | RG2 | Elkh1 | 15.83 | 4.1 | 522.8 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-47 | Combined | 10.62 | 10.62 | 27.5 | 98.1 | 0.5430 | RG2 | Elkh1 | 10.62 | 4.1 | 392.5 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-48 | Combined | 16.21 | 16.21 | 27.5 | 93.7 | 0.5430 | RG2 | Elkh1 | 16.21 | 4.1 | 375.0 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-54 | Combined | 10.52 | 10.52 | 27.5 | 130.1 | 0.5430 | RG2 | Elkh1 | 10.52 | 4.1 | 520.4 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-55 | Combined | 9.25 | 9.25 | 27.5 | 105.8 | 0.5430 | RG2 | Elkh1 | 9.25 | 4.1 | 423.0 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-63 | Combined | 5.53 | 5.53 | 27.5 | 115.1 | 0.5430 | RG2 | Elkh1 | 5.53 | 4.1 | 460.4 | 0.5430 | RG2Spr05 | Elkh1 |
| 118-66 | Combined | 8.75 | 8.75 | 27.5 | 97.8 | 0.3780 | RG2 | Elkh1 | 8.75 | 5.5 | 117.4 | 0.3780 | RG2Spr05 | Elkh1 |
| 118-70 | Combined | 18.04 | 18.04 | 27.7 | 108.9 | 0.3780 | RG2 | Elkh1 | 18.04 | 5.5 | 130.7 | 0.3780 | RG2Spr05 | Elkh1 |
| 119-109 | Combined | 11.12 | 11.12 | 27.5 | 116.7 | 0.7400 | RG2 | Elkh1 | 11.12 | 5.5 | 140.1 | 0.7400 | RG2Spr05 | Elkh1 |
| 119-121 | Combined | 8.40 | 8.40 | 35.8 | 110.5 | 0.7400 | RG2 | Elkh1 | 8.40 | 7.2 | 132.6 | 0.7400 | RG2Spr05 | Elkh1 |
| 119-125 | Combined | 6.83 | 6.83 | 75.0 | 67.3 | 0.7400 | RG2 | Elkh1 | 6.83 | 45.0 | 80.7 | 0.7400 | RG2Spr05 | Elkh1 |
| 119-28 | Combined | 23.39 | 23.39 | 29.6 | 168.6 | 0.7400 | RG2 | Elkh1 | 23.39 | 5.9 | 202.3 | 0.7400 | RG2Spr05 | Elkh1 |
| 119-3 | Combined | 5.55 | 5.55 | 27.5 | 105.2 | 0.3780 | RG2 | Elkh1 | 5.55 | 5.5 | 126.2 | 0.3780 | RG2Spr05 | Elkh1 |
| 119-6 | Combined | 3.57 | 3.57 | 29.6 | 65.6 | 0.3780 | RG2 | Elkh1 | 3.57 | 5.9 | 78.7 | 0.3780 | RG2Spr05 | Elkh1 |
| 119-67 | Combined | 11.49 | 11.49 | 58.3 | 124.5 | 0.7400 | RG2 | Elkh1 | 11.49 | 11.7 | 149.4 | 0.7400 | RG2Spr05 | Elkh1 |
| 119-76 | Combined | 16.33 | 16.33 | 48.0 | 167.7 | 0.7400 | RG2 | Elkh1 | 16.33 | 9.6 | 201.2 | 0.7400 | RG2Spr05 | Elkh1 |
| 120-130 | Combined | 6.49 | 6.49 | 75.0 | 63.9 | 0.7400 | RG4 | Elkh1 | 6.49 | 45.0 | 76.7 | 0.7400 | RG4Spr05 | Elkh1 |
| 120-15 | Combined | 1.76 | 1.76 | 75.0 | 47.5 | 1.5870 | RG4 | Elkh1 | 1.76 | 15.0 | 57.0 | 1.5900 | RG4Spr05 | Elkh1 |
| 120-18 | Combined | 10.80 | 10.80 | 75.0 | 135.8 | 0.7400 | RG4 | Elkh1 | 10.80 | 45.0 | 163.0 | 0.7400 | RG4Spr05 | Elkh1 |
| 120-19 | Combined | 5.23 | 5.23 | 75.0 | 75.7 | 0.7400 | RG4 | Elkh1 | 5.23 | 28.5 | 90.8 | 0.7400 | RG4Spr05 | Elkh1 |
| 120-21 | Combined | 1.73 | 1.73 | 75.0 | 50.0 | 1.5870 | RG4 | Elkh1 | 1.73 | 15.0 | 60.0 | 1.5900 | RG4Spr05 | Elkh1 |
| 120-36 | Combined | 6.52 | 6.52 | 75.0 | 148.8 | 0.5200 | RG4 | Elkh1 | 6.52 | 15.0 | 178.5 | 0.5200 | RG4Spr05 | Elkh1 |
| 120-46 | Combined | 6.14 | 6.14 | 75.0 | 80.8 | 0.7400 | RG4 | Elkh1 | 6.14 | 28.5 | 96.9 | 0.7400 | RG4Spr05 | Elkh1 |
| 120-5 | Combined | 3.47 | 3.47 | 75.0 | 63.1 | 0.7400 | RG4 | Elkh1 | 3.47 | 45.0 | 75.7 | 0.7400 | RG4Spr05 | Elkh1 |
| 120-50 | Combined | 3.82 | 3.82 | 75.0 | 63.3 | 0.7400 | RG4 | Elkh1 | 3.82 | 28.5 | 76.0 | 0.7400 | RG4Spr05 | Elkh1 |
| 120-67 | Combined | 36.52 | 36.52 | 52.3 | 171.8 | 1.5870 | RG4 | Elkh1 | 36.52 | 10.5 | 206.2 | 1.5900 | RG4Spr05 | Elkh1 |
| 120-7 | Combined | 4.40 | 4.40 | 75.0 | 72.1 | 1.5870 | RG4 | Elkh1 | 4.40 | 15.0 | 86.5 | 1.5900 | RG4Spr05 | Elkh1 |
| 120-70 | Combined | 21.85 | 21.85 | 47.1 | 154.7 | 1.5870 | RG4 | Elkh1 | 21.85 | 9.4 | 185.6 | 1.5900 | RG4Spr05 | Elkh1 |
| 120-73 | Combined | 4.49 | 4.49 | 73.2 | 67.6 | 0.7400 | RG4 | Elkh1 | 4.49 | 27.8 | 81.2 | 0.7400 | RG4Spr05 | Elkh1 |
| 120-76 | Combined | 4.77 | 4.77 | 75.0 | 88.4 | 0.7400 | RG4 | Elkh1 | 4.77 | 2.5 | 4.2 | 0.0500 | RG4Spr05 | Elkh1 |
| 120-83 | Combined | 6.47 | 6.47 | 46.1 | 62.8 | 1.5870 | RG4 | Elkh1 | 6.47 | 18.4 | 75.3 | 1.5900 | RG4Spr05 | Elkh1 |
| 121-14 | Combined | 7.19 | 7.19 | 41.9 | 56.8 | 1.2790 | RG4 | Elkh1 | 7.19 | 16.8 | 68.2 | 1.2800 | RG4Spr05 | Elkh1 |
| 122-13 | Combined | 31.55 | 31.55 | 42.6 | 93.5 | 0.1190 | RG4 | Elkh1 | 31.55 | 42.6 | 140.2 | 0.1430 | RG4Spr05 | Elkh1 |
| 122-16 | Combined | 4.30 | 4.30 | 29.2 | 69.9 | 0.1190 | RG4 | Elkh1 | 4.30 | 11.7 | 83.9 | 0.1190 | RG4Spr05 | Elkh1 |
| 122-19 | Combined | 3.99 | 3.99 | 31.3 | 63.6 | 0.1190 | RG4 | Elkh1 | 3.99 | 12.5 | 76.3 | 0.1190 | RG4Spr05 | Elkh1 |
| 122-28 | Combined | 3.77 | 3.77 | 31.3 | 66.5 | 0.1960 | RG4 | Elkh1 | 3.77 | 12.5 | 79.8 | 0.1960 | RG4Spr05 | Elkh1 |
| 122-33 | Combined | 4.87 | 4.87 | 37.3 | 80.2 | 0.1960 | RG4 | Elkh1 | 4.87 | 14.9 | 96.2 | 0.1960 | RG4Spr05 | Elkh1 |
| 122-34 | Combined | 6.59 | 6.59 | 39.7 | 90.7 | 0.1960 | RG4 | Elkh1 | 6.59 | 15.9 | 108.9 | 0.1960 | RG4Spr05 | Elkh1 |
| 122-36 | Combined | 11.55 | 11.55 | 42.8 | 127.3 | 0.1960 | RG4 | Elkh1 | 11.55 | 17.1 | 152.8 | 0.1960 | RG4Spr05 | Elkh1 |
| 122-9 | Combined | 12.01 | 12.01 | 45.4 | 115.2 | 0.1190 | RG4 | Elkh1 | 12.01 | 45.4 | 172.7 | 0.1430 | RG4Spr05 | Elkh1 |

| Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Initial Parameters | | | | | | Final Parameters | | | | | | |
| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 135-13 | Combined | 12.57 | 12.57 | 28.9 | 83.6 | 1.0240 | RG3 | Elkh1 | 12.57 | 11.6 | 100.4 | 1.0240 | RG3Spr05 | Elkh1 |
| 135-15 | Combined | 5.23 | 5.23 | 27.5 | 50.8 | 1.5870 | RG3 | Elkh1 | 5.23 | 11.0 | 61.0 | 1.5900 | RG3Spr05 | Elkh1 |
| 135-16 | Combined | 13.98 | 13.98 | 27.5 | 137.4 | 1.0240 | RG3 | Elkh1 | 13.98 | 11.0 | 164.9 | 1.0200 | RG3Spr05 | Elkh1 |
| 135-28 | Combined | 24.20 | 24.20 | 36.7 | 150.5 | 1.0240 | RG3 | Elkh1 | 24.20 | 14.7 | 180.6 | 1.0200 | RG3Spr05 | Elkh1 |
| 135-29 | Combined | 16.46 | 16.46 | 32.4 | 127.9 | 1.0240 | RG3 | Elkh1 | 16.46 | 13.0 | 153.4 | 1.0200 | RG3Spr05 | Elkh1 |
| 135-46 | Combined | 33.45 | 33.45 | 28.1 | 105.8 | 0.1190 | RG4 | Elkh1 | 33.45 | 11.2 | 126.9 | 0.1190 | RG4Spr05 | Elkh1 |
| 135-5 | Combined | 5.16 | 5.16 | 27.5 | 45.9 | 0.9950 | RG4 | Elkh1 | 5.16 | 11.0 | 55.0 | 0.9950 | RG4Spr05 | Elkh1 |
| 136-115 | Combined | 10.45 | 10.45 | 27.5 | 125.3 | 2.0080 | RG4 | Elkh1 | 10.45 | 11.0 | 150.3 | 2.0100 | RG4Spr05 | Elkh1 |
| 136-12 | Combined | 8.64 | 8.64 | 33.7 | 104.0 | 0.3030 | RG3 | Elkh1 | 8.64 | 13.5 | 124.8 | 0.3640 | RG3Spr05 | Elkh1 |
| 136-20 | Combined | 10.26 | 10.26 | 51.0 | 107.1 | 0.3030 | RG3 | Elkh1 | 10.26 | 20.4 | 128.6 | 0.3640 | RG3Spr05 | Elkh1 |
| 136-4 | Combined | 16.80 | 16.80 | 50.9 | 111.5 | 1.2790 | RG4 | Elkh1 | 16.80 | 20.3 | 133.8 | 1.2800 | RG4Spr05 | Elkh1 |
| 136-59 | Combined | 10.40 | 10.40 | 40.6 | 21.8 | 0.0100 | RG4 | Elkh1 | 10.40 | 16.2 | 26.2 | 0.0100 | RG4Spr05 | Elkh1 |
| 136-63 | Combined | 9.71 | 9.71 | 40.1 | 103.3 | 1.2790 | RG4 | Elkh1 | 9.71 | 16.0 | 124.0 | 1.2800 | RG4Spr05 | Elkh1 |
| 136-69 | Combined | 13.26 | 13.26 | 41.3 | 122.7 | 1.2790 | RG4 | Elkh1 | 13.26 | 16.5 | 147.2 | 1.2800 | RG4Spr05 | Elkh1 |
| 136-78 | Combined | 23.49 | 23.49 | 36.7 | 156.6 | 1.2790 | RG4 | Elkh1 | 23.49 | 14.7 | 187.9 | 1.2800 | RG4Spr05 | Elkh1 |
| 136-9 | Combined | 8.15 | 8.15 | 72.8 | 26.4 | 0.4000 | RG3 | Elkh1 | 8.15 | 27.7 | 31.6 | 0.4000 | RG3Spr05 | Elkh1 |
| 137-15 | Combined | 10.86 | 10.86 | 71.3 | 114.2 | 0.4000 | RG4 | Elkh1 | 10.86 | 2.5 | 9.5 | 0.0500 | RG4Spr05 | Elkh1 |
| 137-18 | Combined | 8.67 | 8.67 | 55.0 | 104.1 | 0.4000 | RG4 | Elkh1 | 8.67 | 2.5 | 37.8 | 0.0500 | RG4Spr05 | Elkh1 |
| 137-19 | Combined | 1.49 | 1.49 | 40.0 | 37.7 | 0.4000 | RG4 | Elkh1 | 1.49 | 2.5 | 6.5 | 0.0500 | RG4Spr05 | Elkh1 |
| 137-24 | Combined | 9.23 | 9.23 | 63.4 | 106.2 | 0.3030 | RG5 | Elkh1 | 9.23 | 63.4 | 127.4 | 0.3030 | RG5Spr05 | Elkh1 |
| 137-27 | Combined | 4.37 | 4.37 | 52.9 | 70.5 | 0.3030 | RG5 | Elkh1 | 4.38 | 2.5 | 19.1 | 0.0500 | RG5Spr05 | Elkh1 |
| 137-29 | Combined | 7.21 | 7.21 | 62.3 | 93.0 | 0.3030 | RG5 | Elkh1 | 7.21 | 2.5 | 31.4 | 0.0500 | RG5Spr05 | Elkh1 |
| 137-31 | Combined | 7.29 | 7.29 | 40.5 | 87.2 | 0.3030 | RG3 | Elkh1 | 7.29 | 2.5 | 31.7 | 0.0500 | RG3Spr05 | Elkh1 |
| 137-33 | Combined | 5.60 | 5.60 | 40.0 | 87.0 | 0.3030 | RG4 | Elkh1 | 5.60 | 2.5 | 24.4 | 0.0500 | RG4Spr05 | Elkh1 |
| 137-34 | Combined | 6.03 | 6.03 | 40.0 | 85.5 | 0.3030 | RG4 | Elkh1 | 6.03 | 2.5 | 26.3 | 0.0500 | RG4Spr05 | Elkh1 |
| 137-55 | Combined | 12.97 | 12.97 | 40.9 | 123.0 | 0.3030 | RG5 | Elkh1 | 12.97 | 2.5 | 56.5 | 0.0500 | RG5Spr05 | Elkh1 |
| 137-59 | Combined | 10.26 | 10.26 | 43.2 | 111.3 | 0.3030 | RG3 | Elkh1 | 10.26 | 2.5 | 4.5 | 0.0500 | RG3Spr05 | Elkh1 |
| 137-68 | Combined | 10.57 | 10.57 | 66.4 | 126.9 | 0.3030 | RG5 | Elkh1 | 10.57 | 2.5 | 4.6 | 0.0500 | RG5Spr05 | Elkh1 |
| 137-71 | Combined | 5.40 | 5.40 | 37.7 | 84.6 | 0.3030 | RG3 | Elkh1 | 5.40 | 2.5 | 2.4 | 0.0500 | RG3Spr05 | Elkh1 |
| 137-8 | Combined | 23.86 | 23.86 | 64.1 | 153.3 | 0.3030 | RG4 | Elkh1 | 23.86 | 2.5 | 103.9 | 0.0500 | RG4Spr05 | Elkh1 |
| 137-81 | Combined | 8.36 | 8.36 | 50.4 | 66.0 | 0.3030 | RG5 | Elkh1 | 8.36 | 20.2 | 79.1 | 0.3640 | RG5Spr05 | Elkh1 |
| 137-84 | Combined | 6.64 | 6.64 | 30.4 | 68.3 | 0.3030 | RG3 | Elkh1 | 6.64 | 12.2 | 81.9 | 0.3640 | RG3Spr05 | Elkh1 |
| 138-117 | Combined | 22.23 | 22.23 | 56.2 | 66.2 | 1.4300 | RG2 | Elkh1 | 22.23 | 11.2 | 79.5 | 1.4300 | RG2Spr05 | Elkh1 |
| 138-20 | Combined | 29.85 | 29.85 | 56.3 | 169.4 | 1.4300 | RG2 | Elkh1 | 29.85 | 11.3 | 203.3 | 1.4300 | RG2Spr05 | Elkh1 |
| 138-25 | Combined | 46.42 | 46.42 | 64.8 | 188.5 | 0.7480 | RG2 | Elkh1 | 46.42 | 19.4 | 282.8 | 0.8980 | RG2Spr05 | Elkh1 |
| 138-35 | Combined | 38.19 | 38.19 | 50.7 | 175.0 | 0.7480 | RG5 | Elkh1 | 38.19 | 15.2 | 262.5 | 0.8980 | RG5Spr05 | Elkh1 |
| 138-51 | Combined | 17.35 | 17.35 | 65.0 | 157.6 | 0.3030 | RG5 | Elkh1 | 17.35 | 2.5 | 75.6 | 0.0500 | RG5Spr05 | Elkh1 |
| 139-1 | Combined | 19.49 | 19.49 | 27.5 | 139.4 | 0.4760 | RG2 | Elkh1 | 19.49 | 4.1 | 557.7 | 0.4760 | RG2Spr05 | Elkh1 |
| 139-123 | Combined | 15.53 | 15.53 | 34.6 | 153.4 | 1.4300 | RG2 | Elkh1 | 15.53 | 6.9 | 184.1 | 1.4300 | RG2Spr05 | Elkh1 |
| 139-13 | Combined | 20.29 | 20.29 | 27.6 | 157.8 | 1.4300 | RG2 | Elkh1 | 20.29 | 5.5 | 189.3 | 1.4300 | RG2Spr05 | Elkh1 |
| 139-42 | Combined | 6.67 | 6.67 | 72.4 | 284.5 | 1.4300 | RG2 | Elkh1 | 6.67 | 14.5 | 341.4 | 1.4300 | RG2Spr05 | Elkh1 |
| 139-49 | Combined | 2.68 | 2.68 | 29.1 | 55.1 | 1.4300 | RG2 | Elkh1 | 2.68 | 5.8 | 66.2 | 1.4300 | RG2Spr05 | Elkh1 |
| 139-53 | Combined | 9.63 | 9.63 | 32.6 | 108.3 | 0.7480 | RG2 | Elkh1 | 9.63 | 6.5 | 130.0 | 0.7480 | RG2Spr05 | Elkh1 |
| 139-55 | Combined | 10.57 | 10.57 | 27.5 | 111.7 | 1.4300 | RG2 | Elkh1 | 10.57 | 5.5 | 134.1 | 1.4300 | RG2Spr05 | Elkh1 |
| 139-88 | Combined | 44.85 | 44.85 | 48.8 | 315.4 | 0.7480 | RG2 | Elkh1 | 44.85 | 9.8 | 378.5 | 0.7480 | RG2Spr05 | Elkh1 |
| 139-95 | Combined | 3.75 | 3.75 | 58.4 | 77.2 | 0.7480 | RG5 | Elkh1 | 3.75 | 46.7 | 92.7 | 0.7480 | RG5Spr05 | Elkh1 |
| 140-21 | Combined | 13.36 | 13.36 | 27.5 | 133.6 | 0.8900 | RG2 | Elkh1 | 13.36 | 5.5 | 160.4 | 0.8900 | RG2Spr05 | Elkh1 |
| 140-29 | Combined | 6.21 | 6.21 | 27.5 | 31.9 | 0.8900 | RG2 | Elkh1 | 6.21 | 5.5 | 38.2 | 0.8900 | RG2Spr05 | Elkh1 |
| 140-41 | Combined | 43.41 | 43.41 | 43.2 | 86.5 | 0.8900 | RG2 | Elkh1 | 43.41 | 8.6 | 103.7 | 0.8900 | RG2Spr05 | Elkh1 |
| 140-7 | Combined | 14.37 | 14.37 | 27.5 | 105.3 | 0.4760 | RG2 | Elkh1 | 14.37 | 4.1 | 421.3 | 0.4760 | RG2Spr05 | Elkh1 |
| 140-8 | Combined | 12.64 | 12.64 | 27.5 | 130.6 | 0.4760 | RG2 | Elkh1 | 12.64 | 11.0 | 261.2 | 0.4760 | RG2Spr05 | Elkh1 |
| 140-80 | Combined | 12.35 | 12.35 | 27.5 | 115.0 | 0.8900 | RG2 | Elkh1 | 12.35 | 5.5 | 138.0 | 0.8900 | RG2Spr05 | Elkh1 |
| 140-97 | Combined | 6.25 | 6.25 | 27.5 | 107.3 | 0.8900 | RG2 | Elkh1 | 6.25 | 5.5 | 128.8 | 0.8900 | RG2Spr05 | Elkh1 |
| 150-10 | Combined | 1.96 | 1.96 | 62.2 | 28.4 | 0.5200 | RG5 | Elkh1 | 1.96 | 49.8 | 34.1 | 0.5200 | RG5Spr05 | Elkh1 |
| 150-12 | Combined | 15.64 | 15.64 | 38.3 | 134.9 | 0.7480 | RG5 | Elkh1 | 15.64 | 30.6 | 161.8 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-13 | Combined | 12.18 | 12.18 | 30.5 | 122.5 | 0.7480 | RG5 | Elkh1 | 12.18 | 24.4 | 147.0 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-14 | Combined | 20.71 | 20.71 | 41.0 | 150.3 | 0.7480 | RG5 | Elkh1 | 20.71 | 32.8 | 180.4 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-15 | Combined | 6.68 | 6.68 | 46.4 | 93.2 | 0.7480 | RG5 | Elkh1 | 6.68 | 37.1 | 111.8 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-16 | Combined | 9.39 | 9.39 | 27.5 | 104.0 | 0.7480 | RG5 | Elkh1 | 9.39 | 22.0 | 124.8 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-17 | Combined | 5.71 | 5.71 | 47.0 | 86.4 | 0.7480 | RG5 | Elkh1 | 5.71 | 37.6 | 103.6 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-18 | Combined | 24.16 | 24.16 | 42.8 | 163.3 | 0.7480 | RG5 | Elkh1 | 24.16 | 34.2 | 195.9 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-19 | Combined | 21.54 | 21.54 | 42.4 | 159.3 | 0.7480 | RG5 | Elkh1 | 21.54 | 33.9 | 191.1 | 0.7480 | RG5Spr05 | Elkh1 |
| 150-20 | Combined | 10.50 | 10.50 | 52.9 | 46.9 | 0.7480 | RG5 | Elkh1 | 10.50 | 42.3 | 56.3 | 0.7480 | RG5Spr05 | Elkh1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 150-9 | Combined | 16.01 | 16.01 | 58.2 | 71.9 | 0.7480 | RG5 | Elkh1 | 16.01 | 46.6 | 86.3 | 0.7480 | RG5Spr05 | Elkh1 |
| 151-10 | Combined | 38.62 | 38.62 | 27.5 | 81.1 | 0.0100 | RG5 | Elkh1 | 38.62 | 27.5 | 97.3 | 0.0100 | RG5Spr05 | Elkh1 |
| 151-13 | Combined | 14.01 | 14.01 | 27.5 | 118.5 | 0.1920 | RG5 | Elkh1 | 14.01 | 27.5 | 142.1 | 0.1920 | RG5Spr05 | Elkh1 |

## Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued)

| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 151-14 | Combined | 12.85 | 12.85 | 33.0 | 174.8 | 0.1920 | RG5 | Elkh1 | 12.85 | 33.0 | 209.8 | 0.1920 | RG5Spr05 | Elkh1 |
| 151-2 | Combined | 12.73 | 12.73 | 44.3 | 203.7 | 0.7480 | RG5 | Elkh1 | 12.73 | 35.5 | 244.4 | 0.7480 | RG5Spr05 | Elkh1 |
| 151-32 | Combined | 14.86 | 14.86 | 27.5 | 155.7 | 0.7480 | RG5 | Elkh1 | 14.86 | 27.5 | 186.8 | 0.7480 | RG5Spr05 | Elkh1 |
| 152-13 | Combined | 13.75 | 13.75 | 27.5 | 131.9 | 0.3030 | RG5 | Elkh1 | 13.75 | 11.0 | 158.3 | 0.3640 | RG5Spr05 | Elkh1 |
| 152-17 | Combined | 11.68 | 11.68 | 27.5 | 103.0 | 0.3030 | RG5 | Elkh1 | 11.68 | 11.0 | 123.6 | 0.3640 | RG5Spr05 | Elkh1 |
| 152-23 | Combined | 18.32 | 18.32 | 27.5 | 74.4 | 0.3030 | RG5 | Elkh1 | 18.32 | 11.0 | 89.3 | 0.3640 | RG5Spr05 | Elkh1 |
| 152-25 | Combined | 15.99 | 15.99 | 27.5 | 105.9 | 0.3030 | RG5 | Elkh1 | 15.99 | 11.0 | 127.1 | 0.3640 | RG5Spr05 | Elkh1 |
| 152-34 | Combined | 6.14 | 6.14 | 28.7 | 110.0 | 0.3030 | RG5 | Elkh1 | 6.14 | 11.5 | 132.0 | 0.3640 | RG5Spr05 | Elkh1 |
| 152-39 | Combined | 28.05 | 28.05 | 33.6 | 702.5 | 0.1920 | RG5 | Elkh1 | 28.05 | 33.6 | 843.0 | 0.1920 | RG5Spr05 | Elkh1 |
| 152-41 | Combined | 24.43 | 24.43 | 29.0 | 432.8 | 0.1920 | RG5 | Elkh1 | 24.43 | 11.6 | 519.4 | 0.2300 | RG5Spr05 | Elkh1 |
| 152-5 | Combined | 12.47 | 12.47 | 27.5 | 121.0 | 0.3030 | RG5 | Elkh1 | 12.47 | 11.0 | 145.2 | 0.3640 | RG5Spr05 | Elkh1 |
| 153-14 | Combined | 3.12 | 3.12 | 27.5 | 60.5 | 0.3030 | RG3 | Elkh1 | 3.12 | 11.0 | 72.6 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-17 | Combined | 21.35 | 21.35 | 27.5 | 160.2 | 0.3030 | RG3 | Elkh1 | 21.35 | 11.0 | 192.3 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-2 | Combined | 3.31 | 3.31 | 27.5 | 59.9 | 0.3030 | RG3 | Elkh1 | 3.31 | 11.0 | 71.9 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-23 | Combined | 7.99 | 7.99 | 27.5 | 98.7 | 0.3030 | RG3 | Elkh1 | 7.99 | 11.0 | 118.4 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-26 | Combined | 4.09 | 4.09 | 27.5 | 75.5 | 0.3030 | RG3 | Elkh1 | 4.09 | 11.0 | 90.6 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-3 | Combined | 7.53 | 7.53 | 27.5 | 90.9 | 0.3030 | RG3 | Elkh1 | 7.53 | 11.0 | 109.0 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-31 | Combined | 19.35 | 19.35 | 50.3 | 157.1 | 0.3030 | RG3 | Elkh1 | 19.35 | 20.1 | 188.6 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-33 | Combined | 9.99 | 9.99 | 27.5 | 109.5 | 0.3030 | RG3 | Elkh1 | 9.99 | 11.0 | 131.4 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-35 | Combined | 4.51 | 4.51 | 27.5 | 74.0 | 0.3030 | RG3 | Elkh1 | 4.51 | 11.0 | 88.8 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-37 | Combined | 9.85 | 9.85 | 27.5 | 109.0 | 0.3030 | RG3 | Elkh1 | 9.85 | 11.0 | 130.8 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-43 | Combined | 6.16 | 6.16 | 27.5 | 82.0 | 0.3030 | RG3 | Elkh1 | 6.16 | 11.0 | 98.4 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-46 | Combined | 4.11 | 4.11 | 27.5 | 72.0 | 0.3030 | RG3 | Elkh1 | 4.11 | 11.0 | 86.4 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-48 | Combined | 1.07 | 1.07 | 27.5 | 35.4 | 0.3030 | RG3 | Elkh1 | 1.07 | 11.0 | 42.4 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-49 | Combined | 1.97 | 1.97 | 27.5 | 48.7 | 0.3030 | RG3 | Elkh1 | 1.97 | 11.0 | 58.4 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-56 | Combined | 8.07 | 8.07 | 27.5 | 95.4 | 0.3030 | RG3 | Elkh1 | 8.07 | 11.0 | 114.4 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-62 | Combined | 14.55 | 14.55 | 64.1 | 131.5 | 0.3030 | RG3 | Elkh1 | 14.55 | 25.7 | 157.7 | 0.3640 | RG3Spr05 | Elkh1 |
| 153-73 | Combined | 12.84 | 12.84 | 43.6 | 124.6 | 1.5870 | RG3 | Elkh1 | 12.84 | 17.4 | 149.5 | 1.5900 | RG3Spr05 | Elkh1 |
| 153-8 | Combined | 21.66 | 21.66 | 27.6 | 159.3 | 0.3030 | RG5 | Elkh1 | 21.66 | 11.0 | 191.2 | 0.3640 | RG5Spr05 | Elkh1 |
| 167-21 | Combined | 15.30 | 15.30 | 27.5 | 137.3 | 0.3030 | RG3 | Elkh1 | 15.30 | 5.5 | 164.7 | 0.3030 | RG3Spr05 | Elkh1 |
| 167-3 | Combined | 5.21 | 5.21 | 27.5 | 78.5 | 0.3030 | RG3 | Elkh1 | 5.21 | 5.5 | 94.2 | 0.3030 | RG3Spr05 | Elkh1 |
| 167-4 | Combined | 9.93 | 9.93 | 27.5 | 116.9 | 0.3030 | RG3 | Elkh1 | 9.93 | 5.5 | 140.3 | 0.3030 | RG3Spr05 | Elkh1 |
| 167-61 | Combined | 34.16 | 34.16 | 62.7 | 197.0 | 0.3030 | RG3 | Elkh1 | 34.16 | 25.1 | 236.4 | 0.3030 | RG3Spr05 | Elkh1 |
| 167-75 | Combined | 9.24 | 9.24 | 27.5 | 111.7 | 0.3030 | RG3 | Elkh1 | 9.24 | 5.5 | 134.0 | 0.3030 | RG3Spr05 | Elkh1 |
| 167-8 | Combined | 21.59 | 21.59 | 27.5 | 231.6 | 0.3030 | RG3 | Elkh1 | 21.59 | 5.5 | 277.9 | 0.3030 | RG3Spr05 | Elkh1 |
| 167-98 | Combined | 18.37 | 18.37 | 43.6 | 150.2 | 0.3030 | RG3 | Elkh1 | 18.37 | 8.7 | 180.2 | 0.3030 | RG3Spr05 | Elkh1 |
| 168-17 | Combined | 11.89 | 11.89 | 27.5 | 117.2 | 0.3030 | RG5 | Elkh1 | 11.89 | 5.5 | 140.6 | 0.3030 | RG5Spr05 | Elkh1 |
| 168-26 | Combined | 12.49 | 12.49 | 27.5 | 119.5 | 0.3030 | RG5 | Elkh1 | 12.49 | 5.5 | 143.4 | 0.3030 | RG5Spr05 | Elkh1 |
| 168-27 | Combined | 12.97 | 12.97 | 27.5 | 126.1 | 0.3030 | RG5 | Elkh1 | 12.97 | 5.5 | 151.3 | 0.3030 | RG5Spr05 | Elkh1 |
| 168-35 | Combined | 17.87 | 17.87 | 33.9 | 220.3 | 0.3030 | RG5 | Elkh1 | 17.87 | 6.8 | 264.3 | 0.3030 | RG5Spr05 | Elkh1 |
| 168-38 | Combined | 18.63 | 18.63 | 27.5 | 159.6 | 0.3030 | RG5 | Elkh1 | 18.63 | 5.5 | 191.6 | 0.3030 | RG5Spr05 | Elkh1 |
| 168-43 | Combined | 10.10 | 10.10 | 27.5 | 109.4 | 0.3030 | RG3 | Elkh1 | 10.10 | 5.5 | 131.3 | 0.3030 | RG3Spr05 | Elkh1 |
| 168-51 | Combined | 10.14 | 10.14 | 27.5 | 108.4 | 0.3030 | RG3 | Elkh1 | 10.14 | 5.5 | 130.0 | 0.3030 | RG3Spr05 | Elkh1 |
| 168-56 | Combined | 9.27 | 9.27 | 27.5 | 107.8 | 0.3030 | RG3 | Elkh1 | 9.27 | 5.5 | 129.3 | 0.3030 | RG3Spr05 | Elkh1 |
| 168-7 | Combined | 23.43 | 23.43 | 33.3 | 149.3 | 0.3030 | RG5 | Elkh1 | 23.43 | 6.7 | 179.1 | 0.3030 | RG5Spr05 | Elkh1 |
| 169-30 | Combined | 49.84 | 49.84 | 31.7 | 134.2 | 1.5680 | RG5 | Elkh1 | 49.84 | 11.1 | 161.1 | 1.5700 | RG5Spr05 | Elkh1 |
| 170-24 | Combined | 26.78 | 26.78 | 27.5 | 178.2 | 0.2030 | RG5 | Elkh1 | 26.78 | 9.6 | 213.8 | 0.2030 | RG5Spr05 | Elkh1 |
| 170-27 | Combined | 48.42 | 48.42 | 27.5 | 246.6 | 0.2030 | RG5 | Elkh1 | 48.42 | 9.6 | 296.0 | 0.2030 | RG5Spr05 | Elkh1 |
| 170-29 | Combined | 12.76 | 12.76 | 27.5 | 26.8 | 0.0100 | RG5 | Elkh1 | 12.76 | 9.6 | 32.1 | 0.0100 | RG5Spr05 | Elkh1 |
| 171-1 | Combined | 22.66 | 22.66 | 65.0 | 80.7 | 0.3370 | RG5 | Elkh1 | 22.66 | 26.0 | 96.8 | 0.3370 | RG5Spr05 | Elkh1 |
| 171-4 | Combined | 54.32 | 54.32 | 64.4 | 171.0 | 0.8700 | RG5 | Elkh1 | 54.32 | 25.8 | 205.3 | 0.8700 | RG5Spr05 | Elkh1 |
| 186-14 | Combined | 127.48 | 127.48 | 41.0 | 224.1 | 0.0400 | RG3 | Elkh1 | 127.48 | 8.2 | 268.9 | 0.0400 | RG3Spr05 | Elkh1 |
| 186-3 | Combined | 30.23 | 30.23 | 28.5 | 385.7 | 0.1340 | RG3 | Elkh1 | 30.23 | 5.7 | 462.8 | 0.1340 | RG3Spr05 | Elkh1 |
| 73-41 | Combined | 77.73 | 77.73 | 29.5 | 445.8 | 0.6150 | RG4 | Elkh1 | 77.73 | 8.0 | 534.9 | 0.6150 | RG4Spr05 | Elkh1 |
| 86-11 | Combined | 72.83 | 72.83 | 65.4 | 194.3 | 0.7880 | RG2 | Elkh1 | 72.83 | 24.2 | 233.1 | 0.7880 | RG2Spr05 | Elkh1 |
| 86-18 | Combined | 4.29 | 4.29 | 63.3 | 78.0 | 0.7880 | RG2 | Elkh1 | 4.29 | 23.4 | 93.6 | 0.7880 | RG2Spr05 | Elkh1 |
| 86-28 | Combined | 15.06 | 15.06 | 55.2 | 127.4 | 0.7880 | RG2 | Elkh1 | 15.06 | 20.4 | 152.8 | 0.7880 | RG2Spr05 | Elkh1 |
| 86-32 | Combined | 45.97 | 45.97 | 43.0 | 129.4 | 0.7880 | RG2 | Elkh1 | 45.97 | 15.9 | 155.2 | 0.7880 | RG2Spr05 | Elkh1 |
| 86-5 | Combined | 58.07 | 58.07 | 55.1 | 263.5 | 0.7880 | RG2 | Elkh1 | 58.07 | 20.4 | 316.2 | 0.7880 | RG2Spr05 | Elkh1 |
| 87-26 | Combined | 17.56 | 17.56 | 33.5 | 134.8 | 0.7990 | RG2 | Elkh1 | 17.56 | 12.4 | 161.7 | 0.7990 | RG2Spr05 | Elkh1 |
| 87-29 | Combined | 10.25 | 10.25 | 39.5 | 106.5 | 0.7990 | RG2 | Elkh1 | 10.25 | 14.6 | 127.7 | 0.7990 | RG2Spr05 | Elkh1 |
| 87-52 | Combined | 41.19 | 41.19 | 29.3 | 150.0 | 1.0400 | RG2 | Elkh1 | 41.19 | 7.9 | 180.0 | 1.0400 | RG2Spr05 | Elkh1 |
| 87-9 | Combined | 17.01 | 17.01 | 30.0 | 145.9 | 0.7990 | RG2 | Elkh1 | 17.01 | 11.1 | 175.1 | 0.7990 | RG2Spr05 | Elkh1 |

| | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 88-21 | Combined | 42.29 | 42.29 | 34.1 | 102.2 | 0.6150 | RG2 | Elkh1 | 42.29 | 9.2 | 122.6 | 0.6150 | RG2Spr05 | Elkh1 |
| 88-42 | Combined | 10.83 | 10.83 | 32.0 | 121.2 | 0.6150 | RG4 | Elkh1 | 10.83 | 8.6 | 145.5 | 0.6150 | RG4Spr05 | Elkh1 |
| 88-48 | Combined | 12.16 | 12.16 | 30.5 | 124.0 | 0.6150 | RG4 | Elkh1 | 12.16 | 8.2 | 148.8 | 0.6150 | RG4Spr05 | Elkh1 |
| 88-52 | Combined | 10.87 | 10.87 | 28.7 | 119.1 | 0.6150 | RG4 | Elkh1 | 10.87 | 7.7 | 142.9 | 0.6150 | RG4Spr05 | Elkh1 |

## Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued)

| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 88-55 | Combined | 23.24 | 23.24 | 46.4 | 133.3 | 0.6150 | RG4 | Elkh1 | 23.24 | 12.5 | 159.9 | 0.6150 | RG4Spr05 | Elkh1 |
| 88-64 | Combined | 5.30 | 5.30 | 28.4 | 75.2 | 0.6150 | RG4 | Elkh1 | 5.30 | 5.7 | 90.2 | 0.6150 | RG4Spr05 | Elkh1 |
| 88-69 | Combined | 62.47 | 62.47 | 33.3 | 279.7 | 0.5560 | RG4 | Elkh1 | 62.47 | 9.0 | 335.7 | 0.5560 | RG4Spr05 | Elkh1 |
| 88-85 | Combined | 7.32 | 7.32 | 29.9 | 89.1 | 0.6150 | RG4 | Elkh1 | 7.32 | 8.1 | 106.9 | 0.6150 | RG4Spr05 | Elkh1 |
| 89-12 | Combined | 3.53 | 3.53 | 30.8 | 53.2 | 0.5560 | RG4 | Elkh1 | 3.53 | 6.2 | 63.9 | 0.5560 | RG4Spr05 | Elkh1 |
| 89-16 | Combined | 13.43 | 13.43 | 27.5 | 193.2 | 0.2000 | RG4 | Elkh1 | 13.43 | 2.8 | 231.9 | 0.2000 | RG4Spr05 | Elkh1 |
| 89-17 | Combined | 11.53 | 11.53 | 27.5 | 125.2 | 0.2000 | RG4 | Elkh1 | 11.53 | 2.8 | 150.2 | 0.2000 | RG4Spr05 | Elkh1 |
| 89-26 | Combined | 11.77 | 11.77 | 28.5 | 156.1 | 0.5560 | RG4 | Elkh1 | 11.77 | 5.7 | 187.3 | 0.5560 | RG4Spr05 | Elkh1 |
| 89-29 | Combined | 8.44 | 8.44 | 27.5 | 108.4 | 0.2000 | RG4 | Elkh1 | 8.44 | 5.5 | 130.1 | 0.2000 | RG4Spr05 | Elkh1 |
| 89-31 | Combined | 4.59 | 4.59 | 30.7 | 112.6 | 0.5560 | RG4 | Elkh1 | 4.59 | 6.1 | 135.1 | 0.5560 | RG4Spr05 | Elkh1 |
| 89-33 | Combined | 35.27 | 35.27 | 51.2 | 200.4 | 0.5560 | RG4 | Elkh1 | 35.27 | 7.7 | 240.5 | 0.5560 | RG4Spr05 | Elkh1 |
| 89-37 | Combined | 12.91 | 12.91 | 27.5 | 116.8 | 0.2000 | RG4 | Elkh1 | 12.91 | 4.1 | 140.2 | 0.2000 | RG4Spr05 | Elkh1 |
| 90-13 | Combined | 10.90 | 10.90 | 27.5 | 118.9 | 0.6600 | RG4 | Elkh1 | 10.90 | 4.1 | 142.7 | 0.6600 | RG4Spr05 | Elkh1 |
| 90-15 | Combined | 9.35 | 9.35 | 27.5 | 105.0 | 0.6600 | RG4 | Elkh1 | 9.35 | 4.1 | 126.0 | 0.6600 | RG4Spr05 | Elkh1 |
| 90-19 | Combined | 38.33 | 38.33 | 27.5 | 80.5 | 0.0100 | RG4 | Elkh1 | 38.33 | 4.1 | 96.6 | 0.0100 | RG4Spr05 | Elkh1 |
| 90-3 | Combined | 6.67 | 6.67 | 32.2 | 81.0 | 0.6600 | RG4 | Elkh1 | 6.67 | 3.2 | 97.2 | 0.6600 | RG4Spr05 | Elkh1 |
| 90-43 | Combined | 40.62 | 40.62 | 38.8 | 150.0 | 0.2000 | RG4 | Elkh1 | 40.62 | 3.9 | 180.0 | 0.2000 | RG4Spr05 | Elkh1 |
| 90-6 | Combined | 3.92 | 3.92 | 27.5 | 67.7 | 0.6600 | RG4 | Elkh1 | 3.92 | 2.8 | 81.3 | 0.6600 | RG4Spr05 | Elkh1 |
| 90-8 | Combined | 32.59 | 32.59 | 27.5 | 168.5 | 0.6600 | RG4 | Elkh1 | 32.59 | 2.8 | 202.2 | 0.6600 | RG4Spr05 | Elkh1 |
| DUMMY3 | Combined | 6.31 | 6.31 | 27.5 | 144.0 | 0.5200 | RG4 | Elkh1 | 6.31 | 5.5 | 216.1 | 0.5200 | RG4Spr05 | Elkh1 |
| DUMMY6 | Combined | 5.73 | 5.73 | 27.5 | 90.4 | 3.9560 | RG2 | Elkh1 | 5.73 | 5.5 | 108.5 | 3.9600 | RG2Spr05 | Elkh1 |
| NEWMH3 | Combined | 13.94 | 13.94 | 60.7 | 138.3 | 0.4000 | RG3 | Elkh1 | 13.94 | 24.3 | 165.9 | 0.4000 | RG3Spr05 | Elkh1 |
| 100-2 | Local Separations in Combined Area | 32.03 | 0.96 | 0.0 | 45.8 | 0.0030 | RG1 | Elkh1-S | 0.16 | 0.0 | 14.0 | 0.0500 | RG1Spr05 | Elkh1-S |
| 100-4 | Local Separations in Combined Area | 1.61 | 0.05 | 0.0 | 10.3 | 0.0030 | RG1 | Elkh1-S | 0.01 | 0.0 | 0.7 | 0.0500 | RG1Spr05 | Elkh1-S |
| 101-13 | Local Separations in Combined Area | 10.79 | 0.32 | 0.0 | 26.6 | 0.0030 | RG1 | Elkh1-S | 0.05 | 0.0 | 4.7 | 0.0500 | RG1Spr05 | Elkh1-S |
| 101-14 | Local Separations in Combined Area | 16.80 | 0.50 | 0.0 | 33.2 | 0.0030 | RG1 | Elkh1-S | 0.08 | 0.0 | 7.3 | 0.0500 | RG1Spr05 | Elkh1-S |
| 101-15 | Local Separations in Combined Area | 15.74 | 0.47 | 0.0 | 32.1 | 0.0030 | RG1 | Elkh1-S | 0.08 | 0.0 | 6.9 | 0.0500 | RG1Spr05 | Elkh1-S |
| 101-17 | Local Separations in Combined Area | 22.62 | 0.68 | 0.0 | 38.5 | 0.0030 | RG1 | Elkh1-S | 0.11 | 0.0 | 9.9 | 0.0500 | RG1Spr05 | Elkh1-S |
| 101-3 | Local Separations in Combined Area | 3.44 | 0.10 | 0.0 | 15.0 | 0.0030 | RG1 | Elkh1-S | 0.02 | 0.0 | 1.5 | 0.0500 | RG1Spr05 | Elkh1-S |
| 101-31 | Local Separations in Combined Area | 3.67 | 0.11 | 0.0 | 15.5 | 0.0030 | RG1 | Elkh1-S | 0.02 | 0.0 | 1.6 | 0.0500 | RG1Spr05 | Elkh1-S |
| 102-14 | Local Separations in Combined Area | 4.84 | 0.15 | 0.0 | 17.8 | 0.0030 | RG4 | Elkh1-S | 0.02 | 0.0 | 2.1 | 0.0500 | RG4Spr05 | Elkh1-S |
| 102-16 | Local Separations in Combined Area | 6.22 | 0.19 | 0.0 | 20.2 | 0.0030 | RG1 | Elkh1-S | 0.03 | 0.0 | 2.7 | 0.0500 | RG1Spr05 | Elkh1-S |
| 102-50 | Local Separations in Combined Area | 12.05 | 0.36 | 0.0 | 28.1 | 0.0030 | RG1 | Elkh1-S | 0.06 | 0.0 | 5.2 | 0.0500 | RG1Spr05 | Elkh1-S |
| 103-29 | Local Separations in Combined Area | 1.20 | 0.04 | 0.0 | 8.9 | 0.0030 | RG4 | Elkh1-S | 0.01 | 0.0 | 0.5 | 0.0500 | RG4Spr05 | Elkh1-S |
| 103-34 | Local Separations in Combined Area | 2.03 | 0.06 | 0.0 | 11.5 | 0.0030 | RG4 | Elkh1-S | 0.01 | 0.0 | 0.9 | 0.0500 | RG4Spr05 | Elkh1-S |
| 104-3 | Local Separations in Combined Area | 9.17 | 0.28 | 0.0 | 24.5 | 0.0030 | RG4 | Elkh1-S | 0.05 | 0.0 | 4.0 | 0.0500 | RG4Spr05 | Elkh1-S |
| 105-24 | Local Separations in Combined Area | 4.36 | 0.13 | 0.0 | 16.9 | 0.0030 | RG4 | Elkh1-S | 0.02 | 0.0 | 1.9 | 0.0500 | RG4Spr05 | Elkh1-S |
| 105-46 | Local Separations in Combined Area | 1.73 | 0.05 | 0.0 | 10.7 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 0.8 | 0.0500 | RG2Spr05 | Elkh1-S |
| 105-57 | Local Separations in Combined Area | 0.83 | 0.02 | 0.0 | 7.4 | 0.0030 | RG4 | Elkh1-S | 0.00 | 0.0 | 0.4 | 0.0500 | RG4Spr05 | Elkh1-S |
| 105-9 | Local Separations in Combined Area | 6.16 | 0.18 | 0.0 | 20.1 | 0.0030 | RG2 | Elkh1-S | 0.03 | 0.0 | 2.7 | 0.0500 | RG2Spr05 | Elkh1-S |
| 106-1 | Local Separations in Combined Area | 9.69 | 0.29 | 0.0 | 25.2 | 0.0030 | RG2 | Elkh1-S | 0.05 | 0.0 | 4.2 | 0.0500 | RG2Spr05 | Elkh1-S |

| Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 106-27 | Local Separations in Combined Area | 3.28 | 0.10 | 0.0 | 14.7 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.4 | 0.0500 | RG2Spr05 | Elkh1-S |
| 106-55 | Local Separations in Combined Area | 3.32 | 0.10 | 0.0 | 14.7 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.4 | 0.0500 | RG2Spr05 | Elkh1-S |
| 106-86 | Local Separations in Combined Area | 7.48 | 0.22 | 0.0 | 22.1 | 0.0030 | RG2 | Elkh1-S | 0.22 | 0.0 | 19.5 | 0.0500 | RG4Spr05 | Elkh1-S |
| 107-11 | Local Separations in Combined Area | 11.21 | 0.34 | 0.0 | 27.1 | 0.0030 | RG2 | Elkh1-S | 0.11 | 0.0 | 9.8 | 0.0500 | RG2Spr05 | Elkh1-S |
| 108-15 | Local Separations in Combined Area | 153.28 | 4.60 | 0.0 | 100.2 | 0.0030 | RG2 | Elkh1-S | 1.53 | 0.0 | 133.5 | 0.0500 | RG2Spr05 | Elkh1-S |
| 108-6 | Local Separations in Combined Area | 1.68 | 0.05 | 0.0 | 10.5 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 0.7 | 0.0500 | RG2Spr05 | Elkh1-S |
| 116-19 | Local Separations in Combined Area | 26.91 | 0.81 | 0.0 | 42.0 | 0.0030 | RG2 | Elkh1-S | 0.13 | 0.0 | 11.7 | 0.0500 | RG2Spr05 | Elkh1-S |
| 116-25 | Local Separations in Combined Area | 12.40 | 0.37 | 0.0 | 28.5 | 0.0030 | RG2 | Elkh1-S | 0.06 | 0.0 | 5.4 | 0.0500 | RG2Spr05 | Elkh1-S |
| 116-27 | Local Separations in Combined Area | 12.29 | 0.37 | 0.0 | 28.4 | 0.0030 | RG2 | Elkh1-S | 0.06 | 0.0 | 5.4 | 0.0500 | RG2Spr05 | Elkh1-S |
| 117-31 | Local Separations in Combined Area | 5.40 | 0.16 | 0.0 | 18.8 | 0.0030 | RG2 | Elkh1-S | 0.03 | 0.0 | 2.4 | 0.0500 | RG2Spr05 | Elkh1-S |
| 118-78 | Local Separations in Combined Area | 5.94 | 0.18 | 0.0 | 19.7 | 0.0030 | RG2 | Elkh1-S | 0.03 | 0.0 | 2.6 | 0.0500 | RG2Spr05 | Elkh1-S |
| 119-134 | Local Separations in Combined Area | 1.73 | 0.05 | 0.0 | 10.6 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.5 | 0.1000 | RG2Spr05 | Elkh1-S |
| 119-20 | Local Separations in Combined Area | 2.64 | 0.08 | 0.0 | 13.1 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 1.1 | 0.0500 | RG2Spr05 | Elkh1-S |
| 119-22 | Local Separations in Combined Area | 2.56 | 0.08 | 0.0 | 13.0 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 1.1 | 0.0500 | RG2Spr05 | Elkh1-S |
| 119-25 | Local Separations in Combined Area | 0.50 | 0.01 | 0.0 | 5.7 | 0.0030 | RG2 | Elkh1-S | 0.00 | 0.0 | 0.2 | 0.0500 | RG2Spr05 | Elkh1-S |
| 119-41 | Local Separations in Combined Area | 1.39 | 0.04 | 0.0 | 9.5 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 0.6 | 0.0500 | RG2Spr05 | Elkh1-S |
| 120-103 | Local Separations in Combined Area | 3.35 | 0.10 | 0.0 | 14.8 | 0.0030 | RG4 | Elkh1-S | 0.02 | 0.0 | 1.5 | 0.0500 | RG4Spr05 | Elkh1-S |
| 120-24 | Local Separations in Combined Area | 2.41 | 0.07 | 0.0 | 12.6 | 0.0030 | RG4 | Elkh1-S | 0.01 | 0.0 | 1.1 | 0.0500 | RG4Spr05 | Elkh1-S |
| 120-60 | Local Separations in Combined Area | 1.10 | 0.03 | 0.0 | 8.5 | 0.0030 | RG4 | Elkh1-S | 0.01 | 0.0 | 0.5 | 0.0500 | RG4Spr05 | Elkh1-S |
| 121-15 | Local Separations in Combined Area | 17.85 | 0.54 | 0.0 | 34.2 | 0.0030 | RG4 | Elkh1-S | 0.09 | 0.0 | 7.8 | 0.0500 | RG4Spr05 | Elkh1-S |
| 122-26 | Local Separations in Combined Area | 4.38 | 0.13 | 0.0 | 16.9 | 0.0030 | RG4 | Elkh1-S | 0.02 | 0.0 | 1.9 | 0.0500 | RG4Spr05 | Elkh1-S |
| 122-38 | Local Separations in Combined Area | 9.34 | 0.28 | 0.0 | 24.7 | 0.0030 | RG4 | Elkh1-S | 0.05 | 0.0 | 4.1 | 0.0500 | RG4Spr05 | Elkh1-S |
| 122-49 | Local Separations in Combined Area | 8.49 | 0.25 | 0.0 | 23.6 | 0.0030 | RG4 | Elkh1-S | 0.04 | 0.0 | 3.7 | 0.0500 | RG4Spr05 | Elkh1-S |
| 122-7 | Local Separations in Combined Area | 64.36 | 1.93 | 0.0 | 64.9 | 0.0030 | RG4 | Elkh1-S | 1.93 | 0.0 | 168.2 | 0.0500 | RG4Spr05 | Elkh1-S |
| 123-13 | Local Separations in Combined Area | 45.11 | 1.35 | 0.0 | 54.3 | 0.0030 | RG1 | Elkh1-S | 0.23 | 0.0 | 19.6 | 0.0500 | RG1Spr05 | Elkh1-S |
| 123-3 | Local Separations in Combined Area | 14.43 | 0.43 | 0.0 | 30.7 | 0.0030 | RG1 | Elkh1-S | 0.07 | 0.0 | 6.3 | 0.0500 | RG1Spr05 | Elkh1-S |
| 136-107 | Local Separations in Combined Area | 6.43 | 0.19 | 0.0 | 20.5 | 0.0030 | RG4 | Elkh1-S | 0.03 | 0.0 | 2.8 | 0.0500 | RG4Spr05 | Elkh1-S |
| 136-67 | Local Separations in Combined Area | 14.63 | 0.44 | 0.0 | 31.0 | 0.0030 | RG4 | Elkh1-S | 0.07 | 0.0 | 6.4 | 0.0500 | RG4Spr05 | Elkh1-S |
| 136-75 | Local Separations in Combined Area | 2.17 | 0.06 | 0.0 | 11.9 | 0.0030 | RG4 | Elkh1-S | 0.01 | 0.0 | 0.9 | 0.0500 | RG4Spr05 | Elkh1-S |

## Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued)

| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 136-98 | Local Separations in Combined Area | 1.50 | 0.05 | 0.0 | 9.9 | 0.0030 | RG4 | Elkh1-S | 0.01 | 0.0 | 0.7 | 0.0500 | RG4Spr05 | Elkh1-S |
| 137-74 | Local Separations in Combined Area | 13.08 | 0.39 | 0.0 | 29.3 | 0.0030 | RG5 | Elkh1-S | 0.65 | 0.0 | 57.0 | 0.0500 | RG5Spr05 | Elkh1-S |
| 137-75 | Local Separations in Combined Area | 6.56 | 0.20 | 0.0 | 20.7 | 0.0030 | RG5 | Elkh1-S | 0.33 | 0.0 | 28.6 | 0.0500 | RG5Spr05 | Elkh1-S |
| 138-48 | Local Separations in Combined Area | 8.09 | 0.24 | 0.0 | 23.0 | 0.0030 | RG5 | Elkh1-S | 0.08 | 0.0 | 7.0 | 0.0500 | RG5Spr05 | Elkh1-S |
| 138-50 | Local Separations in Combined Area | 4.53 | 0.14 | 0.0 | 17.2 | 0.0030 | RG5 | Elkh1-S | 0.23 | 0.0 | 19.7 | 0.0500 | RG5Spr05 | Elkh1-S |
| 138-53 | Local Separations in Combined Area | 2.58 | 0.08 | 0.0 | 13.0 | 0.0030 | RG5 | Elkh1-S | 0.13 | 0.0 | 11.2 | 0.0500 | RG5Spr05 | Elkh1-S |
| 139-11 | Local Separations in Combined Area | 3.62 | 0.11 | 0.0 | 15.4 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.6 | 0.0500 | RG2Spr05 | Elkh1-S |
| 139-18 | Local Separations in Combined Area | 7.84 | 0.24 | 0.0 | 22.7 | 0.0030 | RG2 | Elkh1-S | 0.04 | 0.0 | 3.4 | 0.0500 | RG2Spr05 | Elkh1-S |
| 139-47 | Local Separations in Combined Area | 4.22 | 0.13 | 0.0 | 16.6 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.8 | 0.0500 | RG2Spr05 | Elkh1-S |
| 139-8 | Local Separations in Combined Area | 3.75 | 0.11 | 0.0 | 15.7 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.6 | 0.0500 | RG2Spr05 | Elkh1-S |
| 139-86 | Local Separations in Combined Area | 7.00 | 0.21 | 0.0 | 21.4 | 0.0030 | RG2 | Elkh1-S | 0.03 | 0.0 | 3.0 | 0.0500 | RG2Spr05 | Elkh1-S |
| 139-90 | Local Separations in Combined Area | 14.80 | 0.44 | 0.0 | 31.1 | 0.0030 | RG5 | Elkh1-S | 0.07 | 0.0 | 6.4 | 0.0500 | RG5Spr05 | Elkh1-S |
| 139-92 | Local Separations in Combined Area | 33.02 | 0.99 | 0.0 | 46.5 | 0.0030 | RG5 | Elkh1-S | 0.33 | 0.0 | 28.8 | 0.0500 | RG5Spr05 | Elkh1-S |
| 140-107 | Local Separations in Combined Area | 6.14 | 0.18 | 0.0 | 20.0 | 0.0030 | RG2 | Elkh1-S | 0.03 | 0.0 | 2.7 | 0.0500 | RG2Spr05 | Elkh1-S |
| 140-112 | Local Separations in Combined Area | 1.98 | 0.06 | 0.0 | 11.4 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 0.9 | 0.0500 | RG2Spr05 | Elkh1-S |
| 140-33 | Local Separations in Combined Area | 1.35 | 0.04 | 0.0 | 9.4 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 0.6 | 0.0500 | RG2Spr05 | Elkh1-S |
| 140-42 | Local Separations in Combined Area | 1.54 | 0.05 | 0.0 | 10.1 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.3 | 0.1000 | RG2Spr05 | Elkh1-S |
| 140-50 | Local Separations in Combined Area | 3.61 | 0.11 | 0.0 | 15.4 | 0.0030 | RG2 | Elkh1-S | 0.04 | 0.0 | 3.1 | 0.0500 | RG2Spr05 | Elkh1-S |
| 140-53 | Local Separations in Combined Area | 16.33 | 0.49 | 0.0 | 32.7 | 0.0030 | RG2 | Elkh1-S | 0.16 | 0.0 | 14.2 | 0.0500 | RG2Spr05 | Elkh1-S |
| 151-16 | Local Separations in Combined Area | 26.69 | 0.80 | 0.0 | 41.8 | 0.0030 | RG5 | Elkh1-S | 1.33 | 0.0 | 116.3 | 0.0500 | RG5Spr05 | Elkh1-S |
| 151-20 | Local Separations in Combined Area | 13.82 | 0.41 | 0.0 | 30.1 | 0.0030 | RG5 | Elkh1-S | 0.83 | 0.0 | 72.2 | 0.0500 | RG5Spr05 | Elkh1-S |
| 151-27 | Local Separations in Combined Area | 5.18 | 0.16 | 0.0 | 18.4 | 0.0030 | RG5 | Elkh1-S | 0.31 | 0.0 | 27.1 | 0.0500 | RG5Spr05 | Elkh1-S |
| 151-4 | Local Separations in Combined Area | 15.24 | 0.46 | 0.0 | 31.6 | 0.0030 | RG5 | Elkh1-S | 0.15 | 0.0 | 13.3 | 0.0500 | RG5Spr05 | Elkh1-S |
| 151-49 | Local Separations in Combined Area | 36.51 | 1.10 | 0.0 | 48.9 | 0.0030 | RG5 | Elkh1-S | 2.19 | 0.0 | 190.9 | 0.0500 | RG5Spr05 | Elkh1-S |
| 151-8 | Local Separations in Combined Area | 18.99 | 0.57 | 0.0 | 35.3 | 0.0030 | RG5 | Elkh1-S | 0.95 | 0.0 | 82.7 | 0.0500 | RG5Spr05 | Elkh1-S |
| 154-22 | Local Separations in Combined Area | 10.91 | 0.33 | 0.0 | 26.7 | 0.0030 | RG3 | Elkh1-S | 0.11 | 0.0 | 9.5 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-24 | Local Separations in Combined Area | 24.38 | 0.73 | 0.0 | 40.0 | 0.0030 | RG3 | Elkh1-S | 0.24 | 0.0 | 21.2 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-28 | Local Separations in Combined Area | 11.83 | 0.35 | 0.0 | 27.8 | 0.0030 | RG3 | Elkh1-S | 0.12 | 0.0 | 10.3 | 0.0500 | RG3Spr05 | Elkh1-S |

| Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 151-4 | Local Separations in Combined Area | 15.24 | 0.46 | 0.0 | 31.6 | 0.0030 | RG5 | Elkh1-S | 0.15 | 0.0 | 13.3 | 0.0500 | RG5Spr05 | Elkh1-S |
| 151-49 | Local Separations in Combined Area | 36.51 | 1.10 | 0.0 | 48.9 | 0.0030 | RG5 | Elkh1-S | 2.19 | 0.0 | 190.9 | 0.0500 | RG5Spr05 | Elkh1-S |
| 151-8 | Local Separations in Combined Area | 18.99 | 0.57 | 0.0 | 35.3 | 0.0030 | RG5 | Elkh1-S | 0.95 | 0.0 | 82.7 | 0.0500 | RG5Spr05 | Elkh1-S |
| 154-22 | Local Separations in Combined Area | 10.91 | 0.33 | 0.0 | 26.7 | 0.0030 | RG3 | Elkh1-S | 0.11 | 0.0 | 9.5 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-24 | Local Separations in Combined Area | 24.38 | 0.73 | 0.0 | 40.0 | 0.0030 | RG3 | Elkh1-S | 0.24 | 0.0 | 21.2 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-28 | Local Separations in Combined Area | 11.83 | 0.35 | 0.0 | 27.8 | 0.0030 | RG3 | Elkh1-S | 0.12 | 0.0 | 10.3 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-29 | Local Separations in Combined Area | 16.93 | 0.51 | 0.0 | 33.3 | 0.0030 | RG3 | Elkh1-S | 0.17 | 0.0 | 14.7 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-39 | Local Separations in Combined Area | 18.57 | 0.56 | 0.0 | 34.9 | 0.0030 | RG3 | Elkh1-S | 0.19 | 0.0 | 16.2 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-41 | Local Separations in Combined Area | 14.72 | 0.44 | 0.0 | 31.0 | 0.0030 | RG3 | Elkh1-S | 0.15 | 0.0 | 12.8 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-58 | Local Separations in Combined Area | 30.39 | 0.91 | 0.0 | 44.6 | 0.0030 | RG3 | Elkh1-S | 0.30 | 0.0 | 26.5 | 0.0500 | RG3Spr05 | Elkh1-S |
| 154-59 | Local Separations in Combined Area | 15.57 | 0.47 | 0.0 | 31.9 | 0.0030 | RG3 | Elkh1-S | 0.16 | 0.0 | 13.6 | 0.0500 | RG3Spr05 | Elkh1-S |
| 167-12 | Local Separations in Combined Area | 4.21 | 0.13 | 0.0 | 16.6 | 0.0030 | RG3 | Elkh1-S | 0.02 | 0.0 | 1.8 | 0.0500 | RG3Spr05 | Elkh1-S |
| 167-33 | Local Separations in Combined Area | 86.30 | 2.59 | 0.0 | 75.2 | 0.0030 | RG5 | Elkh1-S | 0.43 | 0.0 | 37.6 | 0.0500 | RG5Spr05 | Elkh1-S |
| 167-64 | Local Separations in Combined Area | 19.68 | 0.59 | 0.0 | 35.9 | 0.0030 | RG3 | Elkh1-S | 0.20 | 0.0 | 17.1 | 0.0500 | RG3Spr05 | Elkh1-S |
| 167-73 | Local Separations in Combined Area | 102.34 | 3.07 | 0.0 | 81.9 | 0.0030 | RG3 | Elkh1-S | 1.02 | 0.0 | 89.2 | 0.0500 | RG3Spr05 | Elkh1-S |
| 169-32 | Local Separations in Combined Area | 49.15 | 1.47 | 0.0 | 56.7 | 0.0030 | RG5 | Elkh1-S | 0.49 | 0.0 | 42.8 | 0.0500 | RG5Spr05 | Elkh1-S |
| 169-4 | Local Separations in Combined Area | 73.40 | 2.20 | 0.0 | 69.3 | 0.0030 | RG5 | Elkh1-S | 0.73 | 0.0 | 63.9 | 0.0500 | RG5Spr05 | Elkh1-S |
| 170-1 | Local Separations in Combined Area | 103.35 | 3.10 | 0.0 | 82.3 | 0.0030 | RG5 | Elkh1-S | 1.03 | 0.0 | 90.0 | 0.0500 | RG5Spr05 | Elkh1-S |
| 170-11 | Local Separations in Combined Area | 92.52 | 2.78 | 0.0 | 77.8 | 0.0030 | RG5 | Elkh1-S | 0.93 | 0.0 | 80.6 | 0.0500 | RG5Spr05 | Elkh1-S |
| 170-22 | Local Separations in Combined Area | 70.05 | 2.10 | 0.0 | 67.7 | 0.0030 | RG5 | Elkh1-S | 0.70 | 0.0 | 61.0 | 0.0500 | RG5Spr05 | Elkh1-S |
| 171-11 | Local Separations in Combined Area | 127.19 | 3.82 | 0.0 | 91.3 | 0.0030 | RG5 | Elkh1-S | 1.27 | 0.0 | 110.8 | 0.0500 | RG5Spr05 | Elkh1-S |
| 184-1 | Local Separations in Combined Area | 94.36 | 2.83 | 0.0 | 78.6 | 0.0030 | RG5 | Elkh1-S | 0.94 | 0.0 | 82.2 | 0.0500 | RG5Spr05 | Elkh1-S |
| 186-22 | Local Separations in Combined Area | 32.99 | 0.99 | 0.0 | 46.5 | 0.0030 | RG5 | Elkh1-S | 0.16 | 0.0 | 14.4 | 0.0500 | RG5Spr05 | Elkh1-S |
| 73-7 | Local Separations in Combined Area | 132.37 | 3.97 | 0.0 | 93.1 | 0.0030 | RG2 | Elkh1-S | 0.66 | 0.0 | 57.7 | 0.0500 | RG2Spr05 | Elkh1-S |
| 83-14 | Local Separations in Combined Area | 89.14 | 2.67 | 0.0 | 76.4 | 0.0030 | RG2 | Elkh1-S | 0.89 | 0.0 | 77.7 | 0.0500 | RG2Spr05 | Elkh1-S |
| 83-7 | Local Separations in Combined Area | 42.80 | 1.28 | 0.0 | 52.9 | 0.0030 | RG2 | Elkh1-S | 0.43 | 0.0 | 37.3 | 0.0500 | RG2Spr05 | Elkh1-S |
| 84-12 | Local Separations in Combined Area | 78.65 | 2.36 | 0.0 | 71.8 | 0.0030 | RG2 | Elkh1-S | 0.79 | 0.0 | 68.5 | 0.0500 | RG2Spr05 | Elkh1-S |
| 84-15 | Local Separations in Combined Area | 54.29 | 1.63 | 0.0 | 59.6 | 0.0030 | RG2 | Elkh1-S | 0.54 | 0.0 | 47.3 | 0.0500 | RG2Spr05 | Elkh1-S |
| 84-4 | Local Separations in Combined Area | 51.96 | 1.56 | 0.0 | 58.3 | 0.0030 | RG2 | Elkh1-S | 0.52 | 0.0 | 45.3 | 0.0500 | RG2Spr05 | Elkh1-S |
| 86-15 | Local Separations in Combined Area | 7.74 | 0.23 | 0.0 | 22.5 | 0.0030 | RG2 | Elkh1-S | 0.08 | 0.0 | 6.7 | 0.0500 | RG2Spr05 | Elkh1-S |

| Hydrology Parameters Summary - "Combined" Subcatchments and "Local Separations in Combined Area" Subcatchments (continued) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Subcatchment ID | Subcatchment Type | Subcatchment Area (acs) | Initial Parameters | | | | | | Final Parameters | | | | | |
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 86-17 | Local Separations in Combined Area | 7.27 | 0.22 | 0.0 | 21.8 | 0.0030 | RG2 | Elkh1-S | 0.07 | 0.0 | 6.3 | 0.0500 | RG2Spr05 | Elkh1-S |
| 86-53 | Local Separations in Combined Area | 4.66 | 0.14 | 0.0 | 17.5 | 0.0030 | RG2 | Elkh1-S | 0.05 | 0.0 | 4.1 | 0.0500 | RG2Spr05 | Elkh1-S |
| 87-57 | Local Separations in Combined Area | 1.70 | 0.05 | 0.0 | 10.5 | 0.0030 | RG2 | Elkh1-S | 0.02 | 0.0 | 1.5 | 0.0500 | RG2Spr05 | Elkh1-S |
| 88-36 | Local Separations in Combined Area | 12.88 | 0.39 | 0.0 | 29.0 | 0.0030 | RG2 | Elkh1-S | 0.06 | 0.0 | 5.6 | 0.0500 | RG2Spr05 | Elkh1-S |
| 88-37 | Local Separations in Combined Area | 21.89 | 0.66 | 0.0 | 37.9 | 0.0030 | RG4 | Elkh1-S | 21.89 | 3.8 | 56.8 | 0.6000 | RG4Spr05 | Elkh1 |
| 88-74 | Local Separations in Combined Area | 5.79 | 0.17 | 0.0 | 19.5 | 0.0030 | RG4 | Elkh1-S | 0.03 | 0.0 | 2.5 | 0.0500 | RG4Spr05 | Elkh1-S |
| 89-47 | Local Separations in Combined Area | 40.55 | 1.22 | 0.0 | 51.5 | 0.0030 | RG4 | Elkh1-S | 0.20 | 0.0 | 17.7 | 0.0500 | RG4Spr05 | Elkh1-S |
| 90-41 | Local Separations in Combined Area | 3.35 | 0.10 | 0.0 | 14.8 | 0.0030 | RG4 | Elkh1-S | 0.02 | 0.0 | 1.5 | 0.0500 | RG4Spr05 | Elkh1-S |
| DUMMY7 | Local Separations in Combined Area | 2.35 | 0.07 | 0.0 | 12.4 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 1.0 | 0.0500 | RG2Spr05 | Elkh1-S |
| DUMMY8 | Local Separations in Combined Area | 1.44 | 0.04 | 0.0 | 9.7 | 0.0030 | RG2 | Elkh1-S | 0.01 | 0.0 | 0.6 | 0.0500 | RG2Spr05 | Elkh1-S |
| DUMMY9 | Local Separations in Combined Area | 0.25 | 0.01 | 0.0 | 4.1 | 0.0030 | RG2 | Elkh1-S | 0.00 | 0.0 | 0.1 | 0.0500 | RG2Spr05 | Elkh1-S |

## Hydrology Parameters Summary - Outlying Separate Sanitary Subcatchments

| Subcatchment ID | Service Area Type | Subcatchment Area (acs) | Surface No.1 - Initial Parameters | | | | | | Surface No.1 - Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 108-5 | Outlying Separate Sanitary | 485.49 | 2.43 | 0.0 | 46.0 | 0.5000 | RG2 | SepFast1 | 0.97 | 0.0 | 845.9 | 0.0500 | RG2Spr05 | SepFast1 |
| 123-8 | Outlying Separate Sanitary | 1944.49 | 9.72 | 0.0 | 92.1 | 0.5000 | RG1 | SepFast1 | 9.72 | 0.0 | 8470.2 | 0.0500 | RG1Spr05 | SepFast1 |
| 140-52 | Outlying Separate Sanitary | 102.78 | 3.08 | 0.0 | 82.0 | 0.0030 | RG2 | Elkh1-S | 1.03 | 0.0 | 89.5 | 0.0500 | RG2Spr05 | Elkh1-S |
| 172-11 | Outlying Separate Sanitary | 600.05 | 3.00 | 0.0 | 51.2 | 0.5000 | RG5 | SepFast1 | 3.00 | 0.0 | 2613.8 | 0.0500 | RG5Spr05 | SepFast1 |
| 183-12 | Outlying Separate Sanitary | 522.07 | 2.61 | 0.0 | 47.7 | 0.5000 | RG5 | SepFast1 | 2.61 | 0.0 | 2274.2 | 0.0500 | RG5Spr05 | SepFast1 |
| 198-6 | Outlying Separate Sanitary | 178.38 | 5.35 | 0.0 | 108.1 | 0.0030 | RG3 | Elkh1-S | 0.89 | 0.0 | 77.7 | 0.0500 | RG3Spr05 | Elkh1-S |
| 69-53 | Outlying Separate Sanitary | 1641.57 | 8.21 | 0.0 | 84.6 | 0.5000 | RG1 | SepFast1 | 6.94 | 0.0 | 4290.4 | 0.0500 | RG1Spr05 | SepFast1 |
| 70-11 | Outlying Separate Sanitary | 483.19 | 2.42 | 0.0 | 45.9 | 0.5000 | RG4 | SepFast1 | 1.45 | 0.0 | 1262.9 | 0.0500 | RG4Spr05 | SepFast1 |
| 70-17 | Outlying Separate Sanitary | 85.46 | 2.56 | 0.0 | 74.8 | 0.0030 | RG4 | Elkh1-S | 1.63 | 0.0 | 129.9 | 0.0500 | RG4Spr05 | Elkh1-S |
| 86-60 | Outlying Separate Sanitary | 1813.58 | 9.07 | 0.0 | 89.0 | 0.5000 | RG4 | SepFast1 | 3.63 | 0.0 | 3160.0 | 0.0500 | RG2Spr05 | SepFast1 |

| Basin ID | Service Area Type | Actual Area (acs) | Surface No. 2 - Initial Parameters | | | | | | Surface No. 2 - Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 108-5 | Outlying Separate Sanitary | 485.49 | 4.85 | 0.0 | 20.6 | 0.0300 | RG2 | SepMed1 | 0.97 | 0.0 | 84.6 | 0.00030 | RG2Spr05 | SepMed1 |
| 123-8 | Outlying Separate Sanitary | 1944.49 | 19.44 | 0.0 | 41.2 | 0.0300 | RG1 | SepMed1 | 9.72 | 0.0 | 847.0 | 0.00030 | RG1Spr05 | SepMed1 |
| 140-52 | Outlying Separate Sanitary | 102.78 | 0.00 | 0.0 | 0.0 | 0.0000 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.00000 | 0 | 0 |
| 172-11 | Outlying Separate Sanitary | 600.05 | 6.00 | 0.0 | 22.9 | 0.0300 | RG5 | SepMed1 | 12.00 | 0.0 | 1045.5 | 0.00030 | RG5Spr05 | SepMed1 |
| 183-12 | Outlying Separate Sanitary | 522.07 | 5.22 | 0.0 | 21.3 | 0.0300 | RG5 | SepMed1 | 5.22 | 0.0 | 454.8 | 0.00030 | RG5Spr05 | SepMed1 |
| 198-6 | Outlying Separate Sanitary | 178.38 | 0.00 | 0.0 | 0.0 | 0.0000 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.00000 | 0 | 0 |
| 69-53 | Outlying Separate Sanitary | 1641.57 | 16.42 | 0.0 | 37.9 | 0.0300 | RG1 | SepMed1 | 8.21 | 0.0 | 715.1 | 0.00030 | RG1Spr05 | SepMed1 |
| 70-11 | Outlying Separate Sanitary | 483.19 | 4.83 | 0.0 | 20.5 | 0.0300 | RG4 | SepMed1 | 2.42 | 0.0 | 210.5 | 0.00030 | RG4Spr05 | SepMed1 |
| 70-17 | Outlying Separate Sanitary | 85.46 | 0.00 | 0.0 | 0.0 | 0.0000 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.00000 | 0 | 0 |
| 86-60 | Outlying Separate Sanitary | 1813.58 | 18.14 | 0.0 | 39.8 | 0.0300 | RG4 | SepMed1 | 3.63 | 0.0 | 316.0 | 0.00300 | RG2Spr05 | SepMed1 |

| Basin ID | Service Area Type | Actual Area (acs) | Surface No. 3 - Initial Parameters | | | | | | Surface No. 3 - Final Parameters | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference | Modeled Area (acs) | Percent Impervious (%) | Width (ft) | Slope (%) | Rain Gauge Reference | Infiltration Reference |
| 108-5 | Outlying Separate Sanitary | 485.49 | 33.98 | 0.0 | 38.5 | 0.0030 | RG2 | SepSlow1 | 0.97 | 0.0 | 42.3 | 0.00003 | RG2Spr05 | SepSlow1 |
| 123-8 | Outlying Separate Sanitary | 1944.49 | 136.11 | 0.0 | 77.1 | 0.0030 | RG1 | SepSlow1 | 9.72 | 0.0 | 423.5 | 0.00003 | RG1Spr05 | SepSlow1 |
| 140-52 | Outlying Separate Sanitary | 102.78 | 0.00 | 0.0 | 0.0 | 0.0000 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.00000 | 0 | 0 |
| 172-11 | Outlying Separate Sanitary | 600.05 | 42.00 | 0.0 | 42.8 | 0.0030 | RG5 | SepSlow1 | 42.00 | 0.0 | 1829.7 | 0.00003 | RG5Spr05 | SepSlow1 |
| 183-12 | Outlying Separate Sanitary | 522.07 | 36.55 | 0.0 | 39.9 | 0.0030 | RG5 | SepSlow1 | 26.10 | 0.0 | 1137.1 | 0.00003 | RG5Spr05 | SepSlow1 |
| 198-6 | Outlying Separate Sanitary | 178.38 | 0.00 | 0.0 | 0.0 | 0.0000 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.00000 | 0 | 0 |
| 69-53 | Outlying Separate Sanitary | 1641.57 | 114.91 | 0.0 | 70.8 | 0.0030 | RG1 | SepSlow1 | 11.49 | 0.0 | 500.5 | 0.00003 | RG1Spr05 | SepSlow1 |
| 70-11 | Outlying Separate Sanitary | 483.19 | 33.82 | 0.0 | 38.4 | 0.0030 | RG4 | SepSlow1 | 3.38 | 0.0 | 147.3 | 0.00003 | RG4Spr05 | SepSlow1 |
| 70-17 | Outlying Separate Sanitary | 85.46 | 0.00 | 0.0 | 0.0 | 0.0000 | 0 | 0 | 0.00 | 0.0 | 0.0 | 0.00000 | 0 | 0 |
| 86-60 | Outlying Separate Sanitary | 1813.58 | 126.95 | 0.0 | 74.4 | 0.0030 | RG4 | SepSlow1 | 3.63 | 0.0 | 158.0 | 0.00030 | RG2Spr05 | SepSlow1 |

| Infiltration Parameters - "Combined" Subcatchments | | | | |
|---|---|---|---|---|
| | Initial Parameters | | Final Parameters | |
| Infiltration Reference | Elkh1 | | | |
| Surface Response | Impervious | Pervious | Impervious | Pervious |
| Depression Storage (in) | 0.05 | 0.05 | 0.05 | 0.05 |
| Overland Manning's N | 0.013 | 0.100 | 0.0130 | 0.100 |
| Zero Detention Percent | 5.0 | | 5.0 | |
| Infiltration Equation | Horton | | Horton | |
| Maximum Infiltration Rate (in/hr) | 3.000 | | 3.000 | |
| Minimum Infiltration Rate (in/hr) | 0.300 | | 0.300 | |
| Decay Constant (1/sec) | 0.00115 | | 0.00115 | |
| Max Infiltation Volume (in) | -- | | -- | |

| Infiltration Parameters - "Local Separations in Combined Area Subcatchments" and "Outlying Separate Sanitary" Subcatchments | | | | |
|---|---|---|---|---|
| | Initial Parameters | | Final Parameters | |
| Infiltration Reference | Elkh1-S | | | |
| Surface Response | Impervious | Pervious | Impervious | Pervious |
| Depression Storage (in) | 0.00 | 0.5 | 0.00 | 0.05 |
| Overland Manning's N | 0.014 | 1.000 | 0.014 | 0.500 |
| Zero Detention Percent | 0.0 | | 0.0 | |
| Infiltration Equation | Horton | | Horton | |
| Maximum Infiltration Rate (in/hr) | 4.000 | | 0.400 | |
| Minimum Infiltration Rate (in/hr) | 0.100 | | 0.100 | |
| Decay Constant (1/sec) | 0.00115 | | 0.00115 | |
| Max Infiltation Volume (in) | -- | | -- | |

| Infiltration Parameters - Outlying Separate Sanitary Subcatchments | | | | | | |
|---|---|---|---|---|---|---|
| | Initial Parameters | | | Final Parameters | | |
| Infiltration Reference | SepFast1 | SepMed1 | SepSlow1 | SepFast1 | SepMed1 | SepSlow1 |
| Surface Response Type | Fast | Medium | Slow | Fast | Medium | Slow |
| Depression Storage (in) | 0.10 | 0.10 | 0.50 | 0.10 | 0.30 | 0.50 |
| Overland Manning's N | 0.200 | 0.800 | 1.000 | 0.200 | 0.500 | 1.000 |
| Zero Detention Percent | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Infiltration Equation | Horton | Horton | Horton | Horton | Horton | Horton |
| Maximum Infiltration Rate (in/hr) | 0.001 | 0.010 | 4.000 | 0.050 | 0.010 | 0.010 |
| Minimum Infiltration Rate (in/hr) | 0.001 | 0.010 | 0.100 | 0.010 | 0.005 | 0.001 |
| Decay Constant (1/sec) | 0.00115 | 0.00115 | 0.00115 | 0.00115 | 0.00115 | 0.00115 |
| Max Infiltation Volume (in) | -- | -- | -- | -- | -- | -- |

**Percent Impervious Values in the Combined Sewer Subcatchments**

Percent impervious is a key parameter in hydrologic modeling, having a major impact on the volume of runoff predicted for a given rainfall. The calibration of Elkhart's model resulted in an area-weighted average of 13 percent impervious in the combined sewer subcatchments, shown in Figure 1. Because a value of 13 percent is at the lower end of the range of typical values for urban areas, it was investigated further to confirm its applicability. The investigation focused on three areas – the magnitude of the calibrated percent impervious values, the geographic distribution of percent impervious values, and related issues that help explain the values in the City's model.

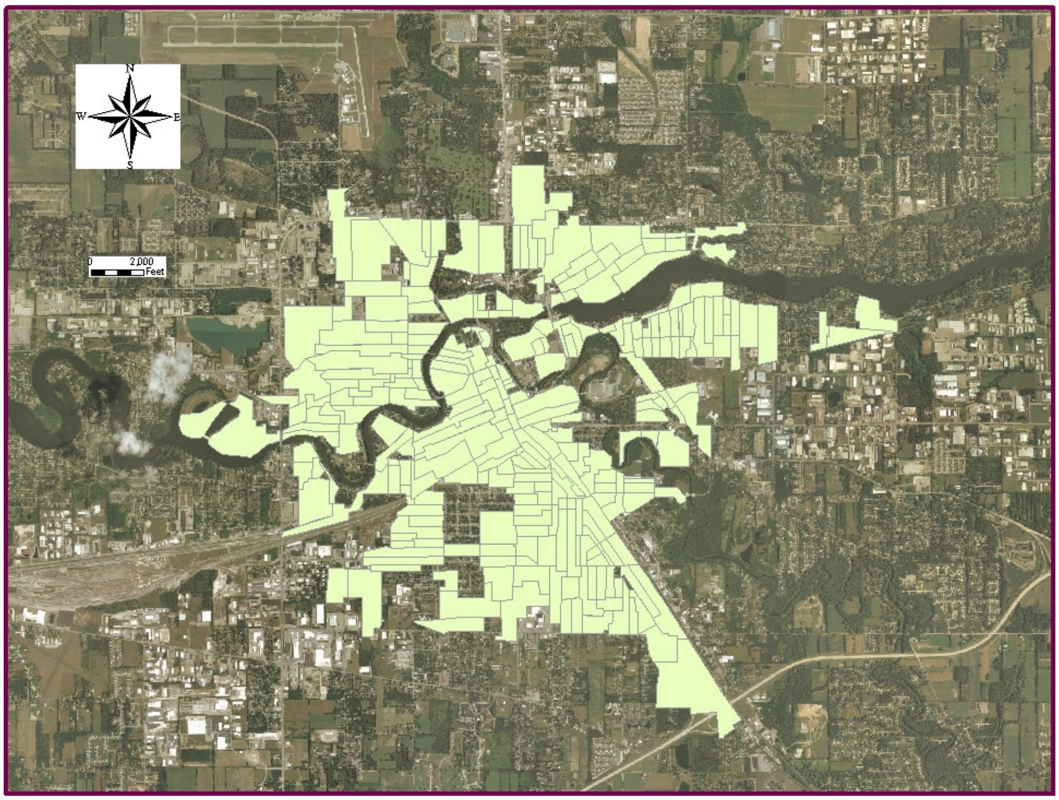



**Figure 1: Combined Sewer Subcatchments**

***Section 1 - Magnitude***

As part of confirming the applicability of the City's calibrated percent impervious values, estimates from other studies and modeling applications were investigated. This allowed comparison of Elkhart's calibrated percent impervious values to general literature values and recent regional applications.

*Comparison to General Literature Values*

The following presents a brief summary of relevant information documented in the wet-weather literature.

Investigation of percent impervious values began in the 1970s, coinciding with the emerging application of urban hydrology computer models. As part of a landmark series of studies on urban wet-weather issues conducted by USEPA, Heaney et al. (1977) compiled data on percent impervious estimates in urban areas as a function of population densities, shown in Figure 2. The purpose of Heaney's study was to conduct a "nationwide evaluation of combined sewer overflows and stormwater discharges," and the percent impervious estimates were used in urban hydrology models to predict annual wet-weather flows (including CSOs) from targeted urban areas. Heaney's work continues to serve as the basis for empirical percent impervious estimating techniques in today's SWMM documentation (see, e.g., James et al. (2003)).

Figure 2 reveals two general rules regarding urban percent impervious values:

- First, urban percent impervious values can vary by an order of magnitude over the range of typical urban population densities. For example, using the curve presented in Figure 2 for New Jersey (based on 567 municipalities), percent impervious values range from 5 percent to 50 percent in East Coast urban areas. Clearly, then, because population densities vary by urban area, percent impervious values will vary as well, indicating that there is not a narrow band of "correct" values for urban hydrology.
- Second, even for similar population densities, there is a wide range in urban percent impervious values. For example, at a population density of 5 per acre, urban percent impervious can range from a low of approximately 15 percent in an Ontario city to a high of near 80 percent in Washington, D.C. Therefore, while anecdotal evidence may suggest that most urban percent impervious values are in the range of 40 to 60 percent, it is clear that some urban areas can have weighted percent impervious values that are much lower (and higher) that this "typical" range.

The City of Elkhart has an area of approximately 22 square miles, or 14,000 acres, and a population of approximately 52,000 (2000 census), resulting in an area-wide population density of approximately 3.7 per acre. This population density is shown as a blue line on Figure 2. Using this population density, the New Jersey curve indicates an area-wide percent impervious value under 20 percent, and the Ontario curve (based on 9 cities) indicates an area-wide percent impervious value under 15 percent. **Therefore, while on the low end of expected urban percent impervious values, an area-weighted value of 13 percent in Elkhart clearly falls within the range defined by industry data and used in SWMM applications.**

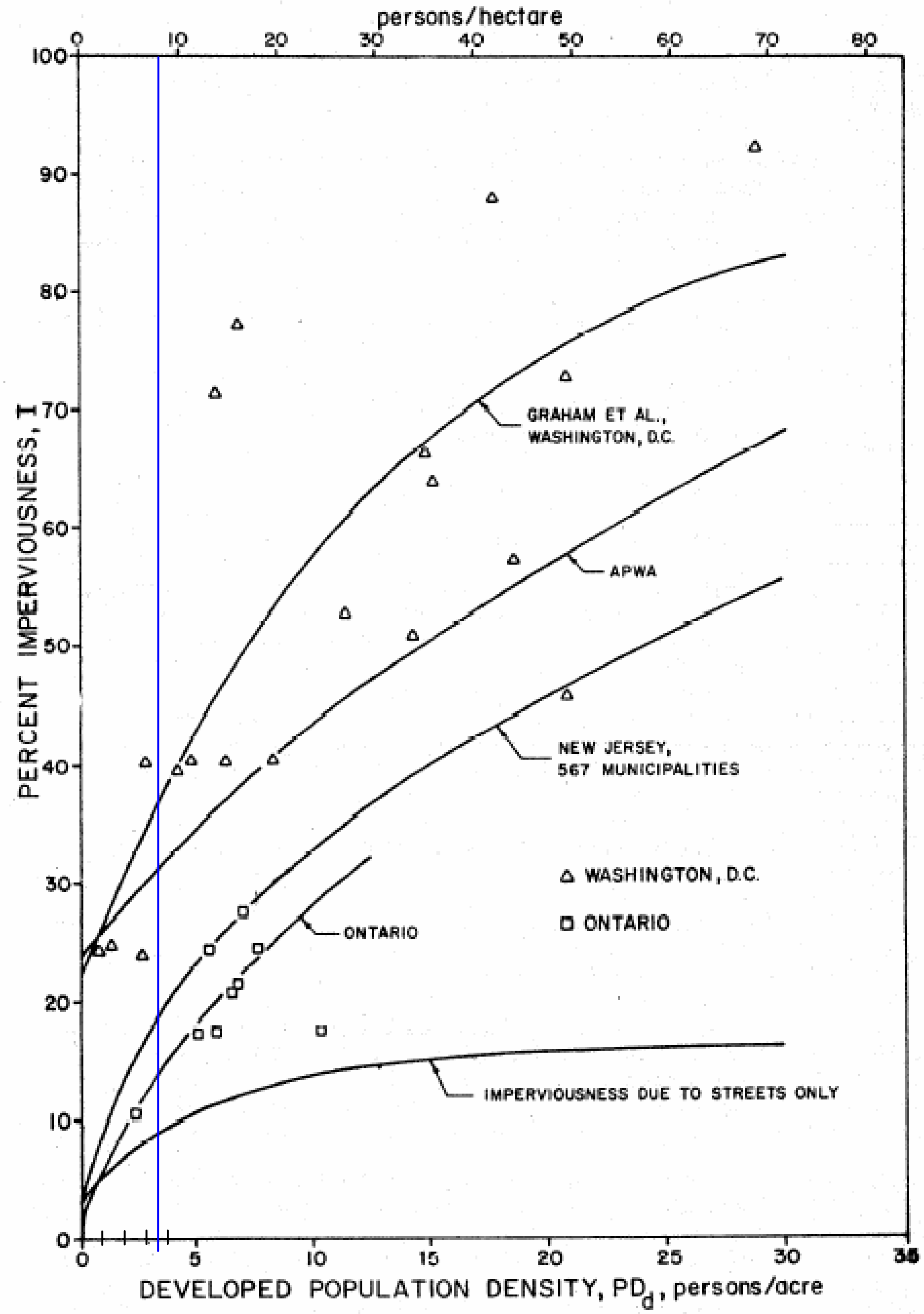



**Figure 2: Imperviousness as a Function of Developed Population Density**

In 2004, the University of Connecticut (Chabaeva et al.) published a paper on urban percent impervious values through NEMO, the Nonpoint Education for Municipal Officials program. NEMO is a partnership program supported by a number of organizations, including the Connecticut Department of Environmental Protection. Chabaeva et al. used digital planimetric data to identify impervious features in 108 census tracts in Connecticut, New York, and Massachusetts. Combining measurements of the total percent impervious with population densities in each tract resulted in the data distribution shown in Figure 3.

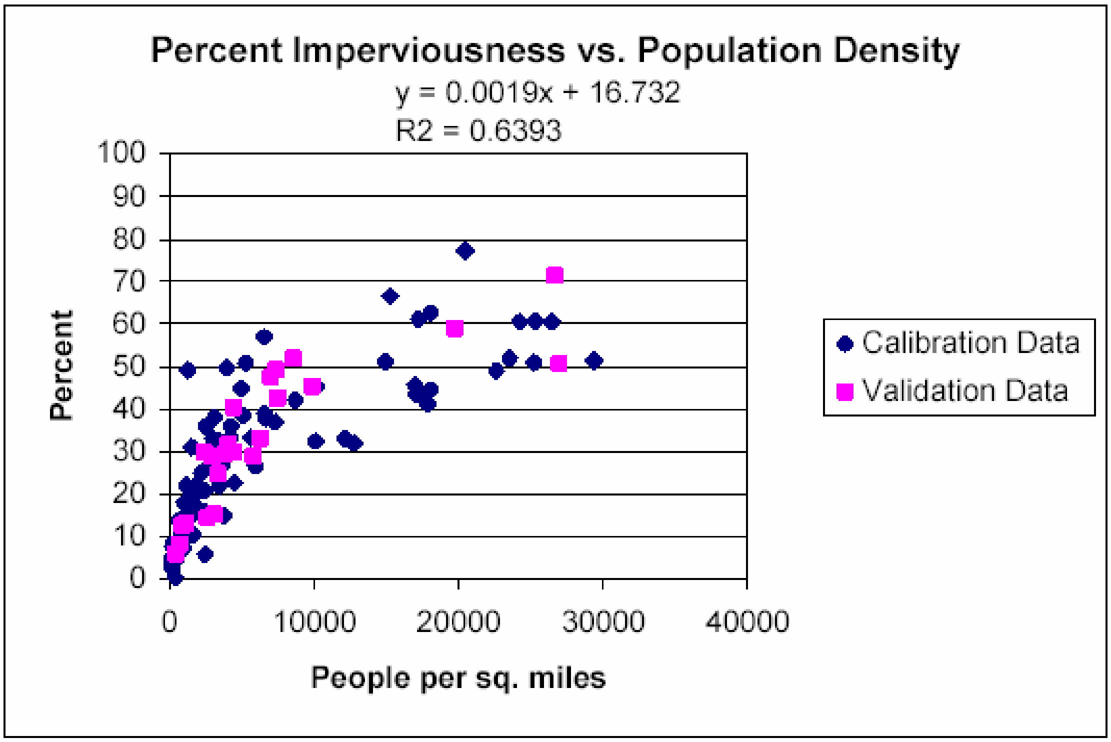



**Figure 3: Total Percent Impervious as a Function of Population Density**

Chabaeva et al.'s approach results in estimates of **total** impervious area, whereas many hydrologic models (including SWMM) require estimates of **directly-connected** impervious area (DCIA). DCIA will always be lower than total impervious area, given that many impervious features (e.g., a roof with splashed downspouts) drain to pervious areas before reaching the collection system. Therefore, for any given population density, Chabaeva et al.'s data would show a higher percent impervious than what would be used in a SWMM model. Given Elkhart's population density (2,363 per square mile, shown as a blue line in Figure 4), Chabaeva et al's data show a scatter in percent impervious from approximately 6 to 25 percent. **Given that these total percent impervious values are higher than the associated DCIA percent impervious, Elkhart's DCIA of 13 percent is clearly reasonable**.

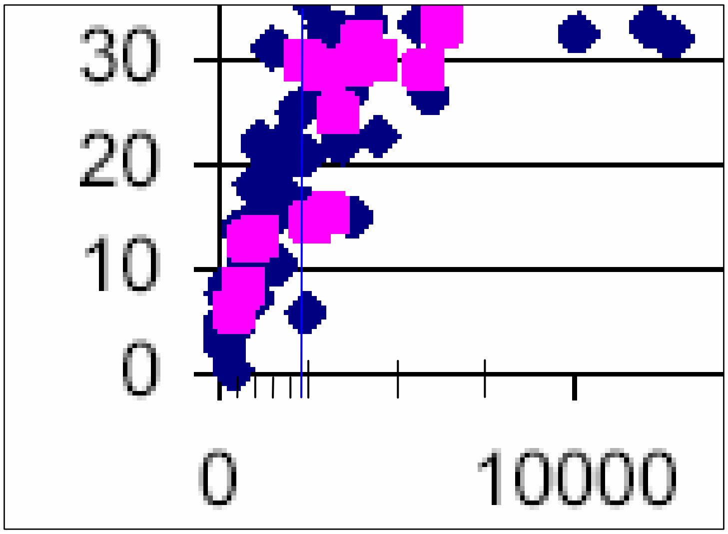



**Figure 4: Total Percent Impervious as a Function of Population Density (Density < 10,000 persons square mile)**

In summary, wet-weather literature spanning from 1977 to 2004 contains clear support that urban areas such as Elkhart can have credible percent impervious values in the range of 10 to 20 percent. Therefore, Elkhart's area-weighted value of 13 percent is reasonable.

*Comparison to Regional Applications*

Elkhart recently had the opportunity to discuss LTCP modeling issues with the City of South Bend, Indiana. Similar to Elkhart, South Bend is in the midst of a collection system modeling effort to support development of their CSO LTCP.

Based on discussions with South Bend, the calibration of their model resulted in an area-weighted average of 16 percent impervious in their combined sewer subcatchments. While slightly higher than Elkhart's, a value of 16 percent supports the reasonableness of an area-weighted value less than 20 percent in northern Indiana urban areas.

Furthermore, the information from South Bend solidifies the conclusions regarding the reasonableness of Elkhart's percent impervious values drawn from the general data of Heaney et al. The City of South Bend has an area of approximately 40 square miles, or 25,600 acres, and a population of approximately 108,000 (2000 census), resulting in an area-wide population density of approximately 4.2 per acre.

Figure 5 shows the lower left quadrant of Heaney's percent imperviousness plot (shown previously in full in Figure 2). Points have been added for both Elkhart's (blue) and South Bend's (green) combination of population density and calibrated percent impervious. As can be seen, the points for both of these northern Indiana cities are consistent with the Ontario data presented by Heaney, showing the expected increase in percent impervious with increasing population density. **This demonstrates that not only is Elkhart's individual percent impervious value consistent with lower values seen in the literature, but also that northern Indiana as a region exhibits consistently low patterns seen in other areas.**

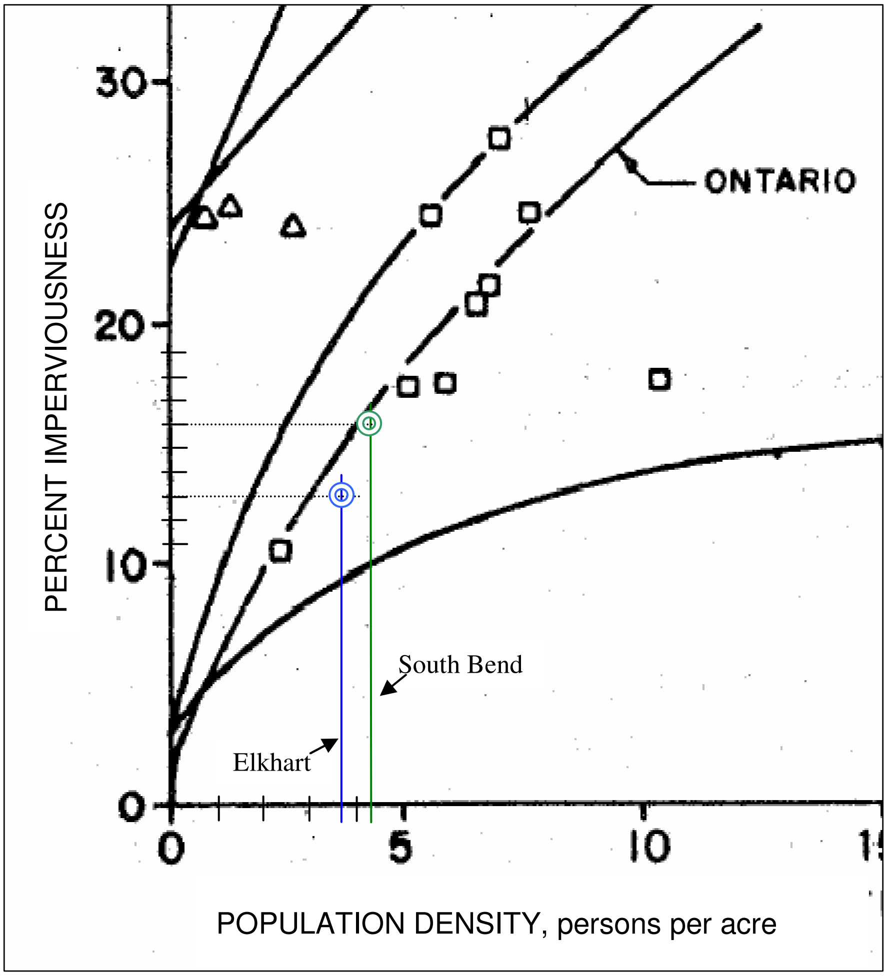



**Figure 5: Comparison of Elkhart and South Bend Percent Impervious Values to Ontario Relationship**

### *Section 2 - Geographic Distribution*

With the magnitude of Elkhart's average calibrated percent impervious value confirmed as reasonable, the geographic distribution of the subcatchment-specific impervious estimates was also investigated. The subcatchment-specific values range from a low of 3 percent to a high of 75 percent. The geographic distribution was reviewed to check that the relative relationship between subcatchment-specific percent impervious values showed a general consistency with land-use patterns.

Figure 6 shows the geographic distribution of combined sewer subcatchments in terms of three percent impervious ranges – 2 to 15 percent, 15 to 30 percent, and 30 to 80 percent. Based on the figure, the following observations can be made:

- The majority of the subcatchments in the 2 to 15 percent range are the older residential areas distributed throughout the combined sewer area. This indicates both a consistent land use in this range, and a land use that in a relative sense is expected to have lower percent impervious values.

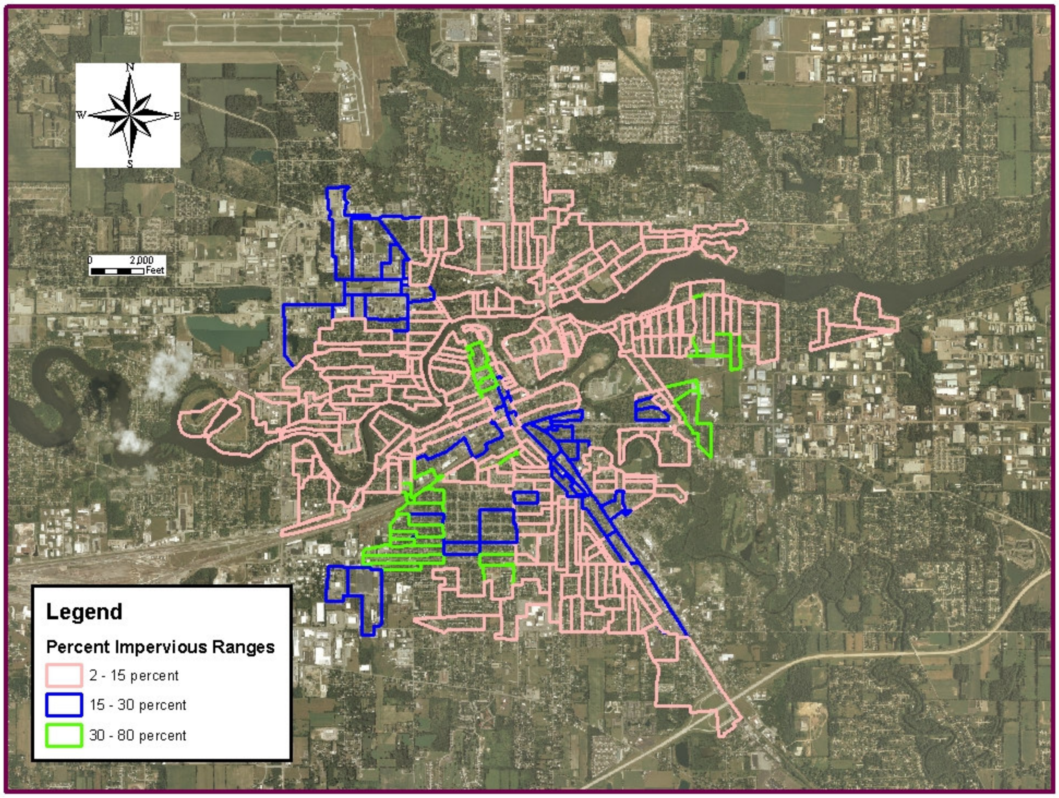



**Figure 6: Geographic Distribution of Percent Impervious Values in Combined Sewer Subcatchments**

- The majority of the subcatchments in the 15 to 30 percent range are either industrial areas (a cluster in the northwest), mixed use areas (a cluster in the southwest), or strip commercial/industrial areas along roads or railways. Therefore, subcatchments in this range fall in consistent land use categories, and ones that in a relative sense are expected to have medium percent impervious values.
- Many of the subcatchments in the 30 to 80 percent range are clustered in the downtown business district or a mixed use area with large buildings on the east side of the city. These land uses are expected to have the highest relative percent impervious values.

- The only noticeable exception to the consistent geographic distribution of percent impervious values by land use is a cluster of high percent impervious residential areas in the southwest portion of the City. This is likely due to the lack of both major and minor local separation projects in these subcatchments. In the future, these areas may be separated as part of Elkhart's ongoing program to perform local separation projects when possible as part of other improvement projects (e.g., street widening/paving). The "locally separated" subcatchments east of this high percent impervious cluster contain several examples of these major and minor separation projects.

Based on the above, the geographic distribution of percent impervious values in the combined sewer subcatchments is consistent with the distribution of land use categories. A detailed land use map showing the model subcatchments titled "Land Use/Zoning and Subcatchments Summary" is provided with this submittal.

***Section 3 - Local Factors***

Based on the information presented in the two previous sections, an area-weighted average of 13 percent impervious is clearly acceptable for an urban area, but falls at the lower end of the range of documented values. One characteristic of the Elkhart system which explains why the calibrated percent impervious values fall in the lower portion of the established range is the wide spatial extent of minor local separation projects, as shown on Figure 7.

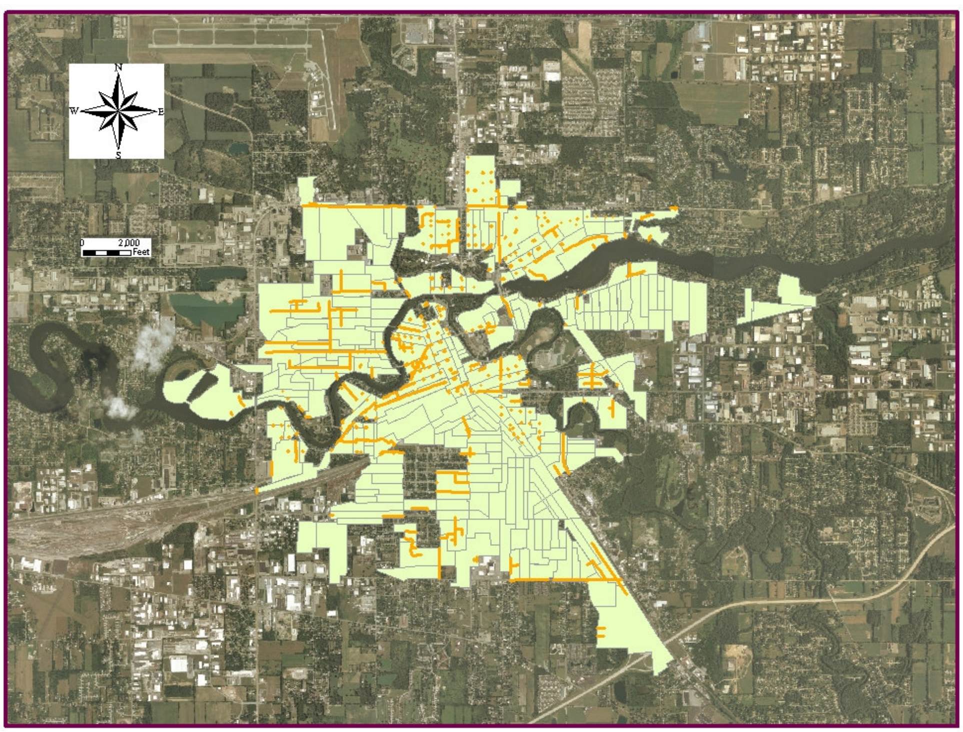


**Figure 7: Minor Local Separation Projects in Combined Sewer Subcatchments**

These projects were not large enough to warrant defining a distinct separate sanitary subcatchment, but they still impact the amount of surface runoff reaching the combined sewer system. In the XP-SWMM model, the effect of these local separation projects is to reduce the amount of DCIA in the subcatchment, resulting in a reduced modeled percent impervious value as explained in Section 1.

***References***

Chabaeva, A., Civco, D., and Prisloe, S. (2004). "Development of a Population Density and Land Use Based Regression Model to Calculate the Amount of Imperviousness."

Heaney, J.P., Huber, W.C., Medina, M.A., Jr., Murphy, M.P., Nix, S.J., and Hassan, S.M. "Nationwide Evaluation of Combined Sewer Overflows and Urban Stormwater Discharges – Vol. II: Cost Assessment and Impacts." EPA-600/2-77-064b (NTIS PB-266005). Environmental Protection Agency, Cincinnati, OH, March 1977.

James, W., Huber, W.C, Dickinson, R.E., Pitt, R.E., James, W.R.C., Roesner, L.A., and Aldrich, J.A. *Water Systems Models – User's Guide to SWMM.* Computational Hydraulics International. 2003.

**Percent Impervious Values in the Local Separations in Combined Area Subcatchments**

In response to the Agencies' Question #5B from the *Summary of Open Issues of SWMM Model Calibration* issued on 7/18/06, Elkhart clarified that the "Combined with Local Separation" subcatchments, as designated in the "Hydrology Parameters Summary - Combined Subcatchments" table issued on 5/1/06 and updated with this submittal, describe subcatchments that include local service areas that were originally part of the combined system, but are now separated as a result of the City's ongoing separation program.

To more clearly communicate the separated nature of these subcatchments, the nomenclature for this category was changed to "Local Separations in Combined Area", as shown on the "Service Area Summary Type" map issued on 8/2/06 (replaced with map titled "SWMM Model Information" provided with this submittal). The map and table of initial and final parameters were revised to use the updated nomenclature and update the service area type/model parameters for a few subcatchments identified during development of this submittal. These updates did not impact model calibration results.

In modeling these locally separated subcatchments in the combined area, the City appropriately used a typical approach for modeling separate systems, i.e. using 0% impervious area. This approach allows all runoff from the modeled subcatchment area to be produced by pervious surfaces, and is the same approach used in modeling the outlying separate sanitary service area. The following examples, selected from the flow metering data for the calibration events, support this modeling approach and demonstrate the typical separate sanitary response in Elkhart's sewer system, whether from locally separated basins in the combined area or separated basins in the outlying service area.

Flow Meter No. 19, located at Middlebury and Denver Streets in the eastern central portion of the CSS service area, was installed to monitor flows from several large subcatchments in the outlying separate sanitary service area (blue area in Figure 8).

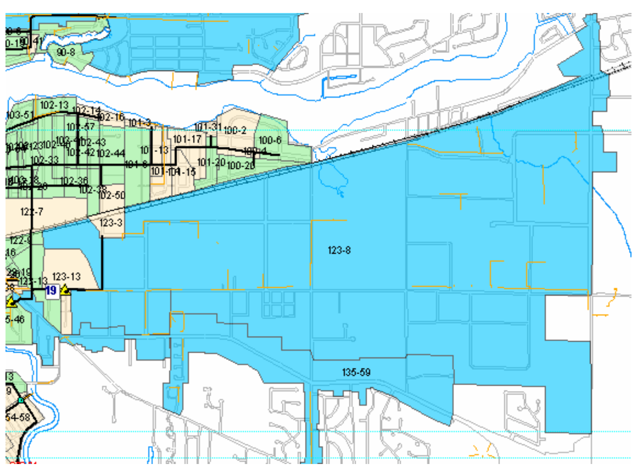



**Figure 8: Flow Meter No. 19 – Location and Tributary Subcatchments**

Figure 9, the June 12th event hydrograph for Flow Meter No. 19, shows a typical wet-weather response from a separate sanitary system with a peaking factor of approximately 5.4 based on the flow meter data. The peaking factor, a metric often used to compare sewer system performance, is the ratio of the peak wet weather flow to the average dry weather flow at the same location. For separate sanitary sewer systems, peaking factors less than 10 are typical, depending on the age and condition of the collection system. In contrast, combined sewer systems generally have much higher peaking factors with values of 30 or higher being typical.

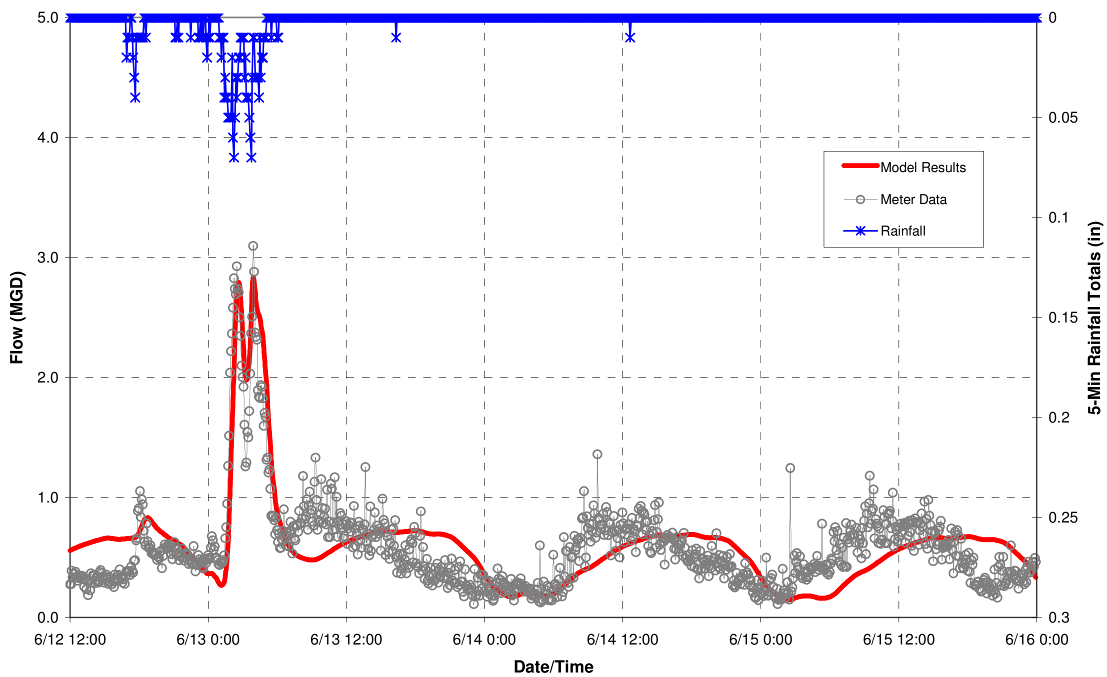



**Figure 9: Flow Meter No. 19 – June 12th Calibration Event Hydrograph**

Flow Meter No. 21, located at Oakland and Fieldhouse Avenues in the southwestern portion of the service area, collects flows from locally separated subcatchments within the combined area, as shown on Figure 10.

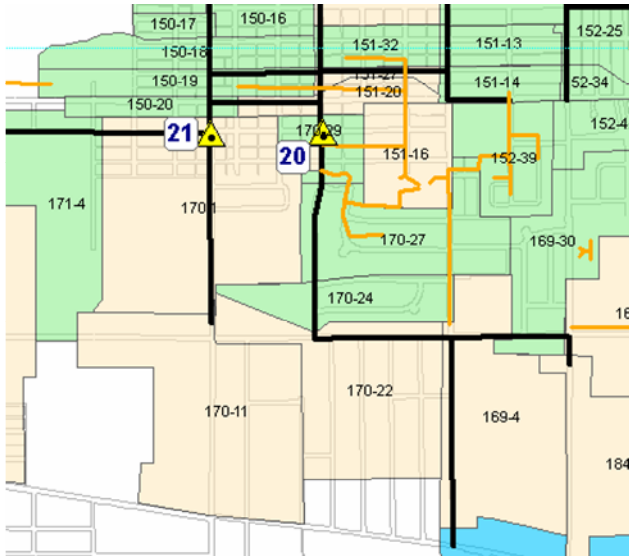



**Figure 11: Flow Meter No. 21 – Location and Tributary Subcatchments**

As shown on Figures 12 and 13, the peaking factors for the three calibration events at Flow Meter No. 21 range from 2 to 12 for this locally separated service area. **Since these values are typical of separate sanitary sewer system response rather than combined sewer system response, this data confirms that Elkhart's locally separated basins in the combined service area behave as separate sanitary basins during wet weather.**

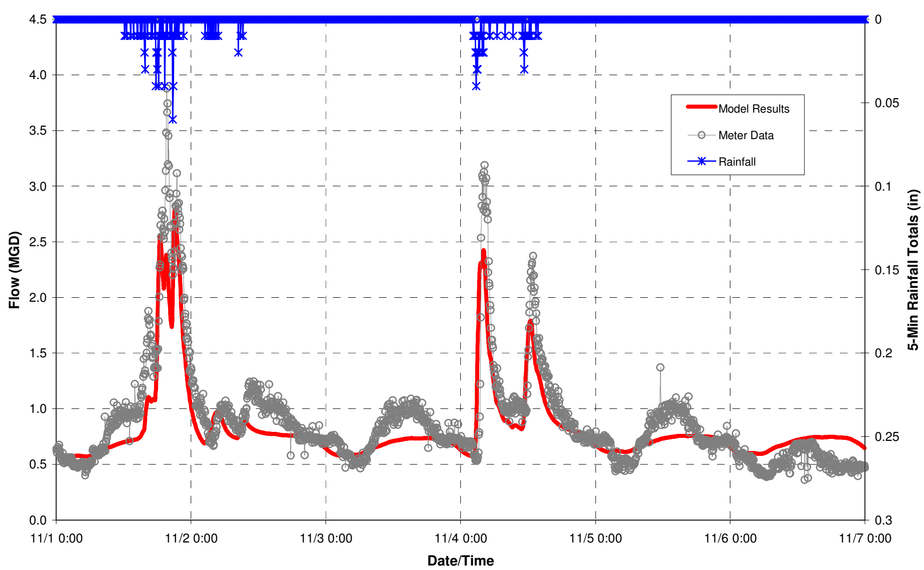



**Figure 12: Flow Meter No. 21 – November 1st and 4th Calibration Event Hydrograph**

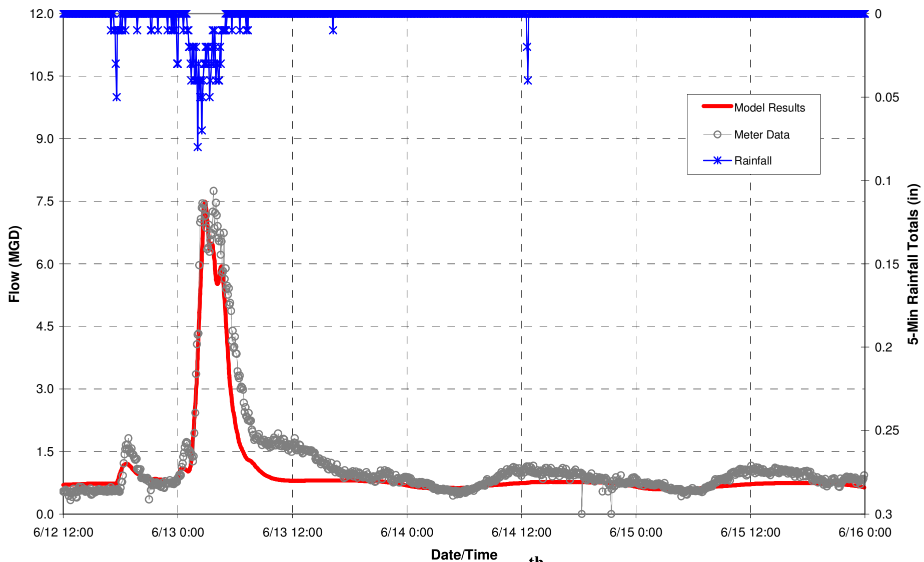
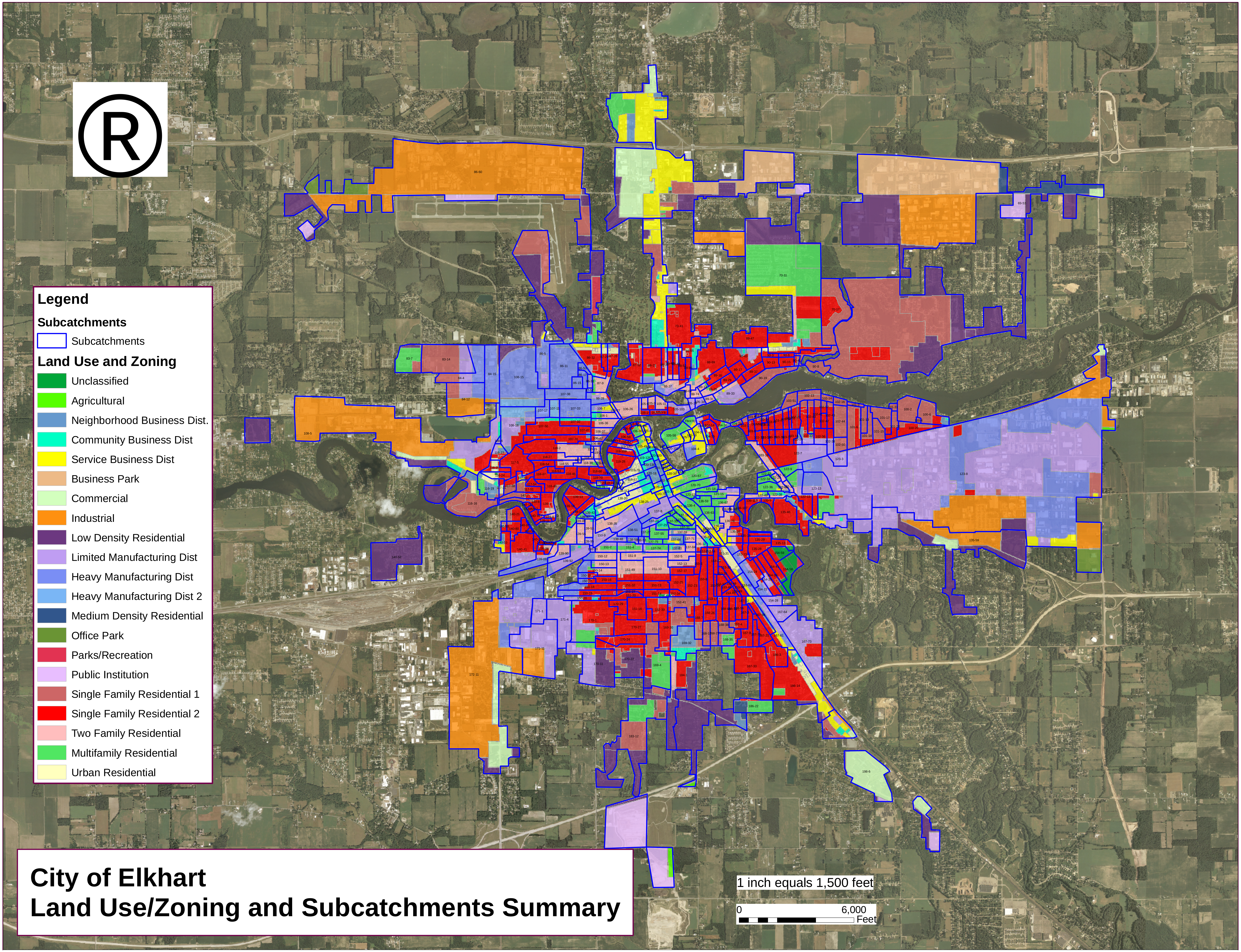
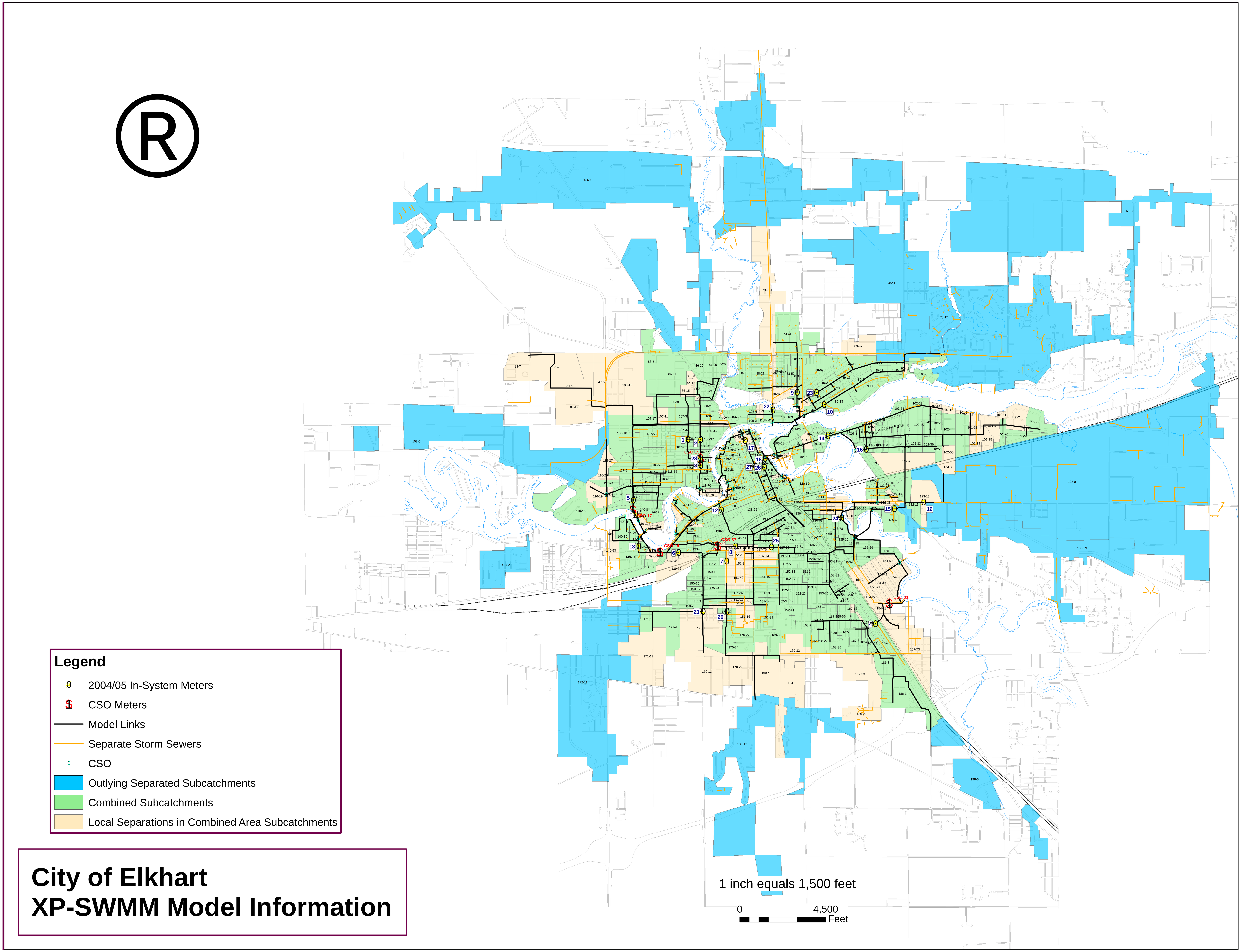
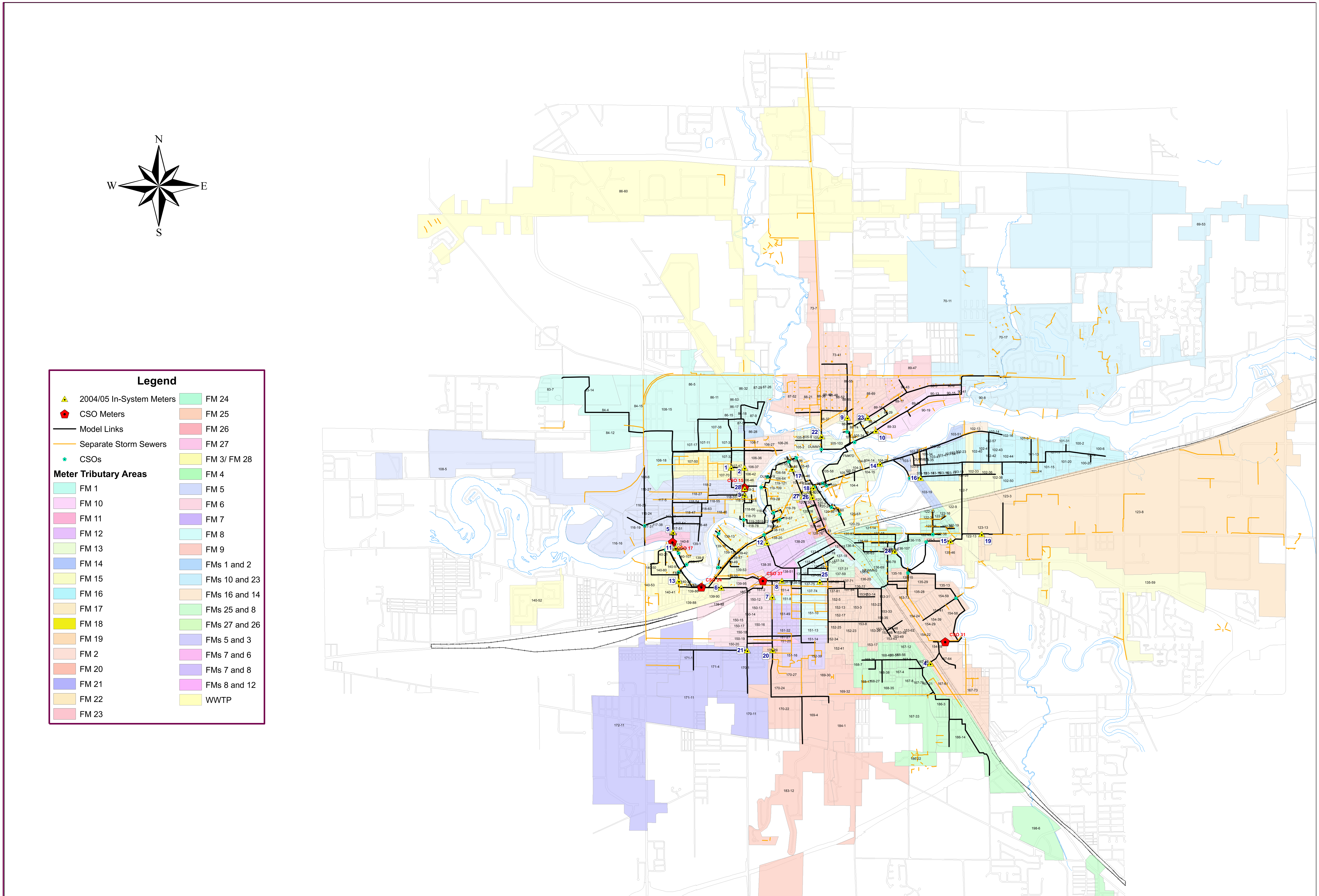



**Figure 13: Flow Meter No. 21 – June 12th Calibration Event Hydrograph**



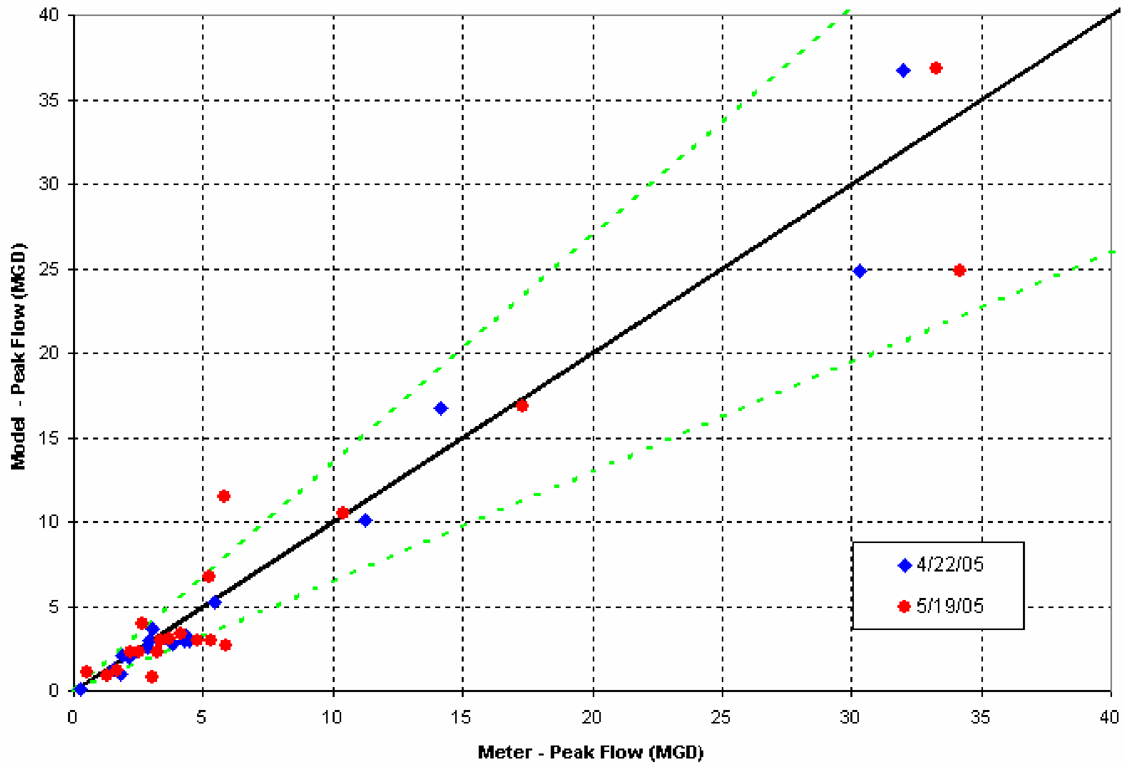

# City of Elkhart
# Land Use/Zoning and Subcatchments Summary


®
Legend
2004/05 In-System Meters
CSO Meters
Model Links
Separate Storm Sewers
CSO
Outlying Separated Subcatchments
Combined Subcatchments
Local Separations in Combined Area Subcatchments
1 inch equals 1,500 feet
0
4,500
Feet
City of Elkhart
XP-SWMM Model Information




# City of Elkhart
# XP-SWMM Model and In-System Flow Meter Information

# SWMM Model Validation Results
# Elkhart LTCP Update




**Malcolm Pirnie, Inc.**
**Elkhart Public Works**
**December 11, 2006**

# 1 Introduction

On October 12, 2006, USEPA approved the City of Elkhart's SWMM Model Validation Plan (the Plan). Following approval, the City implemented the validation approach outlined in the Plan to confirm the SWMM model's applicability for LTCP development purposes. This Technical Memorandum summarizes the results of the validation process.

# 2 Validation Data

As explained in the Plan, two wet-weather events were used for model validation purposes. Table 1 summarizes statistics for these two events, occurring on April 22, 2005 and May 19, 2005.

These two validation events were captured during the City's 2004-05 flow monitoring program, which was described previously in the January 27, 2006 Collection System Field Monitoring Program Report. As part of this program, the City maintained 28 in-system flow meters, five (5) overflow meters, five (5) rain gauges, and the permanent WWTP influent flow meter. The available data from these events was reviewed to determine its applicability for model comparison purposes.

Table 2 summarizes the data review for the 28 in-system flow meters sites and the WWTP influent meter. As shown, approximately 60 to 70 percent of the meter events (18 of 29 locations for the April 22$^{nd}$ event, 20 of 29 locations for the May 19$^{th}$ event) provided credible data for meter-to-model volume and peak flow comparisons.

Table 3 summarizes the available activation data for the five (5) overflow meters. Two redundant systems were used by the City to monitor activation – a simple float mechanism and a depth sensor in the overflow pipe.

# 3 Validation Results

As outlined in the approved September 25, 2006, SWMM Model Validation Plan, the following sequence was used as validation criteria for the flow monitored CSS basins:

- Peak flow timing and the general hydrograph shape are similar. This goodness-of-fit or "suitably close" criterion was the primary measure of success.
- Model runoff volumes were compared to actual flow monitored runoff volumes. The model is validated if the modeled runoff volumes and monitored runoff volumes are within +/- 35 percent for a sufficient number of valid events.
- Model runoff peak flow rates were compared to actual flow monitored runoff peak flow rates. The model is validated if the largest peak flow rate from the model and monitor are within +/- 35 percent for a sufficient number of valid events.
- At locations where valid velocity data is not available, the comparison will focus on flow depths and/or activations.

*Criterion #1: Peak flow timing and the general hydrograph shape are similar*

Appendix 1 of this report provides model-to-meter hydrograph comparisons for *all* 28 in-system flow meter sites and the WWTP influent flow meter for both validation events. As shown, the peak flow timing and general hydrograph shape are similar for the majority of meter events with credible data (identified previously in Table 2).

It should also be noted that at several meter locations, the hydrograph comparisons show clear evidence that baseflow (sanitary discharges plus dry-weather infiltration) was higher during the validation period than the calibration period. This occurrence is not uncommon in a validation effort, given the objective of using independent data to test the model. The calibrated XP-SWMM model was not adjusted to match the elevated baseflow in the validation data; therefore, the difference in baseflow between the calibration and validation periods should be considered in reviewing the validation results and volume comparisons.

**Conclusion: The full set of hydrograph comparisons show that Elkhart's XP-SWMM model clearly meets the goodness-of-fit or "suitably close" criterion for valid data.**

*Criterion #2: Model runoff volumes compared to actual flow monitored runoff volumes*

Figures 1, 2, and 3 show the results of comparing model-to-meter volumes for the two validation events, for valid data from the 28 in-system flow meter sites and the WWTP influent meter.

- Figure 1 presents a histogram showing the proportion of meter-to-model volume comparisons falling in several percent difference ranges. For approximately 70 percent of the meter events, modeled volumes fall within the validation goal (within +/-35 percent of monitored volumes). The remaining 30 percent of meter events are distributed above and below this central range.
- Figures 2 and 3 present volume chart comparisons for the two validation events, where each point on the charts represents a comparison of model-to-meter volumes at an individual meter for an individual event. As shown on these figures, the points cluster along the "ideal" 45-degree line shown on the chart. The visual suggestion of a slight trend towards the model under-predicting volumes is due to the baseflow differences noted above. Therefore, this occasional under-prediction is unique to the validation events and not an indication of model bias.

A tabular summary of meter to model volume comparisons is presented in Table 5.

**Conclusion: With metered and modeled runoff volumes within +/- 35 percent for 70 percent of the validation meter events, the model clearly meets the volume comparison goal for a sufficient number of valid events.**

*Criterion #3: Model runoff peak flow rates compared to actual flow monitored runoff peak flow rates*

Figures 4 and 5 shows the results of comparing model-to-meter peak flow rates for the two validation events using the valid data from the 28 in-system flow meter sites and the WWTP influent meter.

- Figure 4 presents a histogram showing the proportion of meter-to-model peak flow comparisons falling in several percent difference ranges. For approximately 75 percent of the meter events, modeled peak flow rates fall within the validation goal (within +/-35 percent of monitored peak flow rates). The remaining 25 percent of meter events are distributed above and below this central range.
- Figure 5 presents a chart of monitored peak flow to modeled peak flow for the two validation events. Each point on the graph represents a comparison of model-to-meter peak flows at an individual meter for an individual event. As shown, the points cluster along the “ideal” 45-degree line shown on the chart.

A tabular summary of meter to model peak flow comparisons is shown in Table 5.

**Conclusion: With modeled runoff peak flow rates and monitored runoff peak flow rates within +/- 35 percent for 75 percent of the data comparisons, the XP-SWMM model for the Eklhart CSS clearly meets the peak flow comparison goal for a sufficient number of valid events.**

*Criterion #4: At locations where valid velocity data is not available, the comparison will focus on flow depths and/or activations*

Appendix 2 of this report provides model-to-meter depth comparisons for a limited number of in-system meter locations with suspect velocity data (identified previously in Table 2), along with all five overflow meter locations.

The primary comparison for validation at outfall meter locations is assessment of the model’s ability to predict monitored activations. Given credible volume and peak flow comparisons at in-system locations upstream and downstream of these overflows, successful prediction of activations becomes an important indicator of the model’s ability to predict overflow volumes and peak flow rates. Table 4 shows model-to-meter activation comparisons, showing that the model successfully predicted overflow activity with a 70 percent success rate (7 out of 10 times). Given the inherent uncertainty in overflow monitoring data, this is a credible activation comparison.

**Conclusion: With a 70 percent success rate in activation predictions, the model successfully accounts for overflow activity.**

# 4 Conclusion

Based on the validation results outlined above, the XP-SWMM model of Elkhart's CSS meets the validation criteria documented in the City's approved SWMM Model Validation Plan. This successful validation, coupled with the earlier approval of the model calibration, demonstrates that the model is an appropriate tool for LTCP development purposes.

**Table 1**
**Validation Rainfall Event Data Summary**

| Event Date | No. of Antecedent Dry Days | Duration (hours) | Average Rainfall Total (in) | Average Rainfall Intensity (in/hr) | Peak 5-Min Rainfall Intensity (in/hr) | Return Period |
|---|---|---|---|---|---|---|
| April 22, 2005 | 22 | 7.5 | 0.53 | 0.07 | 0.36 | <2 months |
| May 19, 2005 | 5 | 10.6 | 0.58 | 0.05 | 0.36 | <2 months |

Notes
1. Statistics for this event was based upon data from four rainfall gauges.

## Table 2

## Validation Data Screening Summary

| Flow Meter | General Data Categorization for Validation Events | | Flow Hydrograph Data Commentary for Validation Events | |
|---|---|---|---|---|
| | 4/22/2005 | 5/19/2005 | 4/22/2005 | 5/19/2005 |
| 1 | G | G | | |
| 2 | OK | OK | Despite overall data concerns at this location, the scattergraph confirms periods of valid data during the event. | Elevated depth values before event raise general questions about data; however, scattergraph confirms periods of valid data during the event. |
| 3 | DS | ND | Meter "caps out" at approximately 6 MGD. Velocities consistently flatline at ~3 ft/s regardless of depth, suggesting a velocity probe issue. | Inactive meter site |
| 4 | OK | OK | Higher measured flows before event suggest inconsistent velocity probe performance. However, the scattergraph confirms periods of valid data during the event. | |
| 5 | G | G | | |
| 6 | G | OK | Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends. | Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends. |
| 7 | OK | OK | | Model does not replicate metered flows recording filter backwash discharges from the City's South Wellfield on 5/19. |
| 8 | DS | DS | Upstream and downstream meters reveal that flow data for this event is suspect, possibly due to velocity probe issues. However, the comparison shows that model strongly matches the data trends. | Upstream and downstream meters reveal that flow data for this event is suspect, possibly due to velocity probe issues. However, the comparison shows that model strongly matches the data trends. |
| 9 | OK | G | Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends. | |
| 10 | DS | DS | Velocity and depth data show very little variation and no diurnal response. However, the comparison shows reasonable model timing. | Velocity and depth data show very little variation and no diurnal response. However, the comparison shows reasonable model timing. |
| 11 | OK | OK | Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends. | Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends. |
| 12 | G | G | | |
| 13 | DS | DS | Scattergraph shows that Manning's Equation was used to calculate meter velocities. Therefore, depth comparisons are the relevant measure of model performance. | Scattergraph shows inconsistent patterns at all flows during the event. However, the comparison shows reasonable model timing. |

Data Code Legend

| Data Code | Explanation |
|---|---|
| G | Good data |
| OK | Data shows evidence of undefined anomalies, but comparisons are possible |
| DS | Data suspect |
| ND | No data |

Coloring Legend

| | |
|---|---|
| (white) | Data appears reaonable and was used in screened data comparisons for volume and peak flow. |
| (pink) | Not included in screened data comparisons for volume and peak flow |
| (yellow) | Data appears reasonable, and comparisons were performed; however, some differences are expected due to the significant change in baseflow between the calibration and validation periods. |

## Table 2 Validation Data Screening Summary (continued)

| Flow Meter | General Data Categorization for Validation Events | | Flow Hydrograph Data Commentary for Validation Events | |
|---|---|---|---|---|
| | 4/22/2005 | 5/19/2005 | 4/22/2005 | 5/19/2005 |
| 14 | G | OK | | |
| 15 | OK | OK | | |
| 16 | ND | ND | Inactive meter site | Inactive meter site |
| 17 | DS | OK | Scattergraph shows that Manning's Equation was used to calculate meter velocities. Therefore, depth comparisons are the relevant measure of model performance. | |
| 18 | ND | ND | Inactive meter site | Inactive meter site |
| 19 | DS | DS | Scattergraph shows that Manning's Equation was used to calculate meter velocities. Therefore, depth comparisons are the relevant measure of model performance. | Scattergraph shows inconsistent patterns at all flows during the event. However, the comparison shows reasonable model timing. |
| 20 | OK | OK | | Model does not replicate metered flows recording filter backwash discharges from the City's South Wellfield on 5/19. |
| 21 | G | G | | |
| 22 | OK | DS | Despite overall data concerns at this location, the scattergraph confirms periods of valid data during the event. | Scattergraph shows inconsistent patterns at all flows during the event. However, the comparison shows reasonable model timing. |
| 23 | OK | OK | Despite evidence of depth probe randomly "sticking" at certain depths, the scattergraph confirms periods of valid data during the event. | Despite overall data concerns at this location, the scattergraph confirms periods of valid data during the event. |
| 24 | OK | OK | Erratic velocity data readings raise general questions about data. However, scattergraph confirms periods of valid data during the event. | Erratic velocity data readings raise general questions about data. However, scattergraph confirms periods of valid data during the event. |
| 25 | G | G | | |
| 26 | DS | DS | Velocity data shows highly erratic readings. However, the comparison shows reasonable model timing. | Velocity data shows highly erratic readings. However, the comparison shows reasonable model timing. |
| 27 | DS | OK | Scattergraph shows that Manning's Equation was used to calculate meter velocities. Therefore, depth comparisons are the relevant measure of model performance. | |
| 28 | ND | OK | Inactive meter site | |
| WWTP Influent | OK | OK | Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends. | Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends. |

Data Code Legend

| Data Code | Explanation |
|---|---|
| G | Good data |
| OK | Data shows evidence of undefined anomalies, but comparisons are possible |
| DS | Data suspect |
| ND | No data |

Coloring Legend

| | |
|---|---|
| (white) | Data appears reaonable and was used in screened data comparisons for volume and peak flow. |
| (pink) | Not included in screened data comparisons for volume and peak flow |
| (yellow) | Data appears reasonable, and comparisons were performed; however, some differences are expected due to the significant change in baseflow between the calibration and validation periods. |

## Table 3
## Summary of Activation Monitoring

| Outfall Meter Locations | April 22, 2005 Event | | May 19, 2005 Event | |
|---|---|---|---|---|
| | Float Response | Downstream Depth Response | Float Response | Downstream Depth Response |
| CSO#15 | Yes | Yes | Yes | Yes |
| CSO#17 | No | No | No | No |
| CSO#24 | Yes | Yes | Yes | Yes |
| CSO#31 | No | No | Yes | Yes |
| CSO#37 | Yes | Yes | Yes | Yes |

## Table 4
## Summary of Model-to-Meter Activation Comparisons

| Outfall Meter Location | April 22, 2005 Event | | May 19, 2005 Event | |
|---|---|---|---|---|
| | Monitored Activation | Modeled Activation | Monitored Activation | Modeled Activation |
| CSO#15 | Yes | No | Yes | No |
| CSO#17 | No | No | No | No |
| CSO#24 | Yes | Yes | Yes | Yes |
| CSO#31 | No | Yes | Yes | Yes |
| CSO#37 | Yes | Yes | Yes | Yes |

Coloring Legend

| |
|---|
| Model matches metered activation |
| Model does not match metered activation |

## Table 5

## Validation Meter-to-Model Volume and Peak Flow Comparisons

| Flow Meter | General Data Categorization for Validation Events | | Screened Comparisons for 4/22/2005 Validation Event | | | | | | Screened Comparisons for 5/19/2005 Validation Event | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Volume (MG) | | | Peak Flow (MGD) | | | Volume (MG) | | | Peak Flow (MGD) | | |
| | 4/22/2005 | 5/19/2005 | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) | Meter | Model | Percent Difference (%) |
| 1 | G | G | 1.31 | 1.23 | -5.9 | 11.22 | 10.13 | -9.7 | 1.31 | 1.23 | -6.7 | 10.43 | 10.45 | 0.2 |
| 2 | OK | OK | 0.14 | 0.11 | -21.3 | 1.79 | 0.95 | -46.9 | 0.25 | 0.11 | -54.7 | 3.07 | 0.83 | -72.9 |
| 3 | DS | ND | | | | | | | | | | | | |
| 4 | OK | OK | 0.54 | 0.56 | 3.4 | 2.88 | 2.96 | 2.9 | 0.59 | 0.52 | -11.9 | 3.67 | 3.02 | -17.6 |
| 5 | G | G | 0.70 | 0.46 | -34.1 | 4.46 | 3.00 | -32.8 | 1.01 | 0.49 | -51.2 | 5.86 | 2.72 | -53.6 |
| 6 | G | OK | 6.92 | 5.28 | -23.7 | 30.34 | 24.81 | -18.2 | 7.93 | 5.68 | -28.4 | 34.16 | 24.90 | -27.1 |
| 7 | OK | OK | 0.60 | 0.55 | -8.7 | 4.28 | 3.00 | -30.0 | 0.54 | 0.50 | -7.4 | 4.16 | 3.37 | -18.9 |
| 8 | DS | DS | | | | | | | | | | | | |
| 9 | OK | G | 0.45 | 0.45 | -0.1 | 3.06 | 3.64 | 19.1 | 0.41 | 0.48 | 16.3 | 2.66 | 4.00 | 50.5 |
| 10 | DS | DS | | | | | | | | | | | | |
| 11 | OK | OK | 0.83 | 0.49 | -40.5 | 4.33 | 3.22 | -25.7 | 1.20 | 0.52 | -56.6 | 5.27 | 2.99 | -43.3 |
| 12 | G | G | 0.17 | 0.23 | 38.4 | 2.10 | 1.98 | -5.6 | 0.28 | 0.24 | -15.0 | 3.21 | 2.25 | -29.8 |
| 13 | DS | DS | | | | | | | | | | | | |
| 14 | G | OK | 0.68 | 0.53 | -22.0 | 2.85 | 2.58 | -9.6 | 0.70 | 0.61 | -13.2 | 3.36 | 2.93 | -13.0 |
| 15 | OK | OK | 0.88 | 0.92 | 4.5 | 5.41 | 5.27 | -2.5 | 0.69 | 1.07 | 55.5 | 5.24 | 6.71 | 28.1 |
| 16 | ND | ND | | | | | | | | | | | | |
| 17 | DS | OK | | | | | | | 0.04 | 0.11 | 172.7 | 0.53 | 1.10 | 106.8 |
| 18 | ND | ND | | | | | | | | | | | | |
| 19 | DS | DS | | | | | | | | | | | | |
| 20 | OK | OK | 0.31 | 0.43 | 39.9 | 1.90 | 2.09 | 9.9 | 0.33 | 0.38 | 16.9 | 2.19 | 2.30 | 5.2 |

Data Code Legend

| Data Code | |
|---|---|
| G | Good data |
| OK | Data shows evidence of undefined anomalies, but comparisons are possible |
| DS | Data suspect |
| ND | No data |

Coloring Legend

| | |
|---|---|
| (white) | Data appears reaonable and was used in screened data comparisons for volume and peak flow. |
| (pink) | Not included in screened data comparisons for volume and peak flow |
| (yellow) | Data appears reasonable, and comparisons were performed; however, some differences are expected due to the increase in baseflow between the calibration and validation periods. |

| Table 5 (continued) | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Flow Meter** | **General Data Categorization for Validation Events** | | **Screened Comparisons for 4/22/2005 Validation Event** | | | | | | **Screened Comparisons for 5/19/2005 Validation Event** | | | | | | |
| | | | **Volume (MG)** | | | **Peak Flow (MGD)** | | | **Volume (MG)** | | | **Peak Flow (MGD)** | | | |
| | **4/22/2005** | **5/19/2005** | **Meter** | **Model** | **Percent Difference (%)** | **Meter** | **Model** | **Percent Difference (%)** | **Meter** | **Model** | **Percent Difference (%)** | **Meter** | **Model** | **Percent Difference (%)** | |
| 21 | G | G | 0.75 | 0.55 | -27.1 | 3.79 | 2.73 | -27.9 | 0.86 | 0.62 | -27.5 | 4.79 | 2.92 | -38.9 | |
| 22 | OK | DS | 0.01 | 0.01 | 12.7 | 0.24 | 0.12 | -51.6 | | | | | | | |
| 23 | OK | OK | 0.47 | 0.38 | -19.1 | 1.58 | 1.24 | -21.5 | 0.54 | 0.43 | -19.7 | 1.69 | 1.22 | -27.7 | |
| 24 | OK | OK | 0.24 | 0.37 | 54.4 | 2.04 | 2.06 | 0.7 | 0.24 | 0.38 | 61.9 | 2.49 | 2.31 | -7.4 | |
| 25 | G | G | 2.38 | 3.19 | 34.4 | 14.15 | 16.71 | 18.2 | 2.45 | 3.26 | 33.1 | 17.29 | 16.79 | -2.9 | |
| 26 | DS | DS | | | | | | | | | | | | | |
| 27 | DS | OK | | | | | | | 0.09 | 0.10 | 14.2 | 1.32 | 0.90 | -32.2 | |
| 28 | ND | OK | | | | | | | 0.90 | 1.51 | 66.9 | 5.82 | 11.47 | 97.2 | |
| WWTP Influent | OK | OK | 11.57 | 9.66 | -16.5 | 32.00 | 36.75 | 14.8 | 14.42 | 10.93 | -24.2 | 33.30 | 36.86 | 10.7 | |

Data Code Legend

| Data Code | |
|---|---|
| G | Good data |
| OK | Data shows evidence of undefined anomalies, but comparisons are possible |
| DS | Data suspect |
| ND | No data |

Coloring Legend

| | |
|---|---|
| (white) | Data appears reaonable and was used in screened data comparisons for volume and peak flow. |
| (pink) | Not included in screened data comparisons for volume and peak flow |
| (yellow) | Data appears reasonable, and comparisons were performed; however, some differences are expected due to the increase in baseflow between the calibration and validation periods. |

**Figure 1: Wet-Weather Volume Histogram Comparison for Validation Events – Screened Data**

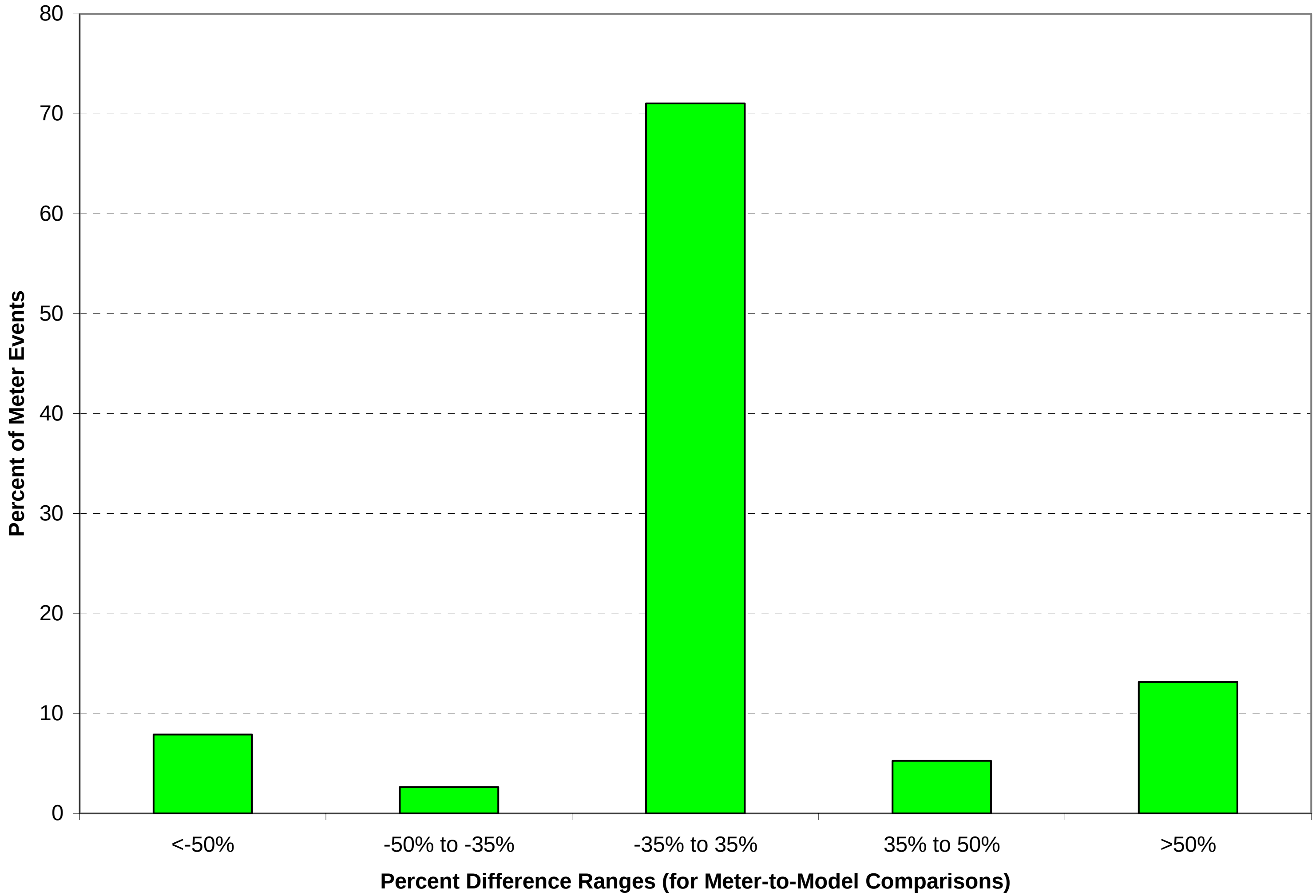


**Figure 2: Model-to-Meter Wet-Weather Volume Comparisons - Screened Data**

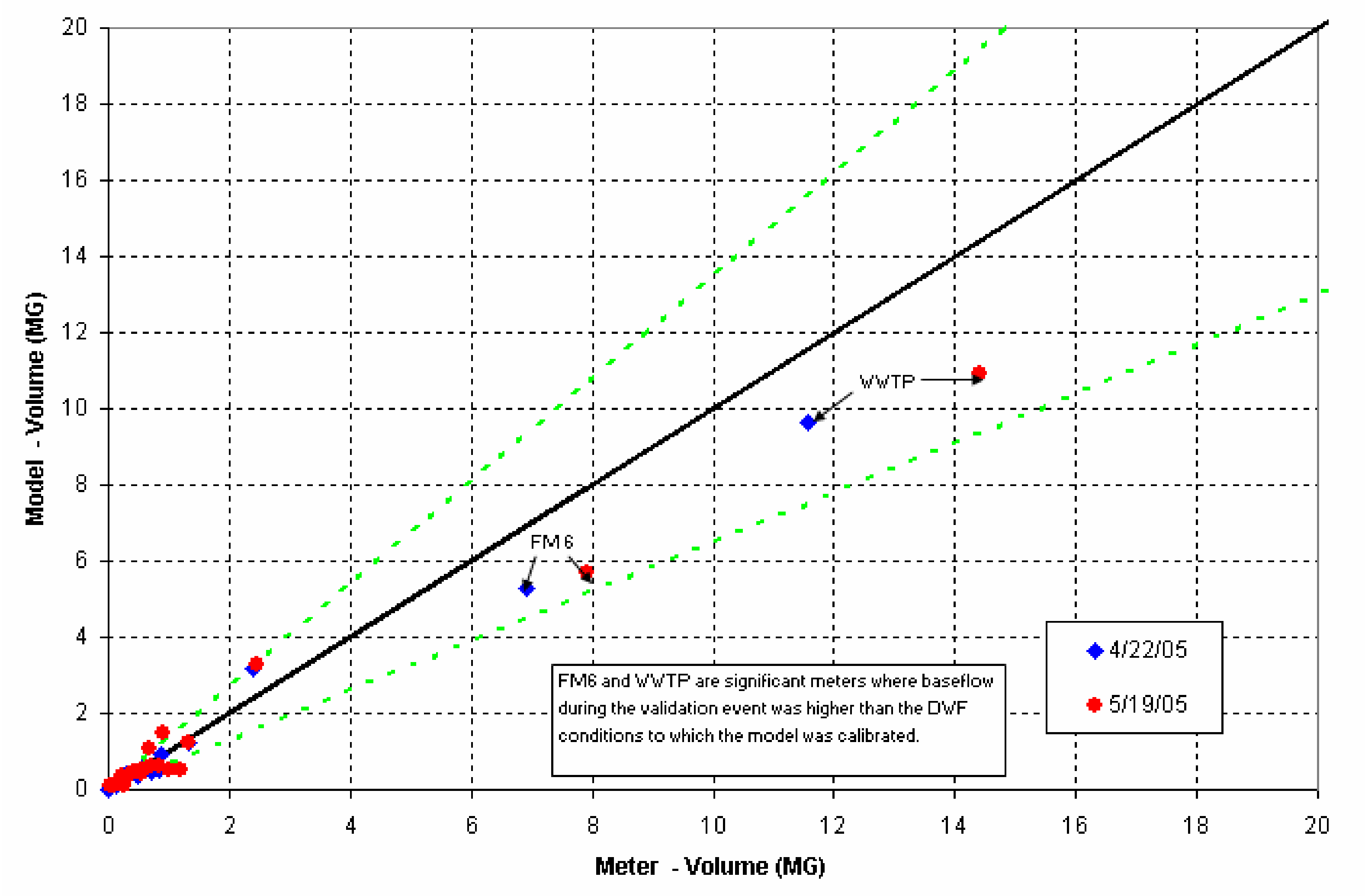


**Figure 3: Model-to-Meter Wet-Weather Volume Comparisons Zoom – Screened Data**

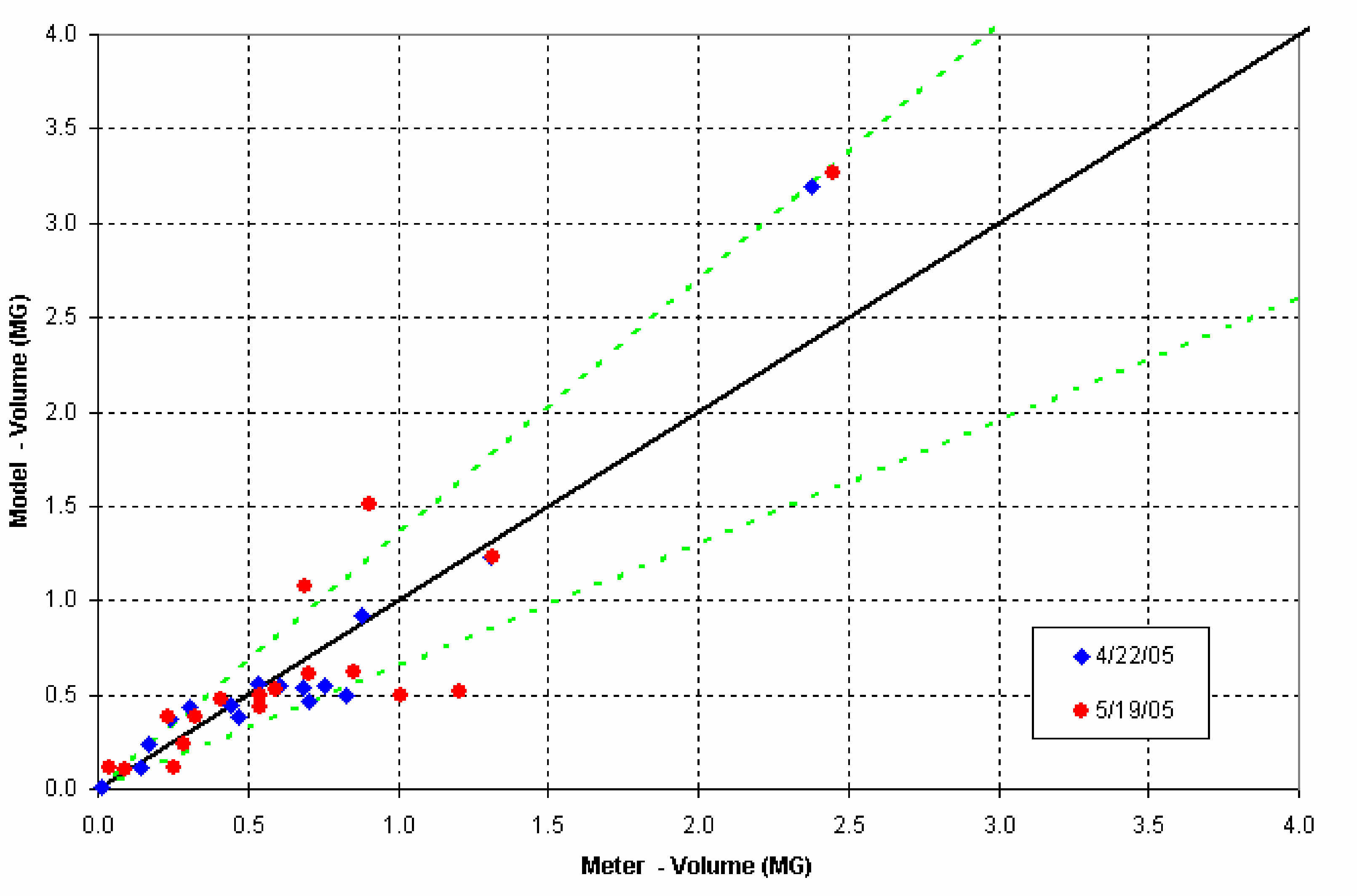


**Figure 4: Wet-Weather Peak Flow Histogram Comparison for Validation Events - Screened Data**

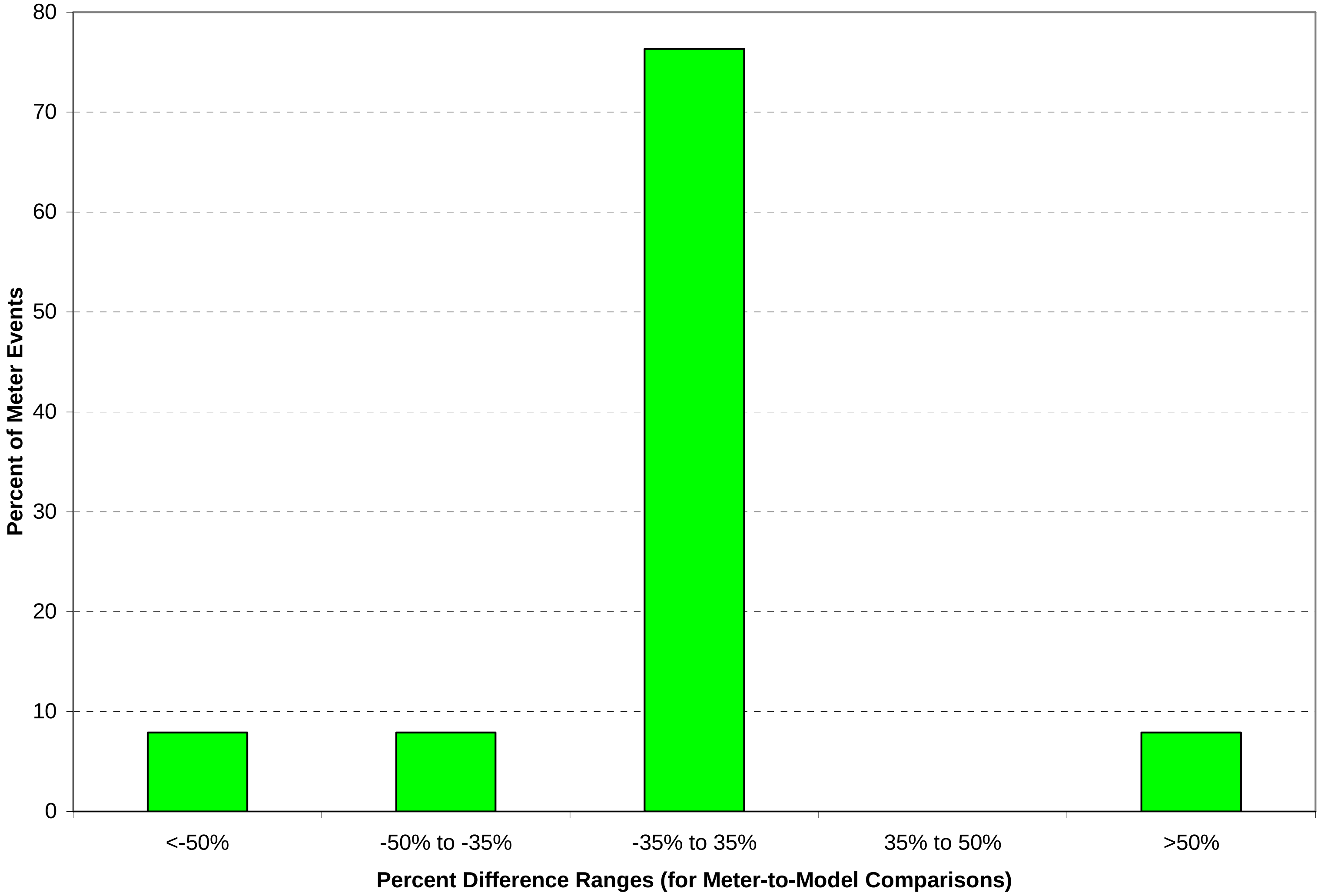
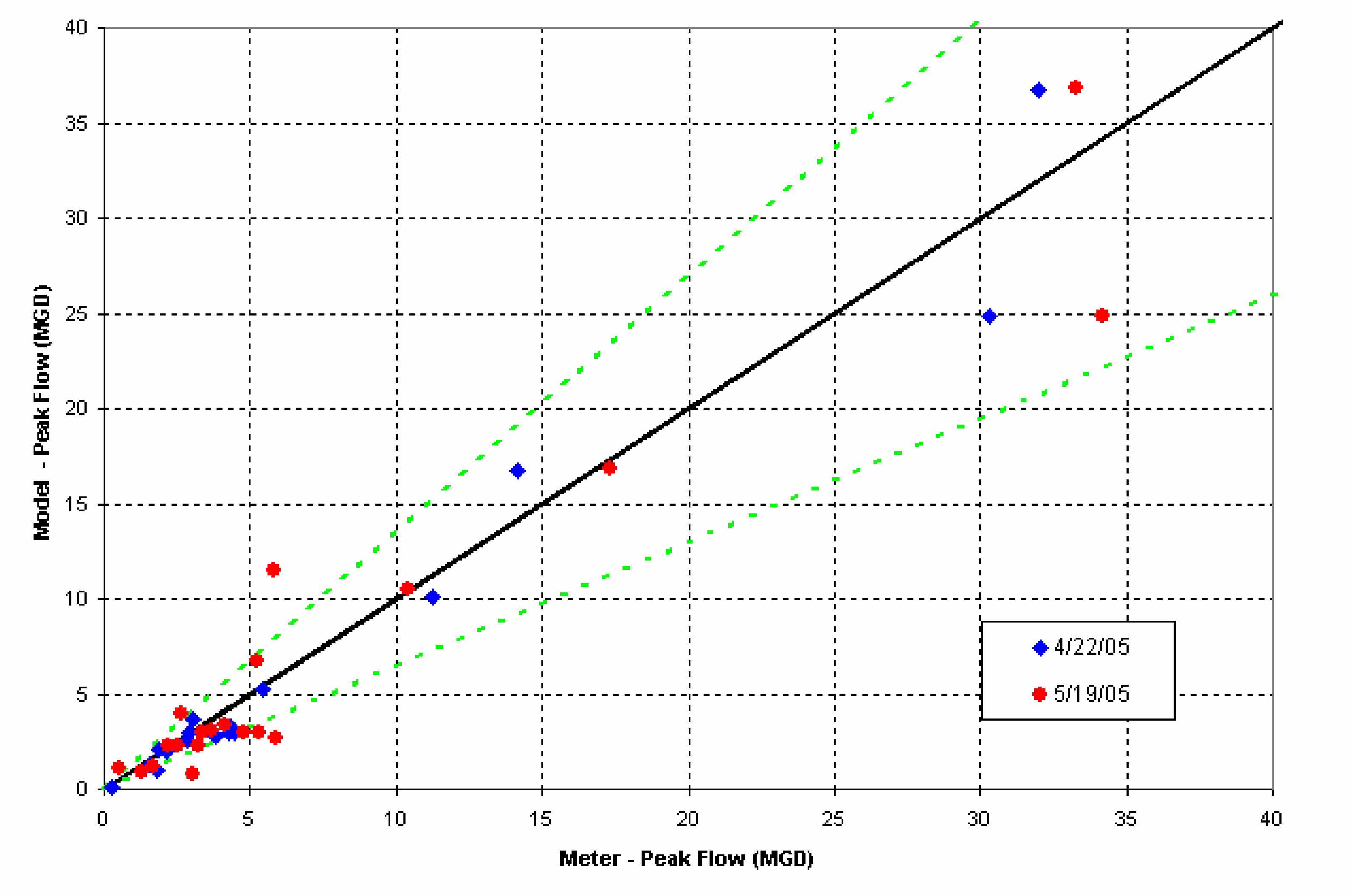
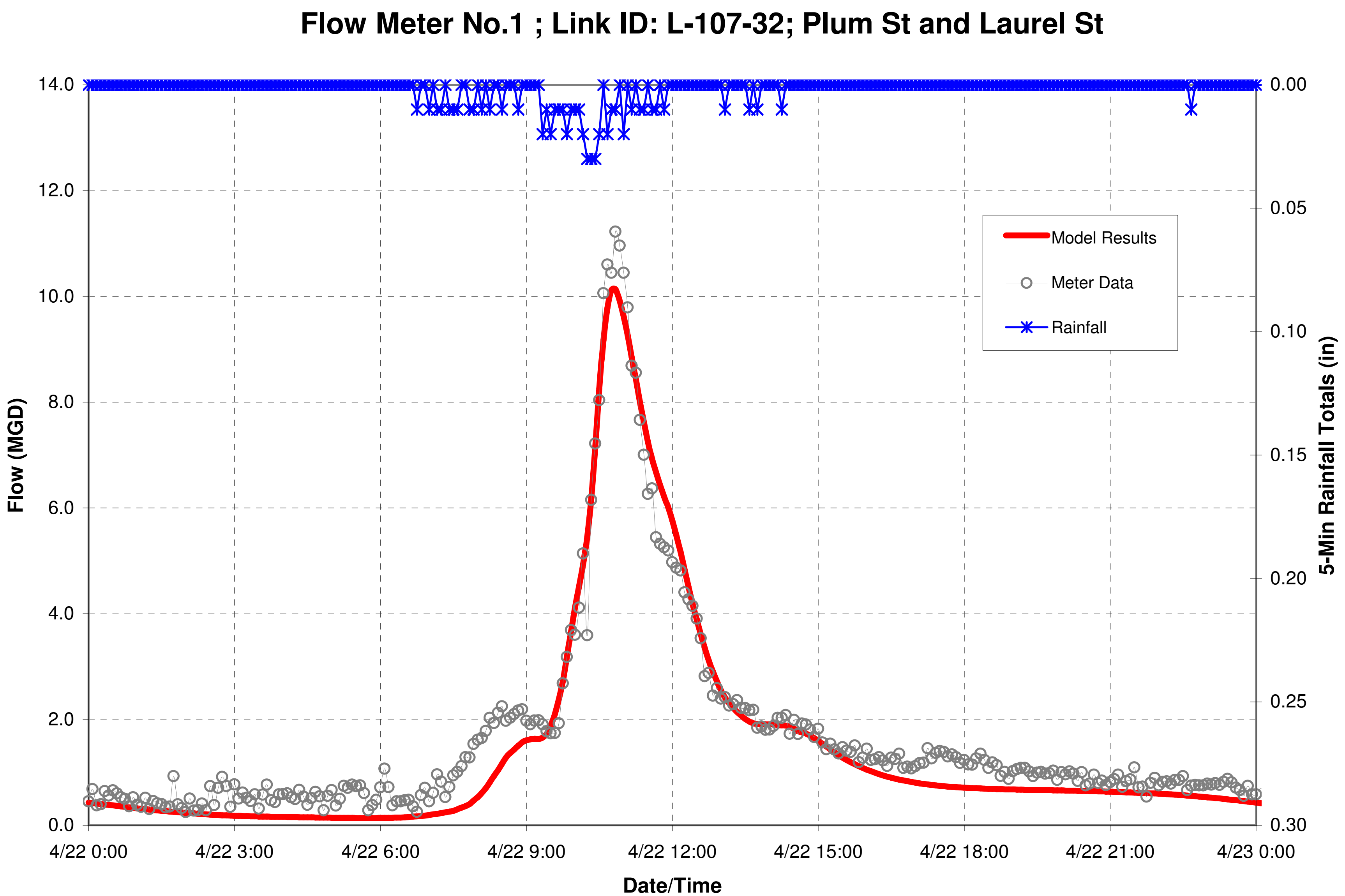


**Figure 5: Model-to-Meter Wet-Weather Peak Flow Comparisons - Screened Data**

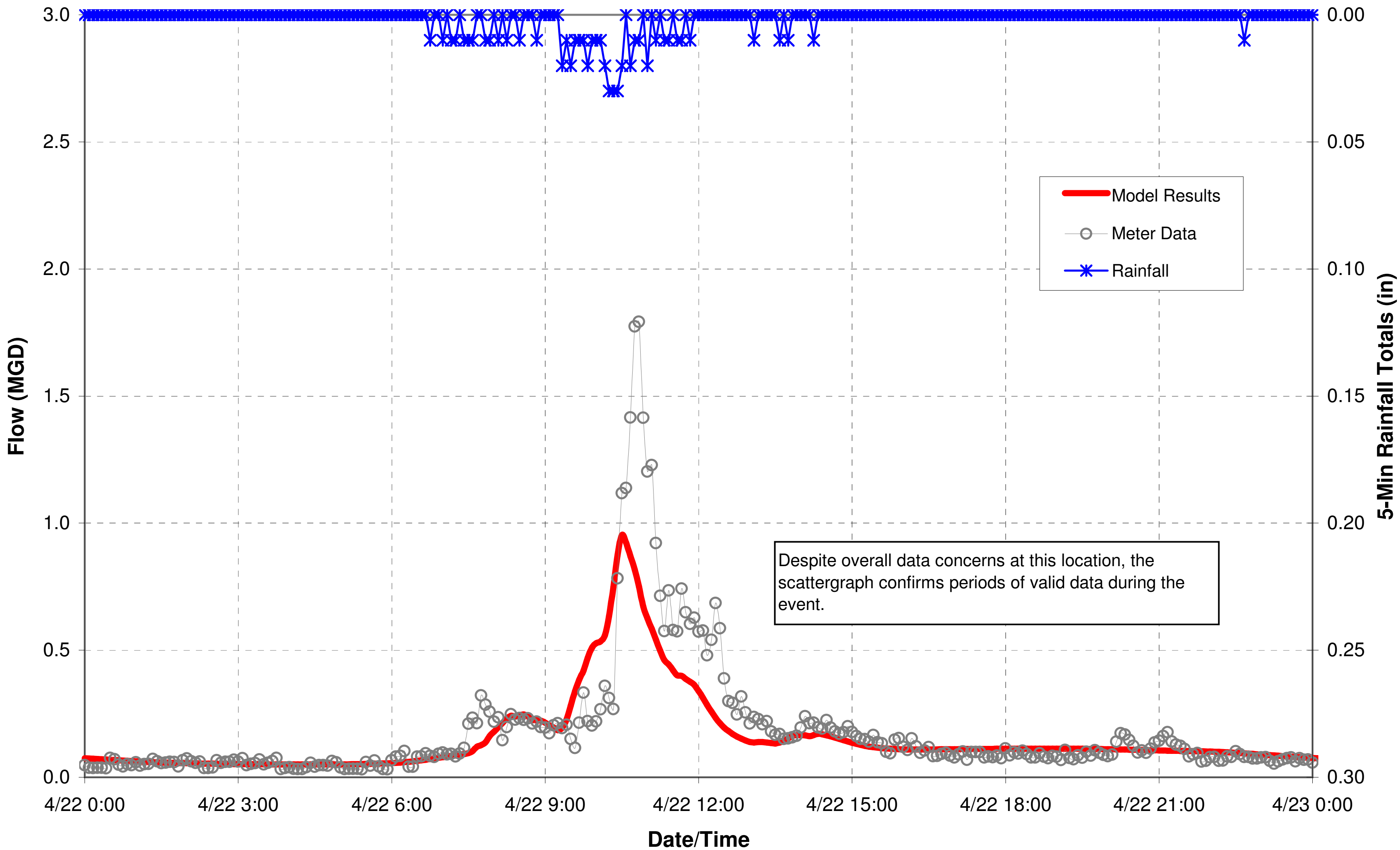


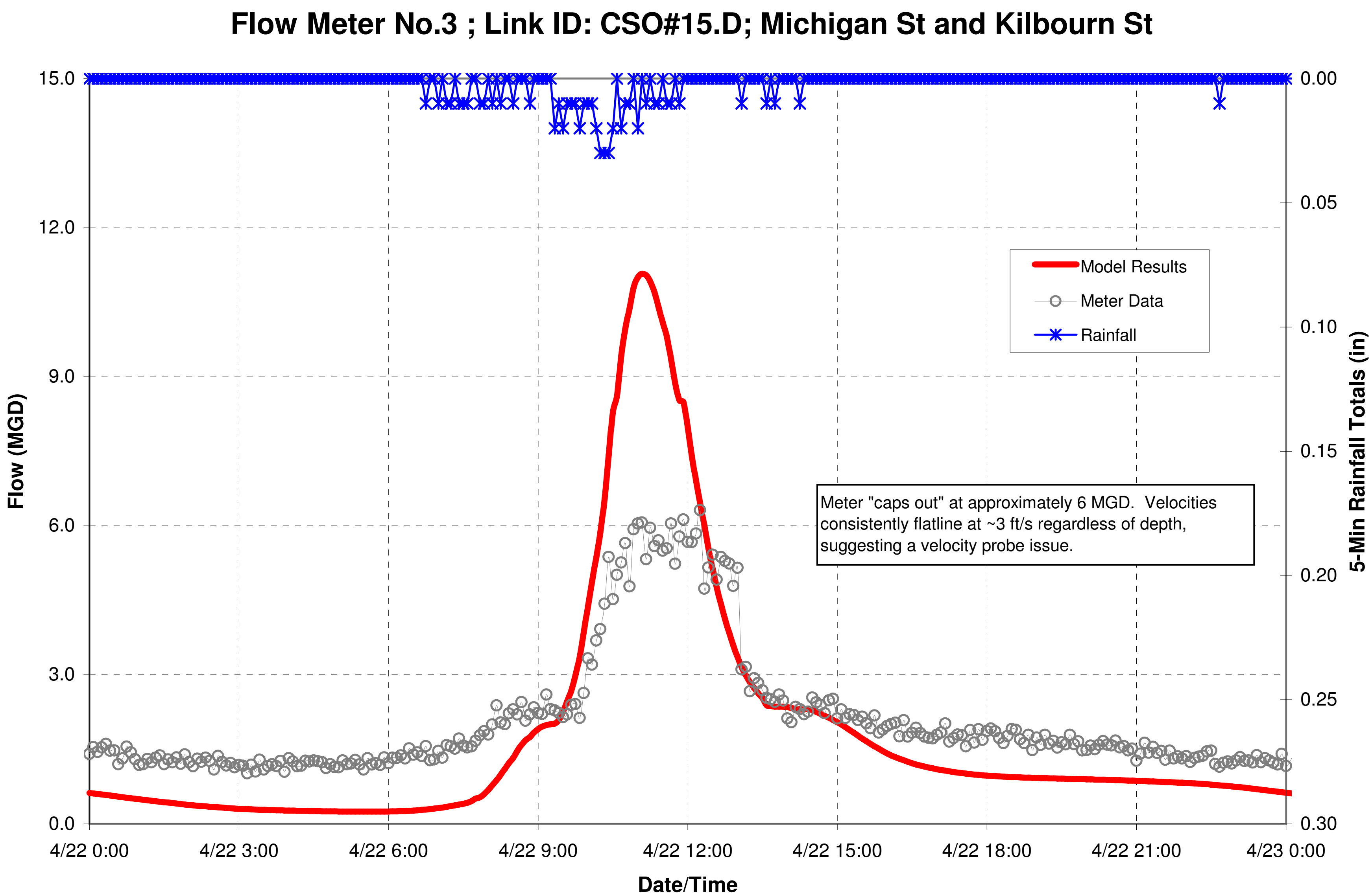
# Appendix 1

# Meter-to-Model Flow Hydrographs

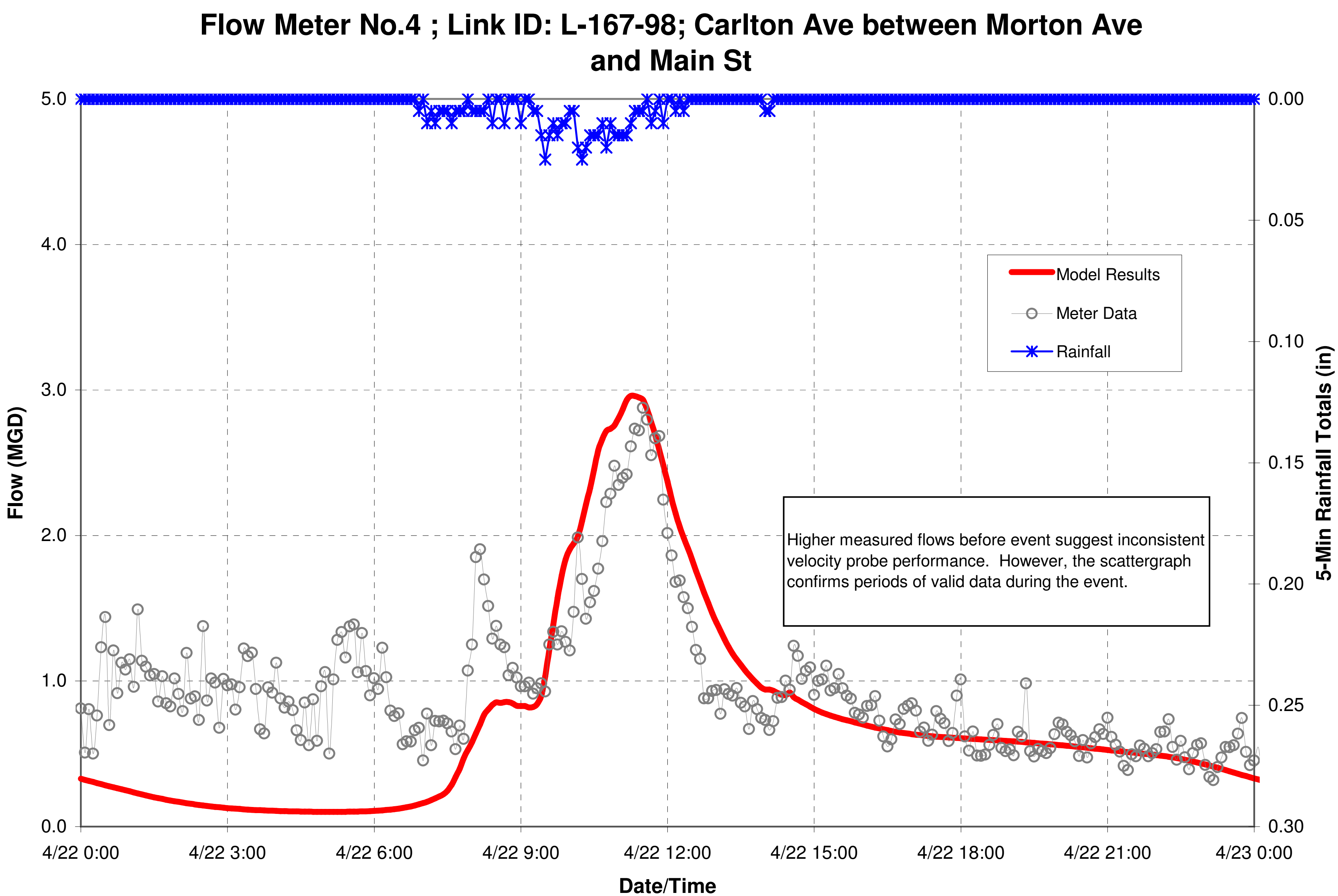

Flow Meter No.1 ; Link ID: L-107-32; Plum St and Laurel St
Flow (MGD)
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall

# Flow Meter No.2 ; Link ID: L-106-37; Michigan St and Laurel St

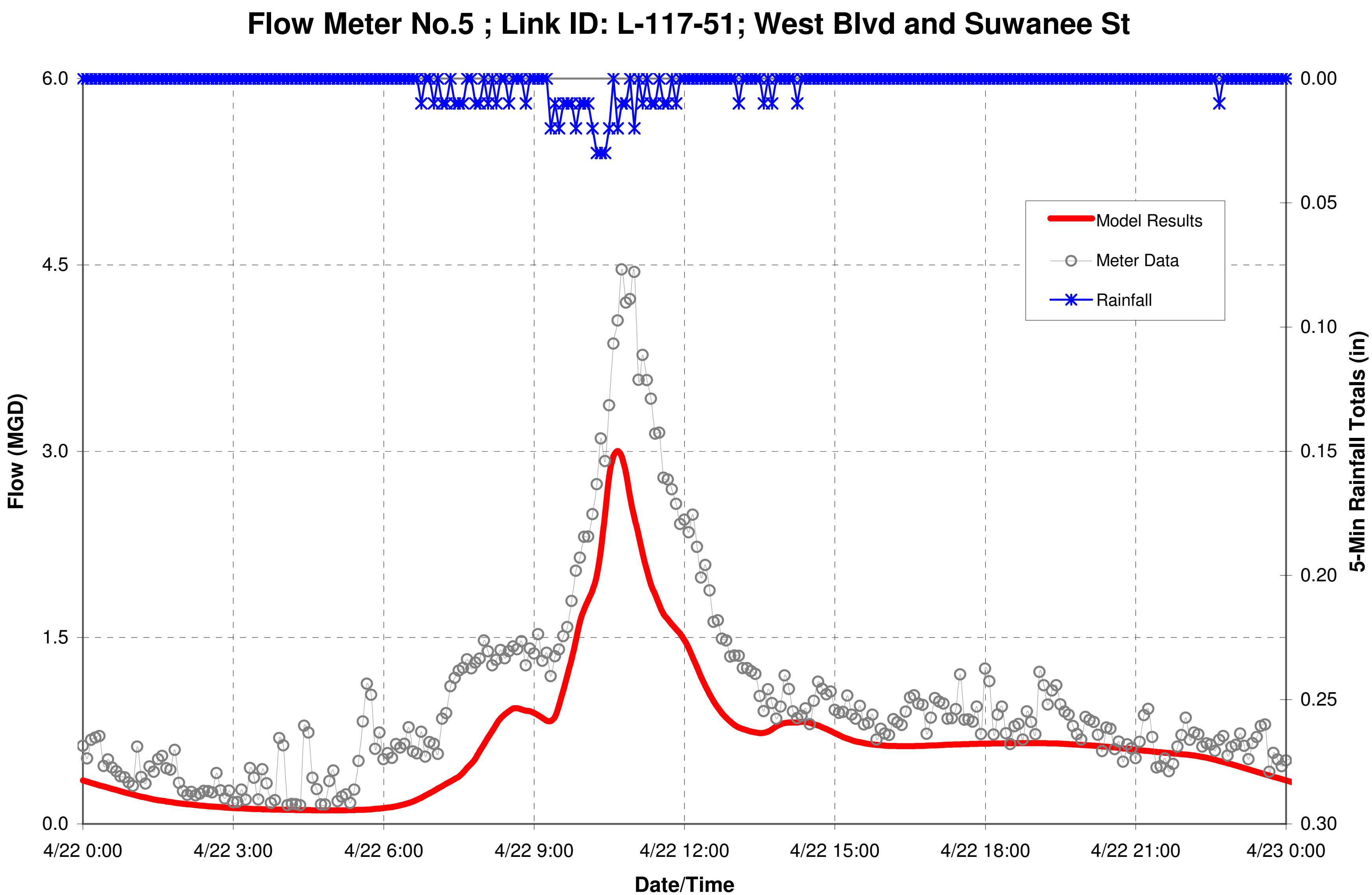




Flow Meter No.3 ; Link ID: CSO#15.D; Michigan St and Kilbourn St
15.0
12.0
9.0
6.0
3.0
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall
Meter "caps out" at approximately 6 MGD. Velocities consistently flatline at ~3 ft/s regardless of depth, suggesting a velocity probe issue.

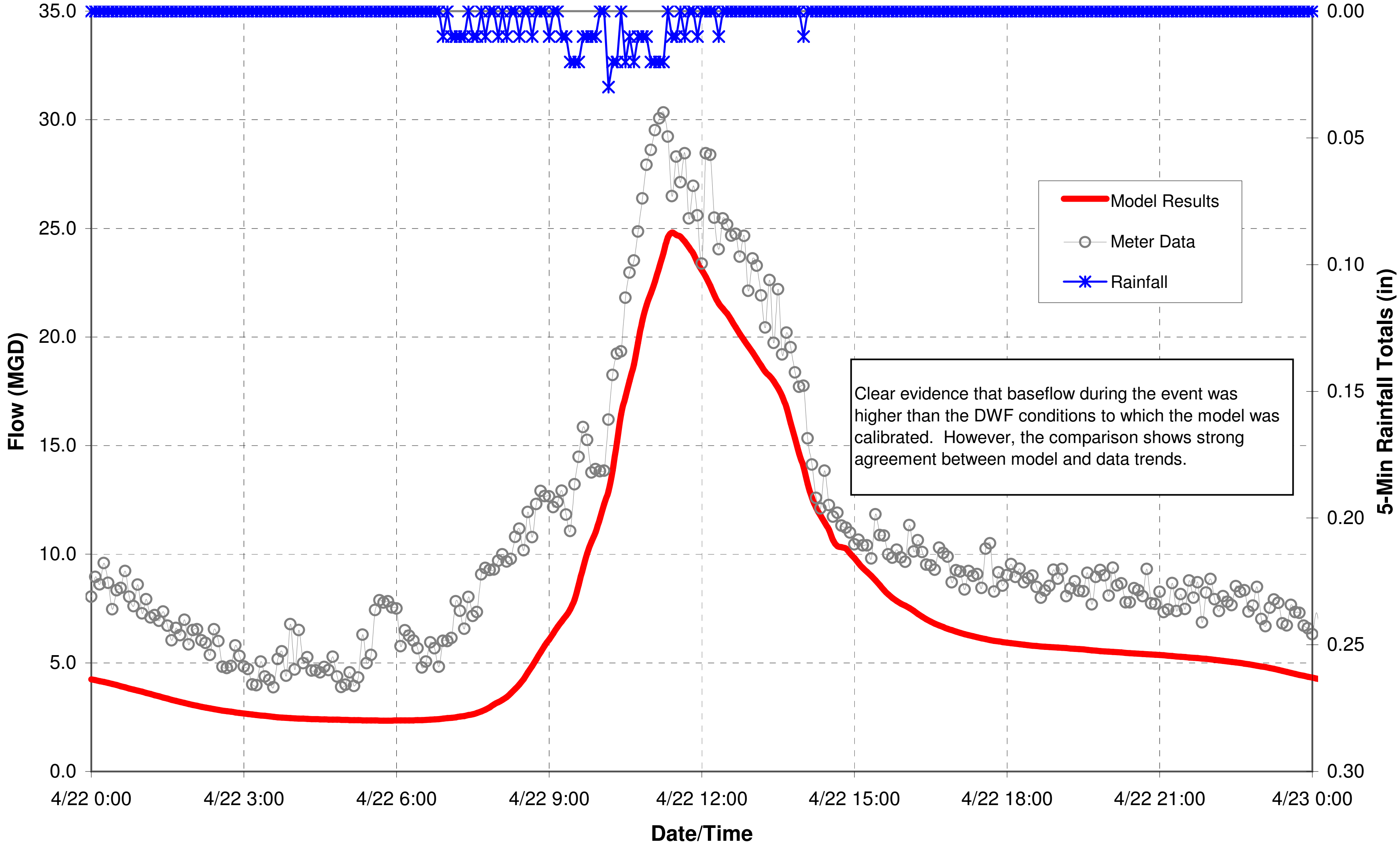


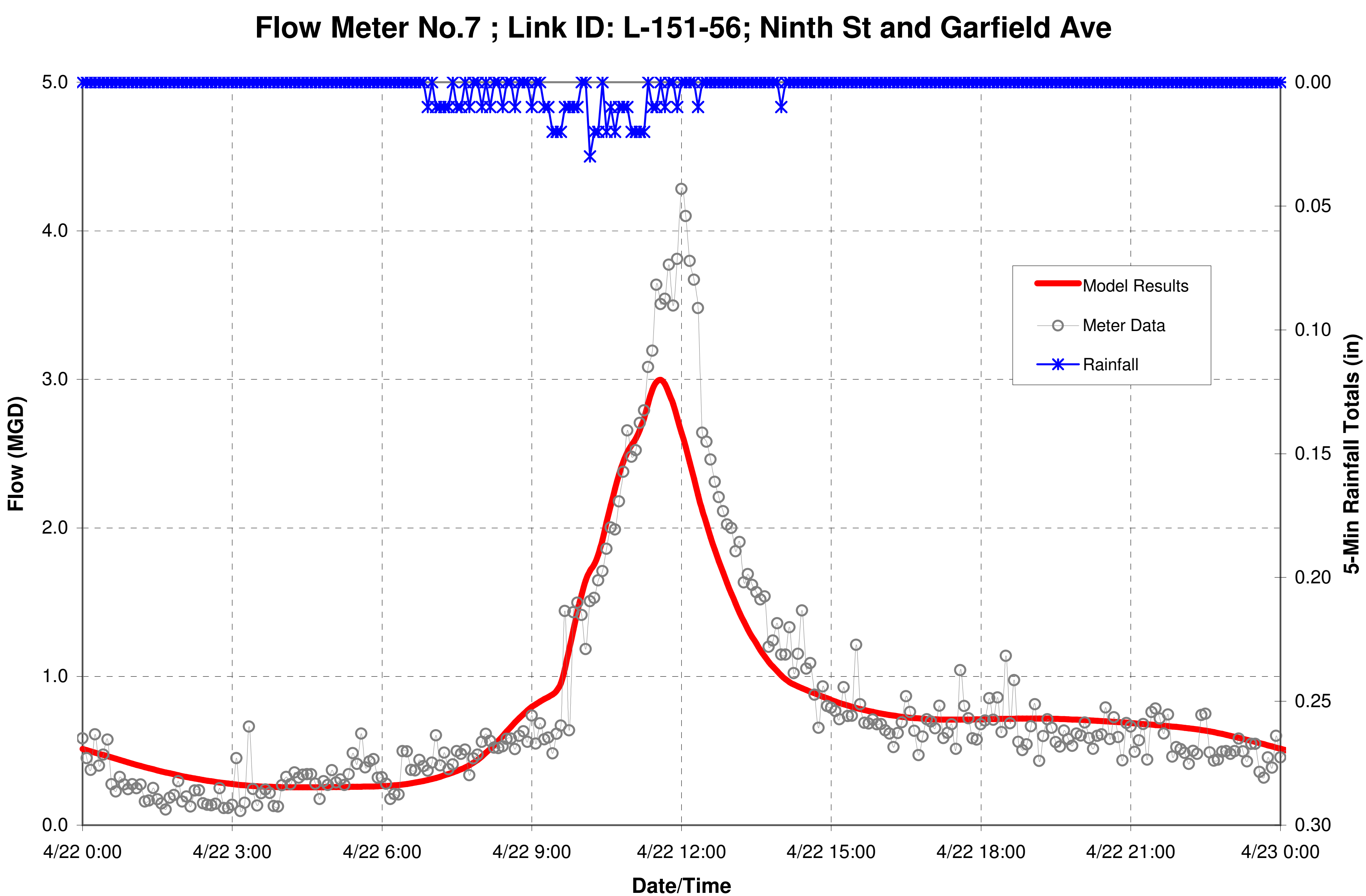
Flow Meter No.4 ; Link ID: L-167-98; Carlton Ave between Morton Ave and Main St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
Higher measured flows before event suggest inconsistent velocity probe performance. However, the scattergraph confirms periods of valid data during the event.
5.0
4.0
3.0
2.0
1.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00



Flow Meter No.5 ; Link ID: L-117-51; West Blvd and Suwanee St
Flow (MGD)
6.0
4.5
3.0
1.5
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Model Results
Meter Data
Rainfall
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time

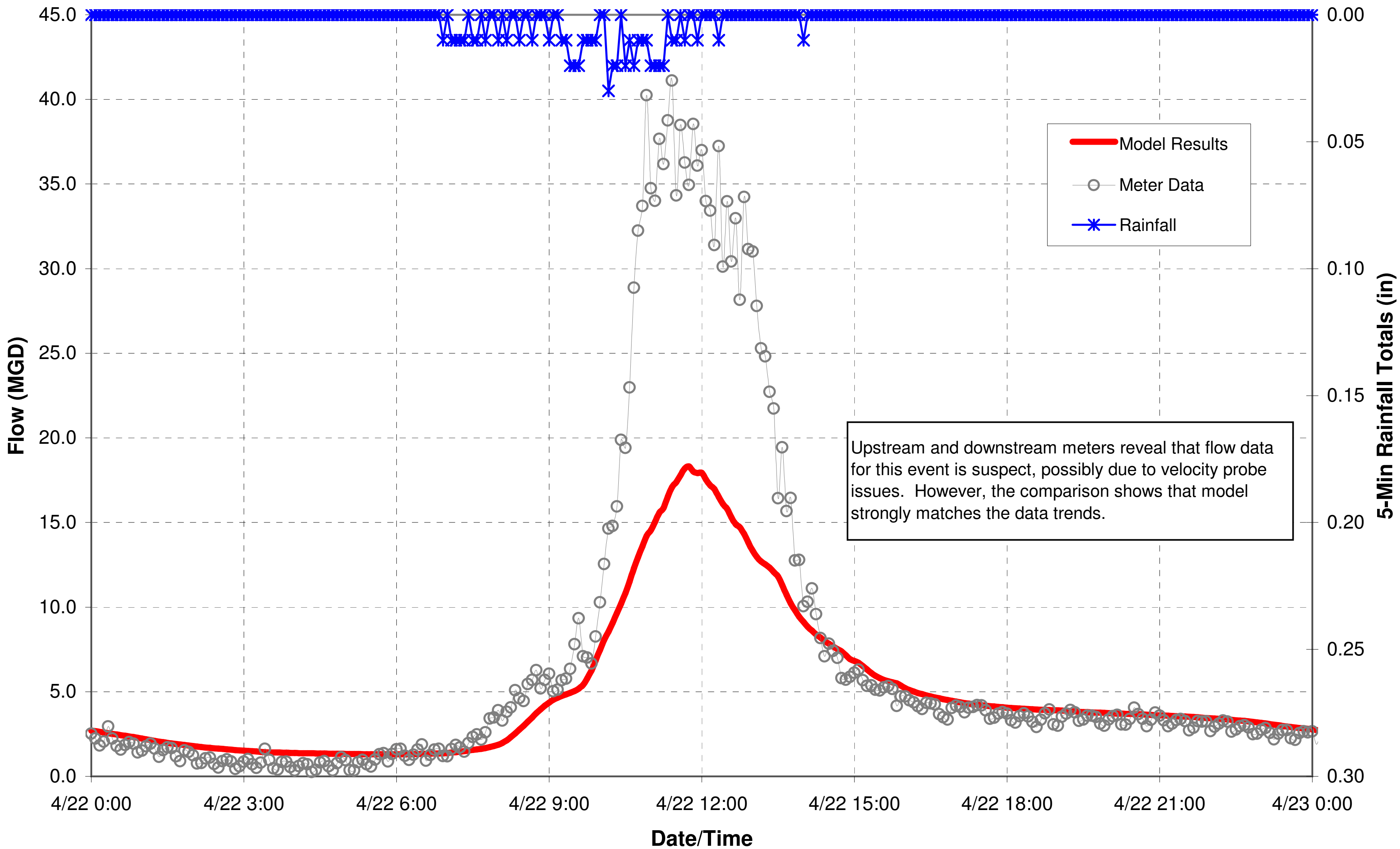
# Flow Meter No.6 ; Link ID: L-139-92; Indiana Ave and Albany St

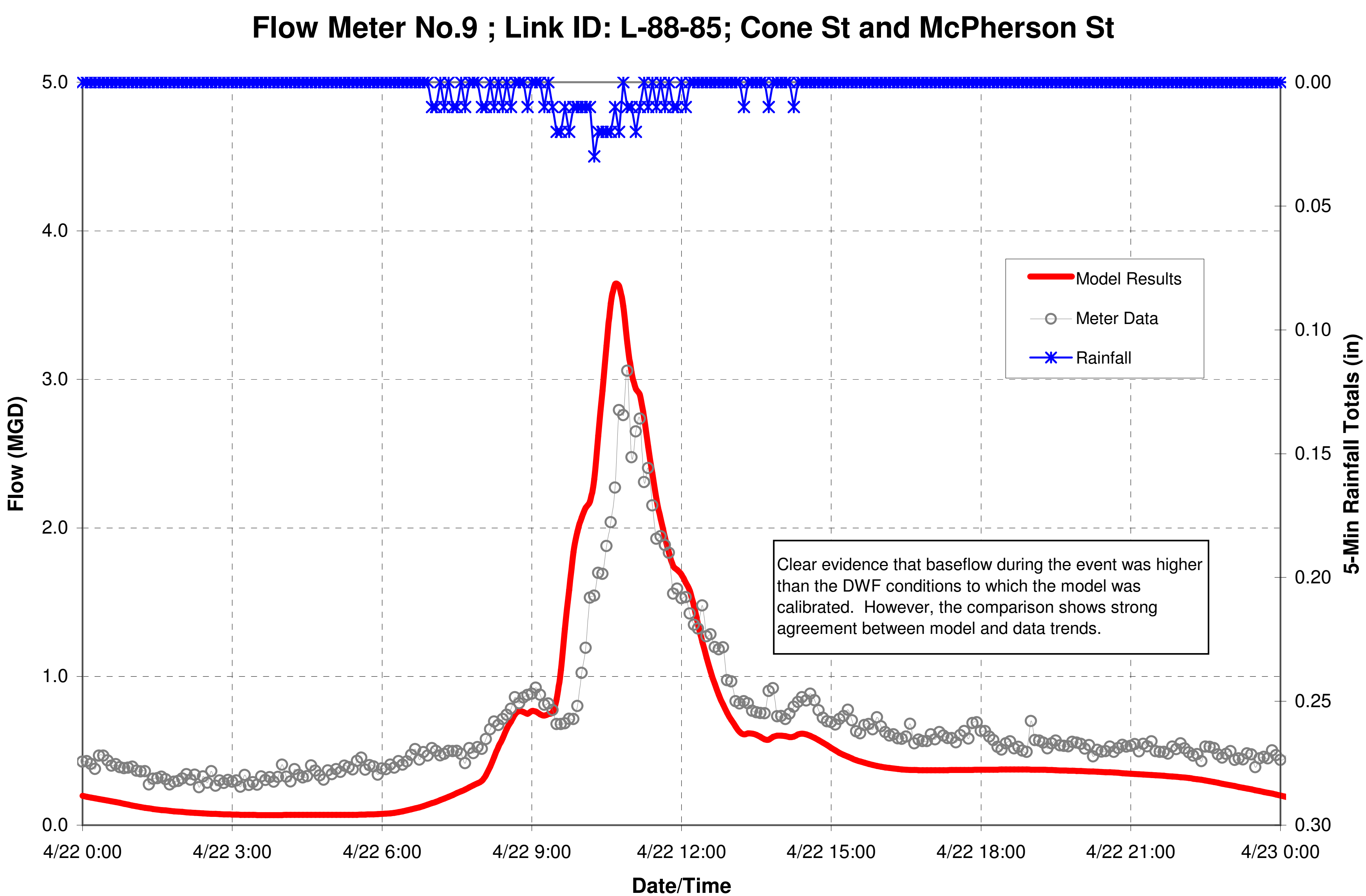




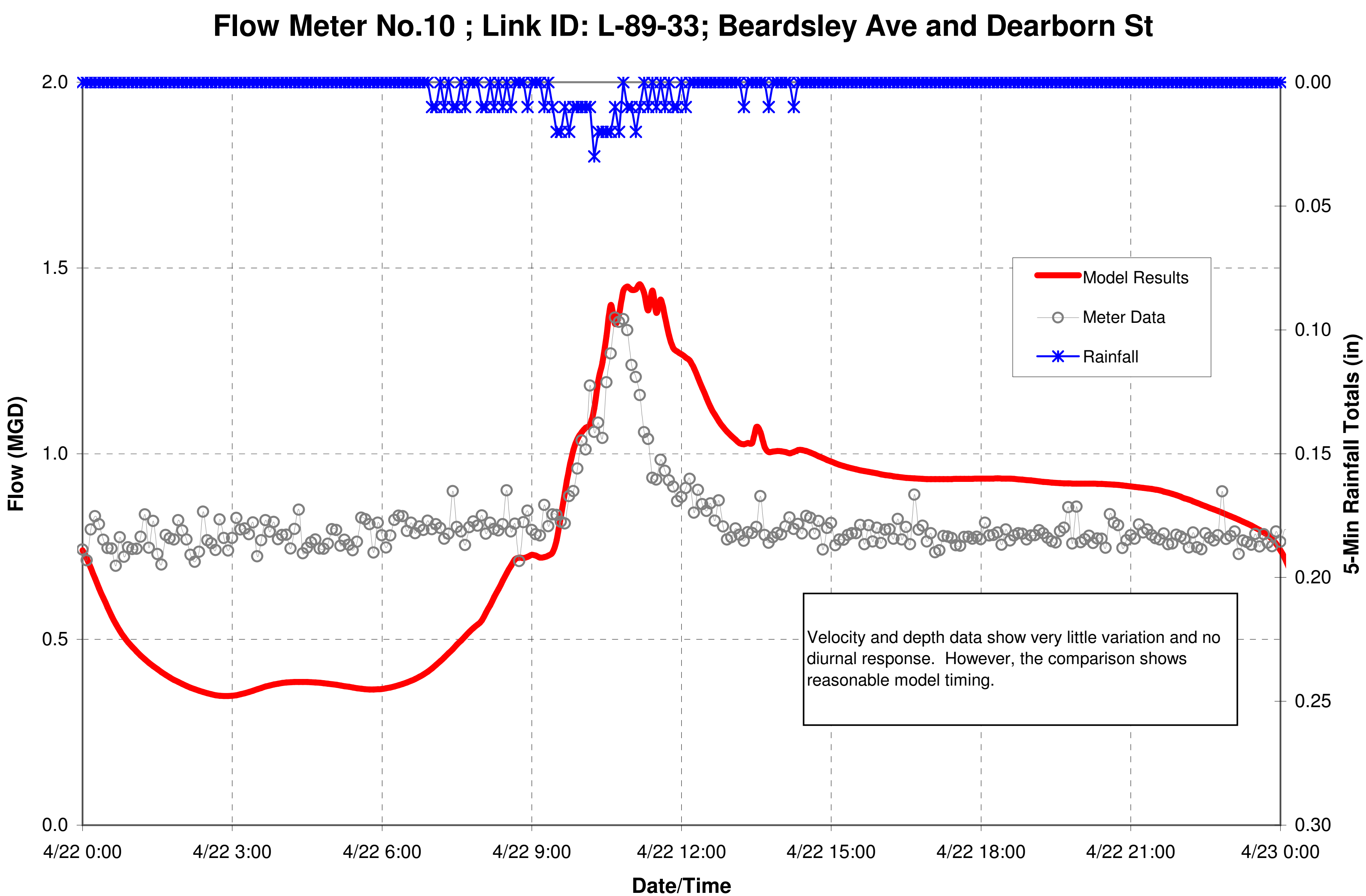
Flow Meter No.7 ; Link ID: L-151-56; Ninth St and Garfield Ave
Model Results
Meter Data
Rainfall
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
5.0
4.0
3.0
2.0
1.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00

# Flow Meter No.8 ; Link ID: L-138-50; Wagner Ave and Eighth St



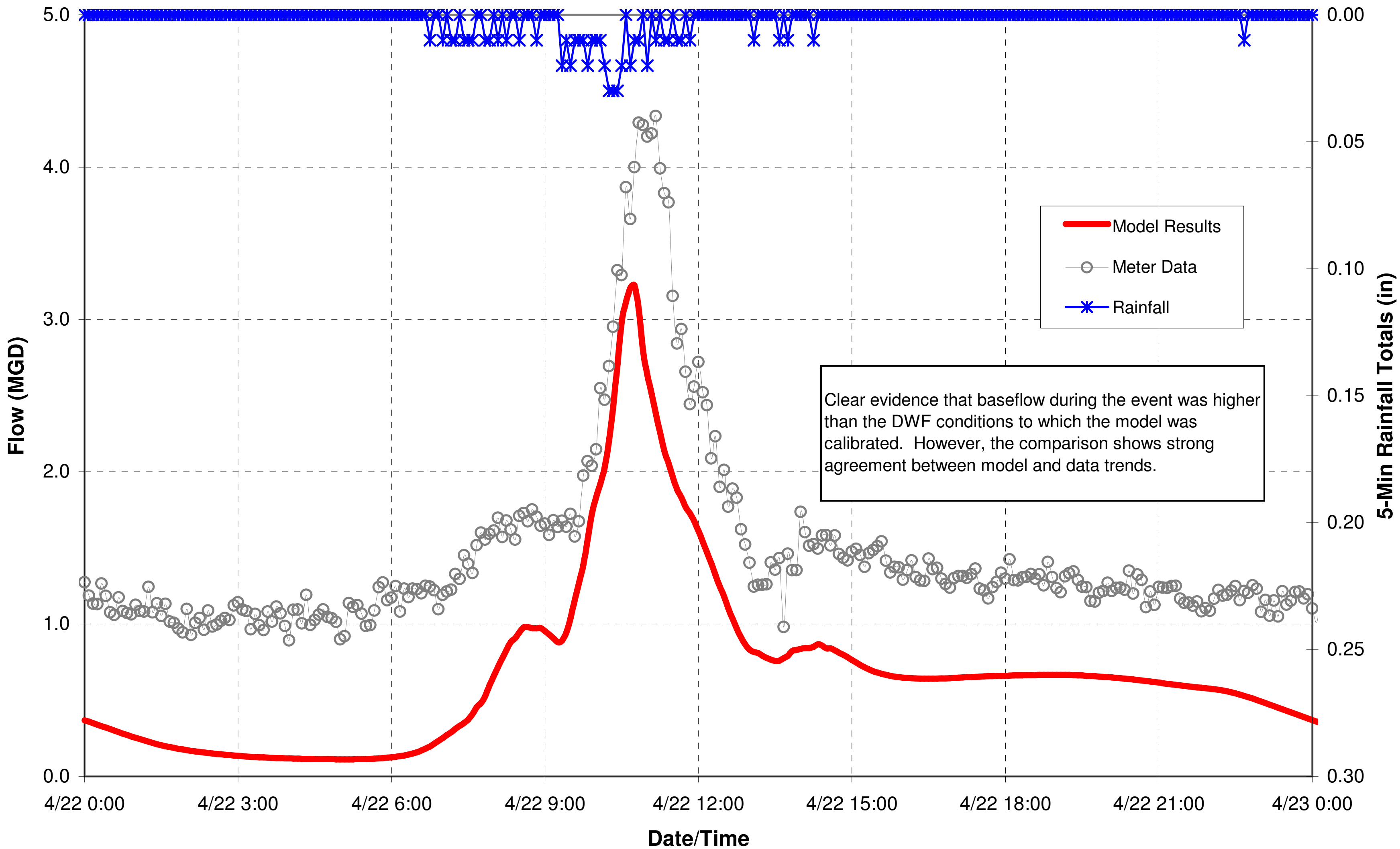


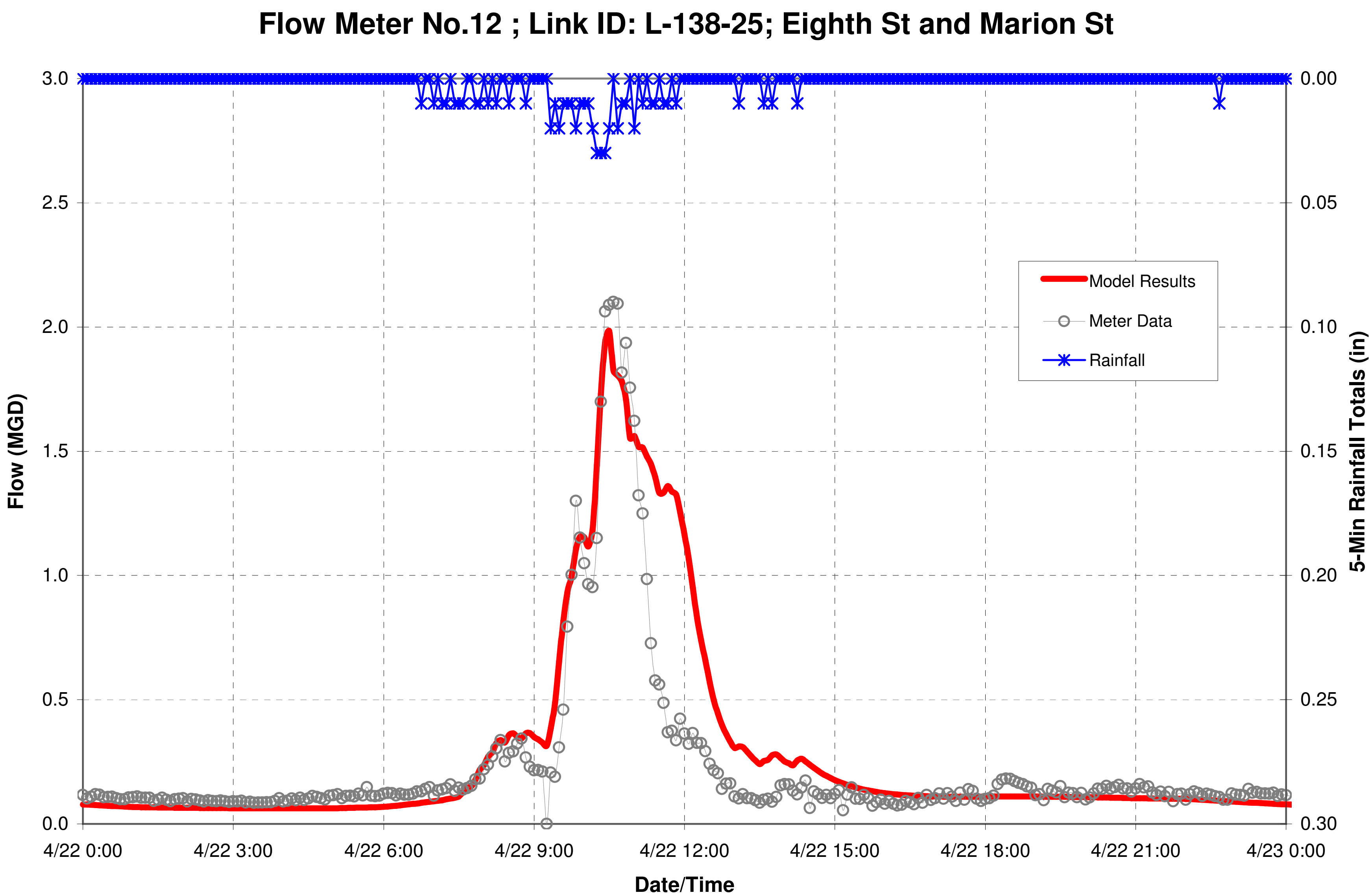
Flow Meter No.9 ; Link ID: L-88-85; Cone St and McPherson St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends.
5.0
4.0
3.0
2.0
1.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00

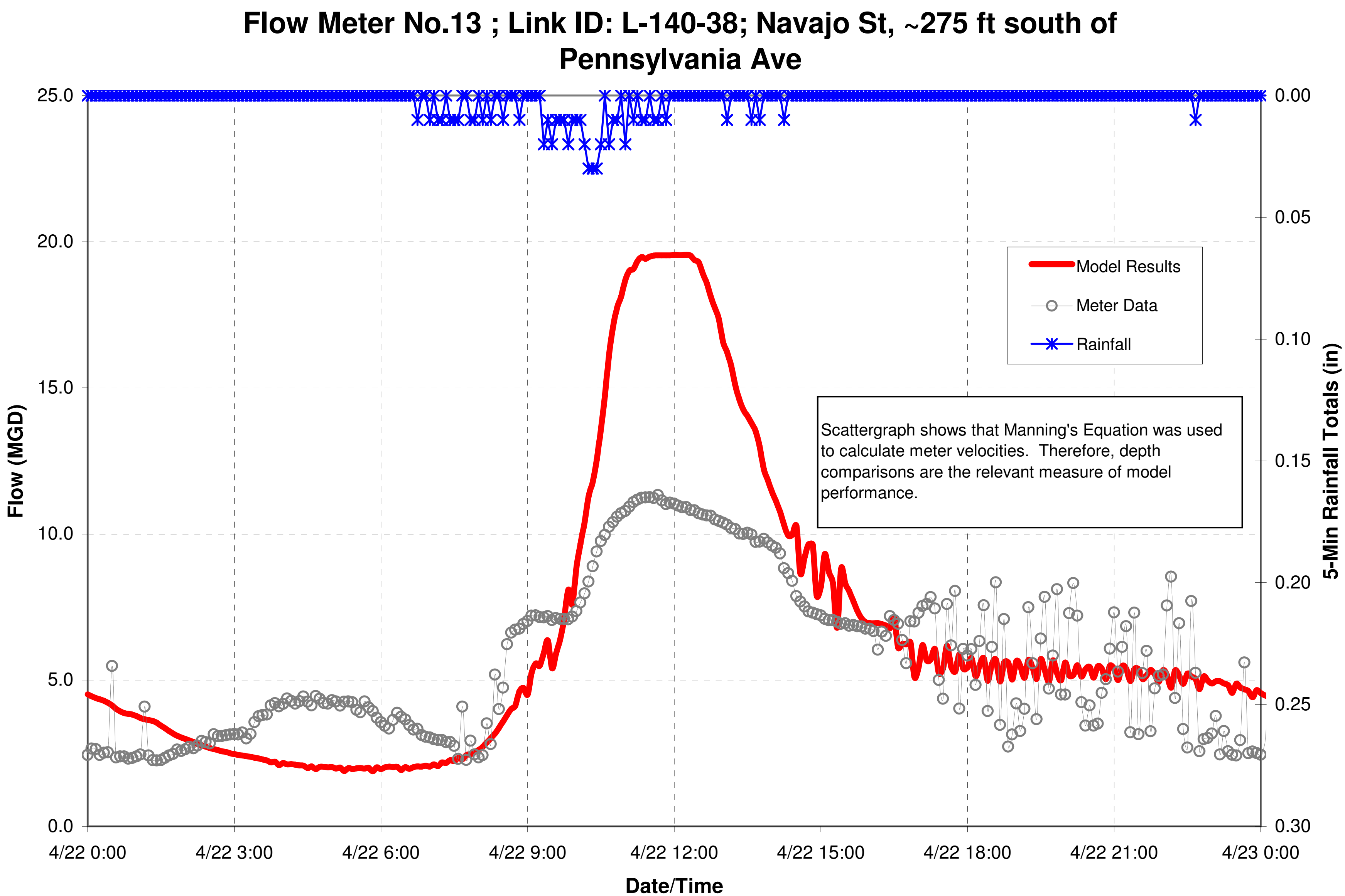


Flow Meter No.10 ; Link ID: L-89-33; Beardsley Ave and Dearborn St
Flow (MGD)
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall
Velocity and depth data show very little variation and no diurnal response. However, the comparison shows reasonable model timing.

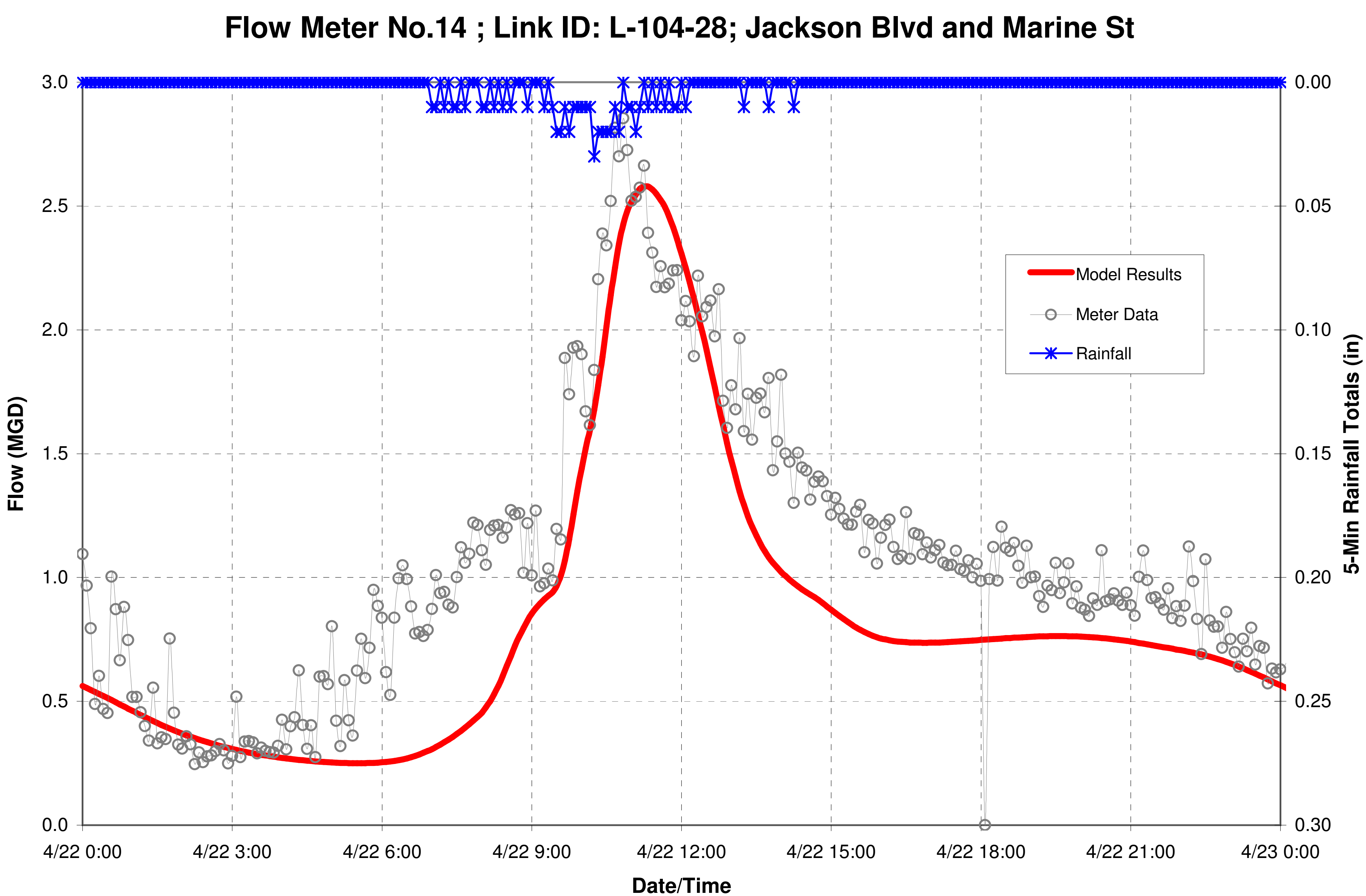
# Flow Meter No.11 ; Link ID: CSO#17.D; McNaughton Park, between CSOs 17 and 18

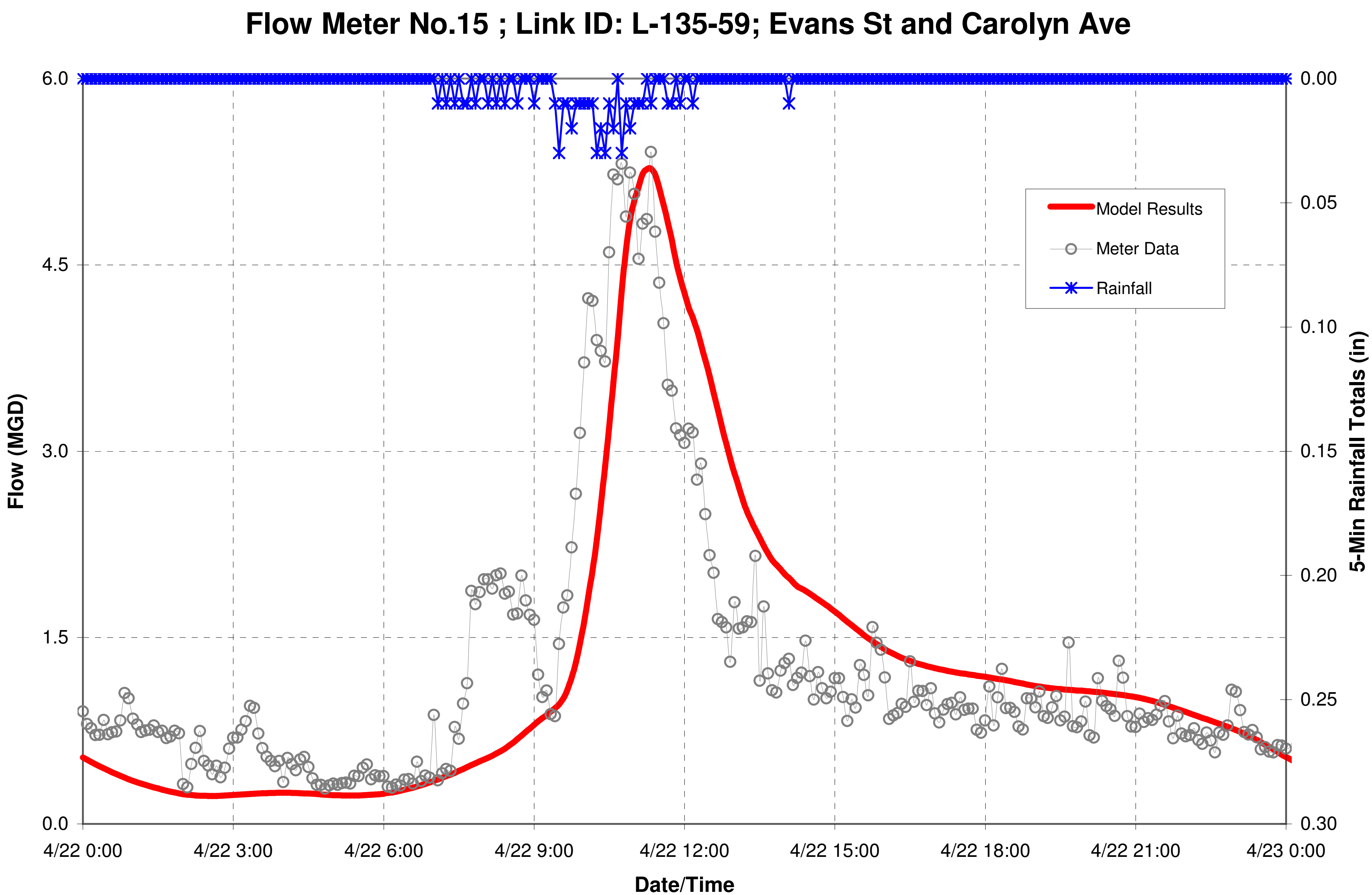



Flow Meter No.12 ; Link ID: L-138-25; Eighth St and Marion St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00



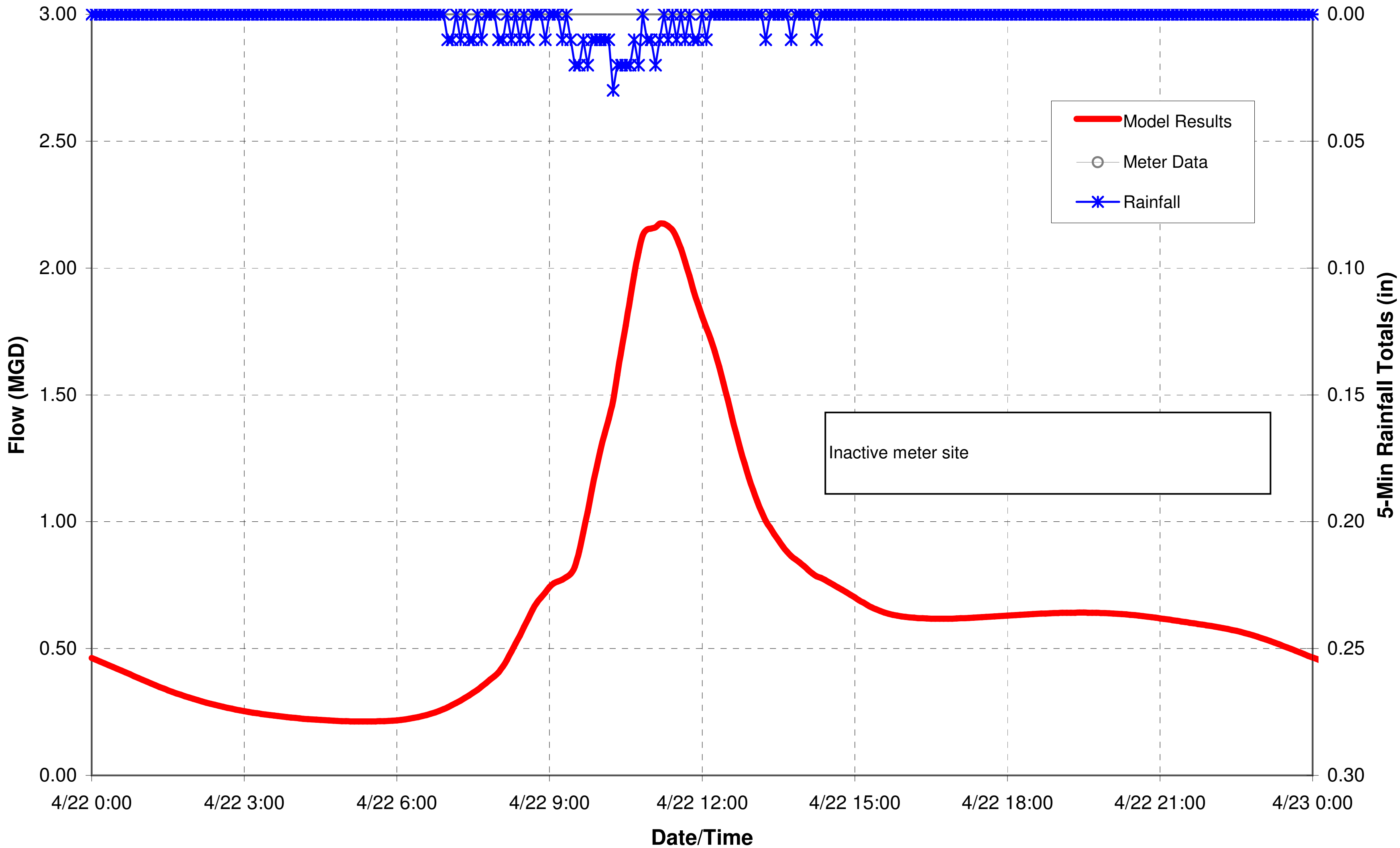
Flow Meter No.13 ; Link ID: L-140-38; Navajo St, ~275 ft south of Pennsylvania Ave
25.0
20.0
15.0
10.0
5.0
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall
Scattergraph shows that Manning's Equation was used to calculate meter velocities. Therefore, depth comparisons are the relevant measure of model performance.


Flow Meter No.14 ; Link ID: L-104-28; Jackson Blvd and Marine St
Model Results
Meter Data
Rainfall
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00

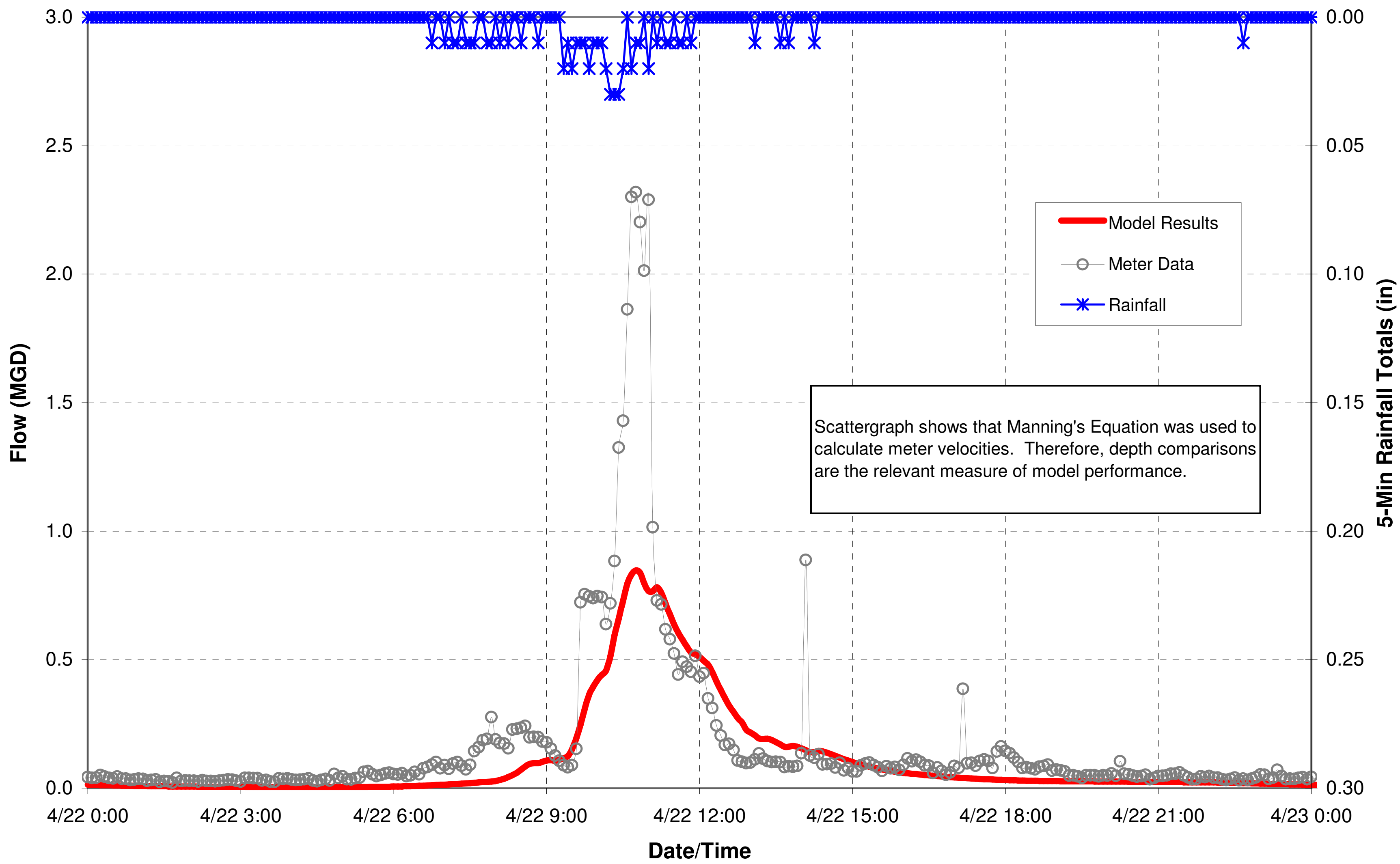


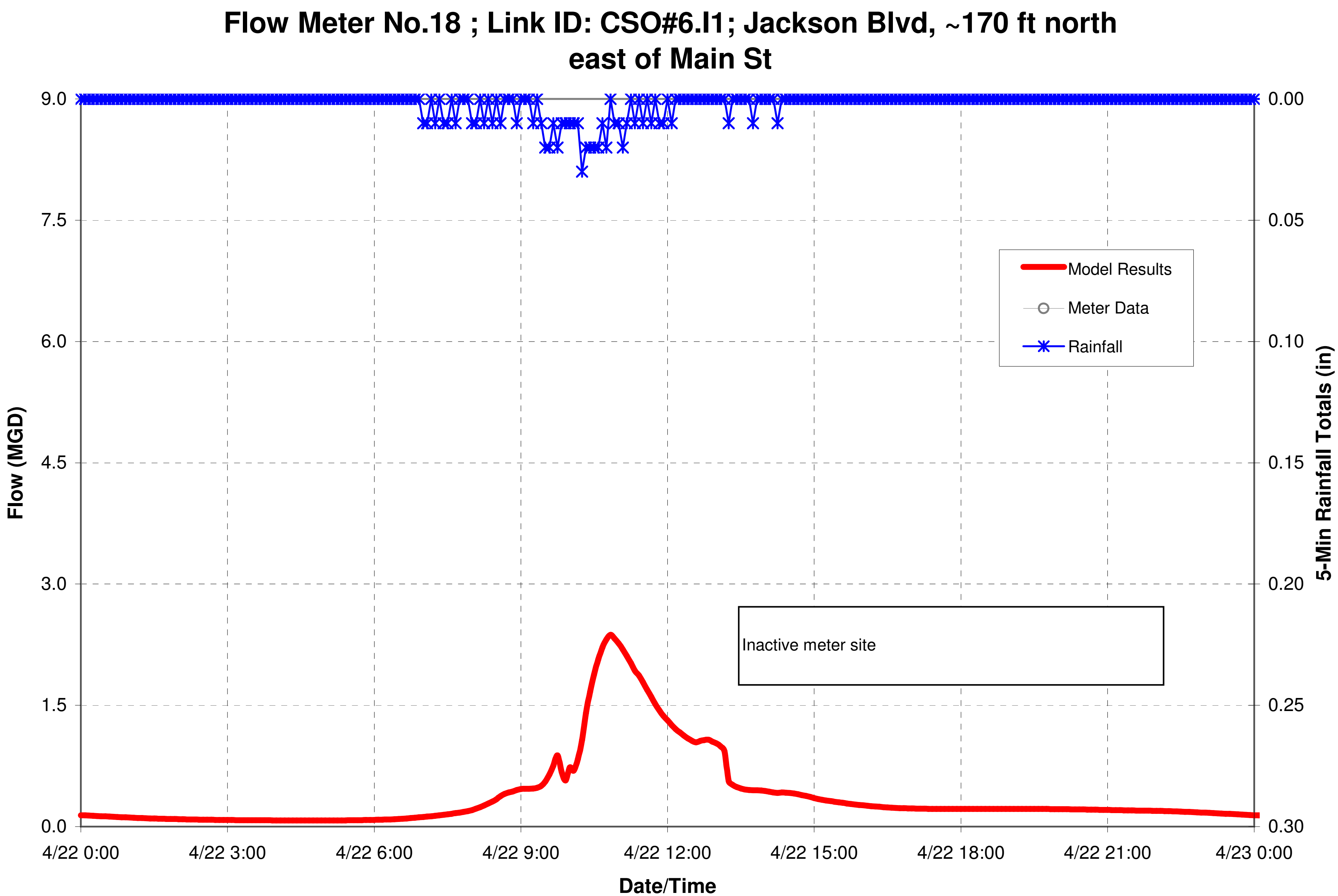
Flow Meter No.15 ; Link ID: L-135-59; Evans St and Carolyn Ave
Flow (MGD)
6.0
4.5
3.0
1.5
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall

## Flow Meter No.16 ; Link ID: CSO#16.I; Southwest corner of Superior St and Kenwood Ave



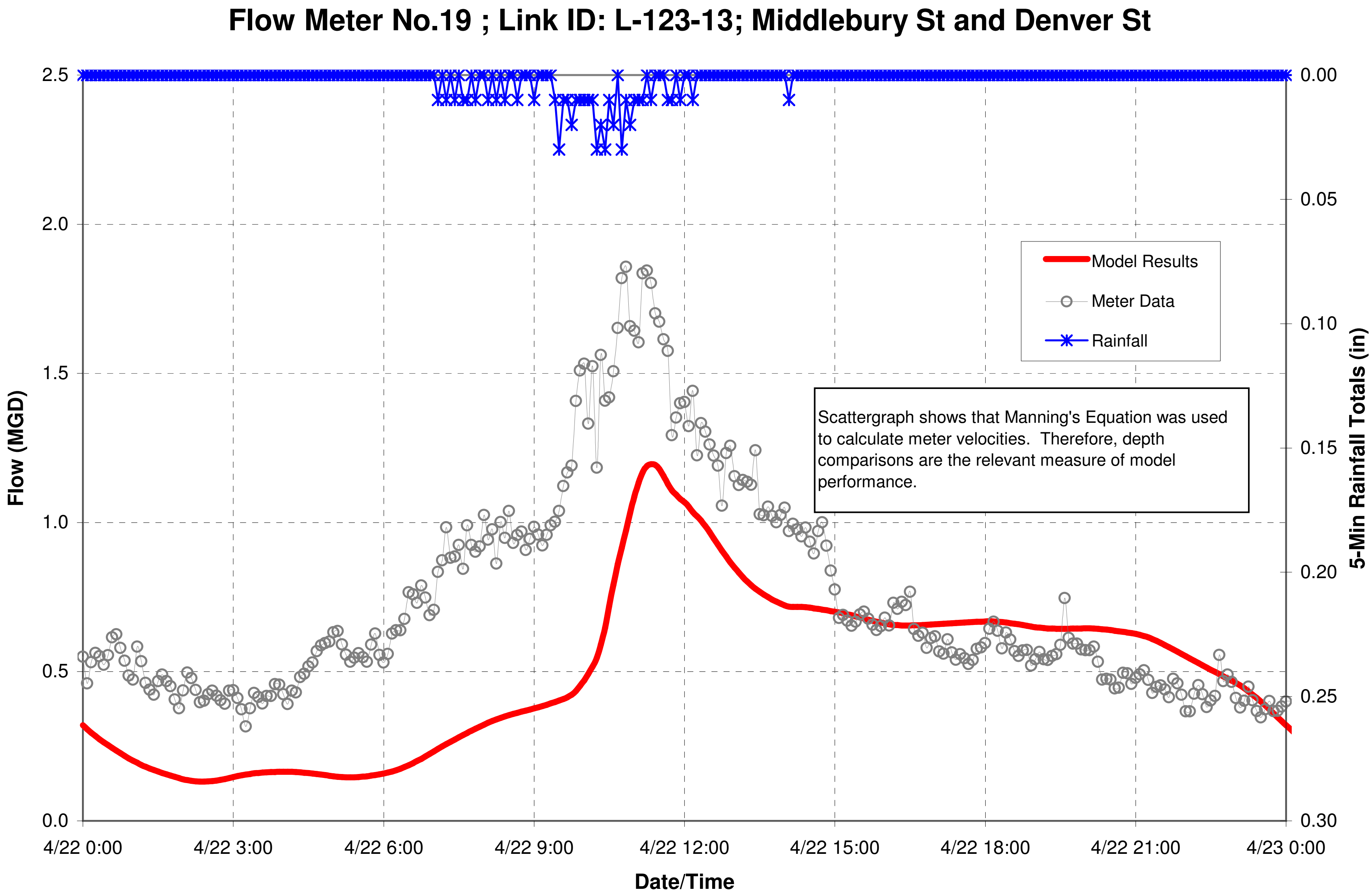
## Flow Meter No.17 ; Link ID: L-105-49; Second St and Sycamore St



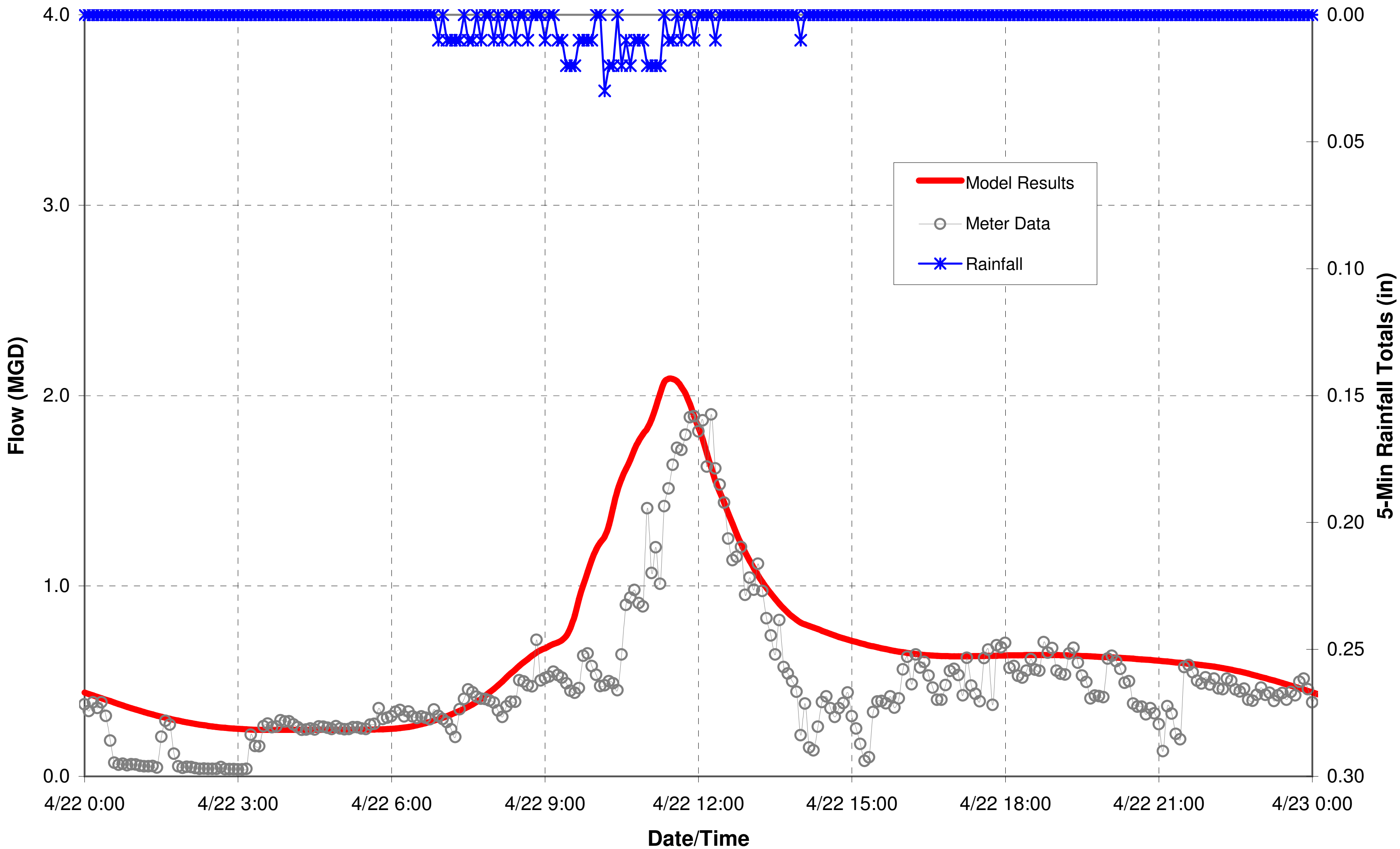


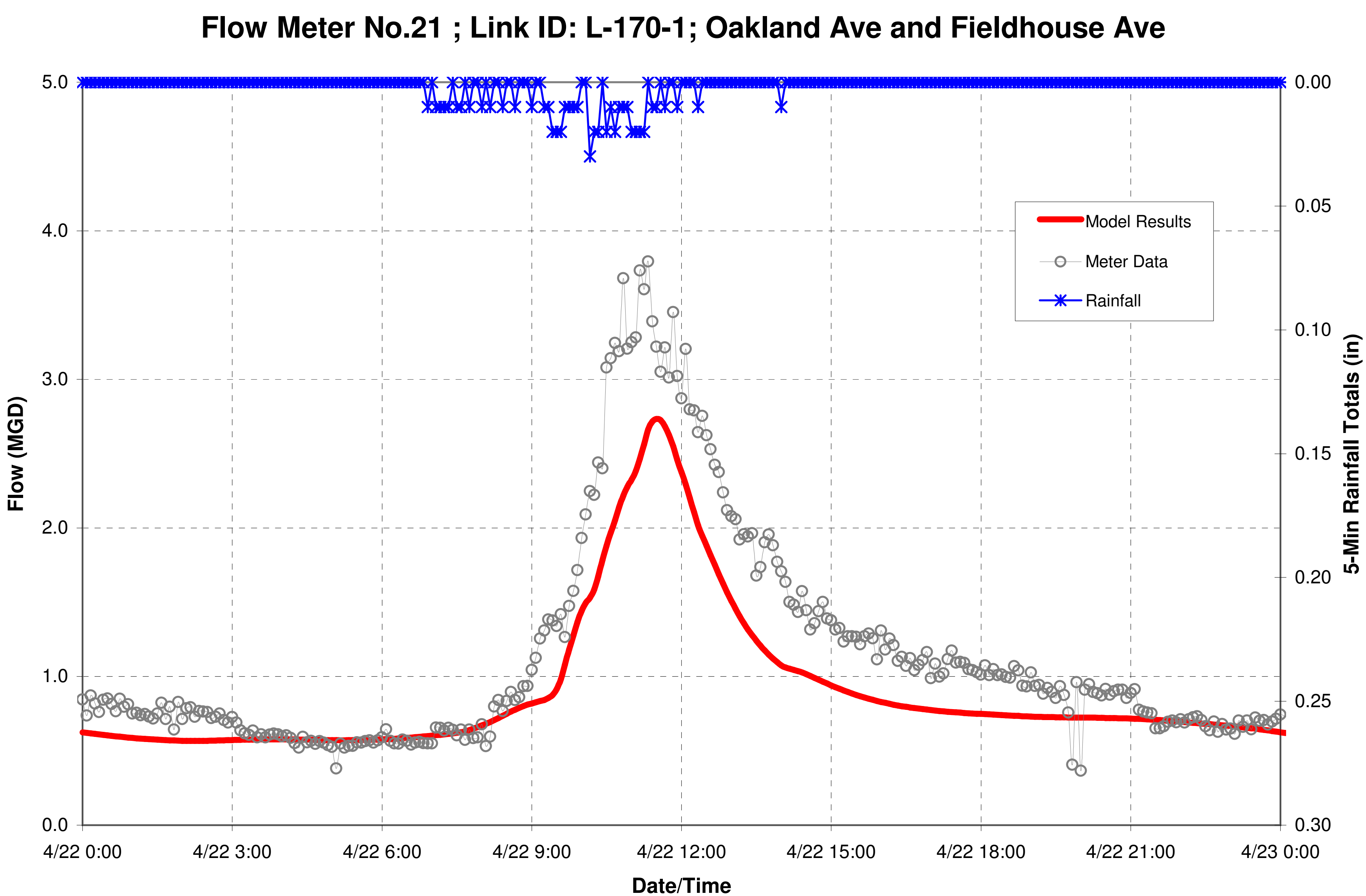
Flow Meter No.18 ; Link ID: CSO#6.I1; Jackson Blvd, ~170 ft north east of Main St
9.0
7.5
6.0
4.5
3.0
1.5
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
Model Results
Meter Data
Rainfall
Inactive meter site
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time

## Flow Meter No.19 ; Link ID: L-123-13; Middlebury St and Denver St

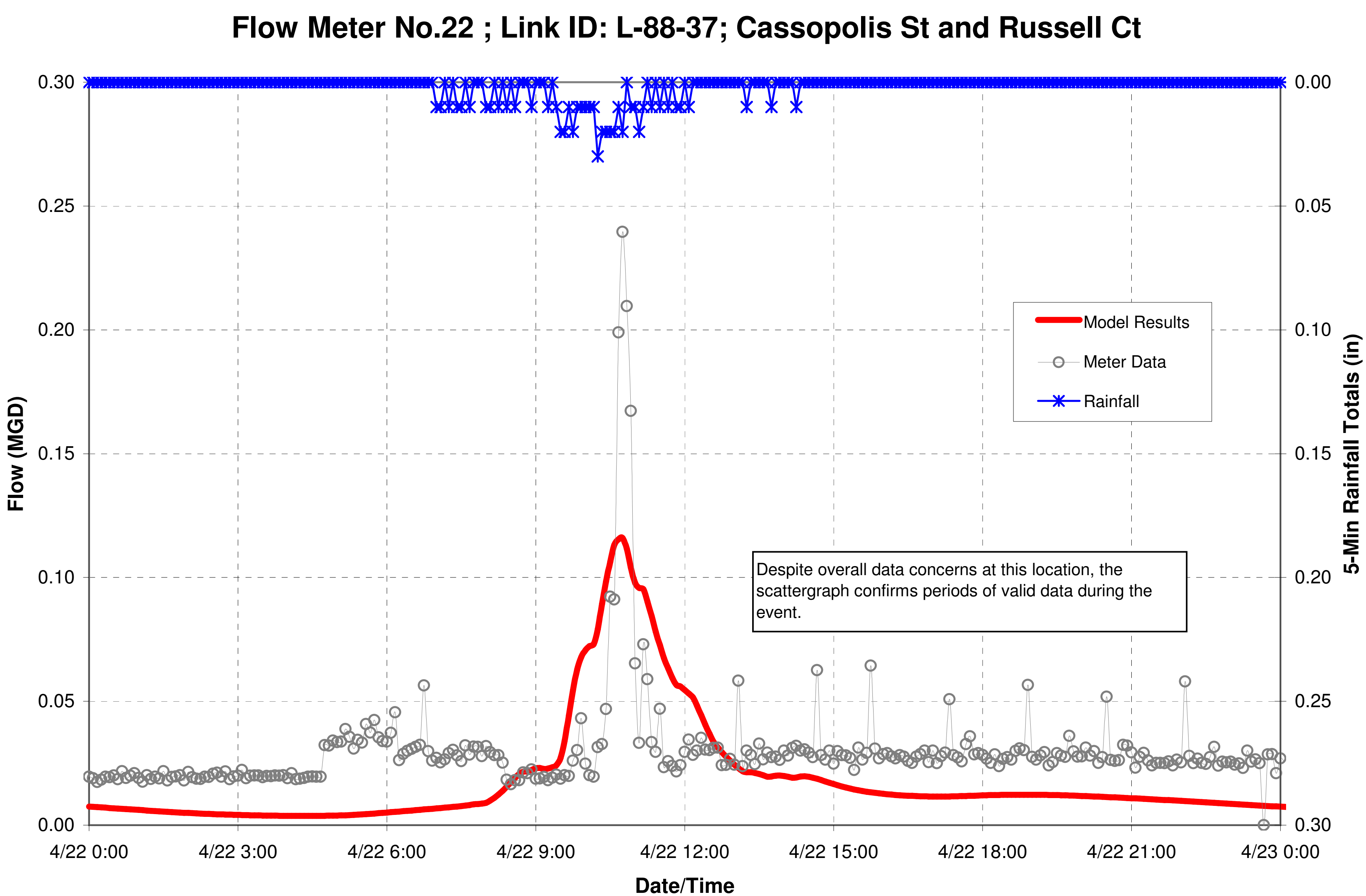


## Flow Meter No.20 ; Link ID: L-170-29; Ninth St and Fieldhouse Ave

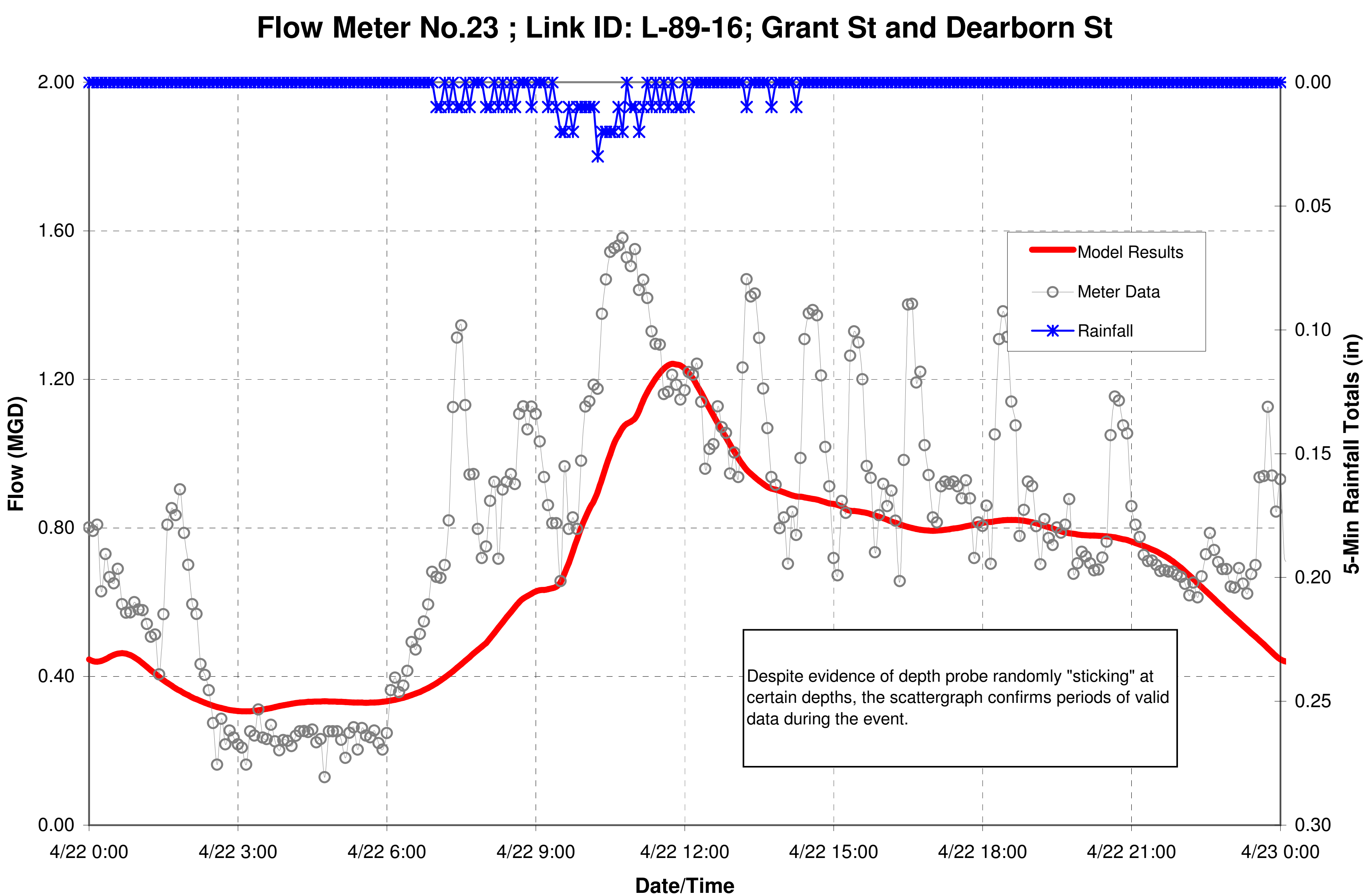




Flow Meter No.21 ; Link ID: L-170-1; Oakland Ave and Fieldhouse Ave
Flow (MGD)
5.0
4.0
3.0
2.0
1.0
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Model Results
Meter Data
Rainfall
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time

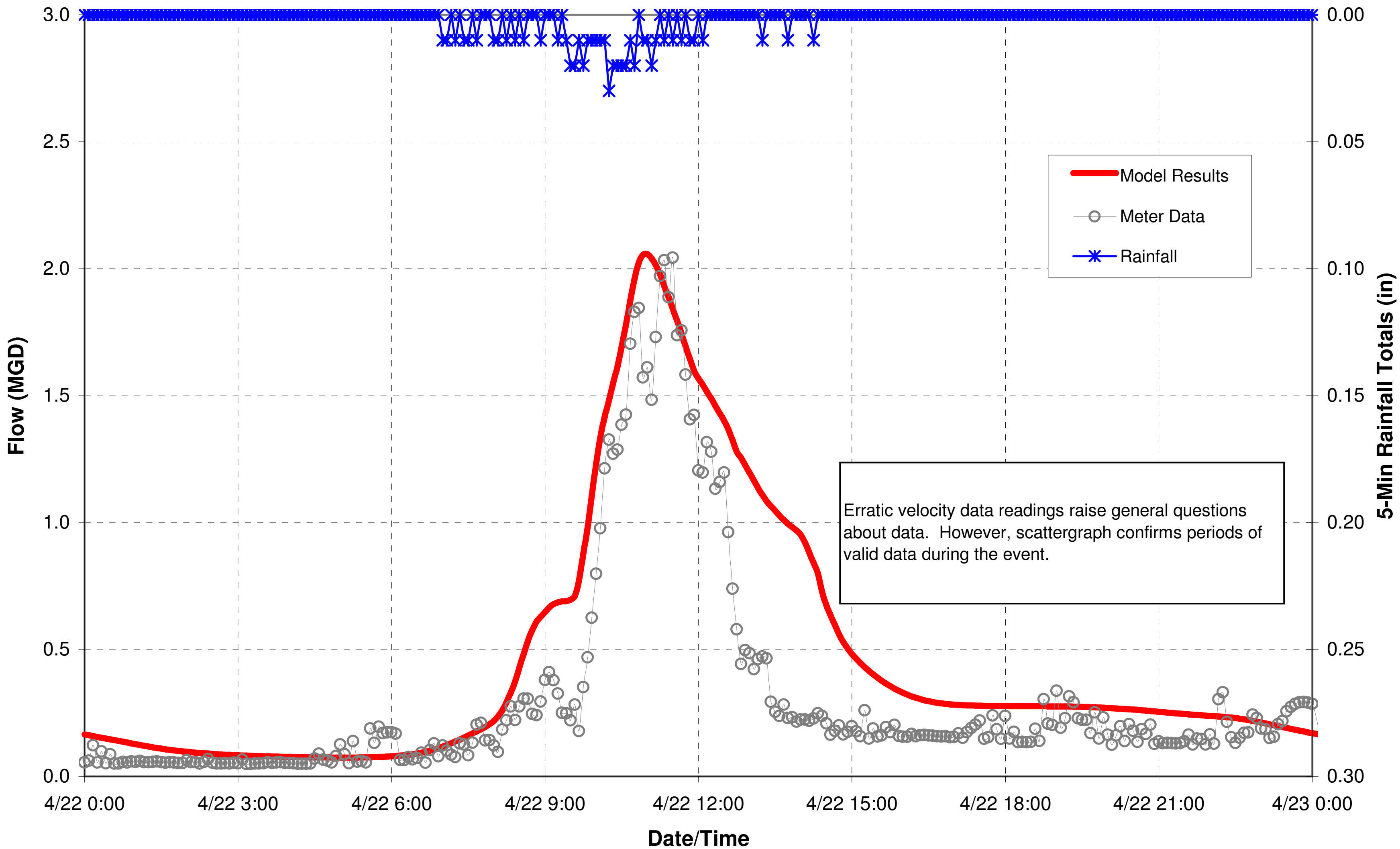


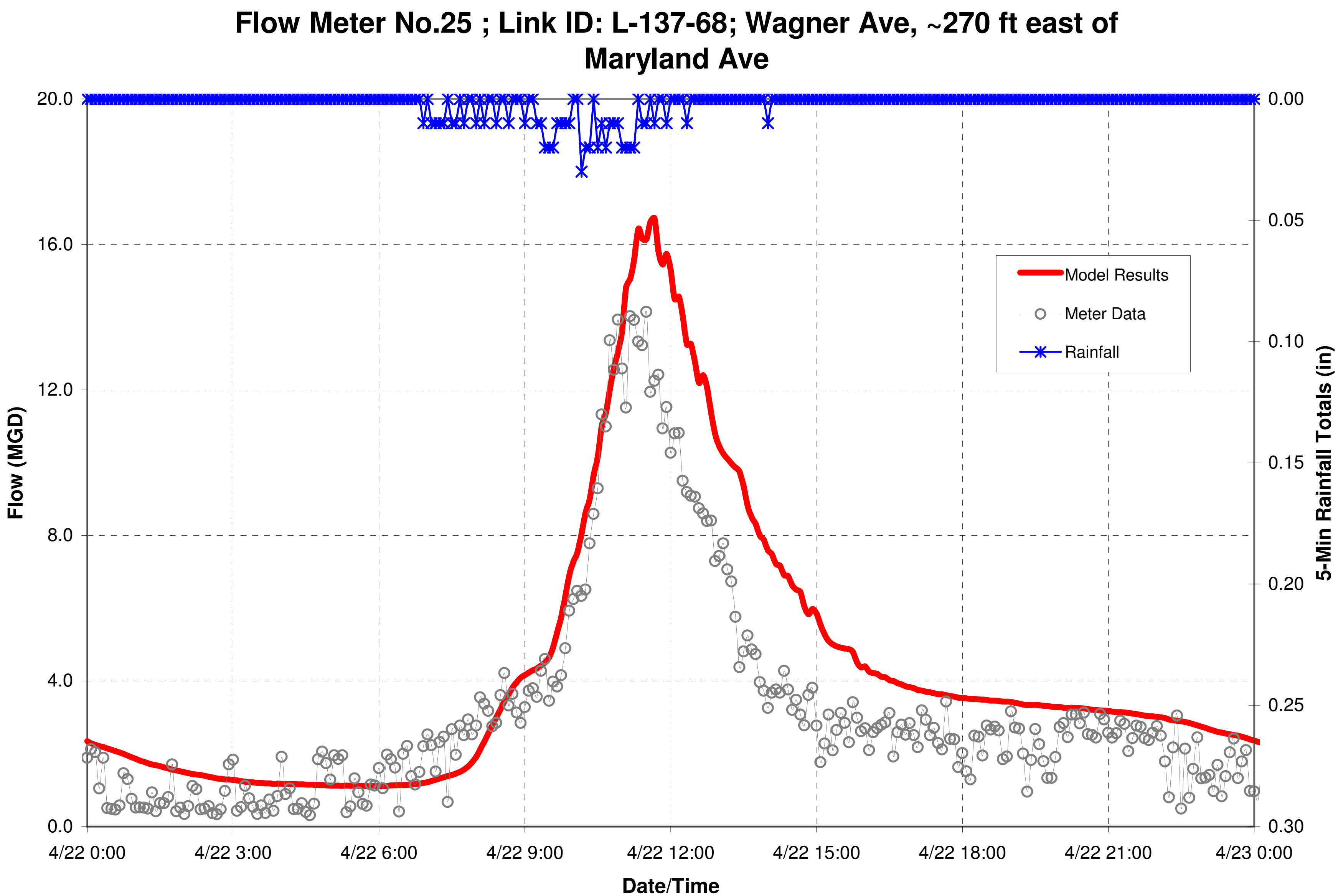
Flow Meter No.22 ; Link ID: L-88-37; Cassopolis St and Russell Ct
Flow (MGD)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall
Despite overall data concerns at this location, the scattergraph confirms periods of valid data during the event.



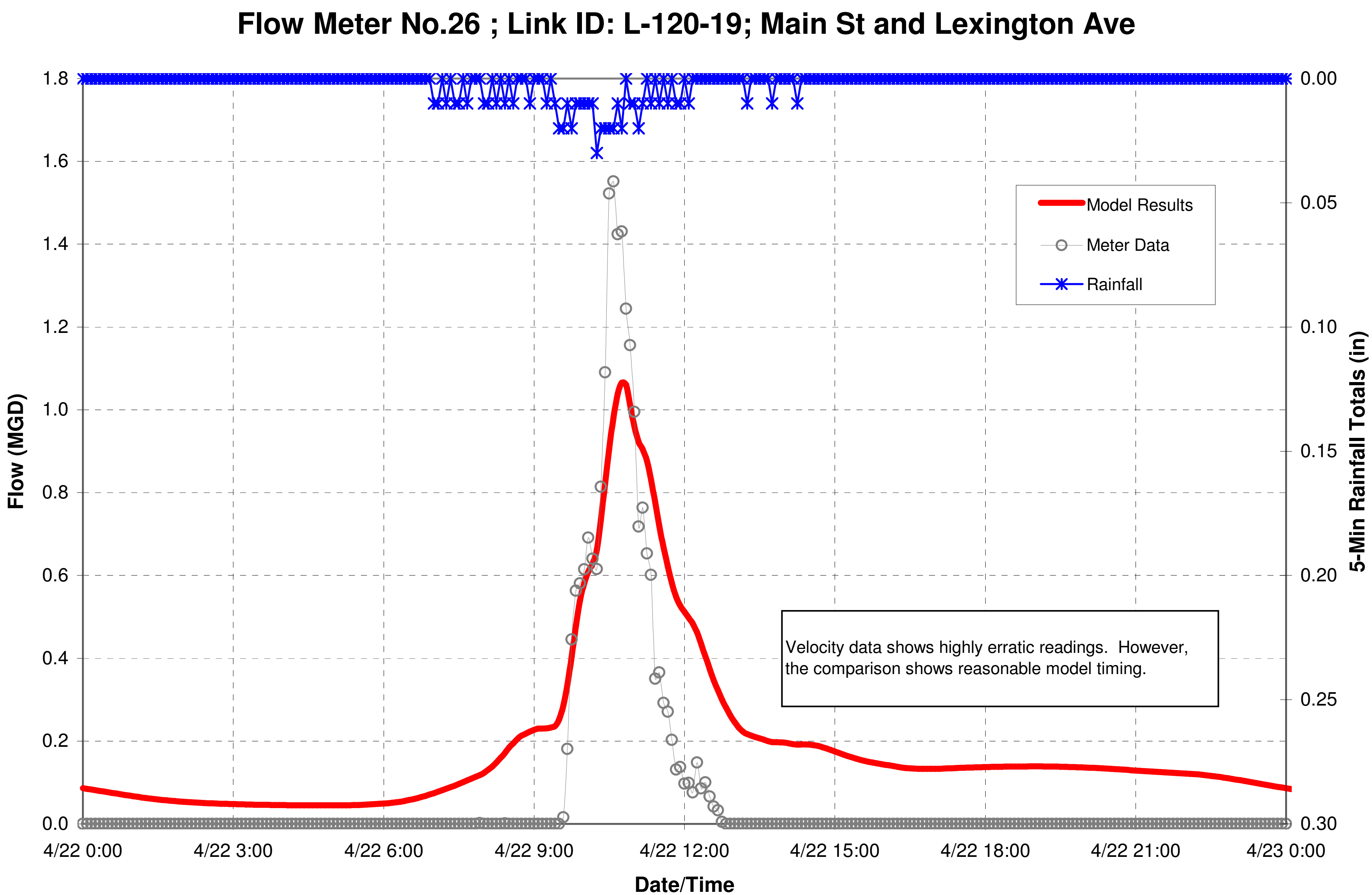
Flow Meter No.23 ; Link ID: L-89-16; Grant St and Dearborn St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
2.00
1.60
1.20
0.80
0.40
0.00
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Model Results
Meter Data
Rainfall
Despite evidence of depth probe randomly "sticking" at certain depths, the scattergraph confirms periods of valid data during the event.

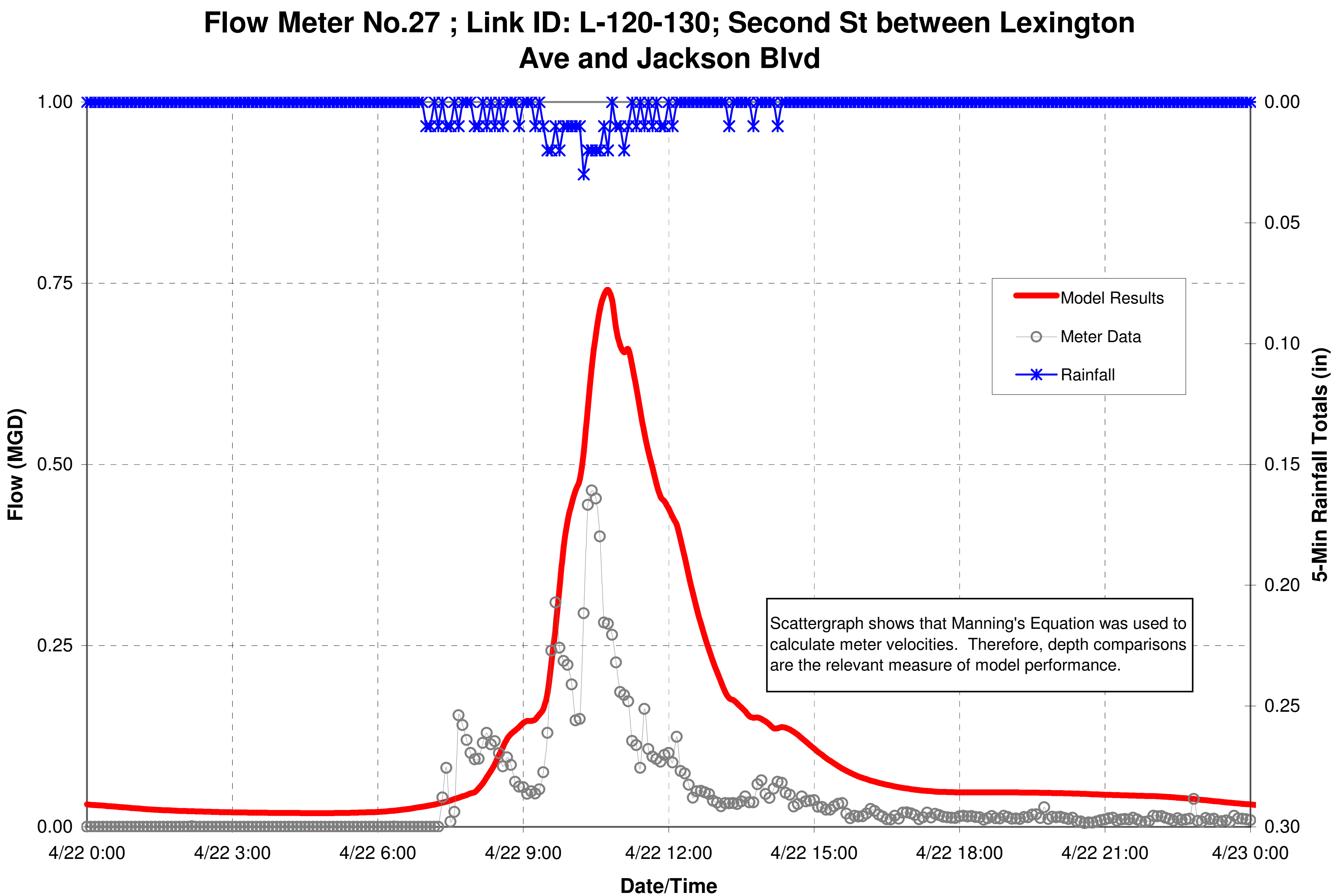
## Flow Meter No.24 ; Link ID: L-136-98; Tipton St and Charles St



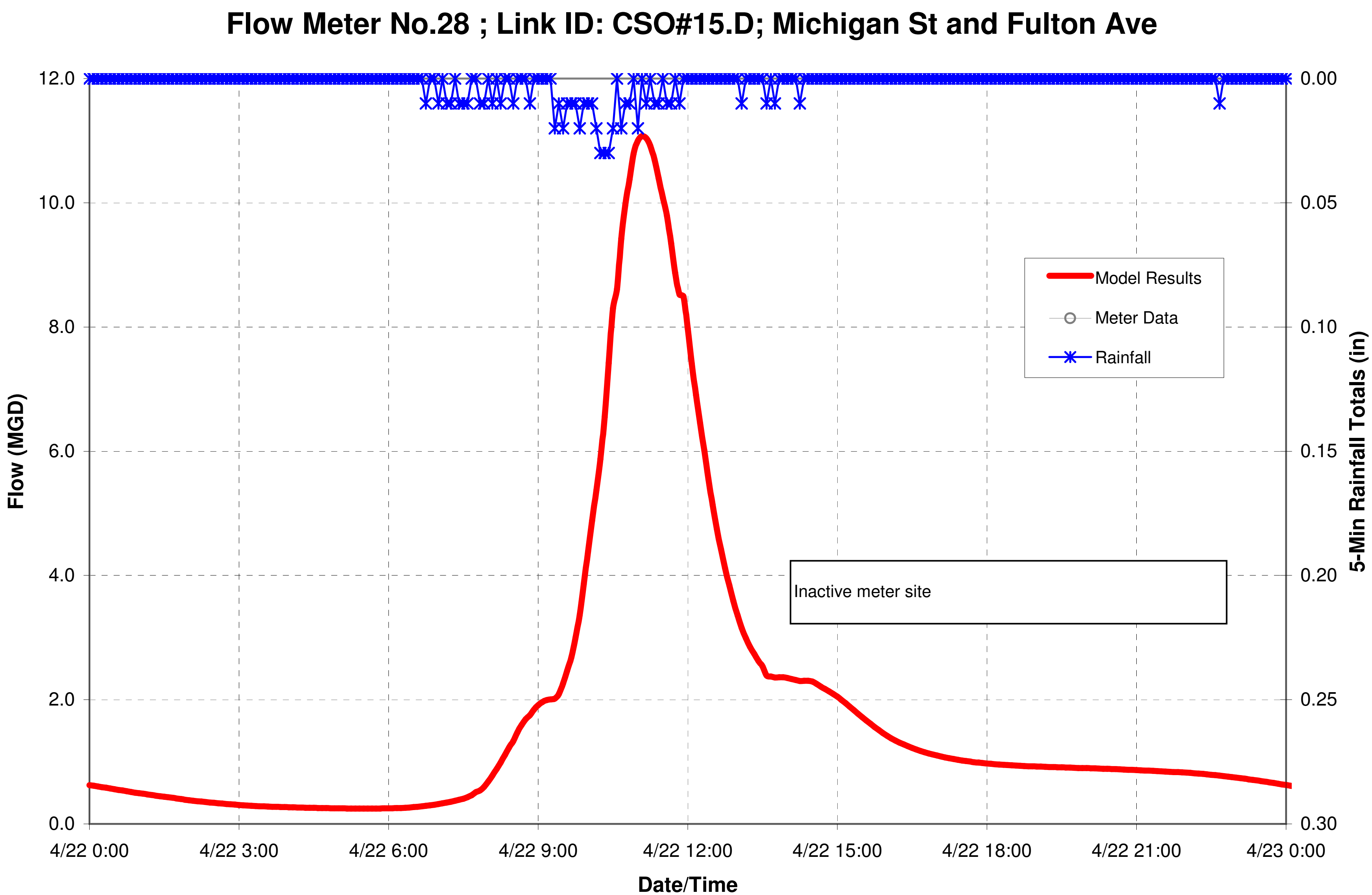


Flow Meter No.25 ; Link ID: L-137-68; Wagner Ave, ~270 ft east of Maryland Ave
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
20.0
16.0
12.0
8.0
4.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00

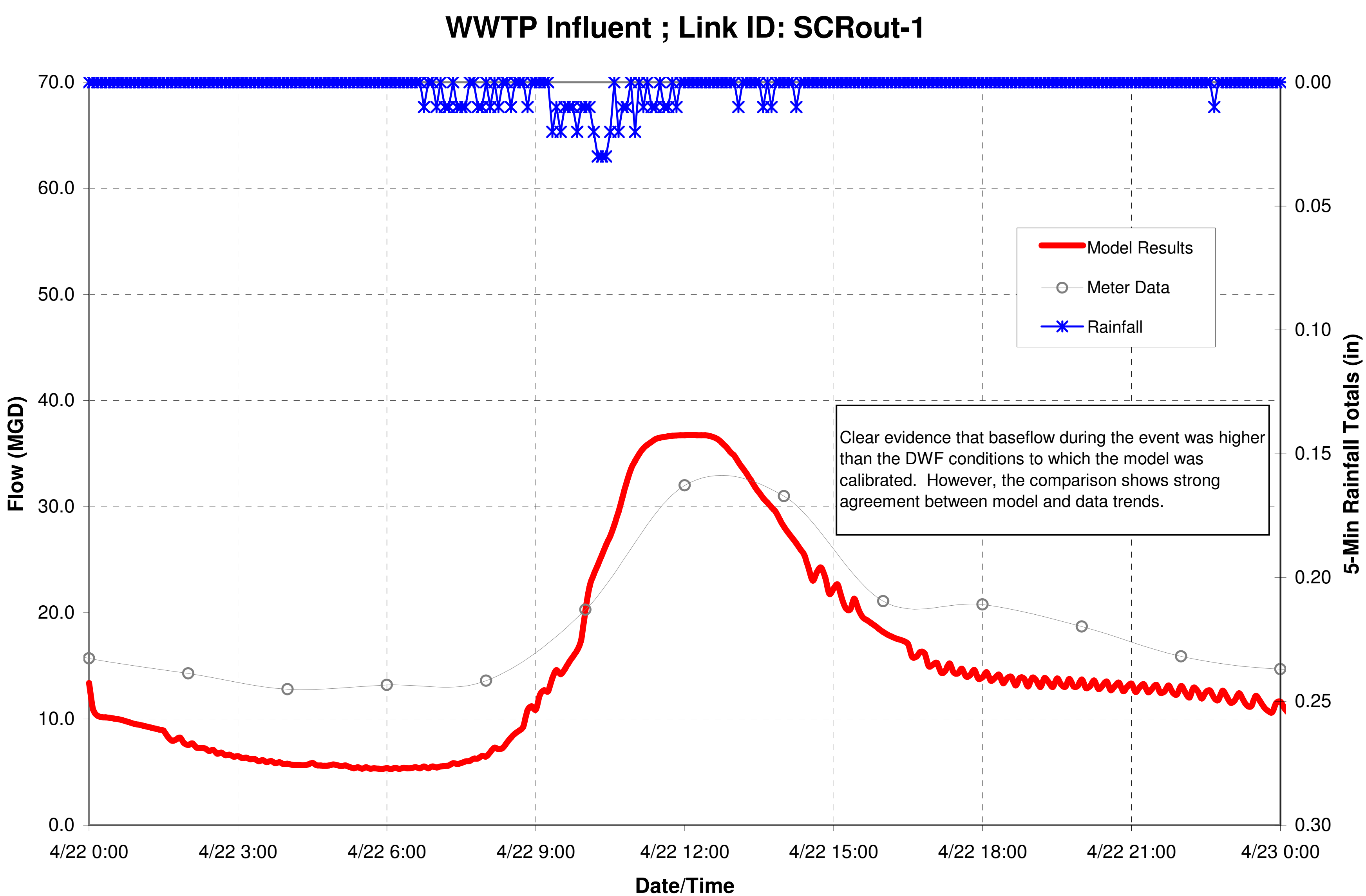

Flow Meter No.26 ; Link ID: L-120-19; Main St and Lexington Ave
Flow (MGD)
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall
Velocity data shows highly erratic readings. However, the comparison shows reasonable model timing.



Flow Meter No.27 ; Link ID: L-120-130; Second St between Lexington Ave and Jackson Blvd
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
1.00
0.75
0.50
0.25
0.00
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Model Results
Meter Data
Rainfall
Scattergraph shows that Manning's Equation was used to calculate meter velocities. Therefore, depth comparisons are the relevant measure of model performance.

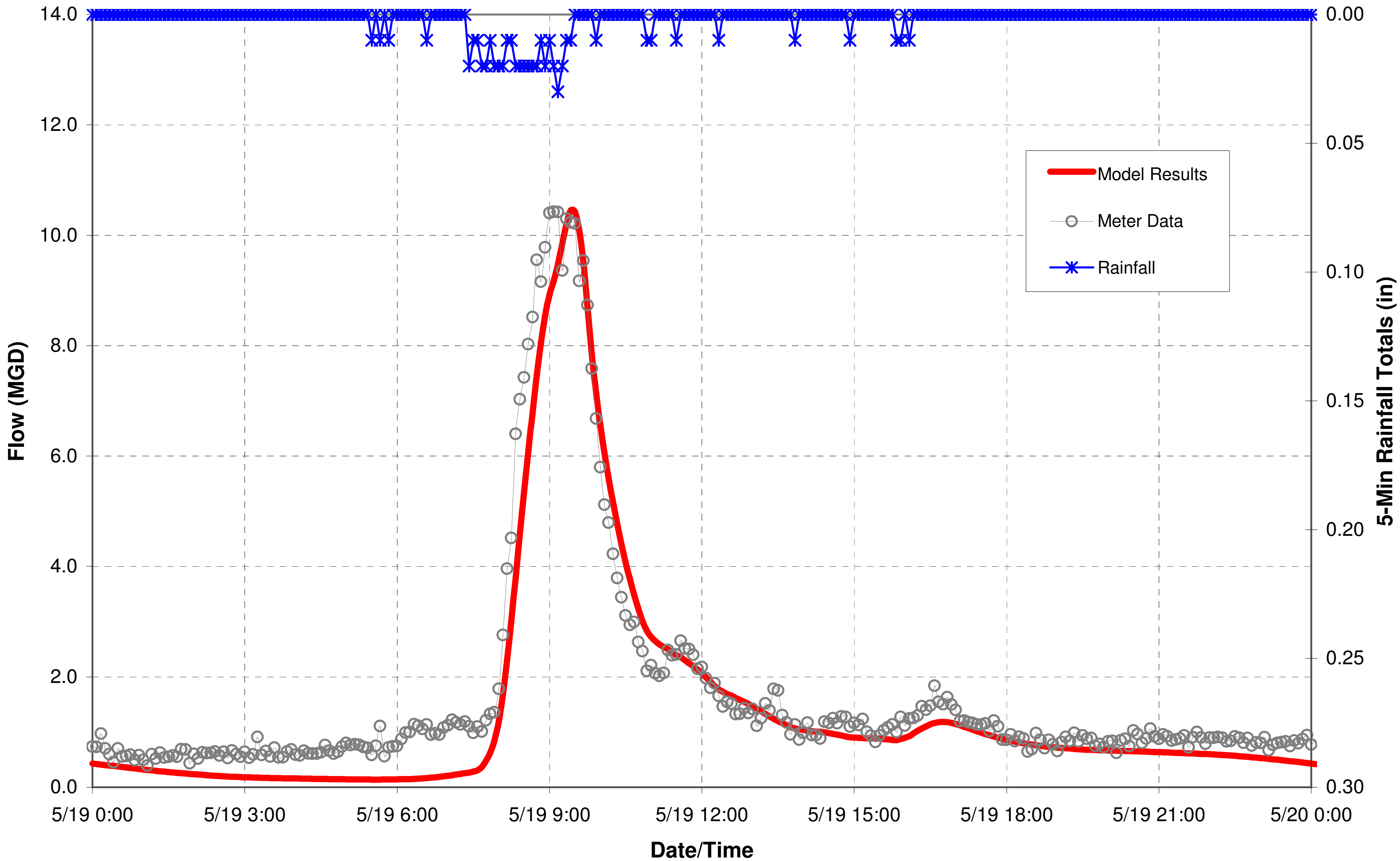


Flow Meter No.28 ; Link ID: CSO#15.D; Michigan St and Fulton Ave
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall
Inactive meter site

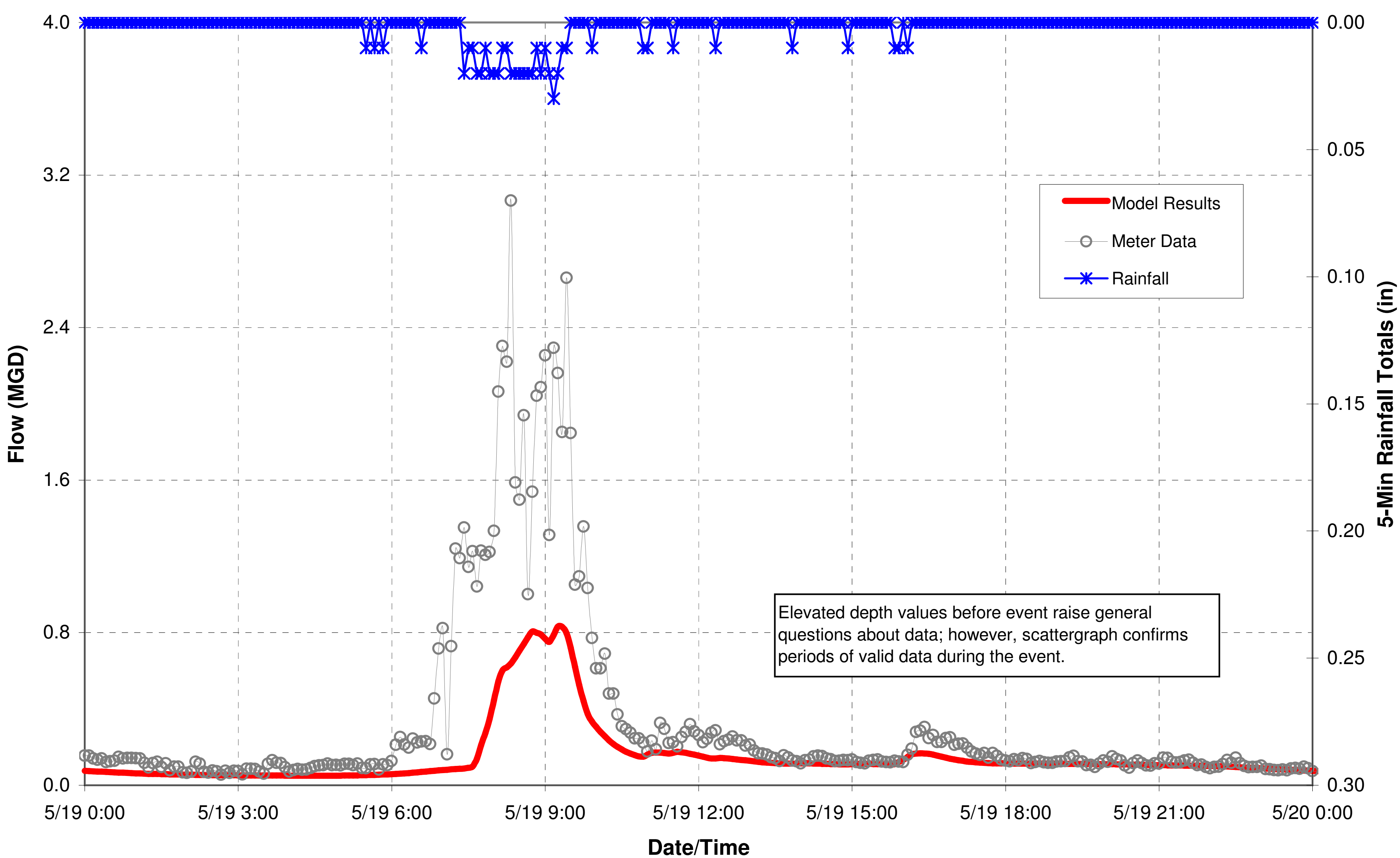


WWTP Influent ; Link ID: SCRout-1
Flow (MGD)
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Date/Time
Model Results
Meter Data
Rainfall
Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends.

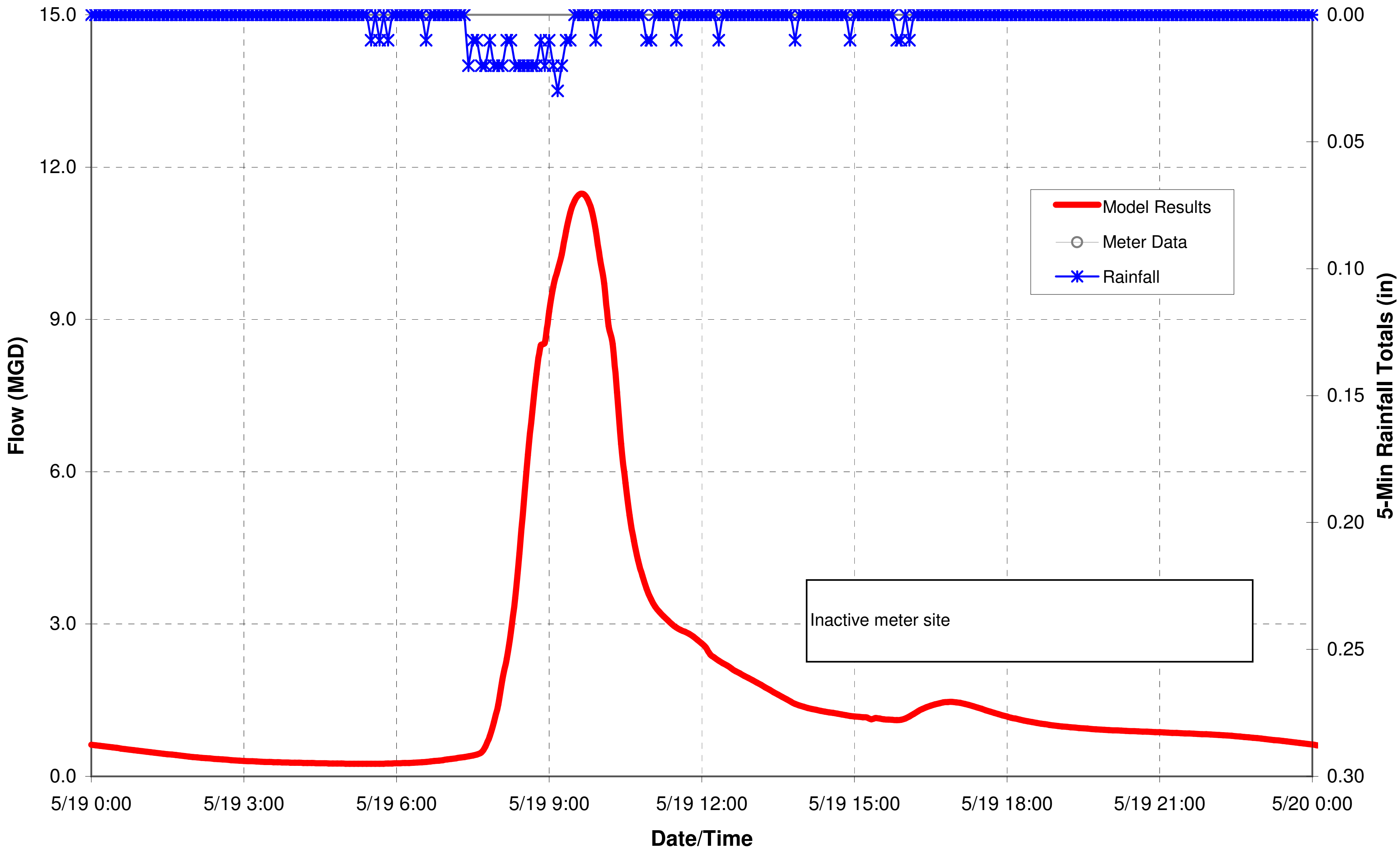
# Flow Meter No.1 ; Link ID: L-107-32; Plum St and Laurel St

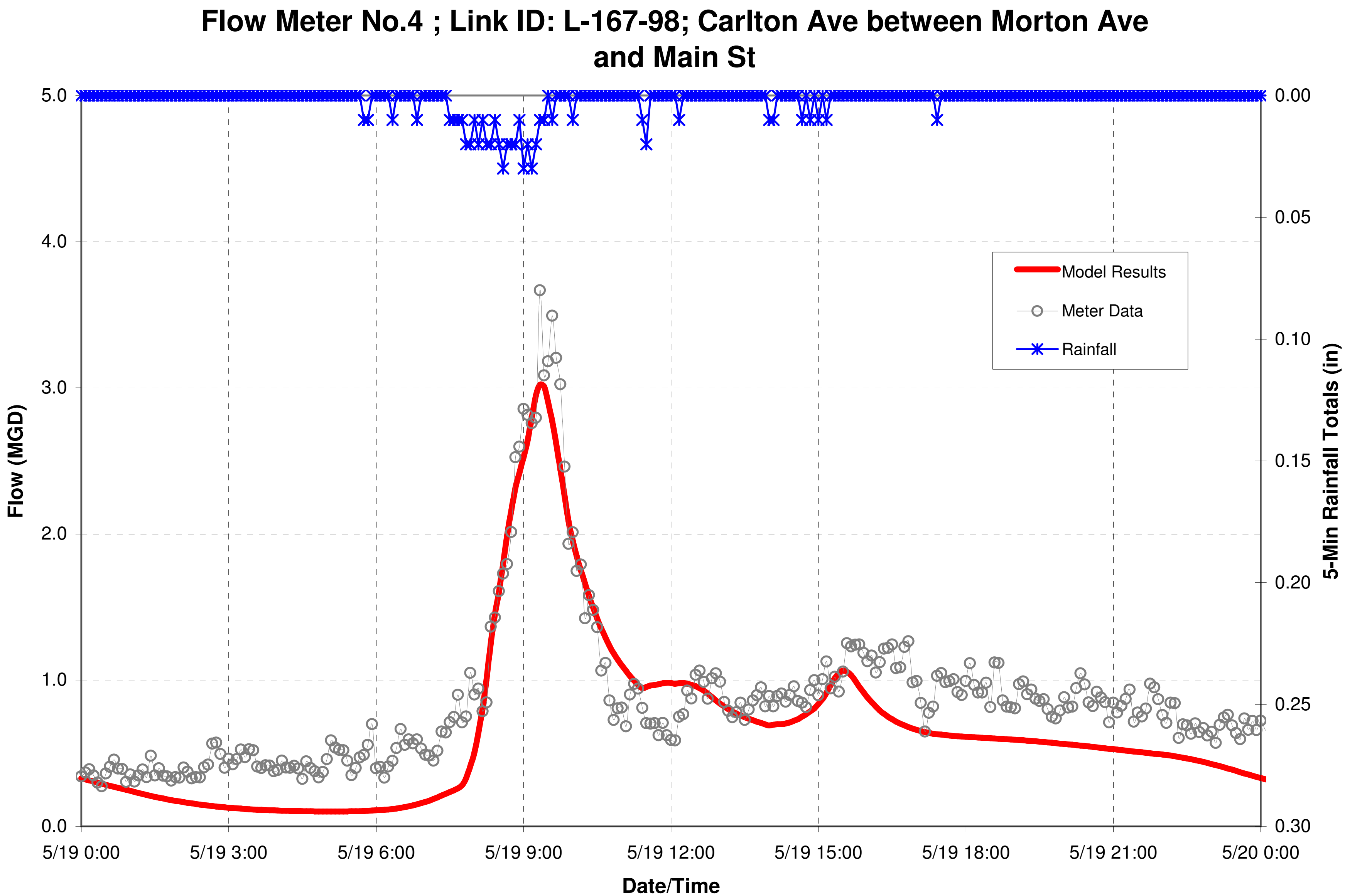


## Flow Meter No.2 ; Link ID: L-106-37; Michigan St and Laurel St



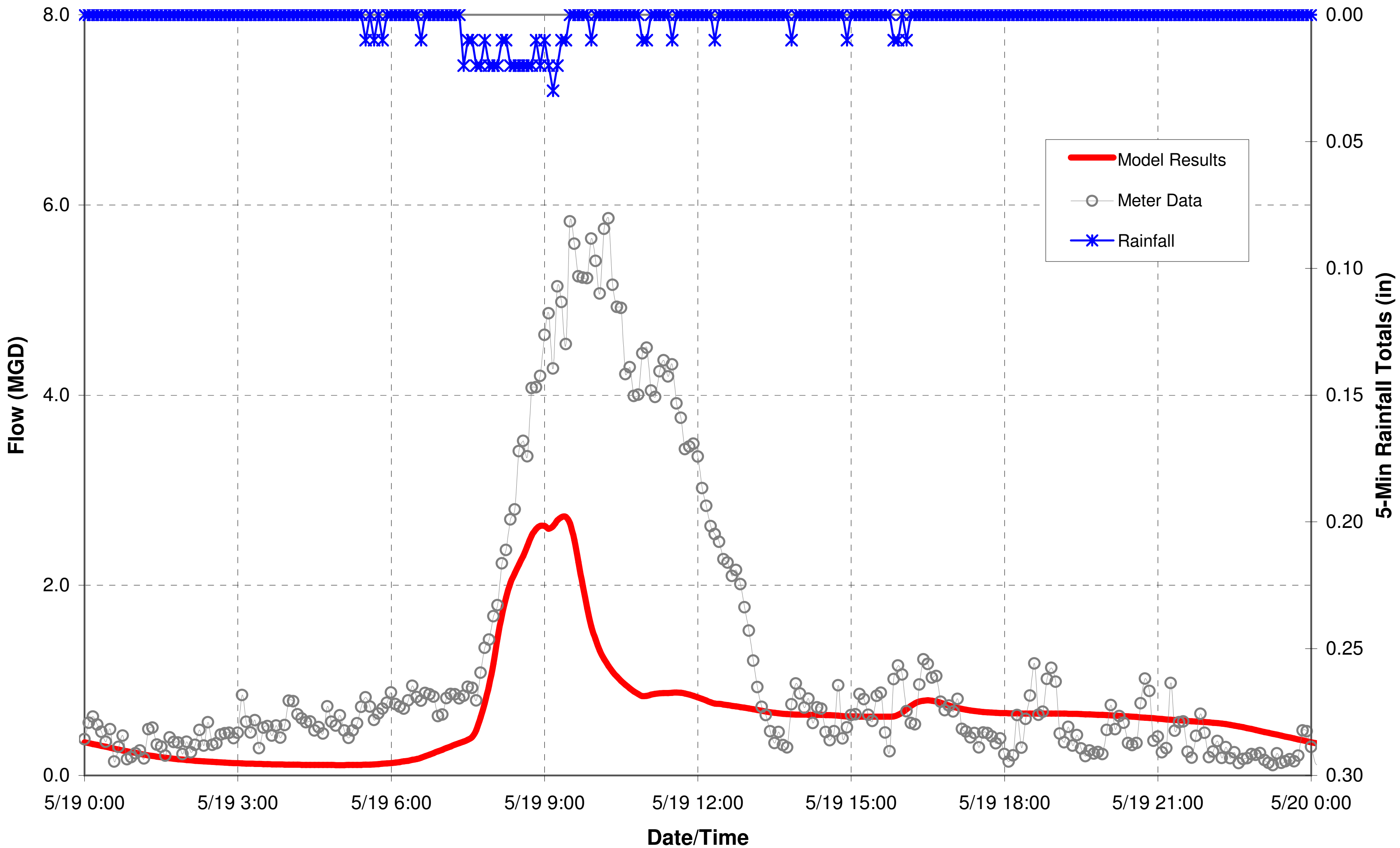
# Flow Meter No.3 ; Link ID: CSO#15.D; Michigan St and Kilbourn St

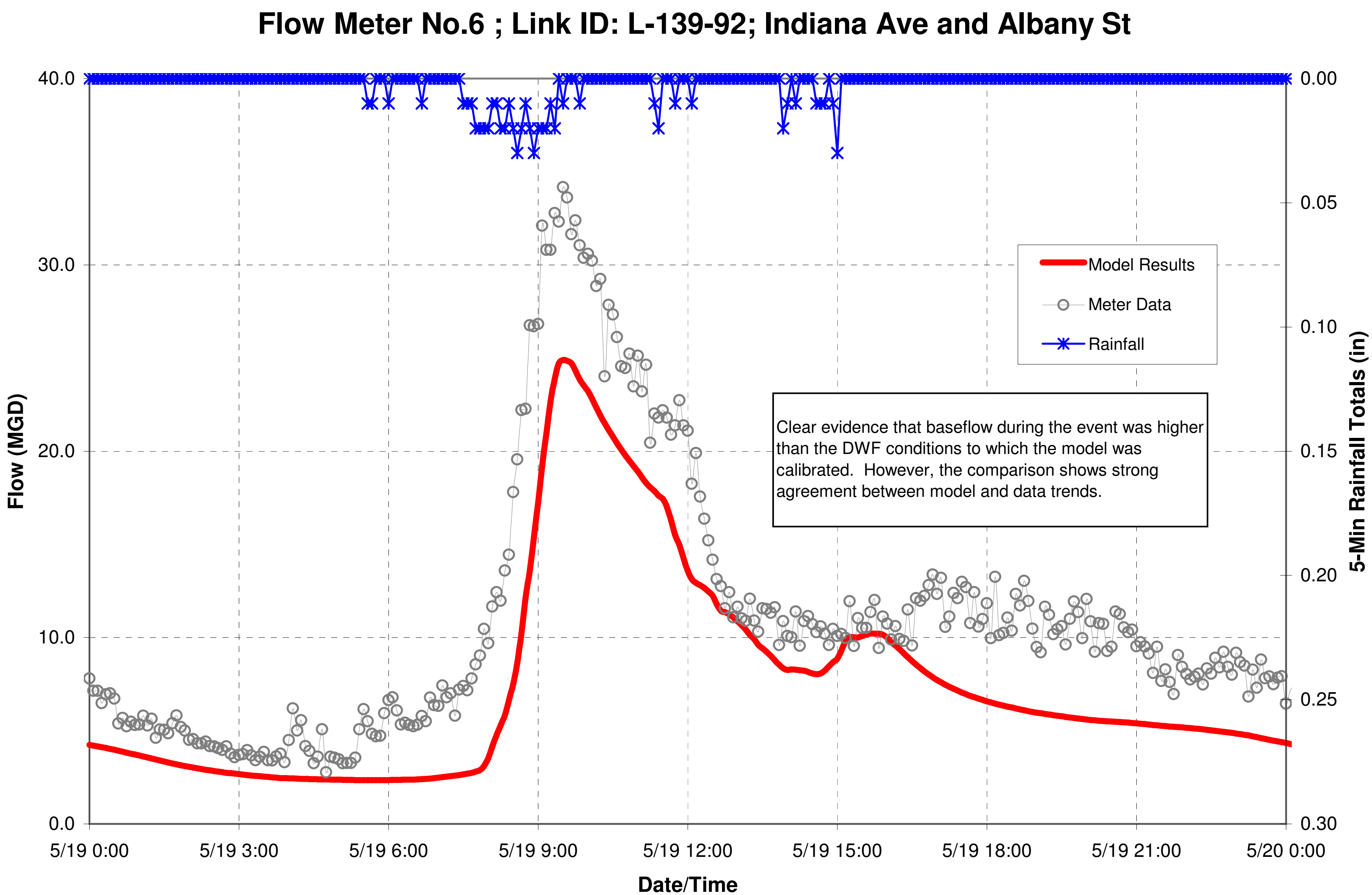




Flow Meter No.4 ; Link ID: L-167-98; Carlton Ave between Morton Ave and Main St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
5.0
4.0
3.0
2.0
1.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00

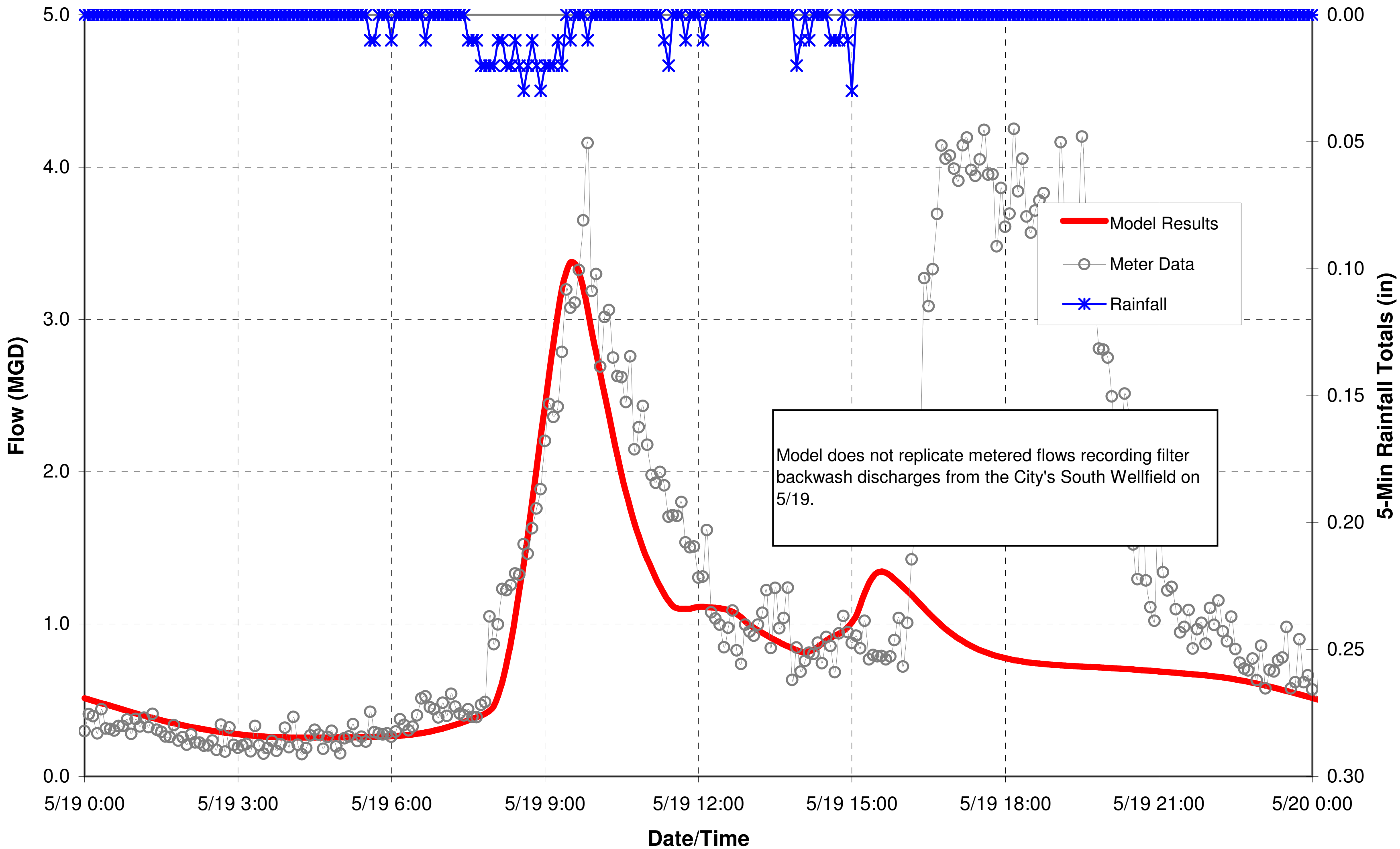
## Flow Meter No.5 ; Link ID: L-117-51; West Blvd and Suwanee St

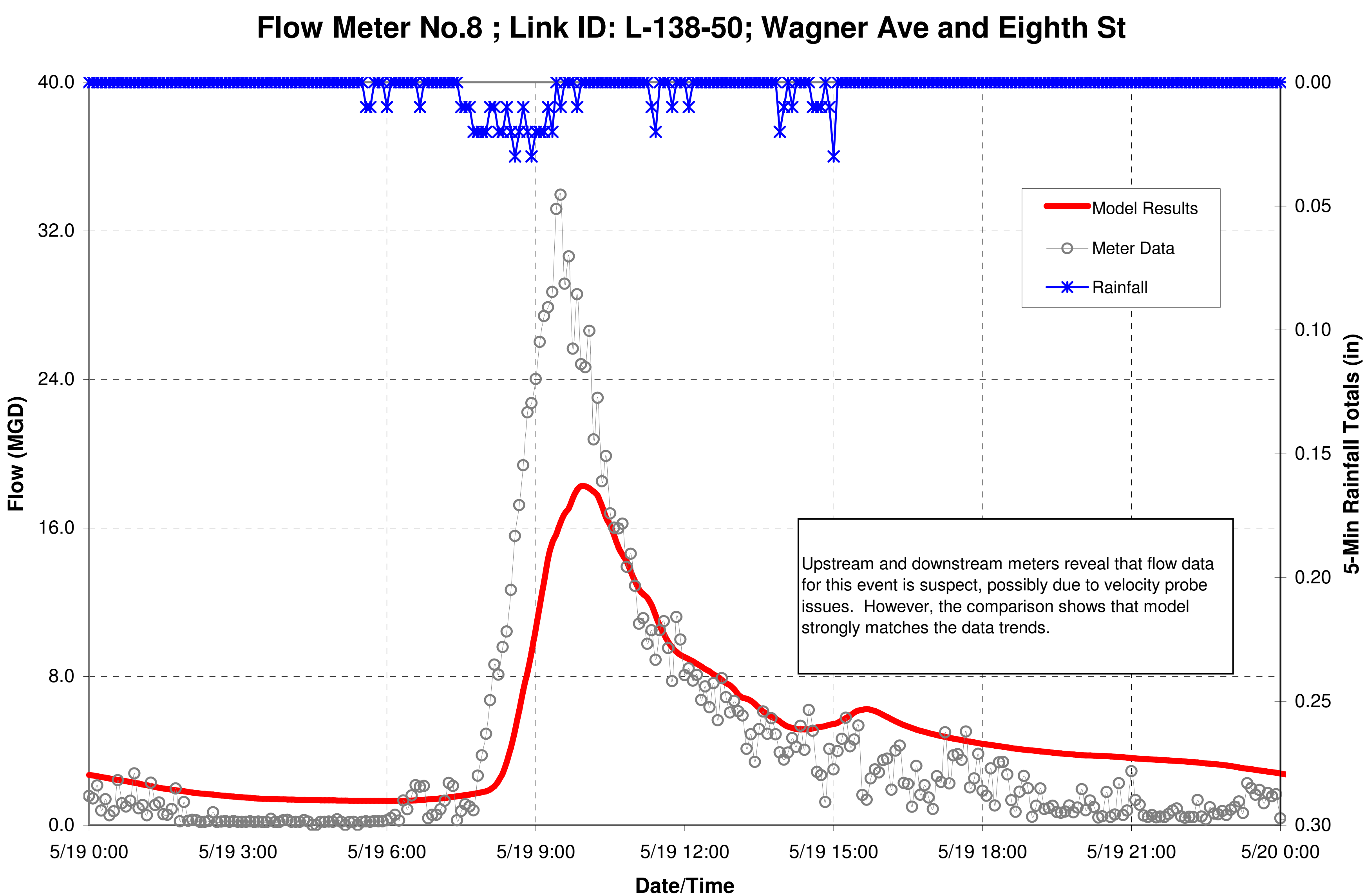




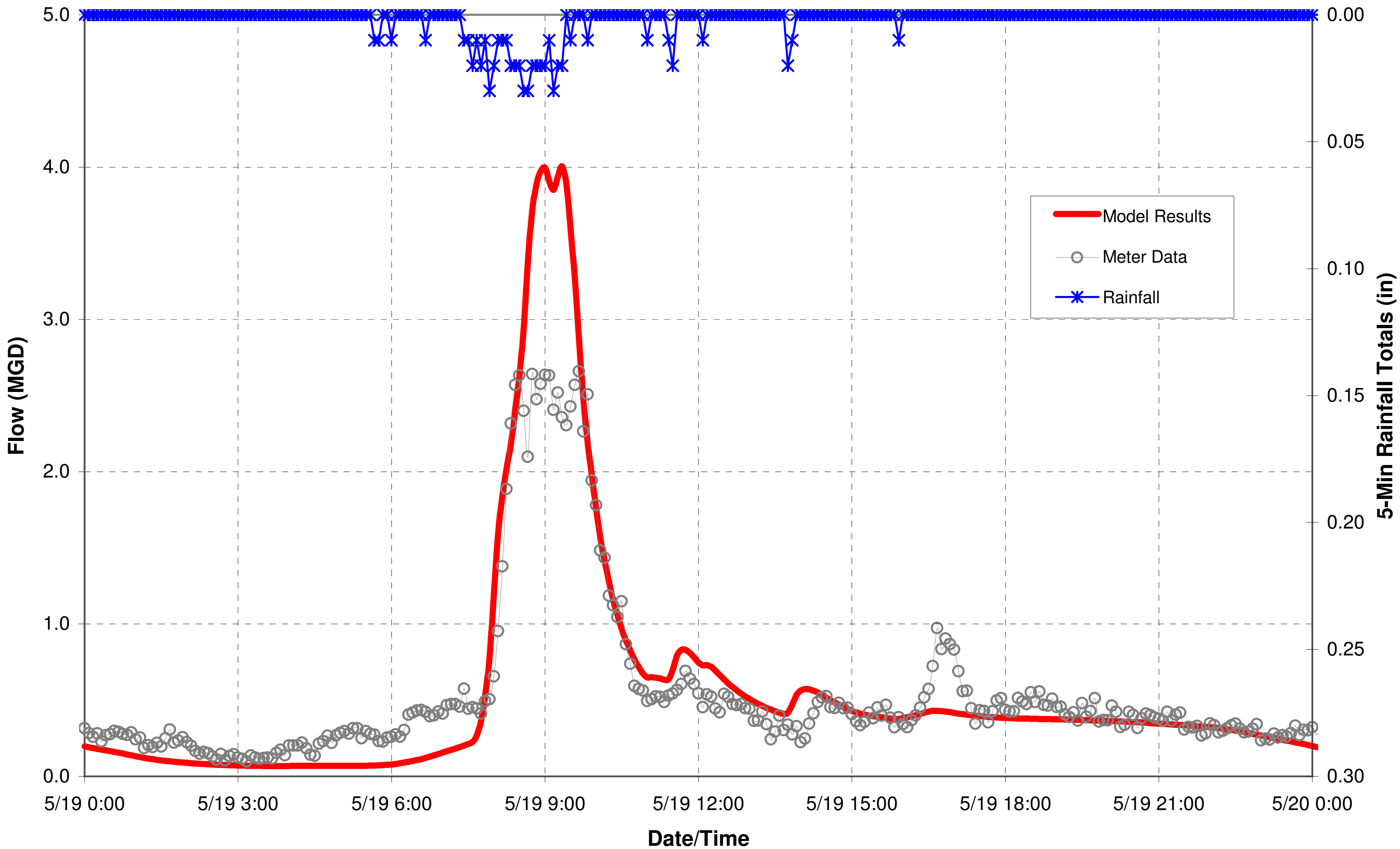
Flow Meter No.6 ; Link ID: L-139-92; Indiana Ave and Albany St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
40.0
30.0
20.0
10.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Model Results
Meter Data
Rainfall
Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends.

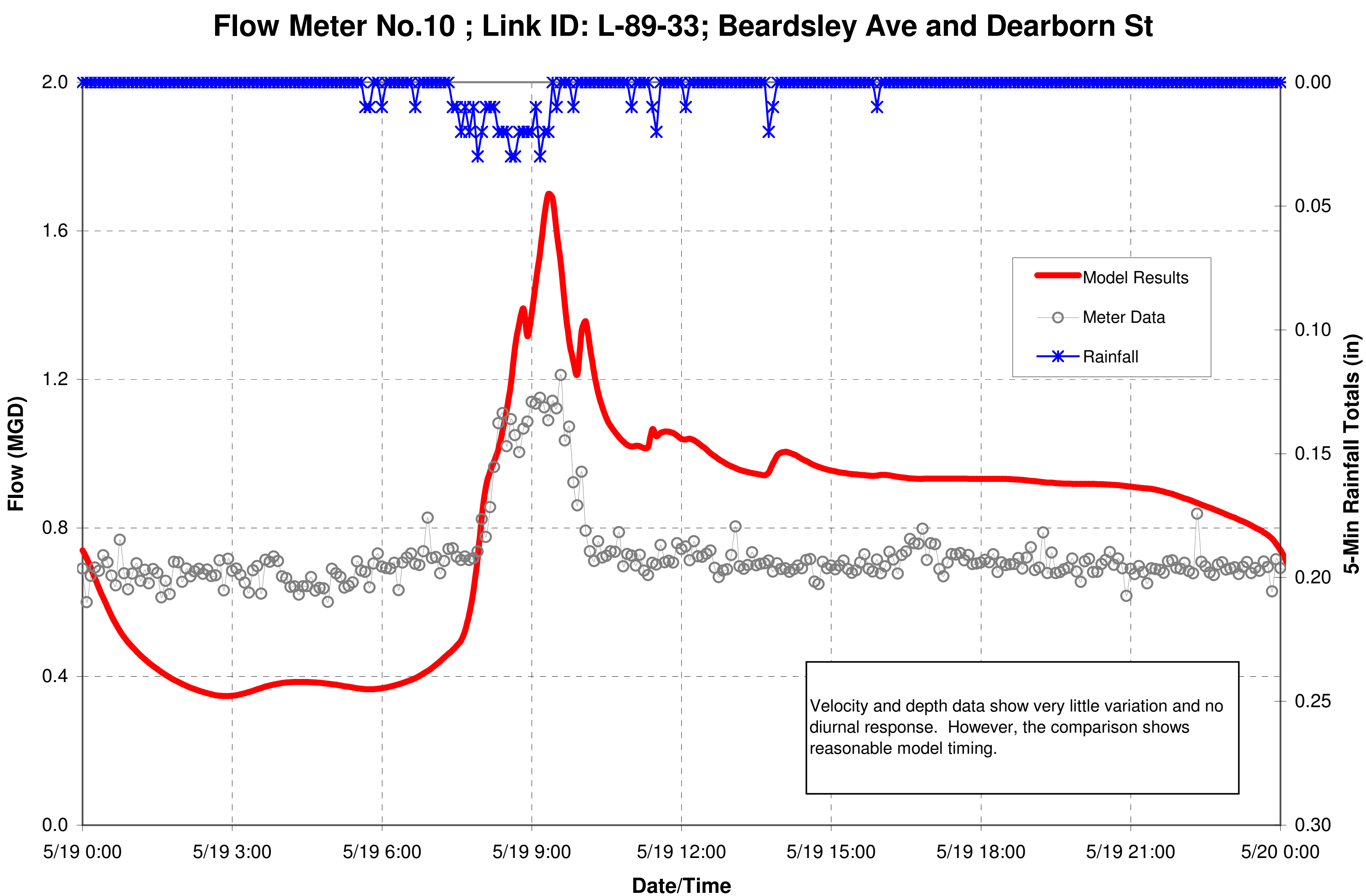
# Flow Meter No.7 ; Link ID: L-151-56; Ninth St and Garfield Ave



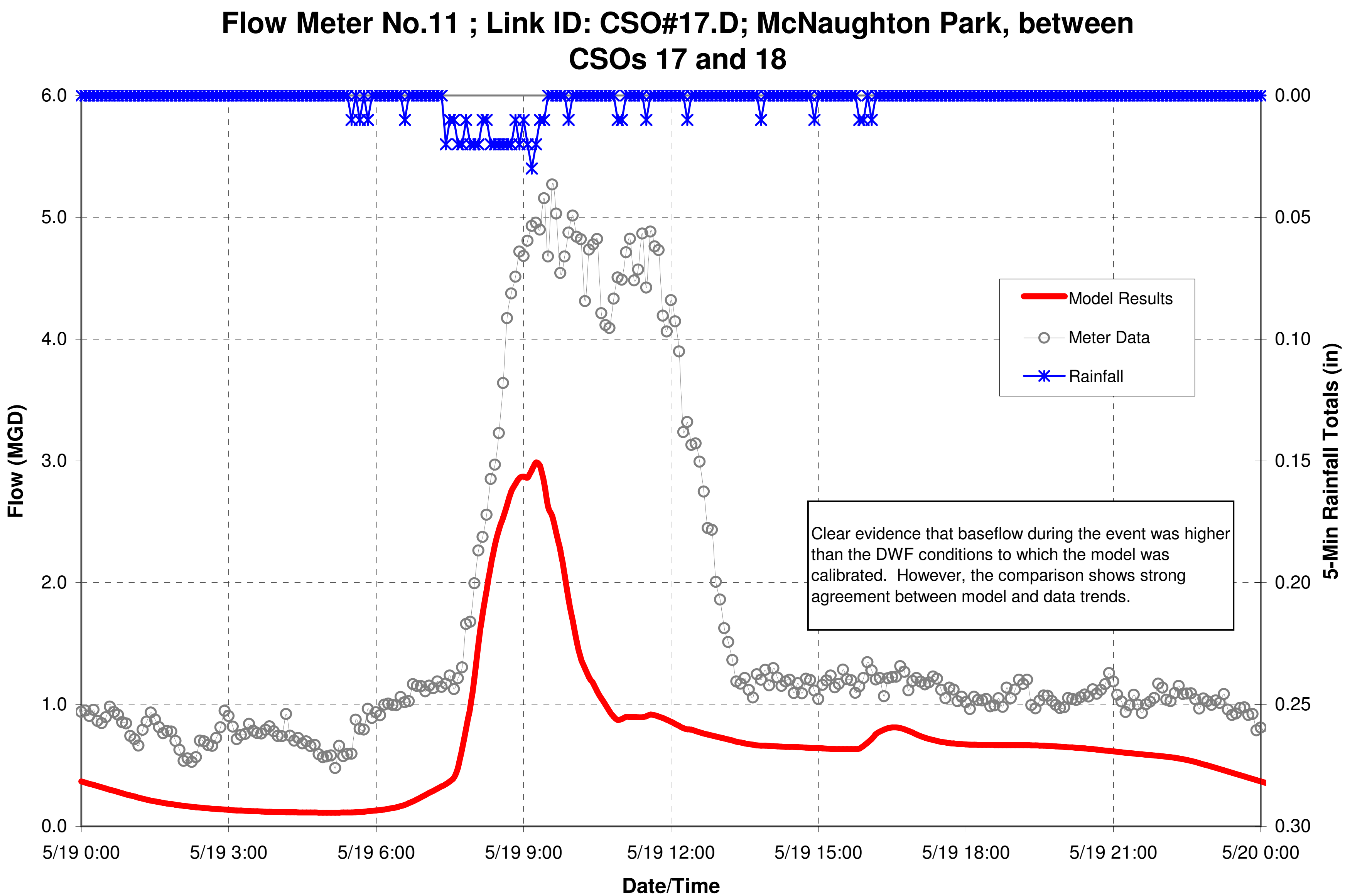

Flow Meter No.8 ; Link ID: L-138-50; Wagner Ave and Eighth St
Flow (MGD)
40.0
32.0
24.0
16.0
8.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
Model Results
Meter Data
Rainfall
Upstream and downstream meters reveal that flow data for this event is suspect, possibly due to velocity probe issues. However, the comparison shows that model strongly matches the data trends.
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Date/Time

# Flow Meter No.9 ; Link ID: L-88-85; Cone St and McPherson St



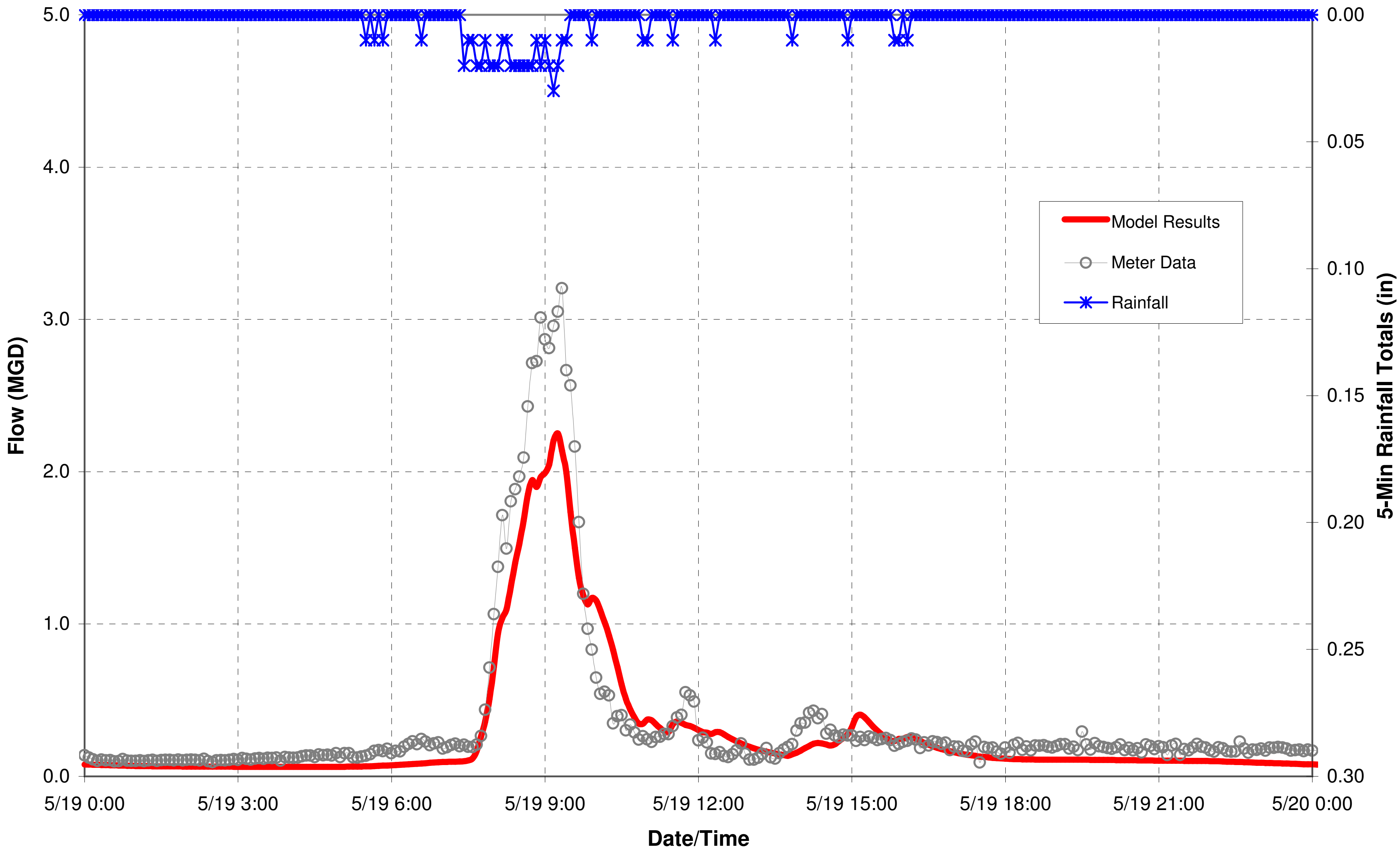


Flow Meter No.10 ; Link ID: L-89-33; Beardsley Ave and Dearborn St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
Model Results
Meter Data
Rainfall
Velocity and depth data show very little variation and no diurnal response. However, the comparison shows reasonable model timing.
2.0
1.6
1.2
0.8
0.4
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00

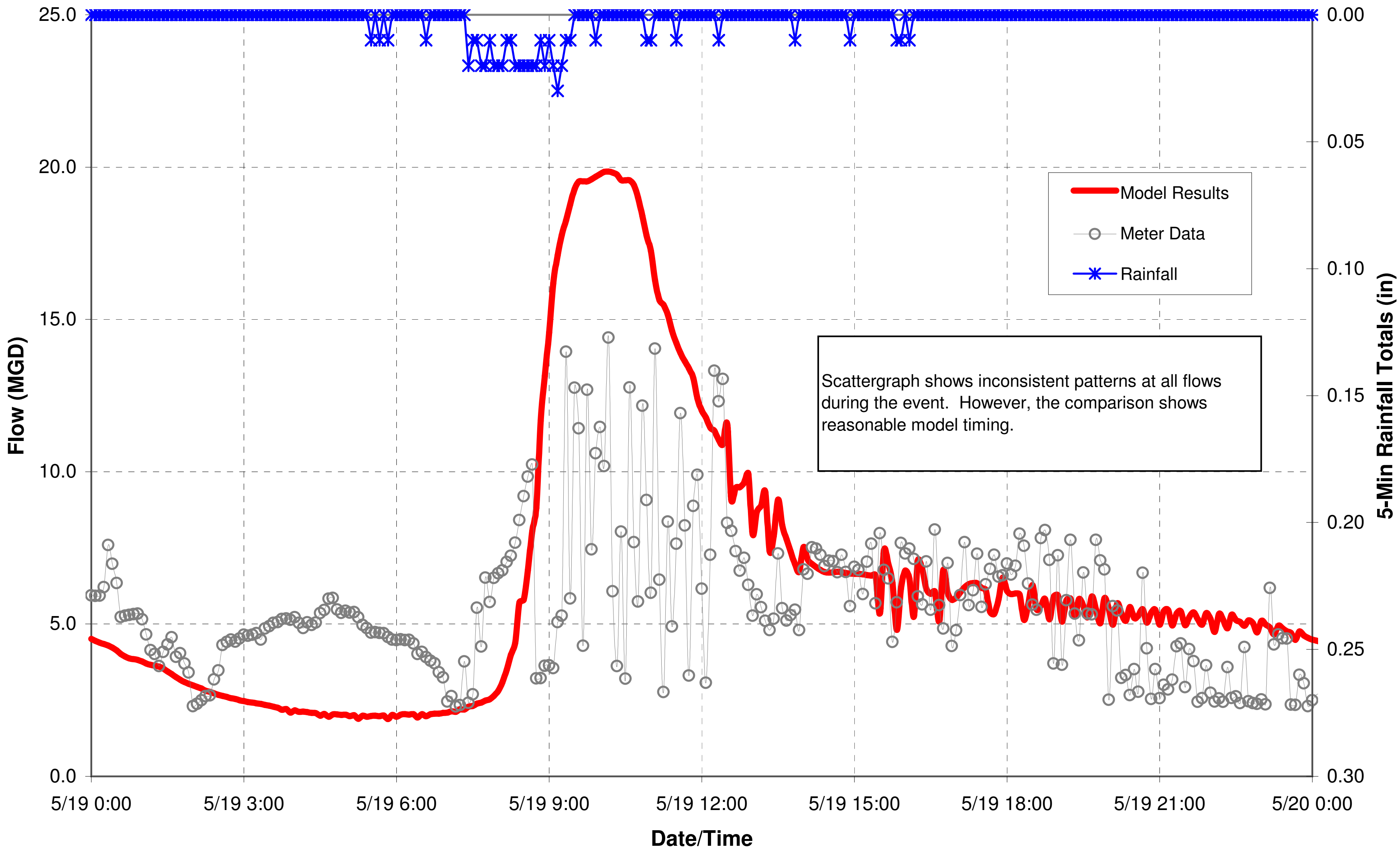


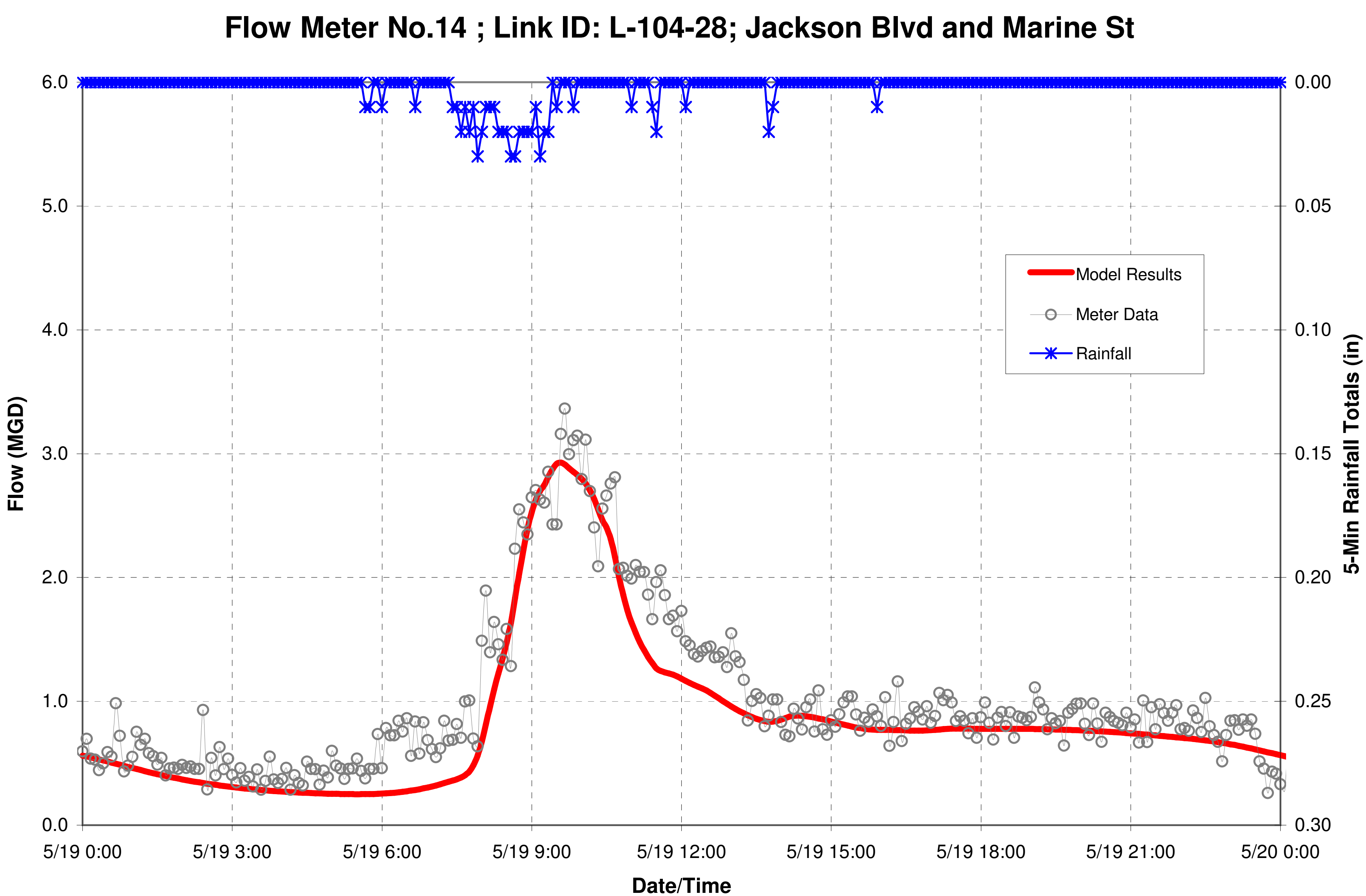
Flow Meter No.11 ; Link ID: CSO#17.D; McNaughton Park, between CSOs 17 and 18
Flow (MGD)
6.0
5.0
4.0
3.0
2.0
1.0
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Date/Time
Model Results
Meter Data
Rainfall
Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends.

# Flow Meter No.12 ; Link ID: L-138-25; Eighth St and Marion St

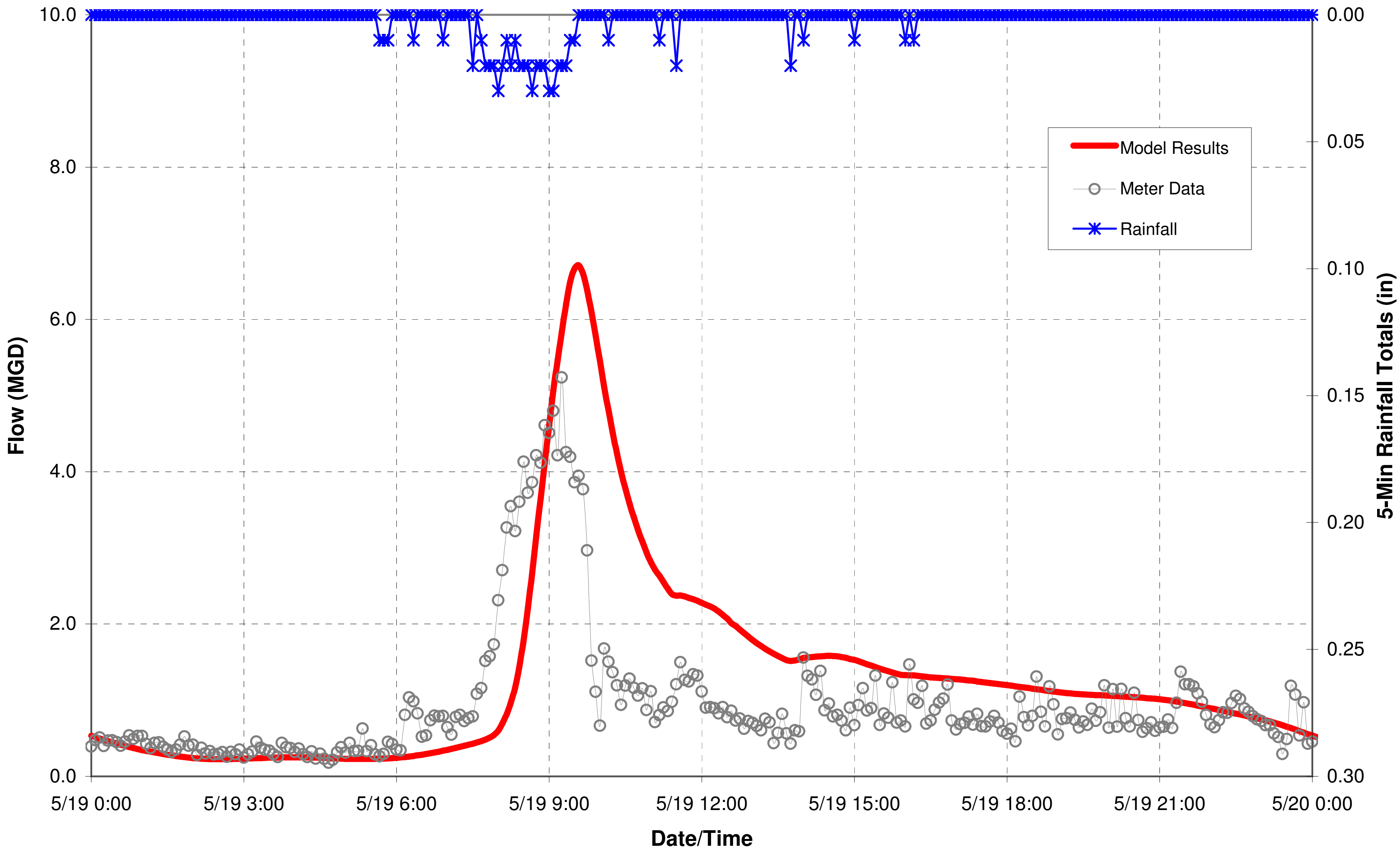


## Flow Meter No.13 ; Link ID: L-140-38; Navajo St, ~275 ft south of Pennsylvania Ave

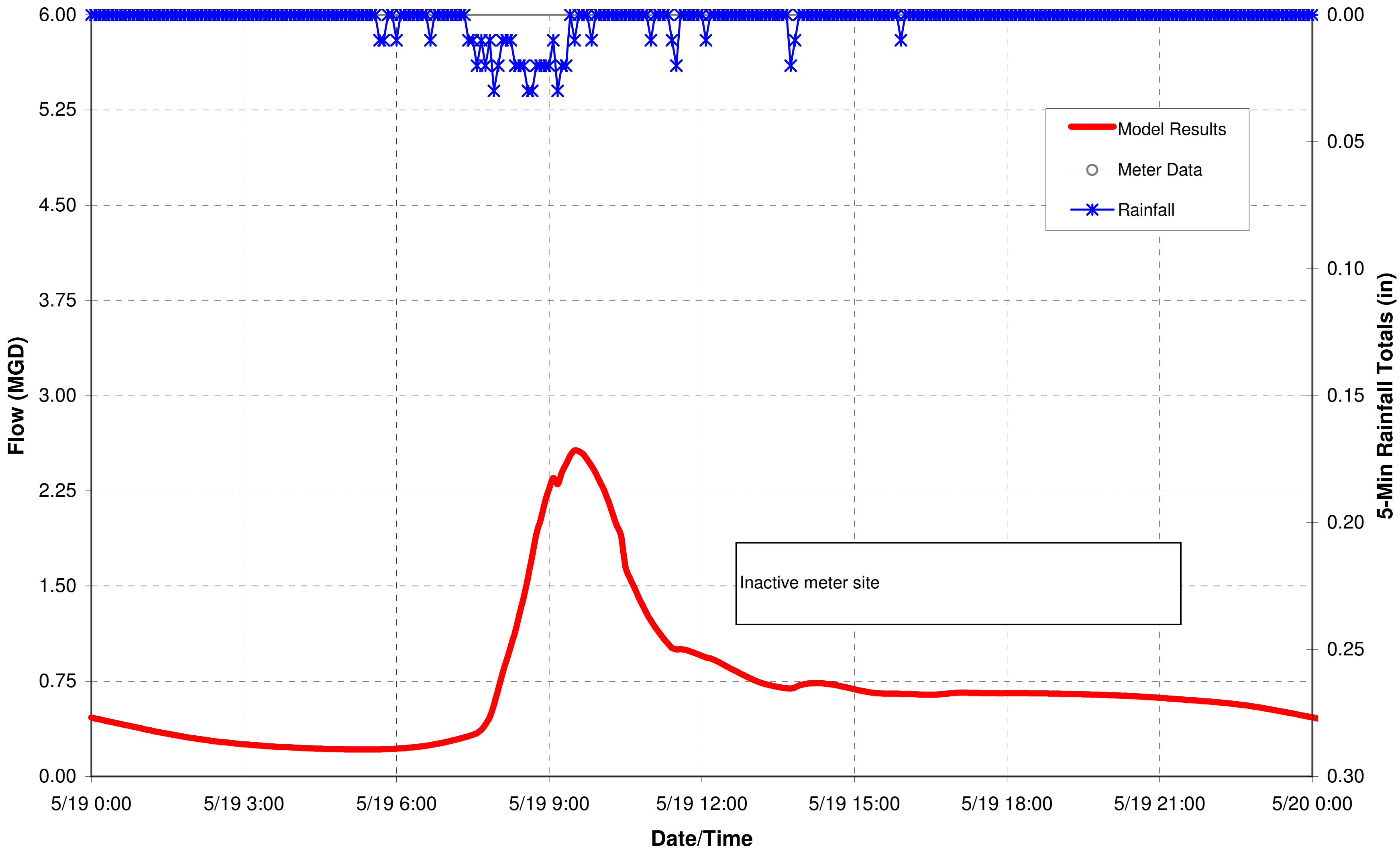


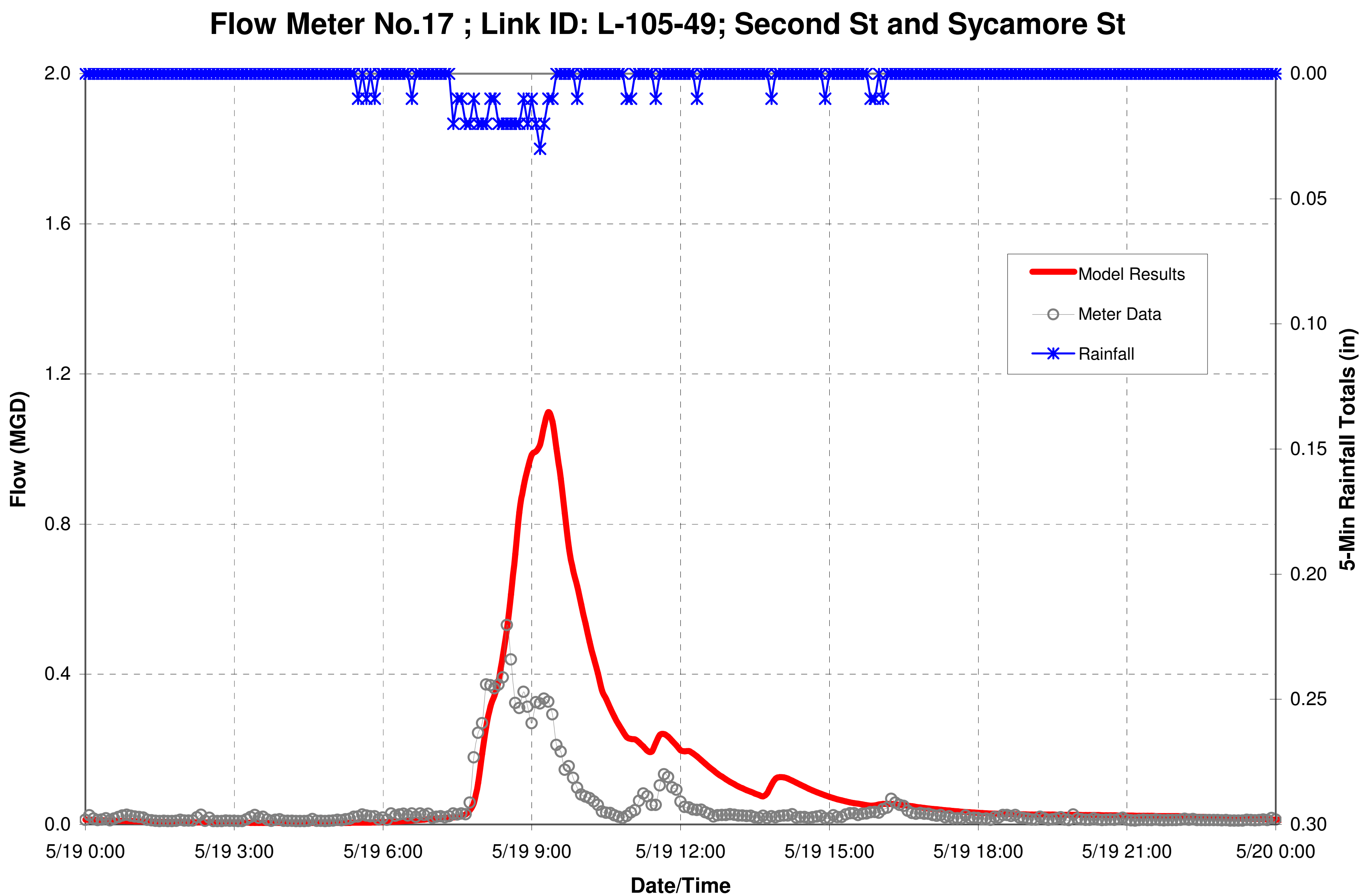

Flow Meter No.14 ; Link ID: L-104-28; Jackson Blvd and Marine St
Model Results
Meter Data
Rainfall
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00

# Flow Meter No.15 ; Link ID: L-135-59; Evans St and Carolyn Ave

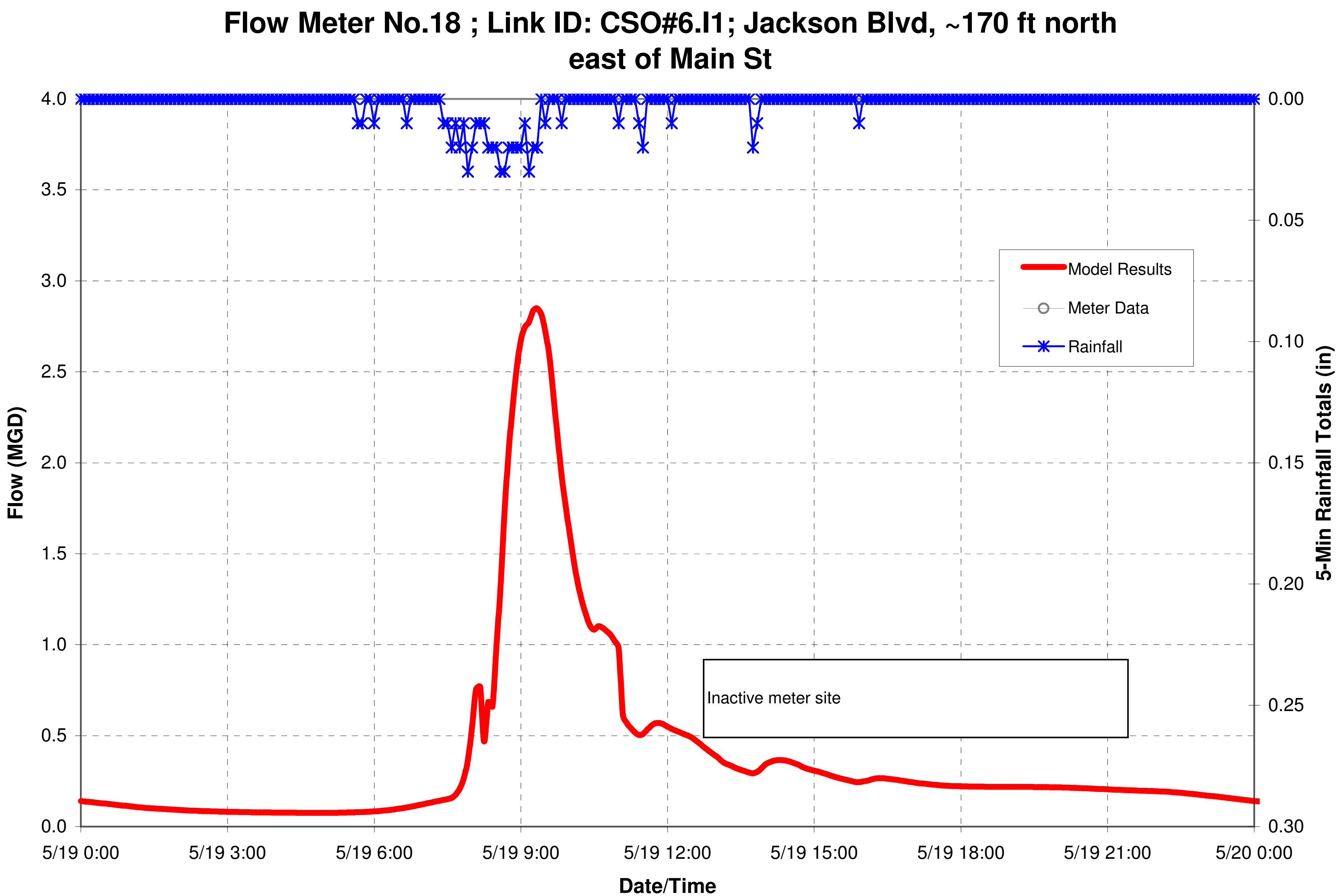


## Flow Meter No.16 ; Link ID: CSO#16.I; Southwest corner of Superior St and Kenwood Ave



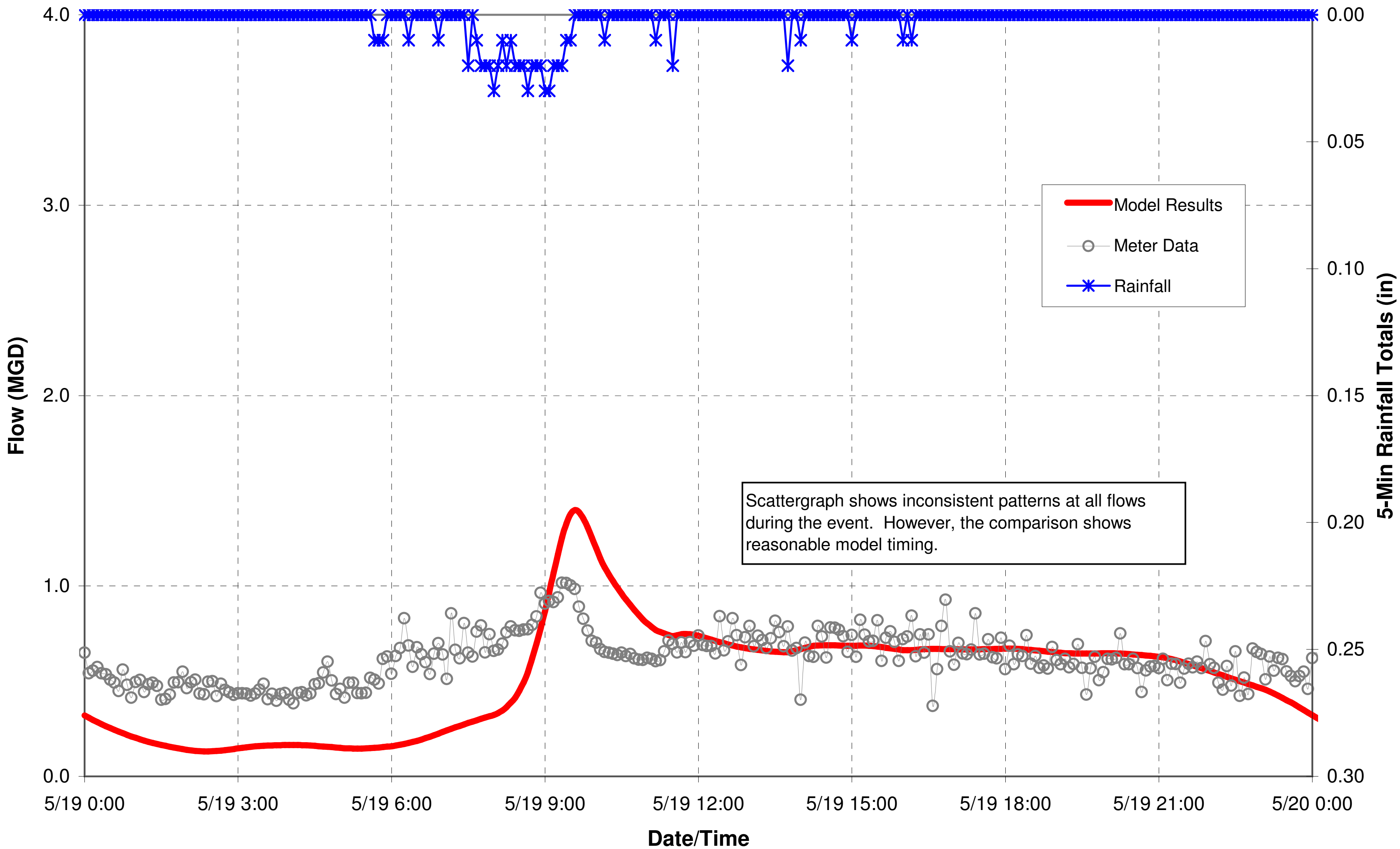


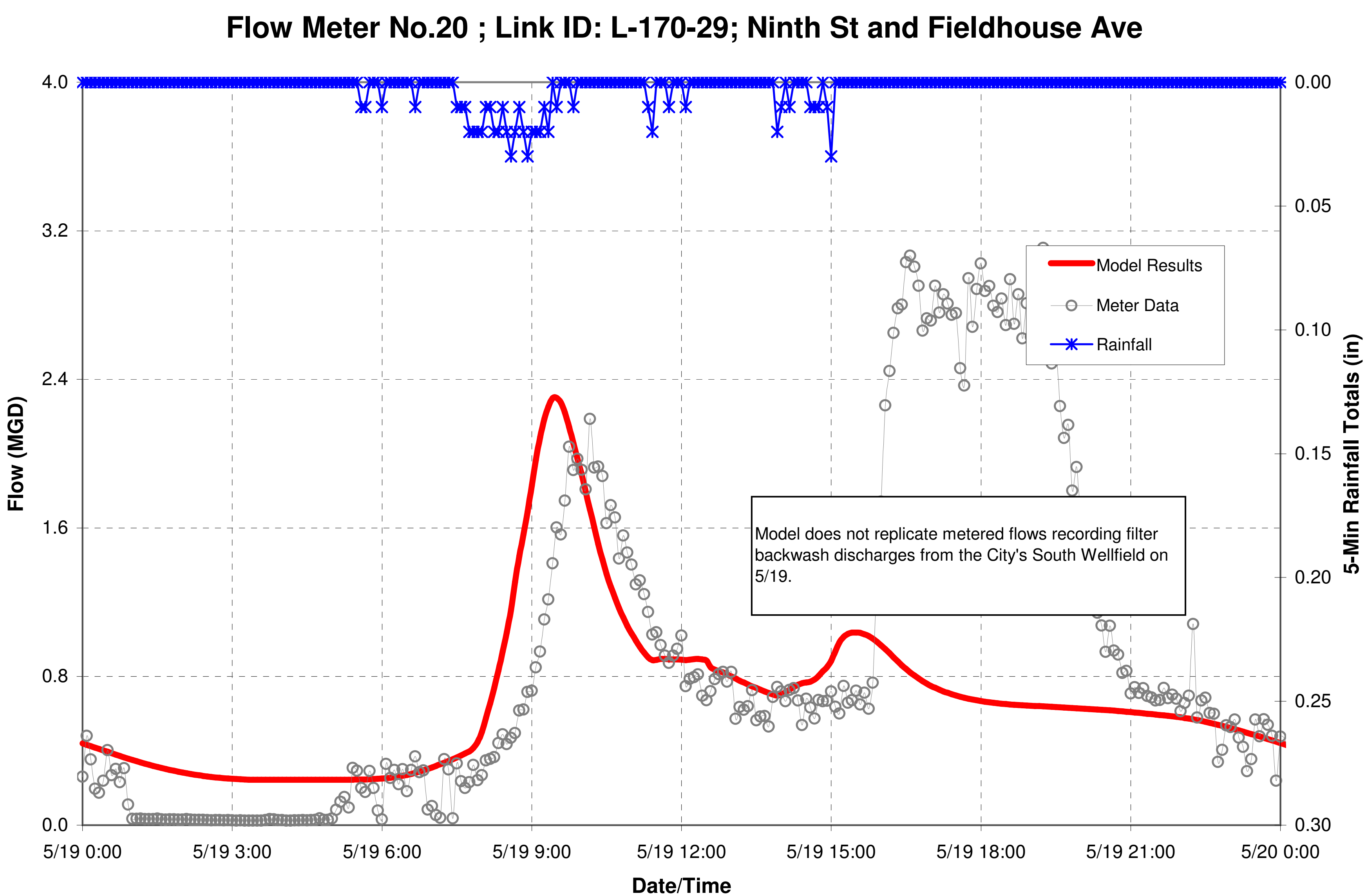
Flow Meter No.17 ; Link ID: L-105-49; Second St and Sycamore St
2.0
1.6
1.2
0.8
0.4
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
Model Results
Meter Data
Rainfall
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Date/Time



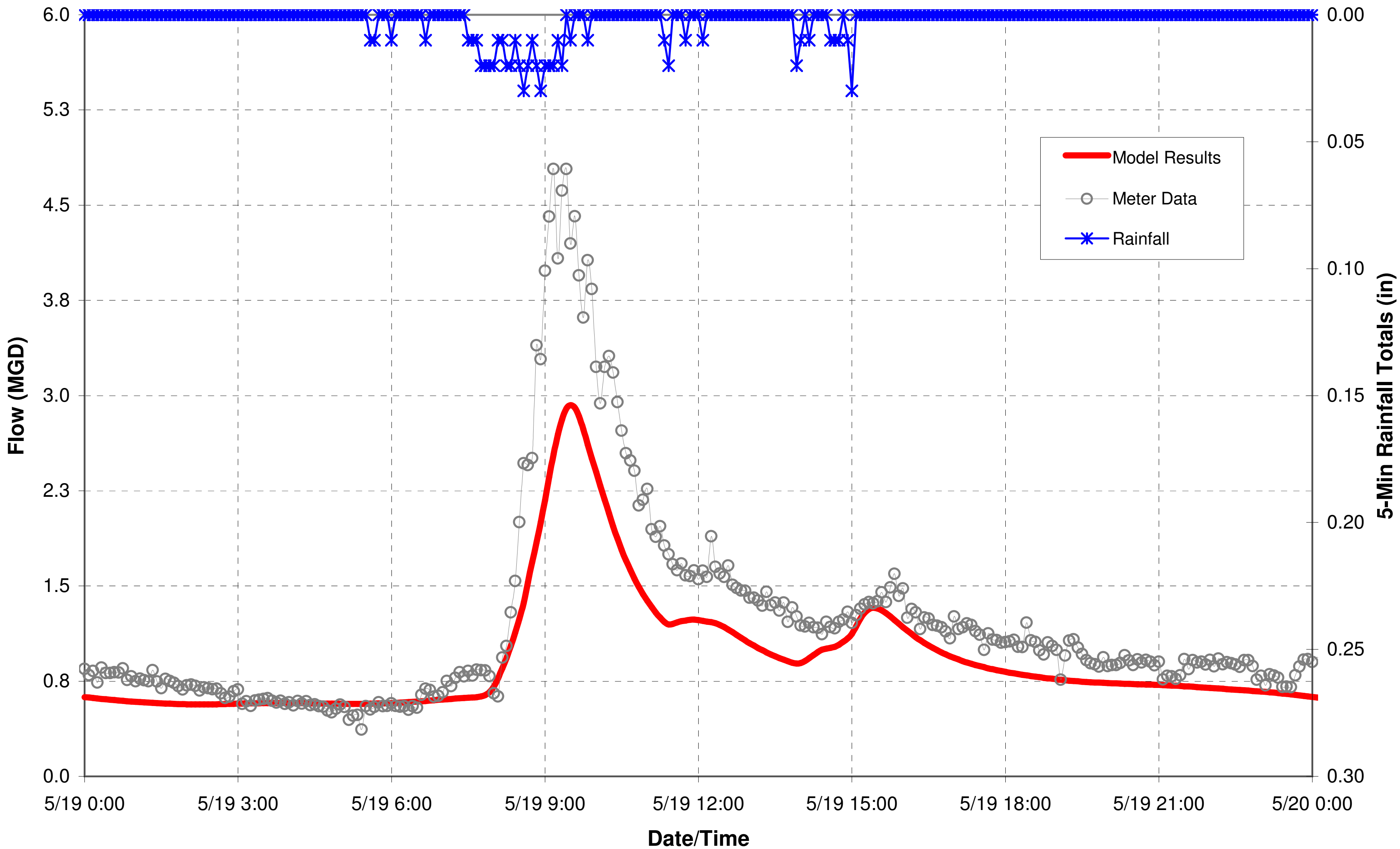
Flow Meter No.18 ; Link ID: CSO#6.I1; Jackson Blvd, ~170 ft north east of Main St
Flow (MGD)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
5-Min Rainfall Totals (in)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
Model Results
Meter Data
Rainfall
Inactive meter site
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Date/Time

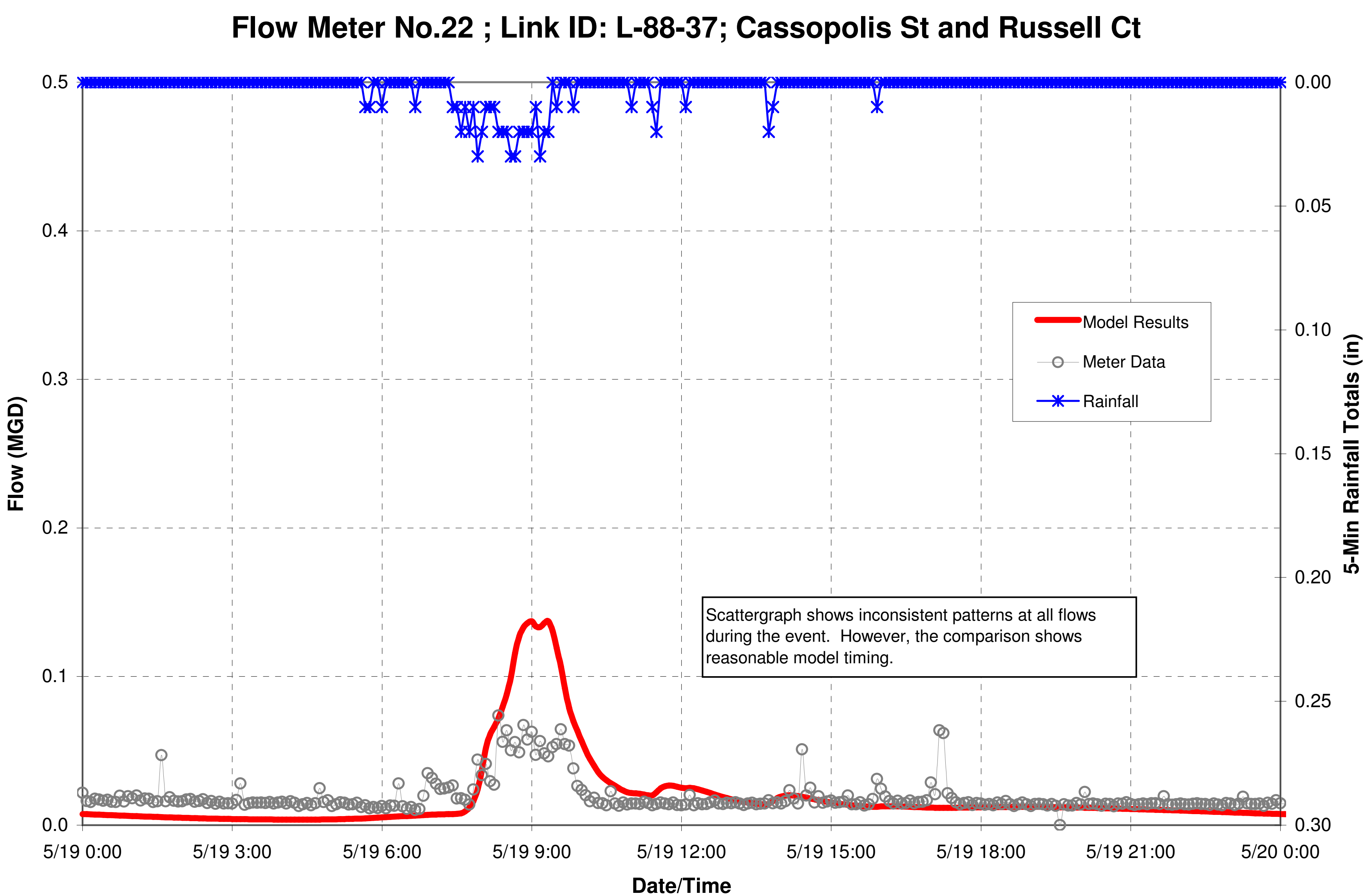
# Flow Meter No.19 ; Link ID: L-123-13; Middlebury St and Denver St




Flow Meter No.20 ; Link ID: L-170-29; Ninth St and Fieldhouse Ave
4.0
3.2
2.4
1.6
0.8
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Date/Time
Model Results
Meter Data
Rainfall
Model does not replicate metered flows recording filter backwash discharges from the City's South Wellfield on 5/19.

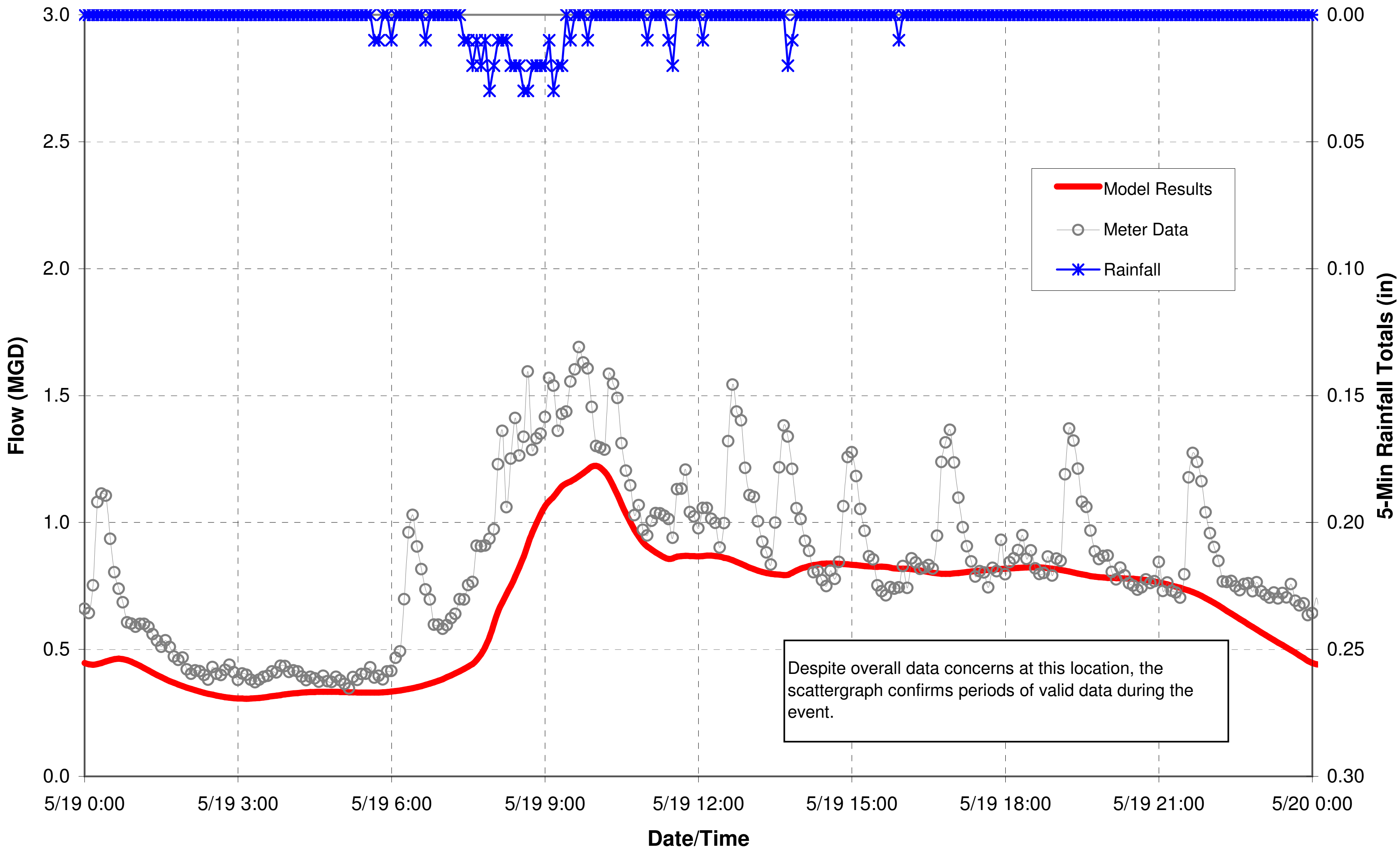
# Flow Meter No.21 ; Link ID: L-170-1; Oakland Ave and Fieldhouse Ave

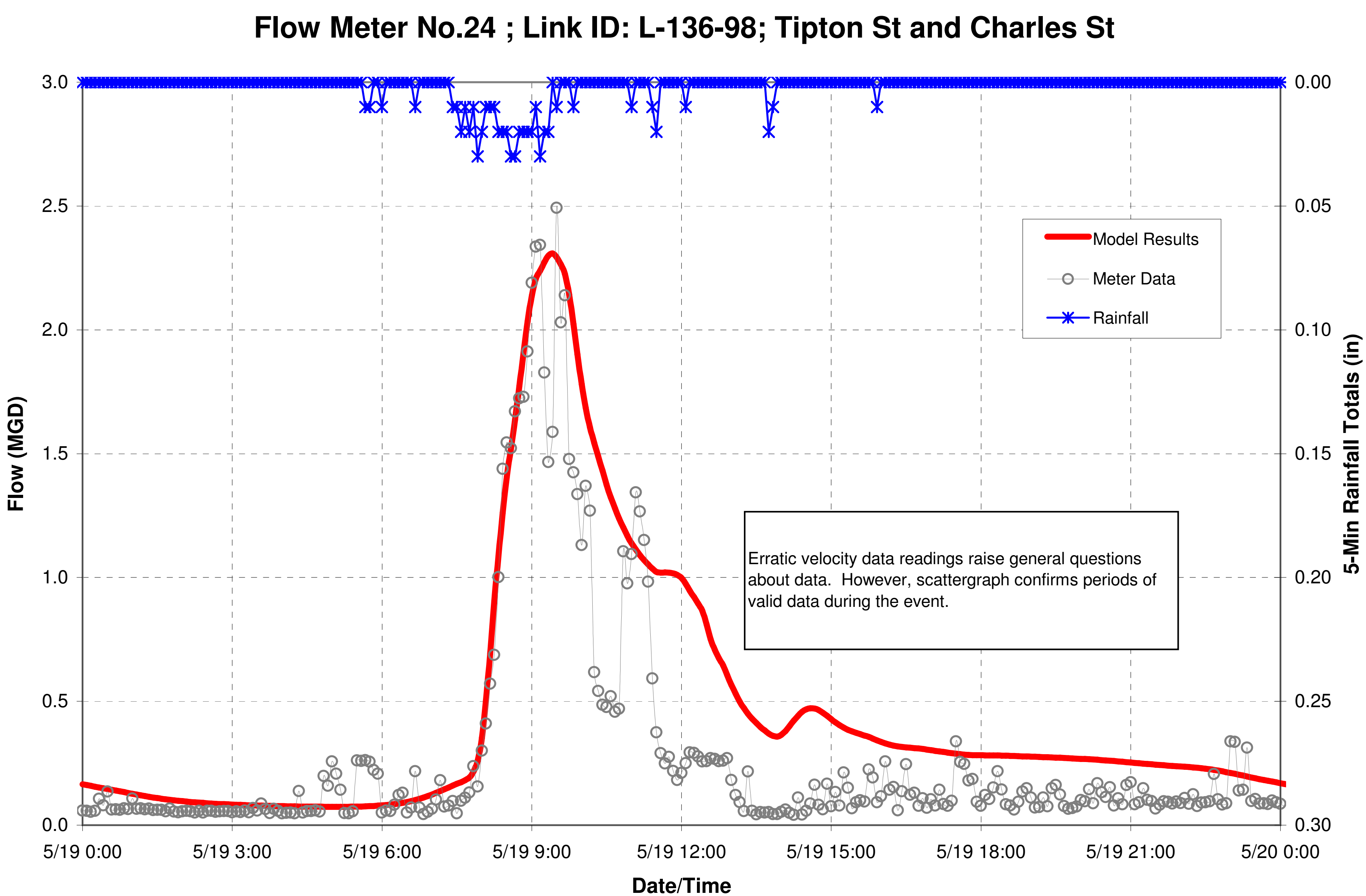




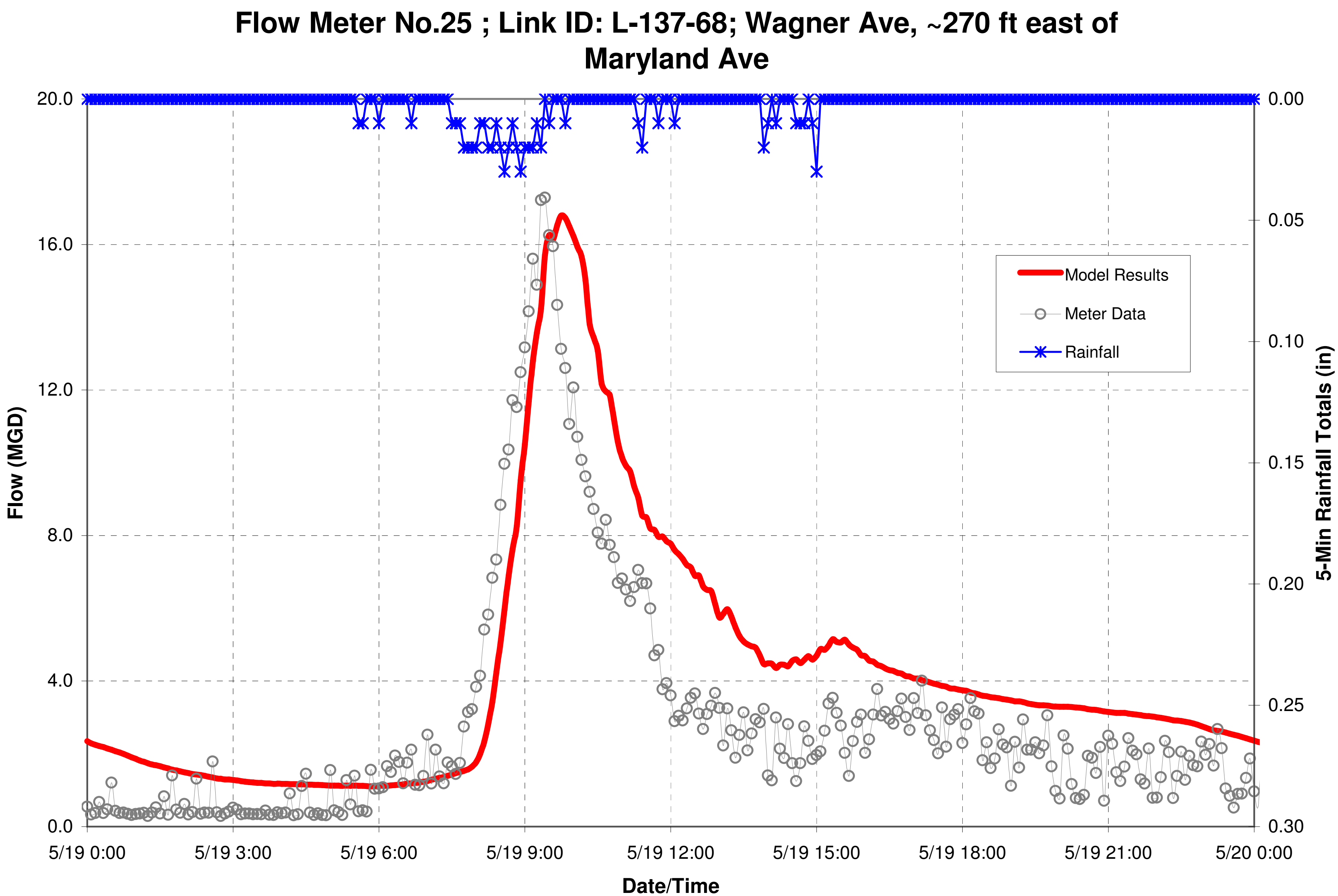
Flow Meter No.22 ; Link ID: L-88-37; Cassopolis St and Russell Ct
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
0.5
0.4
0.3
0.2
0.1
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Model Results
Meter Data
Rainfall
Scattergraph shows inconsistent patterns at all flows during the event. However, the comparison shows reasonable model timing.

## Flow Meter No.23 ; Link ID: L-89-16; Grant St and Dearborn St



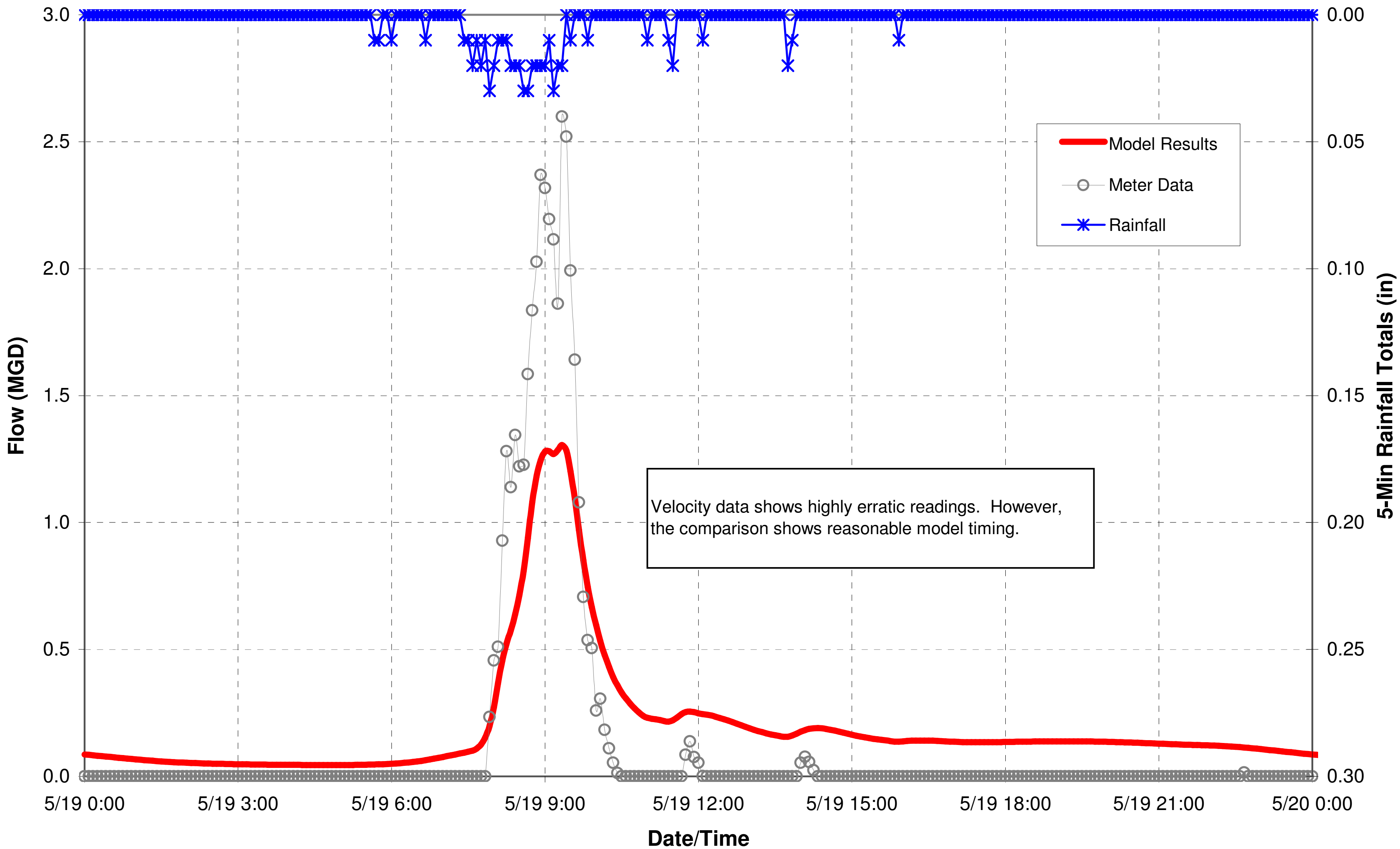


Flow Meter No.24 ; Link ID: L-136-98; Tipton St and Charles St
Flow (MGD)
5-Min Rainfall Totals (in)
Date/Time
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Model Results
Meter Data
Rainfall
Erratic velocity data readings raise general questions about data. However, scattergraph confirms periods of valid data during the event.

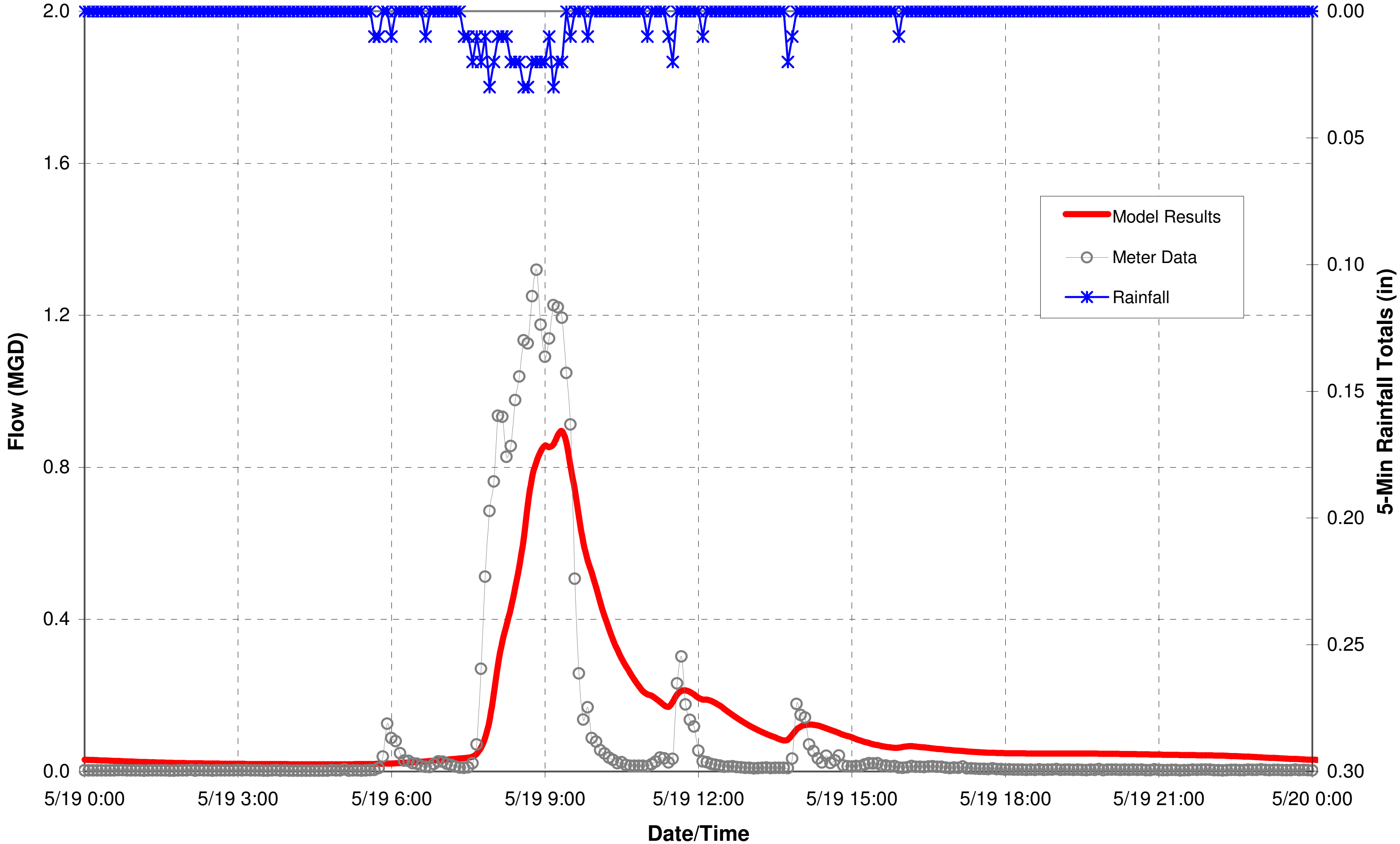


Flow Meter No.25 ; Link ID: L-137-68; Wagner Ave, ~270 ft east of Maryland Ave
20.0
16.0
12.0
8.0
4.0
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Date/Time
Model Results
Meter Data
Rainfall

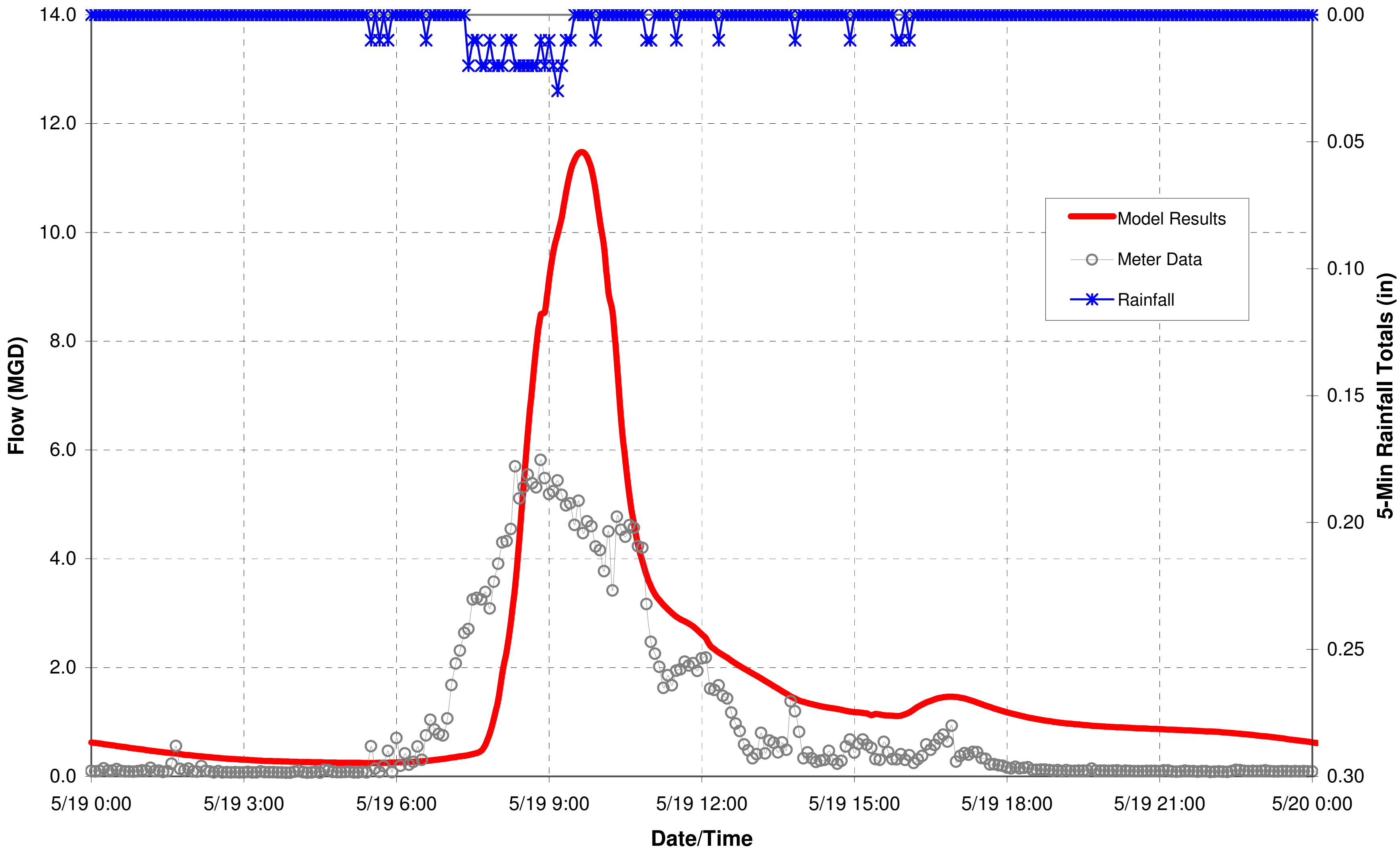
# Flow Meter No.26 ; Link ID: L-120-19; Main St and Lexington Ave

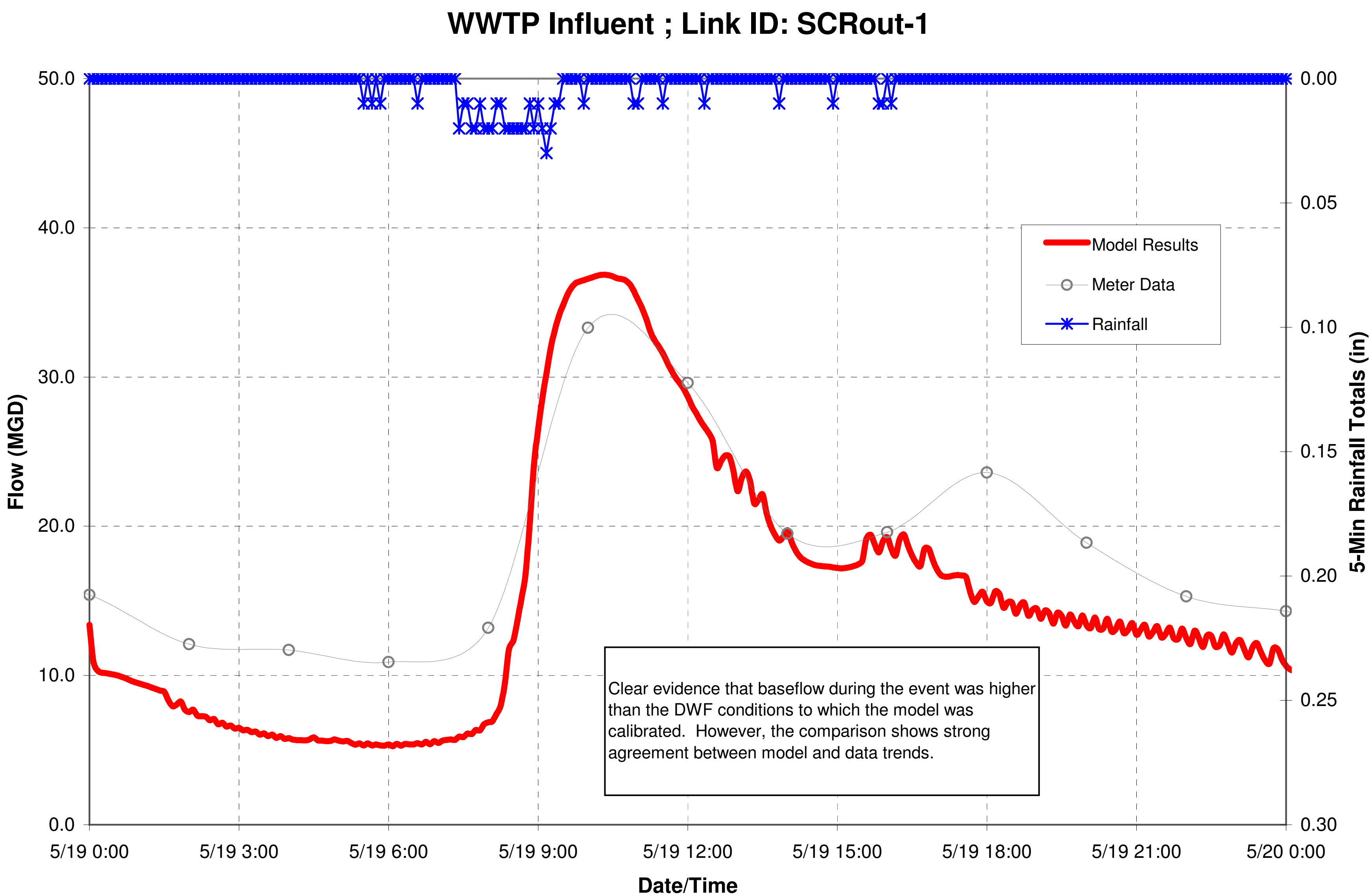


## Flow Meter No.27 ; Link ID: L-120-130; Second St between Lexington Ave and Jackson Blvd



## Flow Meter No.28 ; Link ID: CSO#15.D; Michigan St and Fulton Ave

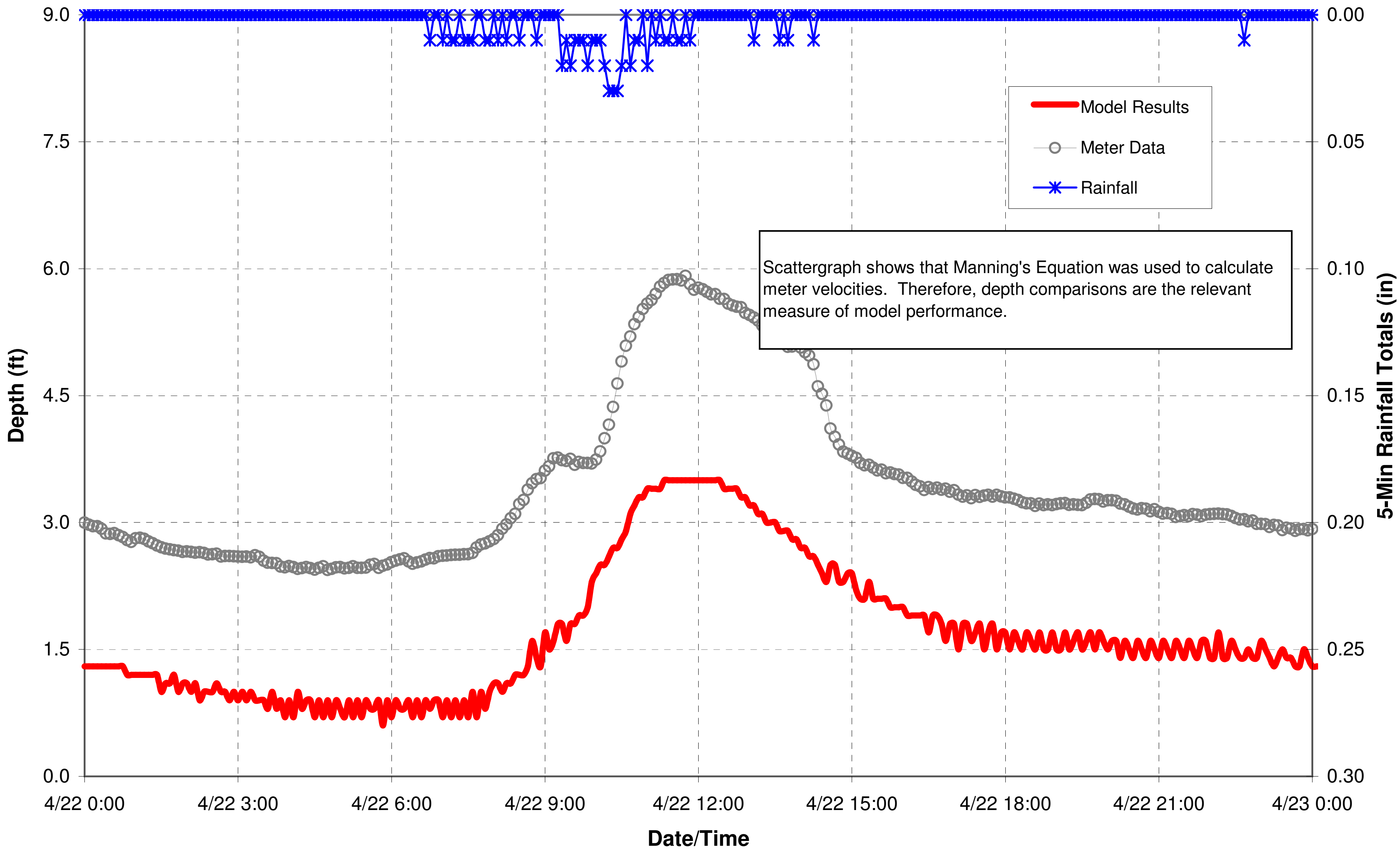



WWTP Influent ; Link ID: SCRout-1
50.0
40.0
30.0
20.0
10.0
0.0
Flow (MGD)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5-Min Rainfall Totals (in)
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Date/Time
Model Results
Meter Data
Rainfall
Clear evidence that baseflow during the event was higher than the DWF conditions to which the model was calibrated. However, the comparison shows strong agreement between model and data trends.

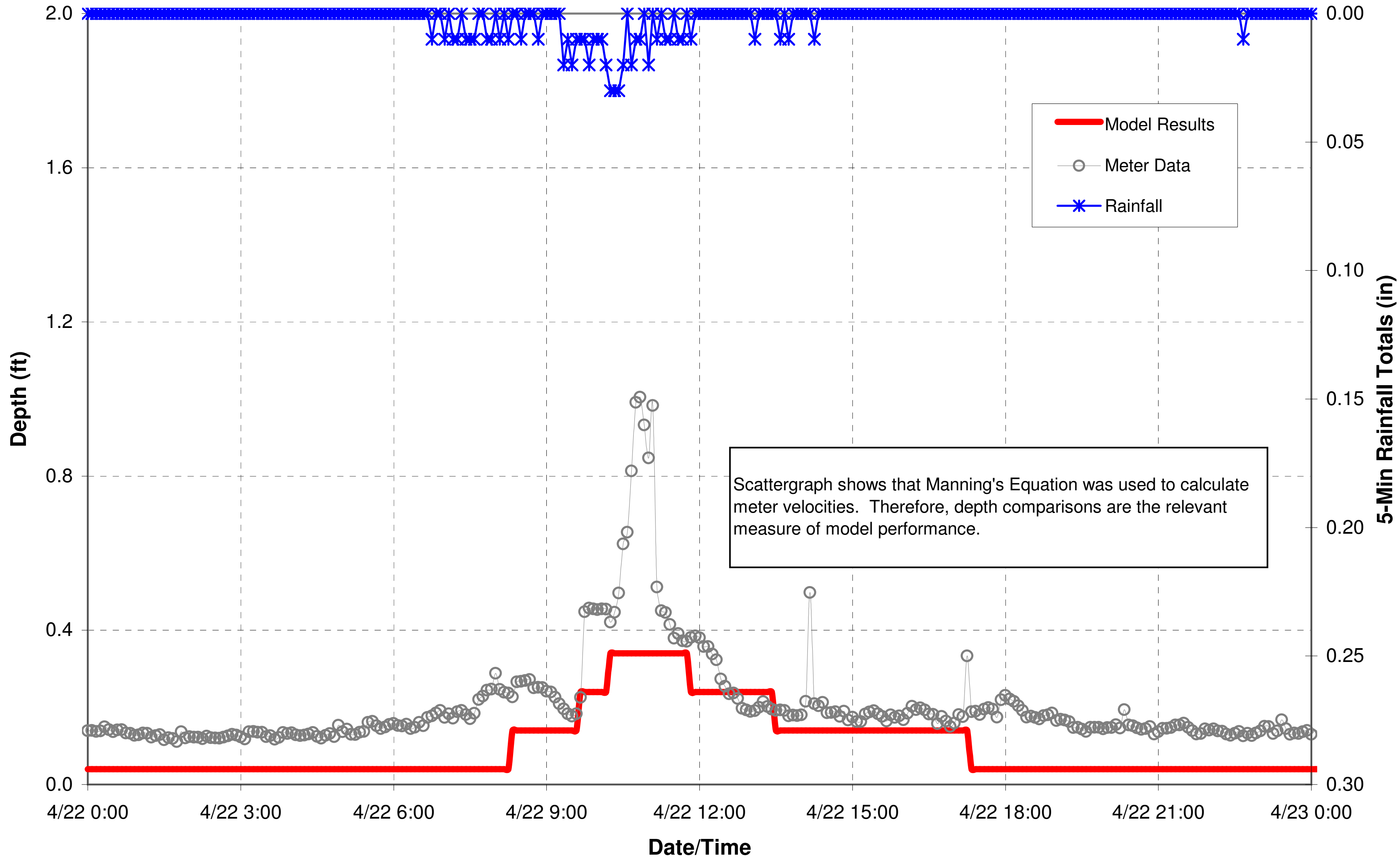
# Appendix 2

# Meter-to-Model Depth Hydrographs

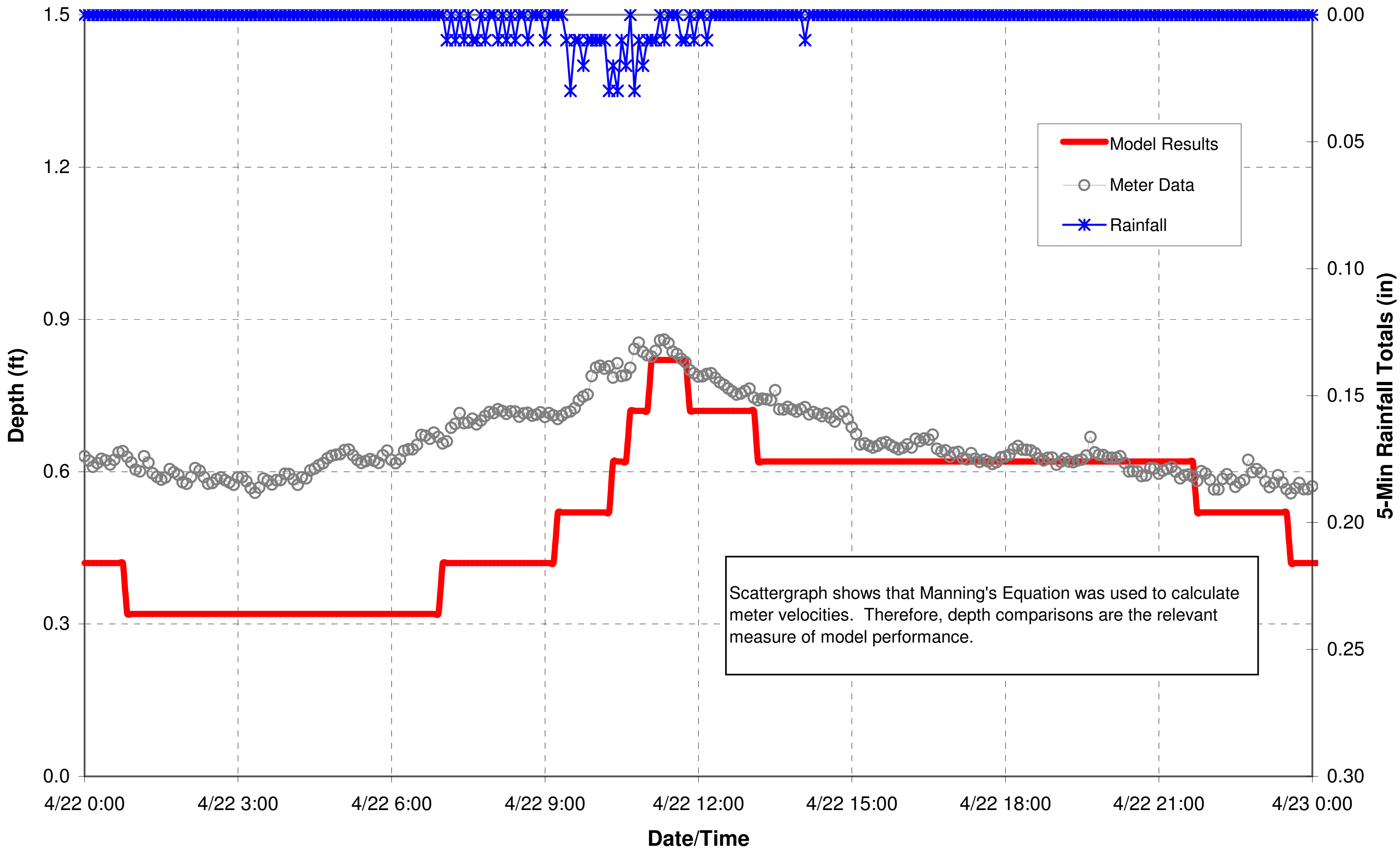
## Flow Meter No.13 ; Link ID: L-140-38; Navajo St, ~275 ft south of



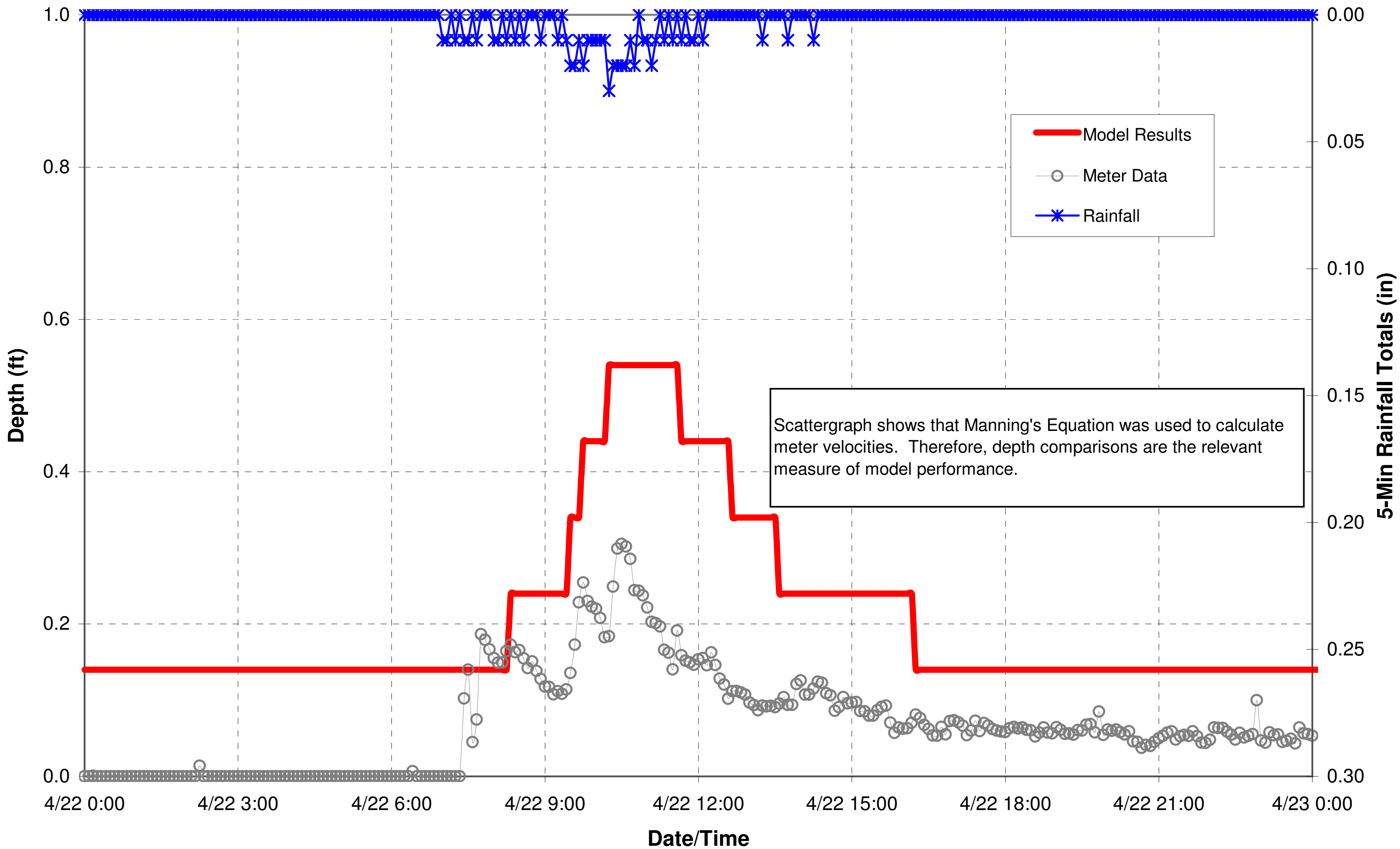
## Flow Meter No.17 ; Link ID: L-105-49; Second St and Sycamore St



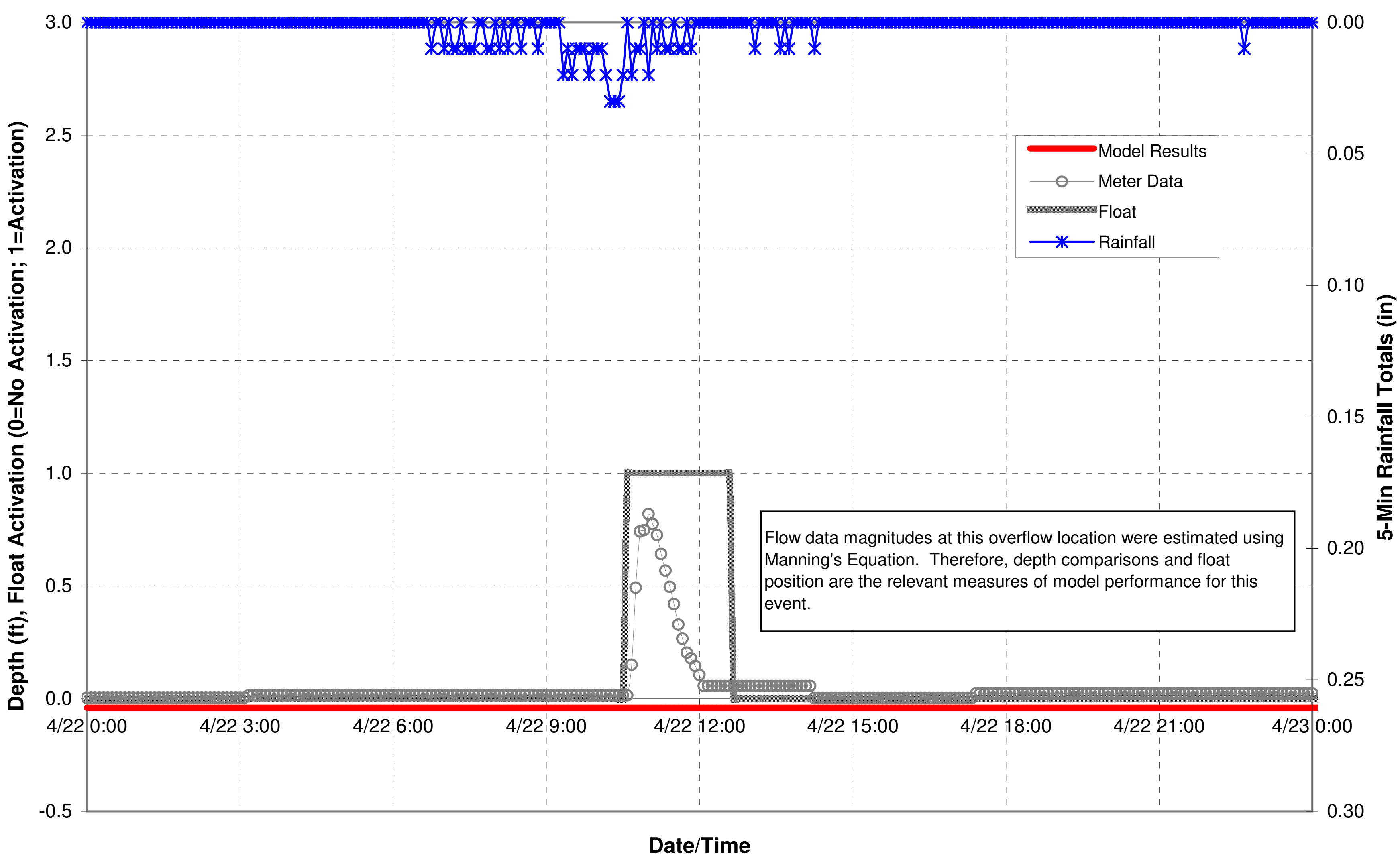
## Flow Meter No.19 ; Link ID: L-123-13; Middlebury St and Denver St



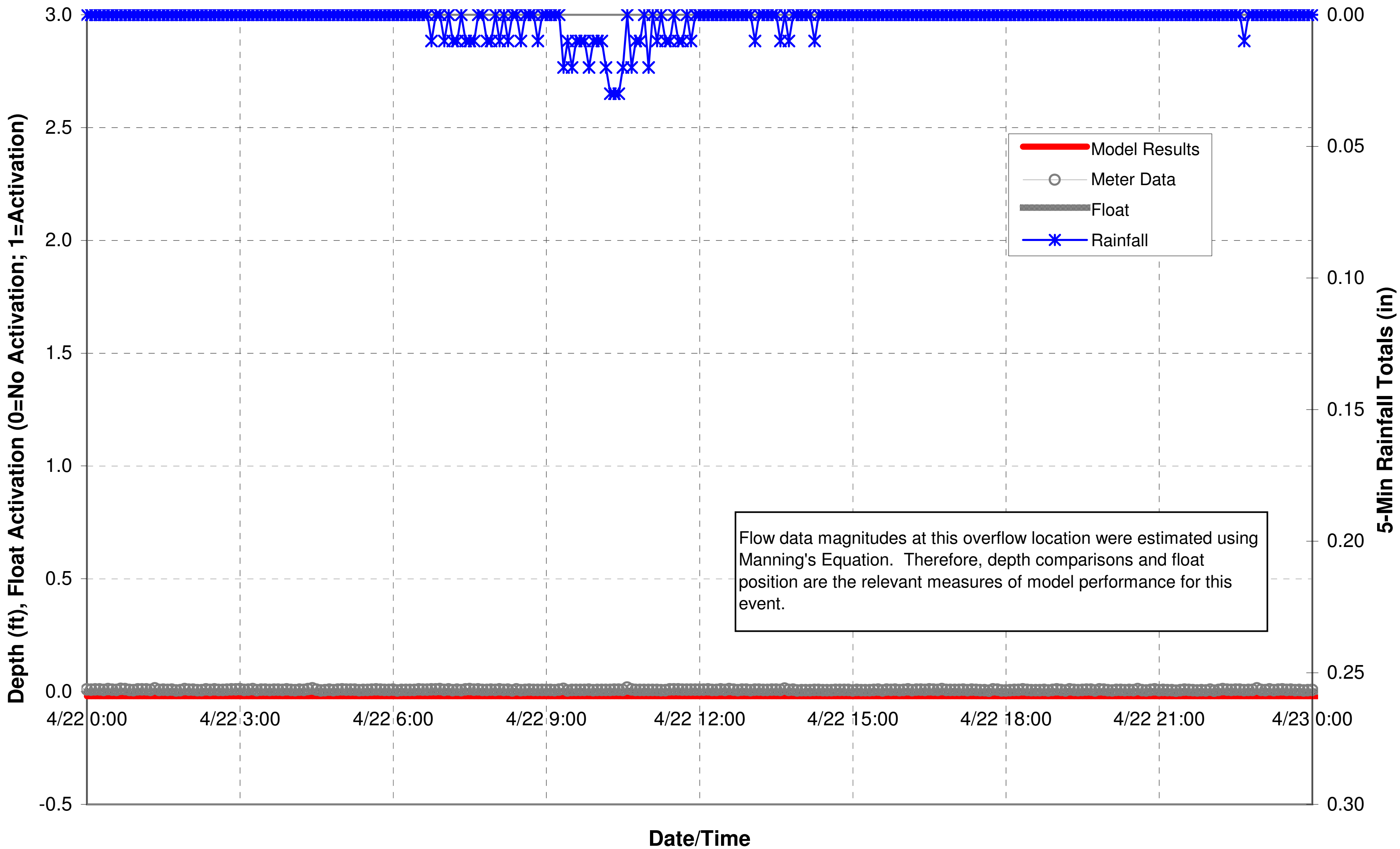
## Flow Meter No.27 ; Link ID: L-120-130; Second St between Lexington

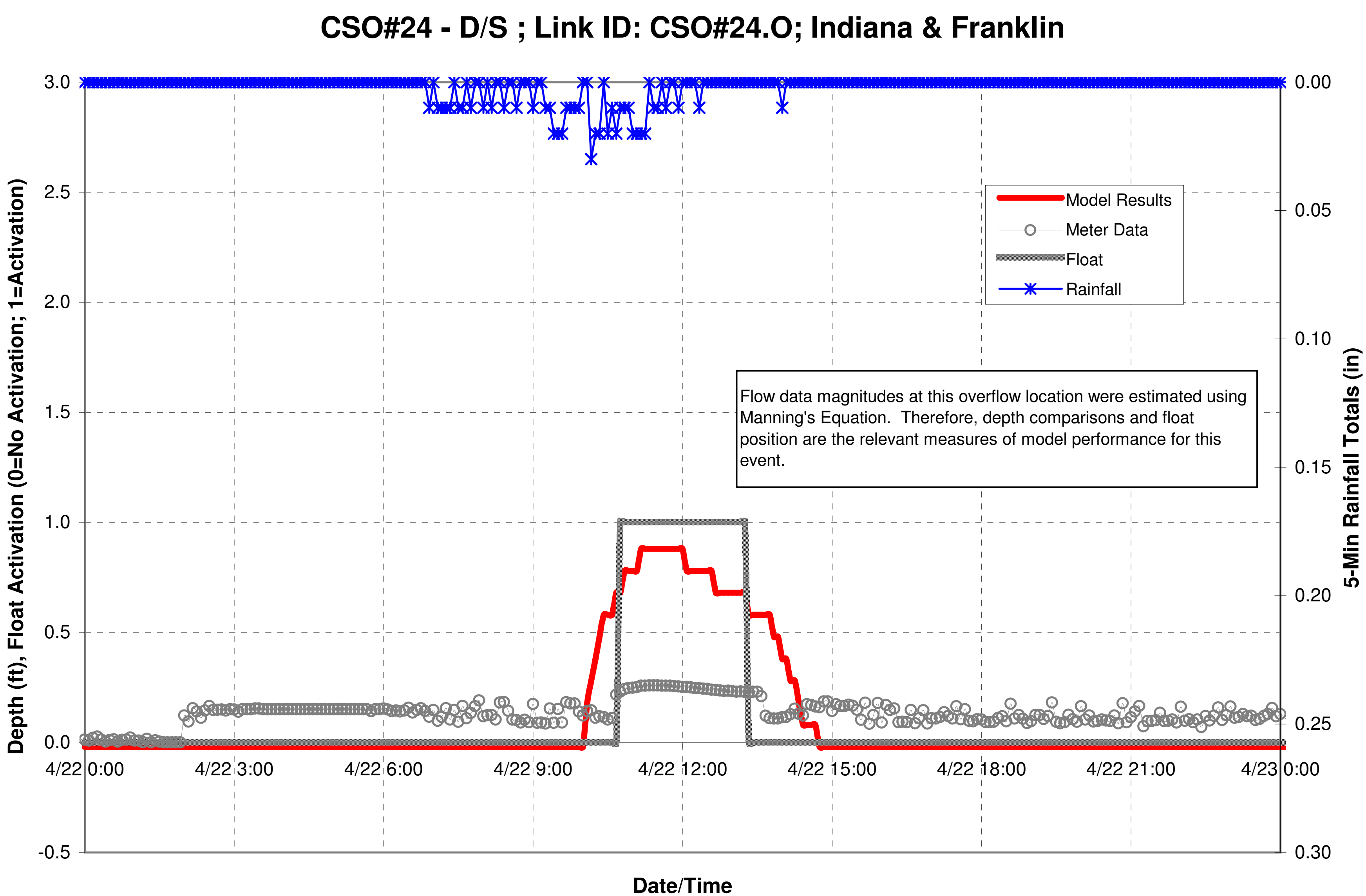


# CSO#15 - D/S ; Link ID: CSO#15.O; Michigan & Fulton



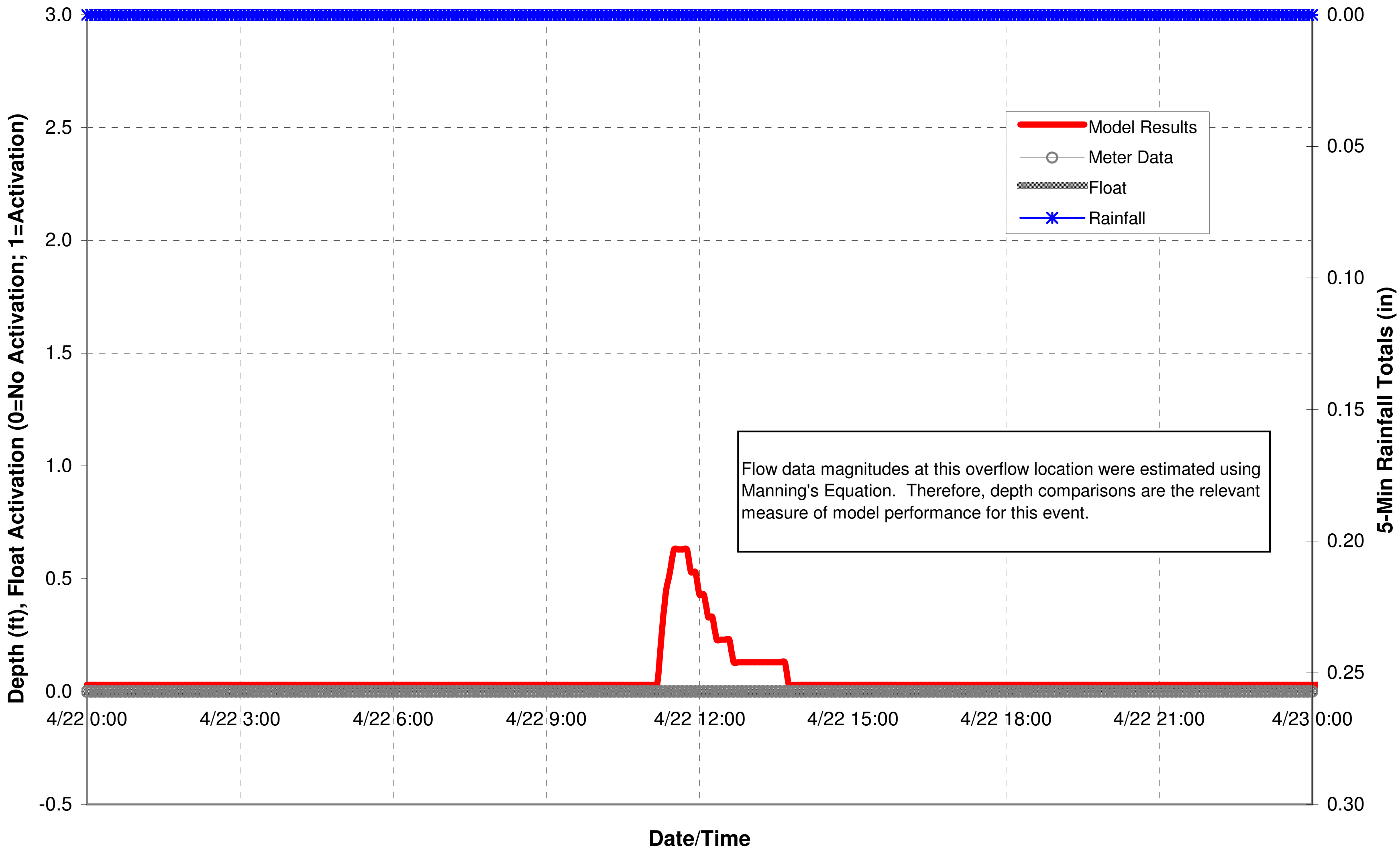
# CSO#17 - D/S ; Link ID: CSO#17.O; McNaughton Park @ West Blvd

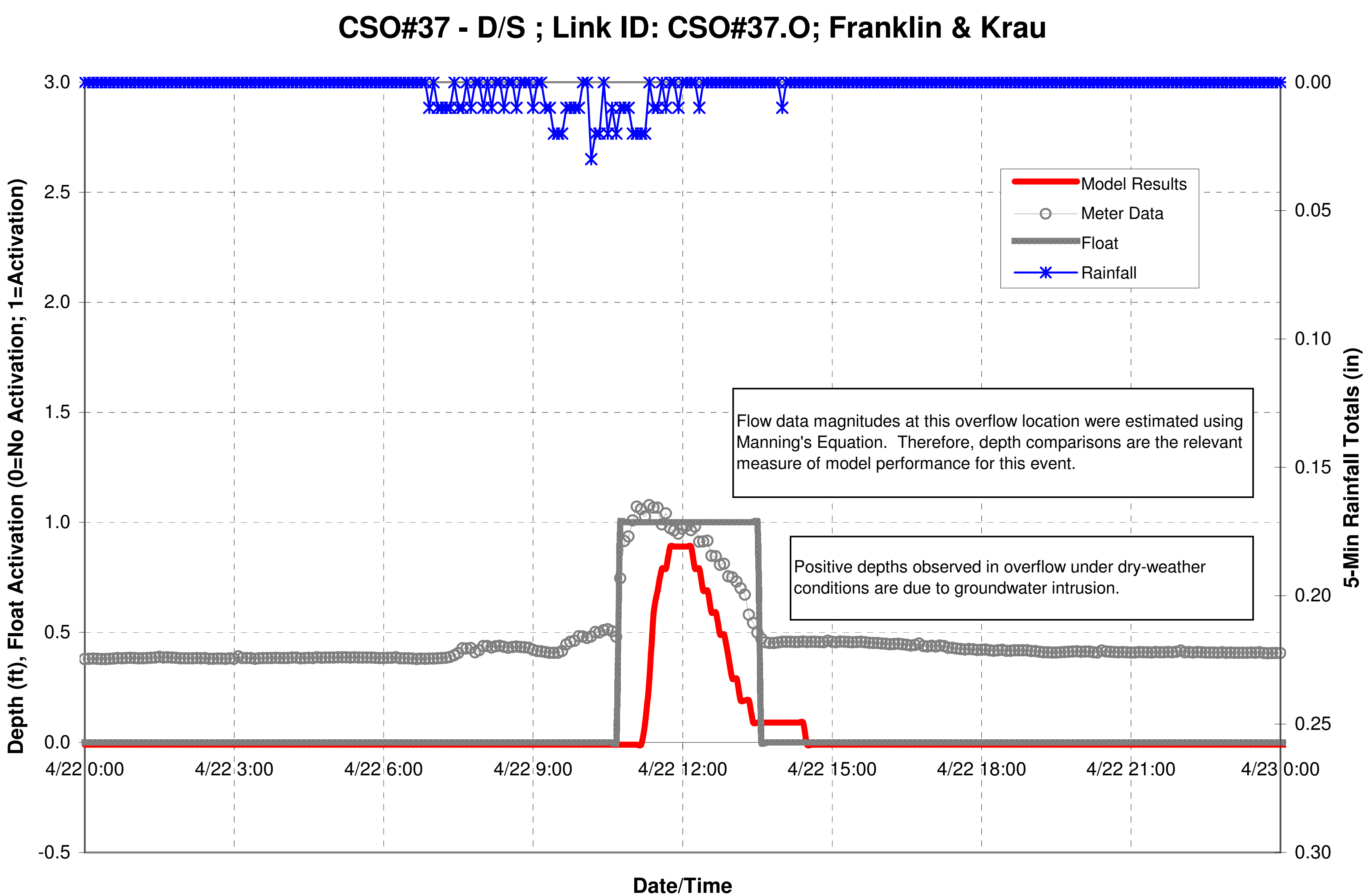




CSO#24 - D/S ; Link ID: CSO#24.O; Indiana & Franklin
Depth (ft), Float Activation (0=No Activation; 1=Activation)
5-Min Rainfall Totals (in)
Date/Time
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons and float position are the relevant measures of model performance for this event.

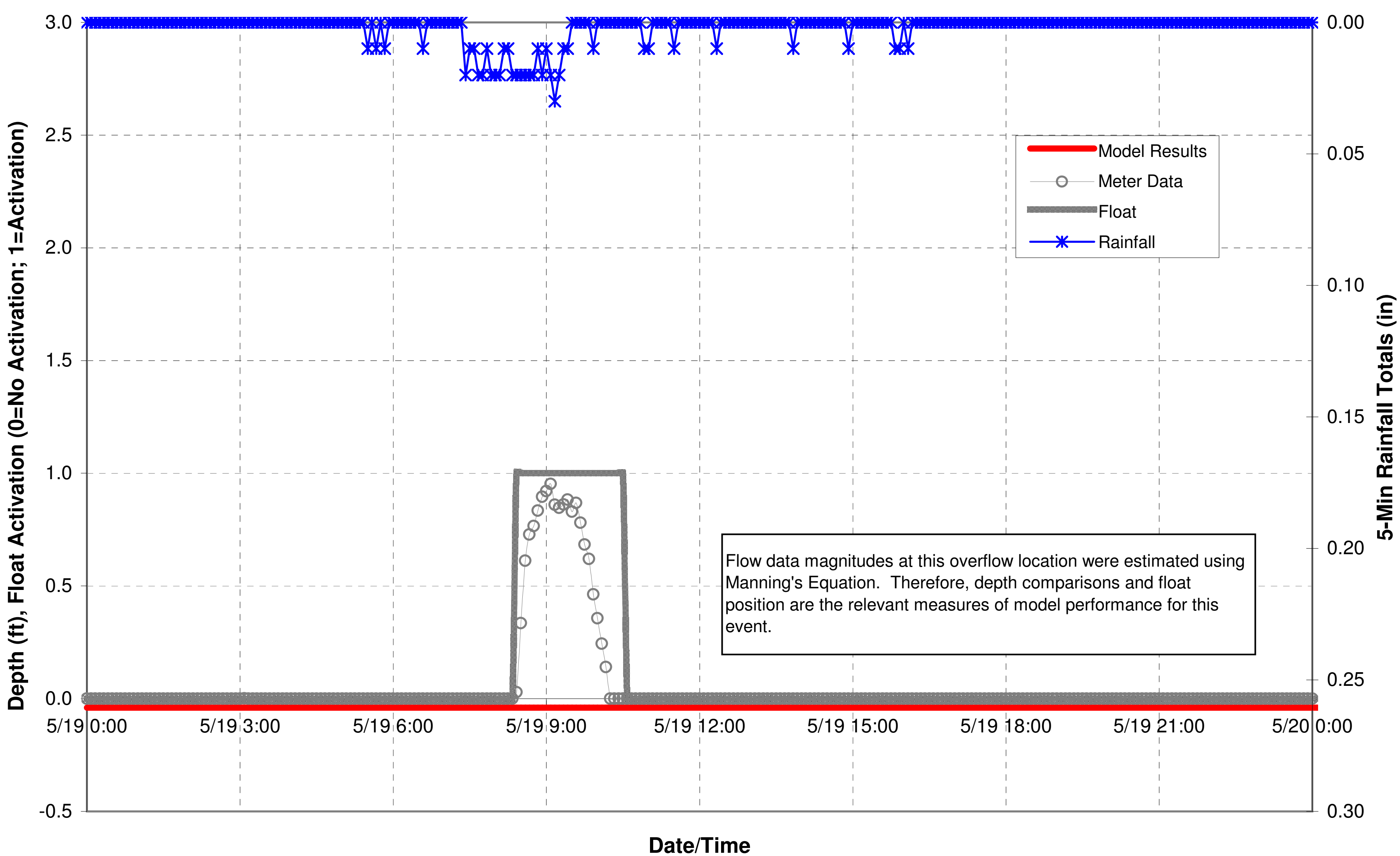
## CSO#31 - D/S ; Link ID: CSO#31.O; Elizabeth & Lusher



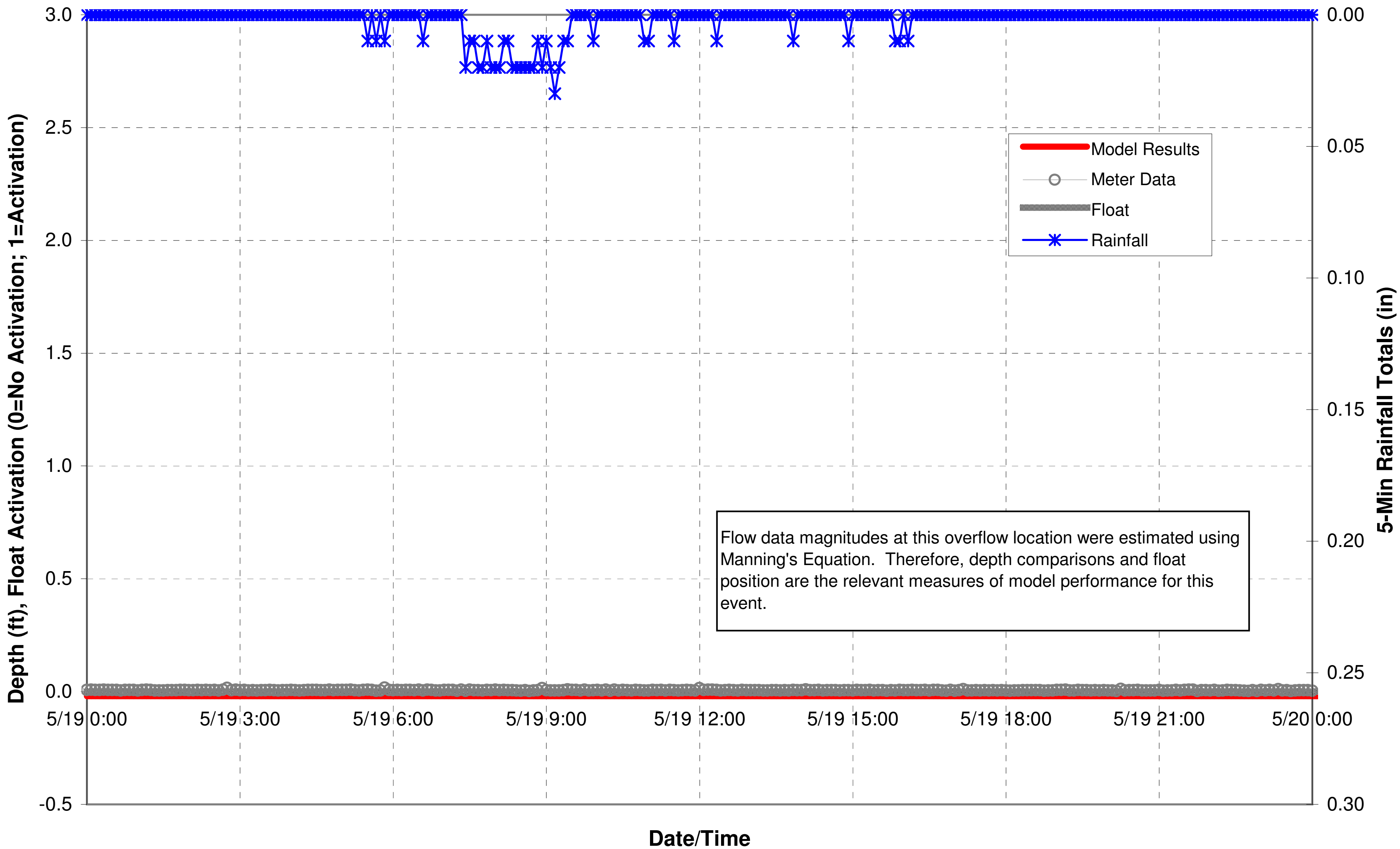


CSO#37 - D/S ; Link ID: CSO#37.O; Franklin & Krau
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons are the relevant measure of model performance for this event.
Positive depths observed in overflow under dry-weather conditions are due to groundwater intrusion.
Depth (ft), Float Activation (0=No Activation; 1=Activation)
5-Min Rainfall Totals (in)
Date/Time
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0.00
0.05
0.10
0.15
0.20
0.25
0.30
4/22 0:00
4/22 3:00
4/22 6:00
4/22 9:00
4/22 12:00
4/22 15:00
4/22 18:00
4/22 21:00
4/23 0:00

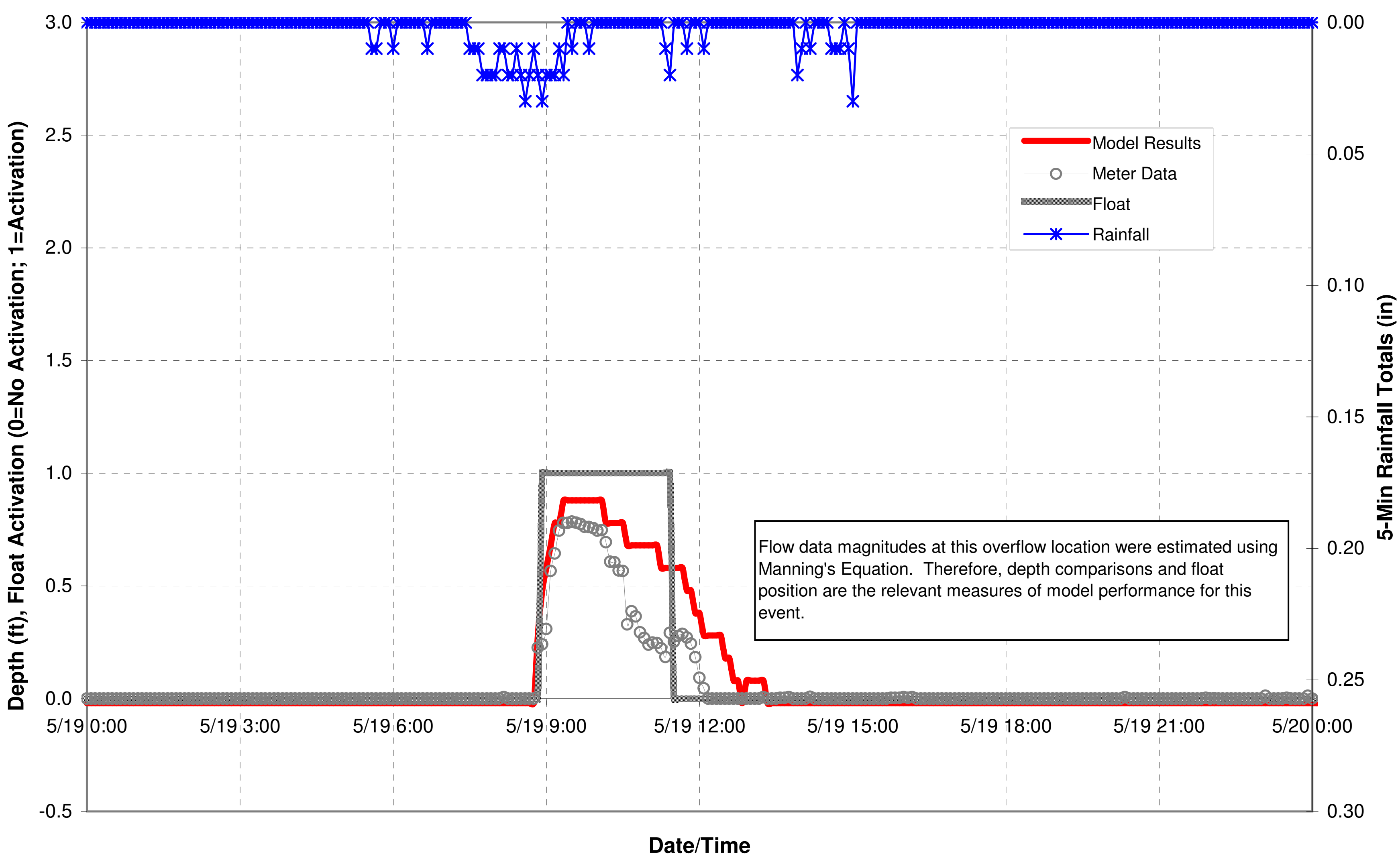
# CSO#15 - D/S ; Link ID: CSO#15.O; Michigan & Fulton



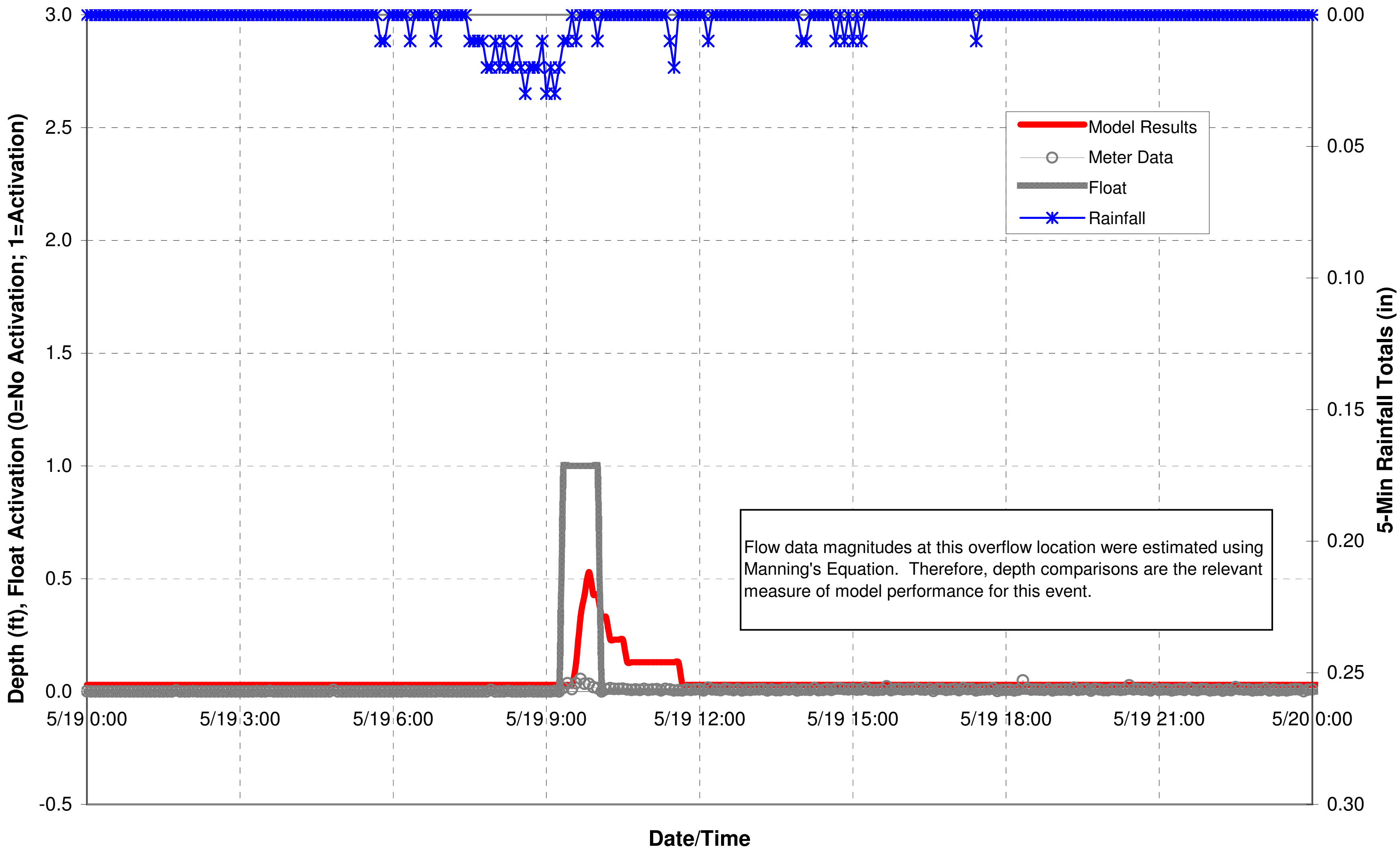
## CSO#17 - D/S ; Link ID: CSO#17.O; McNaughton Park @ West Blvd

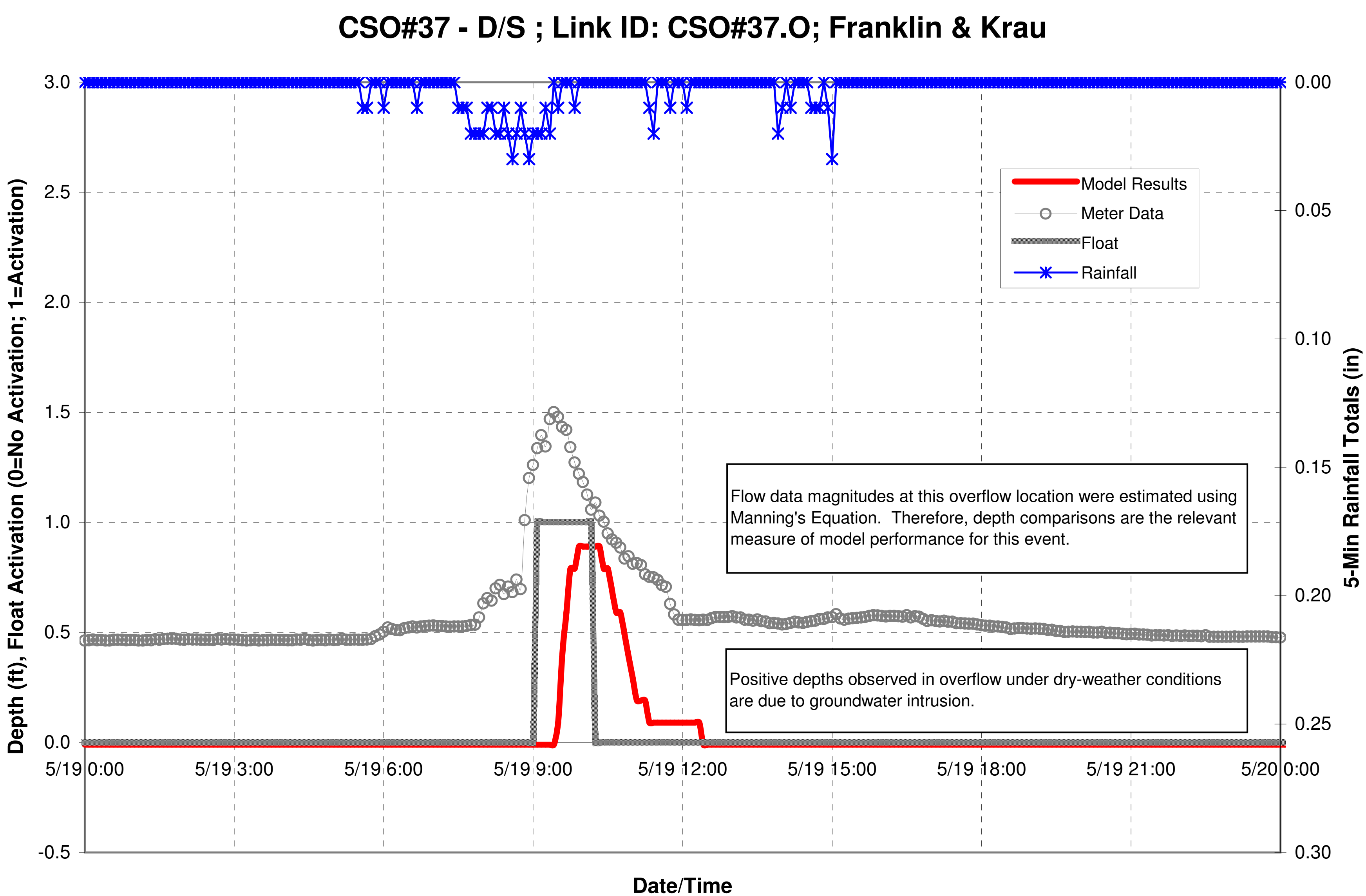


# CSO#24 - D/S ; Link ID: CSO#24.O; Indiana & Franklin



## CSO#31 - D/S ; Link ID: CSO#31.O; Elizabeth & Lusher




CSO#37 - D/S ; Link ID: CSO#37.O; Franklin & Krau
Depth (ft), Float Activation (0=No Activation; 1=Activation)
5-Min Rainfall Totals (in)
Date/Time
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
0.00
0.05
0.10
0.15
0.20
0.25
0.30
5/19 0:00
5/19 3:00
5/19 6:00
5/19 9:00
5/19 12:00
5/19 15:00
5/19 18:00
5/19 21:00
5/20 0:00
Model Results
Meter Data
Float
Rainfall
Flow data magnitudes at this overflow location were estimated using Manning's Equation. Therefore, depth comparisons are the relevant measure of model performance for this event.
Positive depths observed in overflow under dry-weather conditions are due to groundwater intrusion.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5
77 WEST JACKSON BOULEVARD
CHICAGO, IL 60604-3590

FEB 0 9 2007

REPLY TO THE ATTENTION OF:

WC-15J

Mr. Mark Salee
Regulatory Affairs
City of Elkhart
1201 South Nappanee Street
Elkhart, IN 46516

**Re: Combined Sewer Overflow (CSO) Long Term Control Plan (LTCP) Hydraulic Model – Agency Review and Conclusions**

The U.S. Environmental Protection Agency, Region 5 has completed its review of the City of Elkhart's Hydraulic Model (SWMM) submissions.

The City conducted flow monitoring in 2004 and 2005, and utilized 3 storm events for model calibration and 2 storm events for model validation. As described in the **Elkhart Model Summary (Attachment A)** and graphically depicted in **Table 3 - Flow Monitoring Summary Data (color highlighted; Attachment B)**, a significant amount of data was not considered valid for use in the direct volume and peak flow comparisons. Data gaps observed for the 28 in-system meters were as follows: for calibration events, gaps were in excess of 53%; data gaps in validation events were in excess of 35%. Further, none of the CSO data was used for direct comparison of peak flow rates or volumes. Of particular concern, there appears a current inability of the model to accurately predict, for at least one major CSO, overflows which have been physically observed in the flow monitoring program (e.g., CSO#15; see Table 4 of SWMM Validation Report). Given these limitations, EPA has concerns that the loss of data may have affected Elkhart's ability to calibrate and validate the SWMM model thoroughly, necessitating the need to additionally enhance the model so it can accurately predict CSO activity.

Based on the above somewhat limiting data sets for calibration and validation, USEPA strongly encourages continued data collection to further develop the SWMM model and its model predictions to hone in on possible control alternatives for design purposes. The City indicated to USEPA, in an on-site meeting in Elkhart on August 2, 2006, that the

City has, and is acquiring additional, flow monitoring equipment. The City indicated that it will continue flow monitoring going forward. In these next flow monitoring efforts, flow monitoring equipment inspection and maintenance will be essential, as evidenced by the number of equipment malfunctions experienced in 2004 and 2005 (see Attachment B). This diligence will ensure optimum value for the flow monitoring equipment resources investment. Also, the model should be used in a conservative manner, that is, consideration should be given to use of an appropriate safety factor in evaluation in the sizing of various alternatives.

The City, therefore, is authorized to proceed with the use of this model to project hydraulic loading for use in evaluating CSO control alternatives. The City is also reminded that should the LTCP selected CSO control alternative not meet water quality standards as required when implementation is completed, and as observed during post-construction monitoring, an additional level of control will be required at that time.

If you have any questions, please contact John Wiemhoff of my staff at 312-353-8546.

Sincerely,

Cheryl Newton,
Acting Branch Chief
Water Enforcement and Compliance Assurance
USEPA - Region 5

Enclosure

cc: Wayne Ault, USDOJ
Paul Calamita, Aqualaw
Yvonne Ciccone, SAIC
David Denman, IDEM
Gunita Goulding, Malcolm Pirnie
Laura Kolo, Elkhart
Pat Kuefler, USEPA
Michael Machlan, Elkhart
Kathleen Schnieders, USEPA
Cyndi Wagner, IDEM
Dante Zettler, Malcolm Pirnie

A

**Elkhart Model Points**

- The CSO flow monitoring points represent 63% of the overflow volume and 35% of Elkhart's area.

- The numerical calibration goals were to bring volume and peak flow to within +/- 30%. Three storms were used for calibration, 11-1-2004, 11-4-2004, and 6-12-2005. There were 28 in-system flow monitoring points (these do not include the CSO flow monitors or the WWTP influent). Not all of the flow monitoring points were considered adequate to be used in the direct volume and peak flow comparisons. Some of these flow monitoring points represented high flow locations. None of the directly measured CSO data was used in the direct volume and peak flow comparisons, due to issues with the velocity data. All of the WWTP influent data met the goals.

- Calibration events

11-1-2004: 16 flow monitors (57%) were not used in direct volume and peak flow comparisons.
12 flow monitors were used.
For the volume comparison 4 of the 12 were not within the +/- 30% goal. For all 4 the model over-predicted volume.
For the peak flow comparison 1 of the 12 was not within the +/- 30% goal. For the 1 the model over-predicted peak flow.

11-4-2004: 16 flow monitors (57%) were not used in direct volume and peak flow comparisons.
12 flow monitors were used.
For the volume comparison 3 of the 12 were not within the +/- 30% goal. For all 3 the model over-predicted volume.
For the peak flow comparison 2 of the 12 were not within the +/- 30% goal. For 1 the model over-predicted peak flow and for 1 the model under-predicted peak flow.

6-12-2005: 13 flow monitors (46%) were not used in direct volume and peak flow comparisons.
15 flow monitors were used.
For the volume comparison 3 of the 15 were not within the +/- 30% goal. For all 3 the model over-predicted volume.
For the peak flow comparison 1 of the 15 was not within the +/- 30% goal. For the 1 the model over-predicted peak flow.

- The numerical validation goals were to bring volume and peak flow to within +/- 35%. Two storms were used for validation, 4-22-2005 and 5-19-2005. There were 28 in-system flow monitoring points (these do not include the CSO flow monitors or the

B

| Flow Meter | Pipe Diameter (in) | Sewer Type | Meter Function | Spring 2005 * Maximum Flow (MGD) | General Data Categorization for Calibration Events | | | General Data Categorization for Validation Events | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 11/1/2004 | 11/4/2004 | 6/12/2005 | 4/22/2005 | 5/19/2005 |
| 1 | 60 | Combined Sewer | Monitors flows u/s of CSO 15 | 53.08 | | | | | |
| 2 | 24 | Combined Sewer | Monitors flows u/s of CSO 15 | 9.87 | | | | | |
| 3 | 24 | Interceptor | Monitors flows d/s of CSO 15 | 6.36 | | | | | |
| 4 | 66 | Combined Sewer | Monitors flows u/s of CSO 31 | 6.94 | | | | | |
| 5 | 30 | Interceptor | Monitors flows u/s of CSO 17 | 11.64 | | | | | |
| 6 | 48 | Interceptor | Monitors flows u/s of CSO 24 | 47.85 | | | | | |
| 7 | 54 | Combined Sewer | Monitors flows u/s of CSO 37 | 7.99 | | | | | |
| 8 | 72 | Interceptor | Monitors flows u/s of CSO 37 | 81.04 | | | | | |
| 9 | 48 | Combined Sewer | Monitors flows u/s of CSO 14 | 8.26 | | | | | |
| 10 | 24 | Combined Sewer | Monitors flows u/s of CSO 13 | 3.93 | | | | | |
| 11 | 21 | Interceptor | Monitors flows d/s of CSO 17 | 8.31 | | | | | |
| 12 | 24 | Combined Sewer | Monitors flows u/s of CSO 23 | 9.99 | | | | | |
| 13 | 42 | Interceptor | Monitors flows u/s of Edgewater Lift Station | 42.78 | | | | | |
| 14 | 24 | Interceptor | Monitors flows u/s of CSO 7 | 4.25 | | | | | |
| 15 | 48 | Combined Sewer | Monitors flows u/s of CSO 33 | 19.11 | | | | | |
| 16 | 48 | Combined Sewer | Monitors flows u/s of CSO 16 | Inactive Site | | | | | |
| 17 | 24 | Combined Sewer | Monitors flows u/s of CSO 25 | 17.18 | | | | | |
| 18 | 72 | Combined Sewer | Monitors flows u/s of CSO 8 | Inactive Site | | | | | |
| 19 | 36 | Combined Sewer | Monitors flows u/s of CSO 33 | 3.30 | | | | | |
| 20 | 36 | Combined Sewer | Monitors flows u/s of CSO 37 | 4.47 | | | | | |
| 21 | 24 | Combined Sewer | Monitors flows u/s of CSOs 24 and 37 | 5.51 | | | | | |
| 22 | 30 | Combined Sewer | Monitors flows u/s of CSO 12 | 0.84 | | | | | |
| 23 | 36 | Combined Sewer | Monitors flows u/s of CSO 14 | 2.66 | | | | | |
| 24 | 25 | Interceptor | Monitors flows d/s of CSOs 1 and 2 | 2.49 | | | | | |
| 25 | 72 | Interceptor | Monitors flows d/s of Studebaker Lift Station | 32.72 | | | | | |
| 26 | 72 | Combined Sewer | Monitors flows u/s of CSO 8 | 15.68 | | | | | |
| 27 | 72 | Combined Sewer | Monitors flows u/s of CSO 25 and CSO 8 | 3.20 | | | | | |
| 28 | 24 | Interceptor | Monitors flows d/s of CSO 15 | 28.93 | | | | | |

*for magnitude comparison purposes.

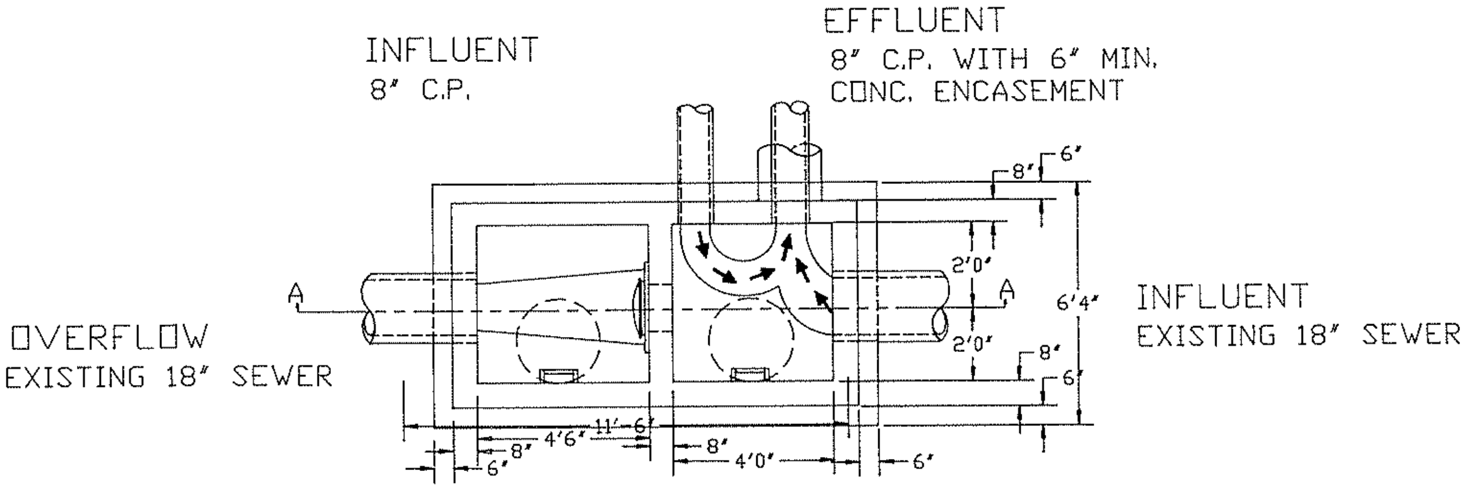
~~Pink~~ boxes indicate data not used in direct peak flow and volume comparisons.

GREY

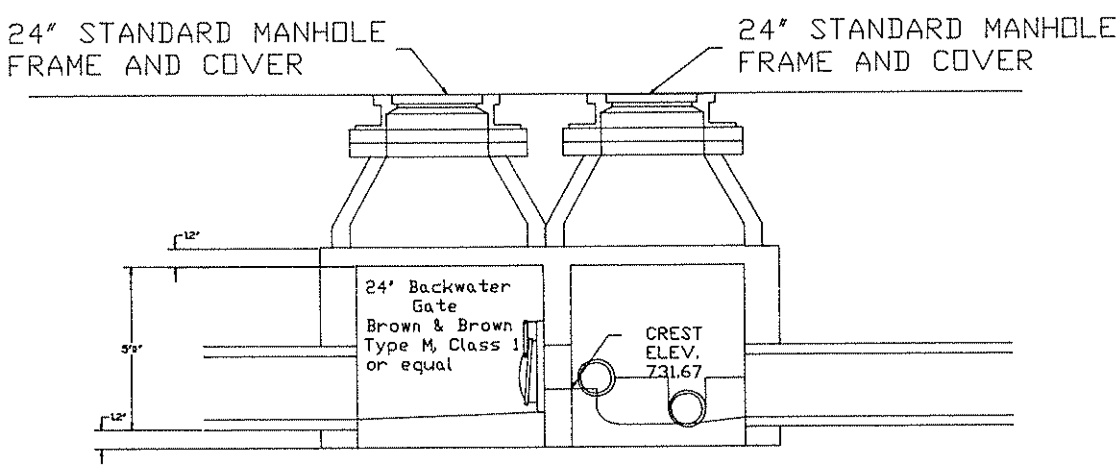
# Appendix B

## CSO Diagrams and Coordinates

# INTERCEPTING CHAMBER AT MIDDLEBURY AND TIPTON

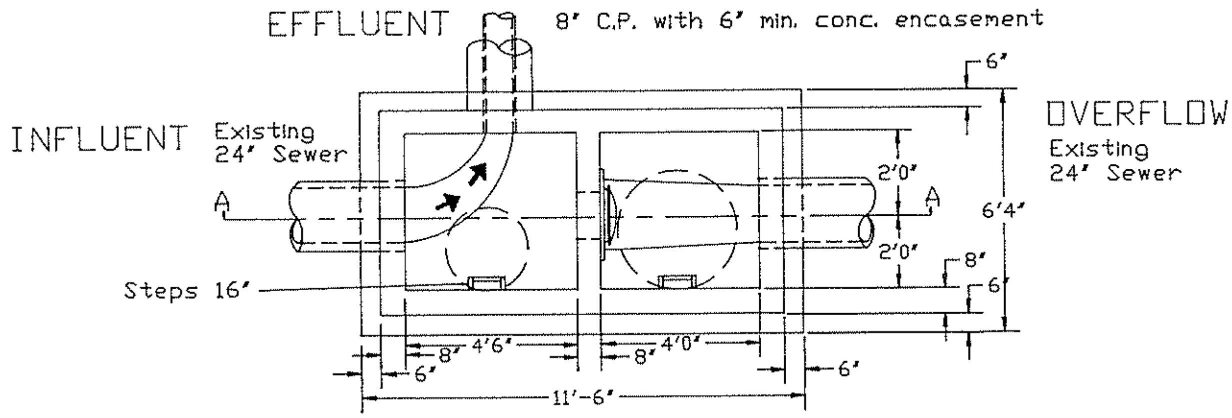



PLAN

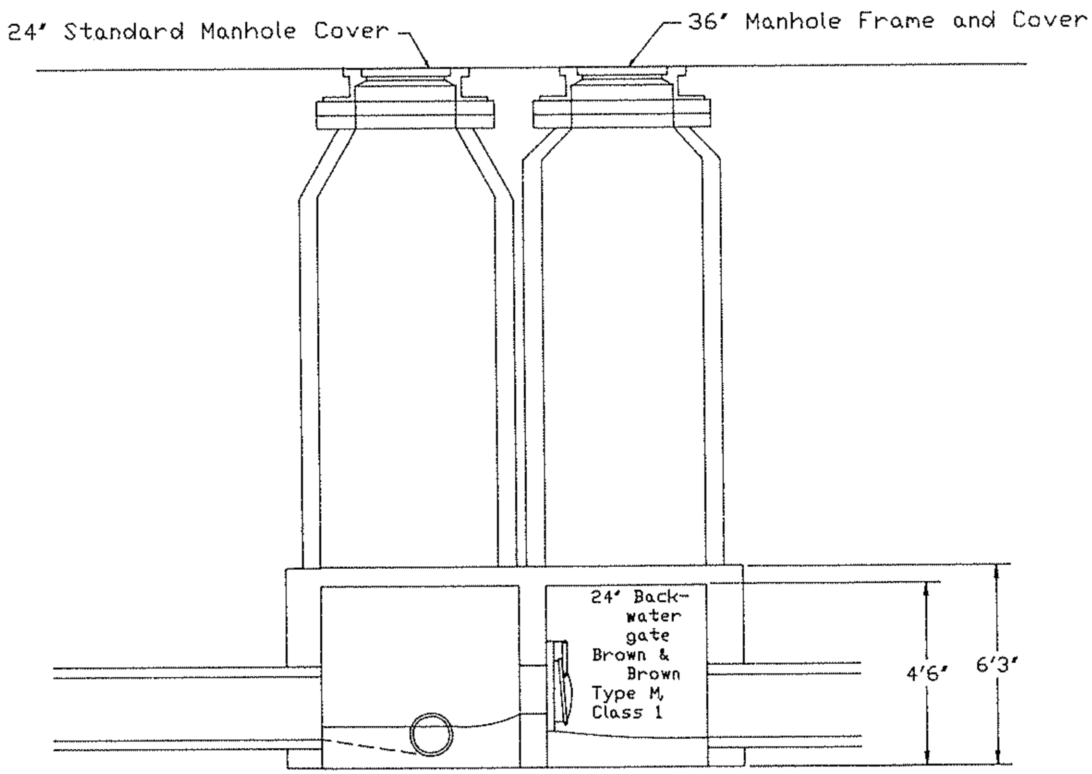



SECTION A-A

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 1 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO1 |



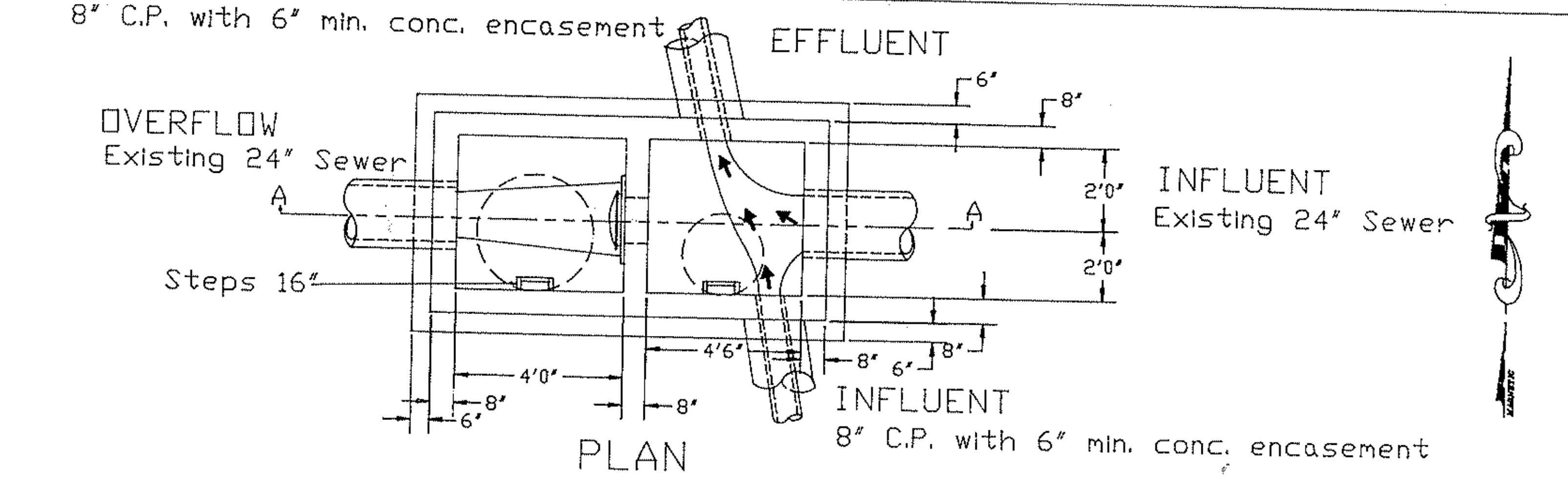

PLAN

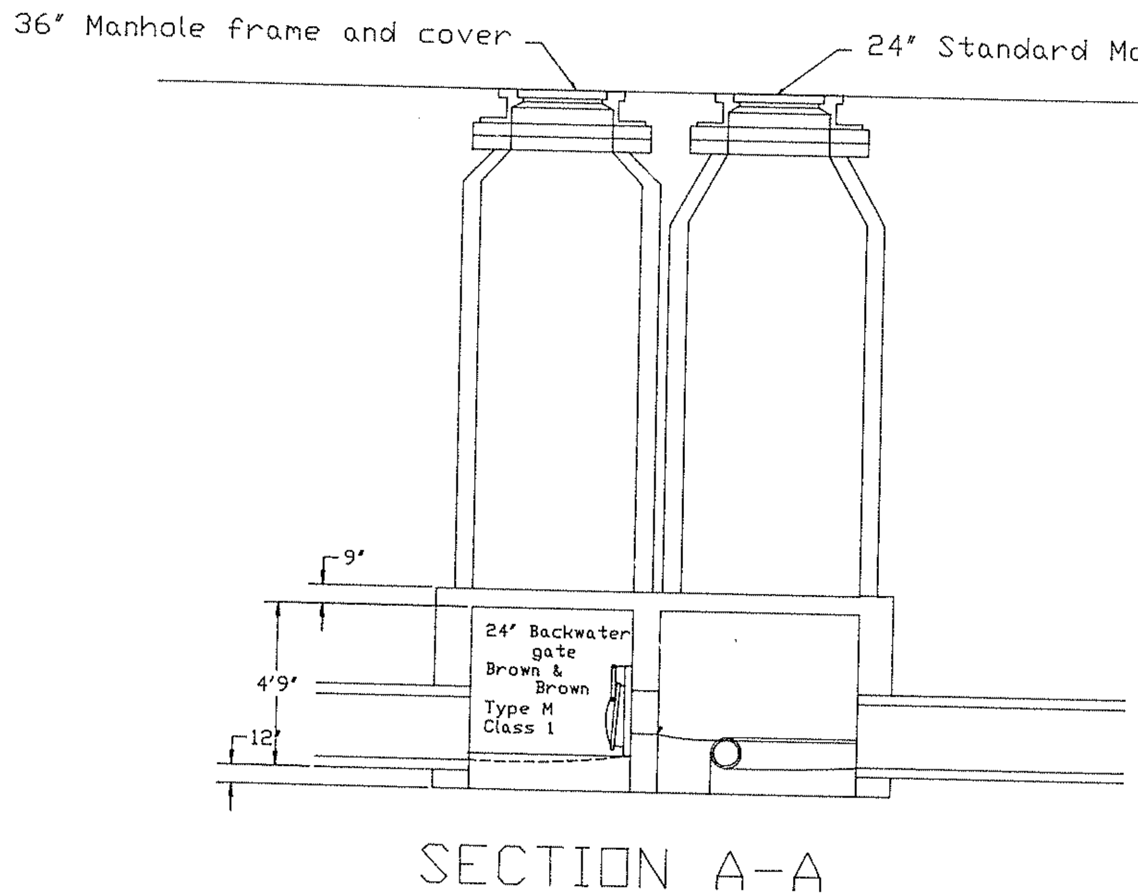



SECTION A-A

Intercepting Chamber at Middlebury and Grand

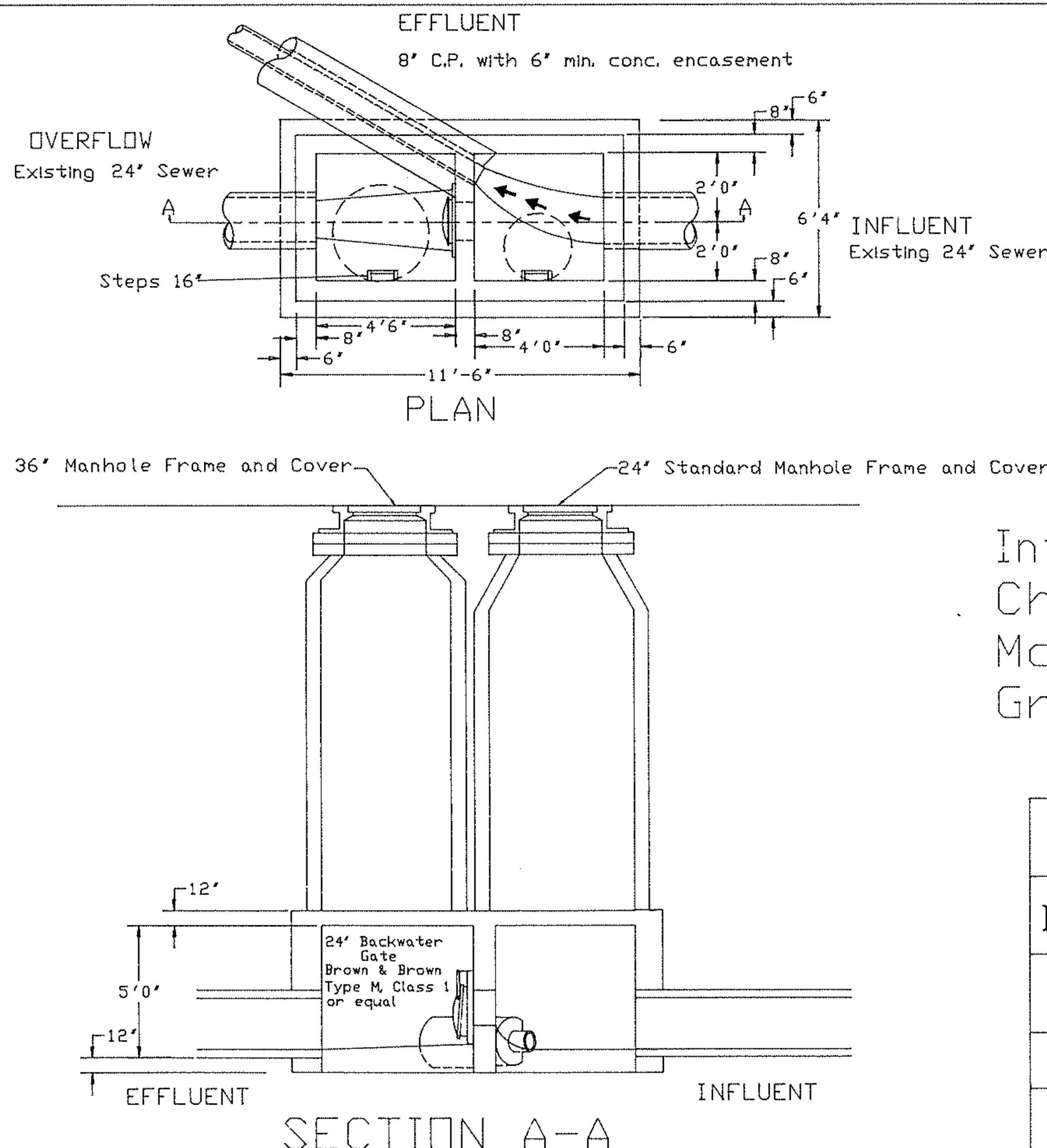
| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 2 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO2 |



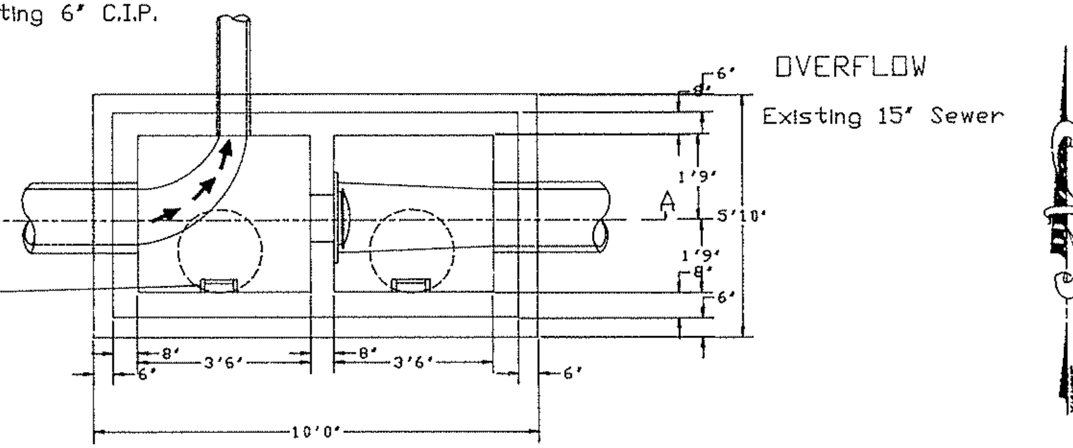

Intercepting Chamber at Tipton and Aspenwald

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 3 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO3 |



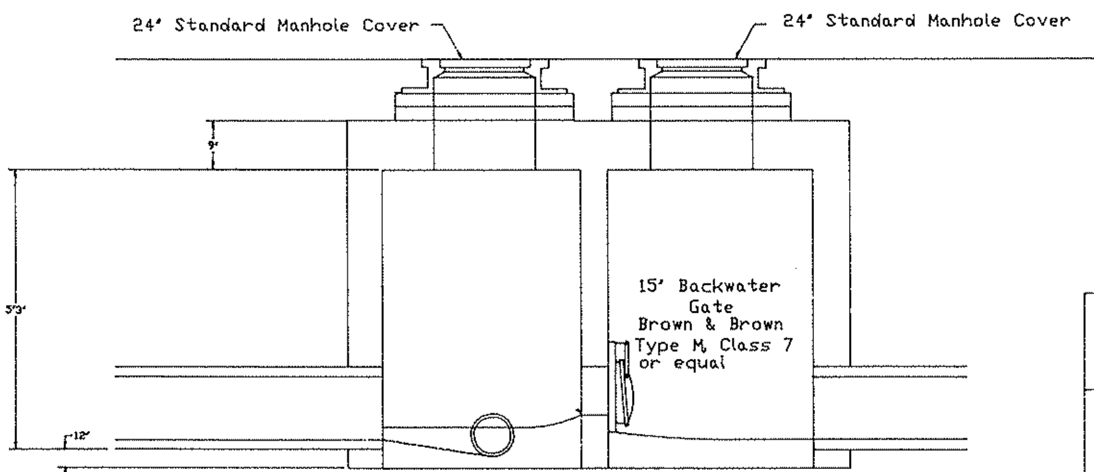

Intercepting Chamber at McDonald and Grand

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 4 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CS04 |



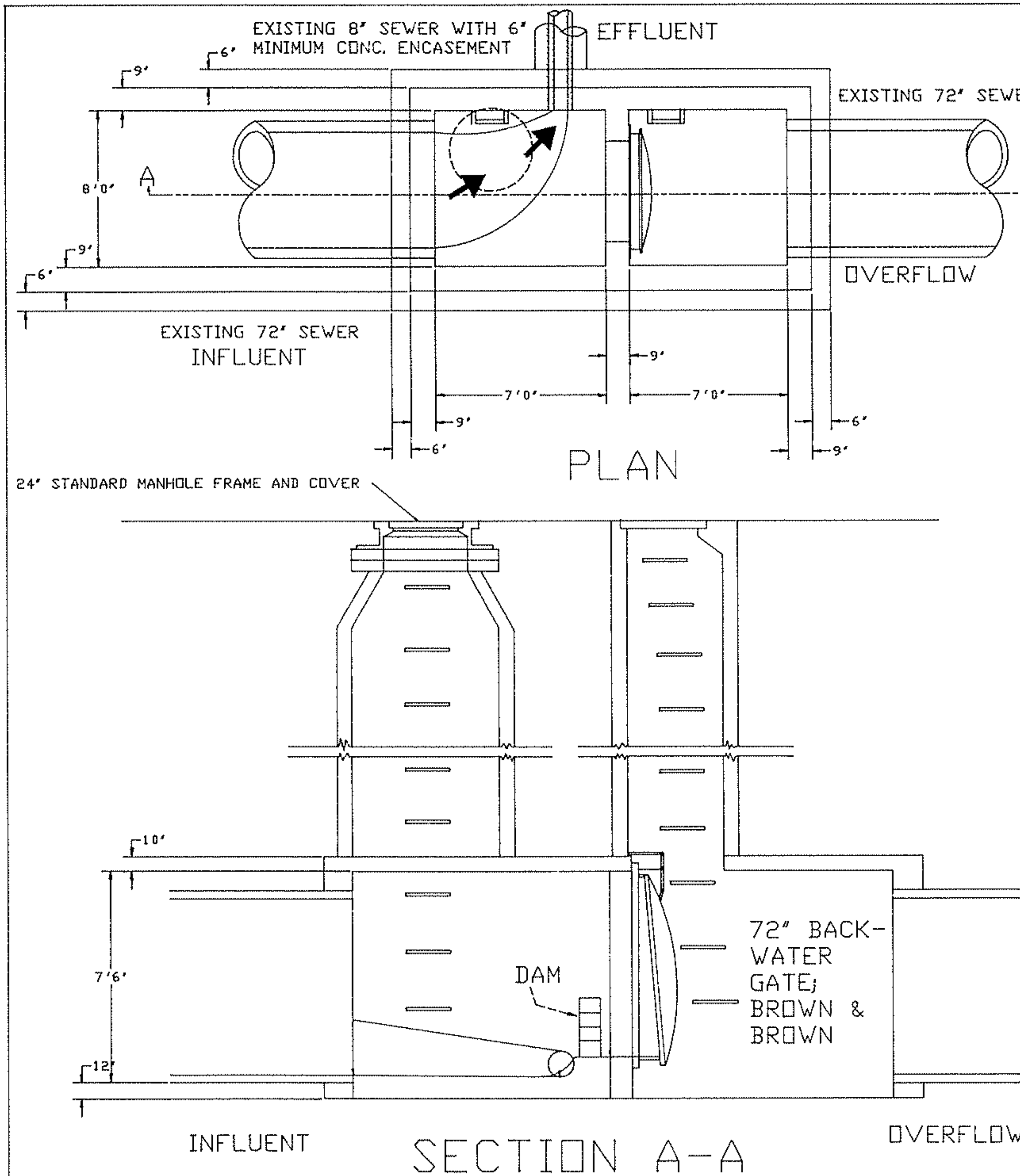

PLAN

# INTERCEPTING CHAMBER AT ARCH AND BAR



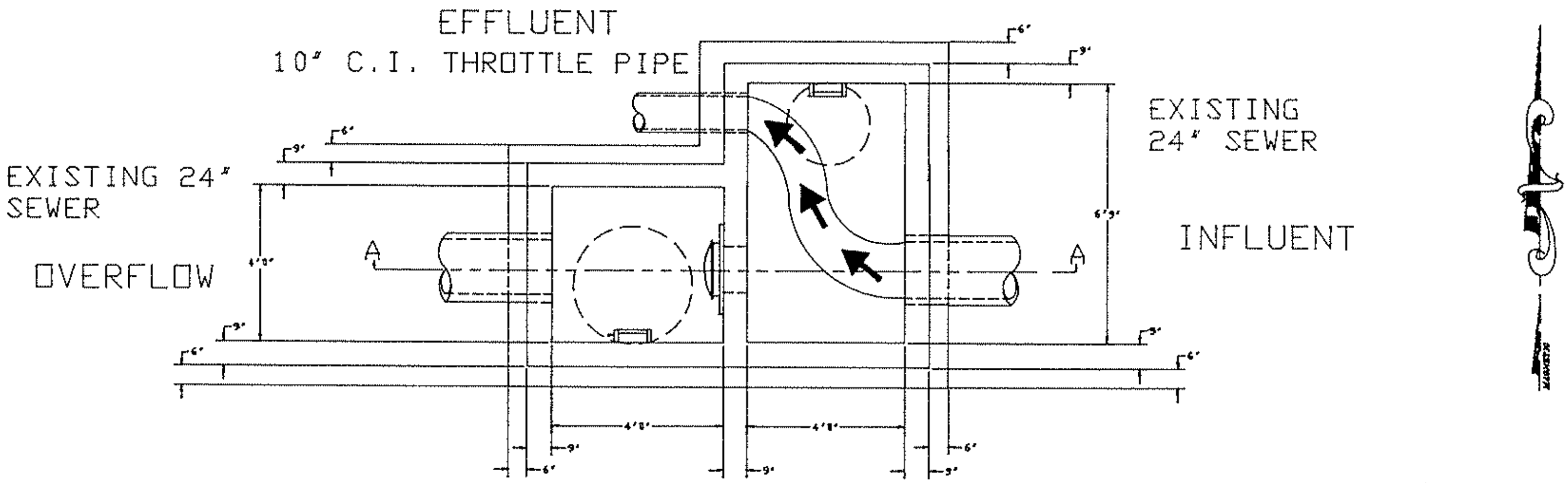

SECTION A-A

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 5 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO5 |

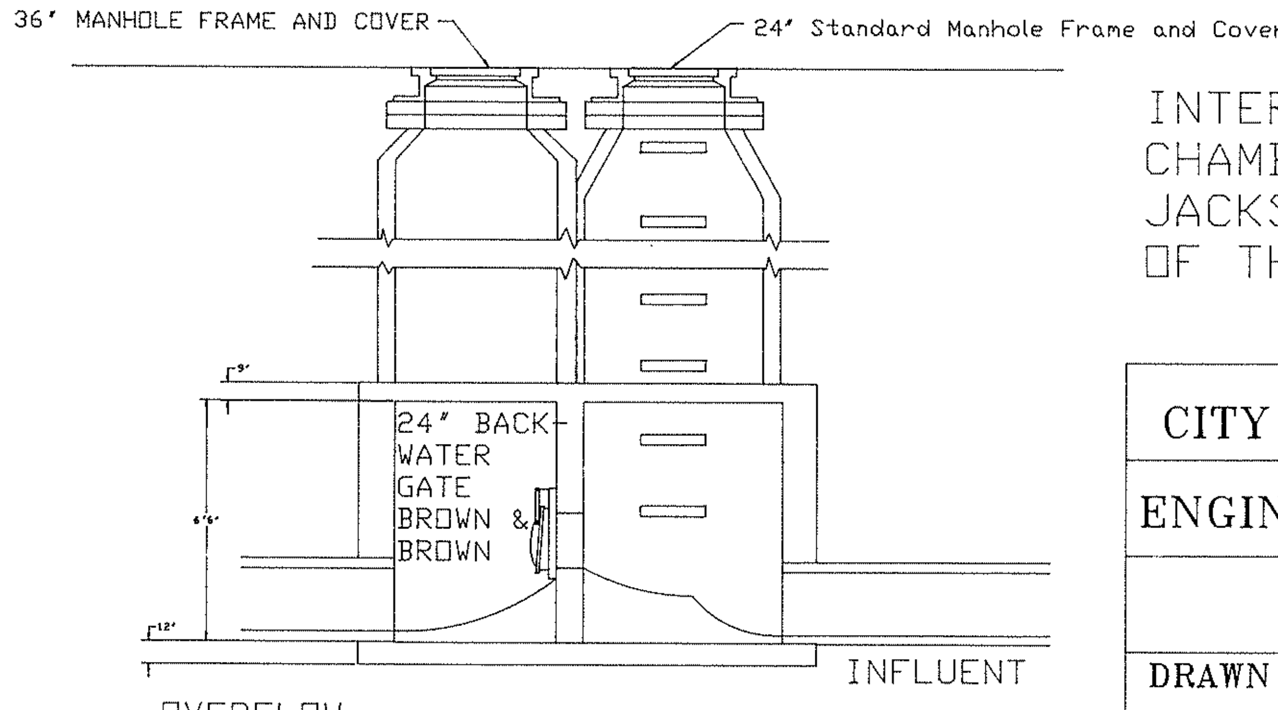



Intercepting Chamber on Jackson West of the Bridge

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 6 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CS06 |



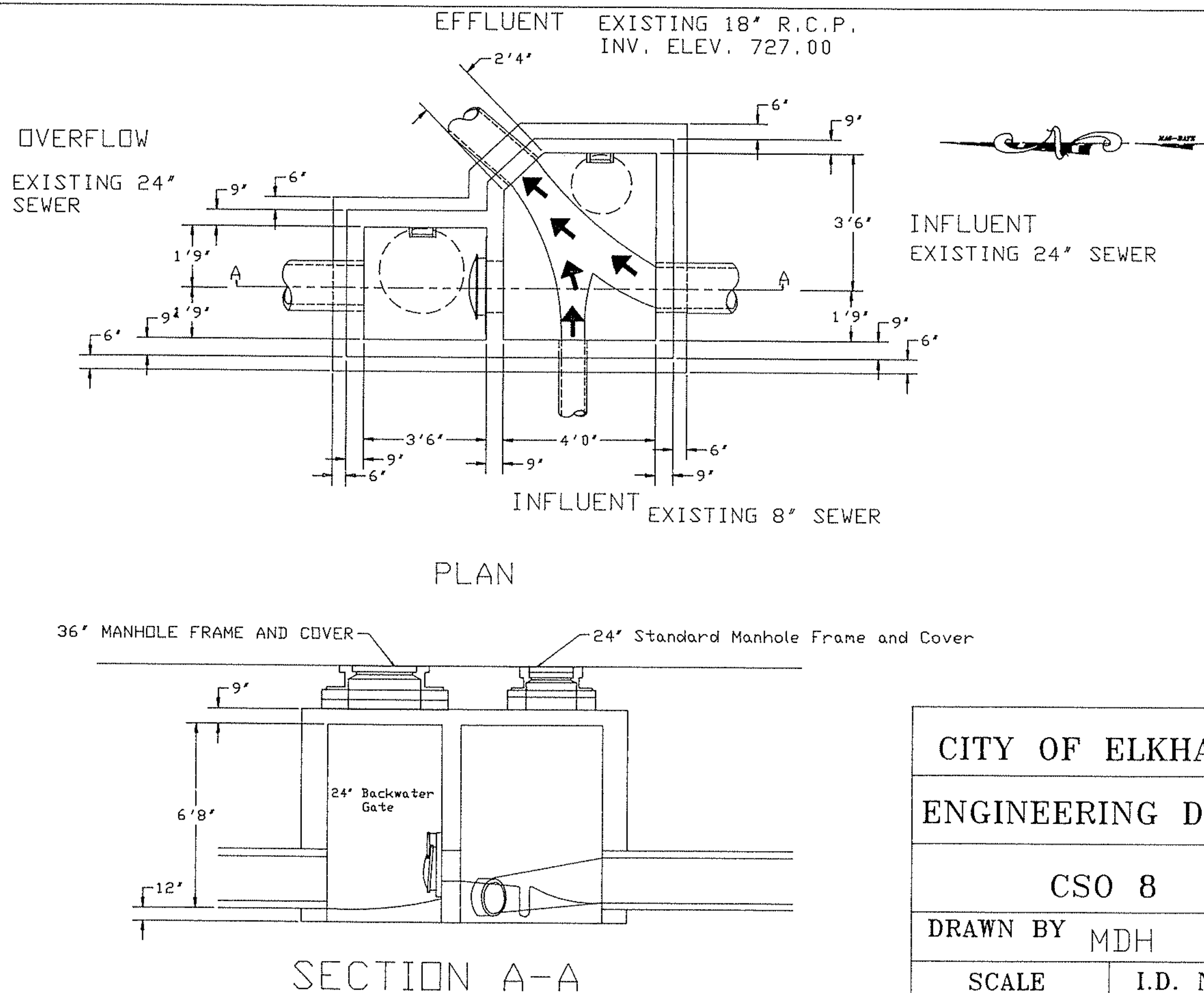

PLAN



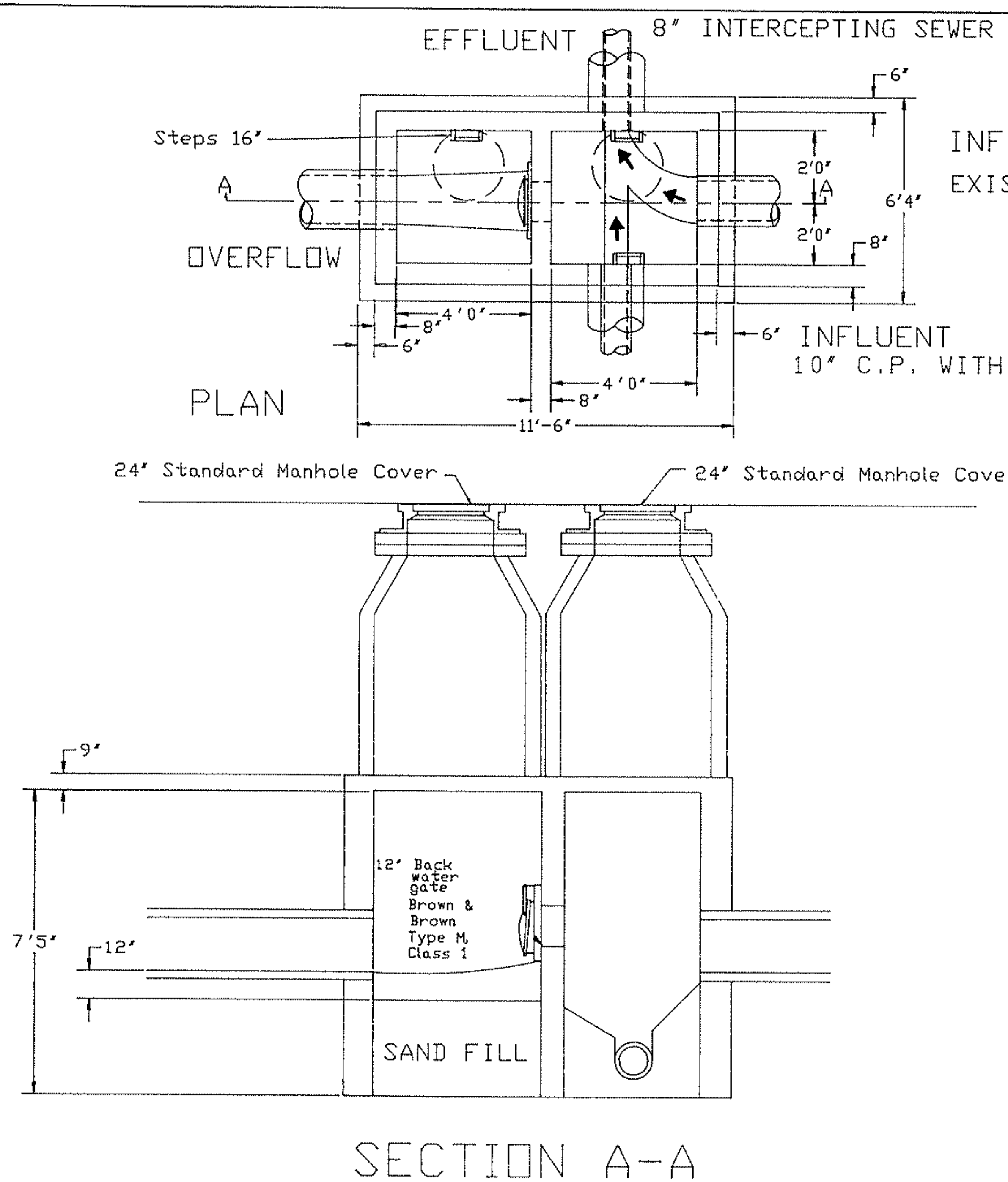

SECTION A-A

INTERCEPTING CHAMBER ON JACKSON EAST OF THE BRIDGE

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 7 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO7 |

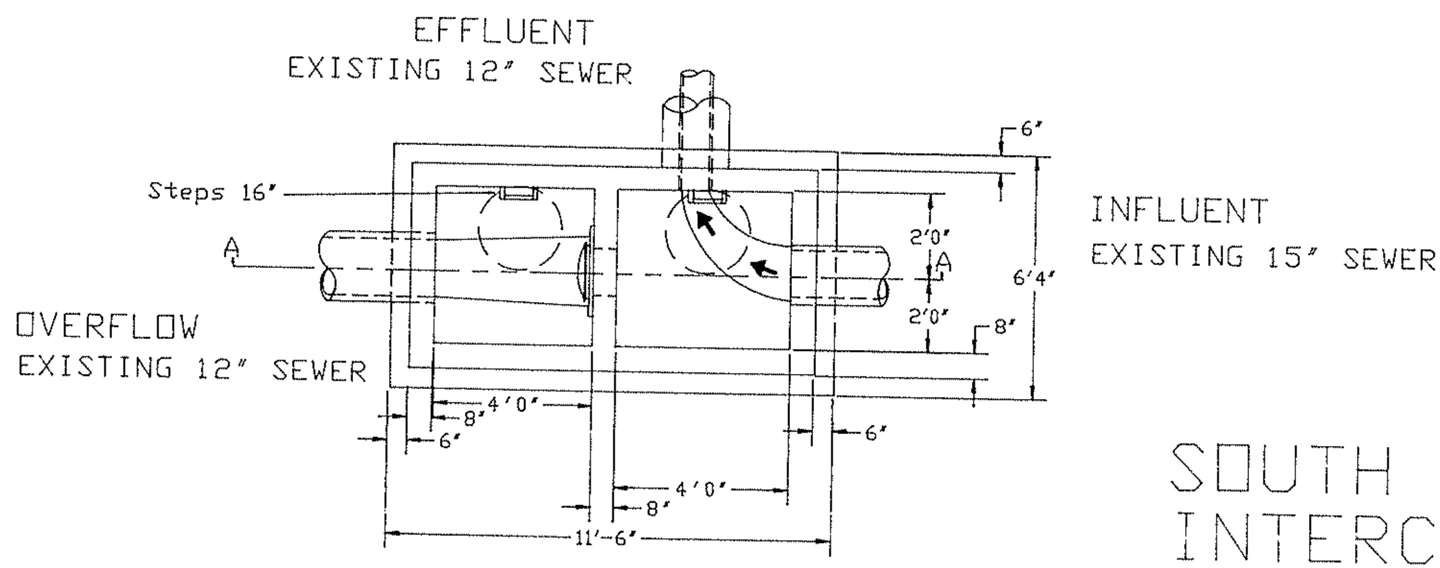



| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 8 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CS08 |

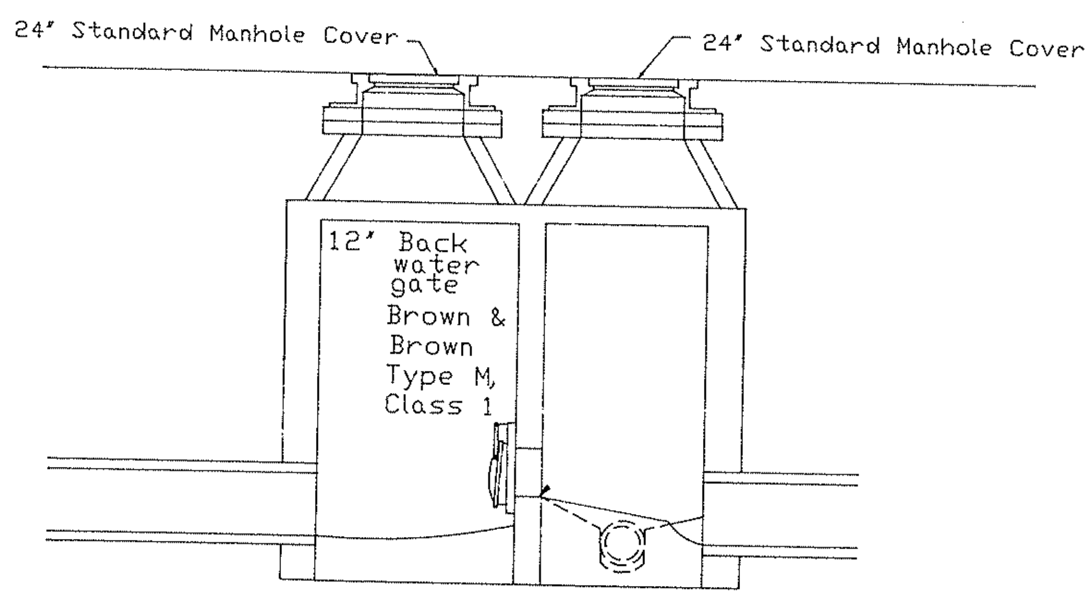



# NORTH INTERCEPTING CHAMBER ON JUNIOR ACHIEVEMENT DRIVE

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 9 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CSO9 |




PLAN

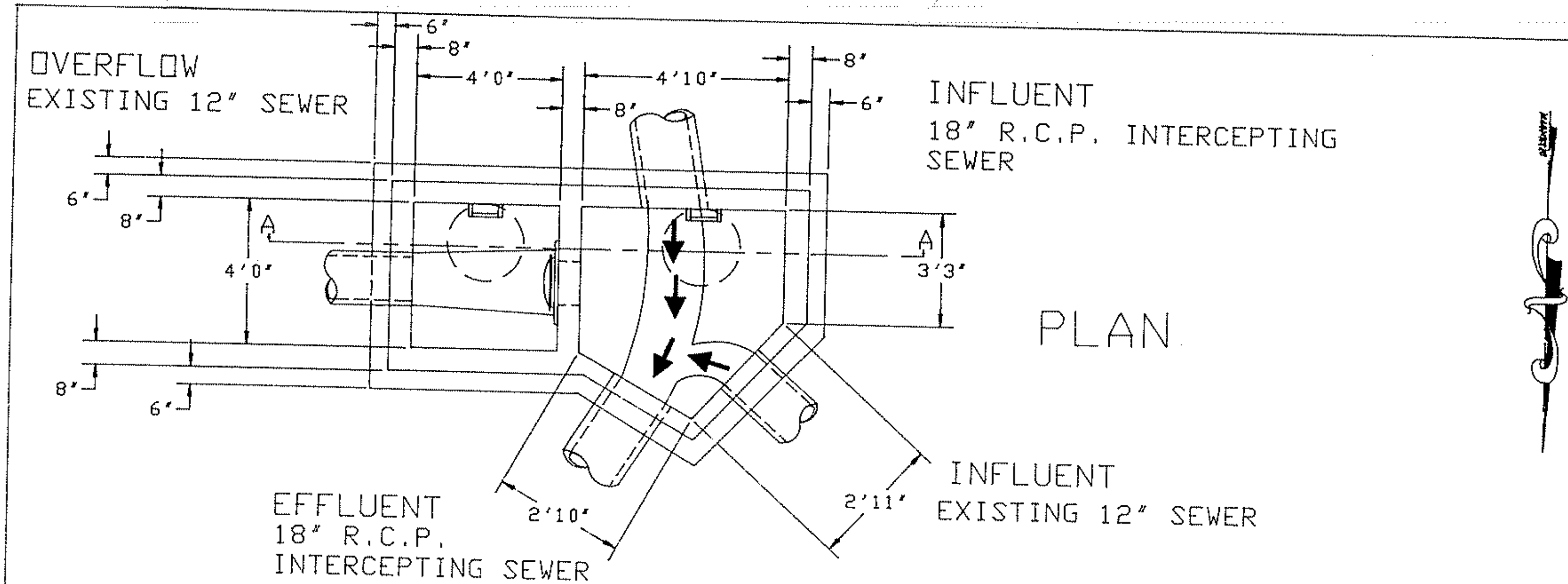



SECTION A-A

# SOUTH INTERCEPTING CHAMBER ON JUNIOR ACHIEVEMENT DRIVE

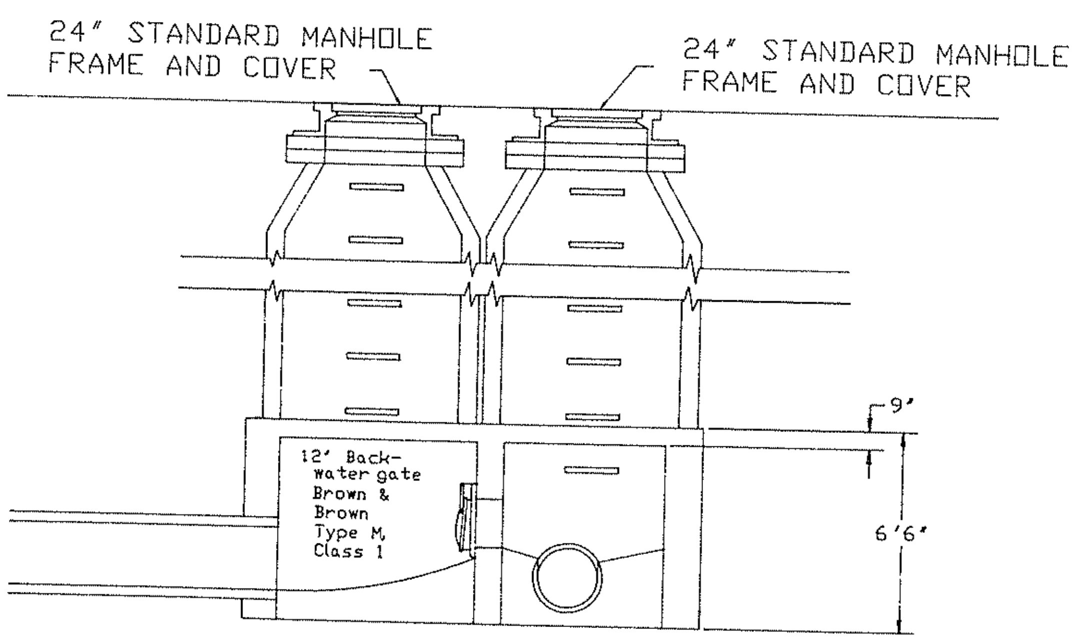
| |
|---|
| CITY OF ELKHART |
| ENGINEERING DEPT. |
| CSO 10 |
| DRAWN BY MDH |

| SCALE | I.D. No. |
|---|---|
| 1"=5' | CSO10 |



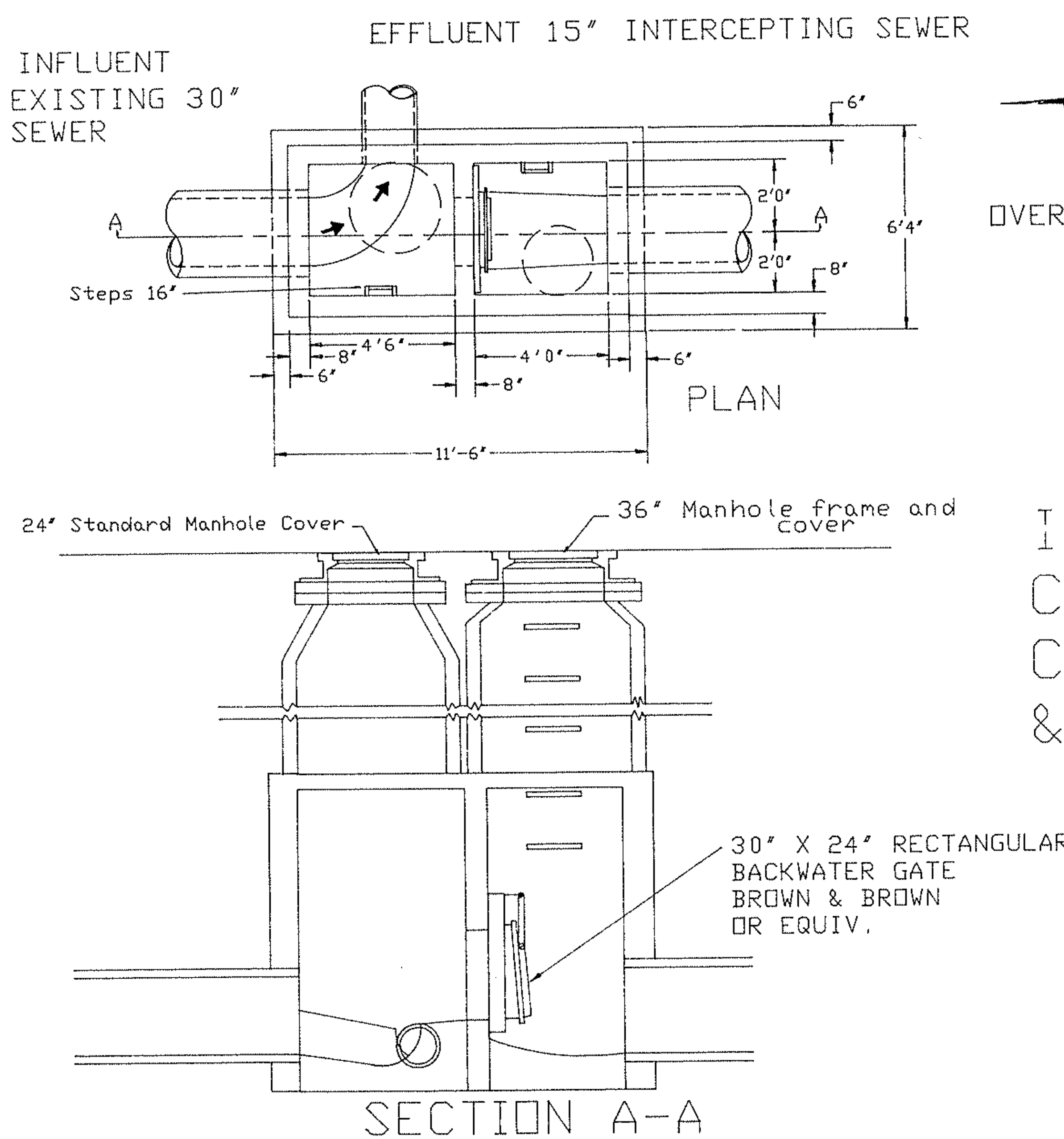

PLAN

# INTERCEPTING CHAMBER AT ELKHART AND FRANKLIN



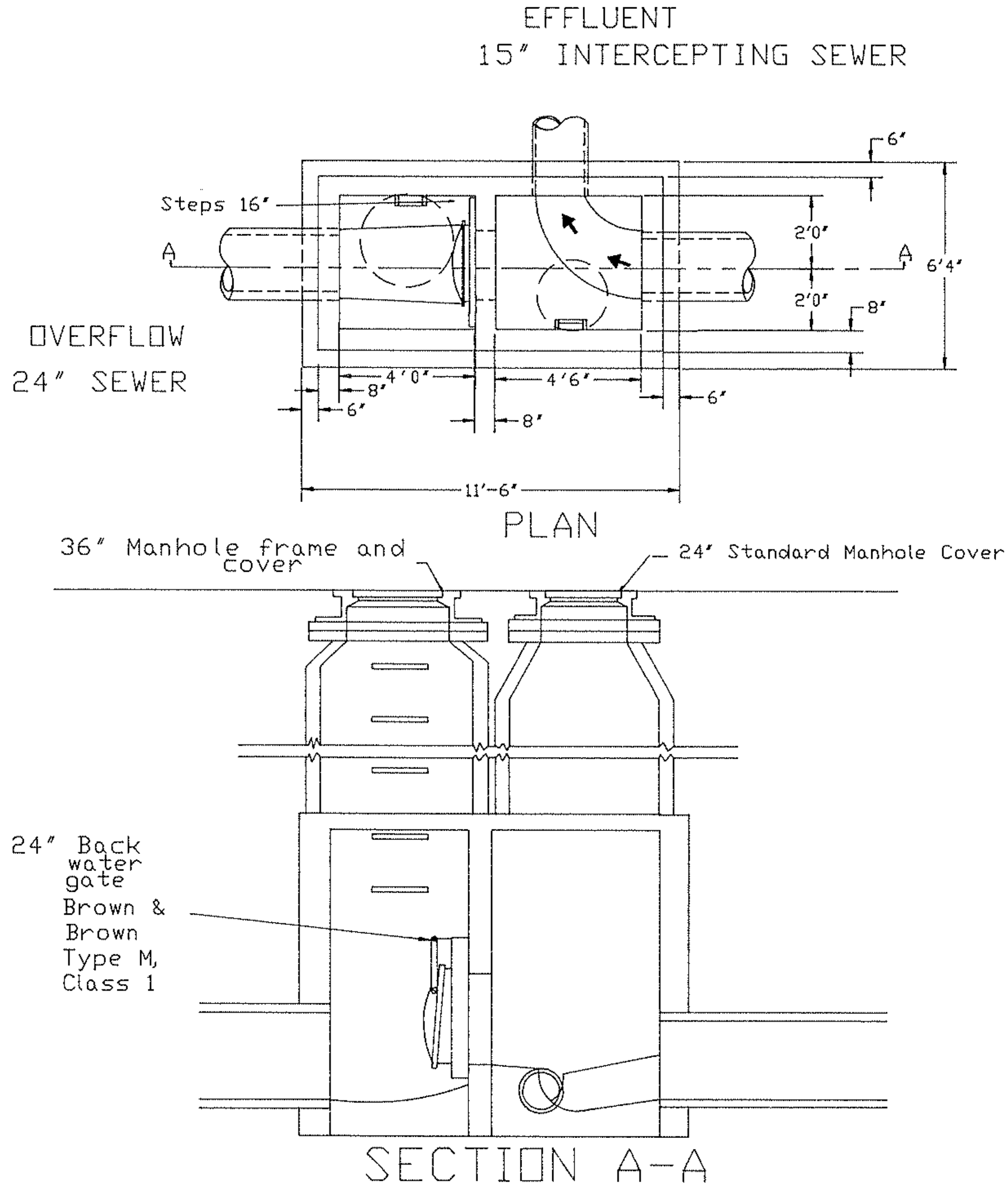

SECTION A-A

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 11 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO11 |



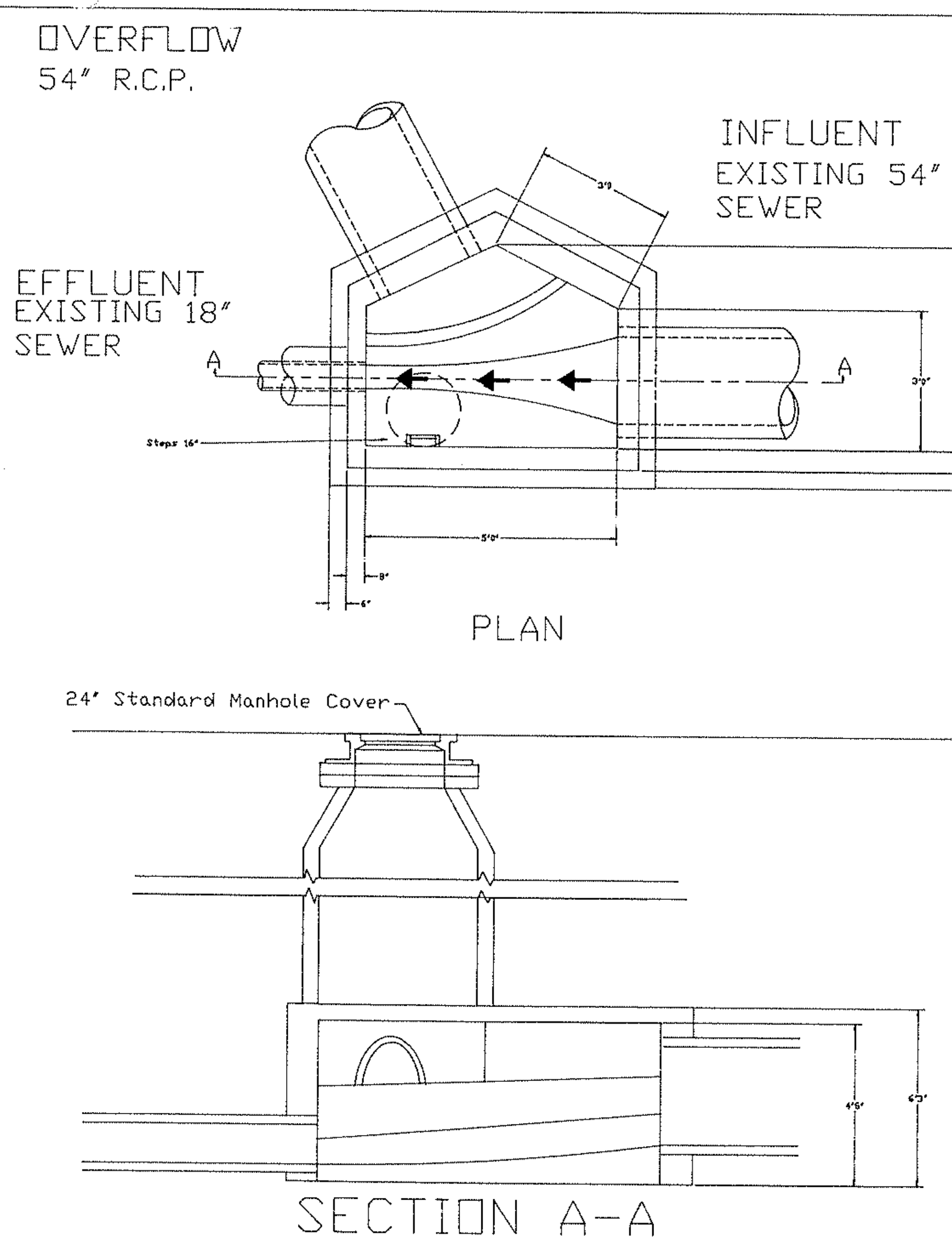

# INTERCEPTING CHAMBER AT CASSOPOLIS & BEARDSLEY

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 12 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO12 |



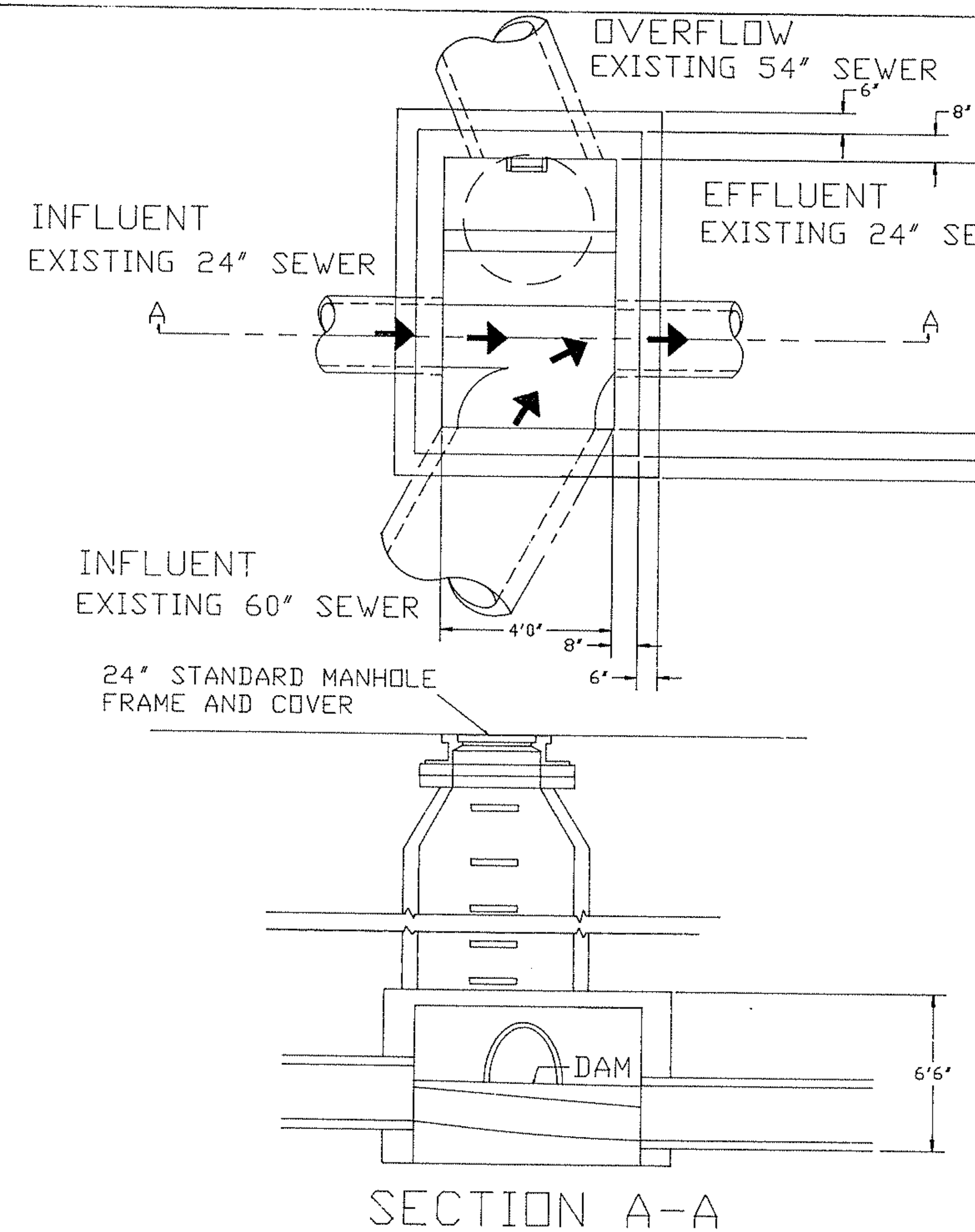

# INTERCEPTING CHAMBER AT JOHNSON AND BEARDSLEY

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 13 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CS013 |



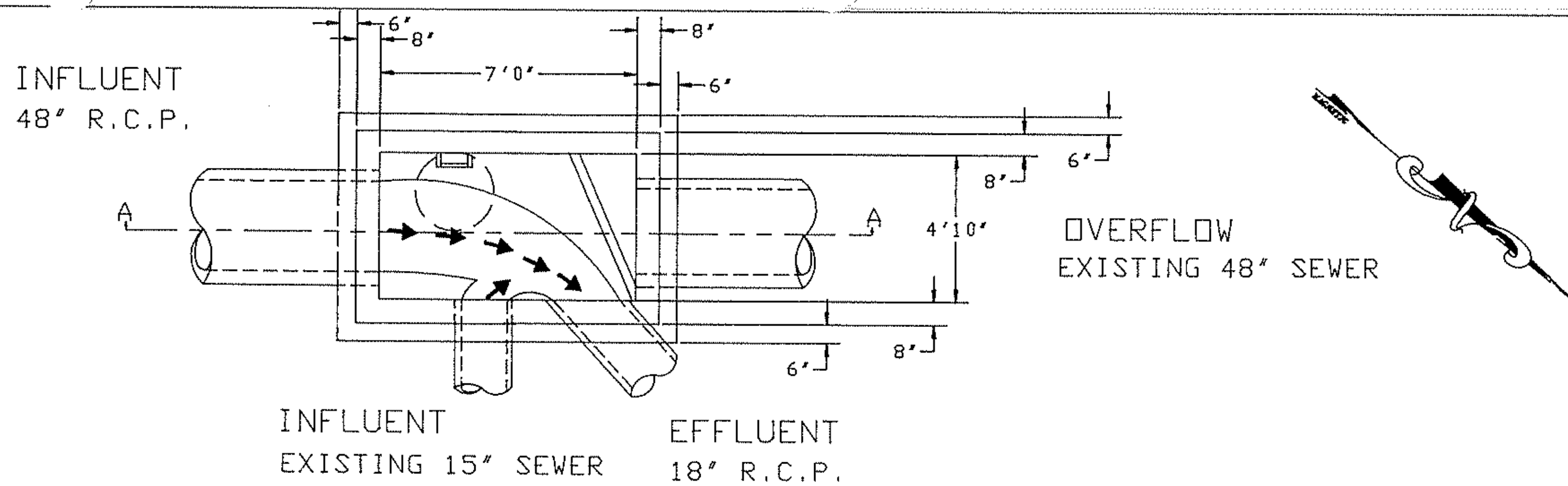

# INTERCEPTING CHAMBER AT CONE AND ERWIN

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 14 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO14 |



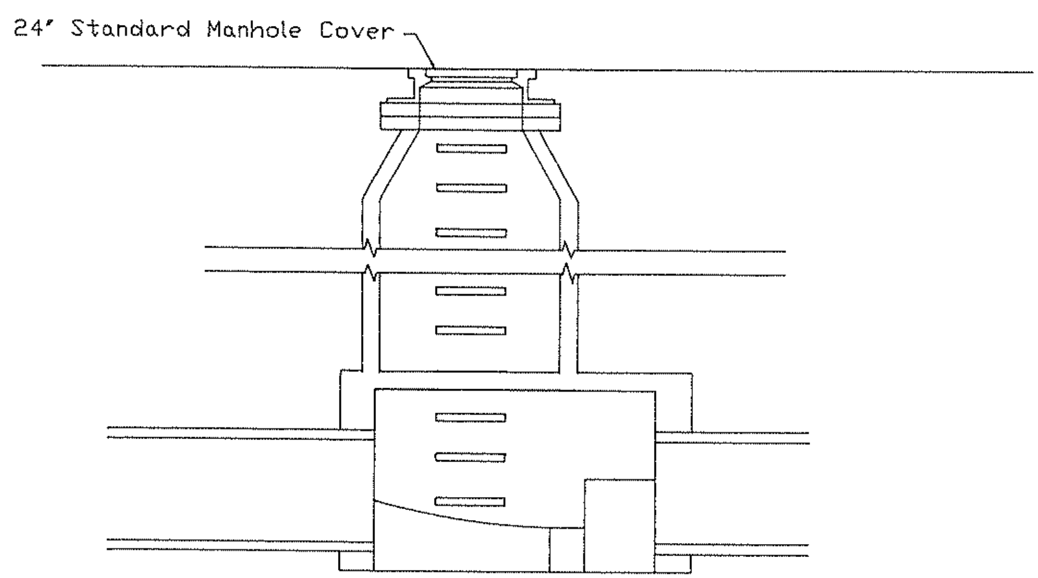

# INTERCEPTING CHAMBER AT MICHIGAN AND FULTON

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 15 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO15 |



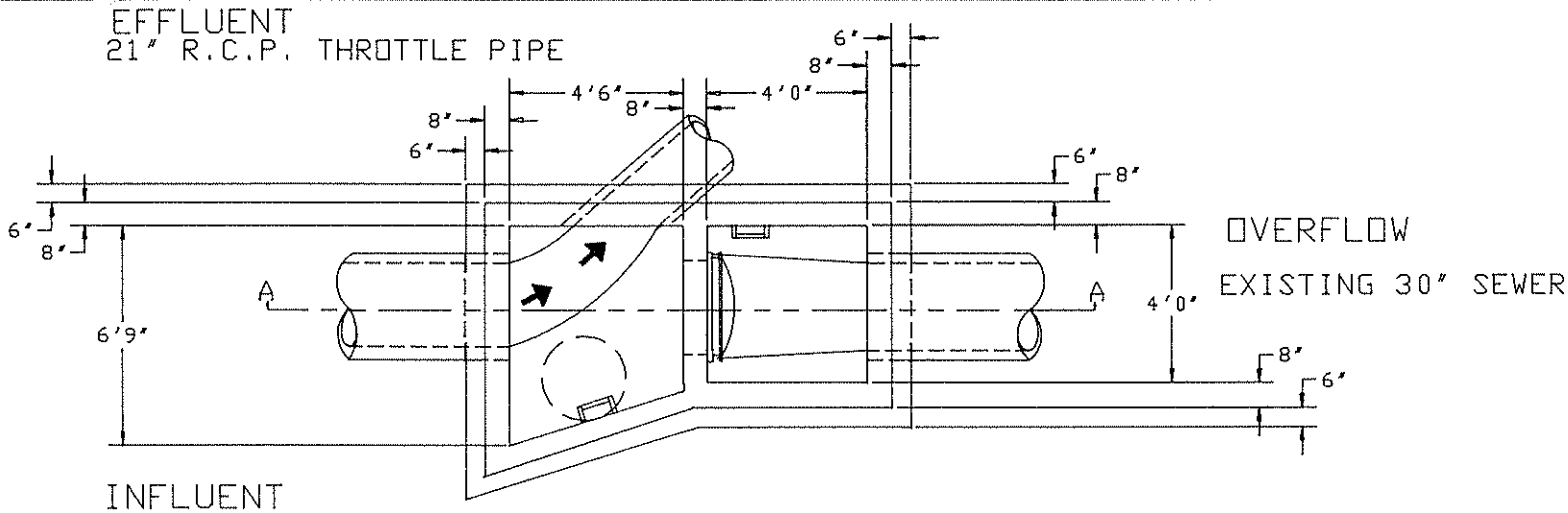

PLAN

# INTERCEPTING CHAMBER AT GOSHEN AND SUPERIOR

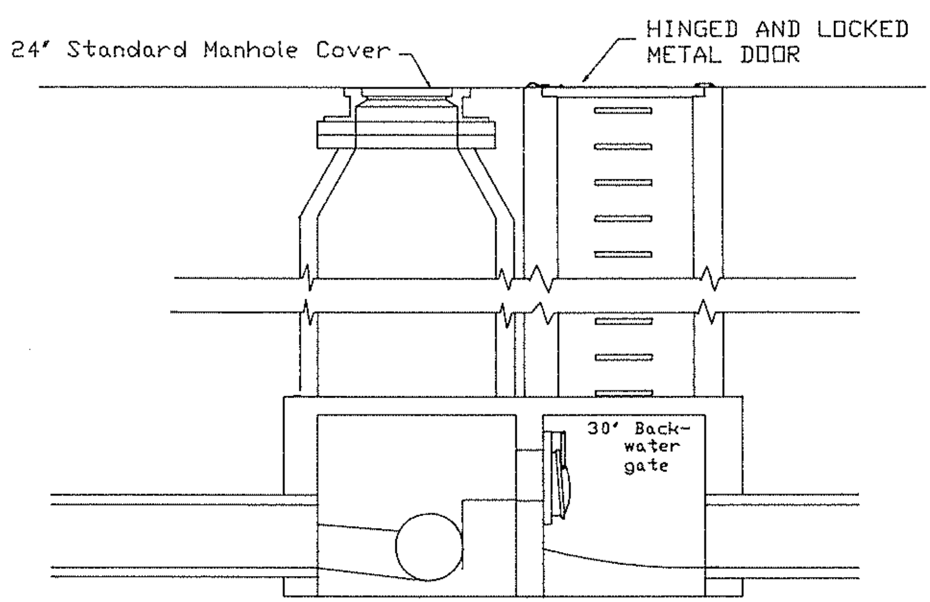



SECTION A-A

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 16 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CS016 |



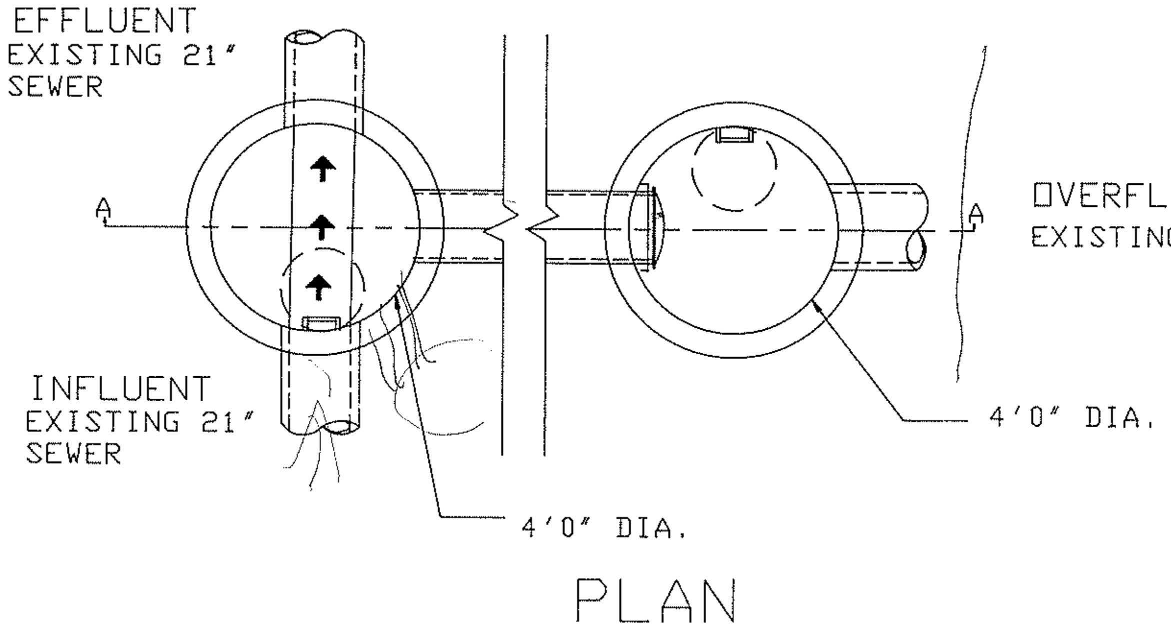

PLAN



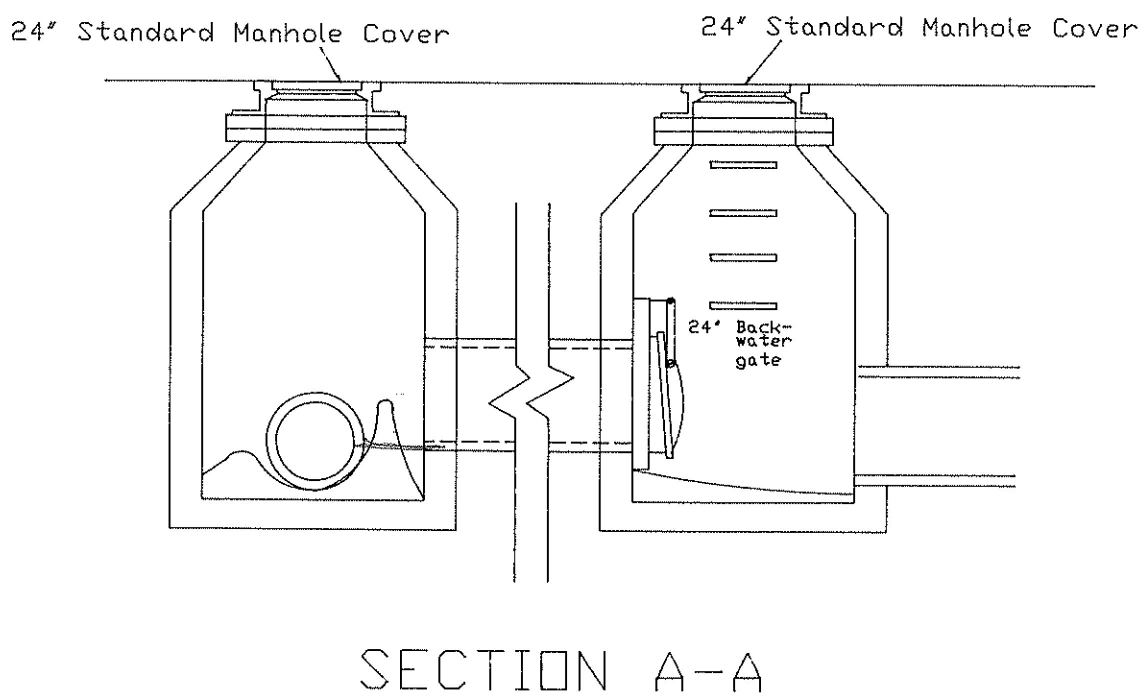

SECTION A-A

INTERCEPTING
CHAMBER IN
McNAUGHTON
PARK ACROSS
FROM WEST BLVD.

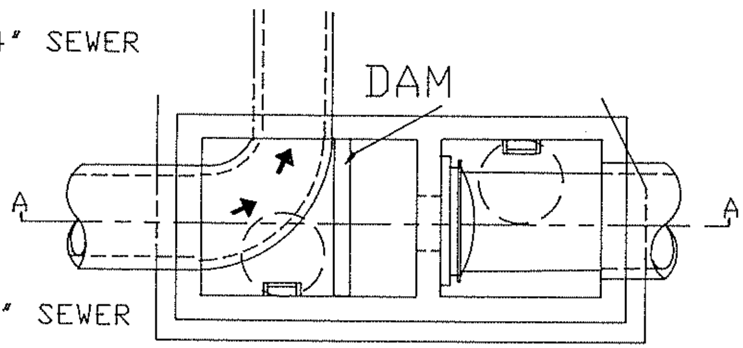
| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 17 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CS017 |



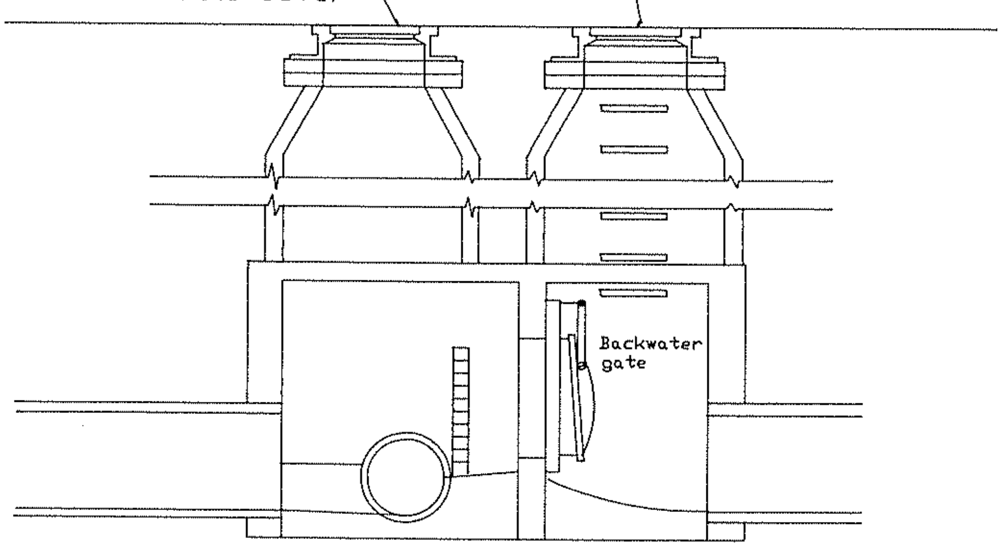

# INTERCEPTING CHAMBER AT McNAUGHTON PARK BY THE BOAT LAUNCH




| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 18 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CSO18 |



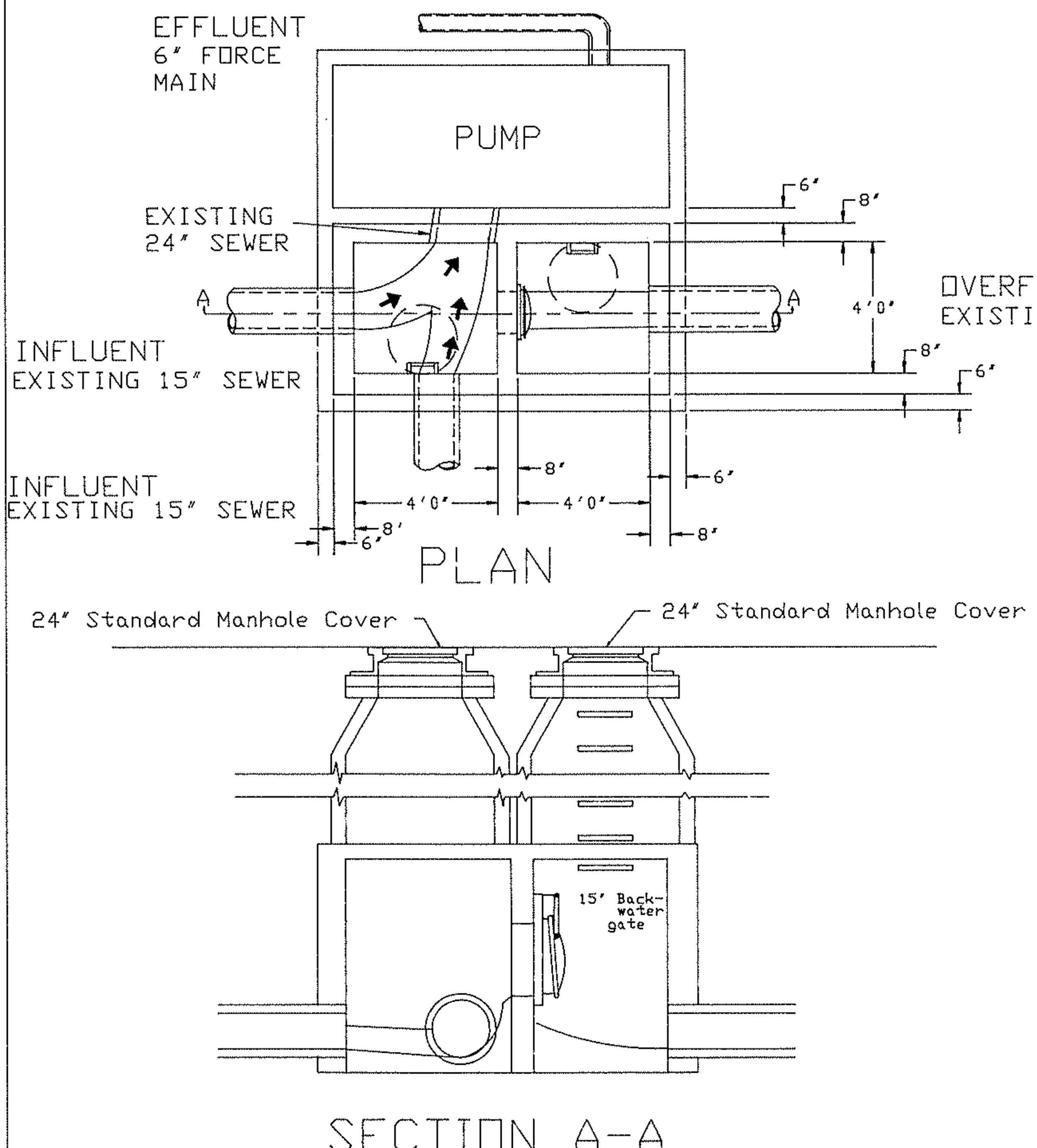

PLAN




SECTION A-A

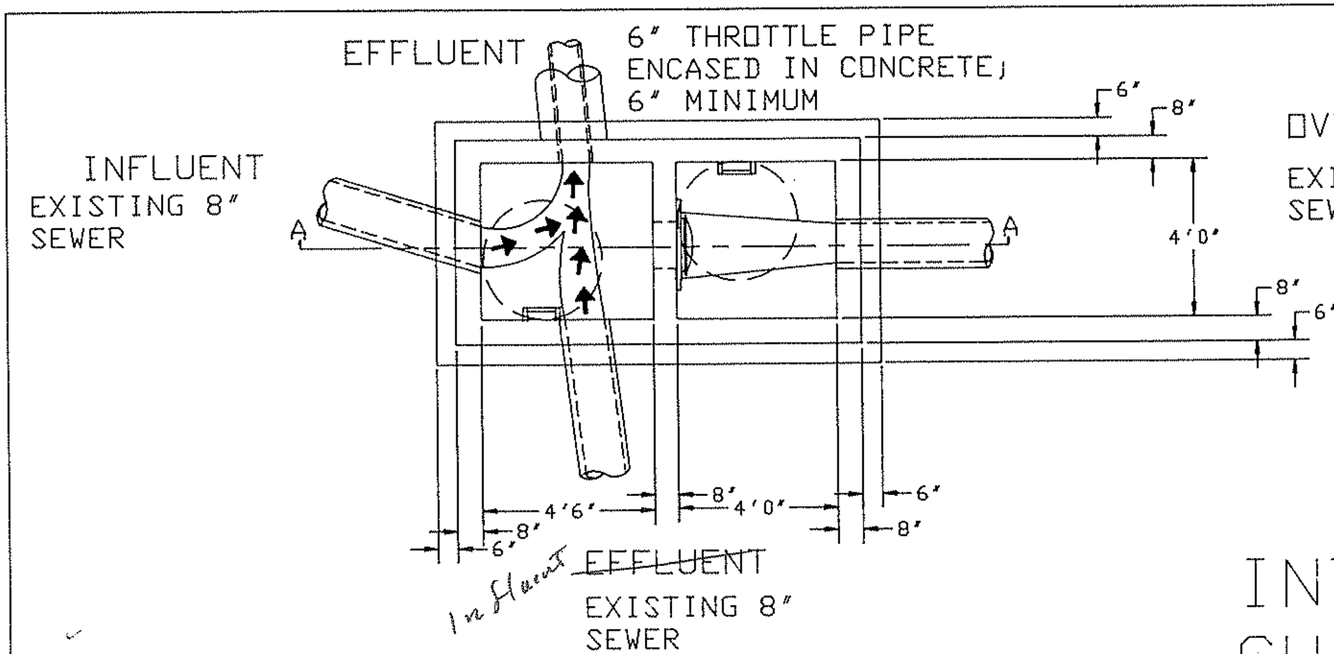
# INTERCEPTING CHAMBER ON MICHIGAN AT THE RIVER

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 19 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CS019 |



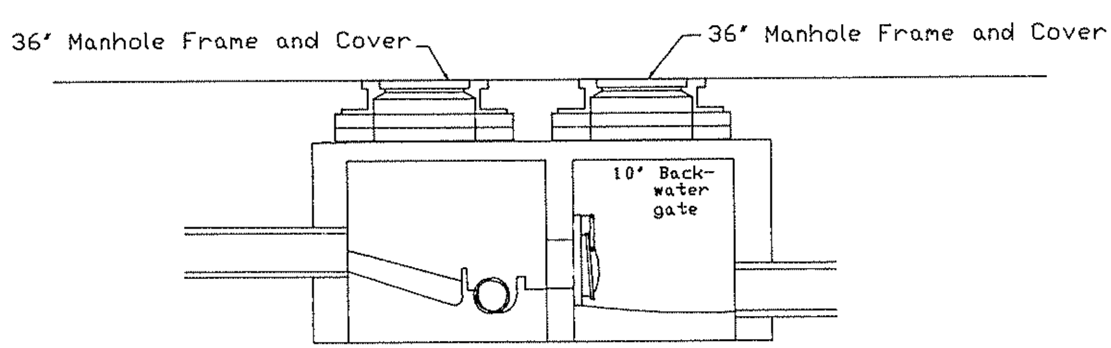

# INTERCEPTING CHAMBER AT HUDSON AND BRIDGE

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 20 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO20 |



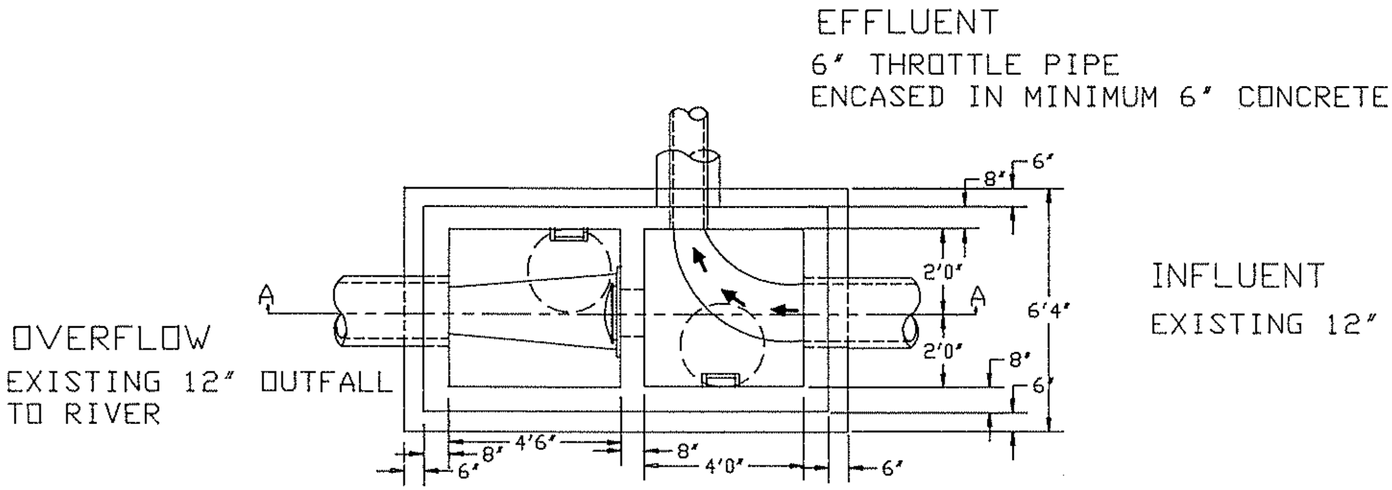

PLAN

# INTERCEPTING CHAMBER AT SOUTH SHORE AND COTTAGE

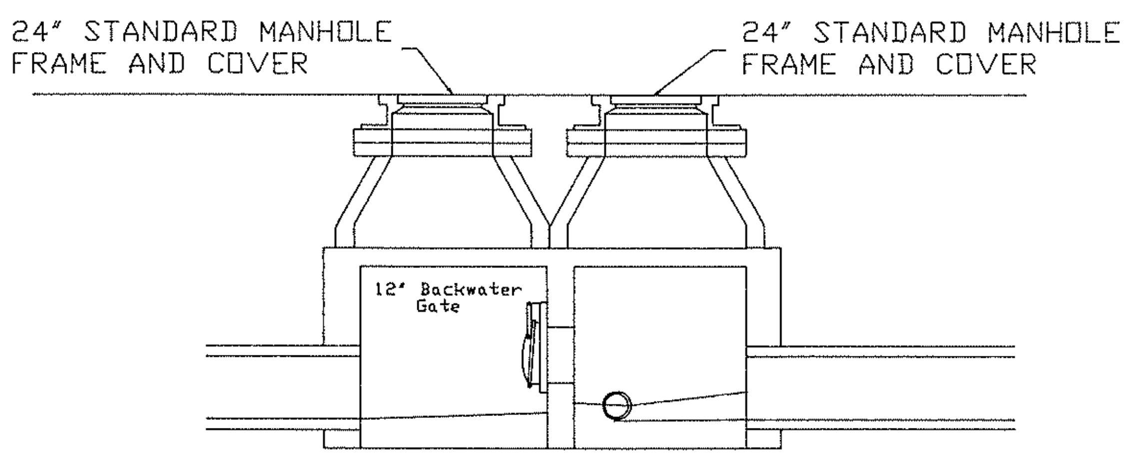



SECTION A-A

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 21 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO21 |




PLAN

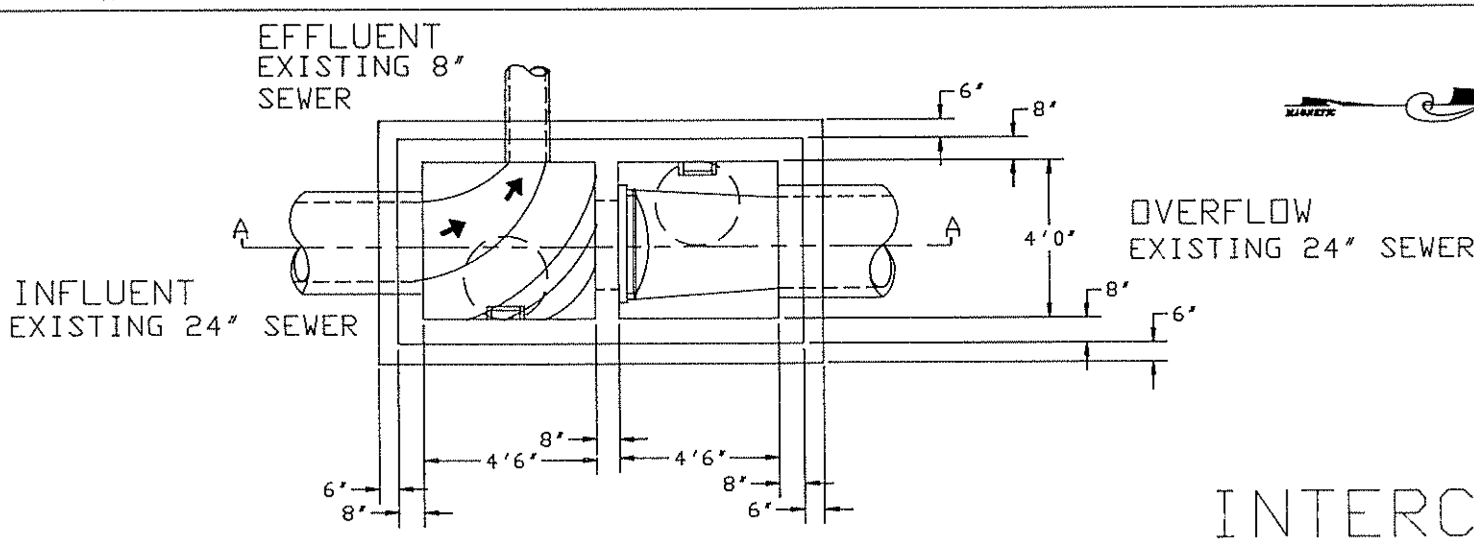



SECTION A-A

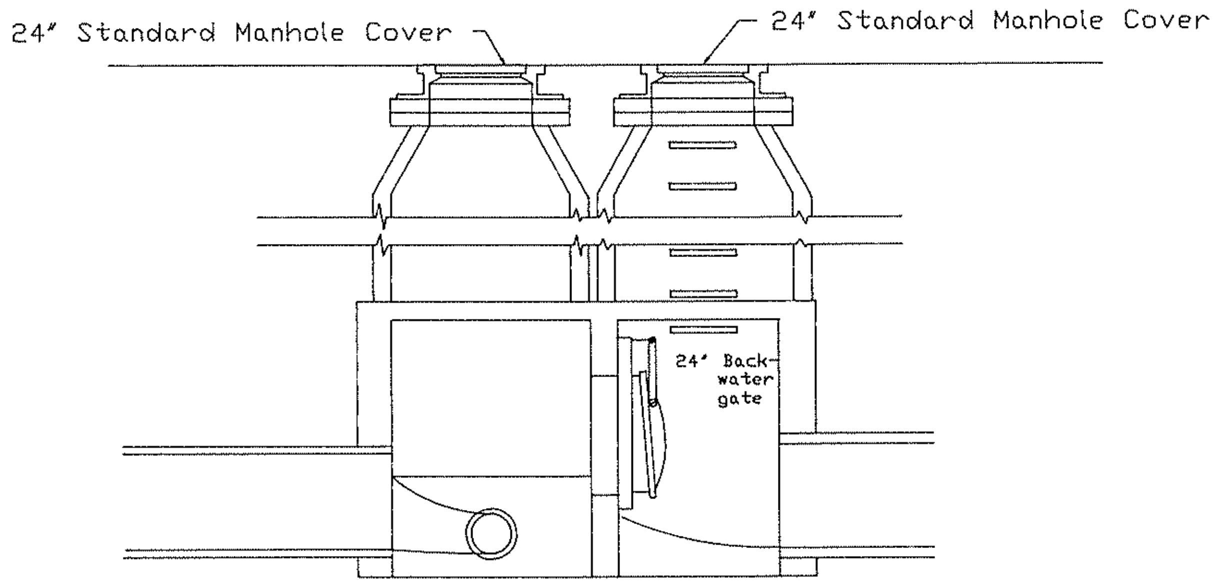
# INTERCEPTING CHAMBER AT NADEL AND SOUTH SHORE

| |
|---|
| CITY OF ELKHART |
| ENGINEERING DEPT. |
| CSO 22 |
| DRAWN BY MDH |

| SCALE | I.D. No. |
|---|---|
| 1"=5' | CSO22 |



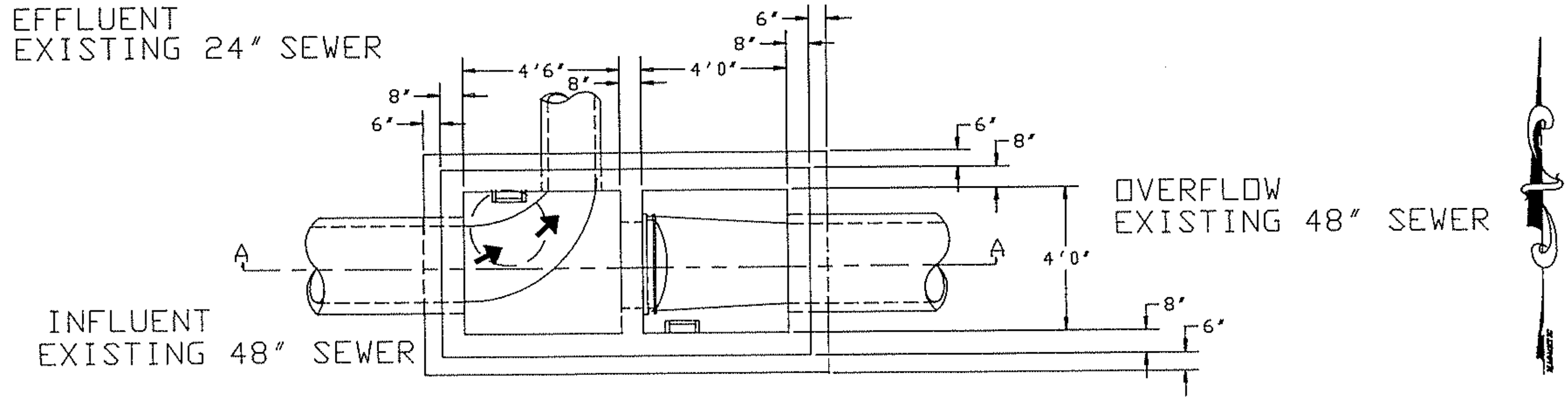

PLAN



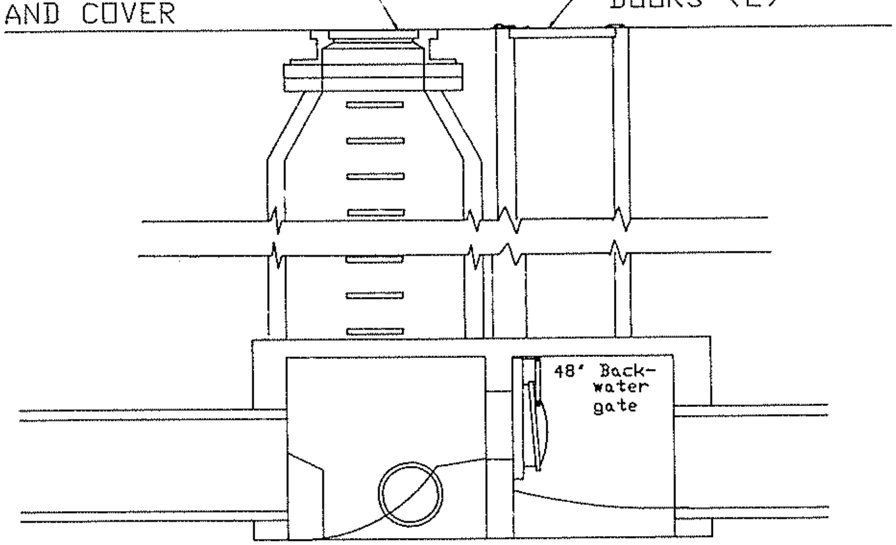

SECTION A-A

# INTERCEPTING CHAMBER AT FRANKLIN AND EIGHTH

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 23 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CS023 |



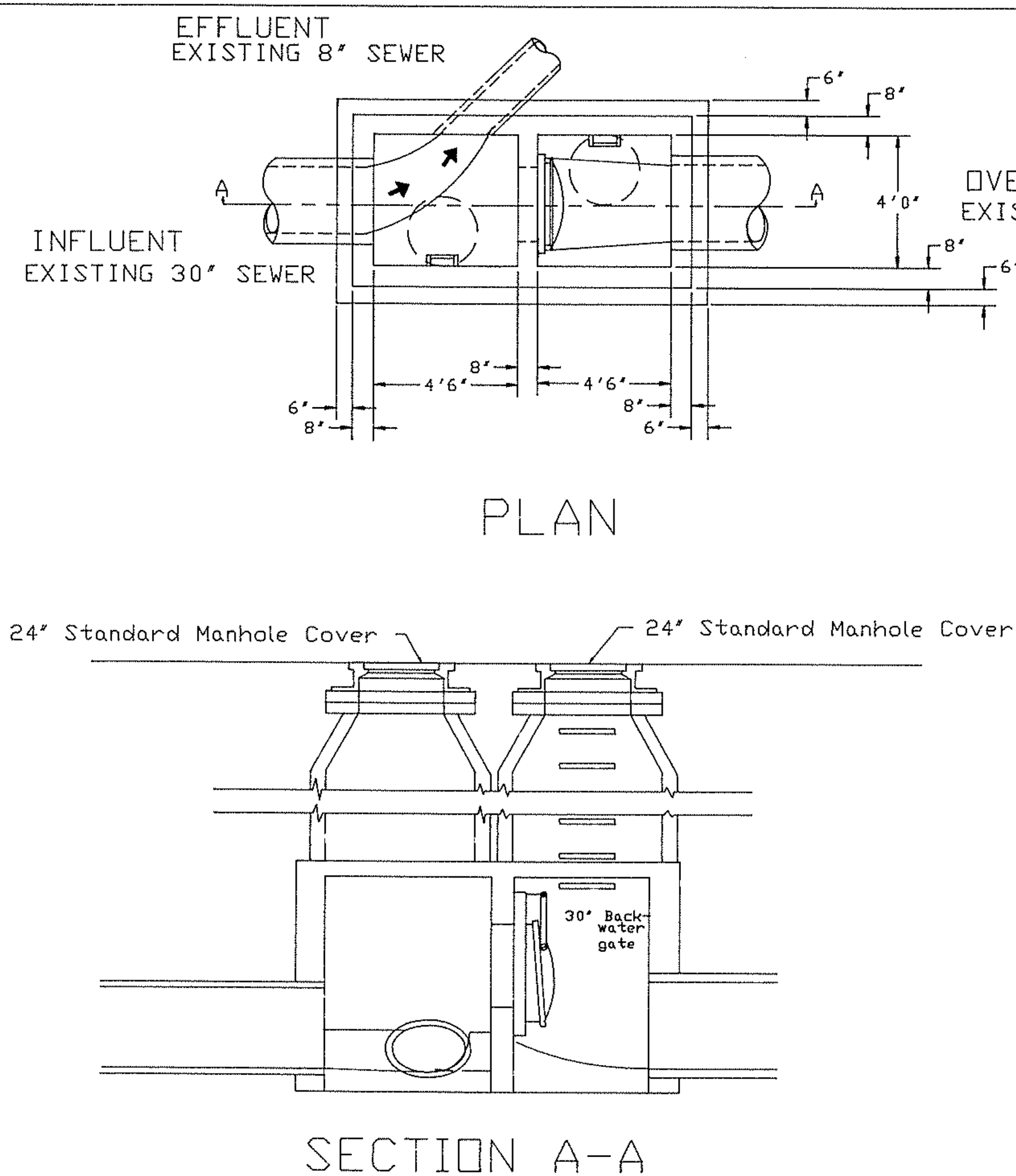

PLAN




SECTION A-A

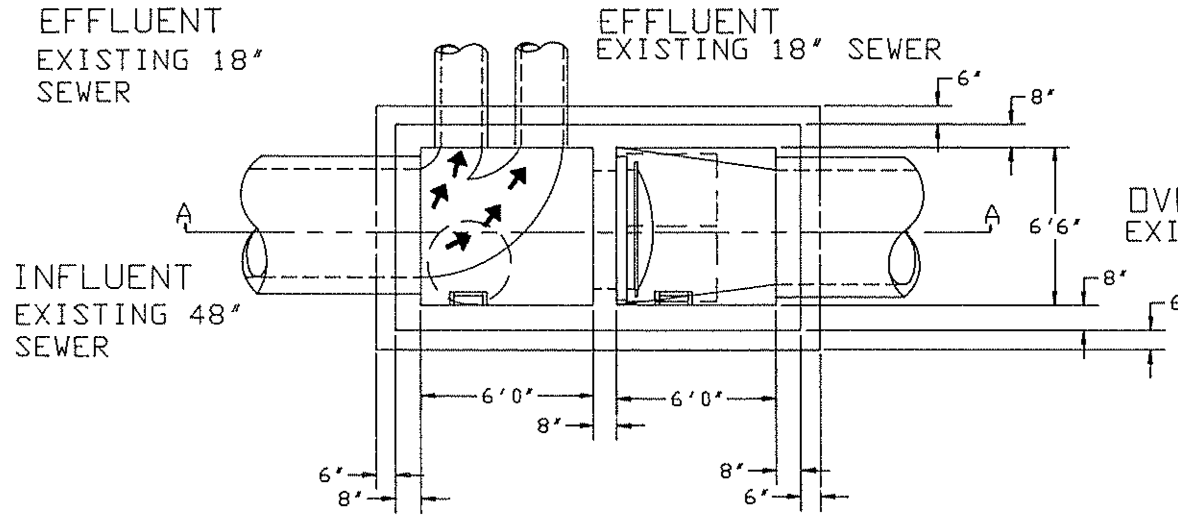
# INTERCEPTING CHAMBER AT FRANKLIN AND INDIANA

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 24 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO24 |



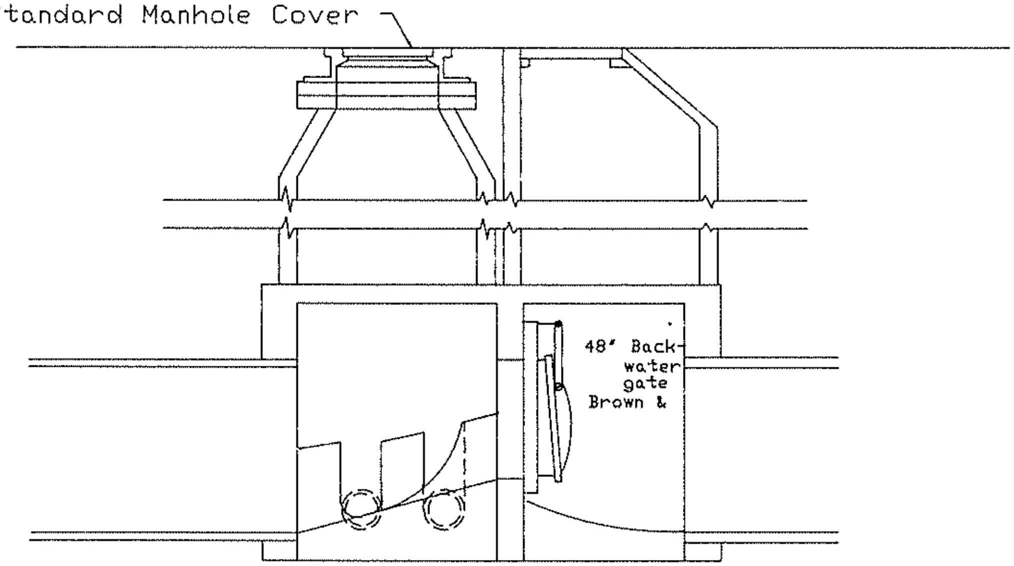

# INTERCEPTING CHAMBER AT POTTAWATOMIE AND SECOND

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 25 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO25 |



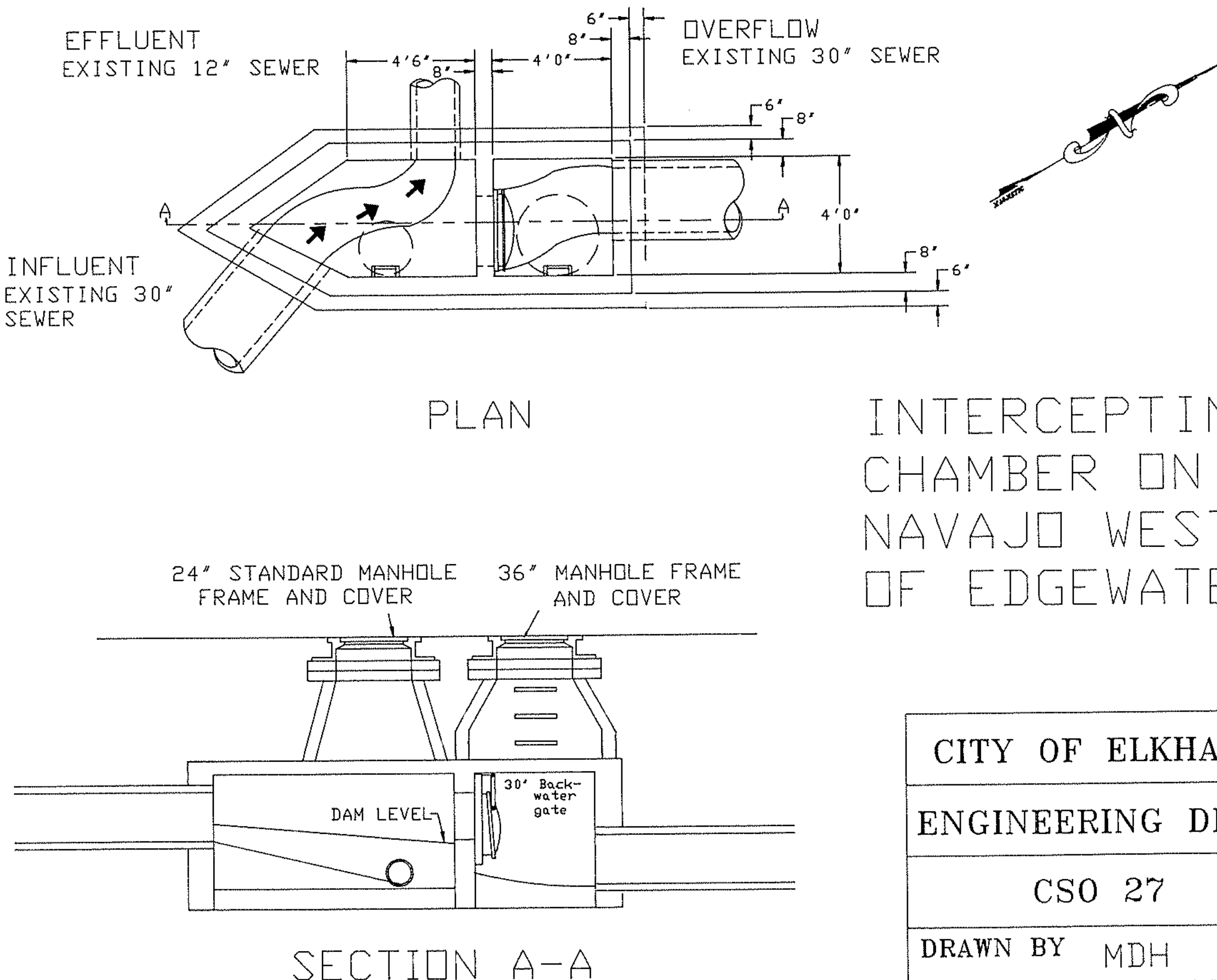

PLAN

# INTERCEPTING CHAMBER AT MAIN AND POTTAWATOMIE




SECTION A–A

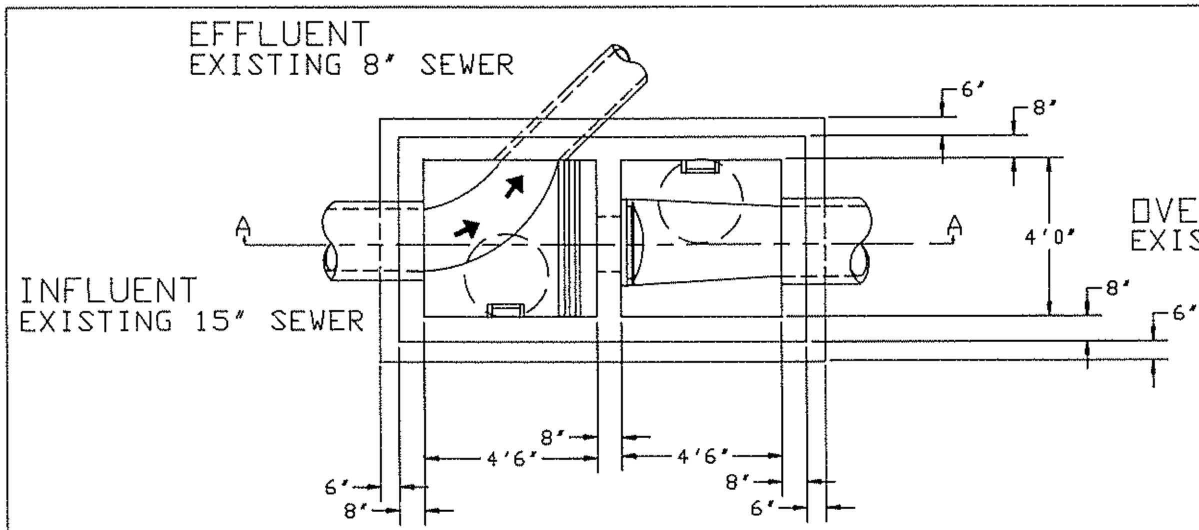
| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT | |
| CSO 26 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CS026 |



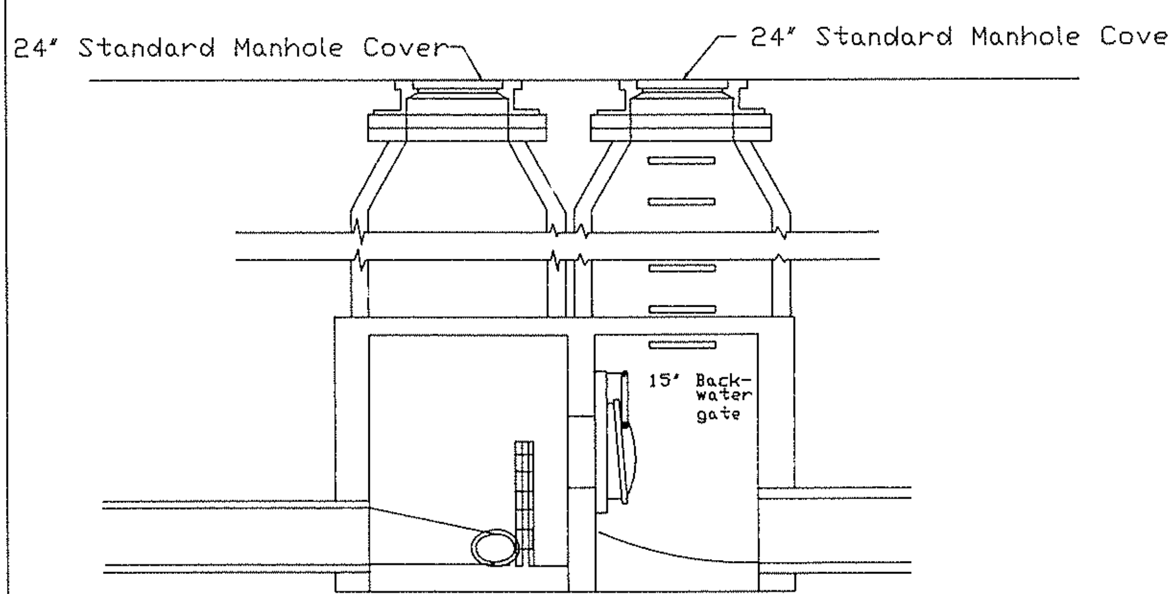

# INTERCEPTING CHAMBER ON NAVAJO WEST OF EDGEWATER

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 27 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CS027 |

# INTERCEPTING CHAMBER ON WASHINGTON AT THE RIVER

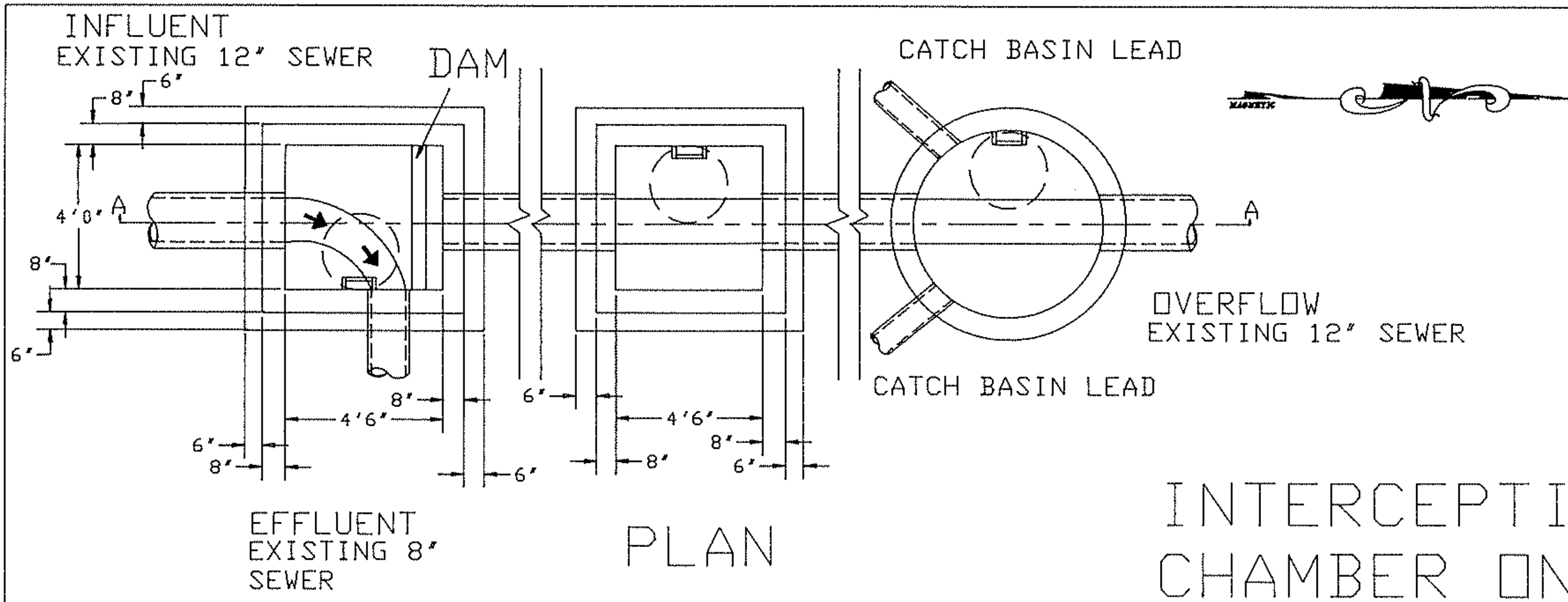



PLAN

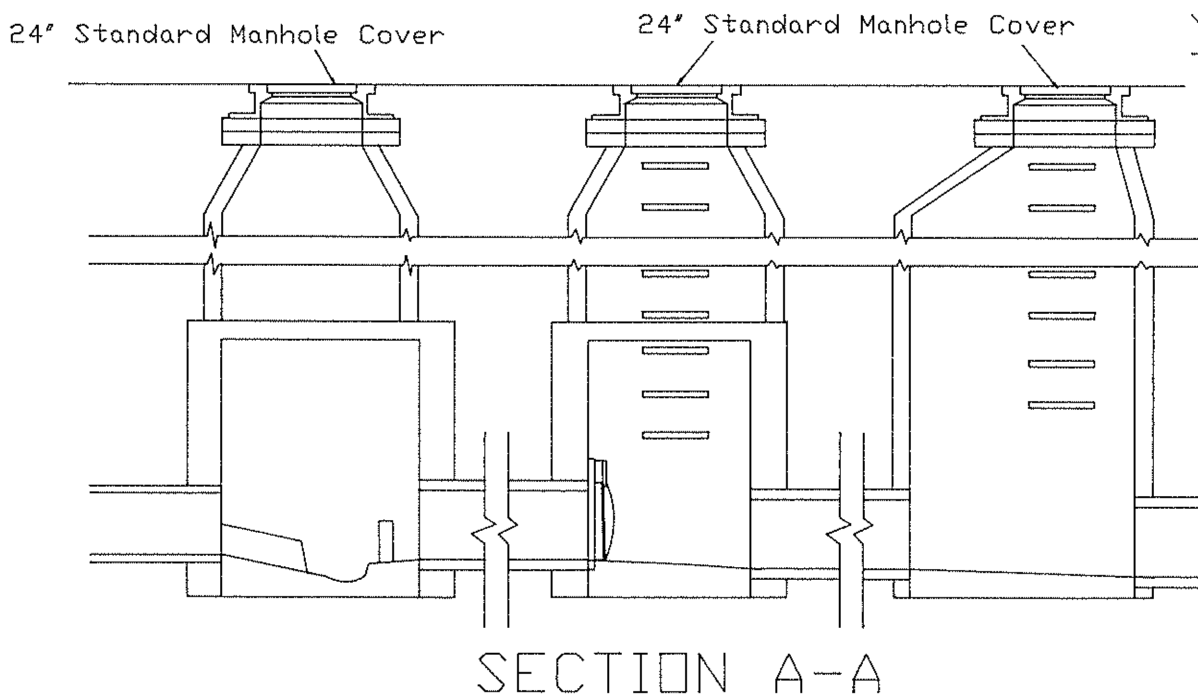



SECTION A-A

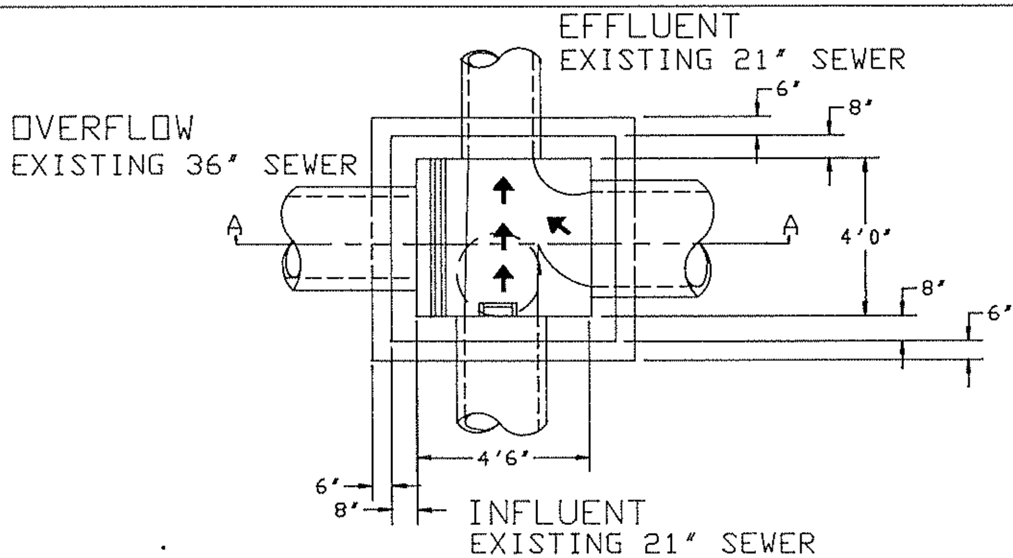
| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 28 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO28 |



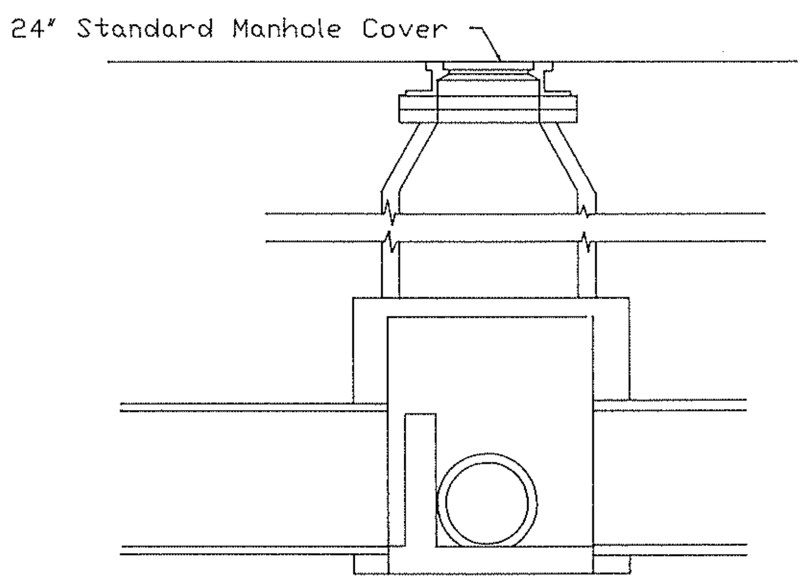

# INTERCEPTING CHAMBER ON JEFFERSON AT THE RIVER




| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 29 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CSO29 |



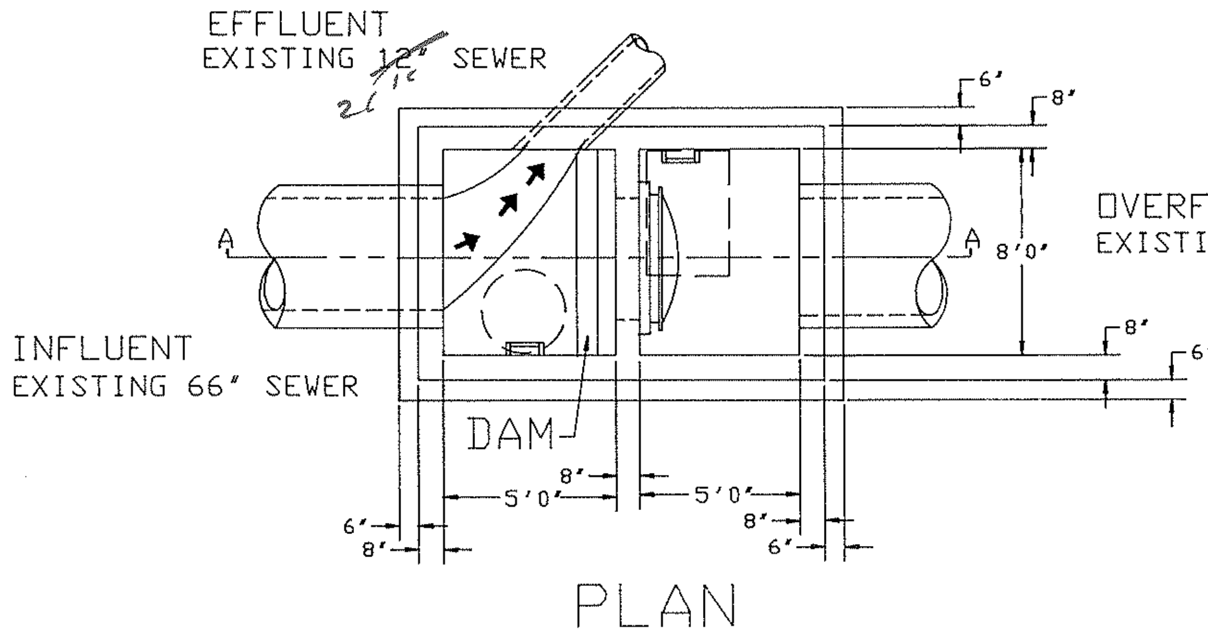

PLAN

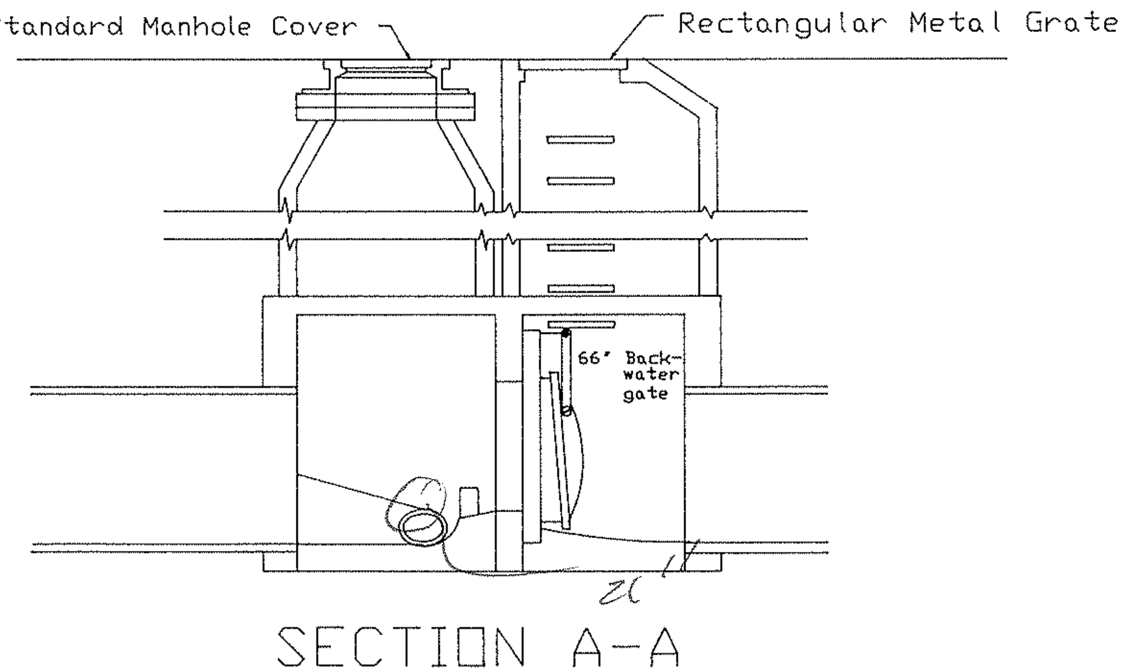



SECTION A-A

# INTERCEPTING CHAMBER AT PRINCETON AND CHARLES

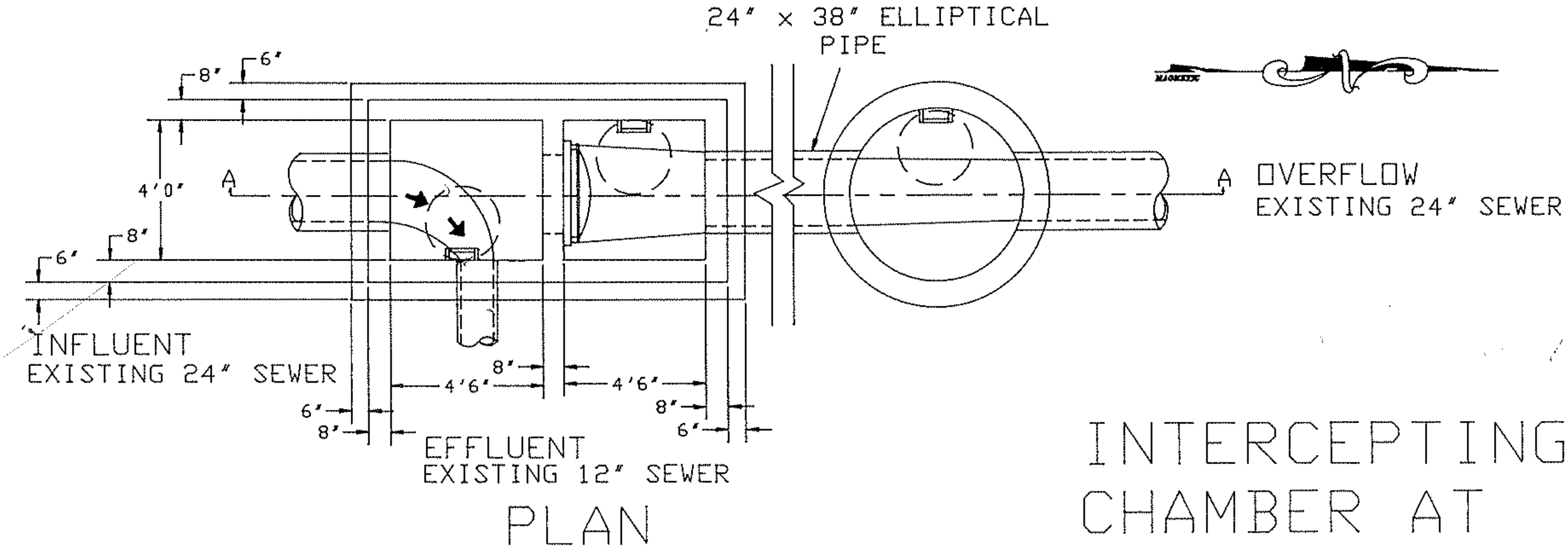
| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 30 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CSO30 |



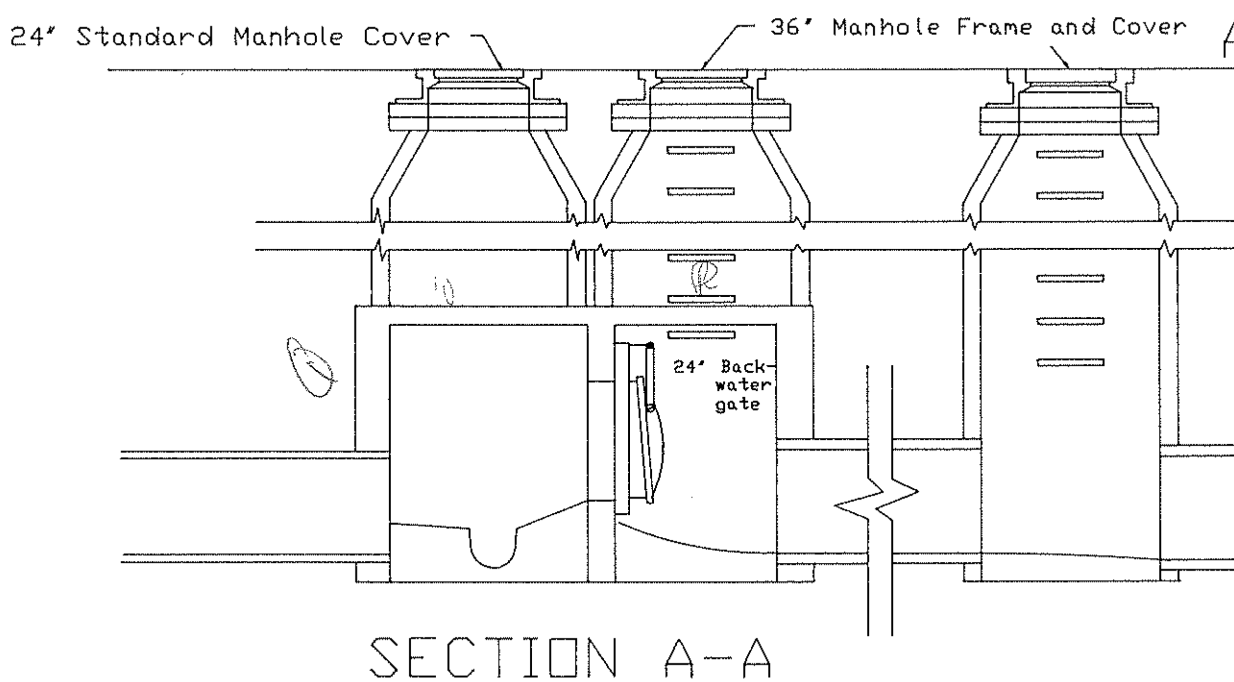




# INTERCEPTING CHAMBER AT ELIZABETH AND LUSHER

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 31 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO31 |




# INTERCEPTING CHAMBER AT EDGEWATER AND OKEMA




CITY OF ELKHART

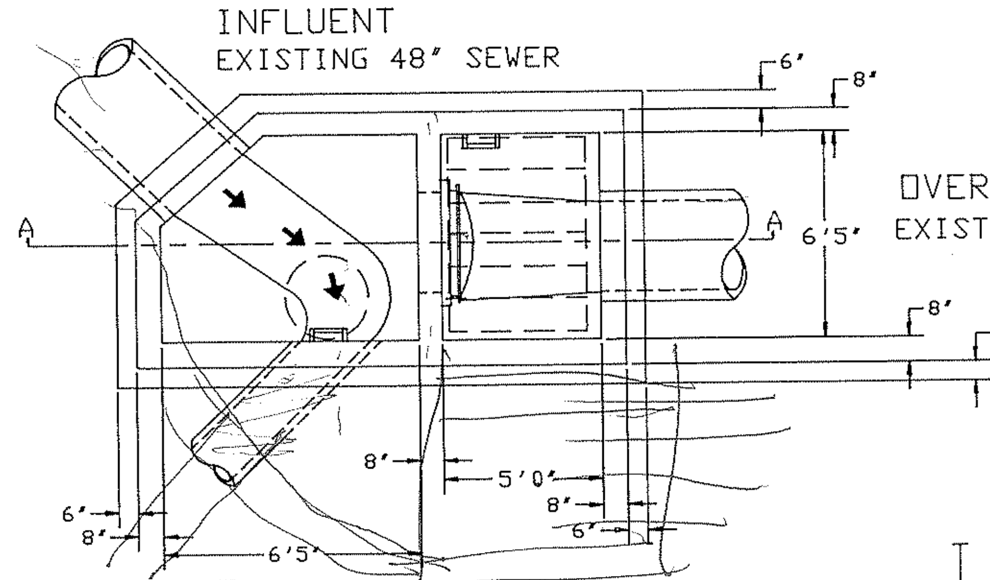
ENGINEERING DEPT.

CSO 32

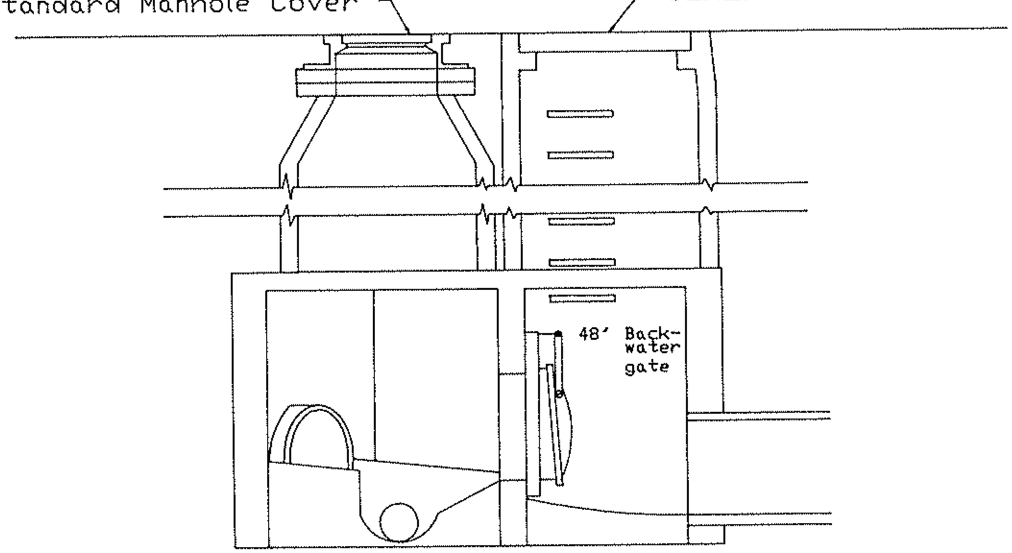
DRAWN BY MDH

SCALE 1″=5′

I.D. No. CSO32



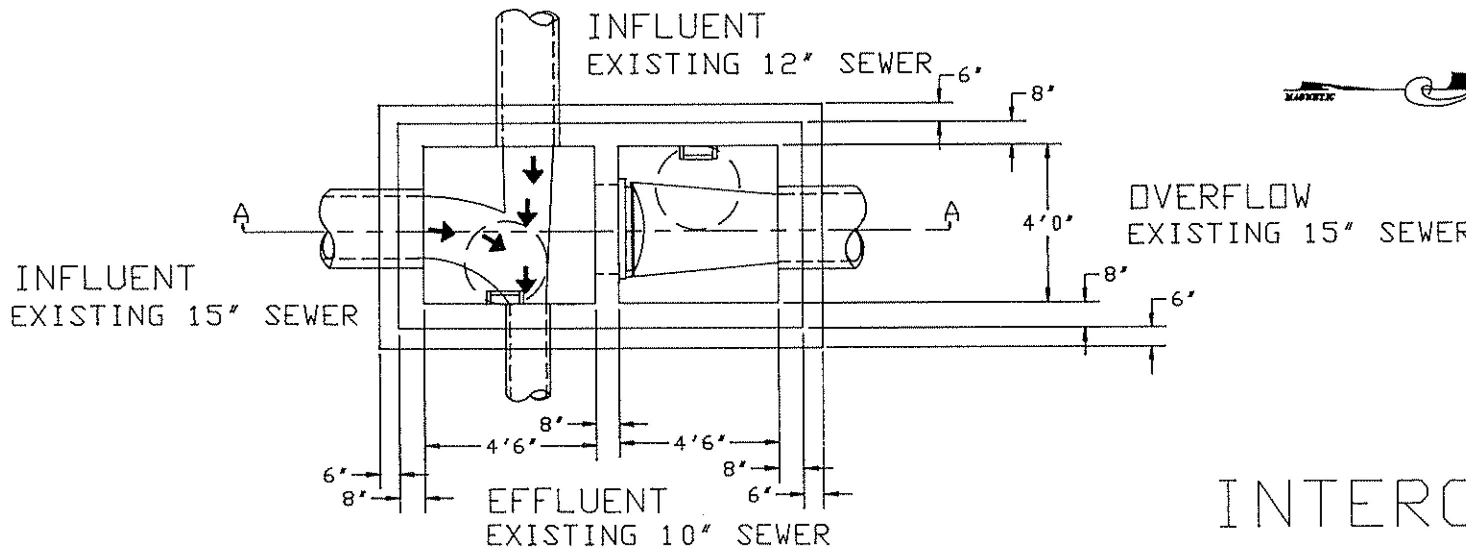

PLAN



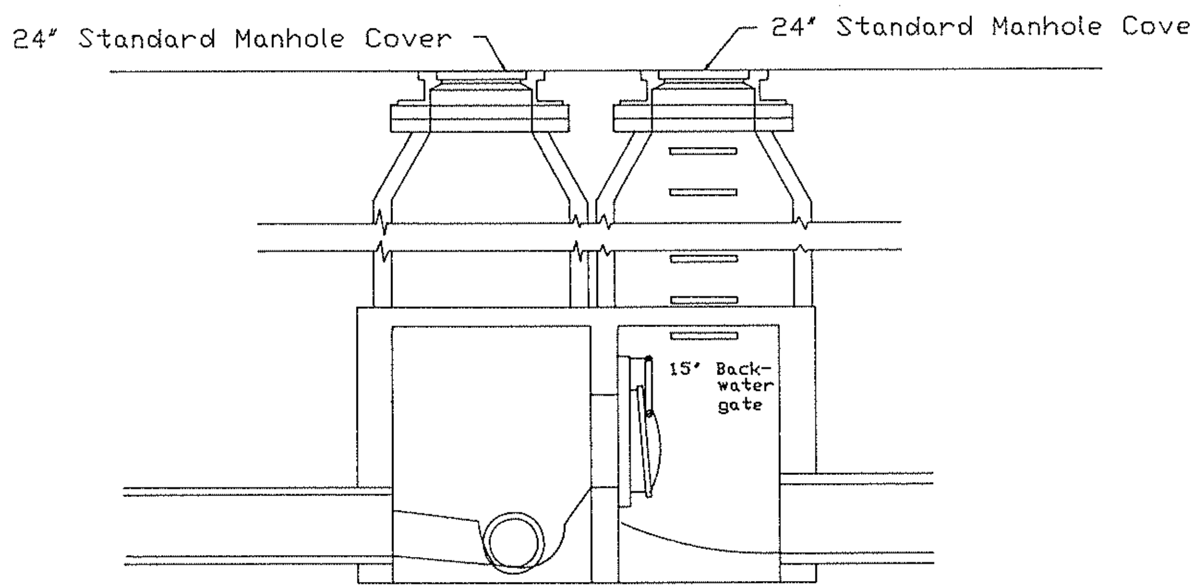

SECTION A-A

# INTERCEPTING CHAMBER AT 1029 EVANS

| |
|---|
| CITY OF ELKHART |
| ENGINEERING DEPT. |
| CSO 33 |
| DRAWN BY MDH |
| SCALE 1″=5′ / I.D. No. CS033 |




PLAN



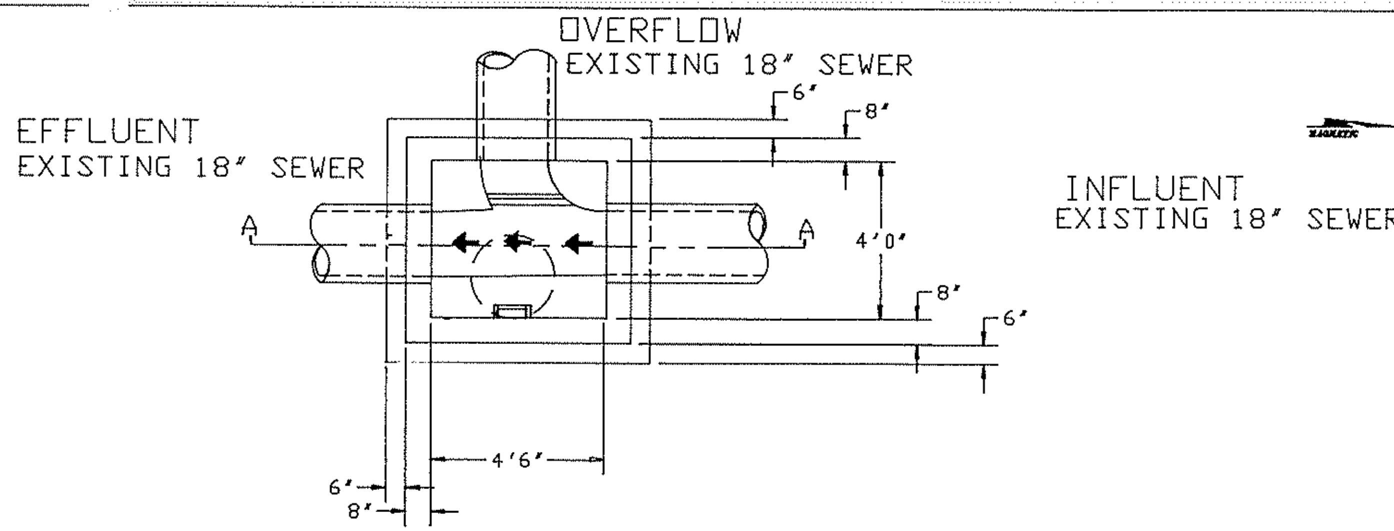

SECTION A-A

# INTERCEPTING CHAMBER AT SIXTH AND LEXINGTON

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 34 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CS034 |

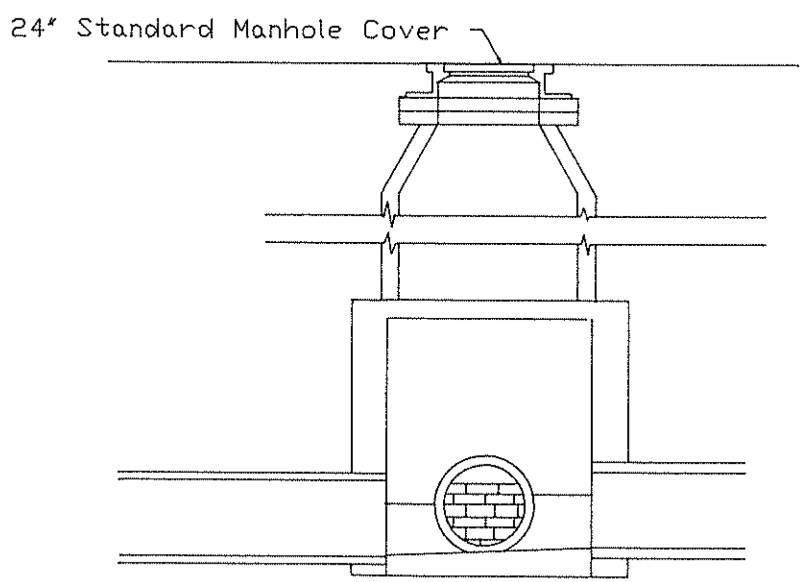
NO. 35 IS THE CITY OF ELKHART'S

PUBLICLY-OWNED TREATMENT WORKS



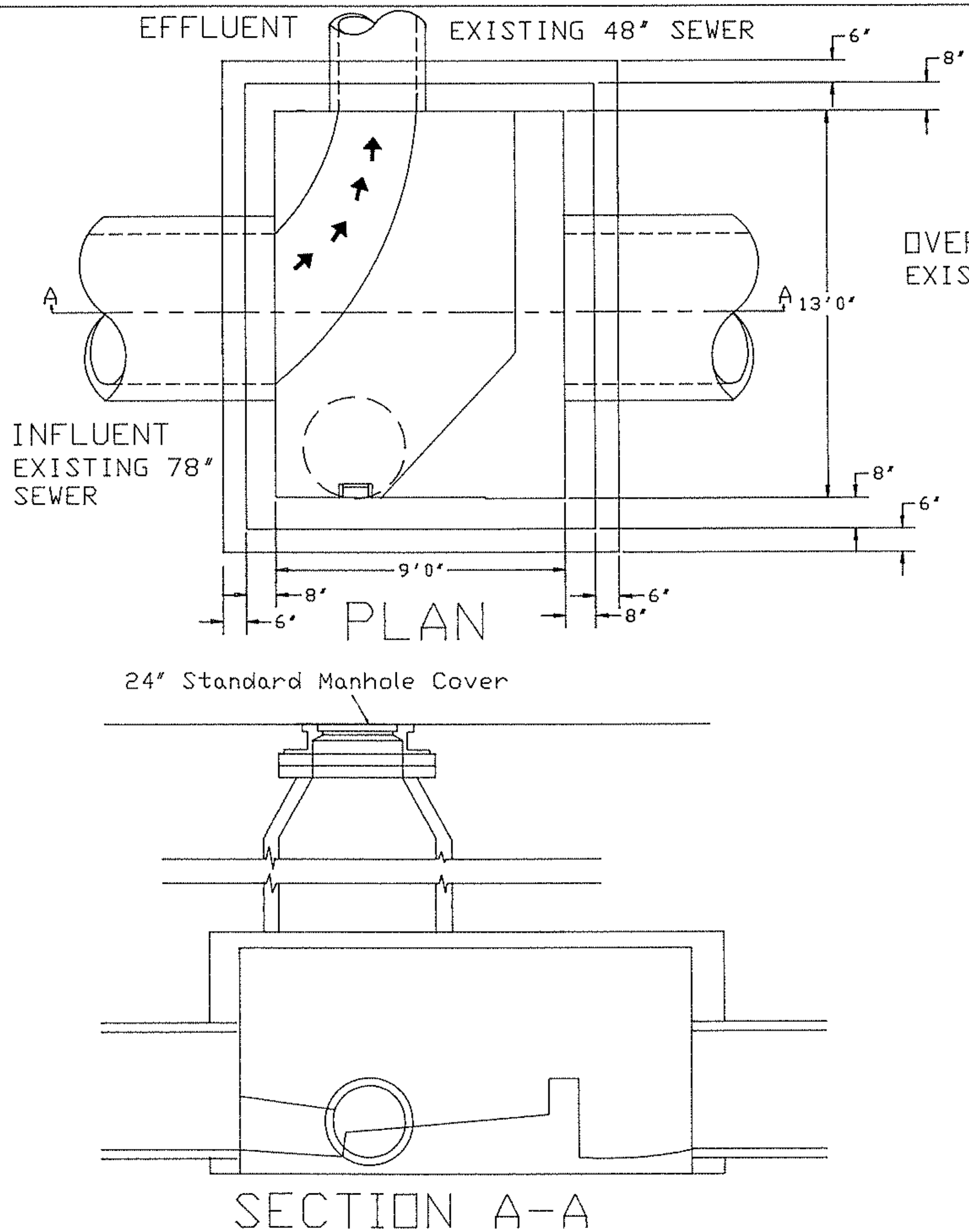

PLAN

# INTERCEPTING CHAMBER AT GOSHEN AND JACKSON



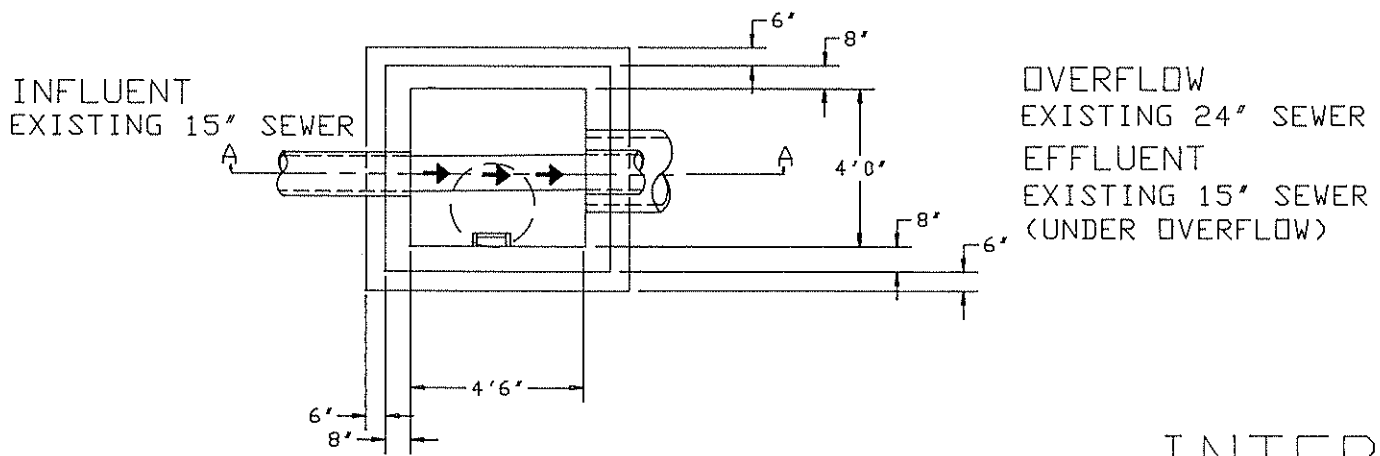

SECTION A-A

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 36 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO36 |



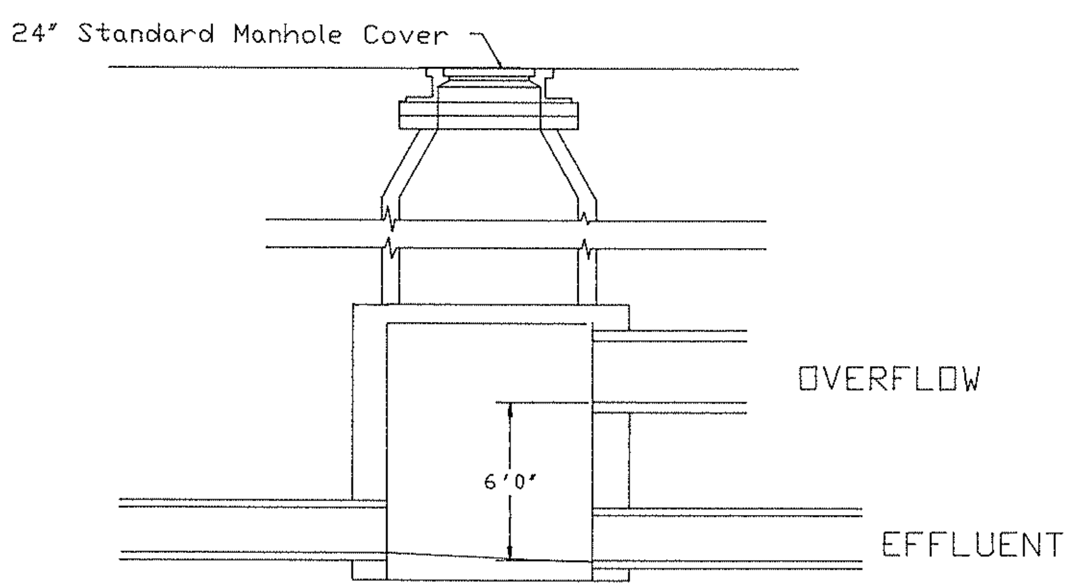

# INTERCEPTING CHAMBER AT FRANKLIN AND KRAU

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 37 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO37 |



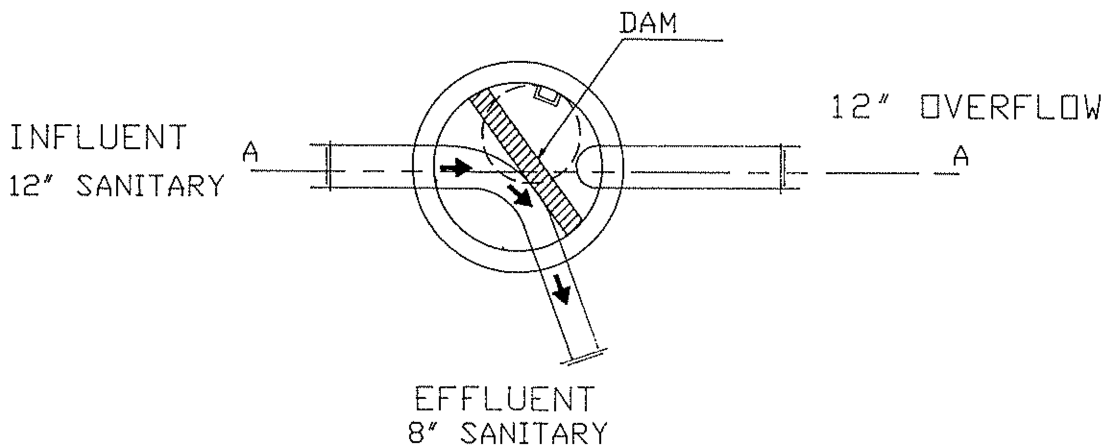

PLAN

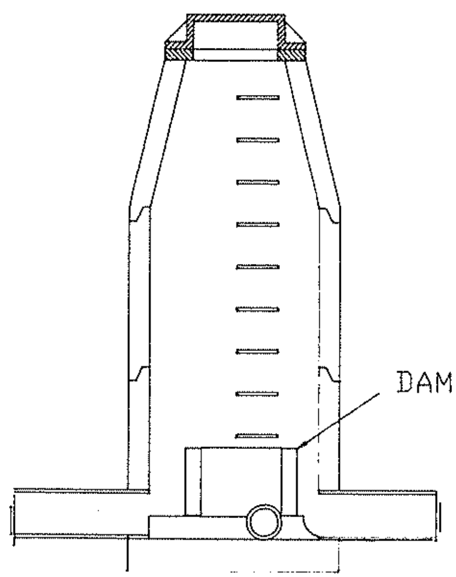
# INTERCEPTING CHAMBER AT BRISTOL AND PUTERBAUGH CREEK



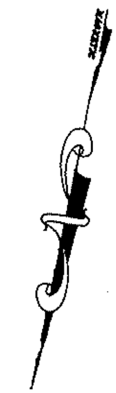

SECTION A-A

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 38 | |
| DRAWN BY MDH | |
| SCALE 1″=5′ | I.D. No. CSO38 |



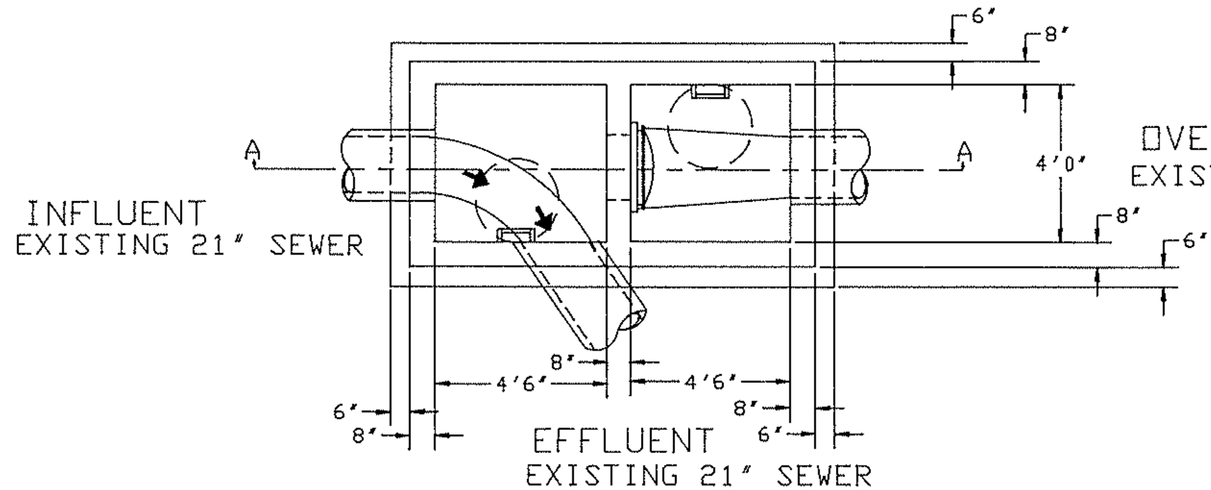




SECTION A-A

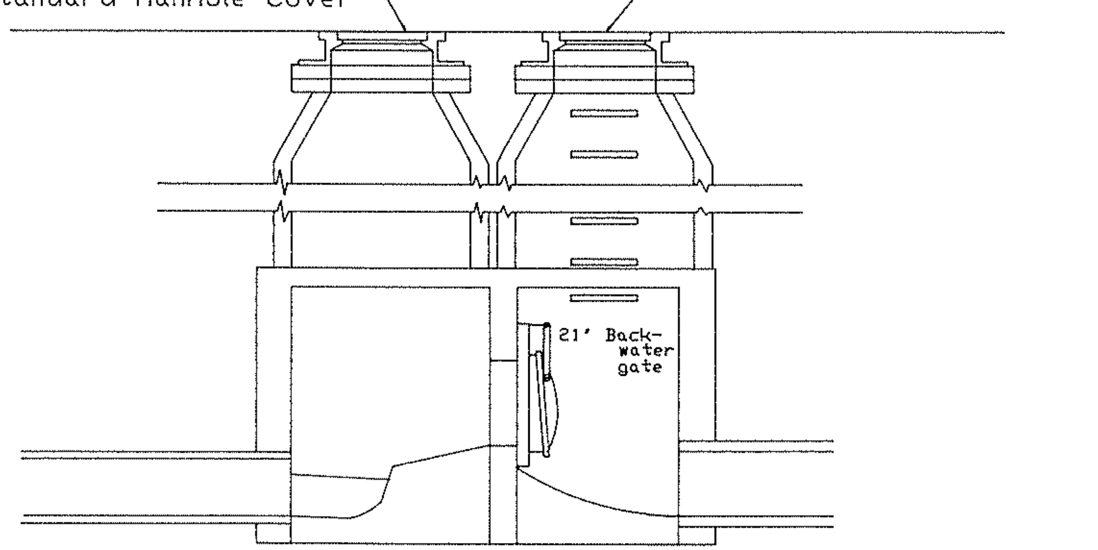


# INTERCEPTING CHAMBER AT HIGH ST. AND VISTULA ST.

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 39 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CS039 |



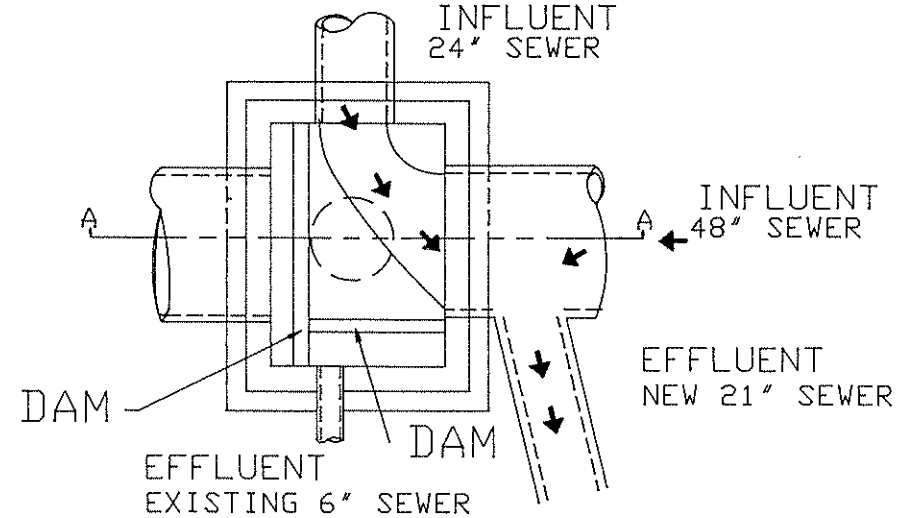

PLAN




SECTION A-A

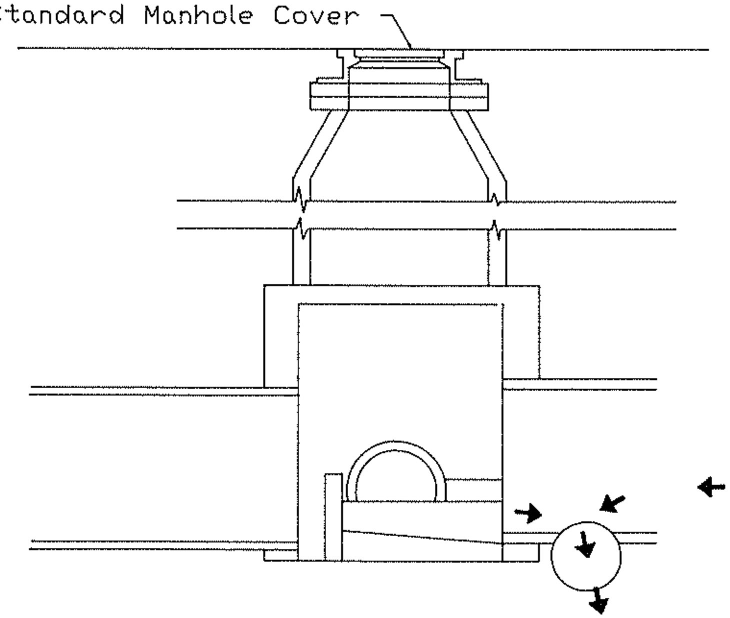
# INTERCEPTING CHAMBER IN McNAUGHTON PARK AT THE RIVER CROSSING

| CITY OF ELKHART | |
|---|---|
| ENGINEERING DEPT. | |
| CSO 40 | |
| DRAWN BY MDH | |
| SCALE 1"=5' | I.D. No. CSO40 |




NOTE: Both the 21″ and the 6″ effluent lines connect into the same down stream manhole.

PLAN




SECTION A-A

# INTERCEPTING CHAMBER AT NAPPANEE ST. AND LEXINGTON AVE.

| | |
|---|---|
| CITY OF ELKHART | |
| ENGINEERING DEPT. | |
| CSO 41 | |
| DRAWN BY AJW | |
| SCALE 1″=5′ | I.D. No. CSO41 |

| CSO Outfall | Latitude (DMS) | Longitude (DMS) |
|---|---|---|
| 4 | 41d40'35.93"N | 85d57'21.74"W |
| 5 | 41d40'23.64"N | 85d56'45.26"W |
| 6 | 41d41'16.02"N | 85d58'20.76"W |
| 7 | 41d41'16.3"N | 85d58'18.73"W |
| 8 | 41d41'05.66"N | 85d58'08.94"W |
| 9 | 41d41'14.73"N | 85d58'16.99"W |
| 11 | 41d41'06.15"N | 85d58'10.31"W |
| 12 | 41d41'34.39"N | 85d58'18.17"W |
| 13 | 41d41'37.83"N | 85d57'57.24"W |
| 14 | 41d41'42.58"N | 85d58'04.04"W |
| 15 | 41d41'16.8"N | 85d59'00.26"W |
| 16 | 41d41'20.28"N | 85d57'21.59"W |
| 17 | 41d40'49.1"N | 85d59'54.18"W |
| 18 | 41d40'43.9"N | 85d59'50.16"W |
| 19 | 41d40'57.54"N | 85d59'07.87"W |
| 20 | 41d40'36.79"N | 85d59'24.93"W |
| 21 | 41d40'54.39"N | 85d59'25.97"W |
| 23 | 41d40'53.04"N | 85d58'55"W |
| 24 | 41d40'28.66"N | 85d59'34.67"W |
| 25 | 41d41'30.5"N | 85d58'38.51"W |
| 26 | 41d41'30.85"N | 85d58'33.41"W |
| 27 | 41d40'35.64"N | 85d59'47.49"W |
| 28 | 41d41'21.47"N | 85d58'52.44"W |
| 29 | 41d41'15.85"N | 85d58'56.07"W |
| 30 | 41d40'44.04"N | 85d57'30.02"W |
| 31 | 41d40'02.48"N | 85d56'46.95"W |
| 32 | 41d40'47.84"N | 85d59'58.11"W |
| 33 | 41d40'47.87"N | 85d57'10.32"W |
| 34 | 41d41'03.03"N | 85d58'49.96"W |
| 37 | 41d40'32.05"N | 85d59'26.71"W |
| 38 | 41d42'08.16"N | 85d56'19.96"W |
| 39 | 41d40'58.69"N | 85d58'49.77"W |
| 40 | 41d40'37.22"N | 85d59'44.82"W |
| 41 | 41d40'47.62"N | 86d00'11.54"W |

| CSO Chamber | Latitude (DMS) | Longitude (DMS) |
|---|---|---|
| 4 | 41d40'33.27"N | 85d57'21.69"W |
| 5 | 41d40'21.57"N | 85d56'49.74"W |
| 6 | 41d41'15.57"N | 85d58'21.94"W |
| 7 | 41d41'16.6"N | 85d58'17.61"W |
| 8 | 41d41'02.08"N | 85d58'04.98"W |
| 9 | 41d41'15.43"N | 85d58'14.38"W |
| 11 | 41d41'05.42"N | 85d58'10.47"W |
| 12 | 41d41'35.57"N | 85d58'18.27"W |
| 13 | 41d41'38.02"N | 85d57'57.22"W |
| 14 | 41d41'43.04"N | 85d58'01.93"W |
| 15 | 41d41'16.14"N | 85d59'07.38"W |
| 16 | 41d41'20.31"N | 85d57'20.5"W |
| 17 | 41d40'49.48"N | 85d59'53.75"W |
| 18 | 41d40'44.28"N | 85d59'49.39"W |
| 19 | 41d41'00.42"N | 85d59'07.85"W |
| 20 | 41d40'37"N | 85d59'24.46"W |
| 21 | 41d40'53.31"N | 85d59'24.09"W |
| 23 | 41d40'52.77"N | 85d58'54.82"W |
| 24 | 41d40'27.24"N | 85d59'34.63"W |
| 25 | 41d41'28.55"N | 85d58'37.57"W |
| 26 | 41d41'30.06"N | 85d58'32.63"W |
| 27 | 41d40'34.61"N | 85d59'49.77"W |
| 28 | 41d41'21.32"N | 85d58'51.68"W |
| 29 | 41d41'15.82"N | 85d58'55.68"W |
| 30 | 41d40'44.03"N | 85d57'35.07"W |
| 31 | 41d40'00.32"N | 85d56'56.82"W |
| 32 | 41d40'45.69"N | 85d59'58.12"W |
| 33 | 41d40'48.84"N | 85d57'10.34"W |
| 34 | 41d41'03.44"N | 85d58'48.34"W |
| 37 | 41d40'30.43"N | 85d58'55.32"W |
| 39 | 41d41'00.23"N | 85d58'44.26"W |
| 40 | 41d40'38.07"N | 85d59'44.2"W |
| 41 | 41d40'57.04"N | 86d00'12.07"W |

# Appendix C

## Water Quality Model Documentation

LimnoTech
Water | Environment | Scientists | Engineers

# St. Joseph River Model Updated Calibration

April 20, 2007

## Overview

This memorandum presents an updated calibration of the St. Joseph River water quality model being used by the Cities of Elkhart, Mishawaka and South Bend to evaluate in-stream impacts from bacteria sources in the watershed, including discharges from their combined sewer overflows (CSOs). The river model's spatial extent spans over 30 miles of the St. Joseph River, from upstream of the City of Elkhart at River Mile (RM) 81.6 downstream to the Indiana-Michigan state line (RM 50). The domain also includes the lower 16 miles of the Elkhart River, from just below the City of Goshen downstream to its confluence with the St. Joseph River. The model was developed and calibrated in 2003-2004 under a 205(j) grant obtained by the Cities from US EPA, and is consistent with US EPA guidance on monitoring and modeling for CSOs (USEPA 1999). This memorandum provides an update to the river model calibration reflecting additional information from the last three years, including:

- Development of a watershed model (HSPF) to estimate runoff volume and bacteria loadings from nonpoint sources in the tributaries to the Elkhart and St. Joseph Rivers;
- Updated calibration of the combined collection system models in the Cities of South Bend and Elkhart to new flow monitoring data; and,
- More accurate delineations of areas serviced by the municipal separate storm sewer system (MS4) in the City of Elkhart.

The Escherichia coli (*E. coli*) data used to calibrate the river model were collected between July 2002-May 2003 over a range of environmental conditions, including wet and dry periods in all four seasons. These data provide a robust dataset for comparison to model simulated concentrations. Results from the update to the river model calibration, which are described below, indicate that the model reasonably reproduces the in-stream data over the range of environmental and seasonal conditions. Therefore, the river water quality model provides a causal linkage between the discharge of CSO pollutants and impacts on water quality. It provides a more complete assessment of water quality conditions than data alone by filling gaps between sampling locations and collection times and for simulating conditions under a "typical" or average year. The calibrated and validated river model will also provide the capability to forecast relative improvements in water quality conditions resulting from various CSO controls.

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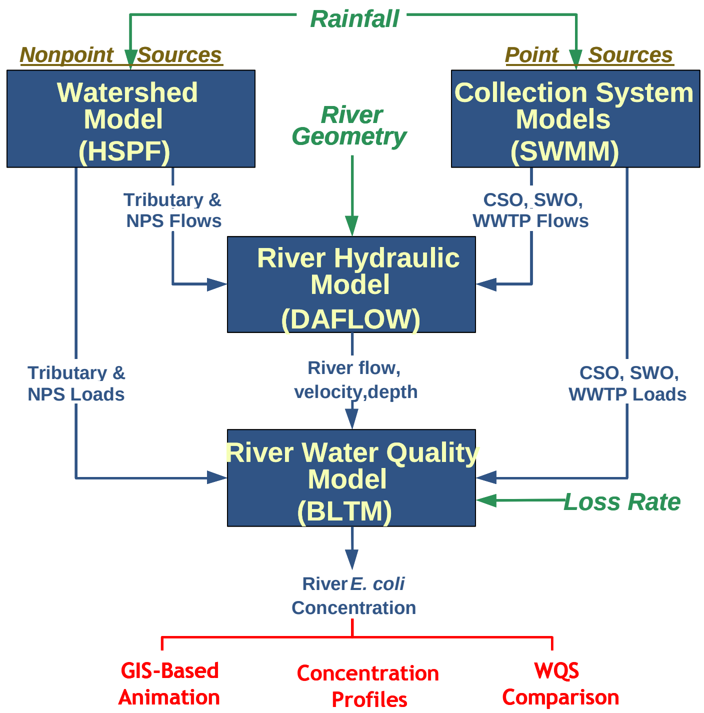
## Background

The St. Joseph River drains 4,725 square miles in Michigan and Indiana and receives bacterial pollution from agriculture, urban storm water, combined sewers overflows (CSOs), and rural sources. Three Indiana cities -- Elkhart (population 47,626), Mishawaka (population 46,557), and South Bend (population 107,789) have a total of 88 CSOs and many more storm water outfalls. The three cities, which initiated CSO planning in 1990, are refining their CSO long-term control plans (LTCPs) and are also developing urban storm water management plans to meet national and state policies.

The portion of the St. Joseph River watershed containing these communities is in Elkhart and St. Joseph Counties, Indiana. Although these two counties encompass only nine percent of the river's watershed, they are among the top 10 counties in Indiana based on the number of livestock. The counties are also significant population and industrial centers in Indiana. St. Joseph County is ranked number four in the state according to population. Elkhart County experienced a 149 percent increase in population since 1970 and now ranks sixth in the state for population. The Indiana Department of Environment (IDEM) has identified a portion of the river and many of the tributaries within the study area as impaired waters for *E. coli* under Section 303(d) of the Clean Water Act. IDEM developed an *E. coli* Total Maximum Daily Load (TMDL) for the river (IDEM, 2003). Also, the Michigan Department of Environmental Quality developed an *E. coli* TMDL for the lower portion of the river, downstream of the study area (MDEQ, 2003). US EPA approved both TMDLs in 2004. Therefore the three cities, and other stakeholders in the two-county area, must identify cost-effective source controls to meet water quality criteria within the Indiana portion of the river and at the Indiana/Michigan state line.

Previous modeling efforts of the St. Joseph River began in the early 1990s, when South Bend initiated their first combined sewer overflow (CSO) study. Mishawaka and Elkhart followed suit, conducting independent river modeling efforts. Several regulatory requirements led the cities to conclude that a single, integrated river model would result in better decision-making about management approaches to reduce *E. coli* in the river. These include the national and state CSO policies, storm water permits, and the TMDL program. Additionally, Indiana adopted guidance for conducting CSO long-term control plans and use attainability analyses in 2000 (IDEM, 2000). The cities formed a cooperative watershed approach that included the goal of developing a single easy-to-use tool to differentiate between different sources of *E. coli* and to assist in developing effective management solutions. The Cities proactively initiated a study with federal and local funding that built on their previous efforts to answer long outstanding questions about the sources of *E. coli* and impacts on the river during wet and dry weather conditions, using a modeling framework that simulated *E. coli* loadings from all sources in the watershed. This framework is illustrated in Figure 1.

**Figure 1. Modeling Framework for the St. Joseph Watershed.**




The study was conducted in two phases. In the first phase (2002-2003), the Cities conducted a coordinated *E. coli* sampling program between July 2002 and May 2003 in the St. Joseph and Elkhart rivers and their tributaries. Samples were collected weekly at approximately twelve locations in the St. Joseph River, two locations in the Elkhart River and at the mouths of seven tributaries (it was necessary to move some sites at times due to access issues). Sampling included both wet weather (8 events) and dry weather (19 events) conditions. The monitoring data span a range of environmental conditions, from dry weather to storms ranging from less than 0.1 inches up to 1.59 inches. The Cities continue to collect water quality data in the St. Joseph and Elkhart Rivers on an approximately weekly frequency to document that water quality conditions are improving as a result of pollution control efforts.

During the first phase of the grant-funded study, the Cities also developed a planning level model of the rivers and calibrated it to the data collected in the monitoring program. The United States Geological Survey's (USGS) Branched Lagrangian Transport Model (BLTM) was selected as the river model because it is a fully dynamic model in which both flow and water quality conditions can vary with time and space (Jobson, 1993). The USGS' stream hydraulic model, the Diffusion-Analogy Flow Model (DAFLOW), is used as a companion model to provide flow input to the BLTM model. BLTM uses a Lagrangian-based reference frame where the pollutant concentrations in parcels of in-stream water are tracked at computational nodes as they (the parcels) move with flow. Using a Lagrangian reference frame in water quality models is advantageous because it reduces numerical dispersion and is stable for any time step size. BLTM is one dimensional in the longitudinal direction. Multiple pollutant source types, including CSOs, urban storm water, wastewater treatment plant (WWTP) discharges and tributaries, can be specified at multiple points along the system. The model can simulate water quality under unsteady flow conditions, such as during a wet weather event. Its customization for the St. Joseph River system is described in more detail below.

In the second phase of the cooperative study (2004-2006), a watershed model was developed to simulate *E. coli* fate and transport in the tributaries to the rivers (City of Elkhart, 2006). This model was calibrated to the data collected in Phase 1 in the seven major tributaries in the study area. This model was then linked to the river model. Additional activities in the second phase also included the development of modeling pre- and post-processors that facilitate understanding and visualization of the model results, including GIS-based animations and comparisons to event data and applications of the model for variously sized design storms and for a "typical" year.

The Cities of Elkhart and South Bend also conducted additional flow monitoring in their combined collection systems in Spring 2004/Fall 2005 (Elkhart) and June through November 2005 (South Bend). These data were used to update the calibration and validation of their collection system models. The updated collection system models, which are more tightly calibrated to monitoring data than earlier versions of these models, now predict much lower volume (<=50%) from the CSOs than the model versions used in the original river model calibration.

As the Cities embark on their CSO LTCP updates, revisiting the river model calibration in light of the recent improvements to the tools in the framework is prudent to ensure that the model will provide reliable simulations of in-stream water quality. This memorandum describes the updated calibration.

## River Model Inputs

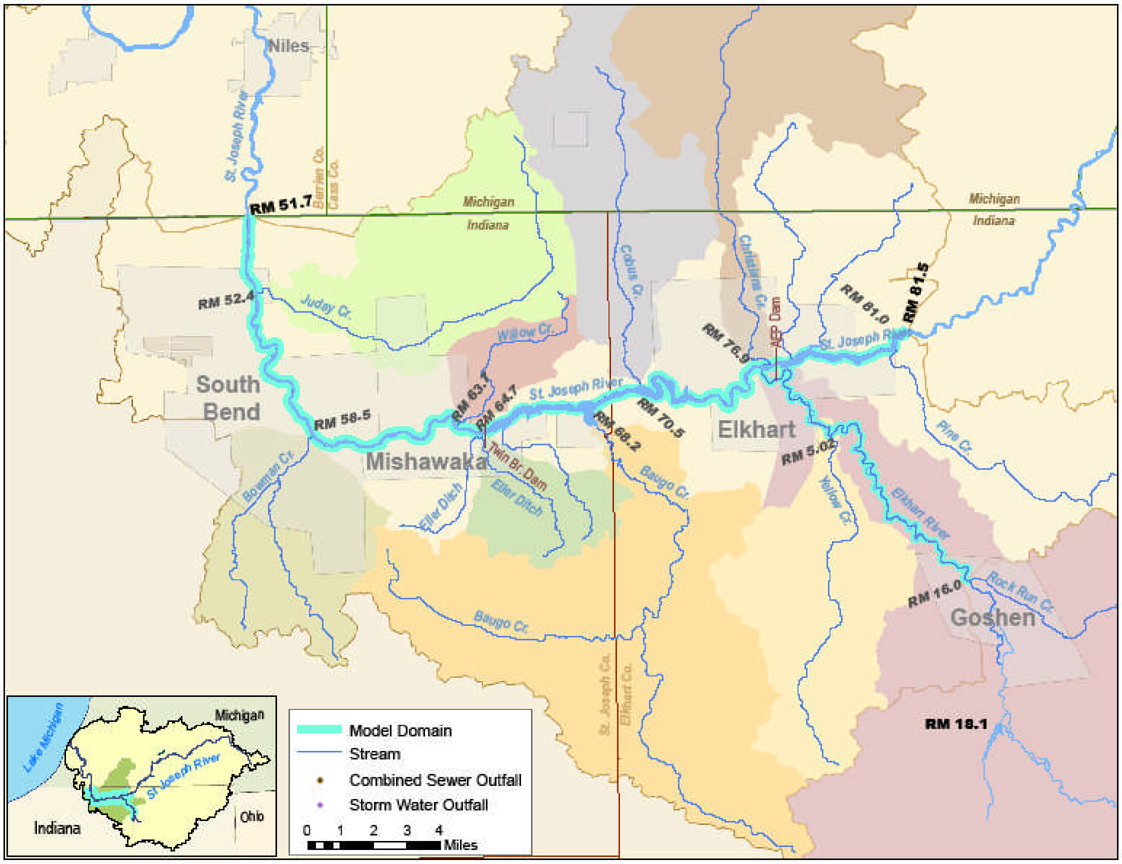
This section describes the inputs to the BLTM river model including the model geometry, *E. coli* source inputs, and the treatment of *E. coli* loss kinetics. The model domain for the St. Joseph River extends from the Indiana-Michigan state line (RM 50.05) upstream to the Six-Span Bridge (RM 81.63). The model domain of the Elkhart River extends from its confluence with the St. Joseph River (RM 0.0) upstream to Goshen (RM 16.2). These reaches were chosen for several reasons:

- Both the St. Joseph and Elkhart model boundaries are upstream of all of the participating cities' CSO and storm water sources;
- The St. Joseph River upstream boundary is routinely sampled (approximately weekly) by the City of Elkhart, providing an in-stream concentration dataset to use as a model forcing;
- A USGS gauge is located at the Elkhart River upstream boundary, providing a flow dataset to use as a model forcing;
- A number of locations within the model domain are routinely sampled by the Cities of Elkhart, Mishawaka, and South Bend, providing an extensive dataset for comparing to simulated concentrations and constraining model formulations;
- The model domain includes the East Race, a kayaking course in downtown South Bend, that is a key location for evaluating recreation; and
- The model extends to the Indiana-Michigan state line, which allows an assessment of the impact of the Cities' sources on in-stream water quality as the river enters Michigan.

*Model Geometry*

The river model (BLTM) is structured in branches, which are defined at their upstream and downstream boundaries by junctions. Branches are subdivided into grid sections that are defined by nodes. Nodes are also used as loading input locations. Multiple branches are allowed but each branch is limited to 100 grid sections. The St. Joseph model consists of 5 branches (4 for the St. Joseph River and 1 spanning the Elkhart River) with a total of 179 grid nodes. Branches were terminated at dams (Johnson St. and Twin Branch) and at confluences of major tributaries (e.g. Elkhart River confluence with St. Joseph River). A schematic of the model is shown in Figure 2.

**Figure 2. Water Quality Model Schematic.**




Channel geometry in BLTM is expressed as a function of flow and can vary by grid section to more accurately simulate the changing bathymetry found in a typical river system. The primary emphasis in defining the channel geometry is to accurately reproduce velocity and travel times with the flow portion of the model. The location and flow characteristics of each branch are summarized in Table 1.

**Table 1. Branches of the BLTM River Model for the St. Joseph and Elkhart Rivers**

| ID | Branch Description (River Mile) | Max Flow (cfs) | Mean Flow (cfs) |
|---|---|---|---|
| 1 | St. Joseph from Six-Span Bridge (81.63) to Johnson St. Dam (77.12) | 8,450 | 3,054 |
| 2 | St. Joseph from Johnson St. Dam to confluence with Elkhart (76.52) | 11,042 | 3,122 |
| 3 | Elkhart from Goshen (16.2) to confluence with St. Joseph (0.0) | 5,108 | 611 |
| 4 | St. Joseph from confluence with Elkhart to Twin Branch Dam (64.82) | 11,275 | 3,197 |
| 5 | St. Joseph from Twin Branch Dam to MI/IN state line (50.05) | 12,409 | 3,252 |

Nodes in the model were first selected to correspond to cross-sections in a hydraulic model (HEC) of the river developed by the Indiana Department of Natural Resources (IDNR, 1977) for evaluating the effects of flooding. Nodes were then added to the model to correspond to loading input locations. The IDNR's HEC model was used to develop the model's geometry inputs and relationships between flow and area and flow and width for each grid section.

*E. coli Sources*

In addition to the geometry inputs described in the previous section, the BLTM river model requires temporal and spatial inputs of flows and concentrations. This section describes the specific data sources used for the model calibration period.

Source types included in the model include upstream, tributary inflows, CSOs, storm water (SWOs), wastewater treatment plant (WWTP) effluent, and drainage from areas adjacent to the rivers (direct drainage). Flow and concentration time series inputs were developed for all source types using the data sources summarized in Table 2. For several sources, event mean concentrations (EMCs) were selected to represent average pollutant concentrations across a CSO discharge event. Use of EMCs is consistent with US EPA's monitoring and modeling guidance for CSOs (USEPA 1999).

**Table 2. Summary of flow and *E. coli* load inputs for BLTM River Model**

| Source | Flow | *E. coli* Concentration |
|---|---|---|
| St. Joseph River-Upstream | USGS gauge (04101000) at Johnson St. Bridge adjusted by drainage area of gage to drainage area at model boundary | Sampling data from the Six Span Bridge |
| Elkhart River-Upstream | USGS gauge (04100500) at Goshen | Estimated from sampling data at County Rd 18. |
| Tributaries | HSPF watershed model | HSPF watershed model |
| Direct Drainage-St. Joseph River | Best Professional Judgment (BPJ) | Literature and BPJ (varied seasonally) |
| Direct Drainage-Elkhart River | BPJ | Literature and BPJ (varied seasonally) |
| Elkhart CSOs | Collection system model | Literature and BPJ<br>EMC = 750,000 (cfu/100mL) |
| Elkhart SWOs | Rational method (Q=ciA) | Literature<br>Road EMC = 1,700 (cfu/100mL)<br>Other EMC = 5,000 (cfu/100mL) |
| Elkhart WWTP | Monitoring data | Monitoring data |
| Mishawaka CSOs | Collection system model | Literature and BPJ<br>EMC = 750,000 (cfu/100mL) |
| Mishawaka SWOs | Rational method (Q=ciA) | Literature<br>EMC = 5,000 (cfu/100mL) |
| Mishawaka WWTP | Monitoring data | Monitoring data |
| South Bend CSOs | Collection system model | Literature and BPJ<br>EMC = 750,000 (cfu/100mL) |
| South Bend SWOs | Rational method (Q=ciA) | Literature<br>EMC = 5,000 (cfu/100mL) |
| South Bend WWTP | Monitoring data | Monitoring data |

The tributary flows and associated *E. coli* loads were modeled using the Hydrologic Simulation Program in Fortran (HSPF), a watershed model supported by USEPA. The tributaries modeled with HSPF are: Rock Run Creek, Yellow Creek, Pine Creek, Puterbaugh Creek, Osolo Township Ditch, Christiana Creek, Cobus Creek, Baugo Creek, Penn Township Ditch, Eller Ditch, Willow

Creek, Bowman Creek, and Juday Creek. A detailed description of the watershed model configuration to the St. Joseph watershed and its calibration to tributary data is provided elsewhere (City of Elkhart, December 2006).

Hourly CSO overflow volumes were obtained using three independent collection system models from the Cities of Elkhart, Mishawaka, and South Bend. CSO discharges were assigned an EMC of 750,000 cfu/100mL, which falls within the range of standard literature values. The sensitivity of the model to the selected CSO EMC value is described in a later section of this document.

Storm water volumes for each of the Cities were calculated using the Rational Method. A detailed delineation of storm water areas and appropriate land use and soil type data were used to establish runoff coefficients. These area delineations were refined for the City of Elkhart using aerial photographs during this calibration update. Storm water overflows for these municipalities were assigned an EMC of 5,000 cfu/100mL, based on the median fecal coliform value from the National Stormwater Quality Database (NSQD). Fecal coliform values from the NSQD were used because more data were available than for *E. coli* and because fecal coliform EMCs provide a conservative (high) estimate of *E. coli* (which is a subset of fecal coliform) in storm water. Because several of the delineated storm water areas in Elkhart drain only roads and/or highways, these areas were assigned an EMC of 1,700 cfu/100mL, which is the median fecal coliform concentration from the NSQD (Pitt et al. 2005).

A direct drainage load was added at 11 nodes along the St. Joseph River and one node along the Elkhart River to allow the model to simulate seasonal dry weather in-stream variation not fully captured by the other source inputs. Specifically, the direct drainage load is increased during the summer (identified as June 15-October 15), and may reflect the presence of waterfowl. The direct drainage loads comprise approximately 4% of the total *E. coli* load during the calibration period and have little effect on simulated concentrations during wet weather.

Figure 3 summarizes the simulated percent contributions of each source type to the total *E. coli* load during the calibration period from July 14, 2002 to May 10, 2003 to the St. Joseph River (including loads from the Elkhart River). Figure 3 also shows the loading distribution solely to the Elkhart River. In the St. Joseph River, CSOs are the predominant source of *E. coli* whereas in the Elkhart River, nonpoint source loads from tributaries are the predominant source. Table 3 presents a more detailed volume and load enumeration for each of the specific sources for the same period.

**Figure 3. Summary *E. coli* load contributions by source type**

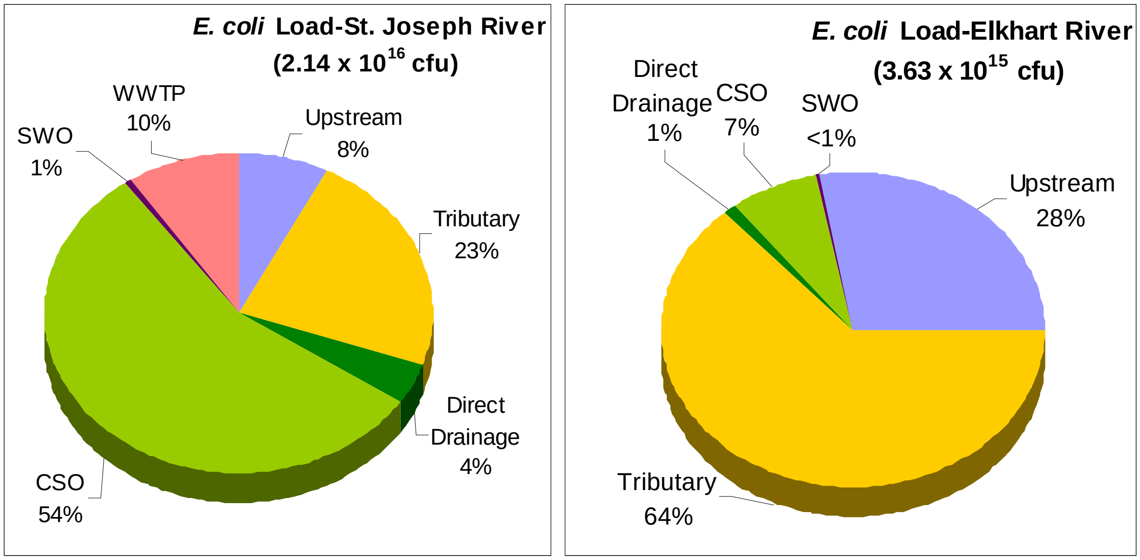



**Table 3. Specific flow and *E. coli* load contribution for each source during the calibration period (7/14/02-5/10/03)**

| Source | Category | Receiving Water | Volume (MG) | *E. coli* Load (cfu) | Percent of Total Load |
|---|---|---|---|---|---|
| St. Joseph River-Upstream | Upstream | St. Joseph | 274,909 | 6.07E+14 | 2.8% |
| Elkhart River-Upstream | Upstream | Elkhart | 47,816 | 1.01E+15 | 4.7% |
| Yellow Creek | Tributary | Elkhart | 2,079 | 1.29E+15 | 6.0% |
| Christiana Creek | Tributary | St. Joseph | 6,246 | 7.53E+14 | 3.5% |
| Baugo Creek | Tributary | St. Joseph | 4,833 | 5.87E+14 | 2.7% |
| Eller Ditch | Tributary | St. Joseph | 252 | 4.16E+13 | 0.2% |
| Willow Creek | Tributary | St. Joseph | 527 | 1.77E+13 | 0.1% |
| Bowman Creek | Tributary | St. Joseph | 979 | 1.69E+14 | 0.8% |
| Juday Creek | Tributary | St. Joseph | 2,043 | 1.62E+14 | 0.8% |
| Cobus Creek | Tributary | St. Joseph | 2,113 | 2.26E+14 | 1.1% |
| Pine Creek | Tributary | St. Joseph | 1,709 | 4.50E+14 | 2.1% |
| Peterbaugh Creek | Tributary | St. Joseph | 798 | 6.12E+13 | 0.3% |
| Osolo Ditch | Tributary | St. Joseph | 711 | 6.96E+13 | 0.3% |
| Rock Run Creek | Tributary | Elkhart | 2,484 | 1.02E+15 | 4.7% |
| Penn Tributary | Tributary | St. Joseph | 444 | 5.84E+13 | 0.3% |
| Direct Drainage-St. Joseph River | Direct Drainage | St. Joseph | 24 | 8.38E+14 | 3.9% |
| Direct Drainage-Elkhart River | Direct Drainage | Elkhart | 2 | 3.98E+13 | 0.2% |
| Elkhart CSOs | CSO | St. Joseph and Elkhart | 56 | 1.60E+15 | 7.5% |
| Elkhart SWOs | SWO | St. Joseph and Elkhart | 215 | 2.76E+13 | 0.1% |
| Elkhart WWTP | WWTP | St. Joseph | 3,864 | 3.36E+14 | 1.6% |
| Mishawaka CSOs | CSO | St. Joseph | 34 | 9.74E+14 | 4.5% |
| Mishawaka SWOs | SWO | St. Joseph | 233 | 4.42E+13 | 0.2% |
| Mishawaka WWTP | WWTP | St. Joseph | 2,957 | 3.12E+14 | 1.5% |

| Source | Category | Receiving Water | Volume (MG) | *E. coli* Load (cfu) | Percent of Total Load |
|---|---|---|---|---|---|
| South Bend CSOs | CSO | St. Joseph | 327 | 9.29E+15 | 43.4% |
| South Bend SWOs | SWO | St. Joseph | 226 | 4.28E+13 | 0.2% |
| South Bend WWTP | WWTP | St. Joseph | 9,311 | 1.40E+15 | 6.5% |

*In-stream Loss Rate*

The bacterial loss rate is a first-order rate that accounts for losses of *E. coli* in the water column due to die-off and net settling. A loss rate of 1.0/day, with an Arrhenius temperature correction coefficient of 1.02, was selected to reproduce the data. This loss rate is within the range of values reported in the literature (USEPA, 1985). A weekly temperature time series was developed from the historical data and applied throughout the model domain to adjust the loss rate. The model's sensitivity to the loss rate was evaluated and is discussed later in this memorandum.

## River Model to Data Comparisons

This section describes the results of the updated calibration of the BLTM river model. It begins with a description of the data from the monitoring period and then presents a comparison of model predictions to observed data using a number of different formats, including:

- Cumulative frequency distribution plots;
- Model error analysis;
- Box and whisker plots; and
- Spatial profiles.

In addition, sensitivity analyses were conducted to determine the sensitivity of predicted concentration to changes in the bacteria loss rate and assumed CSO concentrations.

As described in detail below, the dataset used to calibrate the model spans a ten-month monitoring period, which provides an extended period and eight storm events for evaluating the model's performance. The calibration dataset permits the traditional modeling components of model calibration and validation to be encompassed in this single, extended model to data comparison.

*Calibration Period and Available Data*

For the purpose of this modeling effort, the cities collected samples along 30 miles of the St. Joseph River, approximately seven miles along the main stem of the Elkhart River, and at the mouths of tributaries. The data collection effort included 27 monitoring events and a total of 503 samples collected at 26 stations from July 2002 to May 2003. There were two stations on the Elkhart River, 13 stations along the St. Joseph River, seven tributary stations, and three stations at the cities' wastewater treatment plant (WWTP) outfalls. Eight of the 27 monitoring events reflect wet weather conditions in the river while the remaining 19 events reflect in-stream dry weather conditions. Storm events captured in the wet weather monitoring ranged from 0.1 inches to 1.59 inches. Total rainfall during the monitoring program was approximately 19 inches, which is less than the historical average (30.45 inches) over this period. Staff from Elkhart sampled the upper portion of the modeled area on the St. Joseph River, the Elkhart River, and the mouths of the tributaries. Staff from Mishawaka and South Bend sampled the remainder of the modeled area along the lower St. Joseph River. Sampling frequency was roughly once a week. Samples were analyzed at each of the cities' WWTP laboratories.

The *E. coli* monitoring data from the cities were utilized in the following ways:

- The WWTP outfall data were used to create point source loads as a model forcing;

- Monitoring data from the Six Span Bridge were used as an upstream boundary condition;
- The tributary data were used to calibrate the HSPF watershed model, which was then linked as an input to the BLTM river model; and
- The in-stream data from the stations on the St. Joseph and Elkhart Rivers were used to calibrate the BLTM model.

Table 4 provides the location of each of the sampling stations used to calibrate the BLTM model and the number of samples collected at those locations during the calibration period.

**Table 4. Sampling locations along the Elkhart and St. Joseph Rivers**

| Station ID | Location | River Mile | No of Samples |
|---|---|---|---|
| **Elkhart River** | | | |
| EK-1 | Elkhart River at County Rd. 18 Bridge, upstream of Elkhart | 7.0 | 27 |
| EK-2 | Elkhart River at Jackson St. Bridge, upstream of confluence with the St. Joseph River (Elkhart) | 0.25 | 27 |
| **St. Joseph River** | | | |
| SJ-1 | St. Joseph River at Six Span Bridge, upstream of Elkhart | 81.52 | 26 |
| SJ-2 | St. Joseph River at Johnson St. Bridge (Elkhart) | 77.02 | 27 |
| SJ-3 | St. Joseph River at North Main St. Bridge (Elkhart) | 76.50 | 27 |
| SJ-4 | St. Joseph River at Lexington St. Bridge (Elkhart) | 75.71 | 1 |
| SJ-5 | St. Joseph River at Arcade St. Bridge | 74.62 | 5 |
| SJ-6 | St. Joseph River at Nappanee St. Bridge (Elkhart) | 73.70 | 16 |
| SJ-7 | St. Joseph River at Ash Road Bridge | 68.75 | 25 |
| SJ-8 | St. Joseph River at Bittersweet Bridge (Mishawaka) | 66.37 | 17 |
| SJ-9 | St. Joseph River at Main St. Bridge (Mishawaka) | 61.64 | 27 |
| SJ-10 | St. Joseph River at Ironwood St. Bridge (South Bend) | 59.73 | 27 |
| SJ-11 | St. Joseph River at Colfax Ave. Bridge (South Bend) | 57.36 | 27 |
| SJ-12 | St. Joseph River at Angela St. Bridge (South Bend) | 56.48 | 25 |
| SJ-13 | St. Joseph River at Auten | 51.17 | 27 |

*Cumulative Frequency Distribution Plots*

Figure 4 is the cumulative frequency distribution plot of the observed data at all sampling locations and the corresponding model outputs at noon on the day the samples were collected. Cumulative frequency distribution plots show the percent of values within the dataset that are less than each observed or simulated concentration. They are useful for comparing the range of observed and simulated concentrations and the relative frequencies at which the concentrations occur. These plots are particularly appropriate for evaluating a calibration effort, such as this one, in which an extensive dataset of measured concentrations is available for model comparison.

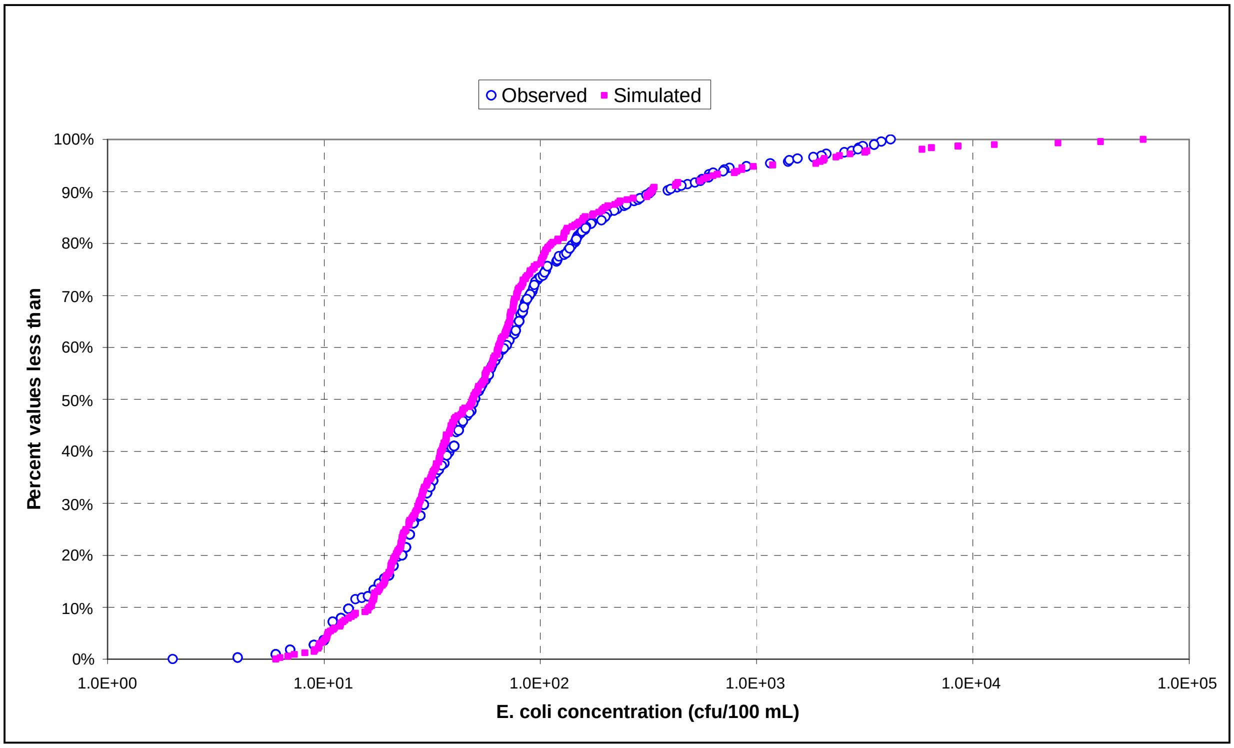



**Figure 4. Cumulative frequency distribution of observed and simulated concentrations on the day of sample collection.**

The cumulative frequency distribution plots of the model and the data match extremely well, indicating that the model is successfully reproducing the range of observed concentrations at the appropriate frequency. Cumulative frequency distribution plots at each location where a minimum of 20 samples were analyzed are included in Appendix A. These plots show the model is successfully reproducing the range of observed data at each location.

*Model Error Analysis*

Tables 5 and 6 provide a simple statistical summary of the model to data comparisons for the calibration period. Table 5 includes model to data comparisons for all sampling events, while Table 6 is limited to wet-weather events, when the Cities' CSO and storm water sources are active. Because bacteria concentrations are not normally distributed, values were transformed to a natural log scale for the statistical analysis. For both tables, the simulated concentrations at noon on the day of sample collection were used for the model values.

Locations SJ-4 and SJ-5 are not included in the table because they were infrequently sampled. Measured *E. coli* data were specified in the model input time series for days corresponding to sampling events at river mile 81.63, the upstream boundary. The upstream boundary was included in the tables for completeness since it is one of the City's routinely monitored locations, however the lines of Table 5 and 6 comparing data to model performance for all locations on the St. Joseph River do not include this location.

The statistical comparisons using all of the data are good at all locations. The mean of the relative errors of the model to data comparisons at all locations are within the range of ±10%. This indicates that the model is reproducing the central tendency of the observed data. The absolute relative error at all locations except SJ-8 is under 20%. This indicates that the model is neither dramatically overestimating nor underestimating the observed data. At the single location where the absolute relative error is above 20%, relatively fewer data are available to compare the model with observed data. This may account for some of the discrepancy at that location.

**Table 5. Statistical comparison of ln-transformed observed and simulated concentrations**

| Location | Count | Data Mean | Model Mean | Data/Model Ratio of Means | Mean Relative Error[1] | Mean Absolute Relative Error[2] |
|---|---|---|---|---|---|---|
| SJ-1 | 26 | 3.41 | 3.41 | 1.00 | 0.0% | 0.0% |
| SJ-2 | 27 | 3.19 | 3.14 | 1.02 | 0.2% | 17.2% |
| SJ-3 | 27 | 3.78 | 3.98 | 0.95 | 7.5% | 17.3% |
| SJ-6 | 16 | 4.05 | 3.99 | 1.01 | 1.9% | 14.2% |
| SJ-7 | 25 | 3.61 | 3.65 | 0.99 | 4.7% | 18.1% |
| SJ-8 | 17 | 3.88 | 3.46 | 1.12 | -6.6% | 33.1% |
| SJ-9 | 27 | 3.74 | 3.45 | 1.08 | -4.0% | 17.7% |
| SJ-10 | 27 | 4.06 | 3.91 | 1.04 | -3.2% | 11.8% |
| SJ-11 | 27 | 4.33 | 4.50 | 0.96 | 5.9% | 14.1% |
| SJ-12 | 25 | 4.46 | 4.24 | 1.05 | -3.5% | 11.5% |
| SJ-13 | 27 | 5.33 | 5.33 | 1.00 | 1.0% | 9.1% |
| All St. Joseph R. Locations | 245 | 4.05 | 3.99 | 1.02 | 0.6% | 15.9% |
| EK-1 | 27 | 4.70 | 5.08 | 0.93 | 9.0% | 9.6% |
| EK-2 | 27 | 4.87 | 5.03 | 0.97 | 4.0% | 15.9% |
| All Elkhart R. Locations | 54 | 4.78 | 5.05 | 0.95 | 6.5% | 12.7% |

[1]Mean relative error = [Σ ((model-data)/data)]/n
[2]Mean absolute relative error = [Σ(|model-data|/data)]/n

The statistical comparisons using only wet-weather observations are also good. Despite the fact that fewer data are available at each location, the mean relative errors are within ±15% and mean absolute relative errors are less than 25% at all locations except SJ-8. Only five wet-weather samples are available for SJ-8.

**Table 6. Statistical comparison of natural log (ln)-transformed observed and simulated concentrations for wet-weather events**

| Location | Count | Data Mean | Model Mean | Data/Model Ratio of Means | Mean Relative Error | Mean Absolute Relative Error |
|---|---|---|---|---|---|---|
| SJ-1 | 8 | 4.07 | 4.07 | 1.00 | 0.0% | 0.0% |
| SJ-2 | 8 | 3.80 | 3.68 | 1.03 | -3.8% | 19.2% |
| SJ-3 | 8 | 4.78 | 5.14 | 0.93 | 6.9% | 13.6% |
| SJ-6 | 5 | 5.56 | 4.92 | 1.13 | -9.6% | 9.6% |
| SJ-7 | 7 | 4.84 | 5.20 | 0.93 | 8.9% | 23.0% |
| SJ-8 | 5 | 4.32 | 4.70 | 0.92 | 19.5% | 57.1% |
| SJ-9 | 8 | 4.85 | 4.07 | 1.19 | -11.8% | 23.2% |
| SJ-10 | 8 | 5.24 | 4.87 | 1.08 | -7.2% | 11.7% |
| SJ-11 | 8 | 5.79 | 5.73 | 1.01 | 0.2% | 18.5% |
| SJ-12 | 6 | 5.80 | 5.39 | 1.08 | -7.5% | 12.3% |
| SJ-13 | 8 | 6.92 | 6.83 | 1.01 | -2.8% | 9.9% |
| All St. Joseph R. Locations | 71 | 5.20 | 5.06 | 1.03 | -1.1% | 18.8% |
| EK-1 | 8 | 5.98 | 6.27 | 0.95 | 3.7% | 4.7% |
| EK-2 | 8 | 5.81 | 6.57 | 0.88 | 13.4% | 16.0% |
| All Elkhart R. Locations | 16 | 5.90 | 6.42 | 0.92 | 8.6% | 10.4% |

*Box and Whisker Plots*

Model results were compared to observed data via the use of a "box and whisker plot." Box and whisker plots show the variability in model predictions and observations, in which the middle of the box represents the median, the bottom and top of the box represent the 25$^{th}$ and 75$^{th}$ percentiles, and the whiskers represent the 5$^{th}$ and 95$^{th}$ percentiles. For simplicity, the stations are grouped by location, and the results are shown in Figure 5. The various percentile concentrations are similar for the observed and simulated data, indicating that the model is successfully reproducing the range of observed concentrations at the appropriate frequency throughout the model domain.

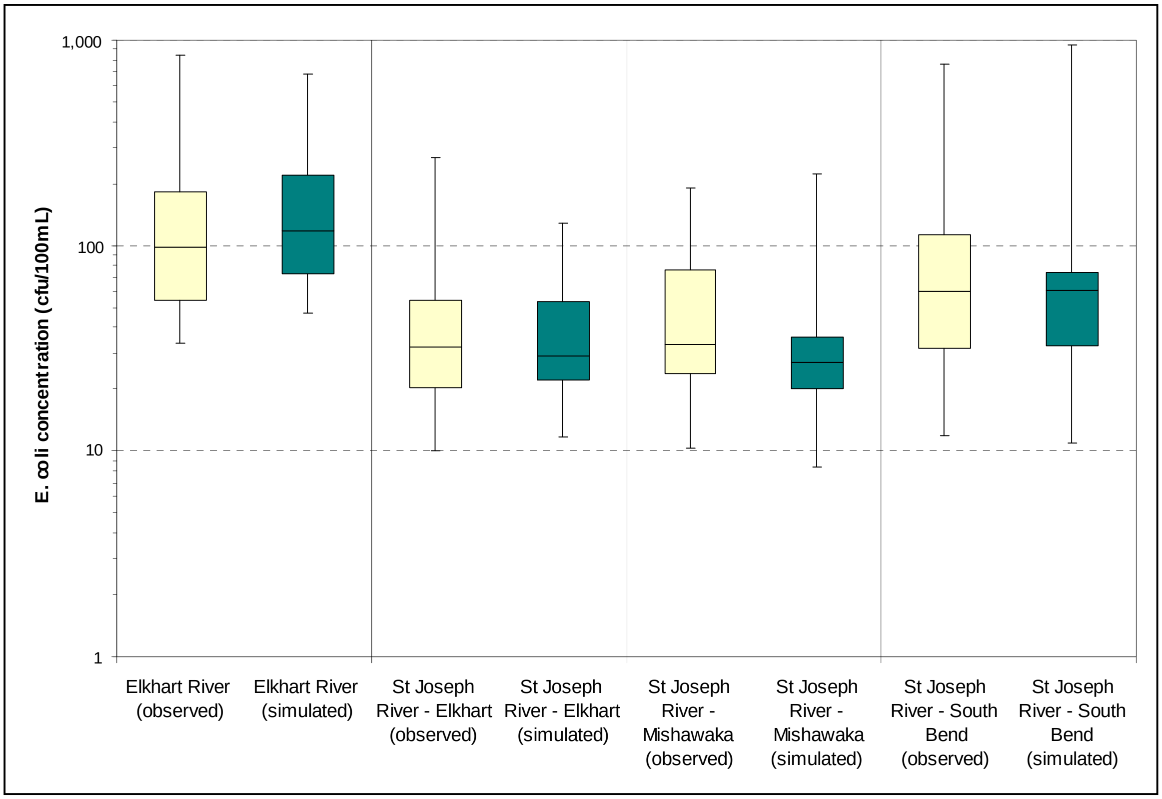



**Figure 5. Box and whisker plot comparing observed and simulated concentrations, grouped by location**

*Spatial Profiles*

The modeling framework includes visualization tools that allow the user to view the model results and observed data when appropriate. These figures are useful for evaluating how well the model reproduces the downstream concentration profile observed in the data, such as the locations of elevated concentrations. The model concentration profile compares well to the observed data profile for most events. Figures 6 and 7 are example snapshots of the model visualization showing observed data and simulated concentrations at noon on the day of select sampling events. The snapshots show the complete model extent for the St. Joseph River. Figure 6 is a sample dry-weather sampling event and Figure 7 is a sample wet-weather sampling event.

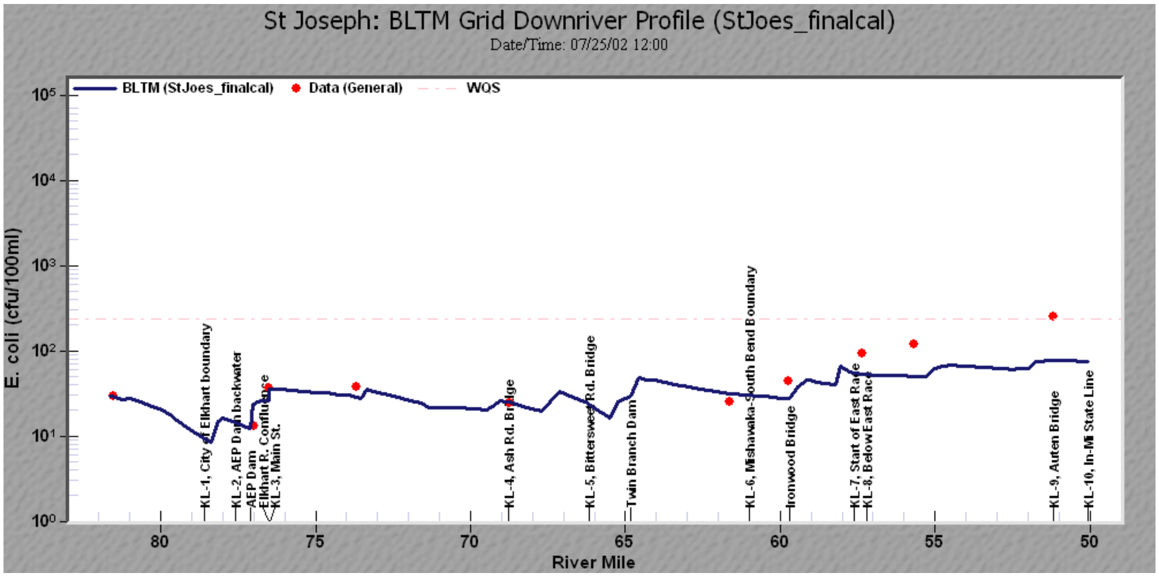


**Figure 6. Sample dry-weather model spatial profile for the St. Joseph River**

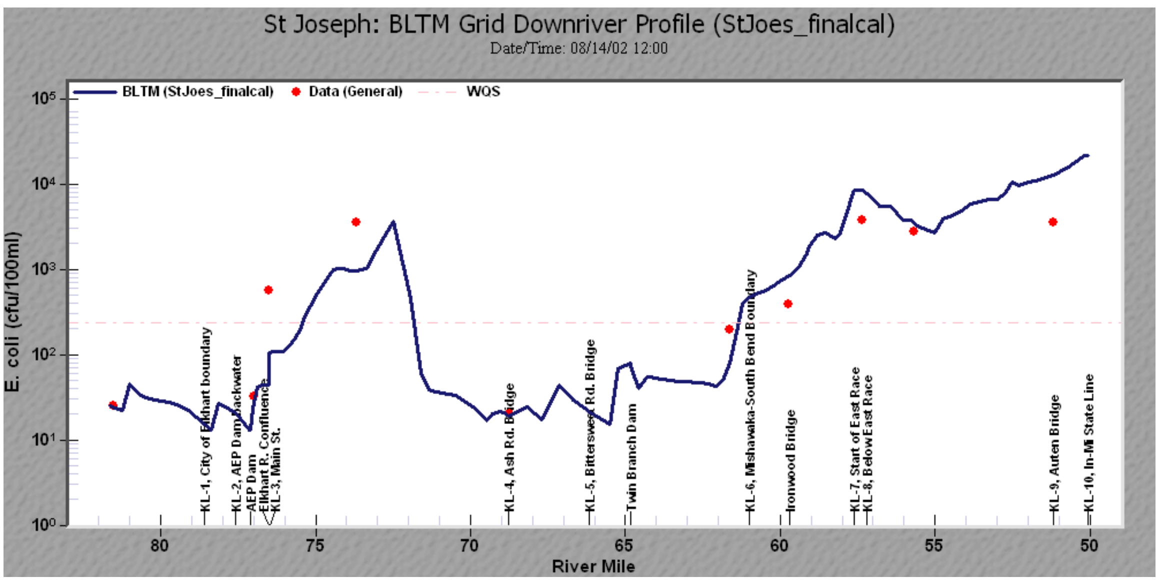


**Figure 7. Sample wet-weather model spatial profile for the St. Joseph River**

Additional snapshots of dry and wet-weather sampling events are included in Appendix B.

*Sensitivity Analyses*

Selection of model inputs can have a significant influence on water quality model concentration predictions. Each of the model inputs has a degree of uncertainty associated with it. The effect on simulated concentrations of the uncertainty associated with the primary kinetic model control, the bacteria loss rate, was tested with additional simulations of the calibration period.

Sensitivity of the model to the values of the *E. coli* loss rate (specified as 1.0 day$^{-1}$) was evaluated by rerunning the simulations using two other decay rates: 0 day$^{-1}$ and 2.0 day$^{-1}$. A comparison of the mean relative error at each sampling location using these loss rates is shown in Table 7. The specified value of 1.0 day$^{-1}$ yields the simulation that best fits the observed data.

**Table 7. Comparison of mean relative errors of simulated and observed concentrations when varying the bacterial loss rate**

| | | Bacterial loss rate ($day^{-1}$) | | |
|---|---|---|---|---|
| **Location** | **Count** | **0.0** | **1.0** | **2.0** |
| SJ-1 | 26 | 0.0% | 0.0% | -1.0% |
| SJ-2 | 27 | 28.9% | 0.2% | -17.7% |
| SJ-3 | 27 | 26.0% | 7.5% | -4.6% |
| SJ-6 | 16 | 24.3% | 1.9% | -13.1% |
| SJ-7 | 25 | 53.3% | 4.7% | -22.1% |
| SJ-8 | 17 | 40.3% | -6.6% | -39.8% |
| SJ-9 | 27 | 52.3% | -4.0% | -27.8% |
| SJ-10 | 27 | 42.7% | -3.2% | -21.5% |
| SJ-11 | 27 | 42.8% | 5.9% | -5.0% |
| SJ-12 | 25 | 35.4% | -3.5% | -16.6% |
| SJ-13 | 27 | 25.7% | 1.0% | -5.7% |
| All St. Joseph R. Locations | 245 | 37.2% | 0.6% | -16.5% |
| EK-1 | 27 | 14.1% | 9.0% | 4.1% |
| EK-2 | 27 | 16.0% | 4.0% | -7.6% |
| All Elkhart R. Locations | 54 | 15.1% | 6.5% | -1.8% |

The range of CSO *E. coli* EMC values in the literature spans several orders of magnitude from $10^5$ to $10^7$ cfu/100 ml (USEPA, 2001). Sensitivity of the model to the choice of the CSO EMC (specified as 750,000-cfu/100mL) was evaluated by rerunning the simulations using two other values: 375,000 and 1,500,000. The results of these model simulations were compared to only wet-weather data since these data reflect loadings from this source. However, because tributary loads are the primary source of Elkhart River wet-weather concentrations (see Figure 3), those stations were not included in this evaluation. Additionally, stations SJ-1 and SJ-2 are upstream of all modeled CSOs and therefore were also excluded from this evaluation. A comparison of the mean relative error at the relevant sampling locations using these CSO EMCs is shown in Table 8. The specified value of 750,000-cfu/100mL yields best overall fit to the data.

**Table 8. Comparison of wet-weather mean relative errors of simulated and observed concentrations when varying the CSO EMC**

| | | CSO EMC (cfu/100mL) | | |
|---|---|---|---|---|
| **Location** | **Count** | **375,000** | **750,000** | **1,500,000** |
| SJ-3 | 8 | 6.9% | 6.9% | 7.0% |
| SJ-6 | 5 | -11.0% | -9.6% | -8.0% |
| SJ-7 | 7 | 3.5% | 8.9% | 15.3% |
| SJ-8 | 5 | 14.6% | 19.5% | 24.7% |
| SJ-9 | 8 | -12.7% | -11.8% | -10.4% |
| SJ-10 | 8 | -9.1% | -7.2% | -4.6% |
| SJ-11 | 8 | -3.2% | 0.2% | 4.0% |
| SJ-12 | 6 | -10.9% | -7.5% | -3.6% |
| SJ-13 | 8 | -6.7% | -2.8% | 1.8% |
| All Locations impacted by CSOs | 64 | -3.5% | -0.8% | 2.3% |

## Conclusions

The information from the water quality modeling effort can be summarized in the following conclusions:

- The St. Joseph River model provides a reasonable reproduction of *E. coli* concentrations in the St. Joseph and Elkhart Rivers for a range of environmental conditions;
- The goodness of fit of the river model calibration provides a secondary check of the accuracy of the methods and models used to specify the source inputs. This calibration suggests that these methods and models are providing reliable estimates of point and nonpoint source bacteria loads;
- The model was successfully calibrated to a range of storm and environmental conditions in terms of reproducing effects of the CSOs and other *E. coli* sources;
- The water quality model will be a useful tool for assessing impacts and for quantifying potential benefits of various control scenarios considered for the LTCP.

The calibration of the river model indicates that it is capable of reproducing the timing and magnitude of most of the observed data. It is the best tool available for evaluating in-stream impacts from watershed sources, including CSOs, under a range of environmental conditions and control scenarios. The model is suitable for evaluating the benefits of different CSO control alternatives and expected compliance with water quality standards.

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# Appendix A.
# Cumulative Frequency Distribution Plots by Individual Sampling Location

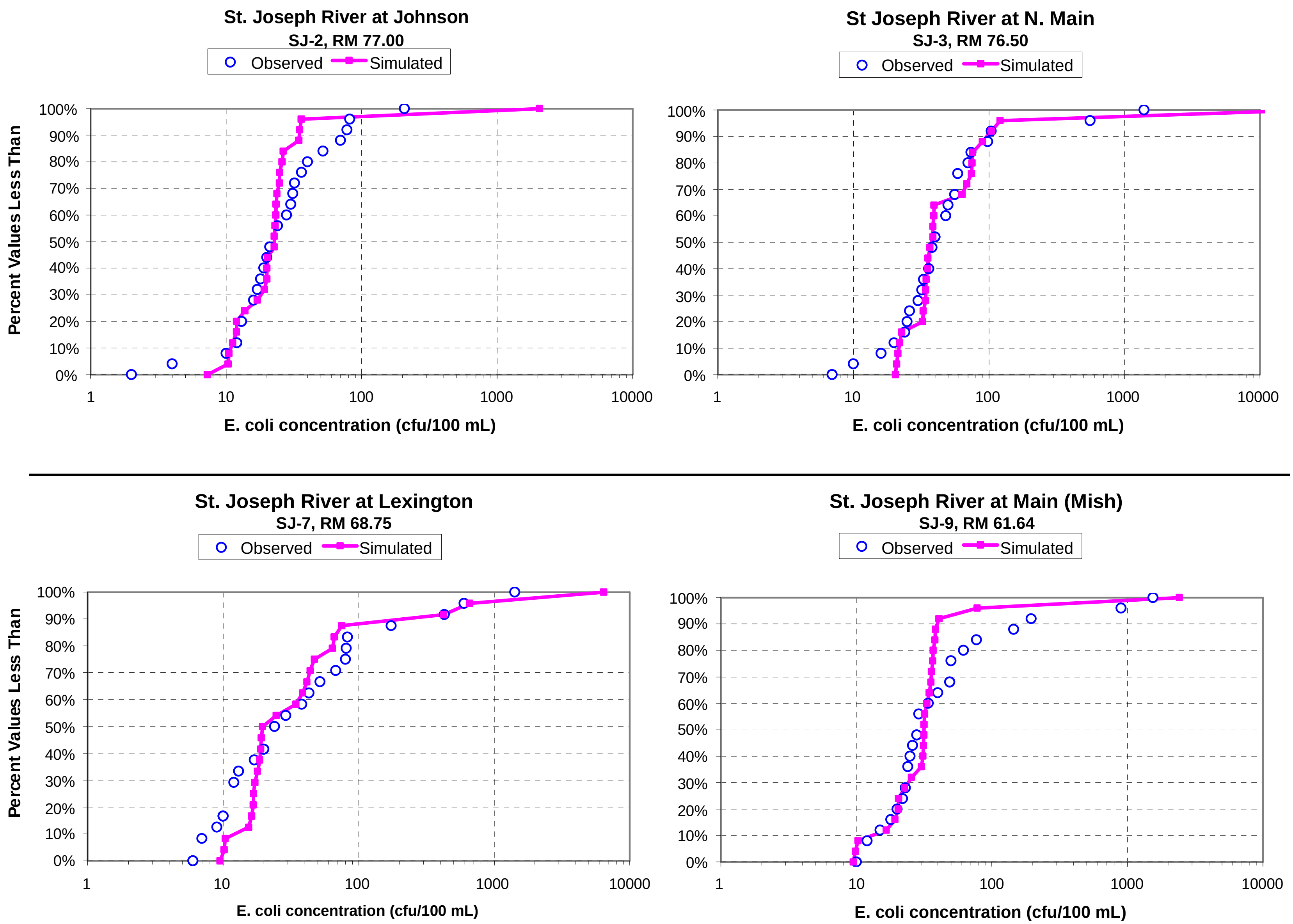



**Figure A.1-Cumulative frequency distribution plots for locations on the St. Joseph River (Elkhart and Mishawaka)**

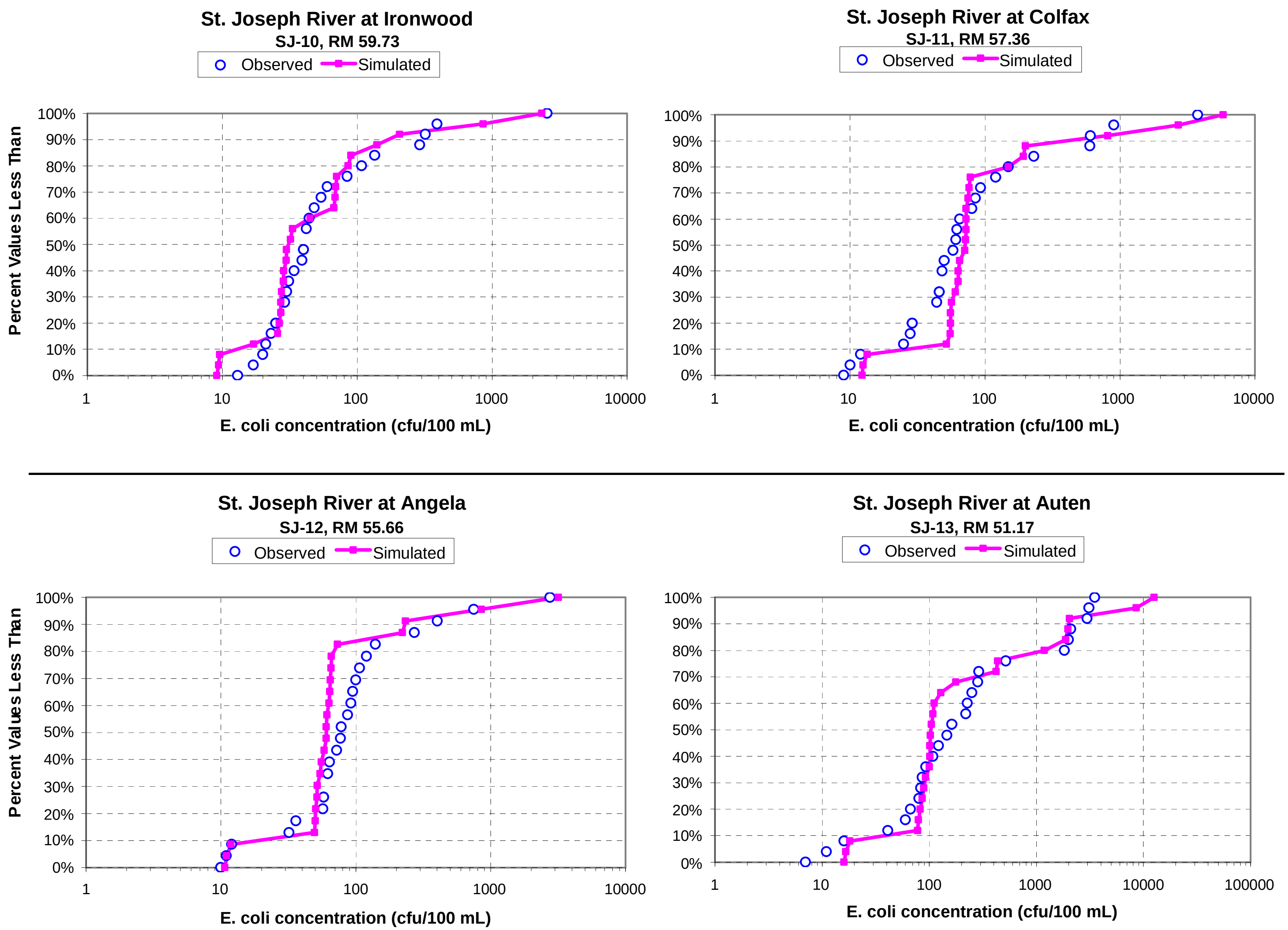
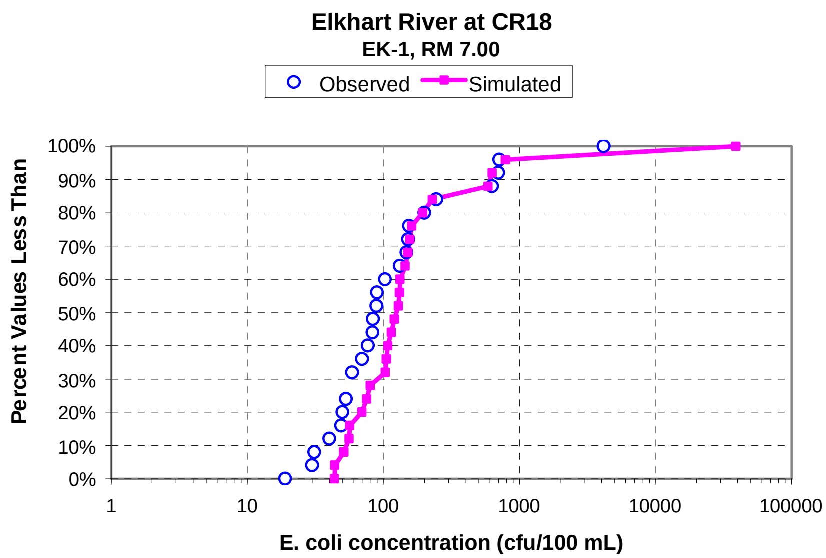



**Figure A.2-Cumulative frequency distribution plots for locations on the St. Joseph River (South Bend).**



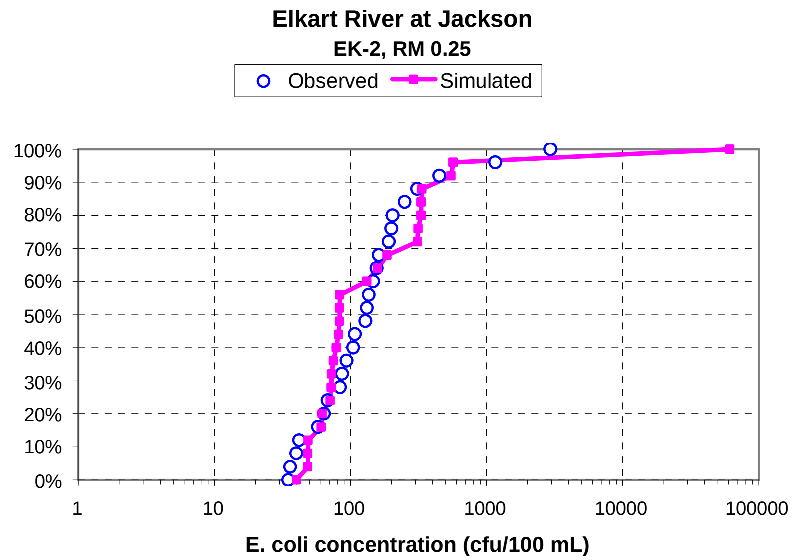




**Figure A.3-Cumulative frequency distribution plots for locations on the Elkhart River**

# Appendix B. Model Visualization Spatial Profiles

**Figure B.1. Summer dry-weather spatial profile for the St. Joseph River on 8/8/02.**

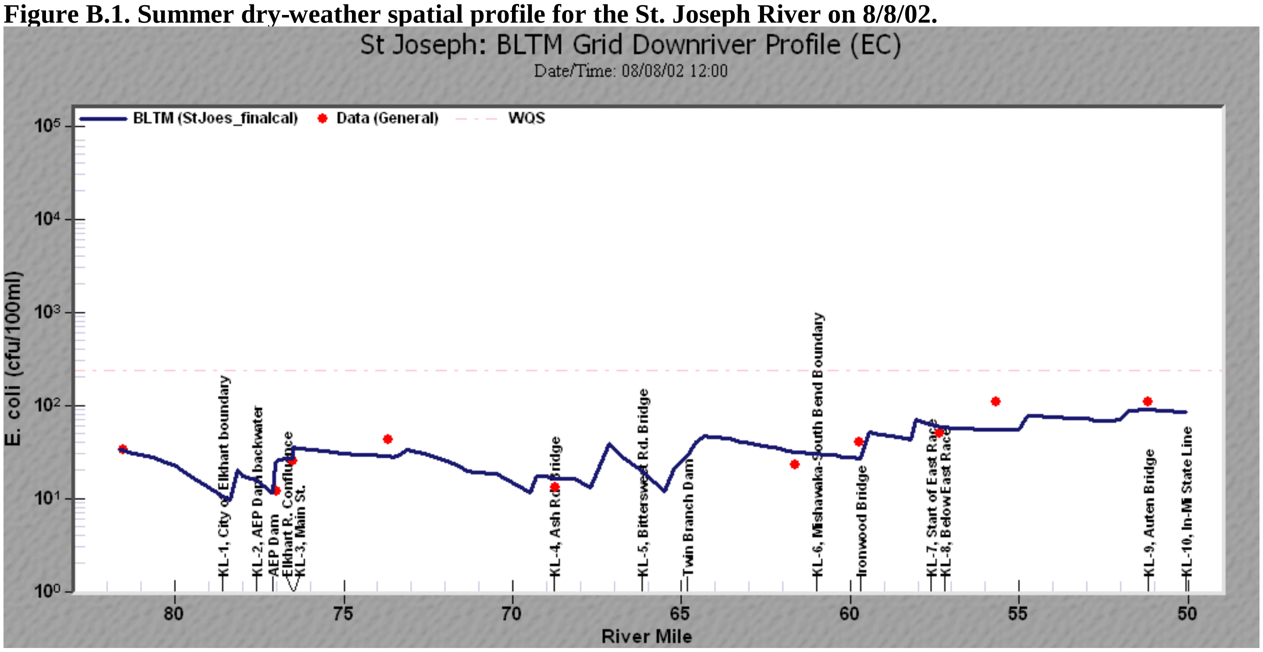



**Figure B.2. Summer dry-weather spatial profile for the Elkhart River on 8/8/02.**

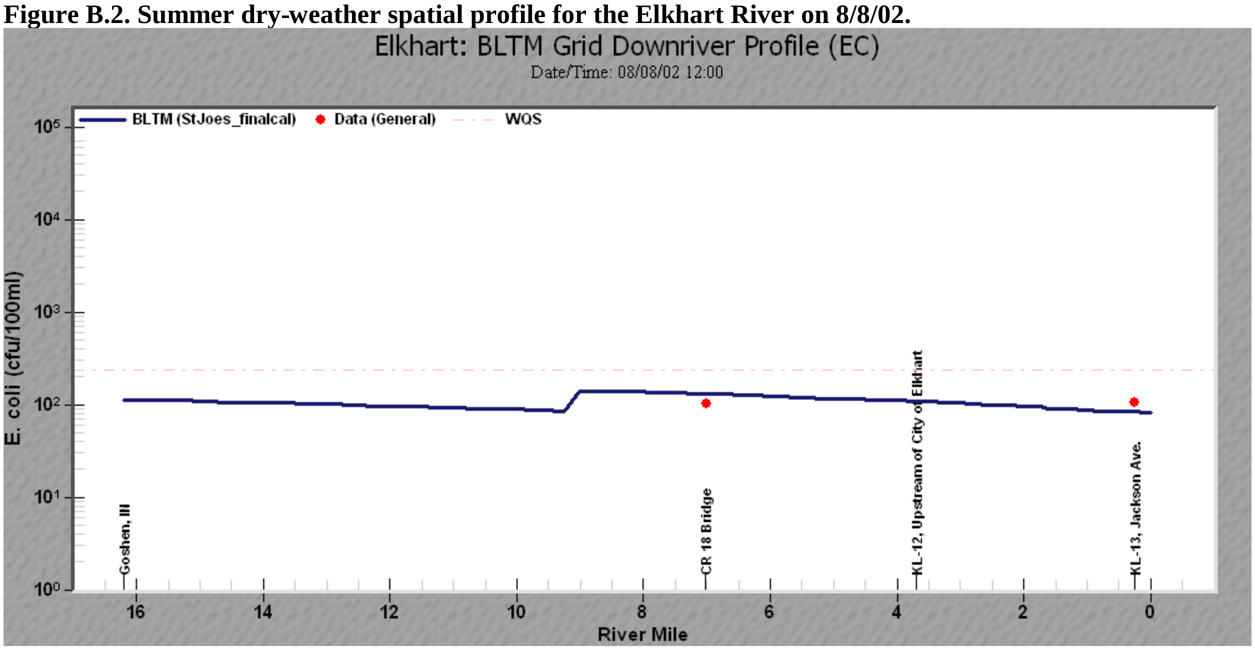


**Figure B.3. Summer dry-weather spatial profile for the St. Joseph River on 8/29/02.**

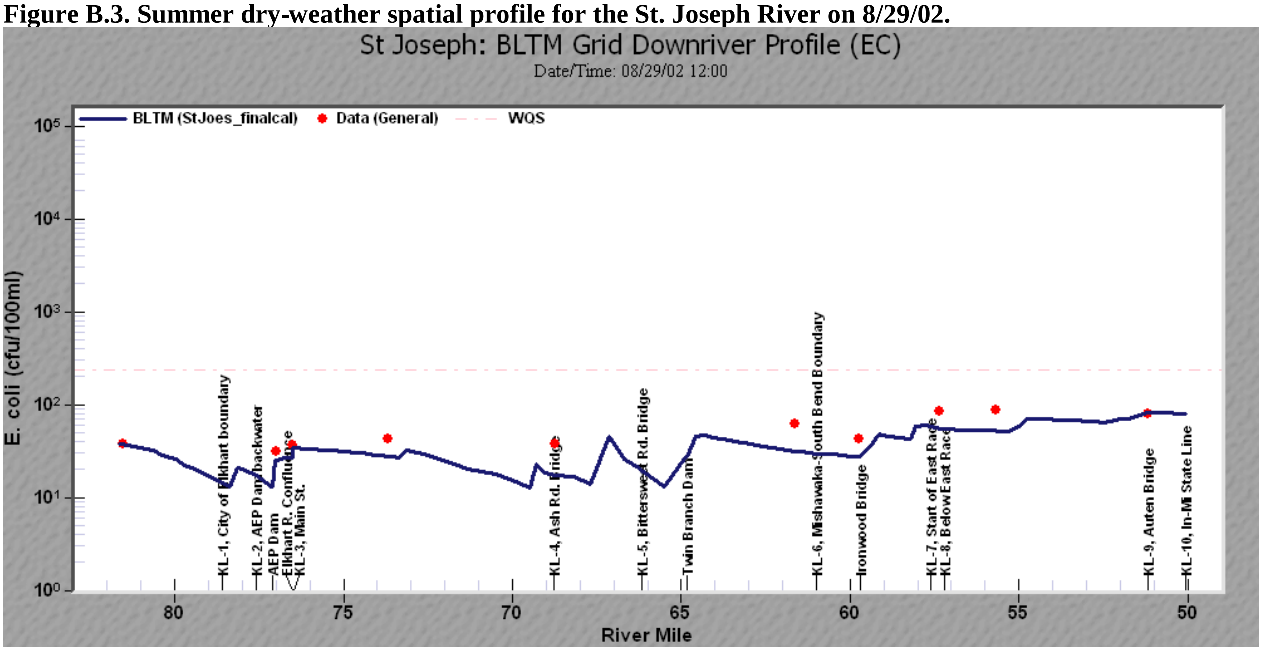



**Figure B.4. Summer dry-weather spatial profile for the Elkhart River on 8/29/02.**

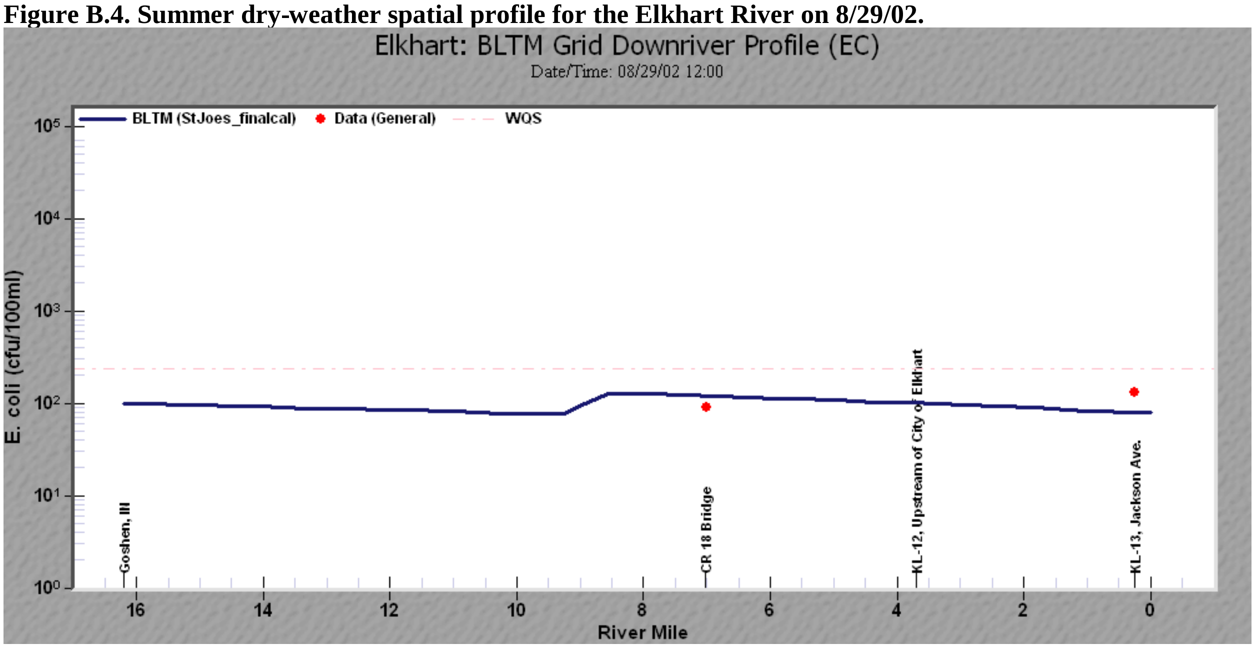


**Figure B.5. Winter dry-weather spatial profile for the St. Joseph River on 12/5/02**

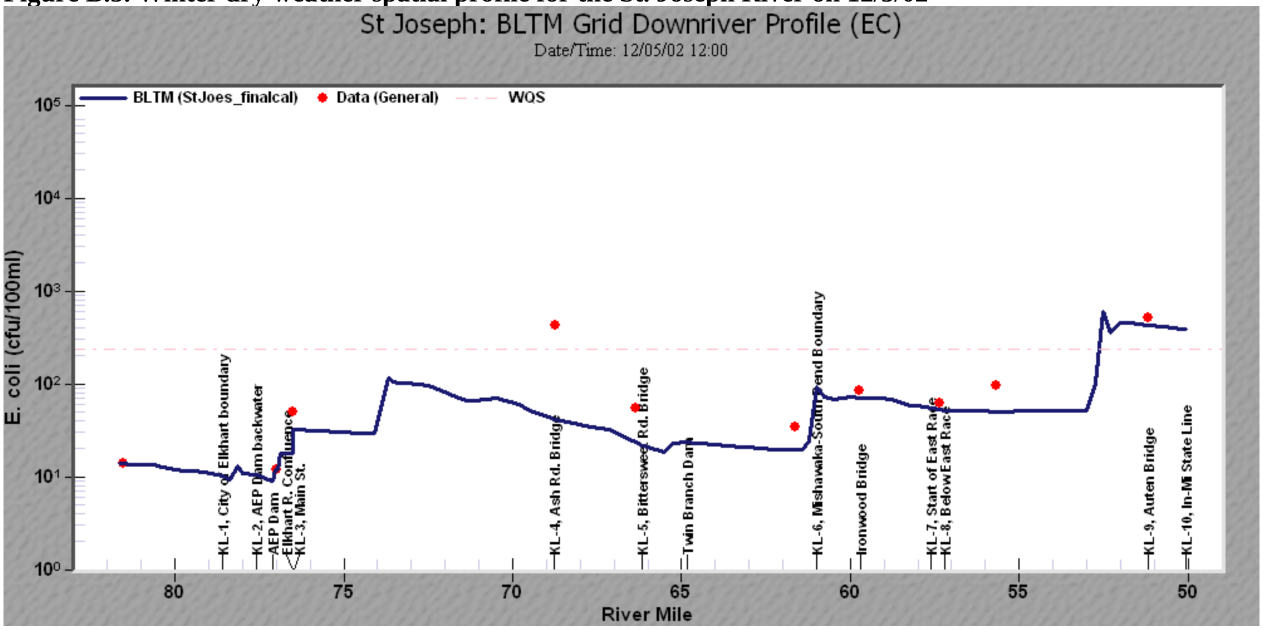



**Figure B.6. Winter dry-weather spatial profile for the Elkhart River on 12/5/02**

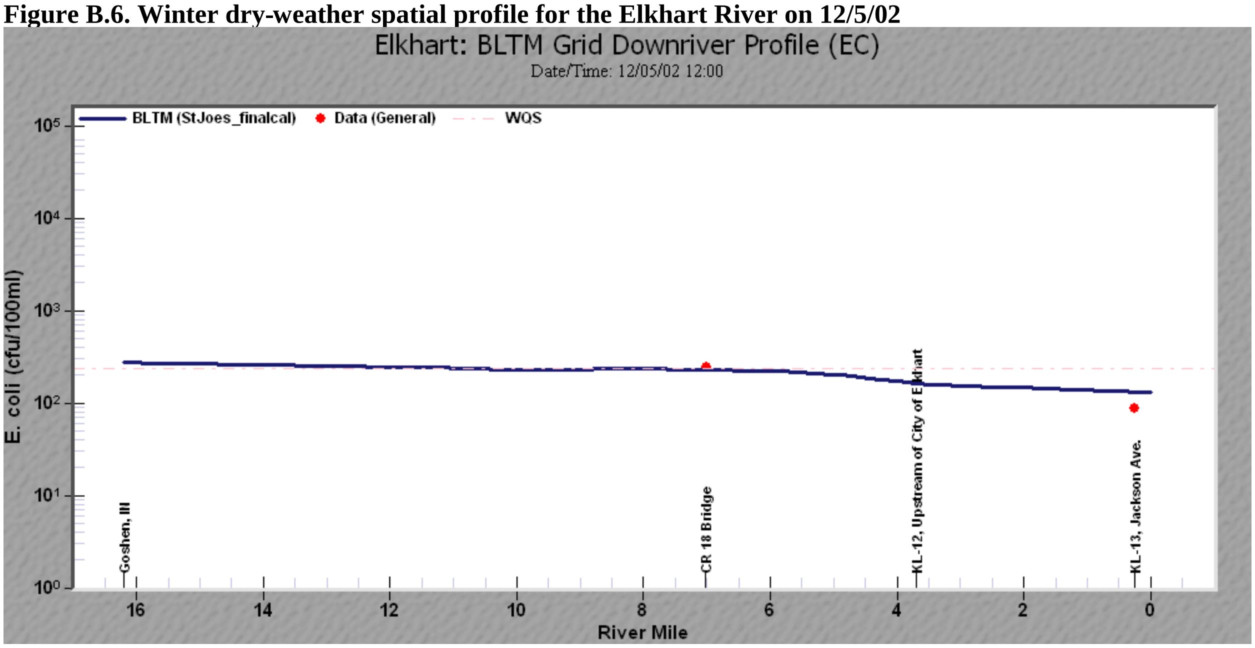


**Figure B.7. Winter dry-weather spatial profile for the St. Joseph River on 1/16/03**

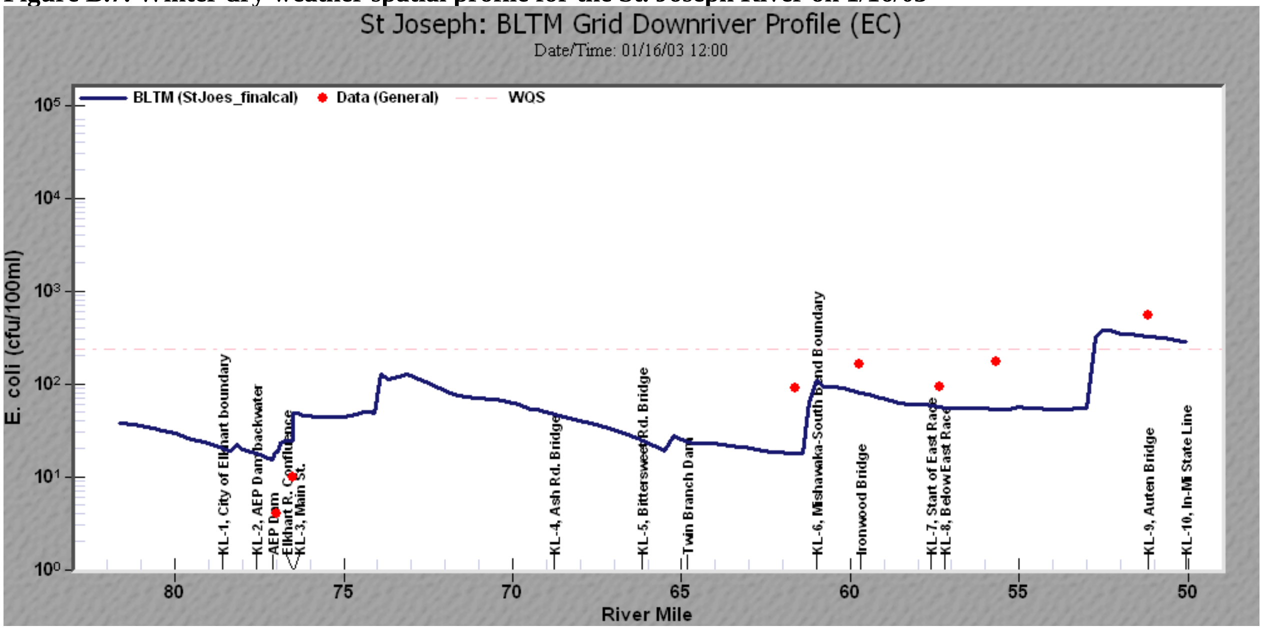



**Figure B.8. Winter dry-weather spatial profile for the Elkhart River on 1/16/03**

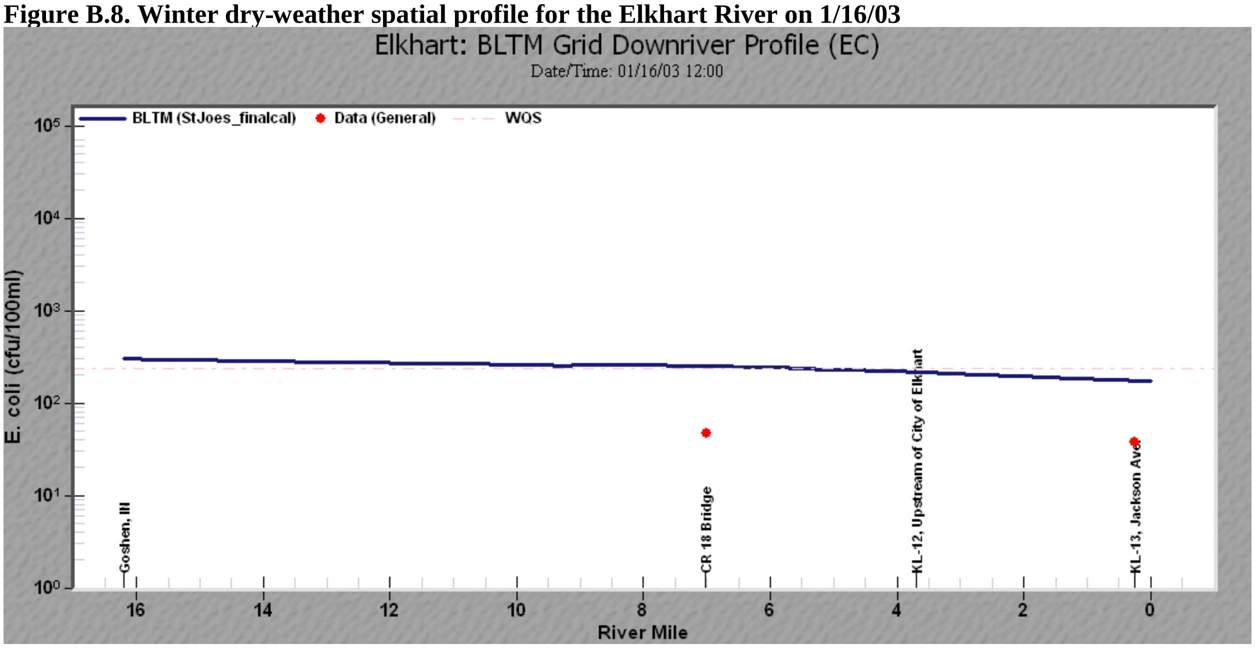


**Figure B.9. Spring dry-weather spatial profile for the St. Joseph River on 3/6/03**

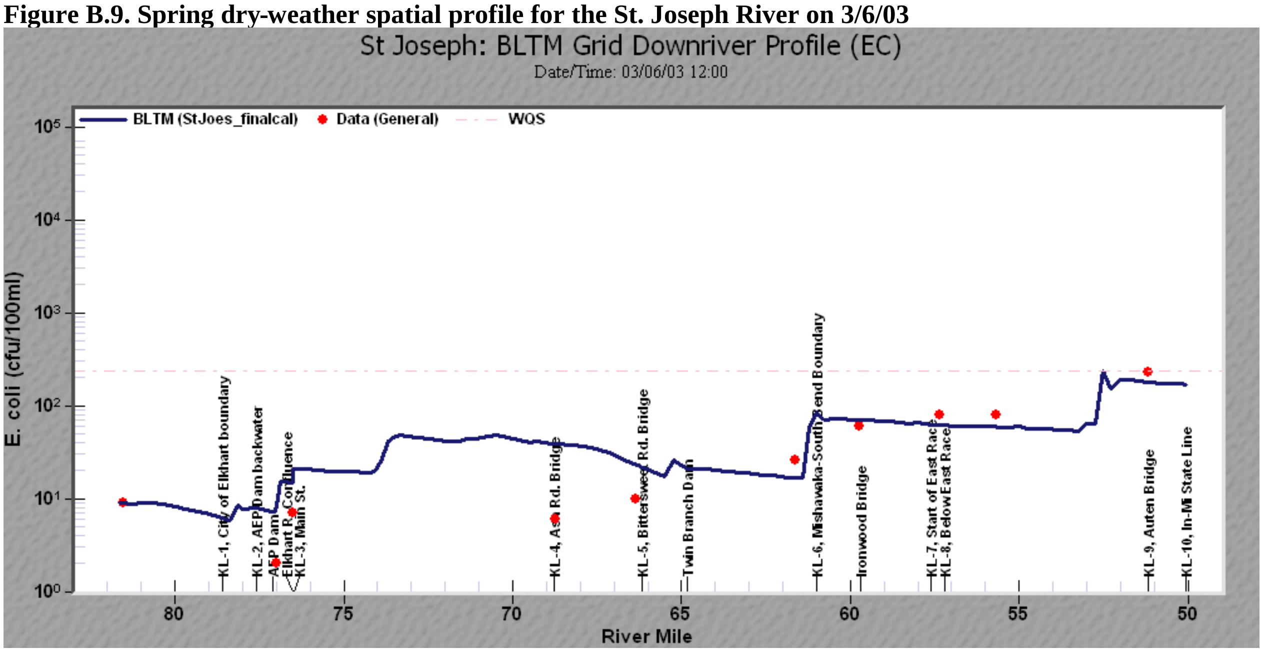



**Figure B.10. Spring dry-weather spatial profile for the Elkhart River on 3/6/03**

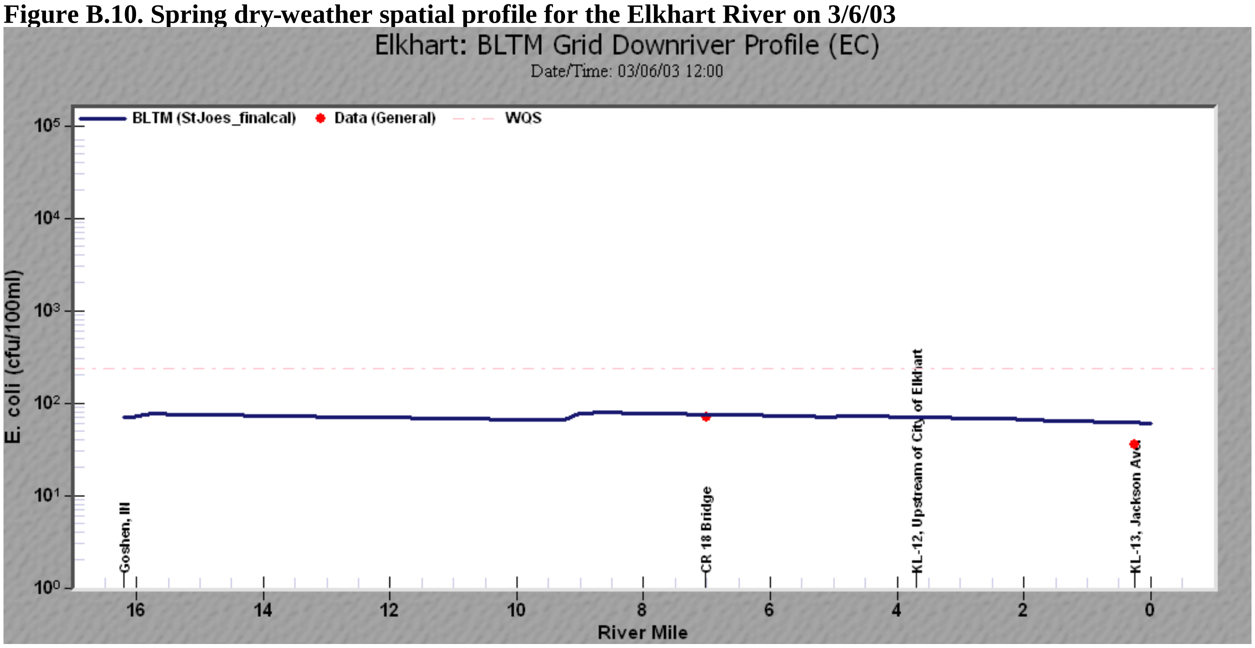


Figure B.11. Spring dry-weather spatial profile for the St. Joseph River 3/20/03

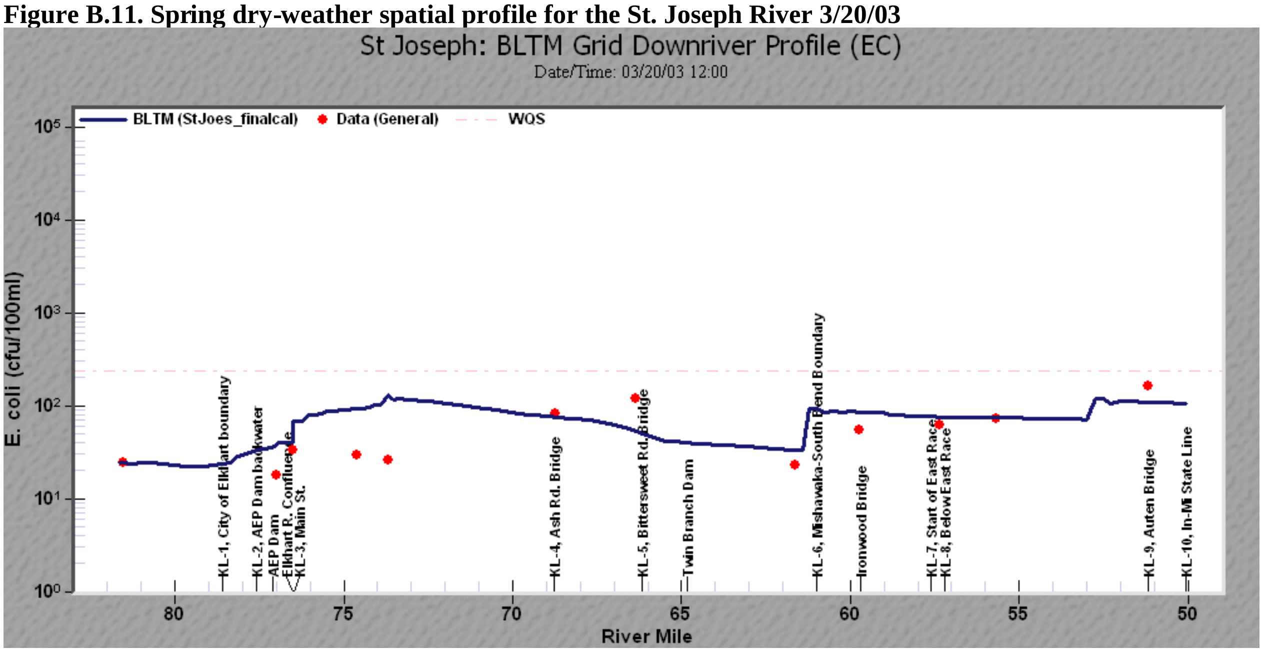



Figure B.12. Spring dry-weather spatial profile for the Elkhart River 3/20/03

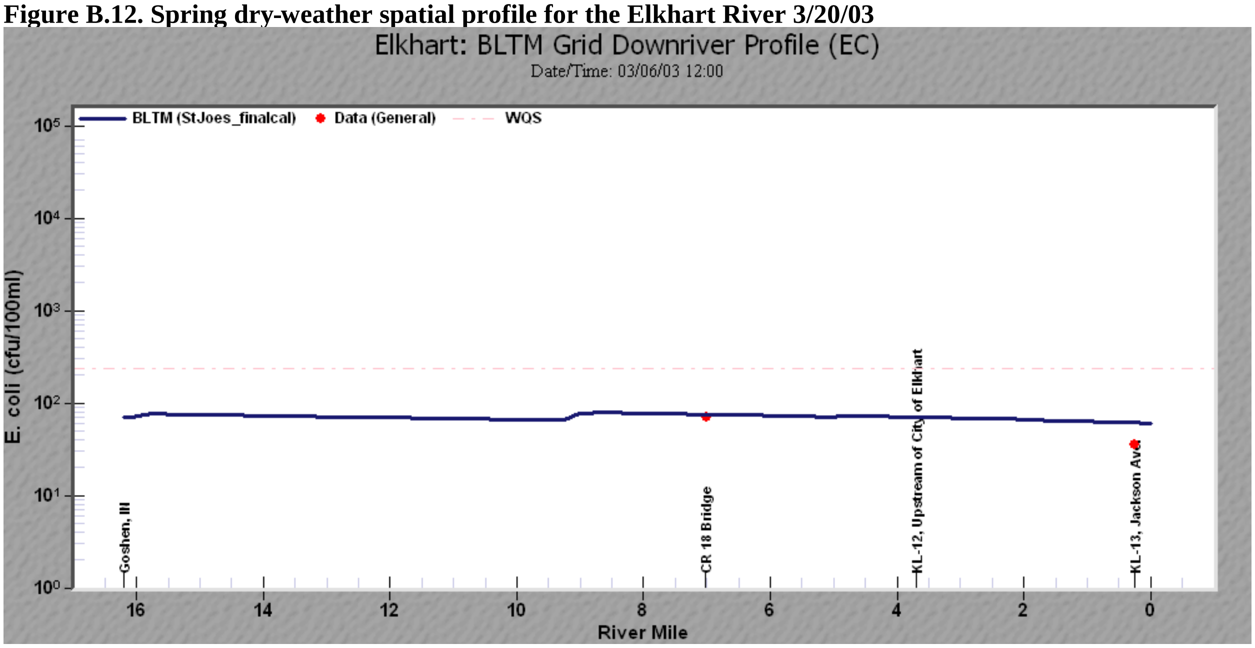


Figure B.13. Wet-weather spatial profile for the St. Joseph River on 12/19/02

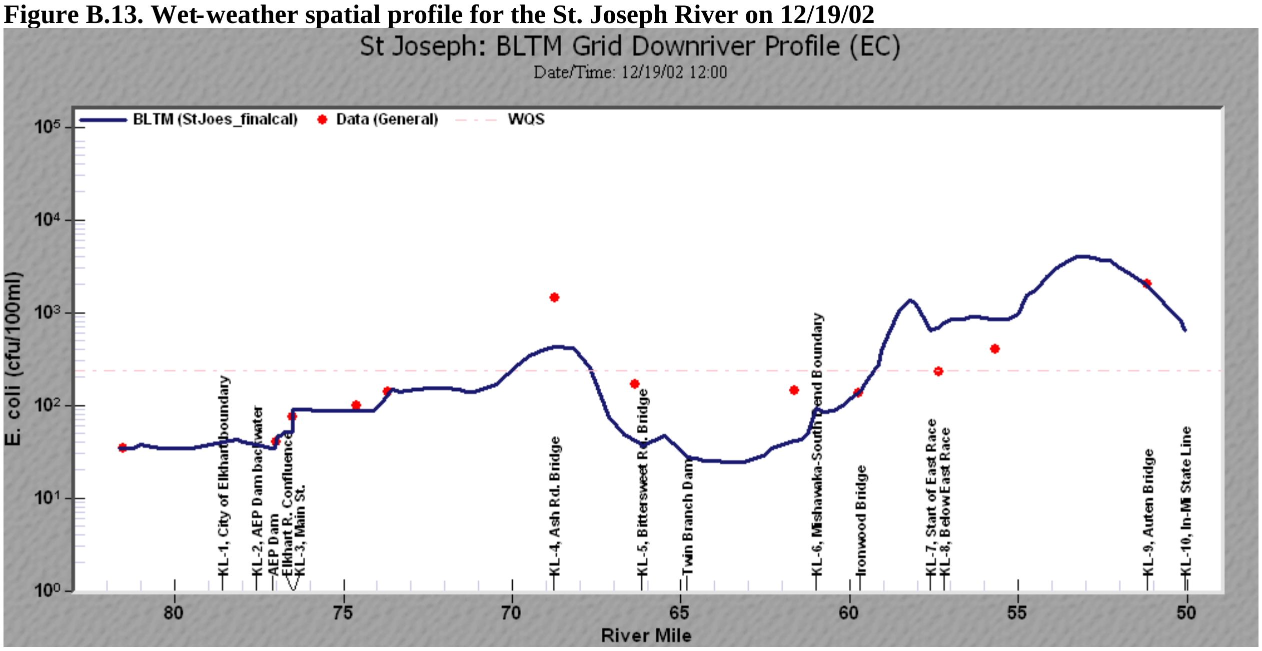



Figure B.14. Wet-weather spatial profile for the Elkhart River on 12/19/02

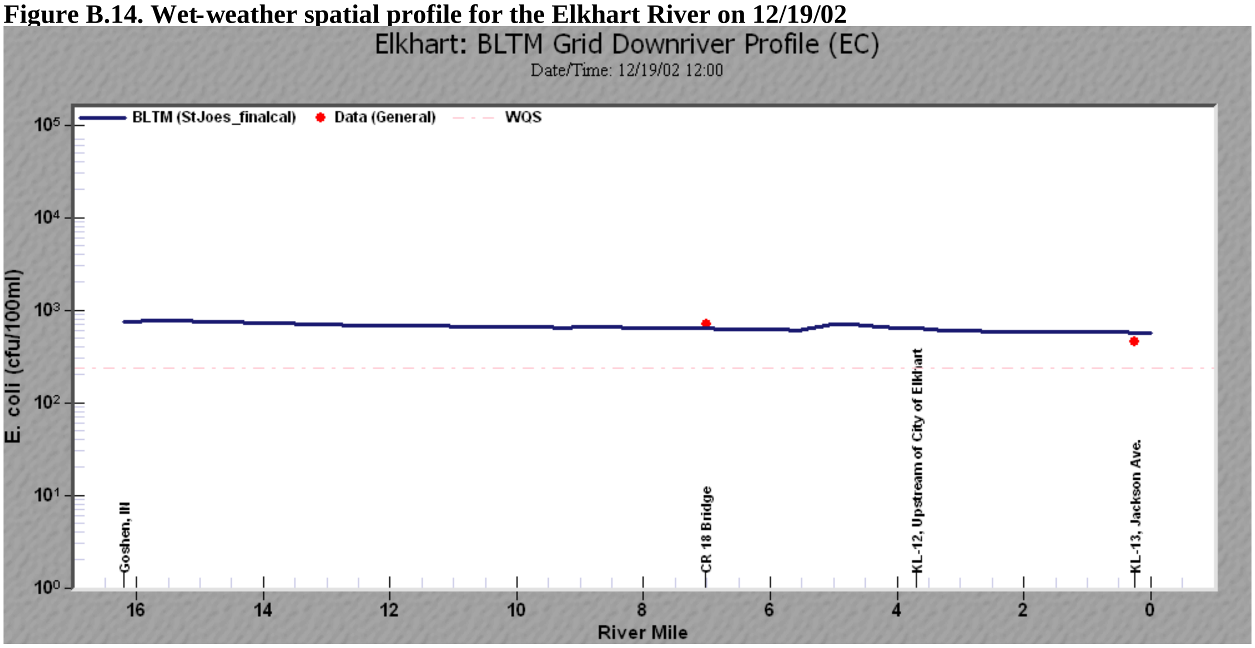


Figure B.15. Wet-weather spatial profile for the St. Joseph River on 3/13/03

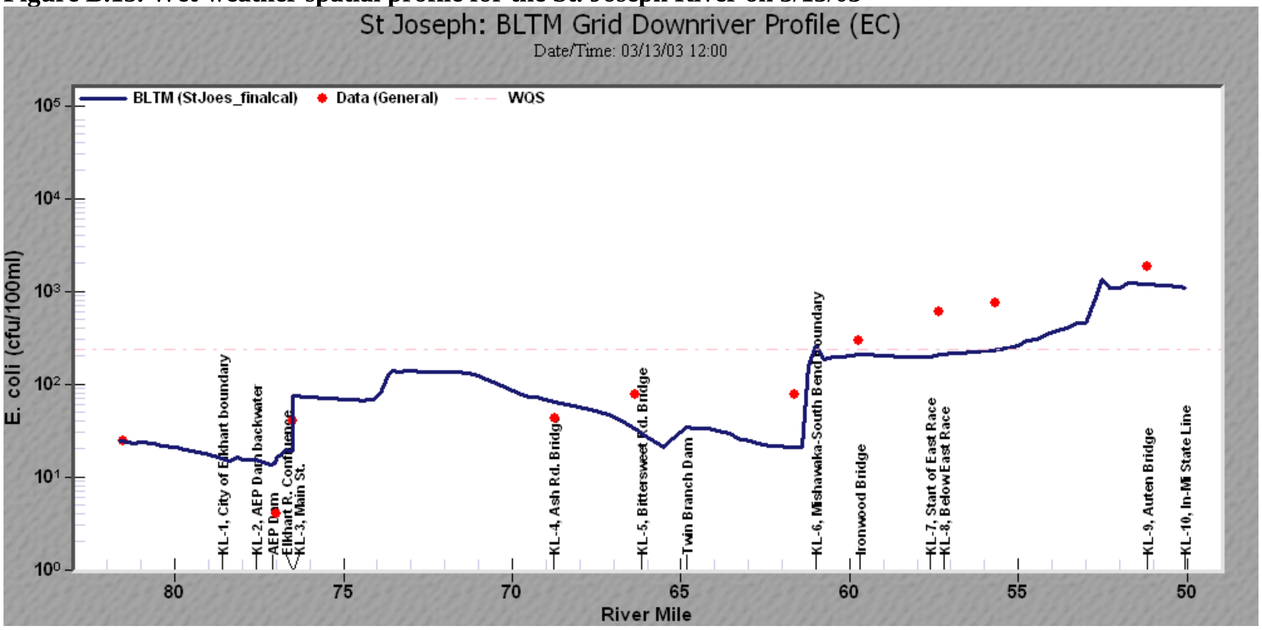



Figure B.16. Wet-weather spatial profile for the Elkhart River on 3/13/03.

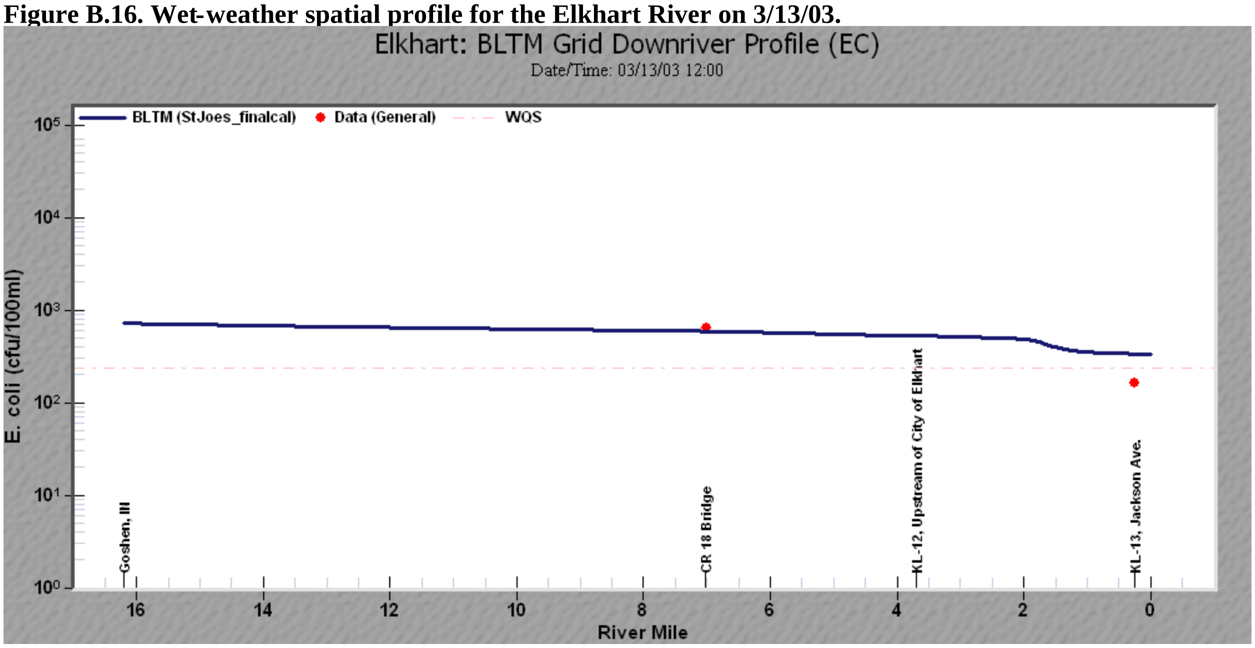


**Figure B.17. Wet-weather spatial profile for the St. Joseph River on 5/1/03**

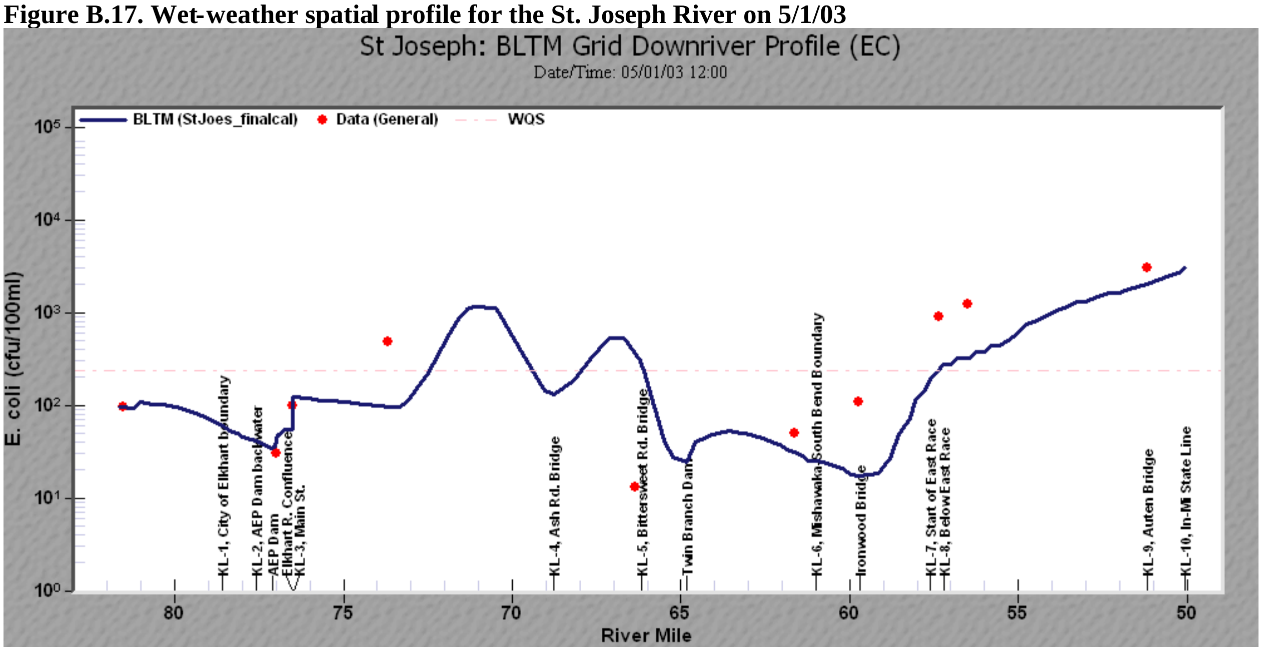



**Figure B.18. Wet-weather spatial profile for the Elkhart River on 5/1/03**

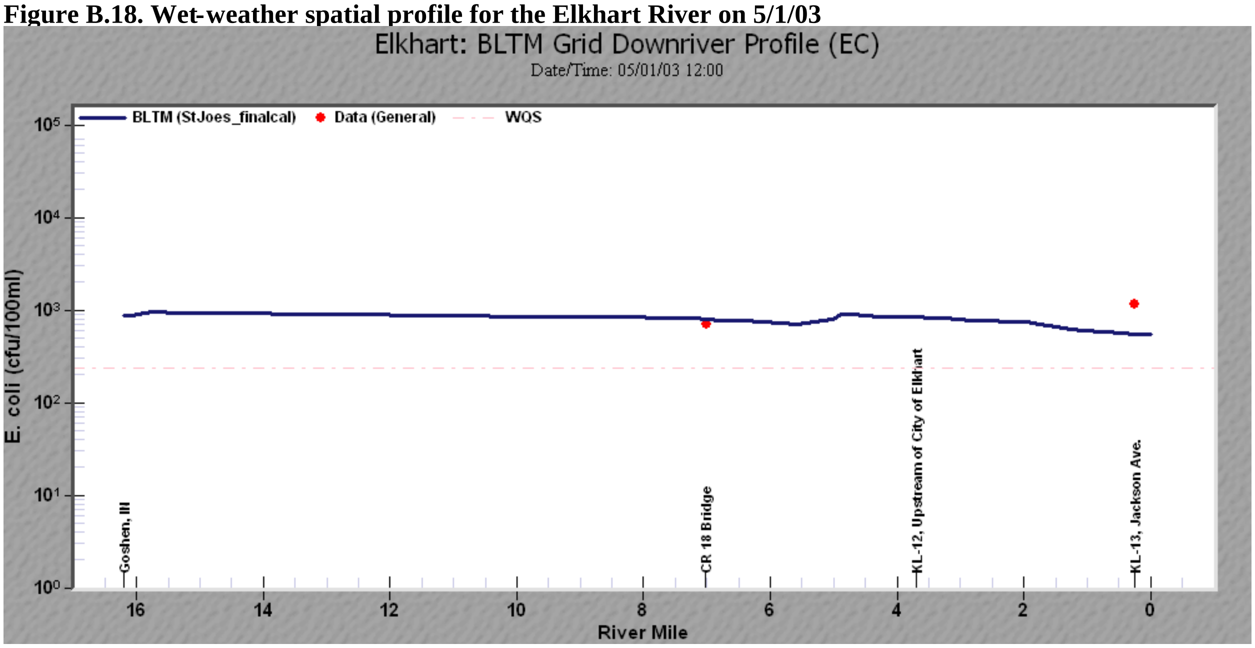


**Figure B.19. Wet-weather spatial profile for the St. Joseph River on 5/9/03**

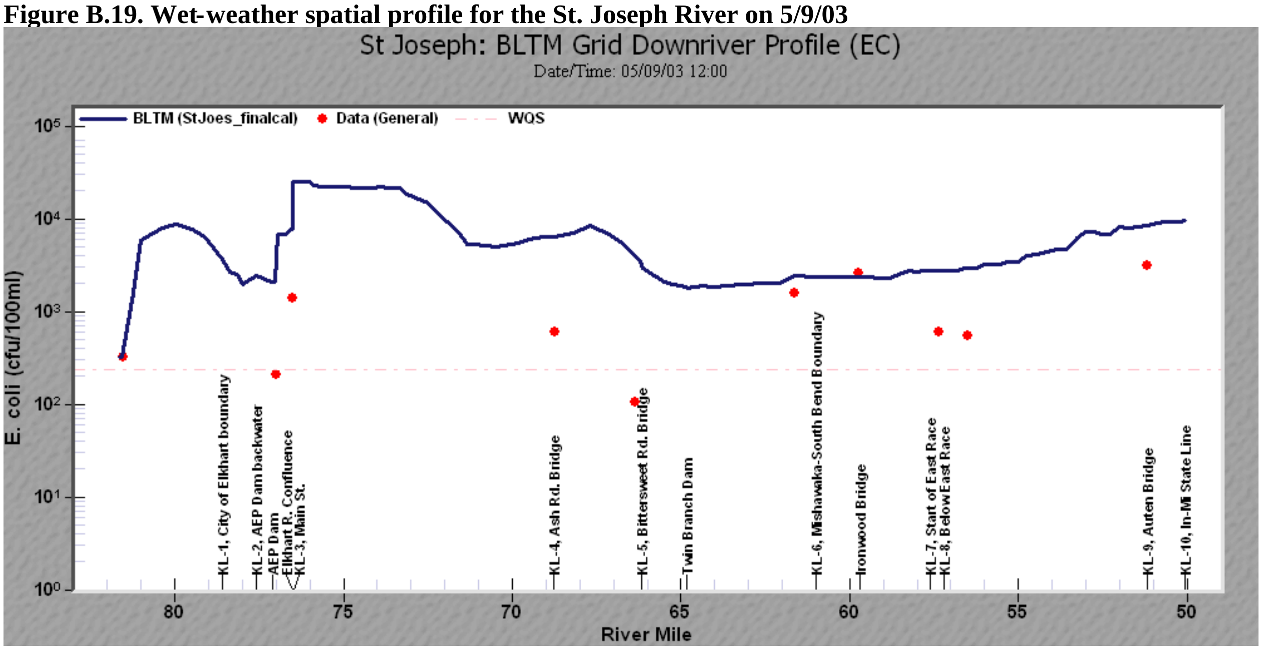
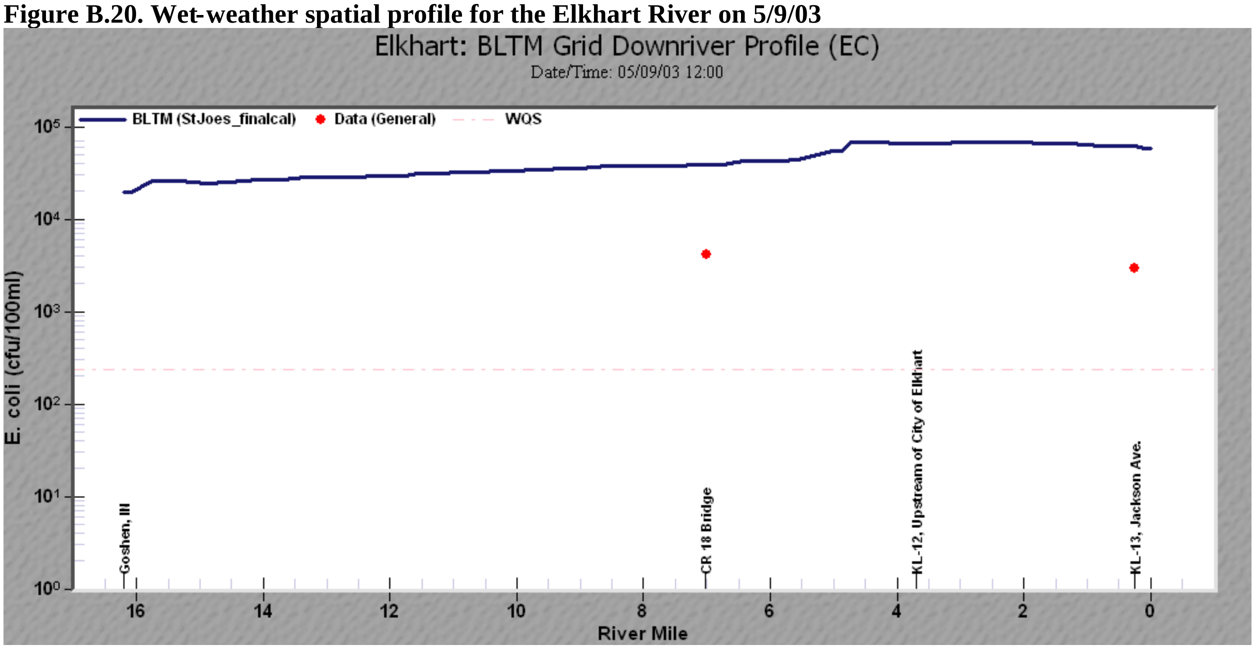


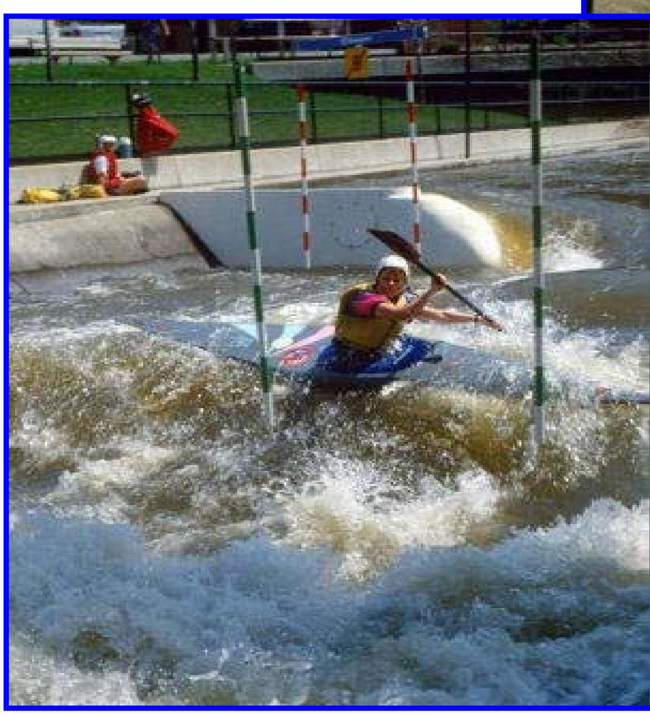

**Figure B.20. Wet-weather spatial profile for the Elkhart River on 5/9/03**



# St. Joseph River
# Watershed Initiative for a Safer Environment
# (WISE)

## Final Report
## 104(b)(3) Grant
## A305-4-37

**Prepared by the**
**City of Elkhart**
**Public Works & Utilities**



**Submitted to the Indiana Department**
**of Environmental Management**
**Office of Water Quality**

**December 6, 2006**

# Table of Contents

# Introduction

In October of 2000, three Indiana communities (Elkhart, Mishawaka and South Bend) initiated efforts to improve and protect the water quality in the St. Joseph River watershed (HUC 0405001) by signing a memorandum of understanding establishing the St. Joseph River Watershed Initiative for a Safer Environment (WISE) (see Appendix 1). Despite implementation of technology-based control measures within the urban areas of the watershed, water quality impairment in terms of bacterial contamination continues to exist within the St. Joseph River watershed. This Section 104(b)(3) grant project was a cooperative effort under the WISE initiative that builds on previous work conducted under a 205(j) grant project (A305-2-01-399-0) and efforts by the three cities to characterize the sources and impacts of *E. coli* contamination in the St. Joseph River watershed during wet and dry weather conditions.

The St. Joseph River drains 4,725 square miles in Michigan and Indiana and receives bacterial pollution from agriculture, urban storm water, combined sewers overflows (CSOs), and rural sources. This bacterial contamination may exceed water quality standards in dry weather conditions, but is more intense following wet weather events. Approximately 70% of the watershed is considered rural and made up primarily of agricultural land uses. In Elkhart County, approximately 48% (133,500 acres) of the 280,695 acres of land in the watershed is used for cropland. Dairy operations as well as beef, hog and poultry operations are also present. Elkhart and St. Joseph counties are among the top 10 counties in Indiana based on the number of livestock. Only about 10% of the watershed is made up of urban and suburban uses. These uses are clustered along the St. Joseph River, with the highest intensities along reaches in Indiana. Industrial parks, consisting mostly of "dry" industries line the suburban communities in the watershed. The three largest Indiana cities on the St. Joseph River, Elkhart (population 51,874), Mishawaka (population 46,557), and South Bend (population 107,789), have numerous combined sewer overflows (CSOs) and many more storm water outfalls.

Evidence shows that tributaries feeding the St. Joseph River contribute significant levels of bacterial contamination. This has been confirmed from existing data sets for fecal coliform and *Escherichia coli* (*E. coli)* from the Elkhart County Health Department, the cities of Elkhart, Mishawaka, and South Bend, and by the Indiana Department of Environmental Management (IDEM). Based on monitoring by the IDEM, portions of the river and many of the tributaries within the grant study area have been identified as impaired waters for *E. coli* under Section 303(d) of the Clean Water Act. Listed waters do not or are not expected to meet applicable water quality standards with federal technology-based standards alone. The IDEM is required to develop a Total Maximum Daily Load (TMDL) for *E. coli* in the St. Joseph River and the impaired tributaries. This TMDL will require point and non-point sources of bacterial contamination in the watershed to implement control measures. Therefore, the stakeholders in Elkhart and St. Joseph Counties must identify cost-effective, environmentally beneficial source controls that will meet water quality criteria within the Indiana portion of the river and at the Indiana/Michigan state line. Alternatively, if the costs of meeting these criteria are unaffordable, revisions to the water quality standards may need to be pursued.

The objective for this project was to complete the development of the hydraulic and water quality models of the Elkhart and St. Joseph Rivers initiated under the 205(j) grant awarded to the City of Elkhart in 2002 as part of WISE initiative. The goal of the project was to develop an expandable, integrated river model (using the Branched Lagrangian Transport Model) of the St. Joseph River from the County Road 17 Bridge at river mile (RM) 81.5 (upstream of Elkhart) downstream to the Indiana/Michigan state line at RM 52.3 (upstream of Niles, MI) and of the Elkhart River from RM 16.1 (downstream of Goshen) to its confluence with the St. Joseph River (RM 0.0). The extent of the watershed model is shown in Figure 1. The resultant hydraulic and water quality model can be used to establish baseline water quality and characterize point and non-point sources of contaminates, including *E. coli*. This work will provide a single model that can be used in NPDES programs to further refine contaminate sources in the St. Joseph River watershed and assist in the selection of cost-effective strategies towards meeting, and possibly refining, water quality standards. Developing effective methodologies such as this model for identifying and isolating watershed-wide sources of bacterial contamination will apply to, and be beneficial for, numerous other communities and stakeholders facing similar challenges. Additionally, the water quality model will provide information valuable to Indiana and Michigan in their efforts in establishing load allocations and implementation plans in TMDLs for bacteria in the watershed.

The project was organized to accomplish five tasks; Screening Level Tool Development, Typical Year Simulation, Watershed Load Estimation and Best Management Practices, Best Management Practice Effectiveness, and Public Education. The project steering committee formed under the 205(j) grant continued with this project to provide guidance and direction and to be a conduit for public promotion of the project. The steering committee meetings were open to the public. In addition to the public steering committee meetings, numerous presentations were made documenting the progress of the project and educating the public on potential water quality impacts from point and non-point sources of bacterial contamination. As previously stated, the primary objective under this project was to develop a St. Joseph River watershed water quality model to establish baseline water quality and characterize point and non-point sources of *E. coli* during wet weather events. Although there is still work to be done, this project was successful in developing a calibrated water quality model for characterizing *E. coli* contamination in the St. Joseph River watershed from point and non-point sources.

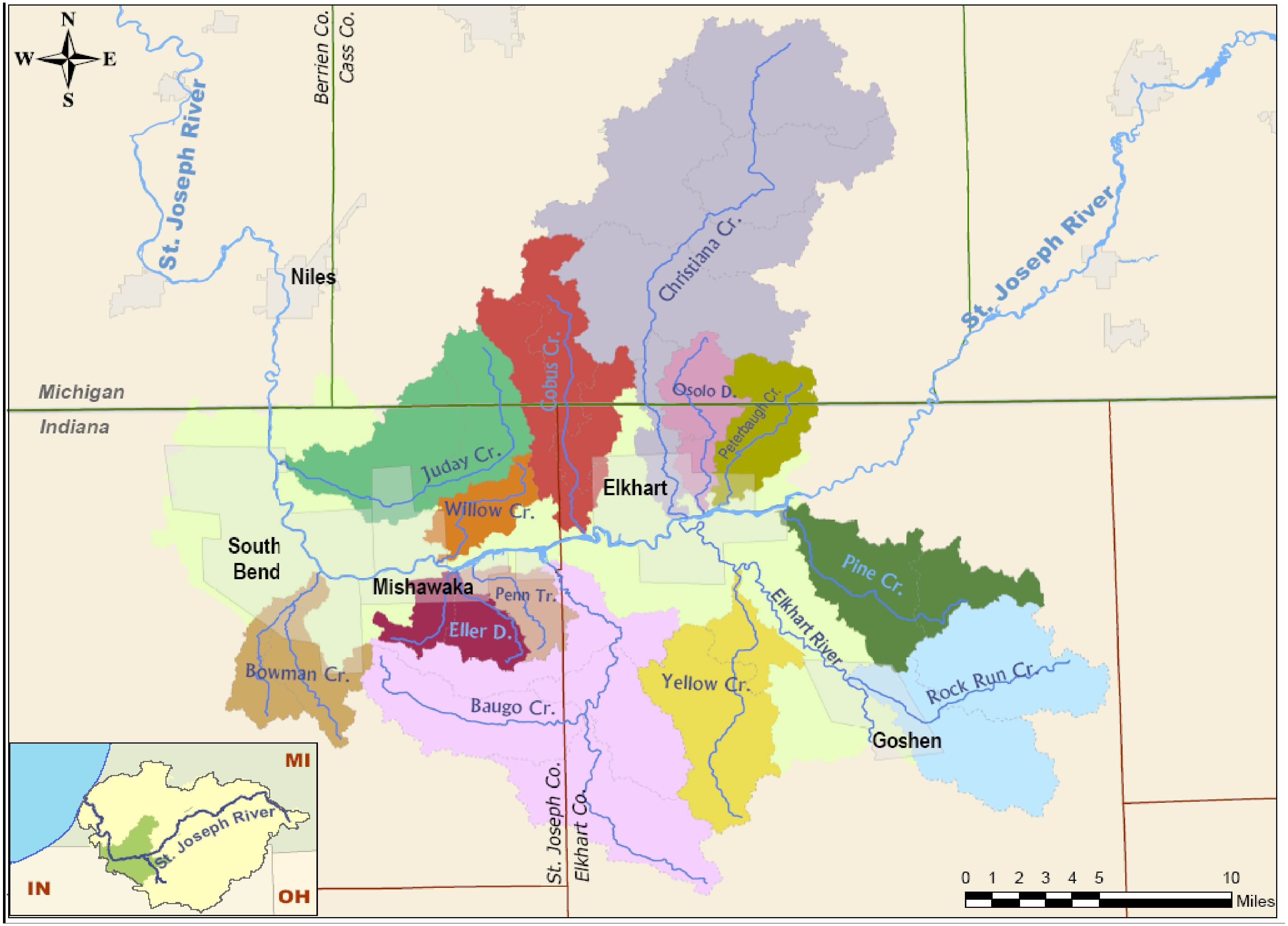



**Figure 1- St. Joseph River Watershed Model Extent**

## Summary of Work

Work performed under this project can be categorized under the eight tasks contained in the grant contract. The development and enhancement of the water quality model was the primary objective under this project. To complete this goal, grant funds were used to sub-contract the model development work. Sub-contractor services were solicited and Limno-Tech, Inc (LTI) was selected to perform the work. Work performed under Tasks A, B, C, D, and E followed the approved Scope of Work submitted by LTI. The following summarizes the work completed for each contract task.

<u>Screening Level Tool Development</u> (Task A)

As documented in the final report for the 205(j) grant dated August 24, 2004, the USGS' Branched Lagrangian Transport Model (BLTM) was selected as the modeling framework and interfaces were developed using Visual Basic for Applications (VBA) and Excel. The BLTM is a fully dynamic model that can vary flow and water quality conditions within time and space. The USGS' stream hydraulic model, the Diffusion-Analogy Flow Model (DAFLOW), was used as a companion model to provide flow input to the BLTM model. Under the 205(j) grant, the model was calibrated and verified. A summary of the work completed under this task is provided below. A detailed description of the model development is contained in Appendix 2. The calibrated model, including the pre-processor and post-processor files and the simulation results, are included in the BLTM folder on the compact disk included with this report.

- ✓ Developed a conceptual approach for programming the screening level tool.
- ✓ Evaluated and selected two design storms to simulate, 1-month and 1-year storms.
- ✓ Developed an approach for specifying representative model inputs for the design storm conditions for upstream and tributary inputs.
- ✓ Evaluated the flow record and concentration data for upstream and tributary design storm inputs.
- ✓ Completed development of the post-processor GIS-based animation viewer.
- ✓ Completed three simulations of the 1-year design month, each representing a different receiving water response based on river and tributary flow data ("mild", "average", and "severe").
- ✓ Completed programming for the "slider" tool in the model post-processing framework.

<u>Typical Year Simulation</u> (Task B)

The water quality model was applied over a typical year of rainfall and stream flow conditions. The purpose of this task was to evaluate the impact on water quality in the St. Joseph River from bacteria sources in the watershed under a range of conditions. The year 1992 was selected as the "typical" year for evaluating CSO, storm water, and non-point source pollutant loads. Rainfall from the South Bend airport and stream flow data from the St. Joseph River were examined on an annual and summer basis, and compared to historical averages to make this selection. Once the typical year was selected the model was run and the output was compared to the water quality standard at various locations along the river. A detailed description of the development of the typical year and the model outputs is contained in Appendix 3. The Excel files containing the loads and results from the baseline typical year run, including comparisons to alternative water quality standards, are included in the BLTM folder on the compact disk included with this report.

Watershed Load Estimation and Best Management Practices (Tasks C & D)

The goals of these two tasks were to simulate flow and *E. coli* loads on a watershed basis for tributaries to the St. Joseph River (between the City of Elkhart and the Michigan-Indiana state line), to simulate best management practices (BMP) removal efficiencies for several sources, and to link each BMP to a cost associated with implementation. As described in the Grant Progress Report (October 13, 2005), EPA's Hydrologic Simulation Program-FORTRAN (HSPF) watershed model was selected for use under this task. The HSPF model developed for the St. Joseph River watershed offers a mechanistic method of estimating the impact of *E. coli* loads from tributary sources on water quality in the St. Joseph River. With the use of the linked HSPF-BLTM modeling framework, the magnitude of all wet weather source loads is now directly related to rainfall.

The watershed model task included compiling a list of best management practices (BMPs), their removal efficiency for bacteria, and unit cost. This information was simplified into broad categories and implemented in the HSPF modeling framework to allow a user to simulate "broad brush" non-point source control scenarios. The HSPF modeling framework includes a summary of key BMP information compiled under this task, including:

- The BMP category (e.g. "Tillage Practices"),
- A description of the specific technologies included in the category,
- The applicable land use,
- The applicable loading pathway,
- The range of reported removal efficiencies, and
- The range of construction and maintenance costs.

Having this information available within the model input file manager is intended to facilitate the simulation of realistic BMP implementation scenarios with the model. Detailed information regarding the development and application of the HSPF model, including BMPs, is contained in Appendix 4. The Excel files containing the BMP information, spatial plots and animation results are included in the BLTM folder on the compact disk included with this report.

Public Education (Task E)

Under this task, specific web pages were developed to describe and illustrate relevant project information including three animations developed from the model post-processor. Model simulations were run and animations were created for three different rainfall events; a 0.24 inch rain event, a 0.46 inch rain event, and a 0.93 inch rain event. The three animations will be linked to the web pages to illustrate the bacteria impact in the St. Joseph River watershed as a result of the different rain events. The public information web pages and a snapshot of one the three animations are included in Appendix 5. The three animation files are included on the compact disk included with this report.

Steering Committee and Presentation of the Project (Task F)

A St. Joseph River WISE Steering Committee was formed under the 205(j) grant project.  This steering committee was invited to continue under this grant project (see the June 20, 2005 letter contained in the Grant Progress Report dated October 13, 2005).  The mission of the Steering Committee was to provide general direction and input on the project.   The project coordinator's goals were to keep the committee members updated on the progress of the project, obtain input and direction relating to project tasks, and develop support for the recommended strategies to be included in any watershed management plan.  All the committee meetings were open to the public.  A news release was issued announcing the date, time and location of each committee meeting.  Appendix 6 contains the news release, meeting agenda and list of attendees for the Steering Committee meetings under this project (copies of new releases and the list of attendees for prior committee meetings are included in the progress report).  In addition to the public steering committee meetings, progress on the grant project was presented to numerous interest groups both locally, regionally and internationally.  Presentations were made to the St. Joseph River Basin Commission, the Michiana Area Council of Governments and at the 2005 Indiana Water Environment Association conference.  See Appendix 6 for documentation regarding presentations on the grant project.

Data and Reports (Tasks G & H)

A progress report was submitted to the IDEM on October 13, 2005 documenting the work accomplished and the products produced.  This is the final report summarizing the entire project, the lessons learned as a result of the project and future activities resulting from or associated with the project.  A digital copy of this report, project supporting data and the watershed model are included with this final report.

## Project Accomplishments

The development of a water quality model for characterizing and assessing *E. coli* contamination in the St. Joseph River watershed was the primary objective of this project. The development of this model is an important first step toward answering two significant questions for the communities, tax payers, stakeholders and users of the streams in this watershed; (1) where should resources be invested to maximize reductions in the frequency, magnitude, and duration of high *E. coli* counts in the rivers, and (2) if current water quality standards are not attainable, is there an alternative standard whereby compliance could be measured to aid in future decision-making? It is important that these questions be addressed so that the true cost of meeting a standard is defined, the benefits of proposed controls are evaluated at a watershed level, and public support is obtained for selecting and implementing controls. The goal of the first phase of this project was achieved under the 205(j) grant project (A305-1-01-399-0); the development of a calibrated water quality model. The goal of this phase of the project was to enhance the model's value as a planning tool by isolating the sources of *E. coli* contamination and presenting the findings in a manner that the public can understand and influence decision-making.

The objectives of this 104(b) grant are to enhance the water quality model developed under the 205(j) grant project with a tool for estimating watershed loads, evaluating the cumulative effect of best management practices (BMPs) on reducing tributary loads of *E. coli*, and to assist in the selection of cost-effective strategies towards meeting, and possibly refining, water quality standards. More specifically, these objectives include:

- Developing a screening-level tool for evaluating river responses to "broad brush" load reduction scenarios;
- Running the model for a "typical" year to evaluate the impact on water quality in the St. Joseph River from bacteria sources in the watershed under a range of conditions;
- Adding a watershed loading model that will calculate *E. coli* loads on a tributary watershed basis, to simulate best management practices (BMP) removal efficiencies for several sources, and to link each BMP to a cost associated with implementation; and
- Development of information from selected scenarios for inclusion on the three cities' web pages for public access.

All of these objectives were accomplished under this project. The development of the screening-level tool, or "slider tool", allows model users to interactively adjust the load associated with a state variable (e.g. source of *E. coli*) from zero to 100 percent by scrolling up or down on the slider tool. The tool then displays the effects of the load reductions at different points along the river.

The use of the "typical" year concept is important because the national CSO Policy considers the annual variability in rainfall and recognizes that the specific number of overflow events each year will vary. The public also relates more easily to performance measures for pollutant reduction programs that link controls to benefits on an annual basis. The model's pre- and post-processors were modified to run the model for the "typical" year, 1992, and compare the total concentrations from all the sources to the water quality standard. A GIS viewer was developed to allow model users to evaluate “compliance” with water quality standards at various locations depending on the level of control selected.

The watershed HSPF model developed under this project offers a mechanistic method of estimating the impact of *E. coli* loads from tributary sources on water quality in the St. Joseph River. With the use of the linked HSPF-BLTM modeling framework, the magnitude of all wet weather source loads is now directly related to rainfall.

Finally, specific web pages were developed to describe and illustrate relevant project information including three animations developed from the model post-processor. Model simulations were run and animations were created for three different rainfall events; a 0.24 inch rain event, a 0.46 inch rain event, and a 0.93 inch rain event. The three animations will be linked to the web pages to illustrate the bacteria impact in the St. Joseph River watershed as a result of the different rain events.

The project team was successful at keeping the public and interested stakeholders informed during the development of the water quality model. This was accomplished through the public steering committee meetings and the numerous presentations to local and regional interest groups. The expansion of the model into other tributaries in the watershed and for assessing parameters other than *E. coli* was presented to local, state and civic leaders in Indiana and Michigan. Fortunately, EPA Region 5 and the IDEM have supported the development of this modeling tool through the previous 205(j) grant and this 104(b)(3) watershed grant. However, the current regulatory framework addressing CSOs, storm water, agricultural, and other non-point sources of *E. coli* makes it a challenge to apply this tool effectively to today’s regulatory decisions. For example, final TMDLs for *E.* coli were developed for the St. Joseph River in Indiana and Michigan prior to the model being available. Thus, decisions regarding the ultimate level of management and control for CSOs, storm water and other sources of *E. coli* may be determined without the benefit of the use of this integrated model. Nevertheless, regulators appear to be committed to improving the coordination of programs on a watershed basis and this project offers one method towards using the watershed approach to assist in making decisions about source reductions, permitting, and attainment of water quality standards in the St. Joseph River watershed.

## Future Activities

Trying to model and account for all inputs to a system such as this watershed is complex and resource intensive. Although the model has been developed and calibrated to available data, there are a few assumptions that must be considered whenever the model is used. These assumptions make it difficult to expect that the model can precisely calculate *E. coli* levels in the river. The importance of these assumptions, and their effect on model uncertainty, will need to be considered prior to making management decisions in the watershed. A few of the significant assumptions are as follows:

- Rainfall during the monitored period was considerably less (18 to 19 inches) than the normal rainfall for the same period, which is 38 inches. Monitoring conducted for larger storm events may identify certain characteristics that are not currently captured in the model.
- Flow data for the tributaries was limited. Since the flow at Pine Creek was used to estimate flow for the other tributaries, the relative distribution of flow between the tributaries may be different and differences from storm to storm may not have been fully captured.
- Two rain gages were assumed to be reflective of rainfall conditions over a large area. One of these gages was operational for only four of the ten months simulated.

To reduce some of the uncertainty associated with the above assumptions, additional data or information can be collected to improve the model's configuration, application or evaluation of BMP implementation. Specific recommendations for additional data include:

1) Intensive surveying of wet weather tributary flow and *E. coli* concentrations in the major tributaries. The purpose of this recommendation is to obtain data that will quantify peak flow and *E. coli* concentration during wet weather, how concentration changes over the course of an event, and the amount of time required to return to base (e.g. non-storm) conditions in the tributaries.
2) Incorporating data from multiple rain gages into the watershed and river models to more accurately simulate the spatial variation in rainfall patterns across the watershed.
3) Refine loading pathway load rate estimates by:
    i. Obtaining watershed-specific information on livestock populations and practices (e.g. how much time animals are pastured each day, etc.);
    ii. Investigating whether seasonal variations currently reflected in the loading rates are appropriate and if necessary, incorporate more refined temporal variation into the load rates;
    iii. Obtaining more accurate information regarding number of head and manure storage and disposal practices for confined animal feeding operations, confined feeding operations and small farms;
    iv. Obtaining information on pet population and waste practices (e.g. how much is picked up by owners) in sub-watersheds where pet waste comprises a large component of the total E. coli load.
4) Identify the limits in applying BMPs and refine the range of reductions in the BMP menu accordingly.

5) Further refine the direct drainage sub-watersheds (~8% of the watershed area) to delineate new sub-watersheds draining to ditches rather than directly to the river.
6) Expand the modeling framework storage capacity by upgrading from MS Access to an SQL database to store model results.

Implementation of the first two recommendations will result in a more robust model calibration at the mouths of the tributaries.  A monitoring program that includes sampling further upstream in these tributaries will also provide valuable data to inform the watershed model calibration.

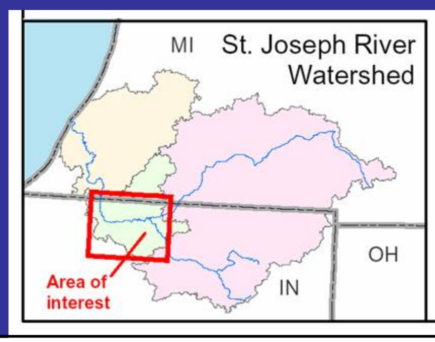
The third recommendation will improve confidence in the accuracy of the loading pathway inputs.  The fourth recommendation will refine the current BMP literature-based information by incorporating limits based on site-specific information. Both of these recommendations will upgrade the model's BMP effectiveness utility from its current status as a general screening level tool to a detailed planning level tool.

The final two recommendations would offer little improvement in the models as they are currently being applied.  However, if more sophisticated applications of the modeling framework are desired (e.g. to answer management questions in more detail or to evaluate river quality over a longer time period), these recommendations will facilitate the use of the model to better address these needs.

# WISE (BLTM) Model
# Updated Calibration

St. Joseph River, IN
CSO LTCP Update for Elkhart, Mishawaka, South Bend
April 30, 2007

Limno-Tech, Inc.

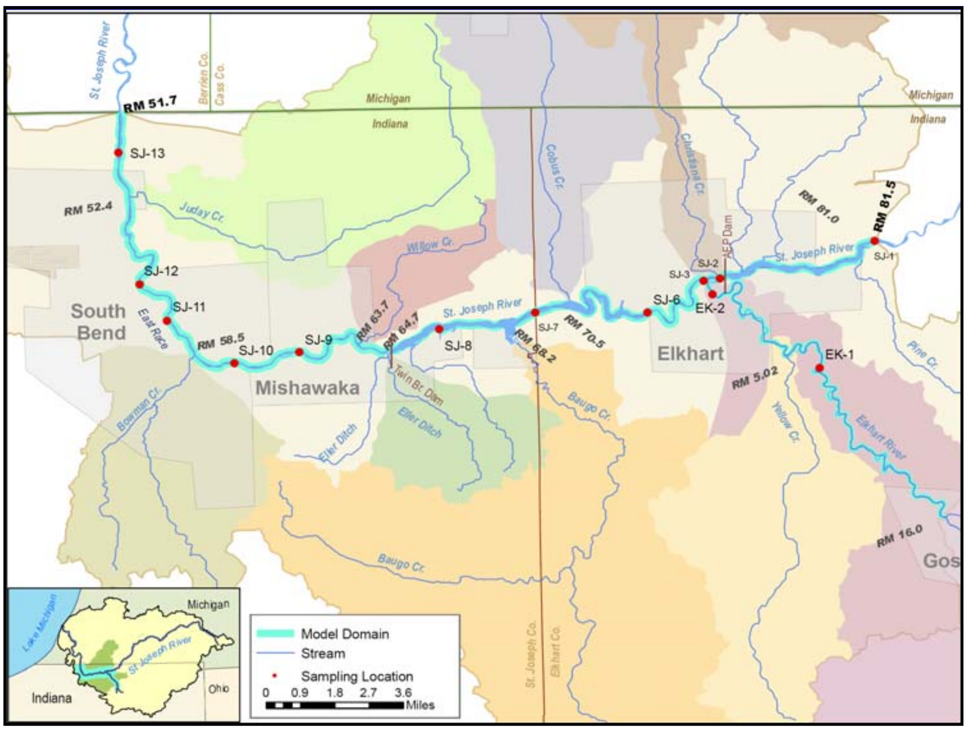



# WISE Introductory Comments

- Planning level tool developed under two EPA grants for Elkhart, Mishawaka, and South Bend
- Model has been updated with new (reduced) CSO volumes for Elkhart and South Bend
  - Confirmed that the model can reproduce the 2002-2003 extended calibration data
- Model is best tool available for evaluating impact of CSO control alternatives on river *E. coli*
- Post-construction compliance monitoring will be conducted to confirm compliance with WQ standards

# Calibration Data Summary

- 10-month Monitoring Period (July 2002-May 2003)
- 27 events sampled
  - 8 wet weather events (0.1-1.59 inches)
  - 19 dry weather days
- Mainstem sampling locations
  - Elkhart River: 2 locations
  - St. Joseph River: 13 locations
- 333 river *E. coli* results to compare to model results



# Bacteria Sources to River

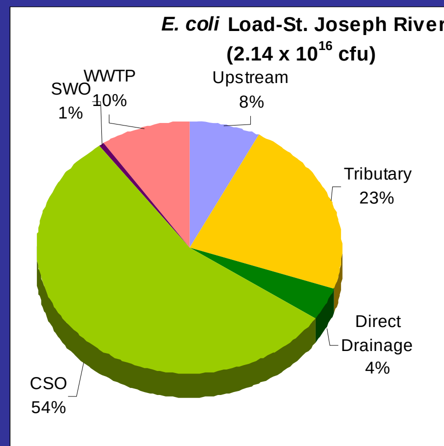
- Combined Sewer Overflows
  - 37 City of Elkhart
  - 21 City of Mishawaka
  - 36 City of South Bend
- Storm Water Outfalls
  - 14 representing City of Elkhart
  - 16 representing City of Mishawaka
  - 18 representing City of South Bend
- Municipal Wastewater Treatment Plants Outfalls
  - City of Elkhart
  - City of Mishawaka
  - City of South Bend
- Upstream
  - St. Joseph River
  - Elkhart River
- Non-point Direct drainage
- Tributaries (Non-point Sources Aggregated by Tributary)
  - Christiana Cr.
  - Baugo Cr.
  - Eller Ditch
  - Willow Ditch
  - Bowman Cr.
  - Juday Cr
  - Yellow Cr.
  - Pine Cr.
  - Cobus Cr.
  - Rock Run Cr.
  - Penn Tributary
  - Osolo Ditch
  - Puterbaugh Cr.

# Calibration Inputs

| Source | Updated Input? | Flow | E. Coli Conc |
|---|---|---|---|
| Upstream St. Joe R. | | DAR of USGS gauge (04101000) at Johnson St. Bridge | Sampling data from the Six Span Bridge |
| Upstream Elkhart R. | | USGS gauge (04100500) at Goshen | Sampling data at County Rd 18. |
| Tributaries | Q & C | HSPF watershed model | HSPF watershed model |
| Direct Drainage | Q & C | Best Professional Judgment (BPJ) | Literature and BPJ (varied seasonally) |
| CSOs | Q & C | Collection system models | Literature and BPJ EMC = 750,000 (cfu/100mL) |
| SWOs | Q & C (Elkhart) | Rational method (Q=ciA) | Literature EMC = 5,000 (cfu/100mL) |
| WWTPs | | Monitoring data | Monitoring data |

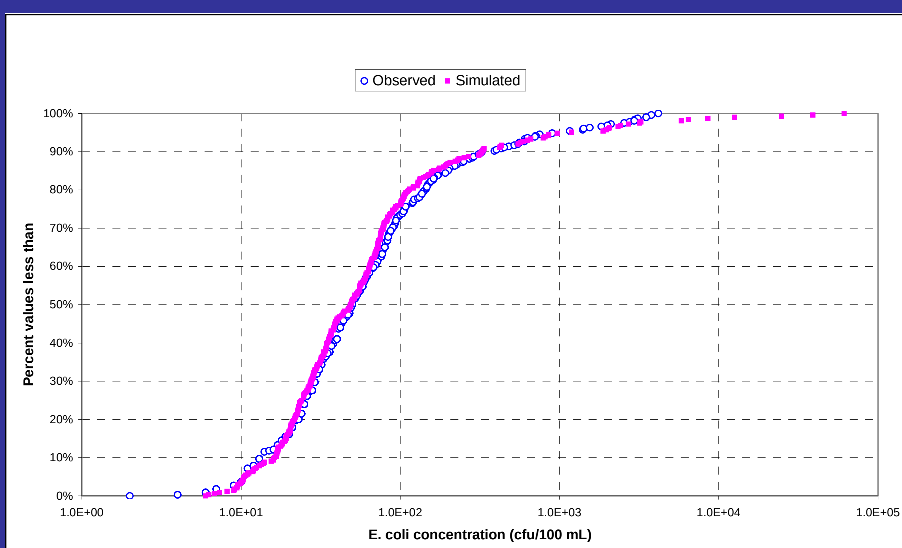
# Loads by Source Type: 10-Month Calibration Period

| Type | % of Load |
|---|---|
| NPS[1] | 35% |
| CSO | 54% |
| SWO | <1% |
| WWTP[2] | 10% |




Notes:
[1] NPS includes upstream, tributary and direct drainage
[2] The WWTP load reflects disinfection during the recreation season only; plants are now disinfecting year-round.

# Updated Calibration Results Overview

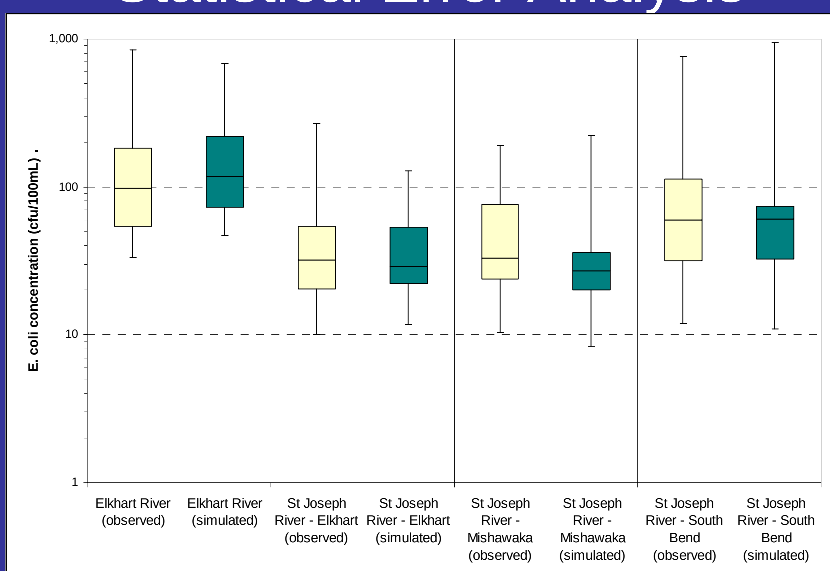


# Updated Calibration Results: Statistical Error Analysis

- Evaluate accuracy/bias in the model versus the data at each sampling location
- Error analysis performed on log-transformed results
- See Tables 5 & 6 in the memorandum

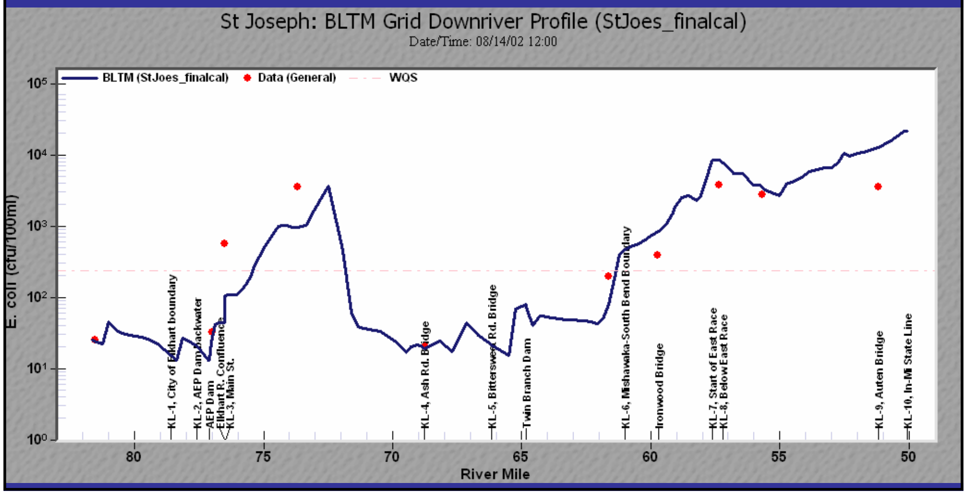
| Condition | Mean Relative Error | Mean Absolute Relative Error |
|---|---|---|
| All Data | <±10% | <20% |
| Wet Weather Data | <±15% | <25% |

# Updated Calibration Results: Statistical Error Analysis



# Updated Calibration Results Example Storm Event Profile

8/14/2002: ~0.46” Storm Event




# Sensitivity Analyses

- Two parameters assessed:
  - Bacteria loss rate (0-2/day)
  - CSO Event Mean Concentration (EMC) (350,000 cfu/100 ml – 1,500,000 cfu/100 ml)
- Best model-data fits obtained with:
  - Bacteria loss rate = 1/day
  - CSO EMC = 750,000 cfu/100 ml

## Updated Calibration Results Summary

- Model reproduces observed concentrations measured for a range of conditions;
- Model's goodness-of-fit provides additional confidence in the methods and models used to specify input flows and loads;
- Model matches downstream profile of concentrations during both wet weather and dry weather;
- Model is best tool for estimating impact of CSO and other source control alternatives on river *E. coli* concentrations.

## Next Steps

- Short-Term:
  - Agency review/approval of river model calibration
  - Agency approval of CSO control alternatives analysis approach
- Next 6-9 months
  - Apply model for baseline (current) conditions
  - Apply model for CSO control alternative(s) in each community:
    - Evaluate overall benefit to river from concurrent efforts by each community
    - Evaluate compliance with water quality standards
  - Each community submits updated LTCPs:

## The End

## River Model Loss Rate

- Literature values (EPA, 1986):  0.5-3.5/day
- Site specific calculation considerations:
  - Section of the river suitable for evaluation?
  - Data reflect in-stream loss processes?
- Model analysis summary:
  - Comparison of mean relative error (target is to get values as close to zero as possible)

| *Loss Rate→* | 0/day | 1/day | 2/day |
|---|---|---|---|
| St. Joseph River | 37.2% | 0.6% | -16.5% |
| Elkhart River | 15.1 | 6.5 | -1.8 |

# Calibration Inputs

| Source | Updated Input? | Flow | E. Coli Conc |
|---|---|---|---|
| Upstream St. Joe R. | | DAR of USGS gauge (04101000) at Johnson St. Bridge | Sampling data from the Six Span Bridge |
| Upstream Elkhart R. | | USGS gauge (04100500) at Goshen | Sampling data at County Rd 18. |
| Tributaries | Q & C | HSPF watershed model | HSPF watershed model |
| Direct Drainage | Q & C | Best Professional Judgment (BPJ) | Literature and BPJ (varied seasonally) |
| CSOs | Q & C | Collection system models | Literature and BPJ EMC = 750,000 (cfu/100mL) |
| SWOs | Q & C (Elkhart) | Rational method (Q=ciA) | Literature EMC = 5,000 (cfu/100mL) |
| WWTPs | | Monitoring data | Monitoring data |

# Appendix D

## Basis for Cost Estimates

City of Elkhart

# Combined Sewer Overflow Long Term Control Plan Update

# Basis for Cost Estimates

**City of Elkhart**
**Department of Public Works**

August 2007

As part of the GHMP Joint Venture

GREELEY AND HANSEN

# Table of Contents

# Table of Contents

## List of Tables (in report text)



## List of Figures (following report text)

# Section 1 General

To compare the CSO control alternatives, cost estimates including construction, capital, and operating and maintenance costs were prepared for each alternative. This appendix provides the bases for cost estimates.

In accordance with the Association for the Advancement of Cost Engineering definitions (AACE, 1997), cost opinions included in this document are considered to be Class 4: Study or Feasibility level estimates, with an expected accuracy of -15% to +30%. The actual capital cost could be 15% lower than the estimate or 30% higher than the estimates. Cost opinions are of this accuracy because alternatives have been prepared with a minimum of detailed design data for the purposes of relative comparison. This type of analysis is appropriate for comparisons between control programs.

# Section 2 Construction Costs

## 2.1 Methodology

The following cost bases were used for the preparation of construction cost estimates:

- Construction Cost Index – The Engineering News Record (ENR) Construction Cost Index (CCI) for July 2007 was 7,959. An ENR CCI of 8,000 was used for the alternatives evaluation.

- Approach to Estimating Construction Costs - costs have been prepared using the following resources:

  - Cost curves from:
    - *Construction Costs for Municipal Wastewater Treatment Plants: 1973-1979* (EPA, 1981)
    - *Manual - Combined Sewer Overflow Control*, (EPA 1993a)
    - *Cost Estimating Manual – Combined Sewer Overflow Storage and Treatment* (EPA, 1976)
    - *Pumping Station Design* (Sanks, 1998).

  - Unit costs in dollars per gallon or cost per linear foot obtained from other projects including Indianapolis and Elkhart. Costs have been adjusted for relative characteristics such as complexity or location using engineering judgment.

  - Cost data from similar facilities:
    - Costs from other studies
    - Engineer's estimates of construction cost
    - Bid tabulations from similar projects.

  - Where facilities are unique or customized and cost curve type data does not exist, conceptual layouts of facilities were prepared and costs were estimated by performing takeoffs to estimate quantities.

- Calculation Procedure - the following calculation procedure in **Table 1** was used for construction costs:

**Table 1**

**Calculation Procedure for Construction Cost Opinions**

| Line Number | Description | Calculation Procedure |
|---|---|---|
| 1 | Subtotal of Construction Line Items | -- |
| 2 | Construction Contingencies | 25% x Line 1 |
| 3 | **Total Construction Cost** | Sum of Lines 1 and 2 |

## 2.2 Sewer Separation

Data used to estimate separation costs was obtained from the following sources, as shown in **Table 2**:

- Data from other Cities – Many cities have evaluated separation as part of the preparation of LTCPs. Either estimated or bid costs of separation were available.

- From the data in Table 2, a sewer separation of $50,000 per acre (ENR = 7,200) was assumed. This cost is between Mishawaka's cost estimates and the average estimate of complete sewer separation projects in South Bend's Stormwater Management Master Plan.

**Table 2**

**Sewer Separation Construction Cost Data**

| City | CSO Drainage Area(acres) | Estimated Construction Cost (ENR=7,200) | Unit Construction Cost($/acre, ENR=7,200) | Type of Data |
|---|---|---|---|---|
| Elkhart, IN | 148 | $6,973,132 | $47,151 | Bid |
| Alexandria, VA | 885 | $34,480,254 | $38,961 | Estimate |
| Chicago, IL | 240,000 | $20,338,519,925 | $84,744 | Estimate |
| San Francisco, CA | 24,995 | $11,015,462,445 | $440,707 | Estimate |
| Peoria, IL | 61.3 | $3,286,770 | $53,618 | Estimate |
| Richmond, VA | 11,000 | $2,570,494,780 | $233,681 | Estimate |
| Minneapolis, MN | 4,000 | $93,145,711 | $23,286 | Estimate |
| Columbus, OH | 22 | $1,099,356 | $49,971 | Bid |
| S. Dorchester Bay, Boston, MA | 786 | $103,237,422 | $131,345 | Bid |
| Stony Brook, Boston, MA | 608 | $54,396,399 | $89,468 | Estimate |
| Cambridge, Boston, MA | 250 | $78,959,737 | $315,839 | Estimate |
| Garden City, MI | 1,180 | $37,555,639 | $31,827 | Bid |
| Livonia, MI | 103 | $1,353,735 | $13,143 | Bid |
| Plymouth Township, MI | 138 | $1,178,180 | $8,538 | Bid |
| Wayne, MI | 288 | $8,353,119 | $29,004 | Bid |
| Westland, MI | 409 | $10,737,342 | $26,253 | Bid |
| Bloomfield Hills, MI | 86 | $2,065,842 | $24,021 | Bid |
| Lansing, MI | 6,900 | $262,088,934 | $37,984 | Estimate/Bid[1] |
| Liberty Drive, Mishawaka, IN | 59.6 | $3,416,725 | $57,328 | Estimate |
| CSO 002 & 003, Mishawaka, IN | 771 | $48,016,057 | $62,278 | Estimate |
| **South Bend Stormwater Management Master Plan[2]** | | | | |
| Combined Sewer Area 26 | 56 | $1,386,777 | $24,764 | Estimate |
| North Area – Eastbank Project | 165 | $8,588,610 | $52,052 | Estimate |
| Eastside Project | 30 | $2,027,244 | $67,575 | Estimate |
| Downtown Project | 62 | $3,780,187 | $60,971 | Estimate |
| Combined Sewer Area 3 – Washington Street Project | 39 | $1,437,247 | $36,852 | Estimate |
| ***Master Plan Subtotal*** | ***352*** | ***$17,220,064*** | ***$48,921*** | ***Estimate*** |

## 2.3 Regulator Structures Modifications

Regulator structures control the diversion of CSO flow from outfall sewers to downstream facilities such

[1] The Lansing sewer separation program is approximately 30% complete, and the actual cost per acre for the projects implemented is close to the original estimate.
[2] Completed sewer separation projects in the Master Plan. Other projects in the plan had an existing storm trunk sewer or ditch to the river, or had areas that were already separated.

as interceptors, retention facilities and treatment facilities. Richmond, VA actual regulator structure construction costs were compiled in 2001 (ENR CCI = 6,383) (**Table 3**). A regulator structure includes a weir, baffle, bar rack and ten seconds of detention for solids and floatable control. The structures are typically large in size. Based on this data, the equation for regulator structure construction cost as a function of flow rate in million gallons per day (mgd) was determined to be (for flows between 10 and 250 mgd):

*Cost = (Current ENR CCI/6,383)*(6075.3(mgd) + 180,000)*

**Table 3**

**Regulator Structure Construction Costs**

| City of Richmond, VA Regulator | Design Diversion Capacity (mgd) | Actual Construction Cost (ENR CCI = 6,383) | Actual Construction Cost/mgd (ENR CCI = 6,383) |
|---|---|---|---|
| Byrd Street | 11.6 | $250,473 | $21,593 |
| 7th Street | 32 | $374,410 | $11,700 |
| Park Hydro | 38 | $410,861 | $10,812 |
| Reedy Creek | 68 | $593,120 | $8,722 |
| 42nd Street | 73 | $623,497 | $8,541 |
| McCloy Street | 81 | $672,099 | $8,298 |
| Woodland Heights | 83.5 | $687,288 | $8,231 |
| Hampton Street | 97 | $769,304 | $7,931 |
| Gambles Hill | 122 | $921,187 | $7,551 |
| Canoe Run | 239 | $1,631,997 | $6,828 |

## 2.4 Conveyance Pipelines

Pipeline costs are shown in **Figure 1**, ENR CCI = 8,000. Figure 1 is based on actual construction costs including pipe, manholes, bedding, excavation, backfill, pavement restoration, and dewatering. Figure 1 was originally developed for the 1994 South Bend CSO Control Study. Figure 1 was recalibrated in 2007 by reviewing recent bid tabs and cost models to better estimate current construction costs. The recalibration increased unit costs by 15%. The unit costs were increased by 50% for construction in urban congested areas for traffic control and disruption costs, and utility relocation and replacement cost. Figure 1 reflects both of these increases.

## 2.5 River Crossings

River crossing costs were estimated as follows:

*Cost = (Current ENR CCI/5,000) * $30 * Diameter (in) * Length (ft)*

## 2.6 Pumping Stations

Cost data for pumping stations were obtained from actual facilities, EPA cost curves, and Sanks (see references). The construction cost data are plotted on **Figure 2**. A best-fit polynomial equation whose values were greater than or equal to most of the plotted values was developed. The equation for construction cost as a function of flow rate (mgd) was determined to be:

*Pumping stations up to 300 mgd:*

$$Cost = (Current\ ENRCCI/6{,}383)*(0.0307(mgd)^3 - 125.76(mgd)^2 + 213{,}533(mgd) + 279{,}183)$$

*Pumping stations for 300 to 2,000 mgd:*

$$Cost = (Current\ ENRCCI/6{,}383)*(-3.2655(mgd)^2 + 45481(mgd) + 40{,}000{,}000)$$

## 2.7 Sedimentation/Storage Basin

Costs for CSO storage facilities were obtained from actual facilities and from EPA cost curves. Costs are summarized in **Table 4** below.

## Table 4

## Existing Storage Facility Construction Cost Data

| Location | Storage Volume (mg) | Actual Construction Cost (Millions, ENR=7,200) | Unit Cost ($/gallon, ENR=7,200) |
|---|---|---|---|
| Mariposa - San Francisco, CA | 0.7 | $14.69 | $20.98 |
| Fitzhugh – Saginaw, MI | 1.2 | $7.24 | $6.03 |
| Seven Mile – Detroit MI | 2 | $18.54 | $9.27 |
| Union Park – Boston, MA | 2.5 | $43.04 | $17.22 |
| Eliza Howell – Detroit, MI | 2.8 | $22.49 | $8.03 |
| Salt/Frazer – Saginaw MI | 2.8 | $16.72 | $5.97 |
| Seneca WWTP | 3 | $4.08 | $1.36 |
| Chattanooga, TN | 3.5 | $7.22 | $2.06 |
| Webber – Saginaw, MI | 3.6 | $10.66 | $2.96 |
| Acacia Park , MI | 4.5 | $17.18 | $3.82 |
| Narragansett Bay , RI[1] | 5 | $32.93 | $6.59 |
| Emerson – Saginaw, MI | 5 | $23.82 | $4.76 |
| Birmingham, MI | 5.5 | $15.58 | $2.83 |
| WSSC – Rock Creek | 6 | $23.90 | $3.98 |
| Sunny Dale - San Francisco, CA | 6.2 | $28.73 | $4.63 |
| $14^{th}$ Street – Saginaw, MI | 6.5 | $18.78 | $2.89 |
| Weiss Street – Saginaw, MI | 9.5 | $32.32 | $3.40 |
| Bloomfield Village, MI | 10.2 | $35.72 | $3.50 |
| Edmund – Oakland, CA | 11 | $36.51 | $3.32 |
| Yosemite – San Francisco, CA | 11.5 | $29.89 | $2.60 |
| Tournament Club, Detroit | 22 | $66.77 | $3.03 |
| North Shore, San Francisco, CA | 24 | $119.96 | $5.00 |
| Market Ave. Retention Basin, Grand Rapids, MI | 30.5 | $43.33 | $1.42 |
| Shockoe basin – Richmond, VA | 38 | $58.78 | $1.55 |

EPA has also produced cost curves for offline covered storage with V=volume in million gallons as follows (for volumes between 1 and 50 mg):

$$\textit{Covered Sedimentation/Storage Basin Cost (\$M)} = (\textit{Current ENRCCI}/6{,}383)*(4.823\ V^{0.826})$$

Based on Engineer's estimates of construction cost, construction costs for open basins are 75% of the cost of covered basins. The following equation was used for open basins (for volumes between 1 and 50 mg):

$$\textit{Open Sedimentation/Storage Basin Cost (\$M)} = (\textit{Current ENRCCI}/6{,}383)*(3.617\ V^{0.826})$$

EPA's cost curve and the construction cost data from actual facilities are plotted on **Figure 3**. As shown on the figure, there is a broad range in actual facility costs. This is due to many factors, including site constraints, geology (e.g. piles or rock excavation required), unit processes included with the basin such as screening or disinfection, and the need to mitigate impacts to the surrounding neighborhood such as including odor control. As an example, the Mariposa facility in San Francisco and the Union Park Detention Center in Boston are two facilities with the highest cost per gallon stored ($20.98 and $17.22 respectively). In the case of Mariposa, the storage facility is an underground, custom-built storage transfer box with small volume (0.7 MG) and varying width (from 20 to 30 feet along its length) in a heavily urban setting. The Union Park Detention Center project included retrofits to an existing pumping station in addition to the construction of four underground storage tanks, fine screens, disinfection, and two sewer diversion structures with control gates.

For the purpose of this study, the cost equation for a covered sedimentation/storage basin was used in developing the cost for facilities at satellite locations, and the cost equation for an open sedimentation/storage basin was used for developing cost for sedimentation/storage basins at the wastewater treatment plant.

Elkhart is also considering the use of Regional Storage Tanks to provide storage and flow equalization for individual CSOs. This type of storage is constructed in-line and utilizes 10 foot by 10 foot box culvert sections. The cost per foot for various depths of installation were developed based on quotes from local suppliers and then compared to the conveyance pipeline cost based on similar carrying capacities.

## 2.8 Tunnels and Drop Shafts

Cost data for tunnels were gathered from a variety of sources as follows:

- Cost estimates were obtained from an engineering firm specializing in tunneling, Dr. G. Sauer Corporation. (Dr. G. Sauer Corp, 2001).

- Actual and estimated cost data for tunnels obtained from various municipalities.

Tunnels in soils are significantly more expensive than those in rock and cost were thus developed separately for each of the tunneling media. This data is shown in **Tables 5 and 6**.

## Table 5

## Construction Cost Data for Tunnels in Rock

| Source of Data | Diameter (ft) | Unit Cost ($/LF, ENR=7,200) |
|---|---|---|
| EPA (Weston) Cost Curve - Estimate | 10 | $2,600 |
| | 15 | $3,360 |
| | 20 | $4,200 |
| | 25 | $4,800 |
| | 30 | $5,601 |
| | | |
| District of Columbia Board of Engineers Estimate | 10 | $3,497 |
| | 15 | $6,171 |
| | | |
| Narragansett Bay, Rhode Island Estimate | 10 | $1,050 |
| | 20 | $2,324 |
| | 30 | $3,739 |
| | | |
| Dr. G. Sauer Corp. Full Face Tunnel Boring Machine, 5-10,000' long tunnel Estimate | 10 | $2,326 |
| | 15 | $2,616 |
| | 20 | $2,907 |
| | 25 | $3,633 |
| | 30 | $4,361 |
| | | |
| Dr. G. Sauer Corp. Full Face Tunnel Boring Machine, greater than 10,000' long tunnel Estimate | 10 | $2,215 |
| | 15 | $2,493 |
| | 20 | $2,769 |
| | 25 | $3,462 |
| | 30 | $4,154 |
| | | |
| Dr. G. Sauer Corp. Hand Mine, New Austrian Tunneling Method, 5-10,000' long tunnel Estimate | 10 | $3,313 |
| | 15 | $3,727 |
| | 20 | $4,141 |
| | 25 | $5,176 |
| | 30 | $6,212 |
| | | |
| Dr. G. Sauer Corp. Hand Mine, New Austrian Tunneling Method, >10,000' long tunnel Estimate | 10 | $3,229 |
| | 15 | $3,633 |
| | 20 | $4,037 |
| | 25 | $5,047 |
| | 30 | $6,056 |

| Source of Data | Diameter (ft) | Unit Cost ($/LF, ENR=7,200) |
|---|---|---|
| | | |
| Dr. G. Sauer Corp., Weathered Rock, Hand Mine, New Austrian Tunneling Method , <2500' long tunnel Estimate | 10 | $3,569 |
| | 15 | $4,016 |
| | 20 | $4,461 |
| | 25 | $5,577 |
| | 30 | $6,692 |
| | | |
| Richmond, Virginia CSO 4/5 – Actual Cost | 14 | $3,793 |
| | | |
| Rochester, NY CSO system – Actual Cost | | |
| Lyell Ave | 12 | $1,680 |
| Saxton-Colvin/Jay-Arnett | 10 | $1,193 |
| Saxton-Colvin/Jay-Arnett | 8 | $1,139 |
| Lake Ave | 14 | $1,558 |
| St. Paul (Siphon) | 7 | $948 |
| Senaca/Norton | 12 | $1,827 |
| Dewey-Eastman/Tiger Carlisle | 14 | $2,293 |
| Lake Ave Extension | 14 | $2,942 |
| State-Mt. Hope | 14 | $3,401 |
| | | |
| WMATA (by contract no) – Actual Cost | | |
| A-6 | 15 | $2,941 |
| A-9 | 15 | $4,932 |
| B-11a | 15 | $1,521 |

**Table 6**

**Construction Cost Data for Tunnels in Soil**

| Source of Data | Diameter (ft) | Unit Cost ($/LF, ENR=7,200) |
|---|---|---|
| South Bend 1994 Study Estimate | 13.5 | $3,240 |
| | | |
| District of Columbia Board of Engineers Estimate | 7 | $4,114 |
| | 10 | $6,686 |
| | 15 | $11,109 |
| | | |
| M & E 1973 Estimate – Low / High | 12 | $ 2,400 / $ 6,000 |
| | 20 | $ 6,000 / $ 10,000 |
| | 30 | $ 11,800 / $ 18,001 |
| | | |
| New York City Estimate | 20 | $6,933 |

| Source of Data | Diameter (ft) | Unit Cost ($/LF, ENR=7,200) |
|---|---|---|
| | 25 | $9,024 |
| | 30 | $11,280 |
| | | |
| Other Cities – Actual Cost | | |
| Cleveland | 20 | $4,113 |
| Birmingham, MI | 11 | $1,267 |
| Chicago, IL | 12 | $1,825 |
| Toledo, OH | 13.5 | $2,286 |
| Toledo, OH | 13.5 | $2,999 |
| PCI, MI | 13.5 | $4,066 |
| Wyandotte, MI | 13.5 | $1,989 |
| Washington, DC | 21 | $5,505 |
| Mishawaka, IN | 10 | $3,689 |
| | | |
| Dr. G. Sauer Corp, in Cretaceuos Formations[3], 5-10,000' long tunnel Estimate | 10 | $3,601 |
| | 15 | $4,051 |
| | 20 | $4,501 |
| | 25 | $5,626 |
| | 30 | $6,751 |
| | | |
| Dr. G. Sauer Corp, in Cretaceous Formations[3], >10,000' long tunnel Estimate | 10 | $3,419 |
| | 15 | $3,846 |
| | 20 | $4,274 |
| | 25 | $5,342 |
| | 30 | $6,412 |
| | | |
| Dr. G. Sauer Corp, in Terrace Deposits[4], 5-10,000' long tunnel Estimate | 10 | $4,555 |
| | 15 | $5,123 |
| | 20 | $5,693 |
| | 25 | $7,117 |
| | 30 | $8,540 |
| | | |
| Dr. G. Sauer Corp, in Terrace Deposits[4], >10,000' long tunnel Estimate | 10 | $4,359 |
| | 15 | $4,903 |
| | 20 | $5,448 |
| | 25 | $6,811 |
| | 30 | $8,172 |

[3] Cretaceous formations are sediments ranging from plastic clay to sand. Shield tunneling machines or hand mining methods using NATM are options.
[4] Terrace Deposits are stiff to hard, plastic clay with trace and pockets of fine sand. Dual mode shield tunneling machines and hand mining are options.

| Source of Data | Diameter (ft) | Unit Cost ($/LF, ENR=7,200) |
|---|---|---|
| | | |
| WMATA (by contract no) Actual Cost | | |
| C-4 | 15 | $3,286 |
| D-9 | 15 | $5,959 |
| F-3c | 15 | $5,253 |
| E4b | 15 | $3,589 |
| E4b | 15 | $4,572 |

The aforementioned cost data per linear foot of tunnel were plotted against finished tunnel diameter, for excavation in both rock and soil, as shown in **Figure 4**. For both rock and soil tunnels, a best-fit polynomial equation whose values were greater than or equal to most of the plotted values was developed. The equations for both rock and soil tunnels as a function of finished tunnel diameter in feet are as follows:

$$Cost = (Current\ ENRCCI/6{,}383)*(3(dia)^2 + 35(dia) + 2{,}410) \qquad (rock)$$

$$Cost = 1.15*\ [(Current\ ENRCCI/6{,}383)*(6.2086(dia)^2 - 79.283(dia) + 4056.6)] \quad (soil)$$

The soil tunnel cost equation was recalibrated in 2007 after discussions with tunneling experts to better estimate current construction costs. The recalibration increased unit costs by 15%.

For the purpose of this study, the equation for tunnels in soil was used to develop costs.

## 2.9 Tunnel Drop Shafts

Drop shafts will be required to convey flow from the elevation of the outfalls (near grade) down to tunnel level. Drop shafts were based on the vortex drop design based on pilot studies by Jain and Kennedy (Jain and Kennedy, 1983) for the Milwaukee CSO tunnel system. The drop shafts typically include:

- Tangential inlets – an approach channel designed to even out the flow streamlines and to force the flow into a spiral pattern.

- Drop shafts – vertical drop shafts where the CSO falls downward in a spiral pattern. The spiral pattern is designed to allow air to escape up the central core, preventing bulking of the flow. It also dissipates the energy gained by the flow when falling vertically.

- Deaeration chamber – chamber at the bottom of the drop shaft where air is allowed to escape before the CSO enters the main tunnel.

Preliminary layouts were prepared for 75, 200 and 1,500 mgd facilities, and quantity takeoffs and cost estimates were prepared as shown in **Table 7**.

**Table 7**

**Tangential Inlet, Drop Shaft and Deaeration Chamber Construction Costs**

| Flow Rate (mgd) | Tangential Inlet | Drop Shaft | Deaeration Chamber |
|---|---|---|---|
| 75 | $237,529 | $1,014,659 | $263,393 |
| 200 | $315,345 | $1,139,258 | $498,640 |
| 1500 | $961,961 | $1,832,252 | $2,330,315 |

The values in Table 7 were used to develop construction cost curves as a function of flow rate in mgd (**Figure 5**). The derived equations are as follows (for flows between 75 and 1,500 mgd):

*Cost = (Current ENRCCI/6,383)*(503.89(mgd) + 206,813)   (tangential inlets)*

*Cost = (Current ENRCCI/6,383)*(4.2855(mgd) + 7,685.3)*VLF   (drop shafts)*

*Cost = (Current ENRCCI/6,383)*(1,433.5(mgd) + 182,624)  (deaeration chambers)*

## 2.10 Enhanced High Rate Clarification

Cost for enhanced high rate clarification facilities were developed by performing quantity take-offs for different sizes of treatment facility. Kruger Actiflo provided equipment costs for the quantity take-off. From the quantity take-offs, the following equation was derived (for flows from 1 to 1,000 mgd):

$$Cost = (Current\ ENRCCI/7{,}200)*(4.4871(mgd)^2 + 89{,}176(mgd) + 2{,}000{,}000)$$

## 2.11 Screening Facilities

Costs for screening facilities were developed by performing quantity take-offs for different sizes of screening facility. Waterlink provided equipment costs for the quantity take-off. From the quantity take-offs, the following equation was derived (for flows between 15 and 500 mgd):

$$Cost = (Current\ ENRCCI/7{,}200)*(0.0000004(mgd)^5 - 0.0009(mgd)^4 + 0.6087(mgd)^3 - 171.79(mgd)^2 + 27921(mgd) - 166{,}355)$$

## 2.12 Chlorine Contact Tank

Costs for the disinfection system were developed by performing quantity take-offs for different sizes of facilities. These costs are based on a contact time of 15 minutes. From the quantity take-offs, the following equation was derived (for flows between 10 and 500 mgd):

$$Cost = (Current\ ENRCCI/7{,}200)*(-0.0002(mgd)^4 + 0.2717(mgd)^3 - 120.92(mgd)^2 + 40{,}534(mgd) + 436{,}059)$$

For flows between 500 and 2,450 mgd, the following equation was derived:

$$Cost = 50{,}058*(mgd)^2 - 8*10^7*mgd + 3*10^{10}$$

## 2.13 Chemical Storage Facility

Costs for the chemical storage were based on:

- Providing tankage for back to back events with one back up tank, based on a chlorine dosage of 10 mg/L
- Event volume refers to total runoff volume for event. Event volume equals tank volume in storage tanks. Event volume does not equal tank volume in high rate treatment tanks.
- Size building for approximately 650 sf building area/storage tank to provide walkways and room for electrical, HVAC, plumbing and electrical systems
- Steel-framed, concrete building with a cost of $150 per square foot of building floor area
- 10' diameter, 4,000 storage tanks with a cost of $15,000 per tank
- Assume electrical costs = 25% of building and tank costs
- Assume HVAC and plumbing costs = 5% of building and tank costs

- ENR CCI = 8,000

**Figure 6** shows chemical storage facility costs for different event volumes.

## 2.14 Solids Storage Tank

Costs for solids storage were developed by performing quantity take-offs for different sizes of storage tanks. The tanks are sized to store solids from back to back storms. A TSS concentration of 5,000 mg/l and ½% sludge was assumed. From the quantity take-offs, the following equation was derived (for volumes between .0012 and 16 mg):

*Cost = (Current ENRCCI/7,200)*(4,000,000(mg) + 321,305)*

# Section 3 Capital Costs

Engineering, legal and administrative fees are added to the Total Estimated Construction Cost by a factor of 20%. This amount is anticipated to cover normal administrative soft costs, exclusive of condemnation, hazardous waste or unique engineering considerations.

# Section 4 Operation and Maintenance Costs

Operation and maintenance (O & M) costs were estimated using the following bases:

- Operation – Labor costs and requirements for the various CSO alternatives were based on the average cost of maintaining a single operating post manned by one operator on a 24 hour, year round basis. Operations labor is approximately $30.12/hour, including benefits. Thus the average cost of one position was approximately $88,000. Assuming an eight hour workday, with three shifts per day, for 365 days per year, the average cost for a Continuous Operating Post (COP) would be $264,000. Although general guidelines concerning the number of COPs are shown in **Table 8**, the number of COPs required for each alternative was determined on a case by case basis.

- Maintenance costs for facilities were taken as a percentage of the construction cost.

- Treatment costs are only for enhanced high rate clarification. This cost includes coagulants, polymers, and sand needed for operation.

- Power & Chemicals – After discussion with utility staff, it was assumed that power and chemical costs are included in operations and maintenance costs.

## Table 8

## Operation and Maintenance Cost Basis

| Item | Unit | Cost Basis (per year) |
|---|---|---|
| **Operation** | | |
| Conveyance pipelines | -- | Included in maintenance cost, see below |
| Sedimentation/Storage Basins | COP | 0.5 |
| Pump stations*<br>Up to 100 mgd<br>Over 100 mgd | <br>COP<br>COP | <br>0.5<br>2.0 |
| Enhanced High Rate Clarification (EHRC) | COP | 2.0 |
| Tunnels | COP | 1.0 |
| **Maintenance** | | |
| Conveyance pipelines | % of construction cost | 0.25% |
| Sedimentation/Storage Basins | % of construction cost | 3.0% |
| Pump stations | % of construction cost | 3.0% |
| EHRC | % of construction cost | 3.0% |
| Tunnels | % of construction cost | 1.0% |
| Vortex Separators | % of construction cost | 3.0% |
| **Treatment** | | |
| EHRC | MG | $120 |

*Pump station operation for storage/sedimentation basins and tunnels included in storage/sedimentation and tunnel operation. Only add pump station operation costs if stand alone pump station.

# Section 5 Present Worth Analysis

All costs were compared on a present worth basis by adding the total capital cost with the uniform series present worth (P/A) of the O&M costs using the following assumptions:

**Table 8**

**Present Worth Assumptions**

| Item | Description |
|---|---|
| Planning Period | 20 years |
| Interest Rate | 7.0 % |

As the LTCP process proceeds, present worth costs are expected to change based on inflation, refinement of alternatives, and a more detailed financial analysis performed by a financial consultant.

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GREELEY AND HANSEN

# Appendix E

## Public Participation Documentation

City of Elkhart

*The city with a heart*

David L. Miller
*Mayor*

Public Works
& Utilities

Administration
1201 S. Nappanee Street
..hart, Indiana 46516
..one: 219.293.2572
Fax: 219.293.7658

Customer Billing
921 N. Main Street
Elkhart, Indiana 46514
Phone: 219.264.4273
Fax: 219.206.8736

Board Of Public Works
229 S. Second Street
Elkhart, Indiana 46516
Phone: 219.294.5471
Fax: 219.293.7964

August 30, 2000

Ducks Unlimited
Ducks Unlimited

RE: Public Participation in Combined Sewer System Long Term Control Plan Preparation and Implementation

Dear : Ducks Unlimited

Our nation continues to work at improving the quality of our surface water bodies and significant progress has been made over the past thirty years. Initially, focus has been on discharges from a "point source." These included elimination of untreated (and partially treated) industrial and municipal wastewater discharges into surface water bodies, improving the technologies of treatment of permitted discharges into the receiving streams, and reducing (or eliminating) overflows from combined systems. With these objectives completed, the focus will then move into controlling the "non-point" sources of pollution, which include management of urban stormwater, management of runoff from construction sites, and the control and mitigation of agricultural runoff. In the next decade or more, however, the focus will be on reducing the contribution to surface water quality degradation due to the discharges from combined sewer system systems.

The City of Elkhart currently owns and operates a combined sewer system. We are one of nearly 1000 such communities across the nation, and one of 106 here in the State of Indiana. A combined sewer system means that portions of our sewage collection network throughout the city is also linked with surface runoff collection. In a rain event, portions of our sewer system carry the combined flow of sewage and stormwater. In large rainfall events, the designed carrying capacity of the system is exceeded, activating discharges from the system at relief points, typically along our city's rivers. This relief keeps the system from surcharging into basements and onto streets. The discharge itself is known as a combined sewer overflow, or CSO. In general, the term "CSO" refers to the discharge and the constructed facility at the point of the discharge.

In 1994, the federal government through the USEPA issued a National CSO Policy which required the states to implement programs toward reducing CSO impacts to our nation's waters. This policy recognizes the technical, socio-economic, and political complexity this challenge. Therefore, it requires communities with CSOs to develop a detailed plan for reducing their CSO impacts to their local receiving waters. By analyzing a set of technical alternatives and their associated costs, the plan must devise an implementation program that prioritizes improvements to the sewer systems over a relatively long period of time (10 – 15 years, for example) such that improvements to the water quality are realized. This plan is called the LONG TERM CONTROL PLAN (LTCP).

The City of Elkhart Public Works and Utilities has been proactively working toward its LTCP over the past 5 years. A number of best management practices in operating our system were implemented in 1995. Public Works staff members have been especially active in working with State of Indiana environmental officials in drafting the state's LTCP strategy. Over the next year, the City of Elkhart will be preparing for submittal to the Indiana Department of Environmental Management our Long Term Control Plan. We are on a schedule for submittal by October 1, 2001.

A key element in the development of our LTCP is participation from our community's stakeholders that both use our sewer systems and who use our community's water bodies. These include business and industrial representatives, residents, community leaders, civic groups, local environmental advocates, and city staff.

You (or your organization) have been identified as a person (or group) which represents one of these interests. We are respectfully requesting that you consider being a participant in the public input aspect of our plan development. Because of your experience and background and commitment to our community, your input to the process would be very helpful and useful. We anticipate that your commitment to our LTCP development group would require attendance at a minimum of five 2-hour meetings over the course of the 13 month period between September 1, 2000 and September 30, 2001. All meetings will be held in the evening hours (7:00 PM – 9:00 PM) at the Dept. of Public Works & Utilities offices located at 1201 S. Nappanee Street. The meetings will be conducted in a "workshop" fashion in which the city staff will outline the issues and facilitate input from the group. The staff will also be responsible to address your comments and feedback. If necessary, additional outside resource persons will be brought in to add to the input.

Our first meeting is scheduled for **Tuesday, September 19, 2000, at 7:00 PM at the City of Elkhart Public Works and Utilities office at 1201 S. Nappanee St.** At this first meeting, staff will present an overview of the CSO program for Indiana, review the studies that have been completed to date, and outline the elements of the LTCP development that will be the focus of the next 12 months. Additionally, an overview of the LTCP development resourcing will be presented for discussion. Your presence and participation will be most welcomed. If you are unable to attend, or wish to send another person in your place, please let our office know ahead of time.

On behalf of the City of Elkhart, I want to personally thank you in advance for this commitment you will make to our community in this effort.

Please call if you have any questions.

Sincerely yours,
City of Elkhart Public Works and Utilities

Art K. Umble, Ph.D., P.E.
Manager of Water and Wastewater Operations

August 30, 2000

«FirstName» «LastName»
«Company»
«Address1»
«City», «State» «PostalCode»

RE: Public Participation in Combined Sewer System Long Term Control Plan
Public Meeting No. 2

Dear : «FirstName» «LastName»

In the last quarter of 2000, you were invited to participate in our Citizen's Advisory Council for the development of the City of Elkhart's Long Term Control Plan (LTCP) for control of combined sewer overflows into our local receiving streams. The first CAC meeting was held on November 19, 2000. At that meeting a presentation was made of the Stream Reach Characterization and Evaluation Report (SRCER) which was submitted to the Indiana Department of Environmental Management (IDEM) as required by state law.

Since that time, we have been working on the baseline data that will be used to develop the LTCP. It is critical to the development process to involve the input from our citizens to ensure that the plan reflects our collective community interests. Consequently, we are planning the second public meeting to begin to address the numerous technical and public policy issues, and we would again encourage and welcome your participation. The agenda that we hope to cover in this meeting is as follows:

1. Review of the technical progress

2. Receive public input on "sensitive areas" along the receiving streams

3. Review of potential CSO control alternatives

The meeting is scheduled for Thursday, May 24, at 7:00 PM. It will be held in the City of Elkhart's Common Council Chambers located on the 2nd floor of the municipal building at 229 S. Second Street. We look forward to your attendance and participation.

Please call if you have any questions regarding the meeting.

Sincerely yours,
City of Elkhart Public Works and Utilities

Art K. Umble, Ph.D., P.E.
Manager of Water and Wastewater Operations

City of Elkhart

*The city with a heart*

# Press Release

For Immediate Release
Elkhart Public Works & Utilities


David L. Miller
*Mayor*

Public Works
& Utilities

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## Elkhart Begins Plans to Improve Water Quality in Our Rivers

The City of Elkhart has begun a planning process to improve the water quality in the St. Joseph and Elkhart Rivers. Historically, bacteria levels in the streams throughout the St. Joseph River watershed have exceeded water quality standards, especially during and after rainfall events. Possible sources of the bacteria include combined sewer overflows, storm water runoff, runoff from livestock areas, improperly installed or failed septic systems and animal waste. Within the next five years the Elkhart Public Works & Utilities will be implementing pollution control measures throughout the City's sanitary and storm water sewer systems to help improve our streams water quality. The Elkhart Public Works and Utilities staff is seeking public input, especially from river users and residents living along the St. Joseph and Elkhart Rivers, on the typical uses observed on the rivers. This information is essential in determining the priority locations for implementing cost-effective pollution control measures in the City. If you have an interest in the future water quality of the St. Joseph and Elkhart Rivers, plan to attend a public meeting on Thursday, May 24 at 7:00 PM at the City Municipal Building, 229 S. Second Street. For more information about this meeting and the City's plan, contact Art Umble, Manager of Water & Wastewater Operations or Mark Salee, Regulatory Affairs Specialist, by calling the Public Works & Utilities office at 293-2572.

The Truth
LOCAL/REGION

ELKHART

# Talk to council about rivers

BY RICK MEYER
Truth Staff

ELKHART — If you enjoy boating, fishing or just sitting along the St. Joseph or Elkhart rivers, the city's water technicians want to hear from you.

Elkhart is developing a plan to improve water quality and reduce sanitary and storm sewer overflow into the rivers during heavy rains, when the wastewater treatment system reaches capacity.

City officials are developing a long-term control plan and want public input, especially involving "sensitive areas" like water craft launching points where people come into contact with the water.

The meeting will begin at 7 p.m. Thursday in the council chambers at the Municipal Building, 229 S. Second St. City staff will present reviews of the technical progress and potential combined sewer overflow control alternatives. In between, public input will be accepted.

"We want to hear from the public to make sure we're viewing the rivers as the community does," said Art Umble, the city's operations manager for water and wastewater. "We want to be on the same page.

"Sometimes we go off on the technical issues and we're not always picking up all the voices," Umble added. "We want to focus on how we as a community see the rivers as they are being used."

Public input will help determine priority locations for imple-

Please see RIVERS/A6

## RIVERS

From Page A6

menting cost-effective pollution control measures in the city.

Groundwater is the only source of the city's drinking water, but the rivers are important to the community for recreation, fishing and aesthetic enjoyment, Umble said.

"We want to make sure that we eliminate or relocate (combined sewer overflow) outfalls from those areas that are very important for resources and quality of life," Umble said.

The city owns and maintains 24 public parks and greenway areas along the banks of the St. Joseph and Elkhart rivers. None of the public areas are designated as bathing beach areas, but four areas have public access points for boat launching.

Historically, bacteria levels in the streams through the rivers' watershed have exceeded water quality standards, especially during and after rainfall events, according to Umble.

Besides combined sewer overflows, bacteria sources can include storm water runoff, improperly installed or failed septic systems, runoff from livestock areas and animal waste.

In records the last 10 years, no combined sewer overflows were observed from the system in 82 percent of all rainfall events less than a half inch. In the same period, approximately 77 percent of the rainfall events were less than a half inch in depth — and about half of those were less than one-tenth of an inch.

"In the smaller storms, the system is designed to handle the rain," Umble said. "One to 1½ inches in a storm is going to have a significant amount of impact. The overflow is predominately storm water (not sewage) so it's diluted.

Cities have received federal and state mandates to develop a 15- to 20-year plan to separate combined sewer overflows. The cost could be millions of dollars, according to Umble.

Elkhart hopes to prepare its program by October, following another meeting to submit details to the public. A citizens advisory committee met last fall to begin the process.

Since 1985, the city has been separating sanitary and storm sewers with street revitalization projects.

For more information, contact Umble or Mark Salee, the city's regulatory affairs specialist, at Elkhart Public Works and Utilities, 293-2572.

*Contact Rick Meyer at rmeyer@elkhart-truth.com.*

## BACKGROUND

Elkhart's city sewer system stretches underground more than 250 miles, with 49 lift stations and more than 3,500 catch basins. Forty-two percent of the network operates with sanitary and storm sewers combined into one line. Flow usually goes to the city's wastewater treatment plant on South Nappanee Street, but during heavy rains, overflow runs directly into the rivers. The original system had 41 overflow locations — 25 along the St. Joseph River and 16 along the Elkhart River. The city has been separating sanitary and storm sewers since 1985 and has eliminated five overflow points. A plan is being developed to continue reducing overflow points and improving water quality, and public input will be encouraged during a meeting at 7 p.m. Thursday at the Municipal Building, 229 S. Second St.

londay,
ugust 6, 2001

The Truth
LOCAL/REGION

ELKHART

# Basement flooding a rising problem

*City officials offer advice to residents during heavy rains*

By Rick Meyer
Truth Staff

ELKHART — City officials have advice to avoid basement flooding during heavy rains, but residents — generally in older neighborhoods — must act upon the advice.

Water can back up in basements — if the basement drain isn't closed with a plug or valve. Between July 21 and 23, when the city was hit with two downpours, almost 60 residents called the Elkhart Public Works and Utilities department with water problems.

During most rains in the last five years, city officials may receive a call or two, according to Mike Machlan, the city's network engineer for water and sewer. Two weeks ago, the ground was saturated on Saturday and then soaked with almost two inches of rain in a couple hours on Monday.

"It wasn't how much rain we had," Machlan said. "It was how much we had in two hours. If we would have had the same rainfall over a whole day, we probably would have had maybe one or two calls."

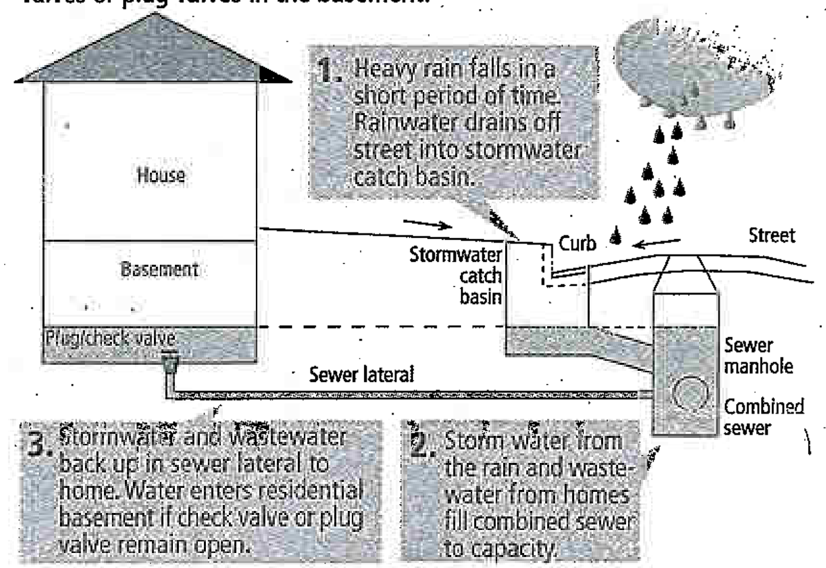
Because the city hasn't had such a deluge since receiving six inches in less than three hours during August 1995, some residents have been lulled into a false sense of security, Machlan believes.

Many houses built before the 1950s have one sewer line carrying both sanitary (including flushing from a toilet) and stormwater into

Please see Flooding/A5

## How to avoid basement flooding ...

in older Elkhart homes with combined storm and sanitary sewers and check valves or plug valves in the basement.




Graphic Provided By Elkhart Public Works And Utilities

## Background

Basement flooding from heavy rainfall in Elkhart is most likely to happen in the hundreds of homes built before the 1950s and connected to the city's combined sanitary and stormwater sewer system.

Although boundaries vary, the effected areas generally go north to Bristol Street, east to Simpson Street/Osolo Road, south to between Lusher and Hively avenues and west to Nappanee Street.

The city stopped building combined sewer systems 22 years ago and has been separating sanitary and stormwater systems since the first project in 1989 along Franklin Street.

The city has been spending at least $1 million a year to separate combined systems and also a 20-year plan for water quality.

At an estimated cost of $150 million or more to separate all combined sewers, city officials are exploring other alternatives to relieve the system.

# FLOODING

From Page A3

the city's combined system. Rainfall on the street moves to the curb to the stormwater catch basin to the sewer manhole.

"Heavy rains can overwhelm the system to the point where it floods," said Art Umble, the city's operations manager for water and wastewater. "The sewer lateral from a home — in the basement — is fairly low with regard to where the sewer is.

"If you don't have anything to stop (the back flow), it's going to come right down the system — and into the basement," Umble continued. "There are precautions to take."

Umble suggests closing the manual plug or valve in the basement before two critical instances — vacation or heavy rainfall.

Some residents have check valves, which allow water to only flow out. Those residents, however, are encouraged to make sure the check valves are operating. In some cases, shutoff valves are located outside, with a wheel-like gate valve.

Basement drains are usually used for discharge from washers, showers, sump pumps, toilets or cleaning runoff. Discharges from the rest of the house are connected to the same sewer lateral — but not through the basement.

The demand on the city's combined sewer system has lessened over the last six years with a program to disconnect downspouts. At one time, roof gutters sent rainfall into 4-inch downspouts, and then into one 6-inch sewer line.

Between homeowners and EnviroCorps volunteers, about 80 percent of those downspouts have been disconnected, according to Machlan. Most rainfall from the downspouts now disperses water in the ground.

"That slows down the process, and that's really helped," Machlan said. "Fifteen years ago, we'd get a rain half as much (as July 21 and 23), and we'd have trouble because of all the downspouts."

Homes with basements but no basement drains are exempt from a backup flooding problem. Also, some of the city's older homes have avoided trouble because they had septic systems — needing no floor drain — installed when the house was build, Machlan said. Others have had their floor drains closed permanently.

Beyond water damage, flooded basements carry health concerns. In a combined system, the backflow contains sewage. Umble offers two suggestions:

- Wait until the water drains out before going in the basement. Water should leave within a couple of hours after the rain stops.
- When cleaning the floor or walls, use water with a bleach solution to help disinfect the area.

Residents who have a recurring flood problem every time it rains probably have trouble in the sewer line itself, according to Machlan. Roots and sediments sometimes work their way into lines.

Residents with questions can call Elkhart Public Works and Utilities at 293-2572 for advice or a private plumber for repairs. Property owners are responsible for lateral lines beyond the street.

*Contact Rick Meyer at rmeyer@elkhart-truth.com.*

**LOCAL DIGEST NOTICE**
**Elkhart Truth**
**For immediate publication**

**Local Citizens Advisory Committee to meet:**

The City of Elkhart Citizen's Advisory Committee on Combined Sewer Overflow Controls will meet on Tuesday, September 11, at 7:00 AM in the Council Chambers at the Municipal Building at 229 S. 2nd Street. The City of Elkhart is one of 105 communities in Indiana having a sewer system designed to carry both sanitary waste and stormwater runoff during a rain event. In large rain events the system is often overwhelmed and a portion of the combined diluted sewage is by-passed from the system through more than 35 overflow points along the Elkhart and St. Joseph River segments in Elkhart. These overflows contribute to short term degradation of the water quality of our rivers. At the meeting, Public Works & Utilities staff will seek input from the public on a series of measures being considered for controlling these overflows as part of the development of a Long Term Control Plan mandated by the State of Indiana. All interested public are encouraged to attend. For more information, please contact Art Umble at the Public Works & Utilities office at 293-2572.

LOCAL DIGEST

## *Elkhart:* Public input sought on sewer overflow issues

ELKHART — The public is invited to attend a meeting on combined sewer overflow controls at 7 p.m. Tuesday in the council chambers of the Municipal Building, 229 S. Second St.

Elkhart is one of 105 communities in Indiana having a sewer system that carries sanitary waste and stormwater runoff during a rain event. During heavy rainfall, a portion of sewage bypasses the treatment facility and flows into the Elkhart and St. Joseph rivers.

At the meeting, public works and utilities staff will accept public input on measures being considered for controlling the overflows in a long-term plan mandated by the state.

For more information, contact Art Umble at public works and utilities, (219) 293-2572.

City of Elkhart

# ***NOTICE OF PUBLIC MEETING***

SEPTEMBER 25, 2001

The City of Elkhart Citizen's Advisory Committee on Combined Sewer Overflow controls will meet on Tuesday, September 25, at 7:00 PM in the Council Chambers at the Municipal Building at 229 S. 2nd Street. The City of Elkhart is one of 105 communities in Indiana having a sewer system designed to carry both sanitary waste and stormwater runoff during a rain event. In large rain event, the system is often overwhelmed and a portion of the combined diluted sewage is by-passed from the system through more than 35 overflow points along the Elkhart and St. Joseph River segments in Elkhart. These overflows contribute to short term degradation of the water quality of our rivers. At the meeting, Public Works and Utilities staff will seek input from the public on a series of measures being considered for controlling these overflows as part of the development of a Long Term Control Plan mandated by the State of Indiana. Additionally, staff will introduce general outlines of costs for the improvements. All interested public are encouraged to attend. For more information, please contact Art Umble at the Public Works and Utilities office at 293-2572.

The Truth LOCAL

LOCAL DIGEST

## *Elkhart:* Sewer overflow meeting to be held Tuesday

ELKHART — The meeting to accept public input on the city's combined sewer overflow plan has been rescheduled for 7 p.m. Tuesday in the council chambers of the Municipal Building, 229 S. Second St.

During heavy rainfall, a portion of sewage bypasses the treatment facility and flows into the Elkhart and St. Joseph rivers.

At the meeting, public works and utilities staff will accept public input on measures being considered for controlling the overflows in a long-term plan mandated by the state.

For more information, contact Art Umble at public works and utilities, (219) 293-2572.

**Elkhart**

# City sewer customers may see rate hike

*Proposal would mean 35 percent increase in charge*

**By Trevor Wendzonka**
Truth Staff

ELKHART — Homeowners and businesses connected to the city's wastewater treatment system likely will pay more for the service in January, the first rate hike in more than a decade. But the increase won't be the last, as city officials work on separating old storm water and sewage lines.

Proposed charges will jump 35 percent, according to figures compiled by city financial consultants. On Tuesday afternoon, Mayor Dave Miller and public works director Eric Horvath began the arduous task of briefing — and convincing — city council members about the proposal.

The minimum monthly charge for sewer customers will rise from $10.43 to $14.09, while most residential customers will see an increase from $14.94 to $20.18. Businesses putting 100,000 gallons into the system each month will pay $209.80, up from $155.29.

Rate changes are necessary to keep a high level of service and make sure the utility is financially sound, according to Horvath. Both he and the mayor emphasized it's not being done to make money, as the utility is cutting into existing cash balances to make sure the impact isn't greater.

"Sewer charges have been kept level for 12 years. The

Please see SEWER/A8

**roposed wastewater increase**

| harge er Month | Present Rate | Proposed Rate |
|---|---|---|
| ,000 gallons | $10.43 | $14.09 |
| ,000 gallons | $11.66 | $15.75 |
| ,000 gallons | $13.30 | $17.97 |
| ,000 gallons | $14.94 | $20.18 |
| 0,000 gallons | $23.14 | $31.26 |
| 00,000 gallons | $155.29 | $209.80 |
| 1 million gallons | $1,191.40 | $1,609.58 |

Source: H.J. Umbaugh & Associates



# Sewer

From Page A1

council has understood that couldn't go on forever without an increase," Horvath said. "The only problem I can see is the size of the increase. We understand 35 percent is significant, but we've always been told by the council that infrastructure is important.

"We can stop doing projects ... (and) run the equipment into the ground and leave things in horrible shape for the next guys, but we're not going to do that. We believe in solid infrastructure for a stronger city."

The last hike was approved in 1989 to pay for the $11 million expansion to the wastewater treatment plant. Rates went up then between 29 percent and 32 percent, based on usage.

Residents and business owners will have the chance to comment when the issue goes to the city council for consideration in at least a month. The first step in the process is a recommendation by the board of works, which Horvath said could come as soon as a Nov. 6 meeting.

In the coming years, users may see annual increases to fund the separation of combined sewers. The city is preparing its long-term control plan, aimed at protecting the rivers from pollution during significant weather events, for state and federal environmental officials to review.

Elkhart has 38 combined sewers, and each year, a couple of them are separated and repaired. About $245 million will be necessary to fix all of them, but environmentalists are expected to stop short of requiring that. The Indiana Department of Environmental Management and the Environmental Protection Agency will make cities reasonably protect public waters, however, and limit the number of days sewage discharge will be allowed.

Horvath said the city is saving a little money each year for the sewer system overhaul, but users will eventually be asked to fund the plan.

While the wastewater system lost 20 percent of its business when the Bayer Corp. citric acid plant closed, Horvath said it is not the sole reason for the rate hike. Increased costs for operations and equipment and, importantly, the need to improve the sewage delivery lines will take more than $2.3 million out of the cash reserves for this year alone.

No plant expansions are planned, and Miller said the city has plenty of capacity to handle new users. He pointed to the Elkhart East business and commercial park development at C.R. 17 and the American Countryside tourist attraction at S.R. 19 as two significant potential customers, but he added the economy will play a role in how those areas develop.

"Everybody hates a price increase — always," the mayor said. "We wouldn't be asking for this if it wasn't necessary. The city of Elkhart should be proud of the infrastructure we have and the service we offer, and we're committed to keeping it up."

*Contact Trevor Wendzonka at trevorw@elkhart-truth.com.*

ELKHART

SATURDAY
OCTOBER 20, 2001
OUR 112TH YEAR, NO. 293
50 CENTS
WWW.UGO2KNOW.COM

# Council backs sewer charges

## *Some members want rate hike to be spread out*

**BY TREVOR WENDZONKA**
Truth Staff

ELKHART — A majority of the Elkhart City Council supports increasing sewer charges to pay for system improvements, though some tinkering could still be done.

Earlier this week, many council members were briefed by public works officials about the need for a 35 percent increase to keep the utility from cutting improvement projects. For two years, cash reserves have been tapped to balance the books.

**Waiting:** Industrial users weighing effects of sewer rate hikes/ **A8**

The proposed rate hike would raise residential user bills by $5, to more than $20 each month. Sewer charges haven't been adjusted since 1989, when users were asked to pay for the expansion of the wastewater treatment plant.

"We hear all the time from people who want us to keep up with the sewers. They say, do what you have to do — just don't let it flood our basements," said Republican council member David Ashe. "I don't like that it's that steep of an increase, but if you average it, it's only like 2 percent a year. This is just a way of playing catch up."

Rod Roberson, a Democrat

Please see SEWER/A8

## SEWER

From Page A1

member, said he has asked the city's financial consultant to consider a gradual increase, possibly spread over four years.

"I think we've had good conversations and been kept abreast of the situation and the eventual need for this increase," Roberson said. "I think the department has had good stewardship ... but a stepping-stone approach to this increase may be for the best. I think it should be done to raise the amount required in each year to cover expenses, not necessarily all at once."

While some of the expenditures in the future will cover machinery upgrades at the plant, a significant amount of money will be dedicated to replacement of combined sewers and other aging lines.

Eric Horvath, director of public works, said two major neighborhood revitalizations are in the works for next year — Middlebury Street, between Main Street and Goshen Avenue, and Blaine Avenue, between Benham Avenue and Ninth Street.

Council President Tim Neese said, "We have a sophisticated wastewater treatment facility that requires a lot of dollars to have a high level of service. I don't think there will be strong opposition to this from any homeowner because people understand the merits of having strong infrastructure."

Both Neese and fellow member Arvis Dawson were on the council the last time an increase was sought. Dawson said little opposition was heard then for the 29 to 32 percent hike.

"Good sewer service is a priority for the people in my district, and while we like to keep the rate down, we have to have the necessary funds to operate," Dawson said. "It's been 12 years since the last increase. We have to make up for some of that, but I hope in the future, we're proactive and out in front of these things so the increase isn't as large."

Republicans Bob Lindahl and David Henke also said they were supportive of public works officials and the request, though Henke made some points similar to Roberson.

"I believe it's a necessary step, but I also believe the increase should be commensurate to the need," Henke said. "In the future, any increases should be viewed as a tax and decided based on the critical need at that time ... with expenditures scrutinized the same as with other departments."

Before the council can debate the issue and accept public opinion, the Elkhart Board of Public Works must first recommend the rate hike. Horvath said the board may receive the proposal at their Nov. 6 meeting.

*Contact Trevor Wendzonka at trevorw@elkhart-truth.com*

City of Elkhart

*The city with a heart*

David L. Miller
*Mayor*

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October 29, 2001

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1529 W Franklin
Elkhart IN 46516

RE: Citizens Advisory Committee meeting
Long Term Control Plan for CSOs

Dear Business Owner:

On behalf of the City of Elkhart's Public Works and Utilities, I am writing to invite you to our next meeting for the Citizens Advisory Committee for the development of our community's Long Term Control Plan for the combined sewer overflow reduction/elimination program. We are very appreciative of your willingness to serve our community in this very significant issue.

**The meeting is scheduled for Tuesday, November 20th at 3:00 PM in the Large Conference Room at the Public Works & Utilities office located at 1201 S. Nappanee St. The meeting will likely last until 5:00 PM.**

The agenda that we intend to cover that evening will be the following:

1. Review the results of the integrated control alternatives applied to address overflow conditions along the St. Joseph and Elkhart River segments
2. Review the results of the water quality simulations that reflect the inputs of these integrated alternative controls
3. Review the results of the initial cost models for the integrated control alternatives
4. Introduce the affordability analysis based on the estimated costs

You will receive a package summarizing the above work, along with the "roadmap" of how we see the project progressing from this point to its completion. We desire that you have a clear understanding of the issues involved and the relative costs.

We look forward to receiving your input and feedback on the development of this plan thus far. If you have any questions, please do not hesitate to call. We hope to see you there.

Sincerely yours,
City of Elkhart Public Works and Utilities

Art K. Umble, Ph.D., P.E.
Manager of Water and Wastewater Operations

cc: Eric Horvath, P.E., Director of Public Works
Mark Salee, Regulatory Affairs Manager
Mike Machlan, P.E., Network Engineer

ELKHART

# Plan would reduce sewer overflow into rivers

BY JAVIER SERNA
Truth Staff

ELKHART — The state wants Elkhart to come up with a plan by April 1 to meet water quality standards. The city has a plan, but a federal policy may not allow Elkhart to afford it.

City officials met for a presentation Tuesday by Art Umble, Elkhart's wastewater treatment operations manager, as he went over options to get away from the city's archaic sewer system, known as combined sewer overflows (CSOs), which combine storm and waste sewage.

When there's as much as a quarter inch of rain, CSOs dump waste into the St. Joseph and Elkhart rivers.

Umble's plan would make an impact on water quality, as the system would overflow when the system received 0.8 inch of rain instead of the current 0.24 inch. On average, the system has around 70 overflows a year, which the proposed system would cut in half.

Indiana's standard of acceptable E. coli is the highest in the U.S. But Indiana, with 106 municipalities with CSOs, has more than any other state. Elkhart had 41 CSOs in 1985, but since then, five vestiges of the 1930s sewer technology have been removed.

Umble's plan will utilize an existing 15,000-foot tunnel for water retention instead of costlier volume upgrades at the plant. It would eliminate the three CSOs responsible for the majority of the wastewater discharge.

The problem is cost at $240 million over 30 years, coming out to $8 million a year. A federal policy won't allow cities to charge more than 2 percent of a city's median household income. Currently, at an average of $20 a month, Elkhart residents pay 1 percent of the median. But Umble's plan would cost 1.7 percent, and would not cover other costs of running a water treatment plant.

Mark Salee, regulatory affairs specialist with Elkhart's public works, said the number would exceed the 2 percent cutoff.

In any case, Umble said he has no choice but to press forward.

By law, his plan must meet IDEM's water quality standard, he said, even if it exceeds the median household income.

"Then the IDEM will come back and say we can either change the water quality standards or we can give you a suspension of the standards any time you get a storm that pushes you beyond that point."

Umble said it could be some time before a plan is decided upon and implemented, but in the meantime Elkhart will continue to take small steps toward removing the CSOs.

"I've seen dramatic water quality improvements since 1972, and I'm convinced there will be continued water quality improvements," Umble said. "Otherwise, there is no reason to do this."

*Contact Javier Serna at jserna@etruth.com.*

## BY THE NUMBERS

- **0.24 inch:** How much rainfall triggers Elkhart's combined sewer overflow system
- **70:** How many times the system annually overflows — dumping sewage into the St. Joseph and Elkhart rivers.
- **0.8 inch:** How much rain would trigger the system under a proposed system
- **235:** Number of columns of E. coli bacteria per column hundred that is the acceptable state standard.
- **80,000:** A one-time reading of E. coli in Elkhart after one big storm.
- **$240 million:** Cost — over 30 years — of carrying out city's proposal to improve system.

*Source: The Indiana Department of Environmental Management*

# The Truth

WHERE YOU GO TO KNOW — THE ELKHART COUNTY AREA

SUNDAY
FEBRUARY 24, 2002
OUR 113TH YEAR, NO. 55
$1.50
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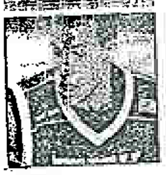
INSIDE

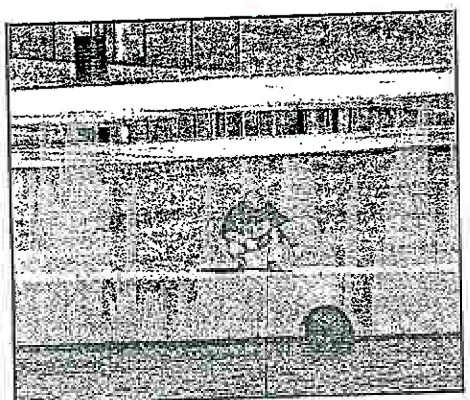
DON'T MISS/A3

A Chicago native has traded big-city life for log- cabin living in Middlebury.

SPORTS/B1



# Sewer issue could halt growth



TRUTH PHOTO BY FRED FLURY

**CSO:** Art Umble points to one of many CSOs along the St. Joseph River bank in Elkhart.

## *State considering action if overflow problems persist*

By TREVOR WENDZONKA
Truth Staff

A new interpretation of environmental rules could put a stranglehold on economic development around Indiana's cities and towns.

If taken to the extreme, no new sewer construction permits would be issued in cities and towns with combined sewers. Officials say they need growth because fees from new construction are part of the funding mix to fix the problem.

**Right to know:** Proposal says cities must warn of overflow/ A2

Residential areas with failing septic systems would still be allowed to hook in to municipal wastewater lines.

Environmental watchdog groups support the strict interpretation to convince communities to do away with combined sanitary and storm lines. During significant weather events like spring thaws and summer storms, overflow from the pipes is discharged into streams, rivers and ditches, compromising water quality.

Even though lines are separated when extended to new development, the water still flows through combined sewers on the way to wastewater treatment facilities.

Cities and towns are in the process of writing long-term control plans for com-

Please see SEWER/A2

**MONDAY**

Combined sewer overflows discharging sewage into rivers and streams is a problem throughout Indiana. Wanting to clean up the problem is easy — but the cost is huge. Starting Monday, *The Truth* will publish a three-day series of articles by The Associated Press on this issue.

# SEWER

From Page A1

bined sewer overflows, but readily admit they cannot match the astronomical price tag for eliminating all such discharge points.

In Indiana, 105 communities have wastewater and storm runoff moving through some of the same sewer lines, mostly in the oldest areas. Elkhart has the fourth most overflow points in the state with 39; Nappanee, Goshen and Wakarusa all have more than five.

A first draft of the "non-rule policy" by the Indiana Department of Environmental Management is expected to be announced March 13. A few people, including State Sen. Marvin Riegsecker, R-Goshen, are worried about the outcome.

"We've been hearing these rumors, and the Senate Environmental Committee is suspicious that IDEM will wait until we adjourn to announce this policy," Riegsecker said. "It would be completely irresponsible of IDEM to not allow any new hookups, particularly if they expect our communities to produce results on these long-range plans."

The city of Elkhart is staring at a $100 million plan just to relieve most of the CSO problem. Sewer fee increases are expected to fund part of the work, but city leaders are counting on new users to pick up some of the tab, too.

"We most definitely want to improve the environment, but as a city, we need to have growth to support these improvements. It's going to be expensive work," said Mark Salee, Elkhart's regulatory affairs specialist. "Economic development is an important element. If we don't have it, we all lose. The economy suffers, and we'll not have implemented the environmental improvements."

A strict interpretation would be "rule making run amok," according to Nappanee Mayor Larry Thompson.

"Every thing we do touches the environment. As long as we show that, in good faith, we're making an effort to solve the CSO problem through our long-term control plan, I don't see a problem," said Thompson, who has an overflow pipe in his back yard, extending into the Berlincourt Ditch. "But to stop growth all together, that's ridiculous."

Groups like Improving Kids' Environment, which brought the issue to IDEM on behalf of the Sierra Club and others, say development won't be stifled. Instead, if industrial and commercial builders want a sewer connection, they can install retention ponds to keep storm runoff on site.

"The law already says 'no net increase' in the system (for combined sewers)," said Tom Neltner, president of IKE. "We understand that the old system is going to take time to get fixed. We have to stop making it worse."

David Kelly of the Greater Elkhart Chamber of Commerce sees the issue differently. If greenfield developments aren't given the opportunity to hook up to city sewer, septic systems will be installed. When septics go bad, the environment still suffers.

"With a non-rule making situation, there were no meetings to attend and no input to be taken from the public," Kelly said. "It makes me nervous not to see what's happening in this process."

And the people making the policy at IDEM aren't receptive to all the discussion and suspicion surrounding their work.

"Like the Bible, regulations are interpreted in a wide number of ways," said Reggie Baker, the department's urban wet-weather section chief. "We already have the authority to deny (construction) permits. ... Nobody (should have) a rub with our policy yet because nothing is firm and set right now."

*Truth staff member Javier Serna contributed to this story. Contact Trevor Wendzonka at trevorw@etruth.com and Javier Serna at jserna@etruth.com.*

The Truth

Sunday, February 24, 2002

# Proposal: Public must be told of overflow

## *Elkhart official gives cautious support to rule*

**BY JAVIER SERNA**
Truth Staff

When rains cause combined sewers to overflow and discharge untreated sewage into rivers and streams, Tom Neltner says cities should inform the public.

"If I tell a parent that, today, there's sewage (in the waterway), they're going to keep their kids away from the water," said Neltner, president of Improving Kids Environment, a coalition of different environmental groups around the state — Hoosier Environmental Council, Save The Dunes Council, Sierra Club and Concerned Clergy. "That alone is important enough."

The Indiana Department of Environmental Management published Title 327, which would require cities with combined sewer overflows (CSOs) to develop a system of informing the public when CSO events occur, educate the public on health impacts of CSO discharges, and immediately alert people likely to come into contact with the tainted water.

Elkhart's sewer system averages 70 combined sewer overflow events every year. The Associated Press reported Elkhart annually discharges 880 million gallons of CSO water from its 150 miles of combined sewer systems.

Neltner, who has been lobbying for the "right-to-know" rule, said in general, cities have been apprehensive about the rule.

"It's a very scary concept," Neltner said. "You don't know what to expect when you tell people, 'Today, it's not a good idea to go boating.'"

Art Umble, superintendent of water and wastewater operations for the city of Elkhart, isn't against such a rule, but is cautious.

"All information is good as long as it's done appropriately," said Umble, who projected the Water Pollution Control Board will likely rule on the idea later this spring. "We need to determine who should know (when events occur), how do we distribute the information, and to what degree it needs to be done."

The public comment period on Title 327 closes March 2.

*Comments can be postmarked, hand-delivered or faxed to MaryAnn Stevens, Rules Section, Office of Water Quality, Indiana Department of Environmental Management, P.O. Box 6015, Indianapolis, IN 46206.*

*Contact Javier Serna at jserna@etruth.com.*

Inside: Special section previews 2002 basketball sectionals

# The Truth

Go To Know The Elkhart County Area

Monday
February 25, 2002
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# Filthy legacy in our water

## *Many communities aware of problem but have made little progress on repairs*

By Rick Callahan
Associated Press

The rivers and streams that run through Indiana conceal a filthy legacy of the 20th century — gaping drainage pipes that spew raw sewage when heavy rains fall and winter snows melt.

In 105 Indiana cities and towns, waste such as excrement, urine, condoms and toilet paper pours into waterways during wet weather.

The sewage problem is so vast and so costly to fix that many communities have made little progress on repairs, despite the threat to human health and wildlife habitat, and a cleanup mandate by the federal government, The Associated Press found in a three-month review.

Repairs and construction of new systems are expected to cost Indiana about $4.5 billion.

The improvements are needed to stop an estimated 20 billion gallons of sewage mixed with rain water that flow annually into the state's rivers and streams — a volume that would fill 228 RCA Domes, from the playing field to the top.

Indiana's sewage problems are the byproduct of antiquated sewer systems and government policy that critics say amounts to tolerance of a public health problem many would equate with developing nations.

Yet for 105 cities and towns, and many of the 2.5 million people who call those communities home, the problem is not the plight of an impoverished culture lacking streets and sewers; it is in their parks and back yards.

"People just assume that when they flush the toilet everything is going to work all right, that it's going to go to the proper place to be treated. But the truth is, that's not the case," said Tim Method, deputy commissioner of the Indiana Department of Environmental Management.

The state's sewer problems arise from an engineering flaw, a problem that was not envisioned when Indiana's cities and towns began laying brick-lined storm sewers more than a century ago.

At the time, indoor plumbing did not exist, and the chief concern was preventing streets from flooding during downpours. But as toilets, sinks

Please see Legacy/A6

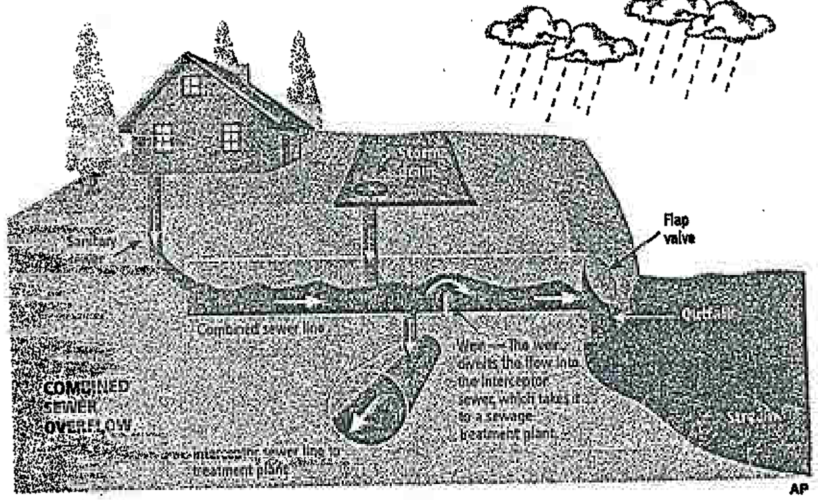
After the Flush
AP

**Scope of Indiana's sewer problems unclear:** Communities not required to monitor volume of overflows /A3

**City sewer system facts:** Elkhart among municipalities considering improvements /A3

### Combined sewer systems

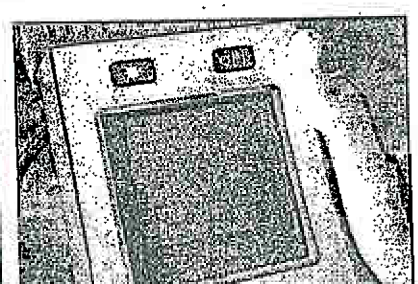
Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. In dry weather, all of the flow is sanitary sewage. In wet weather, the increasing volume flows over the weir and into the stream.




AP


Associated Press

**Water hazards:** The Marion County Health Department recently posted signs on the bank of waterways, like this one along along Fall Creek in Indianapolis warning that contact with the water is hazardous.



Associated Press

**Testing 1,2,3:** Joe Ketterman of the Marion County Health Department uses a Hydo Lab to test the quality of water in Fall Creek, in Indianapolis, last November.

**Tuesday**

On the second day of of a three-day series of articles, the Associated Press examines the politics of the state's sewer problems.

Other stories address the impact on small towns and how Boonville's outdated sewage plant is keeping the city from attracting new industries or housing developments.

Another story relates how many times dangerous bacteria counts have closed beaches and a state park near Chesterton.

# LEGACY

From Page A1

and bathtubs were added to homes during the 20th century, cities responded by funneling the waste into their storm sewers.

Rapid suburban growth, particularly after World War II, continued this trend until the federal government effectively banned the practice in the 1970s by requiring cities to lay separate storm and sewer lines.

By then, older cities had a big problem.

Although most sewer lines carrying both storm water and sewage work fine during dry weather, rain and snowfall can quickly overwhelm municipal sewer treatment plants.

To prevent raw sewage from backing up in homes, businesses and streets, communities send untreated sewage and storm water into area waterways through discharge pipes.

These discharges kill fish, close beaches and taint waterways green from algae blooms fueled by nutrients found in human waste. And they leave behind a sickening smell that can linger for weeks.

For people who swim or wade into these waterways, particularly children attracted to rain-swollen creeks, they hold the threat of stomach and intestinal illness or viral disease such as hepatitis.

It's a problem for cities large and small.

In Indiana, 105 communities — ranging from the state's largest city, Indianapolis, to the small Cass County town of Royal Center, with a population 830 — periodically foul rivers, lakes and streams in their midst.

Boonville, in southeastern Indiana, has such a big problem that it has barred nearly all new sewer hook-ups to businesses for nearly 30 years. But many cities' zoning boards continue to allow new subdivisions to connect to already overburdened sewer systems, worsening overflows.

In Indianapolis alone, between 6 billion and 7 billion gallons of raw human waste mixed with storm water are diverted each year from treatment plants into the White River, Fall Creek and other waterways.

For residents living near those waters, the stench can be repulsive.

"It can smell so bad that it's like something is dead," said Rochelle Edmondson, 41, who lives a stone's throw from Fall Creek, which annually swallows 1.2 billion to 1.8 billion gallons of sewage. "It can be so bad that it makes you feel like you're going to throw up."

Mindful of the enormous cost of addressing their sewer woes, public officials once ignored the overall problem while spending minimal amounts to handle the worst of their sewer overflows.

But now the bill for those outdated sewer designs is coming due, with a federal mandate looming for cities and towns to draft long-term plans for cleaning up the mess.

The plans require cities across the country to enact minimum controls to curtail their overflows. Although there are no specific deadlines for these upgrades, they come with a staggering price tag.

Nationally, the fix will cost about $44.7 billion, according to a 1996 survey by the Environmental Protection Agency. Indiana's piece of the bill was estimated then at $4.5 billion.

As state and federal environmental officials press municipalities into action, residents of dozens of Indiana cities and towns already face sewer rate increases to finance sewer plant improvements or expansions.

Fort Wayne, for example, last year imposed a 38 percent sewer rate increase to raise about $70 million over five years to pay for part of its $250 million effort to clean up its sewers.

And Indianapolis announced a $1 billion plan to capture 85 percent of its sewage and storm water overflows and hold the discharges for treatment until rains subside. The project will raise the typical residential sewer bill from about $11 to $28 within 20 years.

But many communities with big sewer problems have small tax bases from which to finance sewer upgrades, even as expanding suburbs stress their overtaxed treatment plants even further.

As elected officials grapple with those issues, tens of thousands of Indiana residents continue living in areas where human waste pours out of pipes near their homes. In fact, Indiana is home to more than 10 percent of the nation's cities that discharge raw sewage into waterways, said Jim Filippini, a deputy branch chief of the EPA's regional office in Chicago.

Together, older cities in Indiana, Michigan, Illinois and Ohio account for about 42 percent of the nation's communities making such discharges and all face astronomical costs to correct them.

"It's not the fault of these states and it's not the fault of the cities," Filippini said. "This was just the way things were done for a long time, before we started to worry about pollution."

Regardless of who is to blame, public health and recreation is at stake, said Rae Schnapp, water policy specialist for the Hoosier Environmental Council, the state's largest environmental group.

Dirty rivers and streams mean people cannot enjoy recreational pursuits — swimming, fishing and wading — that their grandparents took for granted.

"Many kids can't even play in the waterways near their home and it's a shame because that should be one of the joys of childhood," Schnapp said.

*On the Net:*

*Indiana Department of Environmental Management: www.in.gov/idem/*

*U.S. Environmental Protection Agency: www.epa.gov/*

*EPA's Office of Wastewater Management: cfpub.epa.gov/npdes/*

ASSOCIATED PRESS

**Monitoring overflows:** Betty Derringer, an operations specialist, works in the control room at the Belmont Water Treatment Plant in Indianapolis. Combined sewers overflows in Indianapolis are monitors from this control room.

# Scope of sewage overflow problem remains unclear

## *Cities not required to monitor volume*

By Rick Callahan
Associated Press

Indiana's sewer problems are nothing new. They have been around since toilets were first hooked into early brick-lined storm sewers nearly a century ago.

But even as cities and towns create plans to decrease the amount of sewage flowing into rivers and streams, the scope of the problem remains far from clear.

The state's environmental rules require cities and towns to monitor the frequency and duration, but not the volume, of their sewer overflows. So the total volume is unknown.

"Anything we gave you would be a guess," said Todd Siesky, a spokesman for the Indiana Department of Environmental Management.

Monitoring the amount of sewage escaping treatment would be very expensive because it would likely mean installing hundreds of measuring instruments across the state, Siesky said.

While the state would prefer to spend limited amounts on sewer improvements, environmentalists argue it is important to have a clearer idea of the depth of the problem.

Tom Neltner, a former IDEM official who is now an environmental activist, pored over plans that cities and towns had submitted to IDEM detailing how they intend to fix their sewer problems.


He estimates there are at least 20 billion gallons of sewage-laced rain water flowing into the state's waterways each year, and possibly as much as twice that amount.

Indianapolis alone produces between 6 billion to 8 billion gallons annually, while Fort Wayne and Lafayette produce a billion or more gallons each year, Neltner said. Even a medium-sized city such as Muncie dumps 500 million gallons annually.

But as IDEM officials review and approve each community's long term plan for controlling their sewage overflows, Neltner said no one is taking an inventory of overflow amounts.

## City Sewer System Facts

Most of Indiana's largest cities are struggling to repair and replace aging sewer systems that force raw sewage and rainwater into waterways during storms. Included are the estimated annual discharge amount, where available, proposals to correct problems and the status of each city's federally mandated control plan:

**Anderson:** 180 million gallons of discharge annually at 19 discharge points into the White River. Anderson is still awaiting a state permit to begin developing its control plan.

**Elkhart:** 880 million gallons of discharge annually from its 150 miles of combined sewer systems. Elkhart's control plan is due in April. The city is considering a series of improvements, including wastewater treatment plant expansion and sewage storage, that could cost about $100 million over 25 to 30 years.

**Fort Wayne:** 1 billion gallons of discharge are produced annually by its 400 miles of combined sewers. Fort Wayne submitted its control plan in July. It plans to spend $250 million to significantly reduce its discharges by increasing its wastewater treatment plant's capacity by 25 million gallons per day.

**Indianapolis:** About 7 billion gallons of discharge are produced annually by 850 miles of combined sewers. Its control plan was submitted in April. Indianapolis plans to spend $1 billion to reduce its discharges, building holding systems to retain sewage and rain water until they can be treated.

**Mishawaka:** No estimate on its annual discharge from 18 discharge points. Mishawaka submitted its control plan in May 2000. The plan requires spending at least $15 million to control sewer overflows during heavy rains by separating some combined sewers and expanding a wastewater treatment plant.

## Cities With Permits

Indiana permits 105 cities and towns, those with sewers systems that funnel sanitary waste and storm runoff into the same lines, to discharge sewage-tained storm water into rivers and other waterways. Some of those cities with the number of discharge pipes are listed:

| City | No. of pipes |
|---|---|
| Indianapolis | 133 |
| South Bend | 44 |
| Fort Wayne | 42 |
| Elkhart | 39 |
| Kokomo | 30 |
| Evansville | 23 |
| Hammond | 20 |
| Muncie | 20 |
| Anderson | 19 |
| Mishawaka | 18 |
| Rensselaer | 18 |
| Hartford City | 17 |
| Jeffersonville | 16 |
| Logansport | 16 |
| Peru | 16 |
| Columbia City | 15 |
| Lafayette | 15 |
| Elwood | 14 |
| Huntington | 14 |
| Nappanee | 13 |
| Fortville | 12 |
| Gary | 12 |
| Plymouth | 10 |
| Terre Haute | 10 |
| Ligonier | 9 |
| Marion | 9 |
| New Castle | 8 |
| North Manchester | 8 |
| Noblesville | 7 |
| Tipton | 7 |
| Clinton | 6 |
| Goshen | 6 |
| Wabash | 6 |
| Wakarusa | 6 |
| Connersville | 5 |
| Crown Point | 5 |
| Monticello | 5 |
| West Lafayette | 5 |
| Winamac | 5 |
| Bremen | 3 |
| Chesterfield | 3 |
| Columbus | 3 |
| East Chicago | 3 |
| Mount Vernon | 3 |
| Oxford | 3 |
| Summitville | 3 |
| Angola | 2 |
| Crawfordsville | 2 |
| Michigan City | 2 |
| North Vernon | 2 |
| Speedway | 2 |
| Valparaiso | 2 |
| Chesterton | 1 |
| Kendallville | 1 |
| LaPorte | 1 |
| Milford | 1 |

*Source: Indiana Dept. of Environmental Management*

# Smell sickens some residents

## *Stench like rotten eggs wafts from waterways*


ASSOCIATED PRESS

**Troubled waters:** Students from Harshman Middle School cross a bridge over a contaminated creek in Indianapolis. Raw sewage is diverted into the creek when rainfall overwhelms the sewage treatment center.

BY RICK CALLAHAN
Associated Press

Until he gave up cigarettes, Dwayne Huber didn't pay much attention to the sewage smell that drifted into his Fort Wayne neighborhood from ponds near the Maumee River.

But once he quit smoking, his sharpened sense of smell captured the odor for what it really was — a stench like rotten eggs.

Wafting its way from two retention ponds that capture sewage-tainted water headed for the Maumee River, the smell is strong enough to make him sick to his stomach.

"When I've gone biking along the river greenway I've actually had to turn around and go the other way because it smells so bad it makes you gag," Huber said.

Like thousands of Indiana residents, Huber, 37, and his neighbors on Fort Wayne's northeast side must occasionally live with a stench that assaults their nostrils.

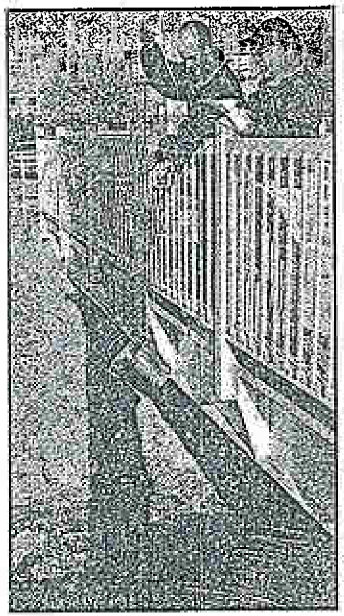
In all, 105 Indiana cities and towns are struggling with these smells and their ori-

Please see SMELL/A6

The Truth
Monday, February 25, 2002

# SMELL

From Page A1



ASSOCIATED PRESS

**Sampling:** Marion County Health Department employees Mike Holeman (left) and Joe Ketterman take water samples from Fall Creek in Indianapolis. In Indianapolis, up to 7 billion gallons of raw human waste mixed with storm water are diverted each year from treatment plants into area waterways.

gins — aging sewer systems that fail miserably during heavy rains, diverting sewage into rivers and streams.

Residents in these cities often accept the smells as a fact of life. Others live with it, but complain often.

Rochelle Edmondson, who lives across the street from Fall Creek in Indianapolis, has put up with sewage smells since moving into the neighborhood three years ago.

When the creek swells into a brownish torrent during heavy rains, Edmondson, 41, said she can smell sewage through the drain in her kitchen sink.

If her sink doesn't stink, all she needs to do is throw open any window in the duplex she shares with her two young nieces and there it is — the smell of the city's toilets churning by in Fall Creek, which is hidden from view by the dense stand of trees and shrubs.

"It can make you feel like you're going to throw up," Edmondson said.

Leon Bates, 41, lives in a neighborhood surrounded on two sides by a bend in the creek. Only a few blocks away, hidden among trees, is a 12-foot discharge pipe.

In the summer, a sudden downpour can make the sewers overflow just enough to dump a layer of sewage-laced water into the pools that line the shallow waterway. "It just lays there in the sun and bakes for days," Bates said. "It can get pretty ripe."

The first influx of sewage into the creek often contains a higher concentration of human waste than water pouring through the combined sewer lines well into a storm, said Carlton Ray, an environmental engineer for Indianapolis' Department of Public Works.

The city is aware of the problem and has developed a $1 billion plan to greatly reduce the sewage discharges.

For Linda Casey, principal of Harshman Middle School in a low-income neighborhood just east of downtown Indianapolis, sewage overflows of any concentration are a cause for concern.

Each morning, her school's 800 students leave their buses and traipse across a pedestrian bridge spanning Pogue's Run, normally a shallow ditch.

In times of heavy rains, however, it rises and turns brown as sewage and rain flow out of a discharge pipe only yards from the school. A sign installed by the city at the foot of the bridge warns of the raw sewage.

Casey said the creek not only poses a potential health risk, it casts a pall over her students' education.

"They should have a clean creek that they can go down to for science studies, or just to enjoy nature," she said.

*On The Net:*

*City of Indianapolis' Department of City Works: www.indygov.org/dpw/*

ELKHART TRUTH February 26, 2002

# Sewer bans hindering industrial growth

## *Cities losing potential businesses because of outdated systems*

By Kimberly Hefling
Associated Press

BOONVILLE, Ind. — Rockport got the steel plant. Newburgh got the subdivisions.

Boonville got stuck in the past.

Despite being a few miles from Evansville and the Ohio River, this city of 6,800 has been unable to attract much industry or housing development.

Its overwhelmed and outdated sewer plant is the main reason why.

"We're known across the state as the sewer plant from hell, and that's basically what it's been," Mayor Pam Hendrickson said.

Boonville has been severely limited in its ability to add new sewer hookups for nearly 30 years. Developers of subdivisions, factories and offices ended up looking elsewhere.

Twenty other communities in Indiana also operate under a whole or partial sewer ban, losing out on potential growth.

"If you don't have the proper infrastructure, you're not going to grow," said Robert Alexander, executive director of the Warrick County Chamber of Commerce in Boonville. "For several years, we have not had the ability to attract industry because of the fact that if you can't hook up, you can't flush. It's been a real hindrance for us."

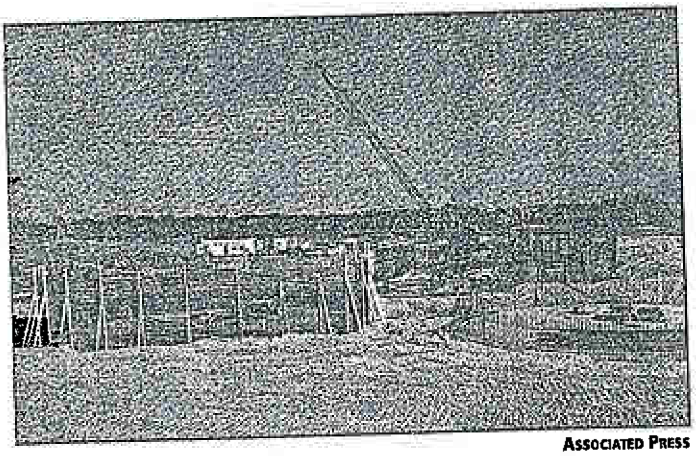
Last year, work began on a $12 million sewage treatment plant in Boonville that is expected to begin operations in January 2003. It is designed to handle 2.9 million gallons a day, compared with 1 million now.

Until then, even if an auto parts maker serving Toyota in Princeton 50 miles away wanted to come to Boonville, the current sewer system couldn't handle the load.

"We're not in a position now to even bargain with a company for that," Alexander said.

Communities with sewer bans "just have to deal with it and do the best you can," said John Roberson, sewer superintendent in Galveston, about 50

Please see BANS/A5



ASSOCIATED PRESS

**Slow to fix:** Construction continues on the site of the new waste water treatment plant in Boonville, Ind. Despite Boonville's location, a few miles from Evansville and the Ohio River, the city has been unable to attract much industry or housing development.

## Sewer Ban

**Indiana communities with sewer facilities that have bans or partial bans restricting expansion:**

| City | County |
|---|---|
| Batesville | Ripley |
| Boonville | Warrick |
| Brazil | Clay |
| Cedar Lake | Lake |
| Farmersburg | Sullivan |
| Flora | Carroll |
| Galveston | Cass |
| Greentown | Howard |
| Galena | Floyd |
| Kentland | Newton |
| Lapel | Madison |
| Milan | Ripley |
| Moores Hill | Dearborn |
| New Albany | Floyd |
| New Providence | Clark |
| Paoli | Orange |
| Paragon | Morgan |
| Santa Claus | Spencer |
| Staunton | Clay |
| Upland | Grant |
| Warren | Huntington |

*Source: Indiana Department of Environmental Management*

# Bans

From Page A3

miles north of Indianapolis.

Galveston undertook a $300,000 storm sewer project last summer, but its ban remains, despite the city's need for new industry. Most people drive about 10 miles to factory jobs in Kokomo, or farther because there is little work in Galveston, Roberson said.

While it is difficult for communities to attract industry without a good sewer system, many cannot afford sewer improvements because they do not have the tax base, said Susie Harmless, director of the community development division of the Indiana Department of Commerce.

"We have a lot of really small communities with limited resources and they have competing priorities," said Harmless, whose agency awards millions of dollars in grants annually to help communities fund sewer and other economic development projects. "It's a matter of taking care of the needs as money is available, and they have so many different needs."

ELKHART TRUTH February 26, 2002

AFTER THE FLUSH, PART 2

# Hidden monster becomes political

*Lawmakers hesitant to spend money to solve sewer problems*

**By Mike Smith**
Associated Press

INDIANAPOLIS — State legislators, like their counterparts in Congress, love to bring taxpayer money back home.

Passing out checks for new fire trucks or police cars or street lights or bridges — politically, that's what photo ops and ribbon-cutting ceremonies are all about.

"It's easier to give money for those kinds of community needs rather than long-term community needs," said Sen. Vi Simpson, D-Bloomington.

And that includes aging, overloaded sewer systems, a long-term community need if there ever was one.

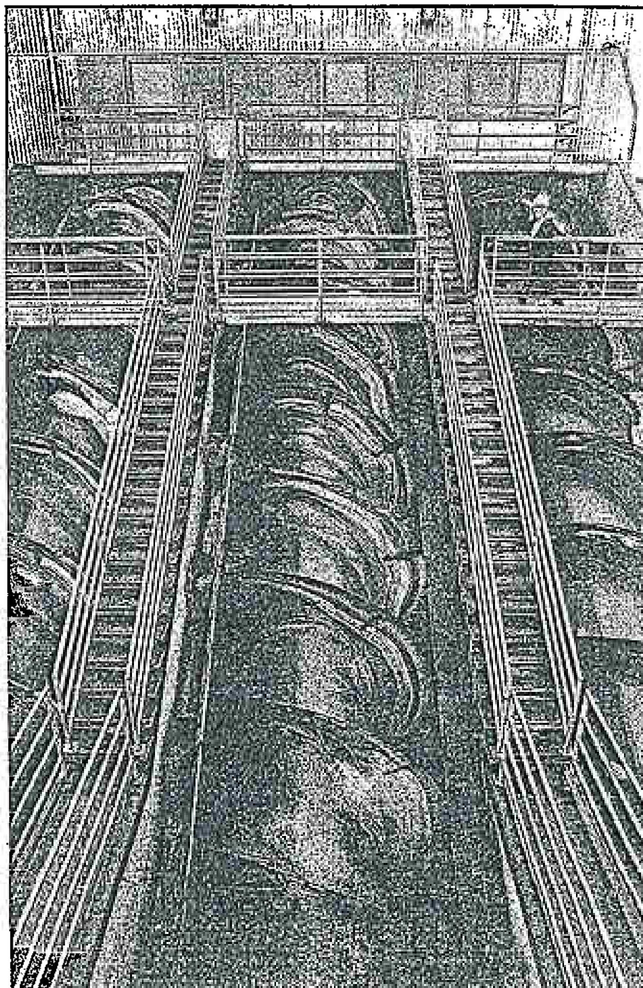
So many municipal sewer systems are so bad that the Indiana Department of Environmental Management has fined, or threatened to fine, some cities and towns for failing to fix their water pollution problems.

Problems arise when raw sewage, mixed with storm water or snow-melt runoff, is discharged directly into rivers and streams from overwhelmed sewer systems. Other problems are created by sewer pipes and treatment plants that are too old for a quick fix here, a stopgap measure there.

The problems have been years in the making, and they seem years from being solved.

Environmentalists complain that state and local officials lack the political will to tackle the problems because they are so vast and so expensive to fix.

Please see POLITICAL/A5



ASSOCIATED PRESS

**Flow patrol:** Shirley Eads, a senior operations and maintenance specialist at the Belmont Water Treatment Plant, walks above three of the six screw pumps that feed waste water into the facility in Indianapolis.

**WEDNESDAY**

On the third day of this series of articles, the Associated Press examines:

- the fix and explains that correcting sewers won't come cheap or easy;
- critics and sewer activists who are urging strict guidelines;
- e-coli pollution which has forced temporary closure of the Indiana Dunes National Lakeshore and adjacent park.

**INSIDE**

**More sewer problems:**

- An outdated, overworked sewer plant has kept Boonville, a city of 6,800, from growing.
- A list of communities with sewer facilities that have bans restricting expansion.

On page A3

# Small cities hit hardest

*Price tag too high to allow repair of old sewer system*

**By Shannon Dininny**
Associated Press

HARTFORD CITY, Ind. — Surrounded by soggy farm fields and swollen creeks and rivers, Waine Ritenour sat at his desk at the city's wastewater treatment plant, brooding about raw sewage.

The pouring rain highlights this small city's biggest problem: an antiquated sewer system that would cost $30 million to repair.

Hartford City, an eastern Indiana community of about 6,900 people between Indianapolis and Fort Wayne, is among 105 Indiana communities with sewer systems that push untreated sewage into waterways during heavy rains.

Last fall, near-record rains that kept farmers from harvesting their corn and soybeans also sent raw sewage from Hartford City toilets into Little Lick Creek and its tributaries.

And like countless other small Indiana communities, Hartford City lacks the tax base and revenue to fix its problems.

"The public wants the streams and rivers as pristine as possible, but they don't seem to realize there is a price tag. A very high price tag," said Ritenour, the plant's superintendent.

Officials at wastewater treatment plants in other communities face the same problem.

Please see CITIES/A5

ELKHART TRUTH

February 26, 2002

# POLITICAL

From Page A1

The Environmental Protection Agency estimates it will cost Indiana $4.5 billion to solve its sewer problems.

"Local communities are wanting to drag their feet and wanting the state to drag its feet, and the state is dragging its feet by not making local communities do what it takes in the long-term to address combined sewer overflows," said Rae Schnapp, water policy coordinator for the Hoosier Environmental Council, Indiana's largest environmental advocacy group.

Almost all cities are operating on expired permits that were written to old standards, Schnapp said. And some cities are still connecting new housing and business developments to their sewer systems, even though they already overflow or malfunction regularly.

The big price tag is a big part of the political foot-dragging.

The state has set aside money for sewer and water system projects for several years. Lawmakers appropriated $45 million during the 1999 budget-writing session and set aside $30 million for the current two-year budget cycle even though money was tight.

Communities that get some of the money are grateful. The town of Cumberland near Indianapolis received a $1.8 million state grant to help upgrade its system. The town still doubled sewer rates to pay for an overhaul, but without the grant, it would have been forced to raise rates even higher.

The state appropriations haven't come close to what it will take.

"This is the hidden monster not only for state government but for local government. We continue to ignore it, but it's serious business and it's big money," Simpson said.

State Sen. Beverly Gard, R-Greenfield, said state and federal governments have a responsibility to help communities.

The Legislature is becoming more aware of the problem's scope, she said, "but quite frankly I don't think it's an issue unless you deal real close with local government issues or environmental issues."

Gard thinks lawmakers should spend more of the state's gambling revenues in the Build Indiana Fund on such projects.

Sewer problems in Indiana's big cities make news, but smaller communities are in dire need of funding, too, said Tonya Galbraith, a lobbyist for the Indiana Association of Cities and Towns.

"The Avillas and Rising Suns have very small populations but are having to comply with the same things," Galbraith said.

While agreeing the state should do more to help communities fix their problems, Senate Finance Chairman Larry Borst, R-Greenwood, contends it is not the state's job to rescue cities and towns that lack the political will to raise rates.

"Ultimately, the cost has got to be borne by the local community," Borst said. "I can't see where the state is going to run in every time and take care of it."

Hartford City provides a good example of a community whose politicians have put off its problems for too long, said David Bennett, the eastern Indiana city's director of redevelopment and environmental affairs.

The city of 6,900 people 20 miles south of Muncie is working to fix the worst of its overflowing sewage problems, and there are efforts to raise community awareness about the pollution.

Politicians answer to people, but not all of the people are affected by the problem. "The people on the southside, high on top of a hill, don't care less," Bennett said. "If it's not in my backyard, they don't scream about it."

Few in the Statehouse are speaking loud about it, either.

The Legislature enacted a law last session, Senate Bill 431, requiring communities to develop specific plans for solving their sewer problems. It also gives them the ability to sell bonds or raise other money to get the job done.

# CITIES

From Page A1

In Columbia City, about half of the city's raw sewage overflows into Blue River during heavy rainfall. Engineers for this city of about 7,000 near Fort Wayne have devised three proposals to correct the problems. But they don't have money for any of the solutions.

In Fairmount, south of Marion, plant manager Steve Deal has just begun to track the amount of overflow from his city's 16 combined sewage and storm water drains. All he really knows is that the pollution problem is more than the community of 3,000 can afford to fix.

"It took us 100 years to get to this point. It'll probably take us that long to get rid of it," Deal said. "It might be easier to just pick the whole town of Fairmount up and move it a mile down the road."

The fact that Hartford City has already tracked its overflow — 25 million gallons of raw sewage spewed into waterways in 2000 — and determined the repair costs puts it ahead of most communities.

But the estimated $30 million price tag is unattainable for a city that is valued at just $52 million.

The average median income in Hartford City is $23,689, far below the $37,909 for the rest of the state. Already, the average monthly sewer bill, not including water, is more than $35, an increase of $7 from previous bills.

And for the first time, the town will begin raising its rates annually starting in 2003.

"It's going to be expensive to live in Smalltown, USA," Ritenour said.

Mayor Joseph Castelo Jr. said that by requiring small communities to clean up their combined sewer overflows without providing funding, the federal government is asking the impossible.

"No matter how lean and mean we get, Hartford City is never going to be able to do this on its own," Castelo said. "If you want us to do this, you're going to have to help us pay for it."

The city plans to fix the dirtiest and most visible of its 17 ...

flowing drains, separating storm water from raw sewage that flows to the water treatment plant. The estimated cost is $1.3 million. About $490,000 came from a federal grant; the city borrowed the rest.

"We came up with a design that was a Jeep instead of a Cadillac," said Dave Bennett, the city's director of environmental affairs. "But we don't have the tax base to borrow that 17 times over.

"We still have to pick up the garbage, pave the streets, plow the snow, put out the fires, provide police protection and all the other things our residents have the right to expect from their tax

ELKHART TRUTH February 27, 2002

# Battle waging to repair costly sewage problems

By Rick Callahan
Associated Press

Across Indiana and across the country, cities and towns are waging a complex and expensive siege against sewage.

During rainstorms, their outdated sewer systems are diverting millions of gallons of rain and untreated sewage into rivers and streams.

Cleaning up those sewers won't come cheap — it will cost at least $4.5 billion for Indiana's cities and about $44.7 billion nationwide, according to estimates by the Environmental Protection Agency.

In Indiana, 105 communities have sewer systems that combine sewage from the city's toilets and runoff from storms and are permitted to dump their untreated sewage into waterways. In sewer parlance, they are CSOs — combined sewer overflows.

Please see BATTLE/A8


ASSOCIATED PRESS

**Be aware:** A sign along Fall Creek in Indianapolis alerts residents to the presence of a combined sewer overflow point that can pour raw sewage into the creek during wet weather. The cost to clean up problems with outdated sewer systems is estimated to be at least $4.5 billion for Indiana's cities, according to estimates by the Environmental Protection Agency.

From Page A1

"For virtually every CSO community in the nation, this will be their largest public works program ever. It's huge," said Mark Poland, executive secretary of the CSO Partnership, a national coalition of representatives of such communities based in Richmond, Va.

In contrast to the 1970s, when state and federal governments financed up to 80 percent of sewage plant upgrades, there is little government money these days for sewer improvements. Property owners often pay much of the cost through sewer rate or property tax increases.

Such increases are likely for each of the Indiana communities as they implement a control plan required by the EPA.

But finding the money to pay for their plans — let alone the actual construction projects to stem overflows — will not be easy, especially for smaller cities, said Tim Method, deputy commissioner of the Indiana Department of Environmental Management.

Some small cities with sewer problems already have unusually high sewer rates, as a result of their small tax base, he said.

"For the smaller communities, where there are obviously fewer people who can bear the costs, you find sewer rates of $50, $60, $70 a month," Method says. "So they are already paying a lot in some situations, and that's just to treat wastewater."

Of the state's 105 communities with combined sanitary and storm sewers, 15 had submitted their long-term plans as of February. Most communities have an April deadline to complete their plans.

There are three basic approaches to dealing with combined sewer overflows:

- installing separate storm and sanitary sewers;
- expanding a sewage treatment plant's capacity;
- catching and holding sewage-tainted storm water until it can be treated.

Cities with combined sewer overflows or other sewer-related problems have two options for financial help from the state — grants and low-interest loans, said Richard Emery of the State Budget Agency.

The State Revolving Fund uses federal dollars to provide low-interest loans to meet wastewater and drinking water needs. During the past five years, about $1 billion in such loans have been made to Indiana's cities and towns, Method said.

In addition, the State Supplemental Drinking Water Wastewater Assistance Fund provides grants to help cities with combined sewer overflows. Last year, $30 million was appropriated for such uses. Ten requests are pending.

Communities can apply for grants of up to $50,000 to help pay for their control plans. While not a lot of money, it can help smaller communities, Emery said.

"When you look at a city like Indianapolis, of course that wouldn't make much difference, but if you have a small community that has one or two CSOs, $50,000 would go a long way," Emery said.

In Indianapolis, city officials have endorsed a $1 billion increase the typical monthly residential sewer bill from about $11 to $28 within 20 years.

The city plans to capture and treat about 85 percent of the CSO sewage and stormwater by expanding its sewage treatment plants and installing huge tanks to hold storm runoff until the rains subside and the excess can be properly treated.

Separating storm and sanitary sewers would be too expensive for a large city such as Indianapolis, which has 850 miles of combined sewers among its total 3,000 miles of sewer lines.

Statewide, only a handful of communities are expected to opt for separating their storm and sanitary sewers.

One community that has already done that is LaGrange, a town of about 2,900 in far northeastern Indiana. It eliminated all seven of its combined sewer discharge points in 2000.

Human waste used to foul Fly Creek, which traverses the farming community, but town council members approved a $1.4 million bond issue to pay for the sewer line separation. The average monthly residential fee jumped 50 percent to $26.02.

The last of the old pipes was cemented shut last year.

"We're all happy with it because we're in a lot better shape," Town Clerk Mike Rowli-

## Coming Monday

This week, The Associated Press examined problems with Indiana's sanitary and storm sewers, which each year pour billions of gallons of tainted water into rivers and streams. Beginning Monday, in a two-part series, the AP looks at the environmental problems associated with the antiquated septic systems throughout the state. Indiana's health department estimates that 800,000 homes and businesses are without sewers. Those properties have septic systems or are discharging waste directly into the environment.

City of Elkhart

*The city with a heart*

David L. Miller
*Mayor*

Public Works
& Utilities

Administration
1201 S. Nappanee Street
Elkhart, Indiana 46516
Phone: 219.293.2572
Fax: 219.293.7658

Customer Billing
921 N. Main Street
Elkhart, Indiana 46514
Phone: 219.264.4273
Fax: 219.206.8736

Board Of Public Works
229 S. Second Street
Elkhart, Indiana 46516
Phone: 219.294.5471
Fax: 219.293.7964

March 6, 2002

Joseph Foy
Elkhart Public Works & Utilities
1201 South Nappanee Street
Elkhart IN 46516

RE: Citizens Advisory Committee meeting
Long Term Control Plan for CSOs

Dear Joe:

On behalf of the City of Elkhart's Public Works and Utilities, I am writing to invite you to our next meeting for the Citizens Advisory Committee for the development of our community's Long Term Control Plan for the combined sewer overflow reduction/elimination program. The City of Elkhart intends to submit this plan for review by the Indiana Department of Environmental Management in early April.

**The meeting is scheduled for Thursday, March 21st at 7:00 PM in the Large Conference Room at the Public Works & Utilities office located at 1201 S. Nappanee St. The meeting will likely last until 8:30 PM.**

The agenda that we intend to cover that evening will be the following:

1. Review the control alternatives studied to address overflow conditions along the St. Joseph and Elkhart River segments
2. Review the preferred alternative for the long term plan
3. Review the results of the affordability analysis
4. Outline the compliance monitoring protocol

At the meeting you will receive a packet summarizing the above. You are encouraged to review and comment on the information. We appreciate your willingness to serve our community in this very significant issue.

We look forward to receiving your input and feedback on the development of this plan thus far. If you have any questions, please do not hesitate to call. We hope to see you there.

Sincerely yours,
City of Elkhart Public Works and Utilities

Art K. Umble

Art K. Umble, Ph.D., P.E.
Manager of Water and Wastewater Operations

cc: Eric Horvath, P.E., Director of Public Works
Mark Salee, Regulatory Affairs Manager
Mike Machlan, P.E., Network Engineer

City of Elkhart

*The city with a heart*



Elkhart City Council

Municipal Building
229 S. Second Street
Elkhart, Indiana 46516

Phone: 219.294.5471

# PUBLIC WORKS & IMPROVEMENTS COMMITTEE-OF-THE-WHOLE MEETING

Monday, March 25, 2002
6:00 p.m.

There will be a meeting of the Public Works & Improvements Committee-of-the-Whole of the Common Council of the City of Elkhart on Monday, March 25, 2002, at 6:00 p.m., in the Council Chambers, Municipal Building, 2nd Floor, 229 S. Second Street, for an explanation of the ***Long-term Control Plan for the Combined Sewer Overflow for the City of Elkhart,*** presented by Dr. Art Umble, Water and Wastewater Operations Manager for the City of Elkhart.

ELKHART

# Sewer control plan stated

## *Fixing combined system problems costly, lengthy*

**By Javier Serna**
Truth Staff

ELKHART — City of Elkhart public works officials presented their long-term control plan for the city's problem of combined sewer overflows to city council members Monday night.

The plan is costly, lengthy and would not eliminate the problem, officials said.

CSOs mix stormwater and wastewater. Rains cause the system to overload, and the tainted water ends up in Elkhart's waterways.

The Indiana Department of Environmental Management standards are for waterways to be fishable and swimmable. IDEM is expecting Elkhart's plan by early April.

"Our system today can't even handle a quarter inch of rain," said Art Umble, Elkhart's wastewater operations manager.

Eric Horvath, director of public works, began the presentation giving the council members background on CSOs.

There are 105 CSO communities in the state, he said. Horvath said that of Elkhart's 250 miles of sewer lines, close to half of it is combined. On average, the sewers overflow 70 times a year.

The plan calls for separating the sewers with the highest impact and constructing a deep retention tunnel, which would buy the system time in the event of heavier rains. It would cost $105 million and take 25 years to be completed. Umble said the tunnel's cost accounts for almost half of the expense.

Even at this cost, a rainfall of more than 0.8 inch would overload the system.

"The only way we can get away from that is to completely separate the system," Umble said.

Umble said it would cost nearly $250 million for complete separation.

"What we are looking for is the most amount of environmental benefit for the least amount of dollars," Horvath said.

The first 10 years would focus on sewer separation, while the remaining 15 years would shift some of the efforts on constructing the tunnel in three phases.

On top of CSOs still contributing to the problem of polluted waterways,

Please see SEWERS/A5

## SEWERS

From Page A3

the plan would and could do nothing to stop runoff from failing septic systems and agriculture, which troubled many of the council members.

"I have a sign by my house, 'Do not swim,'" councilman David Ashe said.

"That's not going to be coming down anytime soon," Umble joked.

*Contact Javier Serna at jserna@etruth.com.*

The Truth
OPINION
A4 Friday, April 5, 2002

John F. Dille (1913-1994)
CORPORATE O
John F. Dille III,
Robert A. Wat

TRUTH EDITORIAL

# Cleaner waters are coming

Raw sewage pollutes the rivers in Elkhart, endangering the environment and threatening public health. This is a serious concern for city residents that must be addressed. Even so, city officials must be practical. The city is doing what it can to clean up the mess with the money and resources it has.

In Elkhart, sewer lines run from the houses into a pipe beneath the street that, in many cases, combines sewage and rainwater. The city wastewater treatment plant often cannot handle the volume flowing through the underground pipes after heavy rains. At overflow points along the sewer line, the excess sewage and storm water flows out of the system into the rivers.

On average, rains cause the system to overflow 70 times per year. As a result, city rivers do not meet the Indiana Department of Environmental Management standards that require waterways to be swimmable and fishable.

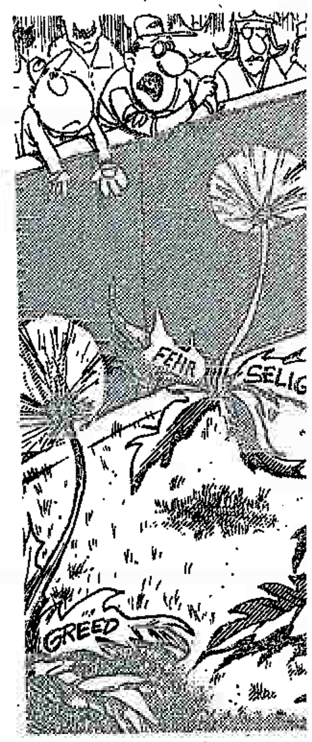
The state has demanded that Elkhart and other cities with similar sewer systems solve the overflow problem. To meet state standards, Elkhart would have to construct separate underground pipes for sewage and rainwater throughout the city. This could cost $250 million, an amount of money the city simply does not have.

But that doesn't mean the city isn't doing anything. The city's proposed sewer control plan demonstrates Elkhart's commitment to the environment. It also highlights just how extensive, costly and complicated the problem is. It calls for the separation of the sewers most crucial to the system and the construction of a deep retention tunnel to hold some of the overflow after heavy rains. As it now stands, this plan would take 25 years to implement and cost a projected $105 million.

Even with a plan, the city faces many obstacles as it works to clean its rivers. For example, the rivers are also polluted by run-off from farms and roads. The state has not yet defined standards for dealing with many of these other sources of pollution. Without specific environmental regulations, the city cannot know how to meet state standards.

Furthermore, the city's plan must be flexible to allow for any technological advancements. Future technology may allow the city to clean up its waterways more quickly and more efficiently.

City officials should be commended for their pragmatic, realistic efforts to deal with sewer overflow. Elkhart residents must be patient and understanding as the city engages in the long cleanup process. No one will be swimming in the local rivers anytime soon, but the city is doing what it can to make clean waterways a definite, if distant, possibility.

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PEOPLE'S FO

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## McCloskey's

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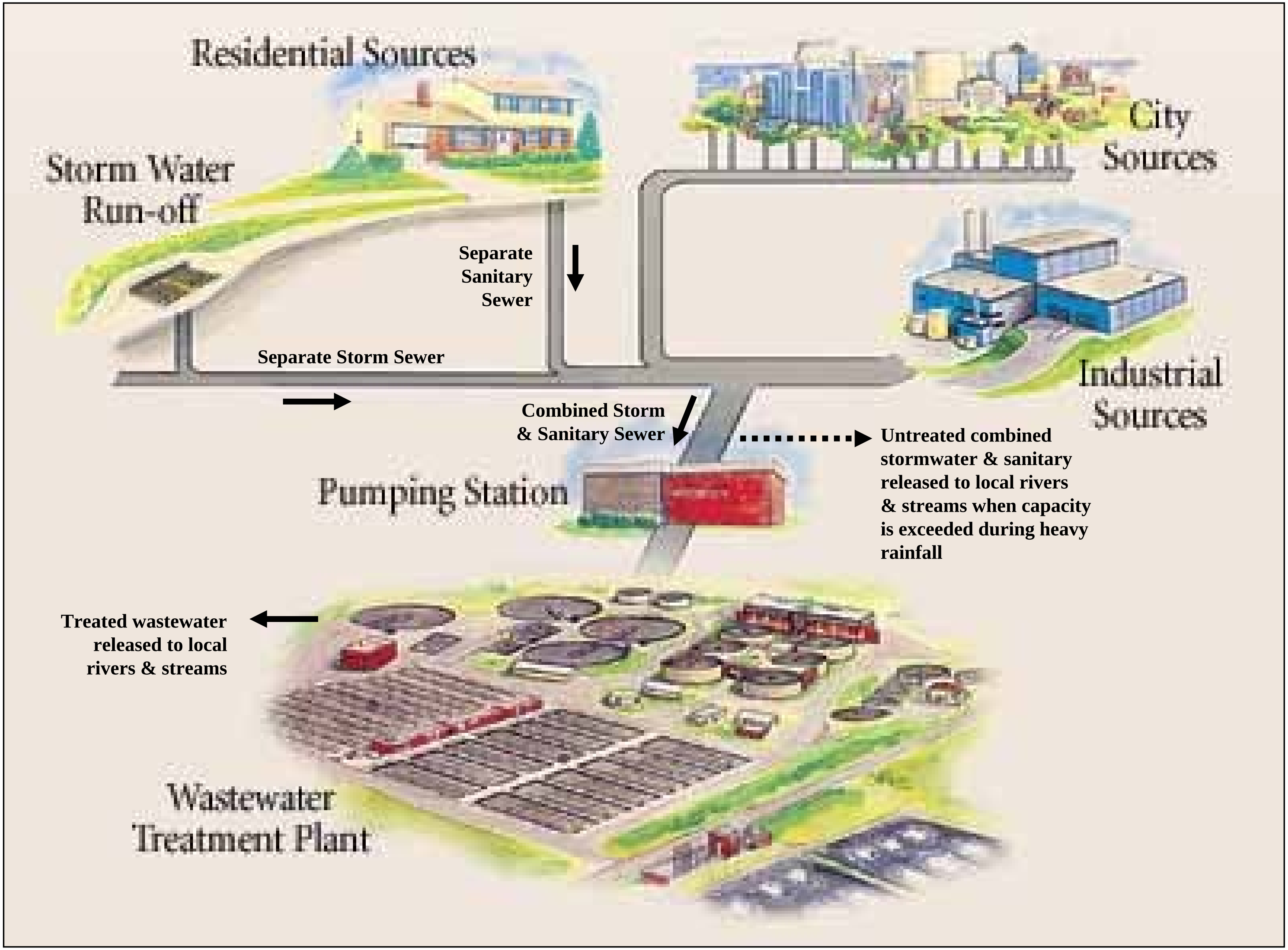
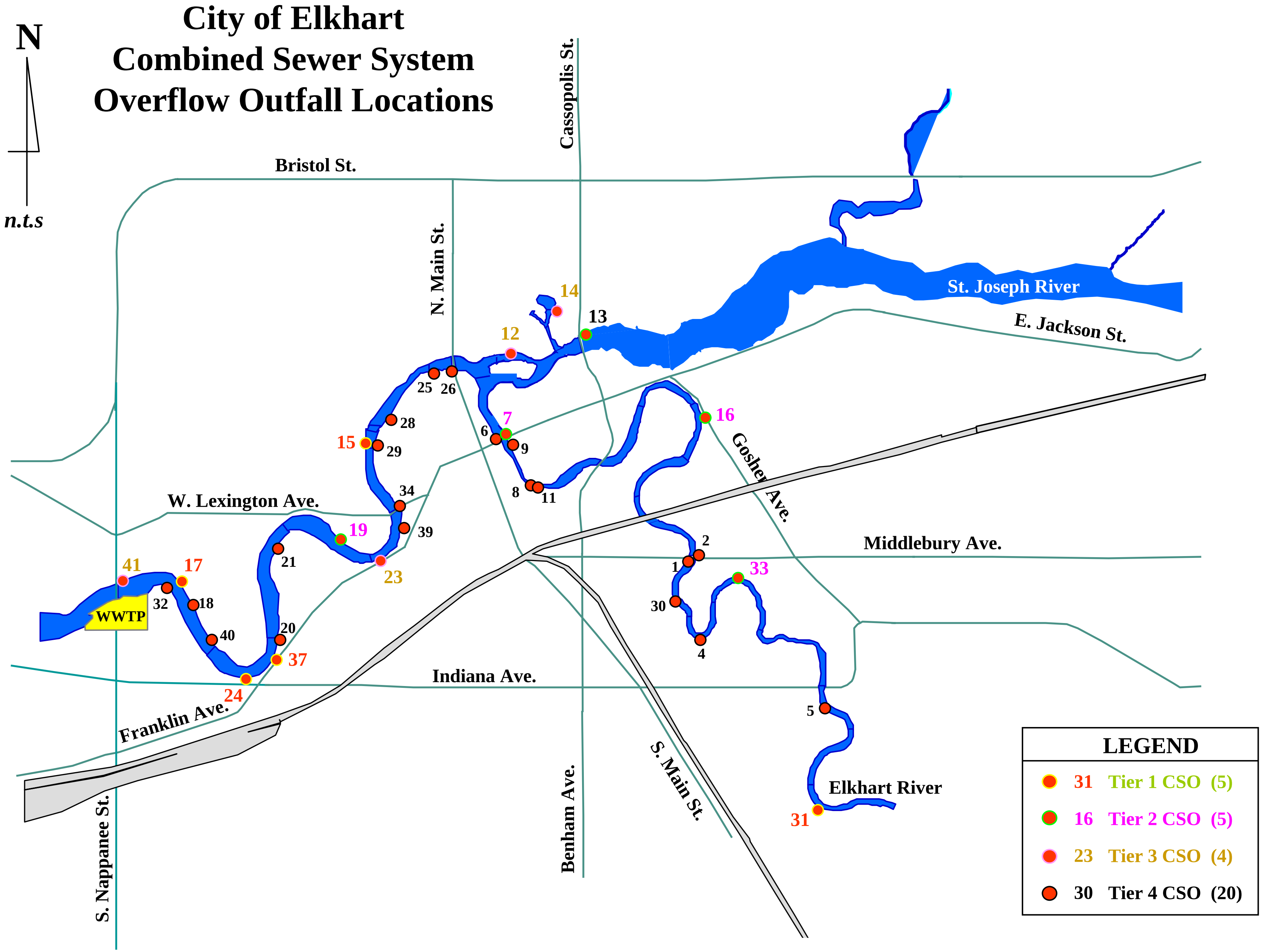
AUSTIN BAY

# Palestinian pragmatists need economic option

Follow the money — in




General configuration of the Elkhart Combined Sewer System


City of Elkhart
Combined Sewer System
Overflow Outfall Locations
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Bristol St.
Cassopolis St.
N. Main St.
St. Joseph River
E. Jackson St.
W. Lexington Ave.
Goshen Ave.
Middlebury Ave.
Indiana Ave.
Franklin Ave.
S. Nappanee St.
Benham Ave.
S. Main St.
Elkhart River
WWTP
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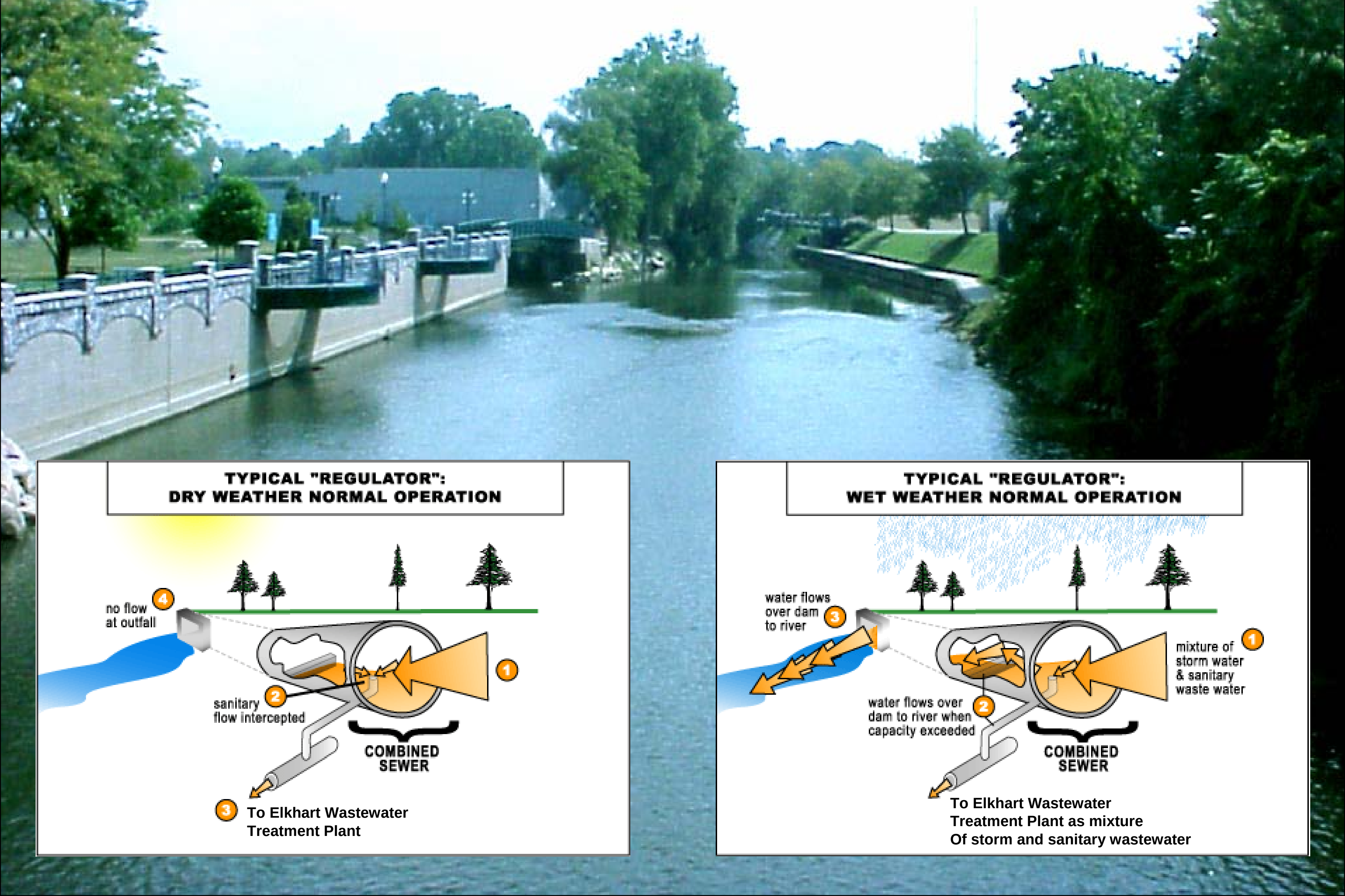
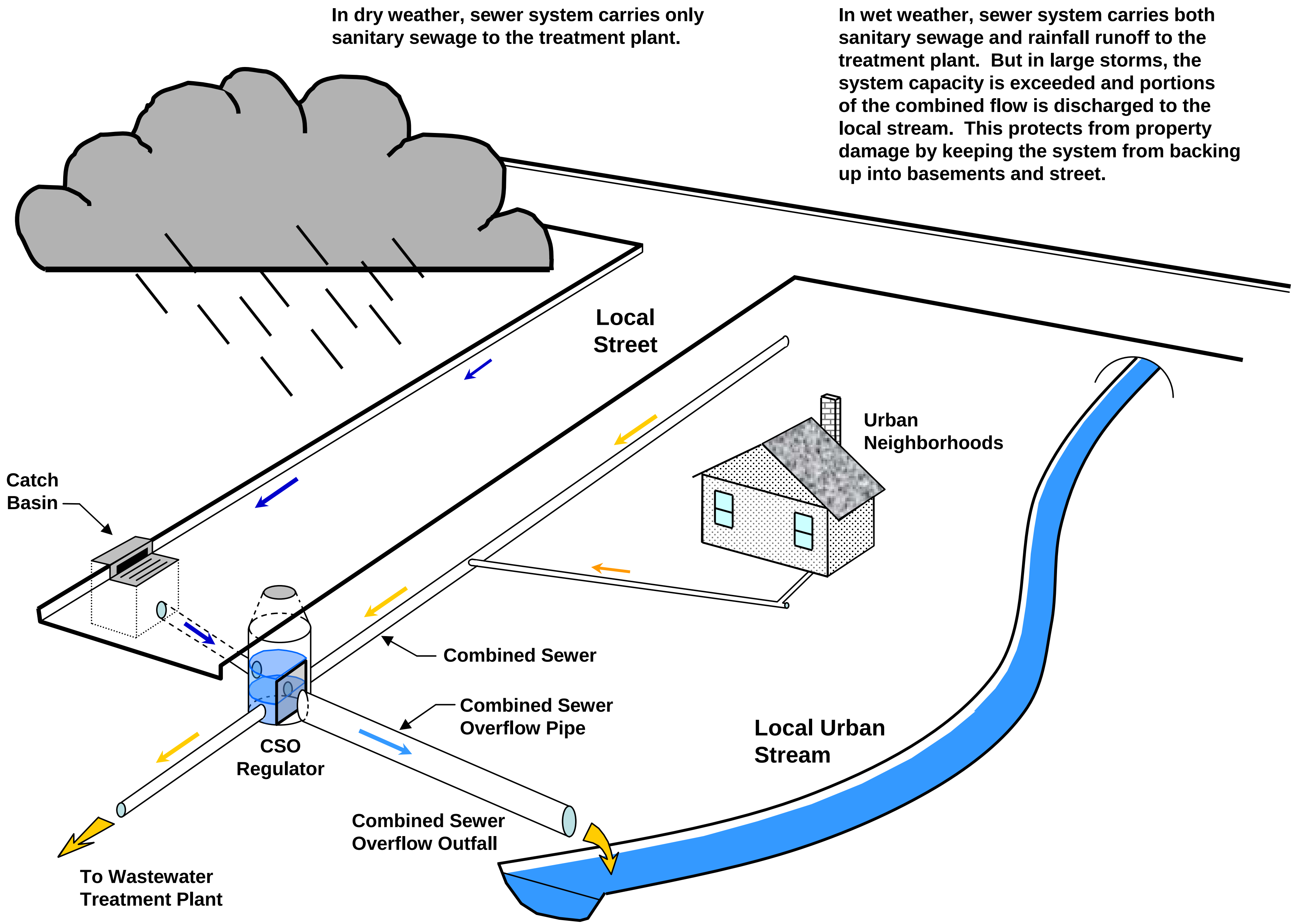
LEGEND
31 Tier 1 CSO (5)
16 Tier 2 CSO (5)
23 Tier 3 CSO (4)
30 Tier 4 CSO (20)

# Operation of a Combined Sewer Overflow regulator structure during normal (dry) and wet weather.






Simulation of how a CSO operates in dry and wet weather conditions



CSO 3 (eliminated in 2003)

**Currently, there are 36 permitted, but only 34 active CSO outfalls are located throughout the City of Elkhart along the St. Joseph and Elkhart Rivers. As improvements are made to the sewer system, all efforts are made to eliminate outfalls where feasible. This is done primarily by separating the sanitary from the stormwater flow by constructing separate pipes.**

# NOTICE

## THIS IS A COMBINED SEWER OUTFALL

**RIVER WATER MAY BECOME POLLUTED DURING OR AFTER PERIODS OF RAIN, SNOW, OR SNOWMELT. SWIMMING IS DISCOURAGED DURING AND AFTER THESE EVENTS. IN THE EVENT OF DISCHARGES FROM THIS OUTFALL DURING DRY WEATHER, OR FOR MORE INFORMATION, PLEASE CALL:**

**574 – 293 – 2572**

**City of Elkhart**
**Public Works & Utilities**

**CSO No. 009** **NPDES No. IN0025674**

**The City of Elkhart owns and operates a combined sewer system. During dry weather conditions the system conveys sanitary sewage to the wastewater treatment plant for treatment. Tied to portions of the sewer system, primarily in the urban core areas, are surface runoff collection catch basins. During wet weather conditions runoff from rainfall or snowmelt enters the sewer system, combining with the sanitary flow. In large wet weather events, the system capacity becomes overwhelmed and portions of the combined flow are discharged into the local rivers to relieve the system. This relief system keeps sewage from backing up into basements, or surcharging manholes and flowing into street gutters. The City is permitted by the State of Indiana for 36 of these overflow discharge points located along the St. Joseph and Elkhart Rivers. The above sign can be found at each of these outfall locations.**

# Combined Sewer Overflow Notification Signage

**In accordance with State of Indiana law, the Elkhart Public Works & Utilities Department utilizes the sign shown at right to communicate to our citizens that caution should be taken when choosing to engage in recreational activity on or in the surface water bodies of our community during and after a rainfall or snowmelt event. These signs can be found placed throughout the Elkhart along areas where public access to the river waters is possible. In general, these areas include of City parks and public boat launches.**


**CAUTION: SEWAGE OR STORM WATER POLLUTION**

Bacteria from combined sewer discharges and storm water runoff may be in the river water during periods of rainfall or snowmelt and may remain for several days after.
People who swim in, wade in, or ingest this water during or after such periods of rainfall or snowmelt may become ill.

**For more information, please call:**
**Elkhart Public Works and Utilities**
**574-293-2572**


**A constructed wetland was built in 1998 to accept and treat overflows from CSO 5 at Arch & Bar Streets along the Elkhart River. The wetland utilizes aquatic plants and natural microbial activity to remove potential pollutants that may be present in the combined sewer overflow discharge including suspended solids, organic material, nutrients, metals, etc. Following the treatment, the effluent is discharged into the Elkhart River. This project was funded through a Grant from the Indiana Department of Environmental Management.**

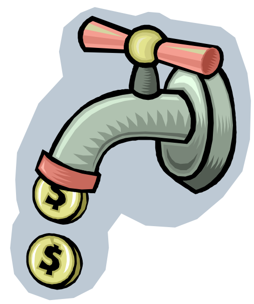
When an overflow has been detected at any of the 5 monitored sites, this alert graphic will appear on the Elkhart home webpage.

# LOOKING TO LOWER YOUR WATER BILL?

The City of Elkhart The city with a heart and Elkhart EnviroCorps

offer City residents FREE water-saving devices, including

- -water-efficient showerheads
- -faucet aerators
- -toilet water tank displacement bottles



This free service is available on a first come-first serve basis while supplies last. Please note that only single-family households within the City limits are eligible.

Homeowners are encouraged to contact EnviroCorps' Sherry Bowen at 293-2572 to schedule an appointment today.

TTY Relay Indiana 1-800-743-3333

GROUNDWATER GUARDIAN®

AMERICORPS INDIANA

City of Elkhart

*The city with a heart*


David L. Miller
*Mayor*

Public Works
& Utilities

Administration
1201 S. Nappanee Street
Elkhart, Indiana 46516
: 574.293.2572
Fax: 574.293.7658

Customer Billing
921 N. Main Street
Elkhart, Indiana 46514
Phone: 574.264.4273
Fax: 574.206.8963

Board Of Public Works
229 S. Second Street
Elkhart, Indiana 46516
Phone: 574.294.5471
Fax: 574.293.7964


November 6, 2003

Mr. Bruno Pigott, Chief
Permits Section
Indiana Department of Environmental Management
Indianapolis, IN 46240-4300

RE: CSO Notification Procedure

Dear Bruno:

The City of Elkhart is pleased to submit our procedure for notification of permitted CSO discharges into the surface water bodies of our community. This procedure is in accordance with 327 IAC 5-2.1.

Please call if you have any questions.

Sincerely yours,
City of Elkhart Public Works and Utilities

Art K Umble

Art K. Umble, PhD, PE, DEE
Manager of Water and Wastewater Operations
City of Elkhart Public Works & Utilities

Cc: Eric Horvath, P.E., Director of Public Works & Utilities
Mark Salee, Regulatory Affairs

# Combined Sewer Overflow Public Notification Procedure

**Submitted by:**
***City of Elkhart Public Works & Utilities***

**IDEM Rule No: 327 IAC 5-2.1**

**November 2003**

# Combined Sewer Overflow
# Public Notification Procedure

## Introduction

In accordance with the State's Combined Sewer Overflow Public Notification Rule (327 IAC 5-2.1), the City of Elkhart has developed this procedure for notifying the public of the occurrence of combined sewer overflows (CSOs). Section 4 of the rule requires the development of a CSO notification procedure that provides notification to the "affected public", other persons within the City of Elkhart, the Elkhart County and St. Joseph County Health Departments, and drinking water suppliers having surface water intakes located within ten (10) river miles downstream of the CSOs. Our method of notification will allow *any* person to determine if a CSO discharge is occurring or has occurred.

The City of Elkhart has 36 active CSOs that discharge to the Elkhart and St. Joseph Rivers and one CSO that discharges to Christiana Creek. These CSO outfall locations are shown on Figure 1. The "affected waters" as defined in Section 3 of the rule means "those waters where the *E. coli* criteria may be exceeded due to a combined sewer overflow discharge." Based on surface water monitoring and water quality modeling used in the development of Elkhart's Long Term Control Plan submitted to the Indiana Department of Environmental Management (IDEM) in April 2002, the affected waters for purposes of this procedure are shown in Figure 2. The affected waters include the stream reach on the Elkhart River beginning at the farthest upstream CSO and ending at the confluence with the St. Joseph River. The affected water on the Christiana Creek is a very short segment beginning at CSO and ending at the confluence with the St. Joseph River. The affected waters on the St. Joseph River start just downstream of the Johnson Street Dam in Elkhart and ends at the upstream side of the Twin Branch Dam in Mishawaka. There are numerous public access points to the affected waters including parks, schools and greenways. The locations of these access points to the affected waters are shown on Figure 2. According to IDEM records, there are no drinking water suppliers having surface water intakes located within 10 river miles downstream of the Elkhart CSOs.

## Notification Method

The CSO notification procedure for the City of Elkhart will use in-place technologies. Currently, the City owns five CSO wireless monitors that are set at five of the largest CSO outfall points. These five were chosen because of their relatively large combined sewer drainage areas, which can result in relatively high volumes of discharge.

The five CSOs are outfitted with a set of sensors that monitor when flow passes over the regulator weir indicating a discharge. A signal is then sent to a web-based server that houses the monitoring data. This server generates a notification message that is sent to the City of Elkhart's Internet web server. The City of Elkhart's server then posts a CSO alert on the City of Elkhart's home web page. The concept of this logic process is shown schematically in Figure 3.

The duration of the posting on Elkhart's home web page depends on essentially two situations. The first case is fairly simple and involves an overflow detected at just one site. For this case, the posting is made at the time of overflow detection, and the total time the posting remains on the Elkhart website is the duration of that event plus 48 hours following cessation of the discharge. The second situation involves more than one overflow detected, though not necessarily detected simultaneously. For this case, as in the first case, the posting is made at the time the initial overflow is detected. The 48-hour post-overflow "timer" would again begin at the cessation of the overflow. But, if another overflow is detected from any of the sites before the "48-hour" posting timer expires, then posting remains and the "48-hour" clock resets to zero at the end of the second recorded overflow duration. In essence, the posting will always remain for 48 hours following the cessation of the most recently detected overflow. These two cases are illustrated for clarity in Figure 4.

When the overflow discharge is detected by the in-line monitors and the signal is sent to post the notification message, the following example message will appear on the City of Elkhart's website homepage:

> "A release of combined sewage and storm water into the St. Joseph and Elkhart Rivers from the City's combined sewer system has been detected. People who swim in, wade in, or ingest water from the rivers during or after such releases may become ill. For more information, please contact Elkhart Public Works & Utilities at (574)-293-2572 or consult the Combined Sewer Overflow information on this website."

This message will be located in a conspicuous place on the Elkhart's homepage. Any person, at any time, can go to this website and receive notification of a CSO discharge.

In March of each year, a public notice will be placed in the Elkhart Truth, the South Bend Tribune and the Goshen News newspapers. This notice will announce the availability of the CSO discharge alert on the City of Elkhart's web page. The web page notice will allow any person, at any time and anywhere, including the local media, persons who live on or adjacent to the affected waters, public or private schools, and owners or operators of facilities that provide access to or recreational opportunities in or on the affected waters, to determine if a CSO discharge is occurring or has occurred from an Elkhart CSO.

### Posting of Informational Signs

In accordance with Section 6 of the rule, the City of Elkhart will post 20 informational signs at public access points within the City's jurisdiction. The sign locations are described below and shown on Figure 5. The sign language and layout is illustrated in Figure 6. These signs will be 11" x 17" in size.

| Sign ID # | Sign Location | Affected Water |
|---|---|---|
| CSON-1 | Along trail under Indiana Ave. bridge | Elkhart River |
| CSON-2 | Boat landing at Studebaker Park | Elkhart River |
| CSON-3 | Canoe launch at Studebaker Park | Elkhart River |
| CSON-4 | Auto bridge to American Park | Elkhart River |
| CSON-5 | Pedestrian bridge to American Park | Elkhart River |
| CSON-6 | NE pedestrian bridge to High Dive Park | Christiana Creek |
| CSON-7 | SE pedestrian bridge to High Dive Park | Christiana Creek |
| CSON-8 | South pedestrian bridge to High Dive Park | Christiana Creek |
| CSON-9 | Parking lot entrance to High Dive Park | Christiana Creek |
| CSON-10 | NE pedestrian bridge to Island Park | St. Joseph River |
| CSON-11 | SE pedestrian bridge to Island Park | St. Joseph River |
| CSON-12 | West pedestrian bridge to Island Park | St. Joseph River |
| CSON-13 | Parking lot in Beardsley Park | St. Joseph River |
| CSON-14 | Trailhead to river in Langle Park | St. Joseph River |
| CSON-15 | Boat landing at Sherman Street bridge | St. Joseph River |
| CSON-16 | Along shoreline in McCreary's Point Park | St. Joseph River |
| CSON-17 | Along shoreline in McNaughton Park | St. Joseph River |
| CSON-18 | Between boat landings at McNaughton Park | St. Joseph River |
| CSON-19 | Boat landing at Edgewater Park | St. Joseph River |
| CSON-20 | Trailhead to river in Elliott Park | St. Joseph River |

Four access points to affected waters outside of Elkhart's jurisdiction have been identified. These are listed below and identified on Figure 7.

- ✓ Treasure Island Park, Elkhart County Park & Recreation Department 211 West Lincoln Avenue, Goshen, IN 46526
- ✓ Midway Marine, 56183 Ash Road, Osceola, IN 46561
- ✓ Wyland's Mishawaka Marina, 13100 Jefferson Blvd., Mishawaka, IN 46545
- ✓ Margarett H. Prickett Marina Park, Mishawaka Parks & Recreation Department, 1122 Lincoln Way West, Mishawaka, IN 46544

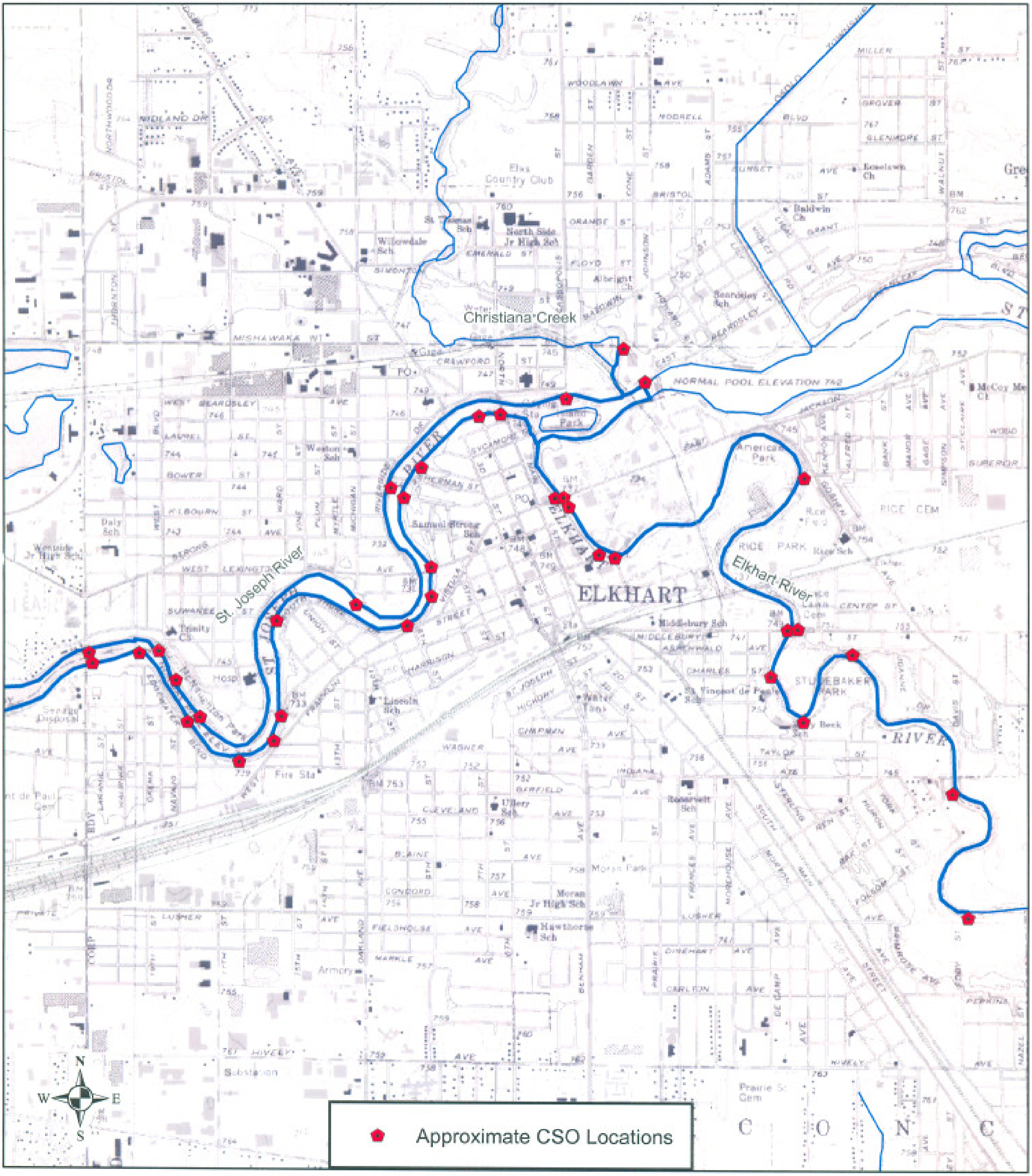
The City of Elkhart will annually offer to provide CSO informational signs to Midway Marine and the Elkhart County Parks Department (for Treasure Island Park). In accordance with the City of Mishawaka's CSO public notification procedure, Mishawaka will post a CSO informational sign at Margarett H. Prickett Marina Park and will offer to provide signage to Wyland's Mishawaka Marina.

These informational signs are in addition to the existing CSO signs posted in compliance with the Nine Minimum Controls as part of Elkhart's CSO Operational Plan. The existing CSO signs are posted at all of the CSO outfall locations shown on Figure 1. An example of the language on these posted CSO outfall signs is illustrated in Figure 8.

## Record Keeping and Reporting

The number of CSO notification alerts posted on the Elkhart website each month will be included on the CSO discharge monitoring report (DMR) submitted to IDEM. The Wastewater Operations Manager will be responsible for maintaining these records and the general oversight of the CSO notification procedure.

## Figure 1 CSO Outfall Locations

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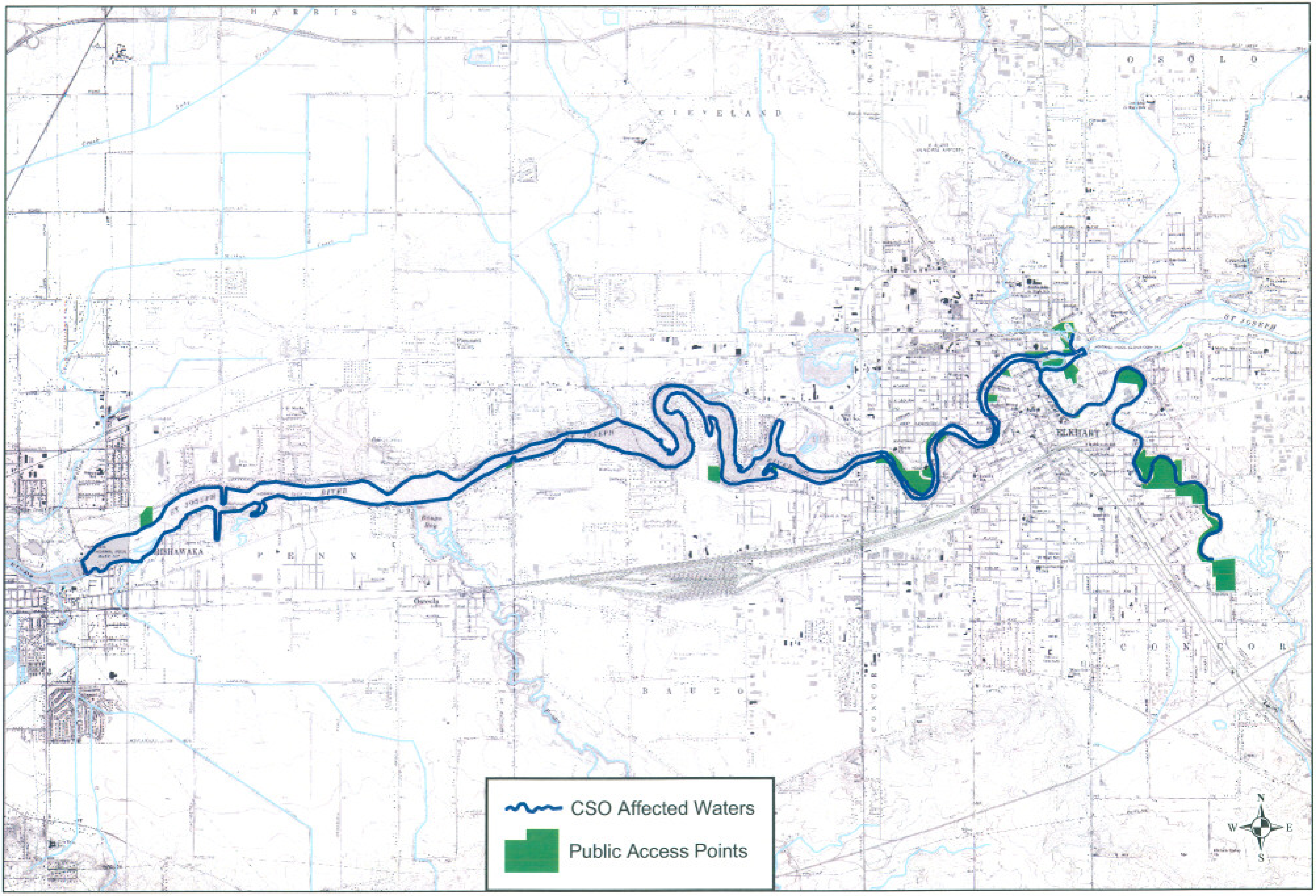
The graphic data provided by the City of Elkhart, Indiana ("City") herein may be inaccurate or out of date. Any person or entity who relies on said information for any purpose whatsoever does so solely at their own risk. Neither the City, or its boards, commissions, officials or employees warrant accuracy, reliability, or timeliness of any of the data provided herein. This data is provided "as is" without warranty of any kind, and all warranties of merchantability and fitness for a particular purpose are hereby disclaimed.

**Figure 2 ...ocation of Public Access Points, Parks and Schools along ...fected Waters**

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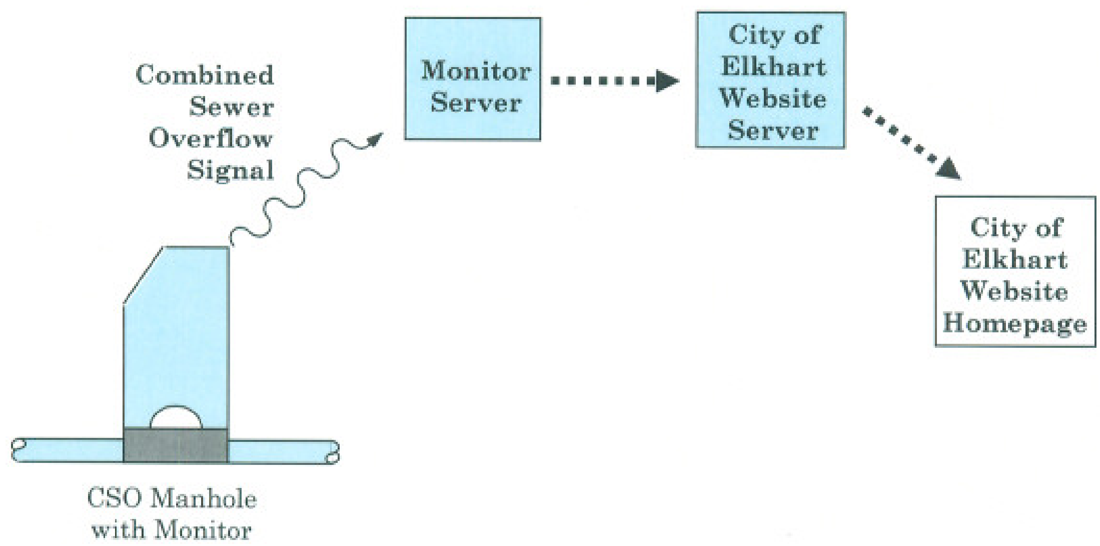
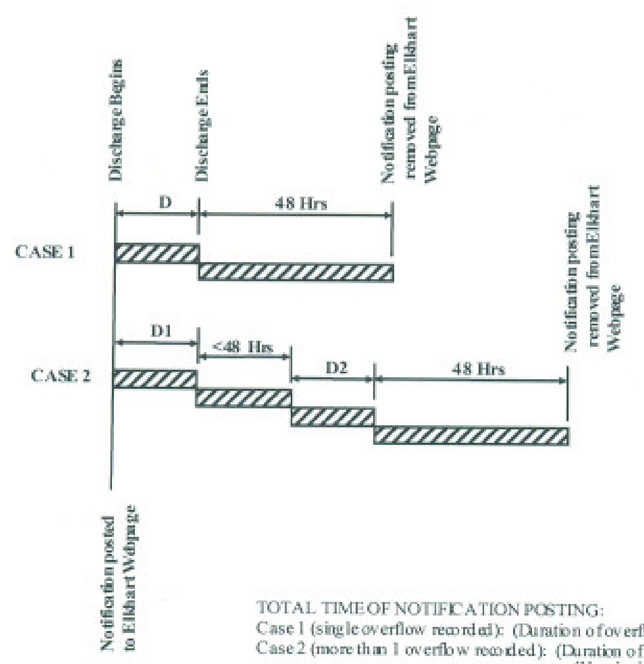
## Figure 3 Logic Sequence for Notification Posting of CSO Discharges




## Figure 4 Duration of Notification Posting on Elkhart's Homepage




TOTAL TIME OF NOTIFICATION POSTING:
Case 1 (single overflow recorded): (Duration of overflow) + (48 hours)
Case 2 (more than 1 overflow recorded): (Duration of initial overflow) + (time less than 48 hrs until beginning of next recorded overflow) + (duration of subsequent overflow) + (48 hours)

## Figure Location of CSO Informational Signs

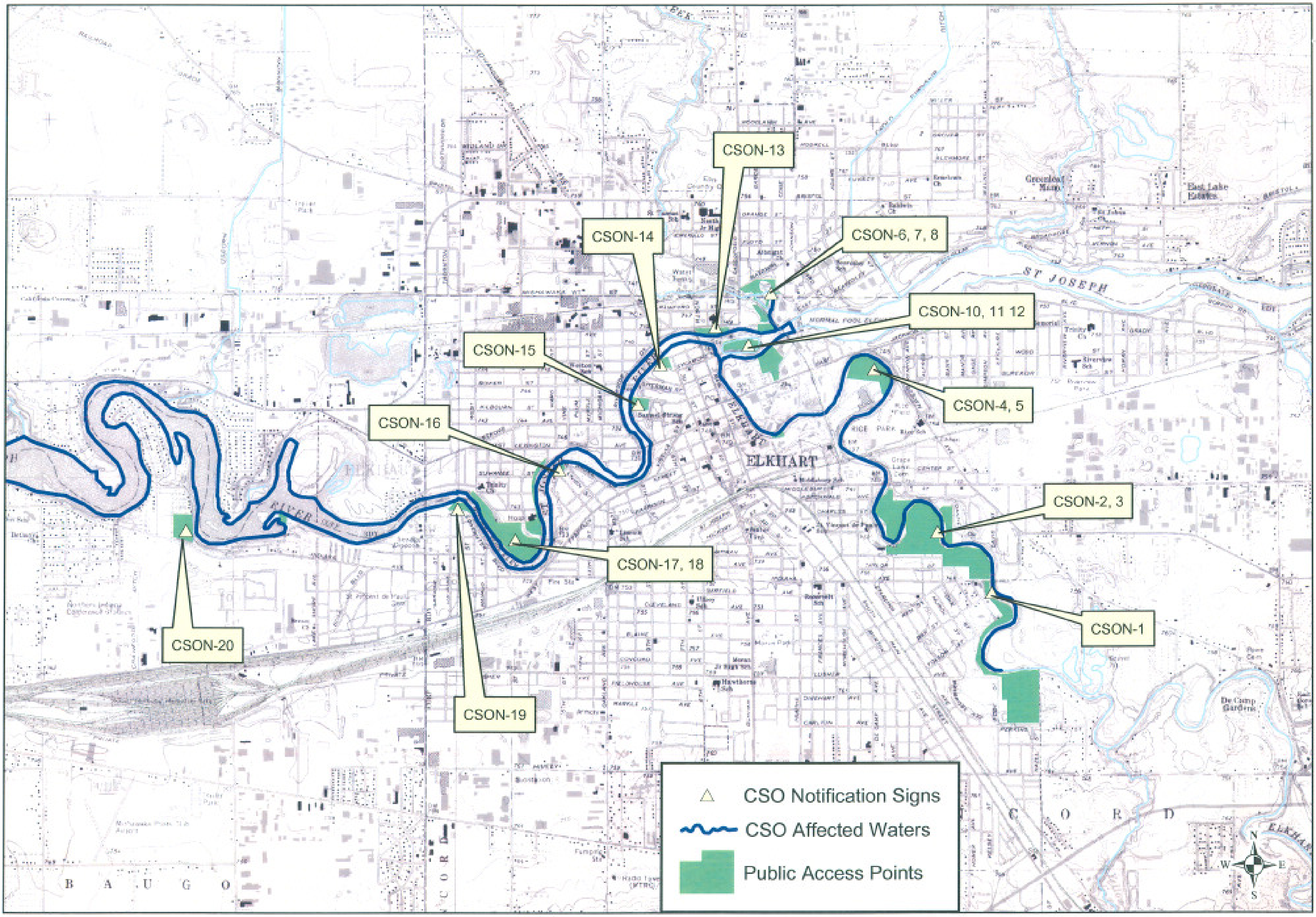



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Figure 6 CSO Informational Sign


**CAUTION: SEWAGE OR STORM WATER POLLUTION**

Bacteria from combined sewer discharges and storm water runoff may be in the river water during periods of rainfall or snowmelt and may remain for several days after. People who swim in, wade in, or ingest this water during or after such periods of rainfall or snowmelt may become ill.

**For more information, please call:**
**Elkhart Public Works and Utilities**
**574-293-2572**

CSON-1

## Figure 7 Location of Public Access Points Outside of Elkhart's Jurisdiction

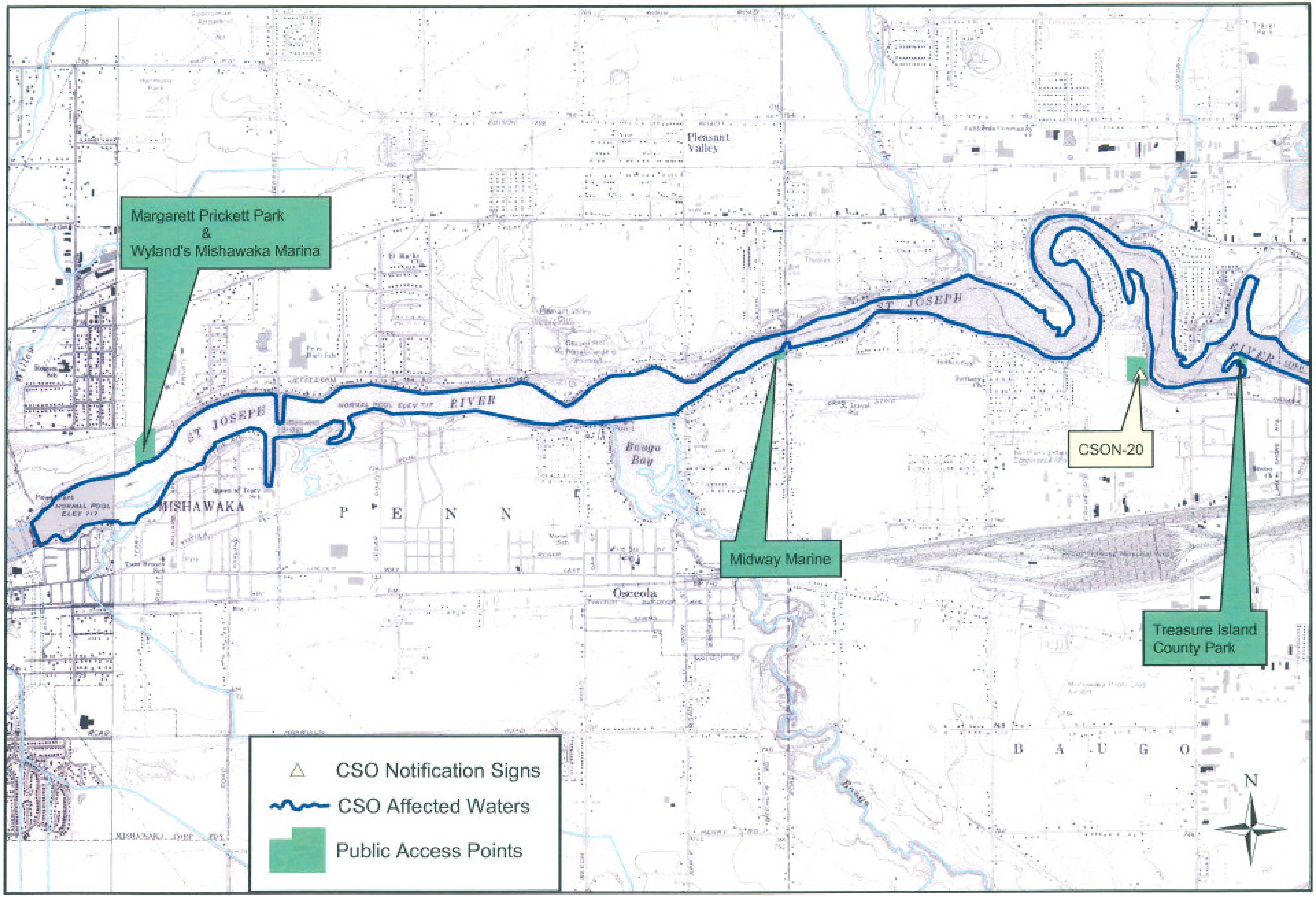


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Figure 8

# NOTICE

## THIS IS A COMBINED SEWER OUTFALL

RIVER WATER MAY BECOME POLLUTED DURING OR AFTER PERIODS OF RAIN, SNOW, OR SNOWMELT. SWIMMING IS DISCOURAGED DURING AND AFTER THESE EVENTS. IN THE EVENT OF DISCHARGES FROM THIS OUTFALL DURING DRY WEATHER, OR FOR MORE INFORMATION, PLEASE CALL:

**574 – 293 – 2572**

**City of Elkhart**

**Public Works & Utilities**

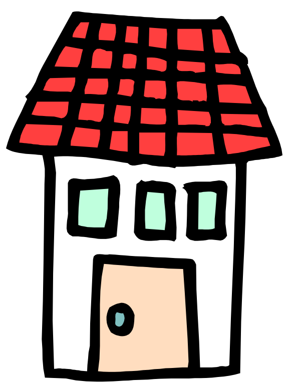
CSO No.

NPDES No. IN0025674

# Downspout Disconnections

Every time Elkhart experiences heavy rains or a great snow melt, the City's sewer system is put to the test. As downspouts and road gutters flood the sewer with water, overflow is routed into the Elkhart and St. Joseph River so it does not exceed wastewater treatment capacity. These combined sewer overflows (CSOs) can contaminate our waterways and threaten the health of both human and aquatic life with raw sewage. Local ordinance therefore requires the disconnection of all downspouts from Elkhart's sewer system. If the waterspouts on your house go directly into the ground, they are allowing water to flow into the sewer system, and need to be re-routed to your lawn. A substantial fine can be yielded for those who fail to comply. A downspout disconnection can cost as much as $150 but is now being offered

**free of charge** through Elkhart EnviroCorps.



In order to avoid harsh fines and service fees while keeping sewage out of the river, contact Sherry Bowen at 293- 2572 for your free disconnection.

Clean river Healthy neighborhoods
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# Water Quality Problems in the St. Joseph River and Their Causes

**The St. Joseph River is a valuable community resource enjoyed by Olympic-caliber kayakers, recreational canoeists and weekend sport fishermen. Its water quality has improved dramatically since the 1950s, with 82 species of fish now found in the river and scores of parks and recreational areas lining its banks.**

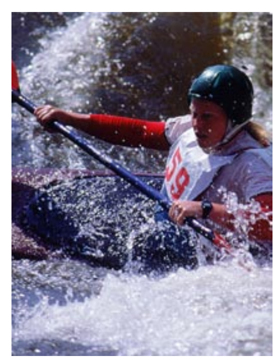
With the river's resurgence, the communities of South Bend, Mishawaka and Elkhart are planning more recreational and economic opportunities on their waterfronts.

Despite this progress, the St. Joe still doesn't meet federal Clean Water Act goals.

From Elkhart to the Indiana-Michigan state line, the St. Joseph River doesn't meet recreational water quality standards for *E. coli* bacteria about 20 percent of the time during a typical year — and 16 percent of the time during the warm-weather months when people use the river for recreation.


*E. coli* bacteria is an indicator of human or animal waste and potentially disease-causing organisms in the water. Some *E. coli* in a waterway is natural, but high levels have been linked to stomach cramps, diarrhea and other gastrointestinal illnesses among swimmers and people who ingest or swallow water during recreation. Children, the elderly and people with weakened immune systems or chronic conditions are most at risk.

During dry weather, approximately 97 percent of St. Joe River water samples meet *E. coli* standards. When it rains, however, many sources combine to cause high *E. coli* bacteria levels in the river. These sources include:



- Sewage overflows during wet weather from cities with combined storm-sanitary sewer systems (South Bend, Mishawaka, Elkhart and Goshen)
- Stormwater runoff from farms and animal feedlots
- Stormwater runoff from parking lots, yards and other areas with wildlife and pet waste
- Runoff from neighborhoods with failed septic systems

The U.S. Environmental Protection Agency and Indiana Department of Environmental Management require cities with combined sewers to develop long-term plans to reduce sewer overflows. Cities also must implement regulations and educational programs to reduce stormwater pollution.

State and local health departments regulate private septic systems and property owners are responsible for properly maintaining those systems. State environmental regulations also govern farms with confined feeding operations.

However, more efforts will be needed in the future to protect the St. Joe — and people who use it — from stormwater runoff, agricultural runoff, failing septic systems and other pollution sources.

# Why Our Sewers Overflow When It Rains

**Every year, more than 850 billion gallons of untreated sewage flows into our nation's rivers, lakes and bays. These sewage overflows come from antiquated "combined" sewer systems built as many as 100 years ago in many U.S. cities.**

South Bend, Mishawaka, Elkhart and many other cities built storm sewers in the early 1900s to carry rainwater and melting snow away from homes, businesses and streets. In those horse-and-buggy days, these cities didn't have sewage treatment or even indoor plumbing.


*During dry weather, all sewage is carried to the treatment plant.*

When indoor plumbing came later, homeowners and business owners hooked their sewage lines to the existing storm sewers, combining storm water and raw sewage into one pipe. The pipes emptied directly into the river, until the 1950s when sewage treatment plants were built.

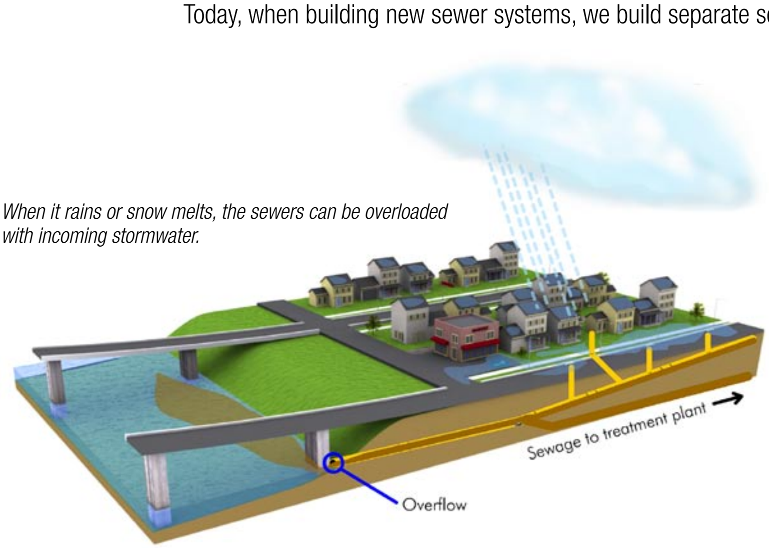
This was common practice in many U.S. cities, especially in the Northeast and Midwest.

During dry weather, a "combined" sewer system works much like a separate sewer — carrying all sewage to the treatment plant for treatment.

However, when it rains or snow melts, the sewers can be overloaded with incoming stormwater. When this happens, the sewers are designed to flow over internal dams in the underground pipes and into nearby streams and rivers. If they didn't have this release valve, raw sewage would back up into people's basements and streets.

Today, when building new sewer systems, we build separate sewers for stormwater and sewage. Yet these older "combined" sewers remain along the St. Joseph River and in many older cities throughout the country.

*When it rains or snow melts, the sewers can be overloaded with incoming stormwater.*

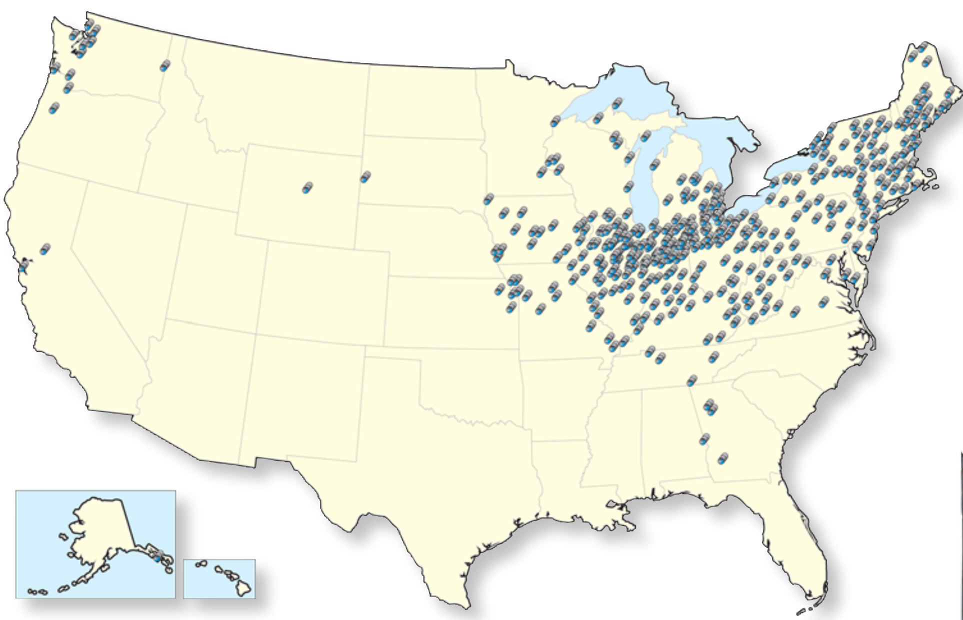



Raw sewage overflowing into the St. Joseph River threatens an important community resource and is hazardous to people's health. Millions of gallons of untreated sewage and rainwater enter the river each year.

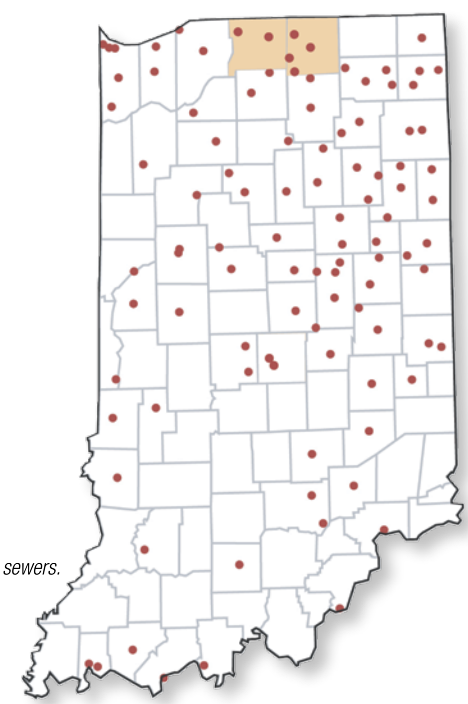
The communities along the river have already invested more than $200 million to reduce these overflows. State and federal regulators will require even more overflow reduction in the future. We need your involvement as the communities seek public input into the best long-term plans to protect the river and those using it.

# Combined Sewer Systems: Nationwide Problem

Combined sewer systems carry both stormwater and raw sewage in the same pipes. Many cities with combined sewer systems have problems with raw sewage overflows when it rains. These overflows contain not only stormwater, but also untreated human and industrial waste, toxic materials and debris. Combined sewer systems serve roughly 772 communities containing about 40 million people, according to the U.S. Environmental Protection Agency. Most communities with combined sewer systems are located in the Northeast and Great Lakes regions and in the Pacific Northwest. Indiana has more than 100 communities with combined sewers.



*Combined sewer systems serve roughly 772 communities containing about 40 million people, according to the U.S. Environmental Protection Agency.*



*Indiana has more than 100 communities with combined sewers.*

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# Early Action Projects To Reduce Sewer Overflows

**The City of Elkhart has spent $28.2 million since 1990 to reduce sewer overflows into the St. Joseph and Elkhart rivers. These improvements have eliminated seven sewer overflow points, redirecting millions of gallons of raw sewage away from the rivers and sending it to the wastewater treatment plant during wet weather.**

The city's investments to date include:

- Separating sewers in high-priority neighborhoods, focusing on high-volume overflow pipes and areas with basement backups, drainage problems and industrial sewage. Future projects will focus on boat ramps, public parks, greenways, schools and other areas where people are likely to access the rivers.

- Increasing sewer cleaning and maintenance activities to reduce overflows and allow more flow to get to the wastewater treatment plant. These activities also have reduced customer complaints about sewer backups and other problems.

- Installing check valves in seven overflow pipes to prevent river water from entering the sewer system during high river flows, saving the city $925,000 per year in unnecessary treatment costs and allowing more sewage to reach the treatment plant during wet weather.

- Replacing or repairing deteriorating manholes and catch basins. Manholes allow access to a sewer for maintenance, repair and cleaning. Catch basins are located below street gutters and are designed to capture trash and other items that can't pass through the sewer. Both structures must be regularly cleaned and maintained – and repaired or replaced when they are in bad condition.

More improvements will be needed in the future to further reduce sewer overflows and meet our Clean River-Healthy Neighborhoods goals. The city is working with the U.S. Environmental Protection Agency and the Indiana Department of Environmental Management on long-term plans to redesign our sewer system so it meets today's standards.

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# Elkhart Sewer Overflow Locations

**Raw sewage has the potential to overflow from 33 locations in Elkhart's sewer system into the St. Joseph and Elkhart rivers and Christiana Creek, as shown on the map below. As little as 1/4 to 1/2-inch rain can overwhelm the sewer system and cause an overflow. In a year with typical rainfall, these overflows can occur up to 70 times a year from some locations, sending untreated sewage and polluted storm water into the streams.**

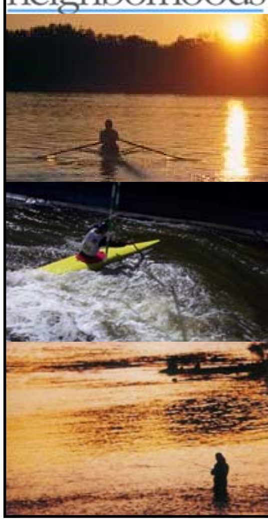
Elkhart is already making progress in reducing overflows. Since 1990, the city has spent $28.2 million on sewer system improvements, eliminating seven overflow points. The city's long-term control plan will reduce overflows even more.


*Overflow pipe near ~~LaSalle~~ and ~~Michigan~~ that sends raw sewage overflows to the St. Joseph River after it rains.*

*Red dots indicate where raw sewage overflows may occur in wet weather.*

Elkhart Citizen Advisory Committee
Meeting 1 – September 23, 2008

## Agenda



- Committee Purpose and Responsibilities
- Public Outreach Video
- Background and Regulatory Requirements
- River Monitoring and Sampling Program
- Early Action Projects
- Next Steps
- Treatment Plant Tour

2

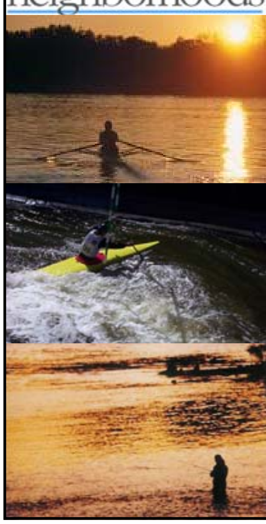
## Committee Purpose and Responsibilities

- **<u>Purpose:</u>** The Citizen Advisory Committee provides input to the Dept. of Public Works on selection, financing and implementation of the right long-term plan to control sewer overflows in Elkhart.
- **<u>Responsibilities</u>:** Committee members have two roles:
  - Advising the city on issues brought before the committee
  - Being a conduit of information to the community on the city's plans and required funding/rate increases

3

## Agenda

Clean river Healthy neighborhoods



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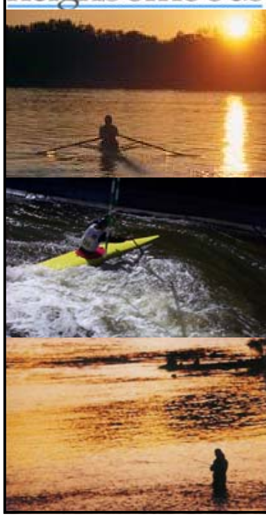
4

## Agenda

Clean river Healthy neighborhoods



- Committee Purpose and Responsibilities
- Public Outreach Video
- **Background and Regulatory Requirements**
- River Monitoring and Sampling Program
- Early Action Projects
- Next Steps
- Treatment Plant Tour

5

## The St. Joseph River: A Community Resource Worth Protecting

6

## A Recreational and Economic Asset




- In 1931, carp was the river's predominant fish; between Mishawaka and Niles, Mich., only pollution-tolerant life found
- Thanks to modern sewage treatment and pollution control, 82 species of fish today
- More than 40 parks and recreation areas along rivers in Elkhart and St. Joseph counties
- Used for boating, fishing, canoeing, kayaking, rafting and sculling
- Future plans to create housing, jobs and community gathering places along river

7

## Elkhart RiverWalk Commons

8

## The East Race Waterway: For Pros and Amateurs

9

## Mishawaka Riverwalk

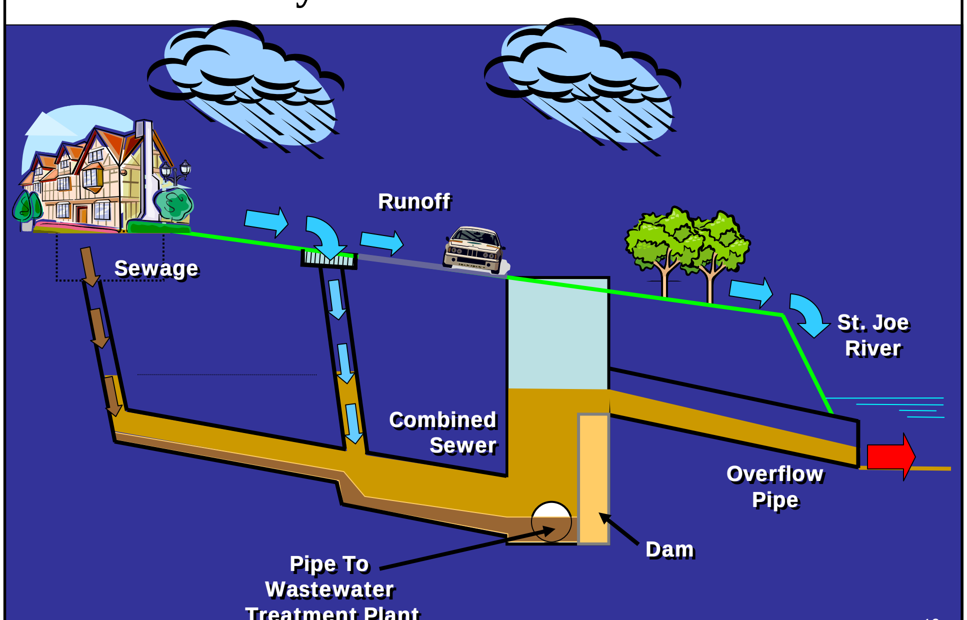
10

## Sewer Overflows – A Regional Problem


- More than 50 times each year, storms cause sewer overflows in Elkhart, Mishawaka and South Bend
- Overflows send 1.8 billion gallons of raw sewage and stormwater into the river in a typical year
- In 2004-05, Elkhart's sewers contributed 180 million gallons of this total (10%)
- Progress being made

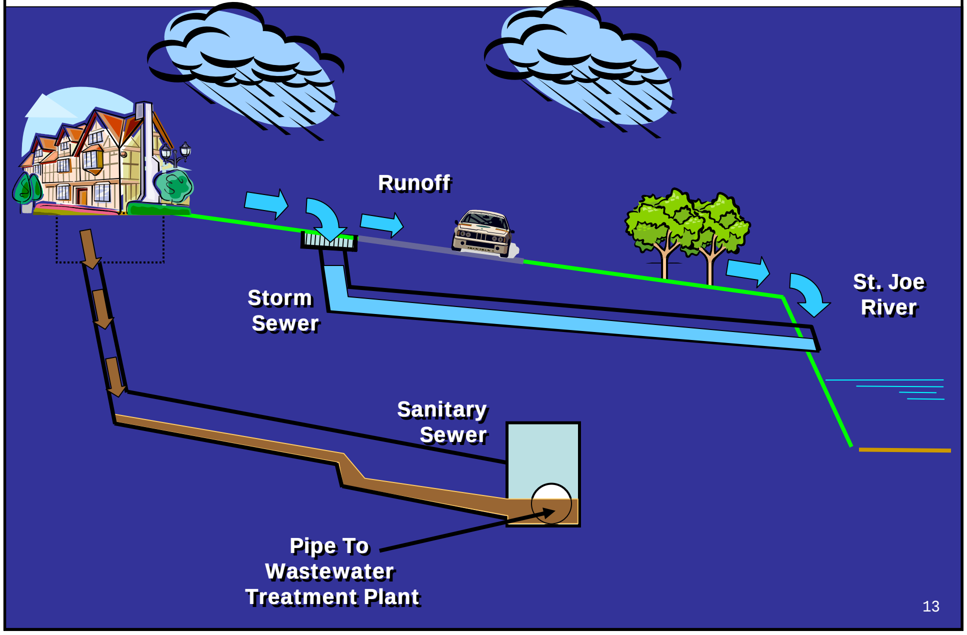
11

## Why Our Sewers Overflow

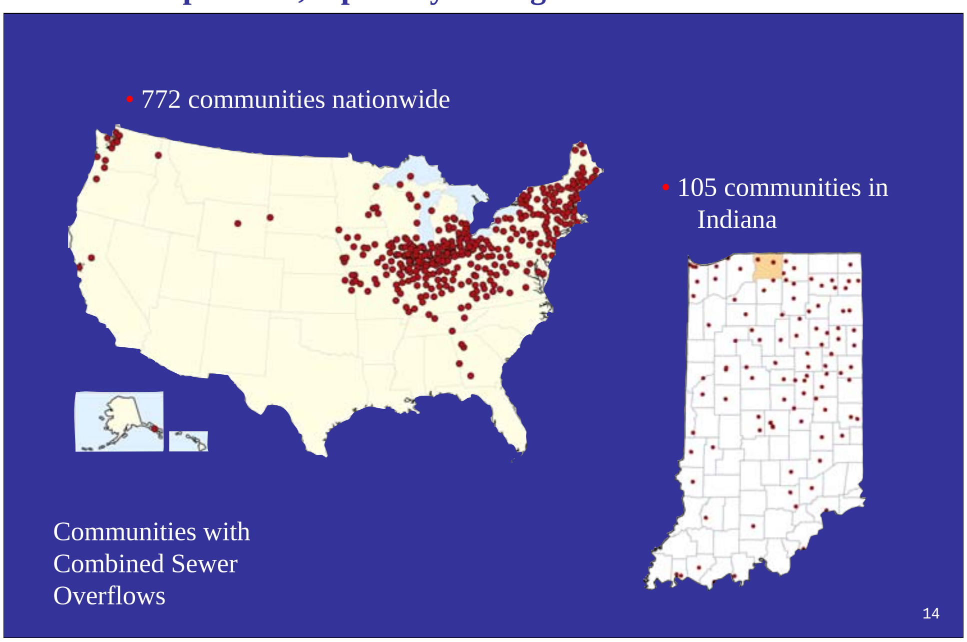



12

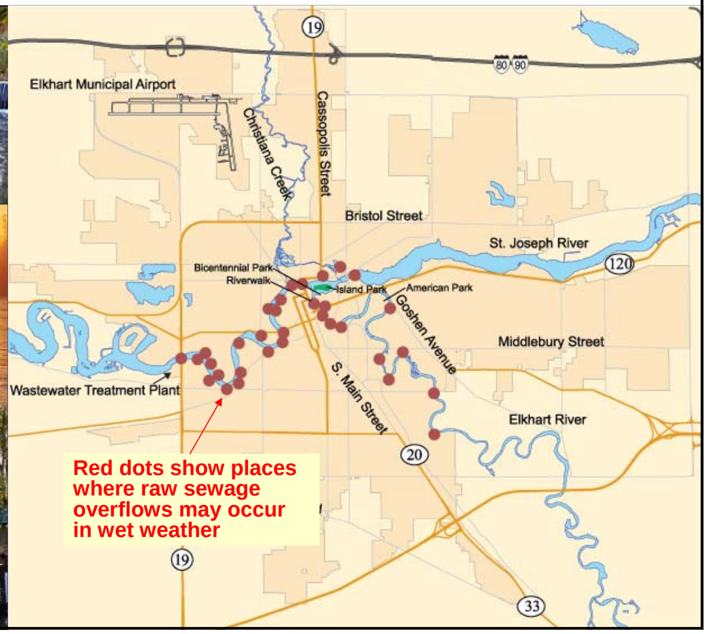
## Separated Sewer System



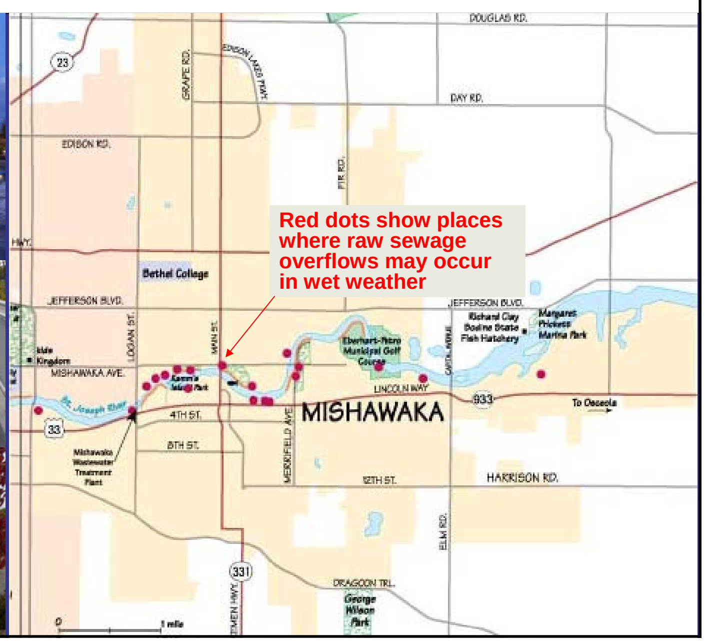

**We Are Not Alone!**
**Nationwide problem, especially throughout Midwest and East Coast**



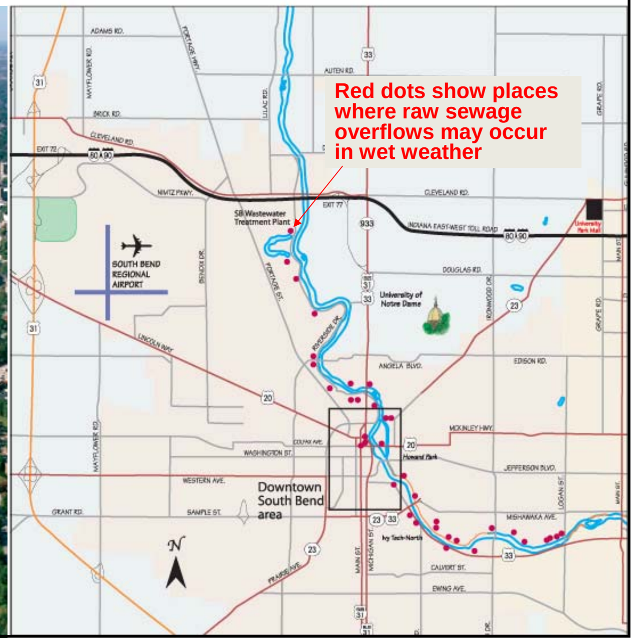
# Elkhart has 33 Sewer Overflow Locations




# Mishawaka has 19 Sewer Overflow Locations



## South Bend has 36 Sewer Overflow Locations




## Regulatory Requirements


- Sewer overflows must be controlled under the Clean Water Act
- 1994 U.S. EPA CSO Control Policy and 1996 IDEM CSO Strategy
- Required development of cost-effective CSO controls through:
  - Studies of sewer system
  - Public participation
  - Consideration of sensitive areas
  - Evaluation of alternatives, including costs and performance
  - Improving operations of the sewer system
  - Maximizing treatment at the existing treatment facilities
  - Review of water quality standards, if appropriate

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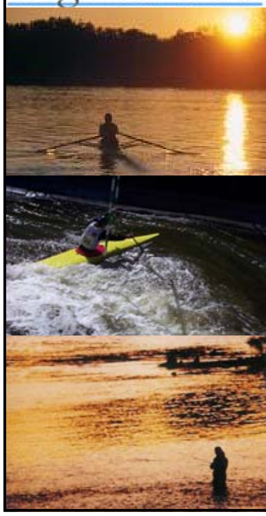
# Agenda

Clean river Healthy neighborhoods



- Committee Purpose and Responsibilities
- Public Outreach Video
- Background and Regulatory Requirements
- **River Monitoring and Sampling Program**
- Early Action Projects
- Next Steps
- Treatment Plant Tour

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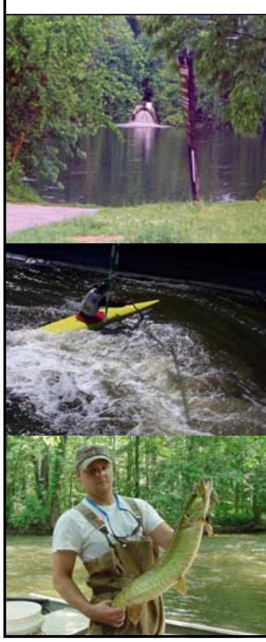
# Water Quality Concerns



- River has come a long way since 1930s
- However…
- St. Joseph River typically does not meet Indiana’s swimming standards for *E. coli* bacteria 10-16 percent of the time from April-October (the recreational season)
- Michigan’s standards also must be addressed

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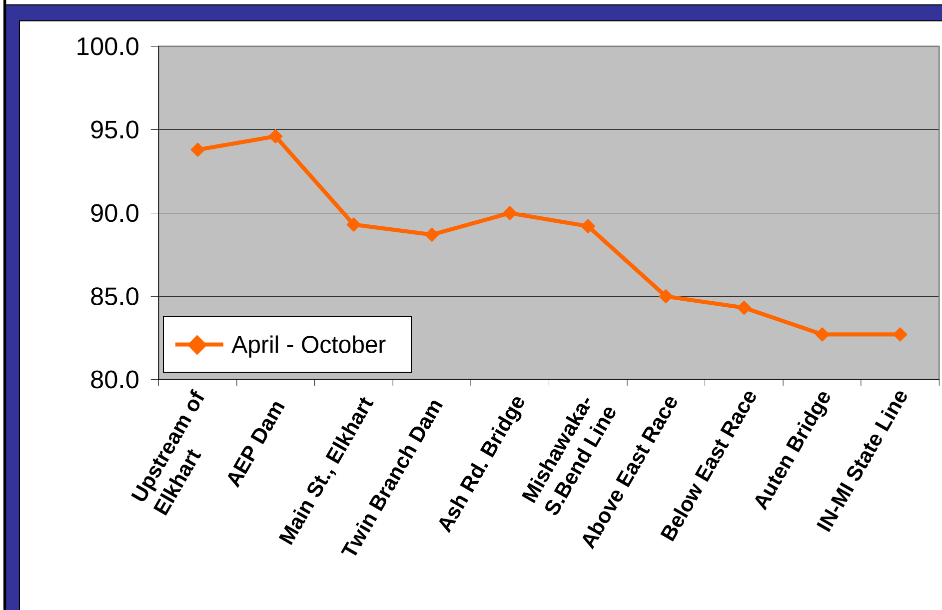
## % of Hours Meeting Indiana "Swimming" Standard

**(Single Sample Maximum: Must be less than 235 *E. coli* colonies/100 mL)**




## E. Coli Monthly Geometric Mean Standard

**(Must be less than 125 cfu/100 mL)**

| | In-Stream geometric mean (cfu/100 mL) by month | | | | | | |
|---|---|---|---|---|---|---|---|
| **Location** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** |
| Upstream of Elkhart City | 33 | 31 | 38 | 59 | 38 | 87 | 22 |
| AEP Dam backwater | 31 | 27 | 34 | 54 | 38 | 93 | 23 |
| Main Street | 50 | 36 | 50 | 94 | 55 | 199 | 35 |
| Ash Road | 38 | 22 | 31 | 66 | 44 | 186 | 28 |
| Bittersweet Road | 31 | 14 | 24 | 53 | 41 | 177 | 25 |
| Mishawaka-S. Bend Line | 29 | 13 | 28 | 64 | 52 | 254 | 29 |
| Start of East Race | 32 | 15 | 42 | 125 | 82 | 375 | 39 |
| Below East Race | 33 | 15 | 42 | 134 | 84 | 399 | 40 |
| Auten Bridge | 35 | 18 | 54 | 181 | 109 | 477 | 49 |
| Indiana-Michigan State Line | 34 | 17 | 52 | 176 | 106 | 468 | 48 |
| | | | | | | | |
| Total Rainfall (inches) (1992) | 2.19 | 1.17 | 1.74 | 5.24 | 2.07 | 8.84 | 1.6 |
| No. of Rainfall Events (1992) | 17 | 6 | 8 | 14 | 8 | 9 | 10 |

**Months & locations not meeting standard (based on 1992 rainfall)**

*Notes:*

- *Based on modeled results and 1992 rainfall amounts – a typical year for the region.*
- *Indiana does not have a 30-day geometric mean standard for November through March.*

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## Causes of Poor Water Quality

- Sewer overflows in South Bend, Mishawaka and Elkhart are a significant cause of water quality problems, but not the only cause
- Other contributors:
  - urban stormwater runoff from streets, yards & parking lots
  - agricultural stormwater runoff
  - upstream sewer overflows
  - failed septic systems

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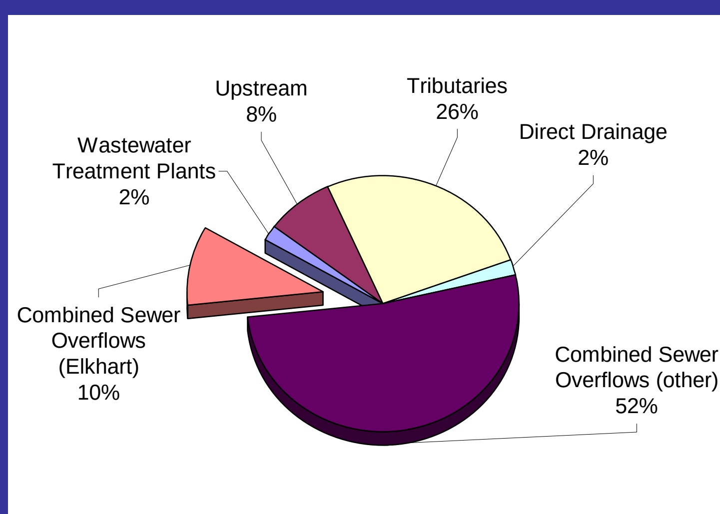
## Typical Year *E. coli* Loads to St. Joseph River

**Current Conditions**

- Sewer overflows are the biggest contributor of *E. coli* bacteria in the St. Joseph River

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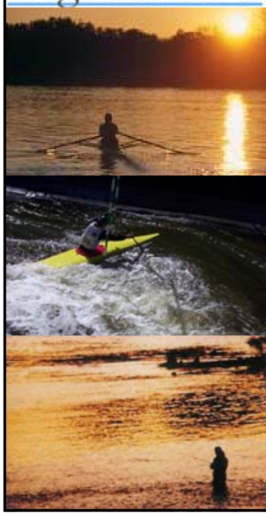
## Agenda



- Committee Purpose and Responsibilities
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- Next Steps
- Treatment Plant Tour

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## Already Working to Reduce Overflows

- The three communities have spent more than $230 million since 1990 to:
  - Expand wastewater treatment plants
  - Eliminate sewer overflow locations
  - Separate hundreds of acres of combined sewers
  - Better manage existing sewer system
- Together, these efforts have reduced overflows by more than 1 billion gallons in a typical year
- Our long-term plans will do even more

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## Elkhart Early Action Projects

- More than $27.6 million invested since 1985 to reduce overflows:
  - Separated sewers in high-priority neighborhoods (basement backups, drainage problems and industrial sewage)
  - Increased sewer cleaning and maintenance
  - Replaced or repaired deteriorating manholes and catch basins
  - Installed check valves to prevent river water from entering sewer system
  - Nationally recognized industrial pretreatment program

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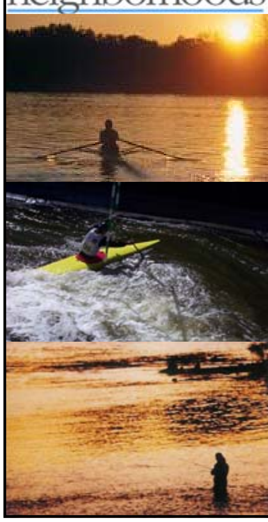
## Agenda

Clean river Healthy neighborhoods



- Committee Purpose and Responsibilities
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- Early Action Projects
- **Next Steps**
- Treatment Plant Tour

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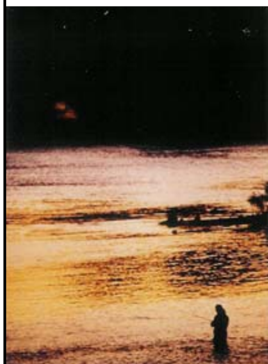
## Next Steps



- Meeting 2 Agenda:
  - Alternatives analysis
  - Costs and benefits of options
- Meeting 3 Agenda:
  - Plan financing
  - Consent Decree requirements
- Meeting 4 Agenda
  - Recommended plan
  - Post-construction monitoring
  - Public outreach
- Meeting 5 Agenda
  - Public comments received
  - Future role of committee

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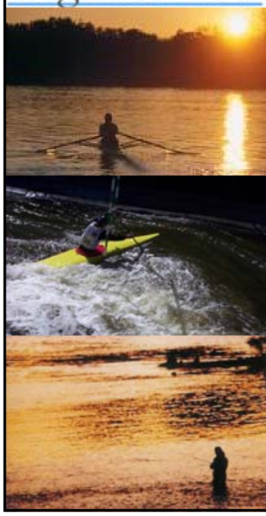
## Questions?


## Agenda

Clean river Healthy neighborhoods



- Committee Purpose and Responsibilities
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- Next Steps
- **Treatment Plant Tour**

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Clean river Healthy neighborhoods
ELKHART ▪ MISHAWAKA ▪ SOUTH BEND

Elkhart Citizen Advisory Committee
Meeting 2 – October 30, 2008

## Agenda

- Technologies for Reducing Overflows
- Elkhart Alternatives & Costs
- Benefits
- Next Steps
- Treatment Plant Tour



## Technologies for Reducing Overflows

1. Separate Sewers
2. Build New Storage Facilities or Larger Sewers
3. Expand or Build New Treatment Facilities
4. Use Existing Sewer System More Effectively
5. Build Green Infrastructure
6. Combination of Above

## 1. Separate Sewers

Separate combined sewers into storm sewer and sanitary sewer

- Most disruptive
- Most costly
- Can be cost-effective when combined with other neighborhood improvements
- Eliminates combined sewer overflows, but adds more untreated stormwater to the river



## 2. Build Storage Tanks, Tunnels or Larger Sewers

Build New Storage Facilities or Larger Sewers:

- – Underground storage tunnel
- – New, larger sewers
- – Storage tank
- Facilities capture overflows during storm when sewers are full
- After storm, flow sent to existing treatment plant or treated on-site



## Some Options for Finished Storage Tanks

- Skate Park
- Parking Lot
- Riverwalk
- Levee
- Tennis Court
- Amphitheater
- Canal
- Soccer Field
- Trail
- Dog Park

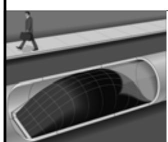
## 3. Expand Treatment or Build New Treatment



- Two options considered:
  - Expand existing treatment plants
  - Build high-rate treatment at remote locations
- Existing plants need to be ready for more wet-weather flow
- Space concerns at Elkhart plant site



## 4. Use Existing Sewer System Better



Create more in-system storage with inflatable dams or pinch valves

- Can hold more flow in existing sewers economically
- Sensors in sewers monitor flow and prevent sewage backups



## 5. Green Infrastructure




- Green roofs
- Rain gardens/vegetated swales & landscape
- Porous pavement
- Downspout disconnection/ rainwater collection
- Wetlands/urban forests

## Agenda

- Technologies for Reducing Overflows
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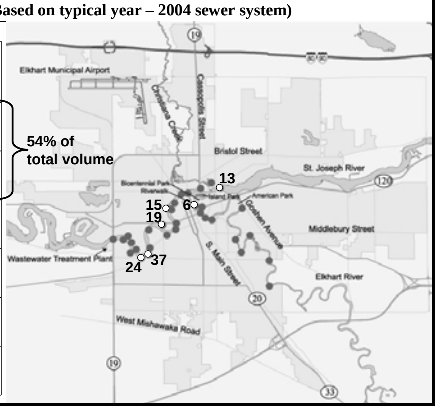
## Overflow Locations with Highest Volume

**(Based on typical year – 2004 sewer system)**

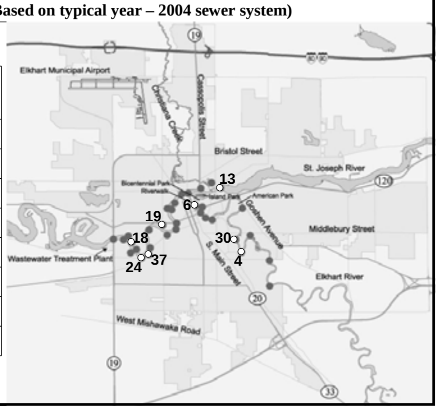
| CSO # | Vol. (MG) |
|---|---|
| 24 | 73.2 |
| 37 | 23.0 |
| 13 | 14.0 |
| 15 | 11.2 |
| 19 | 10.3 |
| 6 | 8.4 |



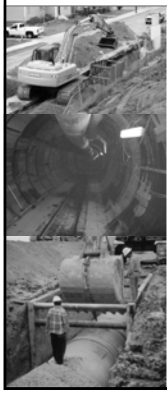

## Locations with Most Frequent Overflows

**(Based on typical year – 2004 sewer system)**

| CSO # | Freq. |
|---|---|
| 24 | 57 |
| 13 | 44 |
| 6 | 39 |
| 19 | 27 |
| 4 | 25 |
| 37 | 25 |
| 18 | 23 |
| 30 | 23 |



## Elkhart Alternatives



- Complete Sewer Separation
- Convey More Flow to Plant
  - Total Conveyance*
  - Deep Tunnel
  - Conveyance Improvements*
- Regional Storage Facilities (4 options: 5A, 5B, 5C, 5D)*

***Includes Wastewater Plant Improvements**

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## Preliminary Cost Estimates

| Alternative | Est. Cost (Capital + 20 Years O&M) |
|---|---|
| **1. Complete Sewer Separation** | **$392 million** |
| 2. Total Conveyance | $1,128 million |
| 3. Deep Storage Tunnel | $307 million |
| 4. Conveyance Improvements | $241 million |
| **5A: Regional Storage** | **$154 million** |
| 5B: Regional Storage | $226 million |
| 5C: Regional Storage | $158 million |
| **5D: Regional Storage** | **$154 million** |

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## Common Elements of Regional Storage Options

- Regional Storage Facilities:
  - Jackson & Waterfall Parking Lot
  - High Dive Park
  - Riverside Drive
  - Goshen Ave Riverbank
  - McNaughton Park
  - Environmental Education Center
- Force Main from Grant & Bristol Lift Station
- Jackson Lift Station Redirection
- Targeted Sewer Separation
- WWTP Improvements

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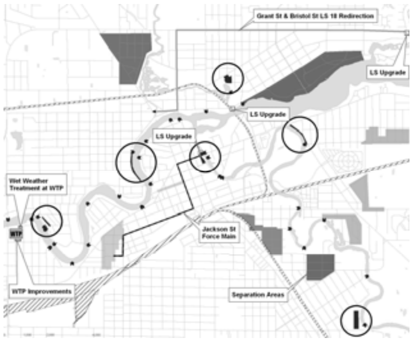
## Alternative 5: Regional Storage – Common Elements

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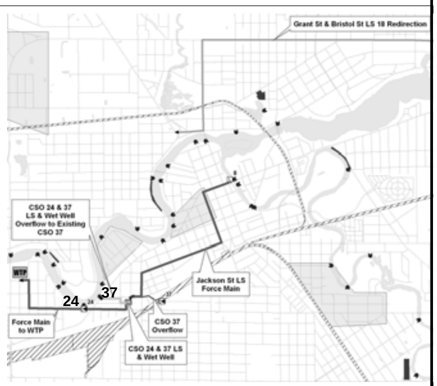
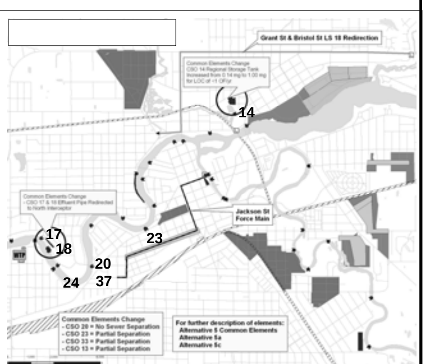
## Regional Storage – Option 5A

- New lift station, wet well and force main for CSOs 24 & 37 and Jackson LS




## 5. Regional Storage – Option 5D

- Option 5A with:
- Partial separation for CSOs 13, 23 and 33
- No separation for CSO 20
- Larger tank at High Dive Park (CSO 14)
- Redirect CSO 17 and 18 to north interceptor

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## Agenda

- Technologies for Reducing Overflows
- Elkhart Alternatives & Costs
- Benefits
- Next Steps
- Treatment Plant Tour

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## Target Benefits

- Reducing volume of overflows
- Reducing frequency of overflows
- Increasing the gallons of wet-weather flows captured and treated
- Meeting water quality standards

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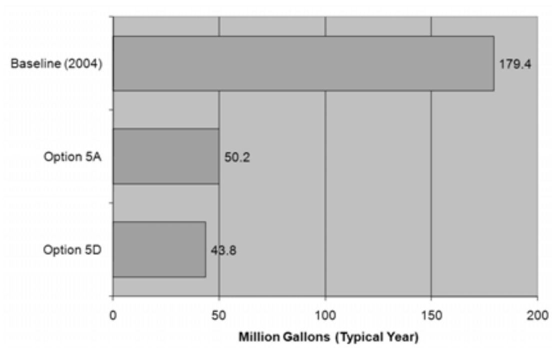
## Overflow Volume in a Typical Year

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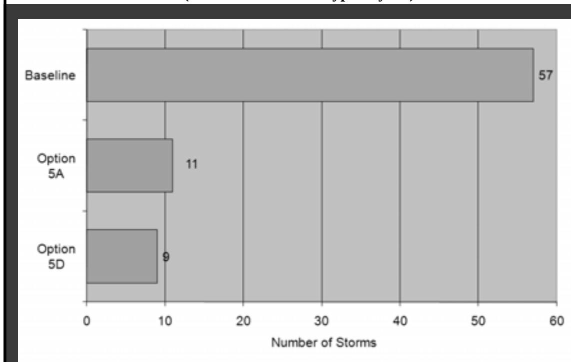
## Number of Storms Causing an Overflow

**(Estimates based on typical year)**

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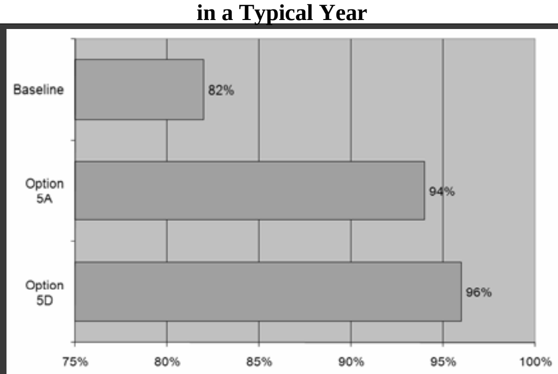
## Percent Capture of Wet Weather Flow in a Typical Year

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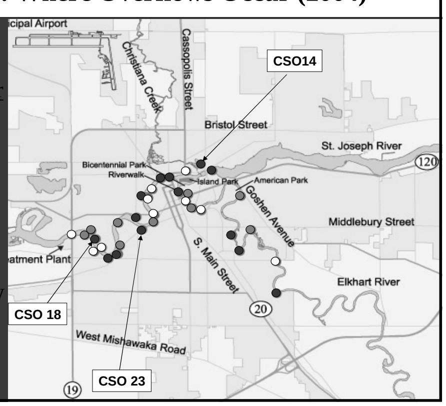
## Before: Where Overflows Occur (2004)

Untreated Overflows - Typical Year

- 0-1
- 2-3
- 6-9
- 10 or more

57 Storms with at least one overflow

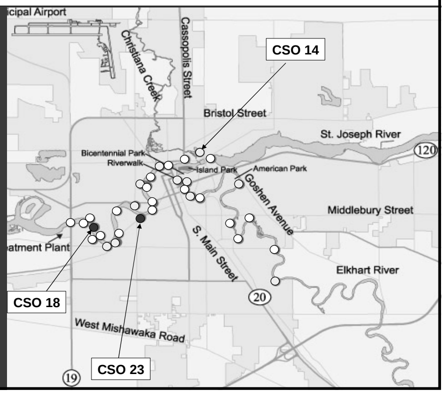


## After: Where Overflows Will Occur (5A)

Untreated Overflows - <u>Typical Year</u>

- 0-1
- 2-3
- 6-9
- 10 or more

11 Storms with at least one overflow

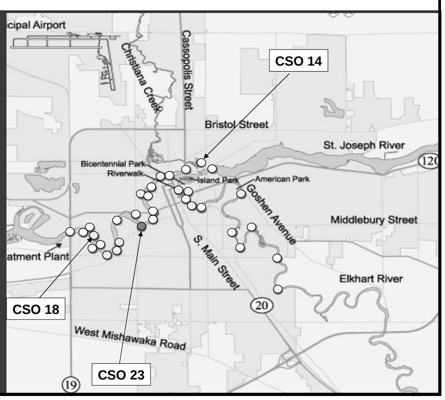



## After: Where Overflows Will Occur (5D)

Untreated Overflows - <u>Typical Year</u>

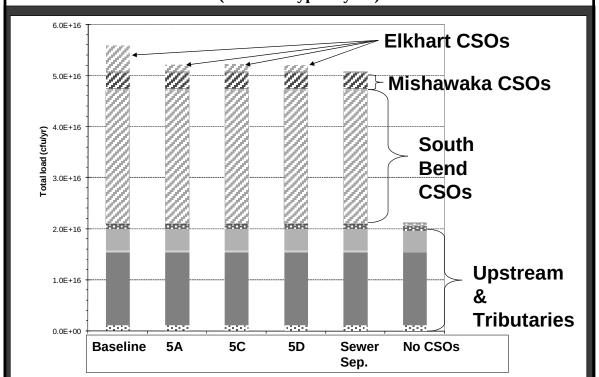
- 0-1
- 2-3
- 6-9
- 10 or more

<10 Storms with at least one overflow

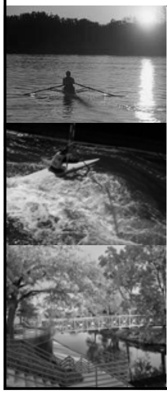



## Annual E. Coli Load to St. Joe River

**(Based on typical year)**



## Ability to Meet Bacteria Standards in Rivers



- Based on a year with typical rainfall…
  - 5D and 5A meet the *E. coli* standard about the same amount of time
  - At the East Race and Michigan State line, 5D performs as well as sewer separation



## Percent of Hours Exceeding E. Coli Standard

**(Based on typical year)**

### St. Joseph River

| | Ash Road Bridge | Start of East Race | IN-MI Line |
|---|---|---|---|
| Baseline Conditions | 11% | 15% | 17% |
| Option 5A (94% Capture) | 7% | 13% | 15% |
| Option 5C (94% Capture) | 7% | 13% | 15% |
| Option 5D (96% Capture) | 7% | 12% | 15% |
| Elkhart Sewer Separation | 6% | 12% | 15% |
| Eliminate all 4 Cities' CSOs* | 6% | 6% | 6% |

*Elkhart, South Bend, Mishawaka and Goshen



## Percent of Hours Exceeding E. Coli Standard

**(Based on typical year)**

### Elkhart River – Jackson Blvd. Bridge

| | Jackson Blvd. Bridge |
|---|---|
| Baseline Conditions | 24% |
| Option 5A (94% Capture) | 24% |
| Option 5C (94% Capture) | 24% |
| Option 5D (96% Capture) | 24% |
| Elkhart Sewer Separation | 24% |
| Eliminate all 4 Cities' CSOs* | 23% |

*Elkhart, South Bend, Mishawaka and Goshen

## Discussion

- Option 5A
  - Costs the same as 5D ($154 M)
  - Overflows more than 10 times per typical year at some locations
  - 94% of wet weather flow treated
- Option 5D
  - Costs the same as 5A ($154 M)
  - More consistent overflow frequency
  - 96% of wet weather flow treated
  - Reduce overflows on Christiana Creek (High Dive Park)



## Agenda

Clean river Healthy neighborhoods

- Technologies for Reducing Overflows
- Elkhart Alternatives & Costs
- Benefits
- Next Steps
- Treatment Plant Tour



## Next Steps

- Meeting 3 Agenda:
  - Plan financing
  - Consent Decree requirements
- Meeting 4 Agenda
  - Recommended plan
  - Post-construction monitoring
  - Public outreach
- Meeting 5 Agenda
  - Public comments received
  - Future role of committee

## Questions?




## Agenda


- Technologies for Reducing Overflows
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- Benefits
- Next Steps
- Treatment Plant Tour

Clean river Healthy neighborhoods

ELKHART ▪ MISHAWAKA ▪ SOUTH BEND

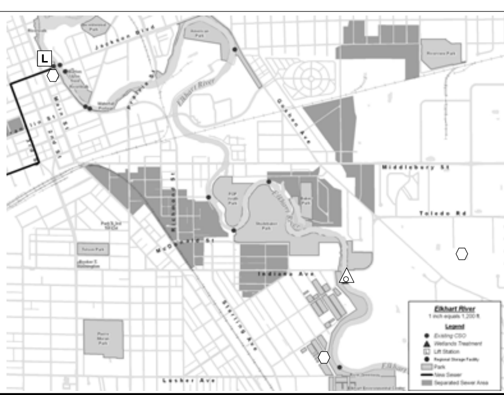
Elkhart Citizen Advisory Committee
Meeting 3 – November 25, 2008

## Agenda

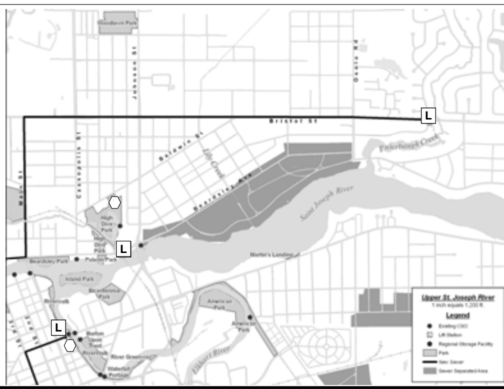
- Recommended Plan
- Financial Capability Analysis
- Consent Decree Requirements



## Elkhart River Recommended Plan



## Upper St. Joseph River Recommended Plan

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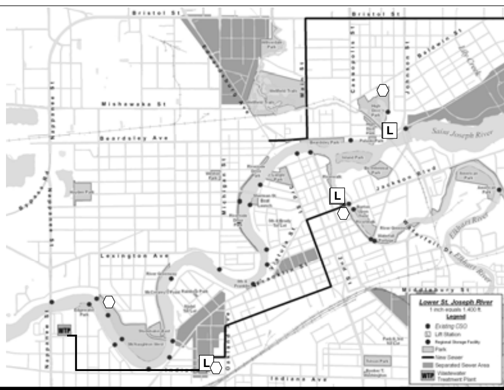
## Lower St. Joseph River Recommended Plan

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## Estimated Cost of Recommended Plan

| **Plan Element** | **Estimated Cost** |
|---|---|
| Sewer Separation | $24,864,000 |
| Force Main Upgrades/Redirections | $6,490,000 |
| Sewer System Upgrades – CSO 37 | $4,410,000 |
| Regional Storage Tanks | $19,810,000 |
| Oakland Ave. Lift Station with Storage | $10,720,000 |
| Other Lift Station Improvements | $3,110,000 |
| Wet Weather Treatment at WWTP | $3,190,000 |
| Other WWTP Improvements | $16,840,000 |
| **Subtotal** | **$89,434,000** |
| Contingency | $44,717,000 |
| **Total Capital Cost** | **$134,151,000** |
| Annual Operations & Maintenance | $1,870,000 |
| **Present Worth Cost (Capital + 25 Years O&M)** | **$158,055,000** |

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## Agenda


- Recommended Plan
- Financial Capability Analysis
- Consent Decree Requirements

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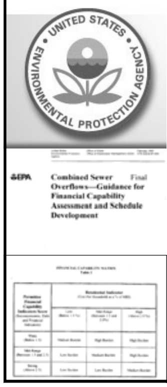
## U.S. EPA's Four-Step Process




- Develop a Cost per Household
- Determine the Residential Indicator Score
  - Based on Cost per Household as a percent of Median Household Income (MHI)
- Develop the Community Financial Indicator Score
  - Based on five factors
- Develop the Overall Financial Capability Indicator Score

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## Cost Per Household

- Calculate current annual wastewater treatment costs
- Calculate future costs
- Calculate residential share (based on % of flow from residential customers)
- Divide by total households

9

## Residential Indicator Score



- Cost Per Household:
  - Current $398 per year
  - Projected $737 per year
- Median Household Income
  - $40,870 (2005)
- Cost per Household as a % of Median Household Income
  - **1.8 percent** (projected based upon 25-year schedule without bonding)



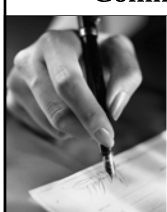
## Our Cost Per Household has a Mid-Range Impact

### U.S. EPA Residential Indicator

| **Cost Per Household** | **Financial Impact** |
|---|---|
| Less than 1% of MHI | Low |
| 1-2% of MHI | **Mid-Range** |
| Greater than 2% of MHI | High |



## Community Financial Indicators




- Median Household Income
- Property Tax Collection Rate
- Bond Rating
- Net Debt Per Capita
- Unemployment Rate

## Median Household Income (2005)


| | |
|---|---|
| National MHI | **$49,230** |
| State MHI | $48,729 |
| Elkhart MHI | $40,870 |
| Comparison | 16-17% below state & national MHI |
| **U.S. EPA and IDEM Score** | **Mid-Range** |

**MHI is based on 1999 census data, adjusted to 2005 dollars using the Consumer Price Index.**



## Property Tax Collection Rate

| | |
|---|---|
| Property Tax Collection Rate (2005-2006) | 97.22 % |
| **U.S. EPA and IDEM Score** | **Mid-Range** |

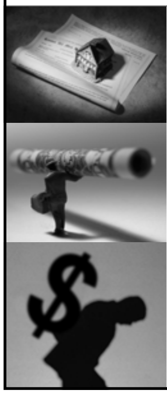


## Bond Rating

STANDARD & POOR'S

| | |
|---|---|
| Standard & Poor's Bond Rating | A+ |
| **U.S. EPA and IDEM Score** | **Strong** |

## Net Debt Per Capita



| | |
|---|---|
| Total Debt (2005) | $118, 396,571 |
| Elkhart Population (2005) | 52,270 |
| Net Debt Per Capita | $2,265 |
| **IDEM Score** | **Mid-Range ($1,000 -$3,000)** |

16

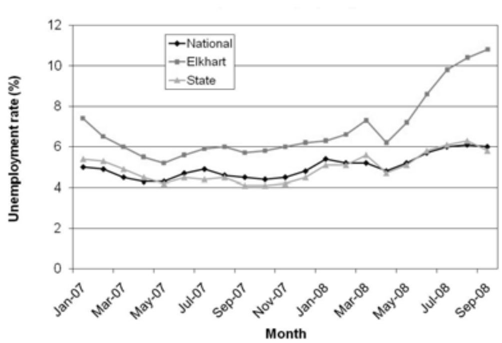
## Unemployment Rate (2005)

| | |
|---|---|
| National Rate | 5.1% |
| State Rate | 5.4% |
| Elkhart Rate | 6.3% |
| Difference | 1.2% above national average |
| **U.S. EPA & IDEM Score** | **Weak** |

17

## Unemployment Rate (Jan. ’07 to Sept. ’08)

**(not seasonally adjusted)**




18

## Community Financial Indicator Score

| Indicator | Rating | Score |
|---|---|---|
| Median Household Income | Mid-Range | 2.5 |
| Property Tax Revenue Collection Rate | Mid-Range | 1.25 |
| Bond Rating | Strong | 1.5 |
| Net Debt per Capita | Mid-Range | 2.25 |
| Unemployment Rate | Weak | 3.0 |
| | | |
| **Total** | | **10.5** |
| **Average Score** | **Mid-Range** | **2.1** |
| **"Weighted" Average Score** | **Mid-Range** | **2.3** |



## Overall Financial Capability Score

| **Community Financial Indicator Score** | **Residential Indicator Score** (Cost per Household as % of MHI) | | |
|---|---|---|---|
| | **Low (< 1%)** | **Mid-Range (1-2%)** | **High (>2%)** |
| **Weak (below 1.5)** | Medium Burden | High Burden | High Burden |
| **Mid-Range (1.5-2.5)** | Low Burden | **Medium Burden** | High Burden |
| **Strong (above 2.5)** | Low Burden | Low Burden | Medium Burden |



## U.S. EPA Scheduling Guidelines

- Most Indiana communities with federal consent decrees have had 18-20 year schedules to complete their plans
- Given Elkhart's economic difficulties and burden near "high," we have requested a schedule of 25 years

## Agenda

Clean river Healthy neighborhoods

- Recommended Plan
- Financial Capability Analysis
- Consent Decree Requirements



## Consent Decree: Why and What Does It Mean?

- All three cities are negotiating federal consent decrees with U.S. EPA & Department of Justice
- Targeted by EPA because our overflows affect Michigan waters
- Decree will be filed in federal court and will require implementation of the plan
- Penalties if we don't meet milestones and deadlines



## Elkhart's Negotiating Goals

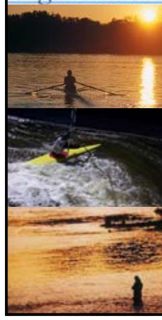
- Agree on long-term control plan details before entering into decree
- Negotiate reasonable performance standards
- Negotiate a reasonable project schedule
- Obtain approval of Use Attainability Analysis to modify Indiana *E. coli* standards during large storms

## Questions?


Our beautiful Riverwalk gives downtown Elkhart a unique and distinct signature all its own.

Elkhart Citizen Advisory Committee
Meeting 4 – December 16, 2008

## Agenda



- Draft schedule
- Post-construction monitoring
- Public outreach
- Closing discussion

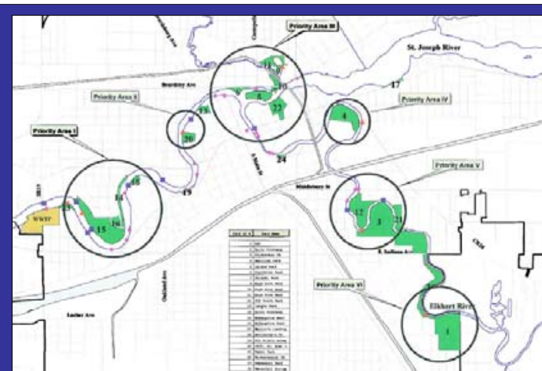


## Scheduling Factors

- Sensitive and Priority Areas
- Impacts on Ratepayers
- Logical construction sequence

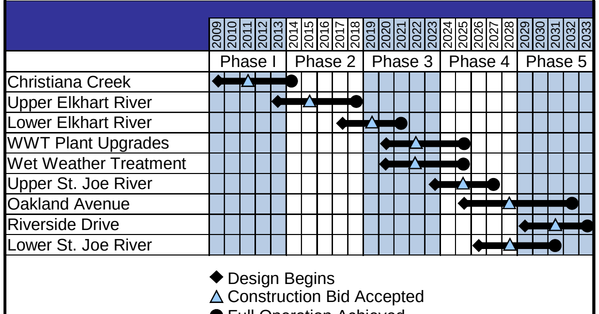


## Parks & Priority Areas






## Draft 25-Year Schedule 2009-2033

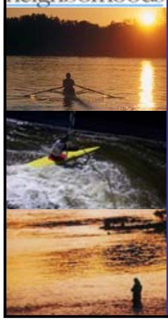





## Financing

- Discuss rate increase options
  - Larger increase every 4-5 years?
  - Smaller increases every year?

## Agenda



- Draft schedule
- Post-construction monitoring
- Public outreach
- Closing discussion

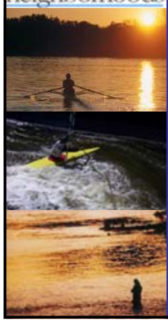
7

## Post-Construction Monitoring

- Monitoring required to ensure that facilities operate as designed and intended
- Monitoring plans: discharge volume, duration and frequency
- “Performance criteria”
  - Percent capture of wet-weather flow into sewer system
- Regular reports to EPA, IDEM and the public

8

## Agenda



- Draft schedule
- Post-construction monitoring
- Public outreach
- Closing discussion

9

## Public Outreach Plans

- Timeframe: Feb.-Mar. 2009
- Activities:
  - Public meetings & 30-day comment period
  - Newsletter
  - Materials on Website
  - Meet with Council and Public Works Board
  - Work with News media

10

## Public Meeting Plans

- Public Meetings
  - How many?
  - Where?
- “Open House” format
  - 4-8 p.m. Open House (information tables with staff to answer questions)
  - 30-minute presentations at 5 and 7 p.m.

11

## Suggested Tables/Displays

- St. Joseph River & Elkhart
  - Water quality issues
  - Sewer system studies
- Recommended Plan (3):
  - Elkhart River
  - Upper St. Joseph River/Christiana Creek
  - Lower St. Joseph River
- How You Can Help

12

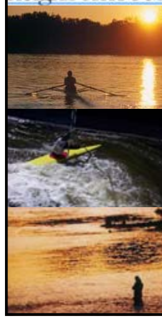
## Discussion

- Key audiences we need to reach?
- Issues and concerns we should anticipate?
- Other advice on reaching out to the public?



## Agenda

Clean river Healthy neighborhoods



- Draft schedule
- Post-construction monitoring
- Public outreach
- Closing discussion



## Discussion & Committee Input

- What are your thoughts?
  - Recommended plan
  - Federal funding
  - Future role of committee
- Draft committee statement
- Next CAC meeting
  - Late March/early April 2009

May 21, 2009

NEWS RELEASE

**Elkhart Reaches Agreement with State, Feds on Sewer Overflow Plan**
*City Needs 25 Years to Implement Plan*

Mayor Dick Moore announced today the City of Elkhart, the Indiana Department of Environmental Management (IDEM), and the U.S. Environmental Protection Agency (EPA) have reached a tentative agreement on a long-term plan for controlling sewer overflows. He also announced a proposed sewer rate increase to pay for the first five years of sewer improvements.

Due to the city's current, difficult economic circumstances, Mayor Moore has told U.S. EPA and IDEM that the City needs a 25-year schedule to implement the plan. The schedule and some technical details are still being negotiated.

Since 2004, Elkhart, South Bend and Mishawaka have participated in required negotiations with U.S. EPA to reduce their sewage overflows to the St. Joseph River. Elkhart's plan would build new sewers and storage tanks to capture and treat more overflows.

"We know this plan is the right plan for our community and our rivers," Mayor Moore said. "Our staff has been working cooperatively with the agencies for several years. We are moving forward, but we need sufficient time to implement the plan."

The City will host open house-style meetings on June 17 at High Dive Park Pavilion (500 E. Beardsley Ave.) and June 18 at Pierre Moran Pavilion (201 W. Wolf Ave.). The public may come anytime between 4 and 8 p.m. to view displays and talk with project managers. Half-hour informational presentations will be offered at 5 and 7 p.m.

The City is taking public comments on the plan until July 17 at cleanrivers@coei.org or by writing to Utility Engineer, Elkhart Public Works, 1201 S. Nappanee St., 46516

During the planning process, the City has continued to implement overflow control/reduction projects. While the plan's schedule and other details are being negotiated, the City is moving forward with the first phase of the final long-term plan. The City has received $4.2 million from federal stimulus funds to help pay for ready-to-go projects. However, $2.9 million of that funding will need to be repaid to the state, at a 3.88 percent interest rate.

"In order to take advantage of these federal funds, we need to move quickly to begin these projects by November of this year," said Mike Machlan, City Engineer. "The federal funds will help reduce the impact on our ratepayers while we make much-needed improvements to our treatment plant and sewer system."

The City will ask the Elkhart City Council to approve a sewer rate increase to finance the loan. If approved, 4 percent increases would go into effect in January 2010 and January 2011.

The average residential user now pays $21.16 per month, based on 5,000 gallons of water used (about 668 cubic feet). Under the new rates, their bill would increase by 85 cents to $22.01 per month in January 2010, and an additional 88 cents to $22.89 in January 2011.

The rate increase is necessary for the following reasons:

- **Construction Projects to Reduce Overflows**: The state's grant and low-interest loan will cover about 22 percent of needed sewer improvements in 2009 and 2010. Elkhart ratepayers must make up the difference in order to take advantage of the federal assistance.
- **Operating Costs**: The cost of operating and maintaining the treatment plant and collection system has increased since the last rate increase went into effect in 2003. The cost of insurance, chemicals, natural gas, gasoline, electricity and other operating expenses have gone up during this time.
- **Fair and Equitable Rates:** Due to substantial changes in the waste stream from industrial customers over the past several years, a cost of service study prepared by Crowe Horwath LLP showed that industrial customers are now being overcharged for excess pollutants they discharge to the sewer system. Because the city has paid off 20-year-old bonds for a treatment plant expansion, these customers are now paying more than their fair share. Revising Elkhart's charges for excess pollutants is fair and will make the City more competitive when recruiting new businesses to locate here.

Mayor Moore emphasized the need for the City's rates to be equitable and fair to all ratepayers. One class of ratepayers should not be subsidizing another, he said.

"We must be able to attract new industries and create new jobs, while also repairing our infrastructure and reducing raw sewage that overflows into our rivers. If we delay, the cost of these projects will only get more expensive," he said.

Like more than 700 U.S. cities, Elkhart has sewers that carry both sewage and stormwater in the same pipe. When it rains, these "combined sewers" can overflow into Christiana Creek, the Elkhart River and the St. Joseph River.

The first combined sewers were built more than 100 years ago, mostly in cities in the Northeast and Midwest. The U.S. EPA and Indiana Department of Environmental Management require cities with combined sewers to meet state and federal requirements to prepare long-term plans to reduce overflows and comply with the Clean Water Act.

During wet weather, overflows can occur at up to 33 locations along our waterways, and can be triggered by as little as two-tenths of an inch of rainfall or snowmelt.

South Bend, Mishawaka, Goshen and 100 other Indiana cities also are required to prepare long-term plans to reduce raw sewage overflows into waterways.

For additional information, please contact Public Works & Utilities at 574-293-2572.

June 2009

# RIVER REPORT

Clean river Healthy neighborhoods
ELKHART ▪ MISHAWAKA ▪ SOUTH BEND

## INSIDE THIS ISSUE



City of Elkhart

Public Comments are due July 17, 2009

Email: cleanrivers@coei.org

Call: 574-293-2572

Visit: www.elkhartindiana.org

Write: Utility Engineer
Elkhart Public Works
1201 S. Nappanee St.
Elkhart, IN 46516

# City Announces Plan to Reduce Sewer Overflows

## Open House-Style Meetings Scheduled for June 17 and 18

These are challenging times for Elkhart. Yet we have always been a community that responded to a challenge and came out the better for it. That is certainly true with the challenge we face to clean up our rivers.

For several years, we have been negotiating with the state and federal governments to reduce sewer overflows to the Elkhart and St. Joseph Rivers. We have now reached a tentative agreement on a $134 million plan to protect our rivers.

Paying for this plan when so many people are out of work is a daunting challenge. We also recently learned that we will receive $4.2 million from the federal stimulus funds to help pay for some ready-to-go projects. However, $2.9 million of that funding will need to be repaid to the state, at a 3.88 percent interest rate. We plan to implement the program over 25 years to ease the burden on ratepayers.

Meanwhile, we recently conducted a study of our sewer rates and found that they need to be adjusted to make them more fair and equitable for some ratepayers.

The combination of these things requires us to ask the City Council for a small sewer rate increase and a new rate structure. You'll find more details on the rate increase on Page 10. We will be hosting public meetings on June 17 and 18 to explain these issues, and to answer your questions.

Many of you are probably asking, "Why are we doing this sewer overflow control program now given our economic problems?"

Put simply, we have no choice. We have identified the most affordable plan that will achieve the most benefits. We have worked to get the biggest bang for our buck and the least disruption to our citizens. We can no longer delay. If we postpone the plan, it won't get cheaper and we run the risk of having the federal and State agencies impose a less cost-effective plan along with higher legal bills, fines and penalties. I would rather put our money to work here in Elkhart, by implementing the right plan to improve our infrastructure, clean our rivers and create jobs.

At one time, the Elkhart and St. Joe were pristine rivers. With the arrival of civilization, they became open sewers. The rivers have been improved over the decades by collecting sewage from homes and businesses and directing it to a treatment plant. However, our older sewer system still overflows during heavy rains, sending untreated sewage into our streams. This was accepted practice when our sewers and treatment plant were built, but not today.

Each investment in our sewers and treatment plant is moving us closer to the goal of restoring our rivers and streams to a more natural state. We need to move forward because it is simply the right thing to do.

Recently, someone passed this message on to me: "Success comes in cans, failure in can'ts." There is no room in our basic working philosophy that allows for the word can't. Even when it looks impossible, we can find a way to do it.

I hope you will learn about Elkhart's sewer overflow control plan and participate in one of our public meetings. We look forward to hearing your comments and concerns, and working with the community on the best way to meet the mandates we face.

Dick Moore
Mayor

### PUBLIC MEETING SCHEDULE
### 4 – 8 PM OPEN HOUSE
### PRESENTATIONS AT 5 AND 7 PM

JUNE 17, HIGH DIVE PARK PAVILION
500 E. BEARDSLEY AVE.

JUNE 18, PIERRE MORAN PARK PAVILION
201 W. WOLF AVE.

## Water Quality Problems in the St. Joseph River and Their Causes

The St. Joseph River is a valuable community resource enjoyed by Olympic-caliber kayakers, recreational canoeists and weekend sport fishermen. Its water quality has improved dramatically since the 1950s, with more than 80 species of fish now found in the watershed and scores of parks and recreational areas lining its banks.

With the river's resurgence, the communities of South Bend, Mishawaka and Elkhart are planning more recreational and economic opportunities on their waterfronts.

Despite this progress, the St. Joe still doesn't meet federal Clean Water Act goals.

From Elkhart to the Indiana-Michigan state line, the St. Joseph River doesn't meet recreational water quality standards for *E. coli* bacteria about 20 percent of the time during a typical year — and 16 percent of the time during the warm-weather months when people use the river for recreation.

*E. coli* bacteria is an indicator of human or animal waste and potentially disease-causing organisms in the water. Some *E. coli* in a waterway is natural, but high levels have been linked to stomach cramps, diarrhea and other gastrointestinal illnesses among swimmers and people who ingest or swallow water during recreation. Children, the elderly and people with weakened immune systems or chronic conditions are most at risk.

During dry weather, approximately 97 percent of St. Joe River water samples meet *E. coli* standards. When it rains, however, many sources combine to cause high *E. coli* bacteria levels in the river. These sources include:

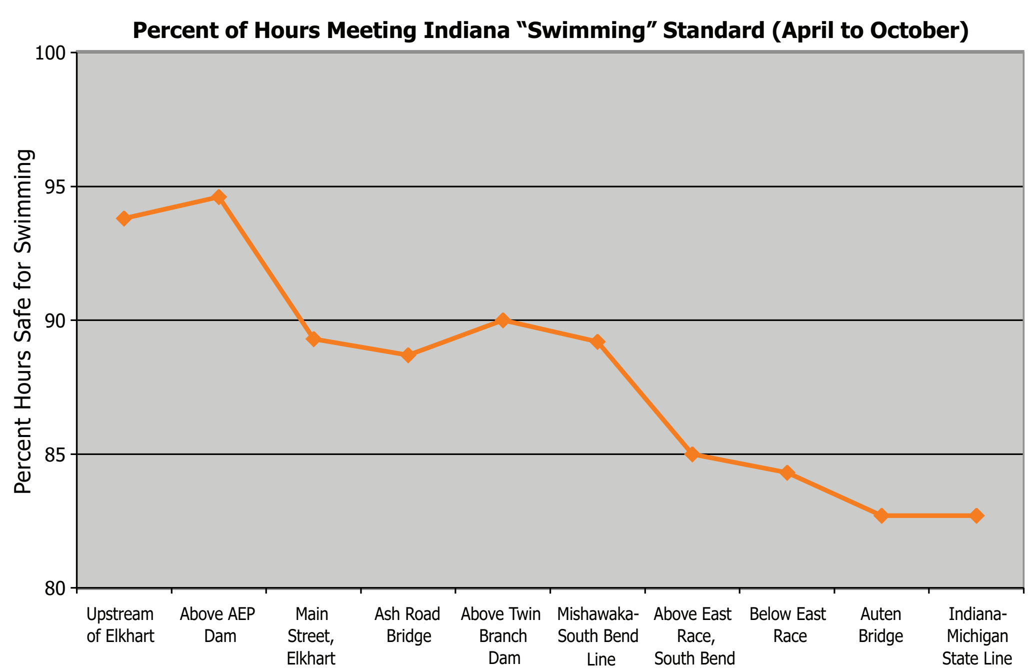
- Sewage overflows during wet weather from cities with combined storm-sanitary sewer systems (South Bend, Mishawaka, Elkhart and Goshen)
- Stormwater runoff from farms and animal feedlots
- Stormwater runoff from parking lots, yards and other areas with wildlife and pet waste
- Runoff from neighborhoods with failed septic systems

The U.S. Environmental Protection Agency and Indiana Department of Environmental Management require cities with combined sewers to develop long-term plans to reduce sewer overflows. Cities also must implement regulations and educational programs to reduce stormwater pollution.

State and local health departments regulate private septic systems and property owners are responsible for properly maintaining those systems. State environmental regulations also govern farms with confined feeding operations.

However, more efforts will be needed in the future to protect the St. Joe — and people who use it — from stormwater runoff, agricultural runoff, failing septic systems and other pollution sources.

*This chart shows how well the St. Joseph River meets Indiana's swimming standard at different locations. The orange line represents the river's water quality during the warm weather months, when people are most likely to be in the water. As you can see, the river meets the* E. coli *bacteria standard about 90-95 percent of the time during warm weather in Elkhart and Mishawaka. But by the time the water flows through South Bend, standards are met 80-85 percent of the time. Sewer overflows, urban stormwater, failing septic systems and farm runoff all contribute to this problem.*






## Why Our Sewers Overflow When It Rains

Every year, more than 850 billion gallons of untreated sewage flows into our nation's rivers, lakes and bays.

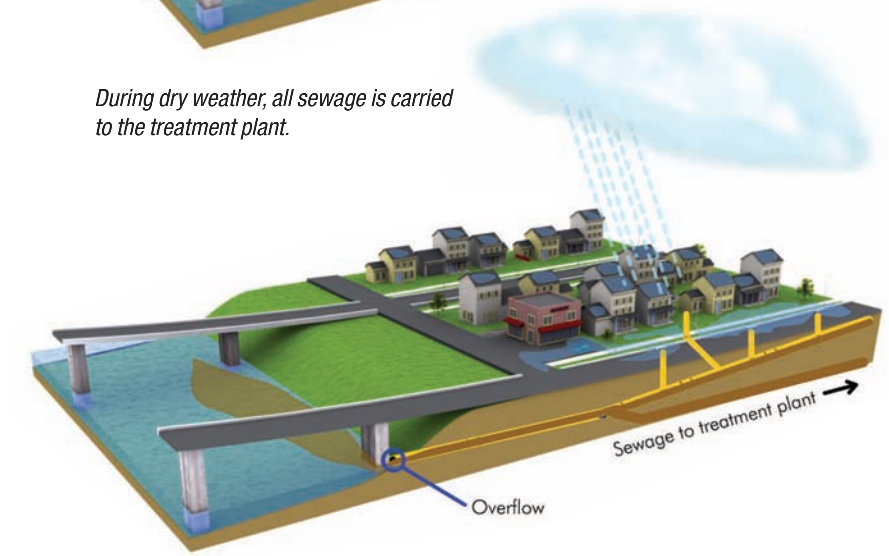
These sewage overflows come from antiquated "combined" sewer systems built as many as 100 years ago in many U.S. cities.

South Bend, Mishawaka, Elkhart and many other cities built storm sewers in the early 1900s to carry rainwater and melting snow away from homes, businesses and streets. In those horse-and-buggy days, these cities didn't have sewage treatment or even indoor plumbing.

When indoor plumbing came later, homeowners and business owners hooked their sewage lines to the existing storm sewers, combining storm water and raw sewage into one pipe. The pipes emptied directly into the river, until the 1950s when sewage treatment plants were built. This was common practice in many U.S. cities, especially in the Northeast and Midwest. During dry weather, a "combined" sewer system works much like a separate sewer — carrying all sewage to the treatment plant for treatment.

However, when it rains or snow melts, the sewers can be overloaded with incoming stormwater. When this happens, the sewers are designed to flow over internal dams in the underground pipes and into nearby streams and rivers. If they didn't have this release valve, raw sewage would back up into people's basements and streets.


*During dry weather, all sewage is carried to the treatment plant.*

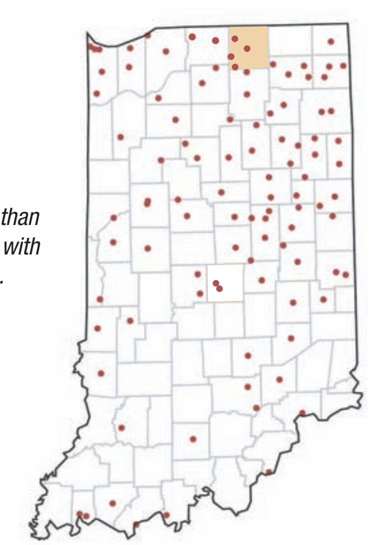


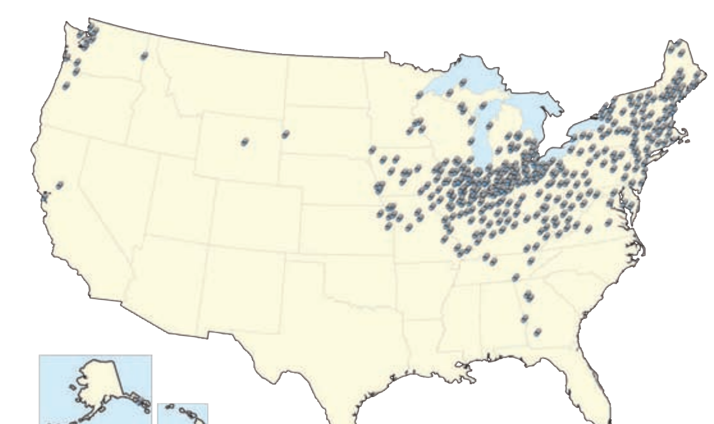

*When it rains or snow melts, the sewers can be overloaded with incoming stormwater.*

## Combined Sewer Systems: Nationwide Problem

Combined sewer systems carry both stormwater and raw sewage in the same pipes. Many cities with combined sewer systems have problems with raw sewage overflows when it rains. These overflows contain not only stormwater, but also untreated human and industrial waste, toxic materials and debris. Combined sewer systems serve roughly 772 communities containing about 40 million people, according to the U.S. Environmental Protection Agency. Most communities with combined sewer systems are located in the Northeast and Great Lakes regions and in the Pacific Northwest. Indiana has more than 100 communities with combined sewers.

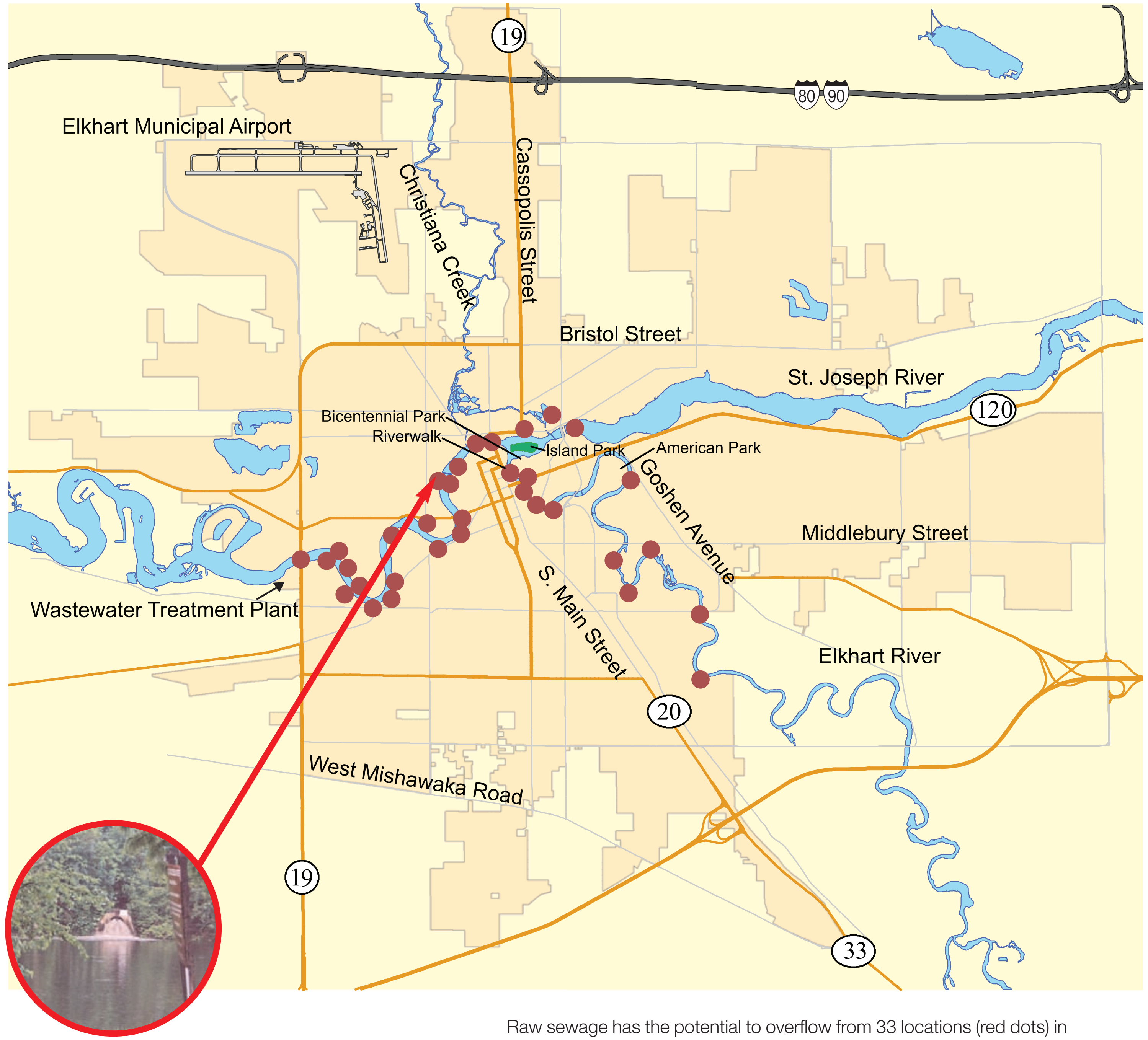
*Indiana has more than 100 communities with combined sewers.*





*Combined sewer systems are found in roughly 772 communities serving about 40 million people, according to the U.S. Environmental Protection Agency.*

# Where Overflows Occur




*Overflow pipe near Sherman Street that sends raw sewage overflows to the St. Joseph River after it rains.*

Raw sewage has the potential to overflow from 33 locations (red dots) in Elkhart's sewer system into the St. Joseph and Elkhart rivers and Christiana Creek, as shown on the above map. As little as 1/4- to 1/2-inch of rain can overwhelm the sewer system and cause an overflow. In a year with typical rainfall, these overflows can occur more than 50 times a year from some locations, sending untreated sewage and polluted storm water into the streams.

# Early Action Projects To Reduce Sewer Overflows

The City of Elkhart has spent $27.6 million since 1985 to reduce sewer overflows into the St. Joseph and Elkhart rivers. These improvements have eliminated eight sewer overflow points, redirecting millions of gallons of raw sewage away from the rivers and sending it to the wastewater treatment plant during wet weather.

The city's investments to date include:

- Separating sewers in high-priority neighborhoods, focusing on high-volume overflow pipes and areas with basement backups, drainage problems and industrial sewage
- Redirecting sewage away from the combined sewer system into separate sanitary sewers with extra capacity, thus allowing more sewage to reach the wastewater treatment plant.
- Increasing sewer cleaning and maintenance activities to reduce overflows and allow more flow to get to the wastewater treatment plant. These activities also have reduced customer complaints about sewer backups and other problems.
- Installing check valves in seven overflow pipes to prevent river water from entering the sewer system during high river flows, saving the city $925,000 per year in unnecessary treatment costs and allowing more sewage to reach the treatment plant during wet weather.
- Replacing or repairing deteriorating manholes and catch basins. Manholes allow access to a sewer for maintenance, repair and cleaning. Catch basins are located below street gutters and are designed to capture trash and other items that can't pass through the sewer. Both structures must be regularly cleaned and maintained — and repaired or replaced when they are in bad condition.

More improvements will be needed in the future to further reduce sewer overflows and meet our Clean River-Healthy Neighborhoods goals.

# What Options Did the City Consider to Reduce Sewer Overflows?

Elkhart evaluated a number of technologies to reduce sewer overflows and meet Clean Water Act requirements. The options included:

- **Full Sewer Separation:** Separating stormwater and sewage into different pipes throughout the city
- **Larger Sewers:** Increasing the sewer system's capacity to convey all flow to the treatment plant and expanding the plant's capacity
- **Tunnel Storage:** Building a deep tunnel to capture sewage during wet weather, then pump flows to the wastewater treatment plant for treatment
- **Regional Storage:** Building regional storage tanks or basins to capture sewage during wet weather, then pump flows to the treatment plant
- **Expanding Wastewater Treatment Plant:** Expanding the capacity of Elkhart's treatment plant so it can handle more wet-weather flows
- **Remote Treatment:** Building new treatment facilities, such as wetlands, to capture and treat overflows where they occur

The city's recommended plan includes a mixture of many of the above technologies. We will be preventing and capturing overflows through sewer separation in targeted neighborhoods and through better conveyance, storage and treatment. The plan is organized into three geographic areas:

- Elkhart River
- Upper St. Joseph River and Christiana Creek
- Lower St. Joseph River

The recommended plan for each area is described on pages 7-9. Pages 10 and 11 list the plan costs and the expected benefits.

*Expanded wet-weather treatment.*

*Sewer separation.*

*Larger sewers.*

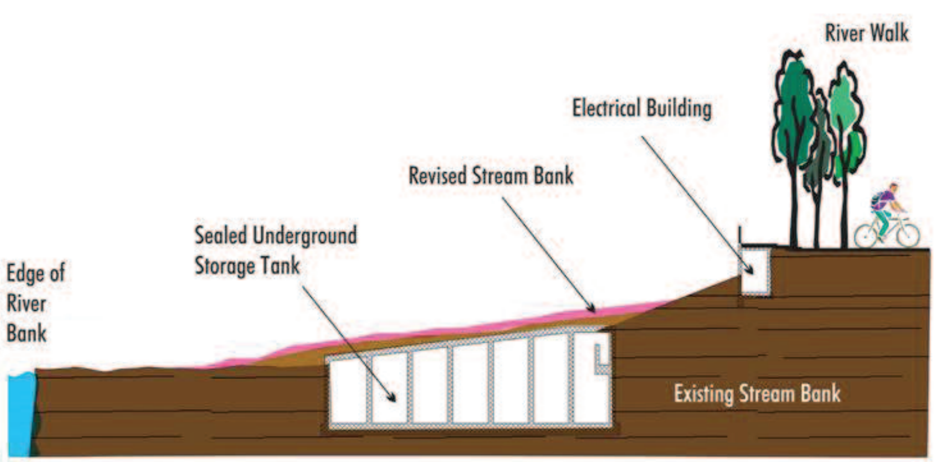
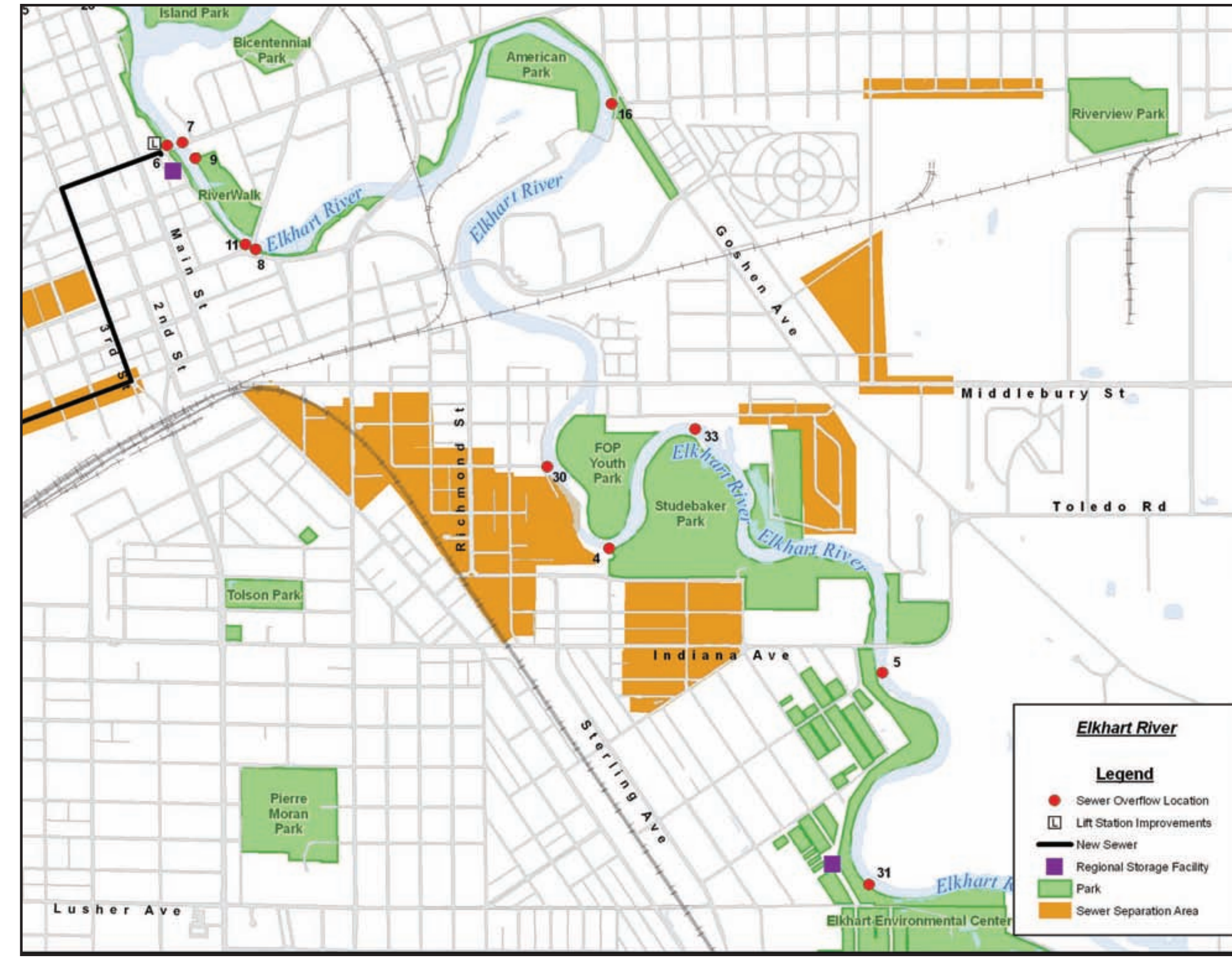



*Illustration of a common underground storage tank.*



# Elkhart River Recommended Plan

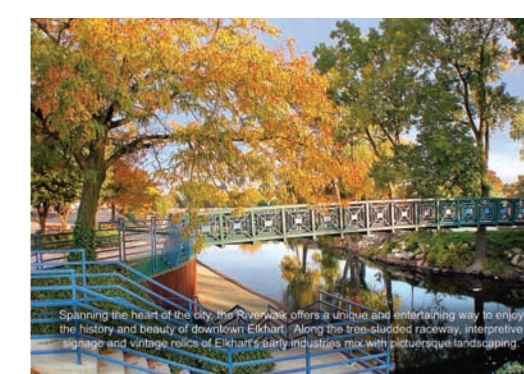



The Elkhart River flows through numerous city parks and neighborhoods, as shown in the map above. Reducing overflows to the Elkhart River will also improve the St. Joseph River, since the Elkhart flows into the St. Joe. The City's plan for reducing sewer overflows here includes the following elements:

- Building a 1-million-gallon storage tank near the Jackson Boulevard Bridge to capture overflows affecting the Riverwalk, Island Park and other downstream parks. Overflows captured by this storage facility will eventually be redirected to a new Oakland Avenue facility when that project is completed.
- Building an 80,000-gallon storage tank near Lusher Avenue to store overflows during wet weather and reduce overflows affecting the River Greenway and many downstream parks.
- Partially separating storm and sanitary sewers in neighborhoods near FOP Youth Park, Studebaker Park and Baker Park to reduce overflows affecting those parks.

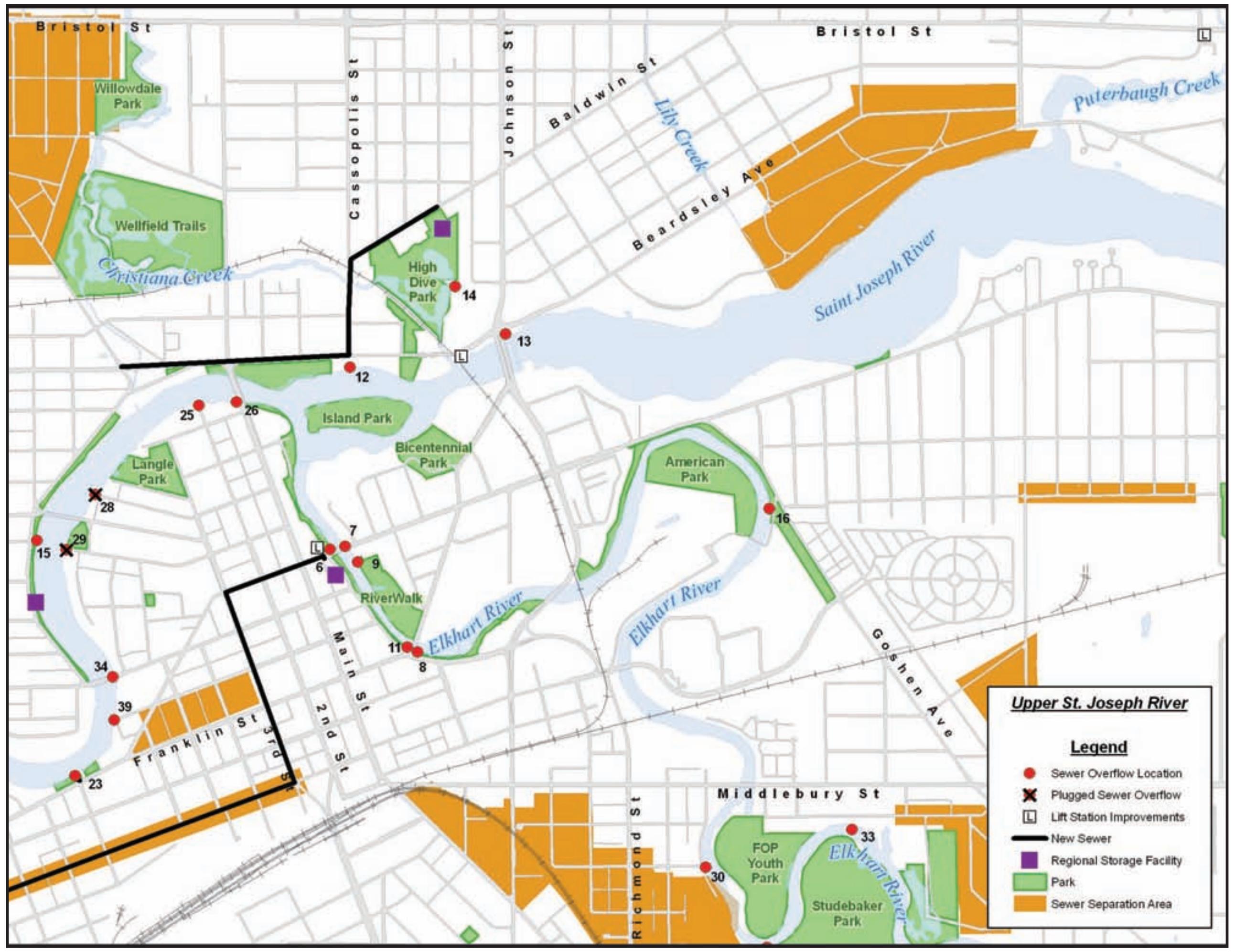
**Elkhart River Recommended Plan:**

- 2 storage tanks to capture overflows during wet weather
- Partial sewer separation to reduce overflows affecting many city parks



*Riverwalk at High Street*

# Upper St. Joseph River & Christiana Creek Recommended




Christiana Creek enters the St. Joseph River downstream from High Dive Park. Sewer overflows into Christiana Creek have an immediate and direct effect on the lagoons in High Dive Park and then impact a number of city parks and downtown Elkhart. To control overflows in this area, the City's plans include:

- A 1-million-gallon storage tank in High Dive Park to capture wet-weather flow when it rains and later release it to the existing sewer system after the storm has passed.
- Redirection of Northeast Elkhart sanitary sewers to the North Interceptor sewer system to redirect those flows away from the combined sewer system.

The Upper St. Joseph River extends from the AEP Dam to the Lexington Avenue Bridge. The City plans the following projects to reduce overflows in this area:

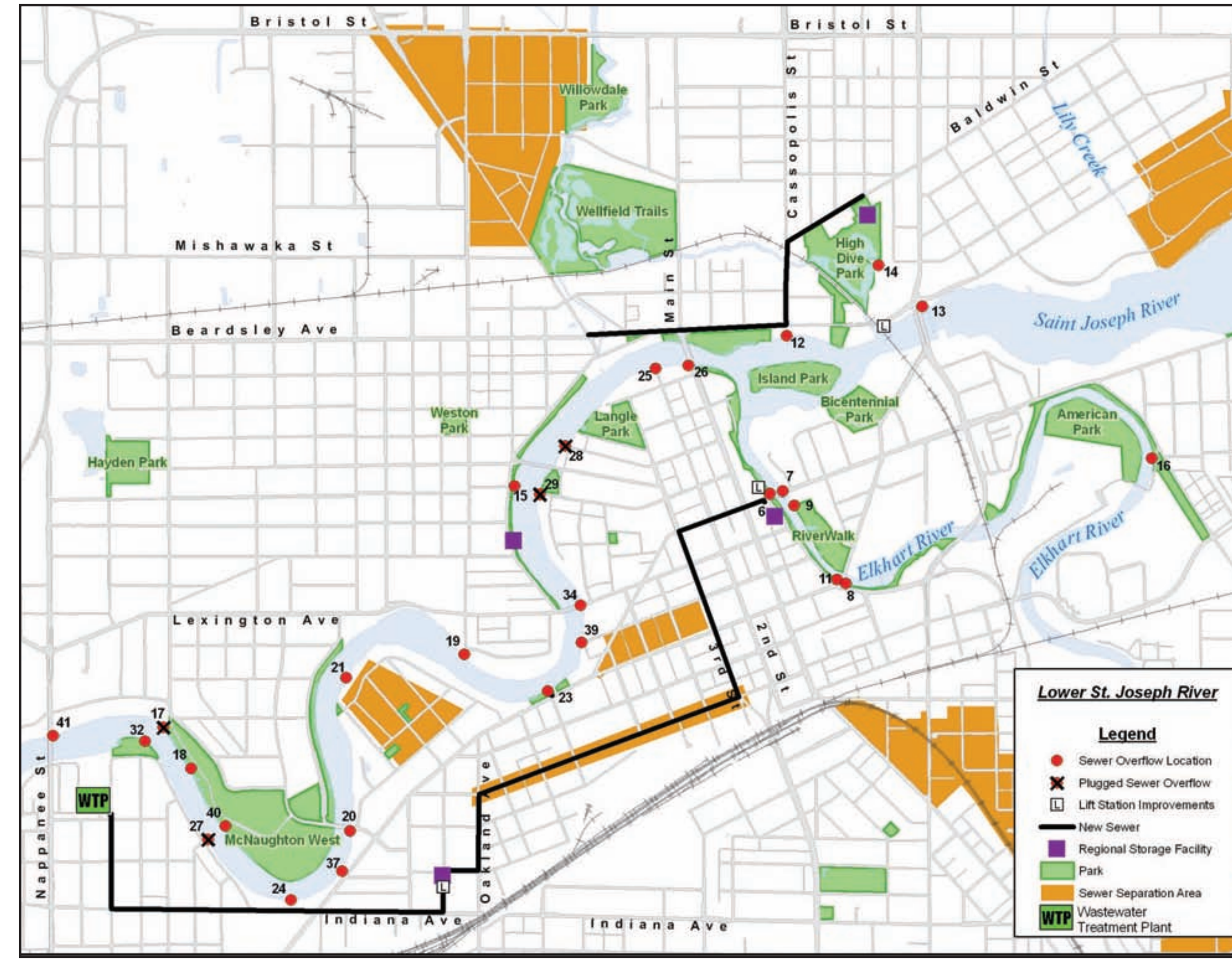
- Partial sewer separation in neighborhoods near Greenleaf Drive and Beardsley Avenue to reduce overflows at the AEP Dam near the Johnson Street Bridge.
- Structural changes within the sewer system to reduce overflows near Pottawattomi Drive and Second Street.

### Upper St. Joe River & Christiana Creek Recommended Plan:

- Storage tank in High Dive Park to capture wet-weather overflows
- Sewer separation in selected neighborhoods
- Redirecting sewage away from combined sewer system

*High Dive Bridge*

# Lower St. Joseph River Recommended Plan




The Lower St. Joseph River includes areas downstream from the Lexington Avenue Bridge. This area includes some of Elkhart's highest-volume sewer overflow locations. Plans to control sewer overflows include:

- A 430,000-gallon storage tank along Riverside Drive.
- A 1.1-million-gallon storage tank near Oakland Avenue.
- Separating a portion of the sewers near Willowdale Park and Wellfield Trails.
- Separating a portion of sewers near Franklin and Vistula Streets and west of Oakland Avenue.
- Redirecting sanitary sewers at West Boulevard and Beardsley for the Northwest area of Elkhart to the North Interceptor system, away from the combined sewer system.
- Redirecting sanitary sewers near McNaughton Park to the North Interceptor system.

### Lower St. Joe River Recommended Plan:

- Storage tanks along Riverside Drive and near Oakland Avenue
- Sewer separation in selected neighborhoods
- Redirecting sewage away from combined sewer system

*McNaughton Spray Park*

# What Will the Projects Cost? How Much Will I Pay?

The plan's construction costs are estimated at $134 million in 2007 dollars, making it the largest investment in clean water infrastructure in Elkhart's history. Operation and maintenance costs will increase, too. Given the current economic conditions, Elkhart is seeking to delay large capital expenditures until the local economy has time to recover. Elkhart also is pursuing federal grants and will continue to seek alternative funding. However, regular rate increases will be needed to finance this project.

The City has been delaying needed rate increases during negotiations with state and federal agencies. The last sewer rate increase was in 2003. A rate increase is necessary for the following reasons:

**Construction Projects to Reduce Overflows:** A storage tank at High Dive Park will capture overflows that now go into Christiana Creek. Other projects will reduce overflows to the Elkhart River by separating sewers. Federal funds are helping to reduce the cost of these projects to Elkhart ratepayers.

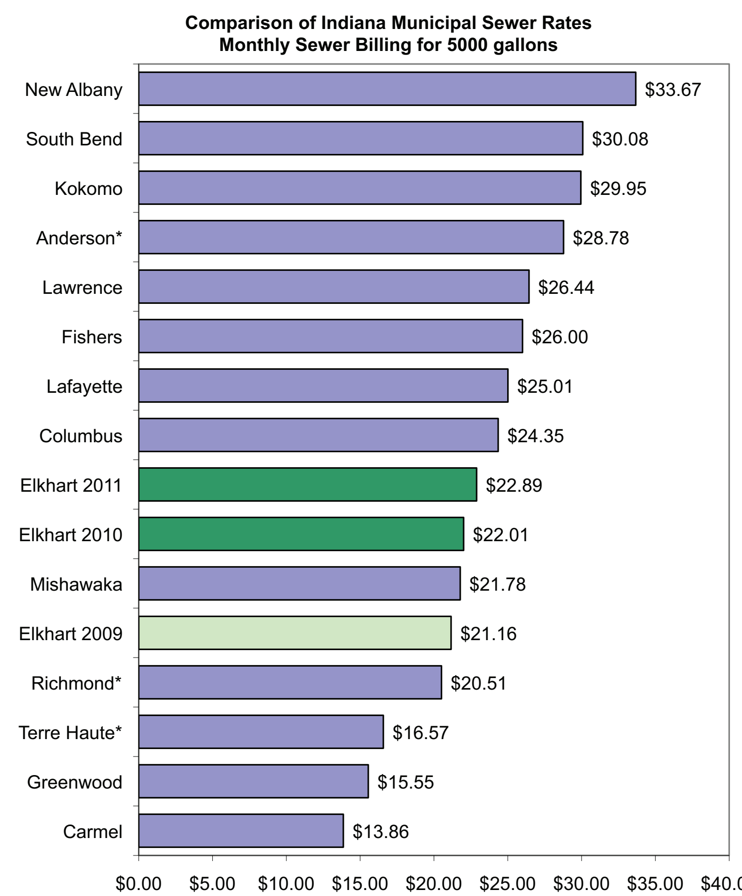
**Other Construction Needs:** Needs include sewer replacements associated with the Main Street Streetscape Project and Jackson Roadway improvements. We will extend sewers to neighborhoods without sewer service, often in conjunction with road projects. We also must replace aging tanks, pumps, valves, a roof and other equipment at the wastewater treatment plant.

**Fair and Equitable Rates:** A recent cost of service study prepared by Crowe Horwath LLP showed that industrial customers are being overcharged for excess pollutants they discharge to the sewer system. These customers are paying more than their fair share. Lowering Elkhart's charges for excess pollutants also will make the City more competitive when recruiting new businesses to locate here.

**Operating Costs:** The cost of operating and maintaining the treatment plant and collection system has increased since 2003. The cost of insurance, chemicals, natural gas, gasoline, electricity and other operating expenses have gone up during this time.

We work hard to keep rates low and competitive with other cities. For the average home using 5,000 gallons per month, rates will increase by about 85 cents per month in 2010 and another 88 cents per month in 2011. The average user now pays $21.16 per month; in 2011, they would pay $22.89.

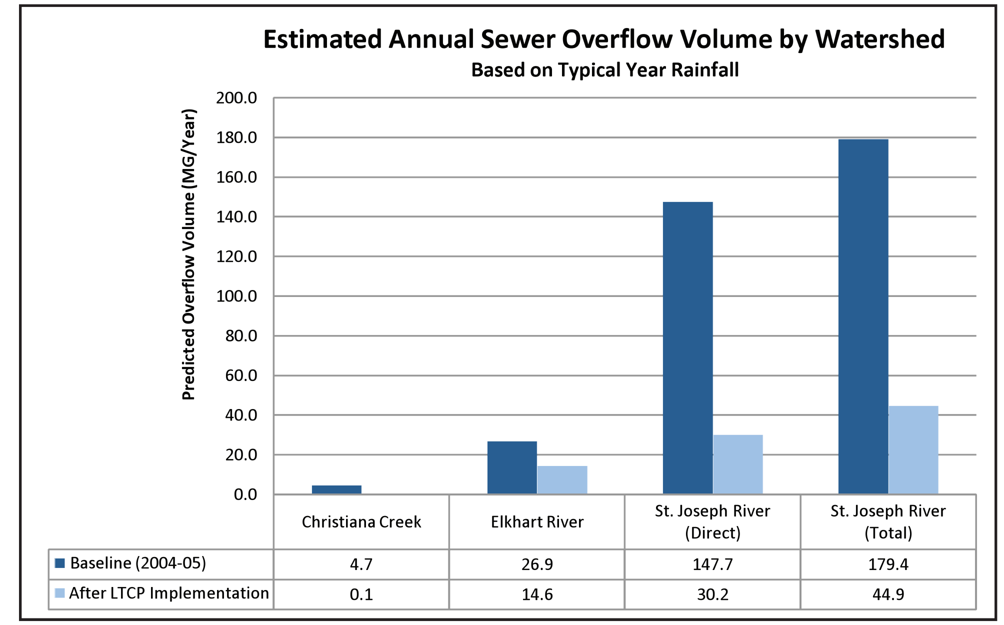
The chart at right compares average residential sewer rates in Elkhart with rates in other Indiana cities of similar size. Elkhart's current and projected rates are shown in green.




* indicates rates are subsidized by property tax

# What Benefits Will We See?

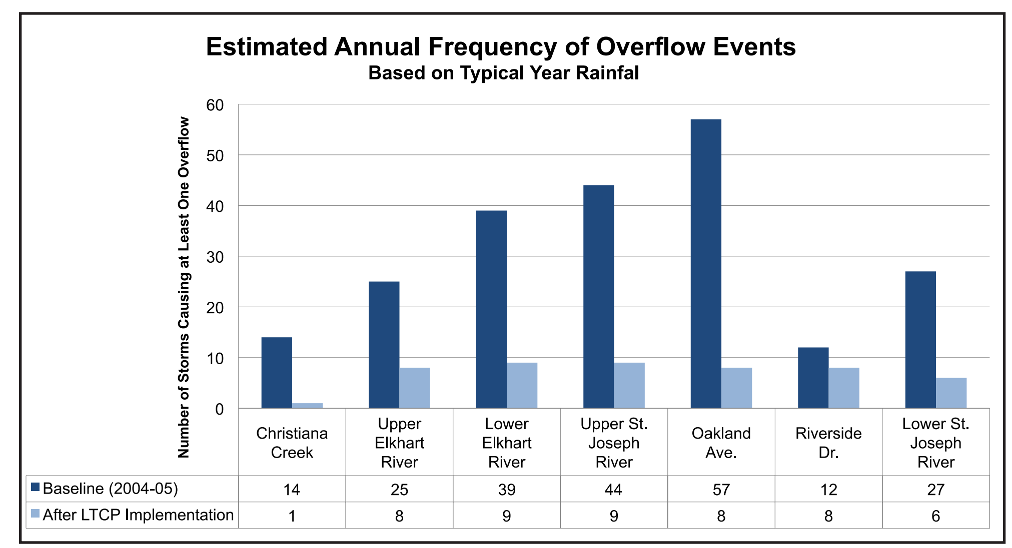
Elkhart's plan will reduce the volume and frequency of sewer overflows into the St. Joseph River, Elkhart River and Christiana Creek. The charts below show estimated overflow volumes and overflow frequency before and after the plan's implementation. Overall, overflow volume will be reduced from 180 million gallons in a typical year to around 40 million gallons. (The St. Joseph River (Total) numbers include estimates for Christiana Creek and the Elkhart River because they eventually flow into the St. Joe.) The frequency of overflows will fall from more than 50 storms in a typical year to less than 10 storms causing a sewer overflow.




**Note: Based upon estimates of baseline and future system conditions using Elkhart's XP-SWMM model of the existing collection system and typical year rainfall inputs.**

The plan is designed to capture 96 percent of flows entering the combined sewer system during wet weather in a typical year, compared to 82 percent a few years ago. The plan will be implemented over a 25-year period at an estimated cost of $134 million in 2007 dollars.

Even if all sewer overflows could be eliminated, *E. coli* bacteria standards will not be fully met in affected waterways. Elkhart's studies have concluded that controlling other sources of bacteria would be more cost-effective than paying for additional controls beyond the city's recommended plan.



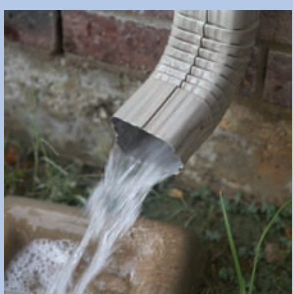

**Note: Overflow event = one or more untreated overflows from the combined sewer system resulting from a precipitation event. For this analysis, it was assumed that the total annual frequency of overflow events for each watershed was equal to the number of overflows at the most active CSO within the drainage basin.**

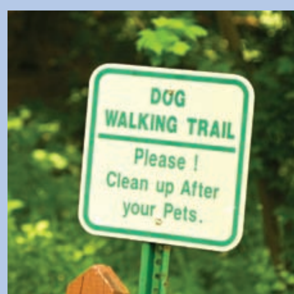
**Based upon estimates of baseline and future system conditions using Elkhart's XP-SWMM model of the exisiting collection system and typical year rainfall inputs.**

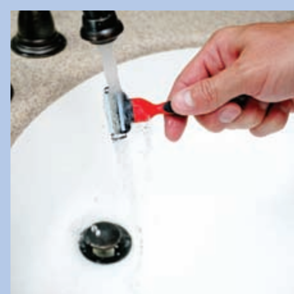

## How You Can Help Reduce Sewer Overflows and Protect the St. Joseph River

Everyone can help solve the problem of raw sewage overflows into the St. Joseph River. Although the long-term solutions will require major investments by South Bend, Mishawaka and Elkhart, every little bit counts when it comes to reducing overflows and protecting the river. You can help in these ways:

- Disconnect your downspouts and sump pumps if they are connected to the sanitary sewer system.
- Don't send fats, oils and grease down the drain. They clog both your plumbing and the sewer system, causing overflows and sewer backups. Pour the grease into a can and throw it in the trash instead.
- Clean up after your pets. Their waste adds to the problem of stormwater pollution.
- Dispose of household chemicals and used oil properly and not down the drain or down a storm sewer. Don't dump paint and oil on the ground; they will end up in our waterways. Contact your local Solid Waste Management District to learn how to safely dispose of these household hazardous wastes:
  Elkhart County
  500 N. Nappanee St., Suite 10B, Elkhart, IN 46514
  Phone: (574) 293-2269
  Internet:
  http://www.in-map.net/counties/ELKHART/GOVERNMENT/sd/swmd/
- Invite city representatives to make a presentation to your civic association or neighborhood group.





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Utility Engineer
Elkhart Public Works
1201 S. Nappanee St.
Elkhart, IN 46516

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Public Meetings: Elkhart Plan to Reduce Sewer Overflows
June 17 & 18, 2009

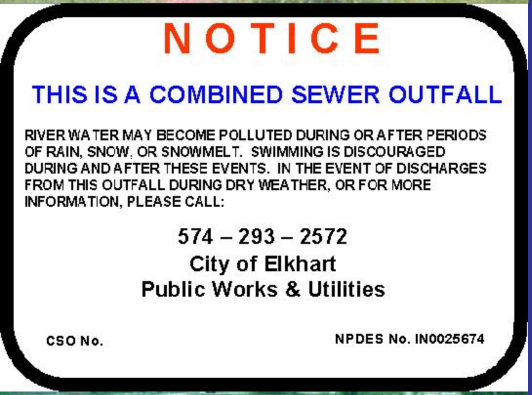
Clean river Healthy neighborhoods

# Agenda

- Background
- Elkhart’s Long-Term Control Plan
- Plan Costs and Benefits
- Proposed Rate Ordinance

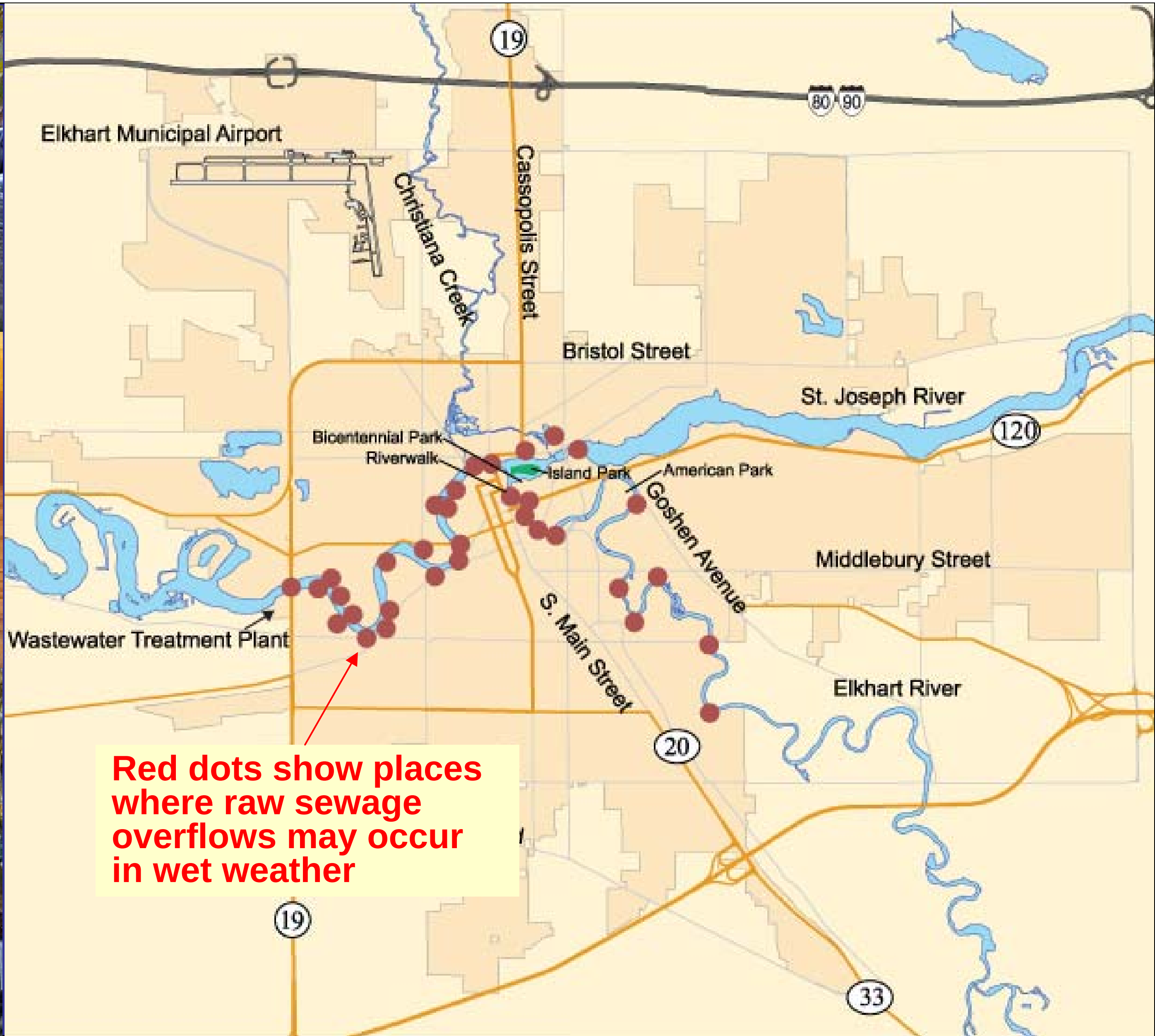
# Elkhart RiverWalk Commons


# Sewer Overflows – A Regional Problem

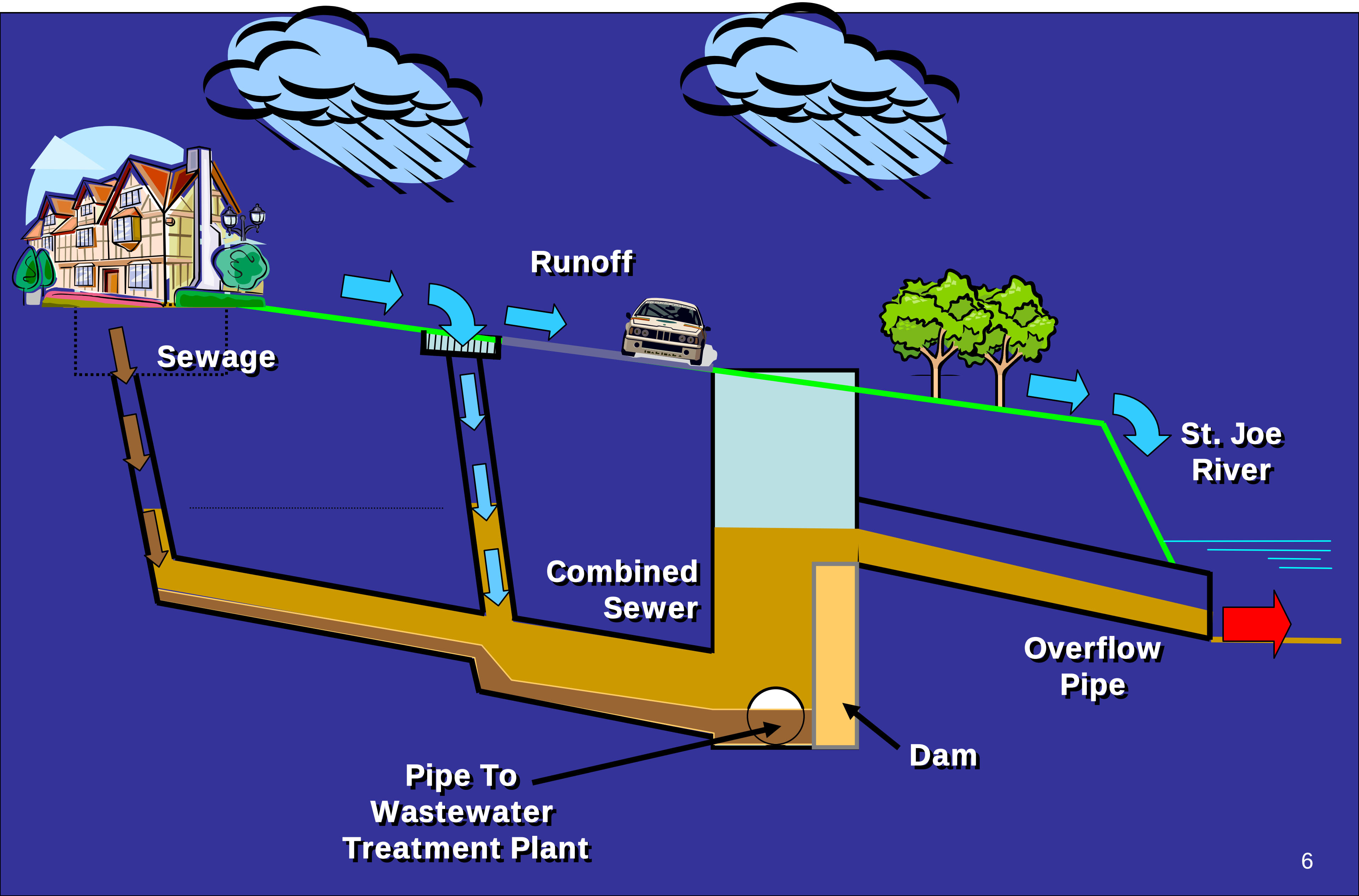



- More than 50 times each year, storms cause sewer overflows in Elkhart, Mishawaka and South Bend
- Overflows send 1.8 billion gallons of raw sewage and stormwater into the river in a typical year
- In 2004-05, Elkhart’s sewers contributed 180 million gallons of this total (10%)

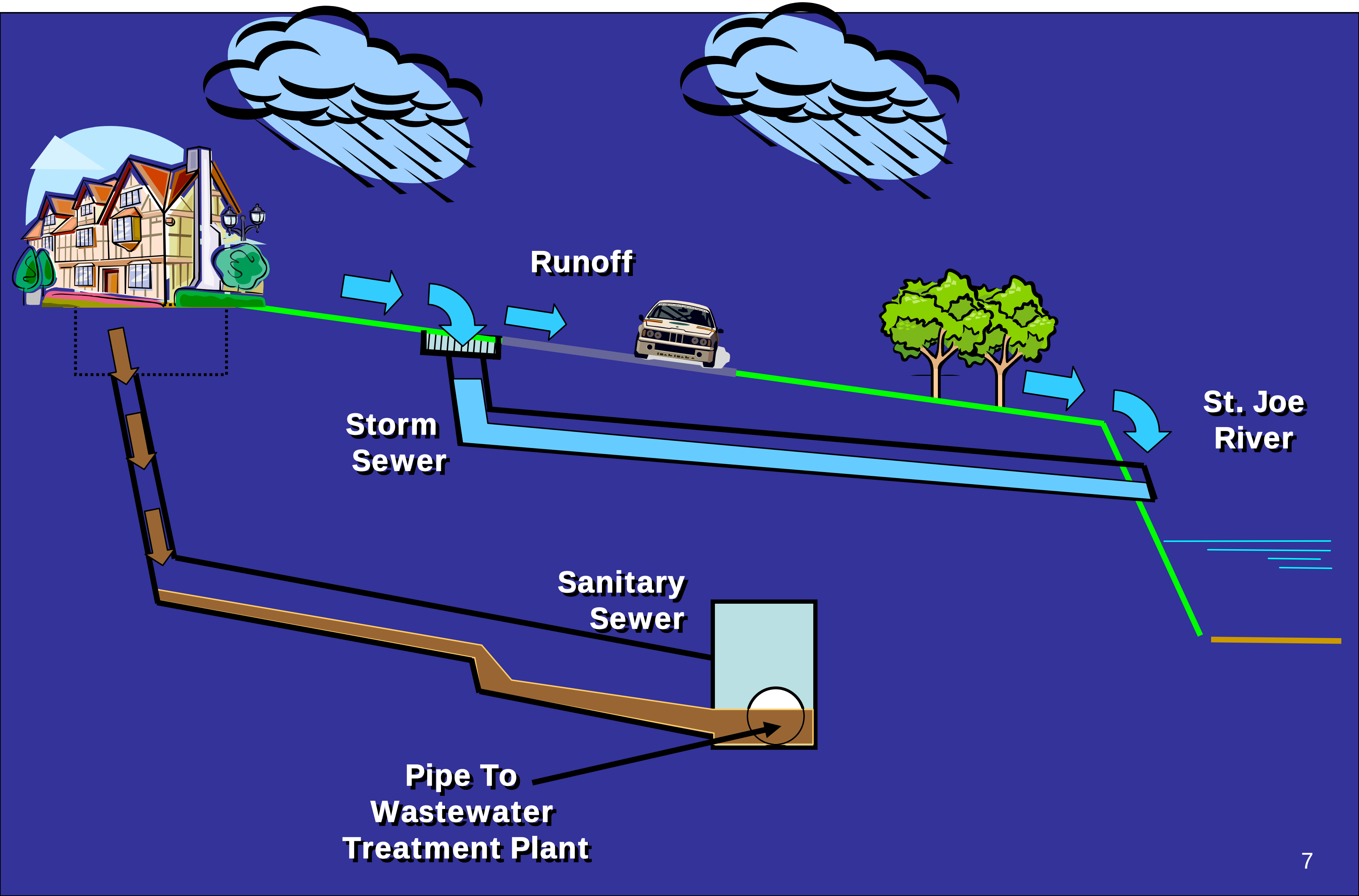
# Elkhart has 33 Sewer Overflow Locations



# Why Our Sewers Overflow

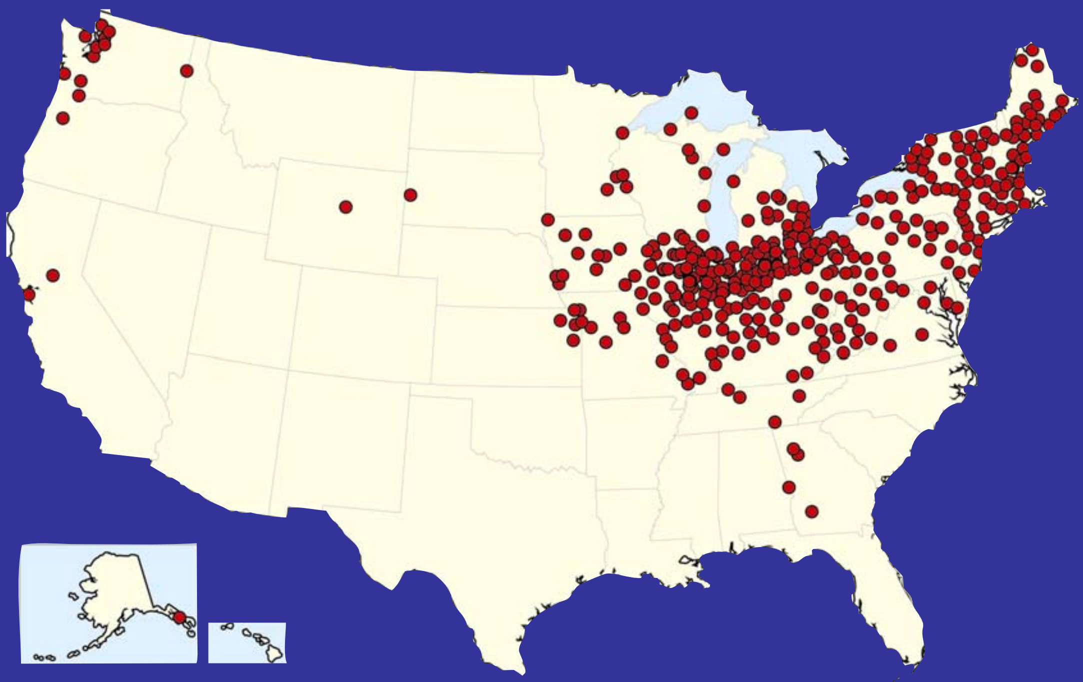


# Separated Sewer System

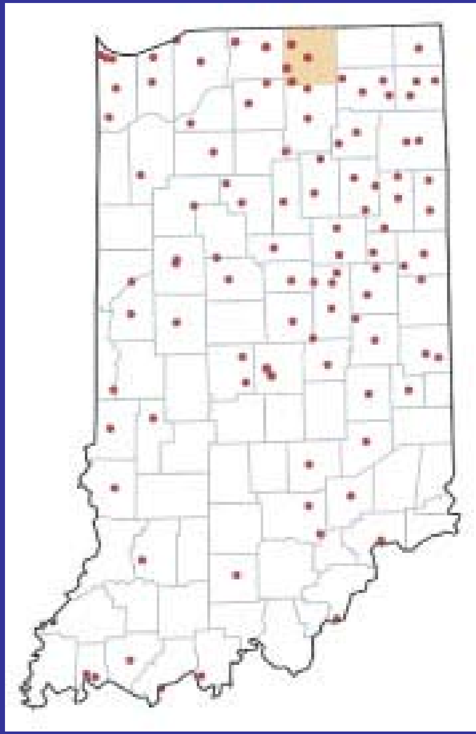


# We Are Not Alone!
# Nationwide problem, especially throughout Midwest and East Coast

- 772 communities nationwide



- 105 communities in Indiana



Communities with Combined Sewer Overflows

# Elkhart Early Action Projects

- More than $27.6 million invested since 1985 to reduce overflows:
  - Separated sewers in high-priority neighborhoods (basement backups, drainage problems and industrial sewage)
  - Increased sewer cleaning and maintenance
  - Replaced or repaired deteriorating manholes and catch basins
  - Installed check valves to prevent river water from entering sewer system
  - Nationally recognized industrial pretreatment program

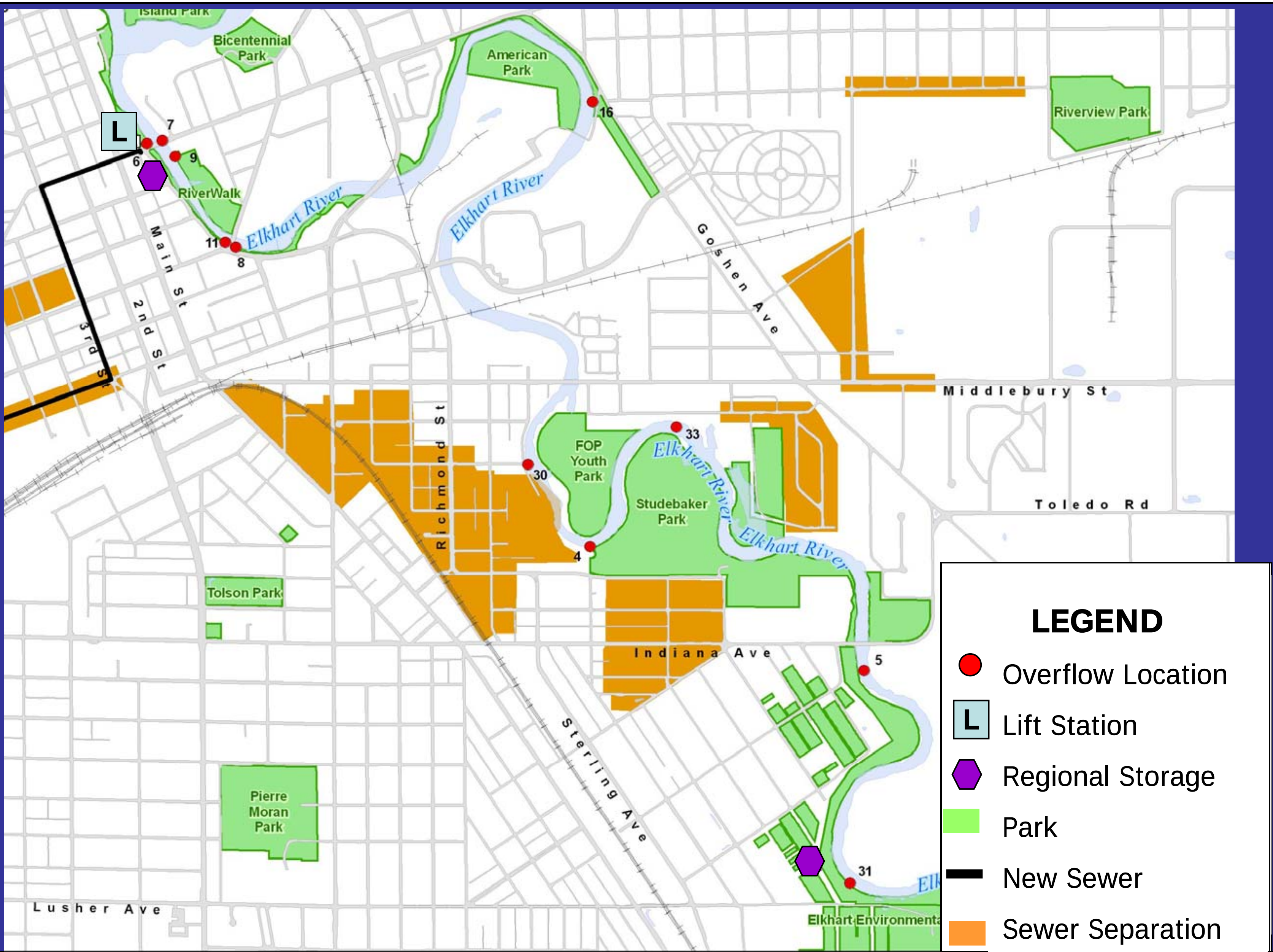
# Agenda

- Background
- Elkhart's Long-Term Control Plan
- Plan Costs and Benefits
- Proposed Rate Ordinance

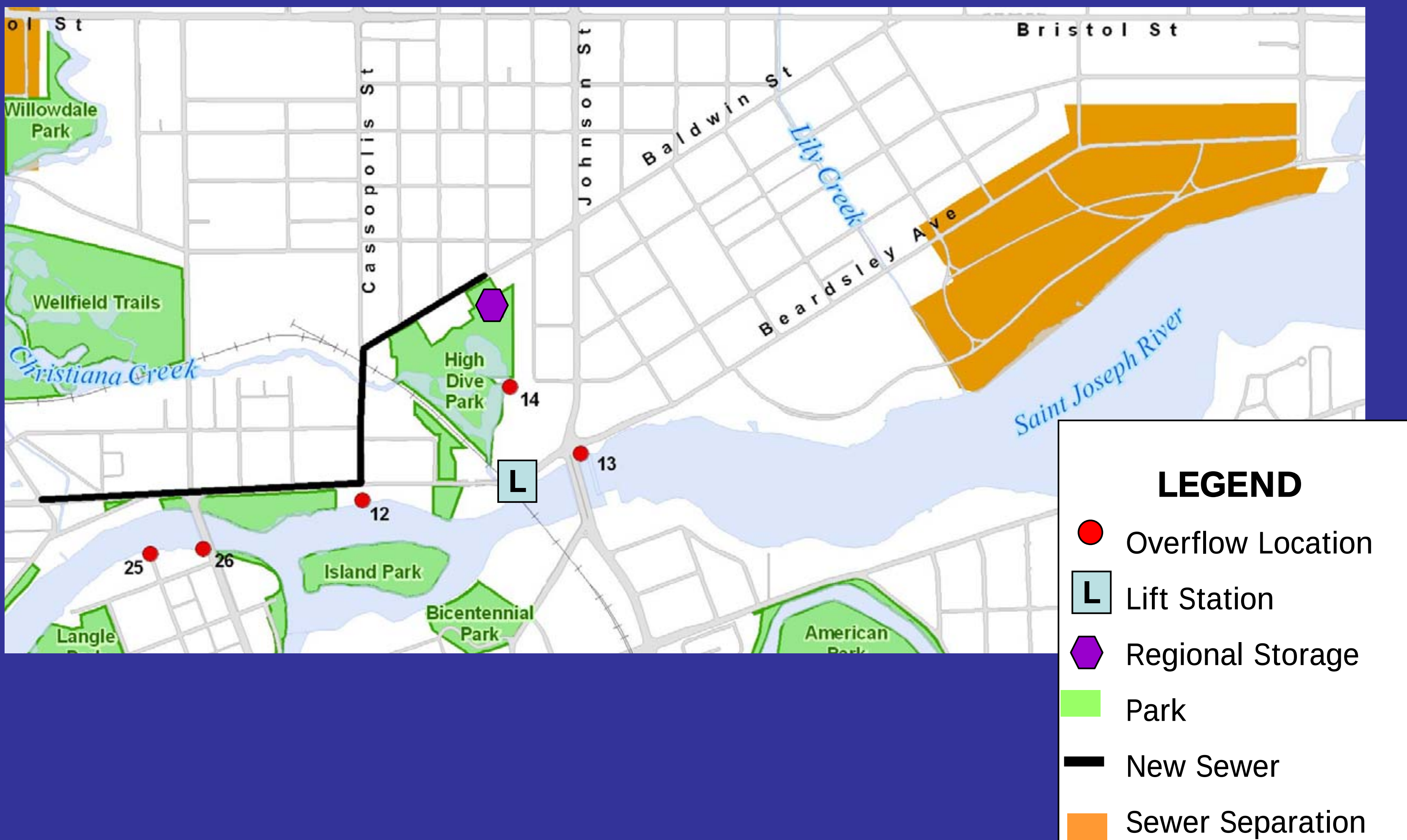
# Options Considered

1. Separate Sewers
2. Build New Storage Facilities or Larger Sewers
3. Expand or Build New Treatment Facilities
4. Use Existing Sewer System More Effectively
5. Build Green Infrastructure
6. Combination of Above

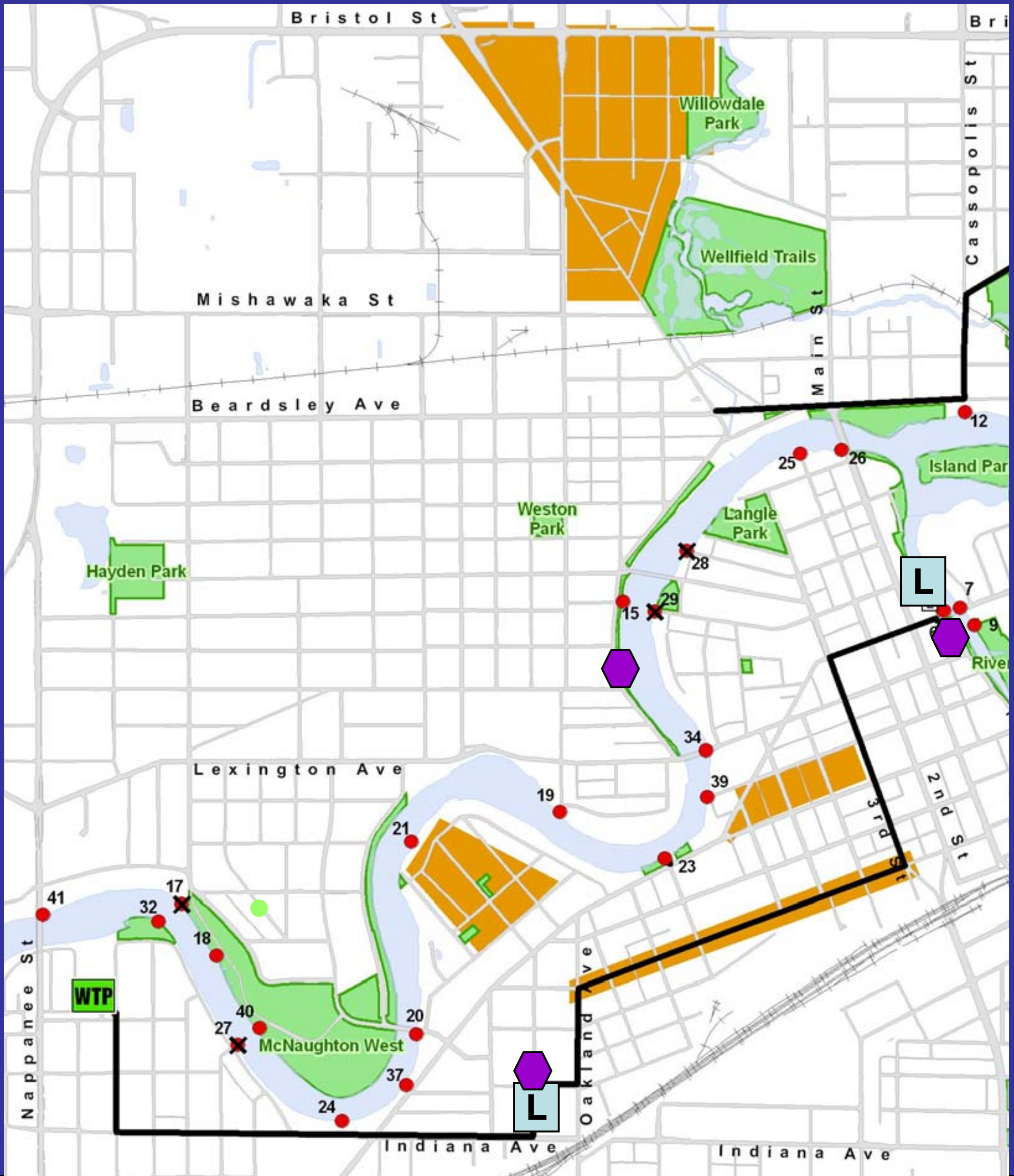
# Elkhart River Recommended Plan



# Upper St. Joseph River Recommended Plan



# Lower St. Joseph River Recommended Plan




**LEGEND**

- Overflow Location
- Lift Station
- Regional Storage
- Park
- New Sewer
- Sewer Separation

# Consent Decree: Why and What Does It Mean?


- All three cities are negotiating federal consent decrees with U.S. EPA & Department of Justice
- Targeted by EPA because our overflows affect Michigan waters
- Decree will be filed in federal court and will require implementation of the plan
- Penalties if we don’t meet milestones and deadlines

Clean river Healthy neighborhoods

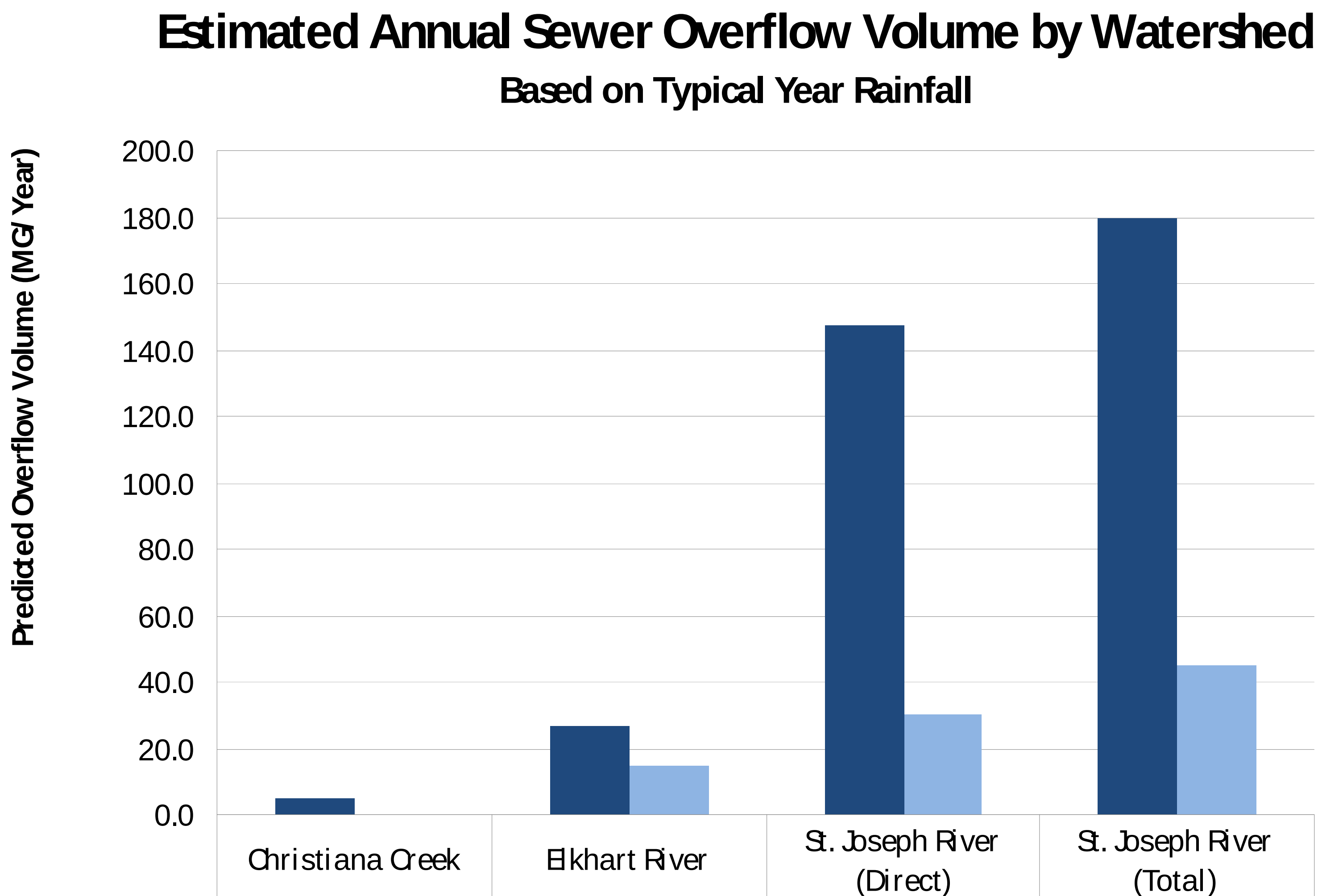
# Agenda

- Background
- Elkhart’s Long-Term Control Plan
- Plan Costs and Benefits
- Proposed Rate Ordinance

# Estimated Capital Cost of Long-Term Plan

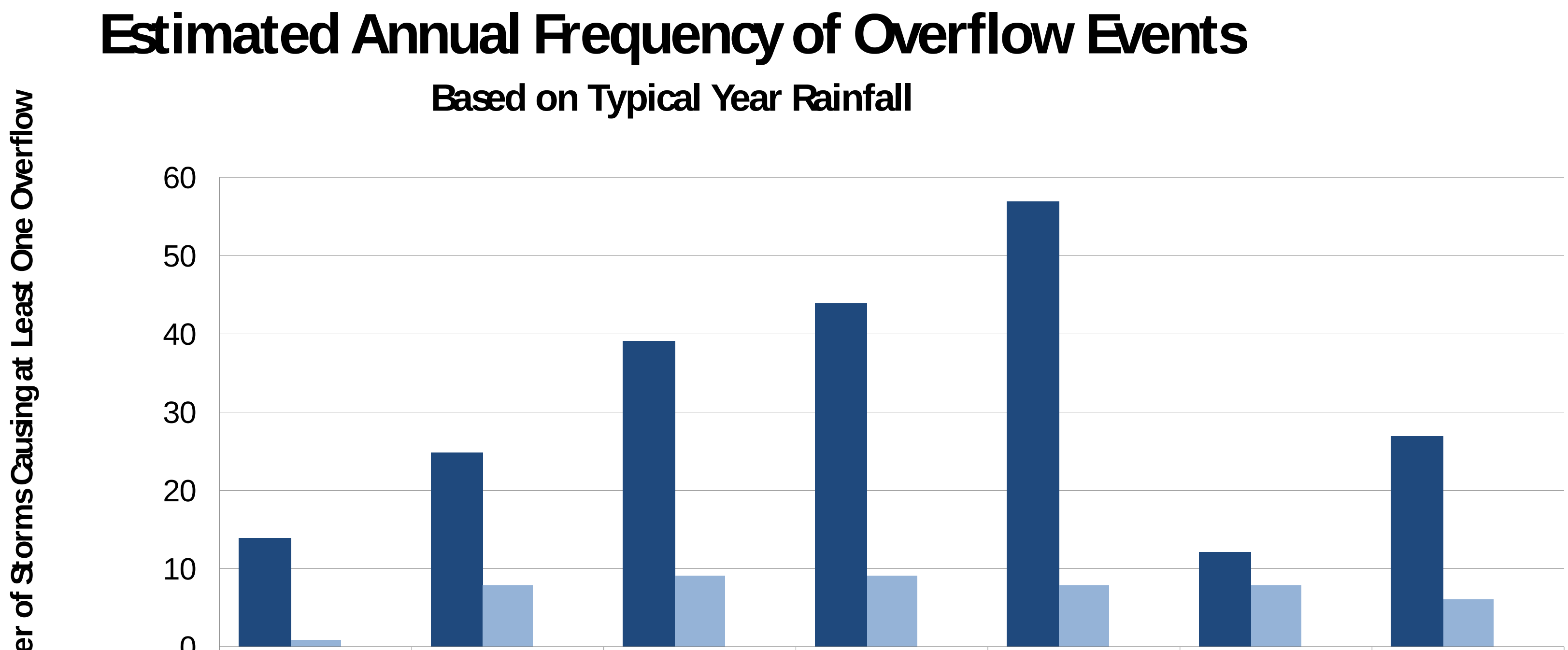
| Plan Element | Estimated Cost |
|---|---|
| Christiana Creek CSO Control | $14,880,000 |
| Upper Elkhart River CSO Control | $20,280,000 |
| Wastewater Treatment Plant Upgrades | $30,045,000 |
| Lower Elkhart River CSO Control | $13,305,000 |
| Oakland Avenue CSO Control | $27,315,000 |
| Upper St. Joe River CSO Control | $6,378,000 |
| Lower St. Joe River CSO Control | $8,073,000 |
| Riverside Drive CSO Control | $13,875,000 |
| **Estimated Capital Costs (includes contingencies)** | **$134,151,000** |

# Benefits: Overflow Volume Reduced



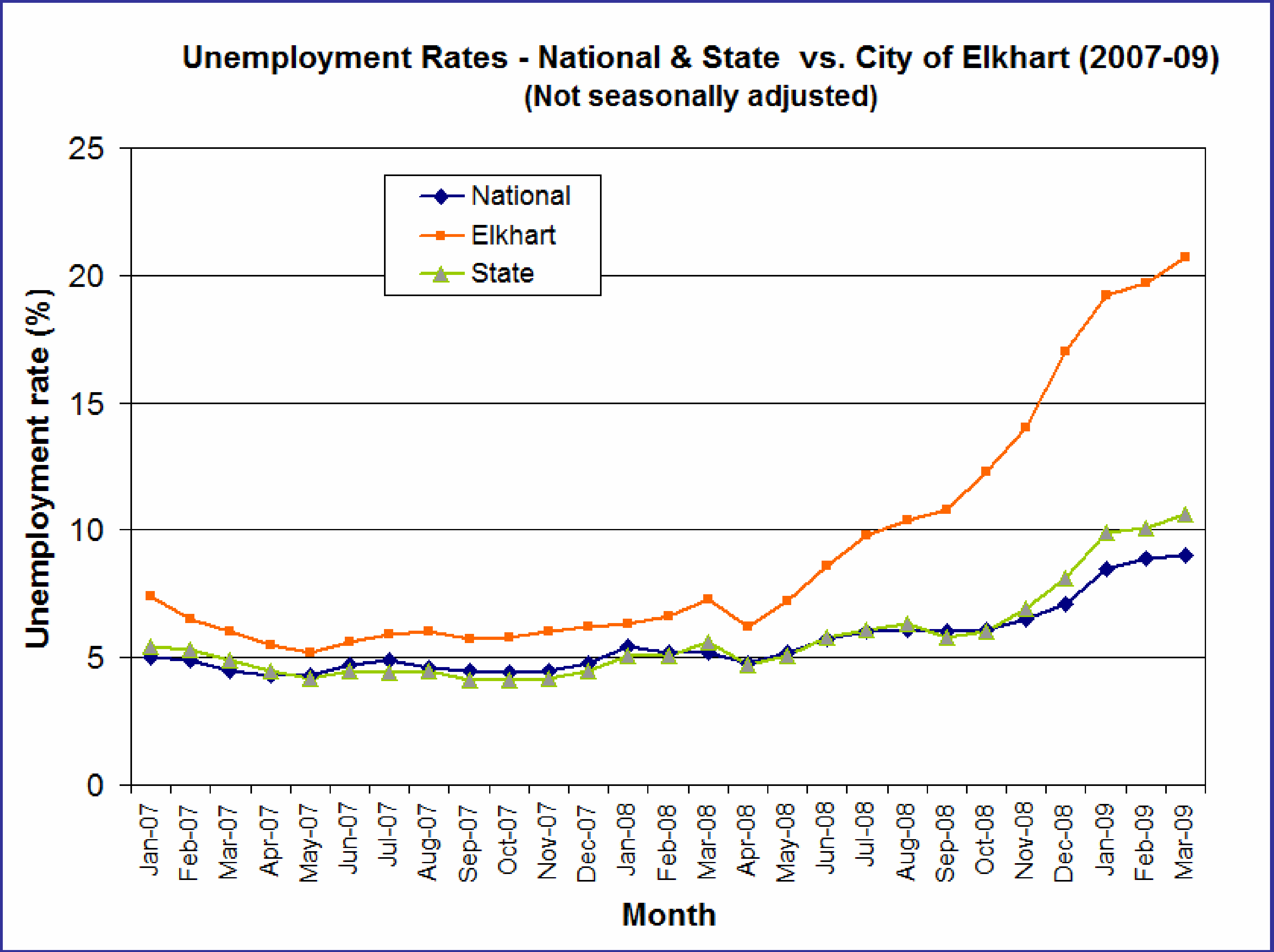

| | Christiana Creek | Elkhart River | St. Joseph River (Direct) | St. Joseph River (Total) |
|---|---|---|---|---|
| Before | 4.7 | 26.9 | 147.7 | 179.4 |
| After | 0.1 | 14.6 | 30.2 | 44.9 |

# Benefits: Overflow Frequency Reduced

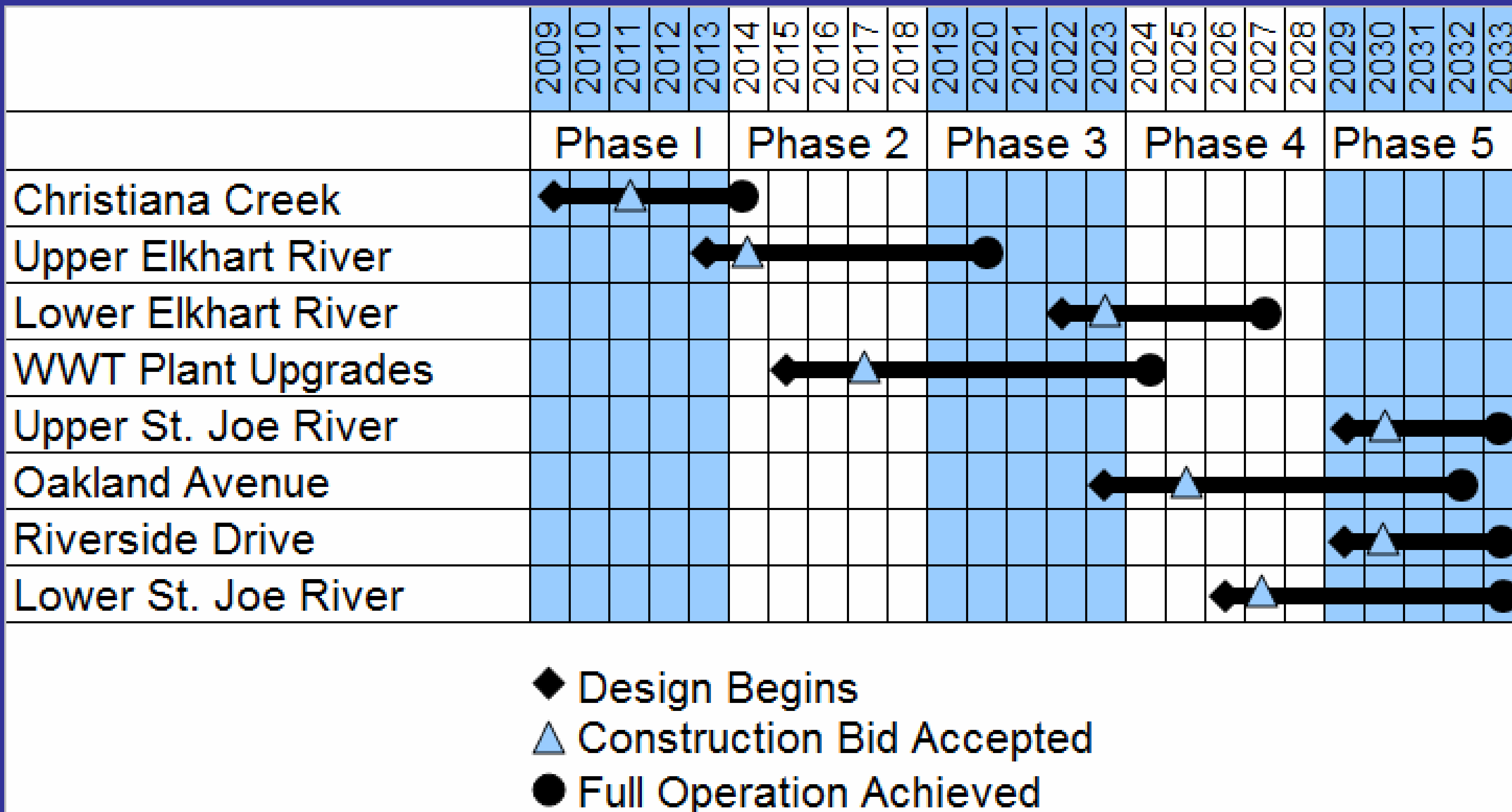



| | Christiana Creek | Upper Elkhart River | Lower Elkhart River | Upper St. Joseph River | Oakland Ave. | Riverside Dr. | Lower St. Joseph River |
|---|---|---|---|---|---|---|---|
| Before | 14 | 25 | 39 | 44 | 57 | 12 | 27 |
| After | 1 | 8 | 9 | 9 | 8 | 8 | 6 |
| Overflow locations | 1 | 6 | 5 | 6 | 2 | 1 | 12 |

# Unemployment Rate Calls for Longer Schedule



# Draft 25-Year Schedule 2009-2033



# Federal Stimulus Funding Available Now

- Applied to state for stimulus funds for Christiana Creek and Upper Elkhart River (ready-to-go projects)
- Received $4.2 million for Upper Elkhart River
  - Approx. $1.3 million grant
  - $2.9 million loan at 3.88% interest
- Waiting to hear on Christiana Creek funding request

# Agenda

- Background
- Elkhart’s Long-Term Control Plan
- Plan Costs and Benefits
- Proposed Rate Ordinance

# Sewer Rate Ordinance

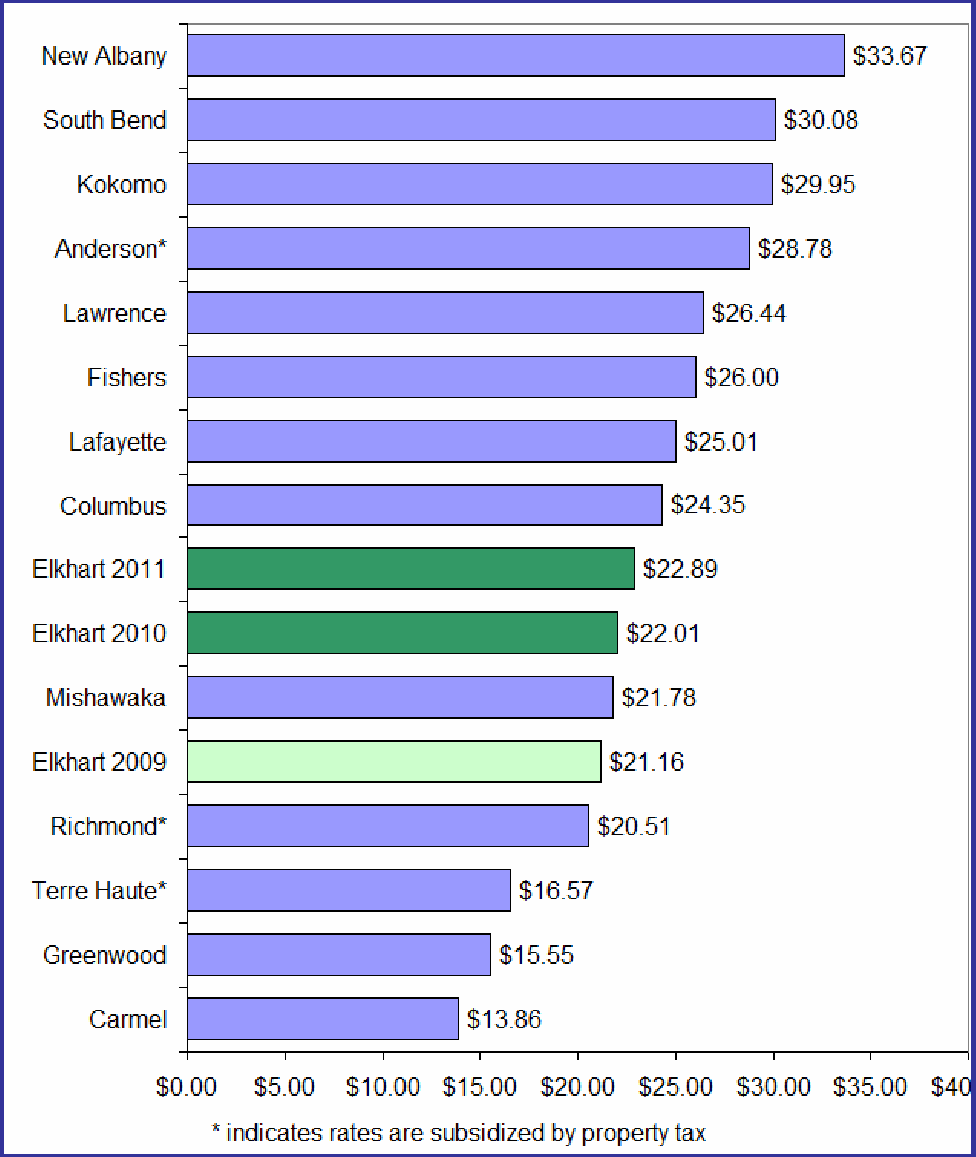
- Goal of Rate Study: Each user should pay their fair share of the cost to treat their wastewater
- Proposed rate ordinance will:
  - Increase rates for all users by 4% in 2010 and 4% in 2011
  - Restructure rate schedule to reduce discounts for businesses that are high volume users
  - Reduce industrial surcharges to reflect our actual cost to treat excess pollutants

# How Will This Affect Residential Rates?

- First 4% rate increase will go into effect January 2010
- Second 4% increase in January 2011
- For average homeowner using 5,000 gallons (668 cubic feet) per month:
  - Current: $21.16
  - 2010: $22.01 (up 85 cents/month)
  - 2011: $22.89 (up 88 cents/month)
- Without help of federal stimulus funds and low-interest loans, rates would have gone up 44%

# Residential Rate Comparison

- Average residential monthly bill
- Based on 5,000 gallons used (668 cubic feet)
- Anderson and Richmond have recently increased their rates



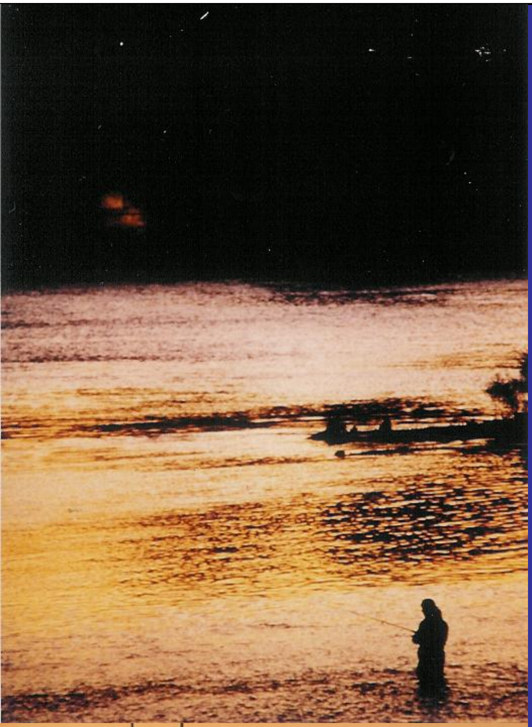
# Changes to Business Rate Structure


- Businesses include apartments, stores, office buildings and manufacturing plants
- Businesses may pay two charges:
  - One based on volume
  - One based on pollutants they send into sewer system (industries)
- Volume-based rates will be restructured from five tiers to three tiers
- Industrial pollution charges will be reduced to reflect city’s cost to treat

# Summary of Proposed Rate Changes

| Proposed Rate Change | Proposed Implementation Date |
|---|---|
| Industrial surcharges reduced | Upon Passage |
| Eliminate high volume discounts by reducing rate structure from 5 tiers to 3 tiers | Jan. 1, 2010 |
| 4% rate increase for all users | Jan. 1, 2010 |
| 4% rate increase for all users | Jan. 1, 2011 |

# Summary



- Long-term plan is the right plan for protecting our rivers
- 25-year schedule and federal stimulus funds will help minimize impacts to ratepayers
- Rates need to be restructured to reflect cost to treat
- Small rate increase necessary to take advantage of federal dollars

# Questions?

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**Work Already Done**

We've already begun reducing overflows by:

- Separating sewers in high-priority neighborhoods, focusing on high volume overflow pipes and areas with basement backups, drainage problems and industrial sewage
- Redirecting sewage away from the combined sewer system into separate sanitary sewers with extra capacity
- Increasing sewer cleaning and maintenance activities to reduce overflows and allow more flow to get to the wastewater treatment plant.
- Installing check valves in seven overflow pipes to prevent river water from entering the sewer system during high river flows
- Replacing or repairing deteriorating manholes and catch basins. Both structures must be regularly cleaned and maintained — and repaired or replaced when they are in bad condition.










**Further Options Considered**

- **Full Sewer Separation:** Separating stormwater and sewage into different pipes throughout the city
- **Larger Sewers:** Increasing the sewer system's capacity to convey all flow to the treatment plant and expanding the plant's capacity
- **Tunnel Storage:** Building a deep tunnel to capture sewage during wet weather, then pump flows to the wastewater treatment plant for treatment
- **Regional Storage:** Building regional storage tanks or basins to capture sewage during wet weather, then pump flows to the treatment plant
- **Expanding Wastewater Treatment Plant:** Expanding the capacity of Elkhart's treatment plant so it can handle more wet-weather flows
- **Remote Treatment:** Building new treatment facilities, such as wetlands, to capture and treat overflows where they occur

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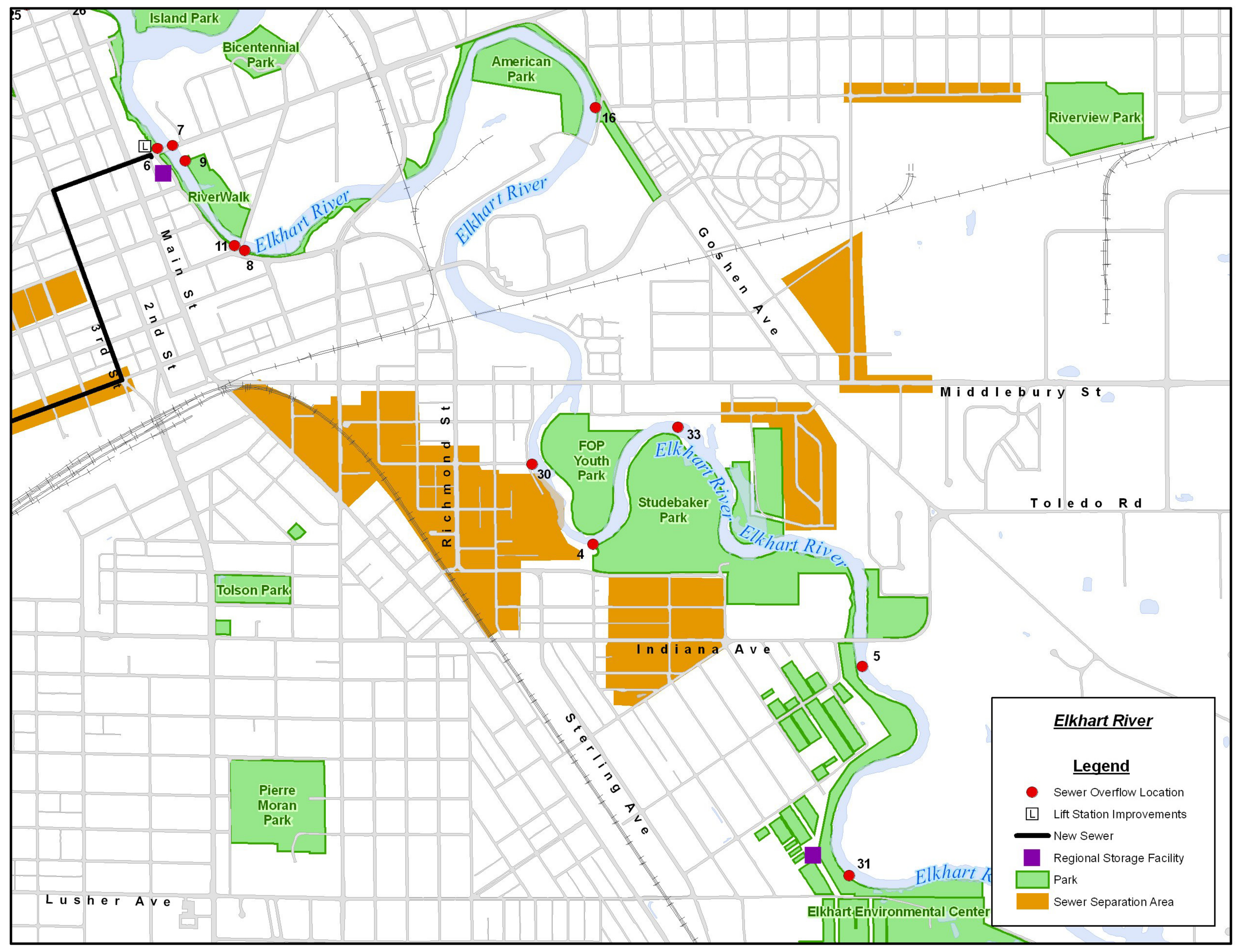


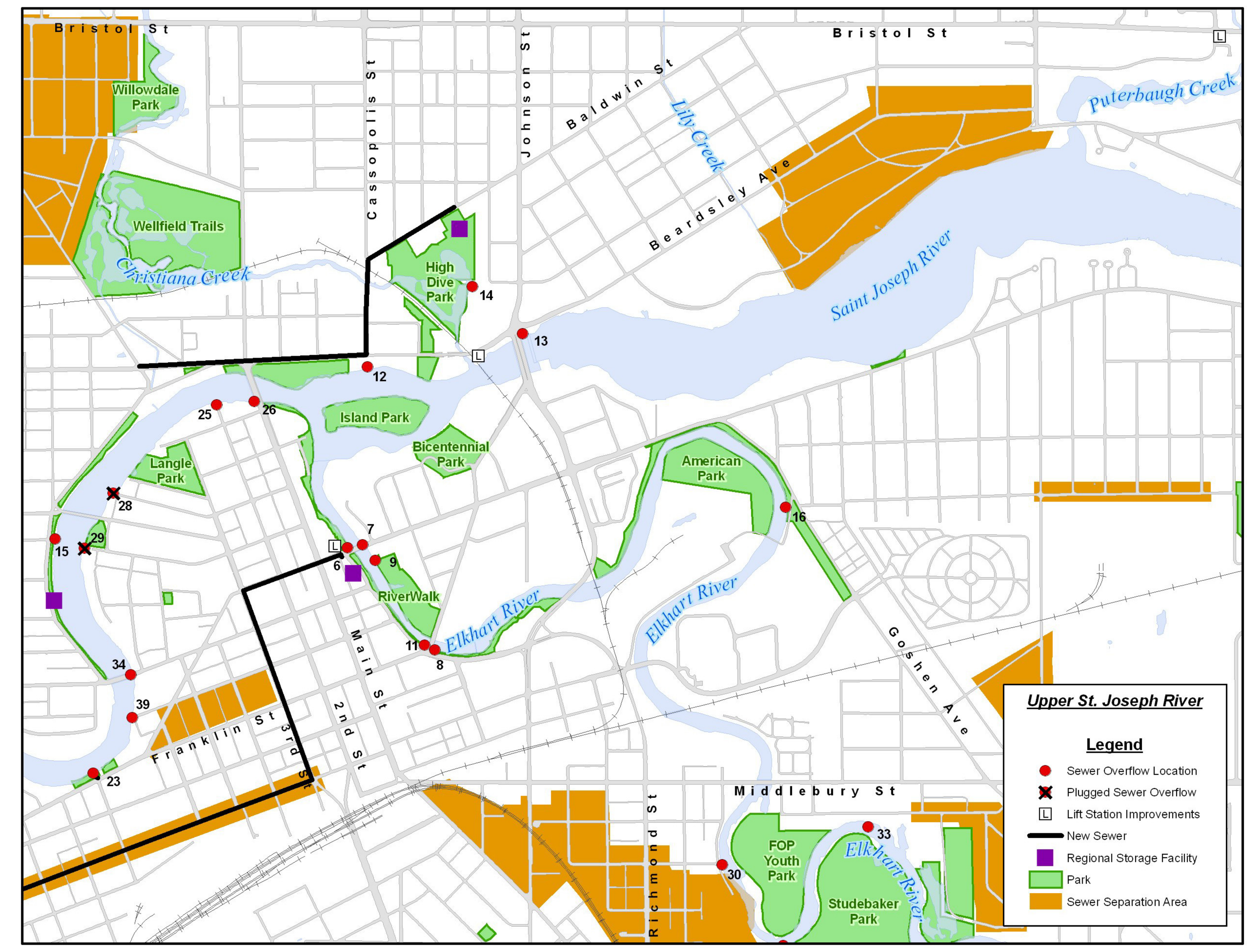


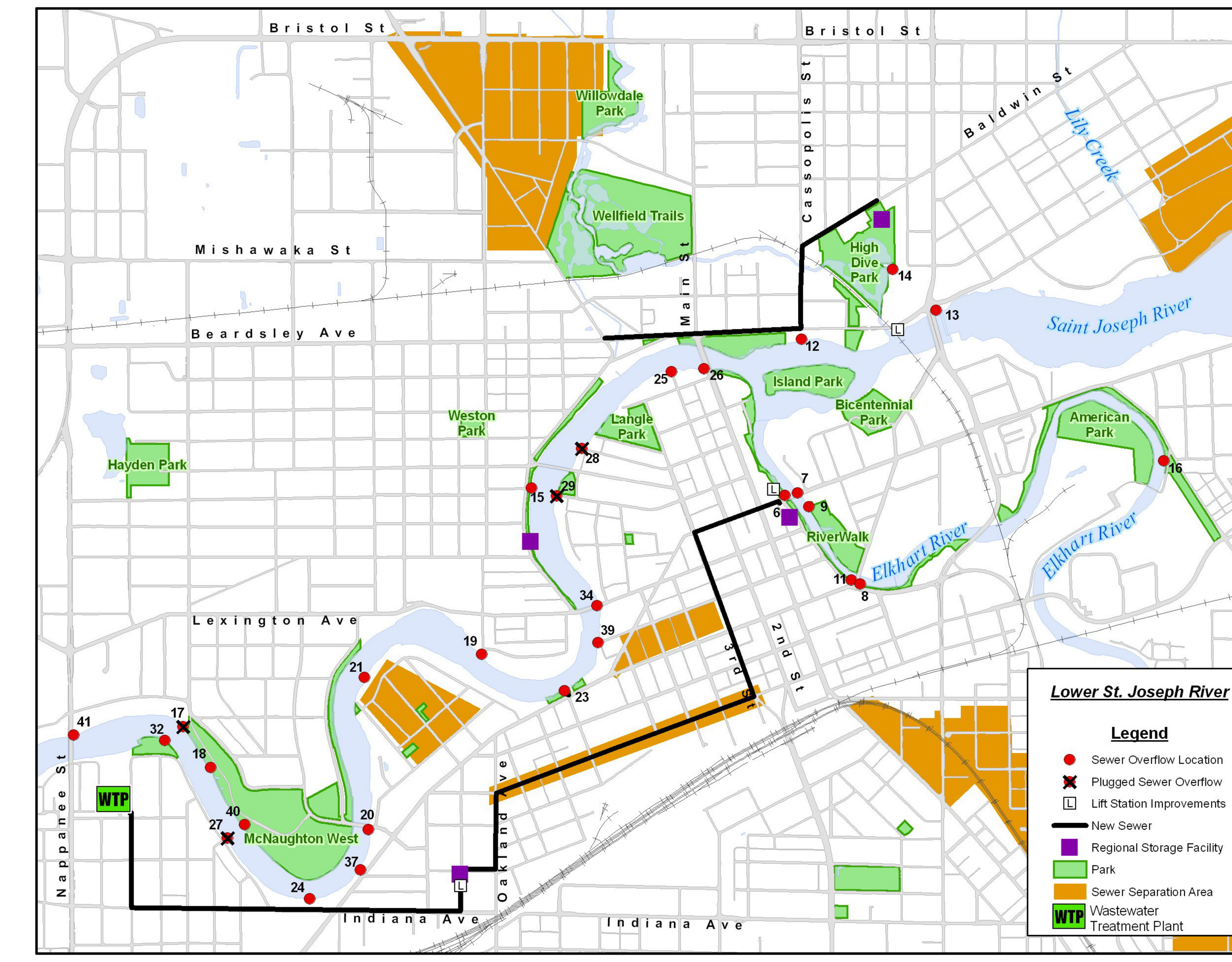


## Elkhart River Plan

- A 1-million-gallon storage tank near the Jackson Boulevard Bridge to capture overflows affecting the Riverwalk, Island Park and other downstream parks.
- Building an 80,000-gallon storage tank near Lusher Avenue to store overflows during wet weather and reduce overflows affecting the River Greenway and many downstream parks.
- Partially separating storm and sanitary sewers in neighborhoods near FOP Youth Park, Studebaker Park and Baker Park to reduce overflows affecting those parks.

## Christiana Creek Plan

- A 1-million-gallon storage tank in High Dive Park to capture wet-weather overflows when it rains and later release it to the existing sewer system after the storm has passed.
- Redirection of Northeast Elkhart sanitary sewers to the North Interceptor sewer system to redirect those flows away from the combined sewer system.

## Upper St. Joseph River Plan

- Partial sewer separation in neighborhoods near Greenleaf Drive and Beardsley Avenue to reduce overflows at the AEP Dam near the Johnson Street Bridge.
- Structural changes within the sewer system to reduce overflows near Pottawatomi and Second Street.

## Lower St. Joseph River Plan

- A 430,000-gallon storage tank along Riverside Drive
- A 1.1-million-gallon storage tank near Oakland Avenue
- Separating some sewers near Willowdale Park and Wellfield Trails
- Separating some sewers near Franklin and Vistula Streets and west of Oakland Avenue
- Redirecting sanitary sewers at West Boulevard and Beardsley away from the combined sewer system
- Redirecting sewers near McNaughton Park to the North Interceptor system

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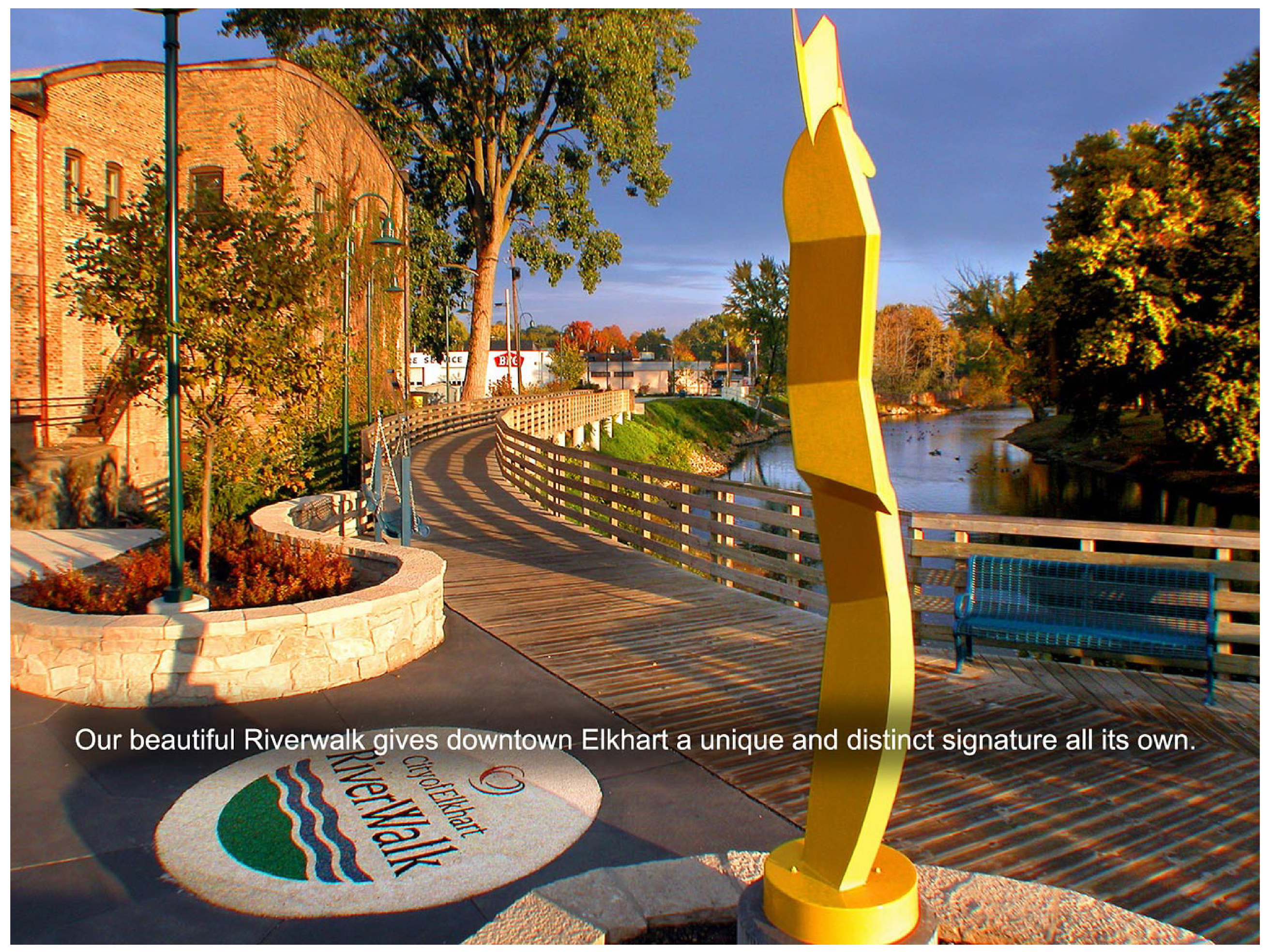
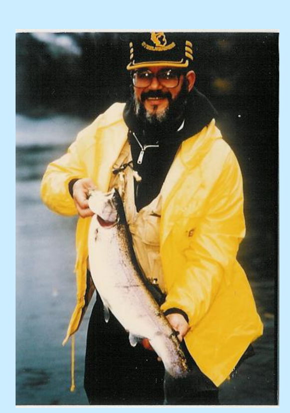


Our beautiful Riverwalk gives downtown Elkhart a unique and distinct signature all its own.

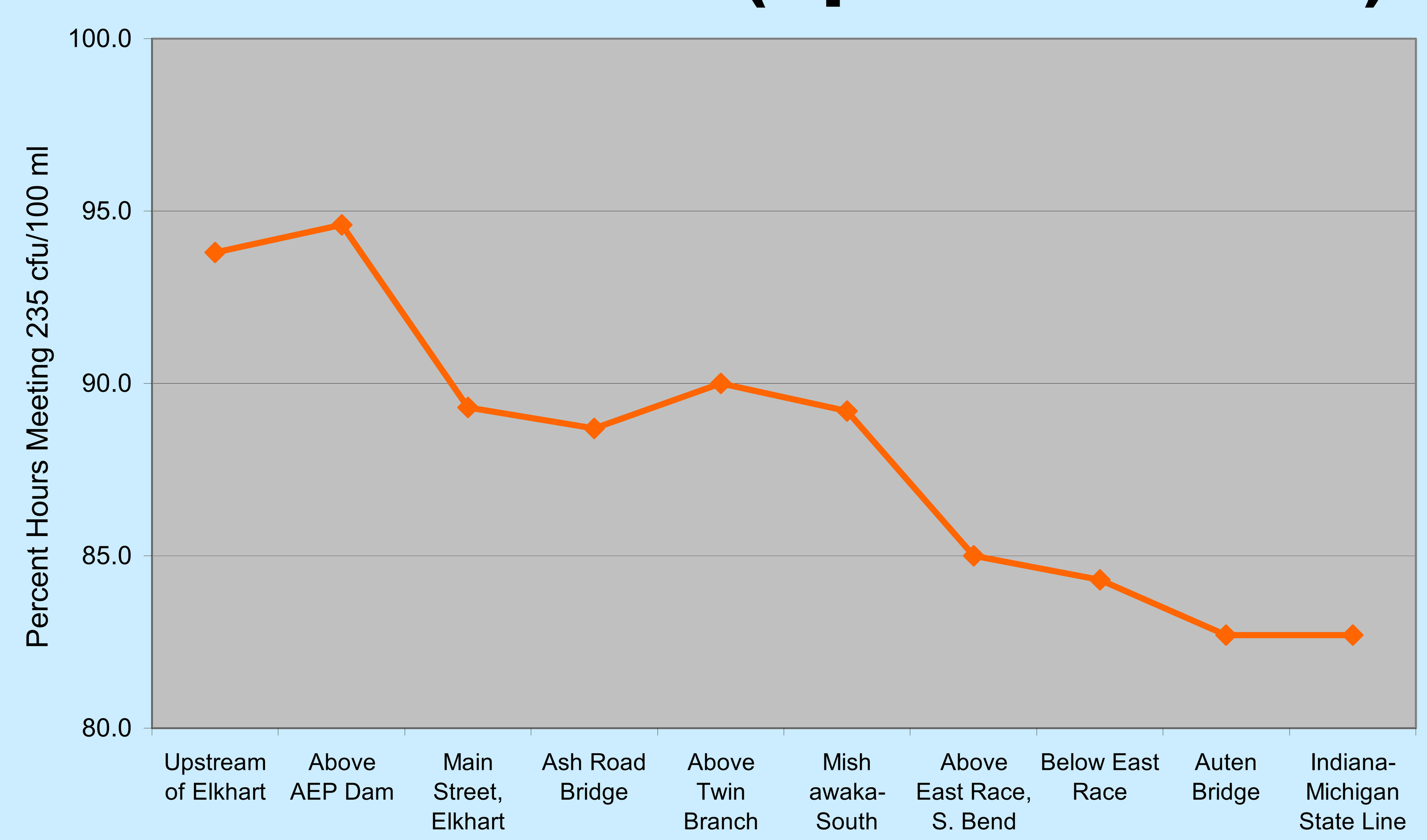
- Our rivers are a valuable community resource enjoyed by Olympic-caliber kayakers, recreational canoeists and sport fishermen.
- Water quality has improved dramatically since the 1950s.
- More than 80 species of fish are now found in the St. Joseph River watershed.
- South Bend, Mishawaka and Elkhart are planning more recreational and economic opportunities on their waterfronts.



## Water Quality Concerns

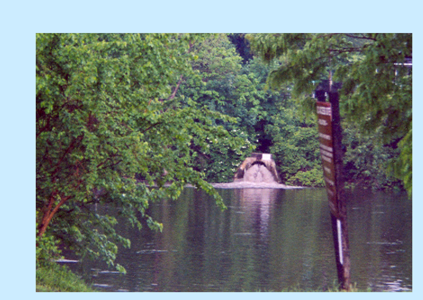
- Bacteria levels in our waterways don't meet state standards at all times, especially during wet weather
- The St. Joe River meets state bacteria standards 97 percent of the time during dry weather
- During wet weather, many sources combine to cause high *E. coli* bacteria levels in the river

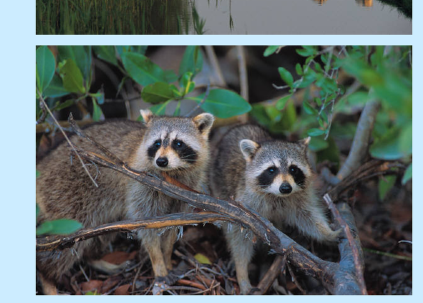
### Percent of Hours Meeting Indiana's Bacteria Standard (April to October)




## Common Bacteria Sources

- Sewer overflows
- Farms and feedlots
- Parking lots, yards and other areas with pets and wildlife
- Failing septic systems





- Disconnect rain gutter downspouts and sump pumps from the sewer system
- Install a rain barrel or rain garden to capture rainwater
- Don't send fats, oils or grease down the drain – they can clog our sewers
- Don't dump household chemicals, paint or oil on the ground
- Clean up after your pets
- Reduce water use by repairing leaks, using low-flow toilets and shower heads, and turning off the water while shaving or brushing your teeth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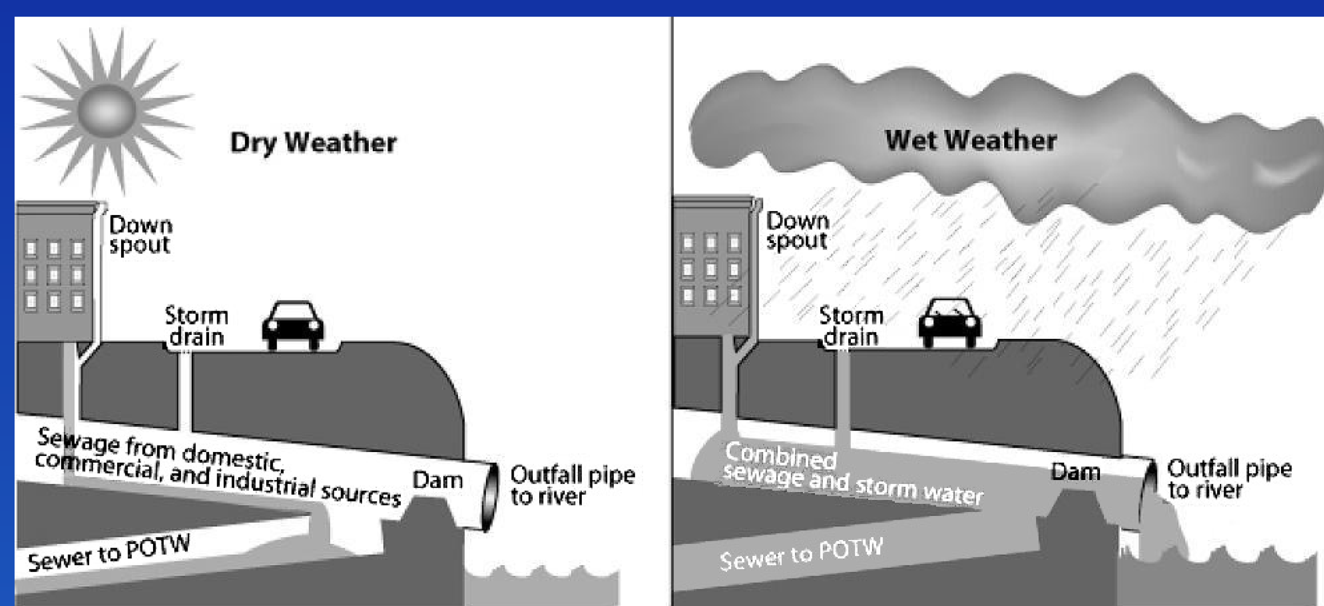
# Why Our Sewers Overflow When It Rains

## Why Our Sewers Overflow




### Our Sewer History

- Cities built storm sewers in the late 1800s and early 1900s to carry away rainwater and melting snow.
- Back then, we didn't have sewage treatment or even indoor plumbing.

Source: www.sewerhistory.org

- Later, homeowners and business owners hooked their new sewage lines to the existing storm sewers.
- All pipes emptied directly into our rivers, until the 1950s when our sewage treatment plant was built.
- Without an overflow pipe, sewage would back up into basements and streets.
- These "combined sewers" were common practice in many U.S. cities at the time. But it's no longer acceptable in the 21st Century.

## Where Our Sewers Overflow


### Sewer Overflow Facts

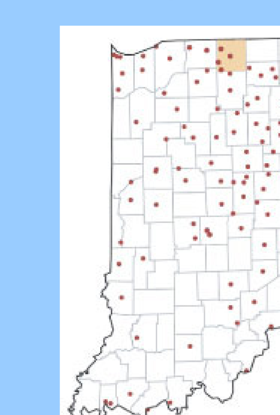
- Rainwater or melting snow can cause our sewers to become overloaded and overflow.
- Overflows can occur in 33 locations in Elkhart, shown as red dots on the map above
- Overflows can occur more than 50 times per year at some locations, depending on rainfall amounts
- They discharge about 180 million gallons of sewage and untreated stormwater to our rivers in a typical year
- Overflows can be triggered by as little as two-tenths of an inch of rain (0.2 inches)

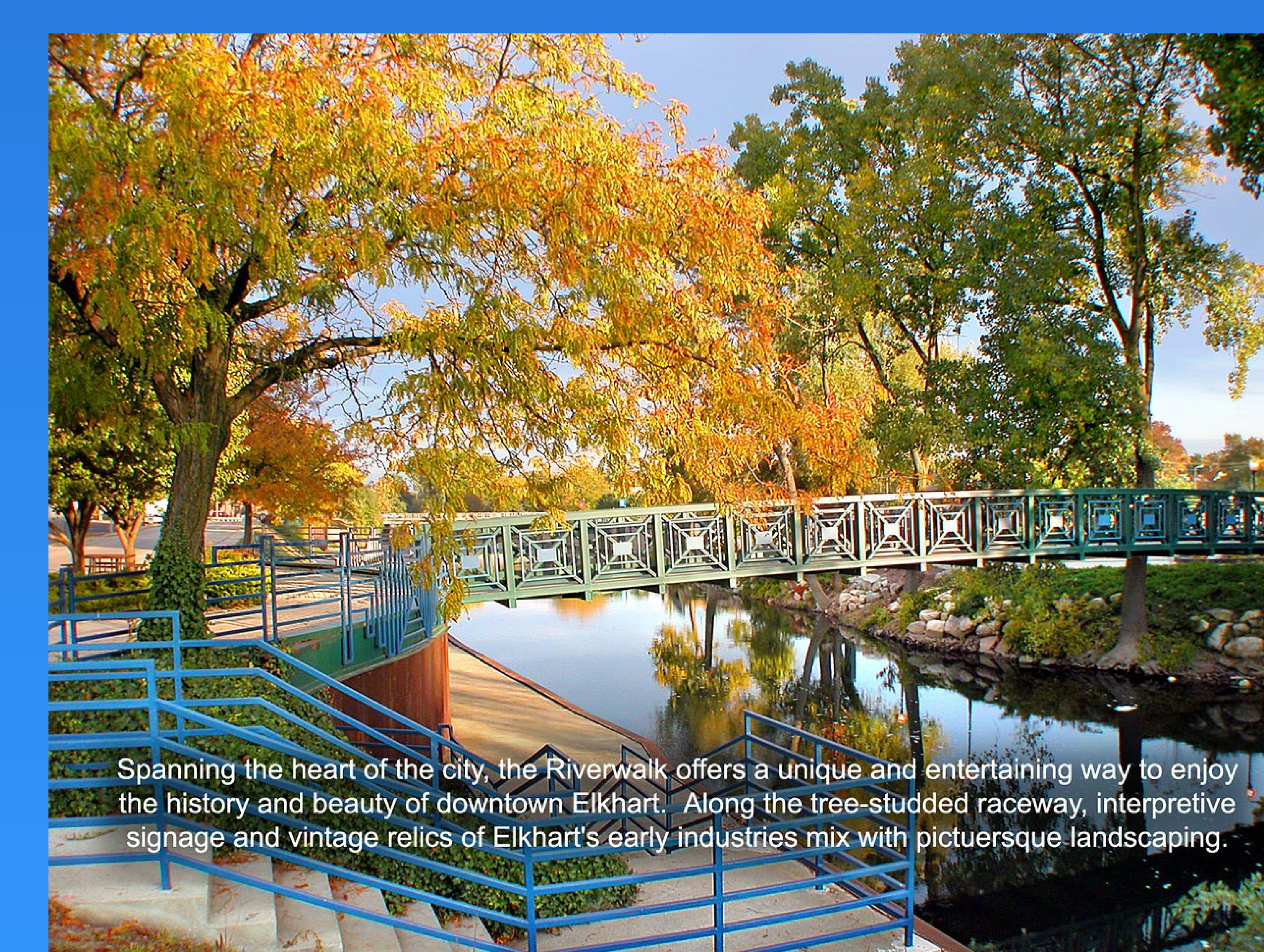
## We Are Not Alone

### A Nationwide Problem

- Combined sewer systems serve roughly 772 communities containing about 40 million people, according to the U.S. Environmental Protection Agency.

- Most communities with combined sewer systems are located in the Northeast and Great Lakes regions and in the Pacific Northwest.
- Indiana has more than 100 communities with combined sewers.





Spanning the heart of the city, the Riverwalk offers a unique and entertaining way to enjoy the history and beauty of downtown Elkhart. Along the tree-studded raceway, interpretive signage and vintage relics of Elkhart's early industries mix with picturesque landscaping.

City of Elkhart, Indiana
the city with a heart

Clean river Healthy neighborhoods
ELKHART ▪ MISHAWAKA ▪ SOUTH BEND

City of Elkhart Engineering

Clean river Healthy neighborhoods
ELKHART ▪ MISHAWAKA ▪ SOUTH BEND

### Your Input Needed

# Reducing Sewer Overflows to Our Waterways

The City of Elkhart has developed a plan to meet federal and state mandates for cleaner water by reducing raw sewage overflowing into the St. Joseph River, Elkhart River and Christiana Creek.

Your input is needed as we begin to finalize the plan. We invite you to answer the following questions and return your responses to Elkhart Public Works. You can also go on-line to www.elkhartindiana.org and email your responses. **Comments are due July 17.**

1. Please rank the following items 1-5 in order of importance to you (1=highest importance; 5=lowest importance):

    ___ Reducing the number of gallons of untreated sewage in the St. Joseph River, Elkhart River and Christiana Creek
    ___ Keeping sewer rates as affordable as possible
    ___ Making our waterways safer for people who use them
    ___ Keeping the cost per gallon reasonable and cost-effective; don't spend beyond the point of diminishing returns
    ___ Minimizing disruption to neighborhoods and downtown

2. Do you think river pollution issues are a very serious, somewhat serious, not very serious or not at all serious problem in Elkhart?

    ☐ Very serious
    ☐ Somewhat serious
    ☐ Not very serious
    ☐ Not at all a serious problem

3. The City's plan is estimated to cost $134 million over 25 years. This represents the maximum amount the City can afford to spend, according to federal guidelines and our current economic conditions. Indiana law allows for a change in water quality standards if higher controls are not affordable. Would you support the revision of water quality standards in our waterways to allow up to nine sewer overflows in a year with average rainfall? Currently, overflows occur about 50 times per year. Without a change to water quality standards, we could be required to spend more to reduce sewer overflows in the future.

    ☐ Yes
    ☐ No
    ☐ Don't know/Not sure

4. Please provide any additional comments, questions or concerns below or on the opposite side:

Fold here

Place
Stamp
Here

Utility Engineer
Elkhart Public Works
1201 S. Nappanee St.
Elkhart, IN 46516

Additional Comments:

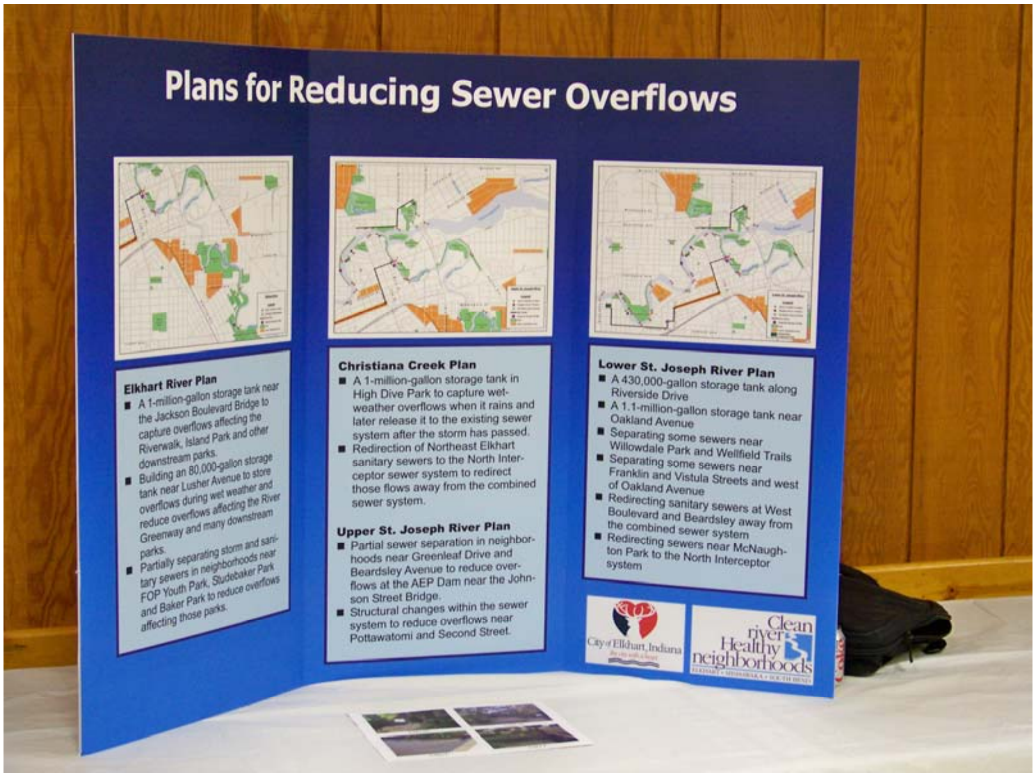
*Optional:*
Name ______________________________________________

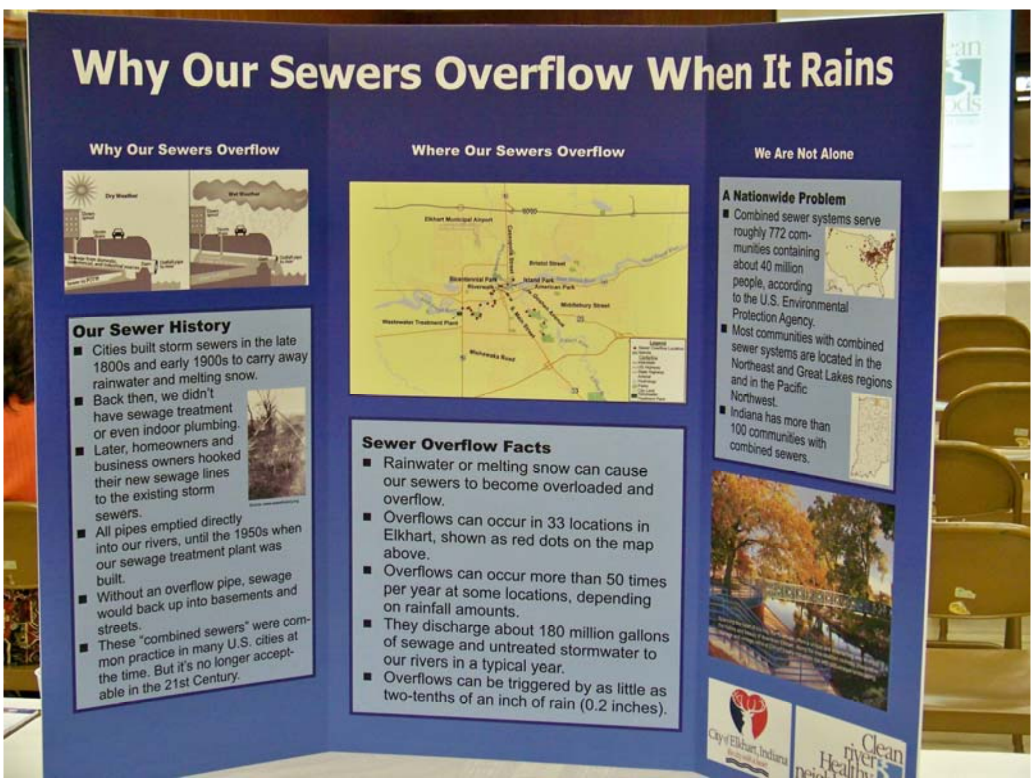
Address ____________________________________________ City ________________ ZIP: _________

Email: _________________________________


Water Quality Problems in Our Rive
St. Joseph & Elkhart Rivers: An Important Resource
Water Quality Concerns
Bacteria levels in our waterways don't meet state standards at all times, especially during wet weather
The St. Joe River meets state bacteria standards 97 percent of the time during dry weather
During wet weather, many sources combine to cause high E. coli bacteria levels in the river
Percent of Hours Meeting Indiana's Bacteria Standard (April to October)
Common Bacteria Sources
Sewer overflows
Farms and feedlots
Parking lots, yards and other areas with pets and wildlife
Failing septic systems


WHEN IT RAINS IT DRAINS
Cost
of
Service
Elkhart Wastewater Utility Cost of Service Study
Quality
vs.
Quantity
Surcharges
Rate Restructuring
Dare
to
Compare


Plans for Reducing Sewer Overflows
Elkhart River Plan
A 1-million-gallon storage tank near the Jackson Boulevard Bridge to capture overflows affecting the Riverwalk, Island Park and other downstream parks.
Building an 80,000-gallon storage tank near Lusher Avenue to store overflows during wet weather and reduce overflows affecting the River Greenway and many downstream parks.
Partially separating storm and sanitary sewers in neighborhoods near FOP Youth Park, Studebaker Park and Baker Park to reduce overflows affecting those parks.
Christiana Creek Plan
A 1-million-gallon storage tank in High Dive Park to capture wet-weather overflows when it rains and later release it to the existing sewer system after the storm has passed.
Redirection of Northeast Elkhart sanitary sewers to the North Interceptor sewer system to redirect those flows away from the combined sewer system.
Upper St. Joseph River Plan
Partial sewer separation in neighborhoods near Greenleaf Drive and Beardsley Avenue to reduce overflows at the AEP Dam near the Johnson Street Bridge.
Structural changes within the sewer system to reduce overflows near Pottawatomi and Second Street.
Lower St. Joseph River Plan
A 430,000-gallon storage tank along Riverside Drive
A 1.1-million-gallon storage tank near Oakland Avenue
Separating some sewers near Willowdale Park and Wellfield Trails
Separating some sewers near Franklin and Vistula Streets and west of Oakland Avenue
Redirecting sanitary sewers at West Boulevard and Beardsley away from the combined sewer system
Redirecting sewers near McNaughton Park to the North Interceptor system
City of Elkhart, Indiana
Clean rivers Healthy neighborhoods


Why Our Sewers Overflow When It Rains
Why Our Sewers Overflow
Where Our Sewers Overflow
We Are Not Alone
Our Sewer History
Cities built storm sewers in the late 1800s and early 1900s to carry away rainwater and melting snow.
Back then, we didn't have sewage treatment or even indoor plumbing.
Later, homeowners and business owners hooked their new sewage lines to the existing storm sewers.
All pipes emptied directly into our rivers, until the 1950s when our sewage treatment plant was built.
Without an overflow pipe, sewage would back up into basements and streets.
These "combined sewers" were common practice in many U.S. cities at the time. But it's no longer acceptable in the 21st Century.
Sewer Overflow Facts
Rainwater or melting snow can cause our sewers to become overloaded and overflow.
Overflows can occur in 33 locations in Elkhart, shown as red dots on the map above.
Overflows can occur more than 50 times per year at some locations, depending on rainfall amounts.
They discharge about 180 million gallons of sewage and untreated stormwater to our rivers in a typical year.
Overflows can be triggered by as little as two-tenths of an inch of rain (0.2 inches).
A Nationwide Problem
Combined sewer systems serve roughly 772 communities containing about 40 million people, according to the U.S. Environmental Protection Agency.
Most communities with combined sewer systems are located in the Northeast and Great Lakes regions and in the Pacific Northwest.
Indiana has more than 100 communities with combined sewers.
City of Elkhart, Indiana
Clean rivers Healthy

Reducing Sewer Overflows


Why Our Sewers Overflow When It R
Where Our Sewers Overflow


Plans for Reducing Sewer Overflows
Christiana Creek Plan
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Structural changes within the sewer system to reduce overflows near Pottawatomi and Second Street.
Lower St. Joseph River
Riverside Drive
Oakland Avenue
Willowdale Park
of Oakland


ELKHART PARK
& RECREATION


CSO 6
CSO 18
CSO 4
CSO 40
CSO 15
CSO 30

# The Truth - Government

First bit of stimulus will serve to separate sewer systems in Elkhart
Published: Tuesday, April 21, 2009 -- The Truth, A
Last updated: 4/20/2009 11:46:10 PM
By Josh Weinhold
Reporter

ELKHART -- The more than $4 million in economic stimulus funds the city was awarded last week will cover part of the cost of a sizable sewer separation project, Mayor Dick Moore said.

The long-term control plan, or combined sewer overflow plan, is estimated to cost $134 million over the next 24 years. Many of the city's combined sewer valves open under heavy rainfall, Moore said, dumping raw sewage into rivers.

The $1.2 million in grants and $2.9 million in low-interest loans will pay for the overhaul of two of the valves, near Studebaker Park, Moore said.

When the city's sewers were built decades ago, the combined sewer process was acceptable. The Environmental Protection Agency now requires updated sewer systems that drastically reduce the frequency of river dumps by separating the stormwater sewers from sanitary ones.

Moore said the $4 million is a good start, but the city is hoping for another $12 million in funding for the project. That would cover the CSO cost for the next seven or eight years, Moore said, and prevent the city from having to increase the sewer utility rate.

"That's what we've been really working hard towards," he said. "To be sure we don't place a great increase in the sewer bill."

The Indiana Finance Authority awarded $122 million in federal stimulus money and $128 million in low-interest loans on Friday to 43 Indiana communities.

Story Link: http://www.etruth.com/Know/News/Story.aspx?id=481077

# Elkhart: How will we pay for updated sewers?

***Here's Elkhart's plan: The city wants to raise millions of dollars by hiking sewer rates for its water customers by 4 percent each of the next two years***

**Published: 5/22/2009 12:00:00 AM**
**Last Updated: 5/21/2009 10:42:28 PM**
**By:** Stephanie Gattman |

Feedback is attached to this story
More Info is attached to this story

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ELKHART -- Residential sewer customers likely will see a 4 percent rate increase in each of the next two years because of a federally mandated plan to control sewage spills into the rivers during heavy rainfalls.

The city has asked the EPA to give it 25 years to implement its $134 million plan. The city will spend about $16.5 million during the next five years to continue addressing the problem.

But the mandate is unfunded, which means ratepayers will foot much of the bill. The city plans a 4 percent increase in 2010 and 2011 for residential customers. Industrial customers will see steeper increases, but also reduce surcharges for what the city calls "excessive-strength waste" users. So for some industrial users, their out-of-pocket costs could actually be less.

The city has received about $4.2 million in federal stimulus money to address the problem and Mayor Dick Moore said the city will continue to apply for more money. However, $2.9 million of that must be repaid to the state as part of a low-interest loan program.

The Combined Sewer Overflow Long-term Control Plan, as it's called, merges several options the city had considered with the EPA to address the problem, including tank storage of stormwater, sewer separations, redirection of existing sewers and expanding the wastewater treatment plant.

City officials acknowledge that because of the economy, this is not the best time for a rate increase, but the options are much worse.

"As good as this plan is and as happy as we are with the plan that we've proposed to get our best bang with our buck, it's the absolute worst time to have to have any sort of increase," said Laura Kolo, utility services manager at the public works and utilities department. "But we don't have a choice."


**Caption: 22a1 SEWER**

Moore said he was pleased that the residential increase amounted to less than 90 cents a month each year. He expected it to be much worse. The average national residential sewer cost is $65 per month, he said.

"We regret having to raise in an economic downturn with so many people in a distressed situation," Moore said. "We didn't want to raise it at all. We can't avoid that, so here we are."



Elkhart is one of more than 770 cities in the nation that have CSOs. A hundred of those cities are in Indiana. "Anybody who had any significant development in the 1800s and early 1900s faced these," said Mike Machlan, engineering services manager and city engineer at the public works and utilities department.

Elkhart has been working on reducing the number of CSOs in its system since the late 1980s by spending $27 million on sewer separations and system improvements, reducing the number of CSOs from 41 to 33, Machlan said. Those early projects positioned the city for moving forward with the current plan, he added. In addition, the city has had an aggressive downspout disconnection program with the EnviroCorps to help with stormwater issues, Machlan said.

If the Elkhart City Council approves the rate increase, it will go into effect Jan. 1, Machlan said. Surcharges will be dropped as soon as the council approves the package.

Once the CSO plan is complete, the city will reduce its overflows from 57 days a year to 9, Machlan said. "It's not perfect," he said.

But getting to zero would increase the cost from $134 million to $300 million, he said, something the EPA recognized in considering the cost benefit of the project.

"It's the right thing to do, to clean up our rivers and streams, to work toward getting them back to where they were before we all got here is the right thing to do," Moore said. "It is mandated. It's a requirement. We can't get away from it."

To view frequently asked questions about the project click here

To view a newsletter going out to residents explaining the Combined Sewer Overflow Long-term Control Plan and the rate increase click here

JOHNSON STREET BRIDGE WEBCAM
Click Here



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- Overflowing with worry: Concord residents concerned about runoff from new school

# The Truth - Local Opinion

Truth editorial — Clean water, sewer system fix are musts
Published: Friday, May 29, 2009 -- The Truth, A
Last updated: 5/29/2009 12:01:32 AM

It's the $134 million elephant in the room: A federally mandated plan to cut down on the number of times raw sewage spills into local rivers and creeks after heavy rain.

The city of Elkhart will probably have 25 years, if the EPA agrees, to complete all the necessary projects. Other cities are not as lucky.

Mayor Dick Moore and his Public Works and Utilities staff recently released a five-year plan that addresses about $16.5 million in projects toward the overall goal. It will mean 4 percent residential sewer rate increases -- about 90 cents a month -- in each of the next two years. Businesses will see a higher increase, but also a significant decrease in surcharges for "excessive-strength waste." Their overall cost could even out or decrease.

The federal mandate is unfunded, although the city is getting a little help from stimulus money -- a very little bit -- and plans to apply for more.

These projects must be done. Clean water is an appropriate federal mandate. And while we wish, as the city does, that there was more federal money available to accompany the requirement, the fact is there isn't.

Moore inherited this mess, which was dumped on Dave Miller and Jim Perron before him. It's part of our industrial legacy.

And since the Perron administration, the city has already invested $27 million on sewer separations and system improvements that reduced the number of combined sewer overflows from 41 to 33 since the late 1980s.

The good news is that we can make the system right. It will be expensive, but it could be worse. Other plans cost up to $300 million. Ridding Elkhart of all of its sewer overflows into the rivers could have cost $1 billion, something even the EPA knows is financially unattainable.

Moore's administration is taking a reasoned and incremental approach. There's no way to do it without a sewer rate increase and no way to delay it any longer.

The city will accept public comment on the plan through July 17 at cleanrivers@coei.org or by writing to Utility Engineer, Elkhart Public Works, 1201 S. Nappanee St., Elkhart, IN 46516.

Two public open houses have been set regarding the CSO plan. Both will be from 4 to 8 p.m. with presentations at 5 and 7 p.m. The meetings will be June 17 at High Dive Park Pavilion, 500 E. Beardsley Ave., and June 18 at Pierre Moran Park Pavilion, 201 W. Wolf Ave.

The first in a series of newsletters and an FAQ list are available on the city's Web site, www.elkhartindiana.org.

There's never a good time for a rate increase, but we believe the city has done the best it can under the circumstances.

Story Link: http://www.etruth.com/Know/News/Story.aspx?id=484335

# The Truth - Local News

CSO plans to be discussed
Open-house meetings to share information, allow public comment.
Published: Tuesday, June 16, 2009 -- The Truth, A
Last updated: 6/15/2009 10:38:56 PM
By Josh Weinhold
Reporter

ELKHART -- The city has spent years negotiating with state and federal regulators on how to reduce sewer overflows into local rivers, but it wants to hear from residents before plans are finalized.

Elkhart officials will host two open-house information meetings this week, giving residents an opportunity to learn about (and voice opinions on) a lengthy, costly plan to overhaul large parts of the city's sewer system.

The Combined Sewer Overflow Long-Term Control Plan, involves separating sewers, using tank storage for stormwater and expanding the city's wastewater treatment plant. The plan will be implemented over about 25 years and will cost $134 million.

All such measures are necessary, city officials said, to prevent sewage from being dumped into the St. Joseph and Elkhart rivers and Christiana Creek during periods of heavy rainfall.

The practice was acceptable when the city's sewers were first constructed, but the Environmental Protection Agency now restricts such action.

At the meetings, informational tables and displays will be set up and CSO project team members and public works staff will be available to answer questions. Thirty-minute presentations will explain the problem, the plan and subsequent sewer rate increases.

The city will collect public comments on the plan before locking it in with state and federal officials. It calls for first spending $16.5 million over the next five years to address the problem.

The EPA mandate is unfunded, however, so residents will bear most of the cost. The city council will consider passing a four percent increase for residential customers in 2010 and 2011, while industrial customers will see higher increases, but reduced surcharges.

More than 770 cities across the country have CSOs, about 100 of which are in Indiana.

Story Link: http://www.etruth.com/Know/News/Story.aspx?id=485776


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# The Elkhart Truth

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Today's Elkhart Truth E-mail Edition for Tuesday, 6/16/2009

## local

### CSO plans to be discussed

The city has spent years negotiating with state and federal regulators on how to reduce sewer overflows into local rivers, but it wants to hear from residents before plans are finalized. Elkhart officials will host two open-house information meetings this week, giving residents an opportunity to learn about (and voice opinions on) a lengthy, costly plan to overhaul large parts of the city's sewer Click Here to Subscribe to The Elkhart Truth

### Fed funds to help Goshen with underpass expense

The Plymouth Avenue underpass near the Millrace Canal is going to cost the city a lot less than some Goshen City Council members feared. The city learned last week that its share of the project, 20 percent -- an estimated $278,000 -- will be covered by federal stimulus dollars, the city's engineering department told the Goshen Board of Public Works on Monday. The city's need for that money ledClick Here to Subscribe to The Elkhart Truth

### She knew the Gabrieles, but she didn't know how bad things were WITH VIDEO

When Susan Manuszak heard the gunshot, she already knew what had happened. She knew her best friends, Philip

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# opinion

## Truth editorial

# Support the cleanup of our wastewater

You probably don't think much about where the waste goes when you flush your toilet.

But there's a complicated process that takes it from your home to the city's wastewater treatment plant, treats it and makes it clean enough to drink. When it rains a lot, in many areas of our city, the sewage mixes with rainwater in the sewer system and ends up overflowing into the Elkhart or St. Joseph rivers or Christiana Creek through outlets called Combined Sewer Overflows, which are basically pipes into the waterways.

Yeah, yuk.

The city of Elkhart has been working with the U.S. Environmental Protection Agency and the Indiana Department of Environmental Management for years on a plan to minimize the number of times those overflows happen. The parties are close to finalizing a $134 million, 25-year plan.

The city has eliminated eight CSOs since the late 1980s by spending $27 million on sewer separations and system improvements. Mayor Dick Moore plans to spend $16.5 million in the next five years.

That means, however, a 4 percent sewer rate increase for residential customers in each of the next two years.

It's an expenditure that needs to happen, regardless of the economic climate.

You can learn more about the need for the CSO Long-term Control Plan at two public open houses this week. The first is tonight at High Dive Pavilion; the second Thursday at Pierre Moran Park Pavilion. We urge you to attend one to ask questions and get information.

This is an important project. The city is mandated by the federal government to meet the parameters of the Clean Air Act. The $134 million solution meets those objectives in the most cost-effective way.

It could have been much worse. Total elimination of CSOs might have cost $1 billion and meant a much steeper rate increase. The timeline could have been much quicker, as well.

Of course, the mandates are unfunded and much of the federal stimulus money the city has received must be paid back to the state in the form of low-interest loans. But it's better than nothing.

The city's Web site, www.elkhartindiana.org, offers a thorough explanation of the history of the issue, maps, the proposed solution and information on the rate increase.

It's a valuable tool. Our site, www.eTruth.com, also has stories about the project.

Learn as much as you can by going to one of the meetings and reading online and then support the city's rate increase.

**IF YOU GO**

**What:** Combined Sewer Overflow Long-term Control Plan public open houses
**When:** 4 to 8 p.m. today and Thursday; 30-minute presentations at 5 and 7 p.m.
**Where:** Today at High Dive Park Pavilion, 500 E. Beardsley Ave.; Thursday at Pierre Moran Park Pavilion, 201 W. Wolf Avenue.
• Information available online at www.elkhartindiana.org.
• Public comments on the plan are due July 17. E-mail to cleanrivers@coei.org or mail to Utility Engineer, Elkhart Public Works, 1201 S. Nappanee St., Elkhart, 46516.

# The Truth - Local News

Local digest — Citizens get Combined Sewer Overflow info at meeting
Published: Friday, June 19, 2009 -- The Truth, A
Last updated: 6/18/2009 11:39:13 PM

About 15 residents attended an open house information meeting Thursday concerning the Combined Sewer Overflow Long-Term Control Plan, which involves separating sewers, using tank storage for stormwater and expanding the city's wastewater treatment plant.

The plan will be implemented over 25 years and will cost $134 million.

Laura Kolo, utility services manager for the city, said about 20 people attended Wednesday night's meeting. Most were curious about how the process will work and how the money will be spent. They weren't angry or overly concerned with proposed sewer rate increases over the next two years, she said.

Mike Machlan, Elkhart city engineer, said questions Thursday centered on whether people upstream were concerned about keeping the rivers clean.

Truth Staff

Story Link: http://www.etruth.com/Know/News/Story.aspx?id=486087

# The Truth - Front Page

Sewer rate increase advances despite concern over EPA plan
Published: Friday, June 26, 2009 -- The Truth, A
Last updated: 6/25/2009 10:50:27 PM
By Stephanie Gattman
Truth Staff

ELKHART -- In the end, an ordinance raising sewer rates roughly 4 percent in each of the next two years passed the first test before the Elkhart City Council, but not without complaining about the unfunded federal mandate by the EPA.

One huge issue still hanging over the heads of city officials: The EPA has yet to agree to a timeframe for the $134 million plan, which will affect the financial bottom line for sewer users in the future.

The city is continuing to ask the EPA to give it 25 years to implement its $134 million plan, particularly because of the economic plight of many of the city's residents. The EPA has given the city 20 years.

The Combined Sewer Overflow Long-term Control Plan, as it's called, merges several options to address raw sewage flowing into the rivers during heavy rain, including tank storage of stormwater, sewer separations, redirection of existing sewers and expanding the wastewater treatment plant.

The city will spend about $16.5 million during the next five years for projects that will address overflows into Christiana Creek and on the upper Elkhart River. The first project is ready for bid later this year.

Financial consultants did a cost of service study and attempted to bring business users more in line with residential customers. However, John Skomp of Crowe Horwath said the shift would have been too big to bring them completely in line all at once.

The city plans a 4 percent increase in 2010 and 2011 for residential customers. Industrial customers will see steeper increases in 2010, but also reduce surcharges for what the city calls "excessive-strength waste" users. For some industrial users, out-of-pocket costs could actually be less.

The average residential user paying $21.16 per month for 5,000 gallons of waste will pay $22.01 in 2010 and $22.89 in 2011.

Laura Kolo, the city's utility services manager, said if the EPA agrees to the 25-year schedule, another rate increase may not be needed for several more years.

Councilman David Henke, R-3rd, expressed frustration with the EPA. He noted that the agency hasn't cleaned up ongoing pollution concerns at the HIMCO Superfund site, and the Conrail Superfund site is once again a concern. "Yet we're so concerned with what we treat every day," he said.

"The EPA has not been friendly to Elkhart," Henke said.

One local resident agreed with concerns about the EPA, although he didn't necessarily agree with the rate increase since he said he doesn't contribute to the stormwater problem. "This is a federal cram-down. There's no doubt about it," said Jerry Ludwig, 3108 Vernon Ave. "I thought we got rid of these."

The ordinance will now go to the full council for approval.

Story Link: http://www.etruth.com/Know/News/Story.aspx?id=486587

# The Truth - Front Page

Suddenly, Elkhart's sewers are a federal matter
Truth of the Matter
Published: Sunday, June 28, 2009 -- The Truth, A
Last updated: 6/27/2009 11:50:23 PM
By Stephanie Gattman
Truth Staff

ELKHART -- City engineers, sewer utility staff and consultants have been working on a long-term Combined Sewer Overflow plan for years.

But now, as the city finally has the plan -- if not the timetable -- approved by the EPA, it still finds itself at the mercy of the U.S. Department of Justice and the EPA in federal court.

Ironically, city officials have the state of Indiana's Department of Environmental Management to thank for the predicament.

Elkhart actually completed its original long-term plan in 2002, according to Mike Machlan, city engineer, but the state didn't do anything with it. Elkhart is now among a handful of cities with which the EPA and the Justice Department are seeking a consent decree.

The document is a contract of sorts, approved in federal court, that sets a strict timeline and milestones the city and future administrations will have to meet or else face strict fines and possible jail time for the mayor and city council members. Takeover of the sewer utility by a federal judge also would be a possibility if they failed to live up to the decree.

And lest you think it's not serious, a city consultant said it has happened.

It shouldn't have come to this step and it's no fault of current or previous city administrations or staff.

"I'm tired of this," admitted Mike Machlan, city engineer, to members of the city council, last week. "I've been working on this project eight, maybe nine or 10 years."

The Indiana Department of Environmental Management "wasn't telling cities what to do," said Jodi Perras of Perras & Associates, one of the city's consultants who helped write the plan.

"We're where we are now," Machlan said.

Even though the consent decree hasn't been signed, the city has to show good faith by moving forward on projects anyway, Machlan said. "We're starting to crank up the pressure on the EPA," he said.

Despite the fact that the $134 million CSO plan is a federal mandate and in spite of the fact that the state has caused this to land in federal court, Elkhart hasn't gotten much stimulus money to help fund it.

One resident speaking at the council's finance committee meeting Thursday unfairly criticized the mayor and council for not going after as much stimulus money as it could. The city has, in fact, done so. So far, the city has received about $4.2 million in federal stimulus money. However, $2.9 million of that must be repaid to the state as part of a low-interest loan program.

Consultants said Thursday the city was still awaiting word on whether it would receive stimulus money from the state for the first phase of the CSO plan addressing overflows into Christiana Creek. Those projects would virtually eliminate sewage flowing into the creek during heavy rainfall.

You would think the state would be happy to help given its role, but that's not how government works.

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