

Flood Inundation Mapping Projects



Outline

- Flood inundation projects completed in Kentucky
- Overview of general steps involved in flood inundation projects
- Closer look at the Hopkinsville, Kentucky flood inundation project
- Closer look at the Frankfort, Kentucky flood inundation project
- Quick demo of USGS Flood Inundation Mapper

Acknowledgements

- The USGS Kentucky Water Science Center would like to thank the many cooperators that make this science possible.

Flood Inundation Projects Completed in Kentucky

Hopkinsville, Kentucky

Frankfort, Kentucky

 **USGS**
science for a changing world

Prepared in cooperation with the City of Hopkinsville, Kentucky, Community Development Services

Flood-Inundation Maps for an 8.9-Mile Reach of the South Fork Little River at Hopkinsville, Kentucky

*Pamphlet to accompany
Scientific Investigations Map 3242*

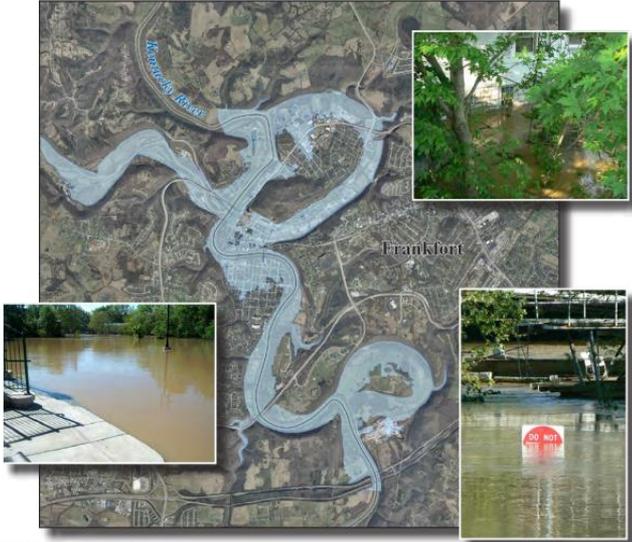
U.S. Department of the Interior
U.S. Geological Survey

<http://pubs.usgs.gov/sim/3242/>

 **USGS**
science for a changing world

Prepared in cooperation with City of Frankfort, Kentucky, Office of Emergency Management

Flood-Inundation Maps for a 6.5-Mile Reach of the Kentucky River at Frankfort, Kentucky



*Pamphlet to accompany
Scientific Investigations Map 3278*

U.S. Department of the Interior
U.S. Geological Survey

<http://pubs.usgs.gov/sim/3278/>

Flood Inundation Project Objectives

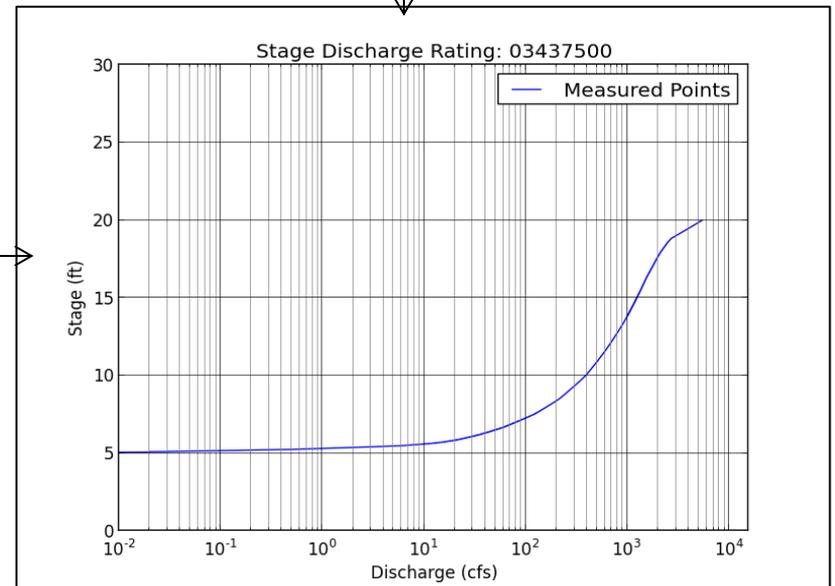
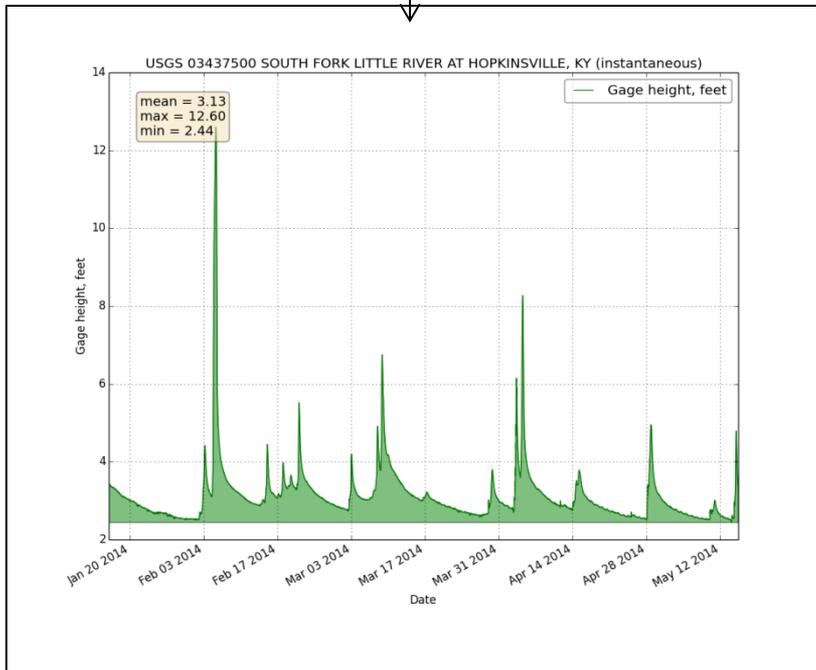
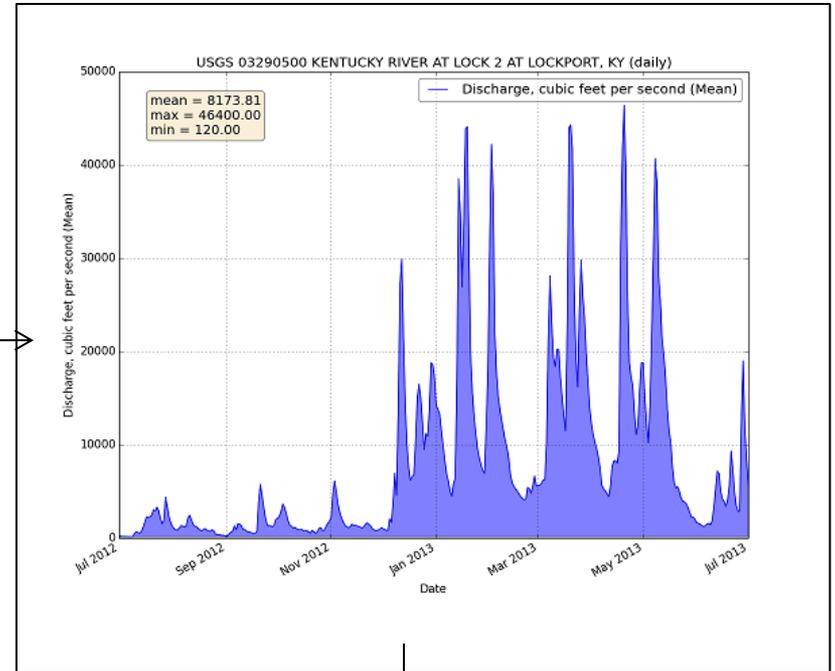
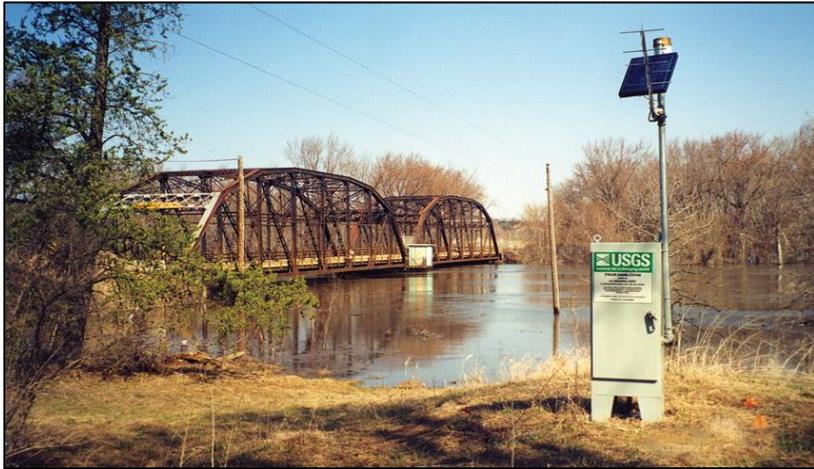
- **Develop** detailed libraries of flood inundation maps for a river reach of interest.
- **Use** the flood inundation maps in conjunction with the National Weather Service (NWS) Advanced Hydrologic Prediction Service flood warning system to show predicted areas of flood inundation.
 - **Helps with** preplanning **flood response** and **early flood warning**
- **Provide** online portals for the public to view USGS flood inundation study information and interact with the flood inundation map libraries.
- **The flood inundation maps**, along with online information regarding current stages from USGS streamgauge and forecasted stages from the NWS, provide emergency management and local residents with **critical information for flood response activities**.

Flood Inundation Project Phases

- **Phase 1** – Project Scoping and Planning
 - Site selection, modeling approach, and data collection
- **Phase 2A** – Hydraulic Analyses
 - Build and calibrate hydraulic model
- **Phase 2B** – Mapping
 - Create and submit map products to NWS and USGS Flood Inundation Mapping Program (FIMI)
- **Phase 3** – USGS Flood Inundation Mapping Science (FIMI) and NWS Advanced Hydrologic Prediction Service (AHPS) Web Implementation
 - Put maps on the Internet

USGS Streamgage

USGS streamgage(s) within study domain

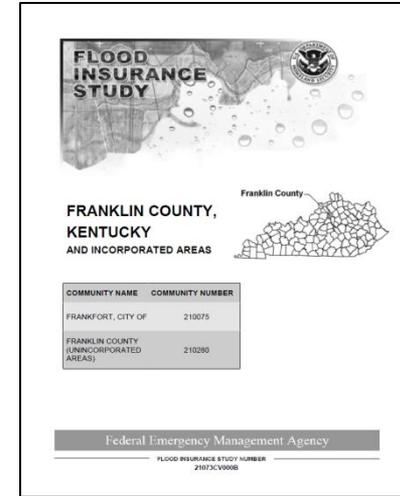
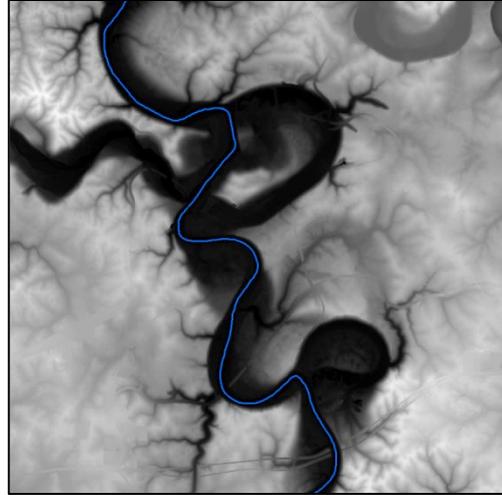
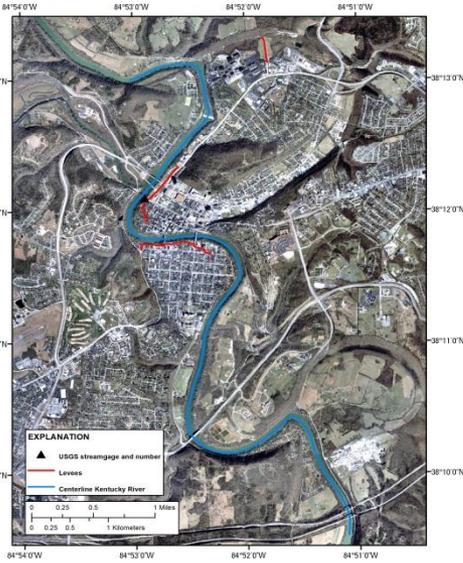


Phase 1 – 2A: Scoping/Approach, Data Collection, Modeling

Study Area

Digital Terrain/Elevation Model

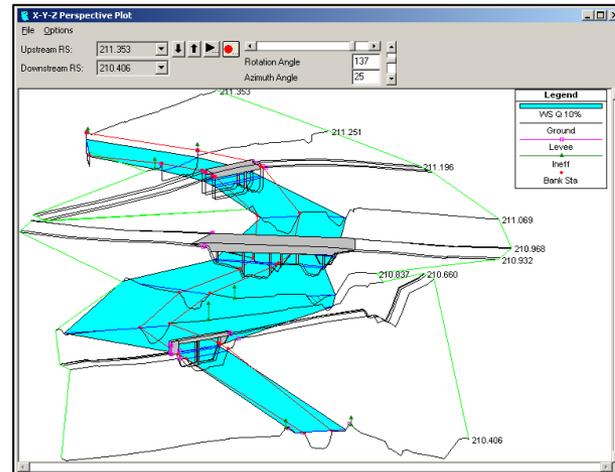
FEMA Flood Insurance Study



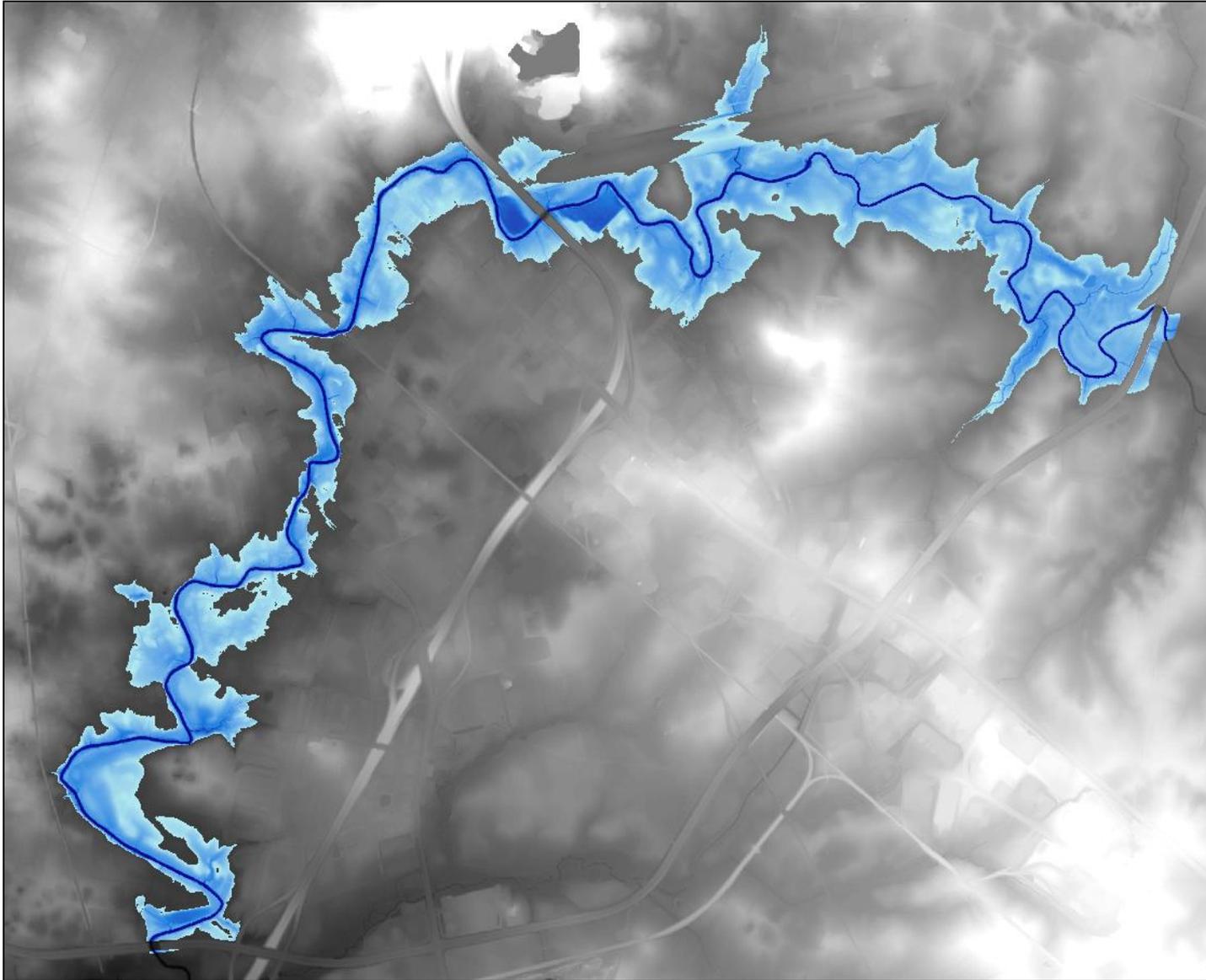
Bathymetry and/or survey data



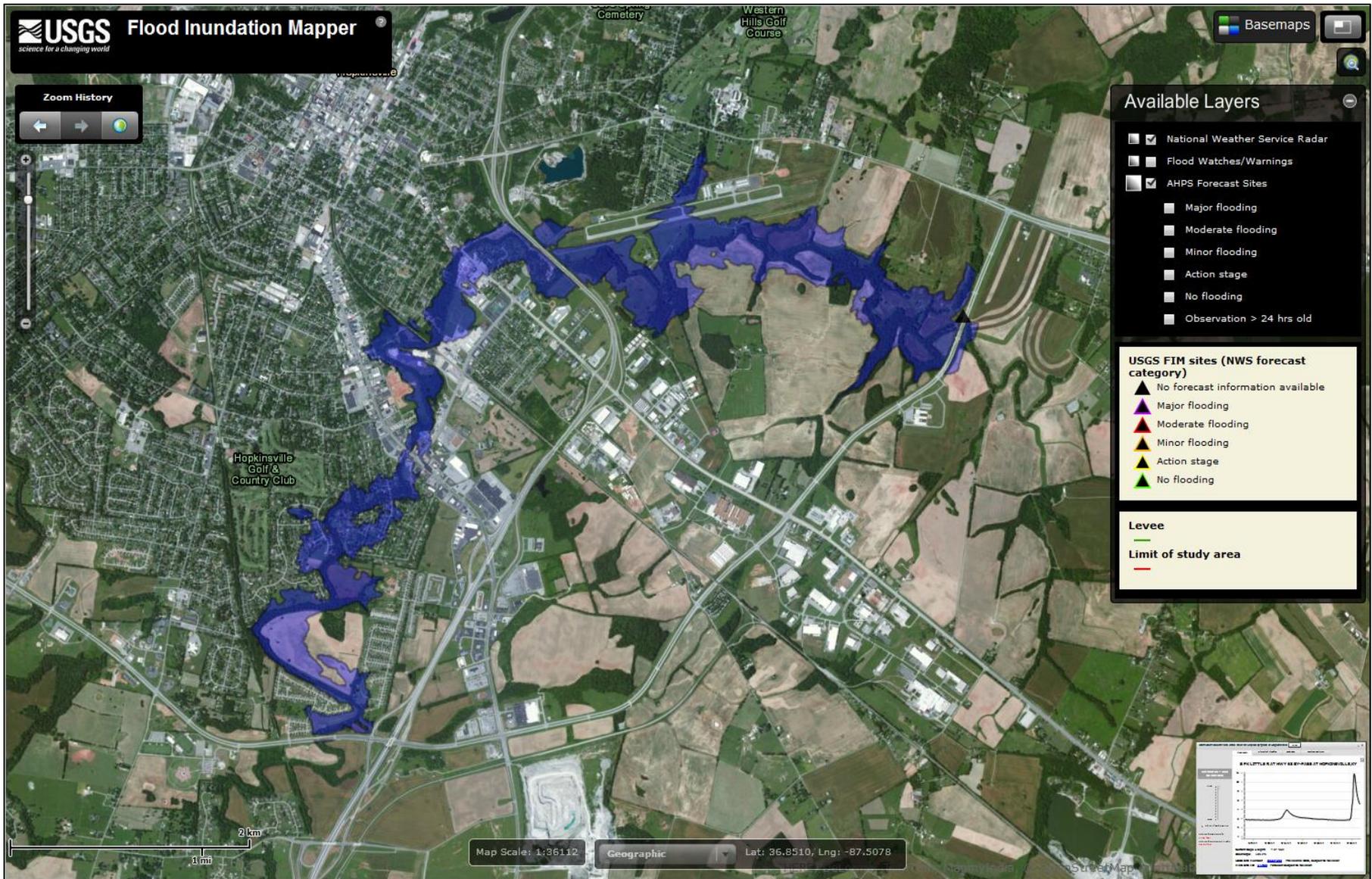
Hydraulic Model and Calibration



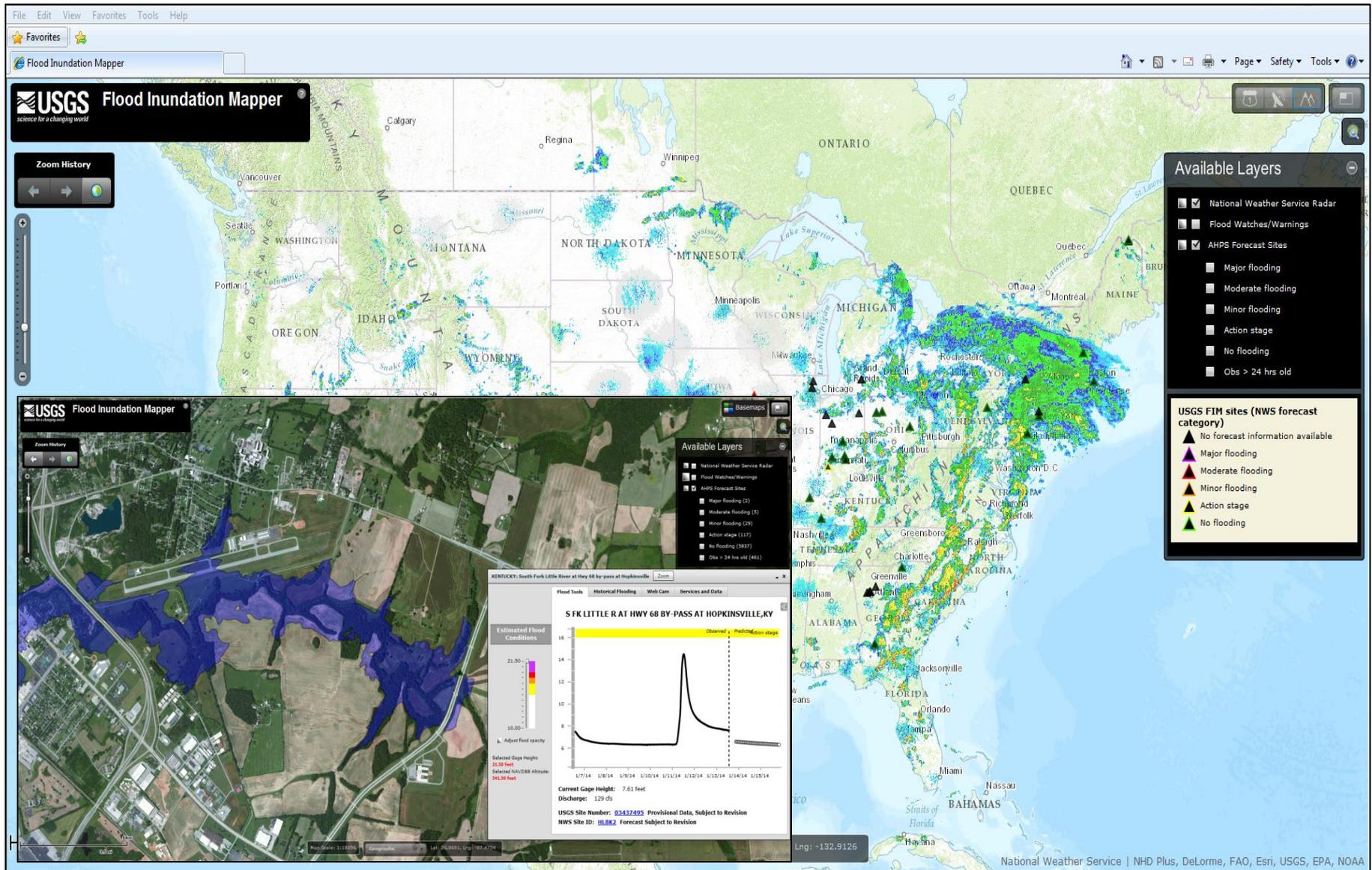
Phase 2B: Flood Inundation Depth Grid



Phase 3: Mapping and Web Implementation



Final Products – USGS Flood Inundation Mapper



<http://wim.usgs.gov/FIMI/FloodInundationMapper.html>

Hopkinsville, KY – Flood Inundation Project

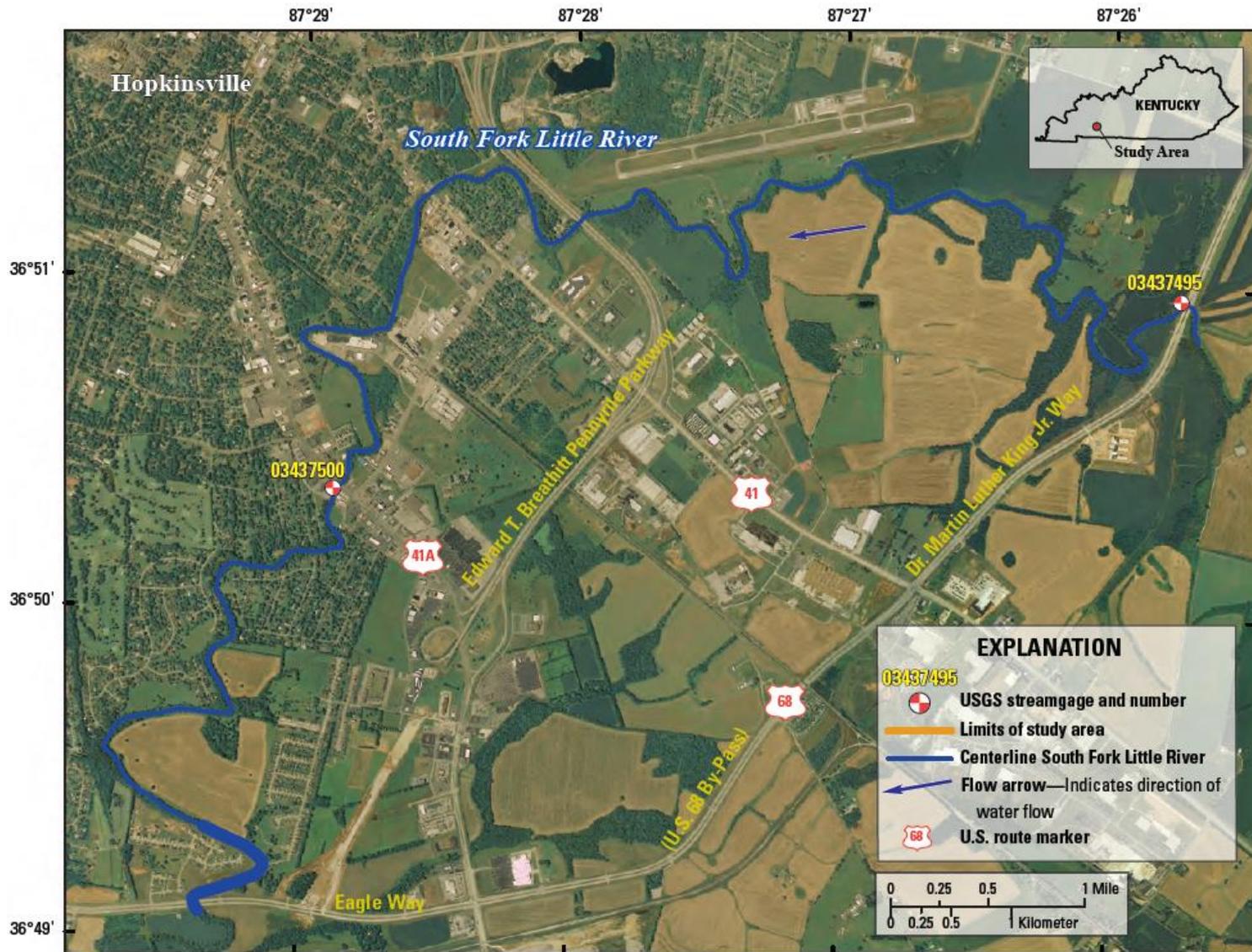


Project Team

- Local Stakeholder:
 - **Dave Herndon**, Planning Services Coordinator, Community and Development Services, City of Hopkinsville Kentucky.
- Technical Partners:
 - **Mike Griffin**, USGS
 - **Jeremiah Lant**, USGS
 - jlant@usgs.gov
 - (502) 493-1949
- National Weather Service Coordinator:
 - **Kris Lander**, NWS
 - kris.lander@noaa.gov
 - (816) 268-3124



Phase 1: Study Area – South Fork Little River



Projection: Lambert Conformal Conic
 State Plane Coordinate System, Kentucky, FIPS, 1600
 North American Datum of 1983 (NAD83)
 Orthophotography from National Agriculture Imagery Program, 2006

Phase 1: Modeling Approach

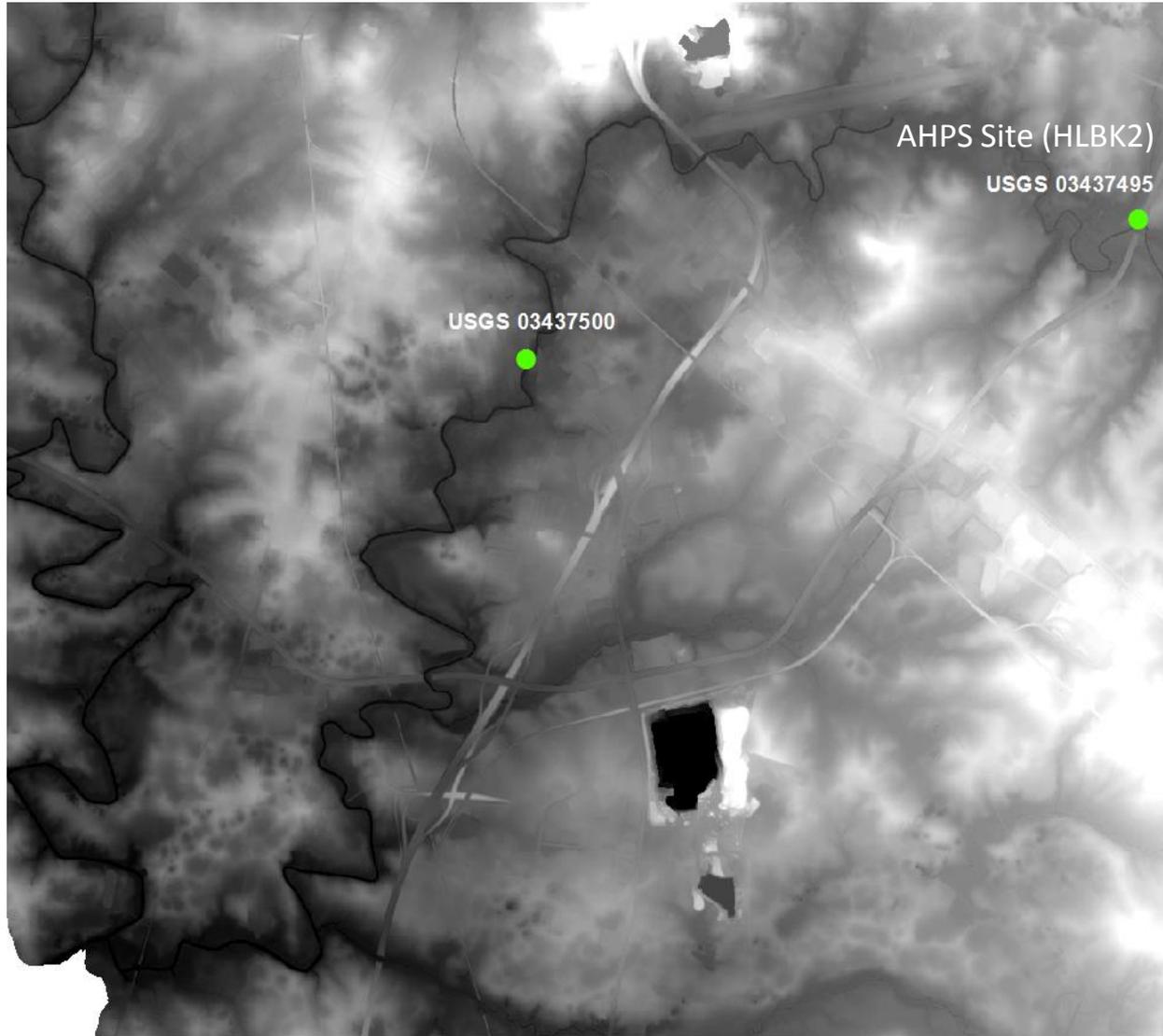
	Stage (ft.)	Elevation (ft.) NAVD88
Highest Inundation Stage:	21.0	541.0
Major Flood Stage:	20.0	540.0
Moderate Flood Stage:	17.0	537.0
Flood Stage:	15.0	535.0
Action Stage:	13.0	533.0
Lowest Inundation Stage:	10.0	530.0
Gage 0 Datum:	0.0	520.0

Mapping Interval (ft): 1.0

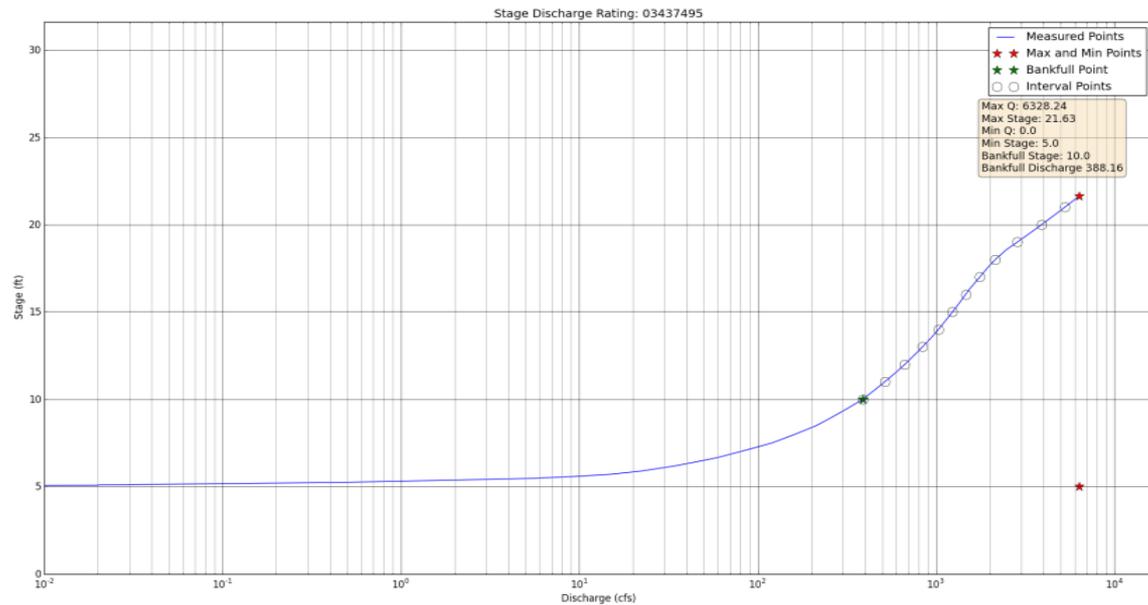
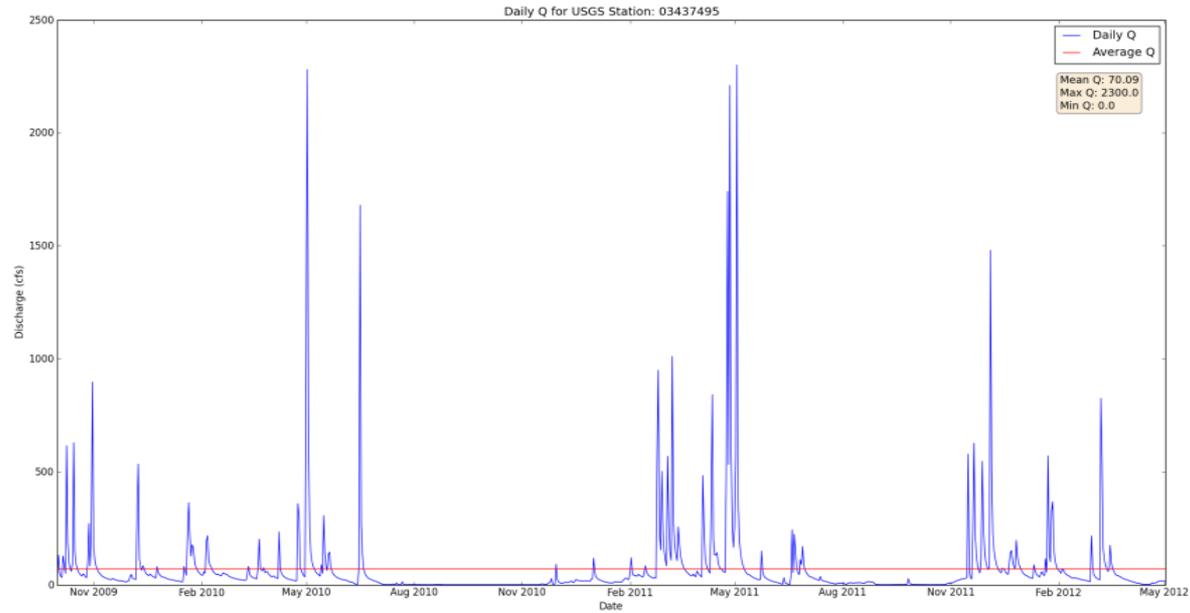
List of Modeled Stages (ft): 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 21.5*

* 21.5 which corresponds to the 1.0-percent annual exceedance probability defined by FEMA at the USGS streamgage at South Fork Little River Highway 68 By-Pass at Hopkinsville, Kentucky (station no. 03437495).

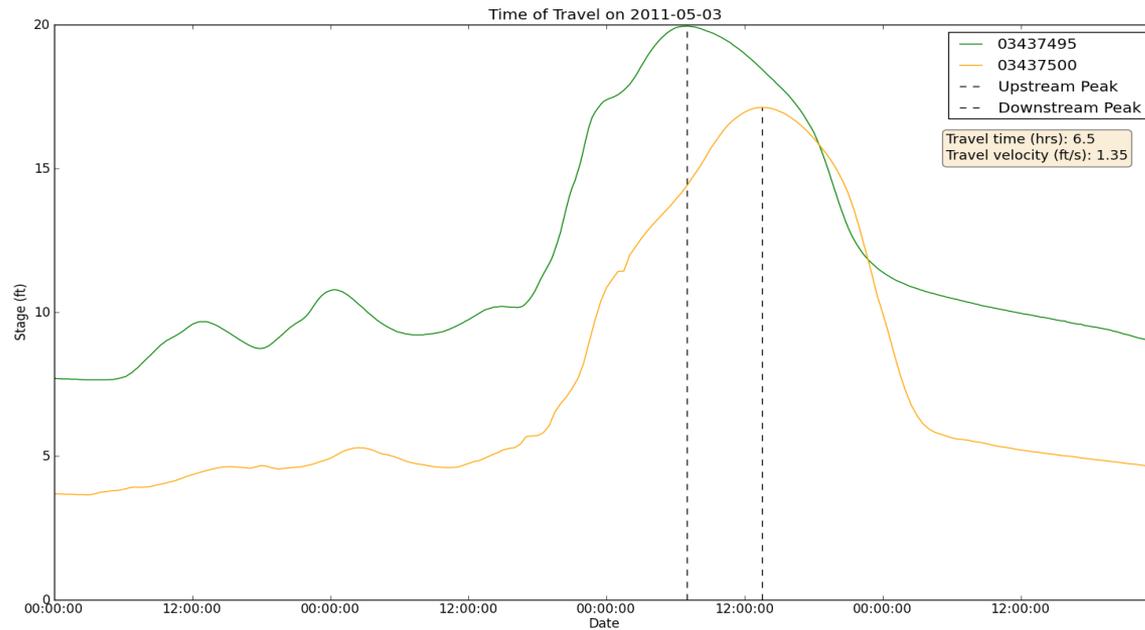
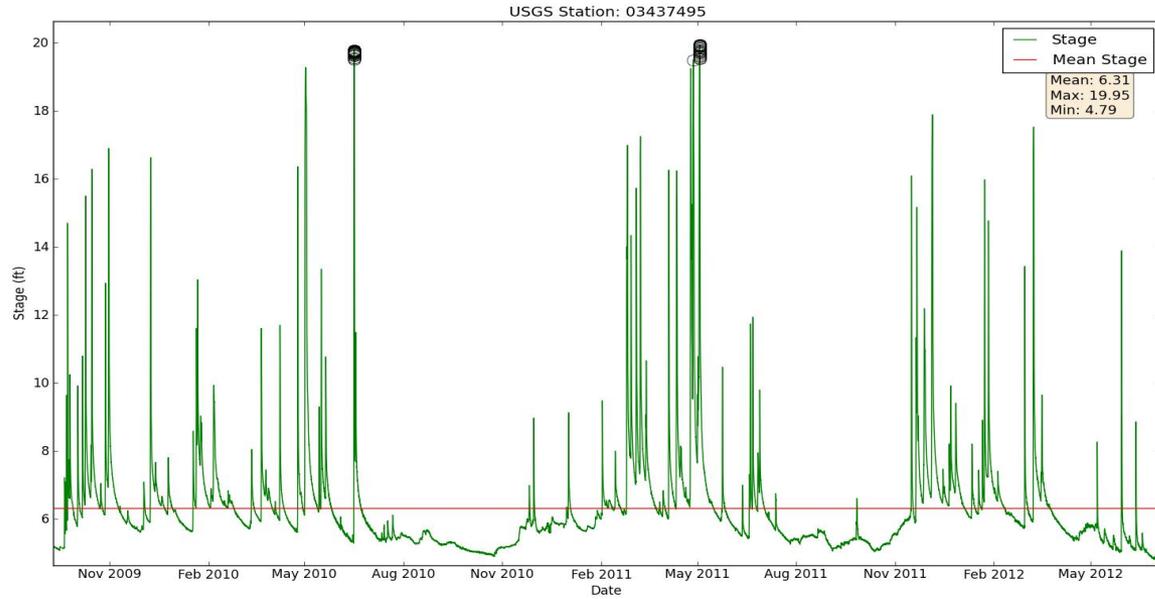
Phase 1: Hopkinsville, KY – 3.28 ft LIDAR DEM



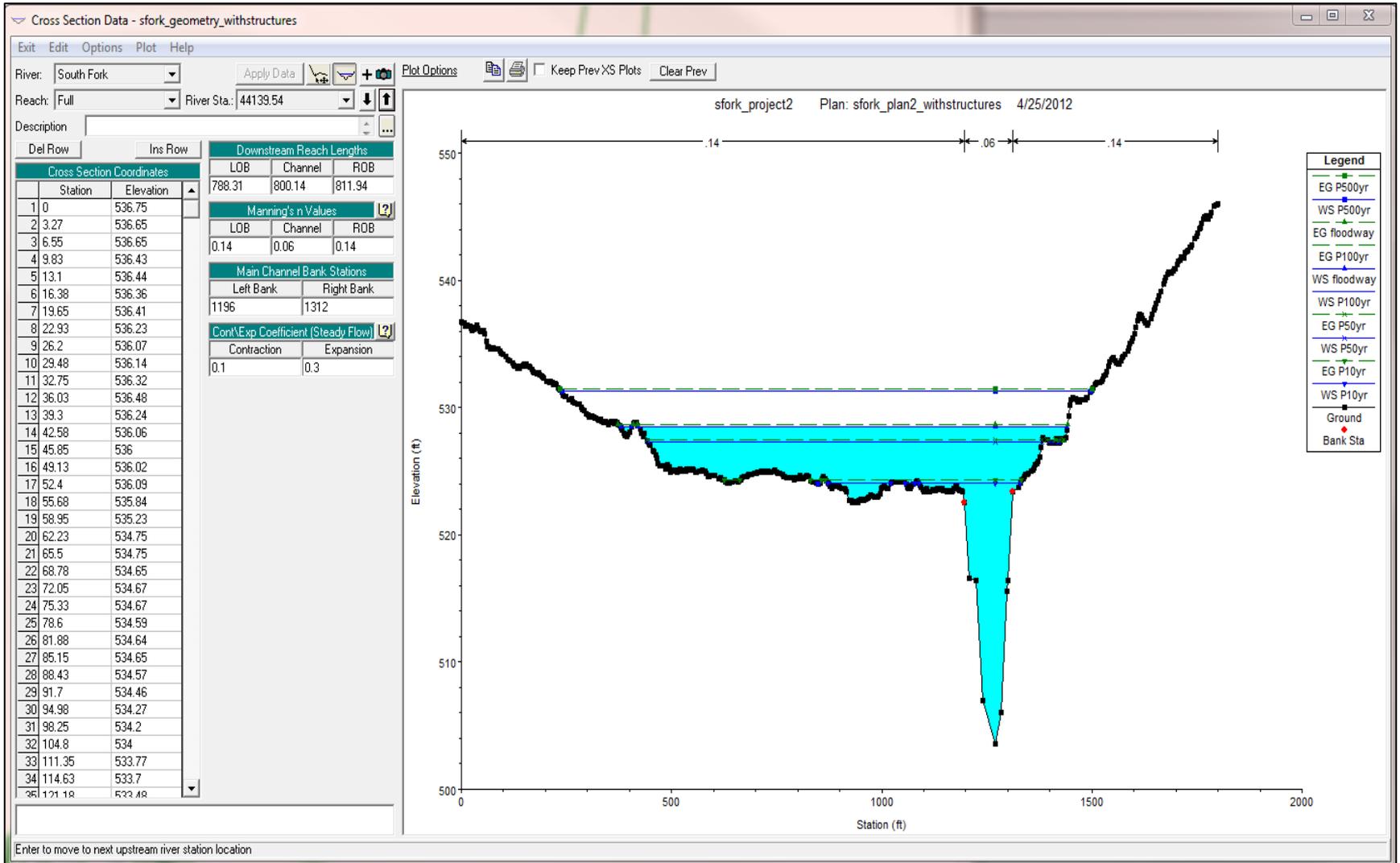
Phase 1: Data Collection and Processing



Phase 1: Data Collection and Processing



Phase 2A: Hydraulic Modeling



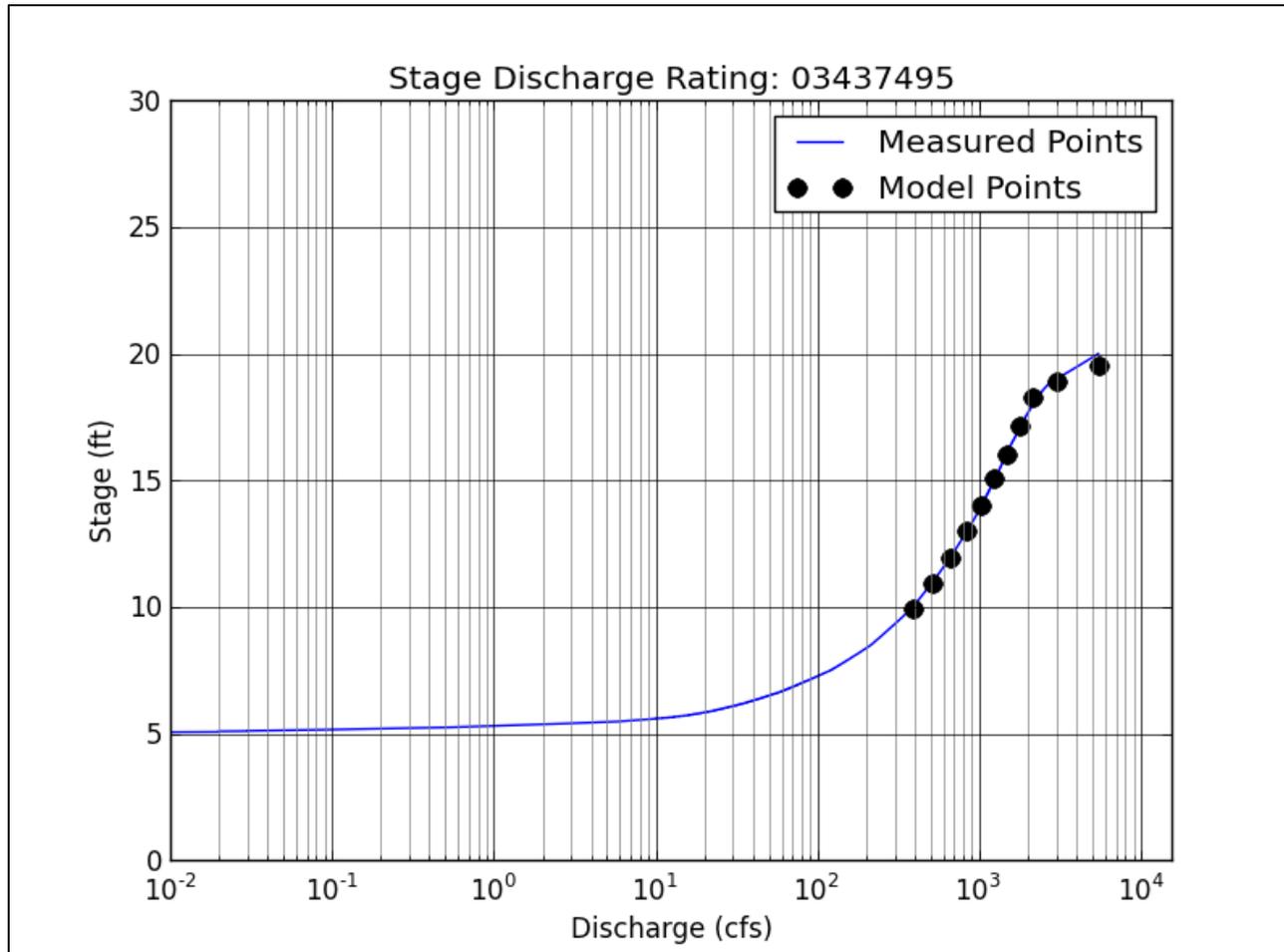
Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
 - **Criteria: Water surface profiles are to be within +/- 0.5 ft. of the established USGS stage discharge rating.**

- 2) High Water Marks or Multiple Recent Flood Events
 - **Criteria: Water surface profiles are to be within +/- 1.0 ft. of the measured high water marks.**

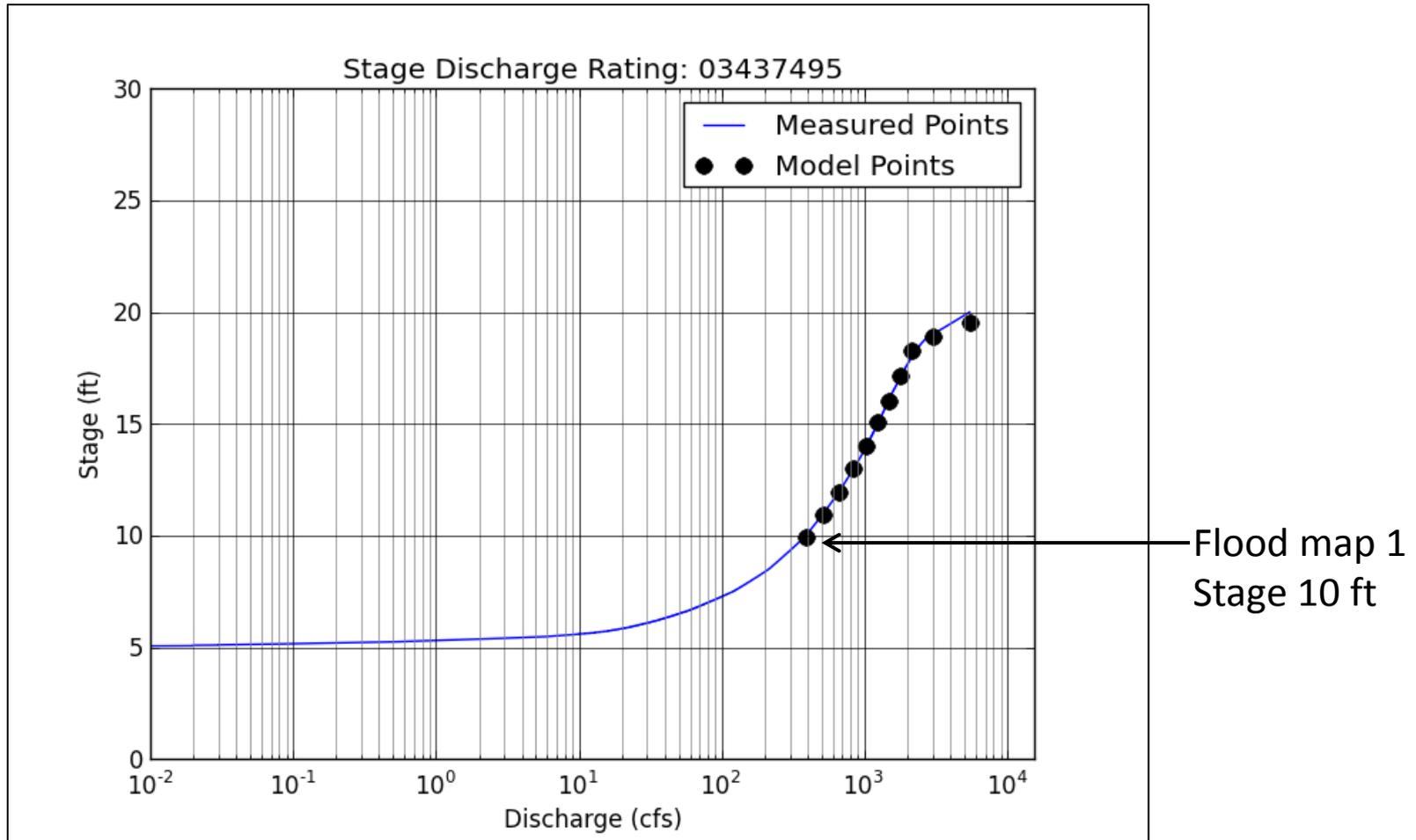
Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
 - **Criteria: Water surface profiles are to be within ± 0.5 ft. of the established USGS stage discharge rating.**



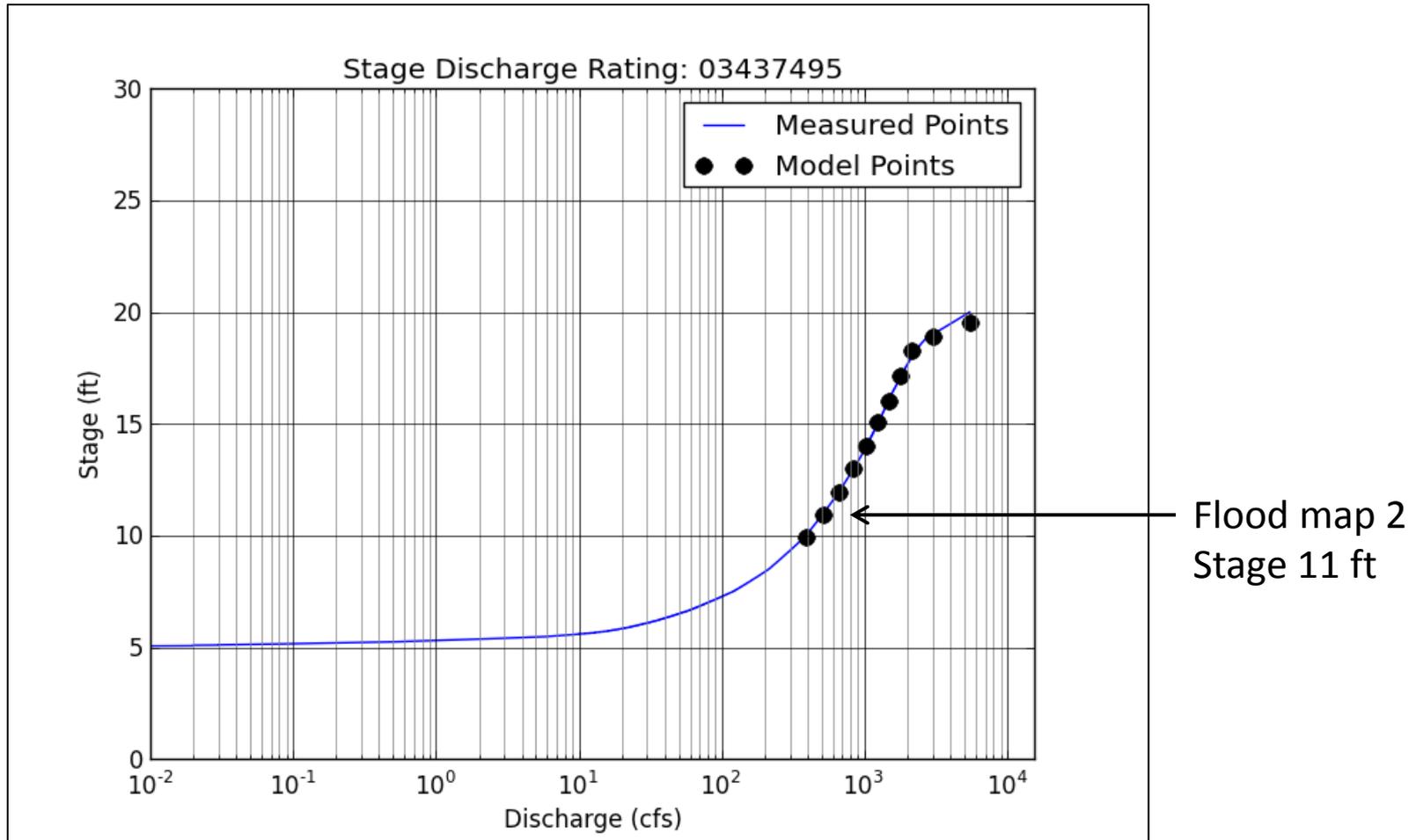
Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
 - **Criteria: Water surface profiles are to be within +/- 0.5 ft. of the established USGS stage discharge rating.**



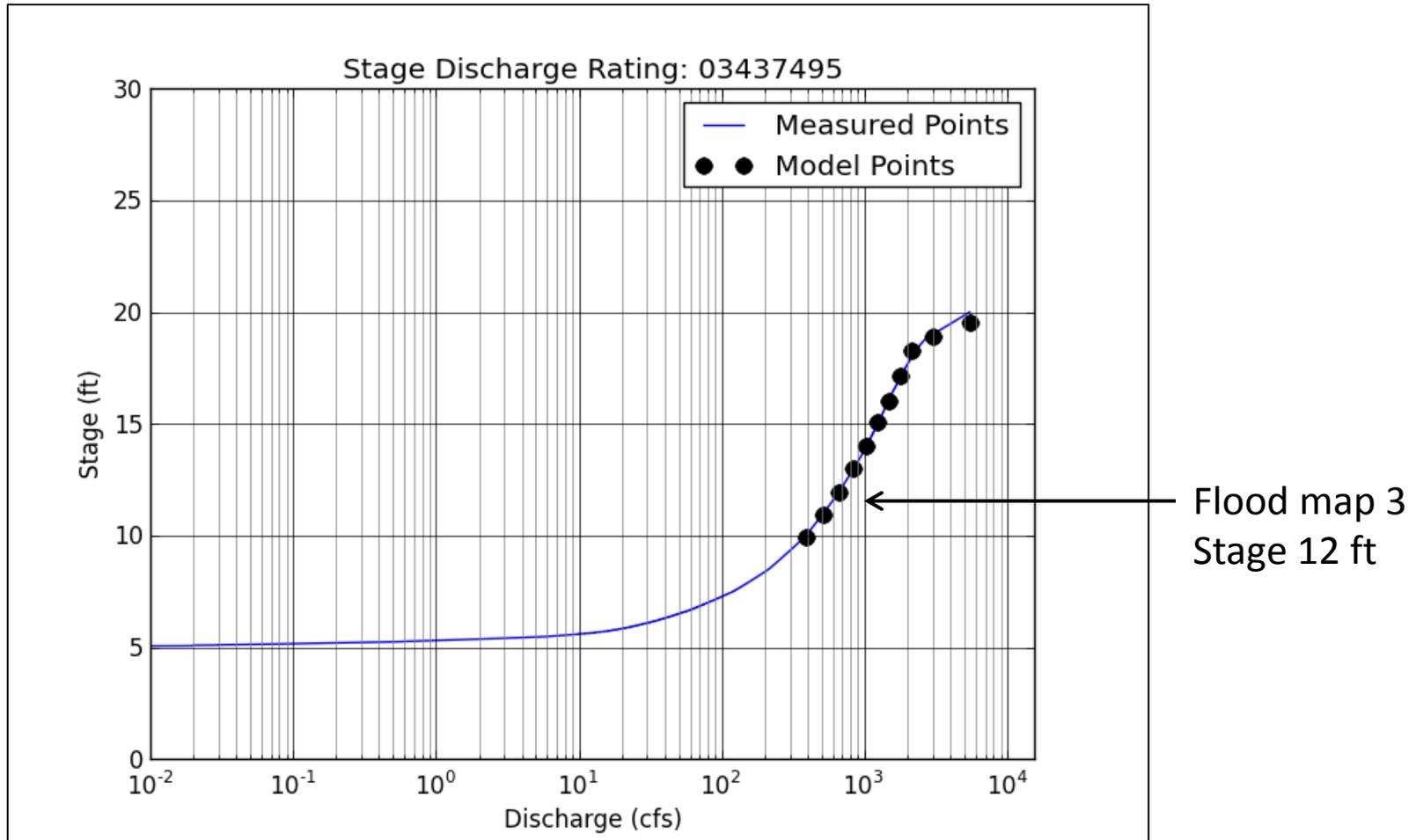
Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
 - **Criteria: Water surface profiles are to be within +/- 0.5 ft. of the established USGS stage discharge rating.**



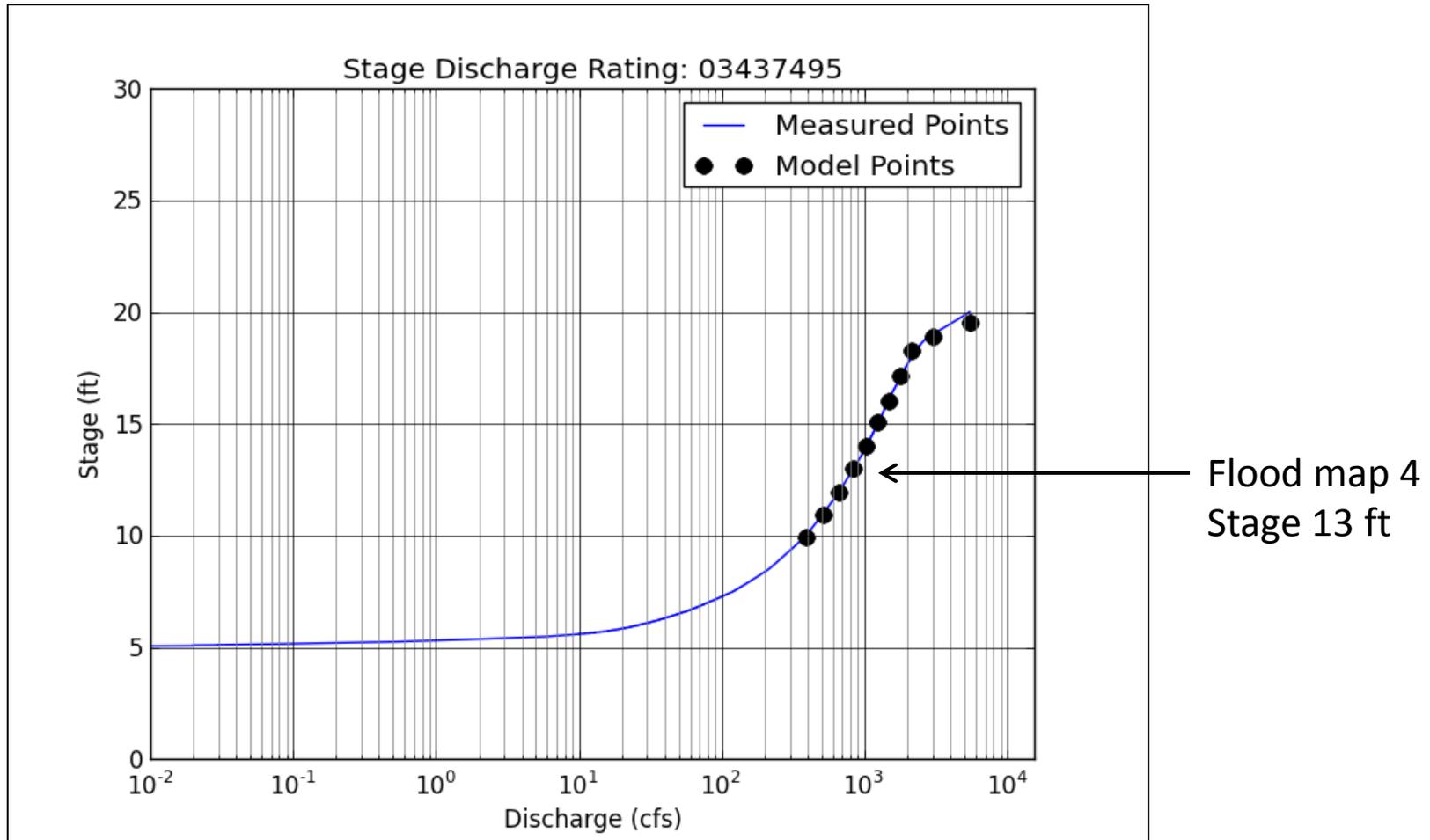
Phase 2A: Model Calibration

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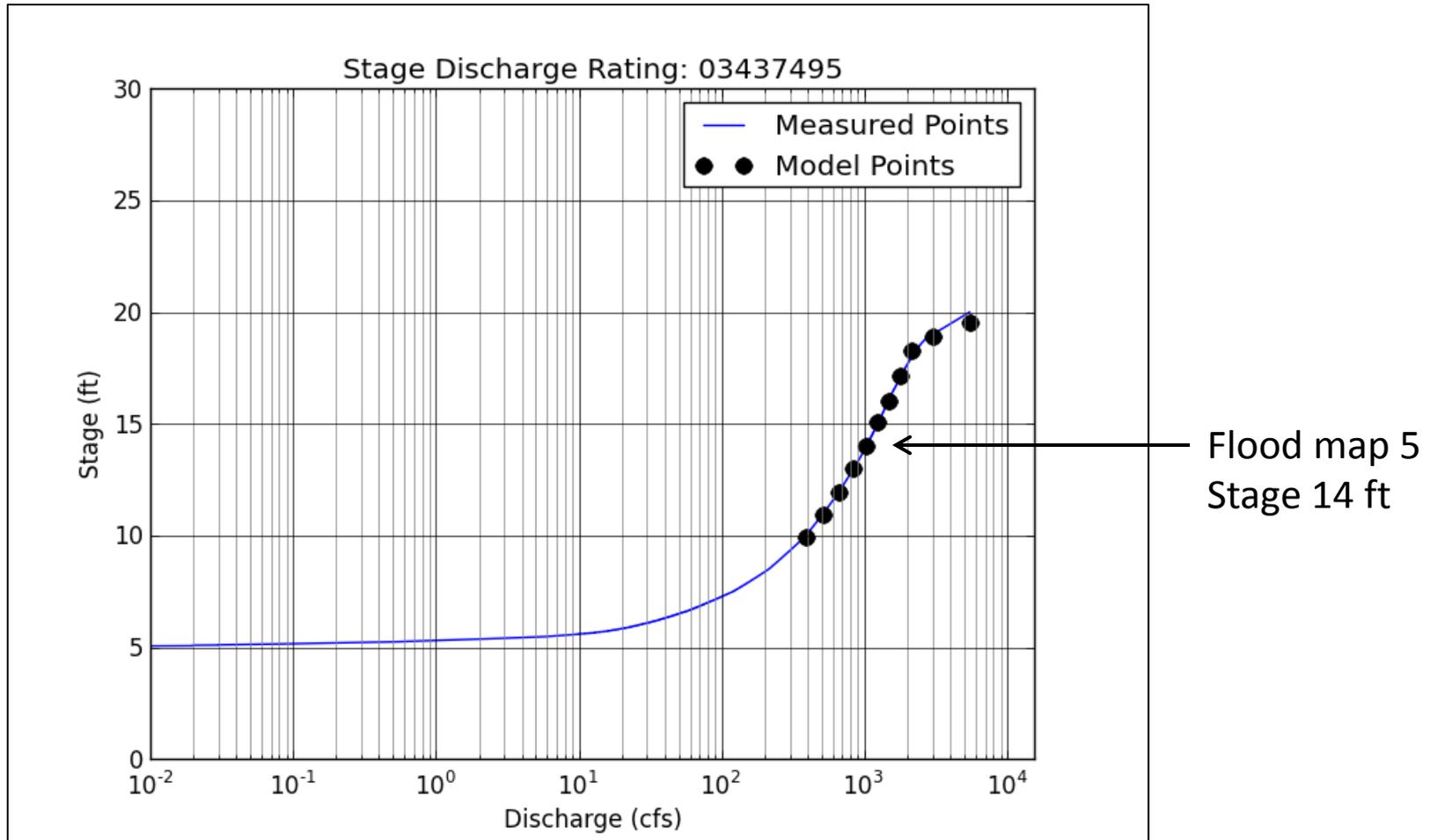
Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
 - **Criteria: Water surface profiles are to be within ± 0.5 ft. of the established USGS stage discharge rating.**



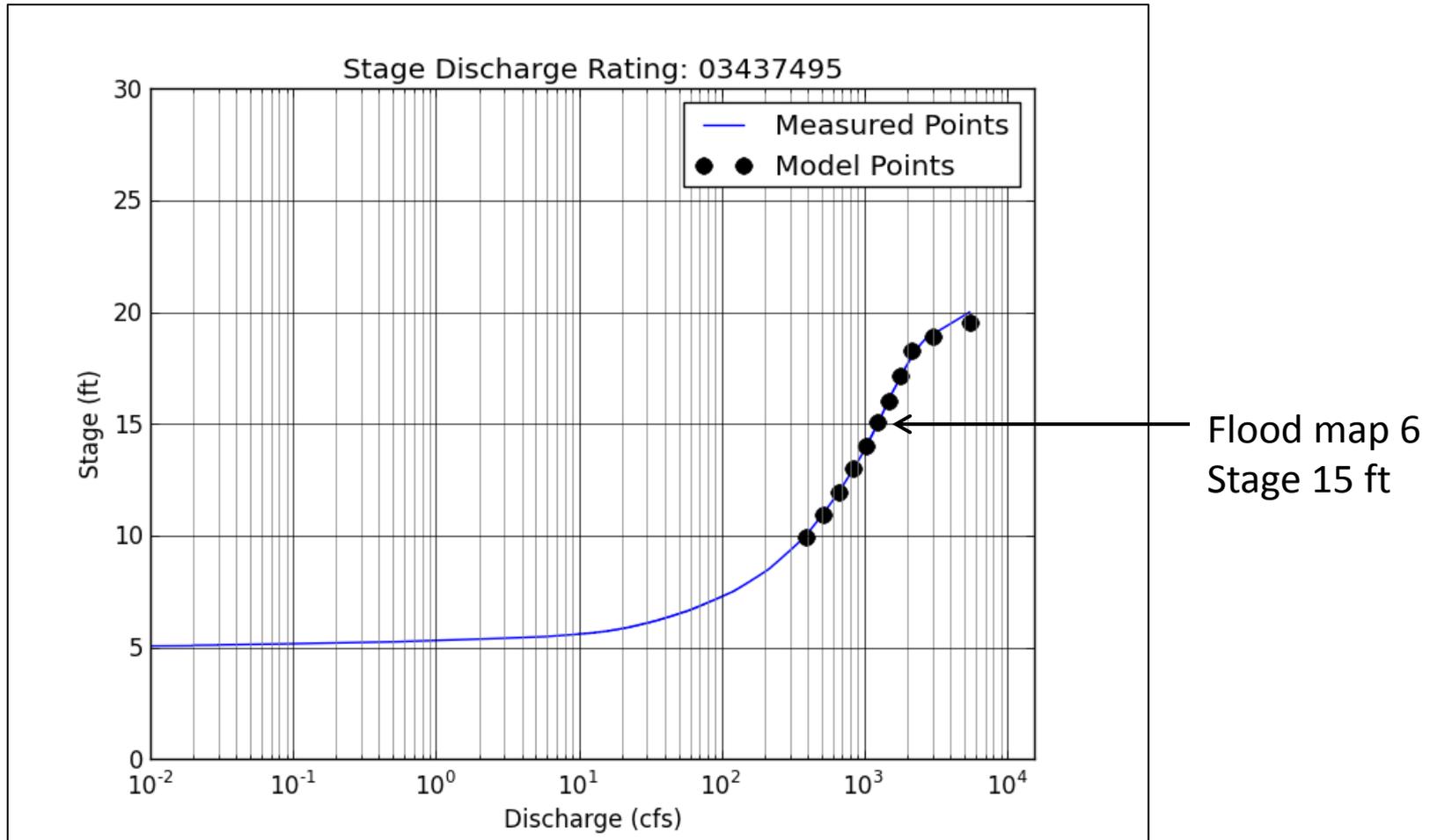
Phase 2A: Model Calibration

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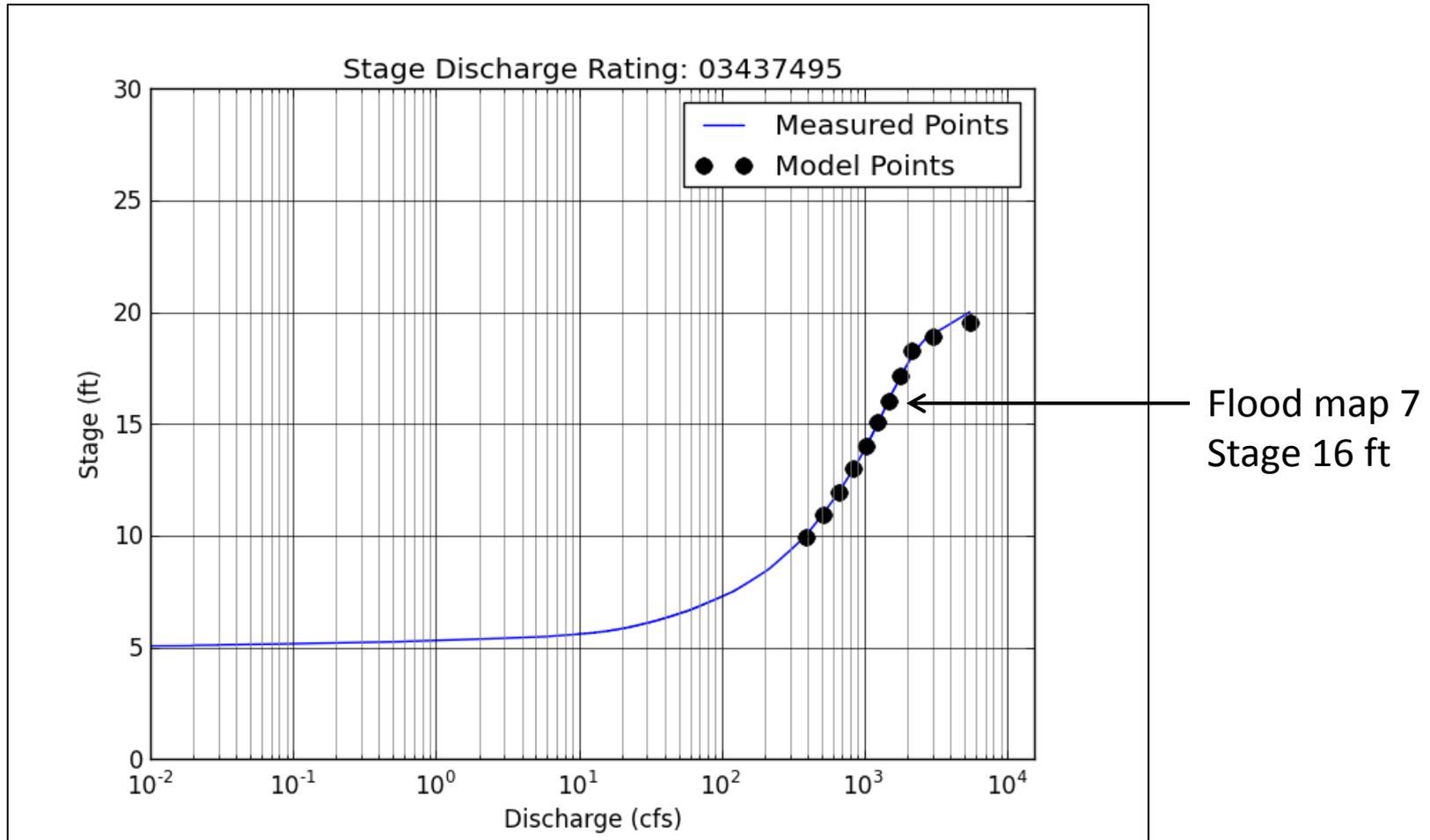
Phase 2A: Model Calibration

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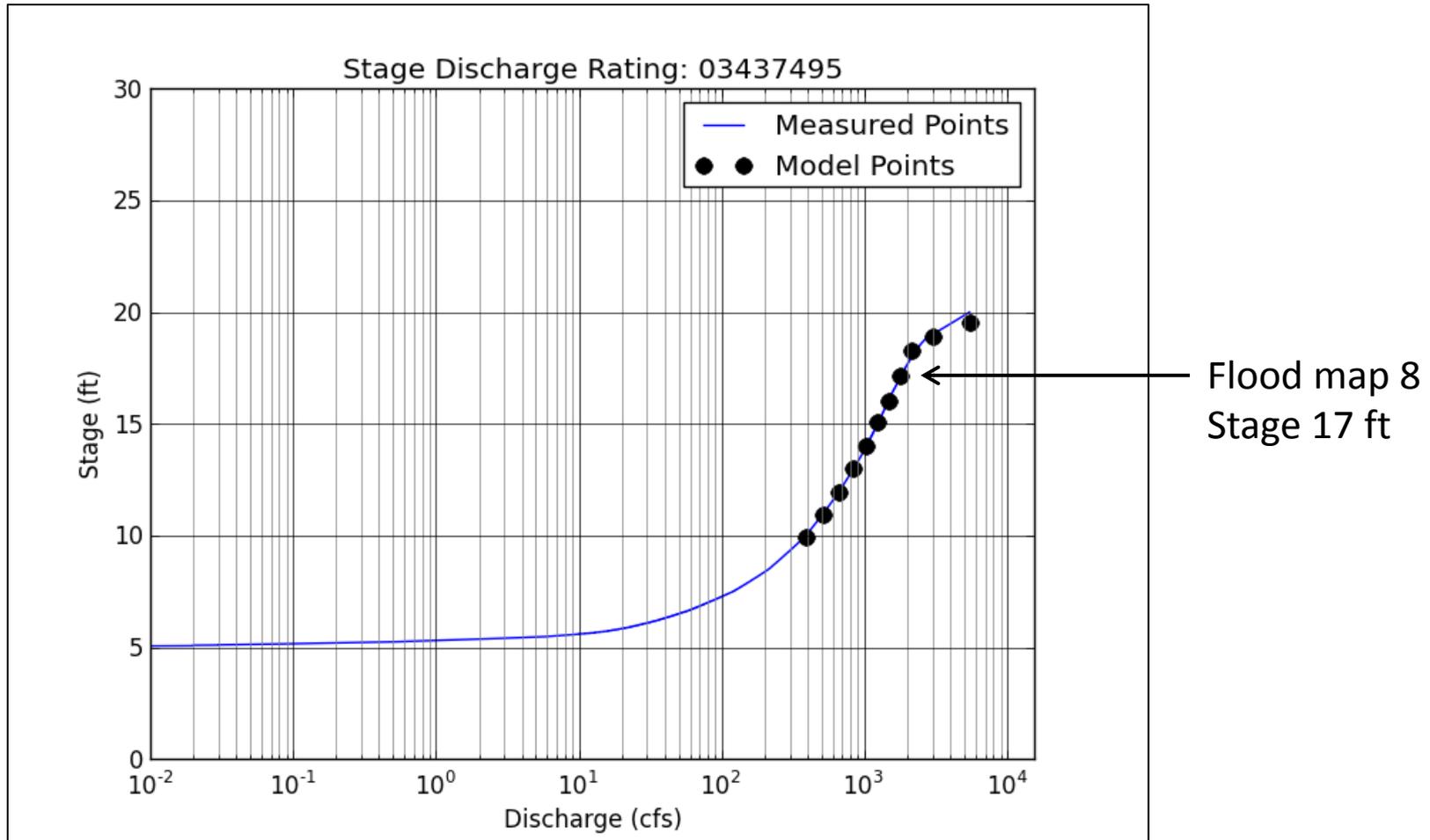
Phase 2A: Model Calibration

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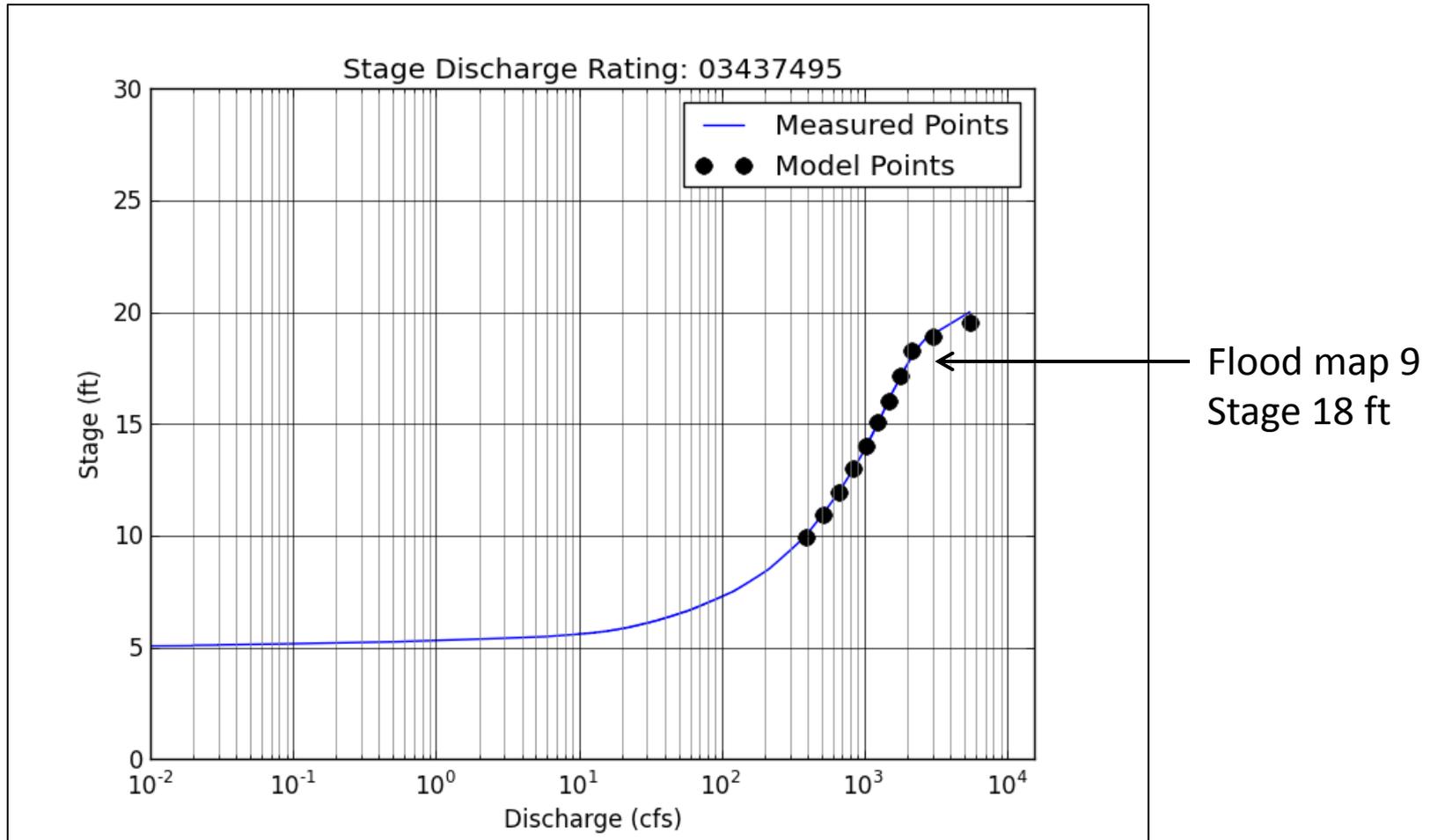
Phase 2A: Model Calibration

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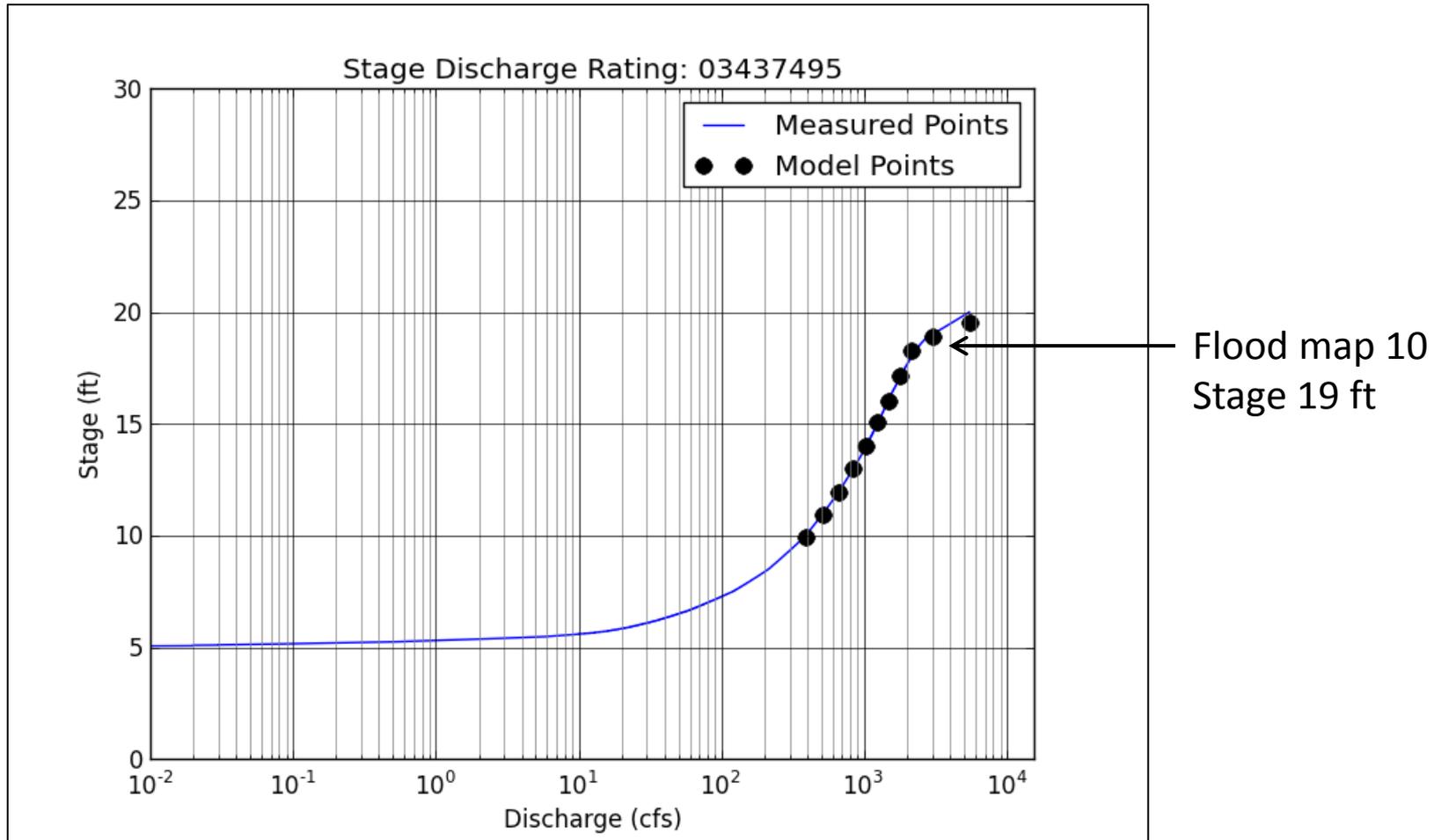
Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
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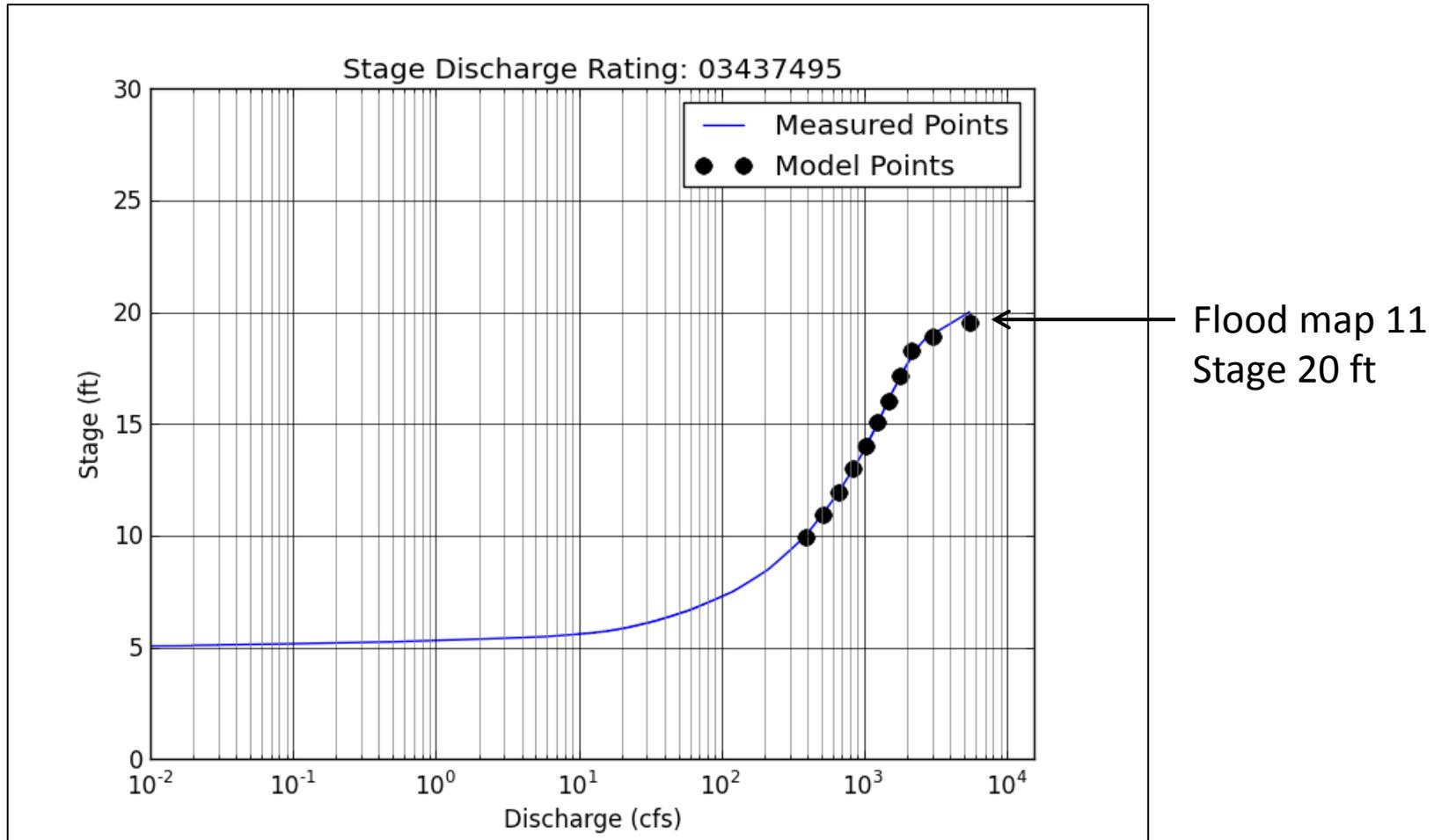
Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
 - **Criteria: Water surface profiles are to be within +/- 0.5 ft. of the established USGS stage discharge rating.**



Phase 2A: Model Calibration

- 1) Current Stage-Discharge Relation
 - **Criteria: Water surface profiles are to be within +/- 0.5 ft. of the established USGS stage discharge rating.**

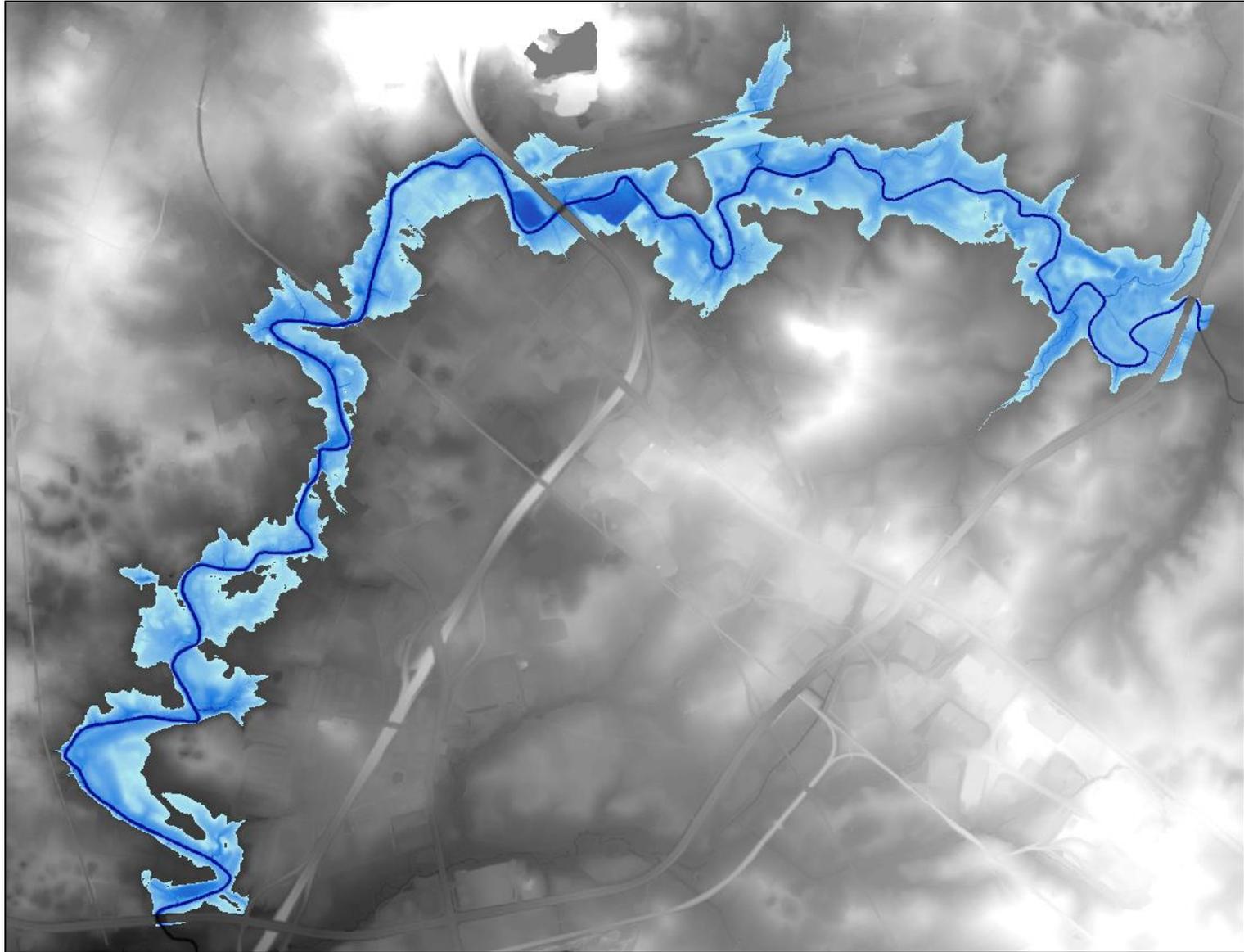


Phase 2A: Model Calibration

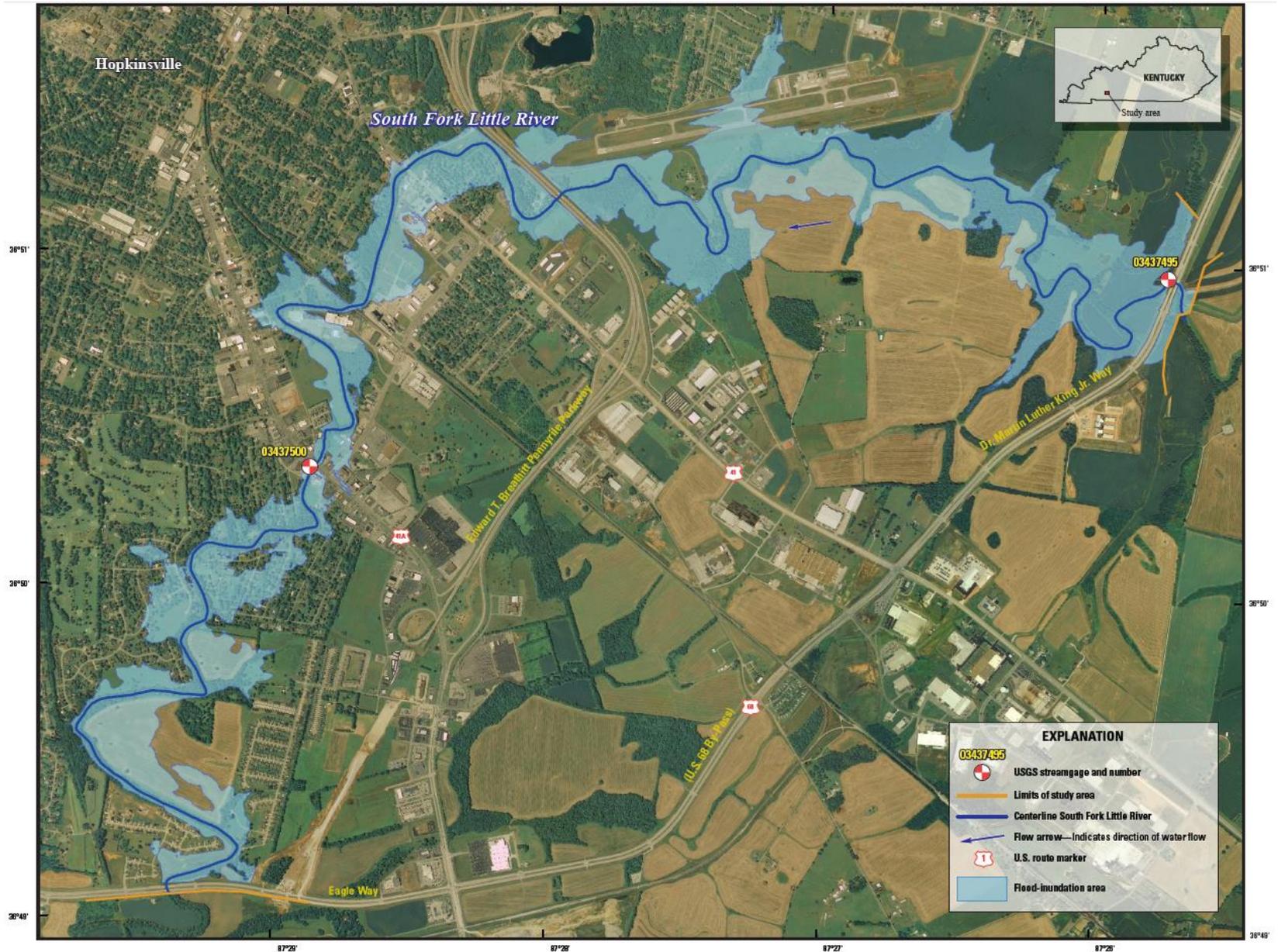
- 2) Multiple Recent Flood Events
 - **Criteria: Water surface profiles are to be within +/- 1.0 ft. of the measured high water marks.**

Date	USGS streamgage (station number)	Peak water-surface elevation (ft)	Model water-surface elevation (ft)	Elevation difference (ft)
June 21, 2011	03437495	531.94	531.92	-0.02
	03437500	526.30	526.27	-0.03
November 21, 2011	03437495	535.17	535.19	+0.02
	03437500	528.21	529.15	+0.94
December 5, 2011	03437495	537.89	538.14	+0.25
	03437500	532.39	532.42	+0.03

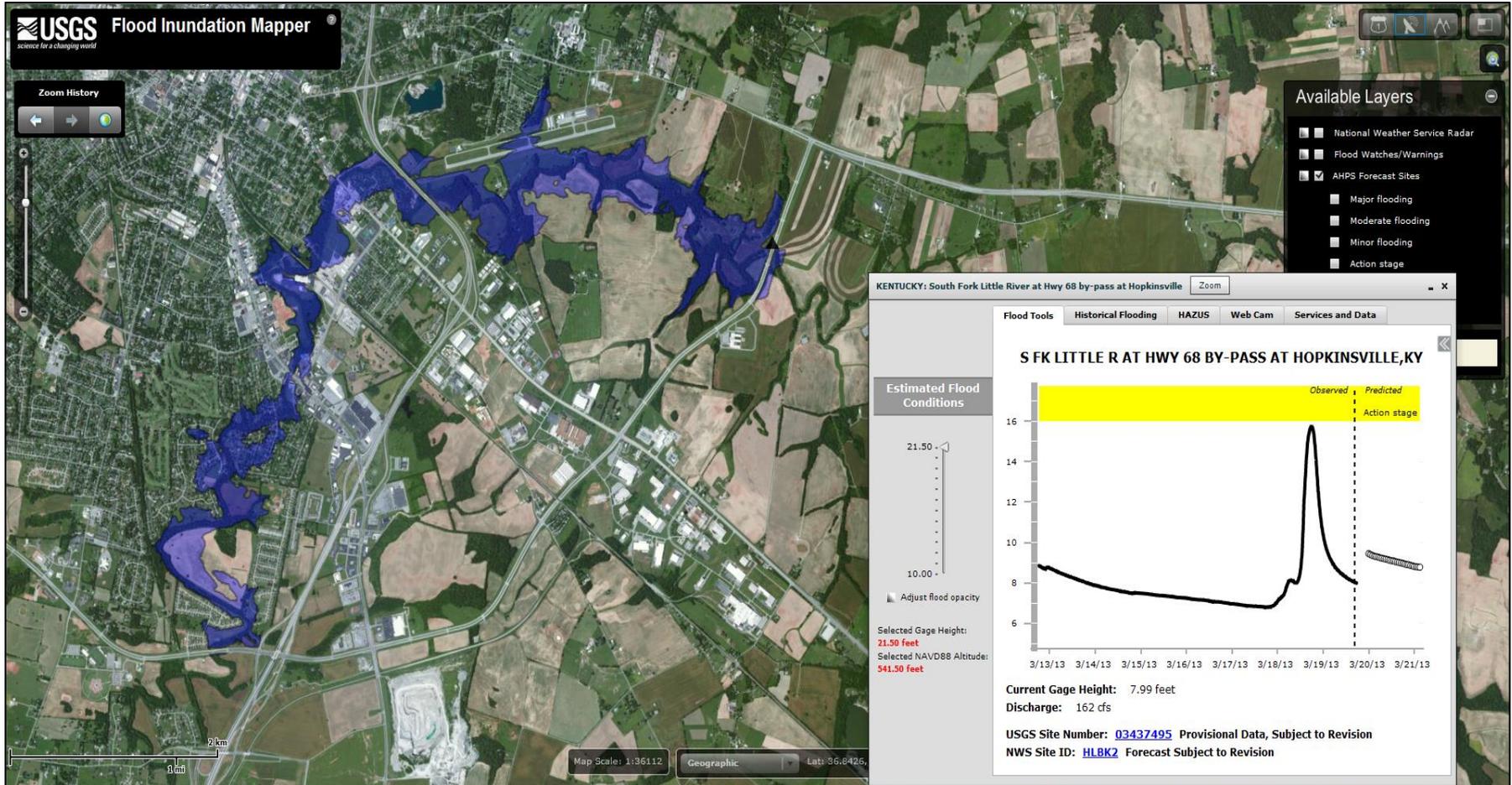
Phase 2B: Mapping



Phase 2B: Flood Inundation Map



Phase 3: Web Implementation



<http://wim.usgs.gov/FIMI/FloodInundationMapper.html>

Phase 3: Web Implementation



National Weather Service
Advanced Hydrologic Prediction Service

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Weather Forecast Office Paducah, KY

Ohio River Forecast Center

[Hydrograph](#)
[River at a Glance](#)
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 [How to print this map](#)
Find your location by address or ZIP code:

Data Type

- Inundation Levels
- Flood Categories
- Current/Forecast

Inundation Levels

NAVD88	Stage
541.5*	21.5*
541.0*	21.0*
540.0*	20.0*

Major Flooding Begins

539.0	19.0
538.0	18.0
537.0	17.0

Record Crest: 19.79 ft

Moderate Flooding Begins

536.0	16.0
535.0	15.0

Minor Flooding Begins

534.0	14.0
533.0	13.0

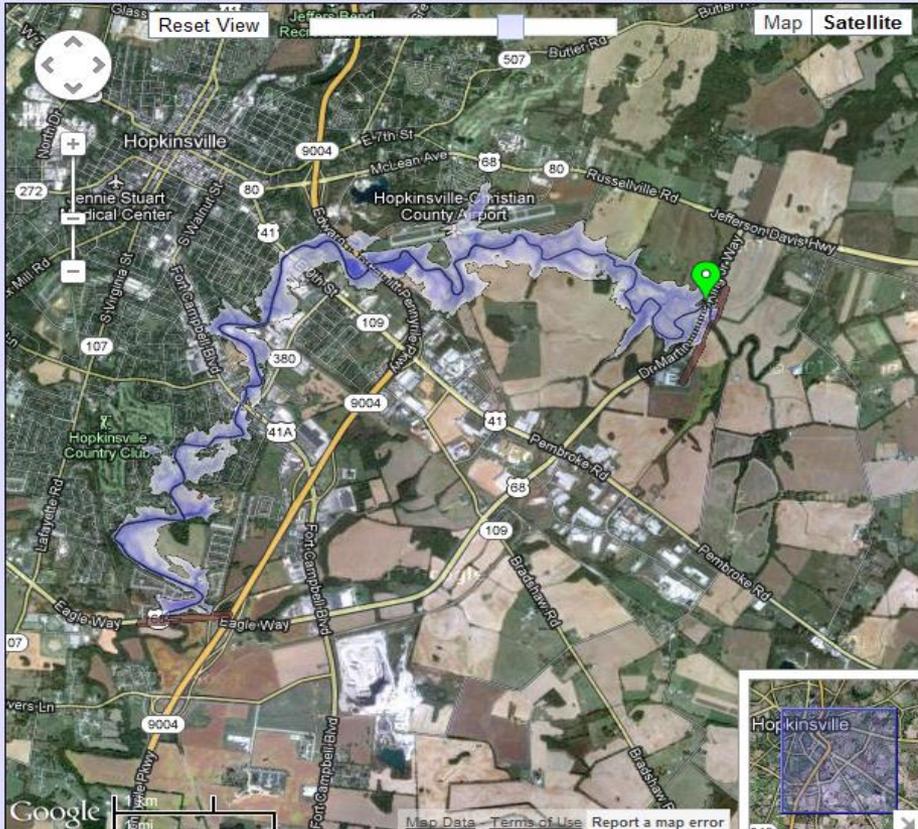
Near Flooding Begins

532.0	12.0
531.0	11.0
530.0	10.0

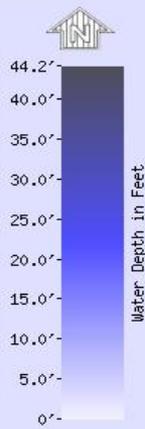
* = Extended rating

Inundation Feedback

Inundation in



[Map](#) [Satellite](#)



Water Depth in Feet

 Gauge Location

About Inundation

- [Download Dataset\(s\)](#)
- [FAQ](#)
- [User Guide](#)
- [Inundation Sites](#)
- [Inundation Legend](#)

User guide video on



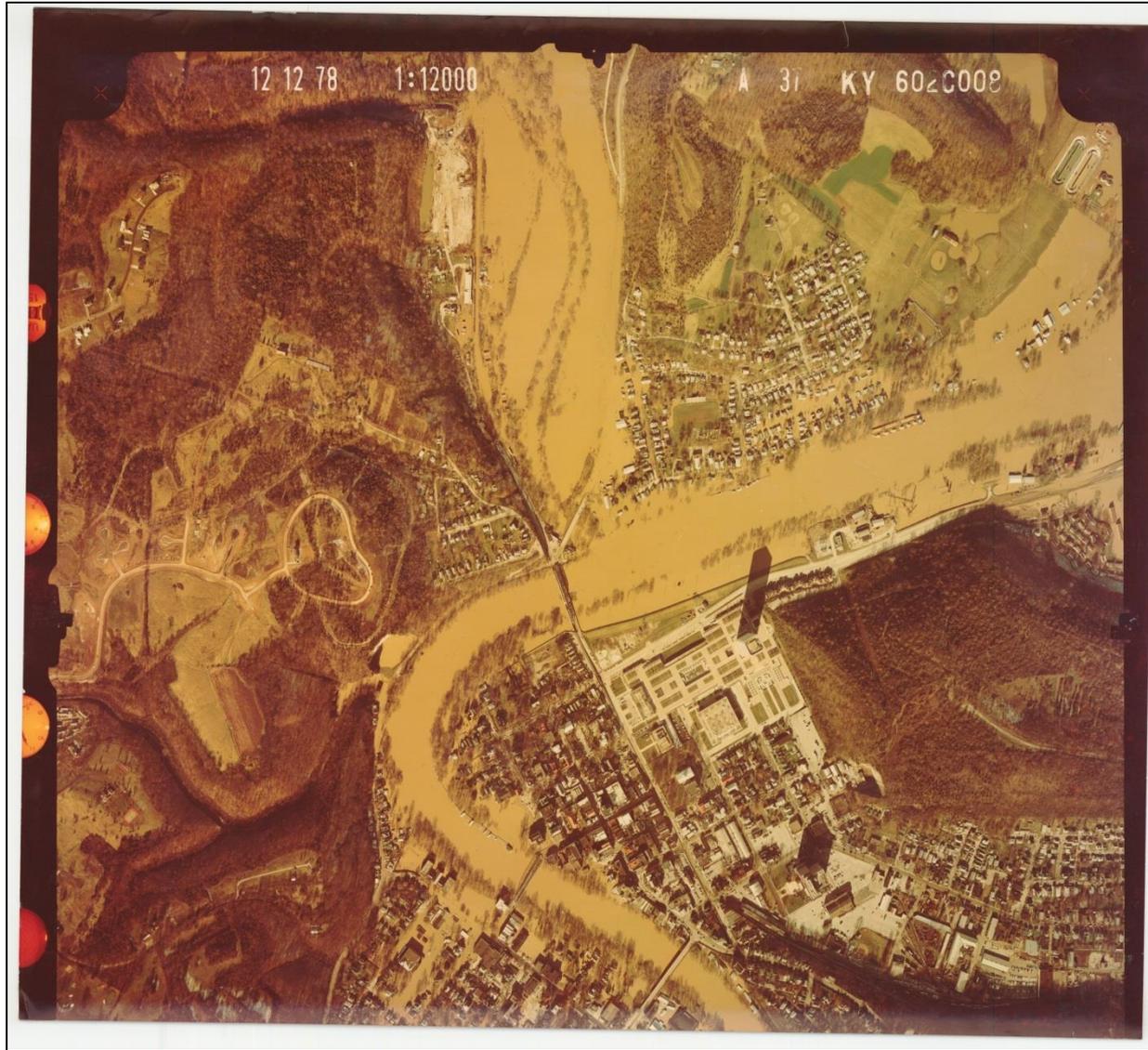


Disclaimer

Click on mapped inundation to see water depth values for that location.

Current Stage: 8.2 ft at 03/19/2013 14:30:00 UTC	Selected Inundation NAVD88: 541.5* ft	Mouse Location Depth: No Data
	Lat: 36.801450	Lon: -87.501640

Frankfort, KY – Flood Inundation Project



Project Team

- Local Stakeholder:
 - **Deron Rambo**, Director of Emergency Management & E-911 for City of Frankfort, Kentucky



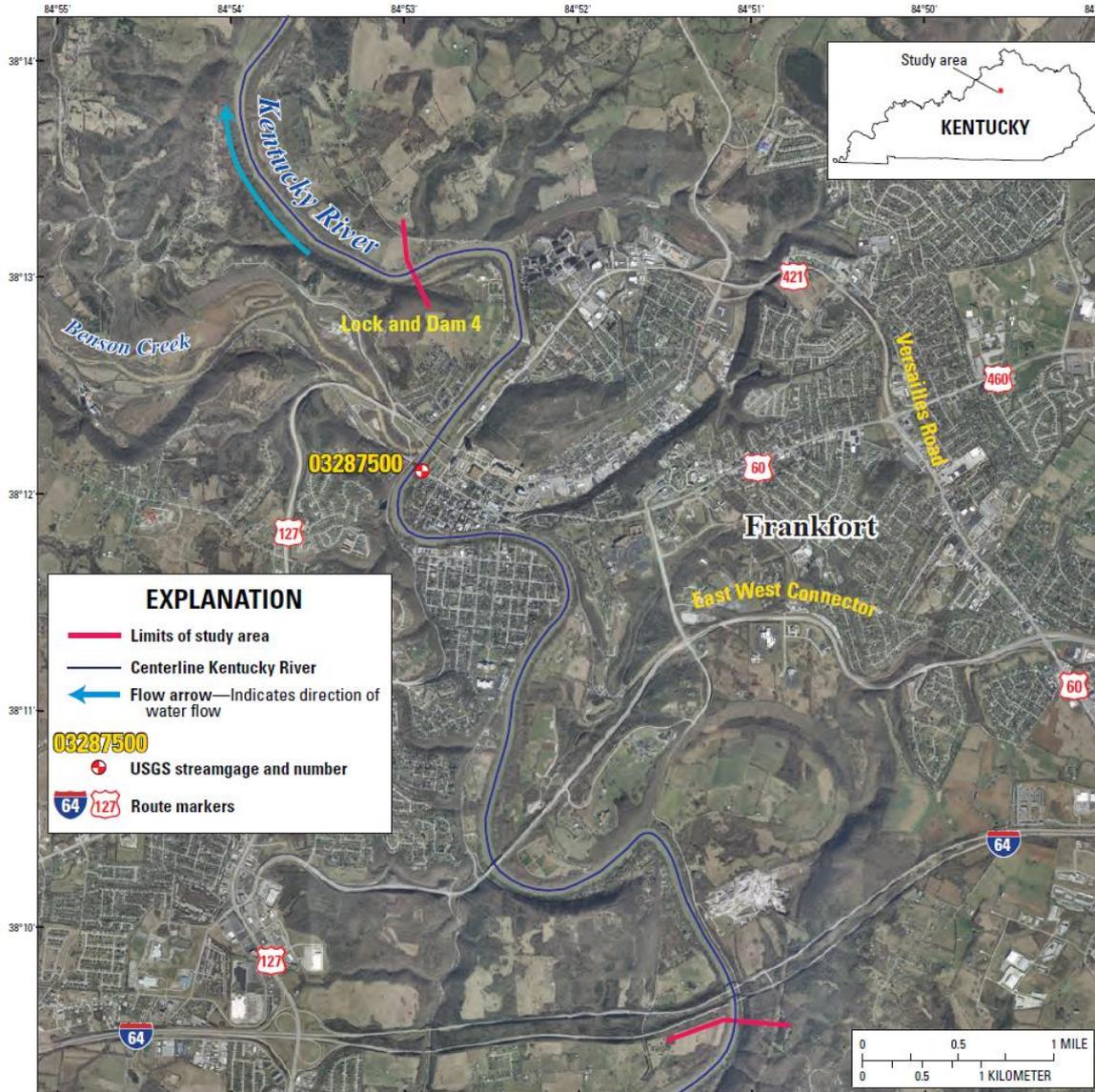
- Technical Partners:
 - **Mike Griffin**, USGS
 - mgriffin@usgs.gov
 - (502) 493-1913
 - **Jeremiah Lant**, USGS
 - jlant@usgs.gov
 - (502) 493-1949



- National Weather Service Coordinators:
 - **Kris Lander**, NWS
 - kris.lander@noaa.gov
 - (816) 268-3124
 - **Mike Callahan**, NWS
 - mike.callahan@noaa.gov
 - (502) 969-8842 x493



Phase 1: Study Area – Kentucky River



Phase 1: Frankfort, KY - Modeling Approach

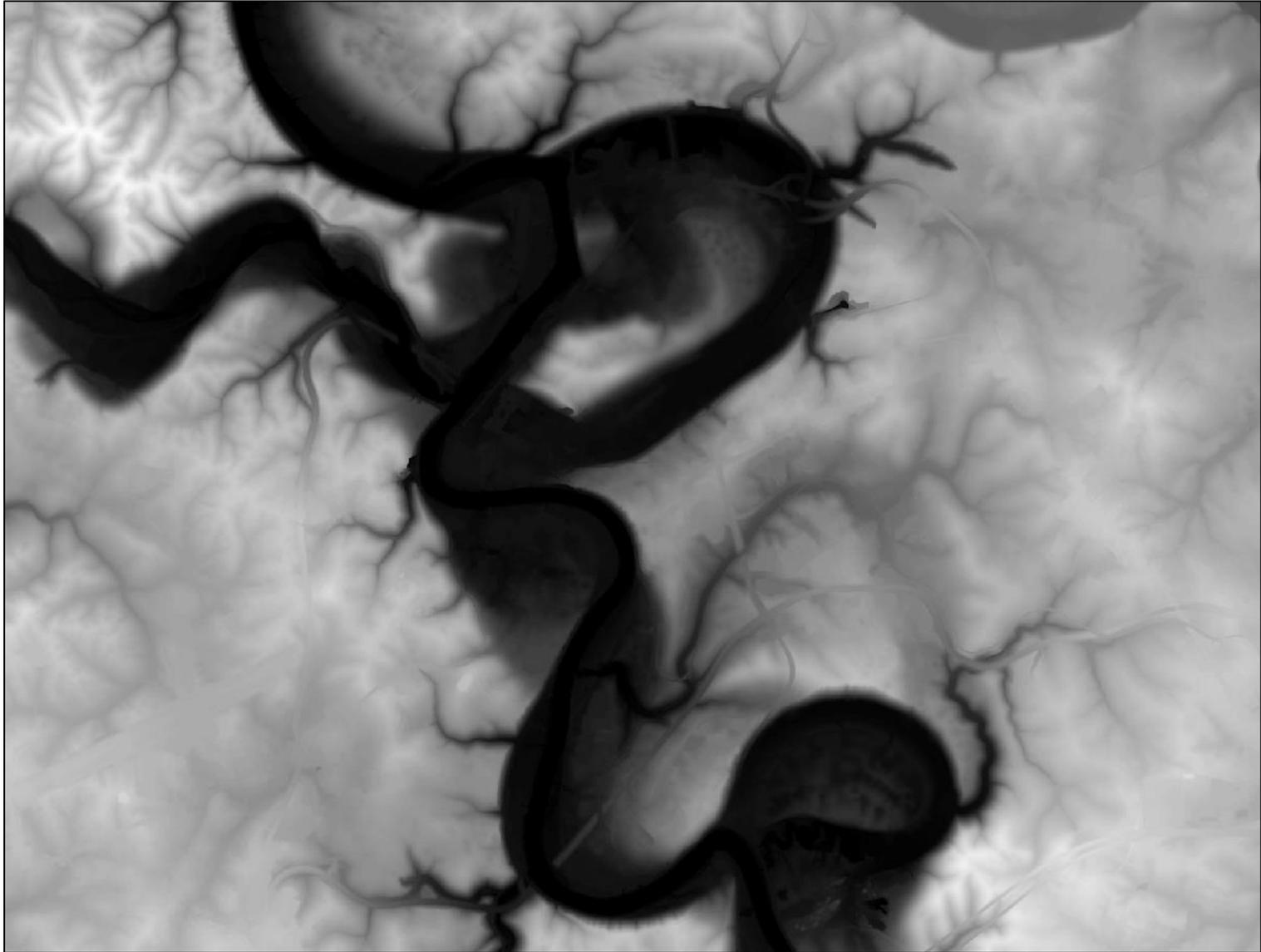
	Stage (ft.)	Elevation (ft.) NAVD88
Highest inundation Stage:	52	513.58
Major Flood Stage:	40	501.58
Moderate Flood Stage:	35	496.58
Flood Stage:	31	492.58
Action Stage:	29	490.58
Lowest inundation Stage:	27	488.58
Gage 0 Datum:	0	461.58

Mapping Interval (ft): 1.0

List of Modeled Stages (ft): 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52

FEMA Elevations for 10, 2, 1, 0.2 % Flood: 10% = 496.0 ft, 2% = 503.0 ft, 1% = 508.0 ft, 0.2% = 510.0 ft

Phase 1: Frankfort, KY – 5 ft LIDAR DEM



Phase 1: Frankfort, KY – 5 ft DEM



Phase 1: Frankfort, KY – Bathymetry



Phase 1: Frankfort, KY – Bathymetry

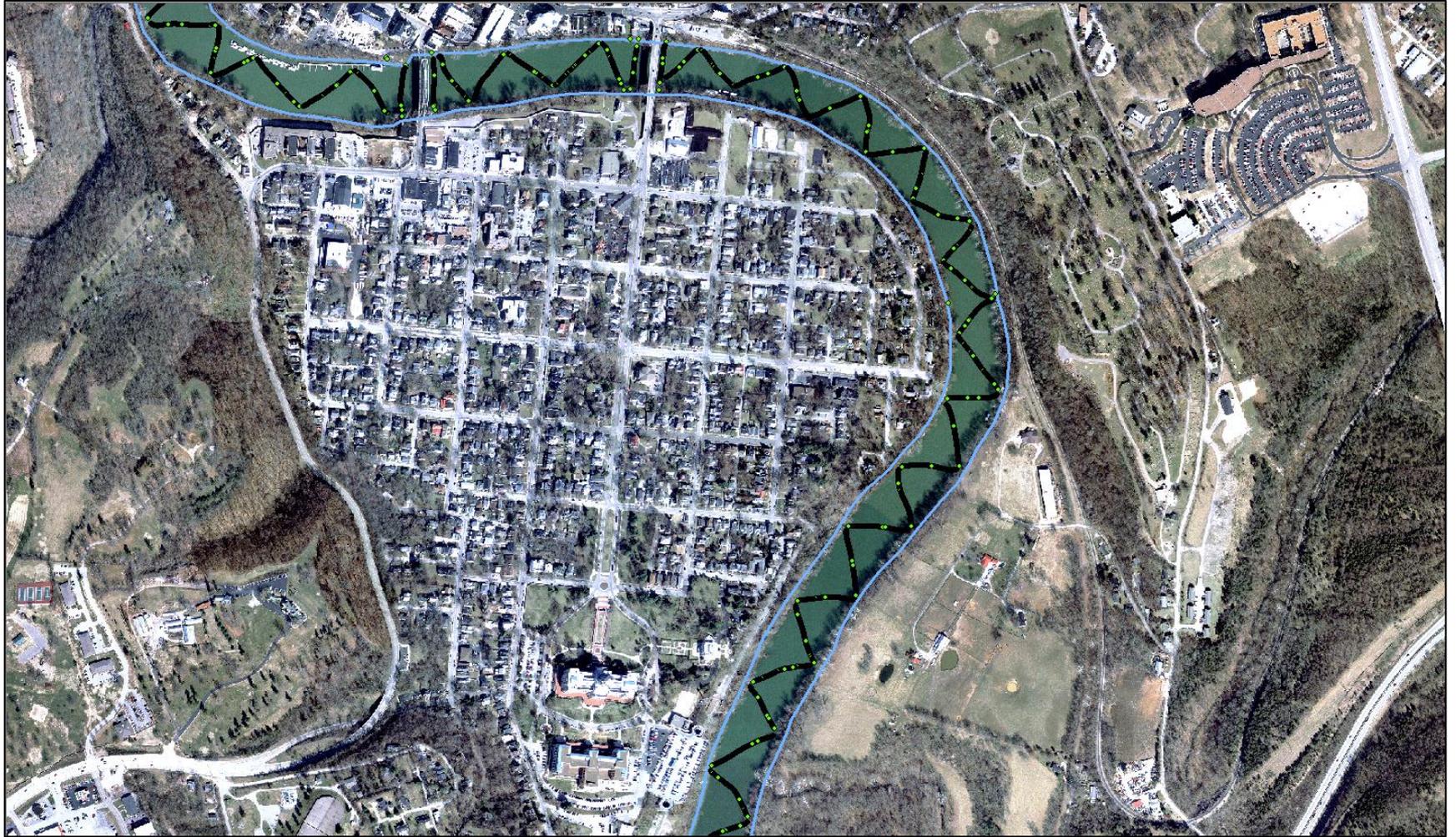


Phase 1: Frankfort, KY – Bathymetry Processing

Raw Points



Frankfort, KY – Bathymetry Processing Cleaned Points

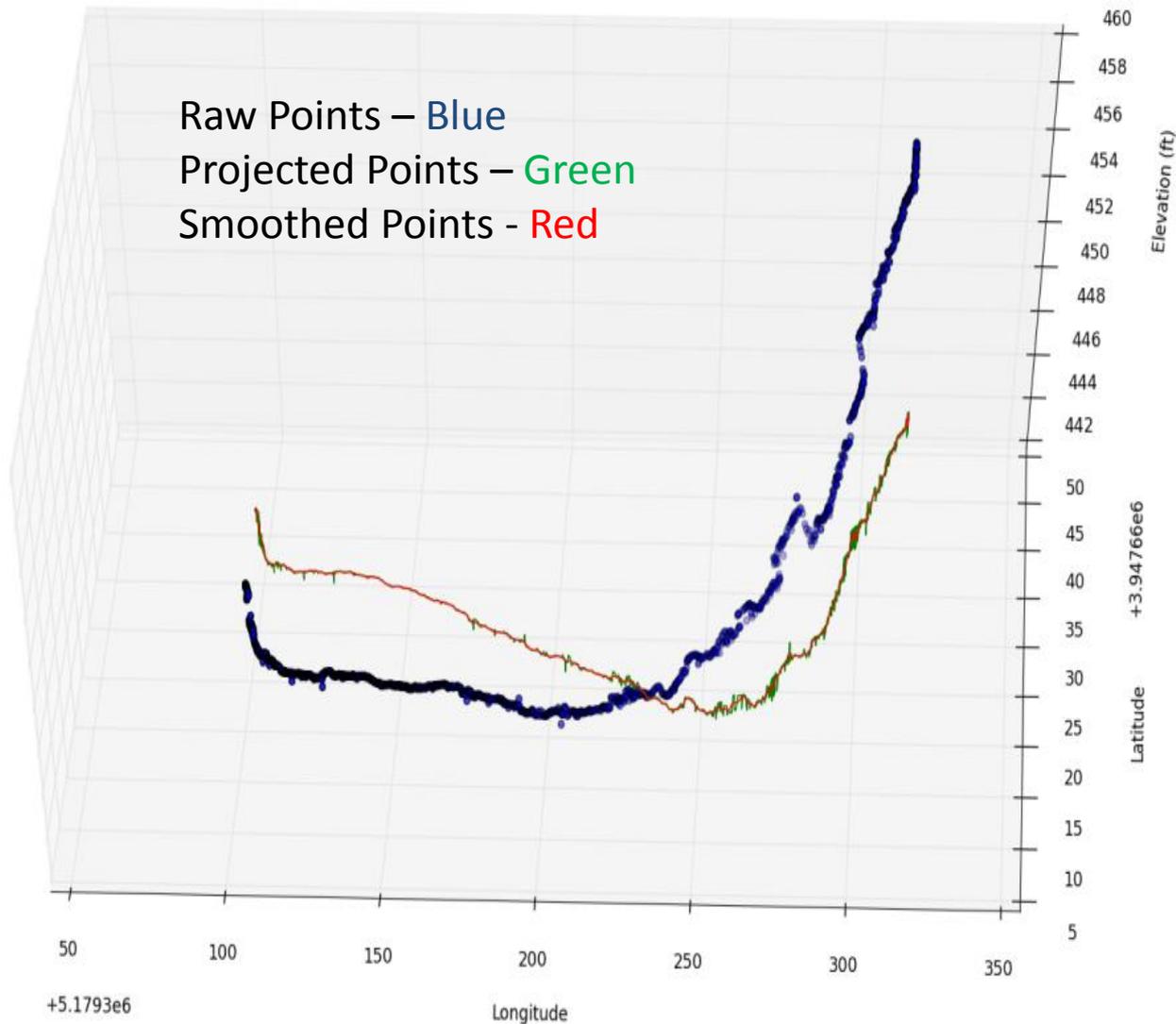


Frankfort, KY – Bathymetry Processing Projected Points



Frankfort, KY – Bathymetry Processing

Sample Cross Section



Frankfort, KY – Bathymetry Processing Interpolation



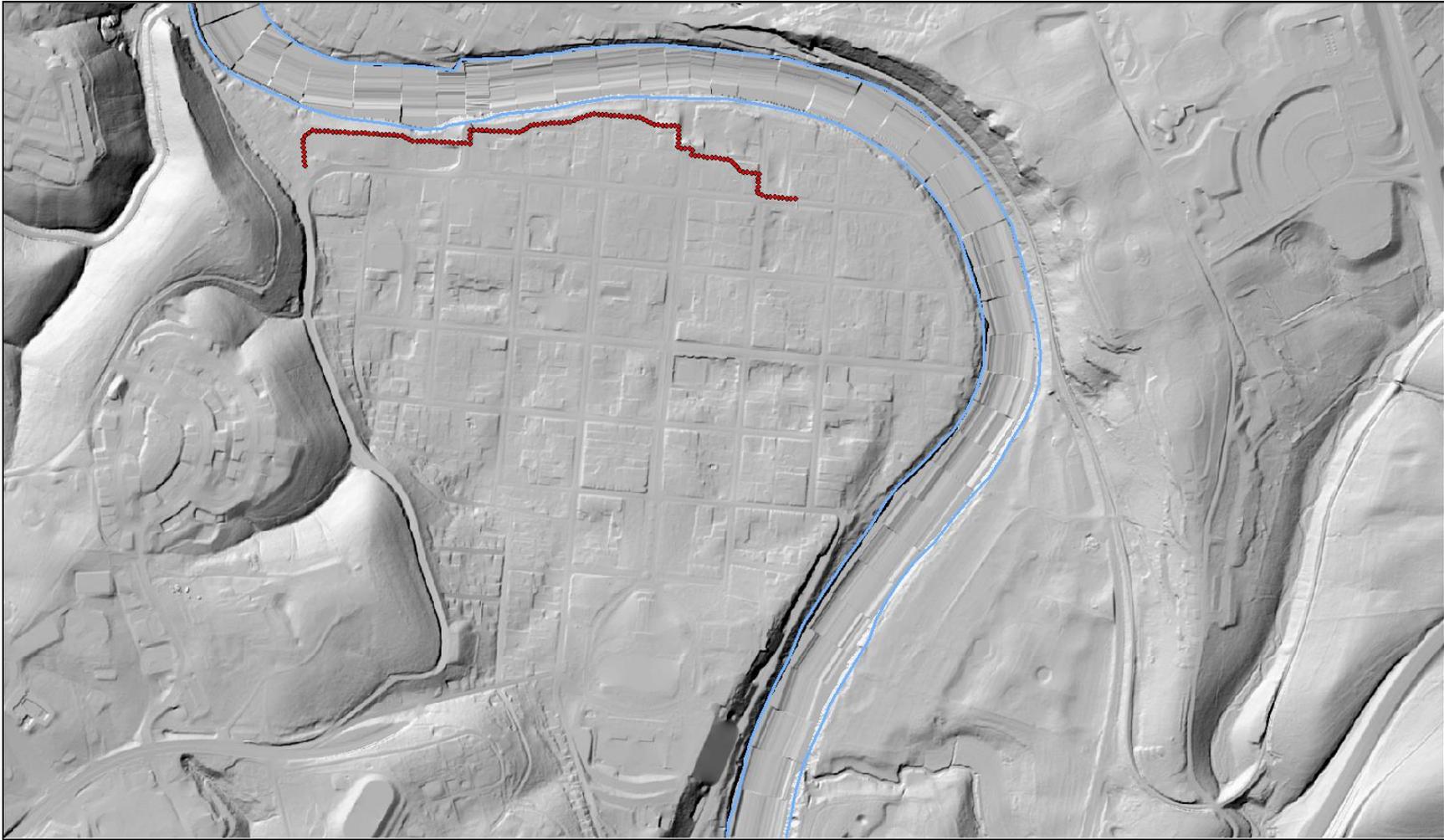
Phase 1: Frankfort, KY – Bathymetry Processing

Merge with LIDAR



Phase 1: Frankfort, KY – Bathymetry Processing

Include Levees



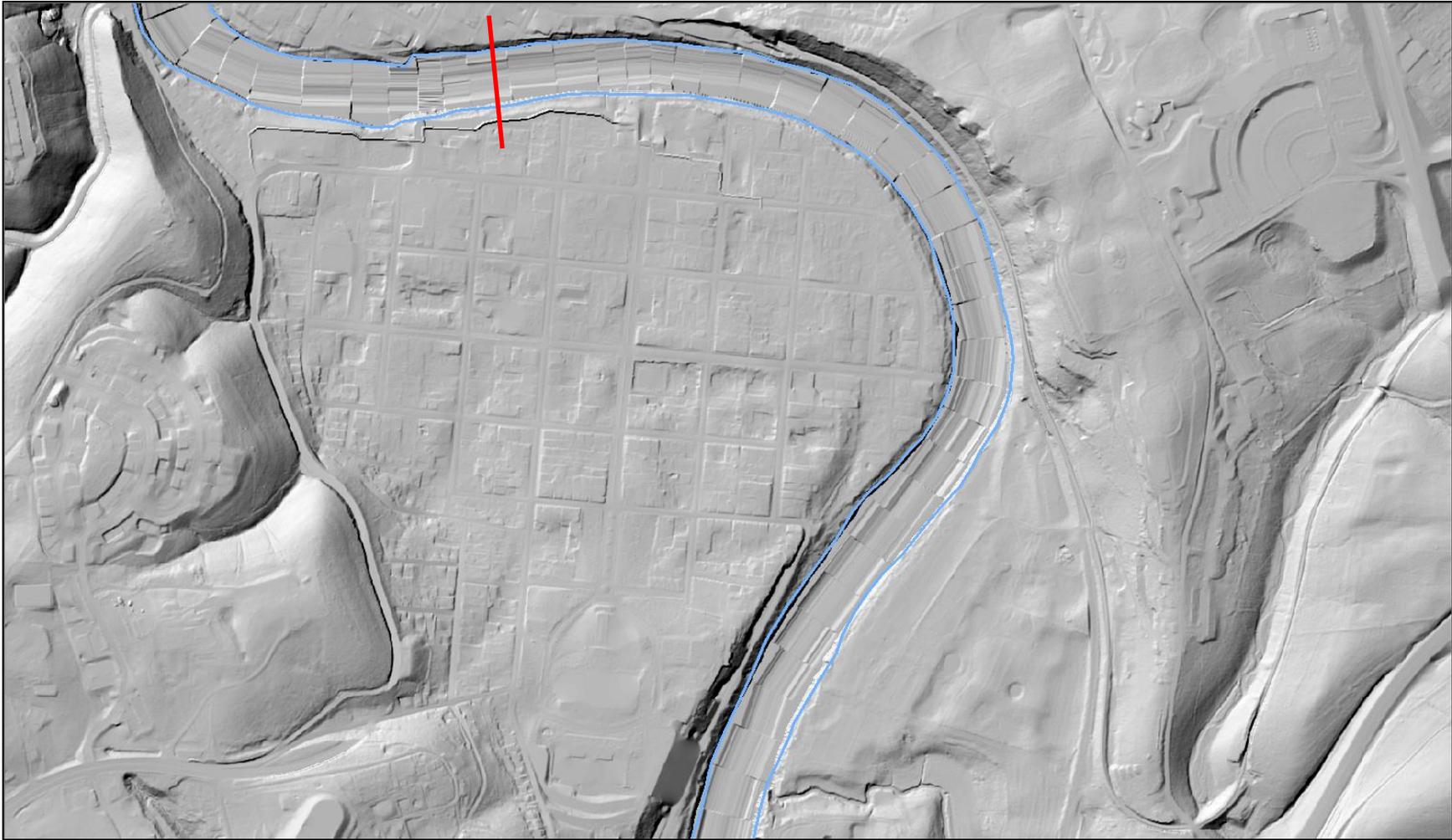
Phase 1: Frankfort, KY – Bathymetry Processing

Final DEM



Phase 1: Frankfort, KY – Bathymetry Processing

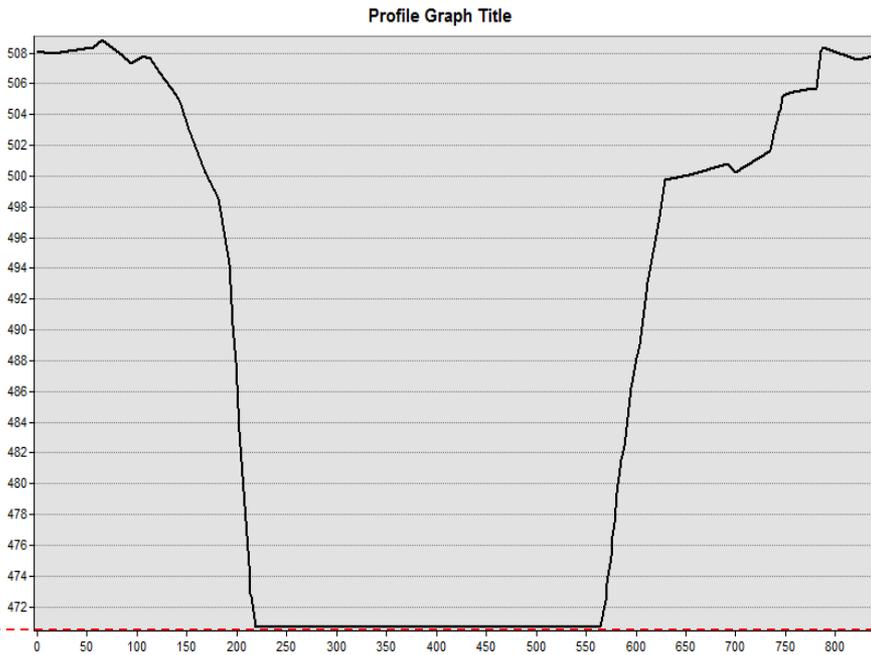
Sample Cross Section



Phase 1: Frankfort, KY – Bathymetry Processing

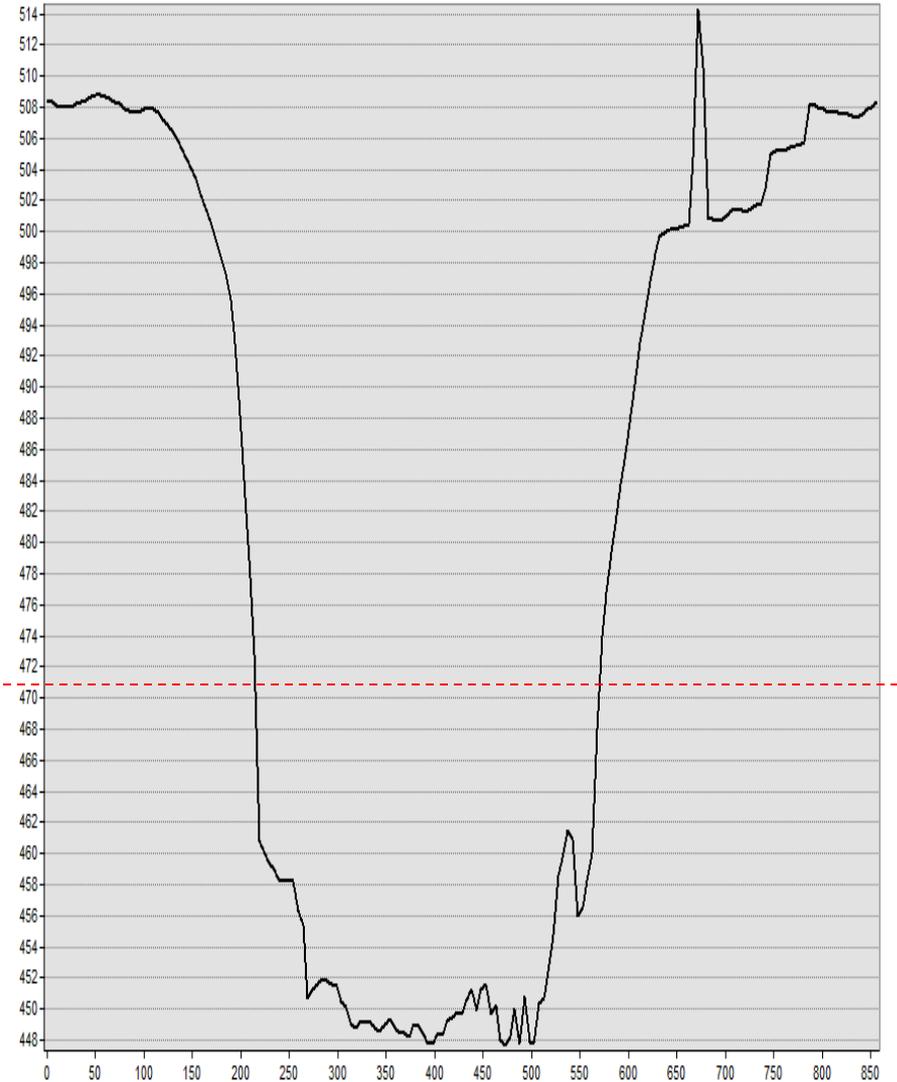
Sample Cross Section

Raw LIDAR



Processed Bathymetry

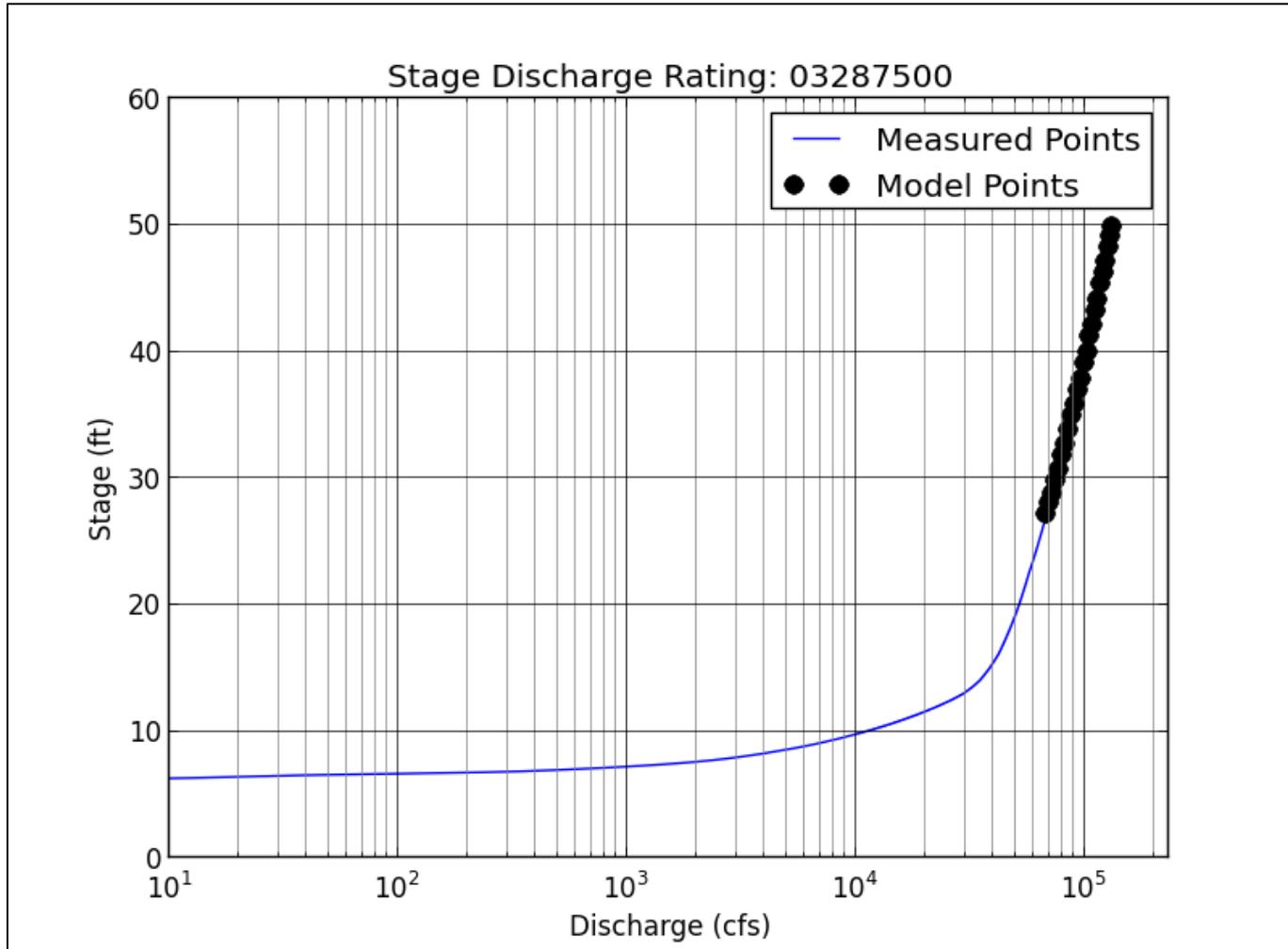
Profile Graph Title



Phase 2A: Frankfort, Kentucky - Model Calibration

Stage Discharge Rating

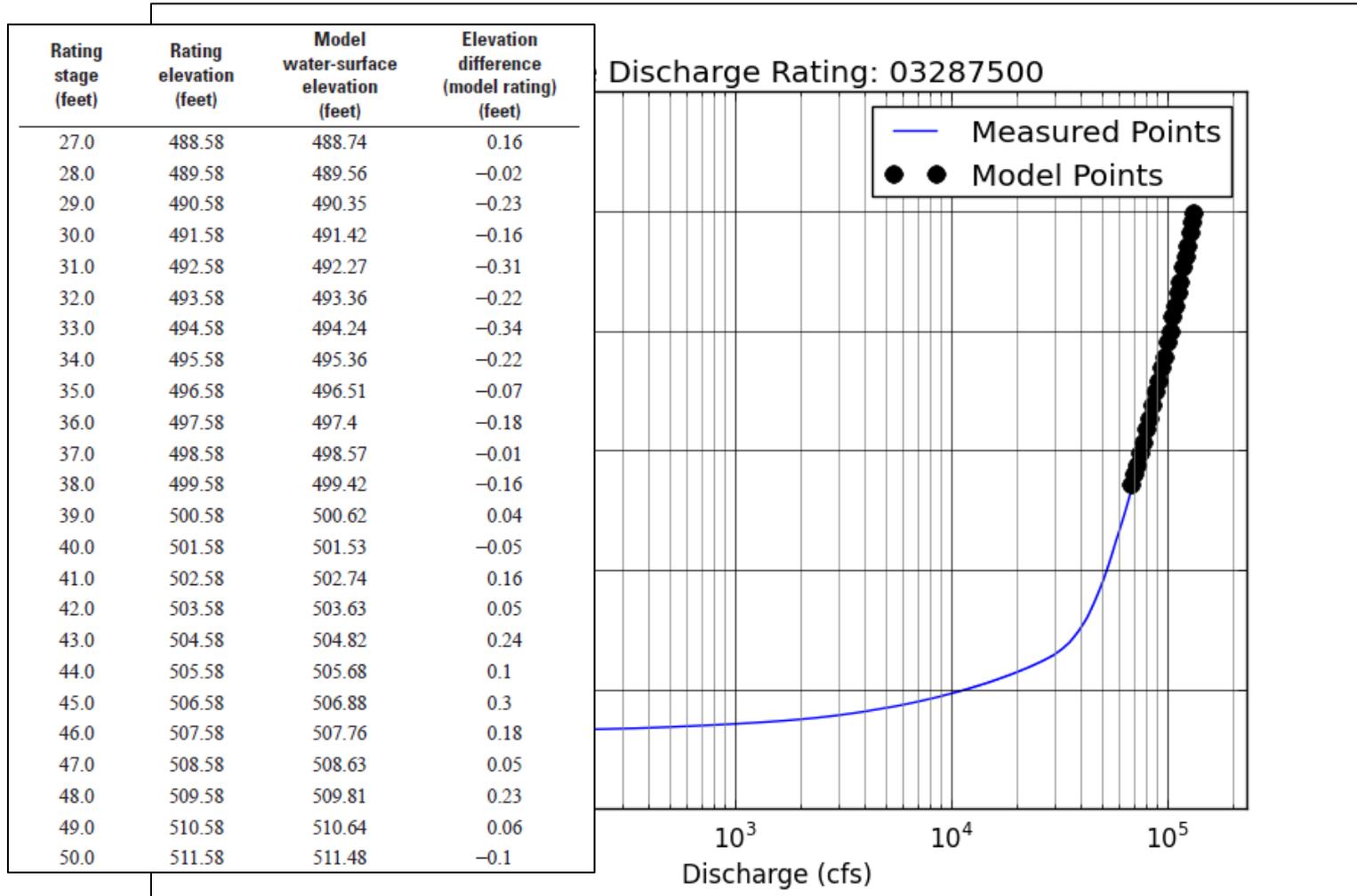
- **Criteria: Water surface profiles are to be within ± 0.5 ft. of the established USGS stage discharge rating.**



Phase 2A: Frankfort, Kentucky - Model Calibration

Stage Discharge Rating

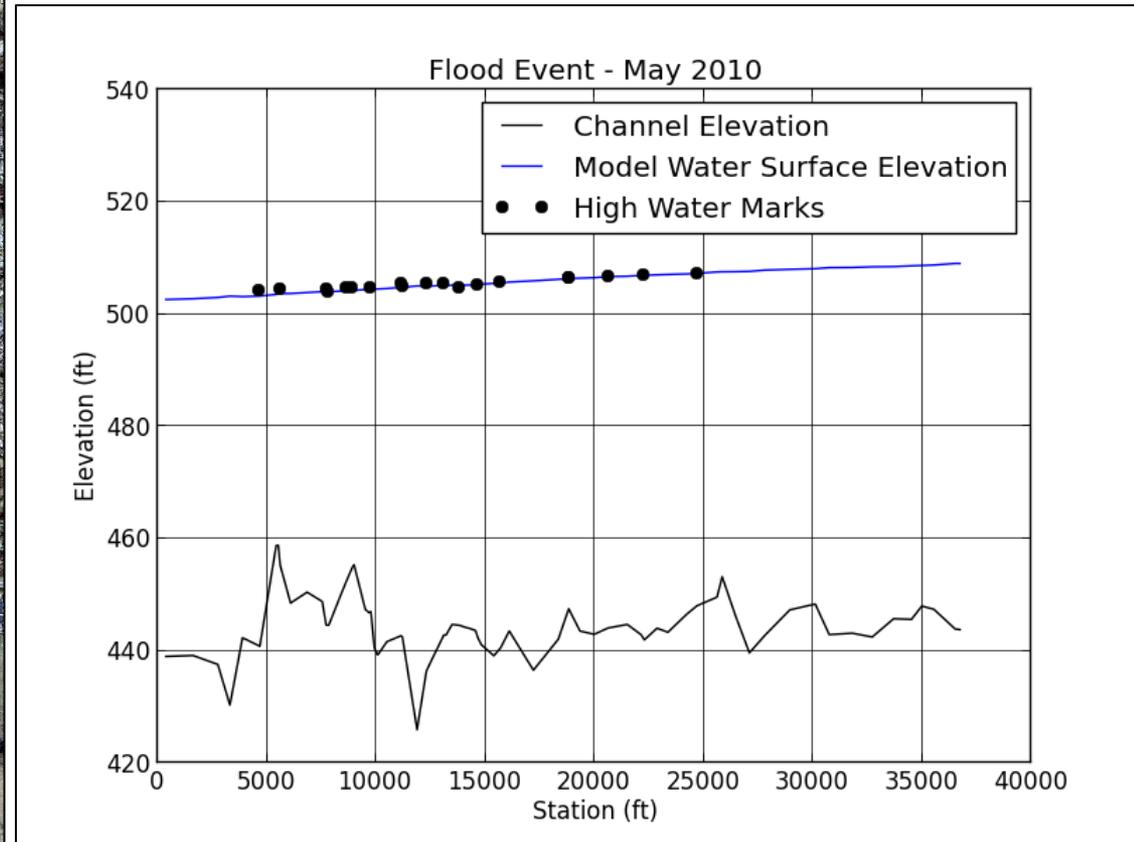
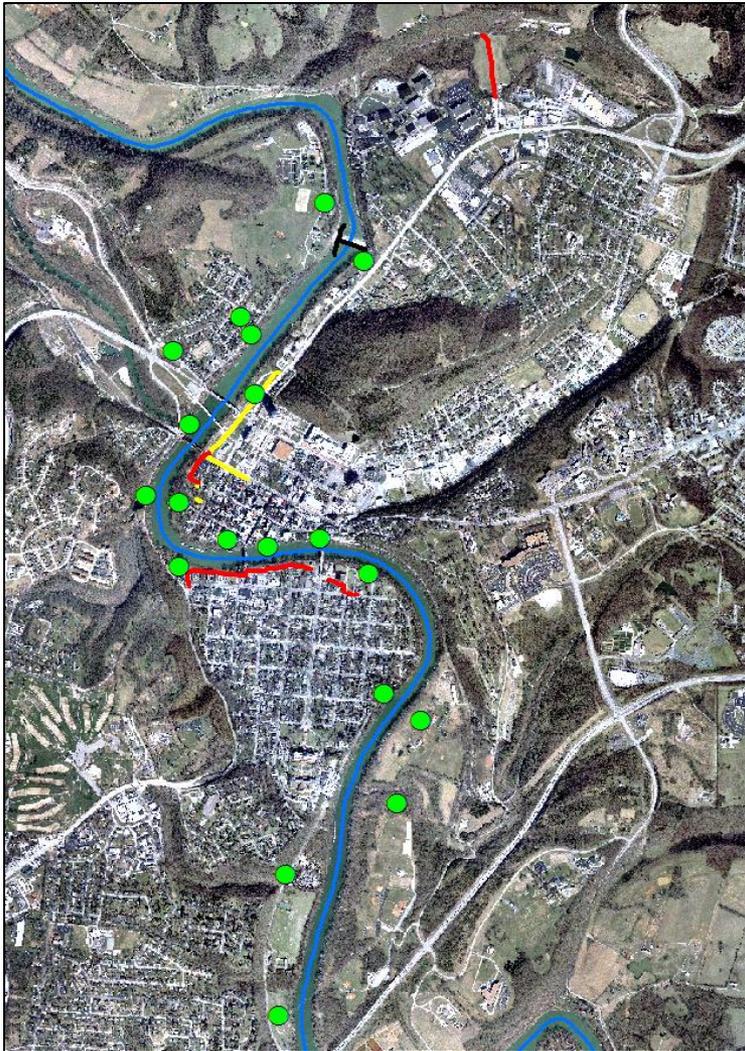
- Criteria: Water surface profiles are to be within ± 0.5 ft. of the established USGS stage discharge rating.



Phase 2A: Frankfort, Kentucky - Model Calibration

2010 Flood Event with High Water Marks

- **Criteria: Water surface profiles are to be within ± 1.0 ft. of the measured high water marks.**

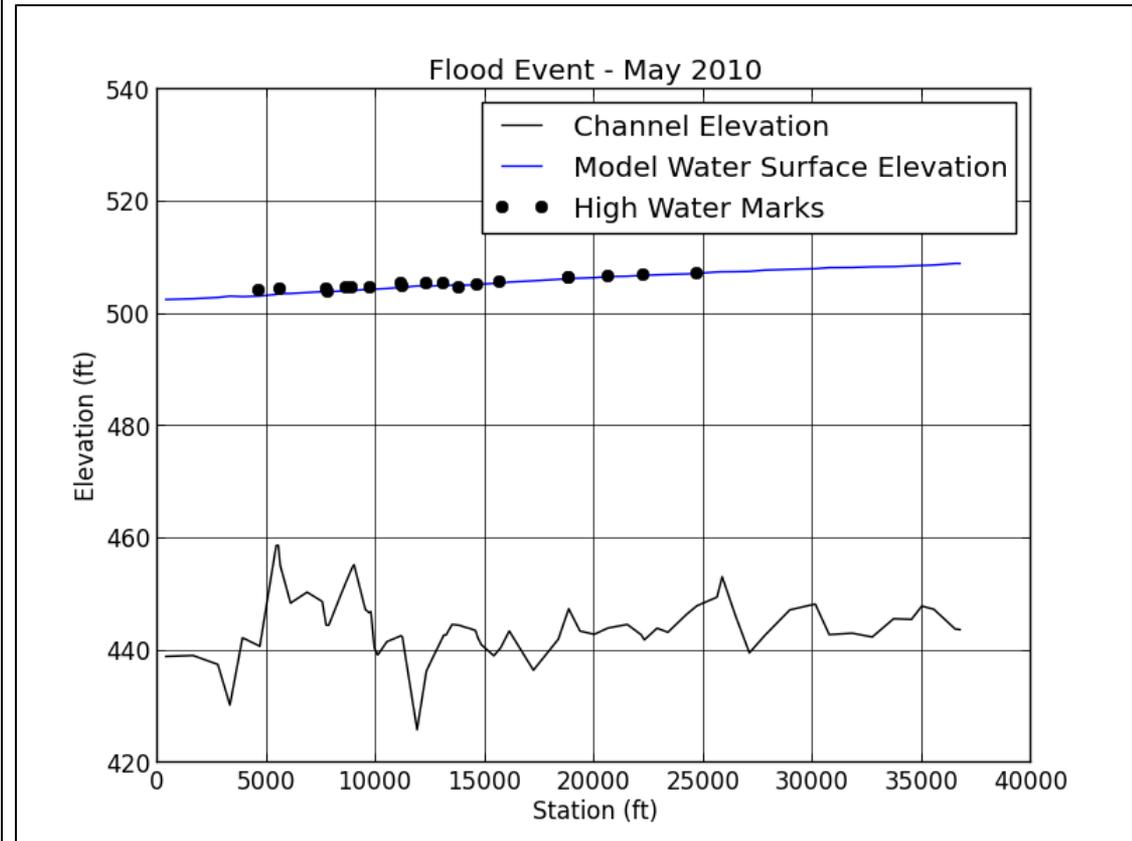


Phase 2A: Frankfort, Kentucky - Model Calibration

2010 Flood Event with High Water Marks

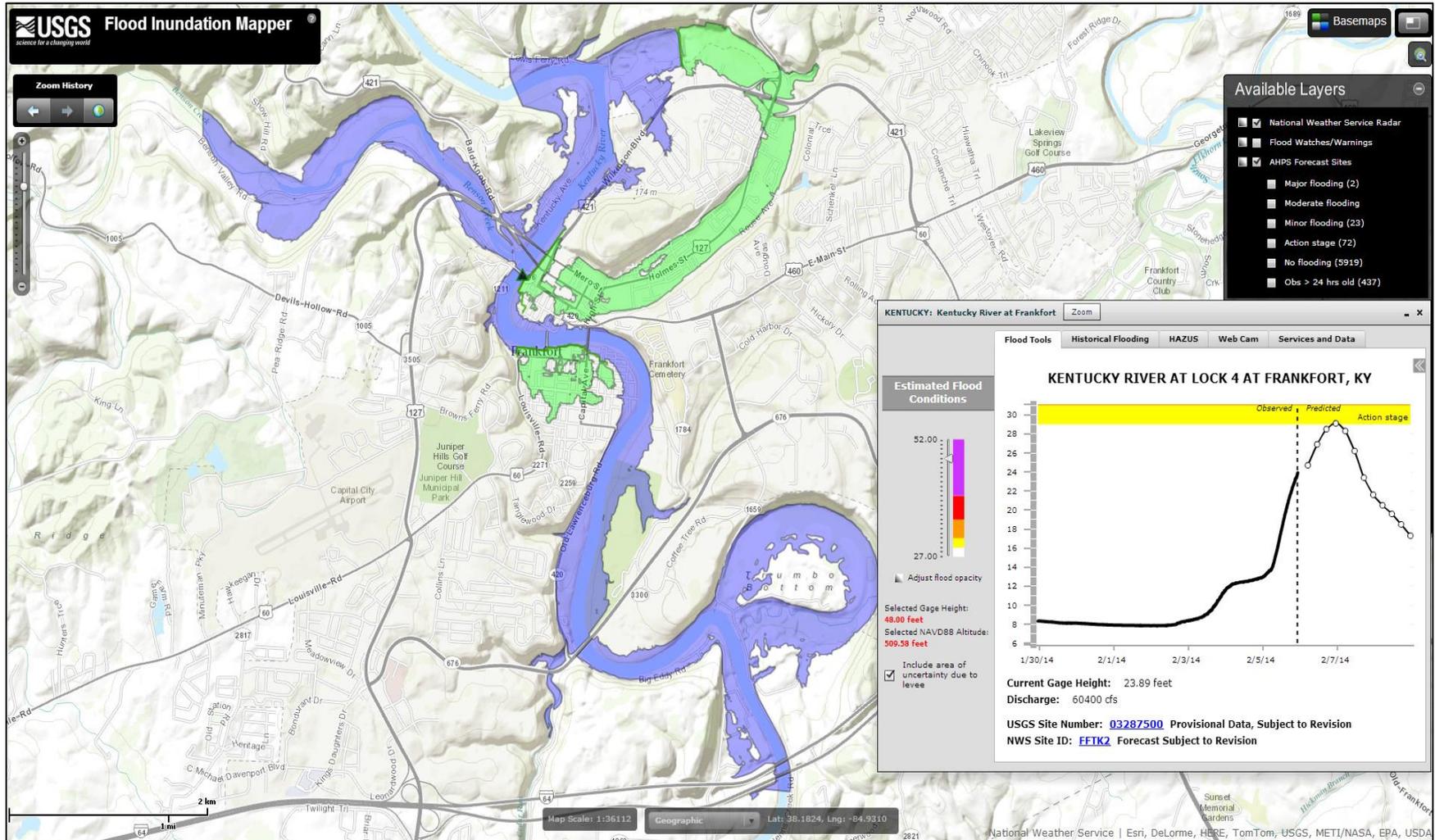
- Criteria: Water surface profiles are to be within ± 1.0 ft. of the measured high water marks.**

High-water-mark station (distance from most downstream cross section) (feet)	High-water-mark elevation (feet)	Model water-surface elevation (feet)	Elevation difference (model high-water mark) (feet)
24,689.61	507.28	507.26	-0.02
22,287.00	507.00	506.91	-0.09
20,614.58	506.57	506.69	0.12
18,819.53	506.50	506.36	-0.14
18,819.53	506.53	506.36	-0.17
15,701.44	505.65	505.52	-0.13
14,661.57	505.11	505.28	0.17
13,825.44	504.61	505.10	0.49
13,101.34	505.42	505.15	-0.27
12,301.77	505.37	504.97	-0.40
11,201.91	504.96	504.78	-0.18
11,137.62	505.44	504.76	-0.68
9,760.12	504.75	504.35	-0.40
8,913.91	504.55	504.20	-0.35
8,634.60	504.63	504.17	-0.46
7,831.73	504.00	504.01	0.01
7,709.92	504.52	503.99	-0.53
5,607.48	504.42	503.67	-0.75
4,674.39	504.06	503.23	-0.83



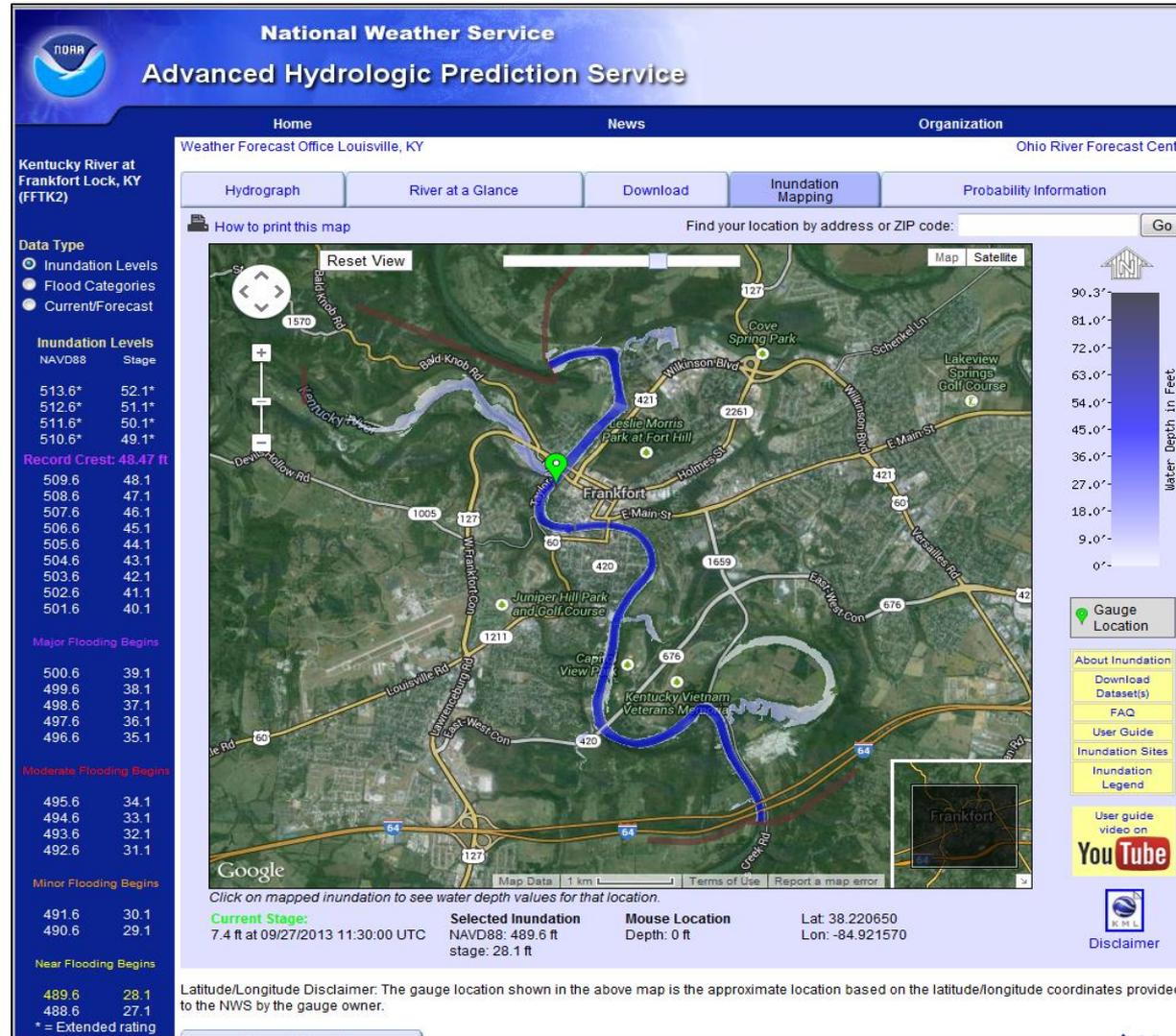
Phases 2B – 3: Frankfort, KY Web Implementation

USGS Flood Inundation Mapper



<http://wim.usgs.gov/FIMI/FloodInundationMapper.html>

Phases 2B – 3: Frankfort, Kentucky - NWS Flood Inundation Mapper



http://water.weather.gov/ahps2/inundation/inundation_google.php?g_datatype=depth&wfo=lmk&gage=fftk2

Questions?



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