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STORMWATER MANAGEMENT



Flood Inundation Mapping

Illinois Association of Stormwater and Floodplain Managers – March 14, 2018

Jack T. Knuepfer Administration Building, 421 N. County Farm Rd., Wheaton, IL 60187

(630) 407-6700 • www.dupageco.org/swm

Overview of Presentation



Background

Motivations

What Is Currently Provided?

- USGS Provisional Inundation Map
- DuPage County Flood Forecasting Simulations

What Are We Working on Now?

- Inundation Maps
- Peak Flood Depth Maps
- Dynamic Flood Inundation Maps

Where Are We Going?

- Animated Flood Inundation Maps and Features

Applications and Users

Contributors

Summary

Questions



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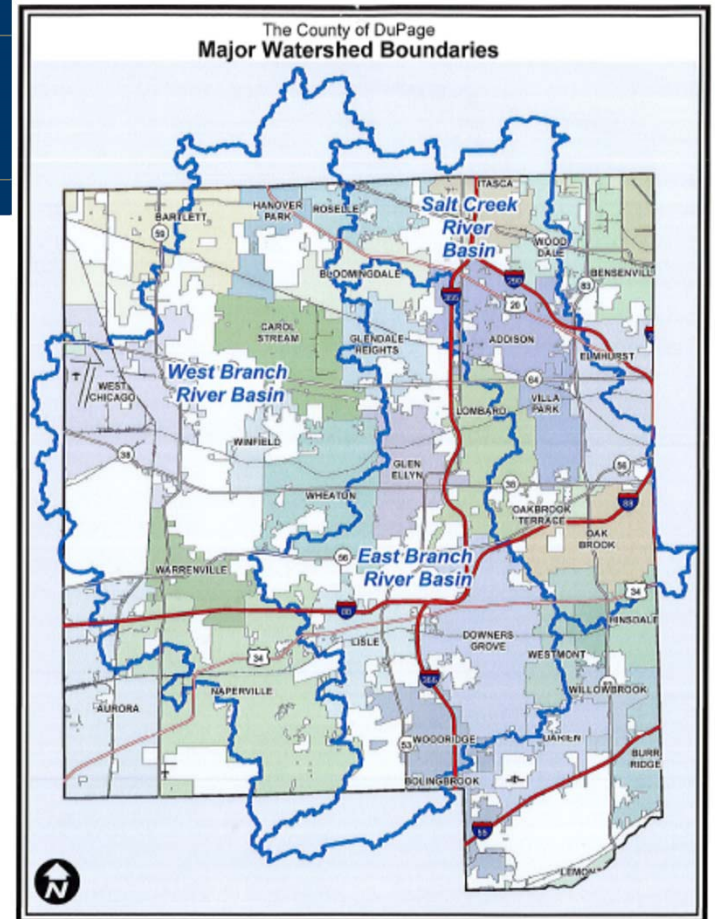
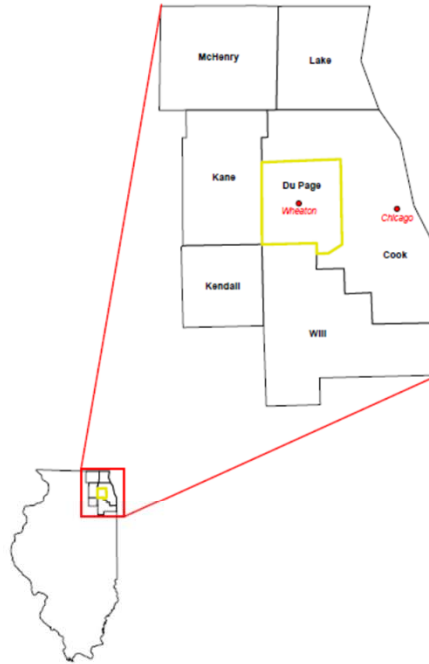


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Background

DuPage County, Illinois

- Suburbs of Chicago
- Nearly 1 million residents
- Highly impervious
- Terrain is relatively flat
- Watersheds: Des Plaines River, DuPage River (East and West Branches), Fox River, and Salt Creek



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Background



Stormwater Management in DuPage County

- Countywide program established in 1989
- Guided by the Stormwater Management Planning Committee and Plan
- Enforce the Countywide Stormwater Management and Floodplain Ordinance
- Flood control facilities have a floodwater capacity of nearly 6 billion gallons
- FY17 operating budget \$7.1 million

Stormwater Department Programs

- Flood Control Operations and Maintenance ←
- Floodplain Mapping
- Regulatory Services
- Water Quality
- Watershed Management

<http://www.dupageco.org/swm/>



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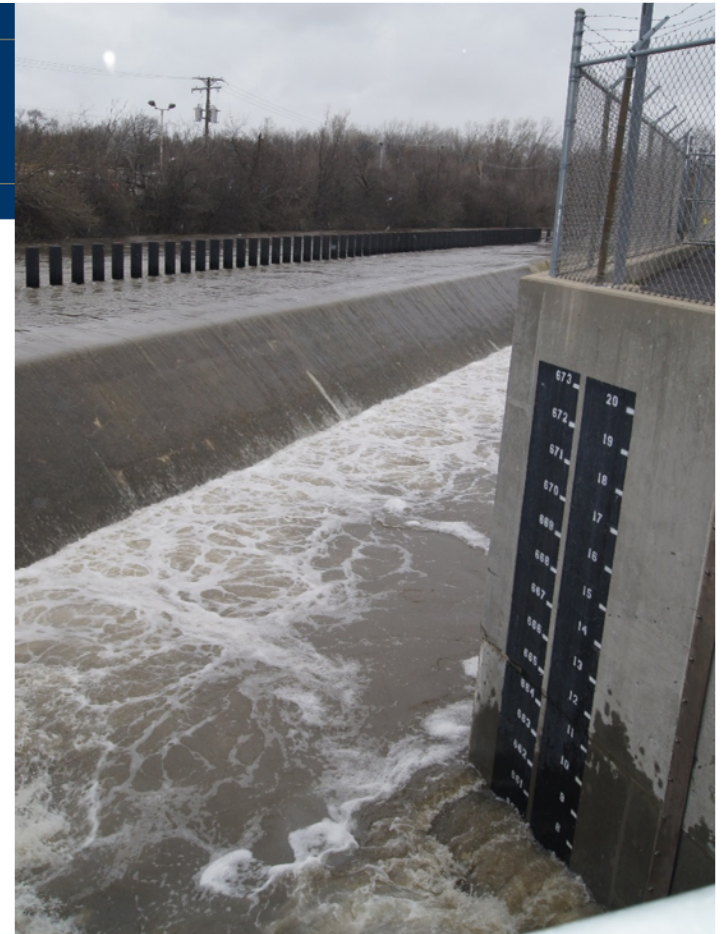
Background

Flood Control Facilities

- DuPage County owns and operates 16 flood control facilities
- Includes reservoirs, pump stations, and dams
- 6 facilities are mechanically-operated by staff, remaining are gravity-operated
- Floodwater capacity of nearly 6 billion gallons

Flood Operations

- Flood forecasting simulations
- Remote operation using rain and stream gages with real time video

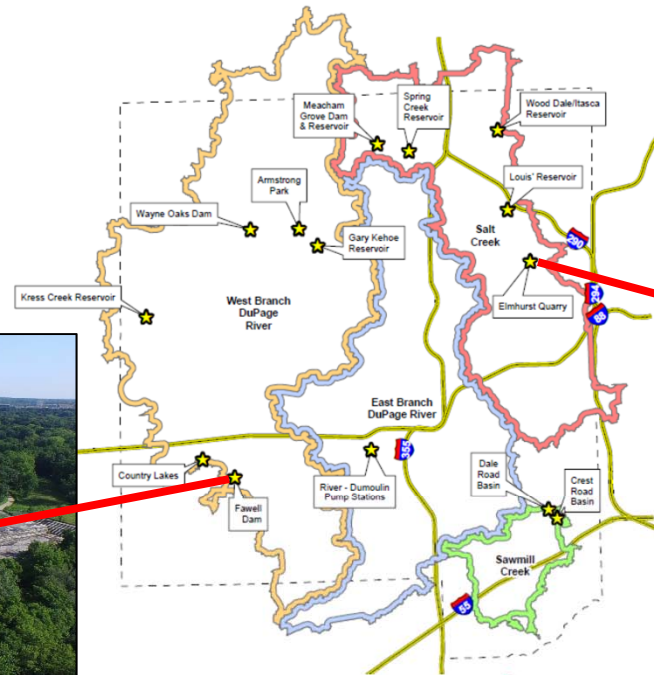


Background



DuPage County Flood Control Facilities

*Fawell Dam – West Branch DuPage River
Naperville
1.6 billion gallons*



*Elmhurst Quarry – Salt Creek
Elmhurst
2.7 billion gallons*



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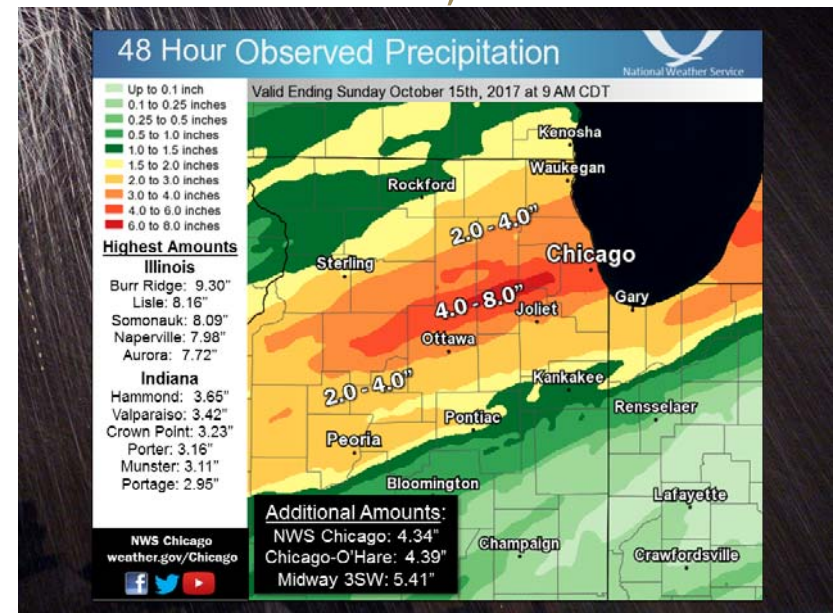
Motivations



Recent Heavy Precipitation and Flooding Events

- September 12-15, 2008
- July 22-24, 2010
- April 17-18, 2013
- October 13-14, 2017

October 13-14, 2017 Event



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Motivations



Can we predict when and where a river will cause flooding? Yes!

Flood Forecasting

Simulate future stream levels using hydrologic and hydraulic models with observed stream gage levels and predicted precipitation as input.



A river overtopping a road

Flood Inundation Maps

A map that depicts the portion of land which will be covered by flood waters. Translates observed stream gage levels and simulated results into a 2-D map.



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Motivations

Translate Water Elevations into Inundation Maps

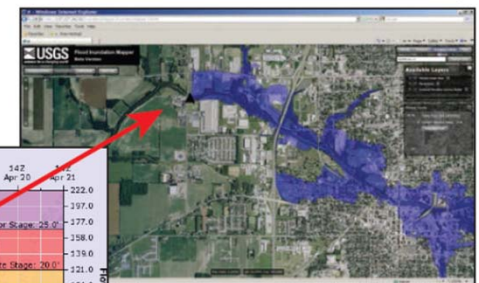
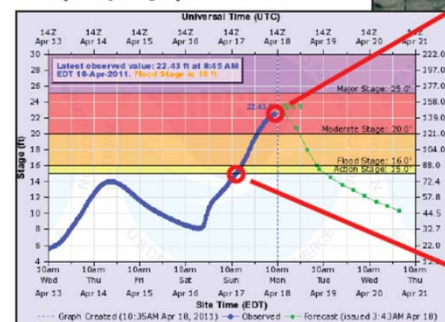
- Current condition inundation map based on current stream gage levels
- Future conditions inundation maps linked to flood forecasting simulations based on the predicted rainfall

Hydrograph: a graph showing the river elevation or flow versus time at a specific point in a river.

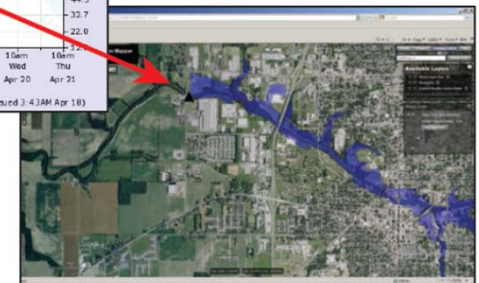


High flood stage inundation map:

Example hydrograph of a flood:



Low flood stage inundation map:



Inundation maps translate flood data into operational maps that communicate risk and the consequences of current and forecasted flooding.



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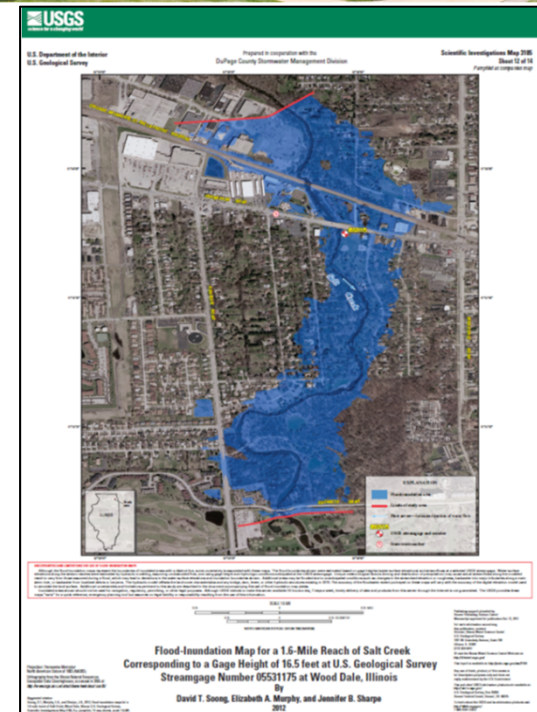


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U.S. Geological Survey (USGS) Provisional Inundation Map

- Salt Creek at Wood Dale
- Limited area near stream gage
- Library of static maps based upon stream gage levels
- User must determine forecasted level
- <https://il.water.usgs.gov/ifhp/dupage/>



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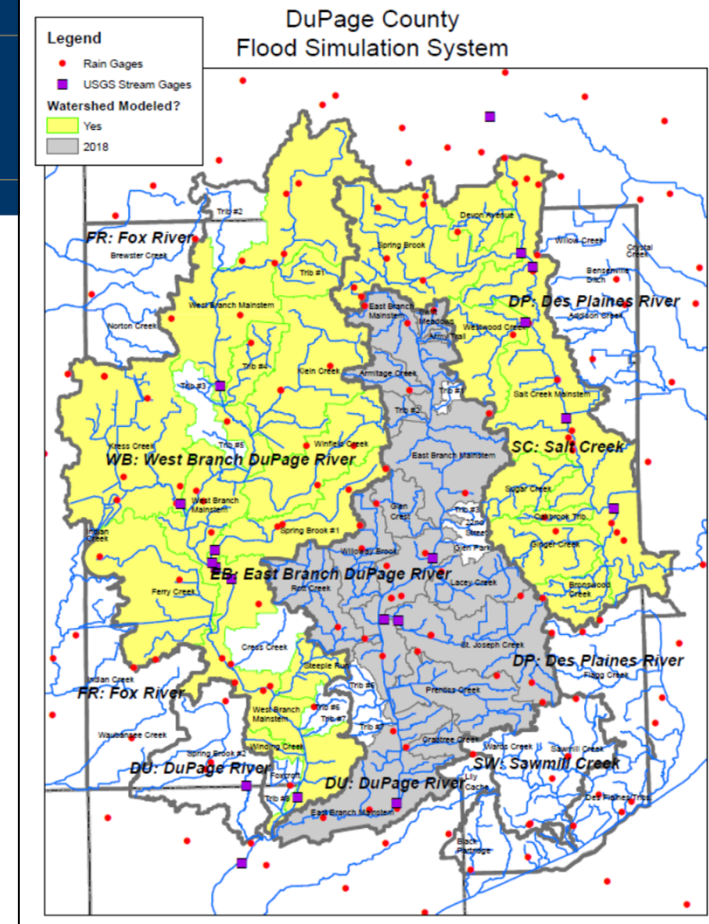


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Flood Forecast Simulations

- Supports operations of flood control facilities
- Observed stream gage heights modeled with forecast precipitation
- Only Salt Creek and West Branch DuPage River are currently modeled
- East Branch DuPage River to be added in 2019
- Updated every Monday, Wednesday, and Friday; updated every 6 hours during an event
- <http://ec.dupageco.org/dec/stormwater/watershed/index.html>



Currently Provided



Hydrologic and Hydraulic Modeling

- Simulations utilize Hydrologic Simulation Program – FORTRAN (HSPF) for the hydrology and Full Equations (FEQ) for the hydraulics

Simulation System Processes

1. Retrieve real-time data
2. Convert, fill, document
3. Input to data base
4. Rainfall-runoff simulation
5. Hydraulic routing
6. Create and analyze output



Simulation System – Modeling Tools

- HSPF (Hydrology)
- FEQ (Hydraulics)
- GenScn/GraphGenScn (Analysis)
- MAGIC (Data Conversion)
- Perl Scripts (Automation)



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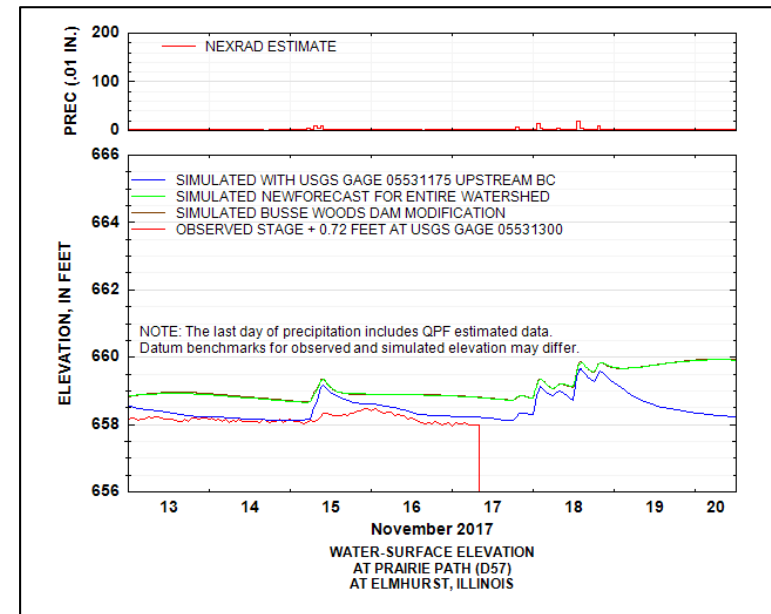
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Currently Provided



Simulation System – Multiple Scenarios

- Various upstream boundary conditions
 - Observed stream gages
 - Entire upstream watershed modeled
- Observed precipitation from rain gages
 - With Quantitative Precipitation Forecast (QPF) for forecast precipitation
 - With manually entered data for forecast precipitation
- Observed precipitation from NEXRAD cells
 - With QPF for forecast precipitation
 - With manually entered data for forecast precipitation



*Various boundary conditions with NEXRAD
precipitation and QPF forecast*



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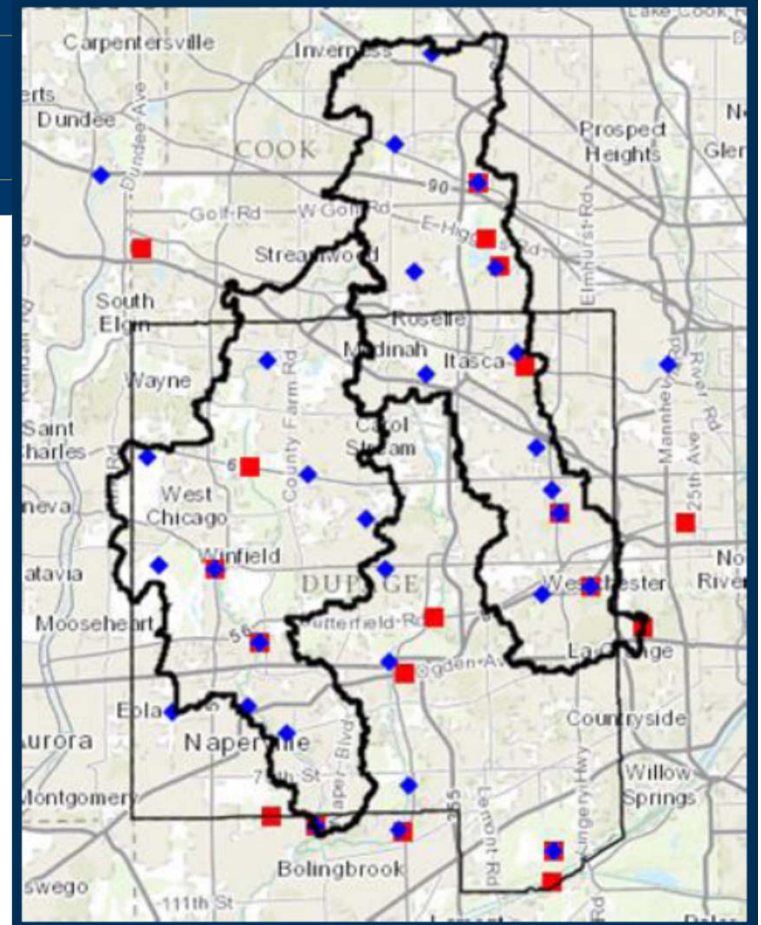
Multiple Scenarios (continued)

Gage Inputs from USGS and DuPage County

- Precipitation (5- or 15-minute converted to hourly)
- Stream stage
- Stream discharge

Salt Creek HSPF/FEQ
4 rain gages,
3 streamgages

West Branch HSPF/FEQ
3 rain gages,
1 streamgage



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Multiple Scenarios (continued)

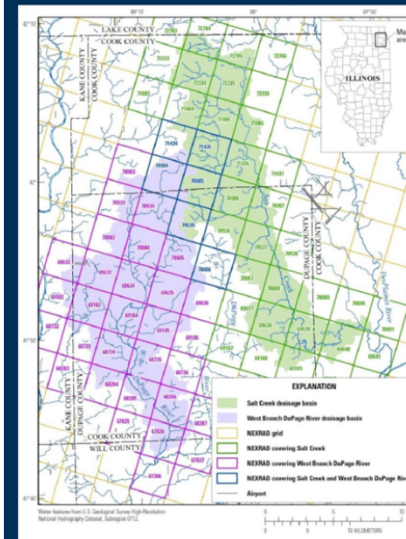
Scenario using MPE Data

**NEXRAD cells converted
to hypothetical gages**

**Salt Creek HSPF/FEQ
4 hypothetical gages**

**West Branch HSPF/FEQ
11 hypothetical gages**

NWS Multisensor Precipitation Estimates (MPE) Data



**MPE
(1-hour total)**

- Radar data
- Gage corrected
- 4x4 kilometer grid

Salt Creek – 36 cells

West Branch – 35 cells



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Multiple Scenarios (continued)

Precipitation Forecasts

- Simulations include 72-hour precipitation forecast
- Simulations use QPF: 6-hourly data distributed into 1-hourly values for modeling
- Simulations use Warrenville (WRNI2) and Western Springs (WSPI2) grid points for the West Branch DuPage River and Salt Creek, respectively
- Simulation system allows forecast precipitation values and distribution to be input manually

Quantitative Precipitation Statement
Issued by NWS North Central River Forecast Center

[Home](#) | [Current Version](#) | [Previous Version](#) | [Graphics & Text](#) | [Print](#) | [Product List](#) | [Glossary On Versions: 1 2 3 4](#)

```
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Currently Provided



Available on our Website

- Includes brief forecast discussion
- 24-hour and 72-hour precipitation forecast
- Facility operation information

<http://ec.dupageco.org/dec/stormwater/watershed/index.html>



File Edit View History Bookmarks Tools Help

West Branch DuPage River Watershed

ec.dupageco.org/dec/stormwater/watershed/WestB

Most Visited Getting Started CNRFC - WPC QPF - 0... http://w1.weather.gov... Illinois Real-Time Prec... WeatherSentry - Publi...

Flood Forecast Simulations

These results are simulated using provisional data with DuPage County Stormwater Management HSPF and FEQ models. These are for guidance purposes only; actual watershed conditions may vary. All local agencies should use individual judgment when making operating decisions.

Simulations have been run at each of the below locations. Summary statistics and notes are listed herein and can be revisited by clicking "SIMULATION NOTES". Further information regarding individual sites and be accessed by visiting their respective hyperlinks.

SIMULATION NOTES NEAR WEST CHICAGO NEAR WARRENVILLE FAWELL DAM NEAR NAPERVILLE

Forecast Discussion: Monday, February 19th, 9:00 AM

The County recorded between 1.11 and 2.13 inches of rain in the past 24 hours. Heavy rain is expected today with an additional 1.18 inches of rain through Tuesday morning.

	2/19	2/19	2/19	2/20									
	6a-12p	12p-6p	6p-12a	12a-6a									
24-hour:	0.35	0.55	0.27	0.01									
72-hour:	0.35	0.55	0.27	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07

Operations of Fawell Dam is possible as simulated water elevations are forecast to reach operating levels on Tuesday morning. Staff will continue to monitor water levels and rain amounts closely. Armstrong Park is currently operating.

IN THE EVENT OF PRECIPITATION, OVERLAND OR DEPRESSIONAL FLOODING MAY OCCUR THROUGHOUT THE WATERSHED. IF YOU ARE EXPERIENCING DEPRESSIONAL FLOODING -NOT FLOODING DIRECTLY FROM STREAMS OVERTOPPING- AND ARE IN NEED OF ASSISTANCE, PLEASE CALL YOUR LOCAL PUBLIC WORKS DEPARTMENT.

Currently Provided



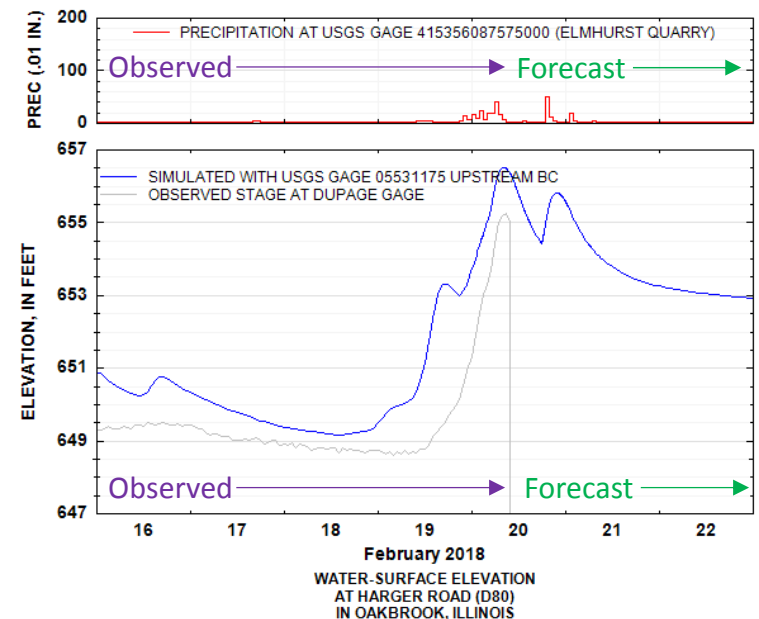
Output Hydrographs

Salt Creek

- Irving Park Road (used to predict operation of Wood Dale-Itasca Reservoir)
- Harger Road (used to predict operation of Elmhurst Quarry)
- Prairie Path

West Branch DuPage River

- Near West Chicago
- Near Warrenville
- Fawell Dam (used to predict operation of Fawell Dam)
- Near Naperville



What Are We Working on Now?



Real Time Flood Inundation Maps

- Current condition inundation map based on current stream gage levels
- Future conditions inundation maps linked to flood forecasting simulations based on the predicted rainfall
- Peak conditions map (flood extents and depths)

Process:

- Requires integration of flood forecast system with mapping program
- Utilizing Full Equations (FEQ) modeling output with HEC-RAS Mapper to create maps
- May be updated with each forecast update (currently 6 hour intervals)

Flood Forecasting Simulations
with FEQ Models



Run Conversion Scripts on
FEQ Output Files



Import results into HEC-RAS



Run HEC-RAS Steady Flow
Model
and RAS Mapper



Flood Inundation Maps



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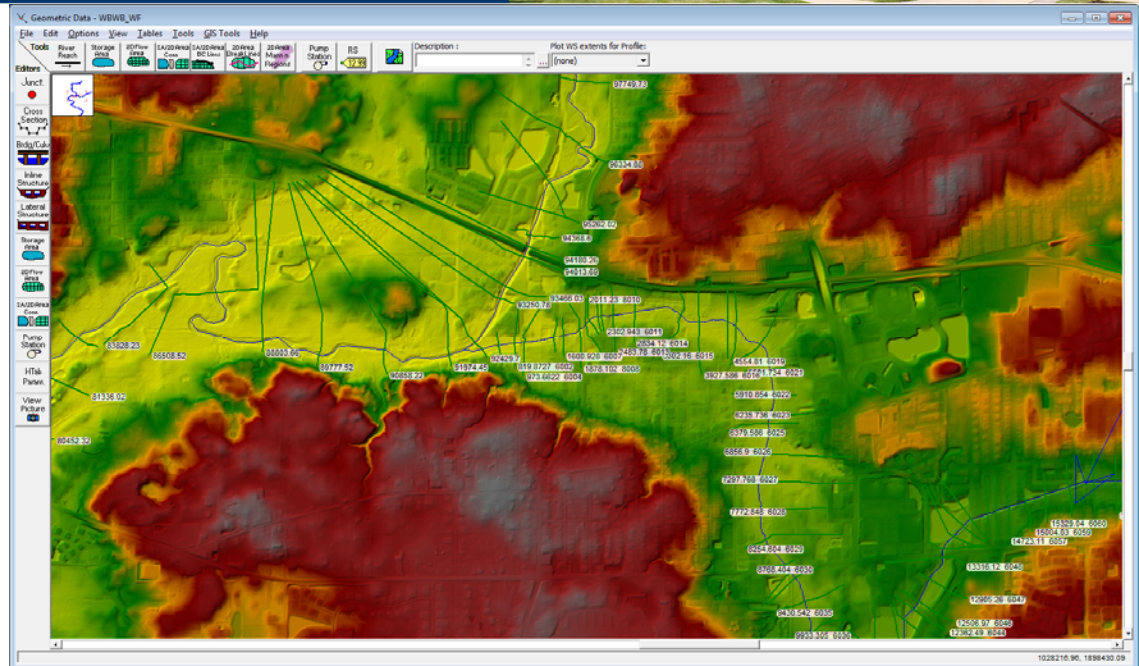
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What Are We Working on Now?



Process to Create Inundation Maps

- Digital Elevation Model derived from LiDAR (2014)
 - Resolution: 1.5 feet grid
- Clean up, extend, and edit cross-sections

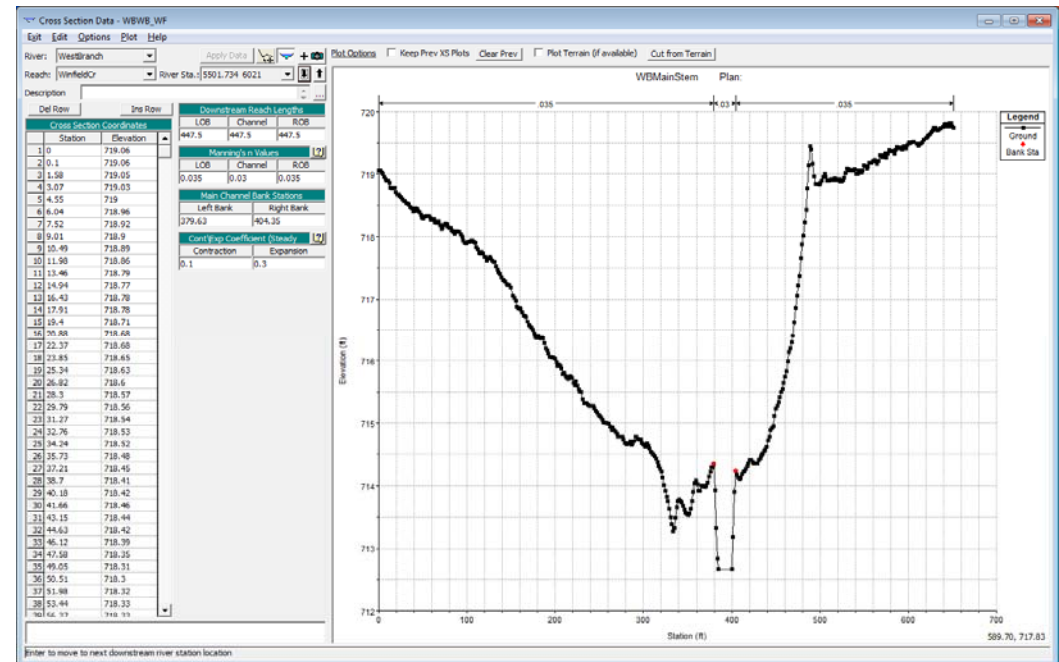


What Are We Working on Now?



Process to Create Inundation Maps

- Extract 2-dimensional cross-sections from the Digital Elevation Model
- Add channel inverts for low flows
- Set parameters required by HEC-RAS model



What Are We Working on Now?



FEQ Output Converted into HEC-RAS Format

```
TextPad - C:\feq\BR-1B\EBEB\EBEBR1bDesign.out.hff
File Edit Search View Tools Macros Configure Window Help
EBEBR1bDesign.out.hff x
1MAXIMA DURING EVENT ENDING AT:
YEAR/MONTH/DAY:HOURL 2048/ 7/ 14: 0.000 JTIME = 6.927200000000000D+04
SUMMARY OF EXTREME ELEVATIONS AND FLOWS
EAST BRANCH DUPAGE RIVER - EBEBR1b
FEQ VERSION 10.73
REVISED DESIGN STORMS 9/2017
Version: 10.73 Version date: 19 November 2009 Date/time of run: 2018/01/25: 09.19.18.532
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Convert - Notepad

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EBEB_2013_4_28	Imported from HEC-RAS	04ACE	02ACE	01ACE
WSP_Station	Invert Stage	10ACE	04ACE	005ACE
128565	703.461	711.991	712.131	712.401
128408	703.461	711.991	712.131	712.401
128067	703.351	711.991	712.131	712.401
127275	703.101	711.991	712.131	712.401
126886	703.101	711.991	712.131	712.401
126844	709.201	710.411	710.511	710.761
125742	708.041	709.021	709.121	709.371
125521	706.281	707.811	708.011	708.351
125193	706.091	707.741	707.941	708.291
124498	705.681	707.461	707.661	708.021
124488	705.681	707.461	707.661	708.021
123552	703.451	705.741	705.921	706.241
123361	703.771	705.561	705.751	706.081
123308	703.771	705.551	705.741	706.061
123080	703.611	704.821	705.011	705.251
122970	703.261	704.781	704.971	705.211
122790	702.771	704.741	704.941	705.181
122637	702.331	704.651	704.841	705.081
122514	701.541	704.601	704.791	705.031
121409	702.141	704.571	704.751	704.971
120568	699.271	704.561	704.751	704.971
120050	700.281	704.371	704.561	704.781
119577	699.671	703.241	703.391	703.801
119433	699.671	703.241	703.391	703.801



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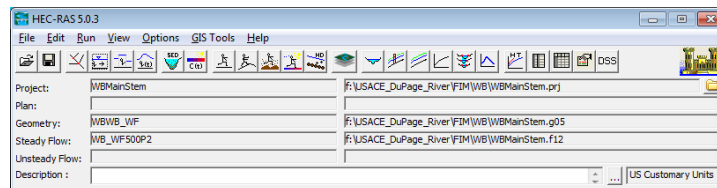


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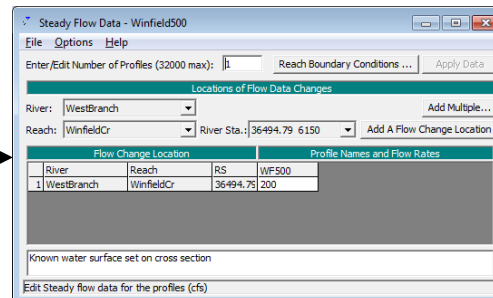
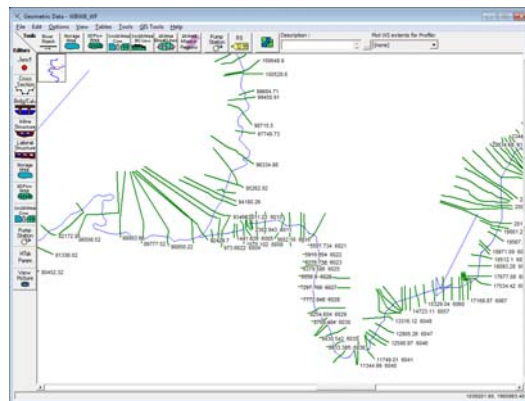
What Are We Working on Now?



HEC-RAS Model Input



- Build geometry
- Copy FEQ output into Steady Flow, including internal changes in Water Surfaces



Set Internal Changes in WS and EG

Add RS Locations One at a Time | Add Multiple RS Locations |

Select Location and Profile, then Select Method

River: WestBranch Profile: 500

Reach: MainStem River Sta.: 163137.2

Additional EG Change in EG Known WS Change in WS K Loss Delete

River	Reach	RS	Prof	Type	Value
1 WestBranch	WinfieldCr	36494.79	500	Known WS(ft)	746.044
2 WestBranch	WinfieldCr	36163.45	500	Known WS(ft)	746.034
3 WestBranch	WinfieldCr	36103.46	500	Known WS(ft)	746.034
4 WestBranch	WinfieldCr	36042.73	500	Known WS(ft)	746.034
5 WestBranch	WinfieldCr	35574.1	500	Known WS(ft)	746.034
6 WestBranch	WinfieldCr	35420.09	500	Known WS(ft)	746.034
7 WestBranch	WinfieldCr	35102.34	500	Known WS(ft)	746.034
8 WestBranch	WinfieldCr	35004.26	500	Known WS(ft)	746.034
9 WestBranch	WinfieldCr	34500.93	500	Known WS(ft)	746.034
10 WestBranch	WinfieldCr	34190.17	500	Known WS(ft)	746.034
11 WestBranch	WinfieldCr	33992.34	500	Known WS(ft)	746.034
12 WestBranch	WinfieldCr	33760.1	500	Known WS(ft)	746.034
13 WestBranch	WinfieldCr	33646.49	500	Known WS(ft)	746.034
14 WestBranch	WinfieldCr	33537.03	500	Known WS(ft)	746.034
15 WestBranch	WinfieldCr	33401.2	500	Known WS(ft)	746.034
16 WestBranch	WinfieldCr	33150.61	500	Known WS(ft)	746.034
17 WestBranch	WinfieldCr	32887.34	500	Known WS(ft)	746.034
18 WestBranch	WinfieldCr	32735.45	500	Known WS(ft)	746.024
19 WestBranch	WinfieldCr	32640.37	500	Known WS(ft)	746.024
20 WestBranch	WinfieldCr	32529.63	500	Known WS(ft)	746.024
21 WestBranch	WinfieldCr	32388.86	500	Known WS(ft)	746.014
22 WestBranch	WinfieldCr	32192.79	500	Known WS(ft)	746.014
23 WestBranch	WinfieldCr	31882.08	500	Known WS(ft)	746.014

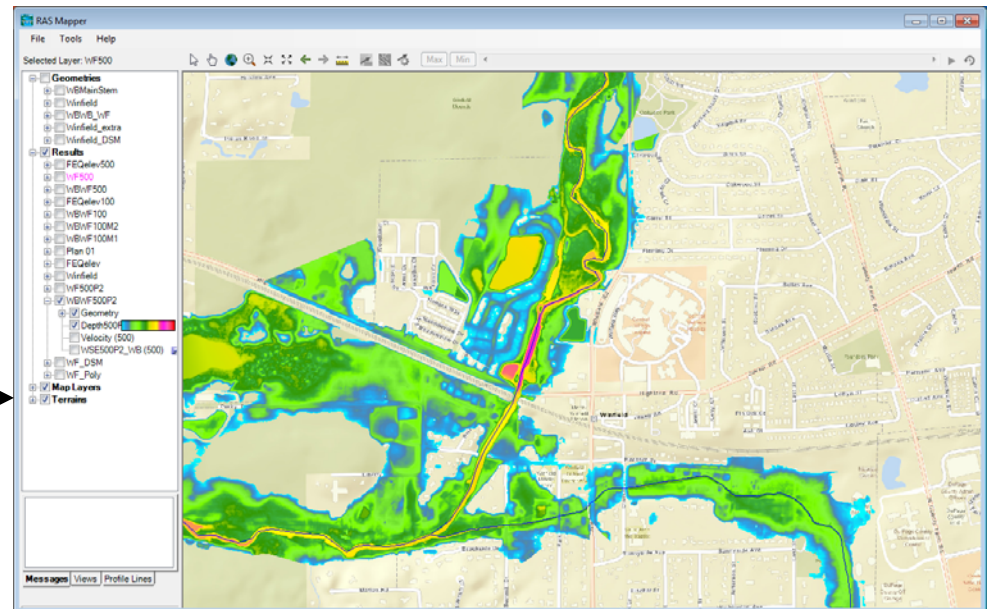
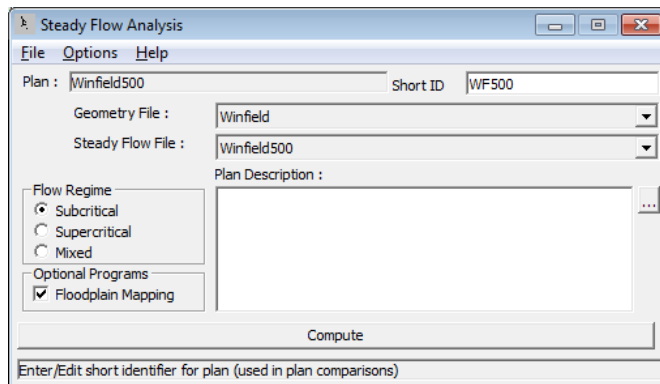
Enter to accept changes

What Are We Working on Now?



HEC-RAS Mapper

- Forcing FEQ output into Mapper
- Not actual hydraulic model



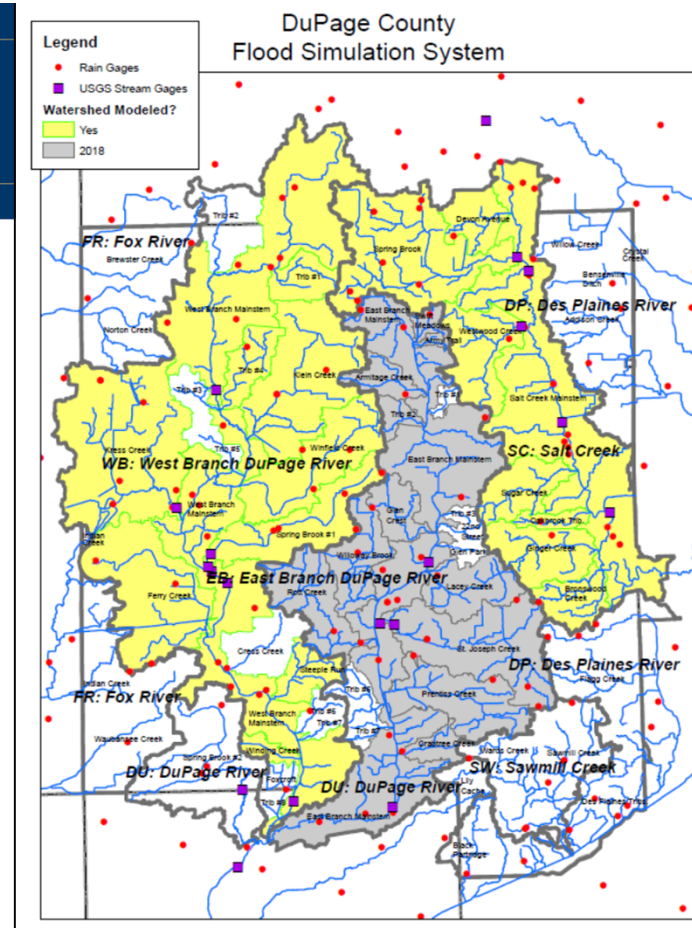
What Are We Working on Now?

Flood Simulations

- Spring 2019 – Add East Branch DuPage River

Inundation Maps

- Fall 2018 – Salt Creek and West Branch DuPage River
- Fall 2019 – East Branch DuPage River

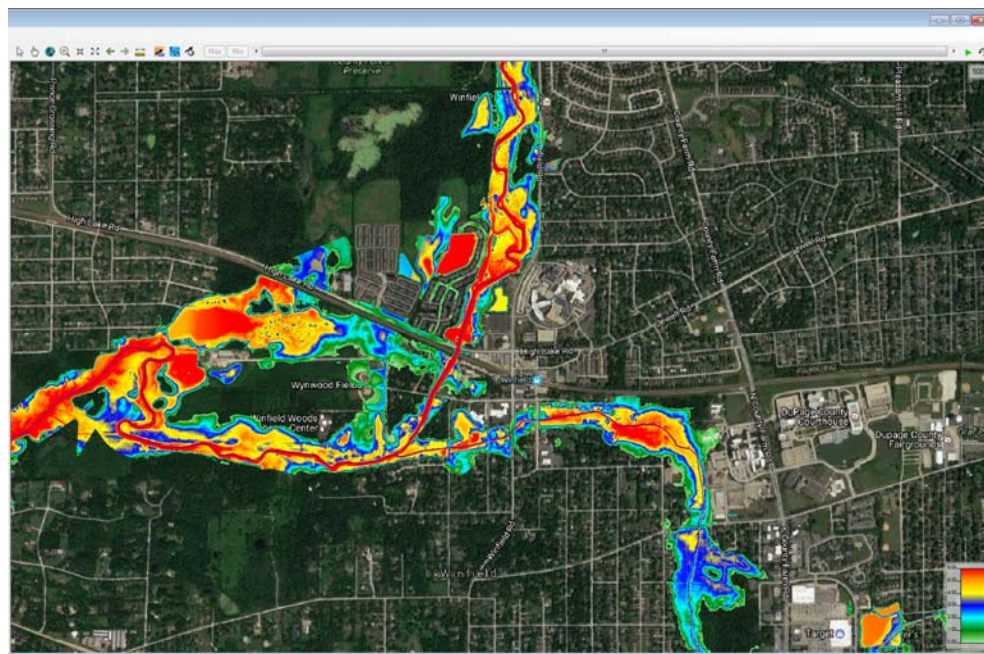


What Are We Working on Now?



Peak Flood Depth Maps

- Static map by watershed
- Peaks of all hydrographs at various times combined
- Flood depths computed from water surface elevations subtracted from Digital Elevation Model
- Conveys severity of extents and depths of flooding for disaster response and recovery



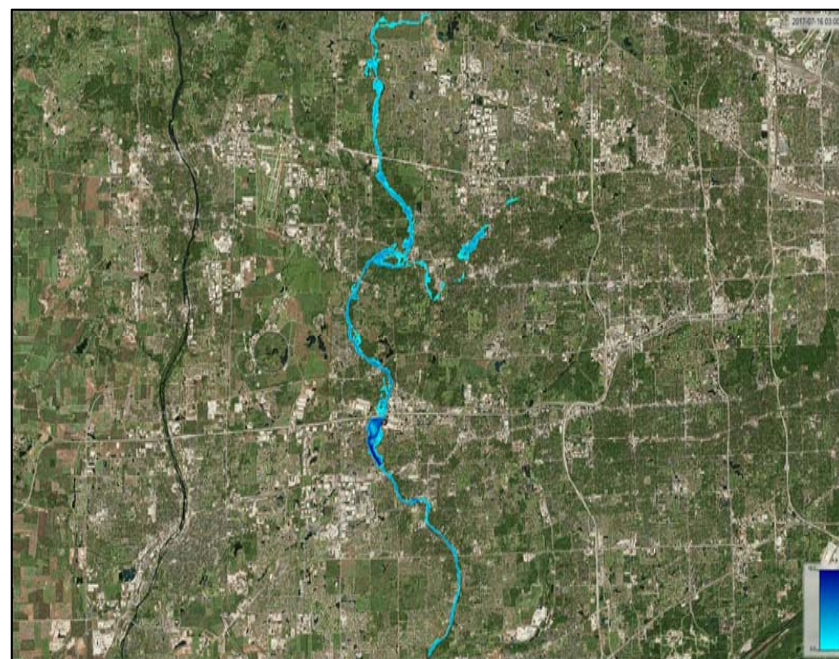
Proof of concept – not actual event Winfield / Wheaton

What Are We Working on Now?

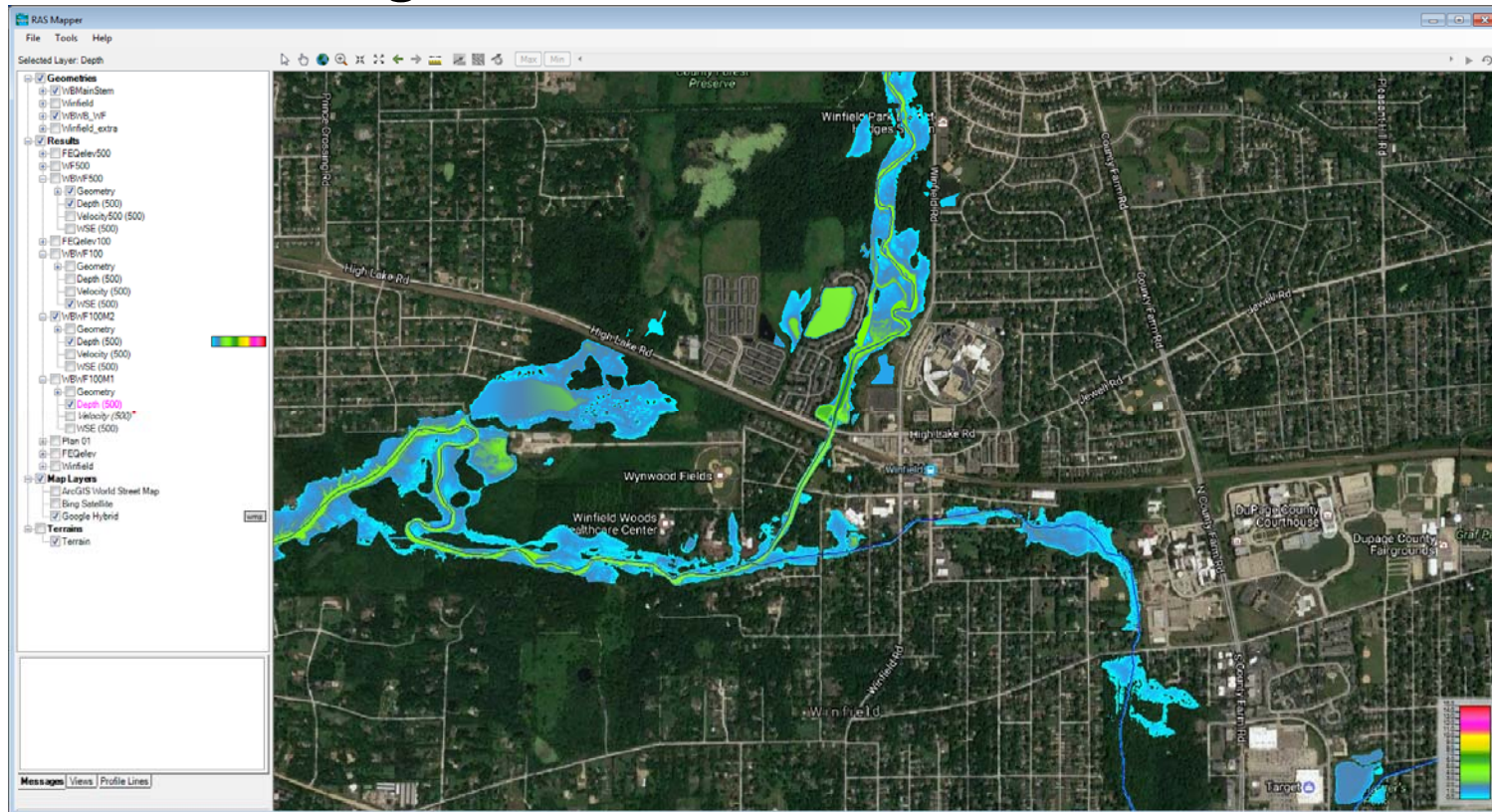


Real Time Flood Inundation Maps

- Dynamic maps at each 6-hour time-step from the current condition through the 72-hour forecast
- By watershed – not limited area around gages
- Each flood forecast and set of inundation maps are unique depending on:
 - the current river levels,
 - how much rain falls, and
 - where the rain falls

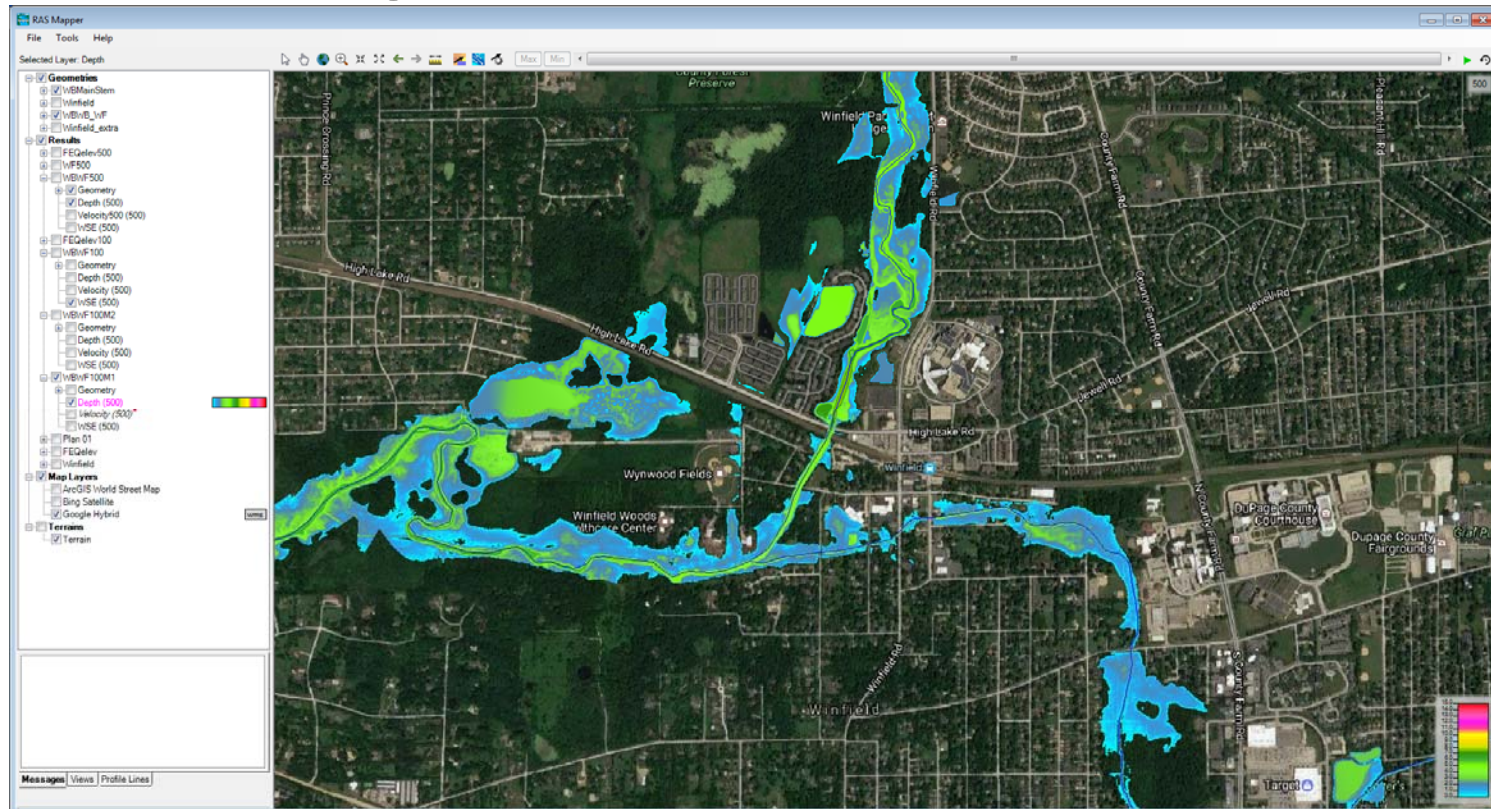


West Branch DuPage River and Winfield Creek – Current Condition



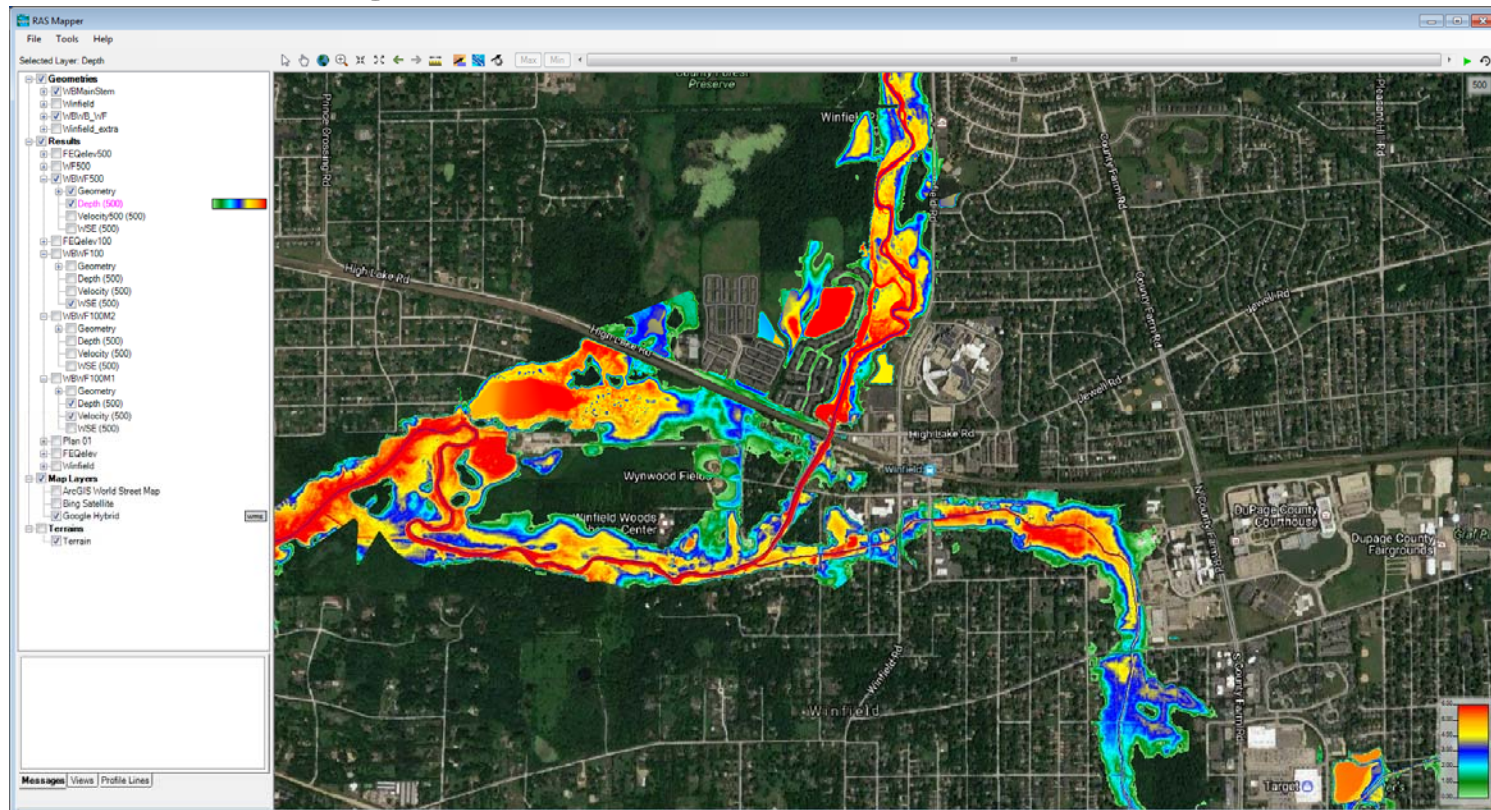
Proof of concept – not actual event

West Branch DuPage River and Winfield Creek – +6 Hour Condition



Proof of concept – not actual event

West Branch DuPage River and Winfield Creek – +12 Hour Condition



Proof of concept – not actual event



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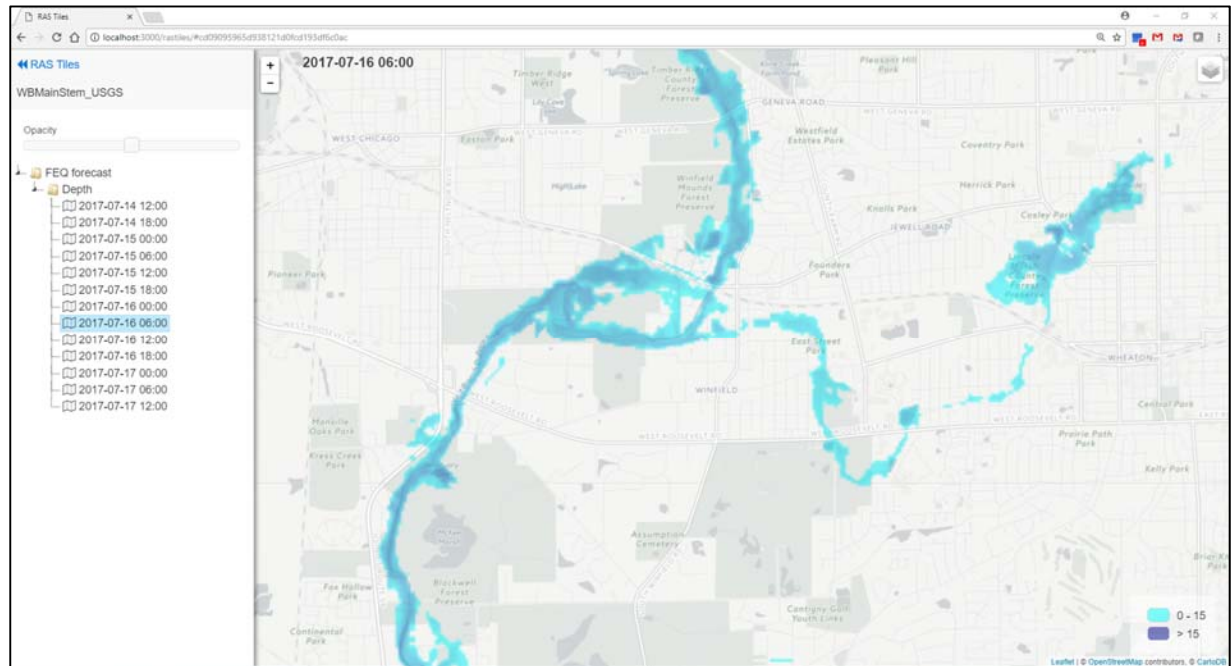
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What Are We Working on Now?



Dynamic Flood Inundation Maps

- Web based maps
- Zoom in / out
- By forecast time periods (6-hour time steps)



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Where Are We Going?



Real Time Animated Flood Inundation Maps and Features

- Animated maps and features from the current condition through the 72-hour forecast
- Work in progress – may require detailed HEC-RAS models (hydraulic structures)
- No timeline established to complete this portion



Where Are We Going?



Animated Maps

- Animation of flood depths showing flood forecast at hourly time steps over 72 hours in future

Modeling to be utilized for internal demonstration purposes only.



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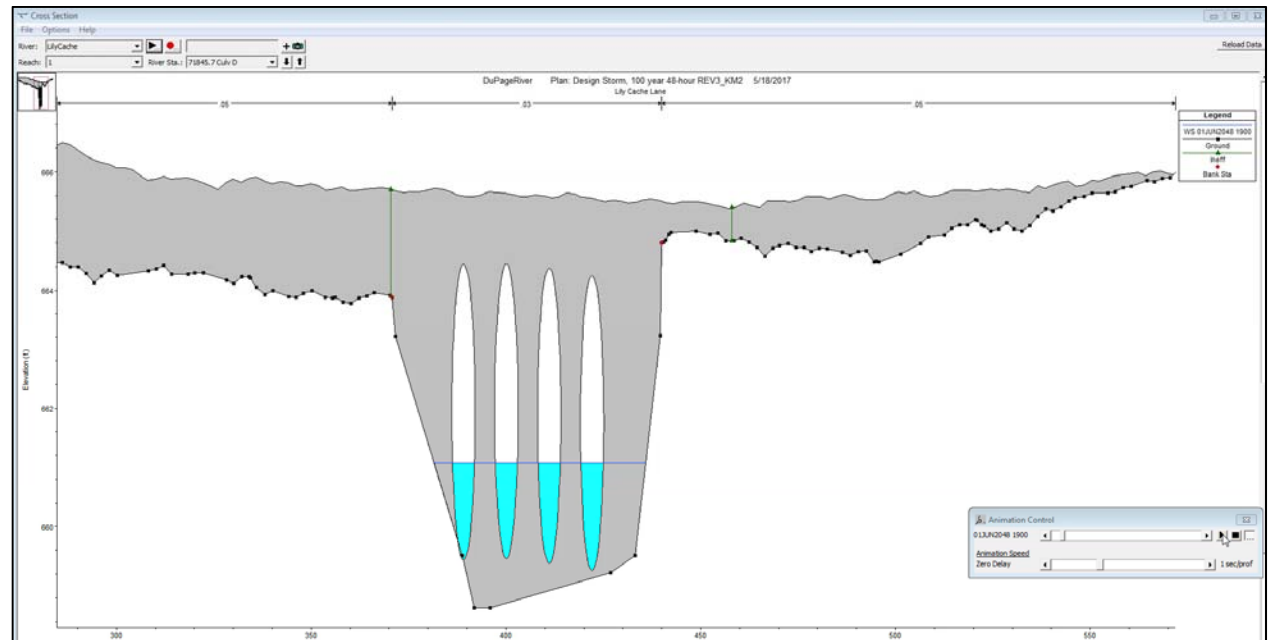
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Where Are We Going?



Animated Features

- Animated cross-sectional view showing the water surface elevation at a particular road crossing



Modeling to be utilized for internal demonstration purposes only.



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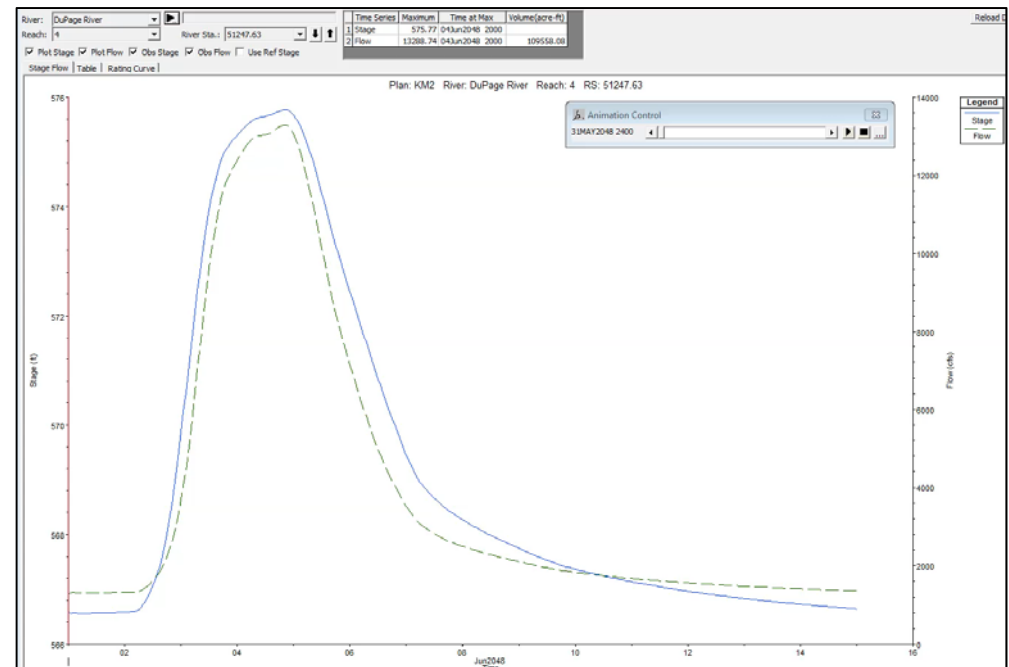
STORMWATER MANAGEMENT

Where Are We Going?



Animated Features

- Animated hydrographs



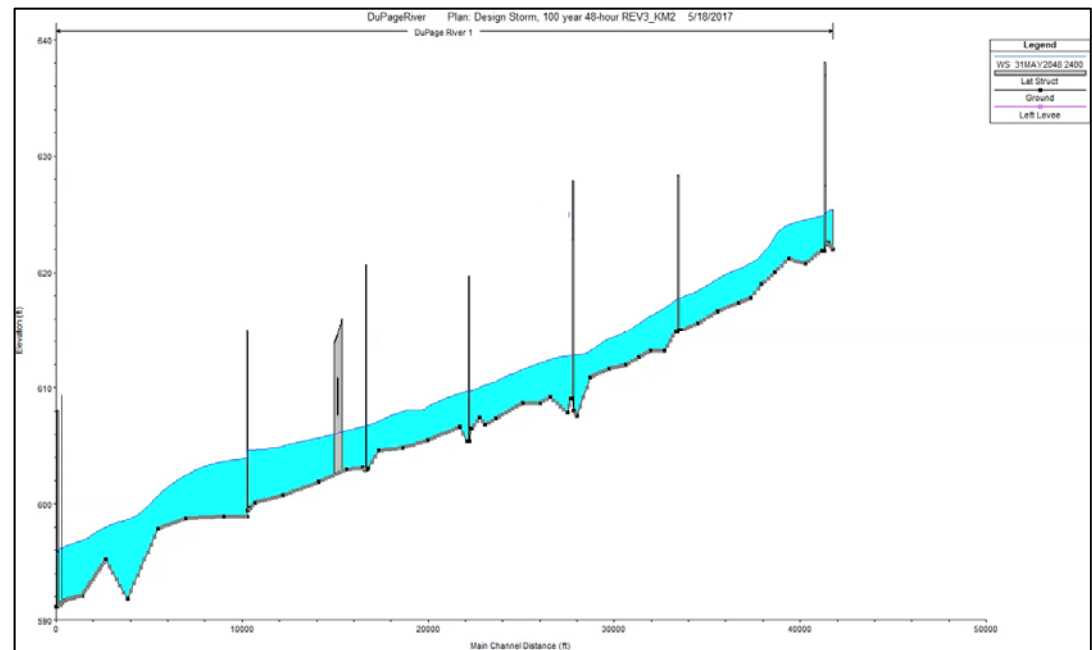
Modeling to be utilized for internal demonstration purposes only.

Where Are We Going?



Animated Features

- Animated flood profile



Modeling to be utilized for internal demonstration purposes only.



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Applications and Users



Applications

- Flood control operations
- Resource allocation and placement
- Evacuations
- Road closures
- Emergency vehicle routing
- Credit for Community Rating System (CRS) program
- Damages documentation for disaster assistance

Users

- DuPage County Stormwater Department
- DuPage County Office of Emergency Management
- DuPage County DU-COMM
- Public Works Departments
- Transportation Departments
- First responders (fire, police)
- Critical facilities (i.e., hospitals)
- Municipalities
- Businesses and residents



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STORMWATER MANAGEMENT

Contributors



U.S. Geological Survey (USGS)

*USGS Central Midwest Water Science Center
in Urbana, Illinois*

- Flood forecasting simulations
- Mapping
- Animations

U.S. Army Corps of Engineers Chicago District

- Conversion of FEQ output into HEC-RAS compatible format
- HEC-RAS Mapper
- Animated maps and features examples



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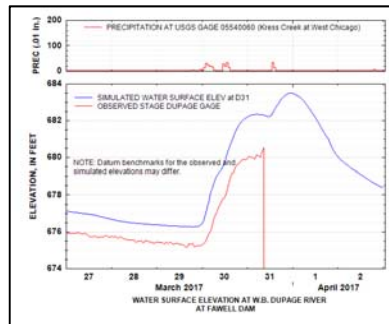
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Summary

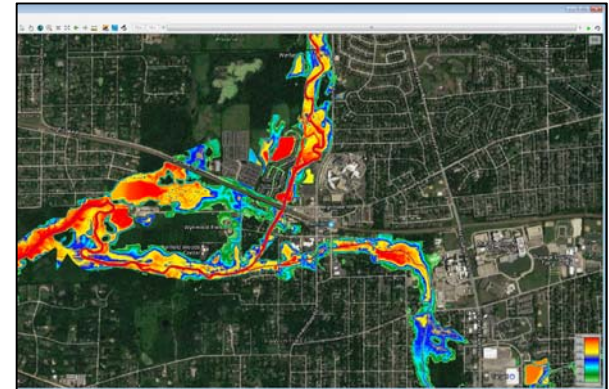


Flood Inundation Maps

- Translate observed and simulated water surface elevations onto maps
- Maps provide more information than hydrograph plots
- Dynamic and animated maps
- Zoom to any point in the watershed
- Web based maps support decision-making for multiple users



Vs.



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STORMWATER MANAGEMENT

Questions / Contact Information



Questions?



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