

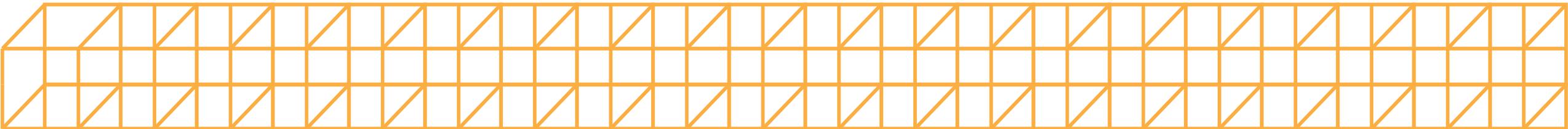


OKLAHOMA
Water Resources Board



Advancing Flood Risk Mapping in Oklahoma

A 2D BLE Modeling Approach through the FEMA CTP Program



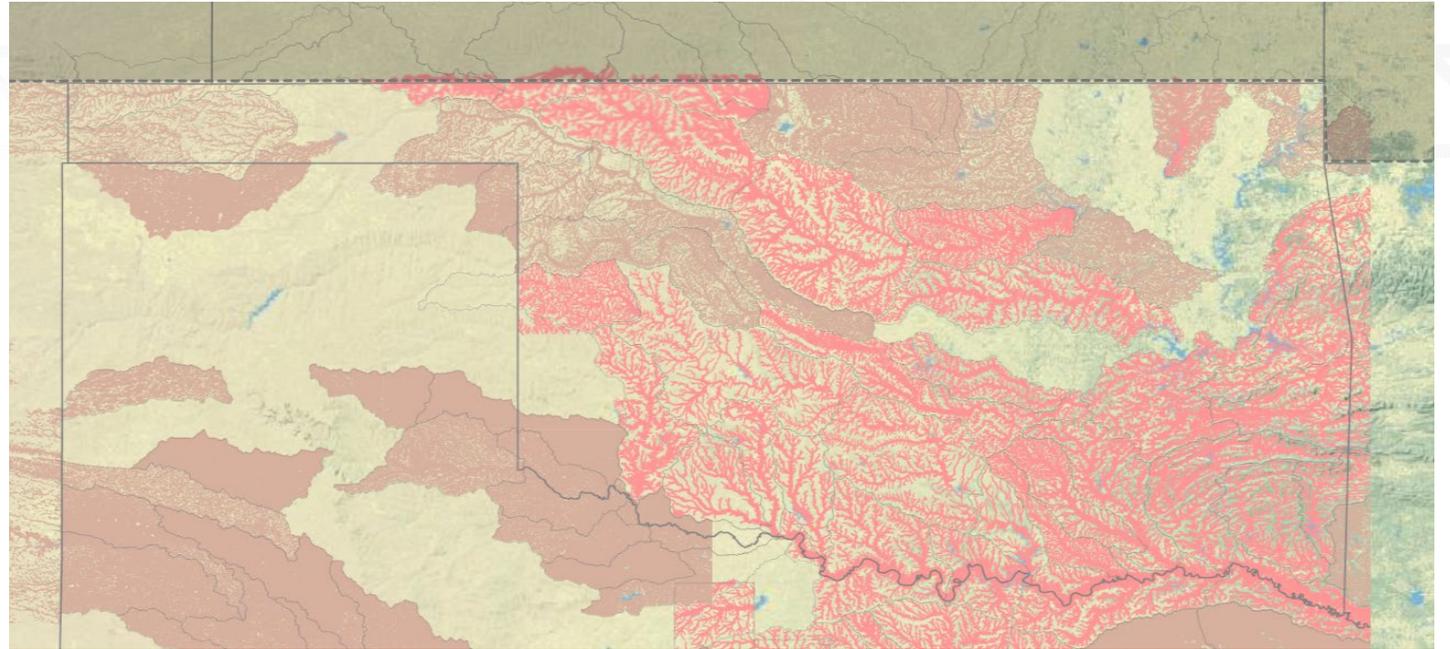
1D vs. 2D BLE MODELING

1D BLE

- Linear, channel-based mode that accurately models hydraulic structures
- Simple to modify to assess project impacts
- Poor approximation of wide floodplains and undefined flowpaths
- May miss flooding along smaller tributaries and flat terrain

2D BLE

- Better for large areas
- Simulates all flooding sources within a watershed in one model
- More accurately shows shallow overbank flows, wide floodplains, and split channel flows
- May require more calibration effort



BLE Components



1 Terrain Data

- High resolution digital terrain data
- Terrain modifications

2 Hydrologic Inputs

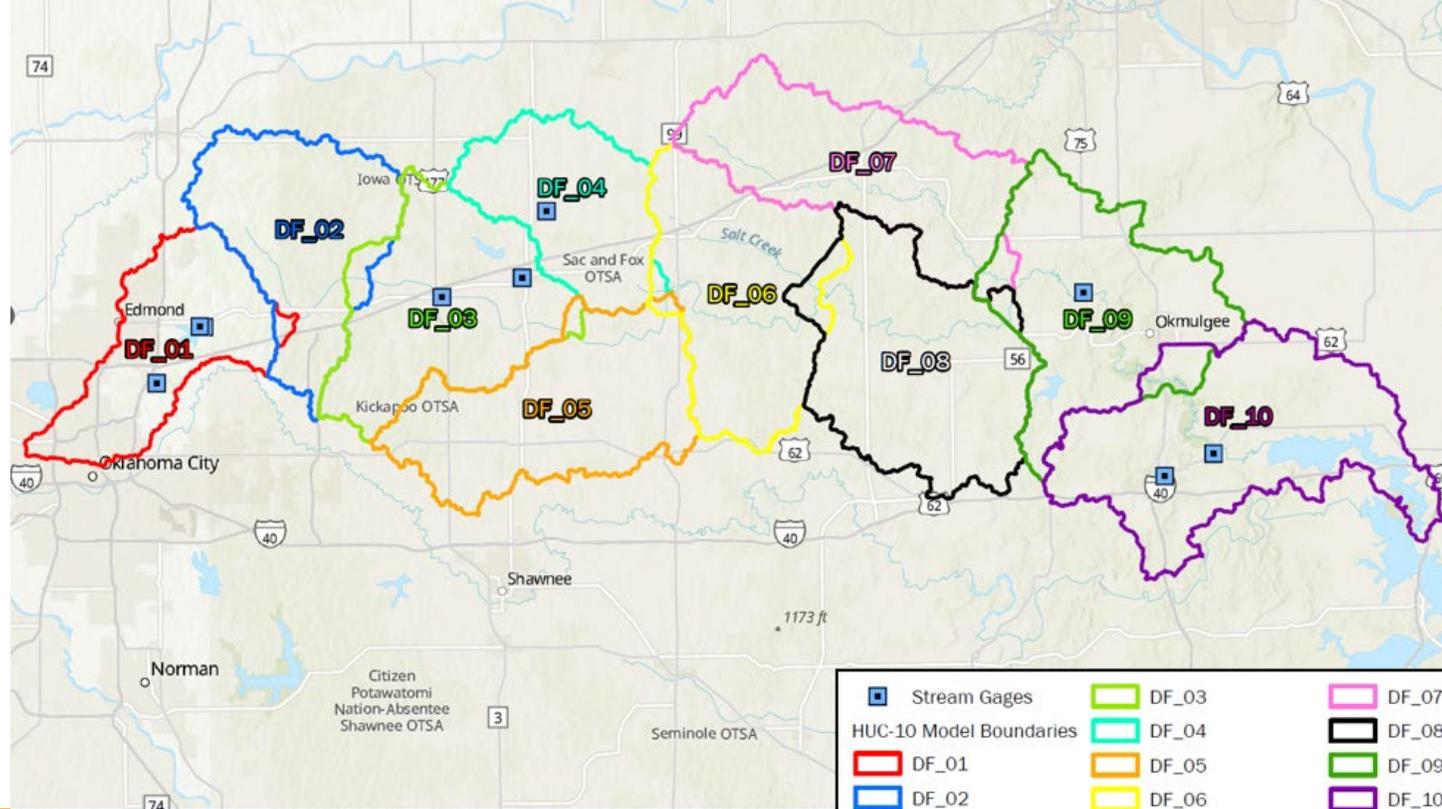
- Rainfall
- Flow Hydrographs from Upstream Basins

3 Hydraulic Modeling

- Computational mesh
- Manning's N
- Mesh enforcement
- Boundary Conditions
- Breaklines
- Infiltration

4 Floodplain Maps

- Depth & velocity grids
- Water surface elevation (WSE) grids
- Floodplain Boundaries



Case Study: Deep Fork Watershed

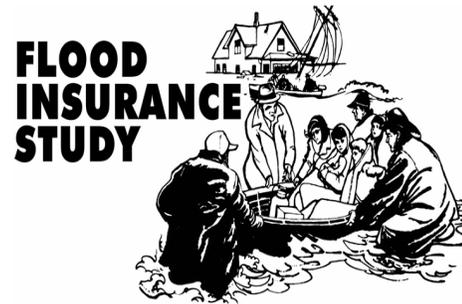
- Urbanized area upstream
- Largely rural throughout
- Discharges to Eufaula Lake
- Approx. 2500 sqmi
- 10 HUC10 basins
- 4 LiDAR sources
- 46 cities
- 9 counties
- 4 Tribal Nations

HYDROLOGY

3 Sources Used for Comparison and Calibration:



StreamStats



OKMULGEE COUNTY,
OKLAHOMA
AND INCORPORATED AREAS



Community Name	Community Number
BEGGS, CITY OF	400345
DEWAR, TOWN OF	400143
GRAYSON, TOWN OF	400568
HENRYETTA, CITY OF	400144
HOFFMAN, TOWN OF	400255
LIBERTY, TOWN OF	400547

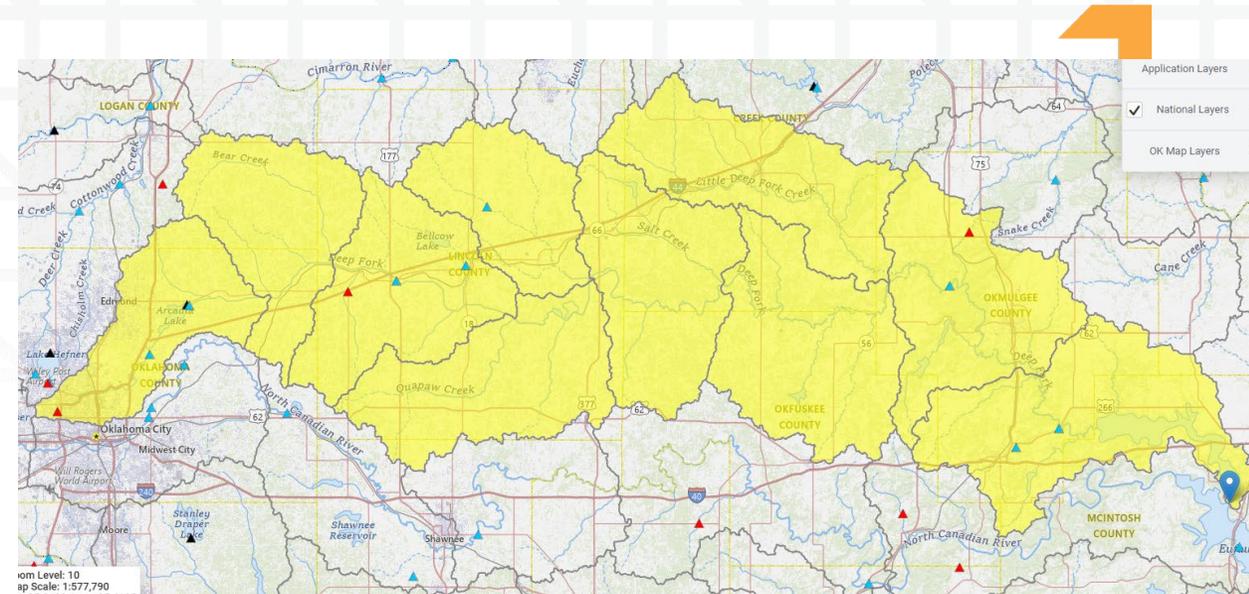
FIS Data



Gage Data

StreamStats & Regression Analysis

- USGS tool for watershed delineation & flow statistics
- Best for ungaged locations
- Quick & accessible
- High uncertainty, limited by available data
- Regression analysis does not account for unique local conditions or changes
- Assumes basins in the region behave similarly



USGS Regression Analysis: Region 2		
Frequency (Return Period)	Equation	Flow (CFS)
2-year	$Q_{50\%} = 61.6(\text{CSL10_85fm})^{0.40} (\text{CONTDA})^{0.75}$	20,096
5-year	$Q_{20\%} = 97.7(\text{CSL10_85fm})^{0.44} (\text{CONTDA})^{0.77}$	38,606
10-year	$Q_{10\%} = 126(\text{CSL10_85fm})^{0.46} (\text{CONTDA})^{0.78}$	54,796
25-year	$Q_{4\%} = 174(\text{CSL10_85fm})^{0.47} (\text{CONTDA})^{0.78}$	76,640
50-year	$Q_{2\%} = 204(\text{CSL10_85fm})^{0.50} (\text{CONTDA})^{0.79}$	100,158
100-year	$Q_{1\%} = 240(\text{CSL10_85fm})^{0.50} (\text{CONTDA})^{0.79}$	117,833
500-year	$Q_{0.2\%} = 363(\text{CSL10_85fm})^{0.51} (\text{CONTDA})^{0.80}$	193,666

FIS Flow Data

- Developed in previous FIS or regulatory mapping efforts
- Provides peak discharges for specified return periods
- Based on the best available data and methods at the time of the study
- Often conservative by design

Table 4: Summary of Discharges (cont.)

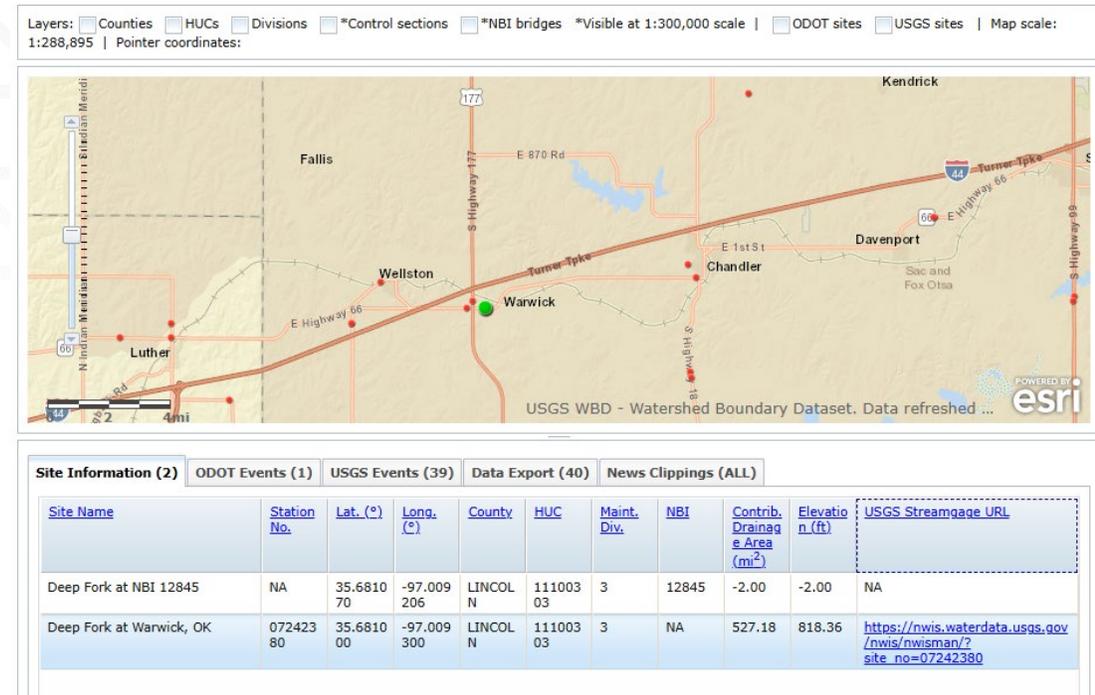
<u>Flooding Source and Location</u>	<u>Drainage Area (Square Miles)</u>	<u>Peak Discharges (Cubic Feet per Second)</u>			
		<u>10-percent</u>	<u>2-percent</u>	<u>1-percent</u>	<u>0.2-percent</u>
DEEP FORK					
At U.S. Highway 66	242.00	14,300	28,500	35,400	54,500
At Oklahoma/Lincoln County boundaries	161.20	*	*	37,500	*
At confluence of Opossum Creek	145.73	13,021	22,550	26,312	44,203
Just downstream of confluence with Coffee Creek	144.90	12,940	22,309	26,334	44,421
At confluence with Coffee Creek ¹	103.62	4,081	6,602	7,889	11,148
Approximately 1,500 feet downstream of Westminster Road ¹	102.88	3,784	5,919	6,885	10,081
Approximately 1,500 feet downstream of Post Road	99.41	2,796	3,688	4,075	5,289
At Post Road ¹	99.10	2,524	3,151	3,421	4,268
Approximately 1,500 feet downstream of Arcadia Dam ¹	98.70	2,217	2,534	2,652	3,050
At Douglas Boulevard	70.40	12,100	20,300	24,700	34,800
At Eastern Boulevard	28.20	10,800	16,000	18,500	24,400
At Broadway Extension	21.40	8,820	12,770	14,780	19,550
At Northwest Highway at Belle Isle Lake	9.88	5,700	8,130	9,330	12,170
At Interstate 44	7.46	4,890	6,980	8,025	10,415
At Youngs Avenue	7.35	4,850	6,910	7,950	10,320
At Northwest 39th Street	5.88	4,280	6,110	7,030	9,115
At Venice Avenue	4.90	3,780	5,400	6,200	8,033
At Drexel Boulevard	4.02	3,100	4,500	5,200	6,800
At Portland Avenue	3.19	2,710	3,930	4,530	5,970
At North Meridian Avenue	1.68	1,780	2,570	2,960	3,880

* Data Not Available

¹Discharges influenced by Arcadia Lake storage.

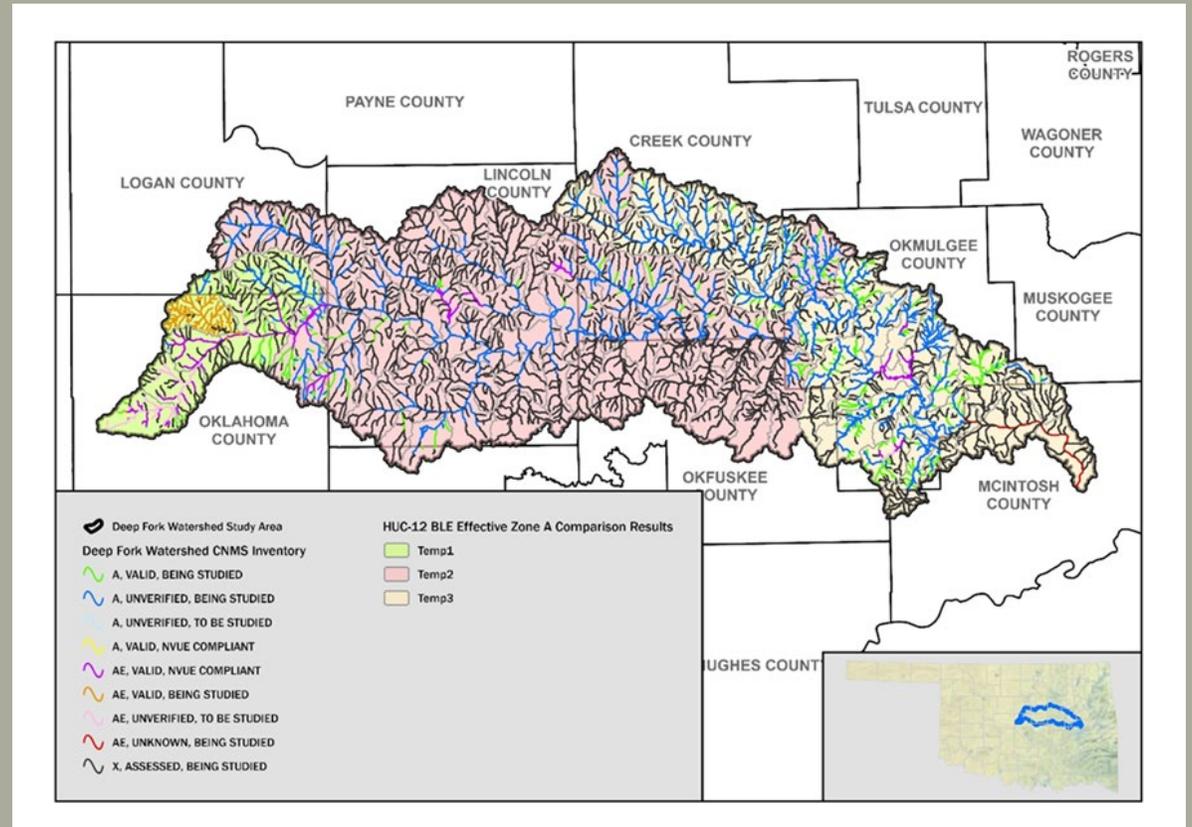
Gage Data

- Based on observed flow at a specific site
- Reflects actual conditions and watershed response
- Requires a long, high-quality record of data
- Limited coverage
 - Only 4 sites in the Deep Fork Watershed



Gage ID	Flooding Source and Location	Published Drainage Area (Sq Mi)	Period of Record
7243000	Dry Creek near Kendrick, OK	68.37	1956 - 1994
7242350	Deep Fork River near Arcadia, OK	100.67	1970 - 1993
7242380	Deep Fork River at Warwick, OK	527.15	1984 - 2023
7243500	Deep Fork River near Beggs, OK	2004.3	1939 - 2023

Building the Model

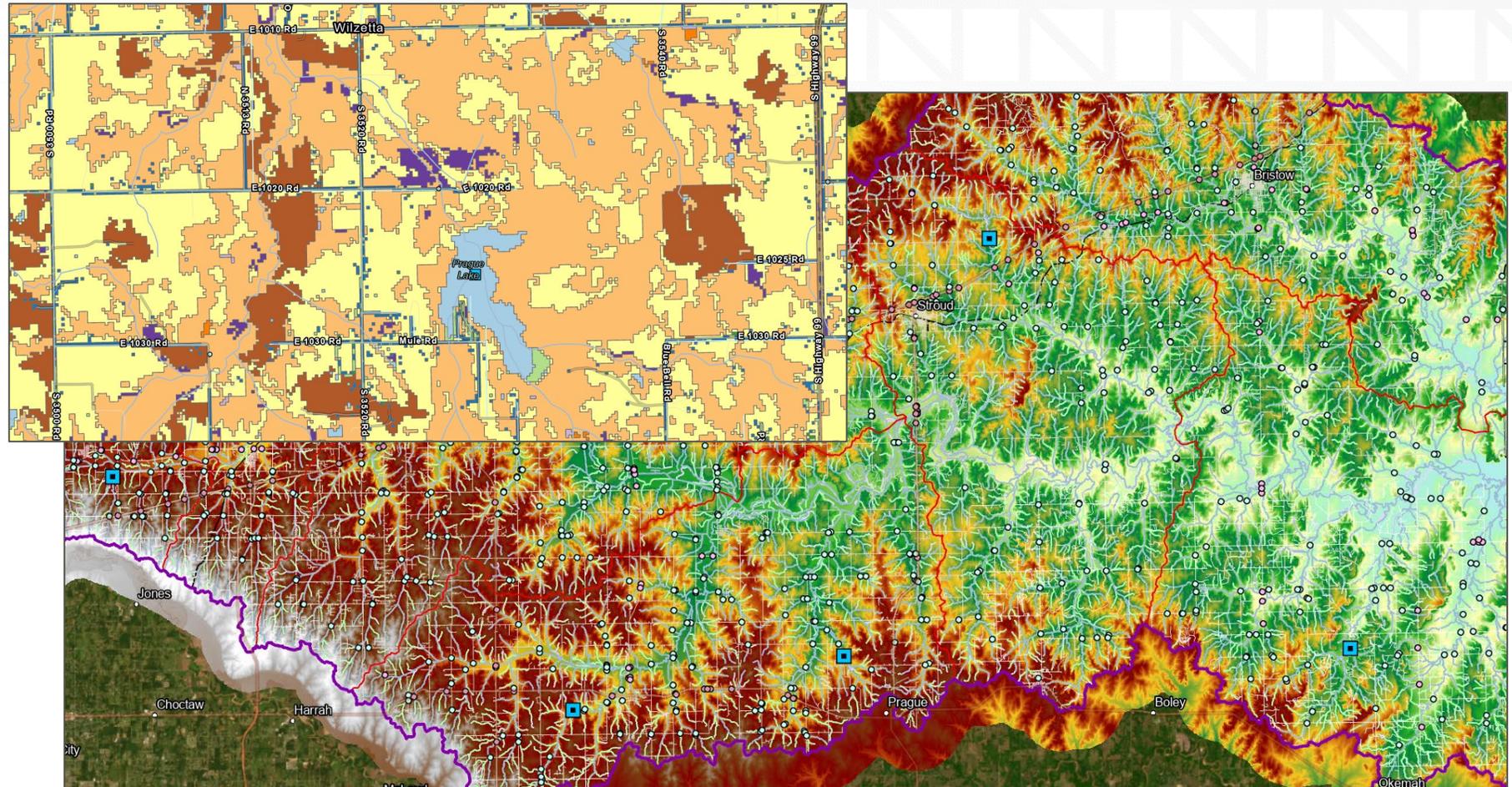


Leverage GIS Data

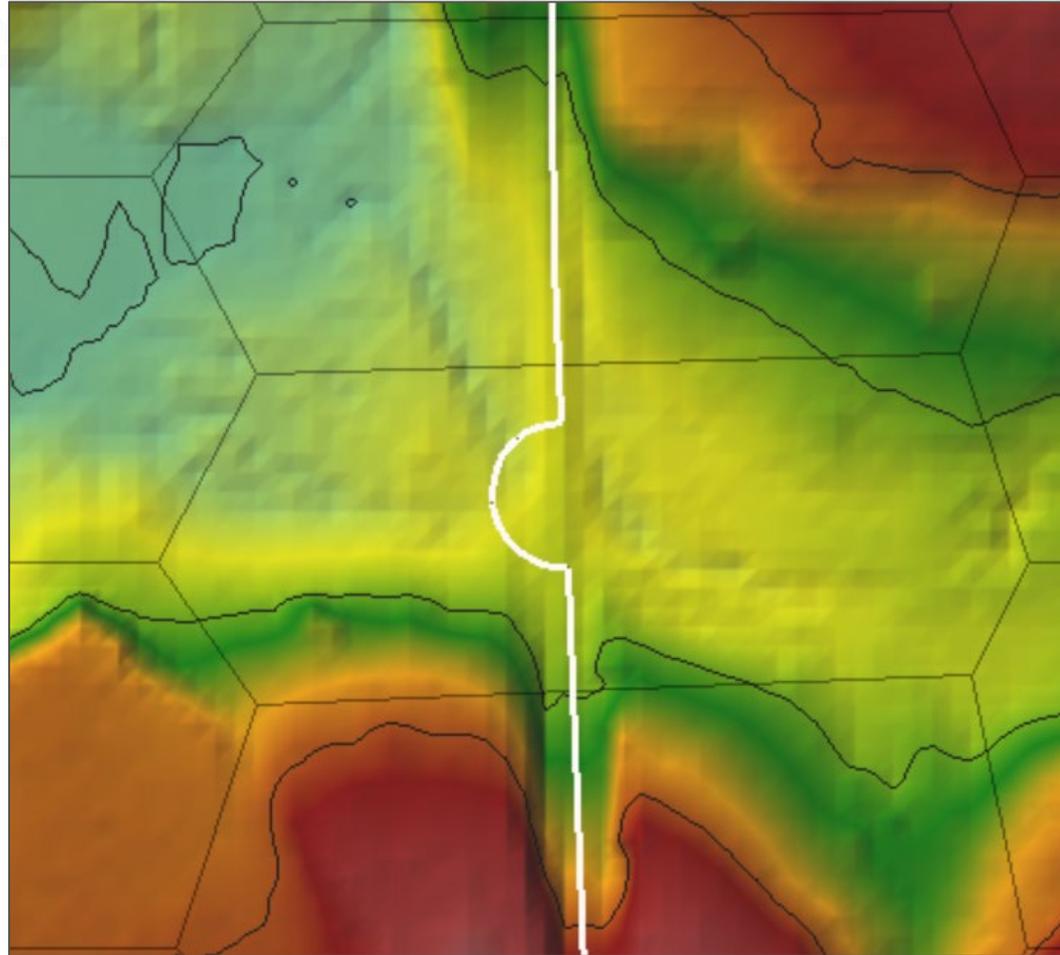


Pre-existing GIS Layers:

- Terrain (USGS)
- HUC basins (USGS)
- Streams (NHD)
- Roads (TIGER)
- Culverts & Bridges (ODOT)
- Railroads (ODOT)
- National Land Cover Dataset
 - Mannings & Infiltration
- Soils (USDA)
- Building Polygons (Microsoft)



Manual Edits

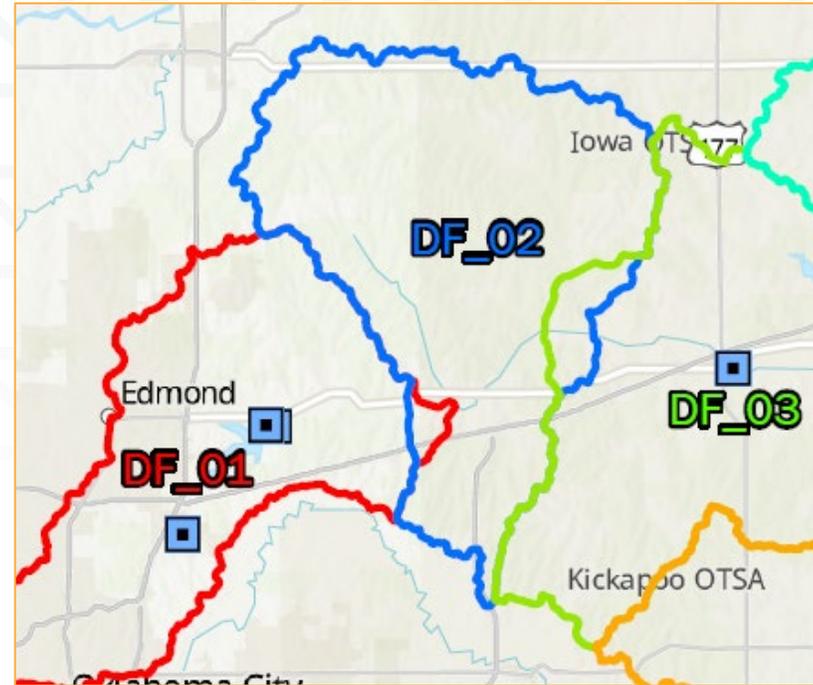


- Terrain Modifications
 - Normal pools at lakes
 - Known culverts
- Cell face edits at unknown culverts
- Mannings
 - Streams classified into Small, Medium, Large
 - Buffered manning's width
- Lake outlet ratings
- Some manual breaklines at key locations

Managing the Models

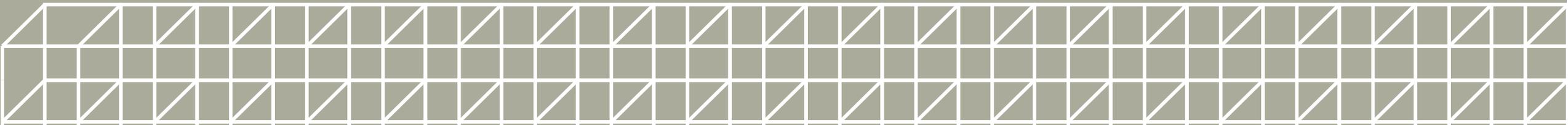
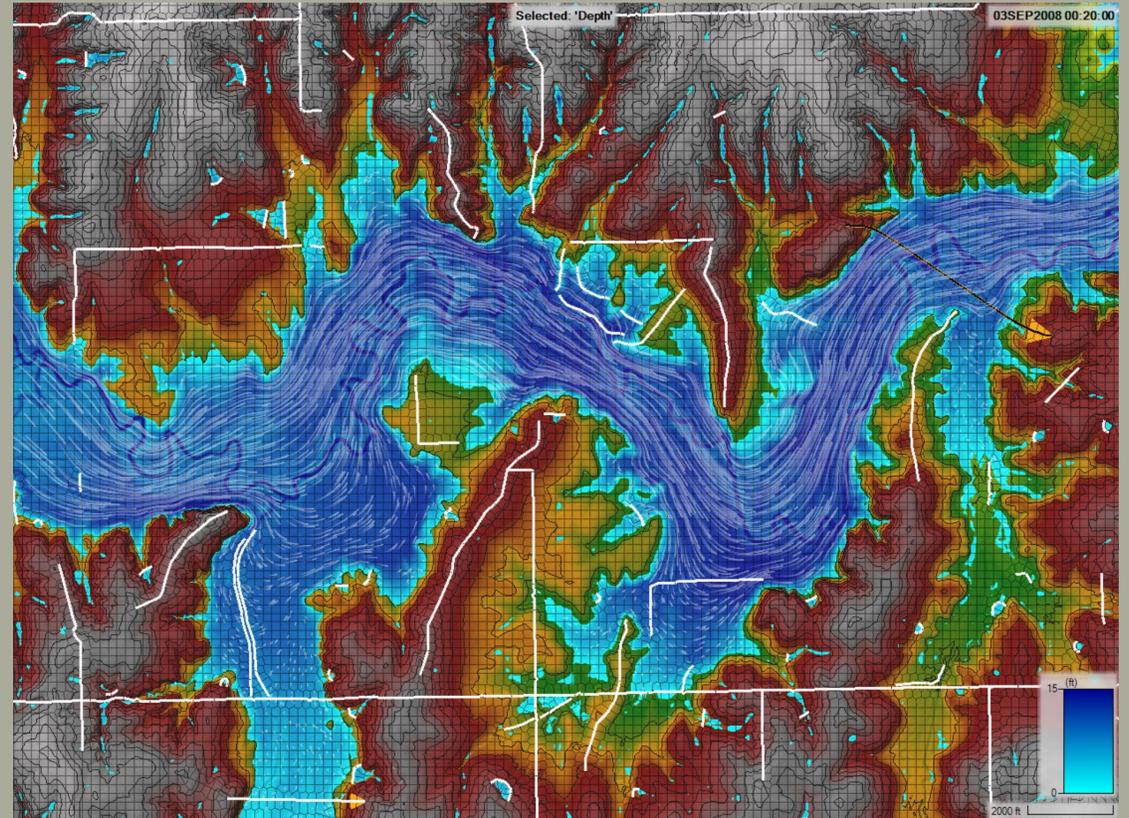
- Teamwork
- Divided the watershed into 10 separate 2D models
- Basin overlaps
- Scripting to automate applying and extracting flows

- 24-hour Storm Event – 13 days to drain.
- Over 1.6 million cells
- Total runtime ~ 7,350 minutes (122.5 hours)

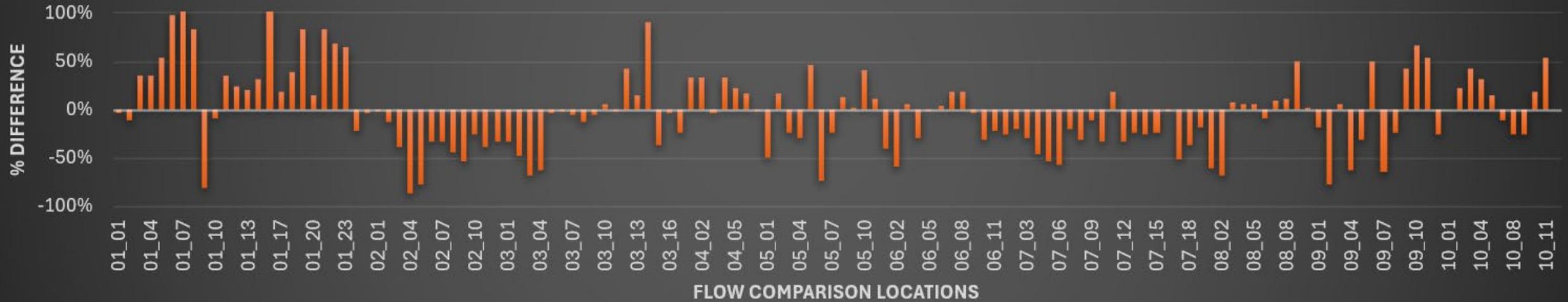


Basin	Cell Count
Basin 1: Lake Arcadia- Deep Fork of Canadian River	137,185
Basin 2: Bear Creek-Deep Fork of Canadian River	157,723
Basin 3: Chandler Lake-Deep Fork of Canadian River	175,817
Basin 4: Dry Creek	120,186
Basin 5: Quapaw Creek	180,984
Basin 6: Salt Creek-Deep Fork of Canadian River	184,698
Basin 7: Little Deep Fork	178,342
Basin 8: Okemah Lake-Deep Fork of Canadian River	210,404
Basin 9: City of Okmulgee-Deep Fork of Canadian River	199,699
Basin 10: Outlet Deep Fork of Canadian River	231,214
Total	1,639,067

— Calibration & Results



100 -year Flow Comparisons: BLE Model vs Hydrology Estimates



Calibration Line ▾

Calibration

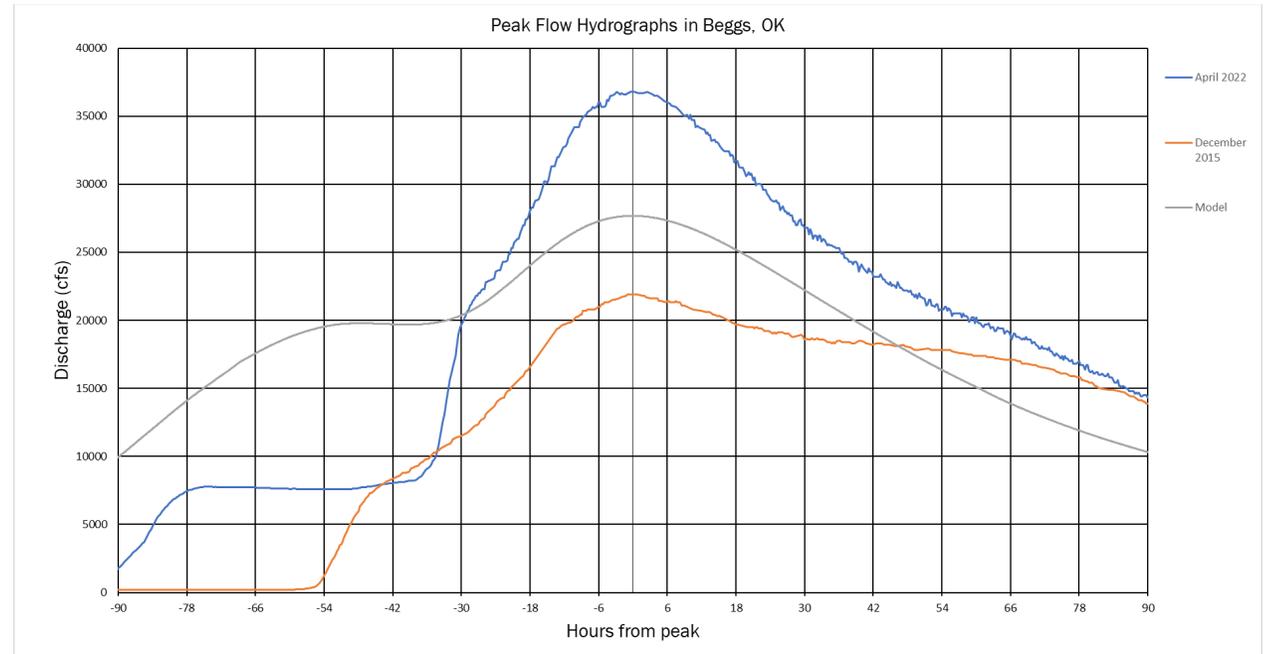
- Curve Numbers
- Storm Area Reduction
- Infiltration

Watershed ▾	Contributing DA ▾	Stream_Size ▾	Stream ▾	Method ▾	Calibration Line ▾	Flow Rate (cfs)
DF01	1.71	Small	Deep Fork	FIS	01_01	2960
DF01	5.95	Small	Deep Fork	FIS	01_02	7030
DF01	9.92	Small	Deep Fork	Regression	01_03	7080
DF01	13.89	Large	Deep Fork	FIS	01_04	9330
DF01	21.26	Large	Deep Fork	FIS	01_05	14780
DF01	37.38	Large	Deep Fork	Regression	01_06	16600
DF01	62.31	Large	Deep Fork	Regression	01_07	21800
DF01	71.05	Large	Deep Fork	Regression	01_08	22700
DF01	100.78	Large	Deep Fork	FIS	01_09	3421
DF01	147.25	Large	Deep Fork	FIS	01_10	26334
DF01	3.51	Large	Deep Fork	Regression	01_11	4670
DF01	2.47	Small	Deep Fork Trib	Regression	01_12	2940
DF01	4.47	Small	Deep Fork Trib	Regression	01_13	4460
DF01	5.71	Small	Harrison	Regression	01_14	4240
DF01	10.21	Small	Harrison	FIS	01_15	4350

BLE Limitations & Uncertainty

Hydrology

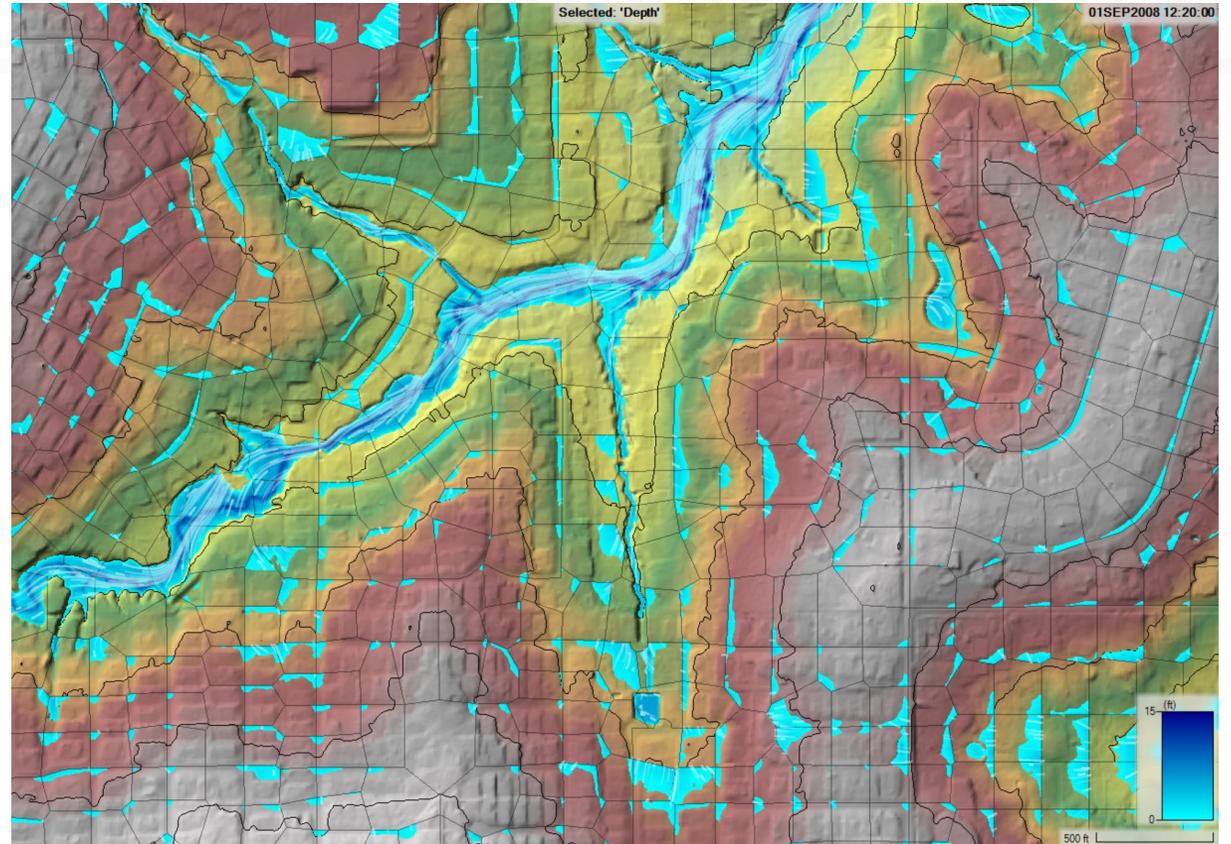
- Assumed equal distribution of rainfall
 - Storm Area Reduction Factors
- 24-hour storm duration
- Comparing to various hydrologic methods with their own uncertainties
 - Regression
 - Gage Analysis
 - FEMA FIS



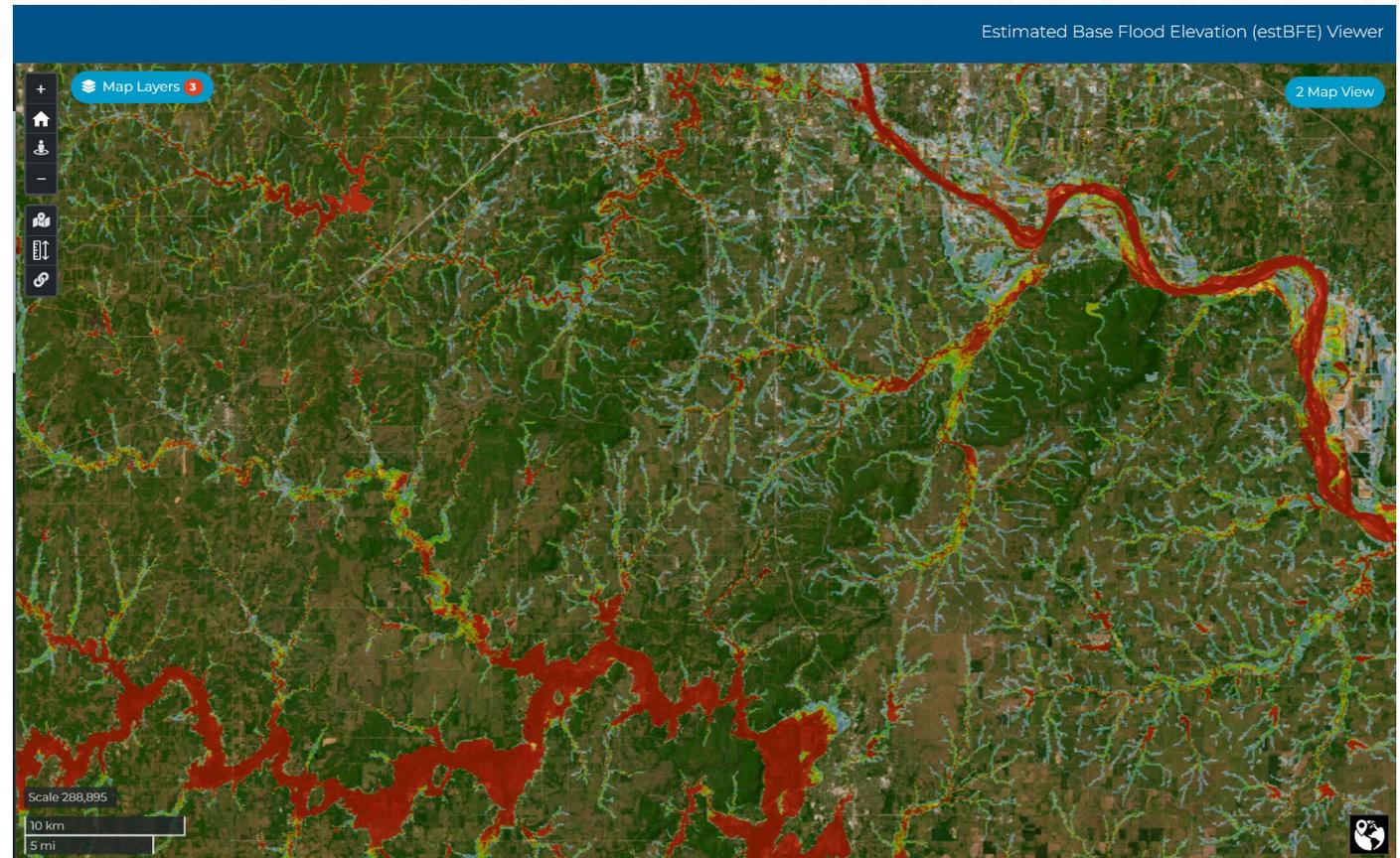
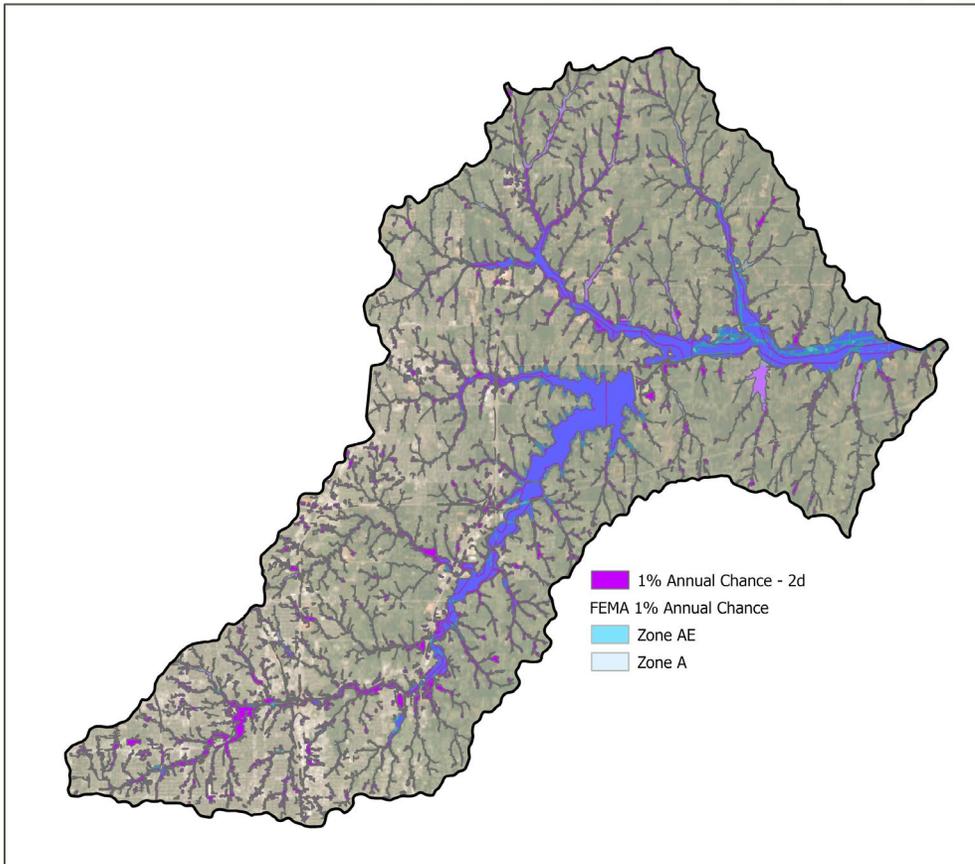
BLE Limitations & Uncertainty

Hydraulics

- The smaller the stream, the less detail and more room for error
- No detailed 2D bridges or culvert hydraulics

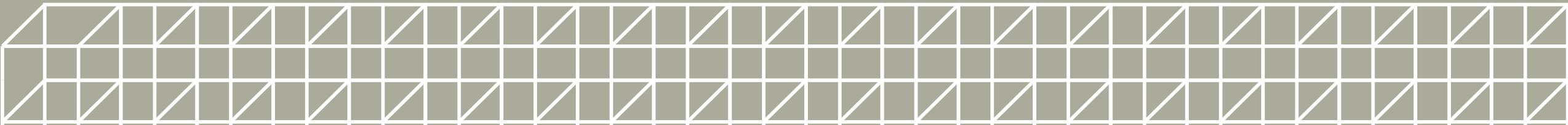


Mapping





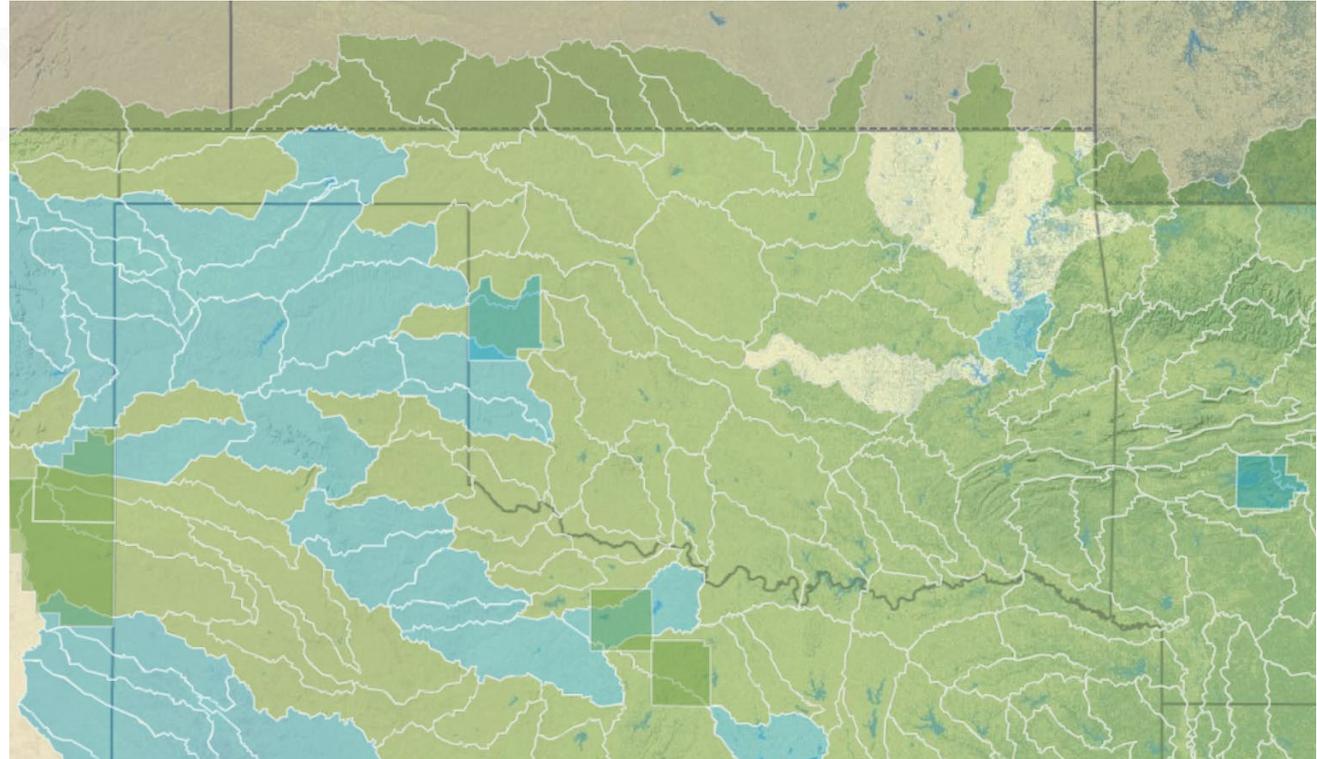
Applications for Communities



When to Use Base Level Engineering

BLE datasets can be used to inform a host of planning decision and activities that can lead to a stronger and more resilient community, including:

- Hazard Mitigation Planning
- Floodplain Management,, Development Review, Permitting
- Community Planning, Land Use, Zoning
- Emergency Management
- Flood Insurance Rating
- Letters of Map Change (LOMC)
- Risk Communications





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THANK YOU

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