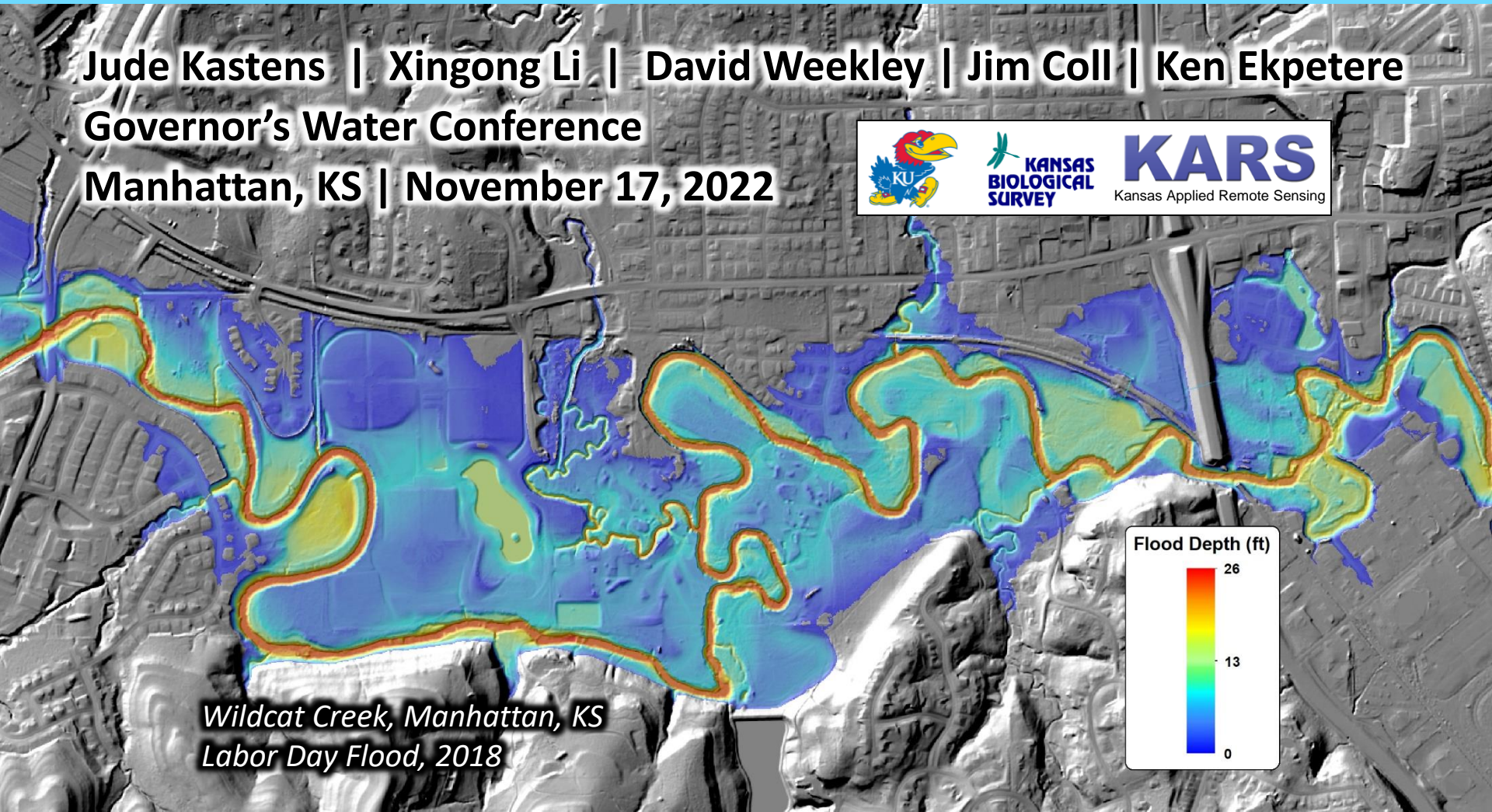


It's Finally Here...

A Live Flood Mapping Tool for Kansas

Jude Kastens | Xingong Li | David Weekley | Jim Coll | Ken Ekpeterere
Governor's Water Conference
Manhattan, KS | November 17, 2022



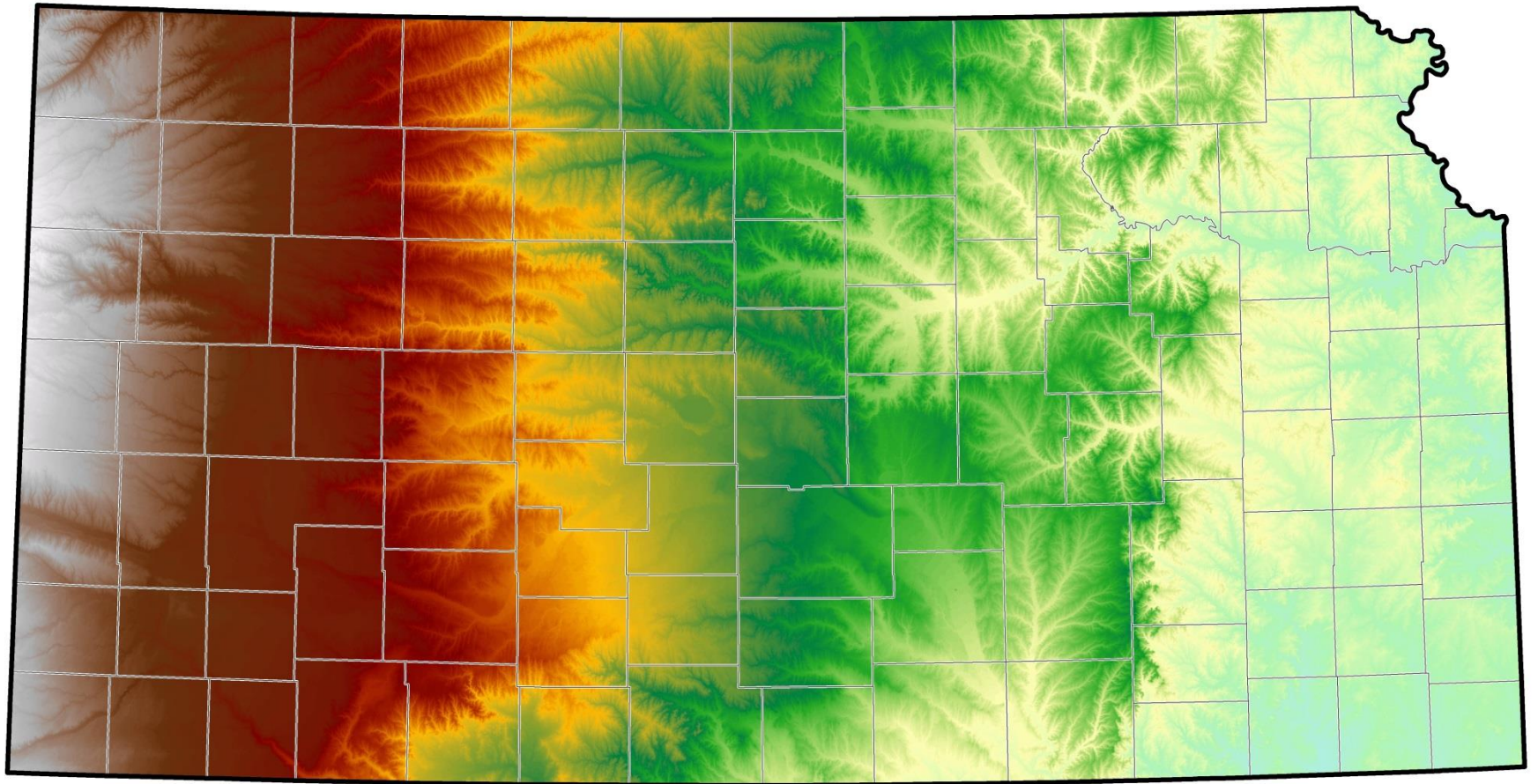
*Wildcat Creek, Manhattan, KS
Labor Day Flood, 2018*



Republican River Flood Crest
Stratton, NE
July 26, 2020



Elevation



Feet

4036

3500

3000

2500

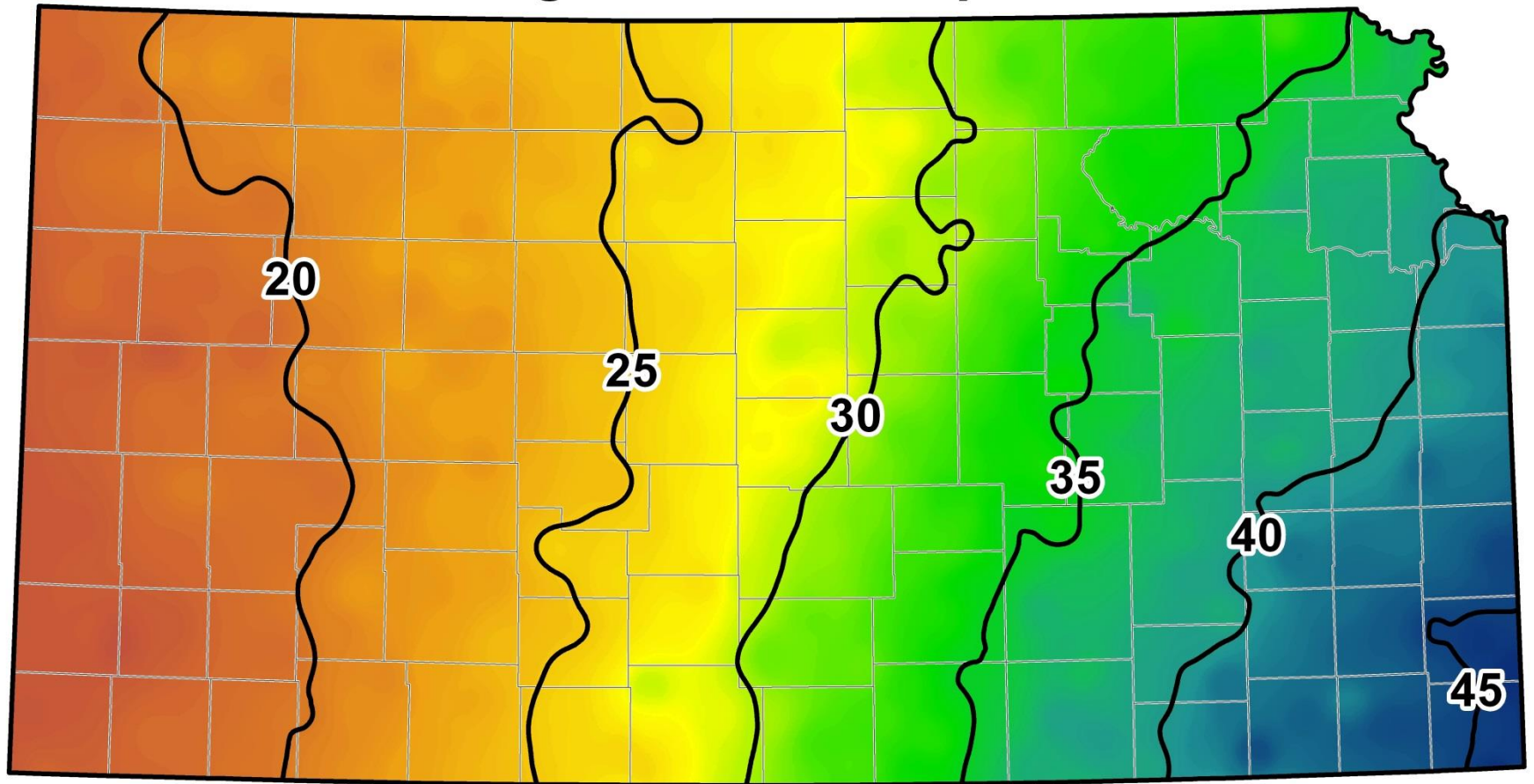
2000

1500

1000

675

Average Annual Precipitation (1981-2010)



Inches

16

20

24

28

32

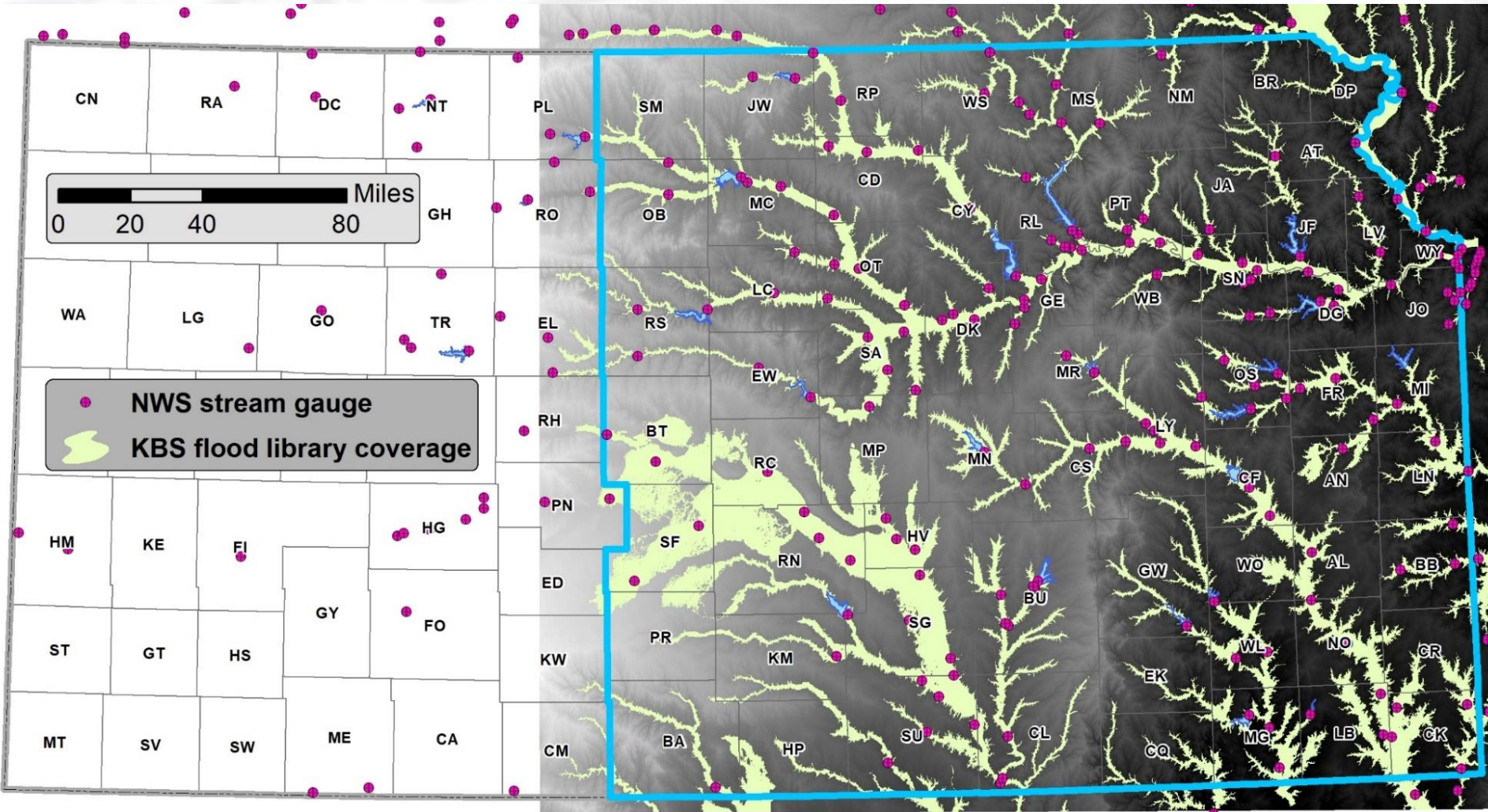
36

40

44

46

Kansas Inundation Library Coverage



Background



- Inundation library coverage developed for gaged stream network spanning greater eastern Kansas (GIS-PB funding 08, 09, 11, 13)
- Library put into action during record 2019 flooding
- Funding for mapping tool development provided by KWO (2020-2023) & KDEM (2020)
- Work in progress
 - More enhancement to come
 - Tool could provide foundation for broader functionality related to water and/or emergency information

Kansas Flood Mapping Dashboard

Kansas Flood Mapping Dashboard

arcgis.com/apps/dashboards/dfa979db9f6f44fd8694bb1e9f53623a

Bookmarks KU ESRI Google Earth Engine Pangeo NASA Earthdata Python TrendySnow Water-Snow Other bookmarks

Kansas Flood Mapping Dashboard

Gauge List (sorted by flood status)

- No Flooding: Pottawatomie Creek at Lane (LNEK1)
- No Flooding: Fall River at Fredonia (FRNK1)
- No Flooding: Neosho River at Chanute (CNUK1)
- No Flooding: Verdigris River

Last update: 8 seconds ago

1 of 10

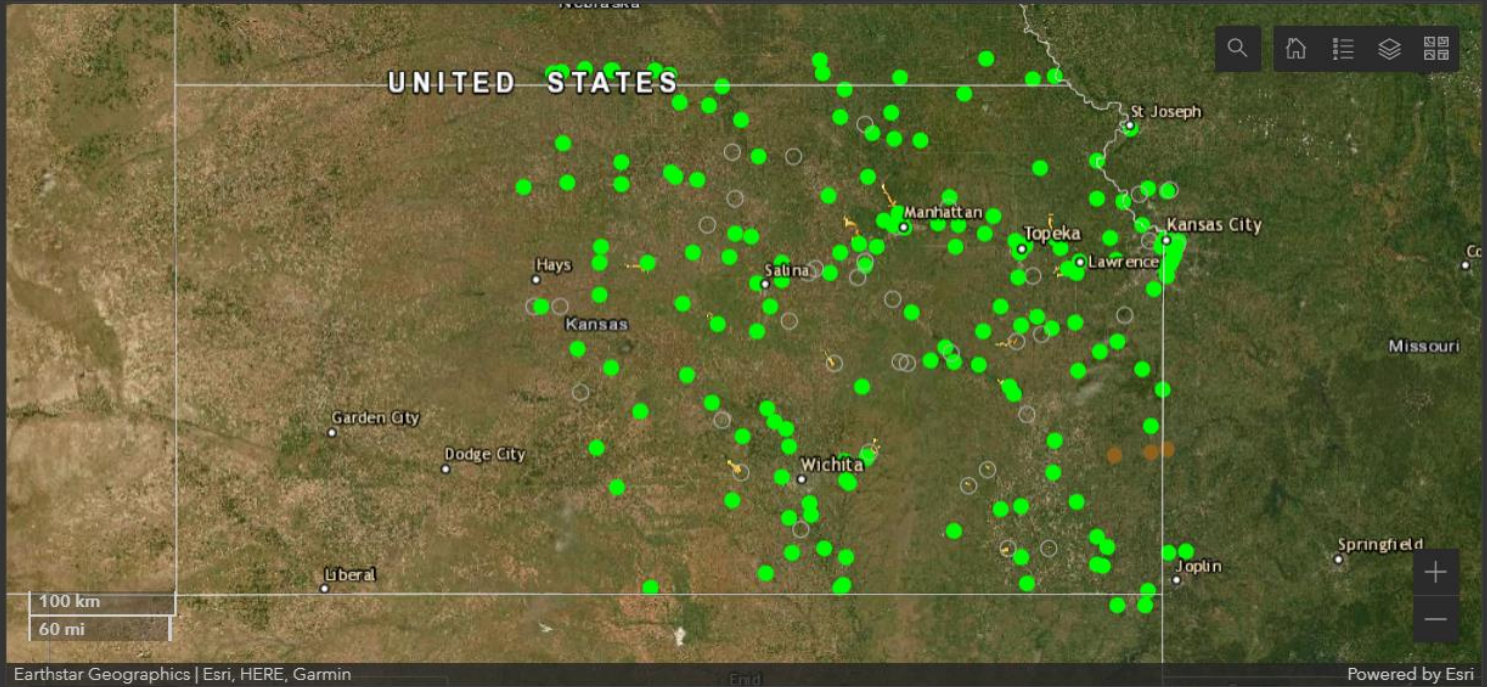
LNEK1: Pottawatomie Creek at Lane

Flood Status: No Flooding
Stage (ft): 5.45
Flood Status Code: 5
Stage Time: July 24, 2022 at 6:30 PM



Last update: 8 seconds ago

Gauges Impacts



Flood Map

Impact Map

Gauges

206

Total: 206

Last update: 8 seconds

Major Flooding

0

Total: 0

Last update: 8 seconds

Moderate Flooding

0

Total: 0

Last update: 8 seconds

Minor Flooding

0

Total: 0

Last update: 8 seconds

Near Flooding

0

Total: 0

Last update: 8 seconds

No Flooding

166

Total: 166

Last update: 8 seconds

Stream Flood Max Depth

20.43 ft

Overall Max Depth: 8.2043

Last update: 8 seconds

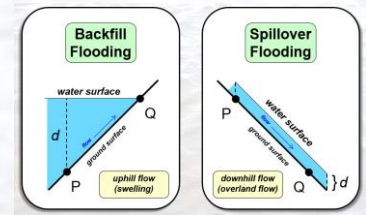
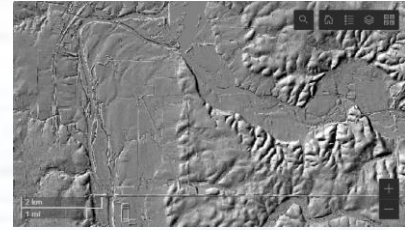
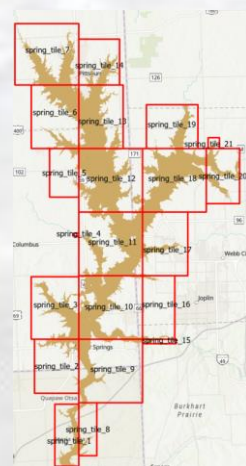
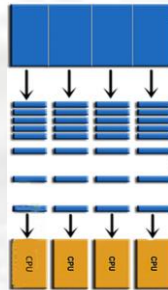
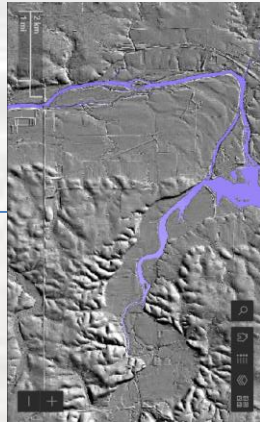
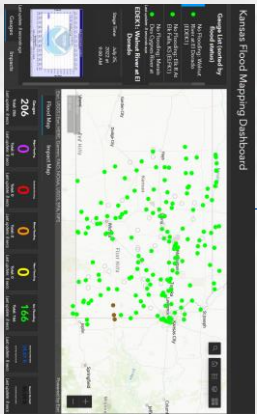
Reservoir Max Depth

80.57 ft

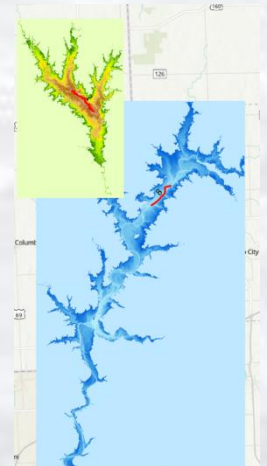
Overall Max Depth: 8.8057

Last update: 8 seconds

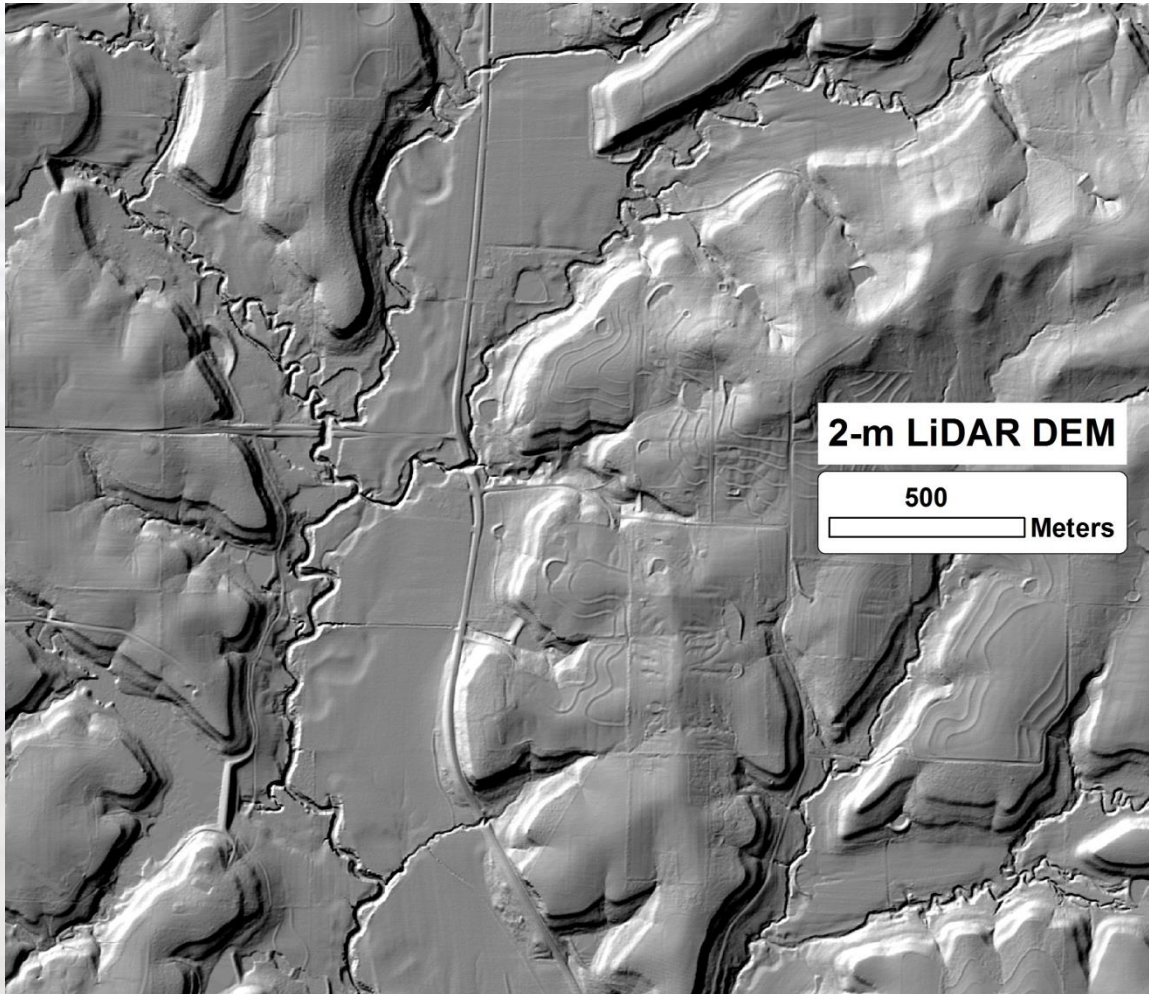
System Structure



FLDPLN



Terrain Processing: *DEM (Digital Elevation Model)*

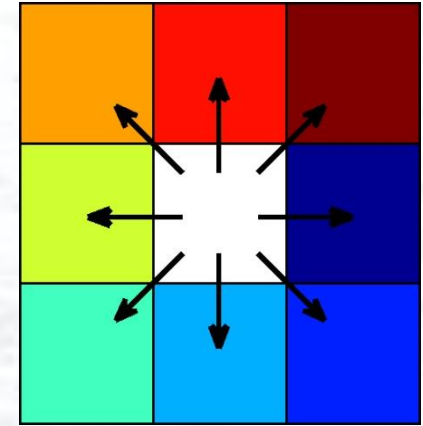
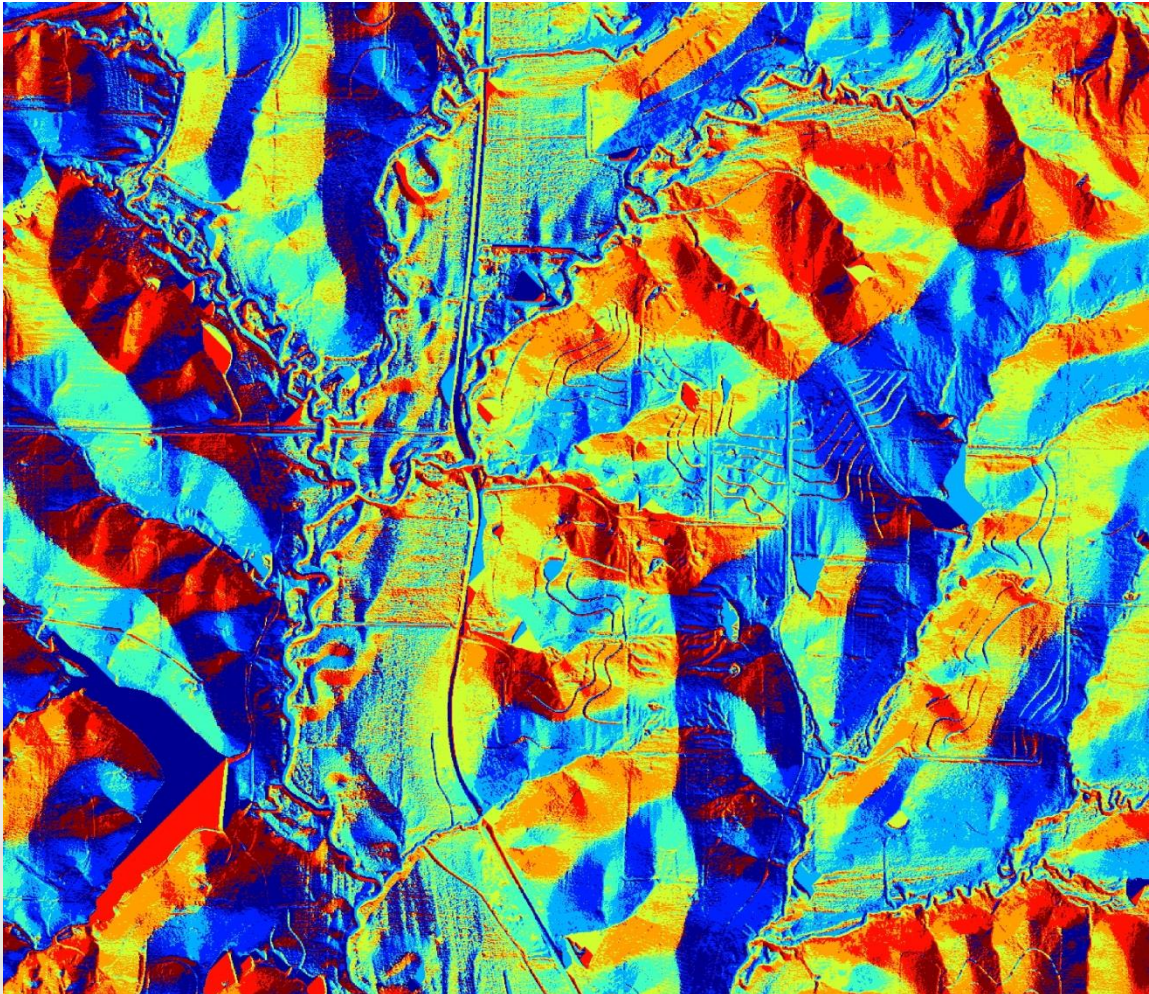


This DEM was created using LiDAR data.

Shown is a portion of the river valley for Mud Creek in Jefferson County, Kansas.

DEM (shown in shaded relief)

Terrain Processing: *Flow Direction*

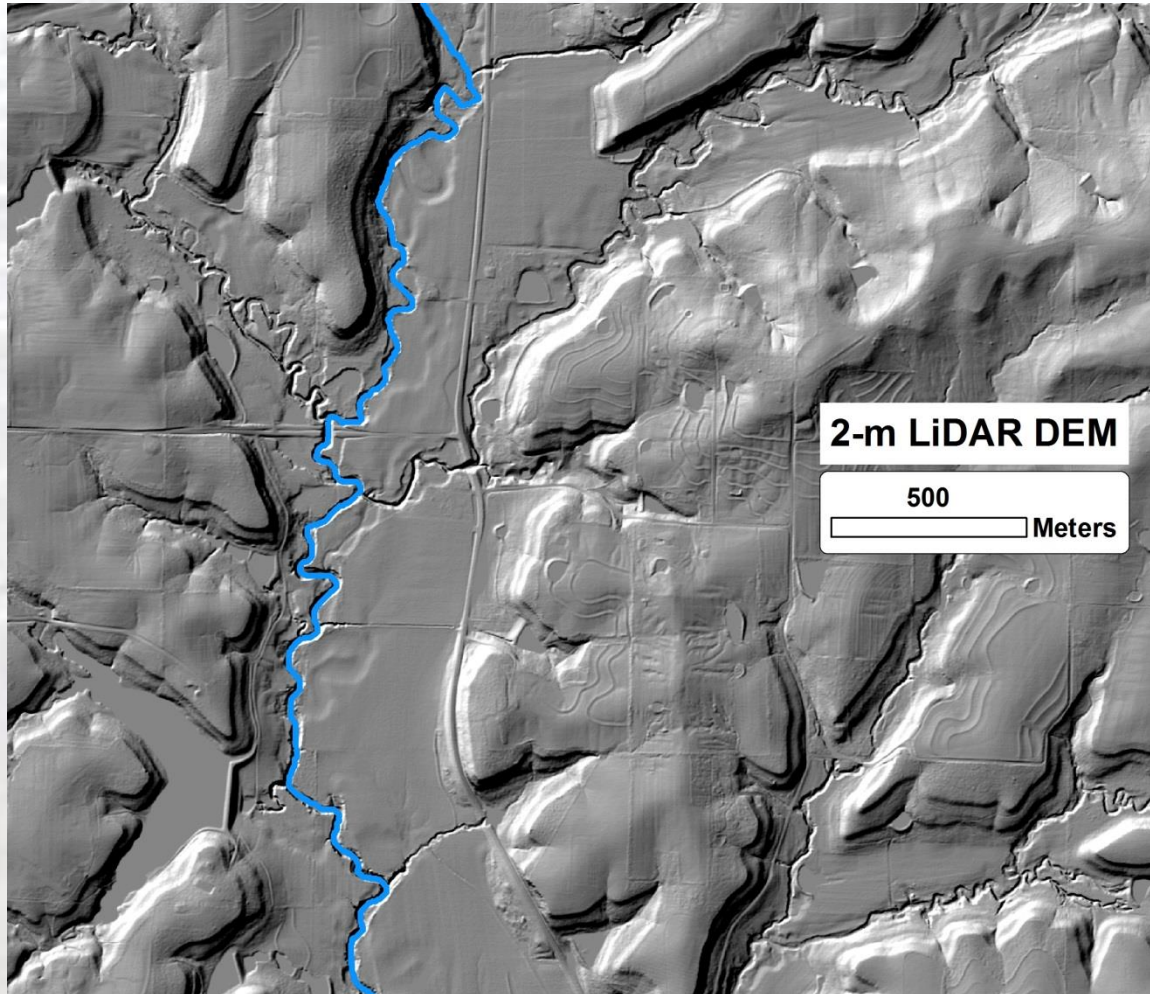


Each pixel is colored based on its flow direction.

Navigating by flow direction, every pixel has a single exit path out of the image.

Flow direction map (gradient direction approximation)

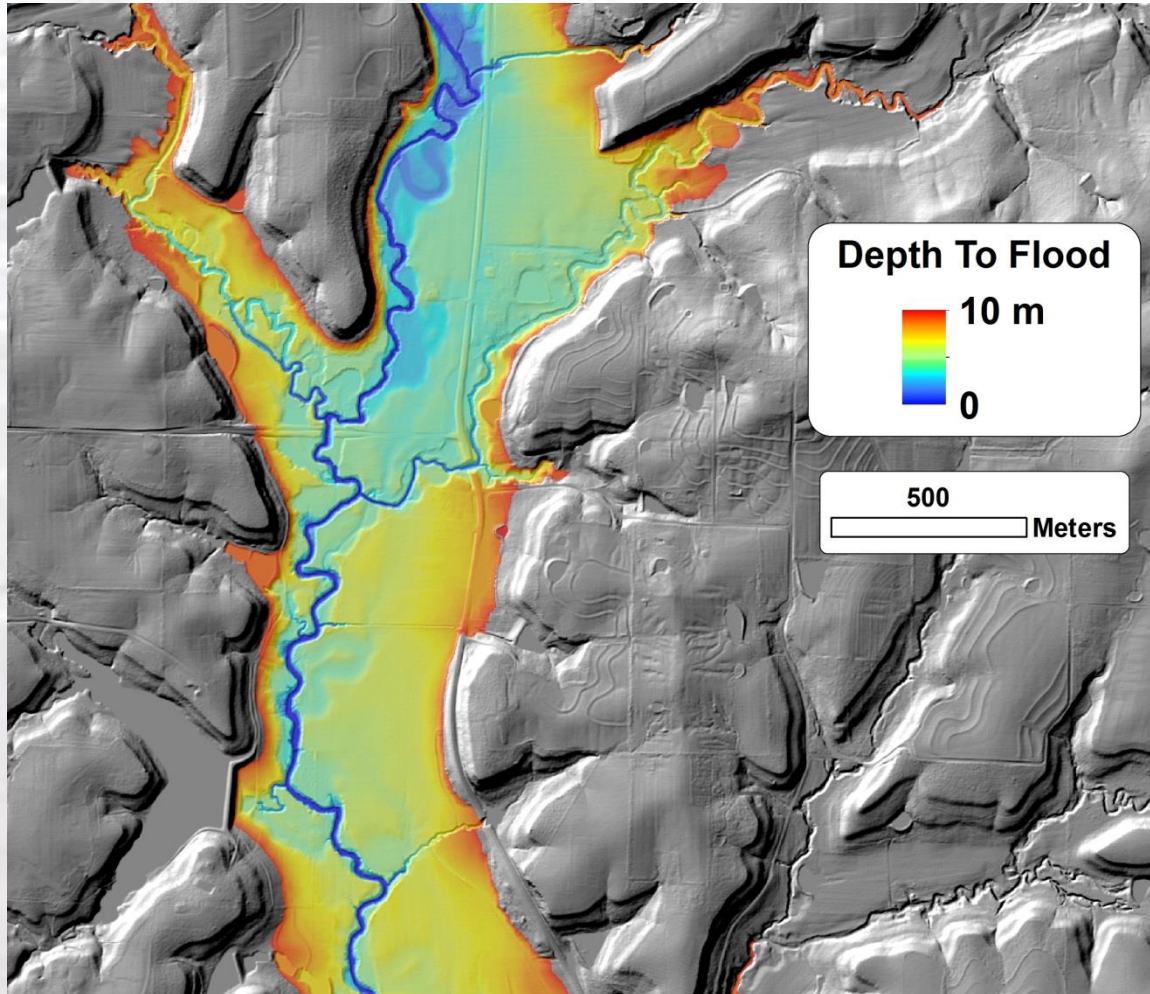
Terrain Processing: *Stream Delineation*



The Mud Creek streamline is identified (shown in blue) using an appropriate flow accumulation threshold.

“Synthetic Stream Network”

Terrain Processing: *Floodplain Mapping*



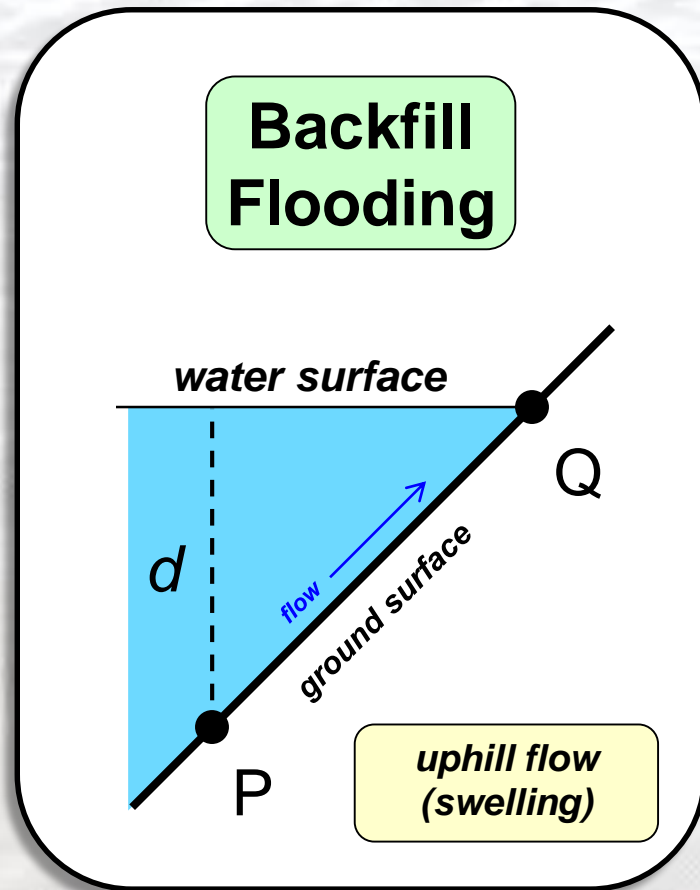
The 10-m floodplain was computed *for Mud Creek* using the FLDPLN model.

FLDPLN is a pseudo-kinematic, 2D flow model that requires only DEM data as input.

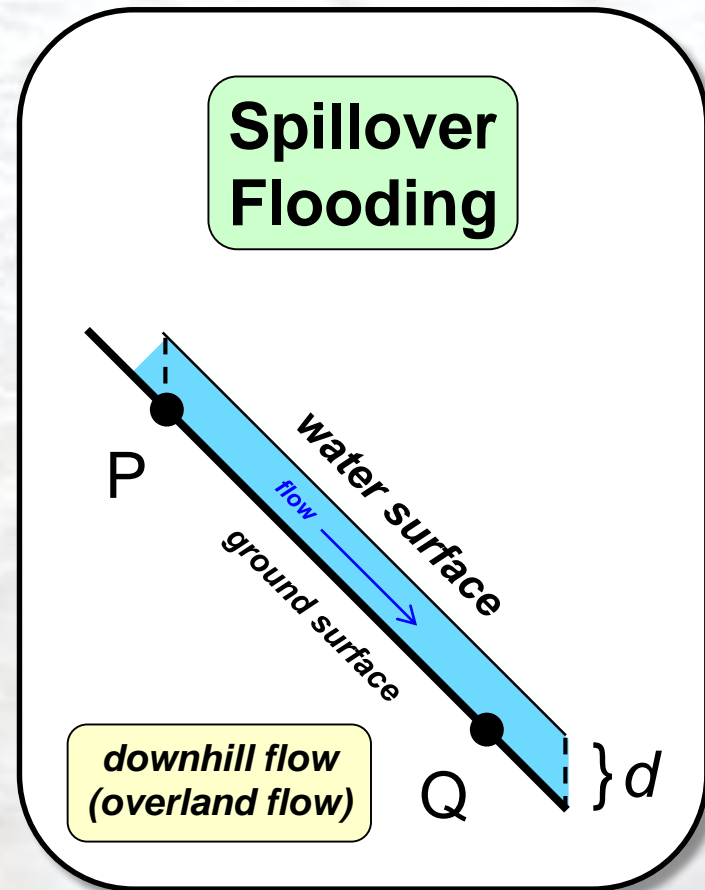
10-m Floodplain (DTF Map)

The FLDPLN (“Floodplain”) Model—

There are two ways that point Q can be flooded by water originating from point P:

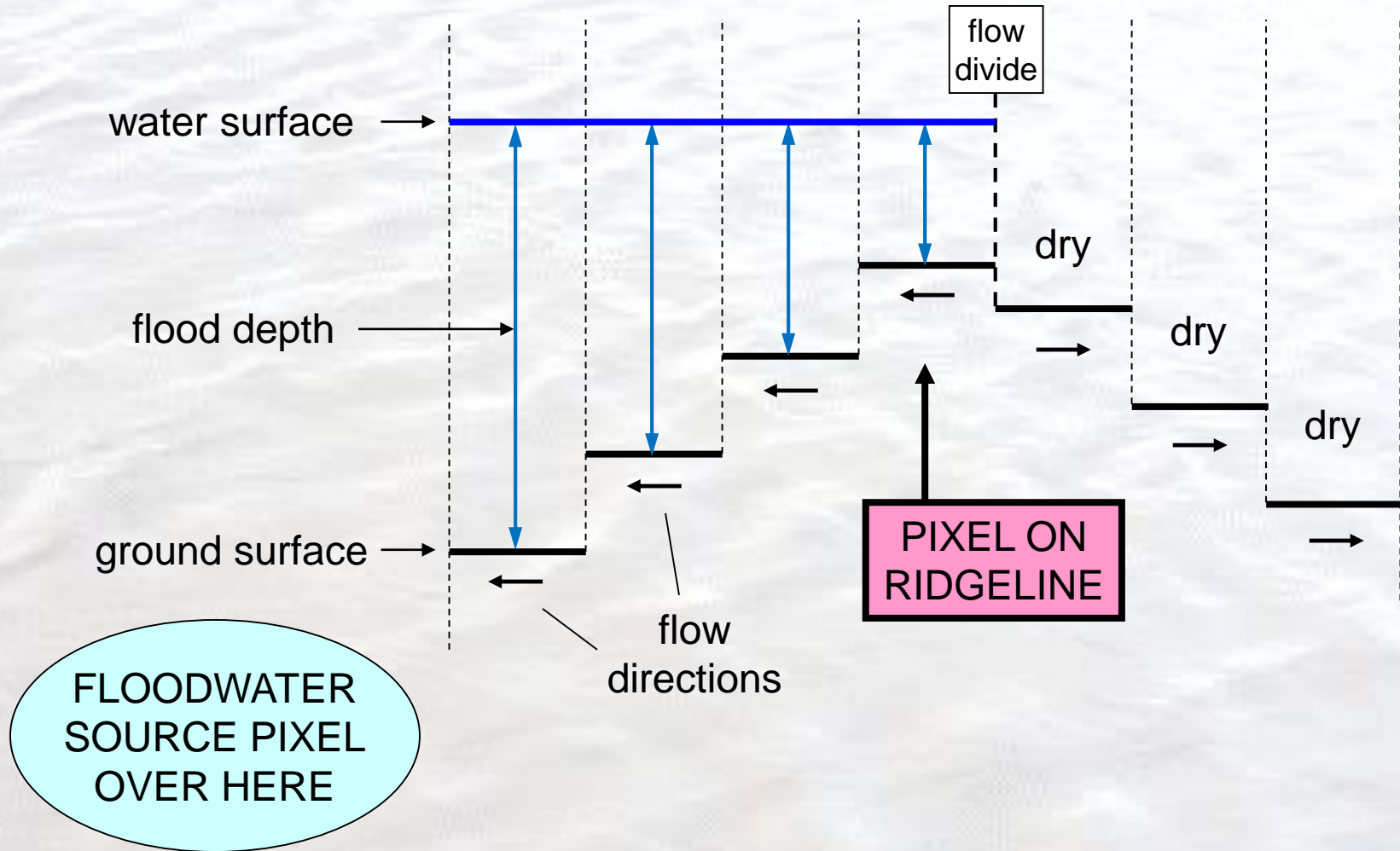


“Water seeks its own level”

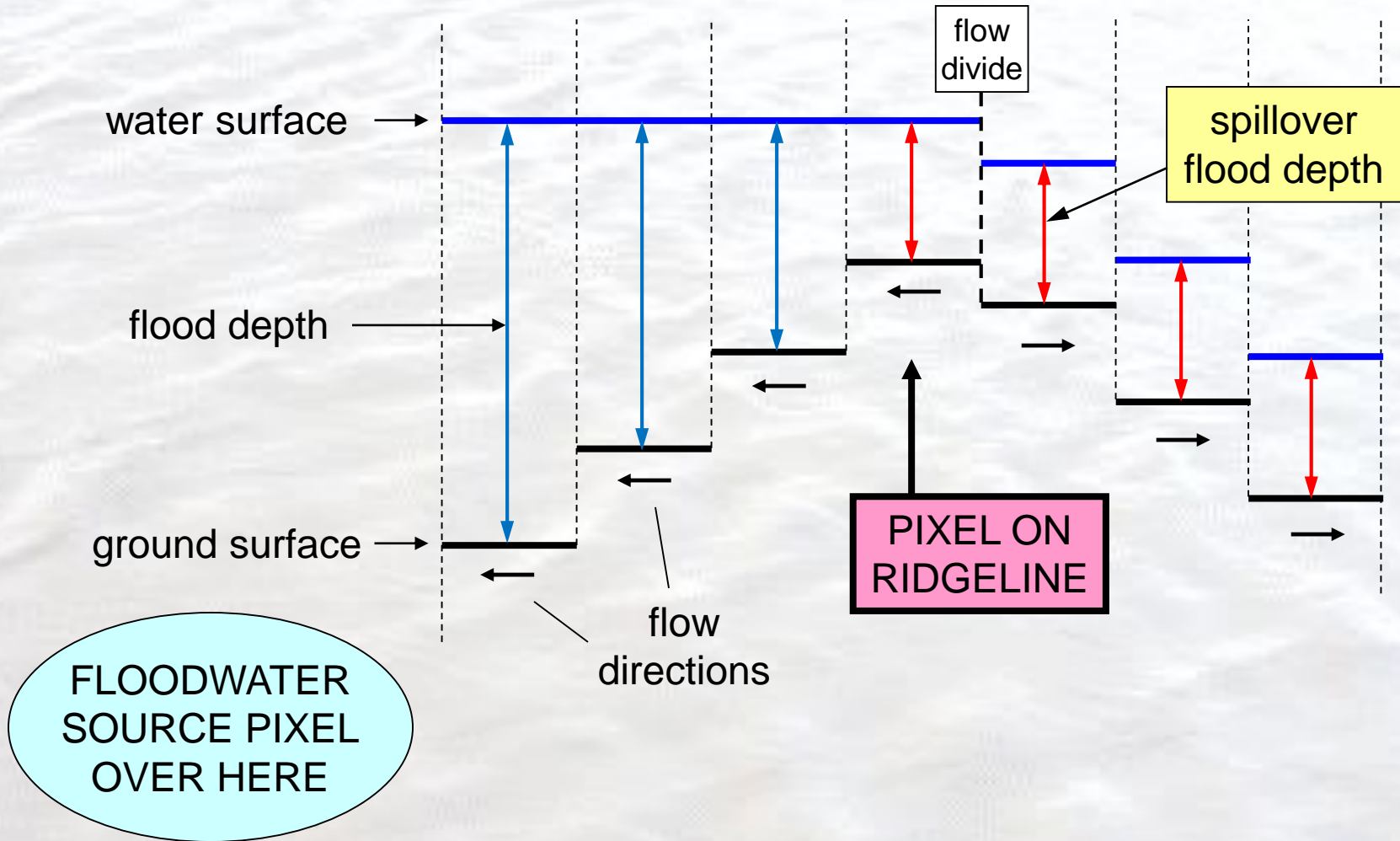


“Water flows downhill”

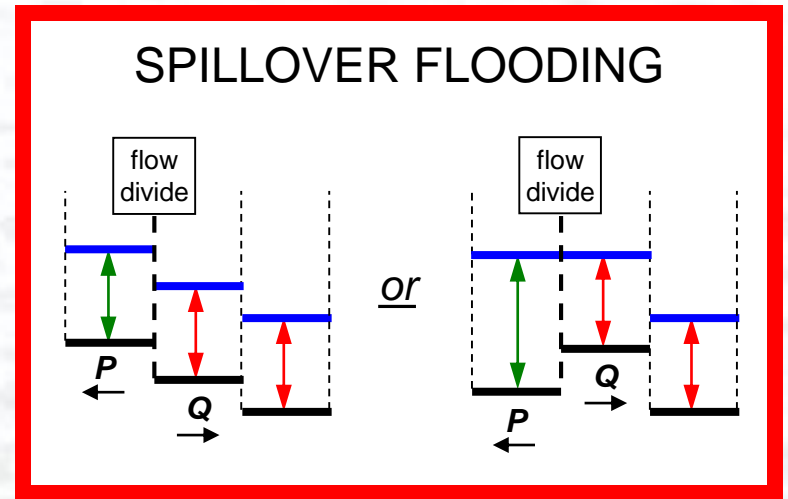
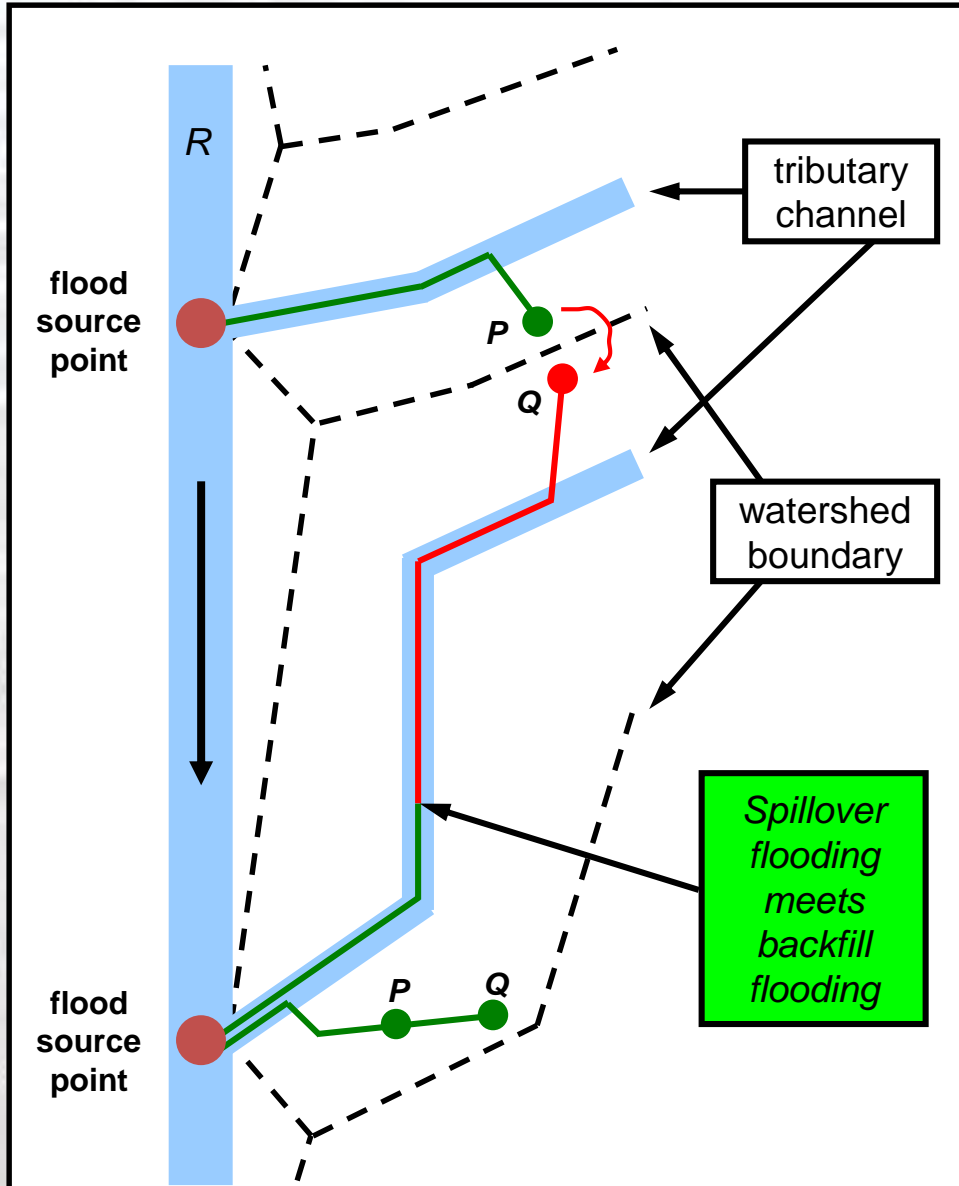
Backfill Flooding—accounts for floodwater expansion due to swelling processes



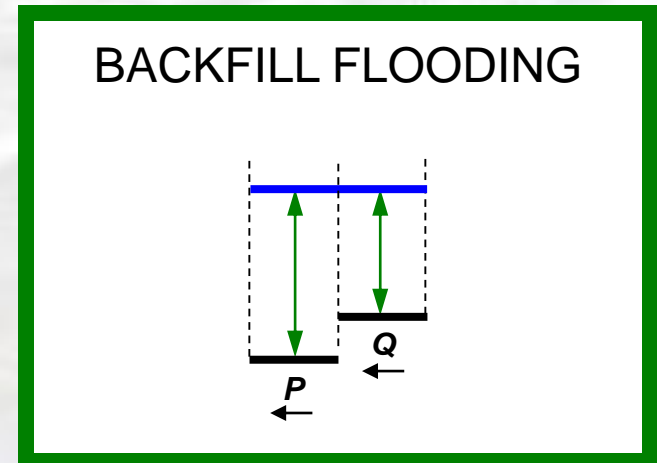
Spillover Flooding—accounts for floodwater rerouting (new flow path development)



PLAN VIEW illustrating backfill and spillover flooding



— Depth To Flood (DTF) Contour

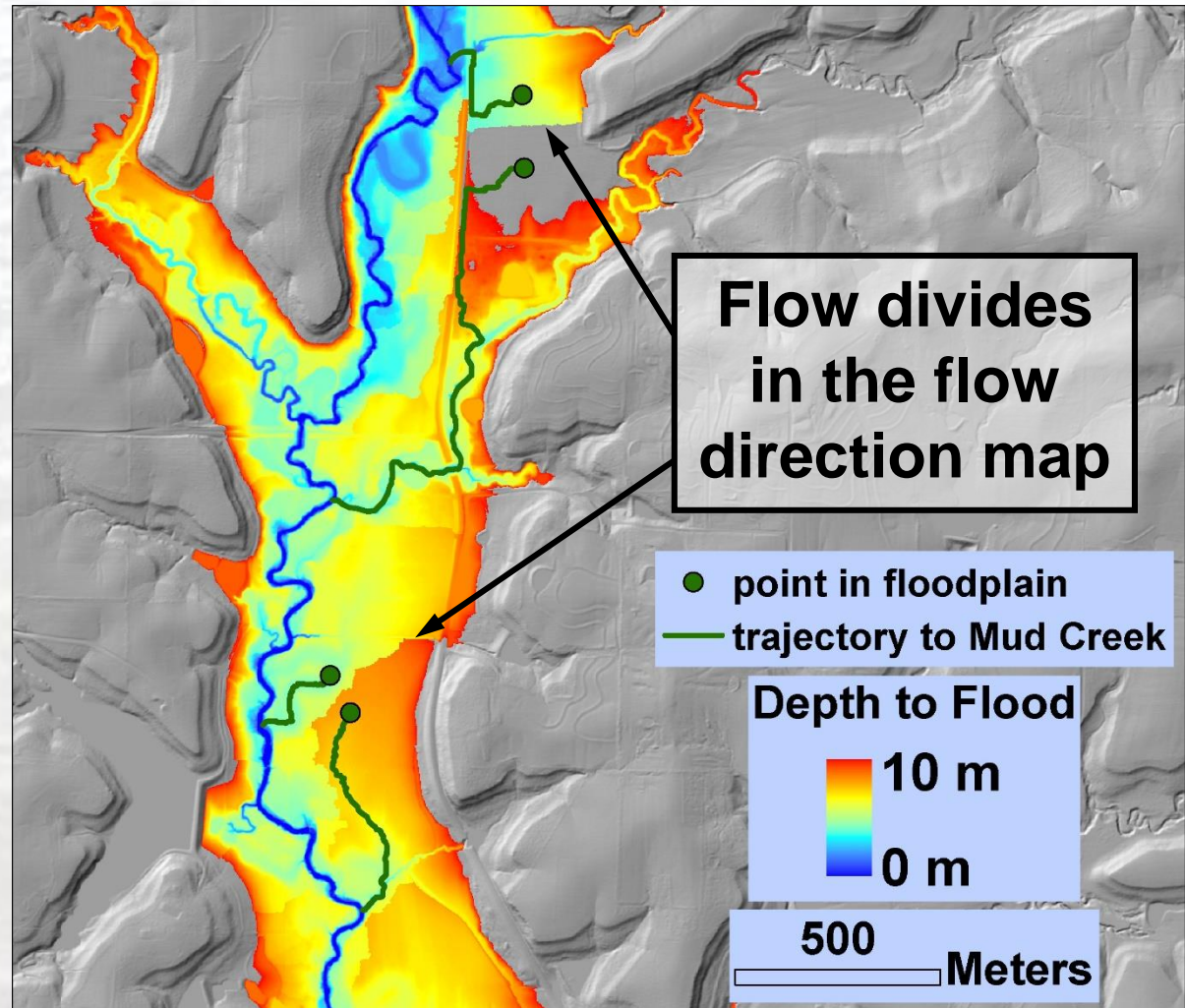


Backfill Flooding Is Not Sufficient

Here is what a DTF map looks like determined using only backfill flooding.

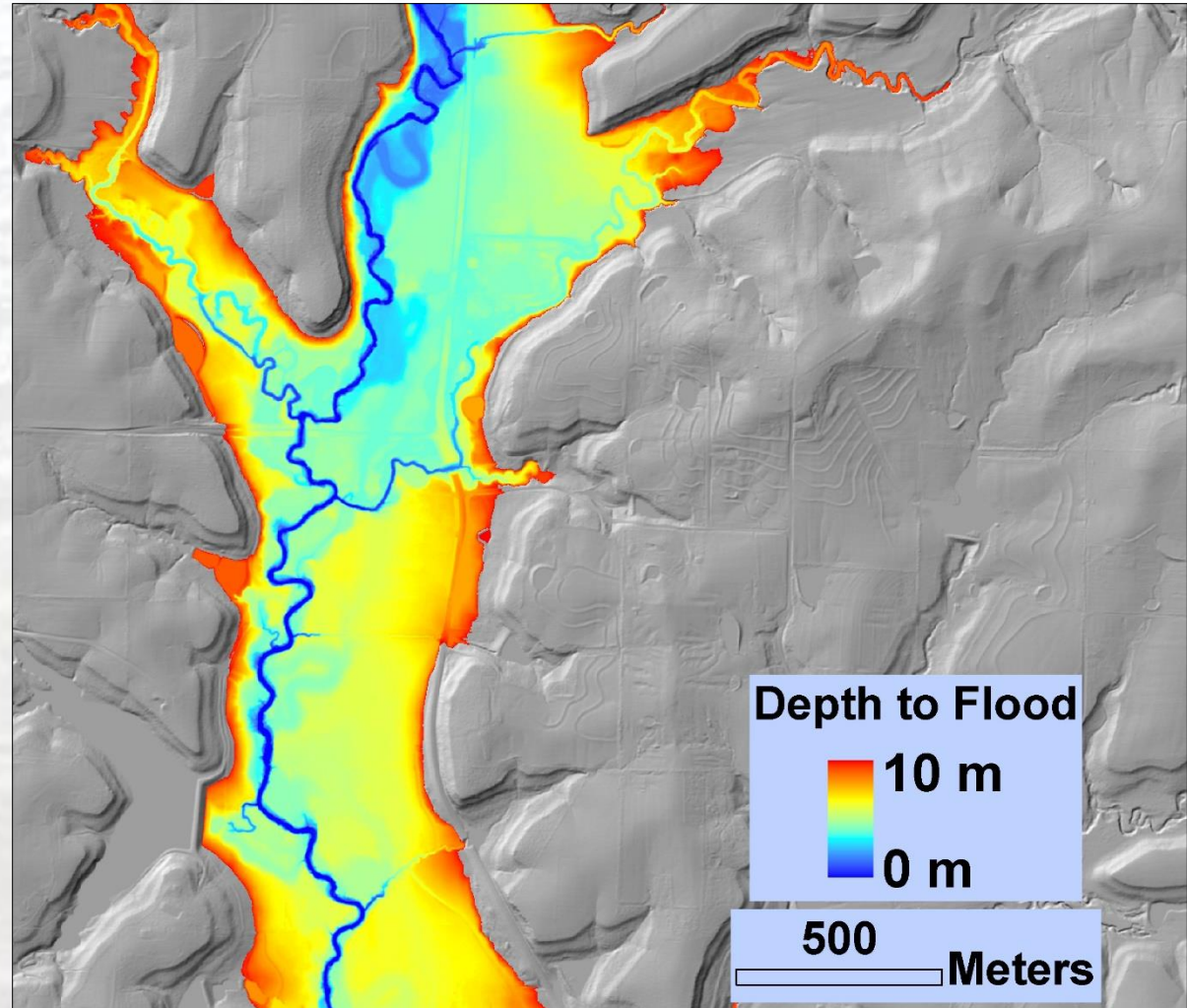
Note the erroneous discontinuities.

These are caused by ridgelines in the DEM.

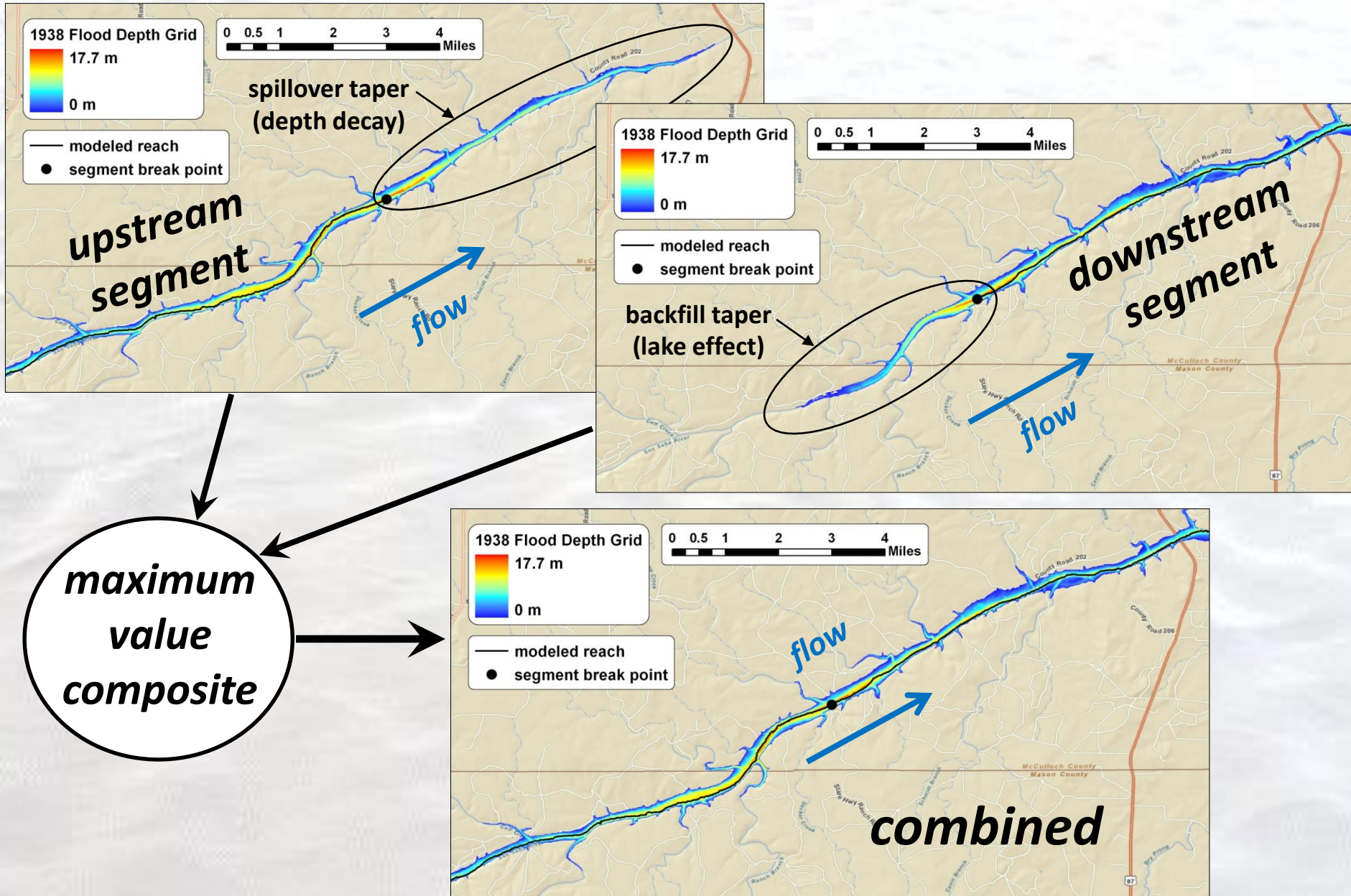


Backfill + Spillover Flooding

By backfill flooding using small flood depth increments and allowing spillover flooding to occur on the floodplain boundary between iterations, the DTF discontinuity problem is mostly resolved.

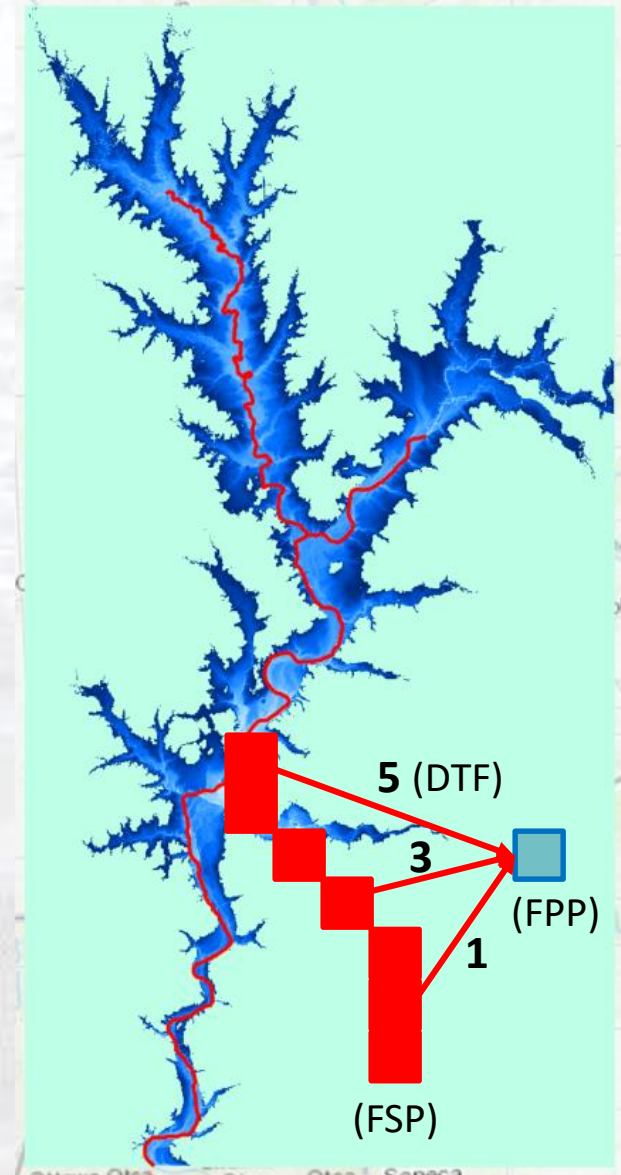


Seamless modeling with FLDPLN



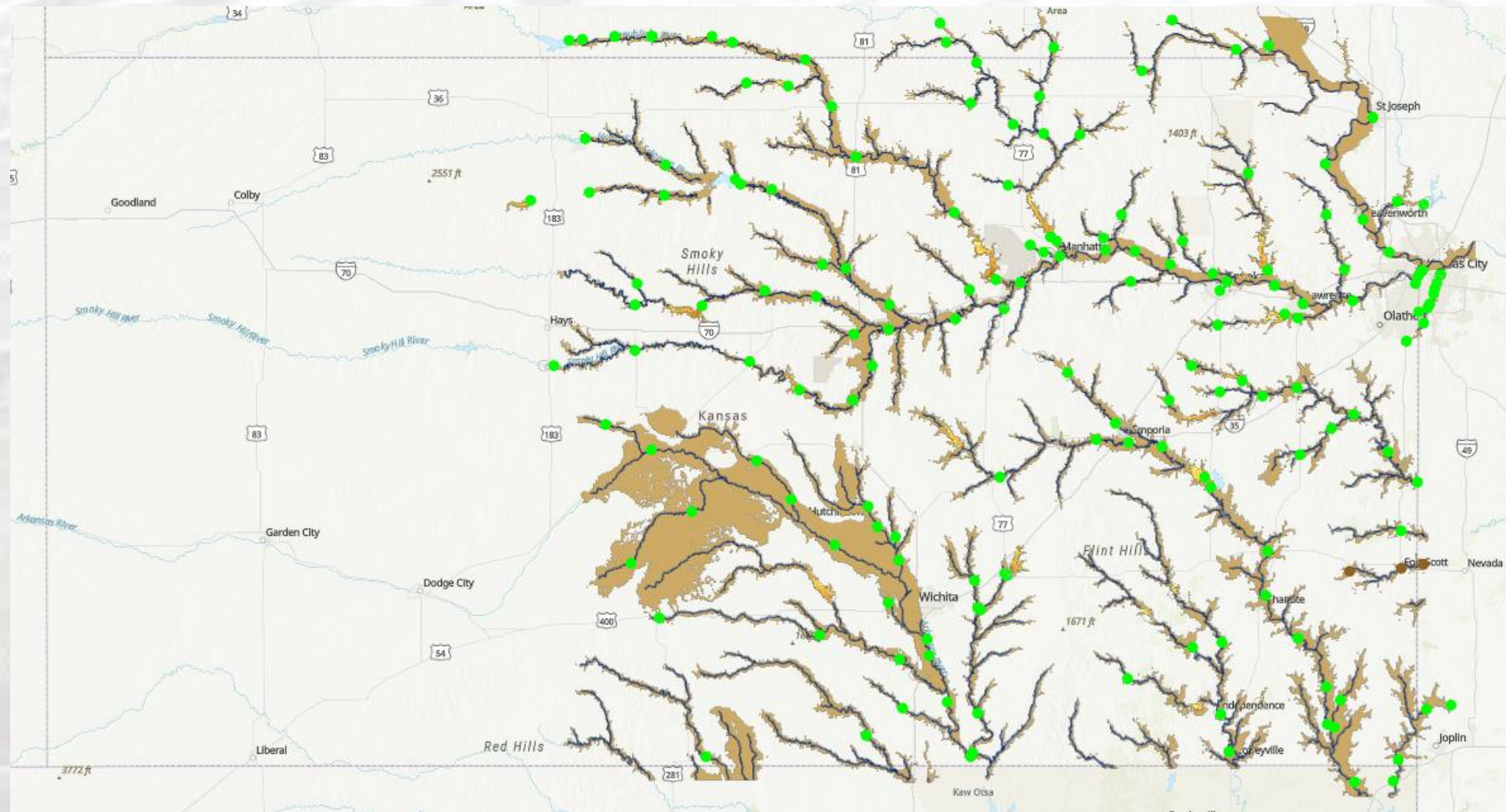
FLDPLN Model – Building a Library

- A floodplain pixel (FPP) can be flooded by the water originated from flood source (stream) pixels (FSPs) through backfill and spillover flooding
 - FSP-FPP flood relation
 - many-to-many relation
- Depth to flood (DTF)
 - Minimum depth at a FSP needed to flood a FPP
 - Attribute associated with a FSP-FPP relation
- FLDPLN model identifies the FSP-FPP flooding relations and their associated DTFs
 - Iterative process

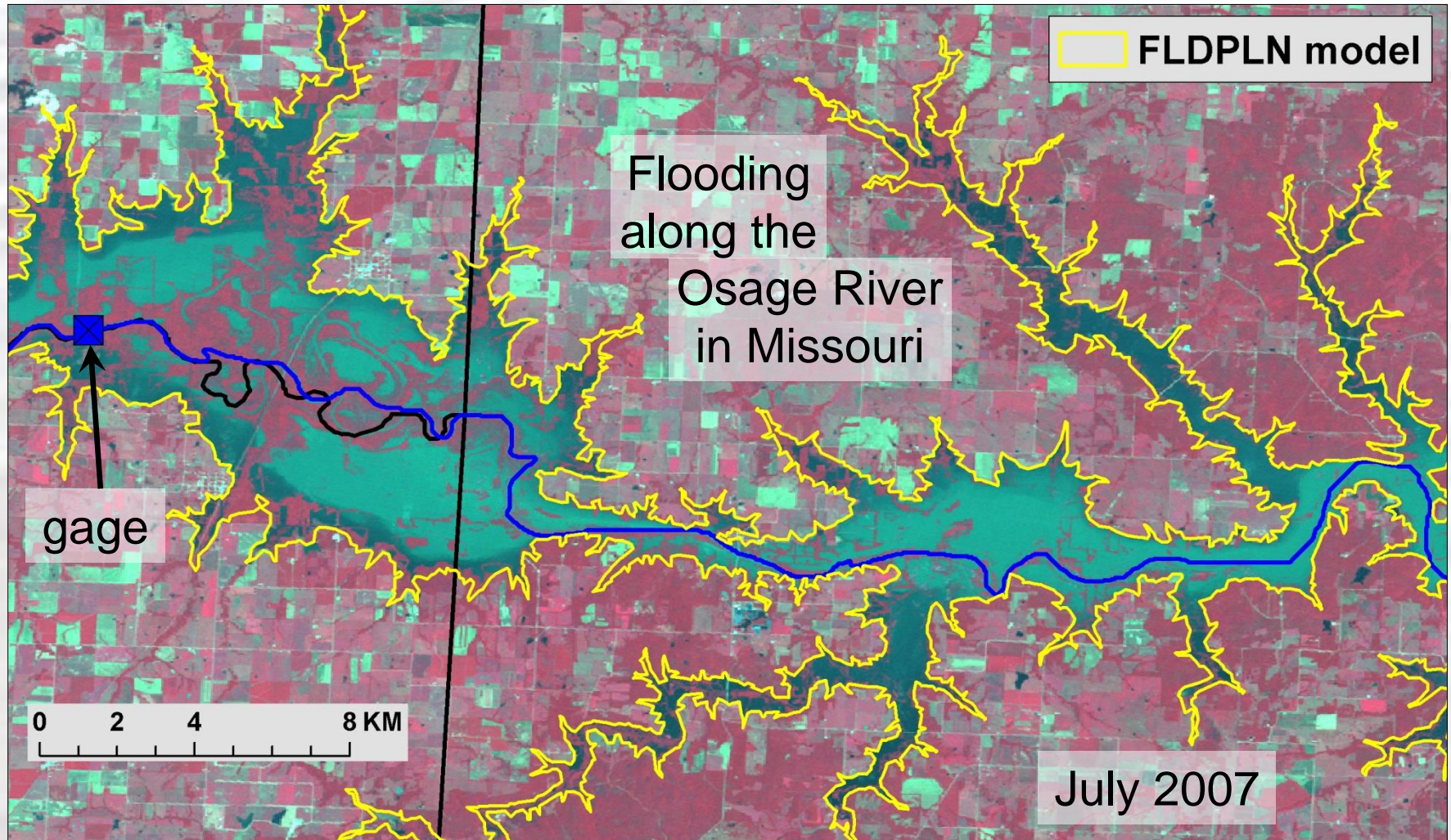


FLDPLN Libraries for Eastern Kansas

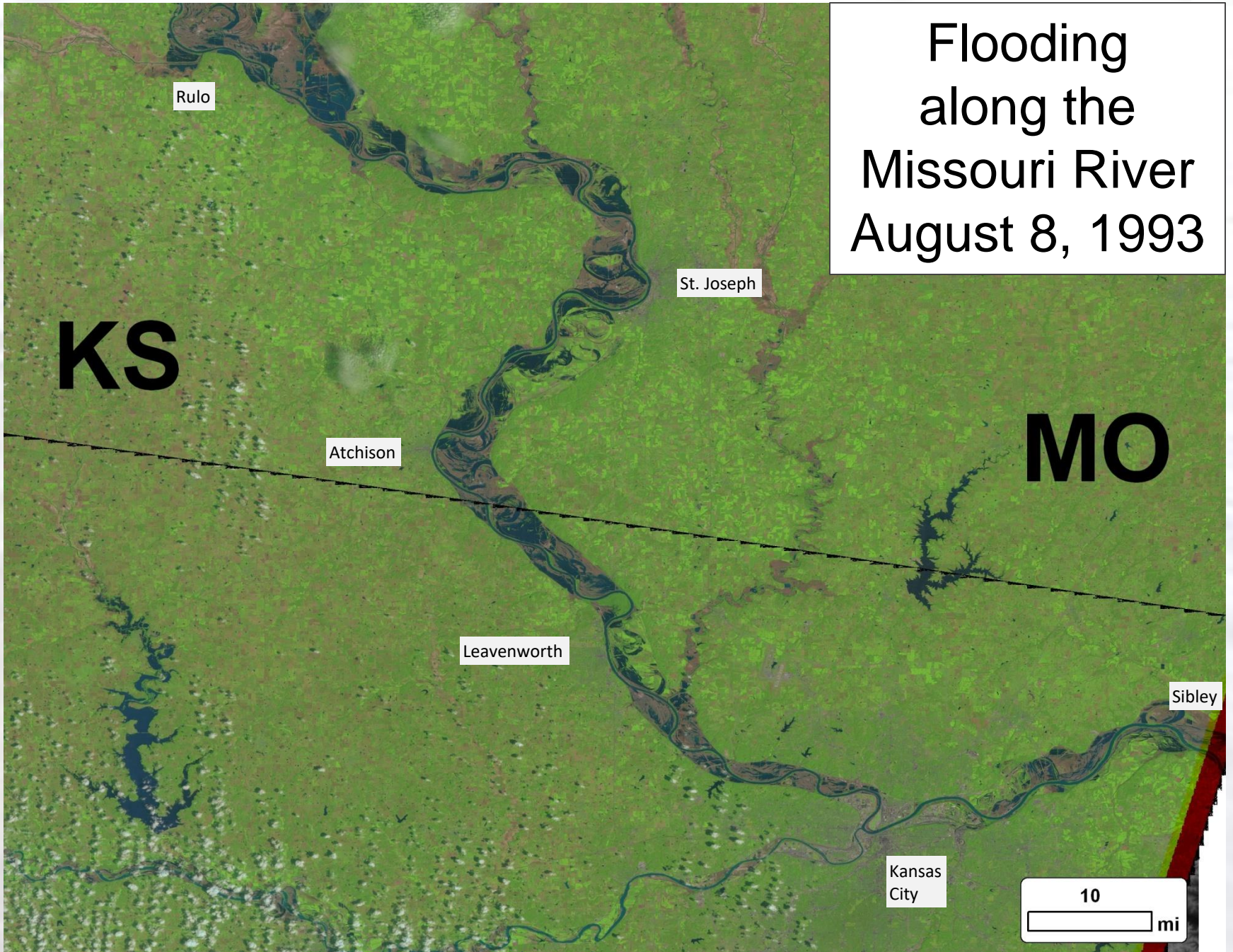
- 25 libraries cover eastern Kansas (~100 GB file size)
- Based on 5-m LiDAR DEM



Flood mapping examples using FLDPLN



Flooding along the Missouri River August 8, 1993



KS

MO

Rulo

St. Joseph

Atchison

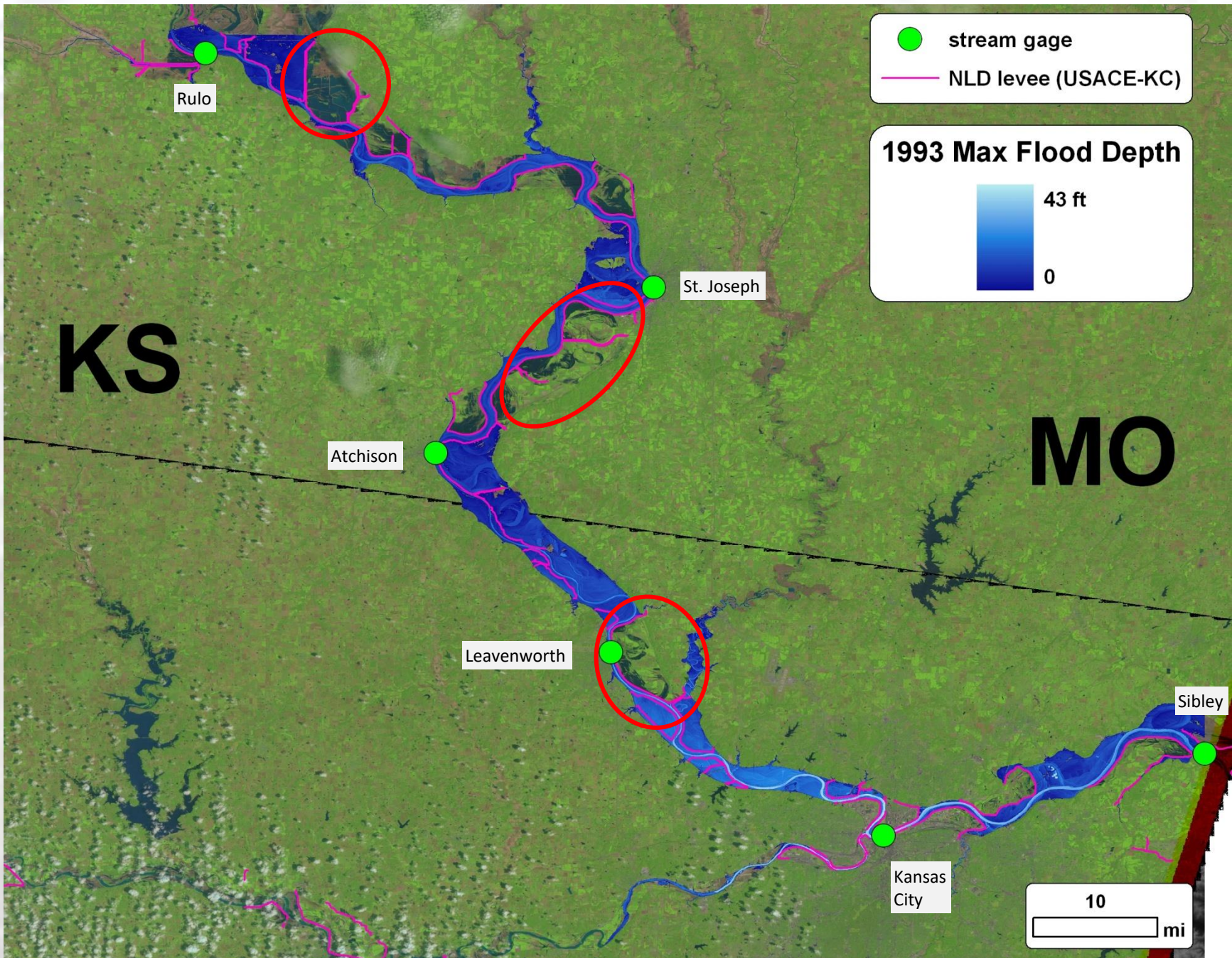
Leavenworth

Kansas
City

Sibley

10

mi



Wildcat Creek Flood, September 3, 2018

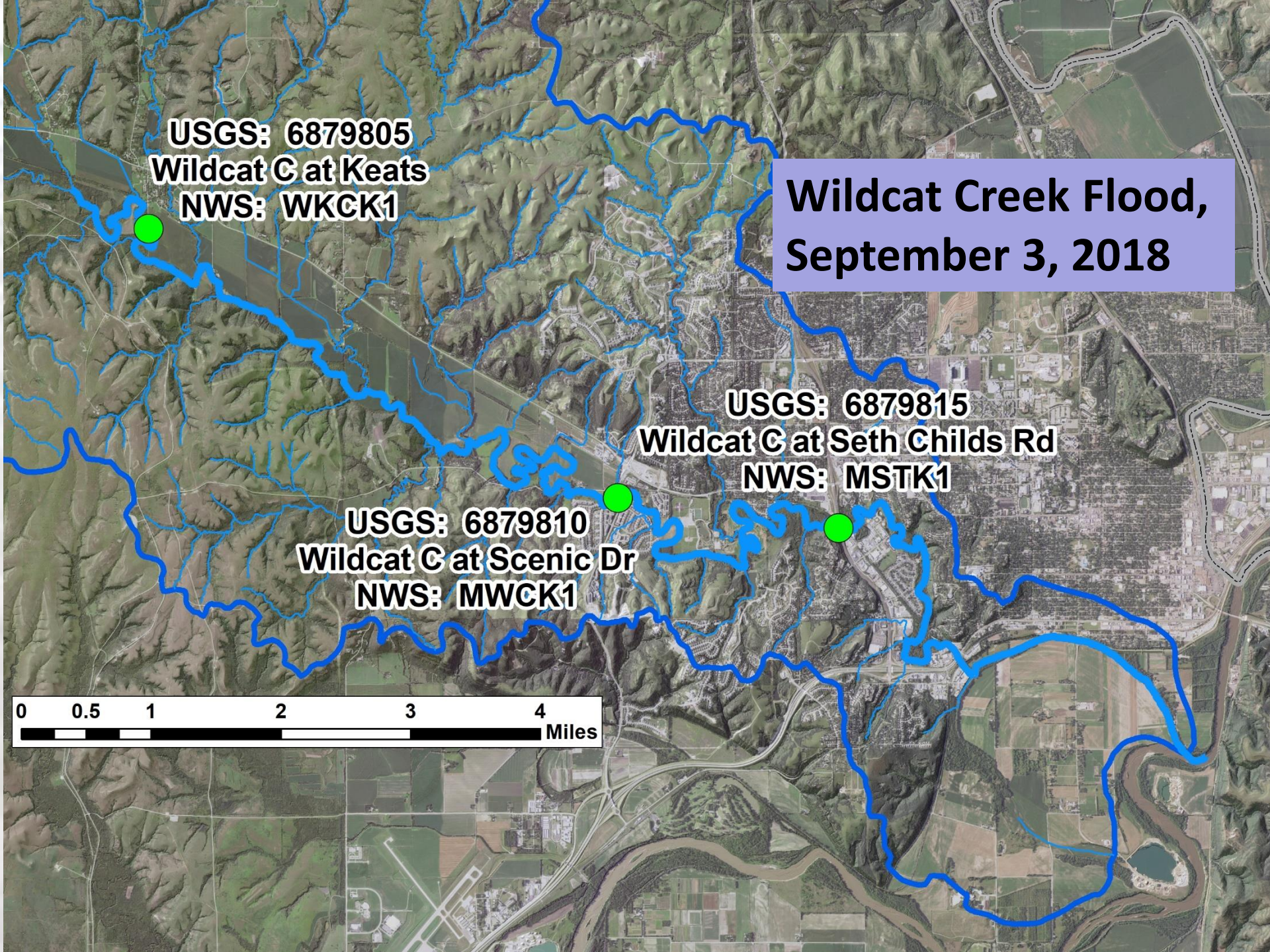
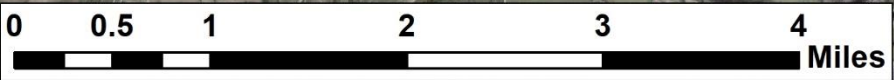
USGS: 6879805
Wildcat C at Keats
NWS: WKCK1



USGS: 6879815
Wildcat C at Seth Childs Rd
NWS: MSTK1

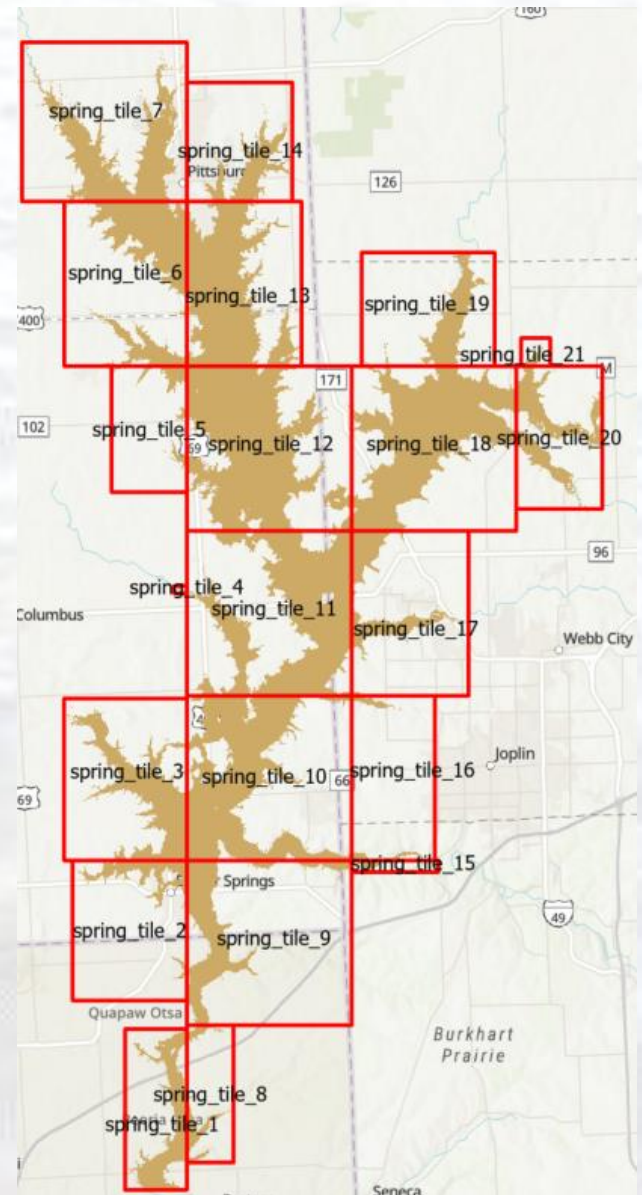


USGS: 6879810
Wildcat C at Scenic Dr
NWS: MWCK1



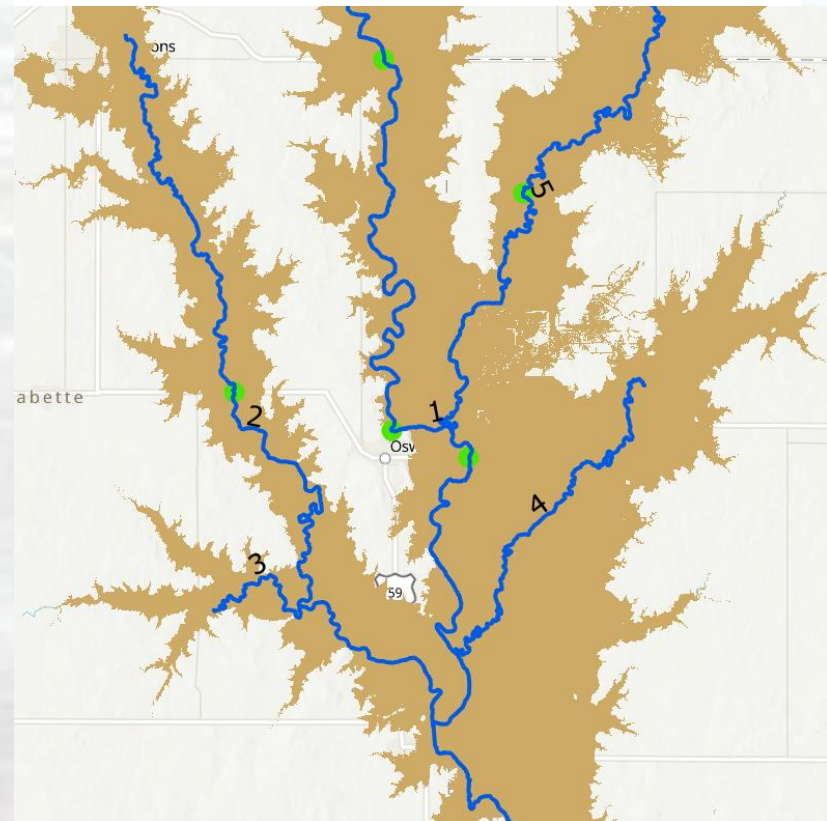
Efficient mapping using tiling

- Organize relations by tiles
- Flood mapping by tiles
 - Avoid memory overflow with a proper tile size
 - Scalable
 - Mapping tiles in parallel
 - Each tile can be mapped independently



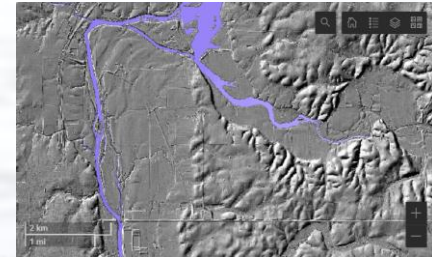
Gauge and Stage

- Driver of floods
- Estimate FSP depth of flow (DOF)
 - Snap gauges to FSPs
 - Based on stream orders
 - From low to high
 - Simple linear interpolation
 - Vertical interpolation
 - Use 100-year-flood profile
- Sources
 - NWS AHPS and USGS
 - State and local networks
 - Bridge gauges



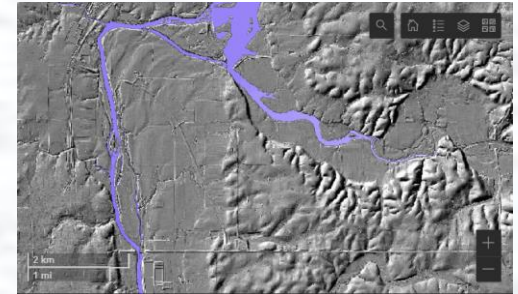
Serve Flood Maps on Web

- Accessible to KDEM and the general public
 - Don't need to run flood mapping locally
- Flood maps are served using ArcGIS Server
 - Tiled flood maps (COGs) are served as ArcGIS image services using mosaic datasets
- Stream flood maps are updated hourly at the hour
- Reservoir are updated every 6 hours



Web Applications

- Flood map services consumed by desktop GIS software
 - ArcGIS or QGIS
- Web applications allow anyone with internet connection to access flood maps
- The dashboard is built using ArcGIS Dashboard template served on AGO
- Exploring an alternate open-source web application
 - streamlit + leaflet



Full Open-Source Experimental Web App

Kansas Flood Mapping · Streamlit

share.streamlit.io/xingongli/fldpln_mapping

Bookmarks KU ESRI Google Earth Engine Pangeo NASA Earthdata Python TrendySnow Water-Snow Rivers Lakes Landsat Other bookmarks

Current Flood Map

This is a test of building flood mapping web application using leafmap and streamlit.

Main Menu

- Flood Map**
- AHPS Gauges
- Images
- Upload

About

Kansas flood mapping uses observed and forecast gauge stage from NOAA Advanced Hydrologic Prediction Service to map potential inundation for 25 floodplains in eastern Kansas. The inundation mapping method is developed by Jude Kastens at Kansas Biological Survey and this application is developed by a group of students and faculty members, including David Weekley, Jim Coll, Ken Ekpetere, James Helgeson and Xingong Li at the

JupyterBook Documentation

3.1. Tiling relations by

The FSP-FPP relations from the FLDPLN model are organized by segment where each segment file stores all the information for that segment. This organization concept (one file per segment) is consistent with the FLDPLN organization concept (one file per segment). The figure below shows the 21 segments (numbered 1 to 21) that are used to tile the FLDPLN model. The figure shows the minimum DTF to flood the FPPs for segments 1 and 8 (note that the length of the segments 1 and 8 are similar, the FPP footprint is different).

Note

Is this organization comes out the convenience of the FLDPLN model?

Kansas Flood Mapping Dashboard

Stream Flood Depth (Nowcast)

(1-hr refresh)



Kansas Flood Mapping Dashboard

Gauge List (sorted by flood status)

- No Flooding: Kansas River at Manhattan (MHKK1)
- Unknown: Wildcat Creek at Manhattan Seth Childs Rd (MSTK1)

Last update: 7 seconds ago

◀ 1 of 2 ▶

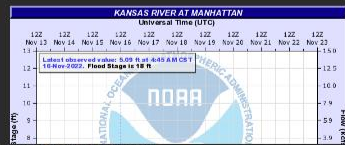
MHKK1: Kansas River at Manhattan

Flood Status No Flooding

Stage (ft) 5.05

Flood Status Code 5

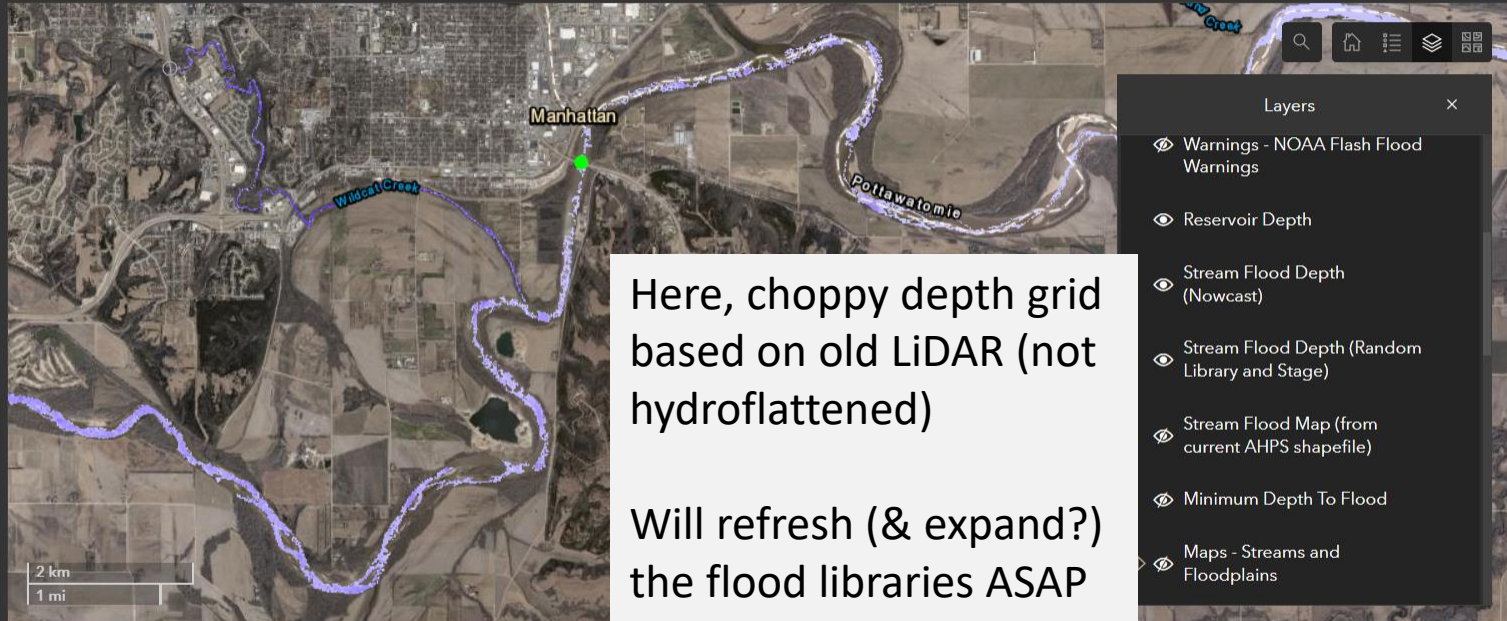
Stage Time November 16, 2022 at 3:45 AM



Last update: 7 seconds ago

Gauges

Impacts



Here, choppy depth grid based on old LiDAR (not hydroflattened)

Will refresh (& expand?) the flood libraries ASAP

Riley County IT/GIS, Earthstar Geographics | Esri, HERE, Garmin

Powered by Esri

Flood Map

Impact Map

Gauges

2

Total: 206

Last update: 7 seconds ago

Major Flooding

0

Total: 0

Last update: 7 seconds ago

Moderate Flooding

0

Total: 0

Last update: 7 seconds ago

Minor Flooding

0

Total: 0

Last update: 7 seconds ago

Near Flooding

0

Total: 0

Last update: 7 seconds ago

No Flooding

1

Total: 165

Last update: 7 seconds ago

Stream Flood Max Depth

8.81 ft

Overall Max Depth: ft 20.49

Last update: 7 seconds ago

No Reservoirs

Last update: 7 seconds ago

Kansas Flood Mapping Dashboard

Stream Flood Depth (random) (for testing)



Kansas Flood Mapping Dashboard

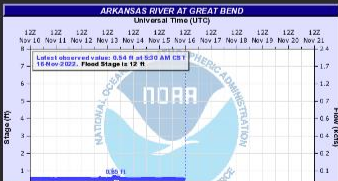
Gauge List (sorted by flood status)

- No Flooding: Arkansas River at Great Bend (GTBK1)

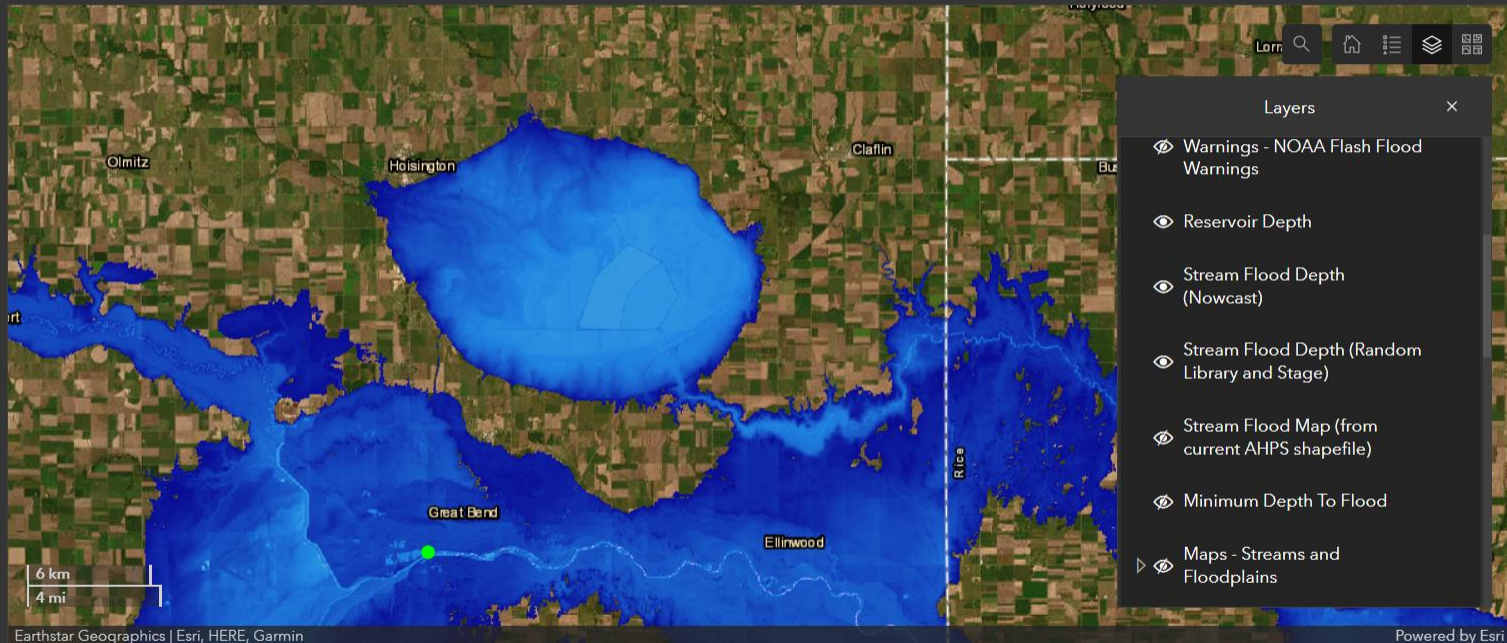
Last update: 18 seconds ago

GTBK1: Arkansas River at Great Bend

Flood Status	No Flooding
Stage (ft)	0.54
Flood Status Code	5
Stage Time	November 16, 2022 at 4:30 AM



Last update: 18 seconds ago



Layers

- Warnings - NOAA Flash Flood Warnings
- Reservoir Depth
- Stream Flood Depth (Nowcast)
- Stream Flood Depth (Random Library and Stage)
- Stream Flood Map (from current AHPS shapefile)
- Minimum Depth To Flood
- Maps - Streams and Floodplains

Earthstar Geographics | Esri, HERE, Garmin

Flood Map Impact Map

Gauges 1 Total: 206 Last update: 18 seconds ago	Major Flooding 0 Total: 0 Last update: 18 seconds ago	Moderate Flooding 0 Total: 0 Last update: 18 seconds ago	Minor Flooding 0 Total: 0 Last update: 18 seconds ago	Near Flooding 0 Total: 0 Last update: 18 seconds ago	No Flooding 1 Total: 165 Last update: 18 seconds ago	Stream Flood Max Depth 2.51 ft Overall Max Depth: ft 20.49 Last update: 32 seconds ago	No Reservoirs Last update: 32 seconds ago
--	--	---	--	---	---	---	---

Kansas Flood Mapping Dashboard

Historical/Scenario Maps (coming soon)



Kansas Flood Mapping Dashboard

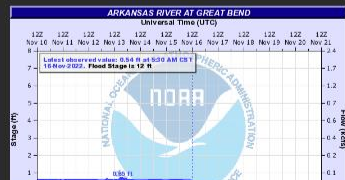
Gauge List (sorted by flood status)

- No Flooding: Arkansas River at Great Bend (GTBK1)

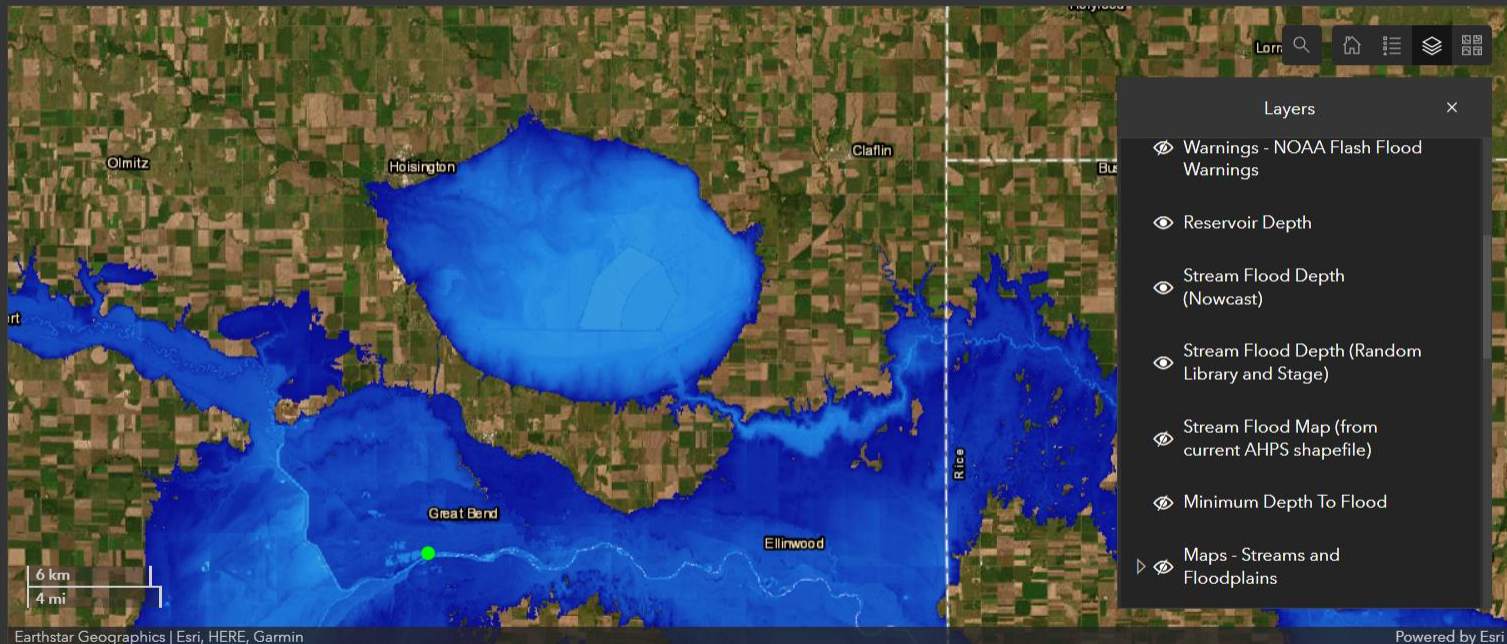
Last update: 18 seconds ago

GTBK1: Arkansas River at Great Bend

Flood Status	No Flooding
Stage (ft)	0.54
Flood Status Code	5
Stage Time	November 16, 2022 at 4:30 AM



Last update: 18 seconds ago



Earthstar Geographics | Esri, HERE, Garmin

Powered by Esri

Flood Map Impact Map

Gauges 1 Total: 206 Last update: 18 seconds ago	Major Flooding 0 Total: 0 Last update: 18 seconds ago	Moderate Flooding 0 Total: 0 Last update: 18 seconds ago	Minor Flooding 0 Total: 0 Last update: 18 seconds ago	Near Flooding 0 Total: 0 Last update: 18 seconds ago	No Flooding 1 Total: 165 Last update: 18 seconds ago	Stream Flood Max Depth 2.51 ft Overall Max Depth: ft 20.49 Last update: 32 seconds ago	No Reservoirs Last update: 32 seconds ago
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Gauges Impacts

kars.geoplatform.ku.edu
--> Web Apps & Projects
--> Rapid Image Viewer

Landsat, Sentinel, and other
remotely sensed imagery
can be viewed & exported

Rapid Image Viewer | KARS Geoplatform

Search places

Earth Engine Apps

KU
KANSAS BIOLOGICAL SURVEY & CENTER FOR ECOLOGICAL RESEARCH
The University of Kansas

KU
DEPARTMENT OF GEOGRAPHY & ATMOSPHERIC SCIENCE
The University of Kansas

Kansas
WATER OFFICE
The University of Kansas

The Rapid Image Viewer

The Rapid Image Viewer (RIV) is a web-based remote sensing application for monitoring and downloading historic, current, and near-real-time satellite images for reconnaissance and rapid decision making. Leveraging Google Earth Engine's big data processing capability, the RIV provides a user friendly-interface and hosts a combination of optical (Landsat 9, 8, 7, 5, Sentinel-2) and non-optical (Sentinel-1 radar) satellite images and data products for near cloud-free visualization. The RIV provides both high resolution imagery (e.g., NAIP) and low-resolution imagery (e.g., Sentinel-3, MODIS) necessary for large-scale and near-ground studies. RIV is capable of detecting wildfire hotspots, identifying flooded areas, and places with drought conditions.

Thanks to Google for Providing the Platform

Dataset Information

Click each Datasets to learn more

- Sentinel-1-SAR: (2014-09-11 to present), ~12 day return, 10m pixel
- Sentinel-2-MSI-1C: (2015-06-27 to present), ~10 day return, 10m pixel
- Sentinel-3: (2016-04-25 to present), ~27 day return, 300m pixel
- LANDSAT-9: (2021-09-09 to present), ~16 day return, 15m (49ft), 30m (98ft),

Layers | Map | Satellite

Dataset Handler Tabs

1) Draw Area Of Interest

Click to Draw AOI

Rectangle

2) Date Filter (YYYY-MM-DD)

check dataset information for accurate date range on left panel

Enter End Date Prior Day(s)

2021-12-25 8

3) Select Collection Checkbox

Optical (moderate to high resolutions):

- Sentinel-2 True Color Sentinel-2 False Color Sentinel-2 I
- LandSat-9 True Color LandSat-9 False Color LandSat-9 I
- LandSat-8 True Color LandSat-8 False Color LandSat-8 I

Google

Keyboard shortcuts | Map data ©2022 | 2 km | Terms of Use | Report a map error

Thanks for Listening...

Any Questions?



jkastens@ku.edu