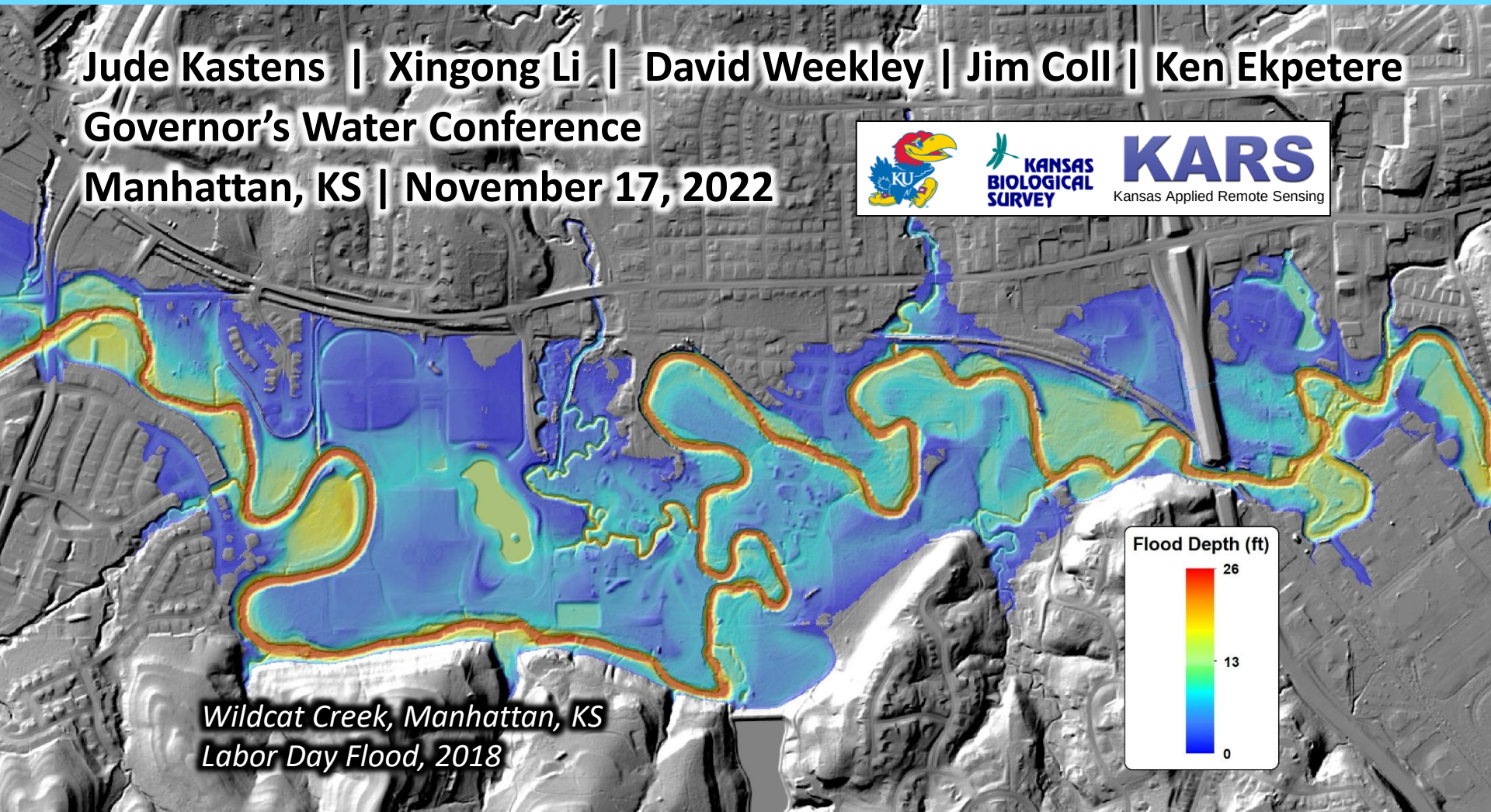
It’s Finally Here…

A Live Flood Mapping Tool for Kansas

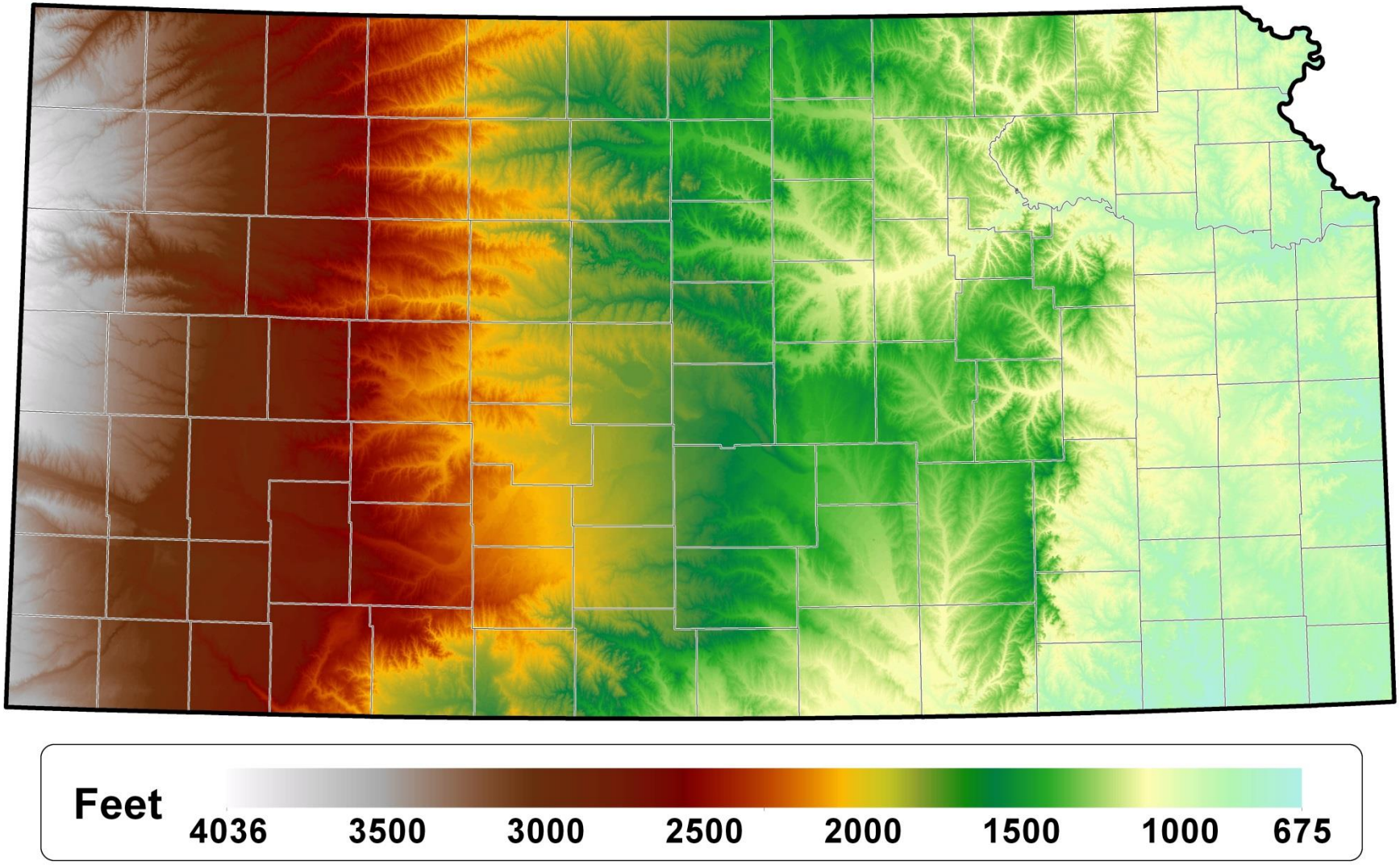


Republican River Flood Crest

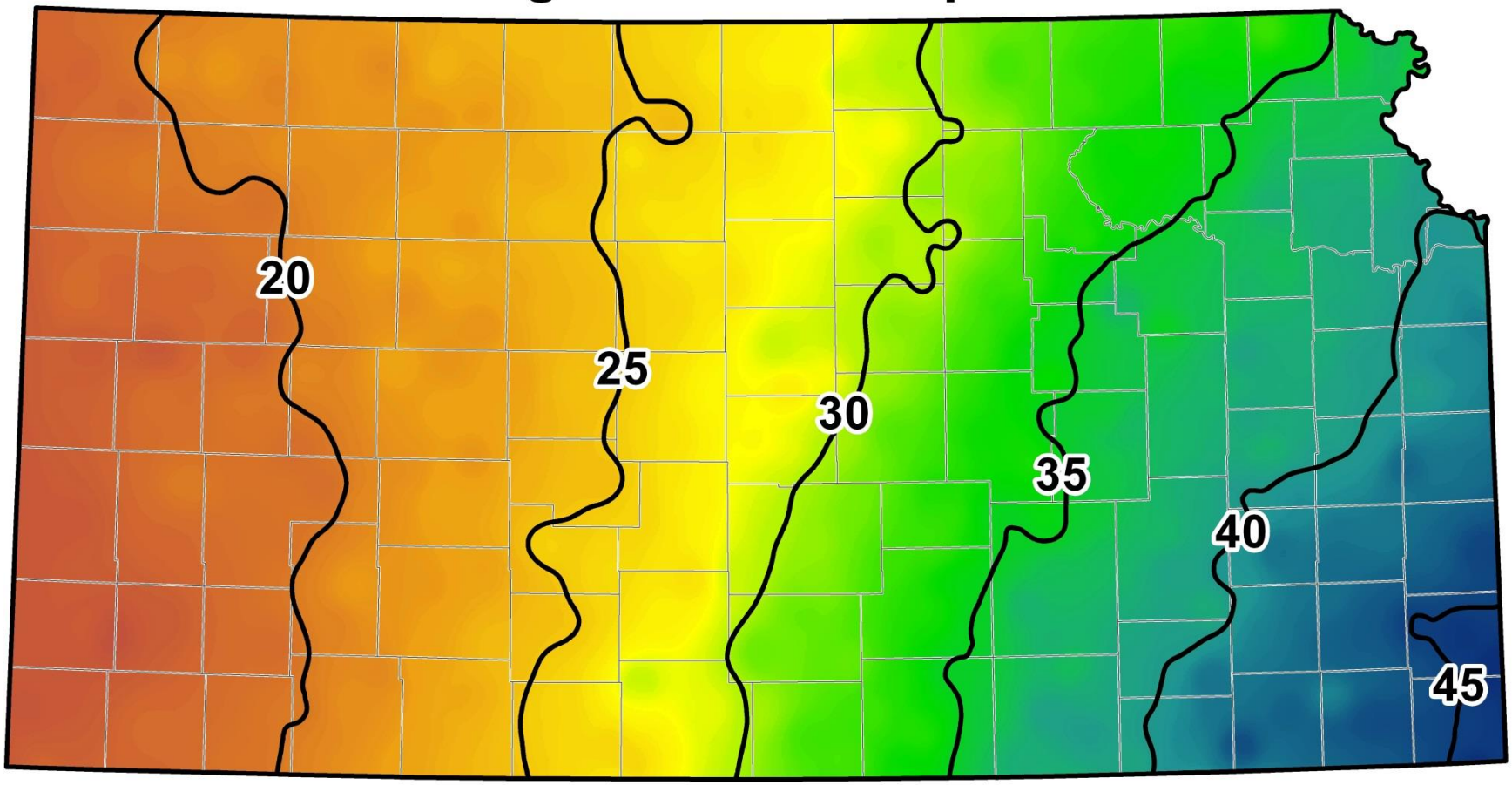
Stratton, NE

July 26, 2020

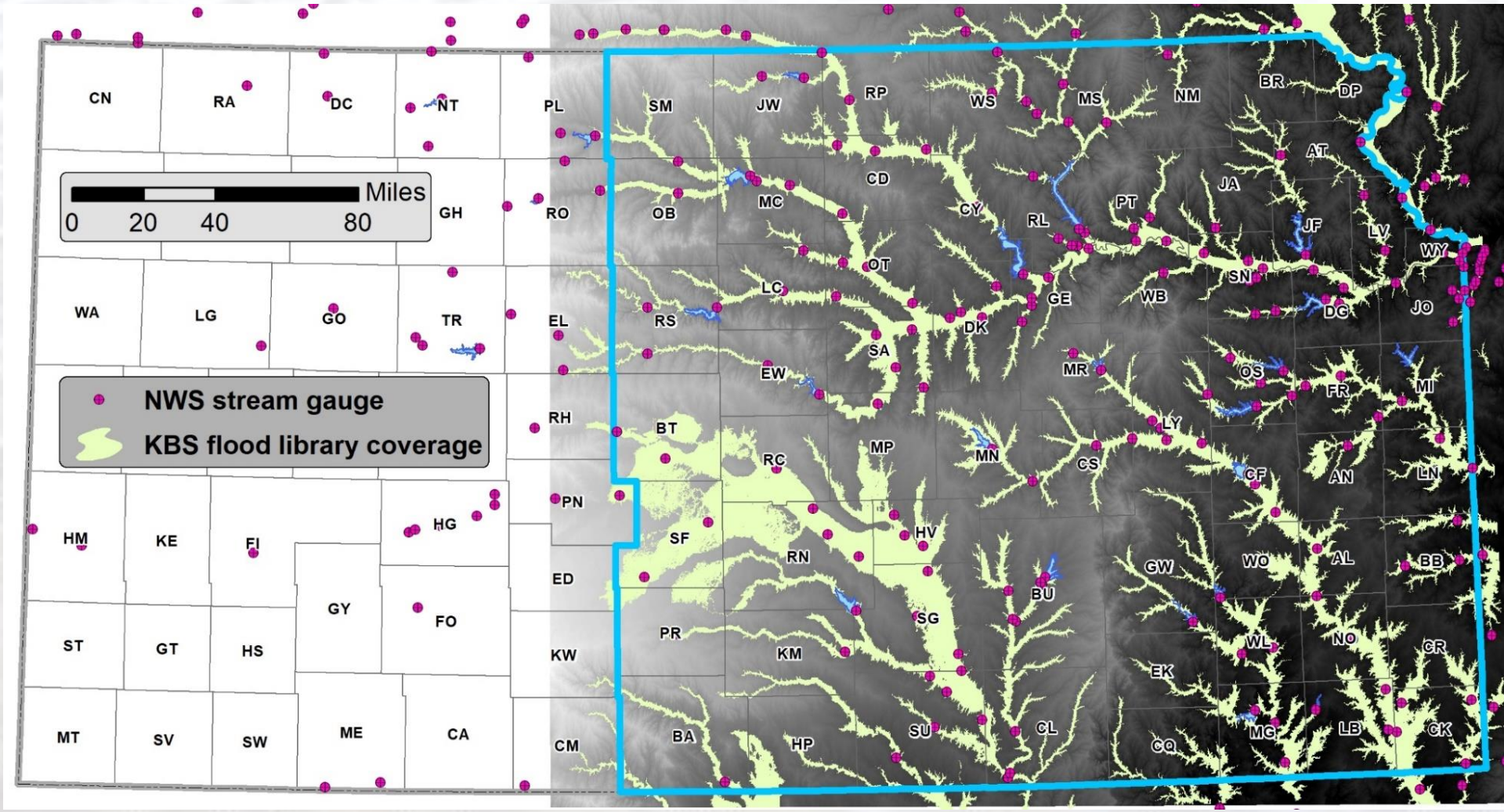
Elevation



Average Annual Precipitation (1981-2010)



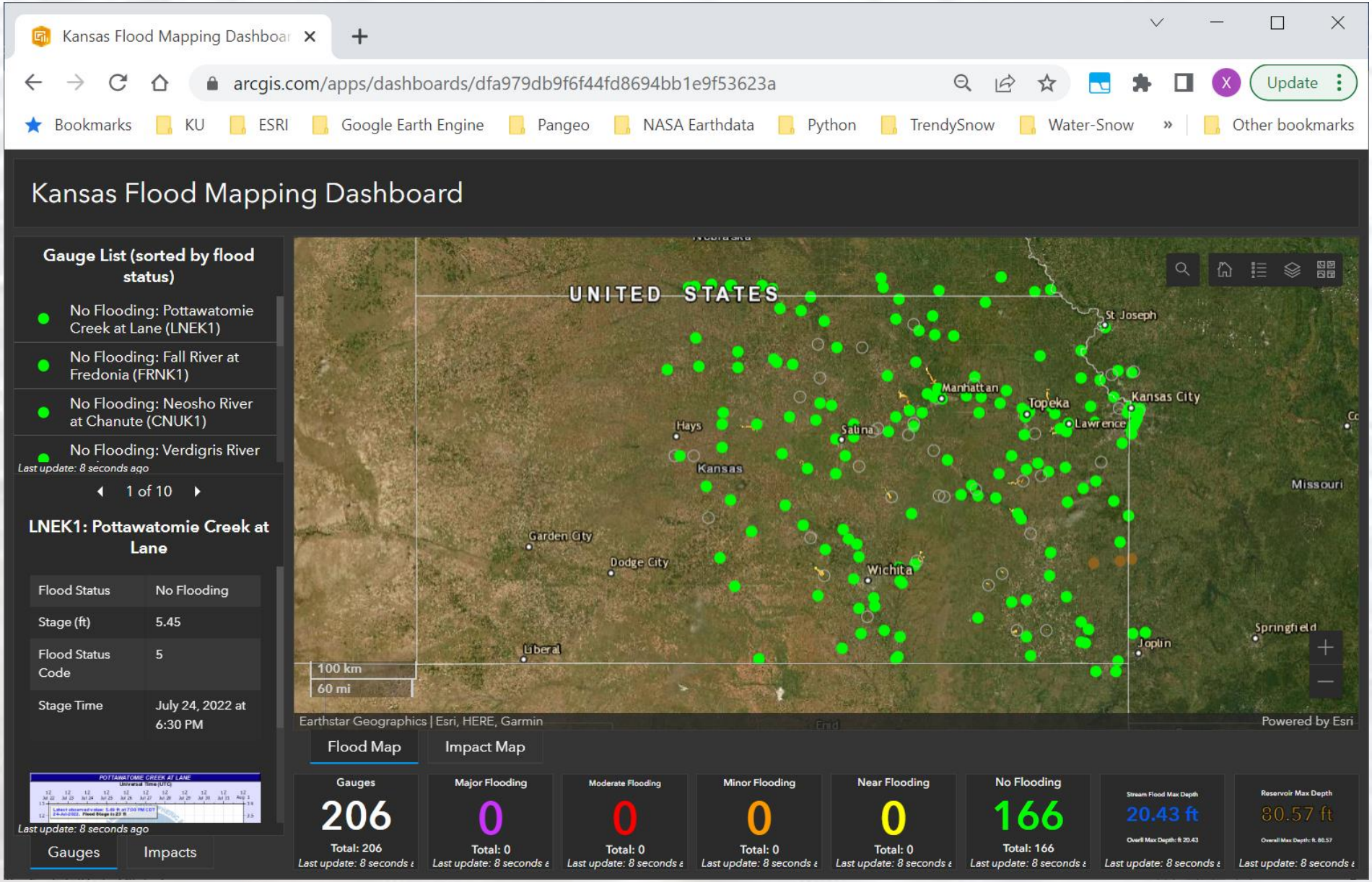
Kansas Inundation Library Coverage



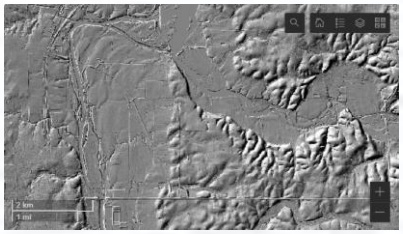
Background

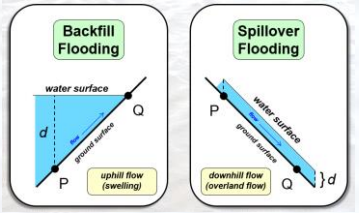
- Inundation library coverage developed for gaged stream network spanning greater eastern Kansas (GIS-PB funding 08, 09, 11, 13)
- Library put into action during record 2019 flooding
- Funding for mapping tool development provided by KWO (2020-2023) & KDEM (2020)
- Work in progress
  - More enhancement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

Kansas Flood Mapping Dashboard

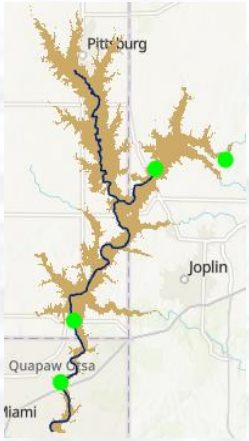


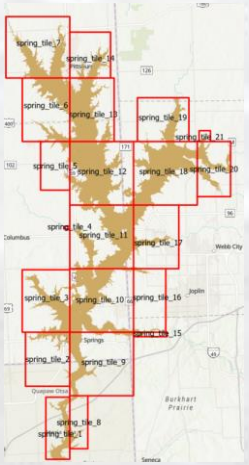
System Structure

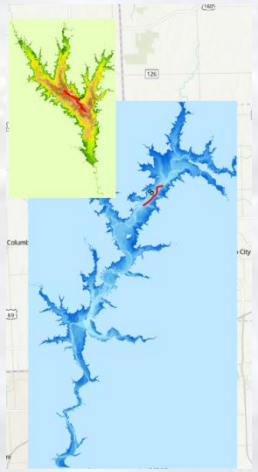


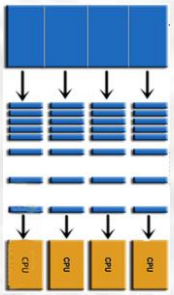


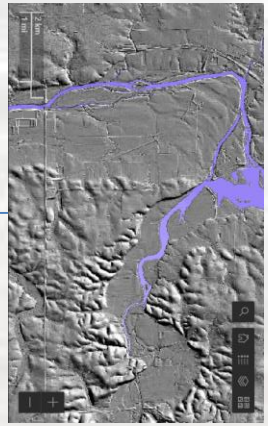
FLDPLN

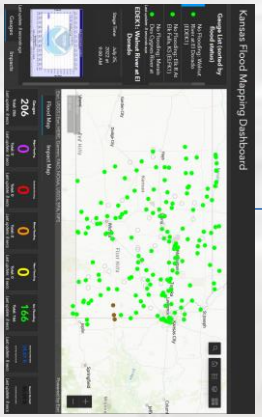




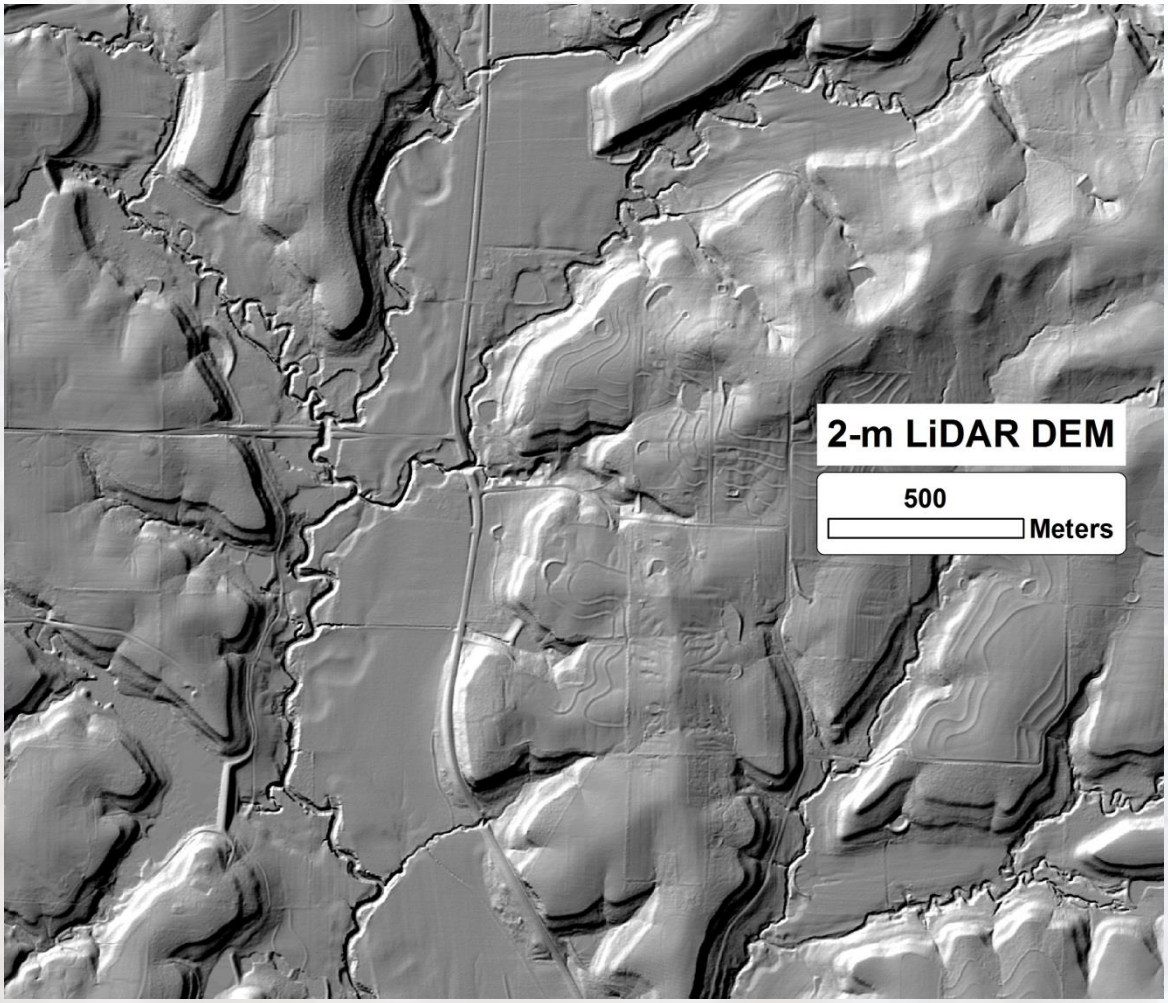








Terrain Processing: *DEM (Digital Elevation Model)*

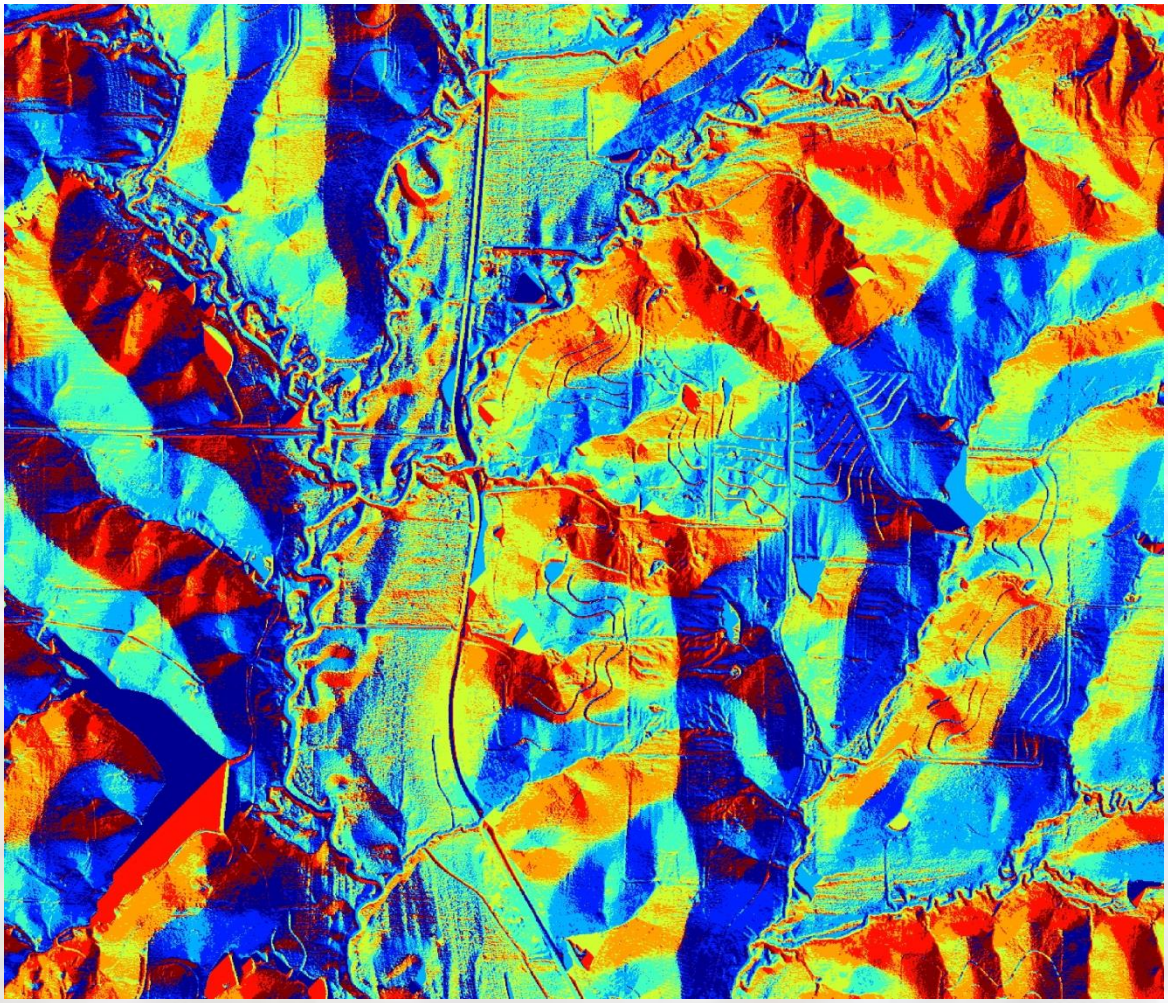


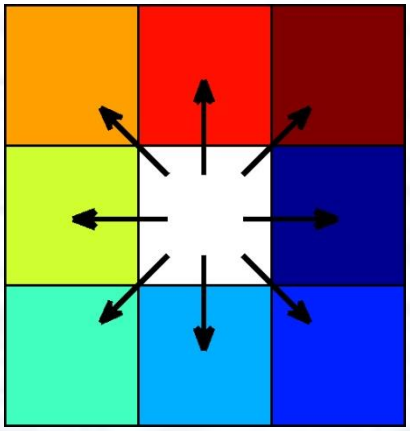
DEM (shown in shaded relief)

This DEM was created using LiDAR data.

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

Terrain Processing: *Flow Direction*



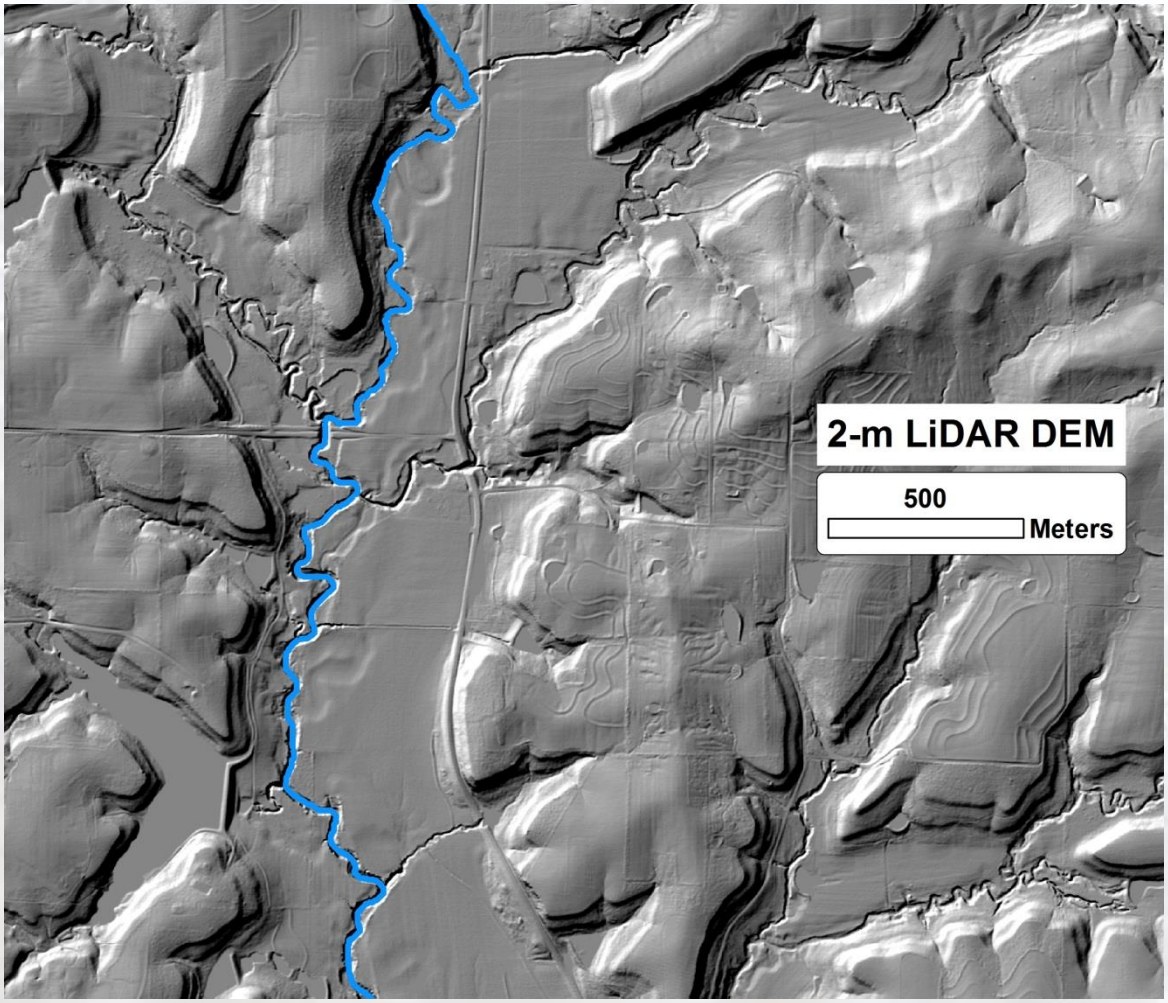


Each pixel is colored based on its flow direction.

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

Flow direction map (gradient direction approximation)

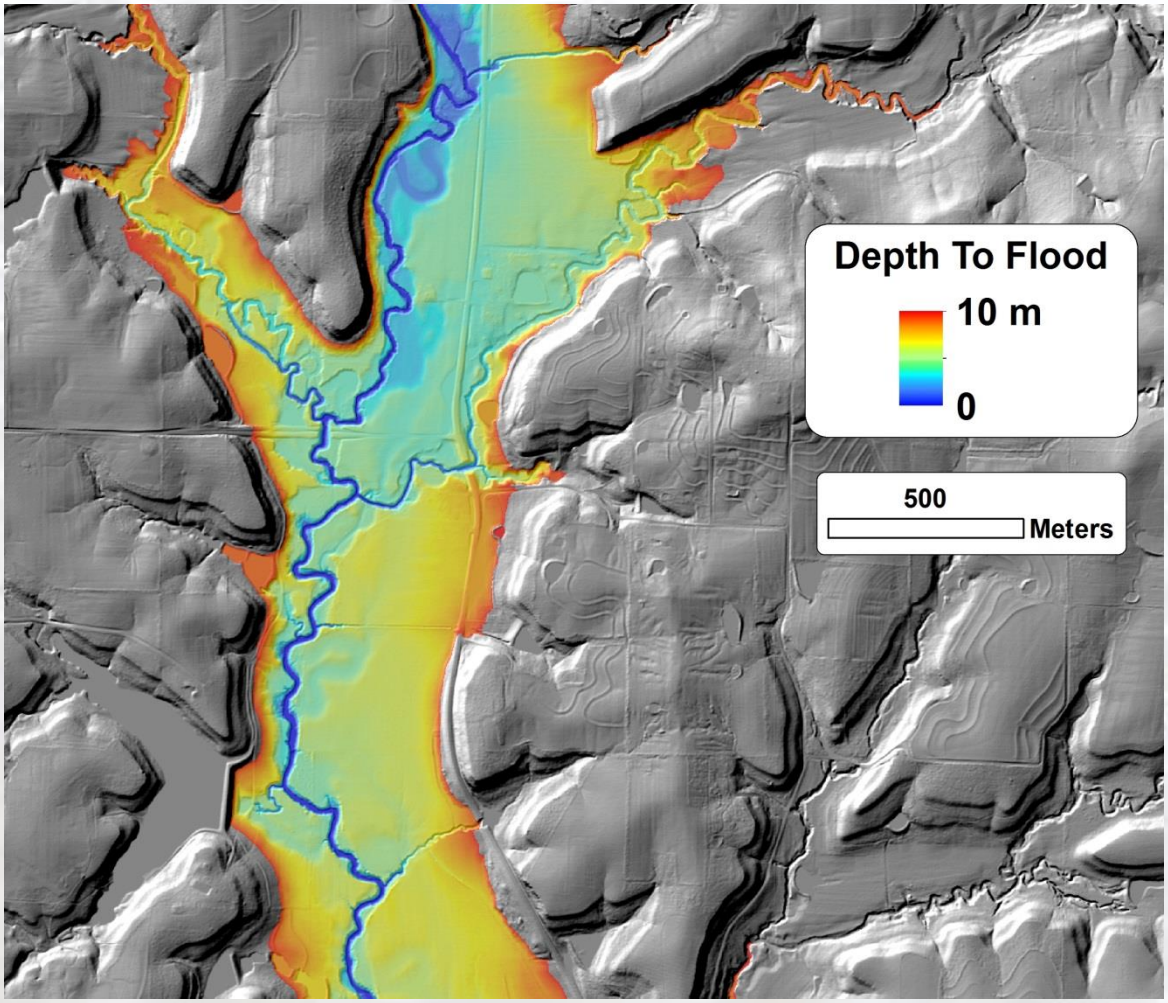
Terrain Processing: *Stream Delineation*



"Synthetic Stream Network"

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

Terrain Processing: *Floodplain Mapping*



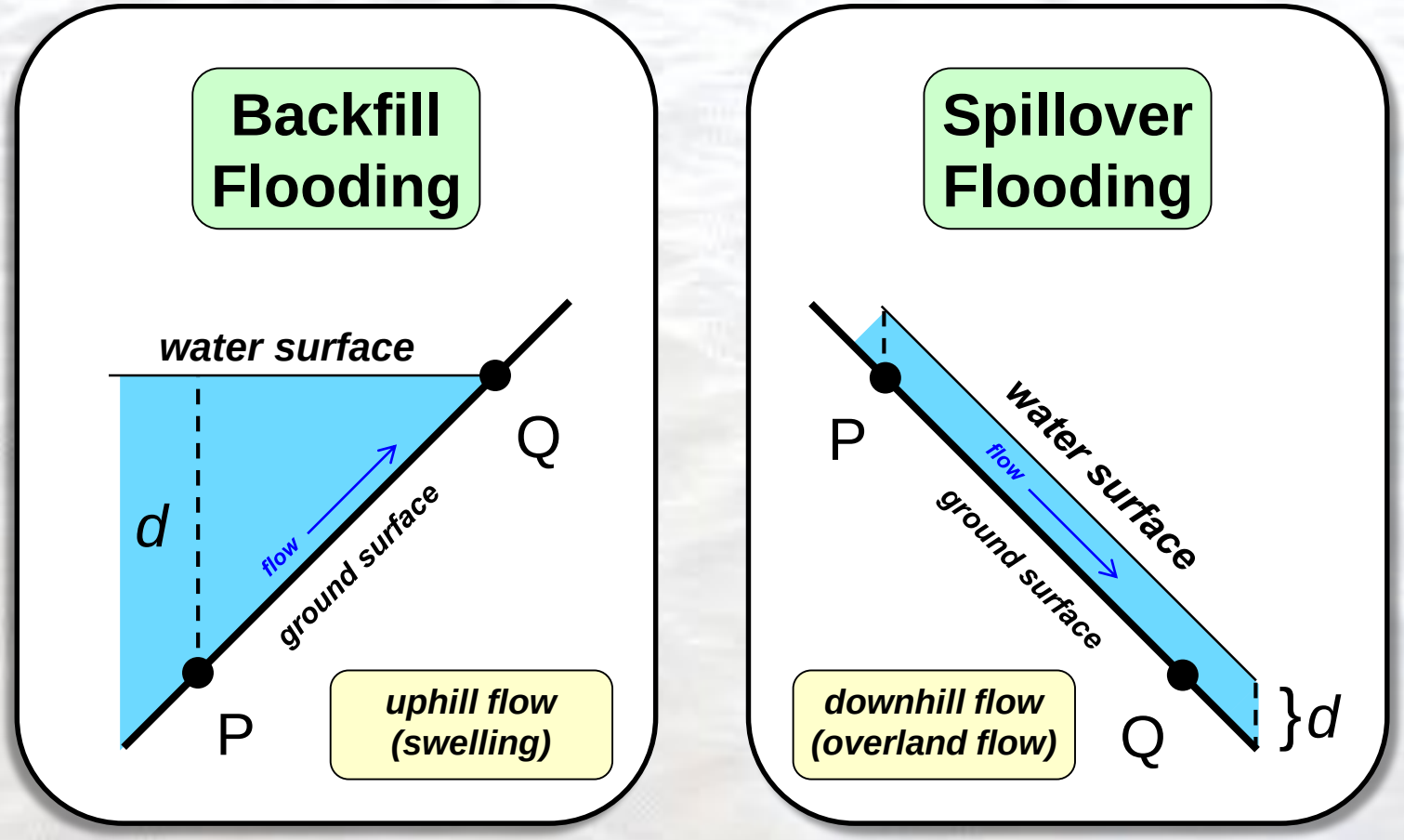
10-m Floodplain (DTF Map)

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.

The FLDPLN ("Floodplain") Model—

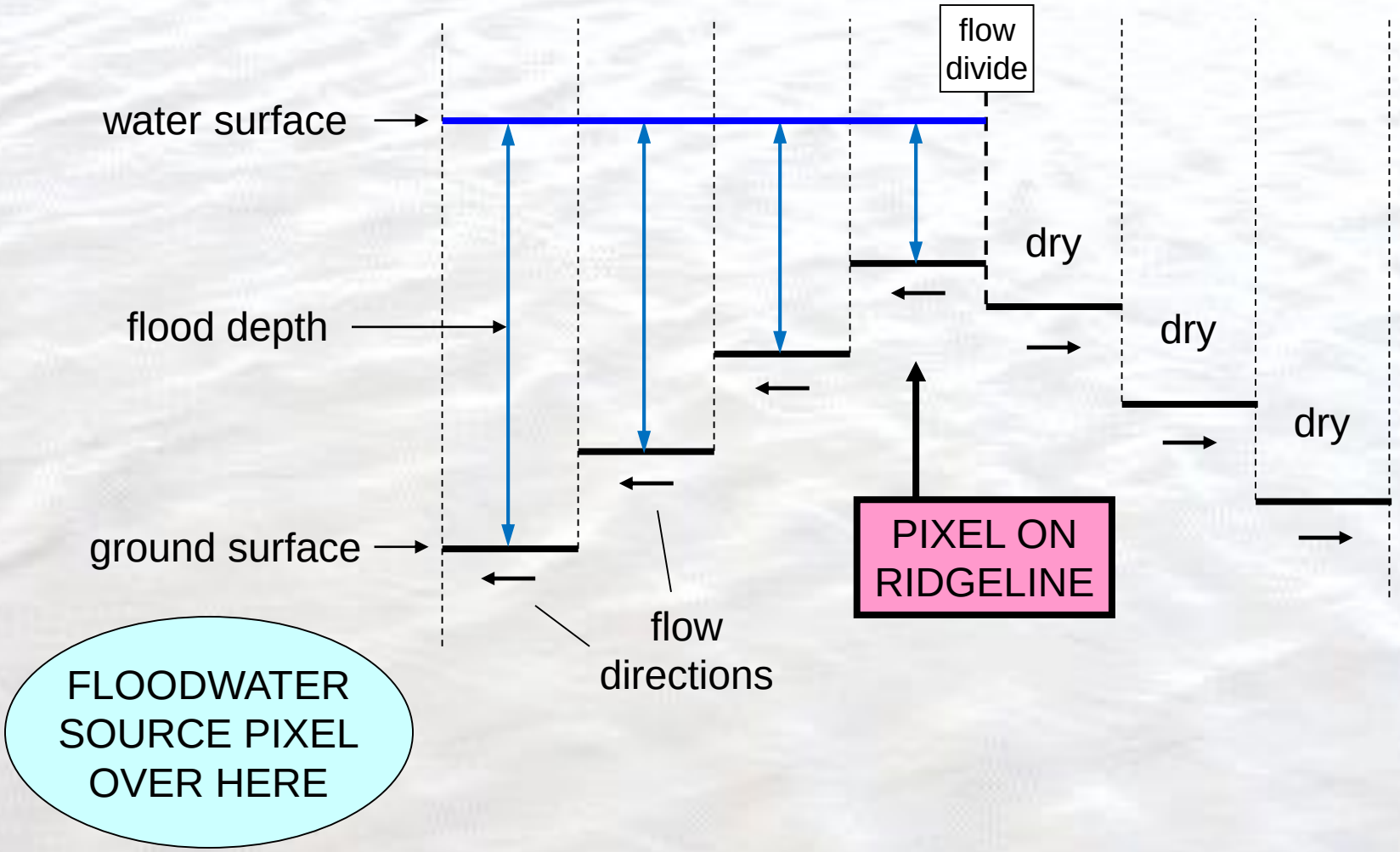
There are two ways that point **Q** can be flooded by water originating from point **P**:



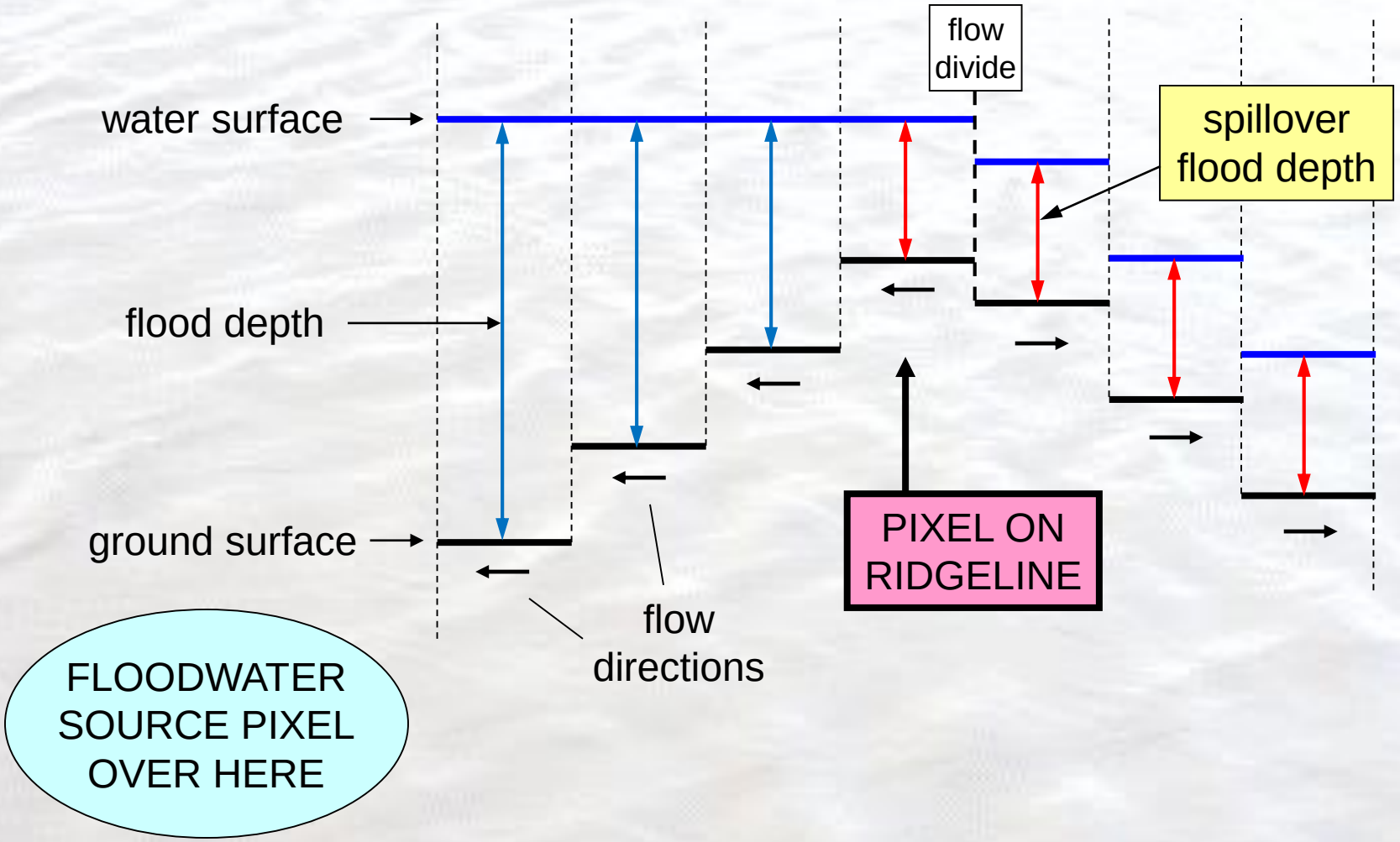
"Water seeks its own level"

"Water flows downhill"

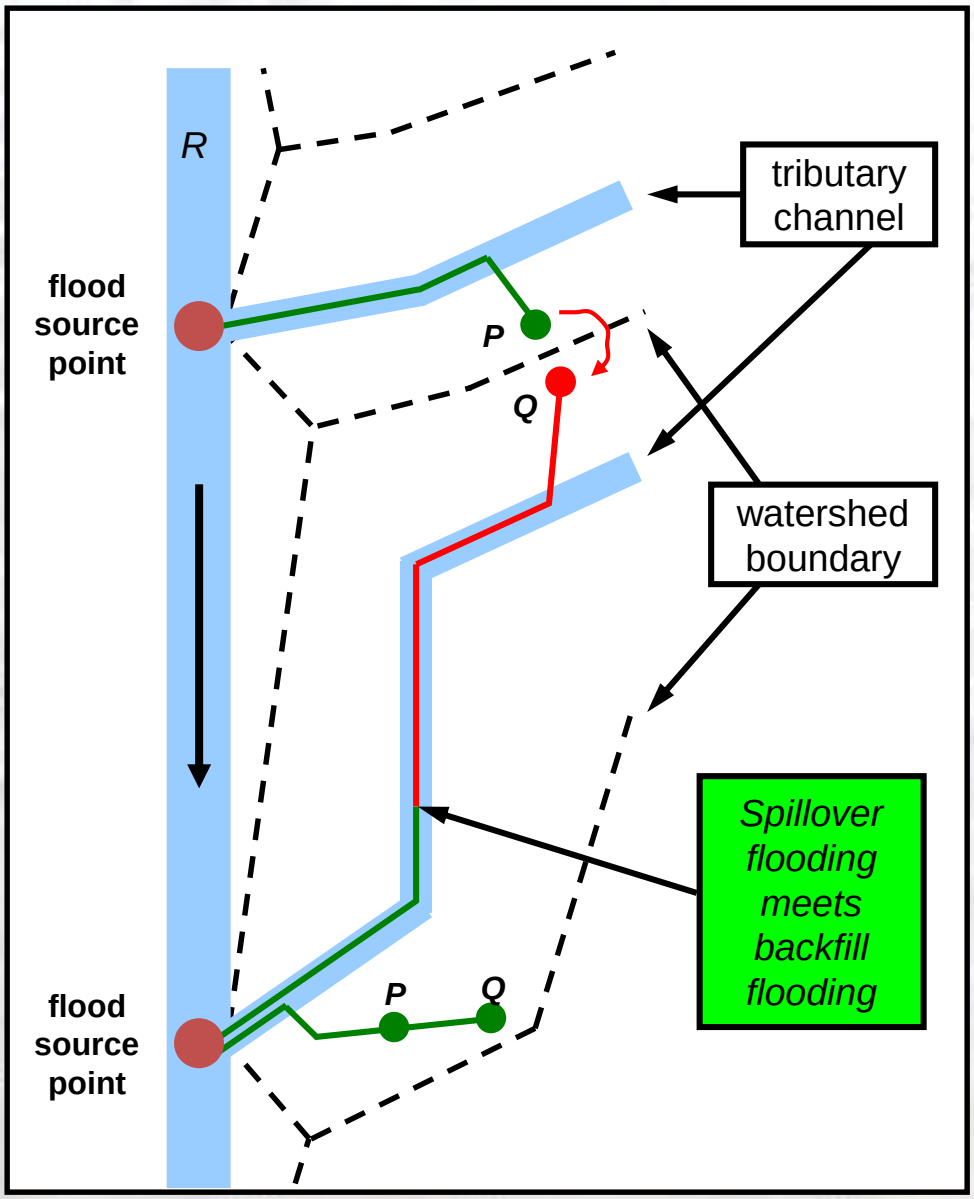
Backfill Flooding—accounts for floodwater expansion due to swelling processes

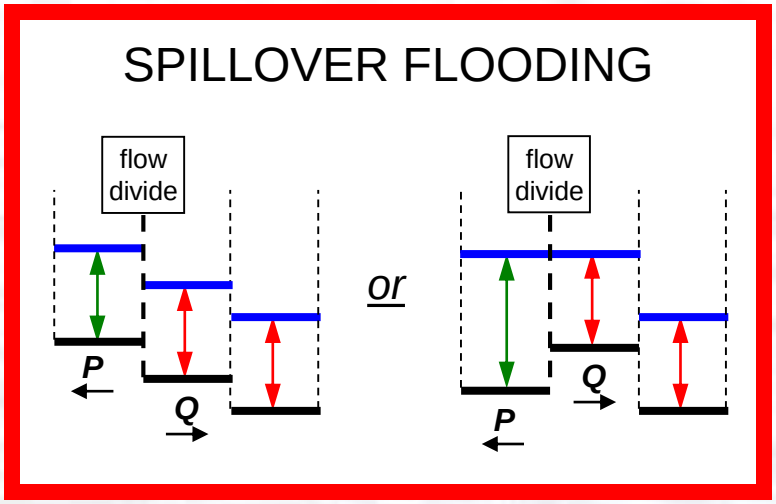


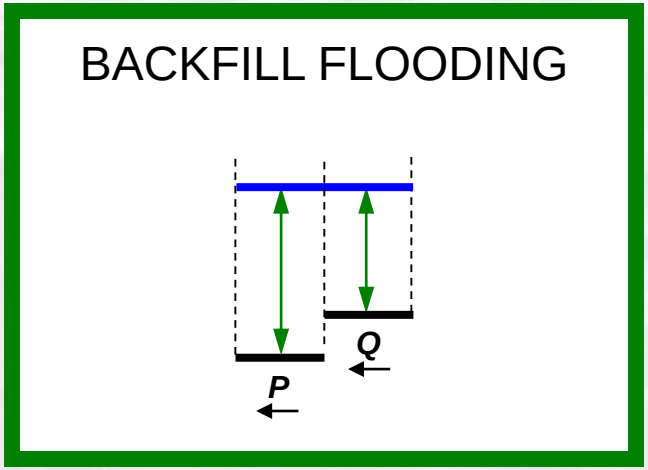
Spillover Flooding—accounts for floodwater rerouting (new flow path development)



PLAN VIEW illustrating backfill and spillover flooding





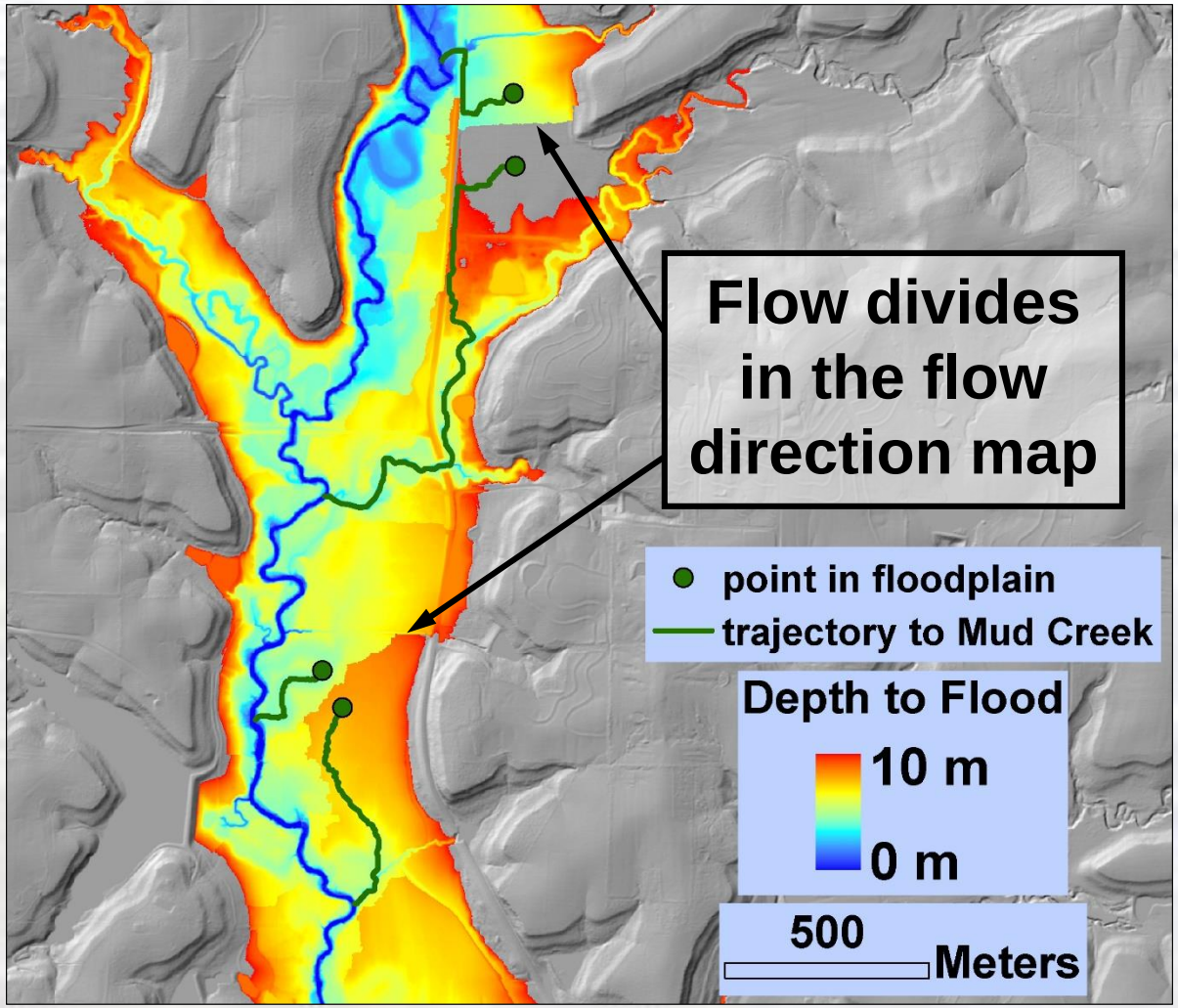


Backfill Flooding Is Not Sufficient

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

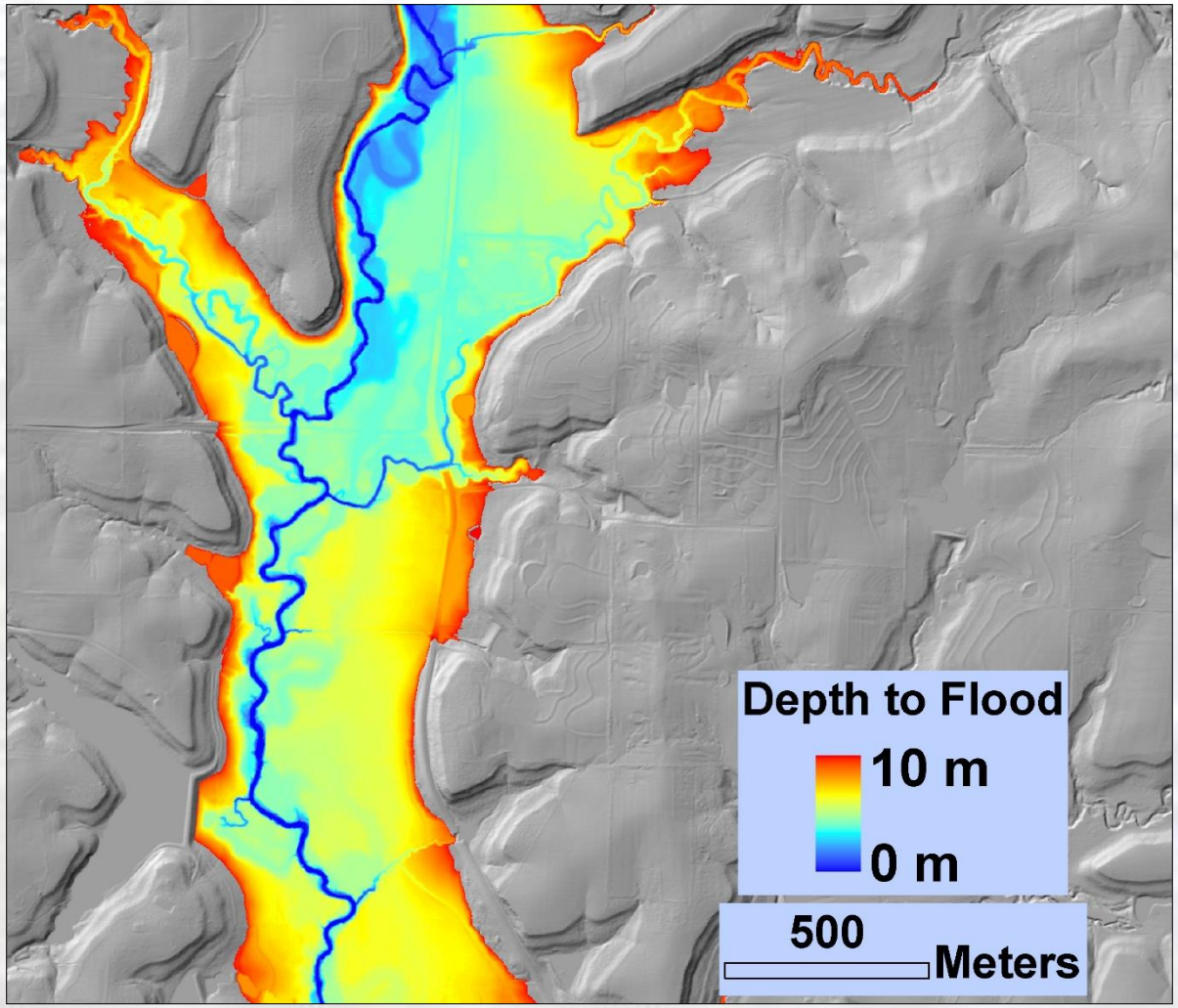
Note the erroneous discontinuities.

These are caused by ridgelines in the DEM.

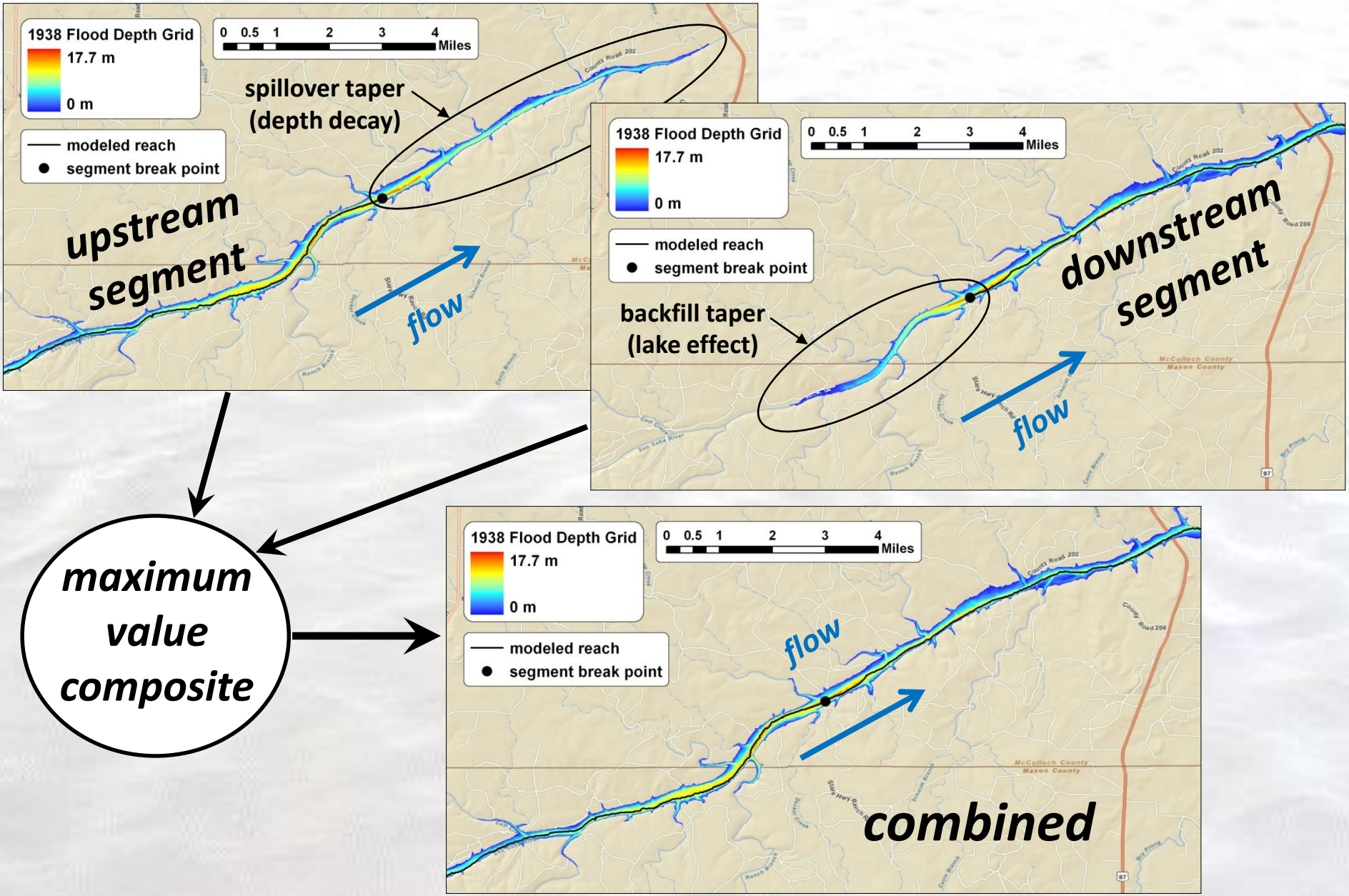


Backfill + Spillover Flooding

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.

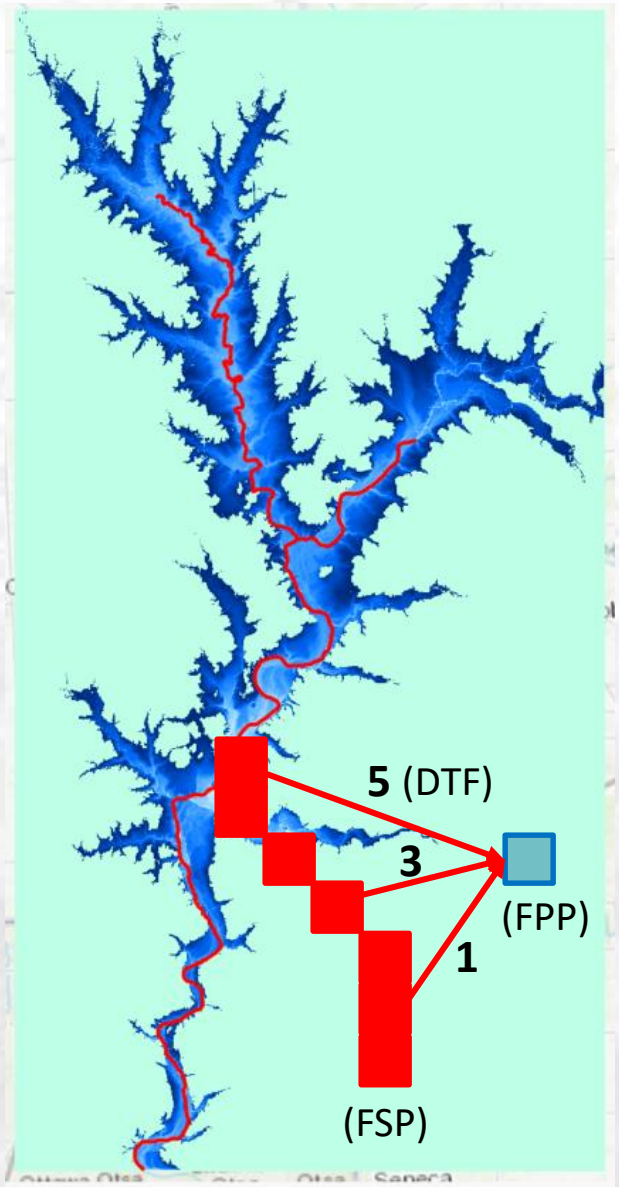


Seamless modeling with FLDPLN



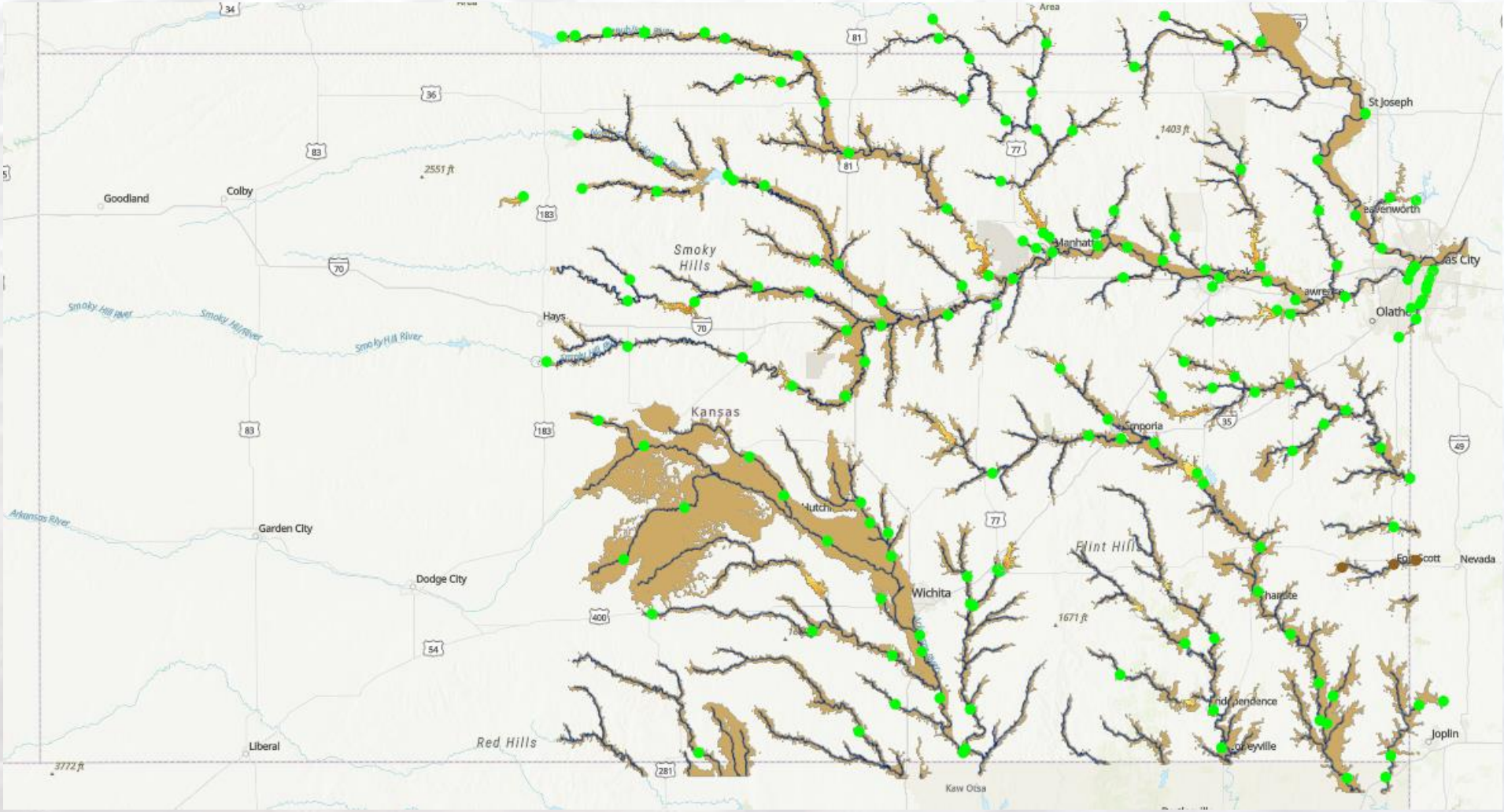
FLDPLN Model – Building a Library

- 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

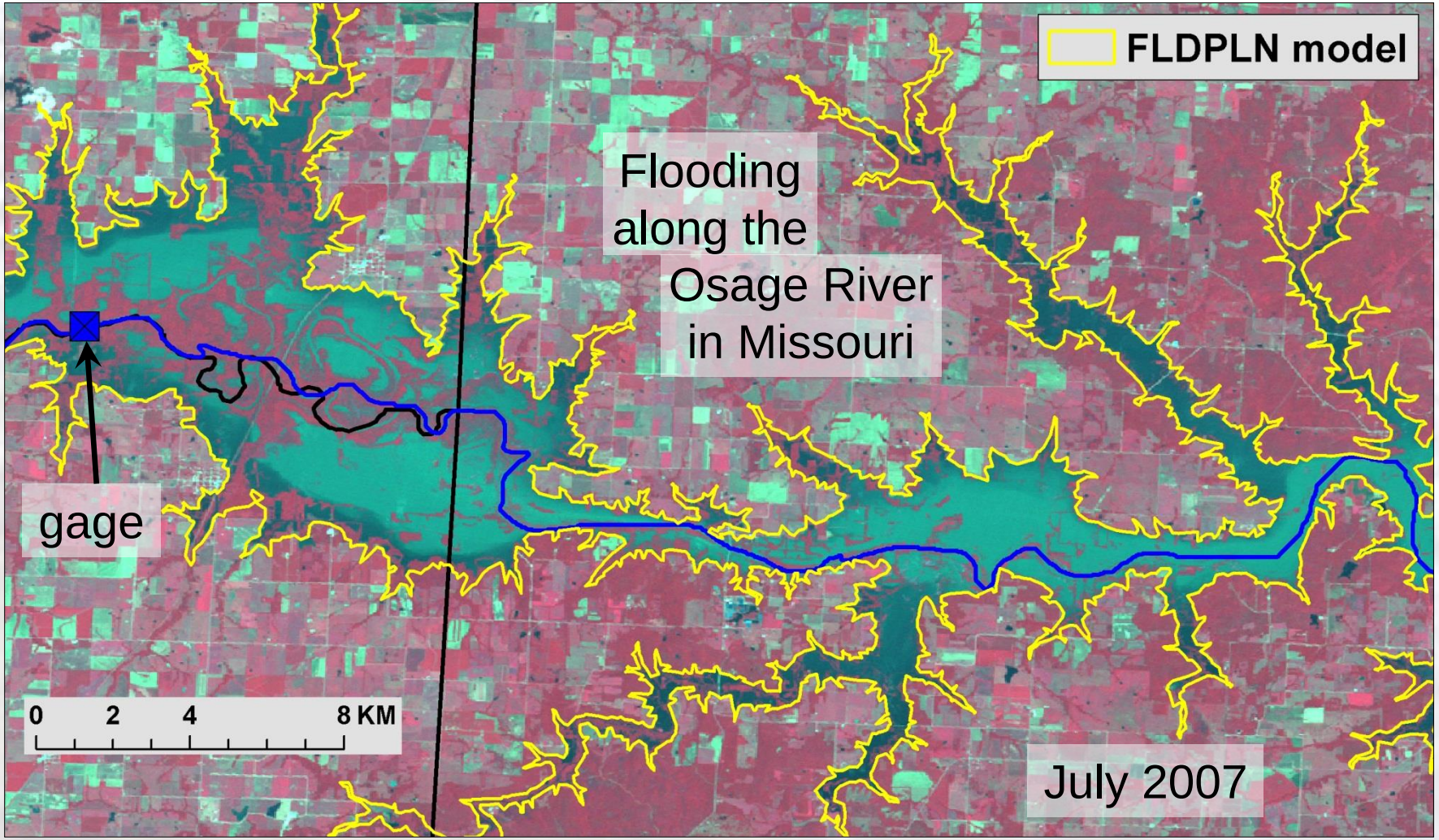


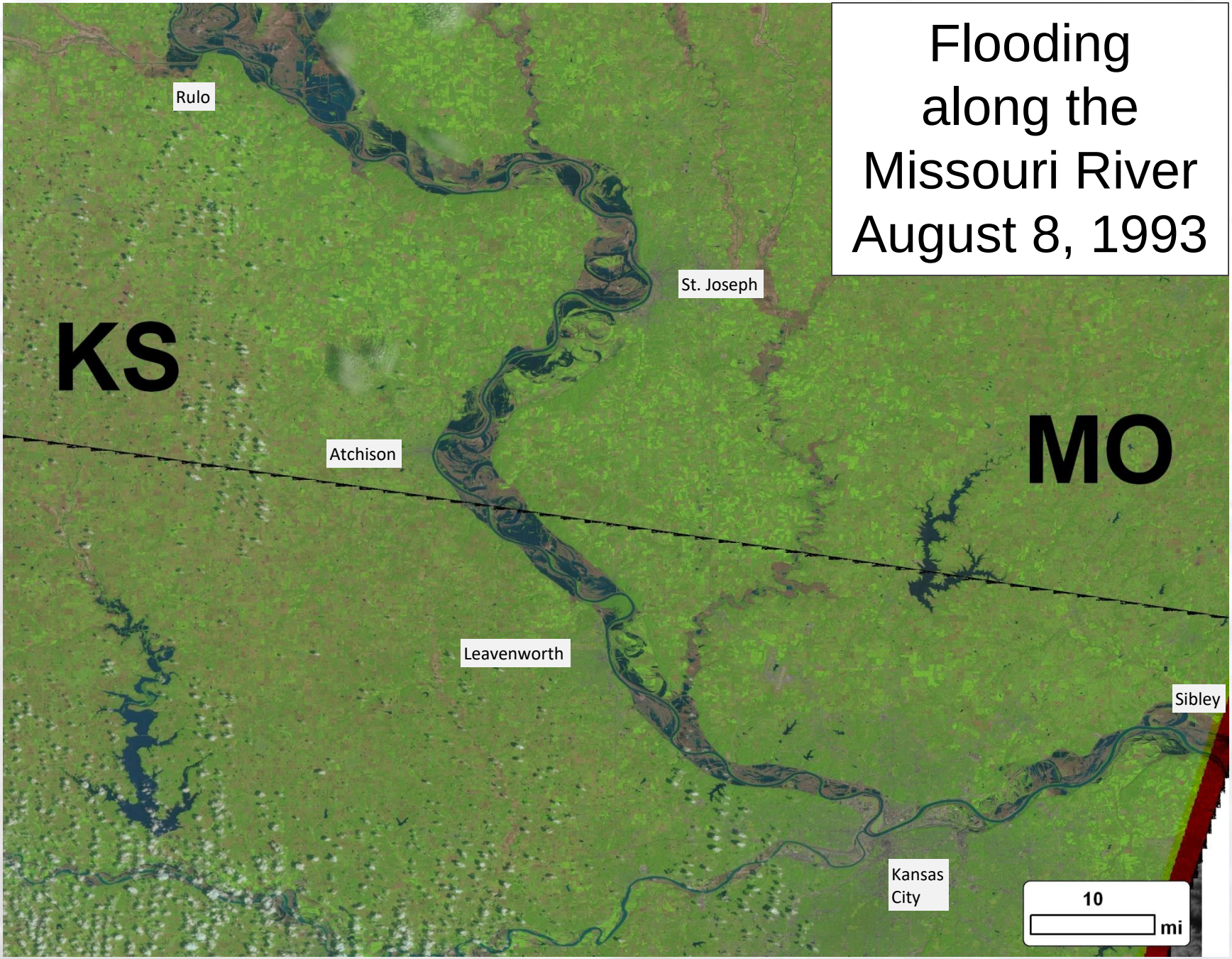
FLDPLN Libraries for Eastern Kansas

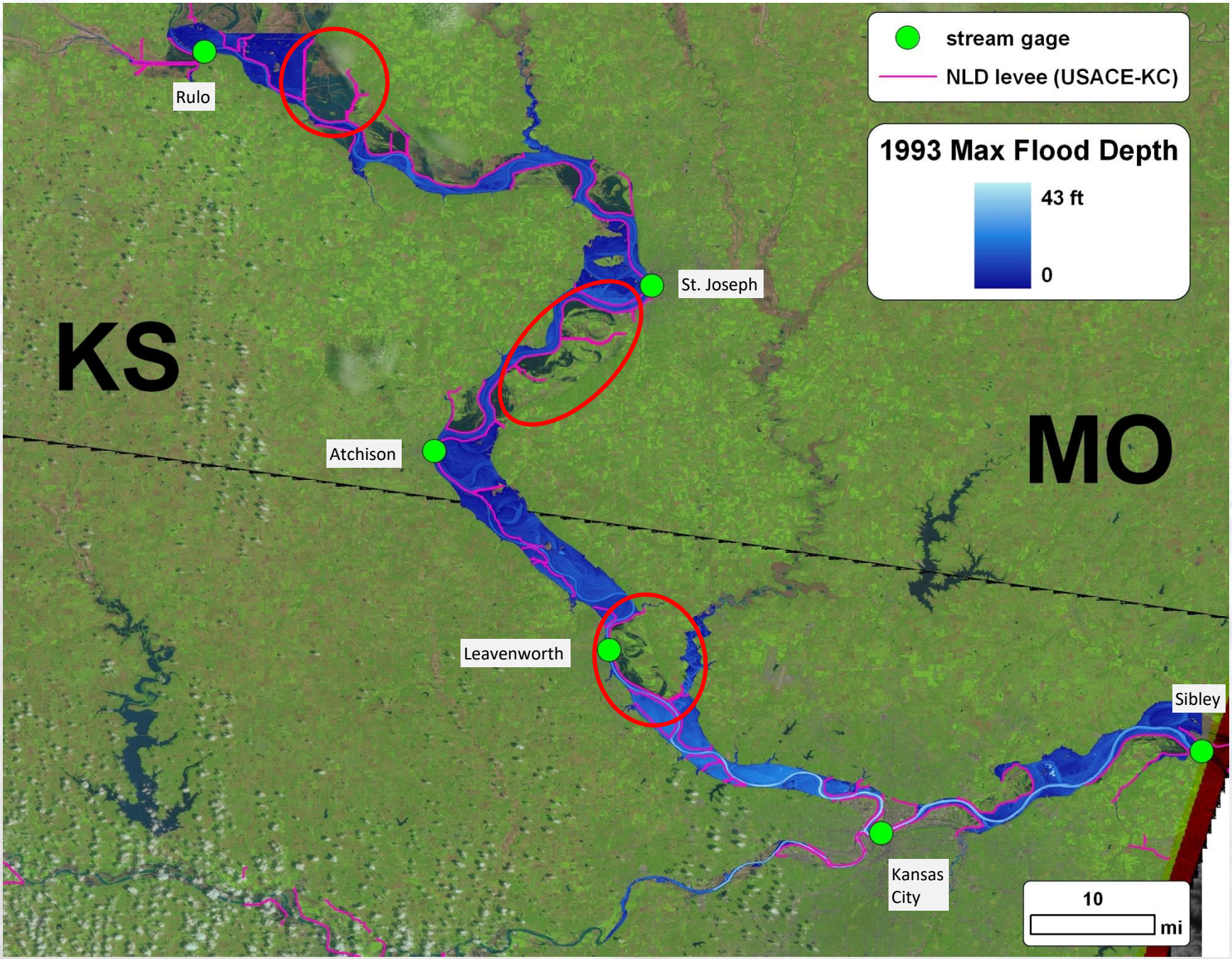
- 25 libraries cover eastern Kansas (~100 GB file size)
- Based on 5-m LiDAR DEM

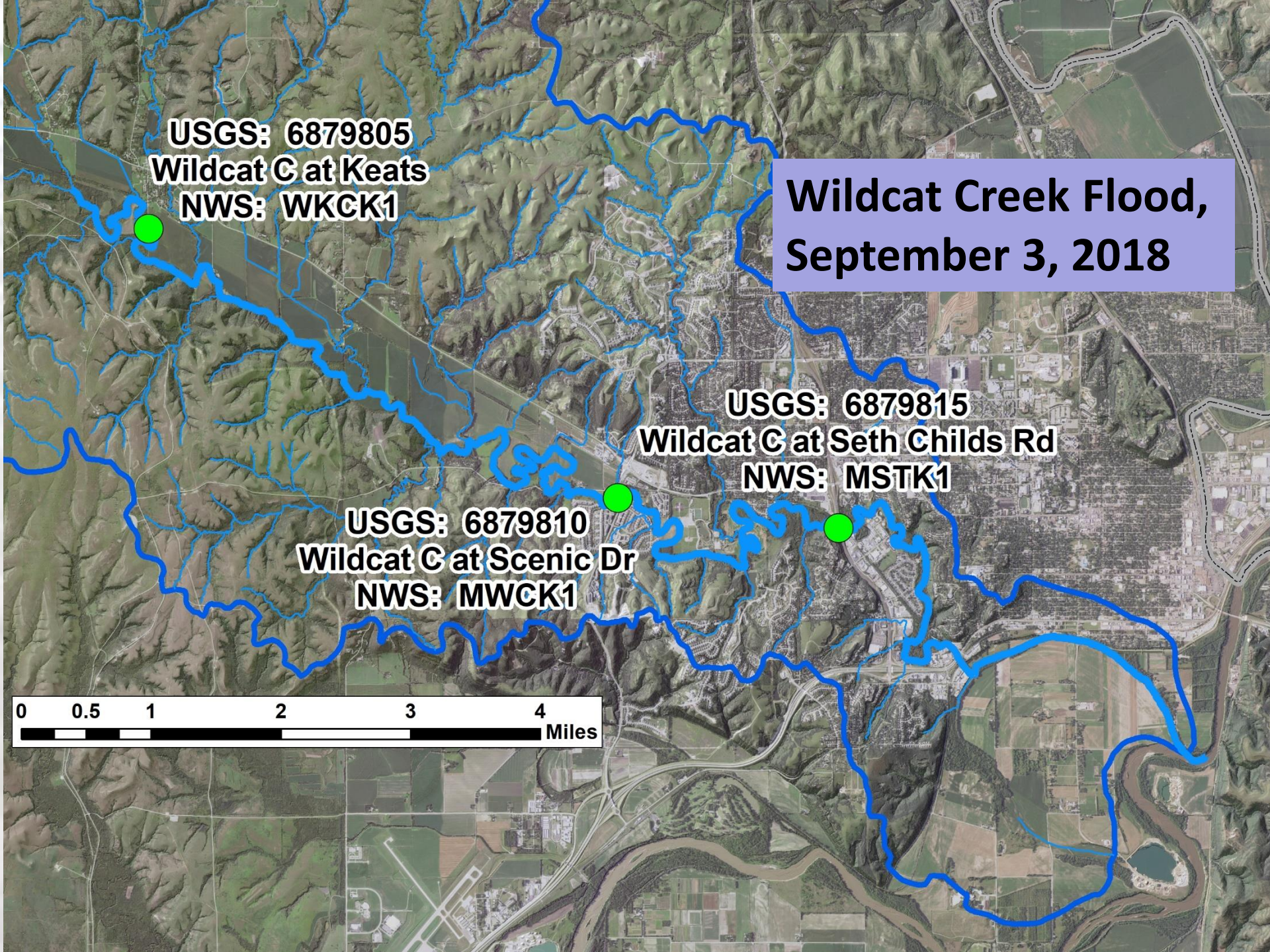


Flood mapping examples using FLDPLN



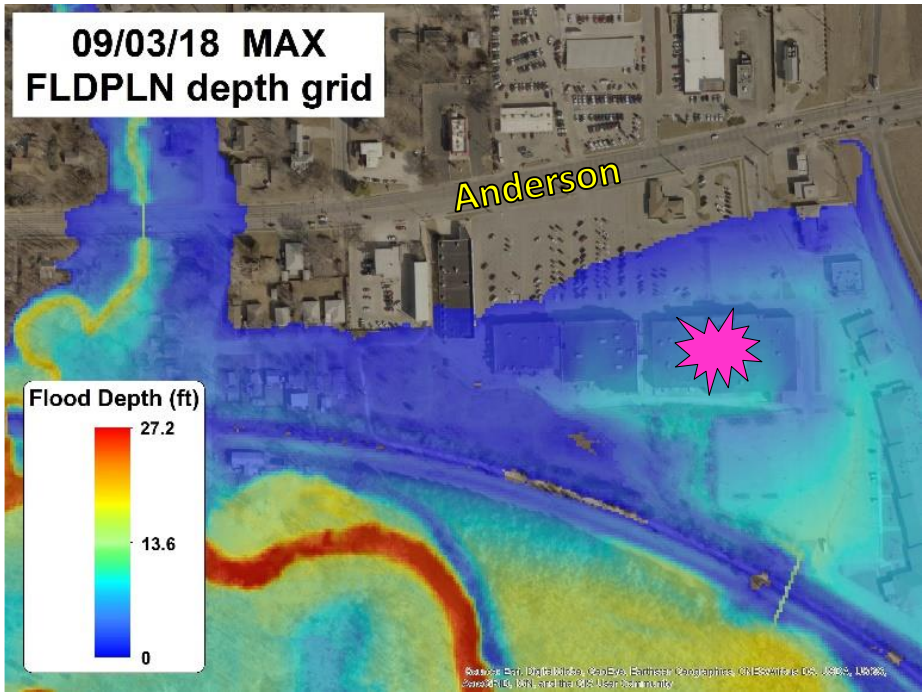

Flooding
along the
Missouri River
August 8, 1993
Rulo
St. Joseph
KS
MO
Atchison
Leavenworth
Sibley
Kansas
City
10
mi


stream gage
NLD levee (USACE-KC)
1993 Max Flood Depth
43 ft
0
Rulo
St. Joseph
KS
MO
Atchison
Leavenworth
Sibley
Kansas City
10
mi


USGS: 6879805
Wildcat C at Keats
NWS: WKCK1
Wildcat Creek Flood,
September 3, 2018
USGS: 6879815
Wildcat C at Seth Childs Rd
NWS: MSTK1
USGS: 6879810
Wildcat C at Scenic Dr
NWS: MWCK1
0 0.5 1 2 3 4
Miles

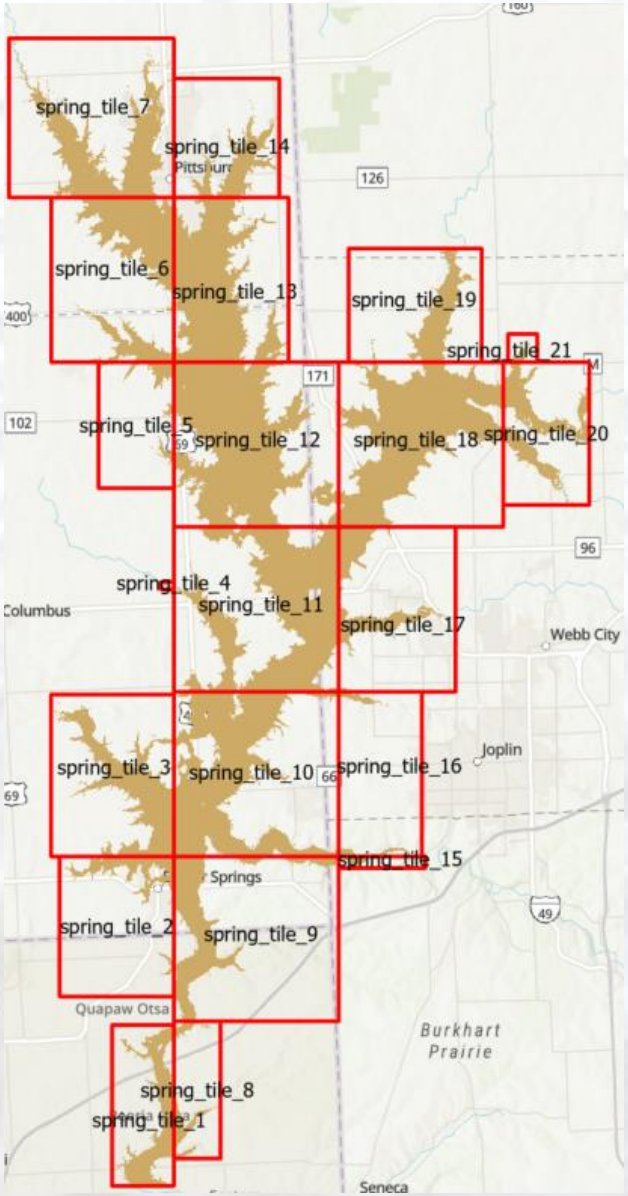
Anderson Ave & Village Drive
(looking east)

Anderson



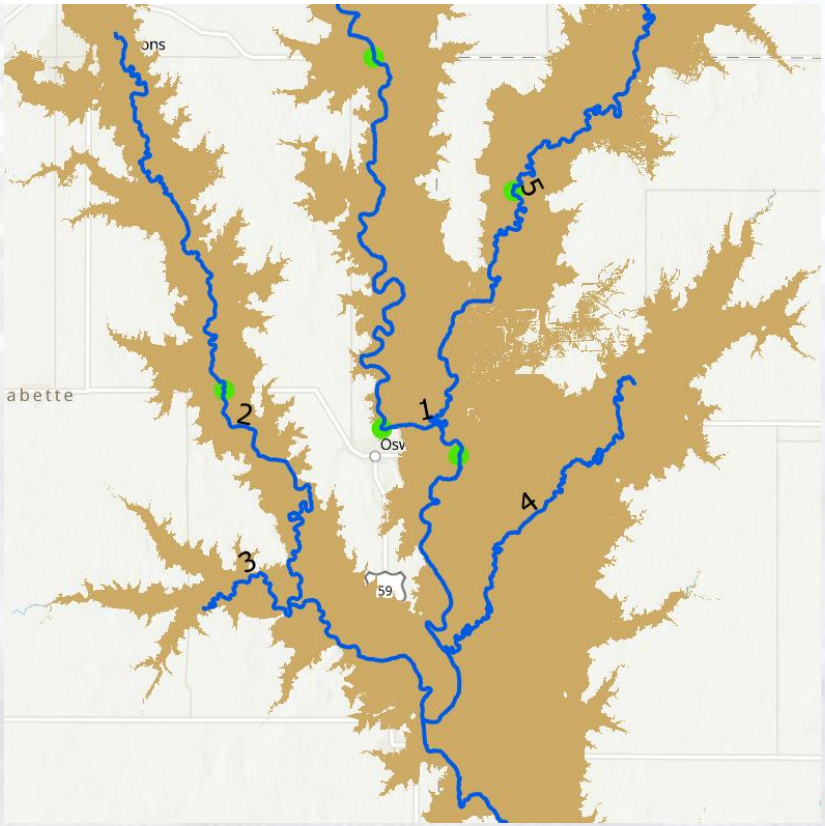
Efficient mapping using tiling

- 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



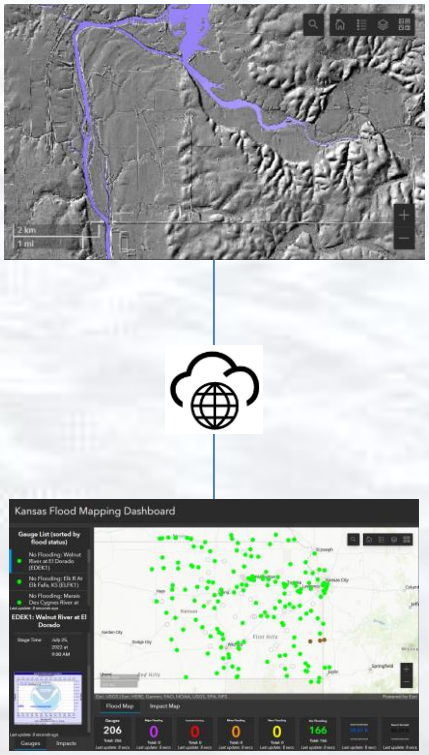
Gauge and Stage

- Driver of floods
- Estimate FSP depth of flow (DOF)
  - Snap gauges to FSPs
  - Based on steam 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



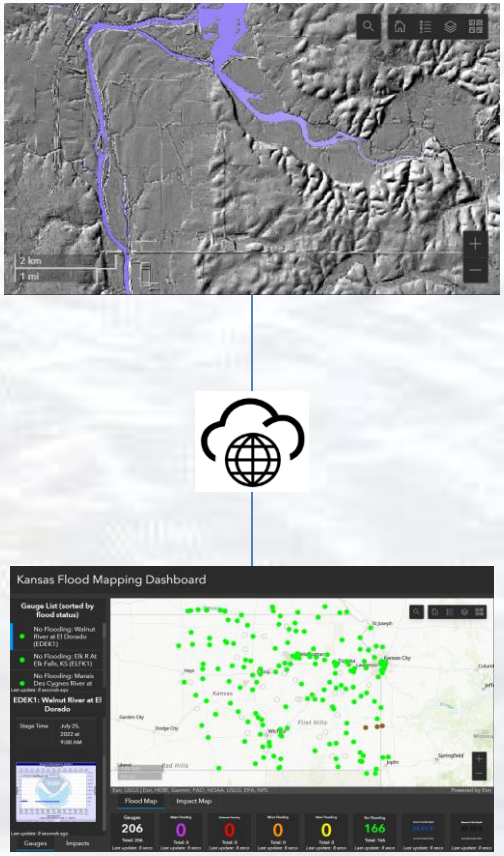
Serve Flood Maps on Web

- 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

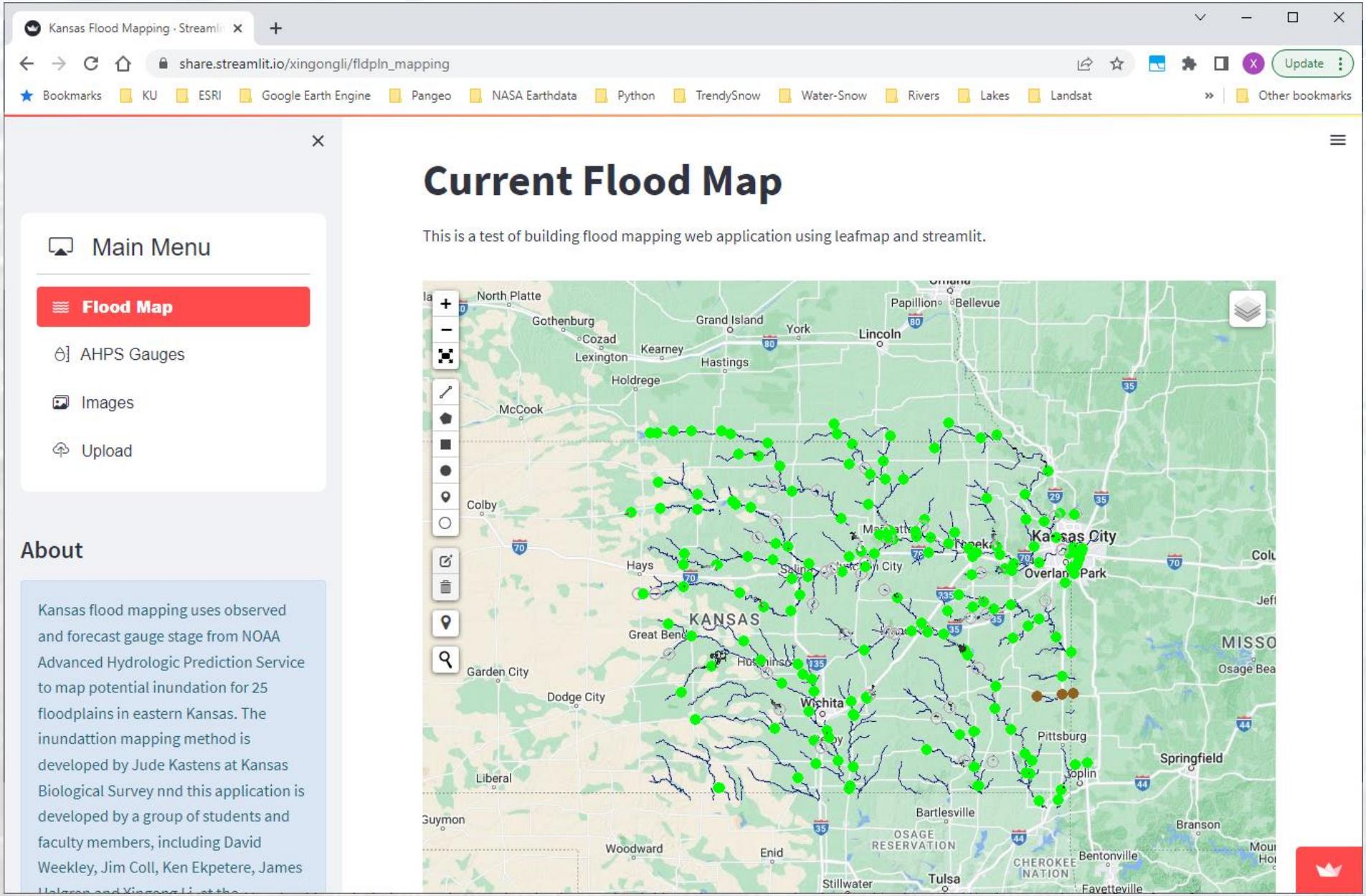


Web Applications

- 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



JupyterBook Documentation

3. Tile FLDPLN Libraries — Mapp

File | E:/FLDPLN/mapping-flood-in-kansas/_build/html/MappingFlood/03_tiling.html

Update

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

Mapping Floods in Kansas

Search the docs ...

CHAPTERS

1. Introduction
2. The FLDPLN Model
3. Tile FLDPLN Libraries
4. Parallelize Flood Mapping
5. Stream and Reservoir Gauges
6. Serve Flood Maps
7. Flood Mapping Dashboard
8. Rapid Image Viewer
9. Future Improvements

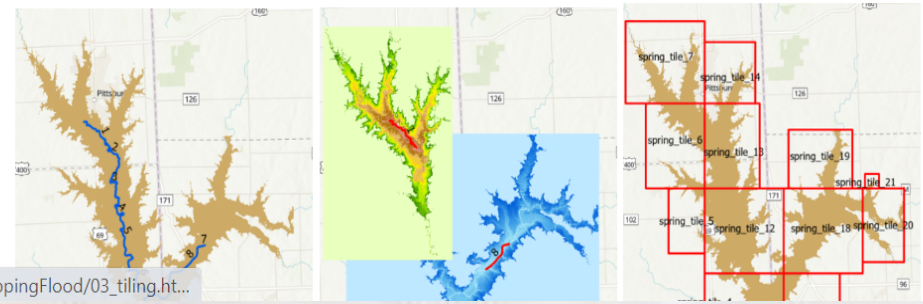
APPENDICES

3.1. Tiling relations by

The FSP-FPP relations from the F ent by segment where each segment file stores al gment. This organization concept egments). The figure below shows the 21 seg num DTF to flood the FPPs for segments 1 and 8 (he length of the segments 1 and 8 are similar, the FPP footpri herent.

Note

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



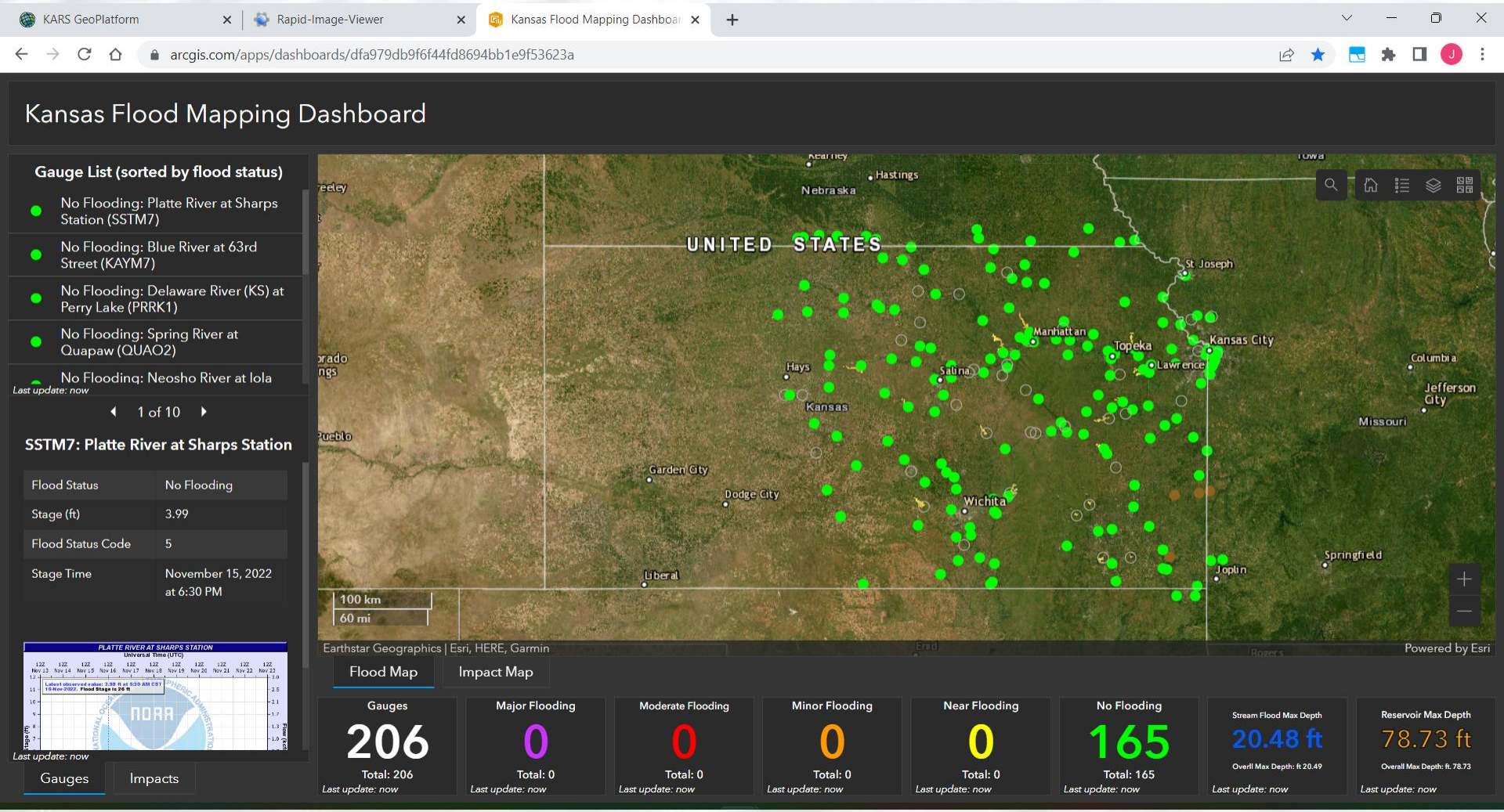
Contents

3.1. Tiling relations by FSPs
3.2. Tiling relations by FPPs
3.3. System bottlenecks
3.4. Issues in tiling the libraries
3.5. Adaptive tiling
3.6. Connection to the Map Compute framework

E:/FLDPLN/mapping-flood-in-kansas/_build/html/MappingFlood/03_tiling.ht...

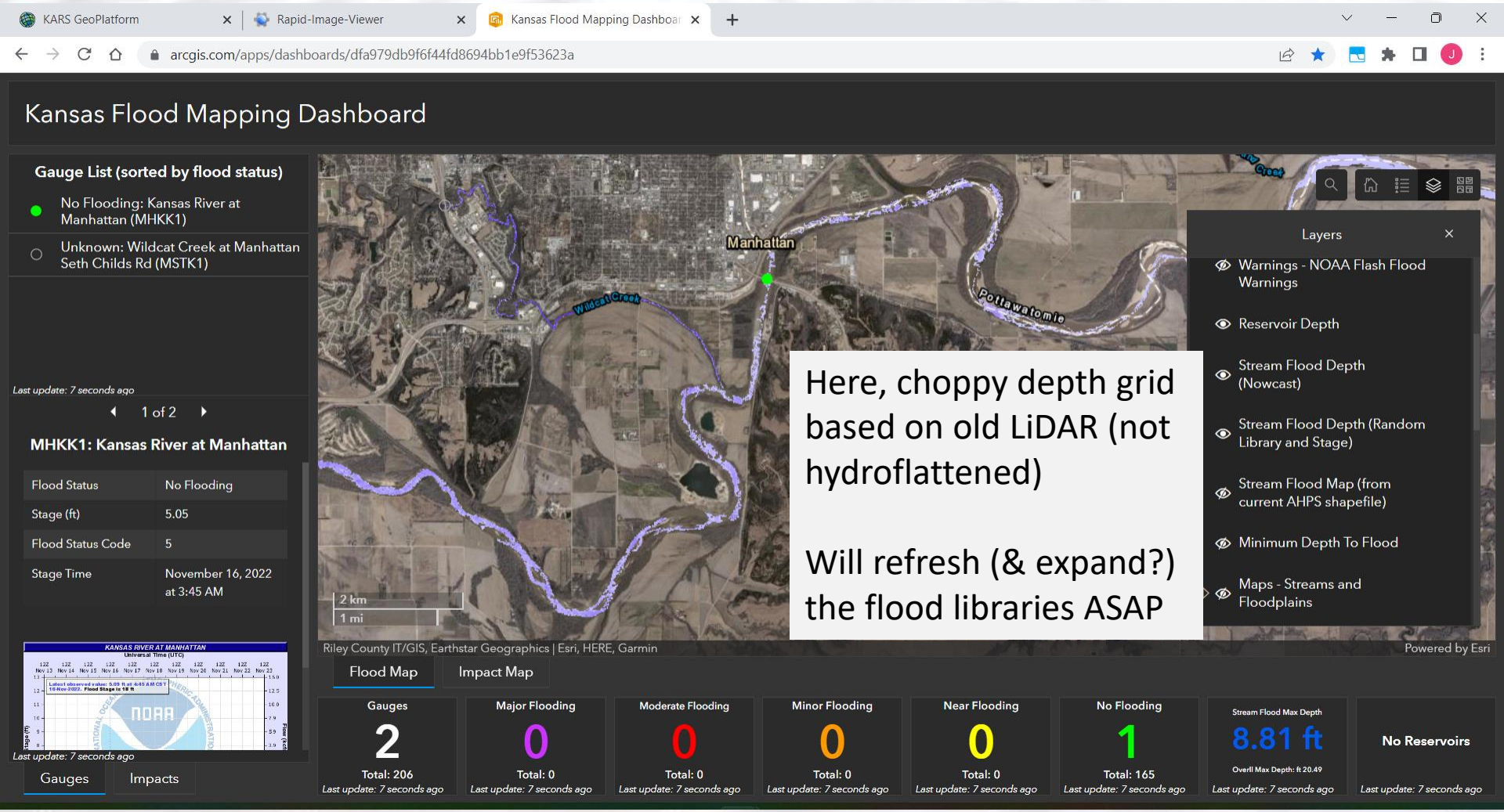
Kansas Flood Mapping Dashboard - temporary website

https://www.arcgis.com/apps/dashboards/dfa979db9f6f44fd8694bb1e9f53623a



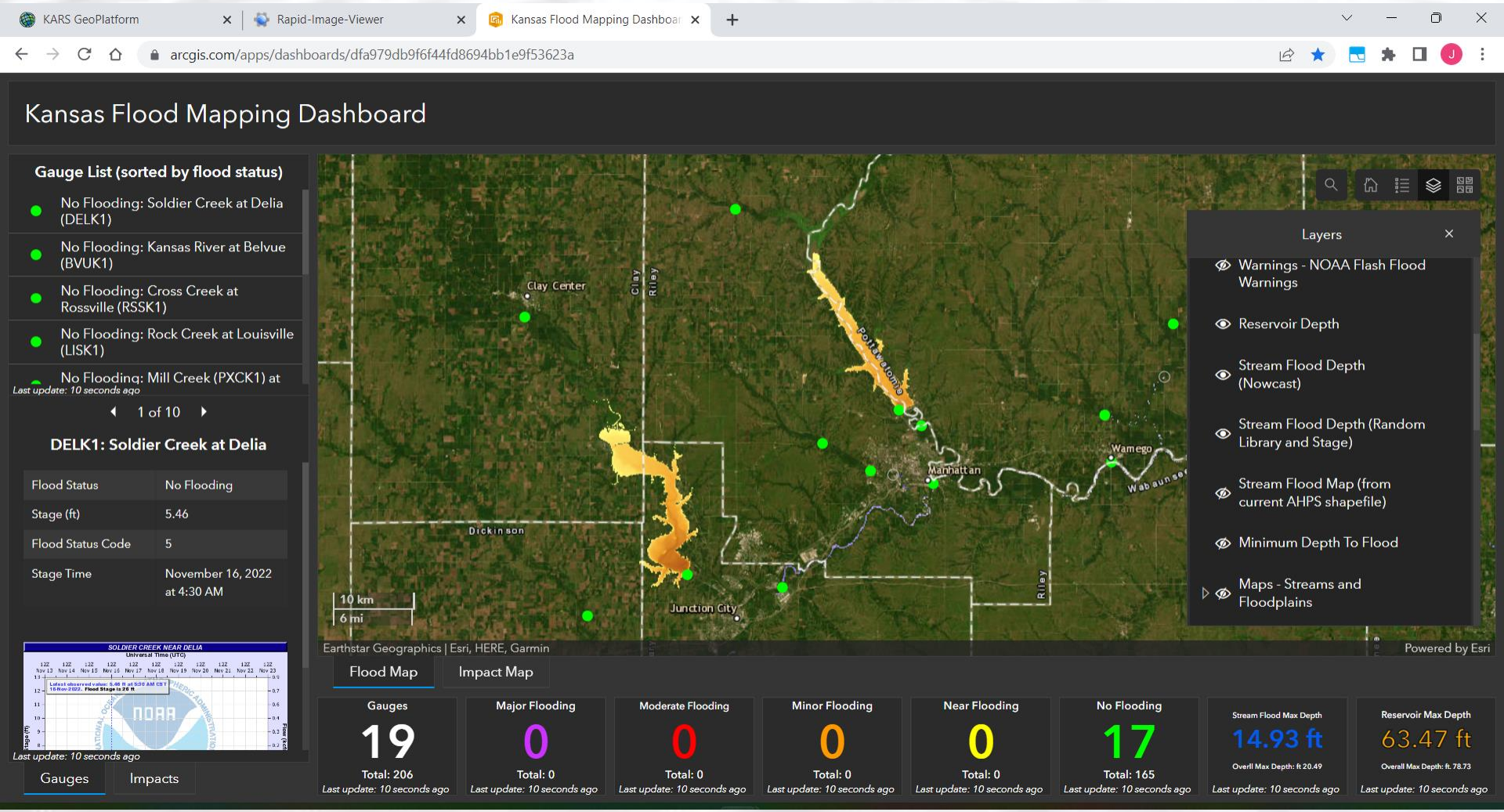
Kansas Flood Mapping Dashboard

Stream Flood Depth (Nowcast) (1-hr refresh)



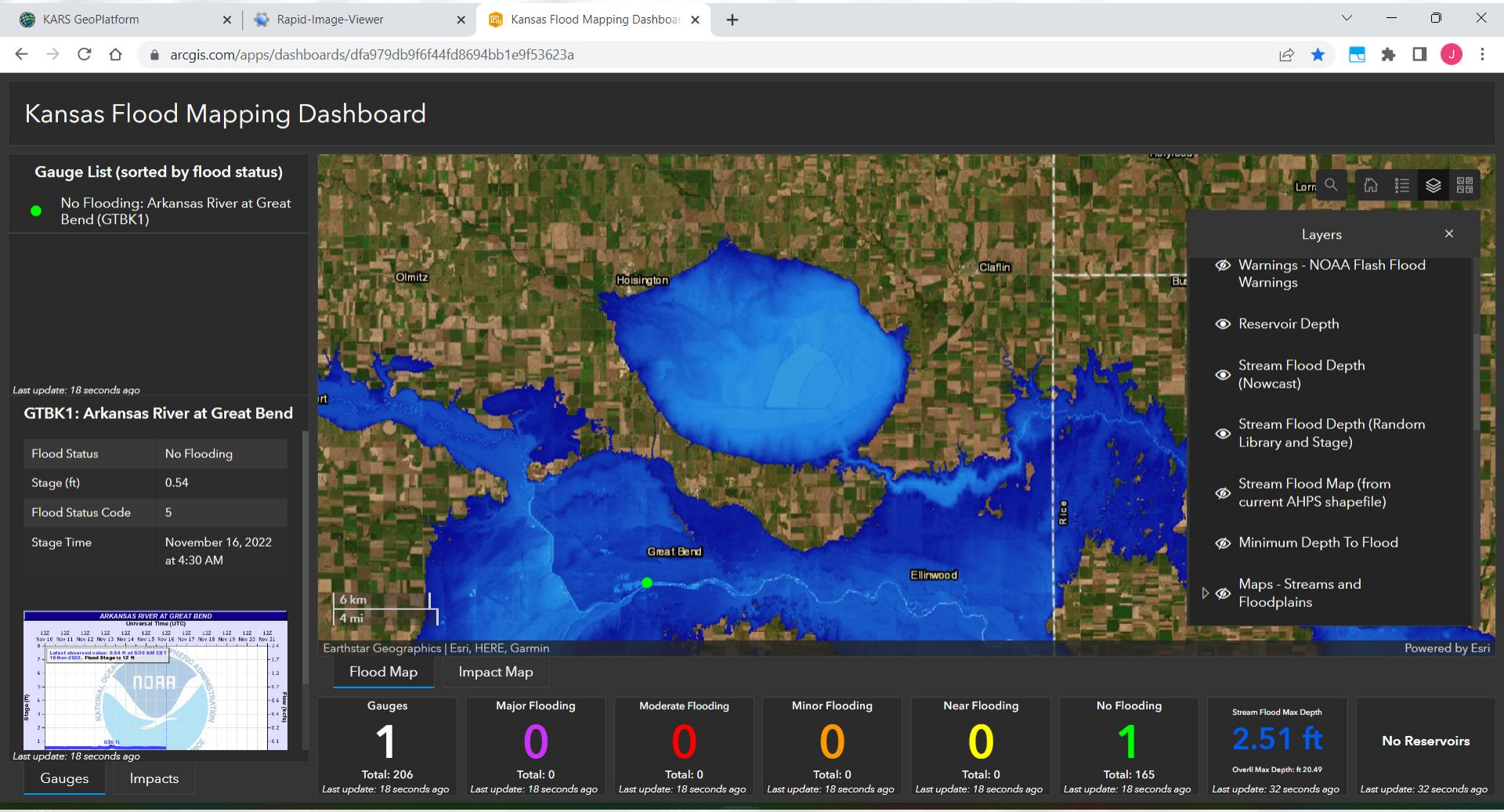
Kansas Flood Mapping Dashboard

Reservoir Depth (bathymetry + LiDAR, 6-hr refresh)



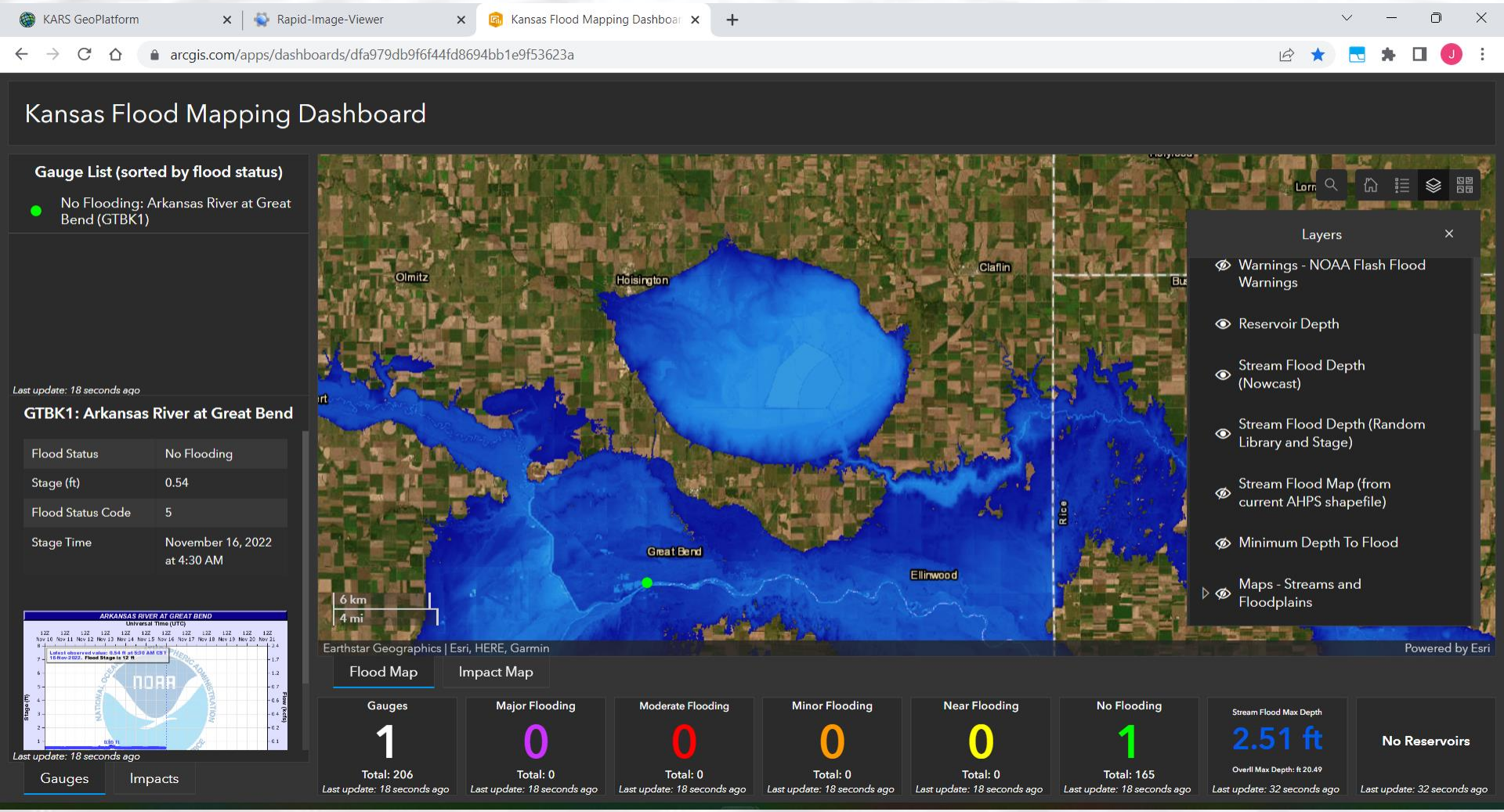
Kansas Flood Mapping Dashboard

Stream Flood Depth (random) (for testing)



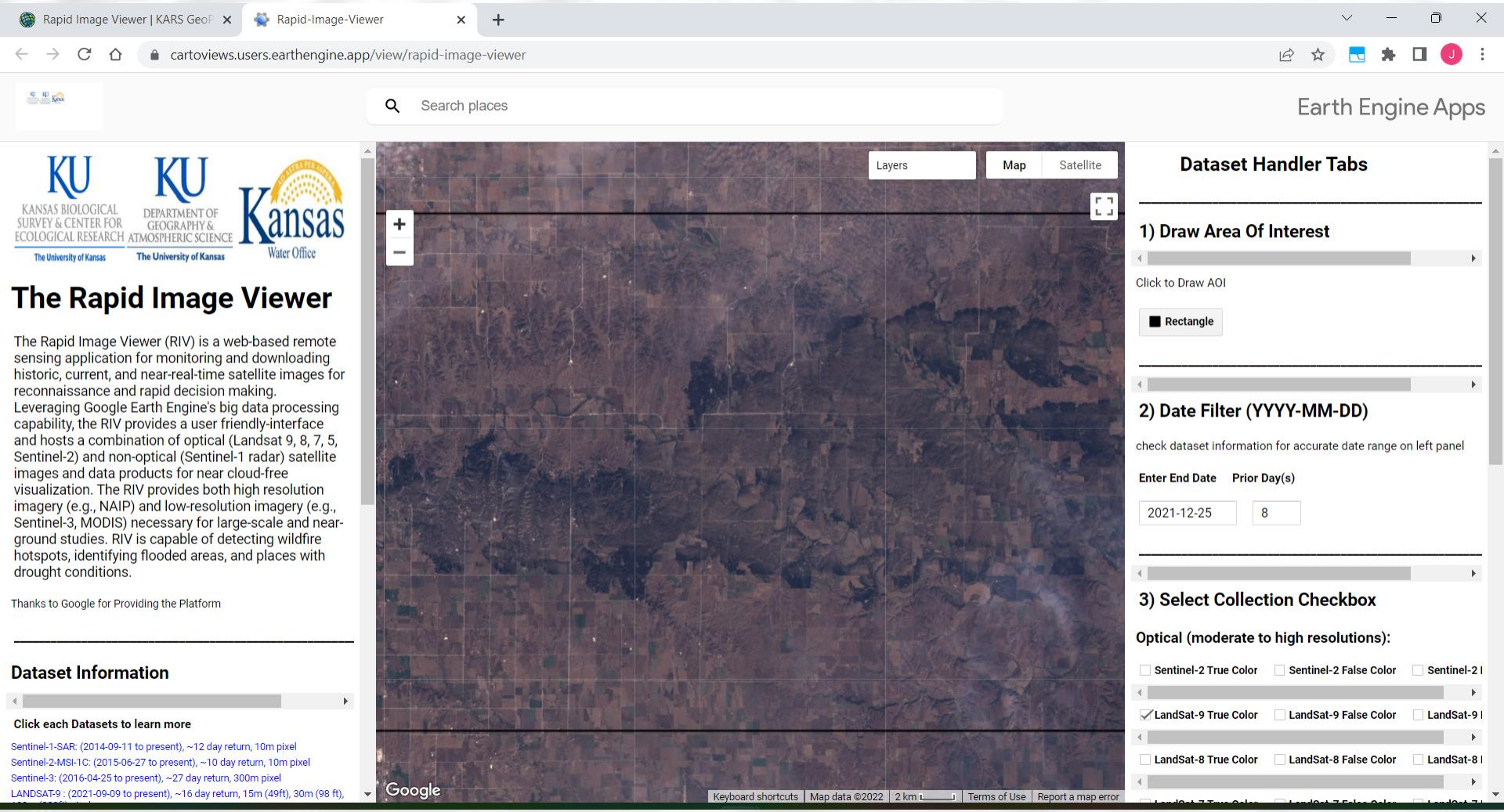
Kansas Flood Mapping Dashboard

Historical/Scenario Maps (coming soon)



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

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




Thanks for Listening…
Any Questions?
FLOOD
THEY MIGHT BE GIANTS
jkastens@ku.edu