Unit 01b:
Technical Overview of DSS-WISE Web

WEB-BASED FLOOD INUNDATION MODELING WITH DSS-WISE WEB

A SHORT COURSE ON RECENT UPDATES WITH HANDS-ON TRAINING

Developed by

NATIONAL CENTER FOR COMPUTATIONAL HYDROSCIENCE AND ENGINEERING

THE UNIVERSITY OF MISSISSIPPI

For

FEDERAL EMERGENCY MANAGEMENT AGENCY

Technical Workshop

September 25th, 2025

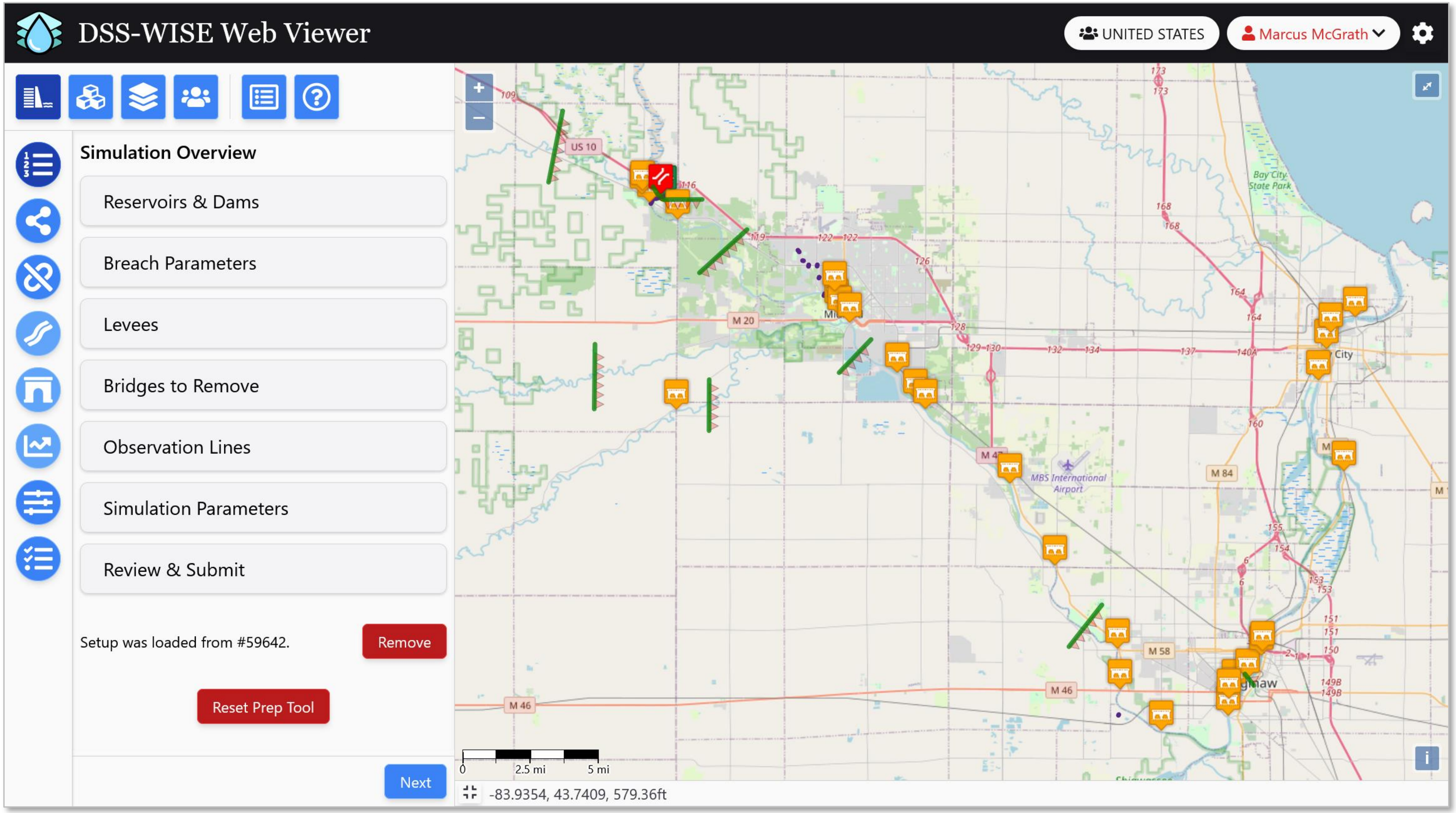
Huntington Convention Center of Cleveland

1 St Clair Ave NE, Cleveland, OH 44114

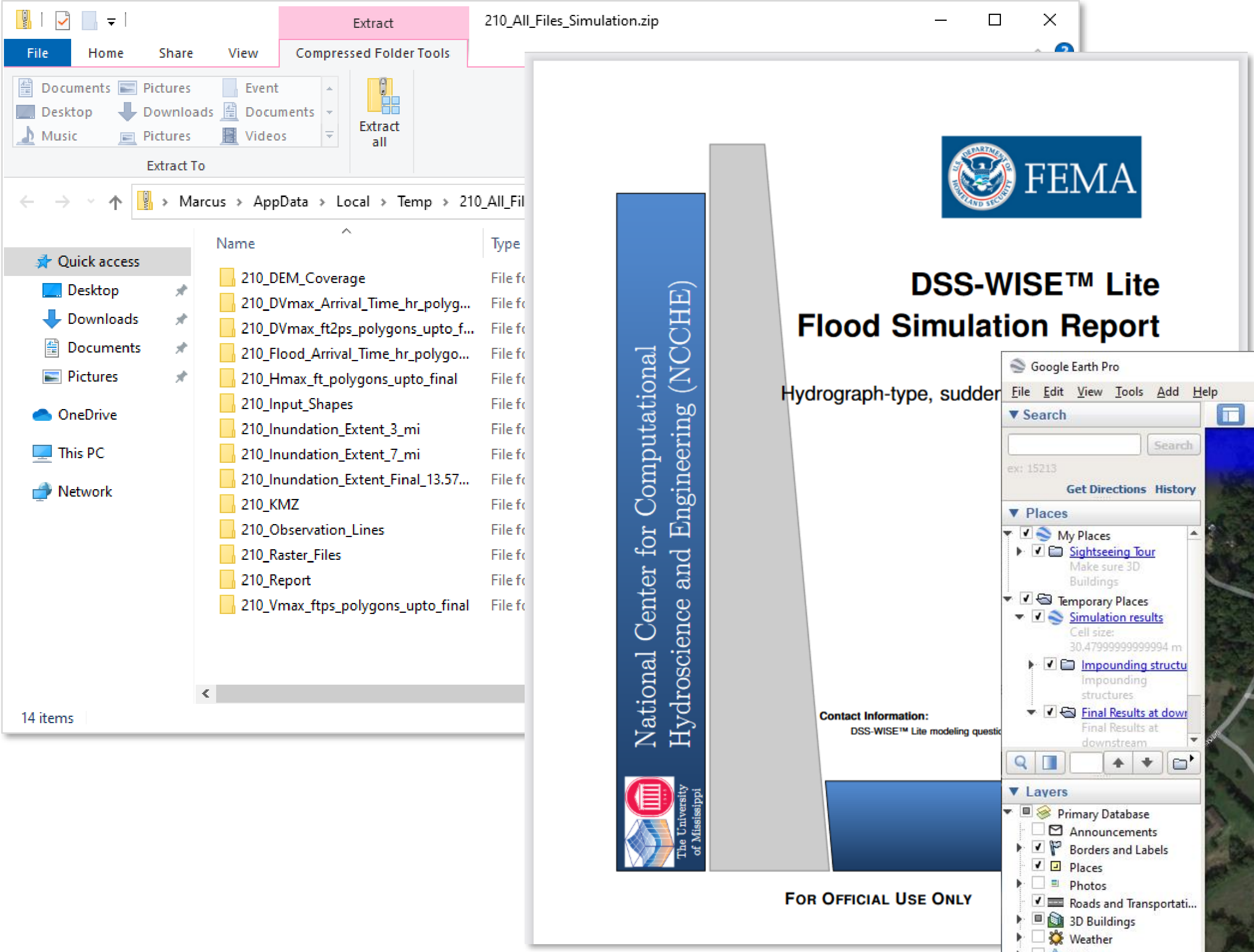
Agenda

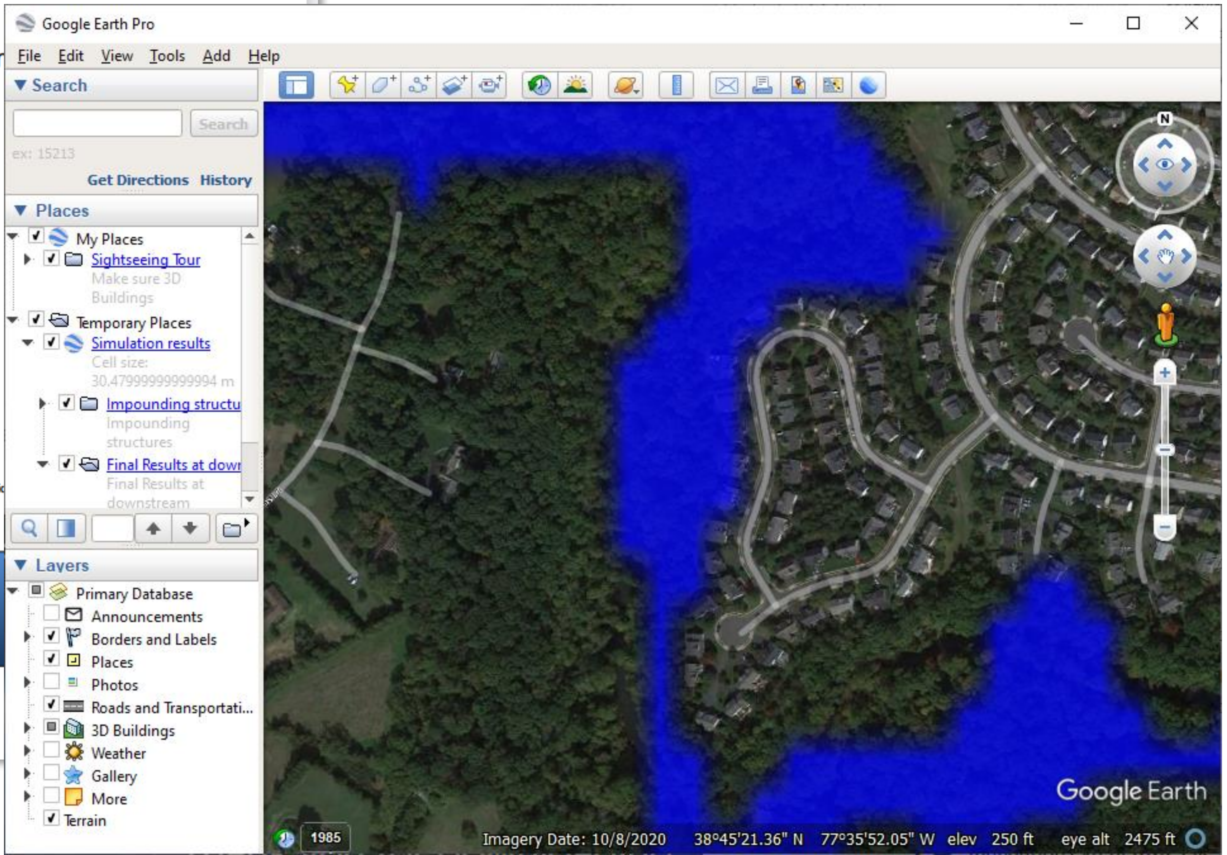
Time	Topic
8:30 AM – 9:20 AM	Introduction/Overview of DSS-WISE Web
9:20 AM – 9:45 AM	Simulation scenario setup and data entry
9:45 AM – 9:55 AM	SHORT 10 MINUTE BREAK
9:55 AM – 10:20 AM	Understanding simulation outputs
10:20 AM – 11:20 AM	Hands-on exercises using the new system features
11:20 AM – 11:30 AM	SHORT 10 MINUTE BREAK
11:30 AM – 11:45 AM	Tips and Tricks/Advanced Techniques
11:45 AM – 12:15 PM	Current System Developments for DSS-WISE 4.0 (Beta Version Jan. 2026)
12:15 PM – 12:30 PM	Questions / Discussion

Web browser-based simulation setup



Web browser-based simulation setup

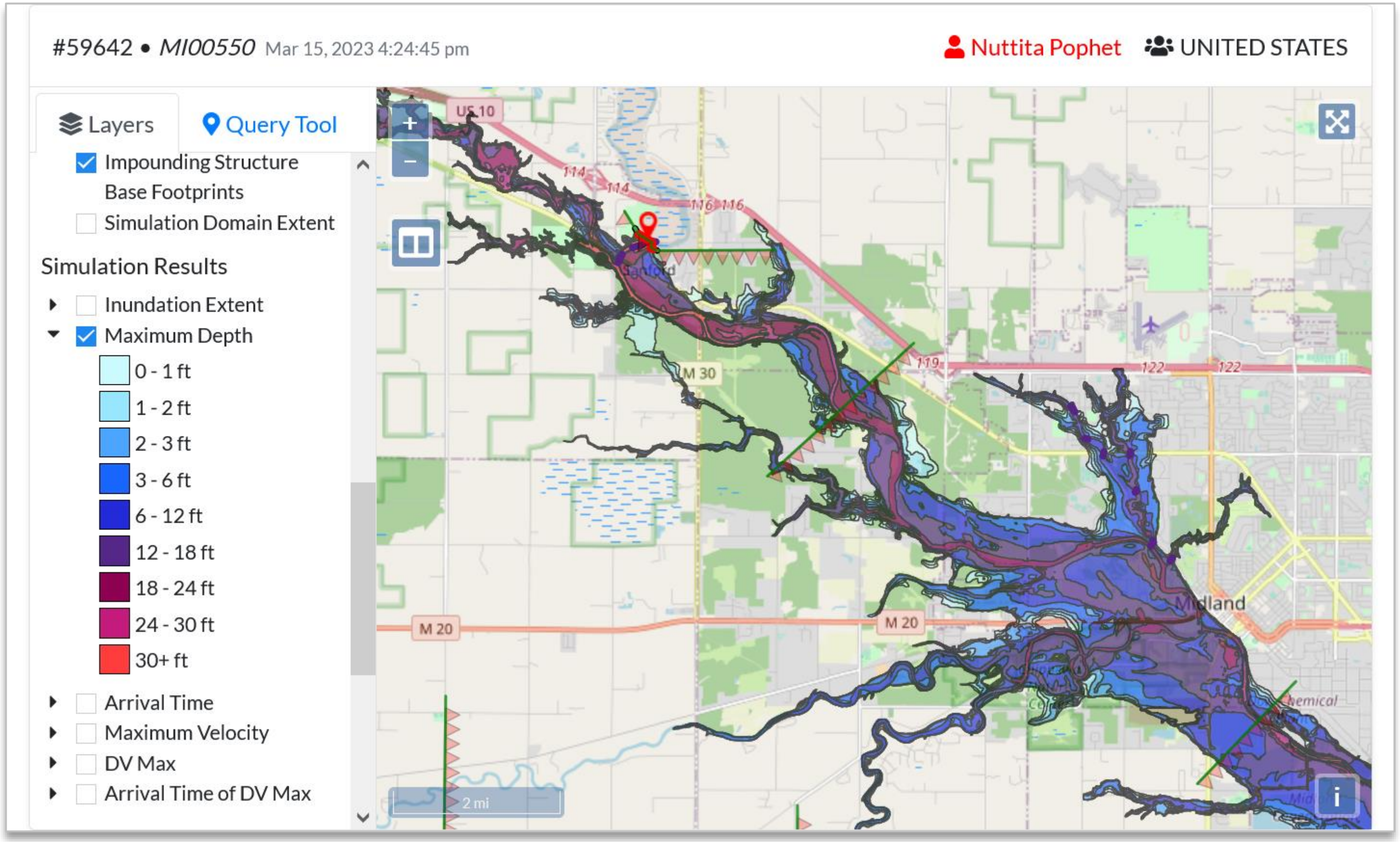


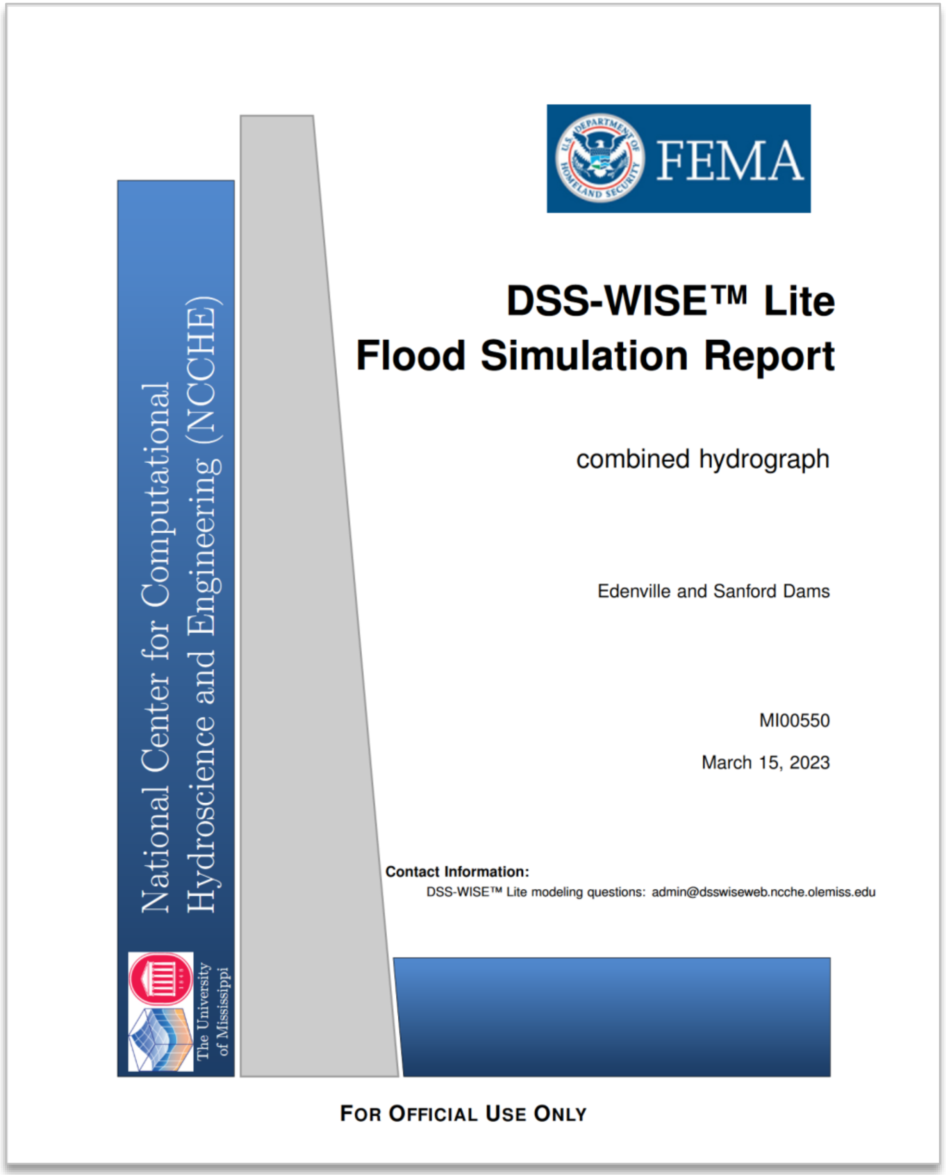


- Gridded raster outputs
- Vector polygon outputs derived from gridded data
- Google Earth .kmz file
- PDF report with map images

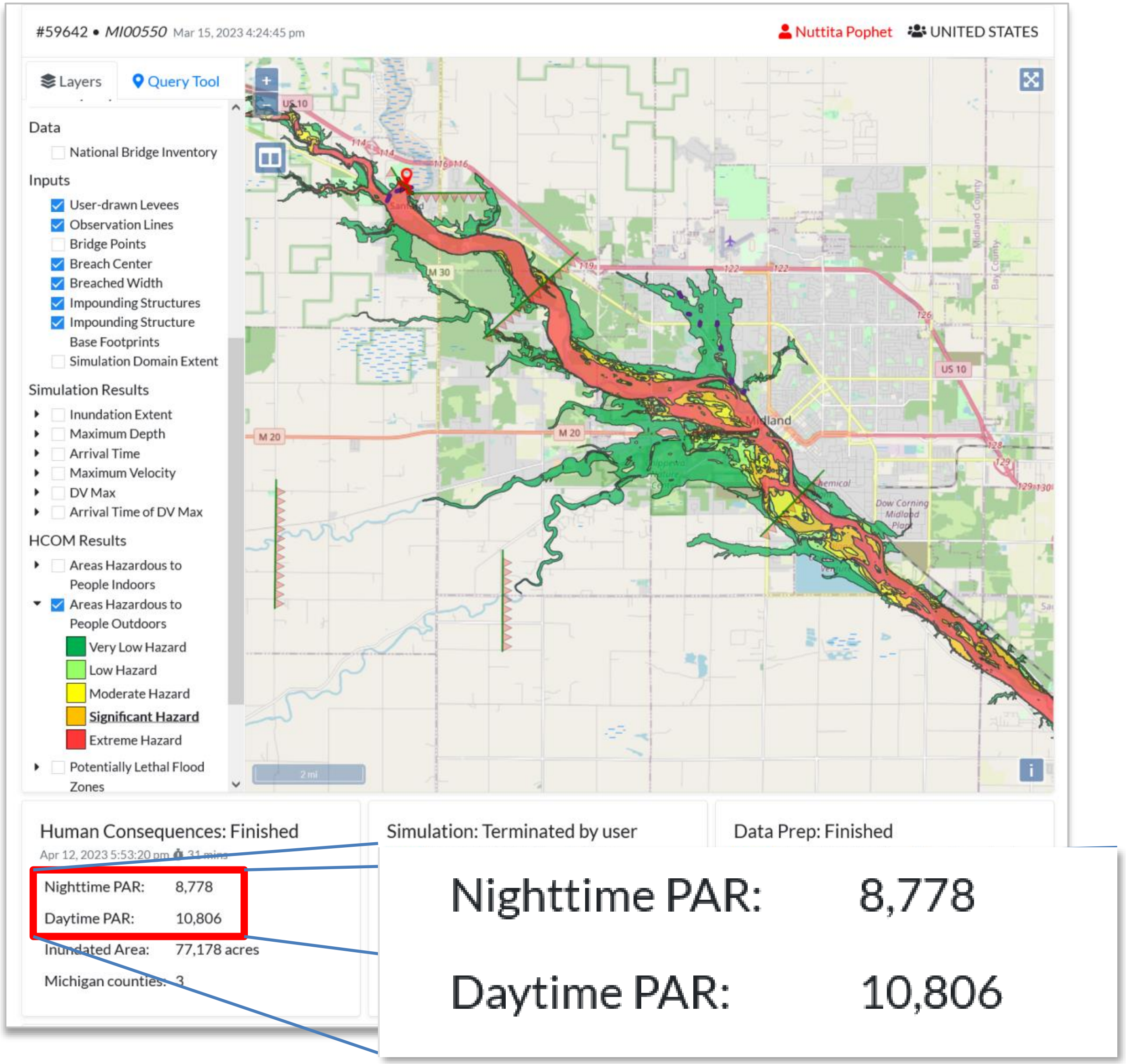
DSS-WISE Web Hydrodynamic results

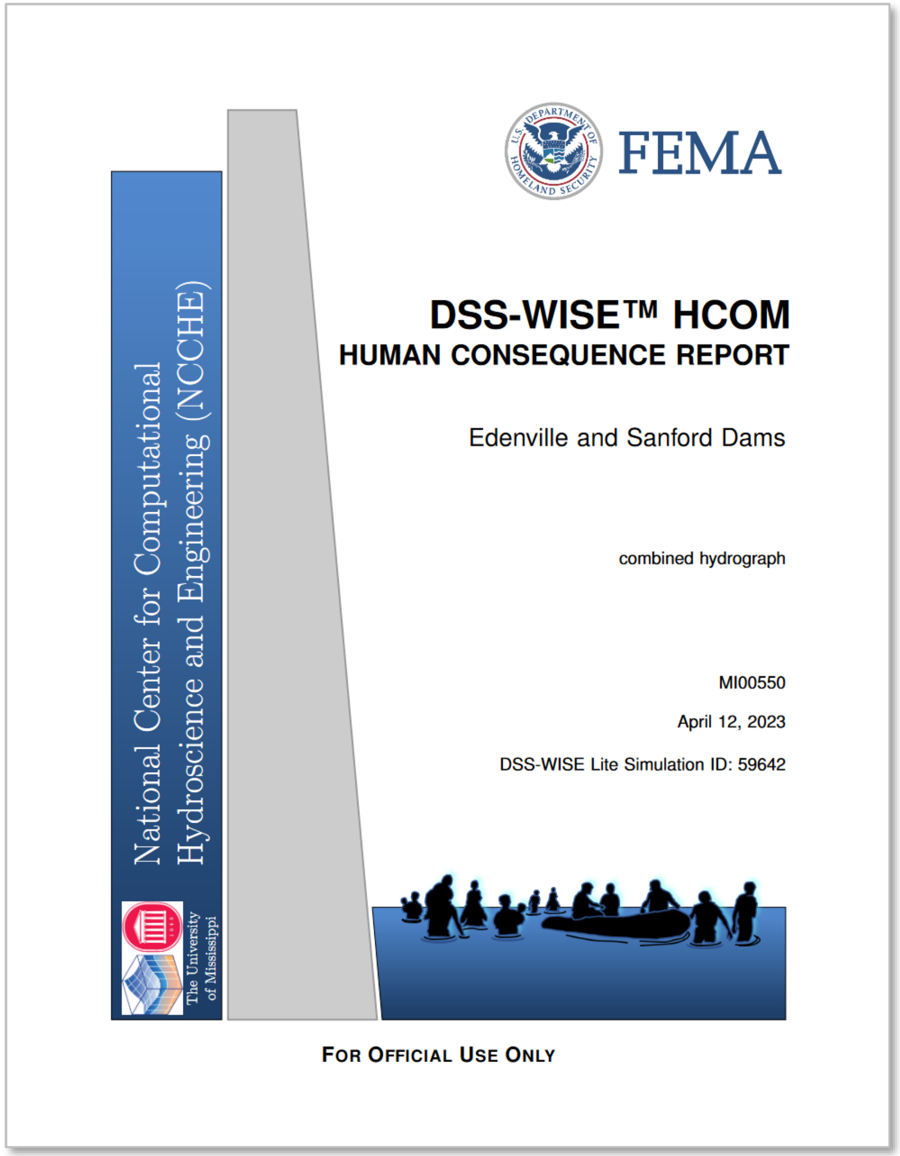
Users can visualize results/maps via the system's interactive GUI on their personal computers and smart phones or download them onto their own servers as GIS layers or just as a summarized PDF report to be handed to emergency managers and first responders.





DSS-WISE HCOM: Human Consequences Module





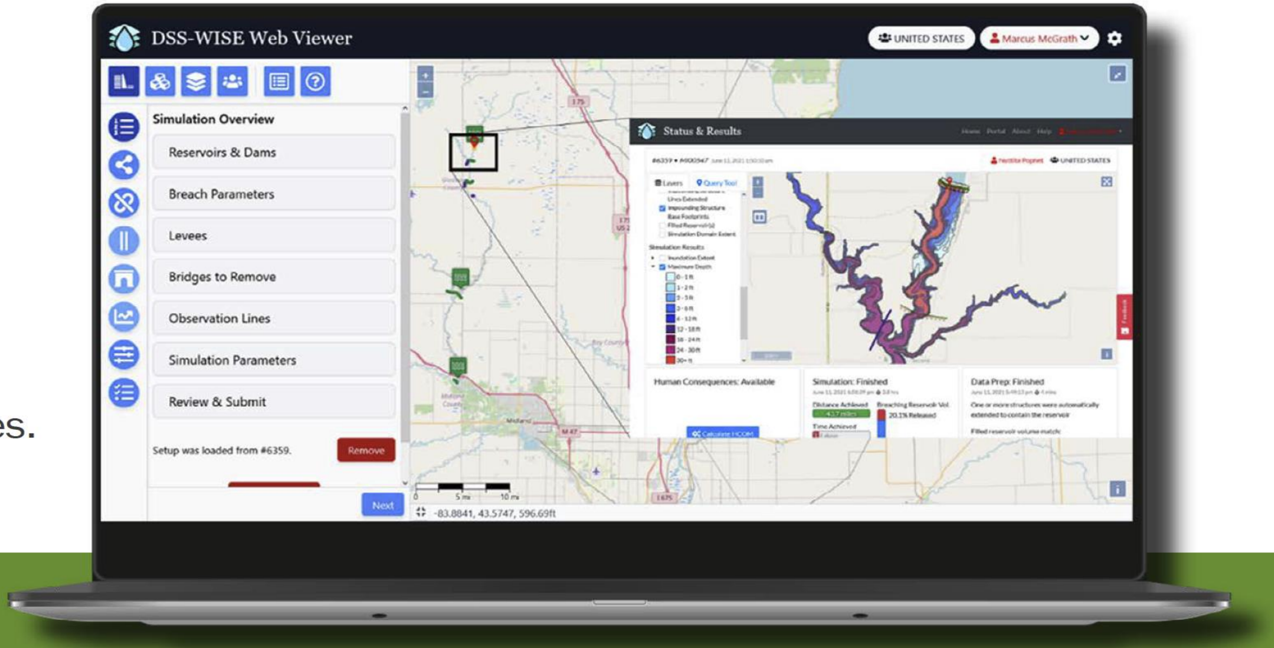
DSS-WISE WEB 3.0

NOW AVAILABLE

The National Center for Computational Hydroscience and Engineering (NCCHE) at the University of Mississippi recently released the new beta version 3.0 of the Decision Support System for Water Infrastructure Security (DSS-WISE) Web system. This was done in coordination with the U.S. Department of Homeland Security Science and Technology Directorate, the Federal Emergency Management Agency National Dam Safety Program, and the California Department of Water Resources Division of Safety of Dams. This update builds upon the previous version 2.0 with a host of powerful new features and a redesigned user interface to assist dam safety professionals, dam safety regulators, community officials, and emergency managers with dam break and flood hazard inundation mapping. These new capabilities and enhancements include the following:

1. A completely redesigned web user interface.
2. An improved, contextualized help system.
3. The generation of intermediate results upon user request.
4. A new dam NID search tool.
5. A new point query tool for results.
6. An improved breach parameter calculator.
7. Improvements to the results package.
8. The ability to load new simulation parameters from a previous submission.
9. The ability to include the presence of user-drawn levees.
10. The ability to model dams in series.

National Center for Computational Hydroscience and Engineering
The University of Mississippi

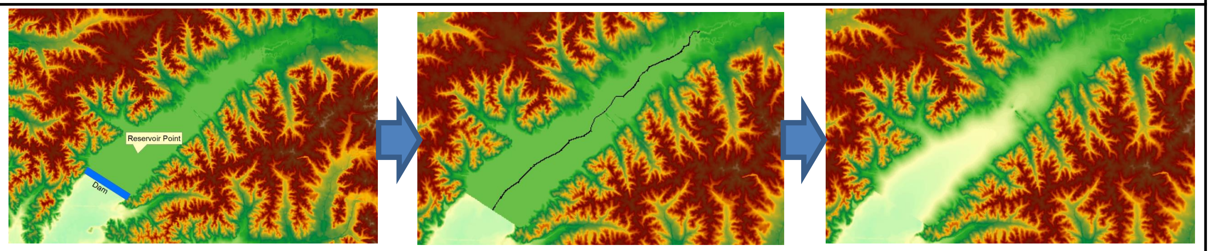


Steps of Automated Input Data Preparation

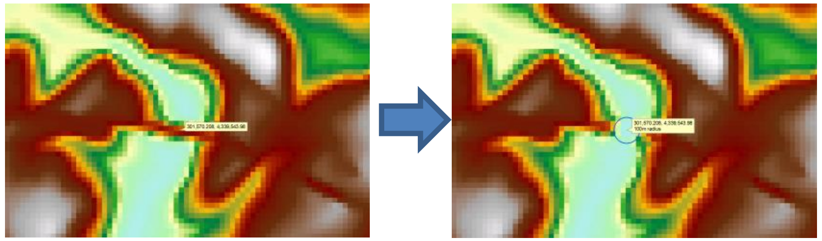
Step-by-Step Automated Input Data Preparation

1 The computational domain centered at the dam is prepared as a virtual raster (15-200 ft) from USGS 3DEP tiles

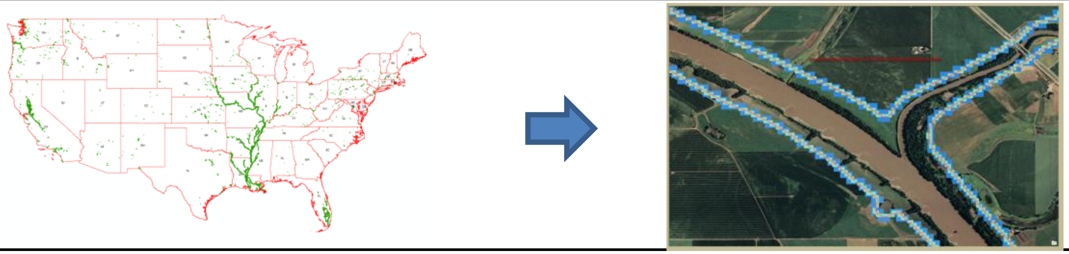
2 Reservoir bed topography is estimated using specially developed skeletonization algorithms



3 The bridges identified by the user are removed if they are represented in the DEM as elevation



4 Levees from the National Levee Database (NLD) are burned into the DEM at the correct cell size



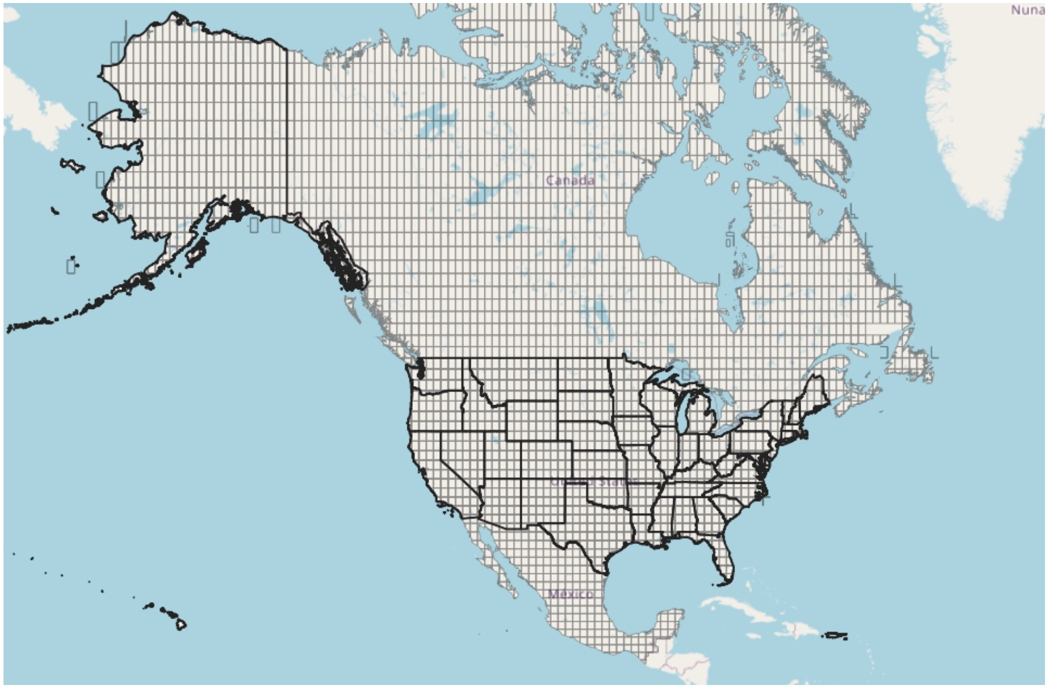
5 Roughness values are assigned based on the 21 classified land use/cover classes from NLCD 2016

CODE	n VALUE	LANDUSE
0	0.035	Unclassified
11	0.033	Open Water
12	0.01	Perennial Snow/Ice
21	0.0404	Developed, Open Space
22	0.0678	Developed, Low Intensity
23	0.0678	Developed, Medium Intensity
24	0.0404	Developed, High Intensity
31	0.0113	Barren Land
41	0.1	Deciduous Forest *
42	0.1	Evergreen Forest *
43	0.12	Mixed Forest *
51	0.035	Dwarf Scrub *
52	0.04	Shrub/Scrub
71	0.04	Grassland/Herbaceuous
72	0.035	Sedge/Herbaceous *
73	0.035	Lichens *
74	0.035	Moss *
81	0.035	Hay/Pasture
82	0.07	Cultivated Crops
90	0.15	Woody Wetlands
95	0.1825	Emergent Herbaceuous Wetlands

* Indicates n values assigned by NCCHE, otherwise it is obtained from literature.

DSSWISE™ Web Uses USGS 3DEP DEM Data After Removing Cells of Large Waterbodies Clipped to the Ocean Shoreline

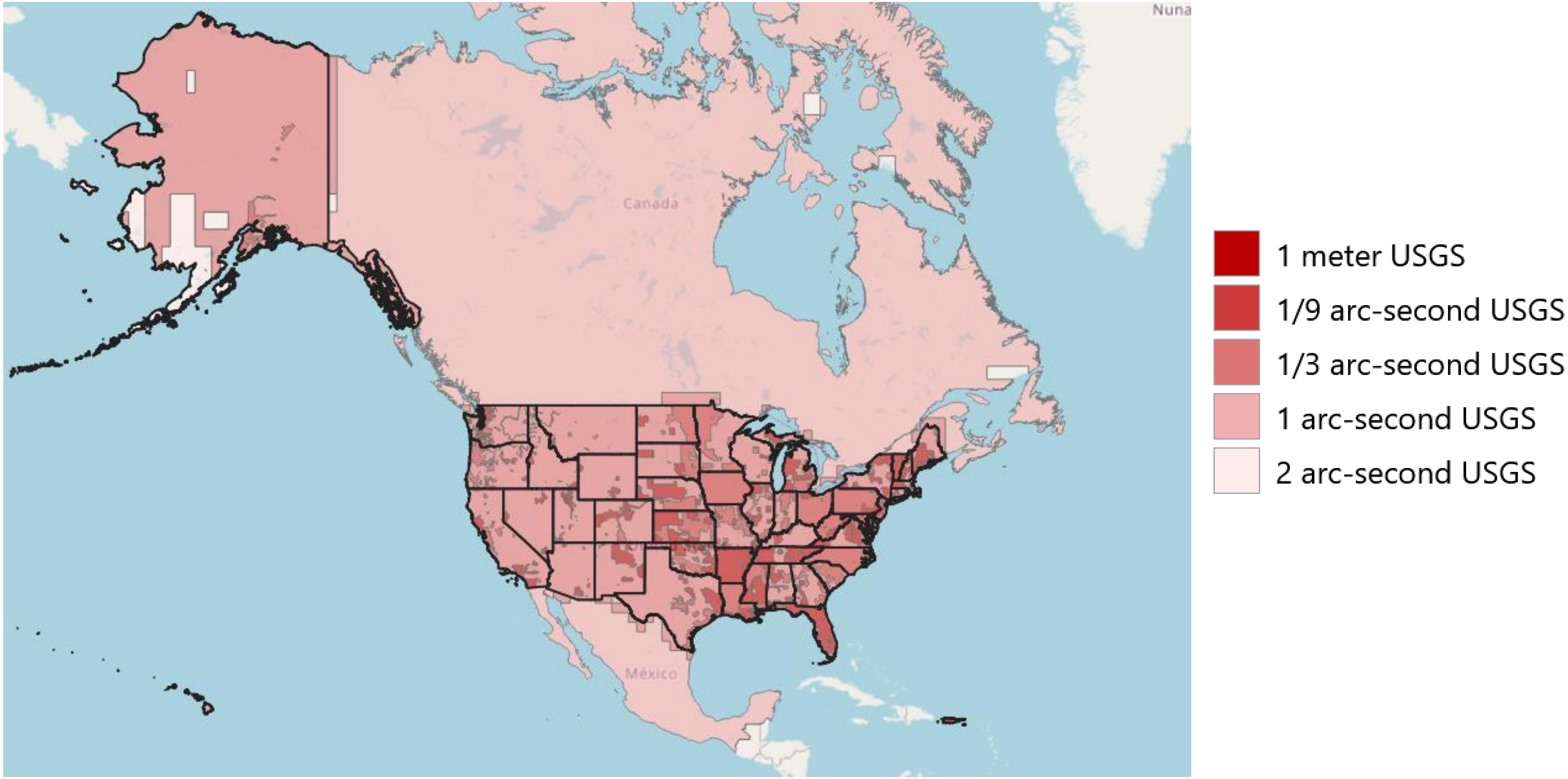
USGS 3DEP Tiles



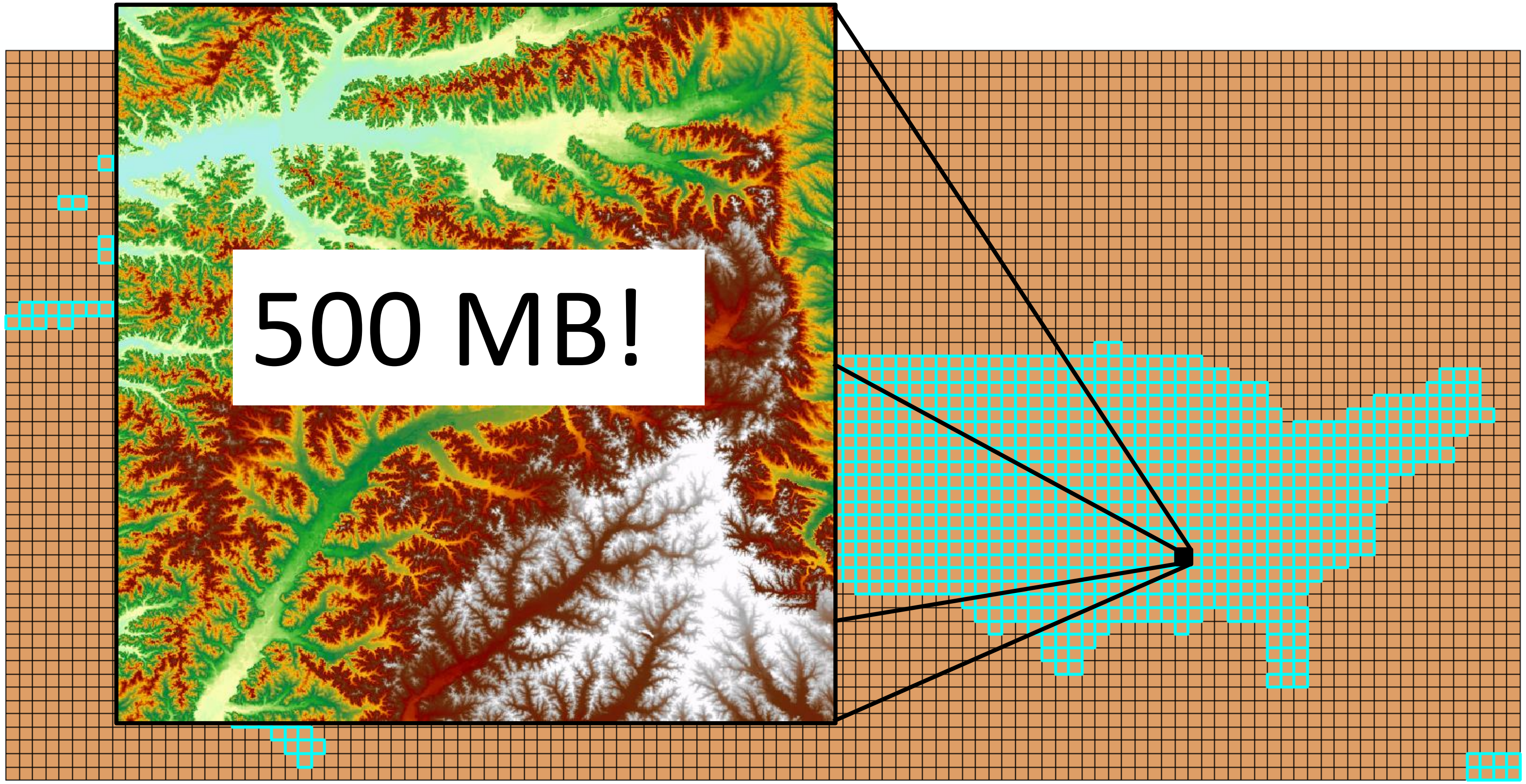
DSS-WISE Web Simulations Use a 2019* Snapshot of the Available 3DEP Data:

Dataset	**Coverage**	**# Tiles**	**Total Size**
2 arc-second (~60-meter)	Alaska	512	5 GB
1 arc-second (~30-meter)	North and South America	3,811	130 G B
1/3 arc-second (~10-meter)	CONUS seamless	1,438	490 GB
1/9 arc-second (~3-meter)	Partial	8,345	865 GB
1-meter	Partial	30,930	4.5 TB

USGS 3DEP 2019 Coverage

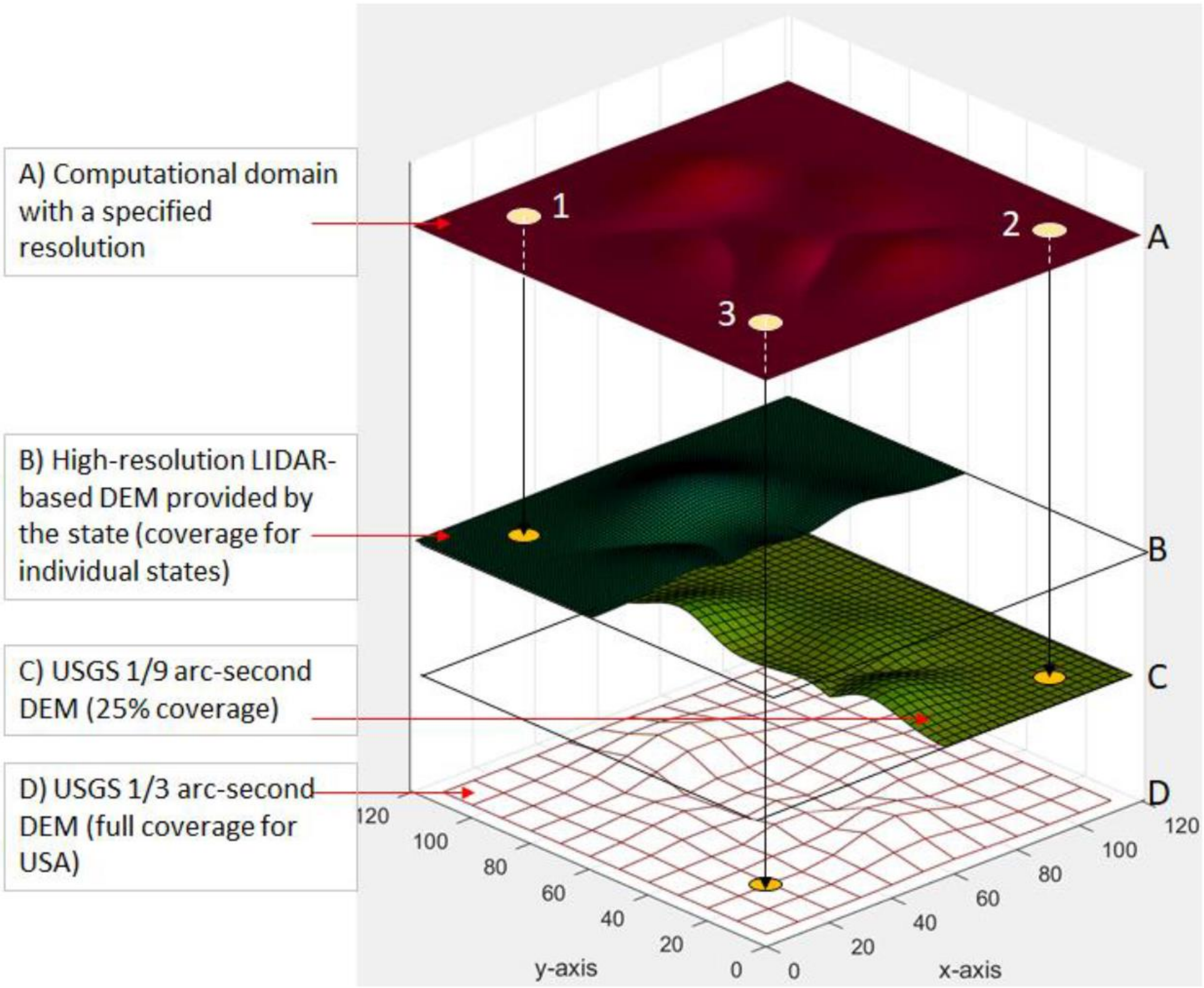


1/3 arc-second USGS 3DEP Tiles



Each 1/3 arc-second tile is about 500MB and covers and area of roughly 110 km by 110 km.

Composite DEM with Best Available Elevation Information



The states will be able to provide their own high-resolution data, which may even remain proprietary and be used only by the state providing the data.

To find the elevation of a point in the computational domain, the algorithm searches the available layers from top to bottom.

The search for the elevation value stops when a value is obtained from the first layer encountered in the search, which will be the highest resolution elevation data available for that particular point.

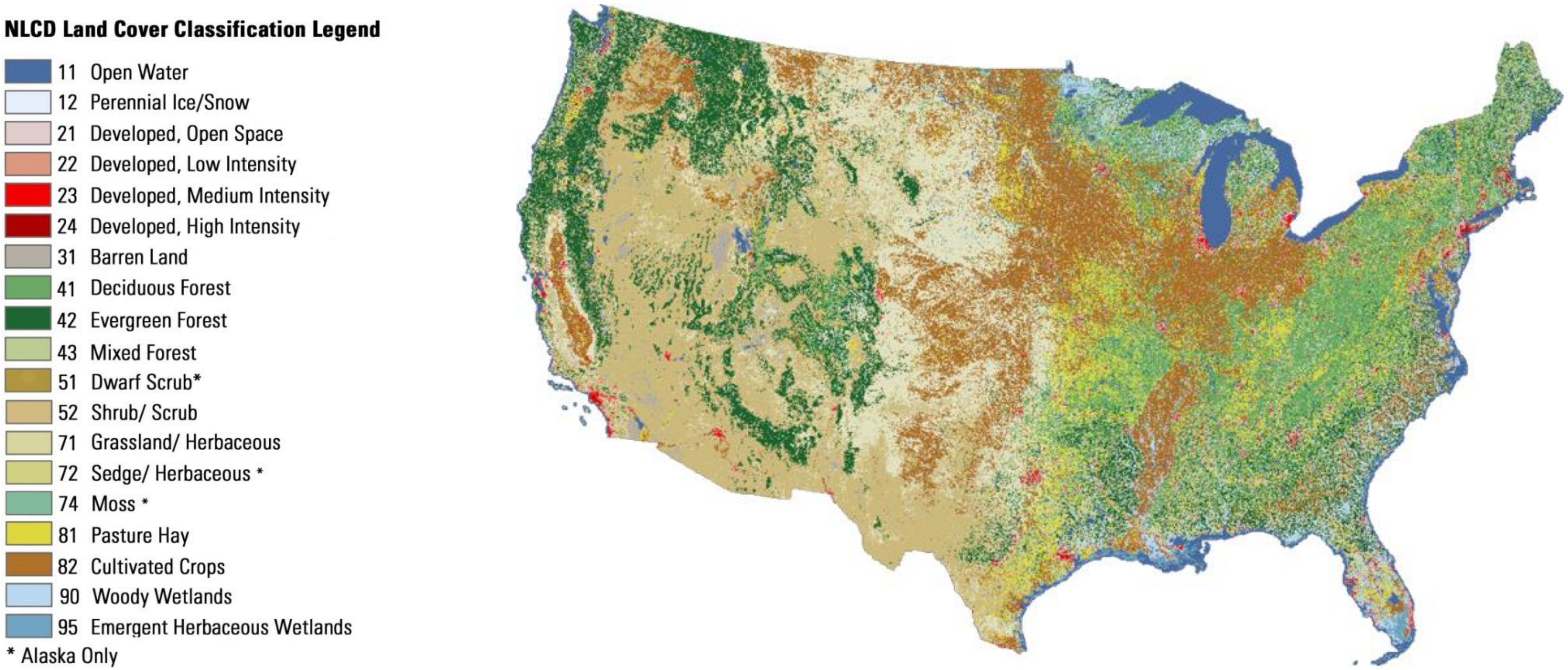
- Point 1 will get its elevation from 1-meter DEM (layer B)
- Point 2 will get its elevation from the 1/9 arc-second USGS NED (layer C)
- Point 3 will get its elevation from the 1/3 arc-second USGS layer.

As the coverage of the layer B grows with new tiles of 1-m DEM released by USGS. More points will be able to get their elevation from it. Thus, the proposed algorithm is general, flexible and remains valid as new data is added to any layer or the existing tiles are updated.

DSS-WISE Uses National Land Cover Datbase (NLCD) for Estimating Surface Roughness

Manning's Coefficients are Assigned Based on NLCD 2016 Classified Land Use/Cover Map

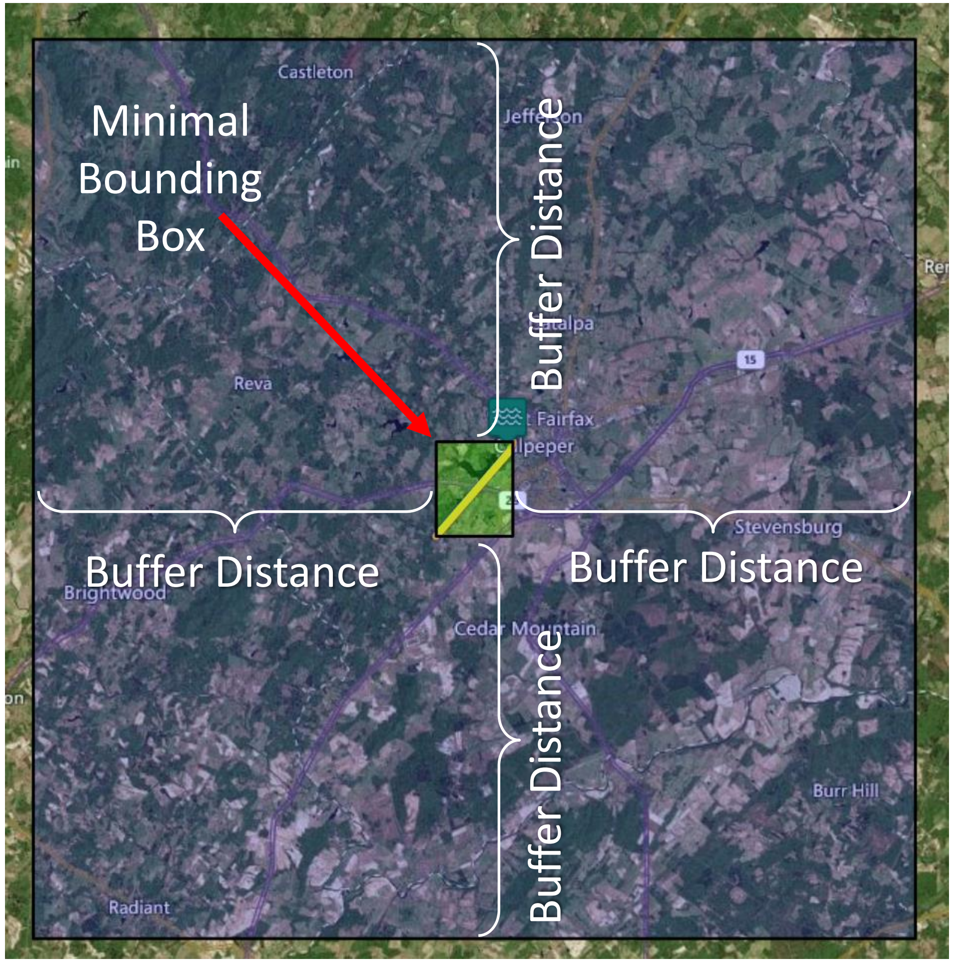
The automated input data preparation module uses NLCD 2016 classified land use/cover map to assign Manning's roughness values to computational cells.

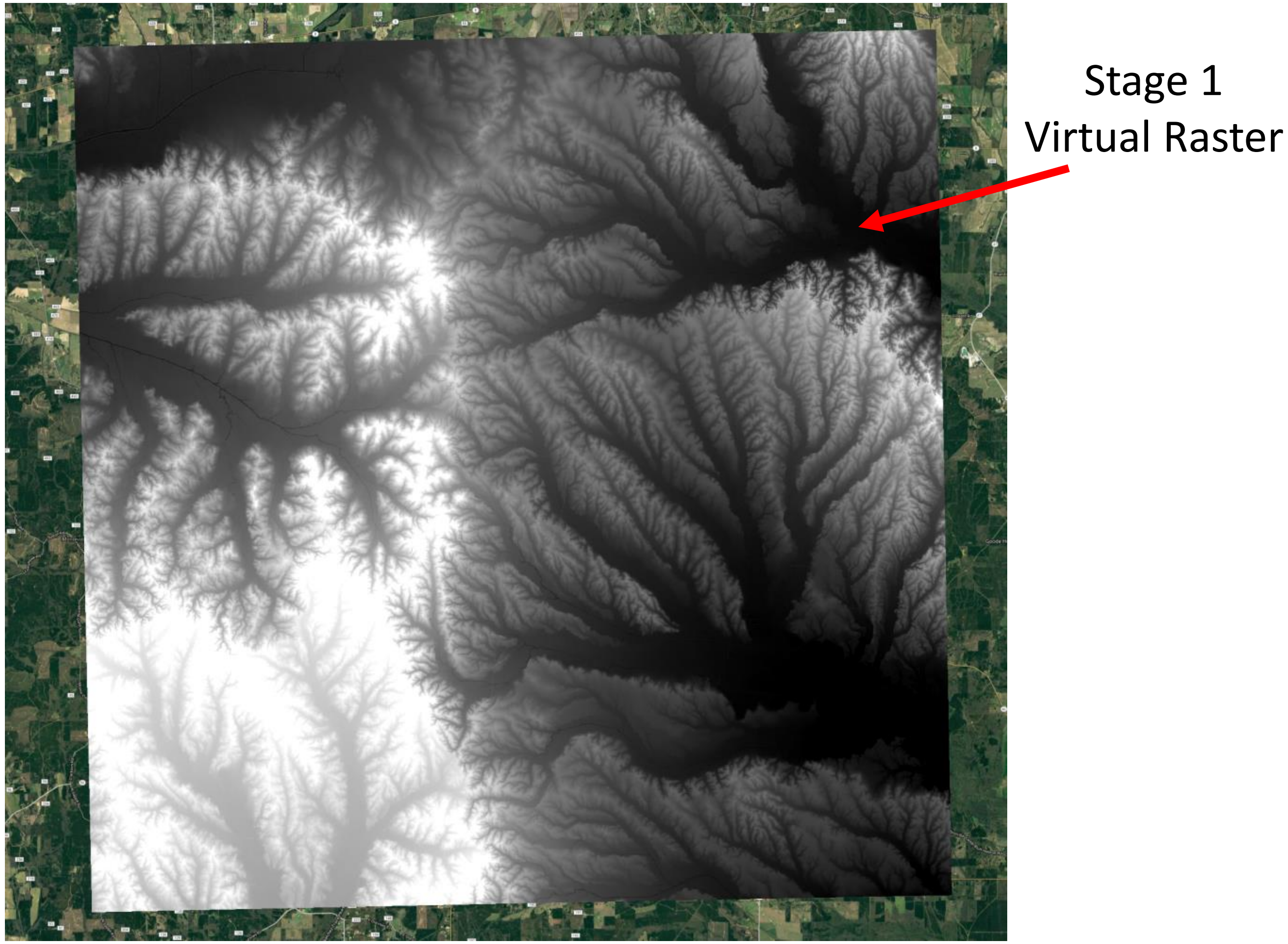


Automated Preparation of Geospatial Model Inputs

Set up domain size and perform consistency checks

The downstream buffer distance provided by the user is used to extract the boundary of the DEM (computational grid) to be prepared. With the minimal bounding box at the center, the domain extends one buffer distance in four cardinal directions.

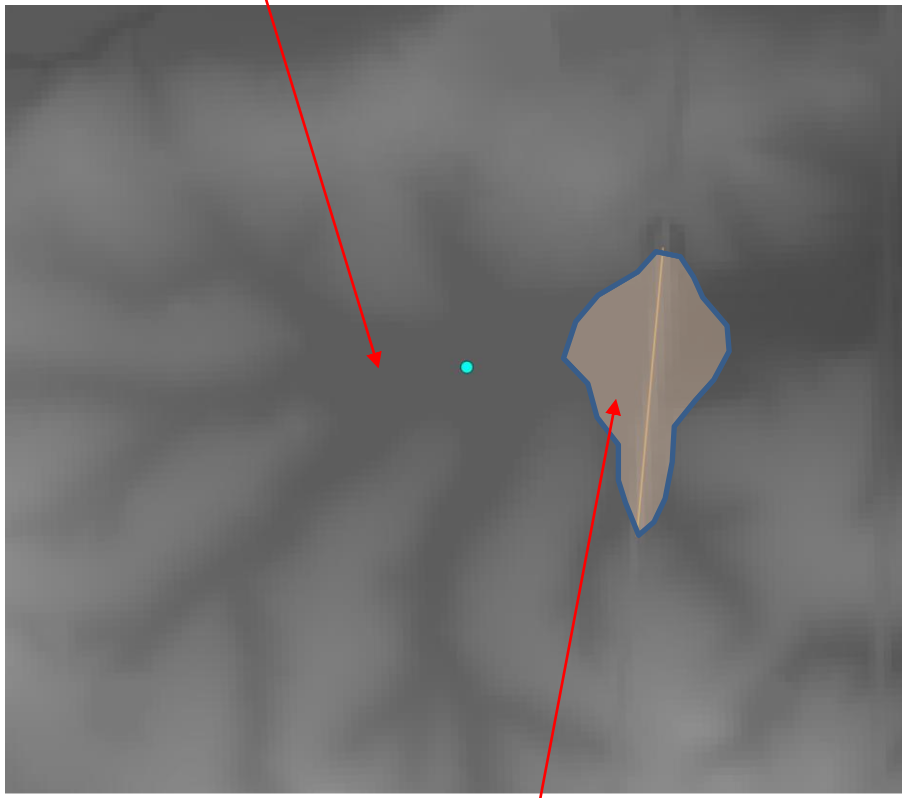




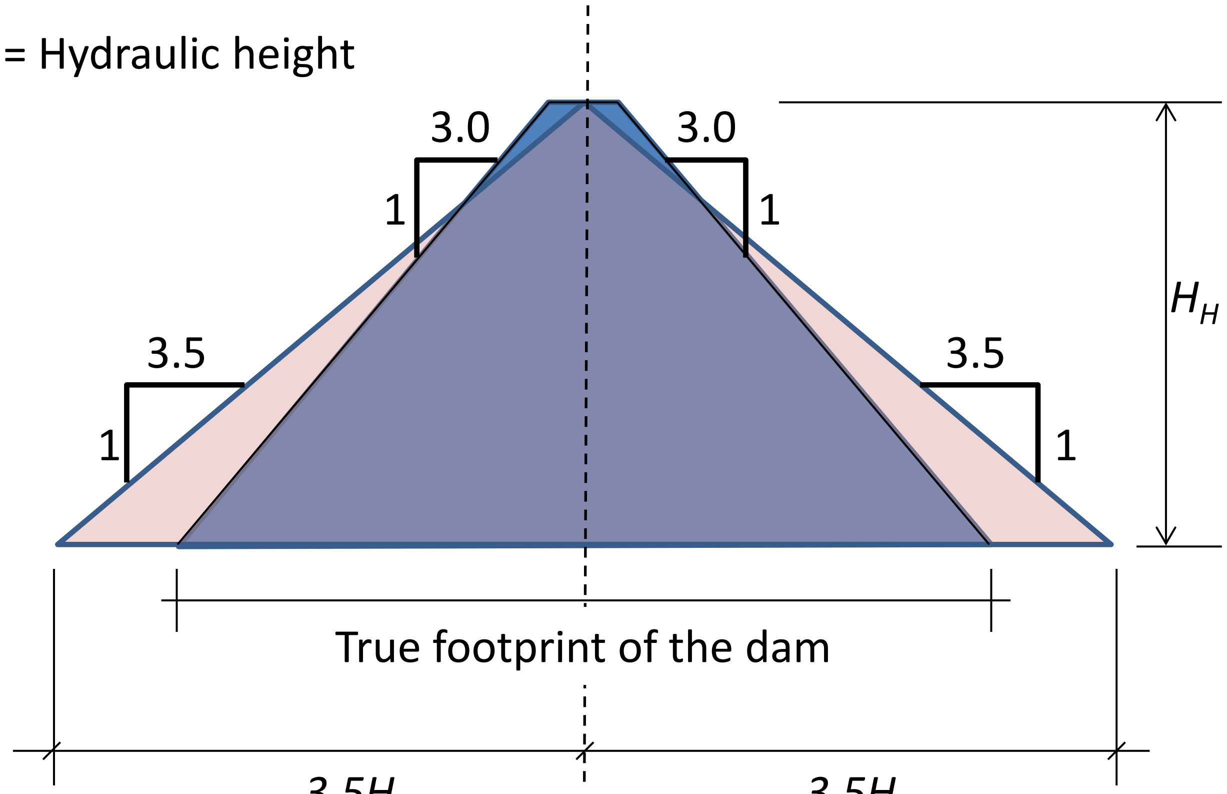
Calculate the footprint of the dam

In this step, first the footprint of the dam at its base is calculated based on some prescribed rules. The area under this base width is removed from the DEM. Later, after the unknown bed topography is estimated, an idealized dam with a constant width will be erected by raising the DEM cells under the footprint of average width to the crest elevation.

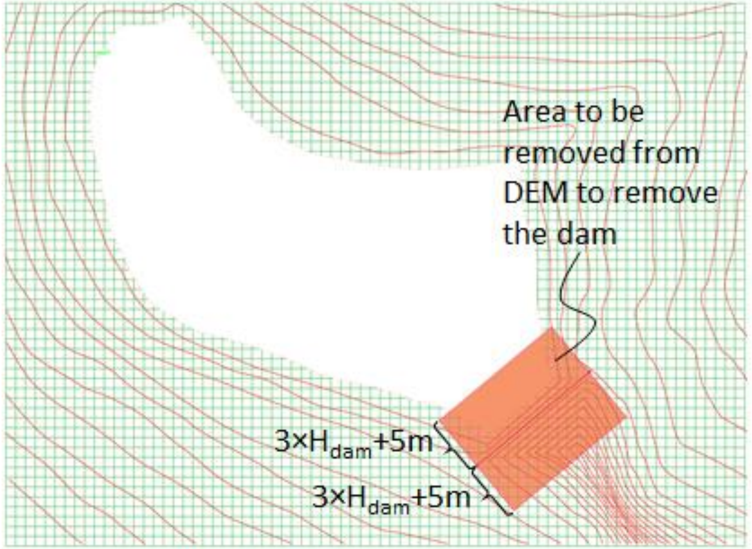
Water surface in the lake is detected as a "quasi" flat topography.



Footprint of the dam in reality

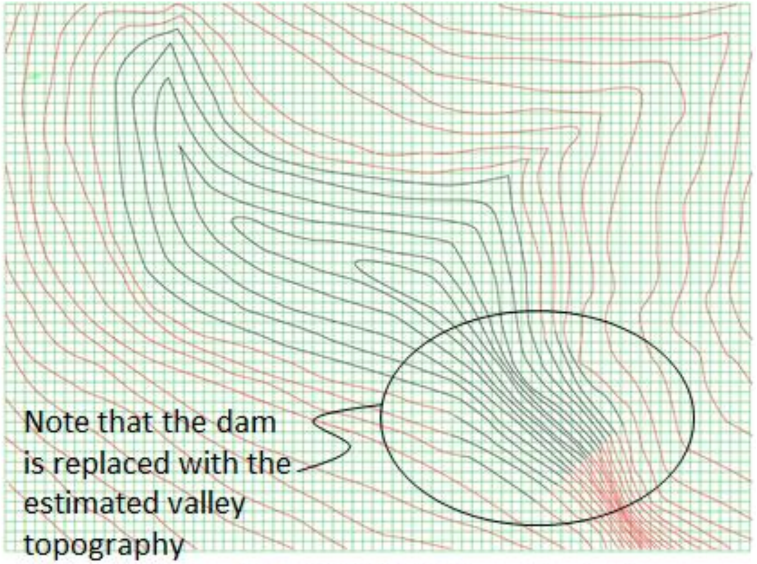


Simplified Illustration of the Estimation of the Removal of Dams, Reservoir Bed Elevation, and Breaching Process

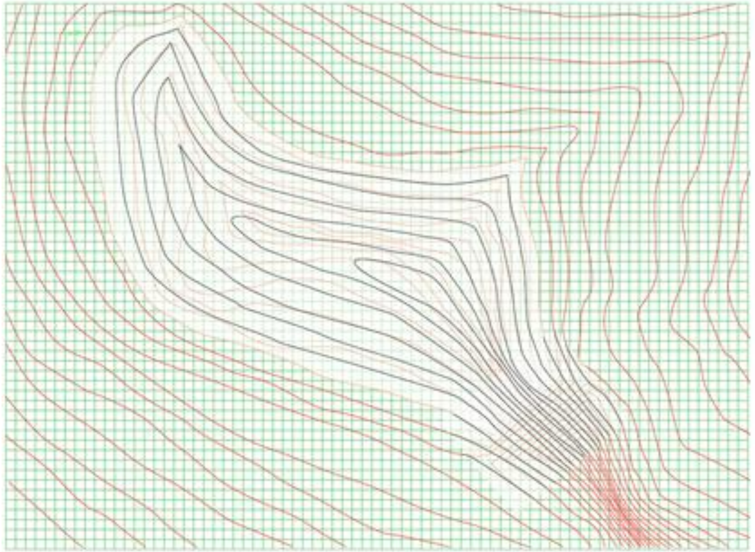


Using the polyline along the dam crest and assuming a profile based on the dam type, the area to remove is determined

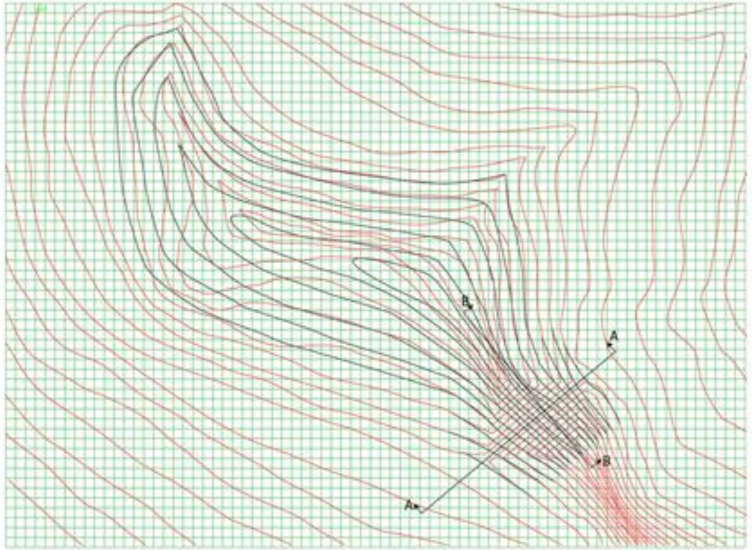
Both the area representing the water surface and the dam are removed from the DEM.



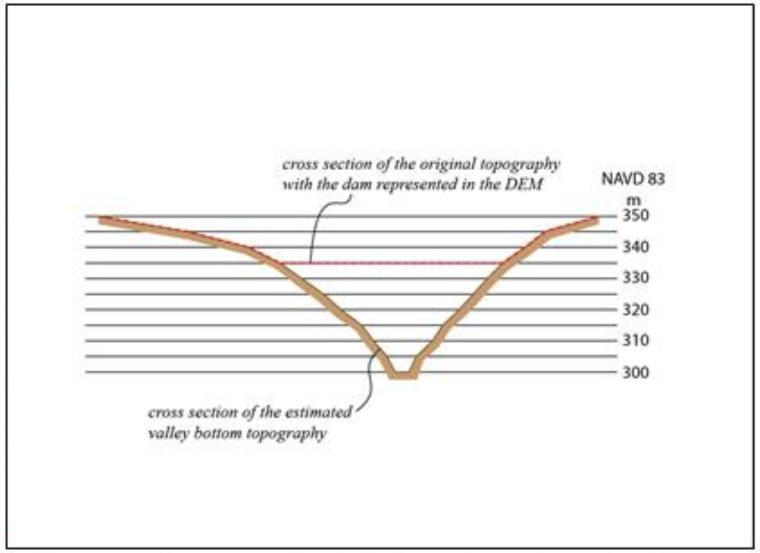
Using special algorithms DSS-WISE™ Lite estimates the bottom topography of (black contour lines) the reservoir.



Note that the estimated topography is not exactly like true topography but DSS-WISE™ Lite tries to match the volumes

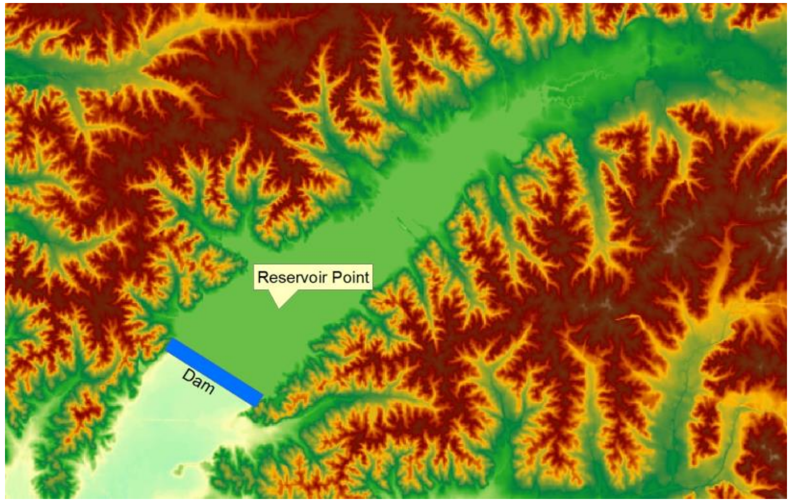


Let us define two cross section to see the topography before and after the modification of the DEM by DSS-WISE™ Lite

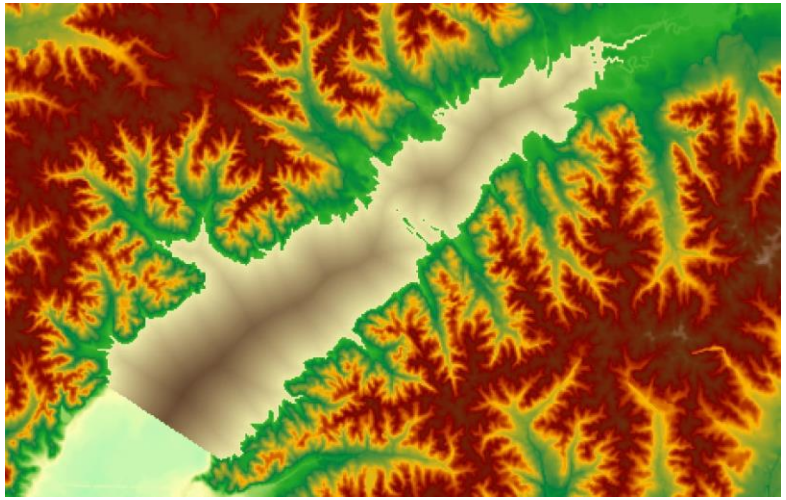


Transversal cross section A-A shows the estimated valley topography and the original topography

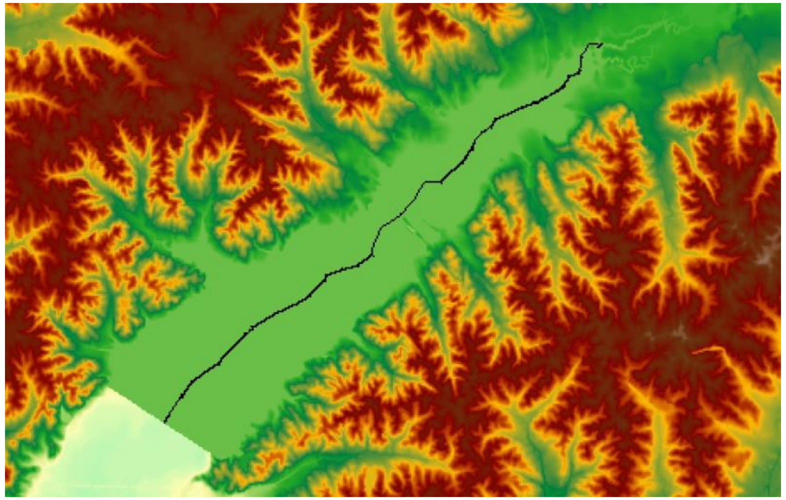
Estimate the reservoir bed topography (execute this step if reservoir bed topography is to be estimated)



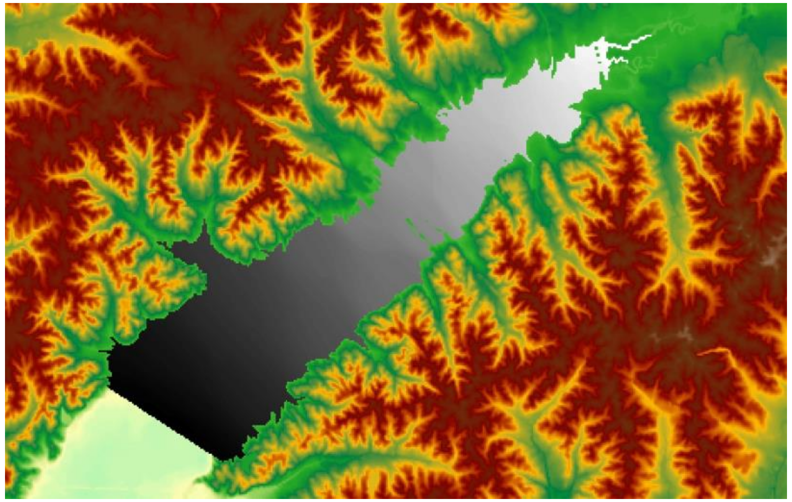
Original DEM.



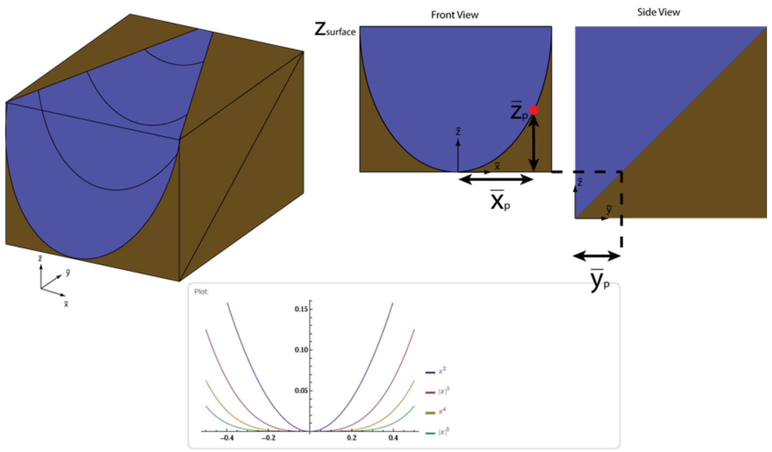
Distance to the shore map is calculated.



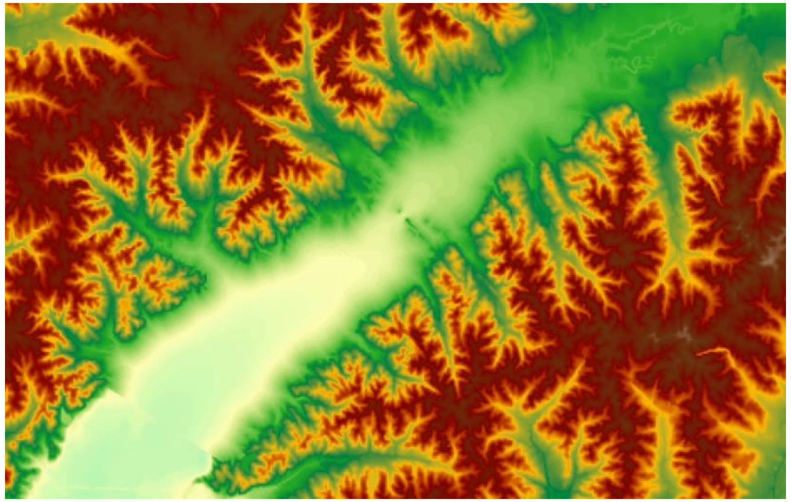
Centerline is obtained



Distance from the reservoir to each cell is calculated



Bottom topography is calculated using parametric cross sections



Final interpolated topography is obtained.

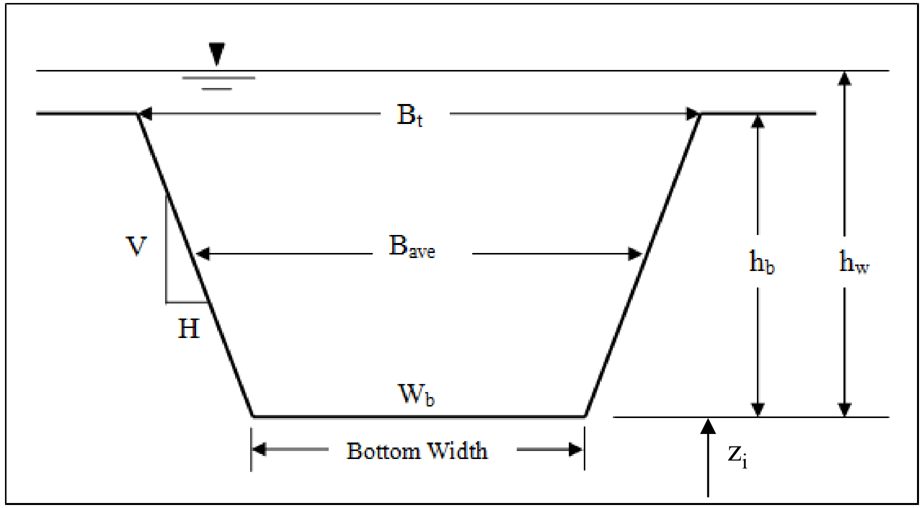
Modeling of Reservoir and Breach

Idealized Breach Geometry for Embankment Dam and Available Semi-Empirical Parametric Equations

DSS-WISE™ Web uses the parametric model approach for defining the breach parameters of embankment dams.

The breach is assumed to have a trapezoidal shape.

The bottom width of the breach and the formation time of the breach are needed.



B_t = Top width of breach

B_{ave} = Average width of breach

W_b = Bottom width of breach

T_f = Formation time of breach

h_w = Depth of water above bottom of breach

h_b = Height from top of dam to bottom of breach

z_I = Breach invert elevation

Parameters needed by DSS-WISE™ Web

When an embankment dam is selected, the user is invited to provide the breach bottom elevation and choose the failure mode either overtopping or piping.

Based on the data given by the user, the DSS-WISE™ Web provides the user with breach parameters computed utilizing the following three equations:

- Froehlich (1995)
- Froehlich (2008)
- Von Thun & Gillette (1990)

The user can either select one of the three pre-computed set of parameters or choose to enter their own set of values. Additionally, the user can define if the embankment is "erosion resistant" or "easily erodible".

Input data needed from the user to compute breach parameters with different equations:

	MacDonald and Langridge-Monopolis	Froehlich (1995)	Froehlich (2008)	Von Thun & Gillette
1	Embankment Top Length =			
2	Top of Dam Elev. =	Top of Dam Elev. =	Top of Dam Elev. =	Top of Dam Elev. =
3	Pool Elev. =			
4	Channel Invert Elev. =			
5	Breach Invert Elev. =	Breach Invert Elev. =	Breach Invert Elev. =	Breach Invert Elev. =
6	Volume @ Pool Elev. =	Volume @ Pool Elev. =	Volume @ Pool Elev. =	Volume @ Pool Elev. =
7	Dam Crest Width, C =			
8	U/S SS =			
9	D/S SS =			
10		K_o =	K_o =	C_B =
11		Side Slope =	Side Slope =	Side Slope =

Depends on the reservoir volume and can be automatically selected. (applies to C_B, Von Thun & Gillette)

Selected based on the mode of failure (overtopping or piping). We can directly ask the failure type and select the values accordingly. (applies to Froehlich (1995) and Froehlich (2008))

Selected based on the soil type (cohesionless or cohesive). (applies to Von Thun & Gillette)

Popular Semi-Empirical Parametric Equations for Embankment Dam Breach

Froehlich (1995a):

Froehlich utilized 63 earthen, zoned earthen, earthen with a core wall (i.e. clay), and rockfill data sets to develop as set of equations to predict average breach width, side slopes, and failure time. The data that Froehlich used for his regression analysis had the following ranges:

- **Height of the dams:** 3.66 – 92.96 m (12 – 305 ft)
  - with 90% < 30 m, and 76% < 15 m
- **Volume of water at breach time:** 0.0130 – 660.0 $m^3 \times 10^6$ (11 - 535,000 acre-ft)
  - (with 87% < 25.0 $m^3 \times 10^6$, and 76% < 15.0 $m^3 \times 10^6$)

$$B_{ave} = 0.1803\, K_o\, V_w^{0.32}\, h_b^{0.19}$$

$$t_f = 0.00254\, V_w^{0.53}\, h_b^{-0.90}$$

Where:

B_{ave}	=	Average Breach Width (m)
K_o	=	Constant (1.4 for overtopping failures, 1.0 for piping)
V_w	=	Reservoir volume at time of failure (m^3)
h_b	=	Height of the final breach (m)
t_f	=	Breach formation time (hrs).

Froehlich states that the average side slopes should be:

1.4H:1V	Overtopping failures
0.9H:1V	Otherwise (i.e. piping/seepage)

Froehlich (2008):

In 2008 Dr. Froehlich updated his breach equations based on the addition of new data. Dr. Froehlich utilized 74 earthen, zoned earthen, earthen with a core wall (i.e. clay), and rockfill data sets to develop as set of equations to predict average breach width, side slopes, and failure time. The data that Froehlich used for his regression analysis had the following ranges:

- **Height of the dams:** 3.05 – 92.96 m (10 – 305 ft)
  - with 93% < 30 m, and 81% < 15 m
- **Volume of water at breach time:** 0.0139 – 660.0 $m^3 \times 10^6$ (11.3 - 535,000 acre-ft)
  - (with 86% < 25.0 $m^3 \times 10^6$, and 82% < 15.0 $m^3 \times 10^6$)

$$B_{ave} = 0.27\, K_o\, V_w^{0.32}\, h_b^{0.04}$$

$$t_f = 63.2\sqrt{\frac{V_w}{g h_b^2}}$$

Where:

B_{ave}	=	Average Breach Width (m)
K_o	=	Constant (1.3 for overtopping failures, 1.0 for piping)
V_w	=	Reservoir volume at time of failure (m^3)
h_b	=	Height of the final breach (m)
g	=	Gravitational acceleration (9.80665 m/s^2)
t_f	=	Breach formation time (Seconds).

1.0 H:1V	Overtopping failures
0.7 H:1V	Otherwise (i.e. piping/seepage)

Von Thun and Gillette (1990):

Von Thun and Gillette used 57 dams from both the Froehlich (1987) paper and the MacDonald and Langridge-Monopolis (1984) paper to develop their methodology. The method proposes to use breach side slopes of 1.0H:1.0V, except for dams with cohesive soils, where side slopes should be on the order of 0.5H:1V to 0.33H:1V. The data that Von Thun and Gillette used for their regression analysis had the following ranges:

- **Height of the dams:** 3.66 – 92.96 m (12 – 305 ft)
  - with 89% < 30 m, and 75% < 15 m
- **Volume of water at breach time:** 0.027 – 660.0 $m^3 \times 10^6$ (22 - 535,000 acre-ft)
  - with 89% < 25.0 $m^3 \times 10^6$, and 84% < 15.0 $m^3 \times 10^6$

$$B_{ave} = 2.5\, h_w + C_b$$

Where:

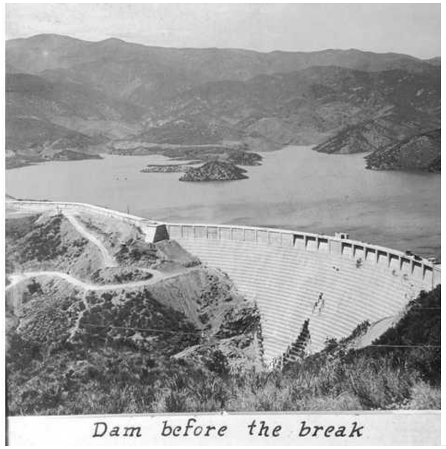
B_{ave}	=	Average breach width (m)
h_w	=	Depth of water above the bottom of the breach (m)
C_b	=	Coefficient, which is a function of reservoir size, see below.

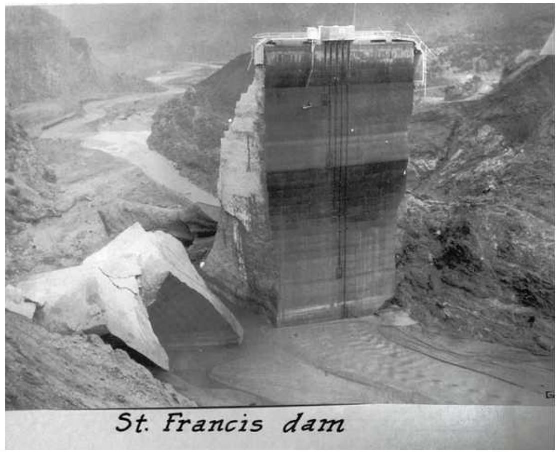
Reservoir Size, m^3	C_b, meters	Reservoir Size, acre-feet	C_b, feet
< 1.23*10^6	6.1	< 1,000	20
1.23*10^6 - 6.17*10^6	18.3	1,000-5,000	60
6.17*10^6 - 1.23*10^7	42.7	5,000-10,000	140
> 1.23*10^7	54.9	>10,000	180

Breaching of Concrete Dams

Concrete Dam Failure

Estimation of breach parameters for concrete dams is challenging. There are no widely accepted procedures or clear guidelines.



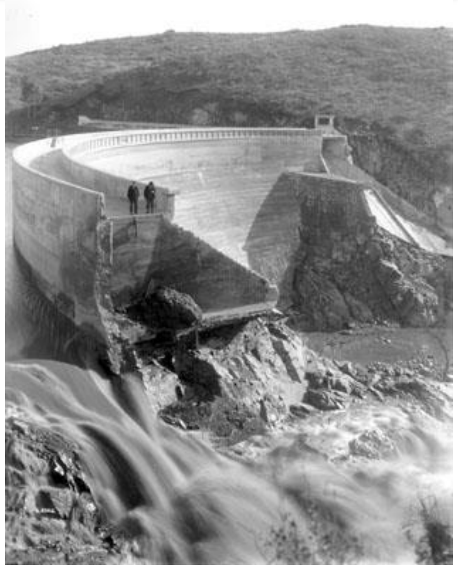


Remnants of the Austin, Pennsylvania, dam after its failure on September 30, 1911.

On March 12, 1928, St. Francis Dam gives way in Los Angeles, failed killing over 500 people. The St. Francis Dam was a curved concrete gravity dam, built to create a large regulating and storage reservoir as part of the Los Angeles Aqueduct.

Concrete dams are built as vertical monoliths that are later connected together.

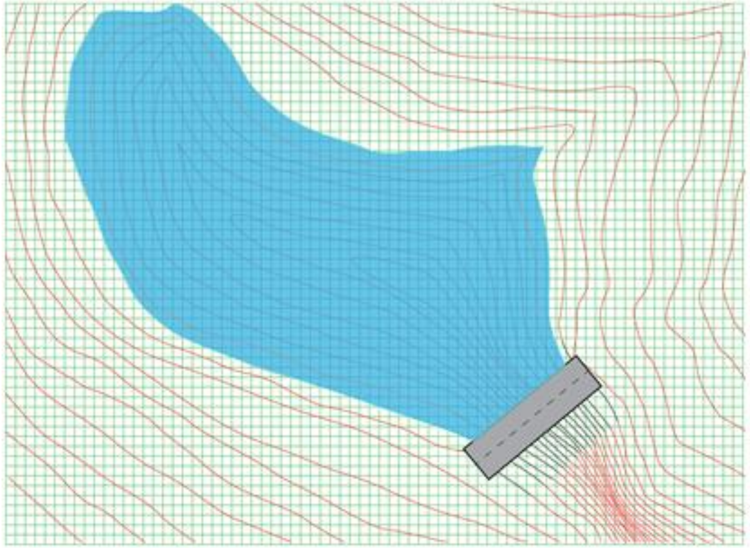
Estimate how many monoliths will fail?



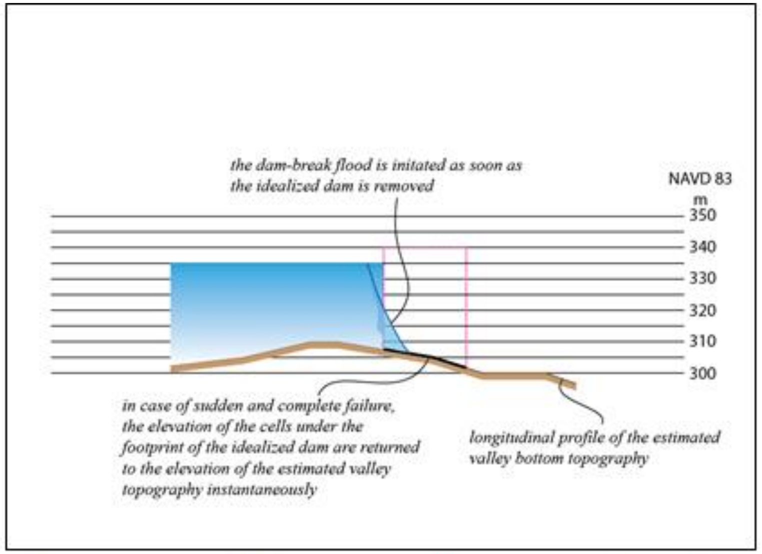
Sweetwater Dam failure of 1916

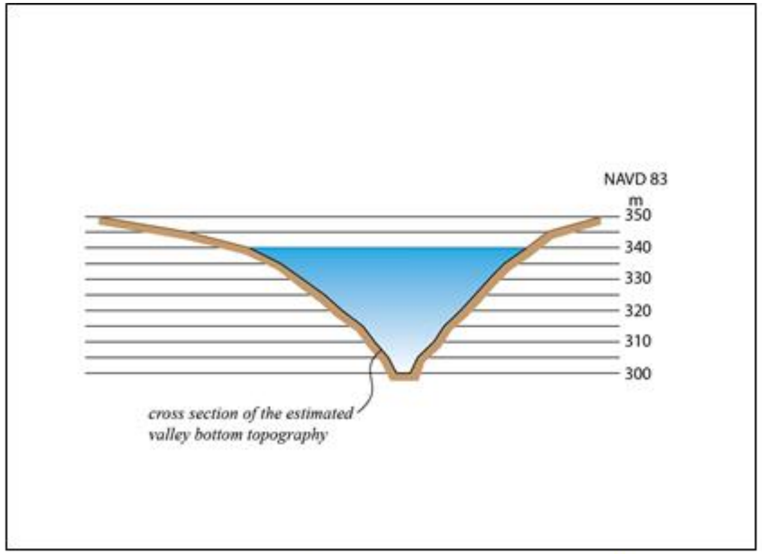
Shih Kang Dam, Taiwan, damaged in the 7.6-magnitude Chi Chi earthquake in September 1999. It is the first concrete dam known to have failed in an earthquake. (http://www.wenatcheeworld.com/photos/2013/mar/08/189085/)

Simplified Illustration of the Estimation of the Removal of Dams, Reservoir Bed Elevation, and Breaching Process / 4

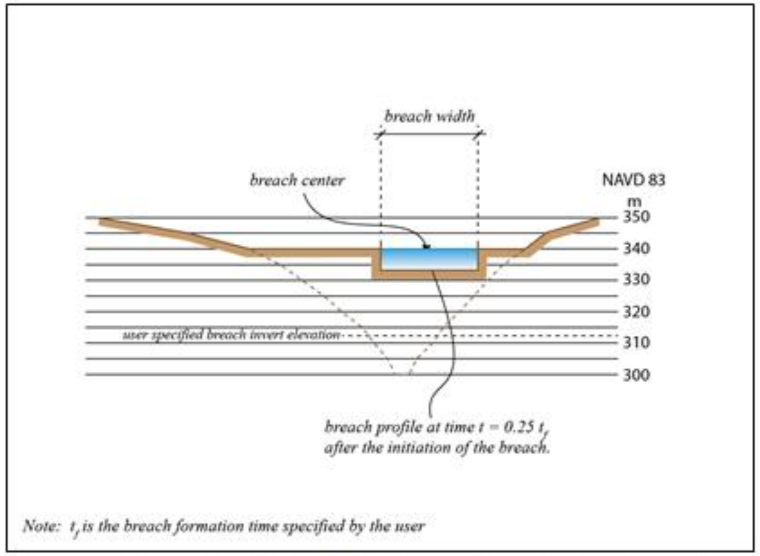


Reservoir is filled up to the water surface elevation at failure, which is specified by the user

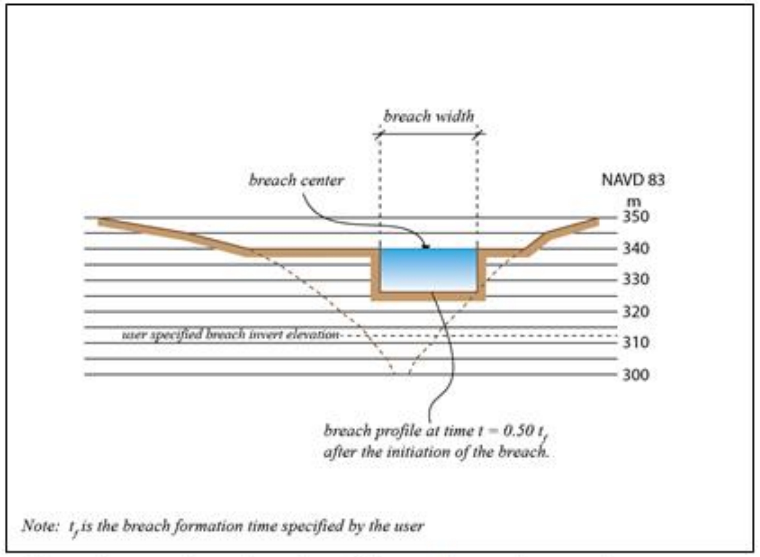




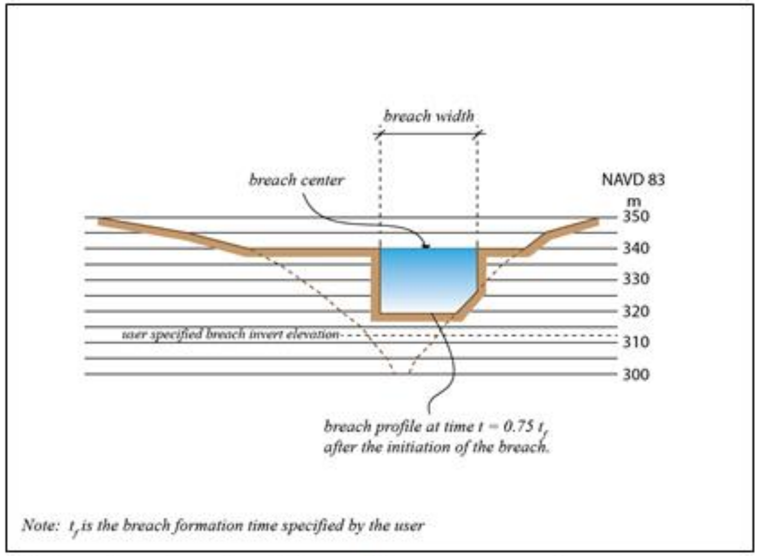
Transversal profile A-A and longitudinal profile BB show that, in case of sudden and complete failure, elevation of cells defining idealized dam are returned to their estimated valley elevation. This initiates the dam-break flood



In case of partial and gradual failure cells under the footprint of the breach area are lowered with a linear speed

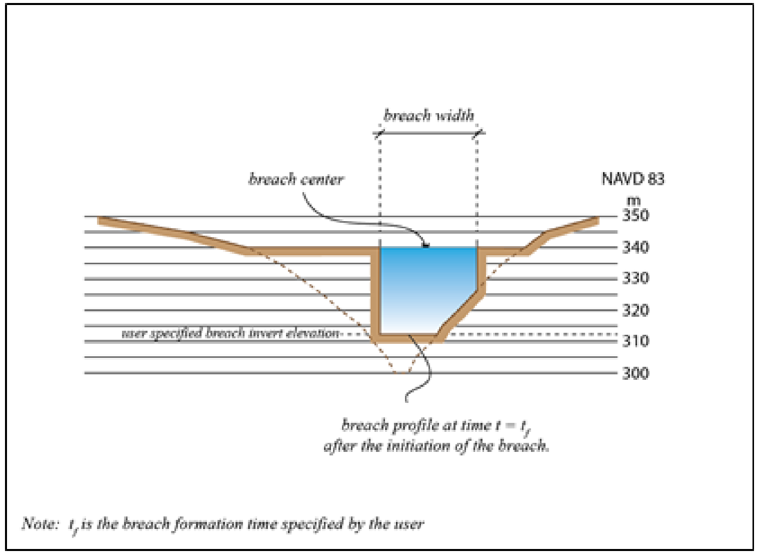


Note that as the elevation of the cells are lowered to create the breach, they do not cut into the original terrain

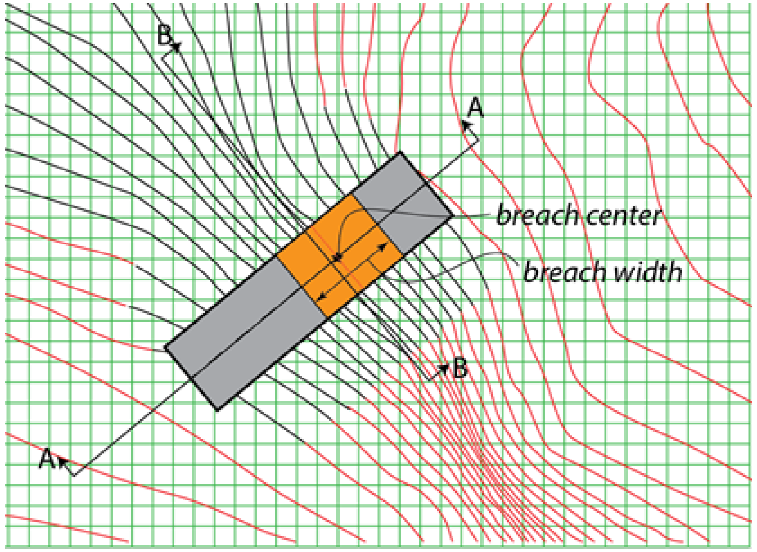


When the elevation of the cell becomes equal to the estimated valley elevation, it is no longer lowered

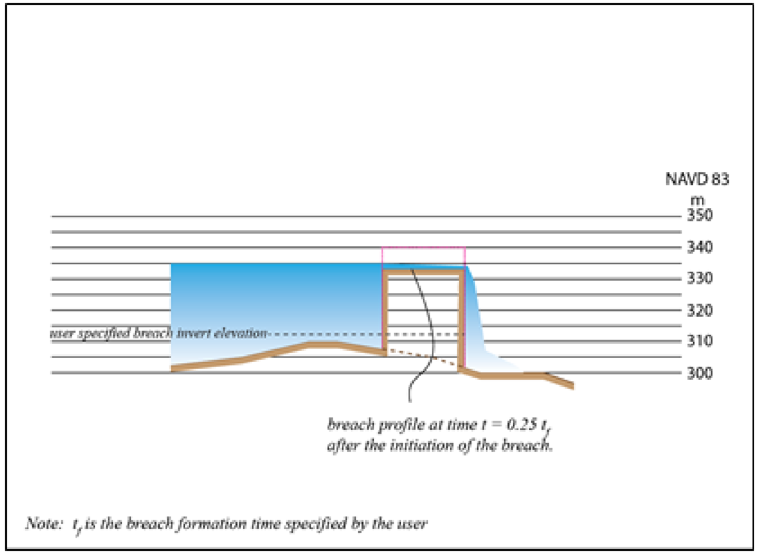
Simplified Illustration of the Estimation of the Removal of Dams, Reservoir Bed Elevation, and Breaching Process / 5



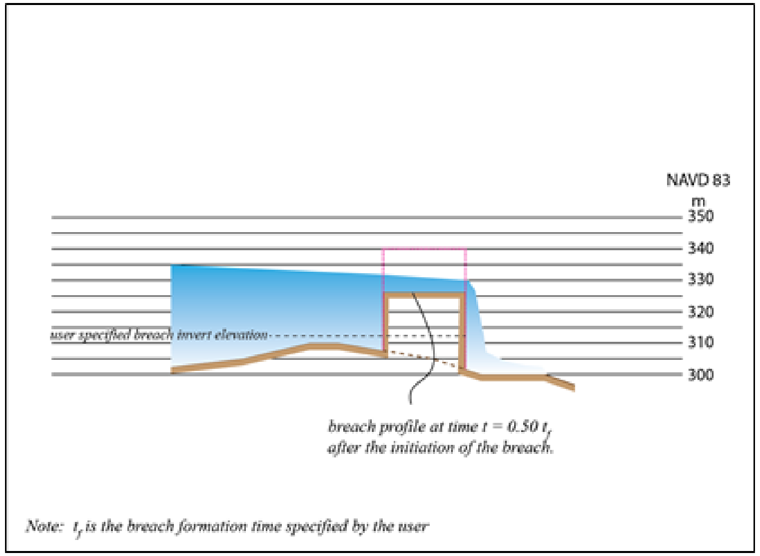
When all the cells reach the specified breach invert elevation, or the estimated valley elevation, breaching stops



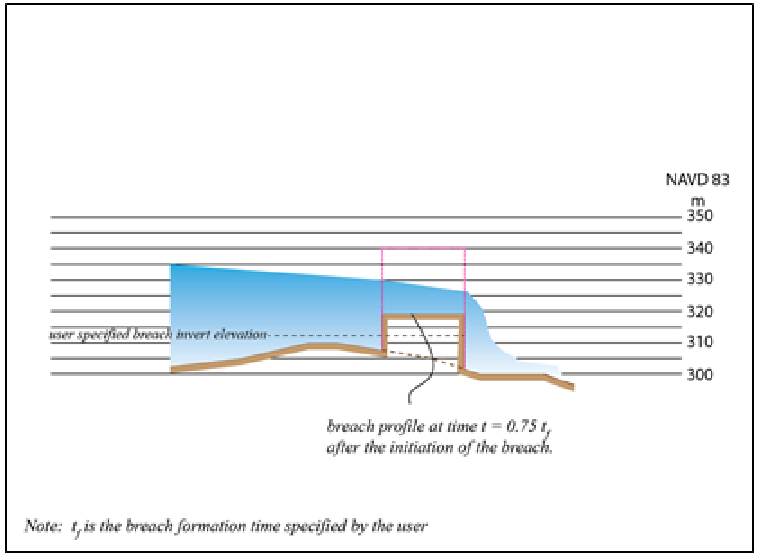
Let us now observe the partial and gradual breaching process on the longitudinal profile B-B



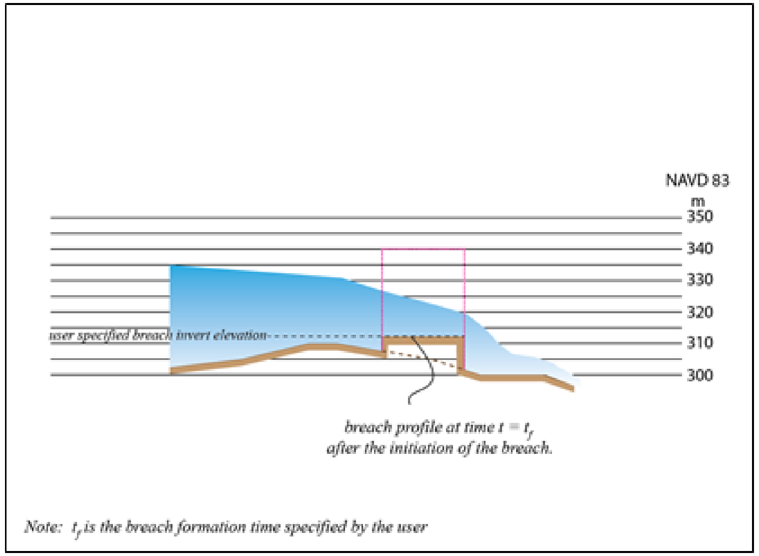
At $t = 0.25\ t_f$, cells are lowered by an amount equal to ¼ of the elevation difference between the crest and breach invert



At $t = 0.50\ t_f$, cells are lowered by an amount equal to ½ of the elevation difference between the crest and breach invert



At $t = 0.75\ t_f$, cells are lowered by an amount equal to ¾ of the elevation difference between the crest and breach invert



At $t = t_f$, the breaching process is completed since all cells have reached the elevation of breach invert of the valley

INTRODUCTION TO DSS-WISE™ HCOM

What is DSS-WISE™ HCOM?

DSS-WISE HCOM is a post-processing module available under DSS-WISE Web. It provides an assessment of the potential consequences of a dam-break (or a levee-break) floods on humans by

- providing flood hazards maps for **humans** (but also indirectly for **structures**) for preparedness, and
- assessing nighttime and daytime PAR counts to assist in emergency response planning and evacuation planning.

DSS-WISE HCOM generates four types of analysis:

1. Flood Hazard Mapping for humans
    a. Flood hazard mapping for population caught outdoors
    b. Flood hazard mapping for population caught indoors

2. Mapping of Potentially Lethal Flood Zones (PLFZ) for humans
    a. PLFZ for children
    b. PLFZ for adults

3. Analysis of Population at Risk (PAR) numbers by interfacing results from DSS-WISE Web with population data
    a. Nighttime PAR analysis using LandScan USA nighttime population
    b. Daytime PAR analysis using LandScan USA daytime population
    c. PAR analysis using 2010 census block data

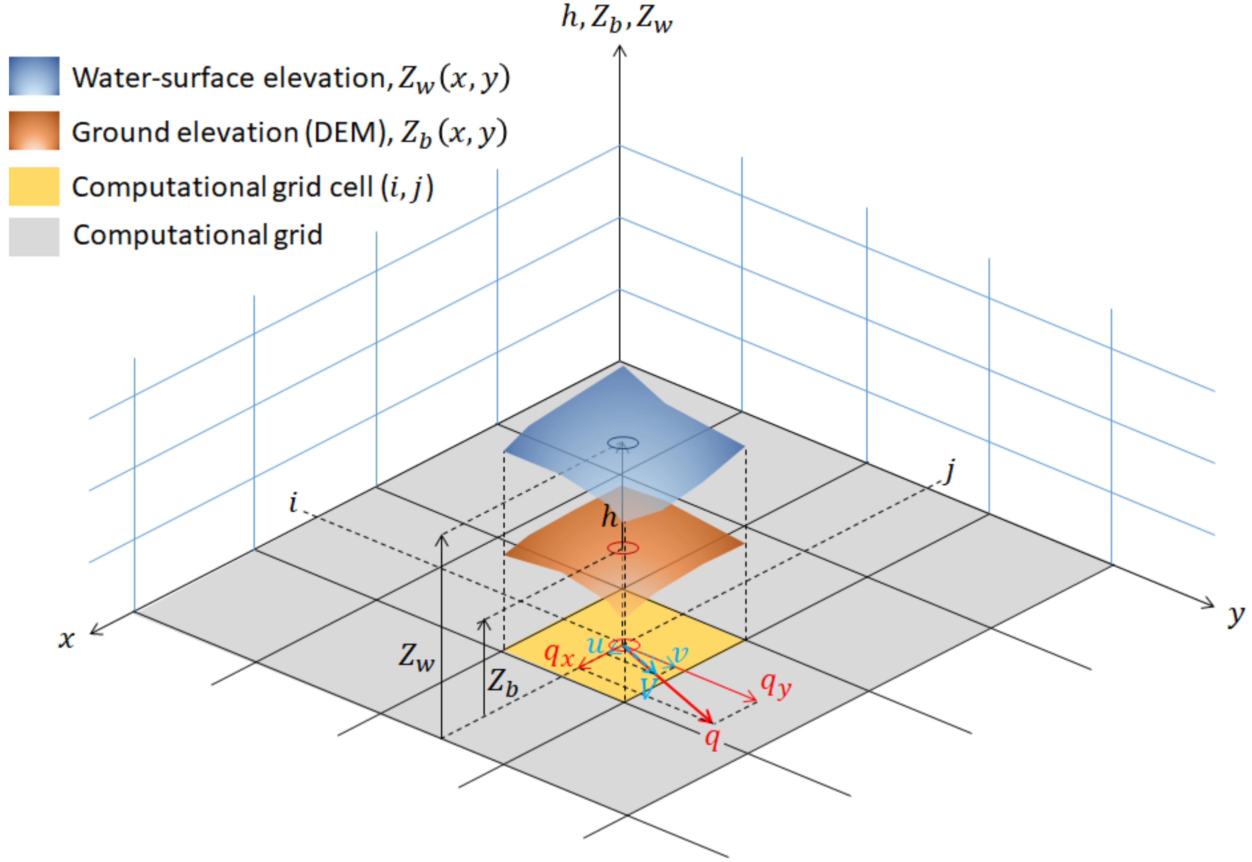
Maximum Specific Discharge ≡ Maximum DV (D: Depth and V: Velocity) / Units: ft²/s

Raster file of the magnitude of the maximum specific discharge, q_{max} (ft²/s), which is calculated from the maximum values of its components in x- and y-directions using the expression:

$$q_{max} = \sqrt{\left(q_{x_{max}}\right)^2 + \left(q_{y_{max}}\right)^2}$$

In literature on the estimation of the consequences of dam-break floods, the specific discharge, q, is sometimes denoted by DV, referring to the product of the depth of flood, D, and the velocity magnitude, V.

Early consequence analysis methods were based on the results provided by one-dimensional flood models. The DV value was not based on depth and velocity computed at any specific location and it could only be computed in an average sense for a cross section or a reach (FEMA 2011, p.20).



Two-dimensional flood models, such as DSS-WISE™ Web, compute the DV value at the center of each cell. The consequence analysis provided in the present report considers DV to be the same as q. It is implicitly implied that we consider the maximum value:

$$DV \equiv DV_{max} \equiv q_{max}$$

DSS-WISE HCOM: Potential Flood Hazard for People Caught Outdoors

For humans caught outdoors, DSS-WISE HCOM maps the ranges of DV_{max} corresponding to five potential hazard (or danger) levels identified by different color codes:

1. "Very Low Hazard: Shallow flow or deep standing water";
2. "Low Hazard: Dangerous to children";
3. "Moderate Hazard: Dangerous to some adults";
4. "Significant Hazard: Dangerous to most adults"; and
5. "Extreme Hazard: Dangerous to all".

The basis is the Cox et al. (2010) (adopted also by FEMA and USBR).

Interpretation of these five zones are given for three population categories defined by an index value corresponding to the product of height (H) and mass (M) of the individual:

1. "Infants and Small Children",
2. "Children", and
3. "Adults";

$q_{max} \equiv DV_{max}$				Potential Hazard (or Danger) Category	Explanation based on Cox et al. (2010)		
(m^2/s)		(ft^2/s)			Adults	Children	Infants, Small Children and Frail/Older Persons
from	to	from	to				
0.0	0.4	0.0	4.3	Very Low Hazard: Shallow flow or deep standing water	Low Hazard	Low Hazard	Extreme Hazard Dangerous to all Infants, Small Children and Frail/Older Persons
0.4	0.6	4.3	6.5	Low Hazard: Dangerous to Children		Significant Hazard; Dangerous to most children	
0.6	0.8[2]	6.5	8.7[2]	Moderate Hazard: Dangerous to some adults	Moderate Hazard: Dangerous to some adults	Extreme Hazard: Dangerous to all children	
0.8	1.2[3]	8.7	13.0[3]	Significant Hazard: Dangerous to most adults	Significant Hazard: Dangerous to most adults		
1.2[3]		13.0[3]		Extreme Hazard: Dangerous to all	Extreme Hazard: Dangerous to all		

1) Small children, children and adult categories are defined based on height (H) time mass (M)

Small children:	H×M ≤ 25 (m.kg)	H×M ≤ 181 (ft.Lb)
Children:	25 < H×M (m.kg) ≤ 50	181 < H×M (m.kg) ≤ 362
Adult:	50 < H×M (m.kg)	362 < H×M (ft.Lb)

2) Recommended upper limit of tolerable working flow regime for trained safety workers or experienced and well-equipped persons

3) Above this value, the hazard is extreme according to majority of the past studies.

Potential Flood Hazard for People Caught Indoors

For people caught indoors during the flood, it will be assumed that the potential danger is associated with the collapse of the building (see FEMA 2011, p. 43).

Thus, the approach neglects the potential of drowning in the structure. Only collapse of the building is considered. Thus, the map of Potential Flood Hazard for People Caught Indoors can also be used as flood hazard map for the structures and can be used in evaluating potential structural damage.

The table below lists the $q_{max}(DV_{max})$-values for the potential collapse of different types of buildings, which are taken from the technical report of the Life Safety Model (LSM) developed by British Columbia Hydro (BCH 2006).

DV_{max}		Color Code	Building Type
(m^2/s)	(ft^2/s)		
≥5	≥54		HZ06: Poorly constructed building
≥10	≥108		HZ07: Well-built timber building
≥15	≥161		HZ08: Well-built masonry building
≥20	≥215		HZ09: Concrete building
≥35	≥377		HZ10: Large concrete building

Mapping Potentially Lethal Flood Zones (PLFZs) for Children and Adults

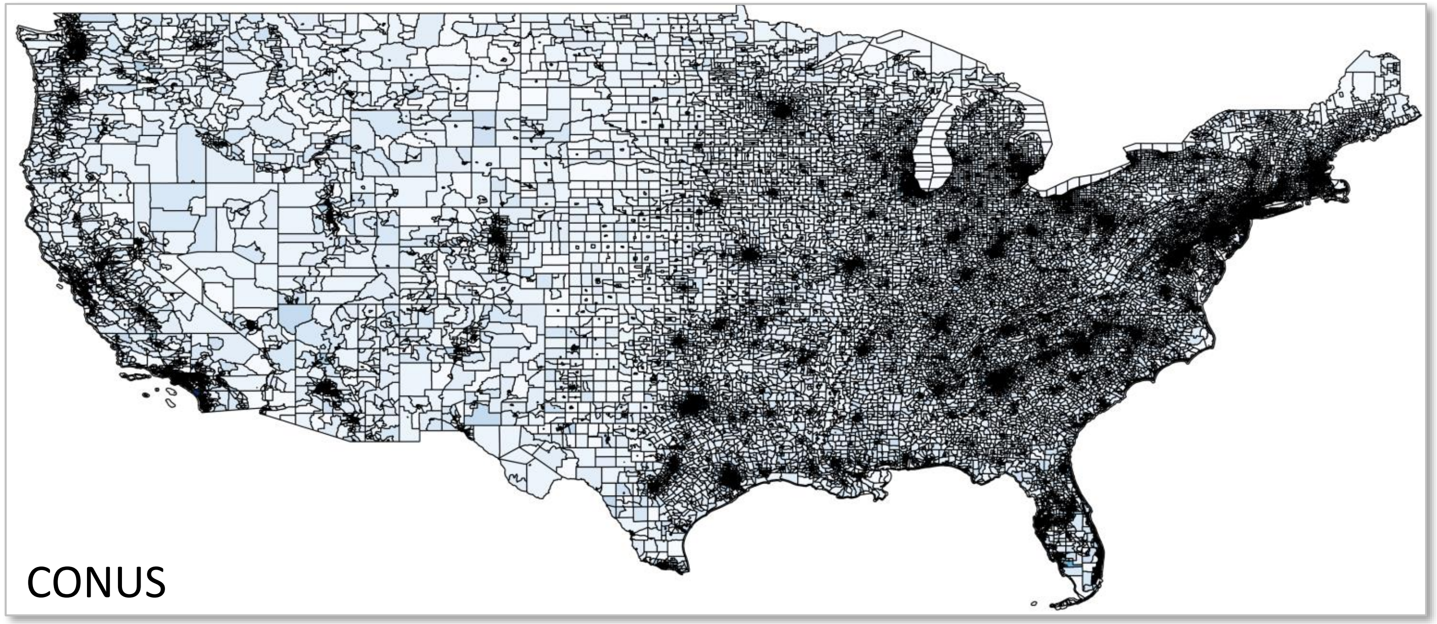
The mapping of potentially lethal flood zones (PLFZs) for humans consists of partitioning the inundation area into zones of pre-defined potential lethality classes for humans. The resulting map is an ESRI polygon shapefile. The polygons correspond to different levels of potential lethality that are defined based on the maximum depth, $h_{max} \equiv D_{max}$, and maximum specific discharge, $q_{max} \equiv DV_{max}$.

The definition of PLFZs for different categories of people caught outdoors, cars, mobile homes and typical residential structures are listed in the table below (Feinberg, 2017).

Category	Color Code	D_{max} $(ft.)$		DV_{max} (ft^2/s)
Children caught outdoors (tent camping, fishing, hiking, etc.)		≥ 2	or	≥ 5.4
Adults caught outdoors (tent camping, fishing, hiking, etc.)		≥ 4	or	≥ 6.5
Motor vehicle (compact car) floating	None	≥ 1	or	≥ 4.3
Motor vehicle (compact car) sliding/toppling	None			≥ 5.4
Mobile homes	None	≥ 2	or	≥ 30
Typical residential structures	None	≥ 4	or	≥ 75

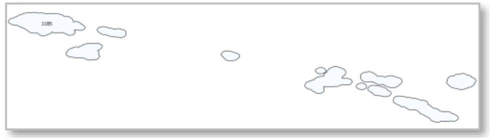
Feinberg, B. 2017. “Using Potentially Lethal Flood Zones to Assess Downstream Impacts from Dam Failure.” Presentation at the National Dam Safety Training Seminar.

2010* Census Block Data

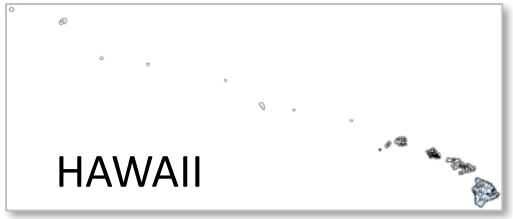


CONUS

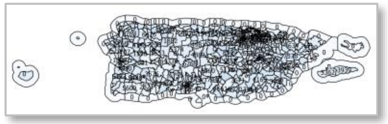
ALASKA



ALEUTIAN (EAST) ISLANDS



HAWAII



PUERTO RICO

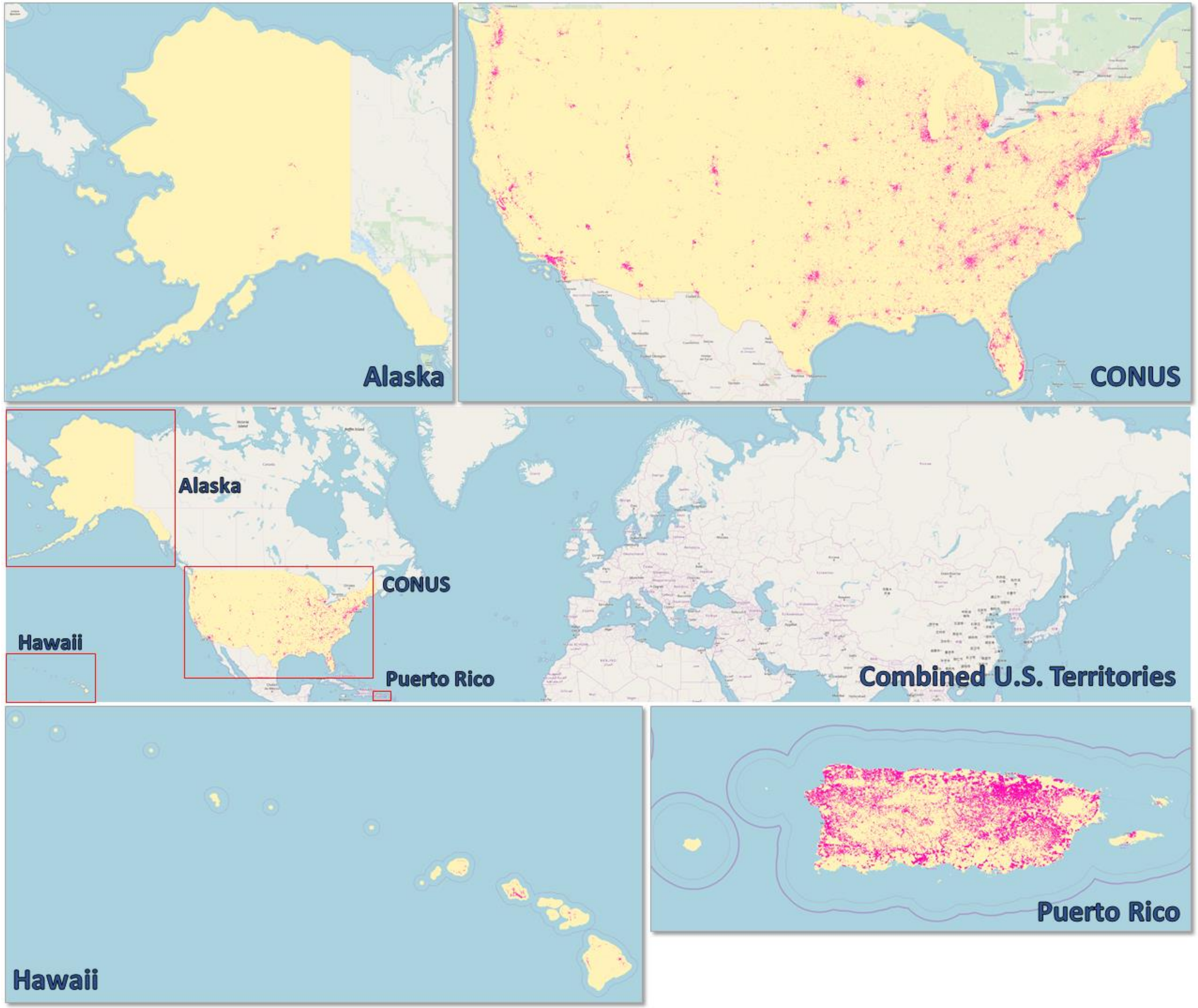
2010 Census Block data is provided by the United States Census Bureau.

A census block is the smallest geographic unit for which USCB collects data from all the houses in the unit (rather than a sample of houses). Census Blocks are bounded by visible features such as streets, roads, streams and nonvisible features such as property lines and limits of city, township, school district, and counties, etc.

2010 Census includes **11,166,336** Census Blocks and 545,653 “water-only” Census Blocks covering the Unites States, Puerto Rico and the Island Areas.

4,871,270 blocks have zero population and they cover an area of 4.61 million square kilometers, which corresponds to 47% of the total territory of the U.S.

Combined (Seamless) LandScan USA Gridded (3 arc-second) Population Data

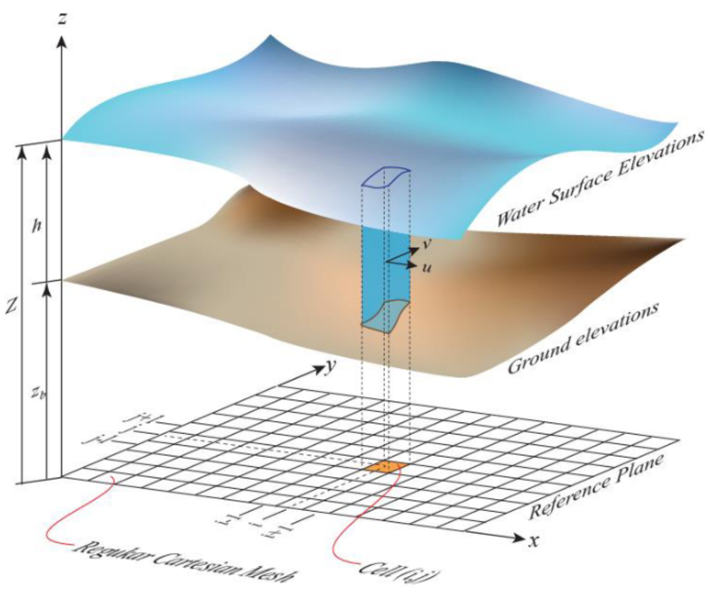


Combined nighttime population density raster at 1/3 arc-second resolution. The scale for the population density in the inserts is locally varied for visibility purposes.

Verified and validated hydrodynamic model: Comparison studies

Conservative Form of 2D Shallow Water Equation (SWE)

DSS-WISE™ Lite solves 2D Shallow Water Equations (SWE) using finite-volume discretization



$$\boldsymbol{U}_t + [\boldsymbol{F}(\boldsymbol{U})]_x + [\boldsymbol{G}(\boldsymbol{U})]_y = \boldsymbol{S}(\boldsymbol{U})$$

$$\boldsymbol{U} = \begin{bmatrix} h \\ hu \\ hv \end{bmatrix}$$

Vector of Conserved Variables

$$\boldsymbol{F}(\boldsymbol{U}) = \begin{bmatrix} hu \\ huu + g\,h^2/2 \\ huv \end{bmatrix}$$

Vector of Fluxes in x-direction

$$\boldsymbol{G}(\boldsymbol{U}) = \begin{bmatrix} hv \\ hvu \\ hvv + g\,h^2/2 \end{bmatrix}$$

Vector of Fluxes in y-direction

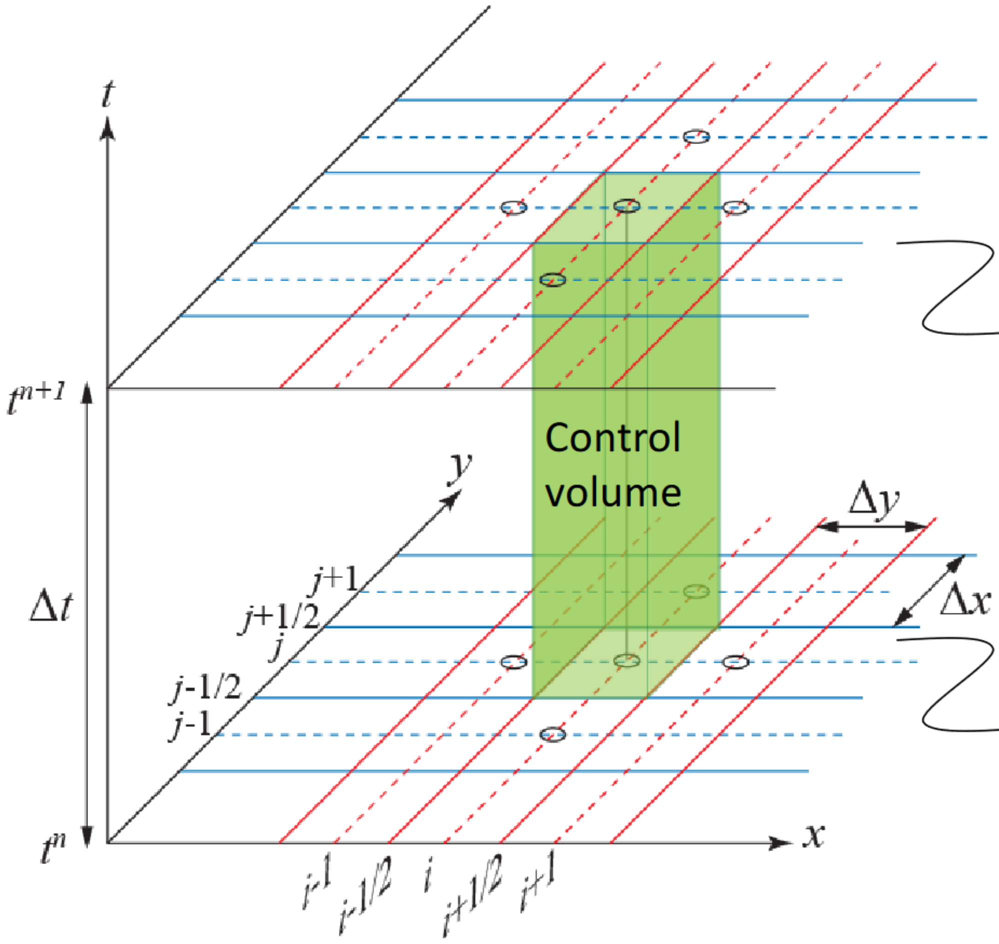
$$q_v$$

$$\boldsymbol{S}(\boldsymbol{U}) = \begin{bmatrix} -gh\left(\dfrac{u\,n^2\sqrt{u^2+v^2}}{h^{4/3}}\right) - g\,\dfrac{1}{2}\,(h_L + h_R)\left(\dfrac{\partial z_b}{\partial x}\right) \\ -gh\left(\dfrac{v\,n^2\sqrt{u^2+v^2}}{h^{4/3}}\right) - g\,\dfrac{1}{2}\,(h_B + h_T)\left(\dfrac{\partial z_b}{\partial y}\right) \end{bmatrix}$$

Vector of Source Terms (due to bed slope and bed friction)

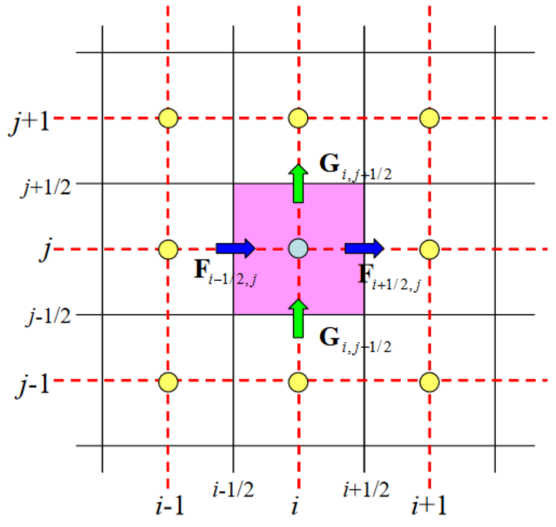
Finite Volume Discretization of the Conservative SWE over A Regular Cartesian Grid

We discretize the domain by creating a computational grid. In the present case, we will use a regular Cartesian mesh with elements Δx by Δy (Δx = Δy). Δx (= Δy) is the spatial resolution of the solution.



This is the plane of next time t^{n+1} (= t^n +Δt). Values of conserved variables are to be calculated based on the known values of the previous time step.

This is the plane of current time t^n. Values of all conserved variables are known at this time



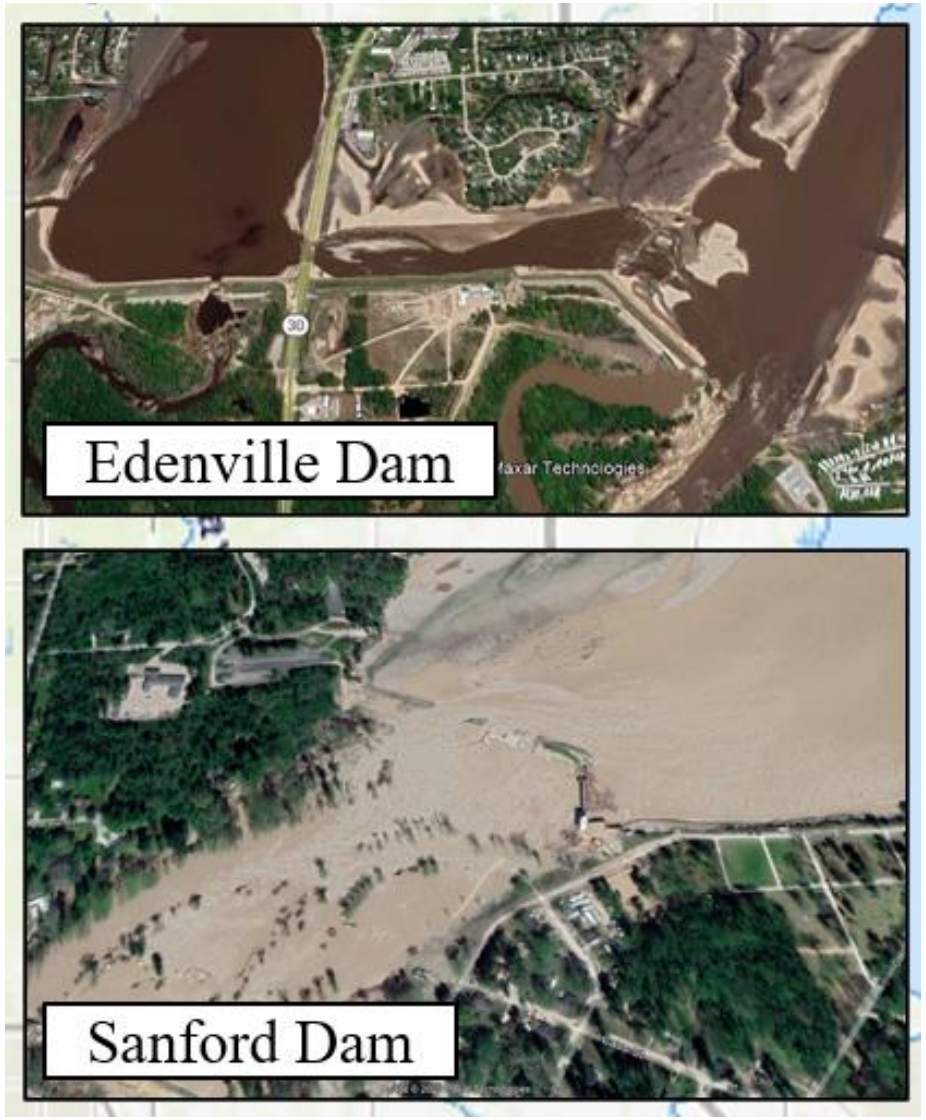
The finite volume formulation is obtained by integrating the vector form of the shallow water equations over the control volume.

The strategy for the selection of Δx, Δy, and Δt will be discussed later.

Dam-Break Flood Simulation

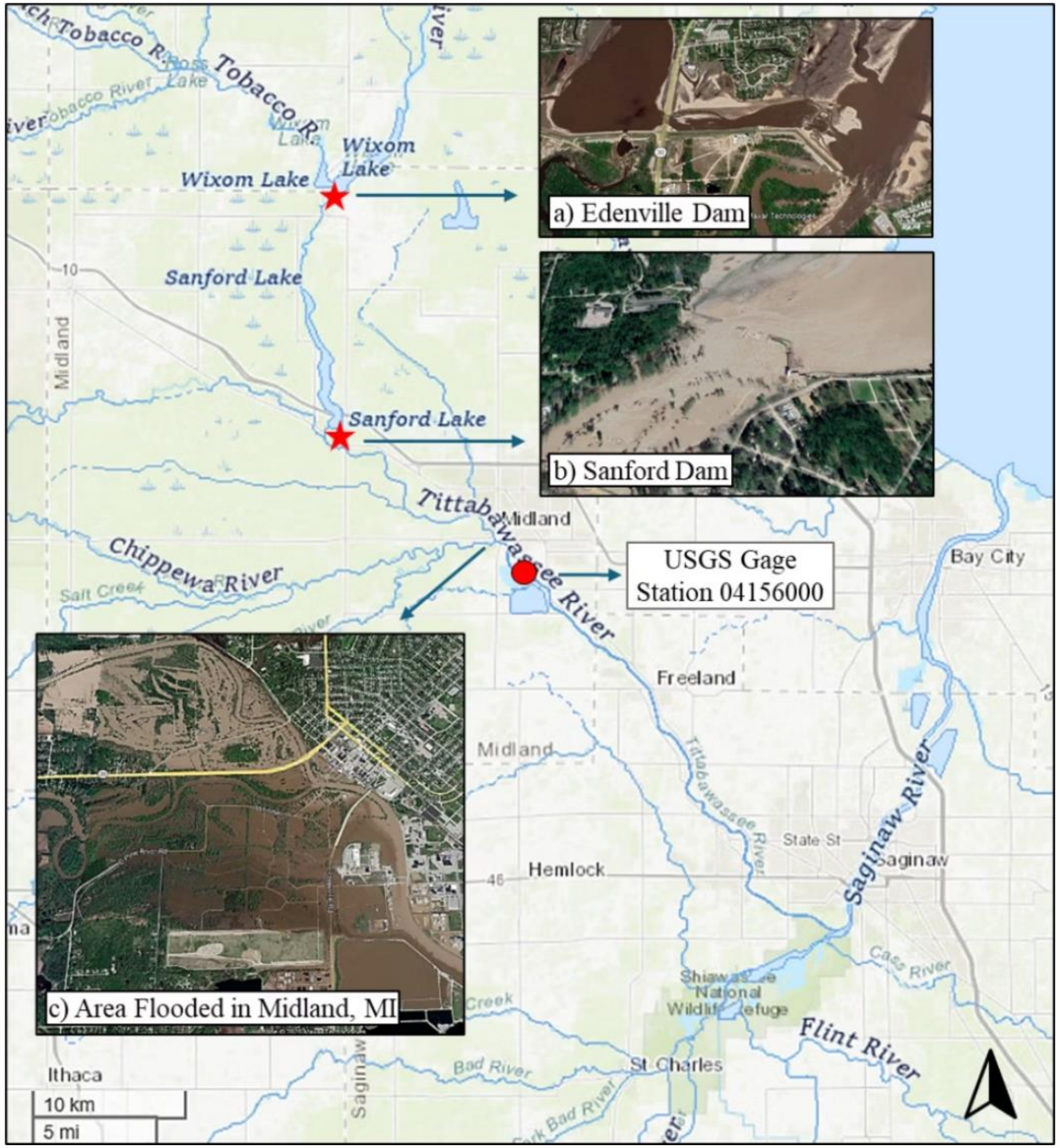
Comparative Analysis of DSS-WISE Web and HEC-RAS 2D

Case Study: 2020 Edenville and Sanford Dam Failures



Research Team: Nuttita Pophet, Ph.D., Navin Thalakkottukara, M.Tech., Marcus McGrath, M.S., Mohammad Al-Hamdan, Ph.D., Thomas Oommen, Ph.D., Paul Smith, Gokhan Inci, Ph.D., P.E., and James Demby, P.E.

Edenville & Sanford Dam Failures (May 19, 2020)



3.78in

Intense Rainfall

Over two days

51,913cfs

Peak Discharge

Flood wave: 23 feet

$245M

Property Damage

Estimated in direct losses

11,000

Evacuations

Residents evacuated, no serious injuries reported

Located on the Tittabawassee River, Michigan. Edenville Dam failed due to static liquefaction after intense rainfall. Sanford Dam failed ~2 hours later, overwhelmed by floodwaters.

Model Setup & Simulation Overview

Two primary simulation approaches were used to model the cascading dam failures and their downstream impacts.

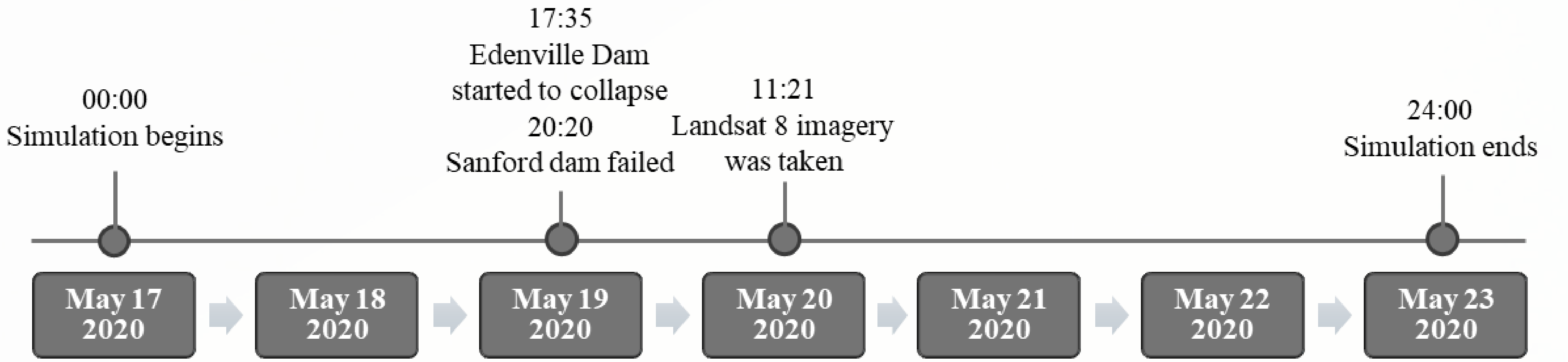
Combined Hydrograph

Merges all flow contributions (dam releases, failures, river inflows) downstream of Sanford Dam.

Reservoir Simulation

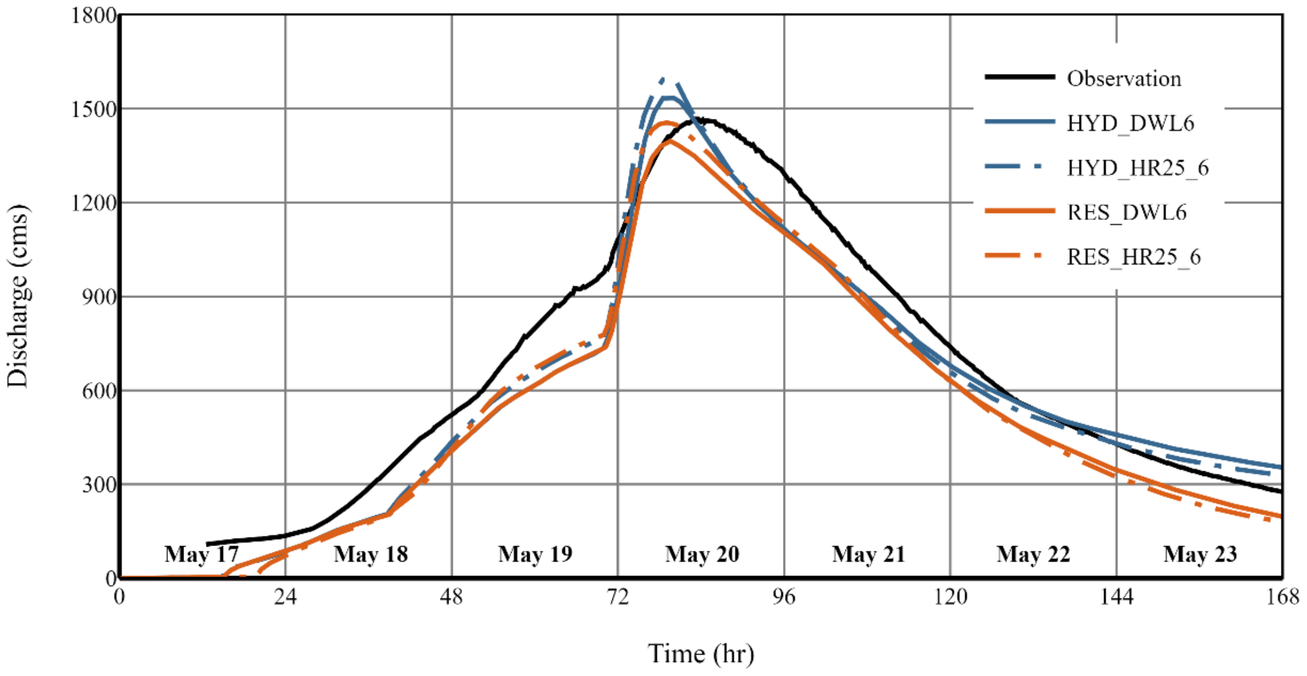
Models cascading failure of Edenville and Sanford Dams, including reservoir filling and breaching.

Simulation Period: Seven days (May 17-23, 2020), starting two days prior to dam breaches



Timeline of dam break events, satellite observation, and simulation period (May 17–23, 2020)

Hydrograph Comparison Results



Observed vs. Model Simulations at USGS Gage Station 04156000

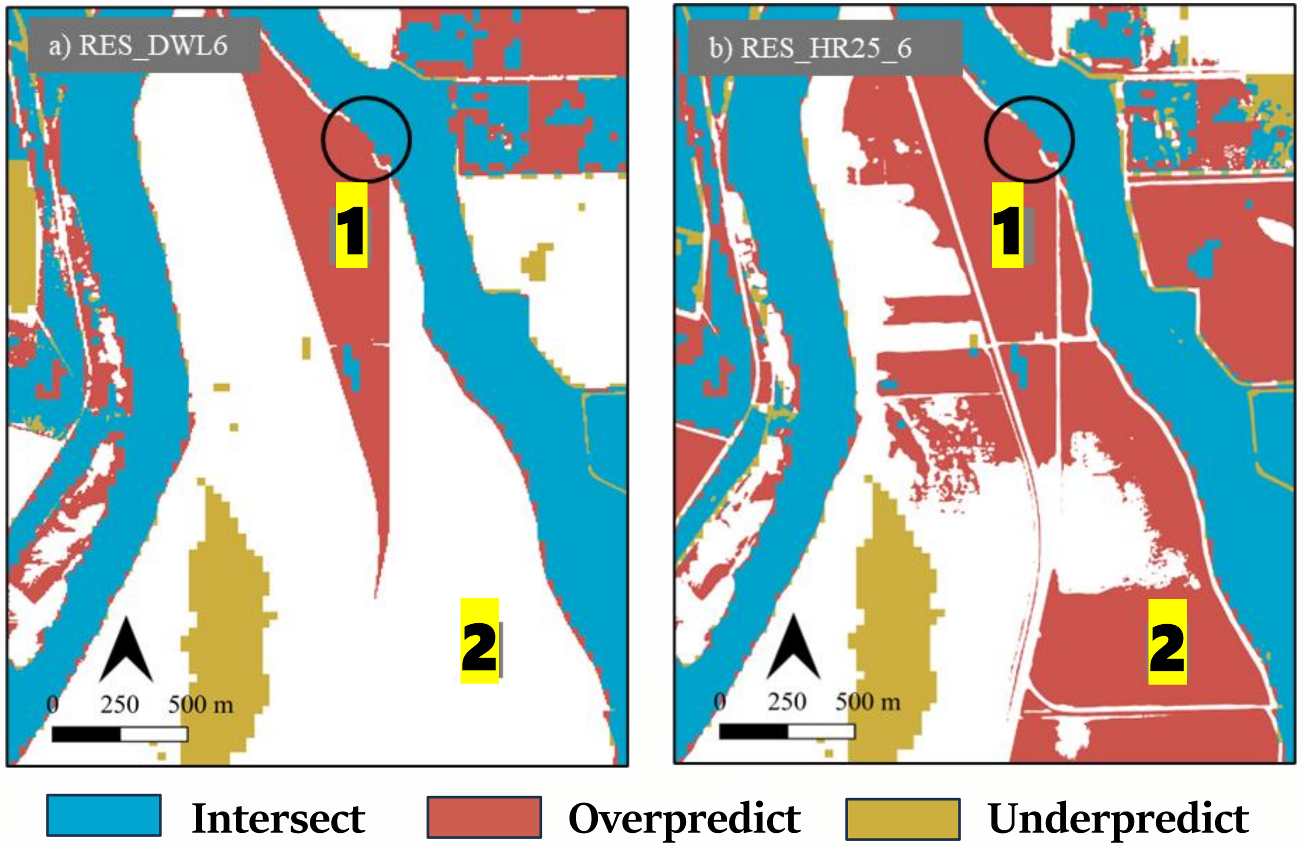
Simulation configurations and abbreviation codes

Simulation Type	Model	DEM resolution (m)	Computational element size (m)	Abbreviation code
Combined hydrograph	DSS-WISE Web	6	6	HYD_DWL6
	HEC-RAS	6	25	HYD_HR25_6
Reservoir type	DSS-WISE Web	6	6	RES_DWL6
	HEC-RAS	6	25	RES_HR25_6

Terrain & Mesh Resolution Challenges

DSS-WISE Web vs. Landsat 8

HEC-RAS vs. Landsat 8



Flood extent comparison between Saginaw and Bay City.
(a) DSS-WISE Web and **(b) HEC-RAS**.

Resolution is critical for accurate flood modeling - inadequate resolution can lead to missed flow pathways and improper hydraulic connectivity.

1

Area 1 Overestimation

Both Models: Due to DEM resolution limitations and coarse mesh. Uncaptured fine terrain details.

Solution: LiDAR data or model-specific features (DSS-WISE Web "burn-in"; HEC-RAS break lines).

2

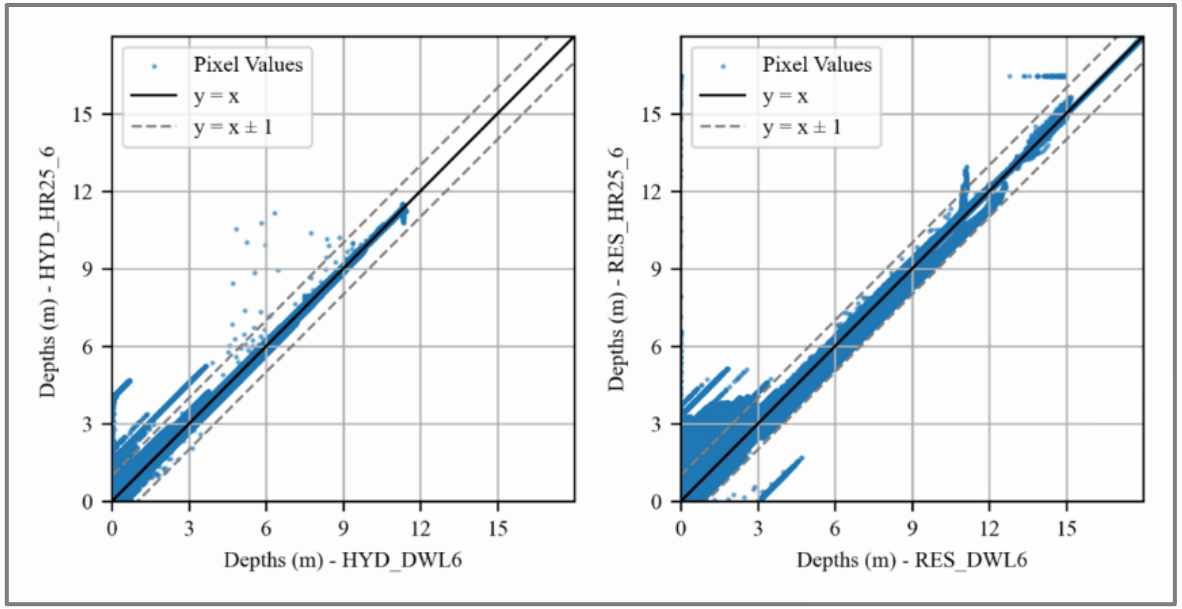
Area 2 Overestimation

HEC-RAS Only: Caused by absent break lines, leading to water "leaking" where cell faces misalign.

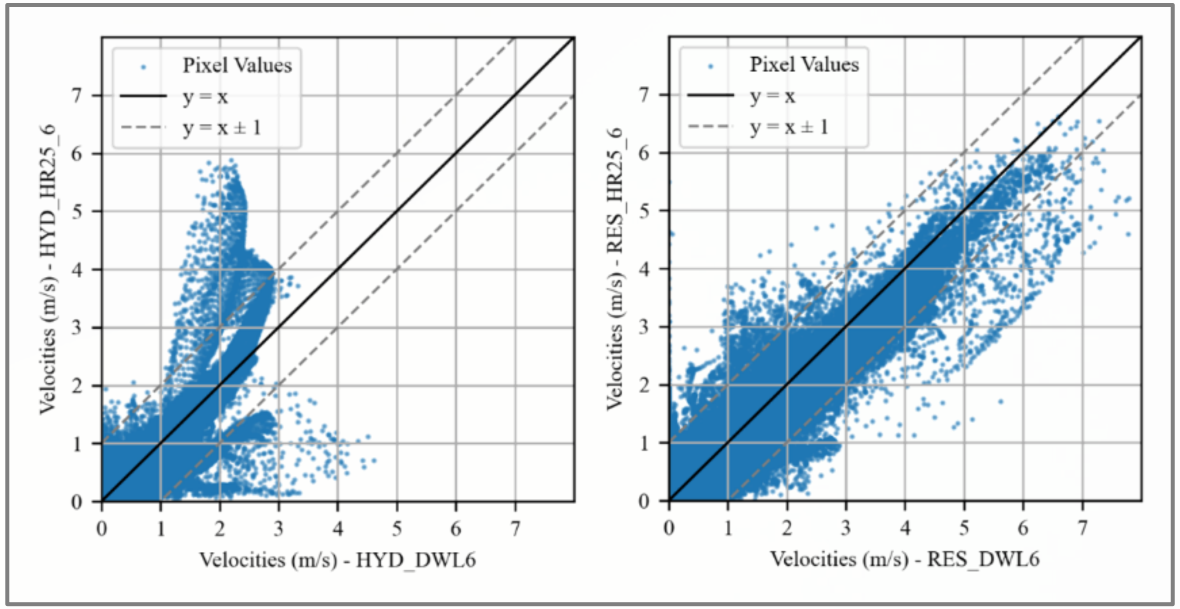
Mitigation: More break lines or local mesh refinement.

Model Comparisons: Depth & Velocity

Analysis of maximum depths and velocities between **DSS-WISE Web** and **HEC-RAS** for combined hydrograph and reservoir-type simulations.



Depth scatter plots for combined hydrograph (left) and reservoir-type (right) simulations



Velocity scatter plots for combined hydrograph (left) and reservoir-type (right) simulations

Maximum Depths

Combined Hydrograph: ~11.5 m

Reservoir-type: ~18.5 m

Over 99.9% of data points within ±1 m agreement

Maximum Velocities

Combined: DSS-WISE 4.6 m/s; HEC-RAS 5.9 m/s

Reservoir: HEC-RAS 6.7 m/s; DSS-WISE 10.0 m/s

Over 99.9% within ±1 m/s

Key Findings

- Strong depth agreement between models
- Velocity deviations near release points due to different modeling approaches

Maximum Flood Extent Comparison

Comparing **DSS-WISE Web** vs. **HEC-RAS** model predictions using **F-statistic** analysis for flood extent accuracy.

94%

Combined Hydrograph Agreement

F Statistic showing strong model agreement

92.5%

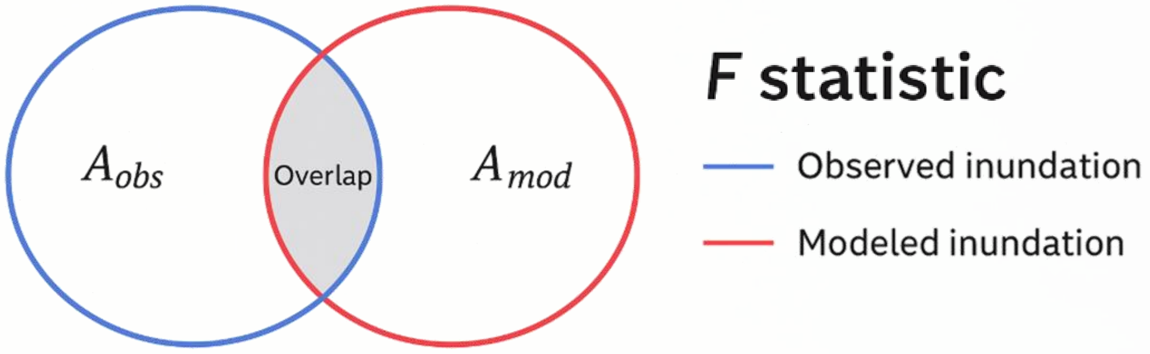
Reservoir-Type Agreement

F Statistic for reservoir simulation scenarios

>92%

Overall Similarity

Both models produce similar maximum flood extents



Runtime Efficiency

4.6x

to 9.1x Faster

DSS-WISE Web speedup at detailed resolutions (6m vs 25m)

856x

Speedup

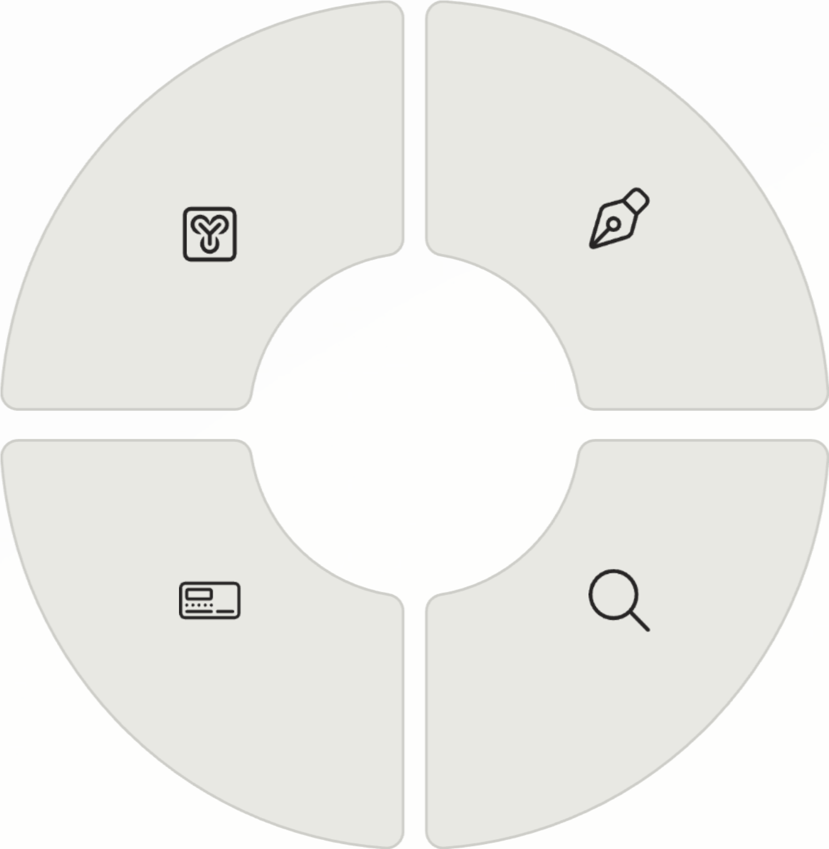
At 50m mesh resolution

Hardware

Intel Xeon Platinum CPU (32 cores) 64GB RAM, 2TB SSD

Key Takeaways/Conclusion

Both models effectively simulate dam-break floods with complementary strengths



DSS-WISE Web

Superior speed, ease of use, emergency response capability

HEC-RAS

Advanced features, customization, detailed analysis (steep learning curve and more challenge for non-expert users)

Continued Evolution

Both tools advancing to address current limitations

Strong Agreement

94% consistency demonstrates reliability of both approaches

Journal of Hydraulic Engineering
(under review)

Pophet, N., Thalakkottukara, N., McGrath, M., Al-Hamdan, M., Oommen, T., Smith, P., Inci, G., Demby, J. (2025).
Comparative Analysis of DSS-WISE Lite and HEC-RAS 2D Modeling for Dam-Break Flood Simulation: Case Study of the 2020 Edenville and Sanford Dam Failures.
Submitted to *Journal of Hydraulic Engineering.* (Under review)