Four Lakes Task Force

Precipitation and Flood Studies

April 13, 2021

Four Lakes Task Force

Two Major Questions Before Restoring Dams

- How should they be designed to make them safe from future floods?
- How will restoring the dams affect people and property downstream for future floods?

Today's Video

- Briefly explain how hydrology and hydraulic studies are performed and how they are applied to our dam rebuilding plans
  - Experts joining us today --
    - Ron Hansen, Spicer Group
    - Bill Kappel, Applied Weather Associates (AWA)
    - Ellen Faulkner, Ayres Associates
    - Paul Drew, GEI Consultants

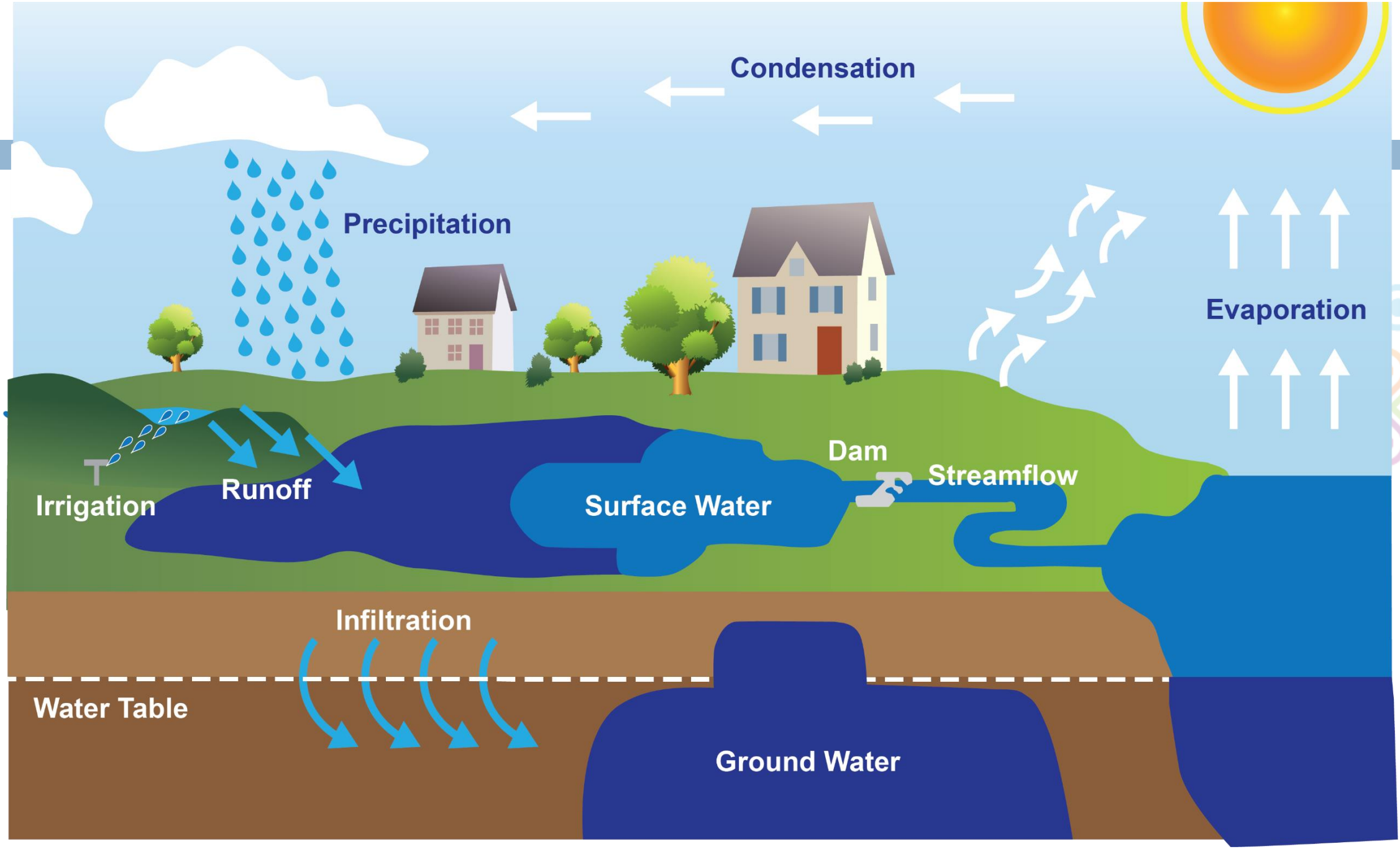
Dam Safety is Our Priority

Our top priority is dam safety! Repairs and reconstruction must be done safely to reduce the risk of dam failure in the future.

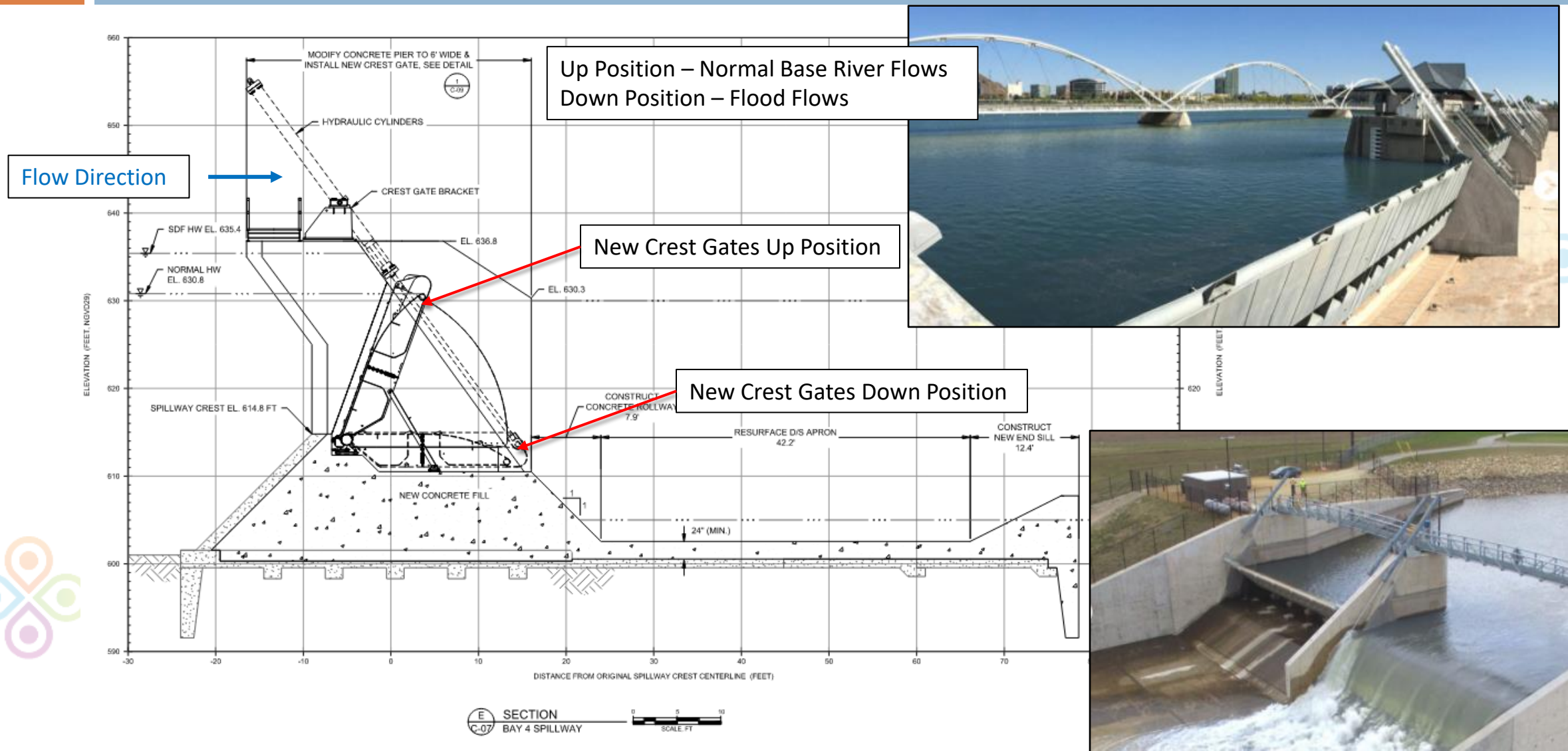
- Steps to reduce risk:
  - Understand probability of extreme storms
  - Select extreme storm as “design storm”
  - Understand the risk associated with the storm
  - Accept the risk
  - Construct dams to withstand extreme flood event

Objective of Dam Safety

- The dams cannot prevent flooding
- Dam safety is not about preventing flooding during extreme events
- Objective of dam safety is to make sure the dams stay intact during extreme floods


Condensation
Precipitation
Evaporation
Irrigation
Runoff
Dam
Streamflow
Surface Water
Infiltration
Water Table
Ground Water

Proposed Section View of Crest Gate Spillway



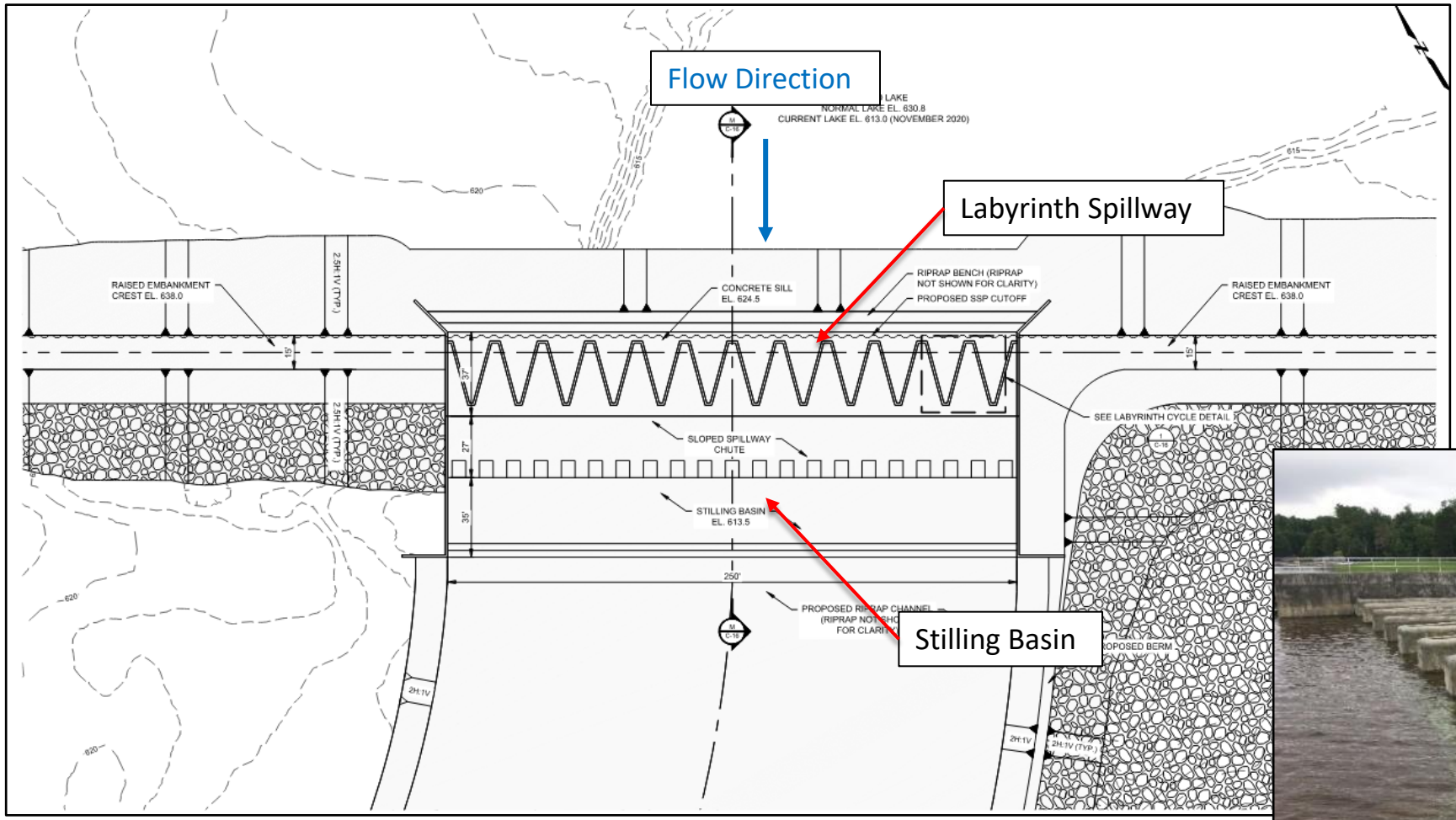
Flow Direction

Up Position – Normal Base River Flows
Down Position – Flood Flows

New Crest Gates Up Position

New Crest Gates Down Position

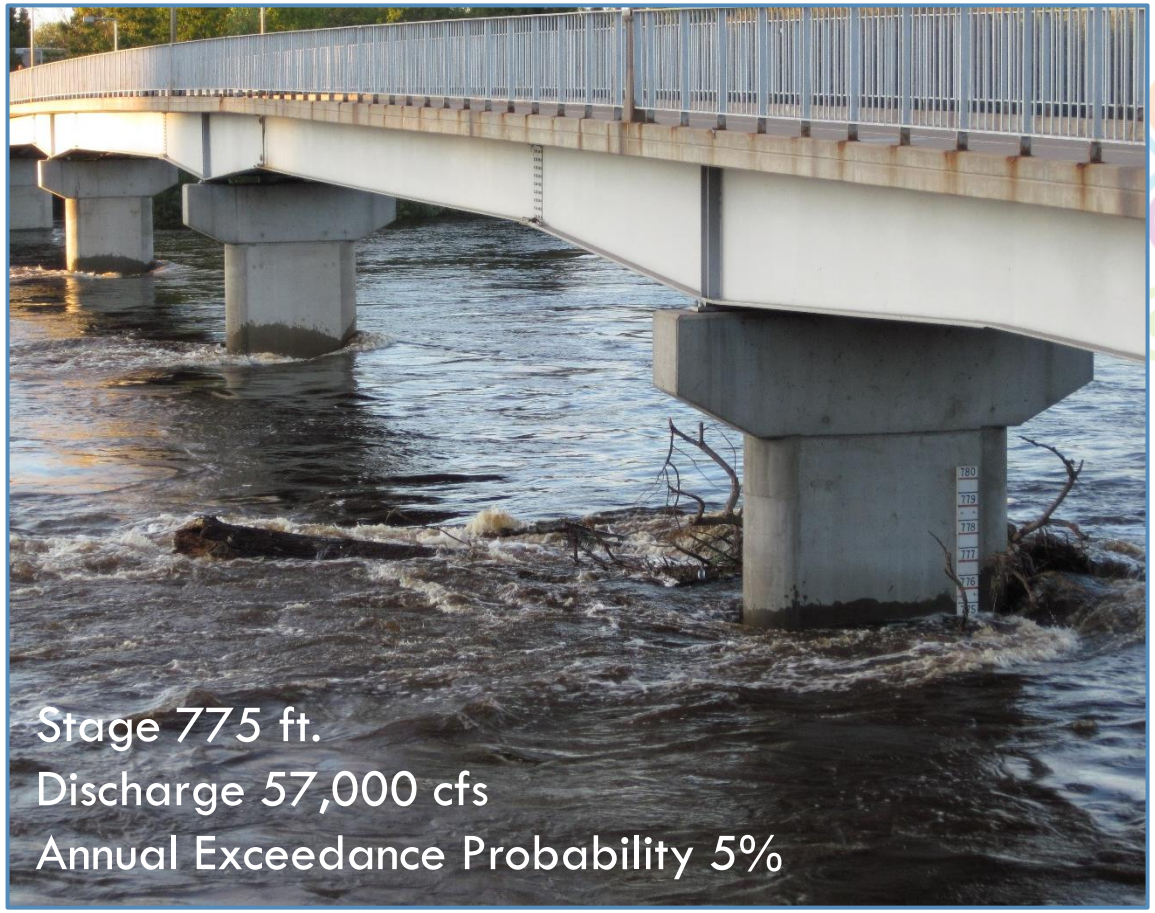
Proposed Plan View of Labyrinth Auxiliary Spillway



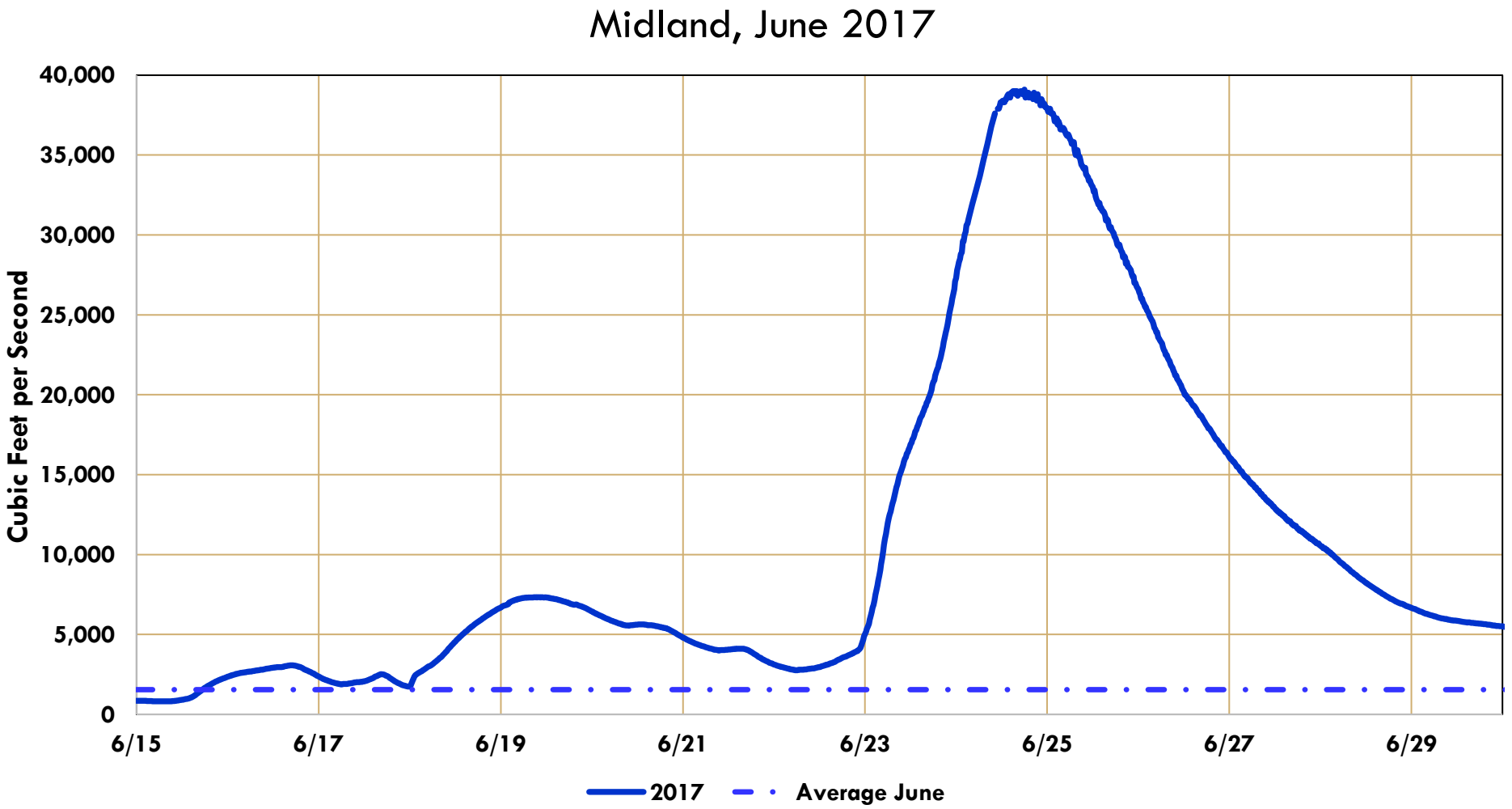
How Do We Define the Size of a Flood?

- **Flood Stage** (how high the flood rises)
  - Used for planning, warning or assessing damages
  - Flood stage is measured in feet
- **Flood Discharge** (how much water is flowing past a point in the river)
  - Used for design of dams, bridges and other hydraulic structures
  - Discharge is measured in cubic feet per second (cfs)
- **Flood Exceedance Probability** (how rare is the flood)
  - Used for communicating and understanding risk
  - Often expressed in terms of years (i.e., “100-year flood”)

Stage, Discharge, Probability



How Big Are Floods on the Tittabawassee River?



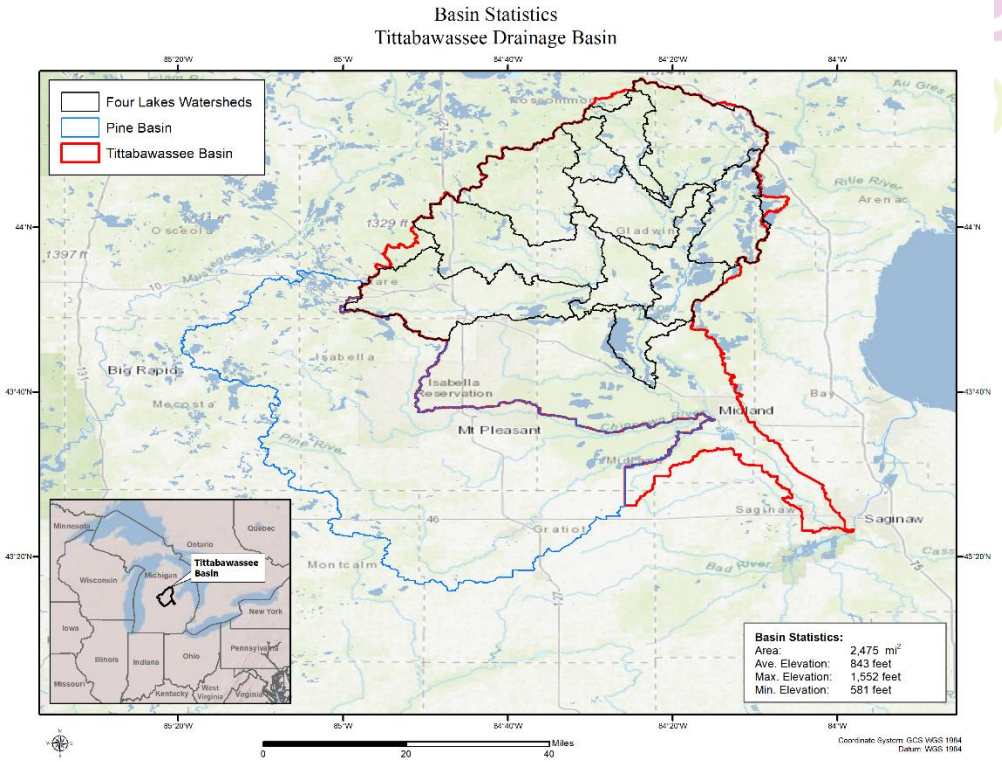
What Determines How Big Floods Get?

- Rain
- Watershed characteristics and conditions, including:
  - Contributing drainage area
  - Snowpack and frost
  - Soils (sand or clay; wet, dry or frozen; deep or shallow)
  - Land cover (forest, farms, lawns, concrete, wetlands, etc.)
  - Morphology (steepness, drainage network, ponds and lakes)

What Determines How Big Floods Get?

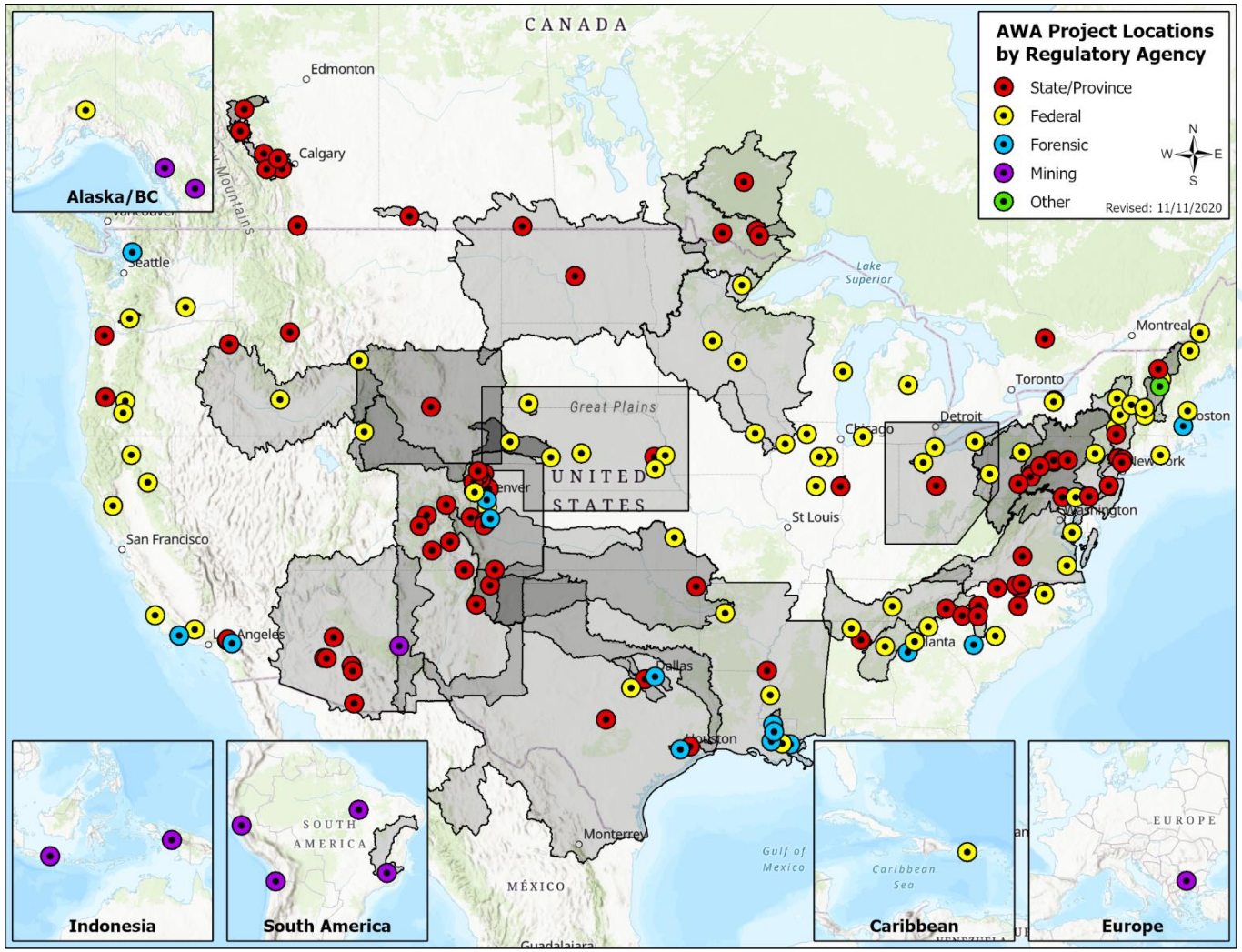
Probable Maximum Precipitation-Development

- Greatest rainfall that could ever occur at a given location:
  - Based on observed extreme events over large regions
  - Each storm maximized and moved to the basin
  - Maximized values enveloped
    - Numerous sensitivities applied to ensure appropriate results and conservatism
  - Probability of PMP depths also derived
    - Provides a recurrence interval of PMP depths
    - Provides information for IDF



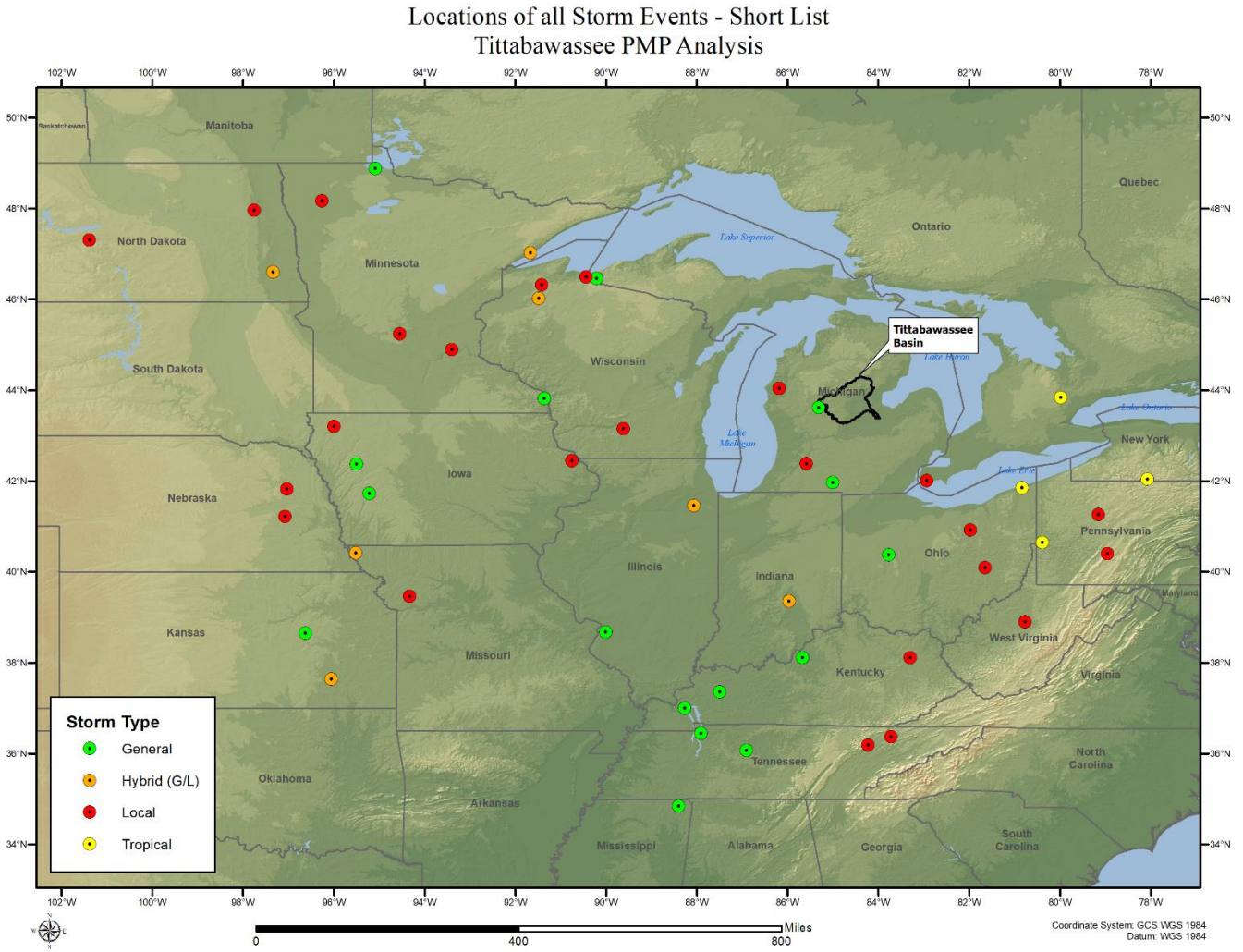
Probable Maximum Precipitation-Experience

- Developed 100's of studies of similar scope and complexity



Probable Maximum Precipitation-Deliverables

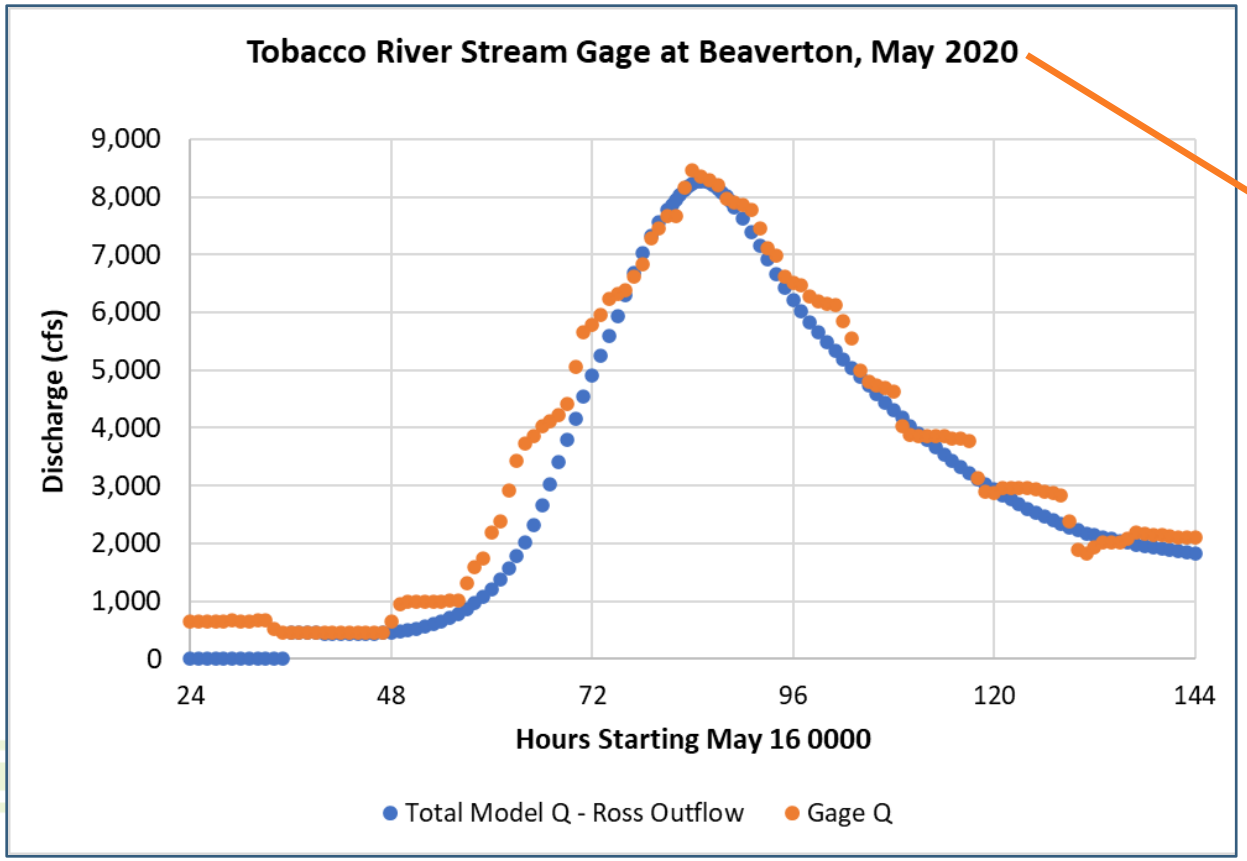
- Gridded PMP depths used for flood modeling
- Detailed documentation
- Extensive database
  - Can be updated as needed



Converting Rainfall Depth to Flood Discharge

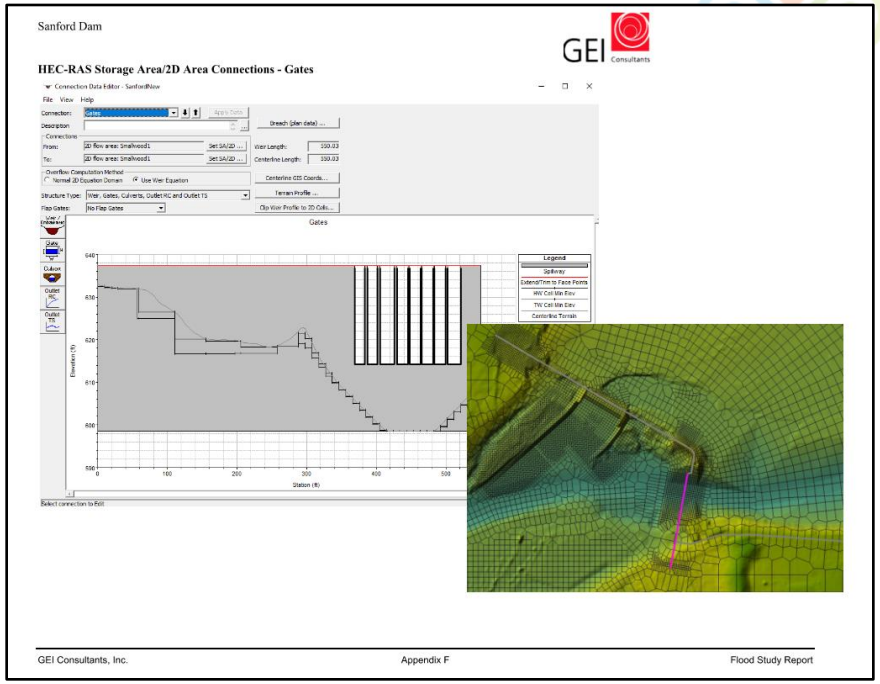
- Use computer software developed by the U.S. Army Corps of Engineers
- Software includes functions for mathematically describing various hydrologic processes
- Computer models must be calibrated – adjusted to make sure they correctly reproduce floods that have already occurred
- After calibration, apply hypothetical storms (e.g., PMP, 500-year storm) to the model to estimate the resulting flood discharge

Tittabawassee River HEC-HMS Model



Flood Study of the Tittabawassee River

- Perform a flood study from Secord and Sanford dams
- Primary goals of the flood study:
  - Site specific PMP and PMF study (by AWA and Ayres)
  - Develop hydraulic computer model to establish flood elevations
  - Evaluate existing spillway capacity prior to May 2020 flood event
  - Develop proposed spillway configurations to pass the newly established design flood for the rehabilitation of Secord and Smallwood dams, and the reconstruction of Edenville and Sanford dams
  - Establish flood inundation limits at critical locations upstream and downstream of each dam

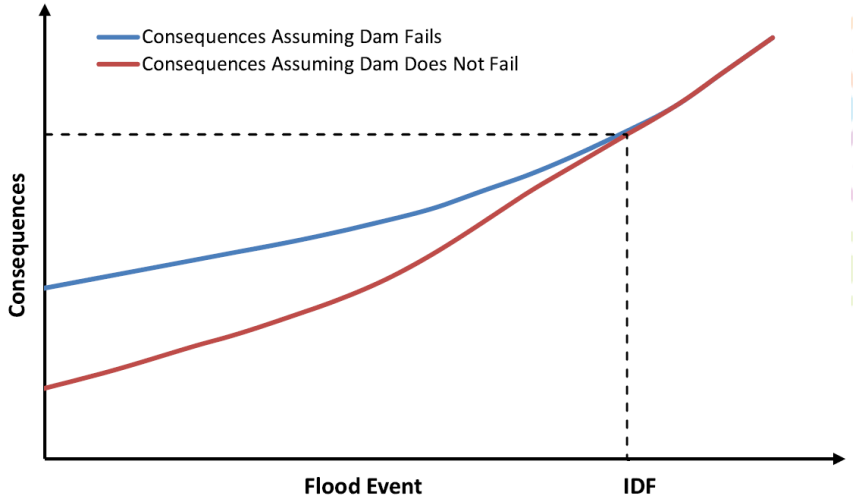


Summary of Risk Based Approach

- Before we develop designs, need to establish design criteria or inflow design flood (IDF) for each of the dams
- Following the Edenville and Sanford dam failures, the Michigan Dam Safety Task Force re-evaluated the EGLE dam safety program
- Goal of providing recommendations for changes to current EGLE dam safety regulations
- Their work culminated in a report to Governor Whitmer and state legislature dated Feb. 25, 2021
- Recommendation to follow the current FEMA model Dam Safety program for selecting design storms
- According to FEMA, the goal of selecting the design storm involves tradeoffs trying to balance multiple objectives
  - Safety to the public
  - Resources of the dam owner
  - Maintaining the credibility of the regulator representing the interest of the public
  - Assessing the publics desire of having the dam impoundment in exchange for the inherent risk that comes from living downstream of a dam

Summary of Risk Based Approach

- FEMA identifies the following approaches to defining the IDF to accommodate for a variety of situations
  - Prescriptive Approach – evaluate dam based on hazard potential of the dam
    - Current State of Michigan EGLE requirement – ½ PMF
  - Site specific PMP and PMF
    - Current work by AWA and Ayres to develop new PMP, ½ PMF and full PMF hydrographs
  - Incremental Consequence Analysis – IDF established by identifying the flood where the downstream consequences with and without a failure are not significantly different
    - During large storm events (1/2 PMF or PMF) evaluate the consequences of a dam not failing (i.e., downstream flooding)
    - Compare to incremental consequences if the dam fails (impacted structures)
    - Sometimes the consequences are identical. If so, little benefit in designing to a larger flood event



Risk Based Design Approach

- Risk informed decision making (RIDM)
  - RIDM requires a site-specific evaluation of probability of hydrologic events and performance of dam during those events and evaluates in detail the social, economic and environmental consequences of failure
  - Break down into two main components
    - Understanding incremental consequences of dam failure vs. non failure (what storm event provide no new incremental consequences)
    - Probability of storm causing the dam to fail
  - The IDF is selected as the design flood which assures that a given level of "tolerable risk" is not exceeded
  - The dam owner and regulators have the ability to cooperatively assess the marginal value of increasing levels of flood protection while balancing capital investment in risk reduction across multiple potential failure modes
  - The FLTF will present the selected design storm based on a risk assessment and request concurrence

Current Design Storm Criteria

- Design storm criteria not final for the following reasons:
  - Site specific PMP and PMF study by AWA and Ayres expected in summer 2021 (ongoing)
  - Uncertainty of EGLE spillway capacity requirements
- Interim design storm was selected for the purposes of developing conceptual design plans and budgetary costs
- The project team selected a more conservative design storm (greater than EGLE required ½ PMF)
- The final design storm criteria will be selected following completion of PMP/PMF study using a risk-based approach

Hydraulic Analysis – Existing Conditions

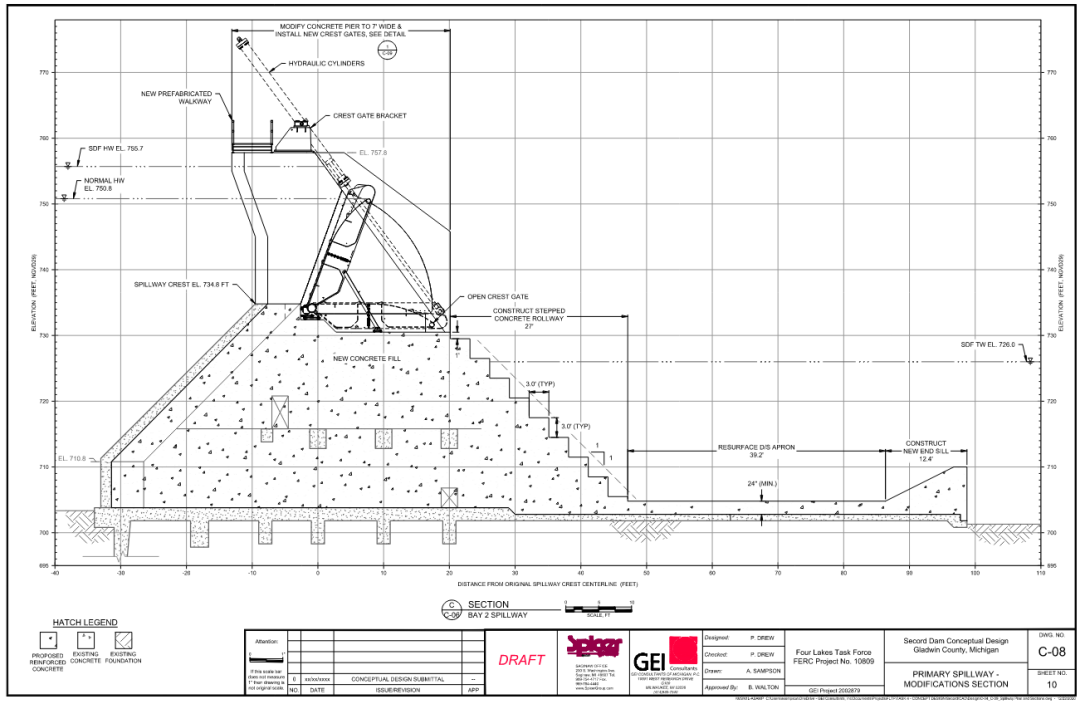
- GEI performed hydraulic analysis to evaluate the existing and proposed spillway capacity at each of the FLTF projects
- Secord Dam:
  - Lacked primary spillway capacity (tainter gate spillway)
  - No auxiliary spillway
  - Water spills over the Secord Lake east shoreline prior to reaching the dam
  - Significant upstream flooding
  - Existing spillway capacity is 7,700 cubic feet per second (cfs)
  - FLTF study currently estimating future spillway requirement being 21,150 cfs
- Smallwood Dam:
  - Lacked primary spillway capacity (tainter gate spillway)
  - Auxiliary spillway (significant overtopping of left embankment).
  - Overtopping occurred in May 2020 flood event. GEI does not consider this adequate for long term dam safety
  - Existing primary spillway capacity is 10,200 cfs
  - FLTF study currently estimating future spillway requirement being 24,100 cfs

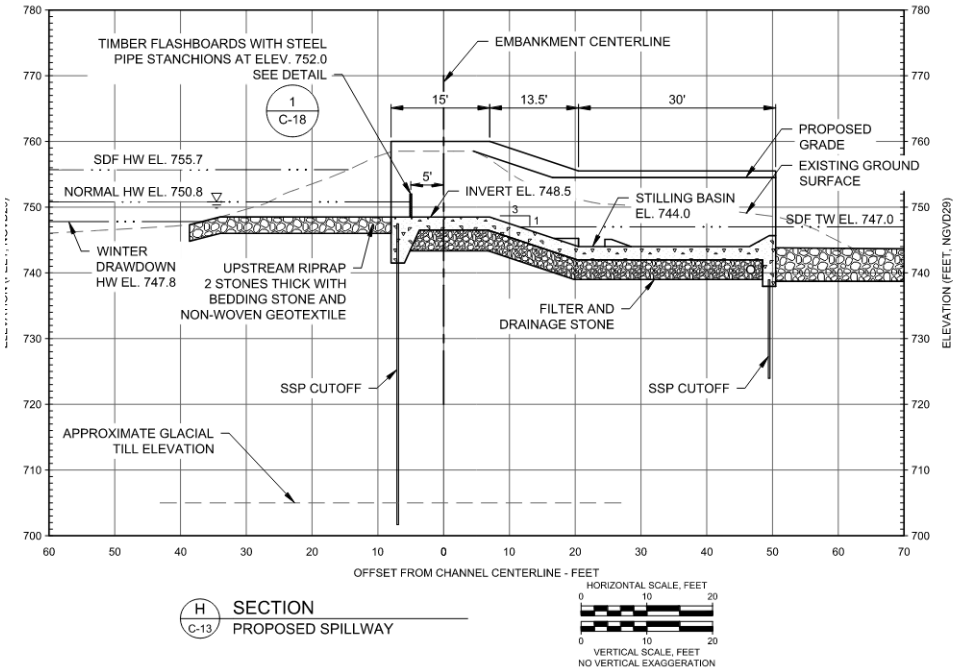
Hydraulic Analysis – Existing Conditions

- Edenville Dam:
  - Lacked primary spillway capacity (tainter gate spillways)
  - No auxiliary spillways
  - Prior to May 2020 flood, the total spillway capacity (Edenville + Tobacco) was approximately 20,670 cfs before water would begin overtopping embankments
  - State of Michigan 1/2 PMF was 25,000 cfs
  - FLTF study currently estimating future spillway requirement being 52,275 cfs
- Sanford Dam:
  - Lacked primary spillway capacity
  - Auxiliary spillway failed to initiate during the May flood event
  - Prior to May 2020 flood, the total spillway capacity was approximately 36,000 cubic feet per second (cfs) before water would begin overtopping embankments
  - Prior State of Michigan 1/2 PMF was 37,000 cfs
  - FLTF study currently estimating future spillway requirement being 47,500 cfs

GEI Conceptual Spillway and Dam Configurations

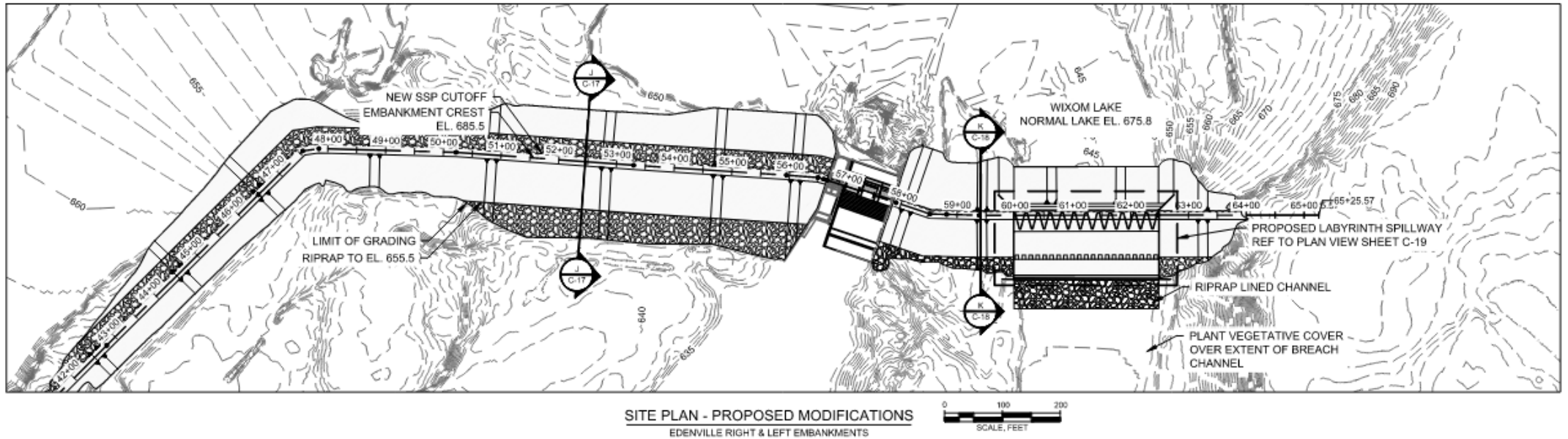
- Secord Dam/Smallwood Dam
  - Existing tainter gates replaced with new crest gates at lower elevation to increase spillway capacity
  - Powerhouse decommissioned and turned into low-level outlet
  - A new passive overflow spillway will be constructed to assist in passing the design storm
  - Stabilize existing embankments





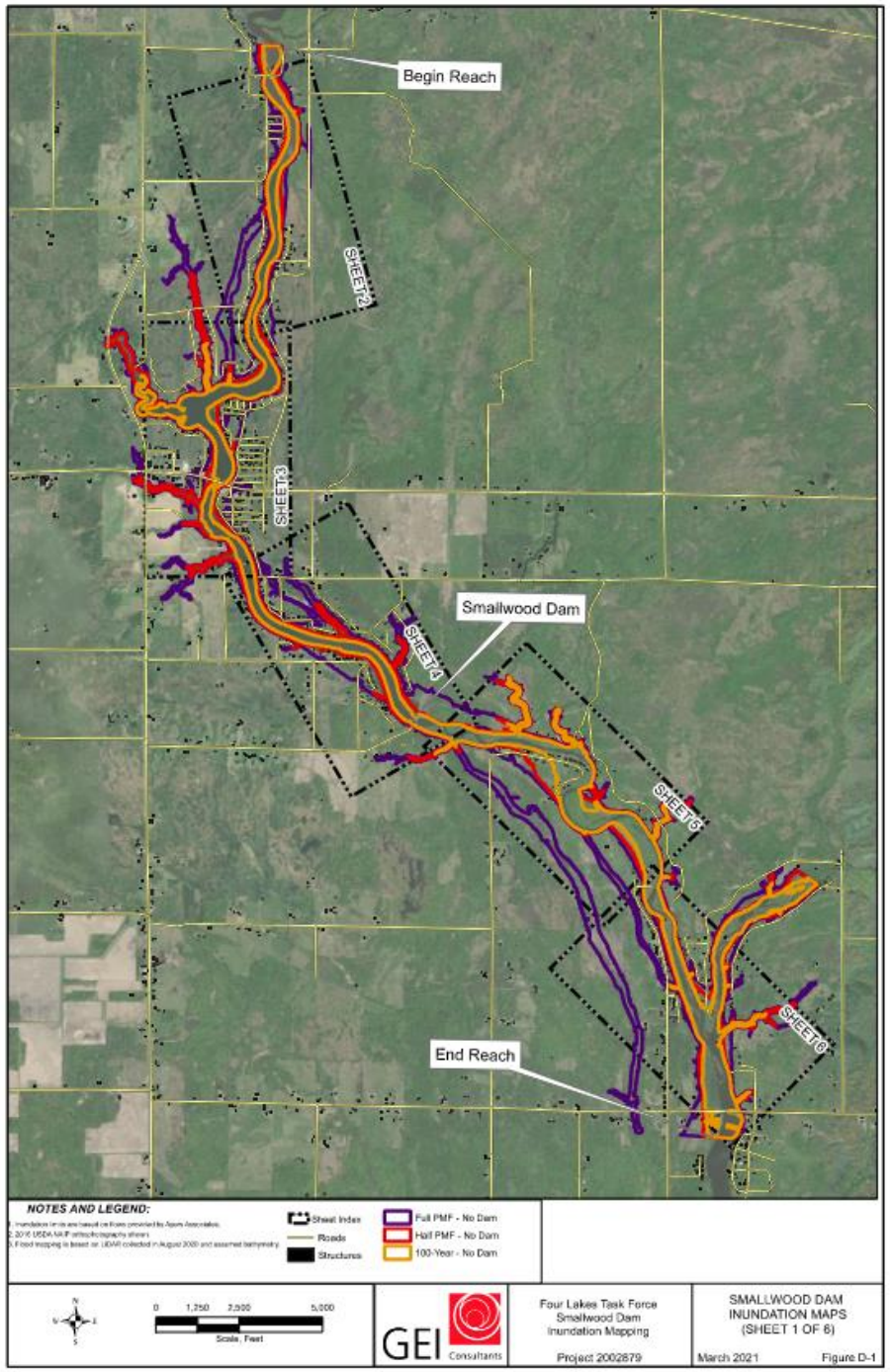
GEI Conceptual Spillway and Dam Configurations

- Edenville Dam/Sanford Dam
  - Existing tainter gates replaced with new crest gates at lower elevation to increase spillway capacity
  - Powerhouse decommissioned and turned into low-level outlet
  - Reconstruct failed embankments with a new passive overflow spillway will be constructed to assist in passing the design storm



Flood Inundation

- GEI developed inundation maps and flood profiles upstream and downstream of the FLFT projects to illustrate the inundation limits at critical locations upstream and downstream of the dams
- Estimated number of impacted structures for a variety of design storms
- Number of inundated structures upstream of the dam reduced for each of the proposed configurations



Next Steps

- Next Steps:
  - Finalize site specific PMP and PMF studies
  - Perform additional risk-based studies to select the design storm using the techniques prescribed by FEMA
  - Finalize flood study
  - Progress conceptual designs at Secord and Smallwood (short term schedule)
  - Progress conceptual designs at Edenville and Sanford (long term schedule)

Next Steps

- Initial Feasibility Report: May 2021
  - Estimated costs
  - Estimated assessment
  - Implementation timelines
  - Funding
- Finalize hydrology and hydraulic studies, inflow design storm flow rates
- Emergency action plans
- Flood inundation mapping
- Downstream coordination

Thank you!

For more information go to:

https://www.four-lakes-taskforce-mi.com/