Louisiana Dam Owners Workshop

Ruston and Natchitoches
January 28 -29, 2025

Tim Harper, PE
DOTD Public Works & Water Resources
Dam Safety Program

Louisiana Dam Owners' Workshop

Agenda:

- Louisiana Dam Safety, Laws, Rules and Regulations
- Dam Hazard Classifications
- EAP/EPP, Inundation mapping etc.
- Inspections and Dam Owner's Responsibilities
- Dam Operation & Maintenance and Best Practices
- Preparing & Responding to Events at Your Dam
- Safety Around Dams

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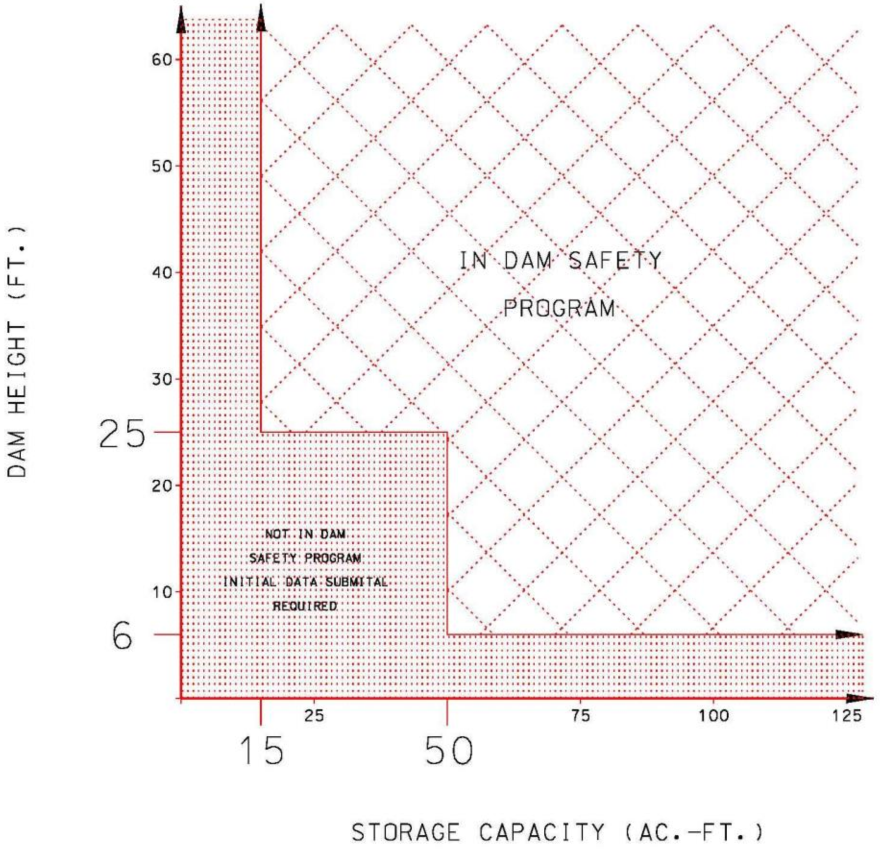
Louisiana Dam Safety Program

- Created by Act 733 of the 1981 Regular Legislative Session (RS 38:21-28)
- The purpose of Dam Safety is to provide a means for the inspection, regulation, and supervision of regulated dams within the State and the operation and maintenance of those as specified in the regulations, in order to prevent and correct potential hazards to downstream life and property in the event of breach of any dam.

Louisiana Dam Safety Program

What is a regulated dam?

- 25 feet or more in height and have an impounding capacity at maximum storage greater than 15 acre-feet, or
- Impounding capacity at maximum storage of 50 acre-feet or more and are greater than 6 feet in height



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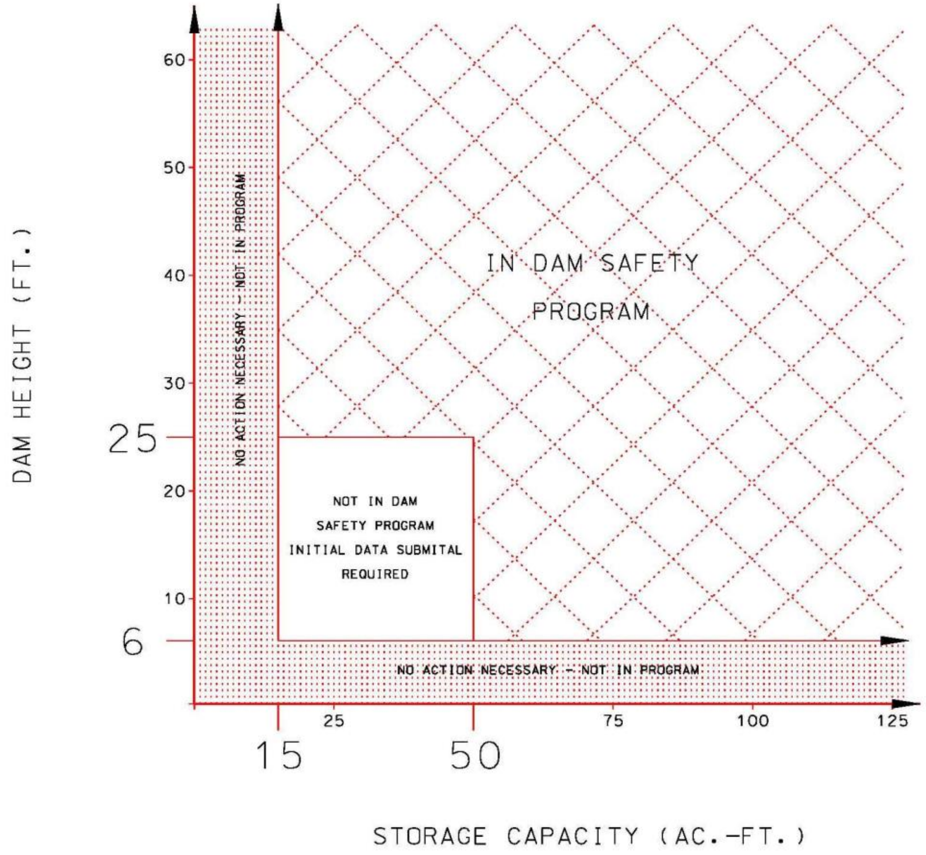
Louisiana Dam Safety Program

- All barriers which are 6 feet or more in height with maximum storage capacities of 15 acre-feet or more must be submitted to DOTD for review

- 1 ac.-ft. = 325,851 gal.
- 15 ac.-ft. = 116,375 bbl
- 50 ac.-ft. = 387,917 bbl
- ** 42 gal./ Barrel (bbl)



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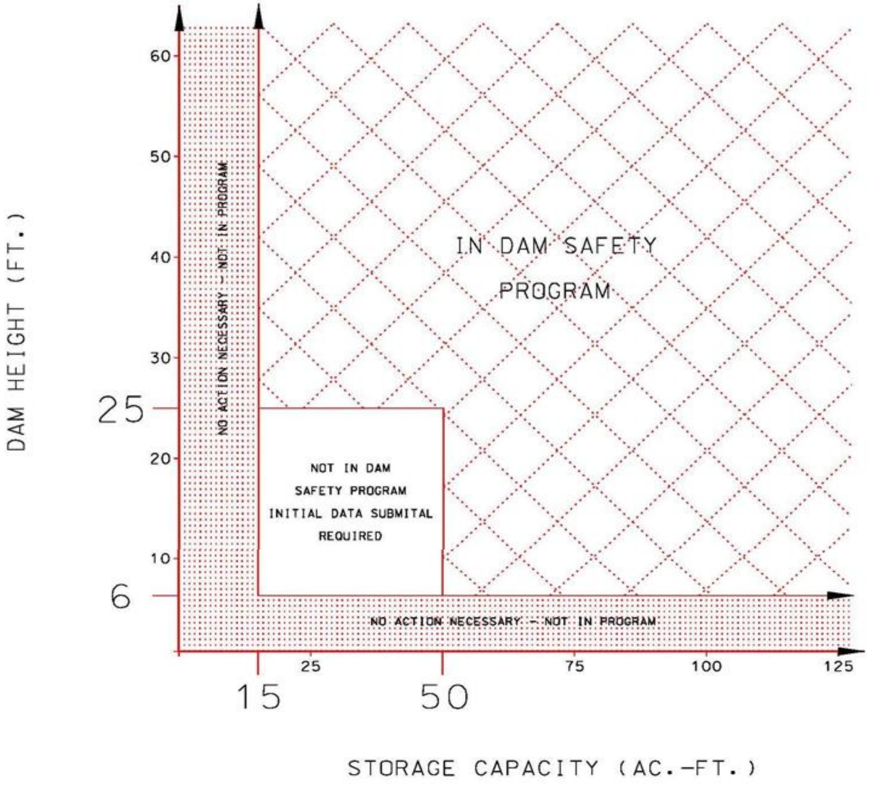
Louisiana Dam Safety Program

Examples:

- 10ft. embankment - 250,000 bbl storage
  - 32 ac.-ft.
  - Submittals Required – Not Likely in the program

- 6ft. Embankment – 500,000 bbl storage
  - 64 ac.- ft.
  - Permit Required – In the Dam Safety Program



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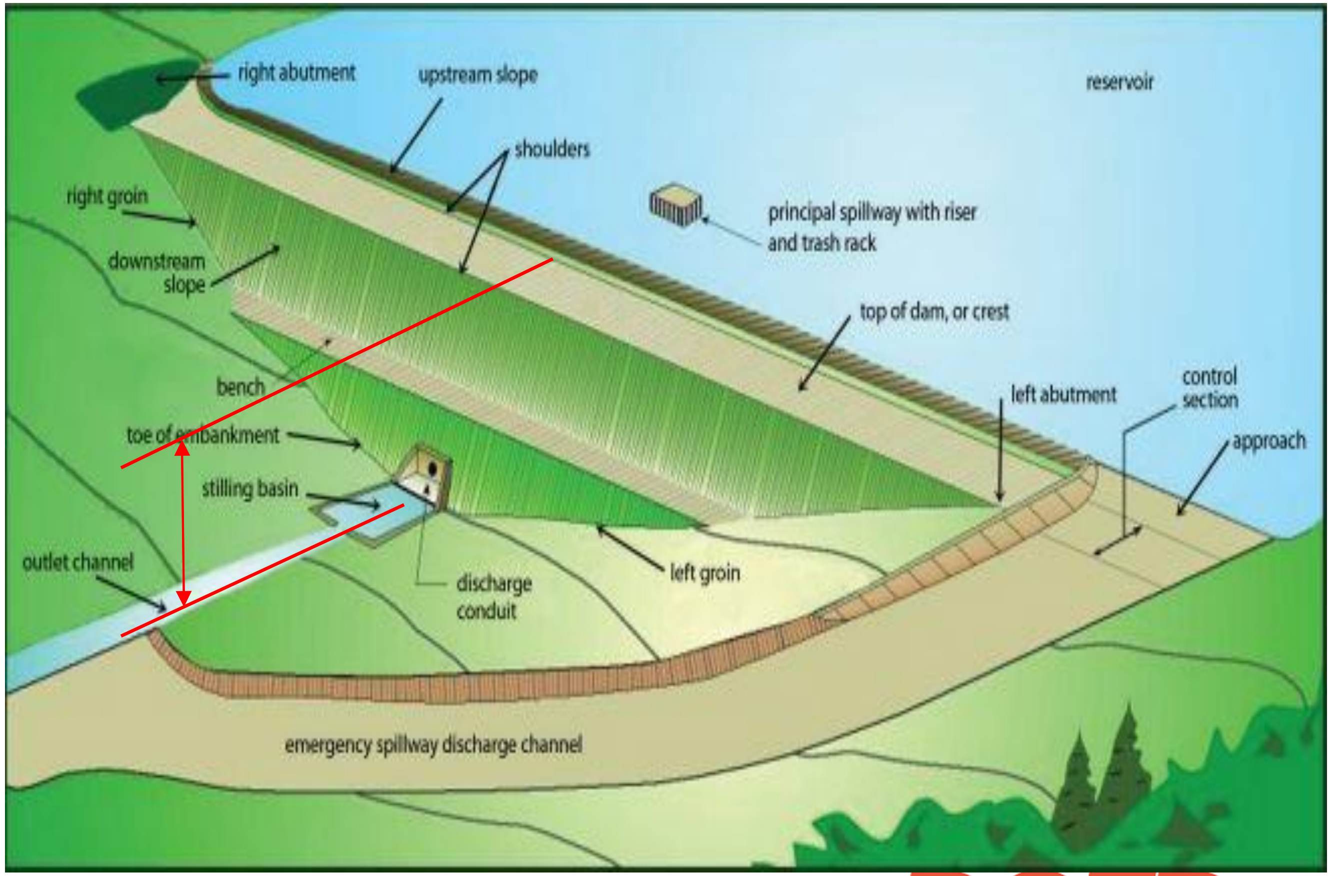
Embankment height:

- Dam Height - the difference in elevation of the bed of the watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier, if it is not across a stream channel or watercourse, to the lowest point on the crest of the dam excluding any spillways or controlled openings.

Storage Capacity:

- Calculated at top of dam, **not at normal pool**



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Louisiana Dam Safety Program

Louisiana Administrative Code (LAC)

▪Title 56 - Part III – Chapter 7

○ Rules and Regulations of the Program

- Defines the purpose of R.S. 38:21-28
- Permitting & Submittal Process
- Design Criteria (H&H)
- Inspections
- Enforcement
- Emergency Preparedness Plans / Emergency Action Plans
- Etc...
- Revisions / Updates expected in near future

Louisiana Dam Safety Program

DOTD Inspections

- "Limited Inspections" - Visual Inspections
- Performed Based on Hazard Classification
  - High Hazard – Yearly Inspections
  - Significant Hazard – Every 3 Years
  - Low Hazard – Every 5 Years
- 150 – 200 Inspections Conducted Yearly

LADOTD DAM INSPECTION AND EVALUATION REPORT

Inspection Date: 09/01/2022

Reviewed and Approved by:

Name (Signature):	10/25/2022
Name (Typed or Printed):	Randy Denmon, P.E.
Firm Name:	Volkert
Address:	114 Venable Lane
City, State, Zip Code:	Monroe, LA 71203
Phone:	(318) 388-1422
Name of Dam:	Turkey Creek Dam
Downstream Hazard:	Low
NID ID #:	LA00029
Parish:	Franklin
DOTD District:	58
District Contact:	Mathew Ziecker, P.E.

OWNER INFORMATION

Name of Owner	Franklin Parish Police Jury
Person(s) to Contact	Callie Harrell, P.E., Program Delivery/Design Engineer P.O. Box 110 Chase, LA, 71324-0110 Tel.: 318-412-3215

DAM INFORMATION

Location of Dam

From Wisner take HWY 562 west for 8.0 miles to Pete Haring Road, then south on Pete Haring Road for 1.3 miles to an unnamed parish road, gravel. Take a right on unnamed parish road and go 0.9 miles to spillway.

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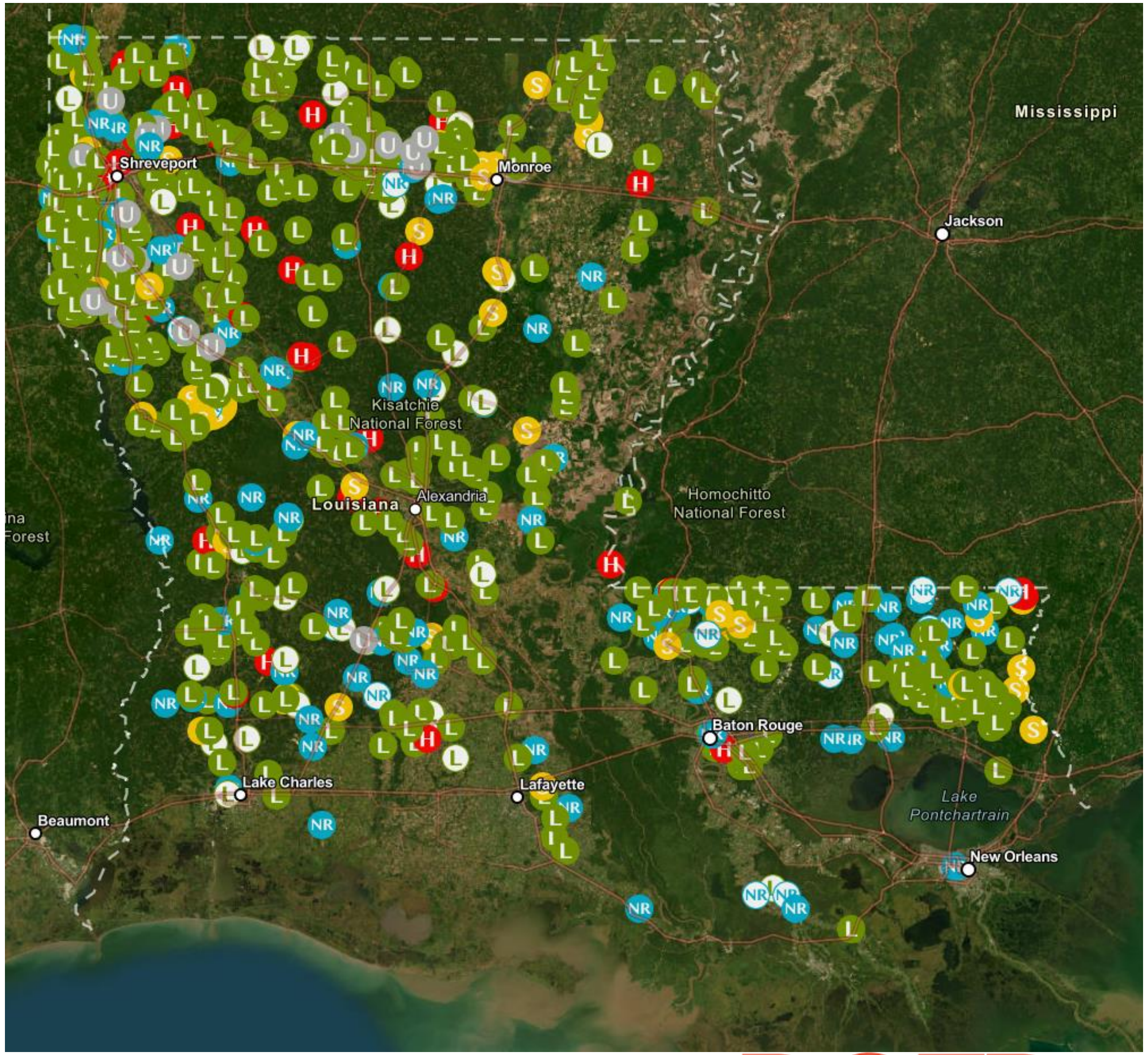
Dams in Louisiana

- High hazard potential: 43
- Significant hazard potential: 69
- Low hazard potential: 641
- Not Regulated: 105
- Undetermined: 14
- Total Dams: 872
- State Regulated Dams: 706

- Texas Total Dams 7,385
- Mississippi Total Dams 6,093



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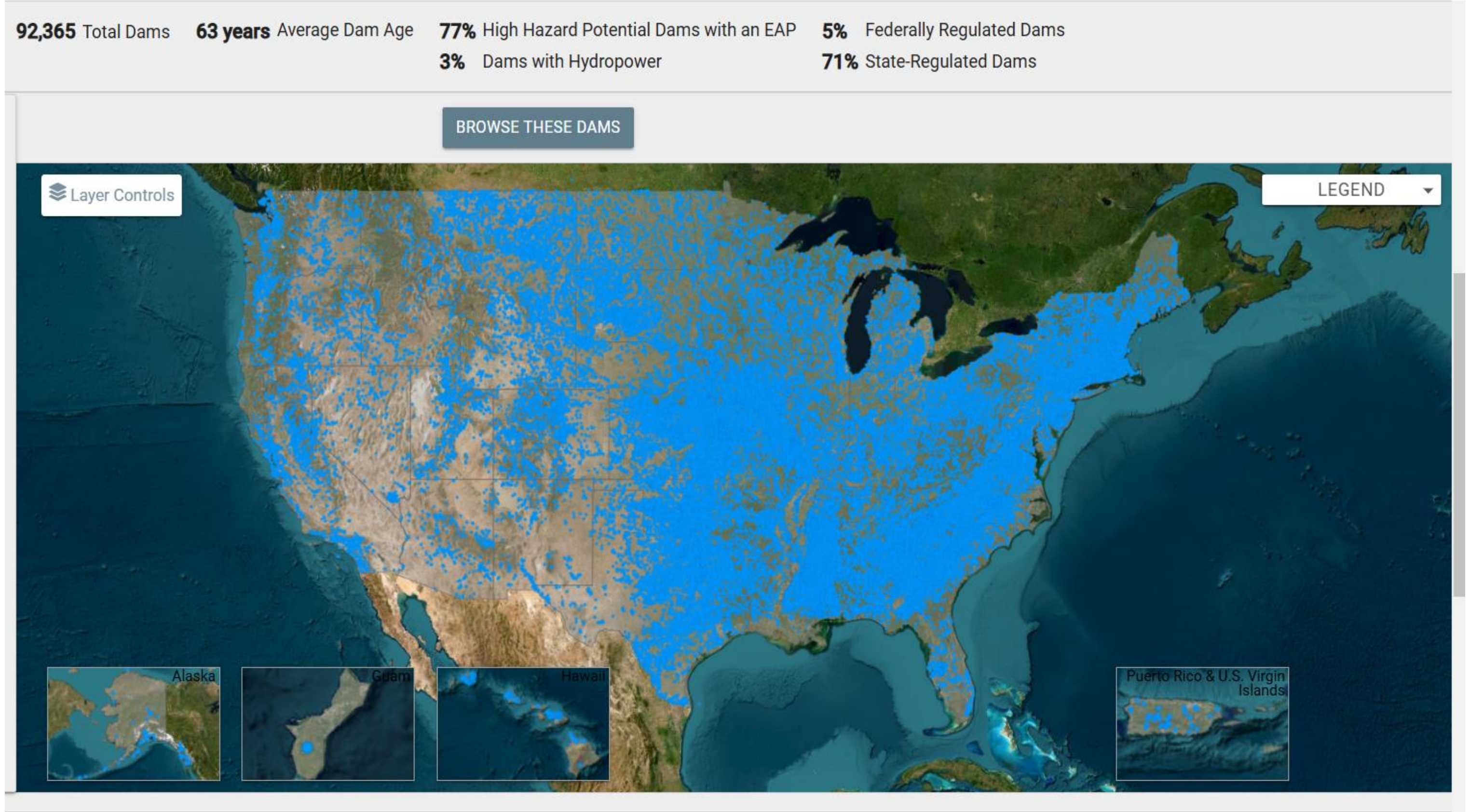
National Inventory of Dams (NID)

- Dams Database maintained by USACE
- https://nid.sec.usace.army.mil/



Other Dam Regulating Organizations

- USACE – U.S. Army Corps of Engineers
- FERC – Federal Energy Regulatory Commission
- FEMA – Federal Emergency Management Agency
- NRCS – Natural Resources Conservation Service (USDA)
- USBR – U.S. Bureau of Reclamation

Louisiana Dam Safety Program - Contacts

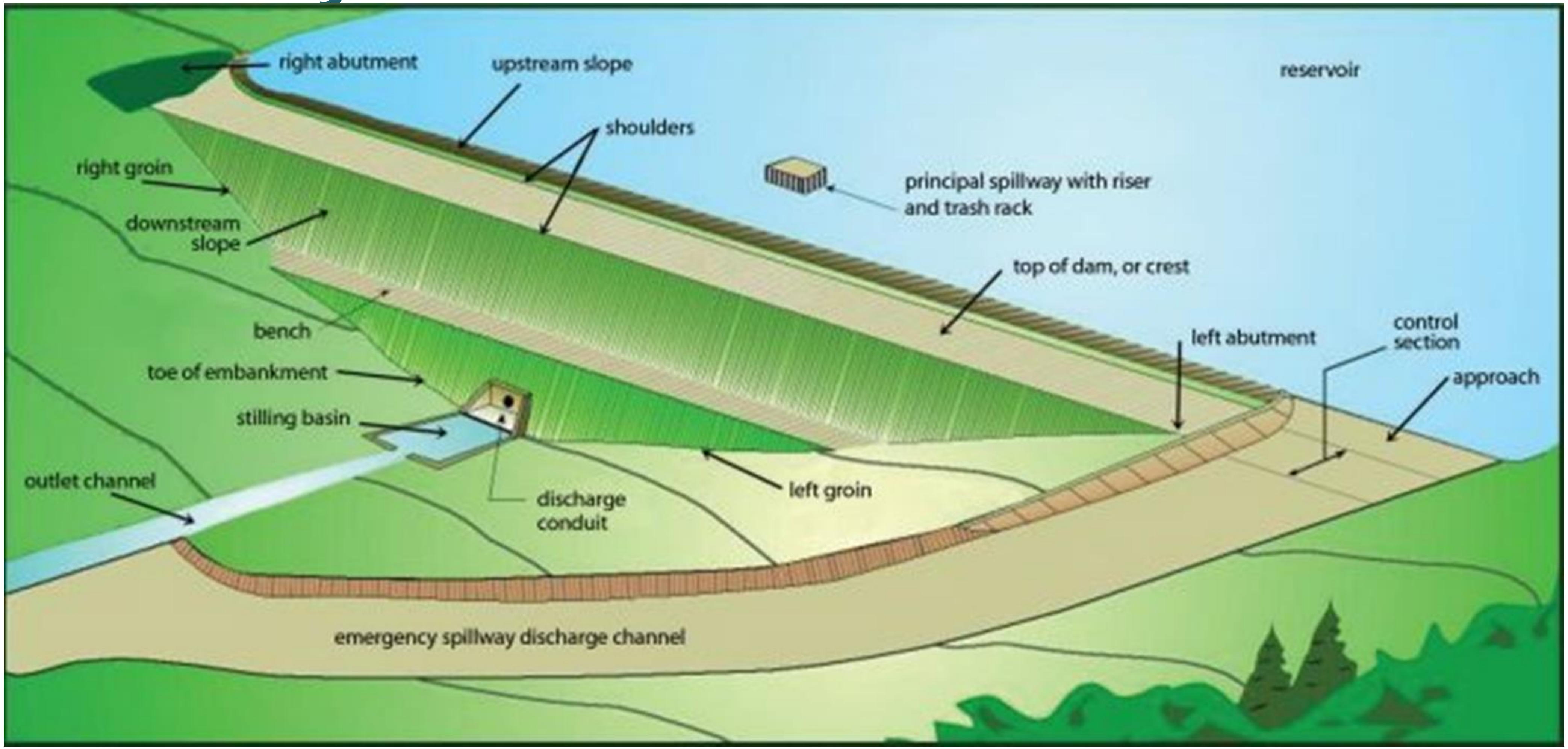
Physical Address	Public Works & Water Resources Division, Dam Safety 1201 Capital Access Rd. Baton Rouge, LA 70802
Mailing Address	P.O. Box 94245 Baton Rouge, LA 70804-9245
Phone Number	(225) 379-3000
Email	DamSafetyInfo@la.gov
Website	www.dotd.la.gov/damsafety

Name	Phone	Title
Billy Williamson	225-379-3023	Director of Dams and Levees
XXXXXXX	225-379-3006	State Dam Safety Official
Tim Harper	225-379-3012	Engineer – Dam Safety Program

DAM HAZARD CLASSIFICATION

RANDY DENMON, P.E., P.L.S
Volkert, Inc.

Anatomy of a Dam



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Hazard Classification Criteria

Changes coming in near future

TABLE I IMPACT CLASSIFICATION AND INFLOW DESIGN FLOOD			
IMPACT CATEGORY	POTENTIAL LOSS OF LIFE	POTENTIAL ECONOMIC LOSS	MINIMUM INFLOW DESIGN (IDF)
LOW	NOT LIKELY	MINIMAL	50-Yr. Freq.
SIGNIFICANT	POSSIBLE	APPRECIABLE	100-Yr. Freq.
HIGH	LIKELY	EXCESSIVE	1/2 PMF

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Floods in Louisiana

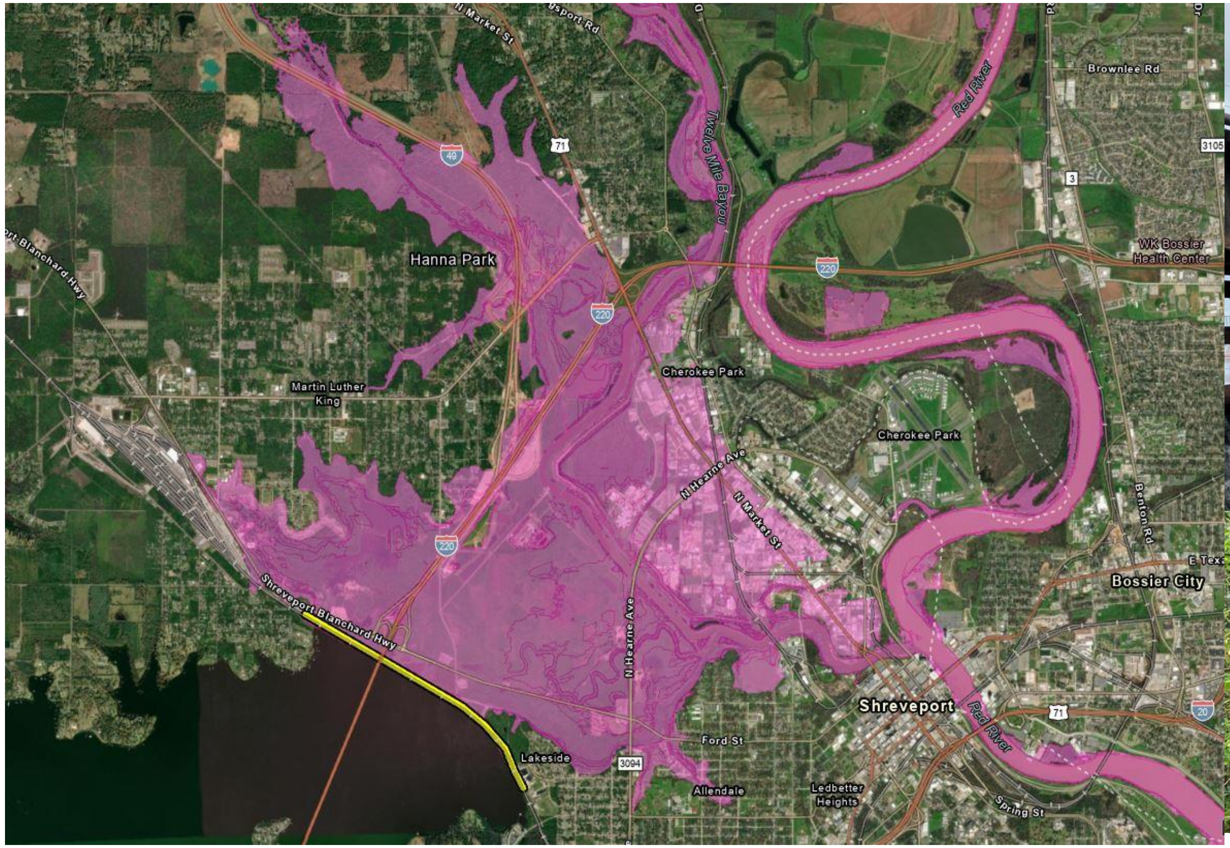
- For dams classified as high hazard, the IDF (Inflow Design Flood) is defined as the flood event above which a breach of the dam does not increase hazard to downstream interests. The upper limit of the IDF for high hazard structures is the Probable Maximum Flood (PMF).
- In Louisiana PMF rainfall is 50-60 inches in 72 hours.
- 100 Year, 18”-22” in 10 Days
- 50 Year, 16”-20” in 10 Days

HOW TO DETERMINE HAZARD CLASSIFICATION?

BREACH MAPPING IS USED TO DETERMINE THE IMPACTS OF DAM FAILURE DOWNSTREAM OF THE DAM

It's not about how big the lake is, but more what is the impact of a failure.

Example High Hazard Dam – Cross Lake: 8,700 Acres, 50' Tall, Dam Length: 8100'



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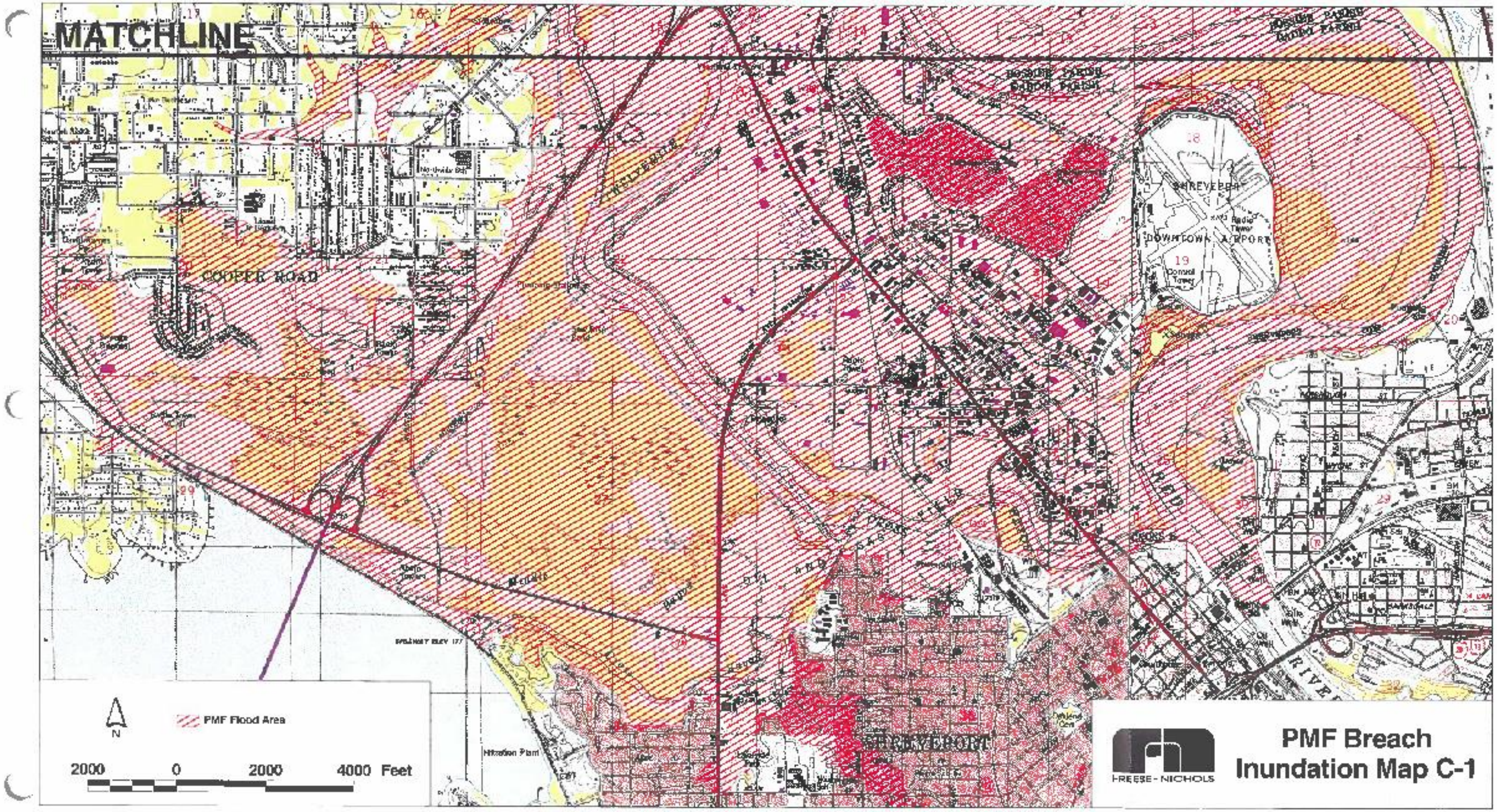

CROSS LAKE BREACH INUNDATION MAP

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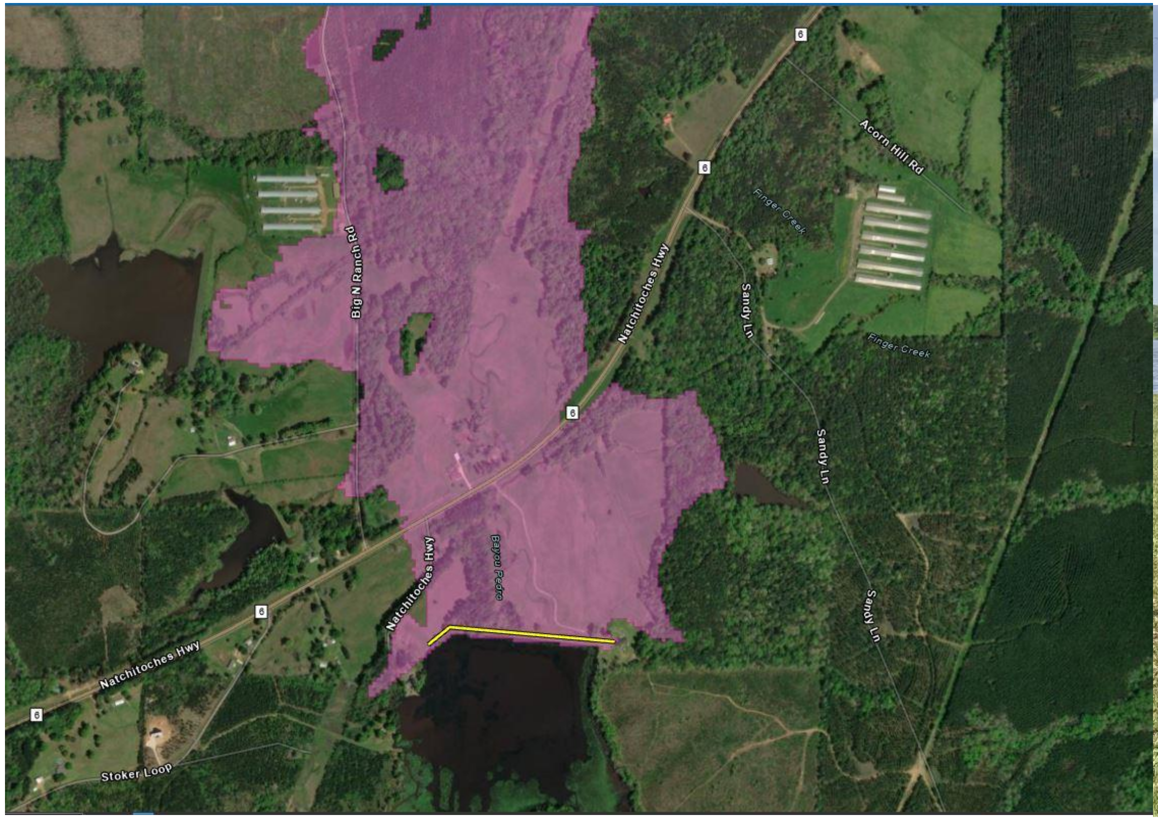
Example Significant Hazard Dam - Bayou Dupont No 10: 98 Acres, 26' Tall



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Bayou Dupont No 10, Breach Inundation Map

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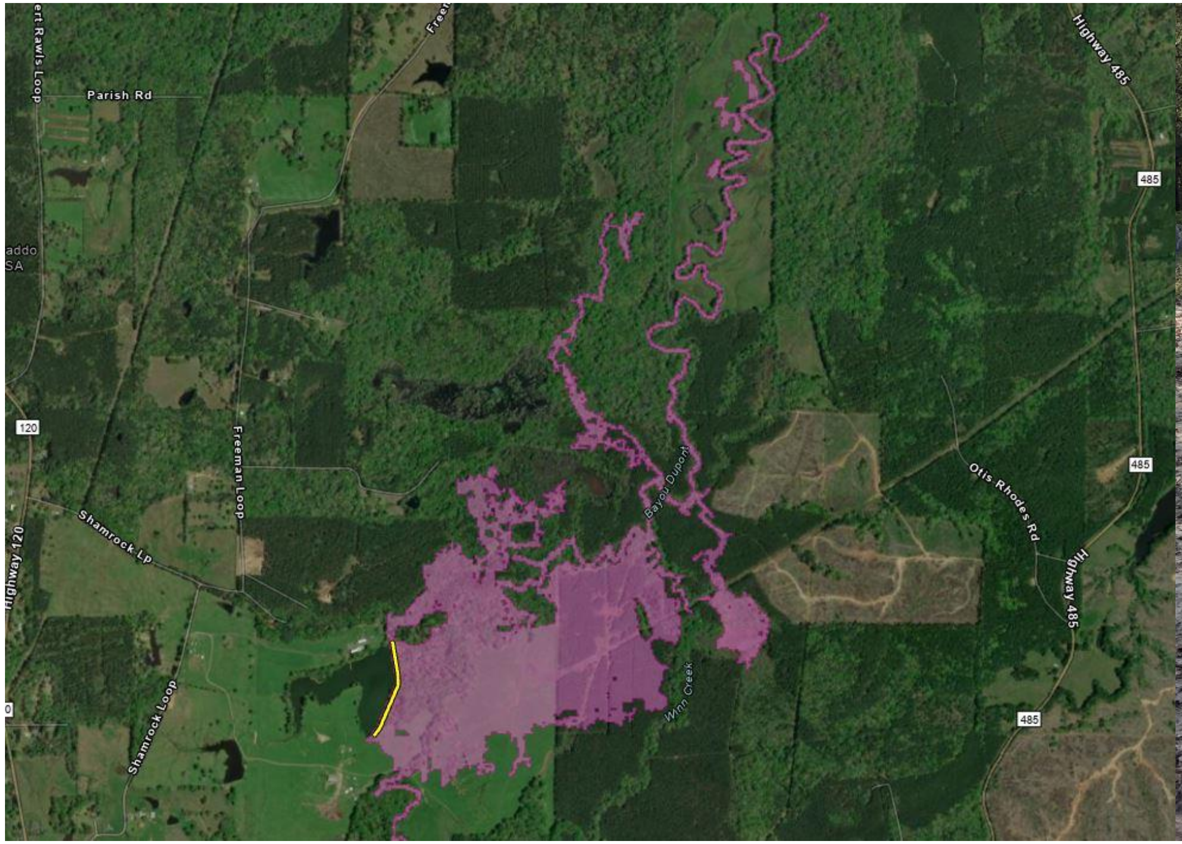
Low Hazard Dam - Lacy Lake Dam
20' Tall, 13 Acres



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Example : Big Lake – Low Hazard
Turkey Creek Lake: 3850 ACRES, LOW HARZARD

Restoration Lake (21 Acres)– Be aware of what's downstream
Little Lake – Big Hazard.

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INUNDATION MAPPING
HOW IS IT DONE

SOFTWARE FOR INUNDATION MAPPING

Recommended Software:

- *HEC*-RAS *(USACE) IF YOU THINK DAM MIGHT BE HIGH HAZARD*
- NRCS TR-60 (LOW OR SIGNIFICANT HAZARD)
- DSS-WISE (DEPARTMENT OF HOMELAND SECURITY) (TYPICALLY USED AS AN INITIAL SCREENING TOOL)
- OTHER INUNDATION MAPPING SOFTWARE CAN BE USED (IF CONDITIONS WARRANT IT'S USE)

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EXAMPLE INUNDATION MAPPING

KEPLER LAKE, 1825 ACRES

28’ Tall

PURPOSE OF INUNDATION MAPPING

A: HAZARD CLASSIFICATION

B: EMERGENCY PREPAREDNESS PLAN

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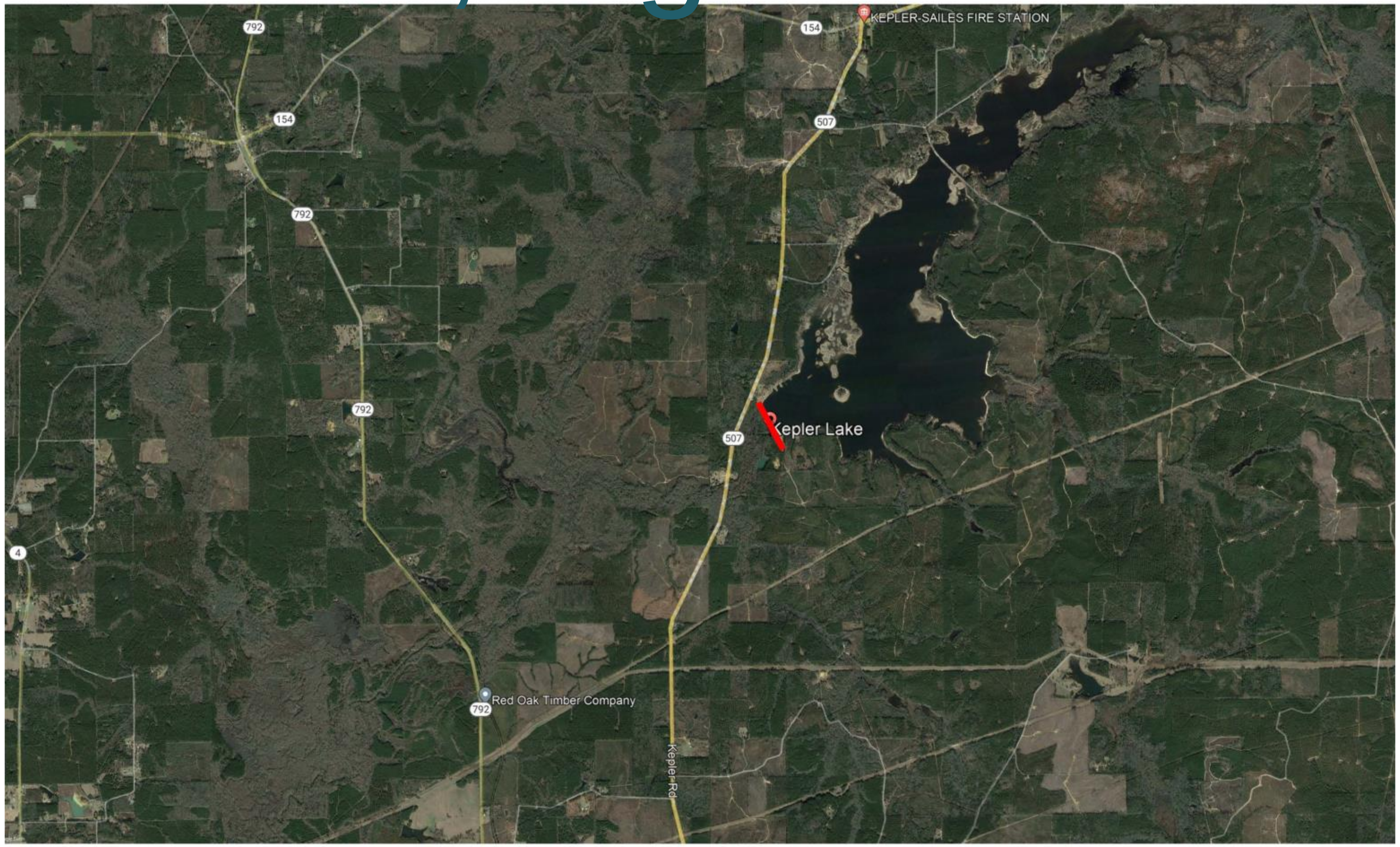
Kepler Lake, High Hazard Dam



HEC-RAS USED TO MODEL BREACH

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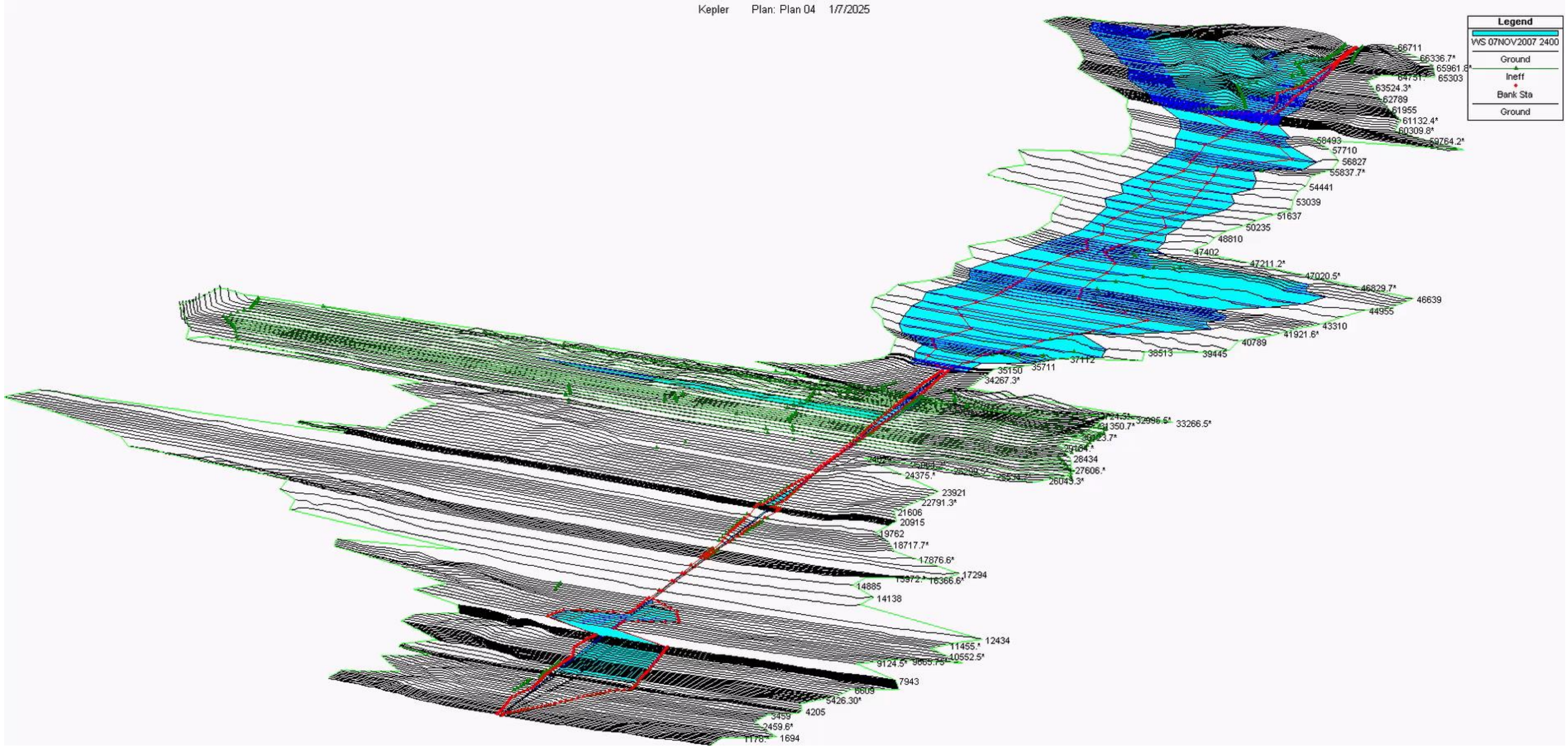
KEPLER LAKE DAM BREACH WITH HEC-RAS



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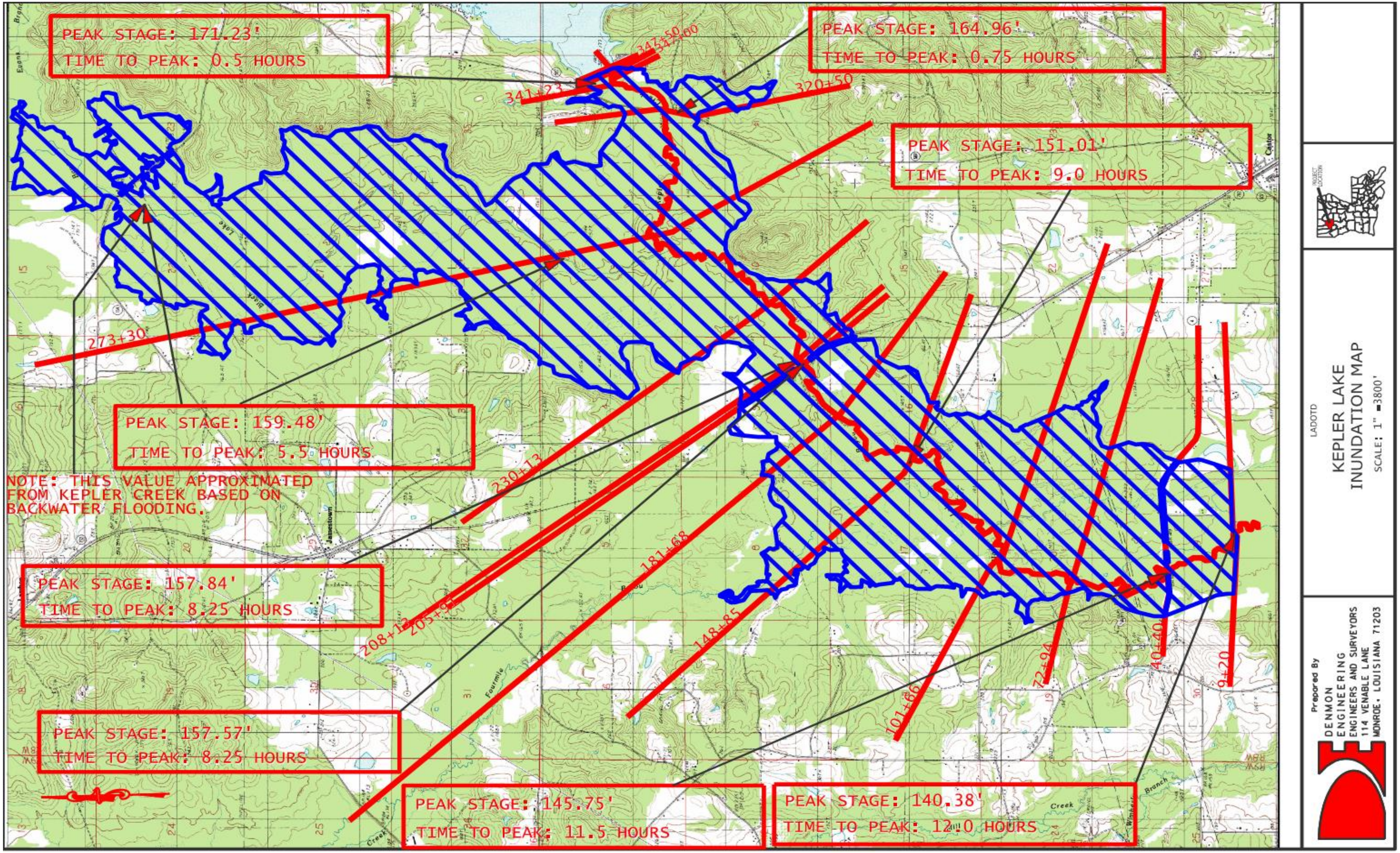
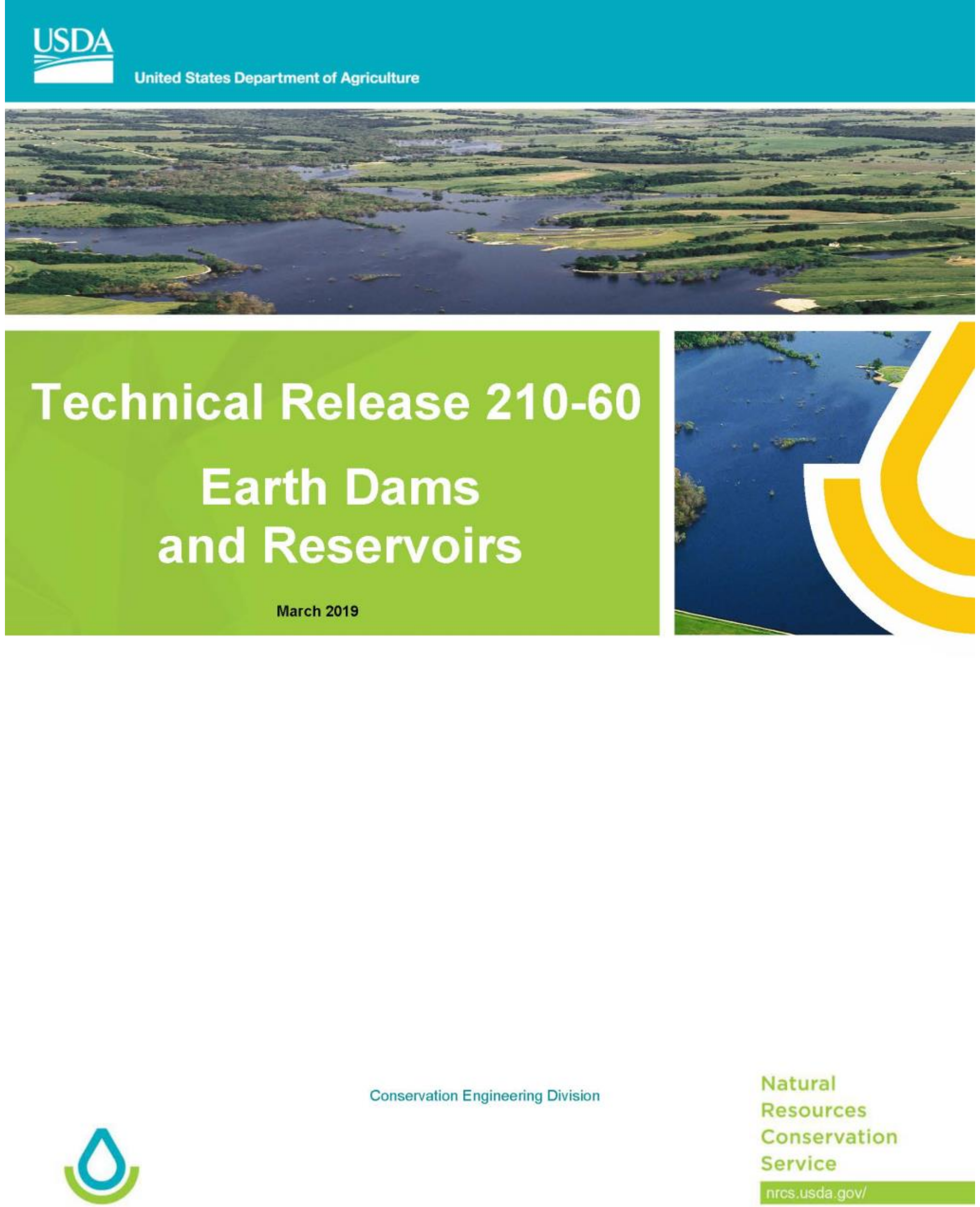

PEAK STAGE: 171.23'
TIME TO PEAK: 0.5 HOURS
PEAK STAGE: 164.96'
TIME TO PEAK: 0.75 HOURS
PEAK STAGE: 151.01'
TIME TO PEAK: 9.0 HOURS
PEAK STAGE: 159.48'
TIME TO PEAK: 5.5 HOURS
NOTE: THIS VALUE APPROXIMATED FROM KEPLER CREEK BASED ON BACKWATER FLOODING.
PEAK STAGE: 157.84'
TIME TO PEAK: 8.25 HOURS
PEAK STAGE: 157.57'
TIME TO PEAK: 8.25 HOURS
PEAK STAGE: 145.75'
TIME TO PEAK: 11.5 HOURS
PEAK STAGE: 140.38'
TIME TO PEAK: 12.0 HOURS
341+23
320+50
273+30
230+13
208+12
205+92
181+68
148+85
101+66
72+94
40+40
9+20
LADOTD
KEPLER LAKE
INUNDATION MAP
SCALE: 1" =3800'
Prepared By
DENMON
ENGINEERING
ENGINEERS AND SURVEYORS
114 VENABLE LANE
MONROE, LOUISIANA 71203



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Peak Breach Discharge Criteria

Use breach routings to help delineate the area potentially impacted by inundation should a dam fail and to aid dam hazard potential classification. Develop routings using topographic data and hydraulic methodologies mutually consistent in their accuracy and commensurate with the level of risk under evaluation. For hazard potential classification, evaluate probable downstream conditions that could exist for the failure mode being evaluated, and incorporate the condition that would represent the highest hazard into routings. Federal Emergency Management Agency (FEMA) 333, "Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams," requires the assignment of classification "based on the worst-case probable scenario of failure or misoperation of the dam," meaning assignment of hazard potential classification "based on failure consequences that will result in the assignment of the highest hazard potential classification of all probable failure and misoperation scenarios."

Evaluate dam failure with the water surface elevation of the reservoir at the dam crest or the peak reservoir stage resulting from the probable maximum flood (PMF). The minimum peak discharge of the breach hydrograph, regardless of the technique used to analyze the downstream inundation area, is—

1. For depth of water at the dam at the time of failure where $H_w \geq 103ft$

   $$Q_{max} = 65\ H_w^{1.85}$$

2. For depth of water at the dam at the time of failure where $H_w < 103ft$

   $Q_{max} = 1100\ B_r^{1.35}$ where $B_r = \frac{V_s H_w}{A}$

   But not less than $Q_{max} = 3.2\ H_w^{2.5}$ nor more than $Q_{max} = 65\ H_w^{1.85}$

3. When the width of the valley, L, at the water surface elevation corresponding to the depth, H_w, is less than—

   $$T = \frac{65 H_w^{0.35}}{0.416}$$

   replace the equation, $Q_{max} = 65\ H_w^{1.85}$, in 1 and 2 above with—

   $$Q_{max} = 0.416 L H_w^{1.5}$$

Where—

Q_{max} = peak breach discharge, cubic feet per second

B_r = breach factor, for the equation, $B_r = \frac{V_s H_w}{A}$, acre

V_s = reservoir storage at the time of failure, acre feet

H_w = depth of water at the dam at the time of failure; however, in the case of dam overtopping, not to exceed depth at the top of the dam, feet

A = cross-sectional area of embankment at the assumed location of breach, usually the template section (normal to the dam longitudinal axis) at the general floodplain location, square feet

T = theoretical breach width at the water surface elevation corresponding to the depth, H_w, for the equation, $Q_{\max} = 65\ H_w^{1.85}, ft$

L = width of the valley at the water surface elevation corresponding to the depth, H_w, feet

The peak discharge value determined by using principles of erosion, hydraulics, and sediment transport may be used in lieu of the peak discharge computed using the equations presented. Examples of acceptable, process-based models include the National Weather Service (NWS) BREACH model and NRCS WinDAM.

Cut Slope Stability

Plan and form excavated cut slopes in a stable and safe manner. Spillways, inlet and outlet channels, borrow pits, reservoir edges, abutment areas, and foundation excavations are all locations where these considerations are needed. Field investigations, methods of analysis, design and construction requirements, and resultant specifications must recognize and provide for safe functional performance. Part 4 of this TR discusses the requirements for a geotechnical investigation plan that may include the evaluation of natural slope stability. Part 5 of this TR discusses the stability evaluation of constructed slopes.

Reservoir Conservation Storage

Analyze reservoirs with water stored for conservation purposes using a water budget to determine a dependable water supply. For most purposes—

- NRCS defines a dependable water supply as one that is available at least 8 out of 10 years or has an 80-percent chance of occurring in any one year.
- A purpose such as municipal and industrial water supply may require a 95-percent chance of occurring in any one year.
- Other purposes, such as recreation, require an analysis of the reservoir surface elevation fluctuation to evaluate the acceptable percent chance of occurrence.

Joint Use of Reservoir Capacity

Efficient use of a reservoir site occurs where hydrologic conditions permit joint use of storage capacity by floodwater and conservation storage. For joint-use storage dams, NRCS requires—

- Reasonable assurance of adequate water supply to meet project objectives.
- Satisfaction of flood protection objectives of the project.
- Spillway conditions that will enable the dam to perform safely.

NRCS may require special hydrologic studies to show compliance with the requirements listed above.

EMERGENCY ACTION PLAN

PURPOSE:
A PLAN OF ACTION IN CASE OF DAM PROBLEM
DESIGNED TO BE USED BY FIRST RESPONDERS

UPDATED EVERY FIVE YEARS OR IF CHANGES ARE MADE TO DAM OR PERSONNEL

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WHEN DO YOU NEED TO HAVE AN EAP?

Louisiana Dam Safety Code states all dams should have an EAP, but it also states that Low Hazards have minimal or no impact?? LADOTD is generally concerned with High and Significant Hazard Dams. Those are the dams with impact to life and property.

- Common Sense. What's downstream!! (see examples)
- When in question, breach mapping will provide guidance.

Main Hazards during potential failure: Residents, businesses and roads.

EXAMPLE EMERGENCY ACTION PLAN

Template for developing an EAP:

- NB 210-19-6 ENG – NRCS Emergency Action Plan Template
- Recommend download from the USDA/NRCS website
- Can also can be found on the DOTD website
- Other templates are available from ASDSO, USBR, etc.

Emergency Action Plan (EAP)

Rock Creek Watershed, Dam No. 23

(Rock City Lake)

National Inventory of Dams (NID) No. OK11111

Section 14, T13N, R21

Latitude: 35.42875; Longitude: -99.19802

Coal County, Oklahoma

Coal County Conservation District

With assistance from the
U.S. Department of Agriculture
Natural Resources Conservation Service

Insert state map showing location of dam

Insert local area map showing specific location of dam

SOMETIMES A LITTLE LAKE CAN BE A BIG HAZARD
22 ACRES, SIGNIFICANT HAZARD

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HAZARD LEVEL OF A LAKE CAN CHANGE OVER TIME WITHOUT THE OWNER DOING ANYTHING DIFFERENT

20 ACRE LAKE

1989

2024

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EXAMPLE EMERGENCY ACTION PLAN

EXAMPLE OF WHERE AN EAP IS NEEDED!
BAYOU DESIARD DAM

EMERGENCY ACTION PLAN COVER PAGE
(Prepared in accordance with LAC 70:XIII:2101)

PHYSICAL SITE DESCRIPTION:

Dam Name: Bayou De Siard Dam — Impact Classification: Significant Hazard

State ID No: 37-00265 — National ID No: LA00265 — DOTD District: 05

City/Town: Monroe, Louisiana — Parish: Ouachita Parish

Latitude: 32:33:16 — Longitude: -92:07:10 — Year of Construction: 1933

USGS Quad Sheet: Monroe North — River/Stream: Bayou De Siard — Drainage Area (sq. mi.): 10

Average Reservoir Depth (ft): 7.2 — Maximum Depth (ft): 27'

Dam Crest Elevation (ft, MSL): 84 — Dam Height (ft): 42

Spillway Crest Elevation (ft, MSL): N/A — Spillway Type: N/A

Reservoir Capacity (ac-ft): 8750 — Spillway Capacity (cfs): N/A

Outlet Other Than Spillway (describe):

Method of Emergency Drawdown (describe):

Significant Upstream or Downstream Dams (if any):

APPROVALS:

Owner (City of Monroe): Tom Janway — Date: 12/16/11

DOTD District Administrator Marshall Hill, P.E — Date: ________

DOTD Dam Safety Engineer: Zahir "Bo" Bolourchi, P.E., PLS — Date: ________

Local Police Jury: Shane Smiley, Secretary — Date: ________

State Police: Captain Kevin Reeves, Commander Troop F — Date: ________

Parish O.E.M: Tracy Hilburn — Date: 12/16/11

Monroe City Police: Quentin D. Holmes — Date: 12-16-11

Prepared By:

Name (Signature): ________ — License No: LA 25492

Name(Typed or Printed): Randy Denmon, P.E. — Date: 12/16/11

Firm Name: Denmon Engineering — Phone: (318) 366-1422

Address: 114 Venerable Lane

City, State, Zip Code: Monroe, LA 701201

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Updates: October, 2012

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EMERGENCY ACTION PLAN

BAYOU DE SIARD DAM/RESERVOIR
OUACHITA PARISH

PREPARED FOR

CITY OF MONROE
PUBLIC WORKS

DECEMBER , 2011

Updated: October, 2012

PREPARED BY

DENMON ENGINEERING, INC
MONROE, LOUISIANA

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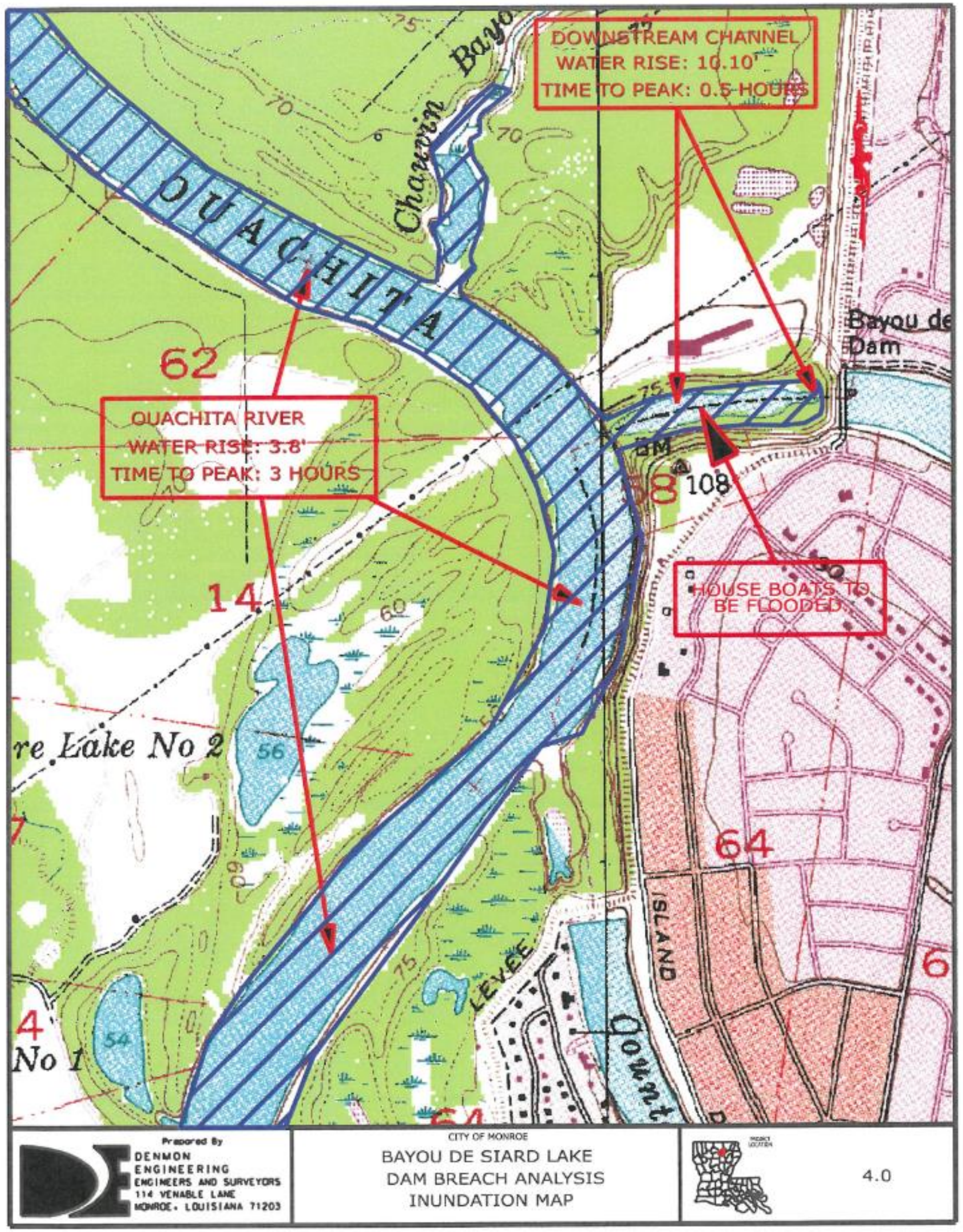
LOUISIANA DEPARTMENT OF TRANSPORTATION & DEVELOPMENT



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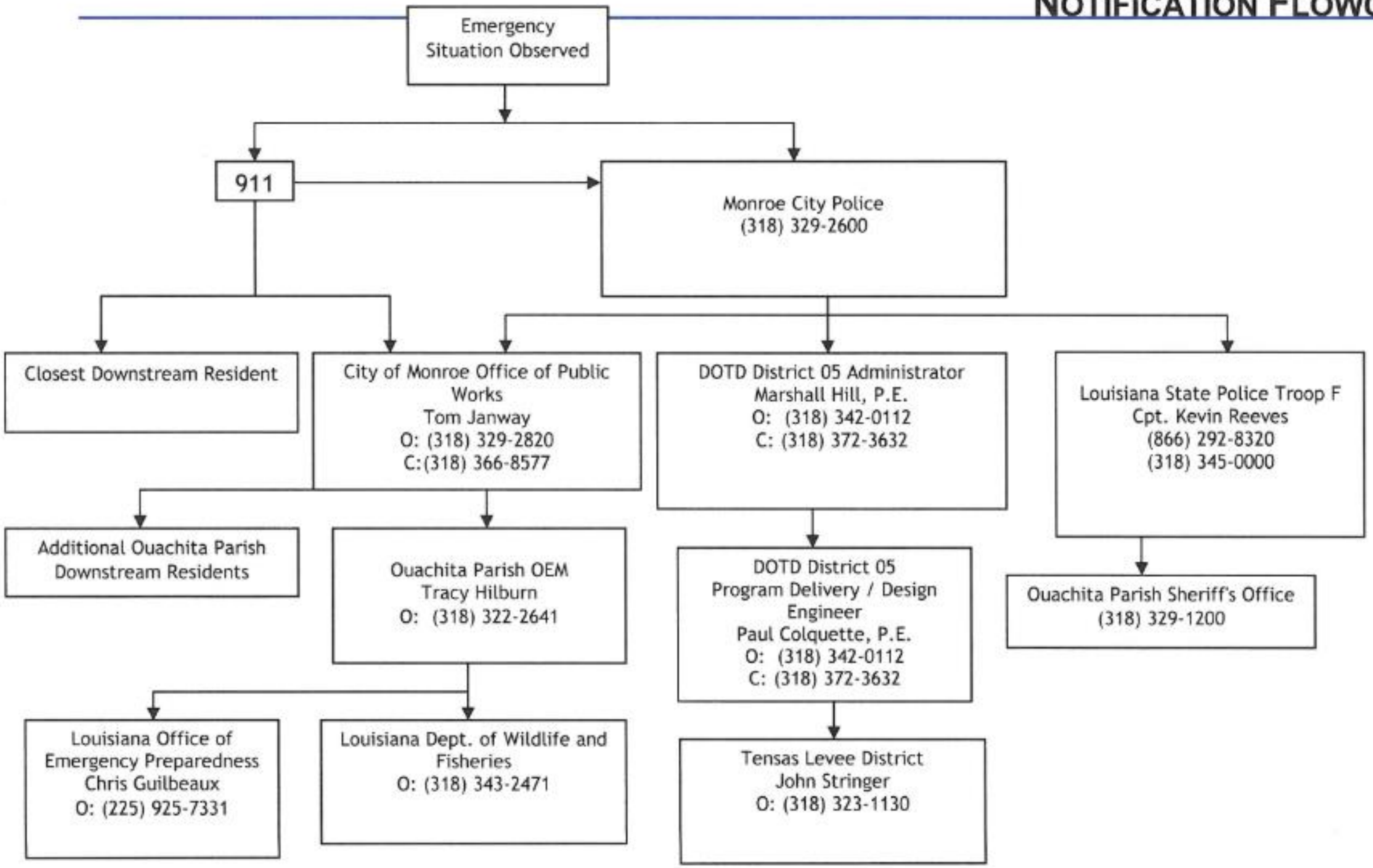
NOTIFICATION FLOWCHART



KEY ELEMENTS OF AN EAP

1) IT IS NOT A TECHNICAL DOCUMENT, BUT SOMETHING FOR FIRST RESPONDERS AND THE PUBLIC.
2) MAPS AND CHARTS SHOULD BE EASY FOR NON-TECHNICAL PEOPLE TO READ AND UNDERSTAND. AERIAL PHOTOGRAPHY RECOMMENDED.
3) SHOULD BE UPDATED PERIODICALLY.
4) HOMELAND SECURITY DIRECTOR SHOULD HAVE A COPY.
5) CONCISE AND HAS PERTINENT INFORMATION.

10 Min. Break

2-54

DAM OPERATION & MAINTENANCE

John Rutledge, P.E.

Freese and Nichols

DAM OPERATION & MAINTENANCE

DAM INSPECTIONS

BEST PRACTICES FOR OPERATIONS AND MAINTENANCE

DAM SAFETY RESPONSES

INSPECTIONS

- Owner should be conducting routine and frequent inspections
  - Informal - Weekly, Monthly, whenever on site
  - Informal - After any unusual event, such as flooding
- Formal State Inspection - Provided by the State and performed by qualified Professional Engineer
- Every Year for High Hazard, Every Three Years for Significant Hazard and every Five Years for Low Hazard

Benefits of Inspecting Under Varying Lake Conditions

- Perform inspections under different water levels to observe differences in the dam's performance, or to observe normally unobserved features.
  - Higher Pool Levels: May detect seepage conditions that may not have been present during lower pools
  - Lower Pool Levels: May be able to inspect features that are normally underwater (upstream riprap, trashracks, intake structures)
- May require adjusting the date of a scheduled inspection or performing an unscheduled inspection.

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Benefits of Inspecting Under Similar Lake Conditions

- Inspect at similar water levels to determine if performance of the dam changes over time under the same loading conditions (phreatic surface, seepage gradient, wave loading)
  - ➢ Ex: Increase in toe drain seepage flow under similar pool levels
  - ➢ Ex: Increase in water levels in piezometers under similar pool levels
  - ➢ Ex: Increase in upstream slope erosion

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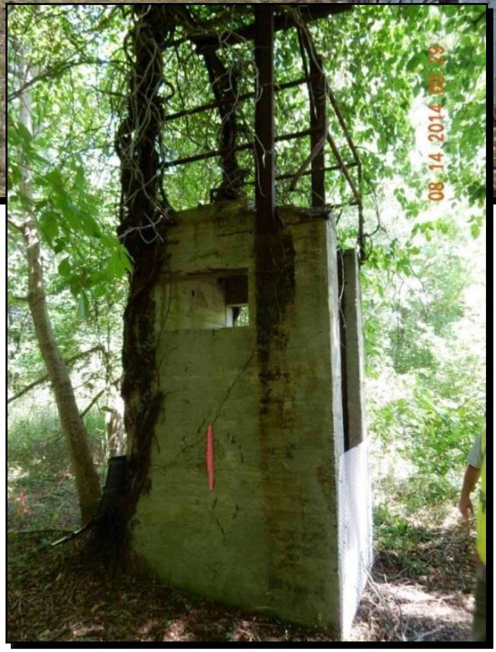
Pre-Inspection



- Review previous inspection reports/checklists
  - Thoroughly review potential defects; make sure to inspect previously identified problem areas. Note description, location, size of any deficiencies (cracks, seepage, vegetative growth, etc.)
  - Identify previous repairs/modifications that may not have been inspected since work was performed.
    - Did the repairs function as intended?

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Pre-Inspection

- Example questions inspector should consider:
  - Are there changes in observed conditions (e.g., new seepage areas, new cracks in embankment)?
  - Have normal operations changed?
  - Is the dam storing or releasing more water than normal?
  - Are there problems with operating mechanical equipment (valves, stoplogs)?
- Review the status of recommendations from the previous inspection.
- Drone? – Becoming more common to use for better views and a recording

Health and Safety

- What are the hazards?
- What PPE is needed?
- Special concerns for specific types of inspections:
  - Confined Space
    - Outlet works, pipes, valve housings, manholes, etc. **Confined space entry should NOT be performed during routine inspections**
  - Water hazards, boat inspections, underwater inspections, swift water – **NOT** part of a routine inspection

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General Inspection Guidelines

Documentation – even for informal inspections

- Document condition of all features at the dam
  - Photos, video, sketches (record drawings can be used to draw locations of defects – seepage areas, sink holes, cracks, etc)
  - Use checklist
- Document Other Conditions
  - Inspection team
  - Weather
  - Ground conditions

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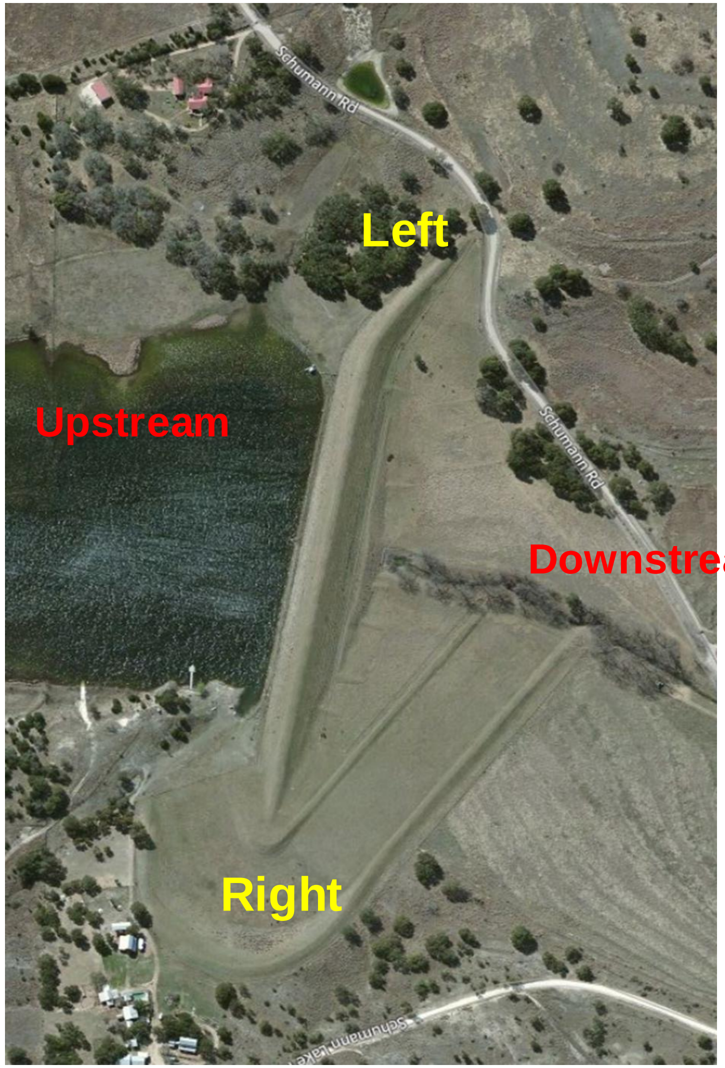
General Inspection Guidelines

Locate/Measure Defects

- Cracks
- Depressions
- Eroded Areas
- Sinkholes
- Any/all seepage
- Burrow holes
- Woody vegetation
- Areas with sparse/thicker vegetation
- Areas of sparse/missing riprap

* Record location and dimensions of all defects (length, width, thickness, volume, etc.)



General Inspection Guidelines

Mechanical Equipment

- Record outlet works/spillway discharges
- Operate equipment (e.g. sluice gates, valves)
  - When was it last operated? Don’t operate if not confident it can be closed.
  - Typically, only performed by O&M personnel
  - Will it work during an emergency?
  - Any problems with operation?

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General Inspection Tips

- Consistency: Take photos at same location with similar orientation as previous photos. Photos can be used for comparison if conditions change. Keep photo log.
- Scrutiny: Take photos of defects not detected during previous inspections.
- Teamwork: If inspecting with 2 people, develop system. One person can be taking photos and keeping photo log, and the other can be measuring locations and documenting observed conditions in field notebook or checklist. One person can inspect crest in parallel with another on the slope.

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Texas Commission on Environmental Quality

Dam Inspection Form

Dam Name:______________________ Inventory No:______________

Name of Inspector/s: ______________________

Name of Contact/s: ______________________

Date of Inspection: ________ Start Time: _______ End Time: ________ Weather: ______________

Crest level (at center) above water: ______________________

Service spillway level ❑ Above or ❑ Below water: ______________________

Emergency spillway level above water: ______________________

Ground Moisture Condition: ❑ Dry ❑ Damp ❑ Wet ❑ Snow ____ ❑ Other: ______________

Crest of Embankment General Condition: ❑ Good ❑ Fair ❑ Poor Width: ______________

Problems Noted: ❑ None ❑ Rutting ❑ Erosion ❑ Poor Drainage Height: ______________

❑ Trees ❑ Depressions ❑ Bulges ❑ Livestock Damage ❑ Cracks Length: ______________

❑ Misalignment of Crest ❑ Misalignment of Utility Poles ❑ Misalignment of Fences or Rails ❑ Sinkhole ❑ Burrows

❑ Breached ❑ Other: ______________________

Comments: ______________________

Upstream Embankment General Condition: ❑ Good ❑ Fair ❑ Poor Slope: ______________

Problems Noted: ❑ None ❑ Rip-Rap ❑ Erosion ❑ Too Steep ❑ Burrows ❑ Trees ❑ Cattails ❑ Depressions

❑ Bulges ❑ Livestock Damage ❑ Slides ❑ Concrete Decay ❑ Cracks ❑ Sinkhole ❑ Benching

❑ Misalignment of Rip-rap ❑ Open Joints in Concrete

Comments: ______________________

Downstream Embankment General Condition: ❑ Good ❑ Fair ❑ Poor Slope: ______________

Problems Noted: ❑ None ❑ Sloughing ❑ Erosion ❑ Too Steep ❑ Burrows ❑ Trees ❑ Cattails ❑ Depressions

❑ Bulges ❑ Livestock Damage ❑ Slides ❑ Concrete Decay ❑ Cracks ❑ Sinkhole ❑ Other:______________

Comments: ______________________

Seepage on Downstream Slope Amount: ❑ Major ❑ Moderate ❑ Minor ❑ None Found

Problems Noted: ❑ None ❑ Saturation Starts at ______________ % up Embankment ❑ Presence of Sediment in Flow

❑ Cattails at Toe of Dam ❑ Surface Water at Toe of Dam ❑ Seepage Associated with Sloughing ❑ Continuous Flow

❑ Sporadic Flow

Comments: ______________________

Main Areas to Inspect – Embankment Dams

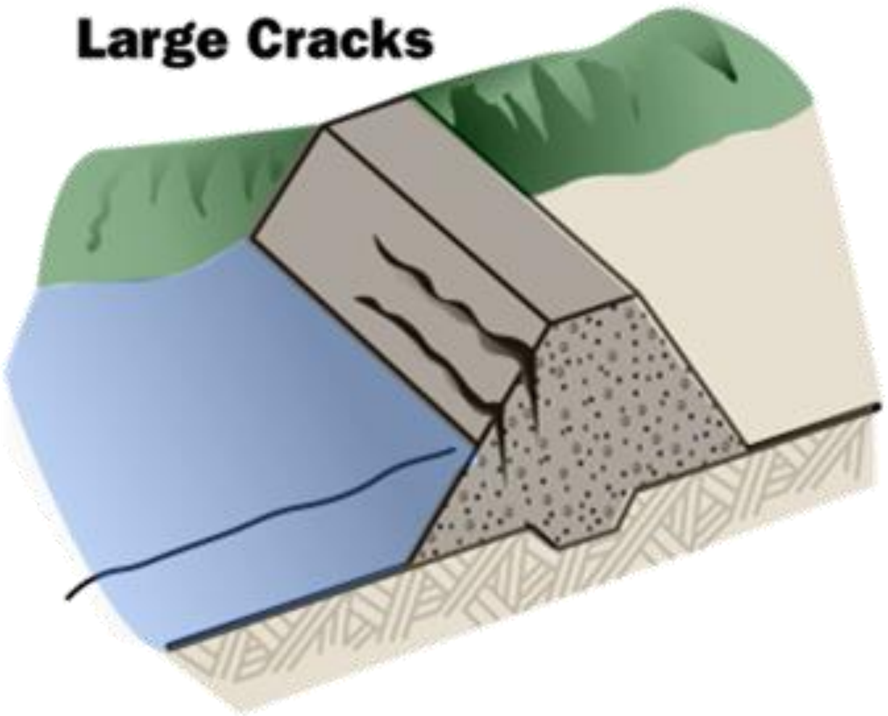
Upstream Slope

Crest (aka Crown)

Downstream Slope

Spillways and Outlets

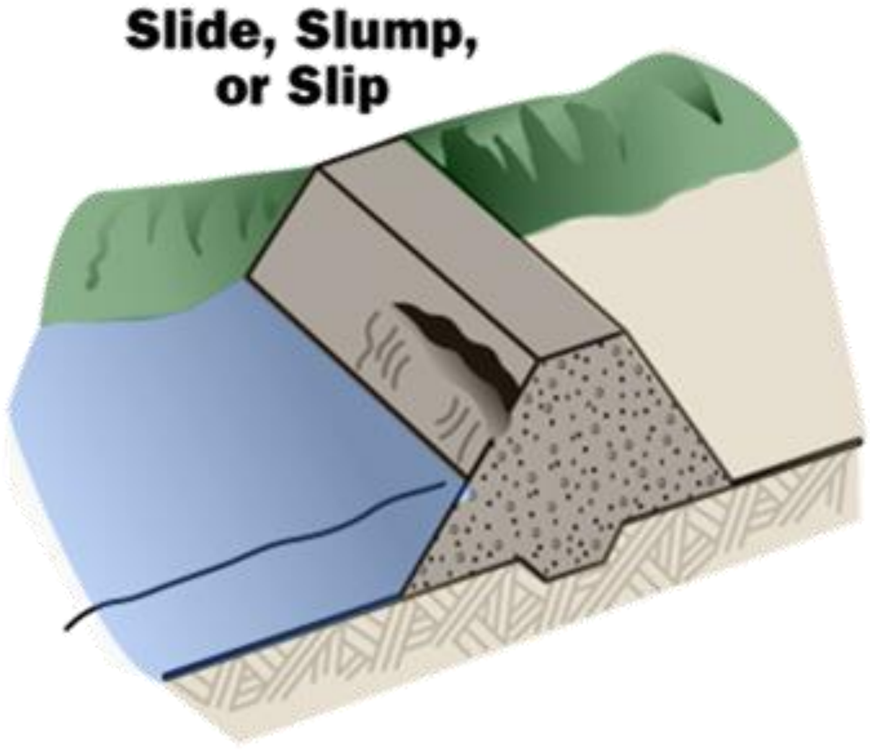
Upstream Slope Large Cracks



- Possible Causes
  - Loss of material strength due to:
    - Saturation
    - Rapid drawdown
    - Differential foundation settlement

- Possible Consequence
  - Slides or large scale settlement resulting in crest loss and overtopping

Upstream Slope Failure



- Possible Causes
  - –May have initiated as large tension cracks (previous slide)
  - –Excessive erosion
  - –Over steepened areas
  - –Saturation
  - –Rapid drawdown

- Possible Consequence
  - –Slides or large scale settlement resulting in crest loss and overtopping

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Upstream Slope Failure

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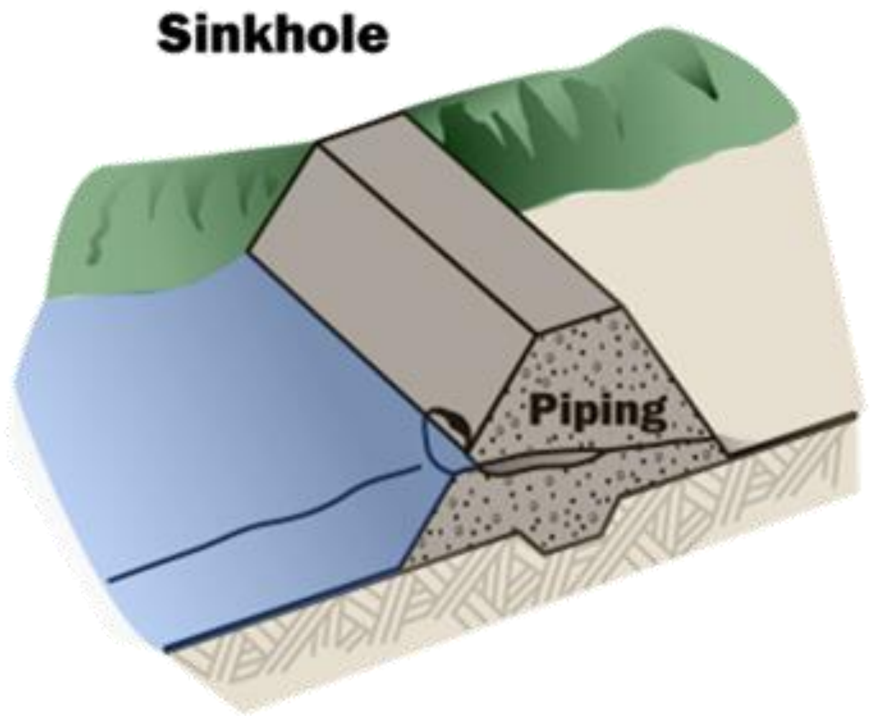
Upstream Slope Sinkhole



- Possible Cause
  - –Embankment material carried downstream through an erosion pipe
  - –Collapse of embankment material into localized animal burrow
- Possible Consequence
  - –Sinkhole may represent serious piping problem in embankment or foundation

Sinkhole

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Upstream Slope - Whirlpool

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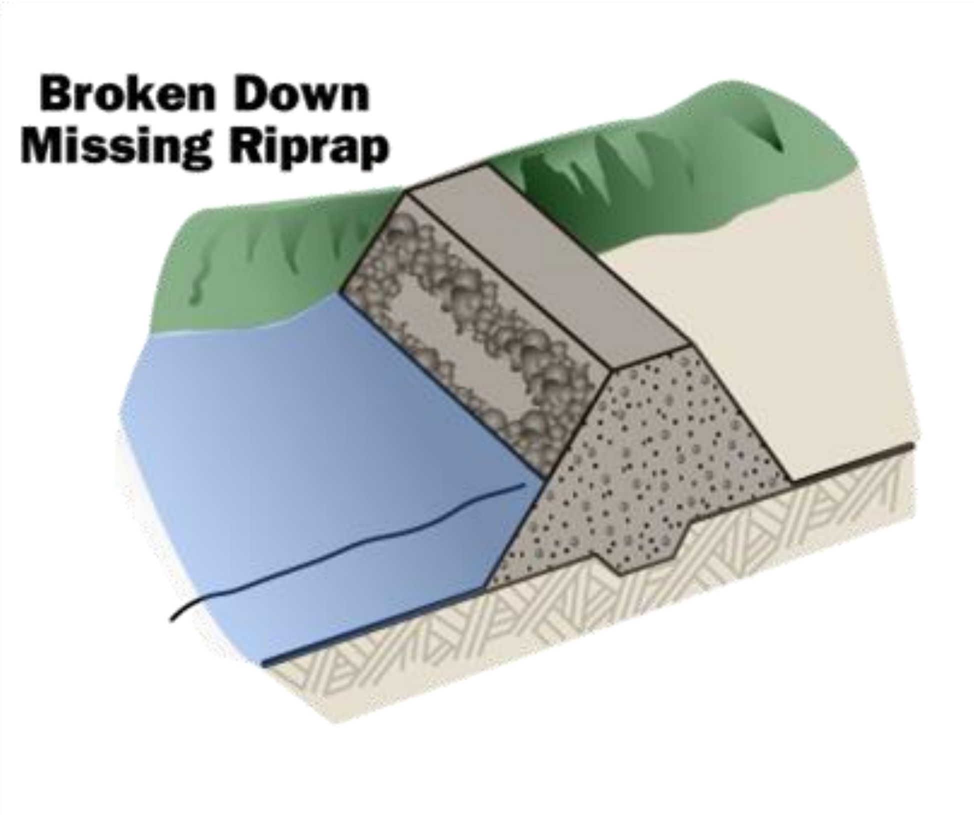
Upstream Slope Erosion or Missing Erosion Protection



- Possible Causes
  - –Poor quality riprap has degraded
  - –Undersized riprap displaced by wave action

- Possible Consequence
  - –Wave action against unprotected area can lead to erosion, loss of crest, and overtopping

Example Upstream Slope Erosion

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Example of a Poorly Maintained Upstream Slope

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Upstream Slope - Benching

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Example of a Well Protected Upstream Slope

Main Areas to Inspect – Embankment Dams

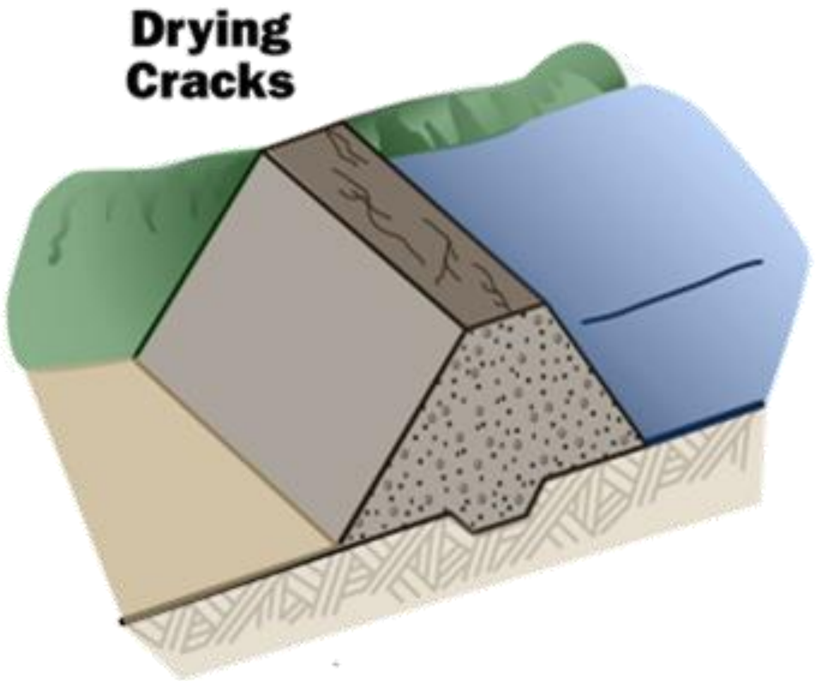
Upstream Slope

Crest (aka Crown)

Downstream Slope

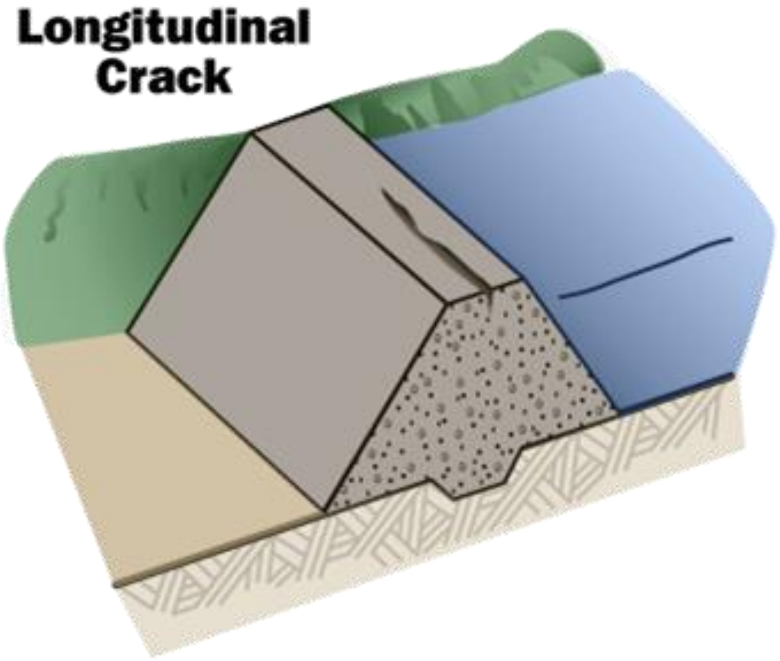
Spillways and Outlets

Crest Drying (Desiccation) Cracks



- Possible Causes
  - Clay material shrinks as it dries and causes cracking
  - No protective cover over clay
- Possible Consequences
  - Slide
  - Reduces embankment cross section
  - Shortens seepage paths
  - Embankment infiltration

Crest Longitudinal Cracks



- Possible Cause
  - –Weak embankment or foundation material (may indicate slide)
  - –Differential settlement of “zoned” embankment
  - –Drying (desiccation) cracks
- Possible Consequences
  - –Can lead to slides and failure
  - –Surface water infiltration which could cause a slide

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Longitudinal Cracks

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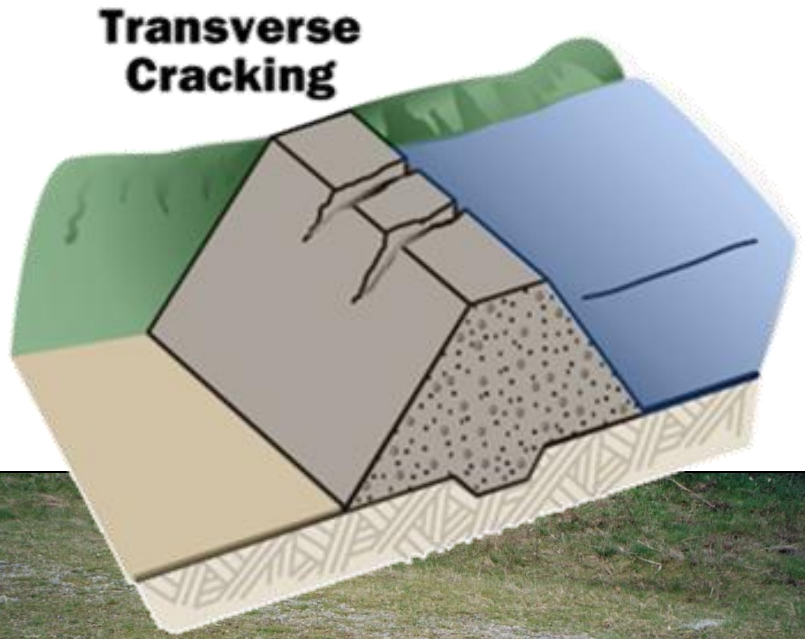
Crest Transverse Cracks

- Possible Causes
  - –Differential settlement of embankment
  - –Foundation settlement



- Possible Consequence
  - –Seepage paths through cracks can lead to internal erosion and failure

Cracks Caused By Differential Settlement

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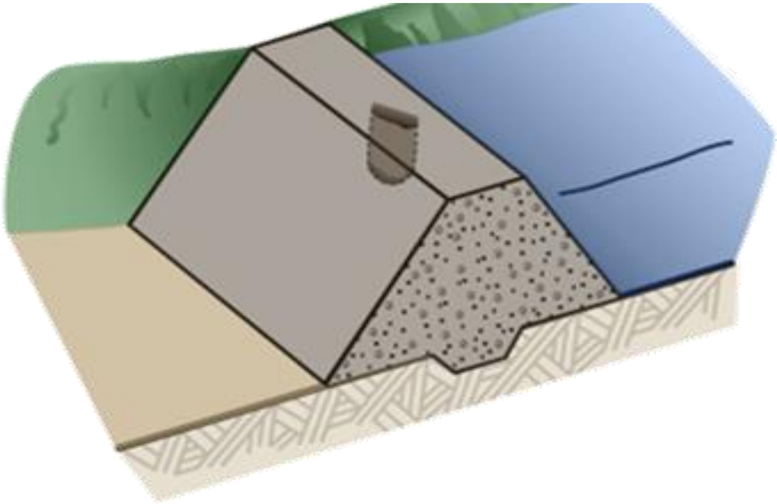
Cracking Inspection Tips

If cracks are observed:

1. Document location, depth, width, length
2. Photograph the cracks (with something for scale: pen, clipboard, ruler)
3. Compare with previous observations
4. If cracks extend below water level, immediately contact a qualified professional engineer.
5. Cracks may not be readily observable on crests lined with gravel, requiring more careful inspection. Inspect slopes just below upstream & downstream crest edge.

Crest Sinkhole



- Possible Causes
  - –Collapse of embankment fill into piping hole, animal burrow, or hole associated with breakdown of dispersive soil; settlement over outlet works conduit

- Possible Consequence
  - –Sinkhole could represent serious piping problem in the embankment leading to failure

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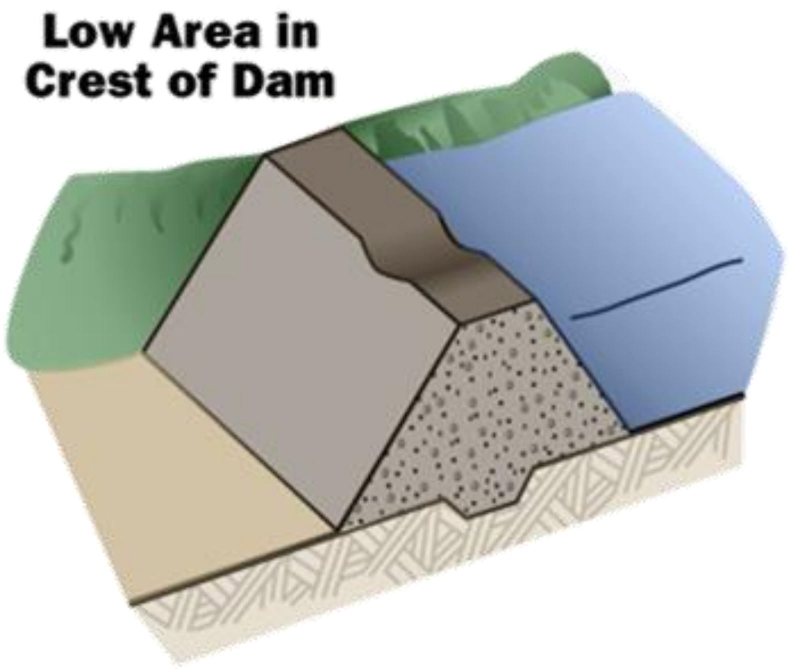
Crest Low Areas



- Possible Causes
  - Settlement
  - Early signs of piping or voids
  - Erosion
  - Poor construction/maintenance

- Possible Consequences
  - Reduced freeboard can lead to overtopping and failure
  - Low areas collect water that could erode downstream slope

* Hand-level and rod are useful for measuring depth of low areas

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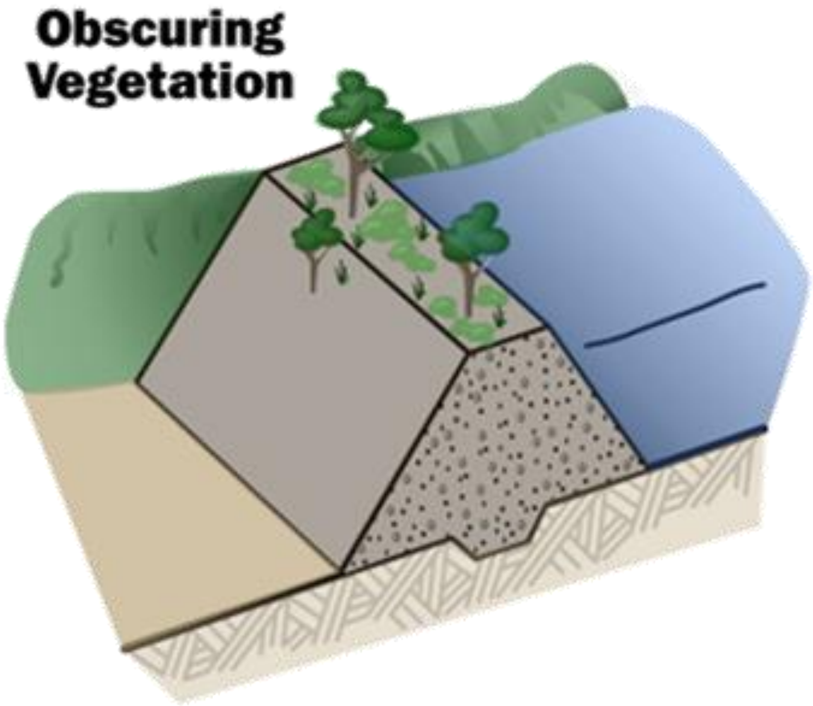
Crest

Major erosion and near breach caused by overtopping

Courtesy of Association of State Dam Safety Officials

Crest Vegetation



- Possible Causes
  - –Poor maintenance
  - –Excessive water promotes growth
- Possible Consequences
  - –Vegetation can obscure inspection
  - –Tree roots can create seepage paths
  - –Large trees can blow over and their root systems can dislodge soil reducing freeboard

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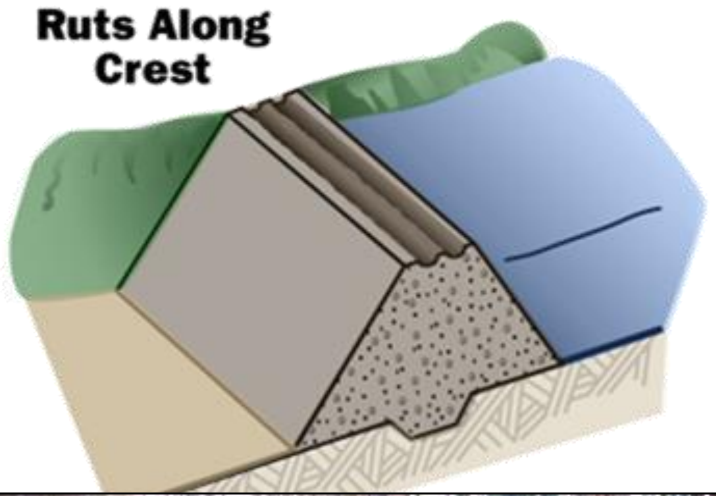
Crest Ruts

- Possible Causes
  - Vehicle Traffic
  - Poor maintenance
  - Poor drainage



- Possible Consequences
  - Ponded water on crest/seepage into embankment
  - Loss of freeboard

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Crest - Ruts

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Main Areas to Inspect – Embankment Dams

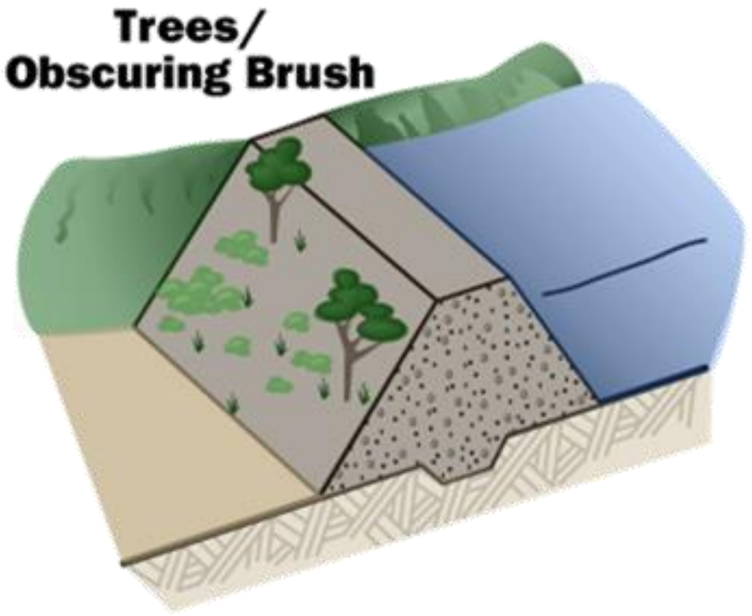
Upstream Slope

Crest (aka Crown)

Downstream Slope

Spillways and Outlets

Downstream Slope Trees



- Possible Causes
  - –Poor maintenance
  - –Excessive seepage promotes growth

- Possible Consequences
  - –Vegetation can obscure inspection
  - –Tree roots can create seepage paths
  - –Large trees can blow over and their root systems can dislodge soil causing erosion

Overgrown Conditions - Before

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Overgrown Conditions - After

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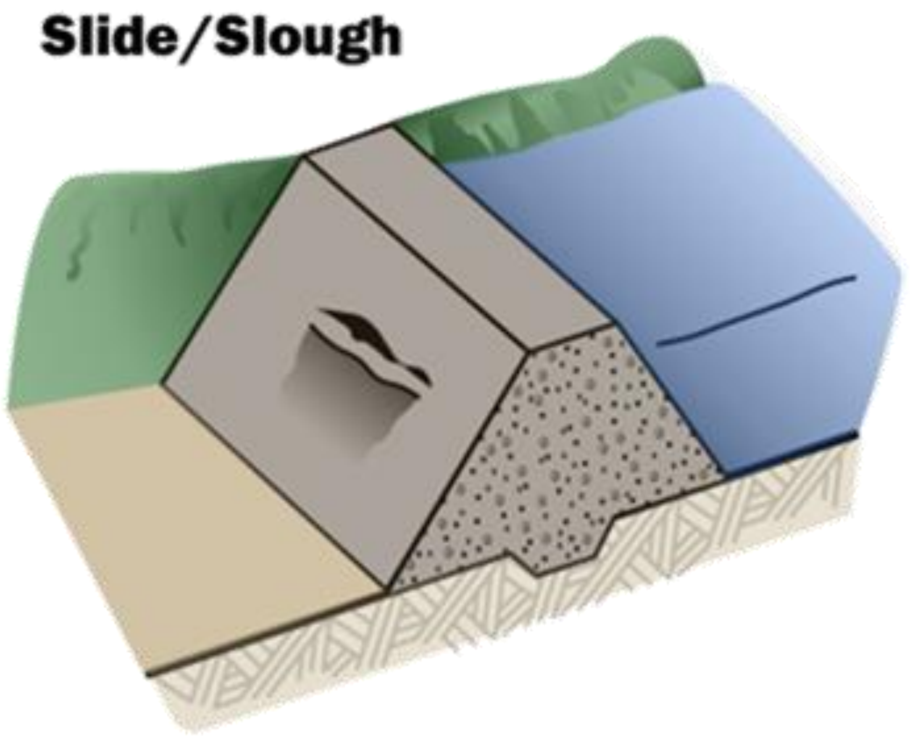
Downstream Slope Slides



- Possible Causes
  - Material becomes saturated and loses strength due to:
    - Seepage
    - Excessive rain or erosion
    - Earthquake
- Possible Consequences
  - Large scale slides:
    - Loss of freeboard and overtopping
    - High exit gradient may develop
  - Small scale slides:
    - Spillway or outlet blockage
    - Could worsen if not detected and repaired

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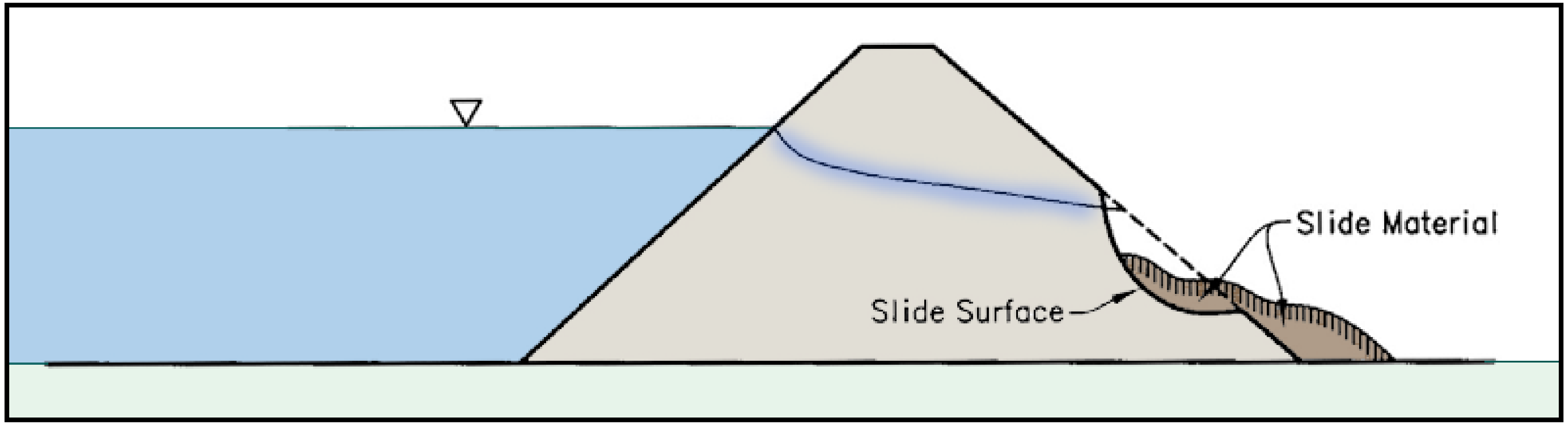
Downstream Slope - Slides

Small Scale – Shallow Slides

- Typically, not immediate risk of failure
- Does not encroach near crest
- If neglected, can progress and lead to possible large-scale slide and failure (deep-seated slide)



Downstream Slope - Slides

Small Scale – Shallow Slides

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Downstream Slide - Instability due to Uncontrolled Seepage

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Downstream Slope - Slides

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Downstream Slope- Slope Movement

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Downstream Slope - Slides

Large Scale – Deep Seated Slide

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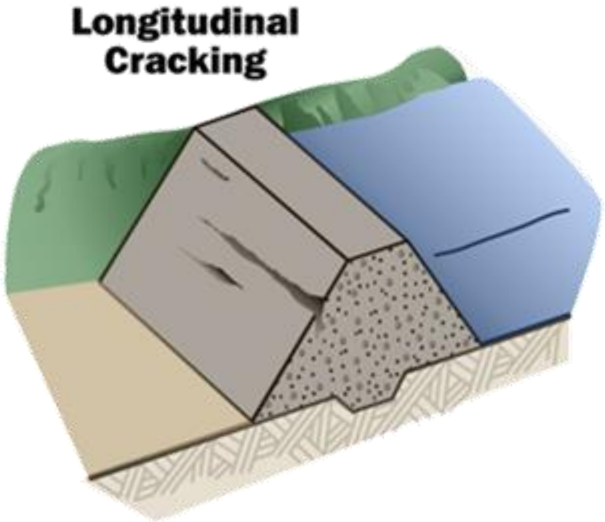
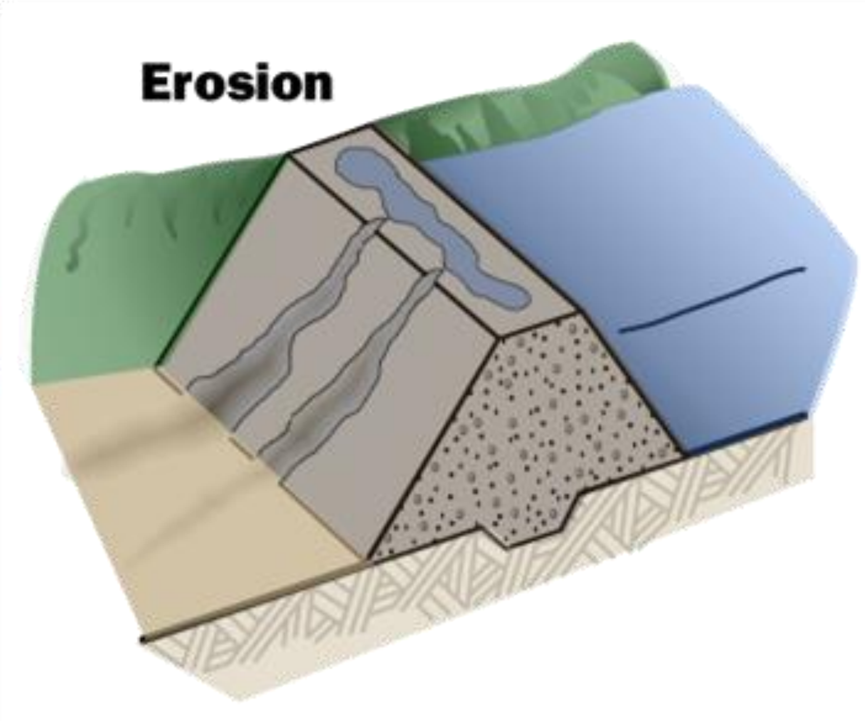
Downstream Slope Longitudinal Cracking



- Possible Causes
  - –Differential settlement of embankment or foundation
  - –Downstream movement
  - –Drying cracks

- Possible Consequences
  - –Can allow surface water to enter, freeze and worsen cracks
  - –Can lead to slumps/slides
  - –Can fill with water, reducing stability

Downstream Slope Erosion



- Possible Causes
  - –Intense rainstorm
  - –Poorly graded crest allows water to pond and concentrate
  - –Poorly maintained crest
  - –Vehicles/animal trails
  - –Common in the groins, or where the embankment meets the abutment

- Possible Consequence
  - –Erosion left unchecked can develop into large gullies which can lead to over steepened areas and stability issues

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Downstream and Upstream Slope Erosion

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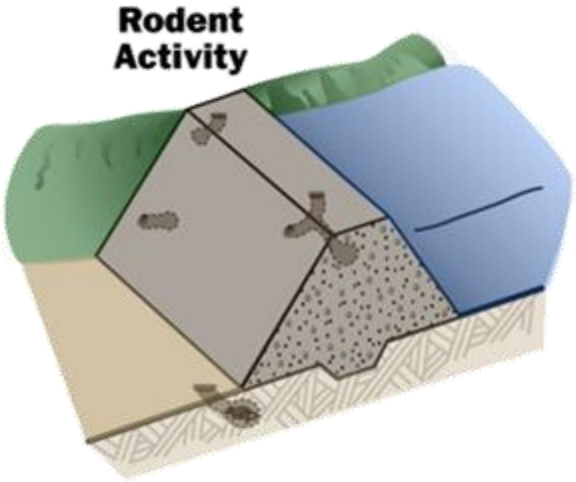
Downstream Slope – Sparse Vegetation

Likelihood of downstream slope erosion increases if vegetation is sparse.

Downstream Slope – Animal Burrows



- Possible Cause
  - Water attracts wildlife
  - Vegetation attracts wildlife

- Possible Consequence
  - Burrows can become seepage paths
  - Burrows can reduce seepage path distance
  - Burrows can collapse leading to erosion, loss of freeboard and other problems

Video – Click video to start,
Click video to pause

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Animal Activity

**Uncontrolled Animal Activity Could Lead
To Uncontrolled Seepage and Piping Failure**

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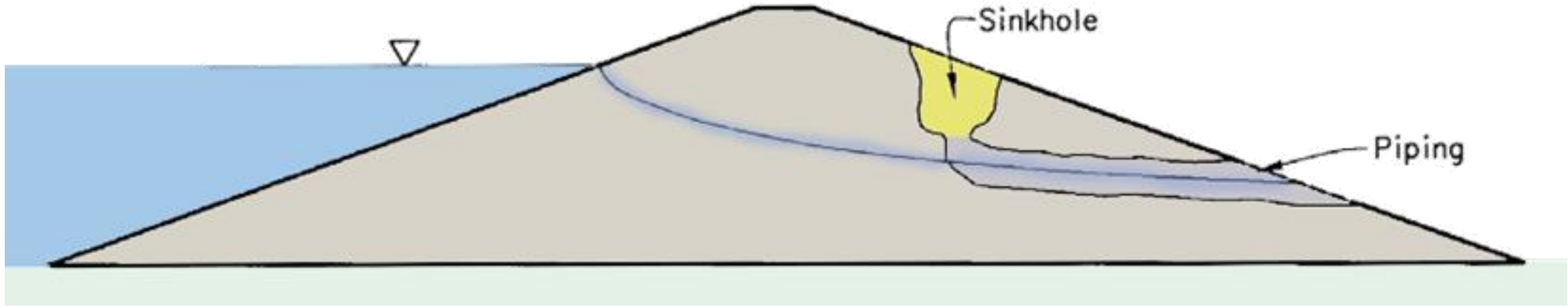
Downstream Slope – Sinkholes

- Sinkholes are caused by loss of embankment or foundation material, causing surface collapse
- Typically have steep sides
- May indicate piping or internal erosion (e.g., along outlet works conduit)
- Can be caused by animal burrows or decomposition of organic matter
- Check for sandboils and cloudy seepage downstream



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Downstream Slope – Sinkhole

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Poorly Maintained Downstream Slope

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Well Maintained Downstream Slope

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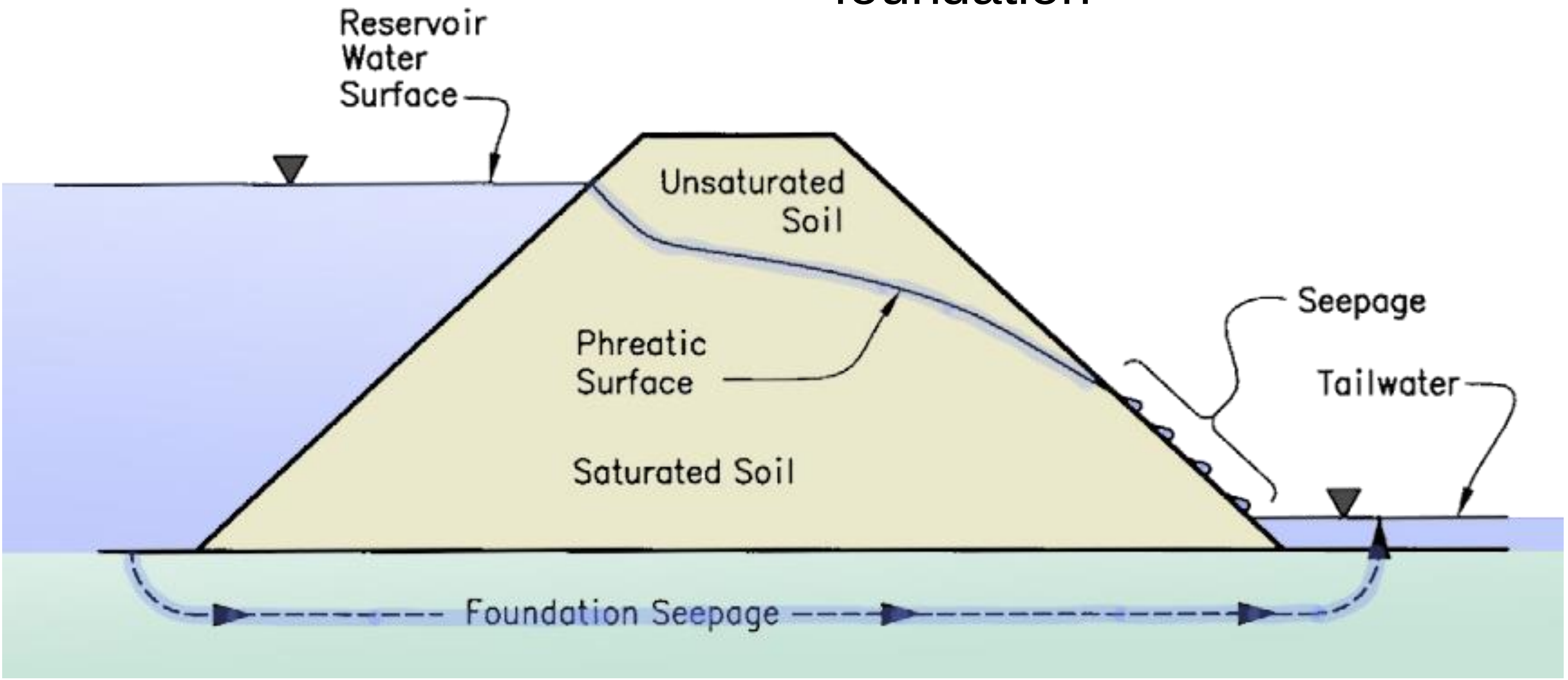
10 Min. Break

Seepage

- Major cause of failure of dams
- Increase in seepage rate under similar pool level
  - Indicator of development of concentrated seepage paths and piping
- Decrease in seepage rate under similar pool level
  - Indicator of plugged drains (look for seepage in new areas)

Seepage

Seepage paths through embankment and foundation



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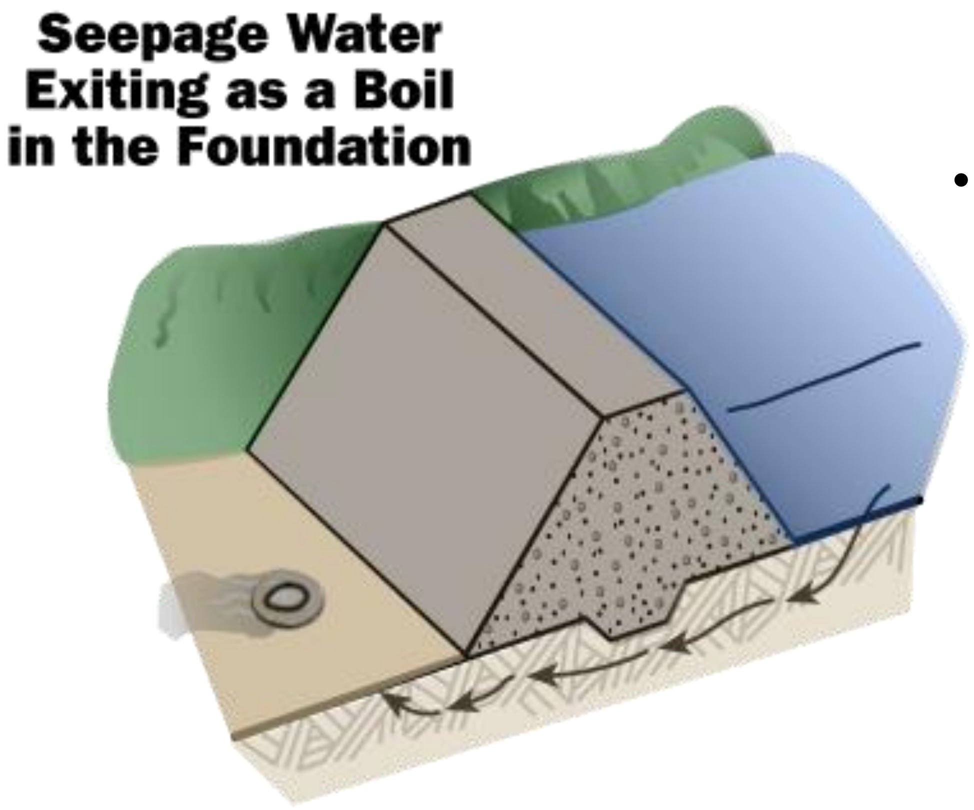
Seepage Areas - Embankment



- Possible Cause
  - –Seepage through the foundation is removing material
- Possible Consequence
  - –Continued seepage and erosion can lead to foundation failure and sinkholes; if seepage “pipe” continues to enlarge, it will eventually involve the embankment, leading to failure

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Uncontrolled Seepage

Plugged Embankment Drains Could Lead To Excessive Seepage and Boils At Toe That Could Lead To Embankment Failure

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Plugged Drains

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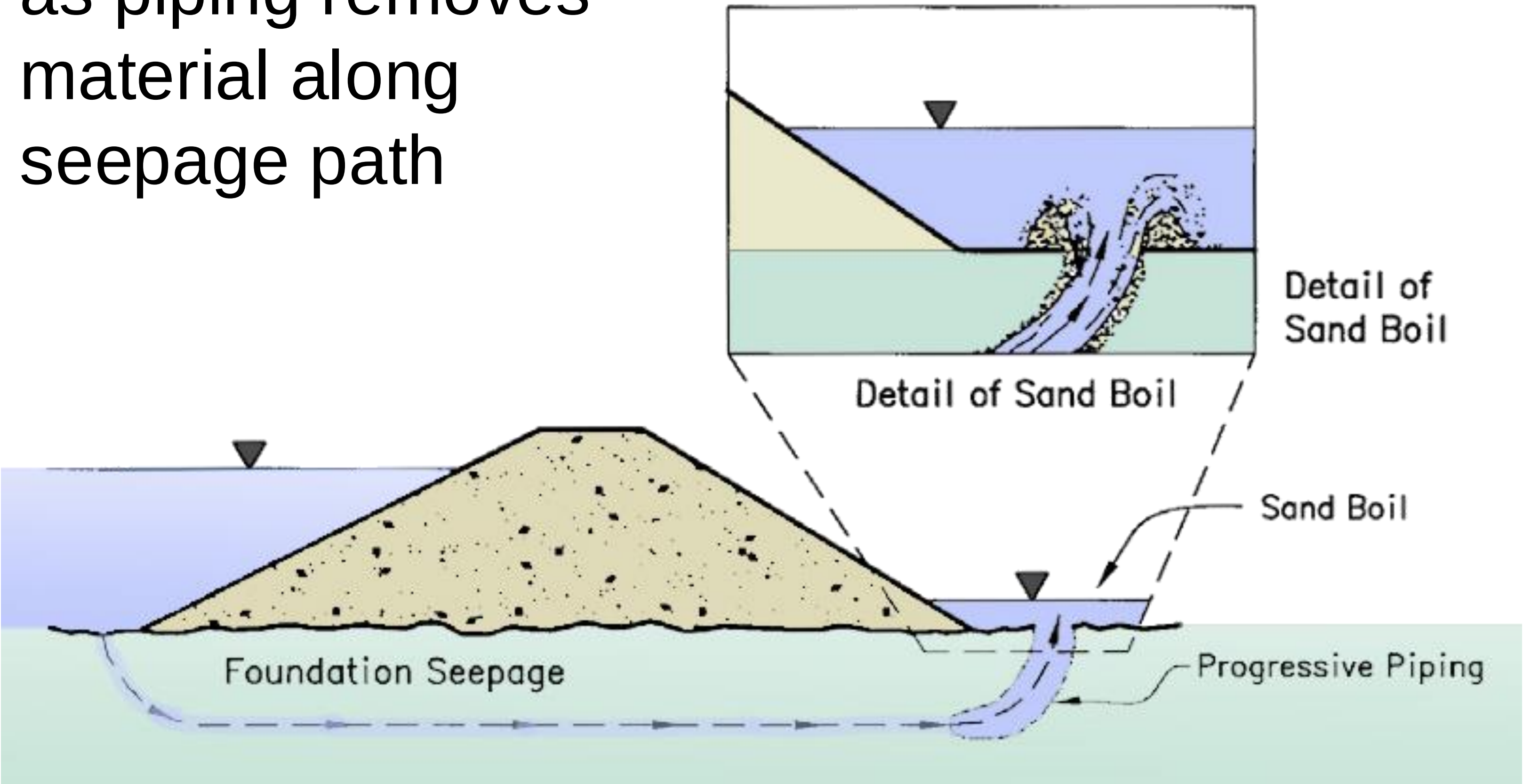
Sand Boils

Sandboils develop as piping removes material along seepage path



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Sand Boils

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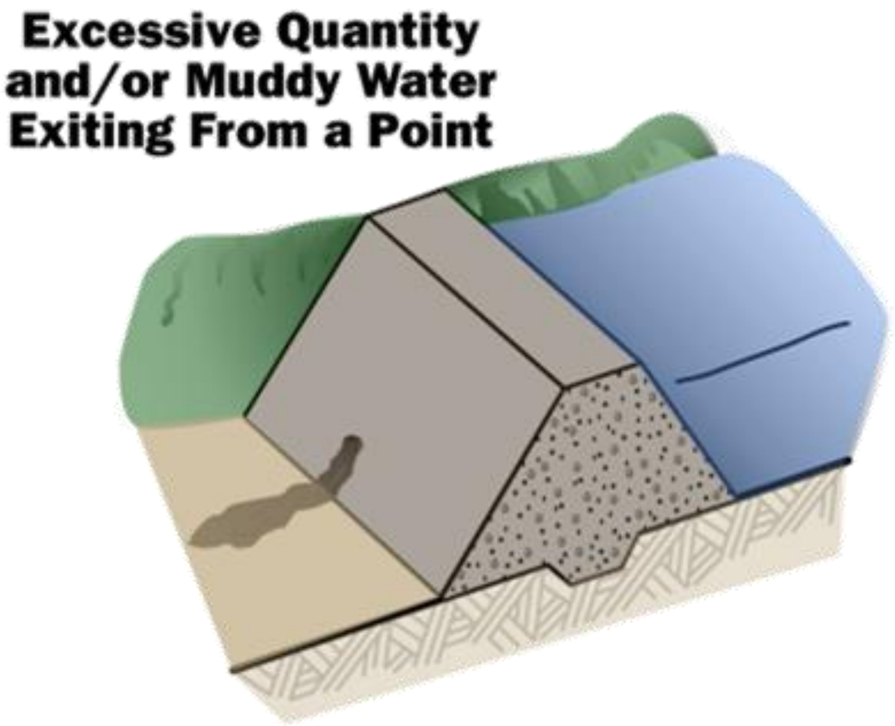
Sand Boils

- Bubbling up or “boiling action” caused by high seepage exit velocities usually in fine sandy soil
- Sand boils may indicate piping; look for:
  - Cloudy discharge
  - Cone of sand around seepage exit point
- Take immediate action:
  - Record pool level and elevation/location of boil
  - Photograph
  - Record seepage flow
  - Get professional help to address. Condition may be serious

Seepage Areas - Embankment



- Possible Cause
  - –Increasing or muddy seepage may indicate piping or internal erosion along defect in the embankment; defect could be from internal crack, pervious zone or animal burrows

- Possible Consequence
  - –Continued flows can lead to progression of piping and erosion of embankment material, and eventually a breach. This type of seepage is a serious dam safety concern.

Embankment Seepage Area at Toe

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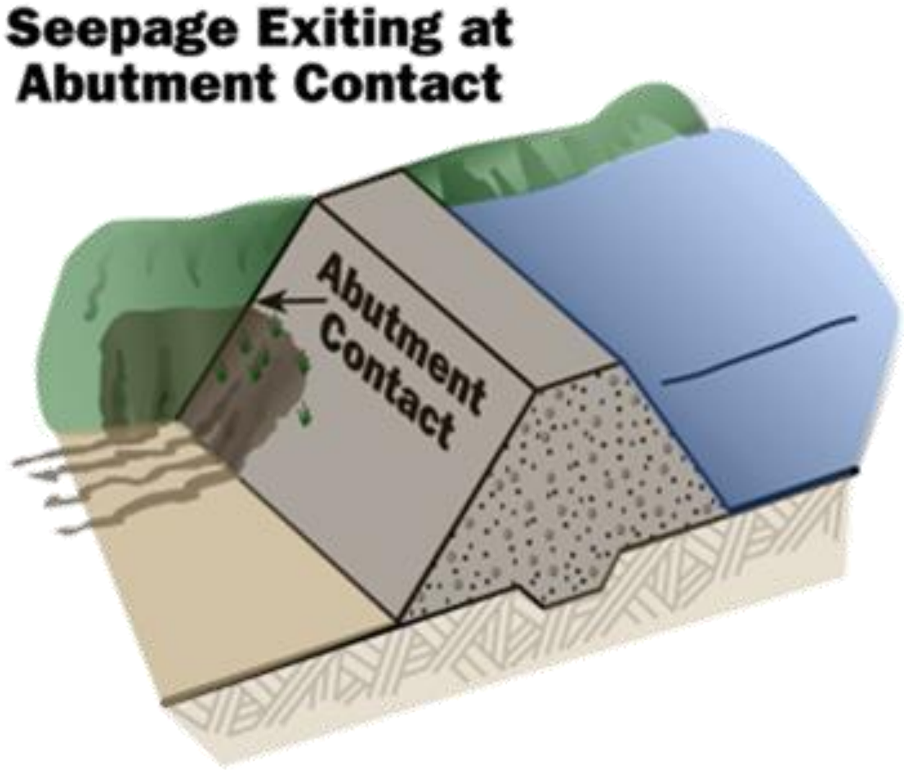
Seepage Areas - Embankment



- Possible Causes
  - –Seepage occurs along poorly compacted contact between embankment and abutment
  - –Seepage occurs through fractures/joints in abutment rock and exits at groin
- Possible Consequence
  - –Continued seepage can lead to internal erosion or erosion of abutment and eventual breaching.
  - –Abutment slide

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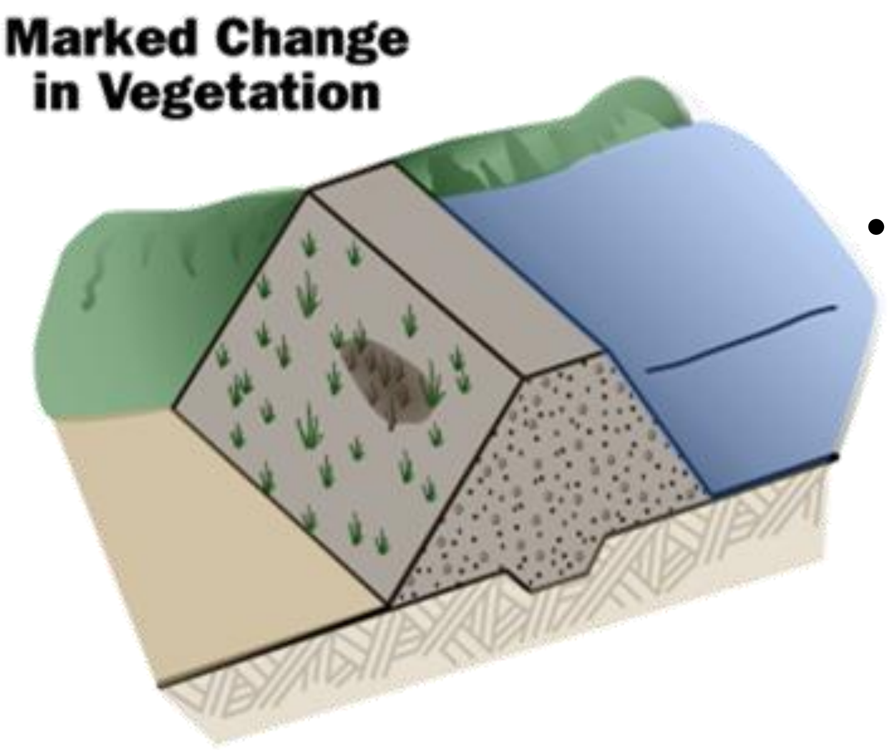
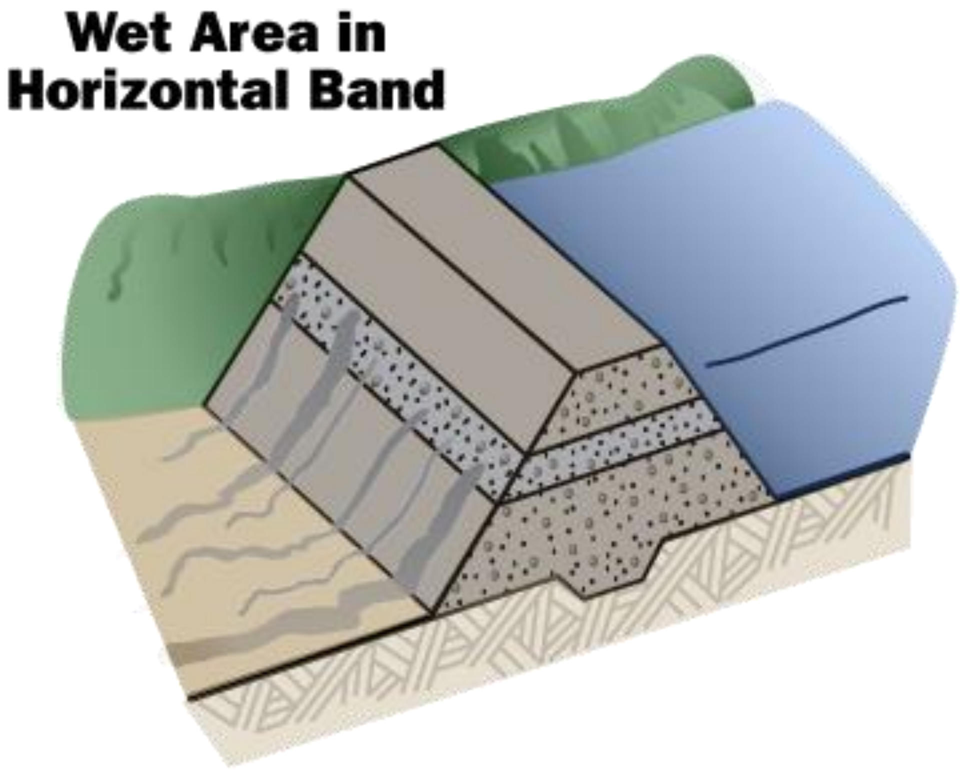
Seepage Areas - Embankment



- Possible Causes
  - –Pervious embankment layer
  - –Soil type, density or other soil property changes
- Possible Consequences
  - –Continued seepage can lead to erosion. If seepage is cloudy or rate increases, internal erosion could occur.
  - –Seepage has saturated soil and soil is beginning to slump

Seepage Areas - Embankment



- Possible Cause
  - Seepage flowing through more pervious horizontal layer placed during construction
- Possible Consequences
  - If seepage is cloudy, internal erosion may be occurring; piping could develop
  - Soil below seepage may become saturated resulting in slides
  - Significant seepage may cause significant loss of water.

Seepage Areas - Piping

Seepage Areas - Piping

Seepage Areas - Piping

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Seepage Areas - Piping

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Seepage Areas - Piping

Seepage Areas - Piping

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Seepage Areas - Piping

Seepage Areas - Piping

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Seepage Areas – D/S Channel

Downstream Area Seepage

May not be a concern depending on seepage volume, distance from embankment, and whether water is cloudy or clear, but still should be reported

Seepage Inspection Tips

Most common seepage locations:

- Downstream slope
- Abutment groins
- Penetrations through embankment (outlets and drains)

Look for:

- Areas of green, lush/wetland vegetation
- Abrupt changes or horizontal lines of greener vegetation
- Flowing water
- Turbid or cloudy water

Seepage Inspection Tips

<u>If seepage is observed, record:</u>

1. Location of seepage
2. Flow rate: use weir, flume, or bucket and stopwatch

   Note: Typical garden hose flow is about 5 gpm
3. Pool level
4. Flowing clear/cloudy
5. Photograph
6. Compare flow with previous readings with similar pool level

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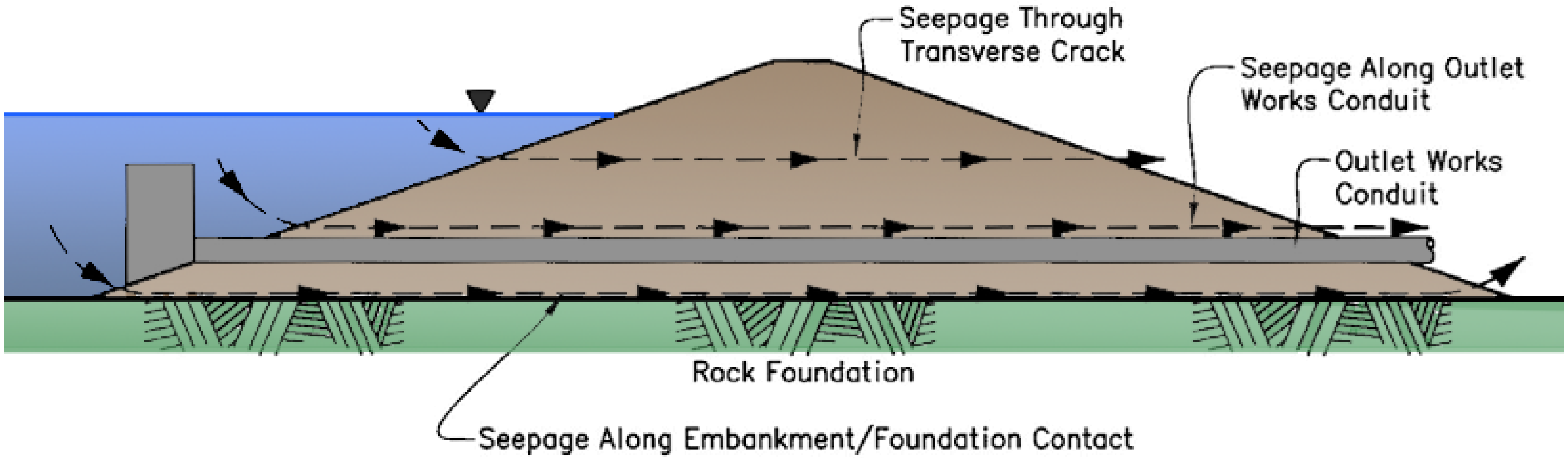
Internal Erosion

Occurs when seepage flows along established pathways, eroding and transporting material through/into:

- Cracks in soil or bedrock (can be naturally occurring joints and fractures)
- Interface between soil and bedrock
- Interface between soil and structures
- Adjacent material with significant void space (rockfill)

Internal Erosion & Piping

Potential Seepage Pathways



Internal Erosion - Piping

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Uncontrolled Seepage and Piping

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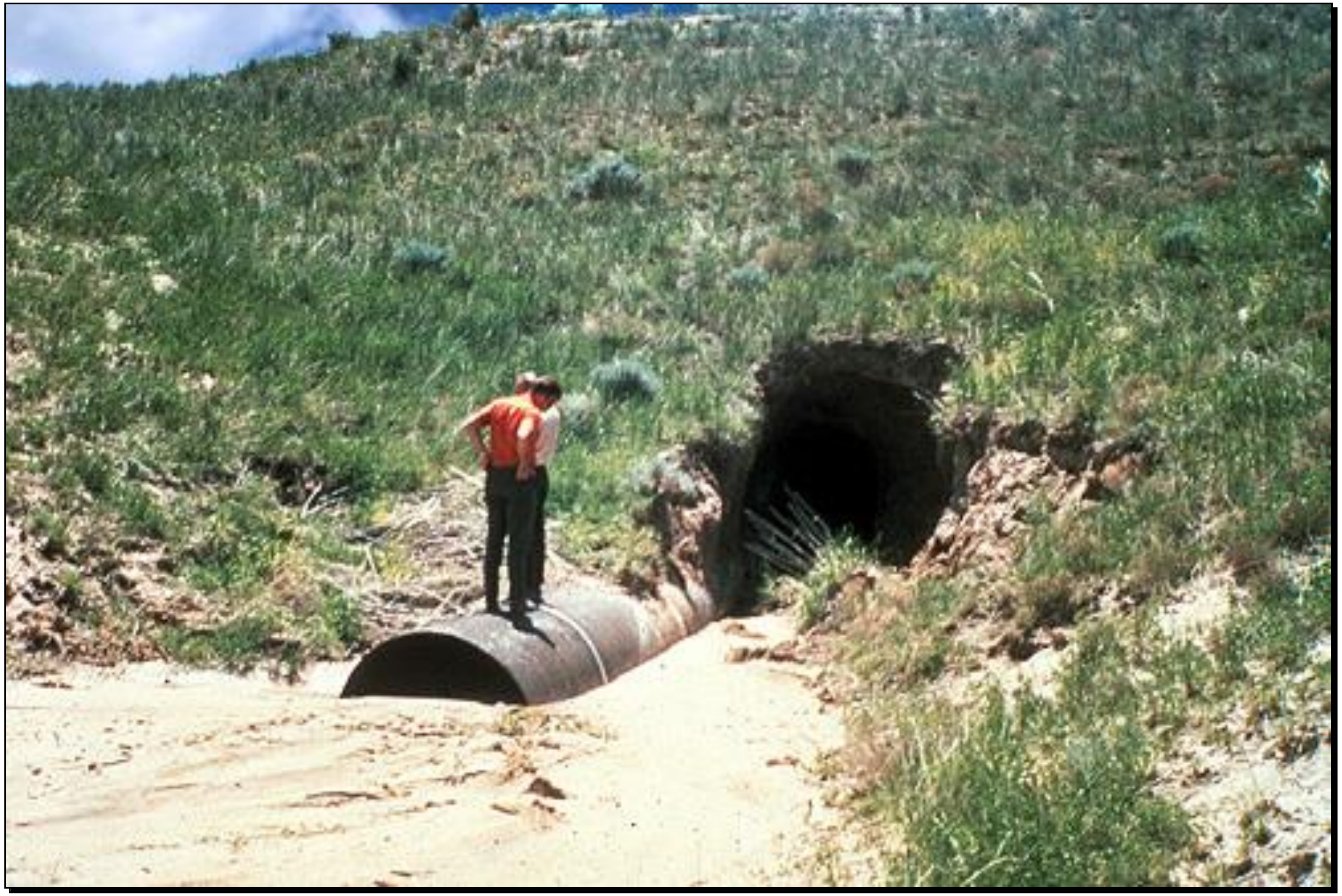
Internal Erosion - Piping



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Summary

EMBANKMENT ISSUES THAT NEED IMMEDIATE ATTENTION:

- Sand boils or turbid seepage.
- Seepage that has increased significantly since the last inspection
- Cracks that extend below the pool level or potential pool level.
- Large transverse and/or longitudinal cracking in the embankment.
- Deep-seated slides or bulging associated with slides.
- Sinkholes or other large depressions.

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Summary

EMBANKMENT ISSUES THAT NEED ATTENTION (NOT AS URGENT):

- Significant erosion or displacement of vegetation or riprap
- Minor surface slide
- Woody vegetation or excessive grassy vegetation
- Clear seepage that is relatively consistent

Main Areas to Inspect – Embankment Dams

Upstream Slope

Crest (aka Crown)

Downstream Slope

Spillways and Outlets

Inoperable Gates

- Bent Stem
- Trash and Woody Vegetation can make Gate Inoperable

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Spillway Inspection

Flow Obstructions

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Upstream Slope/Outlet Works

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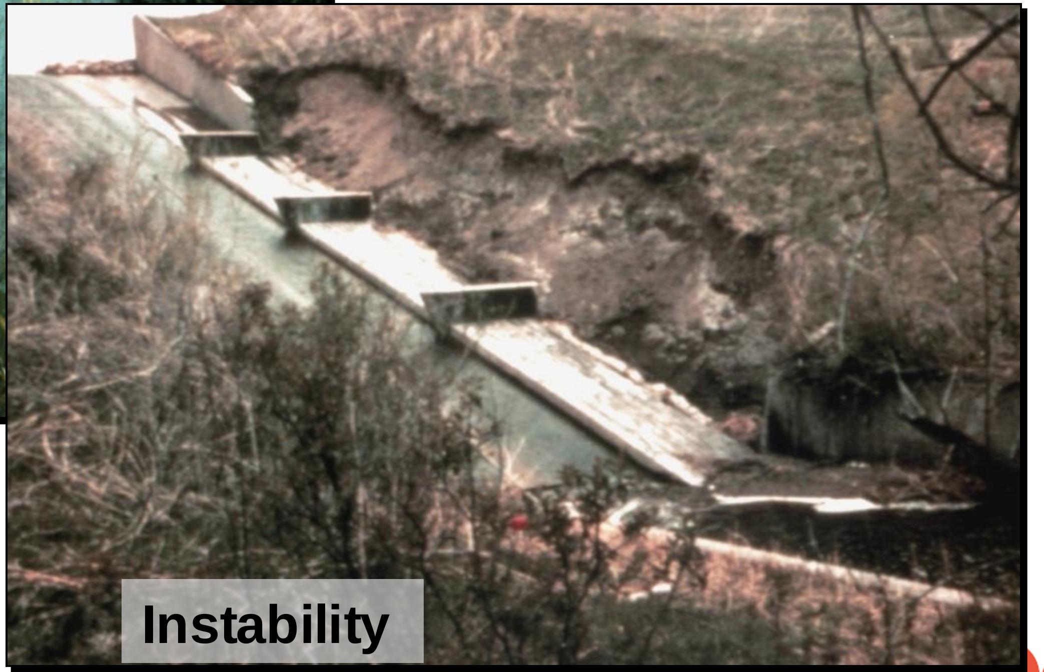
Spillway Defects



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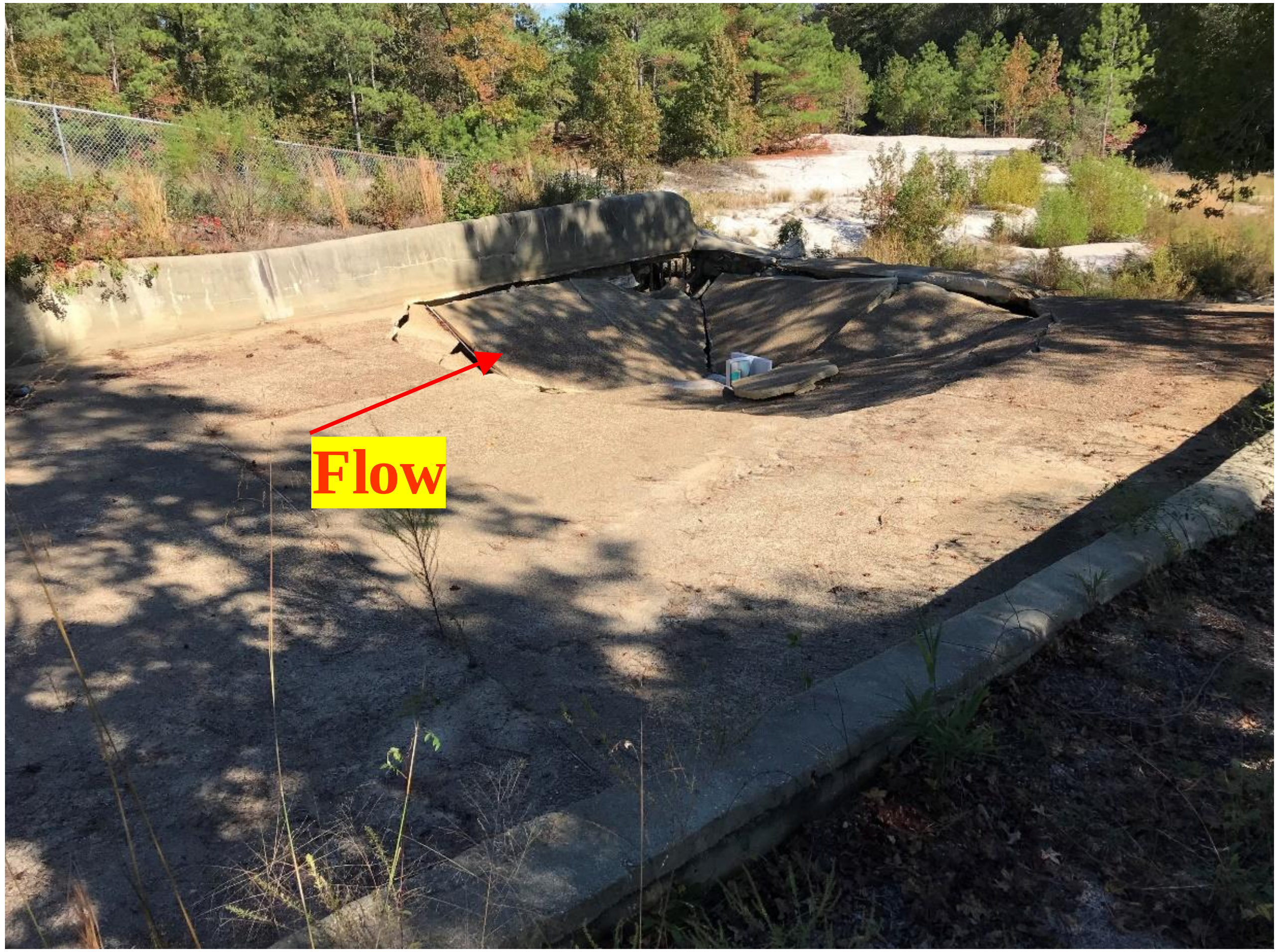
Spillway Chute Failure



Spillway Undermining / Scour

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Spillway Undermining

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Concrete Deterioration

Deteriorated Concrete Spillway Can Lead To Failure During Flow

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Unapproved Modifications

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Blocked Outlet

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Concrete Joint Problems

Open, vegetated joints

Open joint, deteriorated / missing joint sealant

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Spillway Slab

Spillway Crest

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Spillway Discharge Channel

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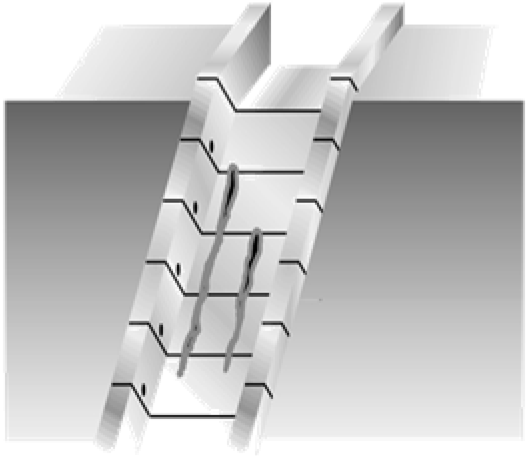
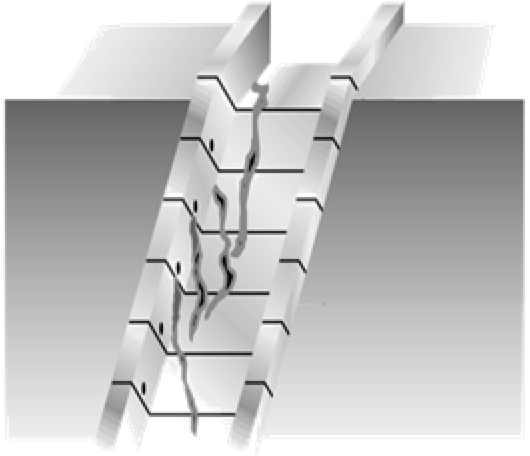
Spillway Issues

Concrete Chute Seepage

Too Much Leakage
From Spillway
Under Drains



Seepage From a
Construction Joint
or Crack in Concrete
Structure



Spillway Issues

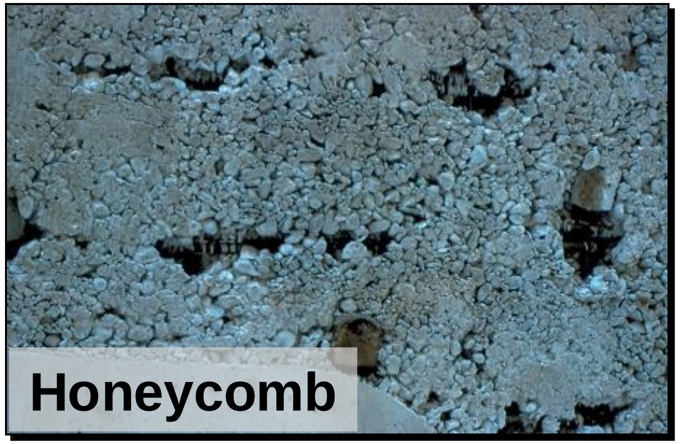
Conduit and Chute Seepage

Seepage flowing out of spillway joints

Conduit Leakage

Seepage Into
Conduit
Could
Lead To
Piping Failure
Of
The
Embankment

Common Concrete Defects



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Outlet Structures

- Obstructions
- Displacement
- Deterioration
- Cavitation or Erosion
- Seepage or Poor Drainage
- Walkways and Ladders

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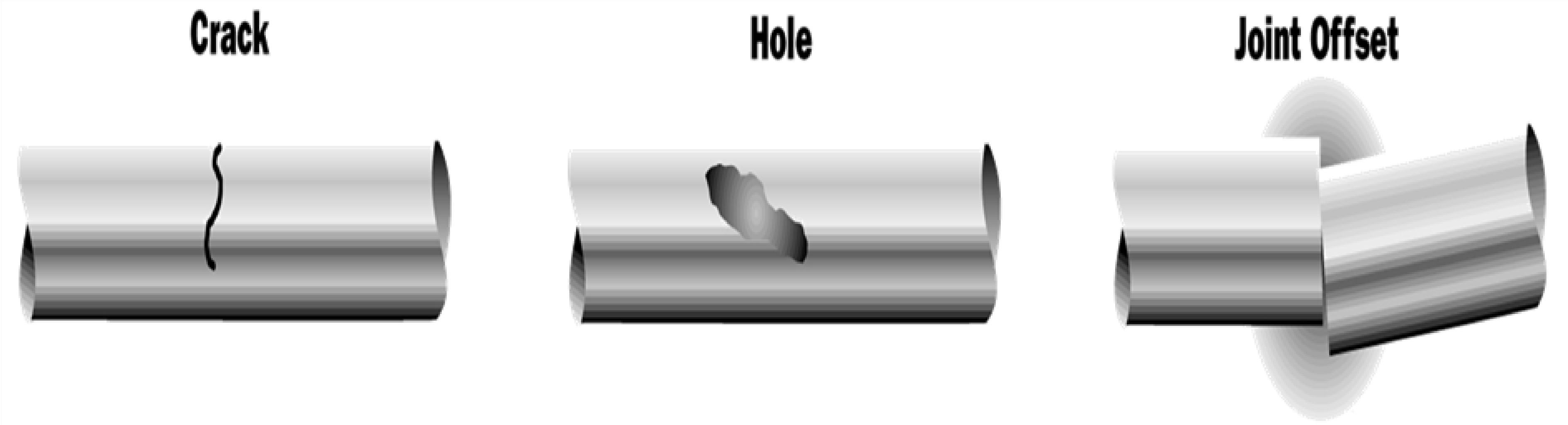
Outlet Pipe Defects



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Outlet Pipe Defects

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Piping around Outlet Pipe

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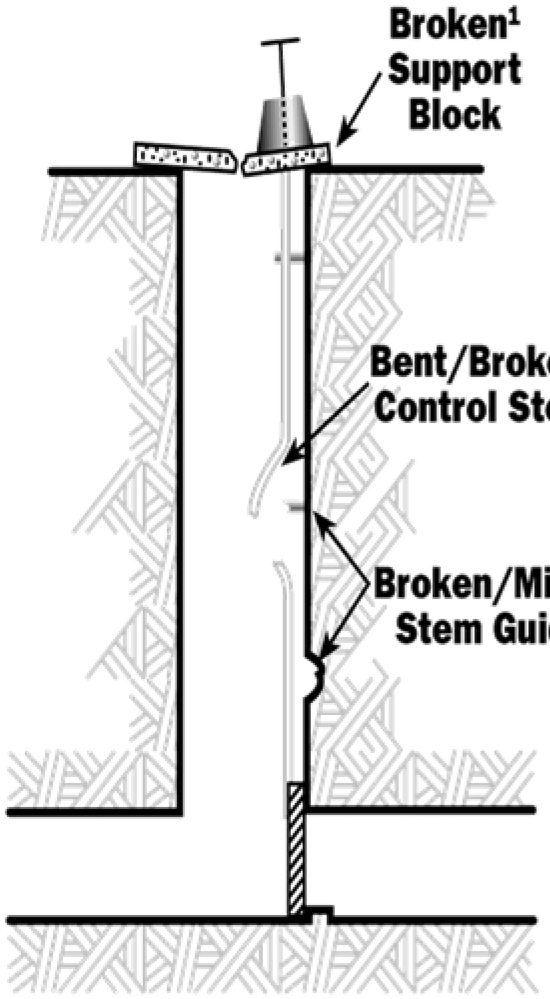
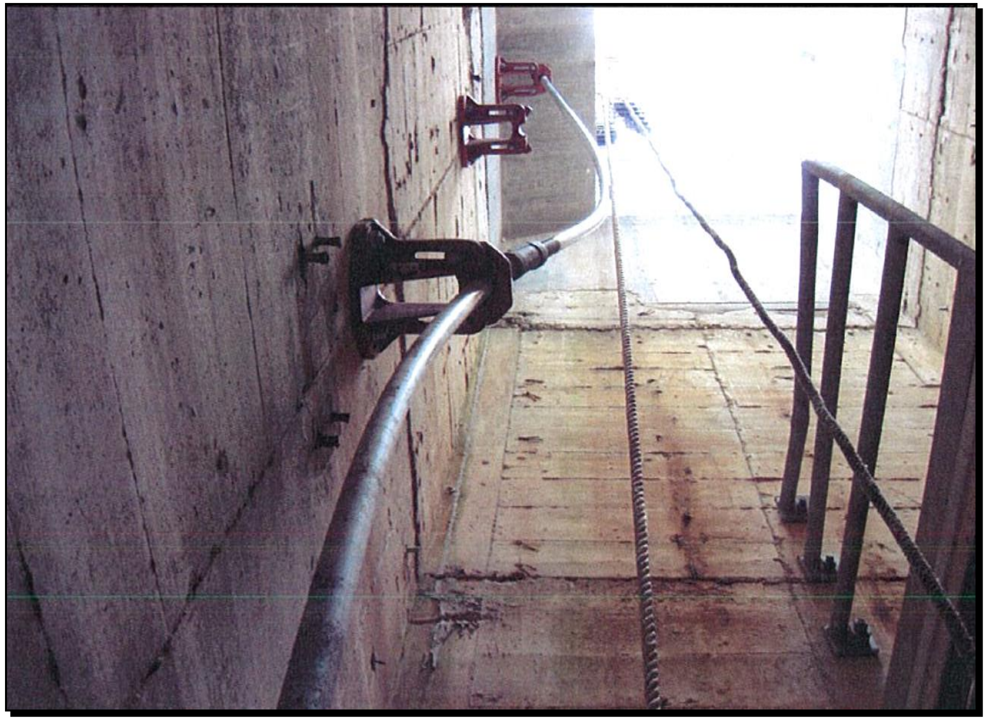
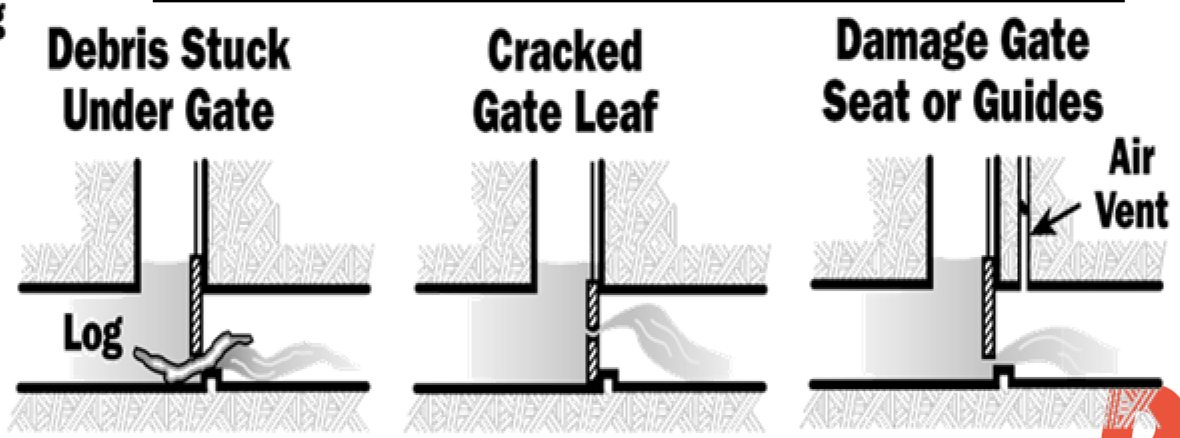
Outlet Structures

Gate Problems







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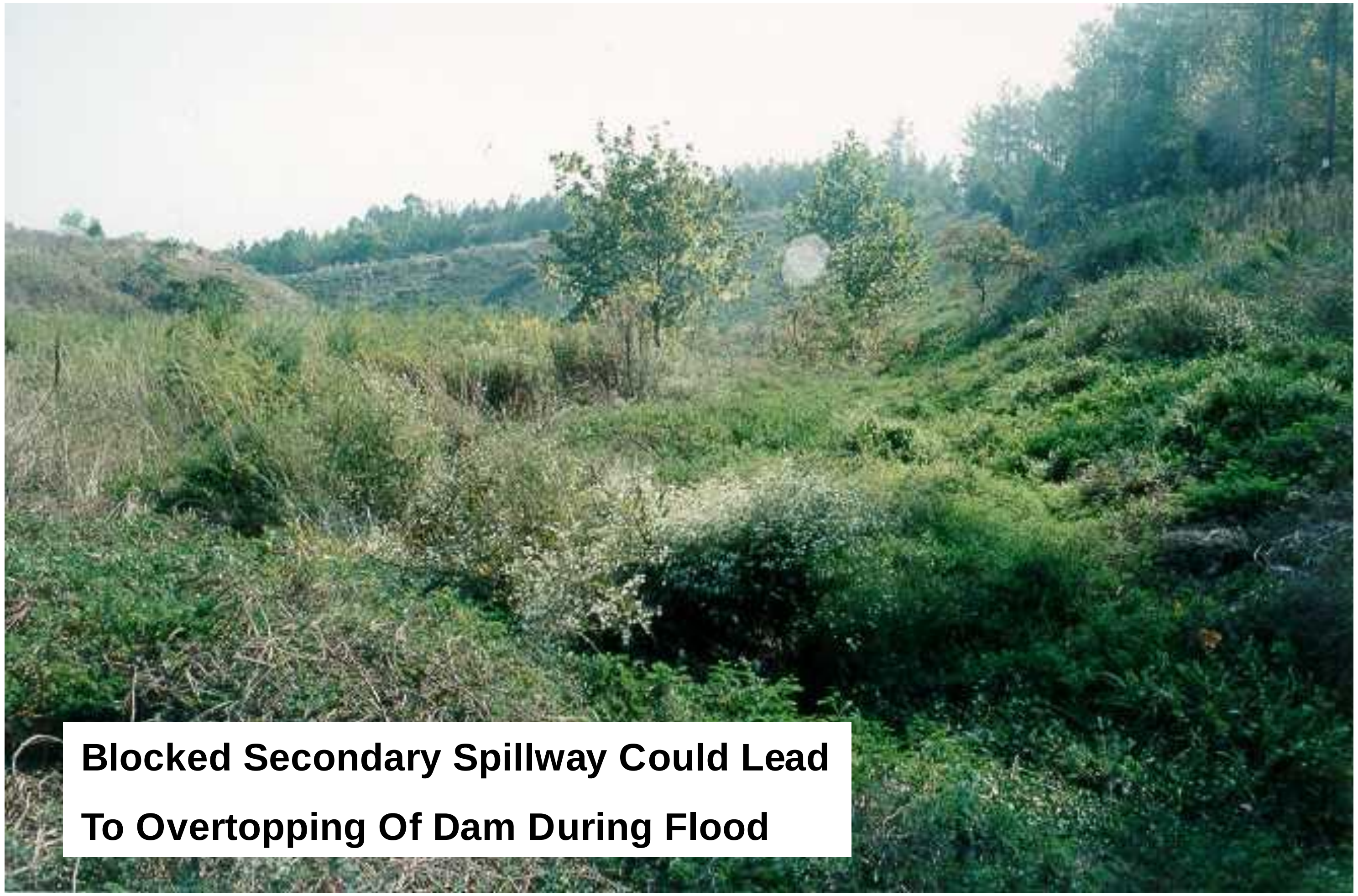
Blocked Secondary Spillway



Blocked Secondary Spillway Could Lead To Overtopping Of Dam During Flood

Summary

SPILLWAY AND OUTLET ISSUES THAT NEED IMMEDIATE ATTENTION:

- Severe structural movement or collapse.
- heavy seepage through joints that indicate loss of material underneath
- Loss of significant conveyance from vegetation or other blockage
- Sinkholes adjacent to the spillway
- Seepage carrying sediment into or adjacent to the spillway or outlet

Summary

SPILLWAY AND OUTLET ISSUES THAT NEED ATTENTION (NOT AS URGENT):

- Cracking or spalling of concrete
- Erosion of areas adjacent to or downstream from the spillway
- significant vegetation in cracks or joints
- Clear seepage that is relatively consistent
- Minor corrosion
- Operational issues for gates and valves
- CMP pipe that is not yet showing problems – they're coming

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Post-Inspection

- Read through checklist and notes before you leave the site; are you missing any information?
- Add notes and captions to photos describing observations, location, action items
- Make recommendation(s) for maintenance or repairs, as applicable.

Review: Potential Problems

- Longitudinal, transverse or desiccation cracks
- Slope failures; slides or slumps
- Sinkholes
- Missing riprap and erosion
- Vegetation and trees
- Animal burrows
- Cloudy Seepage or Rate of Seepage has changed

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Safety Around Dams and Spillways

- **Keep your distance!**
- Obey signage and warning buoys

- Owners of Dams open to the Public:
  - Recommend installing signs and buoys upstream and downstream

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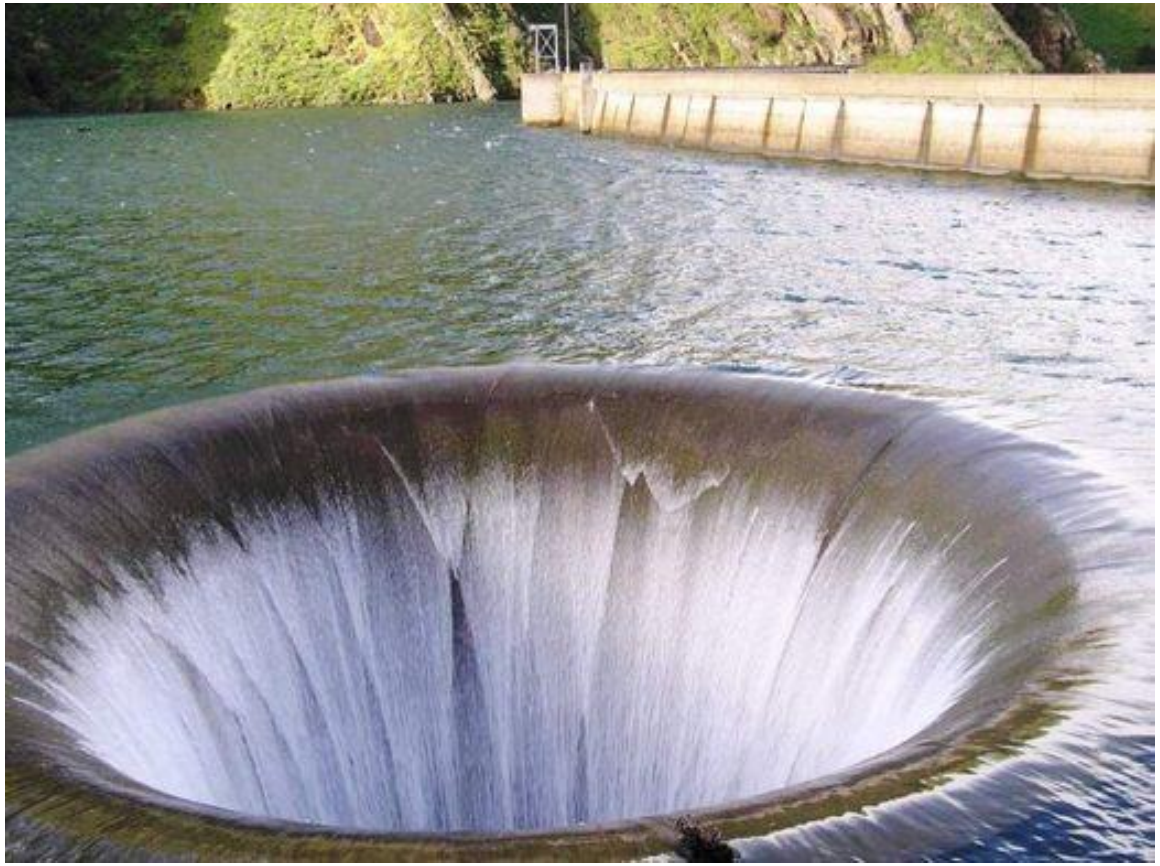
Spillways



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Signs and Buoys

DANGER

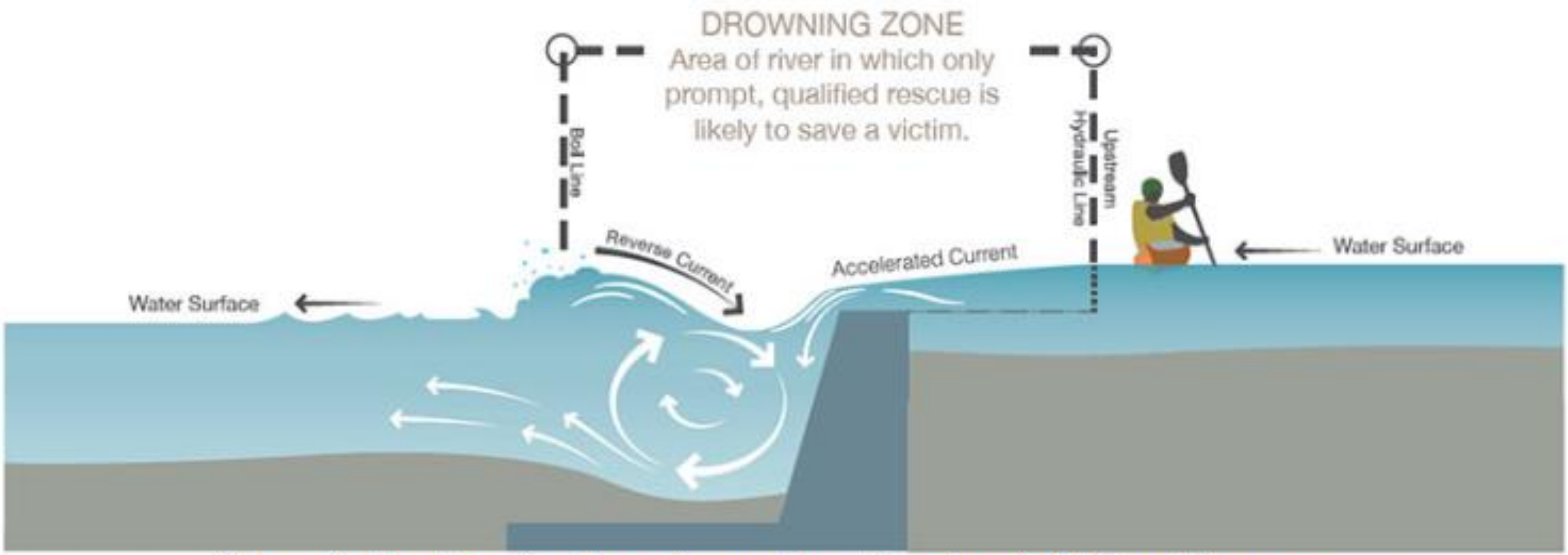
No Trespassing

Access Beyond This Point May Result In Drowning

Common Buoy Systems



Avoid Low Head Dams



Stay out of the Drowning Zone. Source: Iowa Department of Natural Resources

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Resources

- FEMA National Dam Safety Program webpage
- NRCS Earth Dams and Reservoirs TR–60
- ASDSO (damsafety.org)
- LADOTD Dam Safety Program
- damfailures.org

Photos Courtesy of Association of State Dam Safety Officials

Dam Safety Training Aids

Manuals		
Dam Safety Awareness	2 mb	8/10/2007
Dam Safety Process	881 kb	8/3/2007
Documenting and Reporting Findings from a Dam Safety Inspection	919 kb	8/3/2007
Evaluation of Concrete Dam Stability	987 kb	8/3/2007
Evaluation of Embankment Dam Stability and Deformation	4 mb	8/10/2007
Evaluation of Facility Emergency Preparedness	751 kb	8/10/2007
Evaluation of Hydraulic Adequacy	2 mb	8/8/2007
Evaluation of Hydrologic Adequacy	2 mb	8/10/2007
Evaluation of Seepage Conditions	2 mb	8/6/2007
How to Develop and Implement an Emergency Action Plan	557 kb	8/3/2007
How to Organize a Dam Safety Program	2 mb	8/10/2007
How to Organize an Operation and Maintenance Program	2 mb	8/10/2007
Identification of Materials Deficiencies	1 mb	8/10/2007
Identification of Visual Dam Safety Deficiencies	427 kb	8/8/2007
Inspection and Testing of Gates, Valves	3 mb	8/10/2007
Inspection of Concrete and Masonry Dams	1 mb	8/10/2007
Inspection of Embankment Dams	4 mb	8/10/2007
Inspection of Spillways and Outlet Works	1 mb	8/10/2007
Inspection of the Foundation, Abutments	1 mb	8/10/2007
Instrumentation for Embankment and Concrete Dams	4 mb	8/10/2007
Preparing to Conduct a Dam Safety Inspection	1 mb	8/10/2007

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Recent Failure in Mississippi

Archusa Lake Dam
Quitman, Mississippi
Failed July 16, 2023

https://youtu.be/ZR9grgbg93E

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QUESTIONS?

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