Flood Fighting and Surveillance

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US Army Corps of Engineers
BUILDING STRONG®

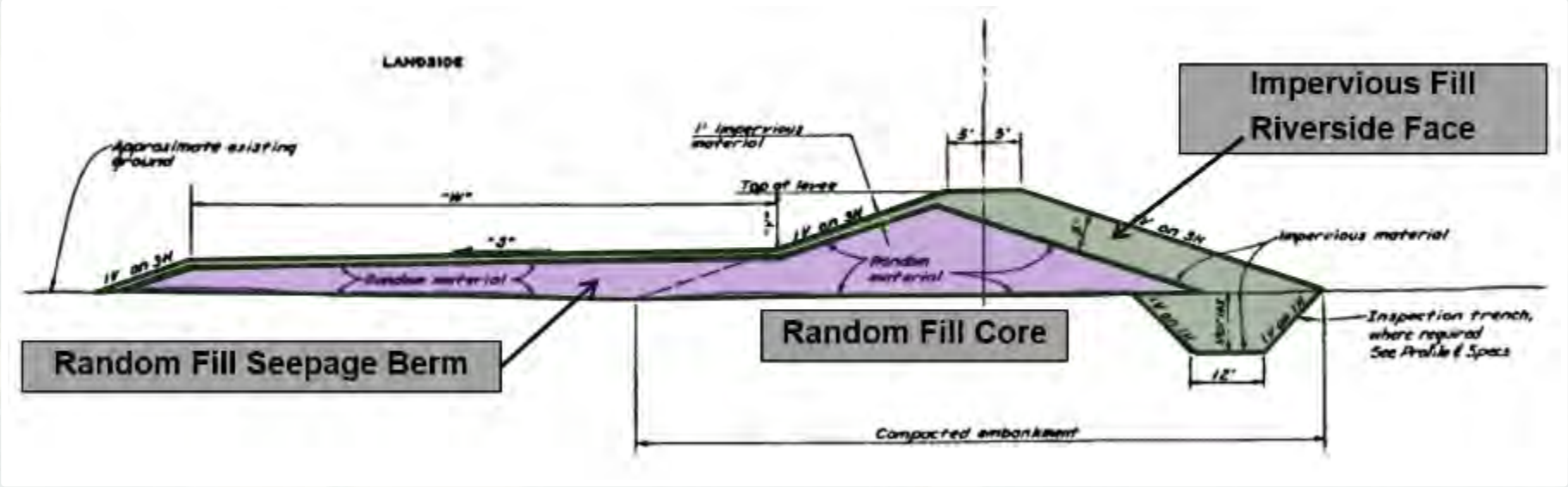
Agenda

- Levee Design
- Common Failure Modes
- Surveillance/Inspection
- Flood Fighting

Levee Design Issues

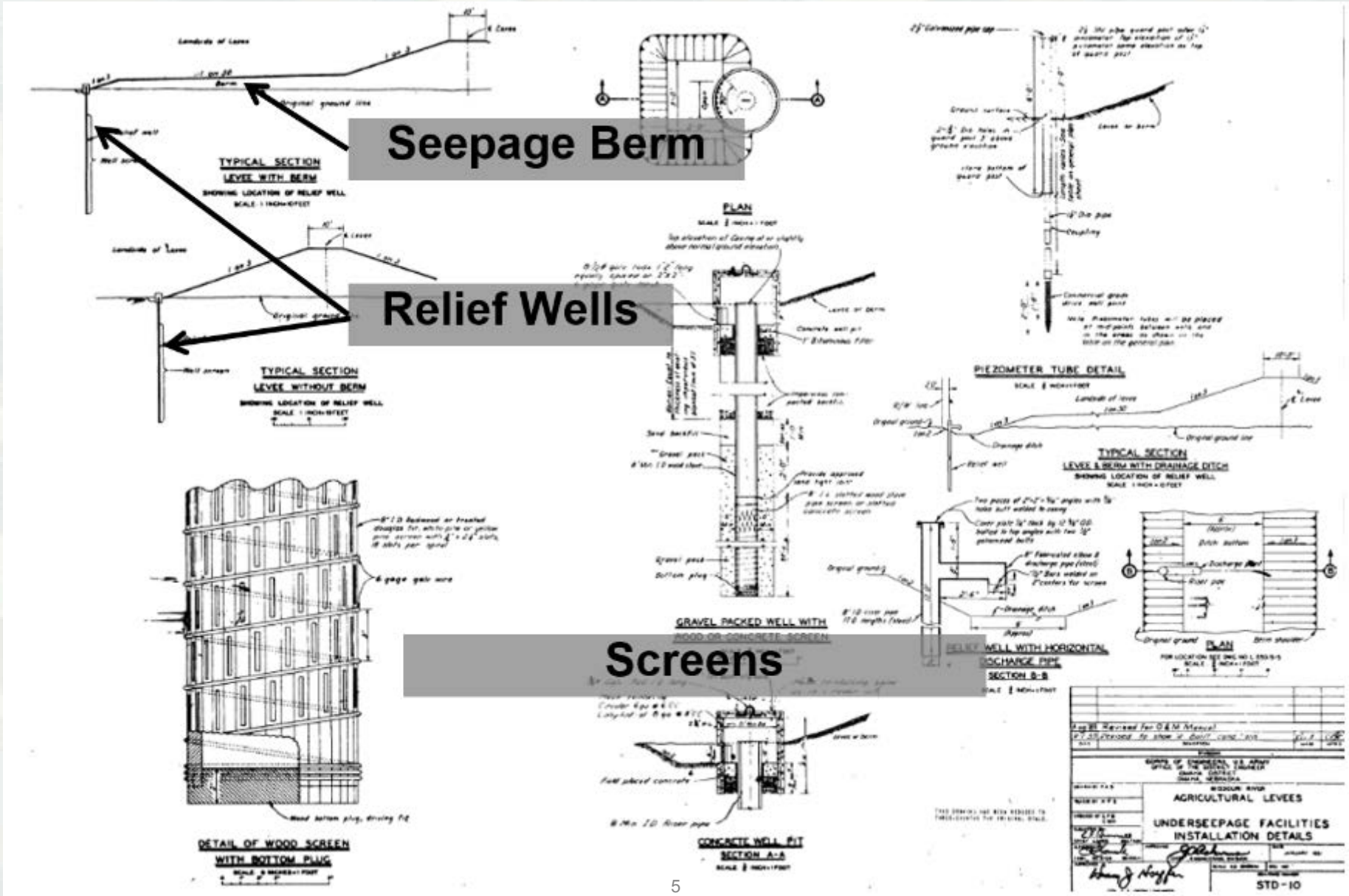
- Slope Stability
- Thru Seepage
- Underseepage
  - Critical Exit Gradient
  - Berm Weight
- Overtopping Resistance
- Streambank Erosion Protection

Levee Components

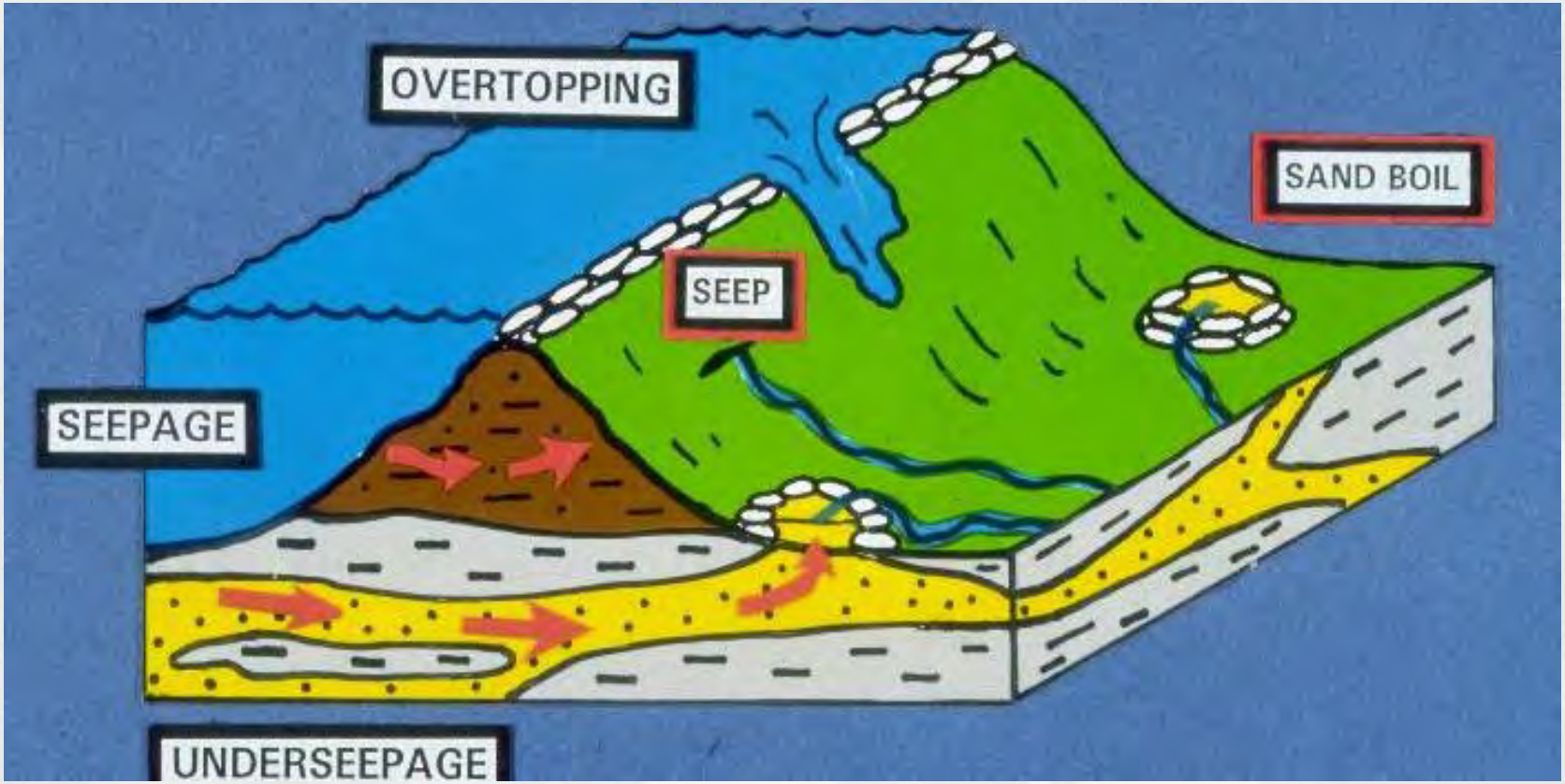


- Riverside Natural Blanket
- Riverside Riprap Protection
- Riverside Impervious Face and Cutoff
- Random Fill Core
- Landside Seepage Control Berm
- Topsoil and Vegetative Cover
- Landside Toe Drain and Relief Wells

Underseepage Control – Relief Wells



Failure Modes



- Overtopping
- Through Seepage/Piping
- Underseepage/Piping
- Slope Failure
- Riverside Erosion

Overtopping at Access Ramp
(June 17, 2011)

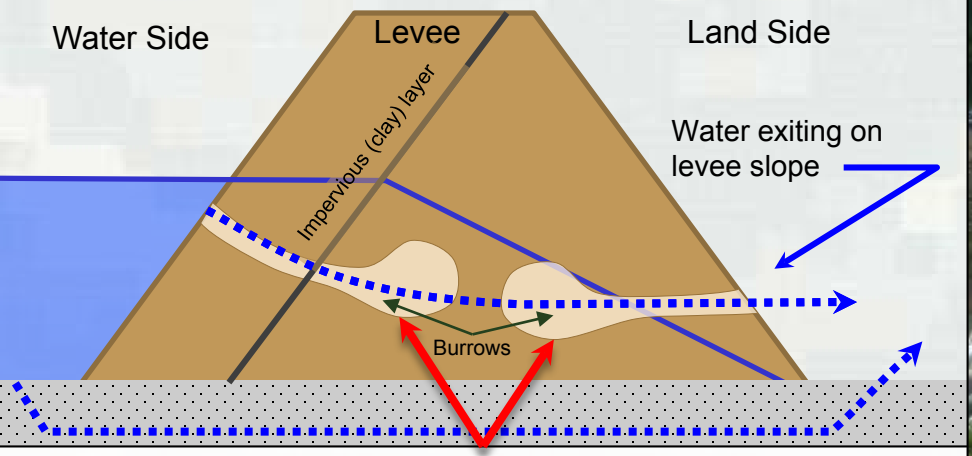
- Low spots created by traffic
  - Common to all levees
- Low spots created by levee foundation settlement
- Sand levee can not resist overtopping
- Clay levees are more resistant to overtopping but will eventually fail with sustained overtopping

L550 North of Hwy 136

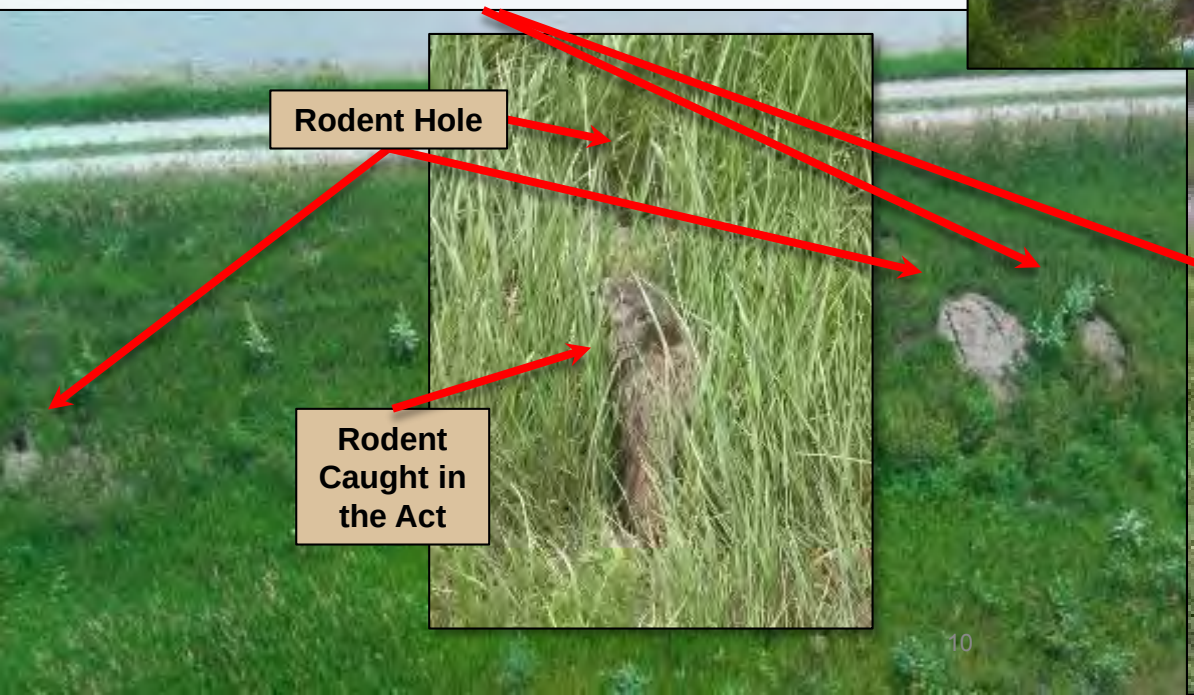
Contributing Factors for Through Seepage

- Lack of Clay Riverside Face on a Sand Levee
- Animal Holes
- Undocumented – non engineered levee penetrations
- Culvert Separations
- Culvert Pervious Bedding Exposed to River

Through Seepage/Piping



Animal Burrows - Beavers and Badgers



Failure Mode – Through Seepage/Piping

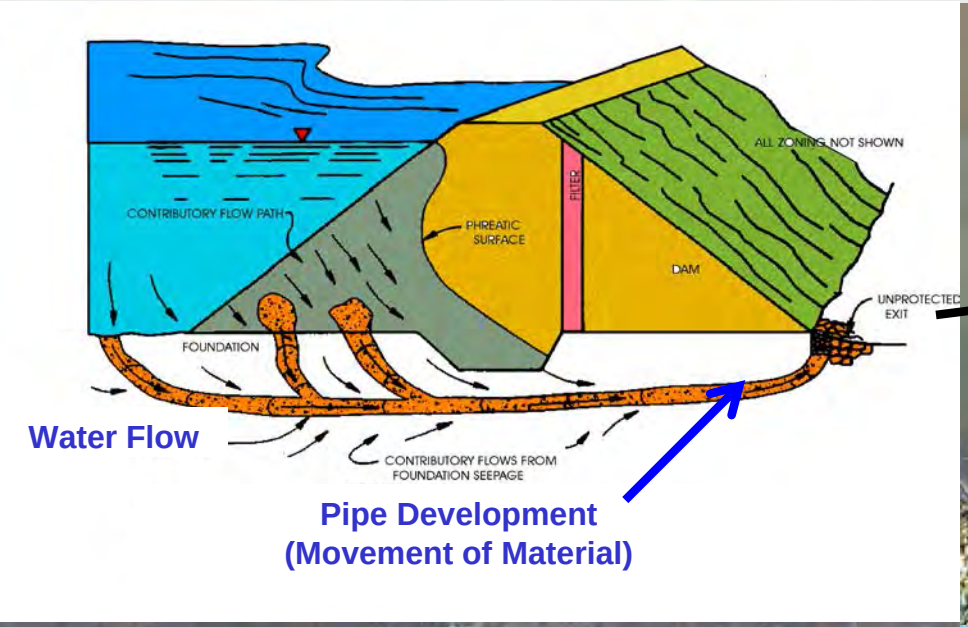
Drainage structures and other changes or transition areas (e.g., levee to floodwall) are potential weak points

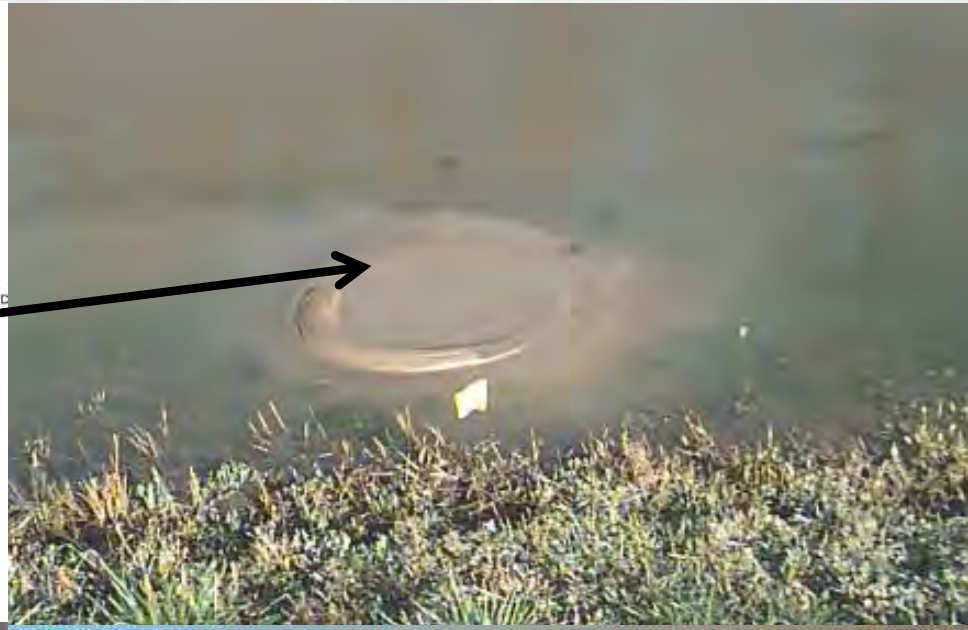
Failure Mode – Through Seepage/Piping

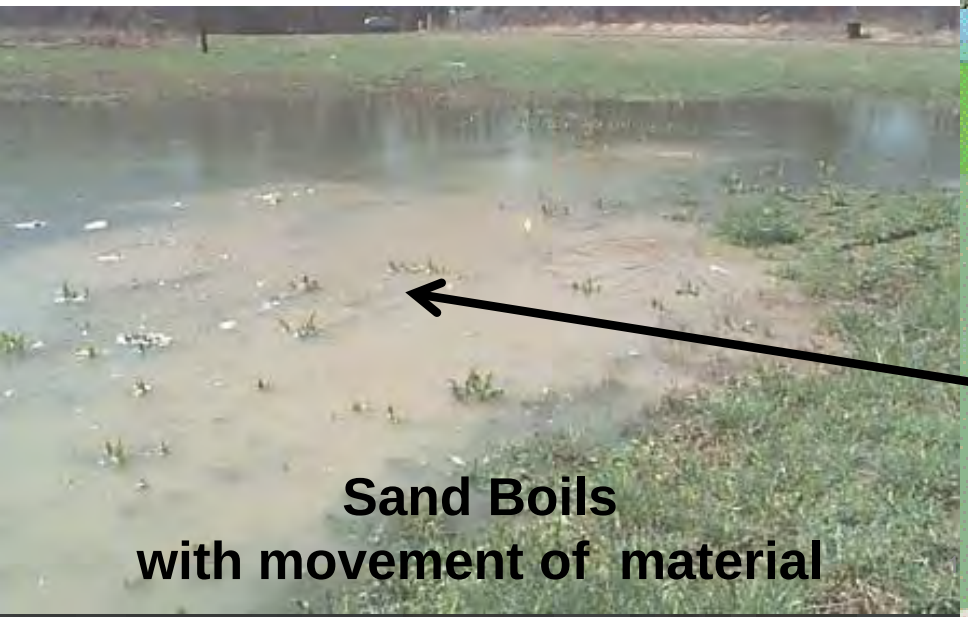
Contributing Factors for Under Seepage

- Geological cross section – Remnant River Meanders
- Lack of Riverside Natural Impervious Blanket
- Damaged blanket from erosion or manmade excavation
- Animal holes
- Encroachments – non engineered levee penetrations
- Encroachments – landside ditch excavations
- Encroachments – landside quarry excavations
- Inefficient relief wells and toe drains
- Historic levee loading
- Riverside erosion

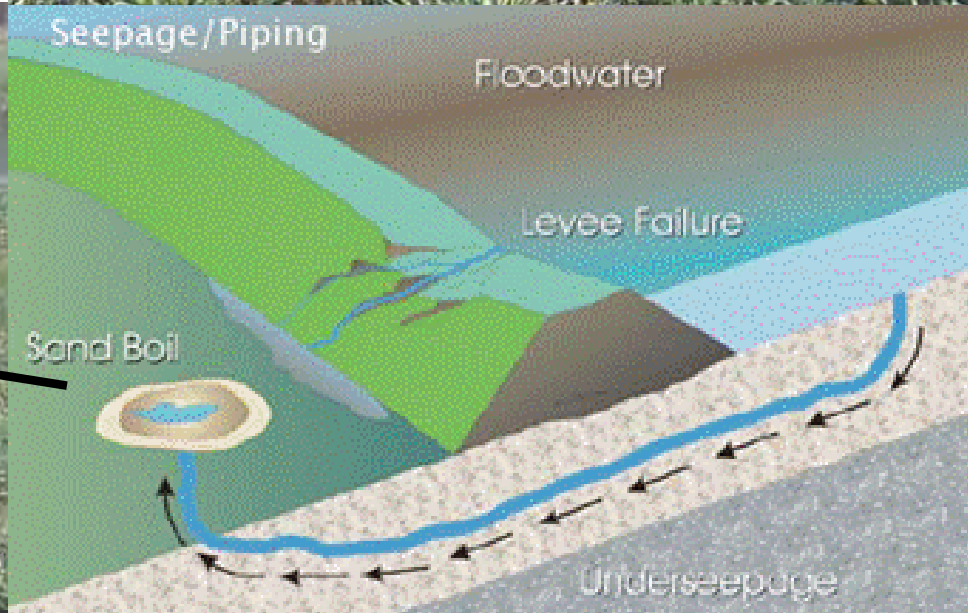
Underseepage/Piping







Sand Boils
with movement of material



Highway 2
(June 17, 2011)

Highway 2

Highway 2 – 3 Mile Setback

Highway 2

Erosion & Landside Sandboils at Riverside Ramps

Same Location - After Water Receded

L575

Riverside swirl - indicates seepage through levee

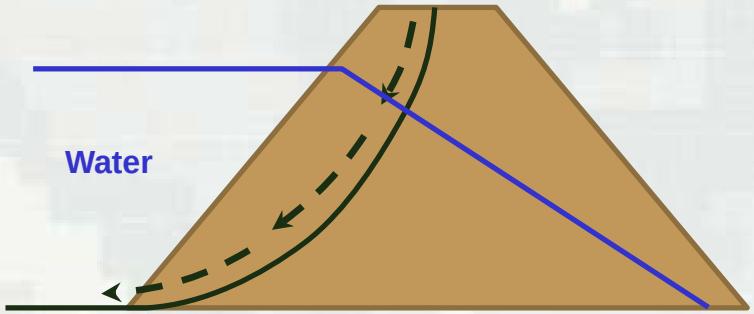
L575 - Landside of Riverside swirl

Water exiting after seeping through levee

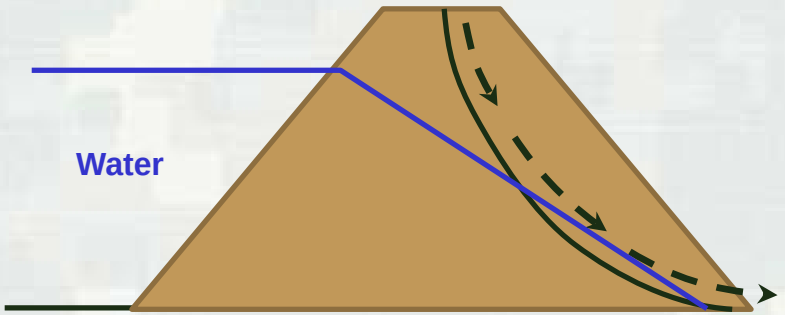
L575 - Levee collapses on itself

Cause by seepage through the levee

Failure Mode – Slope Failure



Riverside Slope Failure
***Most Common**



Landside Slope Failure

Failure Mode – Slope Failure

Areas of Potential Erosion

- Riverside levees
- Riverside ramps
- Riverside fences
- Historic Borrow Pits
- Levee Alignment
- Floodplain Geometry
- Trees

Corning and L536
(June 11, 2011)

L536 Corning Levee
(June 24, 2011)

Surveillance/Inspections

Flood Surveillance Teams

- Partnered for safety and efficiency
- Report to EOC
- Participate in pre and post day hand off meetings
- What is the current & forecasted flood situation
- Project Assignments

Surveillance References

- Drive the levee with the project sponsor
- Operations and Maintenance Manuals
- Annual Levee Inspections
- Periodic Inspections
- Project personnel
- Google Earth Historic and Recent Aerials

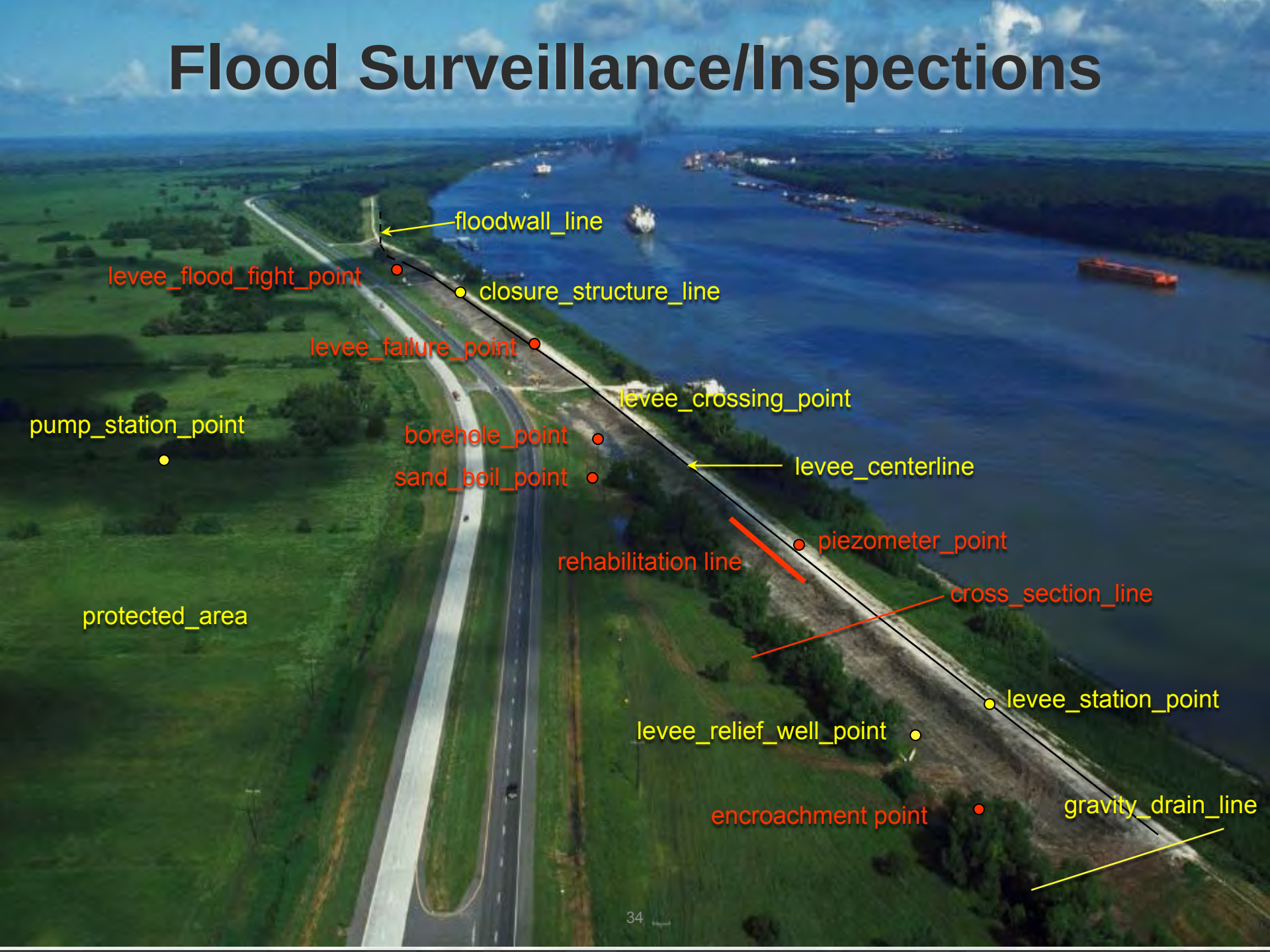
Surveillance Tools

- Cell phones
- Good project map
  - Know your evacuation routes
  - Know your nearest hospital location
- Get on a helicopter early in the process
- GPS cameras
- Rod and level
- Tape

Surveillance Tools

- Lathe
- Markers
- Flagging / Spray Paint
- Life Jackets
- Safety Vests
- Binoculars
- Flash Lights
- Food and Water

Flood Surveillance/Inspections



Surveillance Activities

- Know failure modes and indications of distress
- EARLY IDENTIFICATION OF DISTRESS IS CRITICAL TO EMERGENCY RESPONSE (Repairs or Evacuations)

Walk the Levee Crest and Riverside Toe

- Riverside Issues
  - Levee freeboard – read staff gages
  - Erosion
  - High Water Velocities / Turbulent Flows
- Crest Issues
  - Overtopping
  - Cracking / Slides

Walk the Levee Crest and Landside Toe

- Landside Sideslope
  - Thru Seepage / Piping
  - Rodent Holes
  - Crack / Slides
- Landside Toe and Adjacent Area
  - Sand boils / Piping
  - Slides
- Relief Wells and Toes Drains

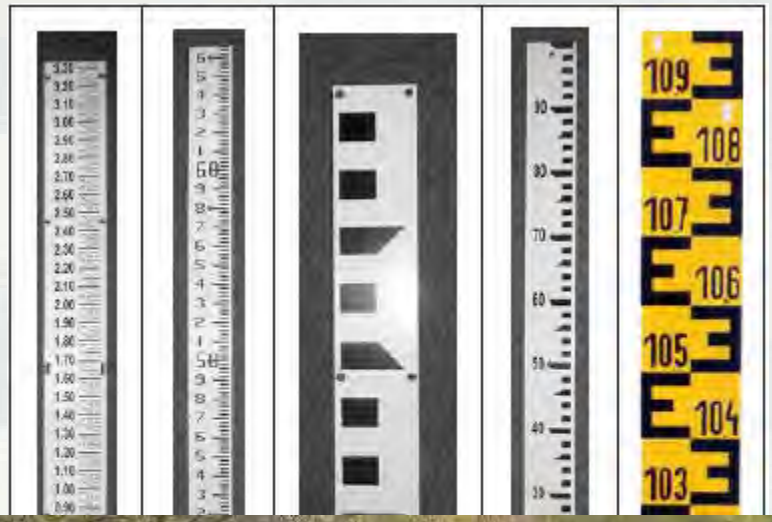
Documentation

- Document conditions in the field
  - Flagging, stakes, paint
  - Photos, videos, daily reports & checklists
- Proper handoff to next inspection team and upward reporting

- ***Ask for assistance***

Staff Gages

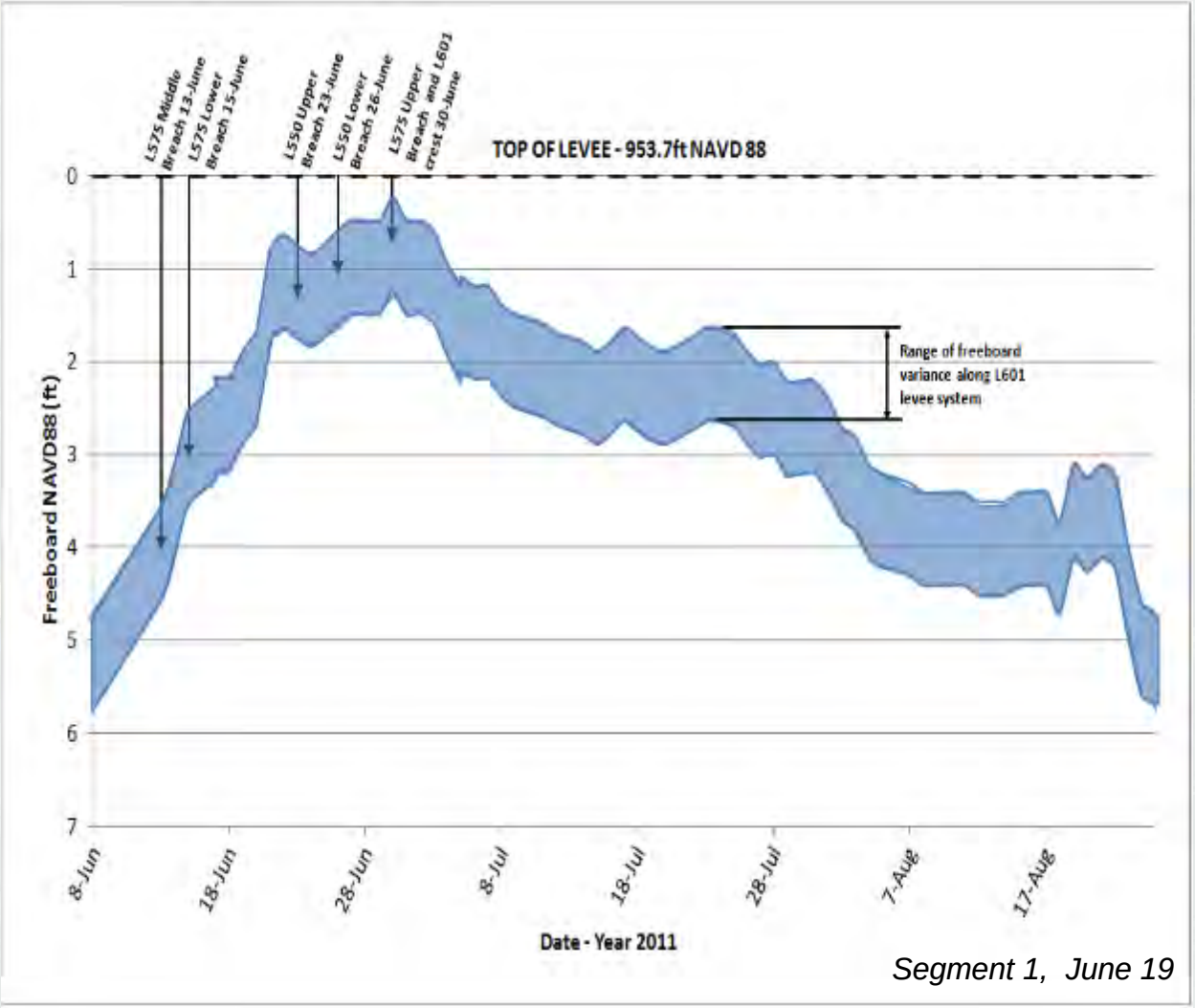
Is the water level going up or down?



Gage 1 - Just Downstream of Highway 1 Bridge			
Date	**Time**	**Reading**	**Water Level**
1-Apr	8:00	84.3	Increasing
1-Apr	12:00	84.8	
1-Apr	16:00	85.3	
1-Apr	20:00	85.7	
2-Apr	0:00	86.0	
2-Apr	4:00	86.1	
2-Apr	8:00	86.0	
2-Apr	12:00	85.9	Decreasing
2-Apr	16:00	85.6	
2-Apr	20:00	85.2	

is at a gage reading of 85.7
Top of water at this location

L-601 Missouri River Elevations



Segment 1, June 19

Mobile Information Collection Application – Flood surveillance

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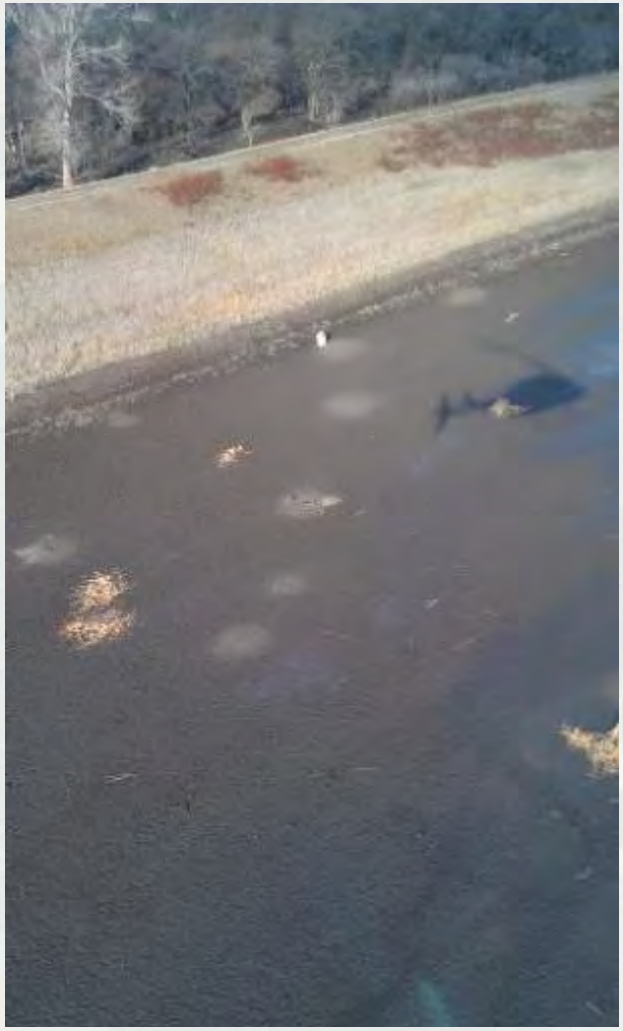
GPS Cell Phone – Flood surveillance



Flood Surveillance/Inspections

Underseepage-Boils
(Landside toe area primarily)

Flowing clear or moving material?

Flood Surveillance/Inspections

Slope Instability – Cracking

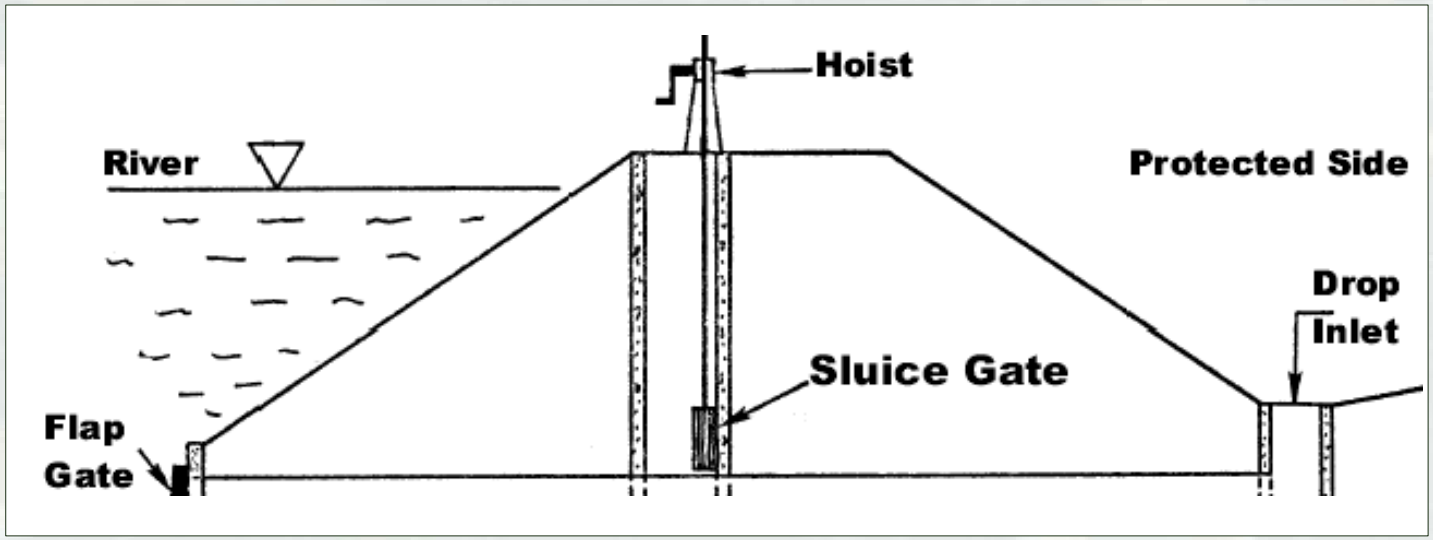
(Levee Crest Primarily)

Flood Surveillance/Inspections

Embankment Erosion

Flood Surveillance/Inspections

Drainage structure, sewers, & other penetrations



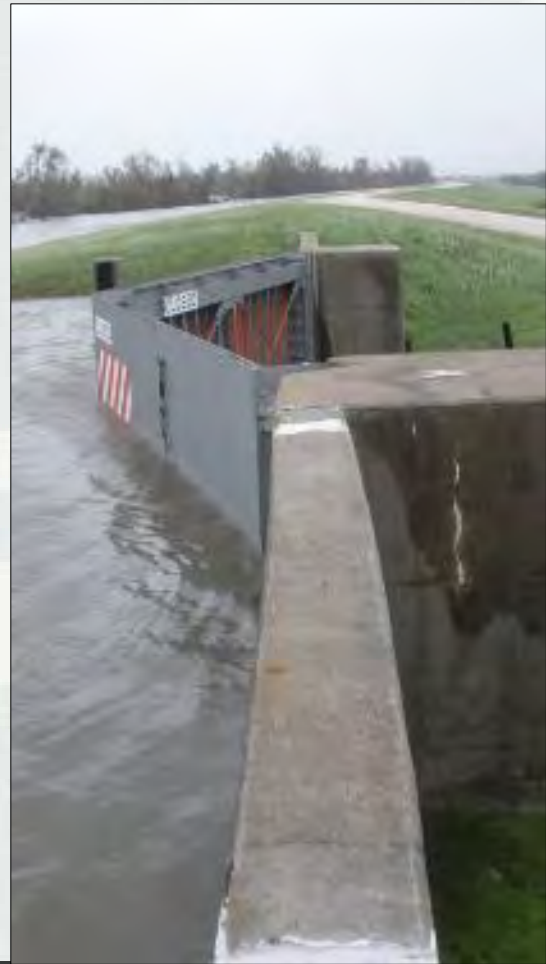
Flood Surveillance/Inspections
Drainage structure, sewers, & other penetrations

Emergency closure of culvert

Flood Surveillance/Inspections

Closure Structures

When do you erect the closure?
How long will it take?
Is it functioning properly?

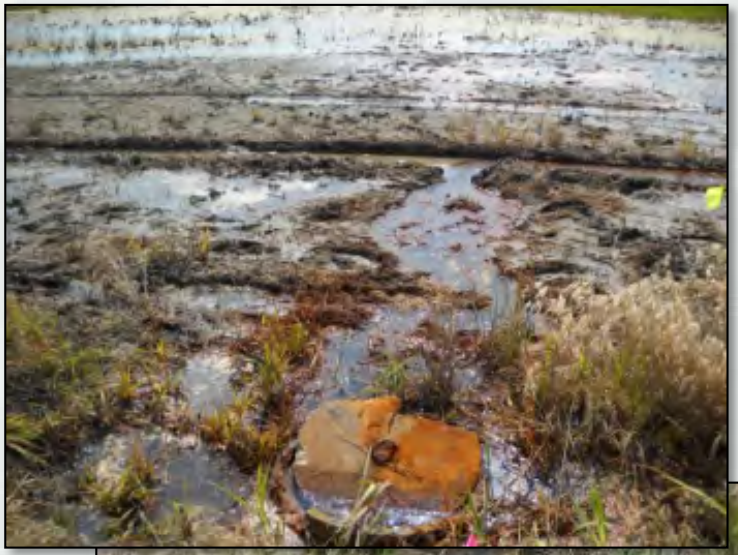


Flood Surveillance/Inspections

Relief Wells

Irrigation Well

Are they functioning?



Flood Fighting Equipment

Ryan Buckley

Emergency Management

February 2016

US Army Corps of Engineers
BUILDING STRONG®

Flood Fighting
What is the need and what are the options?

Need

- Sand Boils/Seepage
- Closure Structures
- Levee Raise
- New levee segments

Options

- Sandbags
- Earthen levees
- Innovative flood fight products
  - HESCO Bastions
  - RDFW
  - Portadam

Time & Place Each?
How much lead time and available resources?


Sandbags
HESCO Bastions
Earthen Levee

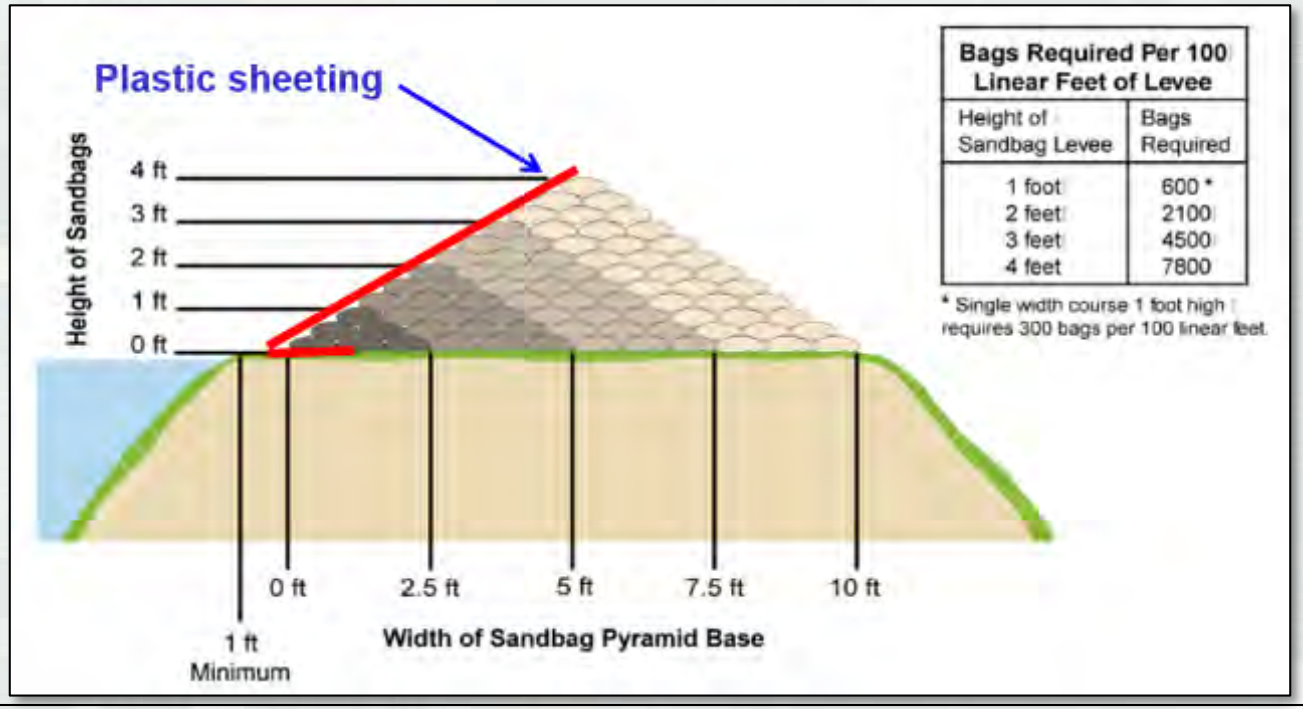
Treating Isolated Boils

- Ring boils if they are moving material
- Do not stop the water flow, it can cause the seepage path/boil to move

Notice Anything?

Sandbag Flood Structure

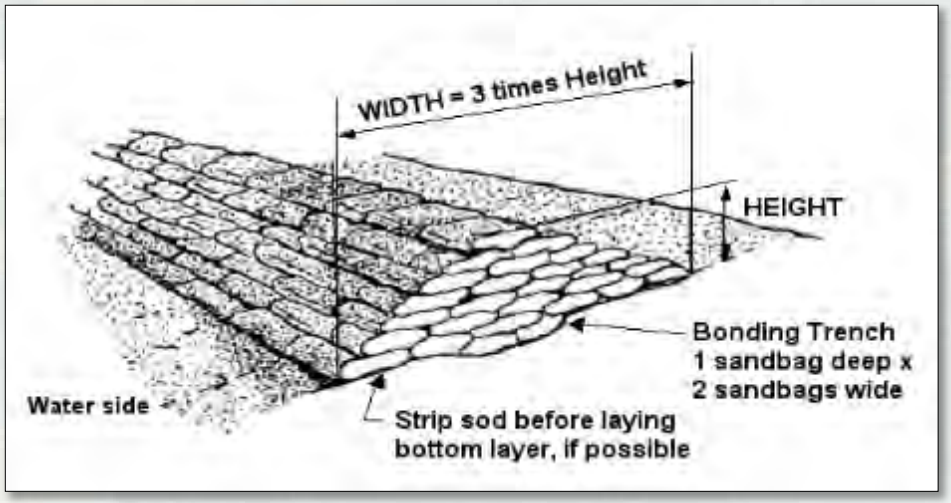
- USACE Recommendations
  - 1V:3H (1 foot high for 3 foot width)
  - 5 foot max (3 foot or less preferred)
- Typical used for low/short barrier, transitions, constricted areas, closures & around sand boils

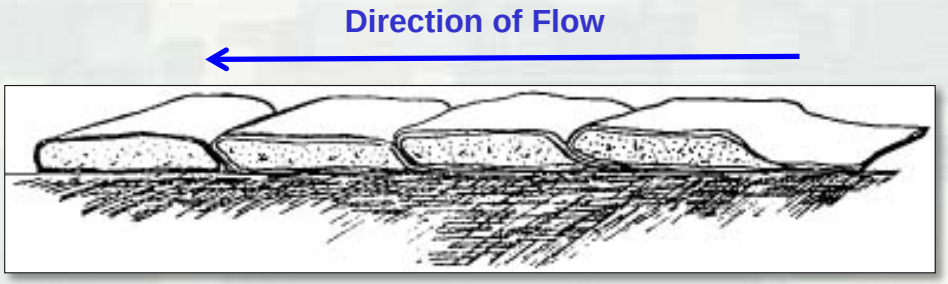


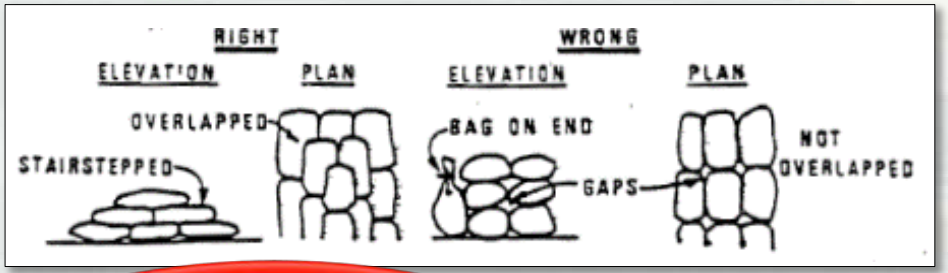
Bags Required Per 100 Linear Feet of Levee	
Height of Sandbag Levee	Bags Required
1 foot	600 *
2 feet	2100
3 feet	4500
4 feet	7800

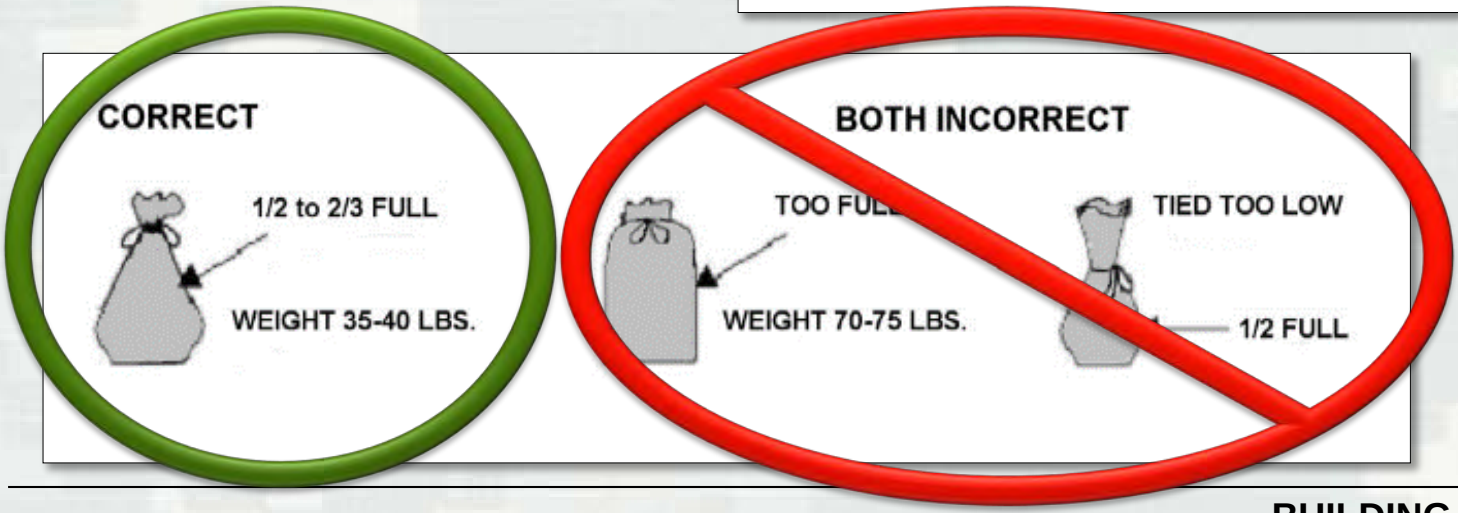
* Single width course 1 foot high requires 300 bags per 100 linear feet.

Sandbag Flood Structure









Sandbag Flood Structure

- Very labor intensive
- Filled sandbags must be kept from freezing prior to placement

Sandbag Flood Structure

Earthen Levees

HESCO Bastion Structure

Rapid Deployable Flood Wall (RDFW) Structure

Portadam Structure

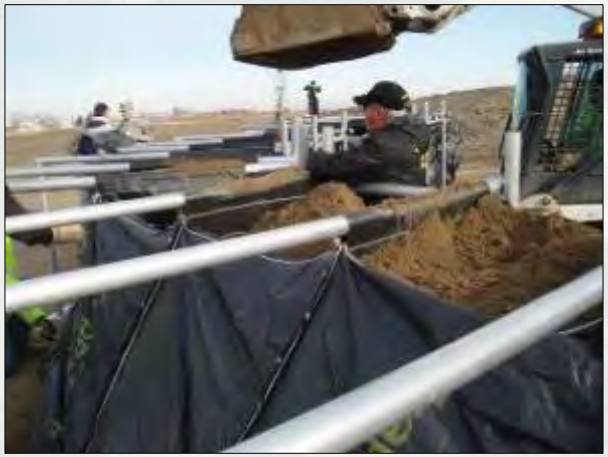
TopoTube

http://www.topocare.com/en/onshore.html

HESCO JackBox

Big Bags USA

TrapBag Structure



DefenCell

www.defencell.com/environmental_flood_protection.html

Combinations/Transitions

RDFW to Earthen Levee

RDFW & Sandbags

Sandbags to Earthen Levee

HESCO, RDFW & Sandbags

Transition Concerns?

Flood Fight Supplies

- Sandbags throughout the District
- Super Sandbags
- Portadam
- RDFW
- Hesco
- Rolls of Poly
- Sandbag filling machines
- Trailer-mounted pumps

QUESTIONS?

402-995-2448

www.nwo.usace.army.mil/Missions/EmergencyManagement.aspx