FLOOD FIGHTING AND SURVEILLANCE

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AGENDA

- LEVEE DESIGN CONSIDERATIONS
- COMMON FAILURE MODES
- SURVEILLANCE/INSPECTION
LEVEE DESIGN CONSIDERATIONS

- Overtopping Resistance
- Through Seepage
- Underseepage
- Slope Stability
- Streambank Erosion Protection
Random Fill or Clay Core

Through Seepage Control:
• Compacted Clay Riverside Face

Underseepage Control
• Cutoff Trench
• Landside Underseepage Berm
• Relief Wells and Toe Drains

Erosion Control:
• Topsoil and Vegetative Cover
• Riprap Erosion Control – River Bank and Levee Face
**UNDERSEEPAGE CONTROL – RELIEF WELLS**

**Seepage Berm**

Intended to provide a controlled method to relieve high underseepage pressures without piping foundation materials. Located at toe of berm or levee.

**Relief Wells**

**Screens**

Screen slot sizes and the gravel pack are designed to prevent the movement of foundation materials into, and clogging, the RW.
POTENTIAL FAILURE MODES

- Overtopping
- Through Seepage/Piping
- Underseepage/Piping

OVERTOPPING

SEEP

SEEPAGE

UNDERSEEPAGE

- Overtopping
- Through Seepage/Piping
- Underseepage/Piping

SAND BOIL

- Slope Failure
- Riverside Erosion
**OVERTOPPING**

- Common locations for overtopping:
  - Low areas created by vehicle traffic such as access ramps
  - Low areas created by post-construction foundation settlement

- Levees with sand cores will not resist much overtopping

- Levees with clay cores are much more resistant to overtopping but will eventually fail with sustained overtopping
OVERTOPPING  (R613 AND R616 SAND BAG LEVEE RAISES)
OVERTOPPING (L550 – NORTH OF HWY 136)
THROUGH SEEPAGE
CONTRIBUTING FACTORS INCLUDE:

• Areas with a Thin Compacted Clay Layer on the Riverside Slope – Sand Core Levees

• Animal Burrows that Extend Through the Compacted Clay Layer

• Levee Penetrations

• Culvert Joint Separations
THROUGH SEEPAGE / PIPING

Water Side
Levee
Inertious (clay) layer
Burrows

Land Side
Water exiting on levee slope

Animal Burrows - Beavers and Badgers

Rodent Hole

Rodent Caught in the Act
Conduits (drainage structures / pump stations / utilities), or other levee penetrations (e.g., floodwalls) can create potential weak areas in a levee. Due to compaction difficulties, there is the potential for seepage and piping of embankment material along exterior of conduits, or into conduit joint separations.
PIPING AT LEVEE PENETRATIONS

L624-627 – INDIAN CREEK

DESIGN APPROVED: 2014
CONST. COMPLETE: FALL 2015
SINKHOLES IDENTIFIED: SPRING 2016
THROUGH SEEPAGE / PIPING
Geological cross section – Historic River Meanders
Lack of an Adequate Riverside Natural Blanket
Lack of an Adequate Landside Natural Blanket (Thickness and/or composition)
Damaged Blanket from Erosion
Damaged Blanket from Encroachments – Riverside or Landside Excavations for Drainage Ditches, Borrow Site Locations, Quarries, Building Foundations, etc.
Inefficient Relief Wells or Toe Drains
UNDERSEEPAGE / PIPING

Sand Boils with movement of foundation material

Pipe Development (Movement of Material)

Sand Boil

Water Flow

Seepage/Piping

Floodwater

Levee Failure
Sand Boils
UNDERSEEPAGE / PIPING (L550)
SLOPE FAILURES

Landslide Slope Failure

Riverside Slope Failure
*Most Common

Note stakes and flagging
SLOPE FAILURES
RIVERSIDE EROSION
AREAS OF CONCERN

- Riverside Ramps
- Riverside Levees
- Riverside Fences
- Historic Borrow Pits
- Levee Alignment / Floodplain Geometry
- Trees / Restrictions
STREAMBANK EROSION
(L575 – NISHNABOTNA RIVER)
SURVEILLANCE / INSPECTIONS
IN-HOUSE FLOOD SURVEILLANCE TEAMS

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

- Operations and Maintenance Manuals
- Annual Levee Inspections
- Periodic Inspections
- Google Earth Historic and Recent Aerials
- USACE Project Personnel
- Meet with the Project Sponsor
SURVEILLANCE TOOLS

• Cell phones
• Good Project Maps
  • Know your evacuation routes.
  • Know your nearest hospital location.
• Aerial Reconnaissance
  (Get on a helicopter whenever possible)
• GPS Cameras
• Rod and Level
• Measuring Tape
**SURVEILLANCE TOOLS**

- Lathe
- Markers
- Flagging / Spray Paint
- Life Jackets
- Safety Vests
- Binoculars
- Flash Lights
- Food and Water
- Bug Spray
- Sun Block
Flood Surveillance / Inspections

Riverside Slope & Levee Crest

- **Riverside Issues**
  - Levee freeboard – read staff gages
  - Erosion
    - High Water Velocities / Turbulent Flows
    - Penetrations

- **Crest Issues**
  - Overtopping
  - Cracking / Slides
Flood Surveillance/Inspections

Landslide Slope & Landslide Toe

- **Landslide Slope Issues**
  - Through Seepage / Piping
  - Rodent Holes
  - Depression at Structures
  - Crack / Slides

- **Landslide Toe and Adjacent Area**
  - Sand boils / Piping
  - Drainage Ditches
  - Slides

- **Relief Wells**
  
  Location
  
  Flow
  
  Boils
FLOOD SURVEILLANCE/INSPECTIONS

STAFF GAGES

Is the water level going up or down?

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<th>Date</th>
<th>Time</th>
<th>Reading</th>
<th>Water Level</th>
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<td>8:00</td>
<td>84.3</td>
<td>Increasing</td>
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<td>12:00</td>
<td>84.8</td>
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<td>16:00</td>
<td>85.3</td>
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<tr>
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</table>

Is at a gage reading of 85.7
Top of water at this location
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
DRAINAGE STRUCTURES, SEWERS, OR OTHER PENETRATIONS

- River
- Hoist
- Protected Side
- Flap Gate
- Sluice Gate
- Drop Inlet
FLOOD SURVEILLANCE/INSPECTIONS

CLOSURE STRUCTURES – ROADWAYS / RAILROAD CROSSINGS

Types: Swinging gates/frames-panels/earth berms/sand bags
When are they erected?-O&M Manual (River Stages, Weather Forecasts)
Surveillance - Monitor for Seepage
FLOOD SURVEILLANCE/INSPECTIONS

RELIEF WELLS/TOE DRAINS

Are they functioning?
(Monitor for Flow and Adjacent Boils)

Irrigation Well
DOCUMENTATION

- Document Conditions in the Field
  - Flagging, stakes, paint
  - Photos, videos
- Prepare Daily Reports
- Discuss issues to USACE Management and Levee Sponsors
- Post-flood Project Information Report (PIR) and Levee Repairs
QUESTIONS?