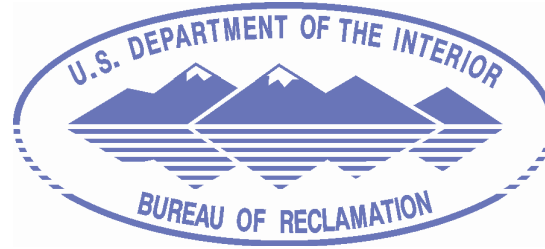


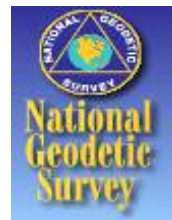


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Interagency Performance Evaluation Task Force (IPET)

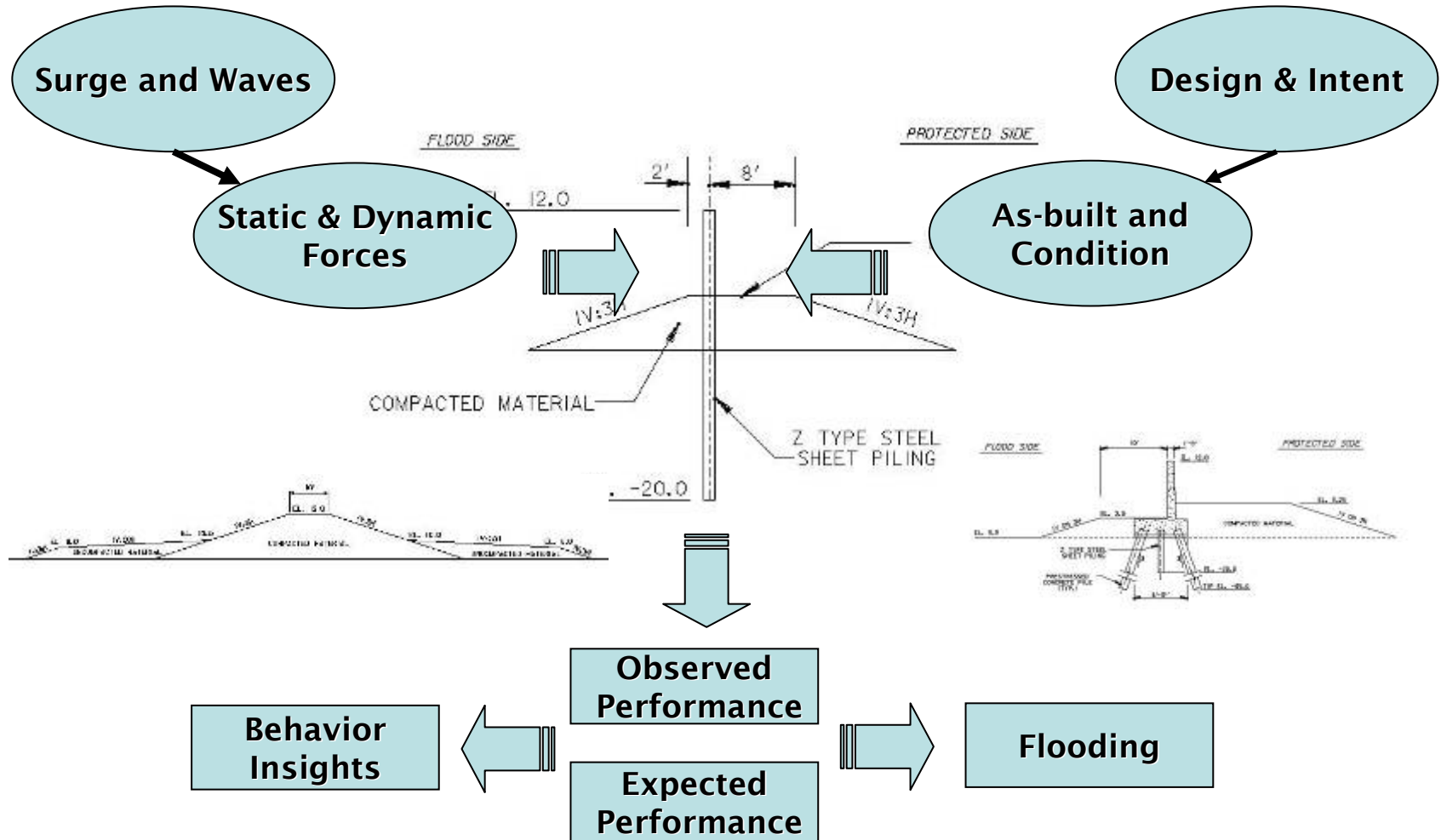
Floodwall and Levee Performance Analysis





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Physical Performance Analysis





Floodwall and Levee Performance Analysis

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Objective

- **Analyze the levees and floodwalls performance during Hurricane Katrina**
- **Investigate the most likely causes of the damage and failure of the levees and floodwalls in the system**
- **Compare them with similar sections or reaches where the performance was satisfactory**
- **Understand mechanisms that led to the breaches along a reaches in order evaluate the potential performance of the similar un-breached reaches of the protective system**



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Floodwall and Levee Performance Analysis

Approach

- **Conduct a comprehensive assessment of the background information**
 - **Geology of the area**
 - **Geological conditions along the system**
 - **History of the construction**
 - **Design criteria and approach**
 - **Actual design documents, the as-built drawings and inspection and maintenance records.**



Floodwall and Levee Performance Analysis

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Approach (continued)

- **Examine entire levee system to identify areas or reaches that have performed satisfactory and those that have suffered damage**
- **Characterize damage areas or reaches based on the type of damage, the surge height and the wave action**



Floodwall and Levee Performance Analysis

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Approach (continued)

- **Select breaches will be analyzed separately in detail to ensure that no important site conditions or breach mechanisms are overlooked**
- **All potential failure possibilities and mechanisms will be considered and evaluated**



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Floodwall and Levee Performance Analysis

Work Plan

- **Data Collection and Assessment**
- **Assessment of Field Evidence**
- **Define Soil Profile**
- **Material Characterization**
- **Conventional Analyses**
- **Numerical Modeling**
- **Comparison to Physical Model**
- **Comparison to Failure Evidence**



Floodwall and Levee Performance Analysis

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Computer Codes

- **Limit equilibrium analyses:**
 - *UTEXAS4.*
 - *SLIDE v5.0.*
 - *CSHTWAL*
- **Soil-structures interaction analyses:**
 - *SAGE* (Finite Element Program for Static Analysis of Geotechnical Engineering Problems)
 - *FLAC2D/3D* (Fast LaGrangian Analysis of Continua)
 - *PLAXIS/3D* (Finite-Element Code for Soil and Rock Analysis)
- **Seepage analysis:**
 - *SLIDE, SAGE, PLAXIS, and FLAC*

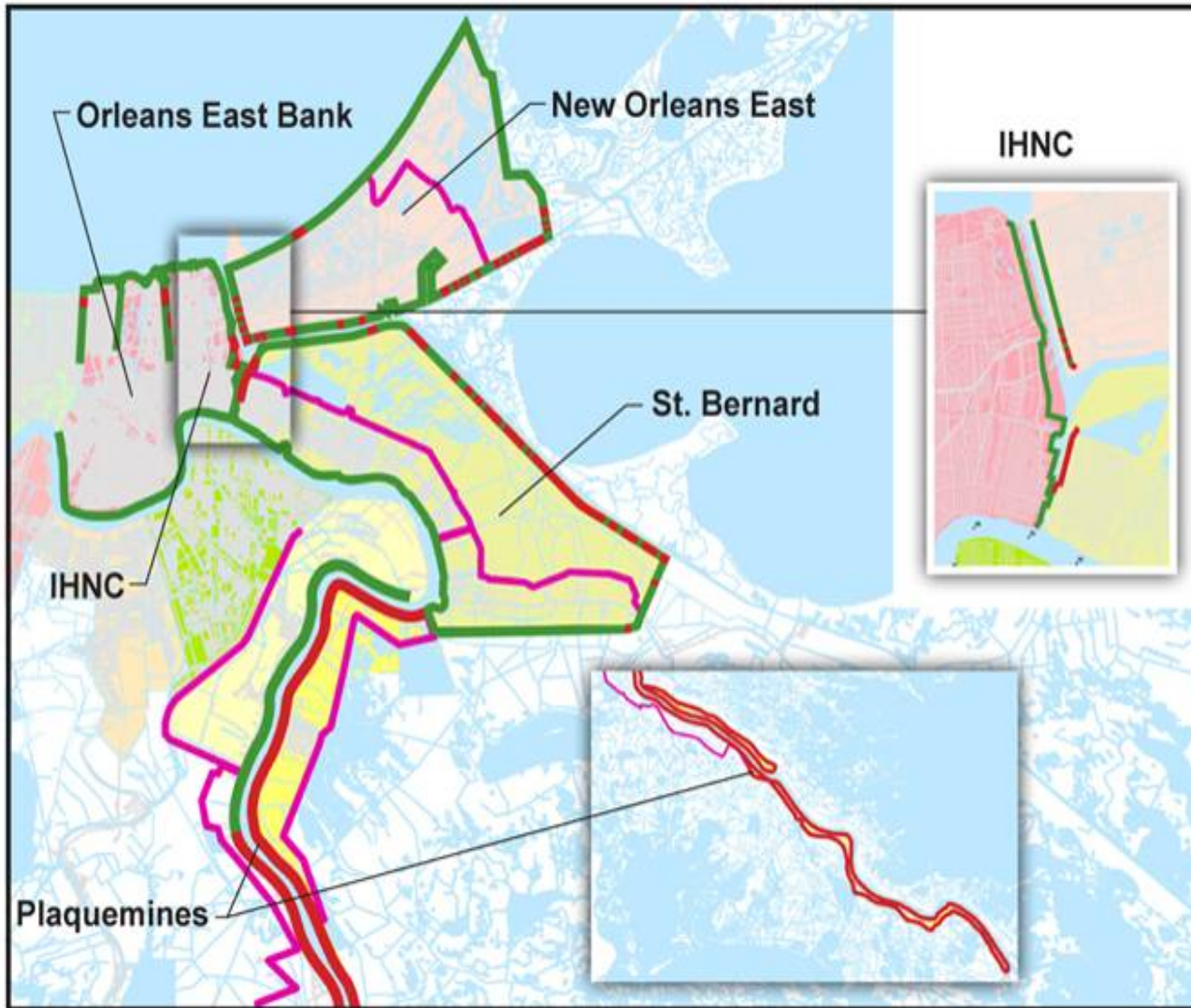


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Status

Floodwall and Levee Performance Analysis

Impacted Area



US Army Corps of Engineers,
New Orleans District

Local Authorities

- Louisiana DOTD
- Port of New Orleans
- Lake Borgne Basin Levee District
- N.O. Sewerage and Water Board
- Orleans Levee District
- Plaquemines Parish Government
- St. Bernard Parish Government

Hurricane Protection System

- 284 miles: Federal levees/floodwalls
- 71 pump stations

Damage

- 169 miles: Federal levees/floodwalls
- 34 pump stations

- Damaged
- No Significant Damage
- Non-Federal Levee



Floodwall and Levee Performance Analysis

**US Army Corps
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Types of Damage

- **Overtopping of Floodwalls**
- **Overtopping of Levees**
- **Non-Overtopping Breaches**
- **Transitions, Closures, Levee and Wall Penetrations**
- **Piping**



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Assessment of Entire System

Selection For Detailed Analysis

- **Walls that failed (category WF)**
- **Walls that were close to failure, indicated by permanent deflection (WCF)**
- **Walls that are stable, with no permanent deflection (WS)**
- **Levees that overtopped and breached (LOB)**
- **Levees that overtopped and did not breach (LONB)**
- **Levee under seepage locations (LU)**
- **Failures at transitions between different types of flood protection structures (TF)**



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17th Street Canal Breach



17th Street Canal Breach



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17th Street Slide Block





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CPT and Soil Borings





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Determine Soil Properties for Use in Analysis



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Borings in the vicinity of the 17th Street canal failure



Legend
● COR/Borings
● Her-Earth_Vibrat_TRL_W
● KROG_Vib_Mon_Pnt/Borings





Borings in the vicinity of the London Avenue canal North failure

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Legend

- ERDC_London_borings_and_cones
- GENM_London_borings
- Everts_Capport_borings

SCALE 1:1,000





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Borings in the Vicinity of the London Avenue canal Sorth failure





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Soil Properties Database



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17th Street Canal



London Avenue Canal

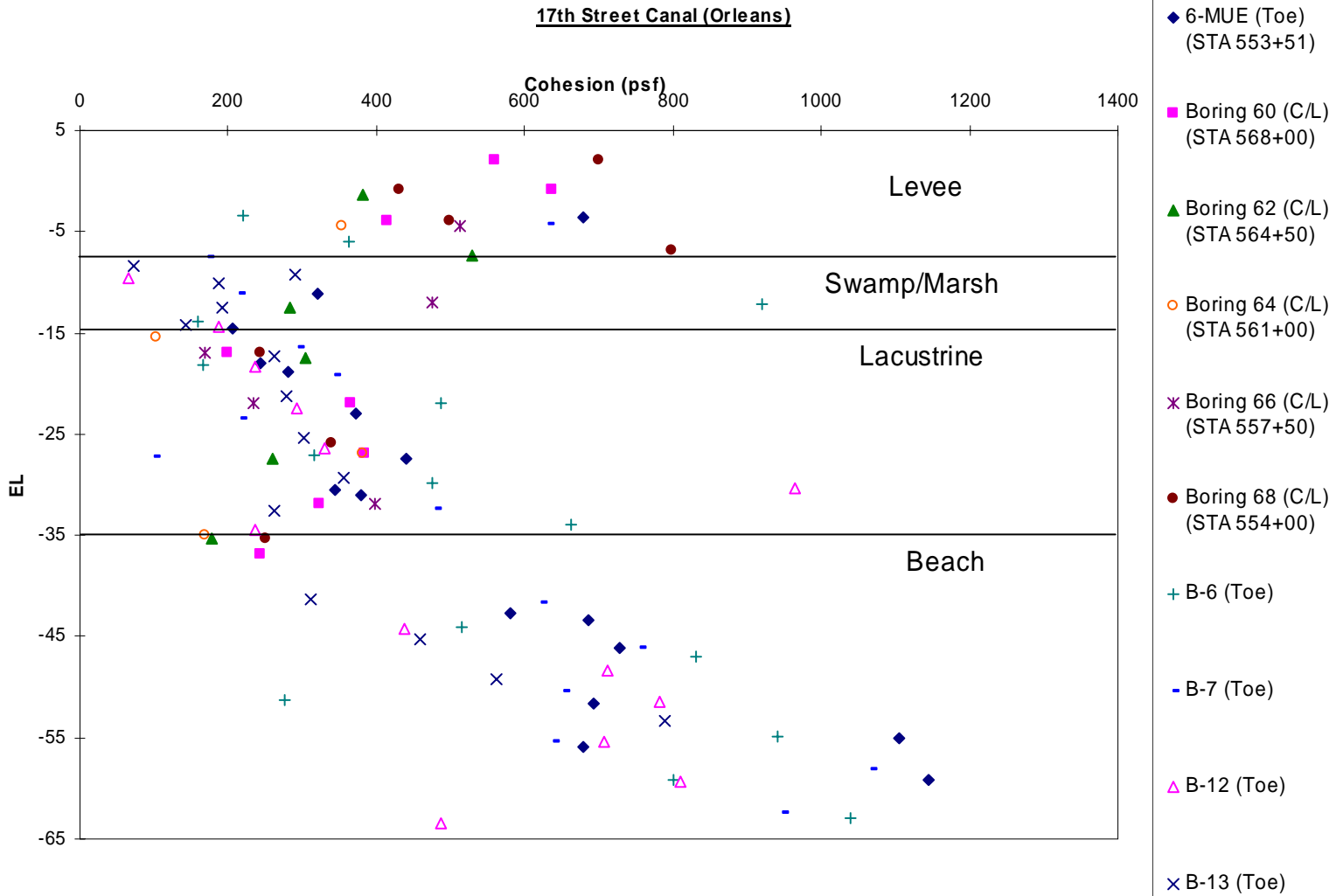


- Currently complete for 17th Street Canal & London
- Scheduled for IHNC, Orleans, MS River Levees



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Undrained Shear Strength





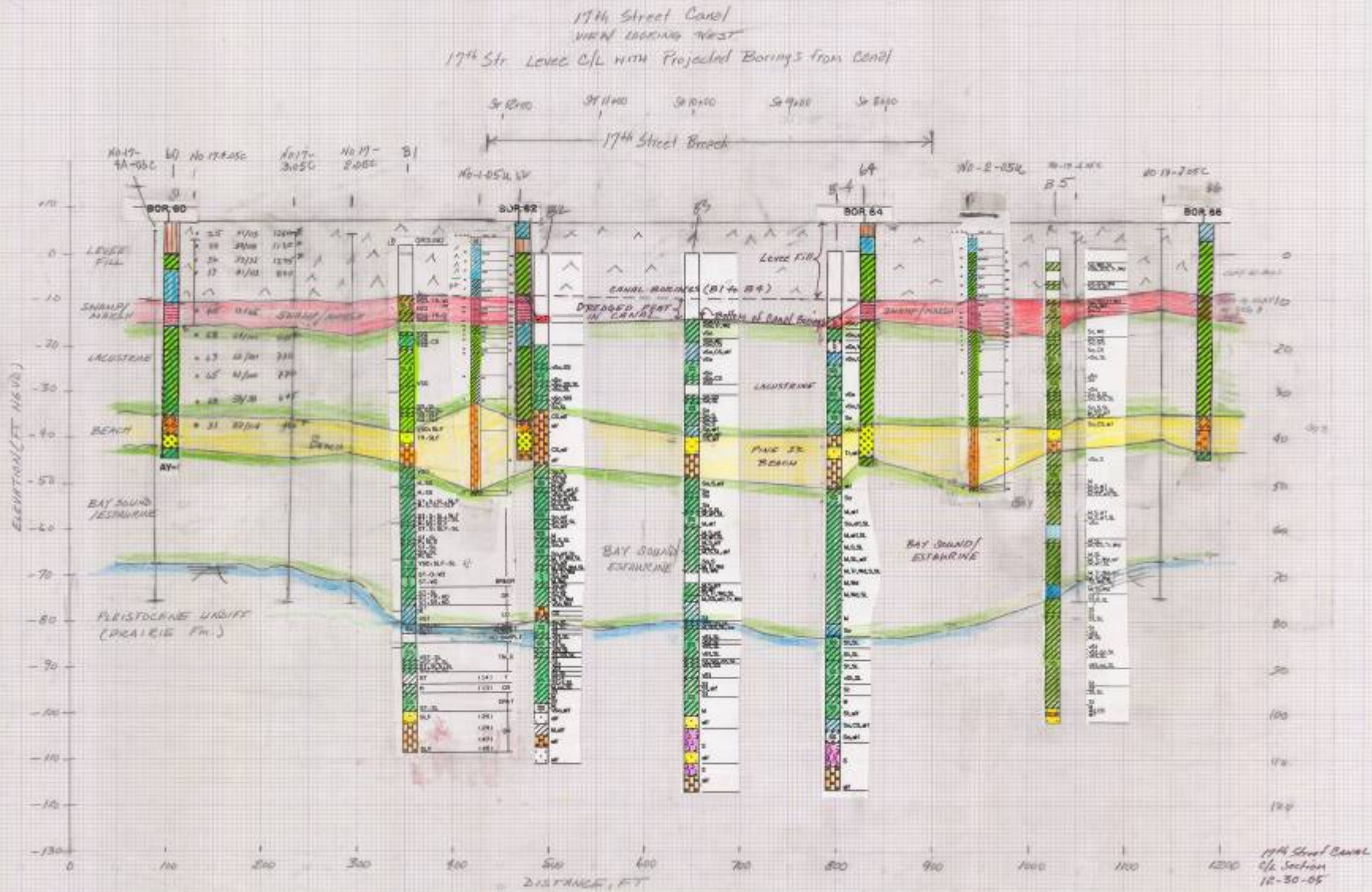
**US Army Corps
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Cross-Sections & Soil Profiles for Use in Analysis



17th Street Canal C/L Failure Section

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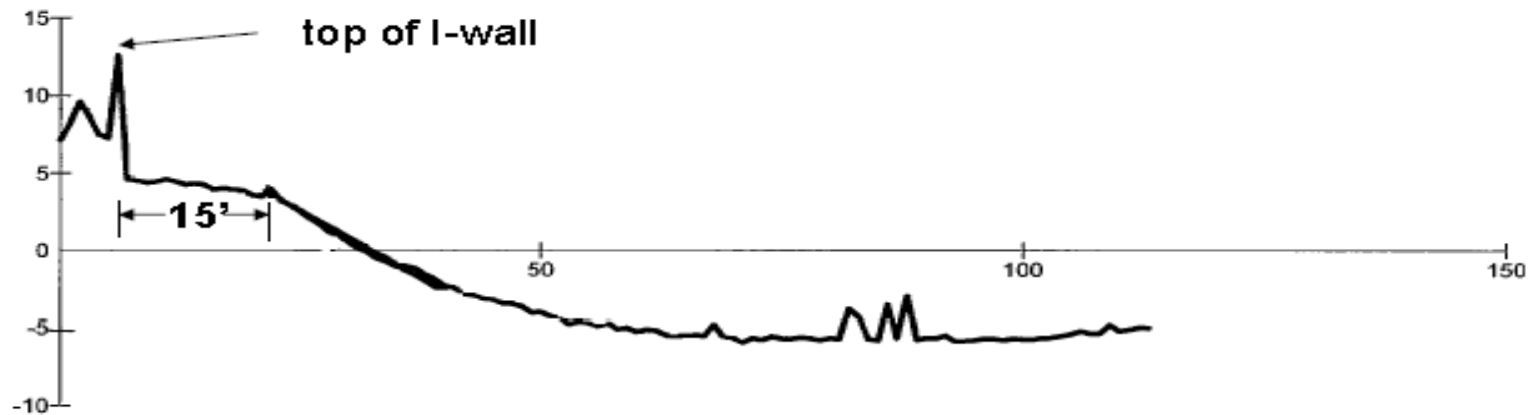




Verification of As-Built Conditions

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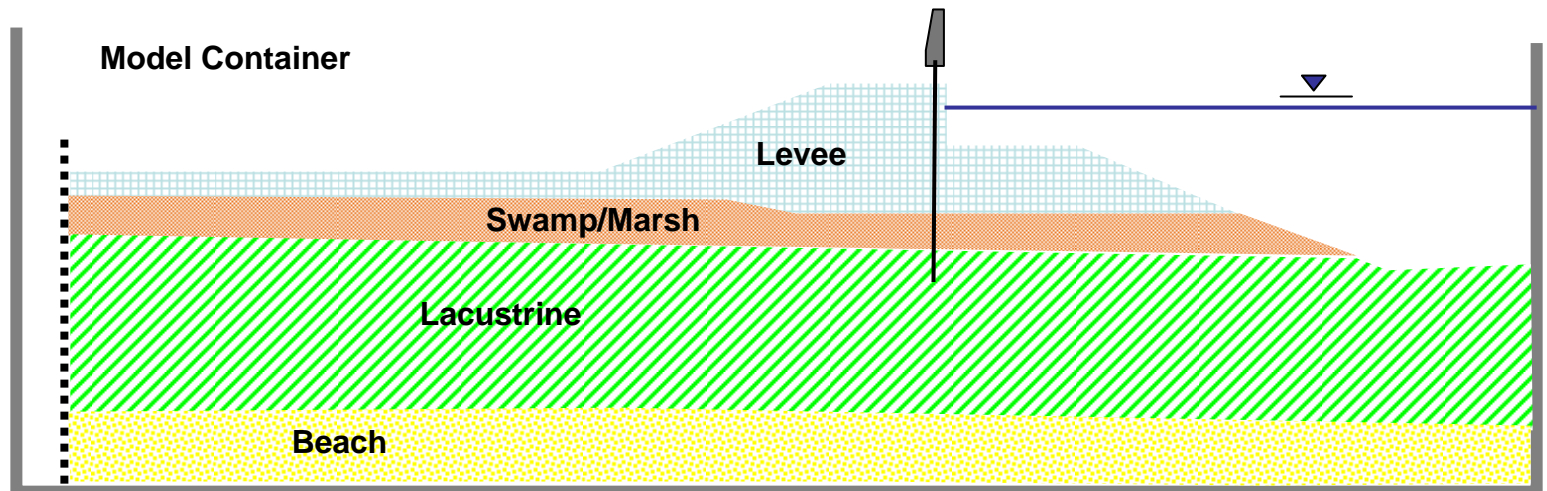
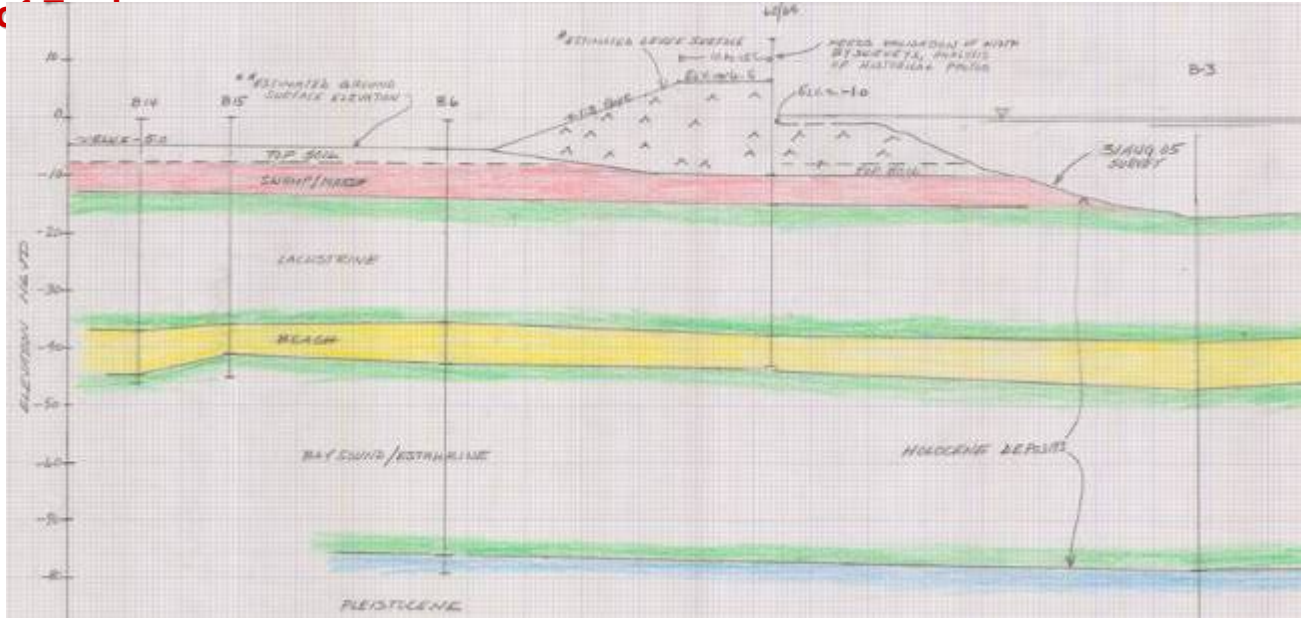
Pre-Katrina Cross-Section Through Breach Area of 17th Street Canal (From LIDAR Survey)





17th Street Model

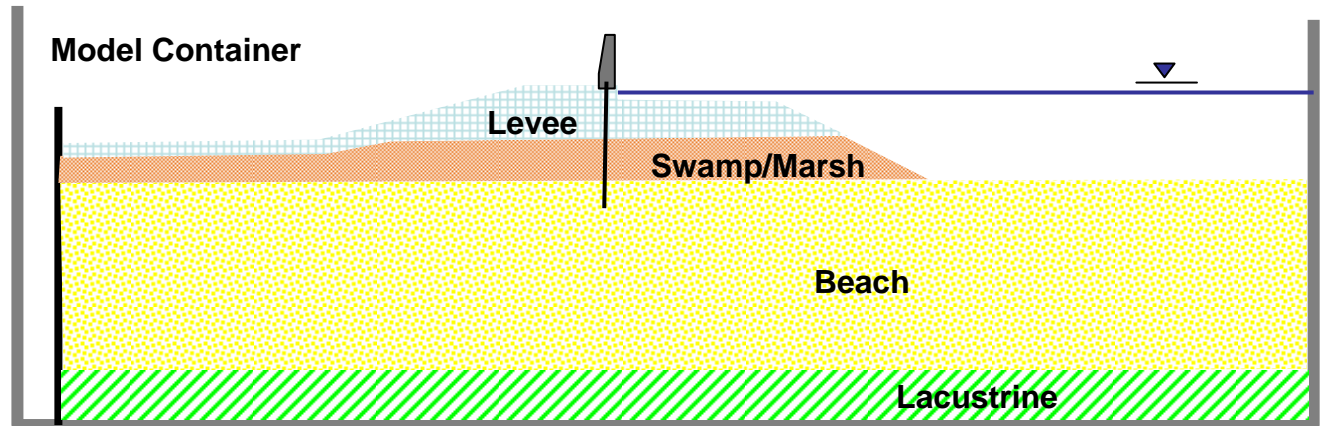
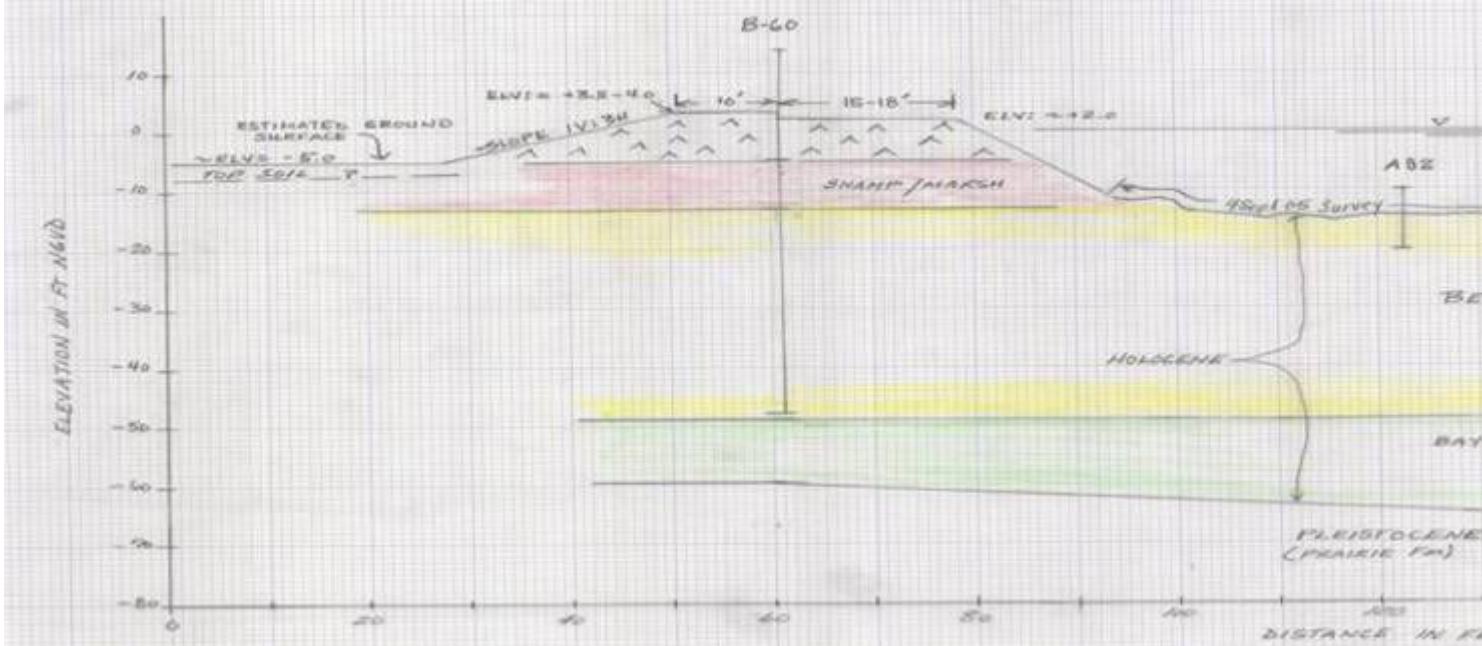
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London Avenue North Model

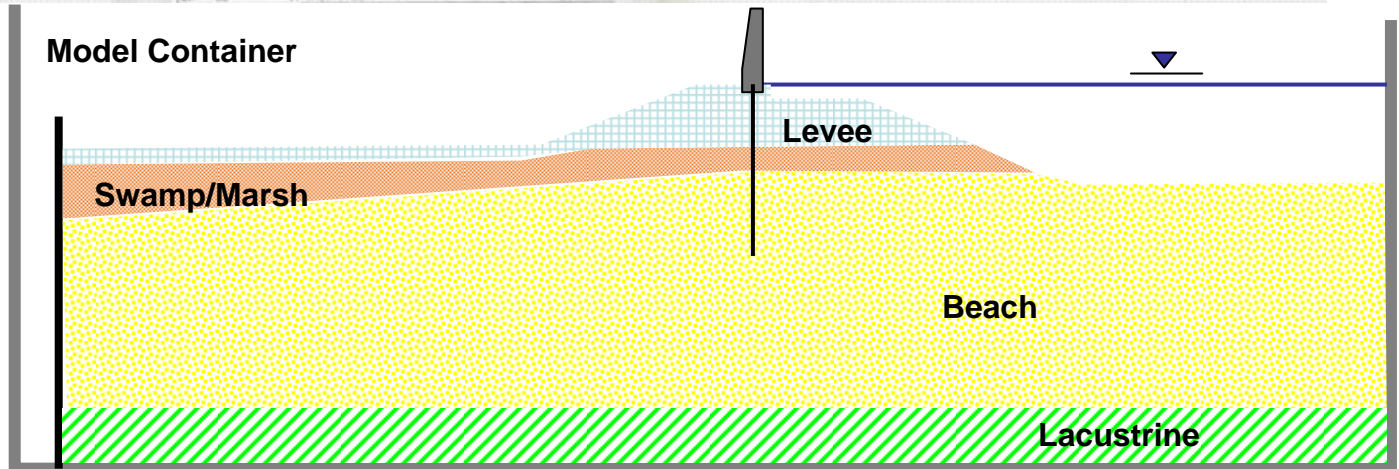
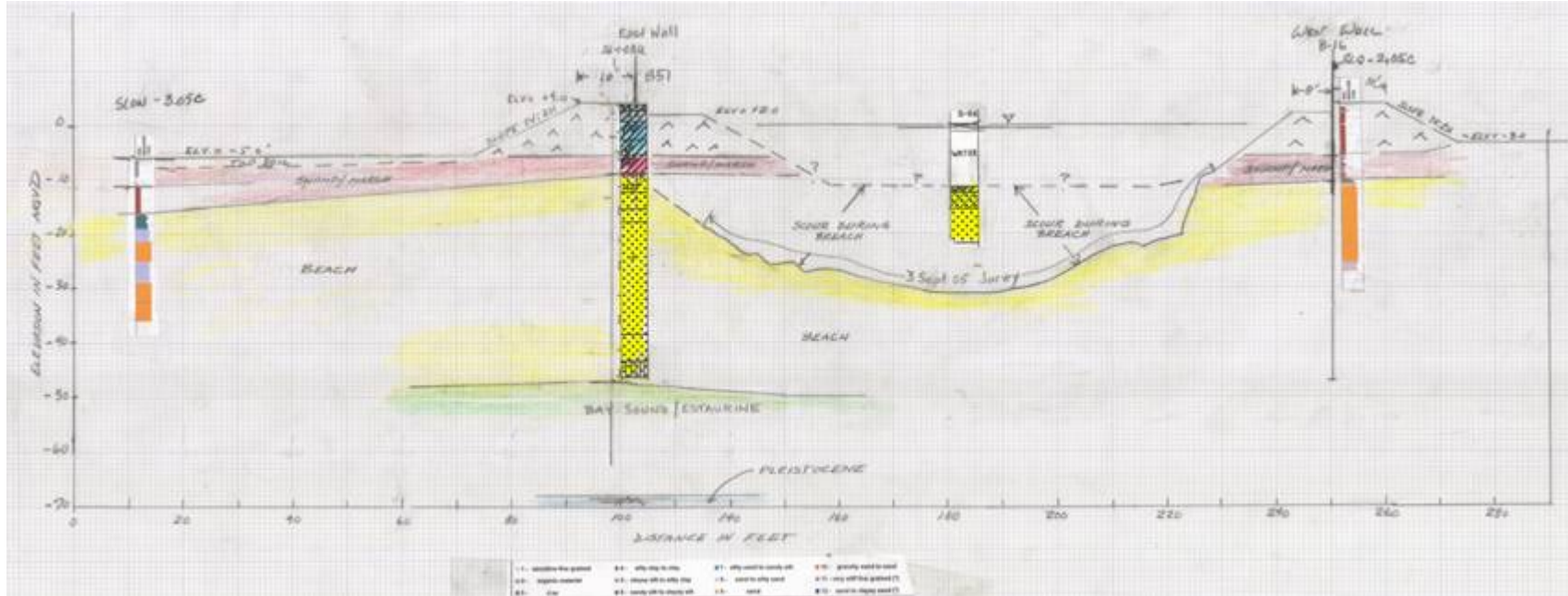
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London Avenue South Model

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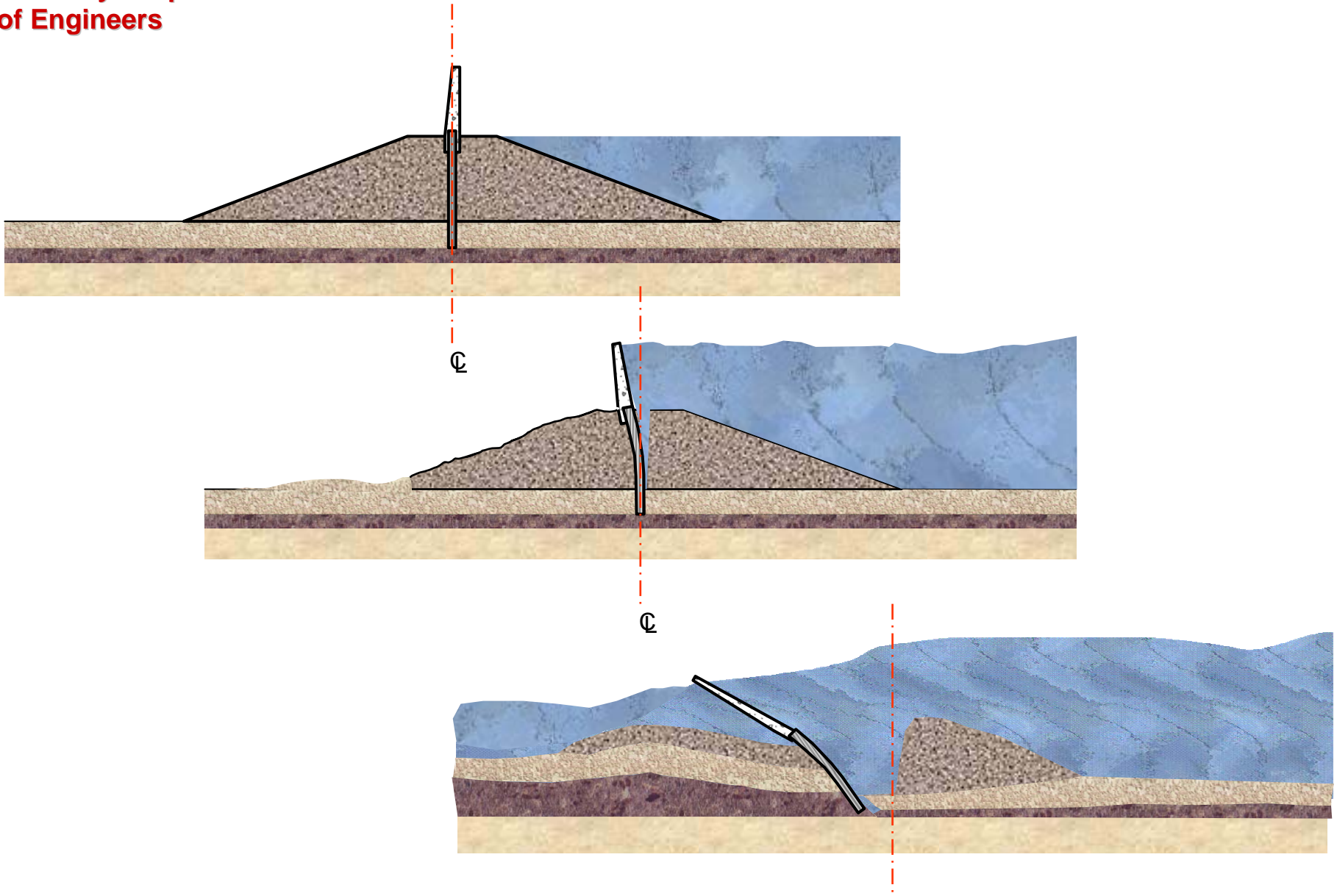
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Analysis



Floodwall Foundation Failure

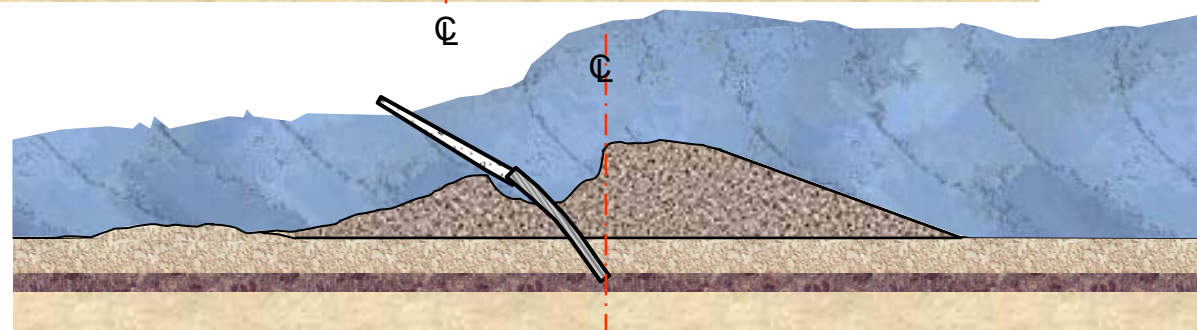
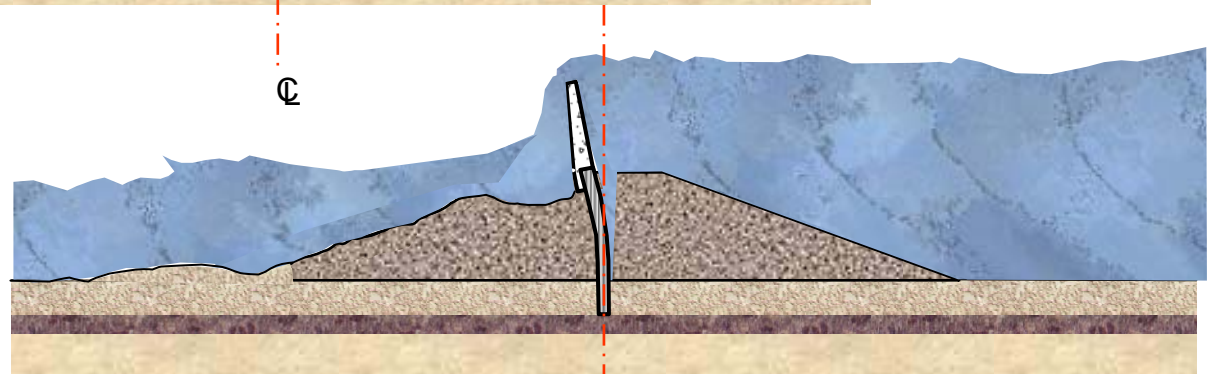
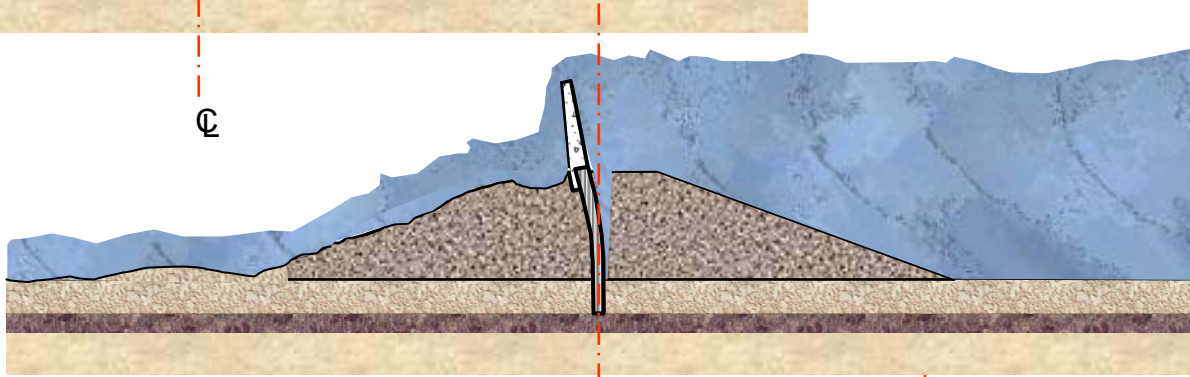
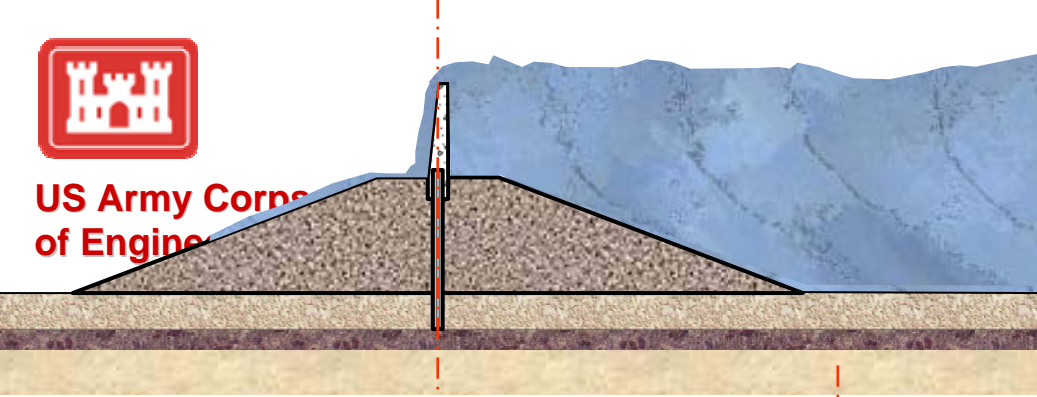
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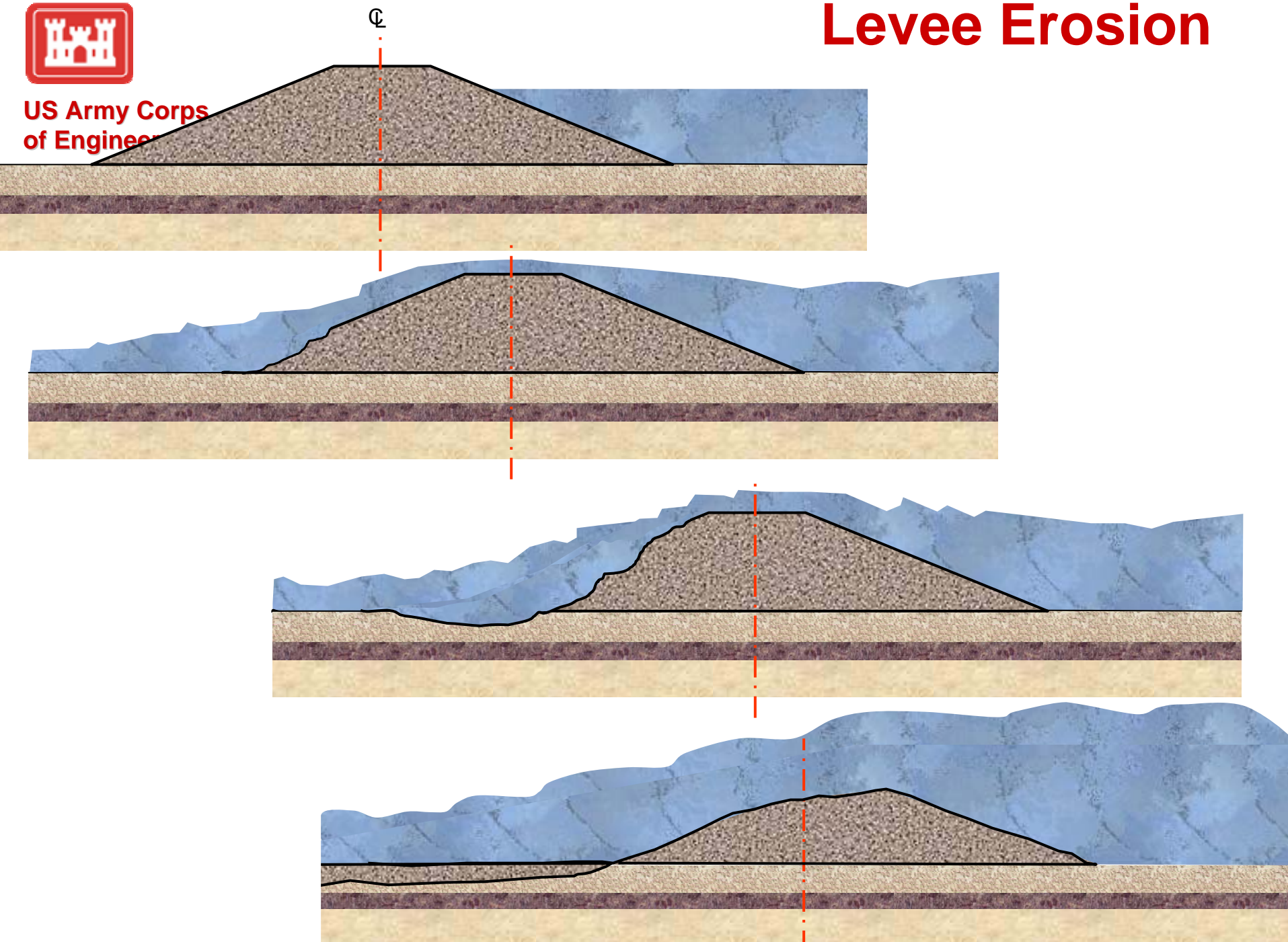
Floodwall Erosion Failure





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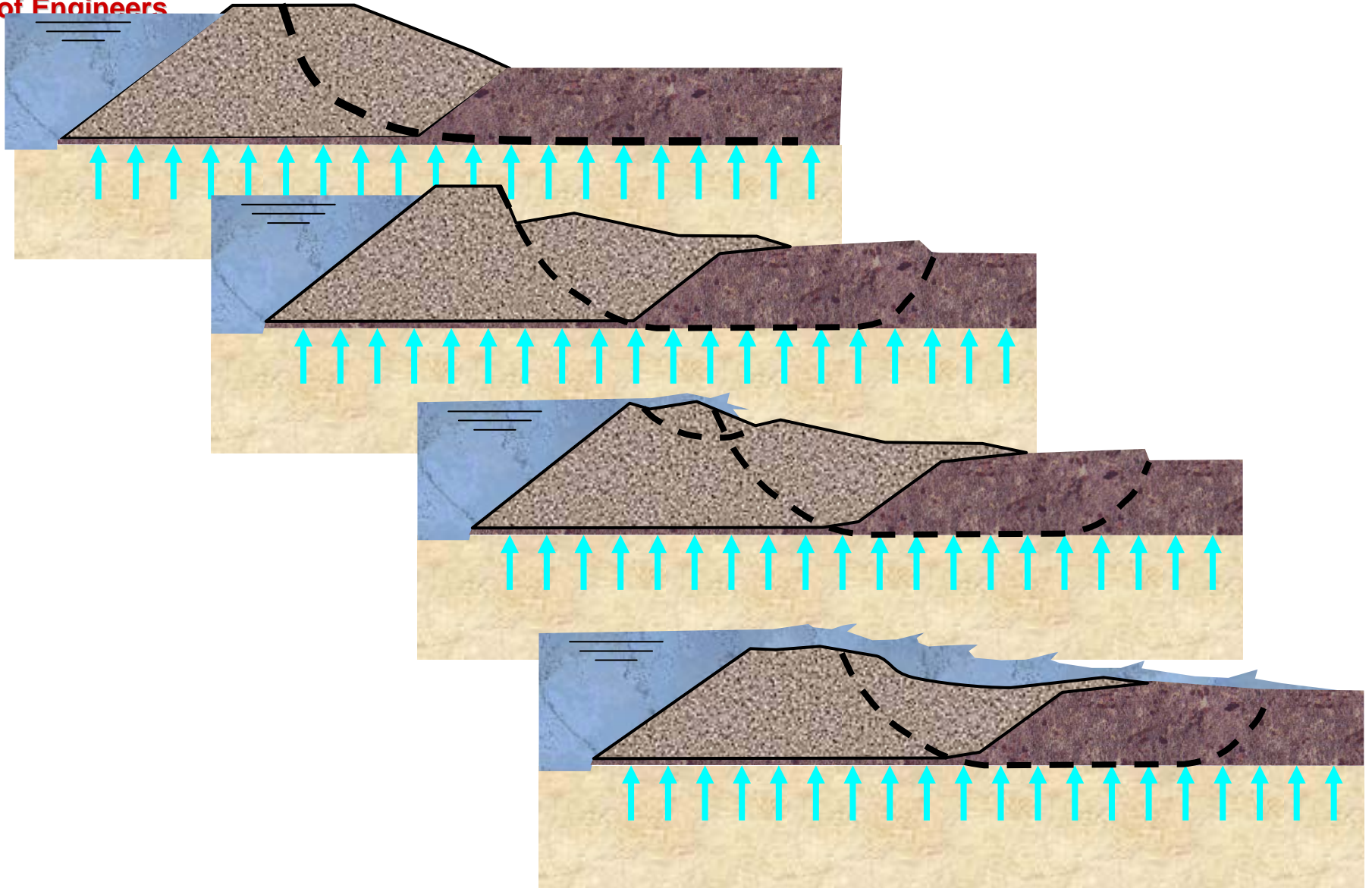
Levee Erosion





Up-lift: deep failure mechanism

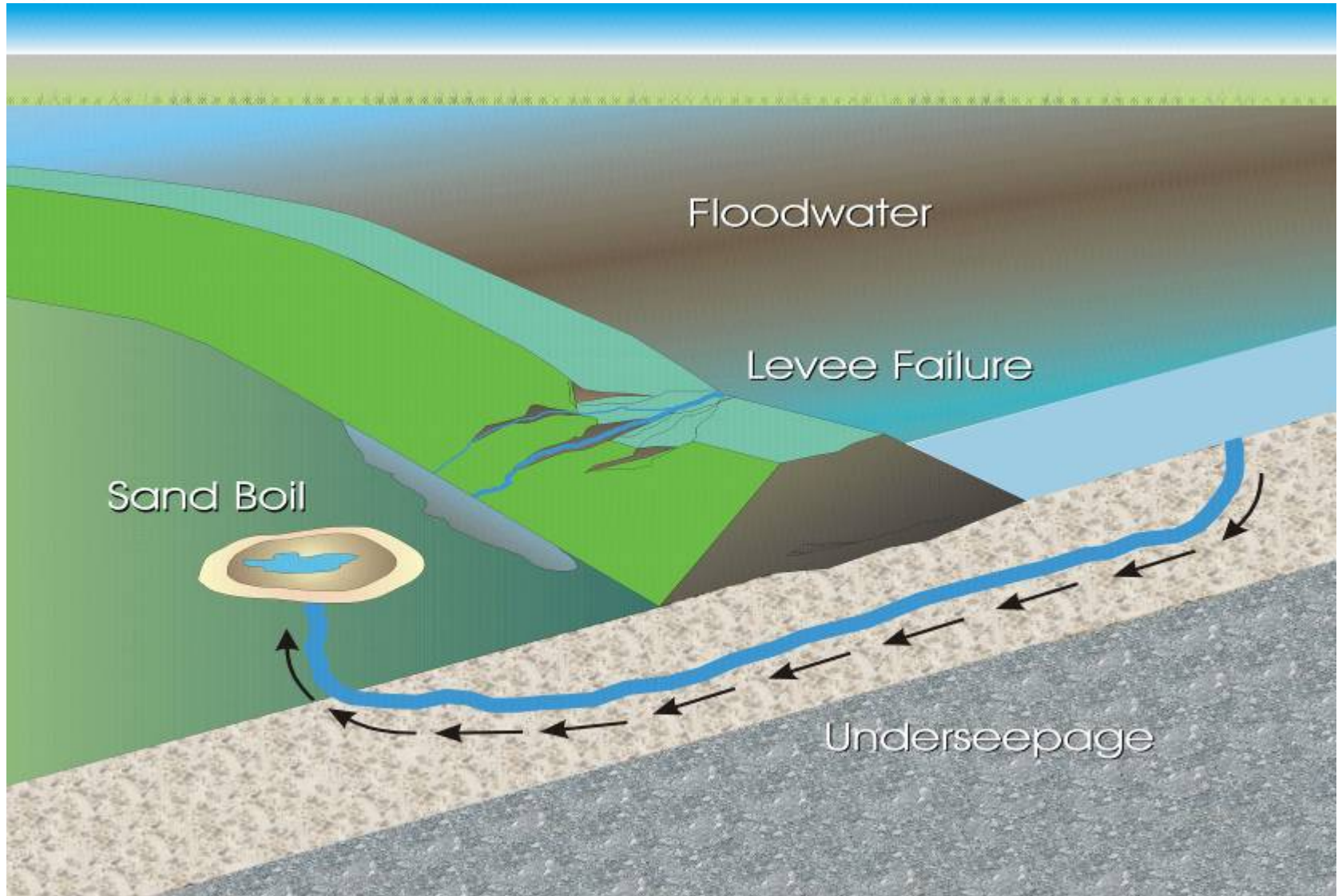
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Piping





17th Street Canal





**US Army Corps
of Engineers**

August 26th 2003



**The
Netherlands**





US Army Corps
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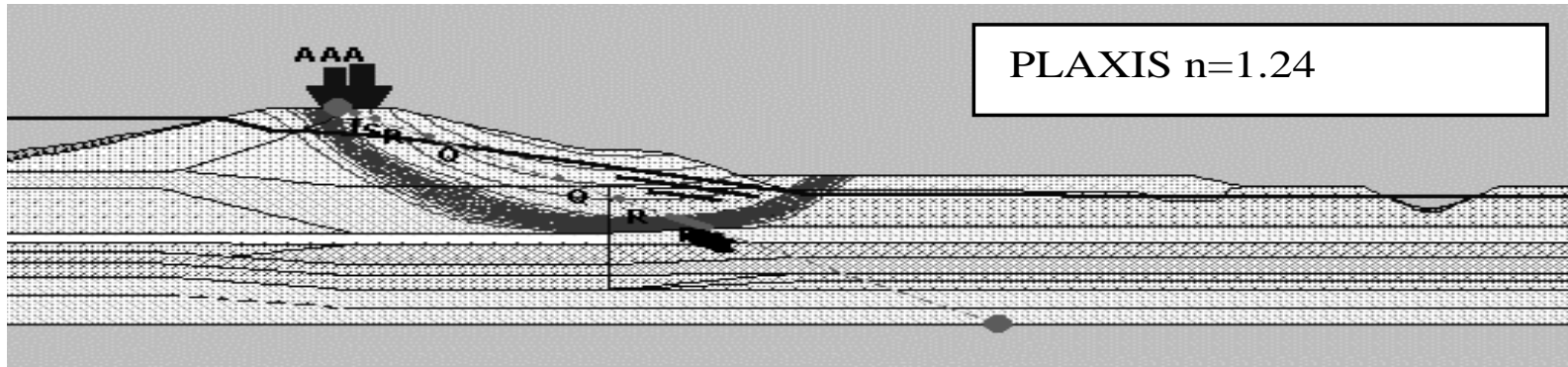
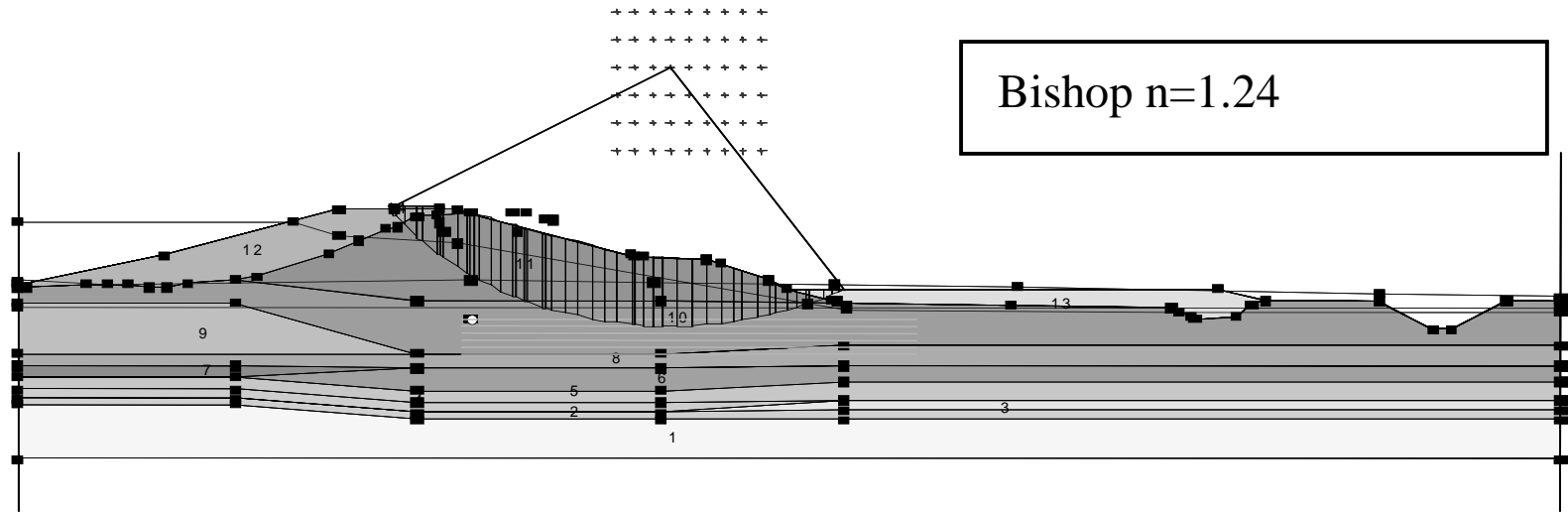
Field Test





Typical Circular Failure Mechanism

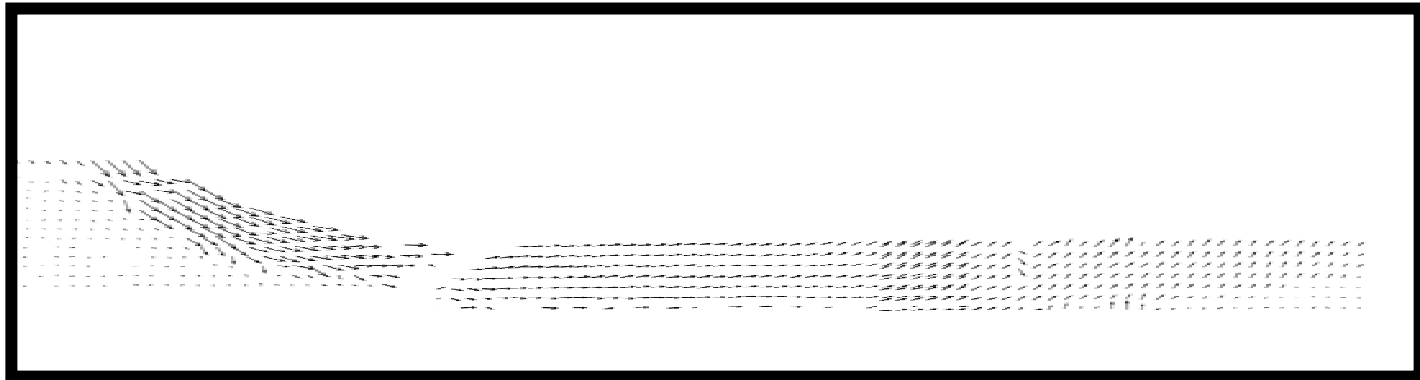
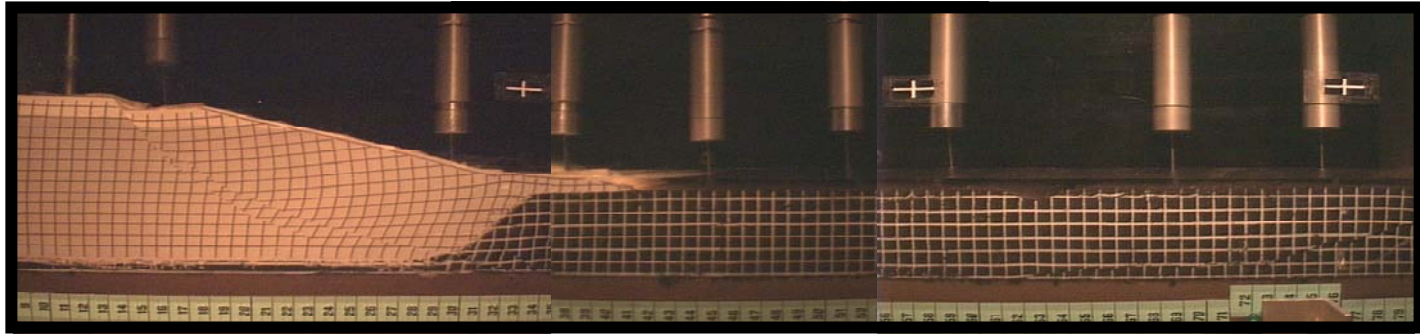
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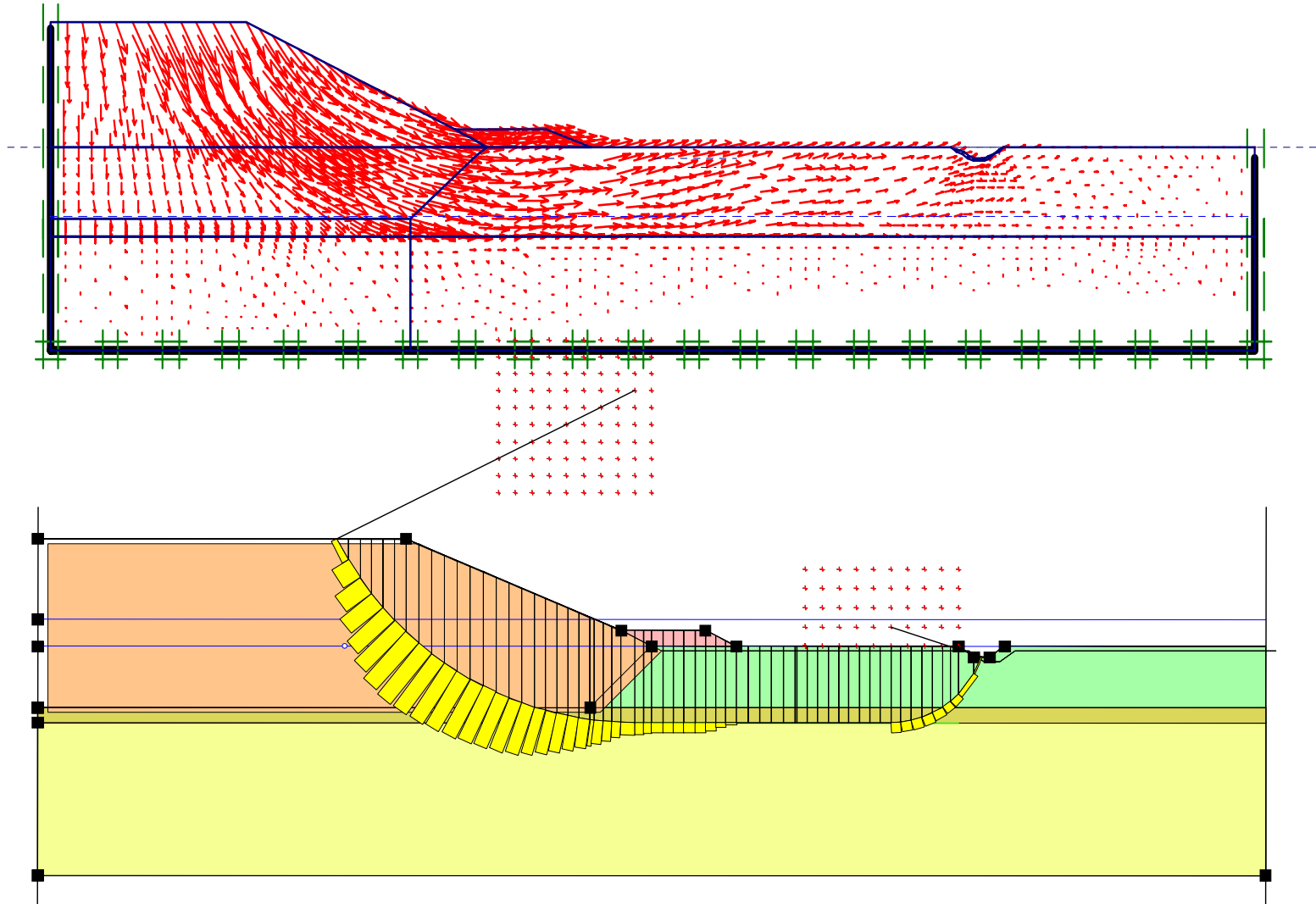
Centrifuge Modeling





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New Failure Mechanism



Effective stress, Safety factor $n = 1.033$



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Floodwall and Levee Performance Analysis, Physical Modeling

Co-Lead

Michael K. Sharp, PhD, PE
ERDC, GSL

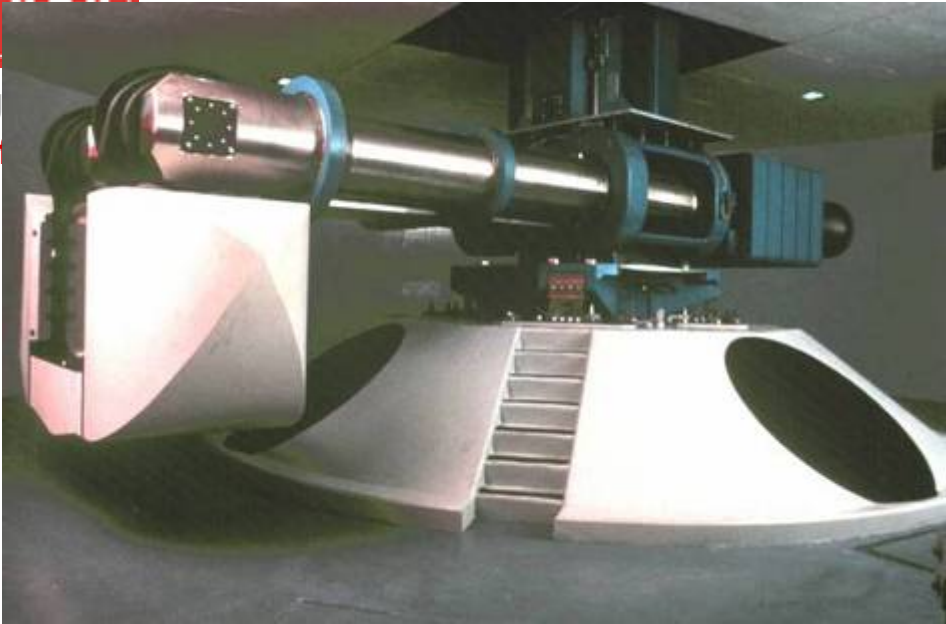
Co-Lead

R. Scott Steedman, PhD, FREng
Steedman & Associates, UK



Rensselaer





ERDC Centrifuge

RPI Centrifuge





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17th Street Canal Failure

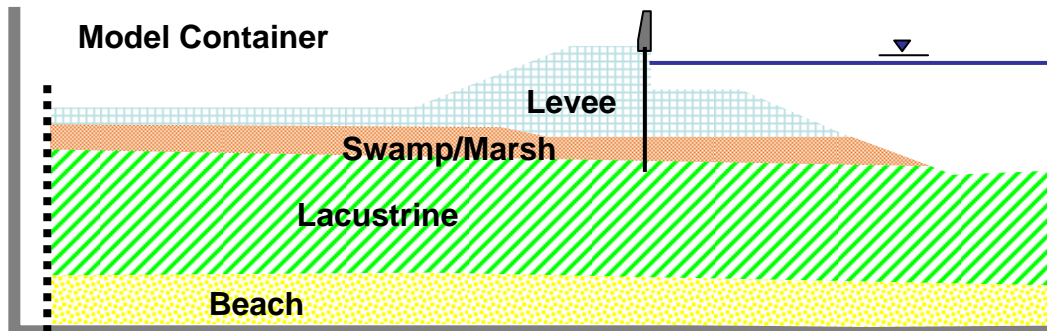




17th Street Model Soils

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- Levee
 - Synthetic clay (match field conditions based on lab test, CPT, etc)
- Swamp/Marsh
 - Actual field material
 - Alternate material (match important characteristics of field material)
- Lacustrine
 - Synthetic clay (match field conditions)
- Beach
 - Fine sand such as Nevada Sand





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17th Street Slide Block





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16 inch block samples of peat
and peat/clay interface at 17th Street Canal



Block samples of material at
17th Street Canal





Draft
Literature Review
Peat Soil

Marcelo González
Tarek Abdoun

December 28, 2005

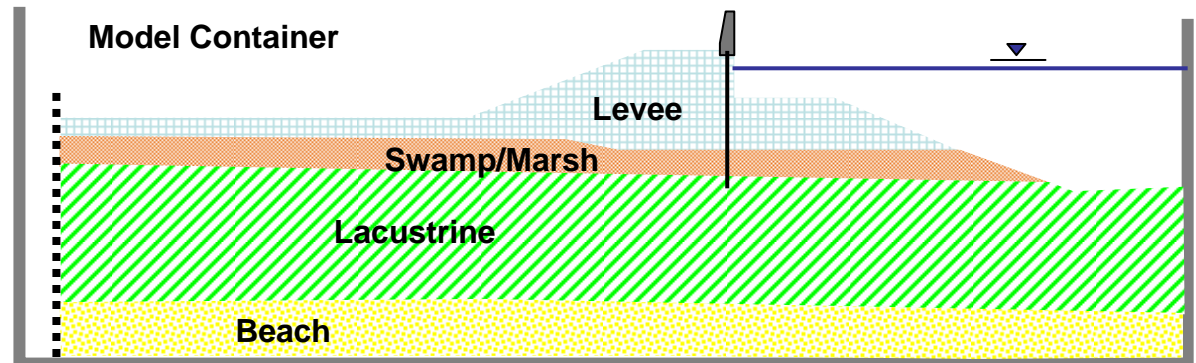
- 1 Introduction**
- 2 Geotechnical classification**
- 3 Physical Properties**
 - 3.1 Fiber Content**
 - 3.2 Ash Content**
 - 3.3 Organic Content**
 - 3.4 Natural density**
 - 3.5 Specific Gravity**
 - 3.6 Void Ratio and Total Porosity**
 - 3.7 Water Retention Properties**
 - 3.8 Atterberg Limits**
 - 3.9 Hydraulic Conductivity**
 - 3.10 Shrinkage**
- 4 Consolidation of Peat**
 - 4.1 Primary Consolidation**
 - 4.2 Secondary Compression**
 - 4.3 Theories Including Secondary Consolidation**
 - 4.4 Factors Affecting Compressibility**
 - 4.5 Compressibility of Natural Organic Deposits**
- 5 Shear Strength of Organic Soil**
 - 5.1 Effect of Fibers**
 - 5.2 Other Influences**
 - 5.3 Determination of Shear Strength**
 - 5.4 Some values of strength**
- References**



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17th Street Planned Tests

- Vary strength of levee material
- Vary strength of lacustrine material
- Explore flow path down sheet pile with increased flow and pressure in the lacustrine material
- Explore possible early movement of wall opening a large flow path





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London Avenue Canal Failures (North & South)



Robert Lee (London North)



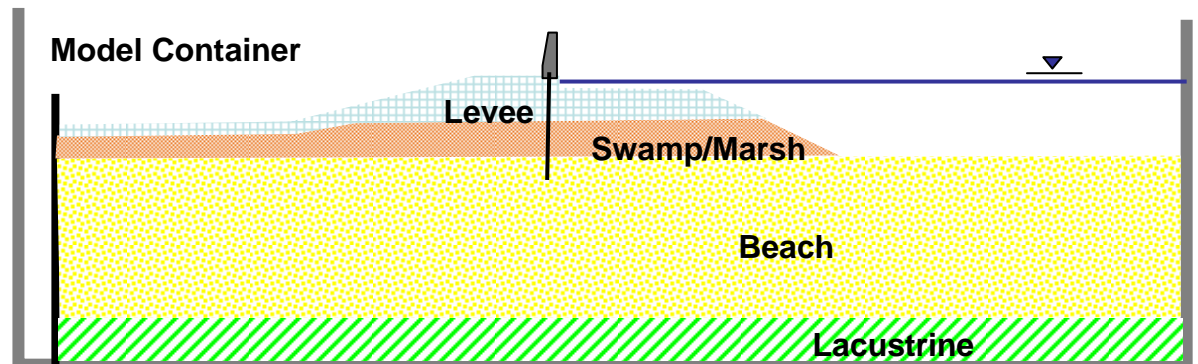
Mirabeau (London South)



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London Avenue Model Soils

- Levee
 - Synthetic clay (match field conditions based on lab test, CPT, etc)
- Swamp/Marsh
 - Actual field material
 - Alternate material (match important characteristics of field material)
- Lacustrine
 - Synthetic clay (match field conditions)
- Beach
 - Actual field material
 - Fine sand such as Nevada Sand





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London Avenue Failures

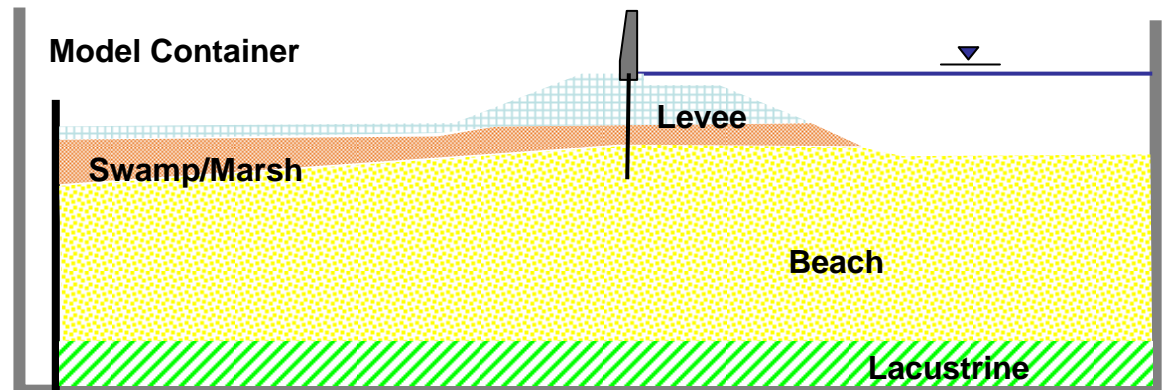




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London Avenue Planned Tests

- Vary strength of levee material
- Explore flow path down sheet pile with increased flow and pressure in the Beach material
- Explore possible early movement of wall opening a large flow path



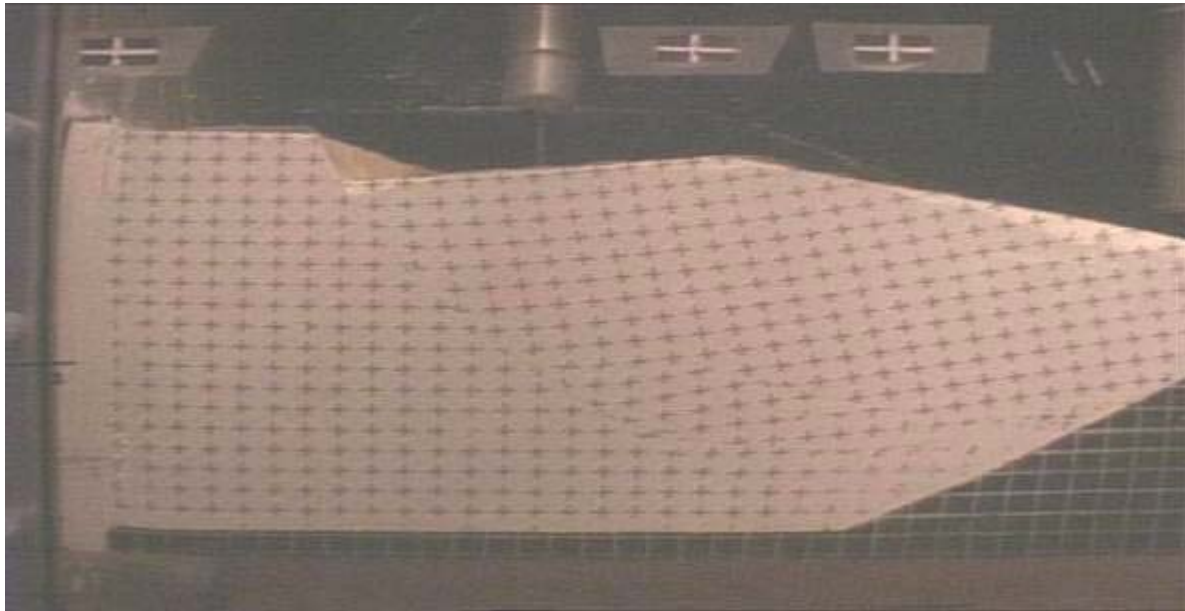
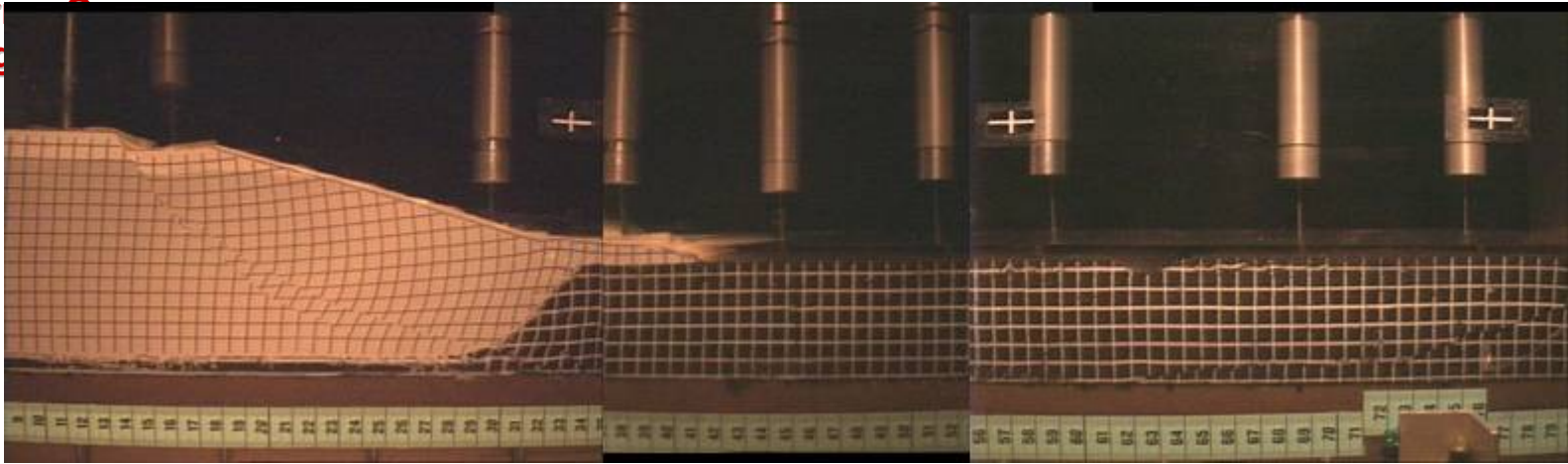


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Typical Results

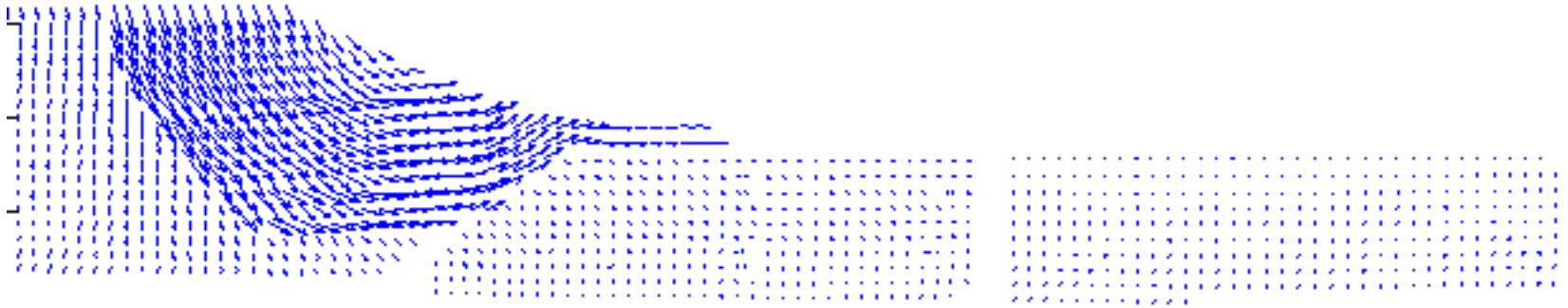


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QUESTIONS