California Central Valley Levee Geotechnical Evaluations: Providing Protection For A Growing Population

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California’s Central Valley

- Sacramento Valley
- Delta
- San Joaquin Valley
Sacramento/San Joaquin/Delta levees now protect

- Communities with over 2 million people
- 200 thousand structures with estimated value over $56 billion
- Public trust resources
- Water supply to 2/3 of California’s population
- 1.5 million acres of cultivated land
FLOOD SCENARIO: Flood in Sacramento

Critical Infrastructure Impacted
- 12 Fire stations, 9 have inundation depth of 4 ft or more
- 1 Police station, minor flooding
- 38 Power substations, including 3 high voltage substations
- 16 Wastewater pump stations; likely many pipe breakages
- 1 Water treatment plant; water not drinkable
- 2 Airports; including 13 ft flooding of Sac. Intl. Airport
- 4 Hospitals, 2 have 1 ft or more
- 26 Medical/health facilities, 19 have 1 ft or more
- 193 Licensed care facilities, 176 have 1 ft or more
- 65 Schools, 59 have 1 ft or more

Cost items

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Property damage</td>
<td>$11.2 billion</td>
</tr>
<tr>
<td>Displacement/temporary housing</td>
<td>$1.5 billion</td>
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<tr>
<td>Lifeline utility repairs</td>
<td>$24 million</td>
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<tr>
<td>Levee repair and pumping cost</td>
<td>$58 million</td>
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<tr>
<td>Emergency response and recovery</td>
<td>$16 million</td>
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<tr>
<td>Additional indirect fiscal impacts up to $15 billion</td>
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Total cost: $12.8 billion
Continuing Development in Deep Floodplain
Urbanized Deep Flood Plain

Natomas Fire Station

Projected Flooding of Natomas Fire Station

Arco Arena, Natomas

Projected Flooding of Arco Arena, Natomas
Sacramento Valley

- Urban levees
- Rural levees
San Joaquin Valley

- Urban levees
- Rural levees
Historic Levee Construction in California

- Originally built to protect fertile farmland
- Constructed of sand, silt, and peat

- Dredge from adjacent river or slough channel
- Excavate from nearby dry land
- Poor compaction, little segregation of suitable vs. unsuitable materials
Historic Levee Construction in California

Results: Levees were often
- permeable
- easily eroded
- possibly not constructed to sufficient height
- susceptible to great settlement
Land use has changed

The levees were never intended to protect

• Urban areas
• Water supply that is vital to Central and Southern California
Central Valley Delta Region

Affected by unique geologic conditions that are generally not present in Sacramento or San Joaquin Valleys
California’s Central Valley

Sacramento Valley

Delta

San Joaquin Valley
Central Valley Delta Region

- Delta is affected by unique geologic conditions that are generally not present in Sacramento or San Joaquin Valleys.
- Wide spread organic soils (peat) are very soft, compressible, and oxidize when exposed to air.
- Levee mass compresses underlying peat and settle.
- Landside area also settles as organic soils irreversibly oxidize. Many are below sea level.
- Susceptible to failure in earthquakes.
- Overtopping and underseepage are big issues.
Delta Map

- Broad flat area composed of a series of more than 70 islands

- Islands are created by ring levees that enclose areas that are now often below sea level
Ways that Levees Fail

- Overtopping
- Through Seepage
- Under Seepage
- Slope Instability
- Erosion
- Seismically Induced Failure
Ways that Levees Fail

Overtopping
Ways that Levees Fail

Through Seepage and Under Seepage
Ways that Levees Fail

Erosion and Slope Instability

Bank erosion has reached a critical condition

Flood level
Ways that Levees Fail

- Seismic Shaking
- Liquefaction and Settlement
- Insufficient Freeboard and Overtopping
Geotechnical Evaluation of Central Valley Levees

Evaluating more than 1750 miles of levees
• Review available historic information and aerial photos
• Perform geologic mapping
• Phased subsurface exploration program and soil testing
• Engineering analyses
• Reporting
Review Available Historic Information and Aerial Photos

- Lots of information is available but is often difficult to locate.
- Meet with Levee District/Reclamation District owners to discuss past performance problems.
- Review historic construction photographs.
- Review aerial photographs.
Geologic Mapping

Map surficial sedimentary geologic units from high altitude aerial photographs

Confirm/refine mapping through field checking and subsurface exploration
Geotechnical Evaluation of Central Valley Levees

- Review available historic information and aerial photos
- Perform geologic mapping
  - Phased subsurface exploration program and laboratory soil testing
  - Engineering analyses
  - Reporting
Phased Approach to Subsurface Exploration

- Cost effective
- Involves up to three phases of soil borings
- Many sites may only get first or first and second phases
- Focuses resources on known problem areas immediately
Subsurface Exploration: Primary Soil Borings

- Drilled on levee crest
- Drilled in known problem areas and on 5000-ft spacing
Subsurface Exploration: Secondary Soil Borings

- Drilled in potential problem areas identified during first phase of exploration
- Drilled on landside toe and offset from toe
Subsurface Exploration: Tertiary Soil Borings

• Drilled on waterside in problem areas
Geotechnical Evaluation of Central Valley Levees

- Review available historic information and aerial photos
- Perform geologic mapping
- Phased exploration program and laboratory soil testing
  - Engineering analyses
  - Reporting
Geotechnical Evaluation (continued)

• Engineering analyses
  • seepage
  • slope stability
  • seismic
  • settlement

• Geotechnical Report
  • Provide recommendations for areas needing repair and type of repair
Examples of Levee Repairs

- Stability berm
- Levee raise/widening
- Erosion protection
- Cutoff wall
Cutoff Wall Construction
Issues with Cutoff Walls

• Expensive to construct
• Difficult to confirm that a positive continuous cutoff has been achieved
• Requires closing access along levee crest during construction
Stability Berm

Stability berm for slope stability and/or seepage control
Issues with Stability Berms

- Expensive to construct
- Requires purchasing land or easement parallel to levee
- Requires large volume of imported fill soil
Erosion Protection
Issues with Erosion Protection

• Expensive to construct
• Requires importing large boulders – expensive material
• Environmental issues related to working in riparian corridor
Examples of Levee Repairs

Setback Levee
Issues with Setback Levees

• Very expensive to construct
• Requires purchasing land for setback levee to be constructed on
• Requires very large volume of imported fill soil
• May also require removal of old levee
Improving Flood Protection for California’s Urban Areas is Expensive

• Current Estimates Show that it will cost almost $5 billion to improve flood protection for just the following six communities:
  - Sacramento
  - West Sacramento
  - Stockton
  - Lathrop
  - Marysville/Plumas Lakes
  - Yuba City

$400 million for West Sacramento alone!
• California State Bonds Provide an Initial $4.89 Billion in Flood Control Funding

• California Submitted FY09 Federal Funding Requests
  – To the Army Corps of Engineers for 27 critical flood control projects
  – Two of these requests are for studies that are essential to engaging the Corps in developing a comprehensive plan to improve flood control in the Central Valley
    • Sacramento and San Joaquin River Basins Comprehensive Study
    • Sacramento River Flood Control System Evaluation
  – Until these two studies have been completed, the Central Valley’s system-wide flood control improvements and the resulting total costs are uncertain
What we want to avoid!

Any questions?