Levee Integrity and Subsidence: Tied at the Hip for the Future of the Delta

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DWR
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- Major failure recovery, if attempted, will be long and costly.
- The Delta ecosystem will change.
- Project export water quality is at risk.
- Subsidence is a primary risk and cost driver.
What this talk is about

• Saying the obvious about Delta levees and subsidence
• What we learned from Jones Tract
• What we didn't learn
• Levee stability
• Needed science

Levee integrity and subsidence are tied at the hip
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• Levee integrity and subsidence are tied at the hip
What we learned

Historical perspective:

• Delta levees built-up incrementally since the 1850's by landowners and reclamation districts.
• 43 levee breaks on 36 islands in the Delta since 1971
• Studies show impending peril to Delta: 1-in-4 chance of multiple levee failures from earthquake in the next thirty years.
What we learned

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• Studies show impending peril to Delta: 1-in-4 chance of multiple levee failures from earthquake in the next thirty years.
What we learned

Connections:

• levees are essential to the integrity of the water projects.
• Levees owned by private reclamation districts not prepared for levee breaks.
• private land problem became a statewide water resource catastrophe.
• could have cascaded to a much larger problem.
• "ounces of prevention versus pounds of cure"
What we learned

Connections:

• Some levees are essential to the integrity of the water projects.
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• *Some* levees are essential to the integrity of the water projects.
• Private reclamation districts are responsible for maintenance of most Delta levees.
• RD’s lack of resources requires intervention.
• Private levee problem became a statewide water resource catastrophe.
• Could have been much worse.
What we learned

Attitudes toward levees
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• Levees are among the most mundane of public works.
• Levees “aren’t sexy enough,” -- “someone else’s problem until they break.”
• CALFED: levees not in draft Delta improvements plan
• Implicit: Levee constituency is difficult to forge
What we didn’t learn

The media did little probing for benefits and costs to State and federal tax payers
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• “…We don’t have the resources.., therefore, we need disaster relief...”
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- “…We don’t have the resources.., therefore, we need disaster relief…”

- Why should the State/feds pay for subsidence cost?
What we didn’t learn

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• “…We don’t have the resources.., therefore, we need disaster relief…”

• Why should the State/feds pay for subsidence cost?

• What is reclamation district incentive?
What we didn’t learn

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• “...We don’t have the resources.., therefore, we need disaster relief...”
• Why should the State/feds pay for subsidence cost?
• What is reclamation district incentive?
• Is this disaster relief or subsidy?
The future…
The future…

• Floods will come
The future...

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• Earthquakes will come
The future…

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• Sea level is rising 1-2 mm per year--accelerating
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• Subsidence is ongoing ~ 1 foot/decade
• Delta wide, another Folsom Reservoir is added every twenty years.
The big elephant in the room:
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- agriculture on peat soils causes subsidence and creates the need for ever larger and more expensive levees to maintain the same level of protection.
Subsidence increases levee cost
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Levee Strength

Cost

\[ \text{Subsidence} \]

\[ \text{CO}_2 \]
Subsidence increases levee cost

Levee Strength

Cost

$\text{CO}_2$

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Levee Strength

Cost

Subsidence

$CO_2$

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CALFED: “Beneficiaries Pay”

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- Calfed has acknowledged subsidence
- Calfed programs will be paid for by beneficiaries.
- Subsidence is really an “impact” of land use.
- Beneficiaries pay for cost of subsidence.
Levee Integrity depends on:

- Material properties (% organic/mineral)
- Foundation properties (weight baring capacity)
- Levee material unit weight
- Levee geometry
- Vegetation
- Wind fetch/wave attack
- Seismic loading
- Cyclic tidal loading
Levee Design

- Stability
- Seepage
- Overtopping
Slope failure

Usually:
- Disintegration of soil structure
- Increase in pore water pressure
- Seismic shock leading to liquefaction
Slope stability

As an illustration, slopes often fail in a circular rotation pattern:
Slope stability

As an illustration, slopes often fail in a circular rotation pattern:

“Slip Circle”
Slope stability

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As an illustration, slopes often fail in a circular rotation pattern:
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Slope stability

Slope failure occurs if gravity force is greater than the shear strength of the soil.
Slope stability

“Slip Circle”
Slope stability

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Weight of Area 1
Slope stability

“Slip Circle”

Area 1

Weight of Area 1

Area 2

Weight of Area 2
Slope stability

Cohesive Resistance

Area 1

Weight of Area 1

Area 2

Weight of Area 2

“Slip Circle”

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Slope stability

Tillis: “Like a teeter totter:”

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“Slip Circle”

Weight of Area 1

Weight of Area 2
Seepage

Seepage reduces cohesive resistance
Seepage reduces cohesive resistance
Subsidence

When the inboard side subsides:

- Cohesive Resistance
- "Slip Circle"
- Weight of Area 1
- Weight of Area 2

Cohesive Resistance

Weight of Area 1

Weight of Area 2
Subsidence

When the inboard side subsides:

- **Cohesive Resistance**

  - **Area 1**
  - **Area 2**

  - **“Slip Circle”**

  - Weight of Area 1
  - Weight of Area 2

  - Cohesive Resistance
Subsidence

Rehabilitation Strategy:

"Slip Circle"

Area 1

Cohesive Resistance

Weight of Area 1

Area 2

Cohesive Resistance

Weight of Area 2

"Toe Berm"
Needed Science

• Risk analysis: probabilities and costs of alternative futures.
• Water quality impacts (modeling)
• Identify proportion of levee cost due to subsidence.
• Consider Delta shallow water ecosystem
• Large scale subsidence reversal research
• Land and water elevation measurement supporting change detection
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Summary

- Levee stability is influenced by many factors.
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- Subsidence is a primary factor.
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- Science investigation needed to apportion levee system cost appropriately.
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• Levee stability is influenced by many factors.
• Subsidence is a primary factor.
• Science investigation needed to apportion levee system cost appropriately.
• Levee integrity is tied at the hip with land subsidence.
Thank you

• Randy Brown
• Steve Culberson
• Bruce Herbold
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