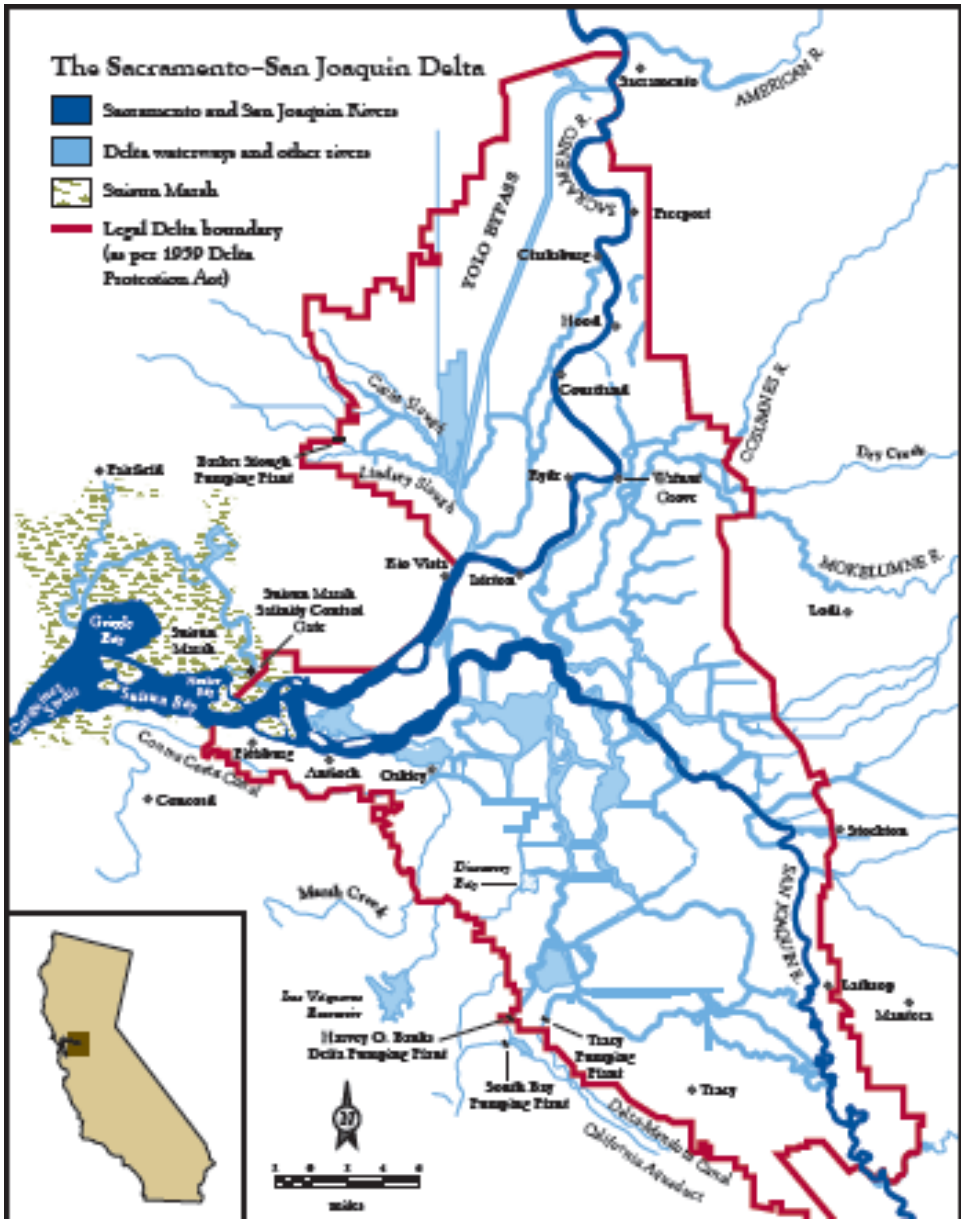
UCLA

Dynamic Response of Levees Founded on Peats and Organic Soils

Scott J. Brandenberg

October 26th, 2012

The Delta



Lund et al. (2007).

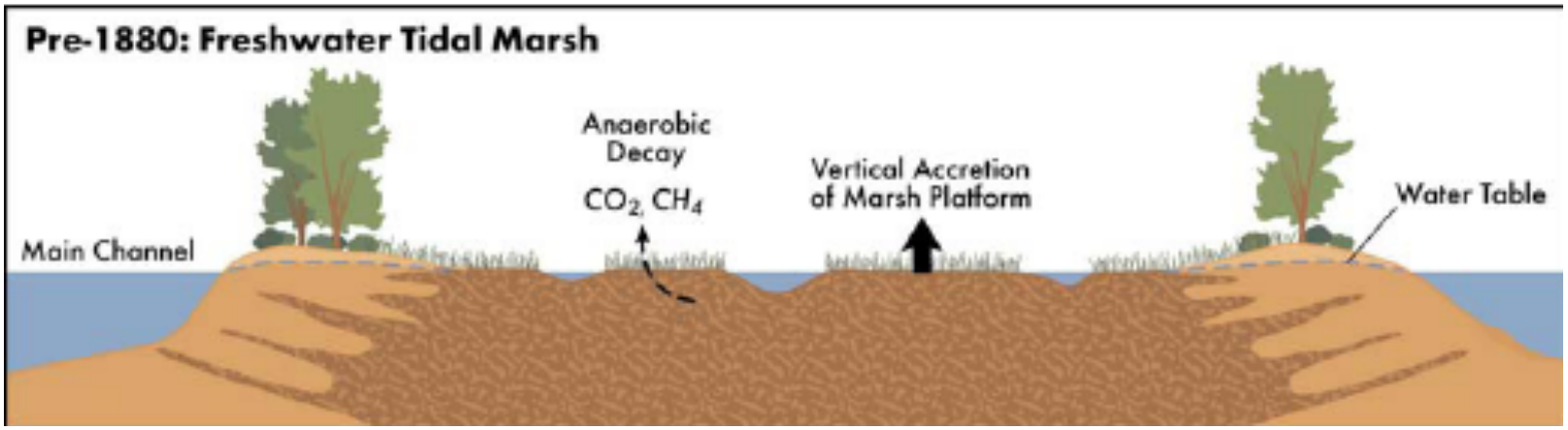
The Delta

The Delta

Adrian Mendoza © 2009 Kitesurfing off of Sherman Island in the California Delta on Memorial Day www.amenfoto.com

The Delta

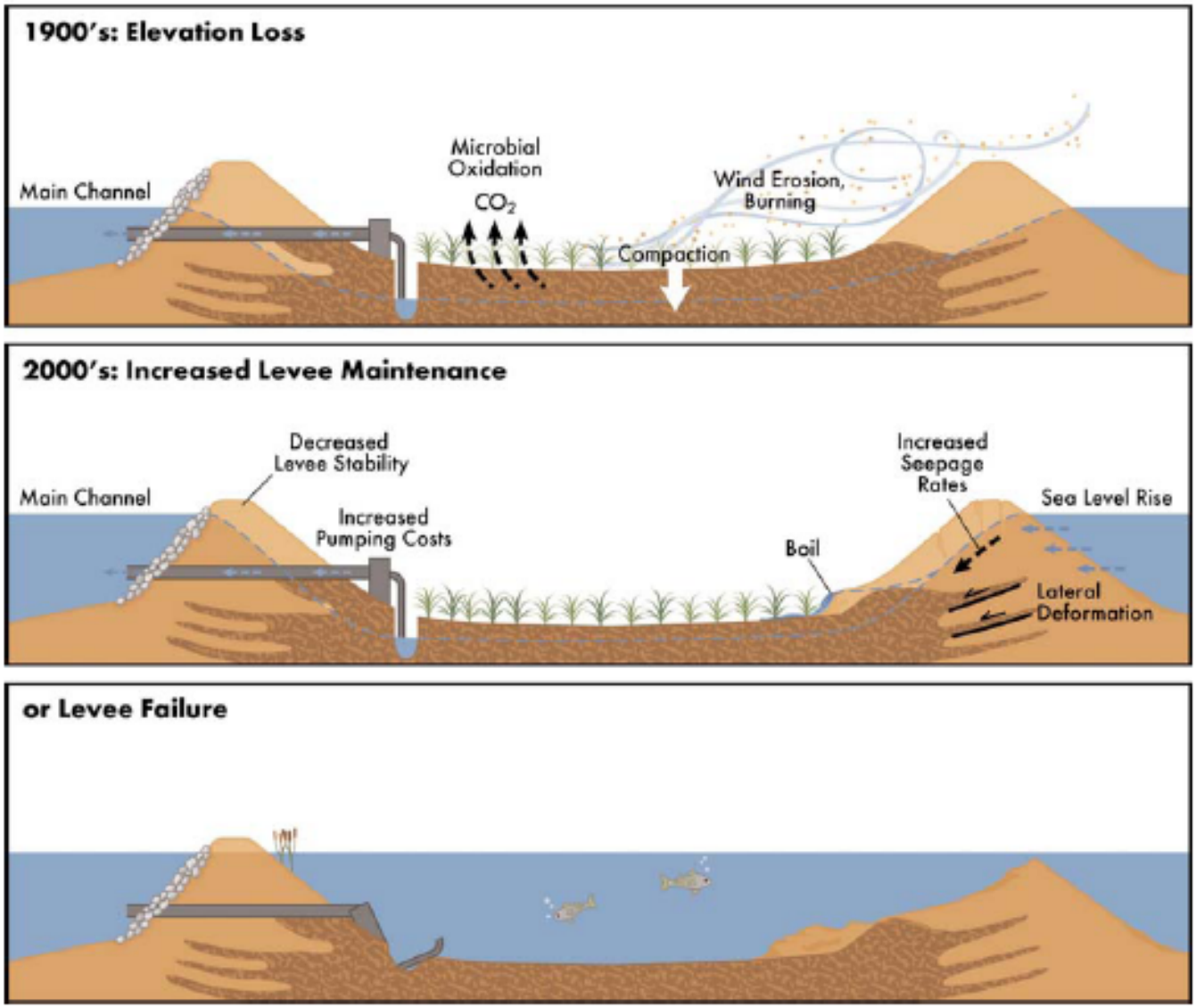
Pre-European Delta (before 1800)



Mount and Twiss (2005)

Reclamation of the Delta (1850-1930)

Land Subsidence



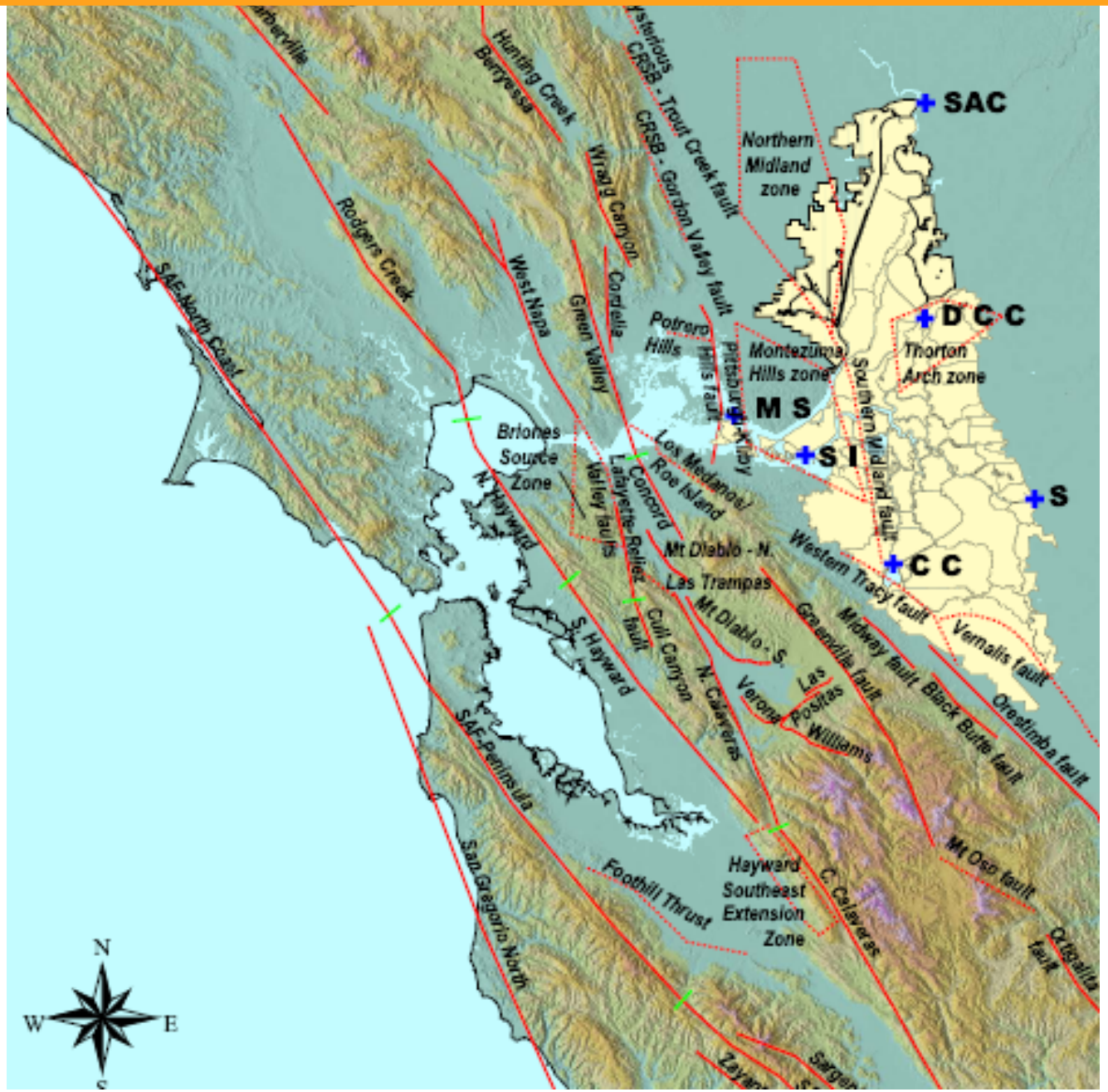
Mount and Twiss (2005)

Land Subsidence

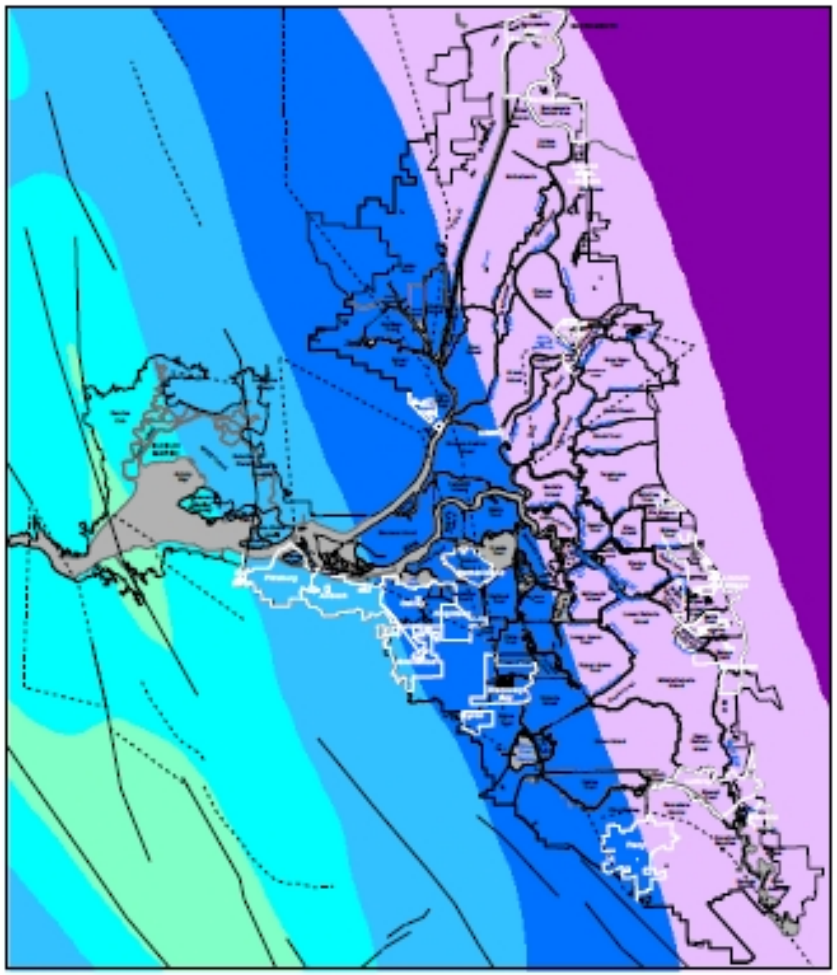
Key Questions

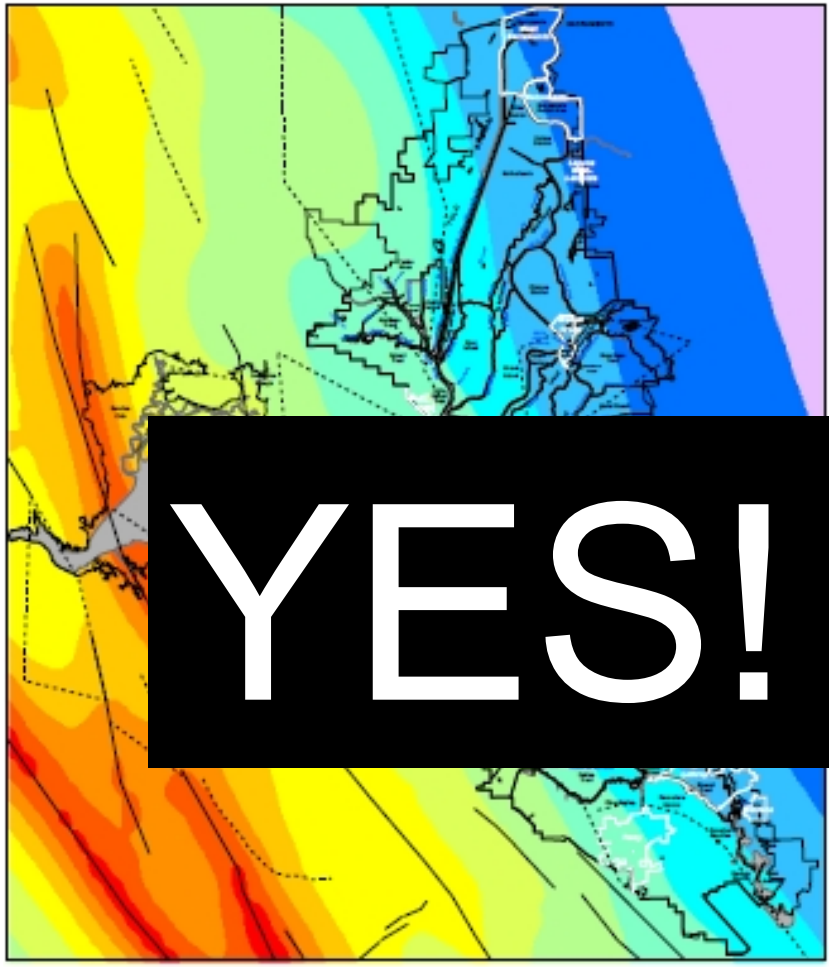
- Does the Delta have seismic hazard?
- Can peaty organic soil transmit significant ground motion, or will the energy be "damped out"?
- We already know liquefaction of levee fills is a significant hazard. Can peaty organic soil also contribute to levee failure?
- Does peaty organic soil generate excess pore pressure during cyclic loading, and subsequently reconsolidate?

Seismic Hazard



Does Delta have Seismic Hazard?





YES!

DRMS (2009)

Legend

Mapped Faults

Surficial faults used in the hazard analysis

Blind Faults

Blind faults used in the hazard analysis

Legal Delta and Suisun March Boundary

PGA, 100 Year Return Period

0.00 - 0.10
0.11 - 0.15
0.16 - 0.20
0.21 - 0.25
0.26 - 0.30
0.31 - 0.35
0.36 - 0.40
0.41 - 0.45
0.46 - 0.50
0.51 - 0.55
0.56 - 0.60
0.61 - 0.65
0.66 - 0.70

Legend

Mapped Faults

Surficial faults used in the hazard analysis

Blind Faults

Blind faults used in the hazard analysis

Legal Delta and Suisun March Boundary

PGA, 500 Year Return Period

0.00 - 0.10
0.11 - 0.15
0.16 - 0.20
0.21 - 0.25
0.26 - 0.30
0.31 - 0.35
0.36 - 0.40
0.41 - 0.45
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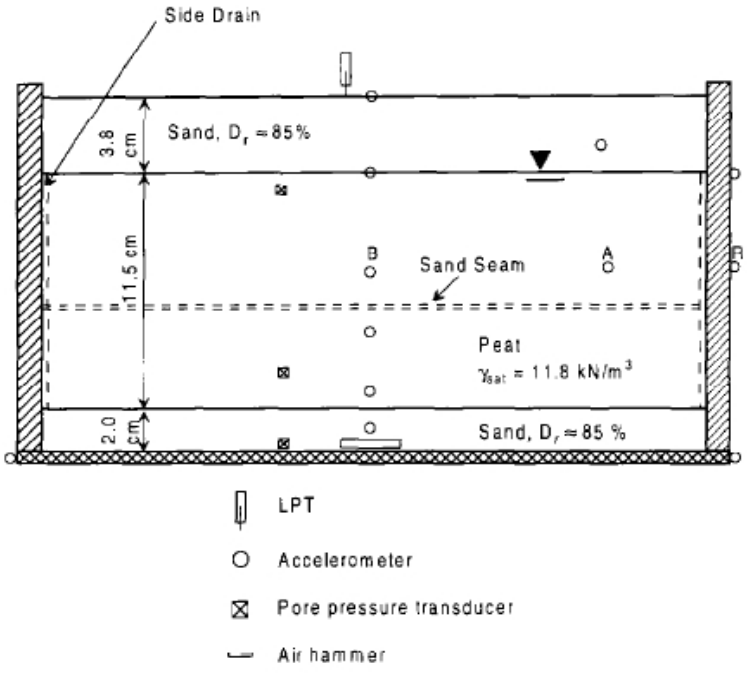
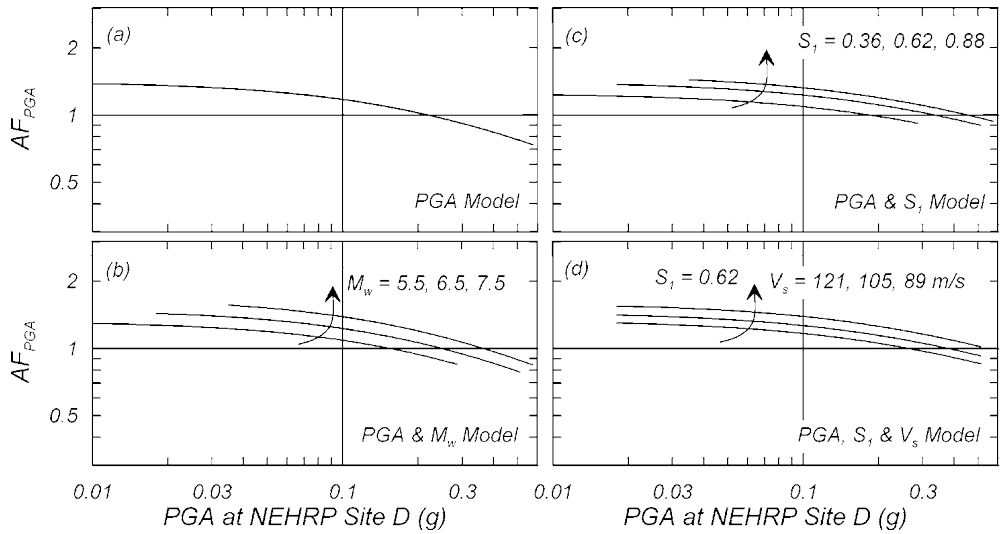
0.61 - 0.65
0.66 - 0.70

Can Peat Transmit Seismic Energy?

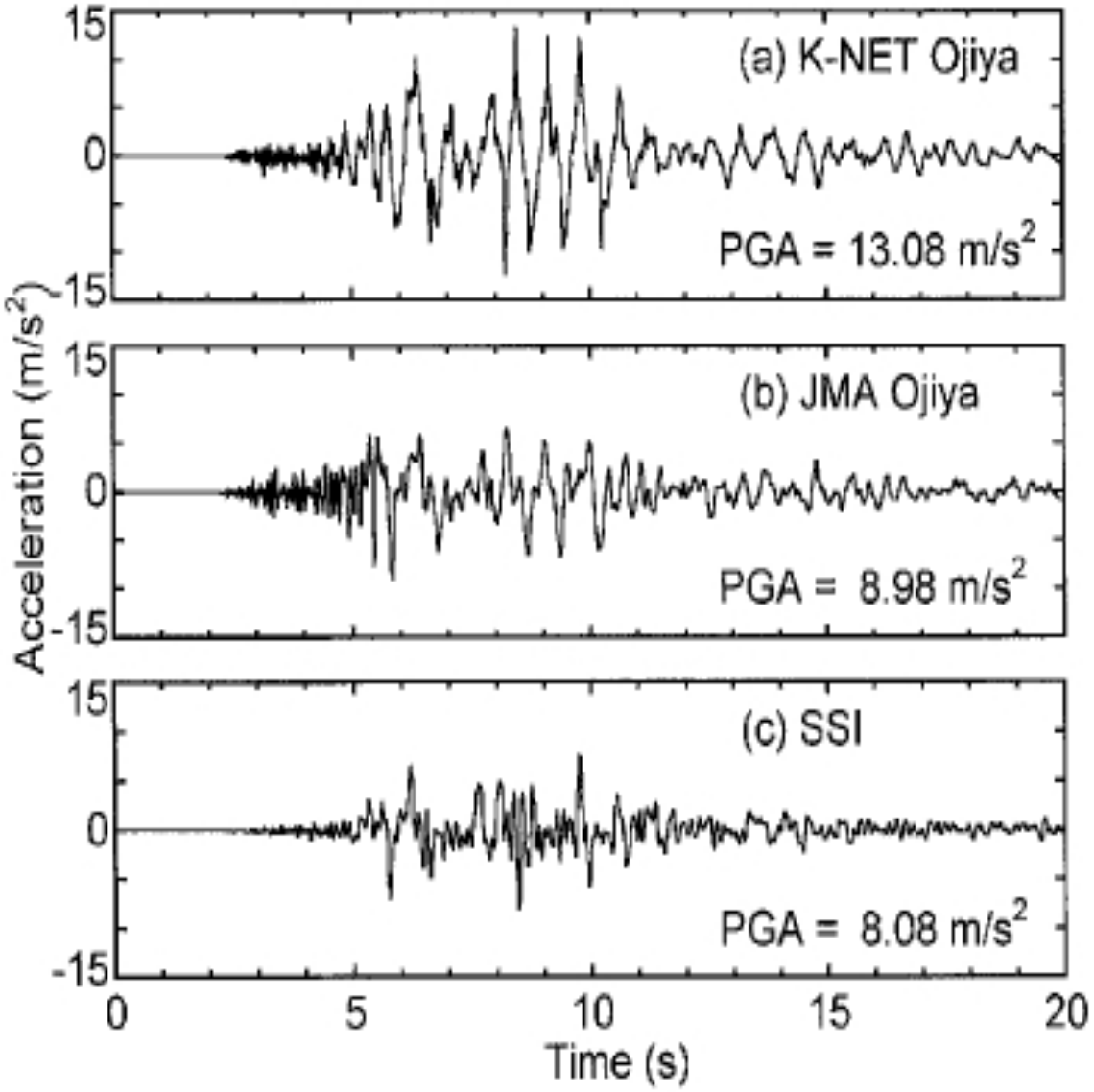


Arulnathan et al. (2001)



Kishida et al. (2009)

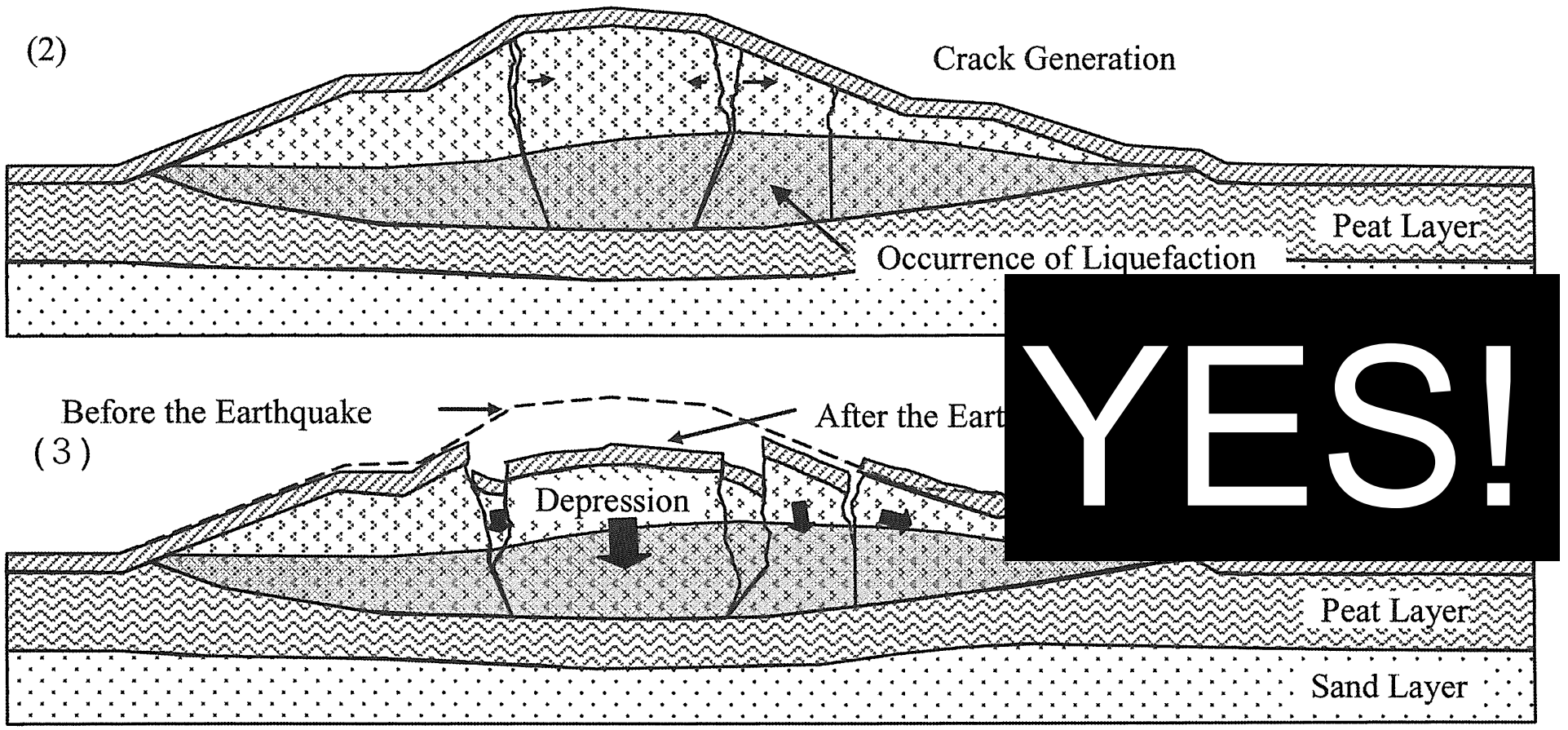
Can Peat Transmit Seismic Energy?



YES!

Tokimatsu and Sekiguchi (2010)

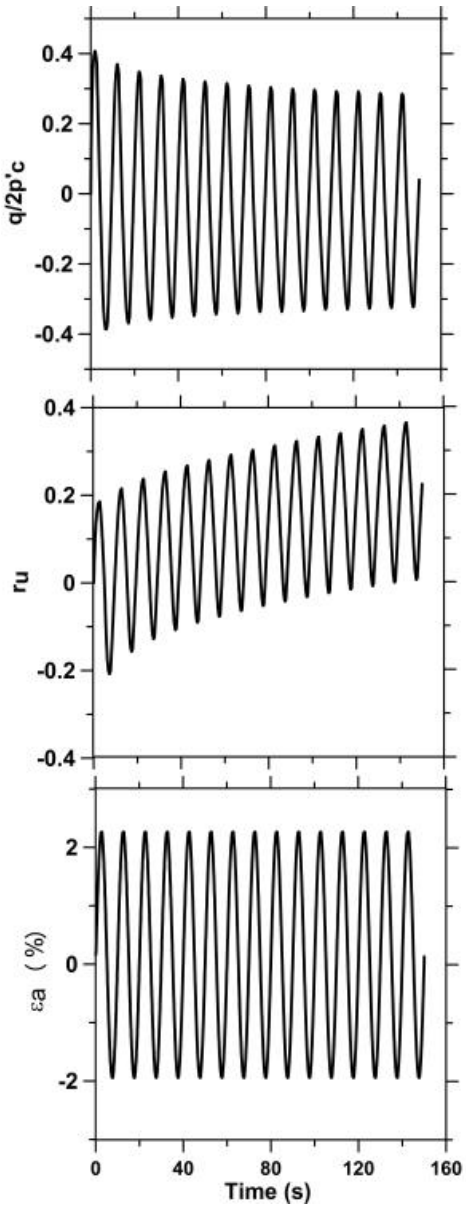
Have Levee Failures Occurred on Peat?

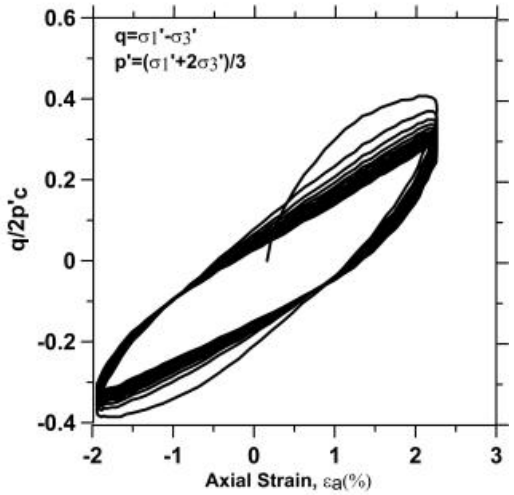


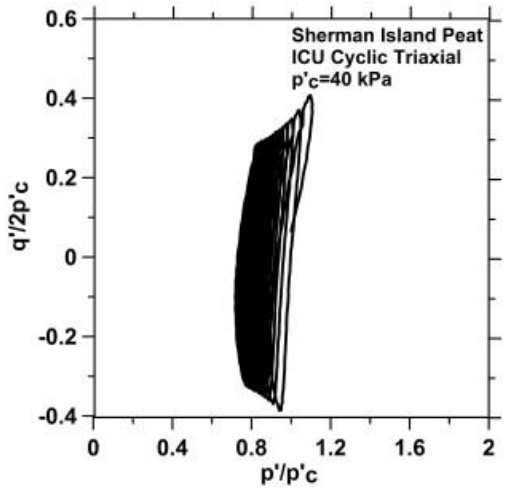
YES!

Sasaki (2009)

Does Peat Generate Excess Pore Pressure?

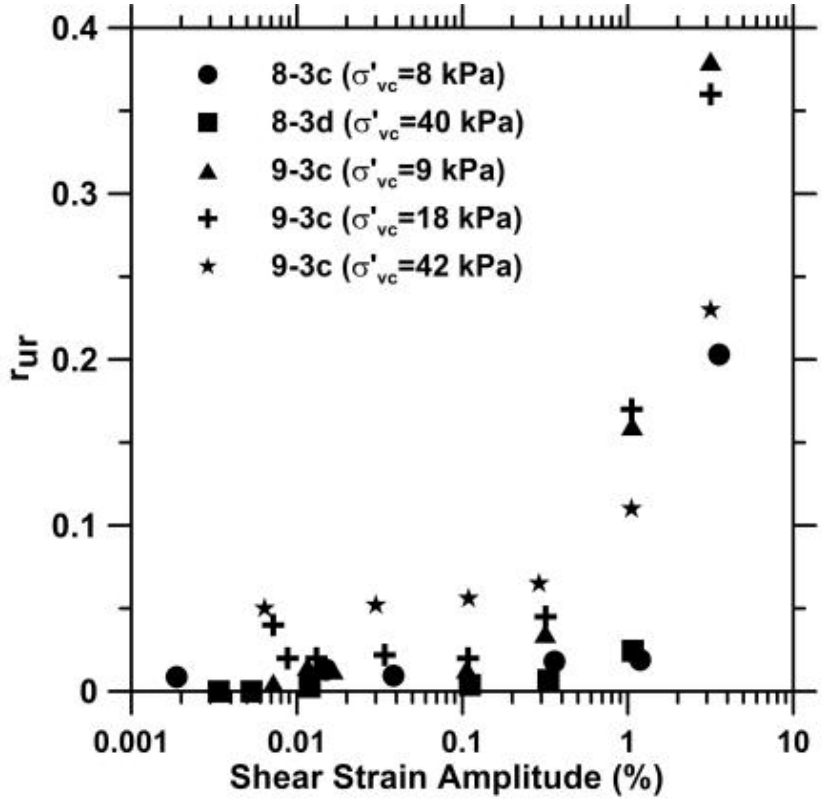


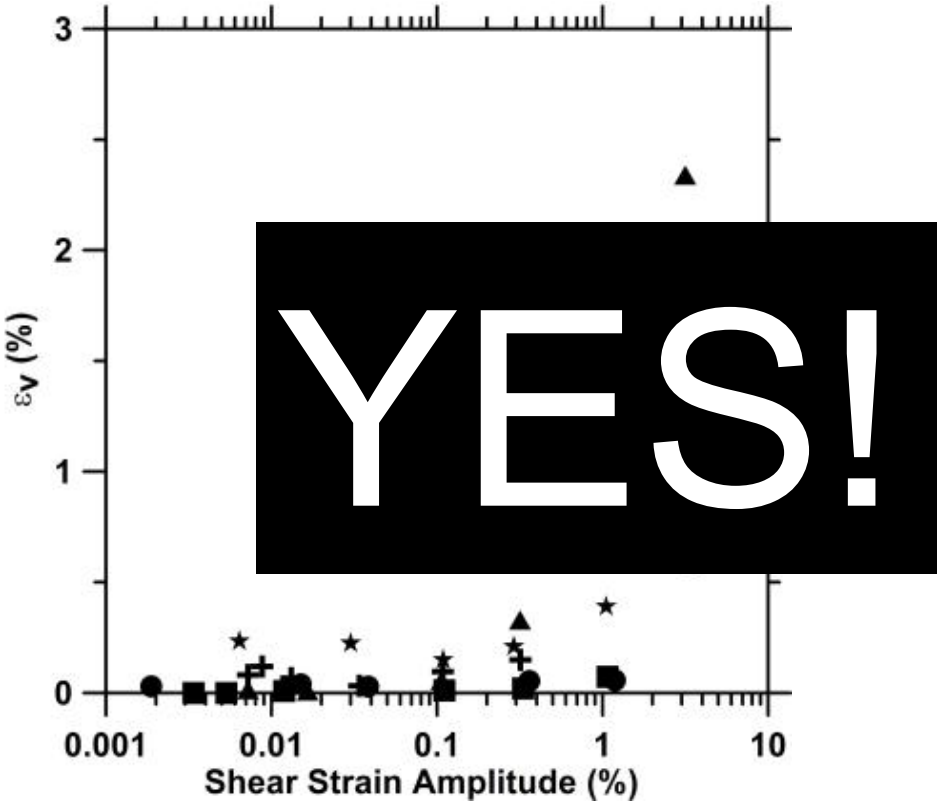




Shafiee et al.(2013)

Does Peat Generate Excess Pore Pressure?

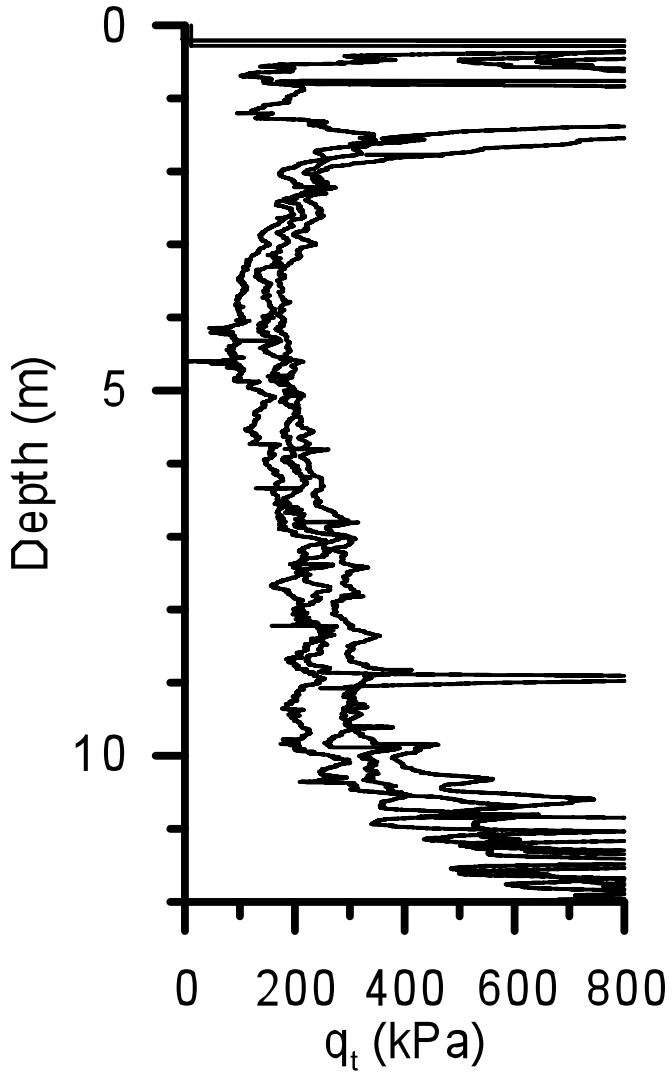




YES!

Shafiee et al.(2013)

How Soft is the Peat?



Movie

Test Location

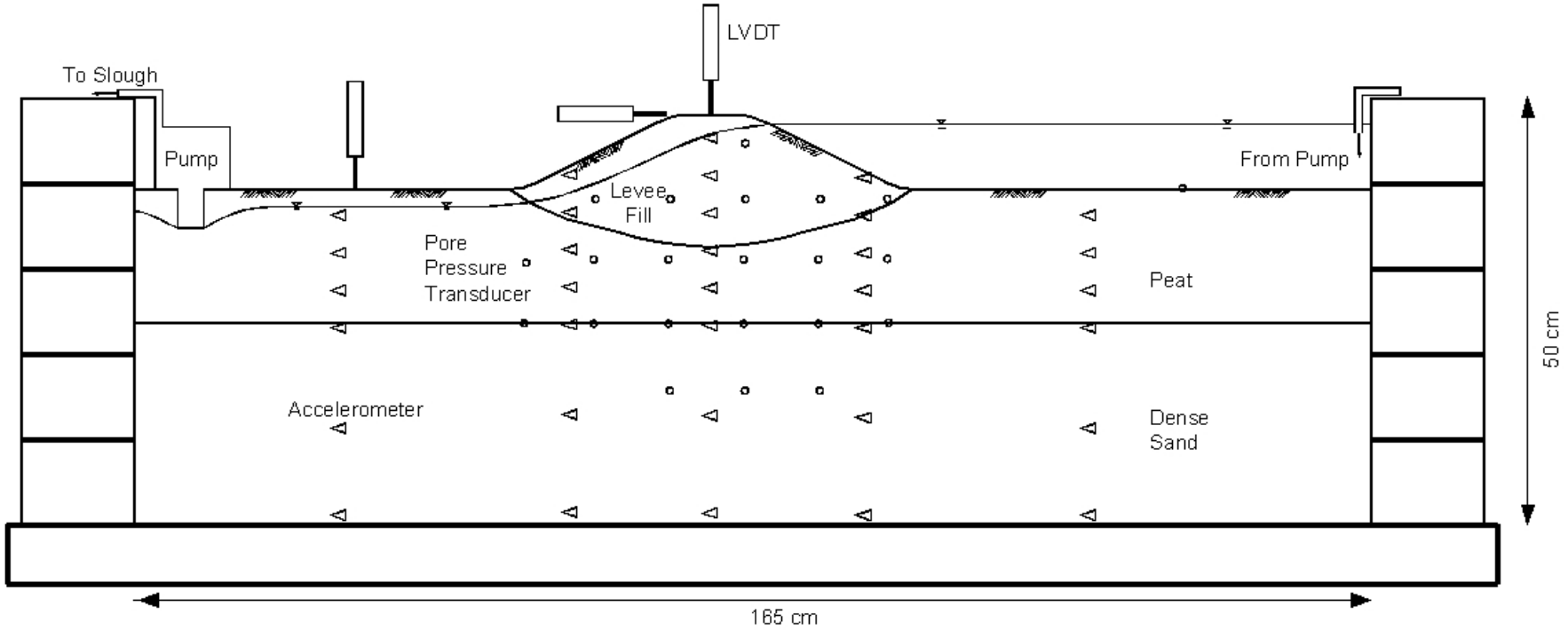
Movie

MK-15 Mobile Field Shaker

Movie

Funding: NSF – NEES
Project Team: Brandenberg, Stewart, Reinert (UCLA)
Moss (Cal Poly)

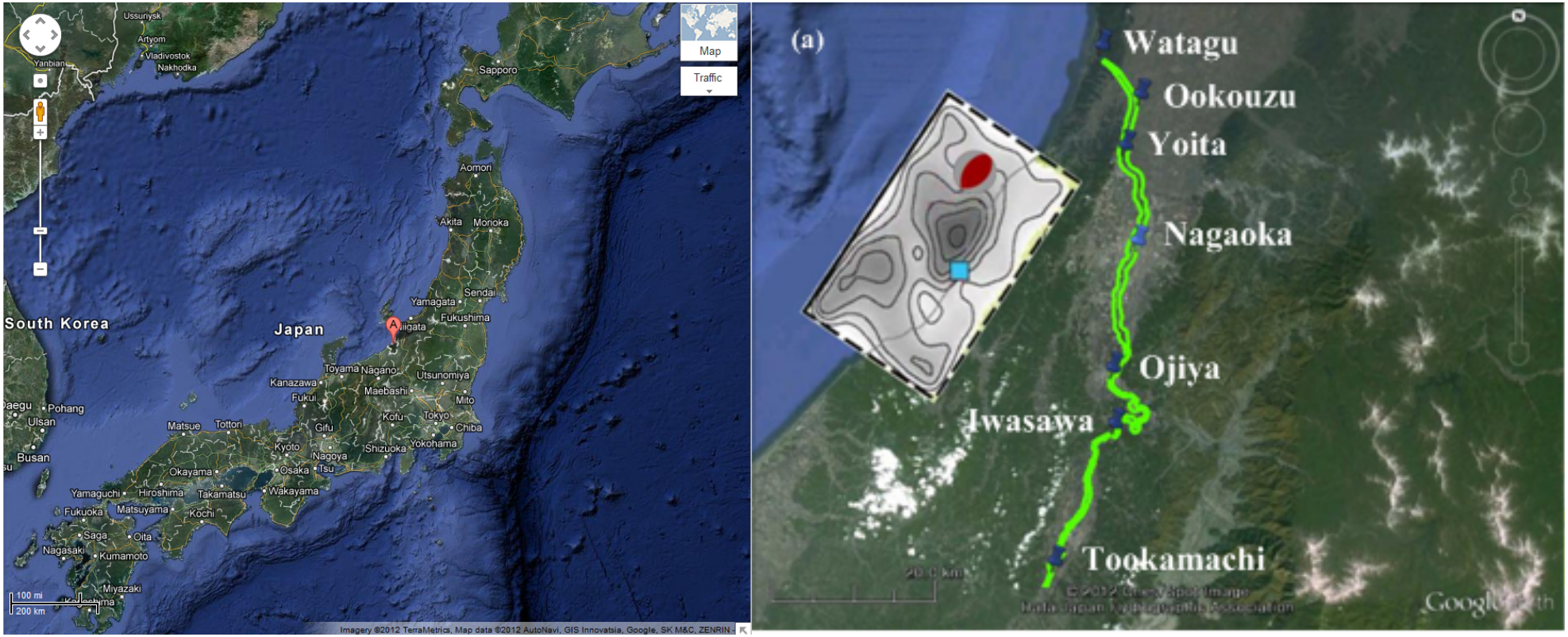
Upcoming Centrifuge Study



Funding: NSF – NEES

Research Team Team: Brandenberg, Stewart, Yniesta (UCLA)
Lemnitzer, Cappa (UC Irvine)
Mylonakis (University of Patras)

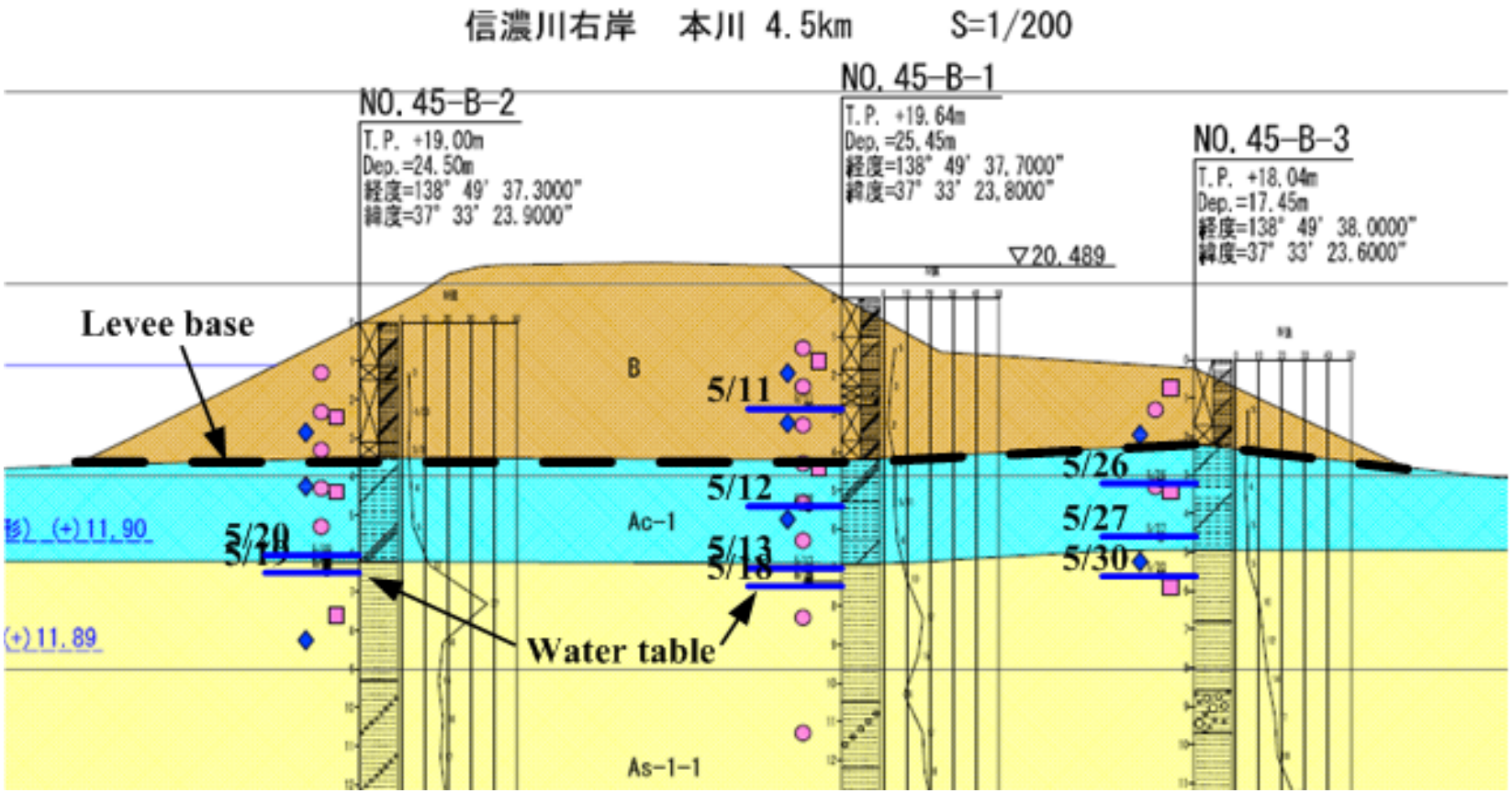
Case History Analysis



Funding: California Department of Water Resources

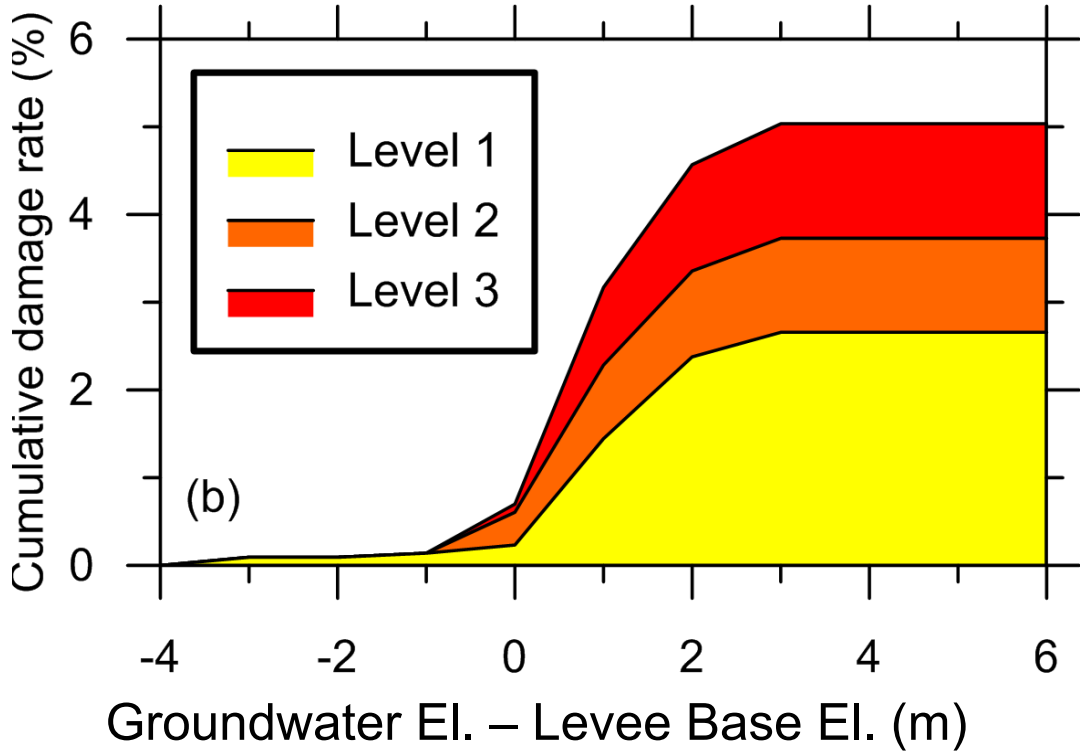
Research Team: Stewart, Brandenberg, Kwak (UCLA), Mikami (U. of Tokushima)
Seed, Pestana (UC Berkeley)

Case History Analysis



Case History Analysis

Damage Level	Crack Depth (cm)	Subsidence (cm)	Description
0			No damage reported
1	< 50	< 10	Slight damage, surface manifestation of liquefaction
2	50~100	10~30	Moderate damage
3	100~300	30~100	Severe damage
4	> 300	> 100	Levee collapse



Kwak et al. (2013)

Conclusions

- Seismic hazard is a significant threat to the Delta, which is the hub of California's water delivery system. Liquefaction of levee fills is a well understood threat, but less is known about the seismic response of the underlying peat.
- Peaty organic soil can transmit significant seismic energy.
- Peaty organic soil has contributed to past levee failures. Ongoing research will help identify fundamental mechanisms.
- Peaty organic soil does generate some excess pore pressure during cyclic shearing. Although nonliquefiable, it may nevertheless undergo significant volume change during post-cyclic reconsolidation.