SIMPLIFIED APPROACH TO ASSESS LEVEE SEISMIC VULNERABILITY

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Assessment of Seismic Vulnerability

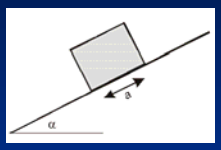
Approach

- Newmark estimation of potential deformation and assessment of post-earthquake flood protection ability

Process

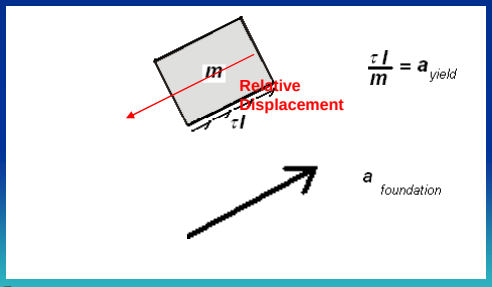
- Seismic Hazard – Urban Levee Program Probabilistic Seismic Hazard Maps
- Liquefaction Triggering CSR – Urban Levee Program CSR Charts
- K_y – Site Specific Estimations
- Earthquake Loading – Urban Levee Program K_{max} Charts
- Displacement – Urban Levee Program Displacement = f(Magnitude, Failure Surface-Type, K_y/K_{max}) Charts

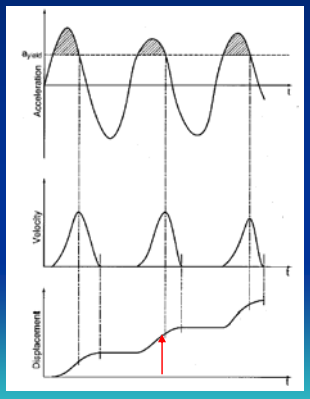
Newmark Approach



*Force = Mass * Acceleration*

Relative Acceleration – a = a_y - a_r
Integrate once – Relative Velocity = at
Integrate twice- Relative Displacement = ½ at^2





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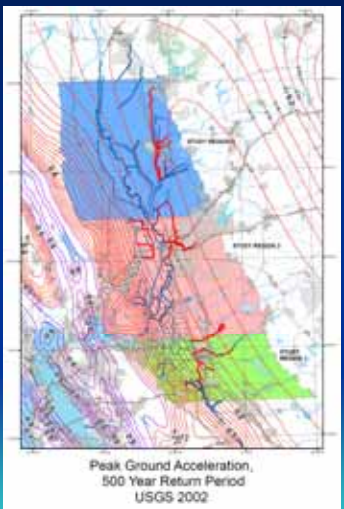
Estimates of Peak Ground Acceleration (PGA)



Peak Ground Acceleration,
500 Year Return Period
USGS 2002

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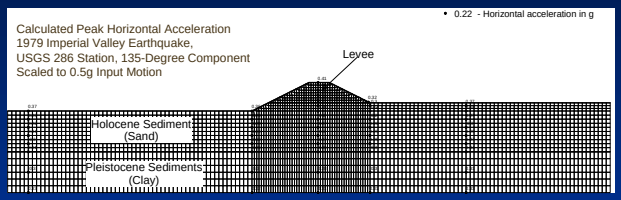
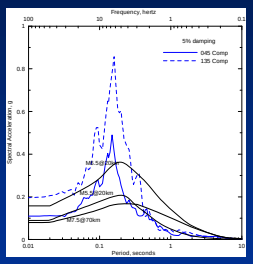
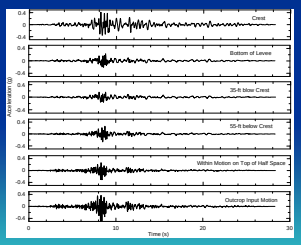
Example Finite Element Model Inputs & Results

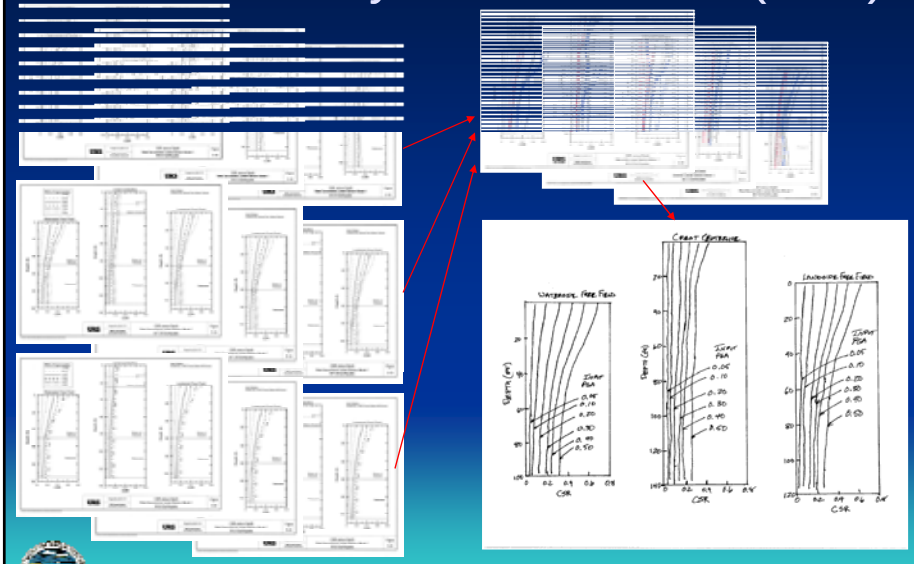




Material	Unit Weight (pcf)	Vs (ft/s)	K_2max	Poisson's Ratio	G/Gmax and Damping Curves
Levee Fill (Silt)	115	-	25	0.35	Seed-Idriss Sand (mean)
Holocene (Medium Dense Sand)	125	-	50	0.35	Seed-Idriss Sand (mean)
Pleistocene (CL)	125	900	-	0.45	Vucetic & Dobry, PI=30
Elastic Base	125	1100	-	-	-



Estimate of Cyclic Stress Ratio (CSR)



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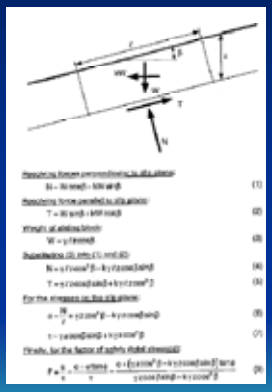
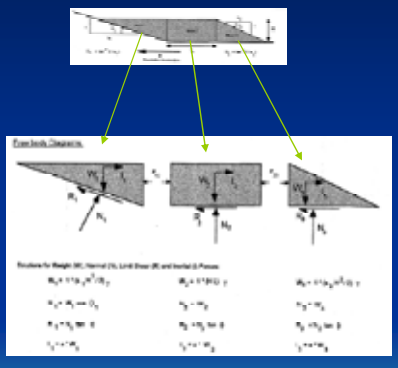
How do we evaluate K_y?

Infinite Slope

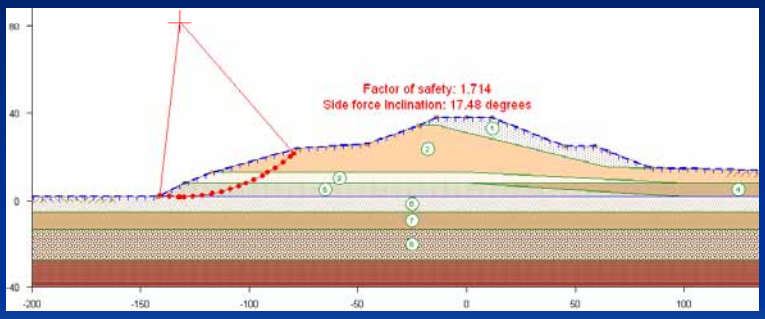


Multi-block Wedge



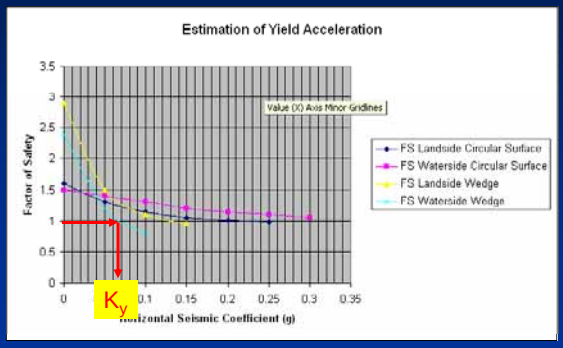
Limit Equilibrium – Increase seismic coefficient until FS = 1

Use Slope Stability Program



UTEXAS4 is the only currently authorized computer program

Interpolate to Evaluate K_y



- Run analysis for increasing a_h (0.0, 0.05, 0.10, … up to to ½ K_{max})
- Plot results on graph
- Interpolate to evaluate K_y at FS = 1

Evaluate Liquefaction Triggering Using Seed et al (2004)*

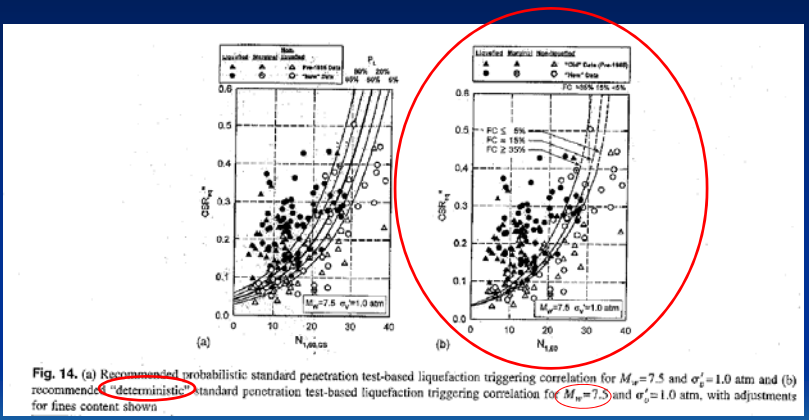
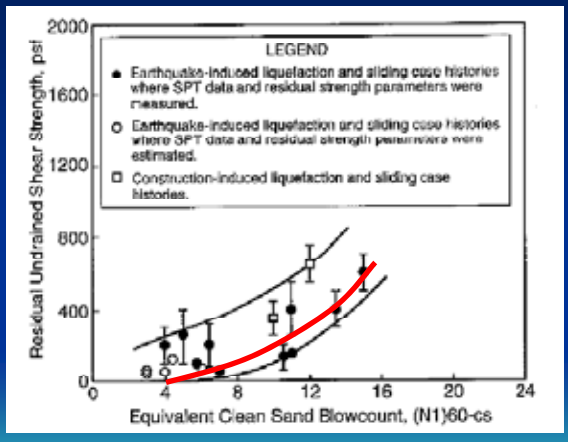


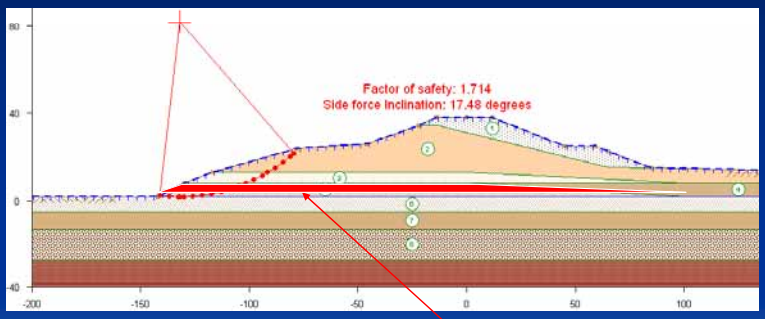
Fig. 14. (a) Recommended probabilistic standard penetration test-based liquefaction triggering correlation for $M_w = 7.5$ and $\sigma'_o = 1.0$ atm and (b) recommended "deterministic" standard penetration test-based liquefaction triggering correlation for $M_w = 7.5$ and $\sigma'_o = 1.0$ atm, with adjustments for fines content shown

Set Duration Weighting Factor = 1 All Events

Estimate Liquefied Soil Strengths using Seed and Harder (1990)

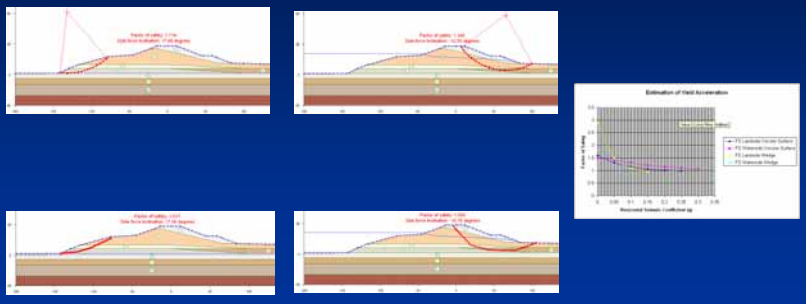


Use Undrained Residual Strength to Assess Post-Liquefaction Triggering K_y



Su = 250psf

Results Presentation



- Show
  - Strengths
  - Analysis water conditions (“summer” “normal winter”)
  - Location of static critical surfaces (landside, waterside, circular, wedge)
  - Show location of K_y failure surfaces (landside, waterside, circular, wedge - usually not the same)
  - Show K_y graph

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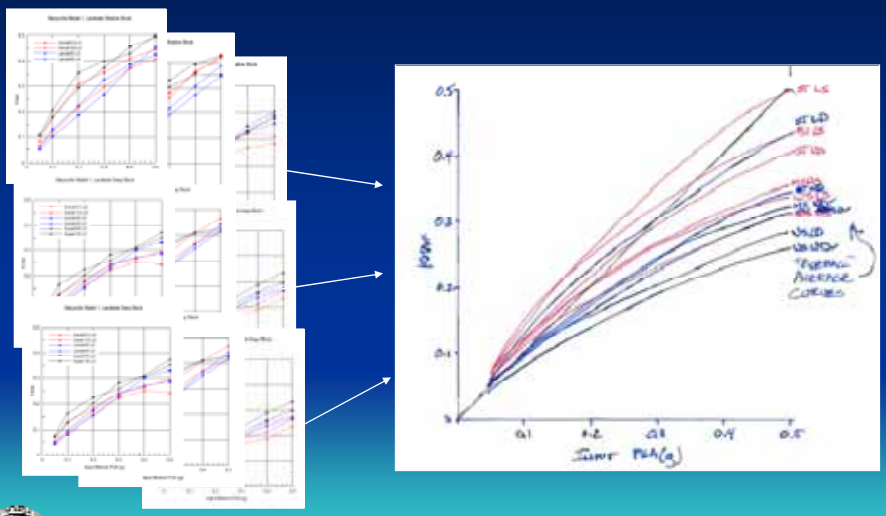
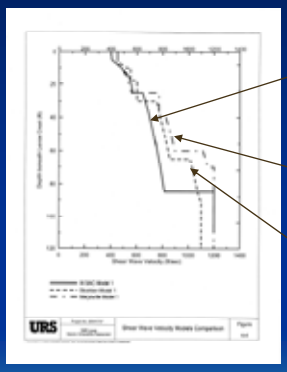
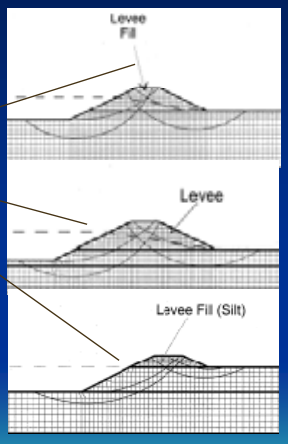
Estimate of Site Response and 2-Dimensional Effects (K_{max})



Asymmetry/Stiffness

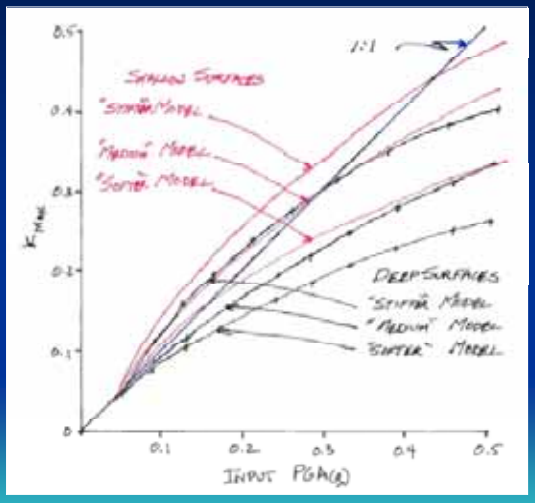




"Sacramento"	Symmetric	"Softer"
"Marysville"	Less Symmetric	"Medium"
"Stockton"	Asymmetric	"Stiffer"

Asymmetry may be important and can be considered.

Choose Model Based on Stiffness



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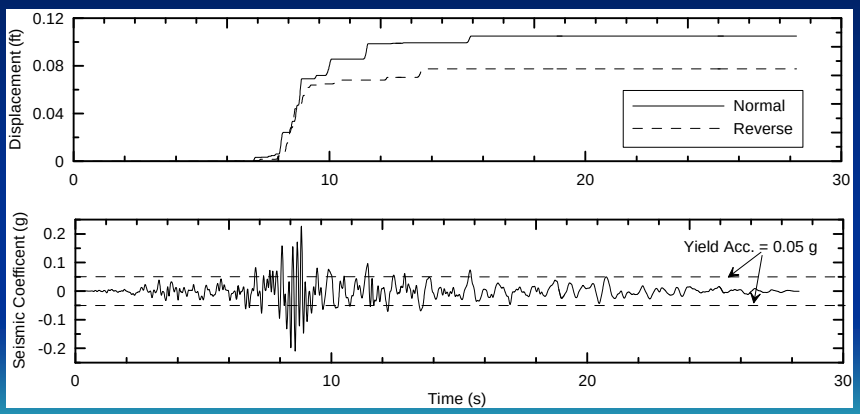
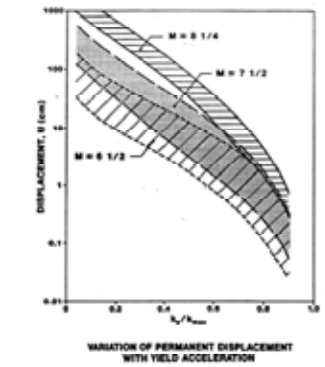
Example Newmark Calculation Results

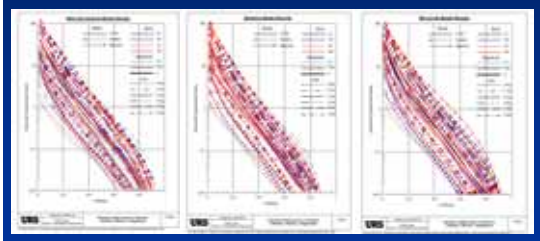


Interpretation of Results

Displacement = f(K_y/K_{max}? Block Type/Depth? Magnitude/Duration? Scaled PGA?)



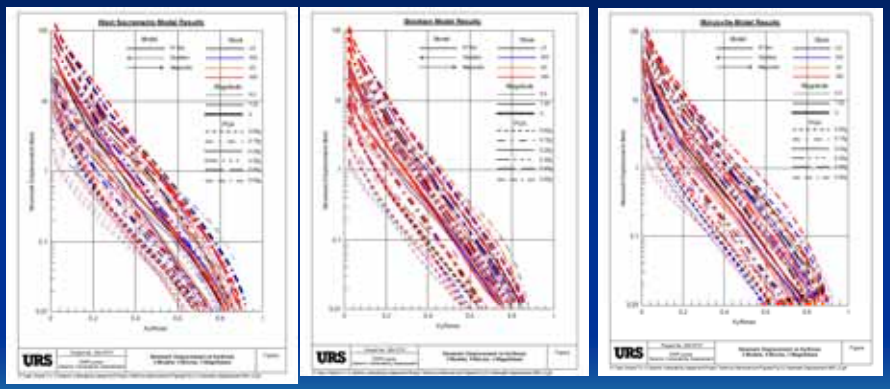
Makdisi-Seed (1978)



West Sacramento Stockton Marysville

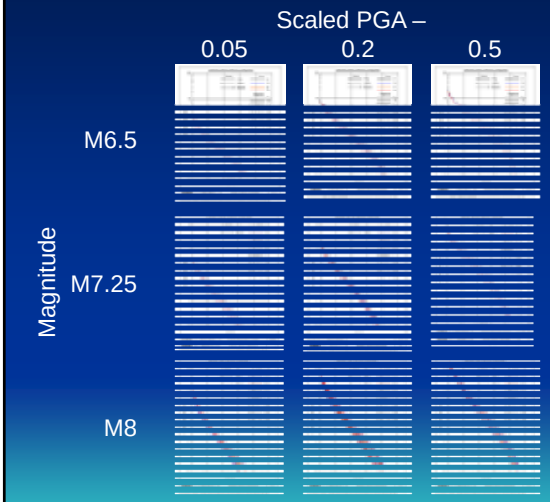
All scaled to be compared directly with Makdisi-Seed (1978)

Displacement = (K_y/K_{max})? YES



K_y/K_{max} has an impact on K_y/K_{max} estimates of displacement

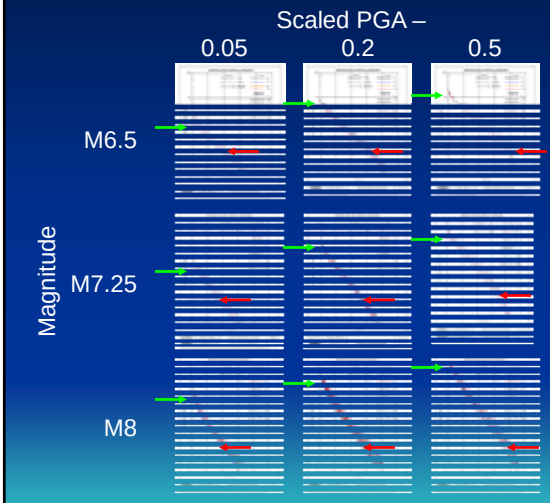
Displacement = f(Block Type / Depth)? NO

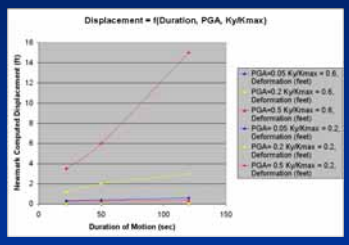


Each figure shows:
- Waterside Shallow,
- Waterside Deep,
- Landside Shallow, &
- Landside Deep surfaces for all 3 regional models

Block Type and Depth have no apparent impact on K_y/K_{max} estimates of displacement

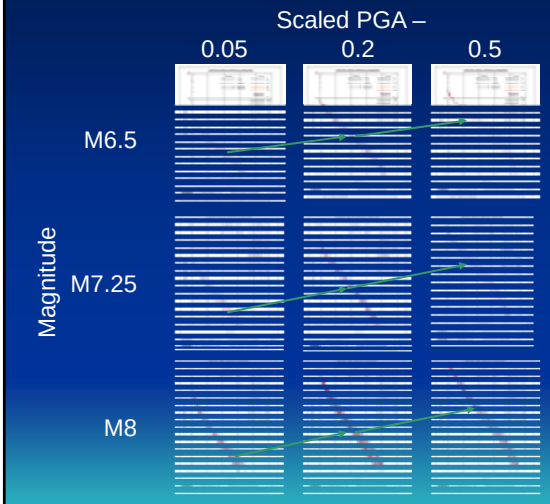
Displacement = f(Magnitude/Duration)? Yes for $K_y/K_{max} < 0.4$

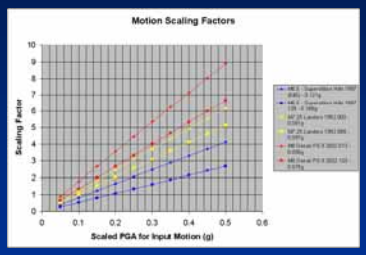




Magnitude / Duration has an apparent impact on K_y/K_{max} estimates of displacement

Displacement = f(Scaled Input PGA)? Yes, but…

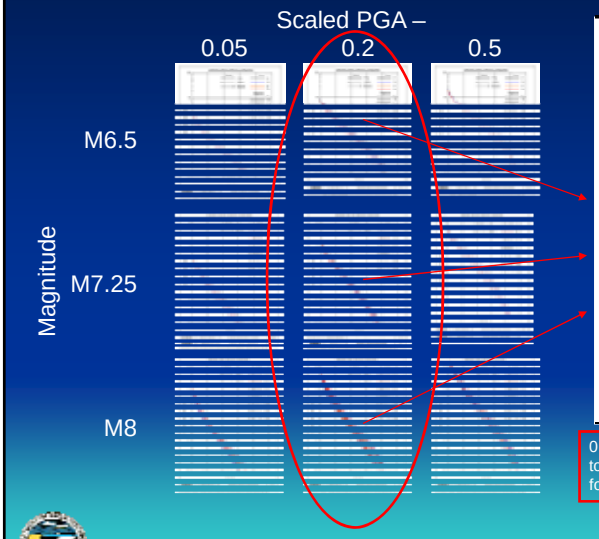


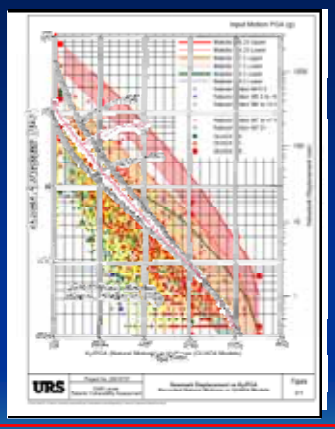


Concern that Scaled Input PGA apparent impact on K_y/K_{max} estimates of displacement is only a numerical result

Possible resolution – Spectral Matching and Arias Intensity screening

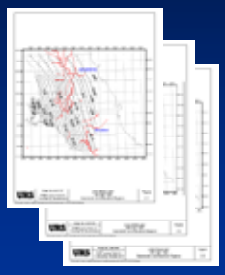
Use Model for Scaled Input Motion = 0.2g for Vulnerability Assessment



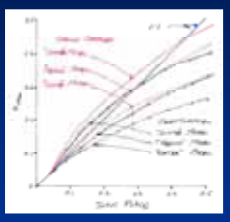


0.2g scaled PGA model results are believed to provide a reasonable expected relationship for the study areas

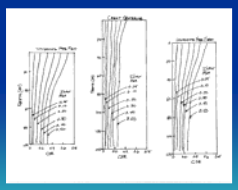
Summary – Levee Deformation Evaluation Charts



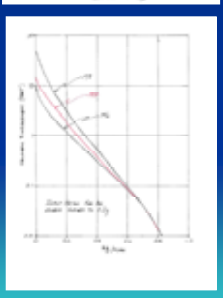
PGA = f(Return Period)



K_{max} = f(PGA, block depth, model stiffness)

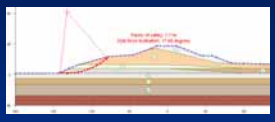


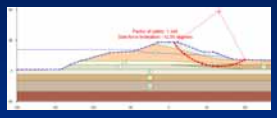
CSR = f(PGA)

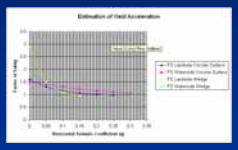


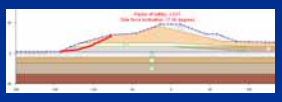
Displacement = f(K_y/K_{max}, Magnitude)

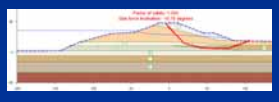
Freeboard Loss Assessment







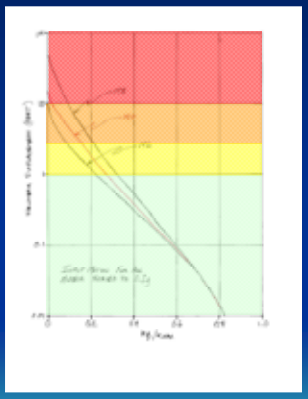




- Consider compound failures each causing freeboard loss (i.e., waterside and landside both causing concurrent loss of freeboard)
- Assume horizontal deformation causes freeboard loss at a rate of 0.7V : 1H for both circular failure surfaces and potential grabens that can form on lateral spreads

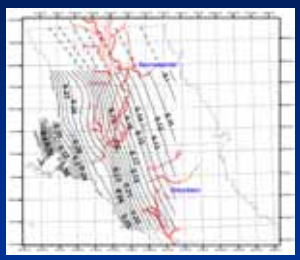
Vulnerability Assessment

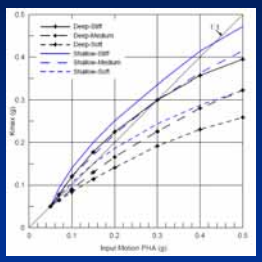
AMOUNT OF DEFORMATION	SIGNIFICANT DAMAGE TO INTERNAL STRUCTURES (E.G. CUTOFF WALLS	REMAINING FREEBOARD FOR POST SEISMIC EVALUATION (2-YEAR FLOOD WATER SURFACE ELEVATION?)	POST SEISMIC FLOOD PROTECTION ABILITY
<1'	No	>1'	Probably Uncompromised
1' to 3'	Possibly	>1'	Possibly Compromised
3' to 10'	Likely if existing	None	Likely Compromised
Unlimited (flow slide condition)	Yes	None	Compromised



Final Evaluation Charts

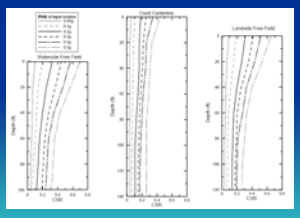
PGA

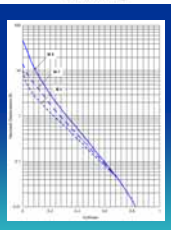




K_{max}

CSR





Displacement

Questions / Discussion