Is VS30 an Effective Parameter for Site Characterization?

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Before VS30

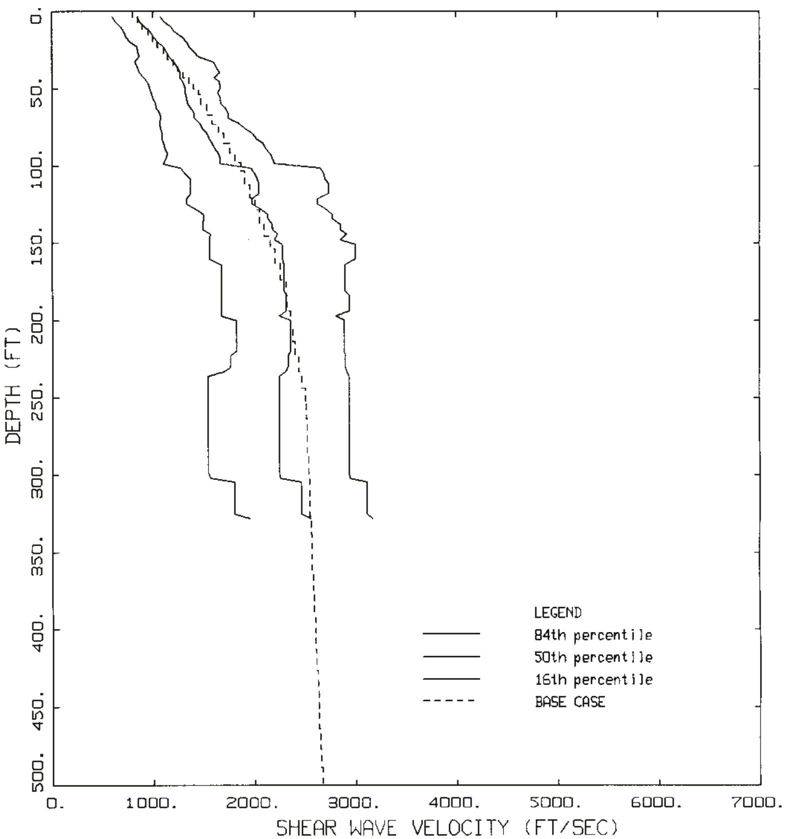
- Generic Site Categories Used in Western U.S. GMPEs
  - Soft soil
    - Requires special consideration
  - Soil
    - Deep soil excluding soft-soil
  - Rock
    - Not deep soil
    - Sometimes separated into hard-rock and soft-rock

VS30

- VS30 is not the fundamental physical parameter.
  - Index of the velocity profile
- Provides a quantitative parameterization of site
  - Less subjective than site categories
  - Provides a smooth transition between site categories
- For typical strong motion sites in California, VS30 correlated with deeper Vs profile
  - Most soil sites are in alluvial basins (deep soils)
  - Need soil depth for shallow soil sites

Correlation of VS Profile and VS30

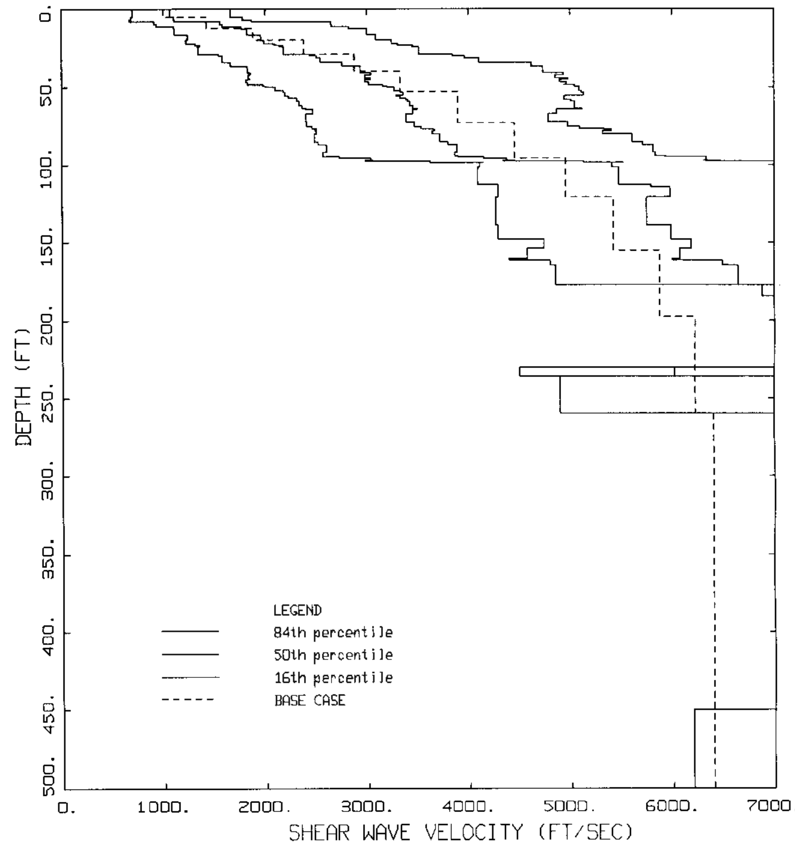
VS30=300



SHEAR WAVE VELOCITY PROFILES
Qo LOS ANGELES AREA

Figure 18. Median and ± 1 σ shear-wave velocity profiles for the Los Angeles area surface geologic unit Q_{oa}, Older Alluvium (Table 1).

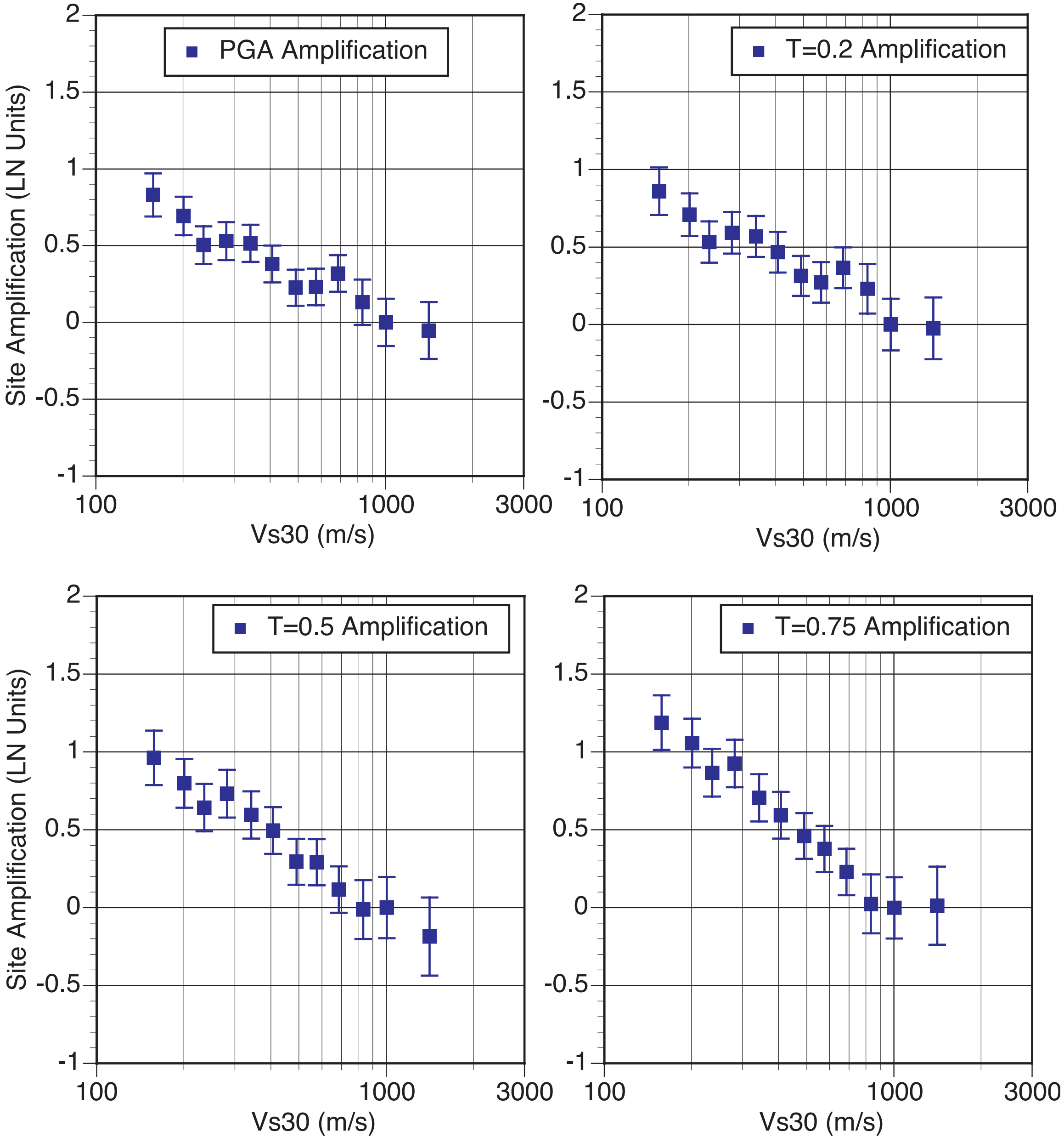
VS30=800



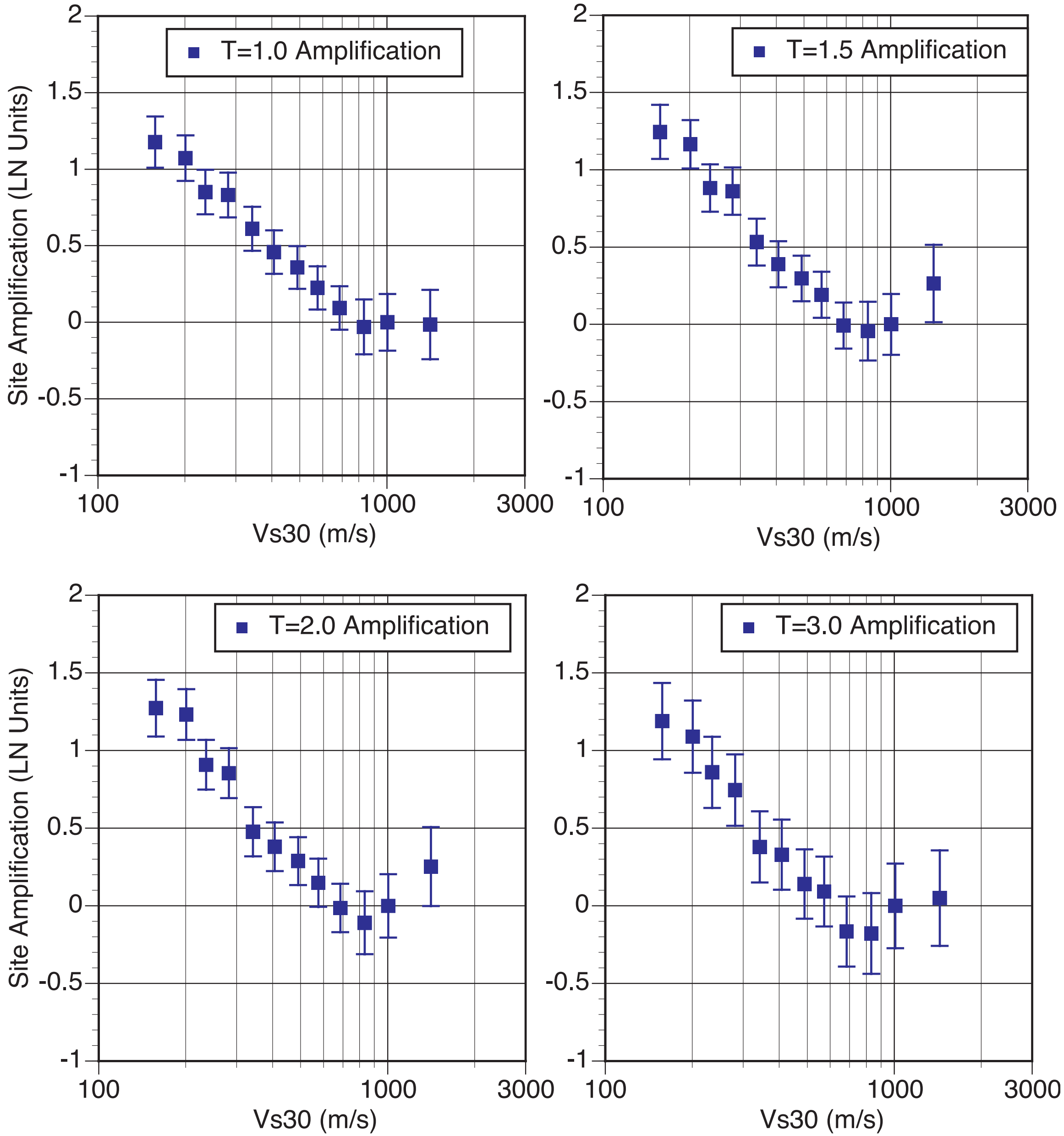
SHEAR WAVE VELOCITY PROFILES
KJf NORTH CALIFORNIA

Figure 9. Median and ± 1 σ shear-wave velocity profiles for the San Francisco Bay area surface geologic unit K_{jf}, Franciscan (Table 1).

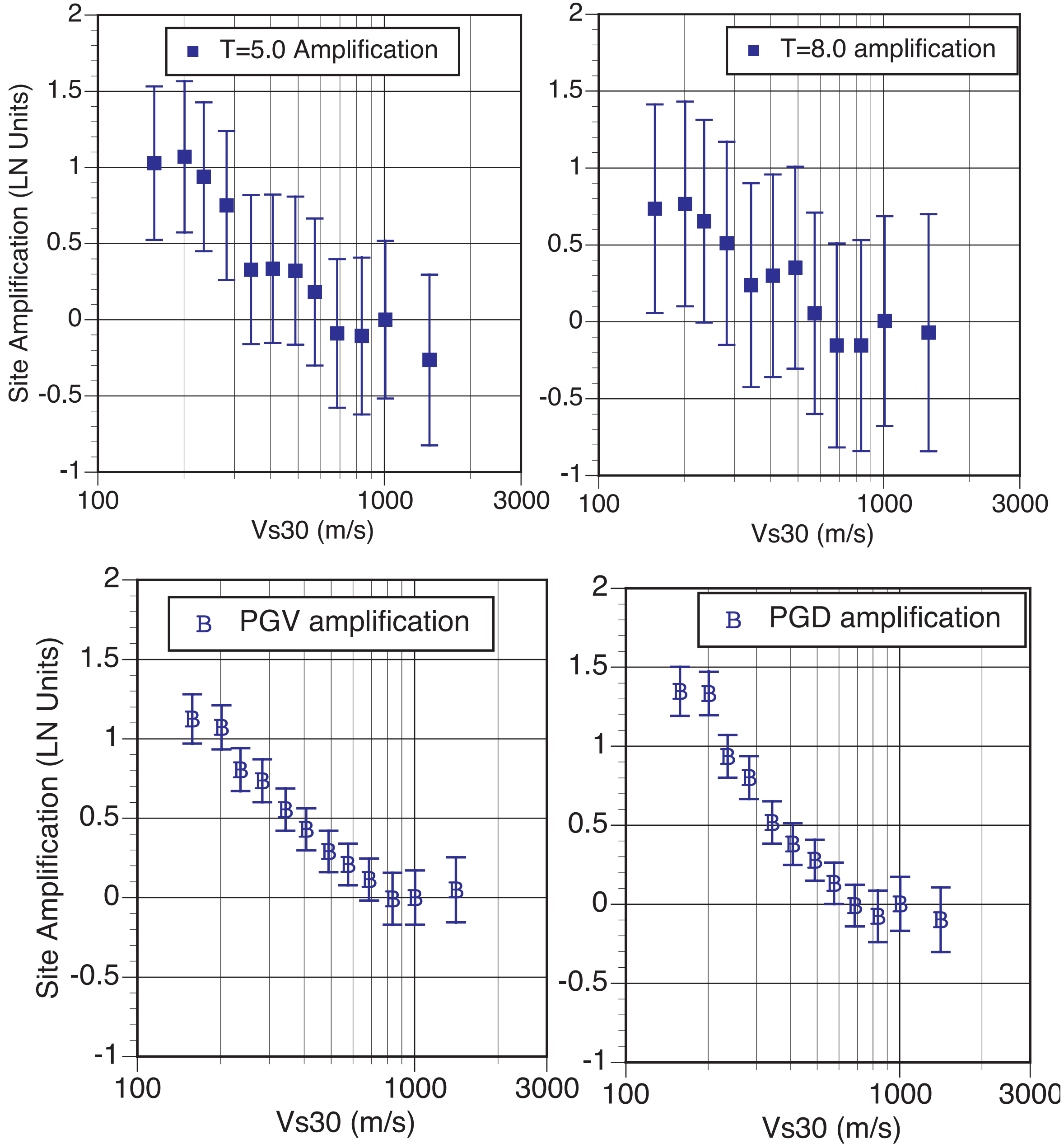
Does VS30 Work?



Does VS30 Work?



Does VS30 Work?



Does VS30 Work?

- Short periods
  - V_{S30} captures general site amplification for soil and soft-rock sites
  - Extrapolating V_{S30} scaling to hard-rock sites may not work
    - Does not capture effects of kappa
    - Most GMPEs put an upper limit on the VS30 used (1000-1500 m/s)
- Long periods
  - V_{S30} captures general amplification for soil sites
  - V_{S30} is not correlated with long period amplification for rock sites

How Well Does VS30 Work?

- At long periods, explains factor of 2-3 differences between soil and rock sites
- Look at the remaining variability of the site response after using VS30
  - Components of variability

Components of Ground Motion Variability

Site effect not explained by VS30

$$Sa(M_i, R_{ik}, VS30_k) =$$

$$F(M_i, R_{ik}, VS30_k) + \delta B_i + \delta WS_{ik} + \hat{S}_k$$

$$\sigma = \sqrt{\tau^2 + \phi_{SS}^2 + \phi_S^2}$$

Between Event

Within Event

Components of Variability from Taiwan Data

	σ	τ	ϕ_S	ϕ_{SS}	
PGA	0.68	0.41	0.28	0.47	
T=0.1	0.76	0.44	0.36	0.50	
T=0.3	0.69	0.38	0.30	0.49	
T=0.5	0.70	0.42	0.32	0.47	
T=1.0	0.74	0.47	0.38	0.43	
T=3.0	0.85	0.59	0.43	0.42	

LN units

(From Lin et al, 2011)

Comparison of ϕ_S based on V_{S30}

		California		Taiwan	
PGA		0.44		0.28	
T=0.1				0.36	
T=0.3		0.46		0.30	
T=0.5				0.32	
T=1.0		0.42		0.38	
T=3.0				0.43	

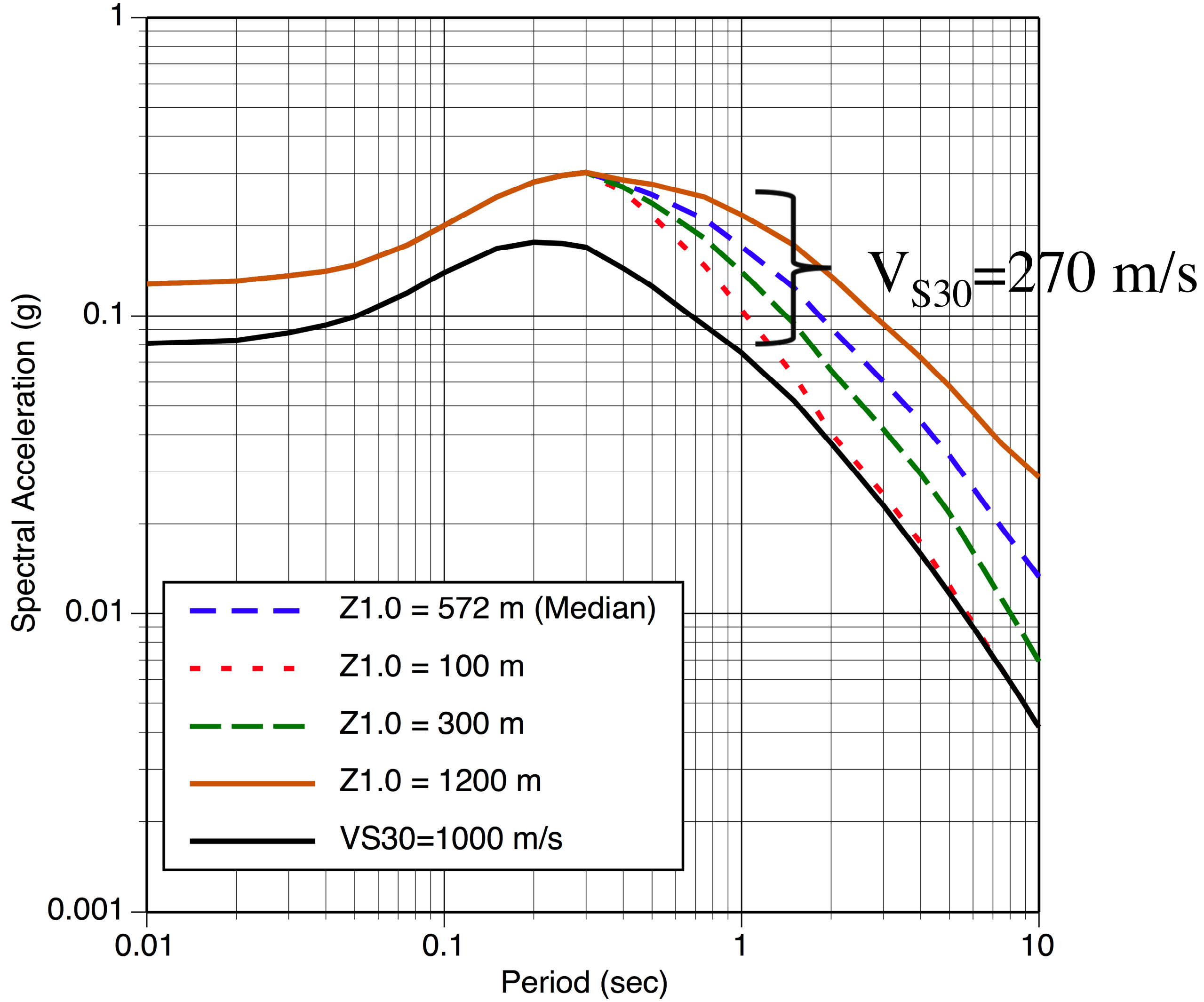
LN units

Beyond VS30

- Add soil depth (2 parameters to VS profile)
  - Allows separation of shallow and deep soil sites
- Add Kappa
  - Allows extrapolation of VS30 scaling to hard-rock sites
    - Only inputs the high frequencies (> 10 Hz)
- Add site period
  - Difficult, sites may have more than one site period (shallow and deep parts of the profile)

Effect of Soil Depth

AS08 model



Plan for Update of AS08 NGA (NGA-west2)

- In addition to VS30:
  - Soil depth (depth to VS=1 km/s)
  - Kappa
- Difficulty in estimating additional parameters
  - Default values will be provided if additional parameters are not known.

Use and Misuse of VS30

- Intended Use of VS30 in NGA models
  - Clear hand-off between ground motion and site response for definition of the input motions
    - Consistent definition of "rock" or input motion
    - VS30 used in the GMPE should be for the 30 m below the level of the input motion
  - Use for deep soil sites that have typical profiles
    - e.g deep soil site in LA basin
- Misuse
  - Replace site-specific analysis (for sites with profiles not typical as contained in GM data base)
    - VS30 was never intended to provide a site-specific site amplification

Conclusions

- V_{S30} remains a useful parameter for general site classification
  - Better than the old categories of soil and rock
    - Less ambiguous
    - Avoids jumps in ground motion from one category to the next)
  - Allows for defining motion for the appropriate layer for the input motion
  - I have not seen an other single parameter that works better

Conclusions (cont)

- Additional site parameters can be added to GMPEs
- Should address common conditions with large effects
  - Shallow soils (not deep alluvial basins)
    - Depth to rock
  - Hard rock conditions (e.g. EUS)
    - Kappa
- Adding a few additional site parameters will not replace site-specific response
  - In my opinion, it is a mistake to try to build detailed site-specific effects into GMPEs
  - This should be handled by site-specific analysis

Comparison of ϕ_S based on V_{S30}

		California	Japan	Taiwan	
PGA		0.44	0.43	0.28	
T=0.1			0.53	0.36	
T=0.3		0.46	0.47	0.30	
T=0.5			0.43	0.32	
T=1.0		0.42	0.38	0.38	
T=3.0				0.43	