Site-Specific MCE_R Response Spectra for Design of Structures in L.A. Region from 3-D Numerical Simulations & NGA West2 GMPEs

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AECOM

11 NCEE Conference Workshop: June 25, 2018

Presentation

- Brief background
- Details of simulation & GMPE approaches
  - MCE_R response spectra from each approach
  - Procedure to combine MCE_R & final site-specific MCE_R response spectra for L.A. area sites
- MCE_R web look-up tool

Project to Develop Earthquake Motions Undertaken by

Utilization of Ground-Motion Simulations Committee (UGMS) of Southern California Earthquake Center (SCEC)

Formed in 2013

UGMS Committee Members

- C. Crouse – Chair
- T Jordan – SCEC
- N. Luco – USGS
- R. Bachman
- J. Hooper – MKA
- J. Bielak – CMU
- C. Kircher
- M. Hudson – Wood plc
- M. Lew – Wood plc
- R. Hamburger - SGH
- A. Frankel – USGS
- N. Abrahamson – PG&E
- R. Graves – USGS
- F. Naeim
- A. Sumer – OSHPD
- P. Somerville – AECOM
- Jack Baker – Stanford
- J. Anderson – UNR
- S. Rezaeian – USGS
- C. Goulet – SCEC

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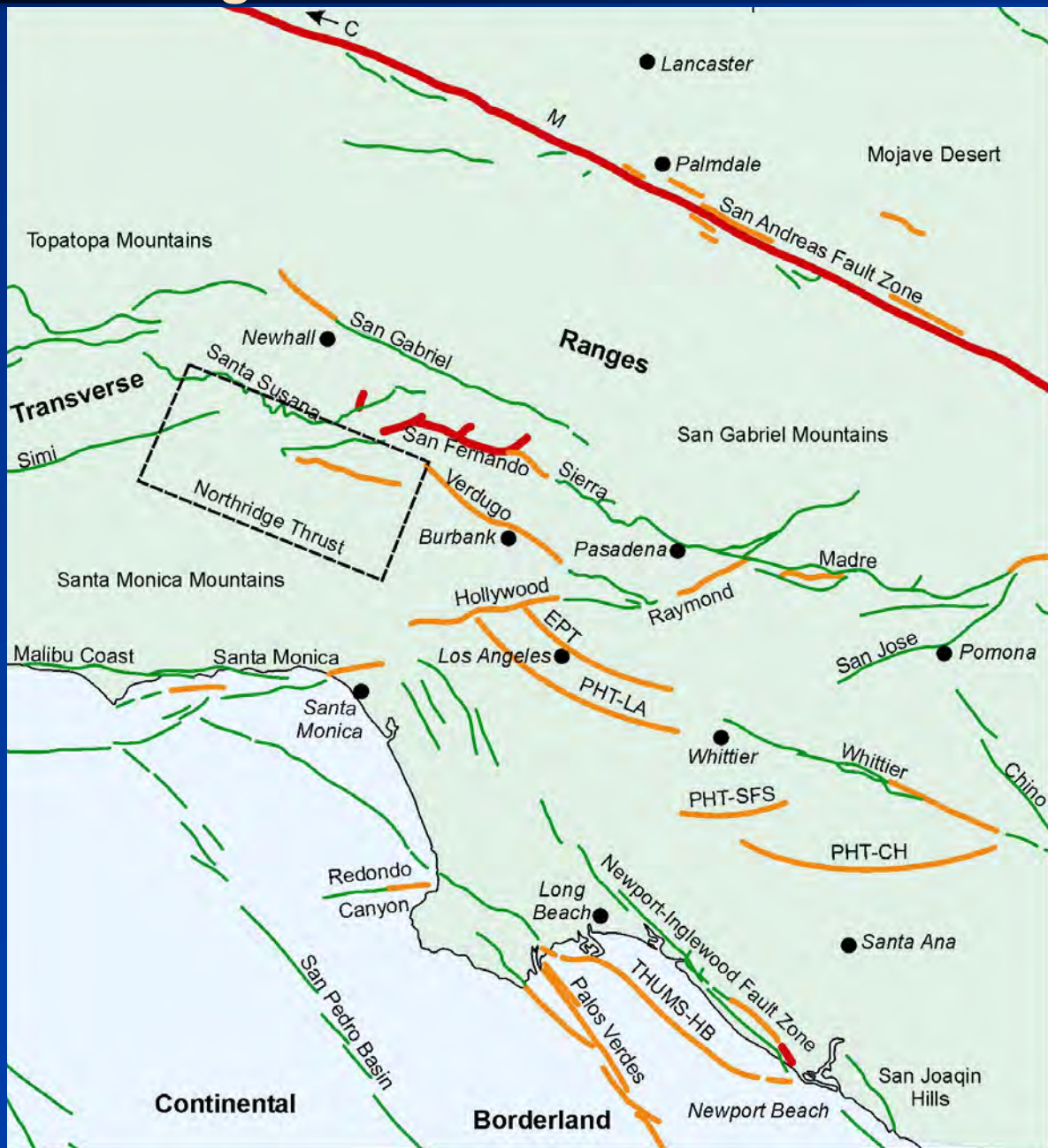
Limitation of Eqns derived from Recorded Motions Los Angeles

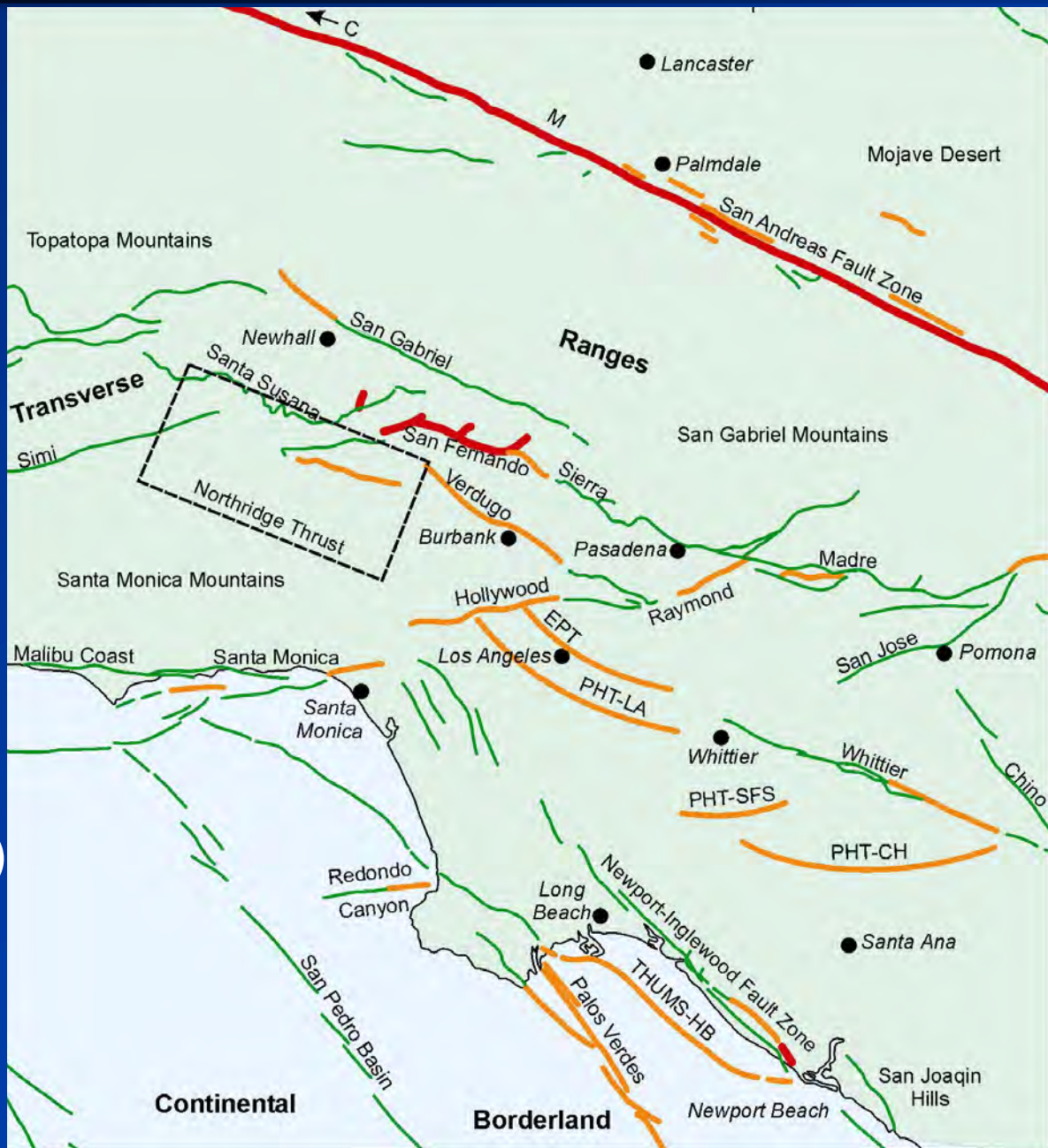
1. Lack of Local <u>Strong</u> Motion Records in L.A. from past EQs

   (Exception: 1994 M6.7 Northridge & 1971 M6.6 San Fernando EQs)



3-D Numerical Simulation Approach

1. Use UCERF2 fault recurrence models
2. Do simulations
   - ⬇
   - H1 & H2 accel. a(t)
   - ⬇
   - response spectra, $S_a(T)$
   - ⬇
   - median $S_a(T)$ & σ_{ln}
3. Proceed with PSHA/DSHA (C. 21, ASCE 7-16)
4. MCE_R Response Spectra



CyberShake Computational Platform used for Simulations

- 3-D physics-based model of fault rupture and wave propagation for S. CA EQs
- 40,000 regional earthquakes (M ≥ 6) were simulated
  - Multiple hypocenter and slip models for each given M on given fault
  - e.g., 140 models for M6.7 on Northridge fault (~ no. for other M on this fault)
- 440,000 ground-motion simulations for each of 336 sites

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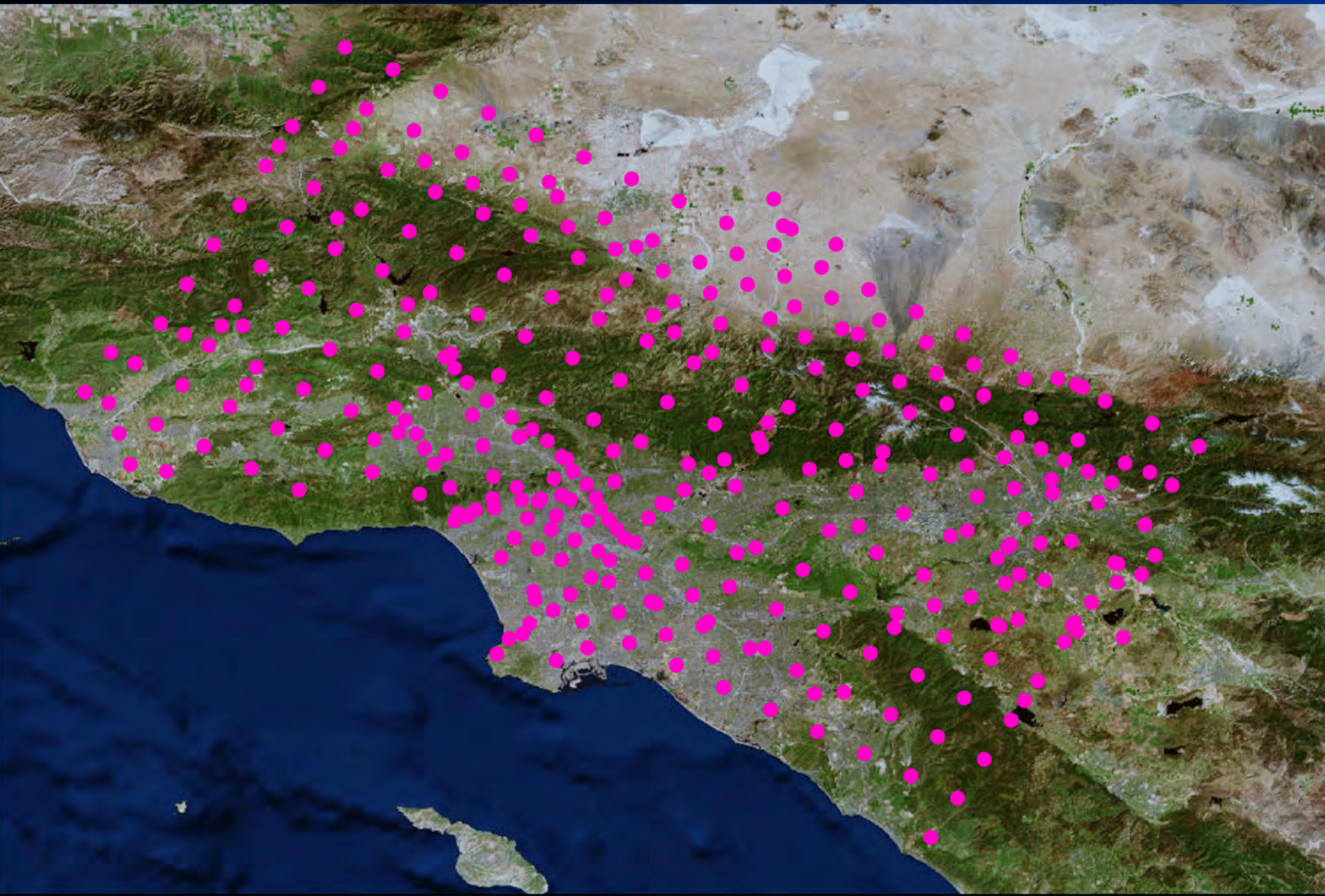
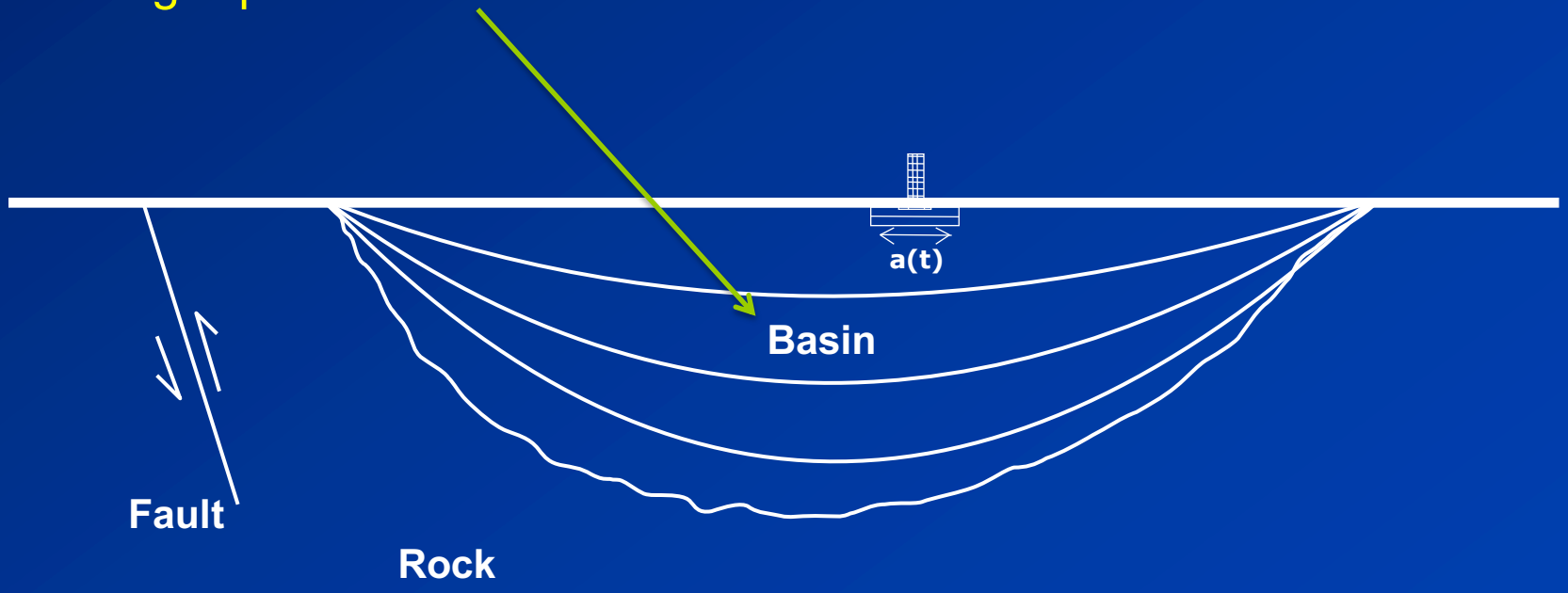
Simulated Motions computed at 336 CyberShake Sites



Advantages of 3D Simulations for L.A. Region

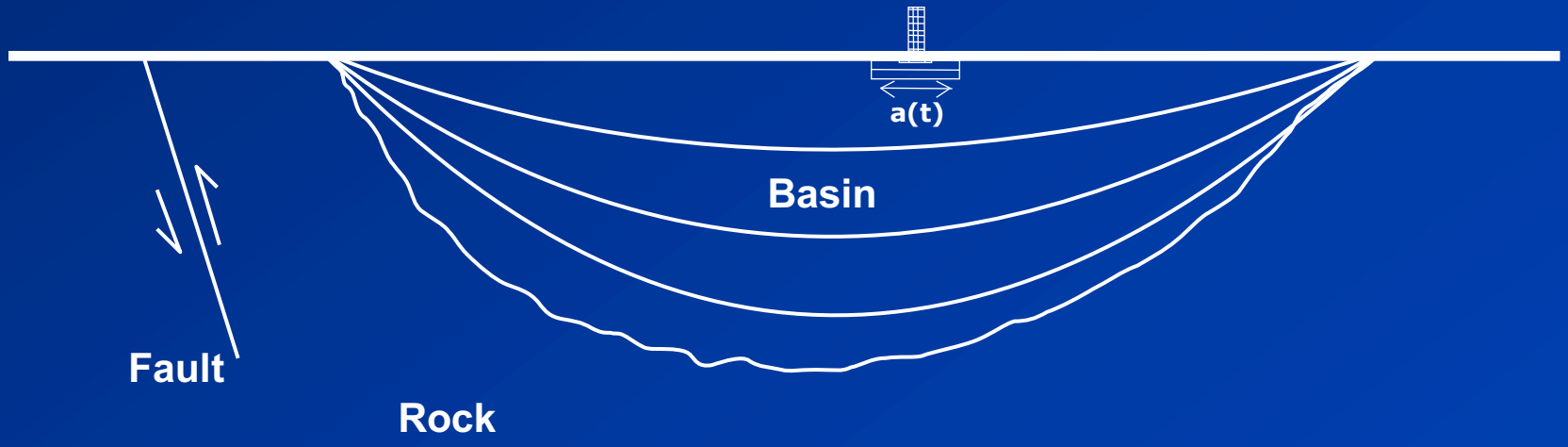
Basin Structure, Vp, Vs, & Q – Well known for modeling propagation of longer period waves.



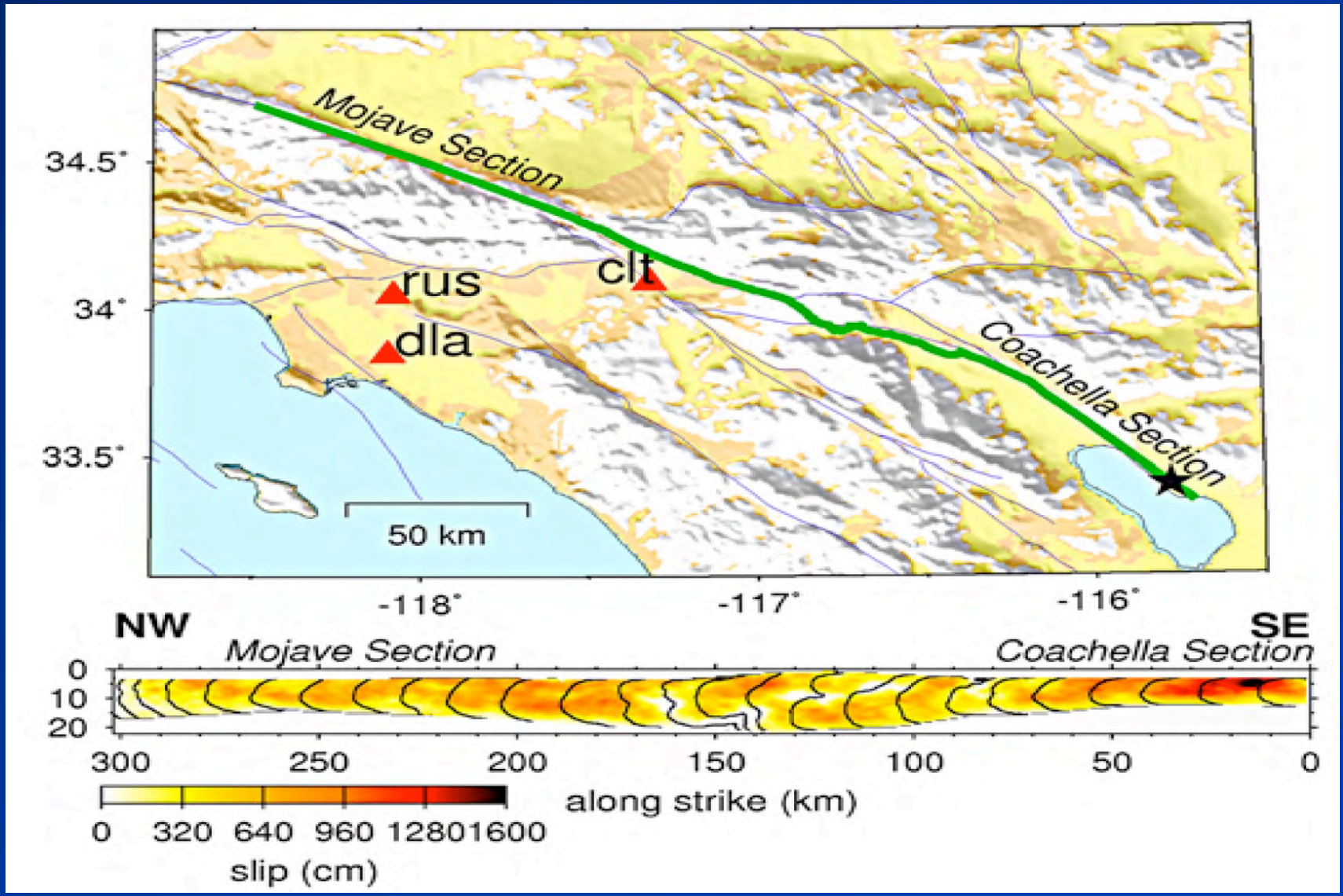
Validation of Simulations

Validated against recordings from moderate M events.

Limited validations done for 1994 M6.7 Northridge EQ.



M 7.8 San Andreas Earthquake Simulations



Graves et al. (2008)

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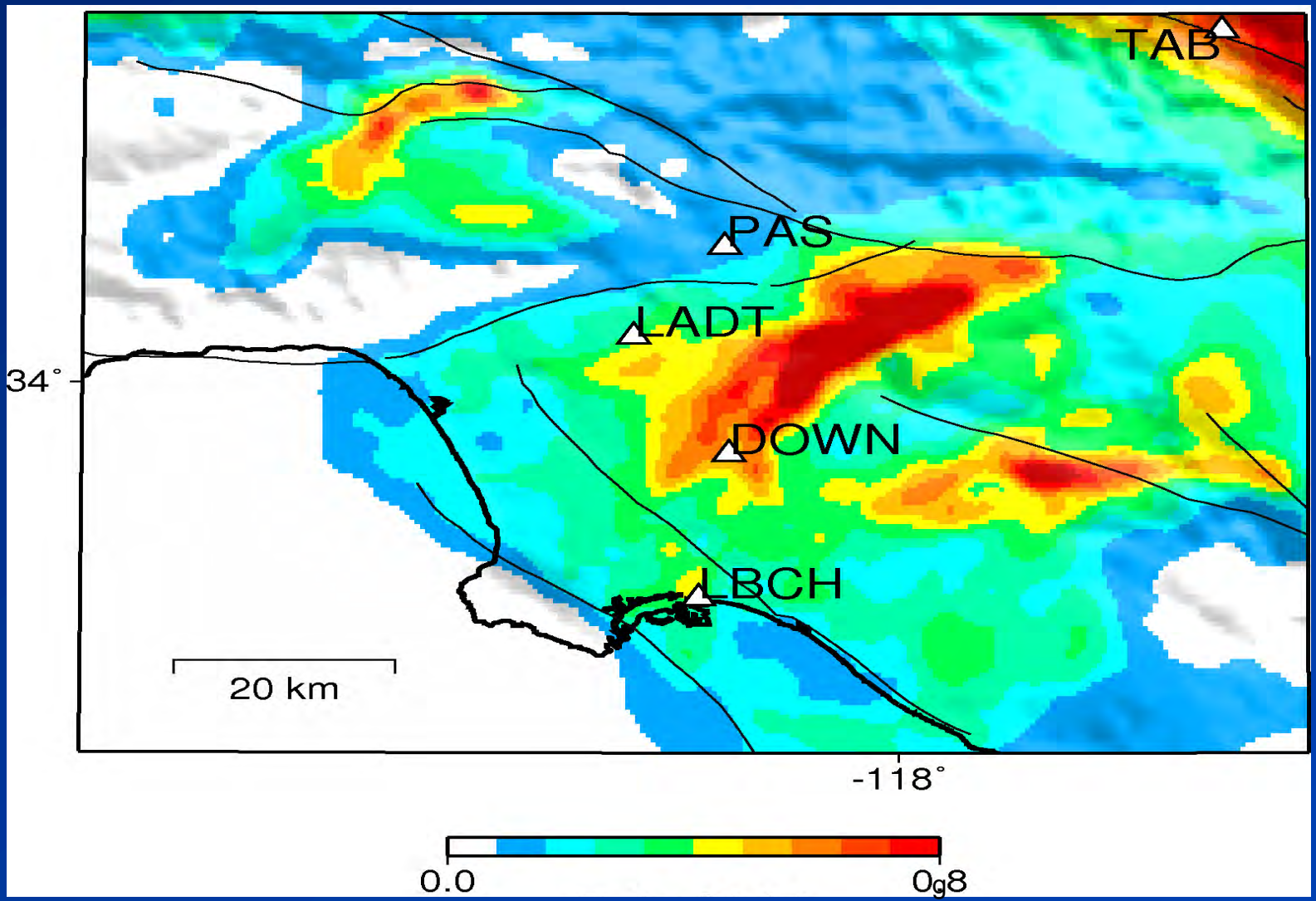
M8 Simulation on San Andreas

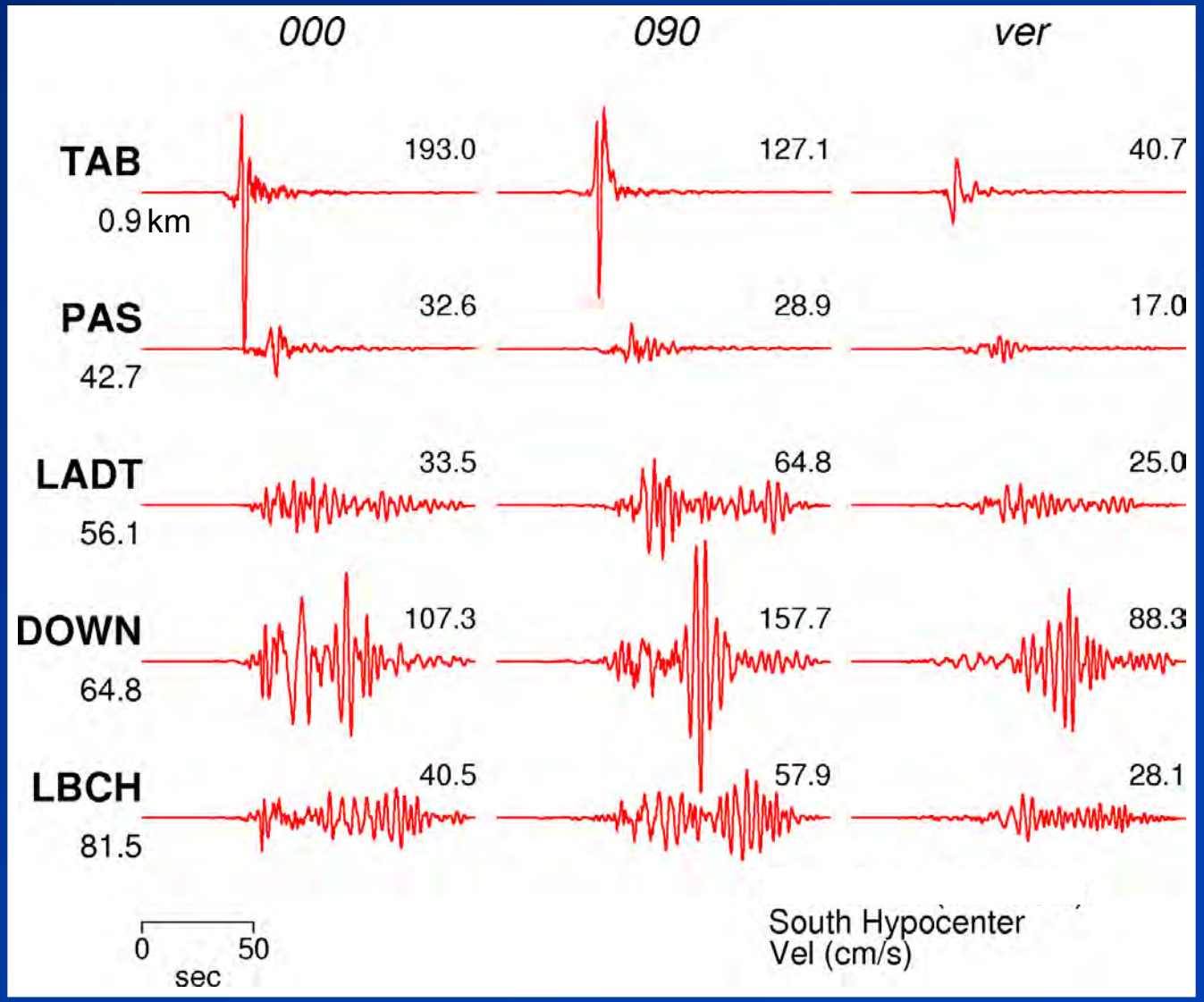
M 7.8 San Andreas Earthquake Simulations

Sa (T = 3 sec, ζ = 5%)



Graves et al. (2008)

Velocity Records for M 7.8 San Andreas Event



Graves et al. (2008)

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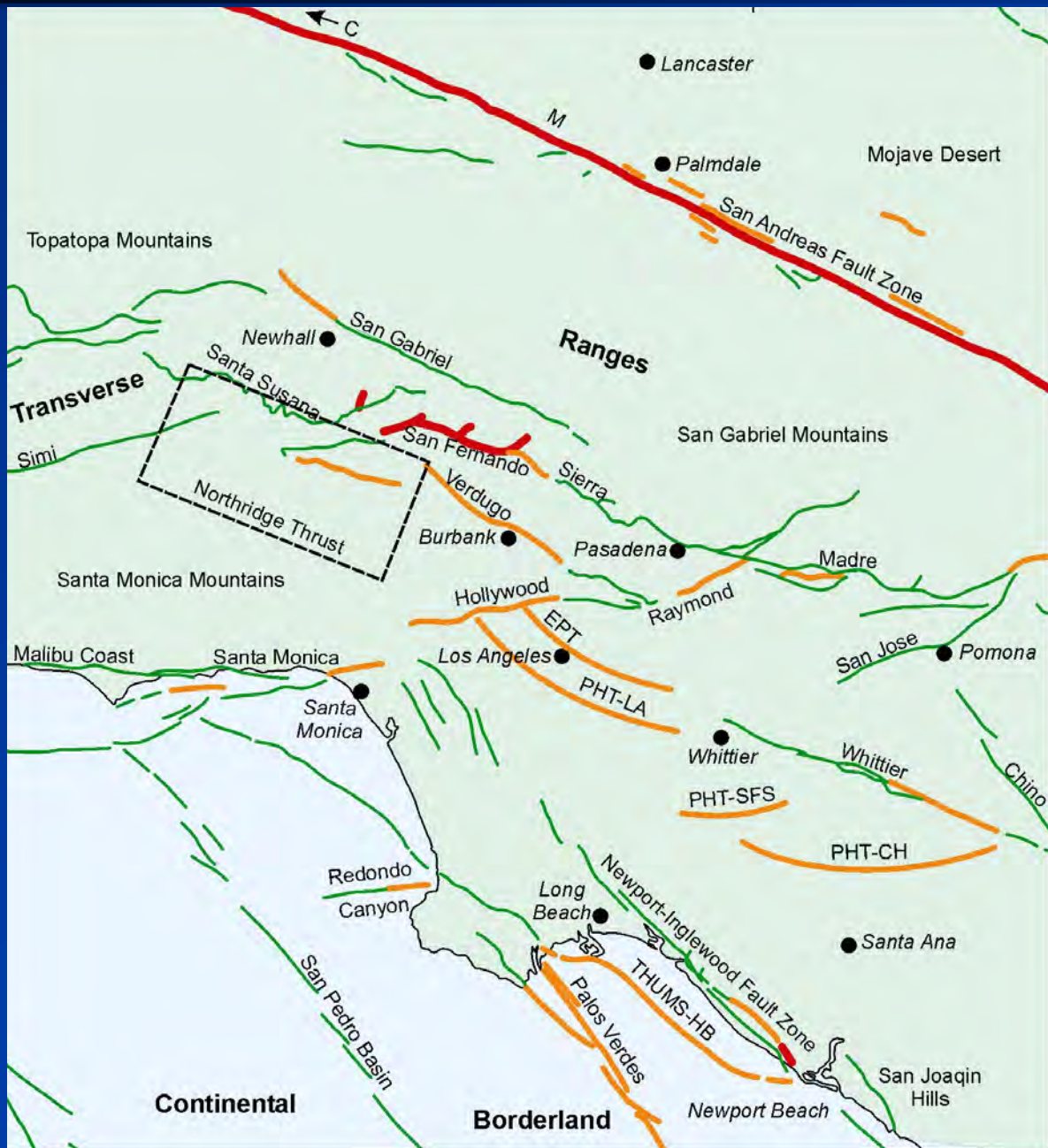
Site-Specific Approach using NGA West2 GMPEs

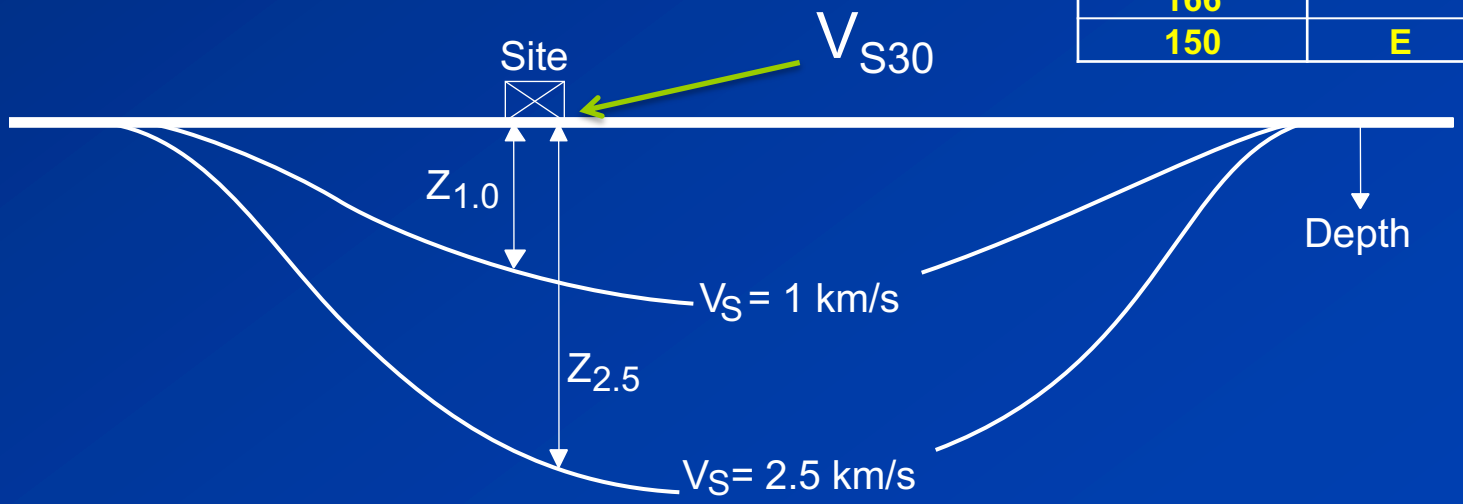
1. Use UCERF3 recurrence models
2. Select ground-motion eqns.
   - Four NGA West 2 eqns.
     - basin depth ($Z_{1.0}$ or $Z_{2.5}$)
     - shear-wave vel. (V_{S30})
   - Substitute $Z_{1.0}$, $Z_{2.5}$, V_{S30} values into eqns.
3. Proceed with PSHA/DSHA (C. 21, ASCE 7-16)
4. MCE_R Response Spectra



2013 NGA West2 Equations with Basin Depth Terms

- Abrahamson et al – $Z_{1.0}$
- Boore et al – $Z_{1.0}$
- Campbell & Bozorgnia – $Z_{2.5}$
- Chiou & Youngs – $Z_{1.0}$

V_{S30} (m/s)	Site Class
1000	A/B
880	
760	B/C
662	
564	C
465	
366	C/D
320	
274	D
229	
183	D/E
166	
150	E



2-D Basin Profile

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MCE_R Response Spectra

- CyberShake (T = 2 – 10 sec)
- NGA West2 GMPEs (0 – 10 sec)

Determination of MCE_R Response Spectra, T = 2 - 10 sec

- Computed MCE_R from both approaches at selected sites in L.A. area
- Developed procedure for combining two MCE_R
- Checked final MCE_R for many L.A. area sites

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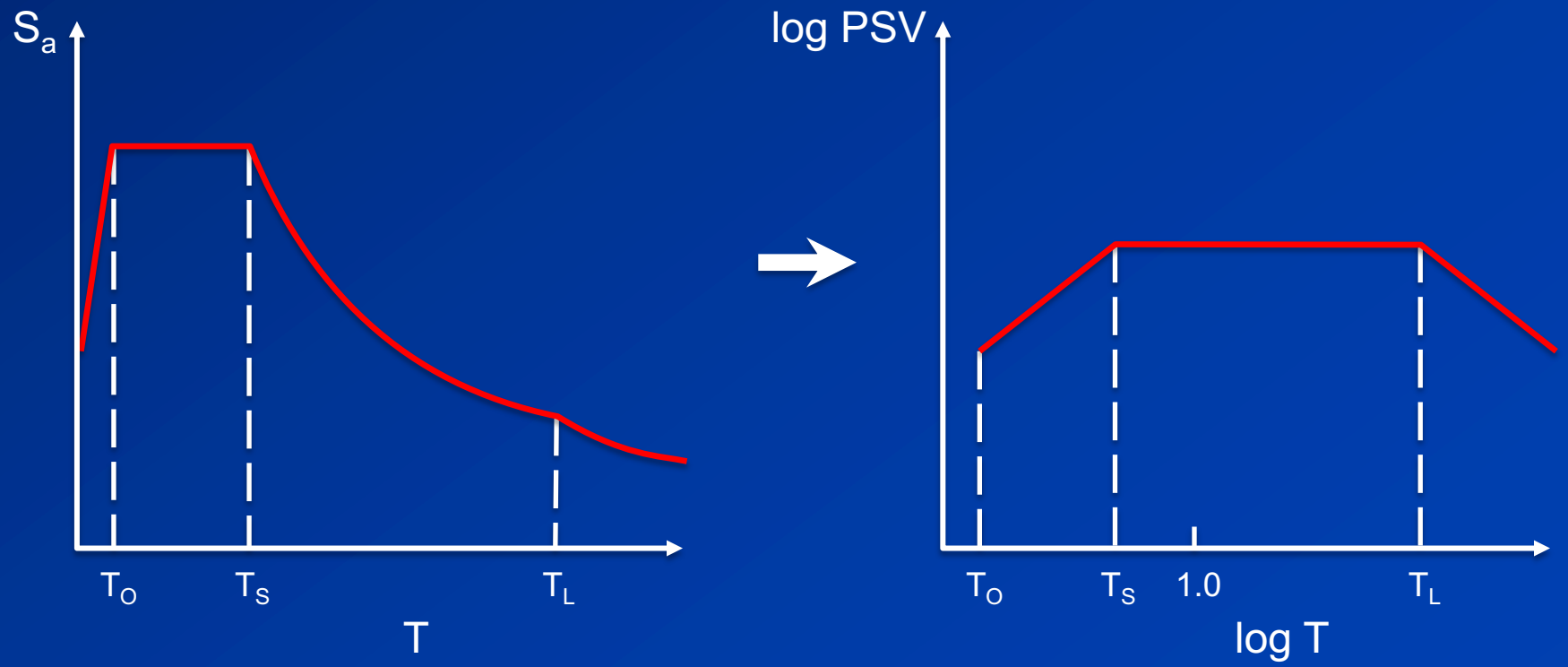
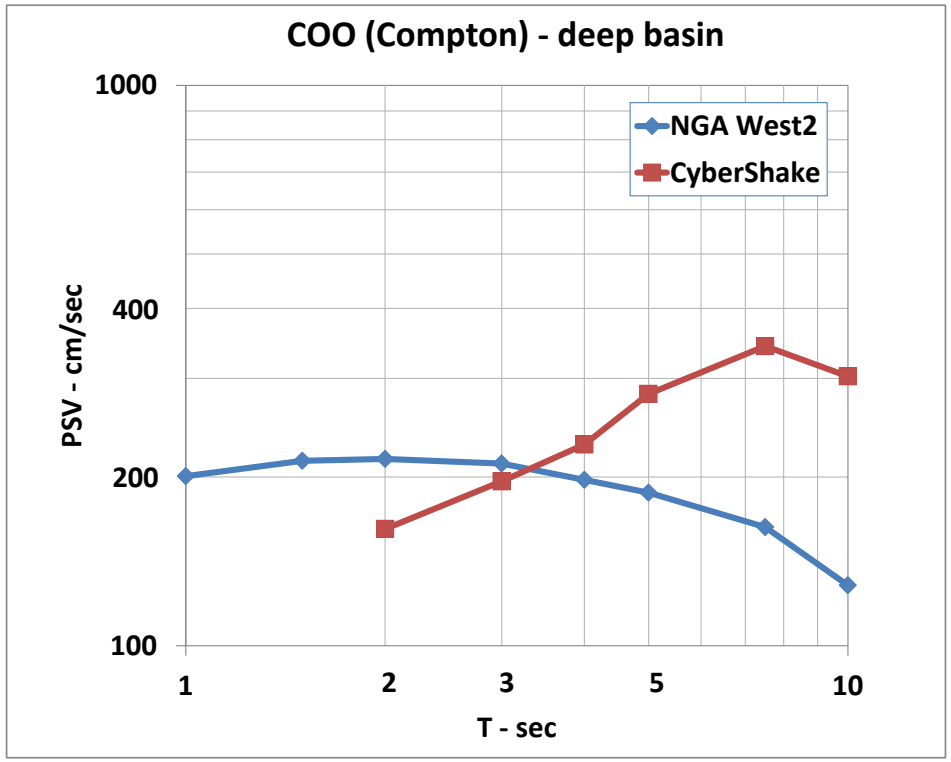
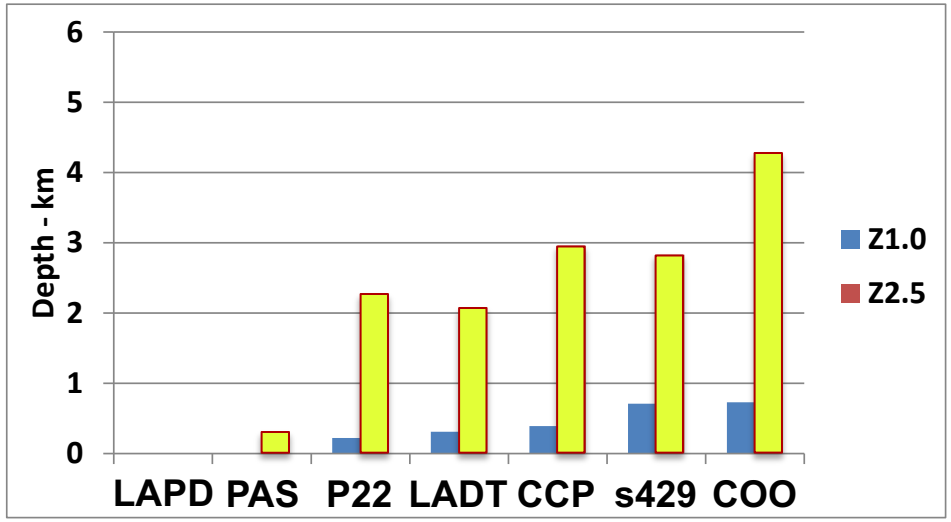
Transform S_a to PSV

$$PSV = (T/2\pi)S_a$$

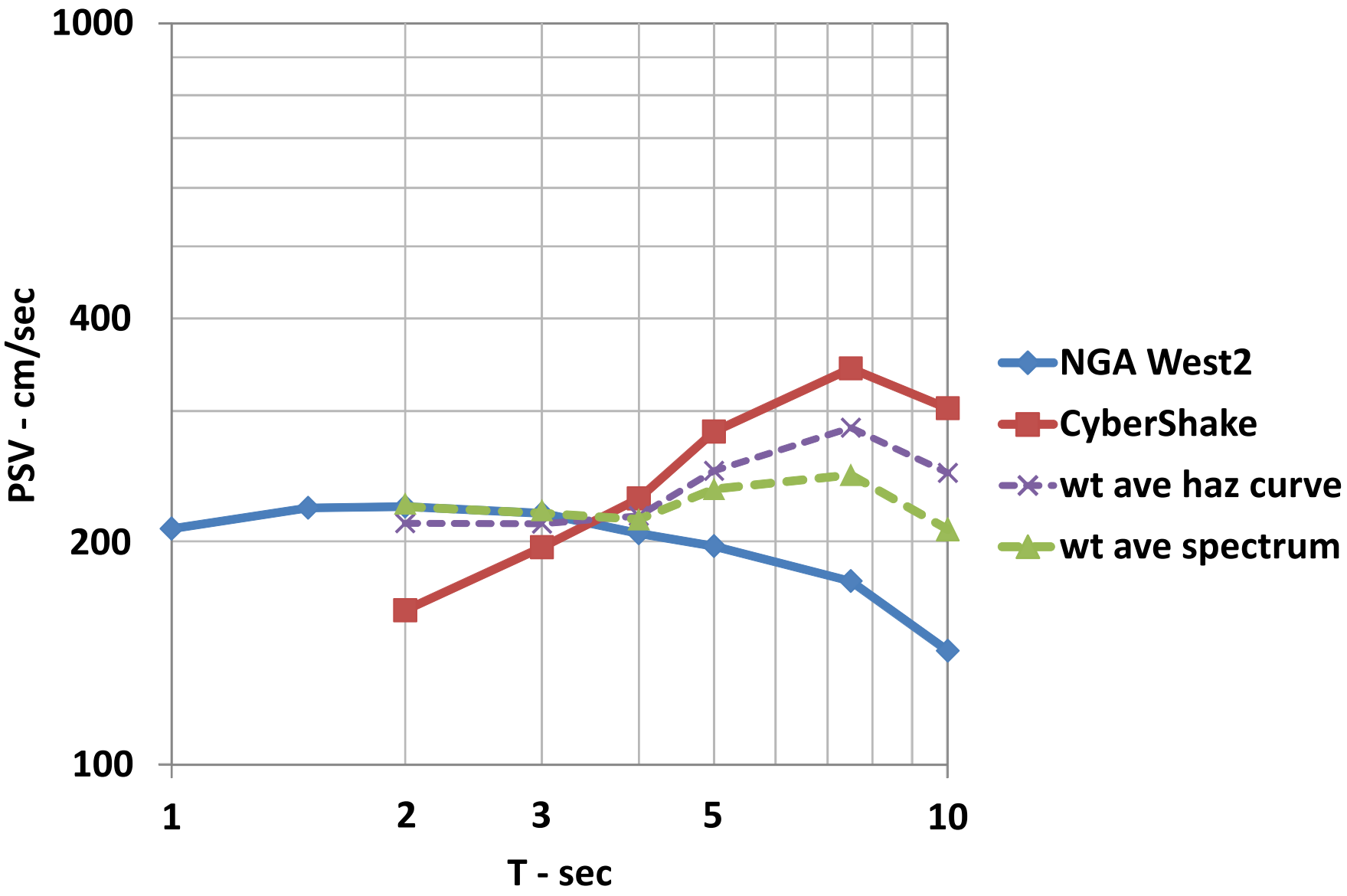


MCE_R PSV for 7 Sites to Illustrate Trends

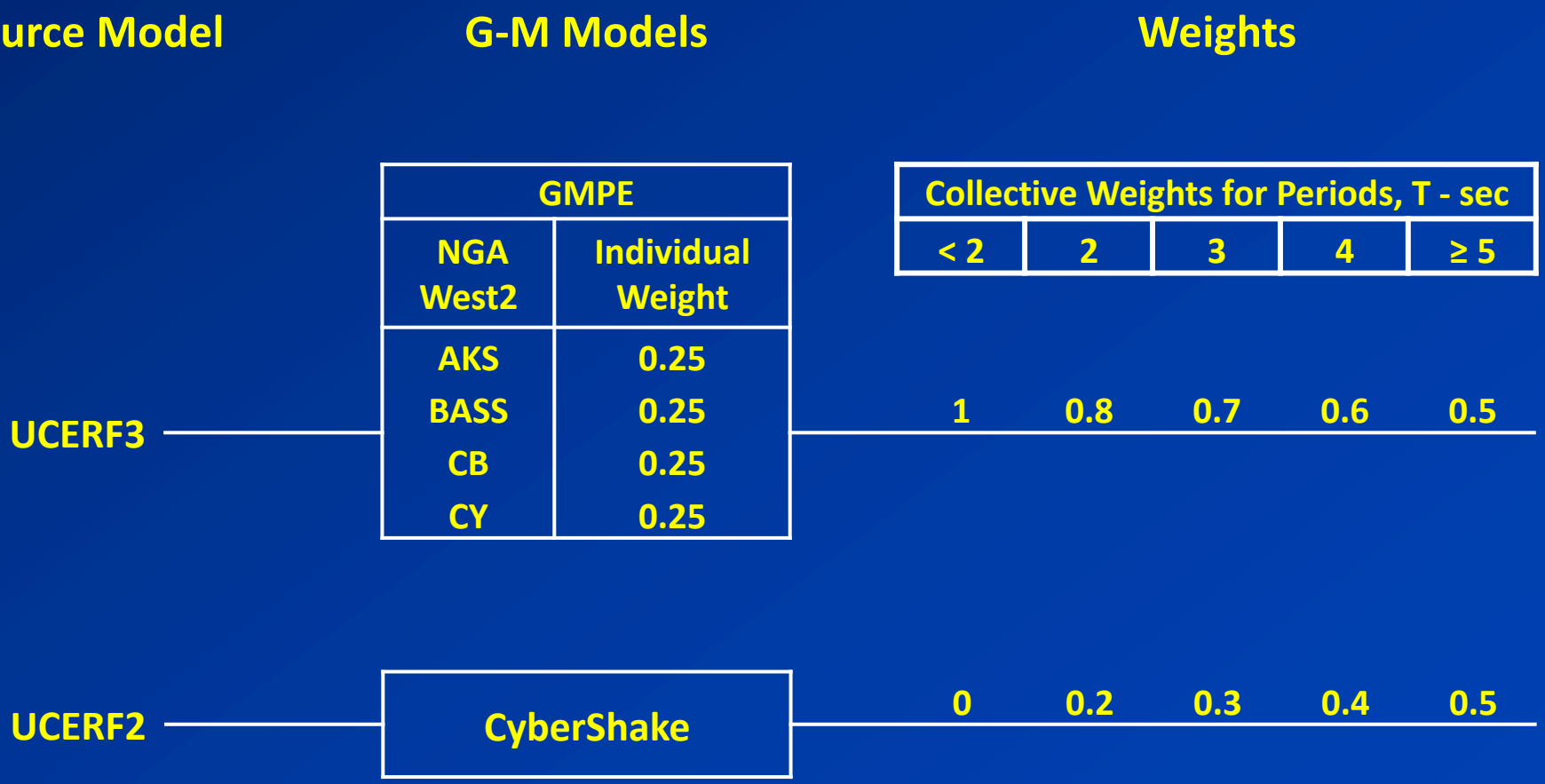




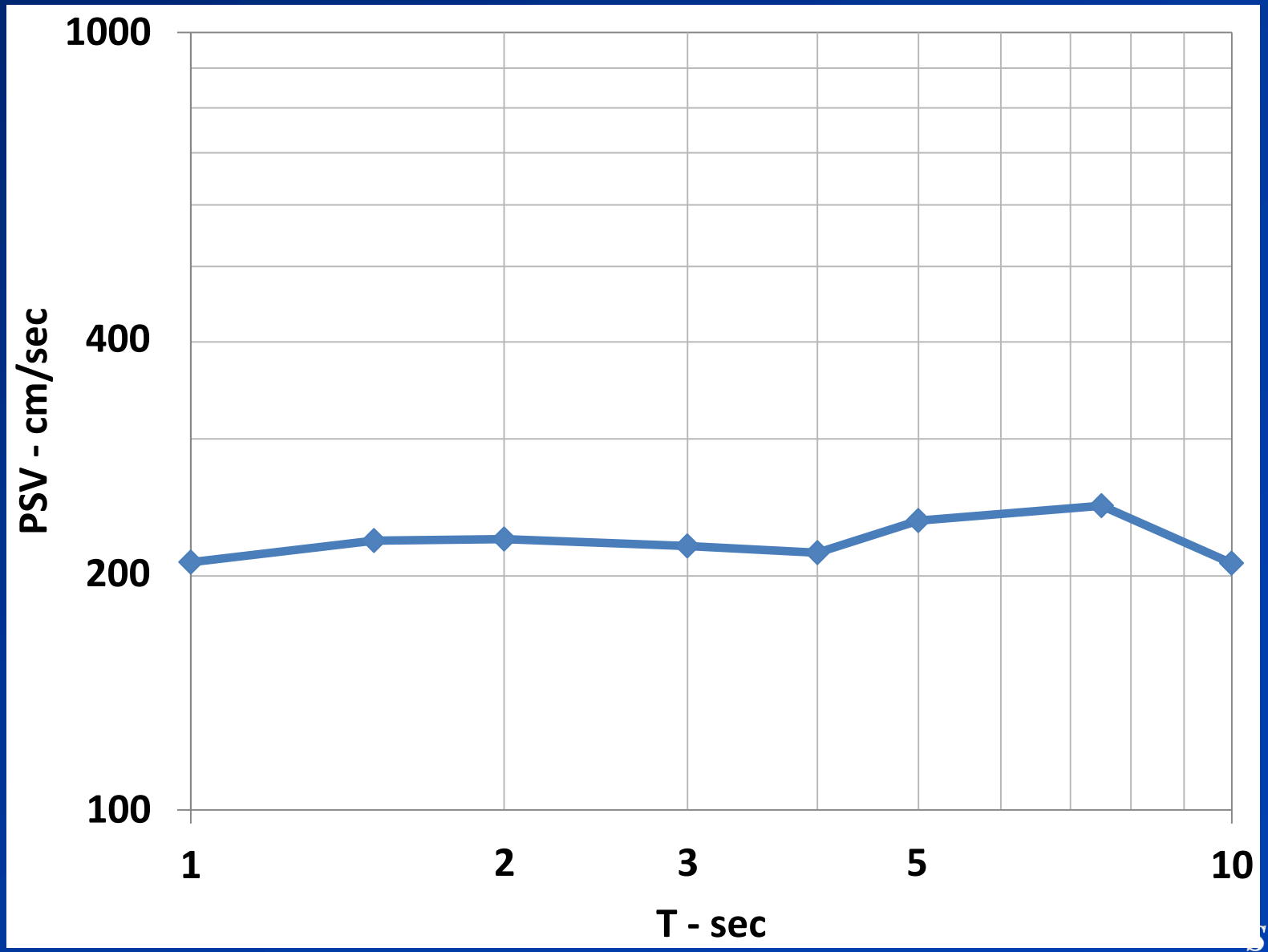
COO (Compton) - Deep Basin



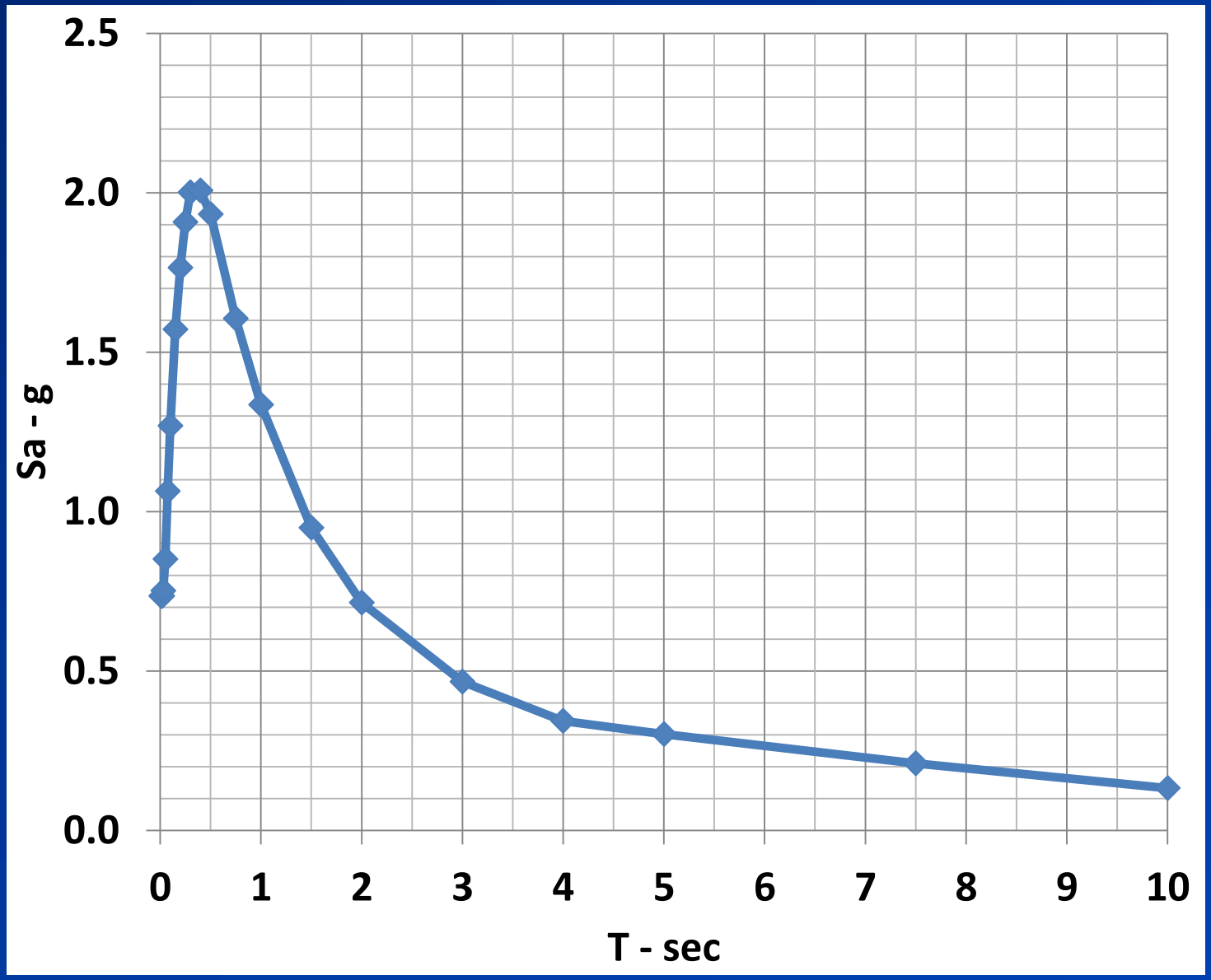
Weighted Averaging of MCE_R Response Spectra



MCE_R: COO (Compton) - Deep Basin

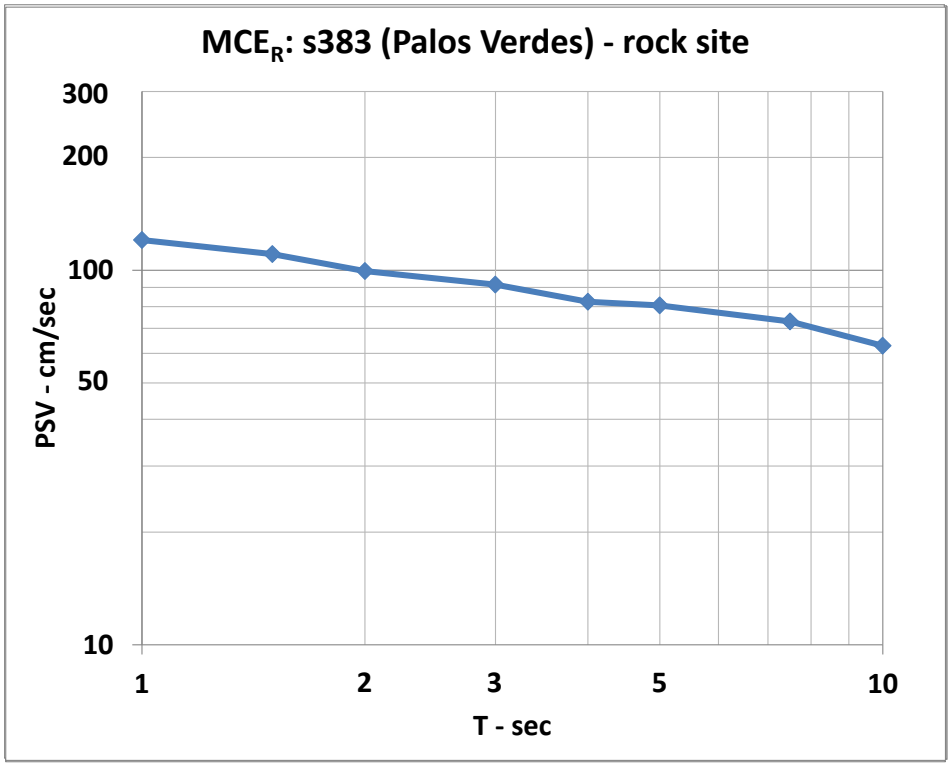


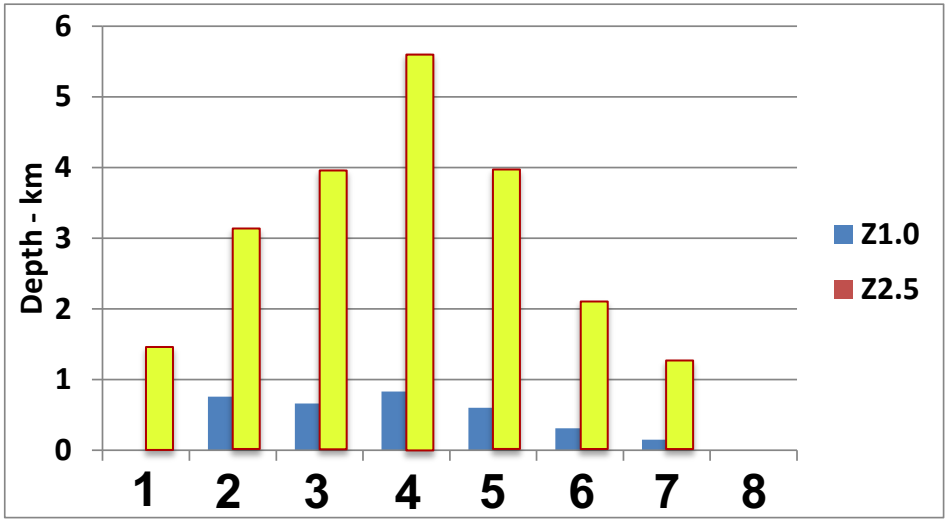
MCE_R: COO (Compton) - Deep Basin



Line 1


8
7
6
5
4
3
2
1


MCE$_R$: s383 (Palos Verdes) - rock site
300
200
100
50
10
PSV - cm/sec
1
2
3
5
10
T - sec


6
5
4
3
2
1
0
Depth - km
1
2
3
4
5
6
7
8
Z1.0
Z2.5

End Products of UGMS Project

- Site-Specific MCE_R for L. A. area
  - Alternative to ASCE 7-16 "maps" (Ch 22) for Southern California and F_a & F_v (Ch 11)
  - Resource to city/county officials & geotechnical & structural engineers

- SCEC/UGMS look-up tool
  - ~ USGS web app tool

Look-Up Tool at:

https://data2.scec.org/ugms-mcerGM-tool_v18.4

SCEC UGMS MCE_R Look-Up Tool

SCEC UGMS MCE_R Tool

Application | User Guide | Disclaimer | Contact

Site-Specific MCE_R & Design Response Spectra per Sect. 21.2, 21.3, 21.4 of ASCE 7-16

Input Parameters

Report Title

My Report

Latitude and longitude in decimal degrees (or click on map to select site):

Latitude (e.g. 34.45)

Longitude (e.g. -118.35)

Site Geotechnical Classification:

- **Site Class** - Select -

Site Class **NOT** automatically determined based on site location

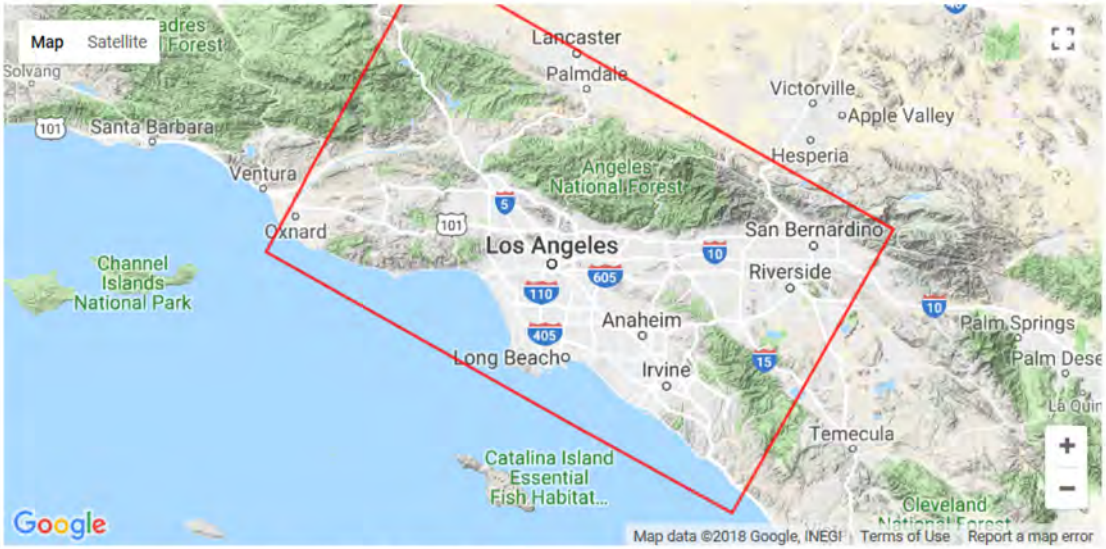
- OR -

- V_{S30} (m/s) Value

- OR -

- Unknown (Vs30 estimated from Wills et al., 2015)

Compute Response Spectra



The UGMS MCE_R tool was developed by the SCEC Committee for Utilization of Ground Motion Simulations (or "UGMS Committee") from research supported by the Southern California Earthquake Center (SCEC). SCEC is funded by NSF Cooperative Agreement EAR-1033462 & USGS Cooperative Agreement G12AC20038. For more information on the UGMS Committee, visit https://www.scec.org/research/ugms.

LADT Example

SCEC UGMS MCE_R Tool

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Site-Specific MCE_R & Design Response Spectra per Sect. 21.2, 21.3, 21.4 of ASCE 7-16

Input Parameters

Report Title

LADT

Latitude and longitude in decimal degrees (or click on map to select site):

34.0548

-118.2487

Site Geotechnical Classification:

- Site Class - Select -

Site Class **NOT** automatically determined based on site location.

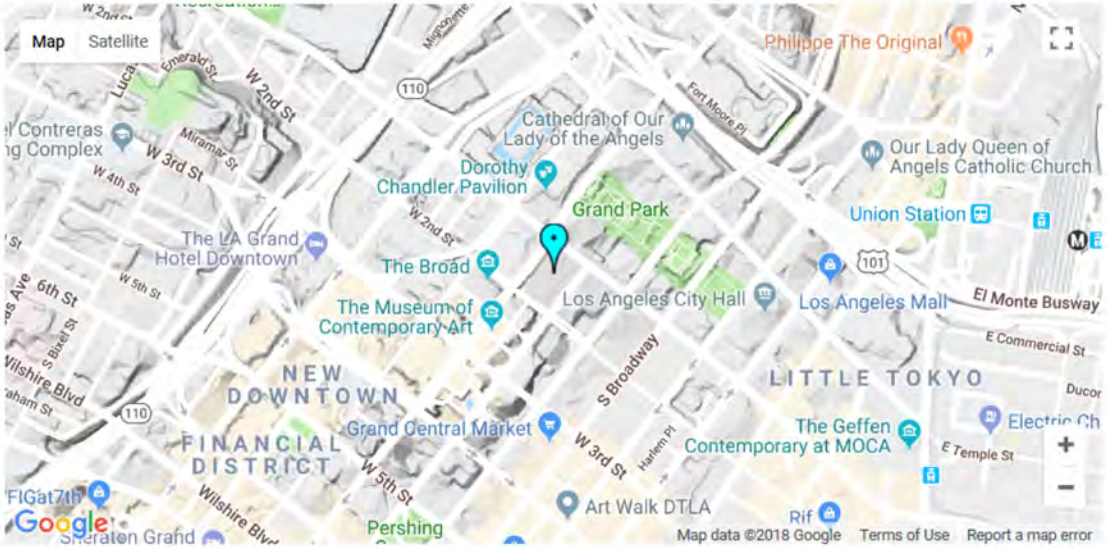
- OR -

- V_{S30} (m/s) 446

- OR -

- Unknown (Vs30 estimated from Wills et al., 2015)

Compute Response Spectra



Recenter Map on Point

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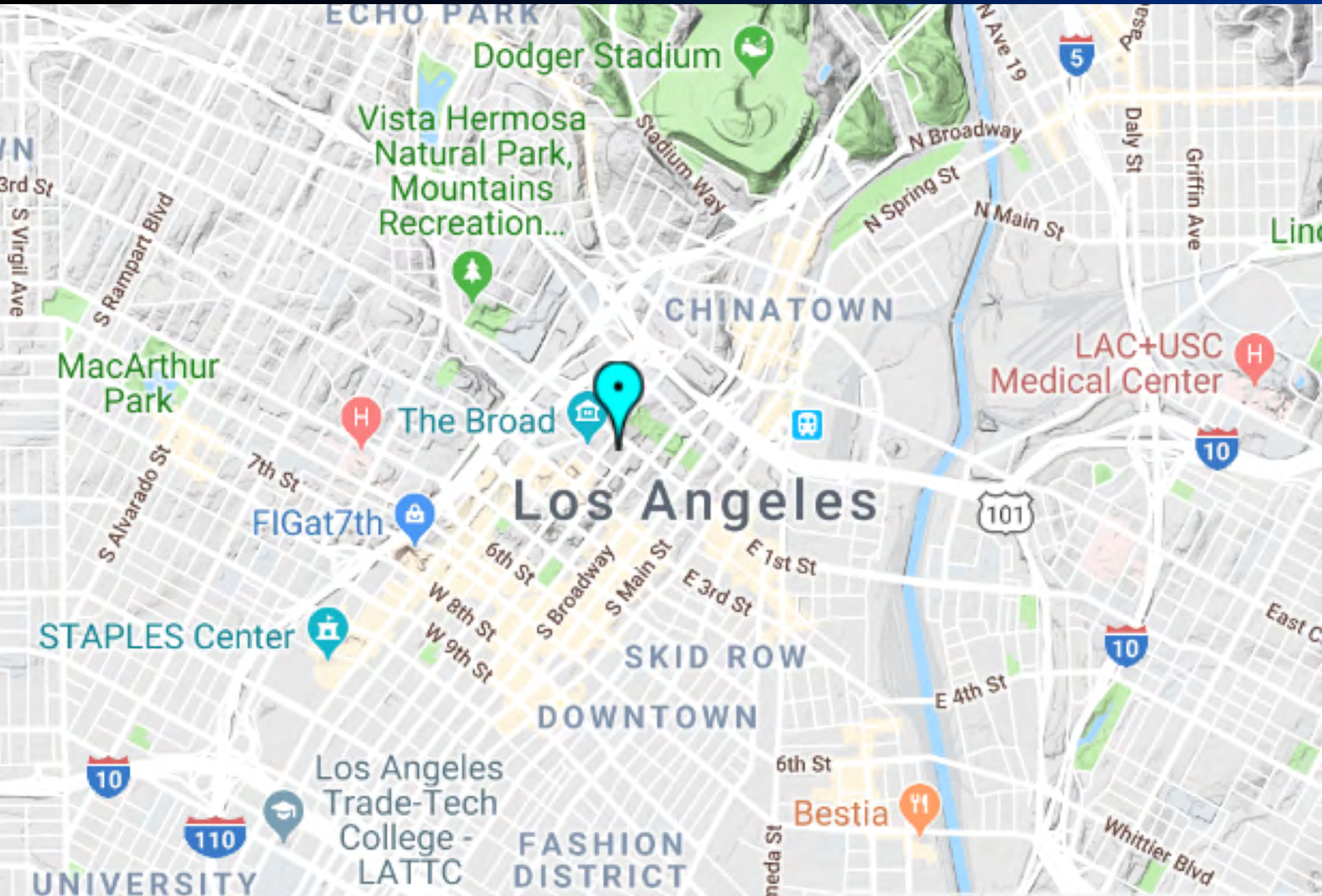
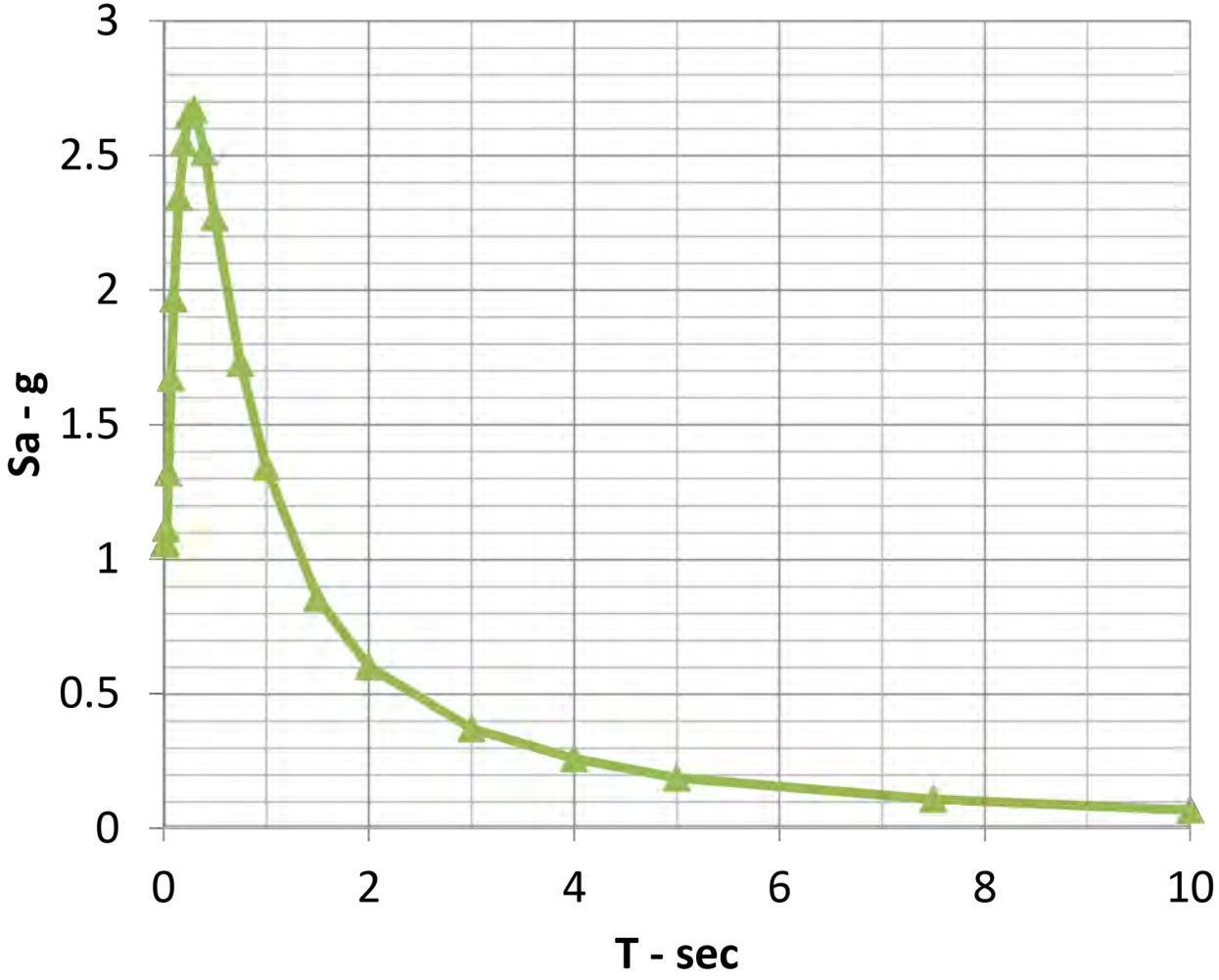
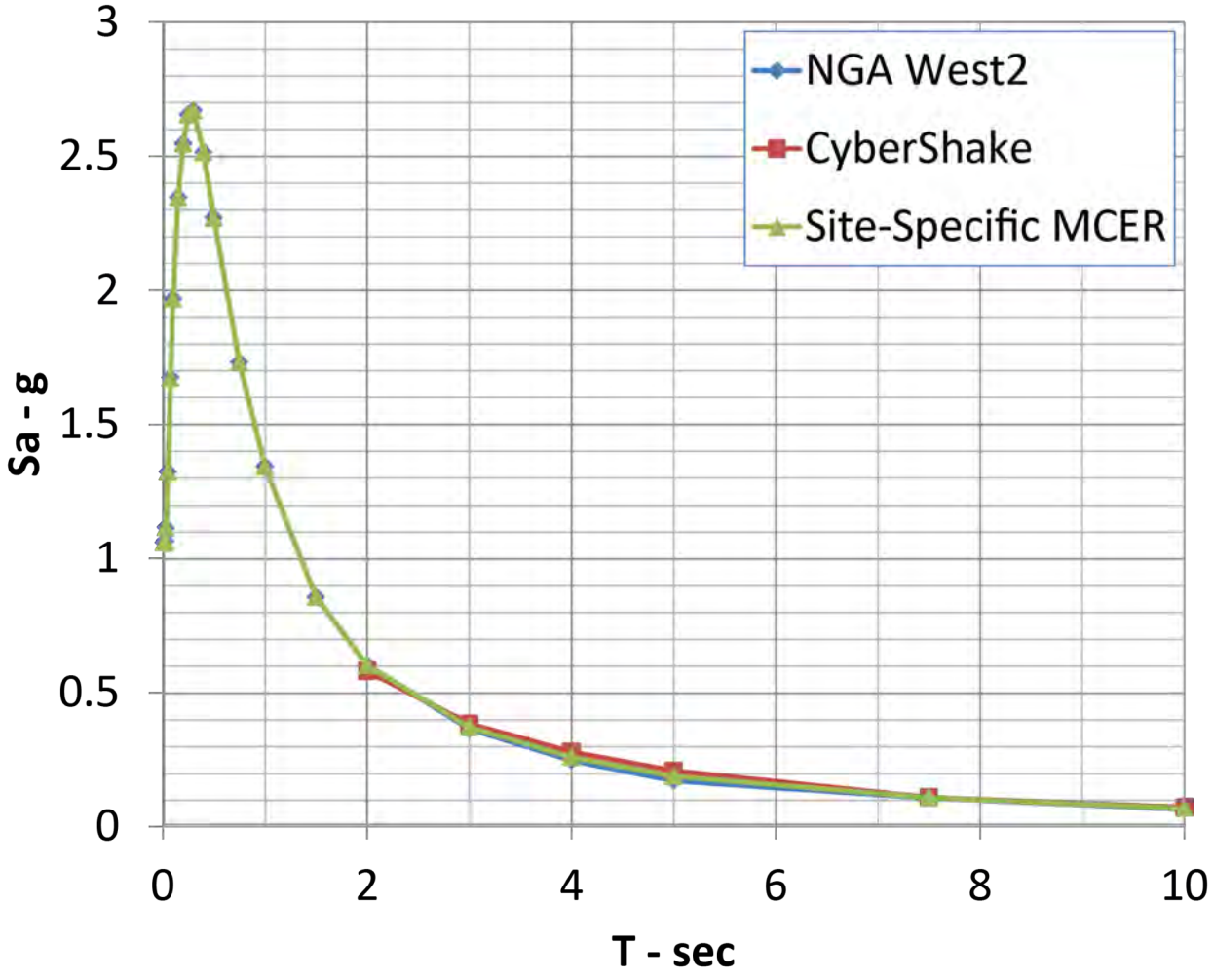
LADT Site


ECHO PARK
Dodger Stadium
Vista Hermosa Natural Park, Mountains Recreation...
Stadium Way
N Broadway
N Spring St
N Main St
Daly St
Griffin Ave
N Ave 19
5
3rd St
S Virgil Ave
S Rampart Blvd
CHINATOWN
MacArthur Park
The Broad
LAC+USC Medical Center
7th St
S Alvarado St
FIGat7th
Los Angeles
101
10
6th St
S Broadway
S Main St
E 1st St
E 3rd St
W 8th St
W 9th St
STAPLES Center
SKID ROW
DOWNTOWN
E 4th St
East C
6th St
Bestia
Whittier Blvd
Los Angeles Trade-Tech College - LATTC
FASHION DISTRICT
110
UNIVERSITY

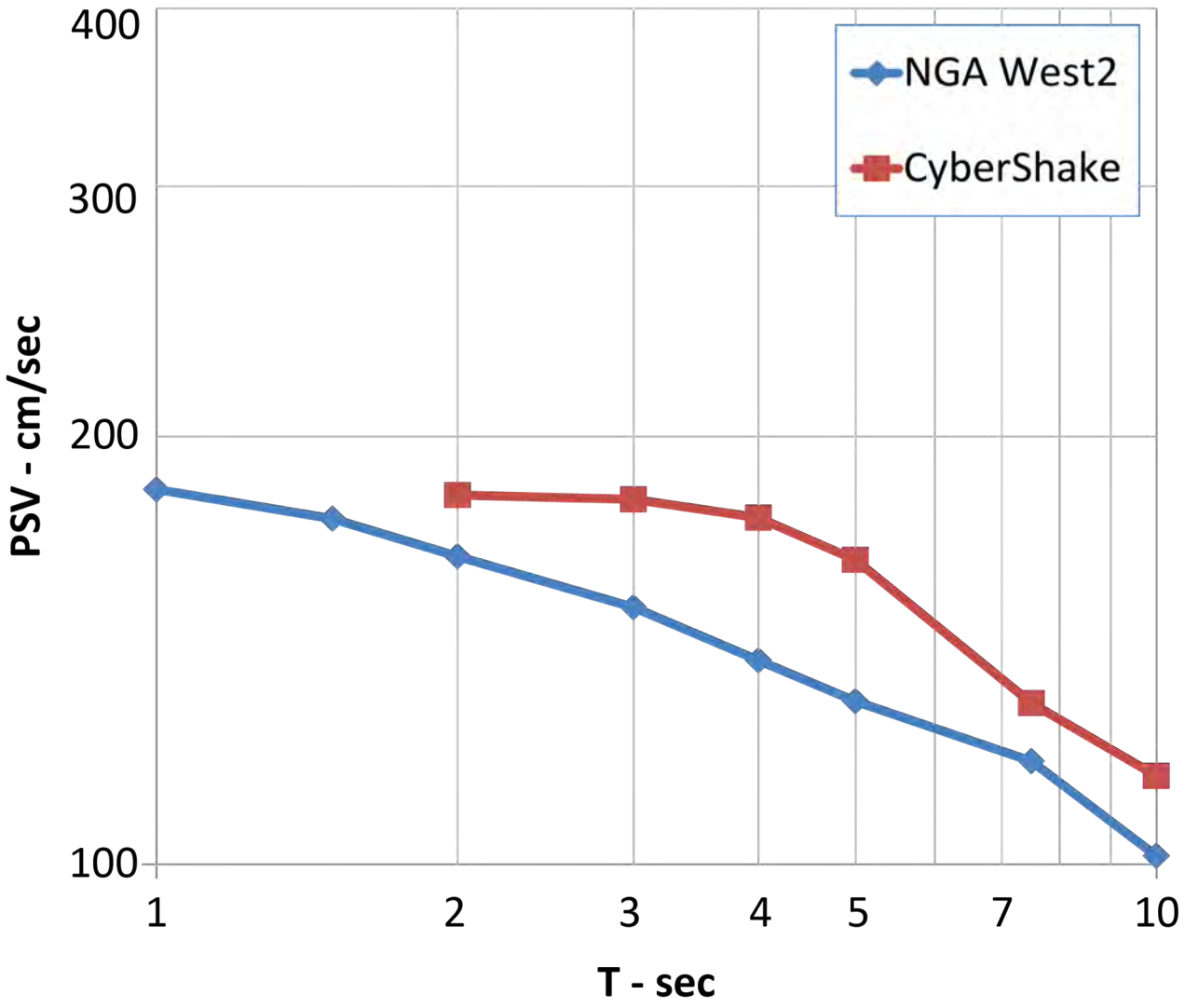
LADT Site-Specific MCE_R Response Spectrum



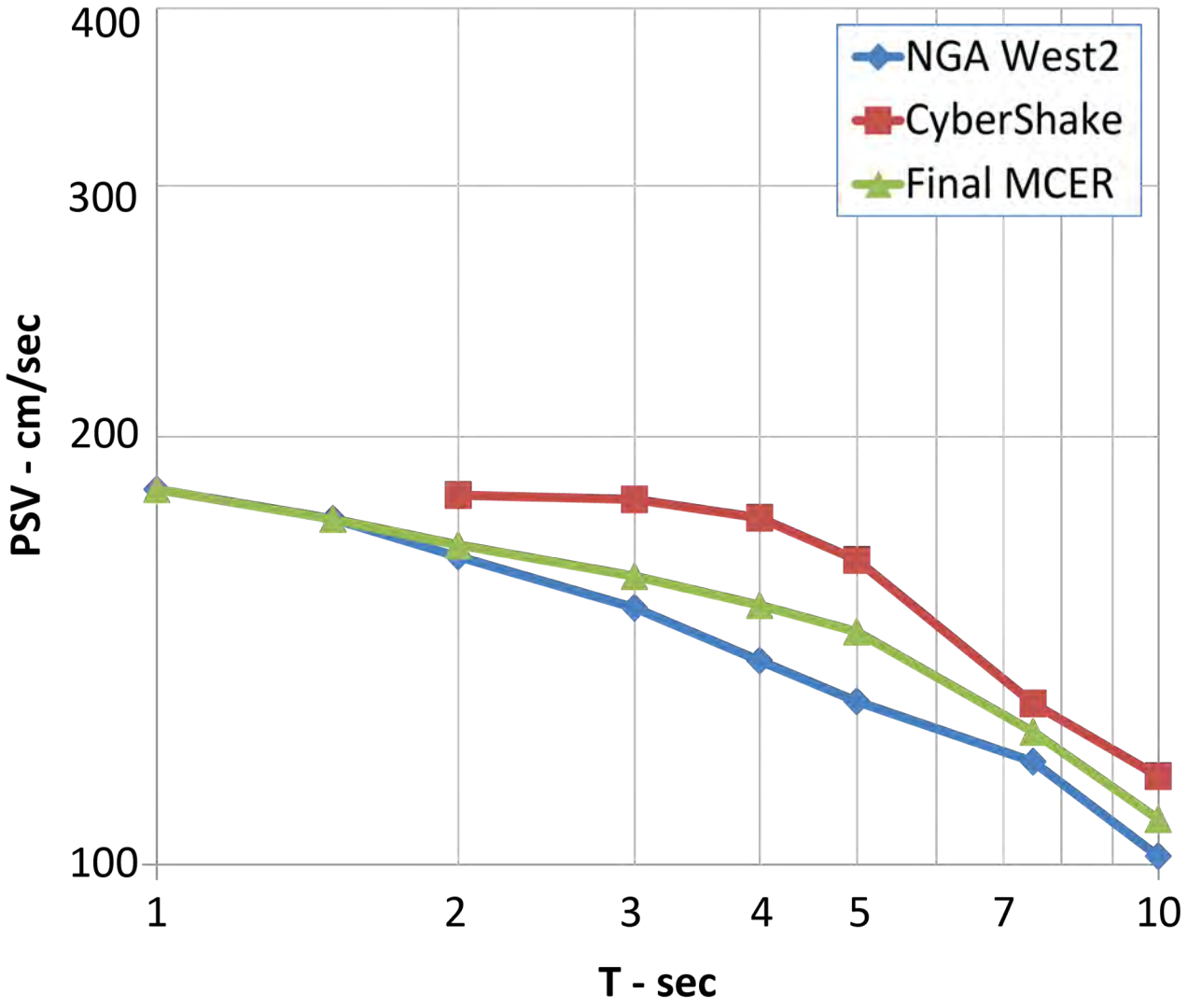
LADT Site-Specific MCE_R Response Spectra



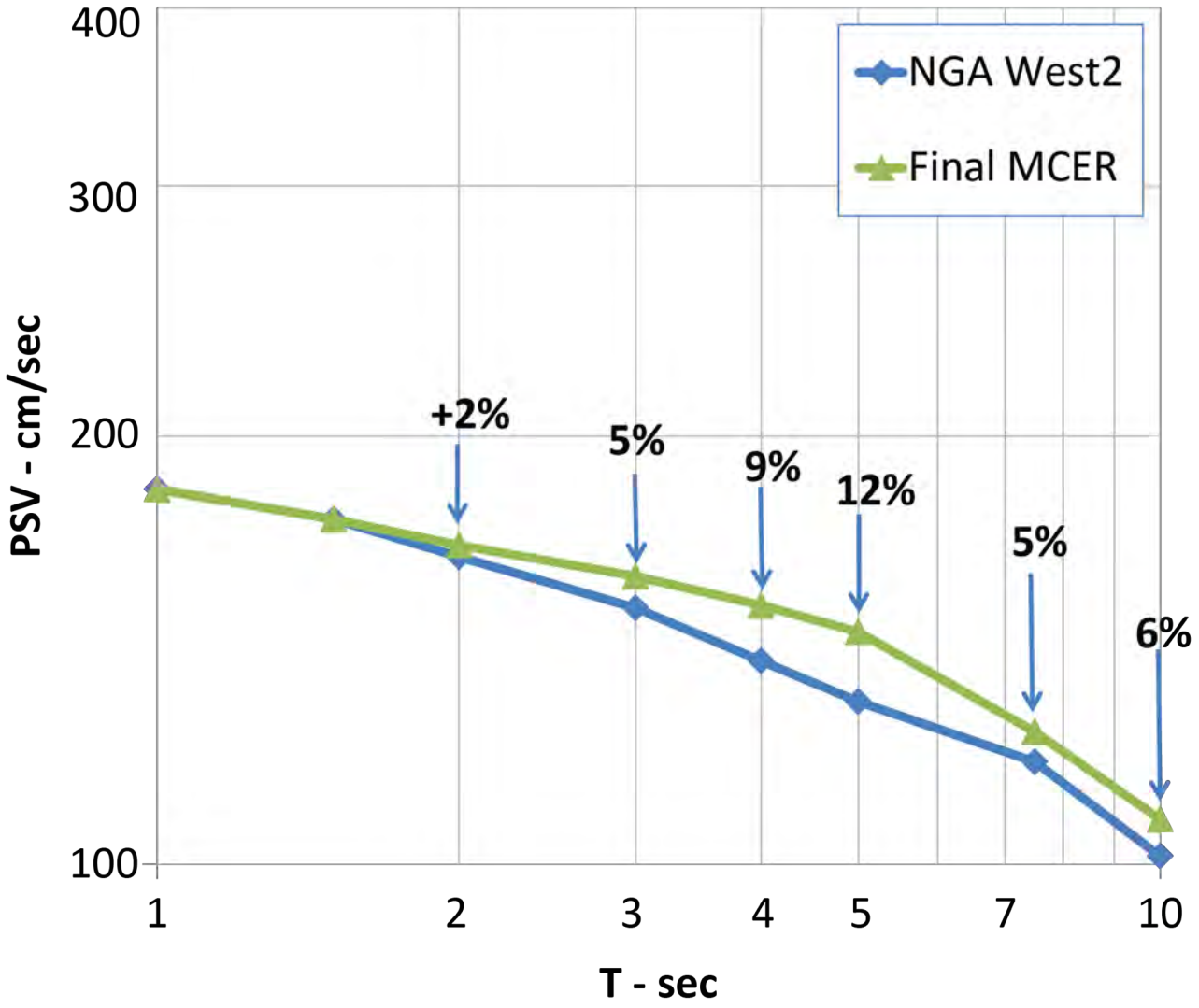
LADT MCE_R Response Spectra



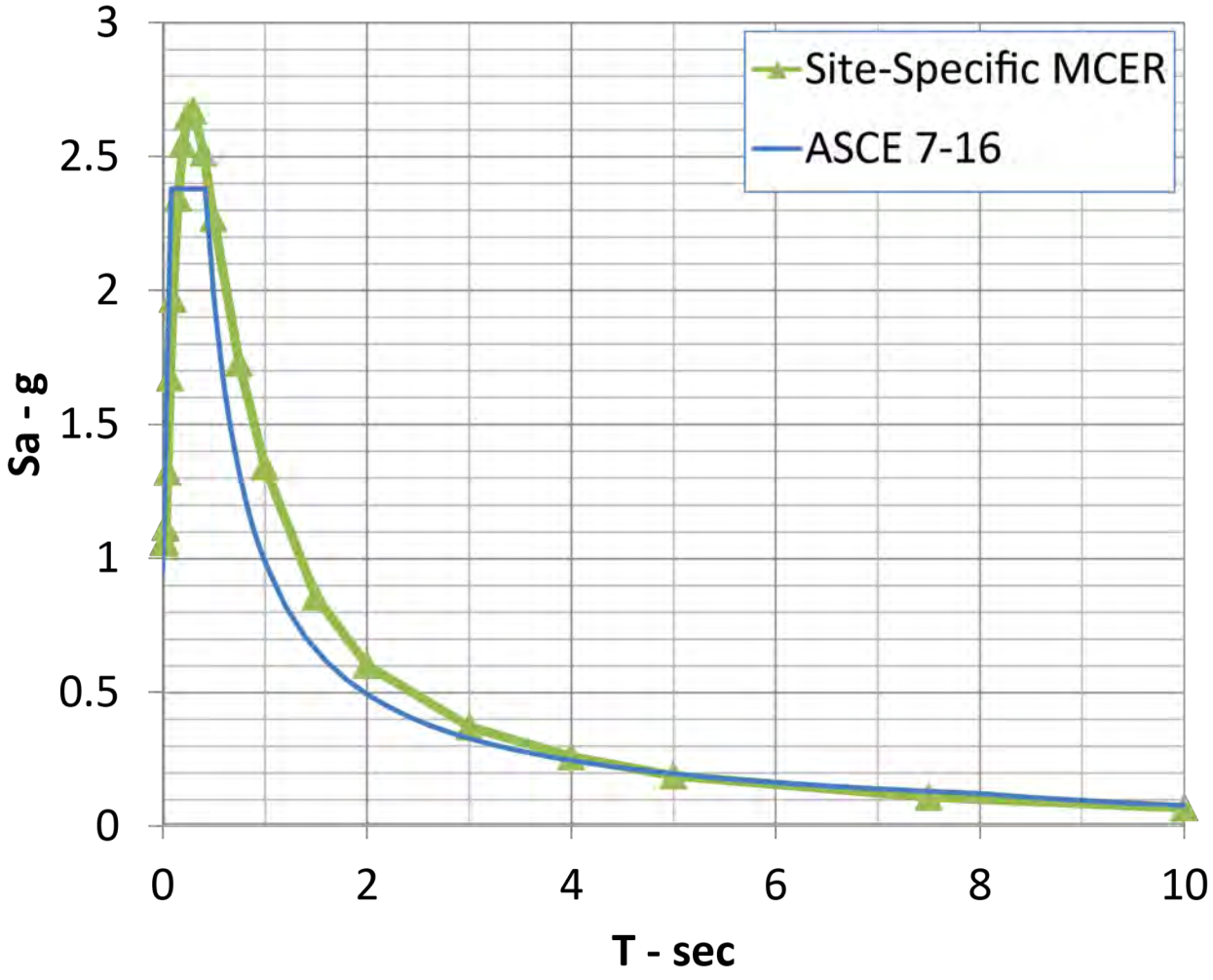
LADT Final Site-Specific MCE_R from Averaging



% Difference between Site-Specific & NGA West2 MCE_R



LADT Site-Specific vs ASCE 7-16 (Ch. 11) MCE_R



Why New MCE_R are Improvement to MCE_R from Chapter 11 ASCE 7-16

- Site-Specific for Los Angeles Region
- Better job in accounting for:
  - local & regional geology
  - fault directivity & fling (CyberShake)
  - 3-D effects of fault rupture & basin structure on ground motion (CyberShake)

Why New MCE_R are Improvement to MCE_R from Chapter 11 ASCE 7-16

- Eliminates need for F_a & F_v tables, which:
  - Don't directly account for basin effects
  - Have step changes at site-class boundaries
  - Are constant for each site class, which covers broad range of Vs30