Project 17

Development of Next-Generation Seismic Design Value Maps

Provisions Update Committee Briefing
4 April 2018

Ronald O. Hamburger, SE, SECB
Senior Principal
Simpson Gumpertz & Heger Inc.

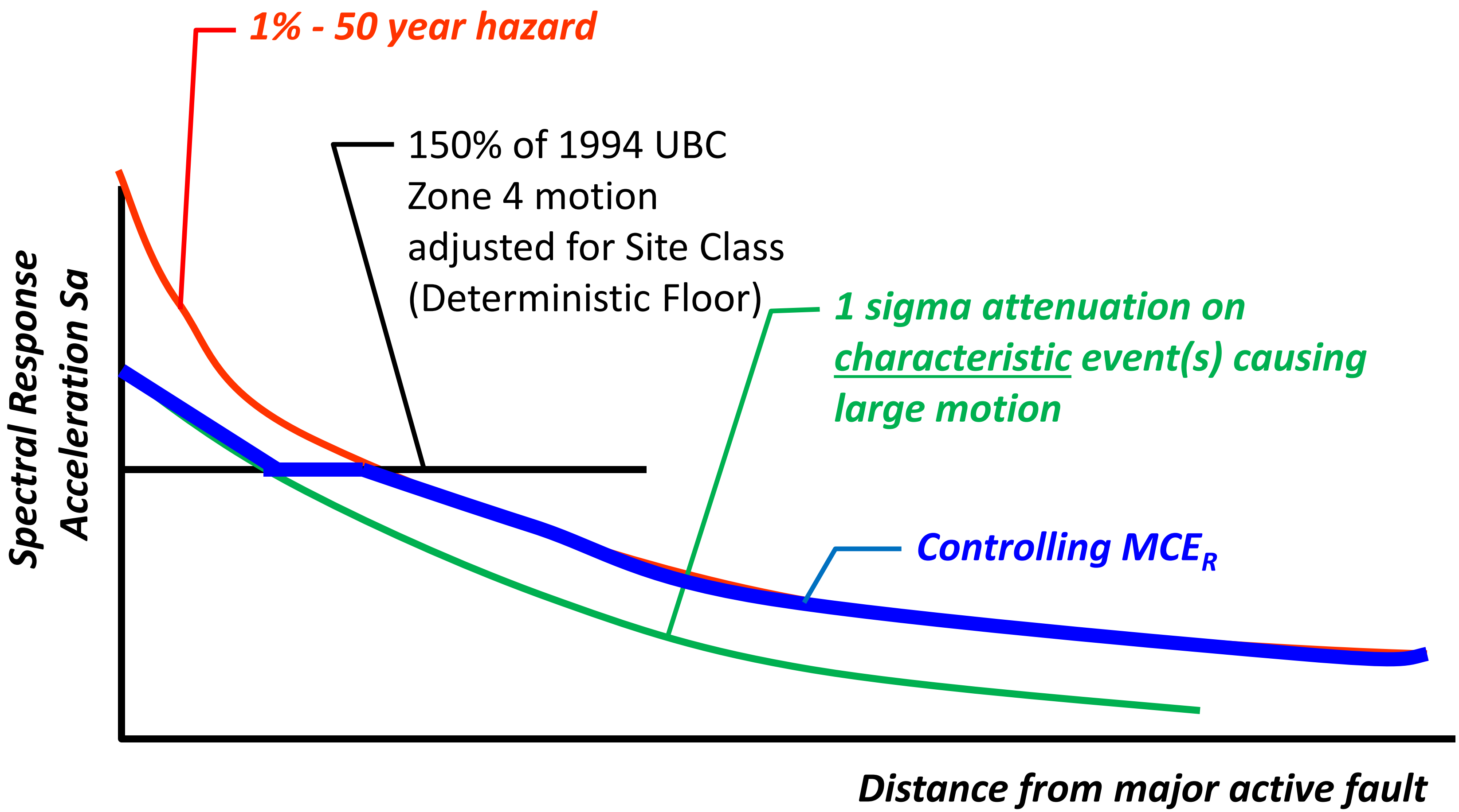
4 Primary Tasks
(3 Primary 1 Secondary)

- Acceptable Risk
  - Deterministic Earthquake Definition
- Yo-Yo Effect
- Multi-point spectra

ACCEPTABLE RISK

Issue Resolved

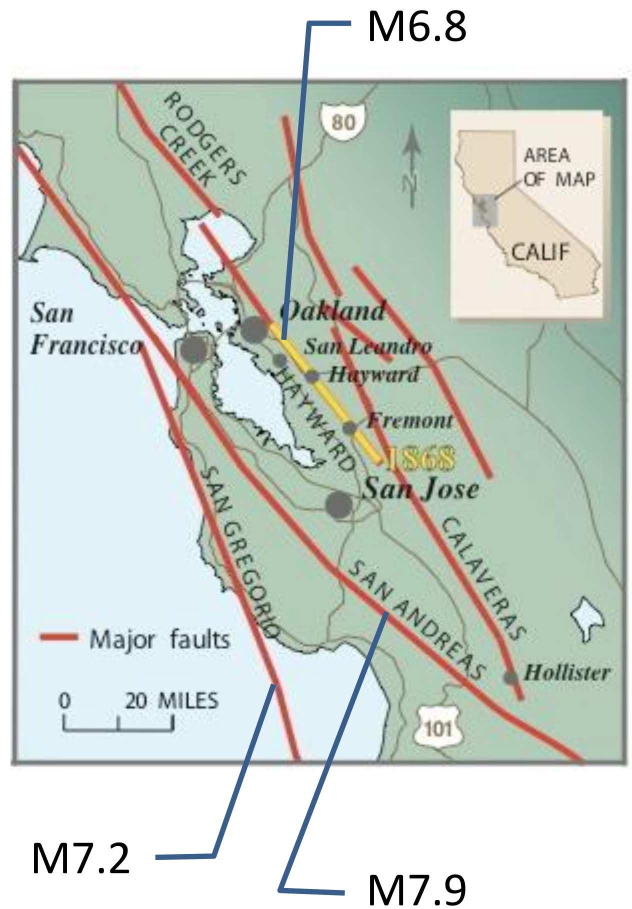
- Project 17 recommends retaining the current risk basis for the maps with:
  - Target Collapse Risk of 1%-50 years
  - Deterministic cap in near fault regions


1% - 50 year hazard
150% of 1994 UBC
Zone 4 motion
adjusted for Site Class
(Deterministic Floor)
1 sigma attenuation on
characteristic event(s) causing
large motion
Controlling MCE_R
Spectral Response
Acceleration Sa
Distance from major active fault

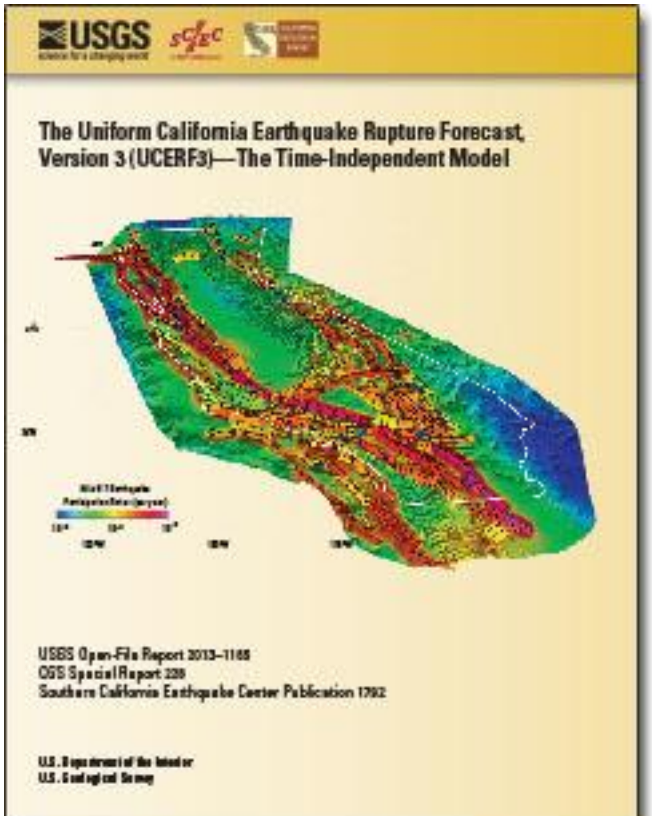
DETERMINISTIC EARTHQUAKE

Characteristic Earthquake

- The largest magnitude event likely to occur along a fault segment, constrained by the fault's length, rupture surface, slip rate and recurrence



UCERF3



- Multiple segments of faults and nearby faults, can with some probability rupture simultaneously
- There is no constraint on earthquake rupture length or magnitude
- Since there is no “characteristic” earthquake, the deterministic earthquake does not make sense

Deterministic Earthquake

- Still needed
- Characteristic events don't exist anymore
- Task Committee looked at 2 options

Project 17 Ballot 02

- Retain current deterministic limit concept, with a new definition of characteristic earthquake – to be defined
- Replace concept of deterministic limit, and instead, adopt alternate targets of acceptable risk (e.g. 3%-50 year collapse risk) where probabilistic risk exceeds the deterministic floor, graded to 1%-50 year where probabilistic risk drops off

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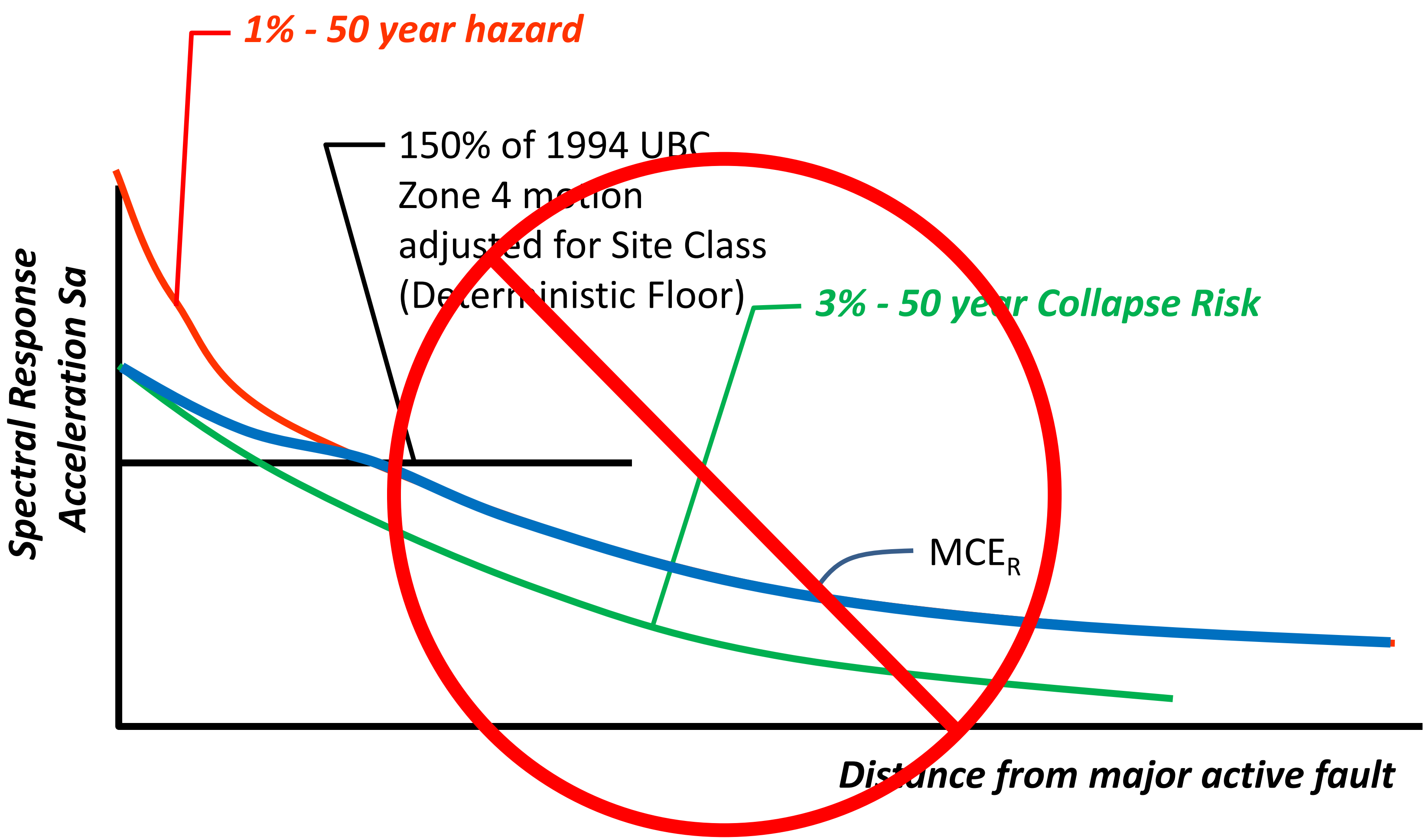

nehrp

FEMA

USGS
science for a changing world

Deterministic Earthquake

- Project 17 Deterministic Task Group to come up with new definition of characteristic earthquake
- Task Committee looked at 2 options
- Deaggregate the hazard at MCE_R return period years and determine the “characteristic” event as the magnitude for dominant events
- Perform PSHA, but where ground motion exceeds deterministic floor, limit hazard to epsilon=1 values (1 sigma)

Step 1: Identify grid points where …

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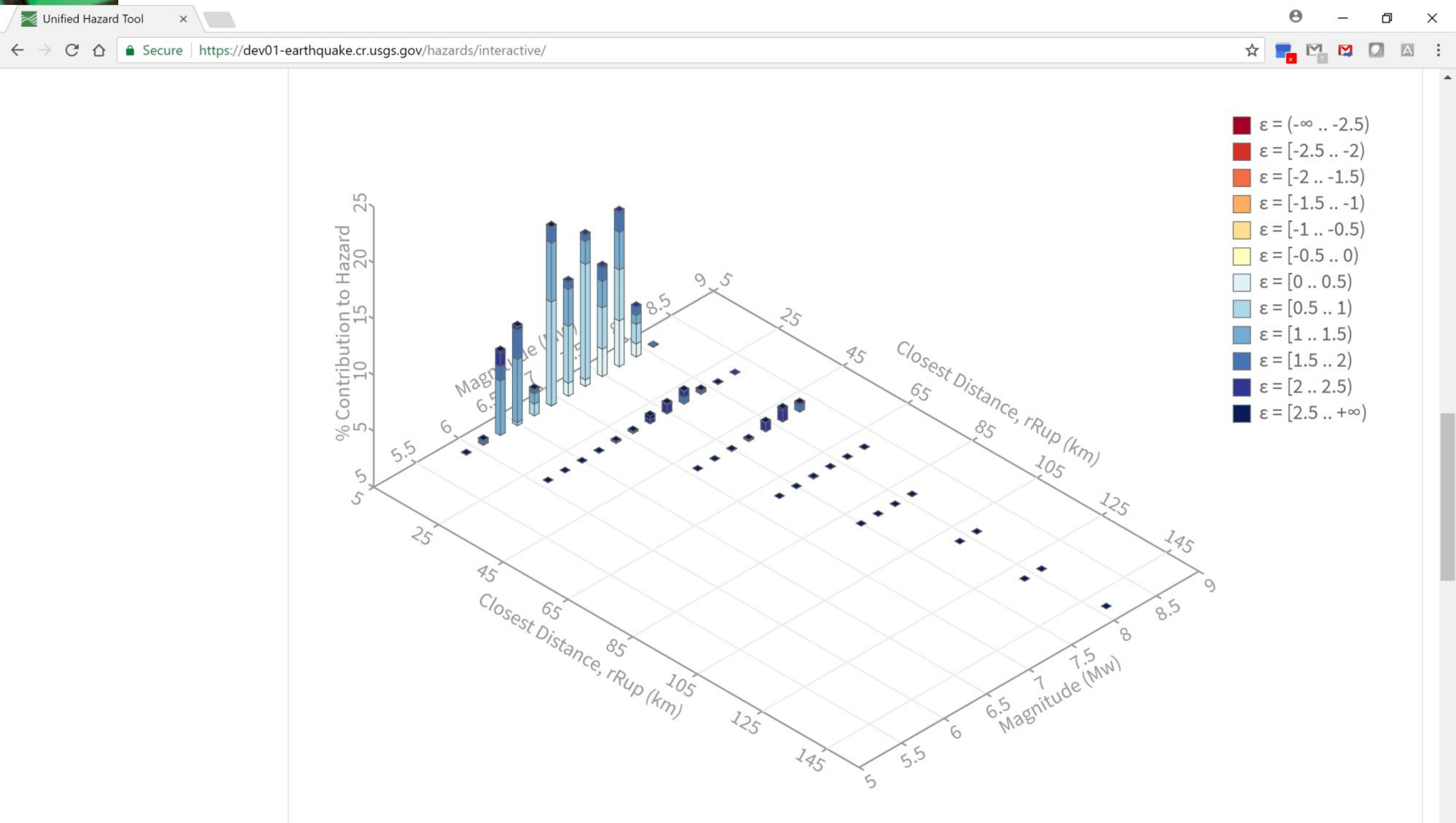
#	Latitude	Longitude	City	S_{SRT} (g)	S_{1RT} (g)
1	34.05	-118.25	Los Angeles	1.970	0.701
2	34.05	-118.40	Century City	2.111	0.753
3	34.20	-118.55	Northridge	1.944	0.686
4	33.80	-118.20	Long Beach	1.683	0.608
5	33.65	-117.80	Irvine	1.249	0.447
6	33.95	-117.40	Riverside	1.584	0.581
7	34.10	-117.30	San Bernardino	2.633	1.065
8	35.30	-120.65	San Luis Obispo	1.089	0.401
9	32.70	-117.15	San Diego	1.576	0.527
10	34.45	-119.70	Santa Barbara	2.119	0.775
11	34.30	-119.30	Ventura	2.020	0.763
12	37.80	-122.25	Oakland	2.291	0.863
13	37.95	-122.00	Concord	2.626	0.904
14	36.60	-121.90	Monterey	1.328	0.496
15	38.60	-121.50	Sacramento	0.566	0.253
16	37.75	-122.40	San Francisco	1.779	0.702
17	37.55	-122.30	San Mateo	2.156	0.886
18	37.35	-121.90	San Jose	2.166	0.795
19	36.95	-122.05	Santa Cruz	1.594	0.602
20	38.10	-122.25	Vallejo	2.141	0.771
21	38.45	-122.70	Santa Rosa	2.637	1.013
22	47.60	-122.30	Seattle	1.397	0.487
23	47.25	-122.45	Tacoma	1.355	0.468
24	48.00	-122.20	Everett	1.201	0.427
25	45.50	-122.65	Portland	0.888	0.394
26	40.75	-111.90	Salt Lake City	1.545	0.555
27	43.60	-116.20	Boise	0.307	0.109
28	39.55	-119.80	Reno	1.465	0.516
29	36.20	-115.15	Las Vegas	0.645	0.206
30	38.60	-90.20	St. Louis	0.461	0.162
31	35.15	-90.05	Memphis	1.025	0.347
32	32.80	-79.95	Charleston	1.418	0.414
33	41.85	-87.65	Chicago	0.117	0.063
34	40.75	-74.00	New York	0.290	0.060

… $S_{SRT} > 1.5g$ and/or $S_{1RT} > 0.6g$

Step 2: Deaggregate Hazard/Risk



Step 3: Identify Primary Source & M

Unified Hazard Tool

Secure | https://dev01-earthquake.cr.usgs.gov/hazards/interactive/

Deaggregation Contributors

Source Set ↳ Source	Type	r	m	ε_0	lon	lat	az	%
UC33brAvg_FM32	System							47.04
$\boxed{\text{Elysian Park (Upper) [1]}}$		5.40	$\boxed{7.09}$	0.92	118.231°W	34.076°N	31.05	$\boxed{12.29}$
Puente Hills (LA) [1]		4.67	7.17	0.52	118.272°W	34.024°N	214.64	9.19
Compton [2]		14.49	7.36	0.72	118.354°W	33.844°N	202.75	4.55
Puente Hills (Santa Fe Springs) [1]		12.77	7.09	1.34	118.144°W	33.926°N	144.53	3.02
Hollywood [0]		8.34	7.22	1.25	118.264°W	34.123°N	351.16	2.44
Newport-Inglewood alt 2 [6]		13.99	7.60	[illegible]	[illegible]	[illegible]	[illegible]	2.41
Newport-Inglewood alt 2 [8]		11.70	7.05	1.40	118.361°W	34.000°N	241.56	2.21
San Andreas (Mojave S) [8]		55.53	8.08	[illegible]	[illegible]	34.498°N	[illegible]	[illegible]
Sierra Madre [5]		19.91	7.74	1.73	118.179°W	34.219°N	19.28	1.28
San Vicente [0]		6.31	6.71	1.28	118.306°W	34.066°N	288.45	1.23
UC33brAvg_FM31	System							46.36
$\boxed{\text{Elysian Park (Upper) [1]}}$		5.40	$\boxed{6.79}$	1.06	118.231°W	34.076°N	31.05	$\boxed{19.11}$
Compton [2]		14.49	7.27	0.76	118.354°W	33.844°N	202.75	3.98
Newport-Inglewood alt 1 [6]		14.24	7.60	0.76	118.306°W	33.931°N	201.48	3.05
Puente Hills [4]		5.83	7.19	0.77	118.250°W	34.045°N	178.71	3.00
Hollywood [0]		8.34	7.40	1.14	118.264°W	34.123°N	351.16	2.21
Newport-Inglewood alt 1 [8]		12.07	6.94	1.63	118.369°W	34.006°N	246.16	2.13
San Andreas (Mojave S) [8]		55.53	8.09	2.23	117.983°W	34.498°N	26.13	1.36
Sierra Madre [5]		19.91	7.71	1.74	118.179°W	34.219°N	19.28	1.31
Puente Hills [3]		7.22	7.31	0.90	118.217°W	34.023°N	134.77	1.03

$$M = \frac{6.79 \cdot 19.11\% + 7.09 \cdot 12.29\%}{19.11\% + 12.29\%} = 6.9$$

Summary for 18 (of 34) Grid Points

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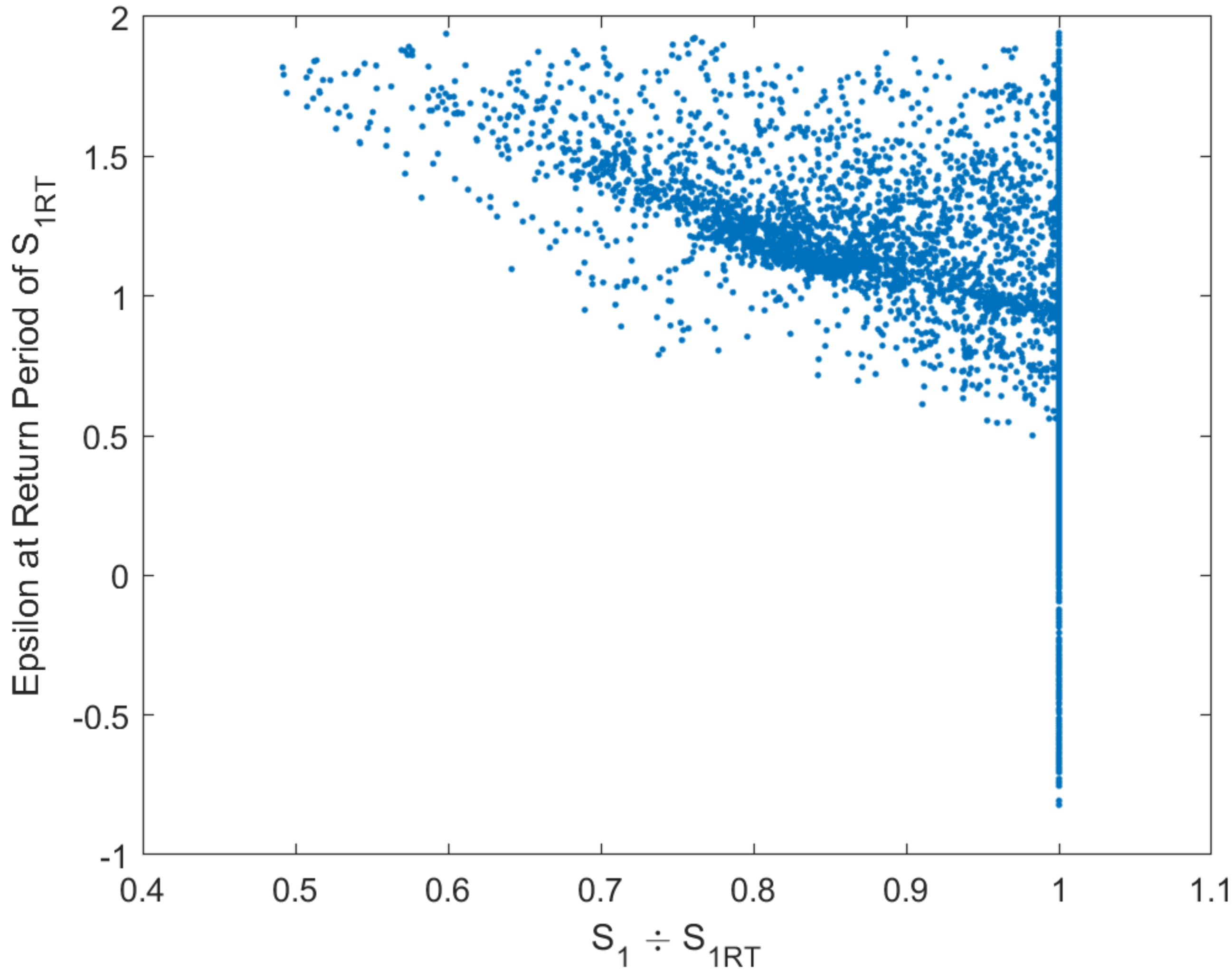
City	S_{SRT} (g)	S_{1RT} (g)	Deaggregation Primary Source	Mean M	S_S (g)	Governing Deterministic Source	Char. M	S_1 (g)	Governing Deterministic Source	Char. M
Los Angeles	1.970	0.701	Elysian Park (Upper)	6.9	1.970	NA (Probabilistic)	NA	0.701	NA (Probabilistic)	NA
Century City	2.111	0.753	Newport-Inglewood	6.7	2.111	NA (Probabilistic)	NA	0.753	NA (Probabilistic)	NA
Northridge	1.944	0.686	Santa Susana East (connector)	6.9	1.735	Compton	7.4	0.600	NA (Plateau)	NA
Long Beach	1.683	0.608	Newport-Inglewood	7.4	1.683	NA (Probabilistic)	NA	0.608	NA (Probabilistic)	NA
Irvine	1.249	0.447	---	---	1.249	NA (Probabilistic)	NA	0.447	NA (Probabilistic)	NA
Riverside	1.584	0.581	San Jacinto (San Bernardino)	8.0	1.500	NA (Plateau)	NA	0.581	NA (Probabilistic)	NA
San Bernardino	2.633	1.065	San Jacinto (San Bernardino)	8.0	2.327	San Jacinto: SBV+SJV+s+A+C	7.7	0.931	San Jacinto: SBV+SJV+s+A+CC+B+SM	7.8
San Luis Obispo	1.089	0.401	---	---	1.089	NA (Probabilistic)	NA	0.401	NA (Probabilistic)	NA
San Diego	1.576	0.527	Rose Canyon	6.7	1.576	NA (Probabilistic)	NA	0.527	NA (Probabilistic)	NA
Santa Barbara	2.119	0.775	Red Mountain	7.3	2.119	NA (Probabilistic)	NA	0.775	NA (Probabilistic)	NA
Ventura	2.020	0.763	Ventura-Pitas Point	7.5	2.020	NA (Probabilistic)	NA	0.763	NA (Probabilistic)	NA
Oakland	2.291	0.863	Hayward (No)	7.2	1.883	Hayward: RC+HN+HS+HE	7.6	0.719	Hayward: RC+HN+HS+HE	7.6
Concord	2.626	0.904	Concord	6.7	2.221	Mount Diablo Thrust North	6.7	0.673	Mount Diablo Thrust North	6.7
Monterey	1.328	0.496	---	---	1.328	NA (Probabilistic)	NA	0.496	NA (Probabilistic)	NA
Sacramento	0.566	0.253	---	---	0.566	NA (Probabilistic)	NA	0.253	NA (Probabilistic)	NA
San Francisco	1.779	0.702	San Andreas (Peninsula)	7.9	1.500	NA (Plateau)	NA	0.600	NA (Plateau)	NA
San Mateo	2.156	0.886	San Andreas (Peninsula)	7.9	1.801	N. San Andreas: SAO+SAN+SAP+SAS	8.0	0.736	N. San Andreas: SAO+SAN+SAP+SAS	8.0
San Jose	2.166	0.795	Hayward (So)	7.1	1.500	NA (Plateau)	NA	0.600	NA (Plateau)	NA
Santa Cruz	1.594	0.602	San Andreas (Santa Cruz Mts)	7.8	1.594	NA (Probabilistic)	NA	0.602	NA (Probabilistic)	NA
Vallejo	2.141	0.771	Franklin	6.7	1.502	West Napa	7.0	0.600	NA (Plateau)	NA
Santa Rosa	2.637	1.013	Rodgers Creek - Healdsburg	7.3	2.413	Hayward: RC+HN+HS+HE	7.6	0.939	Hayward: RC+HN+HS+HE	7.6
Seattle	1.397	0.487	---	---	1.397	NA (Probabilistic)	NA	0.487	NA (Probabilistic)	NA
Tacoma	1.355	0.468	---	---	1.355	NA (Probabilistic)	NA	0.468	NA (Probabilistic)	NA
Everett	1.201	0.427	---	---	1.201	NA (Probabilistic)	NA	0.427	NA (Probabilistic)	NA
Portland	0.888	0.394	---	---	0.888	NA (Probabilistic)	NA	0.394	NA (Probabilistic)	NA
Salt Lake City	1.545	0.555	Wasatch Flt SLC	6.8	1.545	NA (Probabilistic)	NA	0.555	NA (Probabilistic)	NA

ASCE 7-16 Definition of "Active" Faults

of 0.6, as specified in ASCE/SEI 7-10 (Section 21.2.1), for the conterminous US, Guam and the Northern Mariana Islands, and American Samoa. For the other regions (Hawaii, Puerto Rico and the US Virgin Islands, and Alaska), where the latest USGS hazard curves pre-date the change of the logarithmic standard deviation from the 2009 *Provisions* to ASCE/SEI 7-10, the beta value is 0.8. Please see (Luco et al., 2007) for more information on the development of risk-targeted probabilistic ground motions.

The deterministic ground motions have been calculated using the "characteristic earthquakes on all known active faults" (quoted from Section 21.2.2) that the USGS uses in computing the probabilistic hazard curves. The largest characteristic magnitude considered by the USGS on each fault, excluding any lower-weighted magnitudes from the USGS logic tree for epistemic uncertainty, is used for the deterministic ground motions. The active faults considered for the deterministic ground motions are those that have evidence of slip during Holocene time (the past 12,000 years, approximately), plus those with reported geologic rates of slip larger than 0.1 mm/year. This slip rate can result in a magnitude 7 earthquake, which on average corresponds to 1.2 meter of slip (Wells and Coppersmith, 1994), over a 12,000-year time period; it (0.1 mm/year) also is the slip rate assigned by the Working Group on California Earthquake Probabilities (WGCEP, 2013) to faults that, with the information available, could only be categorized as having a slip rate less than 0.2 mm/year. At a user-inputted location, the fault (among hundreds) and corresponding magnitude that govern its deterministic ground motion is outputted by the USGS web tool briefly described in a section of this commentary below. For all the deterministic faults and magnitudes, the USGS has computed median (50th percentile), geometric-mean ground motions. To convert to maximum-response ground motions, the same scale factors described in the preceding paragraph for probabilistic ground motions are applied. To approximately convert to 84th percentile ground motions, the maximum-response ground motions are multiplied by 1.8.

Deterministic Caps vs. Epsilon



Project '17 Deterministic Capping Subcommittee

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YO-YO EFFECT

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Yo-Yo Effect

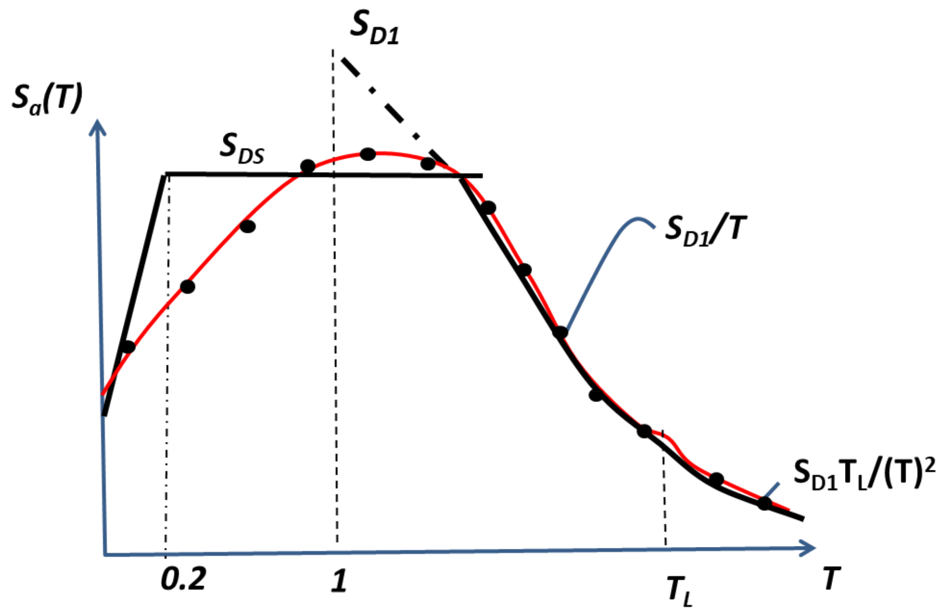
- Looked at ways of smoothing ground motion changes with code editions:
  - Reduce significant figures with which motions are reported (10% changes won't be noticeable)
  - Use weighted average approach to develop maps (50% new model, 25% past model, 25% earlier model)
- Minor (+/-15%) changes in ground motion values are annoying but not generally problematic
- Switches in SDCs are problematic

Stabilizing SDCs

- Use separate SDC map to indicate designation of Design Categories
  - Map tied to ground motion values for a default site class
  - PUC uses judgement to move SDC boundaries or not, depending on reason for increase or decrease in motion and the magnitude of this
- Downsides:
  - Some structures designed too conservative
  - Lot of work for future PUC's
- Passed Straw Pole 7-2
- Going to consensus ballot

MULTI-POINT SPECTRUM

Multi-point Spectrum



- Values provided at multi periods ranging from 0 to 10 seconds
- F_a and F_v no longer used, soil class used directly in hazard analysis
- S_{DS} taken as 90% of max spectral response
- S_{D1} selected, so as to fit the spectral shape

Multi-Period Response Spectrum

Provide hazard curves for 21 periods and 8 site classes:

Period T (s)	Site Class							
	A	B	BC	C	CD	D	DE	E
PGA			PGA					
0.010								
0.020								
0.030								
0.050								
0.075								
0.10								
0.15								
0.20			S_S					
0.25								
0.30								
0.40								
0.50								
0.75								
1.0			S_1					
1.5								
2.0								
3.0								
4.0								
5.0								
7.5								
10.0								

Challenges

- In some regions, presently available GMPEs do not enable filling out all the boxes in the matrix
- Rules are needed to fill out the matrix where this occurs
- Project 17 voted to pass this along to the PUC, but asked BSSC to obtain funding for a project to assist in developing these rules
- Funding for BSSC project cannot be obtained in time to assist for this cycle
- However, separate funding for a small task group is potentially available if the "budget can be agreed to, and is right"

Summary

- Retain Project '07 Risk Model
- Redefine but retain "characteristic" earthquake
- Provide spectral values at multiple periods including Site Class effects
  - PUC needs to complete this
- Separate maps for SDCs – in ballot
- Potential Recommendations re Long Duration Shaking – Part 3