

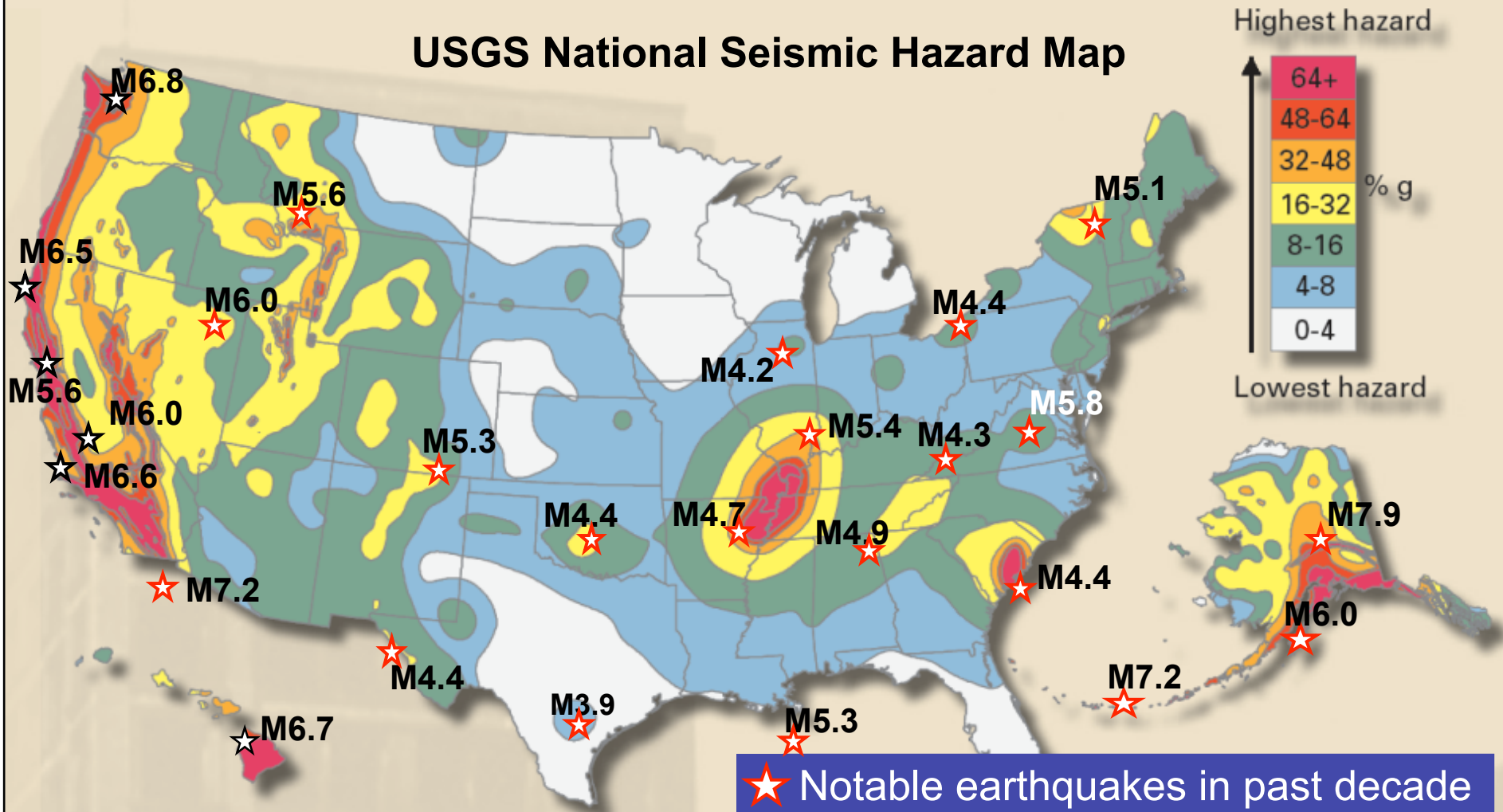
The August 2011 Virginia Earthquake

**NEHRP Advisory Committee for
Earthquake Hazard Reduction**

**Bill Leith
U.S. Geological Survey
September 22, 2011**

Earthquakes are a national hazard

USGS National Seismic Hazard Map



FEMA

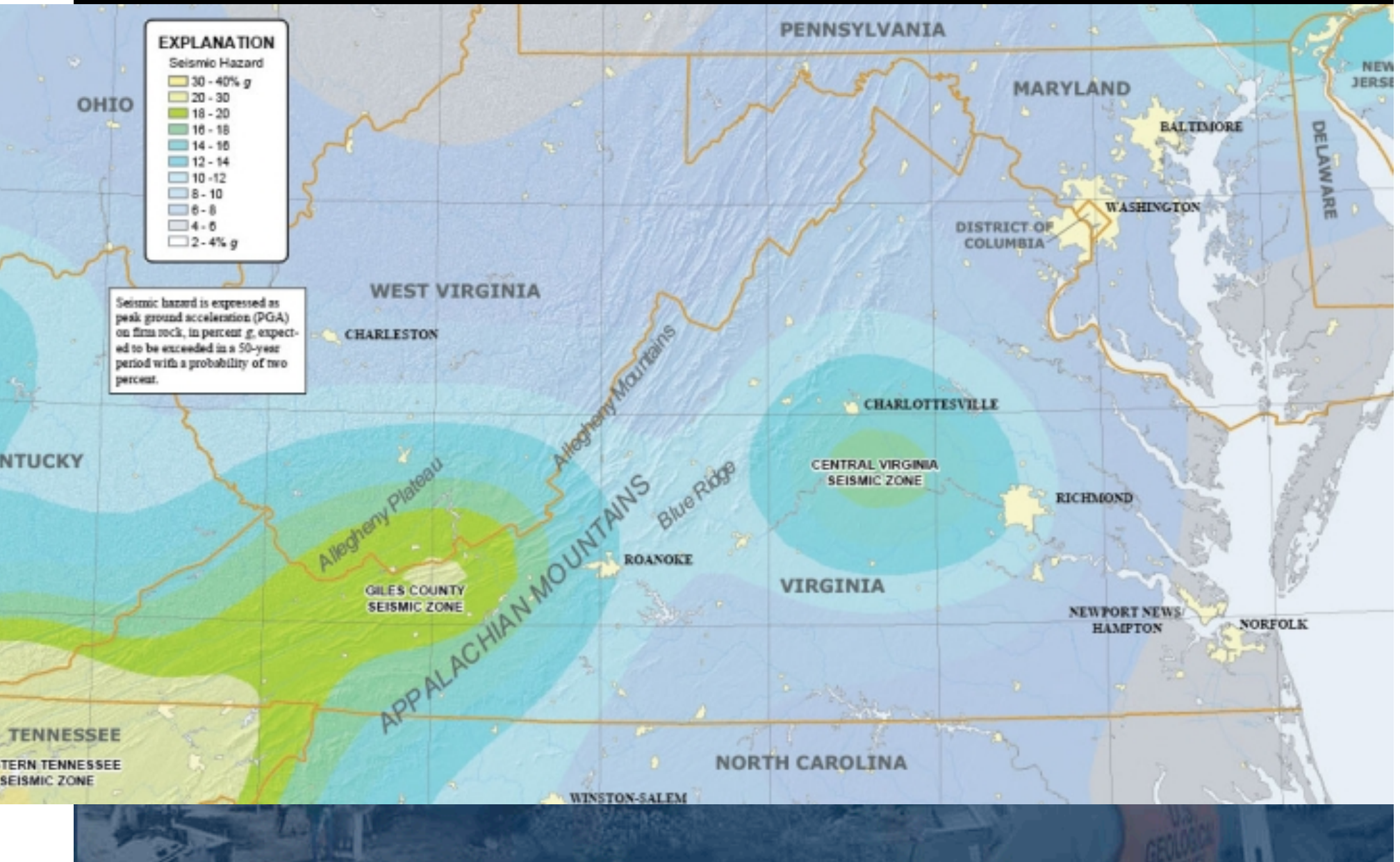
NIST
National Institute of
Standards and Technology



USGS
science for a changing world

national earthquake hazards reduction program

Earthquake hazard in the Mid-Atlantic Region



Virginia Earthquake of August 23, 2011

Largest earthquake in Virginia In 114 years

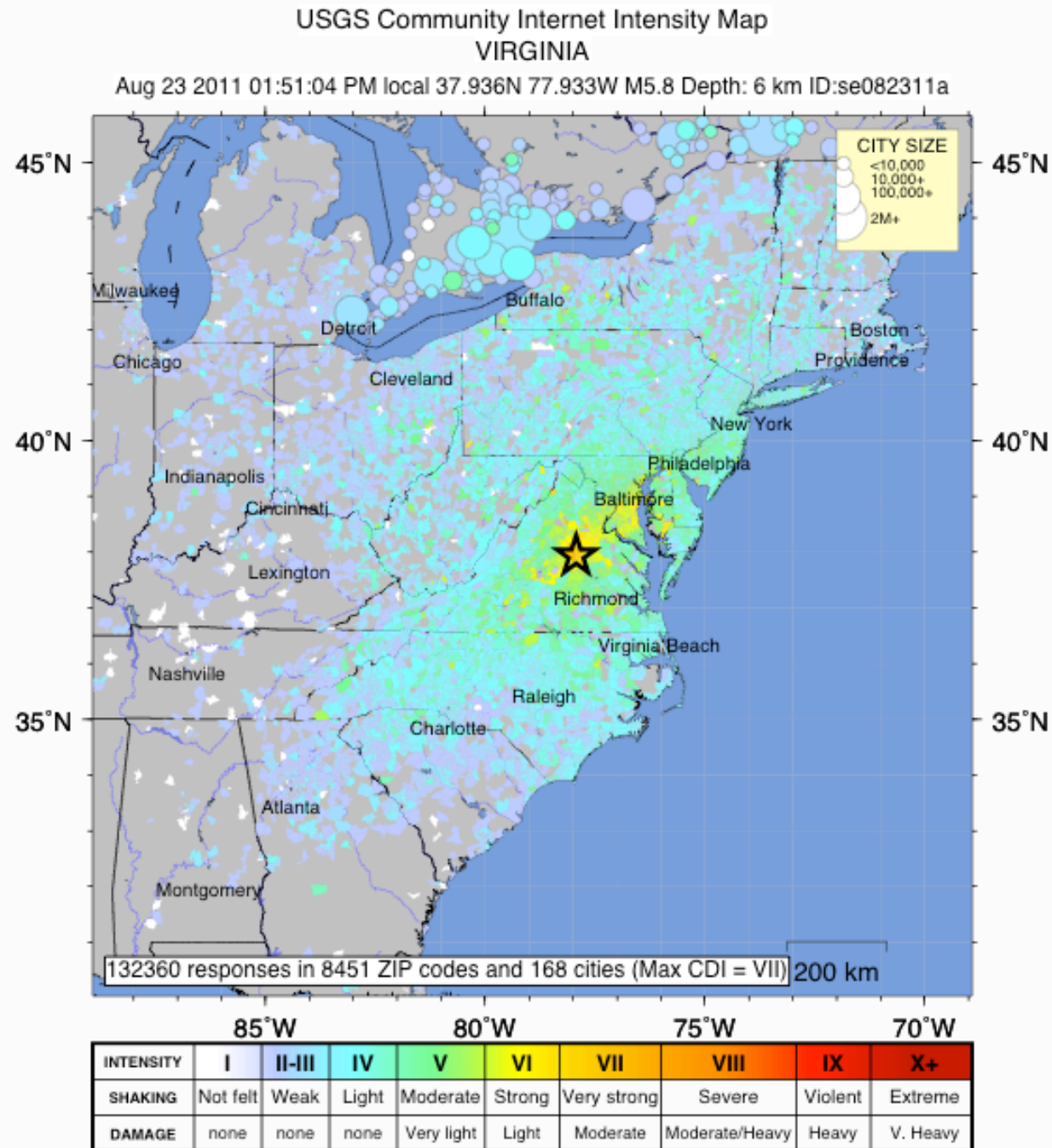
Centered in low-population area between Richmond and Charlottesville

No fatalities

Estimated Damage >\$100M

Felt from Florida to Maine to Missouri (>140,000 reports)

Caused evacuations across Washington DC metropolitan area, and damage to historic structures.

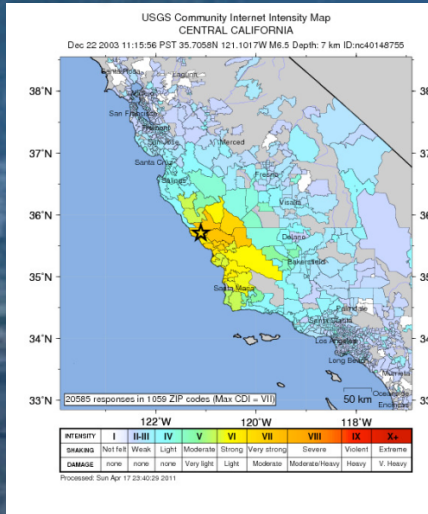


Processed: Fri Aug 26 15:29:21 2011

Magnitude 6.5 San Simeon, CA, 2003

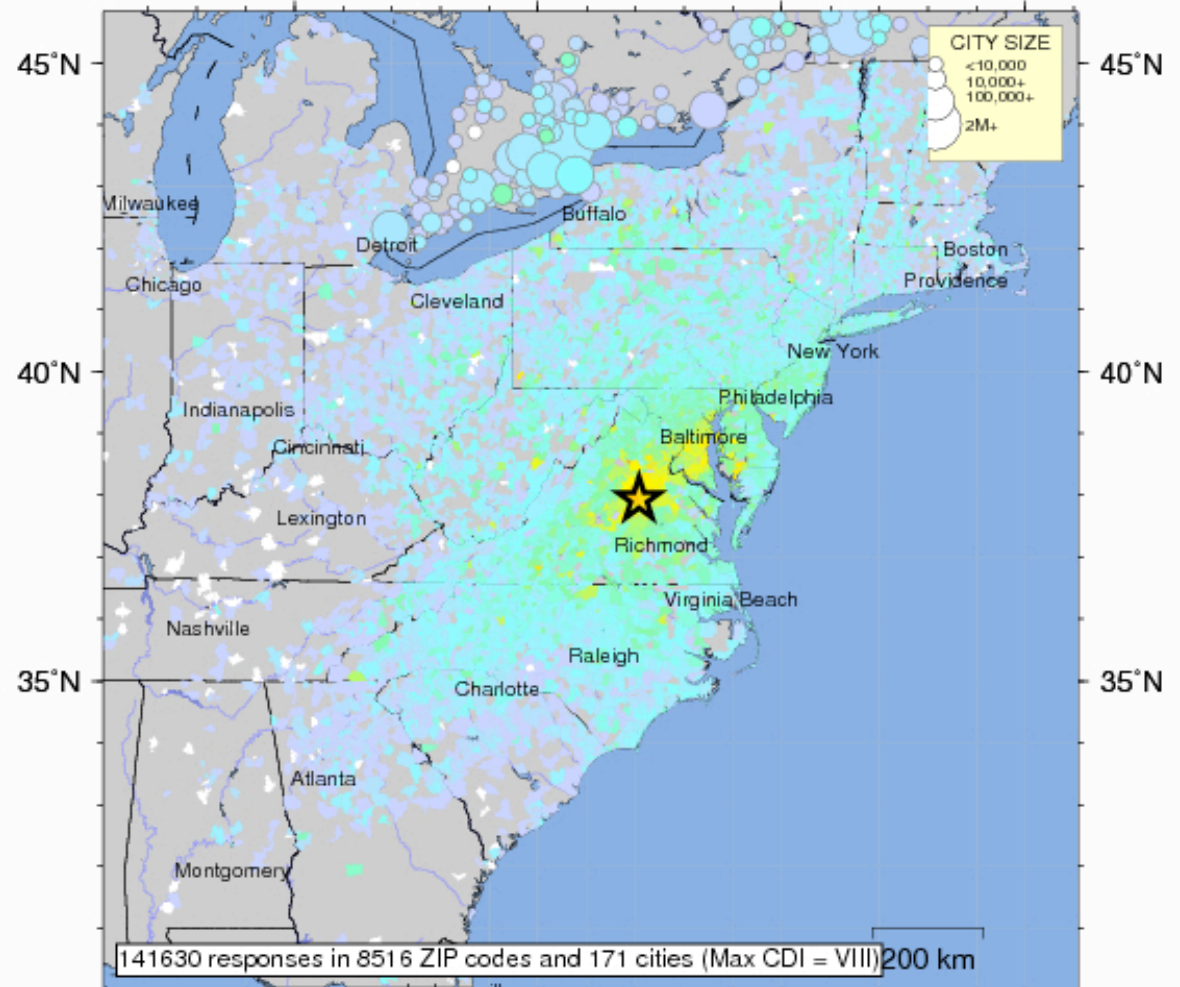
Magnitude 5.8 Louisa, VA, 2011

Same scale



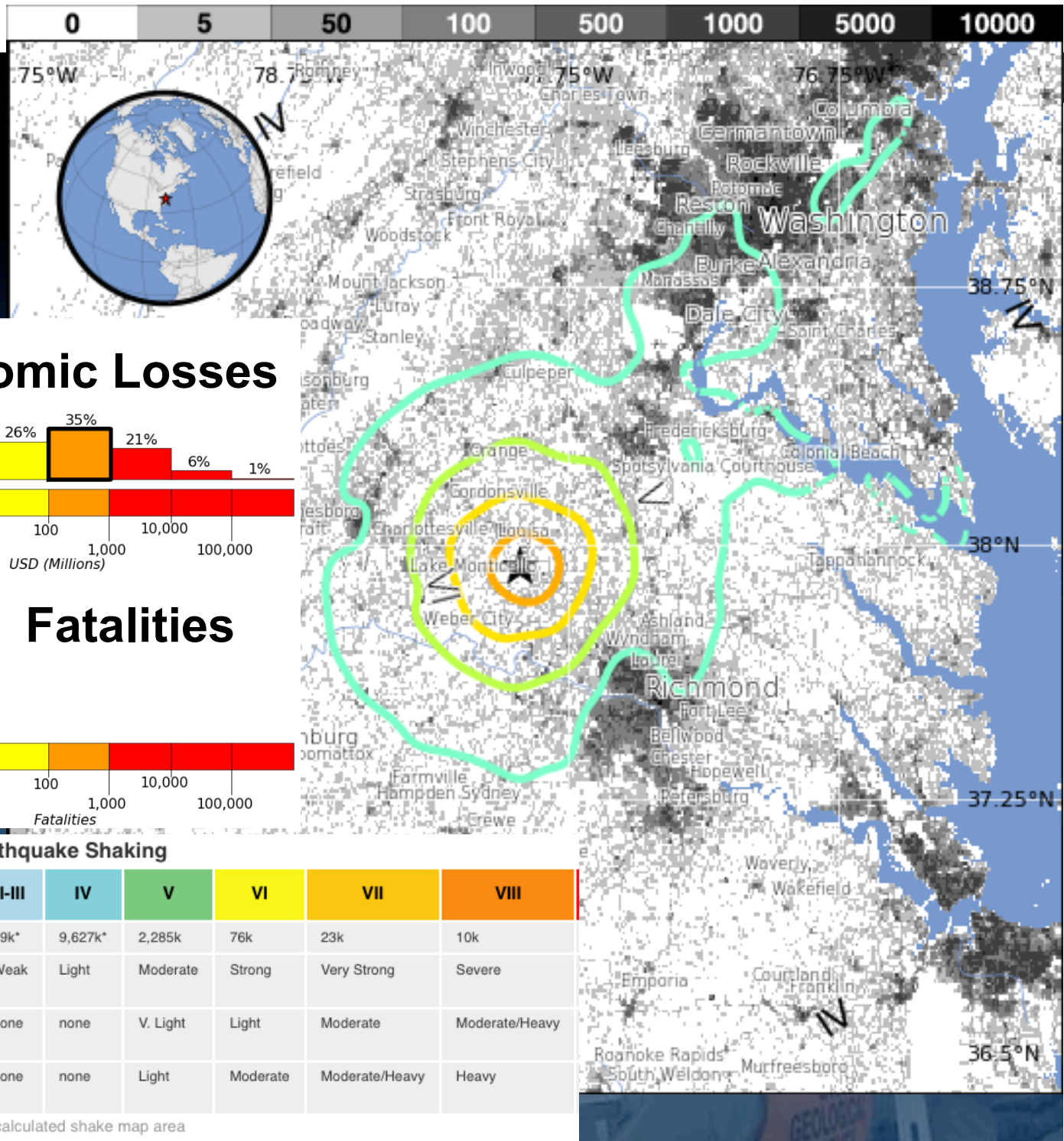
USGS Community Internet Intensity Map VIRGINIA

Aug 23 2011 01:51:04 PM local 37.936N 77.933W M5.8 Depth: 6 km ID:se082311a

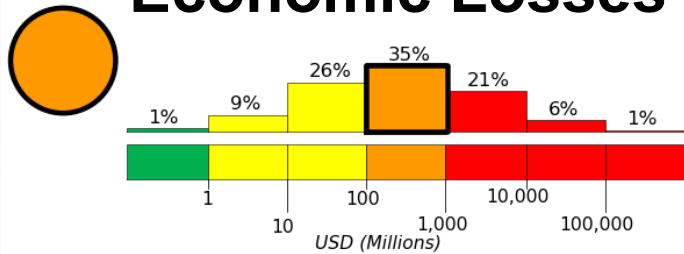


INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+
SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme

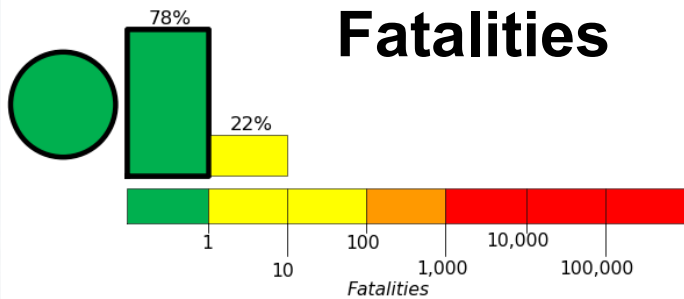
PAGER rapid loss estimates



Economic Losses



Fatalities



Estimated Population Exposed to Earthquake Shaking

Estimated Modified Mercalli Intensity		I	II-III	IV	V	VI	VII	VIII
Est. Population Exposure		---*	19k*	9,627k*	2,285k	76k	23k	10k
Perceived Shaking		Not Felt	Weak	Light	Moderate	Strong	Very Strong	Severe
Potential Structure Damage	Resistant	none	none	none	V. Light	Light	Moderate	Moderate/Heavy
	Vulnerable	none	none	none	Light	Moderate	Moderate/Heavy	Heavy

*Estimated exposure only includes population within calculated shake map area

Damage in Epicentral Area



Yanceyville
Virginia



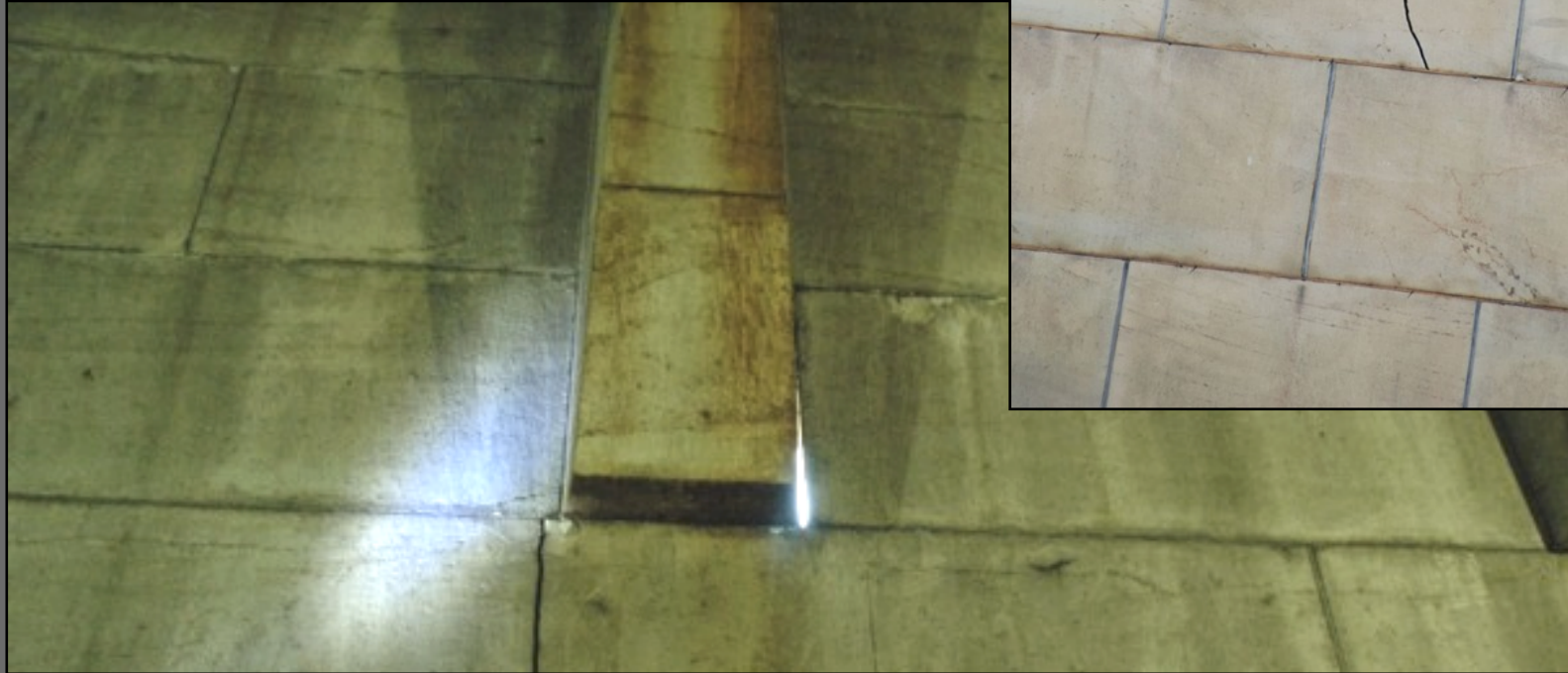
Culpeper
Virginia



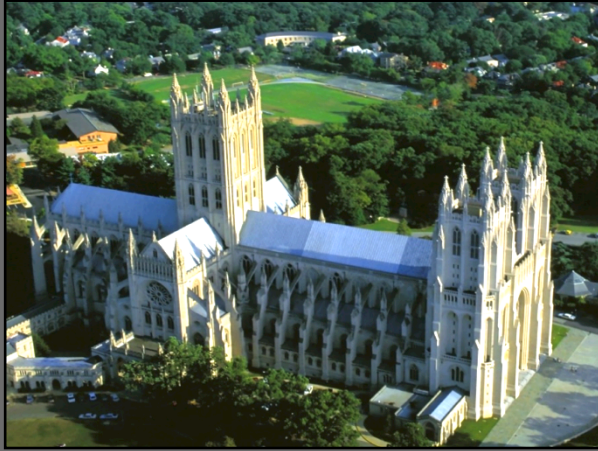
Scant Evidence of Liquefaction

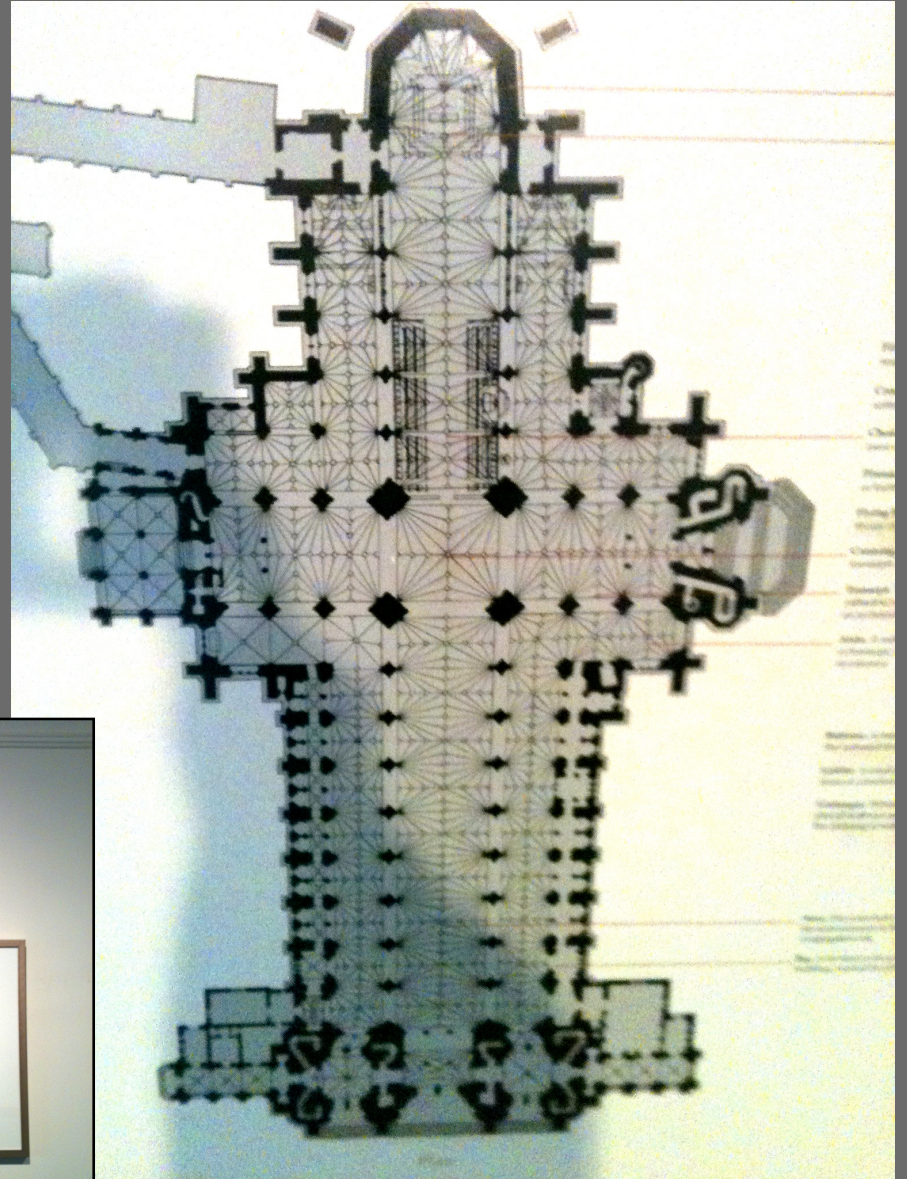


Washington Monument



National Cathedral





National Cathedral

**GENERALIZED GEOLOGIC MAP OF THE CENTRAL VIRGINIA PIEDMONT
WITH FAULTS AND EARTHQUAKES (M >2, 1973-2011)**

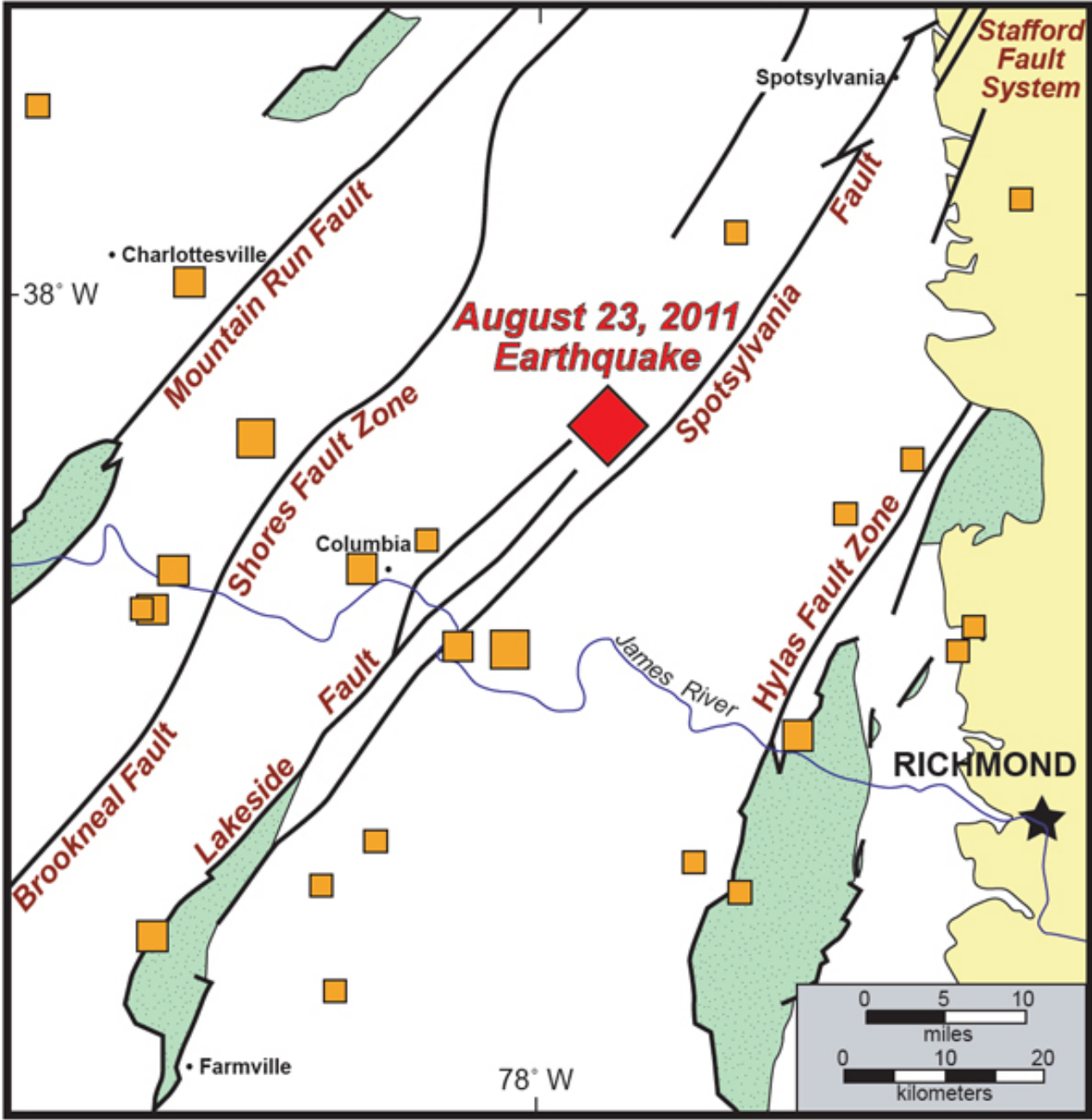
**Locations
of past
earthquakes
in central
Virginia**

Earthquake Epicenters

-  M > 5
-  M = 4
-  M = 3.0 - 3.9
-  M = 2.0 - 2.9

*data from: Virginia Tech Seismological
Observatory and USGS National
Earthquake Information Center*

•Map by C.M. Bailey,
College of Wm & Mary



Christchurch NZ magnitude-6.1 earthquake



North Anna Nuclear Power Plant



Dry Cask Storage



ShakeCast – automated damage estimates for critical facilities.



International Seismic Safety Centre ShakeCast Report



Magnitude 5.9 - VIRGINIA

Time: 2011-08-23 17:51:03 GMT

Location: 37.97 N/ -77.97 W

Depth: 1.0 km

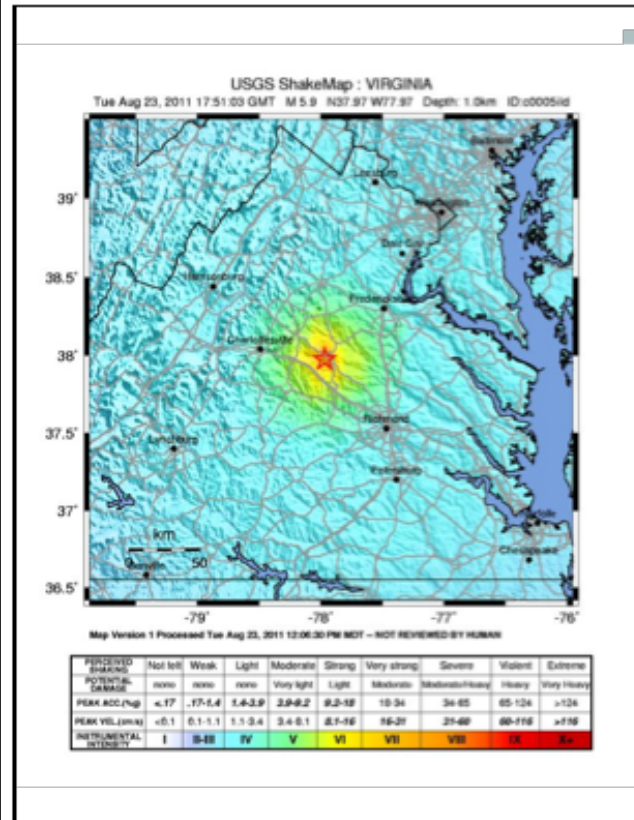
Version 1

Created: 2011-08-23 18:16:12 GMT

For more information and latest version see

<http://nuclearshakecast.iaea.org>

These results are from an automated system and users should consider the preliminary nature of this information when making decisions relating to public safety. ShakeCast results are often updated as additional or more accurate earthquake information is reported or derived.



Recent significant earthquakes in the region

- M4.5 VIRGINIA at 12/9/2003 20:59
- M3.4 POTOMAC-SHERANDOAH REGION at 7/16/2010 9:04



FACILITY TYPE	FACILITY ID	FACILITY NAME	LATITUDE	LONGITUDE	DAMAGE LEVEL	MMI	PGA	PGV	PBA05	PBA10	PBA30
NPP	ORAE	Colvert Creek	38.4319	-76.4434	GREEN	5.63	1.6982	0.8333	2.9834	0.8883	0.0974
NPP	ORAT	North Anna	38.8975	-77.3956	YELLOW	5.33	1.6639	6.3976	21.4418	5.1476	0.3304
NPP	ORAN	Berry	37.1833	-76.6943	GREEN	5.63	1.6397	0.8486	2.9493	0.883	0.0971

NETQUAKES

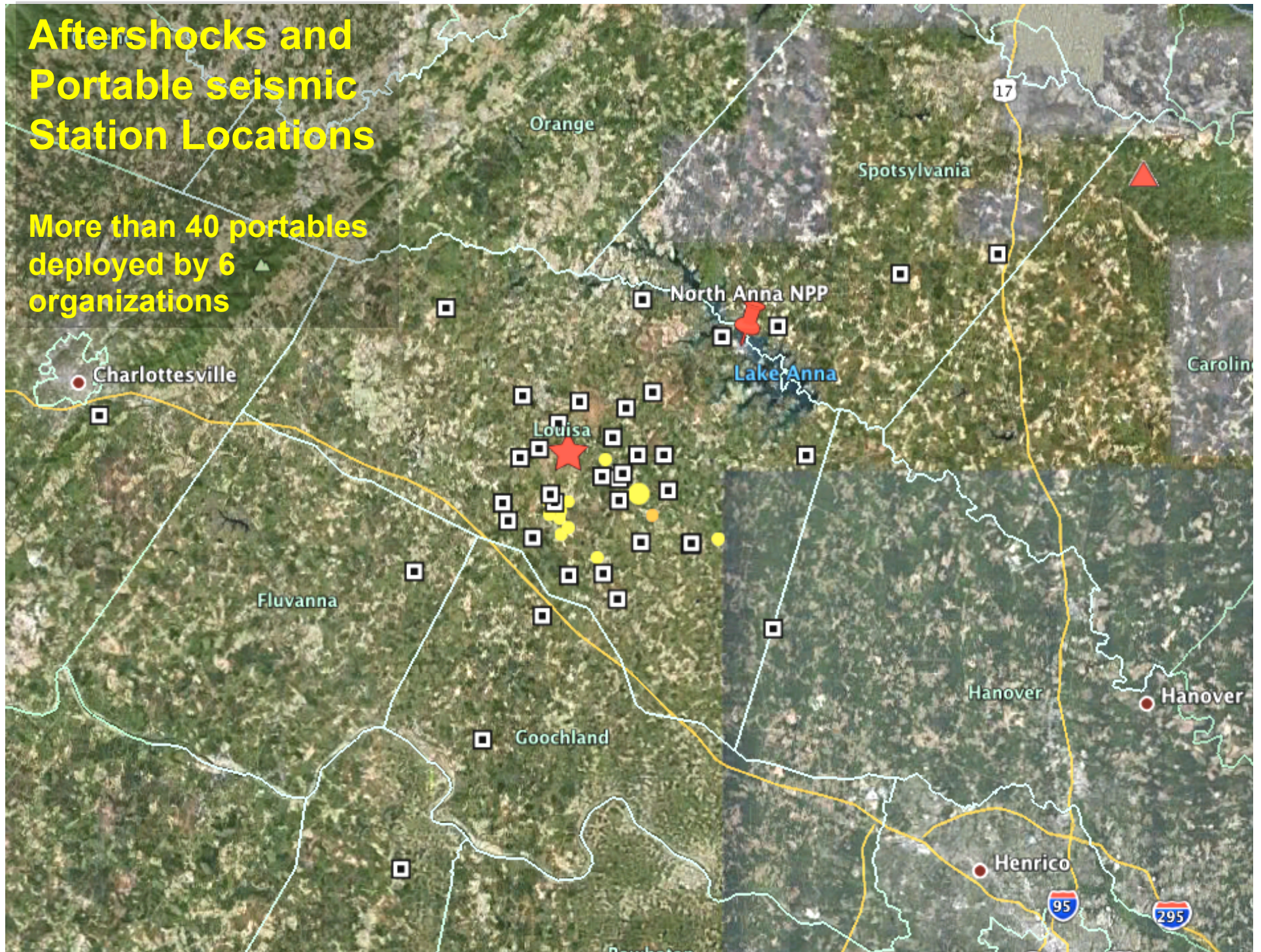
Low-cost, high-fidelity
strong-motion sensor
producing real-time
data for rapid analysis

New sites in
Washington:
--Cathedral
--USGS Reston
--U.S. Capitol
--others sought



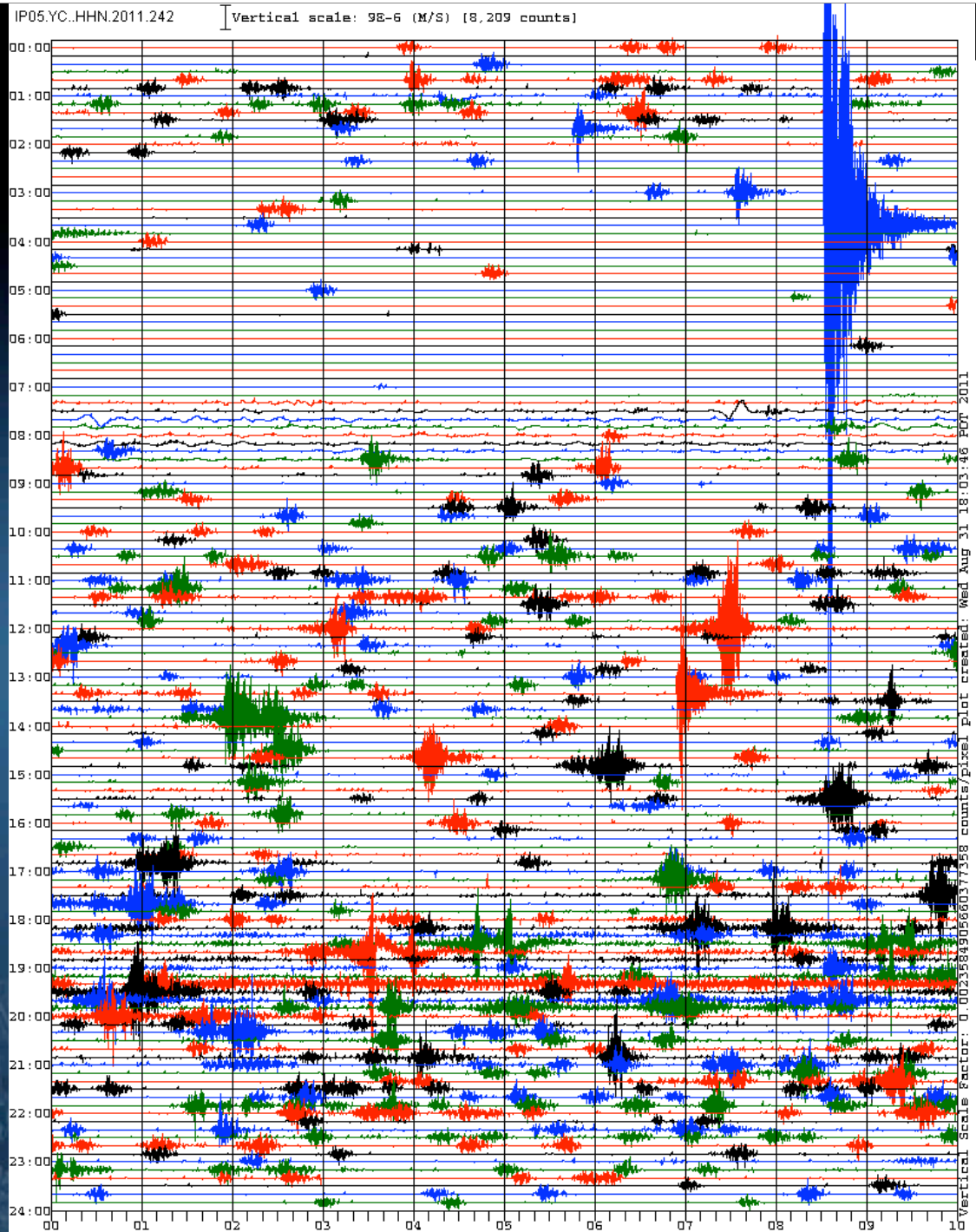
Aftershocks and Portable seismic Station Locations

More than 40 portables deployed by 6 organizations



Aftershocks recorded in epicentral area

August 30, 2011



USGS

nehrp

Aftershocks recorded in epicentral area

date-time	lat	lon	depth	mag
8/23/11 17:51	37.93N	77.93W	6	5.8
8/23/11 18:46	37.96N	77.92W	5	3.0
8/23/11 19:20	37.91N	78.00W	0	2.5
8/24/11 0:04	37.91N	77.89W	8	3.7
8/24/11 4:45	37.92N	77.99W	5	3.3
8/25/11 5:07	37.94N	77.89W	5	3.9
8/25/11 6:37	37.91N	77.96W	0	2.3
8/25/11 15:27	37.98N	77.83W	9	2.6
8/25/11 15:27	37.98N	77.83W	9	2.6
8/25/11 23:40	37.99N	77.91W	5	2.7
8/26/11 22:52	37.88N	77.93W	0	2.1
8/28/11 20:18	37.93N	77.97W	7	2.2
8/29/11 1:06	37.93N	77.98W	5	2.3
8/29/11 3:15	37.93N	77.98W	4	2.0
8/29/11 3:16	37.93N	77.99W	4	2.7
8/29/11 4:19	37.93N	77.98W	4	2.2
8/30/11 3:48	37.90N	77.97W	7	2.6
9/1/11 9:09	37.95N	77.88W	5	3.4
9/5/11 16:54	37.94N	77.97W	5	2.5

**Strong motion
record from
Reston, VA,
Firehouse #25,
(USGS NP2555)**

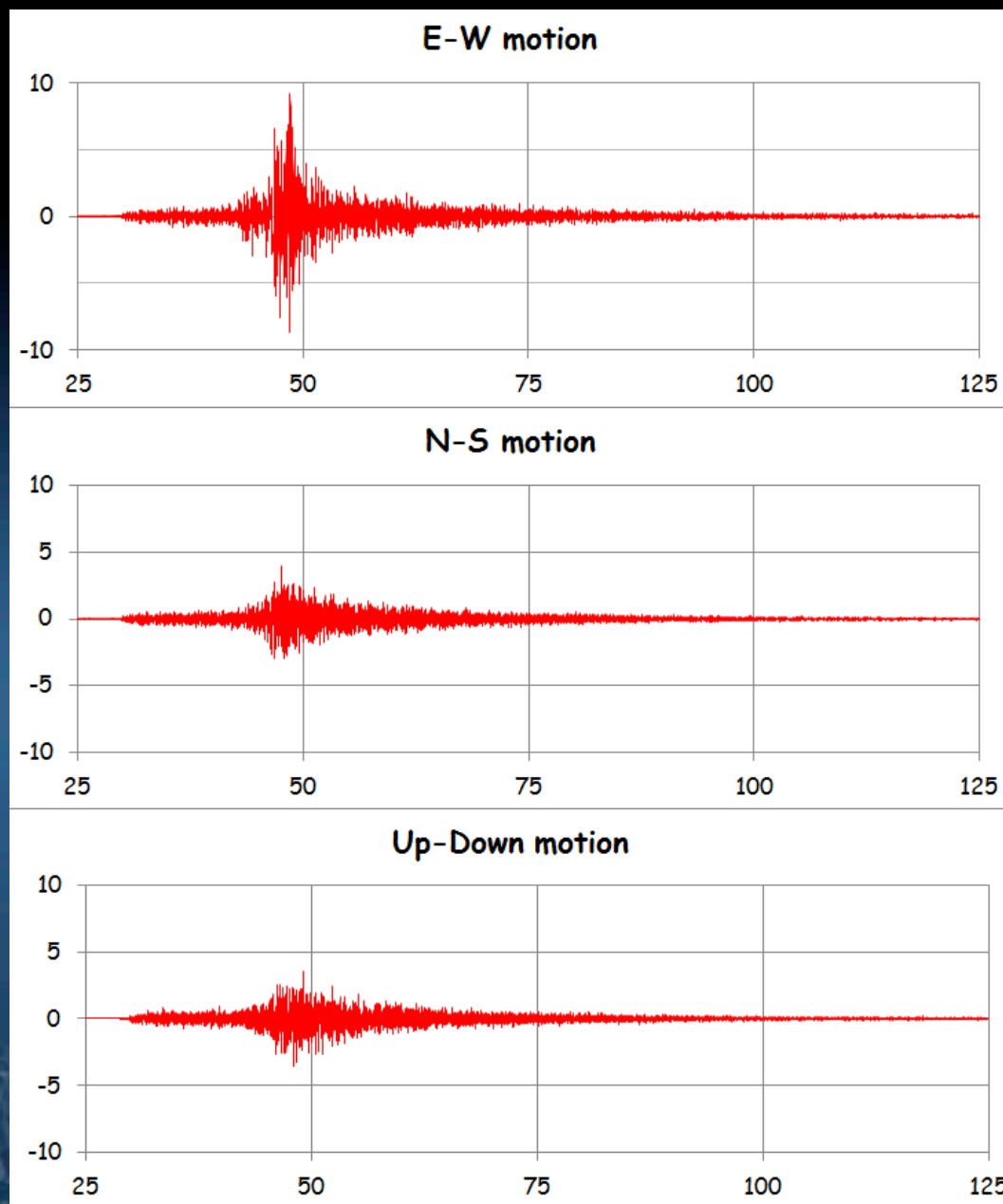
for

**Mineral, VA,
Mw 5.8
earthquake on
Aug 23, 2011**

(USGS Processing)

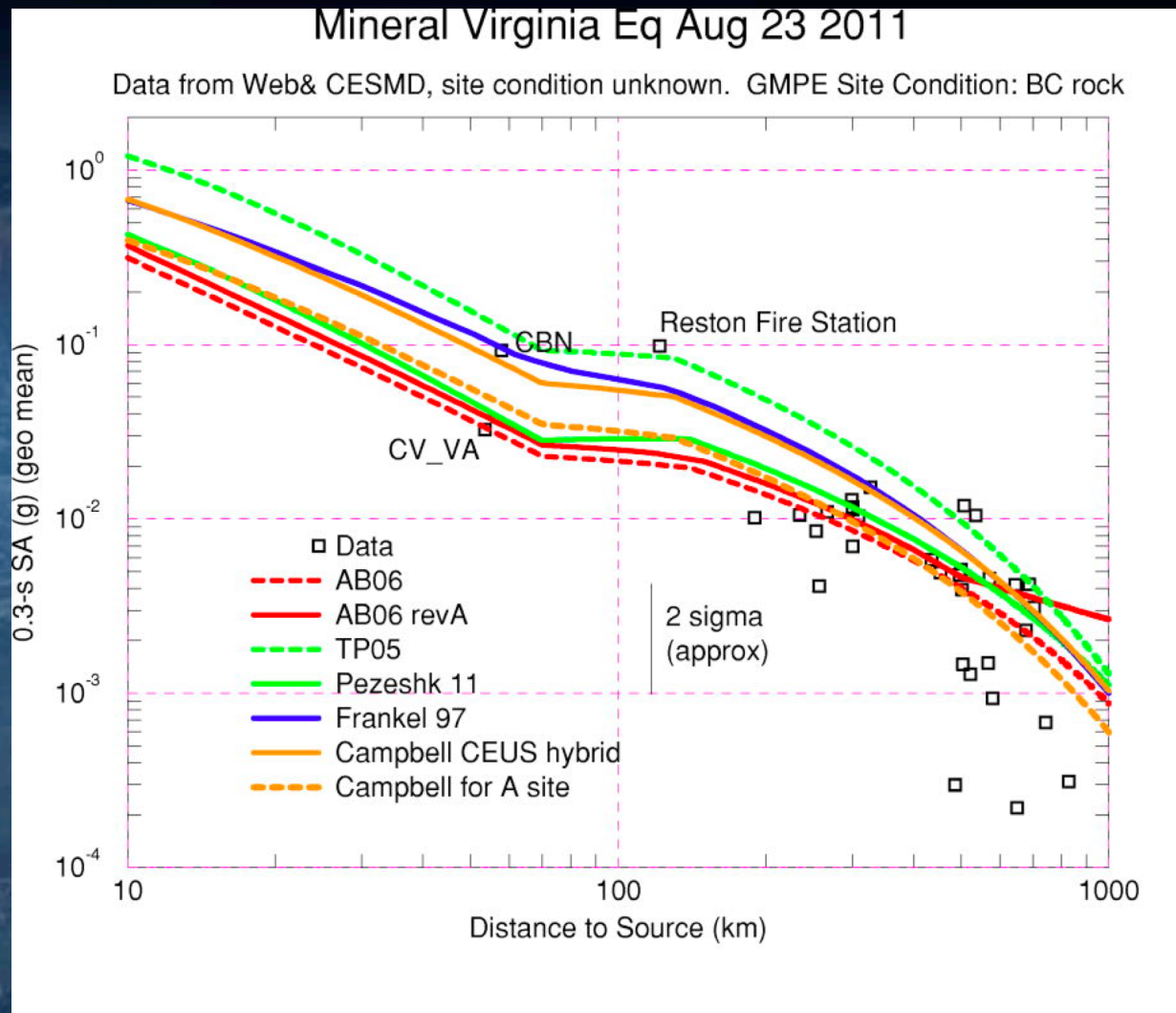


Acceleration, %g

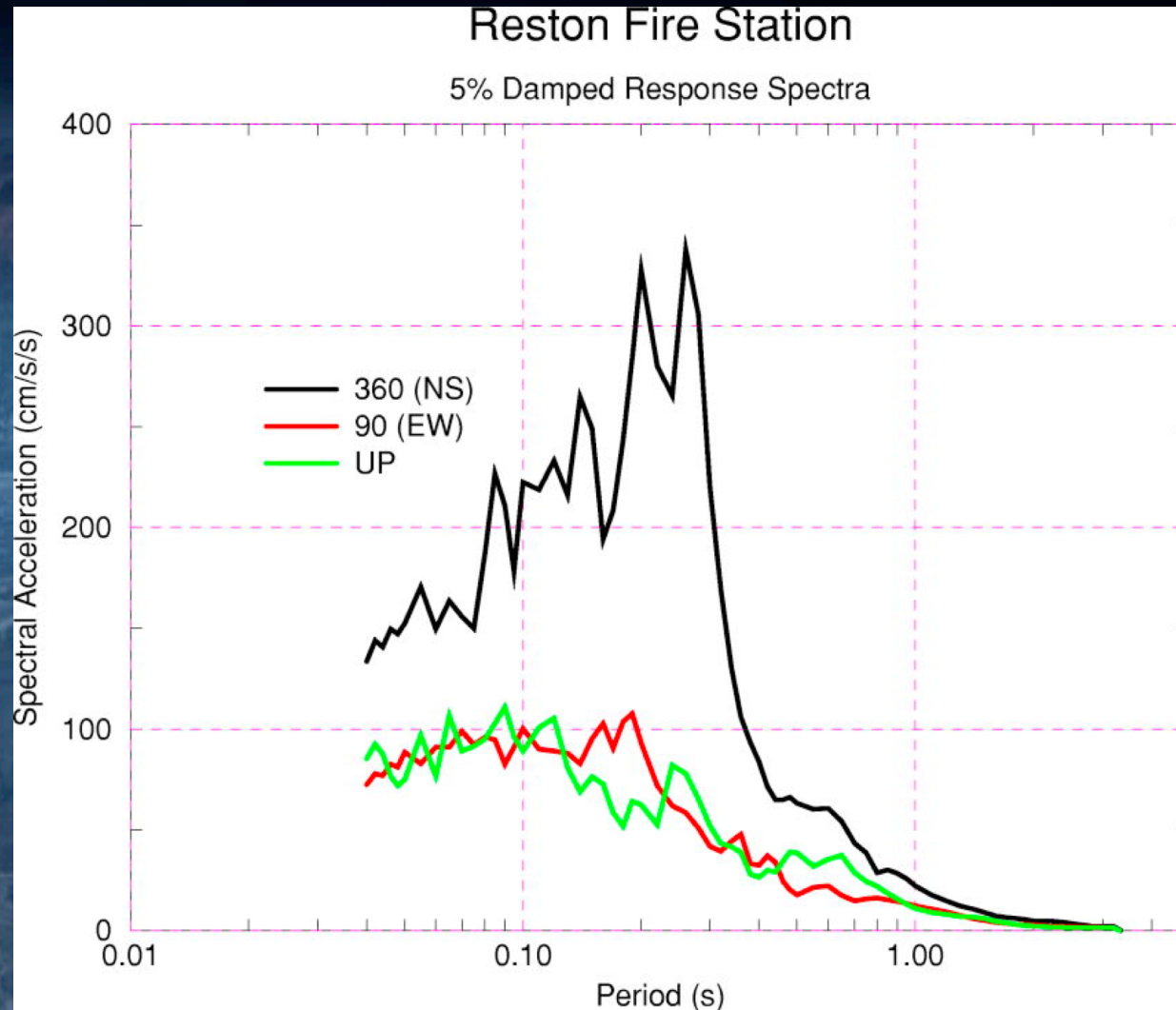


Time, sec

Preliminary analysis of attenuation



Evidence for site resonance in Reston, Virginia



Tasked: Velocity Characterization of seismic station sites that recorded larger events



Additional investigations needed

- Broader site characterization
- Event relocations
- Geology
 - LiDAR
 - Aeromagnetic
 - Trenching
 - Geophysical profiling?
- Geodesy
- Social aspects

