

ShakeCast:

A Tool for Raising Situational Awareness in Emergency Response

Northridge Earthquake Symposium
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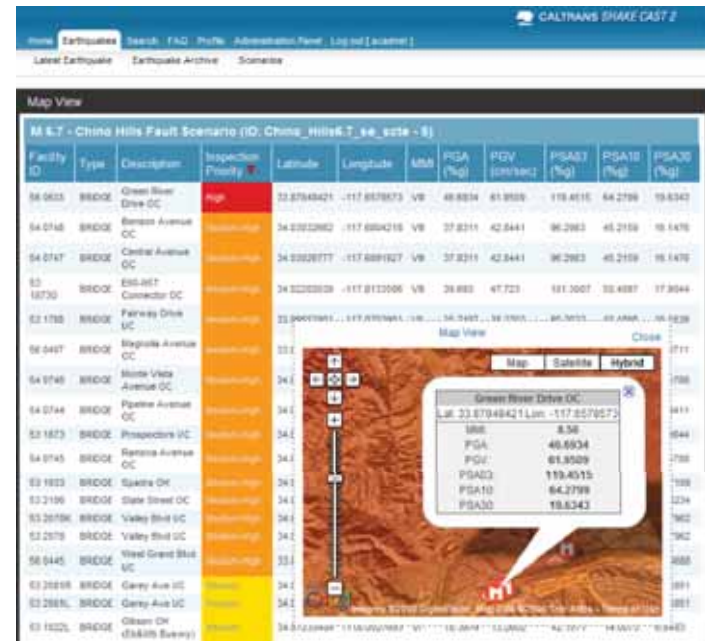
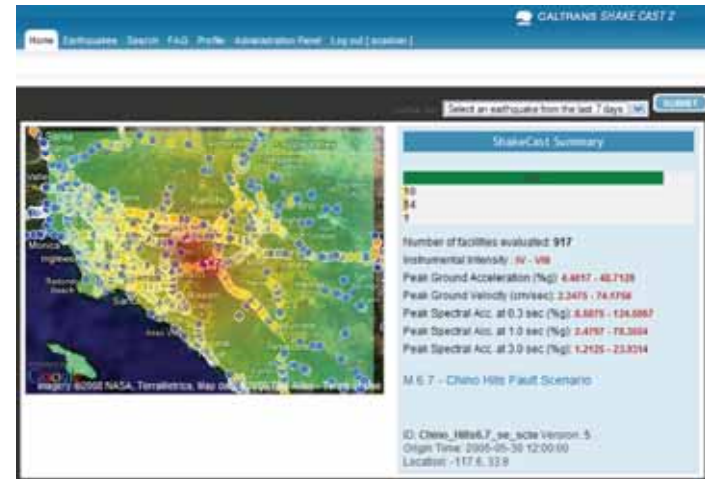


Caltrans Division of Research,
Innovation and System Information



What is ShakeCast?

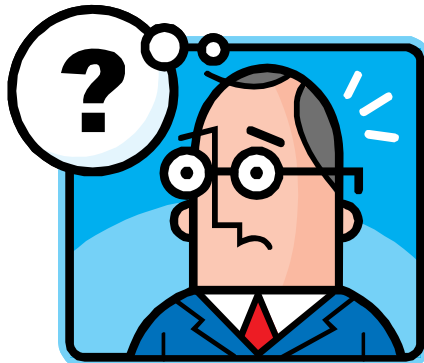
- Open-source web application.
- Retrieves measured shaking data within minutes after an earthquake.
- Compares spatial shaking distribution with unique bridge vulnerabilities.
- Generates hierarchical lists and maps of bridges most likely impacted.
- Sends notifications to responders within 10 minutes following the event.
- Developed by the USGS in 2003.
 - David Wald (USGS)
 - Kuo-Wan Lin (USGS)
- Caltrans-USGS work resulted in *ShakeCast v2* in 2008, and has since been adopted by others.
- *ShakeCast v3* to be released in 2014.



What is ShakeCast?

ShakeCast is a tool that:

- Raises situational awareness after an earthquake.
- Represents the most reliable information within the first minutes to hours following an event.



ShakeCast Products

ShakeCast generates a number of products that meet the varying needs of Caltrans responders and managers. These include:

- Email notifications
- ShakeCast website
- Google Earth KML file
- GIS and CSV files

Caltrans ShakeCast Preliminary Earthquake Bridge Impact Report

This report supplements any earlier reports about this event. This is a computer-generated message and has not yet been reviewed by an Engineer or Seismologist. Information about the earthquake, magnitude, location, date, and time are provided by the California Integrated Seismic Network (CISN). The analysis of potential bridge damage in this report is based upon an Initial Dynamic Analysis and assumed fragilities for California bridges. Bridge fragility curves were adopted from HAZUS and Seismic Manual (1999). This report is intended to be used as a first response tool to assist in identifying California bridges most likely impacted by the event.

CISN ShakeMap for Loma Prieta Earthquake

Time: 1989-10-18 04:00:00 GMT



Event Summary

Name: (Unnamed Event), Version 1
 Magnitude: 6.9
 ID: Loma Prieta, v10a
 Location: 7 km NNE of Aptos, CA
 Latitude: 37.04
 Longitude: -122.58
 Time: 1989-10-18 04:00:00 GMT

Downloads & Resources

Caltrans ShakeCast Internet
 Caltrans ShakeMap Products
 ShakeCast Bridge Assessment
 Caltrans Bridge Inventory
 Caltrans Peak-Amp. Levels
 Local Seismic Accelerations

Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 105.3907g
 Maximum Acceleration: (not measured)
 Total number of bridges assessed: 2039
 Summary by inspection priority:
High 22 High Priority for full engineering assessment
Medium-High 166 Medium-High Priority for full engineering assessment
Medium 106 Medium Priority for full engineering assessment
Low 1795 Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact to bridges.

Bridge Name	Bridge Number	Dist-City-Rte-PM	Inspection Priority	1sec Peak Spectral Acceleration (%g)	Exceedance Ratio
Ralston Avenue OC	35 0114	04-SM-101-9.55-BMT	High	105.3903	2.934
Via Del Oro OH	37 0477L	04-SCL-085-1.22-SJS	High	49.2711	2.472
San Mateo-Hayward Bridge	35 0054	04-SM-092-R14.44-FSTC	High	49.6514	2.167
Constitution Way OC	33 0513K	04-ALA-260-R.86-ALA	High	68.2755	1.415
Meridian Road Underpass	37 0258	04-SCL-280-R3.89-SJS	High	59.9229	1.122
Campbell Underpass	37 0135	04-SCL-017-12.22-CMB	High	70.2112	1.087
East Hillsdale Blvd OC	35 0138	04-SM-101-11.15-SM	High	68.3762	1.071
Redwood Creek	35 0145	04-SM-101-6.2-RDWC	High	61.0924	1.064
Sfobb-Approach Lower Deck	34 0118R	04-SF-080-4.95-SF	High	33.2578	1.057
Holly Street OC	35 0037	04-SM-101-8.4	High	65.904	1.048
Route 13/80 Separation (North)	33 0191G	04-ALA-013-13.92-BER	High	66.6766	1.046
Race Street Overcrossing	37 0260	04-SCL-280-R3.76-SJS	High	59.9229	1.045
Presidio Viaduct	34 0019	04-SF-101-9.14-SF	High	68.3123	1.035
South Delaware Street UC	35 0158L	04-SM-092-R11.61-SM	High	35.1822	1.030
South Delaware Street UC	35 0158R	04-SM-092-R11.61-SM	High	35.1822	1.030
Powell Street UC	33 0020	04-ALA-080-3.79-EMV	High	66.6766	1.020
Redwood Harbor Overhead	35 0065	04-SM-101-5.5-RDWC	High	56.8606	1.018
Macarthur Avenue OC	37 0100	04-SCL-280-L5.18-SJS	High	54.4613	1.012
N101-S84 Connector OC	35 0081G	04-SM-101-5.39-RDWC	High	56.8606	1.009
N17-N85 Connector Separation	37 0515G	04-SCL-017-9.24-LGTS	High	86.2137	1.008
San Francisco Creek	35 0013	04-SM-101-01	High	55.3678	1.007
N&S87-S280 Connector Separation	37 0396H	04-SCL-087-5.1-SJS	High	50.5564	1.001
Blossom Hill Road OC	37 0345	04-SCL-082-R.35-SJS	Medium-High	49.4998	0.951
Harkins Slough Road OC	36 0089	05-SCR-001-R2.27-WAT	Medium-High	56.0768	0.938
Sunol Street Rr UC	37 0263L	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Sunol Street Rr UC	37 0263R	04-SCL-280-R3.41-SJS	Medium-High	52.8878	0.909
Winchester Boulevard OC	37 0195	04-SCL-280-4.57-SJS	Medium-High	55.327	0.898
Lincoln Avenue UC	37 0262L	04-SCL-280-R3.51-SJS	Medium-High	52.8878	0.896
South Gilroy OH	37 0305L	04-SCL-101-R5.1	Medium-High	43.2728	0.896

Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 188.76%g

Maximum Acceleration: (not measured)

Total number of bridges assessed: 3133

Summary by inspection priority:

High	119	High Priority for full engineering assessment
Medium-High	156	Medium-High Priority for full engineering assessment
Medium	152	Medium Priority for full engineering assessment
Low	2706	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Bridge Assessment Details

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South Gilroy OH	37 0305L	04-SCL-101-R5.1	Medium-High	43.2728	0.896

Jump to:

SUBMIT



ShakeCast Summary



Number of facilities evaluated: **917**
 Instrumental Intensity : **IV - VIII**
 Peak Ground Acceleration (%g): **4.4817 - 48.7128**
 Peak Ground Velocity (cm/sec): **2.3475 - 74.1758**
 Peak Spectral Acc. at 0.3 sec (%g): **8.5875 - 124.5867**
 Peak Spectral Acc. at 1.0 sec (%g): **2.4797 - 78.3554**
 Peak Spectral Acc. at 3.0 sec (%g): **1.2125 - 23.9314**

M 6.7 - Chino Hills Fault Scenario

ID: Chino_Hills6.7_se_scte Version: 5
 Origin Time: 2005-05-30 12:00:00
 Location: -117.6, 33.9

Responders can use the link in the email to go to the ShakeCast website for additional information.

Map View

M 6.7 - Chino Hills Fault Scenario (ID: Chino_Hills6.7_se_scte - 5)

Facility ID	Type	Description	Inspection Priority ▼	Latitude	Longitude	MMI	PGA (%)	PGV (cm/sec)	PSA03 (%)	PSA10 (%)	PSA30 (%)
56 0633	BRIDGE	Green River Drive OC	High	33.87848421	-117.6578573	VIII	46.6934	61.9509	119.4515	64.2799	19.6343
54 0748	BRIDGE	Benson Avenue OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
54 0747	BRIDGE	Central Avenue OC	Medium-High	34.03026777	-117.6891927	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 1873G	BRIDGE	E60-N57 Connector OC	Medium-High	34.02202039	-117.8133506	VIII	39.693	47.723	101.3087	50.4097	17.9044
53 1788	BRIDGE	Fairway Drive UC	Medium-High	33.99657901	-117.8703981	VIII	35.7487	38.3303	90.7822	40.1888	16.1639
56 0497	BRIDGE	Magnolia Avenue OC	Medium-High	33.87848421	-117.6578573	VIII	46.6934	61.9509	119.4515	64.2799	19.6343
54 0746	BRIDGE	Monte Vista Avenue OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
54 0744	BRIDGE	Pipeline Avenue OC	Medium-High	34.03026777	-117.6891927	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 1873	BRIDGE	Prospectors UC	Medium-High	34.02202039	-117.8133506	VIII	39.693	47.723	101.3087	50.4097	17.9044
54 0745	BRIDGE	Ramona Avenue OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 1933	BRIDGE	Spadra OH	Medium-High	34.02202039	-117.8133506	VIII	39.693	47.723	101.3087	50.4097	17.9044
53 2106	BRIDGE	State Street OC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 2078K	BRIDGE	Valley Blvd UC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476
53 2078	BRIDGE	Valley Blvd UC	Medium-High	34.03032662	-117.6804218	VIII	37.8311	42.8441	96.2983	45.2159	16.1476

Map View Close

Map Satellite Hybrid

Green River Drive OC ✕

Lat: 33.87848421 Lon: -117.6578573

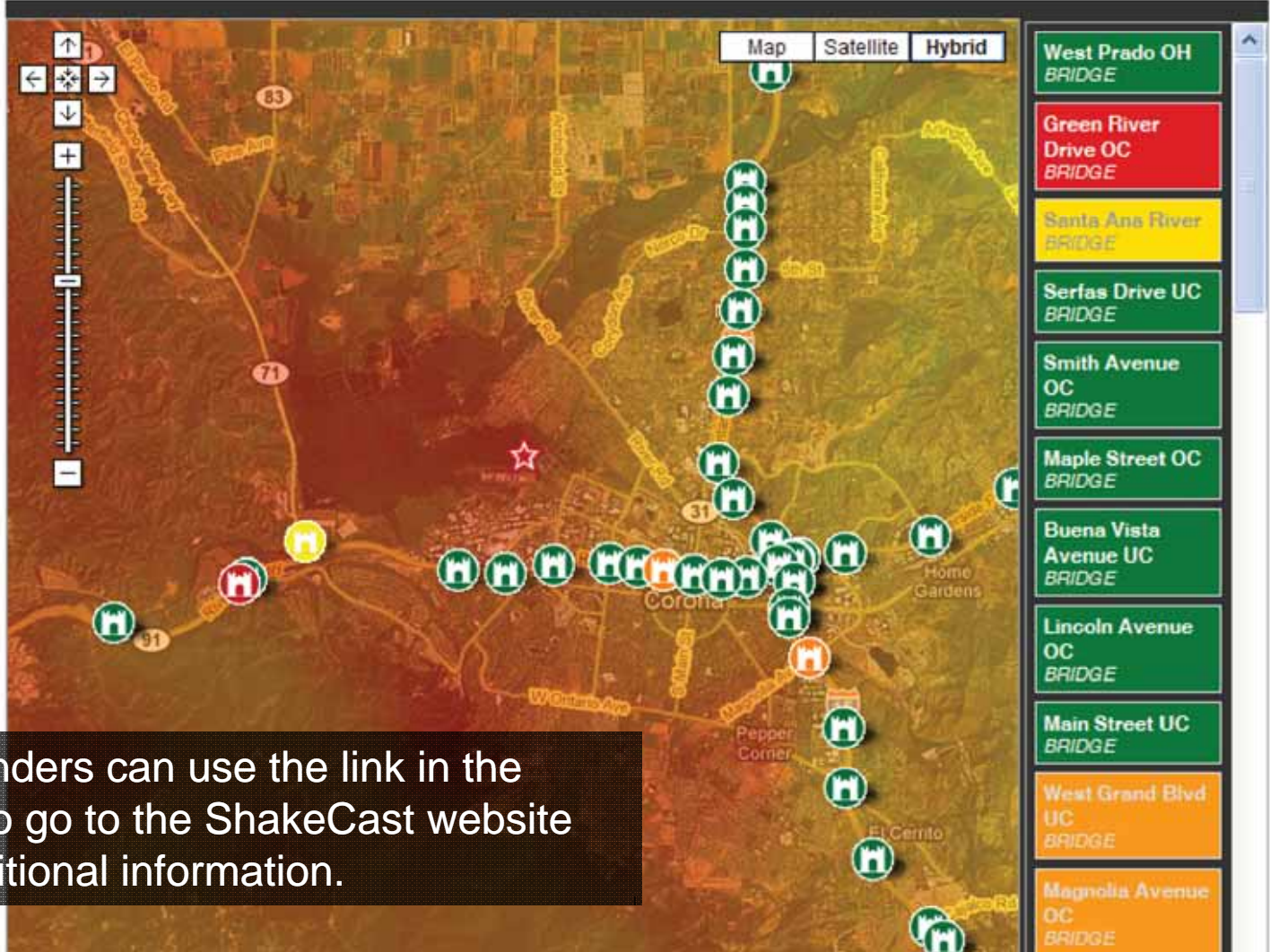
MMI:	8.56
PGA:	46.6934
PGV:	61.9509
PSA03:	119.4515
PSA10:	64.2799
PSA30:	19.6343

The website offers different ways to view the bridge data using maps, tables, or a combination of both.

Table View

Google Maps for ShakeMap Chino_Hills6.7_se_scte

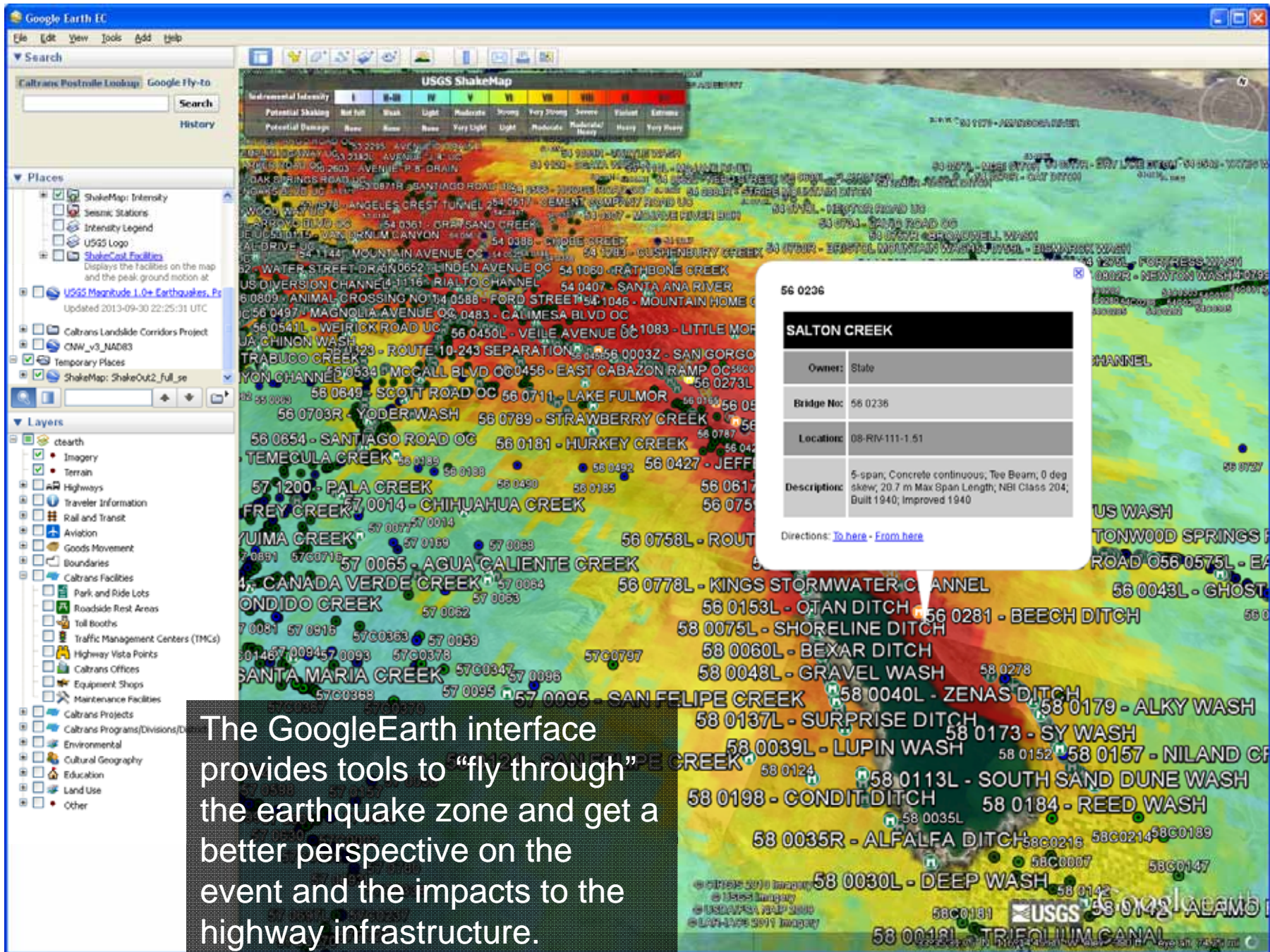
Facility Type: All  BRIDGE



The map displays a satellite view of the Chino Hills area with numerous bridge locations marked by icons. A legend on the right side of the map lists the following bridges with their corresponding colors and codes:

Bridge Name	Code	Color
West Prado OH	BRIDGE	Green
Green River Drive OC	BRIDGE	Red
Santa Ana River	BRIDGE	Yellow
Serfas Drive UC	BRIDGE	Green
Smith Avenue OC	BRIDGE	Green
Maple Street OC	BRIDGE	Green
Buena Vista Avenue UC	BRIDGE	Green
Lincoln Avenue OC	BRIDGE	Green
Main Street UC	BRIDGE	Green
West Grand Blvd UC	BRIDGE	Orange
Magnolia Avenue OC	BRIDGE	Orange

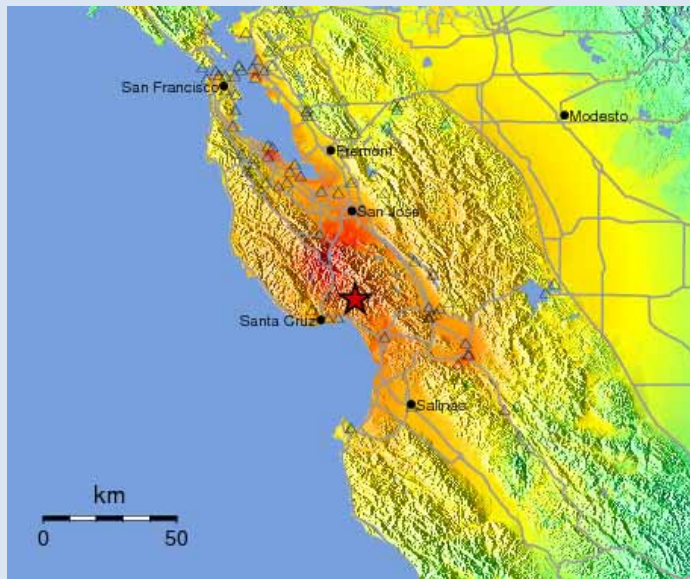
Responders can use the link in the email to go to the ShakeCast website for additional information.



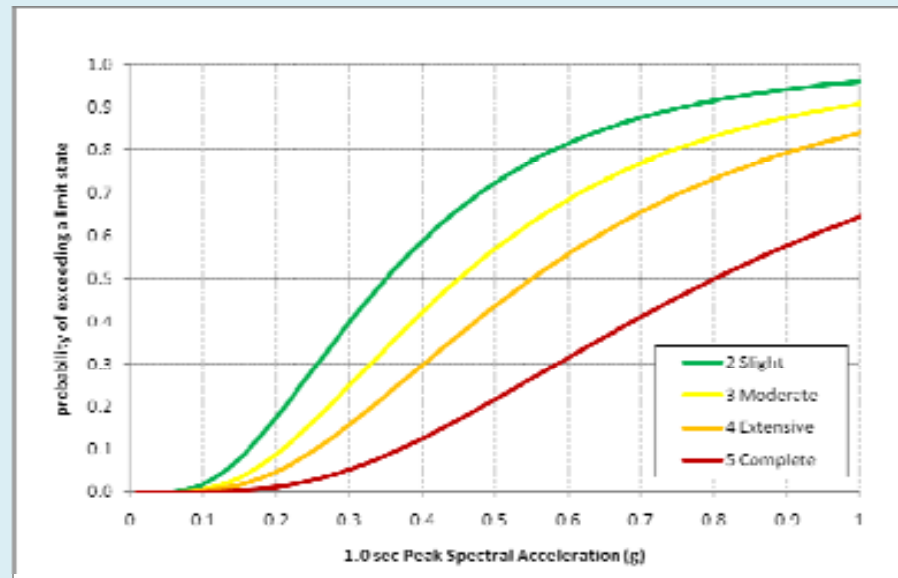
The GoogleEarth interface provides tools to “fly through” the earthquake zone and get a better perspective on the event and the impacts to the highway infrastructure.

Basis for ShakeCast Analysis

At each bridge location, ShakeCast analyzes the measured/interpolated ground motion against a pre-determined bridge fragility model.



Earthquake shaking forces exerted on bridges are determined from USGS *ShakeMap*.



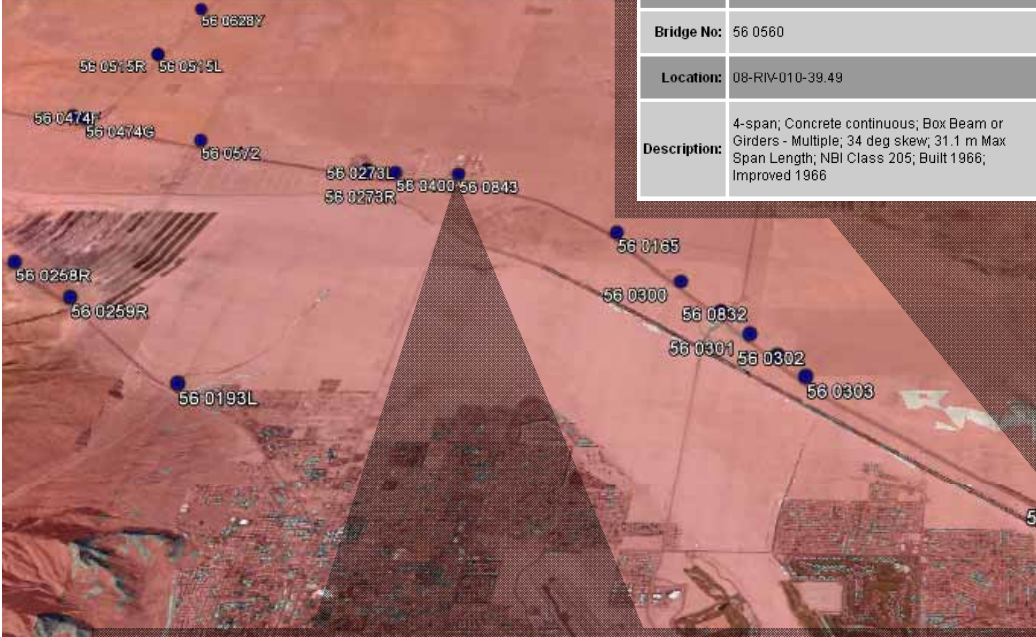
Probabilities of damage relative to varying levels of shaking (or “fragility”) can be determined in advance for each bridge.

USGS ShakeMap

Instrumental Intensity	I	II-III	IV	V	VI	VII	VIII
Potential Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe
Potential Damage	None	None	None	Very Light	Light	Moderate	Major

DATE PALM DRIVE OC	
Owner:	State
Bridge No:	56 0560
Location:	08-RIV-010-39.49
Description:	4-span; Concrete continuous; Box Beam or Girders - Multiple; 34 deg skew; 31.1 m Max Span Length, NBI Class 205; Built 1966; Improved 1966

Medium-High Priority for Inspection



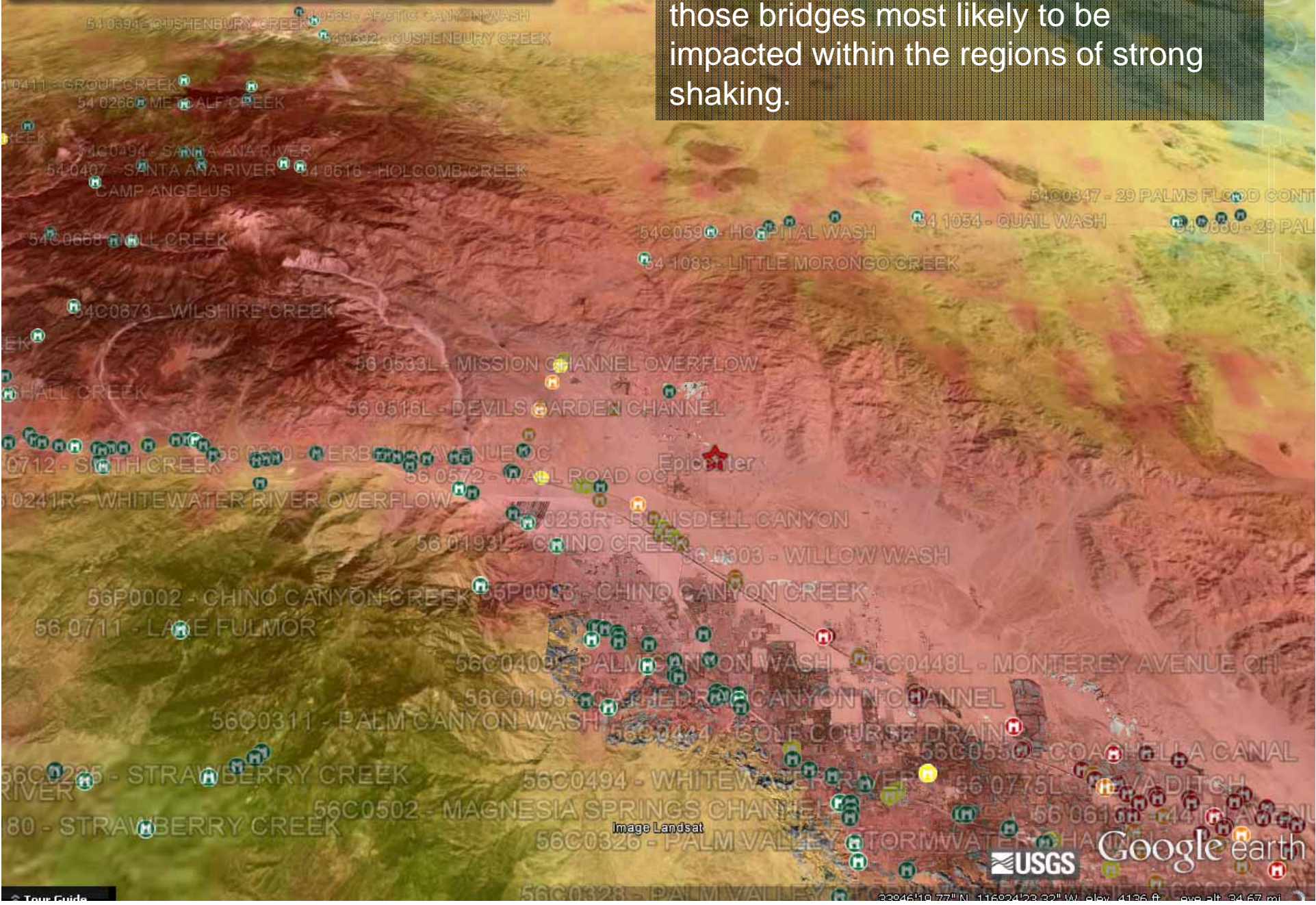
INDIAN CANYON DRIVE OC	
Owner:	State
Bridge No:	56 0843
Location:	08-RIV-010-33.13
Description:	3-span; Prestressed concrete; Tee Beam; 10 deg skew; 34.2 m Max Span Length; NBI Class 504; Built 2012; Improved 2012

Low Priority for Inspection

Bridges that may appear similar in design will in fact have different performance characteristics under similar ground shaking conditions due to a number of design factors.

USGS ShakeMap									
Instrumental Intensity	I	II-III	IV	V	VI	VII	VIII	IX	X
Potential Shaking	Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
Potential Damage	None	None	None	Very Light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy

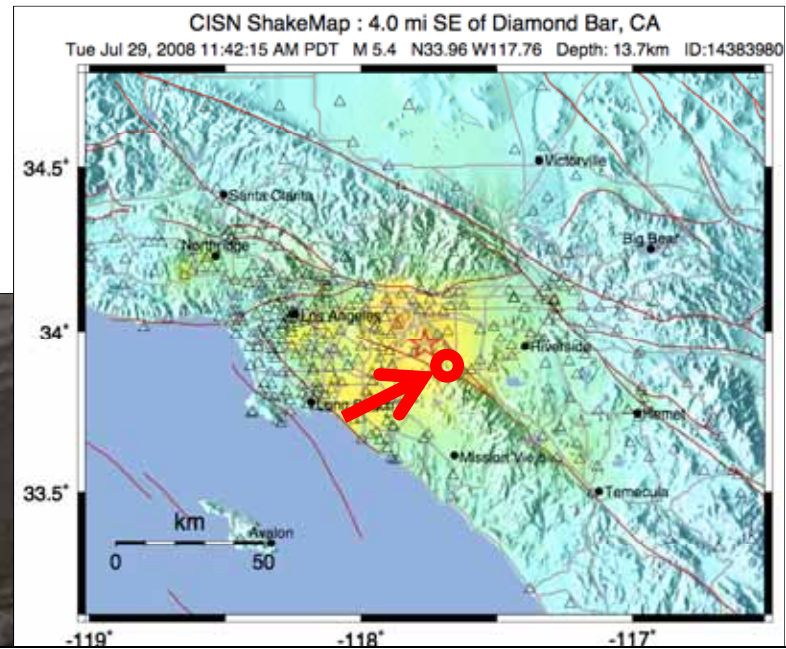
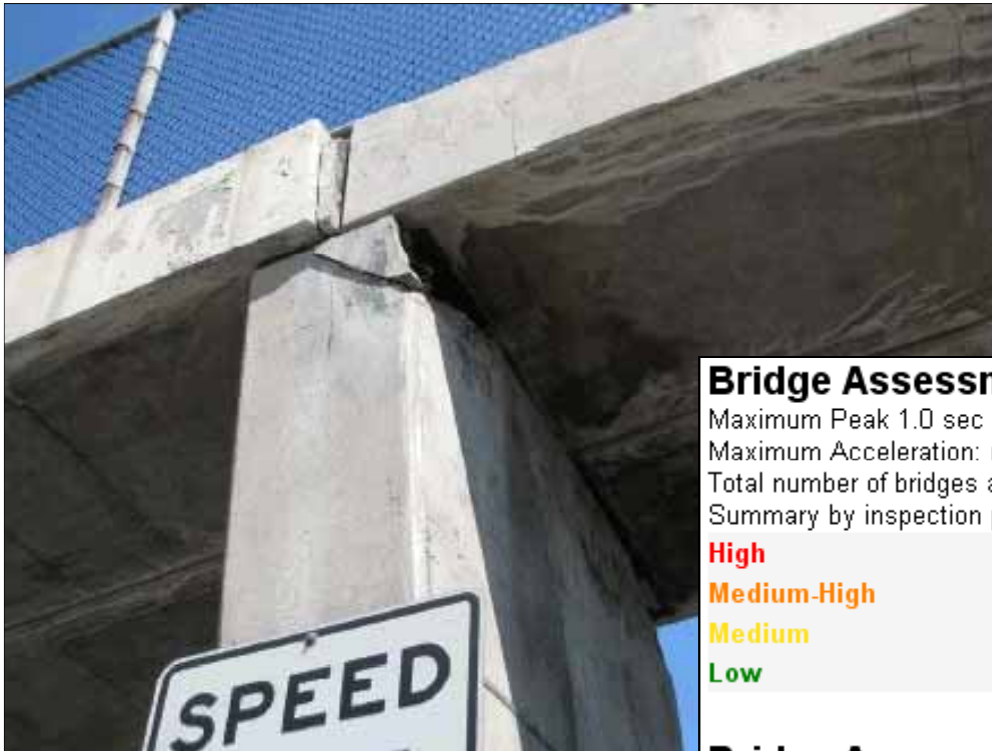
ShakeCast alerts responders to the those bridges most likely to be impacted within the regions of strong shaking.



Caltrans-ShakeCast Usage

- Hundreds of current subscribers to ShakeCast:
 - Structure Maintenance & Investigations
 - Emergency Management
 - Earthquake Engineering
 - Structures Construction
 - Geotechnical Services
 - District Traffic Management Centers (TMC)
 - District Emergency Operations Centers (EOC)
 - District Maintenance Units
 - Executive Management
- Integrated into formal response protocols and manuals.

5.4 Chino Hills July 2008



Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 34.7183%g
 Maximum Acceleration: (not measured)
 Total number of bridges assessed: **468**
 Summary by inspection priority:

High	[NULL]	High Priority for full engineering assessment
Medium-High	[NULL]	Medium-High Priority for full engineering assessment
Medium	[NULL]	Medium Priority for full engineering assessment
Low	468	Low Priority for full engineering assessment

Bridge Assessment Details

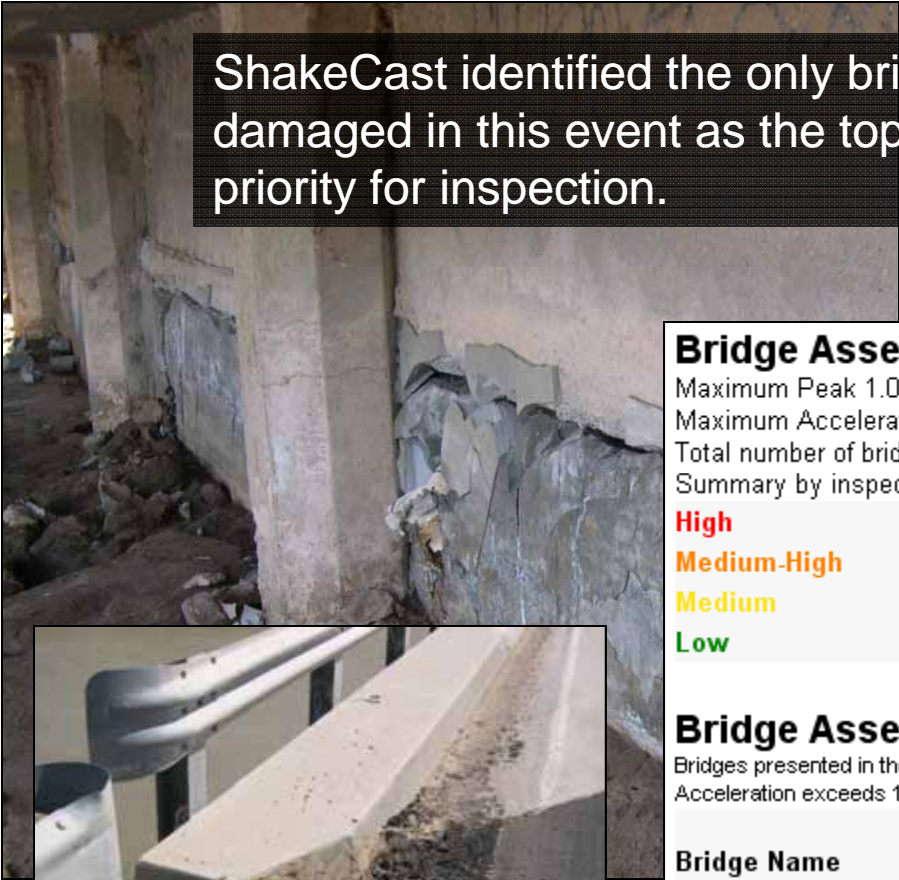
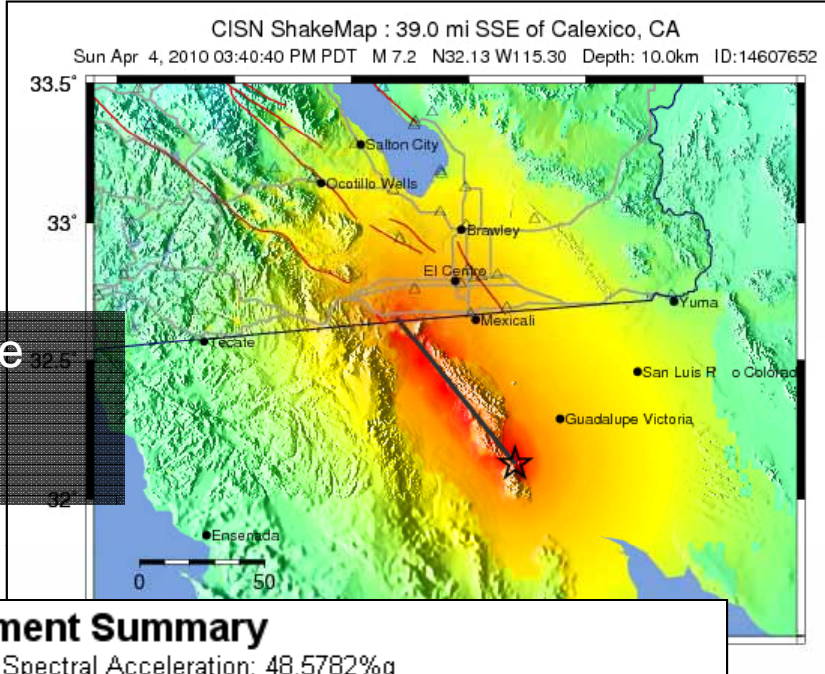
Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The list includes

Bridge Name	Bridge Number	Dist-C
53 2078 - VALLEY BLVD UC	53 2078	07-LA
53 2078K - VALLEY BLVD UC	53 2078K	07-LA
53 1158 - GRIER STREET POC	53 1158	07-LA
53 2107 - TEMPLE AVENUE OC	53 2107	07-LA

ShakeCast identified the only bridge damaged in this event as the 3rd highest priority for inspection.

7.2 Calexico April 2010

ShakeCast identified the only bridge damaged in this event as the top priority for inspection.



Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 48.5782%g

Maximum Acceleration: (not measured)

Total number of bridges assessed: **219**

Summary by inspection priority:

High	[NULL]	High Priority for full engineering assessment
Medium-High	[NULL]	Medium-High Priority for full engineering asses
Medium	[NULL]	Medium Priority for full engineering assessmen
Low	219	Low Priority for full engineering assessment; q

Bridge Assessment Details

Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The list Acceleration exceeds 10% g.

Bridge Name	Bridge Number	Dist-Cty-Rte-PM
58 0274 - WESTSIDE MAIN CANAL	58 0274	11-IMP-098-22.02
58 0275 - WORMWOOD CANAL	58 0275	11-IMP-098-22.07
58 0212L - COYOTE WELLS OH	58 0212L	11-IMP-008-R13.97
58 0212R - COYOTE WELLS OH	58 0212R	11-IMP-008-R13.93

Golden Guardian, November 2008

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Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 273.702%g
 Maximum Acceleration: (not measured)
 Total number of bridges assessed: **5012**
 Summary by inspection priority:

High	49	High Priority for full engineering assessment
Medium-High	130	Medium-High Priority for full engineering assessment
Medium	109	Medium Priority for full engineering assessment
Low	4724	Low Priority for full engineering assessment; quick visual inspection likely sufficient.

Table View

Google Maps for ShakeMap Shake

Facility Type: All B BRIDGE

Map
Satellite
Hybrid

53 0836 - EAST WALKER UP BRIDGE

55 0282 - WESTMINSTER STORM DRAIN BRIDGE

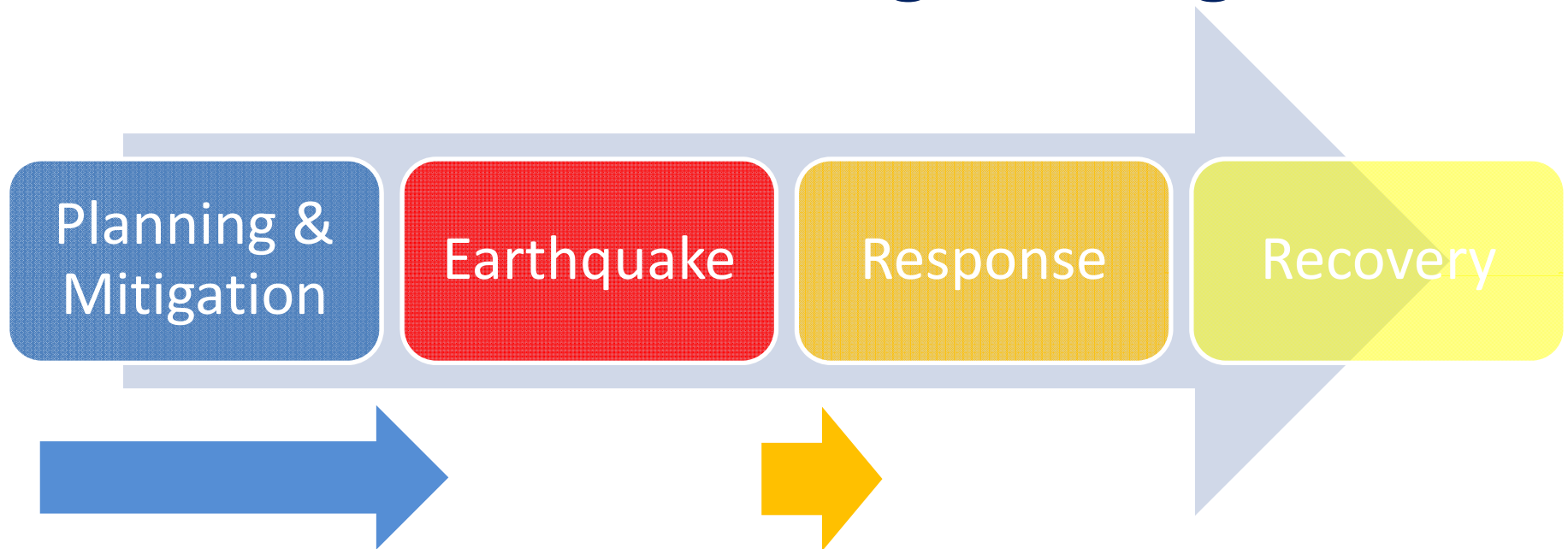
53 0663K - WASHINGTON BLVD PUC BRIDGE

53 2030L - SANTA FE BASIN BRIDGE

53 2648S - SKYLINE EQUESTRIAN UC BRIDGE

Response exercise in Southern CA used ShakeCast to carry out the scenario.

Future Directions: ShakeCast for Planning & Mitigation

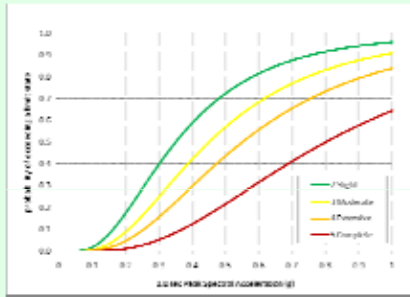


ShakeCast can also be used to evaluate the current bridge inventory against scenario earthquakes and significant historical events. (Over 280 California scenarios available.)

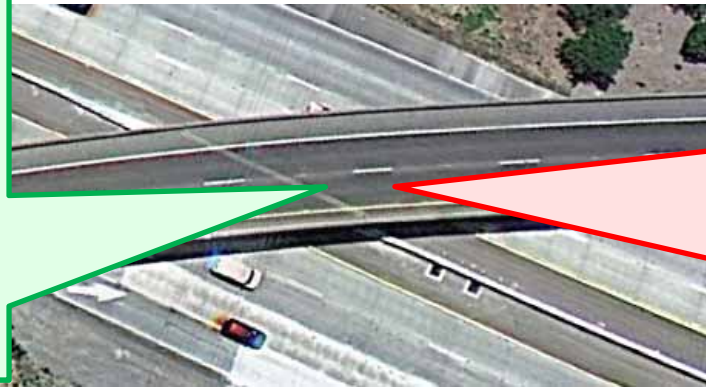
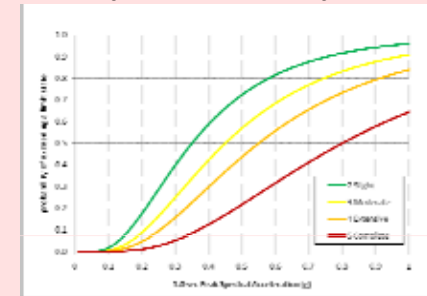
ShakeCast raises situational awareness in the hours immediately following the event.

Future Directions: Improved Bridge Models

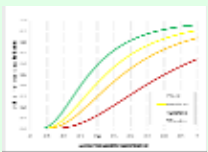
g2F – System Level Fragility (ShakeCast v3)



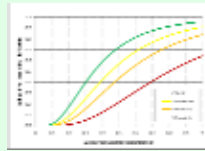
HAZUS – System Level Fragility (ShakeCast v2)



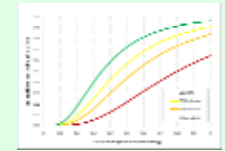
Joints



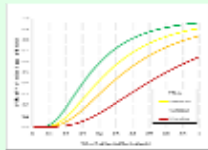
Bearings



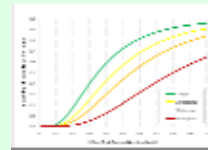
Approach



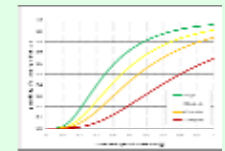
Columns



Restrainers



Seats



Future Directions: Comprehensive Analysis Results

CALTRANS SHAKE CAST 2

Home Earthquakes Search FAQ Profile Register Log in

Map View

Facility ID	Type	Description	Inspection Priority
53 1548	BRIDGE	53 1548 - ROUTE 5T405 SEPARATION	High
53 2217H	BRIDGE	53 2217H - E118-9405 CONNECTOR UC	High
53 2204	BRIDGE	53 2204 - HAYVENHURST AVENUE UC	High
53 1133	BRIDGE	53 1133 - ROUTE 5405 SEPARATION	High
53 1013	BRIDGE	53 1013 - SIERRA HIGHWAY UC	High
53 2793R	BRIDGE	53 2793R - MISSION-GOTHIC UC	High
53 2793L	BRIDGE	53 2793L - MISSION-GOTHIC UC	High
53 1984L	BRIDGE	53 1984L - WEST SYLMAR OH	High
53 1983	BRIDGE	53 1983 - S5TRUCK-	High
53 2925			
53 0996L			
53 1619M			
53 1988F			
53 0688			
53 2343G			
53 2357			
53 2396			

53 2793R - MISSION-GOTHIC UC

Bridge System Analysis

Overall Inspection Priority: **High**

Component Analysis

Primary Components

Columns	High
Seat - Hinge	Medium-High
Seat - Abutment	Medium-High
Seat - Bent Cap	Medium

Secondary Components

Joint Seal - In-Span	Medium-High
Joint Seal - Abutment	Medium-High
Joint Seal - Bent Cap	High
Bearing - In-Span	Low
Bearing - Abutment	Medium-High
Bearing - Bent Cap	Low

Continue

COLUMNS

Probability of Exceedence (%)

PSA 1.0 sec. (%g)

49.707

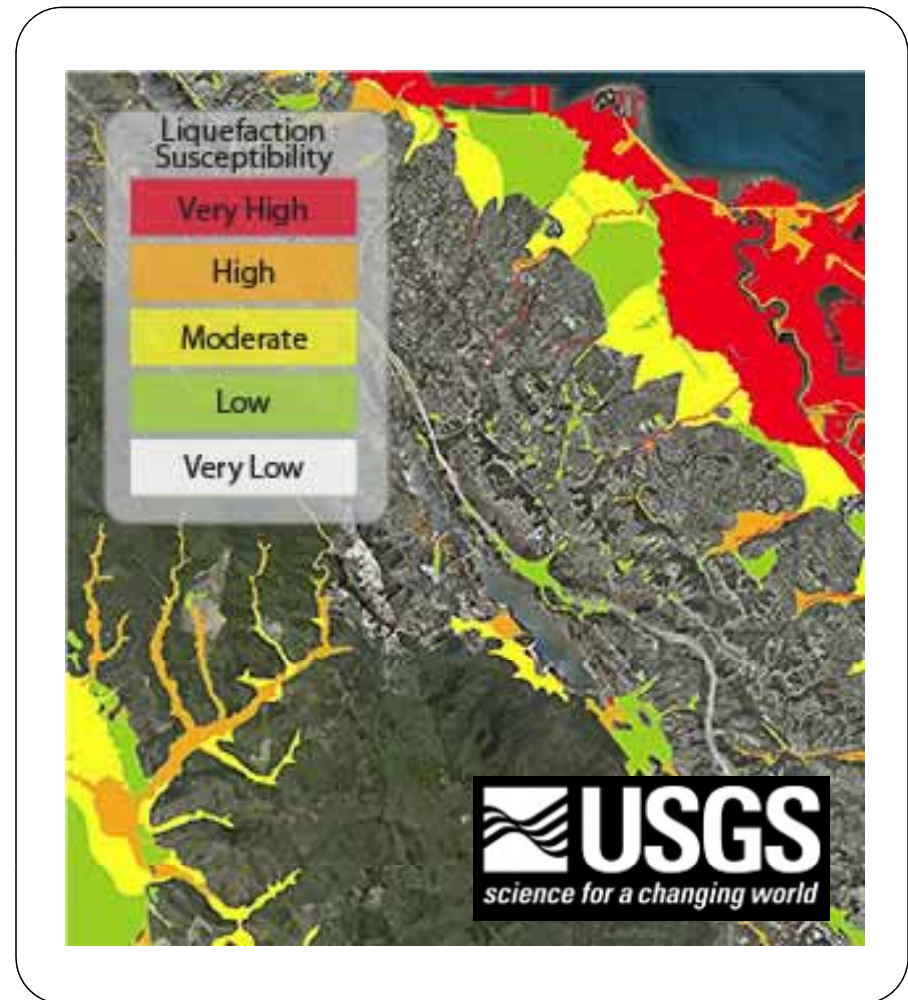
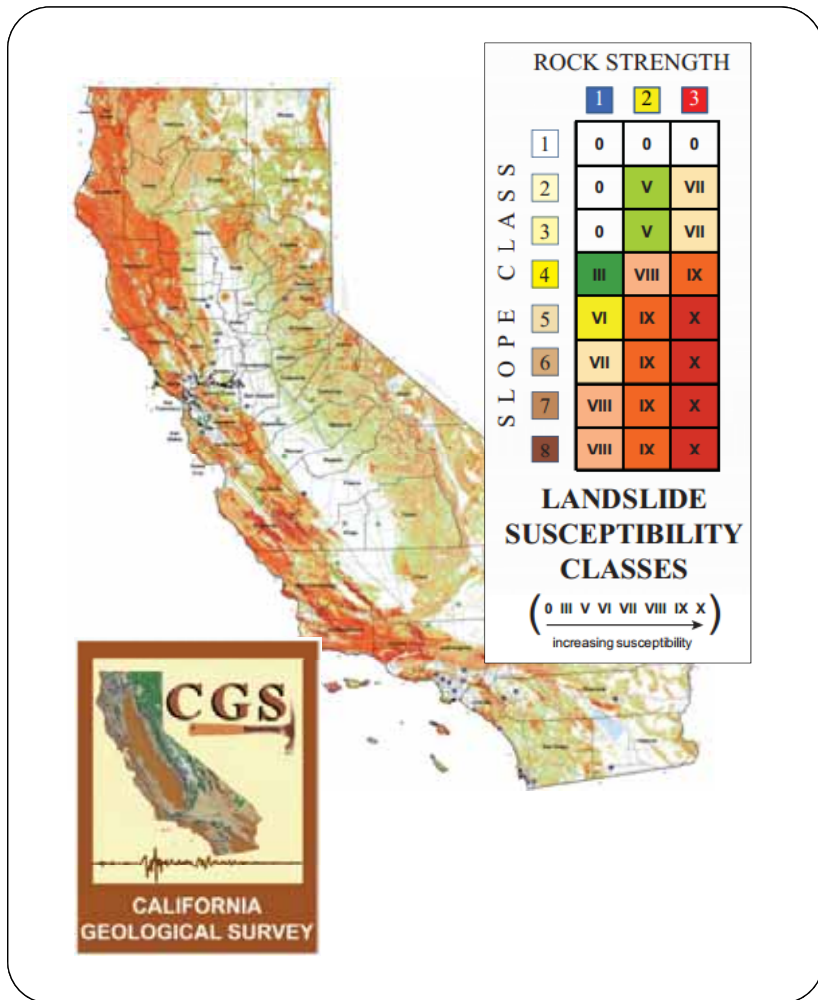
Distribution of Probability

- 7%
- 5%
- 18%
- 70%

OK

sec	PSA03 (%g)	PSA10 (%g)	PSA30 (%g)			
1465	147.2339	127.2633	27.7016			
4843	205.512	140.0625	26.7054			
8967	169.894	166.7484	29.5617			
1465	147.2339	127.2633	27.7016			
57	170.9115	115.578	27.8599			
8967	169.894	166.7484	29.6617			
8967	169.894	166.7484	29.6617			
57	170.9115	115.578	27.8599			
57	170.9115	115.578	27.8599			
802	88.813	144.1786	26.8771			
57	170.9115	115.578	27.8599			
725	163.3938	122.517	26.4666			
118.4895375	IX	77.3146	111.3801	132.0711	129.9839	96.4198
118.5959135	IX	56.4591	82.6902	88.813	144.1786	26.8771
118.4454805	IX	66.2994	94.4066	174.3819	111.3769	23.0464
118.4501225	IX	66.2994	94.4066	174.3819	111.3769	23.0494
118.502105	X	70.9743	150.3675	183.0376	175.8548	29.7802

Future Directions: Landslides and Liquefaction



Future Directions: Caltrans Building Inventory



Toll Plaza (7)



Equipment Shop (14)



Traffic Management Center (5)



District Office (42)



Weigh/Inspection Station (142)



Maintenance Station (262)

USGS
Science for a changing world

USGS ShakeCast

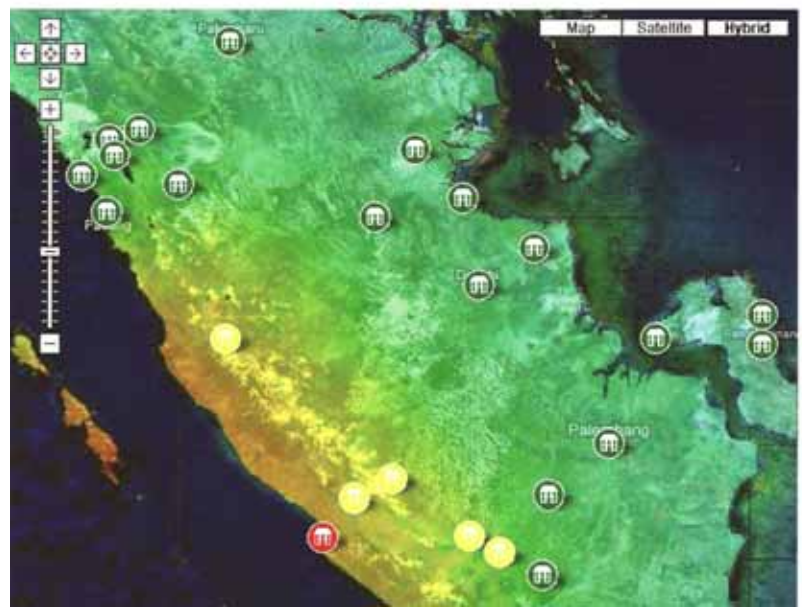
Automating, Simplifying, and Improving the Use of ShakeMap for Post-Earthquake Decisionmaking and Response

ShakeCast is a freely available, post-earthquake situational awareness application that automatically makes shaking data from ShakeMap, and makes it available to users' facilities, and...

VOLUME 24, NUMBER 2 MAY 2008

EARTHQUAKE SPECTRA

The Professional Journal of the Earthquake Engineering Research Institute



TR NEWS

RESEARCH PAYS OFF



ShakeCast

Caltrans Deploys a Tool for Rapid Postearthquake Response

LOREN L. TURNER, DAVID WALD, AND KUO-WAN LIN

Turner is Senior Transportation Engineer, California Department of Transportation, Division of Research and Innovation, Sacramento; Wald is a Supervisory Geophysicist and Lin is a Geophysicist with the U.S. Geological Survey, Golden, Colorado.

After a major earthquake, one of the most critical tasks for the California Department of Transportation (Caltrans) is to assess the impact on the condition of all bridges and roadway corridors in the state highway system. Timely response ensures public safety, guides emergency vehicle traffic, and reestablishes critical lifeline routes.

Problem

Immediately after an earthquake, bridge inspection teams had difficulty accessing critical

data and analyzes the data in relation to individual bridge performance characteristics. Within minutes of an event, the program generates e-mails to set priorities for inspection and assembles other web-based products to assist emergency responders.

ShakeCast was built on ShakeMap, a USGS product that receives measured ground motion data from a network of more than 1,000 sensors throughout California—approximately two-thirds of all sensors nationwide—and combines the information with geological data to create maps that show ground-shaking

ShakeCast: Automating and Improving the Use of ShakeMap for Post-Earthquake Decision-Making and Response

David Wald,^{a)} M.EERI, Kuo-Wan Lin,^{a)} Keith Porter,^{b)} M.EERI, and Loren Turner^{c)}

When a potentially damaging earthquake occurs, utility managers, emergency responders, and other... appropriate decisions...

ShakeCast:

A Tool for Raising Situational Awareness in Emergency Response

Northridge Earthquake Symposium
January 16-17, 2014

Loren Turner, P.E.

Caltrans, Division of Research, Innovation, and System Information

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Caltrans Division of Research,
Innovation and System Information

