ShakeCast:

A Tool for Raising Situational Awareness in Emergency Response

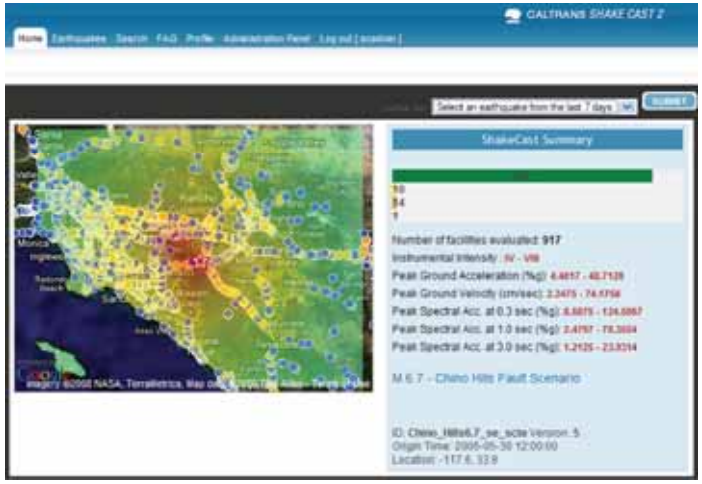
Northridge Earthquake Symposium
January 16-17, 2014

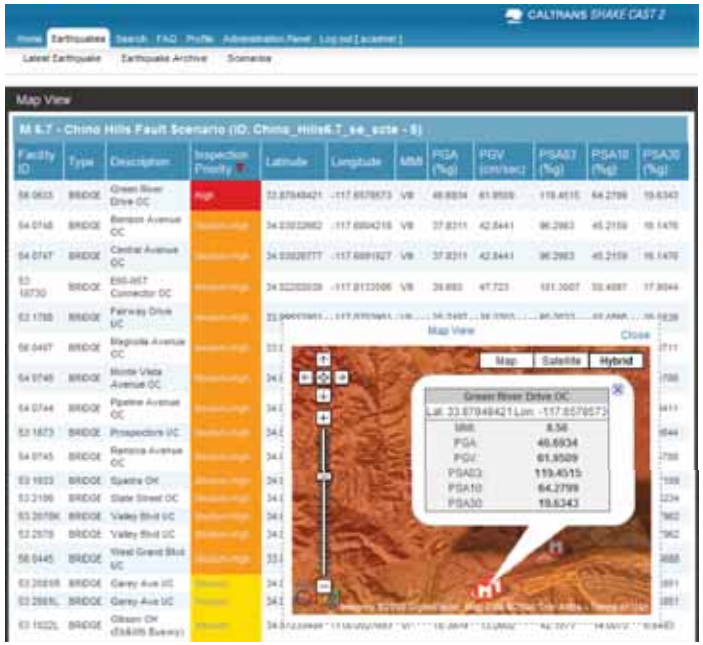
Loren Turner, P.E.
Caltrans, Division of Research, Innovation, and System Information
loren.turner@dot.ca.gov

DRISI
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.



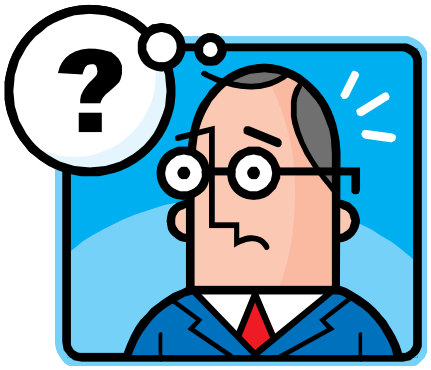


USGS
science for a changing world

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 supersedes 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 epicenter, 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 ShakeMap, ruptureRoch and estimated fragilities for Caltrans bridges. Bridge fragility models were adopted from MA2010 and Basoz & Mander (1999). This report is intended to be used as a first response tool to assist in identifying Caltrans bridges most likely impacted by the event.

CISN ShakeMap for Loma Prieta Earthquake

Event Summary

Name: (Unnamed Event) , Version 1

Magnitude: 6.9
ID: Loma_Prieta_sdlw1
Location: 7 km NNE of Aptos, CA
Latitude: 37.04
Longitude: -121.88
Time: 1989-10-18 00:04:00 GMT

Downloads & Resources

Caltrans Intranet Links:
Caltrans ShakeCast Intranet
Caltrans ShakeMap Products

GoogleEarth KML files:
ShakeCast Bridge Assessment
Statewide Bridge Inventory
Caltrans Real-time Traffic
USGS Realtime Earthquakes

Bridge Assessment Summary

Maximum Peak 1.0 sec Spectral Acceleration: 105.3903%g
Maximum Acceleration: (not measured)
Total number of bridges assessed: 3030
Summary by inspection priority:

High	22	High Priority for full engineering assessment
Medium-High	107	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

Bridge Name	Bridge Number	Dist-Cty-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 Francisquito 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

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

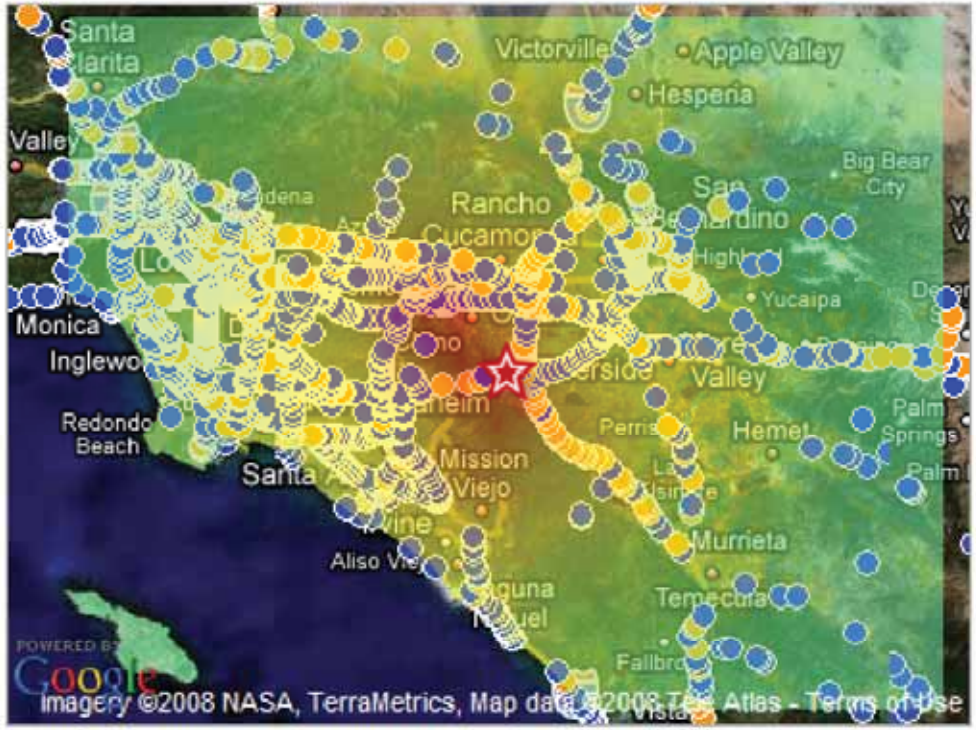
Bridges presented in the table below are sorted in order of severity of impact to bridges.

Bridge Name	Bridge Number	Dist-Cty-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 Francisquito 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

CALTRANS *SHAKE CAST 2*

Home | Earthquakes | Search | FAQ | Profile | Administration Panel | Log out [scadmin]

Jump to: Select an earthquake from the last 7 days | SUBMIT



ShakeCast Summary

892
10
14
1

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**

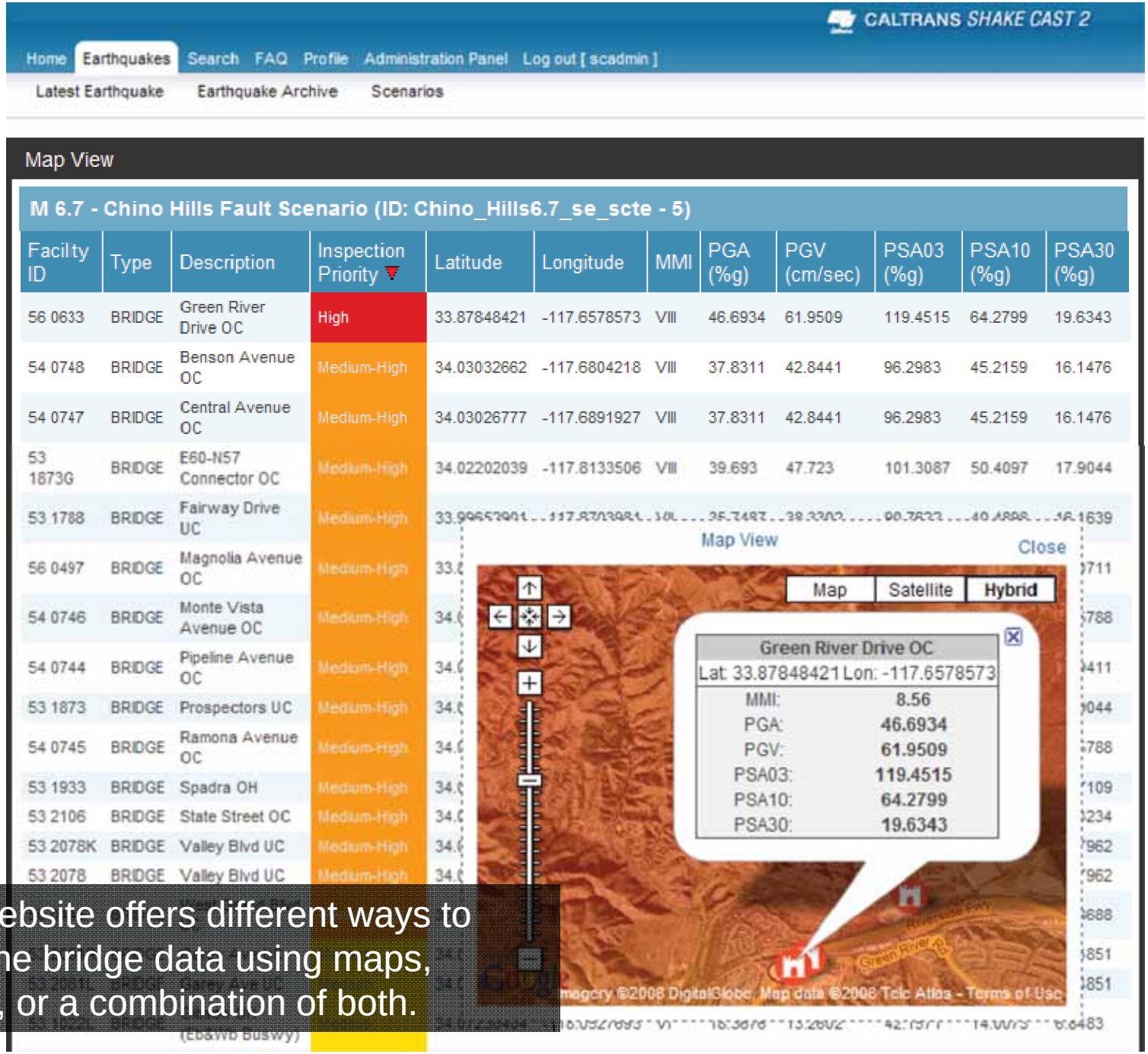
Peak Spectral Acc. at 1.0 sec (%g): **2.4797 - 78.3554**

Peak Spectral Acc. at 3.0 sec (%g): **1.2125 - 23.9314**

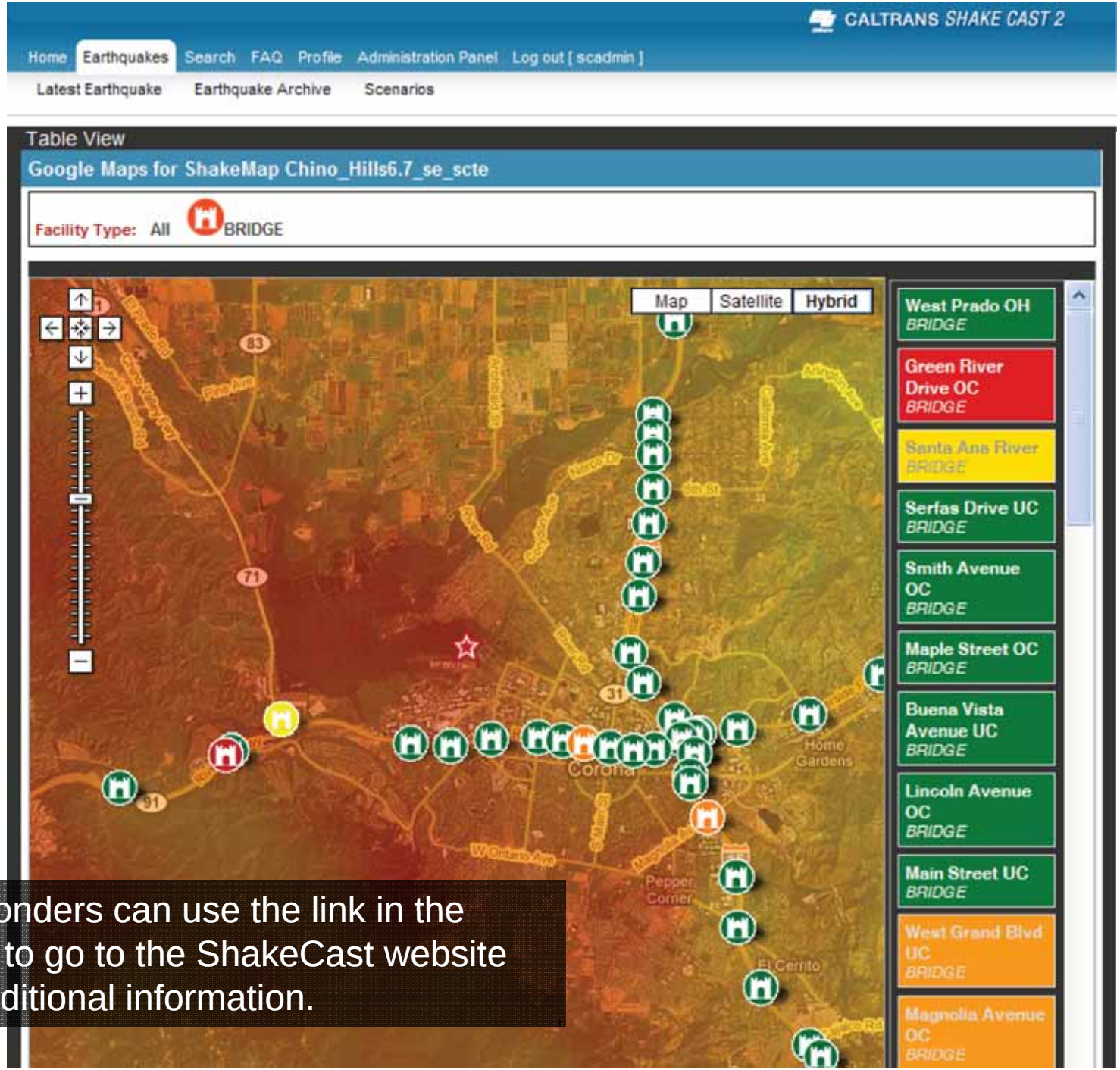
M 6.7 - Chino Hills Fault Scenario

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

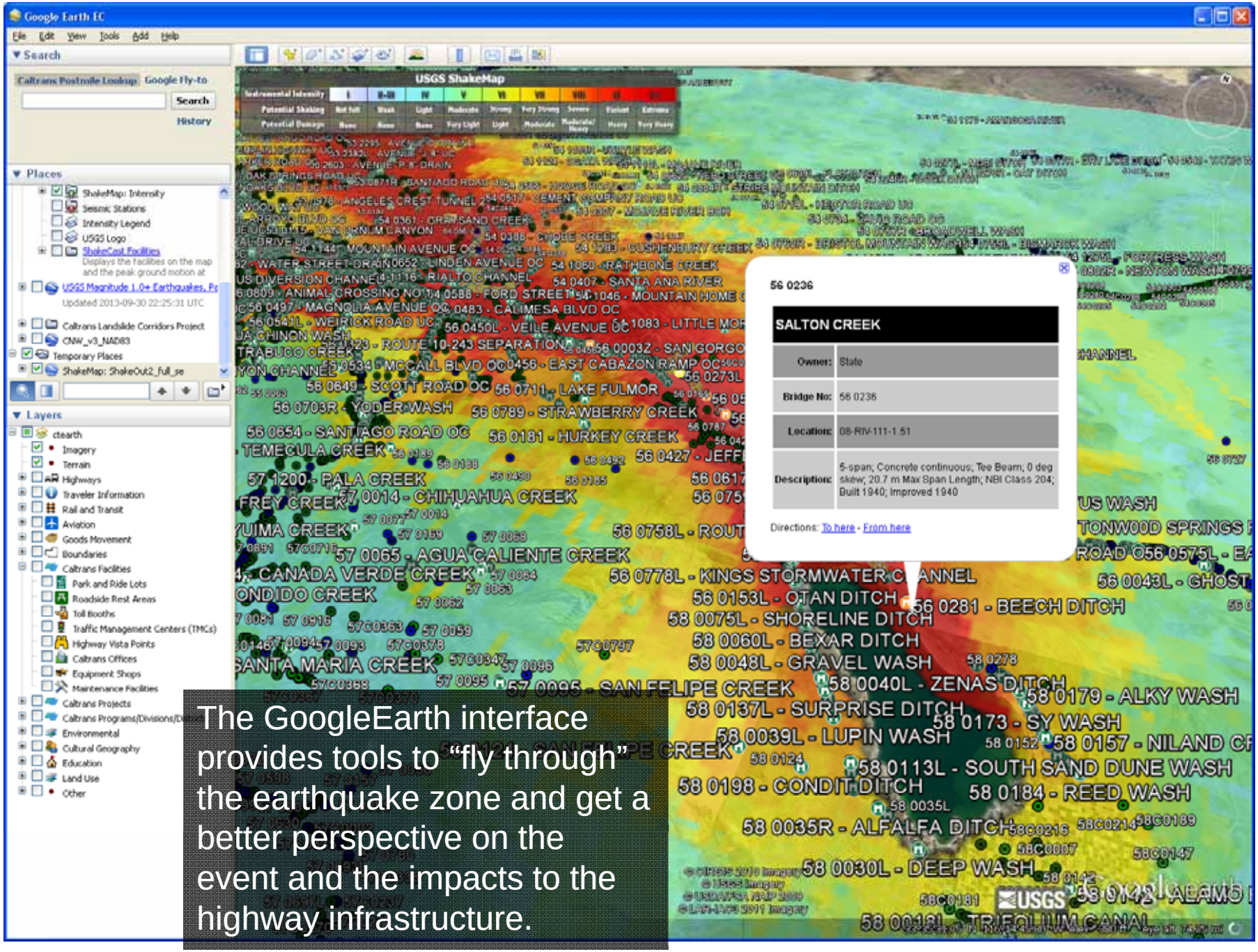
Responders can use the link in the email to go to the ShakeCast website for additional information.



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



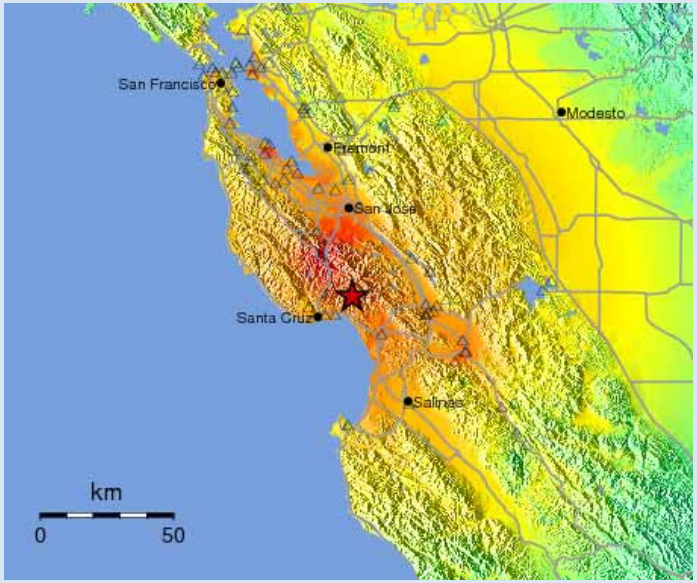
Responders can use the link in the email to go to the ShakeCast website for additional information.



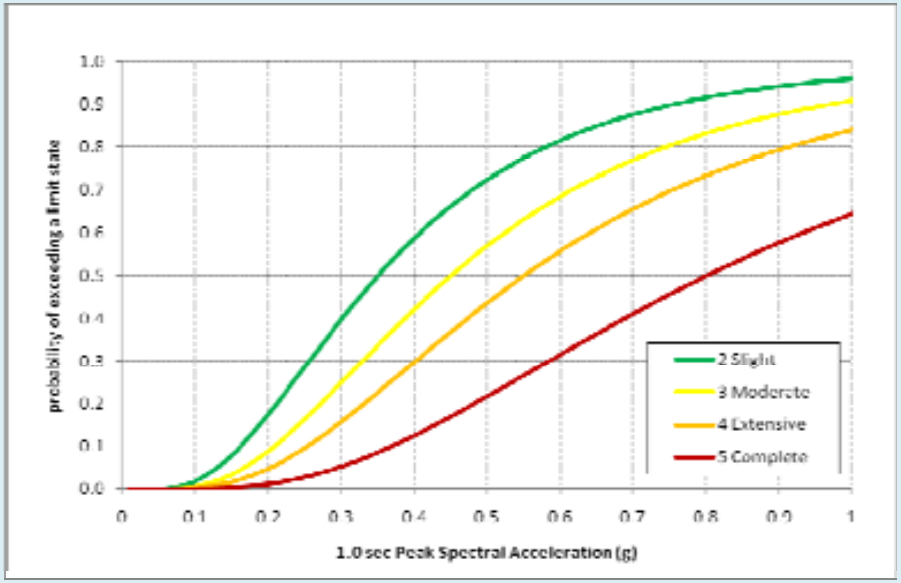
The GoogleEarth interface provides tools to “fly through” the earthquake zone and get a better perspective on the event and the impacts to the highway infrastructure.

Basis for ShakeCast Analysis

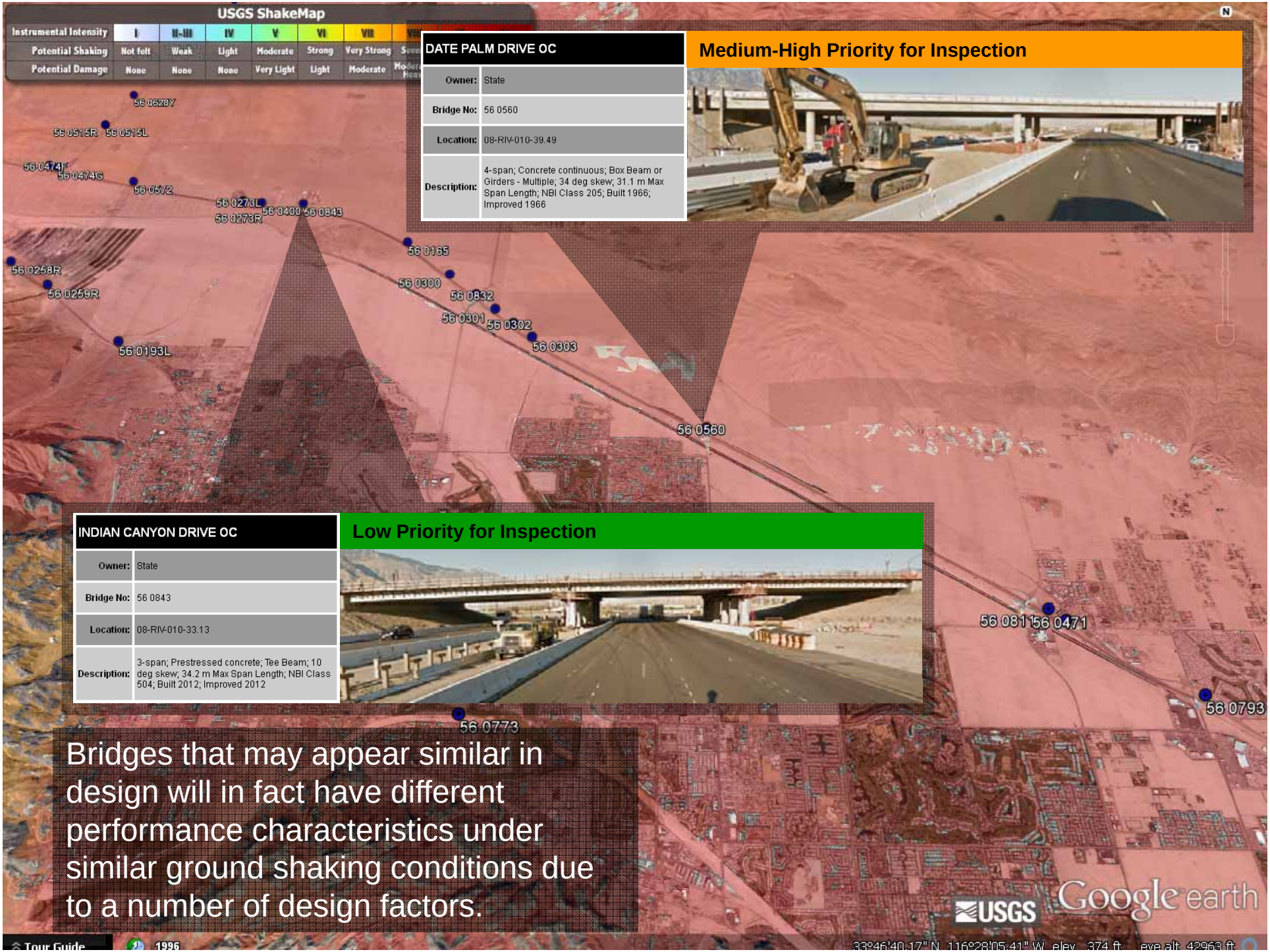
At each bridge location, ShakeCast analyzes the measured/interpolated ground motion against a pre-determined bridge fragility model.



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.



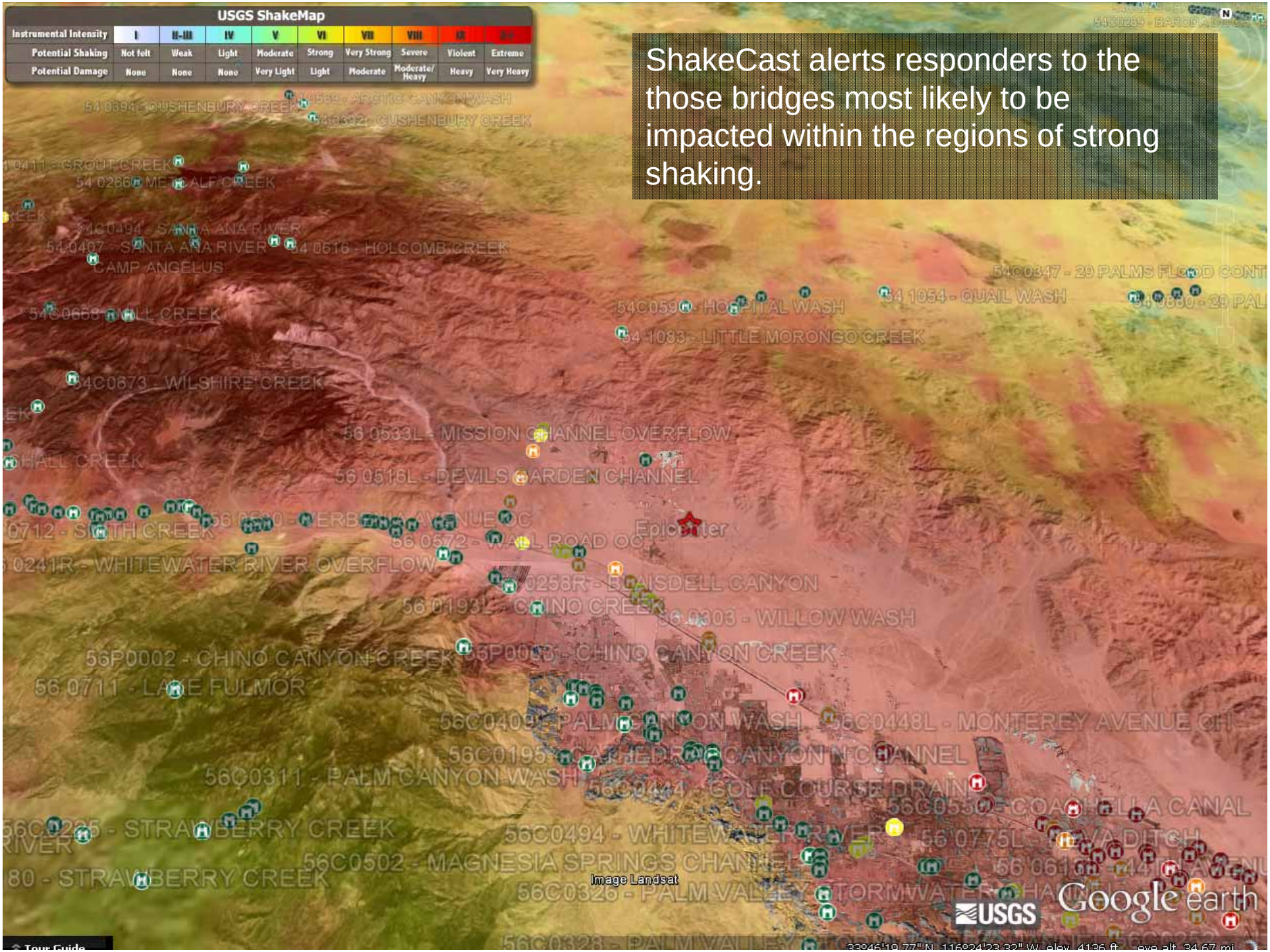
DATE PALM DRIVE OC	
Owner:	State
Bridge No:	56 0560
Location:	08-RIV-010-39.49
Description:	4-span; Concrete continuous; Box Beam or Girders - Multiple; 34 deg skew; 31.1 m Max Span Length; NBI Class 205; Built 1966; Improved 1966

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

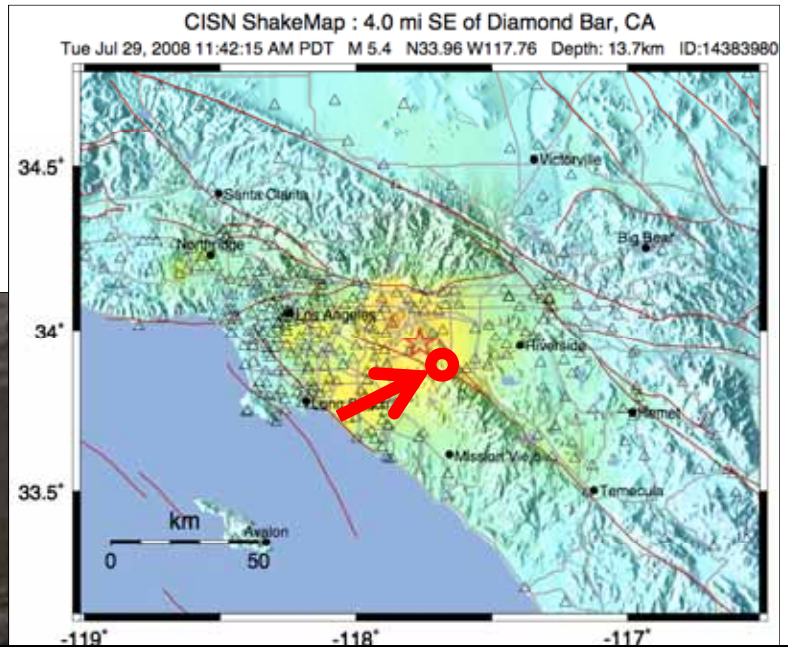
Bridges that may appear similar in design will in fact have different performance characteristics under similar ground shaking conditions due to a number of design factors.

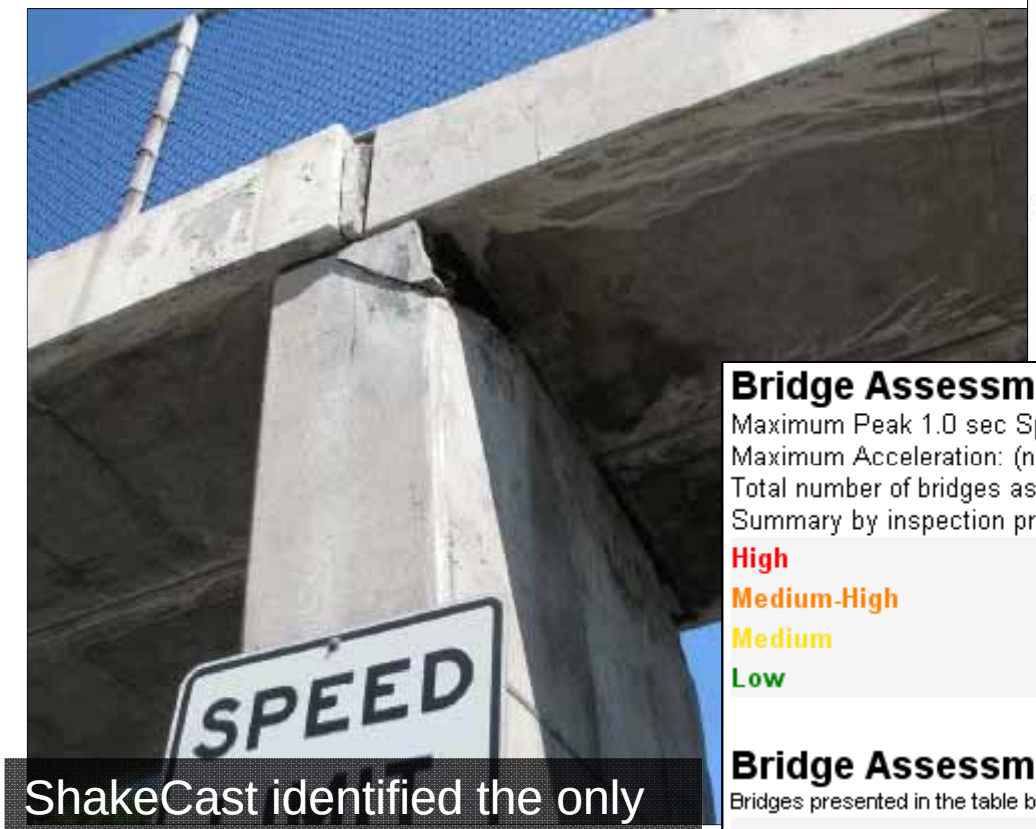

USGS ShakeMap
Instrumental Intensity | I | II-III | IV | V | VI | VII | VIII | IX | X+
Potential Shaking | Not felt | Weak | Light | Moderate | Strong | Very Strong | Severe | Violent | Extreme
Potential Damage | None | None | None | Very Light | Light | Moderate | Moderate/ Heavy | Heavy | Very Heavy
ShakeCast alerts responders to the those bridges most likely to be impacted within the regions of strong shaking.
Epicenter
Image Landsat
USGS
Google earth

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





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

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:

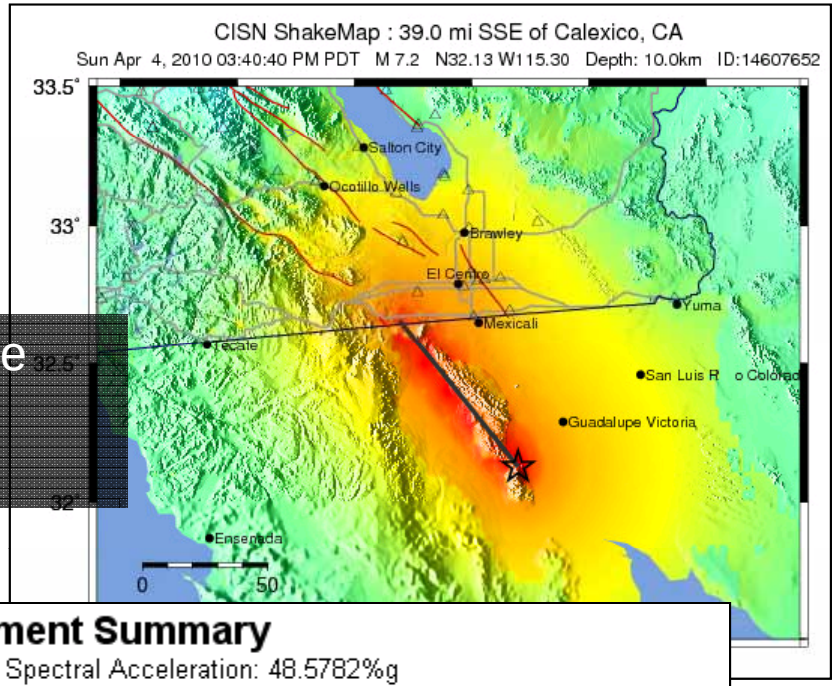
High	**|NULL|**	High Priority for full engineering ass
Medium-High	**|NULL|**	Medium-High Priority for full enginee
Medium	**|NULL|**	Medium Priority for full engineering
Low	**468**	Low Priority for full engineering asse

Bridge Assessment Details

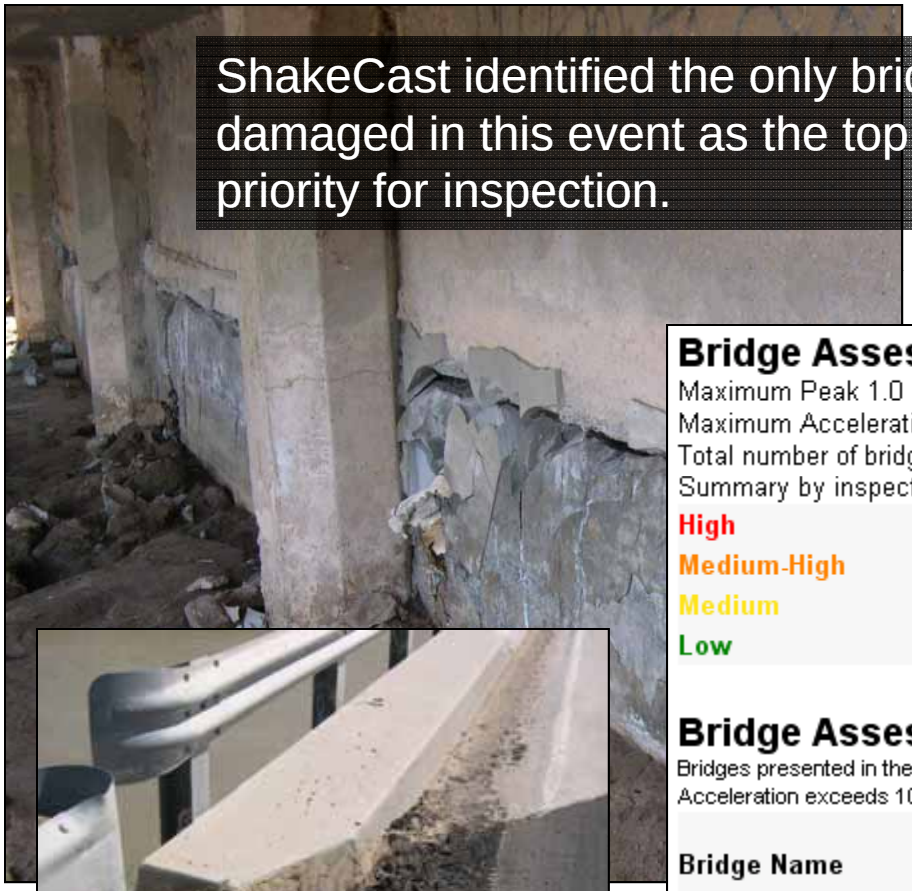
Bridges presented in the table below are sorted in order of severity of impact (exceedance ratio). The list includes

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

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:

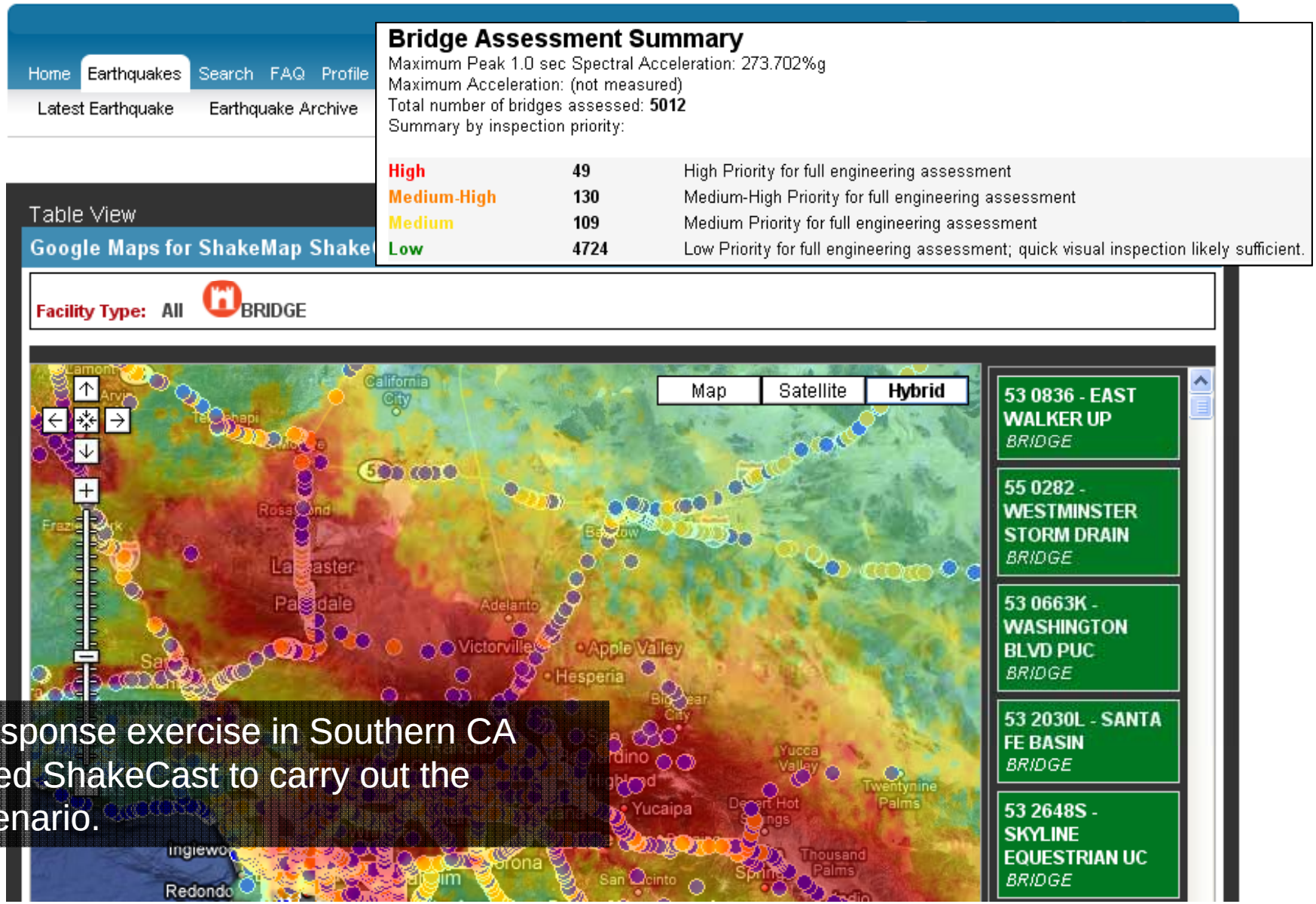
High	|NULL|	High Priority for full engineering assessment
Medium-High	|NULL|	Medium-High Priority for full engineering asses
Medium	|NULL|	Medium Priority for full engineering assessmen
Low	219	Low Priority for full engineering assessment; qu

Bridge Assessment Details

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

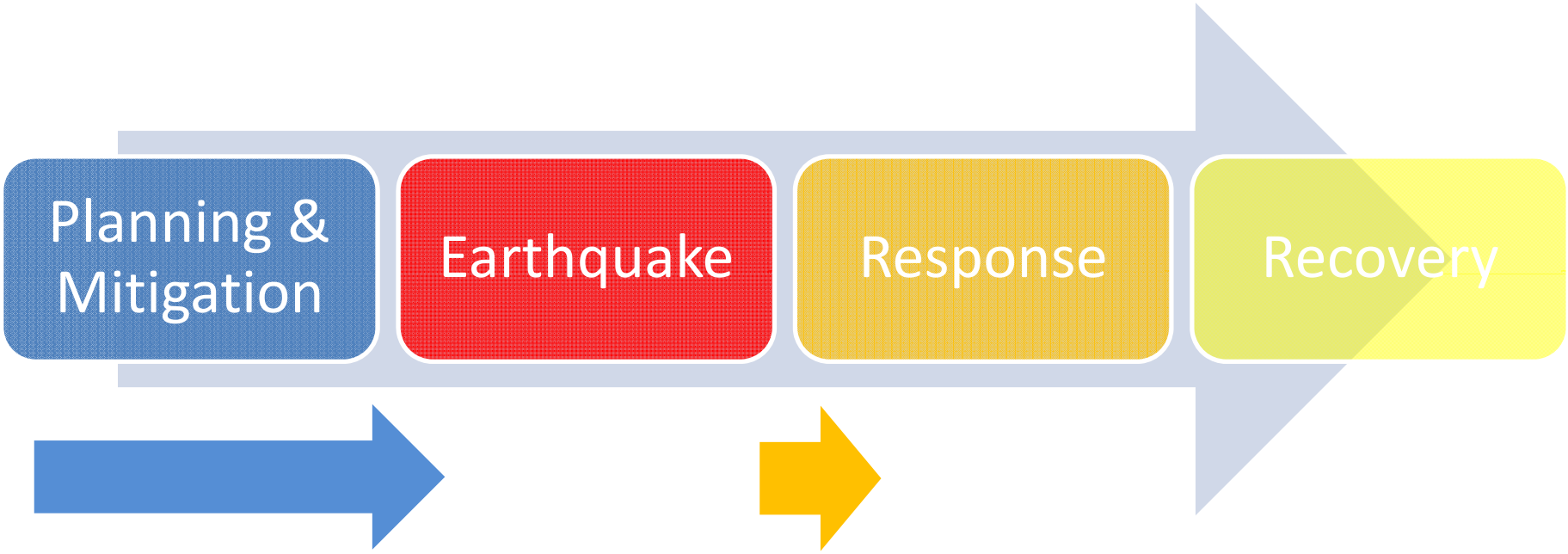
Bridge Name	Bridge Number	Dist-Cty-Rte-PM
58 0274 - WESTSIDE MAIN CANAL	58 0274	11-IMP-098-22.02
58 0275 - WORMWOOD CANAL	58 0275	11-IMP-098-22.07
58 0212L - COYOTE WELLS OH	58 0212L	11-IMP-008-R13.97
58 0212R - COYOTE WELLS OH	58 0212R	11-IMP-008-R13.93

Golden Guardian, November 2008



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

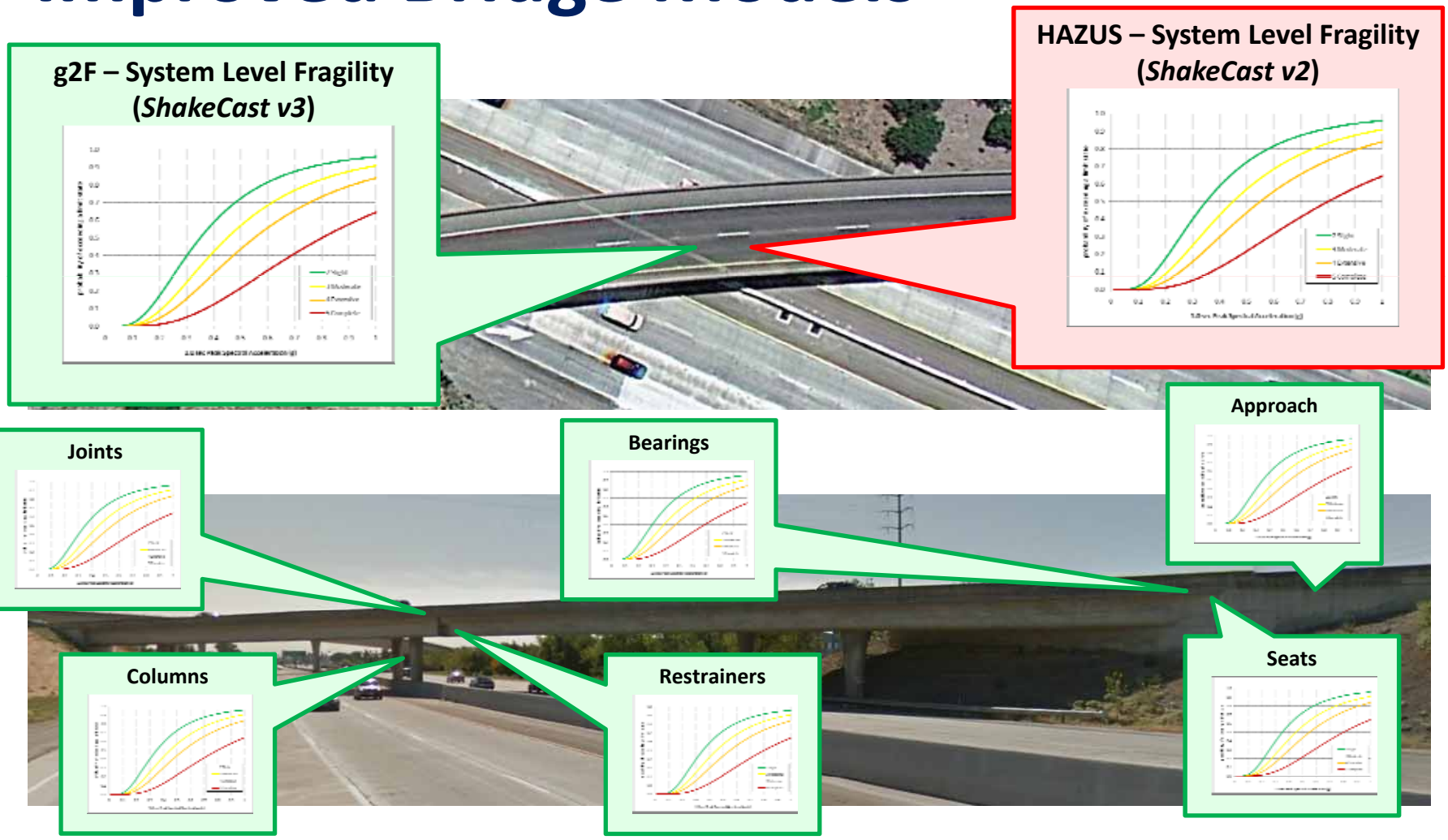
Future Directions:
ShakeCast for Planning & Mitigation



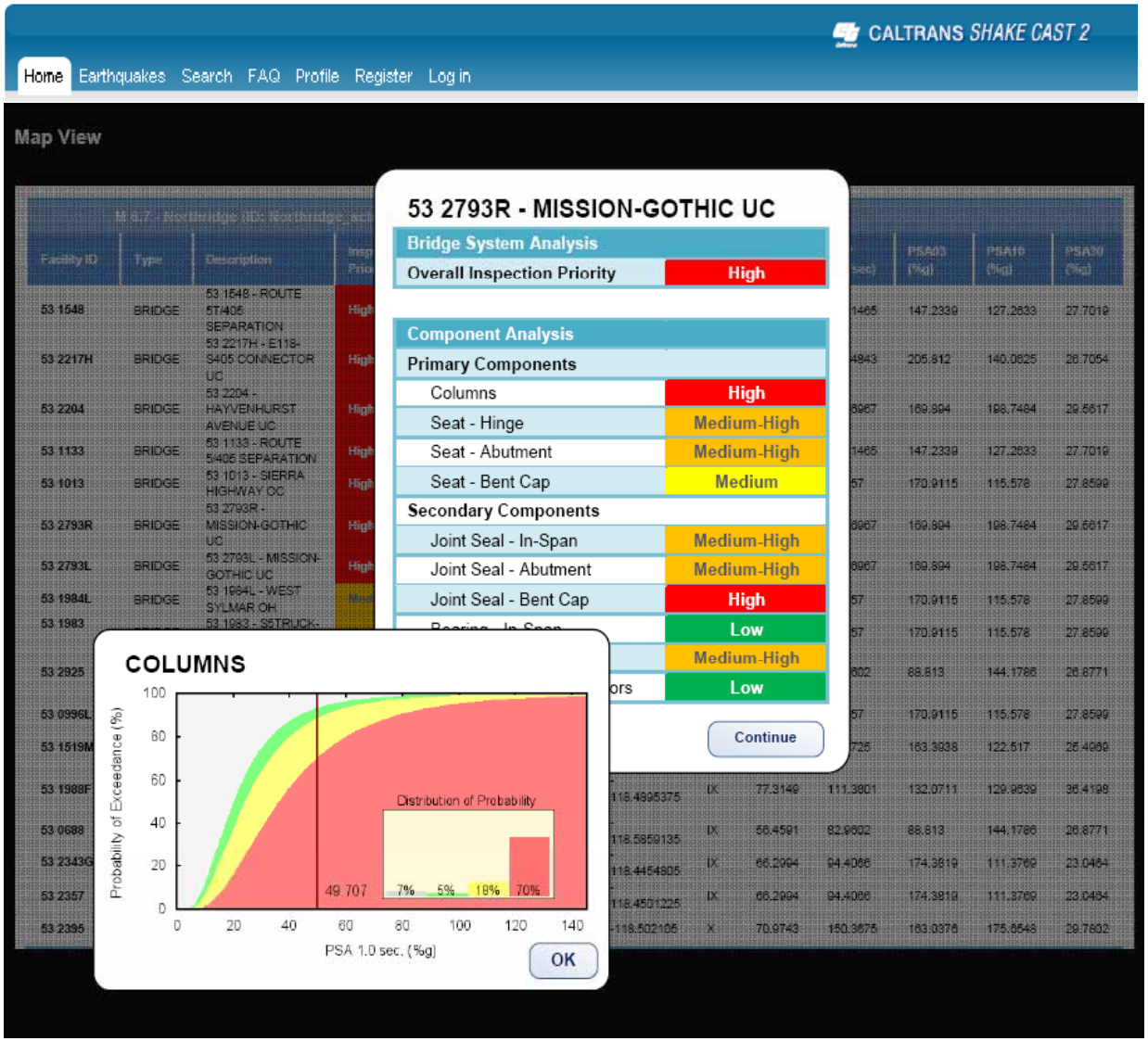
ShakeCast can also be used to evaluate the current bridge inventory against scenario earthquakes and significant historical events. (Over 280 California scenarios available.)

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

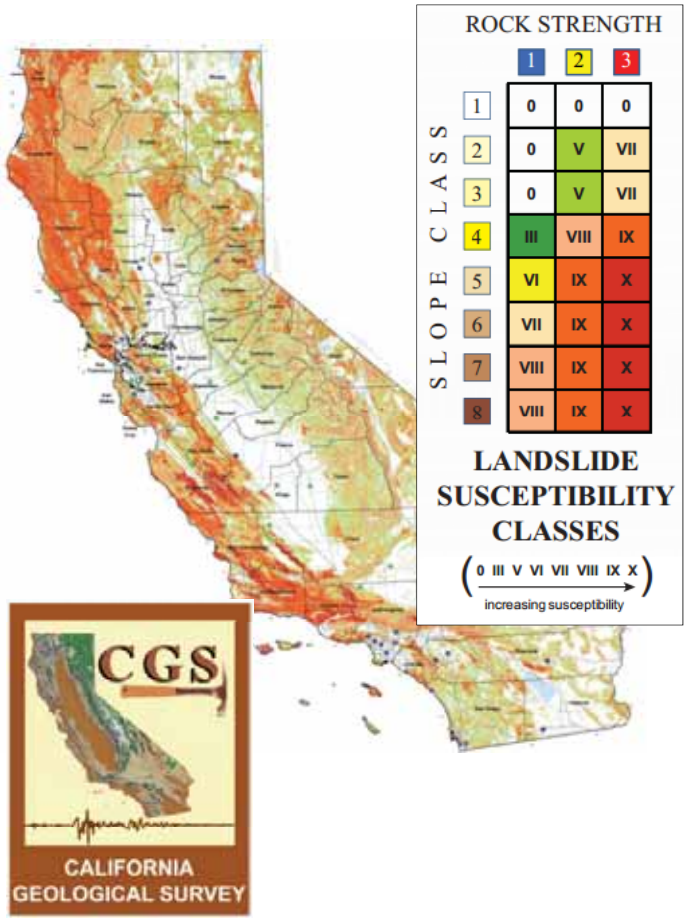
Future Directions:
Improved Bridge Models

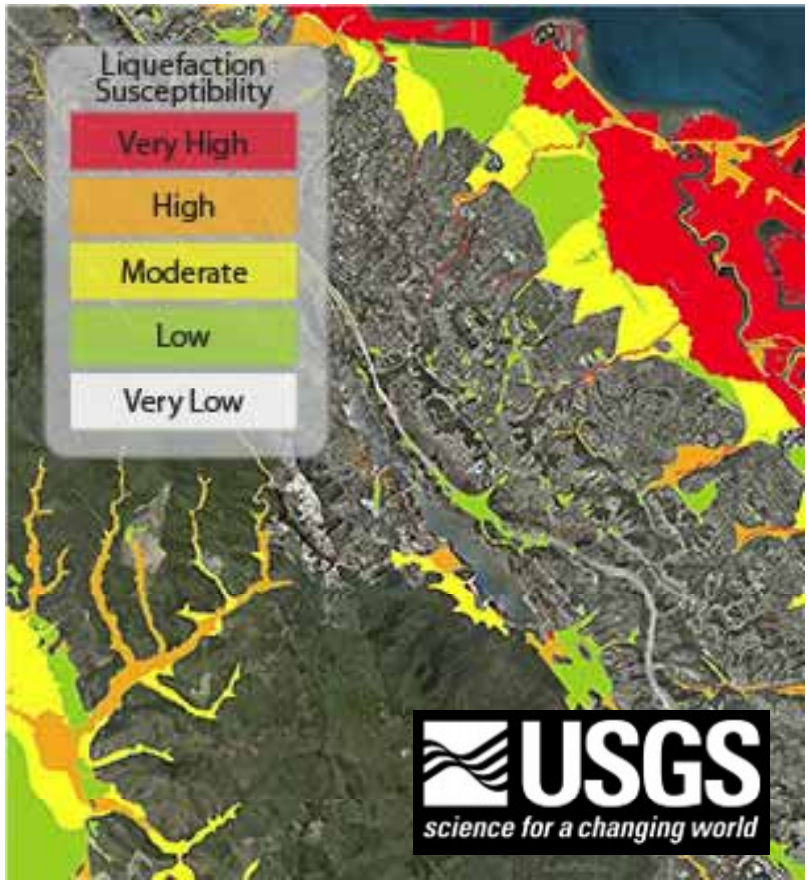


Future Directions:
Comprehensive Analysis Results



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

Caltrans

SGS ShakeCast

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

hakeCast is a freely available, post-earthquake situational awareness application that automatically ... shaking data from ShakeMap, ... users' facilities, and ... facility

TR NEWS

RESEARCH PAYS OFF

GeoResearch Group
Caltrans
Research & Innovation
USGS

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

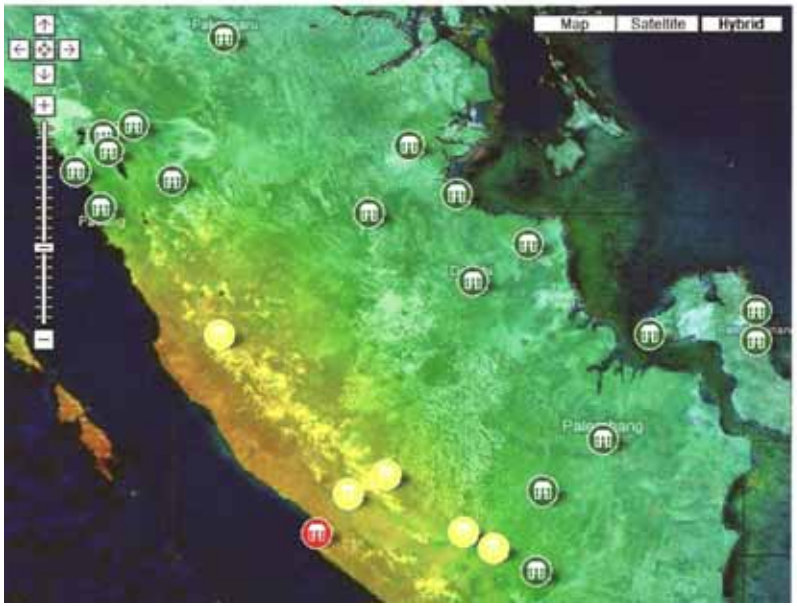
data and analyzes the data in relation to individual bridge performance characteristics. Within minutes of an event, the program generates e-mails to set priorities for inspection and assembles other web-based products to assist emergency responders.

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

VOLUME 24, NUMBER 2 MAY 2008

EARTHQUAKE SPECTRA

The Professional Journal of the Earthquake Engineering Research Institute



ShakeCast: Automating and Improvi the Use of ShakeMap for Post-Earthe 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 ... for information about the impact ... appropriate decisi...

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
loren.turner@dot.ca.gov

DRISI
Caltrans Division of Research, Innovation and System Information