Data Report for
The 2013 East Bay Seismic Experiment (EBSE) – Implosion Data

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Introduction

In August 2013, the California State University—East Bay (CSUEB) in Hayward, California imploded a 13-story building (Warren Hall) that was deemed unsafe because of its immediate proximity to the active trace of the Hayward Fault. The U.S. Geological Survey (USGS) and the CSUEB collaborated on a program to record the seismic waves generated by the collapse of the building. We refer to this collaboration as the East Bay Seismic Experiment (EBSE). The principal objective of recording the seismic energy was to observe ground shaking as it radiated from the source, but the data also may be useful for other purposes. For example, the seismic data may be useful in evaluating the implosion process as it relates to structural engineering purposes. This report provides the metadata needed to utilize the seismic data.

Background

The CSUEB campus is located in the Hayward Hills within the eastern San Francisco Bay area of California (Fig. 1). Warren Hall was an administrative and classroom building on the CSUEB campus, located ~600 m from the active trace of the Hayward Fault and between other associated older faults. Warren Hall was imploded on August 17, 2013 at about 9:00 am PDT. Prior to the implosion, the USGS, CSUEB, and numerous volunteers deployed seismographs within various arrays to capture the ground shaking resulting from the building collapse. The seismographs were set to begin recording about 30 seconds prior to the planned implosion time (9:00 am) and continued recording for several days after the implosion to capture natural sources (earthquakes) along the Hayward Fault and other nearby fault zones and to record ambient noises generated by cultural sources throughout the region.

Warren Hall and the Demolition Process

Warren Hall was a 13-story building (~61 m) located on the Campus of CSUEB, approximately 600 m east of the active trace of the Hayward Fault. With plan dimensions of ~34.29 X 34.29 m, Warren Hall had a structural system consisting of an interior core moment steel frame and an exterior perimeter concrete moment frame (Çelebi, 1998). The building was located on bearing piles with a 45-cm-thick reinforced concrete mat on grade (Çelebi, 1994). Prior to the preparation process for demolition, there were concrete shear walls around the elevator shafts up to the second floor; however, the contractor made numerous changes to the building in preparation for the implosion. The imploded building was estimated to weigh less (about 12,500 tons) than the original building.

Warren Hall was not a particularly old building, as it was built in 1969 and opened in 1971. However, the California State University Seismic Review Board determined Warren Hall to be the most seismically vulnerable building in the California State University system (http://www20.csueastbay.edu/news/2013/03/WA-replacement-bldg-032013.html, last accessed 10-23-14), and the decision was made to demolish the building, rather than to retrofit it.

The planned implosion process involved 13 timed explosions (6.5 second each) to removed key structural supporting elements of the building (http://www.insidebayarea.com/news/ci_23871497/hayward-demolition-landmark-ready-proceed-saturday, last accessed 10-17-14). The contractor expected the demolition process to occur within 17 seconds. The implosion was designed to make the building fall slightly to the west, rather than vertically, to prevent damage to adjacent buildings.

Seismographs

To record the implosion of Warren Hall, the USGS borrowed 600 "Texan" RT125A seismographs, ~600 Oyo-Geospace GS-11D (4.5-Hz single-component) sensors, and ~150 Sercel L-28-3-D (4.5-Hz 3-component) sensors from the Incorporated Research Institutes for Seismology (IRIS) Program For Array Seismic Studies of the Continental Lithosphere (PASSCAL), located in Socorro, New Mexico. The Texan seismographs are single-channel Digital Acquisition Systems (DAS) with 24-bit analog-to-digital conversion and programmable sampling rates (25 to 1000 sps). Data from most arrays (see below) were recorded using the Sercel L-22 sensors, but Sercel L-28-3D sensors were deployed nearest to the implosion, along fault zones, and along special arrays. Oyo-Geospace shows that the undamped response of the GS-11D (4.5 Hz @ 4000 Ohms) ranges from about (~8 v/m/s) at 1.2 Hz to about ~157 v/m/s at 4.5 Hz and remains above 95 v/m/s to at least 100 Hz (overall response range 1.2 to 100 Hz) [www.geospace.com/geophones-gs-11d/, last accessed 10-17-14). Sercel shows that the undamped response of the L-28 (4.5 Hz @ 395 Ohms) ranges from about 1.5 volts/m/s at 1 Hz to about 13.5 volts/m/s at about 4.5 Hz and is above 12 v/m/s to at least 1000 Hz (overall range ~1 to 1000 Hz) (http://www.sercel.com/products/Lists/ProductSpecification/Geophones_specifications_Sercel.pdf, last accessed 10-17-14).

Experiment Design

Seven seismograph arrays were deployed to capture seismic energy from the implosion and collapse of Warren Hall. In this report, we focus only on the arrays designed to primarily capture the implosion and collapse of Warren Hall. Warren Hall was centered at the following coordinates: Latitude: 37.655278; Longitude -122.057222; Elevation 147 m.

<u>(1) Radial/Circular Array</u>:

We refer to the primary array as the radial/circular array, where individual seismographs were spaced at 200-m intervals along 30 radial arrays extending from Warren Hall (Fig. 2). Each radial array consisted of 10 seismographs, thereby forming a 2-km-long radial line. Each radial line was spaced at ~12-degree intervals, forming ten 360-degree circular arrays that were centered on Warren Hall (see Table 1). All circular arrays, except those with diameters less than about 600 m, crossed the active strand of the Hayward Fault and included seismographs within the East Bay Alluvial Plain, the Hayward Hills, and the Hayward Fault zone (Figs. 2-5). All circular arrays included seismographs positioned along topographically varying surfaces. There were 300 recording sites selected for the radial/circular array (Appendix 1). However, a few of the sites could not be occupied because homeowners could not be contacted, or access was denied. Nearly every recorded site was within about 20 m of our desired location, and the listed coordinates for the recording sites are accurate to within about 5 m in most cases.

<u>(2) Near-Source Array:</u>

For measurements closest to the implosion, we deployed six 3-component seismograph arrays at an average of about 75 m from the center of Warren Hall (Figs. 3a,b). These stations approximately encircled Warren Hall, but the azimuthal spacing was highly variable (average of ~60 degrees) due to the presence of nearby buildings (see Table 2 and Appendix 2).

(3) Linear Array:

A linear array that extended from the San Francisco Bay through the center of Warren Hall to San Ramon (25 km) was also planned (Fig. 2). However, due to limited access, sites within 2.4 km of the San Francisco Bay were not occupied. Most planned sites from 2.4 km east of the San Francisco Bay to the City of San Ramon were occupied at 400-m intervals, except for sites within 2 km of Warren Hall, which were occupied at 200-m intervals (Appendix 3).

(4) Schools Array:

A small array was also deployed at greater epicentral distances from the center of Warren Hall than the primary radial/circular array (Fig. 4). This array was deployed principally within the East Bay Alluvial Plain on local public school properties and is referred to as the "Schools" array. When supplemented with stations from the linear array, the Schools Array largely encircles Warren Hall at distances of about 5 km or more.

(5) Hayward Fault Zone Cross-Fault Arrays:

In addition to the seismographs within the radial/circular array that were within the Hayward Fault zone, two small dedicated seismograph arrays were deployed across the active trace of the Hayward Fault to record seismic energy from the implosion/collapse of Warren Hall (Fig. 5). (a) One cross-fault array (Carlos Bee Array) was deployed near Carlos Bee Boulevard in Hayward and consisted of four 3-component seismograph systems. Stations were recorded along the active trace and hundreds of meters southwest and northeast of the active trace. (b) A second cross-fault seismograph array (Chabot Array) was deployed approximately 9 km north of Warren Hall in San Leandro, and it also consisted of three 3-component seismograph systems. As with the Carlos Bee array, stations along the Chabot Array were recorded along the active trace and hundreds of meters southwest and northeast of the active trace.

(6) Hayward Fault Zone Linear Array (Fig. 5):

An array of six seismographs was deployed along the Hayward Fault zone from Warren Hall to Chabot Park in San Leandro (Fig. 5). This array was designed to record seismic energy along the fault zone from the implosion source to about 10 km to the northwest. All stations along the linear array were single component, except stations co-located on the cross-fault arrays.

(7) Far Field Array:

We also deployed an array that extended beyond the immediate study site, with stations located to the north, west, and southwest of Warren Hall at epicentral distances up to 32 km (Fig. 1). To the north, stations were located in Berkeley, Oakland, Alameda, Castro Valley, and Hayward, and to the west and southwest, stations were located in Menlo Park, Palo Alto, Belmont, Union City, and Fremont. When combined with some of the stations along the linear array, the far field array partially encircles Warren Hall at distant offsets. All far-field-array stations were recorded using single-component seismograph systems.

Other Arrays:

Several additional arrays were deployed to record data in the days following the implosion and collapse of Warren Hall. Those data are not considered part of the EBSE and will be included in a separate data release.

Data

Most of the above-described arrays were deployed one or two days before the implosion/collapse of Warren Hall, and the recording arrays were left in place to record passive seismic data for several days after the implosion. Appendices 1-7 contain the approximate deployment and pickup times, as well as locations for arrays 1-7. All data were recorded in the IRIS-PASSCAL field format, with individual files having the format, "IxxxxRAW.TRD", where xxxx is the 4-digit seismograph (DAS) number. For conversion to other formats, contact the IRIS-PASSCAL data center or contact the authors of this report. The trd files consist of continuously recorded data for each seismograph, and each file extends from the turn-on time until that seismograph was turned off following pickup from the recording sites. Collectively, the compressed trd files are about 37 GB in size. To use these data for most purposes, the continuous files must be cut into smaller files. The trd files are available at the following website: https://www.sciencebase.gov/catalog/item/54860802e4b02acb4f0c7ea6. We have converted the implosion data that was recorded with the GS11-D sensors to SEGY format. Data from about 15 seconds before the implosion to approximately 105 seconds following the implosion are in SEGY format for the radial/circular and linear arrays. Those files are approximately 45 MB in size and are also available at the following website: https://www.sciencebase.gov/catalog/item/54860802e4b02acb4f0c7ea6. The data are standard SEGY files (data samples stored as 40 byte IBM floating point values), with the first sample at UTC time: 2013:229:15:59:30 and a total of 120 seconds of record time. The DAS (seismograph) 4-digit serial number of the recorder is stored at byte 175 of the trace header as a 2-byte integer, as named in the appendices of this report. The scheme shown in Table 3 is used to define the field file I D (FFID, bytes 9-12) and channel (CHAN, bytes 13-16) for each trace in the SEGY file:

Acknowledgements

We thank the California State University - East Bay for hosting the command center, providing the seismic source, and providing access to their property. We also thank CalTrans, the East Bay Regional Parks District, the Hayward Area Recreation and Park District, the City of Hayward, the Hayward Unified School District, Kmart (Hayward), and the hundreds of citizens who volunteered their properties as recording sites. A large number of individuals assisted acquiring the EBSE data by deploying and retrieving seismographs, contacting property owners, and surveying recording sites. We especially thank Rebecca Biestman and Risk Management Solutions, Inc. for providing a large number of field volunteers, and we thank the ARC of Alameda County, which provided a number of volunteers and transportation. Individual volunteers who helped in the field include: Pranshu Agarwal, Mukul Agarwal, Gabriel Alcantar, Megan Arnold, Lee Baker, Lesley Barnes, Katherine Baylor, Marguerite Bello, Daniel Brooks, Stefan Burns, Matt Bussman, Joanna Chang, Katherine Chapman, Coye Criley, Charles Dodge, Jennifer Dreiling, Gareth Evans, Gwyneth Evans, Ryan Fay, Gini Gandhok, Marius Isken, Christopher Johnson, Jerry Kolb, Dhir Kothar, Ron Lee, John MacDougal, Raleigh

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References

Çelebi, M. (1994). Response study of a 13-story building, in Fifth U.S. National Conference on Earthquake Engineering, July 10–14, Chicago, Ill.: Earthquake Engineering Research Institute, Oakland, California, v. 1, p. 87–96

Çelebi, M. (1998). Performance of building structures – A Summary, *in* M. Çelebi, editor The Loma Prieta, California, Earthquake of October 17, 1989—Building Structures, U.S. Geological Survey Professional Paper 1552–C, pp. 5–76

Table1. Radial spokes (R#) with heading from the center of Warren Hall outward.

Radial Array Number	Heading (Degrees North)
R1	8.78
R2	19.78
R3	31.00
R4	42.69
R5	54.95
R6	67.68
R7	81.30
R8	94.99
R9	108.43
R10	121.29
R11	133.58
R12	145.23
R13	156.60
R14	167.53
R15	178.12
R16	189.11
R17	200.03
R18	211.22
R19	222.98
R20	235.23
R21	248.04
R22	261.42
R23	275.02
R24	288.35
R25	301.18
R26	313.41
R27	325.16
R28	336.33
R29	347.24
R30	358.03

Table 2. Near-field stations with heading from the center of Warren Hall outward.

Radial Array Number	Heading (Degrees North)
Z1	93.08
Z2	144.82
Z3	193.13
Z4	261.74
Z5	325.61
Z6	10.2

Table 3

Filename	See Appendix	FFID	CHAN
Hayward_13_Linear_Vert.Segy	3	1001	*Distance/100 (non-consecutive, 4-250)
Hayward_13_Linear_North.segy	3	1001	*Distance/100
Hayward_13_Linear_East.segy*	3	1001	*Distance/100
Hayward_13_Radial_Vert.segy	1	**Spoke#	*Distance/100 (non-consecutive, 2-20)
Hayward_13_Radial_North.segy**	1	**Spoke#	*Distance/100
Hayward_13_Near-Source_Vert.segy	2	1003	1-6
Hayward_13_Near-Source_North.segy	2	1003	1-6
Hayward_13_Near-Source_East.segy	2	1003	1-6
Hayward_13_Schools_Vert.segy	4	1004	3,7,11,16,17,21,22,31,33,34,37
Hayward_13_Far-Field_Vert.segy	7	1005	1,2,7-10,12-26
Hayward_13_Inline-FZ_Vert.segy	6	1006	1-7
Hayward_13_Inline-FZ_North.segy	6	1006	1-7
Hayward_13_Inline-FZ_East.segy	6	1006	1-7
Hayward_13_Chabot-Cross-FZ_Vert.segy	5	1007	1-3
Hayward_13_Chabot-Cross-FZ_North.segy	5	1007	1-3
Hayward_13_Chabot-Cross-FZ_East.segy	5	1007	1-3
Hayward_13_Carlos-Bee-Cross-FZ_Vert.segy	5	1008	1-4
Hayward_13_Carlos-Bee-Cross-FZ_North.segy	5	1008	1-4
Hayward_13_Carlos-Bee-Cross-FZ_East.segy	5	1008	1-4

***Channel Named by Distance = Warren Hall to the Station (nearest 100 m)**

**** Spoke# is 1-30. Spokes extend from Warren Hall Outward. See Table 1**

Figures

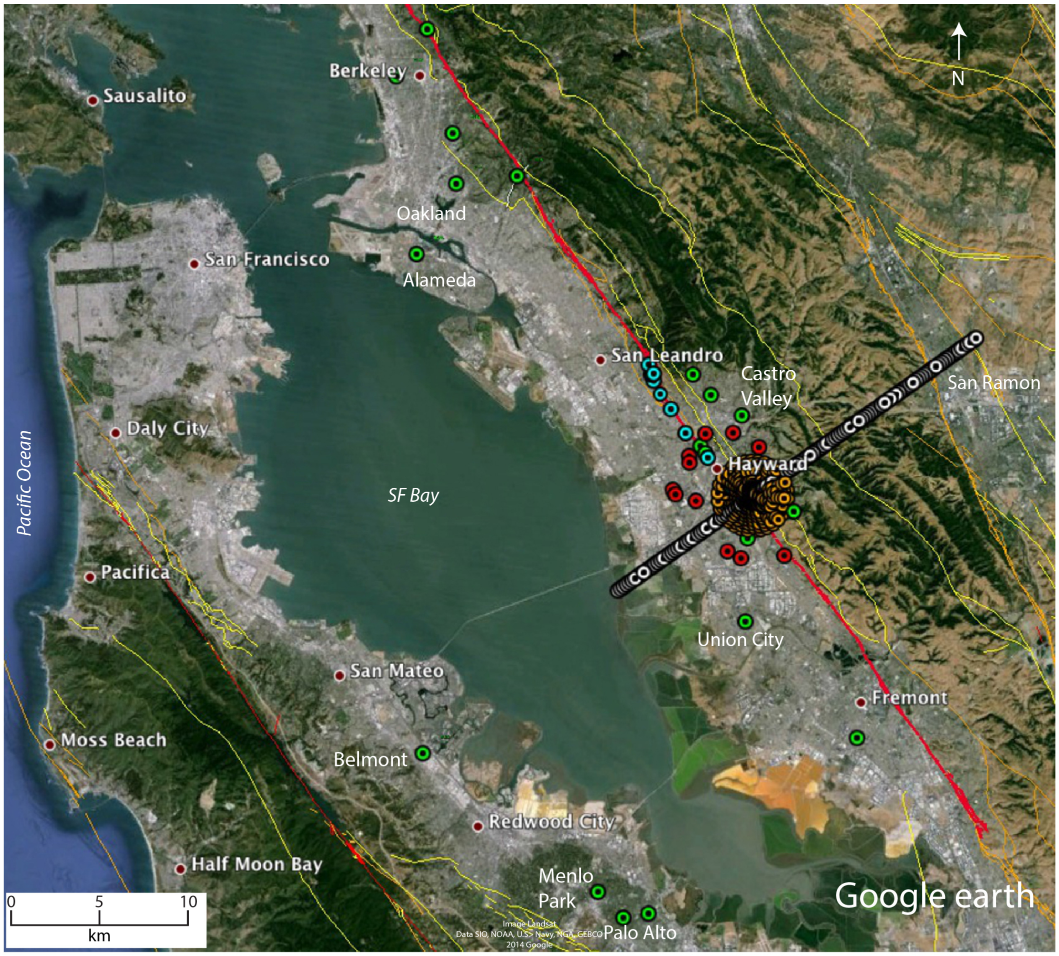

Figure 1. San Francisco Bay area with the locations of various cities, faults (red and yellow), and EBSE arrays: Gold = Radial/Circular; White = Linear; Blue = Fault Zone; Red = Schools; Green = Scatter. The near-source array is at the center of the radial/circular array.

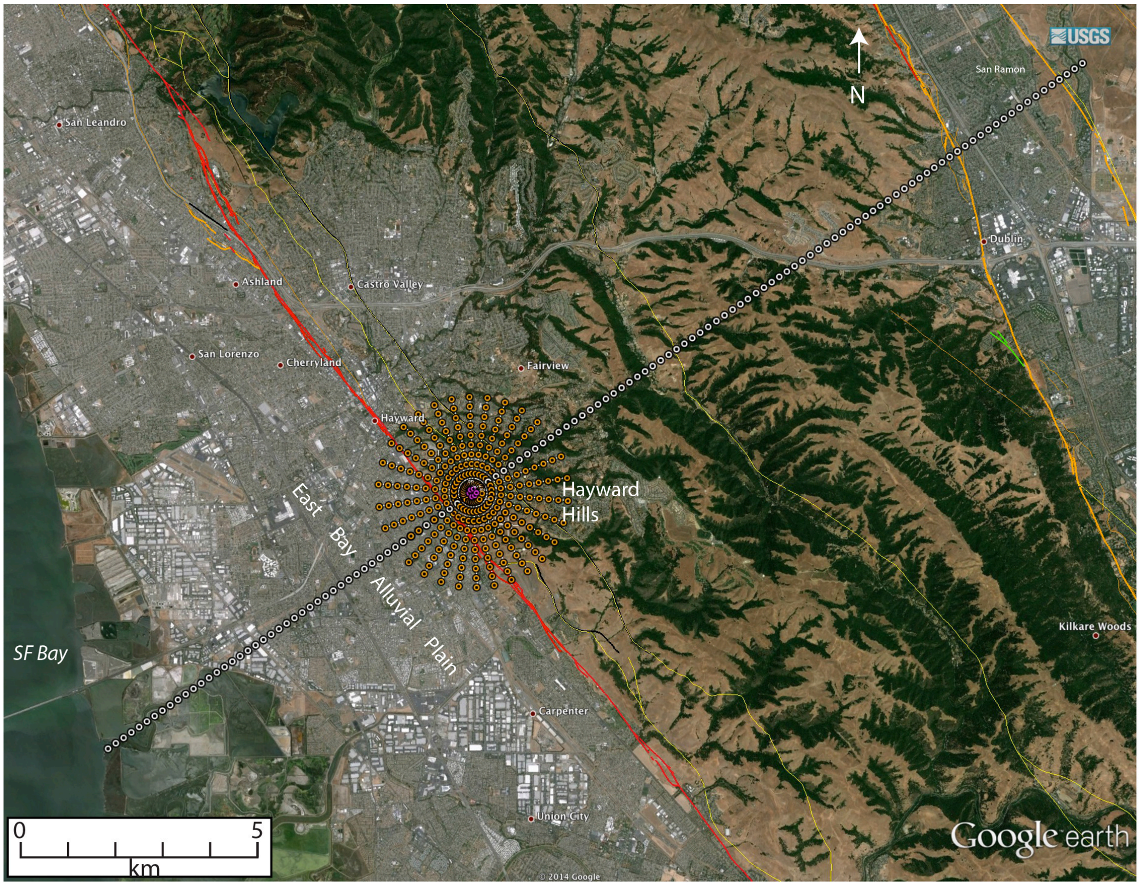

Figure 2. Location of the radial/circular (gold), linear (white), and near-source (magenta) arrays of the EBSE. The red lines show the historically active traces of the Hayward Fault. The yellow lines show locations of other Holocene or Quaternary faults.

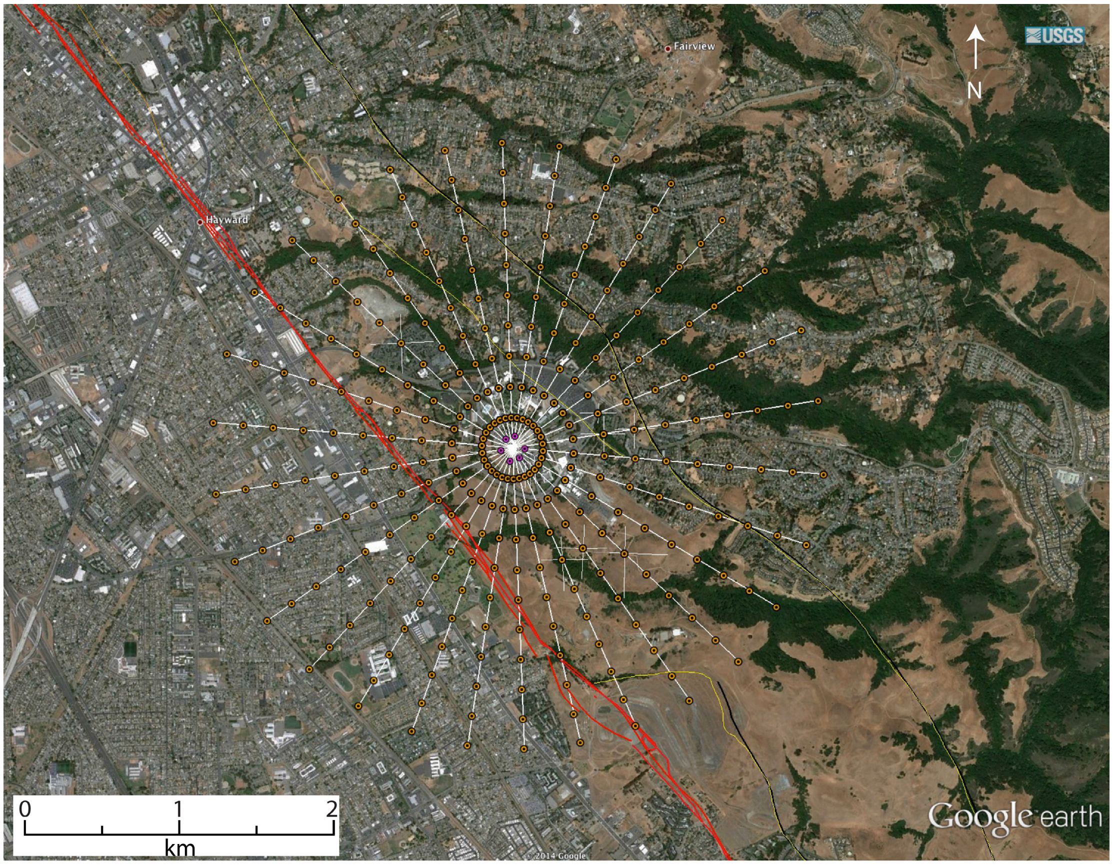

Figure 3a. Location of the radial/circular (gold) and near-source (magenta) arrays of the EBSE. The red lines show the active traces of the Hayward Fault. Other Holocene or Quaternary faults are shown by the yellow lines.

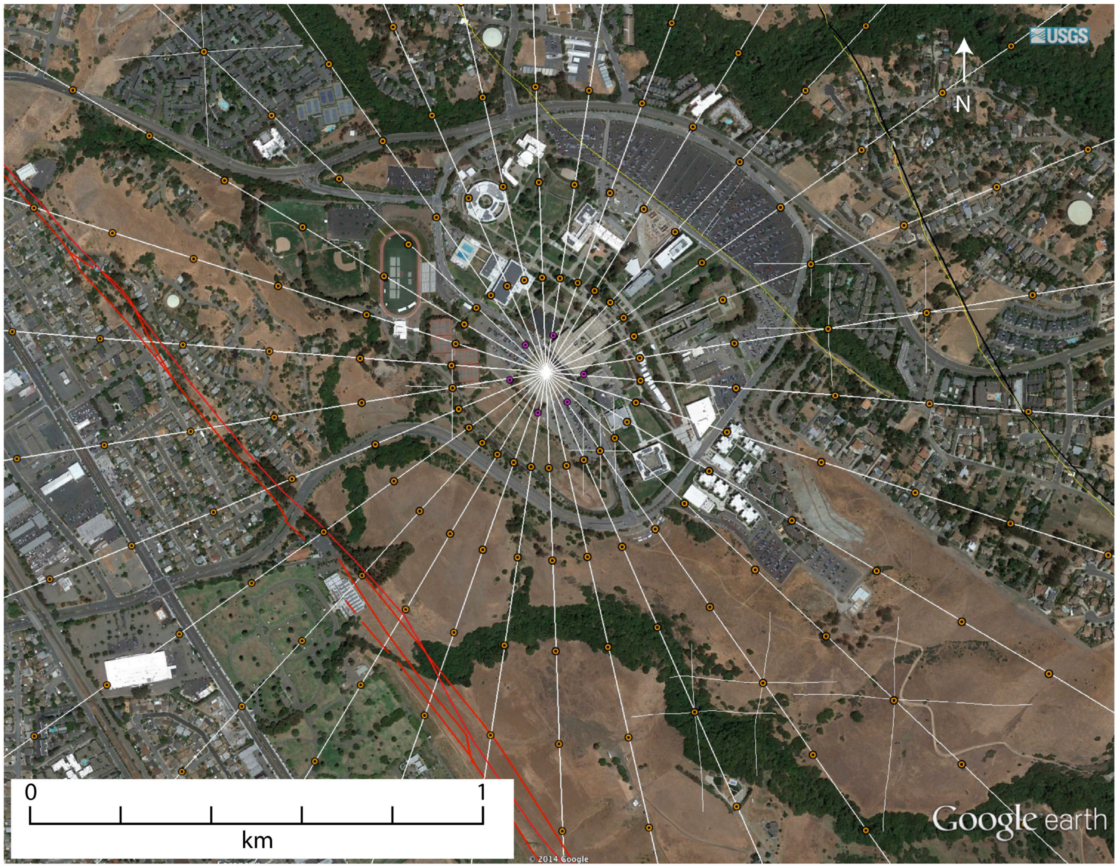

Figure 3b. Location of the radial/circular (gold), near-source (magenta), and fault zone (cyan) Arrays of the EBSE. The red lines show the active traces of the Hayward Fault. Other Holocene or Quaternary faults are shown by the yellow lines.

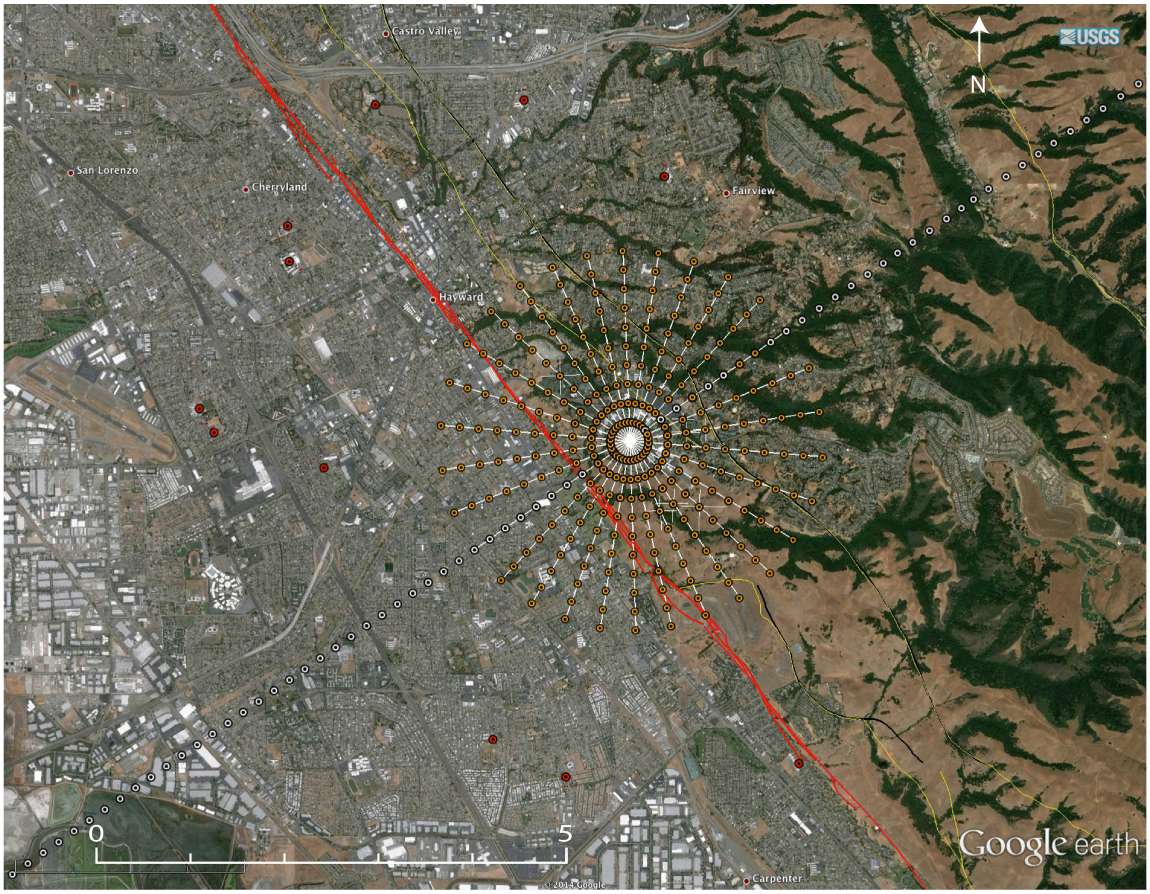

Figure 4. Location of the radial/circular (gold) and schools (red) EBSE arrays. The red lines show the active traces of the Hayward Fault. Other Quaternary faults are shown by the yellow lines.

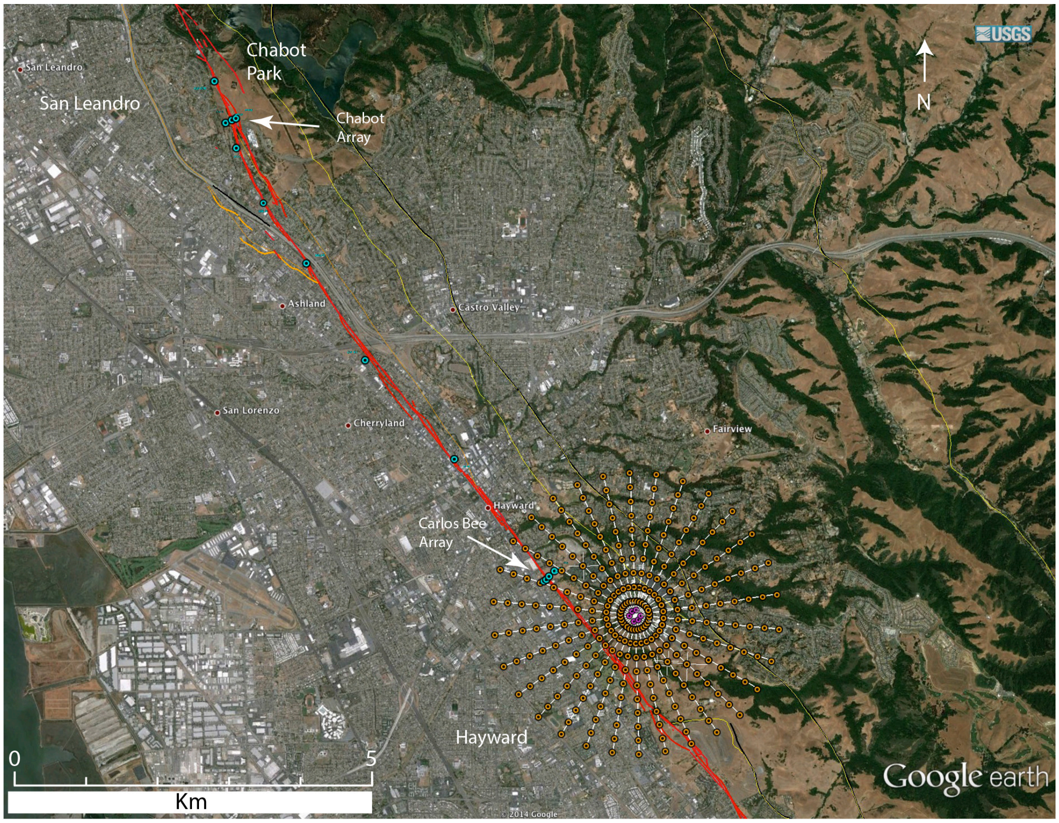

Figure 5. Location of the radial/circular (gold), near-source (magenta), and fault zone (cyan) EBSE arrays . The red lines show the active traces of the Hayward Fault. Other Holocene and Quaternary faults are shown by the yellow lines.

Appendices

Appendix 1 (Radial/Circular)

FFID	Chan #	Station	DAS # (Z, N, E)	Latitude	Longitude	Elev (m)	Comments
1	2	R01-0200	1719	37.65712551	-122.056921	156.2	
1	4	R01-0400	2201	37.65890314	-122.0565681	142	
1	6	R01-0600	1800	37.66068455	-122.0562153	151	
1	8	R01-0800	1940	37.66246604	-122.0558624	142.3	
1	10	R01-1000	1854	37.66414133	-122.0556247	96.7	Same as 3778
1	12	R01-1200	1673	37.66602131	-122.0551567	97.5	
1	14	R01-1400	1793	37.6678028	-122.0548019	129.9	
1	16	R01-1600	1574	37.66957666	-122.0544491	119.9	
1	18	R01-1800	1751	37.67135815	-122.0540962	121.5	
1	20	R01-2000	1617	37.67313578	-122.0537434	99.4	
2	2	R02-0200	3840	37.65697388	-122.0566	158.5	
2	4	R02-0400	1572	37.65868278	-122.0557572	141.8	
2	6	R02-0600	2513	37.66042521	-122.0549565	152.1	
2	8	R02-0800	2466	37.66212272	-122.0541821	103.7	
2	10	R02-1000	1850	37.66381268	-122.0534096	131.1	
2	12	R02-1200	1801	37.66550255	-122.052639	140.3	
2	14	R02-1400	1972	37.6671454	-122.0519712	127.1	
2	16	R02-1600	1729	37.66889378	-122.0510922	146	
2	18	R02-1800	1633	37.67058374	-122.0503216	147.6	
2	20	R02-2000	1974	37.67227748	-122.0495491	136.6	
3	2	R03-0200	2708	37.65688512	-122.0561009	163.9	
3	4	R03-0400	2514	37.6584263	-122.0549259	144.1	
3	6	R03-0600	4048	37.65989115	-122.0538038	156.3	
3	8	R03-0800	2048	37.66151235	-122.0525799	113.8	
3	10	R03-1000	2015	37.66305353	-122.0514068	152.5	
3	12	R03-1200	1893	37.664587	-122.0502376	150.8	
x	x	R03-1400	NA	37.66612818	-122.0490627	153.1	Uncertain
3	16	R03-1600	2268	37.66766927	-122.0478878	175.4	
3	18	R03-1800	1555	37.66921422	-122.0467129	173	
3	20	R03-2000	1775	37.67075541	-122.045538	169.4	
4	2	R04-0200	2571	37.65666392	-122.0557308	165.1	
4	4	R04-0400	1529	37.65798382	-122.0541878	156.9	
4	6	R04-0600	2017	37.65930363	-122.0526467	155	
4	8	R04-0800	3904	37.66096501	-122.0518957	121.4	
4	10	R04-1000	2404	37.66194343	-122.0495605	124.6	
4	12	R04-1200	2695	37.66326333	-122.0480213	162.4	
4	14	R04-1400	2002	37.664587	-122.0464763	140.2	

4	16	R04-1600	1613	37.66590312	-122.0449409	169.3	
4	18	R04-1800	2459	37.66730114	-122.0432778	192.7	
4	20	R04-2000	3645	37.66841593	-122.0421363	204	
x	x	R05-0200	NA	37.65639919	-122.055362	168.4	Uncertain
5	4	R05-0400	2659	37.65740396	-122.0535545	162	
5	6	R05-0600	2181	37.65843392	-122.0516949	154.7	
5	8	R05-0800	2623	37.65946389	-122.0498352	175.1	Same as 1961
5	10	R05-1000	1672	37.66049386	-122.0479755	189.7	
5	12	R05-1200	2530	37.66152383	-122.0461216	140.4	
5	14	R05-1400	3887	37.6625538	-122.0442619	197.2	
5	16	R05-1600	1585	37.66358377	-122.0424061	177.3	
5	18	R05-1800	1873	37.66461373	-122.0405464	165.1	
5	20	R05-2000	1761	37.66635273	-122.0391616	199.5	
6	2	R06-0200	2684	37.65620115	-122.0551874	168.6	
6	4	R06-0400	1867	37.65669443	-122.053072	166.9	
6	6	R06-0600	2190	37.65739513	-122.0510423	151.6	
6	8	R06-0800	1635	37.65804484	-122.0488701	192.8	
6	10	R06-1000	3914	37.65872	-122.0467682	203.1	
6	12	R06-1200	1698	37.65939524	-122.0446758	204.7	
6	14	R06-1400	1857	37.66007426	-122.0425701	154.5	
6	16	R06-1600	2136	37.66094321	-122.0406657	217.8	
6	18	R06-1800	2926	37.66142467	-122.0383644	264.2	
6	20	R06-2000	2246	37.66182809	-122.0362092	269.4	
7	2	R07-0200	2146	37.65558299	-122.0550006	167.1	
7	4	R07-0400	2566	37.65588566	-122.0527935	170.9	
7	6	R07-0600	2589	37.65619109	-122.0503634	156.9	Same as 3637
7	8	R07-0800	1637	37.65644155	-122.0485105	176.6	
7	10	R07-1000	3780	37.65667398	-122.0458897	224.3	
7	12	R07-1200	2929	37.6569691	-122.0438404	227.6	
7	14	R07-1400	3848	37.65724369	-122.0415898	239.3	
7	16	R07-1600	2945	37.65685653	-122.0396385	236.7	
7	18	R07-1800	3864	37.65672427	-122.0369412	252.8	
7	20	R07-2000	1886	37.65805624	-122.0348778	195.6	
8	2	R08-0200	2115	37.65519138	-122.0550156	163.4	
8	4	R08-0400	4085	37.65503883	-122.0527572	173	
8	6	R08-0600	1548	37.65488628	-122.050499	184.2	
8	8	R08-0800	1818	37.65470884	-122.0480859	171.9	
8	10	R08-1000	2062	37.65457724	-122.0459824	185.9	Bad Data
8	12	R08-1200	1883	37.65424532	-122.0437784	222.9	
8	14	R08-1400	2094	37.65426829	-122.0414715	237.8	
8	16	R08-1600	1581	37.6542211	-122.0393154	276.9	
8	18	R08-1800	2918	37.65384927	-122.0370718	282	
8	20	R08-2000	2112	37.65386872	-122.0348424	269.2	

9	2	R09-0200	2425	37.65477941	-122.0551223	154.4	
9	4	R09-0400	1832	37.65434993	-122.0530174	169.8	
9	6	R09-0600	2942	37.65365029	-122.0508175	184.6	
9	8	R09-0800	3591	37.65326514	-122.0486762	195.9	
9	10	R09-1000	3767	37.65256584	-122.0458205	199	
9	12	R09-1200	2567	37.65189679	-122.0443156	224.2	
9	14	R09-1400	1770	37.65139195	-122.0422172	214	
9	16	R09-1600	2804	37.65082743	-122.0400638	205.4	
9	18	R09-1800	2125	37.65026283	-122.0379143	202.1	
9	20	R09-2000	2848	37.64969445	-122.0357647	178.7	
10	2	R10-0200	3797	37.65451899	-122.05523	153.8	
10	4	R10-0400	2116	37.6534824	-122.0533943	162.7	
10	6	R10-0600	2006	37.65275376	-122.0514269	175.9	
10	8	R10-0800	1695	37.65170544	-122.0494101	183.1	
10	10	R10-1000	3571	37.65070179	-122.0475817	195	
10	12	R10-1200	1693	37.64974977	-122.0455933	218.4	
10	14	R10-1400	2470	37.64888308	-122.0437221	199.6	
10	16	R10-1600	1669	37.64789393	-122.0417556	193.7	
10	18	R10-1800	3608	37.64698383	-122.039753	139.8	
10	20	R10-2000	1790	37.64600775	-122.0378788	145.5	
11	2	R11-0200	4019	37.65410802	-122.0556259	145.4	
11	4	R11-0400	2430	37.65296155	-122.0539361	144.6	
11	6	R11-0600	1802	37.65163234	-122.05233	168.1	
11	8	R11-0800	2709	37.65039635	-122.050684	174.8	
11	10	R11-1000	3598	37.64916035	-122.049036	157.8	
11	12	R11-1200	2133	37.64792821	-122.0473957	155.9	
11	14	R11-1400	3988	37.64668468	-122.0457439	111.7	
11	16	R11-1600	2608	37.64544491	-122.044096	160.9	
11	18	R11-1800	1602	37.64420891	-122.0424538	209.7	
11	20	R11-2000	3607	37.64297292	-122.0408097	222.2	
12	2	R12-0200	2467	37.65386771	-122.0559769	139.1	
12	4	R12-0400	1844	37.65239141	-122.0546779	156.1	Same as 3935
12	6	R12-0600	1999	37.65091511	-122.0533791	157	Stolen ?
12	8	R12-0800	3726	37.64943888	-122.0520801	144.5	
12	10	R12-1000	2102	37.64796258	-122.0507813	99.2	
12	12	R12-1200	2704	37.64654654	-122.0494933	93.6	
12	14	R12-1400	3746	37.64501316	-122.0482006	147.9	
12	16	R12-1600	2395	37.64353367	-122.0468922	175.9	
12	18	R12-1800	4036	37.6421178	-122.0455995	167.2	
12	20	R12-2000	3713	37.64058064	-122.0442994	197.4	
13	2	R13-0200	1748	37.65369605	-122.056364	136.7	Bad Data
13	4	R13-0400	2080	37.65204432	-122.0554523	148.9	Same as 2505
x	x	R13-0600	NA	37.65039635	-122.0545426	74.9	Not Deployed

13	8	R13-0800	2063	37.64867194	-122.0537079	79.7	
13	10	R13-1000	1826	37.64709279	-122.0527229	140.1	
13	12	R13-1200	3658	37.64562001	-122.0516443	140	
13	14	R13-1400	1580	37.64380071	-122.0509072	109.1	
13	16	R13-1600	1927	37.64211888	-122.0499678	110.1	
13	18	R13-1800	1632	37.64049724	-122.0490875	118	
13	20	R13-2000	1690, 3586, 3592	37.63884927	-122.0481815	79	Bad File
14	2	R14-0200	2174	37.65358927	-122.056776	137.4	
14	4	R14-0400	1909	37.65183066	-122.0562763	124.5	
14	8	R14-0600	NA	37.64994125	-122.0557897	93.7	Not Deployed
x	x	R14-0800	2256	37.64831353	-122.0552807	109.5	
14	10	R14-1000	2127	37.64659172	-122.0546925	100.2	
14	12	R14-1200	1901	37.64465609	-122.0543601	74.4	
14	14	R14-1400	3953	37.64292321	-122.0537852	58.4	
14	16	R14-1600	2100, 4035, NA	37.64131305	-122.0532896	65.3	Uncertain (E)
14	18	R14-1800	2634, 2419, 1836	37.63952812	-122.0528097	56.1	
14	20	R14-2000	2427	37.63778712	-122.0522982	46	
15	2	R15-0200	3589	37.6535435	-122.0571995	144	
15	4	R15-0400	2622	37.6517429	-122.0571251	99.5	Bad File
x	x	R15-0600	NA	37.64994239	-122.0570507	71.8	Not Deployed
15	8	R15-0800	2169	37.64814187	-122.0569763	83.9	
15	10	R15-1000	3681, 2710, 2126	37.64634135	-122.0569019	63.6	
15	12	R15-1200	4004, 3966, 1654	37.64454075	-122.0568276	39.1	
15	14	R15-1400	3618	37.64274786	-122.0567551	29	
15	16	R15-1600	2399	37.64093972	-122.0566807	24.3	
15	18	R15-1800	2098	37.63913535	-122.0566082	18	
15	20	R15-2000	3783	37.63734246	-122.0565357	10.4	
16	2	R16-0200	3634	37.65356639	-122.0576267	145.2	
16	4	R16-0400	2720	37.6517849	-122.0579796	94.4	
16	8	R16-0600	NA	37.65000726	-122.0583325	47	Not Deployed
x	x	R16-0800	2478, 4034, 1718	37.64822577	-122.0586853	54.3	
16	10	R16-1000	2231	37.64650371	-122.0589169	30.2	
16	12	R16-1200	1589	37.64480403	-122.0592299	23	
16	14	R16-1400	2052	37.64300577	-122.0599999	20	
16	16	R16-1600	2206	37.64089077	-122.0603144	16.2	
16	18	R16-1800	3856	37.63952469	-122.0601231	14	
16	20	R16-2000	2814	37.63796238	-122.0604252	11.8	
17	2	R17-0200	3849	37.65366856	-122.0580666	142.7	
17	4	R17-0400	1511	37.65195656	-122.0588189	111.5	
17	6	R17-0600	2188	37.65026283	-122.0595913	55.2	
17	8	R17-0800	2473, 2752, 3664	37.64865526	-122.0602791	38.1	
17	10	R17-1000	2235	37.64683882	-122.0611402	26.6	
17	12	R17-1200	2092	37.6452507	-122.0618436	24	

17	14	R17-1400	2691	37.64343954	-122.062478	20.4	
17	16	R17-1600	1888	37.6418018	-122.0634518	18.3	
17	18	R17-1800	1696	37.64008359	-122.0645189	14.3	
17	20	R17-2000	2703	37.63835331	-122.0648547	11.1	
18	2	R18-0200	2214	37.65387995	-122.0583953	140.3	
18	4	R18-0400	2722	37.65226174	-122.0596199	104	
18	6	R18-0600	3744, 3745, 2906	37.65072056	-122.060793	52.7	
18	8	R18-0800	3773	37.64917946	-122.0619679	32.9	
18	10	R18-1000	3710	37.64763828	-122.0631427	28.5	
18	12	R18-1200	2016	37.64610096	-122.0643139	25.5	
18	14	R18-1400	2837	37.64448593	-122.0655682	21.1	
18	16	R18-1600	1765	37.64298742	-122.0666713	18.8	
18	18	R18-1800	1686	37.64143643	-122.0673249	15.7	
18	20	R18-2000	2582	37.63973692	-122.0688712	11.1	
19	2	R19-0200	1919	37.65402412	-122.058815	134.9	
19	4	R19-0400	1593	37.65270422	-122.060358	106.7	
19	6	R19-0600	2633, 1651, 1763	37.6515383	-122.0620408	45.2	
19	8	R19-0800	2007	37.65006451	-122.0634442	31.8	
19	10	R19-1000	2152	37.64874461	-122.0649872	27.5	
19	12	R19-1200	2038	37.64742849	-122.0665226	24	Bad File
19	14	R19-1400	2230	37.64610481	-122.0680714	21.9	
19	16	R19-1600	1817	37.64478492	-122.0696106	19	
19	18	R19-1800	2185	37.64346887	-122.0711517	16.4	
19	20	R19-2000	1714	37.64214898	-122.072691	13	
20	2	R20-0200	2575	37.65431405	-122.0591316	130.8	
20	4	R20-0400	2138	37.65328408	-122.0609913	95.1	
20	6	R20-0600	1665, 3969, 2675	37.65225411	-122.0628529	51.2	
20	8	R20-0800	4050	37.65153411	-122.0646299	32.3	
20	10	R20-1000	2799	37.65019418	-122.0665703	25.8	Stolen ?
20	12	R20-1200	2568	37.64908156	-122.0686744	21	
20	14	R20-1400	3925	37.64855602	-122.0706209	18.8	
20	16	R20-1600	4025	37.64710427	-122.0721455	17	
20	18	R20-1800	2504	37.6460743	-122.074007	14.5	
20	20	R20-2000	2745	37.64504434	-122.0758629	14	
21	2	R21-0200	2996	37.65466877	-122.0593738	116.6	
21	4	R21-0400	3822	37.65398489	-122.0614353	96.2	
21	6	R21-0600	3648	37.65331836	-122.0635777	66.2	
21	8	R21-0800	2759	37.65278536	-122.0658126	29.1	
21	10	R21-1000	1825	37.65196804	-122.0677795	23.9	
21	12	R21-1200	2277	37.65129279	-122.0698795	19	
21	14	R21-1400	3823	37.65096657	-122.0719888	17	
21	16	R21-1600	1875	37.65007541	-122.0743124	17	
21	18	R21-1800	1917	37.649271	-122.0761757	16	

21	20	R21-2000	2418	37.64854663	-122.0782858	15.6	
22	2	R22-0200	2084	37.6550732	-122.0595131	111.3	
22	4	R22-0400	2019	37.65479207	-122.0617718	105.2	
22	6	R22-0600	2194	37.65499299	-122.0644482	68.9	
22	8	R22-0800	3803	37.65408388	-122.066316	29	
22	10	R22-1000	2587	37.65417969	-122.0684895	21.5	
22	12	R22-1200	2390	37.65371894	-122.070713	18	
22	14	R22-1400	1904	37.65357887	-122.0730694	17	
22	16	R22-1600	4011	37.65318107	-122.0751877	17.8	
22	18	R22-1800	2072	37.65291025	-122.0774383	18	
22	20	R22-2000	3820	37.65247531	-122.0798996	18.6	
23	2	R23-0200	1732	37.65550043	-122.0595302	122	
23	4	R23-0400	2257	37.65571727	-122.0618319	100.3	
23	6	R23-0600	1523	37.65584425	-122.0640588	94.4	
23	8	R23-0800	3982	37.65586906	-122.0662496	57.1	
23	10	R23-1000	1778	37.65602136	-122.0685322	23.8	
23	12	R23-1200	1588	37.65627852	-122.070988	20	
23	14	R23-1400	1681	37.65647097	-122.0729459	21	
x	x	R23-1600	NA	37.65658764	-122.0753365	21.7	Not Deployed
23	18	R23-1800	2657	37.65674019	-122.0775852	22.2	
23	20	R23-2000	1649	37.65689274	-122.0798435	22.8	
24	2	R24-0200	2888, 2551, 2943	37.65590862	-122.0594254	128.6	
24	4	R24-0400	1908, 1934, NA	37.656477	-122.0615768	130.7	
24	6	R24-0600	2183, 1736, NA	37.65704152	-122.0637283	125.7	
24	8	R24-0800	1900, 3818, NA	37.65760613	-122.0658799	100.4	
24	10	R24-1000	1852, 3003, NA	37.6581745	-122.0680332	66.5	
24	12	R24-1200	1560, 2202, 2766	37.65873911	-122.0701752	30.7	
24	14	R24-1400	1573, 2810, NA	37.65930363	-122.0723286	27	
24	16	R24-1600	2232, 2618, NA	37.65986824	-122.07448	27.5	
24	18	R24-1800	2085	37.66060257	-122.0765815	28	
24	20	R24-2000	2498	37.66099736	-122.078785	29	
25	2	R25-0200	2258	37.65627483	-122.0592117	130.2	
25	4	R25-0400	1890	37.65723045	-122.0612499	134.5	
25	6	R25-0600	3927	37.65814022	-122.0630913	133.8	
25	8	R25-0800	3604	37.65905678	-122.0650703	115.6	
25	10	R25-1000	2447	37.660001	-122.0669702	98.4	
25	12	R25-1200	3796	37.6609184	-122.0688516	78.5	Disturbed
25	14	R25-1400	3933	37.66186715	-122.0708446	68.1	
x	x	R25-1600	NA	37.66279796	-122.0727806	48	Early Pickup
25	18	R25-1800	1728	37.66372869	-122.0747223	41.8	
25	20	R25-2000	2435	37.66466335	-122.0766678	36	
26	2	R26-0200	2535	37.65658379	-122.0589199	133	
26	4	R26-0400	1753	37.65797573	-122.0603754	135.6	

26	6	R26-0600	2613	37.65905955	-122.0622139	135	
26	8	R26-0800	2251	37.66029546	-122.06386	143.1	
26	10	R26-1000	4033	37.66153523	-122.0655079	139.7	
26	12	R26-1200	1735	37.66283677	-122.067163	127.4	
26	14	R26-1400	2217	37.66399356	-122.0687989	99.8	
26	16	R26-1600	2914	37.66524313	-122.0704422	87.4	
26	18	R26-1800	3901	37.6664829	-122.0720902	83.1	
26	20	R26-2000	3743	37.66771504	-122.0737381	62.1	
27	2	R27-0200	2250	37.65672017	-122.0586375	137.9	
27	4	R27-0400	1870	37.65830157	-122.059953	145.1	
27	6	R27-0600	1797	37.65964435	-122.0611631	142	
27	8	R27-0800	2531	37.66125678	-122.0624619	134.1	
27	10	R27-1000	2598	37.66273309	-122.0637588	99.2	
27	12	R27-1200	1889	37.66420553	-122.0650501	104.2	
27	14	R27-1400	3640	37.6656857	-122.0663509	107	
27	16	R27-1600	1871	37.66715814	-122.067646	69.4	
27	18	R27-1800	1760	37.66863822	-122.0689469	90	
27	20	R27-2000	1855	37.67016037	-122.0701053	81.7	
28	2	R28-0200	2561	37.6567513	-122.0580274	149	
28	4	R28-0400	1833	37.65872054	-122.0591856	149.9	Bad Data
x	x	R28-0600	NA	37.66029546	-122.0599976	123.6	Not Deployed
28	8	R28-0800	2651	37.66194728	-122.0609074	136.5	
28	10	R28-1000	2806	37.66359902	-122.0618171	129.5	
28	12	R28-1200	2446	37.66524699	-122.062727	75	
28	14	R28-1400	3981	37.6668911	-122.063633	110.4	
28	16	R28-1600	2451	37.66854669	-122.0645466	103.7	
28	18	R28-1800	2830	37.67010598	-122.0654569	92.7	Bad File
28	20	R28-2000	1747	37.67186978	-122.0664775	86	
29	2	R29-0200	2887	37.65695018	-122.0575123	158.8	
29	4	R29-0400	1988	37.65886115	-122.0582695	162.4	
29	6	R29-0600	1582	37.66061976	-122.0587673	133.9	
29	8	R29-0800	1657	37.66237828	-122.0592651	144.1	
29	10	R29-1000	2654	37.66413303	-122.059763	127.8	
29	12	R29-1200	1786	37.66563574	-122.0600988	81.9	
29	14	R29-1400	1841	37.66765025	-122.0607586	125.5	Same as 3799
29	16	R29-1600	3675	37.669405	-122.0612545	93	
29	18	R29-1800	3619	37.67135186	-122.0616118	113.8	
29	20	R29-2000	1950	37.6729145	-122.0622521	100.9	
30	2	R30-0200	3956	37.65714454	-122.0573463	156.4	
x	x	R30-0400	NA	37.65894505	-122.0574188	162.6	Uncertain
30	6	R30-0600	2408	37.66074942	-122.0574932	141.3	
30	8	R30-0800	3813	37.66392851	-122.057667	126.3	
30	10	R30-1000	2693	37.66432799	-122.0574474	105.7	

30	12	R30-1200	2182	37.66614343	-122.0577125	112.9	
30	14	R30-1400	3786	37.66794395	-122.057787	129	
30	16	R30-1600	1898	37.66974446	-122.0578613	108.2	
30	18	R30-1800	2153	37.67154506	-122.0579357	118	
x	x	R30-2000	NA	37.67334558	-122.0580101	100.1	Not Deployed

Appendix 2 (Near-Source)

FFID	Chan #	Station	DAS # (Z, N, E)	Latitude	Longitude	Elevation (m)
1003	1	ZI01	1861, 2089. 1711	37.65531823	-122.0563618	157.7
1003	2	ZI02	1697, 2045, 2163	37.65479191	-122.0567589	144.8
1003	3	ZI03	1923, 2413, 2241	37.65458843	-122.0574603	135.5
1003	4	ZI04	1989, 2204, 1605	37.65521712	-122.0581268	134.3
1003	5	ZI05	2564, 1684, 1687	37.65587619	-122.0577522	151.1
1003	6	ZI06	1868, 2144, 1583	37.65604936	-122.0570869	164.6

Appendix 3 (Linear)

FFID	Chan#	Station#	DAS # (Z, N, E)	Latitude	Longitude	Elev (m)	Comments
1001	x	L00000	NA	37.60695873	-122.1446096	1	Not Deployed
1001	x	L00400	NA	37.60901758	-122.1408931	0	Not Deployed
1001	x	L00800	NA	37.61107651	-122.1371767	0	Not Deployed
1001	x	L01200	NA	37.61313544	-122.1334603	0	Not Deployed
1001	x	L01600	NA	37.61519428	-122.1297438	2	Not Deployed
1001	x	L02000	NA	37.61725321	-122.1260274	0.3	Not Deployed
1001	x	L02400	NA	37.61931206	-122.122311	2.3	Not Deployed
1001	x	L02800	NA	37.62137099	-122.1185945	2	Not Deployed
1001	32	L03200	1806	37.62342992	-122.1148781	2.3	
1001	36	L03600	1796	37.62548877	-122.1111616	3	
1001	40	L04000	2440	37.6275477	-122.1074452	5.3	
1001	44	L04400	1618	37.62960663	-122.1037288	7	
1001	48	L04800	2179	37.63166548	-122.1000123	8	
1001	52	L05200	2249	37.63372449	-122.0962959	9	
1001	56	L05600	1594	37.63578342	-122.0925794	12.9	
1001	x	L06000	NA	37.63784227	-122.088863	12	Not Deployed
1001	64	L06400	2082	37.6399012	-122.0851466	10	
1001	68	L06800	2140	37.64196013	-122.0814301	10.9	
1001	x	L07200	NA	37.64401898	-122.0777137	11	Not Deployed
1001	76	L07600	2504	37.64607799	-122.0739973	14.5	-1800
1001	80	L08000	3925	37.64813709	-122.070281	19.7	-1400
1001	84	L08400	2799	37.65019619	-122.0665647	25.8	R20-1000,

1001	88	L08800	1665, 3969, 2675	37.65225529	-122.0628483	51.3	-600
1001	92	L09200	2575	37.65431447	-122.059132	130.8	-200
1001	x	L09600	NA	37.65637483	-122.0554133	168	R05-200, DAS#?
1001	100	L10000	2181	37.65843627	-122.0516922	154.8	-600
1001	104	L10400	1672	37.6604978	-122.0479711	189.8	-1000
1001	108	L10800	3887	37.66255933	-122.04425	197.4	-1400
1001	112	L11200	1873	37.66462077	-122.0405289	165.4	-1800
1001	116	L11600	2685	37.66665875	-122.0367597	188.8	
1001	120	L12000	2233	37.66874383	-122.0330866	235.4	
1001	124	L12400	3672	37.67080536	-122.0293655	286.2	
1001	x	L12800	NA	37.67286689	-122.0256444	205.5	Not Deployed
1001	x	L13200	NA	37.67492842	-122.0219233	239	Not Deployed
1001	136	L13600	2033	37.67808421	-122.0160825	131.9	At L13800
1001	140	L14000	2008	37.67898669	-122.0147553	131.3	
1001	144	L14400	2400	37.68111292	-122.01076	199.5	
1001	148	L14800	2423	37.68375163	-122.0061244	187.8	
1001	152	L15200	2707	37.68523598	-122.0033178	215.3	
1001	156	L15600	1749	37.68717572	-121.9997536	263.1	
1001	160	L16000	2443	37.68935904	-121.9958755	349.5	
1001	164	L16400	2506	37.69038968	-121.994015	353	At 16200
1001	168	L16800	3659	37.69348201	-121.9884333	349.9	Site Disturbed
1001	172	L17200	2223	37.69554346	-121.9847122	268.5	
1001	176	L17600	3588	37.69766567	-121.9808076	210.8	
1001	180	L18000	2509	37.69991621	-121.9774974	234.4	
1001	184	L18400	3791	37.70172813	-121.9735489	305.7	
1001	188	L18800	2458	37.70378958	-121.9698278	320.5	
1001	192	L19200	2091	37.70547451	-121.9671092	254.4	
1001	196	L19600	3817	37.70687655	-121.9642347	292.6	
1001	200	L20000	1647	37.70997408	-121.9586644	160.7	
1001	204	L20400	1822	37.71203561	-121.9549433	246.2	
1001	208	L20800	2422	37.714146	-121.9511368	198.7	
1001	212	L21200	2586	37.71655278	-121.9469331	153.2	
1001	216	L21600	1604	37.71811207	-121.9436779	155.7	
1001	220	L22000	2362	37.72014602	-121.9400066	122.5	
1001	224	L22400	3569	37.72215667	-121.9363386	118	
1001	228	L22800	1948	37.72451861	-121.9326106	112	
1001	232	L23200	1547	37.72646623	-121.9288956	107	
1001	236	L23600	3590	37.72838753	-121.9254022	107	
1001	328	L23800	2910	37.72935748	-121.9233625	109.3	Extra Site
1001	244	L24400	2475	37.73265082	-121.9177322	148.1	
1001	x	L24800	NA	37.73471226	-121.9140111	125.4	Not Deployed
1001	250	L25000	1842	37.73564743	-121.9123854	126.4	Extra Site

Appendix 4 (Schools)

FFID	Chan #	Station	DAS # (Z, N, E)	Latitude	Longitude	Elevn (m)	Comments
1004	3	S03	2170	37.67594087	-122.0991812	22	
1004	7	S07	1676	37.68040918	-122.0520909	122.2	Uncertain
1004	7	S07ALT	1676	37.68051077	-122.0533226	114.1	Uncertain
1004	11	S11	3706	37.6588086	-122.1105759	15.9	
1004	16	S16	1526	NA	NA	NA	Uncertain
1004	17	S17	2079	37.62715836	-122.074473	5.8	
1004	21	S21	3677	37.68781543	-122.0877363	58	
1004	22	S22	2805	37.62336035	-122.0379814	13.3	
1004	31	S31	2164	37.67309002	-122.0982174	23	
1004	33	S33	1678	37.65608758	-122.1072539	17	
1004	34	S34	2892	37.62433165	-122.0637737	4	
1004	37	S37	2565	37.68700398	-122.0697938	52.7	

Appendix 5 (Cross-Fault)

(a) Carlos Bee

FFID	Chan#	Station	DAS # (Z, N, E)	Latitude	Longitude	Elev (m)
1008	1	FZ1W	1710, 1869, 1939	37.65954	-122.07176	29.3
1008	2	FZ	2474, 4010, 1847	37.65984	-122.07137	36.9
1008	3	FZ1E	3892, 2718, 2077	37.66016	-122.07093	46.5
1008	4	FZ2E	2121, 1803, 2416	37.66087	-122.07006	66.8

(b) Chabot

FFID	Chan#	Station	DAS# (Z, N, E)	Latitude	Longitude	Elev (m)	Comments
1007	1	FZW	2552, 2050, 2161	37.71792	-122.12257	99.7	
1007	2	FZ	2469, 4023, 2866	37.71825	-122.12152	86.1	
1007	3	FZE	1624, 2265, 1577	37.71843	-122.12083	94.2	

Appendix 6 (In-Line FZ)

FFID	Chan #	Station	DAS # (Z, N, E)	Latitude	Longitude	Elev (m)	Comments
1006	1	F1	3950, 2539, 2590	37.70784	-122.11674	33.2	
1006	2	F2	2922, 2583, 4009	37.70003	-122.11003	23.9	
1006	3	F3	3850, 3884, 3716	37.68783	-122.1005	23.2	
1006	4	F4	3868, 2757, 3979	37.71478	-122.12106	65.2	

1006	5	F5	2833, 3787, 3631	37.67514	-122.0861	46.5
1006	6	FZ	2469, 4023, 2866	37.71825	-122.12152	86.1
1009	7	FZN	3821, 4053, 2902	37.72309	-122.12419	141.8

Appendix 7 (Far Field)

FFID	Chan#	Station	DAS # (Z, N, E)	Latitude	Longitude	Elev (m)
1005	1	Offline01	2252	37.68105	-122.09068	25.4
1005	2	Offline02	2403	37.633874	-122.060708	8
1005	7	Offline07	1839	37.451964	-122.158755	15
1005	8	Offline08	1830	37.53062	-121.990559	12
1005	10	Offline10	1819	37.647681	-122.030232	241.5
1005	12	Offline12	1780	37.440934	-122.125824	2
1005	13	Offline13	2412	37.438663	-122.142449	8
1005	14	Offline14	2479	37.661975	-122.0559	145.3
1005	15	Offline15	4020	37.677081	-122.087684	41.5
1005	16	Offline16	3934	37.69676	-122.06406	61.4
1005	17	Offline17	1724	37.69676	-122.09544	130.3
1005	18	Offline18	1525	37.82	-122.25031	42.1
1005	19	Offline19	2591	37.84232	-122.25031	54.4
1005	20	Offline20	2468	37.81645	-122.24857	35.5
1005	21	Offline21	3602	37.78045	-122.27437	3.4
1005	22	Offline22	1677	37.523747	-122.27098	4
1005	23	Offline23	2699	37.895645	-122.266678	220.2
1005	24	Offline24	2855	37.87237	-122.287485	23.6
1005	25	Offline25	1994	37.590881	-122.061955	5
1005	26	Offline26	3595	37.70733	-122.08404	78.5