APPENDIX B
SUPPLEMENTAL TO SURFACE FAULT RUPTURE ASSOCIATED WITH THE M6.0 SOUTH NAPA EARTHQUAKE OF AUGUST 24, 2014

National Science Foundation (NSF)
Geotechnical Extreme Events Reconnaissance (GEER)

The intent of this appendix is to provide a forum for the contributors to this report a place for additional figures, observations, and interpretations collected in the field not included in Section 3. The appendix sections are organized by field team and include additional figures and downloadable files. For further information regarding the individual subsections, please contact the field team lead.

Appendix B.1: Kelson and Wesling Detailed Observations
Appendix B.2: Leslie F. Harder, Preliminary Observations
Appendix B.3: Fugro observations
Appendix B.4: U.C. Davis observations, made available on SCEC Earthquake Response site via Dropbox: https://ucdavis.app.box.com/s/9zsz84638fp90grhikzx

B.1 Preliminary Observations of Surface Cracking Within the Epicentral Area of the M6.0 South Napa Earthquake of August 24, 2014

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B.1.1 Introduction / Overview

The South Napa M6.0 earthquake generated surface fault rupture over a length of approximately 12 to 15 km (Figure 1). This surface faulting extends from the northwestern bank of the Napa River at the Napa Sea Ranch (Cuttings Wharf area), northward through the Browns Valley residential area, and to Allston Park in the northwestern part of the City of Napa. In the epicentral area, rupture generally occurred along previously mapped traces of the West Napa fault. North of the epicentral area, rupture occurred along or between multiple strands of the West Napa fault and includes a complex pattern of north- to northeast-striking cracks and contractional deformation. South of the epicentral area, surface cracking coincided with mapped traces of the West Napa fault near the Napa County Municipal Airport, which may represent either surface rupture or triggered slip.

In the epicentral area, the rupture strikes about 340˚ to 345˚ (N20W to N15W) and is expressed as an *en echelon* pattern of left-stepping cracks that strike about 360 to 030 (N to N30E). At the time of this writing, a large percentage of the observed cracking occurred after the main earthquake energy release, as “afterslip” during a period at least 48 hours in duration.

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B.1.2 Fault Rupture in the Epicentral Area (Napa Sea Ranch to Congress Valley Rd)

This Appendix describes the primary characteristics of the surface fault rupture in the epicentral area, herein defined as the area from the epicentral location (Figure 1; 38.220˚, -122.313˚, http://earthquake.usgs.gov/earthquakes/eventpage/nc72282711#summary), north to Oak Rock Lane (38.296˚, -122.344˚). This section of the surface rupture is continuous, essentially straight along an azimuth of 340˚ to 345˚, and has distinct surface cracking along a length of about 9.3 km.

The southern end of this fault section is defined here as the western bank of the Napa River at the Napa Sea Ranch, where the rupture extends into an area affected by tidal-dominated river stages. The northern end of the epicentral section is defined here at Oak Rock Lane (38.296˚, -122.344˚), based on field observations of surface cracking to the south, a change in fault orientation from 340˚ to 360˚, and the northern extent of maximum slip distribution (USGS, 2014; (http://earthquake.usgs.gov/earthquakes/eventpage/nc72282711#scientific_finite-fault).

Much of the rupture is easily discernible where it extends through well-groomed vineyard crop rows and adjacent dirt farm roads; where the rupture extends into untilled, tall grassy fields, the cracking is difficult to identify and measure. As a result, rapid field-based offset measurements were easily obtained in vineyards and adjacent roadways, but were very difficult in untilled grassy areas. Also, the central part of the fault rupture includes several roadway crossings that allow for distinct identification of the fault trace and measurement of dextral fault offset.

Throughout this central section of the fault, the fault is expressed as a NW-striking zone of cracks arranged in an *en echelon* pattern (Figures 2 and 3). The zone of cracks generally ranges from about 2 to 10 m wide, measured orthogonal to fault strike, and includes cracks that range in length from about 5 to 10 m long (Figure 4). At the Stone Bridge School in the Carneros District of Napa County, the cracks developed in an asphalt parking lot project northward and in the adjacent dirt yard, cross a large-diameter gas transmission pipeline (Figure 5). The GEER team obtained anecdotal information suggesting little or no deformation of the pipeline, but was unable to collect specific offset information from the pipeline. In dirt areas, the cracks are well developed where not disturbed, and show a similar left-stepping pattern (Figure 6). The cracks almost exclusively show extension of the native ground, and are best expressed across relatively compacted dirt farm roads (Figure 7) or tilled vineyards (Figure 8). Where the rupture passes beneath road asphalt (Figure 9), the cracking tends to be narrower but more distinct, although the measurable amount of right-lateral offset appears to be lower than adjacent total offsets by about 10% to 50%.

At almost all locations, the pattern of surface deformation is consistent with right-lateral shearing, as observed in other lateral-slip earthquakes and summarized in structural geology textbooks. For example, the pattern of deformation across Los Carneros Road near the Stone Bridge School consists of left-stepping en echelon cracks at various scales, antithetic extensional cracks, and contractional features (Figure 10). Based on the originally horizontal plane of asphalt provided by Los Carneros Road, and the originally straight centerline striping, the pattern of deformation is similar to the textbook models of strike-slip deformation (Figure 11).

Field Measurements of Lateral Offset

Surface rupture involved both discrete right-lateral offset across individual cracks within the rupture zone, as well as ductile (folding) deformation over areas as much as 10 m wide. At many locations, reported offset measurements are minimum values because of the presence of multiple

cracks within the rupture zone, and/or because of distributed deformation adjacent to the rupture zone. In addition, the observation of continued post-earthquake surface deformation ("afterslip", see below) indicates temporal variations in the amount of offset, so that the time of the offset measurement should also be noted. A summary of the limited field measurements is provided in Table 1.

The maximum offset measured during the initial, rapid-response GEER reconnaissance was obtained at a site approximately 6.7 km northwest of the M6.0 epicenter, in the northern part of the Clos du Val Vineyards. On August 25 (1430 hrs), members of the GEER team measured 40 to 45 cm right-lateral offset of a linear array of wooden vineyard posts (Figure 12). The measurement was made by extending a fiberglass tape along the southern edge of the wooden posts on the eastern side of the fault, and measuring the offset of posts on the western side of the fault (Figure 13). At this site, the fracture zone is essentially perpendicular to the vineyard rows, and is about 3 m wide. Warping adjacent to the fault extended about 5 to 7 m on both sides of the fault, and little or no measurable deformation was observed beyond the zones of brittle and warping deformations. Qualitative observations within the entire vineyard plot at this site suggests that the right-lateral offset decreased only slightly to the north and south, and probably was in the 30 to 40 cm through most of this plot. This site is on a low-gradient alluvial fan derived from rounded hills to the northwest; there is no topographic scarp associated with the fault rupture, and there is not a strong geomorphic expression of pre-existing fault-related topography.

Notably, this location coincides well with USGS slip distribution models (http://earthquake.usgs.gov/earthquakes/eventpage/nc72282711#scientific_finite-fault), which suggest that the maximum slip on the fault at depth occurred between Henry Road on the south, and Oak Rock Lane on the north. The offset measurement described here is located about 0.5 km north of Henry Road and above this zone of maximum slip. The site is about 7 km north of the epicenter, which corroborates seismological data indicative of a northerly-directed rupture at depth (Figure 14). The spatial relationship of this site to the cross-section slip distribution suggests that areas along the rupture directly to the north, to perhaps Oak Rock Lane, probably also have a comparable amount of right-lateral offset.

Other limited field measurements by the GEER reconnaissance team suggest that there was about 20 to 30 cm of right-lateral offset along most of the rupture in the epicentral area. Right-lateral offsets of 20 to 25 cm were measured on August 25 (1130 hrs and 1150 hrs) at two sites directly north of Old Sonoma Road (Figures 15 and 16, respectively). The fracture zone is about 3 m wide, and typically consisted of one or two primary open cracks with no vertical separation. These sites are about 5.5 km north of the epicenter and are within the southern part of the Clos du Val Vineyard parcel (Figure 16). Field discussion with the operation manager at these sites indicated that the metal posts in this vineyard were placed in a linear array and surveyed via GPS methods; the posts in adjacent rows were claimed to be exactly 7.5 ft apart, providing confidence that the posts were arranged in a straight line prior to the rupture. The rupture through this vineyard extended across an east-facing colluvial slope, and exhibited a subtle mid-slope depression. Aerial reconnaissance of this site on August 27 (1108 hrs) showed a distinct color-difference lineament in the vineyard that coincides with the observed surface rupture (Figure 17).

Right-lateral offset of 20 to 25 cm also was measured at a site located south of Las Amigas Road, about 1.2 km north of the epicenter (Poseidon Vineyard, Figure 18). This measurement was made on September 2 (1800 hrs); qualitatively, the amount of deformation was noticeably greater than that observed during a prior visit by the GEER team on August 25. Similar to the sites described above, the fault rupture included a 5-m-wide zone of extensional cracks, arranged in an

en echelon pattern through the vineyard. The zone of fracturing coincides with a subtle topographic trough that traverses the vineyard, and is about 200 m east of a prominent linear escarpment bordering the floodplain of lower Carneros Creek. About 350 m south of the measurement site, the rupture zone intersects and coincides with an anomalously straight reach of lower Carneros Creek, and then continues southward to the surface features noted at Napa Sea Ranch (Figure 2).

Field Evidence of Afterslip

The amount and character of the surface deformation associated with the M6.0 South Napa earthquake evolved through the hours and days following the main shock at 3:20 am local time on August 24, 2014. There have been and will be many observations along the fault rupture by numerous workers, and these should be interpreted in context of the temporal changes in post-earthquake surface deformation ("afterslip"). This section presents a few field observations of the rupture during the few hours and days after the main shock, and may provide a basis for interpreting the temporal pattern of afterslip deformation.

Initial observations were made of the surface rupture at the Highway 12 fault crossing, near the intersection of Cuttings Wharf Road (4.2 km NW of the epicenter). Approximately 2.5 hrs after the main shock (at 5:45 local time), the northern edge of the highway asphalt was slightly buckled, and the centerline and sidelines exhibited little or no lateral offset (Figure 19). Minor cracking in the adjacent dirt embankments and vineyards was observed to consist of a series of left-stepping open cracks. Because of darkness and hazardous highway conditions, no measurements were made at that time. Approximately 2 hours later (local time 0745), observation of the highway fault crossing showed that the buckling on the northern part of the asphalt was substantially greater, and there was a few cm of lateral offset (Figure 20). As of September 2, subsequent observations have shown as much as about 20 to 25 cm of lateral offset across the zone at this location.

A similar temporal pattern of deformation occurred across the south-trending Cuttings Wharf Road directly south of Highway 12. At about 6:00 am local time on August 24 (about 3.5 hours after the main shock), there was no scarp or cracking across the asphalt. By about 10:00 am local time on August 25 (28 hours later) a 10-cm high scarp had developed (Figure 21). Subsequent to August 25, asphalt patches have been cracked and offset, which demonstrate continued surface deformation. Continued surface deformation is also demonstrated by cracking and offsets of road patches across Las Amigas Road, located about 2.0 km NW of the epicenter.

Post-earthquake surface deformation is also shown by observation of only minor deformation of Old Sonoma Road in the early hours of August 24 (Figure 22). At 0730 on August 24, a series of en echelon cracks had developed in the centerline striping of the road, with only minor offset and vertical uplift (Figure 23). Within 27 hours, this deformation was more distinct, and involved several centimeters of uplift across the road. The roadway was repaired soon thereafter, and there have been no subsequent notes on deformation at this fault crossing.

B.1.3 Summary and Conclusions

The South Napa M6.0 earthquake generated surface fault rupture over a length of approximately 12 to 15 km, from the northwestern bank of the Napa River near Cuttings Wharf, northward to the northwestern part of the City of Napa. In the epicentral area, rupture occurred along previously mapped traces of the West Napa fault, although additional offset occurred to the north

and south of the previously mapped traces. In the epicentral area, the rupture strikes about 340˚ to 345˚ (N20W to N15W) and is expressed as an *en echelon* pattern of left-stepping cracks that strike about 360 to 030 (N to N30E). The largest measurement of right-lateral offset made by the authors was at a site about 7.3 km north of the epicenter, and showed an offset of vineyard rows of 40 to 45 cm. This measurement is consistent with existing slip distribution models produced by the USGS, as are measurements of lesser offsets in areas closer to the epicenter. These measurements also corroborate interpretations that the earthquake rupture at depth had a northward-directed pattern. Based on observations at multiple sites during the days following the earthquake, a large percentage of the observed cracking occurred after the main earthquake energy release, as "afterslip". The pattern and duration of this afterslip will likely be defined more definitively through subsequent detailed analyses, but our observations suggest the much of the offset occurred during a period of at least 48 hours in duration.

Table 1. Offset measurements along the central surface fault rupture produced by the M6.0 South Napa earthquake [NSF-GEER: Kelson and Wesling; 08/25/14 and 9/2/14]

Date	Time	Site Number	Site Name	Latitude	Longitude	Fault zone strike	Measurement Azimuth	Apparent Offset (cm)	True Lateral Offset (cm)
25-Aug-14	1130	20140825-kik009	south Clos du Val-1	N38.2669	W122.3341	005	148	20 to 25	25 to 31
25-Aug-14	1150	20140825-kik011	south Clos du Val-2	N38.2672	W122.3343	005	148	20 to 25	25 to 31
25-Aug-14	1430	20140825-kik027	north Clos du Val	N38.2776	W122.3377	355	090	40 to 45	41 to 46
2-Sep-14	1915	20140902-kik027	Poseidon Vineyard	N38.2314	W122.3153	330	090	20 to 25	23 to 29

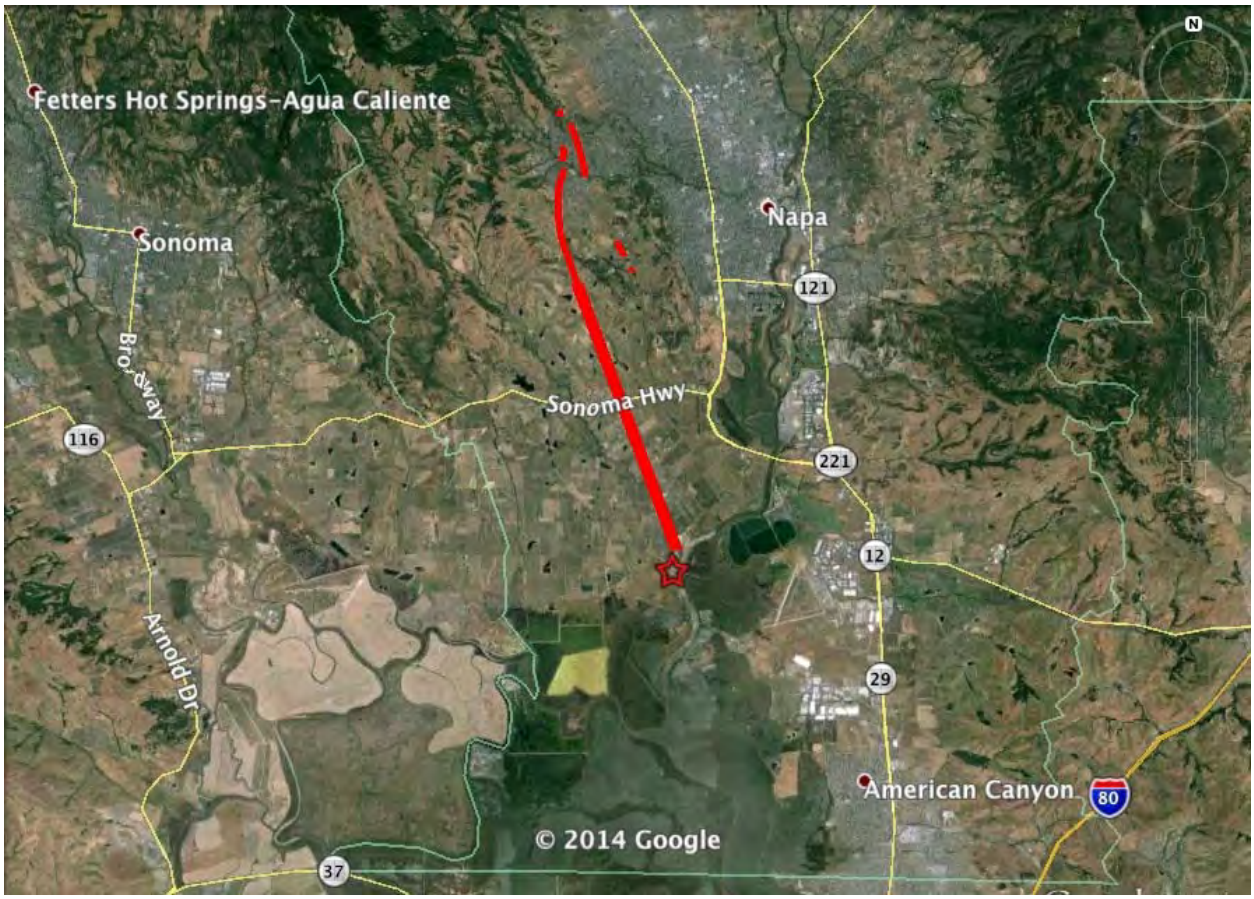

Figure 1. General map of surface fault rupture associated with the M6.0 South Napa earthquake of August 24, 2014.

Figure 2. Surface fault rupture at Napa Sea Ranch (0.5 km NW of epicenter), showing left-stepping pattern of transtensional cracking. Near-vertical view to the east. [NSF-GEER; GPS N38.225 W122.312; 08/25/14: 11:57 am]

Figure 3. Surface fault rupture at South Avenue (2.5 km NW of epicenter), showing left-stepping pattern of transtensional cracking within vineyard, across asphalt, and directly east of residence. Oblique view to the south. [NSF-GEER; GPS N38.242 W122.320; 08/27/14: 11:59 am]

Figure 4. Surface fault rupture at Stone Bridge School (2.7 km NW of epicenter), showing left-stepping pattern of transtensional cracking within asphalt parking lot. View to north-northwest. Overall fault zone strikes 340, cracks strike about 020 to 040. [NSF-GEER; GPS N38.2436 W122.3212; 08/25/14: 3:38 pm]

Figure 5. Oblique aerial photographs of the Stone Bridge School parking lot (Figure 4). Upper photo taken on August 27, 2014; 12:01 pm); view to northwest; cracks extend northwestward from parking lot into adjacent yard. Lower photo taken (by L. Harder, Sept 1; near-vertical) showing pipeline trench excavation along southern border of yard adjacent to school parking lot. [NSF-GEER; school lot: GPS N38.2436 W122.3212]

Figure 6. Surface fault rupture at horse corral west of Cuttings Wharf Road (3.9 km NW of epicenter), showing left-stepping pattern of transtensional cracking across compacted dirt slope. View to south-southeast. Individual cracks have as much as 5 cm lateral offset. [NSF-GEER; GPS N38.2536 W122.3262; 09/02/14: 6:07 pm]

Figure 7. Surface fault rupture at central part of Clos du Val Vineyard (5.9 km NW of epicenter), showing left-stepping pattern of transtensional cracking within compacted dirt farm road. View to south-southeast. [NSF-GEER; GPS N38.271 W122.335; 08/25/14: 12:10 pm]

Figure 8. Surface fault rupture at vineyard directly south of Highway 12 and east of Cuttings Wharf Road (4.1 km NW of epicenter), showing left-stepping pattern of transtensional cracking within vineyard. View to south. [NSF-GEER; GPS N38.2557 W122.3270; 08/25/14: 9:49 am]

Figure 9. Surface fault rupture at Henry Road (6.2 km NW of epicenter), showing left-stepping pattern of transtensional cracking across asphalt. View to southeast. Offset across most prominent crack within this zone is as much as 6 cm, but offset across entire zone measure in adjacent vineyard is about 40 cm [NSF-GEER; GPS N38.2732 W122.3366; 08/25/14: 1:45 pm]

Figure 10. Surface fault rupture at Los Carneros Road (2.5 km NW of epicenter), showing offset of centerline and complex, small-scale deformation in ductile asphalt. View to north. Compare with close up of centerline in Figure 11. [NSF-GEER; GPS N38.2432 W122.3209; 08/25/14: 3:31 pm]

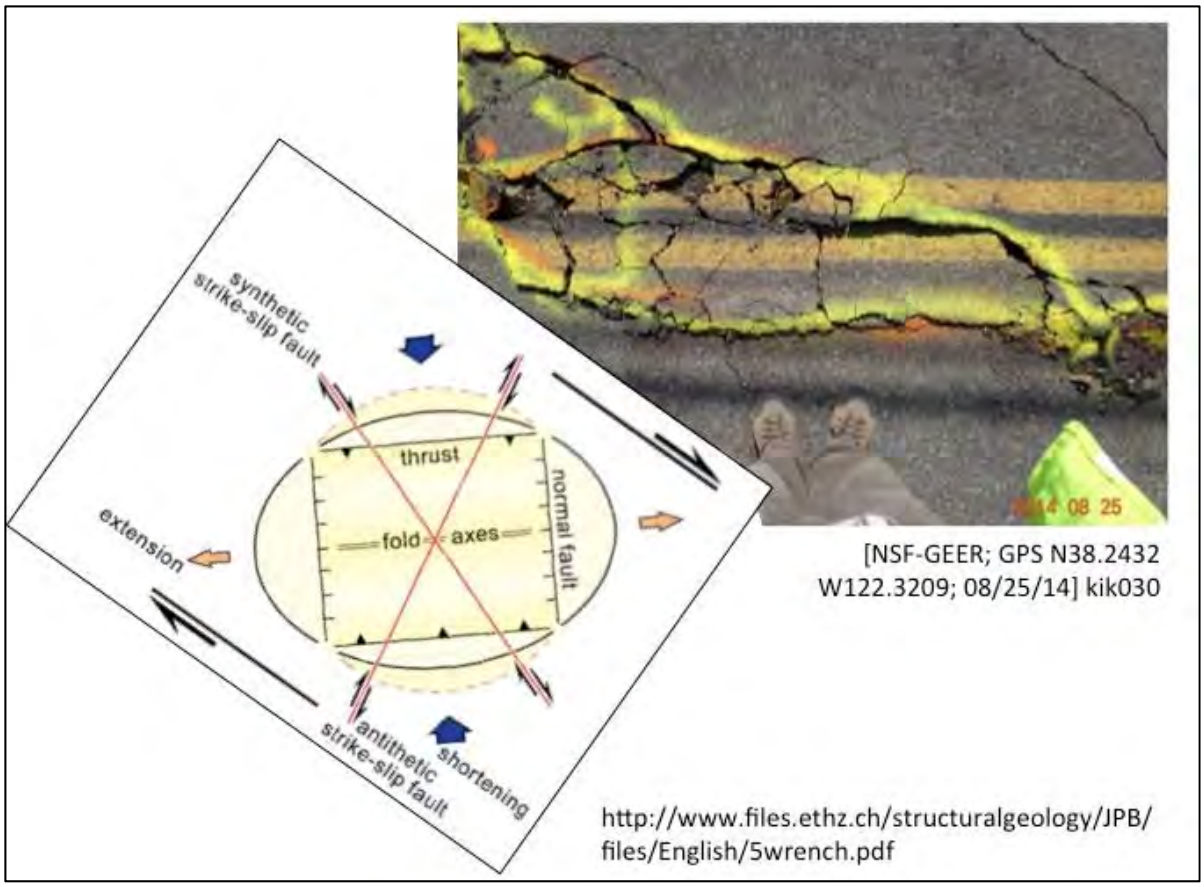

Figure 11. Surface deformation of the centerline of Los Carneros Road (2.5 km NW of epicenter), showing complex, small-scale deformation in ductile asphalt. View is vertical. Deformation is consistent with textbook models of pure shear. [NSF-GEER; GPS N38.2432 W122.3209; 08/25/14: 3:32 pm]

Figure 12. Surface fault rupture at northern part of Clos du Val Vineyard near 2121 Buhman Avenue (6.7 km NW of epicenter), showing measurement alignment along azimuth 090. Yellow engineer's scale is located west of fault zone; offset location is also discernible via offset of vine shadow within the vineyard row. [NSF-GEER; GPS N38.2776 W122.32377; 08/25/14: 2:23 pm]

Figure 13. Surface fault rupture at northern part of Clos du Val Vineyard near 2121 Buhman Avenue (6.7 km NW of epicenter), showing measurement alignment along azimuth 090. Yellow engineer's scale shows measurement of 40 to 45 cm from base of thick wooden post; tape placed along southern edge of wooden posts aligned on east side of fault zone. [NSF-GEER; GPS N38.2776 W122.3377; 08/25/14: 2:24pm]

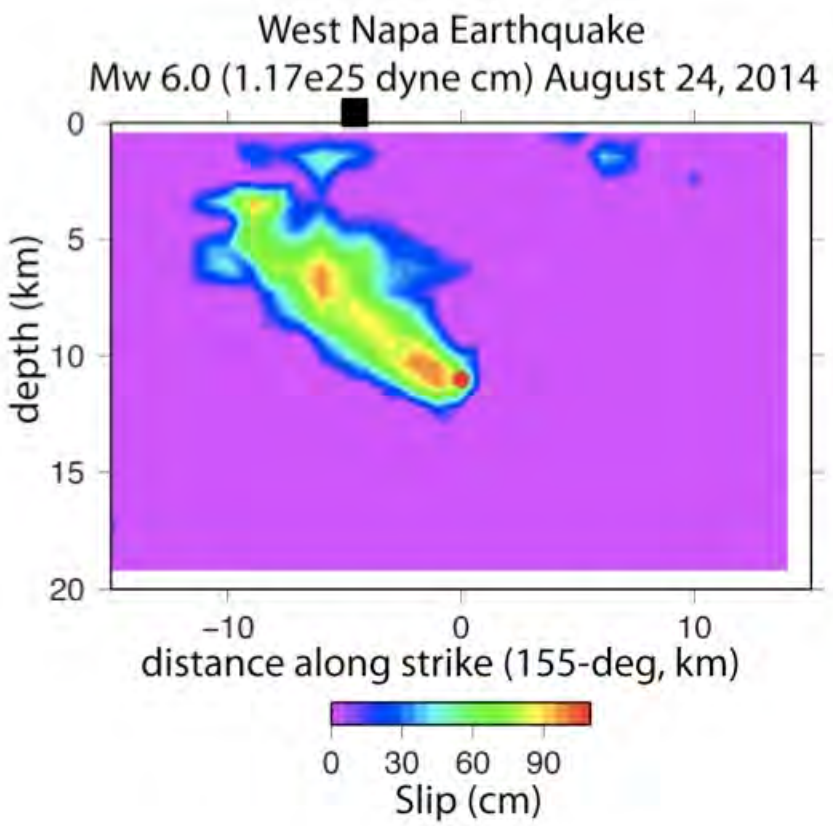

Figure 14. Cross section of slip distribution of the South Napa earthquake, from USGS (http://earthquake.usgs.gov/earthquakes/eventpage/nc72282711#scientific_finite-fault; accessed September 14, 2014; 1800), modified to show approximate location of largest field measurement of right-lateral offset at northern Clos du Val vineyard (black square at surface added by authors).

Figure 15. Surface fault rupture at southern part of Clos du Val Vineyard near Old Sonoma Road (5.6 km NW of epicenter), showing measurement alignment along azimuth 058. Yellow engineer's scale is located west of fault zone, showing 20 to 25 cm of apparent lateral offset. Tape was aligned at base of metal stakes east of fault zone. [NSF-GEER; GPS N38.2669 W122.3341; 08/25/14: 11:19 am].

Figure 16. Surface fault rupture at southern part of Clos du Val Vineyard near Old Sonoma Road (5.6 km NW of epicenter), showing measurement alignment along azimuth 058. This vineyard row is about 40 m northwest of similar row shown on Figure 12; also shows 20 to 25 cm of apparent lateral offset. Geologist Wesling standing on fault zone [NSF-GEER; GPS N38.2672 W122.3343; 08/25/14: 11:51 am]

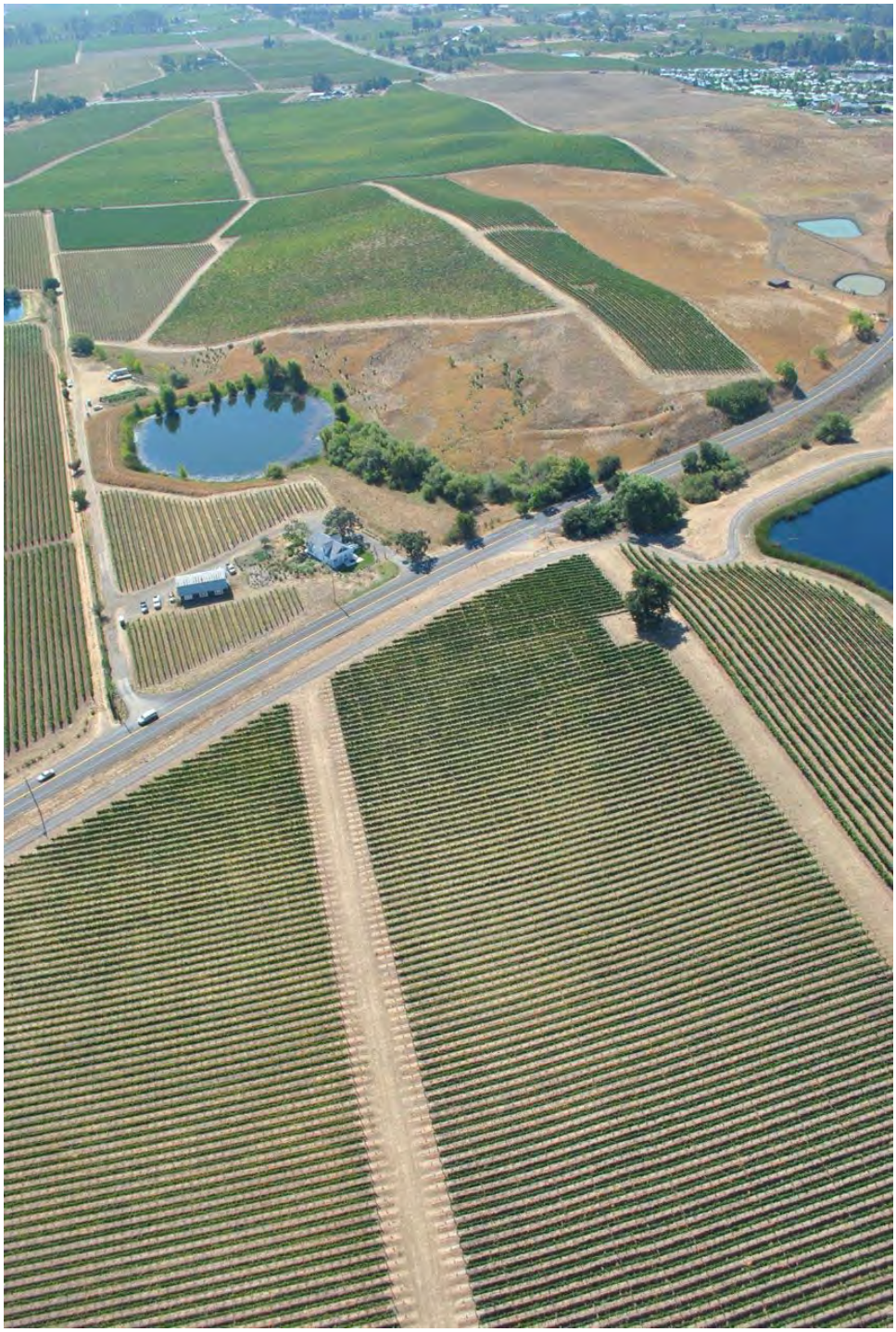

Figure 17. Oblique aerial view looking southeast along rupture toward the vineyard sites measured in Figures 11 and 12, in southern part of Clos du Val Vineyard near Old Sonoma Road (5.6 km NW of epicenter). Note prominent tonal lineament through vineyard north of Old Sonoma Road, which coincides with the 2014 surface rupture. [NSF-GEER; GPS N38.268 W122.334; 08/27/14: 12:07 pm]

Figure 18. Surface fault rupture at Poseidon Vineyard south of Las Amigas Road (1.2 km NW of epicenter), showing measurement alignment along azimuth 090. Yellow engineer's scale is located west of fault zone, showing 20 to 25 cm of apparent offset. [NSF-GEER; GPS N38.2314 W122.3153; 09/02/14: 7:17 pm]

Figure 19. Surface fault rupture at Highway 12 (4.2 km NW of epicenter), showing buckling of asphalt on northern margin and minor lateral offset. Taken at 0554 local time, this photograph precedes road repairs. [NSF-GEER; GPS N38.256 W122.327; 08/24/14: 5:54 am]

Figure 20. Surface fault rupture at Highway 12 (4.2 km NW of epicenter), showing increased buckling of asphalt on northern margin and lateral offset. Taken at 0746 local time, this photograph precedes road repairs. [NSF-GEER; GPS N38.256 W122.327; 08/24/14: 7:46 am]

Figure 21. Surface deformation at Cuttings Wharf Road (4.0 km NW of epicenter), showing recent development of scarp across asphalt (photograph taken at 1000). Field reconnaissance at 0600 on August 24, 2014 observed no deformation along the road at this site. [NSF-GEER; GPS N38.2544 W122.3265; 08/25/14: 9:57 am]

Figure 22. Surface deformation at Old Sonoma Road (5.4 km NW of epicenter, photograph taken at 0730, about 4 hours after main shock). Compare with photograph in Figure 23 [NSF-GEER; GPS N38.2659 W122.3338; 08/24/14: 7:34 am].

Figure 23. Surface deformation at Old Sonoma Road (5.4 km NW of epicenter, photograph taken onAugust 25 at 1036, about 29 hours after main shock). Compare with photograph in Figure 22 [NSF-GEER; GPS N38.2659 W122.3338; 08/25/14: 10:36 am].

B.2 Supplemental Preliminary Observations of Surface Cracking

B.2.1 Introduction

This document summarizes observations of surface cracking made within 5 to 14 days following the main shock of the August 24, 2014 Magnitude 6 Napa, California Earthquake (August 27 to September 7, 2014). The surface cracks were observed mainly on roadways in western Napa County and at least some of them are quite likely associated with surface rupture of the causative fault for the earthquake. Two main alignments of ground cracking potentially associated with fault rupture (A and B) were observed. The principal alignment of ground cracking (Alignment A) was observed from the epicentral area running semi-linearly north-northwest to a point on Redwood Road (Point A1) northwest of Brown's Valley (see green dashed line in Figure 1). No significant cracking was observed on Dry Creek Road north of Redwood Road (Point A1), thus potentially limiting the northern extent of potential surface rupture.

The total length of potential surface rupture between Points A1 and A14 (green dashed line) would thus be estimated to be approximately 12½ kilometers, running from Las Amigas Road (Pointe A14) to Redwood Road (Point A1). The length of rupture could potentially be greater given that the southern end of observed rupture ended in the marshy waters associated with the Napa River and thus could not be observed further south. Point A15 is located on Milton Road on the southern portion of Edgerley Island where ground cracking across the road was observed. However, it was not clear that this ground cracking represents the surface expression of the fault rupture as it was south of the epicenter and the pattern of cracking was not definitive. Nevertheless, the potential for surface fault rupture would have to be assumed to be somewhat greater than the 12½ kilometers observed across roadways.

A second semi-linear alignment of ground cracking, Alignment B (orange line in Figure 1), was also observed about 800 meters to east of Alignment A. Where observed, it had crack dimensions and offsets similar in magnitude to those associated with Alignment A.

B.2.2 Observation Approach

The general approach was to first estimate the general location where potential surface ground rupture might have occurred and to then drive to roadways where the rupture might cross and thus be observed. In many cases, the ground cracking was easily observed more or less where it was expected to be. By the time the observations were made, many of the areas of roadway cracking had already been repaired by City of Napa, Napa County, and Caltrans forces. However, several locations where ground cracking/rupture occurred had not been repaired at the time of this reconnaissance and were thus available for inspection.

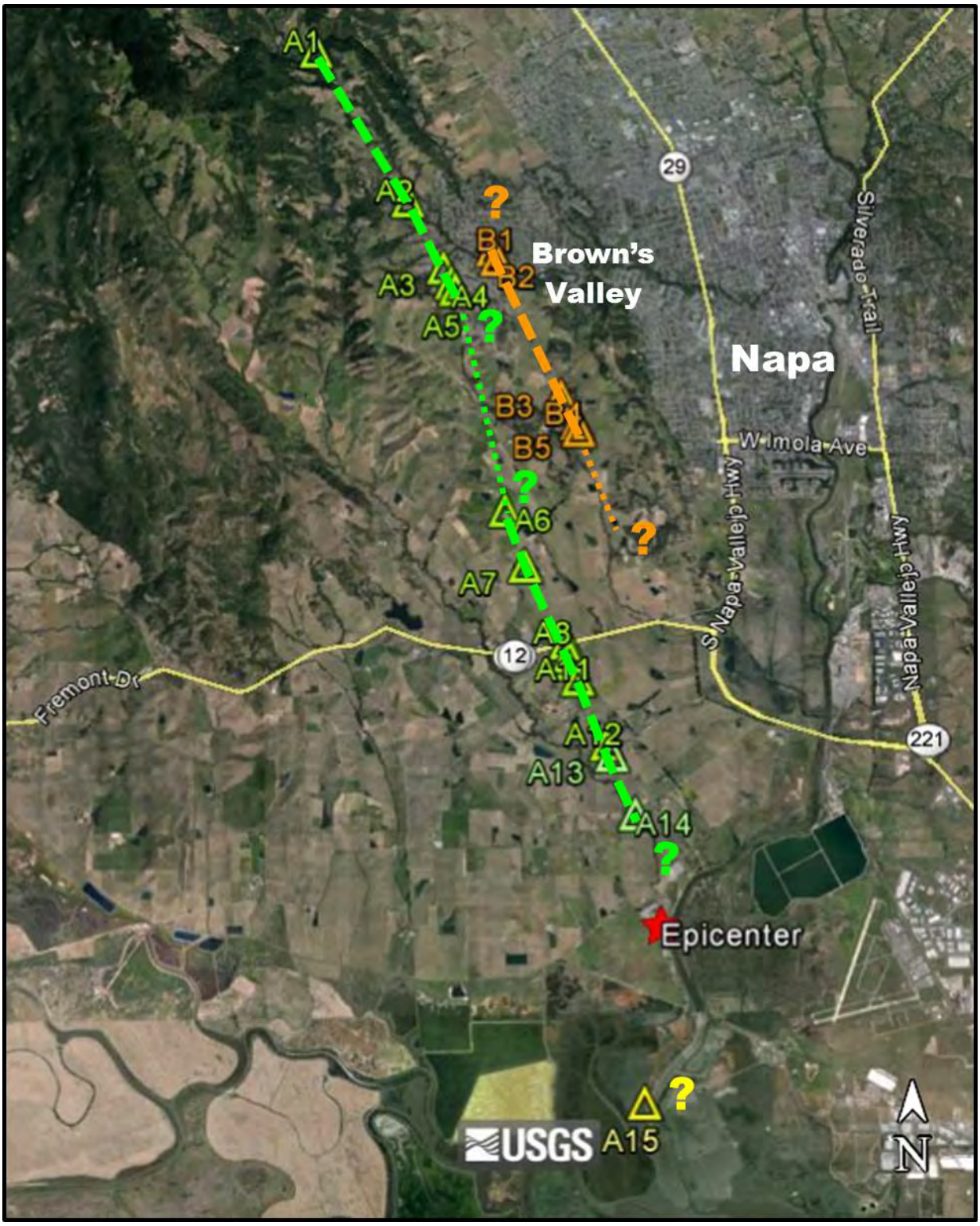

Figure 1: Alignment of surface cracking observed following August 24, 2014 Magnitude 6 Napa Earthquake (adapted from Google Earth [NSF-GEER; Napa, CA, processed 09/03/14]

B.2.3 Summary of Observations

The following represents a summary of the observed ground cracking:

- In all cases where unrepaired cracking was observed, the magnitude of ground cracking/rupture was relatively modest with displacements generally less than 13 centimeters. Nevertheless, many of these areas could be observed as linear features from the air riding in a helicopter.
- The principal displacement was often vertical, commonly on the order of 8 to 13 centimeters, with the western side of the crack/surface rupture higher than the eastern side.
- Horizontal displacements were generally a bit less than the vertical, commonly on the order of 5 centimeters, and generally right-lateral across the roadways. However, in at least one area to the north (Point A2, Partrick Road) and one area to the south (Point A10, Cuttings Wharf Road), the cracking across the roadway appeared to have left-lateral movements on the order of 4 to 5 centimeters – however, this may have been a function of how the pavement displaced over the deforming ground beneath it.
- Cracking was not always continuous, but often intermittent with cracking often disappearing beneath parking lots or roadways.
- The pattern of cracking varied – in some locations, there was one main crack while in other areas, the cracking became distributed over several sub-parallel cracks.
- Residents reported that the cracking had worsened in the days following the main shock on August 24th, perhaps as a result of aftershocks.
- The principal damage observed was pavement cracking, which frequently had been fitted with temporary emergency repairs to provide for interim use. Where the surface cracking ran through residential structures, homes commonly experienced damage, and in some cases were restricted for occupancy. In many developed areas where ground cracking extended, notably the Brown's Valley area to the north, various utilities such as water mains were damaged and required emergency and/or interim repairs. South of State Highway 12/Highway 121 where the ground cracking crossed the alignment of a Pacific Gas and Electric natural gas pipeline, the pipeline was depressurized and, while no overt damage was reported after being inspected, a segment of the pipe was set to be replaced with a new pipe having a larger thickness.

Locations of Observed Surface Cracking

The following represents a summary of the observed ground cracking:

Alignment A:

1. Point A1: Redwood Road (N38^{o} 19.967', W122^{o} 21.967') – at the time of this observation (08-29-14), the roadway cracking had been repaired.
2. Point A2: Partrick Road (N38^{o} 18.795', W122^{o} 21.087') – ground cracking obliquely across Partrick Road and in front yards immediately west of the road. Three main cracks in road, each with about 1½ centimeters of left lateral movement for an overall horizontal displacement of about 4½ centimeters (08-29-14).

3. Point A3: Intersection of Meadowbrook Drive/Stonybrook Drive (N38° 18.271', W122° 20.751') – repaired pavement (08-29-14).

4. Point A4: Intersection of Twin Oaks Drive/Estates Drive (N38° 18.153', W122° 20.676') – repaired pavement (08-29-14)

5. Point A5: Northern end of Twin Oaks Court (N38° 18.102', W122° 20.036') – repaired pavement (08-29-14)

6. Point A6: Henry Road (N38° 16.391', W122° 20.196') – cracked roadway with approximately 1 to 1½ centimeters of right lateral horizontal displacement (09-01-14)

7. Point A7: Old Sonoma Road (N38° 15.961', 122.013') – repaired roadway (09-01-14)

8. Point A8: State Highway 12/121 (N38° 15.369', W122° 19.629') – repaired highway near intersection with Cuttings Wharf Road, ground cracking leading south through vineyards towards Cuttings Wharf Road (08-29-14). Based on video footage from KTVU television, crack had vertical offset of about 10 centimeters (west side up) and right lateral displacement on the order of about 10 centimeters.

9. Point A9: Cuttings Wharf Road (N38° 15.268', W122° 19.597') – repaired roadway approximately 200 meters south of State Highway 12/121, vertical offset approximately 10 centimeters (west side up) with approximately 2½-centimeter left lateral displacement, ground cracking leading south towards horse pasture (08-30-14).

10. Point A10: Horse pasture adjacent and to the west of Cuttings Wharf Road (N38° 15.208, W122° 19.570') – single, linear disruption of soil in horse pasture with right lateral displacement of electrical horse fence of about 4 centimeters (09-01-14).

11. Point A11: Withers Road (N38° 15.089', W122° 19.519) – repaired roadway cracking, an extension of cracking from horse pasture immediately to the north (08-30-14).

12. Point A12: Los Carneros Road/Stone Bridge School (N38° 14.591', W122° 19.254') – ground cracking crossing obliquely across roadway and extending northerly across school parking lot (intermittent asphalt repairs) and across P.G. & E. natural gas pipeline (08-30-14 and 09-01-14).

13. Point A13: South Avenue (N38° 14.506', W122° 19.203') – repaired road, cracked driveway of adjacent property owner (08-30-14).

14. Point A14: Los Amigas Road (N38° 14.056', W122° 19.986') – immediately to the west of Carneros Creek, repaired road cracking.

15. Point A15: Milton Road (N38° 11.879', W122° 18.974') – This location is near the southern extent of Edgerley Island and approximately 2½ kilometers south of the epicenter. In this area, cracking of the road had been repaired with cracking extending eastward along cracked cinderblock wall separately residential properties. It is not clear if this cracking is an extension of the ground cracking/surface ruptures observed north of the epicenter.

Alignment B:

1. Point B1: Southeast intersection of Partrick Road and Rowena Lane (N38° 18.410', W122° 20.257') – repaired roadway (09-01-14).

2. Point B2: Browns Valley Road (N38^{o} 18.333', 122^{o} 20.222') - repaired cracked roadway, cracked driveways and residential property on both sides of street, approximately 30 meters east of Rowena Lane. A few centimeters of right lateral movement indicated (09-01-14).

3. Point B3: Thompson Road (N38^{o} 17.269', W122^{o} 19.620') – ground cracking in asphalt road with approximately 4 to 5 centimeters of right lateral displacements, cracks extending intermittently to the southeast, nearby house on alignment of cracking yellow-tagged for limited use (08-29-14).

4. Point B4: Congress Valley Road (N38^{o} 17.057', W122^{o} 19.471') – ground cracking of asphalt road extending into property and continuing to Old Sonoma Road. Displaced fence on Congress Valley Road property owner property adjacent to roadway indicates about 8 centimeters of vertical offset (west side up) and approximately 5 centimeters of right lateral displacement. Cracks in backyard between Congress Valley Road and Old Sonoma Road had up to 12 centimeters of vertical offset (08-29-14).

5. Point B5: Old Sonoma Road (N38^{o} 17.003', W122^{o} 19.453') – repaired section of roadway, location associated with cracking extending southeast from property and cracks in Congress Valley Road (08-29-14).

Ground Cracking Observed at Selected Locations

1) Point A4, Browns Valley

The Browns Valley area is northwest of downtown Napa and is an older residential area. Both of the alignments associated with surface rupture (Alignments A and B, see Figure 1) are believed to have extended into this area and caused damage to roadways, utilities, and residential structures. Presented in Figure 2 is an aerial photograph taken 8 days after the earthquake showing roadway repairs associated with ground cracking in the general vicinity of Alignment A. As may be seen, multiple roadway repairs (dark asphalt repairs) fall on a linear alignment between Twin Oaks Court and Sandybrook Lane. There were other linear alignments of ground cracking near this area, thus indicating multiple strands of surface rupture in this area.

Figure 2: Alignment of surface cracking observed along Alignment A in Browns Valley following August 24, 2014 Magnitude 6 Napa Earthquake - see dark asphalt patches [NSF-GEER; Napa, CA; N 38.304 W 122.344; Harder, L. F.; 09/01/14]

2) **Point B4, Congress Valley Road (N38° 17.057', W122° 19.471')** – In this area, ground cracking associated with Alignment B extended across Congress Valley Road, through the front fence of the property, through the property, and then across Old Sonoma Road. Selected photographs are as follows:

- Figure 3 presents a photograph of the cracked Congress Valley Road
- Figures 4 and 5 present photographs of the wooden front fence on the property indicating approximately 8 to 12 centimeters of vertical displacement (west side up) and about 5 to 8 centimeters of right lateral displacement as a result of ground cracking.
- Figures 6 and 7 present photographs of ground cracking between the Congress Valley Road property owner front fence and Old Sonoma Road (Point B5).

Figure 3: Photograph of cracking across Congress Valley Road in front of residence – looking southerly (Point B4)
[NSF-GEER; Napa, CA; N 38.284 W 122.325; Harder, L. F.; 08/29/14]

Figure 4: Photograph of wooden fence displaced by ground cracking in front of residence (Congress Valley Road, Point B4) – looking easterly – vertical fence displacements across ground cracking are approximately 8 to 12 centimeters with west side up [NSF-GEER; Napa, CA; N 38.284 W 122.325; Harder, L. F.; 08/29/14]

Figure 5: Photograph of wooden fence displaced by ground cracking in front of residence (Congress Valley Road, Point B4) – looking easterly – right lateral fence displacement across ground cracking is approximately 5 to 8 centimeters [NSF-GEER; Napa, CA; N 38.284 W 122.325; Harder, L. F.; 08/29/14]

Figure 6: Photograph of ground cracking on property
(Congress Valley Road, Point B4) – looking southerly between front wooden fence and towards damaged Old Sonoma Road (Point B5)
[NSF-GEER; Napa, CA; N 38.284 W 122.325; Harder, L. F.; 08/29/14]

Figure 7: Photograph of ground cracking on property
(Congress Valley Road, Point B4) – looking northerly from damaged Old Sonoma Road (Point 5) - vertical offset up to 12 centimeters with west side up
[NSF-GEER; Napa, CA; N 38.284 W 122.325; Harder, L. F.; 08/29/14]

3) **Point A10: Horse pasture adjacent and to the west of Cuttings Wharf Road (N38° 15.208, W122° 19.570') –** single, linear disruption of soil in horse pasture with right lateral displacement of electrical horse fence of about 4 centimeters. Ground cracking extended from cracked pavements on State Highway 12/121 and Cuttings Wharf Road (Points A8 and A9) from the north, across the horse pasture, and continued southerly through vineyards to cracked pavement on Withers Road (Point A11). Figures 8 through 10 illustrate the cracking and displacements observed.

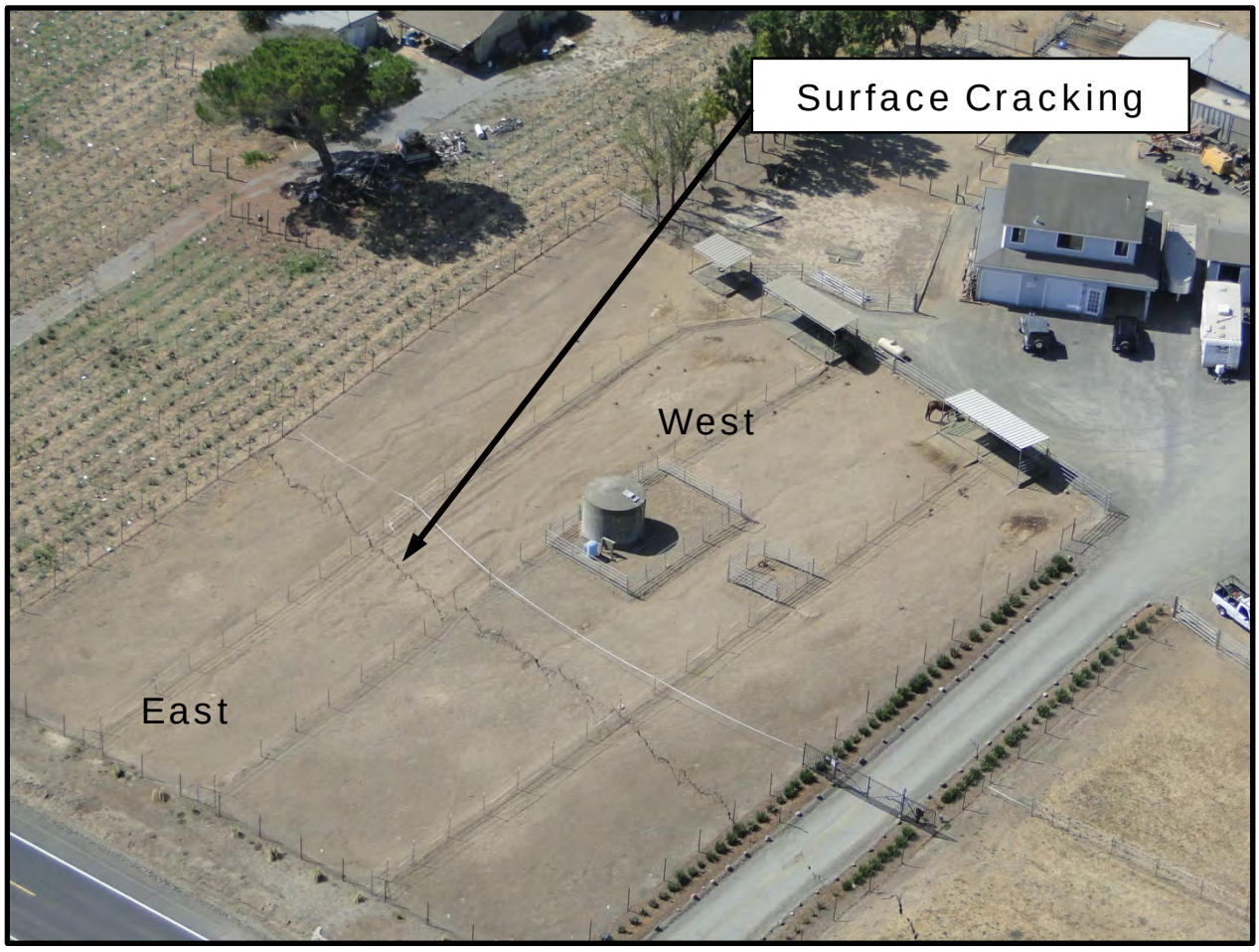

Figure 8: Aerial photograph of linear ground cracking in horse pasture along Cuttings Wharf Road south of Highway 12/121 (Point A10) – looking towards the southwest
[NSF-GEER; Napa, CA; N 38.253 W 122.326; Harder, L. F.; 09/01/14]

Figure 9: Photograph of linear ground cracking in horse pasture along Cuttings Wharf Road south of Highway 12/121 (Point A10) – view looking towards the southeast [NSF-GEER; Napa, CA; N 38.253 W 122.326; Harder, L. F.; 09/01/14]

Figure 10: Photograph of electrical fence in horse pasture along Cuttings Wharf Road south of Highway 12/121 (Point A10) with approximately 4 centimeters of right lateral offset induced by ground cracking – view towards the west
[NSF-GEER; Napa, CA; N 38.253 W 122.326; Harder, L. F.; 09/01/14]

4) **<u>Point A12: Ground Cracking on Los Carneros Road near Stone Bridge School (N38^{o} 14.591', W122^{o} 19.254')</u> –** At this location, ground cracking had displaced the Los Carneros Road and had also extended across the parking lot in front of the school. Damage to both the parking lot and roadway had been temporarily patched for interim use. A Pacific Gas and Electric (PG&E) natural gas pipeline exists immediately northward of the school and the ground cracking obliquely crossed its alignment. The pipeline is a steel pipeline approximately 66 centimeters in diameter and founded approximately 2 meters below the ground surface. The pipeline had been excavated with shoring to inspect the pipeline. According to PG&E personnel at the site on August 30th, preliminary inspections and testing reportedly indicated no damage to the steel pipeline, but the pipeline had been depressurized as a precaution and additional testing and evaluation was planned. During a September 7th visit to the site by a GEER team member, PG&E representatives stated that no damage had been detected as a result of further testing, but that it had been decided to replace the segment of the pipe near the surface cracking as a precaution. The new pipe has the same basic diameter, but has almost twice the thickness at 12.7 millimeters as the current pipeline has (~8 millimeters). Figures 11 through 14 present photographs illustrating the ground cracking observed at this location. Figures 15 and 16 show photographs of the unearthed PG&E pipeline after testing. Also shown in Figure 16 is a view of the new pipeline segments on site on September 7th and ready to be used to replace the segment across the fault.

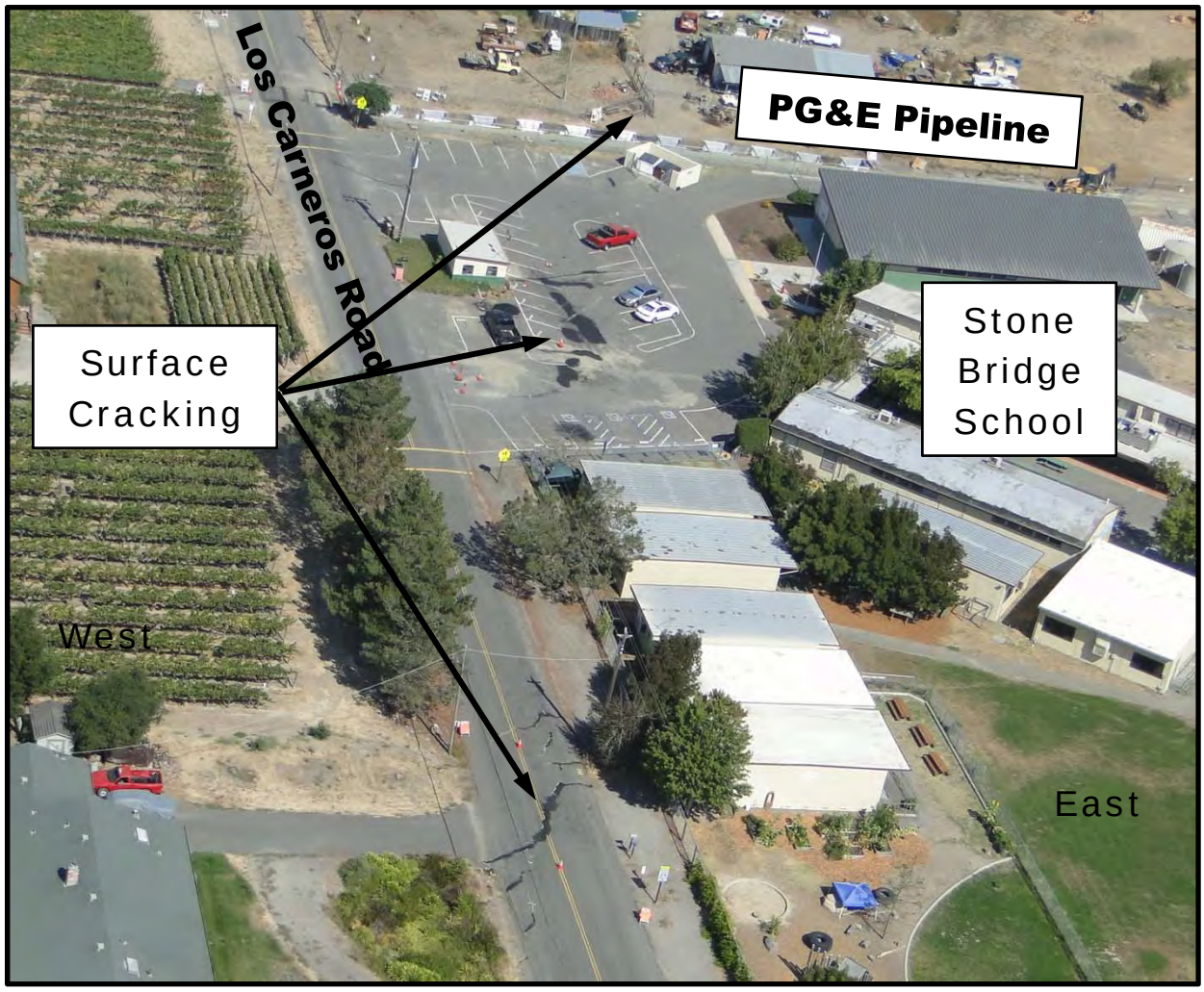

Figure 11: Aerial photograph of linear ground cracking across Los Carneros Road near Stone Bridge School (Point A12) – view looking towards the northeast [NSF-GEER; Napa, CA; N 38.243 W 122.321; Harder, L. F.; 09/01/14]

Figure 12: Aerial photograph of ground cracking crossing PG&E natural gas pipeline on Los Carneros Road near Stone Bridge School (Point A12) – view looking towards the southeast [NSF-GEER; Napa, CA; N 38.243 W 122.321; Harder, L. F.; 09/01/14]

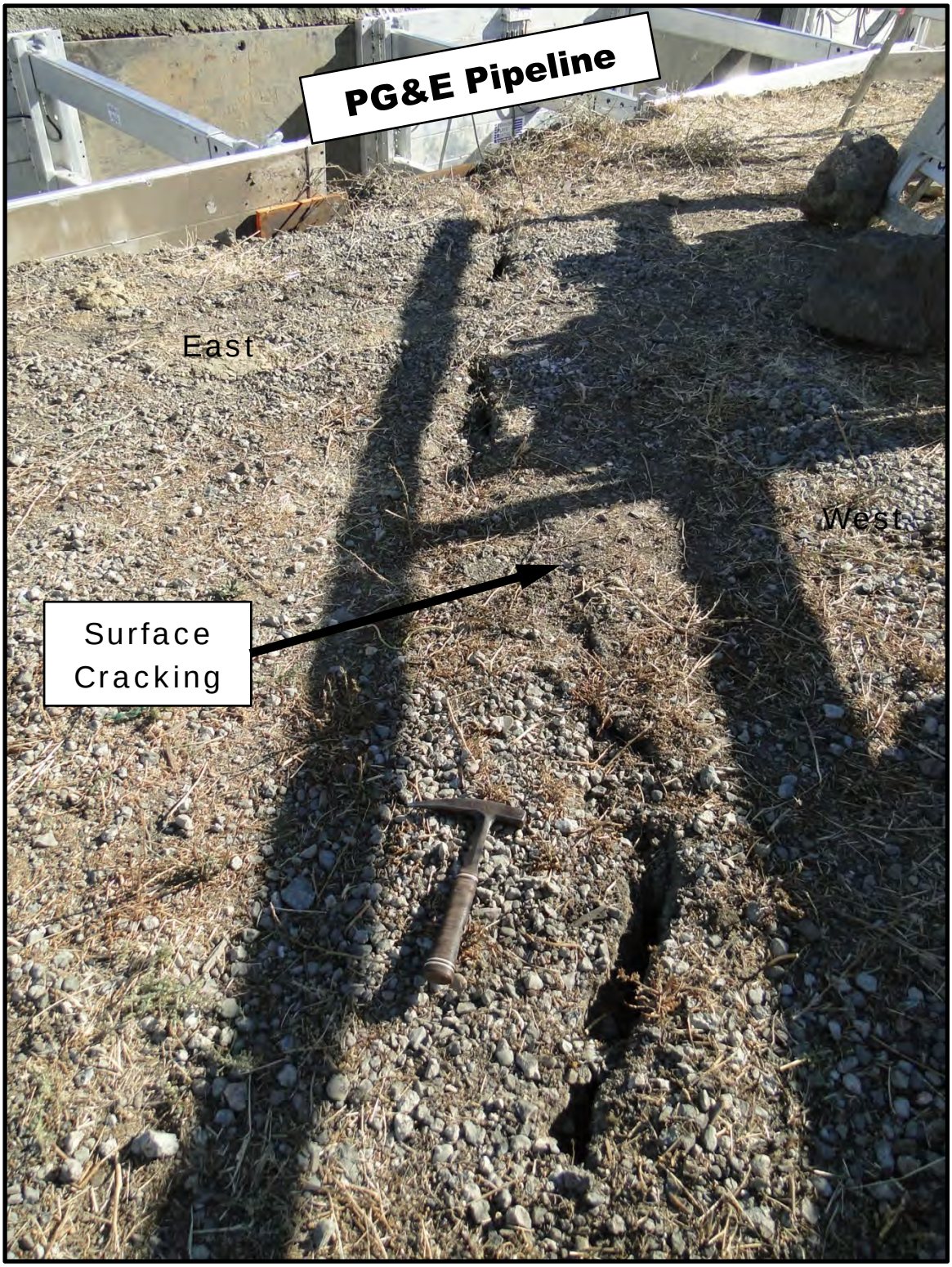

Figure 13: Photograph of linear ground cracking crossing PG&E natural gas pipeline near Los Carneros Road/Stone Bridge School (Point A12)
– view looking towards the southwest from northern side of pipeline
[NSF-GEER; Napa, CA; N 38.243 W 122.321; Harder, L. F.; 09/01/14]

Figure 14: Photograph of excavated and shored PG&E natural gas pipeline crossing Los Carneros Road near Stone Bridge School (Point A12) – view looking towards the east towards alignment of ground cracking [NSF-GEER; Napa, CA; N 38.243 W 122.321; Harder, L. F.; 09/01/14]

Figure 15: Photograph of unwrapped/tested PG&E natural gas pipeline crossing Los Carneros Road near Stone Bridge School (Point A12) – view looking towards the west [NSF-GEER; Napa, CA; N 38.243 W 122.321; Harder, L. F.; 09/07/14]

Figure 16: Close-up view of unwrapped/tested PG&E natural gas pipeline crossing Los Carneros Road near Stone Bridge School (Point A12)
– note also photograph of replacement pipe on site waiting to be installed
[NSF-GEER; Napa, CA; N 38.243 W 122.321; Harder, L. F.; 09/07/14]

Contributing Sources:

Initial Observations: Keith Kelson (Sacramento District, USACE)

Information on ground cracking and access to property at Congress Valley Road: property owner at Congress Valley Road, Napa, CA.

B.3 Summary of South Napa Earthquake Field Reconnaissance on 8/25/14

Fugro Consultants, Inc. (David Trench, Michael Buga, Cooper Brossy)

The following series of observations and preliminary interpretations were collected by Fugro geologists on August 25, one day following the South Napa earthquake of August 24, 2014. At that time the locations of surface fault rupture verses locations of potential deformation from ground shaking were still being determined and the team's main goal was to differentiate between tectonic (surface fault) related and non-tectonic (i.e., ground shaking) features to aid in larger scale fault mapping efforts.

Location: Alston Park, CGS Trench site, 9:09 AM

Goal: Reconnaissance along mapped fault trace of West Napa fault to look for tectonic deformation

Completed brief recon of CGS trench site with John Wesling. No cracking or displacement of natural ground surfaces observed.

Location: Kingston Ave, 10:13 AM

Goal: Reconnaissance along mapped fault trace of West Napa fault near the previously mapped fault exposure on Napa Creek.

Kingston Ave. (38.306416 N, -122.319873 E;)

- Observed minor distributed ground cracking on freshly paved slope on Kingston Ave. In some cases, cracking radiates outward or projects toward manhole covers and utility boxes.
- Cracks up to 15 mm wide, orientations range from 015° - 310°; cracks vary in orientation adjacent to utility covers in the paved surface; population of cracks oriented appx.N-S.
- No apparent deformation in exposed hillslopes adjacent to deformed paved surfaces.
- No apparent lateral displacement of curbs and other linear markers that are oriented perpendicular to mapped fault traces

Interpretation: Distributed ground cracking with lack of clear evidence for tectonic deformation.

Kingston Ave., 10:57 AM (38.306277 N, -122.319082 E)

- Observed vertical displacements in paved surface appx.1.5 cm.
- Curb has apparent left-lateral separation, appx.2.5 cm
- Homeowner stated that vertical separation in paved surface had decreased since the event.

Interpretation: Observed deformation likely represent secondary deformation, not tectonic movement.

Location: Junction of Old Sonoma Rd. and Congress Valley Rd., 11:11 AM

Goal: Per recommendation from CGS assess deformation previously reported in the vicinity of Old Sonoma Rd. and Congress Valley Rd.; tectonic ground movement or secondary deformation?

Congress Valley Rd. (38.284287 N, -122.324500 E)

- Observed cracking in paved road surface perpendicular and parallel to NE-SW oriented Congress Valley Rd.; also evidence of buckling of paved road surface (Figure 1).
- Cracking observed in paved surface with up to appx.5 cm of separation.
- Measured appx.3.5 cm of right lateral separation of NW margin of yellow centerline on Congress Valley Rd. (Figure 2)
- Observed cracking of ground surface in the front yard of private residence on Congress Valley Rd directly adjacent to the south of deformation in paved surface; widths visually estimated at appx.3-5 cm; discontinuous lengths up to appx.2 m.
- No observed surface deformation in field and vineyard north of road; limited visual range due to roadside vegetation.

Backyard of private residence viewed from Old Sonoma Rd. (38.283517 N, -122.324225 E)

- Napa Public Works Dept. in the process of repairing damage to Old Sonoma Rd. upon arrival at 11:11 AM.
- Observed ground cracking north of Old Sonoma Rd. in the backyard of the private residence; linear alignment of left stepping en-echelon ground cracks up to appx.4 m long, with visually estimated vertical separation of appx.5 cm.
- Concrete lining in borrow ditch on south side of Old Sonoma Rd. cracked and deformed with apparent compression in the form of overlapped concrete sections. Apparent vertical movement of appx.8 cm (12:16 PM)

Interpretation: Continuity of deformation in natural ground surface and paved road surface suggest, observed deformation may represent surface fault rupture.

Location: Thompson Ave., 12:35 PM

Goal: Assess whether observed deformation in paved road surface along Thompson Ave. represents tectonic or secondary deformation.

Thompson Ave. (38.287868 N, -122.327012 E)

- Cracking in paved surface parallel and perpendicular to orientation of N-S oriented Thompson Rd. (Figure 3); also evidence of buckling of paved road surface; west side of road separated appx.11 cm from aggregate shoulder material. The zone of cracking ranges in orientation from 295°-305°. Measured appx.5 cm apparent right lateral separation of eastern margin of Thompson Ave. centerline (Figure 4); measured appx.4 cm apparent right lateral separation of western margin.

- Ground surface east of Thompson Ave. has apparent minor ground cracking; unclear if cracks represent tectonic deformation or existing desiccation cracking.

- Ground cracking propagated northwestward underneath private residence northwest of Thompson Ave and continued through the property to the northwest. Structural damage was observed within the house, and according to homeowner, apparent 2 inch movement off foundation. Deck pulled 6 cm from the house. Homeowner pointed to several ground cracks near the barn that appeared later in the day and others that had grown larger – suggesting after-slip.

- Individual ground cracks observed at private residence northwest of Thompson Ave were oriented in a left-stepping, en-echelon manner, oriented between 015^{o} and 345^{o} azimuth. Length of cracks varied between 3 – 12 m in length. The overall orientation of the zone of cracking was 345-350^{o} azimuth. Measured right lateral offsets in natural ground surface ranging from 3-5 cm with a maximum vertical displacement of 7-8 cm.

Thompson Ave. ~1:05 PM (38.287536 N, -122.326769 E)

- Retaining wall on north side of house cracked and separated by appx.4mm in 4 locations; on coincident trend with cracks documented on Thompson Ave to the north. Discontinuous cracking observed in vineyard southeast of main house; cracks appx.6 m long; widths appx.3-5 cm. Homeowner noted that recently stacked wood pile was disrupted by event; additionally noted that landscaping feature with stacked rocks appx.30 m north of woodpile had no damage. A broken (in apparent tension) 1 inch PVC waterpipe at NW corner of residence was buried only 6" deep. A narrow concrete lawn edging on southeast side of yard was apparently right laterally separated by appx.4.5 cm (2:27 PM).

Thompson Ave. Area 2:34 PM

- Observed cracking in paved driveway surface perpendicular to NNE driveway orientation (38.286761 N, -122.325890 E). Four cracks in paved surface; widths range appx.2.5-3 cm; total width of deformation appx.53 ft (appx.16 m) (Figure 5); western-most crack coincident with CMP culvert beneath driveway.

- Apparent ground cracks south of driveway that are in-filled with overlying loose roto-tilled soil. Cracks no wider than appx.15 cm likely less than 10 cm appear to be oriented along strike with cracking documented in paved surface and at south end of vineyard of private residence southeast of Thompson Ave.

Interpretation: Apparent continuity of deformation along strike across paved road surface as well as adjacent natural ground surfaces suggests deformation represents tectonic surface fault rupture.

Location: Browns Valley neighborhood; NNW of Browns Valley Elementary School

Goal: Assess whether deformation previously observed in the Browns Valley neighborhood represents tectonic deformation or secondary deformation associated with ground shaking.

Glenbrook Ln. (38.305354 N, -122.342570 E), 3:27 PM

- Observed buckling of curb and gutter on south side of street in front of house; no apparent cracking in paved street surface north of deformed curb

- Measured deformed length of curb (22.3 ft) and compared to undeformed length (22.5 ft); 0.2 ft +/- 0.03 ft (appx.6-9 cm**) of contraction of curb. **This is only a near-field measurement over appx.22 ft within a 132 ft (appx.40 m) wide zone of deformed curbs and tented sidewalk panels.

- Another measurement of the same curb resulted in 0.3 ft (appx.9 cm) of contraction of curb. Measurements highly influenced by how well curb materials can be reconstructed.

Glenbrook Ln. (38.305288 N, -122.342878 E)

- Observed additional tenting of sidewalk panels on south side of street in front of private residence; no apparent cracking in adjacent paved street surface to north.
- Original length of panels 15.1 ft (appx.4.6 m); deformed length 14.1 ft (appx.4.3 m); 0.3 ft (appx.9-10) cm of shortening.

Total documented shortening based on measurements of buckled curbs appx. 15-19 cm along south side of street over distance of 132 ft (appx.40 m). Not clear if shortening at this site related to tectonic deformation or ground shaking.

Glenbrook Ln. (38.305408 N, -122.342963 E)

- Observed additional tenting of sidewalk panels on north side of Glenbrook Ln. No apparent cracking in adjacent paved street surface
- Original length of panels 10.35 ft (appx.3.15 m); deformed length 10.15 ft (3.09 m); 0.2 ft (appx.6 cm) of shortening.

Sandybrook Ln. (38.304649 N, -122.342822 E)

- Observed apparent right lateral offset of curb appx.11-12 cm.
- Paved road surface to south placed over (thrust) sidewalk and driveway in front of house.
- Buckling in paved road surface; unknown amount of shortening.

Sandybrook Ln. (38.304558 N, -122.342843 E)

- Observed ground cracking with apparent vertical displacement in side yard of private residence.
- Observed cracking but no apparent displacement of retaining wall at northern margin of yard adjacent to cracking in paved road surface and buckling of curb.
- Two sidewalk panels overturned in front of the retaining wall.
- Cracking projects towards private residence on north side of street.

Meadowbrook Rd. (38.303892 N, -122.343070 E)

- Observed buckling of paved road surface; unquantified amount of shortening.
- Observed ground cracking in yard of private residence north side of Meadowbrook Rd.; no address apparent.

Interpretation: Apparent alignment of cracking in paved surfaces and observed ground cracking in adjacent yards suggests surface deformation features through Browns Valley neighborhood may be due to surface fault rupture. However, it is likely that deformed curbs, paved surfaces, and houses may not represent true displacements and kinematics of potential tectonic deformation. The associated measurements should be qualified as such.

B.3 Summary of South Napa Earthquake Field Reconnaissance on 8/25/14

Fugro Consultants, Inc. (David Trench, Michael Buga, Cooper Brossy)

Location: Vicinity of Leaning Oak Rd., 5:15 PM

Goal: Assess whether deformation previously observed south of Browns Valley neighborhood represents tectonic deformation or secondary deformation associated with ground shaking.

Leaning Oak. Rd. (38.298249 N, -122.344272 E)

- Observed linear deformation of ground surface in natural ground surface / graded lot as linear mole track. Deformation apparently confined to zone appx.1-2 m wide and extends appx.50-60 m northward from paved road surface (Figure 5).
- Paved road surface to south buckled and cracked along strike with observed deformation in natural ground surface; width of deformation in paved surface appx.47 ft (appx.14 m).
- Plumbers on site repairing broken water pipe perpendicular to observed deformation in paved surface and natural ground surface; plumbers interpreted that the pipe had compressed and shattered during event.
- At appx.5:30 PM documented a maximum of 1.1ft (appx.33) cm of right lateral separation of aligned bricks at southern margin of crushed granite driveway (Figure 6). High confidence in this measurement because the only surface fault rupture observed in the natural ground surface was limited to a 1-2 meter wide zone that projected perpendicularly through the center of the driveway bricks such that the brick strain marker likely captured most of the deformation at that site.

Slope of private driveway north of Leaning Oak Rd. (38.299274 N, -122.344391 E)

- Observed linear mole track alluvial fan surface adjacent to unnamed creek. Visual estimate of deformation feature appx.20 m long, with apparent vertical displacement appx.3-4 cm (Figure 7); no apparent piercing lines to quantify lateral separation.

Interpretation: Continuity of deformation features in natural ground surface and paved road surfaces suggest tectonic movement and not secondary deformation associated with ground shaking. Deformation apparently confined in natural ground surfaces to narrow (i.e, 1-2 m-wide) zone.

Summary of interpretations:

Kingston Ave: Distributed ground cracking with lack of clear evidence for tectonic deformation. Observed deformation may represent secondary deformation, not tectonic movement.

Congress Valley Rd and Old Sonoma Rd: Continuity and alignment of linear deformation features in paved road surface and natural ground surface suggest observed deformation may represent surface fault rupture.

Thompson Ave: Continuity and alignment of linear deformation features in paved road surface and adjacent natural ground surface suggest observed deformation may represent surface fault rupture.

B.3 Summary of South Napa Earthquake Field Reconnaissance on 8/25/14

Fugro Consultants, Inc. (David Trench, Michael Buga, Cooper Brossy)

Measurements in the Congress Valley Rd-Old Sonoma Rd-Thompson Rd area suggest an approximate minimum of 3 to 5 cm right lateral displacement and with minor local vertical displacements of < 8 cm, depending on soil type and material response. These near-field measurements should be confirmed and supplemented with more far-field measurements.

Browns Valley subdivision: Apparent alignment of cracking in paved surfaces and observed ground cracking in adjacent yards suggests surface deformation features through Browns Valley neighborhood may be the result of surface fault rupture. However, unclear if deformed curbs, paved surfaces, and houses represent actual displacements and/or kinematics of tectonic deformation. The associated measurements should be qualified as such.

Leaning Oak Rd: Continuity and alignment of linear deformation features in paved road surface and natural ground surface suggest observed deformation may represent fault surface rupture. Deformation apparently confined in natural ground surfaces to narrow 1- to 2-m-wide zone and right lateral displacement of up to appx.33 cm observed.

B.3 Summary of South Napa Earthquake Field Reconnaissance on 8/25/14

Fugro Consultants, Inc. (David Trench, Michael Buga, Cooper Brossy)

Figure 1. Photograph showing cracking in paved road surface perpendicular and parallel to NE-SW oriented Congress Valley Rd. [NSF-GEER; N38.2842, W122.3245; 08/25/14; 11:49 AM]

Figure 2. Photograph showing approximately 3.5 cm of right lateral separation of NW margin of yellow centerline on Congress Valley Rd. [NSF-GEER; N38.2842, W122.3245; 08/25/14; 11:37 AM]

Figure 3. Photograph showing cracking in paved surface of N-S oriented Thompson Rd. [NSF-GEER; N38.2878, W122.3269; 08/25/14; 1:02 PM]

Figure 4. Photograph showing approximately 5 cm apparent right lateral separation of eastern margin of Thompson Ave. centerline. [NSF-GEER; N38.2878, W122.3269; 08/25/14; 1:02 PM]

B.3 Summary of South Napa Earthquake Field Reconnaissance on 8/25/14

Fugro Consultants, Inc. (David Trench, Michael Buga, Cooper Brossy)

Figure 5: Photograph showing linear deformation of ground surface in natural ground surface / graded lot as linear mole track. Deformation apparently confined to zone appx.1-2 m wide and extends appx.50-60 m. [NSF-GEER; N38.2983, W122.3442; 08/25/14; 4:13 PM]

Figure 6. Photograph showing right lateral displacement of aligned bricks at southern margin of crushed granite driveway on Leaning Oak Rd. Measured a maximum of 1.1ft (appx.33) cm of right-lateral displacement. [NSF-GEER; N38.2982, W122.3442; 08/25/14; 4:26 PM]

Figure 7. Photograph showing linear mole track in alluvial surface adjacent to unnamed creek. Location is along trend with deformation shown in Figures 5 and 6. Feature estimated at appx.20 m long, with apparent vertical displacement of appx.3-4 cm. [NSF-GEER; N38.2992, W122.3441; 08/25/14; 5:39 PM]