7 PERFORMANCE OF DAMS AND LEVEES

7.1 Introduction

Preliminary reconnaissance efforts of dams and levees were made by GEER team members between August 24 and September 7, 2014 following the main shock. Reconnaissance efforts included several flights in a California Highway Patrol (CHP) helicopter over several dams and levee reaches to look for any major damage from the air. No significant damage was observed at any of the areas viewed from the air. These efforts were then followed up by ground investigations in areas where higher accelerations were thought to have been sustained, notably in the central Napa area and in Vallejo. Again, no major damage was observed at any of the dams or levee reaches visited by GEER team members. The majority of damage observed on either dams or levees consisted of relatively small longitudinal cracks either on the dam/levee crest, or in one location along the landside toe of a small dike on Green Island. New cracking associated with the earthquake, or any other damage, was often not observed at all. Where present, the cracking was commonly less than a few millimeters in width. The largest crack observed was on the crest of Lake Marie Dam and was only about 2½ centimeters in width. Overall, the performance of the small to medium-sized dams and the relatively small levees in the area was very good. The good performance of the dams was confirmed in discussions with several dam owners and with the California Division of Safety of Dams (DSOD).

7.2 Overview of Dams in Earthquake Area

The DSOD regulates non-federal dams in the State of California. According to DSOD's listings of jurisdictional dams (dams that are typically over 2 meters in height and with a minimum reservoir size) there were 34 dams within 20 kilometers of the energy source associated with the 2014 South Napa Earthquake. The locations of these dams are shown in the Google Earth plot presented in Figure 7-1. Tables 7-1 and 7-2 list the names, locations, and basic dimensions for each dam. Tables 7-1 and 7-2 also present estimated peak ground accelerations sustained by the dams during the main shock. The peak accelerations were estimated using two approaches. The first approach estimated peak ground accelerations at the dams by interpolating or extrapolating from the nearest peak accelerations recorded from any nearby strong motion instruments (from ShakeMap, United States Geological Survey). The second approach was to use the geometric mean of the four NGA-W2 GMPEs currently available (ASK14, BSSA14, CB14, and CY14). As shown in the two tables, the two different approaches result in generally similar estimates, although there are some differences in some locations. Table 7-3 presents the numbers of dams shaken to various levels of peak ground acceleration.

The majority of the dams are relatively small, older earth dams. Two of the dams are concrete dams: Milliken Dam is a concrete arch dam that appears to have sustained only about 0.1g peak ground acceleration, whereas the Old Waterworks Dam in Napa is a concrete gravity dam, but its reservoir has not been in use for some time and was empty at the time of the earthquake. As summarized in Table 7-4, the dam heights range from 6 to 50 meters in height, but 20 of the 34 dams are between only 6 and 15 meters in height. Only two dams with heights greater than 20 meters are believed to have sustained peak accelerations greater than about 0.1g: Summit Reservoir Dam (Height = 38 meters, PGA ~0.25g) and Swanzy Lake Dam (Height = 26 meters, PGA ~0.30g), both in the Vallejo area (see Table 7-5).

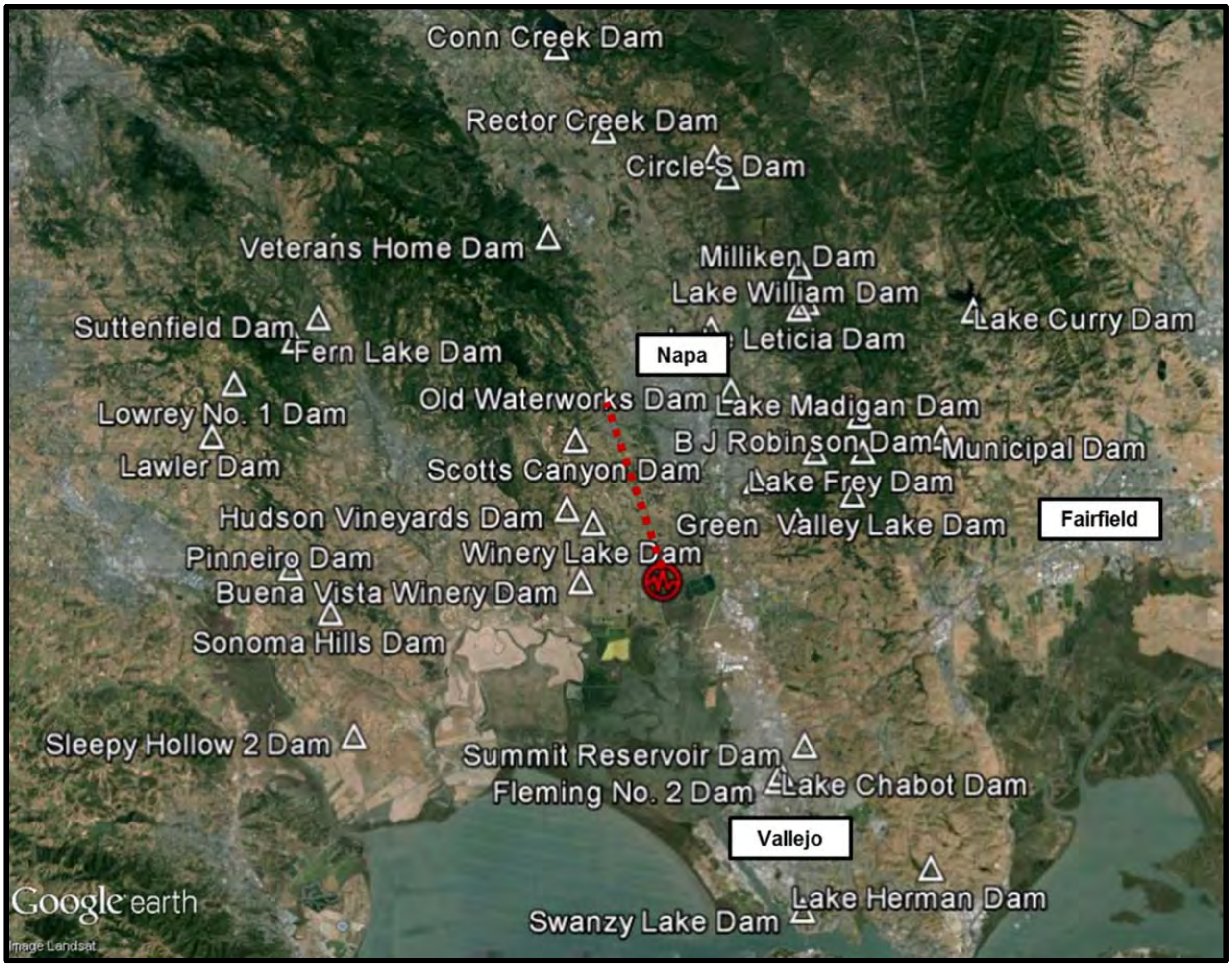

Figure 7-1: Locations of Jurisdictional Dams within 20 kilometers of the energy source associated with the 2014 South Napa Earthquake [NSF-GEER; Harder, L. F.; 09/11/14]

Table 6 shows that the majority of the dams within 20 kilometers of the energy source of the earthquake are also quite old, with several dams having been originally constructed back in the 19th century. Only six of the dams have been constructed since 1960. Of course, several of the dams have had dam safety modifications and improvements since their original construction.

In addition to the jurisdictional dams, there are dozens of small agricultural ponds in the area that are used principally to support the wine industry. These are small ponds with retaining embankments generally less than 3 to 6 meters in height. Many of these ponds were created by borrowing from the pond area for materials to construct the retaining embankments; thus, the upstream slopes are often higher than the downstream slopes. Some of the ponds also have synthetic geomembrane liners.

Due to the ongoing California Drought, many of the reservoirs and ponds were at less than their maximum operating level at the time of the earthquake, and some were very low.

Table 7-1: Summary of Dams in Napa County within 20 kilometer of the energy source of the 2014 South Napa Earthquake [NSF-GEER; Harder, L. F.; Escudero, J. L. M.; 09/11/14)]

Dam	Height (m)	Crest Length (m)	Crest Width (m)	Year Completed	Approx. Distance (km)	Latitude/ Longitude	Prel. PGA[1] (g)
B J Robinson	14	213	5	1957	9.1	N 38° 17.4’ W 122° 13.2’	0.11[a]/0.20[b]
Circle S	9	126	4	1979	13.7	N 38° 25.2’ W 122° 16.3’	0.10/0.15
Conn Creek	38	213	6	1946	18.7	N 38° 28.9’ W 122° 22.4’	0.10/0.10
Foss Valley	17	762	6	1988	14.2	N 38° 25.7’ W 122° 16.7’	0.10/0.15
Hudson Vineyards	8	122	4	1983	2.8	N 38° 15.9’ W 122° 22.0’	0.41/0.37
Lake Camille	9	183	7	1880	6.8	N 38° 16.6’ W 122° 15.3’	0.27/0.29
Lake Curry	33	174	5	1926	19.1	N 38° 21.4’ W 122° 7.5’	0.05/0.13
Lake Cynthia	7	229	3	1955	6.9	N 38° 20.9’ W 122° 16.9’	0.35/0.30
Lake Leticia	15	119	5	1960	11.2	N 38° 21.5’ W 122° 13.7’	0.11/0.20
Lake Marie	18	138	2	1908	8.0	N 38° 15.6’ W 122° 13.8’	0.19/0.22
Lake William	20	175	6	1960	11.8	N 38° 21.6’ W 122° 13.4’	0.11/0.18
Milliken Dam*	34	197	8	1924	12.3	N 38° 22.7’ W 122° 13.6’	0.10/0.17
Old Waterworks**	13	66	2	1883	6.1	N 38° 19.2’ W 122° 16.1’	0.35/0.31
Rector Creek	50	271	9	1946	14.3	N 38° 26.5’ W 122° 20.7’	0.10/0.13
Scotts Canyon	12	98	6	1948	1.6	N 38° 17.8’ W 122° 21.7’	0.45/0.47
Veterans Home	14	98	2	1908	13.6	N 38° 23.5’ W 122° 22.7’	0.10/0.18
Winery Lake	9	189	4	1953	2.1	N 38° 15.5’ W 122° 21.1’	0.41/0.41

Notes: [1] PGA estimates are based on: a) nearest recorded motions and b) NGA-W2 GMPEs

* Denotes concrete arch dam

** Denotes concrete gravity dam, reservoir empty and out of service

▭ Denotes dam inspected or viewed by GEER team

Table 7-2: Summary of Dams in Solano and Sonoma Counties within 20 kilometers of the energy source of the 2014 South Napa Earthquake [NSF-GEER; Harder, L. F.; Escudero, J. L. M., 09/11/14)]

Dam	Height (meters)	Crest Length (meters)	Crest Width (meters)	Year Completed	Approx. Distance (km)	Latitude/ Longitude	Prel. PGA (g)
Buena Vista Winery	12	169	4	1971	3.6	N 38º 13.8' W 122º 21.5'	0.41[a]/0.38[b]
Fern Lake	12	91	5	1921	14.7	N 38º 20.6' W 122º 31.8'	0.09/0.11
Fleming Hill No. 2	12	174	12	1912	11.1	N 38º 8.2' W 122º 14.5'	0.30/0.20
Green Valley	12	101	4	1956	11.2	N 38º 16.3' W 122º 11.8'	0.10/0.19
Lake Chabot	13	113	5	1870	10.9	N 38º 8.4' W 122º 14.4'	0.30/0.21
Lake Frey	25	175	5	1894	11.7	N 38º 17.5' W 122º 11.5'	0.10/0.19
Lake Herman	16	213	4	1905	11.6	N 38º 5.8' W 122º 9.0'	0.09/0.12
Lake Madigan	27	203	5	1908	11.6	N 38º 18.5' W 122º 11.6'	0.10/0.19
Lawler	12	351	7	1910	19.1	N 38º 17.9' W 122º 34.7'	0.08/0.09
Lowrey No. 1	6	64	3	1954	17.9	N 38º 19.4' W 122º 33.8'	0.08/0.10
Municipal	17	131	5	1939	15.6	N 38º 17.9' W 122º 8.6'	0.07/0.11
Pinneiro	8	220	4	1967	17.5	N 38º 14.2' W 122º 34.7'	0.04/0.10
Sleepy Hollow 2	12	183	4	1949	17.7	N 38º 9.5' W 122º 29.7'	0.03/0.10
Sonoma Hills	12	98	5	1991	17.1	N 38º 12.9' W 122º 30.5'	0.04/0.13
Summit Reservoir	38	274	6	1968	10.4	N 38º 9.2' W 122º 13.5'	0.25/0.19
Suttenfield	23	294	3	1938	13.6	N 38º 21.3' W 122º 31.0'	0.10/0.14
Swanzy Lake	26	114	5	1931	17.4	N 38º 4.6' W 122º 13.6'	0.30/0.13

Notes: [1] PGA estimates are based on: a) nearest recorded motions and b) NGA-W2 GMPEs

■ Denotes dam inspected or viewed by GEER team

Table 7-3: Estimated Peak Ground Accelerations at dams within 20 kilometers of the energy source of the 2014 South Napa Earthquake [NSF-GEER; Harder, L. F.; processed 09/11/14)

Range in estimated Peak Ground Acceleration (g)	Number of Dams
< 0.10	9
0.10 – 0.19	14
0.20 – 0.29	2
0.30 – 0.39	5
> 0.40	4
Total	34

Table 7-4: Heights of dams within 20 kilometers of the energy source of the 2014 South Napa Earthquake [NSF-GEER; Harder, L. F.; processed 09/11/14)

Range in Dam Height (meters)	Number of Dams
0 – 5	0
6 – 10	7
10 – 15	13
16 – 20	5
21 – 25	2
26 – 30	2
31 – 35	2
36 – 40	2
> 40	1
Total	34

Table 7-5: Dams with the highest estimated peak ground accelerations associated with the 2014 South Napa Earthquake [NSF-GEER; Harder, L. F.; processed 09/11/14)

Dam	Height (meters)	Year Completed	Estimated PGA (g)
Scotts Canyon	12	1948	0.45
Winery Lake	9	1953	0.41
Buena Vista Winey	12	1971	0.41
Hudson Vineyards	8	1983	0.41
Lake Cynthia	7	1955	0.35
Old Waterworks*	13	1883	0.35
Lake Chabot	13	1870	0.30
Fleming Hill No. 2	12	1912	0.30
Swanzy Lake	26	1931	0.30
Lake Camille	9	1880	0.27
Summit Reservoir	38	1968	0.25

* Denotes concrete gravity dam, reservoir empty and out of service

Table 7-6: Original construction dates for dams within 20 kilometers of the energy source of the 2014 South Napa Earthquake [NSF-GEER; Harder, L. F.; processed 09/11/14)

Year of Original Dam Construction	Number of Dams
1870 - 1900	4
1901 - 1920	6
1921 - 1940	7
1941 - 1960	11
1961 - 1980	3
1980 -2014	3
Total	34

7.3 Performance of Dams

Immediately following the main shock of the 2014 South Napa Earthquake, personnel in DSOD received information from ShakeCast (USGS) regarding the level of shaking in the area and began putting together a list of dams that received different levels of shaking. For dams that were within areas having a Damage Intensity of V or more, DSOD staff contacted the owners within a day and asked them to inspect their dams. Dams in areas associated with a Damage Intensity of VII or greater were contacted within a few hours. The DSOD then put together a priority list of dams for their own inspections with priorities based on the estimated level of shaking and the history of the dam. Dams with the highest priorities were inspected later the same day as the earthquake. Dams with lower priorities were inspected within a few days after the earthquake. As a result of these inspections, DSOD found little to no damage to the dams and appurtenances. As mentioned previously, the main type of damage noted, where any damage at all was observed, reportedly consisted of relatively minor longitudinal cracks on the crest of the dam. The largest such cracking was found on Lake Marie Dam and was approximately 2½ centimeters wide at its widest location.

The GEER team inspected on the ground or viewed from the air 11 of the 34 dams within 20 kilometers of the energy source associated with the earthquake (see brown shaded areas in Tables 7-1 and 7-2). The GEER team inspections that were done supported the results from the dam owners and DSOD inspections in that little to no damage was observed at the dams in the area. The reasons for this low level of damage likely include:

- The level and duration of shaking for most of the dams was relatively small
- Many of the dams are relatively small
- Many of the dams and their foundations are made out of clayey materials and the depths in the foundation to bedrock are small
- Some of the reservoirs were relatively low either due to the ongoing California Drought or due to restrictions imposed for dam safety
- Some of the dams have had various retrofits made to increase their static and seismic stability

Details and photographs for three of the dams inspected by the GEER team are presented in the following sections:

- ➢ Lake Marie Dam
- ➢ Lake Chabot Dam
- ➢ Summit Reservoir Dam

7.3.1 Lake Marie Dam

Lake Marie Dam was originally constructed in 1908 and currently has a maximum height of approximately 18 meters. It is owned by the Napa State Hospital, but is operated as part of a recreation area. According to DSOD's files, Lake Marie Dam is reportedly a clayey earthfill dam (not hydraulic fill) with a concrete core wall. In 1931, the dam crest was reportedly raised 0.6 meters using vertical rock walls on both edges of the crest with soil fill placed in between to improve freeboard. While the records indicate that the dam crest is about 3 meters in width, the inspection by the GEER team on September 1st indicated that the crest width is only about 2 meters. The crest length of the dam is approximately 138 meters. The upstream slope is relatively steep with a slope of approximately 1.5:1, while the downstream slope is significantly flatter at about a 2.5:1 slope. A 1947 inspection report indicated that the freeboard at that time between the dam crest and the uncontrolled spillway was about 3.2 meters. However, following a seismic evaluation in the 1980's, a 30-centimeter diameter steel riser pipe was installed downstream of the upstream valve of the outlet pipeline. This riser pipe limits the maximum reservoir storage to about 7.5 meters below the dam crest. At the time of the September 1st GEER inspection, the reservoir was more than 10 meters below the crest of the dam, leaving less than 8 meters of water on the 18-meter-high dam itself.

Lake Marie Dam was approximately 8.0 kilometers away from the energy source associated with the South Napa Earthquake and is estimated to have sustained a peak ground acceleration of about 0.19g based on nearby strong motion instruments. DSOD personnel inspected the dam during the same day as the earthquake and noted only a longitudinal crack in the upstream portion of the dam crest. The crack ran approximately 17 meters in length along the left central portion of the dam (see Figure 7-2 for general location) and had a maximum width of about 2½ centimeters (see Figure 7-3). Figures 7-3 and 7-4 present photographs taken by DSOD and by the GEER team of the cracking. The cracking may be related to movement of the upstream rock wall reportedly placed on the upstream edge of the dam crest in 1931. The cracking is considered minor, but DSOD staff report that they may require the cracking to be remediated.

7.3.2 Lake Chabot Dam

Lake Chabot Dam was originally constructed in 1870 and currently has a maximum height of approximately 13 meters. It is owned by the City of Vallejo and retains the lake used by the Six Flags Discovery Kingdom in Vallejo. According to DSOD's files, Lake Chabot Dam is a clayey earthfill dam generally composed of stiff clay and clayey gravel. The depth to shale bedrock is less than 3 meters below the foundation. The crest of the dam is approximately 5 meters wide and approximately113 meters in length. Due to stability concerns, a wide berm was added to the downstream side of the dam several years ago. Figure 7-5 presents a cross section of the dam obtained from DSOD files illustrating the general geometry of the dam and downstream berm. Figure 7-6 presents a photograph of the dam taken by the GEER team also illustrating the dam and berm geometry.

Lake Chabot Dam was approximately 11 kilometers away from the energy source associated with the South Napa Earthquake and is estimated to have sustained a peak ground acceleration of about 0.30g based on nearby strong motion instruments. A member of the GEER team inspected the dam on August 27th and found only minor longitudinal cracking less than 2 centimeters in

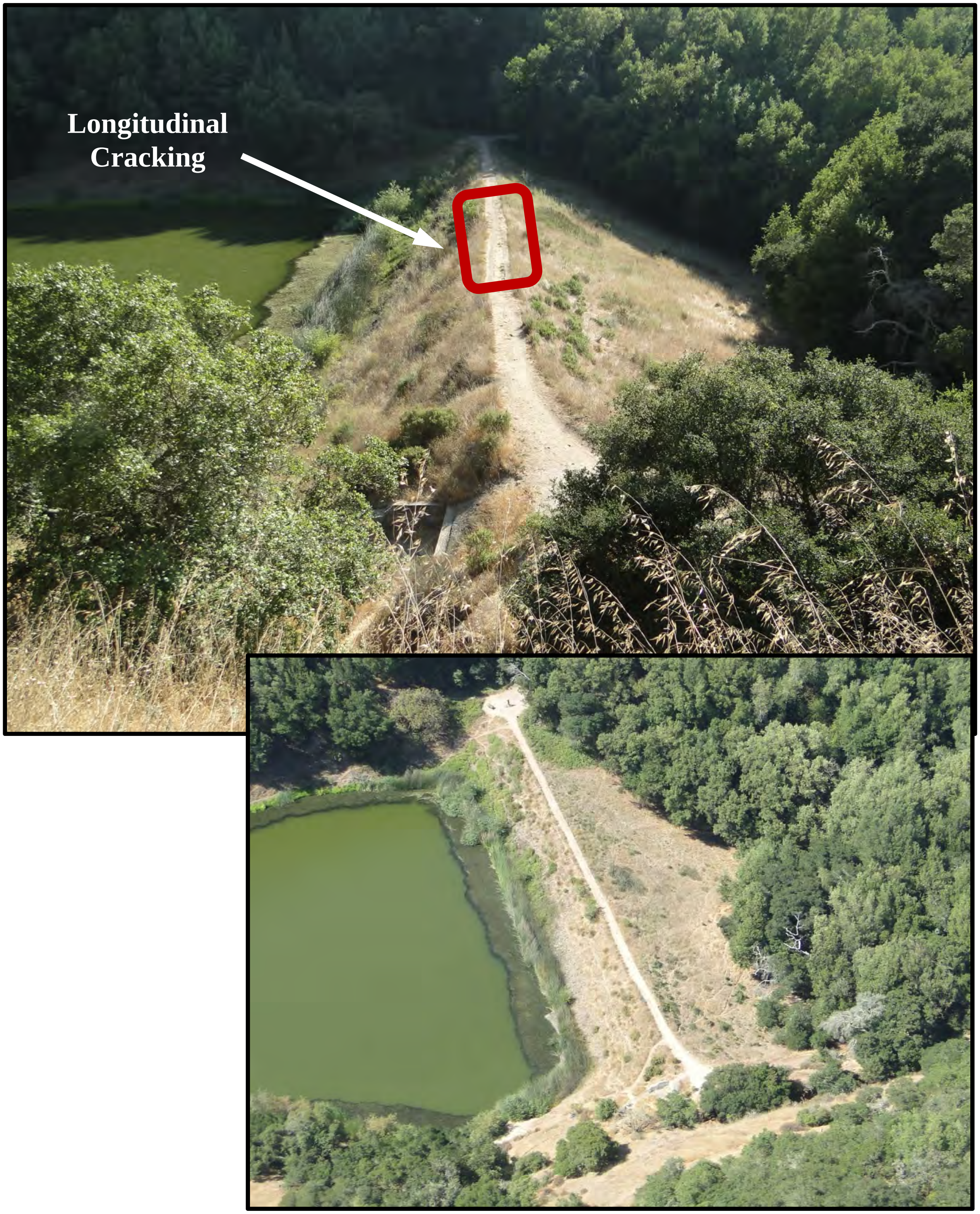

Figure 7-2: Ground and aerial photographs of Lake Marie Dam looking southeast
[NSF-GEER; Napa, CA; N38.260 W 122.230; Harder, L. F.; 09/01/14]

Figure 7-3: Photographs of longitudinal cracking on the upstream edge of the crest of Lake Marie Dam [Napa, CA; N38.260 W 122.230; from DSOD files; 08/24/14]

Figure 7-4: Photograph of longitudinal cracking on the upstream edge of the crest of Lake Marie Dam looking southeast [NSF-GEER; Napa, CA; N38.260 W 122.230; Harder, L. F.; 09/01/14]

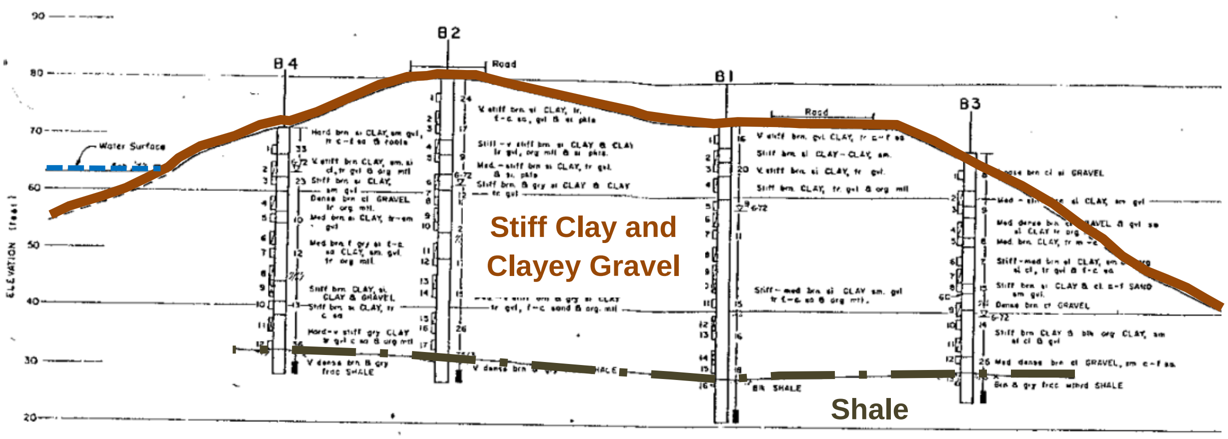

Figure 7-5: Cross section of Lake Chabot Dam
[Vallejo, CA; N38.141 W 122.241; from DSOD files]

Figure 7-6: Photograph of minor longitudinal cracking on the crest of Lake Chabot Dam looking southeast [NSF-GEER; Napa, CA; N38.141 W 122.241; Harder, L. F.; 08/27/14]

width on the dam crest (see Figures 7-6 and 7-7). Much of this cracking may have been associated with pre-existing longitudinally-dominated shrinkage cracks that simply opened up during the shaking. At the time of the August 27th inspection, the reservoir was approximately 4.3 meters below the dam crest. A relatively new reinforced concrete spillway on the right abutment of the dam appeared to be undamaged.

7.3.3 Summit Reservoir Dam

Summit Reservoir Dam was originally constructed in 1968 and currently has a maximum height of approximately 38 meters. Thus, it is one of the highest and most recently constructed dams shaken by the South Napa Earthquake. It is located in the hills above Vallejo and owned by the City of Vallejo. The dam appears to have had seepage issues in the past as there are several piezometers installed in the dam, and there is a plastic geomembrane lining placed within the reservoir to presumably reduce seepage through the dam and its foundation. There is also a 0.3-meter-high concrete parapet wall on the upstream edge of the 6-meter-wide asphalt-paved dam crest. The dam is shaped as an overall bowl and has a total length of about 274 meters. Figure 7-8 presents views of the dam.

Summit Reservoir Dam was approximately 10.4 kilometers away from the energy source associated with the South Napa Earthquake and is estimated to have sustained a peak ground acceleration of about 0.25g based on nearby strong motion instruments. A member of the GEER team inspected the dam on August 27th and found that the dam appeared to have little to no damage. The only distress noted was relatively minor longitudinal cracking, principally located near the downstream edge of the asphalt-paved crest of the main dam section. These cracks were generally only a few millimeters in width with a maximum opening on the order of a centimeter. However, it was clear that these were pre-existing cracks as weeds were growing in them and asphalt mastic had previously been poured over them in the past in an attempt to seal them up. Figure 7-9 illustrates some of the minor cracking noted. It is thought that at most, the effect of the earthquake was to perhaps slightly widen the pre-existing cracks.

Figure 7-7: Close-up photograph of minor longitudinal cracking on the crest of Lake Chabot Dam looking southeast [NSF-GEER; Napa, CA; N38.141 W 122.241; Harder, L. F.; 08/27/14]

Figure 7-8: Views of Summit Reservoir Dam looking southeast
[NSF-GEER; Napa, CA; N38.153 W 122.225; Harder, L. F.; 08/27/14]

Figure 7-9: Photographs of pre-existing longitudinal cracks on the crest of the maximum section of Summit Reservoir Dam
[NSF-GEER; Napa, CA; N38.153 W 122.225; Harder, L. F.; 08/27/14]

7.4 Overview of Levee System

The Napa River drainage basin is just north of San Pablo Bay and through the City of Napa almost all of the land adjacent to the river has been subject to flooding since 1862. By the mid-20th century, development had squeezed the river into a narrow channel as secondary channels were filled and the river was confined by small levees and floodwalls. Many of the levee systems on the Napa River, and on tributary channels upstream and downstream of the City of Napa, are privately owned. These levee systems are generally small, less than 2 meters in height, and intermittent.

To reduce the flood risk to the City of Napa, a federal flood control project led by the United States Army Corps of Engineers, with matching funds from state and local sources, has been underway for more than a decade. The project is being implemented in phases along approximately 12 kilometers along the river and is intended to provide protections for the 1 percent annual chance (100-year) flood within the city, approximately between Trancas Street and Imola Avenue (see Figure 7-10). Major features of the project include widening the channel of the Napa River and nearby Napa Creek, the construction of new flood walls, new pump stations, the replacement of bridges to accommodate the wider channel, the construction of a new bypass past the ox-bow in downtown Napa, and the removal of levees further downstream to allow the river to spread out into multiple channels and wetlands. The major portion of the downtown channel widening and floodwall construction along the Napa River was generally completed by 2006. The construction of the ox-bow bypass was in the early phases when the South Napa Earthquake occurred. Reconstruction and removal of low levees is on-going.

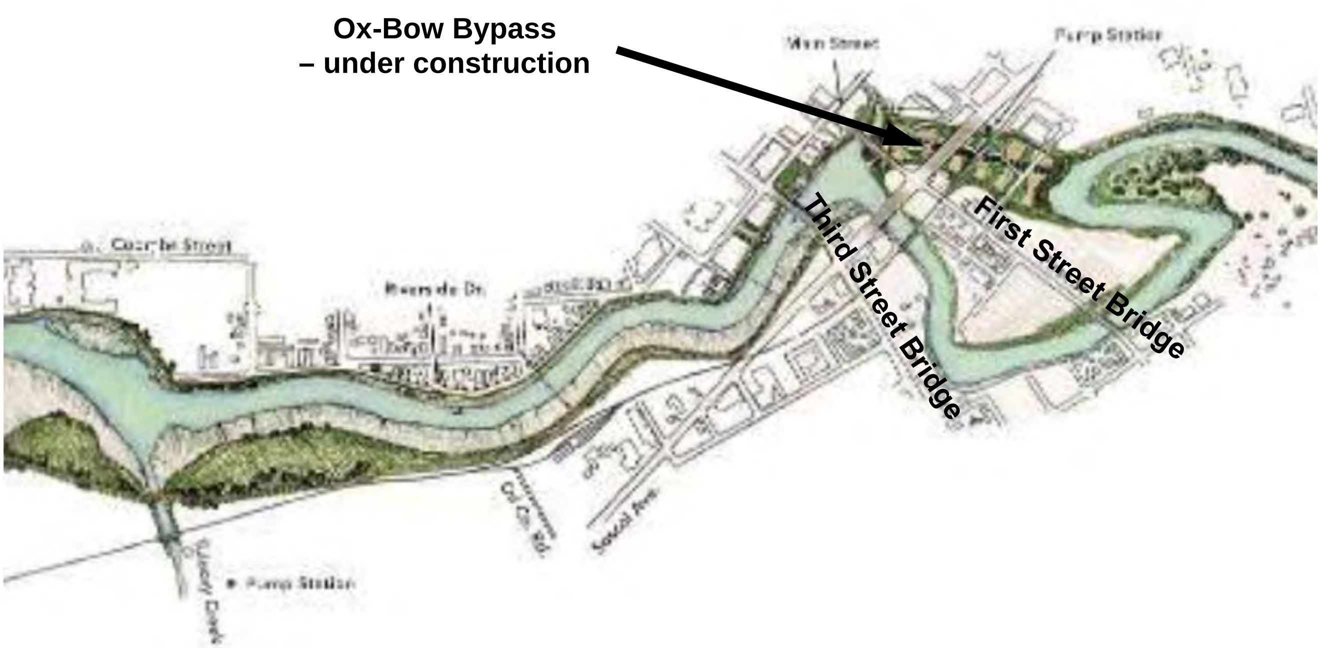

Figure 7-10: Views of improvement area of confined Napa River in downtown Napa
[from County of Napa and USACE]

7.5 Performance of the Levee System

The Napa River levees and floodwalls that are part of the federal flood control project were reported by the Sacramento District of the United States Army Corps of Engineers to have little to no damage. Inspections by GEER team members found only minor cracking of the recently constructed levee/floodwall system in downtown Napa. This was despite very high accelerations reported in downtown Napa ranging up to 0.4 to 0.6g. Older floodwalls and foot-bridges nearby, however, experienced some damage. In addition, while a minor amount of liquefaction was observed in the form of cracking and sand boils in a sand bar in the Napa River near the Third Street Bridge, no signs of cracking or lateral spreading were observed on the riverbank above it.

Downstream of downtown Napa, GEER team members made several aerial surveys of the intermittent levee system along both sides of the Napa River, but no signs of damage were observed from the air. Follow-up inspections on the ground found only minor cracking of the levees themselves, with most of the damage on the levees observed on developed areas where homes and boat docks had been constructed onto the low 2-meter-high levees along Edgerley Island. Across from Edgerley Island, a small former salt pond dike developed longitudinal cracking along the downstream toe of the 2-meter-high embankment which might have been the result of foundation liquefaction. However, the damage was relatively minor.

Details and photographs for three of the levee/floodwall areas inspected by the GEER team are presented in the following sections:

- Downtown Napa Levees/Floodwalls
- Edgerley Island Levee
- Green Island Salt Pond Retaining Dike

7.5.1 Downtown Napa Levees/Floodwalls

In the area of the First and Third Street Bridges, the channel had been widened and new floodwalls and bridges were completed in 2006. Much of the new floodwall system is on the right (west) side of the river near the Third Street Bridge which allowed major new redevelopment in this area of downtown Napa. Figure 7-11 shows a Google Earth view of this area and Figure 7-12 presents an aerial photograph taken during the GEER team reconnaissance.

Downstream of the Third Street Bridge, remnant cracking and sand boils were observed in the sand/mud bar along the left (east) bank of the river and was suggestive that river sediments had liquefied during the earthquake (see Figures 7-12 and 7-13). The crack openings here were estimated to have a maximum width of approximately 2 centimeters. However, the adjacent riverbank appeared undamaged and there was no sign of cracking or lateral spreading on the concrete and gravel walkways above.

On the right (west) side of the river, the recently constructed large reinforced concrete floodwalls appeared to have performed well overall. However, the concrete deck slab behind the walls sustained minor cracking and had pulled away from the floodwalls by as much as 3 centimeters (see Figure 7-14). In addition, a lateral retaining wall supporting part of a restaurant had settled approximately 3 centimeters relative to the wall (see Figure 7-14).

Figure 7-11: Google Earth Plot of Downtown Napa
[NSF-GEER; Napa, CA; N38.308 W 122.281; Harder, L. F.; 09/11/14]

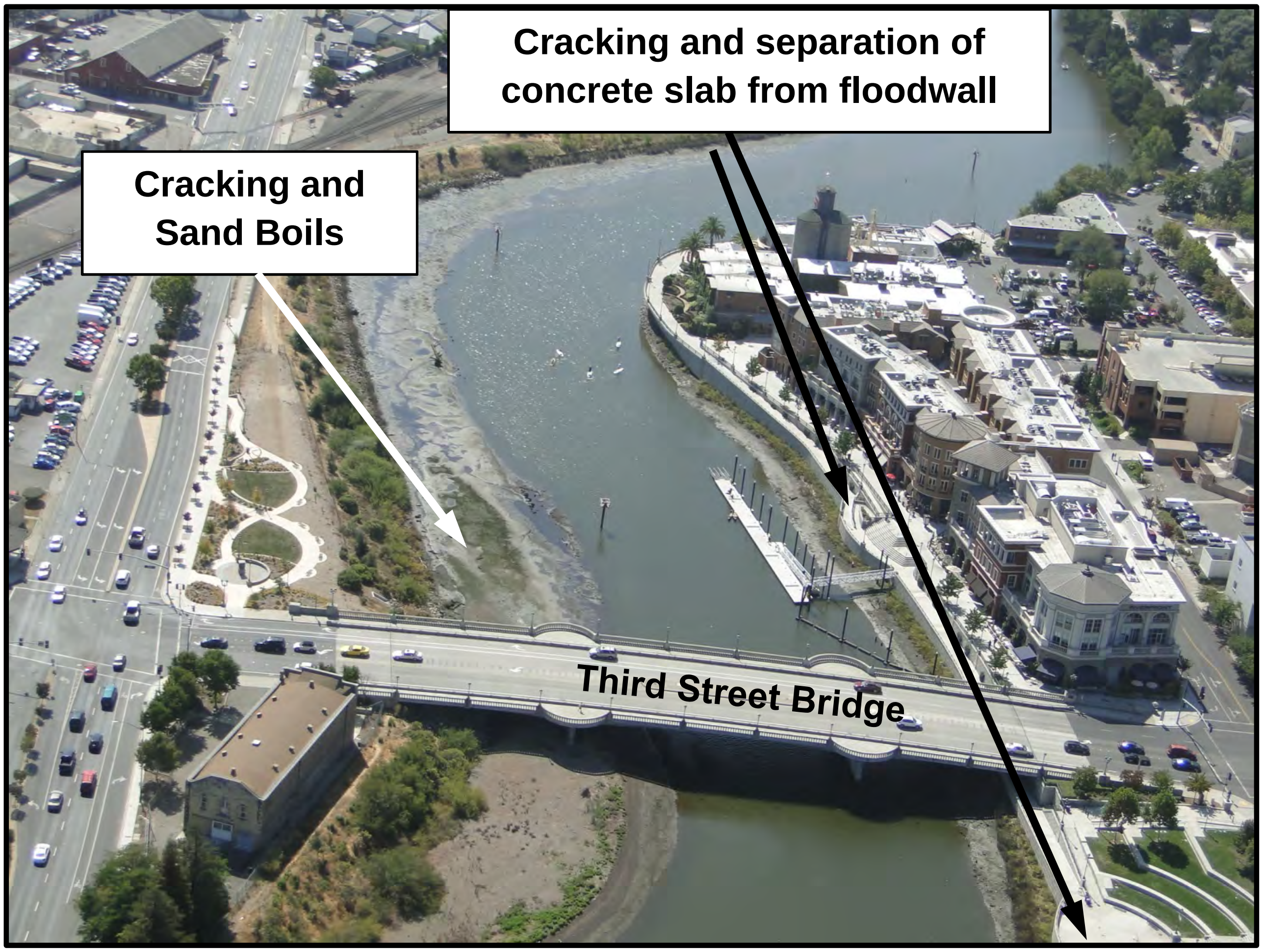

Figure 7-12: Aerial photograph of Napa River looking downstream near Third Street Bridge
[NSF-GEER; Napa, CA; N38.308 W 122.281; Harder, L. F.; 09/01/14]

Figure 7-13: Remnant cracking and sand boils in sand bar along left bank of Napa River looking downstream from Third Street Bridge
[NSF-GEER; Napa, CA; N38.298 W 122.283; Harder, L. F.; 09/04 and 09/07/14]

Figure 7-14: Separation of concrete slab and retaining wall from Napa River floodwall along right bank of Napa River looking upstream from Third Street Bridge
[NSF-GEER; Napa, CA; N38.299 W 122.285; Harder, L. F.; 09/04/14]

7.5.2 Edgerley Island Levee

Along the right (west) bank of the Napa River south of the epicenter the levees are commonly about 2 meters in height. On Edgerley Island, residences have been built on top of the levees along Milton Road and pilings and docks have been constructed on the relatively steep waterside slopes along the river. In many places, short floodwalls on the order of up to a meter in height have been constructed to provide wave protection and freeboard. Figure 7-15 presents a Google Earth plot and an aerial photograph illustrating the area.

In one location along Milton Road, ground cracking was observed across the asphalt pavement. This cracking continued to a fractured low cinderblock wall (see Figure 7-16). At the back of the residence on the waterside portion of the levee, the dock and floodwall had been damaged. It was not clear if the cracking and damage were associated with shaking or ground displacements associated with a continuation of the fault rupture south of the epicenter. The shaking must have been significant as a large water tank moved off its concrete pad and sheared its connection with the residence (see Figure 7-17). However, no damage was observed on the levee embankment itself.

7.5.3 Green Island Salt Pond Retaining Dike

Along the western edge of Green Island along mud flats east of the left (east) bank of the Napa River and south of the epicenter there are small retaining dikes that previously retained brine waters in salt ponds (see location in Figure 7-15). The area has largely been converted into an environmental restoration and recreation area, but many of the retaining ponds for the salt ponds remain in place. No significant damage was observed by the GEER team for the majority of the dikes visited on foot, and no damage was observed during the aerial reconnaissance. However, near the very western tip of the island, approximately 100 meters of longitudinal cracking was observed near the landside toe of the dike. The largest cracks were approximately 2½ centimeters in width, and, while longitudinal, appeared to have enlarged from shrinkage cracks. In addition, there appeared to be sandy ejecta along the cracks, but this was not definitive as the observations were made on September 4th, approximately 10 days after the earthquake (see Figure 7-18).

The retaining dike at this location was approximately 2 meters high and had crown widths on the order of 3 meters. In addition to the longitudinal cracking, four transverse cracks approximately 2 to 4 millimeters in width also crossed the levee in this 100-meter reach (see Figure 7-19). It is likely, but not definitive that the cracking was associated with a limited amount of liquefaction in the foundation in this area.

Contributing Sources:

Initial Observations: Keith Kelson (Sacramento District, USACE)

Computations of PGA estimates at dams using NGA-W2 GMPEs: Jorge Luis Macedo Escudero (University of California, Berkeley)

Background information on dams and DSOD inspections: Y-Nhi Enzler (DSOD); Mark Stanley (HDR Engineering); Brian Vanciel (City of Vallejo); Dan Hiteshew (City of Vallejo)

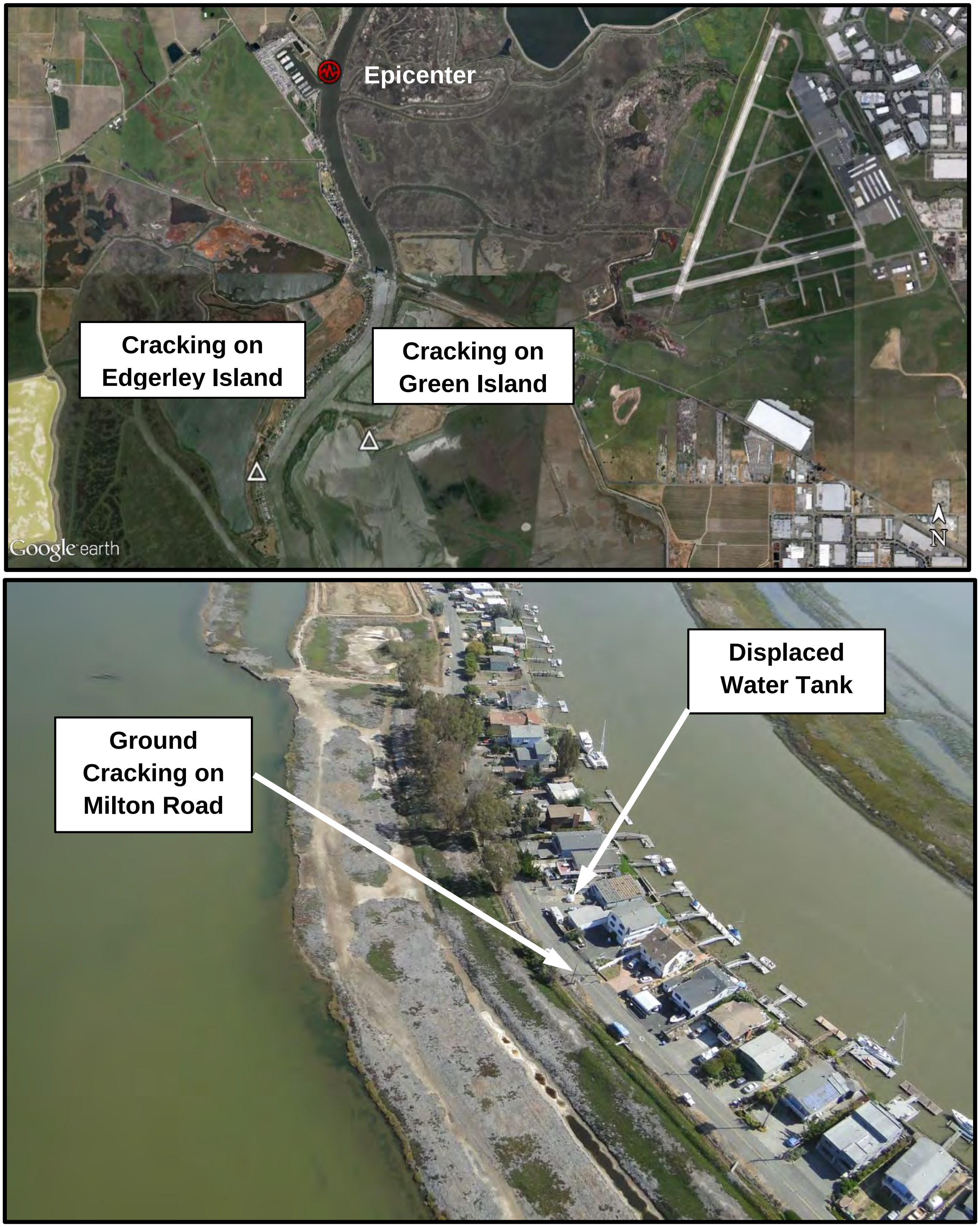

Figure 7-15: Google Earth plot and aerial photograph of Napa River along Edgerley Island south of the epicenter [NSF-GEER; Napa, CA; N38.198 W 122.316; Harder, L. F.; 09/01/14]

Figure 7-16: Photographs of cracked asphalt pavement on Milton Road, cracked cinderblock retaining wall, and damage to waterside floodwall/boat dock on Edgerley Island south of the epicenter [NSF-GEER; Napa, CA; N38.198 W 122.316; Harder, L. F.; 09/01/14]

Figure 7-17: Photographs of displaced water tank moved off its concrete pad and sheared pipe connection – note replacement tanks on pad in its place - on Edgerley Island south of the epicenter [NSF-GEER; Napa, CA; N38.198 W 122.316; Harder, L. F.; 09/01/14]

Figure 7-18: Photographs of longitudinal cracking and apparent ejecta along landside toe of salt pond retaining dike on western edge of Green Island south of the epicenter
[NSF-GEER; Napa, CA; N38.201 W 122.302; Harder, L. F.; 09/04/14]

Figure 7-19: Photographs of transverse cracking on crown of salt pond retaining dike on western edge of Green Island south of the epicenter
[NSF-GEER; Napa, CA; N38.201 W 122.302; Harder, L. F.; 09/04/14]