USGS
science for a changing world

Selected Images of the Effects of the October 15, 2006, Kīholo Bay-Māhukona, Hawai'i, Earthquakes and Recovery Efforts

Data Series 506

U.S. Department of the Interior
U.S. Geological Survey

COVER: Aerial view of the extensive Kohala Ditch trail system, sections of which have been completely filled with debris from rock slides. The trail, once used by residents to transport goods in and out of the valley by mule, zigzags up the walls of the East Branch of Honokāne Nui Valley (North Kohala District, north Hawai'i, 20.19675°N, 155.71975°W; view to the southeast). USGS photo by E.L. Harp, November 8, 2006.

Twenty-four-hour-long seismograph record (15 minutes per rotation) shows the trace of the October 15, 2006, Kiholo Bay and Māhukona earthquakes, South Kohala District, northwest Hawai'i. The *M*6.7, 39-km-deep Kiholo Bay earthquake (19.878°N, 155.935°W) occurred at 7:07 a.m., HST, and the *M*6.0, 9-km-deep Māhukona earthquake, 28 km north-northwest of Kiholo Bay (20.129°N, 155.983°W), occurred 6 minutes, 24 seconds later, at 7:14 a.m., HST. The onset of the Kiholo Bay earthquake is at the minute mark to the left, and the onset of the Māhukona earthquake is at the center of the record. The trace of a large aftershock can be seen to the right. Numerous smaller aftershocks occurred after the larger quakes.

Selected Images of the Effects of the October 15, 2006, Kīholo Bay-Māhukona, Hawai‘i, Earthquakes and Recovery Efforts

By Taeko Jane Takahashi, Nancy A. Ikeda, Paul G. Okubo, Maurice K. Sako, David C. Dow, Anna M. Priester, and Nolan A. Steiner

Data Series 506

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

This report and any updates to it are available online at:

http://pubs.usgs.gov/ds/506/

For product and ordering information:

World Wide Web: http//www.usgs.gov/pubprod

Telephone: 1-888-ASK-USGS (1-888-275-8747)

For more information on the USGS—the Federal source for science about the Earth,
its natural and living resources, natural hazards, and the environment:
World Wide Web: http://www.usgs.gov
Telephone: 1-888-ASK-USGS

Suggested citation:
Takahashi, T.J., Ikeda, N.A., Okubo, P.G., Sako, M.K., Dow, D.C., Priester, A.M., and Steiner, N.A., 2011. Selected images of the effects of the October 15, 2006, Kīholo Bay-Māhukona, Hawai'i, earthquakes and recovery efforts: U.S. Geological Survey Data Series 506.

Contents

Figures

Table

Photographs

(see linked files at http://pubs.usgs.gov/ds/506/ds-506_photographs/)

Site No.	Site Location
1.	Laupāhoehoe Gulch, Laupāhoehoe, Highway 19, North Hilo District
2.	Kawāili Bridge, Pa‘auilo, Highway 19, Hāmākua District
3.	St. Joseph Catholic Church, Pa‘auilo, Highway 19, Hāmākua District
4.	Pa‘auilo Hongwanji Mission and Cemetery, Pa‘auilo, Highway 19, Hāmākua District
5.	Shingon-shu Pa‘auilo Kongoji, Pa‘auilo, Highway 19, Hāmākua District
6.	Kalōpā Cemetery, Kalōpā Highway 19, Hāmākua District
7.	Kalōpā Mauka (“Sand Gulch”) Road, Kalōpā, Highway 19, Hāmākua District
8.	Honoka‘a High School, Honoka‘a, Highway 19, Hāmākua District
9.	Hale Ho‘ōla Hāmākua, Honoka‘a, Highway 19, Hāmākua District
10.	Waipi‘o Valley, Hāmākua District
11.	Coastline, ‘Āinahou debris fan, Hāmākua District
12.	Waimanu Valley, Hāmākua District
13.	Coastline, Laupāhoehoe Iki to Laupāhoehoe Nui debris fans, Hāmākua District
14.	Coastline, Laupāhoehoe Nui debris fan to Honopue Valley, Hāmākua District
15.	Honopue Valley, Hāmākua District
16.	Honoke‘ā Valley, Hāmākua-North Kohala District boundary
17.	Coastline, Honopue Valley to ‘Ākoako‘a Point, Hāmākua and North Kohala Districts
18.	Honokāne Nui Valley, North Kohala District
19.	Pololū Valley and Pololū Valley Lookout, North Kohala District
19A.	Pololū Valley
19B.	Pololū Valley Lookout, Niuli‘i, Highway 270
20.	Kēōkea Park Road intersection to Waikani Gulch bridge, Makapala, Highway 270, North Kohala District
21.	Kēōkea Beach Park, Makapala, Highway 270, North Kohala District
21A.	Kēōkea Beach
21B.	Kēōkea Beach Park gazebo
21C.	Kēōkea Beach Park pavilion
22.	Makapala Chapel, Makapala, Highway 270, North Kohala District
23.	Pūwā‘i‘ole Gulch, Makapala, Highway 270, North Kohala District
24.	Kalāhikiola Congregational Church, Kapa‘au, Highway 270, North Kohala District
25.	Lapakahi State Historical Park, Māhukona, Highway 270, North Kohala District
26.	Honokoa Bridge, Māhukona, Highway 270, South Kohala District
27.	Honokoa Gulch culvert, Māhukona, Highway 270, South Kohala District
28.	North Kawaihae Small Boat Harbor, Kawaihae, Highway 270, South Kohala District
29.	Kawaihae Pier, Kawaihae, Highway 270, South Kohala District
30.	Pu‘ukoholā Heiau National Historic Site, Kawaihae, Highway 270, South Kohala District
31.	Queen Ka‘ahumanu Highway road cut, Puakō, Highway 19, South Kohala District
32.	Moku‘aikaua Church, Kailua-Kona, Highway 11, North Kona District
33.	Hulihe‘e Palace, Kailua-Kona, Highway 11, North Kona District
34.	Hōlualoa Catholic Cemetery, Hōlualoa, Highway 180, North Kona District
35.	Kona Community Hospital, Kealakekua, Highway 11, South Kona District
36.	Kealakekua Bay, Kealakekua, Highway 11, South Kona District

Seismic Overview of the Earthquakes

By Paul G. Okubo

Early on the morning of October 15, 2006, two moderate earthquakes—the largest in decades—struck the Island of Hawai‘i. The first of these, which occurred at 7:07 a.m., HST (1707 UTC), was a magnitude (*M*)6.7 earthquake, centered beneath Kīholo Bay on the northwestern coast of the island (19.878°N, 155.935°W), at a depth of 39 km. The second earthquake, which struck 6 minutes, 24 seconds later, at 7:14 a.m., HST (1714 UTC), was located 28 km to the north-northwest of Kīholo Bay (20.129°N, 155.983°W), centered at a depth of 19 km. This *M*6.0 earthquake has since been referred to as the Māhukona earthquake. Losses from the combined effects of these earthquakes are estimated to be $200 million—the most costly events, by far, in Hawai‘i’s earthquake history.

Figure 1 shows the epicenters of these earthquakes and the first few days of aftershocks from October 2006, as posted on the U.S. Geological Survey (USGS), Hawaiian Volcano Observatory’s earthquakes page on the World Wide Web (http://tux.wr.usgs.gov). To date, the largest aftershock was a *M*5.0 earthquake that occurred on November 23, 2007. The aftershock sequence from the Kīholo Bay earthquake continued through 2008. Analysis of earthquake locations and source mechanisms suggests that the *M*6.7 Kīholo Bay mainshock ruptured a deep fault plane that extends west-northwest from the coastline beneath the bay and dips to the south (Yamada and others, 2008). Stress modeling of the response of a lithospheric plate due to volcanic loading shows the Kīholo Bay and Māhukona earthquakes to be consistent with downward flexing of a layered lithospheric plate (McGovern, 2007).

Since 1973, the USGS has operated accelerographs in Hawai‘i to record strong ground motions of potential engineering interest. Some of these instruments were upgraded in 1999 from their original photographic film-based recording systems, to telemeter digital strong-motion recordings. Following the earthquakes, the upgraded stations automatically transmitted their recordings to the USGS National Strong Motion Data Center in Menlo Park, California, operated by the USGS National Strong Motion Project (NSMP). Records from instruments still using photographic film were retrieved by NSMP personnel in the weeks following the October earthquakes and subsequently were developed and digitized for data reduction and analysis. At the same time, some stations were upgraded with units capable of onsite digitization. Since the October 2006 earthquakes, all USGS NSMP instruments in Hawai‘i have been upgraded with digital recorders and connected by using modems and telephone circuits to automatically transmit their records to the NSMP Data Center (E. Anjal, written commun., 2007).

The strongest ground accelerations from the October 15 earthquakes were recorded at stations on the northwestern part of the Island of Hawai‘i (fig. 2 and table 1). The distribution of peak ground accelerations, as presented in figure 2, reflects the effect of local site conditions at the recording-instrument locations and the amplitude of seismic waves at that distance from the hypocenter. In Hawai‘i, site amplifications of seismic ground motion have been closely linked to the presence of volcanic ash deposits (Munson and Thurber, 1997). Although not the closest station to the Kīholo Bay earthquake, the accelerograph at the Waimea Fire Station, underlain by volcanic ash deposits, recorded the highest peak accelerations in the entire data set. The effects of site conditions are also seen at sites in Hilo, where data reflect relative amplification of recorded peak accelerations, depending upon whether the stations are located on volcanic ash or on hard rock.

Alhough infrequent, damage and other effects of moderate and larger earthquakes in Hawai‘i have been recorded for nearly 200 years. The effects of some 59 moderate and larger earthquakes (magnitudes 6 and above) have been recorded since written accounts of earthquake damage were first kept in Hawai‘i in 1823 (Wyss and Koyanagi, 1992). The largest earthquake ever recorded in Hawai‘i occurred on April 2, 1868; its magnitude was estimated to be 7.9. The October 15, 2006, earthquake was the largest to occur in Hawai‘i in 23 years (fig. 3).

Using information submitted on the Internet by the general public, the USGS has developed a means of collecting and posting reports of earthquakes as USGS Community Internet Intensity Maps (CIIM) (Wald and others, 1999). If an earthquake is felt, individuals may file reports on the effects of the quake at http://earthquake.usgs.gov/eqcenter/dyfi. Contributors reply to a list of standard questions used to determine earthquake intensity. Reports are then compiled and presented in maps, according to postal zip code and Community Decimal Intensity (CDI) per zip code. The intensities displayed on the maps represent average Modified Mercalli Intensity (Wood and Neumann, 1931; Richter, 1958) for these communities or zip codes (see appendix; see linked file http://pubs.usgs.gov/ds/506/ds506_appendix_a.txt)

Figure 4 shows the CIIM posted after the October 15, 2006, Kīholo Bay earthquake, which was felt across the entire State of Hawaii. The strongest individual earthquake effects

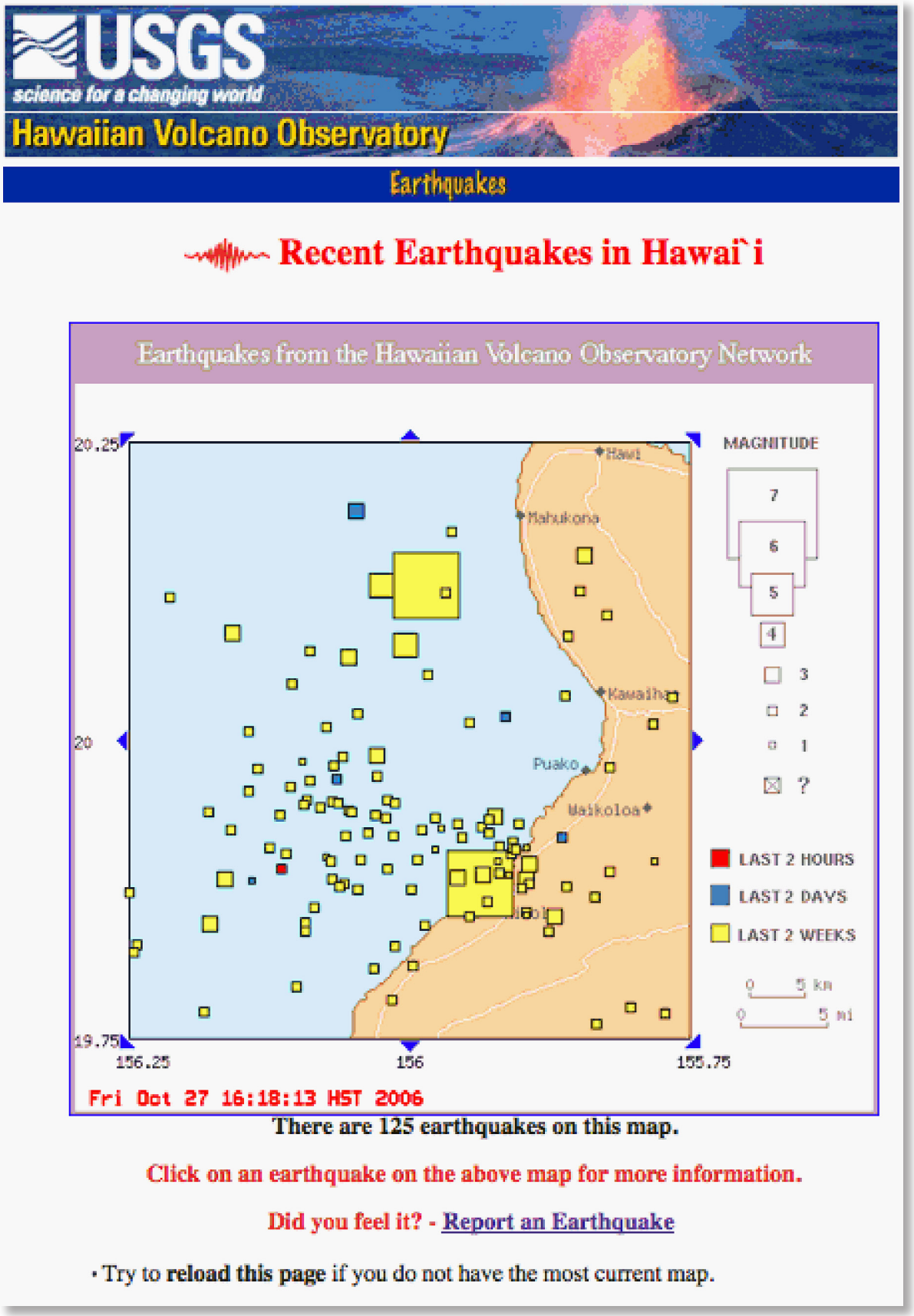


Figure 1. U.S. Geological Survey, Hawaiian Volcano Observatory, October 27, 2006, Web page of recent earthquakes showing the October 15, 2006, Kīholo Bay and Māhukona, Hawai'i, earthquakes.

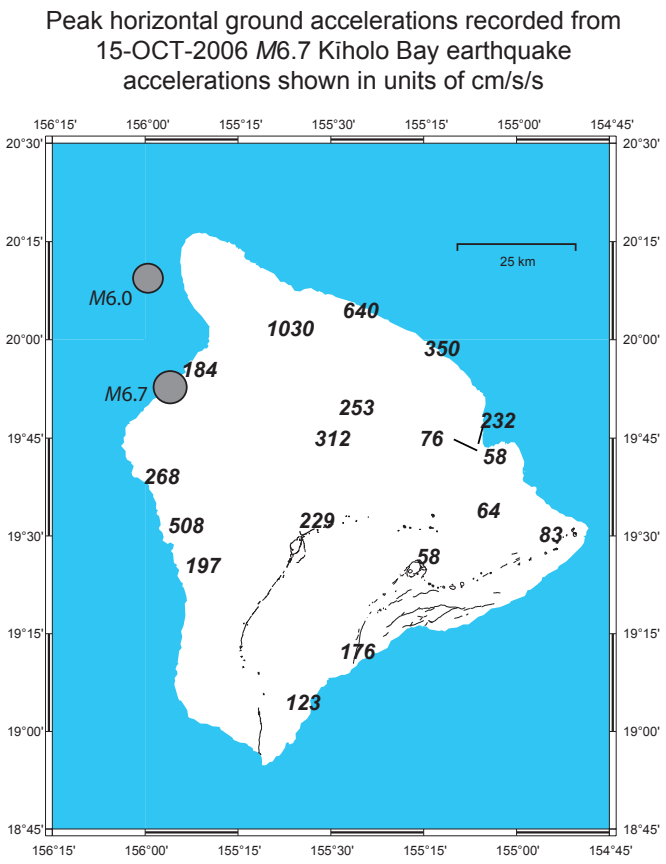


Figure 2. Map showing peak horizontal accelerations recorded during the October 15, 2006, *M*6.7 Kīholo Bay, Hawai‘i, earthquake. Data are from the U.S. Geological Survey National Strong Motion Project (http://nsmp.wr.usgs.gov/data_sets/20061015_1707.html).

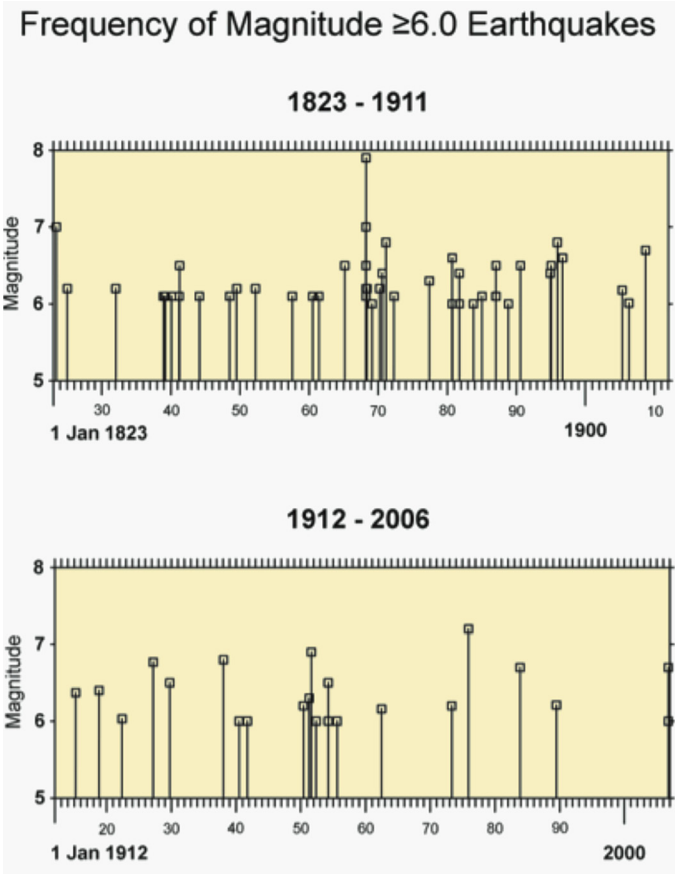


Figure 3. Earthquakes in Hawai‘i of magnitude 6 or greater, 1823–present, adapted from figure 51 of Wyss and Koyanagi, 1992, Isoseismal maps, macroseismic epicenters, and estimated magnitudes of historic earthquakes in the Hawaiian Islands, U.S. Geological Survey Bulletin 2006.

were reported as CDI IX, from the Kohala, Hāmākua, and Kona Districts on the northern and western parts of the Island of Hawai‘i. The close timing and proximity of the Kīholo Bay mainshock and the subsequent Māhukona earthquake did not allow for a clear separation between reports of the effects of the two earthquakes, and a CIIM for the *M*6.0 Māhukona earthquake was not produced.

In the earthquakes' aftermaths, the County of Hawaii received many requests from homeowners for assessments of earthquake-generated building damage. In response to these requests, the Hawaii County Department of Public Works adopted the ATC-20 rapid evaluation procedure (Applied Technology Council, 2005). Nearly 2,000 homes were damaged, and 10 destroyed, by the effects of the earthquakes. Inspectors and engineers from the Hawaii County Department of Public Works coordinated and directed teams of engineers comprised of volunteer engineers (many flown in from other Hawaiian islands) to conduct the ATC-20 evaluations in a timely manner.

Figure 5 is the deaggregated CIIM, which shows the variability of reported earthquake effects across the county. The pattern of individual earthquake reports is somewhat reflective of the home damage assessments resulting from the ATC-20 inspections.

Of the nearly 1,700 homes inspected, approximately 1,000 were evaluated during the first week after the mainshock. Sixty-seven of the 1,000 homes were determined to be unsafe to enter or occupy and received the ATC-20 red-tag designation. Another 227 homes received the ATC-20 yellow-tag designation allowing restricted entry, occupancy, and lawful use. The remaining homes were considered safe to occupy. The ATC-20 evaluations clearly reflected particular vulnerability of wooden homes with single-wall construction to strong shaking as a result of earthquakes. Figure 6 is a map, provided by the County of Hawaii, showing locations of the red- and yellow-tagged homes.

Following the 2006 earthquakes, the Department of Homeland Security's Federal Emergency Management Agency (FEMA) responded quickly and dispatched teams to the affected areas. In addition to disaster relief and recovery, FEMA enabled detailed voluntary inspections and assessments of residential damage and, subsequently, prescribed retrofits

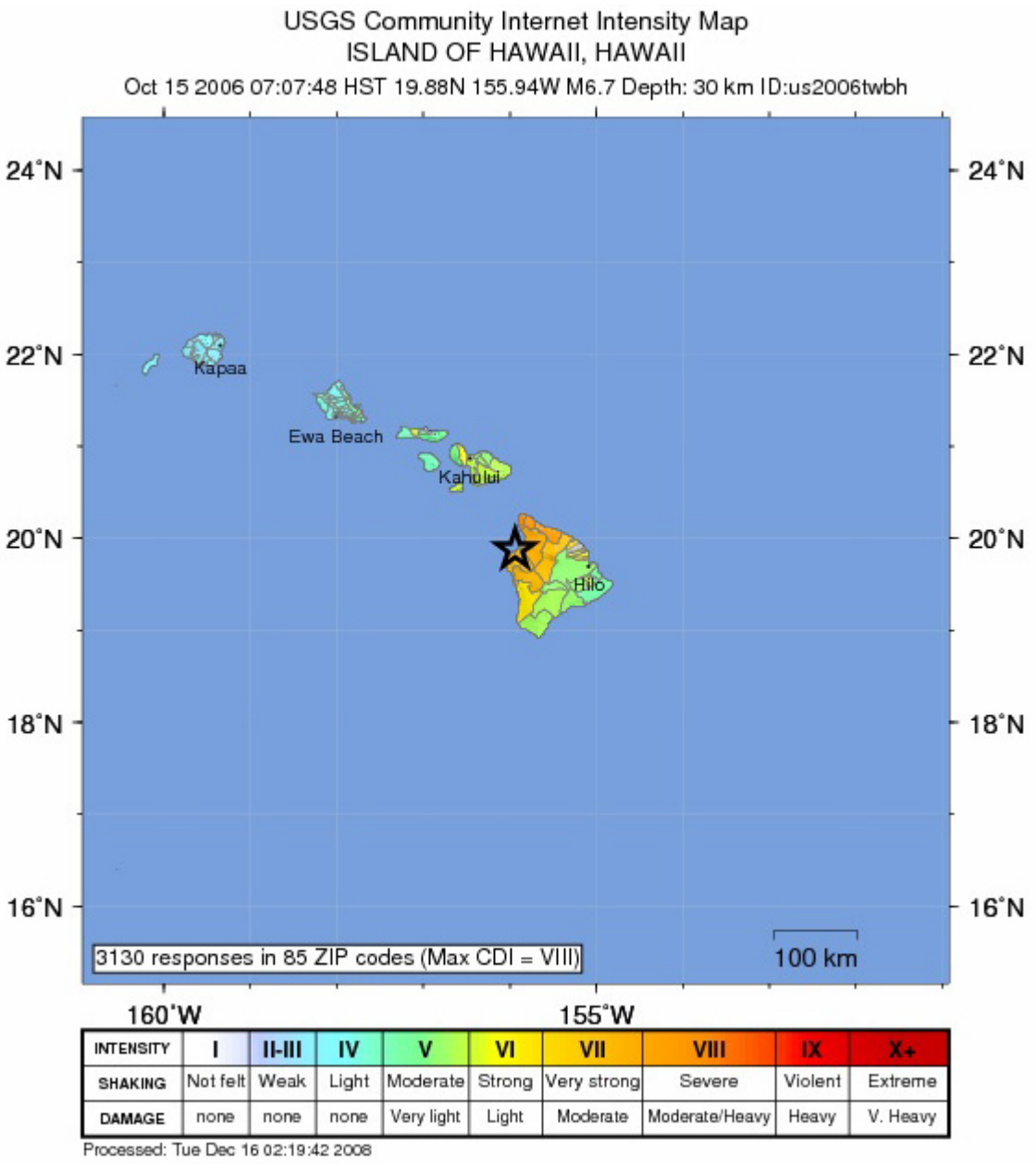


Figure 4. U.S. Geological Survey Community Internet Intensity Map for the October 15, 2006, *M*6.7 Kiholo Bay, Hawai‘i earthquake.

to harden structures against the impact of earthquakes. The agency has supported technical efforts to better understand observed earthquake effects and to promote mitigation against future damaging earthquakes in the State of Hawaii.

A geotechnical project was initiated on the Island of Hawai‘i to help interpret the patterns of strong ground shaking and ground failure following the earthquakes. Using a truck-based controlled seismic source, surveys of seismic wave speeds were done at locations of NSMP strong-motion recorders and the State of Hawaii’s Kawaihae Harbor port facility. In addition to the basic geotechnical data, the results of these surveys will be incorporated into updated calculations of probabilistic seismic hazards in Hawai‘i.

Although the vast majority of earthquakes in the State of Hawaii are closely related to the active volcanism associated with the southeastern part of the Island of Hawai‘i, the October 2006 Kīholo Bay and Māhukona earthquakes clearly suggest the devastating potential of deeper lithospheric earthquakes. Large earthquakes thought to be nearly *M*7 have struck near the islands of Lāna‘i (1871) and Maui (1938). It is thought that these, like the 2006 earthquakes, were deep lithospheric flexure earthquakes (Wyss and Koyanagi, 1992; Klein and others, 2001). Thus, it is important to recognize the potential seismic hazard posed by such earthquakes beneath the older Hawaiian Islands. The data and observations afforded by the 2006 earthquakes promise to improve probabilistic seismic hazards modeling in Hawai‘i.

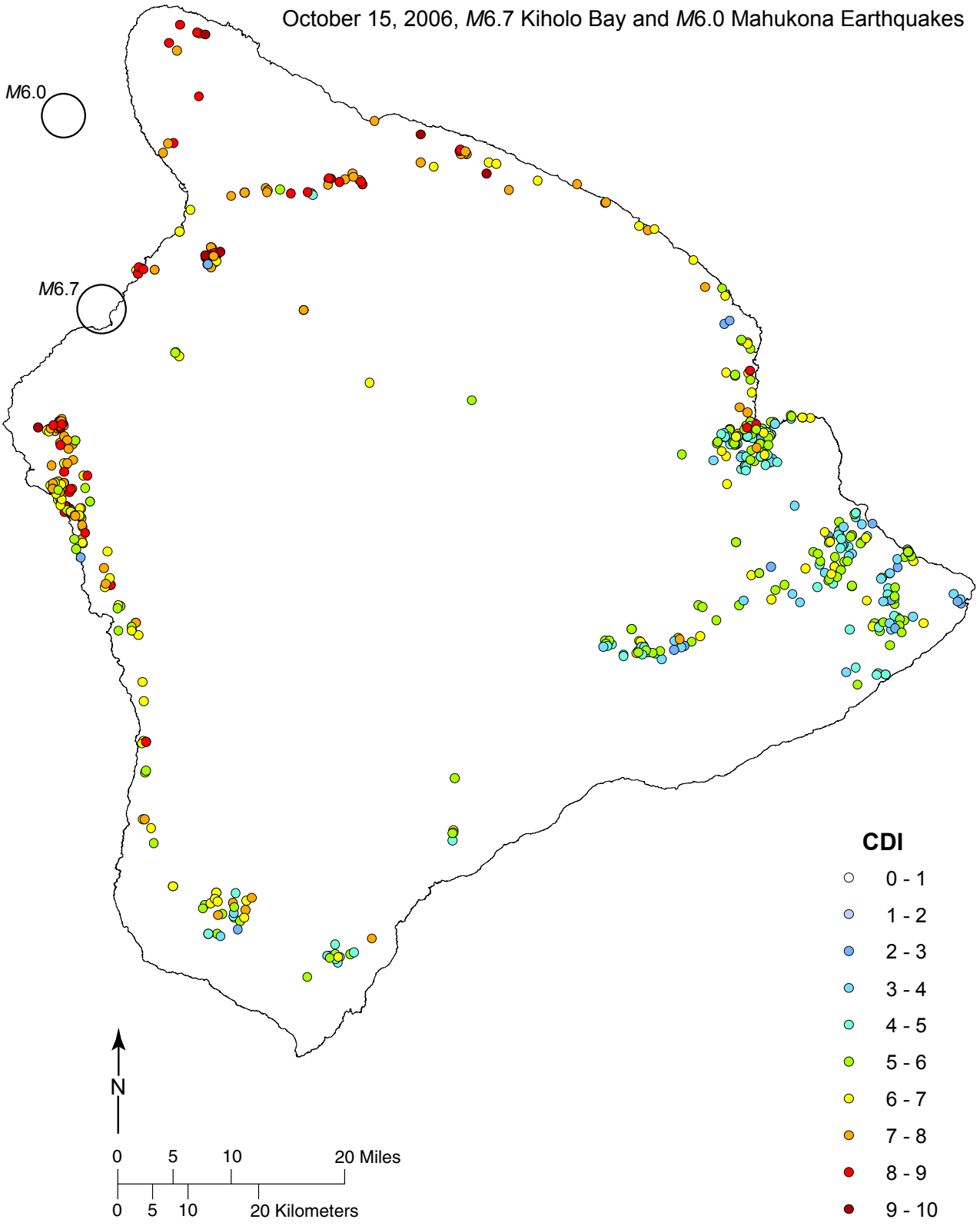


Figure 5. Individually computed Community Decimal Intensities, CDI, compiled from reports posted to the U.S. Geological Survey's Community Internet Intensity Maps Web site after the *M*6.7 Kīholo Bay and *M*6.0 Māhukona earthquakes of October 15, 2006. No attempts were made to discriminate between reports from one or the other earthquake because the events occurred within minutes of each other.

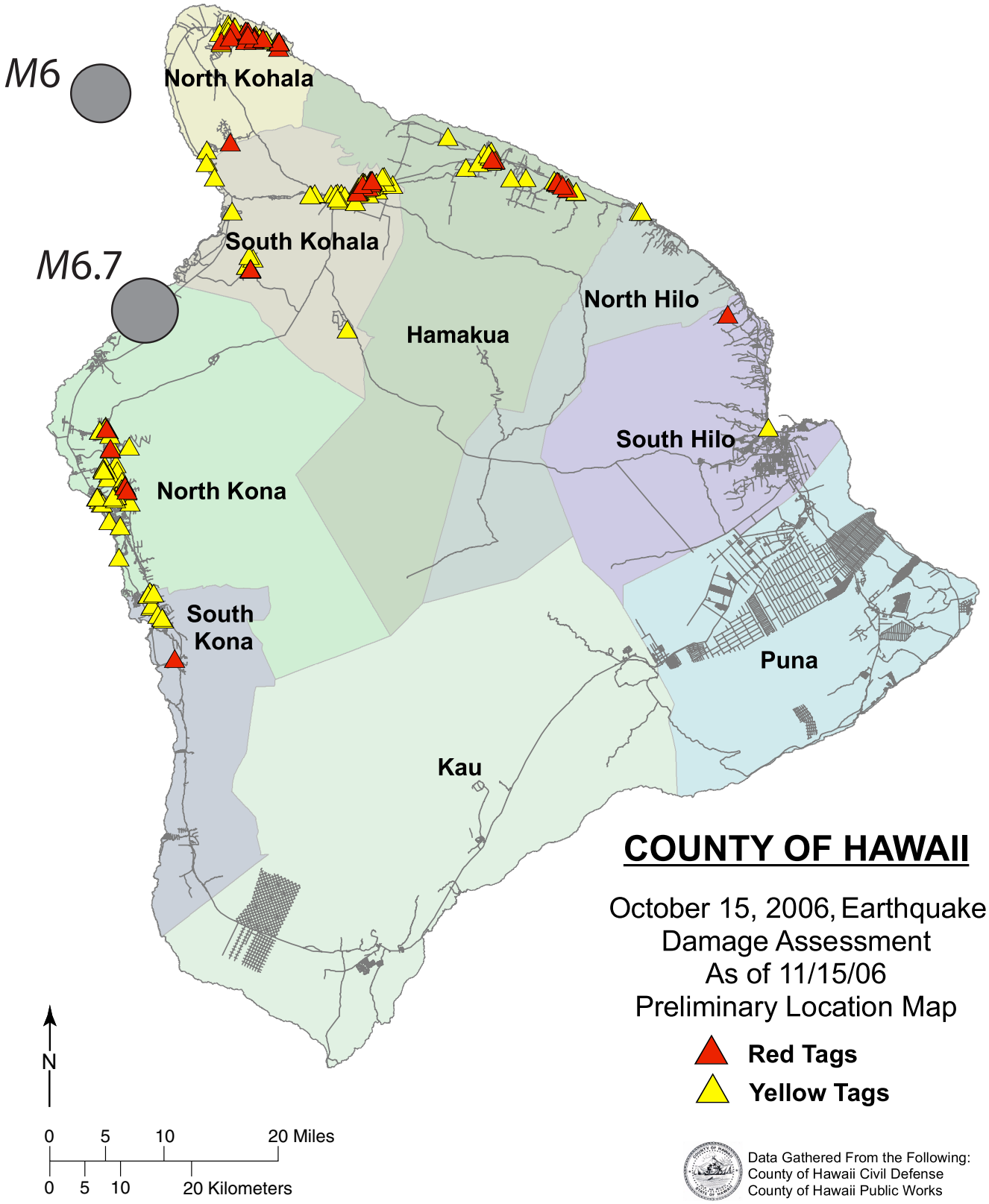


Figure 6. Map showing locations of homes in Hawaii County assigned red and yellow tags following ATC-20 post-earthquake assessments.

Overview of Selected Sites

By Taeko Jane Takahashi

The effects of the October 15, 2006, Kīholo Bay-Māhukona earthquakes are shown in images taken from the coastal route along the northern half of the Island of Hawai‘i, where damage was the most concentrated. The direction of presentation is counter-clockwise, from Pa‘auilo on the eastern or windward (Hāmākua) side to Kealakekua Bay on the western or leeward (Kona) side. A list of sites, their locations, coordinates, and distance from the epicenter at Kīholo Bay are given in table 1. A Google Earth map (fig. 7) and a topographic map (fig. 8) pinpoint the 36 sites where damage was documented and digital images were compiled for this collection.

The selection of sites was based on access, where photographing was not a problem, such as parks and roadways, or where permission to photograph was granted, such as churches, museums, and schools. Areas of restricted access or those that were hazardous to photograph, such as dams and cliffs, and sites that were on private property, such as businesses and residences, were not included.

The photographs constitute a partial record of the damage and, where pertinent, recovery and restoration at selected sites. With limited person resources, around-the-island coverage in the days immediately following the earthquakes was not feasible; however, owing to the lengthy process of recovery, and delays prior to the start of repair work at many of the sites, photo documentation could continue long after the event occurred.

The types of damage photographed include natural and manmade effects, both major and minor, showing evidence of the direction and result of movement in concrete bridges and buildings, cemeteries and churches, mortared and stacked stone walls, roadways, embankments, cliffs, and slopes that altered the face of the Island of Hawai‘i. In order to provide a visual understanding of the extent or nature of the damage, photographs selected include broad overviews, mid-range perspectives, and close-ups of the sites.

The images are in the public domain and may be used without permission. The USGS, however, does not assume responsibility for any modifications that change the nature, intent, or color rendition of the original photographs. The purpose of the photographs was to represent the events as naturally as possible, including the grays of weathered basaltic rocks, the brownish-greens of vegetation, and the deep blues of Hawai‘i’s skies—all colored by the light (often filtered through passing rain clouds) that shines variably down on Hawai‘i.

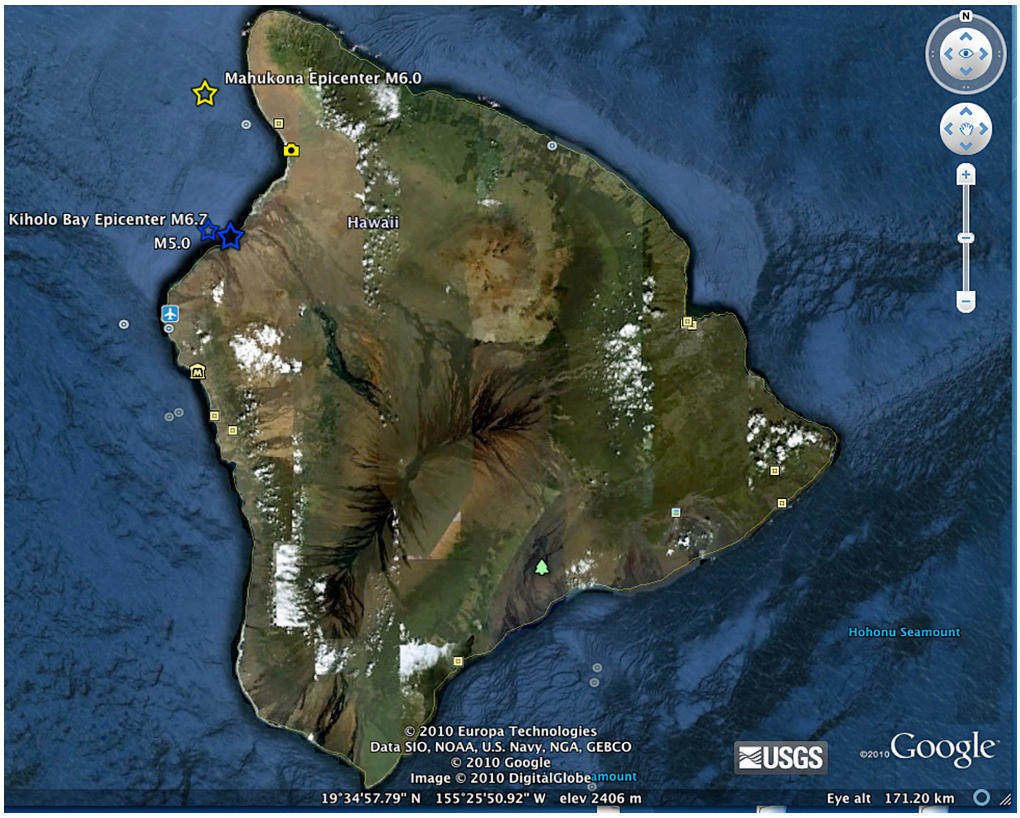
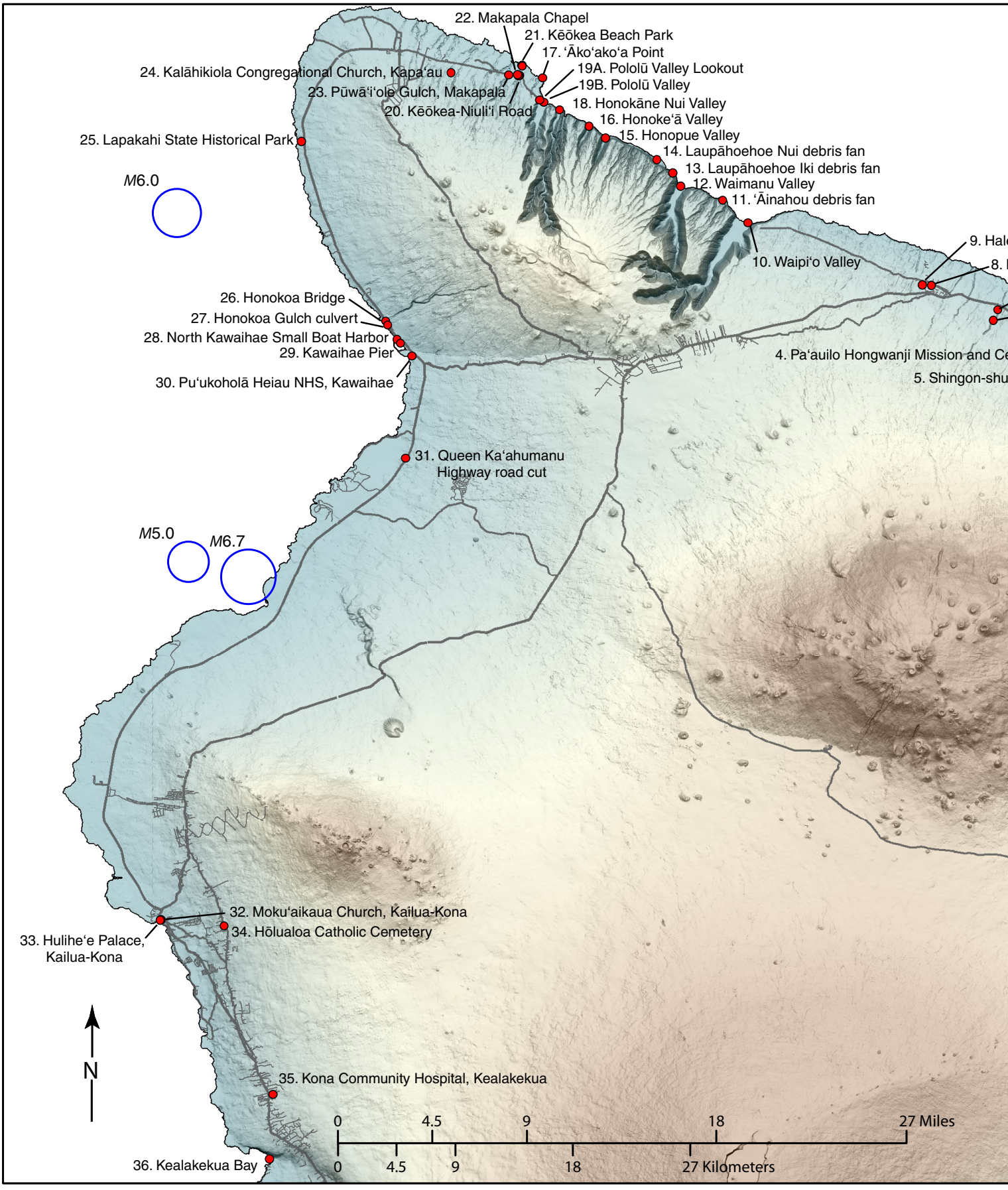
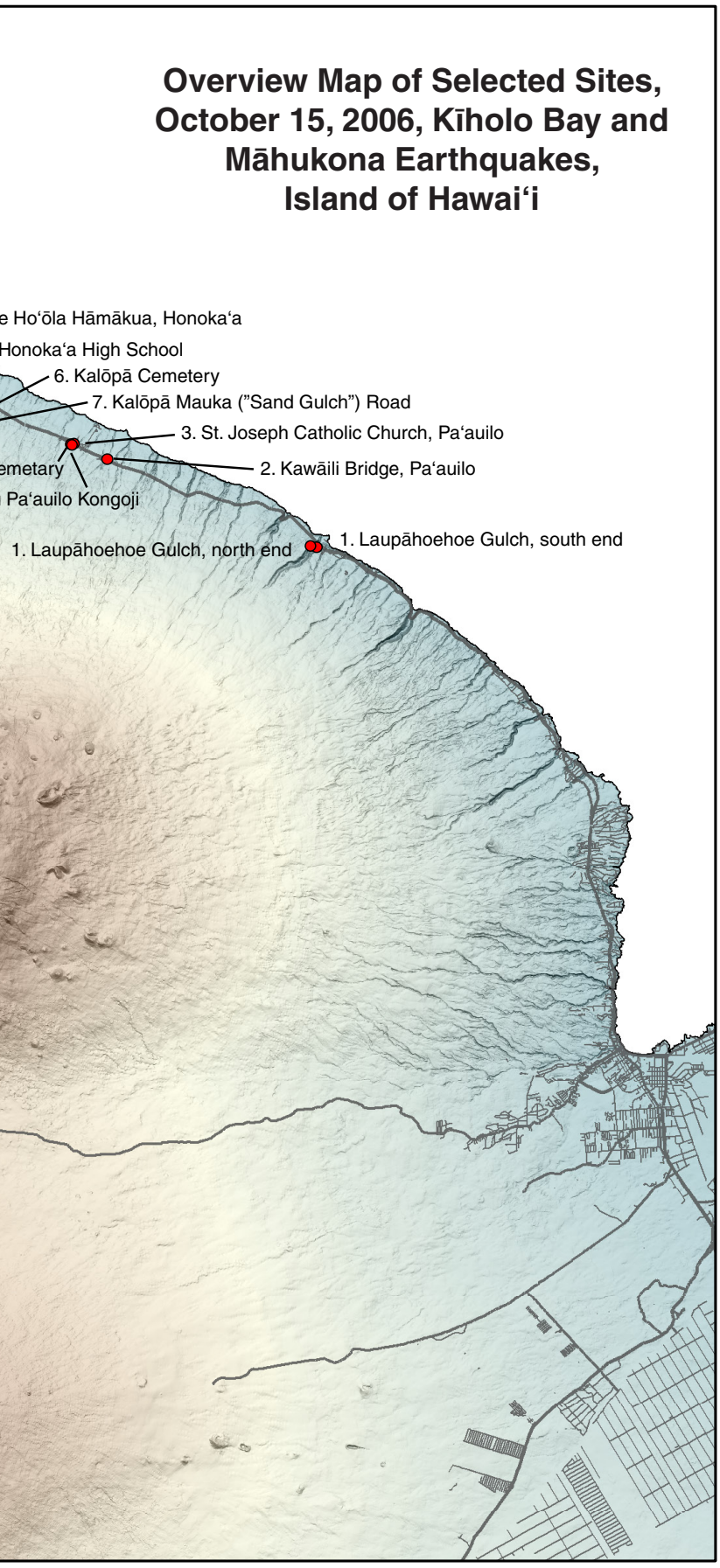


Figure 7. Site locations on Google Earth map, from site 1, Pa‘auilo to the northeast, to site 36, Kealakekua Bay to the southwest, going counter-clockwise around the northern half of the Island of Hawai‘i. The earthquake epicenters and geographic features mentioned in the text are identified, and figures 2, 5, and 6 from the Seismic Overview section of this report have been adapted and overlain on the map.


22. Makapala Chapel
21. Kēōkea Beach Park
17. ʻĀkoʻakoʻa Point
24. Kalāhikiola Congregational Church, Kapaʻau
19A. Pololū Valley Lookout
23. Pūwāʻiʻole Gulch, Makapala
19B. Pololū Valley
20. Kēōkea-Niuliʻi Road
18. Honokāne Nui Valley
16. Honokeʻā Valley
25. Lapakahi State Historical Park
15. Honopue Valley
14. Laupāhoehoe Nui debris fan
M6.0
13. Laupāhoehoe Iki debris fan
12. Waimanu Valley
11. ʻĀinahou debris fan
10. Waipiʻo Valley
9. Hal
8.
26. Honokoa Bridge
27. Honokoa Gulch culvert
28. North Kawaihae Small Boat Harbor
29. Kawaihae Pier
4. Paʻauilo Hongwanji Mission and Ce
30. Puʻukoholā Heiau NHS, Kawaihae
5. Shingon-shu
31. Queen Kaʻahumanu Highway road cut
M5.0
M6.7
32. Mokuʻaikaua Church, Kailua-Kona
34. Hōlualoa Catholic Cemetery
33. Hulihe‘e Palace, Kailua-Kona
N
35. Kona Community Hospital, Kealakekua
0 4.5 9 18 27 Miles
36. Kealakekua Bay
0 4.5 9 18 27 Kilometers



Selected Sites, October 15, 2006, Kīholo Bay and Māhukona Earthquakes, Island of Hawai‘i

1. Laupāhoehoe Gulch, north and south end
2. Kawāili Bridge, Pa‘auilo
3. St. Joseph Catholic Church, Pa‘auilo
4. Pa‘auilo Hongwanji Mission and Cemetery
5. Shingon-shu Pa‘auilo Kongoji
6. Kalōpā Cemetery
7. Kalōpā Mauka (“Sand Gulch”) Road
8. Honoka‘a High School
9. Hale Ho‘ōla Hāmākua, Honoka‘a
10. Waipi‘o Valley
11. ‘Āinahou debris fan
12. Waimanu Valley
13. Laupāhoehoe Iki
14. Laupāhoehoe Nui
15. Honopue Valley
16. Honoke‘ā Valley
17. ‘Āko‘ako‘a Point
18. Honokāne Nui Valley
19A. Pololū Valley
19B. Pololū Valley Lookout
20. Kēōkea Park-Niuli‘i Road
21. Kēōkea Beach Park
22. Makapala Chapel
23. Pūwā‘i‘ole Gulch, Makapala
24. Kalāhikiola Congregational Church, Kapa‘au
25. Lapakahi State Historical Park
26. Honokoa Bridge
27. Honokoa Gulch culvert
28. North Kawaihae Small Boat Harbor
29. Kawaihae Pier
30. Pu‘ukoholā Heiau NHS, Kawaihae
31. Queen Ka‘ahumanu Highway road cut
32. Moku‘aikaua Church, Kailua-Kona
33. Hulihe‘e Palace, Kailua-Kona
34. Hōlualoa Catholic Cemetery
35. Kona Community Hospital, Kealakekua
36. Kealakekua Bay

Figure 8. Locations of selected sites on topographic map, from site 1, Pa‘auilo to the northeast, to site 36, Kealakekua Bay to the southwest, going counter-clockwise around the northern half of the Island of Hawai‘i.

Table 1. Site locations, with coordinates and distances from the Kīholo Bay epicenter, Island of Hawai‘i.

Site No.	Site Location	Hwy	Mile Post	Actual Mileage	Latitude (°N)	Longitude (°W)	Epicenter distance (km)	(mi)
1	Laupāhoehoe Gulch, Laupāhoehoe, North Hilo District							
	Laupāhoehoe Gulch, south end	19	26	26.3	19.98716	155.24615	73.0	45.4
	Laupāhoehoe Gulch, north end	19	26	26.6	19.98808	155.24930	72.7	45.2
2	Kawāili Bridge, Pa‘auilo, Hāmākua District	19	35	35.2	20.03334	155.35542	63.0	39.1
3	St. Joseph Catholic Church, Pa‘auilo, Hāmākua District	19	36	36.4	20.04143	155.37260	61.5	38.2
4	Pa‘auilo Hongwanji Mission and Cemetery, Pa‘auilo, Hāmākua District	19	36	36.4	20.04117	155.37417	61.4	38.1
5	Shingon-shu Pa‘auilo Kongoji, Pa‘auilo, Hāmākua District	19	36	36.4	20.04069	155.37344	61.4	38.2
6	Kalōpā Cemetery, Kalōpā, Hāmākua District	19	39	39.8	20.05916	155.41804	57.7	35.8
7	Kalōpā Mauka (“Sand Gulch”) Road, Kalōpā, Hāmākua District	19	39	39.8	20.05226	155.42113	57.1	35.5
8	Honoka‘a High School, Honoka‘a, Hāmākua District	19	43	43.0	20.07607	155.46380	53.9	33.5
9	Hale Ho‘ōla Hāmākua, Honoka‘a, Hāmākua District	19	43	43.6	20.07651	155.47020	53.4	33.2
10	Waipi‘o Valley, Hāmākua District	N/A			20.11922	155.59030	42.2	26.2
11	Coastline, ‘Āinahou debris fan, Hāmākua District	N/A			20.13467	155.60764	44.5	27.7
12	Waimanu Valley, Hāmākua District	N/A			20.14441	155.63672	43.0	26.7
13	Coastline, Laupāhoehoe Iki to Lauphoehoe Nui debris fans, Hāmākua District	N/A			20.16265	155.65286	43.2	26.9
	Laupāhoehoe Iki debris fan	N/A			20.15363	155.64204	43.3	26.9
	Laupāhoehoe Nui debris fan	N/A			20.16265	155.65286	43.2	26.9
14	Coastline, Laupāhoehoe Nui debris fan to Honopue Valley, Hāmākua District							
	Laupāhoehoe Nui debris fan	N/A			20.16265	155.65286	43.2	26.9
	Honopue Valley	N/A			20.17780	155.68818	42.1	26.2
15	Honopue Valley, Hāmākua District	N/A			20.17780	155.68818	42.1	26.2
16	Honoke‘ā Valley, Hāmākua-North Kohala District boundary	N/A			20.18563	155.69951	42.1	26.2
17	Coastline, Honopue Valley to ‘Ākoako‘a Point, Hāmākua and North Kohala Districts							
	Honopue Valley, Hāmākua District	N/A			20.17780	155.68818	42.1	26.2
	‘Ākoako‘a Point, North Kohala District	N/A			20.19234	155.71646	41.7	25.9
18	Honokāne Nui Valley North Kohala District	N/A			20.19675	155.71975	42.0	26.1
19	Pololū Valley and Pololū Valley Lookout, North Kohala District							
19A	Pololū Valley	N/A			20.20370	155.73111	42.0	26.1
19B	Pololū Valley Lookout, Niuli‘i–Hāwī Road	270	29	29.0	20.20357	155.73375	41.9	26.0
20	Kēōkea Park Road intersection toWaikani Gulch bridge, Makapala, North Kohala District	270	27	27.2	20.22029	155.74826	42.8	26.6
	Kēōkeakea Park Road intersection	270	27	27.3	20.22064	155.74698	42.9	26.6
	Waikani Gulch one-lane bridge, Makapala	270	27	27.2	20.22029	155.74826	42.8	26.5
21	Kēōkea Beach Park, Makapala, North Kohala District							
21A	Kēōkea Beach	270	27	27.3	20.22747	155.74579	43.6	27.1
21B	Kēōkea Beach Park gazebo	270	27	27.3	20.22782	155.74540	43.6	27.1
21C	Kēōkea Beach Park pavilion	270	27	27.3	20.22697	155.74559	43.6	27.1
22	Makapala Chapel, Makapala, North Kohala District	270	27	27.1	20.22133	155.74883	42.8	26.6
23	Pūwā‘i‘ole Gulch, Makapala, North Kohala District	270	26	26.6	20.22104	155.75501	42.5	26.4
24	Kalāhikiola Congregational Church, Kapa‘au, North Kohala District	270	23	23.9	20.22261	155.79454	41.0	25.5
25	Lapakahi State Historical Park, Māhukona, North Kohala District	270	13	13.9	20.17535	155.89753	33.3	20.7
26	Honokoa Bridge, Māhukona, South Kohala District	270	4	4.5	20.05158	155.83952	21.7	13.5
27	Honokoa Gulch culvert, Māhukona, South Kohala District	270	4	4.3	20.04896	155.83803	21.5	13.4
28	North Kawaihae Small Boat Harbor, Kawaihae, South Kohala District	270	3	3.4	20.03887	155.83148	20.9	13.0
29	Kawaihae Pier, Kawaihae, South Kohala District	270	3	3.4	20.03642	155.82916	20.8	12.9
30	Pu‘ukoholā Heiau National Historic Site, Kawaihae, South Kohala District	270	2	2.3	20.02761	155.82148	20.4	12.7
31	Queen Ka‘ahumanu Highway road cut, Puakō, South Kohala District	19	71	71.6	19.95728	155.82577	14.4	9.0
32	Moku‘aikaua Church, Kailua-Kona, North Kona District	11	119	119.6	19.63964	155.99389	27.2	16.9
33	Hulihe‘e Palace, Kailua-Kona, North Kona District	11	119	119.6	19.63929	155.99453	27.3	16.9
34	Hōlualoa Catholic Cemetery, Hōlualoa, North Kona District	180	5	5.0	19.63539	155.95062	27.0	16.8
35	Kona Community Hospital, Kealakekua, South Kona District	11	112	112.1	19.51957	155.91712	39.9	24.8
36	Kealakekua Bay, Kealakekua, South Kona District	11	105	105.8	19.47510	155.91961	44.8	27.9

Acknowledgments

The authors gratefully acknowledge Edwin L. Harp, USGS, Denver, and David C. Wilson and James P. Kauahikaua, USGS, Hawaiian Volcano Observatory, for their thoughtful reviews. In addition, we thank Ed and Jim for images of rock falls along the Hāmākua Coast and in North Kohala valleys, which contributed substantively to the scope of this project.

The persons whose names are listed below gave a tour of a damaged site, provided photographs, stories, and information, or helped with data-gathering and formatting. The authors are deeply grateful for their experience, expertise, and assistance, which enhanced the clarity and accuracy of this work.

Hawaii County Civil Defense Staff

Hawaii County Department of Public Works
Mack S. Asato, Highways Division

Hawaii State Department of Land and Natural Resources
Steven Bergfeld, Division of Forestry and Wildlife
Kevin L. Gooding,
Commission on Water Resources Management

Hawaii State Department of Transportation
Elton Suganuma, Harbors Division, Kawaihae Harbor
Marissa Bondaug, Harbors Division, Kawaihae Harbor

Hulihe‘e Palace Museum Staff and Volunteers

Kalāhikiola Congregational Church
Reverend George Baybrook
Boyd and Rebecca Bond

Kona Community Hospital Staff

John P. (Jack) Lockwood

National Park Service
Adam M. Johnson,
Pu‘ukoholā Heiau National Historic Site
Bobby Camara, Hawai‘i Volcanoes National Park
Laura Schuster, Hawai‘i Volcanoes National Park

Pa‘auilo Hongwanji Mission
Rowan Matsumoto

University of Hawai‘i at Hilo
Center for the Study of Active Volcanoes
David (Dave) A. Whilldin

USGS, Denver
Edwin L. Harp
Randall W. Jibson

USGS, Hawaiian Volcano Observatory Staff
Loren J. Antolik
James P. (Jim) Kauahikaua

USGS, Hawaiian Volcano Observatory Staff—cont
Michael P. (Mike) Poland
Frank A. Trusdell
David (Dave) C. Wilson

USGS, Hawaiian Volcano Observatory Volunteers
Lauren E. Colwell
Cynthia Francos
Charlie G. Jones
J. Katie Marks
Torge S. Steensen

Other Volunteers
Laura S. Mizuno
Ernest C. Pascua
Lorraine Yadao

References

20000-Names.com, 1999, Akoni: http://www.20000-names.com/male_hawaiian_names.htm, last accessed 5/18/2010.

Applied Technology Council, 2005, Field manual—Postearthquake safety evaluation of buildings, no. ATC-20-1, 2nd ed.: Oakland, Calif., R.P. Gallagher Associates, Inc., 159 p.

Cabatu, Elena, 2006, East Hawaii medical facilities respond to Sunday morning earthquake: Hawaii Reporter, Oct. 16, http://www.hawaiireporter.com/story.aspx?c0b55e68-bc2e-4790-b8f6-d5a2b758314b, last accessed 2/23/2009.

Chock, Gary, ed., 2006, Compilation of observations of the October 15, 2006 Kiholo Bay (Mw6.7) and Mahukona (Mw6.0) earthquakes, Hawai‘i: Honolulu, EERI/SEAOH/UH Report, 53 p. [Authors: Robertson, Ian, Nicholson, Peter, Brandes, Horst, Medley, Edward, Okubo, Paul, Hirshorn, Barry, Sumada, Jiro, Kindred, Troy, Iinuma, Gen, Lau, Ernest, Sarwar, Afaq, Dal Pino, John, Holmes, William, Structural Engineers Association of Hawaii, and Hawaii State Earthquake Advisory Committee].

Clark, J.R.K., 1985, Beaches of the Big Island: Honolulu, University of Hawaii Press, 171 p.

Department of Land and Natural Resources, [n.d.], Lapakahi State Historical Park brochure: Honolulu, Hawai‘i Department of Land and Natural Resources, Division of State Parks, 2 printed sides.

Desha, S.L. (translated by Frazier, F.N.), 2000, Kamehameha and his warrior Kekūhaupi‘o: Honolulu, Kamehameha Schools Press, p. 309 [originally published in *Ka Hoku o Hawaii* (The Star of Hawai‘i) between Dec. 16, 1920, and Sept. 11, 1924].

Earthquake Engineering Research Institute, 2006, Preliminary observations on the Hawai‘i earthquakes of October 15, 2006: EERI Special Report, Dec., 12 p.

Eaton, Kim, 2006, Kona Community Hospital should be fully operational by Friday: West Hawaii Today, Oct. 24, http://www.westhawaiitoday.com/articles/2006/10/24/local/local04, last accessed 3/1/2009.

Federal Emergency Management Agency (FEMA), 2006, FEMA situation report, FEMA-1664-DR-HI, DHS SITREP #1: Fort Shafter, Hawaii, unpaginated [9 p.].

FEMA Library, 2007, The case of Kona Community Hospital, Hawaii, in Design guide for improving hospital safety in earthquakes, floods, and high winds—Providing protection to people and buildings: http://www.fema.gov/library/viewRecord.do?id=2739, chap. 2.3.2.2, unpaginated [9 p.], last accessed 5/6/2010.

Hammond, E.V., 1919, The golden treasury of the Bible, new edition: New York, Edwin S. Gorham, p. 34.

Hawaii Herald, 1909, Part of Hamakua slides into the sea: Hawaii Herald, May 27, 1909 [reprinted from *Kohala Midget*, May 26, 1909].

HawaiiWeb.com, 2002, Lapakahi State Historical Park: http://www.hawaiiweb.com/hawaii/html/sites/lapakahi_state_historical_park.html, last accessed 5/6/2010.

HawaiiWeb.com, 2002, Mokuaikaua Church: http://www.hawaiiweb.com/hawaii/html/sites/mokuaikaua_church.html, last accessed 5/6/2010.

Hawaiirama, 2006, Waimanu Valley—Remote, rugged, magical: http://hawaiirama.com/2006/07/flickrsrchttphawaiiramacomwaim, last accessed 5/6/2010.

Huynh, Lisa, 2006, Landslide rips pali at Kealakekua Bay: West Hawaii Today, Oct. 16, http://www.westhawaiitoday.com/articles/2006/10/16/local/local03.txt, last accessed 5/6/2010.

Kamehameha Schools, 1994, The ahupua‘a; life in early Hawai‘i: Honolulu, Bernice Pauahi Bishop Estate, 59 p.

Klein, F.W., Frankel, A.D., Mueller, C.S., Wesson, R.L., and Okubo, P.G., 2001, Seismic hazard in Hawaii—High rate of large earthquakes and probabilistic ground-motion maps: Bulletin of the Seismological Society of America, v. 91, no. 3, p. 479–498.

Knudsen, Greg, 2006, School closures (earthquakes)—Tuesday, October 17, news release: State of Hawaii Department of Education, http://www.hcps.k12.hi.us/STATE/COMM/DOEPRESS.NSF/a1d7af052e94dd120a2561f7000a037c/c594226d1fbaa7770a257146006cbc86?OpenDocument, last accessed 5/6/2010.

Let’s Go Hawaii, 2008, Big Island earthquake 10/15/06: http://www.letsgo-hawaii.com/news/earthquake.html, last accessed 5/6/2010.

Lucas, Carolyn, 2006, Hawaii’s oldest church needs $500K in repairs: West Hawaii Today, Oct. 19, http://www.westhawaiitoday.com/articles/2006/10/19/local/local06.http://www.westhawaiitoday.com/articles/2006/10/19/local/local06.txt, last accessed 5/6/2010.

Lucas, Carolyn, 2009, Church is reborn following quakes: Hawaii Tribune-Herald, Jan. 25, p. A1, A12.

MacGowan, D.B., 2009, Waipi‘o Valley, Hamakua Coast on the Big Island of Hawaii: http://www.spongefish.com/creations/9729-Waipi-o-Valley-Hamakua-Coast-on-the-Big-Island-of-Hawaii/steps/1, last accessed 3/1/2009.

Mason, Glenn, 2006, Hulihe‘e Palace—Assessment of earthquake damage: Honolulu, Mason Architects, Inc., Oct. 23, 7 p.

McClure, Bruce, 2007, Kalopa Sand Gulch Road re-opens: Hawaii County Department of Public Works, press release, Jan. 10, 1 p.

McGovern, P.J., 2007, Flexural stresses beneath Hawaii—Implications for the October 15, 2006, earthquakes and magma ascent: Geophysical Research Letters, v. 34, no. 23, L23305, 6 p.

Medley, E.W., 2006, Geological engineering reconnaissance of damage resulting from the October 15, 2006 earthquakes, Island of Hawaii, Hawaii, USA: Oakland, Calif., Geosyntec Consultants, 37 p.

Munson, C.G., and Thurber, C.H., 1997, Analysis of the attenuation of strong ground motion on the Island of Hawaii: Bulletin of the Seismological Society of America, v. 87, no. 4, p. 945–960.

National Park Service, [n.d.], Pu‘ukoholā Heiau: [s.l.], National Park Service brochure, 2 printed sides.

Neal, Marie, 1965, In gardens of Hawaii: Honolulu, Bernice P. Bishop Museum Special Publication 50, 924 p.

New Moon Foundation, 2006, Kalahikiola Church; history: http://www.newmoonfoundtion.org/facilities/history.html, last accessed 5/6/2010.

Okubo, A.T., 2006, Emergency structural assessment of earthquake damage to North Kawaihae Small Boat Harbor located at Kawaihae, Hawaii: Honolulu, Arnold T. Okubo & Associates, Inc., unpaginated [40 p.].

Pelletier, Mark and Sue, 1999, Hawaii highways road photos—Waipio Valley: http://www.hawaiihighways.com/photos-Waipio-Valley.htm, last accessed 5/6/2010.

Pratt, L.W., and Abbott, L.L., 1996, Vascular plants of Pu‘ukohola Heiau National Historic Site, Hawai‘i Island: Honolulu, University of Hawai‘i at Manoa, Cooperative National Park Resources Studies Unit, Technical Report 101, p. 23 [33 p].

Pukui, M.K., and Elbert, S.H., 2003, Hawaiian dictionary: Honolulu, University of Hawai‘i Press, http://www.wehewehe.org, last accessed 5/6/2010.

Pukui, M.K., Elbert, S.H., and Mookini, E.T., 2003, Place names of Hawai‘i: Honolulu, University of Hawai‘i Press, http://www.wehewehe.org, last accessed 5/6/2010.

Richter, C.F., 1958, Elementary seismology: San Francisco, W.H. Freeman and Company, p. 135–149.

Risk Management Solutions, 2006, 2006 Kiholo Bay, Hawaii earthquake; RMS Event Report: [s.l.], Risk Management Solutions, Inc., unpaginated [16 p.].

Robertson, I.N., Nicholson, P.G., and Brandes, H.G., 2006, Reconnaissance following the October 15th, 2006, earthquakes on the Island of Hawai‘i: Honolulu, University of Hawai‘i College of Engineering, Research Report UHM/CEE/06-07, 65 p.

Structural Engineers Association of Hawaii (SEA), 2007, ATC-20 Post-earthquake building safety evaluations performed after the October 15, 2006 Hawai‘i earthquakes—Summary and recommendations for improvements (updated): Honolulu, Structural Engineers Association of Hawaii, 5 p.

Thompson, Rod, 2006, State opens Kohala trail refurbished after quakes: Star-Bulletin, v. 11, no. 325, Nov. 21, http://archives.starbulletin.com/2006/11/21/news/story08.html, last accessed 5/6/2010.

Thompson, Rod, 2007, Repairs end care home camp-out: Star-Bulletin, v. 12, no. 4, Jan. 4, http://archives.starbulletin.com/2007/01/04/news/story07.html, last accessed 5/18/2010.

Wald, D.J., Quitoriano, Vincent, Dengler, L.A., and Dewey, J.W., 1999, Utilization of the Internet for rapid community intensity maps: Seismological Research Letters, v. 70, no. 6, p. 680–697.

Weaver, Anna, 2008, Quake-damaged Big Island mission church torn down: Hawaii Catholic Herald, Sept. 19, 2008, http://www.hawaiicatholicherald.com, last accessed 5/18/2010.

Weaver, Anna, 2008, Quake-damaged Big Island mission church torn down: Hawaii Catholic Herald, Sept. 19, 2008, http://www.hawaiicatholicherald.org/Home/tabid/256/newsid884/1728/Default.aspx, last accessed 5/18/2010.

Wehewehe.org, 2004, Na puke wehewehe ‘ōlelo Hawai‘i [the books explaining Hawaiian words or language]; Hawaiian dictionaries: Ulukau, The Hawaiian Electronic Library, http://www.wehewehe.org, last accessed 5/6/2010.

Wikipedia, the Free Encyclopedia, 2011, ‘Akoni Pule: http://en.wikipedia.org/wiki/Akoni_Pule_Highway, last accessed 5/01/2011.

Wood, H.O., and Neumann, Frank, 1931, Modified Mercalli intensity scale of 1931: Bulletin of the Seismological Society of America, v. 21, no. 4, p. 277–283.

Wyss, Max, and Koyanagi, R.Y., 1992, Isoseismal maps, macroseismic epicenters and estimated magnitudes of historic earthquakes in the Hawaiian Islands: U.S. Geological Survey Bulletin 2006, 93 p.

Yamada, Takuji, Okubo, P.G., and Wolfe, C.J., 2008, Hypocenter relocation and source parameters of the 2006 Kiholo Bay, Hawaii earthquake sequence [abs.]: Eos (American Geophysical Union Transactions), v. 89, no. 53, abstract no. S23B–1899.

This page intentionally left blank.

Glossary of Hawaiian Words and Place Names

Definitions of words in this section have been taken primarily from http://www.wehewehe.org, the online Hawaiian dictionaries. Where place names were not listed in the dictionaries, literal meanings of the words that make up the names are given to shed light on their etymology. Words defined are listed alphabetically in bold type and their definitions given in italics. For place names, features that are important in this work (that is, bay, gulch, point, stream, valley, town) and their general compass direction are included. More specific locations are provided in the captions.

As in all languages, Hawaiian words have many connotative meanings that enhance their literal definitions. Delving into the connotations of place names is invaluable in understanding the nature of place in Hawaiian geology, history, and culture.

Words in the Hawaiian language (ʻōlelo Hawaiʻi) are pronounced, for the most part, as in pronouncing Spanish, Italian, or Japanese. The glottal stop, or ʻokina (ʻ), between vowels or at the beginning of a word indicates that the glottis is closed when pronouncing the word, as in "accord" for **ʻa**, "echo" for **ʻe**, "if" for **ʻi**, "oh-oh" for **ʻo**, and "ooze" for **ʻu**. The macron, or kahakō, over a vowel, indicates that the sound is extended, as in "ahhh" for **ā**, "ehhh" for **ē**, "eee" (as in Lee) for **ī**, "o" (as in singing "O holy night") for **ō**, and "uuu" (as in Lou) for **ū**.

List of words used:

ʻaʻā Lava with a clinkery, spinose, jagged surface.

ahupuaʻa Land division, usually extending from the uplands to the sea, marked, in ancient times, by a heap (**ahu**) of stones upon which an image of a pig (**puaʻa**) was lain as a marker of a tax payment to the chief.

ʻĀinahou *New land*. Large debris fan north of Waipiʻo Valley and south of Waimanu Valley, Hāmākua District, northeast Hawaiʻi.

ʻĀkoʻakoʻa *Coral, coral head*. Point in Niuliʻi, north of Pololū Valley, North Kohala District, northeast Hawaiʻi.

ʻAkoni Pule Highway 270, dedicated in July 1973, named after the Hawaiʻi State legislator who helped obtain Federal and State funds to construct a safer access to Hāwī and Kapaʻau (towns in the North Kohala District) than through the narrow, winding, Kohala Mountain Road [Wikipedia, 2011].

Alakahi *One-way*. Stream and waterfall in the right branch of upper Waipiʻo Valley, Hāmākua District, northeast Hawaiʻi.

Aliʻi *Chief, royal*. Coastal street from Keauhou Bay to Kailua Bay in Kailua-Kona, North Kona District, west Hawaiʻi.

Āpau *All, entirely.* Debris fan north of Laupāhoehoe Nui and south of Honopue Valley, Hāmākua District, northeast Hawaiʻi.

ʻĀwini *Sharp, bold, forward.* Ahupuaʻa, gulch, and trail (extending from the northern mouth of Pololū Valley and ending at the Kohala Ditch Trail northwest of Honokeʻā Valley), North Kohala District, northeast Hawaiʻi.

hale *House, building, hall.*

Hāmākua *Long corner.* Forest reserve, ditch, ditch trail, district of central and northeast Hawaiʻi.

Hāpuna *Spring*. Beach, State Recreation Area, bay, and ahupuaʻa, South Kohala District, northwest Hawaiʻi.

haukapila *Hospital.*

Hauola *Dew of life.* Road in Paʻauilo, Hāmākua District, northeast Hawaiʻi.

Hāwī Meaning unknown. Literally, **hā**, *to breathe, four, fourth note in the musical scale;* **wī**, *the sound of wind, of gnashing teeth, a high, shrill sound.* Village and land section, north Kohala District, north Hawaiʻi. (Situated at the northernmost tip of the island, Hāwī is known for the high winds that blow through the region and bend its trees.)

heiau Hawaiian place of worship, from earth terraces to stone platforms and enclosures. Different types of heiau:

- **heiau hoʻōla** heiau for treating the sick.
- **heiau hoʻoulu ʻai** heiau for offering first fruit to insure a bountiful harvest.
- **heiau hoʻoulu iʻa** heiau for offering fish to insure good fishing.
- **heiau hoʻoulu ua** heiau for offerings to ensure rain.
- **heiau maʻo** small, temporary heiau covered with tapa dyed green (maʻo) for the hoʻoulu ʻai ceremony.
- **heiau poʻo kanaka** heiau for offering human sacrifices.
- **heiau waikaua** heiau for offerings to insure success in war.

Hiʻilawe *Lift and carry*. The highest unterraced waterfall in Hawaiʻi and one of the highest in the world, with a total height of about 442 m (~1,450 ft), in Waipiʻo Valley, Hāmākua District, northeast Hawaiʻi (Hiʻilawe Falls data from USGS topo sheet, Kukuihaele quad, Island of Hawaii).

Hikiau *A luakini* (a heiau where human sacrifices were made) of Kamehameha I at Kealakekua Bay, South Kona District, southwest Hawaiʻi.

Hōlualoa *Long sled course.* Village, bay, and land section, North Kona District, northwest Hawaiʻi.

Honokaʻa *Cavern, sea cave.* Bay, town, landing, ahupuaʻa, Hāmākua District, northeast Hawaiʻi.

Honokāne Iki Meaning unknown. Literally, **hono**, *valley*; **kane**, *male, or (capitalized) name of Hawaiian god*; **iki**, *little*. Valley, stream, and ahupua‘a, North Kohala District, northeast Hawai‘i.

Honokāne Nui Meaning unknown. Literally, **hono**, *valley*; **kane**, *male, or (capitalized) name of Hawaiian god*; **nui**, *big*. Valley and stream, Kohala Mountains, North Kohala District, northeast Hawai‘i.

Honoke‘ā *Volcanic rock place*. Valley and stream, North Kohala District, northeast Hawai‘i.

Honokoa *Bay of brave warriors*. Derived from **hono**, *bay, gulch*; **koa**, *fearless, martial*. Gulch and bridge, South Kohala District, northwest Hawai‘i.

Honopue Meaning unknown. Literally, **hono**, *the brow of a cliff, a joining, as of mountains*; **pue**, *huddled, crouched*. Valley, stream, and land section, Hāmākua District, northeast Hawai‘i.

ho‘ōla *Life*. **Hale Ho‘ōla**, *house of life*, name of hospital in Honoka‘a, Hāmākua District, northeast Hawai‘i.

Hulihe‘e *Turn [and] flee*. Palace at Kailua-Kona, built in 1838 by Governor Kuakini, restored by the Daughters of Hawai‘i in 1927 as a museum of Hawaiian artifacts, North Kona District, northwest Hawai‘i.

iki Small, little.

‘ilima *Sida* (especially *Sida fallax*), a shrub of the mallow family, indigenous to drier regions of the tropical Pacific, bearing yellow, orange, or dull-red paper-thin flowers, often strung into leis (it takes about 500 blossoms to make a lei).

‘Iole *Name of a legendary rat*. Mountain, stream, and ahupua‘a, Kohala Mountains; name of road leading to Kalāhikiola Congregational Church in Kapa‘au, North Kohala District, northeast Hawai‘i.

Ka‘ahumanu *Bird (feather) cloak*. Queen, name of Kamehameha I’s favorite wife; Highway 19, coastal highway of South Kohala and North Kona Districts, northwest Hawai‘i.

Ka‘awaloa *The distant kava* (referring to runners, who went to Puna or Waipi‘o to get kava for chiefs). Site of the monument to Captain Cook at Kealakekua Bay, South Kona District, southwest Hawai‘i.

Ka‘āpahu *The truncation*. Literally, **ka**, *to strike*; **‘āpahu**, *to cut squarely off, a piece cut off at right angles*. Road in Kalōpā, also known as Sand Gulch Road, Hāmākua District, northeast Hawai‘i.

Kalāhikiola *The sun, bringing life; the day, bringing salvation*. Congregational church, mountain, and ahupua‘a in Kapa‘au, North Kohala District, north Hawai‘i.

Kalākaua King David Kalākaua, who reigned from 1836 to 1891, often referred to as the “Merrie Monarch” for his love of learning and culture. He is author of *The Legends and Myths of Hawai‘i*.

Kālani‘ai Meaning unknown. Literally, **kālani**, *gallon*; **‘ai**, *food*. Road in Kalōpā, Hāmākua District, northeast Hawai‘i.

Kalōpā *The tenant farmer*. Town, gulch, State Recreation Area, land section, Hāmākua District, northeast Hawai‘i.

Kamehameha *The lonely one*. Kamehameha I, the first king of Hawai‘i, credited with unifying the islands.

kāne *Male, man, husband*; when capitalized, name of one of the four primary Hawaiian gods.

Kapa‘au *The elevated portion of a heiau*. Land section, town east of Hāwī, North Kohala District, north-northeast Hawai‘i.

Kawaihae *The water of wrath* (of people who fought for water from a pool in this arid region). Land section, bay, road, town, Hāmākua District, northwest Hawai‘i.

Kawāili Meaning unknown. Bridge in Pa‘auilo, Hāmākua District, northeast Hawai‘i.

Kealakekua *The pathway of the gods, who took a short-cut by sliding down the cliff, thereby leaving an imprint*. Bay (where Captain Cook was killed), trail, village, marine preserve, State Historical and Underwater Parks, and land section, southwest Hawai‘i.

Ke‘ei Meaning unknown. Lagoon, village, coastal area adjacent to, and south of, Kealakekua Bay, South Kona District, southwest Hawai‘i.

Kēōkea *The sound of white [water].* Beach park and bay, North Kohala District, northeast Hawai‘i.

koa *Acacia koa*, a large endemic tree of the legume family with a smooth, gray bark and gnarly branches, bearing clusters of small white flowers that adorn the canopy, and bipinnate leaflets that mature into leathery, crescent-shaped leaves. Its wood was prized earlier in the making of canoes, paddles, surfboards, and calabashes, and is now used in making furniture, ‘ukuleles (a small stringed instrument shaped like a guitar), bowls, and cooking implements and cutting boards.

Kohala *Cherished land.* District famous for the āpa‘apa‘a (name given to a strong Kohala wind), forest reserve, ditch, trail, mountains, north Hawai‘i.

Kona *Leeward.* Leeward district of Hawai‘i; northwest and southwest Hawai‘i.

Kuakini *Innumerable.* Highway, Kailua-Kona, Hawai‘i, named after John Adams Kuakini, a governor of the island (1820–1844) and acting governor of O‘ahu (1831–1834), who was in charge of building Hulihe‘e Palace in 1838 and Moku‘aikaua Church in 1823 and rebuilding it in 1836.

Kūkai‘au *Current appearing.* Village, gulch, and land section south of Pa‘auilo, Hāmākua District, northeast Hawai‘i.

Kūka‘ilimoku Name of war god.

kukui *Aleurites moluccana*, the candlenut tree, a member of the spurge family, the kernels of whose oily nuts were used as lights in ancient times and used today to make **‘inamona**, a relish. The polished and drilled nuts are also strung into leis, as are its flowers and silvery leaves. The soft wood was used

in canoe-making, its nut coats and roots to make black dye, and gum from its bark for painting tapa cloth. An important resource for the Hawaiian people, kukui has a broad distribution throughout Hawai‘i. From the air, it can be distinguished from other large forest trees in the valleys of northeast Hawai‘i by its silvery sage-green canopy.

lānai *Porch, veranda, shed of a house.*

Lapakahi *Single ridge.* Restored Hawaiian coastal village site, State Historical Park, ahupua‘a, North Kohala District, northwest Hawai‘i.

lau hala *Leaf of the pandanus* (screw pine family), native to Hawaii and other Pacific islands, Australia, and southern Asia. Leaves from the many varieties of this tree were used in ancient times for sails, thatching, and garments. **Lau** (*leaf*) **hala** (*pandanus*) continues to be an important source of material for weaving floor coverings and place mats, baskets, hats, fans, and ornaments. The fruit of the hala is still used today as brushes for dying fabric and in lei-making.

Laupāhoehoe *Smooth lava flat*. Land sections, stream, point, village, beach park, ancient surfing area, North Hilo District, northeast Hawai‘i.

Laupāhoehoe Iki *Little, smooth lava flat*. Debris fan, now heavily vegetated, at the base of the sea cliffs adjacent to, and north of, Waimanu Valley, Hāmākua District, northeast Hawai‘i.

Laupāhoehoe Nui *Large, smooth lava flat.* Larger of the two debris fans (the other being Laupāhoehoe Iki), now heavily vegetated, at the base of the sea cliffs adjacent to, and north of, Laupāhoehoe Iki, Hāmākua District, northeast Hawai‘i.

lehua See **‘ōhi‘a lehua**.

lei *Garland, wreath, necklace of flowers leaves, shells, feathers, seeds, beads, paper, or candy, given as an expression of affection, celebration, or respect.*

lele *Sacrificial altar or stand at a heiau.*

lo‘i *Irrigated terrace, especially for taro, but also for rice.*

lua *Hole, pit, crater; toilet.*

Māhukona *Leeward steam.* Beach park, harbor, village, North Kohala District, northwest Hawai‘i.

Mailekini Many maile vines (*Alyxia olivaeformis*; endemic twining shrub with shiny, fragrant leaves used in leis). Ancient heiau at Pu‘ukoholā National Historical Site, south of Kawaihae, South Kohala District, northwest Hawai‘i.

Makapala *Sore beginning to heal.* Village and land section, North Kohala District, north-northeast Hawai‘i.

Māmalahoa *Paddle fragments* (after Kamehameha was struck on the head while his foot was caught in a crevice; probably named after the law of the splintered paddle, which guaranteed safety on the highway to all). Belt road, Island of Hawai‘i.

makai *Ocean; towards the ocean.*

māmane *Sophora chrysophylla*, a high-altitude endemic tree of the legume family, bearing bright yellow flowers and winged seed pods (flowers and seeds were food for native birds), whose hard wood was prized for digging sticks, house and fence posts and beams, and **papa hōlua** (sled) runners; also the name of the endemic bird that feeds on the nectar and seeds of the tree. Main street through Honoka‘a town, off Māmalahoa Highway, Hāmākua District, northeast Hawai‘i.

mauka *Inland.*

Moku‘aikaua Name derived from the forested crown lands, about two miles east of Donkey Mill, that yielded the wood for the church on Ali‘i Drive, Kailua-Kona, North Kohala District, west Hawai‘i.

Mokupuku *Contracted island*. Islet, off-shore Pololū Valley to the north and Honokāne Nui Valley to the south, North Kohala District, northeast Hawai‘i.

Muliwai *River.* Trail, ahupua‘a between Waimanu and Waipi‘o valleys, Hāmākua District, northeast Hawai‘i.

Napo‘opo‘o *The holes.* The place is so named because people in the bay in canoes saw people on-shore peering at them through holes (doors) in their grass huts. Village in Hōnaunau, South Kona District, west Hawai‘i.

Niuli‘i *Small coconut.* Village north of Pololū Valley, ahupua‘a and stream, North Kohala District, north-northeast Hawai‘i.

nui *Big, large, great, important, the greater part.*

Nunulu *growl* [probably referring to the sound of the infamous winds of the Kohala region]. Ahupua‘a in Kapa‘au, North Kohala District, north-northeast Hawai‘i.

‘ōhi‘a See **‘ōhi‘a lehua**.

‘ōhi‘a lehua *Metrosideros polymorpha*, hardwood tree and blossom of the myrtle family with showy blossoms made up of clusters of red-to-yellow stamens. The tree grows from sea level to more than 2,500 m (8,000 ft), the timberline on Mauna Loa, reaching a height of more than 25 m (80 ft) in wet rain forests. Its dark, dense wood is prized for house posts and flooring, spears, poi-pounding boards, and other uses where durability is of the essence.

‘oloke‘a *Scaffolding; ladder made of sticks tied horizontally to the vertical poles.*

Pa‘auilo Meaning unknown. Village, gulch, Hāmākua District, northeast Hawai‘i.

pāhoehoe *Smooth, sometimes ropy, basaltic lava.*

Pakalana *Michelia alba* DC., *Michelia longifolia* Bl, white champak tree or blossom of the tree native to Java. The fragrant flowers are used in making leis [Neal, 1965]. Street in Honoka‘a, Hāmākua District, northeast Hawai‘i.

pali *Cliff, steep hill.*

Paokalani Meaning unknown. Literally, **pao**, *cave, to scoop out, as of the action of the sea on the coast*; **kalani**, *gallon.* Islet, off-shore Pololū Valley to the north and Honokāne Nui Valley to the south, North Kohala District, northeast Hawai‘i.

Papalele *Leaping flats.* Street and gulch in Kalōpā, land section, Hāmākua District, northeast Hawai‘i.

Pololū *Long spear.* Valley, overlook, North Kohala District, northeast Hawai‘i.

Puakea *White blossom; pale, as sunset clouds; to spread, as fog; color of a buckskin horse.* Ranch, land section, point, northeast Hawai‘i.

Puakō *Sugar-cane blossom.* Village, bay, point, road, petroglyph field, South Kohala District, northwest Hawai‘i.

Pu‘ukoholā *Hill of the whale.* National historic site; heiau constructed by Kamehameha I for his war god Kūka‘ilimoku, near Kawaihae, northwest Hawai‘i. Another meaning, spelled **Pu‘ukohola**, is given in *Kamehameha and His Warrior Kekūhaupi‘o*: **Pu‘u**, desire, need (for death); **kohola**, reef flats; **kai kohola**, lagoon—hence, death in the lagoon (of the heiau) to those who do harm to the land and its people [Desha, translated by Frazier, 2000].

Pūwā‘i‘ole Meaning unknown. Literally, **pūwā**, *to shine, reflect brightly*; **‘i**, to say, great; **‘ole**, *not, nothingness.* Gulch in Makapala, North Kohala District, north-northeast Hawai‘i.

Waiakala‘e *Water of the clearness*. Falls, stream, and gulch in Pololū Valley, North Kohala District, northeast Hawai‘i.

Waihīlau *Many trickling waters (as on a cliff face)*. Stream, Waimanu Valley, Hāmākua District, northeast Hawai‘i.

Wai‘ilikahi *Water with a single surface*. Falls and stream, Waimanu Valley, Hāmākua District, northeast Hawai‘i.

Waikani Meaning unknown. Literally, **wai**, *water*; **kani**, *sound*. Gulch near Kēōkea Road, Akoni Pule Highway, North Kohala District, north-northeast Hawai‘i.

Wailoa *Long water.* Stream, Waipi‘o Valley, Hāmākua District, northeast Hawai‘i.

Waimanu *Bird water.* Valley, bay, stream, trail, land section, Hāmākua District, northeast Hawai‘i.

Waipahi Meaning unknown. Literally, **wai**, *water, stream*; **pahi**, *knife*. Stream, south of Honokane Iki Valley and north of Honoke‘ā Valley, North Kohala District, north-northeast Hawai‘i.

Waipi‘o *Curved water.* Valley, bay, gulch, stream, land section, Hāmākua District, northeast Hawai‘i.

Produced in the Western Region, Menlo Park, California
Manuscript approved for publication April 30, 2010
Text edited by Tracey Suzuki
Layout and graphic design by Susan Mayfield