Appendix E

Potential Field Data - Gravity Surveys

Introduction

The USGS has compiled, edited and reprocessed nearly 30,000 gravity measurements to produce an isostatic residual gravity map for the region, spanning Monterey Bay on the north to the Santa Barbara channel on the south (Figure E-1). Isostatic gravity is calculated by subtracting an idealized isostatic compensation for the regional elevation from the Bouguer gravity. Result is a high pass filter that removes regional, long wavelength crustal scale features (wavelengths > 50 to 100 km) while preserving anomalies that have a shallower source and smaller lateral extent (sedimentary basins, lithologic variations in the crust, etc.). Data includes the PG&E LTSP offshore data base as well as data collected at ~ 1 mile spacing by NIMA (formerly the Defense Mapping Agency) for the area south of 36°15'N near Vandenberg Air Force Base. Terrain corrections were applied using 30 m DEMs to create a roughly 2km grid over the LTSP Update study area. (Langenheim et al., 2008). The USGS also collected about 180 new gravity measurements in the Pt-Buchon/Los Osos area and the Santa Maria basin in 2009 (Watt, written communication 2009). Several older measurement sites were reoccupied to aid in editing the old data. The reoccupations have highlighted the inaccuracy of the older data. Figure E-2 shows an overlay of the isostatic gravity map for the Shoreline fault zone study area with the actual gravity stations used to produce the map. The map emphasizes the steep gravity gradients along the boundaries of the Pismo syncline as well as the near vertical dips of the West Huasna and Hosgri faults in this area.

The gravity field offshore of DCPP is dominated by a large NNW trending gravity high that is coincident with mapped Franciscan rocks that are truncated to the SW by the Hosgri fault. The northern boundary of this offshore gravity high is coincident with the western edge of the Pismo syncline, and is well defined based on 2009 measurements. Note the absence of gravity measurements immediately offshore DCPP between Point Buchon and Point San Luis in Figure E-2. We are planning to collect new data in this area as part of the LTSP Update in 2011.

Reference

Langenheim, V.E., Jachens, R.C., Graymer, R.W. and Wentworth, C.M., 2008, Implications for fault and basin geometry in the central California Coast Ranges from preliminary gravity and magnetic data, EOS (Abs. AGU), Fall Meeting 2008, abstract #GP43B-0811.

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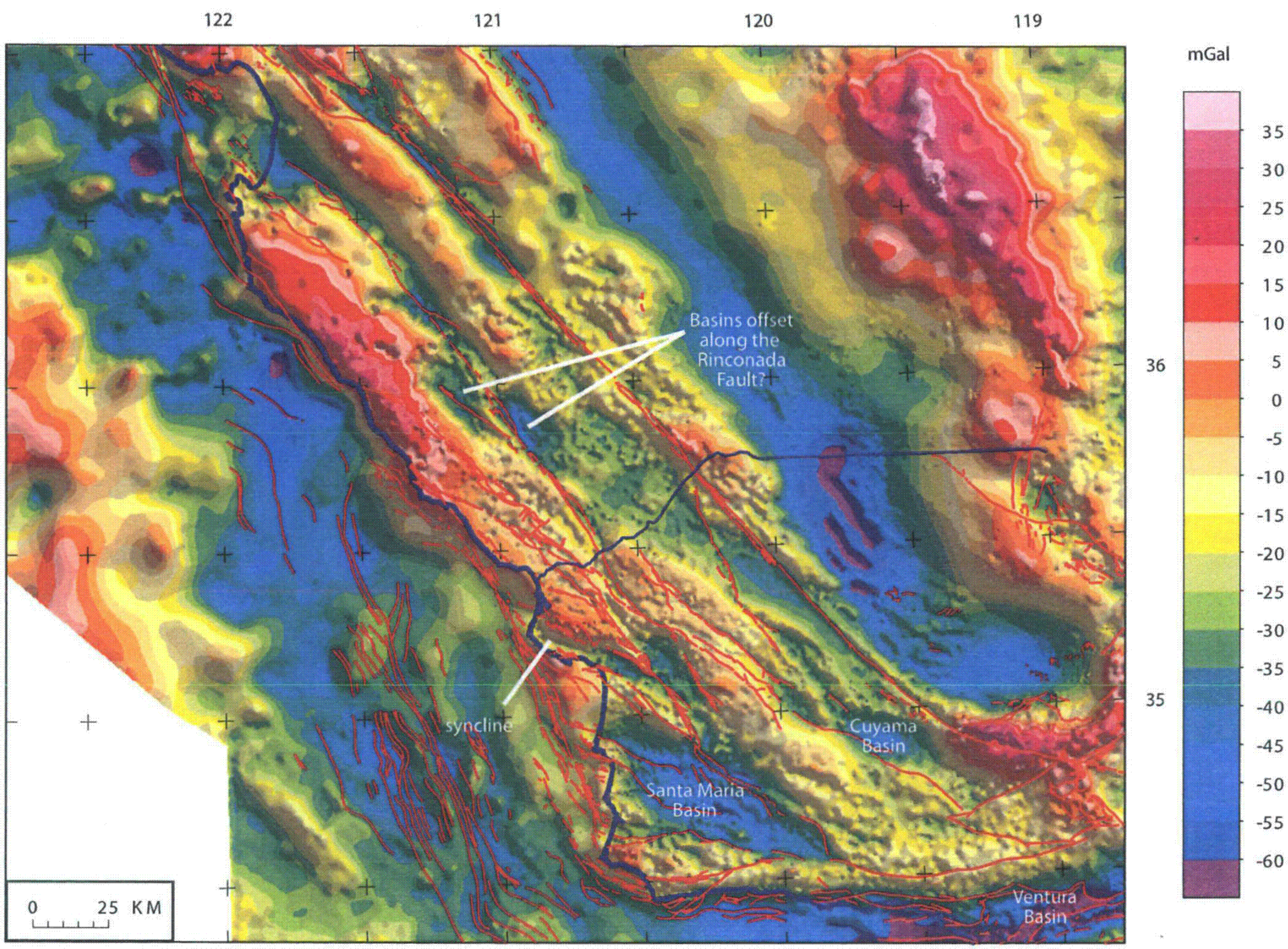

Isostatic gravity map of coastal central California (Langenheim et al., 2008)

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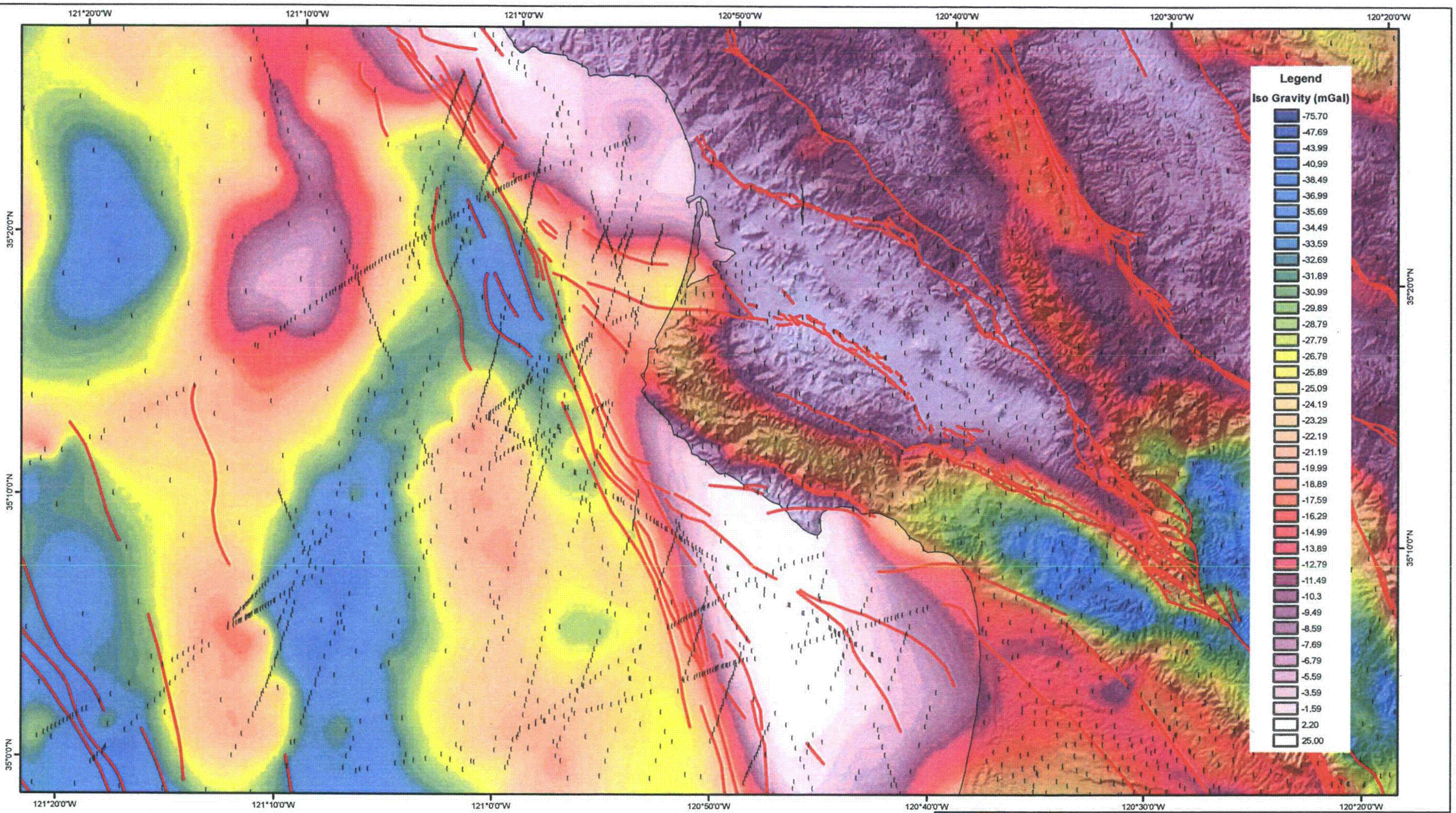
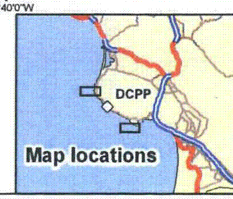


0 10 20 Kilometers

Legend

- Gravity Station
- Gravity Profile Line
- USGS fault (QFF, 2010)

Seismic survey lines are shown as white lines



Isostatic gravity anomaly from Estero Bay to San Luis Bay showing the locations of gravity stations used to construct the map

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Figure E-2

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Appendix F

Multibeam Echo Sounding Surveys

Introduction

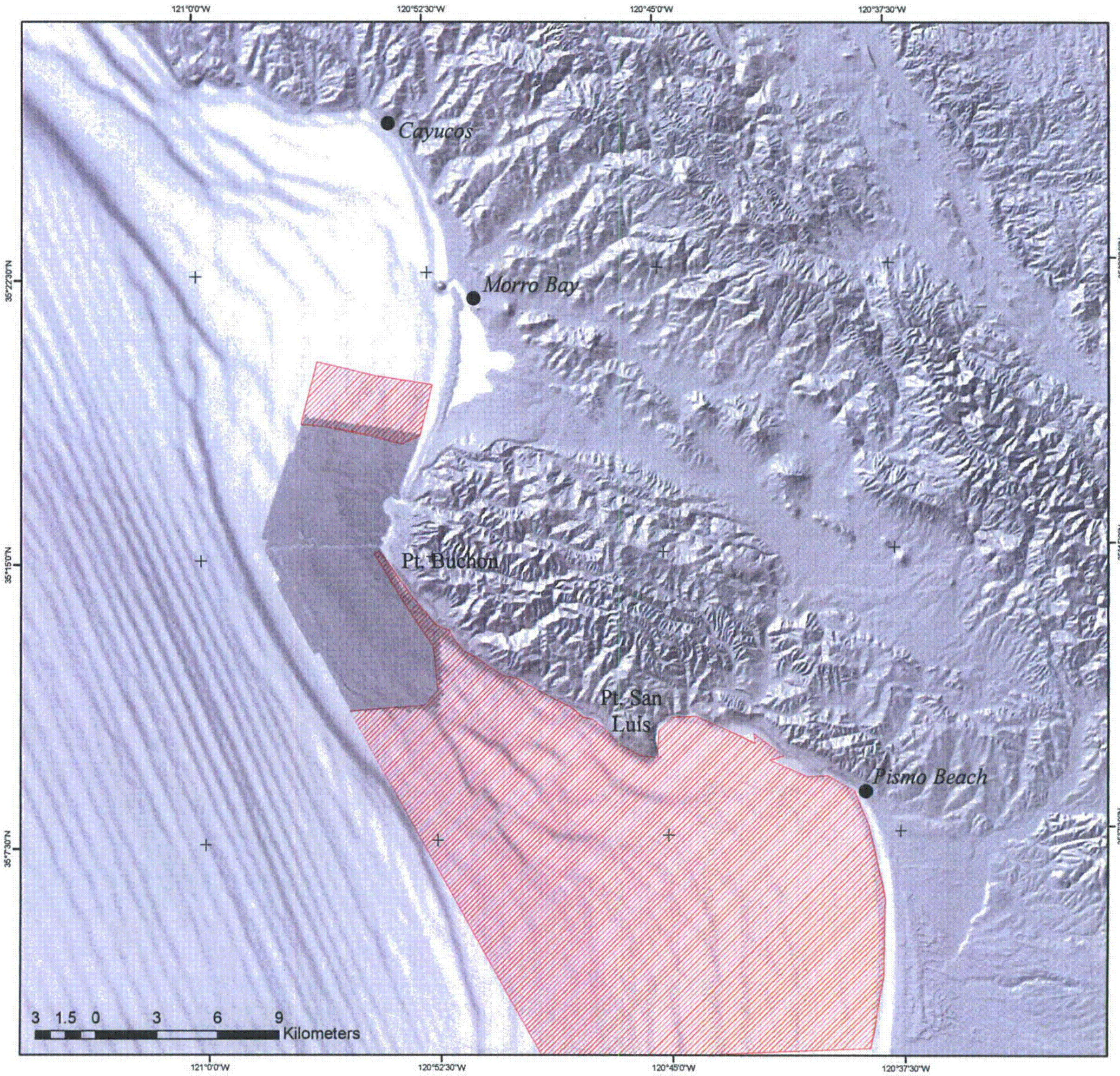
Multibeam echo sounding (MBES) and side scan data from the Estero Bay to San Luis Obispo Bay nearshore region were acquired using a combination of several sonar systems (400 KHz Reson 7125, 240 KHz Reson 8101, SEA SwathPlus) aboard the *R/V Ven Tresca* by the Seafloor Mapping Lab at California State University Monterey Bay during 2007, 2009, and 2010. Figure F-1 shows the areas mapped in the 2007 (Point Buchon) and 2009 (Point Buchon to Avila Bay) surveys. The 2010 data collection focused on nearshore areas adjacent to the Rattlesnake and Olsen Faults. Prior to data collection, a series of planned survey lines were created using the survey navigation and planning software Hypack 2008 from Hypack, Inc. An Applanix POS/MV 320 v4 system with TrueHeave processing was used to provide position and attitude data during data collection and accounted for vessel motion such as heave, pitch, and roll (position accuracy ± 2m, pitch, roll and heading accuracy ±0.02°, heave accuracy ± 5% or 5cm) with input from a Cnav® enabled NAVCON 2050 GPS. KGPS altitude data were used to account for tide cycle fluctuations and sound velocity profiles were collected with an Applied Microsystems SVPlus sound velocimeter.

Bathymetric data were post-processed using CARIS HIPS hydrographic data cleaning system software. Applanix POSPAC software (v 4.31) was used to process the logged POS M/V files and create a Smoothed Best Estimated Trajectory (SBET) composed of an integrated inertial/GPS solution for use in horizontal and vertical positioning of sounding data. Correction for vertical oscillation due to heave and tide was accomplished using these SBET files. Final x, y, z soundings, surface models, and derived products are relative to the NAVD88 Geoid03 vertical datum. Erroneous soundings were removed in CARIS HIPS via basic filtering and detailed swath and subset cleaning; the remaining high-confidence soundings were used in surface model creation and final product generation. Soundings (x, y, z) were exported from a Swath Angle Bathymetry Associated with Statistical Error (BASE) Surface as an ASCII file with 1m (or 2m) spacing. The 1m (or 2m) decimated x, y, z ASCII text file was imported into Fledermaus Average Gridder to create digital elevation model (DEM) grid(s). The 1m (or 2m) Fledermaus grid was exported as an Arc Info ASCII raster file (.asc), which was imported into ArcGIS Spatial Analyst to generate a 1m (or 2m) bathymetry Arc Info grid. Post-survey data cleaning, BASE surface creation, and final products derived from post-processed multibeam bathymetry data were applied by the Seafloor Mapping Lab at CSUMB. Data products are presented at 1m and 2m spatial resolutions based on discrete depth ranges: 1m horizontal resolution for data from the 0-50m depth range, and 2m horizontal resolution for the full survey footprint. Vertical precision is ±10 cm.

Multibeam databases for both the 2007 Pt. Buchon and the 2009 Pt. Buchon to San Luis Obispo Bay surveys can be accessed at the CSU Sea Floor Mapping Lab Data Library http://seafloor.csumb.edu/SFMLwebDATA_c.htm. Data include grey scale and color shaded relief images, sidescan sonar, bathymetry (contours and DEM) as well as survey footprints, tracklines, and XYZ files. MBES data for the study area are shown in Plate 1 of the Shoreline Fault Zone Report at a scale of 1: 35,000, and are discussed in conjunction with the geologic interpretation of the Shoreline fault zone in Section 4 of the Shoreline Fault Zone Report. Comparison of MBES data with earlier bathymetric data collected for the LTSP illustrate the difference improved technology and GPS navigation have made during the last two decades (see Figure F-2 and F-3).

Reference

California State University Monterey Bay Sea Floor Mapping Lab, 2009, website at http://seafloor.csumb.edu/SFMLwebDATA_c.htm (visited 12/15/2010)



Notes: Red track lines show areas where MBES data were collected in 2009. Bathymetry data for the shaded area offshore of Pt. Buchon was collected in 2007 as part of the California State Waters Mapping program. Spatial resolution in water depths less than 50 m is 1 m, and 2 m for water depths greater than 50 m.

Multibeam echo sounding (MBES) coverage of the study area

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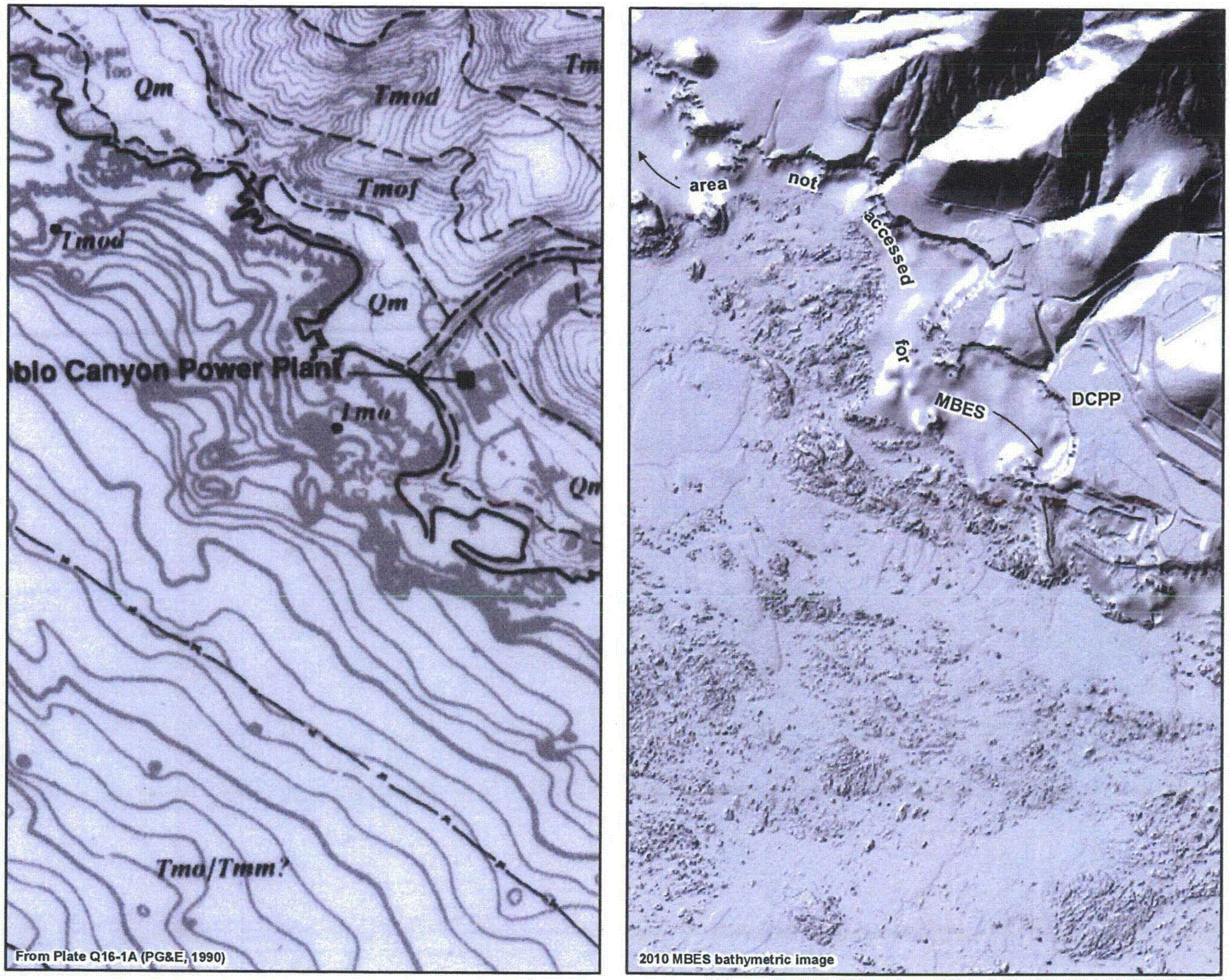

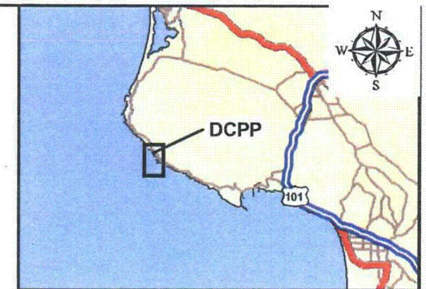

Map scale: 1:15,000
Map projection: NAD 1983, UTM Zone 10 North

0 0.1 0.2 0.3 0.4 0.5 Miles
0 0.2 0.4 0.6 0.8 Kilometers

Comparison of 1990 LTSP bathymetry with the 2009 MBES bathymetry - offshore DCPP area

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Pacific Gas and Electric Company | Figure **F-2**

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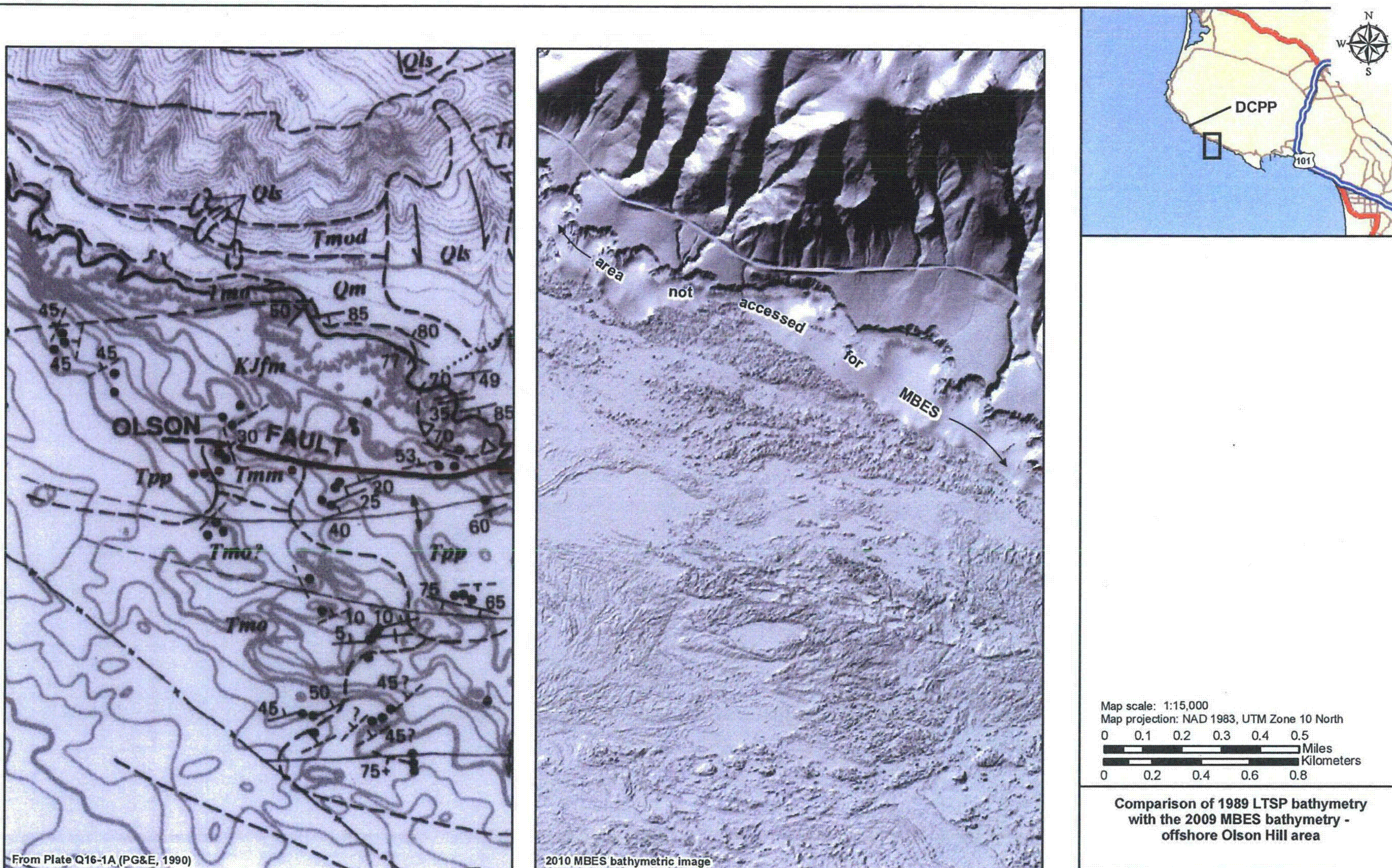

Comparison of 1989 LTSP bathymetry with the 2009 MBES bathymetry - offshore Olson Hill area

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Pacific Gas and Electric Company | Figure F-3

Appendix G

Coastal LiDAR Survey

Introduction

Light Detection and Ranging (LiDAR) data and air photos were collected in January 2010 by Tetra Tech along the coastline from Islay Creek in the north to Avila Bay in the south, and extending from the coast to 1.6 to 2 km inland along the western side of the Irish Hills.

The data were collected during one of the lowest low tides of the year (-1.5 feet relative to MLLW @ 3:02 PM on 28 January 2010) to acquire the best imagery of the tidal zone and the coastal cliffs. Six flight lines were flown, with three flown offshore to afford the best possible view of the seaward-facing cliffs. Figure G-1 shows composite images of the LiDAR and ortho-airphoto coverage along the western side of the Irish Hills.

LiDAR

LiDAR data were collected at 8 points per square meter and interpolated into ArcGIS grid files that were gridded at both 1 and ¼ meter resolution. Digital Elevation Models (DEMs) for the onshore maps above the cliff tops have 1-meter grid spacing, and the tidal area in front of the cliffs have 25-cm grid spacing.

Multiple static GPS ground surveys, accompanied by an RTK survey of ground points with a roving GPS, on selected control points were conducted simultaneous with the LiDAR collection flight. A total of 129 points were collected to assess the absolute accuracy of the LiDAR data. The Root Mean Square Error (RMSE) for the absolute vertical accuracy was calculated at 4 to 5 cm. Elevation data are presented in NAVD88 (North American Vertical Datum 1988), which is measure relative to mean sea level.

Aerial Photography

Aerial photography was also collected during the survey (tide at -0.8 to -1.0 ft., MSL) with a 0.2 meter pixel resolution at a negative scale of 1:12000. These data were used to generate color orthophotos of the coast to accurately map the geology that is well exposed in the sea cliffs and in the low-tide wave-cut platform. The photography was flown with airborne GPS collection to minimize the number of ground points necessary to control the photography for mapping. Stereo-air photos supplemented the LiDAR and provided a current orthophoto and contour map Photography was collected with the LiDAR data

The LiDAR data were used to create hill shade images, contours, and slope maps. Figures G-2 to G-9 show composite ortho-airphotos and LiDAR images for selected areas of the coastline. Both the LiDAR and ortho-photo maps greatly helped in accurately mapping the geology along the coast as well as better locating the elevations of paleoshorelines mapped during the LTSP (Hanson, et. al., 1992; 1994). The tidal zone and cliffs provided extensive rock exposures to help correlate the mapped units onshore to those interpreted from the MBES image offshore. During the geologic mapping of the coast we found that the stereo-air photos showed more detail to map the geology. We transferred the detailed geologic data to the LiDAR orthophoto map for incorporation into the onshore-offshore geologic map (Appendix B).

References

Hanson, K.L., Lettis, W.R., Wesling, J.R., Kelson, K.I., and Mezger, L., 1992, Quaternary marine terraces, south-central coastal California: Implications for crustal deformation and coastal evolution: in Fletcher, C.H., III and Wehmiller, J.F. (eds.), Quaternary coasts of the United States: Marine and lacustrine systems: SEPM (Society for Sedimentary Geology) Special Publication, 48, pp. 323-332.

Hanson, K.L., Wesling, J.R., Lettis, W.R., Kelson, K.I., and Mezger, L., 1994, Correlation, ages, and uplift rates of Quaternary marine terraces, south-central California: in Alterman, I.B., McMullen, R.B., Cluff, L.S., and Slemmons, D.B. (eds.), Seismotectonics of the Central California Coast Range, Geological Society of America Special Paper 292, pp. 45-72.

Ortho-airphoto and LiDAR images showing the coverage of the west coast of the Irish Hills obtained in 2010

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Vertical composite ortho-airphoto and LiDAR image of the DCPP

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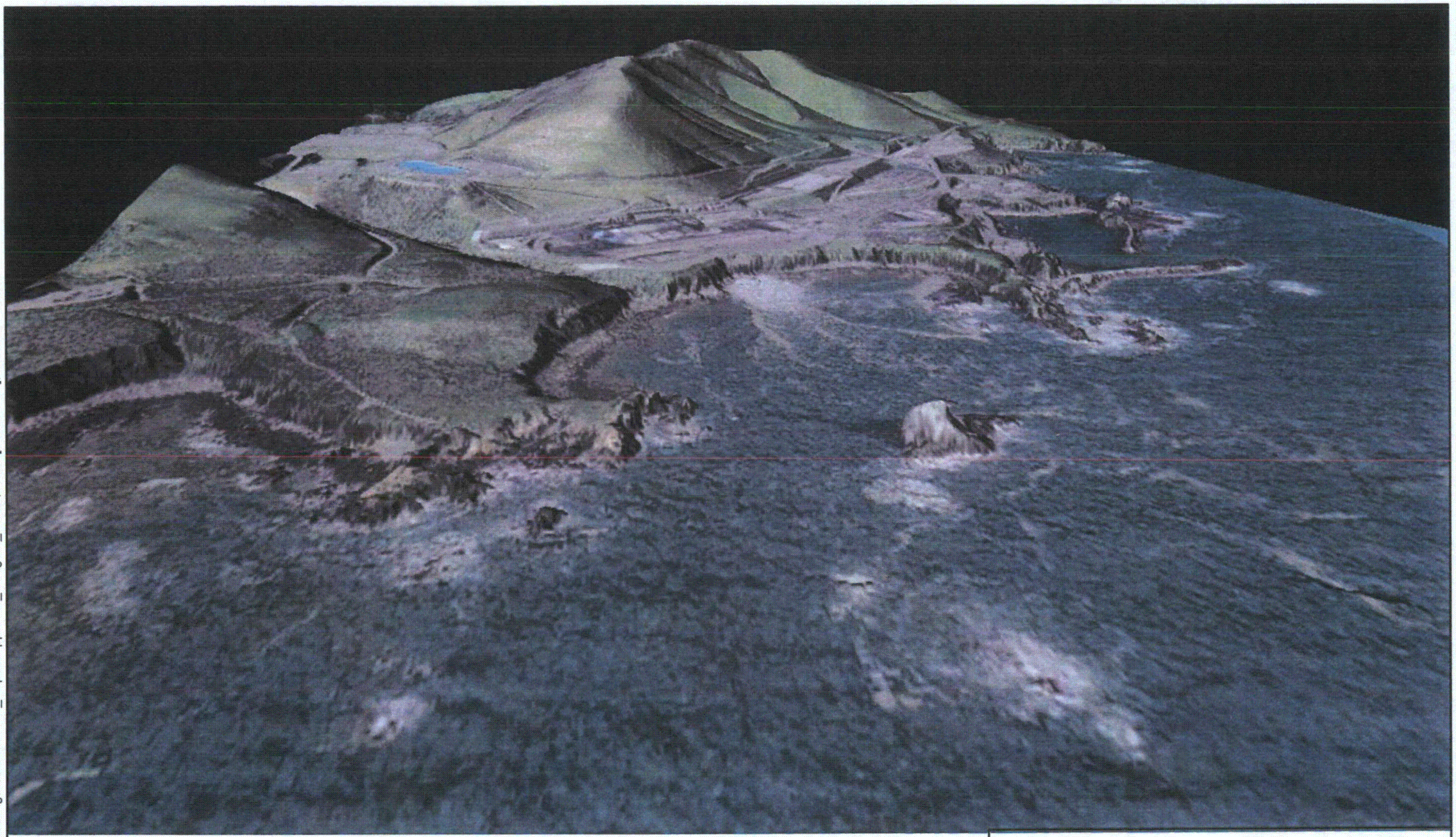
Figure G-2



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Composite ortho-airphoto-LiDAR 'view' to southeast of DCPP from

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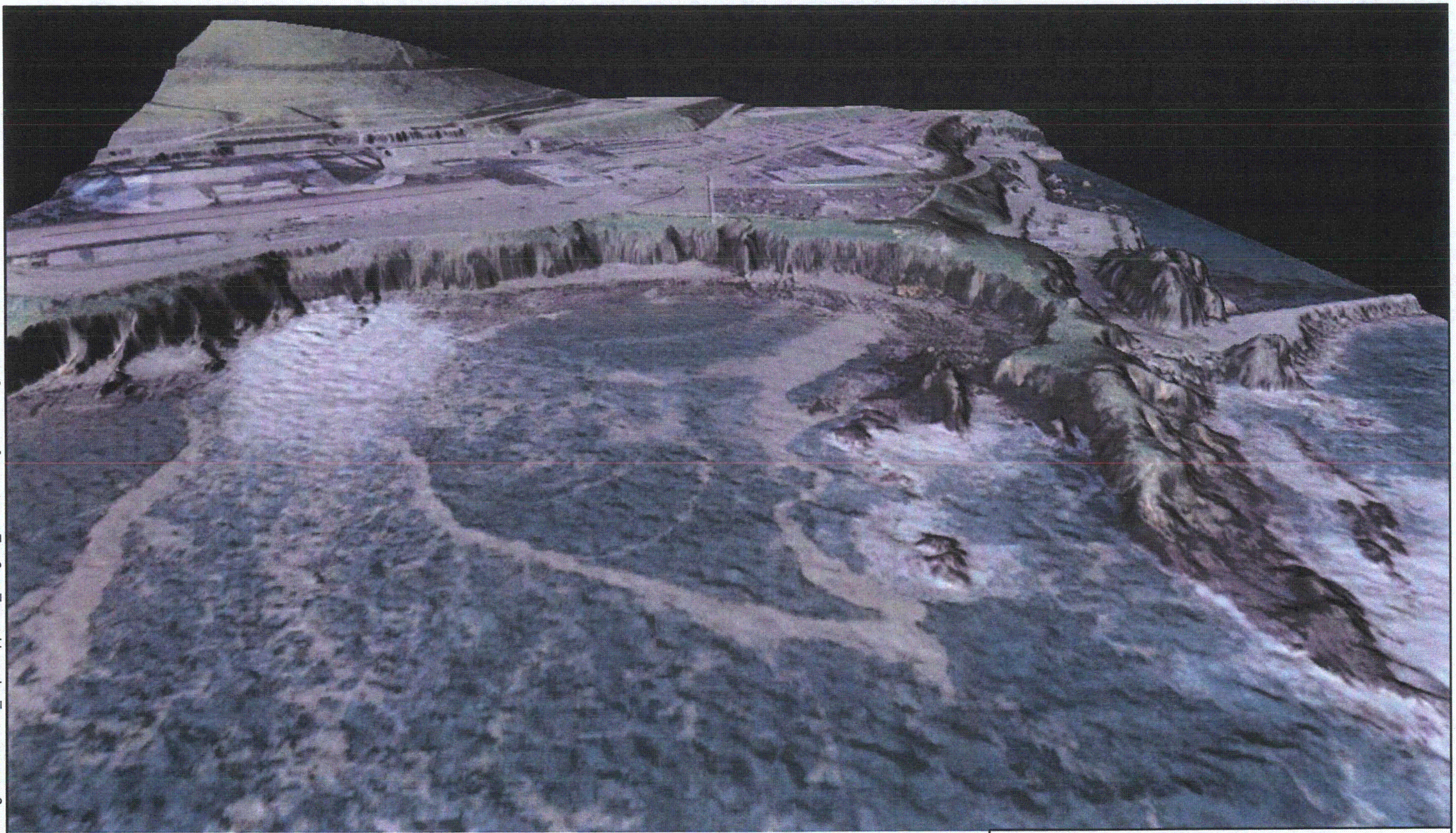
Figure **G-3**



Composite ortho-airphoto-LiDAR 'view' to east of DCPP Discharge Cove

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Pacific Gas and Electric Company | Figure G-4

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Vertical composite ortho-airphoto and LiDAR image of the Olson Hill area

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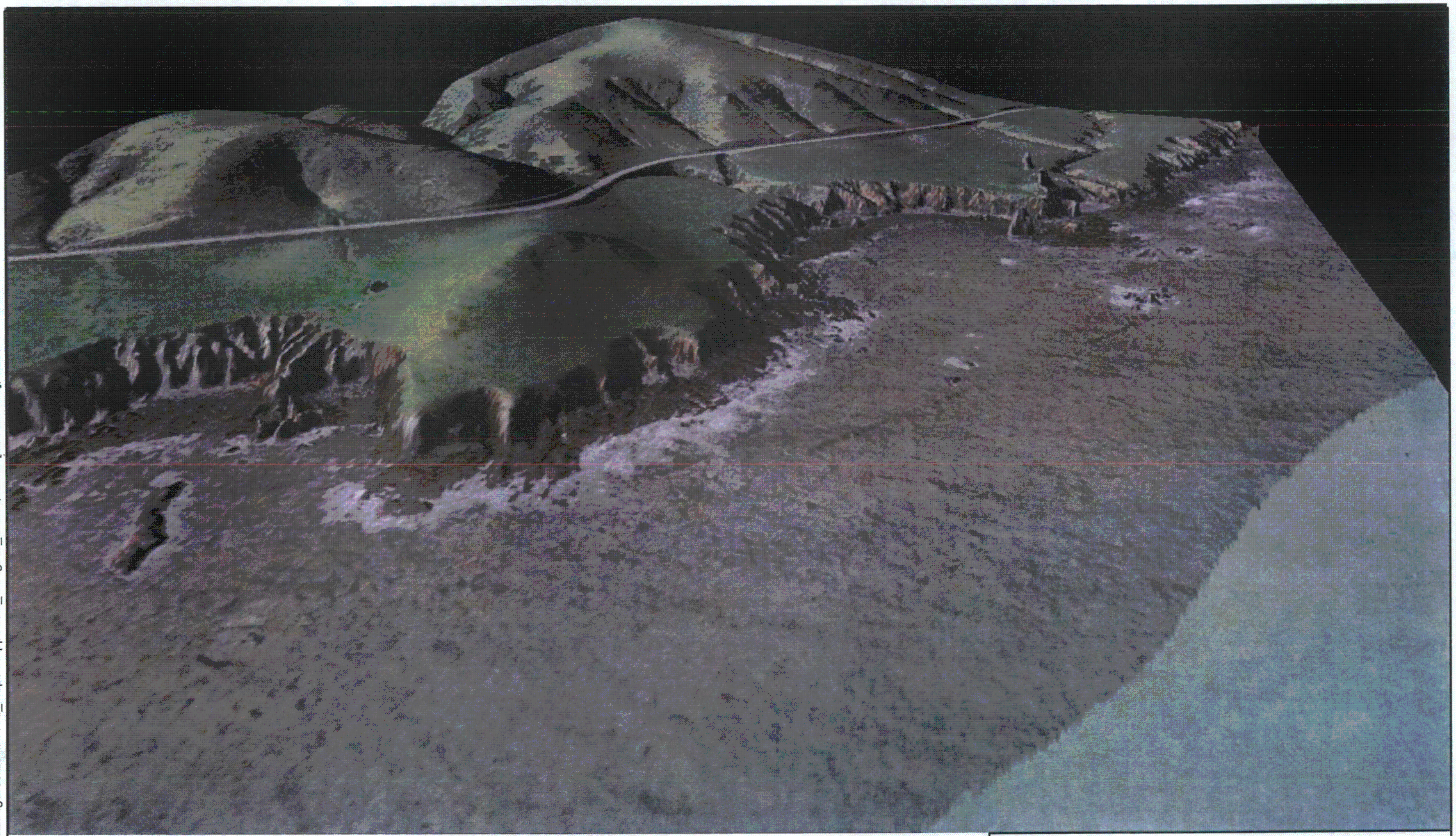

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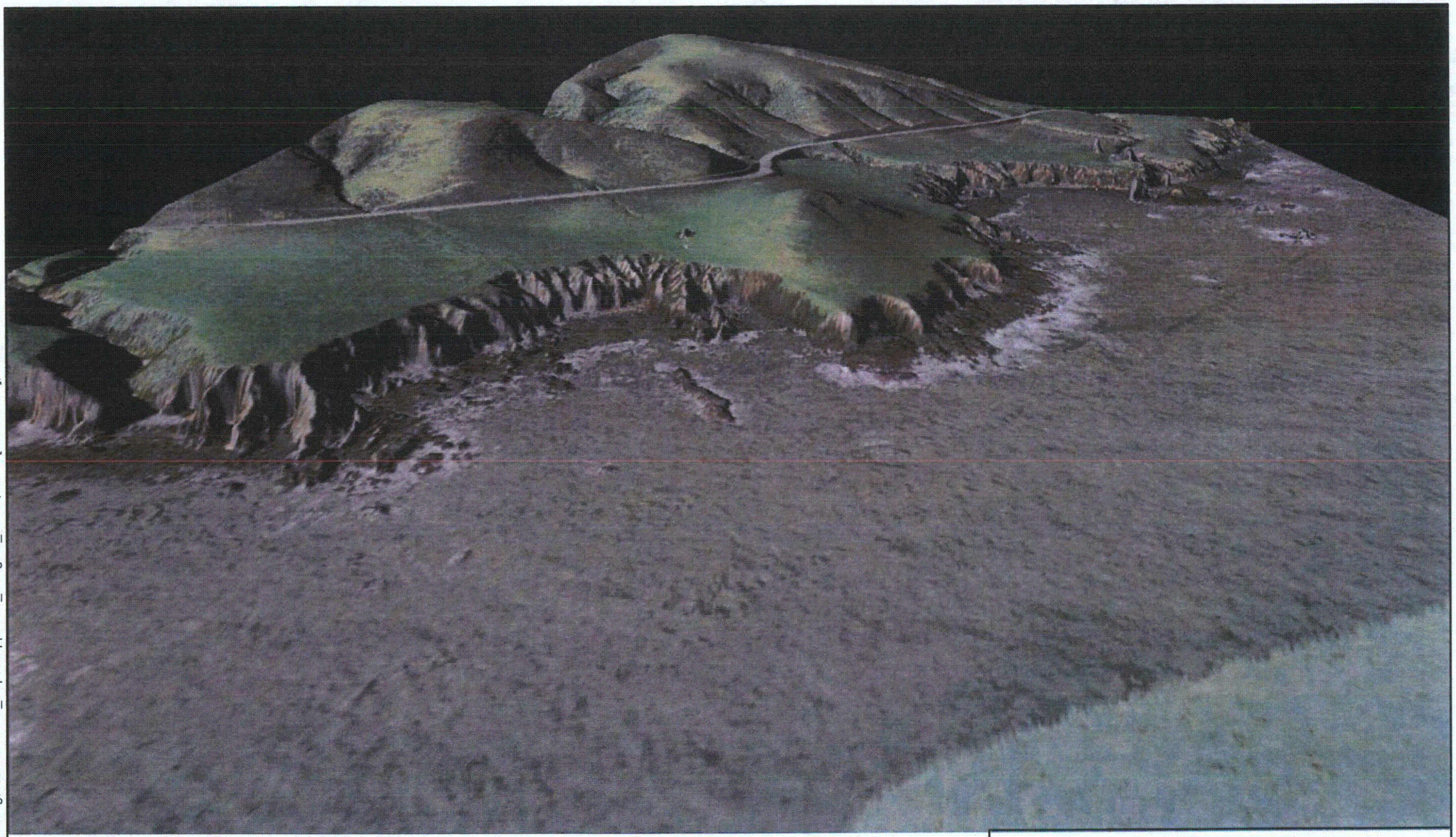
Composite ortho-airphoto-LiDAR 'view' to southeast of Olson Hill area

SHORELINE FAULT STUDY

Pacific Gas and Electric Company | Figure **G-6**



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Composite ortho-airphoto-LiDAR 'view' to east of Olson Hill area

SHORELINE FAULT STUDY

Pacific Gas and Electric Company | Figure G-7

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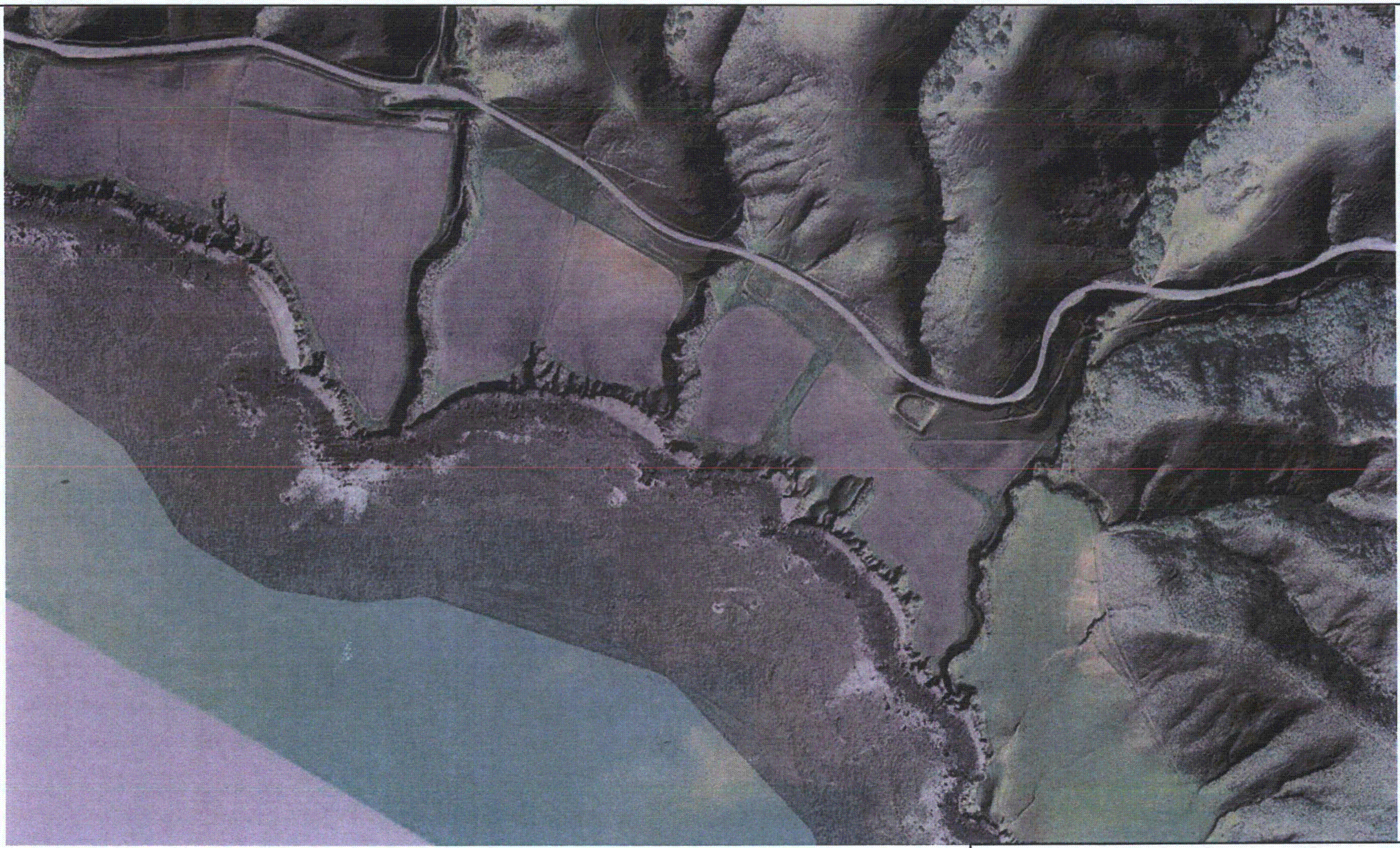
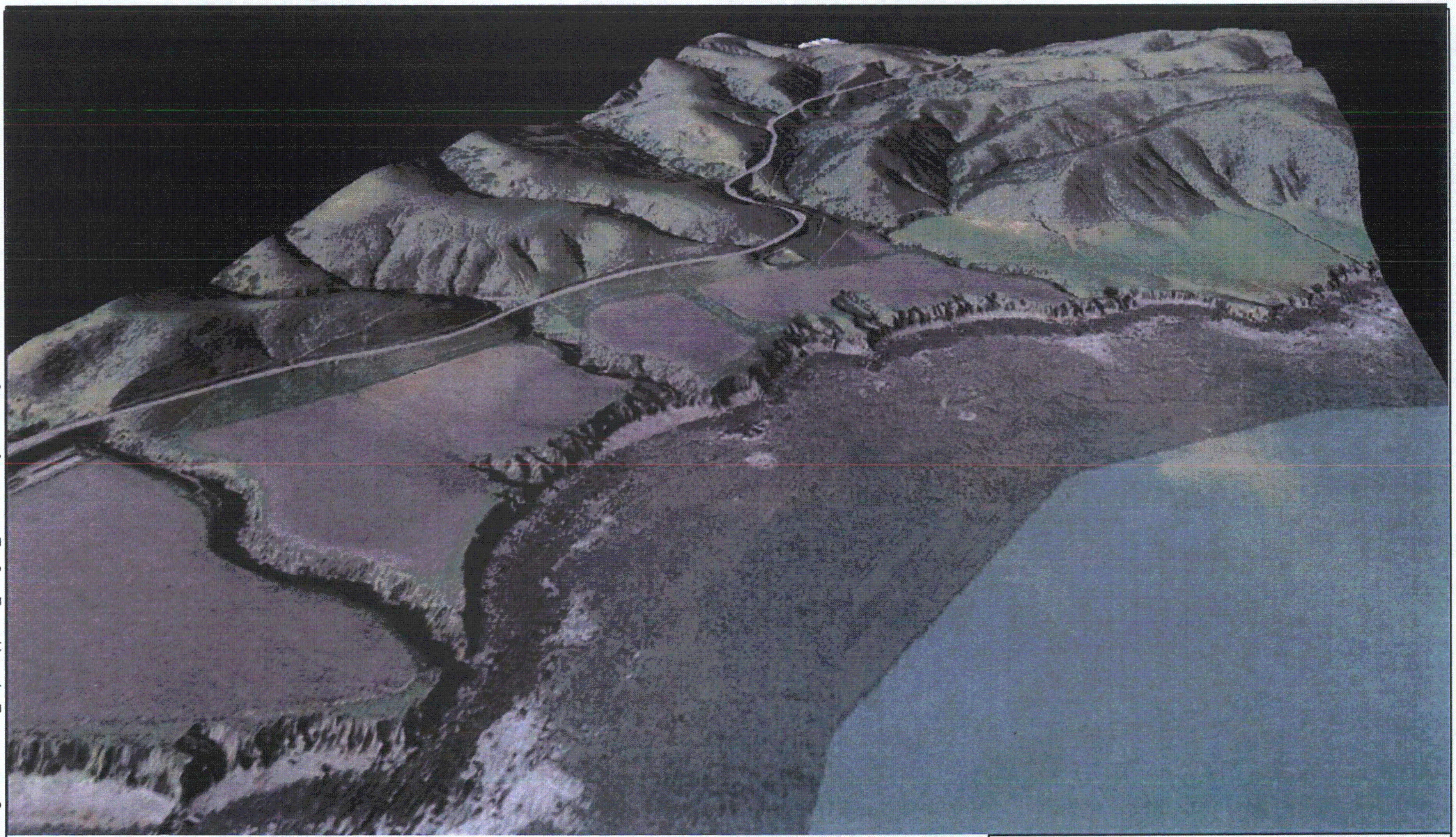


Vertical composite ortho-airphoto and LiDAR image of the Rattlesnake Creek area

SHORELINE FAULT STUDY

Pacific Gas and Electric Company | Figure **G-8**



Composite ortho-airphoto-LiDAR 'view' to southeast of Rattlesnake Creek area

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Pacific Gas and Electric Company | Figure G-9

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Appendix H

High Resolution Marine Seismic Reflection Surveys

Introduction

Single-channel seismic-reflection data were acquired in 2008 and 2009 by the U.S. Geological Survey between Piedras Blancas and Pismo Beach, along shore-perpendicular transects spaced 800 m apart extending beyond the 3-mi limit of California State waters. Data were collected by the *R/V Parke Snavely* using a SIG 2Mille mini sparker and an Edgetech SB-0512i chirp system. Water depths in the survey area ranged from 6 m near shore to 210 m at the northwest corner of the survey area. Figures H-1 and H-2 show the survey area and individual track lines.

The Edgetech 512 chirp subbottom-profiling system consisted of a source transducer and an array of receiving hydrophones housed in a 500-lb fish towed at a depth of several meters below the sea surface. The swept-frequency "chirp" source signal was 500 to 7,200 Hz with a 30-ms sweep length, recorded by hydrophones located on the bottom of the fish. The SIG mini sparker system used a 500-J high-voltage electrical discharge that created a source with greater power and lower frequency than the chirp and was received by a towed 15-m-long hydrophone streamer. The mini sparker source was fired at a rate of 2 times per second, which, at normal survey speeds of 4 to 4.5 knots, gave a data trace every 1 m. Record lengths were 0.35 s for the chirp and 0.5 s for the mini sparker. The data from each system were digitally recorded in standard SEG-Y 32-bit floating-point format with Triton Subbottom Logger (SBL) PC-based software that merged seismic-reflection data with differential GPS navigation data. Digital sampling was 12.5 kHz for the chirp data and 16 kHz for the mini sparker data. Differential GPS position fixes were written into the trace headers of the SEG-Y files and are also available as an ASCII text file. All the lines that were collected with the chirp system are indicated by the prefix "PBC", and mini sparker lines begin with the prefix "PBS".

During initial deployment in 2008, the chirp system was unable to image deeper than 10 m subbottom depth and was quickly abandoned in favor of the lower-frequency mini sparker system, which was able to penetrate as deep as 150 m. Subsequently, only four chirp lines were collected, and in the rest of the 2008 and 2009 surveys, the mini sparker sound source was used.

After the survey, all the SEG-Y files were read by using Seismic Unix software and PostScript (PS)-format image files of all the profiles were generated. A short-window (30 ms) automatic-gain-control (AGC) algorithm was applied to both the chirp and mini sparker data, and a 160- to 1,200-Hz band pass filter was applied to the mini sparker data. These data-processing steps were applied only for display purposes and have not been applied to the available SEG-Y data. The PS-format image files were converted to TIFF- and smaller JPEG-format image files. All of the SEG-Y data files, the navigation file, and the TIFF- and JPEG-format image files are available for download from the Data Tables section of USGS Open File Report 2009-1100 (Sliter et al., 2009, revised 2010).

Specific attempts were made in 2009 to survey closer to shore in order to image portions of the Shoreline fault zone that had been identified from the MBES mapping. The USGS survey vessel, *R/V Park Snavely*, was not able to approach as close to shore as the CSU Monterey Bay vessel, *R/V Ven Tresca* due to the presence of shallow rocks and kelp. As a result, uniform seismic reflection profiling of nearshore areas was limited.

Reprocessing

Several of the USGS seismic reflection lines were reprocessed to improve signal quality and emphasize deeper seismic reflectors. Processing of the 2008 and 2009 USGS sparker data consisted of several steps to reduce noise that impaired resolution of primary reflected energy, particularly large-amplitude water-bottom multiple reflections. To ensure that all processing steps were based on surface-consistent information, reprocessing was only conducted along the portions of each line where high-resolution bathymetry data were available. Suppression or elimination of water bottom multiples in the data requires predicting the time and phase of the multiple arrivals. The basis for the multiple arrival-time predictions was a careful picking of the water-bottom reflection arrival time, and correction for arrival time irregularities along the lines based on arrival times predicted by high-resolution bathymetry. The first step to reduce arrival-time irregularities was to flatten on the primary water-bottom reflection by time shifting each trace according to the water depth and an acoustic sea-water velocity of 1493 m/s. Then several horizons were picked across the entire collection of traces within each line corresponding to the initial and later phases of the water-bottom reflection. These horizons were used to solve for surface-consistent static corrections that removed to first-order, the peculiar short-wavelength "wobble" or oscillation in water-bottom arrival time relative to the predicted arrival time based on high-resolution bathymetry. After statics corrections, the traces where shifted so that the water-bottom arrival time corresponded to observed bathymetry assuming an acoustic sea-water velocity of 1493 m/s. Experiments with varying bandpass filter operators were used to determine the passband with good signal-to-noise. The 2008 data were bandpass-filtered between 100-1200 Hz and the 2009 data were bandpass-filtered between 100-700 Hz. An AGC with a 15 ms operator was applied to provide balanced amplitudes throughout space and time in the seismic sections.

With knowledge of water bottom primary time, local dip, source signature and water velocity it becomes possible to predict and remove several orders of multiple seismic energy with sufficient accuracy to uncover the primary signal (and noise) that is masked by the high amplitude water-bottom multiple reflections. This multiple processing approach is often described as SRME (Surface Related Multiple Elimination) or WEMR (Wave Equation Multiple Rejection). The final seismic line outputs represent the combination of all these surface-consistent static, filtering, amplitude balancing, and surface-consistent water-bottom multiple-reflection rejection processing steps.

Figure H-3 shows a comparison of the original data seismic reflection data along line PBS-22 with the reprocessed data. Figure H-4 presents our preliminary interpretation of the reprocessed line PBS-22. Note that this reprocessing has defined a faulted limb of a fold that may represent the northern segment of the Shoreline fault zone. Earlier interpretations of unprocessed seismic reflection lines in this area (i.e., Figures 9a and 9b in PG&E, 2010) were not able to image this feature. Low energy (< 2 kJ) 3D seismic reflection surveys were conducted in this area during late 2010 to further resolve these features. These data will be available in the spring of 2011.

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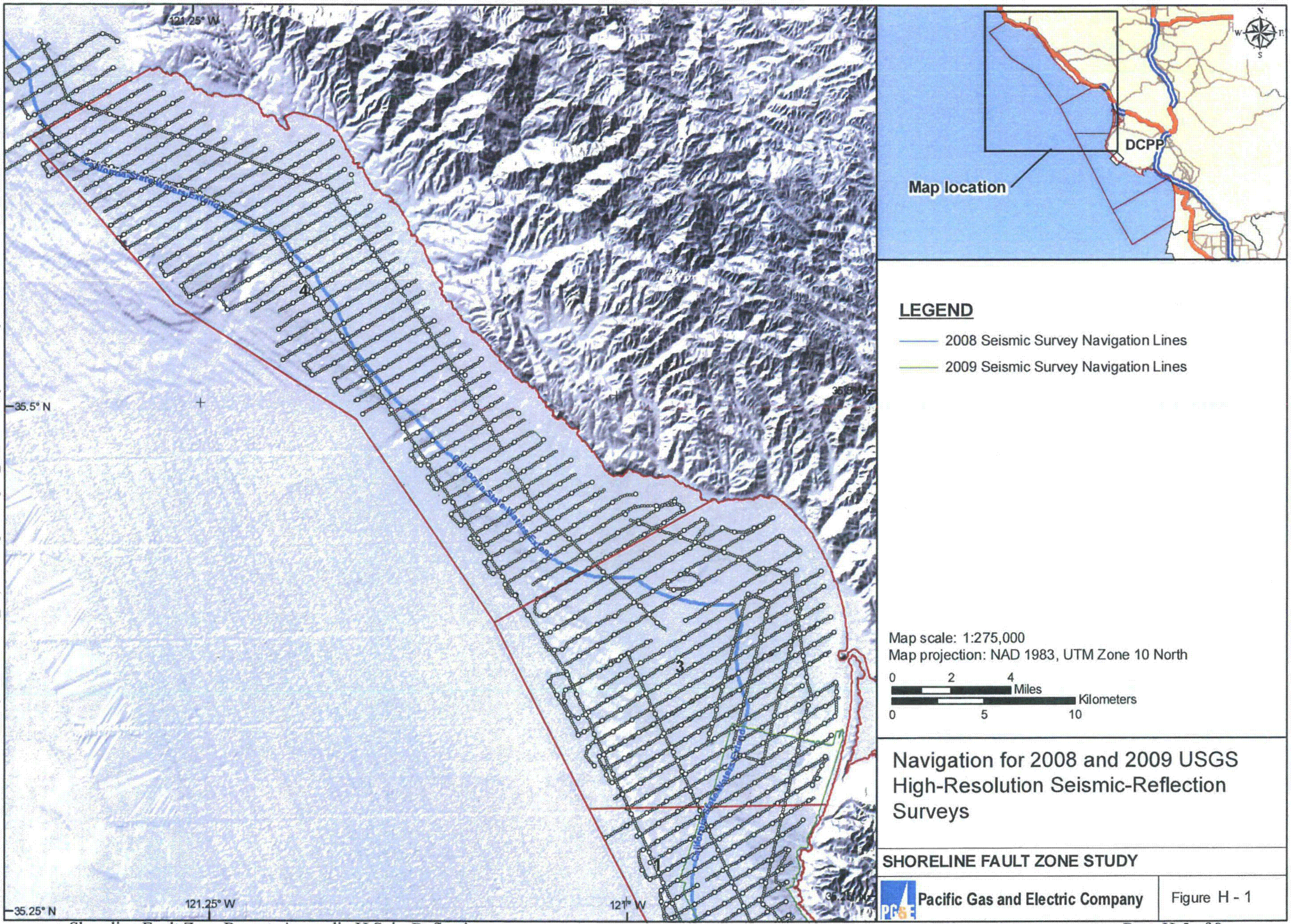

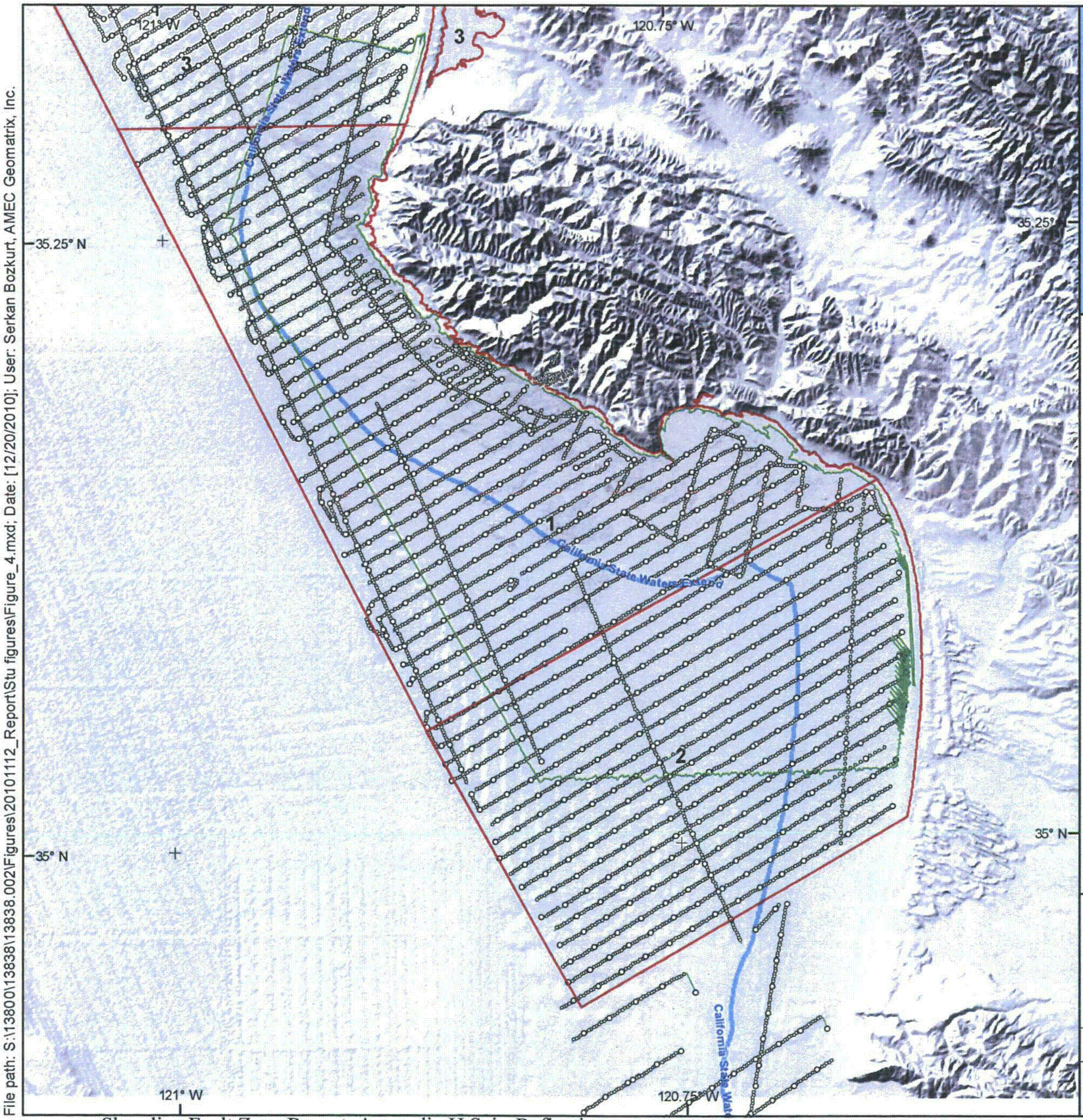

LEGEND

2008 Seismic Survey Navigation Lines

2009 Seismic Survey Navigation Lines

Map scale: 1:275,000
Map projection: NAD 1983, UTM Zone 10 North

0 2 4 Miles
0 5 10 Kilometers

Navigation for 2008 and 2009 USGS High-Resolution Seismic-Reflection Surveys

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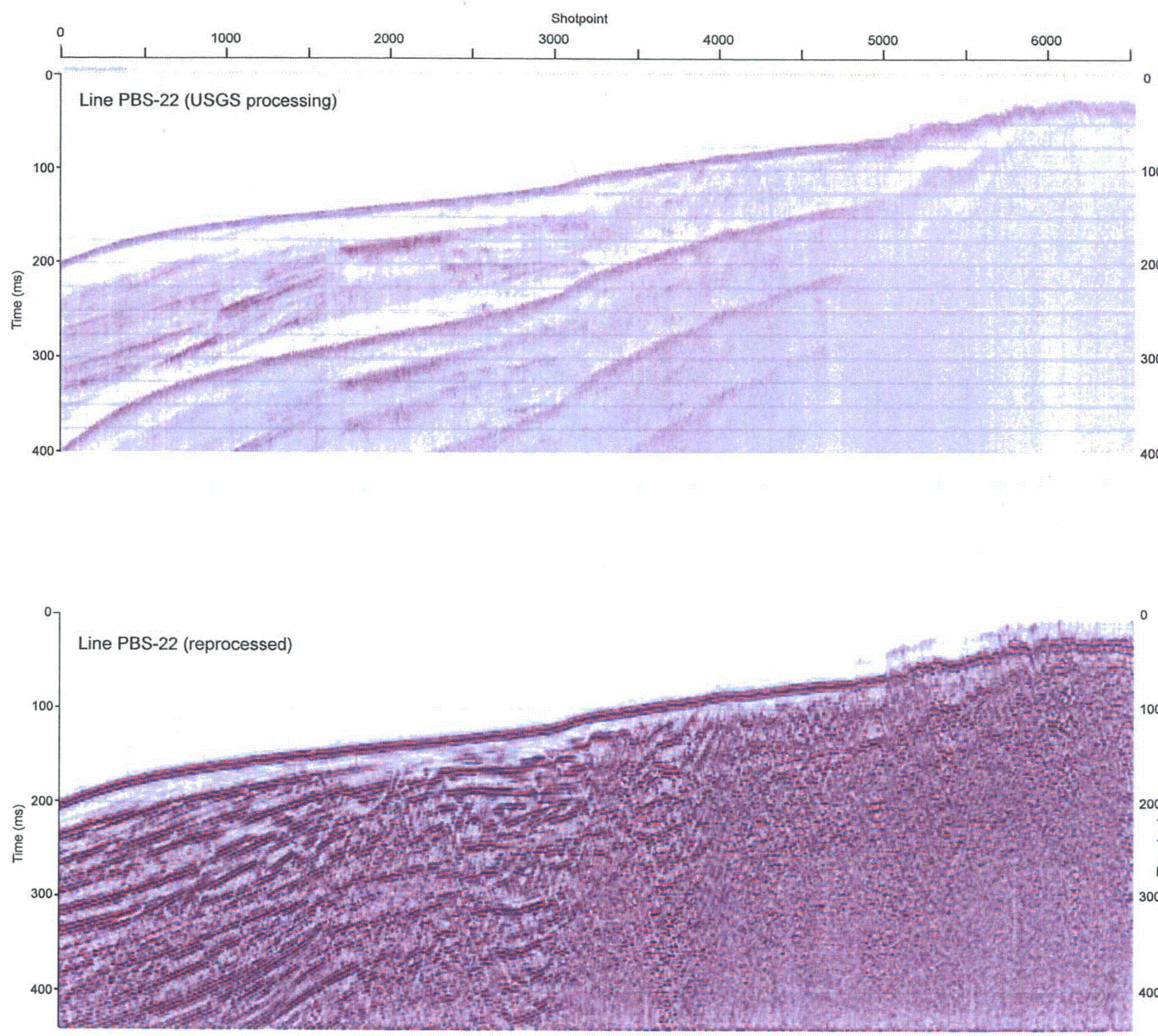
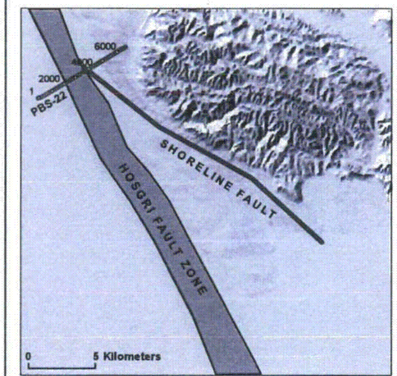
Figure H - 2





USGS Seismic Line PBS-22
USGS Processing and Reprocessed
Data Comparison

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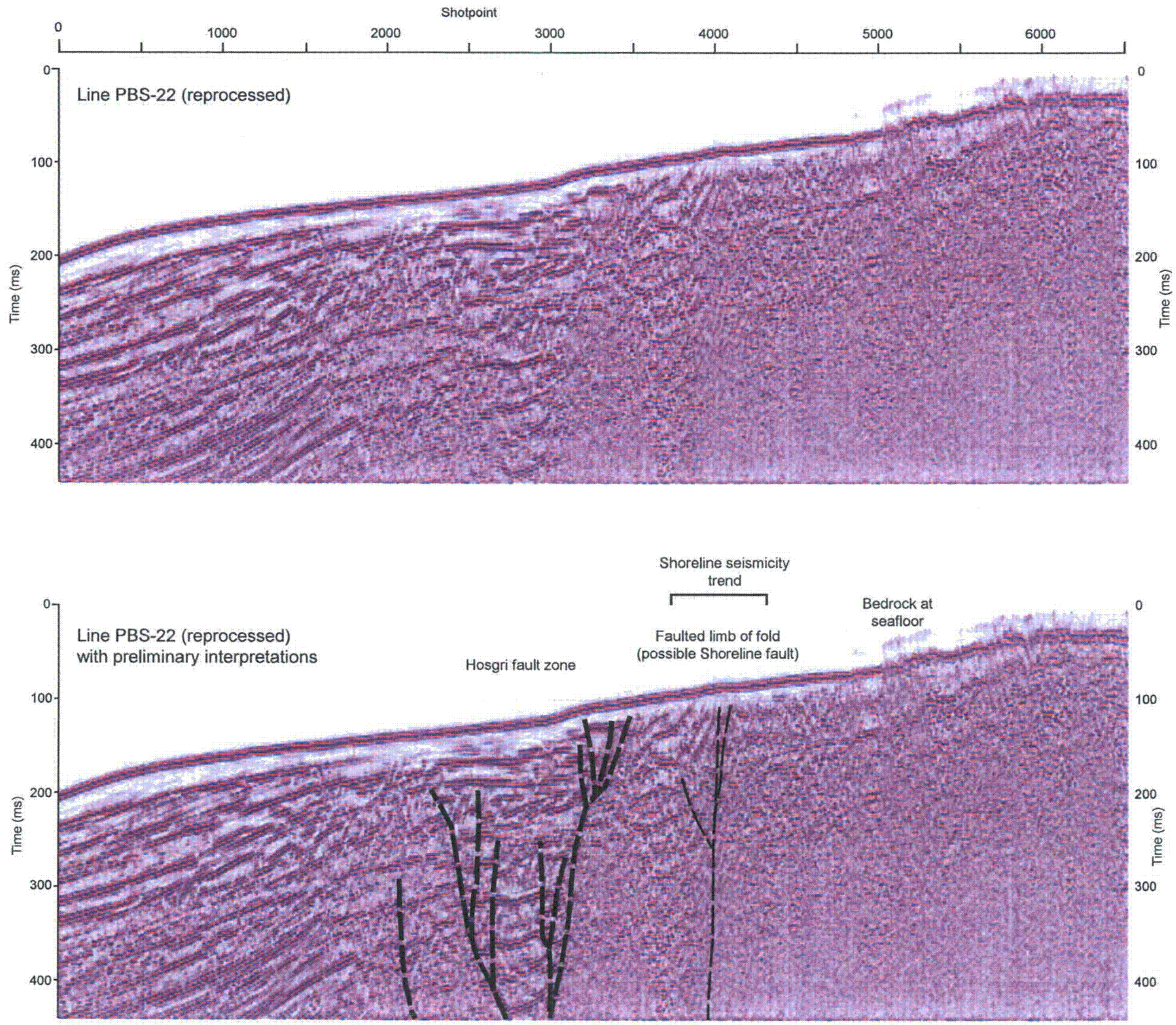
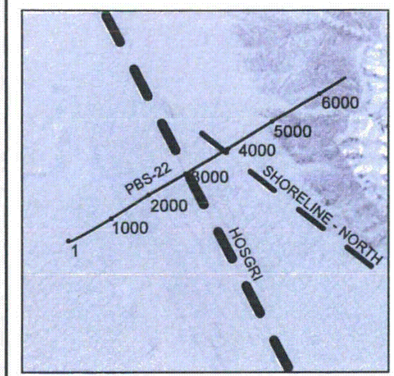
Figure H - 3





Reprocessed USGS Seismic Line PBS-22

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Figure **H - 4**