

# Appendix B

## LiDAR Metadata

## TAGS

Terrain Dataset fused soundings and terrain topo-bathy topographic-bathymetric surface ESRI Terrain Dataset tbsm45cm topographic surface model bathymetric surface model WGS84\_NAVD88 CONTUS\_Geoid\_2003; natural neighbor interpolation between ground-classified points

## SUMMARY

Reference topographic-bathymetric seamless surface for Marin County, California vicinity. Airborne LiDAR surveys flown 2007--2010 and multiple bathymetric data were fused in a single ESRI Terrain Dataset to develop a best-available surface for analytical and cartographic uses. Historic flow paths from USGS 1895 topographic mapping were referenced to estimate pre-inundation topography beneath reservoir pools. Fourth Edition "tbsm50cm\_20121130g" uses only LiDAR sources for land within Marin County. Fifth Edition "tbsm50cm\_20130830a" is patched based on a QA informed by terrain slope analysis, and repairs edge match issues in western county lands Sixth Edition "tbsm50cm\_20131218f" is refined for use with HUC16 watershed boundary delineation, and estimates pre-inundation topography beneath reservoirs.

## DESCRIPTION

Revision 2013.12.18 of County of Marin digital topographic-bathymetric surface model: This is a 50cm gridded surface exported from ESRI Terrain Dataset with natural neighbor interpolation. The Terrain Dataset was used to fuse airborne LiDAR ground-classified points, multibeam sonar bathymetric grids, and depth survey soundings, and elevation-interpolated historical flow paths. The multibeam bathymetric surface was obtained as 1-meter grids in San Francisco Bay and as 2-meter grids offshore; these grid cells were converted to masspoints for use in the fusion process. The original motivation for the surfaces was a countywide implementation of HAZUS-MH, with a surface to support modeling of riverine and coastal flooding peril as well as tsunami inundation. Funding for this dataset has been provided by a series of MarinMap.org projects to map countywide creeks, wetlands, and watersheds at parcel-scale accuracy as a set of model-derived features. This surface is the fifth edition of an integrated countywide terrain model of Marin County, California.

## VERSION HISTORY:

- 1) 2009.09 First Edition "tsm30cm" The fusion of photogrammetric topographic contours and breaklines was the initiative for the first edition of the terrain surface, gridded at resolutions as small as 30cm and stabilized as "2009.09".
- 2) 2010.03 Second Edition "tsm40cm" The further fusion of FEMA LiDAR data in the urban areas and NCALM GeoEarthScope LiDAR along the San Andreas Fault in the western county was the initiative for the second edition of the terrain surface, stabilized as "2010.01" and distributed to a number of engineering companies and published as default terrain in Google Earth by 2010 03.
- 3) 2010.08 Third Edition "tbsm45cm" The fusion of all data sets previously integrated with bathymetry

data was the initiative for the third edition, called "2010.08", With use of the NOAA VDatum Java-based application, it became possible to reprocess the ITRF-2000-based NCALM point cloud directly, along with all NOAA depth surveys from 1931 to the most recent public sets, and the California Seafloor Mapping Project gridded models of multibeam sonar soundings in San Francisco Bay and out to the 3-nautical-mile limit offshore. An additional LiDAR dataset was provided by the Marin Municipal Water District for lower Lagunitas Creek below Kent Reservoir. The original photogrammetric break lines were segregated into sets of ridgelines and road edge lines, with ridges and water lines used as soft constraints, and road edges used as hard constraints in the fusion of points and breaklines in the ESRI Terrain Dataset into the 2010.08 terrain model. This grid has been produced in WGS84 UTM zone 10 North, meters, with elevations in WGS84 NAVD88 (CONTUS Geoid 2003) positioning.

4) 2012.11.30 Fourth Edition "tbsm50cm\_20121130g" After the arrival of ARRA-funded countywide 2ppsm airborne LiDAR, several months of experimentation and discussions with creek-mapping colleagues identified that the photogrammetric contours and breaklines from a 2004 survey should be deprecated and not used further in county terrain models. Likewise, the early ALACE coastal LiDAR which did not have ground classification was deprecated and discontinued from the county terrain models. This surface was the first in the series to only fuse aerial LiDAR surveys wherever available for topographic surface modeling. On land, FEMA 2007 (urban east 2 ppsm), NCALM 2008 (San Andreas Fault 7 ppsm), MMWD/Airborne 1 2009 ( lower Lagunitas Creek 2 ppsm), NOAA 2010 ( urban east 1 ppsm), CA-OPC 2010 ( coastal 1 ppsm), and ARRA 2010 (countywide 2 ppsm) provided LiDAR sources. Some NED 10m grid values were retained for infill of adjacent areas outside of Marin County. The 50cm model grid is projected to WGS 1984 UTM 10 north meters, and positioned WGS84 / NAVD 1988 (CONTUS Geoid 2003). Typical distribution is in single seamless ERDAS Imagine file format.

5) 2013.08.30 Fifth Edition "tbsm50cm\_20130830a" During 2013, the 20121130g surface was intensively analyzed to model surface drainage, and slope surfaces were derived for QA evaluation, which led to several patches of the surface where terrain blocks had been mosaicked and adjacent edges had artifacts from inconsistent interpolation across some boundaries. Data from a 2011 QA 1m grid of ARRA LiDAR prepared by Bill Kruse were used along these match edges. As drainage processing has evolved to production of USGS National Hydrography Dataset (NHD) Local Resolution flow lines and USGS Watershed Boundary Dataset (WBD) HUC-16 polygon areas, contour sets are routinely produced as part of the formal WBD review protocol.

6) 2013.12.18 Sixth Edition "tbsm50cm\_20131218f" To better support the QA requirements of WBD HUC-16 production, pre-inundation topography beneath reservoirs was modeled with reference to USGS 1895 quad sheets and elevations interpolated along enforcement lines traced through each pool and out to all its tributaries. Dam structures are retained and flow paths are modeled through current spillways, but this method supports WBD definitions that join tributaries at their historic confluence, as required in Federal Standards and Procedures for the National Watershed Boundary Dataset (WBD), Fourth Edition. The five reservoirs near Mount Tamalpais, Soulajule and Stafford reservoirs, and Laguna Lake have been given this treatment.

Datasets not positioned in the project's reference vertical datum were exported to ASCII comma-spaced values for adjustment with NOAA VDatum into WGS84 UTM meters-XY, NAVD88 (Geoid 2003) meters-Z. Exported datasets were filtered to remove NULL Z-values, and reloaded as multipoint-Z

features in the Terrain Dataset. Project work was begun in 2009 with ESRI ArcGIS 9.3.1, proceeded for several months in early 2010 using ArcGIS 9.4 beta 1 and beta 2, and completed with ArcGIS 10.0, 10.1, and 10.2 by 2014.

LiDAR data published by FEMA were flown and processed by Dewberry in 2007 and provided by FEMA to County of Marin. The GeoEarthScope LiDAR data were obtained from OpenTopography.org as a bare-earth grid (for edition 2010.01) and as a full point cloud (for edition 2010.08) and positioned with NOAA VDatum. Sounding data were obtained from the National Geophysical Data Center, National Ocean Survey Hydrographic Survey Data portal [map.ngdc.noaa.gov](http://map.ngdc.noaa.gov) and positioned into WGS84\_NAVD88 (CONTUS Geoid 2003) using NOAA VDatum. ARRA LiDAR data were provided on disk by San Francisco State University, CSMP bathymetry were obtained from Cal State Monterey Bay website, CA-OPC and NOAA LiDAR were obtained from NOAA Digital Coast website. Channel soundings were purchased from USACE by FOIA request in 2010.

## CREDITS

1) LiDAR data set from FEMA (2 ppsm), flown by Dewberry in 2007, along the urban eastern county areas, for Digital Flood Insurance Rate Maps / Map Modernization. Nominal 18cm-in-Z accuracy, these data have been used in their entirety below 25 meters NAVD88 elevation, with additional areas above 25 meters included if surface slopes were less than 11 percent as identified in the 2010.01 version of Marin County dsm40cm grid.

2) LiDAR data set of NCALM GeoEarth Scope in 2008 (7 ppsm), obtained from 10-km tiles published by OpenTopography.org, a high density swath along the active San Andreas Fault in western Marin County. Positioned in ITRF-2000 ellipsoid, these data had been consumed in 2010.01 as a bare-earth grid, repositioned to NAVD88 (G873) Geoid 2003 and exported as masspoints. As of 2010.08, the full ITRF-2000 ellipsoid point cloud was obtained, filtered for ground-classified points only, then repositioned to NAVD88 using NOAA VDatum for each ground point.

3) LiDAR data from lower Lagunitas Creek (2 ppsm), obtained by Marin Municipal Water District from an Airborne 1 flight with data files dated 2009 04 29.

4) LiDAR data from NOAA (on urban bay-side) and CA-OPC (on coast side) (1 ppsm), flown 2010 were downloaded from (<http://csc.noaa.gov/dataviewer/index.html?action=advsearch&qType=in&qFld=projectid&qVal=1005>) and incorporated into the Terrain Dataset. In some areas of Petaluma this was the only LiDAR coverage available. Vertical accuracy tested to meet or exceed NSSDA (95% RMSE 10cm vertical)

5) LiDAR from ARRA Golden Gate (2ppsm) flown in April/May 2010 were obtained courtesy of San Francisco State University.

6) NOAA depth surveys, estuarine grids, and offshore background grids were obtained from NOAA Digital Coast website.

7) UACE channel surveys were purchased by FOIA in 2010.

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This folder contains digital raster datasets representing bare earth topographic and bathymetric elevation surfaces for Marin County and surrounding areas, as well as derived rasters of surface slope and hillshade. The topographic-bathymetric surface model raster was exported at 50 cm raster resolution from an ESRI Terrain Dataset developed from multiple source datasets, and resampled to 1m, 2 m and 4 m raster resolutions. Coordinate system datum is WGS 1984 (Geoid 2003), vertical datum is NAVD 1988, elevation values in meters.

#### Elevation values

Detailed metadata, including contact information, for the Elevation and Slope datasets can be found in the included metadata files "marin52\_tbsm50cm\_20131218f\_xsl1.xml" and "marin52\_pslo50cm\_8bit\_201312181.xml", as well as the PDF file "Marin\_tbsm50cm\_20131218f\_text\_metadata.pdf".

By receiving and using this digital data provided by County of Marin you understand that the data may contain errors, that you agree to accept the data in "as is" condition, and that you agree to and are bound by the terms described in the document "Warranty\_and\_Disclaimer Agreement\_DPW\_2014.pdf".

#### Known issues:

- Data are not survey accurate for either horizontal or vertical position.
- Elevation values of marsh surfaces are higher than expected based on local knowledge, and may represent the top of vegetation rather than the ground surface.
- Bathymetry surface was assembled from multiple data sources of widely varying accuracy over a long time span, and should only be use for general visualization.

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