

City and County of San Francisco, California  
Department of Technology, Digital Services Division  
San Francisco Enterprise Geographic Information Systems Program (SFGIS)

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**Motivation:**

For some years, City and County of San Francisco has made available a set of features under the moniker “Building Footprints” that were in fact building masses, sometimes aggregating entire blocks of adjacent residential structures into a single complex structure. These features were somewhat adequate for cartography, but not suitable for any sort analysis at the level of individual structures.

To respond to State of California requirements for monitoring the energy efficiency of certain commercial structures (over 925 square meters), funding was obtained to have these building masses split into individual structures based on building vertices with parcel boundaries as guidance.

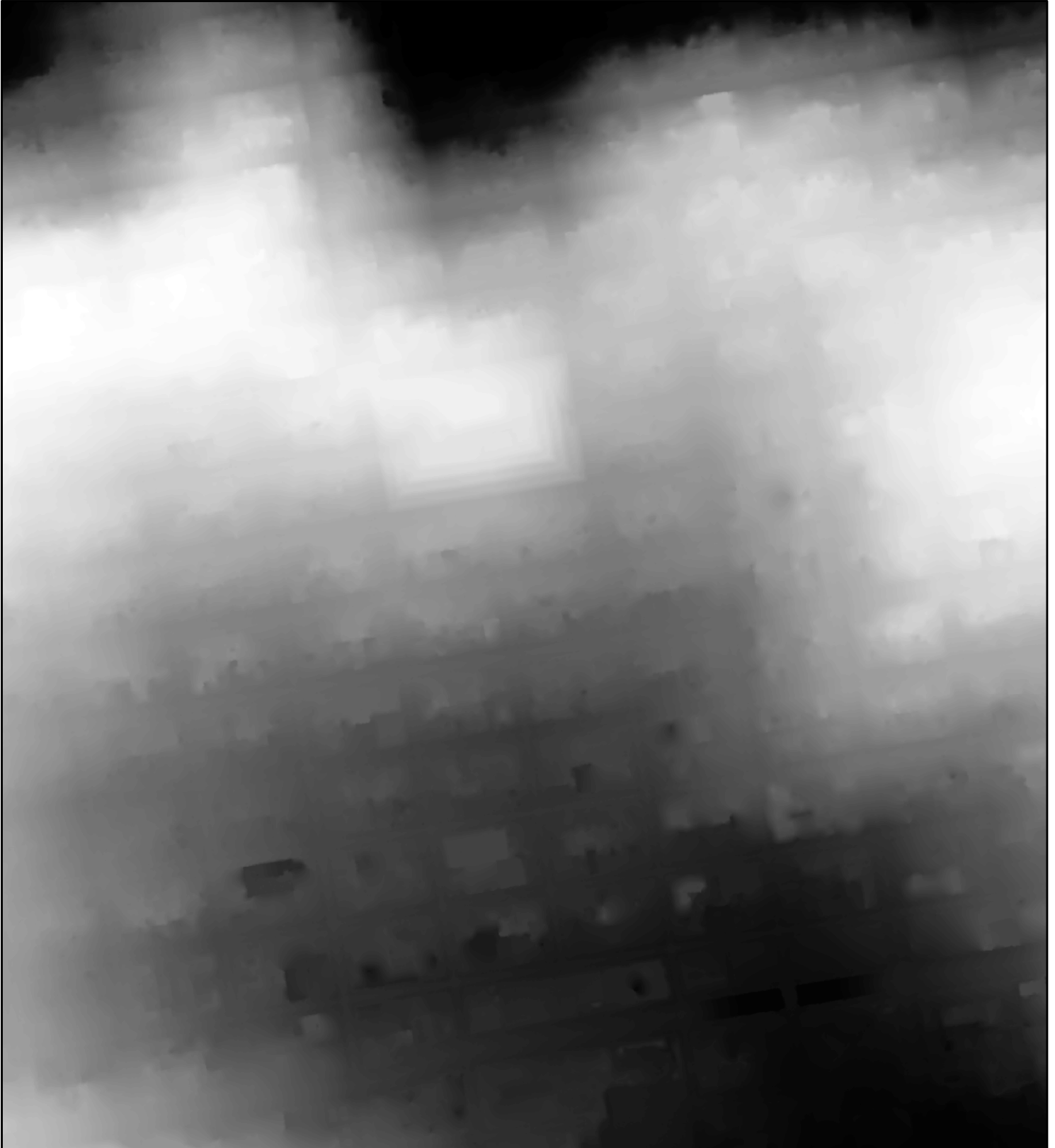
Once individual structure footprints were available, three LiDAR-derived grid surfaces (gridded at 50cm) were used to compile zonal statistics within each building footprint (as gridded at 25cm interval.) These statistics were calculated from an integer representation of bare-earth, first-return, and a grid difference of the two---denominated in centimeters. Evaluating by integers made possible the summary of median values over the full building footprint.

The three LiDAR-derived grids are described in the following three pages.

# Bare Earth Surface [gnd]

This is a 50cm gridded bare earth model, derived from 2 ppsm airborne LiDAR from Pictometry of 2010. Only ground-classified returns were compiled, and a natural neighbor (involving tessellation) algorithm was applied to interpolate across the gaps for every building and beneath the densest tree canopy. The grid was compiled and prepared in NAD 1983 (2011) San Francisco Coordinate System of 2013, denominated in meters (WKID=7131).

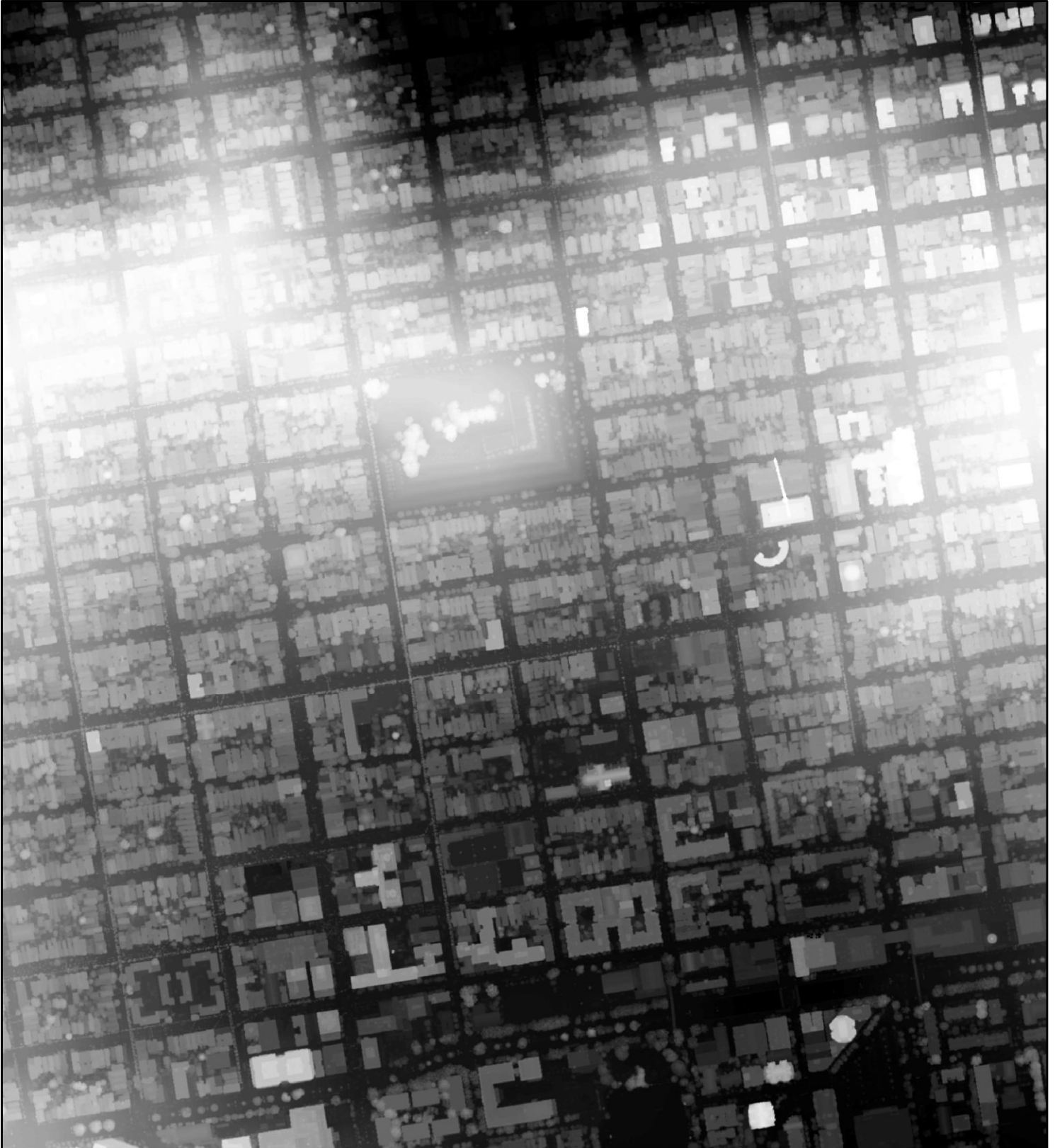
Zonal statistics were compiled for each building footprint based on a 25cm-gridded representation of the vector polygon, discrete for every structure. The 25cm grid representation of the building was co-registered with the 50cm gnd surface.



# First Return Surface [1st]

This is a 50cm gridded first return model, derived from 2 ppsm airborne LiDAR from Pictometry of 2010. This surface shows the highest elevation infrared reflection from terrain, street, roof, and tree canopy. Only first returns were compiled, and a natural neighbor (involving tessellation) algorithm was applied to interpolate in areas of missing data. Morphological processing (grayscale dilation) was applied to the grid to mitigate scan artifacts and create more coherent roof surfaces. The grid was compiled and prepared in NAD 1983 (2011) San Francisco Coordinate System of 2013, denominated in meters (WKID=7131).

Zonal statistics were compiled for each building footprint based on a 25cm-gridded representation of the vector polygon, discrete for every structure. The 25cm grid representation of the building was co-registered with the 50cm grid surface.



# Feature Height Surface [hgt]

This is a 50cm gridded difference model, pixelwise-subtracting [First Return Surface -- Bare Earth Surface]. This surface shows the height above ground for structure roof and tree canopy. Effectively, the terrain has been removed and set to near zero. This grid combines the interpolation used in bare earth with the grayscale dilation used in the first return surface to provide an optimized estimate of LiDAR-derived structure height. The grid was compiled and prepared in NAD 1983 (2011) San Francisco Coordinate System of 2013, denominated in meters (WKID=7131).

Zonal statistics were compiled for each building footprint based on a 25cm-gridded representation of the vector polygon, discrete for every structure. The 25cm grid representation of the building was co-registered with the 50cm grid surface.



Field	Name	Alias	Type	comment
Based on review of Feature Class "sf13m_BldgFoot_withZ_20161005i_pgz"				
The name implies an SF13(meters)(7131) projection of San Francisco building footprint features, including Z-attribute values, in Polygon-Z data type				
1	OBJECTID	OBJECTID	ObjectID	auto-generated unique ID key
2	Shape	Shape	Geometry	Polygon-Z type
3	sf16_BldgID	sf16_BldgID	char-14	San Francisco Building ID using criteria of 2016-09, 6-char epoch, '.', ' ', 7-char zero-padded AreaID or new ID in editing epochs after initial '201006.'
4	Area_ID	Area_ID	Long	Epoch 2010.06 Shape_Area sort of 177,023 building polygons with area > ~1 sq m
5	sf_MBLR	sf_MBLR	char-20	San Francisco property key: Assessor's Map-Block-Lot of land parcel, plus Right-of-way area identifier derived from street Centerline Node Network (CNN)
6	P2010mass_ZminN88ft	P2010mass_ZminN88ft	Double	Input building mass (of 2010,) minimum Z vertex elevation, NAVD 1988 ft
7	P2010mass_ZmaxN88ft	P2010mass_ZmaxN88ft	Double	Input building mass (of 2010,) maximum Z vertex elevation, NAVD 1988 ft
8	gnd_cells50cm	gnd_cells50cm	Long	zonal statistic: LiDAR-derived ground surface grid, population of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
9	gnd_MINcm	gnd_MINcm	Long	zonal statistic: LiDAR-derived ground surface grid, minimum value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
10	gnd_MAXcm	gnd_MAXcm	Long	zonal statistic: LiDAR-derived ground surface grid, maximum value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
11	gnd_RANGEcm	gnd_RANGEcm	Long	zonal statistic: LiDAR-derived ground surface grid, maximum value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
12	gnd_MEANcm	gnd_MEANcm	Double	zonal statistic: LiDAR-derived ground surface grid, mean value of 50cm square cells sampled in this building's zone, from integer NAVD 1988 centimeters
13	gnd_STDcm	gnd_STDcm	Double	zonal statistic: LiDAR-derived ground surface grid, 1 standard deviation of 50cm square cells sampled in this building's zone, centimeters
14	gnd_VARIETYcm	gnd_VARIETYcm	Long	zonal statistic: LiDAR-derived ground surface grid, count of unique values of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
15	gnd_MAJORITYcm	gnd_MAJORITYcm	Long	zonal statistic: LiDAR-derived ground surface grid, most frequently occurring value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
16	gnd_MINORITYcm	gnd_MINORITYcm	Long	zonal statistic: LiDAR-derived ground surface grid, least frequently occurring value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
17	gnd_MEDIANcm	gnd_MEDIANcm	Long	zonal statistic: LiDAR-derived ground surface grid, median value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
18	cells50cm_1st	cells50cm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, population of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
19	MINcm_1st	MINcm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, minimum value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
20	MAXcm_1st	MAXcm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, maximum value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
21	RANGEcm_1st	RANGEcm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, maximum value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
22	MEANcm_1st	MEANcm_1st	Double	zonal statistic: LiDAR-derived first return surface grid, mean value of 50cm square cells sampled in this building's zone, from integer NAVD 1988 centimeters
23	STDcm_1st	STDcm_1st	Double	zonal statistic: LiDAR-derived first return surface grid, 1 standard deviation of 50cm square cells sampled in this building's zone, centimeters
24	VARIETYcm_1st	VARIETYcm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, count of unique values of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
25	MAJORITYcm_1st	MAJORITYcm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, most frequently occurring value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
26	MINORITYcm_1st	MINORITYcm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, least frequently occurring value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
27	MEDIANcm_1st	MEDIANcm_1st	Long	zonal statistic: LiDAR-derived first return surface grid, median value of 50cm square cells sampled in this building's zone, integer NAVD 1988 centimeters
28	hgt_cells50cm	hgt_cells50cm	Long	zonal statistic: LiDAR-derived height surface grid, population of 50cm square cells sampled in this building's zone, integer centimeters
29	hgt_MINcm	hgt_MINcm	Long	zonal statistic: LiDAR-derived height surface grid, minimum value of 50cm square cells sampled in this building's zone, integer centimeters
30	hgt_MAXcm	hgt_MAXcm	Long	zonal statistic: LiDAR-derived height surface grid, maximum value of 50cm square cells sampled in this building's zone, integer centimeters
31	hgt_RANGEcm	hgt_RANGEcm	Long	zonal statistic: LiDAR-derived height surface grid, maximum value of 50cm square cells sampled in this building's zone, integer centimeters
32	hgt_MEANcm	hgt_MEANcm	Double	zonal statistic: LiDAR-derived height surface grid, mean value of 50cm square cells sampled in this building's zone, from integer centimeters
33	hgt_STDcm	hgt_STDcm	Double	zonal statistic: LiDAR-derived height surface grid, 1 standard deviation of 50cm square cells sampled in this building's zone, centimeters
34	hgt_VARIETYcm	hgt_VARIETYcm	Long	zonal statistic: LiDAR-derived height surface grid, count of unique values of 50cm square cells sampled in this building's zone, integer centimeters
35	hgt_MAJORITYcm	hgt_MAJORITYcm	Long	zonal statistic: LiDAR-derived height surface grid, most frequently occurring value of 50cm square cells sampled in this building's zone, integer centimeters
36	hgt_MINORITYcm	hgt_MINORITYcm	Long	zonal statistic: LiDAR-derived height surface grid, least frequently occurring value of 50cm square cells sampled in this building's zone, integer centimeters
37	hgt_MEDIANcm	hgt_MEDIANcm	Long	zonal statistic: LiDAR-derived height surface grid, median value of 50cm square cells sampled in this building's zone, integer centimeters
38	gnd_Min_m	gnd_Min_m	Double	summary statistic: zonal minimum ground surface height, NAVD 1988 meters
39	Median_1st_m	Median_1st_m	Double	summary statistic: zonal median first return surface height, NAVD 1988 meters
40	hgt_Median_m	hgt_Median_m	Double	summary statistic: zonal median height surface value, meters
41	gnd1st_delta	gnd1st_delta	Double	summary statistic: discrete difference of (median first return surface -- minimum bare earth surface) for the building's zone, meters
42	peak_1st_m	peak_1st_m	Double	summary statistic: highest cell value of first return surface in the building's zone, NAVD 1988 meters
43	Shape_Length	Shape_Length	Double	GIS shape statistic: perimeter of the building polygon, meters
44	Shape_Area	Shape_Area	Double	GIS shape statistic: area of the building polygon, square meters