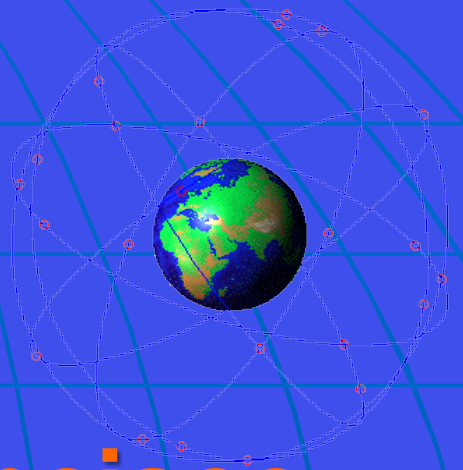


City & County of San Francisco

2013 Vertical Datum (SFVD13)

and

2013 Coordinate System (SFCS13)

BSM/DPW Represented by Bruce Storrs, PLS,
City & County Surveyor and Michael McGee, PLS
michael.mcgee@sfdpw.org

Survey Report

on the

City & County of San Francisco 2013 Second Order Leveling Network Survey and the "CCSF 2013 NAVD88 Vertical Datum"

February 28, 2014

prepared by

McGee Surveying Consulting and F3 & Associates, Inc.

PROJECT OVERVIEW: The City & County of San Francisco (CCSF) performed a Second Order Leveling Survey between January and October 2013. The purpose was to recover the North American Vertical Datum of 1988 (NAVD88) and establish a vertical control reference network within the City and County henceforth known as the "CCSF 2013 NAVD88 Vertical Datum" (see Figure 1). Heights resulting from this survey supersede previously published NAVD88 Heights and the old CCSF Datum. This network will support the utilization of GNSS technology for establishing orthometric heights within the County.

DATUM, REFERENCE SYSTEM and HISTORY: Orthometric heights (elevations) published by this survey are based on the North American Vertical Datum of 1988 (NAVD 88) established by the National Geodetic Survey (NGS) as referenced by monuments in the National Spatial Reference System (NSRS). The analysis and recovery assessment of the NAVD88 Datum in the City and County is provided hereafter.

Circa 1977 and 1988 the NGS performed "First Order Class I" leveling surveys along the northeast side of San Francisco and from Highway 101 south along Highway 1. These surveys were part of a national leveling effort to produce the NAVD88 Datum. The results were published in 1991 as the original national adjustment of NAVD88 superseding the National Geodetic Vertical Datum of 1929 (NGVD29). Zero on NAVD88 is approximately 0.83 meters (2.72 feet) lower than zero on NGVD29 and varies approximately 0.80 to 0.86 meters in CCSF.

Figure 1: Level Network and High Precision Network Points

VERTICAL NETWORK: The vertical control network consists of 22 loops totaling 115 kilometers (72 miles) and range from 2-177 meters (6-581 feet) above sea level. The loops were assigned letter designations of "A" through "V" shown in Figures 1 and 2. Five primary loops labeled "A" through "E" form the backbone network totaling 77 kilometers with 17 secondary loops totaling 38 kilometers. Approximately 670 new permanent benchmarks were established. The "CCSF 2013 High Precision Network" (CCSF-HPN) (points 101-120) were included in the network (see the "Survey Report of the City and County of San Francisco 2013 High Precision Network" on file in the City and County Surveyor's Office).

Survey Report

of the

City & County of San Francisco
2013 High Precision Network Survey

Prepared by

McGee Surveying Consulting and F3 & Associates, Inc.

February 28, 2014

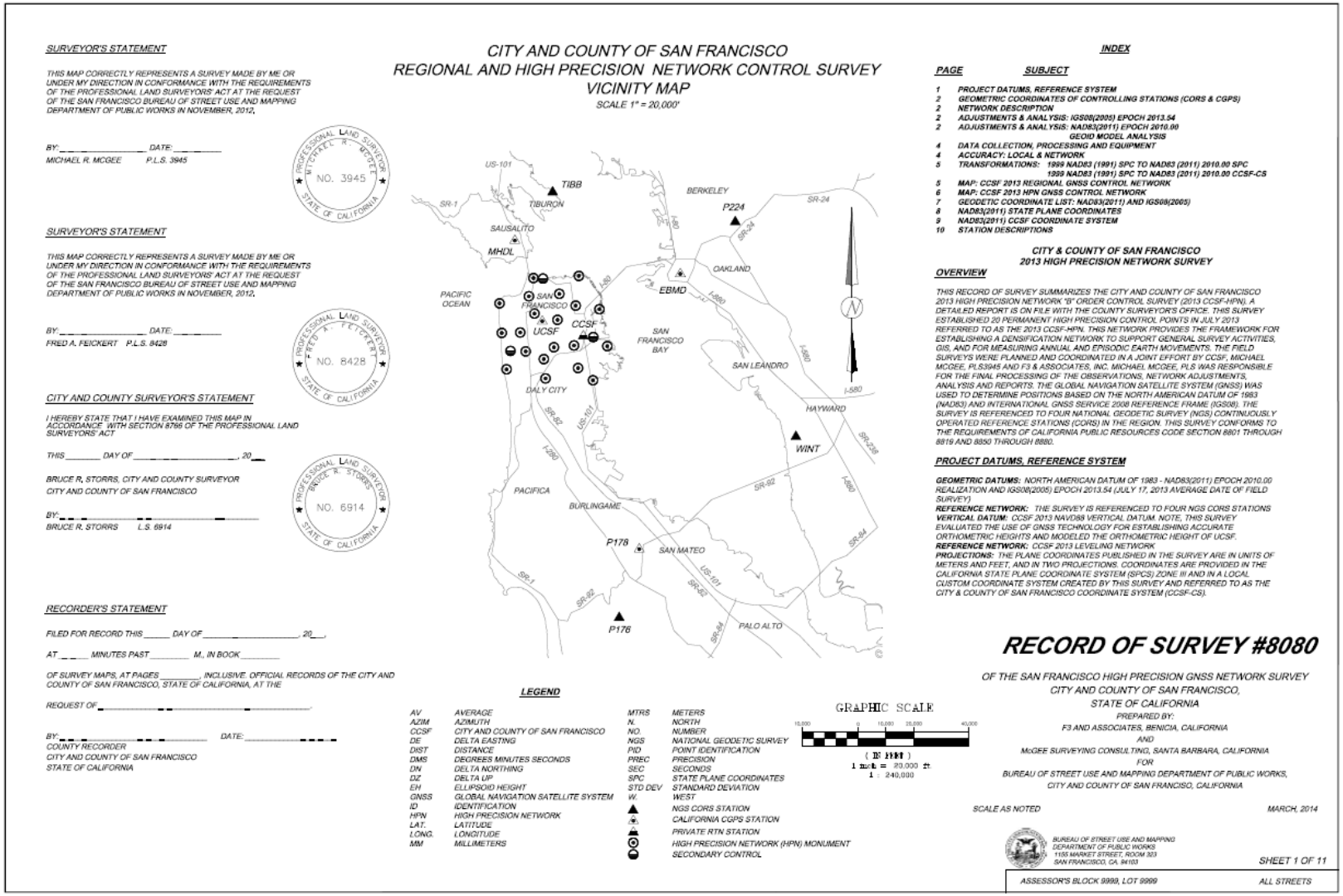
OVERVIEW

Project: City and County of San Francisco High Precision Network Survey (CCSF-HPN)
Surveyed by: City and County of San Francisco supported by McGee Surveying Consulting, F3 & Associates, Inc. and Frederick T. Seher & Associates, Inc.

This document serves as a summary report of the City and County of San Francisco (CCSF) 2013 "B" Order Control Survey. A Record of Survey will follow incorporating the content of this Report and containing detailed descriptions of the points. This survey established 20 permanent high precision control points in July 2013 referred to as the CCSF-2013 HPN. This network provides the framework for establishing a densification network to support general survey activities, GIS, and for measuring annual and episodic earth movements. The field surveys were planned and coordinated in a joint effort by CCSF, Michael McGee, PLS3945 and F3 & Associates, Inc. Michael McGee, PLS was responsible for the final processing of the observations, network adjustments, analysis and reports. The Global Navigation Satellite System (GNSS) was used to determine positions based on the North American Datum of 1983 (NAD83) and International GNSS Service 2008 Reference Frame (IGS08). The survey is referenced to four National Geodetic Survey (NGS) Continuously Operated Reference Stations (CORS) in the region.

CCSF Regional & High Precision Network

RECORD of SURVEY #8080
posted on the City Website (11 Pages)



SURVEYOR'S STATEMENT

THIS MAP CORRECTLY REPRESENTS A SURVEY MADE BY ME OR UNDER MY DIRECTION IN CONFORMANCE WITH THE REQUIREMENTS OF THE PROFESSIONAL LAND SURVEYORS' ACT AT THE REQUEST OF THE SAN FRANCISCO BUREAU OF STREET USE AND MAPPING DEPARTMENT OF PUBLIC WORKS IN NOVEMBER, 2012.

BY: _____ DATE: _____
MICHAEL R. MCGEE P.L.S. 3945

PROFESSIONAL LAND SURVEYOR MICHAEL R. MCGEE NO. 3945 STATE OF CALIFORNIA

SURVEYOR'S STATEMENT

THIS MAP CORRECTLY REPRESENTS A SURVEY MADE BY ME OR UNDER MY DIRECTION IN CONFORMANCE WITH THE REQUIREMENTS OF THE PROFESSIONAL LAND SURVEYORS' ACT AT THE REQUEST OF THE SAN FRANCISCO BUREAU OF STREET USE AND MAPPING DEPARTMENT OF PUBLIC WORKS IN NOVEMBER, 2012.

BY: _____ DATE: _____
FRED A. FEICKERT P.L.S. 8428

PROFESSIONAL LAND SURVEYOR FRED A. FEICKERT NO. 8428 STATE OF CALIFORNIA

CITY AND COUNTY SURVEYOR'S STATEMENT

I HEREBY STATE THAT I HAVE EXAMINED THIS MAP IN ACCORDANCE WITH SECTION 8766 OF THE PROFESSIONAL LAND SURVEYORS' ACT

THIS _____ DAY OF _____, 20__

BRUCE R. STORRS, CITY AND COUNTY SURVEYOR
CITY AND COUNTY OF SAN FRANCISCO

BY: _____
BRUCE R. STORRS L.S. 6914

PROFESSIONAL LAND SURVEYOR BRUCE R. STORRS NO. 6914 STATE OF CALIFORNIA

RECORDER'S STATEMENT

FILED FOR RECORD THIS _____ DAY OF _____, 20__,

AT _____ MINUTES PAST _____ M., IN BOOK _____

OF SURVEY MAPS, AT PAGES _____, INCLUSIVE, OFFICIAL RECORDS OF THE CITY AND COUNTY OF SAN FRANCISCO, STATE OF CALIFORNIA, AT THE

REQUEST OF _____

BY: _____ DATE: _____
COUNTY RECORDER
CITY AND COUNTY OF SAN FRANCISCO
STATE OF CALIFORNIA

CITY AND COUNTY OF SAN FRANCISCO
REGIONAL AND HIGH PRECISION NETWORK CONTROL SURVEY
VICINITY MAP
SCALE 1" = 20,000'

TIBB, TIBURON, SAUSALITO, MHDL, BERKELEY, P224, OAKLAND, EBMD, SAN FRANCISCO, UCSF, CCSF, PACIFIC OCEAN, SAN FRANCISCO BAY, SAN LEANDRO, HAYWARD, DALY CITY, WINT, PACIFICA, BURLINGAME, P178, SAN MATEO, P176, PALO ALTO, US-101, SR-1, SR-82, SR-84, SR-24, SR-238, I-280, I-580, I-880

LEGEND

AV	AVERAGE
AZIM	AZIMUTH
CCSF	CITY AND COUNTY OF SAN FRANCISCO
DE	DELTA EASTING
DIST	DISTANCE
DMS	DEGREES MINUTES SECONDS
DN	DELTA NORTHING
DZ	DELTA UP
EH	ELLIPSOID HEIGHT
GNSS	GLOBAL NAVIGATION SATELLITE SYSTEM
ID	IDENTIFICATION
HPN	HIGH PRECISION NETWORK
LAT.	LATITUDE
LONG.	LONGITUDE
MM	MILLIMETERS
MTRS	METERS
N.	NORTH
NO.	NUMBER
NGS	NATIONAL GEODETIC SURVEY
PID	POINT IDENTIFICATION
PREC	PRECISION
SEC	SECONDS
SPC	STATE PLANE COORDINATES
STD DEV	STANDARD DEVIATION
W.	WEST
▲	NGS CORS STATION
	CALIFORNIA CGPS STATION
	PRIVATE RTN STATION
	HIGH PRECISION NETWORK (HPN) MONUMENT
	SECONDARY CONTROL

GRAPHIC SCALE
1 inch = 20,000 ft.
1 : 240,000

INDEX

CITY & COUNTY OF SAN FRANCISCO
2013 HIGH PRECISION NETWORK SURVEY

OVERVIEW

THIS RECORD OF SURVEY SUMMARIZES THE CITY AND COUNTY OF SAN FRANCISCO 2013 HIGH PRECISION NETWORK "B" ORDER CONTROL SURVEY (2013 CCSF-HPN). A DETAILED REPORT IS ON FILE WITH THE COUNTY SURVEYOR'S OFFICE. THIS SURVEY ESTABLISHED 20 PERMANENT HIGH PRECISION CONTROL POINTS IN JULY 2013 REFERRED TO AS THE 2013 CCSF-HPN. THIS NETWORK PROVIDES THE FRAMEWORK FOR ESTABLISHING A DENSIFICATION NETWORK TO SUPPORT GENERAL SURVEY ACTIVITIES, GIS, AND FOR MEASURING ANNUAL AND EPISODIC EARTH MOVEMENTS. THE FIELD SURVEYS WERE PLANNED AND COORDINATED IN A JOINT EFFORT BY CCSF, MICHAEL MCGEE, PLS3945 AND F3 & ASSOCIATES, INC. MICHAEL MCGEE, PLS WAS RESPONSIBLE FOR THE FINAL PROCESSING OF THE OBSERVATIONS, NETWORK ADJUSTMENTS, ANALYSIS AND REPORTS. THE GLOBAL NAVIGATION SATELLITE SYSTEM (GNSS) WAS USED TO DETERMINE POSITIONS BASED ON THE NORTH AMERICAN DATUM OF 1983 (NAD83) AND INTERNATIONAL GNSS SERVICE 2008 REFERENCE FRAME (IGS08). THE SURVEY IS REFERENCED TO FOUR NATIONAL GEODETIC SURVEY (NGS) CONTINUOUSLY OPERATED REFERENCE STATIONS (CORS) IN THE REGION. THIS SURVEY CONFORMS TO THE REQUIREMENTS OF CALIFORNIA PUBLIC RESOURCES CODE SECTION 8801 THROUGH 8819 AND 8850 THROUGH 8860.

PROJECT DATUMS, REFERENCE SYSTEM

GEOMETRIC DATUMS: NORTH AMERICAN DATUM OF 1983 - NAD83(2011) EPOCH 2010.00 REALIZATION AND IGS08(2005) EPOCH 2013.54 (JULY 17, 2013 AVERAGE DATE OF FIELD SURVEY)
REFERENCE NETWORK: THE SURVEY IS REFERENCED TO FOUR NGS CORS STATIONS
VERTICAL DATUM: CCSF 2013 NAVD88 VERTICAL DATUM. NOTE, THIS SURVEY EVALUATED THE USE OF GNSS TECHNOLOGY FOR ESTABLISHING ACCURATE ORTHOMETRIC HEIGHTS AND MODELED THE ORTHOMETRIC HEIGHT OF UCSF.
REFERENCE NETWORK: CCSF 2013 LEVELING NETWORK
PROJECTIONS: THE PLANE COORDINATES PUBLISHED IN THE SURVEY ARE IN UNITS OF METERS AND FEET, AND IN TWO PROJECTIONS. COORDINATES ARE PROVIDED IN THE CALIFORNIA STATE PLANE COORDINATE SYSTEM (SPCS) ZONE III AND IN A LOCAL CUSTOM COORDINATE SYSTEM CREATED BY THIS SURVEY AND REFERRED TO AS THE CITY & COUNTY OF SAN FRANCISCO COORDINATE SYSTEM (CCSF-CS).

RECORD OF SURVEY #8080

OF THE SAN FRANCISCO HIGH PRECISION GNSS NETWORK SURVEY
CITY AND COUNTY OF SAN FRANCISCO,
STATE OF CALIFORNIA

PREPARED BY:
F3 AND ASSOCIATES, BENICIA, CALIFORNIA
AND
McGEE SURVEYING CONSULTING, SANTA BARBARA, CALIFORNIA
FOR
BUREAU OF STREET USE AND MAPPING DEPARTMENT OF PUBLIC WORKS,
CITY AND COUNTY OF SAN FRANCISCO, CALIFORNIA

SCALE AS NOTED MARCH, 2014

BUREAU OF STREET USE AND MAPPING
DEPARTMENT OF PUBLIC WORKS
1155 MARKET STREET, ROOM 303
SAN FRANCISCO, CA. 94103

SHEET 1 OF 11

ASSESSOR'S BLOCK 9999, LOT 9999 ALL STREETS

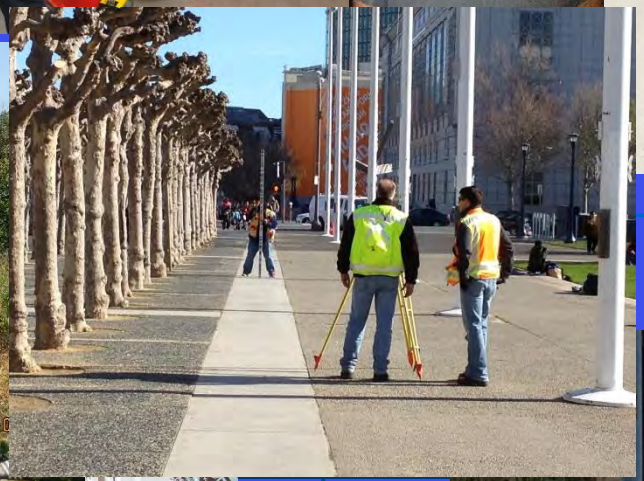
A comprehensive, accurate and cohesive horizontal and vertical coordinate system for the City of San Francisco

Bruce Storrs, City & County Surveyor

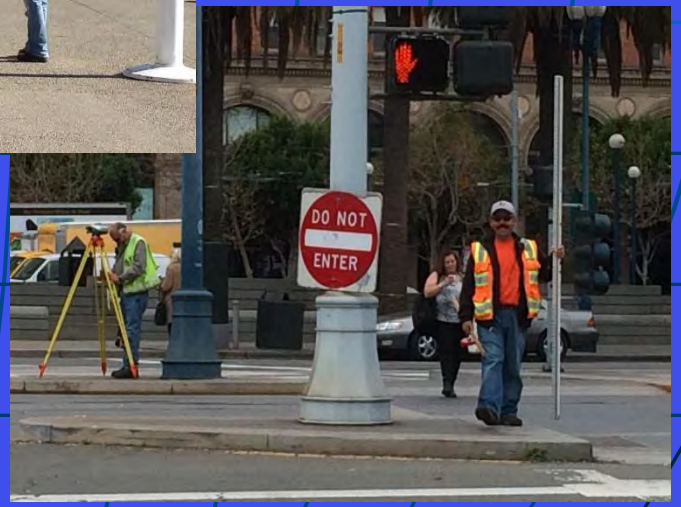
A Vision for San Francisco for the next 150 Years


SURVEY
CREW


06/07/2013




11/19/2012


DO NOT
ENTER

TERMINOLOGY

Datum

- A mathematical model with parameters that define its origin, scale, and orientation
- Used to describe the spatial relationship of points.
- A datum can be 1, 2, 3 or 4 dimensional.

TERMINOLOGY

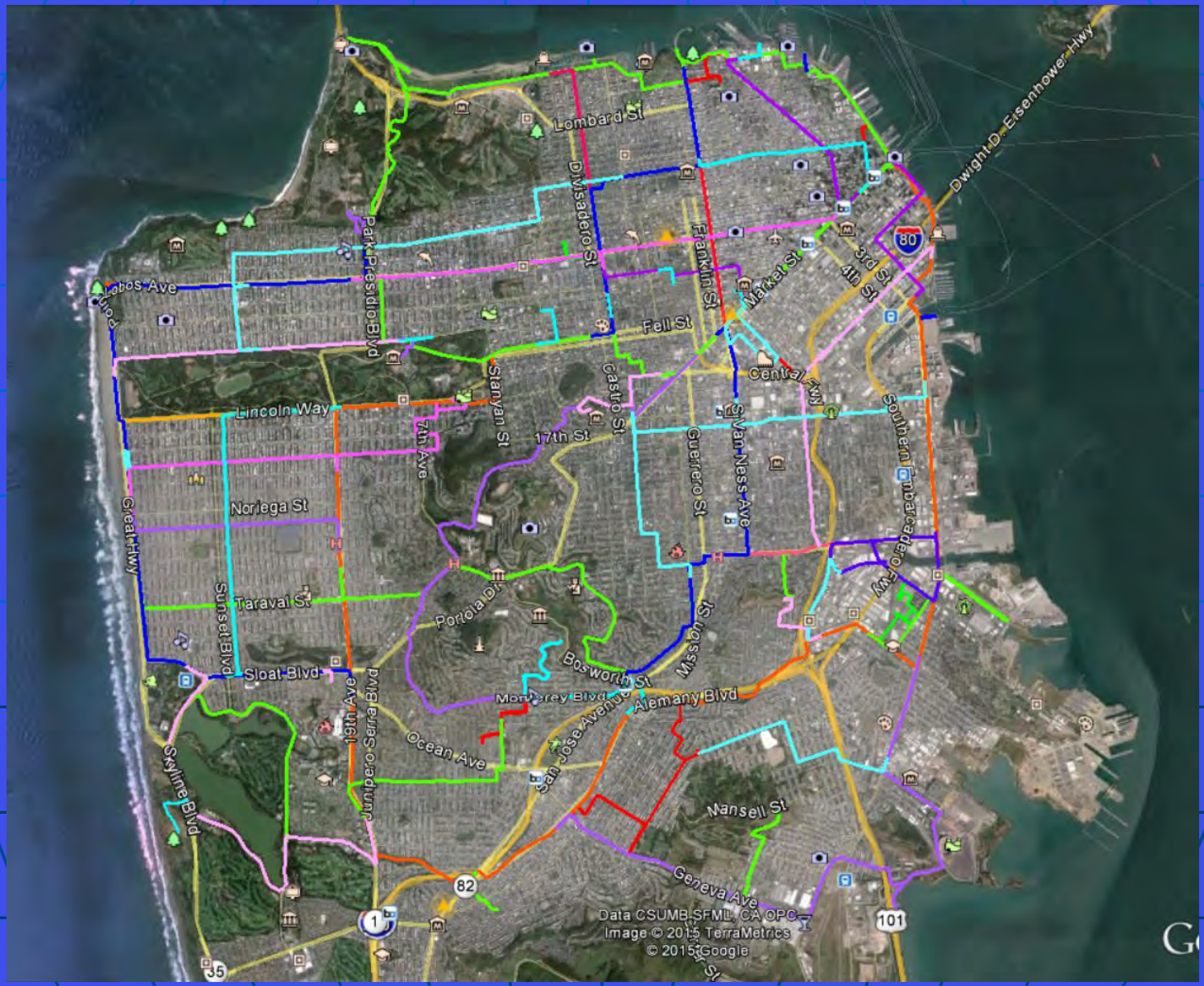
Reference Frame (Reference System)

- A datum is realized by establishing coordinates on points (monuments) in the world which provides physical access to the datum.
- The introduction of new measurements and adjustments is a new realization of the datum.
- New adjustments are used to improve the accuracy of points in an absolute sense relative to the datum, and locally relative to other points.

City Approved Acronyms

- HPN = High Precision Network which references the new coordinate systems
- SFCS13 = San Francisco Horizontal Coordinate System Established in 2013
- SFVD13 = San Francisco NAVD88 Vertical Datum as Recovered in 2013

SFVD13 High Precision Vertical Network

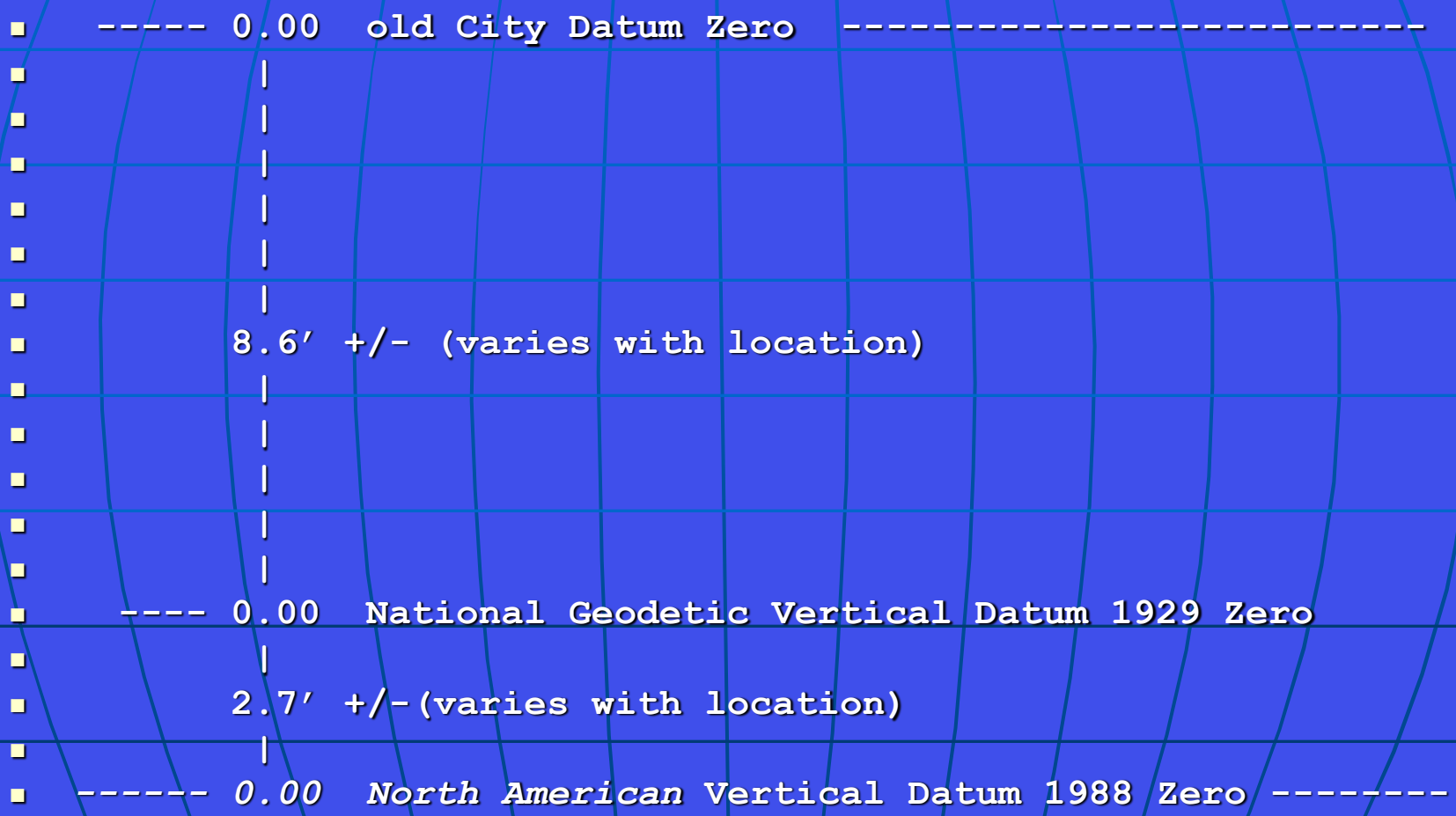


VERTICAL DATUMS in SF

- Old "City Datum": The SF legacy datum still in use today.
  - "Zero" is about 11.35 feet above zero on NAVD88
- National Geodetic Vertical Datum of 1929 (NGVD29): National datum is use between about 1930 and 1991.
  - Zero is approximately mean sea level
- The North American Vertical Datum of 1988 (NAVD88):
  - The current national datum superseded the NGVD29 in 1991.
  - Zero is approximately mean lower low water
  - Zero is about -11.35 feet on the Old City Datum.

Vertical Datum Relationships

NAVD88, NGVD29 and old City Datum



North American Vertical Datum of 1988

- NAVD88 network leveled 1977-1989, adj'd and published in 1991
- Datum is realized by recovering NAVD88 Benchmarks

NAVD88 2013 DATUM RECOVERY:

- NAVD88 Datum was recovered by including 35 NGS benchmarks in the in the City's precise leveling network

CCSF 2013 NAVD88 Vertical Datum (SFVD13)

- "SFVD13" is a new realization of the NAVD88 Datum based on the 2013 leveling surveys
  - Based on the best fit of the published heights on 35 NGS Benchmarks (fit +/- 0.06')
  - Updates the published heights on NGS benchmarks

CCSF 2013 NAVD88 Vertical Datum (SFVD13)

- SFVD13 supersedes the old "City Datum"

WHY?

Not Maintained,

Subsidence,

Many are lost, most will be in a few years,

Benchmarks in same intersection disagree 0.2'

Old City Datum Benchmark Sheet

MISSION ST: 11TH ST intersection [24421000]

subdivision & mapping

benchmark

bench id	location	date of survey	surveyor	book	page	box	comments
503	11TH ST: MISSION ST intersection	MARCH 1991	SCOTT	492	16	4	NONE

strCORNER	strBENCH	strELEVATION	destroyed
NE	crow cut outer rim SWI	29.476	
NW	+ cut E rim MRY MH in walk	30.475	
SE	crow cut outer rim SWI	29.627	
SW	+ cut S rim MRY MH in walk	30.294	
SE 30'S	+ cut top conc fdn. 1' up	31.051	

Most will be lost or destroyed in the next few years

Old City Datum Benchmarks

Most do not fit in the same interesection

BM	DESCRIPTION	NAVD88	CITY	DIFF
SE	3 cuts low stop cock fire hydrant	18.036	6.777	11.259
SE	crow cut outer rim SWI	15.767	4.494	11.273
SW	crow cut outer rim SWI	15.883	4.582	11.301
SW	+ cut ASW @ bldg	16.930	5.608	11.322
		AVERAGE DIFF		11.289

< 0.06'+/-

INTERSECTION: 16TH ST & CONNECTICUT ST (Book 482, Page 37, Record No. 588)

BM	DESCRIPTION	NAVD88	CITY	DIFF
SE	3 cuts low stop cock fire hydrant	17.278	6.103	11.175
SW	crow cut outer rim SWI	15.010	3.747	11.263
SW	+ cut ASW @ bldg	15.968	4.700	11.268
CC 30' N	+ cut conc cess	15.553	4.362	11.191
		AVERAGE DIFF		11.224

< 0.10'+/-

INTERSECTION: 16TH ST & MISSOURI ST (Book 482, Page 36, Record No. 582)

BM	DESCRIPTION	NAVD88	CITY	DIFF
SW	crow cut outer rim SWI	14.526	3.224	11.302
SW 35'W	+ cut E end low conc step	17.174	5.829	11.345
SE	3 cuts low stop cock fire hydrant	17.142	5.850	11.292

The differences across the City found to vary from 10.9' to 11.8'

CCSF 2013 NAVD88 Vertical Datum (SFVD13)

- The City & County Surveyor has determined that the conversion from the SFVD13 to estimate elevations in the old City Datum henceforth shall be:

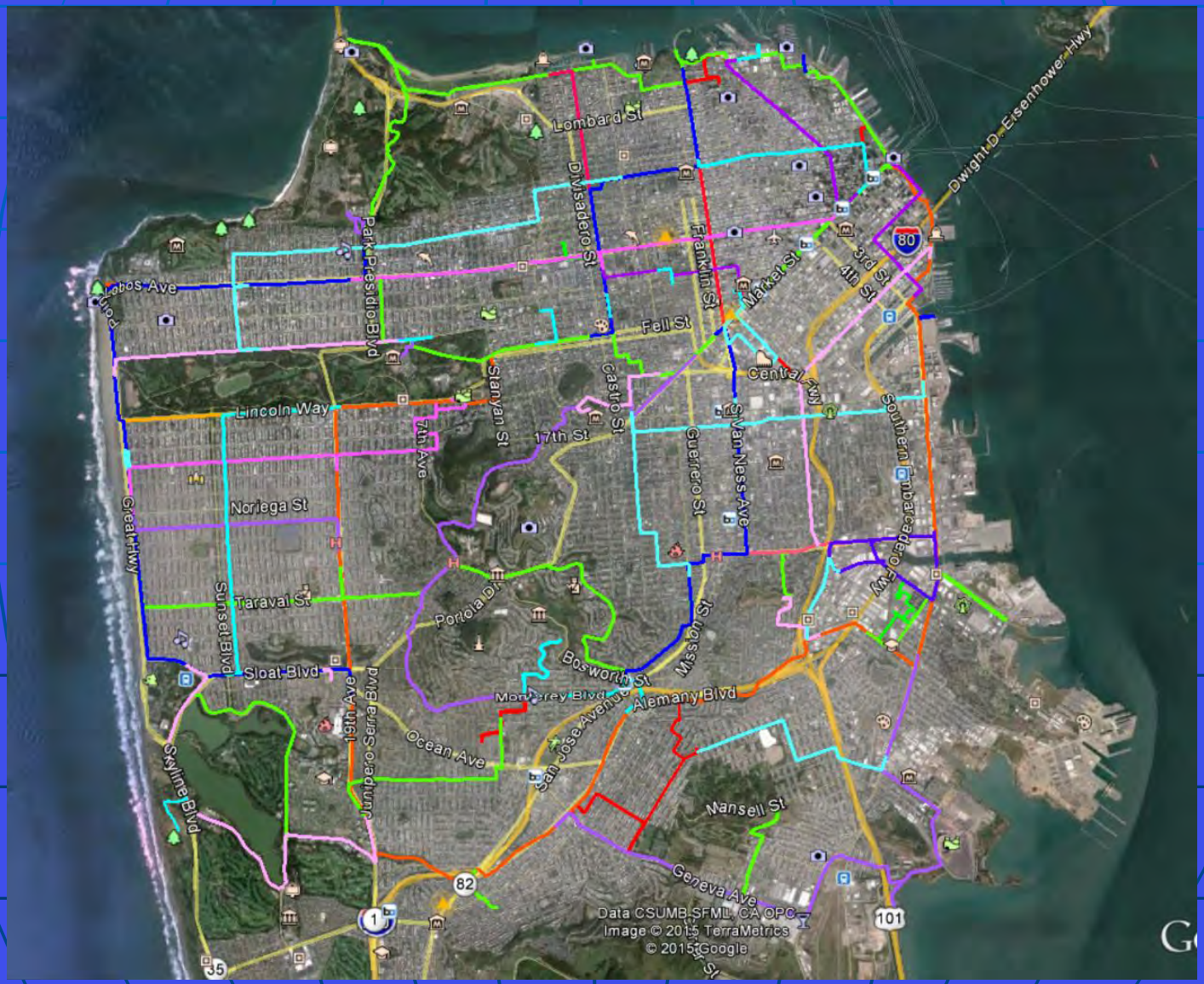
SFVD13 - 11.35 feet = City Datum

~~City Datum + 11.35 feet = SFVD13~~

(cannot go from old City datum to SFVD13)

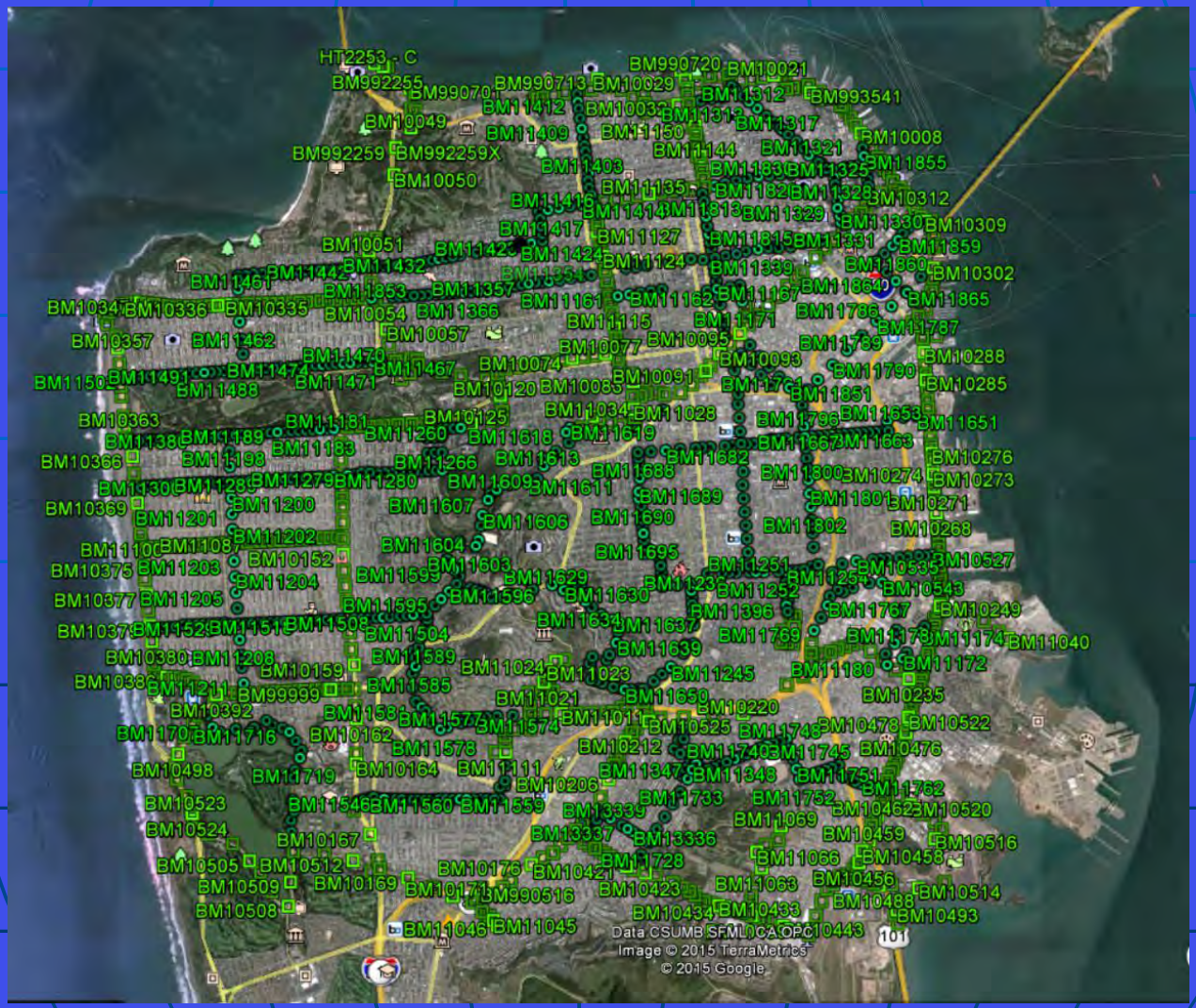
High Precision Leveling Network

142 Miles of Leveling - Average Closures 0.01’

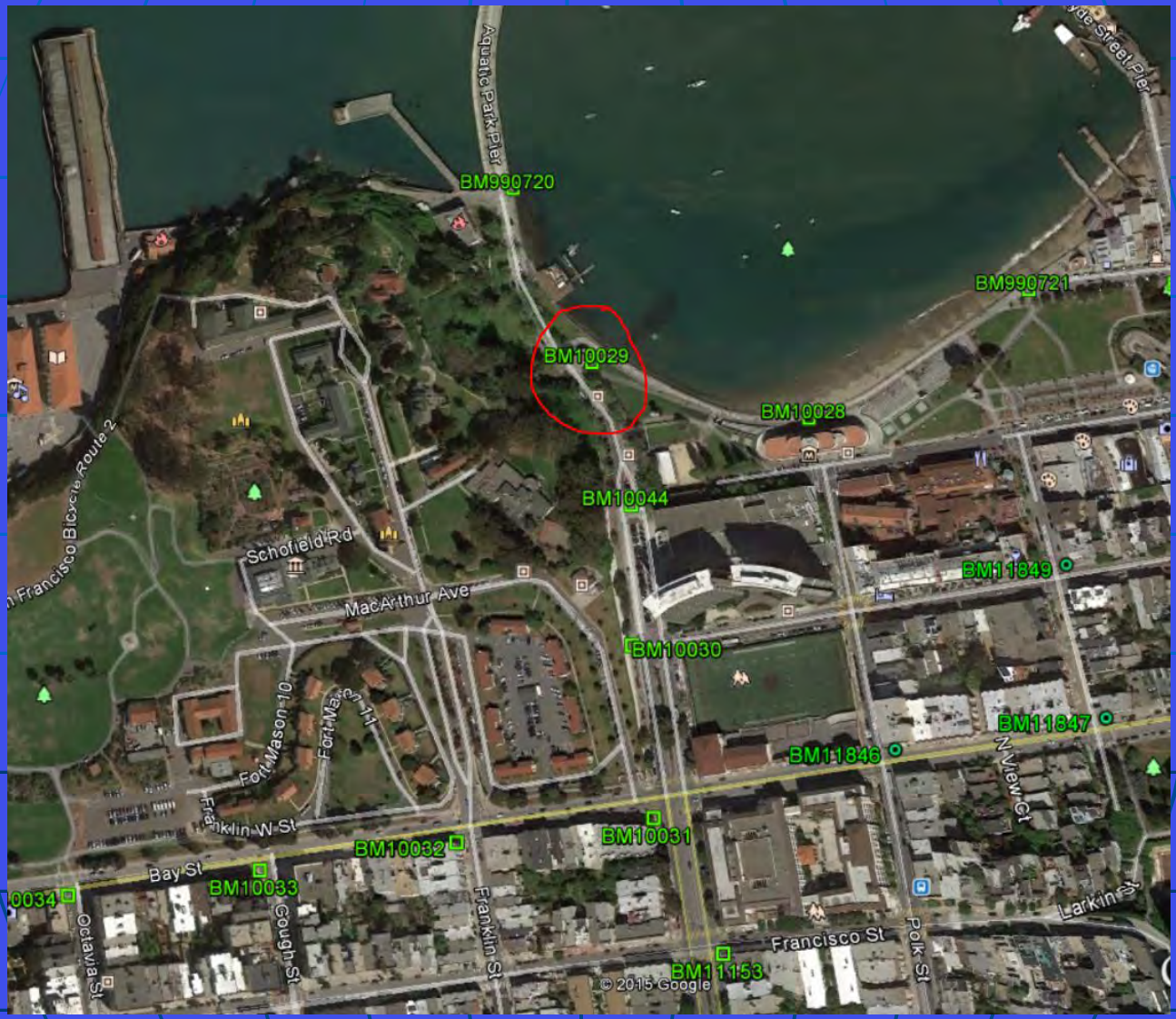


1454 New Benchmarks

(kmz file available for Google earth)



Zoom in to an area of interest in Google



Benchmarks, Routes & Photos available on CCSF Website (kmz files)

631 Benchmarks Established in 2013

2013 Benchmark Monument

823 Benchmarks Established in 2014-15

2014-15 Benchmark Monument

Benchmark Descriptions Available on the CCSF Website

BM#	STA	TYPE	LOCATION	DESC	DATE SET/RECOVERED	AB#	2013 UNad Elev	NGS/CCSF# + ELEV	FILE NAME	LEVEL LINE#-DATE	Comments
BM10021	SET	1/2" DOMED STEEL ANCHOR PIN	SOUTHWEST CORNER OF BEACH @ POWELL	IN SIDEWALK @ SHERATON HOTEL 3.6' NORTHEAST OF BLDG CORNER 8' RADIALLY - SOUTHWEST FROM FACE OF CURB @ CATCH BASIN WEST OF HANDICAP RAMP - FACING POWELL 7' WEST OF TRAFFIC LIGHT @ POWELL 7.5' SOUTHEAST OF TRAFFIC LIGHT @ BEACH ST	11/24/2012	0020	EL = 3.4223m			D003AL01, 1/3/2013	LOOP A
BM10022	SET	1/2" DOMED STEEL ANCHOR PIN	SOUTHWEST CORNER OF BEACH @ MASON	IN SIDEWALK. 9' SOUTHWEST - RADIALLY FROM CENTER FACE OF CURB 1/2 DELTA OF CURB BETWEEN 2 HANDICAP RAMPS 9' SOUTHEAST OF TRAFFIC LIGHT ON BEACH ST. 7.5' NORTHWEST OF TRAFFIC LIGHT ON MASON ST. 0.5' SOUTHWEST OF HANDICAP RAMP INTERSECTION	11/24/2012	0021	EL = 3.4835m			D004AL01, 1/4/2013	LOOP A
BM10023	SET	1/2" DOMED STEEL ANCHOR PIN	SOUTHWEST CORNER OF BEACH @ TAYLOR	2699 BEACH ST. 4.3' SOUTH RADIALLY OF FACE OF CURB @ CATCH BASIN. 3' NORTHEAST OF TRAFFIC LIGHT @ TAYLOR ST. 2' NORTH OF TRAFFIC LIGHT BOX. 5' NORTHEAST OF CENTER OF PAC BELL BOX. 11' SOUTHEAST OF TRAFFIC LIGHT @ BEACH ST. EAST OF HANDICAP RAMP.	11/24/2012	0022	EL = 3.7429m			D004AL01, 1/4/2013	LOOP A
BM10024	SET	1/2" DOMED STEEL	SOUTHWEST CORNER OF BEACH @ JONES	NORTH BEACH LANDING @ 505 BEACH ST. 5' SOUTHWEST - RADIALLY FROM FACE OF	11/24/2012	0023	EL = 4.2350m			D004AL01, 1/4/2013	LOOP A

SFVD13 Benchmark List
(Blue Document)
Available on the CCSF Web Site

Listed below are the SFVD13 orthometric heights of NGS Benchmarks utilized in the recovery of NAVD88 by the City in 2013. NGS PID's were assigned "99+last 4 digits" of its PID (see Survey Report referred to above for details).

CCSF ID (aka)	NGS PID	Feet	Meters
990515	HT0515	300.285	91.527
990516	HT0516	304.209	92.723
990517	HT0517	295.531	90.078
990604	HT0604	15.390	4.691
990687	HT0687	12.402	3.780
990692	HT0692	15.528	4.733
990697	HT0697	16.480	5.023
990698	HT0698	13.937	4.248
990700	HT0700	13.894	4.235

City & County of San Francisco
2013 NAVD88 Vertical Datum (SFVD13) Benchmark List

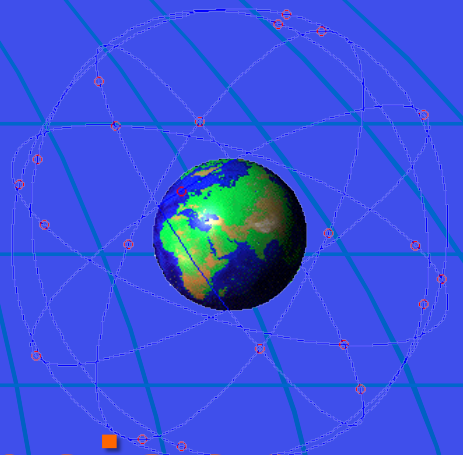
Benchmark	Feet	Meters	Benchmark	Feet	Meters
201	12.005	3.659	240	19.900	6.066
202	77.956	23.761	241	25.414	7.746
204	106.983	32.608	242	22.525	6.866
205	105.411	32.129	243	22.580	6.882
206	123.432	37.622	244	22.662	6.907
207	45.257	13.794	245	22.492	6.856
208	56.198	17.129	246	22.250	6.782
209	61.391	18.712	247	119.907	36.548
210	14.395	4.388	248	120.848	36.835
211	20.189	6.154	249	128.536	39.178
212	12.123	3.695	250	130.136	39.666

CITY & COUNTY OF SAN FRANCISCO

SF Vertical Datum of 2013 (SFVD13) Benchmark List
NAVD88 Orthometric Heights as Recovered by CCSF in 2013
Publish Date: September 15, 2015

The City & County of San Francisco (CCSF) completed 72 miles of precise leveling surveys in 2013 and established 631 benchmarks. The survey recovered the North American Vertical Datum of 1988 (NAVD88) based on a best fit of 35 National Geodetic Survey (NGS) Benchmarks and established a vertical control reference frame known as the "CCSF 2013 NAVD88 Vertical Datum" (referred to as SFVD13) described in detail in the February 28, 2014 Survey Report titled "CCSF 2013 Second Order Leveling Network Survey and the CCSF 2013 NAVD88 Vertical Datum" on file with the County Surveyor and posted on the City web site. In 2014, a densification effort established 823 benchmarks adding 70 miles to the network. The 2014 densification surveys were constrained to the 2013 network. The accuracy of the network is indicated by the loop closures. The pre-adjustment closures of the 2013 loops were generally 0.01 feet (3 millimeters). The pre-adjustment closures of the 2014 densification loops on the 2013 network were generally less than 0.01 feet (3 millimeters). The relative accuracy of undisturbed benchmarks is expected to be 1-2 millimeters. The published NAVD88 Heights on NGS benchmarks were found to vary +/- 2 centimeters from a best fit solution for which their SFVD13 heights are listed below. The survey was performed in metric units carried to the nearest millimeter. The heights are provided below in meters and US survey feet. The units of feet are provided to three decimal places to preserve the metric accuracy of 1 millimeter (0.003 feet). These heights supersede preliminary adjustments of the 2014 densification benchmarks which may vary 0.01 feet.

SFVD13 supersedes the old City Datum. The difference between this SFVD13 and the old City Datum varies across the City. The conversion approved by the City & County Surveyor to estimate the old City Datum follows: SFVD13 (feet) - 11.35 feet = old City Datum in feet. The actual differences on old City Datum benchmarks are found to vary between 11.2' and 11.5' or greater due to subsidence and lack of maintenance. Old City Datum Benchmarks are not acceptable for converting to SFVD13.



City & County of San Francisco

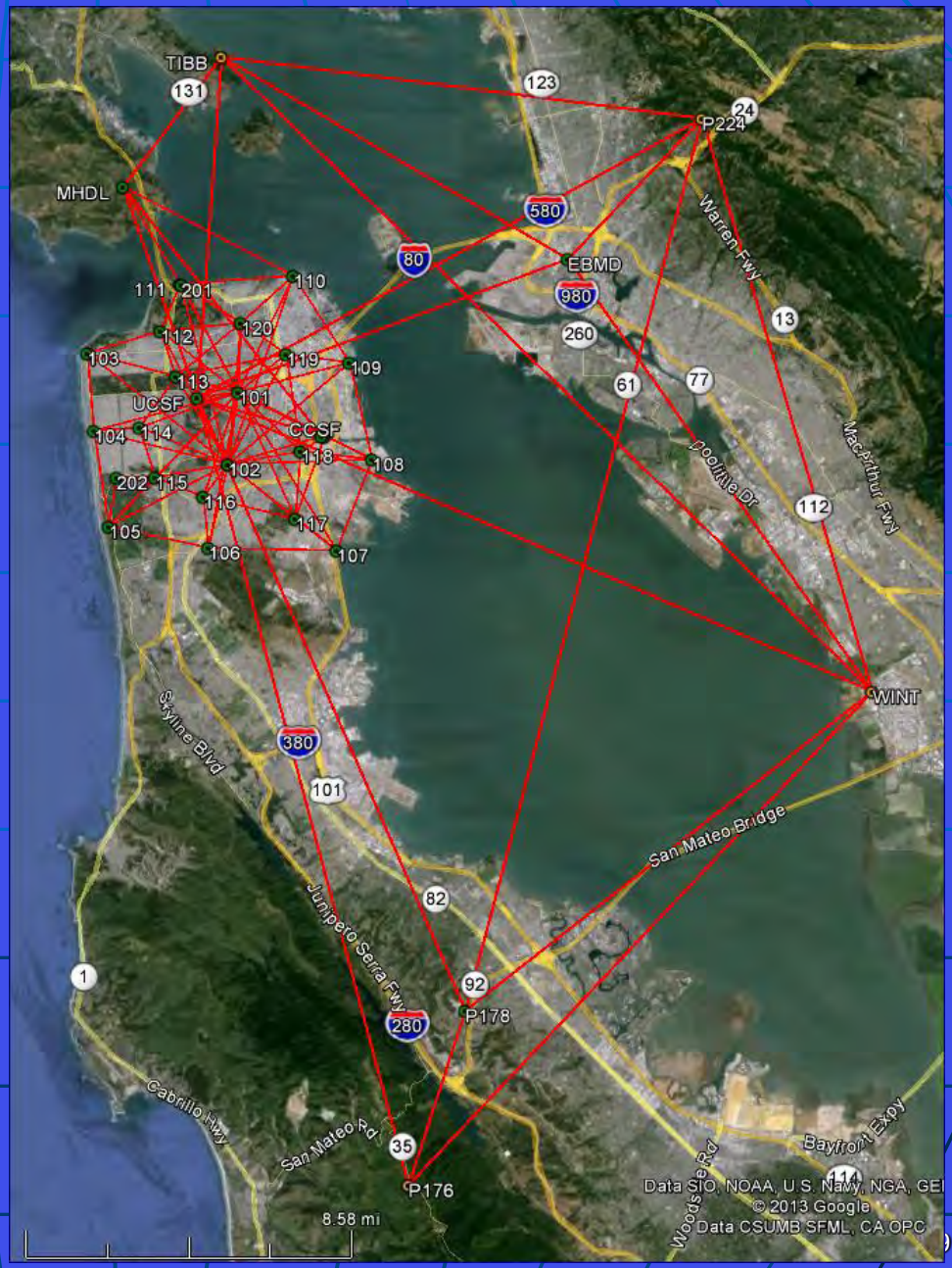
2013 High Precision Network (HPN)

and

2013 SF Coordinate System (SFCS13)

BSM/DPW Represented by Bruce Storrs, PLS,
City & County Surveyor and Michael McGee, PLS
michael.mcgee@sfdpw.org

GNSS Regional & City Control Network



HORIZONTAL DATUMS in SF

North American Datum of 1927 (NAD27)

- The old national datum in use since about 1930

- North American Datum of 1983 (NAD83)
- The current national datum superseded NAD27 in 1986

NAD83 is realized by the

1986 Adjustment 1984.0 Epoch (Triangulation Sta's)
1992 Adjustment 1991.35 Epoch (CA GPS/ellipsoid hts)
2007 Adjustment 2007.00 Epoch, (National Adj)
2011 Adjustment 2010.00 Epoch (Comprehensive Adj)

HORIZONTAL DATUMS in SF
North American Datum of 1983 (NAD83)

- The 1992, 2007 and 2011 Adjustments are realizations that improved the accuracy and precision of the NAD83 Datum reference frame

- NAD83 is fixed to the North American Plate; however, much of California sits on the Pacific Plate and is moving 2-4 centimeters (0.06'- 0.13') per year

- Thus, the necessity for assigning epochs to surveys to determine a points position in time relative to the N. American Plate

HORIZONTAL DATUMS in SF

North American Datum of 1983 (NAD83)

- San Francisco is moving north-northwesterly about 0.12’ per year and the horizontal coordinates are constantly changing relative to NAD83

- The difference in the position of a point published on the 1991.35 Epoch and the current 2010.00 Epoch is about 2.2’. (18.65 yrs x 0.12’ per HTDP)

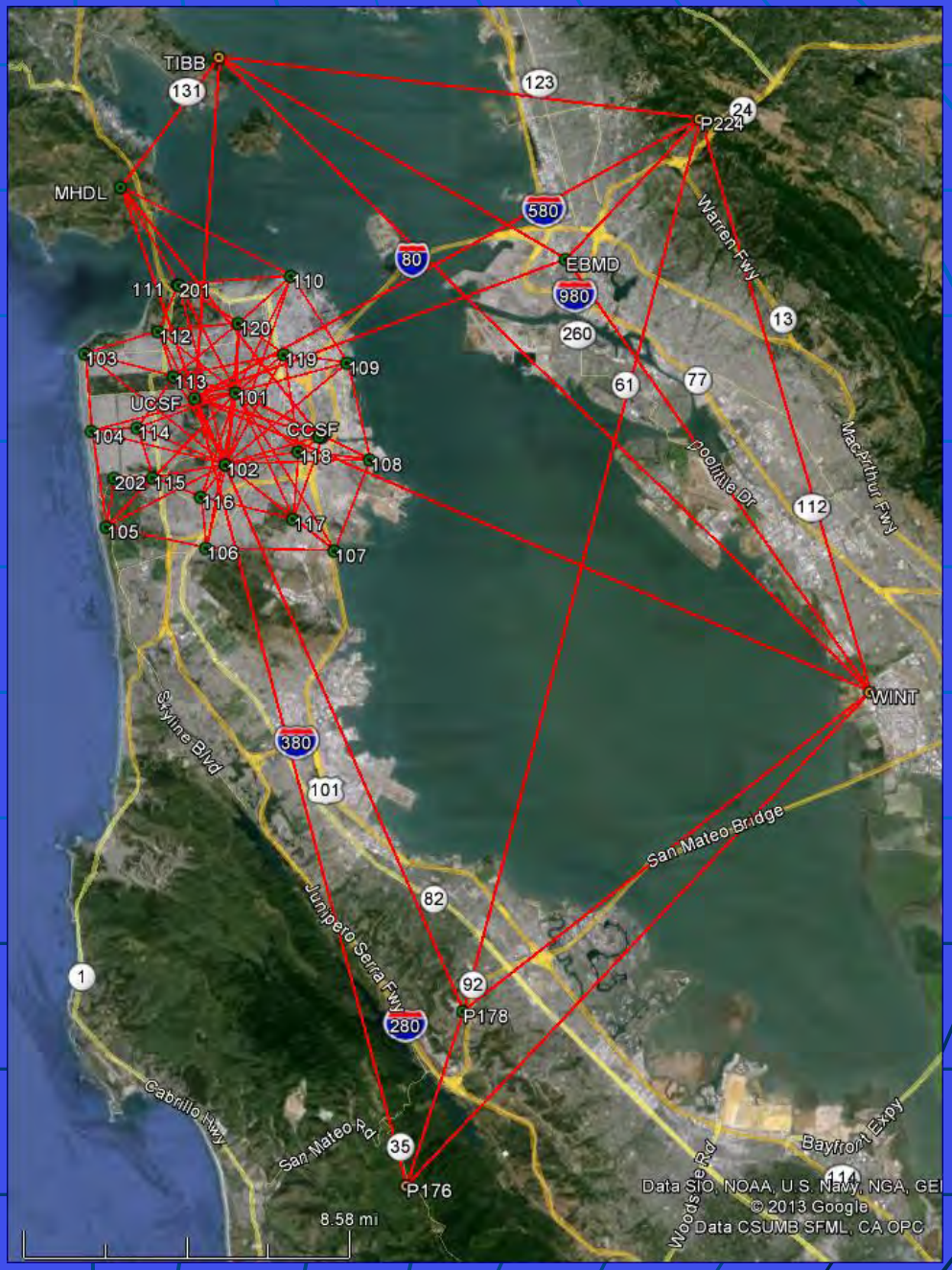
HORIZONTAL DATUMS in SF
North American Datum of 1983 (NAD83)

- Prior to the creation of the San Francisco High Precision Network and Coordinate System in 2013, many BSM surveys were based on the State Plane Coordinates on the 1991.35 Epoch (+/-5')

- Since late 2013, City & County Surveyor has mandated that all projects are to be referenced to the 2013 City Coordinate System with a few exceptions for legacy projects.

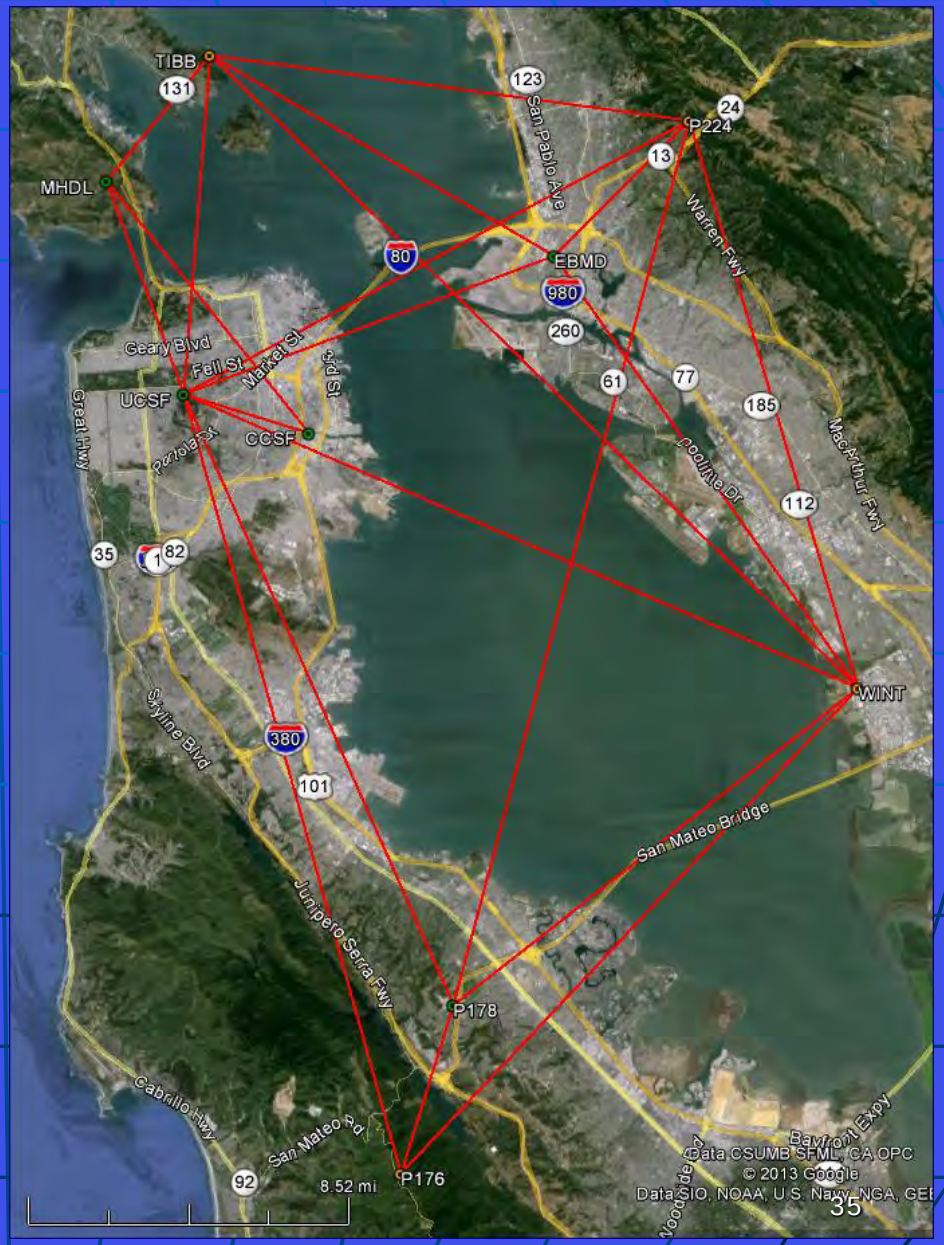
Regional Control Network

Connected the City to the National Spatial Reference System (NSRS)

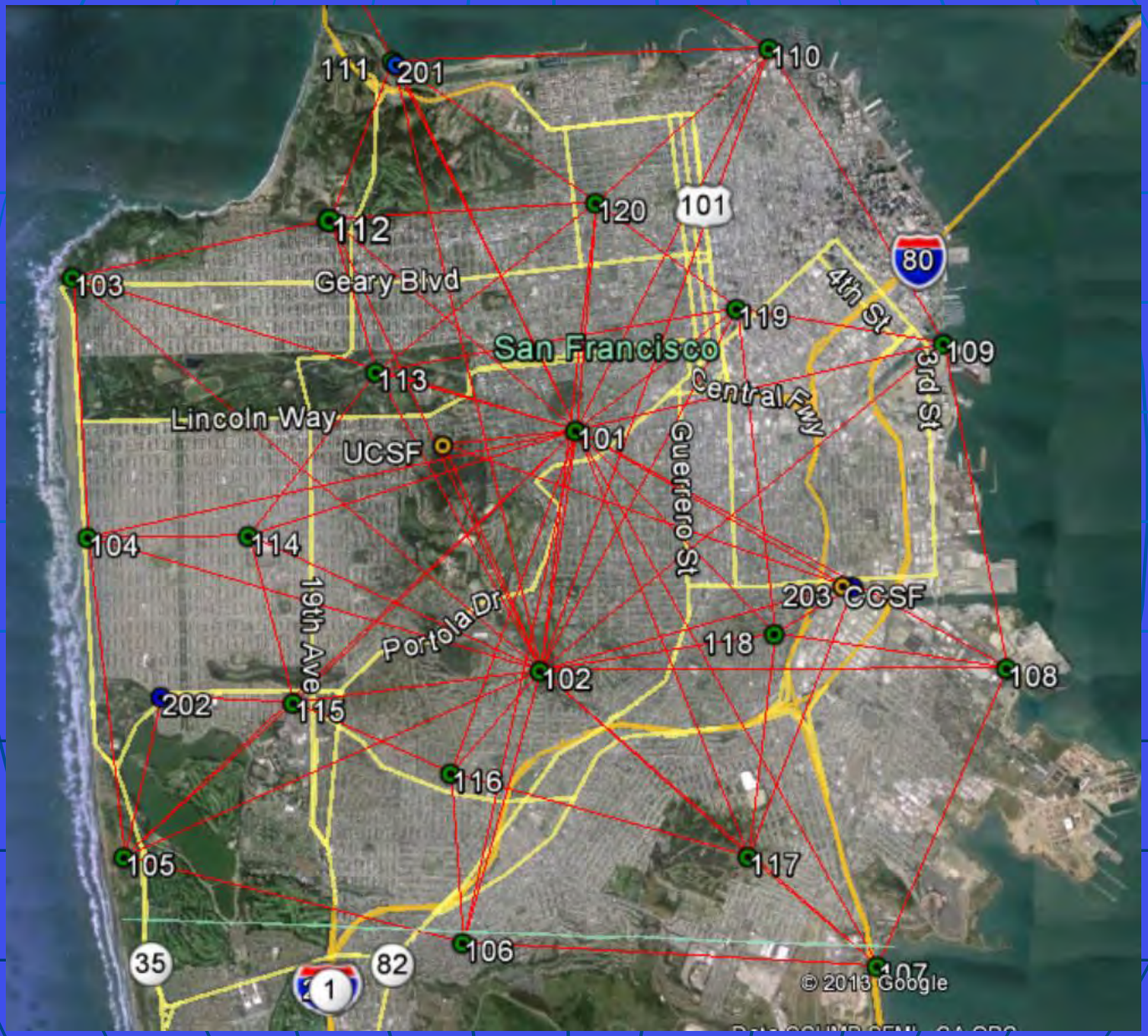


REGIONAL NETWORK

Four NGS CORS stations provided the basis for recovering the NAD83 Datum and establishing coordinates on the City's High Precision Network.



CCSF High Precision Network (HPN)



HPN Monuments

New Monument

Existing Monument

HPN Monuments Set in Stable Structures

HPN-103 at Lands End

HPN-116 at San Francisco City College

Station Recovery & Obstruction Diagram, Photos and KMZ Files are available on the Website

MUSIC CONCOURSE, GGP

City & County of San Francisco

STATION RECOVERY & OBSTRUCTION FORM

STATION ID: 113 **Set by:** SB, RA **Date:** 6-13-13

Monument Desc: 2" DOMED BRASS DISK

Station Description: SET 2" DOMED BRASS DISK STAMPED "CCSF SURVEY MONUMENT DO NOT DISTURB L.S. 6914" W/ △ AND CENTER PUNCH.

SET AT SW'LY END OF 1.1'W x 1.2'H CONC HEAD WALL AT SE'LY EDGE OF AC PATH RUNNING ABOVE THE PEDESTRIAN ENT/EXIT TO MUSIC CONCOURSE UNDERGROUND PARKING GARAGE.

78' SW'LY OF SW'LY EDGE OF STAIRS LEADING FROM MUSIC CONCOURSE TO DE YOUNG MUSEUM (NE'LY OF SAID GARAGE ENTRANCE/EXIT).

2' SW'LY FROM SW'LY END OF 3'H METAL RAILING.

13' NE'LY OF E'LY & PT OF CFC NE'LY EXTENT OF CONC HCR LEADING TO MUSIC CONCOURSE.

35' SE'LY OF CC HIGH PRESSURE FIRE HYDRANT, OPPOSITE SW'LY END OF WOODEN BENCH DEDICATED TO "DORIAN CROCKER ADAMS".

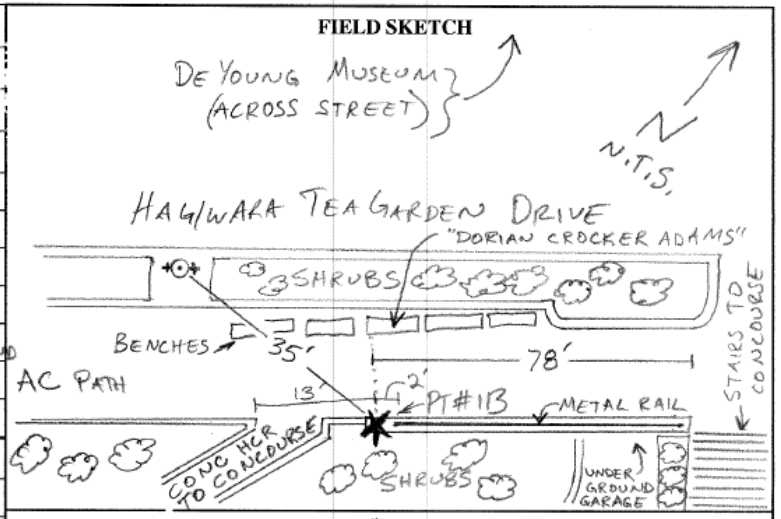
Travel Time: **Pack Distance:**

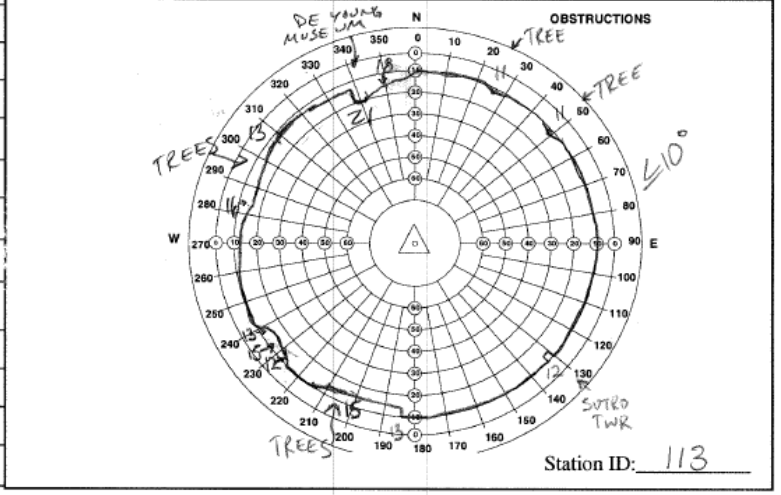
Public | Private | Locked Gate | Parking Adjacent | Offroad | 4W Drive

Key Required: **Contact/Permission:**

Other Information

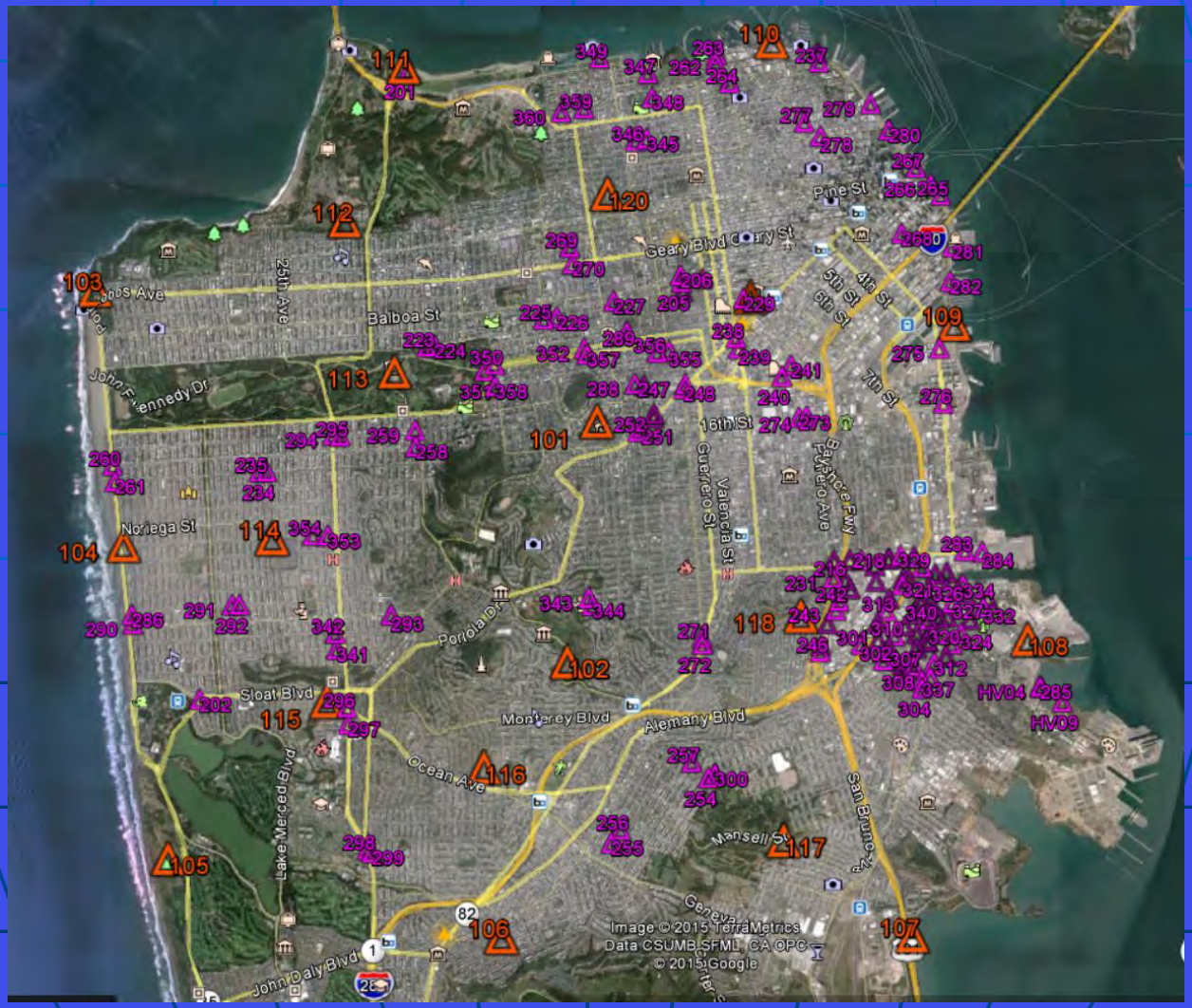
FIELD SKETCH





Densification of the HPN (Ongoing)

HPND Points (purple) Set in Support of Projects



2013 City Coordinate System

City & County of San Francisco Coordinate System of 2013 (SFCS13)

- **SFCS13 is a "low distortion projection" designed for and centered on the City & County of San Francisco**
- **SFCS13 (like SPC) projects a latitude and longitude coordinate onto grid surface resulting in grid or plane coordinate**

City & County of San Francisco Low Distortion Projection

- The height of the projection surface was set at the most common ground height in the City
- A grid distance is the same as a ground distance when surveying at the height of the projection surface
- The projection surface was set at 253 feet (SFVD13) shown as the purple contour on next slide

SFCS13: PPM Scale Change Contours

Purple= 0 PPM, Yellow= -10 PPM, Green= +10 PPM

Twin Peaks= +20 PPM (1/50,000)

SFCS13 Coordinate System

Designed to Minimize the Difference in Grid verses Ground Distances

- SFCS13 provides a scale distortion of less than 1:100,000 (10 ppm) in most parts of CCSF
- For the average of the 20 HPN points across the City, a ground distance of 1000 feet is equal to:
  - 1000.003 feet in the SFCS13
    - Verses
  - 999.925 feet in State Plane Coordinates Zone 3

City & County of San Francisco
Low Distortion Projection

- SFCS13 is referenced to the NAD83 (2011) 2010.00 Epoch reference frame.
- Therefore: Coordinates are referred to as NAD83 (2011) Epoch 2010.00 SFCS13 (see HO)
- North coincides with NAD83 Geodetic North at the Central Meridian through the Origin near the center of the City
- Convergence Angle from North varies +/- two minutes east-west across the City

City & County of San Francisco
Low Distortion Projection

- *SFCS13 Projection specifications for user's software:*

  Projection: Transverse Mercator

  Ellipsoid: GRS-80

  Scale: 1.000007

  Latitude of Origin: 37º45'00" (37.75º)

  Central Meridian: -122º27'00" (-122.45º)

  False Northing: 24,000 meters (78,740 feet)

  False Easting: 48,000 meters (157,480 feet)

(same idea as State Plane Coordinates - much less local distortion)

2D Transformation:
NAD83 1991.35 Epoch SPC to 2010.00 Epoch SFCS13

INPUT COORDINATES (Feet)

1999 NAD83(1991) 1991.35 SPC			NAD83(2011) 2010.00 SFCS13		
PT#	North(1)	East(1)	PT#	North(2)	East(2)
CANDLESTICK	2085128.546	6013911.480	107	62778.214	173801.613
TIDAL	2121772.462	5993470.060	201	98991.152	152599.533
SLOAT	2095678.561	5984226.406	202	72708.341	143900.815
ARMY	2100667.364	6012652.104	203	78288.679	172218.652

TRANSFORMATION SOLUTION RESIDUALS (Feet)

1999	2013	North	East	N.Azim & Dist
CANDLESTICK	107	-0.020	+0.016	140° 0.026
TIDAL	201	-0.032	-0.009	195° 0.033
SLOAT	202	+0.034	-0.012	340° 0.036
ARMY	203	+0.018	+0.004	13° 0.018

Root Mean Square of the North and East Residuals = 0.02

Scale Factor = 1.00007856 Standard Deviation = 0.00000079

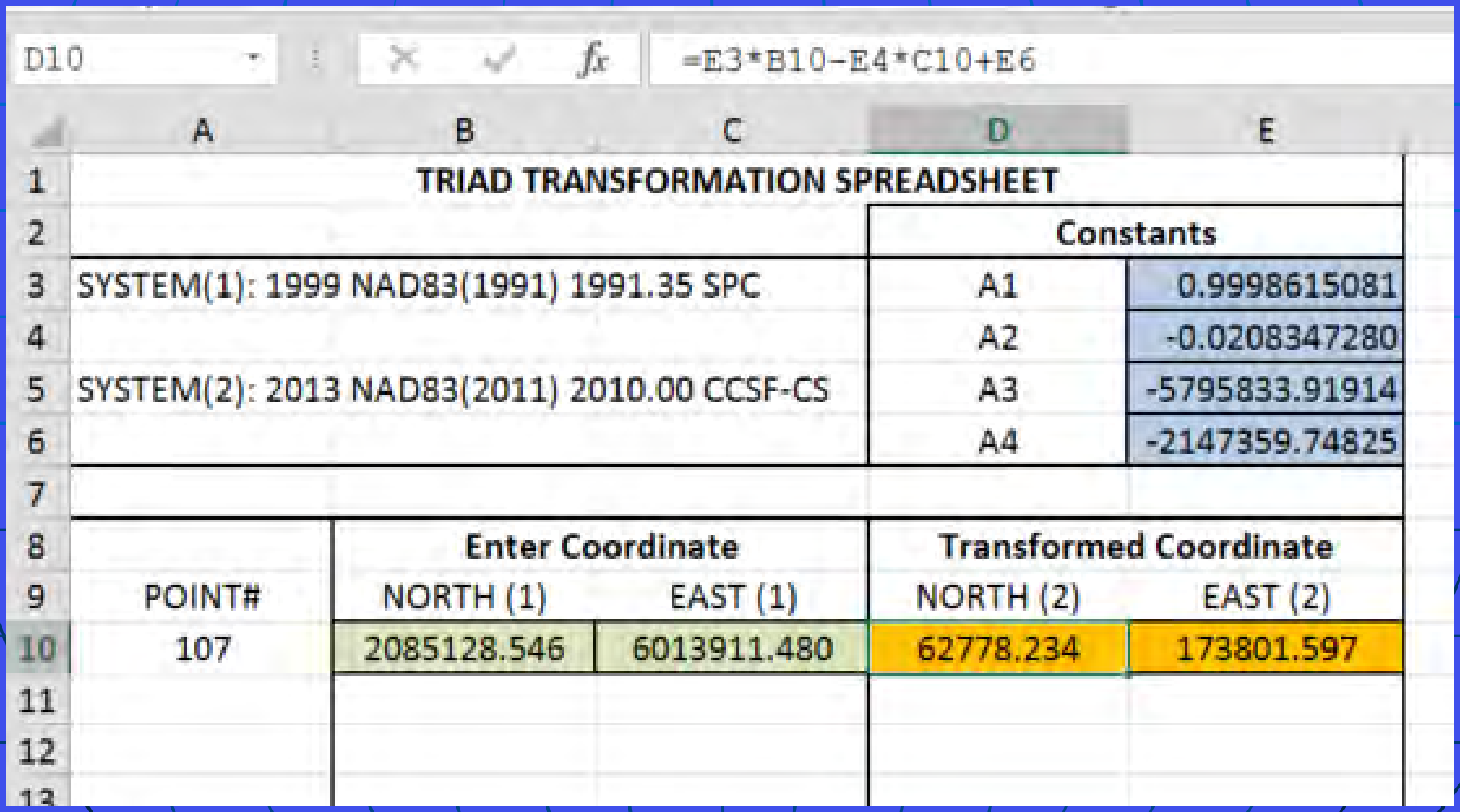
Rotation = -1° 11' 37.4" Standard Deviation = 0° 00' 00.2"

TRANSFORMATION EQUATIONS N2=A1*N1-A2*E1+A4 E2=A2*N1+A1*E1+A3

A1= 0.9998615081 A2= -0.0208347280 A3= -5795833.91914 A4= -2147359.74825

2D Transformation Spreadsheet

TRANSFORMATION EQUATIONS: N2=A1*N1-A2*E1+A4 E2=A2*N1+A1*E1+A3
TRANSFORMATION CONSTANTS: A1= 0.9998615081 A2= -0.0208347280
A3= -5795833.91914 A4= -2147359.74825



D10 | =E3*B10-E4*C10+E6

	A	B	C	D	E
1	TRIAD TRANSFORMATION SPREADSHEET				
2				Constants	
3	SYSTEM(1): 1999 NAD83(1991) 1991.35 SPC			A1	0.9998615081
4				A2	-0.0208347280
5	SYSTEM(2): 2013 NAD83(2011) 2010.00 CCSF-CS			A3	-5795833.91914
6				A4	-2147359.74825
7					
8		Enter Coordinate		Transformed Coordinate	
9	POINT#	NORTH (1)	EAST (1)	NORTH (2)	EAST (2)
10	107	2085128.546	6013911.480	62778.234	173801.597
11					
12					
13					

REFERENCES

Documentation of the High Precision Leveling Network and GNSS Network Surveys

Available At

http://www.sfdpw.org/index.aspx?page=1781

(Google “HPN Survey”)

CCSF Web Site

http://sfdpw.org/index.aspx?page=1781 | San Francisco Public Works : ...

hpn survey | Search | Share | More »

Services A-Z

Home » Services A-Z » more » CCSF Geodetic Network

In This Section

- Envista
- Graffiti
- Permits
- Potholes
- Street Sweeping
- Subdivision and Mapping
- Trees
- more
  - CULCOP Minutes and Agenda
  - Unwanted Handbills and Newspapers
  - News Rack Program
  - Subdivision and Mapping
  - Community Clean Team - Gigantic 3 Recycling Program
  - Pigeons: Reasons why NOT to feed the pigeons
  - Don't Leave it on the Sidewalk!
  - Missing Sewer Vent Covers
  - CULCOP
  - Subdivisions and Mapping

CCSF Geodetic Network

2013 High Precision Network (HPN) Survey

- HPN Record of Survey *(pdf)*
- HPN Survey Report *(doc)*
- HPN Station Descriptions *(pdf)*
- HPN Station Recovery and Obstruction Diagrams *(pdf)*
- HPN Densification (HPND) Published Coordinates *(pdf)* - pending
- HPN Densification (HPND) Station Recovery and Obstruction Diagrams *(pdf)* - pending
- HPN Densification (HPND) Point Descriptions *(xlsx)*

2013 -2014 High Precision Leveling Network

- 2013 Leveling Survey Report *(pdf)*
- Leveling Specs & Procedure *(pdf)*
- CCSF- VD13 Benchmark Elevations *(doc)*
- CCSF- VD13 Benchmark Descriptions *(xlsx)*

Geodetic Documents and Supporting Files

- Horizontal and Vertical Control Network *(kmz)*
- CCSF CS13 & VD13 Datums and Reference Frames *(doc)*
- 1991 SPC to 2010 SPC Transformation *(.xlsx)*
- 1991 SPC to 2010 CCSF-CS13 Transformation *(.xlsx)*
- CS13 Projection Files for AutoCAD *(.csd)*

1992-1998-1999 CCSF GPS Network

- Superseded Control Network Maps *(pdf)*

Superseded Old City Datum Benchmarks

- Benchmark Data Search - locate benchmark elevations at a specific intersection on the Old City datum

CCSF Web Site

Superseded Old City Datum Benchmarks

- Benchmark Data Search - locate benchmark elevations at a specific intersection on the Old City datum

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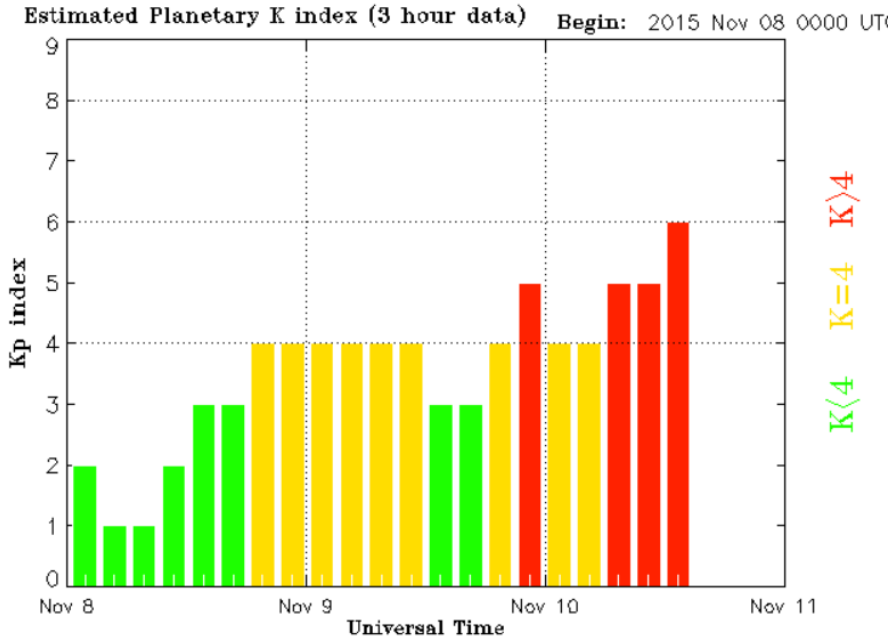

Source: http://www.swpc.noaa.gov/products/planetary-k-index

General Survey Notes for Mapping

- See the Datums Simplified document (HO) for examples of the proper terminology for describing the basis for surveys on maps referencing CCSF horizontal & vertical coordinate systems.

CCSF Datums, Coordinates Systems, Reference Frames and Acronyms

09/22/15 Version 3.4

City Approved Acronyms:

For consistency use the following acronyms when referring to these systems.

CCSF-HPN = City & County of San Francisco 2013 High Precision Network
HPN = High Precision Network
SFCS13 = City & County of San Francisco 2013 Coordinate System
SFVD13 = City & County of San Francisco 2013 NAVD88 Vertical Datum

Geometric & Horizontal Datums:

The City & County of San Francisco (the City) geometric and horizontal datum is the North American Datum of 1983, 2011 Adjustment at the 2010.00 Epoch and referred to as "NAD83 (2011) 2010.00 Epoch". This datum realization is referenced by the published latitudes, longitudes and ellipsoid heights on the 2013 High Precision Network (HPN). A near ground system of plane coordinates was created for the City in 2013 similar to the California State Plane Coordinate System. The System is referred to as the "2013 City & County of San Francisco Coordinate System" (SFCS13). This System is used for coordinating surveying and mapping projects and GIS. The coordinate system is a low distortion mercator projection designed such that the combined scale factor is generally less than 1/100,000. The projection origin (Projection North = Geodetic North) is located near the center of the City which minimizes the convergence of meridians to +/-3 minutes at the east and west edges of the City. This projection is applied to NAD83 (2011) 2010.00 Epoch latitudes and longitudes to obtain plane or grid coordinates which are properly referred to as "NAD83 (2011) 2010.00 Epoch City & County of San Francisco Coordinates". See Record of Survey #8080 and web site at http://sfdpw.org/index.aspx?page=1781).

Vertical Datum:

The City vertical datum is the "CCSF 2013 NAVD88 Vertical Datum" (SFVD13) based on NAVD88 as recovered and modeled in the 2013 City high precision leveling surveys. This datum realization is referenced by benchmarks in the "CCSF 2013 High Precision Leveling Network".

Reference Networks:

The geometric datum "NAD83 (2011) 2010.00 Epoch" and the "2013 City & County of San Francisco Coordinate System" (SFCS13) are referenced by the "CCSF 2013 High Precision Network" (HPN). The "CCSF 2013 NAVD88 Vertical Datum" (SFVD13) is referenced by the benchmarks in the "CCSF 2013 High Precision Leveling Network". A reference to the "HPN" is to the physical monuments constituting the network not to the SFCS13 coordinate system.

(Summary of the above statements)

PROJECT DATUMS & REFERENCE SYSTEM

Geometric Datum: North American Datum of 1983: NAD83 (2011) 2010.00 Epoch
Reference Network: "CCSF-2013 HPN" (High Precision Network) (Record of Survey #8080)
Vertical Datum: "CCSF 2013 NAVD88 Vertical Datum" (SFVD13)
Projection: The plane coordinates are in a local custom coordinate system referred to as the City & County of San Francisco Coordinate System (SFCS13). The SFCS13 is a low distortion grid projection designed for CCSF to be a ground coordinate system with the origin near the center of the City. See Record of Survey #8080 in Book EE at Page 147-157 SFCR.

- **Example Survey Notes for Mapping**
-
- **Basis of Survey - Horizontal Datum & Reference System**
- The horizontal datum is the North American Datum of 1983: NAD83 (2011) 2010.00 Epoch referenced by the CCSF-2013 High Precision Network (HPN) points 101 and 102 shown hereon. Grid coordinates are based on the “City & County of San Francisco 2013 Coordinate System” (SFCS13). See Record of Survey #8080 in Book EE of Survey Maps, 147-157 SFCR and the CCSF DPW Web Site.
-
- **Basis of Elevations - Vertical Datum & Reference System**
- The vertical datum is “CCSF 2013 NAVD88 Vertical Datum” (SFVD13) as referenced by SFVD13 Benchmarks 10001, 10002 and 10003 shown hereon and described on the CCSF DPW Web Site.