

## **Journal of Coastal Research – Supplemental Materials**

### **Ground Control Points for Cliff Mapping Investigations, Fort Funston, California**

PAPER TITLE: New Techniques to Measure Cliff Change from Historical Oblique Aerial Photographs and Structure-from-Motion Photogrammetry.

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#### INTRODUCTION

Survey-grade positions were collected from hard points and structures from the Golden Gate National Recreation Area at Fort Funston, California to serve as ground control points in a mapping investigation. This Supplemental Materials document provides background information and position data for these points.

A total of 41 ground control points were used in the study. The locations of these points are described below with photographs and descriptions. Names for the Fort Funston batteries were taken from maps from the digital Military Museum (<http://www.militarymuseum.org/FtFunston>). Table 1 provides the survey-grade positions of these ground control points. Table 2 provides a matrix describing which points were used in the various Structure-from-Motion model runs presented in the Warrick et al. paper.

As noted in the Warrick et al. paper, all positions were measured with a Trimble R7 differential global positioning system (DGPS) with an antenna mounted on a 2 m rod, and DGPS corrections were provided from a GPS station established by the USGS at the Oceanside Waste Treatment Plant, San Francisco, California. All position data are provide in the projected coordinate system, NAD83 UTM 10N with a NAVD88 vertical datum.

GROUND CONTROL POINT DESCRIPTIONS

Ground Control Point 1: Southeast corner of most landward concrete platform in parking lot.



Ground Control Point 2: Northeast corner of most landward concrete platform in parking lot



Ground Control Point 3: Southwest corner of most landward concrete platform in parking lot



Ground Control Point 4: Northwest corner of most landward concrete platform in parking lot



Ground Control Point 5: Southeast corner of middle concrete platform in parking lot.



Ground Control Point 6: Northeast corner of middle concrete platform in parking lot.



Ground Control Point 7: Southwest corner of middle concrete platform in parking lot.



Ground Control Point 8: Northwest corner of middle concrete platform in parking lot.



Ground Control Point 9: Southeast corner of most seaward concrete platform in parking lot.



Ground Control Point 10: Northeast corner of most seaward concrete platform in parking lot.



Ground Control Point 11: Southwest corner of most seaward concrete platform in parking lot.



Ground Control Point 12: Northwest corner of most seaward concrete platform in parking lot.



Ground Control Point 13: Northern corner of southernmost small battery in the “Funston Group”



Ground Control Point 14: Northwestern corner of a metal plate on the southernmost small battery in the “Funston Group”



Ground Control Point 15: Southwestern corner of a metal plate on the southernmost small battery in the “Funston Group”



Ground Control Point 16: Southern corner of southernmost small battery in the “Funston Group”



Ground Control Point 17: Top of pedestal on the southernmost small battery in the “Funston Group”



Ground Control Point 18: Southwestern corner of northernmost small battery in the “Funston Group”



Ground Control Point 19: Northwestern corner of northernmost small battery in the “Funston Group”



Ground Control Point 20: Northwestern corner of a metal plate on the northernmost small battery in the “Funston Group”





Ground Control Point 21: Southwestern corner of a metal plate on the northernmost small battery in the "Funston Group."



Ground Control Point 22: Center of concrete platform near cliff edge.



Ground Control Point 26: Peak of the dome, southernmost battery of the "Davis Group."



Ground Control Point 32: Peak of the dome, northernmost battery of the "Davis Group."



Ground Control Point 35: Northern corner of concrete block on roof of the northernmost battery of the "Davis Group."



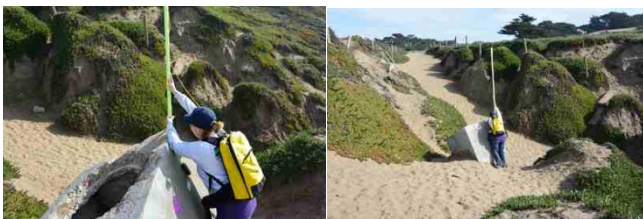
Ground Control Point 36: Western corner of concrete block on roof of the northernmost battery of the "Davis Group."



Ground Control Point 44: Seaward corner of large concrete block on upper portion of beach access trail.



Ground Control Point 45: Highest corner of large concrete block on upper portion of beach access trail.





Ground Control Point 52: Peak of northern concrete pillar in former National Guard Armory.



Ground Control Point 53: Peak of southern concrete pillar in former National Guard Armory.



Ground Control Point 56: Peak of concrete pillar in former National Guard Armory.



Ground Control Point 116: Corner of northern outlet structure at base of cliffs.



Ground Control Point 118: Northern corner of upper portion of the northern outlet structure.



Ground Control Point 119: Base immediately below the southern corner of upper portion of the northern outlet structure (i.e., immediately below point #118).



Ground Control Point 120: Northern corner of seaward portion of the northern outlet structure.



Ground Control Point 121: Southern corner of seaward portion of the northern outlet structure.



Ground Control Point 122: Southern corner of upper portion of the northern outlet structure.



Ground Control Point 123: Corner of northern outlet structure at base of cliffs.



Ground Control Point 125: Corner on southernmost end of the southern outlet structure at base of cliffs.



Ground Control Point 126: Corner on southernmost end of the southern outlet structure at base of cliffs.



Ground Control Point 127: Corner on southernmost end of the southern outlet structure at base of cliffs.



**Table 1. Survey-grade positions of the Fort Funston Ground Control Points (GCP).**

<i>GCP Number</i>	<i>GCP Type</i>	Easting (m)	Northing (m)	Elevation (m)
1	Cliff Top	543962.575	4174339.314	56.586
2	Cliff Top	543959.289	4174343.778	56.701
3	Cliff Top	543949.045	4174329.386	56.571
4	Cliff Top	543945.682	4174333.815	56.682
5	Cliff Top	543916.863	4174305.434	56.573
6	Cliff Top	543913.559	4174310.072	56.688
7	Cliff Top	543903.254	4174295.436	56.556
8	Cliff Top	543899.971	4174299.878	56.683
9	Cliff Top	543871.333	4174271.803	56.583
10	Cliff Top	543868.078	4174276.320	56.666
11	Cliff Top	543856.048	4174260.538	56.564
12	Cliff Top	543852.799	4174265.037	56.676
13	Cliff Top	543787.972	4174219.636	57.990
14	Cliff Top	543786.597	4174217.731	58.022
15	Cliff Top	543786.717	4174216.759	58.020
16	Cliff Top	543788.693	4174215.542	57.978
17	Cliff Top	543788.886	4174216.090	58.285
18	Cliff Top	543783.722	4174239.530	57.828
19	Cliff Top	543781.668	4174244.537	57.782
20	Cliff Top	543781.011	4174241.938	57.666
21	Cliff Top	543781.218	4174241.055	57.691
22	Cliff Top	543746.853	4174318.485	51.907
26	Cliff Top	543786.036	4174613.999	66.582
32	Cliff Top	543705.362	4174777.748	66.593
35	Cliff Top	543714.332	4174774.932	68.903
36	Cliff Top	543713.955	4174774.063	68.797
44	Cliff Top	543644.507	4175041.461	27.872
45	Cliff Top	543645.160	4175040.461	27.916
52	Cliff Top	543725.625	4175199.975	35.878
53	Cliff Top	543726.991	4175195.861	36.000
56	Cliff Top	543745.648	4175172.481	35.640
116	Base of Cliff	543672.397	4174358.873	3.787
118	Base of Cliff	543675.939	4174345.526	7.070
119	Base of Cliff	543675.775	4174345.623	6.152
120	Base of Cliff	543667.605	4174347.752	5.538
121	Base of Cliff	543668.023	4174339.001	5.554
122	Base of Cliff	543676.202	4174342.037	7.061
123	Base of Cliff	543677.713	4174328.273	3.816
125	Base of Cliff	543676.331	4174309.799	4.088
126	Base of Cliff	543677.403	4174310.465	4.896
127	Base of Cliff	543671.746	4174308.957	3.245

**Notes:** All data are reported in NAD83 UTM 10 with a NAVD88 vertical datum.



**Table 2. Matrix for the Fort Funston Ground Control Points (GCP) showing which points were used in the various Structure-from-Motion (SfM) models.**

GCP Number	GCP Type	Marker used in the SfM model with the following number of GCPs...											
		2	3	4	6	8	10	12	15	20	25	30	41
1	Cliff Top									YES	YES	YES	YES
2	Cliff Top				YES	YES	YES	YES	YES	YES	YES	YES	YES
3	Cliff Top												YES
4	Cliff Top												YES
5	Cliff Top											YES	YES
6	Cliff Top										YES	YES	YES
7	Cliff Top							YES	YES	YES	YES	YES	YES
8	Cliff Top										YES	YES	YES
9	Cliff Top												YES
10	Cliff Top											YES	YES
11	Cliff Top												YES
12	Cliff Top									YES	YES	YES	YES
13	Cliff Top						YES	YES	YES	YES	YES	YES	YES
14	Cliff Top												YES
15	Cliff Top											YES	YES
16	Cliff Top									YES	YES	YES	YES
17	Cliff Top												YES
18	Cliff Top									YES	YES	YES	YES
19	Cliff Top	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
20	Cliff Top											YES	YES
21	Cliff Top												YES
22	Cliff Top							YES	YES	YES	YES	YES	YES
26	Cliff Top					YES	YES	YES	YES	YES	YES	YES	YES
32	Cliff Top			YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
35	Cliff Top								YES	YES	YES	YES	YES
36	Cliff Top											YES	YES
44	Cliff Top				YES	YES	YES	YES	YES	YES	YES	YES	YES
45	Cliff Top												YES
52	Cliff Top								YES	YES	YES	YES	YES
53	Cliff Top	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
56	Cliff Top					YES	YES	YES	YES	YES	YES	YES	YES
116	Base of Cliff		YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
118	Base of Cliff												YES
119	Base of Cliff										YES	YES	YES
120	Base of Cliff										YES	YES	YES
121	Base of Cliff												YES
122	Base of Cliff									YES	YES	YES	YES
123	Base of Cliff						YES	YES	YES	YES	YES	YES	YES
125	Base of Cliff												YES
126	Base of Cliff								YES	YES	YES	YES	YES
127	Base of Cliff										YES	YES	YES