Well Sites Survey

(1994-2015)

Arnold, Broad Creek and Crofton Meadows

Well Fields in Anne Arundel County

Maryland

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Report of GPS Surveys

Abstract

This report describes the most recent year of surveys performed by the Maryland State Highway Administration (MDSHA), Division of Plats and Surveys, for the Maryland Geological Survey (MGS).

The survey was part of efforts by the MGS to monitor for changes at three well sites in Anne Arundel County. Height differences were measured using the Global Positioning System (GPS).

This report describes the results of the current survey.

Purpose

The goal of this survey is to monitor one survey monument at three separate well sites in Anne Arundel County.

History

This survey was undertaken as part of an effort begun in 1994 to determine the relationship of the well sites to a monument in the stable Piedmont region of the state as well as to sites in the National Geodetic Survey's Continuously Operating Reference Station (CORS) network.

Measurements were made on 23, 24, and 25 June 2015 using GPS.

Table 1 - Sites used in survey

Station	Site Name	Nearby Community
GORF GPS N	Howard High School	Columbia, MD
ARNOLD-1	Arnold Well Field	Arnold, MD
BROAD-1	Broad Creek Well Field	Annapolis, MD
CROFTON-1	Crofton Meadows Well Field	Crofton, MD
ANP5	Annapolis CORS site	Annapolis, MD
GODE	NASA Goddard CORS	Greenbelt, MD
USNO	US Naval Observatory CORS	Washington, DC

Monumentation

No new survey monuments were established in 2015.

Specifications

Observations at well sites consisted of five and one-half hour sessions on three separate days. One session was offset from the others by four (4) hours. The offset session uses a different satellite constellation and thereby provides an accuracy check.

Equipment used

Four MDSHA GPS\GNSS receivers were used during this project. They are Topcon GR-5 units capable of logging multiple frequencies (L1 and L2) and multiple constellations (GPS and GLONASS). NGS antenna calibrations are available for the antennas.

Table 2 - CORS site equipment

Site	Receiver	Antenna
ANP5	TRIMBLE NET-RS	TRM41429
GODE	ASHTECH UZ-12	AOAD/M_T
USNO	ASHTECH ZXII3T	AOAD/M_T

Conditions effecting surveys

There were a few conditions that changed this year. They are:

The schedule this year changed slightly and will for future years so the survey can be done when school is out of session. It is much better to not have children walking around the GPS equipment occupying the control site (GORF GPS N) at Howard High School.

There was a change in personnel this year. The GPS team members were all different except for the person manning the control site. There was also some miscommunication about the four hour offset for one of the three days. The offset was only one hour or so. Also, the staff had irregular starting times for their sessions. Each session had a minimum of five hours of data, after post-processing. The data was collected at five second intervals, not fifteen seconds as in the past so there was sufficient data for each session.

Vector reduction

GPS observations were initially reduced to vectors using the Topcon Tools software package (version 8.2.3). The position of station GORF GPS N was verified by observations with respect to three NGS CORS sites.

Adjustment

The GPS vectors were then adjusted with the Topcon Tools software package (version 8.2.3). Adjusted coordinates for the well site stations were determined with respect to the NAD 83 (1991) coordinates and NAVD 88 height for station GORF GPS N. As the primary interest is the vertical component, these values were extracted from the adjustment and tabulated below.

Table 3 - Fixed station coordinate

Station Name	Latitude	Longitude	NAVD 88 height	Datum
GORF GPS N	N39 13 34.24168	W076 48 50.46404	156.886	NAD 83 (1991)

Geoid heights were determined for well site stations using the model GEOID 2003. These values are used to convert ellipsoid heights derived from GPS observations into NAVD 88 compatible values.

Table 4 - Heights determined by GPS (all values shown as meters)

YEAR	ARNOLD-1	sigma	BROAD-1	sigma	CROFTON-1	sigma
1994	38.223	0.036	28.282	0.057	41.180	0.086
1995	38.224	0.023	28.303	0.021	41.212	0.017
1996	38.216	0.009	28.306	0.010	41.243	0.009
1997	38.219	0.029	28.309	0.024	41.233	0.017
1998	38.208	0.005	28.304	0.005	41.233	0.005
1999	38.201	0.025	28.323	0.025	41.240	0.025
2000	38.210	0.012	28.318	0.012	41.246	0.012
2001	38.221	0.006	28.322	0.007	41.247	0.006
2002	38.203	0.012	28.289	0.012	41.223	0.012
2003	38.197	0.032	28.289	0.019	41.200	0.019
2004	38.205	0.007	28.293	0.007	41.203	0.007
2005	38.184	0.009	28.288	0.011	41.206	0.008
2006	38.186	0.009	28.296	0.009	41.211	0.006
2007	38.180	0.014	28.281	0.015	41.206	0.011
2008	38.181	0.021	28.272	0.021	41.204	0.016
2009	38.184	0.020	28.293	0.019	41.224	0.015
2010	38.176	0.012	28.286	0.012	41.222	0.009
2011	38.194	0.024	28.295	0.025	41.227	0.027
2012	38.182	0.012	28.292	0.012	41.212	0.009
2013	38.163	0.007	28.294	0.007	41.211	0.007
2014	38.174	0.007	28.286	0.007	41.207	0.006
2015	38.168	0.012	28.271	0.009	41.194	0.009
mean	**38.195**		**28.295**		**41.217**	
max	38.224		28.323		41.247	
min	38.163		28.271		41.180	
range	0.061		0.052		0.067	
stdev	0.019		0.014		0.018	

Note: The data from the January 2006 observations are listed in the following charts under the year 2005 since there were no observations in 2005 and there were two sets in 2006. There cannot be two sets of data for one year due to the format of the charts.

Note: The NAVD 88 height data, determined by precise leveling in 1994 and seen in table 5, has been added to the charts in figures 1 through 3 to allow a graphical comparison between GPS values and the original leveled heights.

Figure 1 - ARNOLD-1 values and uncertainties

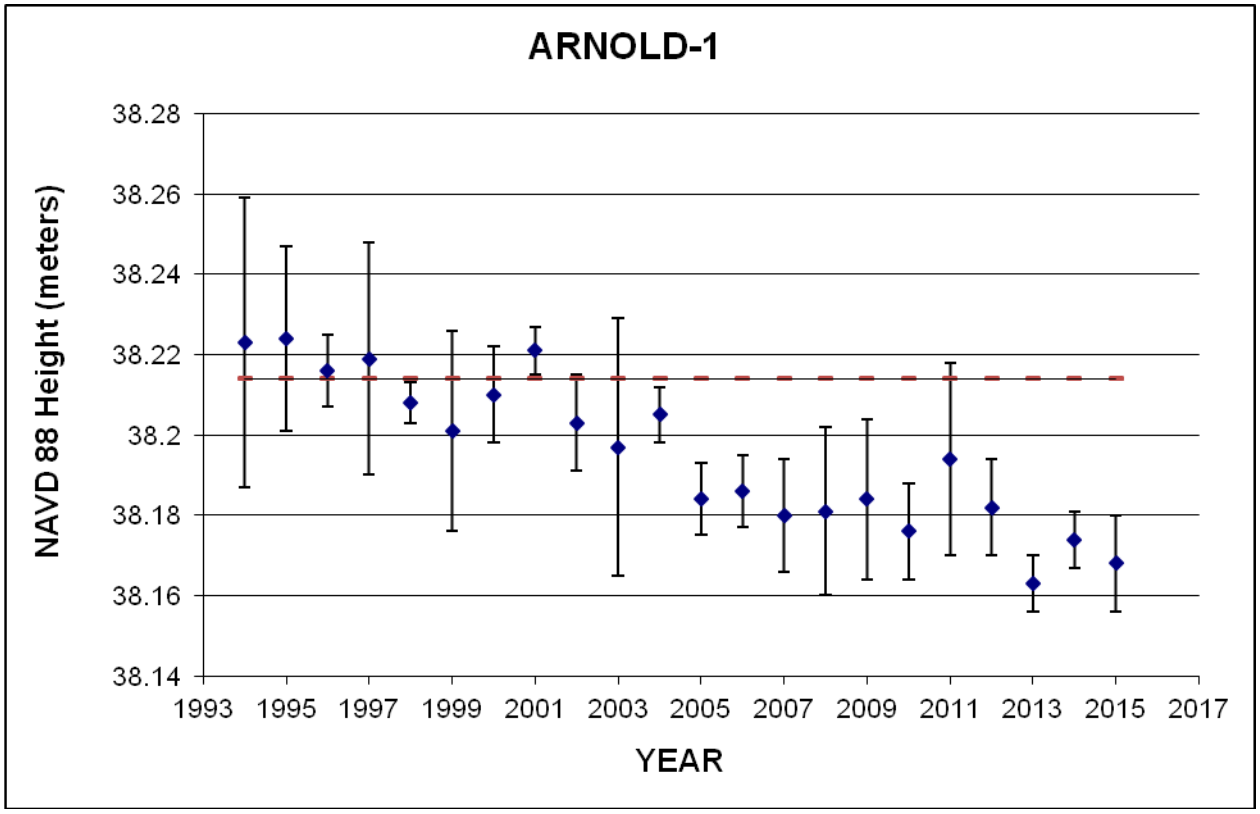

Figure 2 - BROAD-1 values and uncertainties

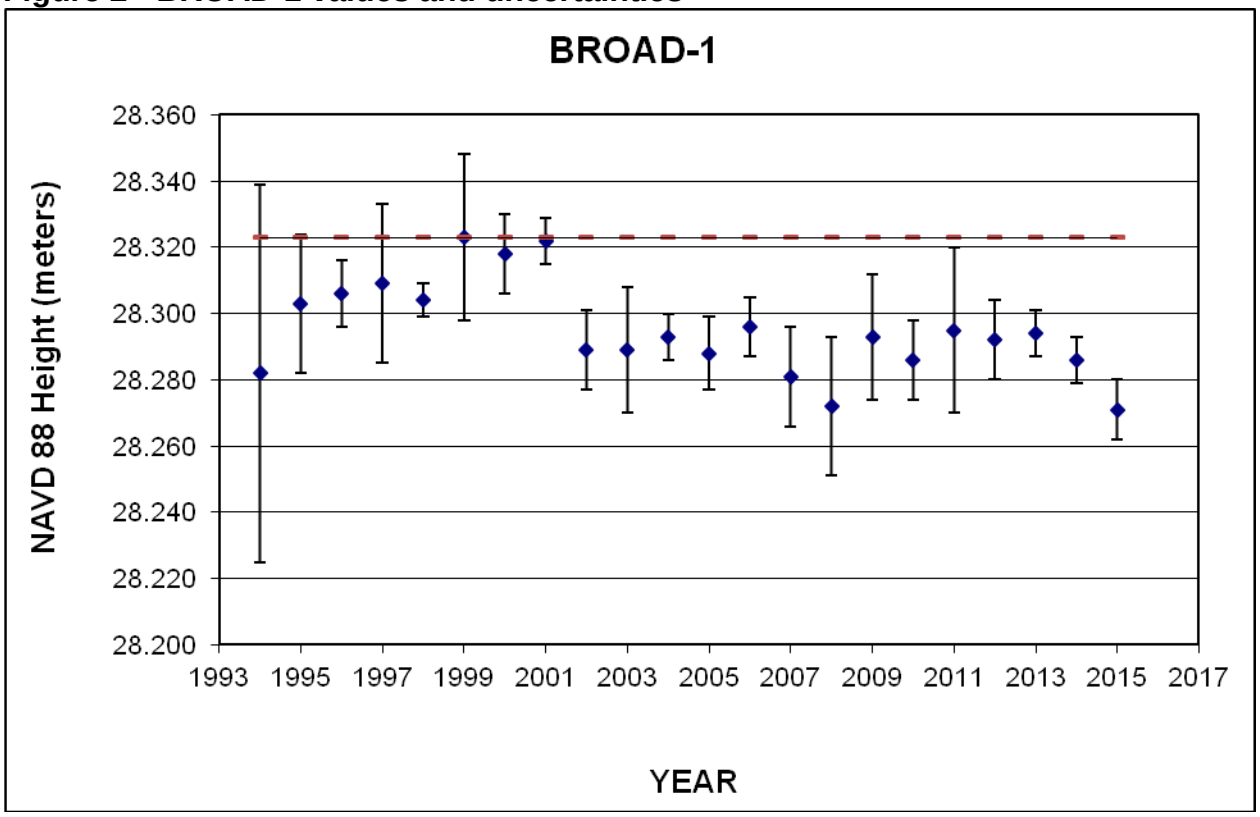

Figure 3 - CROFTON-1 values and uncertainties

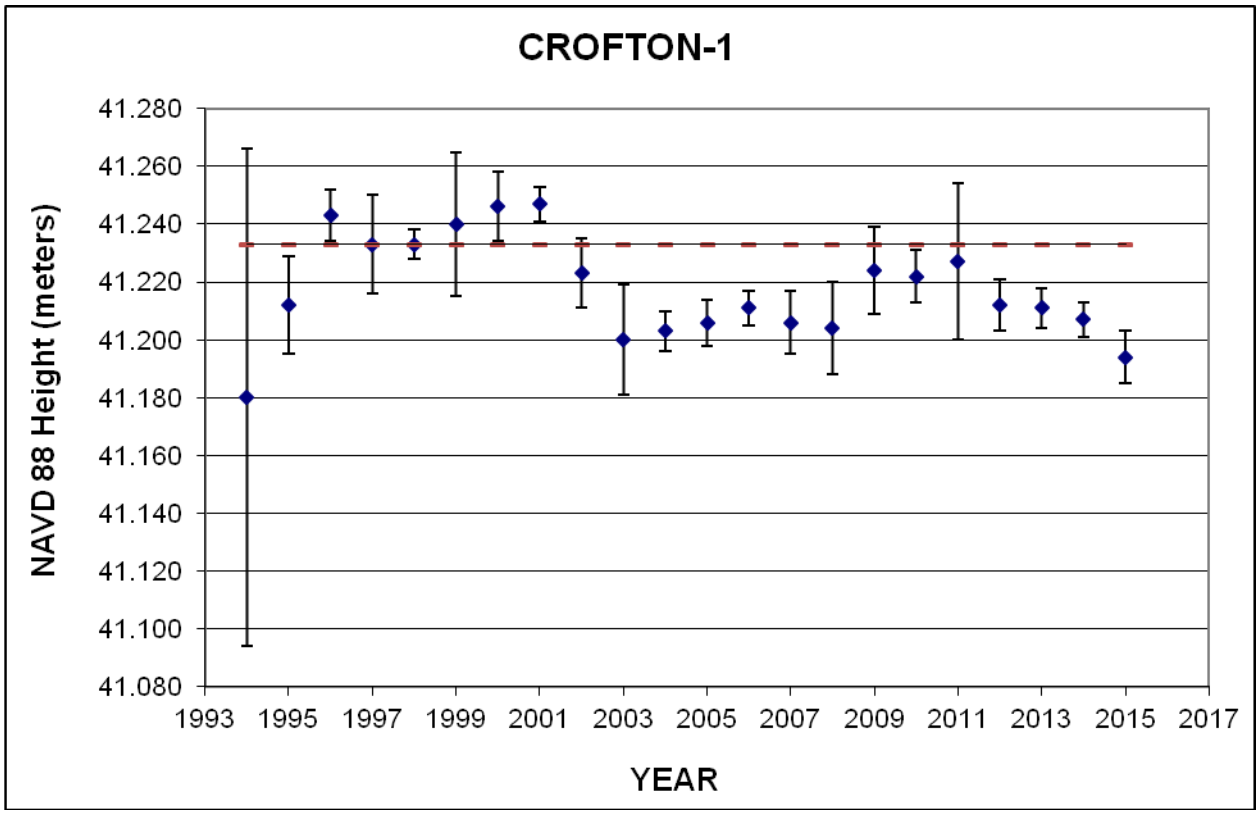

Table 5 - NAVD 88 heights in meters derived from different techniques.

Station	Leveling 1994(L)	GPS-derived 2015(G)	Difference (L-G)
ARNOLD-1	38.214	38.168	+0.046
BROAD-1	28.323	28.271	+0.052
CROFTON-1	41.233	41.194	+0.039

The discrepancy between the height determinations could be due to deficiencies in the geoid model, limitations of GPS as a system for determining heights and possible errors in the network of benchmarks.

Table 6 - Geoid Heights for project monuments

Station	Geoid 2003 Height (meters)
ARNOLD-1	-33.208
BROAD-1	-33.140
CROFTON-1	-32.791
GORF GPS N	-32.212

2015 Observation Schedule

All monuments were to be occupied for a minimum of 5.5 hours. CORS operate continuously (24/7)**.**

DOY: 174 Date: 23 June 2015

Station	Start time UTC	End time UTC
ARNOLD-1	11:34	17:33
BROAD-1	11:54	17:29
CROFTON-1	12:15	17:32
GORF GPS N	12:24	17:32
Annapolis CORS site	00:00	23:59
NASA Goddard CORS	00:00	23:59
US Naval Observatory CORS	00:00	23:59

DOY: 175 Date: 24 June 2015

Station	Start time UTC	End time UTC
ARNOLD-1	13:55	19:03
BROAD-1	12:15	19:01
CROFTON-1	12:54	19:01
GORF GPS N	12:50	19:03
Annapolis CORS site	00:00	23:59
NASA Goddard CORS	00:00	23:59
US Naval Observatory CORS	00:00	23:59

DOY: 176 Date: 25 June 2015

Station	Start time UTC	End time UTC
ARNOLD-1	11:27	17:04
BROAD-1	11:21	17:01
CROFTON-1	11:47	17:04
GORF GPS N	11:48	17:05
Annapolis CORS site	00:00	23:59
NASA Goddard CORS	00:00	23:59
US Naval Observatory CORS	00:00	23:59