

**NATIONAL RADIO ASTRONOMY OBSERVATORY  
Green Bank, West Virginia**

**ELECTRONICS DIVISION INTERNAL REPORT NO. 324**

**NRAO 43m Antenna Coordinates and Angular Limits**  
(Version 4)

Glen Langston

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EDIR Memo #324

## NRAO 43m Antenna Coordinates and Angular Limits

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*NRAO Green Bank*

2012 September 14, version 4

### ABSTRACT

This note records the measurements of the NRAO 43m Telescope coordinate location. The tracking limits are tabulated in Azimuth and Elevation limits due to the Hour Angle, Declination mounting structure. The lowest observable Elevation is tabulated for Azimuth values.

*Change Record*

Revision	Date	Author	Sections/Pages Affected
			Remarks
1.0	2012-Sep-01	G. Langston	All
			Initial version.
2.0	2012-Sep-11	G. Langston	All
			Add Mike Holstine's survey information and Rick Fisher's VLBI coordinates from the web
3.0	2012-Sep-11	G. Langston	All
			Clarify Coordinate definitions and add second measurement of the telescope position
4.0	2012-Sep-14	G. Langston	Geocentric Coordinates
			Jon Romney provided the latest VLBA correlator coordinates.

## 1. Background

The NRAO 43m telescope has participated in many world VLBI observations and from these observations the precise telescope coordinates have been determined. Also the physical coordinate of the telescope has been obtained from geodetic surveys. The telescope coordinates are obtained from both measurement methods.

The NRAO 43m telescope is the worlds largest equatorial mount telescope. The equatorial mount provides very good tracking capability for objects at the zenith. However the telescope has limited hour angle coverage and can not track low Elevation sources in the north.

The 43m telescope Hour Angle coverage is has different limits at different Declinations. The telescope structure is protected by limit switches that have different behaviors at different telescope Declinations.

## 2. Geocentric Coordinates

Rick Fisher, of NRAO, documented the 140ft VLBI coordinates in the 1980s. The reference planes are the equator, the Greenwich Meridian, and the plane through the earth's axis and perpendicular to the Greenwich Meridian, call it the east-west plane. A telescope's rectangular coordinate components (x,y,z) are

**X = 882880.0208m** Distance from the east-west plane, Greenwich being positive x

**Y = -4924482.4385m** Eastward distance from the Greenwich Meridian

**Z = 3944130.6438m** Northward distance from the equator

Astronomical pointing of the telescope requires accurate knowledge the telescope location. The motion of the Green Bank site is relative to observations made at modified julian date EPOCH=50449 (1997 January 01), from the geodetic solutions from the Goddard Space Flight Center. The position was:

**X = 882879.8868m** DX/DT: -0.01380 m/yr

**Y = -4924482.3042m** DY/DT: 0.00020 m/yr

**Z = 3944130.6915m** DZ/DT: 0.00010 m/yr

The most recently available 43m coordinates were provided by Jon Romney, of NRAO, who reports the VLBA correlator uses the following coordinates. **These coordinates should be used for calculations of the 43m position:**

$$\mathbf{X} = \mathbf{882879.7266m} \quad \text{DX/DT: } -0.01487 \text{ m/yr}$$

$$\mathbf{Y} = \mathbf{-4924482.2950m} \quad \text{DY/DT: } 0.00057 \text{ m/yr}$$

$$\mathbf{Z} = \mathbf{3944130.6925m} \quad \text{DZ/DT: } 0.00144 \text{ m/yr}$$

The epoch for these coordinates was April 26, 2011 (MJD=54466). This date should be used for computation of 43m motion with time. The differences between coordinates may be taken as upper limits on the errors of measurement of position. These latter coordinates should be adopted for calculation of spacecraft ranges and range rates.

The correlator software includes a correction for the AXISOFF=14.9390m parameter, which is the vertical distance offset between the hour angle axis and the declination axis.

The astronomical longitude, latitude, and elevation of the telescope are -79 50' 06."365, +38 26' 12."448, and 0.88087 km, respectively. These coordinates were compared with the Geodetic survey markers near the telescope (See Fig. 1). Appendix A more historical measurements of the 43m position and includes a document containing measurements of the distance between survey markers and the telescope.

### 3. Hour Angle Limits

The 43m drive system allows motion over the Hour Angle range -108.5 to 108.5 degrees. The drive system allows motion over the Declination range -46.9 to 88 degrees. However components of the telescope and structures near the telescope prevent telescope motion over this full range.

The hardware travel limits are set several degrees inward from the drive limits to assure the telescope can not travel at high speed through the limits. The motion is limited by contact switches that have a "hysteresis" of a few degrees. This hysteresis further prevents motion to a few degrees from the travel limits.

Table 1 lists a representative selection of Hour Angles and Declinations and the corresponding telescope Azimuths (Azimuth = 0 is North) and Elevations. The Hour Angle, Declination limits are provided by Tim Weadon.

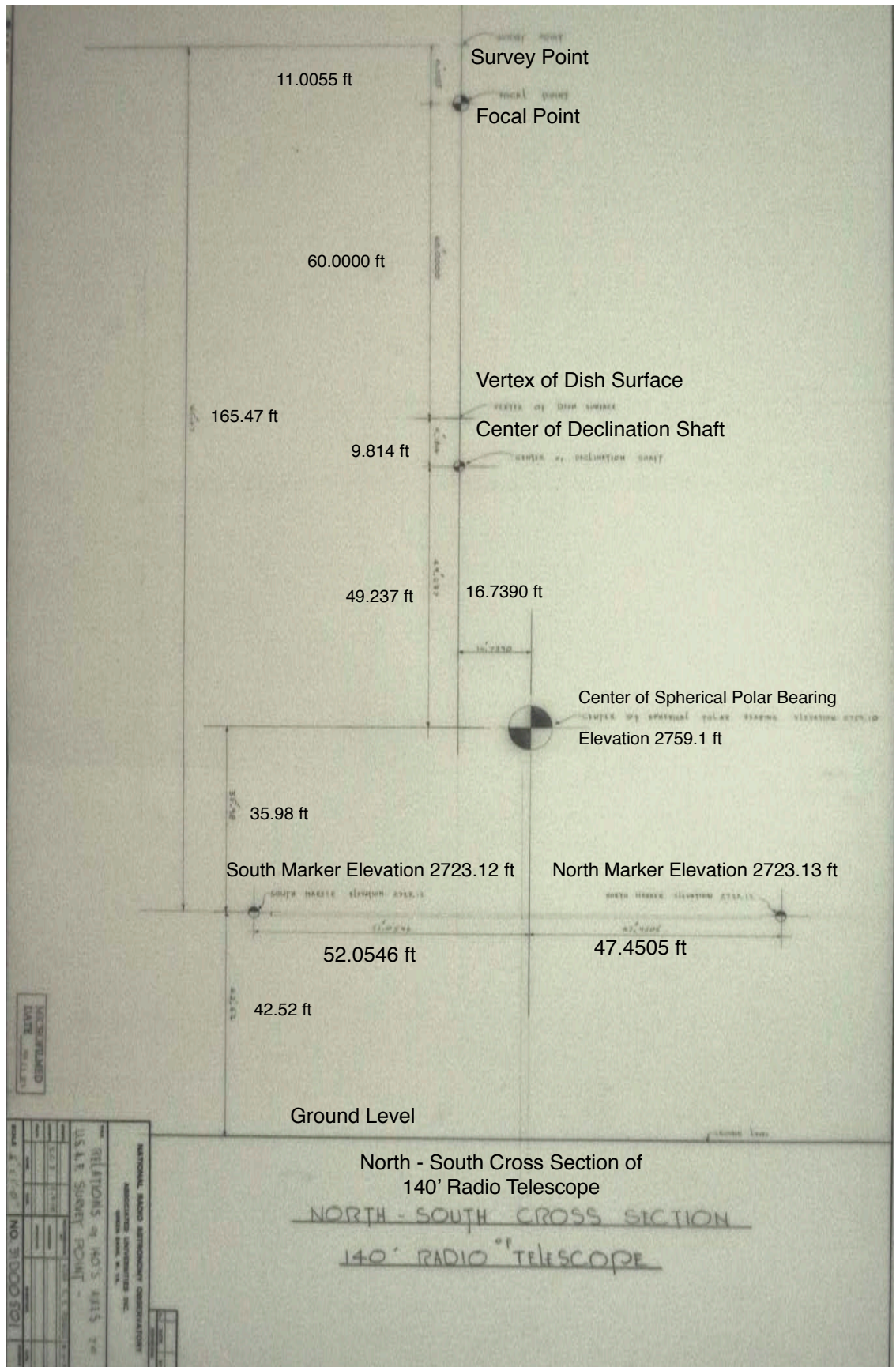


Fig. 1.— Schematic drawing of the relationship between the Geodetic markers and the Telescope hour-angle, declination axes.

#### 4. Horizon Limits

The 43m telescope sits in Deer Creek valley with the Allegheny mountains to the east and west. North and South, the visible horizon is lower.

Wes Sizemore kindly determined the horizon Elevations angles at the location of the 43m telescope based on a computer-based topographical map.

Tables 2 A,B list a representative selection of Azimuths and the Elevations at these Azimuths. The highest Elevation limits are due west of the telescope.

#### 5. Summary

The 43m telescope Azimuth and Elevation tracking limits are presented. At a sizable fraction of the telescope Azimuths, the Hour Angle, Declination limits are above the horizon.

Thanks to Wes Sizemore for his careful determination of the 43m horizon. Frank Ghigo, Mike Holstine, Jon Romney, Butch Wirt and Tim Weadon provided survey and limit measurements.

### REFERENCES

This and all other EDIR memos are available on the web at:

<http://www.gb.nrao.edu/electronics/edir>

#### A. Historical measurements and Telescope Geodetic Survey Log

In the interest of completeness, we include to measures of the 43m position based on survey and VLBI measurements. Frank Ghigo provided these two measurements.

NAD 83 value from NGS data base (1993):

Designation	N. Latitude	W. Longitude
GREEN BANK VLBI 7204		
NRAO 140	38 26 16.13751	79 50 8.79231
Height above MSL (geoid)	844.7 meters (NGVD 29)	

And the following is the VLBI position converted to geodetic coordinates:

VLBI position from Navy 1994-15 reference frame converted to GRS80 ellipsoid:

Designation	N. Latitude	W. Longitude
140-ft (VLBI):	38 26 16.161	79 50 8.799

Hour Angle (deg)	Declination (deg)	Azimuth (deg)	Elevation (deg)
-1.00	-41.01	-179.232	10.548
-10.00	-41.01	-172.353	10.030
-20.00	-41.01	-164.874	8.482
-30.00	-41.01	-157.706	5.967
-43.65	-41.01	-148.603	1.132
-43.65	-31.20	-143.245	9.367
-67.99	-31.20	-127.342	-4.068
-67.99	-11.10	-112.638	9.694
-102.55	-11.10	-91.091	-16.661
-102.55	0.00	-82.121	-9.800
-102.55	10.00	-74.364	-3.421
-102.55	20.00	-66.710	3.020
-102.55	30.00	-58.965	9.406
-102.55	40.00	-50.932	15.617
-102.55	50.00	-42.411	21.519
-102.55	60.00	-33.198	26.953
-102.55	70.00	-23.112	31.732
-102.55	82.00	-9.703	36.293
0.00	82.00	-0.000	46.437
102.30	82.00	9.717	36.326
102.30	70.00	23.156	31.809
102.30	60.00	33.270	27.061
102.30	50.00	42.509	21.651
102.30	40.00	51.053	15.769
102.30	30.00	59.104	9.574
102.30	20.00	66.861	3.200
102.30	10.00	74.522	-3.232
102.30	0.00	82.281	-9.606
102.30	-11.86	91.880	-16.922
69.20	-11.86	112.397	8.306
69.20	-20.00	118.418	2.795
69.20	-31.20	126.634	-4.825
44.70	-31.20	142.487	8.871
44.70	-41.01	147.939	0.700
30.00	-41.01	157.706	5.967
20.00	-41.01	164.874	8.482
10.00	-41.01	172.353	10.030
1.00	-41.01	179.232	10.548

Table 1: Table of Hour Angle, Declinations limits, with corresponding Azimuth and Elevations for the 43m Telescope.



Azimuth (deg)	Elevation (deg)
-177.8	1.429
-171.6	1.499
-165.7	1.273
-165.7	1.273
-163.5	1.008
-160.6	0.159
-156.5	-0.300
-156.0	-0.330
-150.4	0.071
-146.2	0.327
-140.7	-0.380
-129.8	1.808
-124.3	2.566
-112.5	4.240
-98.2	4.020
-82.8	5.040
-68.4	4.036
-56.3	2.697
-46.9	4.134
-31.8	4.360
-26.0	3.536
-19.6	1.689
-12.7	2.017
-5.30	2.351

Table 2: Table of Elevations of the Horizon as a function of the 43m Telescope Azimuth (part A).

Azimuth (deg)	Elevation (deg)
2.2	1.600
9.6	1.154
16.3	0.507
16.8	0.335
24.3	0.000
27.4	0.016
34.9	0.430
35.3	0.343
38.1	0.565
43.8	0.018
50.2	0.420
58.8	0.779
64.6	1.494
66.8	2.243
68.6	3.164
73.0	3.275
79.7	3.508
86.7	4.228
93.7	4.115
100.7	3.976
107.4	3.748
113.6	2.407
119.2	2.291
128.9	3.479
132.9	2.923
136.5	2.919
139.6	2.490
142.4	1.977
147.1	2.510
148.5	2.498
150.8	2.530
153.3	1.970
158.4	1.630
164.0	1.996
169.9	1.850
176.0	1.615

Table 3: Table of Elevations of the Horizon as a function of the 43m Telescope Azimuth (part B).

43M / 140FT LIMITS

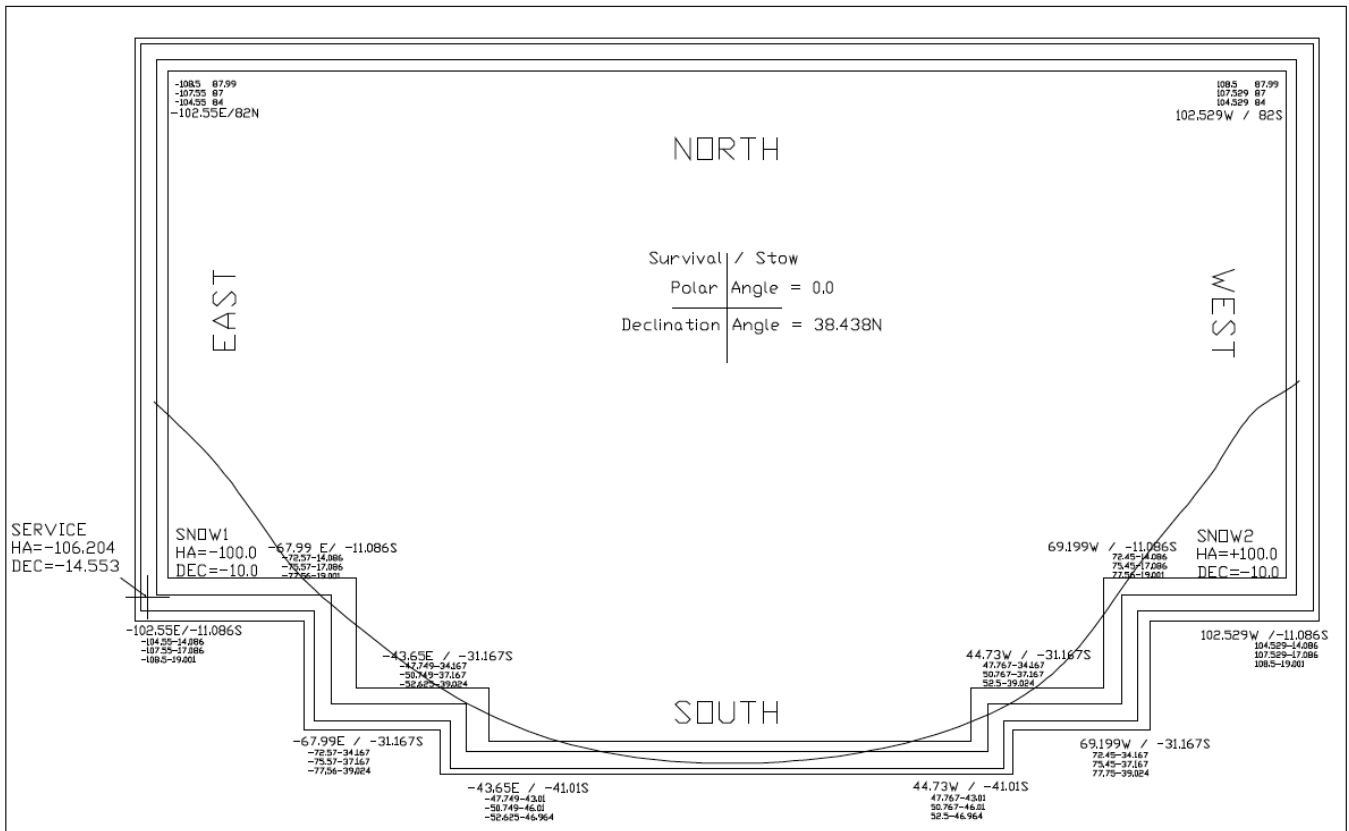


Fig. 2.— Hour Angle, Declination Limits.

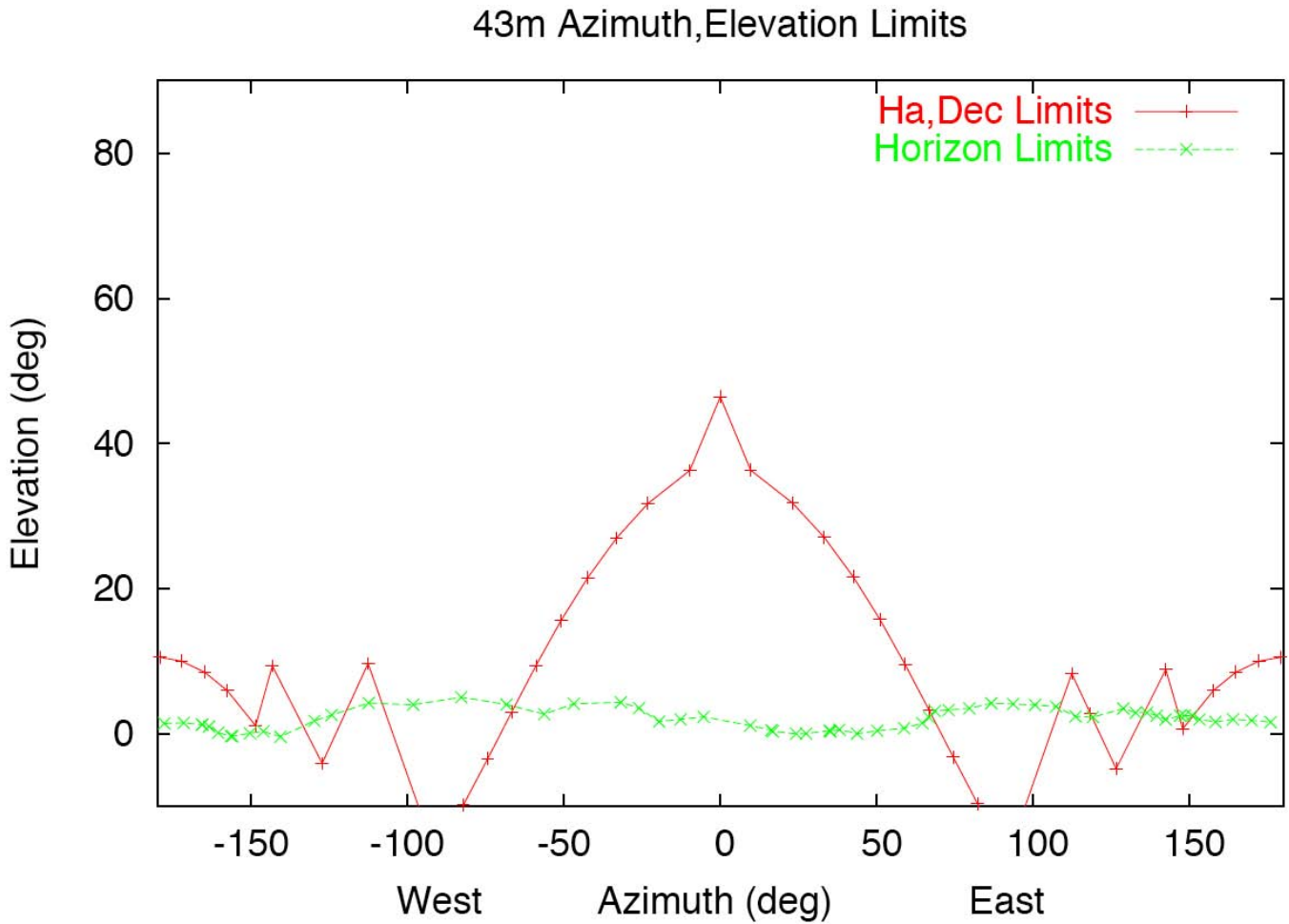


Fig. 3.— Azimuth-Elevation Limits due to Hour Angle, Declination Constraints (Red) and Horizon constraints (Green). For an astronomical object to be visible at a specified azimuth and elevation, the coordinate must be above both the red and green curves. North is at Azimuth = 0, and South is at Azimuth = 180.

Height: 812.62 meters.

Scot Ransom's *presto* database of telescopes has geodetic (not geocentric) coordinates:

Designation	N. Latitude	W. Longitude
GB 140FT	38 26 15.409	79 50 9.613
Height: 880.87		

1 National Geodetic Survey, Retrieval Date = JANUARY 5, 1998

HW3239 \*\*\*\*\*

HW3239 DESIGNATION - GREEN BANK VLBI 7204 NRAO 140

HW3239 PID - HW3239

HW3239 STATE/COUNTY- WV/POCAHONTAS

HW3239 USGS QUAD - GREEN BANK (1979)

HW3239

HW3239 \*CURRENT SURVEY CONTROL

HW3239

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HW3239\* NAD 83(1995)- 38 26 16.13756(N) 079 50 08.79264(W) ADJUSTED

HW3239\* NAVD 88 - 844.7 (meters) 2771. (feet) VERTCON

HW3239

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HW3239 X - 882,880.434 (meters) COMP

HW3239 Y - -4,924,483.834 (meters) COMP

HW3239 Z - 3,944,130.882 (meters) COMP

HW3239 LAPLACE CORR- -0.95 (seconds) DEFLEC96

HW3239 ELLIP HEIGHT- 813.90 (meters) GPS OBS

HW3239 GEOID HEIGHT- -30.62 (meters) GEOID96

HW3239

HW3239 HORZ ORDER - A

HW3239 ELLP ORDER - FIRST CLASS I

HW3239

HW3239.The horizontal coordinates were established by VLBI observations  
HW3239.and local terrestrial surveys and adjusted by the National Geodetic  
HW3239.Survey in April 1992.

HW3239.This is a SPECIAL STATUS position. See SPECIAL STATUS under the  
HW3239.DATUM ITEM on the data sheet items page.

HW3239

HW3239.The NAVD 88 height was computed by applying the VERTCON shift value to  
HW3239.the NGVD 29 height (displayed under SUPERSEDED SURVEY CONTROL.)

HW3239

HW3239.The X, Y, and Z were computed from the position and the ellipsoidal ht.

HW3239

HW3239.The Laplace correction was computed from DEFLEC96 derived deflections.

HW3239

HW3239.The ellipsoidal height was determined by GPS observations

HW3239.and is referenced to NAD 83.

HW3239

HW3239.The geoid height was determined by GEOID96.

HW3239

HW3239;            North    East    Units    Scale    Converg.

HW3239;SPC WV S   - 160,220.769  701,636.521  MT 0.99993542 +0 43 11.0

HW3239;UTM 17   - 4,255,035.224  601,606.705  MT 0.99972714 +0 43 25.7

HW3239

HW3239                    SUPERSEDED SURVEY CONTROL

HW3239

HW3239 NAD 83(1986)- 38 26 16.13751(N)  079 50 08.79231(W)  ADJUSTED

HW3239 NGVD 29   -    844.7    (meters)  2771.    (feet)  GPS OBS

HW3239

HW3239.Superseded values are not recommended for survey control.

HW3239.NGS no longer adjusts projects to the NAD 27 or NGVD 29 datums.

HW3239.See file format.dat to determine how the superseded data were derived.

HW3239

HW3239\_STABILITY: D = MARK OF QUESTIONABLE OR UNKNOWN STABILITY

HW3239\_SATELLITE: THE SITE LOCATION WAS REPORTED AS NOT SUITABLE FOR

HW3239+SATELLITE: SATELLITE OBSERVATIONS - 1986

HW3239

HW3239 HISTORY - Date Condition Recov. By

HW3239 HISTORY - 1976 MONUMENTED NASA

HW3239 HISTORY - 1986 GOOD

HW3239

HW3239 STATION DESCRIPTION

HW3239

HW3239'DESCRIBED BY NAT AERO SPACE ADMIN 1976

HW3239'PRIMARY SCIENTIFIC PURPOSE - MEASUREMENTS SUPPORTING THE DETERMINATION

HW3239'OF PLATE MOTION, PLATE STABILITY, AND POLAR MOTION /EARTH ROTATION.

HW3239'SITE DESCRIPTION - THE STATION IS LOCATED IN EASTERN WEST VIRGINIA AT

HW3239'THE NATIONAL RADIO ASTRONOMY OBSERVATORY (NRAO) OPERATED BY THE

HW3239'NATIONAL SCIENCE FOUNDATION. THE 140-FOOT RADIO TELESCOPE AND THE

HW3239'NUMBER 3 85-FOOT ANTENNA HAVE BEEN USED FOR VLBI MEASUREMENTS.

HW3239'THE MARK IS A REFERENCE POINT ON THE 43-METER (140-FOOT) RADIO

HW3239'TELESCOPE.

HW3239'SITE TOPO MAP - CASS, WV., USGS.

HW3239'GEOLOGICAL PROVINCE - THE VALLEY AND RIDGE PROVINCE

HW3239'LOCAL GEOLOGY - PALEOZOIC CONSOLIDATED SEDIMENTARY ROCKS

HW3239

HW3239 STATION RECOVERY (1986)

HW3239

HW3239'RECOVERED 1986

HW3239'RECOVERED IN GOOD CONDITION.