GBT Memo No. 22

A SUMMARY OF WIND STATISTICS FOR GREEN BANK

D. E. Hogg and J. Nance

October 26, 1989

As input for the design of the Green Bank Telescope it is important to have an estimate of the highest wind speed likely to be experienced during the nominal lifetime of the telescope. In an LFST report von Hoerner (1966) presented detailed observations extending over a period of two years. From these he concluded that there is less than a 1 percent chance that a wind of speed 100 mph will occur in an interval of 30 years. He also noted that the wind speed measured at the 300-ft site is less than that at the 85-1 (Tatel) telescope, by as much as 5 mph for winds between 15 and 25 mph, and by up to 9 mph for winds in excess of 40 mph.

Since von Hoerner's report, a much more extensive data base on wind speeds has been compiled. The interferometer operators record the maximum value of the wind speed observed during each eight hour shift. Recently Len Howell has been constructing a computerized version of these data. For each day the greatest value from the three shifts is entered into a computer file, along with other information such as cloud cover, precipitation, and temperature. Len and the interferometer operators are working back into the records as time permits, and currently have available all data from the present back to 1974 logged into the computer. Len supplied us with a LOTUS-style disk copy of these data.

There are three notes of caution to be made. First, the data come variously from either the wind tower near the interferometer control building or from a tower at the Tatel telescope. They are therefore useful in describing the wind that is typical of Green Bank, but can not be used at all to explore differences in wind statistics from place to place on the site. Second, there was a period of a few months when the Green Bank anemometer appeared to show systematically higher values than expected from the weather station in Elkins. The instrument was changed and the readings returned to normal. However, the date of the problem is difficult to reconstruct, and so no attempt has been made to remove any data. Finally, there is some quantization in the wind speeds as recorded. For example, a speed of 15 mph appears 10 times more frequently than do speeds of 14 or 16 mph. We have therefore binned the data to smooth out this effect.

The data are summarized in Table 1. The first part of the table gives the frequency of occurrence of wind speeds in intervals that are 5 mph in width. From this follows directly the function f(V) defined to be the probability that the maximum wind speed on a given day will fall into a 5 mph bin of a given value. The second part of the table shows the number of days on which the wind speed exceeded a given value. From this follows directly the function F(V), defined as the probability of having a maximum wind greater than a given value. We have attempted to estimate the uncertainty in F(V) by using the square root of the number of occurrences; these uncertainties are also shown in Table 1.

As we tabulated the data it seemed clear that the high winds occurred preferentially in the first part of the observing period. We therefore split the data base into two parts, and have tabulated the results in Tables 2 and 3.

To estimate the survival wind, we plot the data from Table 1 in Figure 1. The data are well-fitted by an exponential function of the form expected using the Weibull model distribution for wind speed (Justus 1985). The model can be expressed as (Justus equation 33.13)

$$p(V > V_0) = \exp[-V_0/A)^k] \qquad (1)$$

where p is the probability that the wind speed V exceeds a given value V_0, A is a scaling term, and k is called the "shape factor". The range of k is typically between 1.2 and 3.5. The best fit to our data is k = 1.61.

Also shown in Figure 1 are the early and late halves of the data. They follow generally the same trend in wind speed, but differ from each other by an amount that is greater than the suggested uncertainties. Perhaps the figure merely emphasizes the well-known result that the weather is highly variable on time scales of years.

In order to estimate the survival wind, we have plotted the function F(V) on an expanded scale in Figure 2. We have added a point representing the highest wind speed recorded in Green Bank in 30 years (74 mph; von Hoerner 1989). We then extrapolate the curve of equation 1 to a probability of 1 percent of one day in thirty years (a probability of 9.1×10^{-7}), and find the survival wind speed to be Vs = 94 mph.

References

Justus, C. G. 1985, in Handbook of Applied Meteorology, ed. David D. Houghton (New York:John Wiley & Sons), p.915.
von Hoerner, S. 1966 LFST Memo Number 16.
von Hoerner, S. 1989 NLSRT Memo Number 64.

TABLE 1. ALL WIND DATA (1974-1987)

Range In V	No. Obs.	f(V)	V	No. Obs.	F(V)	Uncertainty
3 - 7	231	0.045	0	5110	1.000	
8 - 12	2103	0.412	5	5101	0.9982	
13 - 17	1207	0.236	10	4616	0.9033	
18 - 22	812	0.159	15	2628	0.5143	
23 - 27	280	0.055	20	1390	0.2720	
28 - 32	206	0.040	25	701	0.1372	.00518
33 - 37	101	0.020	30	442	0.0865	.00411
38 - 42	86	0.0168	35	252	0.0493	.00311
43 - 47	32	0.0063	40	150	0.0294	.00240
48 - 52	33	0.0065	45	73	0.0143	.00167
53 - 57	10	0.0020	50	41	0.00802	.00125
58 - 62	1	0.0002	55	12	0.00235	.00068
≥ 63	4	0.0008	60	5	0.00098	.00044
TOTAL	5106		65	3	0.00059	.00034

TABLE 2. WIND DATA (1974 - 1980)

Range In V	No. Obs.	f(V)	V	No. Obs.	F(V)	Uncertainty
3 - 7	133	0.0521	0	2554	1.000	
8 - 12	883	0.3460	5	2548	0.9977	
13 - 17	523	0.2049	10	2337	0.9150	
18 - 22	478	0.1873	15	1473	0.5767	
23 - 27	174	0.0682	20	937	0.3669	
28 - 32	129	0.0505	25	509	0.1993	0.00883
33 - 37	81	0.0317	30	344	0.1347	0.00726
38 - 42	81	0.0317	35	225	0.0881	0.00587
43 - 47	27	0.0106	40	137	0.0536	0.00458
48 - 52	28	0.0110	45	65	0.0255	0.00316
53 - 57	10	0.00392	50	36	0.0141	0.00235
58 - 62	1	0.00039	55	12	0.00470	0.00136
≥ 63	4	0.00157	60	5	0.00196	0.00088
TOTAL	2552		65	3	0.00117	0.00068

TABLE 3. WIND DATA (1981 - 1987)

Range In V	No. Obs.	f(V)	V	No. Obs.	F(V)	Uncertainty
3 - 7	98	0.0384	0	2556	1.000	
8 - 12	1220	0.4777	5	2553	0.9988	
13 - 17	684	0.2678	10	2279	0.8916	
18 - 22	334	0.1308	15	1155	0.4519	
23 - 27	106	0.0415	20	453	0.1772	0.00833
28 - 32	77	0.0301	25	192	0.0751	0.00542
33 - 37	20	0.00783	30	98	0.0383	0.00387
38 - 42	5	0.00196	35	27	0.0106	0.00203
43 - 47	5	0.00196	40	13	0.00509	0.00141
48 - 52	5	0.00196	45	8	0.00313	0.00111
53 - 57	0	0	50	5	0.00196	0.00087
58 - 62	0	0	55	0	0	
≥ 63	0	0	60	0	0	
TOTAL	2554		65	0	0	

GBT Site - Green Bank, WV
Immediate Area and Site Information

GBT Construction Site - NRAO, Green Bank, Pocahontas County, West Virginia. Located in east-central West Virginia on Route 28/92.

Area railroad service: CSX Transportation, WV CSX State Office, Chafin Bldg., Suite 910, 517 9th Street, Huntington, WV 25701, 304-522-5711.

CSX Siding - Caldwell, WV. Caldwell is 61 miles south of GB. Caldwell is three miles east of Lewisburg on Route 60 and 3 miles from two exits of Interstate 64. There is staging area and improved bridge to highway. The large and heavy things for the Bath County (Virginia) Pump Storage Facility came in here during 1986-88. They also used much of the highway between Caldwell and Green Bank. They used permits and blocked the road some of the time.

CSX Siding - Cheat Bridge, WV. Cheat Bridge is on top of Cheat Mountain 20 miles north of GB on Route 250/92. Long, steep, curvy roads. Two miles at 7.5% downgrade. Seems to be some question as to how long it may be open.

Rail car size restrictions - Height, length, weight, bridges, tunnels, sharp turns, permits? CSX could provide if required.

Road conditions:

Nationwide interstates - weight limits - GVW of 80,000#.

Secondary roads - GVW of 73,000#.
ICC Permits are needed over 73,000#.
Bonds for bridges may be needed for 100,000#.
Width: -- 10' - permits are needed for >12'.
Length: -- 60'.

Nearest interstate highway - Interstate 64 is 55 miles south on state Route 92 at White Sulphur Springs. On I64, Exit 175 has east and west bound exits while Exit 181 has a west bound exit only.

Nearest airports - Greenbrier Airport, Lewisburg, WV; Elkins Airport, Elkins, WV; NRAO private airstrip in Green Bank, official NRAO business only, prior permission required, 304-456-2231.

Nearest ready-mix concrete - Moore's Ready-Mix, Inc., Green Bank, WV, (6 miles south of Green Bank).

Nearest motor freight company - Burns Motor Freight, Inc., Marlinton, WV, (32 miles south of Green Bank).

Nearest crane service - Dixon Auto Truck Center, White Sulphur Springs, WV; RBS, Inc., N. Caldwell, WV; Worlledge Const. Co., Mt. Lookout, WV.

Nearest medical/dental clinic - Deer Creek Clinic, Green Bank, WV.

Nearest hospitals - Marlinton, WV, 32 miles south; Elkins, WV, 55 miles north.

Nearest schools - Green Bank Elementary and Middle School (K-8), Green Bank; Pocahontas County High School, 11 miles south of Green Bank.

Nearest churches - Complete listing in county phone directory.

Nearest fire and rescue squads - Several are located within 15 miles.

Nearest landfill - Pocahontas County Land Fill, 12 miles south.

Nearest crushed stone suppliers - See local phone directory.

Nearest cement wholesalers - Capital Cement Corp., Martinsburg, WV; Dundee Cement Co., Charleston, WV.

RLF
6/15/90

ENROLLED

W.VA.

House Bill No. 2

(By Mr. Speaker, Mr. Flannery)

[Passed August 9, 1956; in effect from passage.]

AN ACT to amend the code of West Virginia, one thousand nine hundred thirty-one, as amended, by adding thereto a new chapter, numbered and designated thirty-seven-a, consisting of sections one through six, article one, enacting zoning restrictions governing the use of electrical equipment and the emanation of electrical impulses therefrom within a ten-mile radius of any radio astronomy facility in the state of West Virginia.

Whereas, The National Science Foundation has selected, subject to zoning and other arrangements, Green Bank, Pocahontas county, West Virginia, as the site for the installation and operation of a major radio astronomy facility in the state of West Virginia; and

WHEREAS, To avoid interference caused by emanations of electrical impulses from electrical equipment functioning in the area surrounding the proposed site, it is necessary that such area be zoned to avoid interfering electrical emanations; and

WHEREAS, It is in the public interest to encourage the economic improvement and development of all areas in this state and to promote educational and scientific research within this state; and

WHEREAS, The establishment of said radio astronomy facility in an undeveloped area in this state will encourage and contribute to the economic improvement and development of such area and will promote educational and scientific research within this state; and

WHEREAS, The establishment and operation of said radio astronomy facility within the state of West Virginia will lend great prestige to this state and stimulate tourist trade to said area; and

WHEREAS, The establishment and operation of said radio astronomy facility within the state of West Virginia is contingent upon the area within ten miles of the site thereof being substantially free of emanations from unshielded electrical

equipment of such field strength as to interfere with the efficient and proper functioning of said radio astronomy facility; and

WHEREAS, The restrictions necessary to insure freedom from such emanations in such area are reasonable and proper and the benefits to be derived therefrom are substantial; therefore

Be it enacted by the Legislature of West Virginia:

That the code of West Virginia, one thousand nine hundred thirty-one, as amended, be amended by adding thereto a new chapter, numbered and designated thirty-seven-a, consisting of sections one through six, article one, to read as follows:

CHAPTER 37-A. ZONING

Article 1. Radio Astronomy Zoning Act.

Section 1. *Short Title.*—This article shall be known as the "Radio Astronomy Zoning Act."

Sec. 2. *Restrictions Within Two Miles of Facility.*—It shall be illegal to operate or cause to be operated any electrical equipment within a two-mile radius of the reception equipment of any radio astronomy facility if such operation causes interference with reception by said radio astronomy facility of radio waves emanating from any nonterrestrial source.

Sec. 3. *Restrictions Within Ten Miles of Facility.*—It shall be unlawful to operate or cause to be operated any electrical equipment within a radius of ten miles of the reception equipment of any radio astronomy facility, if the instantaneous peak field strength of the emanation from such electrical equipment is in excess of:

Ten microvolts per meter measured at a distance of ten feet from such electrical equipment, if such electrical equipment is located less than three miles from said reception equipment; ten microvolts per meter measured at a distance of fifteen feet from such electrical equipment, if such electrical equipment is located less than four miles from said reception equipment; ten microvolts per meter measured at a distance of twenty feet from such electrical equipment, if such electrical equipment is located less than five miles from said reception equipment; five microvolts per meter measured at a distance of fifty feet from such electrical equipment, if such electrical equipment is located less than six miles from said reception equipment; six microvolts per meter measured at a distance of fifty feet from such electrical equipment, if such electrical equipment is located less than seven miles from said reception equipment; seven microvolts per meter measured at a distance of fifty feet from such electrical equipment, if such electrical equipment is located less than eight miles from said reception equipment; eight microvolts per meter measured at a distance of fifty feet from such electrical equipment, if such electrical equipment is located less than nine miles from such reception equipment; nine microvolts per meter measured at a distance of fifty feet from such electrical equipment, if such electrical equipment is located less than ten miles from said reception equipment: *Provided, however,* That notwithstanding the provisions of this section, it shall not be unlawful to operate or cause to be operated any electrical equipment so constructed or shielded as not to cause interference with the reception by such radio astronomy facility of radio waves emanating from a nonterrestrial source.

Sec. 4. *Exemption for Existing Equipment.*—Nothing in this article shall be construed to render unlawful the continued operation of electrical equipment within a ten-

mile radius of a radio astronomy site if such equipment existed within such distance of such site previous to the commencement of operation of such radio astronomy facility; or if such equipment is intended as a replacement for such existing equipment.

Sec. 5. *Penal Provisions.*—Any person knowingly operating or causing to be operated electrical equipment in violation of the provisions of this article shall be subject to a fine of fifty dollars plus an additional fine of fifty dollars for each day such electrical equipment is knowingly operated after receipt by such person of written notice from the prosecuting attorney of the county in which the radio astronomy facility is situated that such operation is in violation of the provisions of this article.

Sec. 6. *Injunctive Relief.*—The operation of any electrical equipment in violation of this article shall be enjoined by the circuit court of the county in which such electrical equipment is located upon petition filed by the prosecuting attorney of such county or by the attorney general of this state irrespective of any other legal remedy available.

The Joint Committee on Enrolled Bills hereby certifies that the foregoing bill is correctly enrolled.

.....
Chairman Senate Committee

.....
Chairman House Committee

Originated in the House of Delegates

Takes effect.....passage.

.....
Clerk of the Senate

.....
Clerk of the House of Delegates

.....
President of the Senate

.....
Speaker House of Delegates

The within.....this the.....

day of....., 1956.

.....
Governor.