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The climate of the Northeast : heating degree-days

W. H. Dickerson

NORTHEAST REGIONAL RESEARCH PUBLICATION

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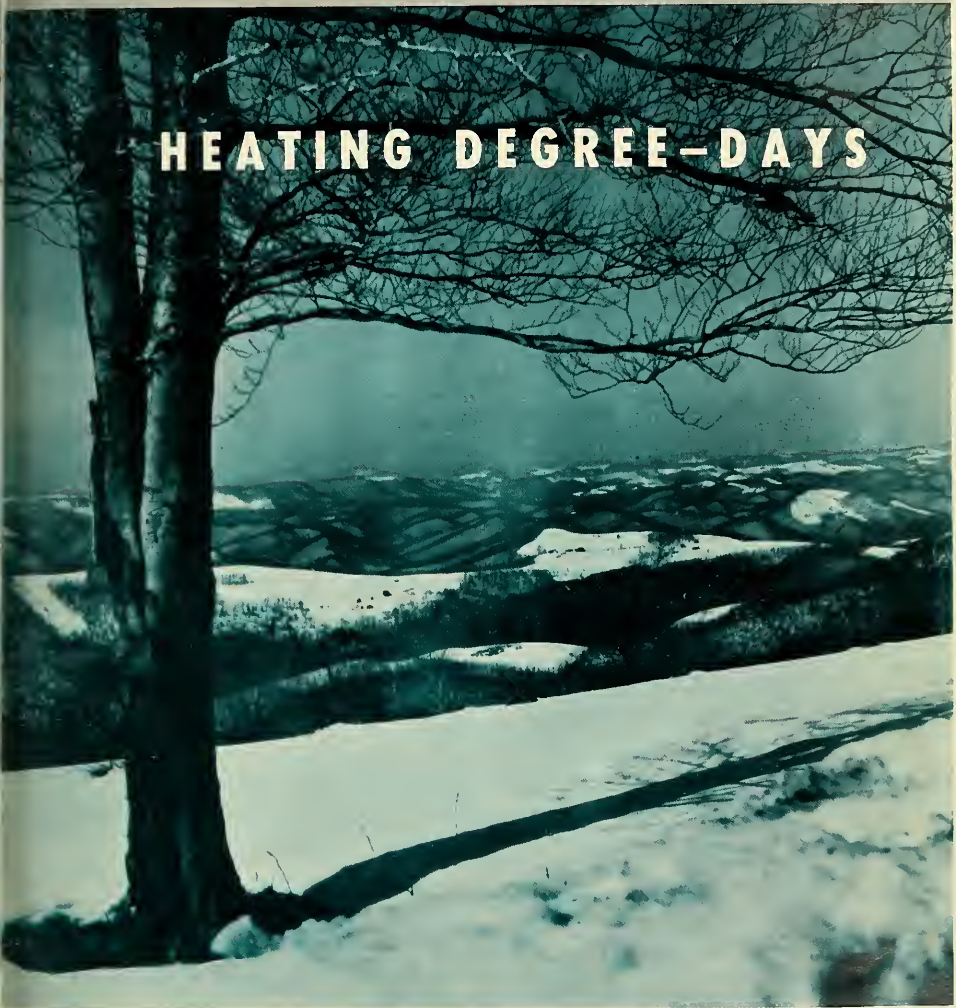
THE CLIMATE OF THE NORTHEAST



HEATING DEGREE-DAYS

BULLETIN 483T

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THE CLIMATE OF THE NORTHEAST
HEATING DEGREE-DAYS

W. H. Dickerson, Agricultural Engineer

THE HDD, or heating degree-day, has been defined as "a unit based on the difference between 65° F and the daily mean temperature when the latter is below 65° F" (2). Thus, the number of degree days for a given day is equal to 65° F minus the average temperature for the day, with negative differences being counted as zero. The HDD for any period such as a month, season, or year is secured by accumulating the daily values over the period.

The concept of the HDD is credited to the American Gas Industry. The theory (verified by extensive statistics) is that an average outdoor temperature of 65° F is the lowest permissible without supplying heat to a building which is used for human occupancy and is to be maintained at approximately 70° F. When the daily mean temperature drops below 65° F, heat is required and the amount of energy or fuel required is proportional to the number of HDD. The method may be applied to the estimation of energy requirements for maintaining indoor temperatures other than 70° F. For instance, according to Strock and Hotchkiss (11), the industrial heating degree day is sometimes based on 55° or 45°, instead of 65°, depending upon the temperature requirements of the structure.

Heating degree-day data may be used as a basis for planning the insulation and heating plants of buildings, and also for estimating the fuel requirements where heat losses can be calculated. Other uses include: checking the efficiency of heating plant operation for commercial buildings, in sales promotional work of insulating materials, or in special types of energy-use (such as electric heating), and for the estimation of fuel consumption to regulate the delivery of fuel by the distributor to the consumer. Current data on HDD may also provide a valuable public relations tool for fuel suppliers. Variations in the weather not readily discernible or remembered by the customer which may cause complaints can be explained where these were due to temperature aberrations.

An example of the application of the HDD concept in agricultural production is found in the work reported by McCune (8). In experiments with the use of electric heat in the production of nursery stock, it was determined that energy consumption for soil heating was related to HDD during the heating period. A basis was provided for estimating energy requirements for various weather conditions.

The purpose of the work reported herein has been to compile, analyze, and prepare for publication basic climatological data on heating degree-days for the Northeastern United States. It is expected that the data will be most useful to engineers and others concerned with practical problems relating to heating, insulation, and construction. The information may also be of value for the development of new applications, methods, or theories, which will extend the usefulness of climatological data. As an example, data made available by the NE-35 program have provided a basis for calculating a multiple regression equation to be used in estimating normal annual HDD. The derivation, uses, and possible advantages of the equation are discussed in a later section of this bulletin.

OUTLINE OF WORK ON HDD

The NE-35 Committee and its Work

This bulletin is one of a series on **The Climate of the Northeast** which is being sponsored by the Northeast Regional Technical Committee on Climatology, commonly referred to as the NE-35 Committee. The committee is composed of representatives of agricultural experiment stations of the region who cooperate with the Weather Bureau in the application of climatology to agriculture. The participating experiment stations and federal agencies are listed elsewhere, as are the titles of bulletins published to date. In addition, Gosslee and Brumbach (4) and Kolega and Palmer (6) have reported the results of work with HDD, supported in part by NE-35.

Source of Data for the Analysis

Data on HDD were compiled as a part of the basic plan for the regional research. Each cooperating experiment station provided, in accordance with the decision of the technical committee, punched cards containing the weather data for selected weather stations. The original data were secured by the Weather Bureau through its network of cooperative observers. Checking and verification of the data prior to its use in the NE-35 program were accomplished through the cooperation of Weather Bureau personnel in the various states, and the Northeast Area Climatologist.

Computer Programs

Information presented in the following sections of this report was secured almost entirely by the execution of electronic computer programs, which tabulated, summarized, and analyzed the raw data supplied by cooperating states. The computer programs were designed to:

A. Re-calculate the four-week period averages and standard deviations, as shown in Table 3.

B. Calculate the average annual HDD, including the estimated 14th period (which was not available for most stations), and the standard deviation.

C. Estimate the return period of the coldest four-week periods by the extreme value frequency distribution.

D. Test the homogeneity of variance between stations for the respective four-week periods and also for the annual means.

E. Calculate a multiple regression equation for estimating the mean annual HDD for a station from its latitude, elevation, and mean annual temperature.

EXPLANATION AND DISCUSSION OF RESULTS AND DATA

Station-Locator Map

The station numbers assigned by the Weather Bureau are shown on Map 1, (Page 25) adjacent to the circle representing the geographical location. These numbers are related to the alphabetical order of the station name within each state. Accordingly, low numbers refer to stations the initial letters of which are in the first portions of the alphabet.

Annual Mean And Standard Deviation

Table 2 is to be used in conjunction with the locator map. The state, station number, and county as well as elevation, latitude, and longitude of each station are shown in the first part of the table. Further information on these stations can be found in the Substation History publications of the U. S. Weather Bureau (17). Also given is the mean annual HDD and its standard deviation. The mean has been adjusted to account for Period 14. The estimate for this period was added to each year prior to calculation of the variance and standard deviation. The leap year date of February 29 was ignored. Table 1, a calendar of the climatological year, will clarify the period system used.

The annual mean and standard deviation is considered to be the most useful and important single statistic derived from the study. It is believed that the map of isolines of HDD, Map 2, is the most detailed and accurate representation that has been developed to date. The basis for this assertion is the station network density, which exceeds by far that previously available. It is advisable to insert a word of caution in using the data. The map is based on 156 stations, and should provide a good regional picture. It is true, however, that some individual stations, or small areas, may deviate significantly from the general picture. This is likely to be most pronounced in mountainous terrain, where differences in elevation and other orographic influences produce anomalies.

The usefulness of the standard deviation is based on the fact that the annual HDD totals follow the normal, or Gaussian, distribution, according to Thom (15). Most applications of HDD have been based on use of the mean. For some purposes, a probability estimate is useful. The mean and standard deviation establish probability relationships for data which are normally distributed. After plotting standard deviations of the annual means on a map of the Northeast, it became evident that regional differences, which had been anticipated, were not large and followed no readily discernible pattern. A statistical test, Bartlett's Test for Homogeneity (10), indicated a common variance for the region. Variances were then pooled, and the standard deviation thereby derived was 443 HDD. This provided the basis for construction of Figure 1. With the annual mean, the annual HDD for any frequency can be determined.

Four-Week Period Means and Standard Deviations

HDD were originally summarized in the NE-35 program by four-week periods of the climatological year. These data are shown in Table 3. Periods covering the summer months show zero or very low values for most stations, with only the coldest localities having any appreciable accumulation of HDD.

A test for homogeneity was made on the variances of the individual periods. No evidence of heterogeneity of variance was found among locations within periods covering the coldest portion of the year. Heterogeneity appeared in the warm periods, notably Periods 4, 5, 6, and 7. Over the region, the mean variance for a particular period was found to be related to mean HDD for that period. A standard deviation was calculated from the pooled variances for each period. These were then plotted against the corresponding average HDD and a smooth curve drawn through the points. Values of the standard deviation scaled from this curve were then used as a basis for constructing Figure 2. By selecting the mean HDD for any period and entering the graph at this value on the ordinate, the four-week period HDD for any frequency is readily determined.

The simplifying assumptions necessary for the construction of Figures 1 and 2 are probably not valid for every individual station and climatological period reported in Tables 2 and 3. Where this is suspected, the procedure outlined in Example 4, Page 6, should be followed to work out frequencies.

Extreme Value Analysis of HDD

Four-week period values were analyzed by the extreme value frequency method (Lieblein procedure) to estimate the probability of occurrence of cold periods (5), (7). Because of the length of the four-week sample in relation to the annual period, the extreme value method has little to recommend it over other frequency distributions, such as for example, the log normal, which could have been used. Frequencies were expressed as a "return period." Used in this manner, return period signifies the number of years within which a given number of HDD will be equaled or exceeded once on the average. These frequencies differ from those determined by the normal distribution, as explained in the previous section, although the differences are not large. The reason for this is that the coldest period (highest HDD) did not occur in the same climatological period each year. In the extreme value analysis, the highest four-week HDD for each year was selected and used in the frequency determination. Results of this phase of the study are shown in Table 4. HDD for selected return periods are indicated, as is the distribution by periods of the annual highest four-week HDD. For example, in Rumford, Maine, it can be expected to have a four-week HDD equaling or exceeding 1,547 one year out of ten. Sixty per cent of the time, the greatest accumulation of HDD occurred during Period 12 at this station.

HDD by Calendar Months

Tabulation and summarization of HDD data by climatological four-week periods was necessary because of machine routines for processing the data. Because the Weather Bureau has reported HDD by calendar months, it was believed to be desirable to work out a method of converting the NE-35 data. The procedure employed involved the construction of a family of curves, secured by plotting accumulated values of HDD against a time scale measured in units of the four-week climatological period. Smooth curves were drawn through the plotted points. These assumed an "S" shape when the beginning and ending time periods were four-week Periods 6 and 5, respectively. Calendar months were fitted to the four-week period scale. The percentage of the total degree days accumulated to the end of each month could be estimated from the "S" curves. Percentage distribution by months derived from these relationships is depicted in Table 5. While no great precision can be claimed for this method, it is presented as a practical means of converting periods of the climatological year to calendar months.

It is interesting, in connection with this procedure, to see if stations having approximately the same annual mean HDD have about the same monthly distribution. More specifically, does Dover, Del., (annual mean of 4,369 HDD), located near the coast, have the same time distribution of HDD as does Point Pleasant, W. Va., (annual mean of 4,356 HDD) located on the Ohio River some 400 miles inland? A cursory examination of a number of stations in this category indicated the time distributions to be similar. This is a question which might well be given a more careful examination.

Equation for Estimating HDD

Map 2 shows that the network of 156 weather stations used in the present study leaves many areas where the isolines are drawn by interpolating between widely spaced stations. These interpolations were modified in some cases by the known features of the terrain. This illustrates the need for a more accurate estimate of the mean annual HDD for a locality that is far removed from a network station. Consideration of this problem led to an attempt to develop a method of estimating mean annual HDD for any station on the basis of parameters which have been determined, and data for which are readily available. A procedure for estimating monthly degree-day totals from monthly mean temperatures has been developed by Thom and adopted by the Weather Bureau (16). While this method gives satisfactory results, it is somewhat time consuming and requires, in addition to monthly mean temperatures, the standard deviation of the monthly mean temperature for the location in question.

In search of a method for estimating HDD, the development of a multiple regression equation was explored. A computer program was available for the study. A variety of parameters, (including station elevation, latitude, longitude, January mean temperature, frost-free days, annual mean temperature, etc.) were tried, and the significance of the terms examined by an appropriate statistical test. This led to the following equation, which will estimate average annual HDD with an error no greater than 3 per cent in most cases.

$$X_1 = 6625 - 186.6\,X_2 + .2X_3 + 209.9X_4$$

Where:

X_1 = mean annual HDD for the station

X_2 = mean annual temperature in ° F

X_3 = elevation above sea level in feet

X_4 = latitude in degrees, with fractions expressed as decimals.

Figure 3 is a nomogram from which an approximate solution to the equation can easily be determined. A more accurate solution can, of course, be obtained by substituting the appropriate values in the equation. The equation has not been tested for stations outside of the Northeastern region.

APPLICATION OF HDD DATA

A more complete description and illustration of the uses of HDD in estimating energy requirements for space heating may be found in publications of ASHRAE, TVA, NEMA, and others (1), (12), (9), (3). A few brief examples are presented to give some idea of possible uses for the data.

The fuel required for heating a structure may be calculated from the following equation as given by ASHRAE (1).

$$F = \frac{XN}{eC} \qquad [I]$$

Where F = quantity of fuel or energy (in same units as C, below)

X = average heat requirements (Btu/hr) for the period under consideration

N = number of heating hours in the estimate period

e = efficiency of utilization of fuel over the period, expressed as a decimal

C = heating value of one unit of fuel (or energy)

The value of X is usually computed by

$$X = \frac{H(t - t_o)}{t_i - t_d} \qquad [II]$$

Where H = calculated heat loss, (Btu/hr), based on t_i and t_d and including infiltration loss

t = average inside temperature maintained, ° F

t_i = inside design temperature, usually 70° F

t_o = average outside temperature for estimate period

t_d = outdoor design temperature (consult references (1), (3), and (9) for design values)

These relationships can then be expressed as

$$F = \frac{H(t - t_o)N}{eC(t_i - t_d)} \qquad [III]$$

or

$$E = \frac{H(t - t_o)N}{t_i - t_d} \qquad [IV]$$

where E = energy requirement, (Btu)

This form IV of the equation will be used as it is more convenient for the present purposes and can easily be converted to fuel requirements by taking into account e and C as defined above.

Thom, (13) and (14), states that the inside temperature product $(t - t_o)$ N is often assumed to be a function of the normal season HDD. This relationship may be expressed as

$$K\bar{d} = (t - t_o)N \qquad [V]$$

where $\bar{d}$ = normal heating degree days

Thom's derivation of the constant, K, produces a value of approximately 30 for mean HDD in the range of 4,000 to 10,000 annually, which includes the Northeastern states.

The ASHRAE Guide (1) notes that X, the average energy requirement, is often overestimated by the use of Equation II because H is the calculated maximum heat loss. There are usually sources of heat, not taken into account in calculating the maximum heat demand, which will tend to decrease the overall energy requirements. Again according to ASHRAE, the most important sources are solar radiation, people, lights, and equipment.

Some allowance for this may be made by using t as 65° rather than 70° F, as is often done. If t = 65° F, then the expression $\frac{(t - t_o)N}{24}$ is identical to degree-days for the period and

$$24\bar{d} = (t - t_o)N \qquad [VI]$$

For electrically heated houses, the Tennessee Valley Authority (12) has developed the following formula for estimating seasonal energy requirements:

$$KWH = \frac{HL \times DD \times 20}{TD} \qquad [VII]$$

Where KWH = the seasonal energy heat loss of building in kilowatt hours
HL = heat loss of building in kilowatts per hour
DD = normal annual degree-days for the locality
TD = difference (°F) between inside and outside design temperatures, or $(t_i - t_d)$, in symbolism employed above

This formula is primarily applicable to residential space heating, according to TVA, and is presumably based on data collected in the electric service area of this agency.

Considering Equations V, VI, and VII, it can be seen that Equation IV can be written in the form:

$$E = \frac{HK\bar{d}}{t_i - t_d} \qquad [VIII]$$

It is evident from the above formulas, selected as representative of those in common use, that a fairly wide range of values has been assigned to the constant K. The suggestion has been made that the constant depends upon such variables as: geographical location, orientation and design of the particular house, living habits of the occupants, and type of heating equipment used. Obviously, the selection of K must necessarily be based on judgment and experience. Studies to develop a more precise and objective method for determining this term are needed.

The Federal Housing Administration (3) has developed a formula which affords a short-cut method of determining H, heat loss. The following form of FHA's Heat Loss Check Formula is limited to one, one-and-one-half-, and two-story detached dwellings that are substantially rectangular in plan, have an inside floor area (exclusive of basement and garage) not in excess of 1,500 square feet, and a total window and door area of between 20 and 28 per cent of the inside floor area.

$$H = A\,(G + U_c + U_w + U_f)\,(t_i - t_d) \qquad [IX]$$

or

$$H = AU(t_i - t_d) \qquad [X]$$

Where H = heat loss (Btu/hr), from one-story building
G = glass and infiltration factor for doors and windows
U_c = heat transmission coefficient for ceiling (Use .5 U_c for 1 1/2 and 2-story dwellings)
U_w = heat transmission for exterior walls (Use 1.2 U_w for 1 1/2 and 2-story dwellings)
U_f = heat transmission coefficient for floor (Use .5 U_f for 1 1/2 and 2-story dwellings)

A = inside floor area in square feet. Sum of floor areas measured to inside face of enclosing exterior walls on each principal floor level, and floor area measured to inside face of enclosing walls and partitions of all finished rooms and spaces in the attic. Basement and garage areas are not to be included.

U = the combined transmission coefficient for the above condition.

Combining Equations VIII and X, we have

$$E = A\ U\ K\ \overline{d} \qquad [XI]$$

Procedures for computing H or HL (conversion can be made on the basis that 1 KWH = 3,413 BTU) in addition to the short-cut method are explained in detail in references (1), (3), (9), and (12). These procedures will not be reviewed here.

SAMPLE CALCULATIONS

Some examples of how HDD data may be applied to the solution of practical problems follow.

Example 1

A dwelling at Frostburg, Md., is calculated to have a heat loss, H, of 45,000 BTU per hour. This includes losses by transmission and infiltration. The normal annual HDD at Frostburg is 5,685, the inside minus the outside design temperature is 70°, and the floor area is 1,200 square feet. What is the estimated normal annual energy requirement for heating?

Use Equation VIII and assume K = 24

$$E = \frac{HK\overline{d}}{t_i - t_d}$$

$$E = \frac{45{,}000 \times 24 \times 5{,}685}{70}$$

$$E = 87.7 \text{ million BTU per year}$$

Example 2

A house has a floor area of 1,500 square feet. The U term for the FHA short-cut method has been calculated as .62. Estimate the average seasonal energy requirements, if the location has a normal annual HDD of 5,200.

Use Equation XI,

$$E = A\ U\ K\ \overline{d}$$

If K is 30, then

$$E = 1{,}500 \times .62 \times 30 \times 5{,}200$$

$$E = 145.1 \text{ million BTU per year}$$

Example 3

With the conditions and location described in Example No. 1,

(a) What will be the energy requirements that will not be exceeded more than one-fourth of the years on the average?

On Figure 1, enter with the mean annual HDD of 5,685 on the ordinate. Projecting to the 25 per cent frequency line and then to the abscissa indicates a value of approximately 6,000 HDD. This means that, on the average, annual HDD at Frostburg will not exceed this figure 3 years out of 4, or conversely, the figure will be exceeded 1 year out of four. Then

$$E = 87.7 \times \frac{6000}{5685}$$

$$E = 92.6 \text{ million BTU per year}$$

(b) What will be the energy requirements for the four-week period during which the HDD will be equaled or exceeded only once in 10 years?

The solution may be determined by referring to Table 4. The extreme value frequency gives about 1,200 HDD for Frostburg for a return period of 10 years. This is to say that once in 10 years a four-week period HDD equaling or exceeding this magnitude will be expected. The analysis does not show in what period this will occur. However, the coldest weather as measured by the highest HDD has been experienced in Period 11 in 40 per cent of the years of record. From this,

$$E = \frac{45{,}000 \times 24 \times 1{,}200}{70}$$

$$E = 18.5 \text{ million BTU for the period}$$

It should be noted that the relationship of HDD to energy requirements is usually more reliable for longer periods than for shorter ones. The four-week period calculation may therefore provide estimates that are not as reliable as can be expected for several periods combined, or for an entire heating season.

Example 4

The frequency charts, Figures 1 and 2, are based upon the premise that the data conform to the normal distribution. A further assumption involved is that the annual means have homogeneity of variance. This provided the basis for calculating the position of the frequency lines on Figure 1. Application of this reasoning to the construction of Figure 2 has been explained briefly in a previous section. Some individual stations do not fit, as well as one might hope, the idealized relationship. The following procedure may be employed to utilize the data for any station and period in working out frequency relationships, as an alternate to use of the charts. (Application to the warmer four-week periods should be with caution, because the HDD may not be normally distributed, and large biases in probabilities result.)

$$HDD = \bar{d} \pm sf \qquad [XII]$$

Using HDD = heating degree-days for any return period or frequency (Table 6)

$\bar{d}$ = average or mean HDD for the period

s = sample standard deviation. This was derived from appropriate pooled variances for constructing Figures 1 and 2. The individual station values of standard deviation, reported in Tables 2 or 3, may be used to work out the frequency relationships.

f = factor for area under the normal curve

Equation XII may be used in conjunction with Table 6 in the following manner:

What is the four-week HDD that will be equaled or exceeded one year in 25 years on the average for climatological Period 1 at Williamson, W. Va.?

From Table 3, the mean is 545 HDD, the standard deviation is 134 HDD, and from Table 6, the area factor for a return period of 25 years is 1.75. Then

$$HDD = 545 + 134\ (1.75) = 780$$

On the average, the Period 1 HDD can be expected to equal or exceed this figure only once in 25 years.

Also,

$$HDD = 545 - 134\ (1.75) = 310$$

In this case, 310 HDD is a figure for which the expectancy is that a lower value will occur only once in 25 years, or that HDD will equal or exceed this 96 per cent of the time.

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Regional Publications

Three additional publications in *The Climate of the Northeast* series have been published by personnel of the NE-35 Committee. Their titles and authors are listed below.

Spring and Fall Low-Temperature Probabilities. New Jersey Agricultural Experiment Station Bulletin 801, June, 1961. The authors of this publication are A. V. Havens and J. K. McGuire.

Probability of Selected Weekly Precipitation Amounts in the Northeast Region of the United States. Cornell University Agricultural Experiment Station Agronomy Mimeo No. 61-4, November, 1961. The authors of this publication are B. E. Dethier and J. K. McGuire.

Growing Degree-Days. New York State Agricultural Experiment Station Bulletin 801, 1963. The authors of this publication are B. E. Dethier and M. T. Vittum.

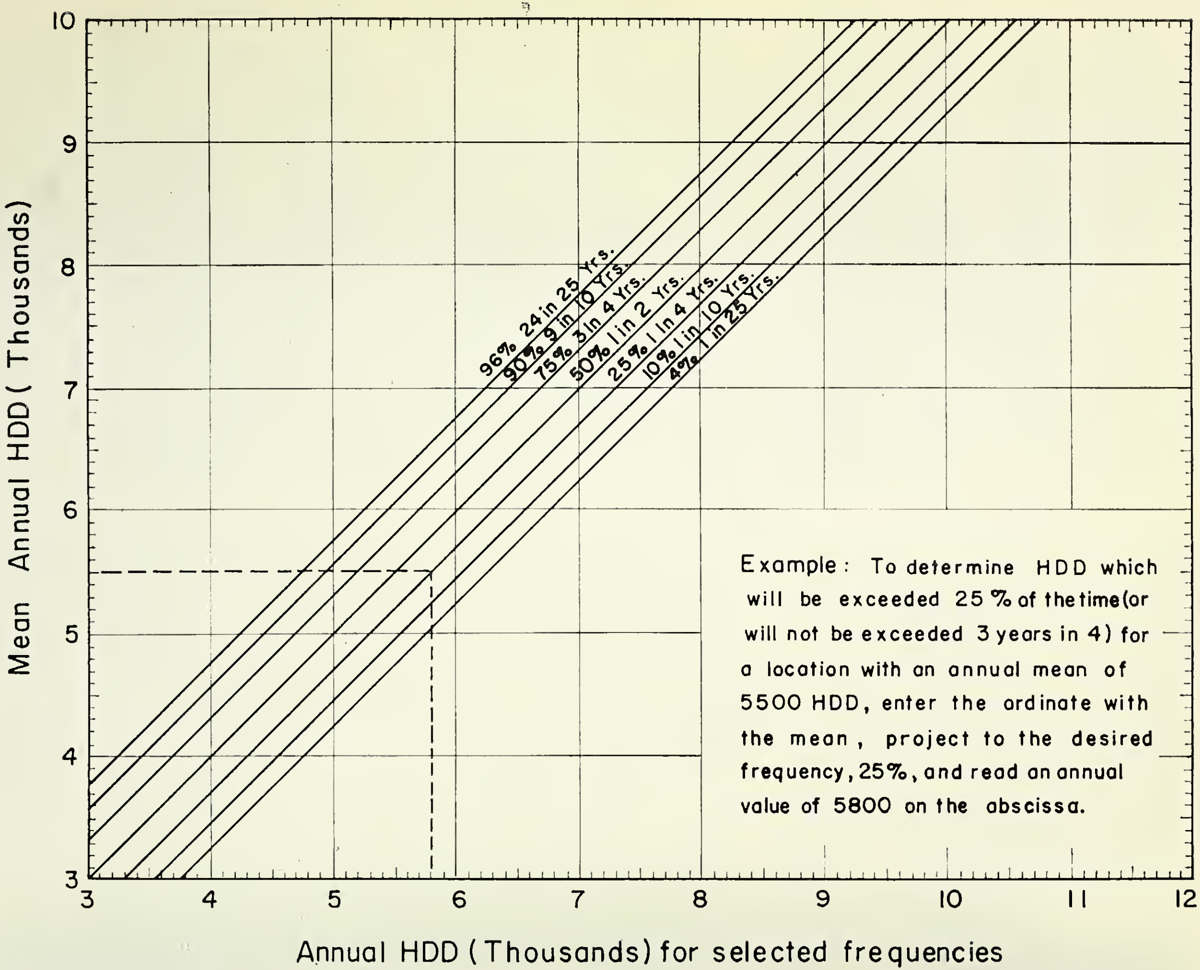


FIGURE 1. Frequency Curves for Mean Annual HDD.

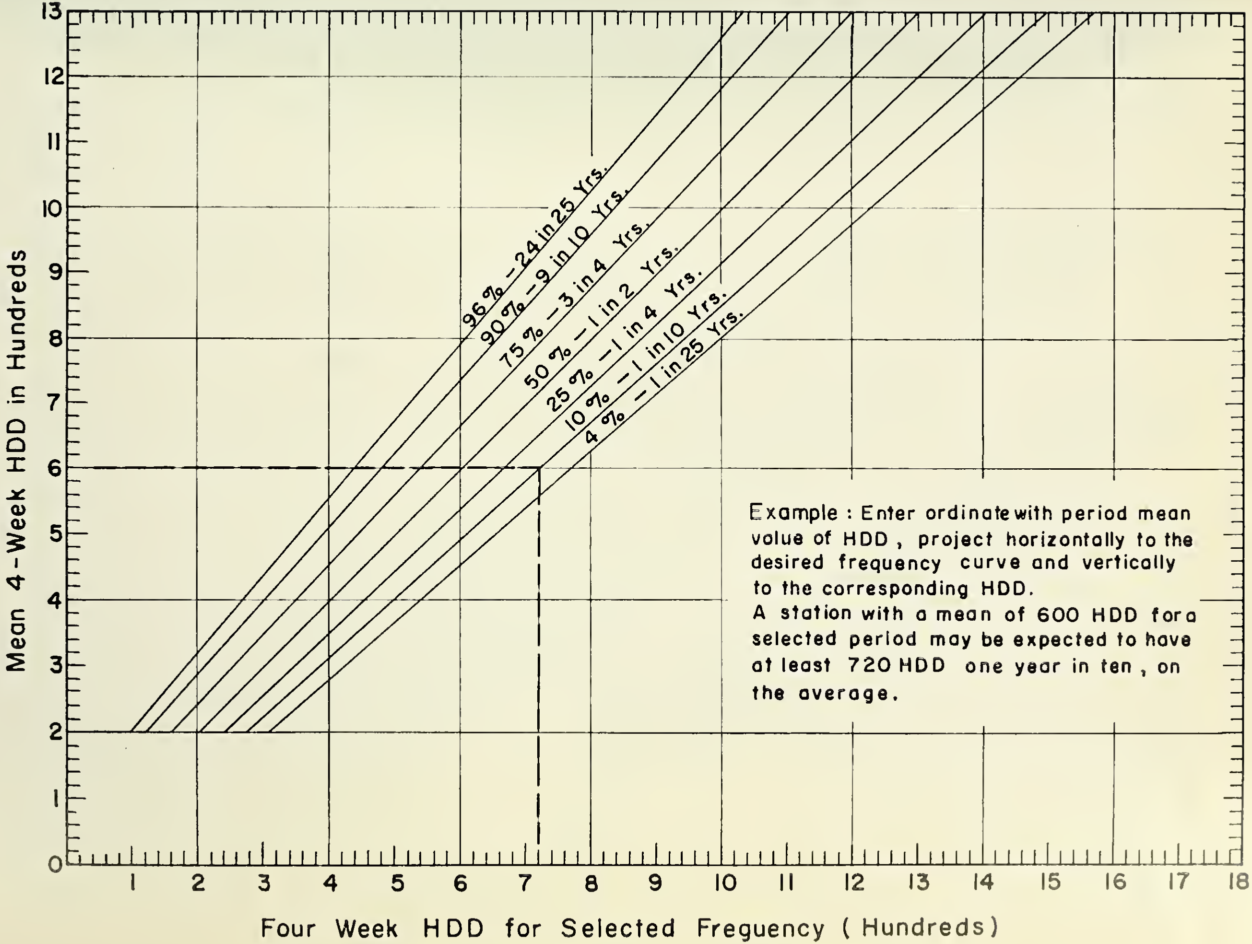


FIGURE 2. Frequency Curves for Four-Week Period Mean HDD.

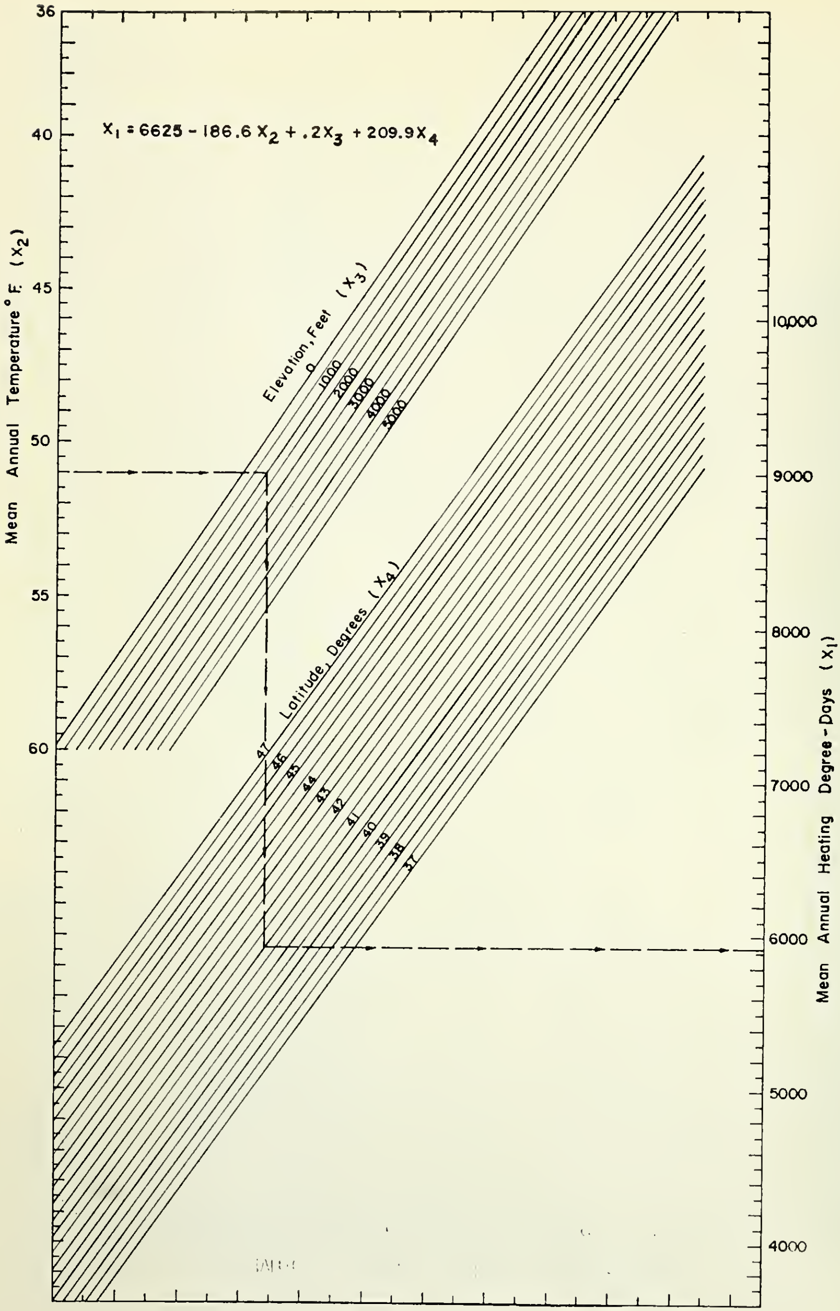


FIGURE 3. Nomogram for Solving Multiple Regression Equation.

Table 1. The Climatological Year.

Week Number	Beginning Date	Ending Date	4-Week Period Number	Beginning Date	Ending Date
01	Mar 1	Mar 7	01	Mar 1	
02	Mar 8	Mar 14			
03	Mar 15	Mar 21			
04	Mar 22	Mar 28			Mar 28
05	Mar 29	Apr 4	02	Mar 29	
06	Apr 5	Apr 11			
07	Apr 12	Apr 18			
08	Apr 19	Apr 25			Apr 25
09	Apr 26	May 2	03	Apr 26	
10	May 3	May 9			
11	May 10	May 16			
12	May 17	May 23			May 23
13	May 24	May 30	04	May 24	
14	May 31	Jun 6			
15	Jun 7	Jun 13			
16	Jun 14	Jun 20			Jun 20
17	Jun 21	Jun 27	05	Jun 21	
18	Jun 28	Jul 4			
19	Jul 5	Jul 11			
20	Jul 12	Jul 18			Jul 18
21	Jul 19	Jul 25	06	Jul 19	
22	Jul 26	Aug 1			
23	Aug 2	Aug 8			
24	Aug 9	Aug 15			Aug 15
25	Aug 16	Aug 22	07	Aug 16	
26	Aug 23	Aug 29			
27	Aug 30	Sep 5			
28	Sep 6	Sep 12			Sep 12
29	Sep 13	Sep 19	08	Sep 13	
30	Sep 20	Sep 26			
31	Sep 27	Oct 3			
32	Oct 4	Oct 10			Oct 10
33	Oct 11	Oct 17	09	Oct 11	
34	Oct 18	Oct 24			
35	Oct 25	Oct 31			
36	Nov 1	Nov 7			Nov 7
37	Nov 8	Nov 14	10	Nov 8	
38	Nov 15	Nov 21			
39	Nov 22	Nov 28			
40	Nov 29	Dec 5			Dec 5
41	Dec 6	Dec 12	11	Dec 6	
42	Dec 13	Dec 19			
43	Dec 20	Dec 26			
44	Dec 27	Jan 2			Jan 2
45	Jan 3	Jan 9	12	Jan 3	
46	Jan 10	Jan 16			
47	Jan 17	Jan 23			
48	Jan 24	Jan 30			Jan 30
49	Jan 31	Feb 6	13	Jan 31	
50	Feb 7	Feb 13			
51	Feb 14	Feb 20			
52	Feb 21	Feb 27			Feb 27
53	Feb 28	Feb 29	14	Feb 28	Feb 29

Table 2

Station list with geographical data, annual mean HDD, and standard deviation.

Station			Elev. (ft.)	Lat. °	Lat. ′	Long. °	Long. ′	No. Yrs. Analyzed	Annual Mean, HDD	Standard Deviation
Name	No.	County								
CONNECTICUT										
Cream Hill	1715	Litchfield	1300	41	52	73	20	30	6867	442
Hartford	3451	Hartford	15	41	44	72	39	30	5973	413
Norwalk	5892	Fairfield	120	41	08	73	27	30	5936	402
Storrs	8138	Tolland	600	41	48	72	15	30	6661	415
Waterbury	8911	New Haven	288	41	33	73	02	17	5648	582
DELAWARE										
Bridgeville	1330	Sussex	50	38	45	75	37	30	4412	386
Dover	2730	Kent	34	39	10	75	32	30	4369	402
Milford	5915	Sussex	10	38	55	75	26	26	4314	377
MAINE										
Caribou	1175	Aroostook	624	46	52	68	01	17	9744	371
Eastport	2426	Washington	100	44	54	66	59	30	8099	432
Farmington	2765	Franklin	390	44	40	70	09	30	7891	411
Fort Kent	2878	Aroostook	530	47	15	68	36	10	9159	338
Houlton	3897	Aroostook	410	46	08	67	50	20	8757	347
Lewiston	4566	Androscoggin	182	44	06	70	14	30	7499	422
Old Town	6420	Penobscot	108	44	56	68	39	20	7444	401
Portland	6905	Cumberland	61	43	39	70	19	30	7261	452
Presque Isle	6937	Aroostook	606	46	39	68	00	30	9259	464
Rockland	7250	Knox	40	44	06	69	07	18	7322	565
Rumford	7330	Oxford	505	44	33	70	33	30	7876	763
MARYLAND										
Chewsville	1790	Washington	560	39	38	77	41	30	5247	429
Crisfield	2205	Somerset	5	37	59	75	51	30	3592	462
Easton	2695	Talbot	28	38	46	76	04	30	4329	404
Elkton	2860	Cecil	28	39	36	75	50	29	4829	365
Frederick	3348	Frederick	380	39	25	77	25	30	4763	389
Frostburg	3410	Allegany	2035	39	39	78	56	30	5685	382
Keedysville	4780	Washington	420	39	29	77	42	30	4833	402
Oakland	6620	Garrett	2420	39	24	79	24	30	6284	442
Owings Ferry Landing	6770	Calvert	120	38	42	76	41	30	4260	385
Princess Anne	7330	Somerset	17	38	12	75	40	26	4312	315
Salisbury	8000	Wicomico	10	38	22	75	36	29	3994	431
Westminster	9435	Carroll	770	39	35	77	00	30	5001	371
Woodstock	9750	Baltimore	415	39	20	76	53	30	4947	389

MASSACHUSETTS										
Adams	0049	Berkshire	750	42	39	73	06	26	7258	523
Amherst	0120	Hampshire	210	42	24	72	32	30	6598	458
Blue Hill	0736	Norfolk	640	42	13	71	07	30	6447	435
East Wareham	2451	Plymouth	20	41	46	70	40	30	6195	410
Hyannis	3821	Barnstable	45	41	41	70	17	24	5870	433
Lawrence	4105	Essex	57	42	42	71	10	30	6427	483
Springfield	8046	Hampden	190	42	07	72	35	30	5716	410
Weston	9360	Middlesex	224	42	23	71	19	27	6156	410
Worcester	9928	Worcester	628	42	18	71	49	30	6641	423
NEW HAMPSHIRE										
Berlin	0690	Coos	1110	44	29	71	10	30	8703	450
Durham	2174	Strafford	73	43	08	70	56	30	6888	456
Hanover	3850	Grafton	603	43	42	72	17	30	7748	465
Keene	4399	Cheshire	490	42	56	72	17	30	7163	507
NEW JERSEY										
Belvidere	0729	Warren	289	40	50	75	05	30	5544	415
Boonton	0907	Morris	280	40	54	74	24	28	5947	448
Charlotteburg	1582	Passaic	760	41	03	74	26	30	6108	431
Flemington	3029	Hunterdon	134	40	31	74	51	30	5259	358
Indian Mills	4229	Burlington	100	39	48	74	47	30	5090	387
Layton	4735	Sussex	480	41	15	74	51	29	6405	420
Long Branch	4987	Monmouth	34	40	18	73	59	28	5252	438
Moorestown	5728	Burlington	55	39	58	74	58	30	5144	369
New Brunswick	6062	Middlesex	80	40	28	74	26	30	5216	413
Pleasantville	7131	Atlantic	8	39	25	74	31	28	5156	412
NEW YORK										
Albany	0047	Albany	19	42	39	73	45	30	6264	446
Alfred	0085	Allegany	1760	42	15	77	47	30	7488	472
Angelica	0183	Allegany	1420	42	18	78	02	30	7215	471
Auburn	0321	Cayuga	715	42	54	76	32	30	6624	431
Binghamton	0691	Broome	858	42	06	78	55	30	6511	465
Bridgehampton	0889	Suffolk	60	40	57	72	18	26	5620	377
Buffalo	1012	Erie	693	42	56	78	44	30	6748	486
Canton	1185	St. Lawrence	406	44	35	75	10	30	7997	560
Carmel	1207	Putnam	500	41	25	73	42	30	6371	439
Cooperstown	1752	Otsego	1240	42	42	74	55	30	7401	484
Dannemora	1966	Clinton	1338	44	43	73	43	30	8138	574
Delhi	2036	Delaware	1460	42	16	74	55	30	7278	461
Elmira	2610	Chemung	863	42	05	76	48	30	6389	458
Fredonia	3033	Chautauqua	750	42	26	79	22	30	6259	471
Geneva	3177	Ontario	615	42	53	77	00	30	6442	421
Hemlock	3773	Livingston	920	42	47	77	37	30	6769	484
Ithaca	4174	Tompkins	950	42	27	76	28	30	6819	468
Jamestown	4206	Chautauqua	1390	42	06	79	15	30	6433	420
Little Falls	4791	Herkimer	890	43	04	74	52	30	7421	438
Lockport	4844	Niagara	520	43	11	78	39	30	6819	439

Table 2 (continued)
Station list with geographical data, annual mean HDD, and standard deviation.

Station Name	No.	County	Elev. (ft.)	Lat. °	Lat. '	Long. °	Long. '	No. Yrs. Analyzed	Annual Mean, HDD	Standard Deviation
NEW YORK (Continued)										
Lowville	4912	Lewis	860	43	48	75	29	30	7965	483
Morrisville	5512	Madison	1325	42	54	75	39	30	7867	466
New York Central Park	5801	New York	132	40	47	75	58	30	4945	414
Norwich	6085	Chenango	1070	42	33	75	32	30	7473	460
Ogdensburg	6164	St. Lawrence	258	44	44	75	27	30	7641	514
Oswego	6314	Oswego	292	43	27	76	31	30	6885	461
Port Jervis	6774	Orange	470	41	23	74	41	30	6143	411
Poughkeepsie	6817	Dutchess	103	41	41	73	56	28	5922	456
Rochester	7167	Monroe	543	43	07	77	40	30	6634	444
Roxbury	7317	Delaware	1494	42	17	74	34	29	7341	453
Salisbury	7413	Herkimer	1300	43	09	74	51	30	8296	495
Setauket	7633	Suffolk	40	40	57	73	06	30	5183	395
South Wales	8058	Erie	1073	42	43	78	36	24	7244	395
Syracuse	8383	Onondaga	419	43	07	76	07	30	6642	472
Walden	8902	Orange	400	41	34	74	10	30	6317	450
Wanakena	8944	St. Lawrence	1510	44	09	74	54	30	8665	536
Watertown	9000	Jefferson	497	43	58	75	52	30	7323	458
Whitehall	9389	Washington	119	43	33	73	24	13	6815	427
PENNSYLVANIA										
Altoona	0134	Blair	1500	40	30	78	29	28	6138	425
Bethlehem	0634	Northampton	436	40	36	75	23	27	5261	395
Brookville	1002	Jefferson	1417	41	09	79	06	25	7002	593
Butler	1130	Butler	1100	40	52	79	54	26	5745	430
Carlisle	1234	Cumberland	460	40	12	77	11	30	5250	392
Claysville	1512	Washington	1150	40	07	80	25	30	5652	490
Corry	1790	Erie	1427	41	55	79	38	25	6743	466
Donora	2190	Washington	814	40	11	79	51	29	4848	414
Ebensburg	2466	Cambria	2090	40	29	78	43	25	6694	451
Fmporium	2633	Cameron	1160	41	31	78	13	24	6638	430
Franklin	3028	Venango	987	41	23	79	49	30	6484	451
Freeland	3056	Luzerne	1900	41	01	75	54	25	6815	547
George School	3200	Bucks	135	40	13	74	56	29	5275	388
Gettysburg	3218	Adams	540	39	50	77	14	30	5058	350
Greenville	3526	Mercer	1026	41	24	80	23	26	6163	427
Huntingdon	4159	Huntingdon	700	40	30	78	01	29	5779	366
Johnstown	4385	Cambria	1214	40	20	78	55	26	5597	502
Lancaster	4758	Lancaster	255	40	03	81	33	29	5407	379
Lawrenceville	4873	Tioga	1000	41	59	77	07	28	6622	457

Lock Haven	5104	Clinton	570	41	08	77	27	26	5712	446
Montrose	5915	Susquehanna	1630	41	50	75	51	22	7309	469
Mount Pocono	6055	Monroe	1915	41	09	75	22	22	7373	532
New Castle	6233	Lawrence	825	41	01	80	22	30	5857	417
Newell	6246	Fayette	805	40	05	79	54	25	5229	490
Palmerton	6689	Carbon	435	40	48	75	37	29	5971	381
Philadelphia-Shawmont	6904	Philadelphia	38	40	02	75	15	28	4892	405
Ridgway	7477	Elk	1371	41	26	78	44	21	7016	541
Selinsgrove	7931	Snyder	437	40	49	76	52	28	5804	364
Somerset	8249	Somerset	2150	40	01	79	05	28	6636	441
State College	8449	Centre	1175	40	48	77	53	30	6070	392
Stroudsburg	8596	Monroe	440	40	59	75	12	22	6051	448
Towanda	8905	Bradford	760	41	46	76	26	30	6386	432
Uniontown	9050	Fayette	1040	39	54	79	44	30	4995	384
Warren	9298	Warren	1280	41	51	79	08	29	6496	449
Wellsboro	9408	Tioga	1920	41	43	77	16	29	7131	445
York	9933	York	390	39	55	76	45	30	5114	404
RHODE ISLAND										
Kingston	4266	Washington	100	41	29	71	32	30	6236	422
VERMONT										
Burlington	1081	Chittenden	331	44	28	73	09	30	7772	504
Cornwall	1580	Addison	500	43	59	73	12	30	7302	440
Newport	5542	Orleans	766	44	56	72	12	26	8523	501
Northfield	5733	Washington	840	44	08	72	40	30	8295	608
St. Johnsbury	7054	Caledonia	699	44	25	72	01	30	7921	484
WEST VIRGINIA										
Bayard	0527	Grant	2375	39	16	79	22	30	6598	537
Charleston	1575	Kanawha	600	38	21	81	39	29	4221	405
Clarksburg	1677	Harrison	977	39	16	80	21	30	5450	399
Elkins	2718	Randolph	1970	38	53	79	51	30	5654	389
Fairmont	2920	Marion	1298	39	28	80	08	30	5040	397
Flat Top	3072	Mercer	3225	37	35	81	07	25	6084	426
Gary	3353	McDowell	1426	37	22	81	33	30	4685	361
Glenville	3544	Gilmer	740	38	56	80	50	30	4528	401
Huntington	4378	Cabell	675	38	25	82	22	29	4082	424
London Locks	5365	Kanawha	623	38	12	81	22	19	4471	418
Mannington	5621	Marion	974	39	33	80	21	30	5316	419
Martinsburg	5707	Berkeley	537	39	24	77	59	30	5040	350
Parkersburg	6859	Wood	615	39	16	81	34	30	4709	396
Piedmont	7004	Mineral	1053	39	29	79	02	29	5375	376
Point Pleasant	7105	Mason	569	38	51	82	08	30	4356	418
Rainelle	7306	Greenbrier	2424	37	58	80	47	25	5666	367
Spencer	8384	Roane	789	38	48	81	21	30	4809	400
Wardensville	9281	Hardy	1200	39	06	78	35	27	5115	462
Wheeling	9492	Ohio	659	40	06	80	42	30	5547	563
White Sulphur Springs	9522	Greenbrier	1914	37	48	80	18	30	5227	473
Williamson	9605	Mingo	673	37	40	82	17	30	4135	349

Table 3
Four-week period means of HDD and standard deviations.*

Station	1 M	1 S	2 M	2 S	3 M	3 S	4 M	4 S	5 M	5 S	6 M	6 S	7 M	7 S	8 M	8 S	9 M	9 S	10 M	10 S	11 M	11 S	12 M	12 S	13 M	13 S
CONNECTICUT																										
Cream Hill	898	187	607	100	309	75	120	52	23	23	11	10	60	29	229	52	473	93	795	94	1074	108	1122	136	1111	118
Hartford	787	107	517	80	239	58	72	35	8	13	3	3	29	18	171	45	400	80	706	82	972	109	1025	140	1012	113
Norwalk	787	99	523	77	246	58	76	37	9	13	3	4	30	21	170	44	407	81	702	74	963	92	1002	132	987	118
Storrs	868	108	599	82	318	72	121	49	23	18	14	13	61	29	227	53	459	81	759	86	1029	99	1079	133	1071	108
Waterbury	752	115	473	89	212	59	58	31	8	14	2	3	28	26	157	42	371	88	673	81	935	121	1000	151	960	107
DELAWARE																										
Bridgeville	587	108	365	66	143	43	32	21	2	4	0	0	8	6	93	39	282	74	551	75	770	108	780	155	772	117
Dover	588	111	356	68	130	42	27	21	1	3	0	0	4	4	82	41	270	74	543	75	771	106	789	152	782	126
Milford	585	91	359	64	132	38	27	21	1	3	0	0	5	5	83	39	282	67	534	77	759	107	773	160	766	122
MAINE																										
Caribou	1205	119	853	109	504	71	248	57	89	35	64	29	171	49	426	56	697	77	1042	113	1415	121	1524	137	1460	115
Eastport	977	87	737	68	519	39	320	41	157	39	98	27	146	34	315	38	528	56	809	86	1095	126	1205	134	1154	93
Farmington	1004	105	682	90	362	69	130	50	31	23	19	15	84	30	293	55	559	72	903	91	1220	126	1298	125	1264	111
Fort Kent	1133	100	783	107	476	65	204	69	50	25	47	24	127	35	384	72	656	75	969	113	1377	130	1474	136	1436	112
Houlton	1085	117	758	89	432	66	178	54	50	30	30	21	125	46	364	61	638	85	971	108	1312	120	1422	128	1349	101
Lewiston	969	101	672	82	376	65	134	46	25	18	11	11	59	26	251	48	515	70	846	85	1144	119	1239	120	1218	114
Old Town	941	104	645	79	353	70	127	50	30	24	13	12	77	32	277	47	521	69	841	88	1149	125	1245	130	1187	101
Portland	924	89	652	72	393	57	169	49	39	19	19	14	74	31	260	56	500	66	799	83	1085	120	1162	137	1148	105
Presque Isle	1154	115	804	93	469	72	210	67	70	35	50	23	144	52	382	54	653	75	1021	114	1365	127	1457	121	1434	114
Rockland	932	95	661	81	426	64	200	43	43	26	25	23	87	34	274	38	508	71	797	83	1032	230	1168	123	1132	78
Rumford	1009	115	695	104	386	79	149	52	34	27	23	18	93	41	303	68	566	89	889	122	1188	144	1267	164	1234	154
MARYLAND																										
Chewsville	676	123	430	84	182	58	50	33	5	8	2	3	22	15	146	52	373	77	661	83	890	99	903	157	877	124
Crisfield	504	141	271	74	76	37	11	13	0	0	0	0	1	2	35	27	178	71	449	80	668	110	683	171	695	119
Easton	576	106	345	74	127	44	26	21	1	3	0	0	5	5	85	42	274	74	542	74	772	98	782	151	771	120
Elkton	634	104	388	68	146	47	30	20	2	4	0	0	9	7	107	42	319	79	612	71	840	96	863	144	852	121
Frederick	613	110	368	69	131	47	27	19	1	3	0	0	11	11	108	45	321	70	615	81	846	99	860	154	834	122
Frostburg	740	129	476	89	213	66	75	41	13	12	7	8	37	23	175	58	409	78	708	96	937	114	939	153	927	121
Keedysville	626	118	381	75	142	48	31	23	2	4	0	0	12	10	116	45	326	79	617	82	851	98	864	153	839	120
Oakland	790	154	533	101	279	72	117	54	36	26	20	18	70	33	231	66	483	90	775	92	974	123	976	174	968	138
Owings Ferry Landing	565	113	338	71	121	43	26	21	1	3	0	0	7	6	88	40	266	72	533	70	759	103	771	150	760	123
Princess Anne	572	93	358	68	133	42	34	23	2	4	1	1	8	7	91	42	293	71	548	69	747	98	748	151	735	115
Salisbury	539	118	320	71	116	36	22	18	1	3	0	0	3	4	72	37	246	75	505	79	719	105	724	157	710	120
Westminster	652	119	406	75	163	53	45	30	3	4	1	2	16	12	124	46	334	79	628	72	862	99	878	149	861	119
Woodstock	638	109	392	71	152	51	40	27	3	5	1	2	16	12	128	49	350	75	633	75	857	96	862	153	850	122

*M = mean; S = standard deviation

MASSACHUSETTS																								
Adams	938	130	626	96	330	66	121	41	29	24	19	15	79	37	273	54	518	88	837	96	1105	124	1165	157	1181	122
Amherst	851	109	568	90	281	64	94	43	15	18	8	7	50	26	214	45	458	91	770	82	1046	113	1113	135	1095	120
Blue Hill	852	111	582	86	314	65	120	38	24	22	9	8	46	21	201	41	424	79	729	94	1002	105	1059	130	1054	112
East Wareham	822	84	579	76	332	49	119	36	22	19	8	7	44	23	189	43	409	73	683	77	946	110	997	124	1012	101
Hyannis	803	75	582	66	346	46	122	30	21	18	5	8	30	19	161	45	365	73	634	83	881	108	940	128	950	97
Lawrence	847	104	563	92	291	63	92	34	13	15	4	5	39	22	192	44	430	78	737	94	1020	115	1089	132	1074	122
Springfield	766	117	476	89	203	53	55	32	5	10	2	5	24	16	149	36	366	81	678	85	959	105	1011	124	991	113
Weston	804	110	533	91	269	65	90	32	15	16	6	6	42	22	195	42	411	79	714	99	987	108	1036	133	1022	114
Worchester	863	110	587	90	306	67	115	48	21	19	13	11	59	27	222	47	460	80	761	89	1036	103	1089	124	1075	111
NEW HAMPSHIRE																								
Berlin	1035	121	751	100	441	72	196	55	73	35	55	27	143	45	355	48	612	76	948	102	1277	131	1361	143	1353	117
Durham	875	101	601	83	340	68	126	45	25	19	14	11	63	31	234	50	481	75	788	88	1068	113	1127	129	1110	115
Hanover	981	120	662	95	354	71	132	45	32	26	21	16	83	33	286	52	554	79	882	100	1204	125	1274	149	1242	121
Keene	909	116	612	94	326	69	122	43	32	30	19	15	79	39	259	48	513	86	821	88	1112	114	1174	137	1150	126
NEW JERSEY																								
Belvidere	724	111	449	87	176	53	50	33	4	6	1	3	18	16	139	50	383	89	694	79	943	94	981	136	952	115
Boonton	786	99	508	89	247	61	86	45	12	14	4	5	32	20	178	49	416	82	711	73	946	96	993	145	995	102
Charlotteburg	793	119	525	82	250	64	97	44	19	16	10	11	49	29	201	53	429	89	717	90	971	94	1009	140	1004	104
Flemington	692	108	436	79	176	52	48	31	4	6	1	3	15	13	122	43	344	82	647	73	900	93	929	135	914	108
Indian Mills	674	111	431	71	181	50	55	33	5	6	1	3	20	13	133	46	342	79	621	85	853	102	877	151	869	117
Layton	821	111	544	88	265	57	94	50	15	17	9	10	51	29	214	52	464	92	766	86	1023	96	1062	144	1043	118
Long Branch	707	99	474	80	229	60	64	32	5	7	1	3	13	11	127	44	339	81	619	75	851	106	891	151	900	123
Moorestown	678	108	434	74	185	52	51	30	3	5	1	2	15	12	127	46	343	79	631	75	864	109	898	141	885	123
New Brunswick	698	108	447	80	184	48	52	31	4	6	1	2	14	12	124	42	339	78	627	77	882	98	912	144	903	121
Pleasantville	703	100	468	72	222	50	66	33	9	9	2	2	18	11	129	4	328	81	614	71	835	94	859	147	875	103
NEW YORK																								
Albany	835	121	532	91	234	60	62	36	7	11	2	3	28	17	181	45	424	82	734	90	1021	115	1093	146	1078	122
Alfred	954	139	664	102	357	85	160	60	51	32	35	25	102	45	285	68	547	94	857	107	1112	111	1159	158	1165	123
Angelica	923	133	634	94	345	85	147	67	42	32	29	24	85	40	265	63	528	86	829	105	1084	111	1127	164	1141	123
Auburn	917	131	626	91	329	71	111	50	15	18	6	7	38	20	184	56	428	83	737	101	1007	101	1084	147	1106	121
Binghamton	858	131	570	96	277	68	97	48	17	19	10	10	51	29	215	54	459	90	756	101	1018	114	1073	153	1078	128
Bridgehampton	772	85	545	66	311	54	104	35	14	15	2	2	22	18	139	38	352	70	619	72	868	98	914	126	929	108
Buffalo	916	130	645	110	358	81	127	54	21	21	7	8	45	28	201	58	448	88	755	102	1008	105	1084	144	1097	118
Canton	1037	147	677	107	354	78	127	55	30	23	20	15	89	36	291	59	555	88	895	127	1240	149	1328	168	1313	134
Carmel	846	109	557	93	271	59	96	42	14	14	6	6	40	20	189	47	427	85	740	76	1012	110	1075	142	1065	125
Cooperstown	960	153	642	112	346	77	144	62	42	35	29	26	96	43	275	58	526	96	833	105	1119	107	1169	155	1180	132
Dannemora	1060	144	719	118	373	86	142	62	40	33	24	18	92	40	295	59	566	108	929	126	1244	120	1315	138	1294	108
Delhi	937	137	644	98	342	72	144	61	40	28	26	21	89	39	268	57	524	91	831	110	1101	120	1148	149	1147	126
Elmira	847	122	555	97	263	67	88	41	15	18	9	9	47	29	219	59	462	101	750	94	995	98	1048	142	1058	112
Fredonia	860	139	580	110	300	78	100	49	14	14	5	6	34	19	167	54	407	84	714	107	961	101	1034	150	1048	131
Geneva	866	134	573	95	282	72	90	48	12	15	7	8	41	23	196	55	439	85	745	101	1013	99	1069	137	1076	111
Hemlock	916	129	622	102	309	74	104	48	16	16	10	9	58	30	220	61	466	85	766	103	1026	107	1102	151	1117	125
Ithaca	896	127	605	91	315	74	123	59	26	21	16	16	64	31	237	58	475	88	775	103	1040	116	1102	153	1110	114
Jamestown	855	149	567	108	278	73	103	49	20	19	11	11	50	25	200	54	442	85	759	106	999	106	1054	153	1061	127
Little Falls	979	137	650	110	321	77	120	56	25	21	15	14	66	28	254	49	516	87	852	102	1154	117	1219	146	1212	118
Lockport	914	129	627	97	334	79	123	58	21	19	10	10	52	25	213	60	468	89	774	102	1032	102	1102	145	1111	118

Table 3 (continued)
Four-week period means of HDD and standard deviations.*

Station	1 M	1 S	2 M	2 S	3 M	3 S	4 M	4 S	5 M	5 S	6 M	6 S	7 M	7 S	8 M	8 S	9 M	9 S	10 M	10 S	11 M	11 S	12 M	12 S	13 M	13 S
NEW YORK (Continued)																										
Lowville	1036	142	687	108	356	76	136	46	34	29	22	17	90	38	293	61	559	94	902	118	1219	121	1301	168	1286	122
Morrisville	1005	130	688	97	387	77	174	66	56	34	37	32	109	43	312	68	568	89	874	101	1164	129	1220	161	1234	121
N. Y. Central Park	692	106	437	81	173	52	41	25	3	5	0	0	5	7	89	37	285	74	581	82	839	102	886	138	886	112
Norwich	954	135	646	99	350	70	148	53	42	28	28	22	93	40	286	59	539	90	842	108	1125	117	1191	151	1191	125
Ogdensburg	1015	130	651	106	337	78	113	50	19	18	10	11	62	33	244	61	509	75	856	108	1204	133	1305	171	1276	124
Oswego	914	121	642	94	369	71	151	58	26	26	7	8	50	27	217	53	454	80	756	100	1037	110	1110	137	1116	115
Port Jervis	805	111	518	91	238	68	81	44	12	16	6	7	36	25	184	52	427	90	733	83	1001	99	1046	135	1025	114
Poughkeepsie	781	112	490	99	212	64	54	28	4	8	1	2	23	17	163	47	393	78	712	92	984	117	1044	154	1029	121
Rochester	895	132	601	96	304	75	102	50	13	13	7	8	48	25	206	55	452	87	758	106	1023	109	1090	146	1101	116
Roxbury	935	133	650	103	350	85	153	66	45	31	28	21	94	40	281	55	535	90	835	95	1107	118	1148	155	1142	125
Salisbury	1056	139	733	112	399	84	180	68	57	36	40	30	119	47	332	60	594	88	927	105	1231	110	1296	148	1291	127
Setauket	730	94	484	76	229	54	66	30	6	9	0	0	10	10	110	37	311	69	583	79	833	95	891	124	901	110
South Wales	950	138	640	103	353	78	133	49	35	27	20	16	81	38	259	61	501	95	822	12	1076	109	1133	163	1159	124
Syracuse	888	135	588	100	293	67	98	51	14	15	7	7	48	26	212	56	451	81	753	104	1039	121	1107	155	1110	121
Walden	821	114	539	88	265	77	95	52	12	12	7	8	48	25	220	56	451	77	739	99	997	115	1052	136	1038	131
Wanakena	1097	139	758	116	418	81	190	59	76	43	58	83	144	52	353	63	621	95	956	123	1275	130	1342	165	1334	135
Watertown	963	138	631	102	328	75	116	55	21	19	11	10	61	26	239	59	493	83	820	113	1150	132	1229	178	1222	127
Whitehall	891	149	532	109	266	60	73	38	5	5	6	6	33	21	206	35	445	80	800	90	1133	130	1209	156	1180	109
PENNSYLVANIA																										
Altoona	796	137	516	90	241	70	92	45	18	16	10	11	49	28	198	52	436	86	756	96	991	111	1001	145	1000	131
Bethlehem	700	118	443	78	174	51	46	33	4	6	1	2	14	12	119	43	346	78	641	85	894	98	925	137	925	112
Brookville	895	122	608	106	326	85	135	50	50	51	26	22	91	56	276	95	533	95	822	93	1045	118	1078	163	1082	151
Butler	752	133	471	101	218	68	67	41	12	11	7	7	37	29	175	58	417	82	724	98	930	118	951	165	952	132
Carlisle	676	106	410	80	150	58	37	27	2	3	1	1	17	15	133	49	366	84	671	76	916	94	935	141	909	118
Claysville	720	139	463	93	218	72	71	36	14	14	8	11	39	27	172	64	417	101	711	105	925	135	941	166	926	130
Corry	880	154	579	111	320	70	122	53	30	25	19	17	62	35	228	59	481	85	792	109	1029	104	1078	153	1088	148
Donora	644	136	387	87	157	57	41	30	3	5	1	2	13	11	113	46	327	83	617	93	824	119	850	167	844	126
Ebensburg	877	136	586	103	291	70	119	50	33	27	21	18	66	40	227	59	488	95	811	81	1026	101	1058	158	1056	118
Emporium	863	111	571	74	294	69	115	51	28	27	19	18	63	32	238	56	487	89	775	92	1019	103	1061	161	1071	126
Franklin	860	137	571	102	285	74	109	50	24	22	12	11	51	27	209	56	469	83	766	96	996	105	1038	148	1060	136
Freeland	892	144	601	104	285	71	111	56	25	20	12	10	62	35	229	63	498	104	803	106	1054	98	1117	153	1092	118
George School	707	99	450	65	181	55	50	33	4	6	1	2	17	15	128	50	349	80	644	82	885	97	920	143	909	121
Gettysburg	659	119	405	73	154	50	39	24	2	3	1	1	15	13	123	43	343	75	637	77	877	95	897	137	879	108
Greenville	784	138	518	93	256	74	93	52	13	9	11	13	42	25	193	59	445	82	743	96	994	106	1033	168	1006	138
Huntingdon	747	113	480	80	210	57	68	39	10	13	5	6	31	20	175	56	423	81	714	82	950	90	973	146	962	114
Johnstown	740	137	466	89	198	64	58	31	10	18	3	5	30	26	158	55	398	99	687	93	938	112	954	165	929	123
Lancaster	688	115	435	84	178	57	46	31	4	6	1	2	18	14	155	50	393	86	680	73	923	95	943	134	916	120
Lawrenceville	859	131	575	91	276	69	102	55	22	22	14	17	56	35	223	65	473	87	779	98	1040	106	1085	161	1083	115

*M = mean; S = standard deviation

Lock Haven	742	121	457	92	186	52	53	33	6	10	3	6	29	21	167	54	415	72	704	89	956	104	984	140	978	110
Montrose	954	146	668	98	345	80	159	66	39	24	24	20	76	36	269	61	518	103	830	104	1089	116	1152	158	1147	92
Mount Pocono	926	135	636	110	352	86	163	60	56	48	33	18	100	49	291	60	513	103	854	101	1102	106	1170	138	1140	93
New Castle	772	138	496	92	235	71	78	44	12	12	7	8	34	21	165	60	413	81	713	97	945	109	978	151	978	137
Newell	685	131	436	111	193	67	61	33	8	10	2	3	18	15	134	52	371	80	654	103	868	144	889	170	882	141
Palmerton	778	107	508	86	234	60	77	41	9	8	4	6	36	21	187	54	430	83	721	84	961	99	995	144	998	109
Philadelphia-Shawmont	653	113	393	78	144	44	30	24	2	3	0	0	6	8	104	43	319	85	612	73	855	96	887	135	861	120
Ridgway	839	123	612	96	310	80	134	57	39	29	28	32	81	37	270	64	543	88	810	88	1072	116	1070	168	1113	169
Selinsgrove	750	117	482	79	207	59	65	38	7	10	3	5	28	21	168	54	413	83	717	85	959	104	1004	139	969	109
Somerset	827	141	564	94	295	76	131	54	41	30	26	19	85	39	258	75	514	81	797	93	1016	116	1021	169	1029	138
State College	792	127	516	93	227	64	77	41	12	13	5	6	42	24	199	54	436	83	741	86	981	99	1013	144	998	116
Stroudsburg	779	115	498	83	246	69	79	43	8	8	7	7	34	19	200	57	425	100	724	91	973	90	1020	145	1026	119
Towanda	830	125	550	91	265	68	100	50	18	18	11	12	50	28	215	56	461	83	748	88	1010	108	1051	146	1044	115
Uniontown	657	140	398	95	171	57	48	32	5	8	2	3	20	12	129	50	351	87	638	93	847	124	858	164	843	133
Warren	866	119	591	98	281	72	104	48	22	25	12	13	50	27	205	63	461	93	771	104	995	106	1048	158	1055	127
Wellsboro	913	114	623	91	323	76	139	59	36	22	22	17	86	40	272	69	529	87	827	93	1073	105	1128	150	1126	113
York	656	117	407	78	157	53	41	30	4	6	1	2	16	14	130	49	357	82	649	78	889	94	900	152	880	123
RHODE ISLAND																										
Kingston	808	82	579	74	333	50	131	42	26	18	11	8	50	27	203	48	428	74	702	78	951	109	995	134	987	113
VERMONT																										
Burlington	1011	130	674	100	353	73	124	46	28	25	16	12	79	34	280	51	538	80	868	109	1193	134	1291	156	1276	123
Cornwall	959	134	623	104	306	71	105	46	21	19	12	10	59	25	242	49	498	84	835	109	1152	123	1235	145	1217	118
Newport	1093	133	741	104	402	78	152	49	47	30	34	21	113	43	331	53	599	82	942	115	1295	146	1377	167	1353	126
Northfield	1039	135	718	108	405	78	174	55	60	40	45	26	125	49	336	58	589	88	913	111	1240	137	1314	160	1294	127
St. Johnsbury	1014	126	679	102	353	74	123	52	31	25	21	15	87	35	288	50	555	79	899	106	1237	132	1313	149	1281	122
WEST VIRGINIA																										
Bayard	818	141	558	104	307	75	135	48	49	32	34	26	95	46	273	76	522	82	803	91	993	126	994	177	986	142
Charleston	559	135	304	87	111	56	24	19	1	2	1	2	5	5	93	96	281	88	556	131	761	126	783	161	706	167
Clarksburg	712	133	438	88	195	66	59	33	9	9	4	5	24	17	154	55	411	86	714	89	897	116	903	168	901	132
Elkins	720	141	466	94	230	72	87	43	19	15	11	12	53	76	190	62	441	93	720	90	894	132	900	171	894	128
Fairmont	664	144	387	94	156	56	42	28	4	4	2	3	13	11	124	49	359	93	662	93	865	116	873	166	862	124
Flat Top	775	150	510	101	268	79	105	47	33	26	19	18	62	35	219	67	462	99	774	97	947	137	940	185	937	132
Gary	616	130	360	83	150	60	42	27	4	5	2	3	14	12	114	47	355	94	638	82	799	112	789	159	778	133
Glenville	593	128	333	90	127	53	28	24	1	2	1	2	7	7	100	49	317	95	619	101	802	128	801	174	776	127
Huntington	524	136	271	95	93	47	24	37	1	1	0	0	4	5	86	94	267	97	595	172	745	127	745	167	714	125
London Locks	589	152	339	101	137	56	24	20	2	3	1	3	6	6	91	49	303	96	615	62	787	105	802	166	750	118
Mannington	676	132	419	86	189	66	58	36	9	11	4	5	30	19	165	57	404	84	694	91	887	123	887	171	867	132
Martinsburg	656	106	401	70	156	70	36	25	3	5	1	2	13	17	130	46	353	79	649	82	866	101	881	148	869	115
Parkersburg	618	135	357	85	140	54	32	22	1	2	1	1	8	9	108	45	324	85	621	91	820	119	838	160	814	132
Piedmont	687	125	427	84	184	61	59	36	8	10	3	4	23	15	152	56	385	84	690	79	916	101	919	136	894	118
Pt. Pleasant	558	135	309	78	120	57	27	27	2	4	1	4	6	6	87	38	295	94	600	82	790	115	789	177	750	156
Rainelle	715	130	459	94	226	70	79	43	19	18	10	10	42	25	185	66	452	100	746	82	923	125	907	167	886	128
Spencer	625	136	369	87	161	60	50	32	7	10	2	4	17	19	126	53	347	91	629	90	820	117	822	170	809	134
Wardensville	665	147	391	113	180	65	58	32	12	13	5	7	32	21	151	56	365	102	653	104	851	139	843	185	885	143
Wheeling	731	147	455	108	204	84	55	41	7	13	3	6	17	15	136	53	386	91	699	81	923	118	959	192	943	166
White Sulphur Springs	662	132	400	90	165	64	52	30	9	9	4	6	22	15	155	68	408	96	714	90	893	100	874	158	843	122
Williamson	545	134	291	78	100	45	18	15	0	0	2	7	9	24	71	39	280	92	577	81	749	109	744	150	727	134

Table 4
Extreme value frequency analysis of heating degree-days.

Station	HDD for Return Periods					% Years with Highest HDD by Clim. Period				
	2-yr.	5-yr.	10-yr.	20-yr.	50-yr.	Period 10	Period 11	Period 12	Period 13	Period 1
CONNECTICUT										
Cream Hill	1171	1286	1361	1434	1528	3	20	47	30	
Hartford	1076	1189	1263	1334	1426		20	50	30	
Norwalk	1052	1152	1219	1282	1365		23	50	27	
Storrs	1130	1239	1311	1381	1471		24	43	33	
Waterbury	1042	1135	1196	1255	1330		29	53	18	
DELAWARE										
Bridgeville	850	961	1034	1105	1196		33	34	30	3
Dover	853	965	1040	1112	1204		34	30	33	3
Milford	833	926	987	1046	1122		35	31	30	4
MAINE										
Caribou	1567	1658	1719	1777	1852		12	59	29	
Eastport	1230	1325	1388	1448	1526		7	56	30	7
Farmington	1337	1445	1517	1585	1675		17	60	23	
Fort Kent	1510	1620	1693	1762	1853		10	50	40	
Houlton	1454	1554	1620	1683	1765		10	70	20	
Lewiston	1272	1382	1455	1525	1615		7	63	30	
Old Town	1278	1389	1463	1533	1625		10	60	30	
Portland	1202	1321	1399	1475	1573		10	50	37	3
Presque Isle	1500	1581	1635	1686	1752		10	57	33	
Rockland	1202	1294	1355	1414	1490		11	56	33	
Rumford	1295	1447	1547	1644	1769		10	60	23	7
MARYLAND										
Chewsville	967	1078	1152	1224	1314		40	37	23	
Crisfield	764	846	900	952	1020		31	38	31	
Easton	844	949	1018	1084	1170		33	40	24	3
Elkton	923	1030	1101	1169	1257		36	39	25	
Frederick	914	1032	1110	1185	1282		37	37	23	3
Frostburg	1014	1124	1197	1267	1358		40	27	26	7
Keedysville	924	1032	1104	1172	1261		37	40	23	
Oakland	1064	1182	1261	1336	1433		40	26	27	7
Owings Ferry Landing	839	945	1014	1081	1167		33	38	26	3
Princess Anne	813	917	986	1052	1138		32	32	28	8
Salisbury	794	897	965	1030	1114		32	32	32	4
Westminster	938	1047	1120	1190	1280		37	34	26	3
Woodstock	928	1036	1108	1177	1267		37	37	26	

MASSACHUSETTS										
Adams	1226	1342	1419	1493	1589		12	42	42	4
Amherst	1164	1285	1365	1442	1541		20	50	30	
Blue Hill	1106	1214	1286	1355	1444		10	47	40	3
East Wareham	1048	1153	1222	1289	1375		17	47	33	3
Hyannis	986	1095	1168	1237	1327		8	42	42	8
Lawrence	1131	1244	1318	1391	1483		17	48	35	
Springfield	1055	1168	1242	1314	1407		23	50	27	
Weston	1082	1193	1267	1337	1429	3	20	43	34	
Worchester	1133	1237	1306	1372	1458		17	50	33	
NEW HAMPSHIRE										
Berlin	1410	1533	1614	1692	1793		7	50	43	
Durham	1167	1292	1374	1453	1555	3	17	53	27	
Hanover	1314	1442	1527	1608	1714		13	53	34	
Keene	1215	1337	1417	1495	1595	3	24	50	23	
NEW JERSEY										
Belvidere	1030	1137	1208	1276	1363	3	34	43	20	
Boonton	1050	1151	1218	1282	1364		25	46	29	
Charlotteburg	1065	1168	1236	1301	1386		23	50	27	
Flemington	989	1085	1149	1210	1289		27	47	26	
Indian Mills	942	1045	1114	1180	1265		33	37	30	
Layton	1121	1232	1305	1375	1466		24	49	27	
Long Branch	955	1059	1128	1194	1280		25	43	32	
Moorestown	964	1070	1139	1206	1293		27	47	26	
New Brunswick	973	1076	1145	1211	1296		26	47	27	
Pleasantville	921	1012	1073	1131	1206		26	37	37	
NEW YORK										
Albany	1141	1269	1354	1436	1541		20	50	30	
Alfred	1223	1349	1432	1512	1615		20	47	30	3
Angelica	1192	1331	1423	1511	1625		17	43	37	3
Auburn	1137	1262	1345	1424	1527		10	43	37	10
Binghamton	1137	1262	1345	1425	1528		16	47	37	
Bridgehampton	969	1080	1153	1223	1314		20	48	32	
Buffalo	1139	1267	1352	1434	1539		14	43	40	3
Canton	1384	1528	1623	1714	1832		13	47	37	3
Carmel	1121	1241	1321	1397	1496		17	50	33	
Cooperstown	1241	1372	1458	1541	1649		20	48	28	4
Dannemora	1357	1472	1548	1621	1715	3	11	53	30	3
Delhi	1215	1336	1417	1494	1594		17	47	36	
Elmira	1105	1216	1289	1359	1450		20	43	37	
Fredonia	1093	1226	1314	1398	1508		13	44	40	3
Geneva	1121	1235	1311	1384	1479		17	50	30	3
Hemlock	1159	1288	1373	1456	1562		14	43	40	3
Ithaca	1156	1274	1351	1426	1523		18	39	43	
Jamestown	1112	1244	1332	1416	1525		23	40	30	7
Little Falls	1273	1398	1480	1560	1663		17	50	33	
Lockport	1156	1281	1364	1444	1547		14	40	43	3

Table 4 (continued)
Extreme value frequency analysis of heating degree-days.

Station	HDD for Return Periods					% Years with Highest HDD by Clim. Period				
	2-yr.	5-yr.	10-yr.	20-yr.	50-yr.	Period 10	Period 11	Period 12	Period 13	Period 1
NEW YORK (Continued)										
Lowville	1351	1488	1579	1666	1778		10	57	33	
Morrisville	1287	1418	1505	1588	1695		17	38	45	
N. Y. Central Park	943	1047	1117	1183	1269		20	50	30	
Norwich	1250	1368	1446	1521	1618		18	46	36	
Ogdensburg	1340	1469	1555	1638	1744	3	14	45	35	3
Oswego	1160	1280	1359	1435	1533		7	50	40	3
Port Jervis	1104	1208	1276	1342	1427		23	47	30	
Poughkeepsie	1098	1211	1287	1359	1452		21	54	25	
Rochester	1144	1266	1346	1424	1524		17	50	30	3
Roxbury	1219	1335	1413	1487	1583	4	21	43	32	
Salisbury	1352	1479	1563	1643	1747		13	50	37	
Setauket	944	1043	1109	1172	1254		17	43	37	3
South Wales	1209	1338	1423	1505	1611		25	42	33	
Syracuse	1167	1303	1394	1480	1593		17	43	37	3
Walden	1113	1225	1300	1371	1464		20	50	27	3
Wanakena	1396	1536	1628	1717	1832	3	17	50	30	
Watertown	1281	1429	1527	1621	1743	3	10	54	30	3
Whitehall	1260	1355	1418	1478	1556		15	46	31	8
PENNSYLVANIA										
Altoona	1075	1184	1256	1325	1414		36	25	35	4
Bethlehem	977	1081	1150	1216	1301		30	44	26	
Brookville	1147	1291	1386	1478	1596		36	36	28	
Butler	1033	1142	1214	1283	1372		38	35	23	4
Carlisle	988	1100	1174	1245	1337		30	43	27	
Claysville	1011	1143	1231	1315	1423		47	24	26	3
Corry	1138	1289	1388	1483	1607		24	36	36	4
Donora	916	1037	1118	1195	1294		31	31	34	4
Ebensburg	1124	1240	1316	1390	1485		28	36	32	4
Emporium	1128	1265	1356	1444	1557		29	38	33	
Franklin	1104	1239	1328	1414	1524		23	30	44	3
Freeland	1159	1266	1337	1405	1493		16	56	28	
George School	977	1081	1150	1217	1303		35	41	24	
Gettysburg	954	1061	1131	1199	1287		37	37	26	
Greenville	1096	1211	1288	1361	1456		23	50	19	8
Huntingdon	1028	1144	1220	1294	1389		31	34	35	
Johnstown	1018	1114	1178	1239	1318		42	31	23	4
Lancaster	996	1105	1177	1247	1336		35	41	24	
Lawrenceville	1147	1247	1314	1377	1460		25	39	36	

Lock Haven	1042	1137	1199	1259	1337		23	46	31	
Montrose	1205	1309	1377	1443	1529		18	50	27	5
Mount Pocono	1202	1306	1375	1442	1527		18	59	23	
New Castle	1045	1178	1267	1352	1462		27	33	40	
Newell	965	1079	1155	1227	1321		28	36	28	8
Palmerton	1057	1168	1241	1311	1402		28	41	31	
Philadelphia-Shawmont	935	1044	1116	1185	1275		29	53	18	
Ridgway	1159	1314	1417	1516	1644		33	19	48	
Selinsgrove	1052	1161	1234	1303	1393		29	46	25	
Somerset	1109	1225	1303	1377	1473		40	21	32	7
State College	1072	1191	1269	1345	1442		33	34	33	
Stroudsburg	1080	1190	1263	1333	1423		23	45	32	
Towanda	1109	1224	1300	1372	1466		23	47	30	
Uniontown	936	1059	1140	1219	1320		40	27	30	3
Warren	1108	1244	1333	1419	1530	3	18	38	38	3
Wellsboro	1174	1300	1383	1463	1566		24	41	35	
York	964	1078	1153	1226	1319		37	40	23	
RHODE ISLAND										
Kingston	1044	1153	1226	1295	1385		27	43	30	
VERMONT										
Burlington	1333	1464	1551	1635	1743		3	53	44	
Cornwall	1275	1399	1482	1561	1663		7	50	40	3
Newport	1429	1572	1667	1757	1875	4	8	54	30	4
Northfield	1361	1493	1580	1664	1772		13	50	37	
St. Johnsbury	1352	1486	1574	1659	1769	3	7	50	37	3
WEST VIRGINIA										
Bayard	1082	1202	1281	1357	1456		43	23	27	7
Charleston	837	938	1005	1069	1152		50	28	18	4
Clarksburg	977	1103	1186	1267	1370		30	37	30	3
Elkins	988	1110	1191	1269	1370		33	33	27	7
Fairmont	950	1070	1149	1225	1323		40	30	27	3
Flat Top	1041	1168	1253	1334	1439		48	20	28	4
Gary	870	979	1052	1122	1212		57	20	20	3
Glenville	871	989	1067	1141	1238		46	32	18	4
Huntington	827	968	1060	1150	1265	4	46	32	14	4
London Locks	856	976	1055	1131	1229		58	26	16	
Mannington	963	1096	1184	1269	1379		43	30	24	3
Martinsburg	946	1062	1140	1214	1309		33	37	30	
Parkersburg	905	1029	1111	1189	1291		40	33	24	3
Piedmont	976	1086	1160	1230	1320		43	32	21	4
Pt. Pleasant	880	1014	1103	1188	1300	3	42	35	17	3
Rainelle	991	1116	1198	1277	1379	4	52	20	20	4
Spencer	903	1028	1112	1191	1295		37	33	27	3
Wardensville	960	1088	1173	1255	1360		39	22	35	4
Wheeling	1026	1172	1268	1361	1481		30	30	37	3
White Sulphur Springs	949	1052	1121	1187	1272		50	27	20	3
Williamson	820	947	1031	1111	1215		48	21	28	3

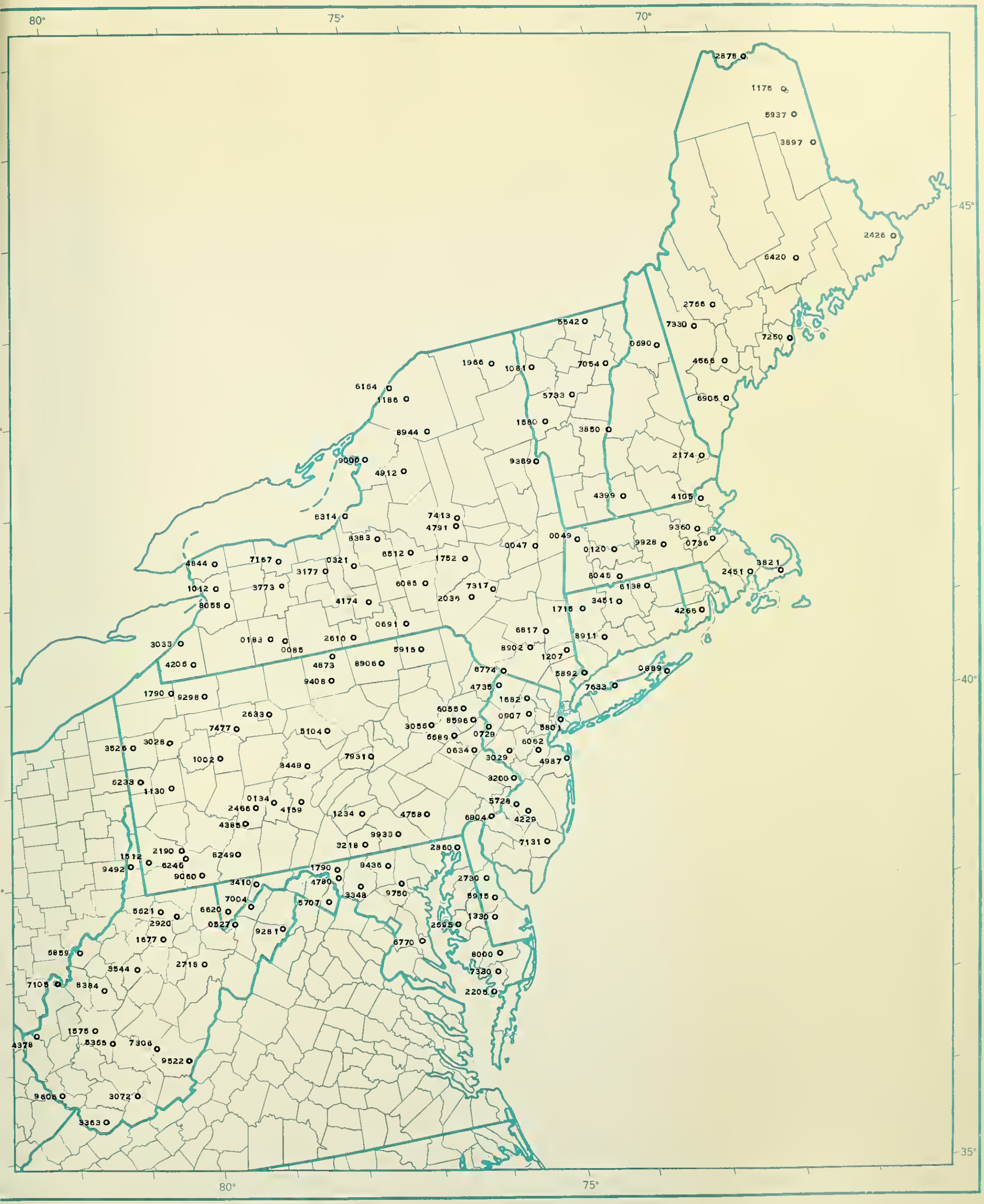
Table 5. Per Cent of total HDD by months.

Normal Annual Range of HDD	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
3000-3999	20.8	18.2	14.7	7.2	1.8	0.3	0.0	0.0	0.4	5.1	12.1	19.4
4000-4999	20.1	17.5	14.4	8.0	2.4	0.3	0.0	0.0	1.0	5.9	12.0	18.4
5000-5999	19.3	17.0	14.2	8.6	3.2	0.4	0.0	0.0	1.6	6.3	11.7	17.7
6000-6999	18.6	16.6	14.1	9.0	4.0	0.6	0.0	0.0	2.2	6.5	11.4	17.0
7000-7999	18.0	16.2	13.8	9.3	4.6	1.0	0.3	0.4	2.5	6.6	11.1	16.2
8000-8999	17.7	15.6	13.4	9.5	5.2	1.6	0.4	0.7	2.8	6.7	10.9	15.5
9000-9999	17.6	15.3	12.9	9.6	5.6	2.0	0.4	0.9	3.0	6.8	10.6	15.3

Table 6. Frequency Relationships.

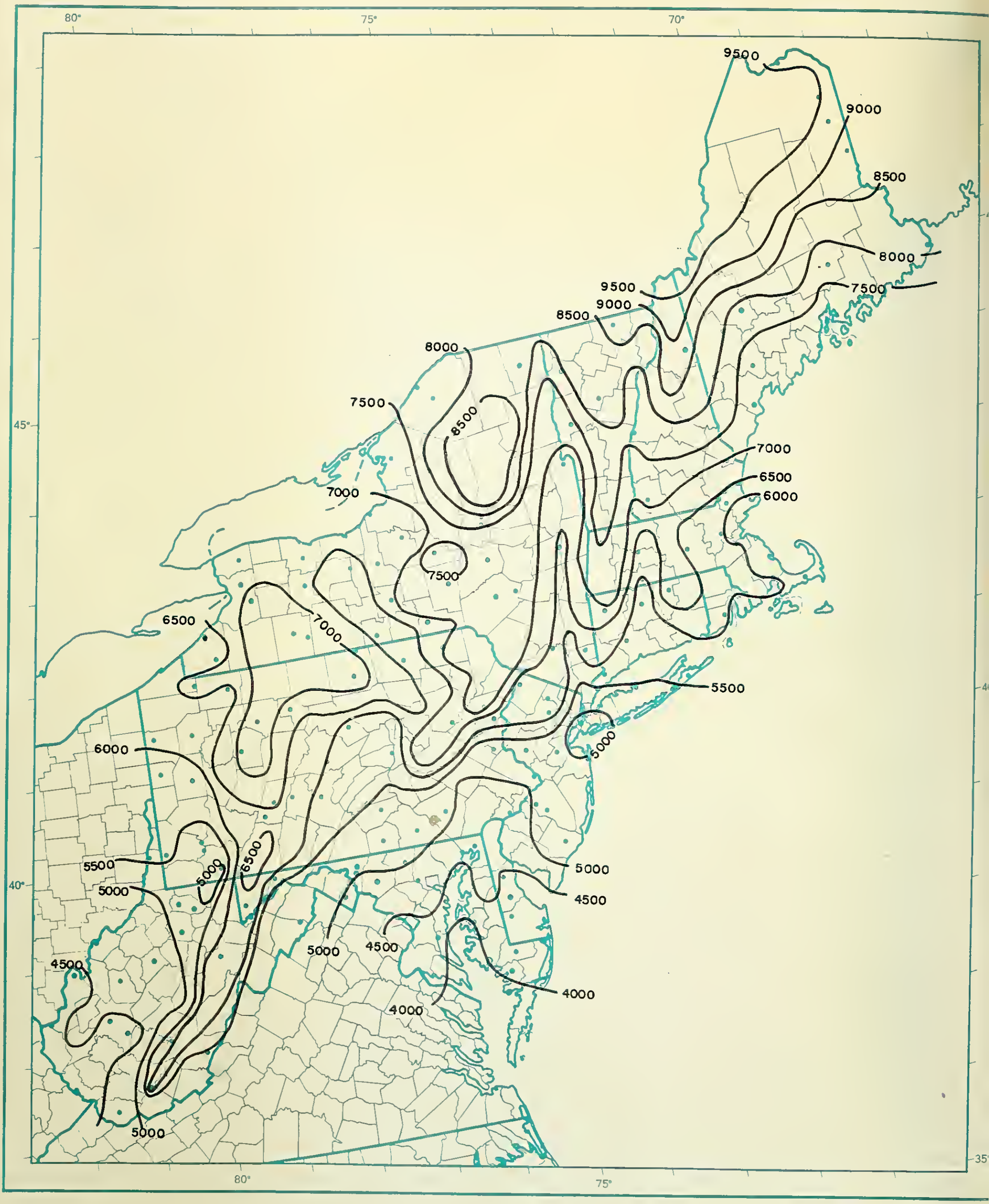
Return Period Years	% Frequency	f*
2	50	0.00
4	75 or 25	0.67
5	80 or 20	0.84
10	90 or 10	1.28
20	95 or 5	1.64
25	96 or 4	1.75
50	98 or 2	2.05

*Factor for area under normal curve.



Map 1

Station Locator Map



Map 2

Mean Annual Heating Degree-Days