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Site-Specific Case Studies for Determining Ground Snow Loads in the United States

James Buska, Alan Grestorex, and Wayne Tobiasson

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Site-Specific Case Studies for Determining Ground Snow Loads in the United States

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Abstract

The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) has mapped ground snow loads for much of the United States. In some areas where extreme local variations preclude mapping on a national scale, “CS” is used to indicate that Case Studies are needed. This report and the accompanying spreadsheet, which contains the 15,104-station CRREL ground snow load database, provide the information needed to conduct Case Studies. When the latitude, longitude, and elevation of a site of interest are provided, the spreadsheet tabulates data available in the vicinity and generates plots that relate ground snow loads nearby to elevation. With this information, the ground snow load at the site of interest can be determined. This report uses 10 examples to illustrate the methodology and provides our answer and the comments we generate for each of these Case Studies and for 16 additional sites of interest, 8 of which have their answers “disguised” for practice purposes. CRREL has conducted over 1000 Case Studies upon request. Practicing structural engineers were involved in over 250 of them to verify that this methodology is ready to transfer to the design profession.

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The location data included herein has been obtained from information developed, produced, and maintained by others. The CRREL Case Study database and methodology used herein to determine ground snow loads meet the requirements of the current national design load standard, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 2017).

Statutory requirements of an Authority Having Jurisdiction may necessitate use of different design loads.

DESTROY THIS REPORT WHEN NO LONGER NEEDED. DO NOT RETURN IT TO THE ORIGINATOR.

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Preface

Over the years, most of the funding for this work has been provided by the U.S. Army Corps of Engineers to update load standards and criteria. However, the U.S. Air Force Civil Engineer Center (AFCEC) East Operations provided funding to bring this effort to completion as part of the Tri-Service Structural Working Group's Unified Facilities Criteria (UFC) program under F4ATA47165JW01, "Comprehensive Case Studies for Determining Ground Snow Loads."

The work was performed by Force Projection and Sustainment Branch of the Research and Engineering Division, U.S. Army Engineer Research and Development Center, Cold Regions Research and Engineering Laboratory (ERDC-CRREL). At the time of publication, Mr. Justin Putnam was Acting Branch Chief, and Mr. J. D. Horne was Division Chief. The Deputy Director of ERDC-CRREL was Mr. David B. Ringelberg, and the Director was Dr. Joseph L. Corriveau.

Mr. George Matsumura, Mr. Peter Rossbach, and Mr. Richard Ludwitzke of the U.S. Army Corps of Engineers and Mr. Robert Dinan of the U.S. Air Force have been instrumental in obtaining funding and then incorporating CRREL-generated snow load information into Department of Defense design manuals and national standards.

Since 1977, valuable feedback has been received from members of the Minimum Design Loads on Buildings and Other Structures Standards Committee of the Structural Engineering Institute, American Society of Civil Engineers (ASCE). Since 1982, CRREL-generated ground snow load maps have appeared in the national load standard (ASCE 7) as has the need for detailed consideration of meteorological information available at surrounding locations (i.e., Case Studies) in areas where "extreme local variations in snow loads preclude mapping at this scale."

Mr. Jeff Tirey, Mr. Joel Fisher, and Mr. Steve Johnson representing Structural Engineers of New Hampshire Inc. participated in the New Hampshire Case Study trials.

Professor Kevin Parfitt of Penn State has used the Beta Test draft of this report and the spreadsheet associated with it in his College of Engineering

classes. Many of his students are now capable of doing snow load Case Studies. Through him, they have provided us valuable hands-on feedback.

Many CRREL colleagues and contractors have contributed to this work. Of mention are Mr. Greg Fellers, Mr. Kevin Knuuti, Ms. Kathy Jones, Ms. Renee Melendy, Mr. Bob Redfield, Ms. Terri Rondos, Mr. Ted Schultz, Mr. Dan Sirois, Mr. Dean Pidgeon, Mr. Tom Vaughn, and Mr. Peter Wren. Additionally, without Mr. Peter Seman's expertise in solving numerous computer-coding problems, it is doubtful that this project would have proceeded beyond the beta test phase.

This report and the accompanying spreadsheet and database have been used and reviewed by Ms. Kathy Jones, Professor Kevin Parfitt, Mr. Robert Redfield, Mr. Peter Seman, and Mr. Jeff Tirey.

COL Teresa A. Schlosser was Commander of ERDC, and Dr. David W. Pittman was the Director.

Acronyms and Abbreviations

AHJ	Authorities Having Jurisdiction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
co-op	Cooperative Observer Program
CRREL	Cold Regions Research and Engineering Laboratory
CS	Case Study
D_g	Depth of Snow on the Ground
DOD	Department of Defense
ERDC	U.S. Army Engineer Research and Development Center
GPS	Global Positioning System
GSL	Ground Snow Loads
IRC	International Building Code
MRI	Mean Recurrence Interval
NCDC	National Climatic Data Center
NCEI	National Centers for Environmental Information
NRCS	Natural Resources Conservation Service
NWS	National Weather Service
P_g	Ground Snow Load
P_{max}	Maximum Observed Ground Snow Load
psf	Pounds per Square Foot
SEI	Structural Engineering Institute
SENH	Structural Engineers of New Hampshire
SI	International System
UFC	Unified Facilities Criteria
W.E.	Water Equivalent

Unit Conversion Factors

Multiply	By	To Obtain
degrees (angle)	0.01745329	radians
feet	0.3048	meters
inches	0.0254	meters
miles (U.S. statute)	1,609.347	meters
pounds (force)	4.448222	newtons
pounds (force) per square foot	0.04788	kilonewtons per square meter
pounds (force) per square foot per 1000 feet	0.0157	kilonewtons per square meter per 100 meters
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic meter
pounds (mass) per square foot	4.882428	kilograms per square meter
square feet	0.09290304	square meters

1 Introduction

1.1 Background

For almost half a century, the Cold Regions Research and Engineering Laboratory (CRREL) has been providing national snow load design guidance to the Department of Defense. Over the years, this guidance has been adopted by other Federal and State agencies, the American National Standards Institute (ANSI), the American Society of Civil Engineers (ASCE), and the International Building Code (IRC).

Our current ground snow load map is the most widely used in the United States. However, extreme local variations in snow loads in some areas preclude mapping. There, site-specific Case Studies are required. Using our snow load database and Case Study methodology, we have generated ground snow loads at many sites of interest where mapped values are not provided.

1.2 Objectives

The information in this report and in the accompanying spreadsheet provides the reader with the ability to generate 50-year mean recurrence interval (MRI) ground snow loads for sites of interest anywhere in the United States.

1.3 Approach

This report describes our current national ground snow load map and calls attention to areas where Case Studies are needed. Specifically, the report summarizes the snow load and snow depth measurements used to generate the 50-year MRI mapped ground snow loads and presents the equations developed to relate extreme-value snow depths to extreme-value snow loads. Additionally, we explain the spreadsheet that assembles database information near sites of interest, including specifying the site information a user must provide and giving several examples of the data table and two plots generated for each Case Study. The examples illustrate the value of various filters that can be applied to the data and how to handle complexities generated by lake effects, windswept sites above the tree line,

very great increases in load with elevation in mountainous areas, and limited data in remote areas. Throughout, we stress the value of independent analysis by two or more individuals before reaching a consensus.

1.4 Context

Worldwide, the first step to establish the magnitude of snow loads on the roofs of buildings and other structures is to use meteorological observations of snow on the ground by various government agencies and private interests to establish ground snow loads. This report does not discuss the several additional steps needed to transfer ground snow loads to snow loads on roofs. Those steps for snow loads in the United States are explained in the Snow Loads section of ASCE Standard 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (ASCE 2017).^{*†}

The information in the report you are reading and in the spreadsheet, which is concurrently being made available to the public (<http://dx.doi.org/10.21079/11681/37574>), does not generate the 50-year MRI ground snow load for the site of interest. However, it does provide the user with the information needed to generate that answer for essentially any place in the United States.[‡]

When the user enters the latitude, longitude, and elevation of a site of interest into the Case Study (CS) Spreadsheet, the CRREL ground snow load database therein is interrogated, pertinent information available near that site is provided in a table, and two plots of ground snow load vs. elevation are created. This report and the spreadsheet provide guidance on how to analyze that information to generate an appropriate 50-year MRI ground snow load for that site. We provide several examples to guide the user in this task. This report also contains background information on the CRREL database and how its use meets the requirements of ASCE 7 (ASCE 2017). Additionally, this report touches on some complications, limitations, and opportunities created by changes incorporated into the current edition of ASCE 7.

* The current edition of ASCE 7 is known as ASCE 7-16 with the “16” an abbreviation of the year 2016. Since it was, in fact, published in 2017, it is properly referenced as (ASCE 2017).

† The provisions of ASCE 7 are widely accepted nationwide. However, Authorities Having Jurisdiction (AHJ), on occasion, exercise their right to make changes.

‡ High-elevation sites on Mauna Kea and Mauna Loa in Hawaii are the only exceptions as no information for Hawaii is included in the CRREL snow load database.

A second report is in preparation that reviews the development of ground snow loads for the United States during the past half century.* This companion report provides additional information on the methods used to measure precipitation, snowfall, and the depth and water equivalent (i.e., load) of snow on the ground and the difficulties encountered in taking and archiving such measurements. It covers the various ways we and others have analyzed snow data to generate snow load design criteria. Additionally, it describes the first CRREL ground snow load map of the United States, which appeared in the National Design Load Standard from 1982 until 1995 when it was replaced by the second CRREL map (Figure 1). That map has been in ASCE 7 ever since. Both maps contain areas where ground snow loads are not provided. In those areas, Case Studies are called for using snow data at surrounding stations to generate loads with attention given to the relationship between load and elevation at those stations.

That report also explains the manual way in which such Case Studies were conducted initially and then describes the improvements made to automate that time-consuming data-gathering procedure. Case Studies involving practicing structural engineers are used to show that the method of analysis developed at CRREL can be used effectively by others willing to study several Case Study examples we have prepared for that purpose.

In addition, that report presents findings of database test updates from 1992 to 2013 at seven stations and provides a glimpse of ground snow loads in the future. It then emphasizes the need to update the entire database and the importance of conducting data credibility checks. Improved analytical methods are needed and a single national procedure agreed upon to eliminate inconsistencies created by the various procedures currently in use in the Rocky Mountain States.

* Once published its citation will be

Tobiasson, W., J. Buska, and A. Greatorex. (year published). Ground Snow Loads for the United States. ERDC/CRREL TR-(report number). Hanover, NH: U.S. Army Engineer Research and Development Center.

Our efforts directed at (1) resolving issues encountered with ASCE's Hazard Tool, (2) providing requested guidance to the ASCE working group on changes proposed to ASCE 7-16, (3) reviewing new studies for Alaska and several Western states, and (4) helping steer new mapping underway by others for ASCE 7-22 have delayed completion of this report. Additional factors may prevent its publication. To determine its status, contact the ERDC Library online at <https://www.erdclibrary.usace.army.mil/Library/> or by phone at 601.634.2355.

Figure 1. Ground snow load, P_g , for the United States (psf). This version of this map is for general reference only. It does not enlarge well. Use the two-part version of it in the accompanying spreadsheet to accurately locate sites of interest. That version enlarges nicely.

Sack (2015) comprehensively overviews the current situation in the Rocky Mountain States. He gives, as an example, a ground snow load that jumps from 60 psf* to 180 psf on crossing from Idaho into Montana when using guidance developed by those two states. He also takes issue with some CRREL mapped values in these states. CRREL studies have encountered situations in Idaho where ground snow load guidance (Al Hataillah et al. 2015) changes drastically over short distances. For example, in downtown **Pocatello, ID**,[†] the Interactive 2015 Idaho map generates loads that jump from 31 psf at 42.866° N and 112.443° W at an elevation of 4467 ft to 104 psf at 42.865° N and 112.442° W at the same elevation. These two sites are only 452 ft apart. The Interactive 1986 Idaho map generates a load of 56 psf at both locations, but an accompanying table indicates that a value of 45 psf should be used at 4460 ft. At each of these locations, a CRREL Case Study generates a ground snow load of 25 psf. Later in this report, an example illustrates an even bigger jump at another site in Idaho. We have brought this problem to the attention of the authors of the Interactive 2015 Idaho map and to ASCE.[‡]

We agree with Sack (2015) that a coordinated research effort is needed to provide consistent, updated ground snow load design criteria for the United States with attention given to Rocky Mountain States. Sack et al. (2017) offer guidelines for achieving this goal for Western States.

We have concerns about some of the ground snow loads that have been in use in the West and others that were introduced in the current edition of ASCE 7. Nonetheless, we acknowledge that these studies offer more-comprehensive coverage and improved design guidance in some situations.

For sites of interest in the Rocky Mountain States, all the above suggests that **second opinions provided by CRREL Case Studies are well worth considering**. Test updates we have done and comparisons with

* Pounds per square foot. For a full list of the spelled-out forms of the units of measure used in this document, please refer to *U.S. Government Publishing Office Style Manual*, 31st ed. (Washington, DC: U.S. Government Publishing Office, 2016), 248–252, <https://www.govinfo.gov/content/pkg/GPO-STYLE-MANUAL-2016/pdf/GPO-STYLEMANUAL-2016.pdf>.

† Case Studies at places referred to are in bold print as are their Case Study answers. Data stations referred to are in italics.

‡ Within the Interactive 2015 Idaho map, a popup notes to “peruse all GSL [ground snow loads] in the vicinity of the location of interest” (Al Hataillah et al. 2015). In our judgment, the note does not solve this problem.

values generated by others support continued use of the CRREL database and methodology.

A Case Study conducted at **Mt. Hood Meadows, OR** (45.3307° N and 121.6643° W at an elevation of 5360 ft), generated a ground snow load of 570 psf, which supported the 560 psf value obtained using the rather different method of analysis developed for Oregon by the Structural Engineers Association of Oregon et al. (2013). That guidance requires Case Studies when listed values exceed specified limits. In the Cascades, where Mt. Hood is located, that limit is 350 psf.

2 The Second CRREL Map

CRREL created the ground snow load map of the United States for ASCE 7 (Figure 1). It first appeared in the 1995 edition of that National Design Load Standard and has appeared unchanged in every subsequent edition through ASCE 7-10. It has also appeared in every edition of the International Building Code (International Code Council 2018) since that code was initiated in 2000. Snow loads are presented as zones. Some zones contain elevation limits above which the zoned value should not be used. These elevation limits, in feet, are shown in parentheses above the zoned value. Some zones contain a series of loads and elevation limits. Zoned values are available over much of the United States. However, in some areas, extreme local variations in ground snow loads preclude mapping at this scale. In those areas, the map contains the designation “CS” instead of a value. CS indicates that a Case Study is required to establish ground snow loads in such areas.

Figure 1 is for general information only as it does not enlarge well. To accurately locate a site of interest, use the two-part version of this map in the accompanying spreadsheet. That version enlarges nicely. Compare county boundaries on it to those on a Google Earth (or other) enlargement of the same area that locates the site of interest. Such a comparison is provided in the instructions in the spreadsheet.

In the 2016 edition of ASCE 7, all guidance has been removed from this map in Washington, Oregon, Idaho, Montana, Colorado, New Mexico, and New Hampshire. Instead, it provides a table of values for several locations for each of these states and includes a reference where values at other places can be obtained.

While we do not agree with all the values presented in the above-mentioned tables, we do agree that most are based on Case Studies as ASCE 7 requires. However, since New Mexico values do not contain any information from surrounding stations, they do not represent Case Studies. For decades, ASCE 7 has warned against the use of on-site information only by including in its commentary the following statement:

It is not appropriate to use only the site-specific information in Table C7-2* for design purposes. It lacks an appreciation for surrounding station information and, in a few cases, is based on rather short periods of record. The map [i.e., Figure 1 in this report] or a site-specific Case Study provides more valuable information (ASCE 2017).

In other words, ASCE does not consider the use of data collected only at a site to be a “Case Study” of that site.

Table C7-2 in ASCE 7-16 contains 50-year MRI ground snow loads (P_g) for National Weather Service (NWS) first-order stations. Even though those loads are based on direct measurements of ground snow loads, they alone are not considered appropriate to use for design purposes. Furthermore, the New Mexico values are from snow depth measurements converted to loads by using the assumption that each inch of snow contributes a load of one pound per square foot. For locations that experience high ground snow loads, this assumption significantly underestimates snow loads relative to essentially all other assumptions that have been used by CRREL, ASCE, and states in the American West for many decades.

ASCE 7-16 continues to require that all ground snow loads used in design

be based on an extreme value statistical analysis of data available near the site using a value with a 2% annual probability of being exceeded (50-year mean recurrence interval) (ASCE 2017).

The CRREL map and CRREL Case Studies meet this requirement.

The CRREL map alone does not provide ground snow loads for all locations in the United States. The CRREL database was used to develop the Case Study methodology for determining ground snow loads for sites not mapped. That methodology can also be used to further investigate values available from the map. Because the Case Study methodology amounts to a more detailed investigation of a site, the Case Study answer is better than

* It was numbered C7-1 until ASCE 7-16 wherein it is C7-2.

that obtained from the map. As has been stated in the Commentary of every edition of ASCE 7,

Detailed study of a site may generate a design value lower than that indicated by the generalized national map. It is appropriate in such a situation to use the lower value established by the detailed study. Occasionally, a detailed study may indicate that a higher design value should be used than the national map indicates. Again, results of the detailed study should be followed (ASCE 2017).

3 The CRREL Database

3.1 NWS first-order stations

Measurements collected by NWS are the largest source of information on snow on the ground in the United States. For half a century, beginning with the winter of 1952–53, most of the 266 NWS first-order stations across the nation (Alaska included) were equipped to measure both the depth of snow on the ground and its load (i.e., its snow water equivalent). At these stations, snow load measurements were required every day that the ground was covered with at least 2 in. of snow. We determined the maximum depth and maximum water equivalent for each winter. These maxima can occur on different days or even different months during the same winter.

Of those stations, 26 never experienced snow; and another 16 did not have enough winters with snow to generate 50-year values per our criteria, which call for at least five winters with snow and at least 10 years of record.^{*} The CRREL database contains 50-year ground snow loads for 224 NWS first-order stations, 20 of which are in Alaska. The 204 first-order stations in the Lower 48 states that met our criteria had from 11 to 40 years of concurrent depth and load measurements with an average of 35 years. Those values for the 20 first-order stations in Alaska were 10 to 40 years with an average of 24 years.

Unfortunately, about 15 years ago, NWS began phasing out snow water equivalent measurements at these stations. We consider this a most unfortunate turn of events because a water equivalent is a direct measurement of load; a depth is not.

At most of the first-order stations, snow depths had been measured for several years prior to when water equivalent measurements began. Because of this, we have analyzed the first-order stations twice: first for those years when both the depth and load of snow on the ground were measured and second for the longer period of snow depth measurements. Our findings from the concurrent depth and load measurement period are labeled “W.E.,” and those from the longer depth record are labeled “depth.”

^{*} Later in this report, filters are introduced that call for longer records.

3.2 NWS co-op stations

At almost all the 11,556 NWS co-op* stations in the CRREL database, the depth of snow on the ground but not its water equivalent has been measured. At each co-op station, we determined the maximum depth of snow on the ground each winter. Of those stations, 7300 in the Lower 48 states met our above-mentioned criteria for calculating a 50-year MRI ground snow load (P_g). They had from 10 to 48 years of record with an average of 29 years. The 186 NWS co-op stations in Alaska that also met our criteria had 10 to 45 years of record with an average of 25 years. The other 4070 co-op stations in the CRREL database did not have their ground snow load calculated. Nonetheless, they are included in our Case Studies because they occasionally provide valuable information.

3.3 Depth-to-load equations

We used lognormal extreme value statistics (Ellingwood and Redfield 1983) to determine the 50-year MRI value (i.e., the value having a 2% annual probability of being exceeded) for each group of seasonal maxima. Winters with no snow were accounted for using the method developed by Thom (1966). It calculates the 50-year value for all winters with snow, then adjusts this value downward to account for the number of winters with no snow.

The nonlinear equation of best fit between the concurrent 50-year depths and 50-year loads at those 204 first-order stations in the **Lower 48 states** that met our criteria for analysis was as follows:

$$P_g = 0.279 D_g^{1.36} \quad (1)$$

where P_g = 50-year load in lb/ft² and D_g = 50-year depth in inches. In SI[†] units with the load in kN/m² and the depth in meters, the equation becomes $P_g = 1.97 D_g^{1.36}$.

The nonlinear equation of best fit between the 50-year depths and 50-year loads at those 20 first-order stations in **Alaska** that met our criteria for analysis was as follows:

* Co-op stands for Cooperative Observer Program. Recently, NWS has adopted the new acronym, COOP. However, we continue to use, "co-op."

† International System

$$P_g = 0.222 D_g^{1.39} \quad (2)$$

where P_g = 50-year load in lb/ft² and D_g = 50-year depth in inches. In SI units with the load in kN/m² and the depth in meters, the equation becomes $P_g = 1.75 D_g^{1.39}$.

The above equations were used to generate 50-year loads from the 50-year depths at all NWS co-op stations where only depths were measured. They were also used to generate the “depth” 50-year loads at first-order stations, most of which have a longer depth record than the concurrent record used to generate their “W.E.” 50-year loads.

The CRREL ground snow depth and load database ends with the winter of 1991–92. As stated in ASCE 7 (ASCE 2017), “Where statistical studies using more recent information are available, they may be used to produce improved design guidance.”

3.4 Non-NWS stations

The database also contains information from 3282 Non-NWS locations where both the depth and water equivalent of snow on the ground are measured concurrently several times each winter. Of these, 3064 are in the Lower 48 states. Of those, 2741 met our above-mentioned criteria for calculation. They had from 10 to 80 years of record with an average of 33 years. Of the 218 Non-NWS stations in Alaska, 158 met our criteria for calculation. They had 10 to 34 years of record with an average of 19 years.

Some Non-NWS measurements are by companies that generate hydroelectric power, others are by the Corps of Engineers for flood forecasting, but most have been collected by the Department of Agriculture’s Natural Resources Conservation Service (NRCS) and the State of California’s Department of Water Resources for similar purposes and for monitoring water supplies. (NRCS was previously known as the Soil Conservation Service.) Most of these Non-NWS locations are in the West in high mountain watersheds, not in populated areas. It is important to realize that the previously mentioned equations are not used for Non-NWS stations because ground snow loads are measured there.

3.5 Mapped values

The 50-year loads on the CRREL map (Figure 1) are based on NWS data only. Table 1 indicates the upper and lower limits of the ground snow load zones shown in Figure 1. Those zones increase by 5 psf to 40 psf; above that, they increase by 10 psf.

We round most Case Studies to the nearest 5 psf even though above 40 psf, mapped zones increase by 10 psf.

Table 1. Upper and lower limits of P_g (psf) shown in Fig. 1.

Upper Limit	2	7	12	17	22	27	32	37
ZONE	0	5	10	15	20	25	30	35
Lower Limit	0	3	8	13	18	23	28	33
Upper Limit	44	54	64	74	84	94	104	
ZONE	40	50	60	70	80	90	100	
Lower Limit	38	45	55	65	75	85	95	

To convert psf to kN/m^2 , multiply by 0.0479

Elevation limits and Case Study zones on the map limit the places where those loads can be used. We established those limits with consideration given to regional topography and to Non-NWS station data. Beyond those limits, extreme local variations in ground snow loads preclude mapping at this scale, and site-specific ground snow load Case Studies are needed. All NWS and Non-NWS information in the CRREL database are used when doing Case Studies.

Much of the Rocky Mountain West requires Case Studies. In addition to those done by CRREL, ASCE references ground snow load studies and mapping done by structural engineering associations and others in those states. Sack (2015) and Sack et al. (2017) discuss those studies.

3.6 Case Study developments

The combination of the CRREL map and the CRREL Case Study methodology allows ground snow loads to be determined for essentially all locations in the United States, including Alaska.

Over the past 38 years, we have developed and used our evolving Case Study methodology to establish 50-year MRI ground snow loads at over 1000 sites across the United States. Of these, 355 were at sites of interest to the Department of Defense (DOD). Current DOD facility design guidance on ground snow loads is in UFC (Unified Facilities Criteria) 3-301-01, *Structural Engineering* (DOD 2019).

Most Case Studies were at places where they are called for on the CRREL map (i.e., within CS areas and in other places above the elevation limits shown in Figure 1). However, to verify or, as stated above, to improve on the mapped values, some Case Studies were conducted at places where values are available on that map.

Our evolving CRREL Case Study database and methodology were first reported in Tobiasson and Greatedorex (1997), and Tobiasson et al. (2002) documents our experience doing Case Studies with practicing structural engineers.

3.7 The CRREL Case Study Log

Of the over 1000 Case Studies conducted by CRREL personnel since 1982, 837 (57 in Alaska and 780 in the Lower-48 States) were conducted after the “old” CRREL database was updated to circa 1992. The CRREL Case Study Log (Appendix D) provides information on each of these 837 Case Studies. For each one, the state, location name, latitude, longitude, elevation, and our 50-year MRI ground snow load answer are provided.

4 The CRREL Case Study Spreadsheet

This spreadsheet, herein referred to as the Case Study Spreadsheet,^{*} contains the CRREL ground snow load database and the programming needed to extract from it ground snow load information available near sites of interest in the United States. The Case Study Spreadsheet also contains instructions on what information the user must provide to have the following information determined and printed out: (1) a table of information, (2) two plots of load vs. elevation, (3) a straight line of best fit shown on each plot, and (4) the 50-year MRI ground snow load (P_g) where each of these lines crosses the elevation of the site of interest. On occasion, plots are not provided because the six data points required to initiate them are not available. The spreadsheet also provides guidelines for analyzing this information. That and the guidance in this report help the user to determine a 50-year ground snow load for the site of interest.

When a user inputs the geographical coordinates and elevation of a site of interest, the spreadsheet examines all NWS and Non-NWS information in the CRREL database. It is essential to input the correct coordinates and elevation. Mistakes in obtaining and entering correct information are common. If just one of the three input values is incorrect, the table, plots, and generated 50-year MRI ground snow load will be wrong.

One minute of latitude always covers a “vertical” (i.e., north–south) distance of about 1.15 miles on the face of the earth. One second of latitude always covers a “vertical” distance of about 100 ft. Because lines of longitude converge at the Poles, one minute of “horizontal” (i.e., east–west) longitude decreases from about 1.15 miles at the equator to 0.9 miles at a latitude of 40° north (Denver, CO; Indianapolis, IN; and Philadelphia, PA), 0.8 miles at 45° north (Portland, OR; Minneapolis, MN; and Bangor, ME), 0.6 miles at 58° north (Juneau, AK), and 0.4 miles at 71° north (Barrow,[†] AK).

The CRREL database lists the coordinates of all stations only to the nearest minute of latitude and longitude. The station itself may be a half a mile

^{*} The spreadsheet is available along with this report at <http://dx.doi.org/10.21079/11681/37574>.

[†] Also known as Utqiagvik.

or more away from such “nearest minute” coordinates. The elevation listed for each station is that at the station itself.*

Since Case Studies for sites only a mile apart each produce essentially the same answer for the same elevation, there is no apparent reason to define the position of sites of interest closer than to the nearest *minute* of latitude and longitude. However, when determining the elevation of a site of interest, in most cases it is essential to know its position much closer than to the nearest mile. The Case Study Spreadsheet contains a “Display Map” link to Google Maps. It is easy to zoom in and, if necessary, adjust the coordinates to be exactly on the site of interest. Then its latitude and longitude can be established to within the nearest second. Unfortunately, that Google Map link does not also provide the elevation information needed for the Case Study. However, Google Earth displays to the nearest foot. Several other online sites have similar capabilities. For Case Studies, rounding the elevation to the nearest 5 or 10 ft is acceptable. Alternatively, U.S. Geological Survey topographic maps provide reasonable elevation information.

If the “Display Map” link does not function, do not omit this step. Go directly to Google Earth or other online site with similar capabilities. We strongly recommend doing this visual verification before running any Case Study. At this point, also confirm the elevation of the site of interest.

Computations begin by determining the distance from the site of interest to each station in the CRREL database. When a station’s coordinates exactly match those of the site of interest, it is listed as “At Site.” Any station less than half a mile away but not “At Site” is listed as “Nearby.”† All other distances are rounded to the nearest mile.

Next, all stations within an initial search radius of 25 miles of the site of interest are examined to determine if 30 or more are present and if 10 or more of them have P_g values that survive all filters, which will be explained in section 7. If either of these requirements is met, the search stops. If not,

* Up until the mid-1990s, nearly all latitude and longitude values were reported by NWS in degrees and whole minutes. In the mid-1990s, many NWS offices began surveying NWS stations with Global Positioning System (GPS) instruments to obtain high-resolution latitude and longitude values. The current requirement for NWS stations is to report coordinates in degrees, whole minutes, and whole seconds (NCDC 2011). NCDC is now National Centers for Environmental Information (NCEI)

† The two **Dover-Foxcroft, ME** example Case Studies in this report have a “Nearby” station. None of the example Case Studies has an “At Site” station; but two mentioned sites, **Fairbanks** and **Cold Bay, AK**, do.

the search radius expands by 5 miles; and the 30 and 10 criteria are checked again. If either is met, the search stops there; if not, it continues by expanding the search radius another 5 miles. This continues until one of the above stops is reached or a “maximum search radius” is reached, ending the search. In the Lower 48 states, that radius is 100 miles. In Alaska, it is 300 miles. Almost all searches stop well before reaching their “maximum search radius.”

All stations within the furthest radius searched are included in the Case Study. The Case Study does not stop at the distance where one of the above-mentioned stops occurs; it includes all stations within the last search increment. This explains why some Case Studies have more than 30 stations or more than 10 P_g values that survive all filters.

Most Lower 48 state searches stop at 25 to 40 miles. Many Alaskan searches stop within 50 miles; but due to the limited number of stations in Alaska, many expand much farther before one of the above stops is reached. Faraway stations are of limited value in almost all cases. However, in a few remote places in Alaska, knowing just how little information is available for great distances can be informative. ASCE Standard 7 (ASCE 2017) contains a table of 33 Alaskan values, which we generated years ago by doing Case Studies.

In conjunction with the above searching, the nearest six stations having P_g values that survive all filters are flagged for inclusion in the first of two P_g vs. elevation plots provided as part of the Case Study. If in searching for six stations mile by mile more than one station is found in the last mile searched, all of them are included, and the subheading is changed to indicate the correct number. The lower “all values” plot contains data from all stations that pass applied filters. Its subtitle indicates the maximum radius searched. This provides both a close-up examination and a broad-brush overview of surrounding data.

5 Case Study Examples

5.1 Salisbury, New Hampshire

A Case Study consists of a table and two plots. Table 2 and Figure 2 shows those two pages for a site of interest in **Salisbury, NH**, with a latitude of $43^{\circ} 23' \text{ N}$ and a longitude of $71^{\circ} 46' \text{ W}$. This site has an elevation of 775 ft. Information for each station located is listed across the table. The station at *Salisbury*, having an azimuth* of 90° is 1 mile due east of the site. *Chase Village*, with an azimuth of 180° , is 16 miles due south; and *Newport* (azimuth 270°) is 21 miles due west. “ P_g ” is the calculated ground snow load with a 50-year MRI at each station and “ P_{max} ” is the maximum observed ground snow load there. For stations where snow loads are measured, P_{max} and P_g are, respectively, the maximum load measured during the years of record and the 50-year MRI load based on those measured loads. For stations where only snow depths are measured (i.e., for all NWS co-op stations and for the “depth” values at NWS first-order stations), these are, respectively, the maximum depth measured and the 50-year MRI depth each converted to a load using equation (1) in the Lower 48 states and equation (2) in Alaska.

Total years of record for these nearby stations range from 4 at *Gilmanton 2E* to 44 at *Concord* (“depth”), *Blackwater Dam*, and *Franklin Falls Dam*. All but three stations had snow every winter. *Grafton* and *Mount Sunapee* had two snowless winters, and *Newport* had one.

P_g was not calculated for seven co-op stations because each did not have at least 10 total years of record and at least five winters with snow. In Table 2, those stations have a gray background. Lacking a P_g value, they do not appear on the two plots. They are included in the table since their Record Max values are worth knowing. Five additional stations are also presented with a gray background. They do have P_g values but also do not appear on the plots because they do not pass one or more additional filters that, in this Case Study, call for at least 15 total years of record and a P_g/P_{max} ratio from 0.8 to 1.7. We currently apply these filters to all Lower 48 state Case Studies. The filters applied to a Case Study are listed above its table. Applying filters often eliminates outliers from the plots and streamlines the analysis. Comparison tests indicate that applying filters changes answers

* Azimuth = the angle measured clockwise from true north.

little, if at all. One analytical justification for them is that a 50-year value created from less than 15 years of record is a big extrapolation of limited value. Another justification is that when the P_g/P_{max} ratio is beyond the previously mentioned limits of 0.7 to 1.8, either the lognormal extreme value distribution being used does not adequately represent that station's data or the P_{max} value itself is an outlier. For **Salisbury, NH**, the 15 years-of-record filter eliminated four of these five stations (*Franklin, Lakeport 2, Nelson Brook, and Washington*). The fifth station, *Deering*, has 16 years of record; but its P_g/P_{max} ratio of 2.02 eliminated it. Had *Lakeport 2* not been filtered out due to less than 15 years of record, it would have been filtered out by its P_g/P_{max} ratio of 2.39. These and other filters are discussed further in section 7.

As shown in Table 2, all NWS first-order stations are listed first. Two rows of values are provided for each first-order station. The upper one, which is designated "W.E.," is from measurements of snow water equivalent (i.e., ground snow load). The lower one, which is designated "depth," is from measurements of snow depth converted to load using equation (1) or, in Alaska, equation (2). The years of record on these two rows are often different (e.g., 40 and 44 for *Concord, NH*) as depths alone were measured before NWS began taking load measurements in 1952–53. The two values of P_g for *Concord, NH* ("W.E." = 63 and "depth" = 44) suggest that equation (1) may under-estimate 50-year loads in this area. This possibility is worth keeping in mind as the Case Study proceeds. While that difference exists for the *Concord, NH*, first-order station, it is an inappropriate over-generalization to assume that it applies to all co-op stations in the vicinity.

In some regions, the West for example, the average value of the "depth" P_g divided by the "W.E." P_g is more than 1.0 while in others, New England for example, it averages less than 1.0. However, because, in any region, this ratio varies greatly among the first-order stations within that region, it should not be applied to "correct" nearby co-op stations.

Where P_g values are based on measured loads, as they are at NWS first-order stations and all Non-NWS stations, they are to be considered somewhat more valuable than P_g values based on depth measurements that use equation (1) or (2) to convert them to loads. All NWS co-op stations are in this latter category. Those stations are, nonetheless, quite valuable because they are so numerous, and many have long periods of record.

Table 2. Salisbury, NH, Case Study table.

SNOW LOAD CASE STUDY FOR

Salisbury, NHLatitude 43° 23' NLongitude 71° 46' WElevation 775 ft

Filters Used: Min. Years of Record 15; Pg/Pmax Ratio: Max. 1.7, Min. 0.8

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
CONCORD (W.E.)	18	125	350	63	43	40	0	1.47
CONCORD WSO AP ("depth")	18	125	350	44	38	44	0	1.16
NEW HAMPSHIRE (NWS co-op)								
BLACKWATER DAM	5	143	600	69	59	44	0	1.17
FRANKLIN	7	56	390	83	94	13	0	0.88
FRANKLIN FALLS DAM	8	54	430	72	67	44	0	1.07
SOUTH DANBURY	10	311	930	101	85	22	0	1.19
NEW LONDON	11	279	1340		51	9	0	
BRADFORD	14	236	970	75	73	39	0	1.03
BRISTOL 2	14	9	590		27	8	0	
WEST HENNIKER	16	201	500		59	5	0	
GRAFTON	16	315	840	101	67	25	2	1.51
MOUNT SUNAPEE	16	261	1260	132	78	18	2	1.69
GILMANTON	18	79	1030	86	55	16	0	1.56
LAKEPORT	19	61	560	69	68	34	0	1.01
LAKEPORT 2	19	61	500	67	28	11	2	2.39
ALEXANDRIA	19	339	1370		38	5	0	
GILMANTON 2 E	20	83	800		23	4	0	
WEARE	21	174	720	50	32	20	0	1.56
NEWPORT	21	270	790	78	57	39	1	1.37
NORTH CHICHESTER	21	109	360		27	8	0	
DEERING	22	201	1010	83	41	16	0	2.02
EAST DEERING	22	189	790	77	65	26	0	1.18
SOUTH WEARE	23	171	700	82	71	18	0	1.15
ALTON	25	84	800		28	5	0	
NEW HAMPSHIRE (Non-NWS)								
SALISBURY	1	90	760	72	54	40	0	1.33
ANDOVER	4	315	700	76	61	32	0	1.25
BLACKWATER	5	166	620	69	56	40	0	1.23
FRANKLIN FALLS	7	45	400	73	54	39	0	1.35
SOUTH DANBURY	10	315	800	74	62	40	0	1.19
DAY POND	12	218	780	83	62	29	0	1.34
LITTLE SUNAPEE	15	287	1490	93	59	31	0	1.58
NEW LONDON	15	287	1170	86	75	26	0	1.15
CHASE VILLAGE	16	180	700	81	59	29	0	1.37
GRANLIDEN	17	276	1220	89	60	31	0	1.48
SADDLE HILL	18	33	1020	73	69	41	0	1.06
GILFORD	18	49	1000	90	71	40	0	1.27
CARDIGAN MOUNTAIN	19	336	1500	72	64	15	0	1.13
NEW HAMPTON	19	24	560	76	62	41	0	1.23
GRAFTON CENTER	19	317	900	69	60	24	0	1.15
NELSON BROOK	20	78	770	89	55	11	0	1.62
EVERETT DAM	22	159	460	78	53	29	0	1.47
WASHINGTON [2]	22	236	1500	88	64	22	0	1.38
MEREDITH	22	43	880	80	62	40	0	1.29
WASHINGTON	22	237	1340	90	61	11	0	1.48
WEIRS BEACH	23	54	520	50	38	27	0	1.32
HOYT HILL	24	360	950	72	73	41	0	0.99
SALMON BROOK	25	223	1300	88	57	22	0	1.54

Figure 2. Salisbury, NH, Case Study plots.

Next, all NWS co-op stations are listed mile by mile followed by all Non-NWS stations mile by mile. Table 2 shows this arrangement for a search that ended at 25 miles. More than 30 stations and more than 10 stations with P_g values that pass all filters were found.

The complete Salisbury, NH, table page is not contained in Table 2. Space below the table itself for listing the current ASCE 7 value (here 75 psf at 775 ft),* the answer generated by this Case Study (also 75 psf at 775 ft), the date and names of those who generated the answer, and their Comments (presented in the text that follows) has been eliminated to avoid having to reduce the size of the words and numbers in the table. The nine other Case Study examples presented herein have all this information presented below their tables.

The many P_g values presented in Table 2 range from 44 to 132 psf. It is seldom easy to establish the sought-after P_g for the site and elevation of interest by simply examining the table. Plots that relate the P_g of each station that passes applied filters to its elevation have proven to be quite valuable. Figure 2 shows the two plots for the **Salisbury, NH**, site of interest. The upper “nearest values” plot contains data from only the nearest six surrounding stations.

A legend to the right of each plot defines the three symbols used to distinguish between (1) NWS “W.E.” values (i.e., NWS first-order-station “W.E.” values), (2) NWS “depth” values (i.e., NWS co-op station values and NWS first-order “depth” values), and (3) Non-NWS “W.E.” values.

On each plot, the elevation at the site of interest is indicated by a thick vertical line. A least-squares line of best fit is also shown on each plot. The P_g value where that line crosses the thick vertical line and that elevation are listed in a box to the right of each plot. In Figure 2, the upper and lower plots have P_g values of 72 psf and 76 psf, respectively. **Salisbury, NH**, was chosen for this introductory, uncomplicated example since these two plots give close to the same answer. Their average value is 74 psf. Because the upper plot focuses on data closer to the site of interest, its P_g value, here 72 psf, is generally considered to be of somewhat more value than

* From the New Hampshire report referenced in ASCE 7-16: 80 psf at 900 ft, reduced by 2.1 psf/100 ft to 77.4 psf, rounded to 75 psf at 775 ft.

that of the lower, “all values” plot. This suggests a rounded answer of 70 psf while data scatter suggests 75 psf.

To the right of each plot, the slope of the line of best fit is given in psf/1000 ft of elevation. The two lines of best fit often have very different slopes. In Figure 2, the upper and lower plots have widely differing slopes of 1.2 psf/1000 ft and 27.7 psf/1000 ft, respectively. The upper plot’s slope is generally of less value than the lower plot’s slope due to the many more data points on the lower plot. Tobiasson et al. (2002) use an “elevation adjustment factor” (i.e., slope) of 2.1 psf/100 ft (i.e., 21 psf/1000 ft) for all of New Hampshire. Estimating the vertical position of a line with that slope, or the slope of 27.7 psf/1000 ft from the lower plot, on the upper plot of Figure 2 adds further support to use of a rounded value of 75 psf at an elevation of 775 ft for this site. In section 6.1, additional information is provided on elevation adjustment factors and the possibility of encountering lines of best fit with negative slopes.

Looking back at the **Salisbury, NH**, table (Table 2) the filters applied eliminated a station (*Franklin*) only 7 miles away with 13 years of record, only 2 years less than the filter required. Before finalizing this Case Study, it is worth noting where *Franklin* lies on both plots to get a sense of how its inclusion might change the answer. The *Franklin* data point has been penciled in on both plots. Its position well above each line of best fit suggests somewhat higher values but not quite enough to convince us to increase our answer to 80 psf.

Tobiasson et al. (2002) call for 80 psf in **Salisbury, NH**, at an elevation of 900 ft. When this value is adjusted downward to the 775 ft elevation of this site of interest, according to the 2.1 psf/100 ft “elevation adjustment factor” in that report, and rounded to the nearest 5 psf, it also becomes 75 psf.

5.2 Twenty-five more Case Studies

Appendix A presents nine other Case Study examples discussed in this report. In addition, eight other mentioned Case Studies, such as **Pocatello, ID**, and **Mt. Hood Meadows, OR**, have their coordinates, elevation, and our answer provided when they are mentioned so that the reader may use them as training aids. Appendix B contains the “Comments” we generated and the answer we arrived at for each of these eight mentioned Case Studies.

As already noted in this report, all eighteen of the example and mentioned sites of interest have their names in bold print. In their Comments, Case Study answers are also in bold print.

Appendix C contains the name, coordinates, and elevation of eight more sites of interest on which the reader may wish to practice, along with the “Comments” we generated when we ran them and our “disguised” answers. We suggest that those Comments not be read or our answers uncovered until after the Case Study is conducted and ideally not until after two or more individuals have independently conducted that Case Study, discussed their findings, and agreed on a final answer.

6 General Guidelines

6.1 The two plots

In most places, stations within a 10- or 15-mile radius are much more valuable than stations farther away. That is why two plots are provided. The filtered plots do not consider years of record or distance from the site. When the plots do not point to a clear answer, examine the tabulation and check off stations with long periods of record within 10 to 15 miles of the site, then highlight those stations on the “all stations” plot. By giving extra weight to them and “eyeballing” in a new line of best fit, the answer may present itself.

“Elevation adjustment factors” (i.e., the slopes of lines of best fit on the two Case Study plots) not only vary across the nation but also locally. The “least squares” line of best fit on the “nearest values” plot often, but not always, has a slope that is less believable than the slope of the line of best fit on the “all values” plot. If all the stations on the “nearest values” plot are close to the same elevation, do not be surprised if the slope of the line of best fit is way beyond your expectation, perhaps negative.

Generally, the slope of the line of best fit on the “all values” plot is more credible than that on the “nearest values” plot. It is often valuable to transfer the “all values” slope or an “about right” slope for that region based on experience to the “nearest values” plot and use it to generate a P_g for further consideration. Figure 2 provides an example.

When both lines of best fit have similar, negative slopes, something else (e.g., lake effects or wind-swept sites above the tree line) may be the cause. See sections 7.4 and 8.1 for additional information on these issues.

Numerous Case Studies for sites in New England with all plotted data points at elevations below about 2500 ft had “all values” slopes ranging from 15 to 35 psf/1000 ft. When plotted data included higher elevation sites below the tree line, slopes increased to as much as 50 psf/1000 ft. In the South, Midwest, and North Central states, slopes are less; but the elevation of a site of interest is still needed to conduct a Case Study. “All Values” slopes that range upward to more than 100 psf/1000 ft are to be expected in the high mountains of Oregon, Washington, Idaho, Montana, and Colorado. Farther south in the West, slopes seldom exceed 50

psf/1000 ft. For many places in Alaska, the limited number of nearby stations cause “all values” slopes to vary widely.

6.2 Station Guidance

Based on the many Case Studies we and others have conducted over the years, we offer the following guidelines:

- Never put full faith in results from a single station. Also, do not completely dismiss any station because its values do not fit with others around it.
- Give a station only a few miles away from the site of interest much more weight than one more than 20 miles away. Elevation differences are also an important issue and are considered in a similar way.
- For all NWS first-order stations, compare the “W.E.” values to the “depth” values. Place somewhat more trust in water equivalent values but keep an open mind as the rest of the Case Study is examined. For example, the “W.E.” and “depth” values of 63 psf and 44 psf, respectively, for *Concord, NH*, in Table 2 do not agree even though they both have long years of record. While the depth-based loads at *Concord* are less than the W.E.-based loads, do not assume that all the depth-based co-op station loads in this area are low. Notice that on both plots, many of the triangular co-op station data points lie in among the Non-NWS squares that are from load measurements.
- Always examine each first-order station’s years of record and its record maximum values before deciding how much to trust its 50-year value. When the 15 years-of-record default filter is applied, this issue usually is of little concern. That is why 15 years has become our recommendation.
- NWS co-op stations are often the largest body of information on the Case Study form. Because stations are arranged state-by-state according to distance (“radius” on the form) from the site of interest, the uppermost stations in each state’s array are the most valuable. If there are several stations within about 15 miles with long periods of record, their collective answer often overpowers anything the rest of the co-op stations farther away can contribute. However, on occasion, valuable information lies farther away.

- At Non-NWS stations, records are based on water equivalent (i.e., load) measurements, not depth measurements; so, they are somewhat more valuable than those of NWS co-op stations with similar periods of record. However, fewer readings are taken each winter, and these stations are frequently at higher elevations than most sites of interest. Some sites of interest are best represented by these Non-NWS stations.
- When Non-NWS information is available, it is quite helpful in resolving questions about NWS first-order-station information as it represents independent water equivalent (i.e., load) measurements, thereby side-stepping any depth-to-load-equation concerns. The Non-NWS stations for **Salisbury, NH**, in Table 2 and Figure 2 certainly influence the value of the ground snow load determined there. The overlapping of Non-NWS and NWS co-op data points on the plots is a small reminder that a correction to account for the difference in the two P_g values of 63 and 44 psf at the *Concord, NH*, NWS first-order station should not be applied to these NWS co-op stations. They fit in with the Non-NWS data points that are based on direct measurement of ground snow loads. It is the *Concord, NH*, first-order station's "depth" P_g of 44 psf that has some credibility issues.

7 Filters Summarized

7.1 Filter effects

The first of the two **Dover-Foxcroft, ME**, Case Studies (Table A-1 and Figure A-1) applies filters currently preprogrammed into the spreadsheet. Those filters are listed on the first page of the table. The second **Dover-Foxcroft, ME**, Case Study (Table A-2 and Figure A-2) does not apply any of these filters. These two “runs” at the same location illustrate that, while filters generally do not change answers much, if at all, they do tend to eliminate outliers, making it easier to reach that answer.

7.2 Universal “10-5” requirement

The CRREL database contains a 50-year MRI ground snow load (P_g) for any station that has 10 or more years of record of snow on the ground of which 5 or more years experienced snow. However, extreme values generated from such limited periods of record often result in “misfits” that complicate the analysis. Because of this, as stated previously, we generally apply a filter that increases the minimum years of record to 15 (13 in Alaska). Once 15 to 25 years of data are available, it is hard to dismiss that P_g as being a bad extrapolation from limited data. When a P_g is based on more than 25 years of data, give it somewhat more weight.

However, knowing the maximum observed ground snow load (i.e., P_{max}) and the years of record it is based on for stations that do not pass this universal “10-5” requirement can be quite valuable in some cases. For this reason, such stations are included in the table of values on the first page of the Case Study, where they are shown with a gray background. The filters discussed below can cause additional stations in the table to be shown with a gray background. All such stations are excluded from the two P_g -vs.-elevation plots that complete the Case Study.

The **Indian Springs, NV**, Case Study (Table A-3 and Figure A-3) shows how, on occasion, the table contains valuable information that the plots lack. When the filtered-out information in the table is also considered, a credible answer can be determined. Table A-3 contains 19 co-op stations with all but *Beatty 8N* filtered out and thus with a gray background. Several of the grayed-out stations have long periods of record but none experi-

enced at least 5 years with snow, so they all lack a P_g . They range in elevation from 1570 to 3800 ft and provide ample evidence that, at least up to 3800 ft, the answer is at most 10 psf. The dashed lines added on the “all values” plot provide far better estimates of P_g than does the original line. The steep dashed line runs from a value of about 6 psf at 3800 ft to where it is estimated to “best fit” the six high-elevation data points. At the 3170 ft elevation of this site, the answer is clearly at most 10 psf. We have set it at 5 psf. At the coordinates of this site, the ASCE 7 mapped value (see Figure 1) is only 5 psf between elevations of 2000 and 3600 ft.

This two-slope “hockey stick” situation occurs most frequently in the West where some high-elevation valleys see little snow but deep snow accumulates on surrounding terrain at higher elevations. In valleys where little or no snow accumulates many winters, not enough years with snow are available to determine P_g . While no data can be plotted, the table does provide valuable information on how little snow has occurred over many years of monitoring in such places and at such elevations. With that information, the elevation at which P_g is less than 5 or 10 psf can often be estimated with reasonable accuracy and that elevation used to adjust the slopes of the lines of best fit.

Not all sites in the mountains of the West are as difficult to analyze. For example, in **Ely, NV** (39°15'4" N, 114°51'59" W at an elevation of 6490 ft), the two Case Study plots generate close P_g values of 20 and 23 psf; and credible information is available nearby at elevations close to 6490 ft. Setting P_g at 20 psf is a simple, straightforward matter. That value fits with the mapped value of 15 psf to 6400 ft in ASCE 7 (i.e., Figure 1). The **Indian Springs, NV**, and **Ely, NV**, sites have low snow loads of 5 and 20 psf, respectively.

Somewhat higher loads are generated at the **Mt. Idaho, ID**, example presented in Table A-4 and Figure A-4. When the single line of best fit on the “all values” plot is converted to a two-slope “hockey stick” to better fit the data, a P_g of 45 psf results. When the lower dashed line’s slope of 10 psf/1000 ft is superimposed on the “nearest 6” plot, that answer increases to about 45 psf.*

* Knowing the limitations of the data available, we have resisted the urge to take our curve fitting to a higher level.

At **Mt. Idaho, ID** (45.903° N and 116.099° W), the Interactive 1986 Map (Sack and Sheikh-Taheri 1986) generates a P_g of 36 psf at 3738 ft. The Interactive 2015 Map (Al Hatailah et al. 2015) generates a P_g of 242 psf at 3697 ft, which is not credible. About 510 ft away at 45.903° N and 116.101° W at 3691 ft (only 6 ft lower), the Interactive 2015 Map generates a P_g of only 24 psf. At both sites, CRREL Case Studies generate a P_g of 45 psf. Step functions such as this one for **Mt. Idaho, ID**, most not as dramatic, occur in many places when the Interactive 2015 Map is used. One already mentioned occurs in downtown **Pocatello, ID**.

The **West Yellowstone, MT**, example (Table A-5 and Figure A-5) is for a site where a CRREL Case Study generates a P_g of 140 psf. At that site, Table 7.2-4 in ASCE 7-16 generates a value of 122 psf at 6713 ft.* The *Montana Ground Snow Load Finder* (Theisen et al. 2004) generates a value of 121 psf when adjusted to the site elevation of 6670 ft.

7.3 Minimum years-of-record filter

This filter increases the years of record required for plotting to more than 10. The Case Study Spreadsheet opens with this filter set at 15 years. If the latitude of the site of interest is above 50° north, indicating it is in Alaska, this filter changes to 13 years. These 13 and 15 increased years of record are based on lessons learned doing Case Studies over the past four decades. Fewer years are used in Alaska in response to the wider distribution of stations there and their generally shorter years of record.

Any station that does not survive this filter is also shown with a gray background in the table.

After studying the first run, the user may wish to change this filter and conduct a second run. The spreadsheet provides this option, allowing this minimum to range from 10 to 25 years. For example, if there are several stations nearby with between 10 and 15 years of record that are not plotted on the first run with the preset filter of 15 years (13 in Alaska), it may be worth reducing this filter to include some of them on the plots. Conversely, in other situations, it may be worth increasing this filter to replace some stations on the “nearest values” plot with others just a few miles farther

* Note 2 of Tables 7.2-2 through 7.2.7 in ASCE 7-16 indicates that this load applies, “at and below the cited elevation, with a tolerance of 100 ft (30 m).” When we requested a clarification of these limits, we were told that the intent is to allow use of this value up to an elevation 100 ft above the cited elevation.

away with longer periods of record. However, there is seldom a need to change this filter.

7.4 Maximum elevation filter

The Case Study Spreadsheet opens with no maximum elevation filter applied (i.e., “None” in the “Maximum Elevation” block). Most initial Case Study runs should be conducted this way.

In New Hampshire, where a CRREL and Structural Engineers of New Hampshire team generated a Case Study for each town in the State (Tobiasson et al. 2002), use of a maximum elevation of 2500 ft statewide is now recommended. Its purpose is to eliminate the NWS co-op station at the above-tree-line summit of Mount Washington, “The Windiest Place on Earth.” The two Case Study examples for **Chatham, NH** (Table A-6 and Figure A-6 and Table A-7 and Figure A-7), illustrate the adverse effect of including such an exposed mountaintop data point and how use of a maximum elevation filter can result in a more appropriate answer.

The first **Chatham, NH**, Case Study (Table A-6 and Figure A-6), which has no maximum elevation filter, includes data from the wind-swept station on the summit of Mount Washington. That data point causes the slope of each line of best fit to go negative, generating a Case Study answer of 90 psf at 1495 ft. This answer is not to be trusted.

When a maximum elevation filter of 2500 ft is added, as in the **Chatham, NH (2)**, Case Study (Table A-7 and Figure A-7), the Mount Washington station is eliminated. The slope of each line of best fit is positive and of credible magnitude, and the Case Study answer increases appropriately to 115 psf.

Tobiasson et al. (2002) recommend a P_g of 110 psf at an elevation of 1500 ft in **Chatham, NH**. We judge that value to be somewhat better than the 115 psf generated by this Case Study. Not only were the three authors of this report involved in the prior Case Studies that generated the 110 psf value, but also three structural engineers practicing in New Hampshire were involved. It is important to realize that the data available is not capable of determining for certain if 110 or 115 psf is best. Either will suffice for design purposes. Of greater importance is that the 90 psf value generated by the initial Case Study, which included the *Mt. Washington* station, has not been used.

Not all high-elevation sites create this problem. Vermont's *Mt. Mansfield* is only 77 miles from Mt. Washington.* The *Mt. Mansfield* co-op station is at an elevation of 3950 ft and is not above the tree line. Its P_g is 234 psf. Including it in a Case Study for a site 3 miles away at an elevation of 1160 ft resulted in "nearest values" and "all values" lines of best fit with slopes of around 50 psf/1000 ft and an answer of about 90 psf. When a maximum elevation filter of 2500 ft was added to eliminate the *Mt. Mansfield* station, the two lines of best fit again had slopes of about 50 psf/1000 ft and an answer of about 90 psf. The coordinates of this **Underhill, VT**, site are 44°30'20" N, 72°51'55" W should you wish to study it further.

A Case Study table and plots generated for **Underhill, VT**, are provided in the spreadsheet to introduce the user to the way nearby information is presented for analysis and the determination of a ground snow load for a site of interest.

Other studies suggest that a maximum elevation filter of 3500 ft may be appropriate, after examination of the first run, for sites of interest in the Central Appalachians. A filter several thousand feet higher may, on occasion, be appropriate for West Coast Mountains and the Rockies. It is unlikely that situations will develop any place that call for a value less than 1000 ft or more than 10,000 ft.

7.5 P_g/P_{max} ratio filters

These filters eliminate from the plots stations with very high or very low P_g/P_{max} ratios. Such stations are often outliers that complicate the Case Study analysis.

The Case Study Spreadsheet opens with the maximum acceptable value of this ratio as 1.7 and the minimum acceptable value as 0.8 for Lower 48 state Case Studies. These rounded values are one standard deviation (0.41) above and below this Ratio's Lower 48 mean value of 1.25. Use of one standard deviation is based on the findings over the years of Case Studies done with a range of values. Very tight limits (e.g., max = 1.5 and min = 1.0) tend to eliminate too many stations while very loose limits (e.g.,

* On Google Earth, going to the summit of Mt. Washington, NH, then to the summit of Mt. Mansfield, VT, shows tree-line differences.

max = 2.0 and min = 0.5) do little to facilitate reaching an answer for most Lower 48 state Case Studies.

Looser limits of max = 2.0 and min = 0.5 are needed in Alaska where stations are few and far between and have shorter years of record than stations in the Lower 48. Alaska's mean value is also 1.25. When a latitude of more than 50° north is entered, indicating that the Case Study is in Alaska, the default values for this filter switch to 2.0 and 0.5.

The initial Case Study done at a site of interest should use the default values in the spreadsheet. However, the user can change these values or, by blanking out the default values, eliminate them altogether. If new maximum and minimum values are used, we recommend that they be equidistant from the mean value of 1.25.

Any station that does not survive these filters is shown with a gray background in the table and is not included on the plots.

7.6 Filter adjustments

After running the first Case Study at a site of interest, it is prudent to examine its table to determine what stations the default filters have and have not eliminated. This may indicate that minor adjustments to one or more filters will allow valuable data points to be added to the plots.

8 Additional Considerations

8.1 Lake effects

The presence of large bodies of water, such as the Great Lakes, increases ground snow loads on land downwind of winter winds. One such area of heavy snow loads is evident in Figure 1 south of Lake Superior. Mapped ground snow loads increase to 100 psf on the Keweenaw Peninsula. Lake effects on snow loads are minimal along the western shore of Lake Michigan; but along its southern and eastern shores, they are enough to preclude mapping at the scale used in Figure 1. Muskegon, MI, lies within that unmapped Case Study (CS) area. The **Muskegon, MI**, Case Study (Table A-8 and Figure A-8) is unusual since both plots have lines of best fit with big, negative slopes. On several other plots used in this report, the distance from the site of interest has been penciled in. Here, instead, the distance from the lake is provided at each data point. Snow loads are high close to the lake; then they diminish, moving inland to the east. Twenty-six miles east of the lake, the land has risen less than 300 ft above lake level. The site of interest is about 4 miles from the lake at an elevation of 615 ft, which is 38 ft above lake level. Our rounded answer of $P_g = 55$ psf is based on both its distance from the lake and its elevation.

Lake effects are minimal along the western (American) shore of Lake Huron. They increase to the point of causing “CS” areas to be present along much of the southeastern and eastern shores of Lakes Erie and Ontario. A Case Study done in the Lake Effect “CS” area of Lake Ontario in **Ellisburg, NY** (43°43′58″ N, 76°8′10″ W at an elevation of 330 ft), did not result in plots with lines of best fit having negative slopes as was the case for **Muskegon, MI**. Instead, both lines of best fit had credible, positive slopes with intercepts of 59 and 61 psf. Within 16 miles of Lake Ontario near **Ellisburg, NY**, the elevation of the land to the east rises more than 1000 ft above the lake level of 246 ft. This causes snow loads to increase in that direction. Our rounded answer of $P_g = 60$ psf is based on both the 330 ft elevation of the site and its being 4 miles from the lake.

The **Muskegon, MI**, and **Ellisburg, NY**, Case Studies illustrate the range of outcomes possible when lake effects and elevation combine to influence snow loads in an area.

8.2 Alaskan issues

Each of the 33 Alaskan values in Table 7.2-1 of ASCE 7-16 were generated by CRREL Case Studies conducted years ago using the database and methodology presented in this report. Because ground snow loads have not been mapped for Alaska, Case Studies are needed for sites of interest not shown in Table 7.2-1.

As has been mentioned, in Alaska, data sources are generally farther apart than in the Lower 48 states, and periods of record are shorter. For this reason, when the latitude of a site of interest is above 50° north, indicating that it is in Alaska, the default Minimum Years of Record filter decreases from 15 to 13 years; and the default P_g/P_{max} ratio filter's maximum increases from 1.7 to 2.0 and its minimum decreases from 0.8 to 0.5. In Alaska as in the Lower 48 states, the default Maximum Elevation filter is set at "none."* The user can change these default filters, but we strongly recommend that they be used in the first Case Study at each Alaskan site of interest.

The Maximum Search Radius for the Lower 48 states is set at 100 miles. In Alaska, it is set at 300 miles. These maximums are seldom reached, but they need to be different.

All searches expand radially in 5-mile increments. Almost all Lower 48 searches are complete in less than 3 minutes; many take only a minute. Alaskan searches that extend out radially more than 200 miles can take up to 10 minutes.

On the Aleutian Islands, individual Case Studies are of limited value as very little off-site information is available. A P_g between 20 and 30 psf is suitable for most low-lying islands. However, Attu Island, at the western end of "The Chain" is mountainous; and a higher P_g is appropriate there even at low-lying sites. The NWS co-op station, *Attu*, has 33 years of record and a rounded P_g of 65 psf at an elevation of 70 ft.

The NWS station, *Shemya*, on a smaller, low-lying island only 38 miles east of the NWS co-op station, *Attu*, has 40 years of snow depth records, a P_g of only 18 psf, but a maximum observed value of 23 psf. A rounded P_g of

* The two **Chatham, NH**, Case Study examples in this report illustrate a situation where a maximum elevation filter results in a more credible answer.

25 psf at an elevation of 120 ft is appropriate there. The next place to the east where information on snow on the ground is available in the CRREL database is at mountainous Adak Island, 396 miles away. There, a P_g of 24 psf results from 39 years of snow depth measurements at NWS co-op station, *Adak*, at an elevation of 20 ft. Because the maximum observed value there was 30 psf, it seems appropriate to use a P_g of 30 psf for low-lying sites on remote Adak Island.

Near the eastern end of “The Chain” on mountainous Unalaska Island at *Dutch Harbor* at an elevation of 10 ft, only a few years of record are available; but with a seasonal maximum load of 50 psf among them, use of P_g = 30 psf does not seem appropriate. Consider instead a P_g of 35 or 40 psf.

Farther east on the Alaska Peninsula near its western end at **Cold Bay, AK** (55°12' N, 162°43' W at an elevation of 75 ft), a Case Study generated a P_g of 25 psf. Proceeding northeast up the Alaska Peninsula, ground snow loads increase. Enough stations are available in this area to allow meaningful Case Studies to be generated for most sites of interest.

While more snow information is available on Southeast Alaska’s panhandle, it is certainly needed there because of the much more dramatic terrain in that area. Snow loads vary greatly from cove to cove and with elevation. The CRREL database does not contain enough information to establish with reasonable certainty credible ground snow loads for some places on the Alaska Panhandle where extreme local variations in snow loads occur, and the limited meteorological information available is unable to account for these variations.

The **Annette, AK**, Case Study (Table A-9 and Figure A-9), illustrates this variability. Our answer of P_g = 40 psf certainly has less credibility than most Case Study answers we have generated. Our Comments on Table A-9 come with the caveat that additional records should be sought and local experience called upon.

Annette, AK’s, P_g of 40 psf should not be used just 24 miles away at *Beaver Falls* at a lower elevation of 40 ft because the 37 years of record at *Beaver Falls* contains a P_{max} of 96 psf and a P_g of 152 psf. Just as these high values at *Beaver Falls* somewhat increased P_g at **Annette, AK**, above measurements made there, the lower values at **Annette, AK**, should somewhat decrease P_g at *Beaver Falls* below measurements made there.

Additional information should also be sought to improve upon any CRREL Case Study conducted at *Beaver Falls*.

Ground snow loads are much easier to establish in many other parts of Alaska. A Case Study for **Fairbanks, AK** ($64^{\circ}49'00''$ N, $147^{\circ}52'00''$ W at an elevation of 440 ft), has a maximum search radius of only 25 miles, takes about a minute to run, and generates “nearest value” and “all values” P_g values of 57 and 55 psf, respectively. In **Fairbanks, AK**, at an elevation of 440 ft, P_g is either 55 or 60 psf. We chose 60 psf.

Kodiak, AK ($57^{\circ}45'13''$ N, $152^{\circ}30'52''$ W at an elevation of 65 ft), represents the common Alaskan problem of limited nearby data. NWS first-order and co-op stations located within a mile of this site of interest indicate that the rounded P_g should be 30 or 35 psf. The two plots call for higher values; but because most of the sites they represent are over 100 miles away, they are not given much weight. Thus, $P_g = 30$ psf.

8.3 Concluding thoughts on conducting Case Studies

Whenever possible, involve at least two, preferably three, people who have Case Study experience. To ensure that everyone is examining the same site of interest, have one person generate the Case Study table and plots pages; then distribute that single version to the others. Nonetheless, each individual should conduct an independent check to verify that the listed latitude, longitude, and elevation are for the site of interest.

Independent analysis by two or more individuals is better than roundtable concurrent analysis as group dynamics can adversely influence results. Have a third-party tally preliminary answers and comments in such a way that they cannot be traced to an individual. After a round or two to discuss and resolve differences between preliminary answers, a group meeting is usually able to reach a consensus.

Once agreements are reached (1) on an answer, (2) on the wording of Comments, and (3) on the current ASCE 7 value, this information should be added to the original table and any annotations added to the plots. This completed Case Study is then ready to be distributed to everyone involved and to others.

Some individuals may wish to consider snow belts, snow shadows, lake effects, weather patterns, and such when they study a site. Others may not

feel they know enough about such matters in each place to accurately consider them, so they do not use this approach. Differing approaches seldom explain the range of answers to be expected. In fact, it is quite valuable to arrive at answers from different viewpoints.

When the information in the CRREL database does not point to a clear answer, admit your concerns as we have done in our Comments on the **Mt. Hood Meadows, OR**, and **Annette, AK**, Case Studies and recommend that additional meteorological information and local experience be sought.

9 Summary

The information in this report and in the accompanying spreadsheet, which contains the CRREL ground snow load database, provides the reader with the ability to generate 50-year MRI ground snow loads for sites of interest anywhere in the United States.

The CRREL snow load database and the CRREL ground snow load map of the United States, first published in ASCE 7 in 1995, need to be updated. Our in-preparation, companion report mentioned in section 1.4 will contain information on the effect of updating records for seven NWS first-order stations in the United States. While additional years of record can be expected to cause some gradual changes in ground snow loads (some will increase, some will decrease), the existing database is still able to provide valuable design guidance overall.

Considering the strengths and limitations of other databases and the wide-ranging ways they are being analyzed, the CRREL database, coupled with the CRREL Case Study methodology, still have considerable direct value, and they still meet the requirements of ASCE 7. In addition, they have important indirect value as a second opinion when other, newer (some likely better) ways of generating ground snow loads are being used.

In ASCE 7, changes are being made to base design loads not on a uniform hazard, such as a 50-year MRI extreme value, but on a uniform risk (DeBock et al. 2015). During this time of transition, having decades-old baselines to refer to can be quite beneficial. Reliability-targeted changes well may result in snow load changes as great, if not greater, than those indicated by longer periods of record and climate change. Time will tell.

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Appendix A: Additional Case Study Examples

Table A-1. Dover-Foxcroft, ME, Case Study table.

SNOW LOAD CASE STUDY FOR

Dover-Foxcroft, ME

Latitude 45° 11' 7" N

Longitude 69° 14' 55" W

Elevation 390 ft

Filters Used: Min. Years of Record 15; Pg/Pmax Ratio: Max. 1.7, Min. 0.8

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
none within 25 miles								
MAINE (NWS co-op)								
DOVER-FOXCROFT		Nearby	460	89	73	16	0	1.22
EAST DOVER	4	214	540	149	80	22	0	1.86
EAST SANGERVILLE	4	214	540	128	78	14	0	1.64
GUILFORD	7	263	500	78	55	14	0	1.42
BLANCHARD	18	286	600	70	42	11	0	1.67
CORINNA	19	184	360	81	62	42	0	1.31
HARMONY	23	232	350	54	34	13	0	1.59
MAINE (NON-NWS)								
DOVER-FOXCROFT 'B'	6	251	580	87	78	31	0	1.12
SEBEC	8	72	550		57	5	0	
SEBEC [2]	9	61	650	77	61	23	0	1.26
DEXTER	10	212	460	89	76	24	0	1.17
MILO	12	66	320	87	83	31	0	1.05
KINGSBURY	16	267	1010	98	96	21	0	1.02
MONSON	19	297	2000	122	89	24	0	1.37
MEDFORD	19	78	340	116	72	23	0	1.61
GREENVILLE	22	306	1040	88	84	36	0	1.05
PITTSFIELD	23	211	170		38	9	0	
HARMONY-ATHENS	24	237	560		41	9	0	

Current ASCE 7 value (psf) <u>CS</u>	Case Study Answer <u>90</u> psf
Date: <u>October 30, 2019</u>	By <u>Greatorex, Tobiasson and Buska</u>

Comments:

The 2 plots have Pg values of 85 and 88 psf which indicate a rounded Pg of 85 or 90 psf. The slope of the “all values” line-of-best-fit is somewhat low for northern New England, but credible. The Pg of 89 psf at the nearby NWS co-op station and the Pg of 87 psf at the Non-NWS station only 6 miles away point to a rounded value of 90 psf. Two filtered-out NWS co-op stations within 4 miles have much higher Pg values but their Pmax values are only 78 and 80 psf. All things considered, **Pg = 90 psf** seems appropriate.

This, the first of two Case Study examples at this location, contains the filters currently pre-programmed into the spreadsheet. They are listed on this page above the table. Those filters eliminated five “NWS co-op” stations (4 stations due to years of record less than 15 years and 1 station due to a Pg/Pmax ratio greater than 1.7). Three other stations with less than 10 years of record are also grayed out since they have no Pg values. On the next page, the “nearest values” and “all values” plots generate somewhat different Pg values of 85 and 88 psf as is to be expected. In combination, they support a rounded answer of 85 or 90 psf. With consideration given to two nearby filtered-out higher values, Pg is set at 90 psf.

Figure A-1. Dover-Foxcroft, ME, Case Study plots with preprogrammed filters applied.

Table A-2. Dover-Foxcroft, ME (2), Case Study table.

SNOW LOAD CASE STUDY FOR

Dover-Foxcroft, ME (2)Latitude 45° 11' 7" NLongitude 69° 14' 55" WElevation 390 ft

Filters Used: Min. Years of Record 10

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
none within 25 miles								
MAINE (NWS co-op)								
DOVER-FOXCROFT		Nearby	460	89	73	16	0	1.22
EAST DOVER	4	214	540	149	80	22	0	1.86
EAST SANGERVILLE	4	214	540	128	78	14	0	1.64
GUILFORD	7	263	500	78	55	14	0	1.42
BLANCHARD	18	286	600	70	42	11	0	1.67
CORINNA	19	184	360	81	62	42	0	1.31
HARMONY	23	232	350	54	34	13	0	1.59
MAINE (NON-NWS)								
DOVER-FOXCROFT 'B'	6	251	580	87	78	31	0	1.12
SEBEC	8	72	550		57	5	0	
SEBEC [2]	9	61	650	77	61	23	0	1.26
DEXTER	10	212	460	89	76	24	0	1.17
MILO	12	66	320	87	83	31	0	1.05
KINGSBURY	16	267	1010	98	96	21	0	1.02
MONSON	19	297	2000	122	89	24	0	1.37
MEDFORD	19	78	340	116	72	23	0	1.61
GREENVILLE	22	306	1040	88	84	36	0	1.05
PITTSFIELD	23	211	170		38	9	0	
HARMONY-ATHENS	24	237	560		41	9	0	

Current ASCE 7 value (psf) <u>CS</u>	Case Study Answer <u>90</u> psf
--------------------------------------	---------------------------------

Date: October 30, 2019

By Tobiasson, Buska and Greatorex

Comments:

The dramatic negative slope of the line-of-best-fit of the "nearest 6" plot calls to question that P_g of 111 psf. The P_g of 90 psf on the "all values" plot and the 17 psf/1000 ft. slope of that plot's line-of-best-fit are more credible. When that slope is applied to the "nearest 6" data, the P_g intercept drops to less than 100 psf. When less weight is given to the 2 data points above 120 psf (because their P_g values are much higher than their P_{max} values), the intercept drops further to about 90 psf. All things considered, **P_g = 90 psf** seems appropriate.

This, the second of two Case Study examples at this location, contains no filters other than our universal "10-5" requirement which grayed out three stations since they have no P_g values. The "nearest 6" stations change and the negative slope of that line-of-best-fit results in a P_g of 111 psf which is hard to accept. The "all values" plot gives 90 psf. Without filters the task of resolving this 21 psf difference took more time and thought than were needed when filters were applied, and this difference was only 3 psf. Further study (see the Comments above) again resulted in a P_g of 90 psf.

Figure A-2. Dover-Foxcroft, ME (2), Case Study plots with no filters applied.

Table A-3. Indian Springs, NV, Case Study table.

SNOW LOAD CASE STUDY FOR

Indian Springs, NVLatitude 36° 34' 11" NLongitude 115° 40' 14" WElevation 3170 ftFilters Used: Min. Years of Record 15; Pg/P_{max} Ratio: Max. 1.7, Min. 0.8

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
LAS VEGAS (W.E.)	44	134	2160	3	3	39	34	0.83
LAS VEGAS WSO AP ("depth")	44	134	2160	4	5	41	35	0.80
CALIFORNIA (NWS co-op)								
SHOSHONE	53	225	1570		0	17	17	
NEVADA (NWS co-op)								
INDIAN SPRINGS	1	16	3140		6	16	14	
DESERT NWR-CORN CREEK	19	114	2920		3	41	37	
DESERT ROCK WSMO	19	278	3300		1	7	5	
PAHRUMP U OF N LAB	31	220	2700		2	30	26	
LITTLE RED ROCK	32	149	3800		0	5	3	
RED ROCK CANYON ST PK	36	156	3780		2	12	10	
LATHROP WELLS 16 SSE	39	257	2180		0	4	4	
LAS VEGAS	41	127	2010		4	7	6	
NORTH LAS VEGAS DOXARM	41	122	1820		0	11	11	
SUNRISE MANOR LAS VEGAS	41	122	1820		4	27	24	
NELLIS AFB (AWS)	42	117	1878		0	17	16	
AMARGOSA FARMS-GAREY	44	270	2450		4	14	12	
PAHRANAGAT WILDLIFE RFG	57	38	3400		1	27	23	
BOULDER CITY	61	126	2530		1	38	37	
ALAMO	62	32	3440		12	6	4	
BEATTY	64	288	3300		6	13	10	
VALLEY OF FIRE STATE PK	65	97	2000		0	17	17	
BEATTY 8 N	65	292	3550	6	6	18	7	1.00
NEVADA (NON-NWS)								
LEE CANYON NO 1	13	169	8300	200	106	26	0	1.89
LEE CANYON #2	15	183	9000	171	175	51	0	0.98
TROUGH SPRINGS	18	201	8500	139	101	35	0	1.38
LEE CANYON #3	20	186	8400	179	164	30	0	1.09
KYLE CANYON	21	182	8200	226	238	51	0	0.95
RAINBOW CANYON #2	21	173	8100	251	251	45	0	1.00
CLARK CANYON	21	195	9000	186	144	39	0	1.29
TAYLOR CANYON	21	195	6200	114	80	56	0	1.43

Current ASCE 7 value (psf) (2000) 5 (3600)Case Study Answer 5 psfDate: October 30, 2019By Buska, Greatorex and Tobiasson

Comments:

The lack of P_g values below 6000 ft. due to many "no snow" years at those stations causes us to question the 79 psf intercept of the line-of-best-fit on the "nearest 7" plot. The 26 psf intercept on the "all values" plot is easier to accept but it also needs to be questioned. When the many filtered-out stations in the table close to the site of interest and at elevations much closer to its elevation are examined, P_g need not be more than 5 psf up to an elevation of at least 3800 ft. The two dashed lines added to the "all values" plot generate credible answers for sites at a wide range of elevations in this area. For this site of interest, **P_g = 5 psf**. We find it convenient to refer to this as the "hockey stick" approach.

Figure A-3. Indian Springs, NV, Case Study plots.

Table A-4. Mt. Idaho, ID, Case Study table.

SNOW LOAD CASE STUDY FOR

Mt. Idaho, IDLatitude 45.903° NLongitude 116.099° WElevation 3700 ftFilters Used: Min. Years of Record 15; Pg/P_{max} Ratio: Max. 1.7, Min. 0.8

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	

NWS FIRST ORDER

none within 35 miles

IDAHO (NWS co-op)

GRANGEVILLE	2	292	3360	28	22	40	0	1.27
GRANGEVILLE 11 SE	9	113	2250	21	16	23	0	1.31
COTTONWOOD	14	296	3400	45	35	18	0	1.29
COTTONWOOD 2 WSW	16	295	3950		3	2	0	
KOOSKIA	18	25	1260	26	18	33	1	1.44
GREENCREEK 3 N	19	326	3350		16	7	0	
SLATE CREEK RS	21	214	1590		2	6	0	
KAMIAH	23	11	1210	19	12	15	1	1.58
NEZPERCE	25	336	3150	33	19	40	0	1.74
LUCILE	27	209	1610		0	1	0	
CRAIGMONT	29	311	3750	23	16	11	0	1.44
FENN R S	30	70	1590	47	41	37	0	1.15
WINCHESTER 1 ESE	32	305	4180	53	48	27	0	1.10
ELK CITY R S	32	96	4060	78	57	35	0	1.37
WINCHESTER 1 SE	34	303	3950	50	36	12	0	1.39
RIGGINS	35	204	1800	5	2	15	2	2.50

IDAHO (NON-NWS)

UPPER SNOWHAVEN	1	49	5600		151	7	0	
WHITEBIRD SUMMIT	1	308	4390	108	61	17	0	1.77
LOWER SNOWHAVEN	3	78	5300		156	7	0	
ELK BUTTE NEW	4	198	5690		216	9	0	
JOHNS CREEK	6	261	3805	65	30	17	0	2.17
CHAPMAN CREEK	7	292	4215	66	36	17	0	1.83
COTTONWOOD BUTTE	22	301	5140		121	7	0	
OROGRANDE MOUNTAIN	25	118	7800	361	321	14	0	1.12
ABOVE GREER	31	351	1240	27	18	12	7	1.50
SWEENEY	32	290	4435	83	57	15	0	1.46
BUCK MEADOWS	32	81	5650	281	282	27	0	1.00
COOLWATER MOUNTAIN	33	66	6040	326	325	30	0	1.00
FOREST	34	289	4550	94	63	15	0	1.49
MC CANN	35	293	4300	98	60	15	0	1.63
SOLDIER MEADOWS	35	293	4650		58	2	0	

Current ASCE 7 value (psf)	<u>242 at 3697 ft.</u>	Case Study Answer	<u>45</u> psf
Date: October 30, 2019	By <u>Greatorex, Tobiasson and Buska</u>		

Comments:

The two plots generate very different P_g values of 37 and 99 psf. The slopes of their lines-of-best-fit are too low to be credible. The “all values” plot clearly indicates that a single line with a slope of 49.1 psf/1000 ft. does not fit those data points. Like **Indian Springs, NV** (Figure A-3) a two slope, “hockey stick” approach is needed here. The 2 dashed lines added on the “all values” plot provide a much better fit and generate a P_g of 45 psf. When the slope of the lower dashed line is applied to the “nearest values” plot, a P_g of 45 psf also results there. Had somewhat more weight been given to the station only 2 miles away, the above method would have lowered both P_g values to 40 psf. We are most comfortable with **P_g = 45 psf**.

The ASCE value is from the Interactive 2015 Idaho Map. About 500 ft. to the west, the ASCE value drops to 24 psf at 3691 ft. Our Case Study value remains at 45 psf. ASCE values in this area are not credible.

Figure A-4. Mt. Idaho, ID, Case Study plots.

Table A-5. West Yellowstone, MT, Case Study table.

SNOW LOAD CASE STUDY FOR

West Yellowstone, MTLatitude 44° 39' 44" NLongitude 111° 6' 15" WElevation 6670 ftFilters Used: Min. Years of Record 15; Pg/P_{max} Ratio: Max. 1.7, Min. 0.8

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
none within 25 miles								
IDAHO (NWS co-op)								
ISLAND PARK	21	227	6300	140	121	42	0	1.16
MONTANA (NWS co-op)								
WEST YELLOWSTONE	1	161	6660	128	101	42	0	1.27
HEBGEN DAM	18	312	6490	99	106	45	0	0.93
WYOMING (NWS co-op)								
OLD FAITHFUL	20	128	7360	121	103	12	0	1.17
IDAHO (NON-NWS)								
TARGHEE PASS	9	277	6980	176	140	16	0	1.26
VALLEY VIEW	11	267	6680	158	155	56	0	1.02
BLACK MOOSE	11	196	8160	403	315	26	0	1.28
POACHERS CABIN	12	211	8000	296	239	12	0	1.24
LUCKY DOG	12	215	6860	244	200	29	0	1.22
BLACK CANYON	14	179	7960	357	279	26	0	1.28
LATHAM SPRINGS	14	193	7630	308	270	31	0	1.14
BIG SPRINGS	14	228	6400	194	181	56	0	1.07
OLD ROAD	15	210	7250	283	213	12	0	1.33
SAWTELL MOUNTAIN	18	255	8720	374	293	25	0	1.28
WHITE ELEPHANT	18	249	7710	266	219	19	0	1.21
ISLAND PARK	21	232	6290	155	160	54	0	0.97
MONTANA (NON-NWS)								
WEST YELLOWSTONE	1	11	6700	117	100	58	0	1.17
WHISKEY CREEK	4	225	6800	212	162	25	0	1.31
MADISON PLATEAU	5	189	7750	252	190	24	0	1.33
BLACK BEAR	11	184	8150	435	347	20	0	1.25
TWENTY-ONE MILE	18	12	7150	173	153	55	0	1.13
HEBGEN DAM	19	314	6550	112	103	58	0	1.09
POTOMAGETON PARK	22	312	7150	136	109	27	0	1.25
CARROT BASIN	24	331	9000	376	312	25	0	1.21
WYOMING (NON-NWS)								
OLD FAITHFUL	20	124	7400	149	114	17	0	1.31
NORRIS BASIN	21	76	7550	99	88	56	0	1.13
NORRIS BASIN (OLD)	21	76	7500	93	81	51	0	1.15

Current ASCE 7 value (psf) 122 at 6713 ft.Case Study Answer 140 psfDate: October 30, 2019By Tobiasson, Buska and Greatorex

Comments:

The "nearest values" and "all values" plots generate P_g values of 138 and 149 psf respectively. The slope of the "nearest values" line-of-best-fit is quite high. If the, often-more-credible "all values" slope is superimposed on the "nearest values" data, its intercept at 6670 ft. increases to about 170 psf. However, since the two stations only one mile away lie somewhat below both lines-of-best-fit and data scatter is minimal on the "nearest values" plot, it seems appropriate to set **P_g at 140 psf**. By way of comparison, the *Montana Ground Snow Load Finder* (Theisen et al 2004) generates a load of 121 psf at 6670 ft. after adjusting for the elevation difference at this site.

Figure A-5. West Yellowstone, MT, Case Study plots.

Table A-6. Chatham, NH, Case Study table with no maximum elevation filter.

SNOW LOAD CASE STUDY FOR

Chatham, NHLatitude 44° 9' 2" NLongitude 71° 3' 5" WElevation 1495 ftFilters Used: Min. Years of Record 15; Pg/P_{max} Ratio: Max. 1.7, Min. 0.8

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
none within 25 miles								
MAINE (NWS co-op)								
LOVELL	8	103	400	67	36	14	0	1.86
BRIDGTON 3 NW	16	106	560	94	101	31	0	0.93
HIRAM	22	137	360	126	76	25	0	1.66
EAST HIRAM	24	132	530	91	57	19	0	1.60
NEW HAMPSHIRE (NWS co-op)								
NORTH CONWAY	8	219	530	61	42	18	0	1.45
CONWAY 1 N	11	203	480	92	82	16	0	1.12
PINKHAM NOTCH	13	300	2030	165	287	44	0	0.57
MOUNT WASHINGTON	15	295	6260	56	45	45	0	1.24
TAMWORTH 3	21	225	790	88	88	18	0	1.00
FABYAN	21	286	1620	134	131	19	0	1.02
BERLIN	22	336	1080	75	75	41	0	1.00
WONALANCET	22	232	1100		38	2	0	
TAMWORTH 2	23	216	500		39	6	0	
MAINE (NON-NWS)								
BRIDGTON	16	103	495	90	67	30	0	1.34
DENMARK	16	125	540	110	70	22	0	1.57
BETHEL	22	35	720	73	81	26	0	0.90
NEW HAMPSHIRE (NON-NWS)								
CONWAY	11	198	450	89	70	28	0	1.27
PINKHAM NOTCH	13	298	2000	184	97	27	0	1.90
MARTIN'S LOCATION	16	320	1220		48	5	0	
GORHAM	17	337	790	147	106	31	0	1.39
EFFINGHAM FALLS	24	188	420	66	50	23	0	1.32

Current ASCE 7 value (psf) 110 at 1495 ft.Case Study Answer 90 psfDate: October 30, 2019By Buska, Grestorex and Tobiasson

Comments:

The P_g values generated by the two plots are 84 and 90 psf. If they are accepted, a P_g of about 90 psf results. The negative slope of the line-of-best-fit on each plot is caused by the low P_g of 56 psf at the windswept station on the summit of Mt. Washington. These negative slopes warn that **90 psf is not the correct answer**. By using a Maximum Elevation filter to eliminate the anomalous data from the windswept summit of Mt. Washington, a more appropriate value can be obtained. A second Case Study was run with a Maximum Elevation filter of 2500 ft. to eliminate the Mt. Washington data point (See Table A-7 and Figure A-7).

Figure A-6. Chatham, NH, Case Study plots with no maximum elevation filter.

Table A-7. Chatham, NH (2), Case Study table with a maximum elevation filter of 2500 ft.

SNOW LOAD CASE STUDY FOR

Chatham, NH (2)Latitude 44° 9' 2" NLongitude 71° 3' 5" WElevation 1495 ft

Filters Used: Min. Years of Record 15; Pg/Pmax Ratio: Max. 1.7, Min. 0.8; Max. Elevation 2500 ft.

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
none within 25 miles								
MAINE (NWS co-op)								
LOVELL	8	103	400	67	36	14	0	1.86
BRIDGTON 3 NW	16	106	560	94	101	31	0	0.93
HIRAM	22	137	360	126	76	25	0	1.66
EAST HIRAM	24	132	530	91	57	19	0	1.60
NEW HAMPSHIRE (NWS co-op)								
NORTH CONWAY	8	219	530	61	42	18	0	1.45
CONWAY 1 N	11	203	480	92	82	16	0	1.12
PINKHAM NOTCH	13	300	2030	165	287	44	0	0.57
MOUNT WASHINGTON	15	295	6260	56	45	45	0	1.24
TAMWORTH 3	21	225	790	88	88	18	0	1.00
FABYAN	21	286	1620	134	131	19	0	1.02
BERLIN	22	336	1080	75	75	41	0	1.00
WONALANCET	22	232	1100		38	2	0	
TAMWORTH 2	23	216	500		39	6	0	
MAINE (NON-NWS)								
BRIDGTON	16	103	495	90	67	30	0	1.34
DENMARK	16	125	540	110	70	22	0	1.57
BETHEL	22	35	720	73	81	26	0	0.90
NEW HAMPSHIRE (NON-NWS)								
CONWAY	11	198	450	89	70	28	0	1.27
PINKHAM NOTCH	13	298	2000	184	97	27	0	1.90
MARTIN'S LOCATION	16	320	1220		48	5	0	
GORHAM	17	337	790	147	106	31	0	1.39
EFFINGHAM FALLS	24	188	420	66	50	23	0	1.32

Current ASCE 7 value (psf) 110 at 1495 ft.Case Study Answer 115 psfDate: October 30, 2019By Greatorex, Tobiasson and Buska

Comments:

The lines-of-best-fit on the two plots have positive slopes within a range considered appropriate for New Hampshire (Tobiasson et al 2002). The Pg values of 114 psf (nearest values plot) and 117 psf (all values plot) are in good agreement. They support a rounded **Pg of 115 psf** which is 25 psf greater than would have been determined if the Mt Washington data point had been included and the resulting negative slopes of the lines-of-best-fit in Figure A-6 had been accepted.

Figure A-7. Chatham, NH (2), Case Study plots with a maximum elevation filter of 2500 ft.

Table A-8. Muskegon, MI, Case Study table.

SNOW LOAD CASE STUDY FOR

Muskegon, MILatitude 43° 14' 3" NLongitude 86° 14' 55" WElevation 615 ft

Filters Used: Min. Years of Record 15; Pg/Pmax Ratio: Max. 1.7, Min. 0.8

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max} Ratio
						Total	No Snow	
NWS FIRST ORDER								
MUSKEGON (W.E.)	5	167	630	51	40	40	0	1.29
MUSKEGON WSO AP ("depth")	5	167	630	46	34	45	0	1.35
GRAND RAPIDS (W.E.)	44	116	710	36	32	40	0	1.13
GRAND RAPIDS WSO AP ("depth")	44	116	710	23	25	45	0	0.92
MICHIGAN (NWS co-op)								
GRAND HAVEN FIRE DEPT	12	169	620	69	70	42	0	0.99
MONTAGUE 4 NW	18	324	660	43	30	39	1	1.43
KENT CITY 2 SW	24	94	840	22	19	41	0	1.16
HESPERIA 4 WNW	25	23	780	44	28	41	0	1.57
NEWAYGO 2 SSE	26	70	750		26	6	0	
HOLLAND	31	163	610	38	45	44	0	0.84
HART	33	346	680	56	46	40	0	1.22
GRAND RAPIDS WB CITY	35	115	640		21	6	0	
NEWAYGO HARDY DAM	35	68	760	39	31	27	0	1.26
WHITE CLOUD 4 SE	42	50	970		11	3	0	

Current ASCE 7 value (psf) <u>CS</u>	Case Study Answer <u>55</u> psf
Date: <u>January 10, 2018</u>	By <u>Tobiasson, Buska and Greator</u>

Comments:

Both plots have lines-of-best-fit with similar, but negative, slopes. The penciled-in values on the plots are distances from the lake, not from the station of interest, as is the case for penciled-in values on most of our Case Study plots. *Lake Effect* increases in snow loads near Lake Michigan and the decrease in snow load inland, away from the lake, explain the negative slopes. The land to the east of the lake rises less than 300 ft. within 26 miles of the lake. The site of interest is 4 miles from the lake at an elevation of 615 ft. which is 38 ft. above lake level. Our rounded **Pg of 55 psf** considers both its elevation and its distance from the lake.

Figure A-8. Muskegon, MI, Case Study plots.

Table A-9. Annette, AK, Case Study table.

SNOW LOAD CASE STUDY FOR

Annette, AKLatitude 55° 2' 17" NLongitude 131° 34' 39" WElevation 100 ft

Filters Used: Min. Years of Record 13; Pg/Pmax Ratio: Max. 2, Min. 0.5

Station	Radius (mi.)	Azimuth (from site)	Elev. (ft)	P _g (psf)	Record Max. (psf)	Years of Record		P _g /P _{max}
						Total	No Snow	Ratio
NWS FIRST ORDER								
ANNETTE (W.E.)	1	114	110	28	14	32	1	1.96
ANNETTE WSO AP ("depth")	1	114	110	36	40	44	1	0.90
ALASKA (NWS co-op)								
KETCHIKAN	22	347	80		19	8	0	
BEAVER FALLS	24	18	40	152	96	37	0	1.58
TREE POINT LIGHT STN	30	110	40	42	22	14	0	1.91
GUARD ISLAND	31	323	20		24	9	0	
HOLLIS	53	292	20		15	2	0	
COFFMAN COVE	83	308	10		26	6	0	
LINCOLN ROCK LIGHT STN	84	310	30		5	6	0	
WRANGELL	104	331	40	53	35	35	0	1.51
CAPE POLE	108	293	50		16	1	0	
LEVEL ISLAND	115	313	30		10	3	0	
CAPE DECISION	120	291	40	22	15	23	7	1.47
PETERSBURG 1	134	322	100	138	103	45	0	1.34
PORT ALEXANDER	146	292	20	65	47	25	0	1.38
LITTLE PORT WALTER	151	294	10	247	166	44	0	1.49
ALASKA (NON-NWS)								
PETERSBURG RIDGE, N.	130	322	1600	319	283	11	0	1.13
PETERSBURG RIDGE, S.	130	322	1650	309	282	13	0	1.10
PETERSBURG RESERVOIR	132	322	550		95	9	0	

Current ASCE 7 value (psf) CS (not in Table 7.2-1)Case Study Answer 40 psfDate: October 30, 2019By Buska, Greateorex and Tobiasson

Comments:

The NWS first-order station a mile away indicates that Pg should be between 30 and 40 psf. The negative slope of the "nearest values" plot suggests that its Pg of 37 is too high but the next-closest station, *Beaver Falls*, 24 miles away at a lower elevation has a Pg of 152 psf, a Pmax of 96 psf and 37 years of record. The *Tree Point Light Station*, 30 miles away, has a Pg of 42 psf. The "all values" plot generates a Pg of 94 psf. From these wide-ranging possible answers, we conclude that a reasonable answer for Annette, AK is **40 psf** at 100 ft. However, we have concerns about our Annette answer and recommend that local experience and additional meteorological information be sought before it is used.

Appendix B: Our Comments on Case Studies Mentioned in this Report

These mentioned Case Studies are not included as examples. Since their names, coordinates, elevations, and our answers are provided where they are mentioned, readers may wish to conduct them. Our Comments on them are provided here to complete those information packages.

B.1 Pocatello, ID

The two plots generate similar P_g values and slopes. Many, long records quickly establish P_g between 20 and 25 psf. The NWS first-order station only 9 miles away suggests that 20 psf is enough. However, the “all values” P_g of 25 psf from stations less than 30 miles away convinces us to set **P_g at 25 psf**. However, we cannot argue against use of 20 psf. Almost three decades ago, we generated the ASCE mapped value of 15 psf up to 4600 ft. We now consider that value to be at least 5 psf too low.

At this site, the Interactive 1986 Map (Sack and Sheikh-Taheri 1986) generates a P_g of 56 psf, and the Interactive 2015 Map (Al Hatailah et al. 2015) generates a P_g of 104 psf, which is not credible. About 450 ft away at 42.866° N and 112.443° W at the same elevation, the Interactive 2015 Map generates a P_g of 31 psf, which is credible. Many step functions lacking credibility result across Idaho when the Interactive 2015 Idaho map is used. The **Mt. Idaho, ID**, example in this report (Table A-4 and Figure A-4) provides another example.

B.2 Mt. Hood Meadows, OR

The lines of best fit on the two plots have similar, high, credible slopes. Because the P_g of 487 psf from the “all values” plot is based on data farther away, the “nearest 8” P_g of 538 psf is more valuable. Both plots have rather high data scatter. The P_g of 650 psf at the *Mt. Hood* station, only 4 miles away at an elevation close to that of the site of interest, and the P_g of 738 psf at *Red Hill* 10 miles away, indicate the need for an answer greater than 538 psf. The P_g of 475 psf at *Tilly Jane* somewhat counterbalances these very high values. Our three preliminary answers ranged from 550 to 600 psf. After a discussion, we settled on **570 psf**. However, we can accept any value between 550 and 600 psf. Local experience that can compare snow

conditions at the site of interest to that at the *Mt. Hood*, *Red Hill*, *Brooks Meadow*, and *Tilly Jane* sites could also prove valuable.

B.3 Ely, NV

A combination of NWS and Non-NWS data nearby at elevations ranging from just below the elevation of the site of interest to almost 3000 ft above it provides excellent information. The two plots have similar P_g values, and their lines of best fit have similar slopes. Here the “nearest 6” value of 20 psf is given somewhat more weight than the “all values” 25 psf. **$P_g = 20$ psf.**

B.4 Underhill, VT

When no Maximum Elevation filter is applied, the two plots generate values of 94 and 87 psf. Both lines of best fit have high but credible slopes for northern New England. The NWS co-op and Non-NWS data points fit together well. It was quick and easy to settle on a **P_g of 90 psf.** If a Maximum Elevation Filter of 2500 ft is applied to eliminate the *Mount Mansfield* station, very little changes and again **$P_g = 90$ psf.**

B.5 Ellisburg, NY

The two plots have lines of best fit with high but credible positive slopes. They generate credible P_g values of 60 and 62 psf. There is very little scatter on the “nearest 6” plot, and all those values are within 19 miles of the site of interest. If the distance from Lake Ontario is penciled in on the “nearest 6” plot, it is evident that the stations closest to the lake are at much lower elevations than those farther away. The decrease in snow loads away from the lake, as was the case at **Muskegon, MI** (Table A-8 and Figure A-8), does not occur. At **Ellisburg, NY**, that trend is overpowered by the increase in snow load associated with the land rising more than 1000 ft above lake level within 16 miles of the lake. The site of interest is 4 miles from the lake at an elevation of 330 ft, which is 87 ft above lake level. Our rounded **P_g of 60 psf** considers both its elevation and its distance from the lake.

B.6 Cold Bay, AK

Beyond the two NWS first-order P_g values of 25 and 17 psf at the site of interest, the next P_g (10 psf) is at *Sarichef*, 97 miles away. Both plots contain the same six data points. They generate a P_g of 19 psf, which fits the at-site values well even though most of the other data points are far away. The

slopes of the lines of best fit are excessive. However, reducing them to more credible values below 100 psf/1000 ft changes their intercepts little, if at all, at the elevation of interest. With on-site P_{max} values of 29 and 24 psf, a P_g of **25 psf** is appropriate.

B.7 Fairbanks, AK

The two P_g values from the on-site NWS first-order station are 50 and 66 psf. Both are based on long periods of record. Many other NWS co-op and Non-NWS stations within 25 miles give the two plots high credibility even with the slope of the “nearest values” line of best fit negative. The plots generate P_g values of 57 and 56 psf. At this site, P_g is either 55 or 60 psf. We chose **60 psf**.

B.8 Kodiak, AK

The two P_g values at the first-order station only 1 mile away are 24 and 36 psf, but the 36 is filtered out due to a high P_g/P_{max} ratio. At the nearby NWS co-op station, P_g is 31 psf. The plots generate higher values of 38 and 37 psf. Because these values are based on many data points over 100 miles away, they are considered suspect. Clearly, P_g (rounded) is between 25 and 35 psf. *Kitoy Bay* pushes for 35 psf, but it is 30 miles away. We chose **30 psf**.

Appendix C: Case Studies to Practice On

This Appendix lists the coordinates and elevations for eight additional sites of interest where we have done Case Studies. Their tables and plots are not included in this report, but our Comments and disguised answers are in this Appendix.

First, three straightforward ones:

Derby Line, VT ($45^{\circ}00'00''$ N, $72^{\circ}06'11''$ W at an elevation of 1035 ft)

Honesdale, PA ($41^{\circ}34'38''$ N, $75^{\circ}15'29''$ W at an elevation of 980 ft)

North Anson, ME ($44^{\circ}51'19''$ N, $69^{\circ}53'49''$ W at an elevation of 300 ft)

Now, some with complications:

Jackson, WY ($43^{\circ}28'46''$ N, $110^{\circ}45'44''$ W at an elevation of 6250 ft)

Ketchum, ID ($43^{\circ}41'02''$ N, $114^{\circ}22'07''$ W at an elevation of 5825 ft)

King Salmon, AK ($58^{\circ}41'08''$ N, $156^{\circ}39'36''$ W at an elevation of 65 ft)

Mammoth Lakes, CA ($37^{\circ}38'55''$ N, $118^{\circ}58'20''$ W at an elevation of 7895 ft)

Talkeetna, AK ($62^{\circ}19'15''$ N, $150^{\circ}05'46''$ W at an elevation of 355 ft)

Please do not refer to the information that follows until after doing one or more of these Case Studies and ideally not until after two or more individuals have independently conducted them, discussed findings, and agreed on a final answer.

C.1 Derby Line, VT

The plots indicate a rounded value of *4.02 cubed* psf. With data from the two closest stations lying below both lines of best fit, there is no need to go higher. Our answer is *4.02 cubed* psf.

C.2 Honesdale, PA

The “nearest 6” plot points to a rounded value of *3.56 cubed* psf, but the “all values” plot suggests 5 psf lower. This is a close call. Large P_{max} values nearby at *Honesdale 4NW*, *Hawley 1S Dam*, and *Lakeville 2NNE* cause us to select *3.56 cubed* psf, but we cannot make a strong argument against use of *3.41 cubed* psf.

C.3 North Anson, ME

The 100 psf value at the closest station, *North Anson*, only 3 miles away suggests use of a value above the “nearest 6” value of 96 psf. However, the “all values” intercept of 80 psf suggests that 90 psf may be enough. Two of us chose *4.64 cubed* psf and the third chose *4.56 cubed* psf. While we cannot argue against use of *4.56 cubed* psf, we settled on *4.64 cubed* psf.

C.4 Jackson, WY

The two plots have lines of best fit with credible slopes, but their P_g values of 55 and 93 psf are quite far apart. They average 74 psf. The “nearest 6” intercept of 55 psf seems credible considering the P_g of 47 at the nearby *Jackson NWS* co-op station. However, below an elevation of 7660 ft, that plot contains data from only two co-op stations. The “all values” plot contains several additional Non-NWS stations with long periods of record. They provide convincing evidence to increase P_g above the 55 psf intercept of the “nearest 6” plot. By giving somewhat more weight to the “all values” intercept of 93 psf since it was generated from additional load measurements (as opposed to depth measurements converted to loads using equation [1]), our rounded P_g value is *4.31 cubed* psf.

C.5 Ketchum, ID

Both lines of best fit have credible slopes, and their intercepts of 116 and 105 psf are close. The two closest data points, both NWS co-op stations, lie below both lines of best fit, suggesting that a P_g of 100 psf may be adequate. However, with considerable scatter among the Non-NWS stations, all of which are within 25 miles of this site of interest and have long periods of record, we have chosen a P_g of *4.79 cubed* psf. At this site, the Interactive 1986 Idaho map generates a P_g of 120 psf and the Interactive 2015 Idaho map generates a lower P_g of 92 psf.

C.6 King Salmon, AK

This is an Alaskan site of interest with a nearby NWS first-order station that provides strong evidence that P_g should be no more than 20 psf, perhaps just 15 psf. Three filtered-out stations within 42 miles support the on-site station's low values. The nearest unfiltered, off-site station, 71 miles away, has a P_g of 141 psf. The two plots give P_g values of 55 and 46 psf, but both were generated from data too far away to be given much weight. In this case, the value of the Case Study is to indicate how little information is available in this area. Here, the credible on-site information and filtered-out information within 42 miles is about all there is to go on. Because of that, it may be worth searching for more meteorological information and seeking local experience before accepting our preliminary answer of *2.71 cubed psf*.

C.7 Mammoth Lakes, CA

Lots of credible data and data scatter are evident within 25 miles of this site of interest. The slope of the "nearest 6" line of best fit is credible as is its P_g of 290 psf for this high-snow-load site in the mountains of the West. The slope of the "all values" line of best fit is too low to be credible. If that plot is overlaid with a dashed line having a credible slope of about 100 psf/1000 ft, a P_g of about 285 psf results. To account for the large amount of data scatter on both plots, we have increased our answer to *6.695 cubed psf* but would find it hard to argue with any value between *6.62 cubed psf* and *6.77 cubed psf*.

C.8 Talkeetna, AK

Lots of valuable data are available within 45 miles. Here, the two P_g values from the NWS first-order station only 1 mile away are quite different (79 and 149 psf) with the larger value based on a much longer record of depth measurements. The Non-NWS station 1 mile away has a P_g of 107 psf. The two plots contain data points relatively close to the site of interest (for Alaska), so their P_g values of 105 and 113 psf are valuable. Our initial answers were *4.93 cubed psf*, *4.79 cubed psf*, and *4.93 cubed psf*. After a discussion, we settled on *4.93 cubed psf*.

Appendix D: Case Study Log

Cold Regions Research and Engineering Laboratory (CRREL) personnel have conducted over 1000 Ground Snow Load Case Studies since 1982. Of those studies, 837 (57 in Alaska and 780 in the Lower-48 States) were conducted after the “old” CRREL database was updated to circa 1992.

For each Case Study, Table D-1 provides the state, location name, latitude, longitude, elevation and our 50-year mean recurrence interval (MRI) ground snow load answer.

Each 50-year MRI value was developed using the lognormal probability distribution function. To account for the probability associated with winters without snow, the “binomial distribution” initiated by Thom (1966) has been used.

Each CRREL Case Study was analyzed independently by at least two engineers or technicians directly involved with CRREL research activities related to snow loads over the years. Three such individuals were involved in many of these Case Studies. A consensus answer was developed for each Case Study. However, not all such investigations resulted in the formal tables, plots, and comments depicted in the body of this report. Because of that, we are not providing such formal documentation for any of these Case Studies.

With this report and its companion Case Study Spreadsheet,* it is a simple matter to generate such formal tables and plots for any site of interest in the United States except Hawaii. This report also provides detailed information on how to arrive at answers “on your own.”

Some Case Studies are for locations where the national ground snow load map calls for Case Studies since “extreme local variations in ground snow loads in these areas preclude mapping at this scale.” That CRREL-generated map has appeared in the national design load standard (i.e., ASCE 7) and in building codes for decades. Other Case Studies in this database are for areas where mapped values are provided. As stated in those codes and

* The spreadsheet is available along with this report at <http://dx.doi.org/10.21079/11681/37574>.

standards, when the map and a Case Study provide somewhat different answers, “results of the detailed study should be followed.”

In this database (Table D-1), latitude and longitude, which are given in degrees and minutes, not decimal degrees, are only given to the nearest minute. A minute of latitude covers 1.2 miles all over the earth. A minute of longitude covers 1.2 miles at the equator then decreases to zero at the Poles. Over the Lower-48 states, it averages about 0.9 miles. In Alaska, it decreases from about 0.6 to 0.4 miles from Juneau to Utqiagvik (Barrow). Thus, depending on where in the nation a Case Study is located, its position, as defined only to the nearest minute of latitude and longitude, is known to be somewhere within a rectangle about 1 mile high and 1/2 to 1 mile wide. Somewhere within that space is the elevation at which the Case Study answer applies. When Google Earth takes you to the coordinates given, the elevation there may not be that for which that Case Study provides an answer.

Within such a space, elevation is a very important consideration. Today, most Case Studies are more precisely located by Google Earth searches. Knowing the elevation to the nearest 5 or 10 ft or so is more important than knowing the coordinates closer than to the nearest minute.

Each load is for the elevation listed with it. It is generally reasonable to limit use of that load to elevations 100 ft above and 100 ft below the listed elevation. Beyond those limits, another Case Study should be conducted. A different way of accounting for elevation differences is used for locations in New Hampshire.

In New Hampshire, a Case Study is presented for each of the 259 abutting “towns” in the state. The coordinates were determined at the geographical center of each town, but the elevation chosen was near the upper limit of most buildings. A New Hampshire–wide elevation adjustment factor of 2.1 psf/100 ft of elevation difference is then applied to each Case Study load for sites with a different elevation. Loads are increased at that rate for higher elevations and reduced at the same rate for lower elevations. Above an elevation of 2500 ft all over New Hampshire, separate Case Studies are called for. Tobiasson et al. (2002) documents this work. We and three practicing structural engineers from Structural Engineers of New Hampshire (SENH) published it in 2002.

Decades ago, CRREL Case Studies were used to generate loads at 33 locations in Alaska. Those values have been in the table of Alaskan loads in ASCE 7 ever since. Recently, in conjunction with review of new studies being done by others for Alaska for ASCE's Ground Snow Load Working Group, we reassessed some of the Alaskan loads in ASCE 7.

At Petersburg, the load dropped from 150 to 100 psf, due, in large measure, to the combination of two short-period-of-record data sets into one data set with a longer period of record. This combination resulted in a much lower 50-year mean recurrence interval ground snow load at that location in Petersburg.

Table D-1. Alaska and Lower-48 States Case Study log.

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Alabama	Anniston (Army Depot)	33° 37'	-85° 58'	765	5
Alabama	Birmingham (MAP)	33° 34'	-86° 45'	620	5
Alabama	Fort Rucker (Cairns AAF)	31° 16'	-85° 43'	305	0
Alabama	Huntsville	34° 42'	-86° 35'	606	10
Alabama	Maxwell AFB (Montgomery)	32° 23'	-86° 22'	169	5
Alabama	Mobile (Bates Field)	30° 41'	-88° 15'	211	0
Alabama	Montgomery (Donnelly Field)	32° 18'	-86° 24'	183	5
Alaska	Adak	51° 52'	-176° 39'	5	30
Alaska	Anchorage	61° 10'	-150° 01'	114	50
Alaska	Angoon	57° 30'	-134° 35'	20	70
Alaska	Annette	55° 02'	-131° 35'	100	40
Alaska	Attu	52° 50'	173° 11'	50	65
Alaska	Barrow	71° 18'	-156° 47'	31	25
Alaska	Barter Island	70° 08'	-143° 38'	40	35
Alaska	Bethel	60° 47'	-161° 53'	160	40
Alaska	Big Delta	64° 00'	-145° 44'	1270	50
Alaska	Cape Lisburne	68° 52'	-166° 06'	15	50
Alaska	Chignik	56° 18'	-158° 23'	30	45
Alaska	Clear	64° 20'	-149° 10'	600	70
Alaska	Cold Bay	55° 12'	-162° 43'	75	25
Alaska	Cordova	60° 30'	-145° 29'	42	100
Alaska	Deadhorse	70° 12'	-148° 28'	55	30

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Alaska	Dillingham	59° 03'	-158° 28'	85	110
Alaska	Dutch Harbor	53° 54'	-166° 32'	25	40
Alaska	Eielson AFB	64° 40'	-147° 06'	545	70
Alaska	Elmendorf AFB	61° 15'	-149° 48'	212	40
Alaska	Fairbanks	64° 49'	-147° 52'	440	60
Alaska	Fort Greely	63° 58'	-145° 44'	1314	50
Alaska	Fort Richardson	61° 16'	-149° 39'	342	40
Alaska	Fort Wainwright	64° 50'	-147° 37'	448	60
Alaska	Fort Yukon	66° 34'	-145° 16'	440	60
Alaska	Galena	64° 43'	-156° 54'	120	60
Alaska	Gambell	63° 48'	-171° 44'	25	60
Alaska	Girdwood	60° 58'	-149° 08'	150	150
Alaska	Gulkana	62° 09'	-145° 27'	1570	70
Alaska	Homer	59° 38'	-151° 30'	70	40
Alaska	Huslia	65° 42'	-156° 23'	180	70
Alaska	Juneau	58° 22'	-134° 35'	12	60
Alaska	Kenai	60° 34'	-151° 15'	90	70
Alaska	King Salmon	58° 41'	-156° 40'	65	20
Alaska	Kodiak	57° 45'	-152° 31'	65	30
Alaska	Kotzebue	66° 53'	-162° 36'	11	60
Alaska	McGrath	62° 58'	-155° 37'	344	70
Alaska	Middleton Island	59° 27'	-146° 18'	79	30
Alaska	Nenana	64° 33'	-149° 05'	360	80
Alaska	Nikolski	52° 58'	-168° 51'	712	30
Alaska	Nome	64° 30'	-165° 26'	13	70
Alaska	Northeast Cape	63° 18'	-168° 42'	38	70
Alaska	Palmer	61° 36'	-149° 07'	225	50
Alaska	Petersburg	56° 49'	-132° 57'	30	100
Alaska	Ruby	64° 44'	-155° 28'	650	70
Alaska	Seward	60° 07'	-149° 24'	15	50
Alaska	Shemya	52° 43'	174° 08'	75	25
Alaska	Sitka	57° 03'	-135° 20'	67	50
Alaska	St. Paul Island	57° 09'	-170° 13'	22	40
Alaska	Talkeetna	62° 19'	-150° 06'	355	120
Alaska	Umiat	69° 22'	-152° 08'	337	25
Alaska	Unalakleet	63° 53'	-160° 48'	15	50
Alaska	Valdez	61° 07'	-146° 16'	49	160

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Alaska	Venetie	67° 01'	-146° 25'	550	35
Alaska	Wales	65° 37'	-168° 05'	9	50
Alaska	Whittier	60° 47'	-148° 41'	31	300
Alaska	Wrangell	56° 28'	-132° 23'	37	60
Alaska	Yakutat	59° 31'	-139° 40'	28	150
Arizona	Flagstaff	35° 08'	-111° 40'	7010	90
Arizona	Fort Huachuca / Libby AAF	31° 35'	-110° 20'	4664	5
Arizona	Luke AFB / Glendale	33° 33'	-112° 22'	1101	0
Arizona	Navajo Army Depot	35° 14'	-111° 50'	7125	90
Arizona	Phoenix (Sky Harbor IAP)	33° 26'	-112° 01'	1112	0
Arizona	Tucson (IAP)	32° 07'	-110° 56'	2558	5
Arizona	Williams AFB (Chandler)	33° 18'	-111° 40'	1385	0
Arizona	Yuma (MCAS / IAP)	32° 39'	-114° 37'	213	0
Arkansas	Eaker AFB (Blytheville)	35° 57'	-89° 57'	256	10
Arkansas	Fort Chaffee	35° 18'	-94° 17'	440	10
Arkansas	Little Rock (AFB)	34° 55'	-92° 09'	311	10
Arkansas	Pine Bluff (Arsenal)	34° 18'	-92° 05'	241	10
California	Barstow (Dagget AP)	34° 51'	-116° 47'	1927	5
California	Camp Pendleton (Pendleton MCB)	33° 18'	-117° 18'	63	0
California	Castle AFB (Merced)	37° 23'	-120° 34'	188	0
California	China Lake (NAF / Armitage Field)	35° 41'	-117° 41'	2283	5
California	Edwards AFB	34° 54'	-117° 52'	2302	5
California	Fort Ord (Fritzsche AAF)	36° 41'	-121° 46'	134	0
California	Hamilton AFB (San Rafael)	38° 04'	-122° 30'	3	0
California	Hunter-Liggett MR	36° 01'	-121° 14'	1090	0
California	Los Angeles (IAP)	33° 56'	-118° 24'	97	0
California	Mammoth Lakes	37° 39'	-118° 58'	7895	300
California	March AFB (Riverside)	33° 53'	-117° 15'	1533	0
California	Mare Island (NAVSHIPYD)	38° 05'	-122° 16'	25	0
California	Norton AFB (San Bernardino)	34° 06'	-117° 14'	1156	0
California	Oakland (IAP)	37° 44'	-122° 12'	6	0

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
California	Port Hueneme	34° 09'	-119° 12'	16	0
California	Sacramento	38° 31'	-121° 30'	17	0
California	San Diego (IAP)	32° 44'	-117° 10'	13	0
California	San Francisco (IAP)	37° 37'	-122° 23'	8	0
California	Sharpe AD	37° 51'	-121° 17'	16	0
California	Sierra AD	40° 09'	-120° 07'	4110	15
California	Stockton	37° 54'	-121° 15'	22	0
California	Travis AFB (Fairfield)	38° 16'	-121° 56'	62	0
California	Truckee	39° 20'	-120° 11'	5869	195
California	Twenty Nine Palms (MCB)	34° 14'	-116° 03'	1781	5
California	Vandenberg AFB (Lompoc)	34° 43'	-120° 34'	368	0
Colorado	Aspen Highlands	39° 11'	-106° 51'	8090	85
Colorado	Colorado Springs	38° 49'	-104° 50'	5989	15
Colorado	Colorado Springs (Peterson)	38° 49'	-104° 43'	6145	15
Colorado	Colorado Springs (USAF Academy)	39° 00'	-104° 53'	7166	30
Colorado	Denver	39° 44'	-104° 59'	5245	20
Colorado	Denver (Stapleton IAP)	39° 45'	-104° 52'	5283	20
Colorado	Estes Park	40° 23'	-105° 31'	7520	45
Colorado	Fitzsimmons AMC	39° 45'	-104° 50'	5375	20
Colorado	Fort Carson (Butts AAF)	38° 41'	-104° 46'	5840	15
Colorado	Golden	39° 47'	-105° 11'	5581	25
Colorado	Pueblo (Army Depot)	38° 17'	-104° 21'	4700	10
Colorado	Telluride	37° 56'	-107° 49'	8790	95
Colorado	Winter Park	39° 54'	-105° 46'	9033	100
Connecticut	Hartford (Brainard Apt)	41° 44'	-72° 39'	19	30
Connecticut	New Haven	41° 19'	-72° 55'	6	25
Connecticut	New London	41° 24'	-72° 05'	14	30
Delaware	Dover AFB	39° 08'	-75° 28'	28	25
Delaware	Lewes	38° 46'	-75° 05'	10	20
Delaware	Wilmington	39° 45'	-75° 33'	79	20
District of Columbia	Bolling AFB (Anacostia Mil Cmplx)	38° 50'	-77° 01'	29	25
District of Columbia	Fort McNair	38° 52'	-77° 01'	15	25

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
District of Columbia	Walter Reed AMC	38° 58'	-77° 02'	285	25
Florida	Coca Beach (Patrick AFB)	28° 14'	-80° 36'	9	0
Florida	Homestead AFB	25° 29'	-80° 24'	7	0
Florida	Jacksonville (AFS)	30° 17'	-81° 41'	110	0
Florida	Ket West (IAP)	24° 33'	-81° 45'	4	0
Florida	Miami (IAP)	25° 48'	-80° 16'	7	0
Florida	Orlando	28° 33'	-81° 23'	100	0
Florida	Panama City (Tyndall AFB)	30° 04'	-85° 35'	18	0
Florida	Pennsacola (Ellyson Field NAS)	30° 31'	-87° 12'	115	0
Florida	Tampa (IAP)	27° 58'	-82° 32'	19	0
Florida	Tampa (MacDill AFB)	27° 51'	-82° 30'	13	0
Florida	Valparaiso (Eglin AFB)	30° 29'	-86° 31'	85	0
Georgia	Albany (NAS / Turner AFB)	31° 36'	-84° 05'	223	0
Georgia	Atlanta (Hartsfield IAP)	33° 39'	-84° 26'	1010	5
Georgia	Augusta (Bush Field)	33° 22'	-81° 58'	136	5
Georgia	Fort Benning (Lawson AAF)	32° 21'	-85° 00'	232	5
Georgia	Fort Gordon	33° 26'	-82° 11'	465	5
Georgia	Fort Stewart (Wright AAF)	31° 52'	-81° 37'	88	0
Georgia	Kings Bay	30° 44'	-81° 31'	20	0
Georgia	Macon (L B Wilson AP ANG)	32° 42'	-83° 39'	354	5
Georgia	Macon (Robins AFB)	32° 38'	-83° 36'	294	5
Georgia	Savannah (AFS)	32° 01'	-81° 10'	68	0
Georgia	Savannah (Hunter AFB)	32° 01'	-81° 08'	42	0
Idaho	Albion	42° 25'	-113° 34'	4705	30
Idaho	Coeur d'Alene	47° 41'	-116° 47'	2166	60
Idaho	Deary	46° 48'	-116° 33'	2960	120
Idaho	Hayden	47° 46'	-116° 47'	2287	80
Idaho	Idaho Falls (Fanning Fld)	43° 31'	-112° 04'	4741	30
Idaho	Ketchum	43° 41'	-114° 22'	5803	110
Idaho	McCall	44° 55'	-116° 07'	5007	145

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Idaho	Mountain Home	43° 08'	-115° 42'	3155	30
Idaho	Mountain Home AFB	43° 02'	-115° 54'	2996	15
Idaho	Mt. Idaho	45° 54'	-116° 06'	3700	45
Idaho	Pocatello	42° 52'	-112° 27'	4470	25
Idaho	Pocatello 2	42° 54'	-112° 24'	5258	80
Illinois	Belleville (Scott AFB)	38° 33'	-89° 51'	453	20
Illinois	Chanute AFB	40° 18'	-88° 08'	753	20
Illinois	Chicago	41° 51'	-87° 35'	600	25
Illinois	Chicago O'Hare AP	41° 59'	-87° 54'	658	25
Illinois	Great Lakes NTC	42° 18'	-87° 50'	650	30
Illinois	Joliet AAP	41° 31'	-88° 10'	582	25
Illinois	Rock Island Arsenal	41° 31'	-90° 33'	575	20
Illinois	Savanna AD	42° 11'	-90° 15'	640	25
Indiana	Fort Benjamin Harrison	39° 51'	-86° 00'	864	20
Indiana	Fort Wayne	41° 00'	-85° 12'	791	20
Indiana	Grissom AFB	40° 39'	-86° 09'	813	20
Indiana	Hobart	41° 32'	-87° 15'	620	25
Indiana	Indiana AAP	38° 25'	-85° 39'	600	20
Indiana	Indianapolis	39° 44'	-86° 17'	792	20
Indiana	Michigan City	41° 44'	-86° 54'	600	30
Iowa	Burlington	40° 47'	-91° 07'	692	20
Iowa	Cedar Rapids	41° 53'	-91° 42'	863	25
Iowa	Des Moines	41° 32'	-93° 39'	938	20
Iowa	Sioux City	42° 24'	-96° 23'	1095	30
Kansas	Forbes AFB	38° 57'	-95° 40'	1064	20
Kansas	Fort Leavenworth	39° 22'	-94° 55'	770	20
Kansas	Fort Riley	39° 03'	-96° 46'	1065	20
Kansas	Kansas AAP	37° 20'	-95° 13'	925	15
Kansas	McConnel AFB	37° 38'	-97° 16'	1371	15
Kansas	Schilling AFB	38° 48'	-97° 39'	1272	20
Kansas	Sunflower AAP	38° 56'	-95° 00'	925	20
Kentucky	Fort Campbell	36° 40'	-87° 29'	571	15
Kentucky	Fort Knox	37° 54'	-85° 58'	753	15
Kentucky	Lexington	38° 02'	-84° 36'	966	15
Kentucky	Louisville	38° 11'	-85° 44'	477	15
Louisiana	Barksdale AFB	32° 30'	-93° 40'	167	5
Louisiana	Fort Polk	31° 03'	-93° 11'	330	5

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Louisiana	Lake Charles	30° 10'	-93° 10'	15	0
Louisiana	Louisiana AAP	32° 34'	-93° 25'	195	5
Louisiana	New Orleans	29° 58'	-90° 02'	5	0
Louisiana	Shreveport	32° 28'	-93° 49'	254	5
Maine	Andover	44° 38'	-70° 45'	720	110
Maine	Anson	44° 48'	-69° 53'	250	95
Maine	Athens	44° 55'	-69° 40'	400	90
Maine	Auburn / Lewiston	44° 05'	-70° 10'	105	70
Maine	Augusta	44° 19'	-69° 47'	400	75
Maine	Bangor	44° 48'	-68° 50'	192	70
Maine	Bethel	44° 25'	-70° 48'	660	100
Maine	Bigelow	45° 03'	-70° 18'	1750	120
Maine	Bingham	45° 04'	-69° 53'	500	100
Maine	Bridgton	44° 03'	-70° 42'	422	90
Maine	Bridgton	44° 00'	-70° 52'	422	90
Maine	Brownville Junction	45° 21'	-69° 04'	400	90
Maine	Brunswick	43° 54'	-69° 56'	75	60
Maine	Carrabassett	45° 02'	-70° 14'	1840	120
Maine	Carrabassett Valley Academy	45° 04'	-70° 19'	1360	110
Maine	Dexter	45° 01'	-69° 18'	440	90
Maine	Dover-Foxcroft	45° 11'	-69° 15'	390	90
Maine	Eagle Lake	47° 03'	-68° 35'	600	100
Maine	East Sebago	43° 52'	-70° 38'	380	90
Maine	Embden	44° 54'	-69° 56'	420	100
Maine	Farmington	44° 41'	-70° 08'	520	100
Maine	Fort Kent	47° 15'	-68° 35'	530	100
Maine	Fryeburg	44° 01'	-70° 58'	360	90
Maine	Gilead	44° 24'	-70° 58'	800	110
Maine	Greenville	45° 28'	-69° 35'	1100	100
Maine	Harmony	44° 58'	-69° 33'	400	90
Maine	Jackman	45° 38'	-70° 15'	1180	100
Maine	Jackman	45° 48'	-70° 24'	1970	110
Maine	Jay	44° 30'	-70° 13'	430	90
Maine	Kingfield	44° 58'	-70° 09'	640	100
Maine	Loring AFB	46° 57'	-67° 53'	746	100
Maine	Madison	44° 50'	-69° 51'	350	95
Maine	Madison-Anson	44° 48'	-69° 53'	400	100

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Maine	Millinocket	45° 39'	-68° 42'	460	90
Maine	Milo	45° 15'	-68° 59'	300	90
Maine	Monson	45° 19'	-69° 29'	650	90
Maine	Moscow	45° 07'	-69° 54'	1120	110
Maine	Norridgewock	44° 43'	-69° 48'	260	90
Maine	North Anson	44° 51'	-69° 54'	300	100
Maine	Oquossoc	44° 58'	-70° 47'	1600	90
Maine	Parsonfield	43° 43'	-70° 55'	800	100
Maine	Phillips	44° 49'	-70° 21'	560	100
Maine	Portland	43° 39'	-70° 19'	43	60
Maine	Rangeley	44° 58'	-70° 39'	1600	100
Maine	Rumford	44° 33'	-70° 33'	600	100
Maine	Stratton	45° 08'	-70° 26'	1150	100
Maine	Strong	44° 49'	-70° 13'	740	100
Maine	Sugarloaf	45° 03'	-70° 19'	2050	125
Maine	Topsham	43° 56'	-69° 58'	120	60
Maine	Van Buren	47° 08'	-67° 57'	820	105
Maine	Waterford	44° 11'	-70° 43'	500	90
Maine	Waterville	44° 34'	-69° 38'	150	65
Maine	Winslow	44° 32'	-69° 37'	500	80
Maine	Winter Harbor	44° 20'	-68° 04'	11	50
Maryland	Aberdeen Proving Ground	39° 28'	-76° 10'	57	25
Maryland	Andrews AFB	38° 49'	-76° 52'	279	25
Maryland	Annapolis	38° 59'	-76° 29'	40	25
Maryland	Baltimore	39° 11'	-76° 40'	148	25
Maryland	Fort Detrick	39° 26'	-77° 26'	355	30
Maryland	Fort Meade	39° 05'	-76° 46'	150	25
Maryland	Fort Richie	39° 40'	-77° 28'	1320	45
Maryland	Lexington Park	38° 17'	-76° 27'	38	20
Massachusetts	Boston	42° 22'	-71° 02'	15	35
Massachusetts	Fort Devens	42° 34'	-71° 36'	268	50
Massachusetts	LG Hanscom Field	42° 28'	-71° 17'	133	45
Massachusetts	Otis AFB	41° 39'	-70° 31'	132	35
Massachusetts	Springfield	42° 06'	-72° 35'	195	35
Massachusetts	Westover AFB	42° 12'	-72° 32'	245	35
Michigan	Detroit	42° 25'	-83° 01'	619	20
Michigan	K I Sawyer AFB	46° 21'	-87° 24'	1220	70

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Michigan	Kinchloe AFB	46° 15'	-84° 28'	799	70
Michigan	Muskegon	43° 18'	-86° 15'	600	50
Michigan	Muskegon	43° 14'	-86° 15'	615	55
Michigan	Selfridge AFB	42° 36'	-82° 50'	583	20
Michigan	Wurtsmith AFB	44° 27'	-83° 24'	634	40
Minnesota	Duluth	46° 50'	-92° 11'	1428	60
Minnesota	Minneapolis	44° 53'	-93° 13'	834	50
Mississippi	Biloxi	30° 25'	-88° 55'	26	0
Mississippi	Columbus AFB	33° 39'	-88° 27'	219	10
Mississippi	Gulfport	30° 22'	-89° 06'	33	0
Mississippi	Jackson	32° 19'	-90° 05'	310	5
Mississippi	Keesler AFB	30° 25'	-88° 55'	26	0
Mississippi	Meridian	32° 33'	-88° 34'	317	5
Mississippi	Mississippi AAP	30° 22'	-89° 06'	40	5
Missouri	Fort Leonard Wood	37° 45'	-92° 09'	1158	20
Missouri	Kansas City	39° 07'	-94° 35'	791	20
Missouri	Lake City AAP	39° 06'	-94° 15'	810	20
Missouri	Richards-Gebaur AFB	38° 51'	-94° 33'	1090	20
Missouri	St Louis	38° 45'	-90° 23'	535	20
Missouri	Whiteman AFB	38° 43'	-93° 33'	869	20
Montana	Billings	45° 47'	-108° 31'	3147	20
Montana	Boulder	46° 15'	-112° 07'	4915	30
Montana	Helena	46° 36'	-112° 00'	3828	20
Montana	Kallispell	48° 18'	-114° 16'	2970	45
Montana	Malmstrom AFB	47° 30'	-111° 11'	3525	20
Montana	Missoula	46° 55'	-114° 05'	3190	20
Montana	Red Lodge	45° 11'	-109° 15'	5575	80
Montana	West Yellowstone	44° 40'	-111° 06'	6670	140
Nebraska	Corn Husker AAP	40° 55'	-98° 29'	1915	25
Nebraska	Hastings	40° 36'	-98° 26'	1954	25
Nebraska	Lincoln	40° 51'	-96° 45'	1180	25
Nebraska	Offut AFB	41° 07'	-95° 55'	1048	25
Nebraska	Omaha	41° 18'	-95° 54'	977	25
Nevada	Carson City	39° 10'	-119° 46'	4675	20
Nevada	Ely	39° 15'	-114° 52'	6490	20
Nevada	Fallon	39° 24'	-118° 43'	4035	10
Nevada	Hawthorne	38° 32'	-118° 40'	4186	10

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Nevada	Indian Springs	36° 34'	-115° 40'	3170	5
Nevada	Las Vegas	36° 05'	-115° 10'	2162	5
Nevada	Reno	39° 30'	-119° 47'	4404	15
Nevada	Stead AFB	39° 40'	-119° 52'	5023	15
Nevada	Zephyr Cove	39° 00'	-119° 56'	6500	160
New Hampshire	Acworth	43° 13'	-72° 18'	1500	90
New Hampshire	Albany	43° 58'	-71° 16'	1300	95
New Hampshire	Alexandria	43° 38'	-71° 50'	1100	85
New Hampshire	Allenstown	43° 08'	-71° 23'	700	70
New Hampshire	Alstead	43° 07'	-72° 19'	1300	80
New Hampshire	Alton	43° 28'	-71° 15'	900	90
New Hampshire	Amherst	42° 52'	-71° 37'	600	70
New Hampshire	Andover	43° 27'	-71° 48'	900	80
New Hampshire	Antrim	43° 03'	-71° 59'	1000	80
New Hampshire	Ashland	43° 43'	-71° 38'	800	75
New Hampshire	Atkinson	42° 51'	-71° 10'	400	55
New Hampshire	Atkinson & Gilmanton Academy Grant	44° 59'	-71° 08'	1600	85
New Hampshire	Auburn	42° 59'	-71° 21'	500	65
New Hampshire	Barnstead	43° 21'	-71° 16'	900	85
New Hampshire	Barrington	43° 13'	-71° 03'	500	70
New Hampshire	Bartlett	44° 05'	-71° 15'	1200	100
New Hampshire	Bath	44° 11'	-72° 00'	1000	65
New Hampshire	Beans Grant	44° 13'	-71° 23'	1800	105
New Hampshire	Beans Purchase	44° 17'	-71° 07'	2000	120
New Hampshire	Bedford	42° 57'	-71° 32'	700	70
New Hampshire	Belmont	43° 28'	-71° 28'	900	80
New Hampshire	Bennington	43° 00'	-71° 54'	1000	80
New Hampshire	Benton	44° 02'	-71° 52'	1600	90
New Hampshire	Berlin	44° 29'	-71° 16'	1600	100
New Hampshire	Bethlehem	44° 16'	-71° 36'	1800	105
New Hampshire	Boscawen	43° 19'	-71° 40'	700	75
New Hampshire	Bow	43° 08'	-71° 32'	800	75
New Hampshire	Bradford	43° 14'	-71° 59'	1200	85
New Hampshire	Brentwood	42° 59'	-71° 02'	250	50
New Hampshire	Bridgewater	43° 40'	-71° 41'	1000	80
New Hampshire	Bristol	43° 37'	-71° 43'	1000	80
New Hampshire	Brookfield	43° 32'	-71° 05'	800	90

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New Hampshire	Brookline	42° 45'	-71° 40'	500	60
New Hampshire	Cambridge	44° 40'	-71° 06'	1300	90
New Hampshire	Campton	43° 50'	-71° 40'	1300	85
New Hampshire	Canaan	43° 41'	-72° 02'	1200	80
New Hampshire	Candia	43° 03'	-71° 19'	700	75
New Hampshire	Canterbury	43° 21'	-71° 32'	900	80
New Hampshire	Carroll	44° 17'	-71° 30'	1700	95
New Hampshire	Center Harbor	43° 42'	-71° 31'	900	80
New Hampshire	Chandlers Purchase	44° 16'	-71° 22'	2500	120
New Hampshire	Charlestown	43° 14'	-72° 24'	1100	80
New Hampshire	Chatham	44° 09'	-71° 03'	500	90
New Hampshire	Chatham (2)	44° 09'	-71° 03'	1495	115
New Hampshire	Chester	42° 58'	-71° 15'	500	65
New Hampshire	Chesterfield	42° 53'	-72° 27'	1000	70
New Hampshire	Chichester	43° 15'	-71° 24'	700	75
New Hampshire	Claremont	43° 23'	-72° 20'	1100	85
New Hampshire	Clarkesville	45° 01'	-71° 19'	2000	90
New Hampshire	Colebrook	44° 54'	-71° 25'	1600	80
New Hampshire	Columbia	44° 50'	-71° 28'	1600	80
New Hampshire	Concord	43° 14'	-71° 34'	600	70
New Hampshire	Conway	44° 01'	-71° 04'	900	95
New Hampshire	Cornish	43° 28'	-72° 19'	1100	85
New Hampshire	Crawfords Purchase	44° 16'	-71° 24'	1800	110
New Hampshire	Croydon	43° 27'	-72° 12'	1200	90
New Hampshire	Cutts Grant	44° 12'	-71° 20'	1700	110
New Hampshire	Dalton	44° 23'	-71° 41'	1300	80
New Hampshire	Danbury	43° 31'	-71° 52'	1000	85
New Hampshire	Danville	42° 56'	-71° 07'	300	55
New Hampshire	Deerfield	43° 08'	-71° 15'	700	70
New Hampshire	Deering	43° 04'	-71° 51'	1200	85
New Hampshire	Derry	42° 53'	-71° 17'	600	65
New Hampshire	Dixs Grant	44° 55'	-71° 12'	1700	90
New Hampshire	Dixville	44° 53'	-71° 16'	1900	90
New Hampshire	Dorchester	43° 46'	-71° 59'	1400	80
New Hampshire	Dover	43° 12'	-70° 53'	200	60
New Hampshire	Dublin	42° 53'	-72° 05'	1600	90
New Hampshire	Dummer	44° 40'	-71° 15'	1400	90

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New Hampshire	Dunbarton	43° 06'	-71° 37'	800	75
New Hampshire	Durham	43° 07'	-70° 56'	150	55
New Hampshire	East Kingston	42° 56'	-71° 01'	200	50
New Hampshire	Easton	44° 08'	-71° 47'	1400	85
New Hampshire	Eaton	43° 54'	-71° 03'	1000	95
New Hampshire	Effingham	43° 45'	-71° 03'	600	85
New Hampshire	Ellsworth	43° 54'	-71° 46'	1400	90
New Hampshire	Enfield	43° 36'	-72° 07'	1300	85
New Hampshire	Epping	43° 03'	-71° 05'	300	55
New Hampshire	Epsom	43° 13'	-71° 20'	800	75
New Hampshire	Errol	44° 46'	-71° 08'	1600	90
New Hampshire	Erving's Location	44° 48'	-71° 21'	2100	100
New Hampshire	Exeter	42° 59'	-70° 58'	200	50
New Hampshire	Farmington	43° 22'	-71° 05'	800	85
New Hampshire	Fitzwilliam	42° 46'	-72° 09'	1300	75
New Hampshire	Francestown	42° 59'	-71° 49'	1100	80
New Hampshire	Franconia	44° 11'	-71° 40'	1700	95
New Hampshire	Franklin	43° 27'	-71° 39'	700	75
New Hampshire	Freedom	43° 49'	-71° 04'	1000	90
New Hampshire	Fremont	42° 59'	-71° 07'	250	50
New Hampshire	Gilford	43° 34'	-71° 23'	1200	90
New Hampshire	Gilmanton	43° 26'	-71° 22'	1100	90
New Hampshire	Gilsum	43° 03'	-72° 16'	1200	80
New Hampshire	Goffstown	43° 01'	-71° 34'	800	75
New Hampshire	Gorham	44° 23'	-71° 12'	1400	100
New Hampshire	Goshen	43° 17'	-72° 07'	1400	90
New Hampshire	Grafton	43° 35'	-71° 58'	1400	90
New Hampshire	Grantham	43° 31'	-72° 09'	1400	90
New Hampshire	Greenfield	42° 57'	-71° 52'	1100	80
New Hampshire	Greenland	43° 02'	-70° 50'	100	50
New Hampshire	Greens Grant	44° 18'	-71° 13'	1700	105
New Hampshire	Greenville	42° 46'	-71° 48'	1000	75
New Hampshire	Groton	43° 44'	-71° 52'	1200	80
New Hampshire	Hadleys Purchase	44° 07'	-71° 20'	1500	100
New Hampshire	Hales Location	44° 02'	-71° 10'	800	90
New Hampshire	Hampstead	42° 53'	-71° 10'	300	55
New Hampshire	Hampton	42° 56'	-70° 50'	150	50

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New Hampshire	Hampton Falls	42° 55'	-70° 53'	150	50
New Hampshire	Hancock	42° 59'	-72° 00'	1300	85
New Hampshire	Hanover	43° 43'	-72° 12'	1300	75
New Hampshire	Harrisville	42° 57'	-72° 06'	1500	90
New Hampshire	Harts Location	44° 08'	-71° 22'	1300	100
New Hampshire	Haverhill	44° 05'	-71° 59'	1200	75
New Hampshire	Hebron	43° 42'	-71° 48'	900	80
New Hampshire	Henniker	43° 11'	-71° 49'	1000	80
New Hampshire	Hill	43° 32'	-71° 46'	1100	85
New Hampshire	Hillsboro	43° 09'	-71° 56'	1000	80
New Hampshire	Hinsdale	42° 48'	-72° 30'	700	60
New Hampshire	Holderness	43° 45'	-71° 35'	1000	80
New Hampshire	Hollis	42° 45'	-71° 35'	500	60
New Hampshire	Hooksett	43° 04'	-71° 26'	600	70
New Hampshire	Hopkinton	43° 12'	-71° 42'	800	80
New Hampshire	Hudson	42° 46'	-71° 25'	400	60
New Hampshire	Jackson	44° 11'	-71° 12'	1800	115
New Hampshire	Jaffrey	42° 50'	-72° 03'	1300	80
New Hampshire	Jefferson	44° 24'	-71° 28'	1700	100
New Hampshire	Keene	42° 57'	-72° 18'	900	70
New Hampshire	Kensington	42° 56'	-70° 57'	200	50
New Hampshire	Kilkenny	44° 30'	-71° 24'	1700	95
New Hampshire	Kingston	42° 55'	-71° 04'	200	50
New Hampshire	Laconia	43° 34'	-71° 28'	900	80
New Hampshire	Lancaster	44° 29'	-71° 33'	1300	75
New Hampshire	Landaff	44° 09'	-71° 53'	1300	80
New Hampshire	Langdon	43° 10'	-72° 23'	1000	80
New Hampshire	Lebanon	43° 38'	-72° 15'	1200	80
New Hampshire	Lee	43° 07'	-71° 00'	200	55
New Hampshire	Lempster	43° 14'	-72° 11'	1600	95
New Hampshire	Lincoln	44° 06'	-71° 35'	1400	95
New Hampshire	Lisbon	44° 14'	-71° 52'	1100	75
New Hampshire	Litchfield	42° 51'	-71° 27'	250	60
New Hampshire	Littleton	44° 19'	-71° 48'	1200	75
New Hampshire	Livermore	44° 02'	-71° 29'	1500	100
New Hampshire	Londonderry	42° 53'	-71° 24'	500	65
New Hampshire	Loudon	43° 19'	-71° 27'	900	80

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New Hampshire	Low & Burbanks Grant	44° 19'	-71° 22'	1800	105
New Hampshire	Lyman	44° 16'	-71° 57'	1200	75
New Hampshire	Lyme	43° 49'	-72° 08'	1100	70
New Hampshire	Lyndeborough	42° 54'	-71° 47'	1000	80
New Hampshire	Madbury	43° 11'	-70° 57'	200	60
New Hampshire	Madison	43° 54'	-71° 09'	1100	90
New Hampshire	Manchester	42° 59'	-71° 27'	500	70
New Hampshire	Marlborough	42° 54'	-72° 11'	1300	80
New Hampshire	Marlow	43° 08'	-72° 13'	1600	90
New Hampshire	Martins Location	44° 20'	-71° 13'	1300	100
New Hampshire	Mason	42° 45'	-71° 45'	1000	75
New Hampshire	Meredith	43° 38'	-71° 30'	1000	80
New Hampshire	Merrimack	42° 51'	-71° 31'	400	60
New Hampshire	Middleton	43° 29'	-71° 04'	800	90
New Hampshire	Milan	44° 34'	-71° 12'	1500	95
New Hampshire	Milford	42° 49'	-71° 40'	600	70
New Hampshire	Millsfield	44° 46'	-71° 16'	1700	90
New Hampshire	Milton	43° 27'	-71° 00'	800	90
New Hampshire	Monroe	44° 17'	-72° 01'	1000	65
New Hampshire	Mont Vernon	42° 54'	-71° 41'	900	75
New Hampshire	Moultonborough	43° 44'	-71° 23'	900	80
New Hampshire	Nashua	42° 46'	-71° 29'	400	60
New Hampshire	Nelson	42° 59'	-72° 08'	1500	90
New Hampshire	New Boston	42° 58'	-71° 41'	800	80
New Hampshire	New Castle	43° 04'	-70° 43'	50	50
New Hampshire	New Durham	43° 28'	-71° 08'	900	90
New Hampshire	New Hampton	43° 37'	-71° 37'	1000	80
New Hampshire	New Ipswich	42° 45'	-71° 52'	1300	80
New Hampshire	New London	43° 25'	-71° 59'	1400	95
New Hampshire	Newbury	43° 19'	-72° 02'	1300	90
New Hampshire	Newfields	43° 02'	-70° 58'	150	50
New Hampshire	Newington	43° 06'	-70° 50'	100	50
New Hampshire	Newmarket	43° 04'	-70° 58'	200	50
New Hampshire	Newport	43° 22'	-72° 12'	1200	85
New Hampshire	Newton	42° 52'	-71° 03'	250	50
New Hampshire	North Hampton	42° 58'	-70° 50'	100	50
New Hampshire	Northfield	43° 25'	-71° 35'	800	75

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New Hampshire	Northumberland	44° 35'	-71° 31'	1200	75
New Hampshire	Northwood	43° 13'	-71° 13'	800	80
New Hampshire	Nottingham	43° 08'	-71° 07'	500	65
New Hampshire	Odell	44° 43'	-71° 22'	1800	90
New Hampshire	Orange	43° 40'	-71° 57'	1500	90
New Hampshire	Orford	43° 54'	-72° 05'	1100	70
New Hampshire	Ossipee	43° 44'	-71° 09'	1000	85
New Hampshire	Pelham	42° 44'	-71° 19'	400	55
New Hampshire	Pembroke	43° 11'	-71° 27'	700	70
New Hampshire	Peterborough	42° 53'	-71° 57'	1000	75
New Hampshire	Piermont	43° 59'	-72° 02'	1400	75
New Hampshire	Pinkhams Grant	44° 16'	-71° 15'	2000	115
New Hampshire	Pittsburgh	45° 09'	-71° 15'	1700	80
New Hampshire	Pittsfield	43° 18'	-71° 18'	900	80
New Hampshire	Plainfield	43° 33'	-72° 17'	1300	90
New Hampshire	Plaistow	42° 51'	-71° 06'	300	55
New Hampshire	Plymouth	43° 45'	-71° 43'	900	75
New Hampshire	Portsmouth	43° 03'	-70° 47'	100	50
New Hampshire	Randolph	44° 24'	-71° 19'	1900	110
New Hampshire	Raymond	43° 02'	-71° 12'	500	60
New Hampshire	Richmond	42° 46'	-72° 17'	1100	65
New Hampshire	Rindge	42° 45'	-72° 00'	1300	80
New Hampshire	Rochester	43° 18'	-70° 59'	500	70
New Hampshire	Rollinsford	43° 13'	-70° 50'	200	60
New Hampshire	Roxbury	42° 57'	-72° 12'	1300	80
New Hampshire	Rumney	43° 50'	-71° 48'	1300	85
New Hampshire	Rye	43° 01'	-70° 45'	100	50
New Hampshire	Salem	42° 47'	-71° 13'	300	55
New Hampshire	Salisbury	43° 23'	-71° 46'	775	75
New Hampshire	Sanbornton	43° 31'	-71° 36'	1000	80
New Hampshire	Sandown	42° 56'	-71° 11'	400	60
New Hampshire	Sandwich	43° 50'	-71° 27'	1100	85
New Hampshire	Sargents Purchase	44° 14'	-71° 17'	2000	115
New Hampshire	Seabrook	42° 53'	-70° 52'	100	50
New Hampshire	Second College Grant	44° 55'	-71° 06'	1500	85
New Hampshire	Sharon	42° 49'	-71° 56'	1300	80
New Hampshire	Shelburne	44° 23'	-71° 05'	800	90

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New Hampshire	Somersworth	43° 15'	-70° 53'	250	60
New Hampshire	South Hampton	42° 53'	-70° 58'	200	50
New Hampshire	Springfield	43° 30'	-72° 03'	1500	95
New Hampshire	Stark	44° 36'	-71° 24'	1200	80
New Hampshire	Stewartstown	44° 58'	-71° 25'	2000	90
New Hampshire	Stoddard	43° 05'	-72° 07'	1600	90
New Hampshire	Strafford	43° 17'	-71° 09'	800	80
New Hampshire	Stratford	44° 42'	-71° 31'	1100	70
New Hampshire	Stratham	43° 01'	-70° 54'	150	50
New Hampshire	Success	44° 31'	-71° 05'	1600	100
New Hampshire	Sugar Hill	44° 13'	-71° 48'	1600	90
New Hampshire	Sullivan	43° 01'	-72° 13'	1400	90
New Hampshire	Sunapee	43° 23'	-72° 05'	1400	90
New Hampshire	Surry	43° 02'	-72° 20'	1100	80
New Hampshire	Sutton	43° 20'	-71° 56'	1100	85
New Hampshire	Swanzey	42° 52'	-72° 18'	800	65
New Hampshire	Tamworth	43° 51'	-71° 17'	1000	85
New Hampshire	Temple	42° 50'	-71° 52'	1300	85
New Hampshire	Thompson & Meserves Purchase	44° 18'	-71° 17'	2500	120
New Hampshire	Thornton	43° 55'	-71° 39'	1200	85
New Hampshire	Tilton	43° 28'	-71° 35'	900	80
New Hampshire	Troy	42° 50'	-72° 12'	1300	75
New Hampshire	Tuftonboro	43° 41'	-71° 15'	1100	85
New Hampshire	Unity	43° 18'	-72° 16'	1500	90
New Hampshire	Wakefield	43° 36'	-71° 01'	900	95
New Hampshire	Walpole	43° 05'	-72° 25'	1200	80
New Hampshire	Warner	43° 17'	-71° 49'	800	80
New Hampshire	Warren	43° 57'	-71° 53'	1300	80
New Hampshire	Washington	43° 11'	-72° 05'	1700	95
New Hampshire	Waterville Valley	43° 57'	-71° 30'	1800	105
New Hampshire	Weare	43° 05'	-71° 43'	900	80
New Hampshire	Webster	43° 18'	-71° 43'	700	75
New Hampshire	Wentworth	43° 52'	-71° 56'	1200	80
New Hampshire	Wentworth Location	44° 51'	-71° 08'	1300	80
New Hampshire	Westmoreland	42° 58'	-72° 26'	800	65
New Hampshire	Whitefield	44° 23'	-71° 35'	1400	80
New Hampshire	Wilmot	43° 27'	-71° 55'	1200	90

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New Hampshire	Wilton	42° 50'	-71° 46'	900	75
New Hampshire	Winchester	42° 47'	-72° 24'	700	60
New Hampshire	Windham	42° 48'	-71° 18'	400	60
New Hampshire	Windsor	43° 07'	-72° 02'	1200	85
New Hampshire	Wolfeboro	43° 37'	-71° 10'	1000	90
New Hampshire	Woodstock	44° 00'	-71° 44'	1200	85
New Jersey	Atlantic City	39° 27'	-74° 34'	64	20
New Jersey	Bayonne	40° 40'	-74° 05'	10	20
New Jersey	Cape May	38° 57'	-74° 56'	20	25
New Jersey	Fort Monmouth	40° 19'	-74° 02'	15	25
New Jersey	McGuire AFB	40° 01'	-74° 36'	133	25
New Jersey	Picatinny Arsenal	40° 56'	-74° 34'	706	35
New Mexico	Albuquerque	35° 05'	-106° 38'	5000	5
New Mexico	Canon AFB	34° 23'	-103° 19'	4283	15
New Mexico	Carlsbad	32° 25'	-104° 14'	3110	5
New Mexico	Chacon	36° 11'	-105° 20'	9400	110
New Mexico	Holoman AFB	32° 51'	-106° 06'	4093	5
New Mexico	Kirtland AFB	35° 03'	-106° 37'	5311	5
New Mexico	Los Alamos	35° 53'	-106° 18'	7269	35
New Mexico	Ruidoso	33° 20'	-105° 40'	6668	30
New Mexico	Sacramento Peak	32° 47'	-105° 49'	9240	50
New Mexico	Tijeras	34° 58'	-106° 20'	7460	45
New Mexico	Valdez	36° 36'	-105° 29'	9106	80
New Mexico	White Sands MR	32° 23'	-106° 29'	4330	5
New York	Albany	42° 45'	-73° 48'	275	40
New York	Alexandria Bay	44° 21'	-75° 59'	280	50
New York	Buffalo	42° 56'	-78° 44'	705	45
New York	Clinton	43° 03'	-75° 23'	890	55
New York	Depew	42° 54'	-78° 44'	680	40
New York	Ellisburg	43° 44'	-76° 08'	330	60
New York	Fort Drum	44° 02'	-75° 46'	655	70
New York	Griffis AFB	43° 14'	-75° 25'	514	60
New York	New York	40° 46'	-73° 54'	11	20
New York	Niagara Falls	43° 06'	-78° 57'	590	35
New York	Plattsburgh AFB	44° 39'	-73° 28'	235	50
New York	Rochester	43° 07'	-77° 42'	540	40
New York	Sidney Landfill	42° 15'	-75° 14'	2000	55

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
New York	Stewart AFB	41° 30'	-74° 06'	471	35
New York	Syracuse	43° 07'	-76° 07'	410	40
New York	Watervliet Arsenal	42° 43'	-73° 42'	35	35
New York	West Point	41° 23'	-73° 57'	160	35
North Carolina	Camp LeJuene	34° 40'	-77° 21'	25	10
North Carolina	Cape Hatteras	35° 16'	-75° 33'	7	5
North Carolina	Charlotte	35° 13'	-80° 56'	736	10
North Carolina	Cherry Point	34° 54'	-76° 53'	29	10
North Carolina	Fort Bragg	35° 08'	-78° 56'	242	10
North Carolina	Greensboro	36° 05'	-79° 57'	897	15
North Carolina	Pope AFB	35° 10'	-79° 01'	218	10
North Carolina	Seymore Johnson AFB	35° 20'	-77° 58'	109	10
North Carolina	Sunny Point Ocean Terminal	34° 00'	-78° 00'	25	10
North Carolina	Wilmington	34° 16'	-77° 55'	28	10
North Dakota	Bismark	46° 46'	-100° 45'	1647	35
North Dakota	Fargo	46° 54'	-96° 48'	896	40
North Dakota	Grand Forks AFB	47° 57'	-97° 24'	911	50
North Dakota	Minot AFB	48° 25'	-101° 21'	1668	35
Ohio	Ashtabula / Saybrook Township	41° 50'	-80° 49'	710	30
Ohio	Chardon	41° 35'	-81° 13'	1303	35
Ohio	Cinncinnatti	39° 03'	-84° 40'	869	20
Ohio	Cleveland	41° 24'	-81° 51'	777	20
Ohio	Columbus	40° 00'	-82° 53'	812	20
Ohio	Geneva-on-the-Lake	41° 52'	-80° 57'	600	25
Ohio	Ravenna AAP	41° 11'	-81° 06'	1130	20
Ohio	Willoughby	41° 39'	-81° 24'	650	20
Ohio	Wright-Patterson AFB	39° 49'	-84° 03'	824	20
Oklahoma	Altus AFB	34° 39'	-99° 16'	1378	10
Oklahoma	Enid-Vance AFB	36° 21'	-97° 55'	1307	10
Oklahoma	Fort Sill	34° 39'	-98° 24'	1187	10
Oklahoma	McAlester	34° 50'	-95° 55'	776	10
Oklahoma	Tinker AFB	35° 25'	-97° 23'	1291	10
Oklahoma	Tulsa	36° 12'	-95° 54'	650	10
Oregon	Baker City	44° 47'	-117° 50'	3440	25
Oregon	Bend	44° 03'	-121° 19'	3630	25
Oregon	Coos Bay	43° 22'	-124° 13'	20	5

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Oregon	Crescent Lake	43° 30'	-121° 56'	4708	225
Oregon	Eugene	44° 07'	-123° 13'	359	15
Oregon	Government Camp	45° 18'	-121° 45'	3901	380
Oregon	Klamath Falls	42° 13'	-121° 47'	4102	35
Oregon	Lakeview	42° 11'	-120° 21'	4759	45
Oregon	Mt. Hood Meadows	45° 20'	-121° 40'	5360	570
Oregon	Parkdale	45° 31'	-121° 36'	1713	100
Oregon	Pendleton	45° 40'	-118° 49'	1026	20
Oregon	Portland	45° 36'	-122° 36'	21	10
Oregon	Umatilla	45° 48'	-119° 25'	590	15
Pennsylvania	Berwick	41° 05'	-76° 18'	540	30
Pennsylvania	Bethlehem	40° 36'	-75° 23'	330	30
Pennsylvania	Carlisle Barracks	40° 12'	-77° 11'	475	25
Pennsylvania	Clarendon	41° 46'	-79° 05'	1420	35
Pennsylvania	Colver	40° 33'	-78° 48'	1985	55
Pennsylvania	Coolbaugh Township	41° 10'	-75° 20'	1840	55
Pennsylvania	Davidsville	40° 15'	-78° 54'	1810	50
Pennsylvania	Dingman	41° 20'	-74° 59'	1560	60
Pennsylvania	Dingmans Ferry	41° 15'	-74° 53'	905	40
Pennsylvania	Easton	40° 42'	-75° 13'	300	30
Pennsylvania	Erie	42° 03'	-80° 06'	1135	30
Pennsylvania	Forks Township	40° 45'	-75° 14'	410	30
Pennsylvania	Fort Indiantown Gap	40° 26'	-76° 34'	475	30
Pennsylvania	Freeland	41° 01'	-75° 55'	1800	50
Pennsylvania	Greensburg #4	40° 17'	-79° 34'	1060	30
Pennsylvania	Greensburg #5	40° 18'	-79° 35'	1234	35
Pennsylvania	Harrisburg	40° 13'	-76° 51'	308	25
Pennsylvania	Hazleton	40° 56'	-76° 04'	1820	45
Pennsylvania	Hazleton	40° 59'	-76° 02'	1470	45
Pennsylvania	Hidden Valley (Seven Spings)	40° 01'	-79° 18'	2852	60
Pennsylvania	Honesdale	41° 35'	-75° 15'	980	45
Pennsylvania	Johnstown	40° 17'	-78° 58'	1590	35
Pennsylvania	Johnstown AP	40° 19'	-78° 50'	2270	60
Pennsylvania	Laflin	41° 16'	-75° 48'	482	25
Pennsylvania	Lake Harmony	41° 04'	-75° 35'	1900	55
Pennsylvania	Leechburg	40° 38'	-79° 36'	850	30

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Pennsylvania	Letterkenny Army Depot	40° 00'	-77° 39'	670	30
Pennsylvania	Linglestown	40° 20'	-76° 51'	460	30
Pennsylvania	Lopez (Job Corps Center)	41° 22'	-76° 18'	2410	55
Pennsylvania	Loretto	40° 30'	-78° 38'	1953	55
Pennsylvania	Lyons	40° 28'	-75° 46'	600	35
Pennsylvania	Mertztown	40° 31'	-75° 37'	430	30
Pennsylvania	Mifflinville	41° 00'	-76° 16'	885	35
Pennsylvania	Milton (Montandon School)	40° 58'	-76° 51'	480	30
Pennsylvania	Mount Pleasant	40° 08'	-79° 33'	1105	30
Pennsylvania	Mountain Top	41° 08'	-75° 53'	1660	50
Pennsylvania	Nazareth	40° 43'	-75° 18'	380	30
Pennsylvania	North Warren	41° 53'	-79° 09'	1220	25
Pennsylvania	Olmstead AFB	40° 12'	-76° 46'	318	25
Pennsylvania	Olyphant	41° 28'	-75° 36'	900	35
Pennsylvania	Palmer Township	40° 44'	-75° 16'	400	30
Pennsylvania	Philadelphia	39° 53'	-75° 15'	5	20
Pennsylvania	Pittsburgh	40° 30'	-80° 13'	1137	25
Pennsylvania	Pocono Lake Preserve	41° 05'	-75° 32'	1650	50
Pennsylvania	Pocono Summit	41° 07'	-75° 23'	1820	55
Pennsylvania	Poplar Neck	40° 19'	-75° 54'	250	25
Pennsylvania	Portage	40° 23'	-78° 40'	1700	45
Pennsylvania	Quehanna	41° 11'	-78° 09'	2100	40
Pennsylvania	Rimersburg	41° 02'	-79° 30'	1520	35
Pennsylvania	SCI Frackville	40° 48'	-76° 11'	1552	45
Pennsylvania	SCI Waymart	41° 34'	-75° 26'	1688	60
Pennsylvania	Scranton	41° 26'	-75° 38'	940	40
Pennsylvania	Scranton	41° 24'	-75° 40'	730	30
Pennsylvania	Shade #1	40° 07'	-78° 49'	2215	55
Pennsylvania	South Center	41° 02'	-76° 19'	519	30
Pennsylvania	Starrucca	41° 54'	-75° 23'	1870	55
Pennsylvania	Stroudsberg	40° 59'	-75° 12'	250	30
Pennsylvania	Tobyhanna (Darlak)	41° 10'	-75° 23'	1985	55
Pennsylvania	Towanda	41° 45'	-76° 30'	800	30
Pennsylvania	Upper Saucon Township	40° 32'	-75° 23'	440	30
Pennsylvania	Wilkes-Barre	41° 18'	-75° 48'	482	25

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Pennsylvania	Wilkes-Barre (Avoca)	40° 14'	-75° 53'	660	25
Pennsylvania	Wind Gap	40° 50'	-75° 18'	740	35
Pennsylvania	Zionsville	40° 28'	-75° 33'	630	30
Rhode Island	Newport	41° 30'	-71° 20'	10	30
Rhode Island	Providence	41° 44'	-71° 26'	51	30
South Carolina	Charleston	32° 54'	-80° 02'	45	5
South Carolina	Fort Jackson	34° 01'	-80° 56'	250	10
South Carolina	Parris Island	32° 21'	-80° 41'	33	0
South Carolina	Shaw AFB	33° 58'	-80° 28'	252	10
South Dakota	Ellsworth AFB	44° 08'	-103° 06'	3276	20
South Dakota	Pierre	44° 23'	-100° 17'	1742	35
South Dakota	Rochford	44° 07'	-103° 43'	5300	50
South Dakota	Sioux Falls	43° 34'	-96° 44'	1418	40
Tennessee	Chattanooga	35° 02'	-85° 12'	665	10
Tennessee	Holston AAP	36° 31'	-82° 40'	1200	15
Tennessee	Memphis	35° 03'	-90° 00'	258	10
Tennessee	Milan AAP	35° 54'	-88° 42'	490	10
Tennessee	Nashville	36° 07'	-86° 41'	590	10
Tennessee	Sewart AFB	36° 00'	-86° 32'	543	10
Texas	Abilene (Dyess AFB)	32° 25'	-99° 51'	1789	5
Texas	Amarillo	35° 14'	-101° 42'	3604	15
Texas	Austin (Bergstrom AFB)	30° 12'	-97° 40'	541	5
Texas	Brooks AFB	29° 21'	-98° 27'	598	5
Texas	Carswell AFB	32° 47'	-97° 26'	650	5
Texas	Corpus Christi	27° 46'	-97° 30'	41	0
Texas	Dallas	32° 44'	-96° 58'	495	5
Texas	Denton	33° 13'	-97° 08'	650	5
Texas	Eagle Pass	28° 52'	-100° 32'	884	0
Texas	El Paso	31° 48'	-106° 24'	3918	10
Texas	Ellington	29° 37'	-95° 10'	40	0
Texas	Fort Bliss	31° 51'	-106° 23'	3947	10
Texas	Fort Hood	31° 09'	-97° 43'	1015	5
Texas	Fort Sam Houston	29° 27'	-98° 26'	760	5
Texas	Fort Worth	32° 50'	-97° 03'	537	5
Texas	Galveston	29° 18'	-94° 48'	7	0
Texas	Goodfellow AFB	31° 26'	-100° 24'	1877	5
Texas	Houston	29° 58'	-95° 21'	96	0

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Texas	Kelly AFB	29° 23'	-98° 35'	690	5
Texas	Kingsville	27° 31'	-97° 52'	75	0
Texas	Kingsville NAS	27° 29'	-97° 49'	50	0
Texas	Lackland AFB	29° 23'	-98° 37'	670	5
Texas	Laredo	27° 37'	-99° 31'	539	0
Texas	Laughlin AFB	29° 22'	-100° 47'	1081	0
Texas	Lone Star AAP	33° 27'	-94° 14'	360	5
Texas	Longhorn AAP	32° 40'	-94° 09'	295	5
Texas	Randolph AFB	29° 32'	-98° 17'	761	5
Texas	Red River AD	33° 27'	-94° 20'	385	5
Texas	Reese AFB	33° 36'	-102° 03'	3338	20
Texas	San Antonio	29° 32'	-98° 28'	788	5
Texas	Sheppard AFB	33° 59'	-98° 30'	1015	5
Texas	Wichita Falls	33° 58'	-98° 29'	994	5
Utah	Brighton	40° 36'	-111° 35'	8707	270
Utah	Dugway PG	40° 12'	-112° 56'	4340	10
Utah	Eureka	39° 58'	-112° 06'	6588	100
Utah	Hill AFB	41° 07'	-111° 58'	4785	40
Utah	Park City	40° 40'	-111° 31'	6795	140
Utah	Salt Lake City	40° 44'	-111° 56'	4239	25
Utah	Tooele AD	40° 31'	-112° 25'	4700	25
Vermont	Bennington	42° 53'	-73° 12'	670	50
Vermont	Berlin Corners	44° 14'	-72° 35'	1000	80
Vermont	Bradford	44° 00'	-72° 08'	440	55
Vermont	Brattleboro	42° 51'	-72° 34'	375	60
Vermont	Bromley	43° 15'	-72° 56'	3260	140
Vermont	Burke Hollow	44° 37'	-71° 57'	900	65
Vermont	Burlington	44° 28'	-73° 09'	332	40
Vermont	Derby Line	45° 00'	-72° 06'	1035	65
Vermont	Essex Junction	44° 30'	-73° 06'	347	40
Vermont	Haystack Mountain	42° 54'	-72° 56'	3420	150
Vermont	Island Pond	44° 49'	-71° 53'	1190	70
Vermont	Jay Peak	44° 56'	-72° 32'	3870	150
Vermont	Londonderry	43° 13'	-72° 49'	1350	90
Vermont	Ludlow	43° 23'	-72° 40'	1150	90
Vermont	Middlebury	44° 01'	-73° 09'	366	45
Vermont	Montpelier	44° 17'	-72° 35'	523	65

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Vermont	Montpelier	44° 16'	-72° 35'	1130	70
Vermont	Morrisville	44° 34'	-72° 36'	650	70
Vermont	Mount Mansfield	44° 32'	-72° 48'	1650	110
Vermont	Newport	44° 56'	-72° 13'	725	60
Vermont	North Springfield	43° 20'	-72° 31'	577	75
Vermont	Peacham	44° 22'	-72° 10'	1400	75
Vermont	Pico Peak	43° 40'	-72° 50'	2000	100
Vermont	Rutland	43° 37'	-72° 57'	600	55
Vermont	Saint Albans	44° 47'	-73° 04'	1310	80
Vermont	Saint Albans Bay	44° 49'	-73° 08'	450	45
Vermont	Saint Johnsbury	44° 25'	-72° 01'	660	60
Vermont	Sugarbush at Warren	44° 08'	-72° 54'	1620	95
Vermont	Underhill	44° 30'	-72° 52'	1160	90
Vermont	Vershire	44° 00'	-72° 21'	1610	70
Vermont	Wilmington	42° 52'	-72° 53'	1533	100
Vermont	Woodstock	43° 38'	-72° 31'	705	80
Virginia	Fort Belvoir	38° 43'	-77° 11'	69	25
Virginia	Fort Eustis	37° 08'	-76° 37'	12	10
Virginia	Fort Meyer	38° 53'	-77° 05'	220	25
Virginia	Langley AFB	37° 05'	-76° 21'	10	10
Virginia	Norfolk	36° 54'	-76° 12'	22	10
Virginia	Petersburg (Ft Lee)	37° 14'	-77° 21'	145	20
Virginia	Quantico	38° 30'	-77° 18'	12	25
Virginia	Radford AAP	37° 11'	-80° 33'	1750	25
Virginia	Richmond	37° 30'	-77° 20'	164	20
Virginia	Virginia Beach Coast	36° 49'	-75° 58'	22	10
Virginia	Yorktown	37° 14'	-76° 31'	25	15
Washington	Bremerton	47° 34'	-122° 39'	7	15
Washington	Ellensburg	47° 00'	-120° 33'	1511	60
Washington	Fort Lewis	47° 06'	-122° 35'	301	15
Washington	Kirkland	47° 39'	-122° 17'	180	15
Washington	McChord AFB	47° 09'	-122° 29'	322	15
Washington	Moses Lake (Larson AFB)	47° 12'	-119° 19'	1060	25
Washington	Pasco	46° 16'	-119° 07'	406	15
Washington	Pullman	46° 44'	-117° 11'	2351	40
Washington	Seattle	47° 36'	-122° 19'	284	15
Washington	Snoqualmie Pass	47° 25'	-121° 25'	2961	410

State	Location Name	Latitude (ddmm)	Longitude (dddmm)	Elevation (feet)	50-yr MRI Ground Snow Load (psf)
Washington	Spokane	47° 38'	-117° 32'	2360	45
Washington	Spokane (Fairchild AFB)	47° 37'	-117° 38'	2462	40
Washington	Tacoma	47° 15'	-122° 30'	100	15
Washington	Walla Walla	46° 06'	-118° 17'	1206	20
Washington	White Pass	46° 38'	-121° 23'	4636	325
Washington	Yakima	46° 34'	-120° 32'	1052	30
West Virginia	Beckley	37° 47'	-81° 07'	2480	30
West Virginia	Buckhannon	38° 59'	-80° 13'	1433	25
West Virginia	Charleston	38° 22'	-81° 36'	939	20
West Virginia	Davis	39° 10'	-79° 26'	3170	65
West Virginia	Fairmont	39° 29'	-80° 09'	991	25
West Virginia	Martinsburg	39° 27'	-77° 58'	600	35
West Virginia	Thomas	39° 09'	-79° 30'	3040	55
West Virginia	Vienna	39° 16'	-81° 34'	649	20
Wisconsin	Badger AAP	43° 22'	-89° 45'	880	35
Wisconsin	Fort McCoy	44° 01'	-90° 41'	870	40
Wisconsin	Green Bay	44° 29'	-88° 08'	682	40
Wisconsin	Madison	43° 08'	-89° 20'	858	35
Wisconsin	Milwaukee	42° 57'	-87° 54'	672	30
Wisconsin	Osceola	45° 19'	-92° 42'	900	60
Wyoming	Cheyenne	41° 09'	-104° 49'	6126	20
Wyoming	Jackson	43° 29'	-110° 46'	6250	80
Wyoming	Yellowstone Lake	44° 27'	-110° 22'	7733	120

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14. ABSTRACT The U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) has mapped ground snow loads for much of the United States. In some areas where extreme local variations preclude mapping on a national scale, instead of loads, "CS" is used to indicate that Case Studies are needed. This report and the accompanying spreadsheet, which contains the 15,104-station CRREL ground snow load database, provide the information needed to conduct Case Studies. When the latitude, longitude, and elevation of a site of interest are provided, the spreadsheet tabulates data available in the vicinity and generates plots that relate ground snow loads nearby to elevation. With this information, the ground snow load at the site of interest can be determined. This report uses 10 examples to illustrate the methodology and provides our answer and the comments we generate for each of these Case Studies and for 16 additional sites of interest, 8 of which have their answers "disguised" for practice purposes. CRREL has conducted over 1000 Case Studies upon request. Practicing structural engineers were involved in over 250 of them to verify that this methodology is ready to transfer to the design profession.					
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