SNOW FREQUENCY ANALYSIS FOR OREGON AND UTAH[1/]

By

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Introduction

An expanding affluent population with more leisure time are pushing building development into once inaccessible snow covered areas. This expansion has created an increasing number of requests for snow load and depth information from building designers and recreation planners.

Snow-oriented recreation activities and sports are growing in popularity. Snow frequency and length of snow season are important in locating these developments.

Snow frequency information can aid in planning for snow removal costs, planning storage reservoir locations, water pollution control, and determining available water supplies for industrial and municipal expansion.

Procedure

The Log-Pearson Type 3 method was selected for the snow frequency analysis by computer(1). The data is converted to logarithmic form during computation. The squares and cubes of the logarithms are tabulated, and the mean, standard deviation, skew, and percent-chance value (10 levels from .5% to 99%) are computed.

Zero readings were not included in the calculations. The Jennings and Benson(2) method was used to revise the percent-chance values for zero items by using the ratio $\frac{m}{n}$ times the percent-chance values, where n is the total number of items entered and m is the number of items greater than zero. Figure No. 1 compares the Log-Pearson Type 3 standard calculation and the revised ratio method curves with the actual data. The actual data more nearly fits the revised curve. The data includes 10 years with no data (zero readings) and 11 years with measurable amounts of snow.

Snow load values which are plotted on Hazen logarithmic-probability paper can be read directly from the snow-water content frequency curves as shown by the dotted line in figure 2. A 30-year frequency value of 11.5 inches of water equals 60 pounds per square foot. Snow load values for other elevations and percent-chance values can be read from the family of curves for snow courses located along the profile illustrated in the figure.

Results - Oregon

Computer-processed Log-Pearson Type 3 snow-water content and depth frequency analysis were calculated on all Soil Conservation Service snow courses in Oregon with more than 5 years of record. Most of the curves presented in this paper use snow-water content data for February 1. The snow courses used are shown on the map in figure No. 3.

Snow frequency curves can be used to locate potential ski areas. An average of 2 inches of snow-water equivalent accumulating by mid-December in 9 out of 10 years is the minimum criterion(3). Since snow surveys do not begin until January first at most snow courses in Oregon, extrapolations have to be made for earlier dates. In figure No. 4, curves are shown for three selected snow courses using the 90 percent-chance frequency values for January 1 and April 1, showing snow-water content vs. elevation. To meet the minimum criterion, it was estimated from precipitation and air temperature records that 4 inches of water would be needed by January 1. The figure indicates that 4,500 feet is the minimum elevation that could be considered feasible for a ski area in this locality. Slope grooming, aspect, accessibility, cost of development, and distance from population centers

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also should be considered. Similar information can be developed for locating potential areas for snowmobiling and other winter recreation activities.

Conditions that affect snow accumulation may be detected by comparing snow frequency curves for several snow courses. For example, Three Creek Meadow snow course, elevation 5,650 feet, and Tangent, elevation 5,400 feet, are about 11 air miles apart with similar conditions of slope, aspect, and cover. One would assume that the snow-water content frequency curves would be nearly the same. Figure 5 shows that Three Creek Meadow is 4 to 6 inches below the curve for the Tangent snow course. The Three Creek Meadow snow course is in the rain shadow of the 10,000 foot Three Sisters Peaks.

The effect of latitude on snow-water content accumulation in the Oregon Cascades is illustrated in figure 6. The Phlox Point snow course latitude, 46° 20', elevation 5,500', shows an increase of from 2 inches to 39 inches more snow-water content between the 99% and 1% levels than the Seven Lakes #2 snow course, elevation 6,200', latitude 42° 40', located 195 miles to the south. Both snow courses are in open meadows. The Seven Lakes #2 course is on a north aspect and is 700 feet higher than the southwest facing Phlox Point snow course.

Results - Utah

Snow survey data has been collected for use in water supply forecasts since the early 1920's in Utah. Analysis was made for all snow courses in Utah having over 5 years of record, using the Log-Pearson Type 3 method for both depth and water content, but only water content or ground snow load will be considered in this paper.

Data from snow courses on or adjoining the Weber River Basin has been selected for discussion in this paper. The Weber Basin lies immediately east of Utah's centers of population--Provo, Salt Lake City, Bountiful, and Ogden. The Weber River heads on the west end of the Uintah Mountains, then it generally flows north to northwest until it empties into the Great Salt Lake near Ogden, Utah.

The Wasatch Front Range divides the Weber Basin from the centers of population. Good access highways, available from Ogden, Salt Lake City, and Provo, make most areas of the Basin less than an hour's driving time away.

Weber Basin has many acres of private land now being developed for summer homes. Several areas closest to population centers are developing homes for yearlong occupancy at higher elevations. General snow load criteria have been available for lower valley locations, but they need to be supplemented with information from higher mountainous areas to make it usable.

Data from 14 snow courses has been selected for comparison in this study. Five of these snow courses are located along the Wasatch Frontal Ridge on the upwind side for most storm patterns. Nine snow courses are located on the eastern side or trailing ridge of the basin. These snow courses are listed in table 1. In general, the 2% computed snow load compares very closely to the maximum of record for all snow courses except for the two located at lower elevations.

The snow courses were divided into those located on the Wasatch Frontal Ridge, west side of the Weber Basin, and those on the trailing ridge or east side of the Weber Basin. The 2% snow load values were plotted by elevation as shown on graphs I and II. The resulting curves are fairly straight lines representing change of snow load with change in elevation.

Abnormal orographic effects can occur however, causing snow load values from some locations to differ from the usual amounts expected for the same elevations. These must be accounted for as special cases. On graph I, the upper curve for Farmington Upper and Lower snow courses, is an example of a much higher snow load than other areas of the Wasatch Front of similar elevation. A range of ground snow load values from 120 lbs/ft^2 at 6,000 foot elevations to 223 lbs/ft^2 at 9,000 foot elevations could be taken from the lower curve on graph I. Loads in Farmington Canyon range from 207 lbs/ft^2 at 6,950 foot elevation to 245 lbs/ft^2 at the 8,000 foot elevation.

Snow load data from the east side of the basin is plotted by elevation on graph II. This side of the basin appears to be less affected by orographic influences but does appear

FIGURE NO. 1

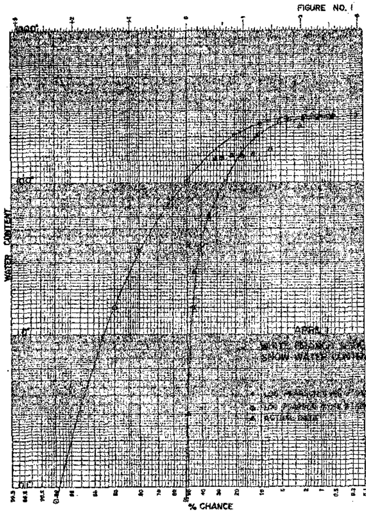
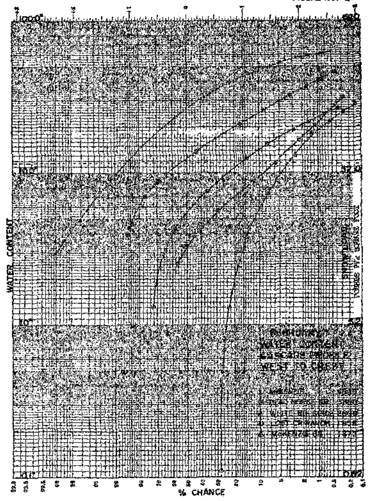


FIGURE NO. 2



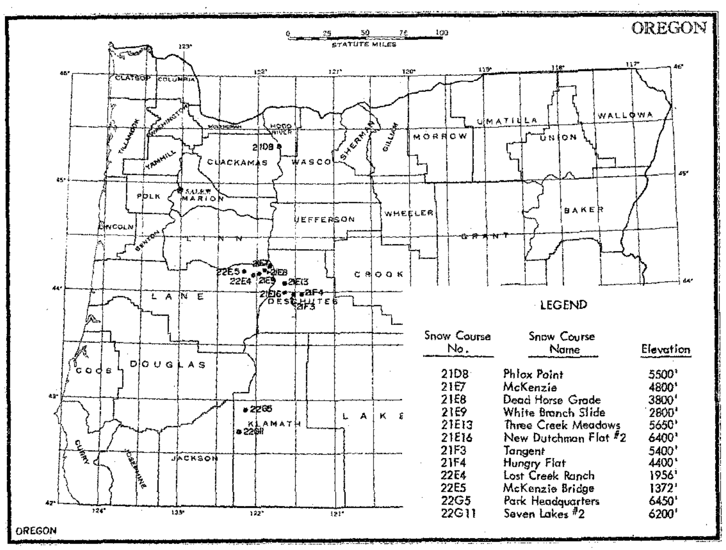
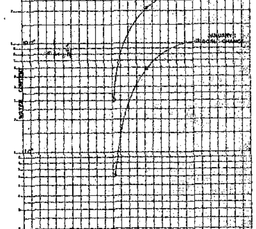


FIGURE NO. 3

FIGURE NO. 4



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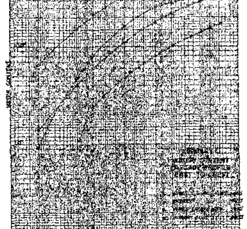

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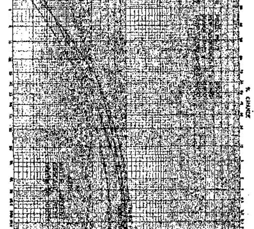

TABLE I

Snow Course	Location	Elevation	Years of Record	Max. Record Year	Max. Record Load (lb/ft^2)	Snow Load Freq. 2% (lb/ft^2)	Snow Load Freq. 1% (lb/ft^2)	Exposure
Ben Lomond Lower	W	6,000	16	4/69	111	120	123	Protected-Shaded
Sage Brush Flat	E	6,300	17	3/69	41	35	36	Open
Lambs Canyon	W	6,600	35	4/52	154	128	137	Protected
Mill D. South Fork	W	7,400	19	4/52	179	163	173	Protected
Beaver Cr. R. S.	E	7,500	39	4/52	97	83	88	Open
Parleys Canyon Summit	W	7,500	19	4/52	168	176	195	Protected
Smith & Morehouse	E	7,600	19	4/52	126	128	132	Open
Chalk Cr. #2	E	7,900	19	4/52	133	134	149	Open
Dry Bread Pond	E	8,250	34	4/52	163	166	179	Open
Reddon Mine Lower	E	8,500	40	4/52	177	163	174	Protected
Silver Lake-Brighton	W	8,725	19	4/52	199	217	227	Open
Reddon Mine Upper	E	9,000	40	4/52	179	174	186	Protected
Chalk Cr. #1	E	9,100	19	4/52	204	201	214	Protected
Trial Lake	E	9,800	39	4/52	204	218	233	Protected
Farmington (Lower)	W	6,950	19	4/52	216	207	226	Protected
Farmington (Upper)	W	8,000	19	5/52	234	245	267	Protected

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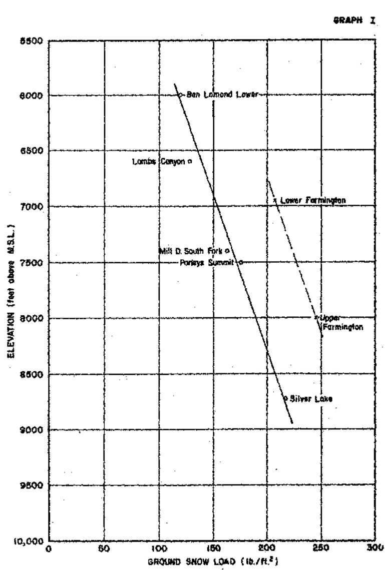
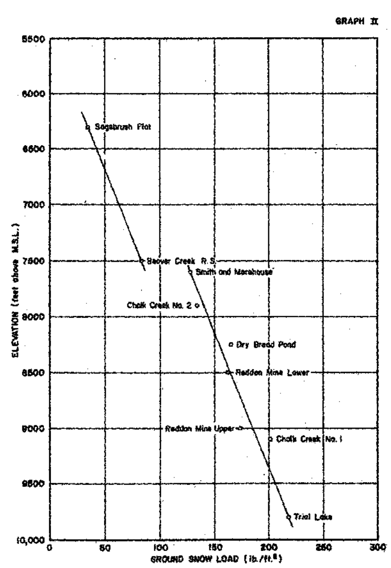
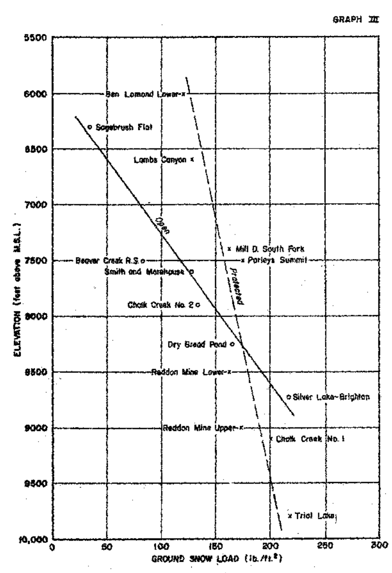


SNOW LOAD VS. ELEVATION
WEST SIDE OF BASIN
(2% - 50 Year Frequency)



SNOW LOAD VS. ELEVATION
EAST SIDE OF BASIN
(2% - 50 Year Frequency)



SNOW LOAD VS. ELEVATION
PROTECTED AND OPEN AREA CURVES
(2% - 50 Year Frequency)

to have two distinct curves. One below 7,500 feet and one from 7,500 feet to 9,800 feet.

Since general aspect, exposure, and protection have an effect on snow catch and retaining capabilities of a snow course, these characteristics should also be accounted for when ascertaining the correct snow load for the design of a building. Graph III shows how to do this: classify the snow courses by these physical features and then replot them. Eight snow courses are located in fairly well shaded or protected areas and six in open meadows or more exposed areas. This segregation produces quite a difference in snow load due to exposure. At the lower elevations, 6,500 feet, for example, a snow load of 45 lbs/ft^2 could be used in open exposed areas but 136 lbs/ft^2 would be the snow load in a protected or shaded area. At an elevation of about 8,250 feet, the snow load would be approximately 175 lbs/ft^2 for both shaded and open areas. Based on the limited amount of available data the open areas above 8,250 feet appear to have a greater snow load capability than shaded areas.

Conclusions

1. Analysis of snow course measurements by the Log-Pearson Type 3 method appears to be suitable for determining percent-chance of occurrence for snow-water content and depth.

2. The data generated can be used to predict expected snow loads, locate potential winter recreation areas, and other uses.

3. Physical location of the snow measuring sites with respect to topography, exposure, and orographic barriers helps to interpret snow frequency data.

4. Frequency analysis data for the rest of Oregon and Utah is being studied and information will be published on both snow load and snow depth frequencies in the future.

REFERENCES

(1) Methods of Flow Frequency Analysis, Subcommittee on Hydrology, Inter-agency Committee on Water Resources.

(2) Jennings, M. E. and Benson, M. A., "Frequency Curves for Annual Flood Series with Some Zero Events or Incomplete Data," Water Resources Research, February 1969, Vol. 5 No. 1.

(3) Farnes, P. E., "Areas with Adequate Snowfall for Potential Ski Areas," USDA, SCS, Bozeman, Montana, April 1969.