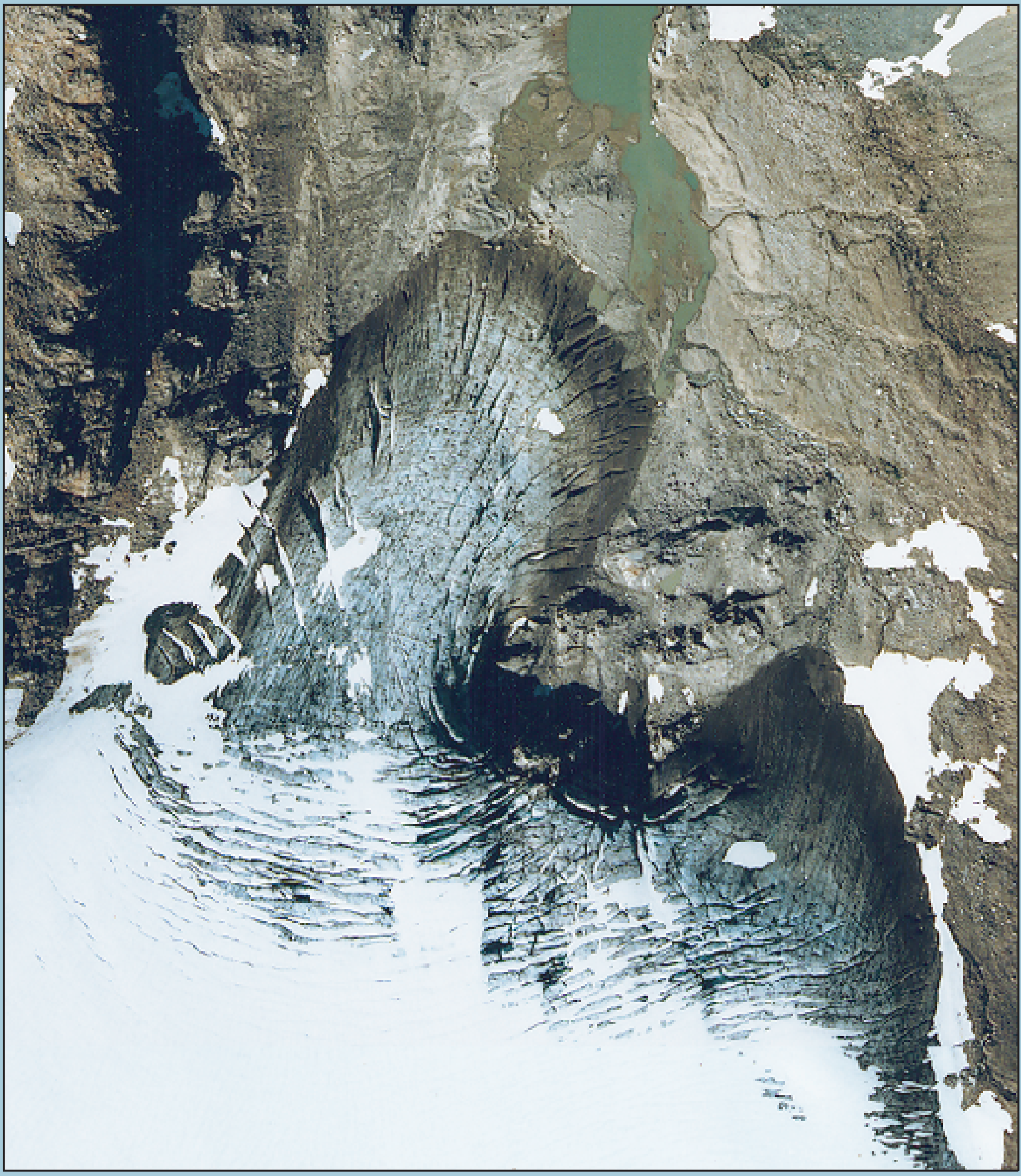
WATER, ICE, METEOROLOGICAL, AND SPEED MEASUREMENTS AT SOUTH CASCADE GLACIER, WASHINGTON, 1999 BALANCE YEAR

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 00-4265



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Lower portion of South Cascade Glacier, September 15, 1999

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By Robert M. Krimmel

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Tacoma, Washington
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Multiply	By	To obtain
kilogram	2.205	pound
kilogram per cubic meter (kg/m^3)	0.06243	pound per cubic foot
kilometer (km)	0.6214	mile
meter (m)	3.281	foot
millimeter (mm)	0.03937	inch
square kilometer (km^2)	0.3861	square mile

Temperature in degrees Fahrenheit (°F) can be converted to degrees Celsius (°C) as follows:
°C = 5/9 × (°F - 32).

VERTICAL DATUM

In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

SYMBOLS USED IN THIS REPORT

$\bar{b}_0$ The change in balance between the minimum balance near the beginning of the water year and October 1.

$\bar{b}_1$ The change in balance between the minimum balance near the end of the water year and September 30.

$\bar{b}_a$ The change in snow, firn, and ice storage between the beginning and end of some fixed period, which here is the water year.

$\bar{b}_m(s)$ The snow above the previously formed summer surface as measured directly by field work in late spring as near as possible to the time of greatest glacier mass.

$\bar{b}_n$ The change in snow, firn, and ice storage between times of minimum mass.

q River discharge.

S River stage.

X Approximate east/west position in the local survey net.

Y Approximate north/south position in the local survey net.

Z Altitude above NGVD of 1929.

MACHINE-READABLE FILES

Most of the data contained in this report have been recorded on easily copied computer media. This machine-readable material is available from the World Data Center, Campus Box 449, University of Colorado, Boulder, CO 80309 <URL: **http://www-nsidc.colorado.edu/NOAA/**>.

Water, Ice, Meteorological, and Speed Measurements at South Cascade Glacier, Washington, 1999 Balance Year

By Robert M. Krimmel

ABSTRACT

Winter snow accumulation and summer snow, firn, and ice melt were measured at South Cascade Glacier, Washington, to determine the winter and net balances for the 1999 balance year. The 1999 winter snow balance, averaged over the glacier, was 3.59 meters, and the net balance was 1.02 meters. Since the winter balance record began in 1959, only three winters have had a higher winter balance. Since the net balance record began in 1953, only 2 years have had a greater positive net balance than 1999. Runoff was measured from the glacier and an adjacent non-glacierized basin. Air temperature, precipitation, and humidity were measured nearby, and ice speed was measured. This report makes these data available to the glaciological and climatological community.

INTRODUCTION

The mass balance program at South Cascade Glacier is part of a larger U.S. Geological Survey (USGS) effort to monitor glacier mass balance throughout the Western States. Mass balance at two other glaciers, Gulkana Glacier and Wolverine Glacier, both in Alaska, is also monitored by the USGS (Kennedy, 1995; March, 1998). The broad USGS glacier monitoring program is discussed in a separate document (Fountain and others, 1997), and South Cascade Glacier is considered to be a "benchmark glacier" as described in that document. The collective records from these glaciers have formed the basis for the analysis of glacier-climate relations on a synoptic scale (Hodge and others, 1998).

South Cascade Glacier is a small valley glacier near the crest of the North Cascade Range, Washington State (**fig. 1**). Numerous variables relating to the glacier regime have been measured on and near South Cascade Glacier since the late 1950's. The long-term goal of this project is to understand the climate-glacier relation. A short-term goal is to document the measurements with sufficient detail so that an internally consistent record of conditions on and around the glacier can be assembled despite personnel changes, discontinuous records, and changing methods of data collection and analysis. Some periods of record at South Cascade Glacier have been documented. Work from 1957 to 1964 is described by Meier and Tangborn (1965), work from 1965 to 1967 is described by Meier and others (1971) and by Tangborn and others (1977). Hydrologic and meteorological data for 1957-67 are presented by Sullivan (1994). Mass balance results for 1958-85 are summarized by Krimmel (1989), and are presented in detail for 1986-98 (Krimmel, 1993, 1994, 1995, 1996a, 1997, 1998, 1999, 2000). The purpose of this report is to document the measurements of the 1999 balance year that are relevant to the relation between South Cascade Glacier and climate. These measurements include basin runoff, precipitation, air temperature, humidity, snow thickness and density, ice ablation, surface speed, and surface altitude.

Description and Climate of the Area

South Cascade Glacier is located at the head of the South Fork of the Cascade River, a tributary to the Skagit River, which flows into Puget Sound about 100 km to the west. The region is dominated by steep terrain, with local relief of more than 1,000 m. Areas within the basin not covered by glacier ice or water are thinly veneered bedrock. The bedrock either is mantled by a thin layer of soil and, in places, with scrub conifer, heather, or other vegetation typical of the high North Cascade Range, or is covered by glacial moraine or outwash material.

South Cascade Lake Basin (fig. 1) has an area[1] of 6.14 km², and ranges from 1,615 to 2,518 m altitude. A subbasin of the South Cascade Lake Basin is the 4.46-km² Middle Tarn Basin[2], which constitutes the southern two-thirds of the South Cascade Lake Basin. Virtually all ice melt[3] within the South Cascade Lake Basin takes place in the Middle Tarn Basin.

Salix Basin is an unglacierized basin adjacent to the South Cascade Lake Basin. It has an area[4] of 0.22 km²2, ranges from 1,587 to 2,140 m altitude, and is predominantly south facing.

The climate of the region is maritime. Near the glacier, typical winter low temperatures are about -10×C and typical summer high temperatures are about 20×C. Most of the precipitation, which commonly amounts to 4.5 m annually (Meier and others, 1971), falls as snow in the period October to May.

Measurement Systems

Glacier mass balance definitions (Mayo and others, 1972) are adhered to in this report, and the stratigraphic system, which is more field compatible than the fixed date system, is usually used. The specific terms are defined where first used. Other mass balance nomenclatures are in use, notably those described by Ostrem and Brugman (1991), which could as well be used to report these results. The definitions by Mayo and others (1972) are used to maintain consistency with earlier reports on South Cascade Glacier work.

The balance year, defined by Mayo and others (1972) as the interval between the minimum glacier mass in one year and the minimum glacier mass the following year, is used in this report because most of the field measurements reference the surface formed at the end of the previous balance year. This report contains recorded data for the 1999 water year (WY), October 1, 1998, through September 30, 1999. The WY is identical to the hydrologic year which was used in earlier mass balance reports (Mayo and others, 1972; Meier and others, 1971). When information concerning these variables is required, but is outside of the WY, the required data are discussed.

All local geodetic coordinates are in meters, in which the local +Y axis is approximately true north. Vertical locations are in meters above the National Geodetic Vertical Datum of 1929. Horizontal locations are defined by a local system that can be converted to Universal Transverse Mercator (UTM) zone 10 coordinates by:

$$\text{UTM easting} = \text{local } X\ (0.99985) + 642{,}000$$

$$\text{UTM northing} = \text{local } Y\ (0.99985) + 5{,}355{,}000.$$

Densities are given as a decimal fraction of the density of water, the density of which is considered to be 1,000 kilograms per cubic meter. All balance measurements are given as water equivalents unless otherwise stated.

[1] The area of this basin has been previously reported as 6.02 km2 and 6.11 km2. These differences are due to different interpretations of the drainage divide.

[2] "Middle Tarn" is an unofficial name.

[3] A small, debris-covered area of perennial ice lies outside of the Middle Tarn Basin.

[4] Salix Creek Basin drainage divides are poorly defined.

1999 BALANCE YEAR DATA COLLECTION

Recorded Variables

Air temperature was measured at the Salix Creek gaging station, the South Fork Cascade River gaging station, the Middle Tarn gaging station, and the Hut (**fig. 1**). These records are shown graphically (**fig. 2**). Air temperature was measured instantaneously once per hour at each station. Temperature is estimated to be accurate to ±±1×C. Daily maximum (highest of the 24 hourly readings), minimum (lowest of the 24 hourly readings), and average temperatures are given in **tables 1-4**. Humidity was measured at the South Fork gaging station (**fig. 2**, **table 5**).

Precipitation was measured at the Salix Creek gaging station (**fig. 3**). The tipping bucket gage catch was accumulated for 1 hour and recorded digitally. The gage orifice was 200 mm in diameter and had no wind screen. The precipitation gage was sensitive to 0.024 mm of precipitation. The gage operated throughout the year, but because it was not heated, measurements during November through March may be dramatically affected by snow and freezing conditions.

Water stage at Salix Creek, South Fork Cascade River, and Middle Tarn were recorded digitally. The sensors are floats with a steel tape driving a potentiometer. Stage records are shown on **figure 3**. The stage recorders are sensitive to ±±3 mm and are estimated to be accurate to ±±3 mm. The well at Salix was frozen from mid-January until mid-March, resulting in lost record. Stage record was lost at Middle Tarn from mid-October until mid-July due to instrument failure.

Intermittent Measurements

Snow depth and density; snow, firn, and ice ablation; and river discharge measurements are made during site visits several times each year. Instruments and facilities are also serviced during these visits.

Snow depth was measured by probing at 20 locations near the centerline of the glacier on May 27, 1999 (**fig. 4**, **table 6**). Snow density was measured with an augered core near P1 (**fig. 1**) on May 27, 1999 (**table 7**). The level of snow on several 33-mm-diameter aluminum stakes (**fig. 1**) with wood bottom plugs was measured several times during the ablation season (**fig. 5**, **table 8**). Aerial photography recorded the condition of the glacier on September 15, 1999 (**fig. 6**). Measurements of the size and shape of the glacier are made from stereo aerial photography. This photography was taken at a scale of 1:12,000 with a cartographic camera on 230-mm-wide color film and is suitable for creating stereo models, four of which cover nearly the entire basin. Other aerial or terrestrial photography or satellite imagery may exist in 1999, but no attempt was made to catalog other sources. An altitude grid (a digital elevation model, DEM) of the glacier was formed by photogrammetric measurement of altitude at a regular 100-m spacing over the area of the glacier. The location of the points in the altitude grid were the same as those used in previous reports (Krimmel, 1999). Photogrammetrically determined altitudes are estimated to be accurate to ±±2 m, and are shown on **figure 7** and **table 9**. Because the glacier surface was 87 percent covered with snow from the winter of 1998-99 on September 15, 1999, it was impossible to measure the elevation of a large portion of the surface photogrammetrically. The 1998 DEM, which was already a composite of the 1997 and 1998 DEM's, was used for most of the glacier surface. The error in the 1999 DEM may be several meters, but the resulting mass balance values are not affected significantly. The DEM elevations within the area of the lower glacier with ice exposed on September 15, 1999, were photogrammetrically determined.

The terminus of the glacier (**fig. 8**) was digitized from the photographs by photogrammetrically measuring the locations of numerous points along the edge of the glacier. The location of the points is estimated to be accurate to ±±1 m. The area of the glacier near the end of the 1998 balance year was 1.966 km² (Krimmel, 1999). Assuming that the area of the glacier south of Y=2,900 m is unchanged since 1998, the area of the glacier near the end of the 1999 balance year was 1.961 km². The retreat from 1998-99 was subjectively averaged to be 5 m (**fig. 8**).

The transient snow line on September 15, 1999, is shown on **figure 1**. Also shown on **figure 1** is the estimated position of the highest elevation the transient snow line achieved in 1999, that is, the equilibrium line. The equilibrium line elevation for 1999 was 1,800 m, and the accumulation area ratio was 0.84.

Certain features on the glacier surface can survive from year to year if ablation does not destroy them. Six features on the 1998 lower glacier surface were identified on the 1999 surface in the vertical photographs. Photogrammetry was used to find the positions, estimated to be accurate to ±1.0 m, of these features on both dates (**fig. 8**, **table 10**). Annual horizontal speed, typically 10 m per year, was calculated from the displacements and is displayed next to the vectors on **figure 8**.

DATA REDUCTION

Precipitation

A precipitation gage at the Salix Creek gaging station operated throughout the 1999 WY (**fig. 3**). Incremental precipitation gage catch was accumulated for each day, and the daily total precipitation is shown graphically on **figure 9** and **table 11**. The Salix Creek precipitation measurement site is not representative of either basin because of local variations in precipitation, the difficulty of measuring precipitation when the weather is windy, and the difficulty of measuring precipitation that falls as snow. The importance of the record is to compare it with records from other years, to indicate the time of precipitation events, and to indicate general precipitation conditions.

Salix Creek Runoff

Salix Creek water stage measurements (**fig. 3**) are converted to instantaneous discharge values, averaged for each day, and converted to a basin-averaged daily runoff (**fig. 9**, **table 12**). The Salix Creek stage recorder operated throughout the water year, but the well was frozen from mid-January to mid-March, resulting in some lost record. The flow of Salix Creek at the gaging station is controlled by a weir supported by bedrock. No visible changes of the control occurred during the year; thus, the rating used to convert stage to discharge was the same as has been used since measurements began in 1960:

$$q = S^{2.57} \times 2.71 \quad ,$$

where q is discharge in cubic feet per second and S is stage in feet. The equation for the rating is in English units for the convenience of the author and reader, because the original stage data are in feet and the machine-readable files are in feet. Except in these two instances, stage has been converted to meters.

South Fork Cascade River Runoff

South Fork Cascade River stage measurements (**fig. 3**) are similarly converted to instantaneous discharge values, averaged for each day, and converted to a basin-averaged daily runoff (**fig. 9**, **table 13**). The controlling weir is built on glacial outwash and moraine, and is known to be unstable. Visual inspection of the weir and surrounding foundation and diversion walls indicated that changes were minor since the last rating, and the one discharge measurement made (gage height = 1.98 feet, discharge = 63.9 ft^3/s, July 21, 1999) indicated that the 1998 rating could be used. The rating used to convert stage to discharge was:

For stage below 0.60 foot:

$$q = 2.47 \times (S + 0.4)^{2.50} \quad .$$

For stage above 0.60 foot:

$$q = 17.45 - 43.14 \times S + 40.94 \times S^2 - 0.90 \times S^3 \quad .$$

Errors in the South Fork Cascade River discharge calculations may be ±±25 percent of the determined values.

Middle Tarn Runoff

Stage measurements (fig. 3) were converted to discharge, and subsequently to runoff (fig. 9, table 14), using a rating determined from 14 discharge measurements made between September 8, 1992, and September 16, 1994. The outlet from Middle Tarn is a bedrock channel that does not change; therefore, the rating curve is expected to remain stable at Middle Tarn. For stages above 0.35 foot,

$$q = 2.064 - 3.673 \times S + 24.770 \times S^2 \quad ,$$

and for a stage of 0.35 foot and below,

$$q = S^{1.809} \times 25.123 \quad .$$

The Middle Tarn stage recorder failed in early October and was not restarted until mid-July, resulting in lost record.

MASS BALANCE

Winter Balance

Winter balance was measured May 27, 1999. Snow depth was measured by probing to the 1998 summer horizon at 20 points (fig. 4, table 6). The locations of these points were measured with an encrypted GPS (Global Positioning System). Most of the locations are accurate to within ±10 m in horizontal and vertical. The probed snow depths are ± ±0.05 m. It was not always certain that the probe penetrated through the 1999 snow, or that it stopped at the 1998 summer surface. A vertical core obtained with a coring auger through the snowpack at the P1 index station (fig. 1) gave an unambiguous snow depth and indicated that most of the probed depths were to the 1998 summer horizon.

Density was measured on May 27, 1999, at the P1 location using a coring auger and the bulk snow pack density was 0.53. The balance at each probe location was taken as the P1 snow density times snow depth, and these balance values were plotted as a function of altitude (fig. 10). A hand-drawn line formed the winter balance-altitude function (fig. 10), and points on that hand-drawn line (table 15) were used to interpolate the winter balance at each altitude in the 1999 DEM. Using the grid-index method, combined with the DEM from 1999, the measured winter snow balance came to 3.59 m water equivalent (WE). In most previous years the spring measurements were made in early May. In 1999 the spring measurement was delayed because of the unusually thick snow pack and general poor weather in the first part of May. Even with the relatively late spring measurements the measured winter snow balance was not much below the maximum balance. April and May were cool, with most days from May 1 to 22 having below freezing temperature at least part of the day. Runoff did not increase dramatically until May 24. For these reasons the measurements on May 27 were considered to be representative of the maximum glacier balance.

Net Balance

One stake (2) was used to measure snow melt through the summer season, and three stakes (3, 4, and 5) were used to measure ice melt (fig. 1). The aluminum stakes were 33 mm in diameter and 2.0 m long with a coupling on one end to allow joining sections. A wooden plug was always inserted into the bottom of the stake to inhibit melt into the firn or ice. The stakes were set in holes that always penetrated into firn or ice. In late May the snow depth suggested that most of the glacier would maintain a positive balance over the entire balance year, and that stakes would not be necessary in the positive balance areas. On the lower glacier, where ice would likely become exposed during the melt season, it was decided to rely on stakes that had be left from the previous year. Three of the 1998 stakes were found (stakes 3, 4, and 5) as the snow melted away. The ice level had been recorded on these stakes at the end of the 1998 balance year, and thus a summer surface reference could be established (fig. 5).

On September 5, 1999, 10 cores (fig. 1) were made through the snow and penetrating into the firn or ice. A stake was set at the 2,072-meter site (fig. 1). The 1998 summer horizon was found in all the cores. The bulk snow pack density was measured at P1 as 0.58. On October 15, 1999, new snow covered most of the glacier and all stakes were measured to the level of the underlying 1999 summer surface. It was assumed that no ablation of 1999 balance year material occurred after the October 15 measurements. The September 5 – October 15 snow ablation was known at P1 (1,834 m) and at 2,072 m, and was estimated at each of the other core locations with a linear interpolation. The September 5 snow density was known at P1, and the snow density ordinarily increases slowly as the season progresses, so it was estimated that the snow density at the end of the balance year was 0.6. By applying this density factor to all the snow on the glacier at the end of the balance year, the minimum balance at each core site was estimated. The minimum balance at stakes 3, 4, and 5 was measured directly. The balance at these 13 altitudes, and one additional altitude near the zero balance line, were plotted as a function of altitude and a hand-drawn curve fitted to these points (**fig. 11**). The points on this hand-drawn curve (**table 16**) were used to interpolate a minimum balance value at all the 1999 DEM points. Using the gird-index method (Krimmel, 1996b), the net balance ($\bar{b}_n$) was calculated at 1.02 m.

Balance-Year to Water-Year Adjustments

The final balance increment, $\bar{b}_1$, for the 1998 balance year was estimated at 0.05 m water equivalent (Krimmel, 1999). This value becomes the initial balance increment, $\bar{b}_0$, for the 1999 balance year.

The glacier was visited on October 15, 1999, at which time there was patchy new snow on the terminus of the glacier and as much as 0.20 m of new snow on the upper glacier. October 1-5, 1999, was mild and dry, but even so, the South Fork Cascade River stage showed no diurnal rises, which suggests that very little ablation was occurring. Precipitation on October 9-10 covered the glacier with snow, and this snow was still on the glacier on October 15. The glacier reached the time of minimum mass on October 8, 1999. It is estimated that melt from October 1-8, called $\bar{b}_1$, was 0.05 m.

The annual balance, $\bar{b}_a$, is defined by Mayo and others (1972) as the change in snow, firn, and ice storage between the beginning and end of a fixed period, which here is the water year. The measured values of $\bar{b}_0$, $\bar{b}_1$, and $\bar{b}_n$ at South Cascade Glacier for the 1998 balance year can be used to derive the annual balance, $\bar{b}_a$, where $\bar{b}_a = \bar{b}_n + \bar{b}_0 - \bar{b}_1 = 1.02$.

Balance Measurement Errors

Errors in glacier balance measurements are difficult to quantify. In prior years of balance measurements at South Cascade Glacier, error values ranging around 0.10 m were placed on the balance values (Meier and others, 1971). In 1965 and 1966, more information was used to derive the balances than in 1992-98. The availability of less information in 1999 would suggest that greater errors should be assigned to the 1998 balance. The relative paucity of data for 1999 is offset somewhat, however, by the experience gained since the mid-1960's, when 20 to 30 ablation stakes were used and it was found that spatial variations in balance were similar from year to year (Meier and Tangborn, 1965). It is more difficult to measure a large accumulation of snow as occurred in the winter of 1998-99 than a thinner accumulation, and hence the estimated error in $\bar{b}_m(S)$ is ± 0.40 m. Other estimated errors are $\bar{b}_n$, 0.20 m; $\bar{b}_0$ and $\bar{b}_1$, ±±0.05 m; and the calculated error for $\bar{b}_a$ is ±±0.21 m. Although other factors that affect the balance, such as internal accumulation of ice, superimposed ice, internal melt, and basal melt, are possible, they are not considered in this report. These unknowns are thought to be small and do not change the error estimations.

CONCLUSIONS

The snow accumulation during the winter of 1998-99 was the fourth highest since the winter balance record began in 1959 (**fig. 12**, **table 17**). Since 1953 when the net balance record began, there have only been 2 years with a greater positive balance. The difference between the winter balance and net balance is the summer balance. The 1999 summer season melt was unusually low, with only three summer seasons with less melt. The glacier continued its retreat, but at a reduced rate of about 5 m per year. The reduction in retreat rate was mainly because the ice at the glacier terminus was buried by snow until well into the summer and had less time to melt than in previous years of negative balance. The 1999 speed was about 10 m per year near the 1,800 m altitude. This is about 20 percent less than the 1995-98 period average speed. The interrelation between mass balance, speed, and terminus change is complex, but certainly more than 1 year of positive balance is required before glacier advance can occur.

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FIGURES

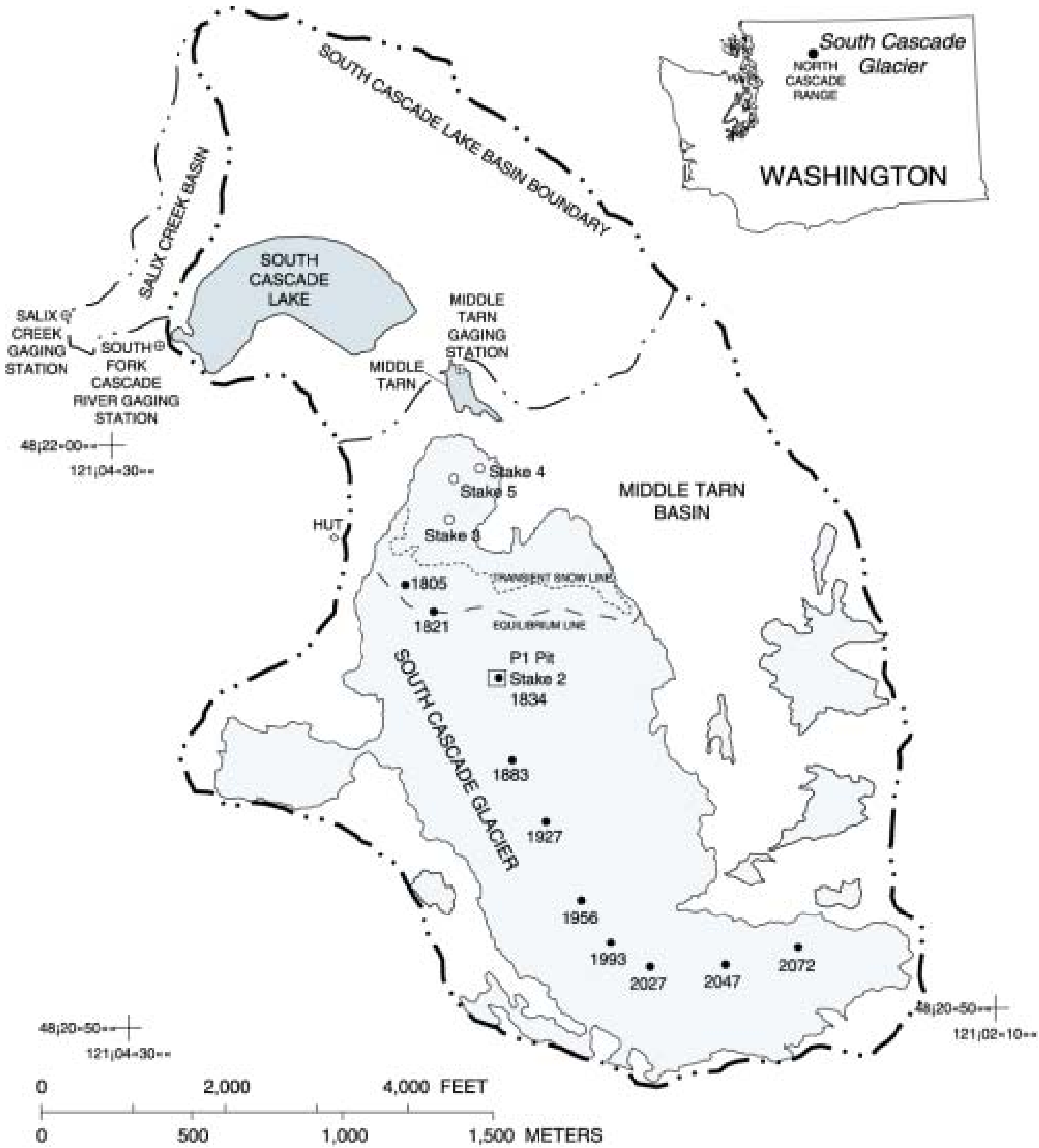

Figure 1. South Cascade Glacier and vicinity.
[Stakes for 1999 are shown as open circles, core locations for 1999 are shown as filled circles with elevation in meters, below.]

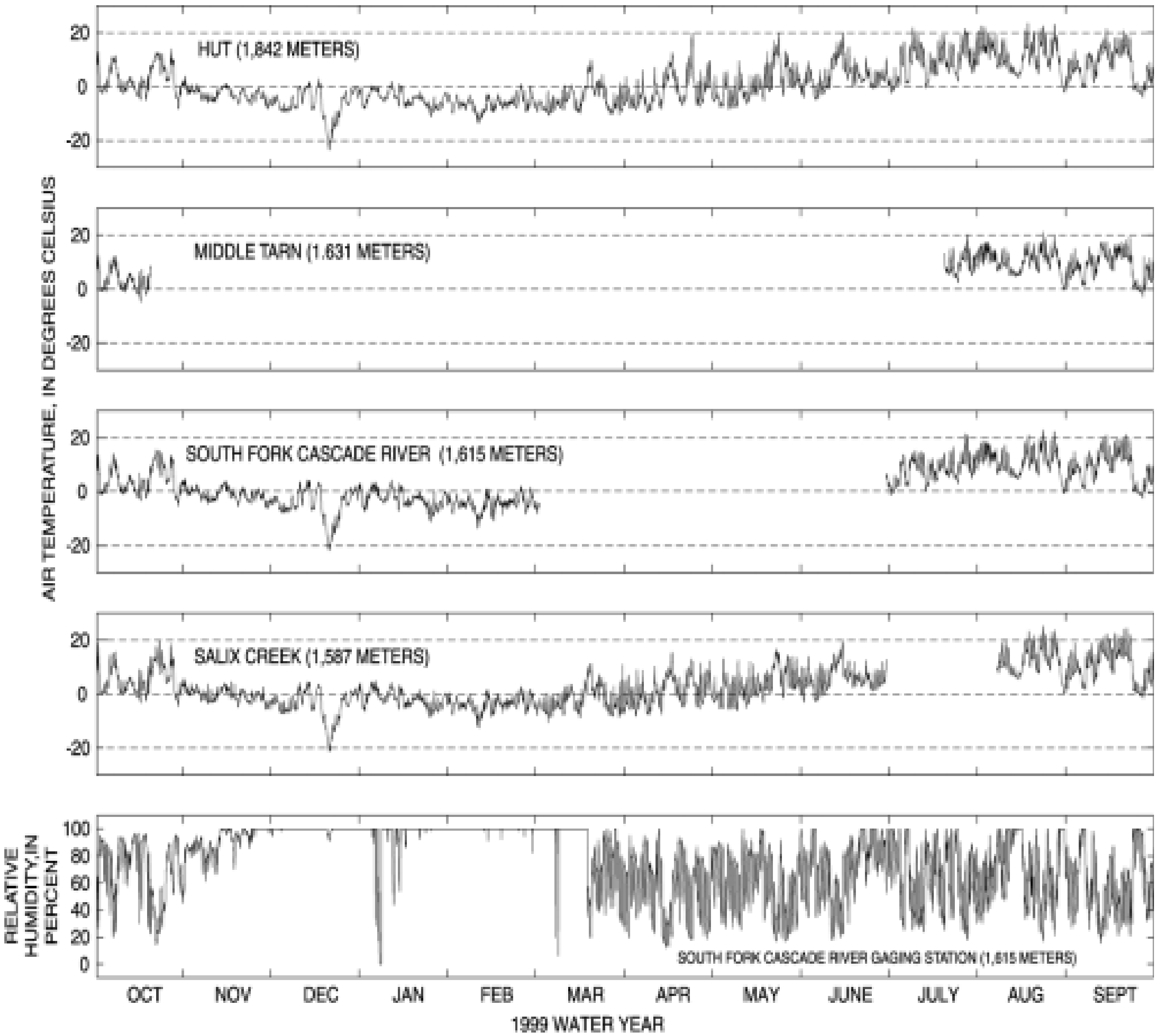

Figure 2. Air temperature and humidity near South Cascade Glacier during the 1999 water year.
[No data available in blank areas.]

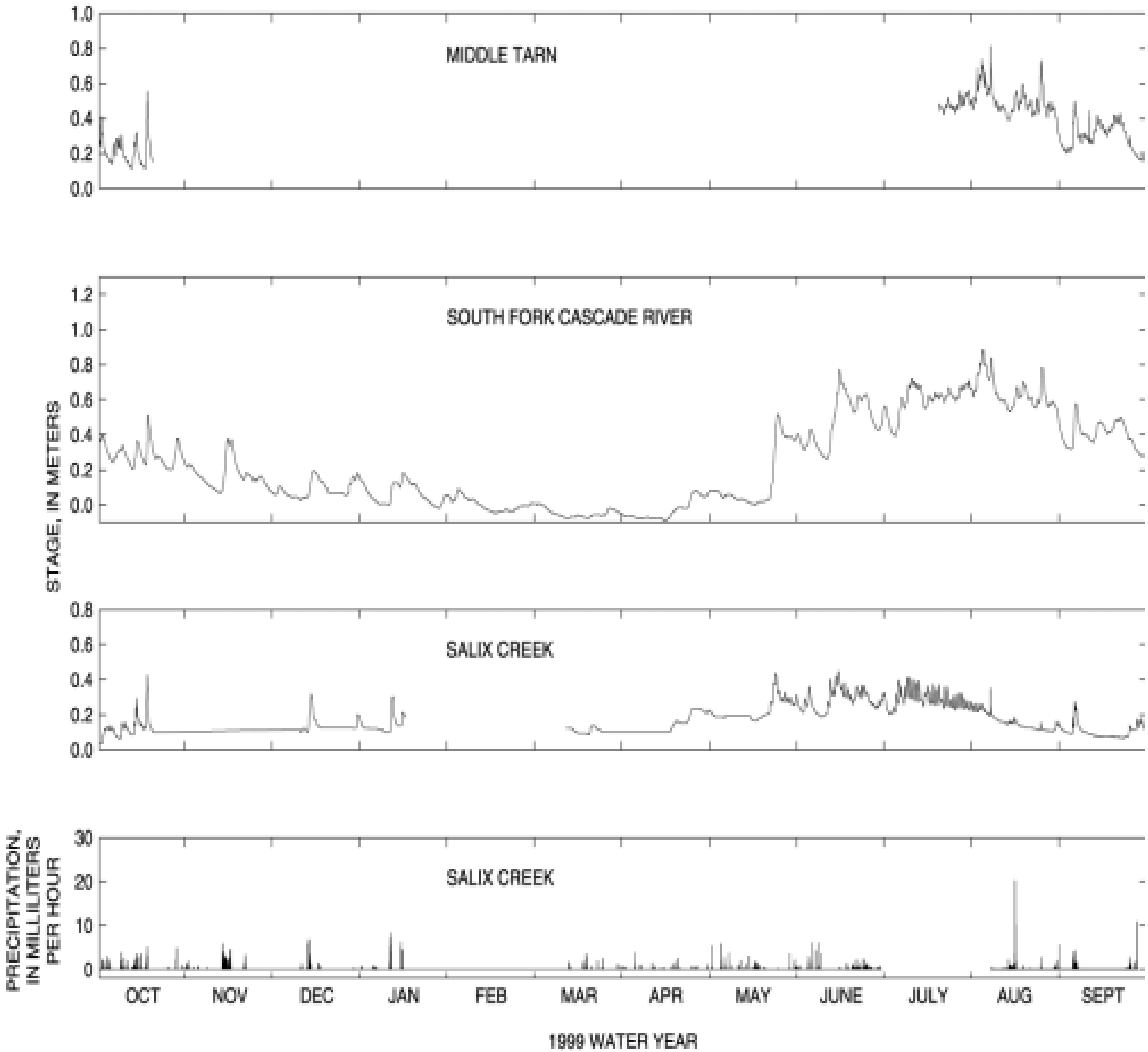

Figure 3. Instantaneous water stages and hourly precipitation of gaging stations near South Cascade Glacier during the 1999 water year.

[No data available in blank areas.]

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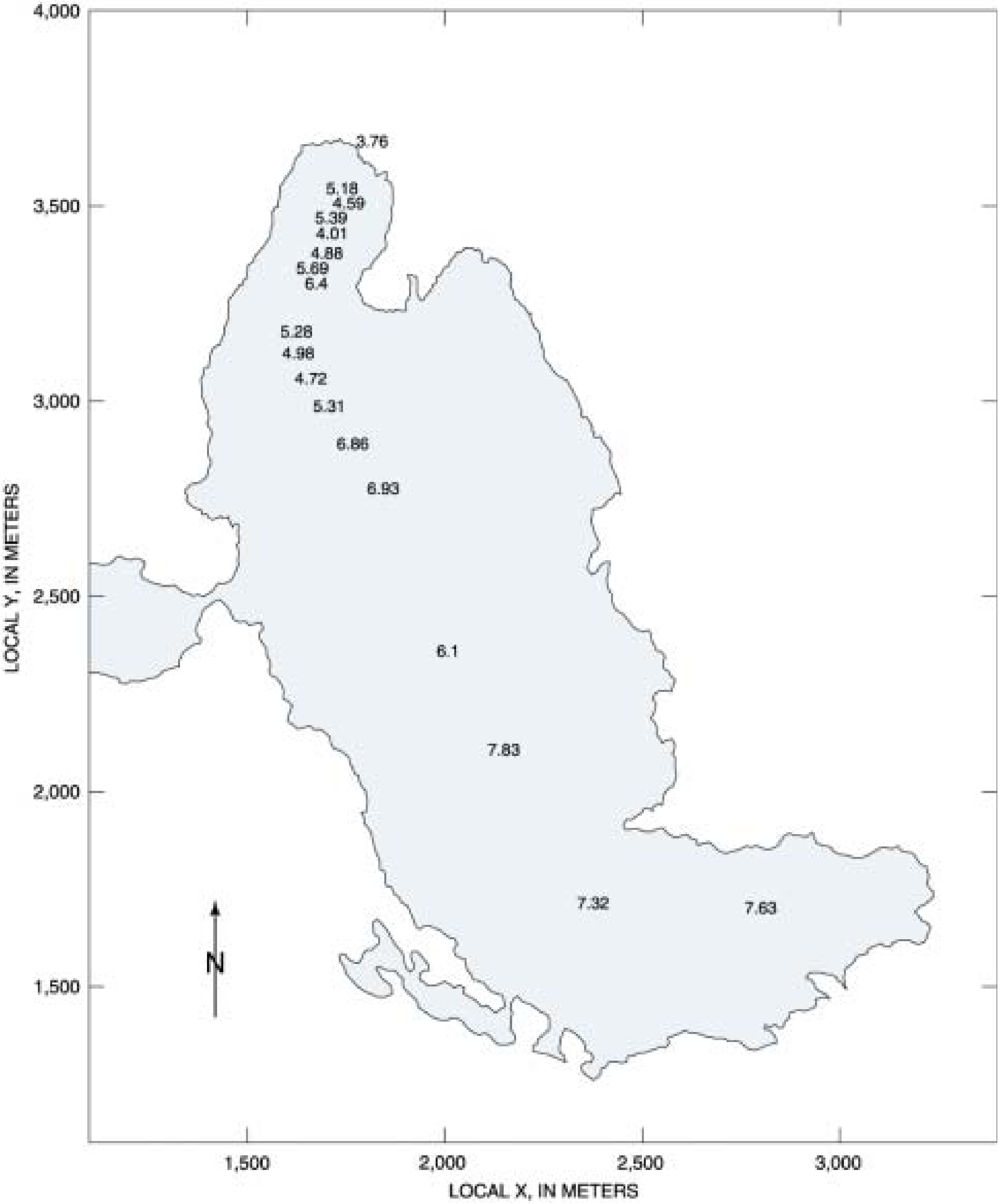

Figure 4. Snow depth, in meters, on South Cascade Glacier on May 28, 1999.

[Table 6 gives the location of the probe points.]

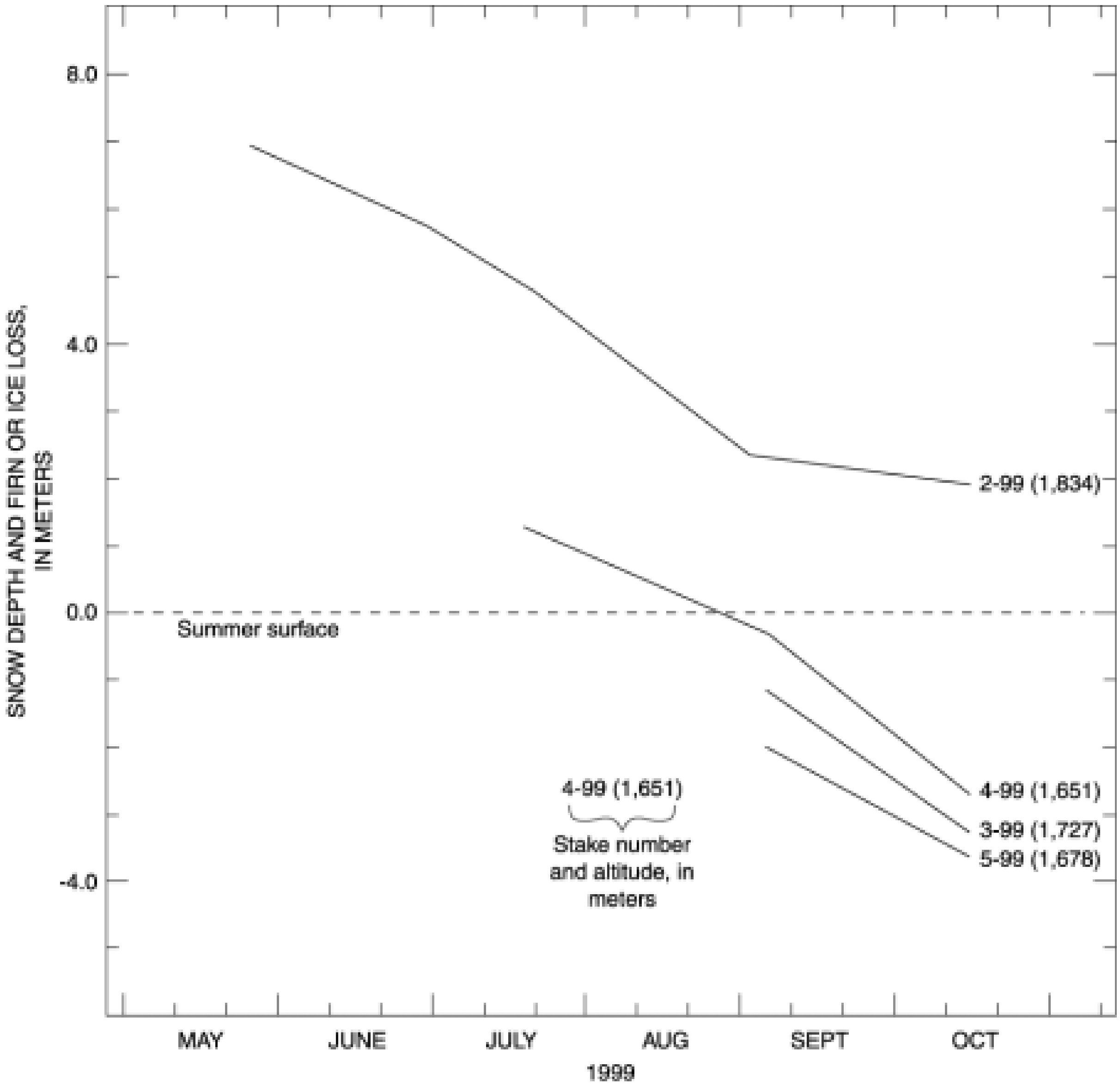

Figure 5. Snow depth and firn or ice loss at South Cascade Glacier at each 1999 stake. [Measurements are accurate to 0.1 meter. Stake locations shown in **figure 1** and **table 8**.]

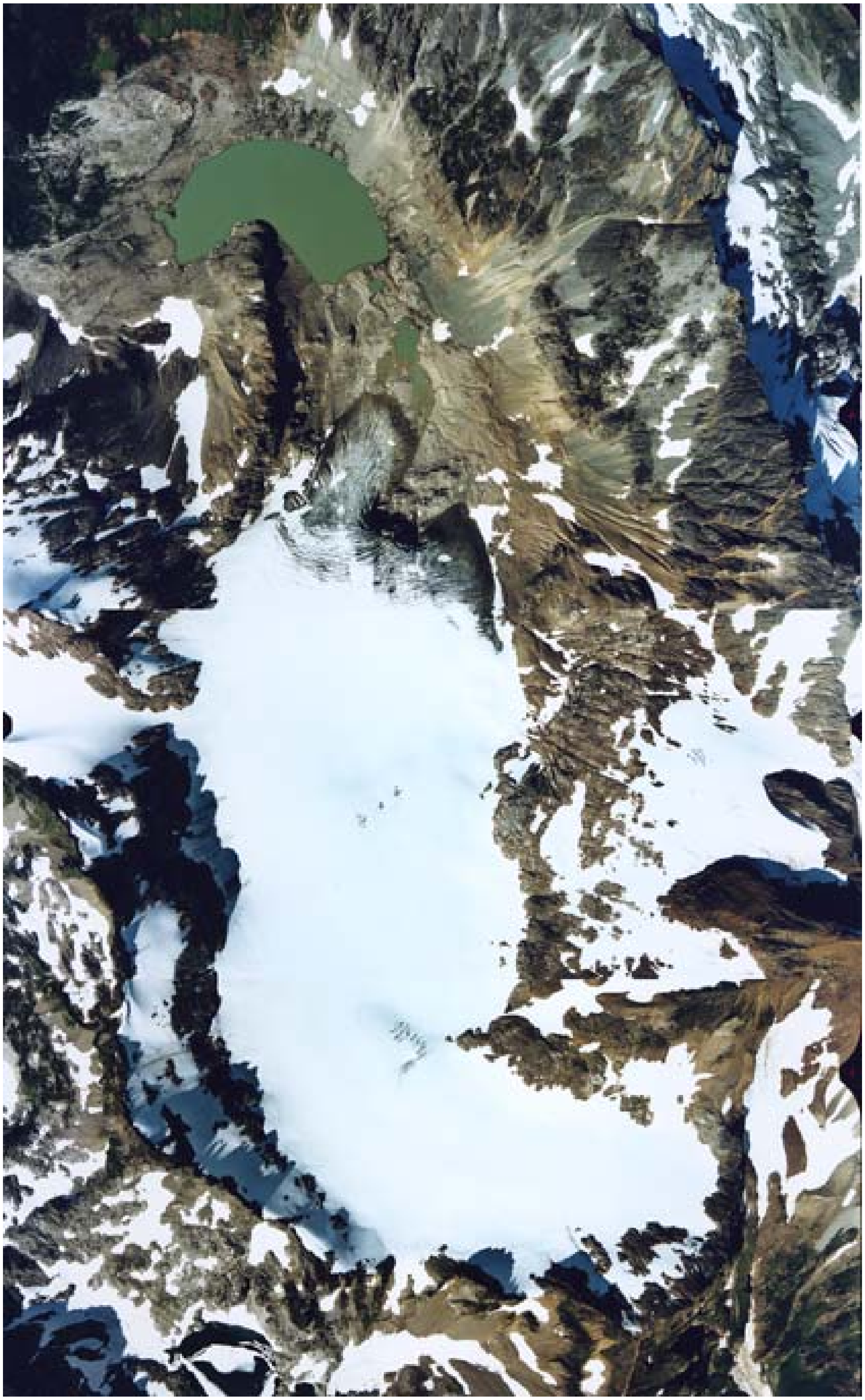

Figure 6. Vertical photograph mosaic of South Cascade Glacier, September 15, 1999. [The maximum width of the glacier is about 1 kilometer, north is approximately up.]

t

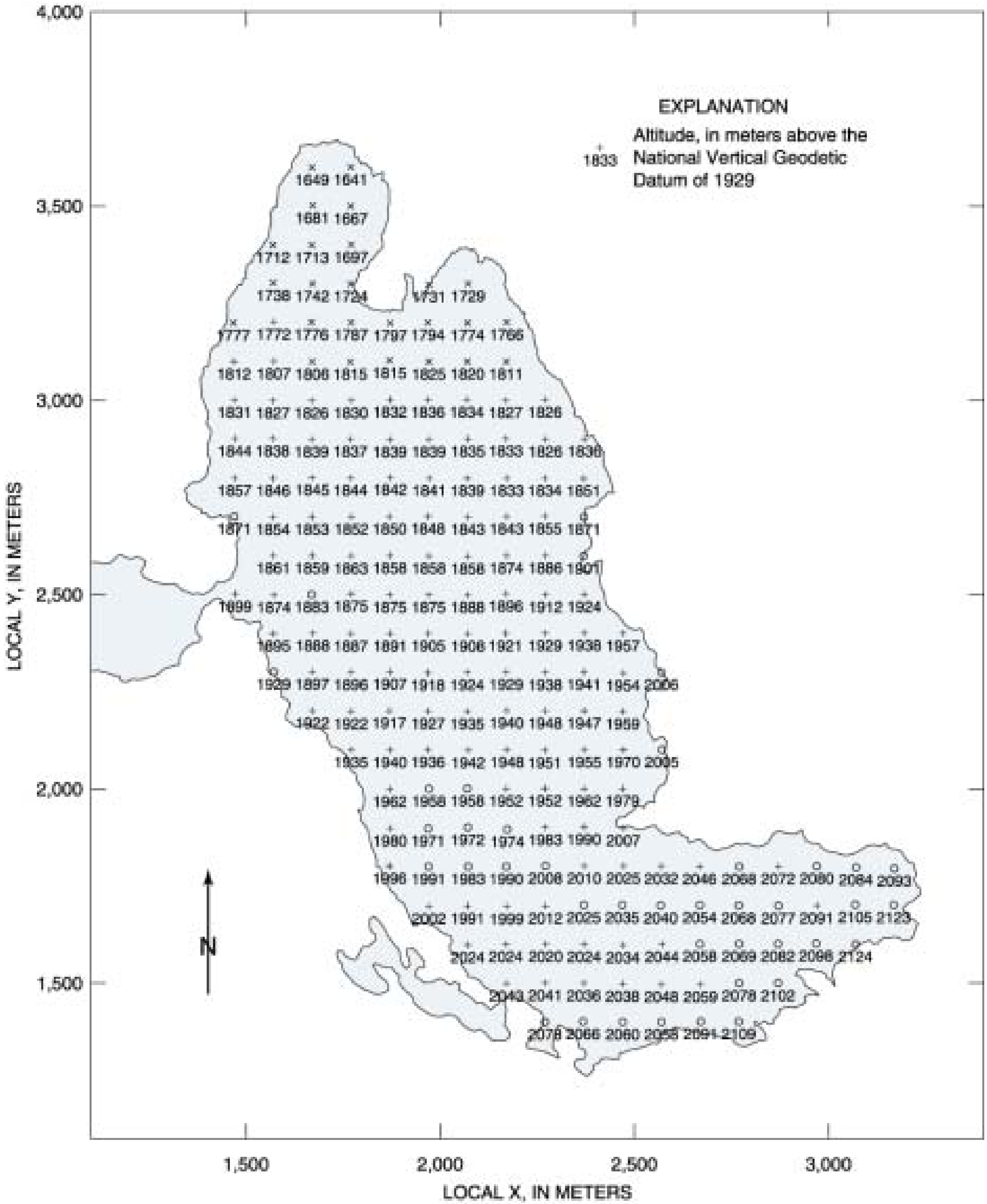

Figure 7. Altitude grid for South Cascade glacier, measured from stereo vertical photographs taken on September 23, 1997 (o), September 14, 1998 (+), and September 15, 1999 (x).

[Tabular data are in **table 9**.]

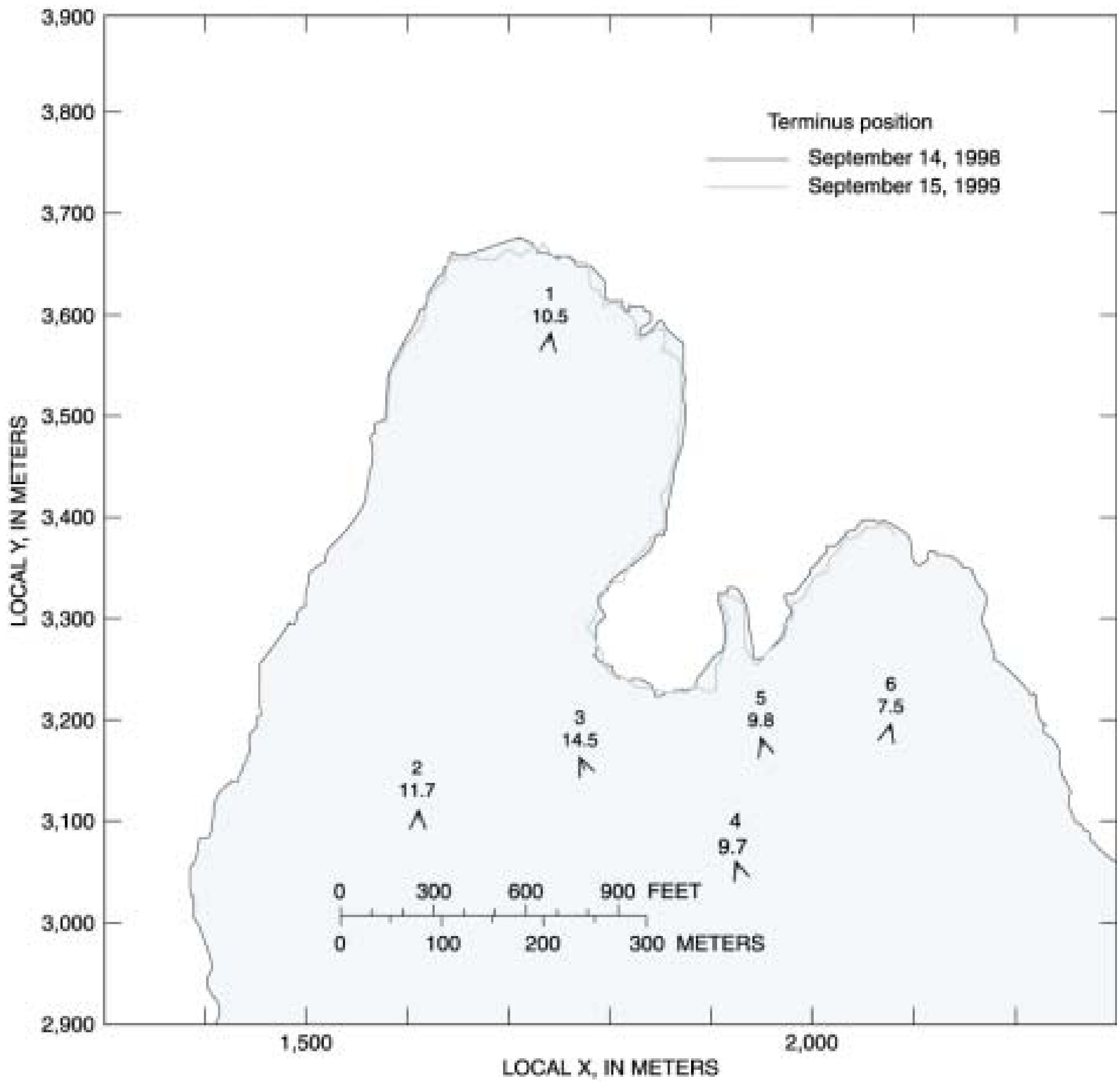

Figure 8. South Cascade Glacier terminus position on September 14, 1998, and September 15, 1999, and ice speeds. [Speed vectors from September 14, 1998, to September 15, 1999, are shown with the point number (see **table 10**) and speed in meters per year.]

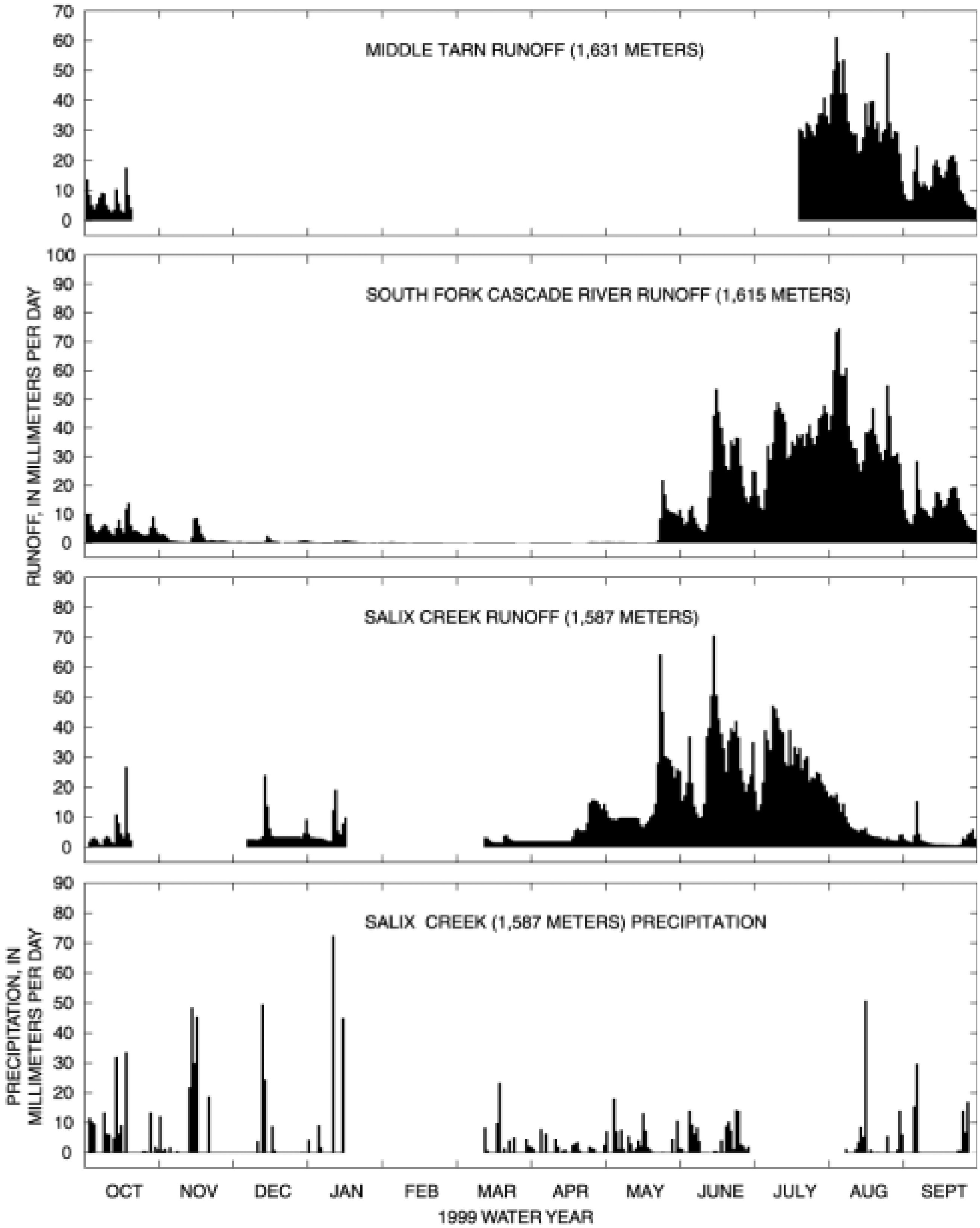

Figure 9. Daily precipitation and runoff at gaging stations near South Cascade Glacier during the 1999 water year. [Data are missing when no "zero" line is shown.]

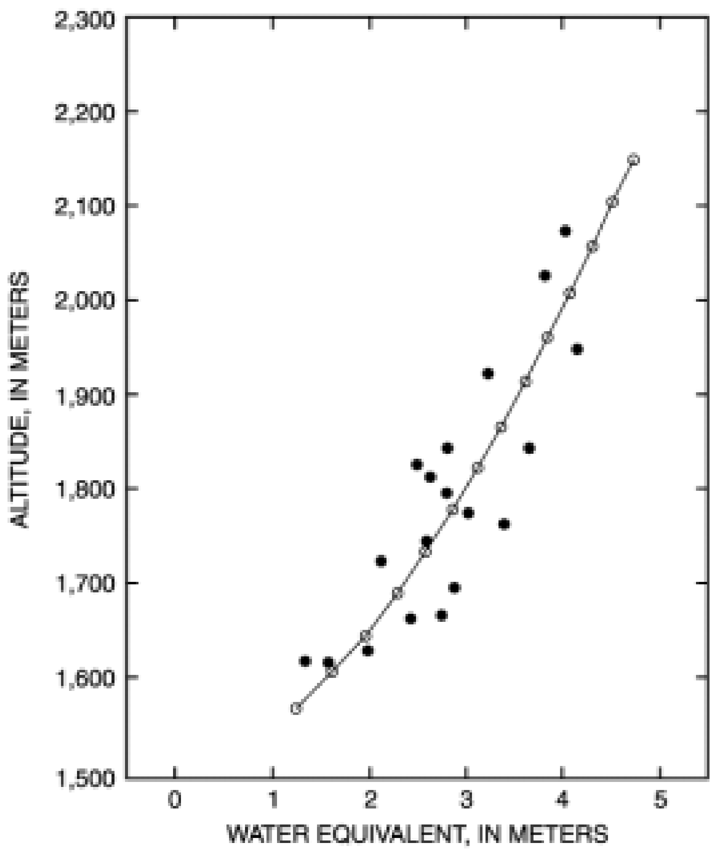

Figure 10. Measured winter snow balance at South Cascade Glacier, May 28, 1999.

[Solid circles are measured, open circles are along a hand-drawn curve used for interpolation.]

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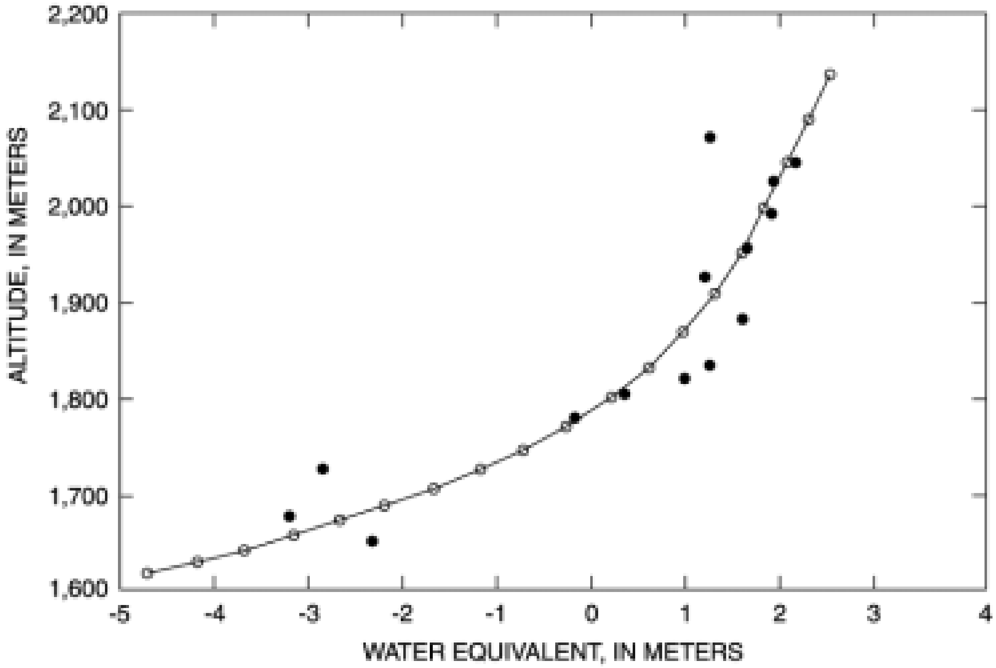

Figure 11. Net balance as a function of altitude at South Cascade Glacier, 1999.
Solid circles are measured, open cirlces are along a hand-drawn curve used for interpolation.]

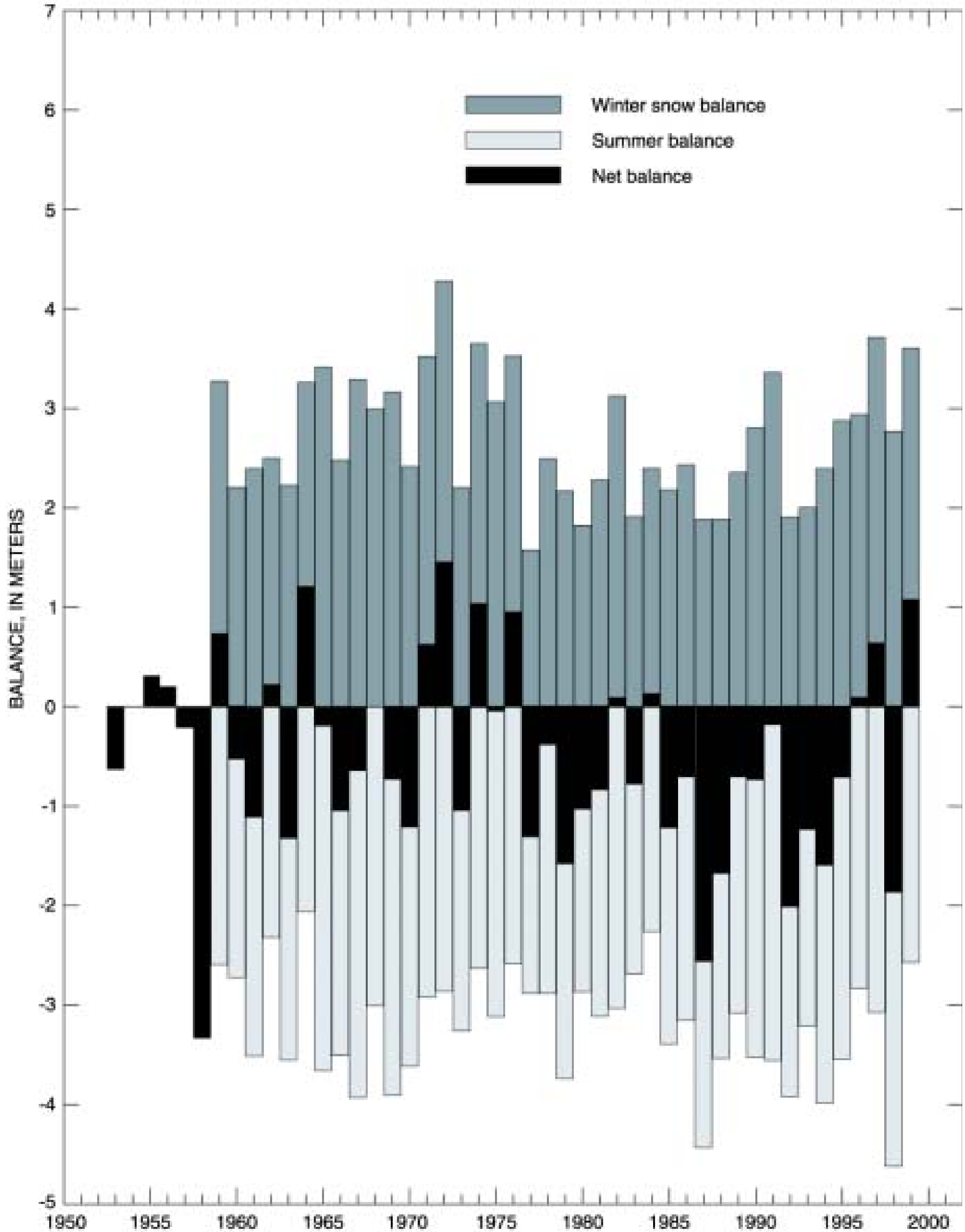

Figure 12. South Cascade Glacier balance, 1953-99.

Table 1. Air temperature at 1,587 meters altitude, Salix Creek Basin, 1999 water year

[Daily maximum, miminum, and average air temperature, in degrees Celsius. Air temperature is sampled once an hour at the Salix Creek gaging station (fig. 1). -99.0 indicates no data]

DAY	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	18.7	5.9	11.2	2.5	-0.4	0.8	-0.6	-3.9	-2.1	-0.1	-6.6	-4.5	-3.1	-7.1	-4.6	2.4	-6.2	-4.3
2	4.2	-.2	.8	3.9	-.6	1.4	-.9	-5.4	-3.1	3	-3.5	-1.2	-.4	-4.6	-2.4	3.4	-7.9	-5.1
3	4.0	-.1	1.3	1.9	.2	1.1	-3.0	-6.9	-5.6	4.2	.0	2.1	-2.9	-6.1	-4.5	-1.7	-5.9	-4.2
4	5.6	.1	2.4	3.6	.4	1.9	-2.3	-7.3	-5.9	4.6	.5	2.9	-2.9	-5.2	-4.2	-1.0	-6.7	-5.2
5	14.7	2.6	7.1	1.3	-2.0	.0	-5.0	-7.2	-6.0	4.9	.4	2.3	-2.9	-5.9	-4.2	.4	-10.7	-6.2
6	15.3	8.5	12.0	1.5	-2.9	-.9	-1.5	-6.6	-5.3	2.1	-2.0	-.3	.0	-3.3	-2.0	-.8	-8.8	-6.1
7	15.8	8.4	10.9	.9	-2.5	-1.3	-.6	-5.1	-2.9	-1.3	-3.1	-2.2	-1.9	-6.3	-4.2	-.4	-8.4	-5.3
8	8.2	.8	4.1	3.7	-3.7	-1.6	-2.3	-6.4	-4.8	-.6	-3.7	-2.5	-4.3	-8.0	-6.3	-2.0	-5.4	-3.8
9	5.4	.2	1.6	1.8	-3.2	-2.0	-3.1	-5.4	-1.3	1.3	-2.6	-.9	-4.1	-12.5	-9.3	.4	-5.4	-3.4
10	5.1	-.2	1.2	-.6	-2.8	-2.1	4.2	-4.1	.2	4.2	1.6	2.9	-6.4	-9.8	-8.3	.8	-6.5	-3.9
11	4.7	1.2	3.1	2.6	-2.8	-.6	1.5	-4.0	-.1	2.5	-2.1	.6	-2.8	-9.4	-5.9	2.9	-7.8	-3.3
12	6.3	3.8	5.3	2.9	-.1	.9	4.7	.8	2.5	-1.1	-3.6	-1.8	1.6	-5.5	-1.6	3.1	-2.4	-.5
13	4.6	.9	3.2	3.8	.5	2.4	4.3	-4.7	1.3	3.4	-5.7	-.7	1.5	-5.3	-1.9	3.6	-1.4	1.6
14	1.7	-1.0	.4	4.0	.7	2.5	-3.7	-6.2	-5.4	2.3	-4.2	-.2	-1.6	-8.7	-5.9	.7	-5.3	-1.0
15	9.2	-2.2	.4	2.6	-1.1	1.4	1.4	-4.1	-1.0	-3.1	-5.5	-4.2	-1.5	-7.6	-4.7	-2.2	-6.5	-4.8
16	8.7	-3.4	1.8	4.7	-1.7	-.3	3.6	2.0	2.7	-1.5	-5.0	-3.6	.1	-2.9	-1.5	-1.9	-9.0	-5.6
17	5.1	-2.2	2.6	3.8	-1.6	-.3	2.5	-9.5	-3.3	-2.8	-4.5	-3.6	-2.5	-7.0	-4.0	1.9	-4.5	-2.0
18	10.5	-2.5	2.1	-1.3	-4.8	-2.6	-7.5	-10.9	-8.9	-.9	-2.2	-1.5	-3.1	-6.5	-4.1	5.4	-4.6	1.2
19	14.0	.0	7.0	1.9	-4.1	-.9	-11.5	-20.0	-15.6	.5	-1.8	-1.1	-1.5	-5.9	-3.8	10.2	.2	5.4
20	13.6	6.3	11.4	2.0	.0	1.1	-14.5	-21.3	-19.1	1.7	-2.8	-1.3	-2.1	-5.1	-3.3	11.3	3.9	9.2
21	17.8	12.3	14.3	.5	-2.7	-1.4	-11.0	-17.2	-13.8	-.6	-3.6	-2.1	-.8	-4.3	-3.2	3.2	-1.0	1.0
22	19.8	7.2	12.3	-2.2	-3.5	-2.8	-7.4	-14.0	-10.6	-1.0	-5.1	-3.6	.6	-5.3	-2.3	4.6	-1.9	2.0
23	16.2	7.8	11.2	1.4	-4.1	-1.4	-7.9	-11.8	-9.8	-3.0	-8.8	-6.0	1.3	-5.5	-2.7	7.4	-2.6	2.4
24	11.1	4.0	8.4	.0	-3.0	-1.5	-1.4	-7.9	-3.2	-2.7	-8.7	-6.6	2.9	-1.8	1.0	6.1	-.8	3.3
25	6.6	4.0	5.0	1.1	-.7	.4	.9	-2.3	-.9	1.3	-6.7	-4.1	1.7	-6.2	-2.5	4.4	-4.9	-1.1
26	18.6	4.6	10.3	.6	-2.8	-.9	-1.8	-4.5	-3.9	-1.3	-6.9	-5.2	1.0	-7.6	-5.4	-3.5	-6.5	-5.2
27	13.6	-.2	8.3	2.7	-3.0	-1.1	1.4	-3.9	-1.1	-2.9	-6.3	-4.6	1.9	-5.2	-1.5	1.2	-7.9	-5.9
28	.6	-2.9	-1.5	-2.6	-5.7	-4.6	.9	-.7	.1	-.5	-5.8	-3.0	.6	-4.8	-1.9	3.2	-8.3	-5.0
29	4.4	-4.6	-.3	-2.1	-5.0	-3.3	2.3	-.4	1.2	.4	-1.2	-.3				-.9	-5.0	-3.3
30	5.7	.1	2.7	-1.5	-5.7	-3.1	3.8	-2.6	.8	.7	-4.3	-2.2				4.8	-8.8	-3.9
31	5.7	.4	3.2				4.1	-5.4	-1.0	-1.3	-7.8	-4.9				11.0	-7.5	-2.1
Monthly average	9.5	1.9	5.3	1.5	-2.3	-0.6	-1.4	-6.7	-4.1	0.3	-3.9	-2.0	-1.1	-6.2	-3.8	2.1	-5.3	-2.1

DAY	Apr.			May			June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	5.3	-6.3	-1.6	1.2	-2.9	-0.7	10.2	-1.8	1.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.0	1.8	6.5
2	7.1	-5.2	-1.5	6.5	-3.1	-.1	9.8	-3.1	3.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.3	5.4	9.9
3	2.7	-5.8	-3.1	1.2	-5.0	-1.8	14.0	2.2	6.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	19.0	6.7	10.5
4	2.6	-6.8	-4.1	2.6	-5.4	-2.8	7.5	2.8	4.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.0	8.1	9.9
5	9.1	-8.3	-1.9	13.2	-5.3	2.5	5.3	-2.5	1.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.9	6.3	8.7
6	3.7	-5.8	-1.7	8.1	-3.7	3.5	9.4	-2.7	1.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	5.5	2.1	3.4
7	8.9	-2.2	1.3	3.8	-5.8	-3.1	11.6	-2.4	2.3	-99.0	-99.0	-99.0	10.0	9.0	9.6	15.8	1.7	7.6
8	.9	-7.2	-3.4	6.8	-5.6	-1.3	11.0	-.8	2.1	-99.0	-99.0	-99.0	15.3	7.9	10.3	16.3	9.7	12.5
9	.1	-7.5	-5.2	6.6	-5.3	-.8	9.1	-.3	3.1	-99.0	-99.0	-99.0	19.2	9.8	13.1	18.8	7.3	12.5
10	1.0	-7.6	-3.3	12.7	-6.1	1.4	9.4	1.1	4.1	-99.0	-99.0	-99.0	20.3	9.9	13.9	14.9	3.1	8.2
11	10.5	-3.5	2.0	6.5	-.8	2.1	11.3	2.6	7.8	-99.0	-99.0	-99.0	17.4	9.2	12.6	18.9	5.1	10.3
12	4.0	-1.9	.7	3.5	-3.0	-.4	15.0	8.6	11.6	-99.0	-99.0	-99.0	10.9	7.1	8.8	19.6	11.5	15.0
13	3.2	-6.6	-2.6	6.0	-5.3	-.2	13.5	7.9	11.1	-99.0	-99.0	-99.0	10.2	6.8	8.0	21.1	15.2	17.3
14	5.5	-7.7	.4	12.1	-3.7	1.8	16.4	11.1	13.7	-99.0	-99.0	-99.0	8.6	6.2	6.9	22.4	13.7	16.8
15	8.4	1.5	5.5	11.2	-1.3	2.6	19.5	6.8	14.3	-99.0	-99.0	-99.0	7.8	5.5	6.4	20.6	10.8	15.0
16	10.0	5.5	7.6	6.3	-1.3	.7	19.5	5.6	7.2	-99.0	-99.0	-99.0	15.1	6.8	9.7	16.9	7.4	11.8
17	15.6	5.1	9.7	7.8	-.9	2.5	12.5	4.3	8.3	-99.0	-99.0	-99.0	19.9	10.7	14.9	22.6	7.6	14.4
18	7.3	1.1	4.4	4.1	-1.2	1.3	9.2	3.8	6.6	-99.0	-99.0	-99.0	23.3	14.0	17.9	22.0	13.0	16.4
19	5.9	-.9	1.3	7.6	-3.4	2.2	12.0	2.3	5.0	-99.0	-99.0	-99.0	20.7	10.0	14.0	21.3	13.9	16.8
20	6.4	-3.9	-1.3	9.0	1.4	4.1	7.4	2.9	5.5	-99.0	-99.0	-99.0	21.8	12.7	15.9	24.0	13.2	16.2
21	3.8	-4.9	-1.4	7.5	.6	3.7	8.3	3.5	5.5	-99.0	-99.0	-99.0	15.1	8.3	11.4	24.4	14.1	17.4
22	9.1	-4.2	2.4	11.5	.8	7.6	6.8	2.7	4.4	-99.0	-99.0	-99.0	21.9	7.6	14.1	22.0	11.7	15.8
23	10.0	2.3	6.4	16.8	9.6	13.7	12.6	3.4	7.1	-99.0	-99.0	-99.0	25.4	15.9	19.4	13.2	1.3	9.1
24	13.1	6.2	9.5	15.4	7.2	12.6	8.2	3.3	6.1	-99.0	-99.0	-99.0	22.2	11.9	16.4	5.1	.6	2.2
25	6.5	-2.3	2.6	9.3	-.4	4.7	5.0	1.6	2.9	-99.0	-99.0	-99.0	14.5	9.3	12.3	4.2	-.2	1.3
26	3.8	-4.8	-2.0	10.7	-1.5	5.7	9.2	1.0	3.8	-99.0	-99.0	-99.0	23.1	8.7	14.4	3.1	-.6	.7
27	11.6	-5.5	.1	14.4	3.0	9.7	9.2	1.3	4.2	-99.0	-99.0	-99.0	23.7	13.4	18.1	9.4	-1.6	1.7
28	8.0	-3.9	1.0	13.5	2.2	6.1	8.8	2.5	4.9	-99.0	-99.0	-99.0	20.8	13.5	16.8	9.7	1.7	5.0
29	9.4	-1.3	4.3	14.0	1.5	4.9	12.0	3.5	6.1	-99.0	-99.0	-99.0	13.5	6.0	10.5	13.4	4.1	8.6
30	12.4	.7	5.0	13.6	2.0	6.0	12.9	3.9	6.8	-99.0	-99.0	-99.0	5.7	.4	3.2	15.6	2.7	7.0
31				6.5	1.4	4.1				-99.0	-99.0	-99.0	9.5	.2	3.1.			
Monthly average	6.9	-3.1	1.0	8.7	-1.3	3.0	10.6	2.5	5.8	--	--	--	--	--	--	15.8	6.6	10.3

Table 2. Air temperature at 1,615 meters altitude, near South Fork Cascade River gaging station, South Cascade Glacier Basin, 1999 water year

[Daily maximum, miminum, and average air temperature, in degrees Celsius. Air temperature is sampled once an hour at the South Fork Cascade River gaging station (fig. 1). A -99.0 indicates no data]

DAY	Oct.			Nov.			Dec.			Jan.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	13.8	6.2	9.5	1.6	-1.7	-0.1	-1.7	-4.2	-2.8	-1.7	-7.5	-5.7
2	3.9	-1.2	.1	2.4	-1.2	.5	-1.7	-6.1	-3.7	.0	-6.5	-2.8
3	3.2	-.4	.6	.8	.0	.3	-4.7	-7.5	-6.4	2.0	-2.1	.1
4	3.6	-.4	1.4	2.8	.0	1.3	-4.2	-7.9	-6.8	3.6	-.4	2.0
5	10.2	2.0	5.6	.8	-2.5	-.8	-5.6	-7.9	-6.7	3.6	-1.7	.9
6	14.1	6.6	10.6	.0	-3.8	-1.6	-5.6	-7.0	-6.4	2.0	-2.9	-1.2
7	12.4	7.0	9.7	-.8	-2.9	-2.0	-1.2	-6.1	-3.4	-2.5	-3.8	-3.1
8	8.1	.0	3.7	.4	-4.7	-3.0	-5.1	-7.0	-5.8	-1.7	-4.2	-3.4
9	3.2	-.4	.7	-1.2	-3.8	-3.0	3.6	-5.6	-1.9	.8	-3.4	-1.8
10	2.4	-.8	.3	-2.1	-3.4	-2.7	3.6	-4.2	-.1	4.3	1.2	2.6
11	3.6	.4	2.0	.4	-3.8	-1.6	.8	-5.1	-.6	2.0	-2.9	.1
12	6.2	3.2	4.7	2.4	-.8	.5	4.3	.4	2.0	-1.7	-4.2	-2.5
13	3.9	.4	2.8	3.6	.8	2.2	3.9	-5.6	.8	3.2	-7.0	-1.7
14	1.2	-1.7	-.4	3.9	.0	2.1	-5.6	-7.0	-6.2	2.4	-5.1	-.5
15	7.0	-2.9	-.8	2.4	-1.7	1.0	.4	-4.7	-1.7	-3.8	-5.1	-4.6
16	5.1	-3.4	.4	.4	-2.5	-1.0	3.6	.8	2.3	-2.1	-6.1	-4.3
17	4.7	-2.5	2.2	1.2	-2.1	-1.2	2.8	-9.4	-3.9	-3.4	-4.7	-4.2
18	4.7	-2.1	.6	-2.1	-5.6	-3.6	-8.4	-12.5	-9.6	-1.2	-2.9	-2.1
19	9.5	.4	6.1	.0	-4.7	-1.8	-11.4	-20.5	-16.3	-1.2	-2.5	-2.0
20	12.7	7.3	10.8	2.0	-.4	.6	-15.9	-21.9	-19.8	.0	-2.9	-1.9
21	15.6	12.4	14.0	.4	-3.4	-1.8	-11.4	-18.4	-14.6	-1.7	-4.2	-2.9
22	15.2	5.8	10.4	-2.9	-3.8	-3.3	-8.9	-15.3	-11.9	-2.9	-5.6	-4.5
23	14.5	5.5	9.3	.4	-4.7	-2.0	-7.0	-13.6	-10.8	-2.9	-10.4	-7.2
24	10.6	3.2	7.5	-.4	-3.8	-2.2	-1.7	-8.4	-3.9	-4.7	-11.4	-8.4
25	4.7	2.8	4.0	1.2	-1.7	-.1	.4	-3.4	-1.5	.4	-8.9	-5.3
26	13.4	3.6	8.7	.0	-2.9	-1.5	-2.5	-5.1	-4.5	-4.2	-7.9	-6.3
27	12.0	-1.2	7.8	.4	-3.8	-1.8	1.6	-4.2	-1.6	-3.4	-7.0	-5.3
28	-1.2	-3.8	-2.5	-3.4	-6.5	-5.0	.8	-1.2	-.2	-.8	-6.5	-3.7
29	3.2	-5.6	-1.4	-2.1	-5.6	-3.9	2.0	-.8	.9	.0	-2.1	-.8
30	4.3	-.8	2.1	-2.5	-5.1	-3.8	2.8	-3.4	.1	-.4	-5.1	-2.9
31	5.1	.0	2.7				3.2	-6.1	-1.6	-2.1	-8.4	-5.4
Monthly average	7.4	1.3	4.3	0.3	-2.9	-1.3	-2.2	-7.4	-4.7	-0.6	-4.9	-2.9

DAY	Feb.			Mar.			Apr.			May		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	-3.8	-7.5	-5.1	-3.4	-7.0	-5.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
2	-.8	-5.1	-2.9	-4.2	-8.4	-5.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
3	-2.9	-6.5	-4.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
4	-2.9	-5.6	-4.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
5	-3.4	-6.5	-4.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
6	-.4	-3.8	-2.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
7	-2.9	-6.5	-4.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
8	-5.1	-8.4	-6.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
9	-8.4	-13.6	-10.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
10	-7.5	-10.9	-9.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
11	-3.8	-9.9	-6.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
12	.8	-6.5	-2.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
13	.8	-6.5	-2.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
14	-1.7	-9.9	-7.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
15	-2.5	-10.9	-6.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
16	-.4	-3.8	-2.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
17	-3.4	-6.1	-4.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
18	-3.8	-8.9	-5.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
19	-2.9	-6.5	-4.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
20	-2.5	-6.1	-3.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
21	-2.9	-5.1	-3.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
22	.0	-6.1	-2.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
23	.4	-6.1	-3.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
24	2.0	-2.5	.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
25	.4	-7.0	-3.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
26	-2.1	-8.4	-6.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
27	1.6	-5.6	-2.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
28	.4	-5.6	-2.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
29				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
30				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0
31				-99.0	-99.0	-99.0				-99.0	-99.0	-99.0
Monthly average	-2.1	-7.0	-4.5	--	--	--	--	--	--	--	--	--

DAY	June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	-99.0	-99.0	-99.0	5.1	-0.8	2.7	15.9	8.1	11.7	11.0	0.4	5.3
2	-99.0	-99.0	-99.0	2.4	-1.2	.0	18.4	11.0	14.7	12.4	3.9	8.0
3	-99.0	-99.0	-99.0	6.2	-.4	2.5	18.7	9.9	14.2	14.9	6.2	9.3
4	-99.0	-99.0	-99.0	5.1	1.2	2.9	18.4	13.1	16.1	10.6	6.6	8.9
5	-99.0	-99.0	-99.0	11.0	2.0	7.3	17.3	9.2	13.0	9.2	3.9	7.5
6	-99.0	-99.0	-99.0	13.8	6.2	11.2	14.9	11.0	12.9	3.2	1.2	2.1
7	-99.0	-99.0	-99.0	7.7	2.0	3.8	15.9	7.3	11.5	13.1	.8	7.1
8	-99.0	-99.0	-99.0	12.0	1.6	7.1	11.0	6.2	8.4	15.2	9.2	11.8
9	-99.0	-99.0	-99.0	14.5	11.0	12.1	15.9	7.7	10.8	13.1	4.7	9.6
10	-99.0	-99.0	-99.0	15.2	8.8	11.8	17.3	7.7	11.6	10.2	2.8	6.1
11	-99.0	-99.0	-99.0	14.5	7.7	10.7	14.5	7.3	10.3	15.6	5.8	10.0
12	-99.0	-99.0	-99.0	14.9	6.2	10.0	9.2	5.8	7.1	18.4	11.0	14.8
13	-99.0	-99.0	-99.0	14.1	5.1	9.4	8.4	5.5	6.5	19.8	12.0	15.7
14	-99.0	-99.0	-99.0	4.3	.4	2.0	6.6	5.1	5.6	21.1	11.0	14.4
15	-99.0	-99.0	-99.0	12.0	2.4	7.4	7.0	4.7	5.7	17.3	8.1	12.1
16	-99.0	-99.0	-99.0	12.4	4.3	8.1	12.0	6.2	8.9	13.4	7.0	9.3
17	-99.0	-99.0	-99.0	8.1	3.2	5.6	18.4	9.2	13.6	18.7	7.3	13.4
18	-99.0	-99.0	-99.0	12.0	3.9	7.7	21.1	9.9	15.7	20.1	12.7	15.7
19	-99.0	-99.0	-99.0	12.4	7.3	10.1	17.0	8.1	11.7	19.1	11.7	15.2
20	-99.0	-99.0	-99.0	14.5	7.3	10.5	18.4	10.2	13.5	19.4	11.0	14.0
21	-99.0	-99.0	-99.0	8.8	5.8	7.1	12.4	6.2	9.2	21.1	11.3	15.0
22	-99.0	-99.0	-99.0	15.2	5.1	9.4	19.4	5.8	13.5	19.4	9.5	13.6
23	-99.0	-99.0	-99.0	16.6	6.2	10.2	22.9	11.7	17.7	13.4	.4	6.9
24	-99.0	-99.0	-99.0	7.3	4.7	5.5	19.1	9.9	14.2	3.6	.0	1.2
25	-99.0	-99.0	-99.0	11.0	2.8	6.6	13.1	7.0	10.4	3.9	-.8	.2
26	-99.0	-99.0	-99.0	14.9	7.3	11.0	19.1	8.1	12.8	.0	-1.2	-.8
27	-99.0	-99.0	-99.0	21.5	10.2	13.6	22.2	11.3	16.3	5.1	-2.5	.9
28	-99.0	-99.0	-99.0	21.1	9.2	14.3	17.7	10.6	14.0	9.9	1.2	5.2
29	-99.0	-99.0	-99.0	14.9	7.0	10.0	12.0	3.9	8.4	10.2	3.2	6.5
30	6.6	4.7	5.7	13.8	4.7	8.7	3.9	-.4	1.7	9.5	2.4	5.3
31				15.6	6.6	11.4	5.1	-.8	1.9			
Monthly average	--	--	--	12.0	4.8	8.1	14.9	7.6	11.1	13.1	5.4	8.8

Table 3. Air temperature at 1,631 meters altitude, near Middle Tarn gaging station, South Cascade Glacier Basin, 1999 water year

[Daily maximum, miminum, and average air temperature, in degrees Celsius. Air temperature is sampled once an hour at the Middle Turn gaging station (fig. 1). A -99.0 indicates no data]

DAY	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.			Apr.			May			June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	12.8	6.0	9.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.5	7.5	11.2	10.5	0.4	5.3
2	3.7	-.7	.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.8	9.8	13.6	13.3	3.6	7.2
3	3.5	-.8	.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.9	8.6	13.3	15.2	4.8	8.6
4	5.2	-1.1	1.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.4	13.3	15.5	11.4	6.7	8.6
5	10.7	1.9	5.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.1	9.3	12.4	9.5	4.2	7.4
6	12.3	7.4	9.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.6	9.9	12.1	3.8	1.1	2.4
7	12.3	6.8	9.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.7	7.1	10.7	10.8	1.1	6.4
8	7.0	.8	3.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	9.8	6.6	8.1	15.8	8.8	11.6
9	3.4	-.3	1.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.9	7.3	10.3	13.0	5.2	9.6
10	2.2	-1.2	.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.4	8.5	11.1	12.4	3.1	6.5
11	4.2	.2	2.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.7	7.1	9.8	12.6	5.8	9.2
12	5.9	3.0	4.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.0	5.0	6.4	17.5	10.2	14.4
13	4.4	.4	2.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.5	5.1	6.0	17.4	12.5	14.8
14	1.3	-1.4	-.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	6.3	4.6	5.6	17.5	11.3	13.4
15	6.5	-3.9	-.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	7.0	4.9	5.7	15.2	8.4	11.5
16	7.4	-5.0	.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	11.0	5.6	8.2	12.7	6.6	8.9
17	4.8	-2.2	2.4	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.8	9.0	12.4	16.6	6.8	12.6
18	5.3	-1.8	.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	17.5	10.0	14.1	16.8	11.2	14.3
19	8.6	.0	5.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.8	7.6	10.7	17.5	11.3	14.0
20	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	13.3	8.5	11.1	16.9	9.8	12.6	16.9	11.3	13.3
21	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	8.2	5.6	7.0	12.8	6.6	9.4	18.4	11.7	13.7
22	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.2	5.3	8.9	17.4	6.1	12.2	19.4	9.8	13.0
23	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.5	5.7	9.2	21.3	11.9	15.4	12.7	.6	6.9
24	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	6.3	4.2	5.1	18.9	9.7	13.5	3.7	.1	1.6
25	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	10.2	2.4	6.4	13.3	7.0	10.4	3.7	-.6	.7
26	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	14.0	8.4	11.0	16.4	7.3	11.8	1.7	-1.0	-.2
27	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	16.4	11.0	13.1	20.2	12.0	15.5	12.2	-3.0	1.0
28	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	20.2	8.4	13.0	15.4	10.1	13.1	9.5	1.0	5.3
29	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	15.3	5.8	9.0	11.3	4.0	8.0	11.5	3.4	6.3
30	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	12.1	4.9	8.0	3.9	-.2	1.8	10.4	2.4	5.1
31	-99.0	-99.0	-99.0				-99.0	-99.0	-99.0				-99.0	-99.0	-99.0				-99.0	-99.0	-99.0	-99.0	-99.0	-99.0				13.9	6.0	11.1	8.1	-.3	2.5			
Monthly average	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	13.9	7.4	10.4	12.7	5.3	8.4

Table 4. Air temperature at 1,848 meters altitude, near Hut, South Cascade Glacier Basin, 1999 water year

[Daily maximum, miminum, and average air temperature, in degrees Celsius. Air temperature is sampled once an hour at the Hut (fig. 1). A -99.0 indicates no data]

DAY	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.			Apr.			May			June			July			Aug.			Sept.		
	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min	Avg
1	12.9	2.1	8.2	0.3	-3.1	-1.5	-3.4	-6.6	-4.8	-4.8	-8.1	-7.1	-5.6	-9.5	-7.1	-5.1	-8.2	-6.8	3.7	-7.0	-3.6	0.6	-5.5	-3.0	1.1	-3.5	-1.6	3.8	-0.4	1.6	20.9	7.7	13.5	10.5	-0.8	4.3
2	1.8	-2.5	-1.4	.9	-2.4	-1.1	-2.9	-7.1	-5.2	-2.7	-6.4	-4.3	-2.8	-6.6	-4.7	-5.7	-9.6	-7.5	-.5	-7.4	-4.2	4.2	-5.5	-2.4	5.7	-4.3	.9	3.2	-2.4	-.8	22.5	12.0	17.2	10.3	2.0	6.5
3	1.0	-2.3	-.7	-1.0	-2.7	-1.8	-7.3	-9.0	-8.3	.5	-3.2	-1.5	-5.3	-8.4	-6.8	-4.9	-8.5	-6.7	-3.2	-8.0	-6.4	-2.5	-7.0	-4.6	9.5	.7	4.4	7.3	-1.5	1.7	22.2	12.6	16.3	13.6	4.6	8.5
4	3.3	-2.2	.0	1.1	-2.5	-.9	-6.1	-9.5	-8.6	.1	-1.6	-.4	-5.3	-7.3	-6.7	-7.2	-8.8	-8.2	-2.8	-8.5	-6.9	-5.3	-7.6	-6.7	6.4	1.6	3.6	3.9	.6	2.0	19.7	12.0	15.7	10.0	5.6	7.8
5	8.3	.3	4.7	-.2	-3.8	-2.0	-7.9	-9.8	-8.6	.2	-1.8	-1.1	-5.4	-8.8	-7.0	-1.5	-10.1	-7.7	2.8	-8.7	-4.7	5.4	-7.4	-2.0	2.8	-4.1	-.4	15.3	.6	7.7	18.7	10.0	14.6	7.3	2.4	5.7
6	11.1	7.3	9.8	-2.4	-5.3	-3.8	-7.0	-8.9	-8.2	-.4	-4.1	-2.7	-3.0	-5.8	-4.7	-5.1	-10.7	-8.9	-2.5	-7.8	-4.8	5.9	-5.2	1.0	1.2	-4.7	-2.7	16.7	7.5	11.4	18.8	12.9	15.2	2.0	-.2	.6
7	11.5	6.0	8.9	-2.5	-4.9	-4.2	-3.4	-7.6	-5.3	-3.8	-5.1	-4.4	-4.9	-8.3	-6.6	-3.2	-9.6	-7.3	6.1	-4.3	-.8	-.8	-8.5	-5.9	6.2	-4.7	-.9	8.0	1.1	3.1	19.6	7.7	11.6	12.0	-.3	5.6
8	5.0	-1.4	1.7	-2.5	-6.1	-4.4	-7.0	-8.2	-7.5	-3.5	-5.7	-4.6	-6.9	-10.5	-9.0	-4.3	-8.7	-6.8	-3.6	-9.6	-6.3	-.9	-8.0	-5.8	2.4	-2.9	-1.4	15.5	1.2	7.7	12.5	6.7	9.1	12.7	6.2	9.4
9	2.8	-2.0	-.7	-2.7	-5.4	-4.5	-.1	-7.8	-3.9	.0	-4.7	-2.6	-9.2	-13.5	-11.5	-4.5	-8.0	-6.3	-6.1	-9.5	-8.3	4.1	-7.7	-4.4	6.7	-2.5	.8	22.0	8.1	13.0	17.9	7.1	11.7	12.2	3.5	9.0
10	2.0	-2.5	-.9	-3.9	-5.7	-4.7	.3	-4.9	-1.6	1.8	-.2	.6	-9.5	-12.0	-10.9	-1.0	-8.1	-6.1	-2.7	-9.0	-6.3	9.8	-7.6	-.4	6.4	-.8	1.6	20.7	11.1	15.6	18.0	8.0	12.2	10.1	1.3	5.1
11	2.2	-1.7	.3	-.7	-5.9	-3.3	-.4	-6.4	-2.6	-.6	-4.2	-2.1	-8.2	-11.9	-9.5	.6	-8.8	-5.4	7.2	-5.7	-1.2	4.9	-1.7	.5	10.9	-.8	6.1	19.2	10.0	13.3	12.9	6.6	9.5	13.6	3.6	8.1
12	3.7	1.4	2.7	.2	-2.5	-1.4	.3	-1.5	-.3	-3.2	-5.5	-4.0	-2.8	-8.9	-6.2	-2.0	-5.7	-4.0	1.1	-3.7	-1.8	-1.1	-5.0	-3.3	12.6	6.4	9.5	16.3	8.5	12.4	8.6	5.1	6.3	16.0	9.1	12.8
13	2.1	-.7	1.0	.3	-1.3	-.2	1.6	-6.7	-.7	1.1	-7.3	-2.9	-2.8	-7.1	-4.6	.7	-4.4	-1.0	-4.0	-7.8	-6.2	-1.5	-6.6	-4.0	16.7	7.8	11.5	14.4	5.3	10.1	7.6	4.9	5.8	17.8	11.7	14.5
14	-.8	-3.2	-1.9	1.0	-.7	.3	-6.8	-8.6	-8.0	.3	-6.4	-2.2	-4.3	-9.4	-7.8	-.5	-7.0	-3.0	5.7	-8.4	-2.1	4.2	-5.9	-2.0	17.4	11.0	13.4	4.3	-.5	1.1	5.7	4.0	4.6	21.4	12.2	15.5
15	1.7	-4.7	-2.5	.3	-3.4	-.5	-.8	-7.2	-3.6	-5.7	-7.8	-6.8	-5.3	-9.5	-7.6	-4.3	-9.2	-7.4	7.4	-.3	2.7	3.9	-3.2	-.9	20.1	6.6	13.2	12.8	1.8	6.4	5.3	3.3	4.3	16.4	7.5	12.3
16	3.9	-4.9	-.4	-.8	-4.1	-2.9	3.1	-.6	.8	-4.5	-7.5	-6.2	-2.7	-5.1	-4.3	-4.6	-10.0	-8.4	9.5	1.8	5.8	4.6	-3.3	-1.3	12.7	4.5	6.8	10.8	4.5	7.5	12.5	4.9	8.4	13.3	6.0	9.3
17	2.5	-5.2	.1	-3.4	-4.7	-3.9	1.1	-12.0	-5.4	-4.7	-7.0	-6.3	-5.3	-7.6	-6.3	-.8	-8.3	-4.9	12.8	4.2	9.0	4.6	-2.7	.6	14.9	2.3	8.0	10.8	3.9	6.5	21.2	10.8	14.9	18.2	7.4	12.7
18	4.6	-4.5	-.6	-3.6	-6.4	-4.8	-10.5	-13.3	-11.5	-3.4	-4.7	-4.0	-5.9	-8.4	-7.0	.3	-5.4	-2.1	6.6	-1.0	2.9	2.9	-3.4	-.7	7.5	1.9	4.9	17.2	4.3	9.9	23.6	10.5	16.2	18.4	12.3	14.8
19	8.0	-.9	5.1	-1.7	-6.8	-3.7	-13.7	-22.5	-18.2	-3.4	-4.5	-3.8	-5.0	-8.2	-6.6	7.8	-1.0	3.5	3.7	-2.7	-.8	8.4	-5.4	.4	10.8	-.3	3.6	19.1	8.4	12.7	16.6	7.8	12.0	18.0	10.8	14.0
20	10.1	6.9	8.3	.3	-2.1	-.9	-15.6	-23.5	-20.8	-1.8	-5.3	-4.2	-5.3	-7.4	-6.0	10.0	5.3	7.3	-3.0	-6.2	-4.8	13.1	-.6	3.2	8.9	1.0	5.3	19.0	10.0	13.4	20.7	9.2	14.9	21.0	11.1	14.8
21	12.8	10.8	11.9	-1.5	-5.1	-3.7	-11.2	-19.2	-15.1	-2.8	-5.7	-4.6	-3.4	-7.1	-5.8	2.7	-3.2	-1.0	-3.0	-7.2	-5.2	9.2	-1.8	1.4	4.9	2.3	3.8	10.2	5.5	8.0	11.6	4.7	7.9	19.6	12.6	16.0
22	12.4	5.6	10.2	-4.4	-5.8	-5.2	-9.1	-14.9	-12.0	-5.5	-7.3	-6.4	-1.3	-7.9	-4.8	2.1	-3.4	-.5	8.9	-5.7	.3	17.1	-.9	7.6	3.1	1.4	2.2	16.6	4.9	10.8	21.5	5.3	14.3	18.7	9.6	13.8
23	12.3	4.2	8.5	-2.5	-7.0	-4.7	-9.2	-14.7	-11.3	-5.3	-9.9	-7.7	-1.3	-8.0	-5.3	2.6	-3.8	-.2	11.5	.5	5.7	15.5	8.3	12.5	10.8	2.2	5.8	15.9	7.0	10.6	22.6	12.1	17.4	11.7	-1.3	5.5
24	7.8	2.3	5.4	-2.5	-5.8	-4.2	-3.9	-9.5	-5.8	-7.1	-11.2	-9.4	.9	-4.3	-1.0	4.7	-1.8	1.0	20.0	4.0	11.3	19.9	7.2	13.2	7.2	2.0	4.4	8.1	3.7	5.3	20.2	11.0	14.4	1.3	-1.4	-.4
25	3.5	1.9	2.5	-.5	-4.0	-1.6	-1.5	-4.9	-3.3	-3.6	-9.2	-7.5	-1.3	-8.4	-5.0	-.2	-6.6	-3.5	5.2	-4.9	.5	6.8	-1.8	2.2	1.6	-.2	.7	12.8	2.0	7.0	11.1	6.0	8.7	1.6	-2.2	-1.2
26	13.9	2.5	7.8	-1.0	-4.5	-3.2	-3.6	-6.8	-6.1	-6.5	-8.6	-7.6	-4.5	-9.3	-7.9	-5.4	-8.7	-7.6	2.0	-7.1	-5.1	13.3	-3.5	5.3	6.1	-.8	1.2	19.4	8.5	13.7	18.6	8.1	13.3	-.3	-2.9	-2.0
27	10.2	-2.1	6.2	-1.6	-5.2	-3.8	-.5	-6.4	-3.4	-5.4	-9.0	-7.1	.3	-7.9	-4.1	-7.9	-10.1	-9.2	6.1	-7.5	-3.2	12.3	2.0	7.8	5.9	-.3	2.0	21.5	11.6	16.4	23.2	12.6	17.9	2.0	-4.2	-1.2
28	-2.6	-5.0	-3.9	-2.8	-8.1	-6.1	-1.0	-2.8	-2.0	-2.9	-7.8	-5.4	-1.9	-7.4	-4.6	-2.5	-10.3	-7.6	3.6	-6.1	-2.0	7.4	.4	3.4	5.9	.3	3.3	20.3	10.6	15.4	18.9	11.3	15.5	8.1	-1.3	2.9
29	-.3	-8.2	-3.9	-4.5	-8.2	-6.2	.0	-2.6	-.8	-2.0	-3.6	-2.8				-2.9	-7.8	-5.9	8.6	-2.2	2.6	9.0	-.6	2.5	6.6	2.5	3.8	14.2	7.2	10.3	11.2	3.0	7.7	9.1	.5	4.7
30	2.4	-3.0	.6	-3.8	-7.2	-6.1	-1.3	-4.5	-2.7	-2.9	-5.9	-4.4				1.6	-10.6	-6.0	9.7	-.8	3.7	9.1	.6	3.8	10.8	1.8	5.1	14.4	5.0	9.2	2.8	-1.7	.5	7.4	1.4	4.0
31	3.9	-1.0	1.2				-.1	-7.8	-3.5	-5.3	-10.0	-7.6				.6	-9.4	-6.1				4.9	.0	2.3				19.6	5.4	11.6	4.1	-2.2	.2			
Monthly average	5.6	-0.2	2.8	-1.5	-4.7	-3.2	-4.1	-8.9	-6.4	-2.8	-6.1	-4.6	-4.2	-8.4	-6.4	-1.3	-7.1	-4.7	3.7	-4.9	-1.3	6.1	-3.2	0.7	8.1	0.9	4.0	14.0	5.0	8.9	15.8	7.5	11.3	11.8	4.2	7.8

Table 5. Humidity at 1,618 meters altitude, near South Fork Cascade River gaging station, South Cascade Glacier Basin, 1999 water year

[Daily average relative humidity measured at the South Fork Cascade River gaging station (fig. 1). Humidity is sampled once an hour.]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	62	86	100	100	100	100	51	76	75	87	53	66
2	90	84	100	100	100	100	53	70	63	85	49	57
3	82	87	100	100	100	100	71	74	59	82	63	53
4	78	88	100	99	100	100	70	67	79	83	54	61
5	73	90	100	84	100	100	57	55	90	65	70	84
6	47	83	100	30	100	100	61	59	68	44	63	98
7	46	78	100	79	100	100	72	68	62	94	76	75
8	81	80	100	100	100	94	72	61	72	73	89	43
9	86	85	100	99	100	93	70	61	68	46	77	62
10	85	82	100	100	100	100	55	52	70	48	67	73
11	75	82	100	71	100	100	46	57	43	51	85	46
12	79	95	100	97	100	100	76	75	38	50	94	26
13	91	100	100	81	100	100	71	71	51	52	97	34
14	90	99	100	100	100	100	38	68	38	85	100	46
15	83	100	100	95	100	100	26	71	44	70	100	54
16	72	96	100	100	100	100	26	73	70	68	93	67
17	94	85	100	100	100	100	40	72	64	82	57	57
18	68	95	100	100	100	100	66	87	80	75	54	39
19	51	93	98	100	100	74	73	63	69	51	73	45
20	45	99	95	99	100	37	72	64	75	50	52	53
21	21	98	100	100	100	72	69	69	89	88	76	50
22	34	94	100	100	100	66	56	50	94	66	46	49
23	42	96	100	100	100	64	46	30	81	67	33	63
24	51	99	100	100	100	68	40	41	83	92	53	89
25	81	100	100	100	100	71	70	61	94	78	79	97
26	79	100	100	100	100	82	68	37	91	47	56	90
27	68	100	100	100	100	77	58	35	84	42	39	75
28	92	100	100	100	99	74	49	46	85	42	61	48
29	71	100	100	100		83	45	53	88	68	94	50
30	59	99	100	100		63	48	47	78	68	100	63
31	75		100	100		58		80		56	84	

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Table 6. Snow depths at South Cascade Glacier, May 27, 1999

[Depths, in meters, ±0.05 meter, measured with a probe rod; X and Y are local coordinates, ±10 meters. Surface altitude (Z), in meters above National Geodetic Vertical Datum of 1929. Locations mapped on figure 4.]

X	Y	Z	Snow depth (inches)
1,835	2,780	1,845	6.93
1,758	2,895	1,845	6.86
1,698	2,991	1,844	5.31
1,652	3,062	1,826	4.72
1,620	3,127	1,813	4.98
1,615	3,182	1,797	5.28
1,638	3,347	1,776	5.69
1,668	3,307	1,764	6.40
1,691	3,357	1,746	4.88
1,707	3,436	1,725	4.01
1,707	3,504	1,697	5.39
1,733	3,561	1,668	5.18
1,770	3,545	1,664	4.59
1,799	3,668	1,630	3.76
1,590	4,050	1,620	2.54
665	4,055	1,618	2.99
2,002	2,364	1,923	6.10
2,140	2,111	1,949	7.83
2,366	1,718	2,027	7.32
2,790	1,706	2,073	7.63

Table 7. Snow density at South Cascade Glacier, May 27, 1999

[Core measurement through entire thickness of the snow, at local X = 1,862, Y = 2,765, Z = 1,834 meter at P1 (fig.1). Diameter of core = 0.0763 meter.]

Core bottom (meters)	Core length (meters)	Core mass (kilograms)	Density (percentage of water)	Length represented by sample (meters)	Core water equivalent (meters)
0.90	0.77	1.740	0.49	0.90	0.44
1.62	0.73	1.775	0.53	0.72	0.38
1.87	0.30	0.665	0.49	0.25	0.12
2.10	0.27	0.660	0.54	0.23	0.12
2.35	0.24	0.605	0.55	0.25	0.14
3.27	0.87	2.060	0.52	0.92	0.48
3.32	0.10	0.260	0.57	0.05	0.03
3.94	0.62	1.580	0.56	0.62	0.35
4.55	0.60	1.425	0.52	0.61	0.32
5.05	0.50	1.235	0.54	0.50	0.27
5.74	0.67	1.575	0.51	0.69	0.36
6.18	0.42	1.040	0.54	0.44	0.24
6.59	0.41	1.080	0.58	0.41	0.24
6.93	0.31	0.810	0.57	0.34	0.19

Total water equivalent = 3.67.
Average density = 0.53

Table 8. Stake measurements at South Cascade Glacier in the 1990 balance year

[Surface material may be snow (s) or ice (i). Balance is the gain or loss of material, referenced to the previous year's melt horizon, in water content. Local X, Y, and Z coordinates (in meters) given for each stake. Stake locations are shown on figure 1 and stake readings are plotted on figure 5.]

Date	Surface material	Depth (meters)	Density	Balance (meters)
Stake 2 [X = 1,862, Y = 2,765, Z = 1,834]				
May 27	s	6.93	0.53	3.67
June 30	s	5.77	0.55	3.17
July 20	s	4.84	0.56	2.71
Sept. 3	s	2.22	0.58	1.29
Oct. 15	s	1.70	0.60	1.02
Stake 3 [X = 1,697, Y = 3,353, Z = 1,727]				
Sept. 6	i	-1.18	0.90	-1.06
Oct. 15	i	-3.23	0.90	-2.91
Stake 4 [X = 1,799, Y = 3,542, Z = 1,651]				
July 20	s	1.25	0.56	0.70
Sept. 6	i	-0.33	0.90	-0.29
Oct. 15	i	-2.65	0.90	-2.39
Stake 5 [X = 1,713, Y = 3,502, Z = 1,678]				
Sept. 6	i	-2.00	0.90	-1.80
Oct. 15	i	-3.62	0.90	-3.26

Table 9. South Cascade Glacier altitude grid, 1999

[Surface altitude (Z), in meters above National Geodetic Vertical Datum of 1929, was measured near the central point for each grid cell. Coordinates X and Y are local, ± 2 meters; Z is accurate to ± 2 meters. The year in which the altitude was measured is given in column 1]

Year	X	Y	Z	Year	X	Y	Z	Year	X	Y	Z	Year	X	Y	Z
1997	2,270	1,400	2,078	1998	2,272	1,601	2,020	1998	2,471	2,298	1,954	1998	1,769	2,900	1,837
1997	2,570	1,400	2,058	1998	2,371	1,600	2,024	1998	1,570	2,400	1,895	1998	1,870	2,899	1,839
1997	2,470	1,400	2,060	1998	2,471	1,598	2,034	1998	1,672	2,401	1,888	1998	1,971	2,899	1,839
1997	2,368	1,401	2,066	1998	2,571	1,600	2,044	1998	1,770	2,399	1,887	1998	2,072	2,901	1,835
1997	2,671	1,401	2,091	1998	1,971	1,698	2,002	1998	1,871	2,400	1,891	1998	2,169	2,902	1,833
1997	2,769	1,401	2,109	1998	2,071	1,699	1,991	1998	1,970	2,400	1,905	1998	2,271	2,900	1,826
1997	2,770	1,500	2,078	1998	2,171	1,697	1,999	1998	2,071	2,399	1,908	1998	2,372	2,901	1,836
1997	2,870	1,500	2,102	1998	2,271	1,699	2,012	1998	2,168	2,400	1,921	1998	1,470	3,001	1,831
1997	3,070	1,600	2,124	1998	2,970	1,700	2,091	1998	2,270	2,401	1,929	1998	1,569	2,999	1,827
1997	2,770	1,601	2,069	1998	1,870	1,801	1,996	1998	2,371	2,401	1,938	1998	1,669	2,999	1,826
1997	2,870	1,601	2,082	1998	2,371	1,802	2,010	1998	2,471	2,400	1,957	1998	1,770	3,000	1,830
1997	2,669	1,601	2,058	1998	2,472	1,802	2,025	1998	1,471	2,501	1,899	1998	1,871	3,002	1,832
1997	2,968	1,602	2,098	1998	2,570	1,,801	2,032	1998	1,572	2,499	1,874	1998	1,969	3,001	1,836
1997	2,871	1,699	2,077	1998	2,668	1,,800	2,046	1998	1,770	2,502	1,875	1998	2,069	3,002	1,834
1997	2,769	1,700	2,068	1998	2,871	1,,800	2,072	1998	1,870	2,499	1,875	1998	2,169	3,000	1,827
1997	2,568	1,700	2,040	1998	1,871	1,898	1,980	1998	1,970	2,499	1,875	1998	2,270	3,001	1,826
1997	3,168	1,701	2,123	1998	2,270	1,901	1,983	1998	2,071	2,499	1,888	1998	1,469	3,100	1,812
1997	2,469	1,701	2,035	1998	2,370	1,902	1,990	1998	2,169	2,502	1,896	1998	1,571	3,100	1,807
1997	2,669	1,701	2,054	1998	2,472	1,900	2,007	1998	2,271	2,500	1,912	1998	1,571	3,202	1,772
1997	2,370	1,701	2,025	1998	1,870	1,999	1,962	1998	2,371	2,501	1,924	1999	1,770	3,600	1,641
1997	3,069	1,702	2,105	1998	2,170	2,001	1,952	1998	1,571	2,601	1,861	1999	1,670	3,599	1,649
1997	3,170	1,795	2,093	1998	2,270	2,001	1,952	1998	1,670	2,600	1,859	1999	1,770	3,500	1,667
1997	3,071	1,798	2,084	1998	2,371	2,001	1,962	1998	1,770	2,600	1,863	1999	1,671	3,502	1,681
1997	2,170	1,800	1,990	1998	2,469	2,001	1,979	1998	1,870	2,601	1,858	1999	1,569	3,400	1,712
1997	2,770	1,800	2,068	1998	1,770	2,101	1,935	1998	1,971	2,600	1,858	1999	1,669	3,399	1,713
1997	2,072	1,800	1,983	1998	1,871	2,101	1,940	1998	2,071	2,599	1,858	1999	1,771	3,401	1,697
1997	1,970	1,800	1,991	1998	1,969	2,101	1,936	1998	2,171	2,600	1,874	1999	2,072	3,300	1,729
1997	2,970	1,801	2,080	1998	2,072	2,099	1,942	1998	2,271	2,601	1,886	1999	1,971	3,298	1,731
1997	2,271	1,802	2,008	1998	2,172	2,101	1,948	1998	1,569	2,700	1,854	1999	1,770	3,300	1,724
1997	2,173	1,896	1,974	1998	2,270	2,099	1,951	1998	1,670	2,700	1,853	1999	1,671	3,300	1,742
1997	1,969	1,898	1,971	1998	2,371	2,101	1,955	1998	1,772	2,700	1,852	1999	1,570	3,302	1,738
1997	2,071	1,901	1,972	1998	2,472	2,101	1,970	1998	1,869	2,701	1,850	1999	1,467	3,199	1,777
1997	1,971	2,000	1,958	1998	1,671	2,201	1,922	1998	1,969	2,701	1,848	1999	1,668	3,201	1,776
1997	2,070	2,001	1,958	1998	1,770	2,199	1,922	1998	2,071	2,700	1,843	1999	1,770	3,201	1,787
1997	2,571	2,101	2,005	1998	1,869	2,201	1,917	1998	2,171	2,701	1,843	1999	1,871	3,199	1,797
1997	2,570	2,300	2,006	1998	1,969	2,200	1,927	1998	2,269	2,702	1,855	1999	1,968	3,200	1,794
1997	1,571	2,301	1,929	1998	2,070	2,199	1,935	1998	1,471	2,800	1,857	1999	2,071	3,199	1,774
1997	1,669	2,500	1,883	1998	2,171	2,202	1,940	1998	1,570	2,800	1,846	1999	2,171	3,201	1,766
1997	2,369	2,599	1,901	1998	2,270	2,201	1,948	1998	1,671	2,802	1,845	1999	2,170	3,100	1,811
1997	2,370	2,700	1,871	1998	2,371	2,201	1,947	1998	1,769	2,800	1,844	1999	2,070	3,100	1,820
1997	1,470	2,701	1,871	1998	2,470	2,199	1,959	1998	1,871	2,802	1,842	1999	1,971	3,099	1,825
1998	2,171	1,499	2,043	1998	1,670	2,301	1,897	1998	1,972	2,800	1,841	1999	1,870	3,103	1,815
1998	2,271	1,501	2,041	1998	1,770	2,300	1,896	1998	2,070	2,800	1,839	1999	1,768	3,099	1,815
1998	2,370	1,500	2,036	1998	1,870	2,301	1,907	1998	2,171	2,800	1,833	1999	1,670	3,099	1,806
1998	2,469	1,498	2,038	1998	1,968	2,299	1,918	1998	2,269	2,800	1,834				
1998	2,570	1,497	2,048	1998	2,070	2,299	1,924	1998	2,369	2,799	1,851				
1998	2,671	1,497	2,059	1998	2,170	2,300	1,929	1998	1,471	2,901	1,844				
1998	2,071	1,598	2,024	1998	2,270	2,300	1,938	1998	1,568	2,902	1,838				
1998	2,169	1,600	2,024	1998	2,370	2,300	1,941	1998	1,669	2,900	1,839				

Table 10. Positions of velocity features, ± 1.0 meter, on South Cascade Glacier on September 14, 1998, and September 15, 1999

[Coordinates X, Y, and Z are local, in meters]

September 14, 1998				September 15, 1999			
ID	X	Y	Z	ID	X	Y	Z
1	1,738.548	3,572.556	1,659.553	1	1,740.348	3,582.927	1,653.958
2	1,607.253	3,103.433	1,803.502	2	1,608.264	3,115.112	1,803.366
3	1,771.283	3,150.150	1,802.843	3	1,766.698	3,163.903	1,800.876
4	1,922.570	3,055.599	1,827.538	4	1,919.574	3,064.838	1,828.641
5	1,948.274	3,176.110	1,805.088	5	1,946.129	3,185.669	1,801.747
6	2,071.608	3,189.623	1,780.129	6	2,073.422	3,196.940	1,776.970

Table 11. Precipitation (gage catch) at 1,587 meters altitude, Salix Creek gaging station, 1999 water year

[Precipitation is summed every hour and the daily sum is given in millimeters. -99.0 indicates no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	0.0	0.8	0.0	0.0	-99.0	-99.0	2.0	2.5	1.5	-99.0	-99.0	0.0
2	11.7	1.3	.0	.0	-99.0	-99.0	1.3	7.1	1.3	-99.0	-99.0	.0
3	10.4	.0	.0	.0	-99.0	-99.0	.0	.0	.0	-99.0	-99.0	.0
4	9.6	1.8	.0	9.1	-99.0	-99.0	.0	.0	.3	-99.0	-99.0	.0
5	.0	.0	.0	1.8	-99.0	-99.0	7.9	18.0	14.0	-99.0	-99.0	15.5
6	.0	.0	.0	.0	-99.0	-99.0	.0	7.1	9.4	-99.0	-99.0	29.7
7	.0	.5	.0	.0	-99.0	-99.0	6.3	1.3	6.3	-99.0	-99.0	.3
8	13.5	.0	.0	.0	-99.0	-99.0	.0	7.6	8.4	-99.0	1.3	.0
9	6.3	.0	.0	.0	-99.0	-99.0	.0	1.3	3.8	-99.0	.0	.0
10	6.1	.0	3.8	72.4	-99.0	-99.0	.0	.0	.0	-99.0	.0	.0
11	.0	.0	.0	.0	-99.0	-99.0	4.6	5.6	.0	-99.0	.0	.0
12	4.8	21.8	49.5	.0	-99.0	-99.0	2.0	3.0	.0	-99.0	1.3	.0
13	32.0	48.5	24.4	.0	-99.0	8.4	.0	.5	.0	-99.0	3.6	.0
14	6.3	30.0	.0	45.0	-99.0	.8	.8	1.5	.0	-99.0	8.6	.0
15	9.1	45.5	.0	-99.0	-99.0	.0	1.0	4.1	.5	-99.0	5.3	.0
16	.3	.0	8.9	-99.0	-99.0	.0	.0	2.3	.5	-99.0	50.8	.0
17	33.5	.0	.8	-99.0	-99.0	.0	.0	13.2	.0	-99.0	.0	.0
18	.0	.0	.0	-99.0	-99.0	9.9	2.5	7.4	4.1	-99.0	1.0	.0
19	.0	.0	.0	-99.0	-99.0	23.4	3.0	1.8	.3	-99.0	.3	.0
20	.0	18.8	.0	-99.0	-99.0	.0	3.6	1.0	8.9	-99.0	.0	.0
21	.0	.0	.0	-99.0	-99.0	1.5	.8	.3	10.4	-99.0	.3	.0
22	.0	.0	.0	-99.0	-99.0	.0	.0	.0	7.4	-99.0	.0	.0
23	.0	.0	.0	-99.0	-99.0	4.1	.0	.0	1.3	-99.0	.0	.0
24	.5	.0	.0	-99.0	-99.0	.3	.0	.0	14.2	-99.0	.0	.8
25	.5	.0	.0	-99.0	-99.0	5.1	2.0	.3	14.0	-99.0	5.6	.8
26	.0	.0	.0	-99.0	-99.0	.0	1.5	.0	2.8	-99.0	.0	14.0
27	13.5	.0	.0	-99.0	-99.0	.0	1.3	.0	2.3	-99.0	.0	6.9
28	.0	.0	.3	-99.0	-99.0	.0	.0	.0	1.0	-99.0	.0	17.0
29	2.0	.0	.3	-99.0		.0	.0	4.6	2.0	-99.0	1.0	.0
30	1.0	.0	.0	-99.0		4.6	.0	.0	-99.0	-99.0	14.0	.0
31	12.2		4.3	-99.0		2.3		10.7		-99.0	6.1	
Total	173.3	169.0	92.3	--	--	--	40.6	101.2	--	--	--	85.0

Table 12. Runoff from Salix Creek Basin, 1999 water year

[Daily runoff in millimeters, averaged over the basin; -99.0 indicates no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	0.1	-99.0	-99.0	3.3	-99.0	-99.0	2.0	14.4	25.4	35.0	16.8	2.8
2	1.8	-99.0	-99.0	3.2	-99.0	-99.0	2.0	12.1	15.7	18.6	17.6	2.2
3	3.0	-99.0	-99.0	3.0	-99.0	-99.0	2.0	9.8	17.4	12.3	16.6	1.9
4	3.2	-99.0	-99.0	3.0	-99.0	-99.0	2.0	9.4	21.6	14.2	17.9	1.6
5	2.6	-99.0	-99.0	3.0	-99.0	-99.0	2.0	9.4	36.9	21.7	14.7	4.0
6	1.3	-99.0	2.7	2.8	-99.0	-99.0	2.0	9.1	21.4	38.9	11.7	15.5
7	.7	-99.0	2.7	2.5	-99.0	-99.0	2.0	9.7	13.8	35.8	14.4	4.5
8	2.8	-99.0	2.7	2.0	-99.0	-99.0	2.0	9.8	11.2	32.4	10.1	2.3
9	3.7	-99.0	2.6	2.0	-99.0	-99.0	2.0	9.8	9.6	47.2	8.1	1.9
10	3.2	-99.0	2.5	12.3	-99.0	-99.0	2.0	9.8	10.2	46.2	6.8	1.6
11	1.7	-99.0	2.8	19.1	-99.0	-99.0	2.0	9.8	14.5	43.0	6.1	1.4
12	1.4	-99.0	3.6	5.4	-99.0	-99.0	2.0	9.8	36.8	39.2	5.7	1.2
13	11.0	-99.0	24.0	4.3	-99.0	3.2	2.0	9.8	39.8	38.3	5.2	1.1
14	8.0	-99.0	13.8	7.9	-99.0	3.1	2.0	9.8	50.6	28.2	5.8	1.1
15	4.6	-99.0	6.3	9.8	-99.0	2.3	2.0	9.5	70.6	27.1	5.7	1.1
16	3.2	-99.0	3.8	-99.0	-99.0	1.8	2.0	7.3	50.7	39.0	6.5	1.0
17	26.7	-99.0	3.4	-99.0	-99.0	1.6	2.0	6.7	42.8	27.4	4.5	1.0
18	4.7	-99.0	3.4	-99.0	-99.0	1.6	3.3	7.6	37.9	33.4	3.9	1.0
19	2.3	-99.0	3.4	-99.0	-99.0	1.5	5.5	8.7	32.9	31.0	3.6	.9
20	-99.0	-99.0	3.4	-99.0	-99.0	1.5	6.3	10.0	25.1	33.0	3.4	.9
21	-99.0	-99.0	3.4	-99.0	-99.0	3.7	5.5	11.0	35.5	26.0	3.4	.8
22	-99.0	-99.0	3.4	-99.0	-99.0	4.0	5.4	14.4	39.6	29.2	3.2	.8
23	-99.0	-99.0	3.4	-99.0	-99.0	2.9	5.5	28.1	38.5	30.2	2.8	.9
24	-99.0	-99.0	3.4	-99.0	-99.0	2.4	8.0	64.4	42.1	22.0	2.6	1.1
25	-99.0	-99.0	3.4	-99.0	-99.0	2.0	14.7	45.1	36.7	23.3	3.3	3.1
26	-99.0	-99.0	3.4	-99.0	-99.0	2.0	15.8	30.4	25.9	22.9	2.5	2.7
27	-99.0	-99.0	3.4	-99.0	-99.0	2.0	15.8	29.8	21.8	25.1	2.3	4.3
28	-99.0	-99.0	3.2	-99.0	-99.0	2.0	15.5	29.0	18.5	24.5	2.3	4.9
29	-99.0	-99.0	4.7	-99.0		2.0	14.3	27.0	21.1	21.7	2.3	6.0
30	-99.0	-99.0	9.3	-99.0		2.0	12.8	23.3	24.0	20.7	4.1	3.0
31	-99.0		4.5	-99.0		2.0		26.0		18.6	4.3	
Total	--	--	--	--	--	--	162.4	520.8	888.6	906.1	218.2	76.6

Table 13. Runoff from South Fork Cascade River Basin, 1999 water year

[Daily runoff in millimeters, averaged over the basin; -99.0 indicates no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	10.1	3.0	0.3	0.5	0.2	0.1	0.0	0.3	11.5	25.0	39.2	11.5
2	10.1	2.7	.4	.3	.3	.1	.0	.4	8.7	24.8	44.4	8.3
3	6.2	1.8	.4	.2	.4	.1	.0	.3	6.4	16.4	60.0	6.8
4	4.3	.9	.3	.2	.3	.1	.0	.3	7.3	12.4	73.4	6.5
5	3.6	.8	.3	.1	.2	.1	.0	.3	11.5	11.7	74.7	9.9
6	4.4	.7	.2	.1	.2	.1	.0	.2	12.8	18.6	58.5	28.4
7	5.6	.6	.2	.1	.2	.0	.0	.3	8.8	33.9	58.3	18.5
8	6.5	.5	.2	.1	.2	.0	.0	.3	6.7	29.0	60.8	12.4
9	6.0	.4	.2	.1	.1	.0	.0	.3	5.2	34.8	40.8	11.7
10	4.3	.4	.2	.2	.1	.0	.0	.2	4.4	46.0	35.5	11.2
11	3.2	.3	.2	.6	.1	.0	.0	.2	4.0	49.0	32.9	9.6
12	2.7	.3	.2	.6	.1	.0	.0	.2	6.3	46.9	32.9	8.9
13	5.2	2.0	.6	.5	.1	.0	.0	.2	15.9	45.1	27.7	12.4
14	8.1	8.5	2.4	.7	.0	.0	.0	.2	25.1	42.3	24.9	17.6
15	5.0	8.6	1.5	.9	.0	.0	.0	.1	44.4	29.3	28.5	17.5
16	3.5	6.1	.7	.7	.0	.0	.0	.1	53.5	30.5	38.5	14.9
17	11.8	3.2	.6	.6	.0	.0	.0	.1	45.6	35.3	38.3	12.5
18	13.8	2.0	.5	.5	.0	.0	.0	.1	40.1	34.0	39.5	13.3
19	6.2	.8	.4	.5	.1	.0	.1	.1	34.2	37.7	46.9	15.6
20	4.2	.8	-99.0	.3	.1	.0	.1	.1	26.8	36.4	37.6	18.8
21	4.4	.9	.3	.2	.0	.0	.1	.2	25.4	37.8	34.4	19.5
22	3.8	.9	.3	.2	.1	.0	.1	.2	35.7	33.6	31.4	19.4
23	3.1	.7	.3	.2	.1	.0	.1	.9	34.0	38.1	28.8	15.5
24	2.7	.7	.3	.1	.1	.0	.1	8.5	36.6	41.0	32.3	11.1
25	2.6	.8	.3	.1	.1	.0	.3	21.8	36.4	36.5	54.7	10.0
26	2.9	.8	.3	.1	.1	.0	.3	16.8	26.9	34.3	44.2	8.0
27	5.4	.6	.6	.1	.1	.1	.3	11.7	19.6	37.2	30.2	6.0
28	9.1	.4	.8	.1	.1	.1	.3	10.9	15.9	43.3	30.4	5.2
29	5.2	.3	.8	.2		.1	.2	10.6	14.1	44.5	31.2	4.6
30	3.5	.3	.8	.2		.0	.2	10.3	16.1	47.8	27.7	4.5
31	2.9		.6	.2		.0		9.6		45.2	18.4	
Total	170.4	50.8	--	9.5	3.4	0.9	2.2	105.8	639.9	1,078.4	1,257.0	370.1

Table 14. Runoff from Middle Tarn Basin, 1999 water year

[Daily runoff in millimeters, averaged over the basin; -99.0 indicates no data]

Day	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.
1	13.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	32.3	8.7
2	8.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	42.2	6.9
3	5.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	50.1	6.6
4	3.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	61.2	6.8
5	5.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	52.9	16.6
6	7.7	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	42.3	24.8
7	9.2	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	53.6	12.8
8	8.9	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	42.3	11.3
9	5.1	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	32.8	12.7
10	3.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	29.5	11.5
11	2.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	28.7	10.3
12	3.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	28.9	11.4
13	10.5	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	22.7	18.5
14	5.8	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	23.1	20.2
15	3.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	27.6	17.8
16	2.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	39.2	15.0
17	17.6	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	31.5	14.3
18	8.3	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	39.6	16.4
19	4.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	39.7	20.3
20	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	30.5	30.6	21.5
21	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	29.7	32.8	21.7
22	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	27.5	26.2	19.5
23	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	32.6	29.3	14.8
24	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	31.5	30.4	10.1
25	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	29.7	55.9	8.9
26	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	28.3	32.7	6.4
27	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	32.1	27.4	5.2
28	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	35.5	29.7	4.3
29	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	35.7	29.4	4.3
30	-99.0	-99.0	-99.0	-99.0		-99.0	-99.0	-99.0	-99.0	41.0	22.4	3.8
31	-99.0		-99.0	-99.0		-99.0		-99.0		34.8	12.9	
Total	--	--	--	--	--	--	--	--	--	--	1,079.9	383.4

Table 15. Values used to interpolate snow water equivalent at any altitude on South Cascade Glacier, 1999

[Values in meters]

Altitude	Snow water equivalent
1,570	1.3
1,608	1.6
1,648	2.0
1,690	2.3
1,733	2.6
1,778	2.9
1,822	3.1
1,867	3.4
1,914	3.6
1,960	3.8
2,007	4.1
2,055	4.3
2,103	4.5
2,148	4.7

Table 16. Values used to interpolate net balance at any altitude on South Cascade Glacier, 1999

[Values in meters]

Altitude	Net balance
1,619	-4.73
1,630	-4.22
1,642	-3.72
1,657	-3.21
1,672	-2.72
1,688	-2.26
1,706	-1.74
1,725	-1.26
1,746	-.81
1,770	-.35
1,799	.11
1,832	.51
1,870	.89
1,911	1.21
1,953	1.47
1,998	1.71
2,045	1.95
2,091	2.18
2,137	2.41

Table 17. Mass balance time series at South Cascade Glacier

[For years 1986–91, net balance, $\bar{b}_n$, was determined by the index regression method discussed in Krimmel (1989) and has an error of 0.23 meter (m). For years 1959–64 and 1968–82, winter balance, $\bar{b}_m(s)$, was determined from unpublished snow accumulation maps and has an error of 0.12 m. For years 1983–91, $\bar{b}_m(s)$ was determined using the index station regression discussed in Krimmel (1989) and has an error of 0.23 m. For years 1992–98, $\bar{b}_n$ and $\bar{b}_m(s)$ were determined by the grid-index method (Krimmel, 1996b)]

Year[1]	$\bar{b}_m(s)$ (m)	$\bar{b}_n$ (m)	Year[1]	$\bar{b}_m(s)$ (m)	$\bar{b}_n$ (m)
[2]1959	3.28	0.70	1980	1.83	-1.02
1960	2.21	-.50	1981	2.28	-.84
1961	2.40	-1.10	1982	3.11	.08
1962	2.50	.20	1983	1.91	-.77
1963	2.23	-1.30	1984	2.38	.12
1964	3.25	1.20	1985	2.18	-1.20
[3]1965	3.48	-.17	1986	2.43	-.71
1966	2.47	-1.03	1987	1.88	-2.56
[4]1967	3.29	-.63	1988	1.89	-1.64
[5]1968	3.00	.01	1989	2.35	-.71
1969	3.17	-.73	1990	2.80	-.73
1970	2.41	-1.20	1991	3.35	-.20
1971	3.51	.60	1992	1.91	-2.01
1972	4.27	1.43	1993	1.98	-1.23
1973	2.21	-1.04	1994	2.39	-1.60
1974	3.65	1.02	1995	2.86	-.69
1975	3.06	-.05	1996	2.94	0.10
1976	3.53	.95	1997	3.71	0.63
1977	1.57	-1.30	1998	2.76	-1.86
1978	2.49	-.38	1999	3.59	1.02
1979	2.18	-1.56			

[1]Balance year (for example, 1959 is from the minimum balances in 1958 to the minimum balance in 1959, and the 1959 $\bar{b}_m(s)$ occurred in the spring of 1959).

[2] $\bar{b}_n$ for years 1959 through 1964 from Meier and Tangborn (1965).

[3]Years 1965 through 1966 from Meier and others (1971).

[4]Year 1967 from Tangborn and others (1977).

[5]$\bar{b}_n$ for years 1968 through 1985 from Krimmel (1989).