United States Department of Agriculture
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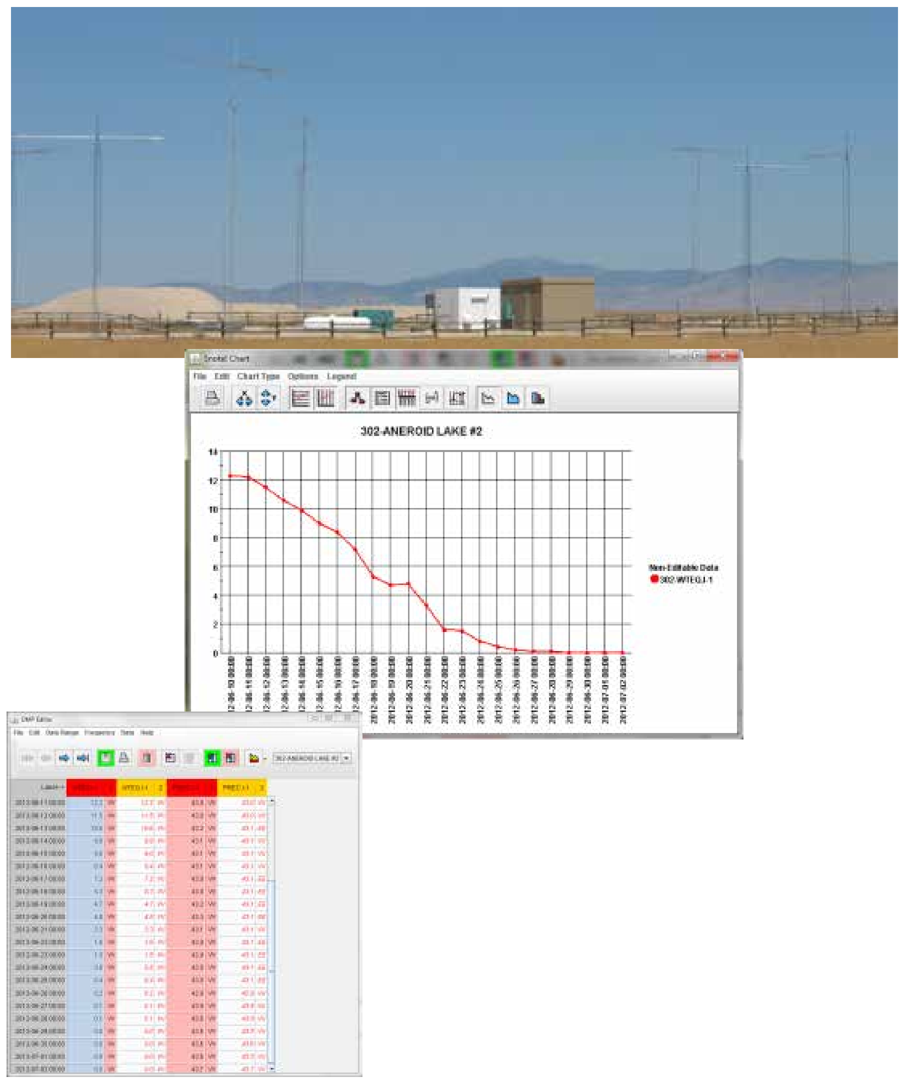
Part 622 Snow Survey and Water Supply Forecasting
National Engineering Handbook

Chapter 6 Data Management



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Cover photos:

Top: Boise Master Station, online since 1978
Middle: Output from DMP Data Editor application
Bottom: DMP Data Editor application

Acknowledgments

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Chapter 6 Data Management

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622.0600 Introduction

This chapter describes Snow Survey and Water Supply Forecasting (SSWSF) Program data management processes. Information on data retrieval, data storage, and data editing techniques for both the manual and automated snowpack telemetry (SNOTEL) systems is included. The chapter also includes quality control methods and details on managing station, sensor, and system data stored in the Water and Climate Information System (WCIS) database.

622.0601 Data retrieval

(a) SNOTEL data retrieval

SNOTEL stations transmit data to master stations in meteor burst format. This format consists of:

- master station date
- master station time
- DATA from (fixed character string)
- station ID
- group number
- number of sensors
- data record date
- data record time
- data value(s) in hex format

Table 6–1 shows examples of meteor burst formats.

Table 6–1 Meteor burst, scaled millivolt meteor burst, engineering unit meteor burst formats

Meteor burst format

(ms date) (ms time) (DATA from) (sta ID) (grp #)
(# sensors) (data date) (data time)
(data value) (data value) (data value) (data value)

Scaled millivolt meteor burst format

04/26/10 16:00:27 DATA from 00339 G1 S08 04/26/10
1600 0AE7 064C 0A16 0605 0637 051B 058D 03FB

Engineering unit meteor burst format

04/26/10 16:00:35 DATA from 02151 G1 S14 04/26/10
1700 45AD 6000 44D8 450F 44D8 44FD 34A5 7DD3
2838 4650 49BE 4AC1 49BE 4E1D

When data are received by each master station, they are immediately available for the WCIS storage application via the Internet.

See the SSWSF Program SNOTEL and manual data storage standards in NEH 622.08.

(b) Manual data retrieval

The data collection office (DCO) staff is responsible for retrieving manually collected data from snow survey personnel and cooperators.

Data are manually measured, sent to the DCO through phone or email, and then entered by the DCO staff into WCIS through the Internet (fig. 6–2).

622.0602 Data storage

(a) SNOTEL data storage

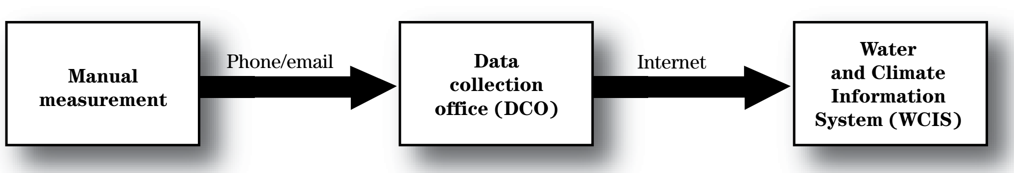
Data are stored near real-time in the WCIS relational database. The storage application is continuously executing to process incoming data. The application is located on a WCIS server. Raw data are automatically stored in the WCIS database regardless of data validity. The raw data are kept as permanent, original records for use in recalculating sensor values when necessary. Part of the information stored is the receiving master station identification.

The storage application stores converted data in the WCIS database if the station sensor for the appropriate group and channel is defined with a valid element/sensor name. If the element/sensor name is not defined for a station, group, and channel, an error message is written in the storage log.

Data outside the valid time window are not stored automatically. The time window is 14 days prior to the current day and 3 hours after the current hour. Data

Figure 6–1 SNOTEL data flow

Figure 6–2 Manual data flow



outside this window are flagged in the log file as being out of range. If the WCIS SNOTEL operator is uncertain of the validity of the data, the DCO supervisor is notified to determine if storage is appropriate.

The National Water and Climate Center (NWCC) monitoring staff determines the appropriate precision for each sensor, which is stored in the WCIS database sensor precision table. The storage program uses this table to determine what precision to use when storing the converted data to the WCIS database. The storage software uses the SSWSF Program standards to determine how to round the converted data.

(b) Manual data storage

The DCO staff inputs the manual data into the WCIS database. Required parameters are station identification, date, element, and data.

During the forecast season (January through June), the first-of-month data should be entered by the third working day of the month. If the data are unavailable, an estimate should be entered. The database must also accommodate mid-month and other survey records.

Snow depth is stored to the nearest inch, and the snow-water equivalent is stored to the nearest tenth of an inch.

622.0603 Data editing

(a) Scope and timing of SNOTEL data editing

SNOTEL editing procedures may be applied to the following standard sensors:

- snow-water equivalent (from the primary snow sensor)
- cumulative precipitation
- maximum, minimum, and average air temperatures
- snow depth

Other nonstandard sensors (such as soil moisture, wind speed, etc.) have varying degrees of quality control procedures applied, depending on the specific use of that information.

An initial validation screening procedure is automatically applied to data received from the SNOTEL station using the sensor profiles assigned to each station. This validation procedure, described in the data quality standard (NEH 622.0604), assigns a V (verified) flag to data that pass the validation tests and an S (suspect) flag to data that fail any of the tests.

Although many SNOTEL sites report multiple readings per day, editing procedures are applied only to the first reading of the day (typically the midnight reading). This midnight reading is standard to all SNOTEL sites.

On a weekly basis, data editors in the data collection offices review the previous week's data (single reading per day) and make editing changes as needed using the Data Management Platform (DMP) editing tool. As more data become available over time, editing decisions made previously can be reevaluated for correctness.

After the end of the water year (September 30), a careful review of the daily data set for the entire water year is performed. By February 1, edits to the previous water year's data should be completed.

These procedures present a basic guideline for data editing. If necessary, suspect data may be corrected by a staff hydrologist using best hydrologic judgment.

(b) Editing rules

Table 6–2 provides the snow-water equivalent (SWE) data editing rules. Table 6–3 gives the precipitation data editing rules. Table 6–4 provides the temperature data editing rules.

(c) Editing techniques

(1) Estimate missing SWE data (accumulation period)

There are several reasons why SWE data may be erroneous or missing for a period, including, but not limited to:

- leak in the snow pillow
- malfunctioning transducer
- complete site or telemetry failure

Table 6–2 SWE data editing rules

General rules	• Negative SWE values reported after melt-out should be edited to zero. • Current SWE reading should be between the upper and lower limits for that day as established by profiles, unless current hydrologic conditions indicate a new maximum or minimum limit is being established. • Physical site configuration and environmental conditions should be taken into consideration for all edit procedures.
If SWE increases…	• Precipitation (PREC) gages should show similar increases (exceptions include wind deposition or free water movement in the snowpack during melt-out). It is well documented that PREC gages are inefficient during months of heavy snow accumulation or strong winds. • Nearby sites of similar elevation should show similar increases, especially during widespread frontal storms. • Redundant sensors (multiple pillows, depth sensors, etc.) should show similar increases. • Increases should generally be within incremental allowable change as established by profiles.
If SWE stays constant…	• No increase in precipitation unless the minimum temperature (T_{MIN}) > 5 °C —this would allow rain to move through the snowpack without causing an increase in SWE. • Temperatures (and previously accumulated degree-days) should not indicate that melt is occurring.
If SWE decreases…	• Is the change within allowable limits based on profiles? • Do average air temperatures indicate melt or sublimation is possible? • Accumulated degree-days may indicate melt is possible (snowpack is ripe). • Redundant sensors show similar changes. • Nearby sites of similar elevation and aspect show similar changes. • Weather conditions indicate that no snowmelt or precipitation is occurring.

Table 6–3 Precipitation data editing rules

General rules	• Water year precipitation begins as 0.0 inch at 00:00 hours on October 1. Water year ends at 23:59 hours on September 30. • Never negative. • Never decreases. • Current reading should be within upper and lower limits as determined by profiles, unless current hydrologic conditions indicate a new maximum or minimum limit is being established. • Precipitation increments during winter months should be similar to SWE increments.
If precipitation increases…	• Incremental change is within limit as determined by profiles. • Nearby sites of similar elevation should show similar increases during winter frontal storm periods. • Redundant sensors should show similar increases.
If precipitation is constant…	• Nearby sites of similar elevation should show similar behavior (not conclusive). • Redundant sensors should show similar behavior. • During periods of intense snowfall, snow may either fill the barrel or cap the opening of the precipitation gage. Once the gage is plugged or capped, additional precipitation is blocked from the gage, resulting in erroneous data values, and followed by a large increase later.

Table 6–4 Temperature data editing rules

General rules	• Maximum temperature (T_{MAX}), minimum temperature (T_{MIN}), and average temperature (T_{AVG}) should not be equal. • $T_{MAX} > T_{AVG} > T_{MIN}$. • All temperature parameters should be within upper and lower limits as determined by profiles, unless current conditions indicate that new max/min limits could be established. • Current temperature should be within upper T_{MAX} and lower T_{MIN} limits. • Identical temperature values should not exceed 3 consecutive days. • Following site maintenance, data should be examined for potential errors. • Other sites with similar elevation and site characteristics should show similar readings.

With the increased use of SNOTEL near real-time data, estimates for missing data should be made during the weekly edits or on a daily basis if needed. It is relatively easy to estimate values accurately during the preliminary edits for sites that transmit data intermittently, provided the transmitted values are accurate.

The pillow system may fail during the winter, or the site may fail electronically, and immediate repairs are not possible. During these instances, the following techniques may be used to estimate the missing SWE data. These estimates should be made during the weekly preliminary edits while the current weather patterns and conditions are still known.

SWE estimates should be based on (in decreasing order of importance):

- similar sensors located at the same site
- other sensors located at the same site
- similar sensors at adjacent sites
- other sensors at other sites
- manual measurements (snowtube or manometer readings)
- other networks

If there is a pillow failure that will not be repaired, and there is another redundant SWE channel, remotely program a swap of the data channels.

If another similar sensor is installed at the site and estimates need to be done for a short period of time (e.g., transducer failure and the site is accessible during the winter), take the incremental difference for the working sensor and add it to the last valid reading from the missing sensor for the same time period.

If the sensors are similar, but different (e.g., a steel pillow vs. a polypropylene pillow), establish a relationship between the two sensors and apply the corrected increment to the missing sensor. If the relationship is one-to-one, remotely program a data channel swap between the two sensors.

(2) Use snow depth to estimate SWE data

If the site has only one primary snow pillow and has a snow depth (SD) sensor installed, use the density percent to estimate the SWE data. Use the following formula to calculate the density percent of the snowpack at the site:

$$\text{Density, \%} = \frac{\text{Snow water equivalent (inches)}}{\text{Snow depth (inches)}} \times 100$$

Example: Blossom Park (not a real SNOTEL site) SWE reads 35.6 inches. The snow depth reads 125 inches. What is the calculated snow density?

$$\text{Density, \%} = \frac{35.6}{125} \times 100$$
$$= 28.5\%$$

Density percents can be calculated for individual storm events from surrounding sites. A group of sites in the same geographical area will tend to have similar density percentages, especially during the winter months. Choose a correlating site of similar elevation and aspect. Apply the appropriate density to the depth increment.

Example: Blossom Park's pillow appears to have failed (table 6–5).

Table 6–6 shows the estimated SWE data. By checking other sites in the area, storm densities were calculated from December 3 to 4 density at 10 percent; December 4 to 5 density at 17 percent, and they are applied to the SD increments.

In this example, the overall pack density is 17 percent (12.0 in/72 in = .1667). Check the overall pack density with other sites in the area.

Table 6–5 Original Blossom Park data

Date	SWE (in)	PREC (in)	SD (in)	T_{AVG} (°C)
12/2	7.4	11.7	41	8.7
12/3	3.9	12.0	44	23.0
12/4	1.2	13.5	60	24.6
12/5	1.8	16.0	76	22.6
12/6	5.0	16.0	72	21.0

A good practice is to check the SWE percent of average from dates prior to the pillow failure with other sites in the basin. After the estimates are done, recheck the percent of average to make sure they are accurate.

(3) Use precipitation increments to estimate SWE values

If snow depth data are not available, use the increment from the precipitation gage and add that increment to the last valid SWE reading.

The following assumptions are made when using this technique:

- The first assumption is that the pillow and precipitation gage have a one-to-one relationship. However, this is not the case for the majority of SNOTEL sites. For these sites, develop a linear regression equation between the SWE increments and the PREC increments for the winter months of the period of record or a range of years. Apply this equation to the PREC increments during storm events at the affected sites.
- The second assumption is that the precipitation reading is correct. During periods of heavy snowfall, the precipitation gage may not accurately reflect the snowfall. In some locations of heavy wet snow or mixed rain and snow events, the precipitation gage may actually record more total precipitation than a properly working pillow system. Other times during heavy, wet snow events, the precipitation gage may cap or plug and not record the entire storm event. During storms associated with very cold temperatures and/or wind, the precipitation gage may not capture the entire storm event. Before applying the storm increment measured by the precipitation sensor, compare other data available, such as temperature, wind (if available), and similar reactions to the storm at adjacent sites.

Table 6–6 Edited Blossom Park data

Date	SWE	PREC	SD	TAVG (°C)
12/2	7.4	11.7	41	8.7
12/3	7.7E	12.0	44	23.0
12/4	9.3E	13.5	60	24.6
12/5	12.0E	16.0	76	22.6
12/6	12.0E	16.0	72	21.0

(4) Use adjacent sites to estimate SWE values

Winter frontal storms generally behave similarly over a large area. Consequently, amounts of snow received at one location may be similar to those amounts received at other nearby locations. However, SNOTEL sites generally do not have a one-to-one relationship for snow measured during a storm. The following methods can be used to estimate missing pillow readings:

- Develop a statistical relationship between the historic values for the accumulation period. A simple linear regression should be developed between the site with missing data (target site) and a nearby site (reference site). Apply this equation to the reference site SWE increments to estimate the target site SWE increments.
- When the target site's nonfunctioning, SWE sensor comes back online, a percentage method comparing total SWE increments can be used. For the target site: if data on both the end points of the period in question seem reasonable, determine the total SWE amount of the down period when the sensor was not reporting properly. Then, using the same period, choose a nearby site (reference site) and determine the total SWE received at that site.

Determine the percentage between the two sites using the following equation:

$$\frac{\text{Target site SWE total increment (inches)}}{\text{Reference site SWE total increment (inches)}}$$

Example: Target site, 3.65, reference site, 3.85. The percentage between the two sites is:

$$\frac{3.65}{3.85} = 0.9481$$

Multiply this percentage against the reference site's daily SWE increments to estimate the target site's SWE increments. Estimates may need to be smoothed to match the valid data at the end of the down period. Compare the values again with other data to ensure that these estimates are reasonable.

Choose a reference site that has a "good" relationship with the target site. Use the last valid SWE value for the target site, and divide that value by the corresponding value from the reference site. Multiply this decimal relationship to the daily increment of the reference site to estimate the missing values of the target site. Compare this estimate to other stations or other sensors to ensure that the estimates are reasonable.

If a site is down for an extended period, a remedial action plan should be implemented. The remedial action plan may include additional ground measurements if feasible.

These manual surveys may consist of ground truth measurements from around the pillow or snow course measurements. Ground surveys will reflect the density of the snowpack, which can be used to verify estimates if snow depth data was used. When using the SWE values from ground measurements, remember that the sample tubes overweigh. Develop a relationship between the historical pillow SWE and the ground truth or snow course SWE data before doing estimates.

If there is a problem with the pillow, manometer readings will most likely reflect that problem and will not give an accurate reading of the actual conditions. For example, if the pillow is drained, the manometer will also read near or below zero.

As a last resort, data from other networks may be used to edit missing SWE data if the data are near real-time and have been shown to be reliable. Once again, relationships need to be developed between the two data sets. Use caution if trying to estimate mountain SWE data from valley (low elevation) stations.

As additional data become available it will be necessary to re-evaluate the preliminary edits.

(5) Estimate missing SWE data (ablation or melt-out period)

There are several reasons why SWE data may be erroneous or missing for a period, including, but not limited to:

- leak in the snow pillow
- malfunctioning transducer
- complete site or telemetry failure

When snowmelt is actively in progress, precipitation gages cannot be used to estimate SWE values. In addition, rain on snow during the melt process complicates the estimation of snowmelt.

There are several methods available to estimate missing or erroneous SWE data. These methods are listed in order of preference, due to accuracy of the results.

Redundant snow sensor data—If the site is equipped with a backup transducer or a duplicate snow sensor, data from these sources are obviously the most useful in estimating missing SWE data for the primary sensor. SWE values may vary slightly from one sensor to another, but daily melt rates should be consistent between two adjacent snow sensors unless there are significant differences in aspect and exposure. The data logger can be remotely programmed to swap channels.

Snow depth sensor data—If a site is equipped with a snow depth sensor, depth data can be used to estimate the SWE data by using a density calculation method similar to the one described in NEH 622.0603(c)(1). Check other nearby sites of the same elevation and aspect to calculate an appropriate density, and then apply this density to the snow depth reading not the snow depth decrease increment. This is different than in NEH 622.0603(c)(1), which applied the density to the increase increment. Decreases in the depth data will be much larger than the decrease in SWE data. Therefore, if density were applied to the increment, it would result in excessively large melt increments. The density of the snowpack is higher during the ablation (melt-out) phase.

Ground truth measurements—The remedial action plan, as mentioned in NEH 622.0603(c)(1), may include additional ground measurements if feasibly possible. Ground truth measurements provide data points in the melt sequence. The daily data can then be interpolated between these points. Ground truth measurements are helpful in determining the density of the snow at the site. When using the SWE values from ground measurements, remember that the sample tubes overweigh. Develop a relationship between the historical pillow SWE and the ground truth data before calculating estimates.

Degree-day method—Another method for estimating ablation SWE data is the degree-day method. This method is based on the relationship of average air temperature to daily snowmelt. In general, air temperature is a good index of the energy available for melt in areas covered by dense forest vegetation. In open areas, temperature is not as reliable because short wave radiation, as well as sensible and latent heat fluxes (none directly related to temperatures), can exhibit wide variations dependent upon weather (Gray and Male 1981).

For SNOTEL sites located in forested environments, the degree-day method is a reliable estimation procedure as long as the melt coefficient is correctly calculated. Before describing this procedure, some definitions of terms are in order.

(6) Definition of terms

Degree-day—The average air temperature for a day (degrees Celsius) minus a base level (usually zero). Negative values should retain their sign to account for the addition of cold content to the snowpack when refreezing occurs during the melt process. Average air temperature is the best of the available temperature indices as an indicator of the energy available to melt snow.

Melt coefficient—Inches of snow-water equivalent melted per degree-day when snowmelt is in process. Melt rates were found to range from .15 to .31 inch per degree Celsius per day in a study by Yoshida (1962). Melt coefficients are site-dependent and vary primarily on the exposure of the site to solar radiation.

Cumulate degree-days—The sum of individual degree-days over a period.

(7) Degree-day procedure

Determine when snowmelt began—If the missing data period includes the start of snowmelt, it is critical to pinpoint when snowmelt began before applying the degree-day method. This can be accomplished through an aggressive ground truth schedule or comparison with nearby sites of similar elevation and aspect. Before the pack actively begins melting, some of the available heat energy (positive degree-days) is used to warm and ripen the pack. Subsequent energy is then converted into snowmelt.

Determine the melt coefficient—This is best determined when there is a clearly defined starting and ending point of the missing or erroneous data in question. If the end point is zero (melt-out), it is important to pinpoint this date as accurately as possible. The subprocedure is as follows:

- Compute the total inches of snow-water equivalent melted for the period in question.
- Sum the individual degree-days (average temperature) for the period in question to arrive at the cumulative degree-days. SNOTEL reports average temperature on the day after it occurred. Negative values need to be included in the summation to account for refreezing of the surface of the pack during cold periods. Divide the inches of snow-water equivalent melted by the number of cumulative degree-days. This gives the melt coefficient (inches of SWE melted per degree-day).

Note that this value can be calculated by analyzing data from previous years. Use caution, as melt coefficients can change from year to year.

Note also that the melt coefficient will need to be adjusted for periods of rain on snow. For periods of rain, the melt coefficient is adjusted (Gray and Male 1981):

$$\text{Melt coefficient}\left(\text{rain}\right) = \text{Melt coefficient}\left(\text{no rain}\right) + 0.0005 \times \text{Precipitation (in)}$$

Distribute the total melt on a daily basis using the observed average temperature for that day multiplied by the melt coefficient.

$$\text{Daily Melt} = \text{Average temperature} \times \text{Melt coefficient}$$

(8) Use nearby sites to estimate snowmelt

Nearby sites of similar aspect and elevation can be used to estimate snowmelt. Check the melt rates as well as the temperature data from the corresponding sites. Plotting the historical snow data with a corresponding site will give a graphical representation of the melt patterns and can aid in developing a relationship between the two sites. The melt rates are affected by the phase of the melt-out. Early melt phase should show smaller melt rates than those of the late melt phase.

If there are no sites in the nearby vicinity, use historic melt rates from a year with a similar pattern.

(9) SWE melt-out not returning to zero

When the snowpack on the snow pillow melts out, the SWE data values rarely return to zero, and, as a result, corrections may need to be made to the SWE data record.

SWE data are dependent upon the accuracy of snow pillows and the pressure transducers. As a rule, transducers are considered to be accurate within ±1 percent of the transducer's capacity. If the melt-out value is within ±1 percent of the capacity of the transducer, the data editor may smooth the data values for the last day or two of the ablation period so that the record shows a melt-out to zero. For example, if the site has a 50-inch transducer and melt-out ranges between –0.5 and +0.5 inch, the data editor will edit the data values to show a steady melt-out to zero.

If the nonzero data value after melt-out stays consistent for several days, the offset should be adjusted so that the data values continue to track at or very close to zero for the summer period. Many sites will require this offset adjustment after melt-out. Note: If the data value is less than ±0.3 inch(es), adjustment of the offset is not recommended.

Having an accurate offset at the beginning of the snow accumulation season is critical for the accuracy of the data values throughout the winter and allows the data values to return close to zero at melt-out. The data values should be at zero or less than ±0.5 inch(es) to begin the new snow accumulation season.

If the melt-out data value exceeds the ±1 percent of the transducer capacity, further analysis of the data is required. The data editor should determine if an offset was made to the SWE data either at the beginning of the water year or sometime during the winter. If so, it is likely that the magnitude of this adjustment will be similar to that of the melt-out value. If the melt-out data value is ±0.5 inch(es), simple smoothing of the data as mentioned above is all that is necessary. If the data value is larger than ±0.5 inch(es), then a larger portion of the data or the whole record from the start of permanent snowpack may need to be adjusted.

Before any mass editing is made to the data, ground measurements taken during the winter must be reviewed. Manometer readings can verify the accuracy of the data. If the data falls in line with a winter manometer reading, then a mass edit to the entire record is not appropriate. The adjustment can be worked into the melt-out data values to end at zero. Plotting of the SWE data with corresponding sites is helpful in verifying the edited data.

Checking the transducer for accuracy and the condition of the snow pillow should be added to the summer maintenance needs list.

(10) Different manometer or ground truth readings and telemetry data values

SNOTEL data should be considered accurate as reported. Manometer and ground truth readings are to be used as verification of the data. The data values should not automatically be changed to match these readings if there is a difference between the two.

Recognize that manometer readings and ground truth measurements have inherent measurement problems. Exercise caution before changing the telemetered data to match them. The SWE manometer readings must be corrected for specific gravity before using the number to verify or adjust the telemetered reading. Snow samples obtained using the standard Federal sampler must be corrected for over measurements as well. Personnel collecting these measurements can make errors, and the readings should be checked for accuracy.

If there is an issue with the manometer reading, such as a drained precipitation gauge or a flat pillow, use the ground truth readings. Also, use the manometer or ground truth measurements to adjust a telemetered data value if the SNOTEL site has been down or the data are unreliable due to instrument failure. These on-site readings are needed for estimation of data values.

(11) Transducer changes

SNOTEL sites rely on pressure transducer voltage values to convert SWE and precipitation amounts to inches of water. These instruments can be the cause of poor quality data due to some internal malfunction or complete failure of the transducer. As a result, they will need to be replaced.

If a transducer is changed, the data editor needs to compare the previous SNOTEL reading to the current SNOTEL reading. If needed the channel offset on the

SNOTEL computer may be adjusted so that the current reading matches either the known or estimated good previous reading. This process yields a smooth transition between the data collected by the old transducer and the new transducer. If the previous reading needs to be estimated, refer to the procedures outlined in other sections concerning estimating missing SWE and precipitation data.

When precipitation, either in the form of snow or rain, occurs at the site while a transducer is being changed, this precipitation increment would not be reflected in the next telemetered value. The data editor should estimate an increment and include this in the new offset calculation. Other sensor data from the site (e.g., snow depth) are most useful in determining storm events. Observations noted on the SNOTEL data sheet about the precipitation event such as “rained heavily—estimate 0.5 inch for an hour between 2:30 and 3:30 pm” or “snowed heavily throughout the day, accumulating about 8 inches,” are very helpful in determining the increment.

If a transducer is changed, it is important to confirm that the correct conversion equation (sensor label) is in place in the SNOTEL database for that particular transducer (e.g., SWC2 = 100 inches) on the pillow.

Manometer readings are also helpful in determining if the wrong label has been assigned. For example, if the 100-inch label were assigned to a 50-inch transducer, the telemetered data would be roughly twice as much as the manometer reading.

After verifying that a wrong label has been assigned to a data channel, the following procedure should be followed:

- Determine the starting date of the error. This can be done by studying previous maintenance notes and offset histories.
- Make the necessary changes to the data in a mass edit of the data in error. Another option is to request a remapping of the sensor data by the SNOTEL database administrator.
- Check the entire record to smooth out any erroneous values.

(12) Remove incidental data fluctuations (smoothing data)

The standard SNOTEL precipitation gage is constructed out of heavy gauge aluminum and comes in a variety of heights designed to keep the top orifice above the maximum expected snow accumulation depth. The precipitation gage is designed to catch all forms of precipitation and is considered an all-weather gage. However, it has been documented and recognized that these gages “under catch” during certain storm events.

For the purpose of this section, smoothing is defined as small fluctuations in the readings of ±0.5 inch(es). If the fluctuations in readings are greater than ±1.0 inch (es), a maintenance need should be noted. When the data values are fluctuating more than the acceptable amount, the data editor should edit the values using techniques described in this document.

The following are examples of fluctuation causes:

- Heating and cooling of the precipitation gage throughout the day results in expansion and contraction of the gage.
- Readings can fluctuate due to air being trapped inside the line which connects the gage to the transducer (devices which translate pressure into an equivalent voltage value).
- The transducer itself may cause the readings to change slightly due to temperature effects on the transducer or air that is trapped inside the transducer chamber.

All of these reasons may cause the SNOTEL precipitation value to vary slightly with no precipitation input and the telemetered value must be “smoothed” by the data editor.

To smooth the telemetered value properly, a general knowledge of weather conditions in the area is extremely valuable. Knowing if precipitation occurred in the area will enable the data editor to examine the amount of precipitation increases and make proper adjustments to the reading if necessary. If weather conditions are not known or are not available, then the data editor must rely on other sensors available at the site, or use adjacent (companion) sites to corroborate any change in precipitation. During the summer months, using adjacent sites can be difficult due to the nature of spotty, convective types of storms. During the winter months, when there is a permanent snow pack on the snow pillows, the data editor should use the pillow telemetry change to verify a change in a precipitation value. The snow pillow and precipitation gages, while two different sensors, should record similar changes if precipitation actually occurs. The data editor should examine the air temperature data to determine the type of precipitation that may have occurred (rain or snow) to make an accurate judgment of a smoothing type of change.

(13) Match amount and timing of precipitation and/or SWE increases

SNOTEL sites include two independent means of measuring winter precipitation: storage precipitation gages and SWE sensors (typically fluid filled snow pillows). During the winter, precipitation gages and SWE sensors may not necessarily have a one-to-one incremental relationship. Reasons for this include:

- Extensive research has proven that precipitation gages are subject to “under catch” of snowfall, especially when wind accompanies the snowfall event.
- Precipitation gages can lag in response to a snowfall event due to plugging, capping, or adherence of snow to the inside of the gage.
- SWE sensors can lag in response due to bridging of the snowpack over the snow sensor, especially when ice layers exist within the snowpack.
- Low data logger battery voltages may affect the data values.

Precipitation gages and SWE sensors may report different increments during winter snowfall events because of the reasons stated. However, the timing of increases should be the same. Therefore, editing adjustments may be applied so that SWE and precipitation data values agree in terms of timing, but the increment of either data value should not be adjusted unless an identified problem exists.

The data editor should use all available information to determine the timing of precipitation events if the two sensors do not agree. Useful information includes:

- snow depth and other redundant sensor data
- general knowledge of current weather conditions
- response from nearby sites
- satellite imagery over the period in question

When a discrepancy exists between the two sensors, the data editor should distribute the precipitation or SWE increments to match the best estimate of when the snowfall event actually occurred. Offsets should not be made to adjust actual increments unless there is a clearly defined problem with one of the sensors (such as capping of the precipitation gage).

(14) Decreases in precipitation

By definition, cumulative precipitation cannot decrease. There are several potential causes of apparent precipitation decreases, including:

- Data flutter—Telemetered SNOTEL precipitation data from a properly working site should only require smoothing minor fluctuations of the data values. Minor fluctuations (±0.5 in) sometimes occur between the telemetered values from day-to-day due to temperature variations. If minor fluctuations are observed in the data, refer to the techniques referenced in the previous section for removing minor fluctuations in precipitation data. At the beginning of the water year, minor fluctuations around zero may occasionally produce a slightly negative number. Negative values should be edited to zero.
- Recharging the precipitation gage—The SNOTEL precipitation gage is recharged annually. This process includes draining the old antifreeze solution and accumulated precipitation and adding new recharge solution and oil. After the gage is recharged, the offset is adjusted accordingly to return to the data value reported prior to the recharge. Any precipitation that has occurred since the recharge must be included in the new offset. Data fluctuation in all records resulting from the recharge should be reviewed and edited.
- Equipment changes—If a transducer has failed, data values may need to be estimated until the transducer has been replaced. The precipitation manometer reading may be used to re-evaluate the estimated data values to determine if additional editing is required. The offset may need to be adjusted accordingly. Changes of transceivers, cables, shelters, etc., may also necessitate editing.
- Evaporation from precipitation gages—Even though an oil layer is present on top of the solution in the precipitation gage, some sites may experience a slow decrease in the telemetered

values during warm periods in the summer with no precipitation. This decrease is probably due to evaporation rather than a leak in the system. If the problem were a leak, the data values would continue to decrease with little or no fluctuation of data. If the problem is due to evaporation and the data editor is confident there is no leak in the system, the following guidelines should be used to correct the problem:

— If the decrease is 0.5 inches or less, edit the data to the telemetered value on the day the dry spell began. The difference will be dispersed with the next precipitation event.

— If the decrease is 0.6 inches or greater, edit the data to the telemetered value on the day the dry spell began. The data editor may choose to apply an offset change to increase the precipitation channel to the edited value. It is prudent to make a single offset change when precipitation resumes rather than making multiple offset changes during the dry period.

- Leaking precipitation gages—If a leaking precipitation gage is suspected due to a consistent decrease in telemetered data values, the data from the time the leak began until the time the gage was repaired will be edited to approximate what the gage would have read. Refer to these editing procedures. If a site is reporting consistent decreasing precipitation data values, use the following proportioning method to eliminate missing or erroneous precipitation data.

— During the snow accumulation period, SWE increments can be used to help estimate the precipitation (PREC) increments. It should be understood that it is rare to have a one-to-one relationship between the two. An analysis of incremental changes in SWE and PREC should be done to establish the appropriate relationship. Ideally, this analysis will cover a minimum of 10 years.

— When reliable SWE data are not available, a relationship of incremental precipitation data values should be established between the problem site and a corresponding reference site.

— Compare with nearby site(s) to ensure the edited values are reasonable.

- Plugged or capped precipitation gages—During periods of intense snowfall, snow may either fill the barrel or cap the opening of the precipitation gage. Once the gage is plugged or capped, additional precipitation is blocked from the gage. This phenomenon results in no apparent precipitation increases for an extended period of time, followed by a large increase in precipitation at a later date within a very short period of time. This anomalous increase in precipitation usually occurs when solar radiation warms the barrel of the precipitation gage, allowing the plug to slide down into the fluid solution at the bottom of the gage. The total increase in precipitation observed after the plug or cap is incorporated into the fluid may or may not represent the total precipitation received by the station during the period when the gage was affected. Following are techniques and editing procedures to be used for determining if a precipitation gage is plugged or capped.

- If a gage is plugged or capped—Plugged or capped gages are usually discovered during preliminary edits or when reviewing data during storm events. The gage in question usually does not have the same increase as the associated pillow or other stations in the area. Further evidence of a plugged or capped gage becomes apparent at some time after a storm (this period of time may range from hours to weeks) when there is a sudden increase in precipitation at the station with no increase in SWE or precipitation at other adjoining sites. This increase in precipitation is usually associated with an increase in temperature or exposure of the gage to direct solar radiation.

- Edit the data—When precipitation data are believed to be incorrect, incoming data should be assigned a suspect flag and remain suspect until the problem is resolved. Prior to editing the data from a capped or plugged precipitation gage, the data editor should determine whether the gage was capped or just plugged. If the increase in precipitation after the plug is incorporated into the precipitation fluid equals or exceeds the amount recorded on the pillow at the same site, then the gage was most likely plugged, and all the precipitation that fell during the storm period was caught inside the gage. In this case, the lag in precipitation can be edited by redistributing the precipitation increment using the increases on the pillow channel. This technique can be accomplished providing there is no snowmelt. To edit the precipitation data, a relationship between precipitation and SWE increments must be developed. The percentage method which is explained in the following example may be used to estimate data values.

Example (readings in inches): Table 6–7 provides the information for example original data, percentage method.

In this simplified example, the total SWE and precipitation for the storm event were equal. However, it is apparent that the precipitation did not follow the timing of the snow event, and made a large increase when the temperature increased. Table 6–8 is an example of edited data. After determining the SWE values are correct (by comparison with other sensors or other sites), this data can be handled as a "plugged precipitation gage" and one can apply a one-for-one increment for the PREC sensor.

Table 6–7 Example original data (percentage method)

Date	Time	SWE	PREC	TEMP (max)
Jan 9	0000	10.9	15.3	–2.5
Jan 10	0000	13.5	15.9	–3.5
Jan 11	0000	14.2	15.9	–5.6
Jan 12	0000	14.2	15.9	–2.5
Jan 13	0000	14.2	18.6	5.0
Total		**3.3**	**3.3**	

Table 6–8 Edited data (percentage method)

Date	Time	SWE	Diff	PREC (edited)	TEMP (max)
Jan 9	0000	10.9		15.3	–2.5
Jan 10	0000	13.5	2.6	17.9E	–3.5
Jan 11	0000	14.2	0.7	18.6E	–5.6
Jan 12	0000	14.2	0.0	18.6E	–2.5
Jan 13	0000	14.2	0.0	18.6	5.0

If, after a storm, the precipitation increment is greater than the SWE increment, the precipitation may be edited by using a "percentage" method. Table 6–9. is an example of this method.

$$\frac{\text{Total PREC increment}}{\text{total SWE increment}} = \frac{4.5}{3.3}$$
$$= 1.36\%$$

1.36% times SWE increment is equal to the PREC increment (example: $1.36 \times 3.3 = 4.5$; $15.3 + 4.5 = 19.8$) as shown in the table 6–9 in the PREC column. Multiply the daily SWE increment by 1.36 to obtain the daily estimated PREC increment (Jan 9–10 PREC increment $= 1.36 \times 2.6 = 3.5$).

If the precipitation increment lags behind the SWE increment after the plug has fallen in, the precipitation gage may have been capped and not all of the precipitation (snowfall) captured in the gage. Before editing the precipitation data, one must verify which sensor has the erred data by a review of data from surrounding stations (both SNOTEL and other networks). Again, the past relationship between the precipitation and the SWE for each site has to be reviewed. If history has shown a good relation between SWE increases and precipitation increases, then one can generally edit the precipitation by applying the same increment measured by the pillow to the precipitation as was exhibited in table 6–10. If a site does not generally exhibit a one-to-one relationship, then the relationship between precipitation and pillow increments can be used. In instances of a capped precipitation gage, an offset must be made to correct the transmitted data.

Table 6–9 Original data, percentage method

Date	Time	SWE	PREC	TEMP (max)
Jan 9	0000	10.9	15.3	–2.5
Jan 10	0000	13.5	15.9	–3.5
Jan 11	0000	14.2	15.9	–5.6
Jan 12	0000	14.2	15.9	–2.5
Jan 13	0000	14.2	19.8	5.0
Total		**3.3**	**4.5**	

Example: Based on historic comparisons between SWE and PREC at a site, it is determined that the precipitation gage usually only receives 90 percent of the SWE measured by the snow pillow. In this example, if the precipitation gage was capped, the data could be estimated by taking 90 percent of the amount of SWE measured by the pillow and applying this to the precipitation for the duration of the capped gage.

After editing data and applying offsets as needed, the corrected data values should be compared to the same data values for the surrounding sites. Generally, the total precipitation in a localized area should be approximately the same percent of average. If the site in question is "significantly" different, further investigation may be warranted.

There are many environmental factors that can affect precipitation gages. However, there are also nonenvironmental factors that can affect the performance of the gages. For example, there may be a leak in the precipitation gage at a certain height (e.g., bullet holes), or a manometer line may be overtopping. The site may have been damaged by a storm or vandals.

Generally, plugged or capped gages adjust fairly rapidly to warming conditions. However, there may be times when this is not the case. In areas of deep snow, snow may adhere to the inside of the gage below the snow line, in which case the snow will insulate the gage, often preventing the plug from falling in for an extended period of time.

In extremely deep snow years, the entire precipitation gage may be buried. In locations where there are prolonged periods of little or no sunshine, capped or plugged gages may not thaw out for months. When this happens, estimates will need to be made over an extended period using techniques mentioned in the "Missing Precipitation" section. Such techniques would include comparison to other sensors at the site, adjacent sites, percent of average, etc. Estimates of the missing data need to be done to ensure the completeness of the archive database.

Table 6–10 Percentage method results

Date	Time	SWE	PREC	TEMP (max)
Jan 9	0000	10.9	15.3	–2.5
Jan 10	0000	13.5	18.8E	–3.5
Jan 11	0000	14.2	19.8E	–5.6
Jan 12	0000	14.2	19.8E	–2.5
Jan 13	0000	14.2	19.8	5.0
Total		**3.3**	**4.5**	

(15) Air temperature data

SNOTEL sites report current (T_{OBS}), maximum (T_{MAX}), minimum (T_{MIN}), and average (T_{AVG}) air temperature data. Current air temperature data are at the time of polling. Daily maximum, minimum, and average air temperature data are reported for the previous 24 hours (midnight to midnight). All air temperature data are recorded in degrees Celsius.

The air temperature is updated in the data logger every minute for a total of 1,440 updates (60 minutes × 24 hours). The highest value of the 1,440 updates is considered the maximum reading for the day. The lowest value of the 1,440 updates is considered the minimum reading for the day. The daily average is the calculated average of the 1,440 updates.

General rules for editing air temperature data—

- T_{MAX}, T_{MIN}, and T_{AVG} should not be equal.
- $T_{MAX} > T_{AVG} > T_{MIN}$
- All temperature parameters should be within upper and lower limits as determined by profiles, unless current conditions indicate new max/min limits could be established.
- Current temperature should be within upper T_{MAX} and lower T_{MIN} limits.
- Identical T_{MAX}, T_{MIN}, T_{AVG} values should not occur on more than three consecutive days.
- Following site maintenance, data should be examined for potential errors.
- Other sites with similar elevation and site characteristics should show similar readings.

Daily editing of air temperature data—The data editor should check for missing or potentially suspect values using the general editing rules. Profiles should be developed to establish upper and lower bounds for

T_{MAX}, T_{MIN}, and T_{AVG}. Initial screening should involve single station checks (site history and redundant sensor data) and surrounding station or other network station checks. Plotting the temperature data with surrounding sites is very beneficial in determining if the data are reasonable.

Unusual measurements can come from several sources:

- sunlight radiating from the snow heating the solar shield from below
- the temperature sensor closer to the "ground" as snow accumulates during the winter
- insects or animals eating the wiring
- insects or birds building nests in or around the gill shield
- trees or other dark objects growing close to the sensor absorb solar radiation
- deep snow burying the sensor
- sensor degradation or calibration change occurs
- nearby lightning strikes
- thermistor drops inside the pipe
- stray voltage

During the winter months and in periods of inactive weather, inversions (temperature increases with elevation) are frequent in the mountainous and intermountain regions where nearly all of the sites are located. These inversions can be surface-based or elevated and sometimes lie atop very deep pools of cold air trapped in valleys. Most SNOTEL stations are at or above the inversion level, so their temperatures will be quite different from temperatures reported at other SNOTEL sites at lower elevations or nearby valley stations.

Reasonable limits checks—If the temperature data exceed an established profile and are marked with suspect flags, the data can be graphed against surrounding sites for an extended period of time. If the suspect data fall within the graphed data with other sites, the data should be considered valid and the suspect flag changed to valid.

If the suspect data are outside the graphed data, further investigation is necessary. Redundant temperature data such as hourly readings can be used to support or refute the daily data value.

Spikes—Spikes in temperature data are very obvious when the data are plotted against surrounding sites. Spikes can increase or decrease by 30 to 40 degrees within an hour's time, and most likely would not be supported by the temperature data at nearby sites. If hourly temperature data are available, the spike will likely be included in that data string as well, and may need to be edited or removed from non-midnight readings. If the spike does not appear to be a real value, look at previous and subsequent data to determine an appropriate edit value for the spike.

Large increases or decreases—Large increases or decreases in temperature data are different than spikes. These increases and decreases are typically supported by other site comparisons and other temperature parameters.

At certain SNOTEL sites arctic blitzes or warm Chinook winds are common. Temperatures can fall or rise rapidly within an hour as the storm front approaches or passes. Other weather reports can also support large increases or decreases in temperature data.

Estimate missing or erroneous daily temperature data—If a SNOTEL site has lost the data from the data logger or the data are not accurate, daily temperature data will need to be estimated. Cross comparisons over a period of time should be processed with surrounding sites to determine the best reference site. After a reference site has been selected, a correlation and equation can be developed between the two sites for the period in question. Summer temperatures should be evaluated separately from winter temperatures. Inversions and weather anomalies should be noted.

Once the T_{MAX} and T_{MIN} data have been estimated, calculate the average between the two for the T_{AVG} values. After the estimates are done, plot the estimated data against data from surrounding sites for a final evaluation.

Ongoing research continues with other agencies and universities to create automatic data estimates for air temperature values. These software programs may be used after sufficient testing has been completed to determine reliability of the estimation programs.

(16) Snow depth

Snow depth is a measurement of the depth of snow on the pillow and is recorded to the nearest inch. The measurements are taken with an ultrasonic sensor positioned above the pillow. Snow depth is directly related to the SWE data. Editing of the snow depth data in conjunction with the SWE data is recommended. (See section 622.0603(b), Editing rules.)

Edit from beginning of water year to start of permanent snowpack—Depth sensors tend to fluctuate significantly and rarely read zero with no snow on the pillow. Due to these fluctuations, it is difficult to determine if a storm actually occurs. Examining the SWE, temperature and precipitation data will assist in making that determination. Once permanent snowpack begins, the depth sensors work very well.

Temperature fluctuations can influence the snow depth readings when there is no snow on the pillow. The sensor can pick up heat radiation waves from the pillow which result in false depth values.

Maximum depth readings—A maximum depth reading is approximately equal to the height of the depth sensor. Causes of erroneous maximum depth readings may include:

- heavy snow storms with strong winds
- colder temperatures typical with clearing after a storm
- ice on the sensor lens
- poor connection or wiring
- bad sensor
- sensor is buried by snow

In some cases, the sensors will start reporting good values on the same day of the storm. In others, the data may have to be edited for an extended period of time using the methods mentioned.

When feasible, ground truth measurements should be taken to verify the depth and density percent of the snowpack.

Edit snow depth during accumulation of permanent snowpack—As the SWE data increases with a storm, so should the depth sensor. The amount of depth increase is dependent on the density of the newly fallen snow. Typically, newly fallen snow has a density of approximately 10 percent. This can vary depending on temperature and site location.

The following equation is used to calculate the density of the snow during storm events:

$$\text{Daily Melt} = \text{Average temperature} \times \text{Melt coefficient}$$

For example, SWE Increment = 1.5 inches and snow depth increment = 14.

$$\frac{1.5}{14} = .107 = 11\% \text{ density}$$

Depth data will increase appropriately with new snow and then can decrease substantially the next day due to settling. This is very apparent when the density of the new snow is fairly light (4 to 5%). A density of 3 percent or lower needs to be investigated.

If the SNOTEL site is configured to report multiple readings per day, those extra readings can be very helpful when editing a midnight (timestamp 00:00) reading.

During heavy, windy storm events, it is not unusual for the depth sensor to read a maximum depth reading, such as 220 inches compared to a previous reading of 80 inches, and may read this value for several days while the SWE values continue to increase. Snow depth data are edited by looking at the incremental densities from a corresponding site and applying this density to the SWE increment. Use the formula:

$$\text{Depth} = \frac{\text{SWE increment (in)}}{\text{Density (\%)}}$$

Example: For example if SWE increment = 1.5 inches, and density percent = .12, what is the depth?

$$\text{Depth} = \frac{1.5}{.12}$$
$$= 12 \text{ inches snow depth increase}$$

The actual calculated value in the previous example is 12.5, but snow depth precision is to the nearest whole inch. Use the SSWSF-approved rounding method.

SSWSF rounding method—The SSWSF Program rounding convention is bankers rounding, also known as unbiased rounding and round half to even.

In bankers rounding, if the value is in a perfect half case, one must round to the nearest digit that can be divided by 2.

Positive numbers	*Negative numbers*
1.245 round to 1.24	–1.245 round to –1.24
1.255 round to 1.26	–1.255 round to –1.26

- Data will be stored at the most significant figures available to enable precise conversions.[1/]
- When data are accessed, they will be accessed at the precision or accuracy specified for that specific data element.
- A data precision data element will be maintained in all future SSWSF Program databases where these data are stored.
- Any stored values used in calculations will be rounded to the specified precision prior to starting the calculation. Intermediate results are not rounded. Final results are to be rounded to the precision specified by the business application owner.
- Rounding is to be performed as the last calculation.

During periods of no storm activity and colder temperatures, as the snowpack is settling, the depth sensors will typically decrease by an appropriate amount per day for that site (e.g., 1 inch). This is a good rule if estimates have to be made during this period and past records support this rate of decrease.

After a heavy storm, if the sky clears and the temperatures drop, the depth sensors will behave strangely. Some sensors will report a maximum or a negative depth reading for several days until the temperatures moderate. These values will need to be smoothed as the data becomes more accurate.

Ground truth measurements are very useful for verifying the depth and density percent of the snowpack. The ground truth and the sensor readings will not be an exact match but should be within a 5 percent range.

Edit snow depth data during ablation (melt out)—Once the snowpack has gone isothermal and begun earnest melt, the snow depth decreases correspond to the SWE decreases and are more consistent and uniform than the decreases seen during periods of no storm activity. In most cases, there will be very little editing during the melt phase.

When using the density percent method to estimate snow depth data during melt out, apply the density percent to the SWE reading not the increment. Use the following formula:

$$\text{Depth} = \frac{\text{SWE reading (in)}}{\text{Density (\%)}}$$

For example, SWE = 13.5 inches, Density percent = .35;

$$\text{Depth} = \frac{13.5}{.35}$$
$$= 39 \text{ inches}$$

The actual calculated reading is 38.57 inches, but snow depth precision is to the nearest whole inch. Use the SSWSF-approved rounding method.

Density of the snowpack should be checked throughout the melt phase. If the density is greater than 55 percent, the SWE data needs to be reviewed for excessive melt rates, and edits may need to be applied.

Maximum depth readings can also be erroneously reported during the melt phase. Use the density percent method to estimate the depth data.

A snow depth sensor will rarely read zero when the pillow is bare of all snow. Adjusting the offset to force the data to zero is not recommended. Because the sensors are ultrasonic, the data will fluctuate significantly

1 For example, consider temperature data, which may be in either Fahrenheit or in Centigrade. Fahrenheit has whole integer precision, while Centigrade has 0.1 degree precision. Converting from C_1 -> F -> C_2 with rounding of the intermediate value prior to conversion back will result in $C_1 \neq C_2$. We retain the ability to freely convert without loss by retaining additional digits in the database.

when the pillow is bare. Any coverings on the pillow, such as hardware cloth or chain link fence, can be read by the depth sensor. Debris on the pillow, such as twigs or branches, can also be registered. During this time, the data editor should edit the data to zero.

(17) Nonstandard sensors

Nonstandard sensors include, but are not limited to:

- wind
- relative humidity
- solar radiation
- battery voltages
- soil moisture and soil temperature sensors

This data should be reviewed for performance issues and data validity. Obvious spikes or false data may be edited or removed as determined by the data collection officer.

622.0604 Data quality control

(a) SNOTEL data quality control

(1) Data flagging system

A flag is attached to each data record to indicate its validity. A valid, or V, flag indicates the data met basic profile limits. However, if no profile is in place for the sensor, a V is attached by the WCIS storage program to the data record as the default.

If the data does not meet the limitations of the sensor profile, a suspect, or S, flag is attached by the storage application to the data record. This alerts the data editor to review this data for its validity.

Note: When the S flag is manually inserted, once valid data are again observed, the S flag should be manually removed.

If the data editor edits a value, an edit, or E, flag is attached to the data record by the data management platform (DMP).

For more information on data flags, refer to “WCIS Data Flag Definitions.”

(2) Profile development

Profiles are created for sites and sensors to automate data quality checks. These profiles are developed by the data editor from historical data, if available, or data from other sites with similar characteristics. Profiles will be developed and implemented for SWE, snow depth, cumulative precipitation, and maximum, minimum, and average air temperatures (T_{MAX}, T_{MIN}, and T_{AVG}).

Recommended parameters

- SWE—upper, lower, increase, and decrease
- cumulative precipitation—upper, lower, and increase
- snow depth—upper and lower
- temperature (T_{MAX}, T_{MIN}, T_{AVG})—upper and lower

In addition, profiles can be developed for other sensors as desired. These profiles are used by the storage application to place the appropriate flag (V or S) to each data record to identify questionable data.

Profiles are intended to be used for first-of-day (00:00 or 00:01) readings only.

(3) Data review and editing
All SNOTEL data must be edited using the DMP.

Preliminary review and editing of the SNOTEL data (00:00 or 00:01 reading for SWE, cumulative precipitation, air temperature, and snow depth) must be completed at least once a week. Daily edits or estimates are required if the SNOTEL station's data are used in a forecast model. Other nonstandard sensors (soil moisture, wind speed, etc.) have varying degrees of quality control procedures applied, depending on the specific use of that information.

The data editor and WCIS database manager will run a final quality control check prior to archiving final water year data.

(4) Correction of improperly configured data
When a data editor determines that a catastrophic error has occurred in a sensor configuration, the data editor will notify the SNOTEL database administrator that the data record block may need to be deleted and reloaded. The original data record block will be extracted by the SNOTEL database administrator from the master station log files for reloading into the database.

When a sensor definition is determined to be incorrect after data has been stored, and if the correction would result in a different converted value, a retroactive correction to a sensor record must be performed, and the appropriate algorithm will be applied to the raw data set by the SNOTEL database administrator with approval from the appropriate data editor.

(5) Manual data quality control
See quality control standards in NEH622.08.

622.0605 Station management

(a) Management of SNOTEL and snow course stations

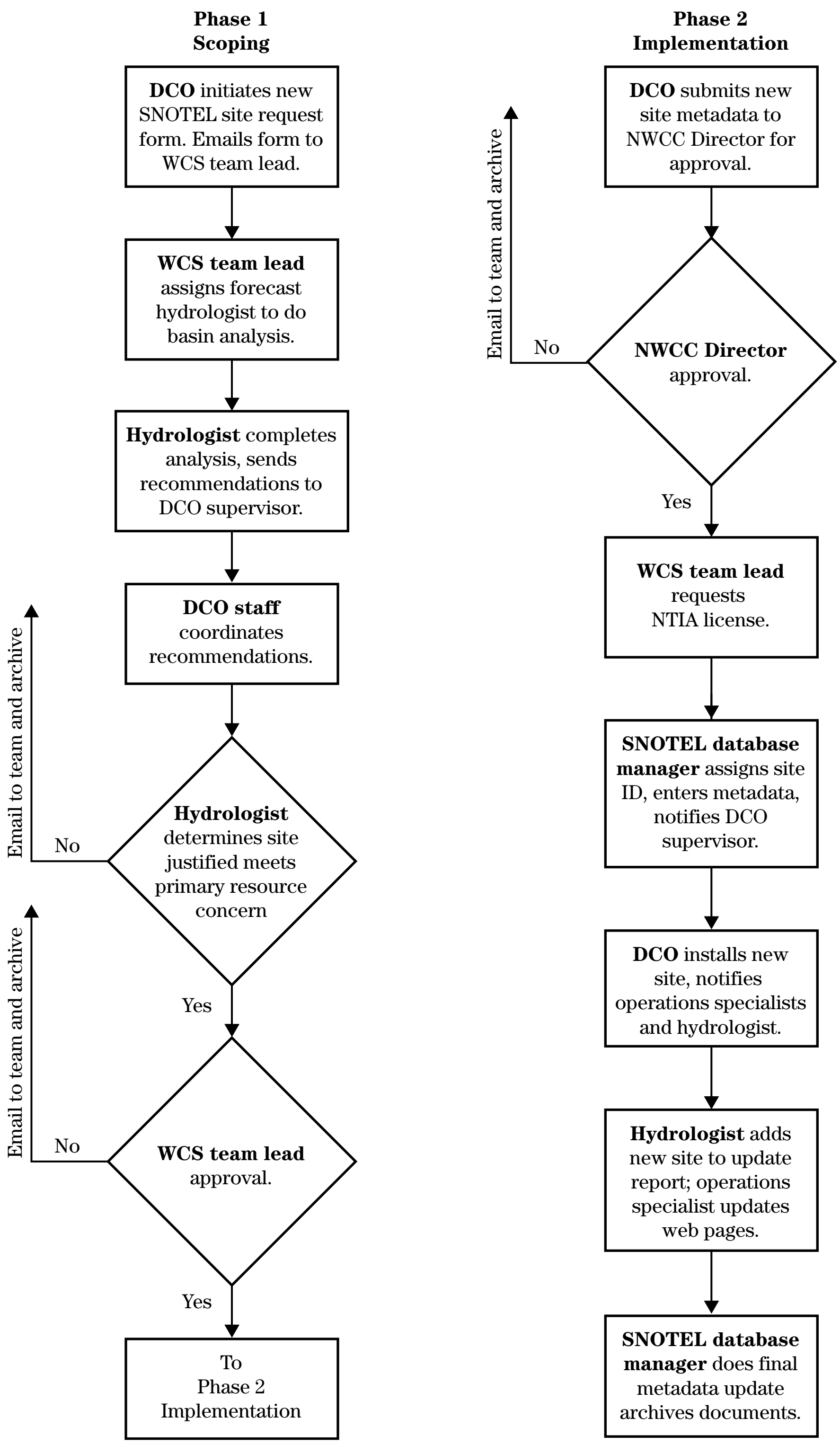
The following sections describe the procedures to request a new SNOTEL station or snow course.

(1) SNOTEL stations
Prior to the request for the addition of a new SNOTEL site, the DCO supervisor works with the SSWSF Program manager, NWCC director, and NWCC hydrologist to determine the advisability and cost-effectiveness of adding the station. The flowchart in figure 6–3 shows the process to set up a new snow survey data collection site.

(2) Remote site form metadata

- SNOTEL ID
- station name (see standard)
- latitude
- longitude
- elevation
- GPS datum
- state
- county
- data collection office
- hydrologic unit code
- time zone
- nearest town
- direction to nearest town
- ACTON ID (CDBS ID) (see section 3).
- installation date
- other helpful data:
  - — section, township, range
  - — Will the site report in engineering units or scaled millivolts?

Figure 6–3 Process to set up a new snow survey data collection site



— Does this site correspond to or replace a snow course site?

— number of reporting groups

(3) Assign an ACTON ID

The ACTON ID is based on a grid system. It is used to designate snow courses, aerial markers, soil moisture sensors, precipitation gages, and SNOTEL sites. Numbers are assigned based on coordinates of 1 degree latitude and 1 degree longitude to form cells within which snow courses and SNOTEL sites are numbered from 1 to 99. Each cell is designated by a number and a letter.

For example, the Morse Lake snow course (21C17) is located in the cell that is bounded by 121 degrees and 122 degrees longitude and 46 degrees and 47 degrees latitude. The number 21 designates longitude and the letter C designates latitude.

Numbers designating longitude are derived by subtracting 100 degrees from the lesser of the two longitude values. Letters designating latitude start in the first tier south of the Canadian border and run south as A, B, C….Z. The letters I, O, and Q are not used.

The number 17 in the example differentiates Morse Lake from other snow courses in the cell.

A soil moisture sensor at or near a snow course is designated by the letter M at the end of the ACTON ID. An aerial marker at a snow course is indicated by the letter A; a precipitation gage is indicated by the letter P; a SNOTEL site is indicated by the letter S.

In Alaska, the longitude letters begin with GG at 55 degrees north and continue to WW in extreme northern Alaska.

(b) Manual snow courses

The data collection officer assigns a snow course station ID based on the same ACTON grid identification system as listed in section 3 and then notifies the NWCC database manager.

In addition, the data collection officer provides the following metadata information for the snow course:

- station name
- latitude
- longitude
- elevation
- GPS datum
- state
- county
- data collection office
- hydrologic unit code
- time zone
- first measurement date
- section, township, and range

(c) Status of stations

The DCO will advise the NWCC if a station or snow course becomes discontinued.

(d) Station permissions

The DCO can authorize personnel to access station and sensor information and advise the SNOTEL and AWDB database manager(s) to add those permissions and/or limitations to the individual logins.

622.0606 Sensor management

(a) SNOTEL sensor management specifications

(1) Sensor definition

- must be defined within WCIS
- must include information for converting raw data to sensor data values
- must be unique by group and numeric channel for a specified time interval to determine where it is stored in the database
- must be unique by element, reporting interval, height, and ordinal for a specified time interval
- authorization to modify sensors is controlled by permissions as defined in the station management standard (NEH 622.08)
- historical sensor configuration information will be stored in the database for each station from date of installation

622.0607 System management

(a) WCIS server backups

All WCIS database and web servers are backed up on a daily basis (Monday through Friday). A complete set of backup tapes is sent off-site for storage on a weekly basis.

622.0608 References

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