United States Department of Agriculture
Natural Resources Conservation Service

Part 622 Snow Survey and Water Supply Forecasting National Engineering Handbook

Chapter 2 Data Parameters

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622.0200 General

The U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) forecasts water supply in 12 Western States where snowpack is the principle contributor to surface water supplies (7 CFR 612). The basic data collected for the purpose of developing water supply forecasts are specific to that use, and the data collection parameters are determined based on that use. Snow survey data are available to the public and are valuable for a wide range of purposes outside of snow survey. All data users should be aware of the data collection parameters and carefully evaluate the appropriateness of the data for individual applications.

Snow survey data are collected manually and remotely. Manual measurements are taken at snow courses and using aerial markers to collect snow depth and snow water equivalent (SWE) data. Scheduling of manual measurements varies, but is generally once a month, on or near the first of each month during the snow season (January 1 to May 1), depending on the location and specific needs of data users.

Data are collected remotely using a large network of automated data collection platforms known collectively as the SNOw TELemetry (SNOTEL) network. The standard data types collected at a SNOTEL site are SWE, total accumulated precipitation, air temperature, and snow depth. Additional sensors may be included to measure soil moisture, soil temperature, wind speed, wind direction, solar radiation, relative humidity, barometric pressure and precipitation (tipping bucket). The standard reporting period for SNOTEL data is once a day, at midnight, although it is recommended that data be reported on an hourly bases when possible. Besides making the data more valuable to more users for more applications, hourly report periods also make the data more consistent with the guidelines for hydroclimatic stations of other agencies such as National Oceanic and Atmospheric Administration (NOAA), World Meteorological Organization (WMO), and National Weather Service (NWS). Many of the data types require scheduled sample time intervals and specific report periods.

This chapter contains parameter specifications for each of the data types collected from snow courses, aerial markers, and the SNOTEL network. Many of the parameter standards and specifications are based on values from specific sensor manufacturers specifications or WMO standards. Sources for specifications are noted for each data type below each table. Values not noted were developed by the NRCS for the measurement.

622.0201 Definitions

For each of the data types collected from snow courses, aerial markers, and SNOTEL stations, some, or all, of the following attributes are identified.

Accuracy—Represents how close a measurement is to actual conditions. In some cases, accuracy is determined by a manufacturer's specification for a specific sensor.

Beamwidth—Width or diameter of an area being measured. Generally refers to the area directly beneath a sonic snow depth sensor that will affect the measurement.

Measurement range—Represents the range of values over which a measuring instrument or counter can reliably perform within specifications.

Orifice diameter—Diameter of the opening in a precipitation gage which precipitation falls through for measurement.

Reporting interval—For automated measurements, the amount of time between generating summaries of sampled data and making them available to users.

Resolution—The smallest unit of measurement for which a data type is reported.

Sampling interval—Amount of time between successive measurements taken by a sensor or sensors.

Sensor operating range—Limits of environmental conditions (such as heat or cold) in which a sensor can be expected to perform normally.

Shielding—A device used to protect a sensor by deflecting the effects of wind, solar radiation, or other environmental effect on collection of data.

Temperature correction—An adjustment to measurements made by sensors for which accuracy is affected by temperature.

Transducer based measurements—Measurements of precipitation of snow water equivalent that are made using a pressure transducer as the primary electronic component.

Units—The fundamental quantity of measurement for a specific data parameter.

622.0202 Snow water equivalent (SWE) data

Definition—The amount of water equivalent held in the snowpack.

Purpose—To determine the amount of water content in the snowpack at a particular location primarily for stream flow/water supply forecasting.

Scope—This standard covers all NRCS measurements for SWE.

Standard criteria—Table 2–1 shows the criteria for SWE data.

Measurement types
Manual—Snow tube measurements and manometer measurements.

Approved equipment
- Standard Federal Sampler
- McCall cutter
- Snow pillow manometer

Automated—An observation using a snow pillow (hypalon or metal) and associated instrumentation to collect SWE on a predetermined sampling and reporting interval.

Approved equipment
- Fluid based
- Flexible
- Snow pillow

Calculated—Any process that is used to determine SWE from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–1 Criteria for SWE data

Attribute	Threshold
Units	Inches
Resolution	0.1 inches
Accuracy	
Snow tube manual measurement (cutter teeth sharpened flat)	+4% to +10% depending on snow conditions
Fluid base, flexible, snow pillow/ transducer based	±4% over full scale **
Measurement range	0 to 250 inches of water
Sensor sampling interval	Minimum 1 hour
Sensor reporting interval	24-hour current SWE

** Consistent with WMO standard

622.0203 Snow depth data

Definition—The depth of the snow above the ground surface is snow depth.

Purpose—To aid in the determination of snow depth.

Scope—This standard covers all NRCS measurements for snow depth.

Standard criteria—Table 2–2 shows standard criteria for manually measured snow depth data. Table 2–3 shows standard criteria for snow depth data collected using aerial markers. Table 2–4 shows standard criteria for snow depth data collected using an automated system.

Measurement types

Manual—Visual observation of depth taken at regularly scheduled time intervals.

Approved equipment
- Standard Federal Sampler
- McCall cutter
- Snow stakes
- Snow board
- Aerial markers

Automated—Use of electronic equipment to measure and record snow depth on a scheduled time frame.

Approved equipment
- Ultrasonic snow depth sensor

Calculated—Any process that is used to determine depth from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–2 Criteria for snow depth data—Manual observation

Attribute	Threshold
Units	Inches
Resolution	0.5 inches
Accuracy	±0.5 inches
Measurement range	0 to 30 feet

All manual measurement devices with the exception of aerial markers.

Table 2–3 Criteria for snow depth data—Aerial marker observation

Attribute	Threshold
Units	Inches
Resolution	2 inches
Accuracy	6 inches
Measurement range	0 to 35 feet

Table 2–4 Criteria for snow depth data—Automated observation

Attribute	Threshold
Units	Inches
Resolution	0.5 inches
Accuracy	±2 inches or 0.4% distance to target *
Temperature correction	Must have temperature compensation built into device
Beamwidth	22 degrees *
Sensor operating range	–30 to +70 °C *
Measurement range	0.5 to 10 meters *
Sensor sampling interval	Minimum 1 hour
Sensor reporting interval	One reading of the current value reported in inches of depth

* Based on specifications of Judd Communications Depth Sensor

622.0204 Precipitation data

Definition—Moisture falling from the sky to the earth in both liquid and solid forms.

Purpose—To measure the incremental and total accumulated amount and intensity of precipitation that falls over a period of time. Some sensors measure only liquid precipitation while others measure liquid and frozen precipitation. Used primarily for water supply forecasting and flood and drought management.

Scope—This standard covers all NRCS measurements for precipitation.

Standard criteria—Table 2–5 shows standard criteria for precipitation data collected using manual gages. Table 2–6 shows the standard criteria for liquid precipitation data collected using automated tipping bucket gages. Table 2–7 shows the standard criteria for precipitation data collected using automated all-season storage gages. Table 2–8 shows standard criteria for liquid precipitation data collected using automated optical gages.

Measurement types

Manual—Storage gage device that can be read using dip stick or manometer method.

Approved equipment
- 8-inch diameter storage gage
- 12-inch diameter storage gage

Automated—An observation, that utilizes a electronic gage that is automatically recorded on a scheduled time frame.

Approved equipment
- 6-inch orifice tipping bucket (for liquid precipitation only)
- 8-inch orifice tipping bucket (for liquid precipitation only)
- 12-inch diameter storage gage with pressure transducer
- optical rain gage (for liquid precipitation only)

Calculated/estimated—A calculation that is used to determine precipitation amounts from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–5 Criteria for precipitation data—Manual gage observation

Attribute	Threshold
Units	Inches
Resolution	0.1 inches
Accuracy	0.1 inches
Orifice diameter	8 and 12 inches
Measurement range	0 to 250 inches of water
Sensor sampling interval	Infrequent
Sensor reporting interval	Variable

Table 2–6 Criteria for liquid precipitation data—Automated tipping bucket gage observation

Attribute	Threshold
Units	Inches
Resolution	0.01 inches over the full scale
Accuracy	
Liquid precipitation only	±2% at up to 1 inch per hour. Loss of 1% for every 1 inch per hour above 2 inches per hour *
Orifice diameter	6 and 8 inches
Measurement range	0 to 27 inches per hour *
Sensor sampling interval	10 seconds
Sensor reporting interval	One value of the total incremental amount per hour and one value of the accumulated for the 24-hour period

* Based on specifications for Texas Electronics Tipping Bucket

Table 2–7 Criteria for precipitation data—Automated all-season storage gage observation

Attribute	Threshold
Units	Inches
Resolution	0.1 inches over the full scale
Accuracy	
Transducer based	± 5% over the full scale
Orifice diameter	12 inches
Shielding	Alter
Measurement range	0 to 250 inches of water (determined by transducer)
Sensor sampling interval	Minimum 1 per hour
Sensor reporting interval	One value of the accumulated total for the 24-hour period

Table 2–8 Criteria for liquid precipitation data—Automated optical gage observation

Attribute	Threshold
Units	Inches
Resolution	0.01 inches
Accuracy	
Liquid precipitation only	± 2% at up to 2 inches per hour. Loss of 1% for every 1 inch per hour above 2 inches per hour *
Measurement range	0 to 20 inches per hour*
Sensor sampling interval	10 seconds
Sensor reporting interval	One value of the total incremental amount per hour and one value of the accumulated for the 24-hour period

* Based on specifications for Texas Electronics Tipping Bucket. Optical must meet or exceed standard

622.0205 Soil moisture data

Definition—Soil moisture is the amount of water that is held in the soil at a given depth.

Purpose—To measure the amount of moisture (water) in the soil at standard depths below the ground surface. Used primarily in estimating the amount of runoff intercepted by soil absorption.

Scope—This standard covers all NRCS measurements for soil moisture.

Standard criteria—Table 2–9 shows the standard criteria for soil moisture data collected using an automated system.

Measurements types
Automated—Observation using an electronic measurement to determine the percent volume of water to total volume of soil at a certain depth.

Approved equipment
- Soil probe that uses a high frequency electrical measurements of capacitance and conductance through the soil to determine moisture content (Stevens-Vitel Hydra Probe)
- Gypsum blocks (Watermark Gypsum Block)

Table 2–9 Criteria for soil moisture data—Automated observation

Attribute	Threshold
Units	Percent
Resolution	0.5% over the full scale
Accuracy	
No soil specific calibration	±0.03 (fraction water by volume)*
Measurement range	Zero to 100 percent of saturation
Sensor sampling interval	Minimum 1 sample per hour
Sensor reporting interval	One current value per hour

*Based on specifications for Stevens® Hydra Probe II

622.0206 Soil temperature data

Definition—Soil temperature is the temperature of the soil at a given depth.

Purpose—To measure the temperature of the soil at a standard depth below the ground surface. Used primarily to help determine if soils are available for absorption of water or are frozen.

Scope—This standard covers all NRCS measurements for soil moisture.

Standard criteria—Table 2–10 shows criteria for soil temperature data collected using an automated system.

Measurement types
Automated—Temperature measurements using electronic thermistor to automatically record soil temperature on a scheduled timeframe.

Approved equipment
- Calibrated thermistor (Stevens-Vitel Hydra Probe or CS-107 temperature sensor)

Calculated—Any process that is used to determine soil temperature from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–10 Criteria for soil temperature data—Automated observation

Attribute	Threshold
Units	Degrees Celcius
Resolution	±0.1 °C over the full scale *
Accuracy	±1.0 °C over the full scale*
Measurement range	–10 °C to +65 °C *
Sensor sampling interval	Minimum 1 sample per 15 minutes
Sensor reporting interval	One value of the current sample at the top of the hour

* Based on specifications for Stevens® Hydra Probe II

622.0207 Air temperature data

Definition—Air temperature is the ambient air temperature at a given height aboveground.

Purpose—To measure the temperature of the air at a SNOTEL station. Used primarily in analyzing the rate of snowmelt and forecasting whether precipitation will occur as snow or rain.

Scope—This standard covers all NRCS automated measurements for ambient air temperature.

Standard criteria—Table 2–11 shows the standard criteria for air temperature data collected using an automated system.

Measurement types
Automated—Temperature measurements collected using an electronic thermistor to automatically measure and record air temperature inside a naturally aspirated shield on a scheduled timeframe.

Approved equipment
- Thermal linear thermistor (YSI approved temperature sensors, CS–107, HMP35C, HMP45C)

Calculated/estimated—A calculation/method used to determine air temperature from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–11 Criteria for air temperature data—Automated observation

Attribute	Threshold
Units	Degrees Celcius
Resolution	0.1° C
Accuracy	±3.0° C over the full scale *
Measurement range	
Average areas	–40° C to +60° C *
For extreme cold areas	–55° C to +60° C
Sensor sampling interval	Minimum 15-minute sample
Sensor reporting interval	One 24-hour value current. 24-hour maximum, minimum, and average of minimum 4 samples per hour

* Based specification of the Campbell Scientific CS–107 thermistor

622.0208 Wind speed data

Definition—Wind speed is the speed at which air is moving relative to the Earth's surface.

Purpose—To measure the speed the air moves across the Earth's sun at a SNOTEL station. Used primarily to help determine if drifting or other wind effects may be affecting other data collection sensors at SNOTEL stations.

Scope—This standard covers all NRCS measurements for wind speed.

Standard criteria—Table 2–12 shows the standard criteria for the wind speed data collected using an automated system.

Measurement types
Automated—Use of cup or propeller anemometer to measure and record wind speed on a scheduled time frame.

Approved equipment
- AC Generator/Pulse Output (RM Young 5305 Wind Monitor)

Calculated/estimated—Any calculation/method that is used to determine wind speed from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–12 Criteria for wind speed data—Automated observation

Attribute	Threshold
Units	Miles per hour
Resolution	0.1 miles per hour
Accuracy	±0.6 miles per hour over the full scale *
Measurement range	0 to 134 miles per hour *
Sensor sampling interval	10 seconds
Sensor reporting interval	One value for hourly maximum, hourly average and 24-hour average of 360 samples per hour

* Based on specifications for RMY 5103 Wind Monitor

622.0209 Wind direction data

Definition—Wind direction is the direction from which air is moving. Measured in degrees azimuth with 0 degrees or 360 degrees representing north, 90 degrees representing east, 180 degrees representing south, and 270 degrees representing west.

Purpose—To measure the direction from which wind is coming. Used primarily to aid in determining the effects of wind on other data collection sensors at SNOTEL stations.

Scope—This standard covers all NRCS automated measurements for wind direction.

Standard criteria—Table 2–13 shows standard criteria for wind direction data collected using an automated system.

Measurement types

Automated—Use of wind vane attached to a potentiometer and oriented to true north to measure and record wind direction on a scheduled timeframe.

Approved equipment:
- Calibrated Potentiometer aligned to true north. (RM Young 5305 Wind Monitor)

Calculated/estimated—A calculation used to determine wind direction from other collected data.

Approved equipment:
- Standard statistical procedures

Table 2–13 Criteria for wind direction data—Automated observation

Attribute	Threshold
Units	Degrees Azimuth
Resolution	± 1° over the full scale *
Accuracy	± 3° over the full scale *
Measurement range	0 to 355 degrees
Sensor sampling interval	10 seconds
Sensor reporting interval	One value for 1 hourly average and one 24-hour average of 360 samples per hour

* Based on specifications for RMY 5103 Wind Monitor

622.0210 Solar radiation data

Definition—Solar radiation is energy (electromagnetic radiation) emitted by the sun and sky.

Purpose—To measure the amount of energy reaching the Earth's surface from the sun and sky. Used primarily in determining the effects of solar radiation on snow melt.

Scope—This standard covers all NRCS measurements for ambient air temperature.

Standard criteria—Table 2–14 shows the standard criteria for solar radiation data collected using an automated system.

Measurement types
Automated—Use of electronic pyranometers to measure and record solar radiation on a scheduled time frame.

Approved equipment
- Calibrated pyronometer (Thermopile or photocell type) (Example: LI200L–X)

Calculated/estimated—A calculation/method used to determine solar radiation from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–14 Criteria for solar radiation data—Automated observation

Attribute	Threshold
Units	Watts per meter^2
Resolution	.01 watts per meter^2
Accuracy	± 5% over the full scale *
Measurement range	0 to 1500 watts per meter^2
Sensor sampling interval	10 seconds
Sensor reporting interval	One value for hourly, 1 hourly average of 360 samples per hour

*Based on specification for LI Cor LI200 pyranometer

622.0211 Relative humidity data

Definition—Relative humidity is the ratio of water vapor in the air at a specific temperature to the maximum capacity of the air at that temperature.

Purpose—To measure the amount of moisture in the air as a percentage of the amount it would be able to hold at saturation. Used primarily to aid in predicting precipitation events.

Scope—This standard covers all NRCS measurements of relative humidity.

Standard criteria—Table 2–15 shows the standard criteria for relative humidity data collected using an automated system.

Measurement types
Automated—Use of electronic equipment to measure and record relative humidity on a scheduled time frame.

Approved equipment
- Capacitive Relative Humidity Sensor (Campbell Scientific HMP45C)

Calculated/estimated—A calculation/method used to determine relative humidity from other collected data.

Approved equipment
- Standard statistical procedures

Table 2–15 Criteria for relative humidity data—Automated observation

Attribute	Threshold
Units	Percent
Resolution	1% over the full scale
Accuracy	± 3% over full scale*
Temperature correction	Must have temperature compensation built into device
Measurement range	10 to 100% RH
Sensor sampling interval	Minimum 15 minutes
Sensor reporting interval	One value for 1 hourly average of 4 samples per hour One value hourly current One value for 1 hourly maximum of 4 samples per hour

*Based on specifications for HMP45–C RH sensor

622.0212 Barometric pressure data

Definition—Barometric pressure is the pressure exerted by the weight of air (dry air and water vapor mixture) above a given point.

Purpose—To measure the barometric pressure. Used primarily to help determine weather patterns for short-term streamflow forecasting.

Scope—This standard covers all NRCS measurements for barometric pressure.

Standard criteria—Table 2–16 shows the standard criteria for barometric pressure data collected using an automated system.

Measurement types
Automated—Use of electrical barometer to measure and record barometric pressure on a scheduled time-frame.

Approved equipment
- Silicon capacitive pressure sensor with 0 to 2.5 VDC signal

Calculated estimated—A calculation/method used to determine barometric pressure from other collected data.

Approved equipment
- Standard statistical methods

Table 2–16 Criteria for barometric pressure data—Automated observation

Attribute	Threshold
Units	Inches Hg
Resolution	1% over the full scale
Accuracy	± 0.18 inches Hg over full scale*
Temperature correction	Must have temperature compensation built into device
Measurement range	18 to 30 inches Hg
Sensor sampling interval	Minimum 1 hour
Sensor reporting interval	One current value hourly

*Based on specification for Vaisala CS105 sensor

622.0213 References

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