

Standard Operating Procedure (SOP) 11: Quality Control and Record Processing, Version 2.01

Weather and Climate Monitoring Protocol

Arctic (ARCN), Central Alaska (CAKN), and Southeast Alaska (SEAN) Inventory and Monitoring Networks

Change History

Previous Version #	Revision Date	Revised By	Changes	Justification	New Version #
1.00 (SOP 21 – Data Access and Archiving)	12/20/2006	P. Sousanes	Added last line to 1 st paragraph	Incorporated comments from peer review	1.01
1.01 (SOP11)	March 2017	K. Hill B. Johnson M. Bower P. Sousanes S. Miller	Update quality control procedures.	New software. Changes in data archive procedures.	2.0
2.0	March 2018	K. Hill	Update quality control and data export procedures.	Clarification for data corrections with redundant air temperature sensor. Included multiple data export options.	2.01

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Note: This SOP outlines procedures for storing, processing, and exporting continuous climate records after raw data files have been successfully downloaded from the datalogger (SOP 9). The Arctic, Central Alaska, and Southeast Alaska Inventory and Monitoring Networks have successfully used Aquarius Time-Series Software to meet its record processing needs, but its use does not constitute an endorsement by the U.S. Government.

Required Training: Overview documentation and tutorials of Aquarius Software are available at <http://nrdata.nps.gov/programs/water/aquarius/AquariusVideos.htm>

Overview

This SOP outlines basic rulesets for quality control of climate data and provides examples on how to accomplish these guidelines using Aquarius software. The National Park Service Water Resources Division (WRD) purchased and supports the Aquarius Time-Series Software produced by the Aquatic Informatics (AI) Company in Vancouver, British Columbia. The software streamlines the climate data record processing. It should be noted that Aquarius software may not directly meet every need, and future development of data management tools is likely.

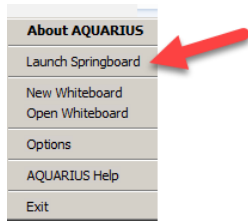
Aquarius software has a significant learning curve and will continue to improve and change. This SOP is not a complete guide for learning Aquarius. The best way to learn how to operate Aquarius is by using the training videos and user manual. Aquatic Informatics Support is online at <http://aquaticinformatics.com/support/>. To log into the Aquarius 360 Support site, however, you'll need a username and password which can be obtained without charge via an email request to support@aquaticinformatics.com. Once you can log into the AI webs site, click the AI Training Video tab.

Connecting your desktop to the Aquarius system

One uses Aquarius through Windows' "remote desktop" function. The software actually runs on a computer in Colorado that recognizes your screen, keyboard, and mouse. This provides reasonable responsiveness in low-bandwidth locations, but usually slower performance than software running locally. The WRD license allows no more than five people to have Aquarius sessions running at once. Also, WRD must first give you permission to access Aquarius through your active directory user credentials. Currently, Dean Tucker is the person issuing permissions.

To get into the system, one needs to download a copy of the "AQAssistant.RDP" file from <https://nrdata.nps.gov/Programs/Water/Aquarius>. Once downloaded, open the RDP file to create a path between your local workstation and the Colorado server. Once the path is established, users may sign on to the Colorado host from the internal DOI network using a regular PIV card sign-in. (Currently your password must be provided two times whenever you connect, which may be confusing.)

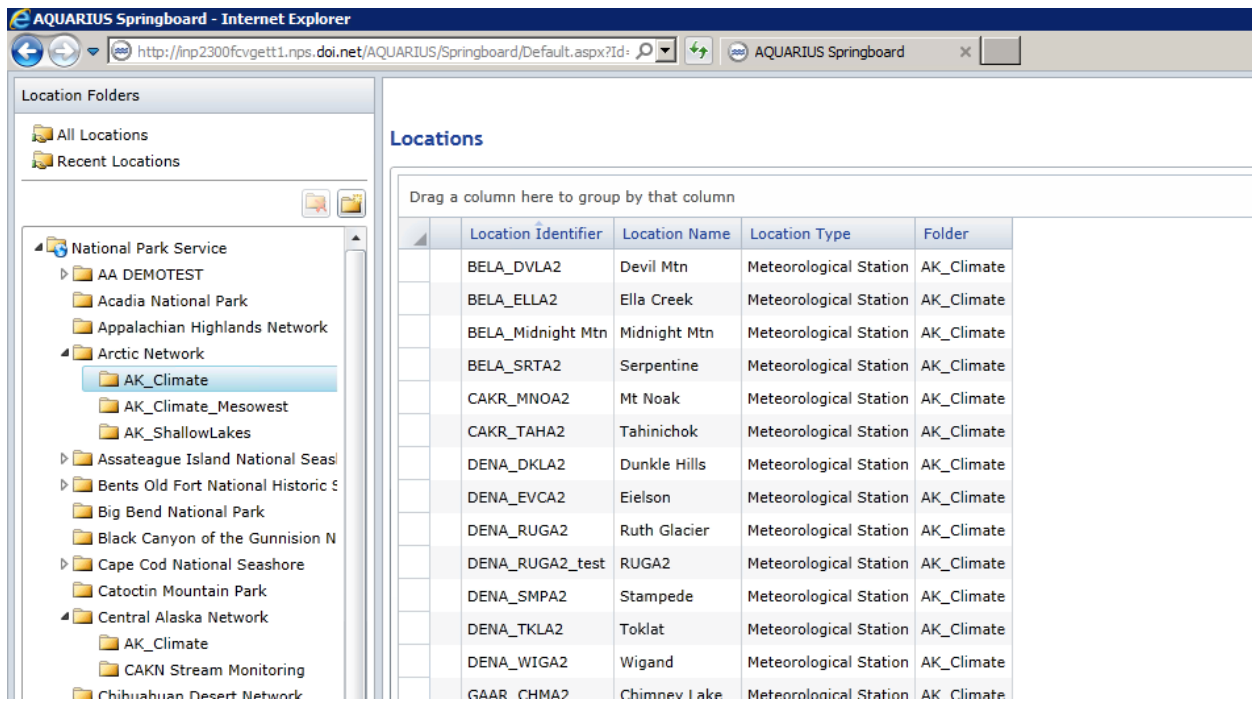
After connecting to the server, one needs to start up an Aquarius session. The desktop tray (lower right corner of screen) should have an Aquarius Assistant icon showing (). Right click the icon to see the menu and select Launch Springboard.



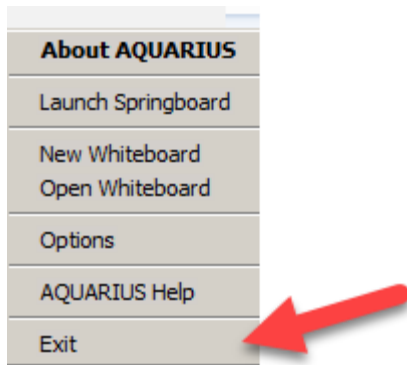
The Aquarius system will wake up and ask again for credentials. Aquarius, itself, doesn't currently recognize PIV cards. Enter your normal DOI userid, then your network password – not your PIV pin.



Press the LOGON button and you should be presented with a workspace.



After completing an Aquarius session, it is important to explicitly log out of Aquarius in order to free up the license for another user. Right click the Aquarius icon on the task bar desk tray to see the menu and select Exit.



General Aquarius Workflow

Aquarius is used to manage continuous time series data. The software organizes data by geographic location. Each location (weather station) contains unique continuous “data sets” (time series), typically one data set for each parameter measured over all years. New data are appended to these time series from raw data files. It should be noted that once imported, raw data are never deleted in Aquarius. All flags, corrections, and grades are logged in the software and any changes are stored in an audit log.

1. Site setup. Each location (weather station) is configured with basic geographic information. Within each location, time series are configured as data set containers to accept raw data. Each data value must have an associated timestamp reflecting when it was measured.
2. Notifications. Automated quality control is established by configuring Aquarius notifications. Values that exceed thresholds are flagged when they are imported (appended) into the data set containers.
3. Appending (importing) data. Raw data files are uploaded to the data set containers. Values that exceed defined thresholds are automatically flagged.
4. Data Corrections.
 - a. All flagged data are reviewed and erroneous measurements are suppressed in the corrected dataset.
 - b. All time series are reviewed manually. Additional flags and corrections are made as needed.
5. Data grading. All data are graded as good, suspect, or unusable. Data that have been corrected may still be considered “Good” depending on the type of corrections.
6. Data approvals. After all data corrections are complete, data values can be designated as “Working”, “In Review”, or “Approved”.
7. Data export. Corrected data values may be exported from Aquarius with associated quality grades and approvals.

Site Setup

This section describes procedures for setting up site information in Aquarius. Before attempting to use Aquarius, the documents and tutorials noted in the Introduction should be reviewed.

1. To create a new site location, select the appropriate folder (or create a new one) in the left frame.

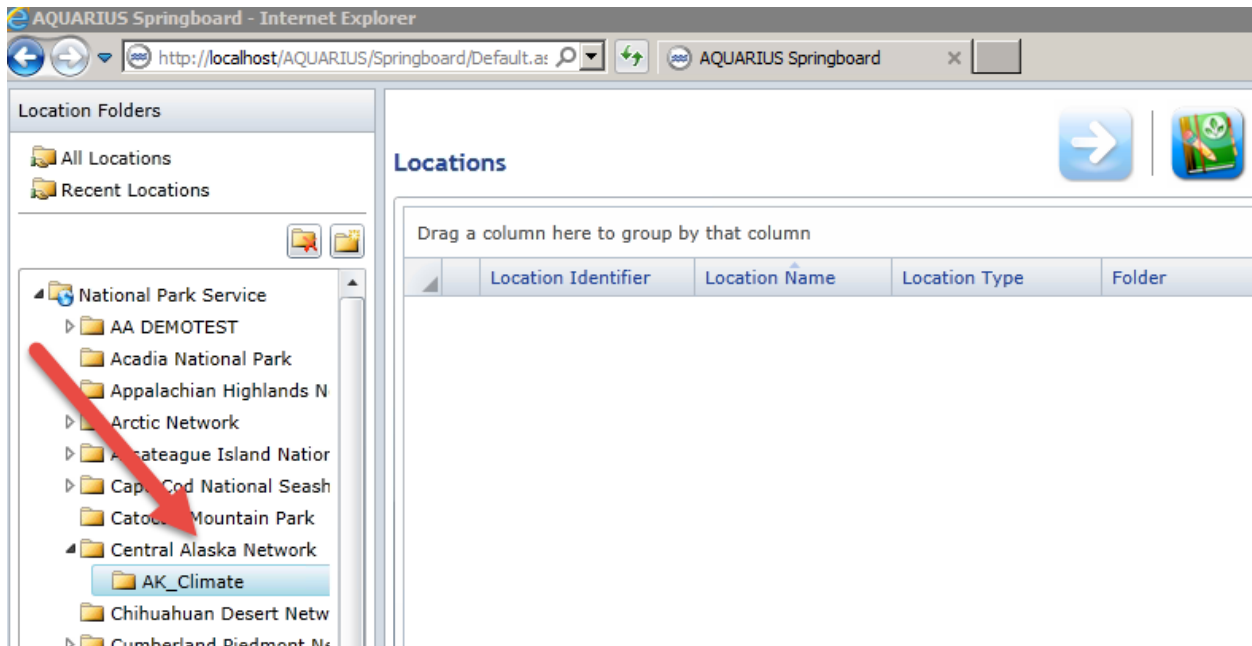


Figure SOP 11-1. Setting up a new location in Aquarius.

2. Click on the Location Manager Toolbox icon to set up a new site.



3. General Settings in the Location Manager
 - a. Under the general tab of the Location Manager, fill in the Identifier field. The NPS WRD standard for naming sites includes both the park code and the site name (e.g., DENA_RUGA2 for Ruth Glacier in Denali National Park and Preserve). For site name use the NWS identifiers from SOP 2 Appendix A.
 - b. Complete the Name field. Use the NWS identifiers from SOP 2 Appendix A.
 - c. Select the Type from the drop-down list (Meteorological Station).
 - d. Fill in the Latitude, Longitude, and Elevation fields.
 - e. Select the time zone as GMT (UTC). This is the time zone that will be displayed as the default throughout the Aquarius graphs and tables for this location.
 - f. Select the Park Name from the drop-down list.

Figure SOP11-2. The General tab of the Aquarius Location Manager.

4. Data Sets in the Location Manager: Aquarius “Data Sets” are “containers” for raw data to be imported into. First, new data sets must be created in Aquarius. After data sets for all parameters are configured, raw data can be imported into these containers.
 - a. Under the data sets tab of the location manager, select a new “Time Series – Basic” to create the first data set container.
 - b. Fill in the Label field using the short headers described in SOP 4 (e.g., ATF for air temperature). When naming the datasets follow these guidelines:
 - i. The string “WC_G” must be somewhere (anywhere) in the dataset name. When exporting the corrected data from Aquarius (SOP10 Appendix B), only datasets with this string will be included. Datasets without the “WC_G” tag will not be included in the export.
 - ii. The WFMI parameter ID (e.g., RNIN) must start after the first period (“.”) and end at the next punctuation mark of any sort.
 - iii. The NWS station ID (e.g., RUGA2) is taken as the string between the last underscore (“_”) encountered and the end of the dataset name.
 - c. The long identifiers will auto-fill to the Aquarius default as “Parameter.Label_WC_G@PARK_SITE” (Figure SOP11-3).
 - d. Select the Parameter from the drop-down list, or use the ellipsis (...) button to search for the correct parameter (Table SOP 11-1).
 - e. Select the appropriate units (Table SOP 11-1).
 - f. Select the time zone as UTC. This is the time zone that will be displayed throughout Aquarius.

- g. Set the Gap Tolerance to 61 minutes. This will make Aquarius recognize as a gap any missing data beyond the sampling interval of 60 minutes. For more information on gap processing, consult the Aquarius help.
- h. Continue creating basic time series for all the parameters listed in Table SOP 11-1. Save changes before continuing to the Notifications tab.

The screenshot shows the 'Location Manager' application window with the 'Data Sets' tab selected. The window title is 'DENA_RUGA2_test - RUGA2'. The 'Data Set Details' panel on the right is configured for a 'Time Series - Basic' data set. The 'Identifier' is 'Peak Wind Vel.WSMP_WC_G@DENA_RUGA2_test', the 'Label' is 'WSMP_WC_G', and the 'Description' is empty. The 'Publish' option is set to 'Yes'. The 'Data' section shows the 'Parameter' as 'Peak Wind Vel', 'Units' as 'mph', and 'Time Zone' as 'GMT (UTC)'. The 'Gaps' section has 'Gap Tolerance (mins)' set to 61 and 'Total Gaps' set to 2. The 'Statistics' section shows a 'Start Time' of 2014-06-24 13:00:00, an 'End Time' of 2015-08-13 09:00:00, a 'Min' value of 0.00, a 'Max' value of 39.62, a 'Mean' value of 10.01, 'Total Samples' of 18933, a 'Start Value' of 3.41, an 'End Value' of 2.65, and a 'Sampling Rate' of 0.00. The left pane shows a list of data sets under the 'Time Series' category, with 'Peak Wind Vel.WSMP_WC_G@DENA_RUGA2_test' selected.

Figure SOP11- 3. The Data Sets tab of the Aquarius Location Manager. Create a new Basic Time Series by selecting the button at upper left. Empty data set containers should be configured for all parameters before raw data are appended (imported).

Table SOP 11-1. Specifications for creating Data Sets and Appending in Aquarius. *Rainfall values are transmitted as a cumulative total as required by the National Interagency Fire Center. However, both cumulative and hourly rainfall totals are stored in the datalogger. Only hourly totals should be appended into Aquarius.

Element	Measurement (hourly)	Aquarius Parameter Name	Units	Gap Tolerance	Aquarius Label Name	Aquarius Interpolation Type	Aquarius Grade
Rainfall*	Hourly Total	Precip	in	61	RNIN	5- Preceding Totals	0- UNDEF
Wind Speed	Vector Average	Wind Vel	mph	61	WSM	2- Preceding Avg.	0- UNDEF
Wind Direction	Vector Average	Wind Dir	deg	61	WDD	2- Preceding Avg.	0- UNDEF
Air Temperature	Average	Air Temp	F	61	ATF	2- Preceding Avg.	0- UNDEF
Relative Humidity	Sample	Rel Humidity	%	61	RHP	1- Inst. Values	0- UNDEF

Battery Voltage	Average	Battery Voltage Under Load	V	61	BVV	2- Preceding Avg.	0- UNDEF
Wind Direction (of gust)	Direction of Peak Gust	Peak Wind Dir	deg	61	WDDP	2- Preceding Avg.	0- UNDEF
Wind Speed (of gust)	Speed of Peak Gust	Peak Wind Vel	mph	61	WSMP	2- Preceding Avg.	0- UNDEF
Solar Radiation	Average	Solar Rad	W/m2	61	SRW	2- Preceding Avg.	0- UNDEF
Snow Depth	Sample	Snow Depth	in	61	SDI	2- Preceding Avg.	0- UNDEF
Air Temperature	Minimum	Air Temp	F	61	AT1L	2- Preceding Avg.	0- UNDEF
Air Temperature	Maximum	Air Temp	F	61	AT1H	2- Preceding Avg.	0- UNDEF
Soil Temperature (10 cm)	Average	Soil Temp	F	61	STF	2- Preceding Avg.	0- UNDEF
Soil Temperature (20 cm)	Average	Soil Temp	F	61	STF2	2- Preceding Avg.	0- UNDEF
Soil Temperature (50 cm)	Average	Soil Temp	F	61	STF3	2- Preceding Avg.	0- UNDEF
Soil Temperature ()	Average	Soil Temp	F	61	STF4	2- Preceding Avg.	0- UNDEF
Soil Temperature ()	Average	Soil Temp	F	61	STF5	2- Preceding Avg.	0- UNDEF

Notifications: Basic Data Thresholds and Automated Quality Control

This section describes the procedures for setting up notifications in Aquarius. Aquarius uses “Notifications” to automatically flag data based on predefined thresholds, rates of change, spikes, and flat lines (no net change in value over a specified time range). Table 2 lists the thresholds defined for all parameters. Notifications should be configured before raw data are imported (appended) into the software. Values are flagged “on append”. All raw data are initially screened through these Aquarius notifications, and subsequently reviewed and edited/deleted as needed through the Data Corrections toolbox.

To configure automated quality control thresholds, open the notifications tab in the location manager toolbox.

1. Select the Notifications tab. Click on the green plus (+) sign to add a new notification.
2. Click the Severity drop-down and select “Warning”. “Info” and “Error” flags are also available, but are currently not used in the CAKN workflow.
3. Name the Ruleset to describe the notification trigger (Figure SOP 11-4).

4. Select the Data Set ID.
5. Click the magnifying glass under the Configuration column. Configure the notification according to Table SOP 11- 2.
6. Continue adding notifications for all rulesets in Table SOP 11-2, as shown in Figure SOP 11-4.

Location Manager						
File Help						
DENR_RUGA2 - RUGA2						
General Data Sets User Access Notifications Hot Folder Analysis & Remarks						
Notification Rulesets						
Enabled	Severity	Ruleset Name	Data Set ID	Recipients	Trigger	Configuration
☒	Warning	ATF Thresholds -70 to +110	Air Temp.ATF@DENR_RUGA2		On Append	
☒	Warning	WSM Thresholds 0 to +120	Wind Vel.WSM@DENR_RUGA2		On Append	
☒	Warning	WSP Thresholds 0 to +120	Peak Wind Vel.WSPMPH@DEN.		On Append	
☒	Warning	AT1H Thresholds -70 to +110	Air Temp.AT1H@DENR_RUGA2		On Append	
☒	Warning	AT1L Thresholds -70 to +110	Air Temp.AT1L@DENR_RUGA2		On Append	
☒	Warning	RHP Thresholds 0 to 100	Rel Humidity.RHP@DENR_RUGA2		On Append	
☒	Warning	SRW Thresholds 0 to 1100	Solar Rad.SRW@DENR_RUGA2		On Append	
☒	Warning	STF Thresholds -65 to +110	Soil Temp.STF@DENR_RUGA2		On Append	
☒	Warning	STF2 Thresholds -65 to +110	Soil Temp.STF2@DENR_RUGA2		On Append	
☒	Warning	STF3 Thresholds -65 to +110	Soil Temp.STF3@DENR_RUGA2		On Append	
☒	Warning	WDD Thresholds 0 to 359	Wind Dir.WDD@DENR_RUGA2		On Append	
☒	Warning	WDDP Thresholds 0 to 359	Peak Wind Dir.WDDP@DENR_RUGA2		On Append	
☒	Warning	WSM flat line 6+ hours	Wind Vel.WSM@DENR_RUGA2		On Append	
☒	Warning	WDD flat line 6+ hours	Wind Dir.WDD@DENR_RUGA2		On Append	
☒	Warning	WSPMPH flat line 6+ hours	Peak Wind Vel.WSPMPH@DEN.		On Append	
☒	Warning	WDDP flat line 6+ hours	Peak Wind Dir.WDDP@DENR_RUGA2		On Append	
☒	Warning	SDI Threshold -6 to 67.0	Snow Depth.SDI@DENR_RUGA2		On Append	
☒	Warning	SDI=0	Snow Depth.SDI@DENR_RUGA2		On Append	
☒	Warning	ATF flat line 6+ hours	Air Temp.AT1H@DENR_RUGA2		On Append	
☒	Warning	AT1H flat line 6+ hours	Air Temp.AT1H@DENR_RUGA2		On Append	
☒	Warning	AT1L flat line 6+ hours	Air Temp.AT1H@DENR_RUGA2		On Append	
☒	Warning	RHP flat line 6+ hours	Air Temp.AT1H@DENR_RUGA2		On Append	
☒	Warning	STF flat line 6+ hours	Air Temp.AT1H@DENR_RUGA2		On Append	
☒	Warning	SDI flat line 6+ hours	Air Temp.AT1H@DENR_RUGA2		On Append	
☒	Warning	RNIN_Cumul 0 to 100 or Rate of Change	Precip cumul.RNIN_Cumul@DENR_RUGA2		On Append	
☒	Warning	BVV Thresholds 11 V to 16 V	Voltage.BVV@DENR_RUGA2		On Append	
☒	Warning	RNIN_Tot 0 to 1 inch	Precip Total.RNIN_Tot@DENR_RUGA2		On Append	

Figure SOP 11-4. Notifications tab in the Location Manager. Notifications (automatic flagging on import) are defined based on high and low thresholds, flat lines, and rates of change.

Time Series Ruleset Configuration:

Data
☒ Use Raw Data ☐ Use Corrected Data

Analyze the data for Any of the following: ☒ Flags On ☐ Flags Off

Threshold

☒ Values above: °F Flag as: Very high

☒ Values below: °F Flag as: Very Low

☐ Values between: °F and °F Flag as: In Range

Rate of Change

☐ Rising faster than: °F per Flag as: Rapid Rise

☐ Falling faster than: °F per Flag as: Rapid Fall

Spike

☐ Absolute value to value change greater than: °F within the last Hour(s) Flag as: Abs Spike

☐ Percentage value to value change greater than: % within the last Hour(s) Flag as: Spike

Flat Line

☐ Net change less than or equal to: °F within the last Hour(s) Flag as: Flat Line

% of data deleted by corrections within last

☐ More than: % of data deleted by corrections within last Hour(s)

Cancel OK

Figure SOP 11-5. Configuration of a notification. This example shows a threshold notification for air temperature. Values greater than 110° F or less than -70° F will be automatically flagged when imported.

Table SOP 11-2. Notification thresholds for all parameters. Parameter short names are listed in Table SOP 11-1.

Parameter	Low	High	Flat Line	Other
WSM	0 mph	120 mph	6+ hours	
WDD	0°	359°	6+ hours	
ATF	-70° F	110° F	6+ hours	
RHP	0%	100%		
BVV	11 V	16 V		
WDDP	0°	359°	6+ hours	
WSMP	0 mph	120 mph	6+ hours	
SRW	0 W m-2	1100 W m-2		
SDI*	0 inches	Sensor Height	6+ hours	0.00 inches

AT1L	-70° F	110° F	6+ hours	
AT1H	-70° F	110° F	6+ hours	
STF	-65° F	110° F	6+ hours	
STF2	-65° F	110° F		
STF3	-65° F	110° F		
RNIN	0.00 inches	1.0 inches		

*Example: snow depth (SDI) values are flagged if measurements are less than zero, greater than the height of the sensor, flat lined for 6 or more hours, or equal to 0.00 inches.

Appending (importing) Data

After general site information has been added, data containers have been configured, and automated notifications (flagging) criteria have been defined, Aquarius is ready to accept raw data. All columns in the raw data file need to be defined before Aquarius can accept data. This section describes the procedures for appending (importing) raw data.

1. Click on the Append To Logger toolbox.



2. Click the upper ellipsis (...) icon and select the raw data file (WC_F; SOP 10).
3. Click the Config Settings... button to define all columns in the raw data file (Figure SOP 11-6). Import from File Wizard will open.

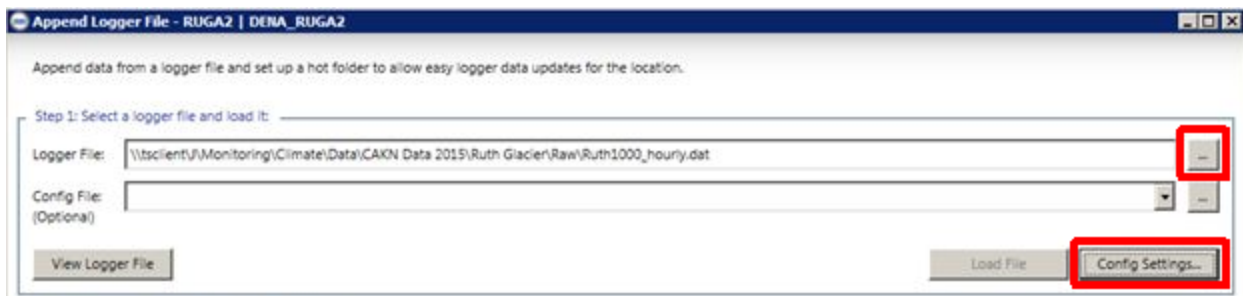


Figure SOP 11- 6. The Append To Logger Toolbox. The upper red box indicates how to select the raw data file to import. The lower box is used to define all column headers in the raw file.

- a. In step 1 of the wizard, select Text File as the type of Time Series file to import (Figure SOP 11-7).



Figure SOP 11-7. Import from File Wizard, Step 1.

- b. In step 2 of the wizard, edit the number of headers and define which row holds the first data record (Start import at row:). These values may vary with the data file, but under the current datalogger program there are four headers. Data records begin on the fifth row (Figure SOP 11-8). Confirm that the file is Comma delimited.

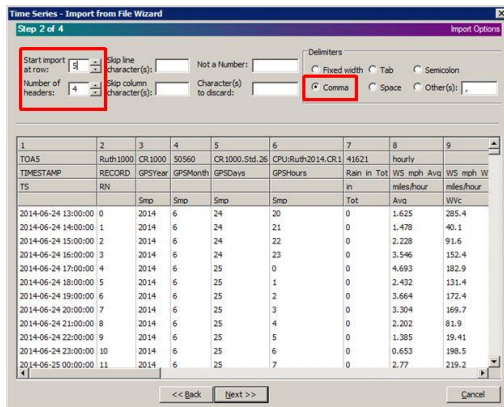


Figure SOP 11- 8. Import from File Wizard, step 2.

- c. Step 3 of the wizard requires that all columns in the raw data file are defined. Columns can be defined as Date/Time or Data. Columns that do not need to be imported into Aquarius can be skipped. Data to be imported should be configured according to Table SOP 11-1. As datalogger programs evolve, the configuration of data files may change.
 - i. The first column contains the Date/Time (Figure SOP 11- 9). To configure the date/time, select the first column by clicking on the grey header fields. The column should become highlighted. Select the Date/Time Format from the drop-down menu. If the correct option is not available, manually type in the appropriate date/time format (i.e. yyyy-mm-dd HH:MM:SS). Select the time zone. Important: this is the time zone in which the data were collected

and should match the time zone configured on the CR1000 datalogger. All dataloggers should be configured to ADT.

Time Series - Import from File Wizard
Step 3 of 4

Column 1

☒ Date/Time
☐ Data
☐ Do not import column (skip)

Date/Time Format: yyyy-mm-dd HH:MM:SS
Time Zone: UTC-08:00

1:yyyy-mm-dd HH:MM:SS	2:Raw/Ruth1000	3:Raw/CR1000	4:Raw/S0560	5:Raw/CR1000.Std.26	6:Raw/CPU/Ruth2014.CR1	7:Raw/416
TOA5	Ruth1000	CR1000	S0560	CR1000.Std.26	CPU/Ruth2014.CR1	416
TIMESTAMP	RECORD	GPSYear	GPSTMonth	GPSTDays	GPSTHours	Rain
TS	RN					In
		Smp	Smp	Smp	Smp	Tot
2014-06-24 13:00:00	0	2014	6	24	20	0
2014-06-24 14:00:00	1	2014	6	24	21	0
2014-06-24 15:00:00	2	2014	6	24	22	0
2014-06-24 16:00:00	3	2014	6	24	23	0
2014-06-24 17:00:00	4	2014	6	25	0	0
2014-06-24 18:00:00	5	2014	6	25	1	0
2014-06-24 19:00:00	6	2014	6	25	2	0
2014-06-24 20:00:00	7	2014	6	25	3	0
2014-06-24 21:00:00	8	2014	6	25	4	0
2014-06-24 22:00:00	9	2014	6	25	5	0
2014-06-24 23:00:00	10	2014	6	25	6	0
2014-06-25 00:00:00	11	2014	6	25	7	0

Figure SOP 11-9. Import from File Wizard, step 3. Define the timestamp.

- ii. The current datalogger program contains numerous columns with additional date/timestamp information (Figure SOP 11-10). The additional information is recorded as a backup in case the datalogger clock malfunctions. If the datalogger has recorded the correct timestamp, these columns can be “skipped” because they do not need to be imported to Aquarius. Select these columns by clicking on the grey header rows, and select “Do not import column (skip)”.

Time Series - Import from File Wizard
Step 3 of 4

Column 2

☐ Date/Time
☐ Data
☒ Do not import column (skip)

1:yyyy-mm-dd HH:MM:SS	2:Raw/Ruth1000	3:Raw/CR1000	4:Raw/S0560	5:Raw/CR1000.Std.26	6:Raw/CPU/Ruth2014.CR1	7:Raw/416
TOA5	Ruth1000	CR1000	S0560	CR1000.Std.26	CPU/Ruth2014.CR1	416
TIMESTAMP	RECORD	GPSYear	GPSTMonth	GPSTDays	GPSTHours	Rain in To
TS	RN					In
		Smp	Smp	Smp	Smp	Tot
2014-06-24 13:00:00	0	2014	6	24	20	0
2014-06-24 14:00:00	1	2014	6	24	21	0
2014-06-24 15:00:00	2	2014	6	24	22	0
2014-06-24 16:00:00	3	2014	6	24	23	0
2014-06-24 17:00:00	4	2014	6	25	0	0
2014-06-24 18:00:00	5	2014	6	25	1	0
2014-06-24 19:00:00	6	2014	6	25	2	0
2014-06-24 20:00:00	7	2014	6	25	3	0
2014-06-24 21:00:00	8	2014	6	25	4	0
2014-06-24 22:00:00	9	2014	6	25	5	0
2014-06-24 23:00:00	10	2014	6	25	6	0
2014-06-25 00:00:00	11	2014	6	25	7	0

Figure SOP 11-10. Import from File Wizard, step 3 (cont.). Skip columns that do not contain data.

- iii. Continue configuring each column in the raw file. For each column containing data for import, the parameter, units, gap tolerance, label, interpolation type, and grade should be defined according to Table SOP 11-1. Parameters are chosen from a list of preset options in Aquarius. The interpolation type defines how the software displays data in graphics and tables. More information is available in the help manuals.

1. Rainfall is logged as both a cumulative total (reset on October 1 of every year) and as an hourly total (Table SOP 11-1). The cumulative total does not need to be imported into Aquarius and can be “skipped”. An example for the hourly total precipitation (RNIN) is shown in Figures SOP 11-11 and 11-12.

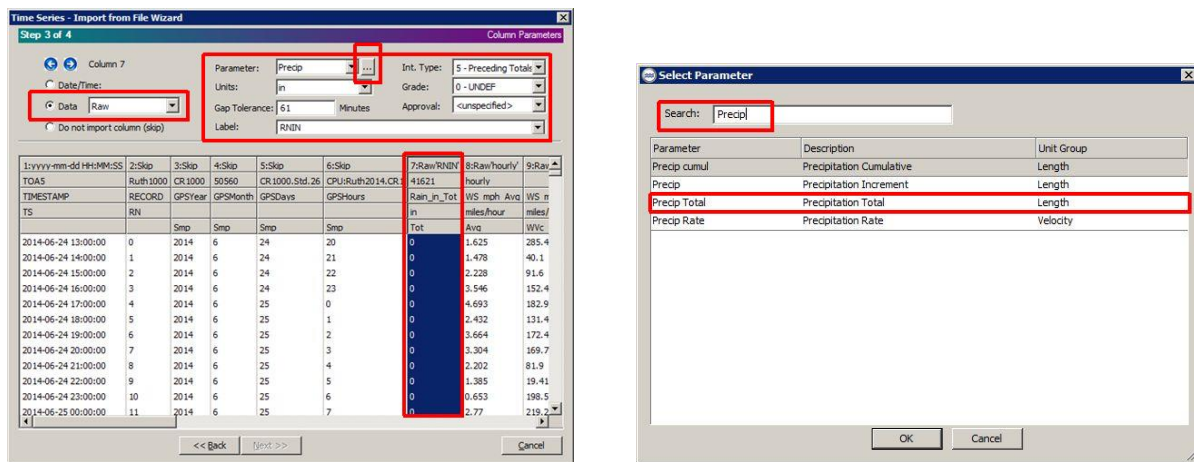


Figure SOP 11-11. Import from File Wizard, step 3 (cont.). Column 7 contains hourly rainfall totals. The parameter, units, label, interpolation type, grade, and gap tolerance are defined according to Table 1. The Parameter list (at right) is opened by clicking the (...) button. The search bar can be used to find relevant parameters.

2. Each column needs to be defined or skipped before step 3 of the wizard is complete (Figure SOP 11-12). Continue defining the columns of the raw data file according to Table 1. When all columns have been configured, click Next.

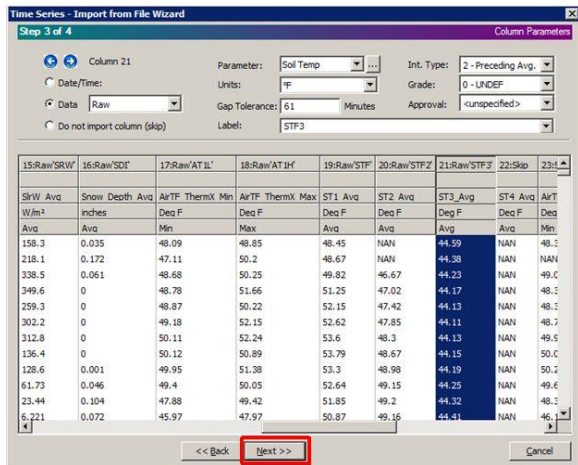


Figure SOP 11-12. Import from File Wizard, step 3 (cont.). After each column has been defined, the Next button becomes available.

- d. Complete step 4 of the wizard (Figure SOP 11-13). Save the configuration file. The configuration file can be selected and used (Figure SOP 11-6) for all raw data files with identical column structure. Confirm that gap processing will be applied, and click Finish.

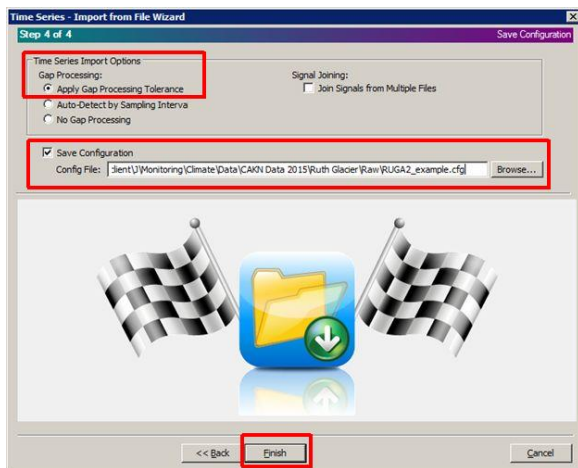


Figure SOP 11-13. Import from File Wizard, step 4.

4. After the import wizard has finished, the data are loaded into the Append Logger File toolbox (Figure SOP 11-14). Complete Step 2 of the toolbox by selecting the appropriate data containers for each time series under the “Append to” drop-down lists. After all parameters have been selected, click Append. The bottom frame of the toolbox (History) will update and display the number of data points that have been appended to each data set.

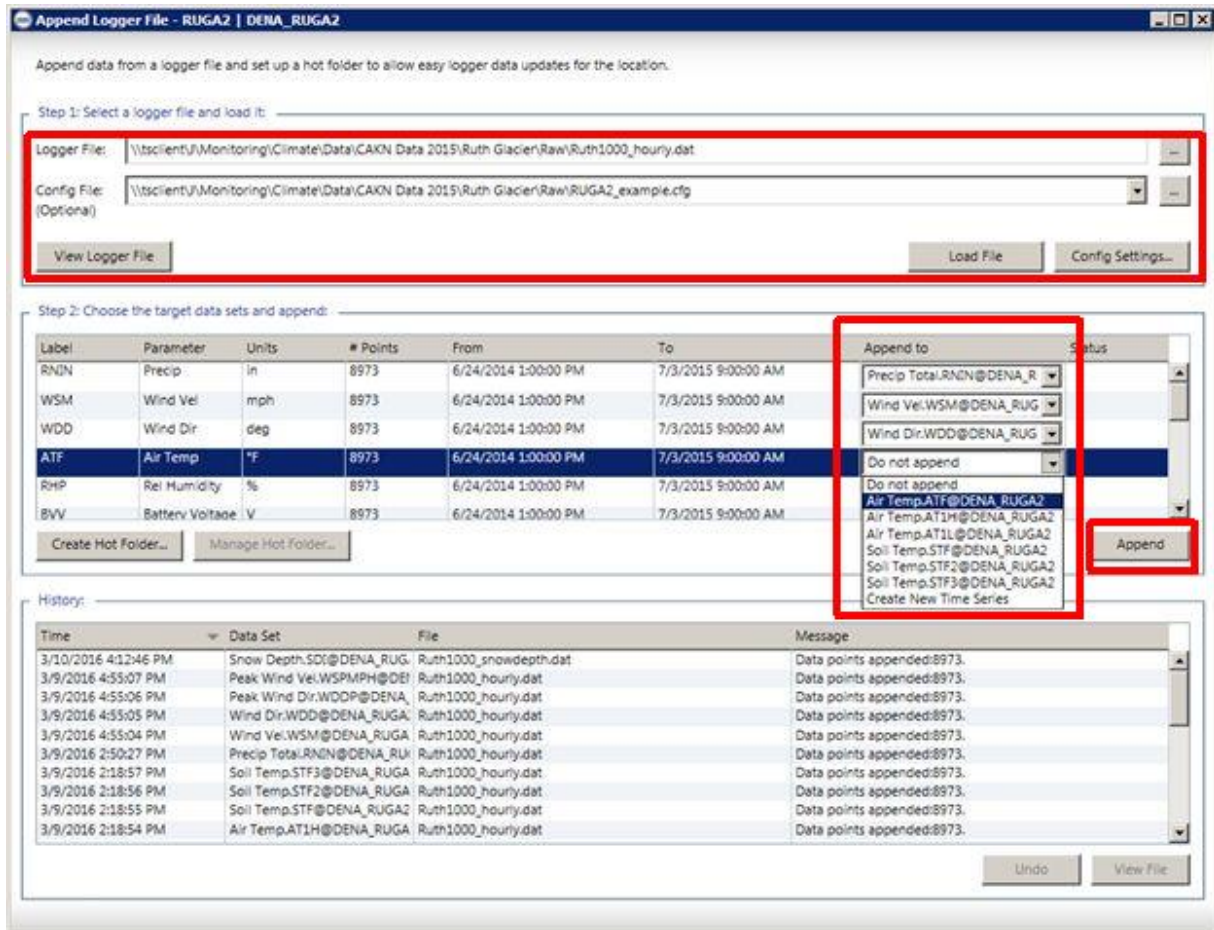


Figure SOP 11-14. The final step of the Append Logger File Toolbox.

Data Corrections and Data Quality Grading

Many stations operate under extreme environmental conditions which cause a variety of challenges. The most common problems are caused by wildlife and/or icing. Wildlife (usually bears), can damage sensors, cables, hardware, or the power supply. Icing can obstruct free-air movement on naturally aspirated radiation shields, build up on wind sensors, or block incident solar radiation sensors. Blowing snow or corrosion of snow depth transducers can lead to false snow depth measurements. This SOP describes what may affect weather station data, and how to view, flag, correct, quality grade, and set approval levels for data in the Aquarius software. Numeric codes for grades, interpolation types, and approval levels are summarized in Table SOP 11-3. Interpolation types are assigned at data import (Table SOP 11-1). These codes describe how the raw data were collected and are not related to any corrections or edits in the quality control phase.

Table SOP 11-3. Codes for quality grades, interpolation types, and approval levels.

Type	Description	Code
Grade	Good	31
Grade	Suspect	6

Grade	Unusable	-2
Interpolation	Preceding Average	2
Interpolation	Preceding Total	5
Interpolation	Instantaneous Values	1
Approval	Working	1
Approval	In Review	2
Approval	Approved	3

Data values that exceed defined thresholds are automatically flagged when new data are appended (Table SOP 11- 2, Figure SOP 11-4). For an overview of that dataset, select it and open the

Quickview Toolbox. 

The toolbox will display a graph and associated numerical data (Figure SOP 11-15). The timestamp, corrected values, raw values, interpolation type, and flags will be displayed on the numeric table. Any values that have been flagged by the system will be highlighted in red with an abbreviated code (i.e. VH = Very High, IR = In Range).

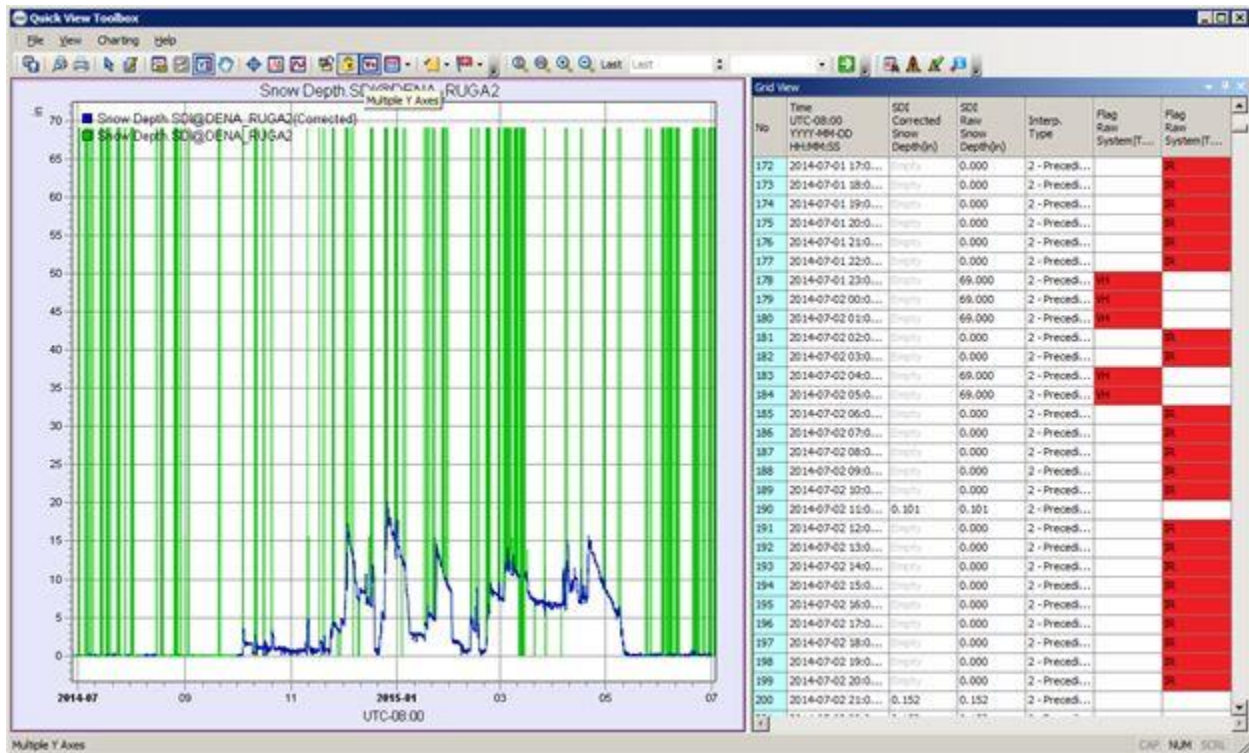


Figure SOP 11-15. Quickview Toolbox example displaying snow depth at Ruth Glacier. Raw values are shown in the table and flagged as red if they exceed defined thresholds. Corrected values are graphed in blue and raw values that have been changed are graphed in green.

Rainfall

The tipping bucket measures liquid precipitation and is primarily used to monitor summer (June-August) rainfall. Rainfall measurements during time periods with air temperatures near or below freezing should be reviewed. Snow that collects in the tipping bucket and melts will record a false-positive measurement for rainfall. This is most common during the spring snowmelt period or during midwinter if air temperatures rise above freezing. Mixed (rain-snow) precipitation is also common during the shoulder seasons and may produce false-positive measurements. As advancements in quality control procedures are made, techniques will evolve. The current process for quality controlling rainfall data includes:

- 1- Automatically setting warning notification flags based on specified thresholds (Table SOP 11-2). Rainfall totals that exceed one inch per hour are flagged.
- 2- Manually deleting erroneous measurements based on notification flags and expert opinion (see Figure SOP 11-20).
- 3- Set quality grades for values outside the summer season as “suspect”.

To set quality grades on rainfall data outside the summer season using Aquarius software, open the RNIN dataset in the Data Correction Toolbox.



1. Select the non-summer period (September-May) by defining start and end points in the correction control frame at the upper-left part of the screen. The selected area should be highlighted in blue. Note: the “Mark Region” button (a green pencil on the top toolbar) can also be used to manually select a time period.
2. Select the “Set Grade” action.
3. Select the Grade as “6 - SUSPECT”
4. Click Apply.

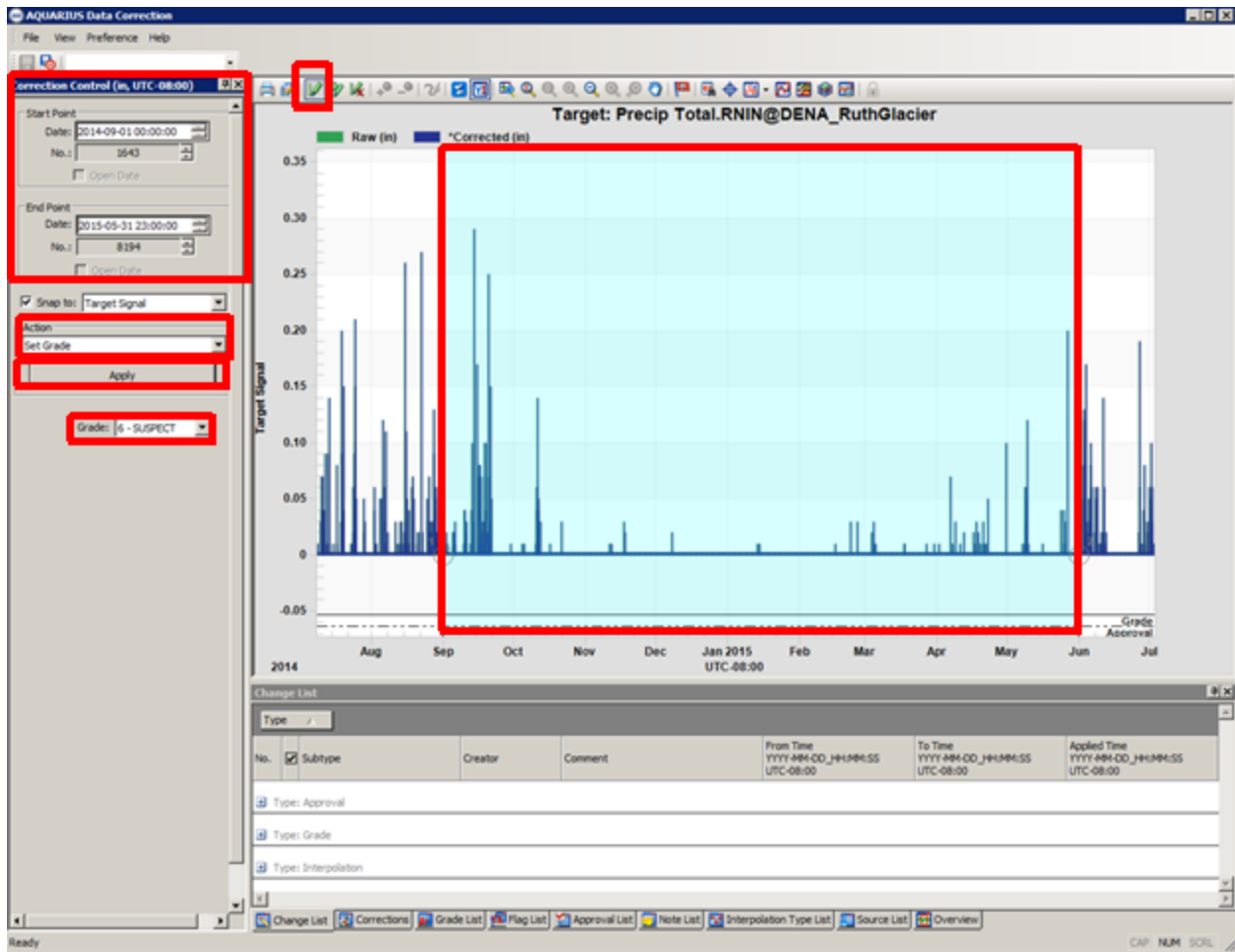


Figure SOP 11-16. Setting a data quality grade in the data corrections toolbox.

5. In the pop-up box, edit the comment field to describe the reason for the quality grade. Enter the text: “Set Grade: 6 - SUSPECT. Rainfall outside summer season”. Click OK to set the grade.

Figure SOP 11-17. Adding a comment to an assigned data quality grade.

- If data during the summer season appear to be valid values, set the grade to “31- Good” using the same procedure. Note that the color coded grading bar is updated and all changes are logged within the software. Save all changes before exiting the Data Corrections toolbox.

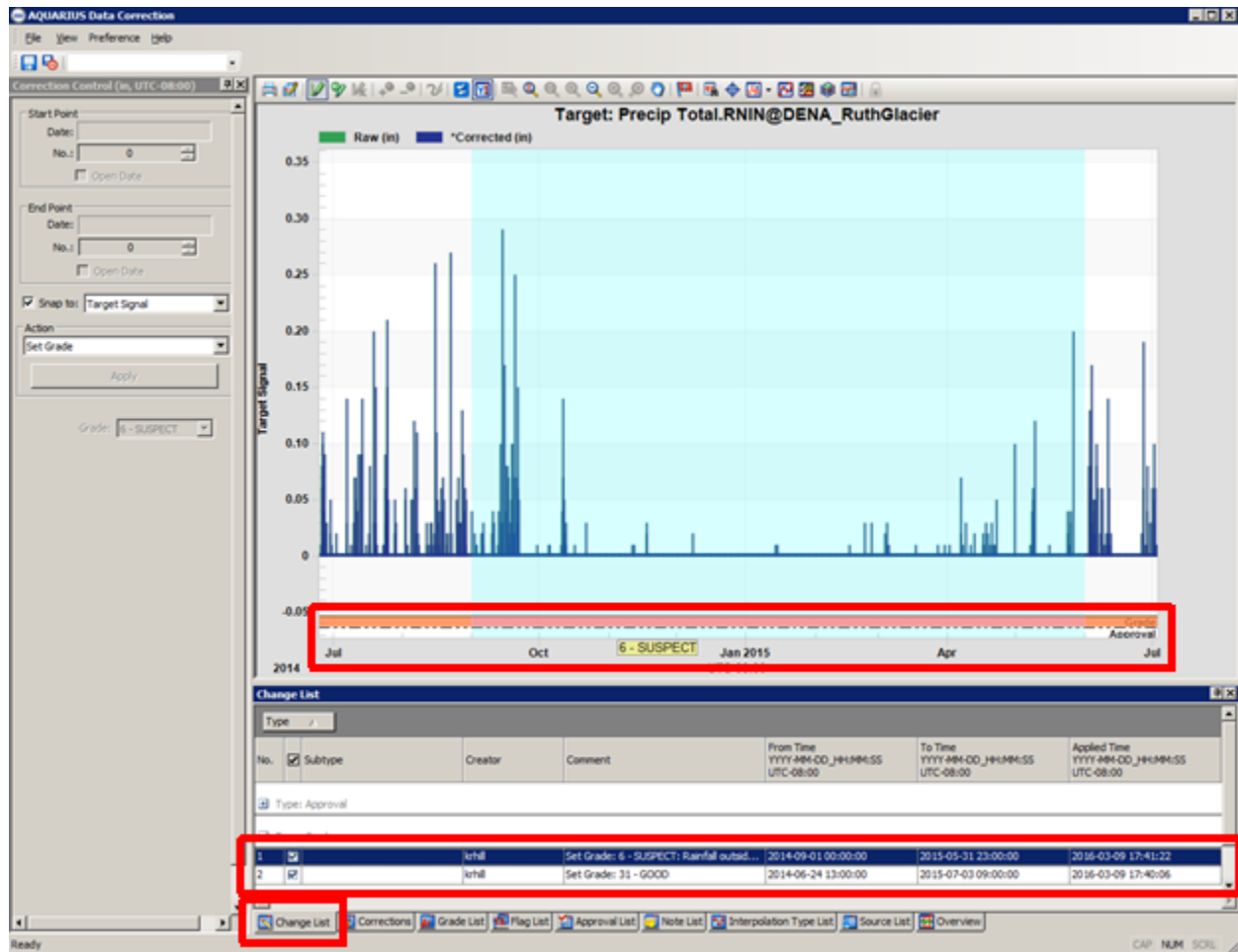


Figure SOP 11-18. Precipitation data quality grading. Data outside the summer period are graded as Suspect. All changes are stored in the software.

Wind Speed and Direction

The most common problem related to wind speed and direction measurements is icing. Icing can affect both measurements simultaneously, or each measurement may be affected separately. Wind speed and direction values are flagged automatically based on the thresholds and flat line criteria (Table 2). These flags can be manually reviewed and graded in Aquarius software.

- In the data corrections toolbox, select the Flag List tab (Figure SOP 11-18) to view flags that have been automatically placed through the notification thresholds.
- Double click on the flagged entries to zoom to the timeframe of interest.

3. Review the flags for accuracy based on expert opinion and grade the data accordingly. Automated flags are meant to assist manual corrections, not to replace expert knowledge of site conditions.
4. A common practice is to select the flat line periods (using the green pencil “Mark Region” button on the top toolbar) and grade these data as “Suspect” (Figure SOP 11-16). A note can be added to the assigned quality grade such as “Possible Icing” (Figure SOP 11-17).

In addition to reviewing the automated flags, the entire record should be reviewed for accuracy.

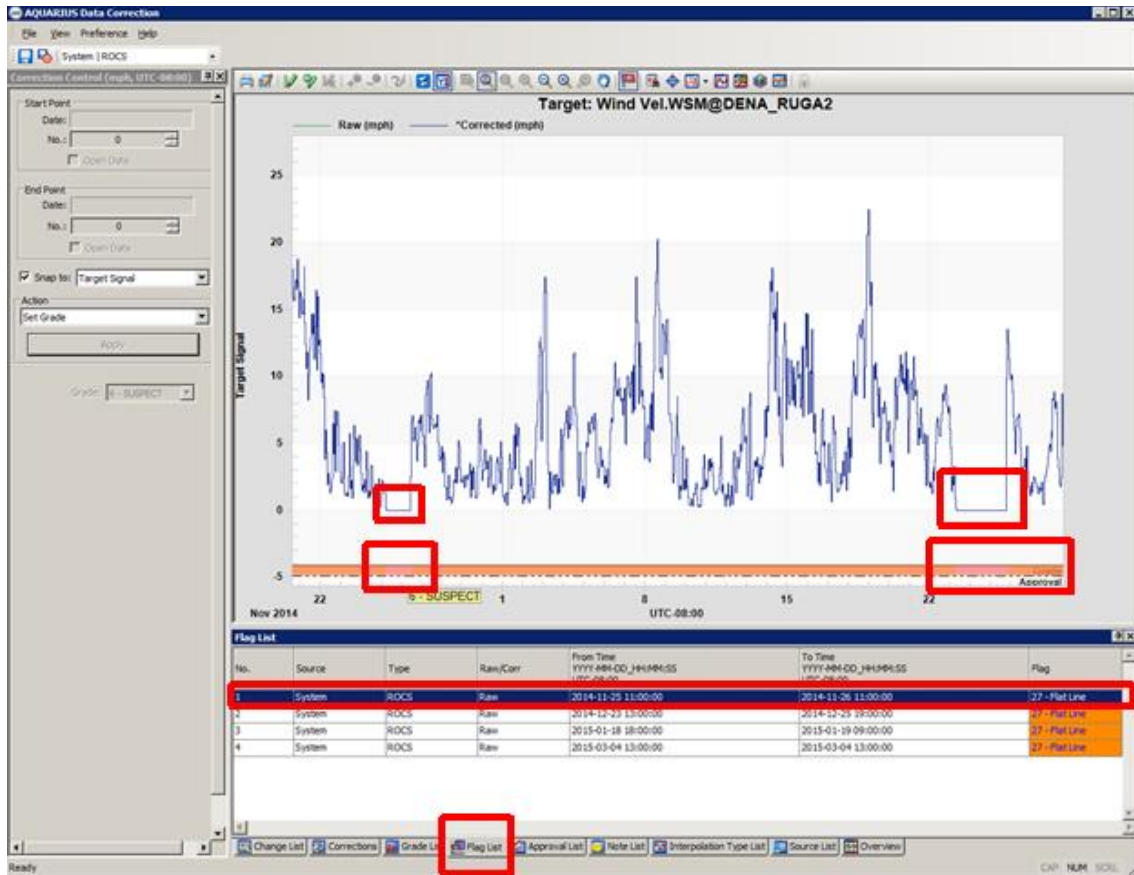


Figure SOP 11-19. Quality grading example for wind speed measurements. Automatically flagged data are shown in the Flag List tab (bottom). Note that the flat-line periods were manually graded as Suspect and are shown on the bottom color-coded bar in pink. Other data periods were graded as Good and are colored in orange. For a detailed example on grading data, review the section on Rainfall above.

Air and Soil Temperature

Air temperature measurements may be affected by (1) sensor/cable damage due to wildlife or corrosion, (2) reduced air flow due to obstruction by ice or snow and (3) if not secured correctly, sensors may also fall out of the radiation shield, exposing them to solar heating. Wildlife can also pull the sensors out of the radiation shield. The most common problems with soil temperature sensors are (1) cable damage caused by wildlife, and (2) sensor placement altered from freeze-thaw processes

or wildlife. If soil sensors are found on the ground surface during a site visit, this is noted in the field visit data sheet (SOP 9).

Temperature measurements are automatically flagged based on the notification thresholds (Table SOP 11- 2). Additional quality control may include:

1. Inspect automatically flagged data. Correct and grade as needed with comments describing the changes (Figure SOP 11-19).
2. Set additional flags with associated comments (Figure SOP 11-20).
3. Data corrections (i.e. deleting regions with erroneous measurements caused by damaged sensors).
4. Data grading. An example of data retrieved from a damaged air temperature sensor is shown in Figure SOP 11-20.
5. Note the type of air temperature sensor. Each location may have multiple air temperature sensors for redundancy. The primary sensor is typically a stand-alone thermistor (SOP 4). The combination air temperature-relative humidity sensor is used as a backup measurement if the primary thermistor fails. The type of sensor used in the final data series should be noted by using the Action – Set Note instruction in the Data Corrections Toolbox (Figure SOP 11-21).

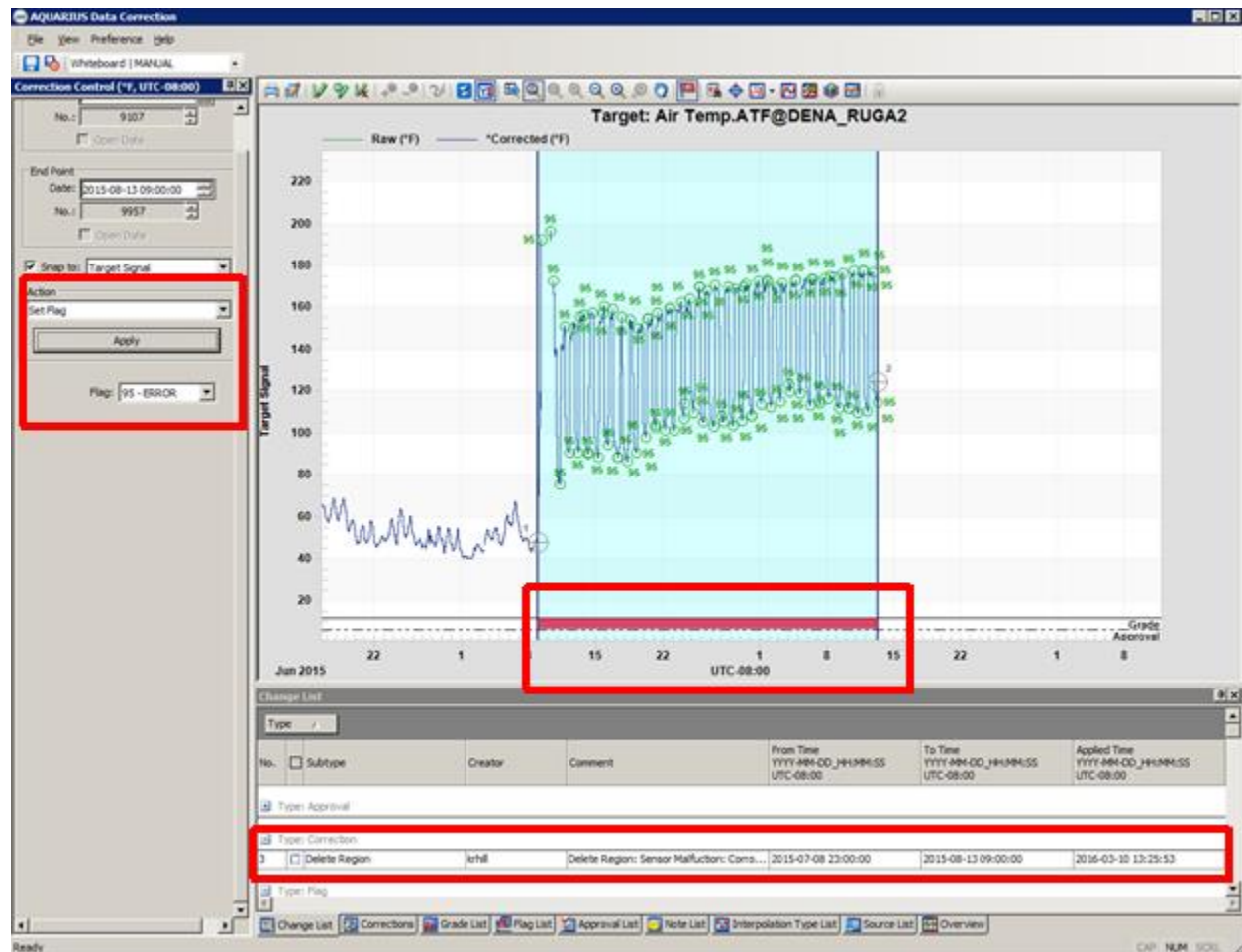


Figure SOP 11-20. An example of data retrieved from a damaged air temperature sensor. Note that data exceeding 110°F were automatically flagged based on the notifications outlined in Table SOP 11- 2. However, despite obvious erroneous measurements starting June 8, data values below 110°F were not flagged because they did not exceed the threshold. In this example, three steps were completed in the quality control procedures. (1) The Set Flag action was used to flag all values during the questionable time period. This manual flag was set with the code: “95 – ERROR”. A unique comment (“sensor damaged”) was added to describe the flag. (2) The “Delete Region” correction action deleted all values during the selected time period. A custom comment (“Sensor malfunction”) was added to describe the delete region action. (3) The quality grade for the time period was set to “-2- Unusable” with a descriptive note added to describe the reason for grading.

Figure SOP 11-21. An example showing how to note the type of air temperature sensor used to collect the measurements. The Set Note action is accessed in the Data Collections toolbox under the

Relative Humidity

Relative humidity measurements are flagged based on the automatic notifications outlined in Table SOP 11-2. In rare cases, damaged or uncalibrated sensors may report erroneous values within the threshold range (0%-100%). Sensor malfunction is most easily recognized by identifying a time period with measurements consistently below expected values (e.g., <20%). Based on the opinion of data reviewers, these values should be flagged, graded, and corrected as needed in Aquarius.

Solar Radiation

The pyranometer measures incoming shortwave radiation. In Aquarius, appended data are flagged automatically based on the notifications outlined in Table SOP 11-2. Snow or ice build-up on the sensors may require the need for additional data corrections. Currently, there is no process for determining if and when suspect measurements are occurring. Future techniques and software enhancements may include comparing measured values to ideal clear-sky conditions.

Snow Depth

The snow depth sensor determines the distance to the ground surface by emitting an ultrasonic pulse and measuring the elapsed time between the emissions and the return of the pulse. Snow depth is calculated by subtracting measured distance from the known height of the sensor. The measurements, to some degree, could be used to infer plant growth in the summer, and thus measurements are collected year round. Beyond general system problems (wildlife damage, power failure, etc.), erroneous measurements may be caused by:

1. Icing of the transducer. This often returns a snow depth value equal to the sensor height (i.e., the measured distance is equal to zero).
2. Blowing snow.
3. Shifting of the sensor height or angle.
4. Alteration of the ground surface.

Automatic flags are produced by Aquarius software according to Table SOP 11-2. Values are flagged if measurements are less than zero, greater than the height of the sensor, flat lined for six or more hours, or equal to 0.00 inches. The upper threshold for automatic flagging is site specific and should be set at or near (below) the height of the sensor. Due to the precision of the sensor, exact 0.00 values are a common erroneous measurement and are flagged through the automatic notifications using the “In Range” option between -0.01 and +0.01 inches (Figure SOP 11-4).

In general, quality control of snow depth measurements requires extensive manual inspection. Multiple methods for data correction are possible in Aquarius and tutorials are available online through both the software support portal and NPS WRD. An example of correcting snow depth data is shown in the following figures.

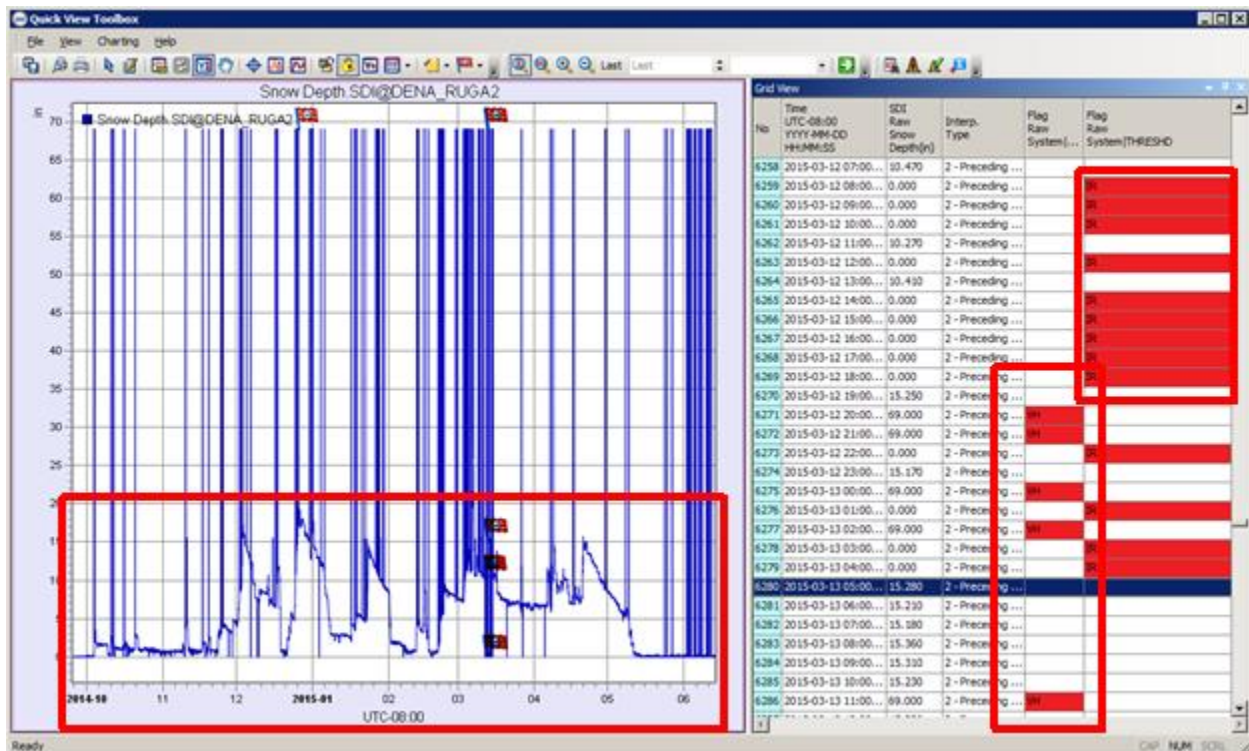


Figure SOP 11-22. An example of raw snow depth data from Ruth Glacier in 2014-2015. Before data corrections, the clean signal is obstructed by many sensor errors. This figure shows the overview data in graphic and tabular form in the QuickView Toolbox. Raw data values are shown on the table at right, with erroneous high values automatically flagged as very high (VH) according to Table 2. Zero values are flagged as “In Range (IR)”.

To delete all sensor values that have been automatically flagged as “Very High” (Table SOP 11-2):

1. Open the data corrections toolbox
2. Select the time period of interest. To select the entire time period, click the “Mark All Region” button on the top toolbar.
3. Select the Trim Flagged Values Action on the left frame.
4. Select the Flagging Type as THRESHS.
5. Select the Flag Code as 1- Very High
6. Click Apply.
7. Enter a comment that describes the correction (Figure SOP 11-24).
8. Click OK. This will delete all values that were flagged as very high based on a threshold criterion.

Note: A similar common correction for snow depth time series is deleting all zero values during the winter months. This is done through the “Delete Specific Values” action.

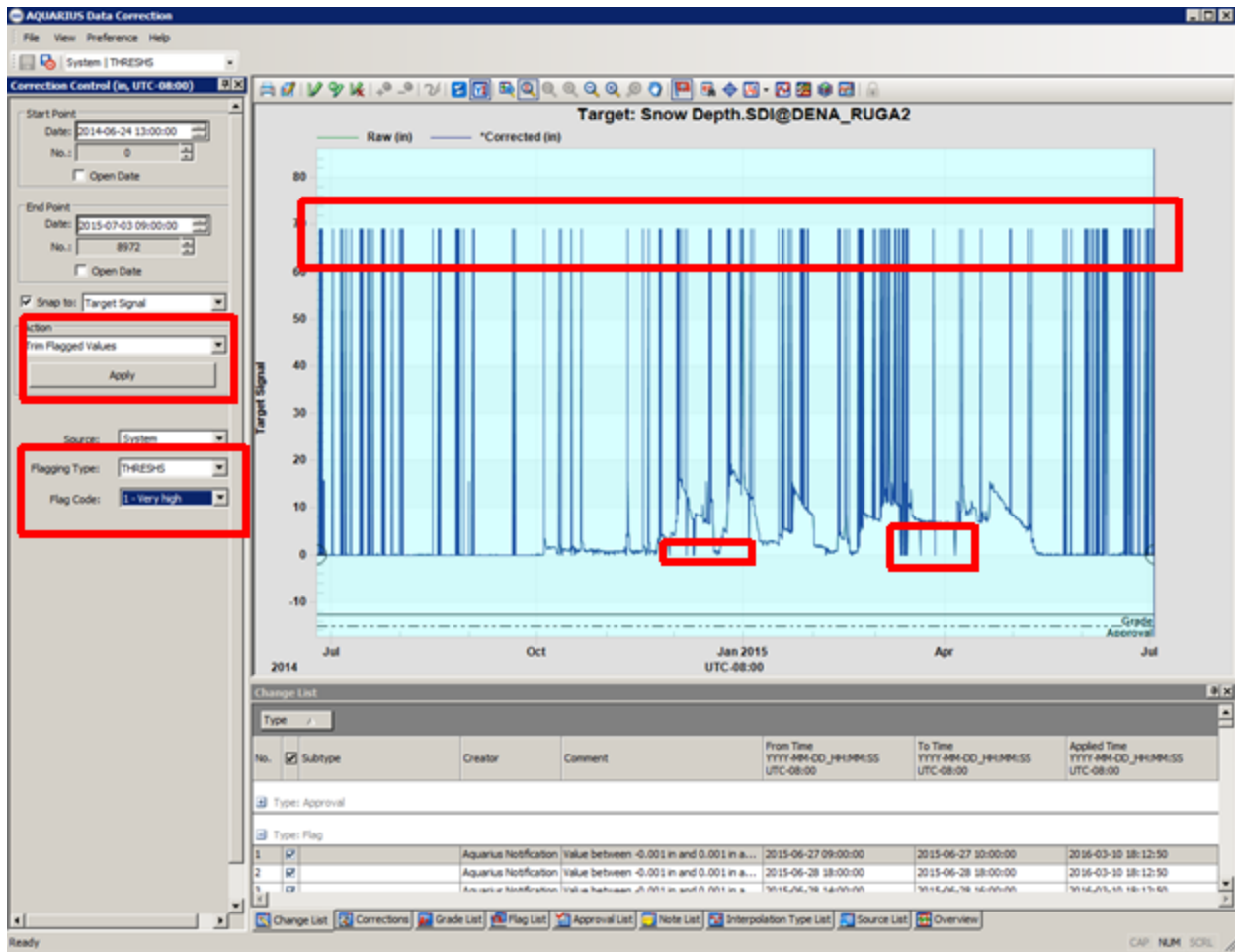


Figure SOP 11-23. Data corrections for a snow depth time series. This correction action deletes all values that were automatically flagged as Very High. Note that additional corrections could be implemented, including deleting zero values during the snow accumulation season.

Figure SOP 11-24. Example of how to enter a custom comment for a data correction.

Data Approvals

In addition to data grading, time series approval levels can be designated as 1- Working, 2- In Review, or 3- Approved. The suggested workflow is to include data approval levels for all datasets. After all corrections have been implemented and data grades have been assigned, approvals are set in Aquarius according to Figure SOP 11-25.

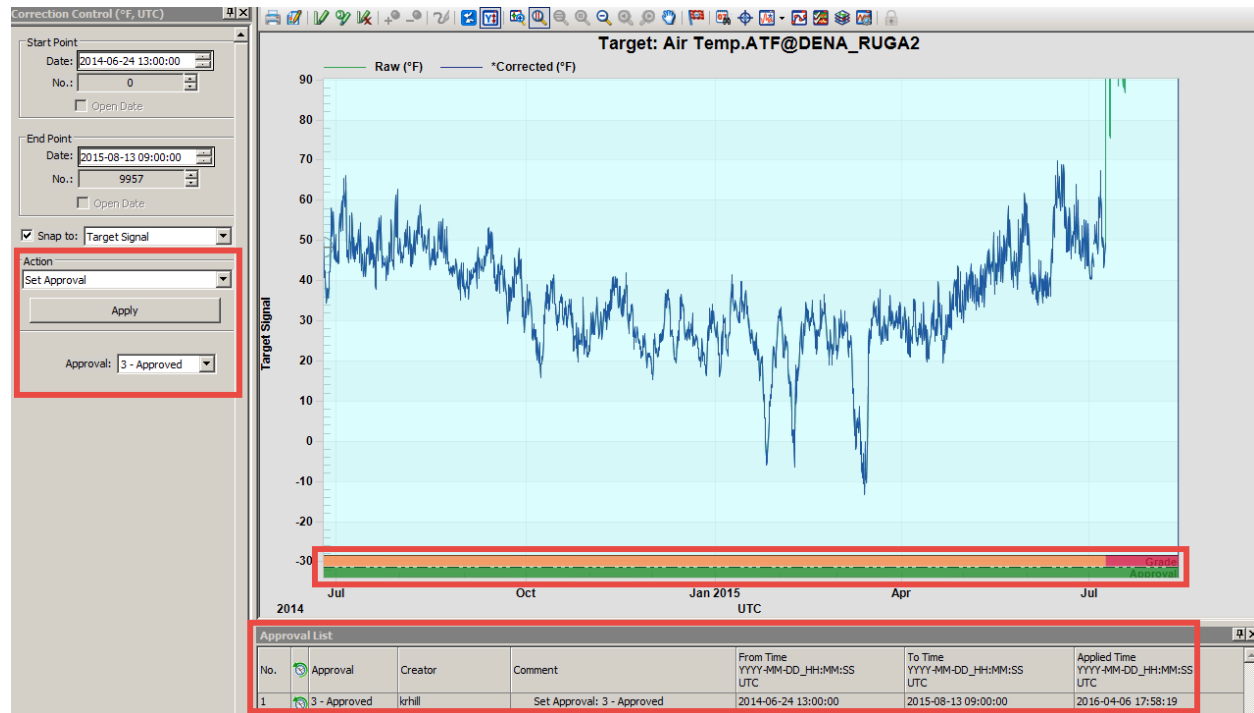


Figure SOP 11-25. Data approval levels set for the air temperature time series shown in Figure SOP 11-20. The approval is set using the “Action” options in the Correction Control frame at left. The audit log is updated as shown in the Approval List at bottom. Note that the color coded timeline bar includes data grades of both “Good” (orange) and “Unusable” (red). Underneath the data grades, the green approval bar indicates that the time series approval level has been set to “Approved”.

Data Export

After all time-series have been reviewed and corrected, the final corrected data should be exported and formatted according to the specifications for WC_G in SOP10. Aquarius has an export toolbox or SEAN has developed a web export tool at http://sean-dm.glba.nps.gov/WC_G_Generate2_DM.aspx

Outlined below is the Aquarius Export method:

1. Control-click the data sets following the order of the data stream (RNIN, WSM, WDD, ATF, RHP, BVV, WDDP, WSMP, SRW, SDI, AT1L, AT1H, STF, STF2, STF3, STF4, STF5). Note that the hourly total rainfall is exported, not the cumulative total.

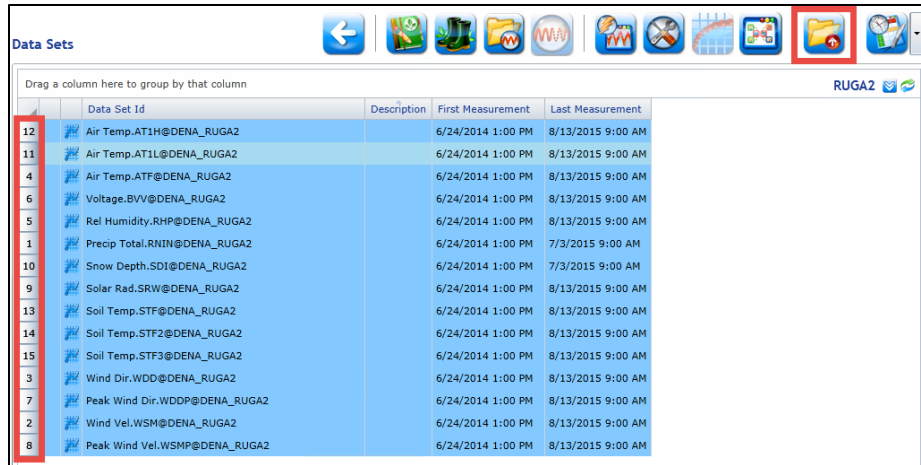


Figure SOP 11-216. Data sets selected for export. Note that the order of parameters (numbers on left) is specified by control-clicking.

- Click the Export Time Series button



- In the pop-up window, confirm that the units are correct, the time zone is UTC, and the start and end dates encompass the duration of the cumulative time series (Figure SOP 11-26).

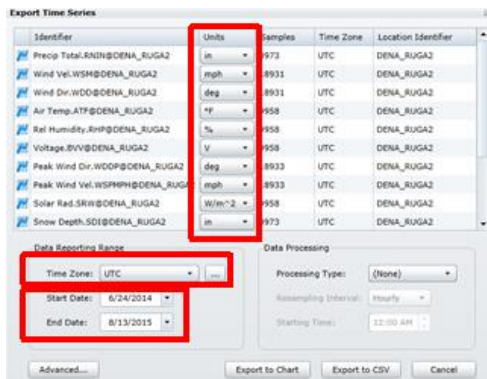


Figure SOP 11-27. Export Time Series options.

- Click Export to CSV.
- In the pop-up window, select Save CSV File... (Figure SOP 11-27).

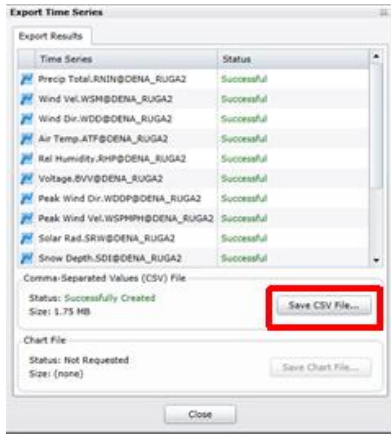


Figure SOP 11-28. Export Time Series results.

6. Rename the file with the park code, site code, start date, and end date. (e.g.,
DENA_RUGA2_20140624_20150813.csv

The first column in the exported file contains the date/time stamp. Subsequent columns include corrected data values, quality grades, approvals, and interpolation codes for each parameter (Figure SOP 11-29). The codes are described in the Aquarius help files. Relevant codes are summarized in Table SOP 11-3. Note that there are many other export options available in Aquarius. Future workflows and/or future software developments may include different export options for the formatting of the final corrected data file.

	A	B	C	D	E	F	G	H	I	J	K	L	M
		Precip Total.RNIN @DENA_RU	Precip Total.RNIN @DENA_RU	Precip Total.RNIN @DENA_RU	Precip Total.RNIN@ DENA_RUGA2	Wind Vel.WSM @DENA_	Wind Vel.WSM @DENA_	Wind Vel.WSM @DENA_	Wind Vel.WSM@ DENA_RUG	Wind Dir.WDD @DENA_	Wind Dir.WDD @DENA_	Wind Dir.WDD @DENA_	Wind Dir.WDD@DE NA_RUGA2
1													
2	mm/dd/yyyy HH:MM:SS	in			Interpolation	mph			Interpolati	deg			Interpolation
3	Date-Time	Value	Grade	Approval	Code	Value	Grade	Approval	on Code	Value	Grade	Approval	Code
4	6/24/2014 13:00	0	31	3	5	1.625	31	3	2	285.4	31	3	2
5	6/24/2014 14:00	0	31	3	5	1.478	31	3	2	40.1	31	3	2
6	6/24/2014 15:00	0	31	3	5	2.228	31	3	2	91.6	31	3	2
7	6/24/2014 16:00	0	31	3	5	3.546	31	3	2	152.4	31	3	2
8	6/24/2014 17:00	0	31	3	5	4.693	31	3	2	182.9	31	3	2
9	6/24/2014 18:00	0	31	3	5	2.432	31	3	2	131.4	31	3	2
10	6/24/2014 19:00	0	31	3	5	3.664	31	3	2	172.4	31	3	2

Figure SOP 11-29. An example of the column headers from the default export toolbox in Aquarius springboard Grade, Approval, and Interpolation codes are given in Table SOP 11- 3.