

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 1

Compliance and Permitting

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the steps necessary to engage in snowpack monitoring within the National Park Service which is subject to legal justifications of the National Environmental Protection Act (NEPA) of 1969.

The purpose of NEPA as stated in section 2 of the act that created it is to *“encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of man; and to enrich the understanding of the ecological systems and natural resources important to the Nation....”*

This SOP is included in the protocol because this step in the process is not insignificant and could have a bearing on the annual workload. Both climate and snowpack monitoring involve installations of permanent fixtures on the landscape. During the initial planning phase of the project it is necessary to begin the process of permitting and compliance. The permitting and compliance phase could take up to a year for final processing depending on the level of NEPA compliance necessary. It is also possible that the project or upgrades to the project are not congruous with the management policy of the park. Compliance and permitting are constantly evolving; always inquire about current requirements.

Research permits and compliance

1. Determine if the project is already covered under an existing project name in either individual compliance databases for the park or through the U.S. National Park Service Research and Reporting System (<http://science.nature.nps.gov/research/ac/ResearchIndex>)
2. Follow the guidelines for the individual park to initiate the compliance process. This often begins with the application for a research permit which triggers the internal compliance review within each park.

Natural Resources Conservation Service (NRCS) SNOTEL (SNOW TELemetry) sites are being planned within the network for the next few years. Some discussion still remains over potential sites located within designated wilderness areas or areas that are considered suitable wilderness (for potential future designation). These lands are subject to more stringent regulations governed under the Wilderness Act of 1964.

The purpose of the Wilderness as stated in section 2 (a) is to *“secure for the American people of present and future generations the benefits of an enduring resource of wilderness... for the use and enjoyment of the American people in such manner as will leave them unimpaired for future use and*

enjoyment as wilderness, and so as to provide for the protection of these areas, the preservation of their wilderness character, and for the gathering and dissemination of information regarding their use and enjoyment as wilderness...”

Attached to this SOP is an example of a study plan submitted under the National Park Service Research and Reporting System for initial climate station placement in Yukon-Charley Rivers National Preserve. This is the final revision of the plan.

**Revised Study Plan for
Central Alaska Network (CAKN)
Climate Monitoring
Yukon-Charley Rivers National Preserve
2004**

Submitted by:
Pamela Sousanes
Environmental Specialist
Denali National Park and Preserve
PO Box 9
Denali Park, AK 99755
Phone: (907)683-9573
Fax: (907) 683-9634
E-mail: pam_sousanes@nps.gov.

I. Abstract:

The Inventory and Monitoring Program is the result of the National Parks Omnibus Management Act, which was passed by Congress in 1998. This act directs the National Park Service “to establish baseline [resource] information and to provide information on the long-term trends in the condition of National Park System resources.” To accomplish this formidable task, the NPS has grouped parks into 32 networks which are characterized by their ecological similarities. Four of these networks are in Alaska. Denali National Park and Preserve, Wrangell-St. Elias National Park and Preserve and Yukon-Charley Rivers National Preserve have been organized into the Central Alaska Network (CAKN). One objective of the program is to monitor and record weather conditions at representative locations in order to identify long and short-term trends, provide reliable climate data to other researchers, and to participate in larger scale climate monitoring and modeling efforts.

In an attempt to better understand climate variation as well as possible long-term changes in ecosystems of the Central Alaska Network and in particular Yukon-Charley Rivers National Preserve, two new long-term climate monitoring stations are being proposed within the Preserve. The sites under consideration are the upper east fork of the Charley River near the Three Fingers area and the Coal Creek camp area. These weather stations would record the following parameters: Air temperature, relative humidity, wind speed and direction, incoming solar radiation, precipitation, soil temperature, and snow depth. We are proposing that the station in the Upland area be augmented in two years to become a Natural Resources Conservation Service snow telemetry (SNOTEL) site which would measure year-round precipitation as well as the other parameters. The data from the stations will be available real-time via the internet through the Western Regional Climate Center. These stations are recording long term variations in climate, so it is intended that they remain at the selected locations indefinitely. Once a station is placed it is imperative that the site not be moved in order to have the most accurate long term record possible.

This document includes the original study plan for climate monitoring submitted in March 2004 with some revisions, as well as the amendment for the additional site evaluations done in May of 2004.

II. Overview

Numerous studies describe the effects of climate change on selected ecosystems. It is important to quantitatively monitor meteorological conditions directly so that a reliable record of long term change can be established. Climatic variations are a primary driver of ecosystem dynamics, impacting both terrestrial and aquatic flora and fauna. There is one climate station within Yukon Charley at present located on Ben Creek. In order to better characterize the region we are proposing to add a paired low elevation site near Coal Creek Camp as well as an Upland site in the upper east fork of the Charley River near the Three Fingers area.

The two most important climate parameters to monitor are air temperature and precipitation. Air temperature is a relatively easy measurement to make accurately using the right instrumentation. While rainfall in summer is relatively easy to measure the transitional fall and winter precipitation events and the snowfall in winter are difficult to measure accurately, especially when a station is remote. The Natural Resources Conservation Service (NRCS) has been successfully running remote SNOTEL sites, or snow telemetry sites, in the state of Alaska for many years. These sites have a year-round precipitation gage that accurately records both snow and rain, using a shielded gage to increase accuracy. NRCS has a robust program in place which includes periodic maintenance of sites and data quality control and quality assurance as well as internet data dissemination. NRCS has worked with the NPS for years with snow courses and aerial snow markers and are prepared to engage in an interagency cooperative agreement to install SNOTEL sites within the three CAKN parks. In order to best record changes in precipitation over the next 50-100 years a robust and proven method is necessary. Two sites are being proposed in Denali National Park & Preserve, 2 sites in Wrangell-St. Elias National Park and Preserve, and 1 in Yukon-Charley Rivers National Preserve.

A climate monitoring site evaluation document has been presented to the National Weather Service, the Natural Resources Conservation Service, the Western Regional Climate Center, and Sharon Alden, the meteorologist with the interagency Alaska Fire Service. Comments and reviews have been compiled and the sites proposed in Yukon-Charley Rivers national Preserve meet the recommendations of the peer group.

Objectives

Goal: Monitor principle components of the physical environment.

Objective: Monitor and record weather conditions at representative locations in order to identify long and short term trends, provide reliable climate data to other researchers, and to participate in larger scale climate monitoring and modeling efforts.

III. Methods

A. Study Area

Climate is currently monitored at Yukon Charley Rivers National Preserve at Ben Creek within the Preserve, and Eagle just outside the boundary. Potential new sites in Yukon-Charley were selected

based on valuable information of the area supplied by Nikolina Guldager (YUGA Wildlife Biologist) and Jay Martin (YUGA Park Pilot). Several factors influenced potential site locations. Firstly, the few climate monitoring sites currently existing in and around Yukon-Charley are at lower elevations, so an effort was made to find a potential new site at a higher elevation within the preserve. Secondly, five new aerial snow markers were installed by Guldager within the preserve in 2001 and 2002, and an effort was made to locate sites near these markers for correlation with snow survey data. Initially an attempt was made to locate sites proximal to existing airstrips for fixed-wing access, however after conferring with the Interdisciplinary Compliance Team it was suggested that more remote sites be evaluated due to the concerns of proximity (of the original proposed sites) to the Charley River which is classified as a National Wild and Scenic River. Table 1 lists all of the potential sites with the preferred sites highlighted.

Table 1. Potential sites identified in Yukon-Charley Rivers National Preserve.

Site	Area	Elev (ft)	Latitude (NAD27)	Longitude (NAD27)	Access*
Three Fingers	Y-T Uplands	3180	64° 34' 32.47"	143° 14' 27.67"	F
Crescent Creek	Y-T Uplands	2850	64° 48' 31.53"	143° 54' 37.92"	F
Gelvin's Airstrip	Y-T Uplands	2100	64° 49' 20.00"	143° 25' 57.00"	F
Beverly Airstrip	Y-T Uplands	4110	65° 06' 40.16"	143° 50' 12.20"	F
Coal Creek	Y-T Uplands	870	65° 18' 50.05"	143° 07' 56.38"	F/S
Slaven Cabin	Y-T Uplands	704	65° 21' 02.56"	143° 07' 21.51"	F/S
Three Fingers Aerial Snow Marker Site #1	Y-T Uplands	3082	64° 32' 08.8"	143° 09' 10.4"	H
Site # 2	Y-T Uplands	3570	64° 31' 20.3"	143° 07' 30.7"	H
Site #3	Y-T Uplands	3590	64° 31' 02.0"	143° 11' 58.2"	H
Site #4	Y-T Uplands	3610	64° 30' 14.05"	143° 15' 18.59"	H
Site #5	Y-T Uplands	3530	64° 38' 57.0"	143° 08' 52.27"	H
Site #6	Y-T Uplands	3530	64° 40' 29.2"	143° 51' 00.0"	H

Access: (H) helicopter, (F) fixed-wing aircraft, (S) snowmachine/ATV

Pamela Sousanes, Paul Atkinson (DENA Physical Science Technician), Jay Martin (YUGA Park Pilot), and Guy Adema (DENA Physical Scientist) conducted the initial on-the-ground surveys of Coal Creek and Three Fingers sites and fixed-wing over flights of the remaining sites on 27 August 2003. An additional five sites in the Yukon-Tanana Uplands were evaluated in 2004 via helicopter by Pamela Sousanes and Marsha Henderson. Figure 1 shows the location of all sites included in the original site selection. Topographic maps with site locations, descriptions and photos are included in Appendix A for Three Fingers, and in Appendix B for Coal Creek and Slaven Cabin. Descriptions, maps, and photos for the additional sites evaluated in 2004 are included in the attached amendment.

B. Procedures

In a 2002 scoping meeting the CAKN physical science team met with Larry Hinzman of the University of Alaska Fairbanks to discuss instrumentation. Hinzman has been involved with the Long Term Ecological Research (LTER) areas at Bonanza Creek, Poker Flats and Toolik Lake in Alaska for many years. He made suggestions on instrumentation based on their study design and others like it around the country. During the site evaluation process the instrumentation was also presented and was accepted by all. Through discussions with the CAKN technical committee it was

decided that temperature and precipitation were the most important variables or drivers in the ecosystem context, followed by wind, solar radiation, and relative humidity. The station design described below was submitted and approved by the technical committee.

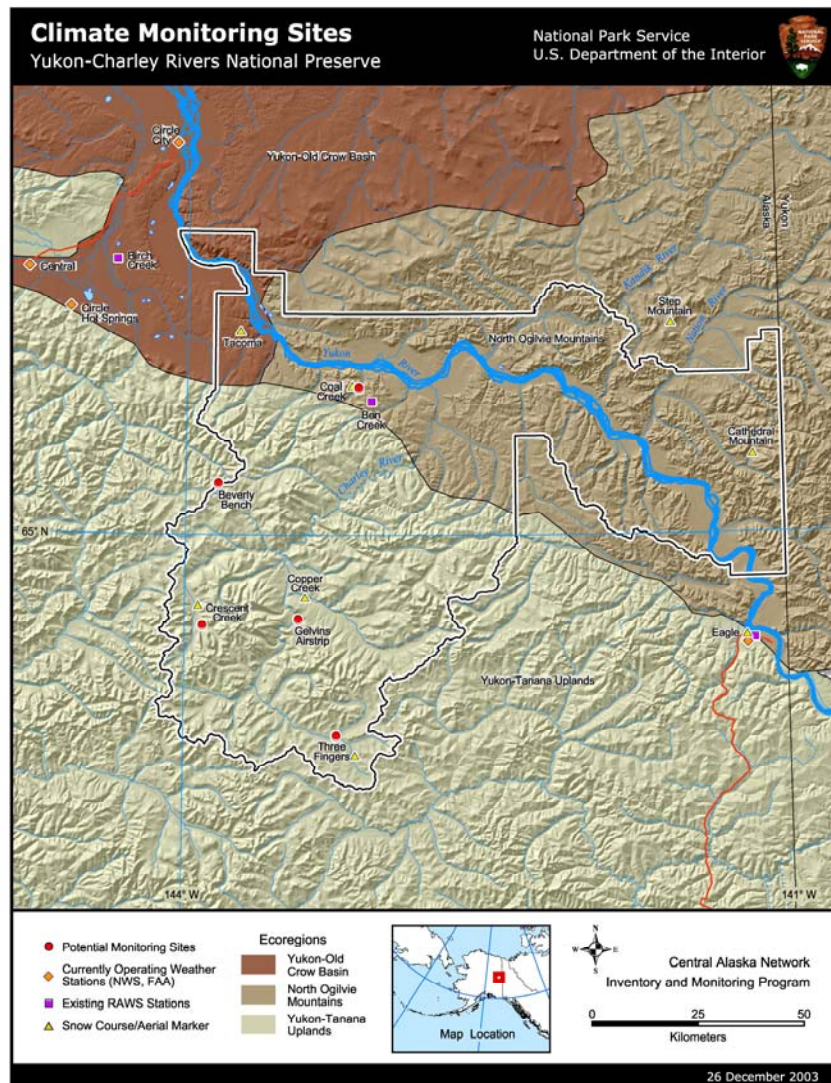


Figure 1 Location of sites in selection process.

There are two variations of climate stations being proposed, a standard tripod station and a tripod station with the additional instrumentation necessary to upgrade to a NRCS SNOTEL station. The NRCS SNOTEL station would be installed after 2-3 years of data were collected from both the climate station and the aerial snow marker in the area. The standard tower is a ten-foot mast on a tripod base with a 12' diameter footprint. The station is guyed via cable to itself and augmented with guy wires to the surrounding ground surface via cable and rebar (1/2" diameter x 3' length). The station includes a Campbell Scientific, Inc. CR10X data logger and Seimac High Data Rate GOES satellite data transmitter. Basic instrumentation includes air temperature, relative humidity, wind speed and direction, incoming solar radiation, tipping bucket rain gauge, an acoustic snow depth sensor, and 3 soil temperature probes. The soil temperature probes are inserted into the ground near

the station via a 1" diameter soil auger, the ground disturbance is minimal. A pipe (2" diameter x 3' length) will be inserted in the ground and used to hold the precipitation tipping bucket 30 cm above the vegetation. Figure 2 shows a typical station.

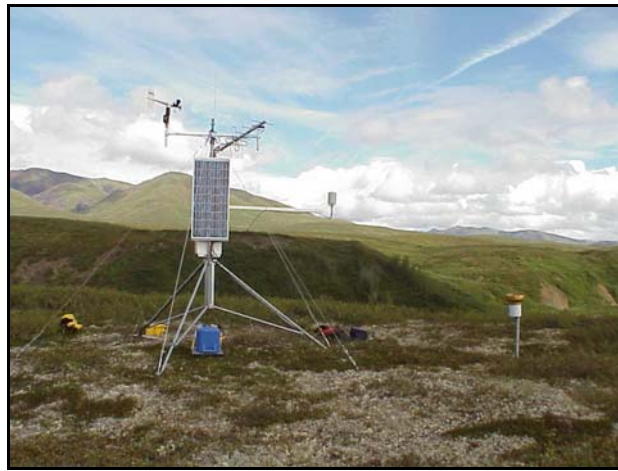


Figure 2 Standard climate station

The equipment for the new stations was purchased in 2002 and 2003. Three of these stations have already been deployed in a testing phase at remote locations in Denali; the remaining nine are currently set up near the Denali National Park & Preserve Visitor Center for testing and assessment prior to deployment in 2004. This testing phase is an extremely valuable stage for the network. Inherent bugs in programming, instrumentation, power systems, and many other miscellaneous problems will be identified before these stations go remote. The stations were specifically designed for remote, high latitude, extreme cold conditions. Special consideration was taken to minimize visual and physical impacts by making the stations as compact as possible to comply with wilderness values within national park lands. The stations have a small footprint, low-impact anchoring systems, and wooden platforms to stand on while visiting the site to minimize vegetation disturbance. Stations are powered year-round by two solar panels. A sealed lead-acid battery is enclosed in an insulated cargo container and is the only hazardous material on site (Figure 3). This station is ready for deployment in summer 2004.



Figure 3 Battery and enclosure for climate station

The augmented SNOTEL station would continue to use the tripod configuration to measure the meteorological parameters described in the previous section, with the addition of a rocket type year-round precipitation gage and a small shelter (4' x 4' x 8') with a 20' tower attached for a solar panel

and telemetry antenna. The precipitation gage would be constructed from irrigation pipe with a pressure transducer in the bottom of the device. A mixture of propylene glycol would be used in the reservoir to melt the falling snow (It would be contained in the system). The shelter will sit on 16" x 16" concrete pads at each corner. The precipitation gauge will also be anchored on a 16" x 16" concrete pad. The precipitation gage height would be @ 6-7 feet. The equipment will be painted brown to blend in as much as possible with the surroundings. Figure 4 shows an example of a snow telemetry (SNOTEL) site using the year round precipitation gage used by NRCS at Coldfoot. Site specifics, including maximum annual snowfall will ultimately determine the final design and of the station. Data from the aerial snow marker in the area will be used to determine the height of the gage. The aerial marker was installed in 2002 and at least two more years of data are necessary to determine the gage height, putting an installation date of the augmented SNOTEL site in 2006.



Figure 2 Example of SNOTEL site at Coldfoot

Some brushing might be necessary in the immediate area surrounding the station to ensure accuracy of the measurements. At the Upland site this will be minimal due to the location above treeline. At the lower proposed site every attempt will be made to locate the station within an adequate clearing, however the site might require some maintenance brushing over the years as vegetation changes take place.

C. Data Collection Methods

Data will be collected and stored electronically at all sites. Campbell Scientific Inc. CR10X dataloggers will be used for data collection at each station proposed for Yukon-Charley

Rivers national Preserve. Measurements will be taken at 60 second intervals and recorded hourly. Data are stored on-site within the datalogger which has a one million datapoint capacity; these data will be retrieved from the site during annual maintenance trips. These data are also sent out via satellite each hour and will be disseminated and archived at the Western Regional Climate Center (WRCC) in Reno, Nevada. A corresponding database will also be archived within the CAKN network with the data manager. After a site visit the data will be sent via ftp to WRCC to ensure there are no data gaps due to satellite problems. The data will also ultimately be archived with the National Climatic Data Center (NCDC) in Asheville, NC.

Air Temperature and Relative Humidity

A Vaisala HMP45C air temperature and relative humidity sensor will be used to record hourly minima, maxima and average air temperatures and relative humidity. Temperature measurements will be recorded in degrees Celsius and relative humidity will be recorded in percent.

Solar Radiation

The Li-Cor LI-200X pyranometer sensors that will be used consist of silicon photodiodes which measure total sun plus sky radiation in the 280 to 2800 nm spectral band. Average solar radiation will be recorded in W/m^2 and summarized as daily global radiation in $MJ/m^2/day$. Solar radiation figures will be considered reliable only when daytime temperatures are above freezing since snow and frost will occasionally accumulate on the sensors, thus obscuring them from the sky.

Wind

A R.M. Young Wind Monitor will be used to measure horizontal wind speed and direction at each site. Average wind speed and unit vector mean wind direction will be logged every hour; standard deviation of wind direction and maximum gust speed and direction will also be recorded. All wind speeds will be recorded as meters per second. It should be noted that because wind gusts can occur in very short time intervals and because speeds are sampled only once every 60 seconds, some peak gusts may not be recorded.

Precipitation

A Texas Electronics TE525WS tipping bucket will be used to measure seasonal precipitation. Because this tipping bucket will not be heated, precipitation can only be measured when temperatures are reliably above the freezing point – most likely between June and September. Precipitation is measured in millimeters.

A Campbell Scientific acoustic distance sensor will be used to measure snow depth. This sensor records the difference between the sensor and the snow surface and subtracts the distance from the sensor to the ground surface giving you the snow depth. These measurements will be taken every 15 minutes and averaged hourly. Snow depth will be recorded in meters.

Soil Temperatures

Soil temperatures will be measured using a Campbell scientific 107 temperature probe inserted in the ground at .5m and 1 m. Soil temperatures will be sampled every 15 minutes and averaged hourly. Temperatures will be recorded in degrees Celsius.

D. Analysis

These data will be used to support various projects occurring within the Central Alaska Network as well as statewide research applications, National Weather Service forecasting, fire weather indices, and global climate models. The potential use of these data is unlimited. Annual summaries will be compiled for the CAKN climate monitoring network which will include a narrative presentation of the data as well as summary charts and graphs. In the protocol development stage of the program (Fall 2004) the details of the annual reporting will be addressed in detail.

Meaningful climatic trend analysis will require a longer period of record than just a few years. Analysis schedules will be addressed in detail in the protocol development slated for completion in fall 2004. However, correlation of preliminary data with other nearby sites will be documented. A number of summaries and products will be available in real-time via the WRCC webpage including daily and monthly summaries, time series graphs, wind rose graphs, and histograms. The stations metadata will also be archived at this location as well as with the data manager for CAKN and with the Environmental Specialist (Climate Monitoring) at Denali. Specific analysis might be done on an individual project basis depending on the information needed, or through global models used by NOAA, NWS, or university researchers. Again, the potential use of these data is unlimited.

E. Schedule

The tentative schedule plan for climate monitoring in Yukon-Charley Rivers is as follows:

June: Reconnaissance site visit to Coal Creek via fixed-wing to identify site specifics. Photo document and mark exact location with GPS. Clear with cultural resources team. Potentially cache some of the equipment at Coal Creek Camp for future deployment.

August/September: Deployment of climate station at Coal Creek and/or upper east fork of the Charley. This work will be accomplished by Pamela Sousanes and a Physical Science Technician. They will spend approximately 1 full day at each site installing the station and another day at Coal Creek troubleshooting any potential problems. Preferably they would stay at Coal Creek camp during the visit.

September: If necessary visit site(s) an additional time before winter to ensure everything from initial setup is running as desired.

F. Budget

The budget for this program is part of the Central Alaska Network pilot projects for 2004. The budget includes the OAS cost of fixed-wing access to Coal Creek and helicopter access to the upper east fork Charley River site and per diem for Sousanes and the physical science technician involved in the installation. The equipment for the climate stations was purchased in 2002. Additional miscellaneous tools and equipment might be necessary depending on the ultimate location. The proposed cooperative SNOTEL site would be funded for 2006, but design development would occur this fiscal year. Some of the instrumentation for the SNOTEL sites has already been acquired. Annual maintenance will be required and built into the budget of the program. The stations will require annual visits for sensor calibrations and general maintenance. The maintenance trip could be coordinated with the annual Remote Automated Weather Station (RAWS) maintenance trip.

V. PRODUCTS

- A. **Publications and reports** – These data will be used to support various projects occurring within the Central Alaska Network as well as statewide research applications, National Weather Service forecasting, fire weather indices, and global climate models. The potential use of these data is unlimited. Annual summaries will be compiled for the CAKN climate monitoring network which will include a narrative presentation of the data as well as summary charts and graphs. In the protocol development stage of the program (Fall 2004) the details of the annual reporting will be addressed in detail.
- B. **Collections** – None
- C. **Data and other materials** - Photographs, handouts, exhibits, presentations, raw data, and GIS coverages will be developed using these data. These data will be available on the CAKN website and through WRCC. The climate station sites will be plotted as an NPS coverage with links to the data and metadata.

VI. LITERATURE

Nothing was cited specifically in this proposal but reference to all of the reports below has gone into the culmination of this program.

AMAP, 1998. AMAP Assessment Report: Arctic Pollution Issues. Arctic pollution Issues. Arctic Monitoring and Assessment Programme (AMAP), Oslo, Norway. 859 pp.

Juday, G.P. 2000. Recent climate and forest history of the Denali National Park and Preserve Headquarters area, based on tree ring analysis. Agricultural and Forestry Experiment Station. University of Alaska Fairbanks. Report to U.S. Geological Survey Biological Research Division. 26 pp.+ figures.

McClure, R.J. 1998. Artificial Shielding of precipitation Gauges in the Arctic. Report to Soil

Conservation Service, Anchorage Alaska. 1 p.

- Searby, H.W. 1970. Mount McKinley National Park Alaska – Climatic Summaries of Resort Areas. National Oceanic and Atmospheric Administration-National Weather Service. No. 21-49-1. 5pp.
- Simpson, J.J., G.L. Hufford, M. Fleming, J.S. Berg and J.B. Ashton. 2002, Long-term climate patterns in Alaskan surface temperature and precipitation and their biological consequences, *IEEE Trans. Goes. Rem. Sens.*, **40**, 1164-1184
- Simpson, J.J., G.L. Hufford, C. Daly, J.S. Berg, M.D. Fleming, Submitted to *Weather and Forecasting*. Two Views of Alaskan Surface temperature and Precipitation: Implication for the Development of an Improved Operational Climate Monitoring System.
- Solomon, H. 1992. A preliminary report on meteorological observations on Mt. McKinley, Alaska. The Journal of the Japanese Alpine Club. Sangaku. Vol. 87. A25-A27.
- Stafford, J.M., G. Wendler, J. Curtis. 2000. Temperature and precipitation of Alaska: 50 year trend analysis. *Theor. Appl. Climatol.* **67**, 33-44.
- Sousanes, P.J. 2002. 2001 Long term Ecological Monitoring. Climate Data Summary. Denali National Park and Preserve. 120 p.
- Walter, H. 1963. Climatic diagrams as a means to comprehend the various climatic types for ecological and agricultural purposes. Pp. 3-9 in Rutter, A.J. and F.H. Whitehead (ed.). The Water relations of plants. A symposium of the British Ecological Society, London, 5-8 April 1961. London. Blackwell Scientific Publications.
- Weller, G. 1979. Alaska's Weather and Climate – A collection of articles written for the educated layman by staff members of the Geophysical Institute and the National Weather Service in Alaska. Geophysical Institute, University of Alaska Fairbanks. 24 pp.

Monthly Publications (February – May)

Natural Resources Conservation Service. Alaska Basin Outlook Report. (Month, Year)

National Oceanic and Atmospheric Administration. Climatological Data. Alaska (Month, Year).

VII. QUALIFICATIONS

Pamela Sousanes has been working in Denali National Park and Preserve for 11 years as a Backcountry Ranger, Physical Science Technician, and most recently an Environmental Protection Specialist in Physical Sciences. Pamela has been working with the climate monitoring program for the Long-term Ecological Monitoring program in Denali for 5 years. This program

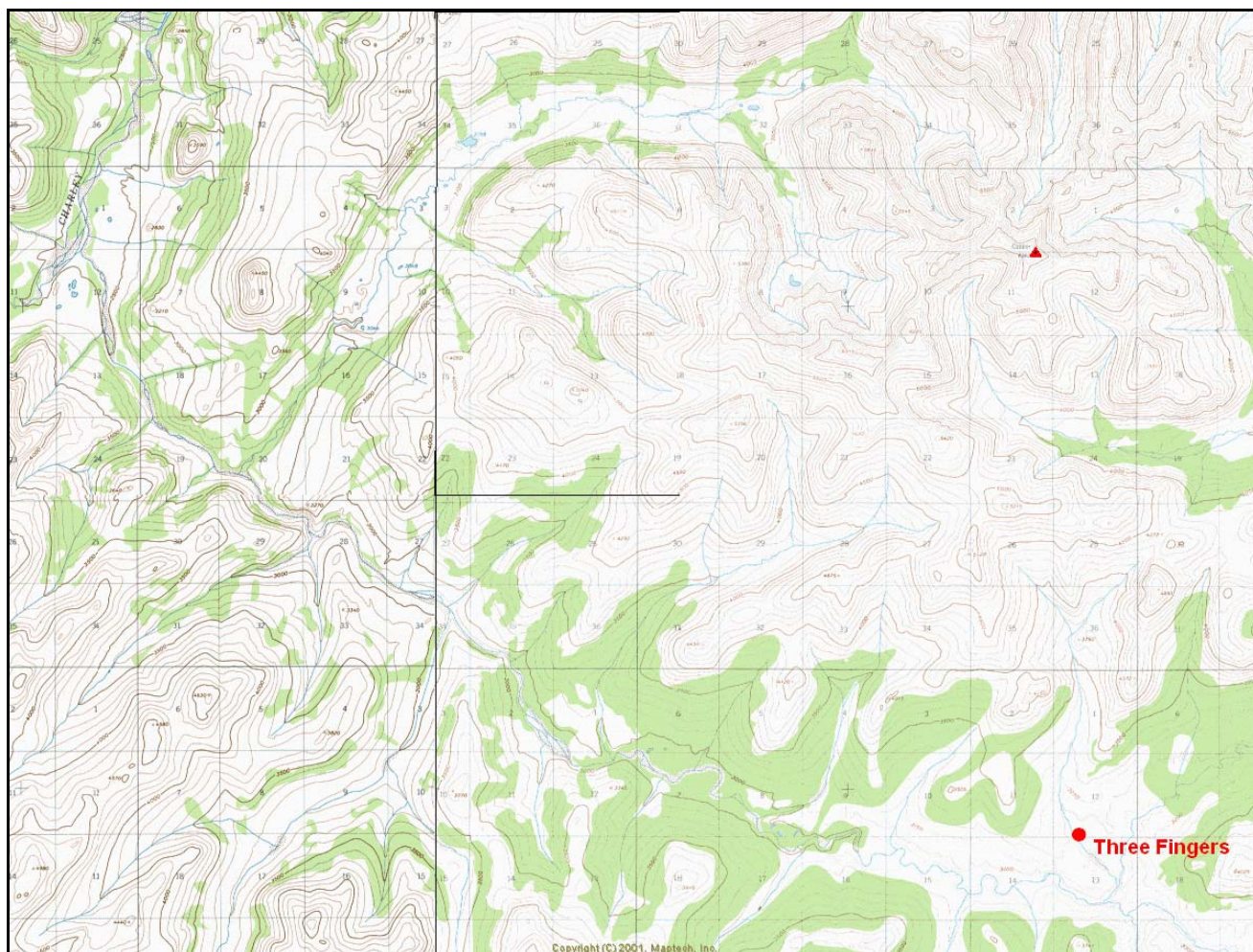
will continue indefinitely so the Principle Investigator for the project will most likely change over time.

VIII. SUPPORTING DOCUMENTATION AND SPECIAL CONCERNS

- A. **Safety** – Fixed-wing aircraft and a helicopter will be used to access the sites. All personnel will have updated required certification courses for aircraft use.
- B. **Access to study sites** – Access will be by fixed wing aircraft and helicopter. For the initial deployment of the climate stations two people will be on site for three days. Coal Creek camp is the preferred lodging choice for work in the area. Logistics and arrangements will be made with the park well in advance of the trip. Barring any major equipment failures, an annual maintenance trip will be made to each new site to swap out sensors for calibration, download data, and perform routine work. If a station fails during the year and a fixed wing flight is available additional day trips might occur. These might also coincide with snow surveys or other project work that is occurring in the area.
- C. **Use of mechanized and other equipment** – The climate stations described and pictured above will be on site. These sites will remain indefinitely. If, for any reason, the site needs to be removed there will be no evidence of site manipulation once the station is removed.
- D. **Chemical use** – Two 100 amp hour deep cycle sealed 12 volt battery will be used to power the station. The battery will be housed in a specialized cargo box and be protected from the weather and wildlife. The batteries will be swapped approximately every 4-5 years. The SNOTEL site will require the use of propylene glycol within the precipitation gage to melt the falling snow. The gage is contained and leakage should not be a problem. This site will also have 12 volt deep cycle sealed batteries on site.
- E. **Ground disturbance** – Ground disturbance would minimal. A small soil auger would be used to bore a hole 1m deep and a second one at .5m depth to insert the two soil temperature probes. Once in place the soil would be packed around the probe and any vegetative covering removed to start the hole would be replaced with little to no observable damage to the ground surface.
- F. **Animal welfare** - Not an issue unless they consume part of the station or get stuck in the guy wires supporting the station.
- G. **NPS assistance** – Accommodation for two people at Coal Creek Camp for 3 nights in August or early September. Use of the park pilot, if available, for flight from Fairbanks to Coal Creek. Use of park ATVs or snowmachines, if necessary, to access Coal Creek site.

Wilderness “minimum requirement” protocols – A helicopter is necessary to get all of the equipment to the Upland site for the installation. Due to the amount of equipment necessary to do annual maintenance annual helicopter trips will be necessary to maintain the station at this site. The footprint of the climate station requires no permanent foundation or footings. The footprint of the SNOTEL site is also minimal, but will require concrete anchors as footings for the precipitation gage and the shelter.

Appendix A: Map and photos of Three Fingers Site



Site: **Three Fingers**

Area: Yukon-Tanana Uplands Ecoregion

Coordinates: 64° 34' 32.47" N, 143° 14' 27.67" W (NAD27)

Elevation: 3180'

Description: Broad, open plain at headwaters of Charley River. Level, well-drained gravel with scattered dwarf birch on floodplain next to small creek. Bench above floodplain very tussocky with denser, higher dwarf birch. Site is ~5 km from existing aerial snow marker.

Access: Airstrip suitable for landing a 185



Appendix B: Coal Creek and Slaven Cabin



Site: **Coal Creek**

Area: Yukon-Tanana Uplands Ecoregion

Coordinates: 65° 18' 50.05" N, 143° 07' 56.38" W (NAD27)

Elevation: 870'

Description: Bottom of broad, open valley, ~4 km above confluence with Yukon River (170 feet higher than Yukon River). Occasional, protected openings in dense alder and willow thickets; rocky substrate (old gold dredge tailings)

Access: Adjacent to large, well-maintained airstrip near Coal Creek Camp.



Site: **Slaven Cabin**

Area: Yukon-Tanana Uplands Ecoregion

Coordinates: 65° 21' 02.56" N, 143° 07' 21.51" W

Elevation: 704'

Description: Near historic Slaven Cabin located adjacent to Yukon River just downstream of mouth of Coal Creek. Mixed forest with open tundra meadow to the south of cabin.

Access: ATV/Snowmachine accessible road from Coal Creek airstrip.



**Amendment to
Study Plan for
Central Alaska Network (CAKN)
Climate Monitoring
Yukon-Charley Rivers National Preserve
May 2004**

Submitted by:
Pamela Sousanes
Environmental Specialist
Denali National Park and Preserve
PO Box 9
Denali Park, AK 99755
Phone: (907)683-9573
Fax: (907) 683-9634
E-mail: pam_sousanes@nps.gov.

After discussions and meetings with the Integrated Compliance team which reviewed the original permit it was decided that further reconnaissance of sites within and outside the boundaries of the Preserve was necessary. On May 19, 2004 Pam Sousanes and Marsha Henderson visited the Preserve and evaluated a number of sites within the upland area of the preserve and those areas beyond the boundary to the south.

After reviewing comments submitted by many climate experts it was determined that locating a site with the Yukon-Tanana Uplands was the priority for this area. A number of Remote Automated Weather Stations (RAWS) currently exist in the lower elevations within the boreal forest including Ben Creek, Preacher Creek, Birch Creek, and Eagle. There are no sites that exist at higher elevations.

Site Selection

Kelly Redmond the Deputy Regional Climatologist for the Western Regional Climate Center offered the following relevant comments when presented with the entire suite of sites to consider for the Central Alaska Network.

Climate measurements must meet a higher standard than “weather” measurements. The most demanding of these is consistency through long periods of time. A time frame of 50-100 years should be envisioned, and a few decades at minimum. The process of choosing appropriate sites for long-term climate monitoring should take into account a variety of considerations: representativeness, accessibility, security, budgetary demands (personnel & maintenance), communications, stability of exposure characteristics, local hazards (flooding, avalanches, riming, etc). In some cases, successional processes may

be at work, and the site supervisor is confronted with choices: an open site may become a closed site as a forest regrows, or as the climate changes and new vegetative forms replace old, or as a burn or disease opens up closed vegetation.

No site will be without local influences of some sort: on wind, on precipitation, on temperature, on humidity, on solar radiation, or on any other climate element. The best and only recourse is to thoroughly document the site, and to re-document periodically as the site changes with time. It is impossible to over-document. The rule of thumb is to preserve whatever information will be needed to properly interpret the each of the separate element records a generation or two hence, when today's site supervisor is no longer accessible or even in existence.

Scientific justification for choosing a particular site over another.

This is an inherently difficult task especially when mountainous topography is introduced. When doing reconnaissance for the climate station site evaluation process in 2003 the following list of criteria was used, this comprises not only the scientific justification, but the social implications as well.

- Ecoregion representation
- Vegetation and soil type
- Known precipitation and temperature trends
- Gaps in knowledge
- Access to site
- Elevation
- Land management issues (Wilderness, Preserve)
- Use patterns (hiking, snowmachine, etc.)
- High density bear habitat, wildlife trails
- Exposure (solar and GOES capabilities)
- Wind scour

It is not a matter of finding the ultimate scientifically valid site – there are many. What is necessary is to find one that suits most criteria for our climate monitoring plan and also fits best with the views of park management. Again, it is hard to make a case for a single site that is scientifically superior to any other sites within the same ecoregion.

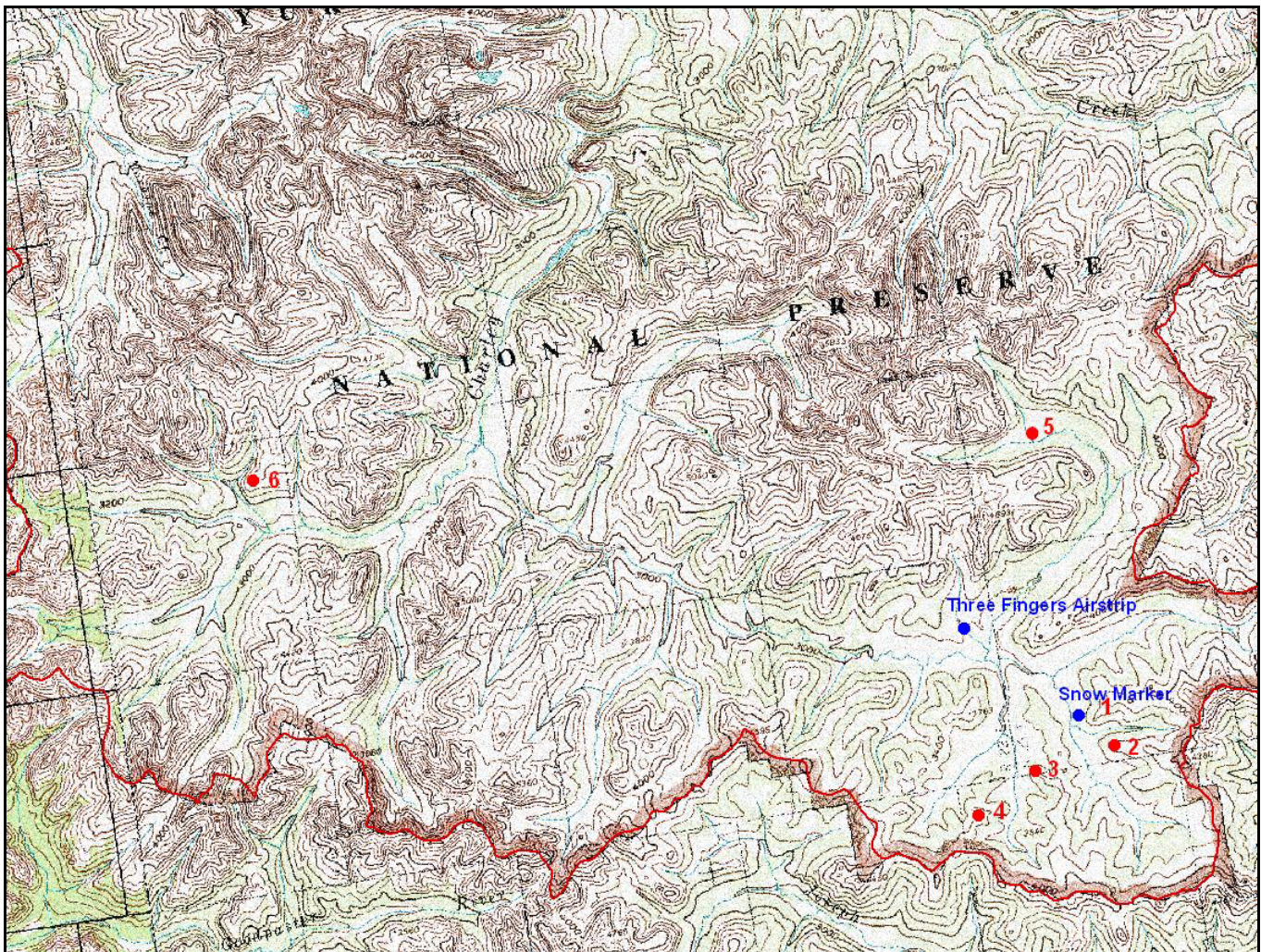
Process for second reconnaissance mission

- Review comments from review team
- Review comments from climatologists who provided valuable insight to our task
- Review maps of Yukon-Tanana upland Area
- Complete reconnaissance of upland area including areas to the southwest, southeast and south of the preserve boundary
- Photo document
- Fill out siting criteria form
- Prepare compiled evaluation

Site Selection May 2004

The following list of sites represents what was found to be the best choices for an alternative upland site to the originally proposed Three Fingers Airstrip site. Sites outside of the Preserve boundary were considered but not evaluated because we could not find a location that fit our criteria within a reasonable distance. The drainages were steeper and deeper, lacking the gentle undulating hills that offer broad expanses and a more representative view of climate. On the map it looked as if the area northeast of the Three Fingers Airstrip looked promising, but found that the site would be in a large bowl, almost a hole, with steeper mountains on all sides (Site #5). The Copper River area was evaluated, but the open areas that would make more suitable climate sites were at elevations that were 1000' below the areas we looked at the SE area of the Preserve and we are hoping to get sites in at higher elevations. The upper west fork of the Charley River offered another suitable location; however the mountains were in closer proximity to the potential site than any in the upper east fork of the Charley River, which might create more of a microclimate.

Map of sites

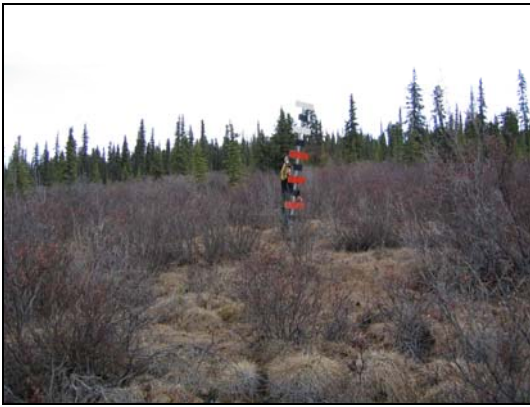


Site #1

Description: This site would be co-located with the existing aerial snow marker on a west sloping drainage of the upper east fork of the Charley River. Below band of spruce in a broad open area with dwarf birch about 3-4' in height. Ground surface is hummocky and uneven with standing water during the spring breakup period. 3.8 miles SE of Three Fingers Airstrip. Note: The ground surface is uneven and tussocky and would make anchoring a station difficult.

Coordinates: 64° 32' 08.8" N, 143° 09' 10.4" W (NAD 27). Elevation: 3082'

Photos for Site #1



Site #2

Description: Southeast upper Charley River drainage, southeast of aerial snow marker. Broad, level hilltop in rolling hills with good exposure in all directions. Covered in dwarf birch about 3' in height. Just above the highest spruce band. 5 miles SE of Airstrip
Coordinates: 64° 31' 20.3" N, 143° 07' 30.7" W (NAD 27). Elevation: 3570'

Photos of site #2



Site # 3

Description: Southeast upper Charley River drainage. Long bench just above treeline. Expansive and open in all directions. Scattered dwarf birch cover 1-2' in height. Located in drainage to the southeast of snow marker 4.2 miles SE of airstrip.

Coordinates: 64° 31' 02.0" N, 143° 11' 58.2" W (NAD 27). Elevation: 3590'

Photos Site # 3



Site #4

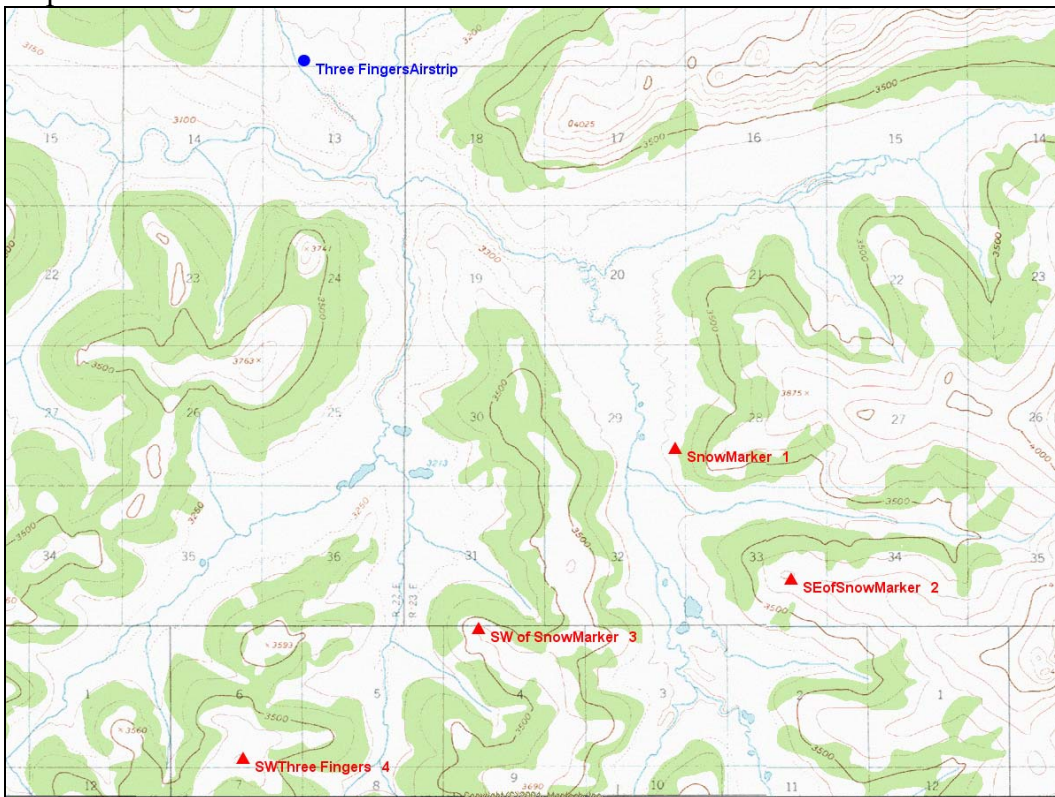
Description: Southeast upper Charley River drainage. Knoll above spruce in upper SW corner of the drainage. Open expanses on all sides, some higher ridges to the distant south. Dwarf birch cover 1-2' in height. 5 miles south of airstrip.

Coordinates: 64° 30' 14.05" N, 143° 15' 18.59" W. Elevation: 3610'

Photos of Site #4



Map of Sites #1-4



Site #5

Description:

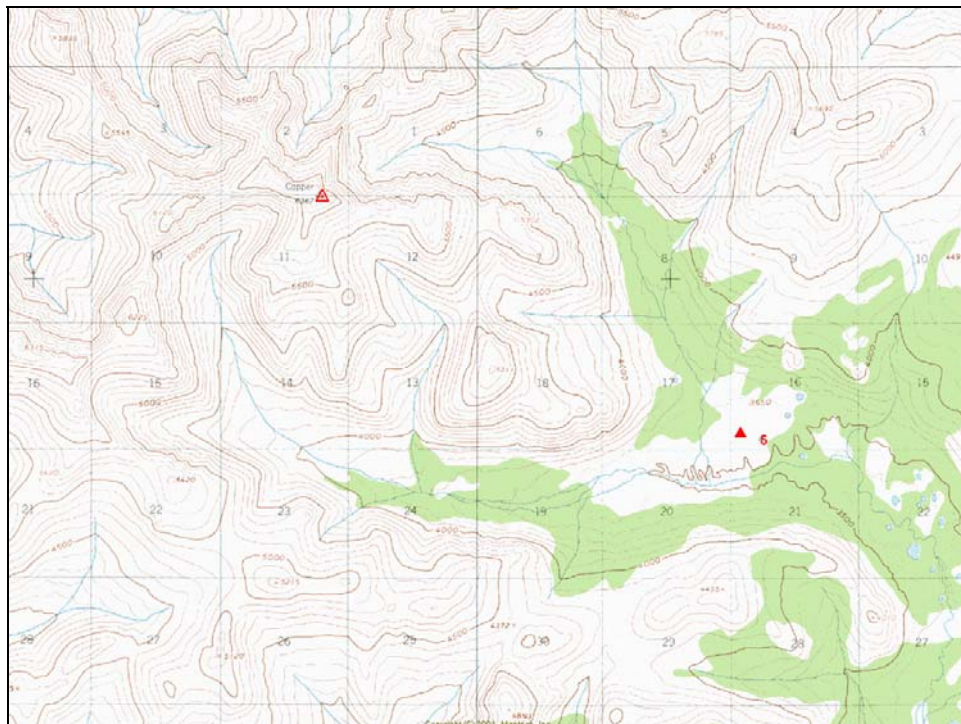
Upper reaches of the east fork of Charley River 5.8 miles NE of airstrip. At confluence of far northeast drainages. Open area surrounded on all sides by higher mountains. Scattered dwarf birch cover.

Coordinates: 64° 38' 57.0" N, 143° 08' 52.27" W (NAD 27). Elevation: 3530'

Photo of site #5



Map of site #5



Site # 6

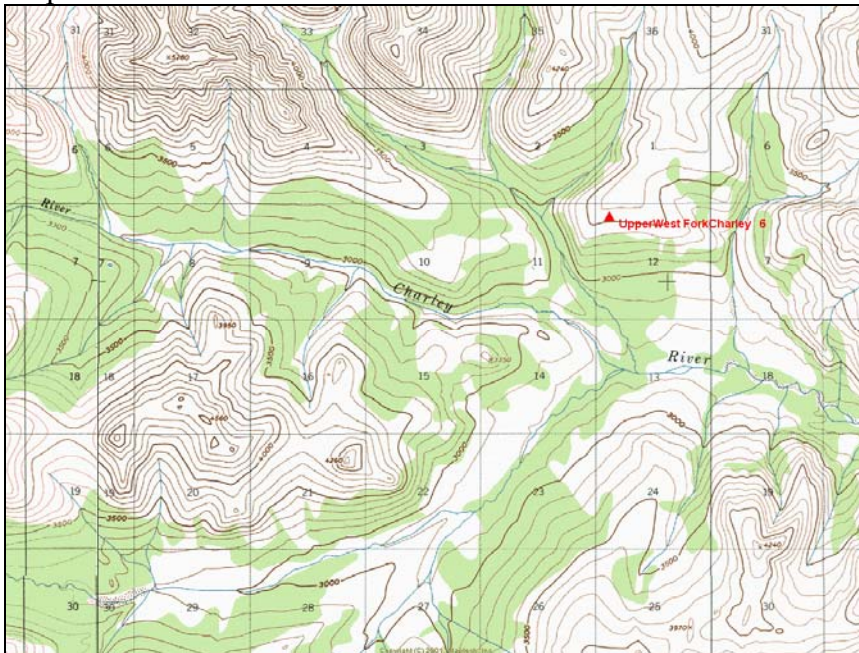
Description: Large rounded knob in middle of upper west fork Charley River drainage above confluence of three branches of the river. Good exposure on all sides. Scattered spruce and dwarf birch with open areas with only low ground vegetation. Higher mountains in all directions.

Coordinates: 64° 40' 29.2" N, 143° 51' 00.0" W (NAD 27). Elevation: 3530'

Photos of Site # 6



Map of Site #6



Preferable site: Site #3

After that #4, #6, #2, #1, #5

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 2

Acquiring Equipment

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP outlines the necessary equipment, tools, and materials needed for all levels of snowpack monitoring. Some of the equipment is made to order and involves planning 6 months to a year ahead of time. For the Natural Resources Conservation Service (NRCS) SNOTEL (SNOW TELelemetry) site the list of equipment reflect the 2004 cooperative agreement to install the first SNOTEL site. The list of equipment that the NPS provides is negotiable but will be reflected in the cost of the agreement.

Level 1: NRCS SNOTEL site

The SNOTEL sites will be installed under a cooperative agreement with NRCS. The CAKN snowpack monitoring program manager will provide assistance in the installation and will provide the following equipment. The equipment required for the SNOTEL site can be procured through Campbell Scientific, Inc. (<http://www.campbellsci.com/home.html>). The equipment needs to be purchased by phone order at (435)-753-2342. A current price list should be obtained before purchasing.

Table 1. Equipment List

Quantity	Description	Approximate Cost
1	Shelter 8'	2500.00 (NRCS)
1	Precipitation Gauge (10' storage)	1500.00 (NRCS)
1	Precipitation Gauge (Tipping Bucket)	400.00(NPS)
1	Antenna Tower (20')	400.00 (NRCS)
1	Antenna (MBY3)	800.00 (NRCS)
1	Met tower (10')	350.00(NPS)
1	Solar radiation	300.00(NPS)
1	Relative humidity/air temperature	173.00(NPS)
1	Snow depth sensor	945.00(NPS)
1	Batteries	300.00 (NRCS)
1	Solar panel (MSX60)	350.00 (NRCS)
1	Solar panel regulator	100.00 (NRCS)
1	NEMA 4 enclosure	500.00 (NRCS)

1	550-Micromet transmitter	2500.00 (NRCS)
1	CR10X datalogger	1250.00(NPS)
1	Misc. electrical and plumbing	100.00 (NRCS)
1	Installation, Travel and Per Diem	4000.00 (NRCS)

Level 2: Snow Course

Snow courses may be added to the CAKN snowpack monitoring network in the future. The materials needed to install one snow course, including the tools, are listed below. The site requires 5 markers and a sign.

- Five Carsonite markers (brown) with logo shown below available at Carsonite International (<http://www.carsonite.com/>)
- Carsonite driver (for installing markers)
- A placard (yellow) available for the NRCS for signing the site.
- Two lag screws and a socket driver (for mounting sign)
-

Level 3: Aerial Marker

Aerial markers will be added to the three CAKN parks in the future. Aerial markers are fabricated by a machine shop following the specifications below. The cost of a single aerial marker in 2002 was \$200.00.

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 3

Installing a Snow Course

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the procedures for installing a snow course. The guidelines are provided by the Natural Resources Conservation Service (NRCS) and adapted to suit the NPS requirements for siting issues. This Sop includes an equipment list, the procedures for installation, and a site documentation procedure.

Equipment needed for installation:

- Five 6' Carsonite markers/with labels (described in SOP #2 Acquiring Equipment")
- Carsonite driver
- Placard (from NRCS)
- Measuring tape (100')
- (2) Lag screws
- Socket driver for lag screws
- Digital Camera
- Notebook
- Compass
- Shovel/Digging bar
- Loppers/Hand saw
- Weed wacker

Procedure for Installing a Snow Course:

1. Prepare the ground surface. The site needs to be relatively level and free of trees and brush. Use a handsaw, loppers, and/or a weed wacker to clear the area. Use a digging bar and shovel to smooth the surface. Try to do your best to minimize the disturbance to the ground.
2. If possible, align the transect so that there is a sizable tree at one end to use for posting the sign.

3. Mark each of the markers 18" from the pointed end with a black permanent marker.
4. Install the first marker. Insert the marker into the driver with the pointed end exposed.
5. Rotate driver with marker into installation position. Stand behind the marker and align into desired position.
6. Drive marker into the ground with a series of light taps. Brace your foot against the back of the marker to control bucking. Repeat driving procedure until the depth indicated by the black line on the marker.
7. Using the first marker as 0', use the measuring tape to lay out a 100' transect. Lay out the remaining markers in either 15' or 20' increments, depending on the space you have to work with. Intervals should be no less than 15'.
8. Install the remaining four markers in the same manner as the first.
9. Attach the yellow placard to a nearby tree using the lag screws and socket driver.

Documenting the site

1. After the snow course has been installed it is important to fully document all aspects of the site. This description will be included in the sitemaps created by NRCS staff.
2. Digital photos – Follow the guidelines in SOP # XXX, "Photo Documentation"
3. Draw a sketch of the area. The sketch should be oriented north and include noticeable landscape features such as slope, aspect, land form, drainages, vegetation type(s), and any manmade features such as the snow course sign. Give details such as size, shape, species/type, and distances.
4. Use a GPS unit to mark the location of the new site following the procedures in SOP# XXX, "Using GPS".
5. Document the interval between the markers and the number of markers.
6. Document the personnel involved, date, time, and weather conditions.

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 4

Installing an Aerial Marker

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP provides the instructions for installing an aerial snow marker according to the Natural resources Conservation Service (NRCS) guidelines.

Site location:

The perfect site is a small hole (120-160 ft. diameter circle or so) of 1/4 to 1/2 acre in a dense forest. The size of the hole should depend on the height of the trees. Fortunately, in much of Alaska where the forest is far less than ideal or nonexistent, sites can still be found that are perfectly adequate. The objective is to find locations where snow pack and/or dense brush can produce the desired effect. Locations where snow scouring, loading and/or drifting occur should be avoided as the measurements are likely to be more associated with how much the wind blew rather than how much snow fell.

Sites also need to be near terrain features that are readily distinguishable in order to be easily located from the air. Most important of all is the consideration for safe airplane operations, which means there must be room for a safe low-elevation approach and recovery, plus plenty of turn-around room for a second fly-by observation.

Locating the marker within a site:

In the case of fairly tall trees (80' - 100') on a fairly large site of a 200 ft. or more diameter circle (greater than 1/2 acre), the marker could be located anywhere in the opening. In a smaller opening of a circle 100 ft. diameter (less than 1/4 acre), the marker may need to be located near one edge to have an adequate clear window view for the aerial observation. In the case of sparse tree growth, these considerations may not be necessary.

At a chosen site, the specific spot to place the marker should be as smooth and level as possible, avoiding high spots, low spots, and bumpy, undulating ground. The area of consideration here is a 4-5 ft. diameter circle in the center of which the aerial marker is placed. If necessary, vegetation growth should be removed with a weed whip to be sure the selected spot is as flat and smooth as possible. Any brush within 12 ft. or so of the marker should be cut back.

Placing the marker:

The hole dug in the ground to stand the marker up should be as small as possible as, no larger than 4 or 5 inches in diameter. The use of a digging bar and picking out the soil and particles by hand works well. The hole should be dug exactly 27 inches deep, which places the crossbars dead center on 12, 24, 36, etc., inches.

Once the marker is set in the hole and backfilled and soil/rocks are tamped in as firmly as possible, the measurements should be taken. Make the final measurement from ground surface to the middle of the first orange crossbar and record the measurement. If this measurement is not exactly 24 inches (k), the difference becomes a permanent adjustment (Correction Factor). Usually this Correction Factor will be plus or minus an inch. The Correction Factor will apply to the final reading. Markers often settle or heave by an inch over the first winter before stabilizing, so another measurement should be taken the next summer season to determine any possible further adjustment as the Correction Factor.

Crossbars are normally placed parallel to the line of flight. Later, if it is discovered that the marker is not easy to spot from the air, by turning the marker 90 degrees so the bars are facing the oncoming aircraft, the marker can be spotted quicker, giving the pilot time for a last second flight line adjustment. This adjustment is sometimes necessary when a marker is placed within a scattered spruce forest, which has no natural opening in the forest to line up on in advance.

Guying the marker to keep it vertical:

Reasons for guying the marker may include boggy ground, permafrost, a hole dug too large, or where bear activity is common.

Use 3 cables per marker.

For permafrost ground with no trees, attach plastic-covered cable, which lasts much longer where cable is below ground, to “duckbill” anchor. Drive anchor along same plane as anchor cable. A homemade driver can be made by welding a 2” stub of 1/2” diameter pipe to a 4’ length of iron bar.

If trees are present, some of the stumps left when clearing could be used for anchors.

Screw-in anchors work equally well in soft ground, but they are more expensive.

Tightening the cable between the anchor and marker is easily done by pulling on cable end with vise grips as the cable clamp is tightened down.

Aerial Marker tool list:

- 1 ea. 2" x 12.5' pipe, or 3-4.5' (for telescoping marker)
- 5 ea. 6" x 12" black crossbars
- 5 ea. 6" x 24" orange crossbars
- 20 ea. 3/8" x 3" machine bolts with nuts and washers, or
- 4 ea. 3/8" x 4", 8 3/8" x 2 1/2" for telescoping
- weed whip
- chain saw, bow saw, brush ax
- sledge
- digging bar
- duckbill driver
- duckbill anchors
- aircraft cable (plastic coated)
- cable clamps (3/16" wire rope clips)
- cold chisel and hammer (to cut cable or bolt cutter)
- 7/16", 9/16" socket and driver
- crescent wrench
- tape measure
- maps
- camera and film

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 5

Preparing for the Field Season

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the preparation needed for field equipment and personnel before the start of the field season. The field season for snow surveys is November through May. Careful planning of each trip will ensure accuracy and safe work.

Preparing for the field season:

1. Check field equipment
 - a. Inspect the cutter teeth on the snow sampling tubes. Sharpen if necessary with a flat file.
 - b. Inspect the threads on the tubes and make sure they are clean
 - c. Spray the inside of the tubes with silicone spray.
 - d. Check the spring mechanism on the scale.
 - e. Inspect the clip on the spring scale
2. Outfit your survival bag, it should include:
 - a. Sleeping bag rated to at least -20°C
 - b. Sleeping pad
 - c. Tent
 - d. Extra food for 2-3 days
 - e. Water
 - f. Extra hat, gloves and warm clothes
 - g. Hand warmers
 - h. Snowshoes
 - i. Satellite phone
 - j. Matches
 - k. Stove and Fuel/Cook pot
3. Inquire about park pilot availability for the winter and alert him/her that you will be requesting their services during the last three days of each month.

4. Check with the communication center at park to get the most up to date information on flight following procedures. Also make them aware of your field season plans.
5. Have a helmet and Nomex flight suit ready prior to the first flight. Make sure the helmet has the proper connections.

Snowpack Monitoring Protocol for Central Alaska Network

Standard Operating Procedure (SOP) # 6

Collecting Data

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the procedure for performing snow surveys. Snow surveys are done within the last three days of each month beginning in late November and ending in late April. This involves both traveling on foot and flying to remote locations in the three CAKN parks. Most of the sites are accessible only by aircraft.

Arrangements should be at least two weeks in advance with park pilots to fly the surveys. If park pilots are not available for the surveys, the Office of Aircraft Services (OAS) office in Anchorage should be contacted to arrange for the services of an approved commercial flying service. Be sure to request that the commercial pilot have wheel-skis and a GPS navigation unit.

The data sheets for the snow course and aerial marker surveys are provided by the NRCS. The snow survey notebook (SCS-ENG-708) and Aerial Marker notebook (SCS-ENG-166) contain two different forms to use for the two different surveys. Completed snow course forms must include calculation of *Water Content Inches* and *Density Percent*. Instructions for calculating these values from the measured parameters can be found on the green instruction page at the front of every snow survey notebook. Make sure that all necessary blanks are filled in on both the snow survey and aerial marker forms. Photocopy both sides of each form and fax a copy to the NRCS office in Anchorage to *Attn: Snow Surveys* at (907)271-3951. The original forms should then be placed in an envelope and mailed to the following address:

ATTN: Snow Surveys
Natural Resources Conservation Service
510 L. Street, Ste. 270
Anchorage, AK 99501-1949

The hard copies of the field forms used to fax the datasheets should be kept on file with the program manager in case of discrepancies with the web based data archives.

The equipment checklist is listed below. Make sure you have all of the items before you leave on the survey.

Snow Survey Equipment Checklist

Snow Course Surveys (flying)

- ☐ Snow sampling tubes & scale.
- ☐ Thermometer.
- ☐ Snow Survey Notebook.
- ☐ Mechanical pencils.
- ☐ Watch.
- ☐ Snow survey maps and instructions (w/ GPS coords).
- ☐ Snowshoes.
- ☐ Orange survival vest
- ☐ Bunny boots or other warm footgear.
- ☐ Warm clothing for temperatures down to -40F, with extras sufficient for overnight survival.
- ☐ Food and water for 2-3 days in case of emergency.
- ☐ Camp stove & fuel (park plane has these).***
- ☐ Sleeping bag & pad (park plane has bags).***
- ☐ Tent (park plane has one).***
- ☐ Park radio w/ extra battery.
- ☐ Satellite phone

***Before you leave any of these items out of your personal gear, check with the pilot to make sure the Park plane actually has them onboard. Its best to do this before you go down to the airstrip to start your trip.

Aerial Marker Surveys

- ☐ Aerial Marker Readings notebook.
- ☐ Mechanical pencils.
- ☐ Watch.
- ☐ Maps and instructions (w/ GPS coords).
- ☐ Nomex flight suit & gloves
- ☐ Flight helmet (!!with proper intercom connectors for C-185 or Supercub etc!!)
- ☐ Same clothing, survival gear, and food as mentioned in the right-hand column (!!Except NO synthetic clothing materials under or over your Nomex suit!!). **

Procedures for Snow Course Survey Sampling

1. Upon arriving at the snow course, hang the thermometer on a nearby tree. Leave it to be read after the sampling is completed.
2. Remove the sampling tubes from the pouch and screw together as many lengths as are needed (usually no more than two). If the tubes are still warm let them cool until they equilibrate with the outside temperature. Using them while warm causes ice to form inside the tubes, which is difficult to remove and adds error in the weight measurements.
3. Begin by filling out the top portion of the survey notes page. Do not worry about identifying the *Drainage Basin*.
4. The first step is to measure the *Weight of Empty Tube* with the spring loaded scale. If the inside of the tube is clean and free of ice and snow, the weight should be **13** (with two tube sections).
5. Begin sampling by inserting the tube vertically into the snow at the first stake. Make note of the depth in the first column in the notes. If resistance is encountered before the tube hits the ground, make note of the depth and enter it as a “crust @ __inches” in the remarks column. To get through a crust, try slightly more pressure and/or rotating the tube so that the teeth will cut through the layer.
6. When the tube is on the ground, rotate it 1/4 to 1/2 turn clockwise to make the teeth grab some of the material below the snow. Slowly remove the tube from the snow. Measure the length of the snow core by looking through the slats in the tube. It may be necessary to blow some snow out of the slats to take the reading. Also, check the bottom end of the core to see whether it has shifted up into the tube. If so, estimate the distance from the end of the tube to the bottom of the core and subtract that from the core length. Mark the core length value in the second column.
7. Weigh the tube with core still inside and mark the measured value in the 3rd column in the notes. Be careful to balance the tube in the scale’s cradle before letting it go to weigh it. If the tube is not balanced it may swing down and dump the core.
8. Empty the tube and proceed to the next stake. Repeat steps 4 through 7 at each of the five stakes. If there is an aerial marker at the site it will be the last point in the transect.
9. When finished sampling all five stakes, check to make sure the values are reasonably consistent. If one or more values is significantly different from the mean, those samples should be repeated to make sure they are correct.
10. The last step is to fill in the blanks on the back side of the survey notes page. Under *General Conditions*, the only thing you need to record is the ***Air Temperature***. Disregard also the *PRECIPITATION DATA* section. Record any elaborations or unusual observations under *Remarks*.

Procedures for Aerial Marker Readings of Snow Depth

1. Wear a Nomex flight suit for the aerial marker survey
2. Bring along a helmet with the proper intercom connector for a fixed-wing aircraft. Wear the helmet during all low altitude portions of the flight.
3. Help the pilot navigate to the aerial markers by giving him the GPS coordinates for each location (have him store them as waypoints if he doesn't have them already).
4. Use the maps and descriptions in the pages that follow to get an idea of where you should be looking for each marker.
5. Discuss the approach to each marker with the pilot so you will understand how he is going to setup the pass in order to give you the best possible view.
6. Have the notebook out and ready and make note of the time before descending to observe the marker.
7. As you pass the aerial marker, count the number of large horizontal slats that are visible above the snow surface. Draw a line on the notebook diagram that indicates where you observed the snow surface to be relative to the nearest slat. See the green pages at the front of the notebook for further details. Fill in all the blanks on the survey notes page while you are flying to the next marker or after the survey is completed.

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 7

Maintaining sites

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the maintenance procedures for snow courses and aerial snow marker sites. The more intensive SNOTEL (SNOw TELelemetry) sites are maintained by the Natural Resources Conservation Service (NRCS) under a five year cooperative agreement (Appendix D). The recommended schedule for summer maintenance visit is every 2-3 years.

Snow Course Maintenance:

Tools required for Maintenance:

- Extra Carsonite markers
- Carsonite driver
- Lag screws/socket driver
- Loppers
- Weed cutter
- Bow saw
- Measuring tape
- Notebook
- Camera
- GPS w/location waypoint entered

Snow course maintenance procedures:

1. Arrange a fixed-wing flight to the site according to the parks aviation management plan.
2. Once on the ground, use the GPS unit to navigate to the site if unfamiliar with site and site is located away from the airstrip. It will look considerably different than the standard winter conditions.

3. Take a “before” photo to document the condition of the site upon arrival. Start from the north and take a shot at each major cardinal direction. Also photograph anything unusual, i.e. a marker is broken off at the top.
4. Brush the entire area using the weed whip and other tools. Ensure that no vegetation near the course will affect the snow measurements in the winter.
5. Replace any markers that are missing or starting to deteriorate.
6. Use the Carsonite driver to install the new marker. Use the measuring tape to verify the interval between the markers.
7. Take an “after” photo of the site from the same locations as the “before” shot.
8. Record, in a notebook, the date, time, personnel involved, current weather and a description of what was done at the site.

Aerial Marker Maintenance

Tools and materials required

- Loppers
- Weed cutter
- Bow saw
- Red
- Measuring tape
- Red enamel paint
- Black enamel paint
- Paint brushes
- Gloves
- Notebook
- camera
- GPS w/location waypoint entered
- Step ladder (4')

Aerial marker maintenance procedure:

1. Aerial markers are usually located in remote areas where there is no fixed-wing landing area, so it is often necessary to arrange for a helicopter flight to the site. If a helicopter is being used, be as efficient as possible and maintain all of the sites in the area.
2. Use the GPS locations to help the pilot navigate to the site. Find a location where it is safe to land. The landing site may be a distance away from the marker, and you might be required to hike to get to the marker.
3. Once at the site take a “before” photo to document the site conditions. Start from the north and take a shot at each major cardinal direction. Also photograph anything unusual, i.e. crossbar is bent.
4. Brush the area around the marker to a 4-5 foot diameter. Use the weed cutter to “mow” the vegetation down around the marker.
5. Repaint the crossbars if necessary. If you do not have a step ladder, the crossbars can be used as a ladder. Start from the top and work down. Use gloves to protect your hands.

6. Measure the distance from the ground to the middle of the first small crossbar. The distance should be 12", if it is not record the distance in your notebook.
7. Take an "after" photo of the site from the same locations as the "before" shots.
8. Record, in a notebook, the date, time, personnel involved, current weather and a description of what was done at the site.

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 9

Data Management

Version 1.0 (November 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP describes the data management procedures for the snow surveys conducted as part of the snowpack monitoring program. The Natural Resources Conservation Service (NRCS), through cooperative agreements, will be responsible for the data verification, data dissemination, data analysis, data archiving, and data security. The NPS link in data management consists of collecting accurate data and getting the data sheets to NRCS in a timely manner.

SNOTEL (SNOW TELelemetry) data

The data management for the SNOTEL site is included under a cooperative agreement with NRCS. SNOTEL sites are set up to transmit the data hourly via Meteor Burst communication. The NRCS Portland, Oregon office receives the transmissions and processes the data. NRCS provides the data verification and validation, as well as data summary, analysis and reporting. NRCS has an existing database and web site for data archiving, data security, dissemination and database design.

Snow Course and Aerial Snow Marker Data

The data from the snow course and aerial marker surveys are collected each month by NPS program personnel and sent to NRCS for compilation, analysis, dissemination and archiving. NRCS requires that the original data sheets are sent to the Anchorage office as soon as possible after the first of the month during snow survey season. In order to disseminate these data in a timely fashion, NRCS requests that the datasheets be faxed to the Anchorage office before the originals are sent, so they arrive a few days before the mailed copies.

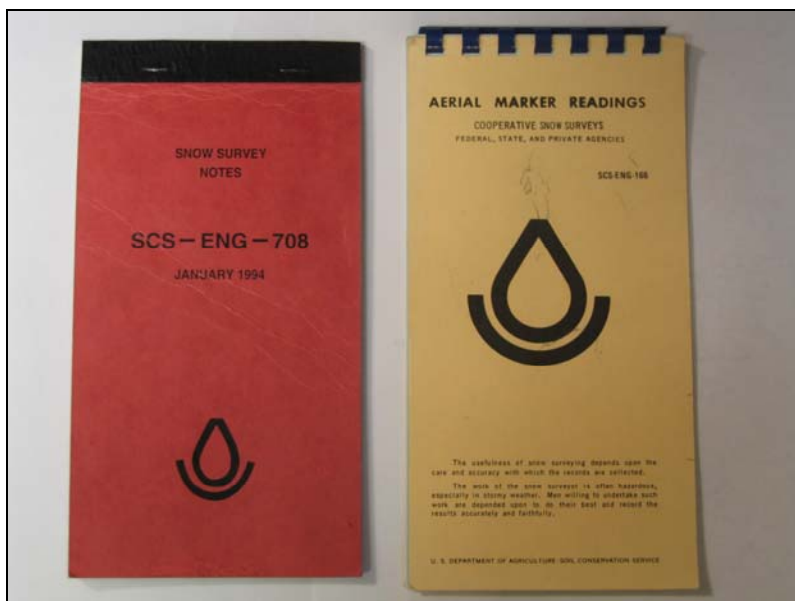


Figure 1 Field data sheet notebooks for snow course and aerial marker surveys

The data sheets for the snow course and aerial marker surveys are provided by the NRCS. The snow survey notebook (SCS-ENG-708) and Aerial Marker notebook (SCS-ENG-166) contain two different forms to use for the two different surveys (see Figure 1). For the snow course data sheets, completed forms must include calculation of *Water Content Inches* and *Density Percent* (Figure 2). Instructions for calculating these values from the measured parameters can be found on the green instruction page at the front of every snow survey notebook. Make sure that all necessary blanks are filled in on both the snow survey and aerial marker forms (Figure 3). Photocopy both sides of each form and fax a copy to the NRCS office in Anchorage to *Attn: Snow Surveys* at (907)271-3951. The original forms should then be placed in an envelope and mailed to the following address:

ATTN: Snow Surveys
 Natural Resources Conservation Service
 510 L. Street, Ste. 270
 Anchorage, AK 99501-1949

The hard copies of the field forms used to fax the datasheets are kept on file with the program manager in case of discrepancies with the web based data archives.

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 10

Snowpack Monitoring Reporting

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP outlines the procedure for compiling an annual report for the snowpack monitoring program for the Central Alaska Network. NRCS has an existing database and web site for data dissemination. Automated data charts and reports are available for the public at the following website: <http://www.wcc.nrcs.usda.gov/snow/snotel-reports.html>. The data network products include basin snow water content maps, aerial extent of snowcover, daily and weekly reports and graphs on all parameters, Water year graphs, snow equivalent reports and graphs. These data are also posted at the Western Regional Climate Center at <http://www.wrcc.dri.edu/snotel.html>.

NRCS produces monthly basin reports from December through May which include the compilation of Alaska statewide data by basin and a general overview of snowpack, precipitation, and temperature conditions related to a 30-year normal. The three CAKN parks fall within the Matanuska-Susitna, Tanana, Copper River, Central-Yukon, and Upper Yukon basins. NRCS also produces a report titled *Alaska Annual Data Summary Water Year XXXX*. This report summarizes the snow water equivalent and precipitation data collected during the current water year. Copies of both of these reports are sent to the parks where snow survey operations occur. They are also available from NRCS in Anchorage at 510 L Street, Suite 270, Anchorage, Alaska, 99501-1949.

Reporting at the network level will consolidate the information found in the regional reports to the areas specific to the Central Alaska Network. The reporting date will occur after the winter snow survey season. The last data are collected on May 1. Compilation and analysis will take a few months to process. The report will be completed by August 31 of the reporting year. The report will include a compilation and summary of the snow survey sites within each of the three CAKN. A general narrative summary of the region as a whole will be included as well as individual descriptions of the various ecoregions within the network. The report will include also include a summary of the data collected at each individual site. The following outline will be used as a guideline:

- I. Introduction
- II. Central Alaska Network Snow Year Summary XXXX (Year)
- III. Central Alaska Network – Snowpack by Ecoregion Summary

- IV. Snow Survey Sites
 - a. Data displayed in tables
 - b. Graphs
- V. Comparisons (Among years, among sites, with normals)

Snowpack Monitoring Protocol for the Central Alaska Network

Standard Operating Procedure (SOP) # 11

Revising the Protocol

Version 1.0 (October 2004)

Revision History Log:

Prev. Version #	Revision Date	Author	Changes Made	Reason for Change	New Version #

This SOP explains how to make changes to the Snowpack Monitoring Protocol Narrative and accompanying SOPs, and tracking these changes for the Central Alaska Network. Observers asked to edit the Protocol Narrative or any one of the SOPs need to follow this outlined procedure in order to eliminate confusion in how data are collected and analyzed. All observers should be familiar with this SOP in order to identify and use the most current methodologies.

Procedures:

1. The Snowpack Monitoring Narrative for the Central Alaska Network and accompanying SOPs adheres to the guidelines of the NRCS snow survey program. The protocols incorporate the National Park Service's role in the monitoring effort. The NRCS guidelines are built on sound principles and methodologies and are the accepted standard. However, all protocols regardless of how sound require editing as new and different information and technology becomes available. Required edits should be made in a timely manner and appropriate reviews undertaken.
2. All edits require review for clarity and technical soundness. The NPS Snowpack monitoring program will keep abreast of any changes to the guidelines authored by the NRCS and make appropriate changes to this set of SOPs. Small changes or additions to existing methods will be reviewed in-house by Central Alaska Network physical science staff. However, if a complete change in methods is sought, than an outside review is required.
3. Document edits and protocol versioning in the Revision History Log that accompanies the Protocol Narrative and each SOP. Log changes in the Protocol Narrative or SOP being edited only. Version numbers increase incrementally by hundredths (e.g. version 1.01, version 1.02, ...etc) for minor changes. Major revisions should be designated with the next whole number (e.g., version 2.0, 3.0, 4.0 ...). Record the previous version number, date of revision, author of the revision, identify paragraphs and pages where changes are made, and the reason for making the changes along with the new version number.
4. Inform the Data Manager about changes to the Protocol Narrative or SOP so the new version number can be incorporated in the Metadata of the project database. The database may have to be edited by the Data Manager to accompany changes in the Protocol Narrative and SOPs.
5. Post new versions on the inter-net and forward copies to all individuals with a previous version of the effected Protocol Narrative or SOP.

Reference

Pietz, D.G., S.G. Fancy, L.P. Thomas, B. Witcher. 2002. Bird Monitoring Protocol for Agate Fossil Beds National Monument, Nebraska and Tallgrass Prairie National Preserve, Kansas. Prairie Cluster Prototype Monitoring Program. Prepared for: National Park Service, U.S. Department of the Interior, 24p.