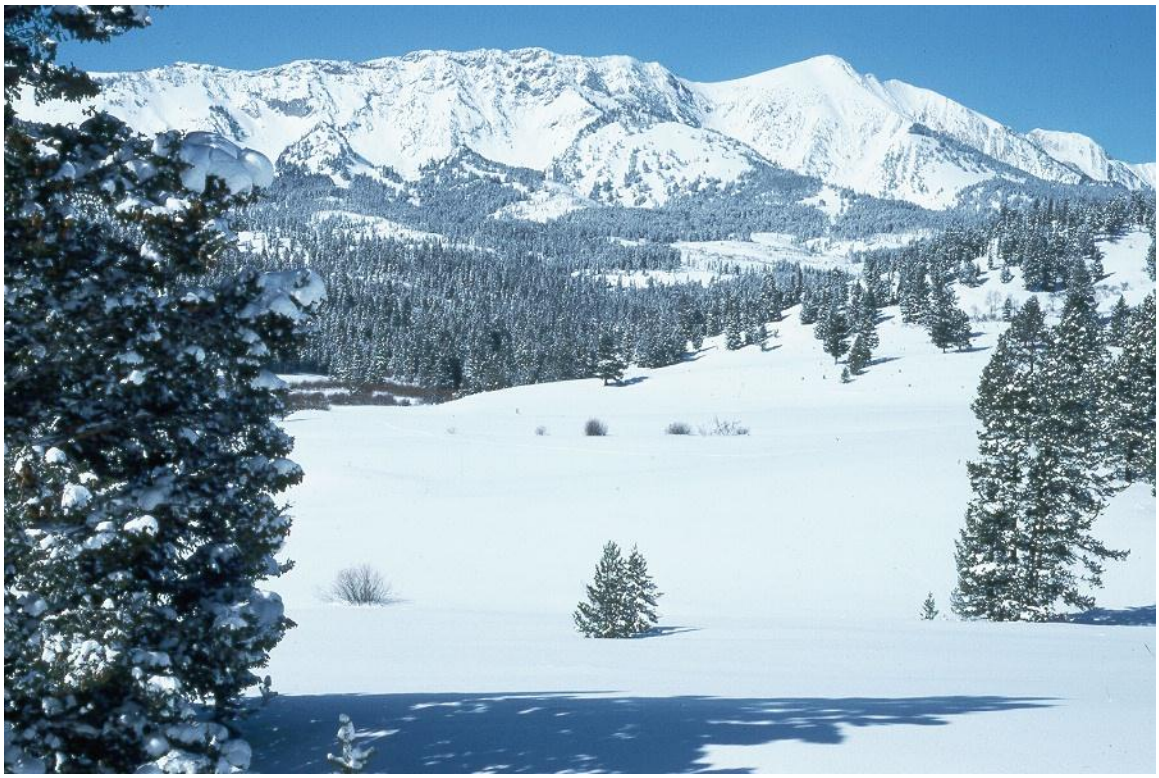
A PROPOSED PLAN TO COMPLETE INSTALLATION OF THE SNOTEL NETWORK IN MONTANA



By

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The author has been involved with the snow survey and water supply forecasting program in Montana and northern Wyoming since 1954. He has served as Civil Engineer, Hydrologist and Snow Survey Supervisor in Montana and Data Collection Office Supervisor for Montana and Northern Wyoming. He prepared the first plan for automation of snow surveys in the West and is very familiar with the historic needs, uses, and requests for data from specific areas in Montana and Northern Wyoming. He has been to all of the sites in this area and supervised the installation of the majority of them. Since retirement from the Soil Conservation Service, he has been a consultant specializing in mountain hydrology. The current system appears to have stagnated over the past 20+ years as there are still areas that would greatly benefit from installation of new SNOTEL (Snow Survey Telemetry) sites. This is particularly true where measurements at some significant snow courses are being discontinued to save money. This report has been prepared to identify those areas where new SNOTEL sites would greatly benefit not only the water supply forecasting program, but the multitude of other uses that the SNOTEL sites are now providing additional data that was previously unavailable from manual snow surveys such as daily data on snow water equivalent, precipitation, temperature year-around.

HISTORY

In July 1971, the Montana Soil Conservation Service Snow Survey Unit developed the first proposal to automate snow survey measurements in a report titled "Proposed System for Montana—Telemetry of Mountain Snowpack and Related Data". This proposal was presented as a way to increase the value of snow and related climatic variables and it was envisioned that this implementation of some key sites in combination with manual snow courses would be the most economical system for evaluating Montana's water supplies and for other uses of this data. The automation of this system has proven to be of great value and it now appears that more benefits could be realized if more sites were automated which would reduce the number of sites being read manually. The Snow Survey program has always been a cooperative program with many agencies, and other cooperators sharing in the use of the data. During earlier administrations, before any of the measurements were reduced, all cooperators were invited to provide input if the reduction would impact their operation. Many of the existing sites were established at the request of other agencies, Conservation Districts, private companies and individuals. The Soil Conservation Service has since been renamed the Natural Resources Conservation Service (NRCS).

NEED FOR OUTSIDE PROPOSAL

In 1990, there were 85 SNOTEL sites in Montana and about 550 in the Western United States. Today, there are 90 SNOTEL sites in Montana and 860 in Western United States. Using the same percentage as existed in 1990, today Montana should have about 130 sites. Why has Montana only installed five new sites in the past 23 years and cannot even find funds to keep the manual measurements intact? The Montana program appears to have stagnated regarding additional SNOTEL sites. The Montana NRCS did not answer inquiries as to whether or not they had any plans to add additional SNOTEL sites. It appears that the Montana NRCS only has plans to maintain existing SNOTEL sites, not install any additional SNOTEL sites and eliminate manual snow courses that are being measured by NRCS personnel or that are being reimbursed by NRCS that are not used directly in water supply forecast equations.

Little or no consideration was given to other uses of the data such as for wildlife wintering severity, hydrology, snow loads, recreation, climate change, effects of fires, insects or logging on forested watersheds, and irrigation water supply for smaller un-gaged tributaries. Even the NRCS's own publication "A Measure of Snow" dated September 2010 touts the many uses for the snow survey data other than just for water supply forecasts.

Montana NRCS did not use recommendation of Portland Water Supply staff before discontinuing snow course that were recommended for SNOTEL sites. The Water Supply Forecasting Unit at Portland has suggested that Montana install SNOTEL sites at the following sites that were discontinued in 2013. These are Notch, White Pine Ridge, Goldstone, Jahnke

Lake Trail, Kings Hill and Blue Lake.

Many of the sites discontinued in 2013 have the longest record in the area and would be useful for determining long-term trends in changes of climate and whether or not the relationship between the high and low elevation snowpack is changing because of mid-winter melting. These are Grasshopper (1938), East Fork RS (1937), Kings Hill (1934), Nez Perce Pass (1937), Intergaard (1936), Chessman Reservoir (1936) and Independence (1940).

Measurements at snow courses where measurements were discontinued in 2013 need to be resumed at snow courses that are proposed to be converted to SNOTEL sites.

News releases issued by NRCS indicate that the discontinuance of manual snow courses was needed to save money, yet when asked about total 2013 FY appropriation, the Montana NRCS said the personnel funds during 2013FY were paid out of the National Office. Apparently none of the other State offices were required to discontinue any measurements.

According to a recent report in the American Water Resources Association "Global Hydrologic Monitoring Industry Trends Report", networks are expected to grow by 53% more stations by 2022 and 83% reported an increase in importance of data modeling. This would imply that Congress and Cooperators need to obtain additional funds in order for the NRCS to establish the additional sites now to keep up with current trends to provide the necessary data for hydrologic modeling. Modeling requires historic data in order to cover the great variability of the mountain climates and differences created by the number of mountain ranges with different orientation.

Storms approaching mountain ranges at right angles deposit more precipitation due to orographic effects as the storms must rise up to get over the mountain range. Storms travelling parallel to the mountain range do not respond with the same precipitation pattern by elevation as they can split and do not exhibit any orographic response. Storms coming out of the Arctic are generally cold and dry while those coming out of the Gulf of Mexico in May or June deposit large amounts of precipitation either in the form of snow or rain along the first mountain range the storm approaches. These events occur about every 11 years and are responsible for most of the major flooding that has occurred in Montana east of the Continental Divide.

Additional snow pillows need to be installed under the forest canopy at existing sites in Ponderosa stands and spruce-fir stands similar to Onion Park that is under a Lodgepole Pine canopy. Results from Onion Park over the past 20 years indicate that snow accumulation under the forest canopy is 77 percent of that in the open but that melt rates under the canopy are only 44 percent of that in the open. Snow under the canopy persists 7 to 10 days after the open site goes bare. This is very critical information needed when modeling runoff from watersheds that are mainly forested when the models use data from SNOTEL sites that are located in openings not subject to influences by forest canopy.

ADDITIONAL SNOTEL SITES

REPLACE EXISTING SNOW COURSES WITH SNOTEL SITES

		Lat			Long			NAD 83	
No.	Sitename	Deg	Min	Sec	Deg	Min	Sec	Elev, ft	1981-2010 Avg Ann Precip, in
1	Black Mountain	46	18	59	112	34	42	7750	30.40
2	Branham Lakes	45	31	03	111	59	40	8850	45.10
3	Blue Lake	48	09	07	113	05	41	5900	50.40
4	Cedar Grove	48	08	33	115	33	15	3760	35.30
5	Chicken Creek	48	37	26	114	31	35	4060	41.70
6	Chicago Ridge	43	03	42	115	41	52	5800	65.10
7	Copper Mountain	46	01	02	112	25	27	7700	25.80
8	Dad Creek Lake	44	46	36	113	07	20	8800	28.90
9	Foolhen	45	45	36	113	10	47	8280	31.10
10	Grasshopper	46	31	38	110	46	29	7000	24.00
11	Gunsight Lake	47	58	40	113	20	22	6300	64.10
12	Halfmoon	46	48	18	109	17	19	5800	27.00
13	Haymaker	46	42	36	110	13	28	8050	31.00
14	Highwood Divide	47	24	23	110	34	28	5650	25.50
15	Hudson Bay Divide	48	41	30	113	23	11	5800	41.90
16	Jahnke Lake Trail	45	13	00	113	30	05	7200	24.70
17	Johnson Park	46	37	56	110	21	14	6450	19.50
18	Middle Mill Creek	45	29	38	111	59	35	7850	31.90
19	Mill Creek	45	15	48	110	24	15	7500	24.90
20	Mission Mountain	47	54	52	108	37	02	5050	23.00
21	Mudd Lake	45	54	55	113	24	59	7650	33.30
22	Notch	44	52	54	112	08	06	8500	31.90
23	Picket Pin Middle	45	25	58	109	59	26	7250	26.80
24	Potomageton Park	44	55	29	111	21	40	7150	30.10
25	Rock Creek	46	48	56	109	30	02	5600	33.30
26	Rock Creek Meadow	45	11	02	111	05	00	8160	28.60
27	Storm Lake	46	05	18	113	16	05	7780	28.30
28	Stryker Basin	48	40	48	114	39	49	6180	48.90
29	Twenty-One Mile	44	55	12	111	03	15	7150	31.90
30	White Pine Ridge	44	36	55	112	44	20	8850	21.50

Note: Halfmoon is an old snow course in the Little Snowy Mountains. Hudson Bay Divide is an old snow course on the Milk and Saint Mary's divide. Mission Mountain is an old snow course in the Little Rockies.

SNOTEL SITES AT NEW LOCATIONS

		Lat			Long			NAD 83	
No.	Sitename	Deg	Min	Sec	Deg	Min	Sec	Elev, ft	1981-2010 Avg Ann Precip, in
1	East Pryor	45	10	06	108	20	04	8776	21.00
2	Judith Peak	47	13	03	109	13	18	6400	43.00
3	Little Wolf	45	44	05	106	54	24	4571	21.00
4	Long Pines	45	36	43	104	14	25	4056	17.00
5	Red Bluff	46	13	49	108	21	38	4744	17.00
6	State Line	45	00	03	107	54	39	9257	32.00
7	West Butte	48	55	53	111	31	53	6983	33.00
8	Wolf Mountain	45	50	32	106	54	40	4807	16.70
9	Wolf N Shorty's	45	18	01	107	10	11	5205	24.00

ADD SNOW PILLOWS TO GOES SITES

Add snow pillows to Geostationary Operational Environmental Satellite (GOES) sites or convert GOES sites to SNOTEL sites.

		Lat			Long			NAD 83	
No.	Sitename	Deg	Min	Sec	Deg	Min	Sec	Elev, ft	1981-2010 Avg Ann Precip, in
1	Ashley Divide	48	12	06	114	30	54	4820	21.53
2	Bassoo Peak	47	51	21	114	45	50	5150	24.50
3	Lost Coulee	48	57	24	110	51	20	3230	12.60
4	Lower Tootsie Cr	48	48	12	111	02	29	3910	12.30
5	Upper Sage Creek	48	53	39	111	05	54	4480	18.00

ADDITIONAL SITES IN OTHER STATES

The Jones Canyon snow course in Idaho near the Montana border needs to be converted to a SNOTEL site as recommended by the Portland Water Supply Forecasting Unit. In Wyoming, the Madison Junction site needs to be automated as it is critical for monitoring over-snow vehicle travel conditions and wildlife wintering conditions in Yellowstone National Park. A snow pillow needs to be added to the NWS's (National Weather Service) automated station at the Lake Yellowstone Climatological station. This site is critical for forecasting ice-off of Yellowstone Lake, elevations of Yellowstone Lake, and runoff from the Yellowstone River.

JUSTIFICATION

As population increases, the need for better forecasts of water supplies will be needed to better manage this variable and critical commodity. Water will be one of the most critical resources in the future. Snow survey and related climatological data is being used for more than water supply forecasting. These uses include but are not limited to:

Snow loads for structure design

Hydrology of un-gaged watersheds

Bridge design for both flow and snow load

Culvert design for expected flow

Precipitation Map

Recreation (Ski areas, oversnow travel and avalanche conditions)

Climate change trends

Cost of snow plowing for roads

IWS (Index of Winter Severity for Wildlife)

Optimizing hydro electric power vs use of fossil fuels

Estimating dates and amount of peak snowmelt runoff

Fisheries and aquatics

Phenology of different plants and trees

Emergence of bears from hibernation

Monitoring effect and extent of heavy precipitation in mountains during spring runoff

Various uses of the data for input on the modeling of snowpack, precipitation, snow loads, snowfall, hydrology, temperature, growing seasons, ground truth for satellite imaging, and other climatic relationships. Other uses are shown in NRCS publication "A Measure of Snow" dated September 2010.

One of the reasons used by NRCS to justify no more SNOTEL sites is that electronic technicians have all of the sites they can handle. One option to correct this situation would be to station an Electronics Technician in Wyoming to service their 88 sites. This would reduce travel

costs as electronic maintenance in Wyoming is now being done by three separate offices, Colorado, Idaho, and Montana. This would enable Montana to maintain the additional sites. Also, west-wide, there should be at least two El Techs in training that could be moved to DCO's when a replacement is needed.

Transferring the forecasting responsibilities back to the States would enable better coordination between data collection and water supply forecasting activities. Also, when forecasts were under the state's responsibility prior to the time they were moved to Portland, the forecast accuracy was better than it has been since moving this responsibility to Portland. When questioned why the poorer accuracy of forecasts, it was blamed on greater variation in spring precipitation due to climate change. Yet when a statistical analysis is performed on spring precipitation at 16 valley stations from 1950-1985 and 1986-2012 the standard deviation of the two periods are nearly equal to a little less for the later period when forecast were being made at Portland. Also, Portland has had precipitation from mountain areas not available to earlier forecasters. Some of the staff savings could be converted to field training positions to provide a source of trained individuals that could move into state positions as they become vacant.

Justification for Individual Sites:

Black Mountain – Near Clark Fork/Boulder divide and has 2nd highest correlation with Boulder River and should correlate well with the Clark Fork River.

Branham Lakes – Highest elevation site in Tobacco Root Mtns. and has 3rd highest correlation with Jefferson River inflow between Twin Bridges and Three Forks. One of 3 sites installed at request of Ruby Conservation District. Used by irrigators downstream from Ruby Reservoir.

Blue Lake – Mid elevation site in South Fork Flathead that is critical for forecasting inflows to Hungry Horse Reservoir.

Cedar Grove – Low elevation site established in cooperation with US Corps of Engineers for operation of Lake Koocanusa and adjusting outflow to compensate for downstream inflows.

Chicken Creek – Low elevation site to monitor inflows into Flathead Lake from Stillwater, Whitefish and North Fork Flathead Rivers.

Chicago Ridge – Newer site in Cabinet Mountains that should be used to correlate with Baree Creek snow course which is in the Wilderness and cannot be automated.

Copper Mountain – High elevation site on the divide between Upper Clark Fork and Boulder/Jefferson Rivers that can be used for forecasting runoff on both sides of the divide.

Dad Creek Lake – Higher elevation site used to index inflows into Clark Canyon Reservoir and for forecasting flows of the Lemhi River in Idaho.

Foolhen – High correlation with the Big Hole River runoff. Highest correlating site with the Big Hole near Melrose and 2nd highest correlation with the Big Hole near Wisdom. NRCS discontinued measurements at this site and another high elevation site at Abundance Lake in 2013. These were the only two high elevation sites in the Pioneer Mountains that provides a large portion of the Big Hole River runoff and Wise River runoff. This is a high priority site.

Grasshopper – Low elevation site with measurements dating back to 1938 that were discontinued by NRCS in 2013. Low elevation site near divide between Smith and Musselshell Rivers in the Castle Mountains. Also used by city of White Sulphur Springs to evaluate snowpack in the drainage that is the source of their city water supply.

Gunsight Lake – Higher elevation site used to forecast inflow to Hungry Horse Reservoir. One of the few locations not within wilderness in the South Fork Flathead River drainage.

Halfmoon – A discontinued mid elevation site in Little Snowy Mountains in the Musselshell River drainage in an area subject to intense May or June storms originating in the Gulf of Mexico that create severe flooding when they occur.

Haymaker – High elevation site on east end of Big Belt Mountains on the Musselshell/Judith River Divide.

Highwood Divide – Only higher elevation site in Highwood Mountains which are prone to large precipitation/snow events during Gulf of Mexico storms.

Hudson Bay Divide – Mid elevation site on Saint Mary's/Milk River divide that was a snow course measured by USGS before the site was logged.

Jahnke Lake Trail – The only low elevation site in the Upper Big Hole River drainage that represents a large portion of the drainage with a highly variable snowpack.

Middle Mill Creek – A mid elevation site which correlates well with inflow to the Jefferson River between Twin Bridges and Three Forks. One of 3 sites installed at request of Ruby Conservation District. Used by irrigators downstream from Ruby Reservoir.

Mill Creek – Needed to index the inflow to the Yellowstone River from the west side of the Absaroka Mountains between Gardiner and Livingston. The snow packs in this area do not generally track the same as snowpacks in the upper portions of the Yellowstone River drainage.

Mission Mountain – A high elevation site in the Little Rocky Mountains previously established at the request of the Fort Belknap Tribal Recreation staff to evaluate possibility of a winter recreation area. Also needed to monitor climatic conditions in Little Rocky Mountains which can have orographic storms creating snowpack and precipitation conditions different from the interior mountains and which generally result in severe flooding.

Mudd Lake –Mid elevation site in northern part of Big Hole River drainage needed to monitor snowpack and other climatic conditions since Palisade Creek snow course has been discontinued.

Notch – Important site for forecasting inflow to Ruby Reservoir. It has the 2nd highest correlation among all sites in Ruby River headwaters. Also important for monitoring snow and precipitation on the Blacktail and Robb Creek Wildlife Management Areas. A high priority site.

Picket Pin Middle – Mid elevation site in Stillwater River drainage necessary to index the snowpack and precipitation midway between the 2500 foot elevation difference between Placer Basin and East Boulder Mine.

Potomageton Park – Lower elevation site in Upper Madison River Drainage used for monitoring inflows below Hebgen Lake and managing flows in one of the top trout streams in the lower 48.

Rock Creek – Mid elevation site in Snowy Mountains that contribute runoff to the Judith and Musselshell River systems.

Rock Creek Meadow – Higher elevation site near the Yellowstone/Gallatin divide and used for forecasting runoff from both drainages.

Storm Lake – A critical site in the Upper Clark Fork, Rock Creek and Warm Springs Creek drainages. Used for forecasting runoff from Warm Springs Creek which is managed by Butte Silver Bow to provide water to the Ramsay Industrial Area and for irrigation and trout spawning and rearing in Warm Springs Creek and downstream areas. A high priority site.

Stryker Basin – Higher elevation site in upper Stillwater River drainage used to monitor flows into Flathead Lake. Near the divide between the Kootenai, Whitefish and North Fork Flathead River drainages.

Twenty-One Mile – Mid elevation site on the Madison/Gallatin divide with a long record that started in 1937. Used for forecasting runoff from both drainages.

White Pine Ridge – High elevation site in the Tendoy Mountains that are in a rain shadow portion of the Beaverhead River drainage above Clark Canyon Reservoir.

FUNDING

The lack of funding provided by Congress is the excuse most generally given for lack of additional SNOTEL sites needed to replace existing snow courses and for new SNOTEL sites needed in areas not previously indexed. This lack of funding will continue until Congress decides if it is more important to fund $18 billion for projects identified by Senator Tom Coburn of Oklahoma as being wasteful or to use the money to adequately monitor the mountain snowpack, precipitation and temperature in Montana that will benefit the present as well as future generations, not just in Montana but all downstream areas. Studies have shown the benefit to cost ratio for snow survey data has always been quite high and has always been positive. Funding provided by Congress for implementation of the SNOTEL system has exceeded expectations and additional funding should be provided to complete the system in Montana.

If the NRCS is not interested is establishing additional SNOTEL sites, possibly the US Bureau of Reclamation would be interested in adding new sites to their system as they already have comparable sites on their Pacific Northwest System, or the Bureau of Land Management/US Forest Service may be interested in adding these sites to their Remote Automatic Weather Stations (RAWS) system, or US Geological Survey may be interested in adding these sites to their telemetry system since they were involved in the snow survey program from its inception in Montana and have an operational telemetry system.

Installation of all sites could require 5 to 10 years in order to locate sites, obtain special use permits, train installers and train electronics technicians. Estimated cost to complete the network may be in the order of $2 to $2.5 million. Some savings will be incurred by reducing manual measurements after the correlation period. The main benefit will be from the daily climatic data from watersheds that generate the majority of the Montana's stream flow at previously un-monitored daily sites. Prior to installation of SNOTEL sites, funding for manual measurements at snow courses designated to become SNOTEL sites should be continued to preserve their original records and provide continuity between the manual and automated measurements, NRCS should also be required to continue all snow course measurements until a analysis is completed and published in the Federal Register and after water users and managers have adequate time to comment and concur with a proposal to discontinue any site that was being measure through 2011.