CODOS – Colorado Dust-on-Snow – WY 2009
Update #1, February 15, 2009

Greetings from Silverton, Colorado on the 3-year anniversary of the February 15, 2006 dust-on-snow event that played such a pivotal role in the early and intense snowmelt runoff of Spring 2006. This CODOS Update will kick off the Water Year 2009 series of Updates and Alerts designed to keep you apprised of dust-on-snow conditions in the Colorado mountains. We welcome two new CODOS program participants – Northern Colorado Water Conservation District and Animas-LaPlata Water Conservancy District – to our list of past and ongoing supporters – Colorado River Water Conservation District, Southwestern Water Conservation District, Rio Grande Water Conservation District, Upper Gunnison River Water Conservancy District, Tri-County Water Conservancy District, Denver Water, and Western Water Assessment-CIRES. This season we will issue "Updates" to inform you about observed dust layers in your watersheds, and how they are likely to influence snowmelt timing and rates in the near term, given the National Weather Service's 7-10 forecast. We will also issue "Alerts" to give you a timely "heads up" about either an imminent or actual dust-on-snow deposition event in progress. Several other key organizations monitoring and forecasting weather, snowpack, and streamflows on your behalf will also receive these products, as a courtesy.

As you may know, some Colorado ranges already have a significant dust layer within the snowpack. The photo below taken at our Swamp Angel Study Plot near Red Mountain Pass on January 1 shows, very distinctly, a significant dust layer deposited on December 13, 2008, now deeply buried under 1 meter of snow. We have received reports, and observed from the air, that this December 13 layer was deposited at other locations south of I-70. Wherever it fell, this dust layer will persist and we will find it as we dig snowpits later on this season, during our first tour of the nine sites we will be monitoring throughout the mountains, and we will update you then on its presence/absence in your watersheds. Another very early dust-on-snow event here in the San Juan Mountains, on October 11 (D1-0809), quickly melted back into the ground except at the highest elevations on steep, N'ly slopes where it remains at the very bottom of the snowpack. As of this writing, we have observed no additional dust-on-snow events since the December 13th event (D2-0809).

December 13, 2008 Dust Layer (D2-0809) – Swamp Angel Study Plot, Red Mountain Pass

Thanks to our original National Science Foundation research grant, and to your subsequent support, we have now accumulated several seasons of dust-on-snow observations at our Senator Beck Basin Study Area (SBBSA) at Red Mountain Pass, summarized in the table below. It is reasonable to assume that our skill at detecting dust-on-snow events has improved over these six-plus seasons and that we may have failed to observe very small events during the early years of this work. Therefore the table represents an absence of events in grey for the first two years but thereafter indicates an absence of observed events as "0" (zero). Clearly, this history is too short to enable us to characterize what is, or is not, a 'normal' number of dust events per season, or their 'normal' timing, or any trend in deposition frequency. Ongoing field monitoring will eventually provide a sufficiently large sample for such analyses, in conjunction with other observational programs including remote sensing analyses by Tom Painter and source area monitoring by the USGS.

Dust-on-Snow Events Documented per Month, by Winter

Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
2002/2003					2		1			**3**
2003/2004							2	1		**3**
2004/2005	0	0	0	0	0	1	2	1	0	**4**
2005/2006	0	0	1	0	1	1	3	2	0	**8**
2006/2007	0	0	1	0	1	1	3	1	1	**8**
2007/2008	0	0	0	0	0	3	3	1	0	**7**
2008/2009	1	0	1	0	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*	*TBD*

Early winter 2008/2009 (Water Year 2009), from October 1 through December 31, 2008 began here in the San Juans with *both* the largest amount of precipitation in our (albeit short) history at the Swamp Angel Study Plot *and* the most wind we've measured at our 'free air' Putney Study Plot in early winter. Notably, we've also documented two dust deposition events, a direct consequence of the exceptional winds. The dust event of October 11, 2008, was delivered by ferocious and sustained winds, which averaged 50 mph for the full 24 hours at our Putney Study Plot, had 14 hours with gusts over 80 mph, and a 24-hour maximum of 108 mph. Considerable blow-down resulted, with acres of trees toppled in some areas. The table below presents several 'fun facts' for the early winter of 2008/2009; *mm* = millimeters and *m* = meters. Storms are precipitation events of >= 12 mm (0.5") of water equivalent and no break in precipitation > 12 hours.

'Early Winters' Comparison - October 1 through December 31

Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains

	0304	**0405**	**0506**	**0607**	**0708**	**0809**
Number of Storms 10/1 thru 12/31	11	7	10	11	9	9
Total precipitation 10/1 thru 12/31 (*mm*)	290	342	314	365	363	396
HS on 12/31 at SASP (*m*)	1.30	1.28	1.06	1.05	1.21	1.44
HS on 12/31 at SBSP (*m*)	Na	1.02	0.85	0.77	0.46	0.58
Year-to-Date Max HS at SASP (*m*)	1.36	1.34	1.1	1.29	1.27	1.77
Year-to-Date Max HS at SBSP (*m*)	Na	1.09	0.85	1.03	0.63	0.83
Total Miles of Wind 10/8 thru 12/31 at PTSP	Na	32,079	30,886	31,424	33,928	37,284
Total Miles of Wind in December at PTSP	Na	11,956	12,875	11,490	13,631	14,741
HS Diff betw SASP and SBSP on 12/31 (*m*)	Na	0.26	0.21	0.28	0.75	0.86

For details about the Senator Beck Basin Study Area at Red Mountain Pass see http://www.snowstudies.org/senbeck_sa.html

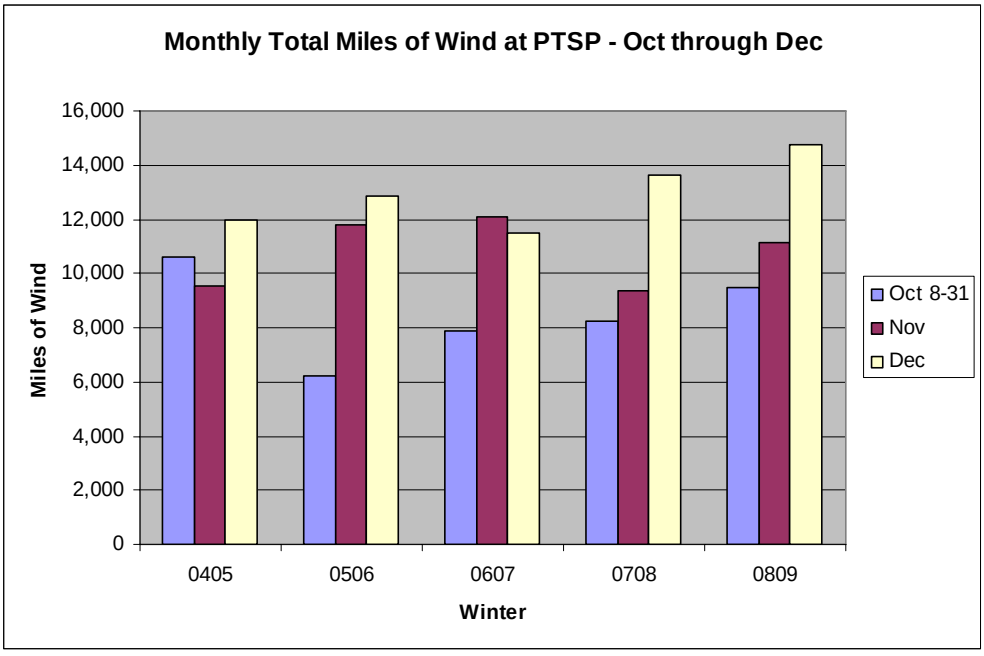
The study plot abbreviations used above are:

SASP = Swamp Angel Study Plot, at 11,050' in sheltered meadow below treeline

SBSP = Senator Beck Study Plot, at 12,200' in alpine tundra basin

PTSP = Putney Study Plot at 12,325' on exposed summit well above treeline

We understand that other Colorado mountain locales also experienced a very windy early winter this season. In Senator Beck Basin this has produced another unusual pattern of snowcover, as seen last winter, wherein very deep and very dense depositions of wind-blown snow have filled in terrain depressions more extensively than in less windy years, and this may have occurred in other ranges as well. We also observed that snowpack depths (shown as HS, or height of snow, in the table above) at our alpine Senator Beck and subalpine Swamp Angel Study Plots showed the largest 'spread' at the end of December, in our period of record, despite the deepest snowcover we'd ever observed at Swamp Angel. Further, we also have seen (not shown in the table) a very significant 'drying' of soil moisture measured continuously at 20 cm below the surface at the alpine Senator Beck Study Plot during that period, where snowcover was quite shallow throughout those three months, dropping from 48% volumetric water content in mid-October (during a period of early snowmelt) to just 17% by December 31, and further to only 11% as of this writing, February 15, 2009. (The Swamp Angel Study Plot soil moisture values have remained steady at/about 30%, underneath the thick snowcover). "Wind pumping" of the snowpack, drawing water vapor from the snowcover and the soil, may (I speculate) have contributed to this loss of soil moisture in the alpine terrain where snowcover was thinner, enhancing normal temperature gradient-driven movement of water vapor from the soil surface up into the snowpack. The graph below presents monthly "miles of wind" at the Putney Study Plot, a simple measure of air moving past that point based on the 24-hour average wind speeds measured at the top of the 30 foot PTSP mast. Due to missing data in some early years, October data begin on the 8th of the month.



That concludes this, our first, CODOS Update for Water Year 2009. We are now, of course, vigilantly monitoring for dust-on-snow. Our observed events history (table above) indicates that we could see our next dust deposition at any time and, as and when we do, we will keep you apprised. In the meantime, we welcome any observations or thoughts you may wish to send our way.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #2, March 5, 2009

Greetings from Silverton, where mud season is unpleasantly early this year! Late February featured a very unusual 24-hour rain event all over the West Slope on Monday, the 23rd, saturating Silverton's snow-packed streets and resulting in street 'streamflows' approaching several cfs! Rain was briefly observed that day as high as Red Mountain Pass, at 11,100', but the majority of that storm's 1.22" of water equivalent fell as very 'wet' snow at that elevation. Since then, March has begun with extremely mild weather, keeping 24-hour average air temperatures near, at, or above freezing for the past few days up to elevations as high as 12,325', as measured in 'free air' at our Putney weather station. Although our snowpits on March 1 showed that plenty of 'cold content' remains in the snowpacks at our level study plots, southerly slopes near our subalpine Swamp Angel Study Plot have warmed very rapidly and are now approaching 'isothermal' temperatures of 0° C throughout, and skiers are plunging through up to their hips in wet and weak snow there. Aside from the storm on the 23rd, the latter half of February also was disappointingly dry, and early March has been completely dry here in the western San Juans, up to this writing.

Since February 15th, and Update #1, we have observed or learned from fellow observers that the December 13th dust layer (referred to as event D2-0809) described in Update #1 is present in the snowpack to our north and east. A snowpit dug by Landry on Grand Mesa on February 22nd near "Skyway", a high point on the Mesa, revealed a substantial D2 layer 20" above the ground (and 40" below the snowpack surface), "just where it should be" in reference to the season's accumulation and timing of that event. D2 is also very clearly present quite low in the snowpack at McClure Pass and is also reported "at depth" in the much deeper snowpack at Wolf Creek Pass.

Further, since Update #1, we have received one new dust deposition event here in the San Juan Mountains which we will refer to as D3-0809. Late on Friday, February 27th, and/or early on Saturday, the 28th, Senator Beck Basin experienced a very brief period of extremely light precipitation containing small amounts of dust. That trace of new snow and dust lay quite loosely on the crusted and slick old snow surface and was easily redistributed by wind on Saturday, the 28th. In the days since being deposited, and in the absence of any additional clean new snow, the D3 contaminated snow has heated during daytime, generating melt, and then refrozen during nights, resulting in a delicate melt-freeze crust at the snowpack surface on all but steeper N'ly slopes or in shady areas. An avalanche forecaster colleague at Wolf Creek Pass has also reported seeing the D3 event on the snowpack during his fieldwork on Saturday, the 28th. We've not yet heard reports of or confirmed a D3 event on March 27th/28th in the Central or Northern mountains. Since the D3 event, strong SSW'ly winds on March 3rd and 4th may have resulted in dry deposition of additional traces of dust, without additional precipitation, landing on top of and merging with the exposed D3-0809 layer in Senator Beck Basin and beyond. Field observations at Red Mountain Pass on the morning of March 5th could not distinguish between the D3 event and any subsequent additional dust loading.

Given the early and rapid warming we've experiencing here in the western San Juan Mountains, we have re-started the Senator Beck Basin stream gauge some 2 weeks earlier than in

prior years. (We don't operate the sensors during mid-winter in order to avoid freezing damage). However, despite the warm weather, and the presence of the relatively minor D3-0809 layer at the snowpack surface, discharge from Senator Beck Basin is currently very low, still at mid-winter 'base flow' rates of near 0.1 cfs, not surprising given the low snowpack temperatures we observed in our March 1 snowpits, averaging -6° C at our alpine Senator Beck Study Plot (SBSP) and -4° C at the subalpine Swamp Angel Study Plot (SASP)). While snowmelt at the snowpack surface has occurred on the sunny aspects of Senator Beck Basin, producing extensive melt-freeze crusts on the surface, this melt cycle has not been sufficient to result in enough free water exiting the snowpack and entering our stream to register a 'surge' of snowmelt. None of the Snotel sites that we routinely monitor, and that we will begin visiting and sampling for dust in coming weeks, are showing any decline in SWE at this time either. In addition to our intensive monitoring at the Senator Beck Basin Study area at Red Mountain Pass, the Snotel sites we will monitor and visit this year are: Wolf Creek Summit, Park Cone, Hoosier Pass, Grizzly Peak, Berthoud Summit, Willow Creek Pass, Rabbit Ears Pass, and McClure Pass. We will also sample near Slumgullion Pass, but no Snotel is present there.

However, snowmelt has clearly begun at the lowest snow covered elevations here in the San Juan Mountains, well below the Snotel sites, initially driven by increasing air temperatures and rain during the February 23rd storm and then, for the past five days, enhanced by the D3-0809 layer. Melting is no doubt also underway at the lowest elevations in other ranges as well, given statewide temperatures. Wherever snowcover was present here in the San Juans on December 13th, the D2 dust layer discussed in Update #1 has been present in the snowpack. At our lowest elevations, the vast majority of the snowcover's SWE sits above the D2 layer. The current warm air temperatures and direct absorption of solar energy by the D3 dust layer are facilitating ablation of the low-elevation snowcover, and the D2 dust layer has begun to emerge on south facing slopes first, and will emerge on other slope aspects later, further reducing the snowcover albedo and resulting in even more rapid melt of what little snow lies underneath the D2 layer at those elevations.

At higher elevations in the locales where we've confirmed the presence of D2, some 2/3 of this season's SWE lies above that dust layer (and now under D3, where present). For instance, in our March 1st snowpit at our Swamp Angel Study Plot, at 11,050', 14.2" (64%) of the 22.2" of total SWE sits above the D2 dust (leaving about 8" of SWE below D2). At the Grand Mesa pit site at 10,800', on February 22nd, a similar proportion (63%, or 11.5") of the total of 18.3" of SWE was sitting on top of the December 13th, D2 dust layer. Given its depth of burial within the snowcover at those mid and higher elevations, it will be some time before the D2 layer widely emerges, reducing snowcover albedo, and becomes a snowmelt 'forcing' factor during this year's snowmelt season. In the meantime, until we receive additional new snow, the D3 dust layer, where present, in tandem with warm ambient air temperatures. In areas where D3 is absent, ambient air temperatures, in tandem with the lesser absorption of solar energy by clean snow, will be the dominant drivers of snowmelt.

Yesterday, colleagues in Grand Junction and Durango reported quite strong winds at those locations, and the Salt Lake and Utah Valleys were choked with dust originating from the western deserts and Milford Flat fire scar in SW Utah. The Wasatch Range received 3 dust deposits just in the last week. As we conclude and distribute this Update at mid-day on Friday, March 5th, we're still experiencing very strong SW'ly winds here in Silverton. While we do not see the tell-tale red tinge of dust in the SW Colorado atmosphere at this time, today, it is sometimes the case, here on

the western edge of the state, that dust storms only become apparent later in the afternoon or evening. With several years of observation now completed, we note that 26 of the 35 dust-on-snow events that we have documented at Senator Beck Basin since 2003 have arrived after March 21st (i.e., the spring equinox). Because of that timing, the vast majority of events occur closer to the period of greatest solar loading, maximizing their impact on snowmelt processes. Based on this week's large deposition in the Wasatch, from drying deserts, and our deposition climatology showing an average of 4 events past the spring equinox, we are likely in for several more events in Colorado this season.

We will provide another routine Update near the middle of the month, and apprise you of any dust events in progress with an Alert, as needed.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #3, March 17, 2009

Although the vernal equinox is still a few days away, we extend spring greetings from Silverton. Given the unseasonably warm and very dry weather underway this week, and forecast into the coming weekend, and the very dry March we've experienced to-date, it seems more like April than March here in the San Juan Mountains.

Since our last Update on March 5th, and our e-mail Alert shortly thereafter on March 7th regarding D#4-0809, we received one additional dust-on-snow event here in the San Juan Mountains – D#5-0809 – on March 9th. That event was diffusely entrained within a modest snowfall and, like D4 and D3, was somewhat difficult to see for a day or two, until the snow containing D5 settled into a denser, more concentrated layer and the dust became evident at the surface. The D5 layer has become very evident on southerly aspects at and below treeline in the San Juan Mountains, and is only covered by an inch or two of clean snow (which fell on Saturday, March 14th) on the shadier aspects at those elevations. Further, only a few inches of clean snow separate D5 from the already-merged D4 and D3 layers at our (level) Swamp Angel Study Plot near Red Mountain Pass. It is entirely possible that, by the end of this week, the D5 layer will melt down to and then merge with the already merged D4/D3 layer, further reducing the snow albedo on most east-, south-, and west-facing slopes at and below treeline here in the western San Juan Mountains.

Given the number of dust-on-snow events (5) already observed this season at our Senator Beck Basin Study Area, and by observers at some other locations, it is time for the CODOS team to obtain a first-hand overview of the dust-on-snow conditions around the State. Following our routine weekly dust sampling at Senator Beck Basin yesterday and today, we will conduct our first field tour of our nine monitoring sites beginning tomorrow, Wednesday, March 18th. Again, those sites are all (except at Slumgullion or Spring Creek Pass) adjacent to the following Snotel sites: Park Cone, Slumgullion/Spring Creek Pass (which one is TBD on this trip), Wolf Creek Summit, Hoosier Pass, Grizzly Peak, Berthoud Summit, Willow Creek Pass, Rabbit Ears Pass, and McClure Pass.

As of this writing, none of these eight Snotel sites are indicating any loss of SWE since March 10th, the day after D5-0809 was deposited here in the San Juan Mountains. It is likely that the snowpacks at most of our monitoring sites are not yet in or even near an isothermal state at 0° C, making it unlikely that any surface snowmelt is exiting the snowpack at this time. The possible exceptions to that assumption are the low elevation McClure Pass and Willow Creek sites, where the snowpack may be approaching isothermal temperatures by the end of the week. During this field campaign we will verify the presence or absence of dust-on-snow layers at those sites, document the depth(s) below the snowpack surface of the dust layers we find, and measure snowpack temperatures. Our next CODOS update, later this month, will describe our findings.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #4, Tuesday, March 24, 2009

As the mayor of Silverton put it during coffee on Monday morning, March 23rd, referring to the D6-0809 event reported in our CODOS Dust Alert issued Sunday evening, March 22nd, " … *well Landry, we didn't get much snow [a trace in Silverton], but at least we got plenty of dust* …". Sunset on Sunday evening was indeed a spectacle of red skies precipitating dirty snow, and Ridgway residents reported a muddy rain. D6-0809 has been reported by snow observers to our east and north as far away as Winter Park and in Boulder (also as muddy rain). Based on field observations during the 1,040 mile road tour of our nine monitoring sites around the state on March 18-21, during which dust layer D5-0809 was seen exposed at or just beneath the snowpack surface at all nine of those sites and in their vicinity, the D6-0809 dust fell directly onto an already dirty snow surface. A scan of the Snotel sites adjoining our monitoring sites shows moderate accumulations of generally 6" of new snow from the storm delivering D6, now winding down, with new amounts of 9" and 12" at McClure Pass and our Swamp Angel Study Plot sites, respectively. A second storm later this week may supply additional new snow, further decreasing the solar radiation reaching the D6 dust, assuming that the second system does not also deliver additional dust.

While the D5-0809 layer was widely observed at our CODOS monitoring sites, many of the layers we've documented in our Senator Beck Basin Study Area (SBBSA) Swamp Angel Study Plot at Red Mountain Pass were not found. The following table indicates which layers were observed in snowpits during our tour last week. Because of their close proximity in time, it appeared at many sites that the brown D5-0809 dust had been deposited directly on or very near to the grayer D4-0809 event, and that the two had merged, as is seen at Senator Beck Basin. Event D1-0809 was so early in the season that the snow it fell on at the time subsequently melted back to the ground at our sub-alpine Swamp Angel Study Plot, and is only found in patches in the alpine terrain of Senator Beck Basin. Layer D2 is very deep in the pack at respective locations and will only be a factor during the final stages of snowmelt, merging with the overlying layers as the melt down to D2. At this juncture, the extent and intensity of the D6 event may render the underlying layers as 'secondary' contributors to reductions in snowpack albedo, augmenting but superceded by D6, barring further major dust-on-snow depositions later this spring.

CODOS Monitoring Site	CODOS Snow Pit	D1 10/11/08	D2 12/13/08	D3 2/27/09	D4 3/6/09	D5 3/9/09
SBBSA at Red Mountain Pass	3/17/09	Alpine Only	20" abv gd	Very Light	Merged w/D5	Surface
Park Cone	3/18/09		5" abv gd		Merged w/D5?	Surface
Spring Creek Corrals	3/18/09		8" abv gd		Merged w/D5?	Surface
Wolf Creek Summit	3/19/09		16" abv gd			Surface
Hoosier Pass	3/19/09				Merged w/D5?	Surface
Grizzly Peak	3/20/09		At ground			Near Surf
Berthoud Summit	3/20/09					Near Surf
Willow Creek Pass	3/20/09					Surface
Rabbit Ears (West Summit)	3/20/09					Very Faint
McClure Pass	3/21/09		8" abv gd		Merged w/D5?	Surface

Despite the reduced albedo caused by the D5 layer observed at or just beneath the snowpack surface throughout the mountains during the road tour late last week, and the warm temperatures, SWE values remained nearly constant during the week of March 15-21 at the Snotel sites adjoining eight of our nine monitoring locations. This can be attributed to the cold content still found in the snowpacks at those monitoring sites, refreezing free water generated by surface melt as it percolated into the pack. The exception to that pattern was the McClure Pass Snotel site, which recorded a 6% drop in SWE during that period and where our snow profile found an isothermal snowpack at 0° C. The table below shows the coldest mid-pack snow temperatures observed and the change in SWE between March 15th and March 22nd. (Mid-pack temperatures are slower to change and a better indicator of the average temperature of the snowpack, over a 24-hour period, than near-surface temperatures that reflect overnight cooling or daytime thawing.)

CODOS Monitoring Site	Elevation	Slope & Aspect	Date	CODOS Snow Pit Depth	Coolest Mid-Pack Snow T	SNOTEL Change SWE March 15-22
SBBSA Swamp Angel	11,050	3° NE	3/16/09	67”	-4.5° C	Error
Park Cone	9,600’	8° N	3/18/09	34”	-2.7° C	-0.1”
Spring Creek Corrals	10,800’	9° NE	3/18/09	33”	-3.9° C	Na*
Wolf Creek Summit	11,000’	9° SSW	3/19/09	78”	-2.0° C	-0.2”
Hoosier Pass	11,600’	5° WSW	3/19/09	39”	-3.5° C	+0.1”
Grizzly Peak	11,100’	12° W	3/20/09	49”	-4.2° C	-0.1”
Berthoud Summit	11,300’	3 ° SE	3/20/09	56”	-3.3° C	0.0”
Willow Creek Pass	9,540’	3° W	3/20/09	37”	- 0.8° C	-0.5”
Rabbit Ears (West Summit)	9,400’	3° NNW	3/20/09	71”	-1.6° C	-0.1”
McClure Pass	9,500’	3° S	3/21/09	43”	0.0° C	-1.2”

* No Snotel near Spring Creek Pass site

The sustained string of sunny days during the week of March 15-21 resulted in daily periods of snowmelt at the snowpack surface and free water percolation, to varying depths, wetting and warming the snowpack. A strong trend toward isothermal snowpack temperatures was evident in our snowpits, and the pervasive presence of the D5 dust layer at the surface clearly accelerated that process through direct absorption of solar energy. New snow received this week will serve to temporarily insulate the old snowpack and conserve the heating experienced last week, despite cooler air temperatures.

Thus, the stage is set for a significant increase in snowmelt rates as and when the D6 dust layer approaches and reaches the snowpack surface, merges with the D5 layer, and significantly reduces snowcover albedo on what could be a very large spatial scale spanning most or all of Colorado’s mountains. The state’s snowpack was driven much closer to or actually achieved an isothermal state at 0° C last week, under the influence of D5. The extra direct absorption of solar energy by the D6 layer (quickly merged with D5) at/near the snowpack surface, and the percolating free water generated by that energy, will henceforth be offset by substantially less, or no, cold content remaining within the snowpack. That free water will percolate (vertically and/or laterally) more freely through the snowpack at the elevations we monitor near Snotel stations.

During the tour of monitoring sites, the lowest elevation margins of snowcover, which were often observed to be not very much lower than our Snotel sites, have long since become isothermal.

While it is well above the lower extent of snowcover here in the San Juans, our Senator Beck Basin had been generating very minor snowmelt on the lowest, south facing slopes, and we experienced a minor increase in flows last week. Your local gauges may have shown, or you may have simply observed, an increase in flows (and decrease in low elevation snowcover) last week in your areas. Depending on the duration of exposure of the D6 and D5 dust layers at the snowpack surface, beginning at the lower elevations and quickly ascending to higher elevations, snowmelt rates and the stream flows that you are monitoring may surge very quickly. National Weather Service mid-range forecasts, as of this writing, anticipate a drying in the southern mountains of the state over the weekend, with showers persisting in the northern mountains. Temperatures are expected to rebound to near-normal levels, but the critical factor to watch will be cloud cover – a return to an extended period of generally sunny skies, even under seasonable air temperatures, will result in rapid settling of the new snow layer, emergence of D6 (and merger with the D5 layer), and rapid acceleration in snowmelt rates.

Some other observations from the road tour:

March 18 – Silverton to South Fork

- Gunnison Valley notably snow free
- D5 was clearly seen in drifts on the Taylor Reservoir spillway structure
- Creede area very dry

March 19 – Wolf Creek Pass to Hoosier Pass and Fairplay

- Snowpack on the east side of Wolf Creek Pass was extremely dirty
- San Luis Valley was desiccated, and the west side of the Sangre de Cristo very bare
- Arkansas River running clean and clear; the valley and Collegiates very bare
- South Park snow free; Mosquito Range was also wind stripped

March 20 – Fairplay to Steamboat Springs via North Park

- East side of 10 Mile Range has better snow cover, slightly cleaner than other ranges
- Loveland and Berthoud Pass areas very bare; Henderson Mine emitting a lot of local dust
- Fraser Valley very dry; North Park completely snow free except for residual drifts

March 21: Steamboat Springs to Silverton via McClure Pass

- Still a shallow snowpack in the valley floor near Steamboat Springs, D5 at the surface
- Colorado River running turbid green, at Eagle River confluence; Crystal River running dirty gray; Muddy Creek running chocolate brown

More soon, as events unfold.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #5, Friday, March 27, 2009

As you're all aware, the major winter storm that NWS predicted earlier in the week has transpired, adding substantial SWE to your watersheds ***and*** further burying the very extensive and substantial D6-0809 dust layer deposited throughout the Colorado mountains during the evening and night of March 22nd. To our knowledge, as of this writing, this new 'snow-on-dust' layer is composed of relatively dust-free snow that will buy some additional time, before the D6 layer re-emerges at the snowpack surface. Here and there, you may still be able to see the odd patch of exposed D6 dust even after this stormy weather clears out, where wind stripping has prevented the new snow from accumulating on top of the dirty surface containing D6, but these will be very local in nature.

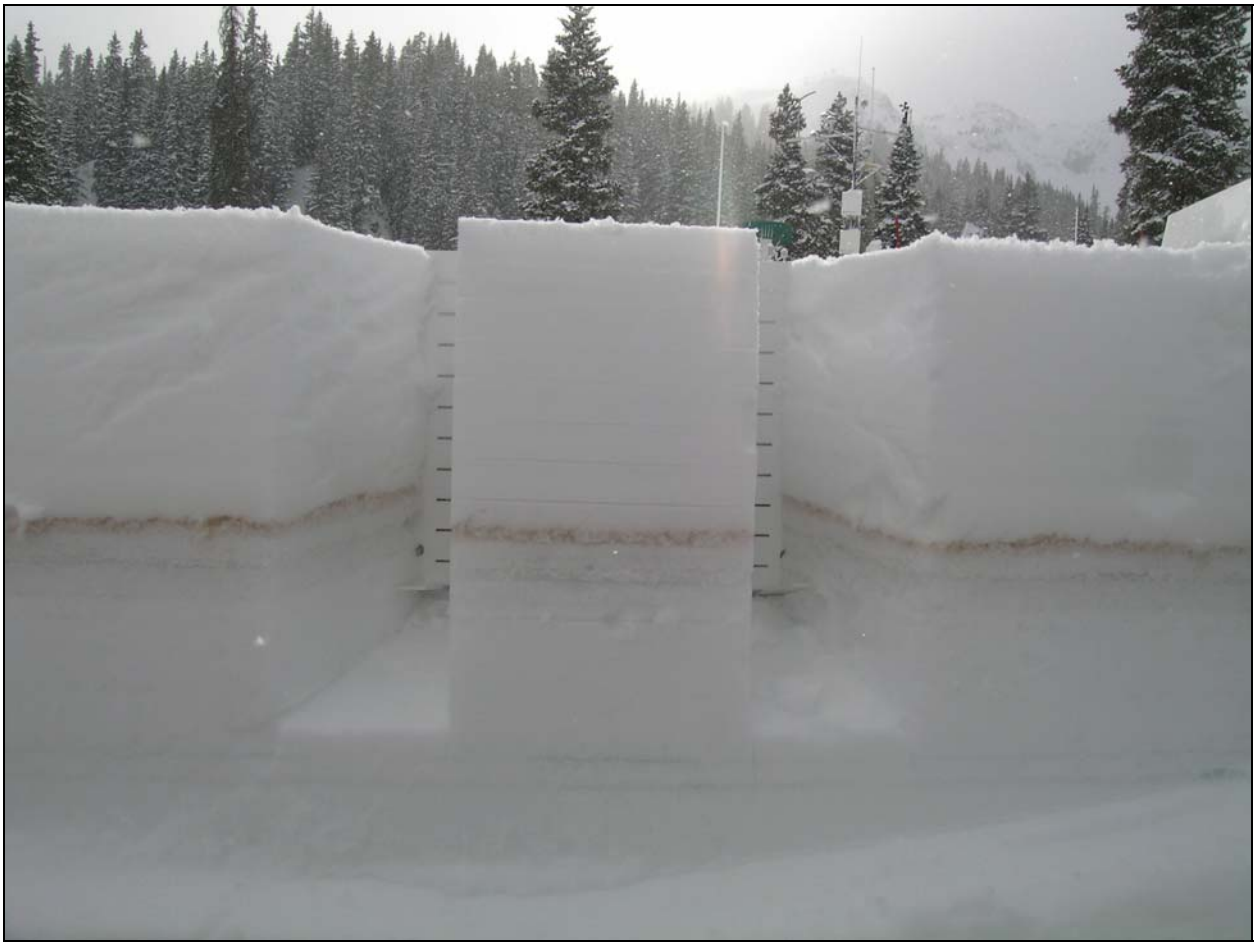

Figure 1 - Snow pit face at Swamp Angel Study Plot, March 22, 2009 showing the brown D6-0809 layer. This photograph shows the preparation of our gravimetric sampling column (0.05 m^2 x 30 cm deep) before ten separate 'slices' are made of the column, moving downward in 3 cm layers (scoring can be seen on the face of the column, matching the saw-guiding slots in the metal plate behind the column). Each snow sample is bagged, melted, then filtered through a pre-weighed filter which is then re-weighed to obtain the mass, in grams per square meter, of dust contained in that 3 cm layer.

Eventually, of course, the D6 layer will emerge at the snowpack surface in your watersheds. The photo above (Figure 1) was taken last Tuesday at the CSAS's Senator Beck Basin Swamp Angel Study Plot showing the dark brown D6 layer at about 8" beneath the snowpack surface, that day, and illustrates what a substantial layer D6 is, here in the San Juan Mountains at Red Mountain Pass. The photo below (Figure 2) shows the entire 71" snowpack at Swamp Angel that day, with the significant D2-0809 layer visible low in the pit face, and D6 near the top. We've seen other photos of the D6 layer from other locations throughout the state showing the same layer in the snowcover.

Figure 2 – Complete snow pit face at Swamp Angel Study Plot, March 22, 2009

With D6-0809 located 8" below the surface at Swamp Angel, on the day of these photographs (March 24th) the vast majority of incoming solar radiation was not penetrating the overlying snow. Still, a nontrivial amount of solar energy was being absorbed by the dust and the D6 layer snow temperature was -0.1 degrees C, virtually isothermal. Since then, additional new snow has buried D6 close to or more than 12" deep at our sites, reducing direct absorption of incoming solar energy by the D6 layer. On the other hand, that new snow is also insulating the underlying 'old' snowpack (starting from the D6 layer, downward) from the cooler storm and post-storm air temperatures.

Similarly, D6 has been buried by substantial amounts of new snow throughout the mountains and the table on the next page estimates how much new snow has accumulated, as of this morning (Friday, March 27th), at our CODOS monitoring sites. These estimates are based on increases in the

depth of snow (aka, height of snow or *HS*) at the nearby Snotel sites since mid-day March 22nd. Note that our CODOS snow pit sites are generally located in more open areas than their associated Snotel site (to minimize confusion of tree debris for dust in our snow pits), and the Snotel sites are not often representative of new snow accumulations in alpine terrain, where wind redistribution can be the dominant factor governing snowcover depth. Hence, these are only "point" estimates of the new snow coverage above D6 and should not be interpreted as an average, a maximum, or a minimum – just a best guess for the CODOS snow pit site. You could also estimate the depth of new snow above the D6 layer at other Snotel sites around the state (at sites where snow depth is being measured) by comparing the depth of snow in the late afternoon on Sunday evening, March 22nd, with the depth shown today, March 27th, or on any subsequent day.

CODOS Monitoring Site	Most Recent CODOS Snow Pit	Most Recent CODOS Snow Pit Depth (HS)	HS at Adjacent SNOTEL 1200 hrs Sunday, 3/22/09	HS at Adjacent SNOTEL 0600 hrs Friday, 3/27/09	**Estimated Depth New Snow Above D6-0809 as of 0600, Friday, 3/27/09**
SBBSA Swamp Angel Plot *(1)*	3/24/09	71"	SASP = 61"	SASP = 72"	**11"**
Park Cone	3/18/09	34"	~32"	47"	**15"**
Spring Creek Corrals *(2)*	3/18/09	33"	*na*	*na*	**na**
Wolf Creek Summit	3/19/09	78"	73"	90"	**17"**
Hoosier Pass	3/19/09	39"	39"	54"	**15"**
Grizzly Peak	3/20/09	49"	49"	62"	**13"**
Berthoud Summit	3/20/09	56"	52"	62"	**10"**
Willow Creek Pass	3/20/09	37"	36"	50"	**14"**
Rabbit Ears (West Summit) *(3)*	3/20/09	71"	53"	72"	**19"**
McClure Pass	3/21/09	43"	39"	50"	**11"**

(1) Swamp Angel Study Plot (SASP) data present actual, automated snowpack depth (HS) measurements
(2) No Snotel station near our Spring Creek (Pass) Corrals CODOS monitoring site
(3) Rabbit Ears Snotel is located in timber on a W'ly aspect, whereas the CODOS site is in an open area with a NNW aspect

Finally, an additional observation regarding recent increases in snowpack temperatures. In the week between the Swamp Angel Study Plot snow pit seen in the photographs above and the prior, March 16th pit (dug just a couple of meters away from this pit), the snowpack temperature profile warmed dramatically, with -0.6° C being the coldest temperature observed in the March 24th profile. Those increased snow temperatures, nearly eliminating the cold content in the snowpack observed on March 16th, when we observed mid-pack temps of -4.5° C, are highly unlikely to be reversed. It is reasonable for us to speculate that the same factors causing this snowpack warming at the Swamp Angel Study Plot – sunny skies, warm air temperatures, and extensively exposed D5 dust at the surface producing surface melting that percolated deeply into the snowpack – led to additional warming of the snowpack at the CODOS monitoring sites in the days following our measurements of snow temperatures on the dates of the snow pits (shown in the table above).

More to come, as the weather unfolds.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #6, Monday, April 6, 2009

Fig. 1 - Dust storm D8-0809 in progress at 5 PM, Friday afternoon, April 3rd, in Silverton.

This Update falls on the heels of yet another major, statewide dust-on-snow event, D8-0809 of Friday, April 3rd, 2009. Because of its intensity, spanning several daylight hours (and into the night Friday), and because it came so soon after the very substantial D7-0809 event of March 29th, D8-0809 has long-term San Juan Mountains residents surmising that this is the worst dust season in their memory, and that D8-0809 was the most intense single event they'd ever witnessed (perhaps because many dust events do arrive late in the day and continue during darkness). Very shortly after issuing our CODOS Alert on Friday afternoon, April 3rd, reports began to arrive from sources as far away as Phoenix that an unusually intense dust storm was underway, with remarkably rapid deposition of dust-on-snow. Satellite imagery clearly showed that most of the northeastern corner of Arizona was releasing dust plumes heading northeastward, into Colorado. Based on their descriptions, the photo above (Figure 1) seems to be representative of the scene in other San Juan Mountain locales that retained comparatively good visibility on Friday! Reports from Durango indicated visibility reduced to 3-4 blocks, and drivers in the 4-Corners area reported visibility of 30 feet to 'zero', at times. As reported in the April 3rd Alert, visibility from Silverton was dramatically reduced, completely obscuring adjoining mountains just a mile away. Observers have reported that D8, like D7 and D6, was seen across most of the state's mountains, often with the same dramatic skies seen here in Silverton.

The photograph below (Figure 2) was shot early Sunday morning, April 5th, at our Swamp Angel Study Plot and shows the three most recent dust-on-snow depositions here in the San Juan Mountains. D8-0809 is the uppermost of the three dust layers, with D7 (March 29) in the middle and D6 (March 22) below. The layer of snow just above D8 also contains additional dust and as this

new snow settles, the D8 layer will further consolidate. Several inches of comparatively clean new snow lay above D8 at the time of this photograph, but much of that snow was very low density and will be subject to rapid settlement. Within 24-48 hours the thickness of the clean snow layer overlying D8, at this very slightly NE facing location, will be very substantially reduced enabling the D8 layer to absorb increasing amounts of radiation under generally sunny skies and increasing air temperatures today, April 5th, through Tuesday, April 7th. That new snow settlement will occur even more rapidly on sunnier E, S, and W aspects, accelerating the emergence of the D8 layer there. At exposed alpine locations near and above treeline, winds have already removed the overlying clean snow and D8 was clearly visible along ridges and other terrain features on Sunday morning. Again, we assume that D8 was deposited at all nine of our monitoring sites around the state, based on reports. Snowfall on Friday and Saturday fell well below forecasted amounts due to a northward shift in the storm track so D8 was, for the most part, not deeply buried by new snow at most sites and may not have been buried at all (or has already emerged) at other sites. For comparison to the Swamp Angel layering, Table 1 (next page) uses Snotel precipitation and snowcover depth data to estimate the amount of new snow that was overlying D8 at 0600 on Sunday morning, April 5th, if D8 was, in fact, present at those sites.

Fig. 2 – Snowpit on Sunday morning, April 5, showing the succession of D8-, D7-, and D6-0809 dust layers in the upper snowpack, and the 7" of clean snow overlying D8 and the thickness of clean snow between layers D7 and D8, and D6 and D7.

Whether or not this is an unprecedented Colorado dust-on-snow season, these three layers are very extensively distributed throughout the state's mountains and contain an indisputably large amount of dust. While noting that D8-0809 is almost certainly not the last dust-on-snow event of the spring of 2009, any single one of the D8/D7/D6 layers would have, by itself, constituted a significant snowmelt forcing agent. Each of these three layers could be considered comparable to the February 15, 2006 dust layer (D2-0506) that we've discussed with you in the past. When that D2-0506 layer emerged at the snowpack surface, and remained exposed for extended periods of dry and sunny weather, snowmelt timing was advanced by 5 weeks at the Senator Beck Basin Study Area and enhanced snowmelt rates resulted in a curtailed spring 2006 runoff. Similar advances in snowmelt timing and rates were observed throughout the state's watersheds.

CODOS Monitoring Site	Estimated Depth of Burial of Possible D8-0809 Layer at Adjoining Snotel Site as of 0600, 4/5/09
SBBSA at Red Mountain Pass	7"
Park Cone	3"
Spring Creek Corrals	*na**
Wolf Creek Summit	13"
Hoosier Pass	4"
Grizzly Peak	<1"
Berthoud Summit	4"
Willow Creek Pass	7"
Rabbit Ears (West Summit)	<1"
McClure Pass	10"

* No Snotel near Spring Creek Pass site

Table 1 – Estimated depth of burial of D8 layer on Sunday morning, April 5th, if layer D8 is present.

Even in the unlikely absence of additional dust events later this spring, the D8 layer, alone, could have the same effect as the February 15, 2006 layer. Worse, as D8 eventually merges with D7, and they then merge with D6, the reduction in snowpack albedo will certainly match and may exceed any previously measured snow albedo values at Senator Beck Basin. Should that reduced albedo persist for days or weeks, unmitigated by frequent snowfalls as occurred during the spring seasons of 2007 and 2008, snowmelt forcing caused by the merged D8/D7/D6 layers may also meet or exceed the affects on runoff timing and duration observed, statewide, in 2006. Short of experiencing long duration rain-on-snow events at high elevations, a persistent low albedo scenario represents a worst case, vis-à-vis snowmelt runoff rates and duration. Only time will reveal the weather over the coming weeks and whether we alternate from high-to-low-to-high albedo, with frequent additional snowfalls (and additional SWE) temporarily burying the merged D8/D7/D6 layer, or whether we experience prolonged periods of high pressure between infrequent snowfalls, leaving D8/D7/D6 exposed at the surface and directly absorbing solar energy.

In the near term, the National Weather Service in Grand Junction has identified the potential for another spring snow event on Wednesday, April 8th, but uncertainties persist in their suite of models about the likely track of that system. As of this writing, NWS is leaning toward a track that would favor the northern and central mountains, perhaps largely missing the southern mountains,

but the progressive weather pattern could deliver another period of unsettled and showery weather over the following weekend (April 11-12). In light of that pattern, we anticipate that wherever D8 has emerged on sunny aspects in the coming few days, any new snow received will temporarily and perhaps only partially mitigate its absorption of energy; new snow will also slow the emergence of D8 on shadier aspects. Where no new snow is received mid-week, D8 may melt the snow between it and D7 on sunny aspects and also begin to emerge on shady aspects. Some of the energy contained in the free water produced during this period will be consumed by the cold content contained in the layers of snow between D6 and D7, and D7 and D8, but the snowpack underneath D6 remains very close to isothermal. Prolonged exposure of D8 (and possibly D8 merged with D7) will result in the entire snowpack becoming isothermal, releasing snowmelt, and a surge in runoff. Low elevations sites where some combination of the D8/D7/D6 layers is present and merging will lose snowcover very rapidly. Emergence of the D8 layer for a prolonged period this week may initiate snowmelt runoff in alpine terrain for the first time this season. To-date, runoff from our Senator Beck Basin Study Area has been minimal, from the lowest elevation south facing slopes, and discharge has recently fallen back to near the base flow, as seen in Figure 3, below.

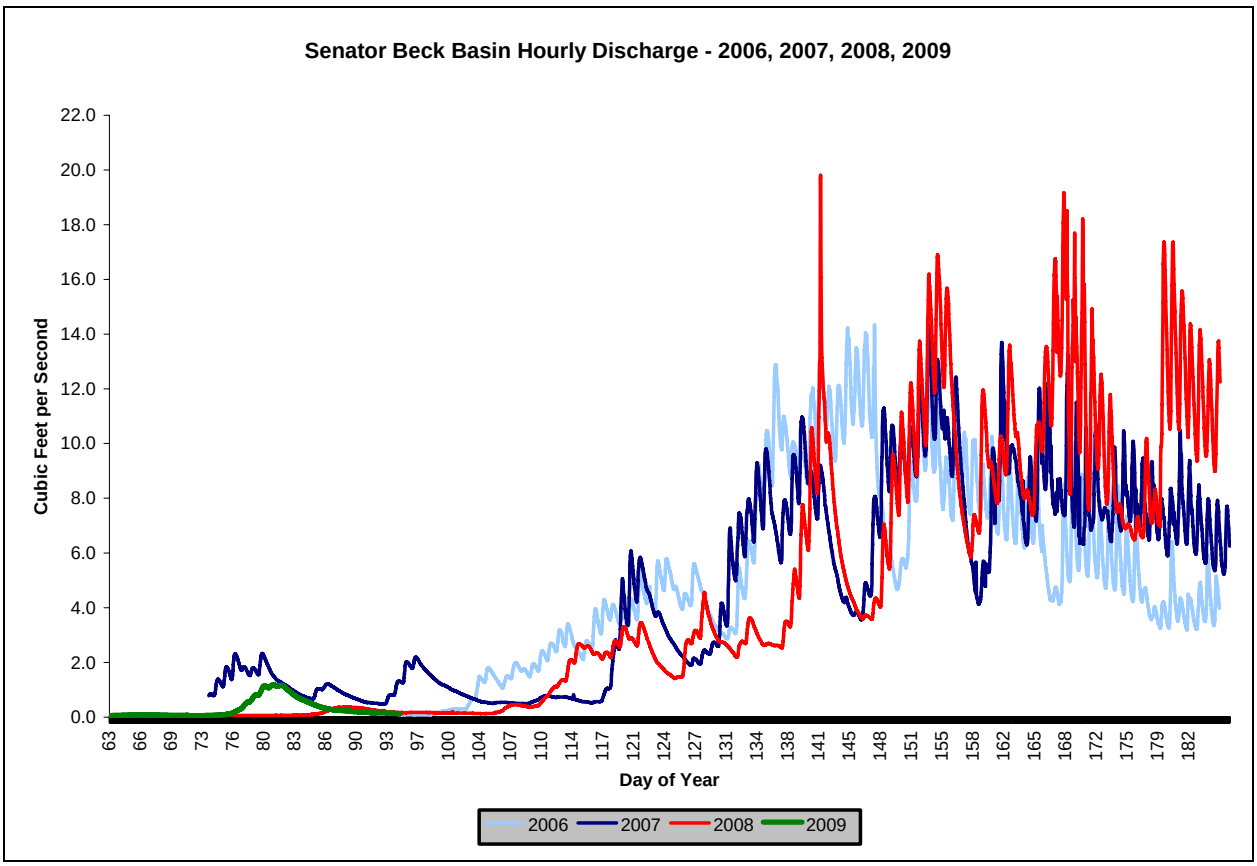

Fig. 3 – Senator Beck Basin Discharge

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #7, Tuesday, April 21, 2009

Greetings from the CODOS crew, upon completion of another 1,000 mile tour of our nine Colorado dust-on-snow monitoring sites over the past several days. That tour began, as always, at the CSAS's Senator Beck Basin Study Area Swamp Angel Study Plot on Wednesday morning, April 15th, and then proceeded over the next four days to Park Cone, Spring Creek Pass, Wolf Creek Pass, Hoosier Pass, Grizzly Peak (Loveland Pass), Berthoud Pass, Willow Creek Pass, Rabbit Ears Pass, and finally to McClure Pass on the return to Silverton on Sunday, April 19th. The beginning of the trip also happened to coincide with yet another dust deposition, D10-0809, on April 15th and 16th, primarily in the southern half of the state, late in the afternoon.

Our team was comprised of Chris Landry, Tom Painter, and his two University of Utah Snow Optics Laboratory graduate students Annie Bryant and McKenzie Skiles. In addition to updating our inventory of which dust layers are present at each of these nine sites, and at what depth below the surface, Painter's students also collected a complete column of the snowpack from all the sites, sometimes during rather challenging weather conditions. Those samples will be melted and filtered in order to quantify and compare the total amount of dust material deposited at each site so far this winter. To our knowledge, this sampling and analysis has only been done at a couple of sites and not in the same year.

Tom Painter, McKenzie Stiles, and Annie Bryant collecting the first of twenty-two snow samples, capturing a complete snowpack column, at the Berthoud Summit CODOS monitoring site on Friday, April 17, 2009. As of 5 PM that afternoon, 25" of new snow had already accumulated above the old snow surface.

Our snowpits during this tour also verified that one, or two, or all three of the D8, D7, and D6-0809 dust layers described and shown in Figure 2 of our April 6th CODOS Update (#6) are present within the snowpack at all nine of our CODOS monitoring sites, either as distinct and separate layers or as variously merged layers. The most recent deposition, D10-0809 on April 15th, was observed in the sites south of I-70. Because of the relative low loading of the D10-0809 April 15 event, we will have to wait to determine from lab analysis if it was present in the pits north of I-70. The extent of layer D9 (April 9th) was not possible to determine since it fell on a dirty snow surface in many locations. As previously discussed, because of their magnitude, dust layers D6, D7, and D8 represent the dominant dust-in-snow feature(s) throughout the Colorado mountain snowpack. A series of photographs at the end of this report show the snowpack at each site during our tour and illustrate the information about the dust layering shown in Table 1 (below).

CODOS Monitoring Site	CODOS Snow Pit	D6 3/22/09	D7 3/29/09	D8 4/3/09	D9 4/8/09	D10 4/15/09
SBBSA at Red Mountain Pass	4/15/09			<<<< merged >>>		
Park Cone	4/15/09	<<<< merged >>>			?	?
Spring Creek Corrals	4/16/09	<<<< merged >>>			?	
Wolf Creek Summit	4/16/09				?	
Hoosier Pass	4/17/09	<<<< merged >>>			?	
Grizzly Peak	4/17/09				?	
Berthoud Summit	4/17/09				?	
Willow Creek Pass	4/18/09	<<<< merged >>>			?	
Rabbit Ears (West Summit)	4/18/09				?	
McClure Pass	4/19/09	<<<< merged >>>			?	?

Table 1 – recent dust layers observed in CODOS monitoring snowpits in mid-April, 2009. In many cases, a very thick layer of dust is thought to represent the merger of all or some of the D6, D7, and D8 layers.

At some sites, clean storm snow and other recent snow had fallen on top of the uppermost dust layer. Table 2 (below) indicates the thickness of clean snow overlying the uppermost dust layer in our recent snowpits, at the time of the pit. The recent storm added additional clean new snow to some, but not all, of these sites, but very rapid settlement in new snow at this late date in the season makes it infeasible to estimate a current (as of this writing) depth of clean, overlying snow.

CODOS Monitoring Site	Most Recent CODOS Snow Pit	Most Recent CODOS Snow Pit Depth (HS)	Depth below surface of uppermost dust layer at time of pit	Coldest snow temperature observed in snow pit
SBBSA Swamp Angel Plot *(1)*	4/15/09	89”	0” (D10)	-2.0 C
Park Cone	4/15/09	28”	0” (merged)	0.0 C
Spring Creek Corrals *(2)*	4/16/09	33”	2“ (D10)	-1.6 C
Wolf Creek Summit	4/16/09	78”	<1” (D10)	-0.4 C
Hoosier Pass	4/17/09	61”	8” (merged)	-2.2 C
Grizzly Peak	4/17/09	62”	13” (merged)	-1.3 C
Berthoud Summit	4/17/09	90”	28” (D9)	-5.0 C
Willow Creek Pass	4/18/09	39”	6” (D8)	-1.5 C
Rabbit Ears (West Summit) *(3)*	4/18/09	89”	8” (D8)	-0.9 C
McClure Pass	4/19/09	45”	0” (D10)	0.0 C

Table 2 – Depth of clean snow above the uppermost dust layer observed in our recent snowpits

Given these site-to-site variations in the depth of burial, the variations in depth of dust caused by elevation at the local scale (a narrow fringe of very red snow is visible in many areas at the lower extreme of the snowpack), and the exposure of the uppermost dust layers by wind stripping in alpine terrain, the sequence of emergence of those uppermost dust layers will be complex and vary by basin. But, the photograph in Figure 2 illustrates the magnitude in change in snowcover albedo that is, whether in the near-term or later, inevitable - the snowcover in the background, now white, will be the rust-red color of the snow in the foreground, in the aspen forest.

Figure 2 – looking south from McClure Pass at Chair Mountain, with the rust-red D8 layer fully emerged in the forest, and fully buried in the alpine terrain above.

Looking forward, the National Weather Service in Grand Junction anticipates a prolonged dry and very warm period from the time of this writing into and possibly through the coming weekend, with only scattered afternoon clouds and showers, if any precipitation, this week. A system arriving late in the week but tracking largely to the north of Colorado may also generate another significant wind event on Friday or Saturday. Regionally, we anticipate the following consequences.

WESTERN SAN JUANS: as of this writing, under clear blue skies in Silverton, dust is quickly emerging or fully exposed at all elevations on S, W, and E aspects in the western San Juan Mountains, aided by the D10 layer embedded within the new snow. With virtually no cold content remaining in the snowpack at/near treeline, the radiation being absorbed all this week by that uppermost dust layer will translate directly into surface melt and perhaps even widespread merging of the D10 and D9/8 layers by the end of the week, on all but north aspects. A surge in runoff is

already underway at lower elevations (enhanced by new snow that fell on bare ground) and snowmelt discharge may finally initiate sub-alpine and alpine terrain this week. Streamflow at the Senator Beck Basin weir remains very low as of this writing, given the quite high elevation (>11,000 feet) of our catchment, but has begun to rise above base flow in just the past 24 hours. Low- and mid-elevation runoff seems highly likely to accelerate during the prolonged period of dry, sunny, and warm weather ahead in the Animas, Uncompahgre, and San Miguel watersheds.

EASTERN SAN JUANS: at Wolf Creek Pass and Spring Creek Pass, in the eastern San Juan Mountains, even less clean snow was covering the older D8/7/6 dust layers (all merged at Spring Creek Pass) and the D10 layer was clearly evident in that new snow on the east side of Wolf Creek Pass and at Spring Creek Pass, substantially lowering the snowpack albedo over the terrain. We expect that snowmelt runoff will also surge in the Rio Grande and San Juan River basins, given the large proportion of south-facing terrain in those headwaters.

GUNNISON: in the Gunnison Valley, the astonishing intensity of the rust-red D8 layer at the lower margins of snowcover, now augmented with darker D9 and additional red D10 material, is apparent to any observer. Very dirty snow was apparent on the lower, south and west aspects of the West Elk, Elk, and Collegiate ranges last Wednesday and we assume that those merged dust layers have emerged over even more terrain, and to higher elevations, since then. Snowmelt will certainly surge and accelerate throughout that basin this week at lower and mid-elevations, and should initiate in alpine terrain as the cold content remaining in the snowpack is overcome by heating from surface melt-water infiltration.

EASTERN RANGES: farther east, the recent up-slope storm deeply buried the uppermost dust in the vicinities of Hoosier, Loveland, and Berthoud Passes and at Front Range sites where an old snowcover was present prior to the storm. That depth of burial may range, today, from 8-10" to over 36", by location, although many exposed alpine slopes may already have exposed dust layers due to wind stripping. (Once a dust layer emerges and begins melting in the alpine, and then refreezes, new snow often does not bond to that dirty surface). While we travelled through the I-70 corridor in the thick of the storm, with no visibility, and we departed before the post-storm clearing couldn't observe the terrain surrounding the Fraser valley, the amount of new snow in those watersheds will substantially delay the emergence of the uppermost dust layers there. It may require this entire week's energy inputs to overcome the cold content contained in that new snow (snow temperatures were as cold as -6 C at Berthoud Pass, during the storm) and settle the layer.

RABBIT EARS & NORTHERN GORE RANGES: on the other hand, new snow amounts at Willow Creek Pass from the recent storm were comparatively minimal and coverage of the uppermost dust was quite thin on the south side of the Pass, transparent enough that a faint red/brown tint was apparent in the snowpack surface. (Unfortunately, we had no visibility above the Pass elevation). That veneer of clean snow has likely already been largely ablated revealing the D8 layer, which is only a few inches above the D7 layer, itself only a few inches above D6. The largely south-facing Willow Creek drainage is likely to see an accelerating surge in snowmelt this week. This area has the interesting additional feature of a drastically altered forest cover with many standing dead trees shedding dried, red needles. While our research has not investigated the affects of those needles on snowcover albedo, it seems possible that those red needles will also contribute to the absorption, rather than reflection, of solar energy at the snowpack surface.

At Rabbit Ears Pass, new snow totals were also meager, and D8 may already be emerging on southerly aspects at that elevation. Since snowpack temperatures at that elevation were virtually isothermal, new snowmelt may result in quick runoff response. In the Yampa Valley, remnants of the snowcover observed near Steamboat Springs on the first road tour remained, and were very dirty. Further up in the Yampa watershed, near the town of Yampa, more extensive and very dirty snowcover was observed in the valley.

ELK AND WEST ELK RANGES: finally, although the Colorado River near Burns is still shallow and slow enough for deer to wade across, a narrow fringe of intense red dust was apparent at the surface on the lowest elevation snowcover of the southeast side of the Flat Tops, with clean snow higher above. In the Crystal River Valley, that narrow fringe of red snow extends as high as McClure Pass but quickly transitions to apparently clean snowcover above; Mount Sopris was substantially more snow-covered and white than was observed in March and the upper Crystal River was still comparatively clear. Nonetheless, the D10 layer was entrained in that apparently clean new snow and will enhance the rapid settlement and melt of that layer. This week's weather will likely result in the rapid emergence, upward in elevation, of the D8 layer, and merging at some elevations of D8, D7, and D6, already closely spaced. Figure 3 illustrates, at close range, the difference in snowcover albedo that will result, leading to a surge in snowmelt in those drainages.

Figure 3 – showing the contrast between D8 and remnants of recent new snow near McClure Pass.

We will continue to monitor the mid-range weather forecast as the week progresses, re-assessing the duration of this period of dry, sunny, and warm weather. And, if and when another dust-on-snow event appears imminent or is observed in progress, we will issue another Dust Alert.

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Swamp Angel Study Plot (Red Mountain Pass) – April 15, 2009

Spring Creek Pass – April 16, 2009

Park Cone – April 15, 2009

Wolf Creek Pass – April 16, 2009

Hoosier Pass – April 17, 2009

Berthoud Summit – April 17, 2009

Grizzly Peak (Loveland Pass) – April 17, 2009

Willow Creek Pass – April 18, 2009

Rabbit Ears Pass – April 18, 2009

McClure Pass – April 19, 2009

CODOS – Colorado Dust-on-Snow – WY 2009
Update #8, Tuesday, April 28, 2009

Following Update #7, issued on April 21st, much of the state experienced the first prolonged period of sunny weather in April. In locales such as the San Juan Mountains, Gunnison Basin, and lower elevation portions of the Yampa and Colorado River basins, where merged dust layers D9/D8 were only thinly covered in clean new snow on April 19, snowmelt was enhanced by reduced albedo. In other areas where the major spring storm of April 15-18 deeply buried the D9/D8 layer, snowmelt proceeded at slower rates, particularly at higher elevations. Then, as seen in the graph of Senator Beck Basin streamflow shown in Figure 1 below, that several-day surge in snowmelt was curtailed over the weekend of April 25-26, during cloudy and cooler weather.

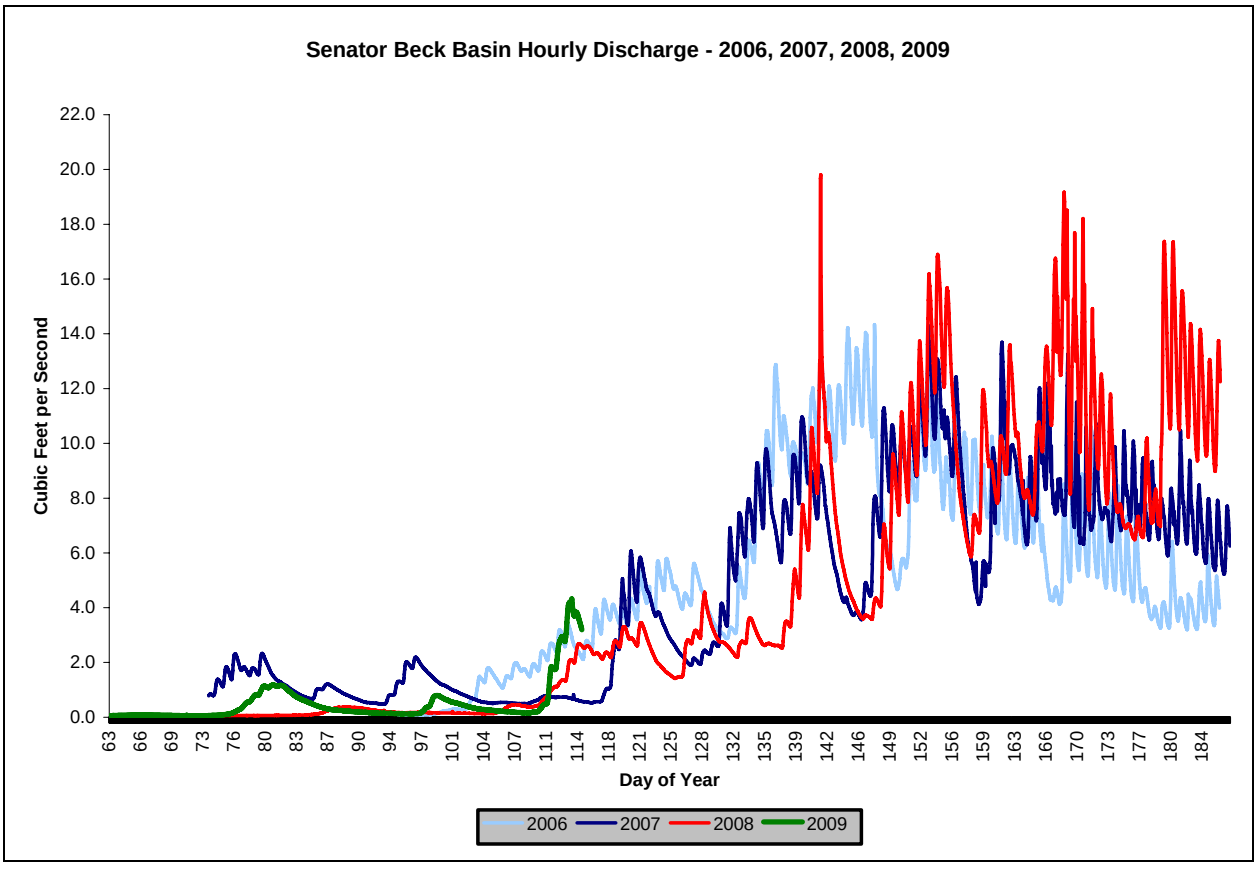

Figure 1 – Senator Beck Basin Streamflow during Spring 2009, to-date, Compared to 2006, 2007and 2008

Nonetheless, many locations did experience substantial losses of snowpack and SWE since Update #7. Table 1 below shows the loss of SWE over the period April 19-27 at our nine CODOS monitoring sites and at other sites of interest. The warmer, lower elevation sites, and San Juan sites where D8 was either already exposed on April 19, or rapidly re-emerged, show the largest losses.

Table 1 – Loss of SWE April 19-27, 2009 at CODOS and Other Sites

CODOS Monitoring Sites Adjoining SNOTEL Sites * No Snotel near Spring Creek Pass	**Elevation**	**SNOTEL Change SWE April 19-27**	**SNOTEL Change SWE April 19-27**
Red Mountain Pass	11,200'	-2.5"	-9%
Park Cone	9,600'	-3.8"	-30%
Spring Creek Pass *	10,800'	na	na
Wolf Creek Summit	11,000'	-1.5"	-4%
Hoosier Pass	11,600'	-1.0"	-6%
Grizzly Peak	11,100'	-1.2"	-6%
Berthoud Summit	11,300'	-1.4"	-6%
Willow Creek Pass	9,540'	-1.1"	-7%
Rabbit Ears (West Summit)	9,400'	-3.0"	-9%
McClure Pass	9,500'	-10.0"	-44%
Other SNOTEL Sites			
Upper San Juan	10,200'	-4.2"	-15%
Beartown	11,600'	-4.1"	-15%
Schofield Pass	10,700'	-3.5"	-7%
Lizard Head Pass	10,200'	-6.4"	-34%
Mesa Lakes	10,000'	-3.0"	-16%

By Monday morning, April 27th, almost all of our CODOS sites recorded 1-5 inches of new snow. However, some areas also experienced two additional dust events over the weekend, the first on Friday evening, April 24th (as described in an Alert issued that evening) and the second, more substantial event on Saturday evening, April 25th. A colleague in Boulder noted a fresh and substantial coating of dust on his car on Sunday morning but we've not been able to confirm the spatial extent of either of those events with other observers in the mountains. In any event, whether those events fell on generally dirty snow (as was the case here), or contaminated a generally clean snow surface, the subsequent new snow that fell on Sunday night temporarily raised snowpack albedo. Here in the San Juan Mountains, where we received 3-4" of new snow, that clean snow layer will be short-lived as solar energy penetrates through the new snow layer and is absorbed by the underlying dirty snow, melting it from below and re-exposing the merged D8/9/10/11/12 layer.

This program has accumulated several seasons of dust-on-snow observations at our Senator Beck Basin Study Area (SBBSA) at Red Mountain Pass, summarized in Table 2, below. We assume that our skill at detecting events has improved during that period so Table 2 represents the absence

Dust-on-Snow Events Documented per Month, by Winter
Senator Beck Basin Study Area at Red Mountain Pass – San Juan Mountains

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	**Total**
2002/2003					2		1			**3**
2003/2004							2	1		**3**
2004/2005	0	0	0	0	0	1	2	1	0	**4**
2005/2006	0	0	1	0	1	1	3	2	0	**8**
2006/2007	0	0	1	0	1	1	3	1	1	**8**
2007/2008	0	0	0	0	0	3	3	1	0	**7**
2008/2009	1	0	1	0	1	4	*5 so far*	*TBD*	*TBD*	*TBD*

Table 2 – Tally of Dust-on-Snow Events

of events in grey for the first two years of observation and thereafter indicates an absence of observed events as "0" (zero). Our tally for the winter of 2008/2009, as of this writing, stands at 12 dust-on-snow events, half-again as many as we've observed since beginning observations in 2002/2003. The explanation for this up-tick in dust events is beyond the scope of CODOS's monitoring efforts but, like you, were are certainly curious and giving it thought, as are others whose work focuses on the emission of dust from the Colorado Plateau. As and when we can report credible findings about this increase in the frequency of dust storms, we certainly will. In the meantime, Figure 2 below illustrates, qualitatively, what long-time residents of Silverton agree is an exceptionally dirty snowpack, exceeding anything they can recall. While that is anecdotal information, and no more, Silvertonians are, as a community, very astute observers of snow and weather, by necessity. Certainly, within our term as observers of dust-on-snow in the western San Juans, this is an unprecedented scene.

Figure 2 – D10/D9/D8 layer emerging near Chattanooga, south of Red Mountain Pass, April 24

As of this writing, the National Weather Service in Grand Junction anticipates a generally dry and warm SW'ly flow over western Colorado, starting Tuesday, with precipitation potential limited to the northern areas until Saturday. Models then show divergence on the timing of the next weather system. If that pattern verifies, snow albedo will quickly degrade during the week and dust-enhanced snowmelt will resume, perhaps at equivalent or higher rates than seen last week.

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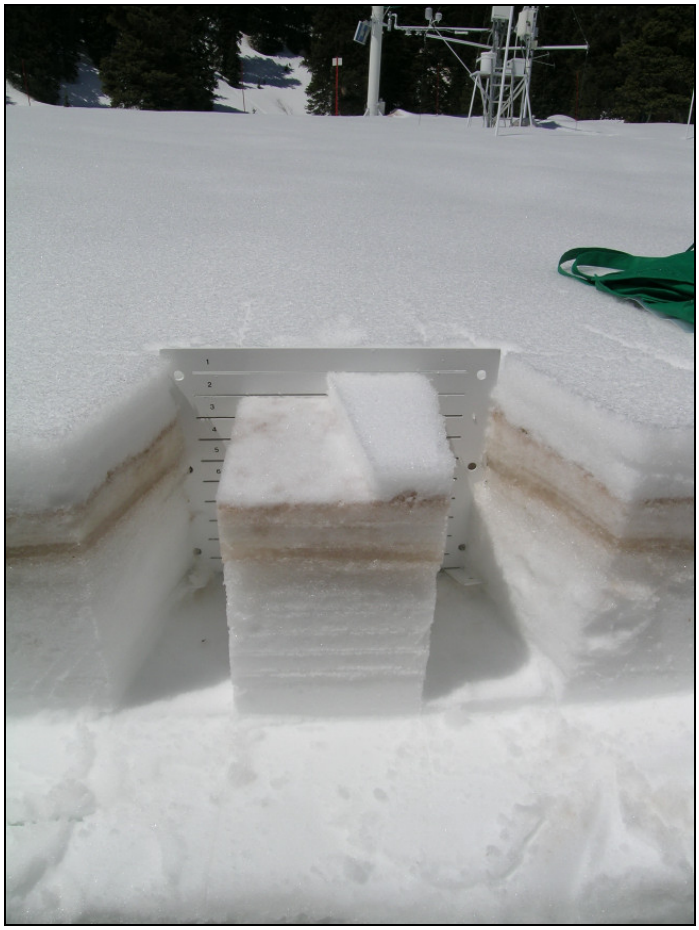
CODOS – Colorado Dust-on-Snow – WY 2009
Update #9, Thursday, May 7, 2009

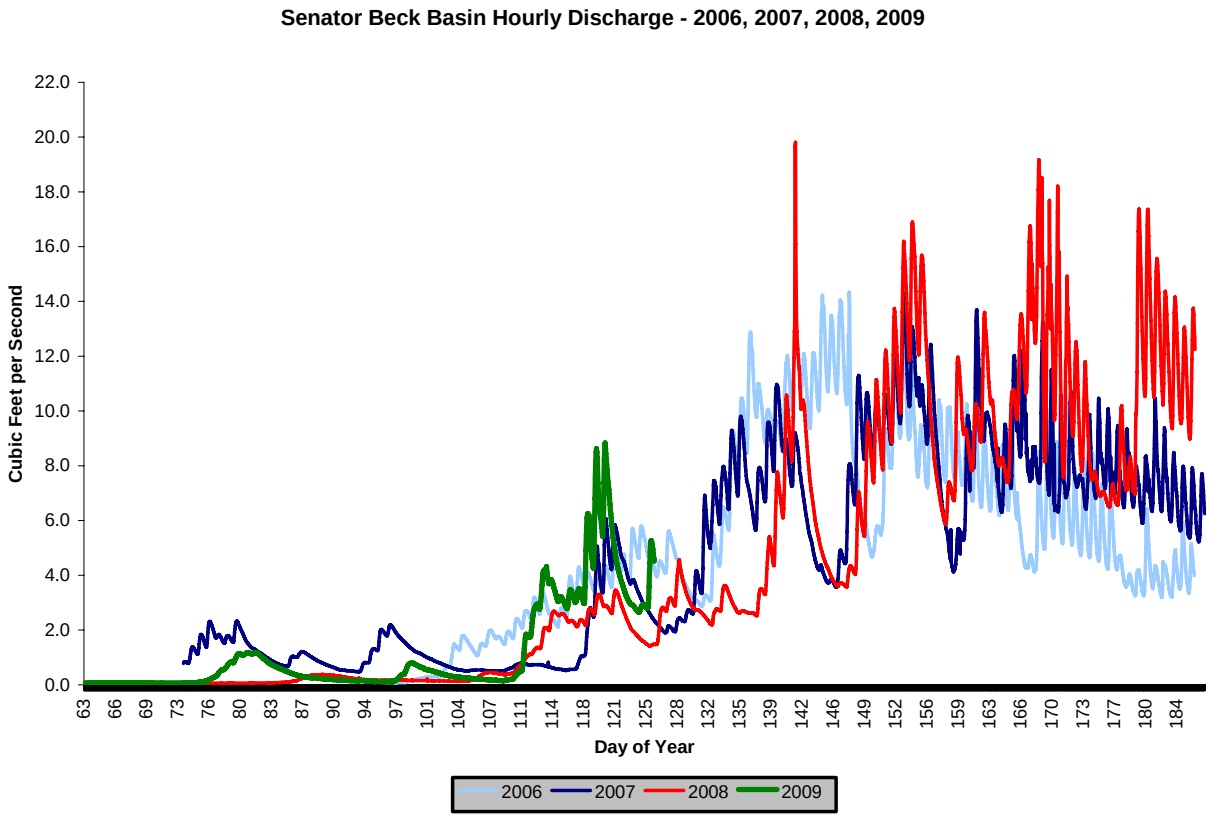


Dust Layers D12-0809 through D6-0809 merging at Swamp Angel Study Plot, Red Mountain Pass, May 6, 2009.

This snowmelt season continues to produce remarkable conditions – twelve dust-on-snow events (and counting), record-breaking snow-on-dust storms in the Front Range, and most recently several days of rain-on-dust here in the western San Juans (at least), with rain up to treeline elevations during the day. During that May 2-5 period we saw only one brief snow flurry here in Silverton, at 9,300'. Our snowpit and gravimetric sampling at the Swamp Angel Study Plot (11,050') on Wednesday, May 6th, found the snowpack thoroughly wetted by the rain water and all of our dust layers in the upper snowpack virtually merging underneath 4" of very wet new snow. No new dust layers have been deposited since D12-0809 on April 25th, but this intensely dirty, merged dust layer just beneath the surface at the Swamp Angel Study Plot will soon be exposed to direct sunlight, perhaps as early as Thursday afternoon. That rapid emergence is already underway on sunnier aspects around Red Mountain Pass, reaching all the way to ridgeline as of this writing, even on some N'ly slopes.

The same May 2-5 weather event produced widely varying amounts of rain and new snow elsewhere in the state as well. Our CSAS and CODOS field assistant, Andrew Temple, flew from Denver to Montrose at mid-day on Tuesday, May 5th, and observed the same abrupt transition from very dirty lower elevation snowcover to cleaner snow at higher elevations (with still-exposed patches of dirty snow on exposed ridges) in the Front, 10-Mile, and Collegiate ranges that was present here in the western San Juans, a reflection of the rain/snow line during the stormy weather.

Yesterday, Wednesday, May 6th was our first sunny day in the Senator Beck Basin Study Area since April 30th (day-of-year 120 on the chart below). Although the recent rainy and cloudy weather was comparatively mild, and cloud cover prevented overnight freezing, streamflows at our Senator Beck Stream Gauge steadily declined from May 1st until Tuesday, May 5th but then rose from almost 3 cfs at midnight Tuesday to 5.3 cfs by midnight on Wednesday.



Dry, westerly flow is now dominating Colorado weather and delivering much higher air temperatures and clear, sunny skies, and the National Weather Service expects this pattern to persist well into next week. Diurnal fluctuations in air temperatures are not providing freeze/thaw relief to the snowpack since, even under clear skies, the overnight low air temperatures above treeline at our Putney Study Plot (12,325') are now remaining well above 0° C. Radiant cooling of the snowpack surface under clear night skies can still produce superficial surface re-freezing, even when air temperatures are above freezing, but those thin, re-frozen crusts very rapidly thaw as soon as the sun rises, especially when they include dust. Remarkably, temperatures in the Arizona desert are expected to exceed 100° F for several days in a row this week and coming weekend.

Should this forecast for a prolonged period of dry, sunny, and very warm weather materialize as the National Weather Service currently anticipates, the albedo of the remaining Colorado mountain snowpack, as a whole, will drop to extremely low values as the very substantial D6, D7, and D8 (augmented by D9-12 in many areas) dust layers fully and rapidly emerge at progressively higher and higher elevations. Direct absorption of solar energy by that unprecedentedly dirty surface, reinforced by higher than average air temperatures, may result in a prolonged and early snowmelt surge comparable to that observed in the spring runoff of 2006 (light blue line in the graph), enhanced that year by the February 15, 2006 dust layer. As long as the current weather prevails, this snowmelt surge will be sustained and may continue accelerating for an extended period, or until a significant change in the weather brings new snow and a return to temporarily higher snow albedo values, and cooler temperatures.

In order to directly observe conditions in your watersheds, the CODOS team will begin our final 2009 tour of our dust-on-snow monitoring sites tomorrow, Friday, May 8th, traveling clockwise around the 1,000 mile circuit this trip. In addition to our usual observations of the dust layers on and within the snowpack, we will collect "full column" snow samples at each site, to estimate the total mass loading of dust deposited there this season, as well as make spectroscopic measurements of the snowpack surface and a snowpack profile at each site, to enable albedo analyses of remote sensing imagery of the Colorado snowpack.

We will provide another full update following that trip.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #10, Friday, May 15, 2009

Greetings from Silverton and the CODOS team following completion of our final tour of CODOS monitoring sites earlier this week. This Update comes during the prolonged, dust-enhanced surge in snowmelt anticipated in Update #9, producing very rapid losses of SWE at Snotel sites in the southwest and western central mountains. Due in part to recent fresh snowfalls of 1-6" that intermittently buried substantial, merged layers of dust, snowmelt in the far northern mountains and along the I-70 corridor is in earlier stages of SWE loss, but rates are also now accelerating in those areas. At all of our CODOS sites that retain snow, all dust layers in the upper snowpack have merged into effectively a thick single layer with very low albedo. The few inches of fresh snow observed on the snowpack surface at some sites earlier this week is thinning and melting away, revealing that merged dust layer. Figures 1 and 2 below illustrate the difference between snow surface conditions at sites north and south of the I-70 corridor.

Figure 1 – snowpit at Berthoud Summit Snotel site May 10, 2009, with merged dust layers 3" beneath a (then) clean snow surface.

Figure 2 – snowpit at Wolf Creek Pass on May 11, showing merged dust layers at snowpack surface and December 13, 2008 layer near base of snowpack.

Figures 3 and 4 illustrate the extraordinary degree to which dust-on-snow has reduced snowpack albedo in the far western San Juan Mountains (you may wish to view these at 200%). During our recent tour of CODOS sites we observed comparably low albedo snow cover in the Elk Mountains up to treeline mixed with somewhat cleaner snow at the highest elevations. A side trip into the Yampa River headwater drainage on May 9th displayed a similar pattern. Unfortunately, a dusting of new snow that night, May 9th, obscured the underlying merged dust layer in the Rabbit Ears Pass, North Park, and Front Range areas, but our snowpits found very dirty and very wet snow

Figure 3 – view of the Telluride valley looking west from Peak 13,510', the high point of the Senator Beck Basin Study Area at Red Mountain Pass, showing the D6-0809 through D12-0809 dust layers merged at the snowpack surface.

Figure 4 – Swamp Angel Study Plot, May 13, 2009, with Pit #24 in progress, showing the extreme contrast between the merged dust layers at the surface and the underlying snow removed from the pit. This site lost 28" of snow in the prior 7 days.

just underneath that 1-3" of new snow at the Rabbit Ears, Berthoud Summit, and Grizzly Peak sites (our Willow Creek Pass was dry). That thin layer of clean new snow also blanketed the 10 Mile Range but then ended, very abruptly, south of Hoosier Pass (where our monitoring site was also reduced to thin patches of snow among willows). Southward, dust was fully emerged on what little snow remains in the Collegiate Range and the Rio Grande watershed.

Streamflow data reflect the enhanced snowmelt produced by reduced albedo, supplemented by warming air temperatures. Figure 5 shows current streamflow data from the Senator Beck Basin Stream Gauge. Many streams and rivers in southwest Colorado are exceeding their prior record flows, for a given day, by large margins.

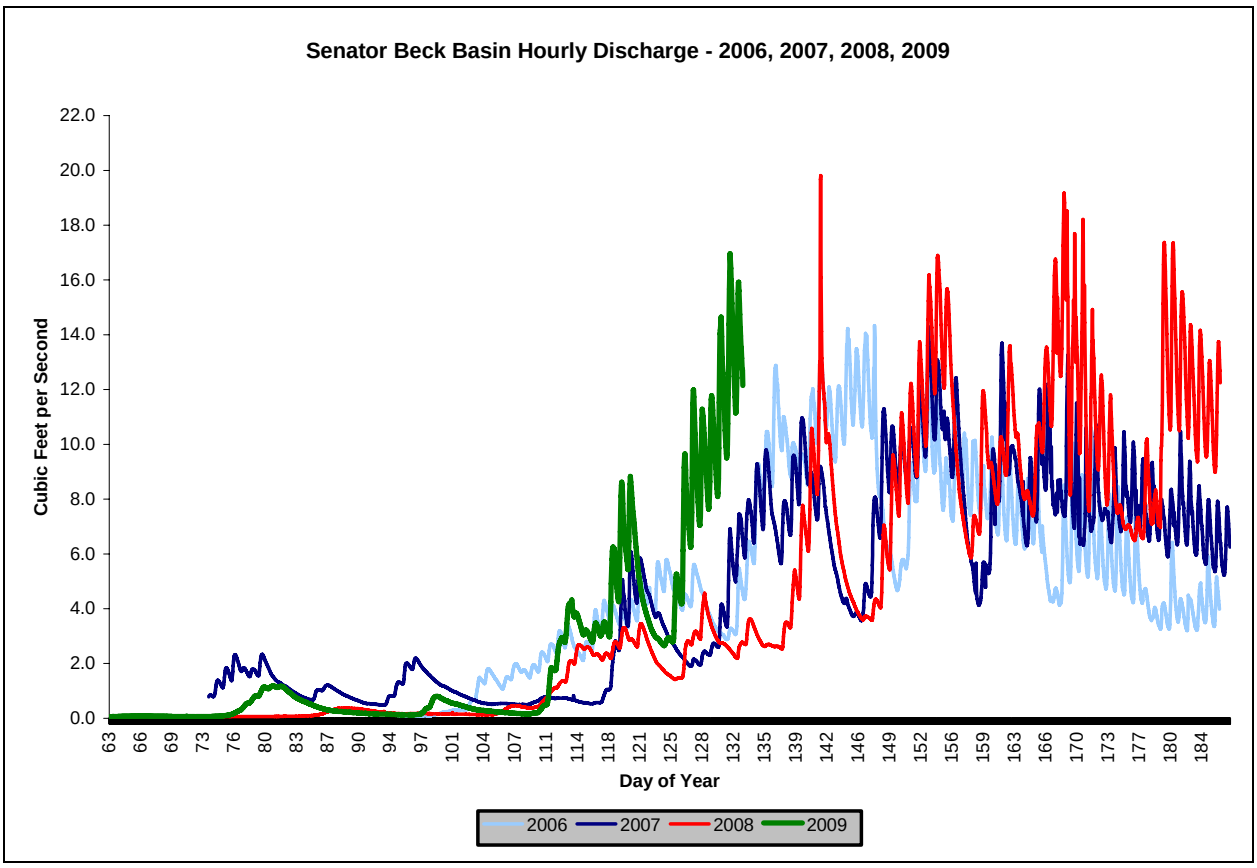

Figure 5 – Senator Beck Basin Study Area Discharge 2006, 2007, 2008, and 2009 to-date

As a consequence of this reduced albedo and largely sunny weather, many of our CODOS monitoring sites – Park Cone, McClure Pass, Willow Creek Pass, Hoosier Pass, and Spring Creek Pass – have lost their snowcover in the open meadows adjoining their nearby Snotel sites even though many of those Snotel sites still show SWE on the ground (there is no Snotel near the Spring Creek Pass site). The extremely high rates of loss at many of those sites are apparent in their adjoining Snotel site data, as you've undoubtedly noted. Because of its location in the extreme southwestern corner of the state, the Lizard Head Pass Snotel data may show most clearly the impact of desert dust on snowmelt rates, driven by reduced snow albedo. Figure 6 shows above-average peak SWE accumulations at Lizard Head Pass followed by very steep ablation curves.

Because of its remoteness, we do not visit the Beartown Snotel site in the headwater of the Rio Grande River (at 11,600', 550 feet higher than the Swamp Angel Study Plot). However, because of its proximity to our Senator Beck Basin Study Area, it is highly likely that albedo conditions there are comparable to those seen in these two photographs. Figure 7 shows WY 2008 and WY 2009 SWE data from Beartown, and 2009 at one of the earliest dates of snow-all-gone on record there.

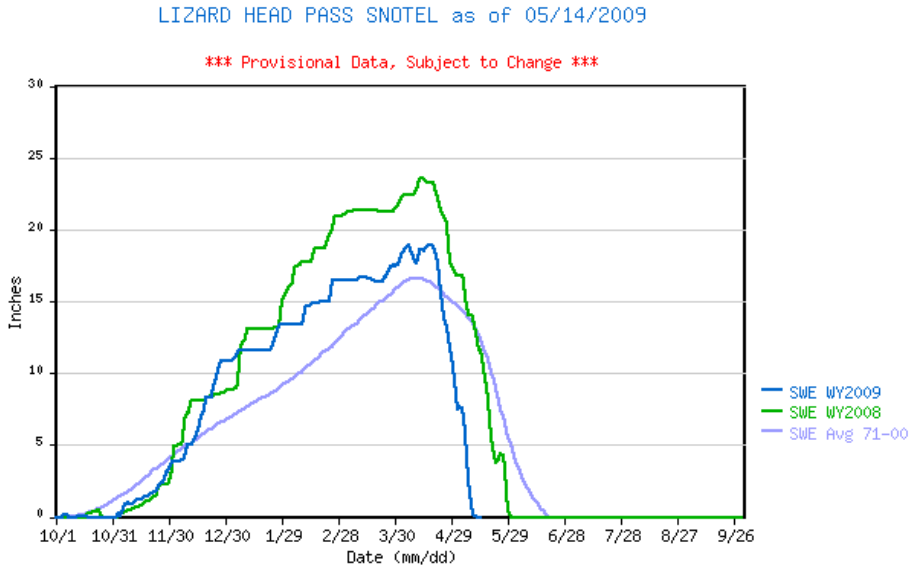

Figure 6 – SWE data from USDA-NRCS Lizard Head Pass Snotel, WY 2008 and 2009.

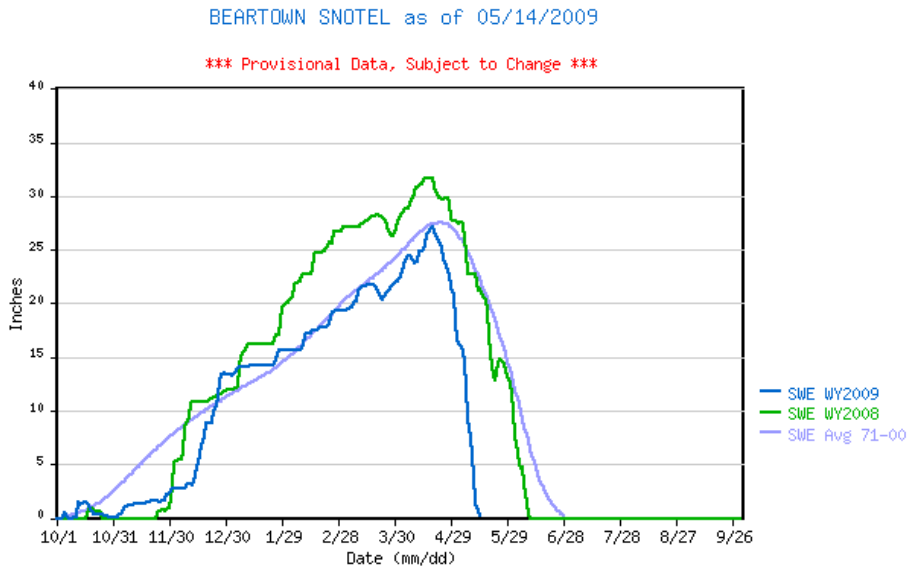

Figure 7 - SWE data from USDA-NRCS Beartown Snotel, WY 2008 and 2009.

As of this writing, the National Weather Service in Grand Junction anticipates only very minor shower activity over the coming weekend, followed by ongoing dry and warm weather into mid-week, with increasing chances of showers in the southern mountains. Temperatures will climb over the weekend reaching into the 90's in some western valleys next week, and convective cloud cover may develop as a result of daytime heating during this period. Even with partial, afternoon cloud cover, we anticipate additional reductions in snow albedo, particularly in the northern mountains and front ranges. It's beyond our expertise and scope to forecast the timing of peak flows, or to evaluate when particular watersheds have reached or passed their center of mass, in discharge, and we'll leave those analyses to you. Nonetheless, we do anticipate that the presently exposed, or soon to be exposed, dust layer(s) in your watersheds will sustain and maximize their snowmelt affects for as long as snowcover is present or until those layers are substantially buried underneath clean new snow, temporarily restoring higher albedo. Ranges north of or along the I-70 corridor that retain a large portion of their SWE, at this date, will be the most susceptible to the affects of low albedo and accelerating snowmelt rates.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #11, Friday, May 22, 2009

While Colorado snowmelt has proceeded much as we anticipated under the dry and sunny weather experienced over the past week, a brief Update on the hydrograph of our Senator Beck Basin Study Area may be of interest. Since CODOS Update #10, May 15th, weather conditions here in the San Juan Mountains have maximized dust-on-snow affects on snowmelt, with nearly full potential solar loading onto very low snowpack albedo, rapidly ablating the snowpack in tandem with seasonably warm air temperatures. Merged dust layers, particularly the March 22nd, 29th, and April 3rd layers, have been fully exposed at all elevations to the generally high levels of incoming solar radiation. As of Thursday, May 21st, our alpine (12,200') and sub-alpine (11,050') study sites in the Senator Beck Basin Study Area at Red Mountain Pass contained bare ground. We understand, from other observers, that widespread reduced albedo has been the general case in ranges south of I-70. Based on how thinly the dirty snow was buried during our recent tour of CODOS monitoring sites, we assume that dirty snow has also emerged over large areas and at increasingly high elevations north of I-70 during the past week, enhancing the rapid snowmelt seen in Snotel data in those locales.

Figure 1 below presents this year's Senator Beck Basin snowmelt discharge data and may exemplify the early, intense, and compressed shape of WY 2009 spring hydrographs throughout this region of the state – you will be the best judge of that. While a substantial fraction of the Basin's accumulated SWE remains, those portions of the basin most susceptible to enhanced absorption of solar energy and warm air have largely melted out. Cloudy, cooler and showery weather now under-

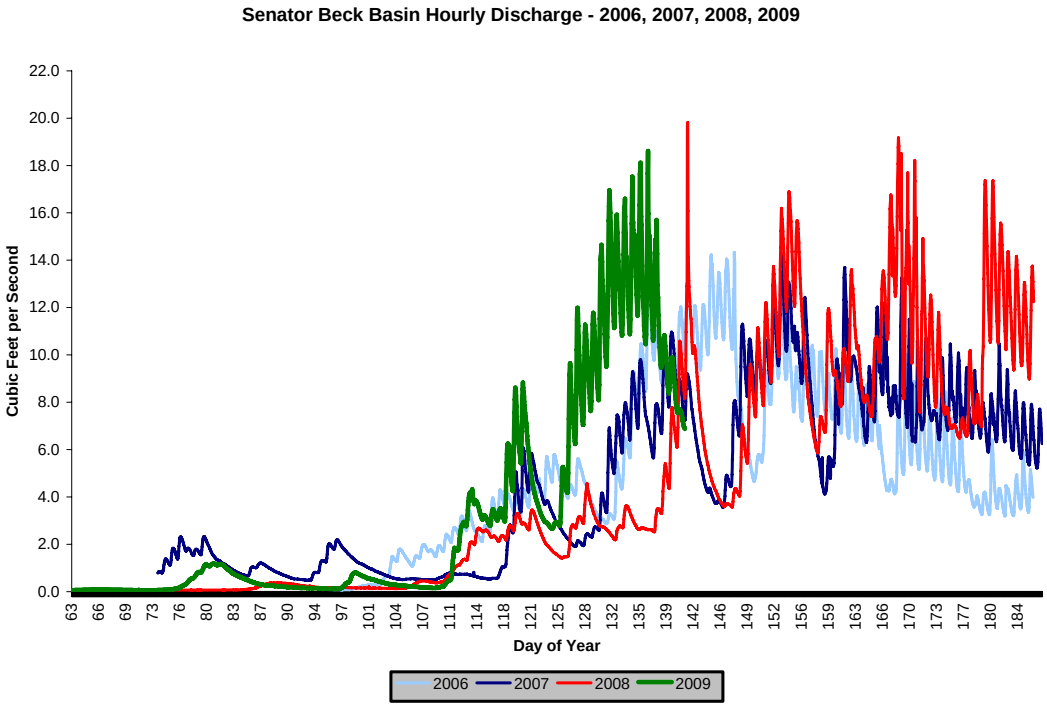

Figure 1 – Senator Beck Basin spring runoff for the past several years, with 2009 shown in green.

way, and expected to run through the weekend (perhaps including a few inches of new snow) and into early next week, will further reduce the already declining rate of runoff in Senator Beck Basin. A return later next week to warm and dry weather, should that actually transpire, would produce a second surge of runoff but at rates less than the peak flows seen in the graph above. After the smaller initial surge, and depending on the duration of warm and dry weather, rates could follow the pattern seen in prior years, gradually tapering off as the remaining, more stubborn snow covered portions of the Basin melt out.

Snowpack ablation is not as advanced in the mountains generally north of or on the I-70 corridor, so the upper reaches of those watersheds may see a quick resumption of dust-enhanced snowmelt at the higher elevations when this period of unsettled weather ends, particularly as any new snow melts and the merged and substantial dust layers that have been recently exposed at the snowpack surface re-emerge. Rain-on-snow in coming days could sustain runoff at lower elevations still possessing snowcover. This weekend's stormier weather is not currently expected to generate any significant large-scale wind events capable of producing another regional dust-on-snow event.

That concludes this brief Update.

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CODOS – Colorado Dust-on-Snow – WY 2009
Update #12, Friday, June 5, 2009

Cooler, showery, and cloudy weather has persisted here in the San Juan Mountains since the dry and sunny period of May 5-17, 2009. Unlike the late spring of 2008, when substantial snowfalls occurred at the Senator Beck Basin Study Area (and even in Silverton) in late May and early June, with dry periods between, this spring we have received 1-10 mm of rain virtually every day since May 19th. Some small amounts of new snow have fallen at the higher elevations, restoring high albedo to the dirty snowpack at times. Those depositions of new, clean snow are often thin and ephemeral, melting quickly and revealing the underlying dust within the following 24 hours, only to be replaced by additional, but spatially quite variable, new snow and hail in subsequent days. As a result, even with dust often widely exposed at the surface of our remaining, high elevation snowpack (as seen in Figure 1), generally cloudy afternoon skies and cooler temperatures have reduced rates of snowmelt in our Senator Beck Basin Study Area for the past two weeks. Discharge from Senator Beck Basin has dropped to sustained 24-hour mean flows of 5-6 cfs, down considerably from the nine days of 24-hour mean flows at 10-15 cfs experienced in mid-May (Figure 2). Daily showers (as mixed rain/snow/hail at higher elevations) were widespread in the Colorado mountains over the latter half of May and into early June.

Figure 1 – Senator Beck Basin Study Area at Red Mountain Pass, viewed from the east on May 29, 2009, showing recent new snow at the higher elevations.

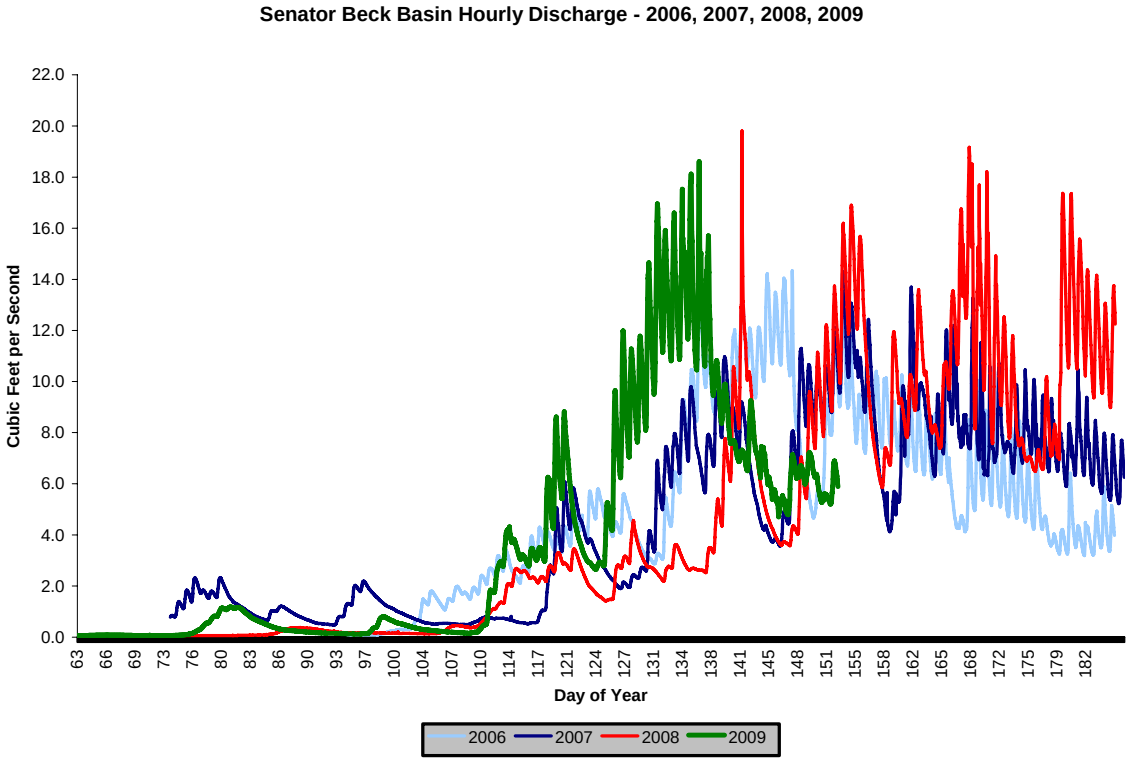

Figure 2 – Senator Beck Basin spring runoff for the past several years, with 2009 shown in green.

SWE depletion at SNOTEL sites, including those adjoining our CODOS monitoring sites around the state, has continued to show a north/south difference throughout this snowmelt season. Hoosier Pass, Beartown, and our own Red Mountain Pass adjoining our Senator Beck Basin Study Area – reached near-normal peak SWE accumulations but experienced advanced snowmelt timing and lost their snowpack (to "snow all gone", or SAG) substantially earlier than the median date for period of record at those sites. Other SNOTEL sites south of I-70, in the Elk Mountains – McClure Pass and Schofield Pass – recorded well-above-normal peak SWE accumulations and yet still saw SAG at dates significantly earlier than the median date of SAG for the site. Park Cone SNOTEL also received substantially more than normal peak SWE yet SAG there occurred slightly after the median date for the site. Graphic representations of SWE loss during the dry, sunny and warm weather between May 5th and May 19th show accelerated rates of SWE loss, from the date of their peak to the date of SAG, at all those sites. Among those sites, only Hoosier Pass showed a substantial slowing of snowmelt rates during the cloudy, showery weather following the dry and sunny period; the other sites had either already achieved SAG or were minimally affected by that cooler, wetter weather. As this season's previously reported dust layers emerged and merged at the snowpack surface, dramatically reducing albedo on range-wide scales, the combination of direct absorption of radiation during that prolonged period of sunny weather and warmer than average air temperatures resulted in the accelerated rates of snowmelt seen in the SNOTEL data at those locales, and that water managers observed in streamflow data in those watersheds.

At SNOTEL sites adjoining our CODOS monitoring sites along and north of I-70 – Grizzly Peak, Berthoud Summit, Willow Creek Pass, and Rabbit Ears Pass – the season peak SWE values in late April were either at or above normal values for the period of record. The Willow Creek site reached SAG ahead of the median date for the site, whereas Grizzly Peak is on track to reach SAG, very soon, on/about the median date for that site; Berthoud Summit still has a few inches of its above-average peak SWE remaining but also seems on track to reach SAG just prior to or on the median date. Rabbit Ears reached SAG just recently, one week ahead of the median date. Again, as previously reported, substantial dust-on-snow layers were observed at all of those sites during our field tours. The major winter storm in the Front and northern ranges in mid-April delayed the emergence of dust in those locales, compared to the earlier emergence of dust in the mountains south of the I-70 corridor, but those dust layers did eventually emerge and merge at the snowpack surface during the dry, sunny, and warmer-than-average weather in mid-May and influenced snowmelt rates in the same way that the southern portions of the state had been experiencing.

Some of our CODOS Update readers have mentioned to us their sense that runoff peak flows occurred earlier than is the norm for their basins, even much earlier. While we only have four years of record, our own Senator Beck Basin hydrograph certainly exhibits a substantial advance in the timing of the spring maximum flow rate and may also show a substantial advance in the center of the snowmelt discharge mass – that will become more evident later this summer, as snowmelt slowly tapers off. Given our own record, and the flows observed in other watersheds in the San Juan Mountains, it does appear that the advance in timing of snowmelt this season exceeds the 2006 advance in snowmelt that we often referenced in Updates this season, while discussing the potential affects of this year's twelve observed dust-on-snow events. We will defer to your own expert analyses of hydrographs in your watersheds, and we welcome your interpretations and thoughts regarding interesting patterns or behaviors that you observe in your data and how this spring may compare to 2006.

For the duration of this snowmelt season, the existing dust-caused reduction of snowpack albedo will continue to affect the melting rate of the remaining snowpack, in direct proportion to the amount of direct sunshine received at the dirty snow surface on a given day. As always, warmer-than-average air temperatures would also accelerate snowmelt rates and exacerbate the affects of reduced albedo. Episodic, local snow showers may, of course, restore high albedo in your locales and moderate those dust-enhanced melt rates and prolong runoff. At this time, no major, state-wide snowfalls are foreseen by the National Weather Service through this weekend or into next week, but afternoon showers and thunderstorm activity is expected and may result in localized squalls of fresh snow and hail.

With that, this concludes our final Update for the 2008/2009 season. It is our hope that this series of twelve Colorado Dust-on-Snow Updates, starting with Update #1 on February 15th, has proven beneficial to your agency during this snowmelt season and that they will also inform your future review of the spring 2009 runoff behavior in your watershed(s). We will be in contact over the summer regarding how CODOS can serve you in the future but we'd also be glad to hear from you in the meantime. Once again, we thank you for your support of CODOS in 2008/2009.

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