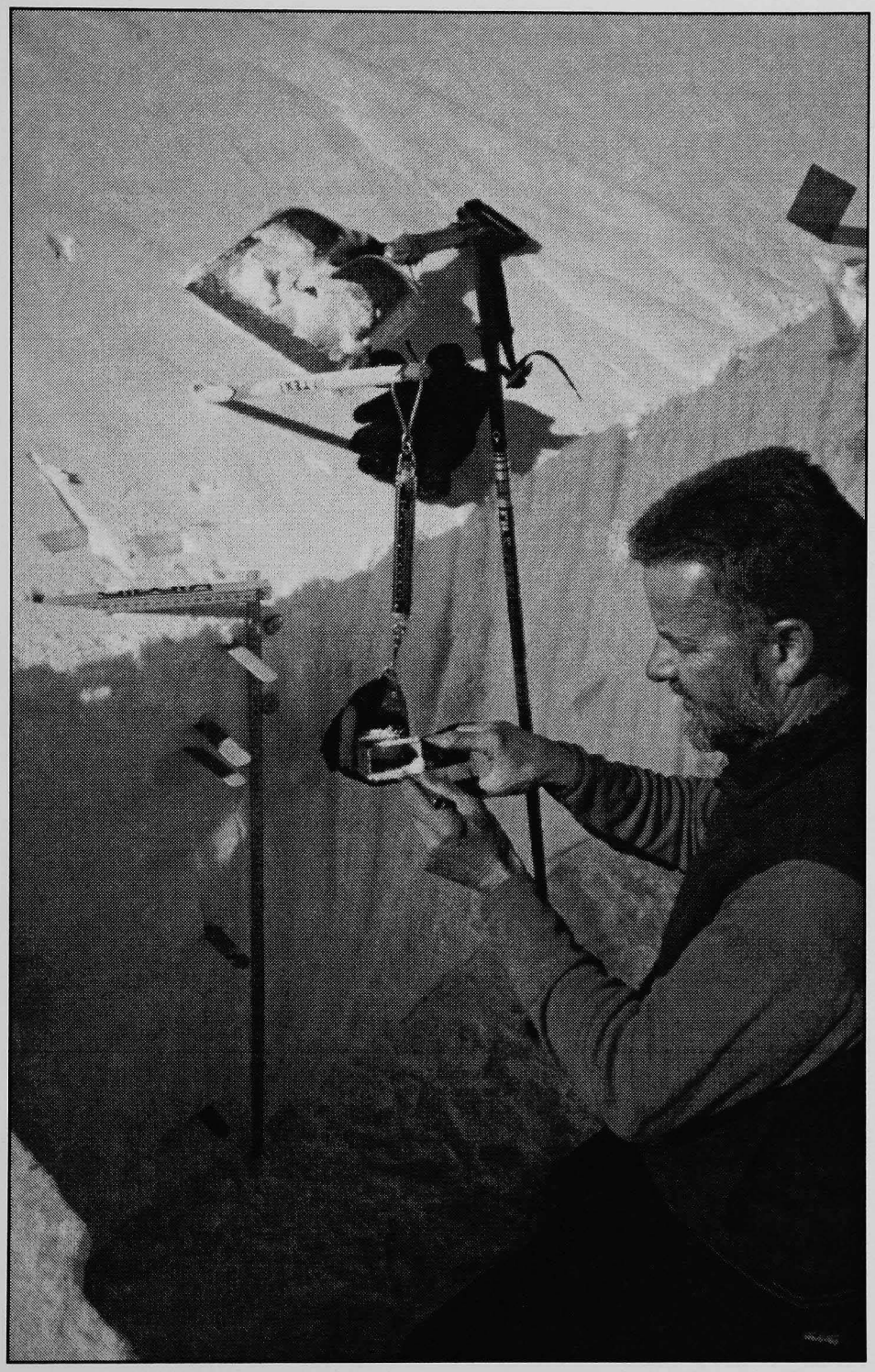
# Snow and Avalanche

## Colorado Avalanche Information Center



INFORMATION SERIES 61

# Annual Report 2000-01

Colorado Geological Survey
Division of Minerals and Geology
Department of Natural Resources
Denver, Colorado
July 2001

**Cover photo:** Silverton forecaster Jerry Roberts analyzes weak layers in a snowpit (photo from Jerry Roberts collection).

INFORMATION SERIES 61

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# Annual Report 2000-01

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# Foreword

CGS Information Series 61 is the Annual Report of the Colorado Avalanche Information Center for the winter of 2000–2001. It describes the operations of the CAIC and the important events of the winter season.

Partial funding for this report came from the Colorado Severance Tax Operations Fund. Severance taxes are derived from the production of gas, oil, coal, and minerals.

Knox Williams
Director of the Colorado Avalanche Information Center

Vicki Cowart
State Geologist and Director

# STATE OF COLORADO

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DEPARTMENT OF NATURAL RESOURCES

Bill Owens
Governor

Greg E. Walcher
Executive Director

August 16, 2001

Dear Friend,

As the State of Colorado continues to grow and winter travel through our beautiful high country continues to increase, the role and mission of the Colorado Avalanche Information Center (CAIC) has never been more important.

The CAIC is funded through a cooperative effort by federal, state, and local governmental entities, as well as by private industry and individual contributors. As a result of these funds – especially state Severance Tax funds – the CAIC has been able to utilize new technologies that are helping to make Colorado's high country safer than ever. Along with these new technologies, the hard-working men and women of the CAIC have made a concerted effort to educate Coloradans about avalanche safety through publications, media outlets, and community seminars.

Our improvements in avalanche education and the addition of new technologies have translated into one thing: Colorado's avalanche mortality rate has steadily declined over the past two decades.

With the help of the CAIC, I encourage everyone to be conscientious about traveling through Colorado's beautiful, but often dangerous, high country. After all, maintaining safety in avalanche country is up to all of us.

Sincerely,

Greg E. Walcher,
Executive Director

# Director's Report

To Our Sponsors and Patrons:

The Colorado Avalanche Information Center has just completed its 18th year as a program of the State of Colorado. I have been around for all of them, and I like what I see. Our mission is safety, our methods are education and forecasting, and our efforts are working.

To see how, lets look at two sets of numbers. First, in the decade from 1981–1991 there were 129 avalanche deaths in the U.S., 55 of which occurred in Colorado. That means 42% of the deaths were in Colorado. Next, in the decade from 1991–2001 there were 259 deaths in the U.S. (double the previous decade), 63 of which were in Colorado, meaning that only 24% were in Colorado. (The winter of 2000–2001 showed an even better ratio, with but 4 of 33 avalanche deaths occurring in Colorado.)

This is a great improvement in the Colorado avalanche statistics, and we think it is no fluke. Rather, we think our efforts in education and forecasting are paying off. These services include:

- Getting the word out every day via hotlines and emails to Friends of the CAIC
- Broadcasting avalanche information over mountain radio stations
- Working with the media for full coverage of avalanche news
- Training more than 3,000 citizens in avalanche safety every winter
- Forecasting for Colorado's highways to stay a step ahead of the danger

It's a program that's appreciated and effective, so we'll keep doing it.

A second topic I want to address is our use of Severance Tax funds. This was our second year of using this fund to develop our program. Our level of service and our ability to get beyond the bare bones of forecasting and education have taken a giant step forward because we have conducted more training courses, gathered better backcountry data, built a weather and avalanche database, upgraded our Web site, created a GIS highway avalanche map, and developed a computer avalanche-forecast model. See the section of this report entitled Severance Tax Projects for full details.

The CAIC has completed another interesting and successful year. Looking forward, we will continue to provide the services asked for by the public and our clients. As always I want to thank all our sponsors who make our mission of avalanche safety possible. And I want to thank my staff of forecasters for the professionalism they bring to the job everyday. Nick Logan, Dale Atkins, Scott Toepfer, Mark Mueller, Lee Metzger, Stu Schaefer, Rob Hunker, Andy Gleason, Jerry Roberts, Halsted Morris, and Denny Hogan—thank you all. It's a pleasure to work with you.

Knox Williams
Director

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# Executive Summary

***Mission***: The Colorado Avalanche Information Center promotes safety by reducing the impact of avalanches on recreation, industry, and transportation in the State through a program of forecasting and education.

***Administration***: The Center is a program of the Colorado Geological Survey of the Department of Natural Resources.

***Funding***: The Center is funded by Severance Tax and cash-funded by grants and donations. In FY 01, total revenues were $520,001.

***Housing***: The main office of the Avalanche Center is at the National Weather Service Forecast Office in Boulder. Offices for CDOT operations are located in Silverton, Pagosa Springs, Carbondale, and the Eisenhower Tunnel.

***Staff***: Total staff was 12. Four forecasters shared the duties of a 7-day work week during the winter season at the main office in Boulder. Two forecasters were at the Silverton office, two at the Eisenhower Tunnel, one at Pagosa Springs, and one at Carbondale; they provided specific training and forecasting for CDOT. Two staff members taught classes as part of the outreach program.

***Avalanche events of 2000–01***: Winter had trouble establishing a pattern and sticking to it. The result was seasonal snowfall that was overall below normal, though a few sites managed to end the year above normal. The mountain snowpack was typically shallow, sugary, and very weak most of the winter. This meant it was very easy to trigger avalanches, and thus there was a record number of people caught by avalanches. But avalanche size was typically small, so that most victims escaped unharmed. A total of 2,867 avalanches was reported to the Center (33% above the average of 2,160). There were few large storms, few extensive avalanche cycles, and no large destructive avalanches. Avalanche Warnings were posted on 14 days (less than half of normal). There were 4 avalanche deaths (2 below normal), despite a record number of people caught by avalanches (113). Property damage was nil.

***Dissemination of forecasts via hotlines, Internet, e-mail, and radio broadcasts***: The public made 54,586 calls to the CAIC hotlines this winter. In addition, we sent 149,000 forecasts via e-mail to Friends of the CAIC, and there were 189,887 hits on our Web site forecast page. That is a total of about 393,000 send outs of our forecast messages. Finally, about 11 mountain radio stations broadcast our hotline messages daily.

***Media contacts***: As Colorado's spokes-agency for avalanche matters, we received or initiated 166 contacts with broadcast and print media.

***Public education and outreach***: We presented 98 avalanche seminars to 4,042 people. Additionally, we produce an informational newsletter, *The Beacon,* three times a year for Friends of the CAIC.

# Funding and Budget

For FY 2000–2001, funding came from severance tax and from donations, grants, and contracts as listed below. Additionally, in-kind support is listed.

| | |
|---|---|
| ***State*** | ***$388,340*** |
| CDOT contract for services | 248,000 |
| CDOT grant | 22,000 |
| Parks, Snowmobile Fund | 2,000 |
| Severance Tax Fund | 116,340 |
| ***Federal*** | ***$24,000*** |
| U.S. Forest Service | 24,000 |
| ***Local Government*** | ***$8,054*** |
| Summit County | 3,000 |
| Town of Breckenridge | 2,400 |
| Town of Frisco | 1,000 |
| Eagle County | 1,000 |
| Summit Co. District Court | 654 |
| ***Ski Resorts*** | ***$32,950*** |
| Colorado Ski Country USA | 20,000 |
| Vail Associates | 2,000 |
| Breckenridge | 2,000 |
| Aspen Skiing Company | 2,000 |
| Winter Park | 1,500 |
| Steamboat | 1,500 |
| Arapahoe Basin | 1,000 |
| Copper Mountain | 1,000 |
| Keystone | 1,000 |
| Keystone Pro Patrol | 500 |
| Monarch | 300 |
| Breckenridge Pro Patrol | 150 |
| ***Friends of the CAIC*** | ***$29,092*** |
| ***Avalanche Seminars*** | ***$13,705*** |
| Colorado Mountain Club | 2,250 |
| Summit County Rescue | 1,000 |
| Summit Huts | 875 |
| Vail Associates | 750 |
| Silverton Avalanche School | 743 |
| Colorado Snowmobile Assoc. | 710 |
| Mountain Rescue—Aspen | 700 |
| Fort Collins Mountain Shop | 650 |
| Steamboat Ski Haus | 641 |
| Colorado School of Mines | 600 |
| Telluride Avalanche School | 600 |
| Summit County Pro Course | 600 |
| Custer County | 577 |
| Pikes Peak Alpine School | 558 |
| Blue Sky West | 489 |
| Bent Gate | 330 |
| Skiing Magazine | 330 |
| Wilderness Medical Society | 300 |
| Loveland Ski Areas | 182 |
| Buena Vista Snowmobile Club | 150 |
| Front Range ENA | 125 |
| Breckenridge Pro Patrol | 100 |
| Colorado College | 100 |
| Grolier Inc. | 100 |
| Amer. Adventures Expeditions | 65 |
| Arapahoe Basin Pro Patrol | 60 |
| Boy Scout Troop | 60 |
| Colorado Wilderness Sports | 60 |
| ***Ski-related Businesses*** | ***$6,002*** |
| Backcountry Access | 1,500 |
| REI | 1,000 |
| Mountain Chalet | 900 |
| Rescue Technology | 500 |
| Tenth Mountain Hut Association | 500 |
| EKW Fund | 500 |
| Fort Lewis Outdoor Pursuits | 400 |
| People Productions | 369 |
| Alpine Rescue | 300 |
| Alpineer, Crested Butte | 33 |
| ***Other Donors*** | ***$17,858*** |
| Rich & Liz Salem | 5,610 |
| Koessler Foundation | 5,000 |
| Hearthstone Restaurant, Breck. | 3,112 |
| Jon Krakauer | 1,000 |
| Samuel S. Johnson Foundation | 1,000 |
| Ericsson Wireless | 950 |
| Bikes Aren't Bad | 500 |
| Sale of accident slide sets | 280 |
| Buen Tiempo, Ouray | 245 |
| Digital Ranch | 100 |
| Book sales | 46 |
| Donald & Dorothy Bachman | 15 |
| ***Total Funding*** | ***$520,001*** |
| ***Estimated In-kind Support*** | **$120,000** |
| Colorado Geological Survey | 30,000 |
| National Weather Service | 30,000 |
| Field observations | 30,000 |
| CDOT | 20,000 |
| Hotline sponsors | 10,000 |
| ***Grand Total*** | ***$640,001*** |

## Friends of the CAIC

The number of *Friends* totaled 651 for 2000–01. We thank each and every one for the grassroots support necessary to sustain the CAIC. We offer two levels of service, at base rates of $30 or $45. Many of our friends generously gave an extra donation amount. Below is a list of special friends that donated $100 or more.

Brent Adams
Pat Ahern
Aspen Alpine Guides
David & Juli Booton
Aaron Bork
Walter & Mary Jane Briney
Kingsley Brown
Chris Bunting
Cathy & Dick Carleton
John Champoux
David & April Christenson
Mark Collins
Dan Connell
Diana & Roy Conovitz
Doc & Ann Cornwell
Jackson Dennis
Gwen Dickinson
John Dobashi
Norman "Doug" Douglass
Philippe Dunoyer
Sherry & Tim Gaines
Jerry Greene
Michael Halpert
Tom Hays
Christoph Henkel
Dixon Hutchinson
John Scot Jackson
Mike Jamison
George Janson
Ann Jeffrey
Richard Johnson
Kevin McCall
Elizabeth Morris
Kurt Morscher
Tom Myers
Adam Newman
Dr. John Prentice
Joe Puchek
Joe Ramey
Rescue Technology
Peter Rex
Mark Rohrer
Laura & Steve Rossetter
Tim & Kathryn Ryan
Richard Salem
San Juan Ski Company
Randall Streufert
Cheryl Teuton

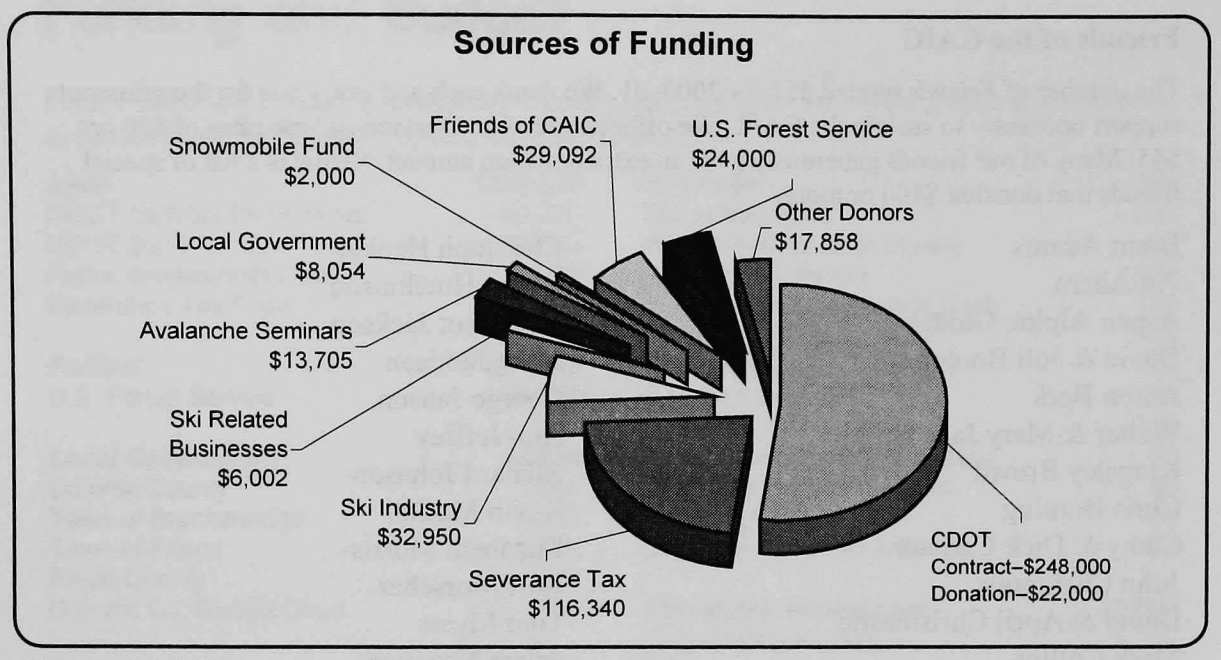


**Figure 1. CAIC sources of funding.**

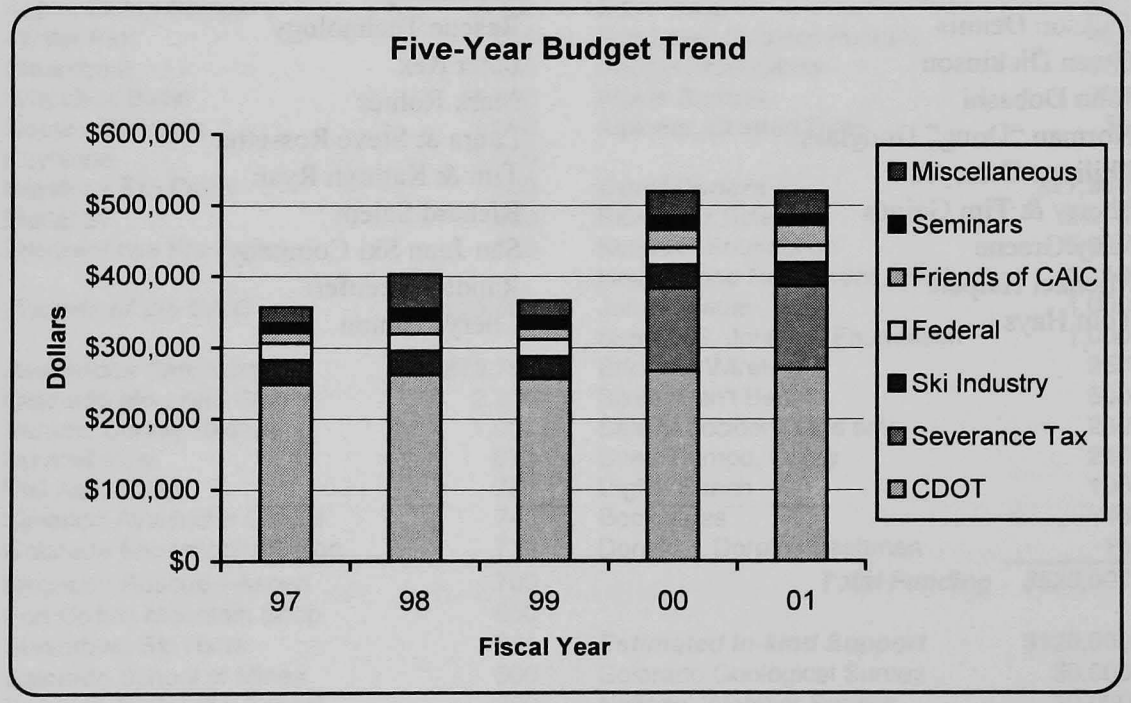


**Figure 2. CAIC five-year budget trend.**

# Operations

***Administration:*** The CAIC is a program of the Geological Survey under the directorship of State Geologist Vicki Cowart. The Center is cash-funded by grants and donations and from the Severance Tax Operational Fund.

***Housing:*** The CAIC central office is with the National Weather Service in Boulder. For CDOT forecasting operations, the Center maintains offices in Silverton, Pagosa Springs, Carbondale, and the Eisenhower Tunnel.

***Season:*** From November–April, the Center is fully operational seven days a week and is staffed with 12 forecasters/educators. From May–October, the Center is closed and three staff members provide administrative and other necessary services.

**Purposes:** The purposes of the Center are to:

- monitor the changing weather, snow cover, and avalanche conditions in the Colorado mountains (see Data Sites below);
- provide mountain weather and avalanche risk information to the public, via recorded hotline messages and via the Internet and e-mail (see Section VII);
- warn of dangerous avalanche conditions by issuing Avalanche Warning Bulletins via the NOAA Colorado Weatherwire and news media (see Section VII);
- provide the Colorado Department of Transportation weather and snowpack data for reducing avalanche hazards along mountain highways (see Section IX);
- provide avalanche education through slide talks, seminars, videos, publications, and media contacts (see Section VIII);
- be the focal point and spokes-agency in state government for all avalanche matters;
- provide specialized forecasts and consulting to sponsoring agencies;
- investigate all significant avalanche accidents (see Section VI);

***Staffing and Duties at the Main Office:*** Personnel for the 2000–01 season were Knox Williams (Director), Nick Logan (Associate Director), Dale Atkins, and Scott Toepfer. Collectively, this staff has more than 100 years of snow and avalanche experience. The Center was manned daily from 4:30 am to 3:30 p.m., from opening day on November 10, 2000, until closing on April 23, 2001.

The forecasters are responsible for:

- monitoring mountain weather, snow, and avalanche conditions;
- logging all incoming data from observers;
- evaluating field data and National Weather Service data;
- making daily snow stability evaluations and forecasts;
- updating public hotlines daily;
- issuing forecasts for five highway areas daily;
- issuing and terminating Avalanche Warnings when warranted;
- initiating or responding to calls from the news media;
- handling special requests from sponsors/clients.

***Highway Forecast Offices:*** The CAIC maintains four mountain offices to provide specific forecasting and training services to CDOT maintenance personnel. Section IX gives details of this program. These offices are operational from November 1 to April 30, with forecasting services available earlier or later as needed.

- ***Silverton:*** This office is staffed by forecasters Andy Gleason and Jerry Roberts, who coordinate the forecasting for the avalanche reduction program for CDOT along U.S. 550 from Coal Bank Hill to Red Mountain Pass, Colorado 145 over Lizard Head Pass, and Colorado 110 along Cement Creek.
- ***Pagosa Springs:*** This office is staffed by forecaster Mark Mueller and provides forecasting for the avalanche reduction program along U.S. 160 over Wolf Creek Pass, U.S. 50 over Monarch Pass, and Colorado 17 over Cumbres and La Manga passes.
- ***Eisenhower Tunnel:*** This office is staffed by forecasters Lee Metzger and Stu Schaefer and is the forecast center for CDOT's avalanche reduction program in District 1. The primary area of responsibility is the I-70 corridor from Georgetown to Vail, U.S. 6 over Loveland Pass, and U.S. 40 over Berthoud Pass. Outlying areas of responsibility are Colorado 82 over Independence Pass and Colorado 14 over Cameron Pass.
- ***Western Slope:*** This office is in Carbondale and is staffed by forecaster Rob Hunker. It is responsible for forecasting for Colorado 133 over McClure Pass, Colorado 139 over Douglas Pass, and Colorado 65 on Grand Mesa.

***Data Sites:*** The Center maintains a network of observation sites for providing weather, snowpack, and avalanche data to the forecast office. Altogether there are about 35 manned sites, 20 of which are ski areas and the remainder are highway and backcountry sites. The Center has long supported a contract observer at Gothic, and this year began a network of back-country observers. The Highway Forecast Offices maintain and access data from remote weather stations, and also use the NRCS Snotel sites.

***Education:*** One mission of the Center is to provide avalanche education opportunities to citizens, tourists, and avalanche practitioners. We do this through talks and field seminars. Two staff members, Halsted Morris and Denny Hogan, worked exclusively to teach educational classes. Additionally, forecasters maintain frequent contact with news media personnel to give broad (and accurate) coverage of current avalanche conditions. Such news stories both inform and enhance avalanche education with the public. Section VIII details our efforts toward public education and safety.

***Publications and Web Site Outreach:*** The Center publishes avalanche-related articles and produces videos as need and opportunity arise. Section VIII details this year's publications. Our Web site generated 532,975 hits for avalanche information.

***Friends Association:*** The Center manages a grassroots support group called "Friends of the CAIC" which totaled 651 members in 2000–01. For an annual donation of $30 or $45, the Friends receive three issues of *The Beacon* newsletter and receive the daily forecast via e-mail once or twice a day.

# Weather and Avalanche Synopsis

The winter of 2000–01 got off to an early and snowy start especially in the Central and Southern Mountains[1]. Early season snows meant avalanche workers and skiers alike were especially upbeat. A very dry spring and a sweltering summer had left doubts about the upcoming winter in the minds of many.

A short-term climatic change was in the wind; actually more accurately it was in the Pacific Ocean. By the end of the summer of 2000 sea-surface temperatures in the eastern Pacific Ocean had returned to normal. For the first time since the mid-1980s there would be no El Niño (warmer than average sea temperatures off the west coasts of North and South America) or La Niña (colder than average temperatures) to affect Colorado's weather. With neutral sea temperatures and the no anticipated dominating storm-track it would seem Colorado could expect an average winter. By the end of the season when all the numbers were added together and compared the winter of 2000–01 was pretty typical. There were very snowy months, very dry months, very cold months and some warm months.

This winter seasonal snowfall ranged from near normal to below normal in all mountain areas, only one site (Loveland) reported above normal snowfall. The number of reported avalanches was above normal; however, the number of avalanche warning periods and days was below normal. Avalanche accidents were well above average, but deaths were below average, and property damage was nil.

## *Snowfall*

Unlike the fall of 1999 when almost no snow fell anywhere in the mountains during October and November, this winter started in earnest in October with abundant snows in the Southern and Central Mountains. The Northern Mountains were missed by the early season storms, but by November a meridional storm-track (north to south flow) took aim at the Northern and Central Mountains bringing very cold and snowy conditions that persisted through December.

To the delight of ski areas the northerly jet stream brought a nearly continuous series of small storms with steady but light snows and little wind. By early December all mountain areas from the high peaks to the valley floors were blanketed in a mantle of snow. From afar snow coverage resembled late February more than early December. The ski resorts were experiencing some of the best early-season skiing in years; however, in the backcountry these same conditions were setting a dangerous trap. The persistent northerly flow caused Colorado to shiver through its eighth coldest November and December in 106 years of records. (According to the National Climatic Data Center the November-December two-month period was the coldest on record in the United States.) Despite steady snows the light accumulations meant the Colorado snowpack remained shallow. With cold air temperatures the snow cover in all mountain areas only grew weaker by the day under the strong and persistent temperature gradient.

[1] The geographical regions called Northern, Central, and Southern Mountains of Colorado are used extensively in this report. The Northern Mountains extend from the Wyoming border to a line from Denver to Hoosier Pass (just south of Breckenridge) to Glenwood Springs, as the southern boundary. This boundary roughly follows the I-70 corridor but dips south in the area of Breckenridge to include the Ten Mile Range. The Central Mountains extend south from the Denver-Hoosier Pass-Glenwood Springs line to a southern boundary line from Pueblo to Montrose. The Southern Mountains lie between this Pueblo-Montrose line and the New Mexico border.

In November and December the storms favored the Northern and Central Mountains, but in January the storm track shifted to the southwest favoring the Southern Mountains. Very dry conditions in the Northern Mountains only accelerated the growth of depth hoar. The Southern Mountains were snowy with totals ranging from very near normal to well above normal thanks to the season's first big storm during the last few days of the month.

In February the storm track wandered back and forth across Colorado making for a snowy month. No single storm dominated snowfall totals, rather numerous small storms raced across the Northern and Central Mountains. In the Southern Mountains storms were fewer but bigger.

A steady stream of small March storms favored many sites in the Northern and Central Mountains with above normal snowfall. In the Southern Mountains storms were relatively few and far between. High pressure during the latter part of March chased away old-man winter. As the temperature rose to record levels in the Central and Southern Mountains, wet-snow avalanches spilled down. By the end of the month winter had sneaked back setting the stage for a battle between the seasons.

Early April saw a return of springtime with sunny and very warm conditions, but winter forced its way back. The month was characterized by a steady flip-flop between winter and spring. By the end of the month snowfall over the Northern and Central Mountains were generally below normal but above normal in the Southern Mountains.

Though April ended sunny and warm, winter roared back in early May when heavy snows blanketed all mountain areas. Spring quickly reclaimed her position as the snow cover melted fast. Not to be out done old-man winter came back with one more assault in mid June that resulted in several avalanche accidents in the Northern Mountains.

Table 1 shows monthly and seasonal snowfalls for all sites that regularly reported data to the Avalanche Center this year.

**Table 1. Colorado snowfall in inches, 2000–01.**

| | Nov | Dec | Jan | Feb | Mar | Apr | Total Dec–Mar | % of Normal | Total Nov–Apr | % of Normal |
|---|---|---|---|---|---|---|---|---|---|---|
| **Northern Mountains** | | | | | | | | | | |
| Arapahoe Basin | 44 | 65 | 13 | 44 | 51 | 44 | 173 | 91 | 261 | 91 |
| Bear Lake (RMNP) | 28 | 48 | 12 | 29 | 43 | 34 | 132 | 82 | 194 | 81 |
| Beaver Creek | 72 | 58 | 32 | 45 | 70 | | 205 | 90 | | |
| Berthoud Pass | 27 | 72 | 24 | 40 | 61 | 48 | 197 | 95 | 272 | 87 |
| Breckenridge | 33 | 86 | 24 | 42 | 102 | | 254 | 125 | | |
| Copper Mountain | 55 | 66 | 20 | 56 | 86 | | 228 | 121 | | |
| Keystone | 33 | 45 | 20 | 42 | 62 | | 169 | 100 | | |
| Loveland | 49 | 88 | 19 | 71 | 90 | 62 | 268 | 117 | 379 | 111 |
| Steamboat | 47 | 70 | 46 | 48 | 41 | | 205 | 84 | | |
| Vail | 70 | 65 | 53 | 49 | 74 | 48 | 241 | 94 | 359 | |
| Winter Park | 76 | 82 | 45 | 66 | 57 | | 250 | 98 | | |
| **Central Mountains** | | | | | | | | | | |
| Aspen Mountain | 23 | 31 | 23 | 33 | 42 | | 129 | 76 | | |
| Aspen Snowmass | 36 | 35 | 21 | 46 | 37 | | 139 | | | |
| Crested Butte | 29 | 53 | 26 | 48 | 47 | | 174 | 102 | | |
| Gothic | 42 | 67 | 24 | 75 | 57 | 42 | 223 | 92 | 307 | 91 |
| McClure Pass | 51 | 35 | 40 | 41 | 27 | 25 | 143 | | 219 | |
| Monarch | 28 | 49 | 45 | 40 | 67 | | 201 | 105 | | |
| Powderhorn | | 18 | 41 | 42 | 25 | | 126 | | | |
| Sunlight | 25 | 46 | 25 | 41 | 42 | | 154 | 88 | | |
| **Southern Mountains** | | | | | | | | | | |
| Purgatory | 29 | 34 | 71 | 50 | 38 | | 193 | 106 | | |
| Red Mountain Pass | 38 | 34 | 50 | 54 | 30 | 62 | 168 | 82 | 268 | 91 |
| Telluride | 21 | 32 | 46 | 56 | 51 | | 185 | 97 | | |
| Wolf Creek | 56 | 48 | 108 | 78 | 58 | | 292 | 113 | | |

## *Avalanches*

This winter a total of 2,867 avalanches was reported to the Center from November to April. This number is 33% above the average of 2,160. Table 2 shows the monthly distribution of these events.

Light early season snows and the absence of strong winds produced relatively few November avalanches (173), mainly because of little slab formation from the light early-season snows in the Northern and Central Mountains. Though avalanches were not falling the snowpack grew weaker by the day. The very cold weather conditions promoted significant depth-hoar formation and by December a tenuous snow cover developed—a snow cover ripe for avalanches. Though no major storms struck Colorado, December was a very active avalanche month with 739 reported slides. The snowpack was so weak that even small storms produced widespread but small avalanches.

In January mountain snows retreated from the high country resulting in relatively few avalanches (291 compared to January 1999 when a record number of 1,169 avalanches was reported). By February the fragile snow cover was set to shatter with the usual arrival of February's big storms. The storms did arrive, but only to the Southern Mountains. February was another active avalanche month (751 reported). Though the "big" February storm cycle never materialized in the Northern and Central Mountains the snowpack was so weak that even light loads of new snow or blowing snow caused extensive avalanching.

The steady flow of winter-like storms only interrupted by a five-day period of major thaw resulted in March being another active avalanche month (639). The weak winter-like snowpack continued to produce dry-snow avalanches with little additional load. Even by the end of the month observers in the Northern and Central Mountains were still reporting collapsing and "whumpfing" snow; conditions that typically disappear in February. The five-day warm-up near the end of the month resulted in numerous wet-snow avalanches, mainly in the Central and Southern Mountains. At the lower elevations the thaw conditions turned the snowpack wet and rotten; much of the snow melted away. At higher elevations the mild and warm conditions only consolidated the snowpack creating a stronger and more stable snowpack.

Most of April's 244 avalanches occurred in dry snow from winter-like storms. After a brief cycle of wet-snow releases favoring the Northern Mountains early in the month relatively few wet-snow avalanches released. By the middle of the month the warm temperatures had melted away much of the snow at lower elevations and further consolidated the snow at higher elevations. After a heavy spring storm in early May the snowpack quickly started to melt away, only to be briefly interrupted by a cold snap in mid June.

## *Avalanche Danger and Warnings*

Table 2 shows the daily hazard ratings (low, moderate, considerable, high, extreme) for the Northern, Central, and Southern Mountains on a day-per-month basis. The table also shows avalanche counts, accidents, and warning periods by month.

The 14 Avalanche Warning days were well under the long-term average of 33 days. A warning day is one on which the danger was rated high or extreme and an Avalanche Warning was issued.

## *Avalanche Accidents*

The last part of Table 2 lists a monthly breakdown of avalanches involving people and property in 2000–01. Unlike the winter before when relatively few people (44) were caught the winter of 2000–01 had a record number of people caught. The 113 people reported caught were far above the 1990s average of 64. This huge increase was the result of the exceptionally weak snowpack and the steady light snows that enticed people into the backcountry. With more people caught it is no surprise that 24 people were partly buried, which was almost double the 1990s average of 13. The 14 buried were above the 1990s average of 11, but astonishingly only four died! This number is well below the average of 6 deaths per winter. It was mostly a matter of luck that so few people died in avalanches. Several of the victims were shallowly buried and were able to free themselves. While most buried victims carried no rescue gear they fortunately had a foot or hand sticking from the snow. In only one case was a buried victim found with an avalanche rescue transceiver, and his companions found him alive in a textbook rescue.

**Table 2. Summary of avalanches, hazard days, and accidents in Colorado, 2000–01**

| | Nov | Dec | Jan | Feb | Mar | Apr | May–June | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Avalanches reported | 173 | 749 | 291 | 750 | 639 | 244 | 21 | **2867** |
| Days with 1 or more slab | 23 | 28 | 20 | 28 | 28 | 25 | 4 | **156** |
| Avalanche warning periods | 0 | 2 | 1 | 2 | 0 | 0 | 0 | **5** |
| Days with warning in effect | 0 | 6 | 5 | 3 | 0 | 0 | 0 | **14** |
| **NORTHERN MOUNTAINS** | | | | | | | | |
| Days with hazard rated ... | | | | | | | | |
| LOW | 0 | 0 | 8 | 0 | 0 | 2 | | **10** |
| MODERATE | 8 | 13 | 19 | 2 | 19 | 14 | | **75** |
| CONSIDERABLE | 10 | 12 | 4 | 24 | 11 | 6 | | **67** |
| HIGH | 2 | 6 | 0 | 2 | 1 | 0 | | **11** |
| EXTREME | 0 | 0 | 0 | 0 | 0 | 0 | | **0** |
| **CENTRAL MOUNTAINS** | | | | | | | | |
| Days with hazard rated ... | | | | | | | | |
| LOW | 0 | 5 | 8 | 0 | 0 | 2 | | **15** |
| MODERATE | 13 | 12 | 15 | 1 | 23 | 18 | | **82** |
| CONSIDERABLE | 7 | 8 | 8 | 25 | 8 | 2 | | **58** |
| HIGH | 0 | 6 | 0 | 2 | 0 | 0 | | **8** |
| EXTREME | 0 | 0 | 0 | 0 | 0 | 0 | | **0** |
| **SOUTHERN MOUNTAINS** | | | | | | | | |
| Days with hazard rated ... | | | | | | | | |
| LOW | 0 | 6 | 6 | 0 | 0 | 3 | | **15** |
| MODERATE | 7 | 10 | 17 | 1 | 24 | 17 | | **76** |
| CONSIDERABLE | 7 | 9 | 6 | 23 | 7 | 2 | | **54** |
| HIGH | 6 | 6 | 2 | 4 | 0 | 0 | | **18** |
| EXTREME | 0 | 0 | 0 | 0 | 0 | 0 | | **0** |
| **AVALANCHE ACCIDENTS** | | | | | | | | |
| People caught | 16 | 34 | 6 | 27 | 24 | 3 | 3 | **113** |
| People partly buried | 3 | 5 | 2 | 8 | 6 | 0 | 0 | **24** |
| People buried | 1 | 4 | 0 | 4 | 3 | 2 | 0 | **14** |
| People injured | 3 | 0 | 0 | 1 | 4 | 0 | 0 | **8** |
| People killed | 0 | 1 | 0 | 1 | 1 | 1 | 0 | **4** |
| Vehicles caught | 0 | 1 | 0 | 1 | 0 | 0 | 0 | **2** |
| Property sites damaged | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **0** |

Figure 3 represents a 10-year look at the number of people caught and killed in avalanches each winter. Interestingly, the number of victims caught increased dramatically; however, the number killed decreased.

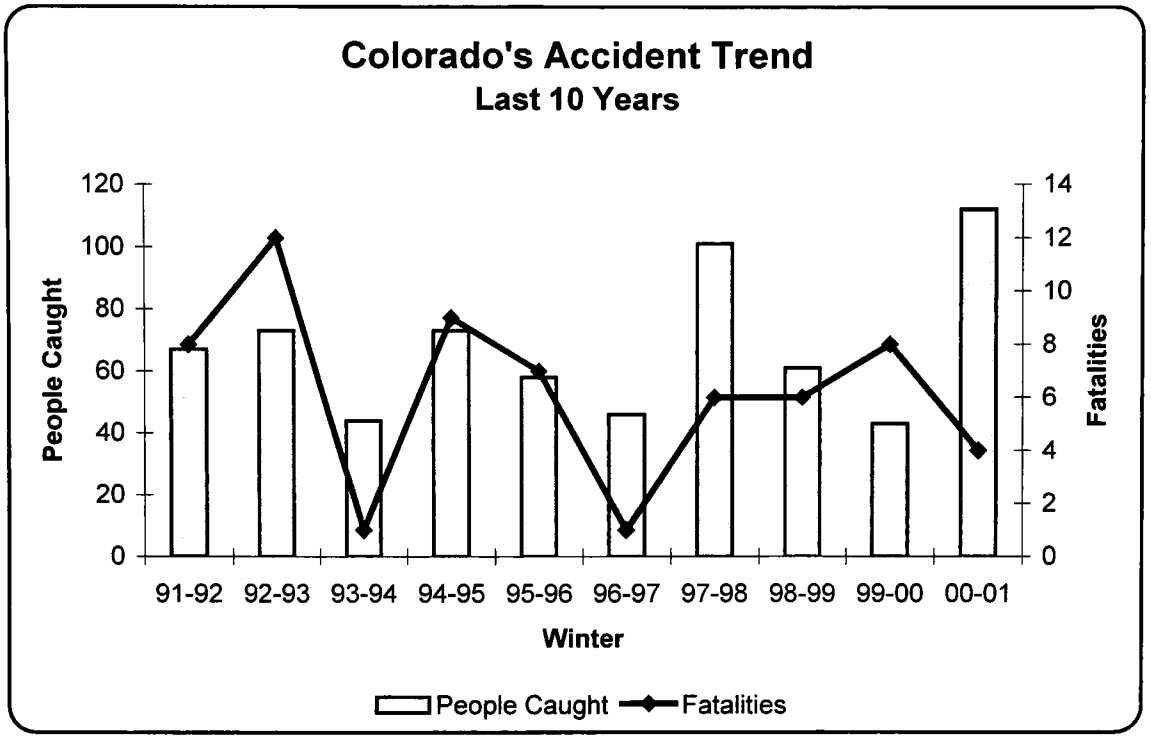


**Figure 3. Colorado's accident trend in the last 10 years.**

Table 3 lists all avalanche accidents reported this winter. The fatal accidents are italicized. Avalanche Center personnel try to investigate all fatal accidents (see Section VI). It is remarkable to note the grouping of accidents by month. Avalanche accidents started early with the season's first snows, but as the storms abated in January so, too, did the number of accidents. Steady light snows on an exceptionally weak snow snowpack created dangerous conditions in February and March and a significant number of accidents was reported. By April the weak layers had been removed and few accidents were reported. The avalanche season was not over and accidents occurred with each storm in May and June. Though the June accident was the last incident to occur and no one was caught, it certainly may foretell of future accidents: people triggering avalanches that catch people in other groups—especially in high-recreation-use areas. This June it was a case where two backcountry skiers triggered an avalanche above a rescue team evacuating an injured skier. Though no one was caught, an anchor system and other rescue equipment was buried. It was a chilling close call.

**Table 3. Colorado avalanche accidents, 2000–01.**

(Italics indicate fatal accident.)

| Date | Location | Details |
|---|---|---|
| 11/4 | Red Mtn. Pass | 2 backcountry skiers caught, 1 partly buried & injured, 1 snowboarder caught & buried |
| 11/7 | Grays Peak | 1 climber/skier caught, injured |
| 11/? | La Plata Mountains | 2 people caught, partly buried |
| 11/19 | Telluride Ski Area | 2 patrollers caught (manmade snow) |
| 11/26 | Berthoud Pass (west side) | 1 backcountry skier caught |
| 11/29 | Loveland Pass (east side) | 3 backcountry skiers caught, separate incidents |
| 11/22 | Aspen Highlands | 4 patrollers caught |
| 11/29 | Berthoud Ski Area | 1 patroller caught |
| 12/1 | Loveland Pass (west side) | 1 backcountry skier caught |
| 12/2 | Loveland Pass (west side) | 2 hikers caught, partly buried |
| 12/3 | Herman Gulch (near I-70) | 1 backcountry skier caught |
| 12/3 | Arapahoe Basin | 1 out-of-area skier caught |
| 12/6 | Loveland Pass (east side) | 1 backcountry skier caught |
| 12/7 | Breckenridge Ski Area | 2 patrollers caught, separate incidents |
| 12/11 | Wolf Creek Pass | 1 snowboarder caught |
| 12/13 | Berthoud Pass | 1 motorist & vehicle caught |
| 12/14 | Rocky Mountain National Park | 11 guides caught, 3 partly buried |
| 12/16 | Irwin Lodge (near Crested Butte) | 1 snowcat guide caught |
| 12/16 | Irwin Lodge | 1 snowcat guide caught, 2nd incident |
| 12/16 | Arapahoe Basin | 1 patroller caught, buried |
| 12/22 | Aspen Mountain | 1 patroller caught, partly buried |
| 12/26 | Berthoud Pass (east side) | 4 snowboarders caught |
| *12/29* | *Cameron Pass* | *1 snowboarder caught, buried & killed* |
| 1/1 | Loveland Pass (east side) | 1 snowboarder caught |
| 1/10 | Loveland Pass (west side) | 1 snowboarder caught (1.5 mi below Arapahoe Basin) |
| 1/19 | Telluride Ski Area | 1 patroller caught |
| 1/29 | Durango (just west of town) | 1 snowboarder caught, partly buried |
| 1/29 | Lizard Head Pass | 1 backcountry skier caught |
| 2/1 | Monarch Snowcat Tours | 1 guide caught, partly buried |
| 2/3 | Red Mountain Pass (south side) | 3 people caught, partly buried |
| 2/4 | Berthoud Pass (west side) | 1 snowshoer caught |
| 2/4 | Vail Pass | 1 backcountry skier caught |
| 2/4 | Loveland Basin | 1 patroller caught, partly buried |
| 2/9 | Ptarmigan Pass (near Vail Pass) | 1 backcountry skier caught |
| 2/9 | Blue Sky Basin (near Vail Ski Area) | 1 backcountry skier caught, partly buried |
| 2/10 | Ptarmigan Pass (near Vail Pass) | 1 snowmobiler caught, partly buried |
| 2/10 | Ptarmigan Pass (near Vail Pass) | 1 snowmobiler caught |
| 2/10 | Shrine Bowl (near Vail Pass) | 2 snowmobilers caught (separate incidents) |
| 2/11 | Aspen Highlands | 1 skier caught |
| 2/11 | Keystone Ski Area | 2 out-of-area skiers caught, 1 partly buried |
| 2/15 | Washington Gl. (near Crested Butte) | 1 backcountry skier caught, partly buried |
| 2/16 | West Lime Creek (near US 550) | 1 backcountry skier caught, 1 snowboarder caught & buried |
| 2/17 | Cameron Pass (near Lake Agnes) | 1 backcountry skier caught, partly buried |
| 1/18 | Cameron Pass | 1 backcountry skier caught, buried |
| 1/18 | Wolverine Basin (nr Crested Butte) | 1 backcountry skier caught, injured |
| 2/25 | near Ashcroft | 1 backcountry skier caught |
| *2/25* | *Ohio Pass (near Crested Butte)* | *1 backcountry skier caught & killed* |

**Table 3. Continued**

| Date | Location | Details |
|---|---|---|
| 2/25 | Peru Creek (near Montezuma) | 2 backcountry skiers caught & buried |
| 2/28 | Loveland Pass (east side) | 1 semi-trailer hit |
| 2/28 | Loveland Pass | 1 snowboarder caught |
| 3/1 | Breckenridge Ski Area | 1 patroller caught, partly buried, injured |
| 3/1 | Arapahoe Basin | 1 out-of-area snowboarder caught, injured |
| 3/1 | East Flattops | 1 backcountry skier caught |
| 3/2 | Loveland Basin | 1 patroller caught |
| 3/4 | Loveland Pass (west side) | 3 snowboarders caught & partly buried |
| 3/4 | Loveland Pass (west side) | 2 backcountry skiers caught |
| 3/11 | near Winter Park | 1 snowboarder caught, injured |
| 3/13 | Jones Pass | 1 backcountry skier caught |
| 3/13 | Berthoud Pass | 1 snowboarder caught |
| 3/14 | Aspen Mountain | 2 out-of-area skiers caught, lost equipment |
| 3/17 | Breckenridge Ski Area | 1 patroller caught, partly buried |
| *3/18* | *Farwell Mtn. (near Steamboat Lake)* | *1 backcountry skier caught, buried, killed* |
| 3/18 | Snowmass Ski Area | 1 out-of-area snowboarder caught |
| 3/19 | Eisenhower Tunnel (west side) | 3 backcountry snowboarders, 2 buried, 1 partly buried |
| 3/20 | Breckenridge Ski Area | 1 out-of-area snowboarder caught |
| 3/25 | Cottonwood Pass | 1 snowmobiler caught |
| 3/25 | Telluride Ski Area | 1 patroller caught |
| 3/29 | Arapahoe Basin | 1 out-of-area snowboarder caught, injured |
| 4/1 | Vail Ski Area | 1 out-of-area skier caught, buried |
| *4/3* | *Ten Mile Range (west side)* | *1 snowmobiler caught, buried & killed* |
| 4/16 | Snowmass Ski Area | 1 out-of-area skier caught |
| 5/6 | Breckenridge Ski Area | 1 backcountry skier caught (area closed for season) |
| 6/15 | Ten Mile Range | 2 backcountry skiers caught, separate incidents |

# Detailed Winter Summary

## *October*

The winter of 2000–01 started off uncertain as to if it would follow a La Nina or El Nino pattern. This uncertainty was enough that the National Weather Service did not issue any long range projections for Colorado.

Some avalanche workers were optimistic when snows came early to the San Juan Mountains, with 8 in. of snowfall in September. In the Central and Southern Mountains, October was a snowy month. At the end of the month there was 28 in. of snow on the ground at Wolf Creek Pass and 25 in. at Red Mountain Pass. Meanwhile in the Northern Mountains, October was a dry month.

## *November*

The first day of November started off with a storm in the Northern and Central Mountains. The snowy and windy conditions brought moderate amounts of snow: 7 in. at Steamboat, 11.5 in. at Rabbit Ears Pass, 11 in. at Copper Mountain and 14 in. at Beaver Creek. Light snows continued until the 4th of the month.

Clear and calm conditions statewide on the 4th may have clouded the decision-making of two skiers and one snowboarder on Red Mountain Pass who triggered and were caught by an avalanche. The skiers were partially buried and the snowboarder was completely buried. Luckily, the snowboarder's hand was sticking out of the snow and her companions were able to quickly rescue her.

November 5 brought moderate snows to the Southern and Central Mountains, with 12 in. at Wolf Creek Pass and 6 in. at Gothic. This storm continued the next two days and brought snows and cold temperatures throughout the state.

The Colorado snowpack depths in early November ranged from 6–36 in. in the Northern Mountains, 10–20 in. in the Central Mountains, and 24–50 in. in the Southern Mountains. This early season snowpack was mainly made up of weak depth hoar crystals, with a melt-freeze crust on top of this weak base layer. Winds later added soft and hard slabs on top of these weak layers.

November 10 was "opening day" for the Colorado Avalanche Information Center's 18th season of operation. Strong southwest flow and an approaching storm marked opening day, but this system only brought light snow showers throughout the state.

November 13 was a cold day with strong winds. The windchills in the Northern Mountains ranged from -40 to -60 degrees. These cold temperatures and strong winds created tender soft slabs. There were nine avalanches in the western San Juan Mountains and around Lake City. These were mainly natural releases although two were skier triggered.

By mid-month Colorado was off to a good start with early season snows. In the Northern and Central Mountains snow depths ranged from 1.5 to 2 ft in the Elk, Sawatch, Front Range and Summit County areas. The Southern Mountains snowpack ranged from to 2 to 3 ft in the west San Juan Mountains, and 4 to 6 ft in the east San Juan Mountains around Wolf Creek Pass. But cold temperatures had caused major depth

...cold temperatures had caused major depth hoar development...

hoar development that inhibited stabilization. The problem with the snowpack was not quantity but quality of the snow.

November was a cold month in the Northern Mountains. Berthoud Pass recorded –11°F on two consecutive days, while Loveland Pass had six days below zero and a coldest temperature of –10°F. All of these low temperatures came in the middle of the month. The average maximum temperature was seventeen for Berthoud Pass, and eighteen for Loveland Pass. Only once during November did either location record a temperature above freezing.

November 15 saw a system pass over Colorado that brought light to moderate snow to all mountain sites, but Rabbit Ears Pass got 10 in. Then a series of storm systems were lined up right behind this low-pressure system, and these brought light snows for the next couple of days.

Cold clear conditions dominated throughout Colorado until Sunday, November 19 when a ridge of high pressure moved over Colorado. This brought strong winds to the Northern Mountains for several days, but then the winds decreased and the temperatures warmed, which was welcome relief from the recent deep freeze temperatures.

The cold temperatures helped to develop strong temperature gradients near the snow surface, which created a weak layer of faceted snow crystals in the snowpack. With a warming trend it was hoped that the upper level layers of the snowpack would stabilize. But the warming trend did not help the deeper weak layers that would persist throughout the remainder of the winter.

High pressure dominated until Thanksgiving. Some light snow fell in the Southern Mountains on Thanksgiving Day, and then clear weather dominated once more until the 25th. That day a cold front brought upslope snow showers to the Front Range, which was then followed by high winds in the Northern Mountains. Another disturbance on the 27th brought strong winds and only light snows to the Northern and Central Mountains. By now the snowpack in many areas consisted of poorly bonded faceted snow crystals with shallow wind slabs on top of that. This "house of cards" type of snowpack seemed even weaker than the typical weak Colorado snow structure.

A high-pressure system on northwesterly flow moved into the state on the 28th. Once again this brought winds and light snows ahead of the system to the Northern and Central Mountains. These winds again contributed to slab formation in the Northern Mountains. On the 28th and 29th, 31 avalanches were reported in the Loveland Pass, Berthoud Pass and Ten Mile Range areas. Most of these avalanches ran to the ground, which showed that the base of the snowpack was extremely weak. Field observers reported lots of tension in the snowpack, which allowed fracture lines to propagate long distances. "Whumpfing" noises of snowpack collapses were quite common.

During November there were 173 avalanches reported to the CAIC: 96 in the Northern Mountains, 16 in the Central Mountains and 61 in the Southern Mountains. There were 10 reported avalanche incidents that caught 16 people and injured 3.

Snowfall was above normal for several sites in the Northern Mountains: Loveland Basin, 102%; Arapahoe Basin, 105%; Keystone, 110%; Winter Park, 117%; Vail, 127%; Copper Mountain, 140%; and Steamboat, 151%. Other sites in the Northern Mountains and all in the Central and Southern Mountains were below normal: Bear Lake and Breckenridge, 79%; Monarch, 74%; Gothic and Red Mountain Pass, 85%; and Wolf Creek, 97%.

## *December*

In early December high pressure dominated after the last storm of November blew itself out. This period of relatively calm and settled weather helped to deceive a few backcountry users. The high winds of November had created slab conditions above timberline throughout the state. These slabs were sitting on top of a very weak snowpack. Collapsing snow under the weight of a skier was quite common, but this warning sign wasn't noted by a number of backcountry users.

Early December was marked with numerous avalanche incidents. On Friday, December 1, a lone skier triggered the upper portion of the "Little Professor" slide path on the west side of Loveland Pass. He was lucky to remain on the surface of the avalanche and was able to pull himself free when it came to a stop. The next day two CAIC instructors happened to watch two hikers trigger an avalanche that caught them near the summit of Loveland Pass. Once again these hikers where able to stay on the surface of the running avalanche. On Sunday the 3rd, two backcountry skiers where involved in an avalanche in Herman Gulch near Loveland Pass. Once again these skiers escaped without injury.

The snowpack in the Northern and Central Mountains ranged from 1–2 ft deep, while in the Southern Mountains it was a bit deeper at 2–4 ft. But a strong temperature gradient within the snowpack had turned the snow grains to sugar-like faceted snow, creating a weak foundation for future snowfalls.

The first meaningful storm of December arrived on the 5th, when a fast-moving system moved down from Wyoming. The storm brought light to moderate snows with brisk winds to the Northern and Central Mountains. Berthoud Pass received the most snow with 9 in.

Weak high pressure dominated the weather over Colorado for the next couple of days, then a weak upper-level system moved in from the west. This once again brought light to moderate snows over the entire state. The town of Steamboat received 3 in.; Berthoud Pass, 4 in.; Silverton, 4 in.; Molas and Coal Bank Passes, 7 in. each; Pagosa Springs, 6 in.; Ashcroft, 3 in.; and McClure Pass, 1 in.

On the heels of this storm an arctic cold front oozed into northeastern Colorado. Along with the cold temperatures came high winds along the Front Range. There were numerous avalanches statewide. The snowpack was very fragile and seemed to be nearing a critical state in the Northern Mountains, mainly in the Front Range and Summit County areas. Also in the west San Juans a similar snowpack situation was developing. On December 11th, an Avalanche Warning was issued for the Central Mountains and west San Juan Mountains, because of heavy snows overnight. Ashcroft received 11 in.; Snowmass, 10 in.; Sunlight, 12 in.; Irwin Lodge, 13 in.; Crested Butte, 13 in.; and Berthoud Pass, 12 in. During the three days from December 11–13, an avalanche cycle produced 133 reported avalanches. From the 9th–12th, Irwin Lodge received 25 in. of new snow.

> The snowpack was very fragile and seemed to be nearing a critical state...

Starting on the 14th, a series of storm systems began to line up that would bring storms every two days. Along with moderate snowfalls came high winds. Winds gusted to 90 mph at Breckenridge and Loveland Pass on the 15th. A gust of 102 mph was also recorded that day at Red Mountain Pass, which blew several trees onto the highway. While most of the ski areas recorded 5–8 in. of snowfall, Wolf Creek Pass recorded 36 in. during this storm.

With moderate snowfall and high winds statewide, the Avalanche Center issued an Avalanche Warning on December 16. This warning remained in effect through the 18th for the Northern and Central Mountains, as moderate snowfall and strong winds continued daily. (High winds in the Northern Mountains along the Continental Divide would persist throughout December. During

December the measured peak wind gust on Loveland Pass was 96 mph, and the daily average wind speed was above 15 mph for an astounding 25 of 31 days.)

Finally on the 19th the Avalanche Warnings for the Northern and Central Mountains were dropped. But the avalanche danger was still rated considerable for all mountain areas, as strong winds and cold temperatures remained over the state.

December 20th brought a fast-moving storm system through the state. Strong northwest winds brought moderate snows to the Northern Mountains, while in the Central and Southern Mountains only light snows where recorded. Cold temperatures continued to inhibit snowpack settlement and stabilization. Snow flurries and moderate winds persisted over the Northern Mountains, along the Continental Divide for the next several days.

Also on the 20th a backcountry skier triggered a 5-foot-deep slab avalanche near Aspen but escaped unharmed. The CAIC backcountry observers in all mountain areas reported the snowpack to be mostly faceted snow or advanced depth hoar grains. So far 42 people had been caught in avalanches, but with no fatalities. One observer stated that in the San Juans, "many slopes are just waiting for a trigger." Many avalanche workers wondered aloud how long could this lucky streak continue.

On the 23rd the jet stream sagged southward over Colorado and brought high winds and light to moderate snowfall to the Northern Mountains. Winter Park received 9.5 in. of snow, while the ski areas of Summit County got 4–6 in., just in time for the holiday skiers. Christmas Eve and Christmas day proved to be beautiful days, except in the Four Corners area where light snow was recorded. The remainder of the holiday week had Colorado sitting under high pressure. This allowed for warmer temperatures, but not long enough to help stabilize the weak snowpack.

This period of good weather and the holidays contributed to a couple of avalanche incidents. In one case four snowboarders where caught in one avalanche near Berthoud Pass. The Colorado luck seemed to hold, as they all escaped without injury.

Sadly the luck ran out on December 29. The first avalanche fatality of the winter happened on South Diamond Peak, above Cameron Pass in the Northern Mountains. A forty-year-old male snowboarder triggered an avalanche while ascending the slide path. Coincidentally, this accident happened on the same face where the first fatal avalanche of the previous winter happened.

The first avalanche fatality of the winter...

The 30th and 31st saw Colorado under light northwest winds and light snow in the Northern and Central Mountains, and the snow cover continued to be widely unstable. Reports of collapsing and shooting cracks in the snowpack were reported from all mountain areas.

During December there were 749 avalanches reported to the Avalanche Center (the largest December total of record): 442 in the Northern Mountains, 174 in the Central Mountains, and 133 in the Southern Mountains. There were 17 reported avalanche incidents that caught 34 people and killed 1.

Snowfall was above normal in the Northern and Central Mountains: Vail, Beaver Creek, and Sunlight all got 106% of normal; Steamboat, 108%; Keystone, 110%; Monarch, 122%; Crested Butte, 128%; Winter Park and Gothic, 134%; Bear Lake, 140%; Arapahoe Basin and Copper Mountain, 145%; Loveland Basin, 172%; Breckenridge, 180%; and somehow Aspen Mountain got shorted with but 82%. Snowfall was below normal in the Southern Mountains: Purgatory and Red Mountain Pass, 81%; Telluride, 84%; and Wolf Creek, 89%.

## *January*

January began with a few snow flurries in the Northern Mountains left over from the final storm system of December, but these were quickly squashed by a dome of high pressure moving over Colorado from the west. High pressure would dominate Colorado's weather through the 9th, with generally clear skies, cool temperatures, and light winds except for typical gustiness over the Front Range. Avalanche activity was almost non- existent during this stretch of fair weather. But there would be a delayed result of more avalanches releasing to the ground, because the immediate effect was to accelerate the growth of depth hoar in an overall shallow snow cover that varied from 30–45 in.

A weak system blew through the mountains on the 10th–11th, but it only produced T-2 in. snows everywhere, with the exception of Wolf Creek which got 5 in. A stronger system hit on the 13th. The heaviest snows were in the Southern Mountains, with 7–11 in. in the Western San Juans and 18 in. at Wolf Creek. As winds veered from SW to NW, snowfall quickly ended in the Southern Mountains and began in the Central and Northern Mountains. This snow ended on the 15th with storm totals of 14 in. at Steamboat, 11 in. at Winter Park, 21 in. at Vail, and 14 in. at Irwin Lodge near Crested Butte. Another minor system followed on the 16th and brought 2–5 in. to the San Juans, although Purgatory got 9 in. Avalanche activity with this storm was limited to 20 small, shallow releases, mostly because of the lack of sustained wind and blowing snow.

Three days of fair weather followed on the 17th–19th, and then another weak system brought light snow to the Northern and Central Mountains on the 20th–21st. Amounts were minimal at 1–2 in. at most sites, but Steamboat, Vail, and Irwin Lodge all got 6 in. Fair weather returned for the 22d–24th. There were no significant avalanches during this 8-day period.

On the 25th, a strong southern storm brought moderate snow to the Southern and Central Mountains. This storm continued through the 28th in the Southern Mountains, and storm totals there were 23 in. at Telluride, 45 in. at Purgatory, and 59 in. at Wolf Creek. In addition, winds gusted to 60 mph early in the storm. This prompted an Avalanche Warning which was issued on the 27th and stayed in effect until the 31st. 168 avalanches were recorded from the 25th–31st in the San Juans. These blocked the highways over Red Mountain Pass and Wolf Creek Pass, but no incidents were reported in the backcountry.

This storm also hit the Central and northern Mountains and continued until the 30th there, and snow totals were decent. Steamboat got 22 in.; Winter Park, 20 in.; Vail, 24 in.; Crested Butte, 17 in.; Irwin Lodge, 32 in.; and Monarch, 25 in. However, the storm did no favors to the Summit County area, which managed but 8–10 in. storm totals. Avalanche totals reflected the smaller snow totals: 77 reported in the Central Mountains, and only 21 in the Northern Mountains.

For January, snowfall was below normal at all sites in the Northern and Central Mountains: Arapahoe Basin, 27%; Bear Lake, 30%; Loveland, 33%; Gothic, 38%; Copper Mtn, 41%; Breckenridge and Keystone, 44%; Crested Butte, 57%; Steamboat, Beaver Creek, and Aspen, all 61%; Winter Park, 65%; Vail, 77%; and Monarch, 97%. In the Southern Mountains, the big storm at the end of the month greatly helped Wolf Creek and Purgatory to both reach 164% of normal, while Telluride and Red Mountain Pass got 97%.

Avalanche totals followed the snowfall, with 291 being reported: 52 in the Northern, 83 in the Central, and 156 in the Southern Mountains. Only 6 avalanche incidents that caught 6 people were reported, for one of the quietest Januarys ever.

## *February*

A weak disturbance brought light snow flurries and blowing snow to the Northern Mountains on February 1, which caused a handful of shallow slab releases. Flurries continued on the 2d–3d (three backcountry skiers were partly buried on Red Mountain Pass on the 3d), then snowfall intensified in the Northern Mountains on the 4th with accumulations of 7–13 in. and heavy blowing snow. The result was 52 avalanches being reported on the 4th and another 70 the next 2 days. On the 4th, a snowshoer was caught on Berthoud Pass, a skier was caught on Vail Pass, and a ski patroller was partly buried at Loveland. A minor cycle in the Central Mountains produced 43 avalanches in the same time period.

A stronger system hit on the 7th, initially with strong winds that caused blowing snow in all mountains, followed by snow on the 8th–9th. Most sites in the Northern and Central Mountains got 4–9 in., though Monarch got 15 in. The Southern Mountains got the heaviest snow, with Telluride and Wolf Creek recording 21 in. and Red Mountain Pass, Molas Pass, and Coal Bank Pass all getting 18 in. The Avalanche Center issued an Avalanche Warning for the Southern Mountains, and a significant avalanche cycle from the 7th–12th brought down 109 recorded slides. The Central Mountains had a similar cycle of 97 recorded avalanches. On the 9th–11th, eight separate avalanche incidents resulted in nine people being caught.

The next system hit on the 14th, continued into the 15th, and brought snow to all mountains: 4–8 in. in the Northern Mountains, 6–14 in. in the Central Mountains, and 6–12 in. in the Southern Mountains. Again, many small avalanches ran, especially in the Central and Southern Mountains, where a total of 52 avalanches was recorded on the 14th–16th. On the 15th a backcountry skier near Crested Butte was partly buried, and on the 16th a backcountry snowboarder was buried and was saved by his skier companion.

Clear weather prevailed on the 16th–17th, and then the next system came in from the southwest and brought snow to the Southern and Central Mountains on the 18th. Two notable accidents occurred on the 18th: on Cameron Pass west of Fort Collins, a skier was pulled alive from a 3-foot burial because of a textbook beacon rescue by one of his companions, and a skier near Crested Butte sustained a broken leg in a slide.

Light snow continued through the 22nd, with the heavier snow amounts being 13 in. at Steamboat, Winter Park, and Aspen; 14 in. at Crested Butte and Irwin Lodge; but 34 in. at Gothic. During this snowy period, 39 avalanches were reported in the Northern Mountains and 45 in the Central.

Another small system rapidly followed and brought light snow to all mountains on the 24th–25th, when 3–6 in. fell in the Northern Mountains (though Steamboat got 9 in.), 4–8 in. in the Central Mountains (though Irwin Lodge got 11 in.), and 6–9 in. in the Southern Mountains (though Telluride and Wolf Creek got 15 in.). In the San Juans, winds gusted to 60 mph on the 24th, and control work along Red Mountain Pass was very effective, with 17 releases.

The 25th was an active day for avalanches in the Central Mountains, with 16 being reported around Aspen and Crested Butte. One of these caused the second death of the winter. On Ohio Pass west of Crested Butte, a woman triggered a slide and was swept into a tree; the collision caused her death. This party of five very skilled skiers were well equipped for rescue, but that did not help the victim once she was caught.

The weather took a breather on the 26th and brought a cool, party cloudy day, but then another system blew in and brought snow to all mountains on the 27th–28th. Amounts in the Northern and Central mountains were 4–8 in., but the Southern Mountains got hit harder with 11 in. at Purgatory, 12 in. at

Molas Pass, 13 in. at Coal Bank Pass, and 25 in. at Wolf Creek. Once more avalanche activity picked up, with 24 releases coming from the San Juans. Several of these were medium to large in size. On Loveland Pass on the 28th, a semi-truck stuck in the snow was hit by a slide.

Overall February was a snowy month with many days of light snow. Most sites in the Northern and Central Mountains recorded snow on about 20 days. For the record, Loveland Basin got 142% of normal; Copper Mountain, 130%; Keystone, 117%; Crested Butte, 115%; Winter Park, 113%; Gothic, 110%; Arapahoe Basin, 96%; Breckenridge, 93%; Monarch, 88%; Steamboat and Vail, 84%; Beaver Creek, 82%; Aspen Mountain, 77%; and on the low end, Bear Lake, 67%.

The Southern Mountains had many fewer days of snowfall (10) but the storms were bigger. Wolf Creek and Telluride got 120% of normal; Red Mountain Pass, 110%; and Purgatory, 104%.

February was an active month for avalanches, with at least one slab avalanche being reported every day. There were 750 avalanches reported altogether: 272 in the Northern, 248 in the Central, and 230 in the Southern Mountains. There were also numerous avalanche incidents, with 27 people caught, 1 injured, and 1 killed. The absolute weakness of the snowpack was apparent when even light loads from falling and blowing snow were enough to trigger extensive avalanche outbreaks. It was remarkable and fortunate to have had only one injury and one death caused by avalanches.

February was an active month for avalanches, with at least one slab avalanche being reported every day.

## *March*

The storm of late February extended into March and brought 3–6 in. of snow to all mountains on the 1st, though Berthoud Pass got 10 in. The snowpack was still unstable, especially in the San Juans, and on the 2d, 14 avalanches were reported from that region. Several had fracture depths of 4–6 ft. No accidents came from the San Juans, but on the 1st, two people were injured in avalanches ... a patroller at Breckenridge and an out-of-area snowboarder at Arapahoe Basin.

Unsettled weather on the 2d–4th brought flurries to all mountains, but accumulations were minimal. On the 4th three snowboarders on Loveland Pass were buried to their necks in a slide they triggered. The weather held fair on the 5th–6th, and then a new system moved in on the night of the 6th. By the next morning 1–4 in. of snow had fallen. Snow ended in the Northern Mountains, but continued in the Central and Southern Mountains through the 12th. Some typical storm totals were Aspen Mountain and Crested Butte, 14 in.; Irwin Lodge, 22 in.; Monarch, 29 in.; Telluride, 19 in.; Coal Bank, 33 in.; and Wolf Creek, 27 in. Few avalanches occurred because snowfall intensities and winds were light.

Meanwhile in the Northern Mountains, snowfall began once more on the 10th and continued daily through the 19th. This extended system brought 28 in. to Steamboat and Winter Park; 31 in. to Eldora; 39 in. to Vail and Beaver Creek; and 40 in. to Breckenridge. Avalanche activity picked up on the 12th because winds gusted to 70 mph above timberline that day, and by the 15th 89 avalanches had been observed. Another small cycle of 36 slides ran on the 18th–20th. One of these claimed the third life of the season: on the 18th a backcountry skier was buried and killed in a slide on Farwell Mountain north of Steamboat Springs. Another close call occurred on the west side of the Eisenhower Tunnel when three snowboarders were buried shallowly but survived.

Snowfall returned to the Central Mountains on the 15th and continued through the 20th. Amounts were 10 in. at Aspen Mountain, 12 in. at Crested Butte, 20 in. at Irwin Lodge, and 27 in. at Monarch. Avalanche activity was only modest ... 39 reported ... probably because winds were on the light side.

A one-day storm hit the San Juans on the 17th and dropped 9–11 in. at Telluride, Coal Bank, and Molas Pass, and 15 in. at Wolf Creek. Seven controlled slides ran on this day on Red Mountain and Wolf Creek Passes.

A strong warm-up between the 20th–25th caused temperatures in the Central and Southern Mountains to reach the mid 40s and low 50s. This triggered a cycle of wet slides that totaled 100 recorded slides by the 26th, many of which blocked highways, especially over Red Mountain Pass.

In the last week of March the weather cooled as another system moved into the mountains, and this brought light snow daily to the Northern Mountains on the 25th–31st, and to the Central Mountains on the 27th–31st. Some typical amounts were Steamboat, 9 in.; Winter Park, 14 in.; Vail, 23 in.; Breckenridge, 34 in.; Aspen Mountain, 13 in.; and Gothic and Irwin Lodge, 15 in. The jet stream dropped over the Northern Mountains on the 28th–31st and brought gusty winds and blowing snow above timberline. This led to a cycle of 73 reported avalanches. One accident occurred on the 29th at Arapahoe Basin when an out-of-area snowboarder was injured.

March snowfall was generous for many sites in the Northern and Central Mountains: Breckenridge, 180% of normal; Copper Mountain, 162%; Loveland Basin, 140%; Keystone, 138%; Monarch, 118%; Crested Butte, 113%; Beaver Creek and Vail, 108%; and Arapahoe Basin and Bear Lake, 100%. Other sites in the North and Central Mountains, and all sites in the Southern Mountains, were below normal: Steamboat, 84%; Winter Park, 85%; Aspen Mountain, 82%; Gothic, 92%; Telluride, 85%; Purgatory, 76%; Wolf Creek, 79%; and Red Mountain Pass, a paltry 48%.

There were 639 avalanches reported in March: 319 in the Northern, 152 in the Central, and 168 in the Southern Mountains. And just as in February, there were also numerous avalanche incidents, with 24 people caught, 4 injured, and 1 killed.

## *April*

Full-blown spring conditions with lots of sunshine and afternoon temperatures in the 40s and 50s prevailed in the mountains on April 1–5. The snowpack turned rotten and weak from thaw conditions near and below timberline, while strong winds above timberline maintained light blowing snow and the potential for dry slab releases. On the 1st there was a rash of natural releases (12) in Summit County because of blowing snow. Another 15 avalanches ran in the same area on the 2d–4th for the same reasons of blowing snow where the snow remained cold and thaw instability where the snow was melting.

One of these avalanches caused the fourth avalanche death of the season. On the morning of the 3rd a snowmobiler riding solo on the west side of the 10 Mile Range, just east of Copper Mountain, was buried and killed in an avalanche. It appeared he had gotten his machine stuck in the rotten snow, and the avalanche came down from the ridge above while he was attempting to dig out.

A vigorous spring storm hit the San Juans on the 6th–8th. Snow totals were 18 in. at Red Mountain Pass, 24 in. at Purgatory, and 28 in. at Wolf Creek. Winds gusted to 82 mph on Red Mountain Pass on the 8th. 35 avalanches were reported in these three days. This same storm brought 13 in. to Aspen and 18 in. to Gothic in the Central Mountains, and 3–8 in. to sites in the Northern Mountains.

Another strong storm blew in on the 11th–12th. It brought 12 in. to Steamboat, 19 in. to Arapahoe Basin, 20 in. to Vail, 21 in. to Beaver Creek and Breckenridge, 25 in. to Copper Mountain, 27 in. to Irwin Lodge, 14 in. to Telluride, and 16 in. to Wolf Creek. It was a borderline warning situation with

65 avalanches recorded on the 11th–13th. The next two days saw the snow from this storm being blown off the ridges in the Northern and Central Mountains, resulting in another 20 avalanches.

A notable dust cloud was observed throughout the region during the third week of April. This originated on the Mongolian-China border and drifted over areas from Canada to Arizona for an unusual duration. It was about 4 miles thick over Colorado but had little effect except for haze obscuring the mountains.

Clear, sunny, warm, spring conditions prevailed on the 16th–19th, but almost no wet slides ran because there had been earlier wet avalanche cycles and the snowpack had settled and gained considerable strength by this time in April. However, one final April storm was poised to hit the mountains. On the 20th the jet stream brought winds that gusted to 75 mph at Berthoud Pass and Copper Mountain, and some very light snow fell that day. But the heaviest snow fell on the 22d–23d, when Breckenridge got 16 in.; Bear Lake, 18 in.; Vail, 19 in.; Aspen Mountain, 19 in.; and Wolf Creek, 11 in. A total of 41 avalanches was reported on the 22d–24th.

The Avalanche Center ceased its daily backcountry forecasts on the 23d, but remained open for highway forecasting as warranted until the end of the month. April in the mountains ended with sunny skies and afternoon temperatures in the 50s.

April snowfall was below normal in the North and Central Mountains, as Arapahoe Basin and Bear Lake got 80% of normal, and Gothic, 90%. However, Red Mountain Pass got 135%.

There were 244 avalanches reported in April: 88 in the Northern, 47 in the Central, and 109 in the Southern Mountains. There were only three avalanche incidents reported, but one of these was a fatal accident.

## *May*

A strong spring storm hit the Southern and Central Mountains on May 3–4 and dropped 18 in. at Telluride and Red Mountain Pass, 19 in. at Snowmass, and 22 in. at Gothic. In addition, 3–4 ft of snow was reported to have fallen around the town of Salida and Poncha Pass. 19 avalanches were reported on Red Mountain Pass, Loveland Pass, and Berthoud Pass.

On May 5 a backcountry skier was caught in a slide near Breckenridge, and on June 15 two skiers were caught, also near Breckenridge.

## *June*

One final avalanche incident occurred in mid-June. It happened on the 16th, 3 miles southwest of Loveland Pass on Torreys Peak. Alpine Rescue was evacuating an injured skier from the east face of the mountain when two skiers dropped into the gully above the rescue. They triggered a slow-moving, wet slide that buried the anchor system and other rescue gear. The avalanche guard shouted a warning and nobody was caught in the slide, but it could have been much more serious as debris also covered the work area where the injured skier had only recently been evacuated. All of the gear was eventually found. Thus the season came to an end.

One final avalanche incident...

# Information Acquisition

## Daily Weather, Snowpack and Avalanche Data

Aficionados of Sherlock Holmes stories know the snooping and brooding Holmes' success comes from his keen eye for observations and a quick mind to create deductions. Data—key for Holmes to solve a case—is essential for the Avalanche Center's forecasts. The Center relies on incoming data to make accurate assessments of current avalanche stability, and to make mountain weather and avalanche danger forecasts. There are two main sources of these data—the Colorado observer network and the National Weather Service.

***Colorado Observer Network:*** The Center has established a network of about 33 manned observation sites in the Colorado mountains. Twenty-one sites are developed ski areas, from which snow-safety personnel report current weather, snowpack and avalanche data. The remaining sites are highway, heli-ski, and backcountry sites from which volunteers or contract observers report to the Center.

***Snowmobile Observer Network:*** In its third season this volunteer network of observers—trained by the Center's staff—take snow and avalanche observations during the course of their backcountry excursions. Their observations are then e-mailed or faxed to the Center. This network supplies the Center with information and data from many distant mountain areas and has created a partnership with the Colorado Snowmobile Association that is unique in the avalanche industry.

***Backcountry Observers Network:*** During the past two seasons Scott Toepfer has forged a small network of avid backcountry skiers dedicated and contracted to providing the Center with avalanche and snowpack information. During the course of their recreational travels the observers gather information and data and send it to the Center before the next forecast day. The network supplies us with information found away from sites within our Colorado Observer Network.

***Remote Weather Net:*** The Center's network of remote, high-elevation weather stations provide forecasters real-time data any time during the day or night. The seven stations, located on Mt. Abrams in the San Juans, and Red Mountain, Lizard Head, Wolf Creek, Loveland, Berthoud, and McClure passes are all accessed via computer modem. Forecasters can also access similar stations located at several ski areas.

***National Weather Service:*** Avalanche Center forecasters have access to all products and expertise of the NWS-Boulder staff. Computerized weather maps, satellite imagery, radar data, and radiosonde data are all available from the state-of-the-art AWIPS workstations. Information is also available from manned and remote weather stations, and written analyses and forecasts. Additionally, discussions with NWS forecasters in interpreting data and products are an immense help.

## Westwide Avalanche Network

As a cooperative member in the Westwide Avalanche Network (www.avalanche.org) the Avalanche Center serves as a repository for avalanche accident data for the United States. Information on avalanche accidents is stored in a database maintained by the Center. It is used by Center personnel on a real-time basis and also for later analysis. Trends in avalanche accidents, relationships between survival and burial times and depths, and types of rescues are essential information to be passed along

to snow scientists, search and rescue teams, and the public. Lectures, field seminars, media contacts, and publications by Center personnel are some of the methods for disseminating this information.

Additionally, the Center responds to about 30 requests a year for raw or tabulated data. These requests come from the ski industry, the Forest Service, universities, secondary schools, snow researchers, consultants, and lawyers.

## *Accident Investigation*

Avalanche Center personnel try to investigate all significant avalanche accidents and fatal accidents. This winter the Center staff investigated several accident sites and interviewed witnesses. Information obtained from field data, witnesses, survivors, and rescuers is used for current stability evaluations and for future educational purposes.

# Dissemination of Hazard Forecasts

The Colorado Avalanche Information Center provides vital information to the public, specialized audiences, and sponsors. Following are the means by which the Center disperses information on mountain weather, avalanche, and snowpack conditions.

## *Public Hotlines*

Data from some 35 field-observation sites are used to prepare forecasts for seven hotlines in Colorado. People can call for three types of information: an up-to-date mountain weather forecast, a current snow condition report, and an avalanche hazard evaluation. Long-time phone sponsors include the USFS in Denver and Aspen; the Mountain Shop in Ft. Collins; the Mountain Chalet in Colorado Springs; Pine Needle Mountaineering in Durango and the Summit County Rescue Group in Summit County.

This winter a total of 54,586 calls was placed to the hotlines, 11,341 fewer than last year. We believe this is due to the increasing number of people who are getting e-mailed forecasts through Friends of the CAIC, and off of the CAIC Web site. The following table breaks down the call counts by location. The hotlines in Aspen and Vail do not have counters.

| Location | Phone # | Number of calls |
|---|---|---|
| Denver | 303-275-5360 | 12,802 |
| Fort Collins | 970-482-0457 | 3,414 |
| Colorado Springs | 719-520-0020 | 5,156 |
| Summit County | 970-668-0600 | 17,803 |
| Durango | 970-247-8187 | 15,411 |
| Aspen | 970-920-1664 | N/A |
| Vail | 970-287-5687 | N/A |

## *E-mail to Friends, Observers and Forecasters*

Our grassroots support organization, "Friends of the CAIC," was comprised of 651 members. For a contribution of $30, "Friends" who have e-mail receive a daily mountain weather forecast and snowpack evaluation. Friends who donated $45 or more also received an afternoon forecast via e-mail. About 307 members took advantage of this, which added substantially to our budget. CAIC observers and highway forecasters also get the forecast via e-mail. We have found this to be an effective and efficient way to distribute CAIC's regular updates. "Friends" also use e-mail to communicate address changes, make suggestions, and report avalanche occurrences and accident information to the CAIC. Approximately 149,000 forecasts were sent via e-mail to our Friends.

## *Web Site*

The Center's own Web site (www.caic.state.co.us) consists of 20+ different pages with a text information, pictures, and links that can be used by backcountry travelers, students and snow workers.

The most popular page is the daily-forecast page. It received 189,887 hits by the end of May. The public made a total of 532,975 hits accessing all of the pages on the site.

Figure 4 below shows CAIC's total product dissemination growth from all outlets. Note that hotline use has declined as e-mailed forecasts increased beginning in 1997–98. CAIC's Web site has become very popular in a short time and an increasing number of people are now getting the daily forecast via e-mail through our "Friends of the CAIC" program.

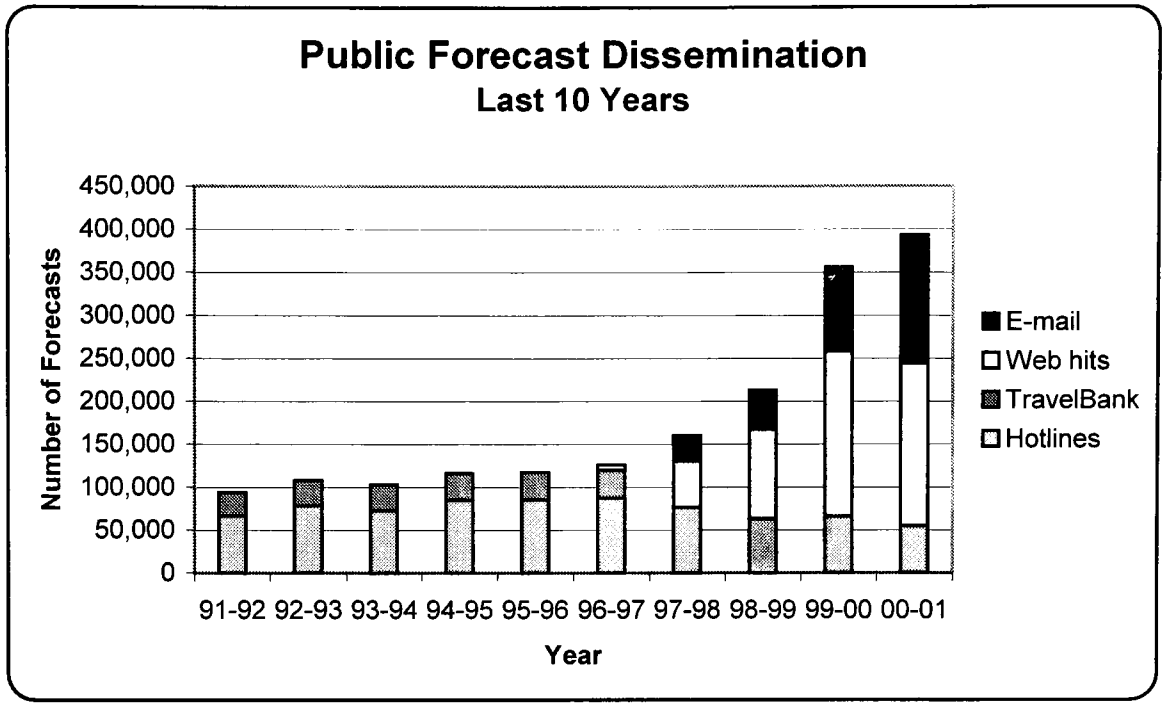


**Figure 4. Public forecast dissemination.**

## *Radio Broadcasts*

The Avalanche Center continues to enjoy a large listening audience through dedicated radio stations in mountain communities. This is especially beneficial to regions where long distance telephone calls to an avalanche hotline would be inconvenient and costly. While some stations broadcast our message daily, others have been most helpful by broadcasting Avalanche Warnings and Special Avalanche Advisories when necessary. Some stations conveying these bulletins include public radio KVNF-FM in Paonia, KOTO in Telluride, KVMT in Vail, KFMU in Steamboat, and KYSL-FM in Frisco.

## NOAA Colorado Weatherwire

During times when the avalanche danger is rated high or extreme, CAIC forecasters issue Avalanche Warning bulletins twice daily until the danger subsides and an Avalanche Warning Termination Bulletin is dispensed. Special Avalanche Advisories are issued when the avalanche danger could increase significantly if a storm forecast verifies. These bulletins are transmitted to the news media via the National Oceanic and Atmospheric Administration (NOAA) Weatherwire. Five separate warning periods covered 14 days and several one-day Special Avalanche Advisories were issued this winter.

## News Media

Throughout the winter avalanche-related incidents draw the public's, and therefore the media's, attention. These events usually involve people, property, highways, or anomalous mountain weather conditions. When this occurs, CAIC forecasters are obligated to respond to, and sometimes initiate contacts. Television, radio, newspaper, and magazine reporters from Colorado, other states and other countries are provided accurate information for broad news coverage. This winter the Center made 166 contacts with the media. For reasons of timeliness, the daily forecast is not issued through the printed media. However, it is not uncommon for the media to follow up on avalanche warnings, special advisories and accidents.

# Public Education

A prime responsibility of the Avalanche Center is to provide education about avalanches. Education is key to reducing avalanche accidents. Our education objective is achieved through the following means.

## *Avalanche Courses*

To meet the demand for the increasing numbers of avalanche education programs the Center utilized the teaching talents of Halsted Morris and former CAIC forecaster Denny Hogan. Morris coordinated the Center's education efforts and taught numerous courses across the state, while Hogan taught programs mainly on the west slope. The addition of Morris and Hogan ensures an active Center's presence in avalanche programs across the state and enhances the Center's reputation for the best avalanche educators.

Demand for avalanche education started early in October and the pace was fast and furious—averaging nearly 4 programs a week—until the last talk was given in May. By the end of the season the Center staff had spoken on 98 different occasions—about 20 more then in previous years—to some 4,042 people.

The programs vary from 1-hour seminars to multi-day field workshops. The scope and content varied from a simple overview of avalanche hazard to multi-day programs covering mountain meteorology, avalanche terrain recognition, the Colorado snowpack, methods of safe winter travel, and survival and rescue techniques. Students this winter included backcountry enthusiasts, professional ski patrollers, snowcat-skiing guides, search and rescue volunteers, law enforcement officers, members of ski and snowmobile clubs, the Colorado Mountain Club, USFS and the Colorado Department of Transportation.

Through our agreement with CDOT the Avalanche Center staff provided specialized training to CDOT winter maintenance personnel on avalanche awareness, rescue, safety, and avalanche reporting. Table 4 below lists all of the programs presented by CAIC staff.

**Table 4. Avalanche talks and seminars, 2000–01.**

| Date | Personnel | Group | Participants |
|---|---|---|---|
| 10/2–6 | D Atkins, M Mueller | ISSW, Big Sky, Montana | 600 |
| 10/9 | A. Gleason | CGS Earth Science Week, Red Mountain Pass | 11 |
| 10/10 | H. Morris | EMS, Denver | 46 |
| 10/13 | H. Morris | Backcountry Skiers Alliance, Golden | 212 |
| 10/14 | H. Morris | REI, Earth Science Day, Denver | 57 |
| 10/16 | D. Hogan | Salida Snowmobile Club, Salida | 25 |
| 11/1 | M. Mueller | CDOT, Wolf Creek Summit | 6 |
| 11/2 | D. Atkins | CDOT, Hidden Valley | 17 |
| 11/8 | D. Atkins | Mountain Miser, Englewood | 45 |
| 11/10–11 | Atkins, Morris | Custer Co. S & R, Westcliffe and Monarch Pass | 22 |
| 11/14 | H. Morris | Front Range Nurses, USAFA | 38 |
| 11/15 | Aleph Johnston-Bloom | Montrose Middle School, Montrose | 60 |
| 11–15 | D. Atkins | Alpine S & R, Evergreen | 29 |
| 11/16 | AG, JR, AJB | CDOT, Silverton | 37 |
| 11/16 | H. Morris | REI, BPPG, Lakewood | 33 |
| 11/18 | D. Hogan | Buena Vista Snowmobile Club, Buena Vista | 28 |
| 11/20 | R. Hunker | CDOT Patrol 15 | 9 |
| 11/21 | S. Toepfer | Vail Public Course, Vail | 50 |
| 11/22 | D. Atkins | Alpine S & R, Evergreen | 27 |
| 11/22 | S. Toepfer | Gore Range Natural Science School | 10 |
| 11/27 | H. Morris | Boy Scouts Troop 171, Boulder | 68 |
| 11/28 | R. Hunker | CDOT Patrol 6 | 6 |
| 11/28 | Hogan, Toepfer | Public Awareness, Crested Butte | 85 |
| 11/29 | D. Atkins | Alpine S & R, Evergreen | 32 |
| 11/30 | N. Logan | Mountain Chalet, Colorado Springs | 45 |
| 12/1 | D. Hogan | Public Awareness, Buena Vista | 40 |
| 12/2 | Atkins, Morris | Alpine S & R, Loveland Pass | 25 |
| 12/4 | H. Morris | The Logan School, Denver | 12 |
| 12/4 | H. Morris | Boy Scout Troop 712, Denver | 28 |
| 12/5 | K. Williams | Mountain Shop, Ft. Collins | 50 |
| 12/5–6 | D. Hogan | Snowcat Guide Course, Steamboat Springs | 24 |
| 12/6 | R. Hunker | CDOT Patrol 20 | 8 |
| 12/6 | Hunker, Schaefer | CDOT Patrols 21/22 | 10 |
| 12/6 | H. Morris | REI, BPPG, Denver | 73 |
| 12/7–8 | Morris, Hogan | Colorado School of Mines, Golden/Ike Tunnel | 20 |
| 12/9–10 | NL, DA, HM | Colorado S & R Board, Summit County | 70 |
| 12/10 | D. Hogan | AAE, Salida | 18 |
| 12/10–11 | S. Toepfer | Summit Huts, Francie's Cabin | 16 |
| 12/11 | S. Toepfer | Gore Range Mountain Works, Vail | 15 |
| 12/12 | M. Mueller | Public Awareness, Pagosa Springs | 34 |
| 12/12 | N. Logan | Summit County Awareness, Breckenridge | 110 |
| 12/16 | A. Gleason | Tri County Avalanche Training | 42 |
| 12/18 | J. Roberts | Telluride Mountain Club, Telluride | 35 |
| 12/19 | R. Hunker | CDOT Patrols 3 & 7 | 7 |
| 12/20–21 | S. Toepfer | Rescue Beacon Clinic, Breckenridge | 31 |
| 12/28 | M. Mueller | CDOT, Poncha Springs | 10 |
| 1/2 | D. Atkins | Loveland NSP, Denver | 14 |
| 1/3 | J. Roberts | CDOT | 4 |
| 1/4 | Logan, Morris | CMC Avalanche Instructors, Eisenhower Tunnel | 13 |
| 1/4 | H. Morris | REI, BPPG, Englewood | 55 |
| 1/5–8 | Toepfer, Gleason | Telluride Avalanche School, Telluride | 51 |

**Table 4. Continued**

| Date | Personnel | Group | Participants |
|---|---|---|---|
| 1/6–7 | Hogan, Morris | Colorado Snowmobile Assn., Leadville | 40 |
| 1/8 | K. Williams | Loveland Mountain Club, Loveland | 45 |
| 1/9 | H. Morris | Hill Middle School, Denver | 23 |
| 1/10 | D. Atkins | Neptune Mountaineering, Boulder | 65 |
| 1/11 | A. Gleason | Silverton High School, Silverton | 8 |
| 1/11–12 | H. Morris | Bent Gate, Golden/Eisenhower Tunnel | 9 |
| 1/12 | A. Gleason | Fort Lewis College | 52 |
| 1/12–13 | N. Logan | Ski Haus, Steamboat Spgs., Rabbit Ears Pass | 65 |
| 1/13, 17, 22, 25 | Roberts, Gleason | Prescott College, Silverton | 8 |
| 1/13 | D. Atkins | CMC Avalanche Instructors, Eisenhower Tunnel | 8 |
| 1/16 | K. Williams | Colorado Mountain Club, Golden | 40 |
| 1/16 | D. Atkins | National Park Service, RMNP | 21 |
| 1/18 | D. Atkins | Colorado Mountain Club, Golden | 40 |
| 1/19–20 | S. Toepfer | Aspen S & R, Aspen | 112 |
| 1/19–21 | AG, AJB, HM | Silverton Avalanche School, Silverton | 82 |
| 1/22 | N. Logan | Breckenridge Elementary School, Breckenridge | 35 |
| 1/23 | H. Morris | The Mountain Shop, Estes Park | 43 |
| 1/24 | K. Williams | The Mountain Shop, Ft. Collins | 30 |
| 1/24 | H. Morris | Colorado College, Colorado Springs | 87 |
| 1/26–29 | AG, AJB, DH | Silverton Avalanche School, Silverton | 80 |
| 1/27 | KW, DA, HM | The Mountain Shop, Cameron Pass | 32 |
| 1/29–30 | DH, HM, MM, SS | CDOT, Silverton | 28 |
| 2/1 | D. Atkins | CU Baker Science Dorm, Loveland Pass | 18 |
| 2/2–4 | D. Hogan | Silverton Avalanche School, Silverton | 49 |
| 2/4 | Logan, Morris | CMC Avalanche Instructors, Eisenhower Tunnel | 9 |
| 2/6 | N. Logan | Wilderness Medical Society, Breckenridge | 27 |
| 2/7–8 | N. Logan | Summit Professional Course, Breckenridge | 9 |
| 2/6–7 | Williams, Atkins | Colorado Mountain Club, Golden | 40 |
| 2/12 | M. Mueller | CDOT, LaManga Camp | 8 |
| 2/15 | H. Morris | DB Tanner (snowcat guides), Denver | 1 |
| 2/17–19 | S. Toepfer | Babes in the Backcountry, Francie's Cabin | 16 |
| 2/20 | H. Morris | Colorado Mountain Club, Golden | 45 |
| 2/20 | S. Toepfer | Skiing Magazine, Vail | 10 |
| 2/21 | Toepfer, Williams | Vail Ski Patrol, Vail | 32 |
| 2/22 | D. Atkins | Colorado Mountain Club, Golden | 40 |
| 2/23–25 | H. Morris | Pikes Peak Alpine School, Colo. Spgs./Pikes Pk. | 11 |
| 3/6 | M. Mueller | CDOT, Wolf Ck. & Pagosa Springs | 12 |
| 3/8 | D. Atkins | Bryan Mtn Ski Patrol, NSP, Boulder | 24 |
| 3/9 | J. Roberts | Sterling College | 4 |
| 3/12 | D. Atkins | USFS, Clear Creek Ranger Dist., Idaho Springs | 12 |
| 3/15 | K. Williams | Colorado School of Mines Alums, Denver | 25 |
| 3/20 | D. Atkins | AIPG, Denver | 33 |
| 3/28 | D. Atkins | High Plains Weather Workshop, Cheyenne, WY | 62 |
| 3/31 | H. Morris | 3-Pin Grin Beacon Clinic, Loveland Ski Area | 80 |
| 4/12 | D. Atkins | AIPG, Colorado School of Mines | 8 |
| 4/17 | D. Atkins | Mike Wiegele Heli-ski Guides, Blue River, BC | 25 |
| 5/7 | D. Atkins | Colorado Mountain Club, Golden | 76 |
| | | ***98 Courses*** ***Total*** | ***4,042*** |

Figure 5 shows CAIC's education data for the last 10 years. While there are peaks and valleys the figures remain fairly constant. When compared to the same data for the 1980s, the current numbers are significantly higher.

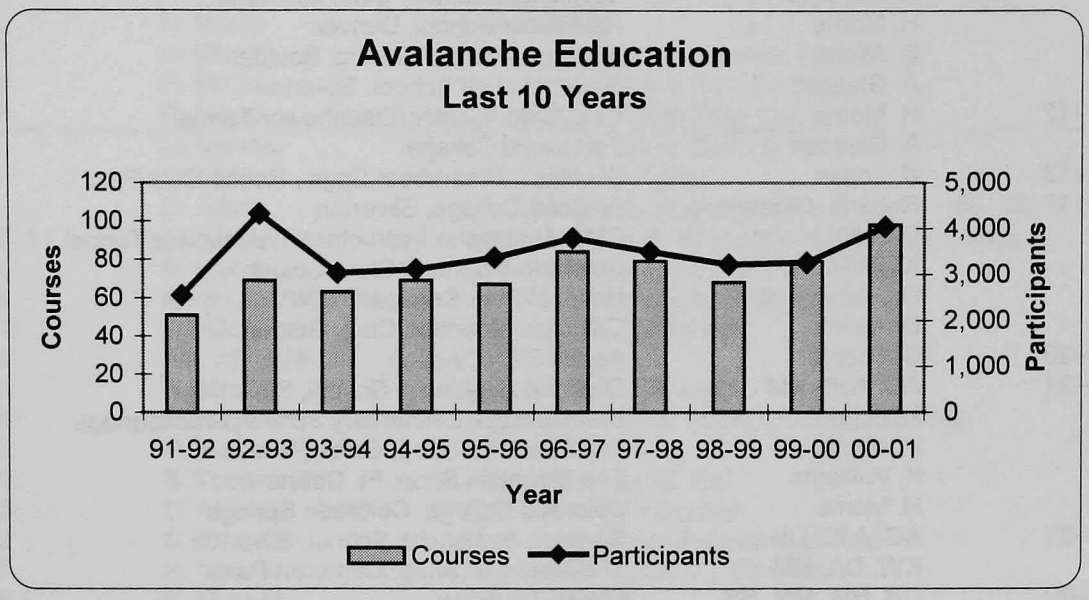


**Figure 5. CAIC avalanche education data for the last 10 years.**

## *Professional Conferences*

The Center's staff was busy attending and presenting at several national and international conferences. At the biannual International Snow Science Workshop held in Montana Atkins and Williams presented a poster on U.S. avalanche fatalities from 1950 to 2000. Atkins also presented a technical paper on human factors in avalanche accidents. Mueller presented a technical paper on snow stability trends at Wolf Creek Pass.

Later in the winter Atkins also presented general avalanche information at the National Weather Service winter-weather workshop held in Cheyenne, Wyoming. Nick Logan presented basic avalanche information at the annual winter meeting of the Wilderness Emergency Medicine Society held in Breckenridge.

## *Publications*

The Center's staff organized and wrote all articles for the Colorado Geological Survey's quarterly publication *RockTalk* (Oct. 2000). This issue featured the Center and what we are doing to mitigate avalanche danger in Colorado. During the winter the Center's staff was busy contributing to a variety of publications. Williams wrote for The Avalanche Review. Atkins had articles in the National Ski Patrol's Ski Patroller Magazine and in Backcountry Magazine. Scott Toepfer also had an article in Backcountry Magazine.

## *Web Site*

The Center's web page (www.caic.state.co.us) remains very popular. The site provides avalanche and weather information useful to novices and experts alike. In addition to the popular daily forecast page Internet surfers can get information, pictures, and graphics on all sorts of avalanche and weather related topics.

# Forecasting for Colorado's Highways

In 1992, Silverton was chosen for the location of the first CAIC–CDOT avalanche forecast office. Following a successful trial run under heavy winter conditions, the Statewide Avalanche Reduction Plan officially took effect on October 1, 1993. Now six CAIC avalanche forecasters are based in Silverton, Pagosa Springs, Carbondale and at the Eisenhower Tunnel. They prepare daily stability evaluations, provide recommendations for avalanche reduction and road closures, maintain weather and avalanche records and conduct avalanche training for highway personnel. CDOT provides the funds necessary to run this program.

Table 5 shows the impact of avalanches this season on Colorado's mountain highways. It lists the number of natural and explosive-triggered avalanches that reached the roadways. There was a significant increase (120%) over the previous winter with more than twice the number of slides reaching the pavement. Read on to learn more about the highway forecasting program and the winter's events for each forecast region.

**Table 5. Avalanches reaching Colorado highways (does not include bank-slips).**

| Forecast Office | Inclusive Highways | Natural Avalanches | Triggered Avalanches | Total |
|---|---|---|---|---|
| Silverton | U.S. 550 Ouray to Coal Bank Pass; U.S. 145 Lizard Head Pass; Colo. 110 (Silverton to Gladstone) | 117 | 219 | **336** |
| Eisenhower Tunnel | U.S. 40 Berthoud Pass; U.S. 6 Loveland Pass; I-70 Georgetown to Vail Colo. 82 Independence Pass | 7 | 89 | **96** |
| Pagosa Springs | U.S. 160 Wolf Creek Pass; U.S. 50 Monarch Pass; Colo. 17 Cumbres and La Manga passes | 33 | 4 | **37** |
| Western Slope | Colo. 133 McClure Pass; Colo. 139 Douglas Pass; Colo. 65 Grand Mesa; Colo. 24 Tennessee Pass; Colo. 82 Shale Bluffs, Snowmass Canyon; I-70 Glenwood Canyon | 10 | 6 | **16** |
| | | | **Total** | **485** |

## CDOT-Silverton Forecast Office

The Silverton Forecast Office has completed its ninth winter monitoring and forecasting avalanches for more than 100 slide paths along the U.S. 550 corridor from Coal Bank Pass on the south end to Ouray on the north end. Additionally, this office is responsible for avalanche forecasts along Colorado 145, Lizard Head Pass. Colorado 110 (Silverton to Gladstone) is also inspected for avalanche activity and snowfall accumulations.

The forecasters work closely with plow drivers who contribute valuable storm data and slide observations to help formulate the forecasts. Training, including procedures for avalanche rescue and personal safety, is provided to CDOT workers and others. This winter lead forecaster Andy Gleason and assistant forecaster Jerry Roberts prepared daily evaluations to keep CDOT apprised of avalanche conditions in their region. Intern Aleph Johnston-Bloom provided assistance by collecting study plot data, digging snowpits, monitoring avalanches and helping teach avalanche courses.

### Synopsis

The season started out quickly with 60 in. of new snow in November on Red Mountain Pass. There was less snow in December and a cold, clear period created a thick layer of well-developed depth hoar that persisted in the snowpack until a wet avalanche cycle in March. Missing this year were the large mid-winter storms of January and February and the large, full-depth avalanches that normally clean out much of the depth hoar. While there were more avalanches recorded this season they were generally smaller. This was due, in part, to aggressive, pro-active avalanche reduction undertaken by CDOT. The numerous control missions resulted in a record number of triggered avalanches in February. The wet avalanche cycle came early this year with numerous large, wet slides running in mid March. April brought some large storms that caused road closures right up to the last few weeks of the season.

### Weather and Snowpack Highlights

Snowfall totals were near average this year. Much of the snow fell in mid-winter in smaller but more frequent storms. Winds were a problem for drifting avalanche starting zones and creating poor visibility along the highways. The peak gust was 82 mph on Red Mountain Pass in April. The dominant wind direction was out of the southwest.

**Snow and Water Equivalent**

| Station | Total snowfall (in.) | Total water equivalent (in.) | Comments |
|---|---|---|---|
| Red Mountain Pass | 302 | 43 | 95% of average at seasons end* |
| Molas Pass | 259 | 24 | NA |
| Coal Bank Pass | 307 | 26 | 116% of average at seasons end* |
| Monument | 176 | 14 | 99% of average at seasons end* |
| Gladstone–CO Hwy 110 | 156 | 15 | NA |

*all data based on SNOTEL yearly averages.

The first avalanches triggered on Red Mountain Pass came in late October when there were numerous skier triggered releases on basal facets. The 60 in. of snow that fell in the first 2 weeks of November quickly became faceted when December arrived with clear skies and cold temperatures. This depth hoar layer increased the hazard during every storm where avalanche paths had not yet run full depth.

Because of the smaller snow amounts during the frequent storms this season, some paths did not slide on the depth hoar layer until early March. A wet avalanche cycle occurred in March after 5 days of warm temperatures that created an isothermal snowpack on all but north-facing aspects. A significant slide resulted in the Telescope which ran naturally and put 25 ft x 250 ft on the highway.

### Avalanche Mitigation

Avalanche control was conducted 22 times this season on Red Mountain Pass, Molas and Coal Bank passes, Lizard Head Pass and Colo. 110 to Gladstone. The avalauncher was utilized the most, the 105 mm Howitzer was used only five times this season. The helicopter was used twice and one of those was a training mission. Most control missions were conducted during spot closures when the highway was closed temporarily, and only at the locations of the control missions.

Full gate closures on Red Mountain Pass totaled 83 hours. Molas and Coal Bank passes were closed 30 hours. Spot closures occurred on 19 days from November through April.

**Avalanches Affecting the Highways**

| Highway | Natural | Triggered | Depths and Total Length in Feet of Debris on Centerline |
|---|---|---|---|
| Hwy 550/RMP [Hit road] | 72 | 153 | 1–20 x 6,934 (triggered)<br>1–25 x 2,140 (natural) |
| Hwy 550/RMP [did not hit road] | 141 | 652 | NA |
| Hwy 550 Molas/Coal Bank (hit road) | 4 | 26 | 1–5 x 875 (triggered)<br>1–5 x 285 (natural) |
| Hwy 550 Molas/Coal Bank (did not hit road) | 17 | 238 | NA |
| CO 145/Lizard Head Pass | 17 | 30 | 4 x 300 |
| CO 110 to Gladstone | 24 | 10 | 3 x 30 (triggered) |
| **Totals** | **275** | **1,109** | **10,564** |

### Media Contacts and Avalanche Training

The Silverton office had nine media contacts this year. These included newspaper articles in the Durango Herald, Denver Post, Telluride Watch, Telluride Times, Silverton Standard, and the Silverton Mountain Journal.

The Silverton forecasters taught avalanche courses for both CDOT personnel and the general public, reaching 643 people this winter. To do this, they dedicated some 135 hours in preparation and teaching, and 24 hours driving to and from these courses.

### Fundraisers

The Silverton forecast office partook in three fundraisers for the CAIC this winter. These were at Carvers Brewery in Durango, the Buen Tiempo restaurant in Ouray, and at the Swede Finn Hall in Telluride. These establishments were generous in their donations of time and money. Coupled with a very generous matching contribution from Rich Salem, the forecasters were able to raise about $10,000 for the CAIC.

## *CDOT-Pagosa Springs Forecast Office*

This office is located in the CDOT maintenance barn in Pagosa Springs and staffed by Mark Mueller. The office has completed its eighth winter of forecasting for U.S. 160, Wolf Creek Pass; U.S. 50, Monarch Pass; and Colorado 17, Cumbres and La Manga passes.

### Synopsis

Long-range weather forecasts that told us to expect near normal snowfall and temperatures this winter were quite correct. Snowfall was abundant at the southern passes this season and Monarch began the season dry, but received significant snowfall after the new year began. Highway Avalanche Advisories were issued regularly from November 6, 2000 to April 26, 2001. Avalanches effecting the highways were small and encounters between avalanches, motorists, and CDOT maintenance workers were minor.

### Weather Summary

On November 1 there was already 28 in. of snow on the ground at Wolf Creek Pass, but at elevations below 10,000 ft there was little to no snowpack. The largest storm of the winter hit the area at the end of January. It brought 66 in. of snow with 3.3 in. of water content over a four day period at Wolf Creek Pass. At times snowfall rates were very high. Strong winds caused widespread avalanching that effected the highways and led to the need for avalanche control. The maximum 24-hour snowfall accumulation was recorded during this period: 25 in. with 1.3 in. of water content. A maximum snow depth of 109 in. was recorded on March 18. Snow depth rose to over 100 in. again during a stormy April. This season's total snowfall was the third greatest in 8 years of measurements at this site.

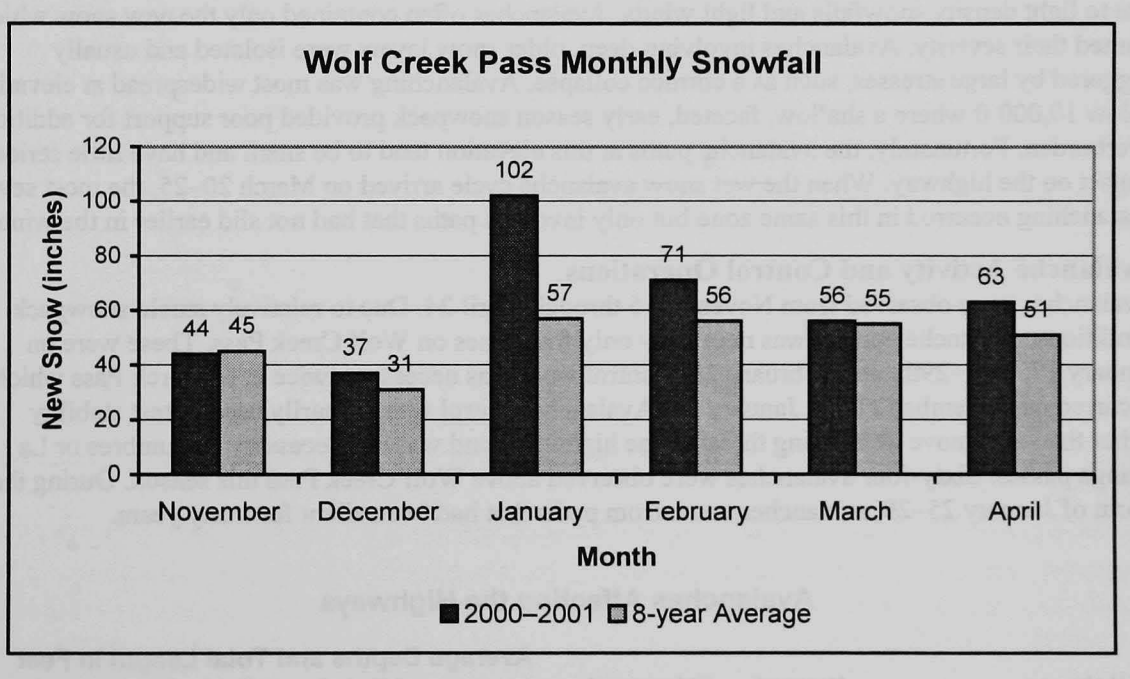


**Figure 6. Wolf Creek Pass monthly snowfall.**

Early season snowfall was very modest at Monarch Pass, but by late December snowfall increased and remained above normal for the remainder of the season. At Cumbres and La Manga passes much of the precipitation before November 1 fell as rain. Snowfall and avalanche activity were, as usual, less than at Wolf Creek.

**Snow Water Equivalent (inches)**

| Site | Nov | Dec | Jan | Feb | Mar | Apr | Total / Percent of Average |
|---|---|---|---|---|---|---|---|
| Wolf Creek Summit [1] | 2.9 | 3.0 | 4.7 | 7.5 | 5.1 | 8.1 | 30.2/m |
| Upper San Juan [2] | 3.0 | 3.6 | 5.8 | 8.3 | 4.6 | 8.2 | 33.5/125% |
| Cumbres Trestle [3] | 2.5 | 3.1 | 3.5 | 4.0 | 4.6 | 4.2 | 21.9/119% |
| Porphyry Creek [4] | 0.8 | 1.9 | 3.6 | 2.3 | 2.7 | 2.3 | 13.6/70% |

[1] Wolf Creek Pass Snotel site at Wolf Creek summit, south of the highway, 11,000 ft
[2] Wolf Creek Pass Snotel site at Wolf Creek access road, 10,200 ft
[3] Cumbres Pass Snotel site NW of Cumbres Pass, 10,040 ft
[4] Monarch Pass Snotel site NW of Monarch Pass, 10,760 ft

### Snowpack and Avalanche Highlights

At the southern passes, a strong, early season snowpack lost strength during extended periods of clear weather in November and December. However, when stormy weather returned in mid-January and continued for the next 2 months, the stress necessary for widespread avalanching was often lacking due to light density snowfalls and light winds. Avalanches often contained only the new snow which limited their severity. Avalanches involving deep, older snow layers were isolated and usually triggered by large stresses, such as a cornice collapse. Avalanching was most widespread at elevations below 10,000 ft where a shallow, faceted, early season snowpack provided poor support for additional overburden. Fortunately, the avalanche paths at this elevation tend to be small and have little serious impact on the highway. When the wet snow avalanche cycle arrived on March 20–25, the most severe avalanching occurred in this same zone but only involved paths that had not slid earlier in the winter.

### Avalanche Activity and Control Operations

Avalanches were observed from November 5 through April 24. Due to relatively stable snowpack conditions, avalanche control was necessary only four times on Wolf Creek Pass. These were on January 17, 28th–29th, and February 28. Control work was necessary twice at Monarch Pass which occurred on December 21 and January 30. Avalanche control was primarily used to test stability rather than to remove an existing threat to the highways, and was not necessary at Cumbres or La Manga passes. Sixty-four avalanches were observed above Wolf Creek Pass this season. During the storm of January 25–29, avalanches came from paths that had been silent for many years.

**Avalanches Affecting the Highways**

| Highway | Natural | Triggered | Average Depths and Total Length in Feet of Debris on Centerline |
|---|---|---|---|
| Wolf Creek Pass | 29 | 2 | 2 x 1100 |
| Monarch Pass | 4 | 2 | 3 x 500 |
| Cumbres/La Manga | 0 | 0 | None |

The highways remained open to traffic the entire avalanche season except for delays for avalanche control. Wolf Creek Pass was closed for a total of 9 hours, and Monarch Pass was closed a total of 3 hours. The Howitzer at Wolf Creek Pass was re-targeted on November 30 because the original gun position had been moved the previous summer during construction activities. This caused an additional 4-hour delay.

### Avalanche Education

Mark Mueller also taught several avalanche classes this winter. Participants included both CDOT personnel and the general public. A total of 98 people attended these courses from November to March.

### Conclusion

Despite significant snowfall and a rather fragile snowpack, there was less serious avalanche activity than one might have expected. Although the season's snowfall was the third largest recorded, the highways remained open for almost the entire avalanche season.

## *CDOT-Eisenhower Tunnel Forecast Office*

This was the eighth season of operation for this office which is housed in the CDOT engineers building (Road Control) at the west portal of the Eisenhower Tunnel. Lead forecaster Lee Metzger and coworker Stu Schaefer staffed this office.

The forecast area, CDOT Region 1, includes U.S. 40, Berthoud Pass; U.S. 6, Loveland Pass and Interstate 70 from Georgetown to Vail. Cameron and Independence passes are monitored when required. Snowfall and weather data are gathered daily from snow study plots located at Road Control, Berthoud Pass, Loveland Pass, Vail Pass and the highway shop near the Arapahoe Basin ski area. Forecasters are on duty from November 1st through April 30 but continue into May if snow conditions warrant.

### Synopsis

The season of 2000–01 started off pretty well in terms of snowfall, especially when compared to last season when November showed the lowest total on record. Snow continued to fall into December, decreased in January, then picked up again through March and April. When all was said and done snowfall totals were slightly below average. Avalanches naturally followed snowfalls and the typical wind problems were always a factor.

The decrease in snow in January, accompanied by cold temperatures, allowed depth hoar to dominate the deeper snowpack and the threat of full-depth slides existed throughout the season. Depths on the master snow stakes continued to increase until mid April.

Overall, avalanche control efforts were quite successful and surprises were minimal. Control missions were more frequent this season due to the potential of snow failure within the many weak layers of the snowpack. Mixed results were noted on many occasions when one path would release only the new snow and others would release older layers deeper in the snowpack. By mid March heavy, wet snow also contributed to stresses applied to the weak snowpack. This make for a very interesting season.

### Weather

The winter started off very strong with consistent snowfall from November 1 through December. Berthoud Pass recorded close to 100 in. by the end of December. Wind events were common and speeds as high as 96 mph were recorded. As January approached snowfall diminished, temperatures remained cold and winds were average.

Snowfall increased again in February and was consistent into March. Some of the snowfall during March came with intensities of 2–3 in. per hour which resulted in road closures for both avalanche danger and visibility problems. These shower-type storms continued into April but with periods of very warm, nice days between storms.

One very significant event was noted in late April when a 2-day storm total exceeded 20 in. However, avalanche counts were minimal and the following warm weather helped the new snow settle significantly and gain strength. The following table and graph show how the snowfall was distributed this winter.

**Monthly Snowfall (inches)**

| Location | Nov | Dec | Jan | Feb | Mar | Apr | Total |
|---|---|---|---|---|---|---|---|
| Berthoud Pass | 27 | 72 | 24 | 40 | 61 | 48 | **271** |
| Loveland Pass, Tunnel Curve | 36 | 57 | 9 | 38 | 49 | 32 | **221** |
| Road Control (Ike Tunnel) | 29 | 54 | 10 | 36 | 59 | 47 | **233** |
| Vail Pass, summit | 12 | 49 | 21 | 30 | 48 | 8 | **168** |
| Vail Pass, Narrows | 14 | 30 | 13 | 29 | 42 | 19 | **146** |
| Arapahoe Basin CDOT Barn | 34 | 58 | 19 | 29 | 56 | 33 | **228** |

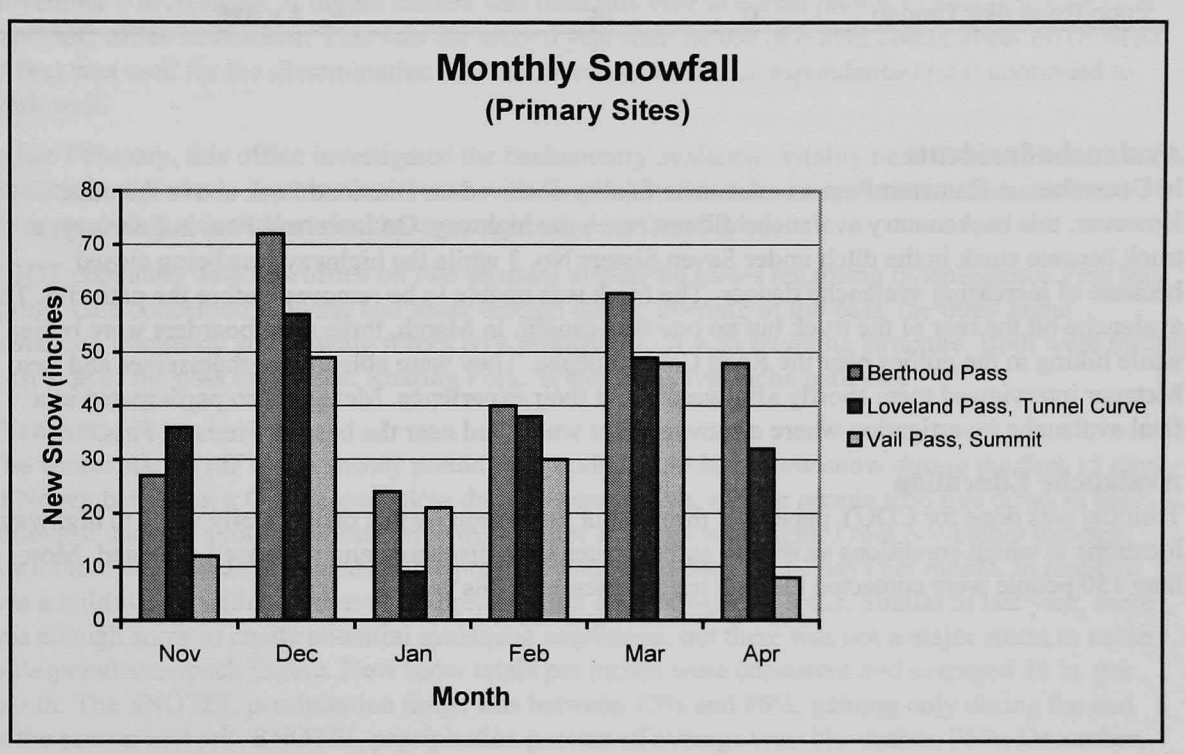


**Figure 7. Monthly snowfall for primary sites.**

### Snow and Avalanche

Avalanche activity was recorded on a consistent basis throughout the winter. Control work was first needed on November 11 and the last mission was on Loveland Pass on May 5 with significant results following a May storm. There were 37 avalanche control missions in the forecast region this season.

With a more observed weak layers in the snowpack than normal, explosive testing was recommended more often this season. The early snows of November and December turned to depth hoar during January with cold temperatures and little snowfall. Thus, the heavier snowfall and strong winds in February and March contributed to a snowpack that could not be trusted.

Typically when control missions produce avalanches that run full depth early in the season this does not occur again. However, that was not the case this season. The Stanley avalanche path and the Seven Sisters avalanche paths were repeaters this year with full-depth slides were recorded more than once. Weak depth hoar persisted toward the end of the season and the snowpack was monitored

closely for the potential of a wet-snow avalanche cycle. This, however, never occurred. The following table shows the winter's avalanche activity that reach the highways.

**Avalanches Affecting the Highways**

| Highway | Natural | Triggered | Average Depths and Total Length in Feet of Debris on Centerline |
|---|---|---|---|
| I-70—Georgetown to Vail | 1 | 22 | 3 x 880 |
| U.S.-6—Loveland Pass | 6 | 49 | 4 x 1,375 |
| U.S.-40—Berthoud Pass | 0 | 4 | 8 x 320 |
| Loop Road (Ike Tunnel) | 0 | 14 | 3 x 825 |

### Avalanche Incidents

In December on Cameron Pass an avalanche fatality occurred on Diamond Peak above the pass. However, this backcountry avalanche did not reach the highway. On Loveland Pass in February, a truck became stuck in the ditch under Seven Sisters No. 3 while the highway was being closed because of increasing avalanche danger. The truck was unable to be removed before the path slid. The avalanche hit the rear of the truck but no one was caught. In March, three snowboarders were buried while hiking in the gullies near the Road Control office. They were able to free themselves and Lee Metzger interviewed them shortly afterward about their experience. Metzger also participated in a fatal avalanche investigation where a snowmobiler was killed near the base of Fremont Pass.

### Avalanche Education

Training was done for CDOT personnel throughout the season by this office. Daily visits to highway locations in which conditions as well as safety issues were discussed and were well accepted. More than 150 people were contacted through training sessions this year.

## *CDOT-Western Slope Forecast Office*

The Western Slope Avalanche Forecast Office, based in Carbondale, provides avalanche forecasts to Region 3, Maintenance Section 2, for four highways in the Central Mountains and for the opening of Independence Pass in the spring. State Highway 133 over McClure Pass near Marble is the primary area of responsibility, with additional forecasting for Highway 139 over Douglas Pass, Highway 65 on Grand Mesa, and U.S. highway 24 at Battle Mountain.

Forecaster, Rob Hunker issued 50 regular-season *Avalanche Hazard Advisories* to CDOT from November 7 to April 13. A digital camera was used this year to e-mail photos of events to CDOT & the CAIC office in Boulder. This was the second year that the use of e-mail communication (instead of fax) was used for the dissemination of *Advisories* and other correspondence and it continued to work well.

In late February, this office investigated the backcountry avalanche fatality near Crested Butte. Media contacts included two separate interviews with Grand Junction television stations, channels 8 and 11. One was during an actual avalanche control mission on Grand Mesa.

CDOT consulted with this office on two separate avalanche issues regarding Independence Pass this spring. One concerned plowing and snow erosion during opening of the pass, the other about avalanche frequency and flowing forces on a proposed rock wall retaining structure. Both were for the west side of the pass in the East Roaring Fork, Water Hole avalanche path area.

### Weather

The winter started off with a snowy period that produced 50 in. of new snow during the first 15 days of November. From a CDOT snowplow driver's perspective, and for people who live down in the valleys, it snowed a lot this winter. However, water contents were light. From November through April there were 69 days of measurable precipitation, an average of 12 days per month. In reality it was a mild winter with below average precipitation and snowpack depths. Similar to last year, there was enough snow to create potential avalanche conditions, but there was not a major storm to cause widespread snowpack failure. New snow totals per month were consistent and averaged 36 in. per month. The SNOTEL precipitation range was between 75% and 86%, gaining only during the end of the season in April. SNOTEL precipitation percent of average was: November, 75%; December, 78%; January, 77%; February, 86%; March, 82%; and April, 86%. The total snowfall amount for McClure Pass was 219 in. The following graph shows a breakdown of monthly snowfall totals on McClure Pass.

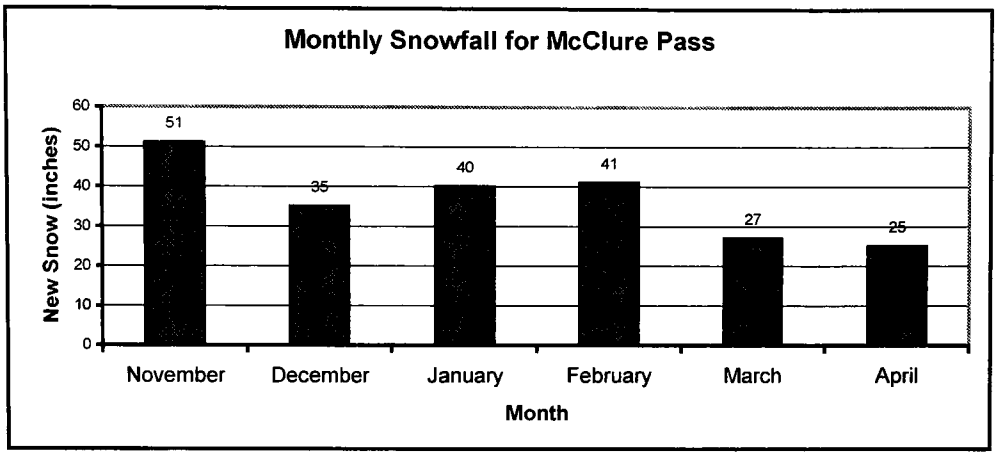


**Figure 8. Monthly snowfall for McClure Pass, Colorado.**

### Snowpack and Avalanche Summary

This avalanche season balanced on the edge between stability and instability. The pattern of snowfall followed by a periods of dry, cold weather created the classic Colorado depth hoar near the ground and thin, mid-pack faceted layers. The snowpack water content was 100% of average at the end of November, but the rest of the season remained in the low-to-mid 70% range. The ongoing discussion was, "How much more load would the snowpack take before failure?" While the depth hoar layer was weaker than normal, it did not fail. Precipitation intensities throughout the season were light which resulted in a "bridging," mid-pack slab. The potential was there for a major avalanche cycle, but it never happened. During an early wet avalanche cycle in March, and another in early April, intermittent slab avalanche releases in the backcountry occurred in both normal and unusual places.

There was only one road closure in Region 3 during the season. That was on Grand Mesa on February 22 to test stability with explosives. Two small, wet slab and loose snow avalanche cycles occurred on Battle Mountain and McClure Pass on March 7–9, and again from the 22d–24th. These deposited generally small amounts of snow on the highways but did not require road closures. Somewhat larger avalanches occurred on March 23 in Lone Tree and Hairpin bowls on McClure Pass but did not reach the highway. This was another very unusual winter for Grand Mesa because it is normally closed from five to nine times per season for avalanche control work. In fact, this was another very unusual winter for all the other avalanche hazard areas. On Douglas Pass no avalanches reached the highway, and even a significant wet avalanche cycle did not occur this year. After the small wet avalanche cycles in early March, the snowpack on McClure Pass, Battle Mt and Douglas Pass began to melt out. The avalanche season ended by mid April. A summary of road closures and avalanches reaching the roads is shown below.

**Avalanches Affecting the Highways and Road Closures**

| Highway | Natural | Triggered | Road Closures |
|---|---|---|---|
| CO 133/McClure Pass | 7 | 0 | 0 |
| CO 65/Grand Mesa | 0 | 6 | 1 |
| CO 139/Douglas Pass | 0 | 0 | 0 |
| U.S. 24/Battle Mountain | 3 | 0 | 0 |

# Severance Tax Projects

Severance tax is paid by the producers of oil, gas, coal and a few minerals, and goes into an operational account to be used for (among other things) the legislative charge of mitigating geologic hazards, which includes avalanche hazards. The Minerals, Energy, and Geology Policy Board (MEGA Board) has oversight responsibility of the fund.

We used severance tax revenue to fund several projects that will help us make better forecasts and expand our outreach. Some had immediate results in the form of a product, while others were projects lasting more than a year and will produce deliverable results in the near future. Here are brief descriptions of the projects.

**Weather and Avalanche Database**: All historical weather and avalanche data gathered by the CAIC beginning in 1983 is being converted to an Access database. This is a 2-year project that is nearing completion. The historical data will be available for retrieval by the forecasters, for research projects, and for developing nearest-neighbors models. Project leader, Nick Logan.

**GIS Highway Map**: We have converted the CAIC-CDOT Highway Avalanche Atlas to a GIS. This will be made available on CD-ROM and will have photos, maps, and physical and historical data attributes for these slide paths. It will be a valuable tool for CAIC forecasters, CDOT maintenance and engineering personnel, and land-use planners. Project leader, Dale Atkins.

**Web Site Clickable Map and Danger Rose**: With the help of an outside contractor, we have developed a clickable map for our Web site that will show the 10 avalanche zones of the Colorado mountains. The idea is for a user to click on a zone, town, or mountain range and get current snow, weather, and avalanche data. Additionally, we will have a graphical presentation of the current avalanche danger ratings (danger rose), which will display the avalanche danger elevation and aspect (compass bearing). This system will be operational on our Web site next winter. Project leader, Dale Atkins.

**Avalanche Forecast Model (Nearest-Neighbor Model)**: Nearest-neighbor avalanche forecast models have been used in Europe for 20 years. With inputs of current snowfall, wind, temperature, snow depth (and other field data), the model searches an historical database to find the days in the data set that nearest match the input data. The model then displays the avalanche activity that occurred on those days, which gives the forecaster a heads-up on what could happen.

This winter we bought the NXD2000 model developed by the Swiss Federal Avalanche Institute and installed it in our Silverton Forecast Office. We tested it with local data and will use it as a forecast tool in the winter of 2002. In addition we have revised a different model developed by the Department of Geophysics at the Colorado School of Mines for the Berthoud Pass area and will put it in use in 2002. Project leader, Dale Atkins.

**Backcountry Observers Network**: We contracted with eight observers in key backcountry areas to have them gather and send data to the CAIC forecast office in Boulder. We have trained each and have provided computer software for plotting snow profiles. The data add detail and accuracy to our daily hotline messages. This will be a continuing program. Project leader, Scott Toepfer.

**Observers' Manual**: We have created a manual of proper methods of making weather and avalanche observations. This will be distributed next winter to all observers who gather and send data to the CAIC forecast office in Boulder, to ensure consistent and accurate incoming data. Project leader, Nick Logan.

**Avalanche Education**: We hired Halsted Morris and Denny Hogan to teach 26 avalanche courses, which helped us meet the demand for avalanche education by the public and took some of the burden off the forecast staff. These were attended by 1,165 students.

**Web Site Maintenance**: The CAIC website is an important asset, for it makes thousands of people aware of the services and products that we provide. Last year we upgraded our Web site with a cosmetic facelift and more substance in the form of additional pages and content. We will continue to use Severance Tax funds as warranted to improve our Web site to make it a valuable outreach service. This year there were 532,975 hits on our Web site from people seeking avalanche information. Project leader, Dale Atkins.