AVALANCHE ACCIDENT REPORTING FORM
UTAH AVALANCHE FORECAST CENTER

I. General information

1. Date: **12 February 1992**

2. Time of Accident: **1500 hrs (est.)**

3. Exact Location: **Talking Mountain Cirque of Gold Basin in the Central Massif of the La Sal Mountains in San Juan County, Utah**

4. Victims:

Name	Age	Address	Condition/Injuries
Herbert Mark Yates	**37**	**Box 477, Moab, UT**	**Death by asphyxia**
Maribel Loveridge	**31**	**640 Locust Lane Moab, UT**	**Death by asphyxia**
Jeremy Kent Hopkins	**26**	**309 E 300 S Moab, UT**	**Death by asphyxia**
William V. Turk	**38**	**690 Westwood Moab, UT**	**Death by asphyxia**
Craig Bigler	**54**	**550 Mtn. View Moab, UT**	**Buried, but survived uninjured**
Steven Meleski	**34**	**3270 Rimrock Rd Moab, UT**	**Buried, but survived with minor injuries**

5. Eyewitnesses: **No witnesses other than survivors.**

6. Damage to vehicles, building, lifts, etc.: **None**

II. Accident summary

1. Events leading up to the accident.

The group consisting of Mark Yates, Maribel Loveridge, Bill Turk, Jeremy Hopkins, Craig Bigler, and Steve Meleski left the Geyser Pass trailhead (elev. 9600') at 1030 hrs on Feb. 12, 1992 for a backcountry ski trip in the central massif of the La Sal mountains in southeastern Utah. All party members were friends, were considered to be experienced mountain travelers, and most were trained, to varying degrees, in avalanche safety. All were equipped with rescue transceivers and shovels. Mark Yates was the program director for the La Sal Avalanche Forecast Center, which he had established in 1988, and which he ran as a contractor to the

U.S. Forest Service. Craig Bigler worked for Mark Yates as an assistant at the La Sal Avalanche Forecast Center. All party members were prepared for backcountry skiing, were wearing rescue transceivers, and were carrying shovels and other necessary equipment.

The group proceeded up the snow-covered road towards Geyser Pass, and after 1/4 mile left the road and took a short-cut through the woods, joining the Gold Basin road (also snow-covered) a short distance later. They followed the road a short distance and turned left onto the Laurel Highway, a summer road marked for ski touring. The Laurel Highway ascends gradually through open meadows and aspen groves before gaining a ridge which separates Horse Creek to the east from Gold Basin to the west. The party followed this ridge to a high point on the ridge known as Pre-Laurel, elevation 11,705'. In several places along the route the group experienced collapsing of the snowpack, and from the high point noticed at least one avalanche which had run out of a chute high on the north face of Mt. Tukuhnikivatz (elev. 12,482').

The party removed their climbing skins on the summit of Pre-Laurel, and prepared to ski down into Gold Basin on a southwest facing slope known as Goldminer's. The conditions on the slope consisted of new snow on a sun crust, and the group's evaluation of the slope was that it was quite stable. The group skied the slope without incident, and near the base of the slope (elev. 10,700') they ate lunch at approximately 1330 hrs.

After lunch the group put their climbing skins back on and began skiing up the Gold Basin valley through the forest and openings in the forest. Shortly after starting up from lunch the party again noted some collapses of the snowpack. The party emerged from timberline (elev. 10,800') at the base of Talking Mountain cirque, which forms the head of Gold Basin. Talking Mountain cirque lies below Talking Mountain (elev. 12,145'), so-called because of near-constant rockfall during summer months. The cirque walls wrap around to include aspects from east to north to west and southwest, and the cirque is open to the northwest. There is a small tarn or pond in the base of the cirque, and the cirque walls rise abruptly to the east and west of the cirque base, and more gradually to the south of the cirque base.

A few members of the party left their packs near the base of the cirque, carrying their shovels tied on their backs with webbing. After leaving timberline, the group did not experienced any further collapsing of the snowpack as they began climbing directly up the gradual north facing slopes which lie in the center of the cirque. They were heading due south towards a saddle in the ridge (elev. 11,740'). Their general destination was a large rock outcrop approximately 3-400' below the saddle and slightly to the east.

The slope they were climbing was quite gradual, from 15-25 degrees, while the northeast, north, and northwest facing slopes above them were 30-40 degrees. Their climbing skins allowed them to ascend the low angle slope directly in the fall line without the need for switchbacks. They measured the slope angle at one point, found it to be 23 degrees, and continued climbing. At least once during the climb the group stopped to assess the situation, but the

decision was made to continue slightly further.

The group was arranged single file, with Steve Meleski breaking trail, Mark Yates following at a short distance, Jeremy Hopkins, Maribel Loveridge, and Bill Turk close together some distance behind, with Craig Bigler trailing 50' further behind. At the point of slope transition where the angle increased to 30 degrees, Steve Meleski began to switchback to climb the steeper slope. All the party members were stopped and discussing whether they should continue when all except Bigler felt and heard a huge collapse of the snowpack. The party was commenting on the collapse when Craig Bigler noticed the slopes above them starting to avalanche and yelled "Here it comes." The time was approximately 1500 hrs.

2. Accident account

The collapse of the snowpack triggered three avalanches in the cirque, on northeast, north, and northwest facing slopes, and two of these slides ran down towards the group. As the slides approached, the party members attempted to scatter, but with their climbing skins on they did not get far before they were hit. Craig Bigler dove under the debris just before it hit him, and he felt himself carried for a short distance. Steve Meleski felt his skis come off shortly after he was hit, which allowed him to ride up in the slide. As the snow slowed, the second slide joined the first, pushing Steve further down slope. When the debris stopped moving, Meleski was completely buried with his face 2 to 3 inches below the surface, and Bigler was almost completely buried with only his hand out of the snow and his head buried about 1 foot deep.

III. Rescue

1. Self-rescue and hasty search:

Meleski proceeded to dig himself out of the snow, which took him approximately 15 minutes. He then climbed uphill to a dark object which turned out to be a rock. At this point he began a beacon search, and after approximately 10 minutes he pinpointed a signal and began digging. After 15 minutes of digging Meleski uncovered a ski and after 15 minutes uncovered Mark Yates enough to begin CPR. He continued CPR for 10-15 minutes with no response before noticing a shovel waving further down slope.

Craig Bigler had ended up near the edge of the debris, and while he was buried he could hear some moaning that persisted for about 5 minutes. Using his free hand, Bigler was able to slowly flip snow out of his hole, and managed to reach his shovel and begin digging himself out. Meleski ran down slope to help Bigler, and soon had him out of the snow. Meleski then returned to do CPR on Yates while Bigler searched and found Bill Turk with his beacon. Turk was buried about 3' deep, and his face was a pasty, muddy color.

Bigler then began another beacon search, and soon located two strong signals six to eight feet from Bill Turk's position. Bigler

used his probe to locate Loveridge under 3 feet of snow, and began to dig her out. Meleski returned to help Bigler and soon had her out of the snow. Hopkins was located directly underneath Loveridge, and as Meleski began CPR on Loveridge, Bigler continued to uncover Hopkins. Bigler looked at his watch as he was uncovering Hopkins and the time was 1600 hrs.

Meleski and Bigler continued CPR on Loveridge and Hopkins for the next hour, and finally gave up at 1715 hrs. The pair were able to retrieve their skis and one pole and began to ski out at 1720 hrs. They experienced numerous large collapses of the snowpack on the 5 mile ski out, and reached the trailhead at 1925 hrs. They traveled to Moab by vehicle and reported the accident to the Grand County Sheriff's office at 2020 hrs.

2. Description of search procedures:

Steve Meleski was the first person out of the snow, and in surveying the debris mistook a rock in the debris for a clue. He climbed up to the rock and began a beacon search. Beacon searches were used to recover all four of the victims, and only Bigler mentions using a probe to pinpoint Bill Turk's position. Meleski mentions digging down to Yates' ski first, then uncovering his body. There were no other apparent surface clues.

3. Time, location, and position of victims when found:

There is some discrepancy in the time lines described by Meleski and Bigler, but it appears that Bigler's version may be a more accurate reflection. The slide occurred at 1500 hrs, and Meleski has himself out of the snow by 1515 hrs, and Yates was probably recovered by 1545 hrs. Bigler states that by 1600 hrs they had reached Hopkins and had partially uncovered him.

Yates was found highest in the avalanche path, approximately 150 yards above the others. Meleski was near the east side of the debris and slightly below Yates. The remaining four were buried near the toe of the debris, and Bigler was near the west edge of the debris. Turk was buried just uphill of Bigler, while Loveridge and Hopkins were slightly to the east and on top of one another.

The exact position of all the victims is not known.

4. Depth of victims, length of burial, and condition and injuries:

Meleski was buried with his face 2-3" below the snow surface, Bigler was buried with his hand out of the snow, Yates was buried about 5' deep, Loveridge about 3' deep, Hopkins about 6' deep, and Turk about 2-3' deep.

It took Meleski about 15 minutes to dig himself out. Yates was probably buried 30-45 minutes before Meleski reached and uncovered him. Bigler was out of the snow about 45 minutes after the slide, and Turk was buried about 50 minutes before Bigler uncovered him. Loveridge and Hopkins were buried 50 minutes to one hour before they were uncovered.

The only apparent injuries sustained by the victims were a

sprained ankle suffered by Craig Bigler, and some trauma to the face and head suffered by Bill Turk.

5. Cause of injury or death:

The coroner's reports for those killed in the accident states that all died as a result of asphyxia or suffocation.

6. Secondary search and body recovery:

Bigler and Meleski notified the sheriff's office of the accident at 2020 hrs on 2/12/92. The sheriff notified Jerry Shaw, District Ranger for the US Forest Service Moab District of the Manti-La Sal National Forest. Members of the San Juan and Grand County's Search and Rescue teams, the newly-formed Southeast Utah Winter Hasty Team from Moab, and National Forest Personnel from Moab and Salt Lake City were alerted and advised to be at the Geyser Pass Trailhead on 2/13/92 for search and recovery operations.

Doug Abromeit, Winter Sport's coordinator for the Salt Lake District of the Wasatch National Forest arranged for explosives to be used to control other avalanche hazards in the accident area, and also arranged for a helicopter from Rocky Mountain Helicopters to assist in the recovery operation. On the morning of 2/13/92 Abromeit flew in the helicopter to Moab and met with other rescue personnel.

Members of the Hasty team and the Grand and San Juan County Search and Rescue teams met at the Geyser Pass trailhead and established a base camp for the recovery operations. Because the ground access route into the accident site crosses numerous avalanche paths, it was reasoned that the helicopter be used to transport rescue workers to the site. The early morning was clear, but by mid-morning a storm had moved in and heavy snow and strong winds were obscuring the mountains. With a forecast from the National Weather Service indicating improving conditions on 2/14/92, further recovery efforts were postponed until the following day.

The storm on 2/13/92 brought another 14" of snow, with a water content of 1.3" of water, as measured at the Soil Conservation Service Snotel site.

On the morning of 2/14/92, rescue crews again convened at the Geyser Pass trailhead, and waited for the helicopter and crew to complete avalanche control work with explosives. At 1010 hrs clouds lifted sufficiently to allow the helicopter to fly into Gold Basin for an assessment. The ship returned shortly to pick up Bigler to pinpoint the accident site. A visual assessment of the site determined that numerous avalanches had run onto the site and had covered the bodies with avalanche debris. The helicopter returned to the trailhead to off-load Bigler and on-load explosives, and then flew back into Talking Mountain cirque to perform avalanche control work on surrounding slopes.

Explosive control work using 35 explosive charges produced 6 avalanches, with fractures up to 4' in depth and several hundred yards wide. Nearly all the slide paths which affected the accident site had run at least once during the storm, and some paths had

obviously run more than once. Many of the slide paths which affected the ground access route were controlled, and several paths, including one known as the Funnel, performed spectacularly. The entire cirque was full of avalanche debris, and the control crew felt that the area was safe for rescue workers. However, there were several small avalanche paths that affected the ground access route which had not avalanched, and the control crew the only acceptable means of reaching the site was by helicopter.

The decision was made to transport all rescue workers to the site by helicopter, and to only use persons prepared and trained to travel on skis through avalanche terrain should the helicopter experience problems. The first rescuers were put down on the debris at 1330 hours, and a total of 12 rescuers were brought in to the sight. An avalanche guard was posted near the bottom of the cirque, while rescuers moved up to the accident site.

Shortly after reaching the site, rescuers picked up a rescue beacon signal, and at 1440 had recovered the body of Maribel Loveridge from under 10' of avalanche debris. (This first body was initially mis-identified as Bill Turk, and this error was corrected by the coroner at 0900 hrs on 2/15/92. This mis-identification proved to be misleading as Bigler and Meleski, who were on the site throughout the recovery, diagramed the layout of where the bodies had been when they had skied out. With Bill Turk's body located, it was presumed that Loveridge and Hopkins would be found further to the east. Rescuers were also uncertain whether the bodies had been moved by subsequent slides, and if so how far. Meleski confirmed that Turk's position was unchanged, and so the mis-identification slightly changed the area of focus.)

Two dog handlers from Rocky Mountain Rescue Dogs arrived at the site by helicopter at 1443 hrs and began working two rescue dogs.

At approximately 1500 hrs another beacon signal was pinpointed, and through probing a second body was located. (Meleski and Bigler both thought they had turned off all the rescue beacons when they had recovered the bodies initially, but they had in fact only turned off the beacons on the first two found, Yates and Turk. Since Loveridge and Hopkins were found last and together there was no need to turn those beacons off. And, since Meleski and Bigler assumed they would be returning the next day to retrieve the bodies, they did not think to turn the beacons back on to transmit.) At 1600 hrs, the body of Jeremy Hopkins was recovered from a burial depth of 12-15'. (Interestingly, subsequent avalanches had carried rocks down with the snow, and in trying to pinpoint Hopkins' body with probes, numerous rocks were hit before a probe went between two rocks to the body below.)

The weather began to deteriorate, with moderate snow falling, and at 1630 hrs the decision to evacuate the site was made. All workers were evacuated and safe by 1730 hrs.

On 2/15/92, rescue workers again convened at the Geyser Pass trailhead, and the helicopter made a pass of the site to inspect conditions. Some windloading was occurring along the ridges so the decision was made to do more explosive control work before re-entering the site. Only one small sluff was released with 7 charges, and by 0840 hrs all rescue workers were on the scene.

Organized probing began, and at 0940 hrs random probing discovered Bill Turk buried 14-16' deep. Probe lines continued in the areas where Mark Yates was expected to be found. Rocks in the debris produced numerous false strikes, including one that resulted in an 18' deep hole dug to investigate. The depth of the debris was found to be up to 30' in places, and most of the probes in use were 12' in length. At 1341 hrs, Mark Yates was discovered by a probe line, buried at a depth of 12'. The recovery operation was completed at 1514 hrs and all rescuers returned safely to Moab.

IV. Weather and Snowpack Data

1. Weather synopsis:

Much of the western U.S. experienced heavy snowfalls in November which established a stable early-season snowpack. However, the weather pattern developed a split in December which diverted the storm tracks north and south of the western states. This split flow persisted through January into early February, with monthly snowfalls well below normal. January snowfalls in Utah and Colorado averaged only 20 to 40% of normal, and in the La Sal mountains 31 days passed from January 7 to February 7 with no measurable snowfall. On the 6th of February the snow depths in the La Sals ranged from 31" at 9600' to 45" at 10,000', and the water content of the snowpack had dropped down to 64%.

During this extended period of dry weather extensive snowpack weakening occurred throughout the western U.S. The snowpack on the ground in most mountain locations in Colorado and Utah consisted almost entirely of faceted snow ranging from large-grained depth hoar to fine-grained upper-level faceted snow and surface hoar. By the first week of February the entire snowpack in the La Sal mountains consisted of cohesionless and unsupportable faceted snow crystals.

Near the end of the first week of February high pressure began to give way to storms tracking through the southwestern U.S. Snow began to fall in the La Sal mountains on the afternoon of February 7th, and by the morning of Feb. 8th 3-4" of snow had accumulated, with .3" of water. A low pressure center off the California coast continued to push small amounts of moisture into the La Sals for the next several days, with occasional breaks in the weather. An additional inch of snow fell on 2/9, another 2" on 2/10, 1 1/2" on 2/11, and 1-2" early on the morning of 2/12. By the morning of Feb. 12th 10" of snow had fallen since 2/7, with .8" to 1.1" of water. All snow and water amounts are from the La Sal Avalanche Forecast Center snow study plot and the Soil Conservation Snotel site, both located near the Geyser Pass trailhead at 9600'.

Temperatures during the period from 2/7 to 2/12 were fairly constant, with daytime highs in the 30's and 40's and nighttime lows in the upper teens and low 20's. The periods of precipitation were accompanied by gusty southwest winds at speeds of 15-30 mph along the ridgetops, while on days without precipitation the winds were light and variable.

Snow showers continued into the morning of February 12th, and at 1030 hrs on 2/12 there were scattered clouds over the La Sal

mountains. The temperature at 3 AM on 2/12 was 22 degrees Farenhite and the maximum temperature for 2/12 was 37 degrees F. The ridgetop winds most of the day were from the southwest at 10-20 mph. At 1500 hrs on 2/12 skies were mostly clear and sunny.

2. Snowpack structure:

The snow climate of the La Sal mountains is more similar to that found in the mountains of Colorado than to the snow climate of the mountains of northern Utah. The mountains of Colorado usually experience small snowfall events at widely spaced intervals with long intervening periods of cold and clear weather. The mountains of Colorado have a very definite treeline, and winds above treeline are frequently quite strong, especially during precipitation events.

The snow climate in the mountains of Colorado is classified as continental, and the snowpack that typically forms in a continental snow climate is shallow and weak in structure. Long, clear weather periods metamorphose the snow that is on the ground into a variety of forms of faceted crystals, creating a weak snowpack structure. Even small loading events of new snow or wind drifted snow create an unstable situation which can linger for many weeks.

Continental snowpacks are often referred to as depth hoar snowpacks because a significant portion of the snowpack, usually the bottom half, is composed mainly of well-developed faceted snow, or depth hoar. Depth hoar snowpacks are notorious for maintaining instability for extended periods, as well as propagating failure in the form of collapse over long distances. These factors partly explain why Colorado has the highest avalanche fatality rate of any state in the country.

The La Sal mountains can be said to have a continental snow climate that is typified by a shallow and weak snowpack structure which maintains instability for extended periods. As mentioned above, the snowpack structure prior to 2/7/92 was shallow and extremely weak. The snowpack consisted almost entirely of cohesionless faceted snow crystals, interspersed with a few layers of slightly more cohesive snow. In short, the snowpack prior to 2/7 could be called a depth hoar snowpack.

During the extended period of fair weather from 1/7/92 to 2/7/92 many of the upper-elevation slopes were affected by wind scouring and wind hardening of the snow surface. This resulted in an irregular snow surface pattern on the slopes above treeline. In some areas the snow surface was cohesionless faceted snow, while others, sometimes only a few feet away, had a supportable windslab of up to 4" overlying the faceted weak snow. The skiing at the upper-elevations prior to the accident was quite variable, with areas of bottomless sugar snow adjacent to breakable and unbreakable wind crusts and windslab. At the lower elevations, the snowpack was uniformly weak, consisting of cohesionless faceted snow from top to bottom, and many protected areas had large surface hoar as well.

The weakest layer in the pack was at or near the snow surface prior to 2/7, and consisted of a 10-20 centimeter thick layer of well-developed faceted snow crystals 1-2 mm in size. (See attached

snow profiles.) The majority of the avalanches subsequent to the accident on 2/12 ran on the upper-most weak layer, but many slopes avalanched two or three times, finally removing all the weak layers down to the ground. In fact, one of the subsequent avalanches which reburied the bodies carried numerous rocks down with it. It is presumed here that the avalanches which struck the party failed on the upper-most weak layer in the snowpack.

Because of the large number of avalanches which ran in Talking Mountain Cirque before recovery teams could access the site, the fracture lines of the original avalanches which struck the party were no longer visible. It was impossible to do a fracture line profile of the original avalanches, and the attached profiles were done two days after the accident. At the time the profiles were done there had been an additional 15-20" of snow since the accident, and the profiles are reconstructions of the snowpack which existed at the time of the accident on 2/12.

3. Were there warnings, restrictions, or closures in effect?

There were no warnings, restrictions, or closures in effect in the La Sal mountains at the time of the accident. The avalanche forecast issued by the La Sal Avalanche Forecast Center on 2/11/92 at 7:30 PM read as follows:

> "Regarding avalanche concerns, conditions are deteriorating as we steadily load our predominantly weak old snowpack. At present the main problem is the winds, which are transporting our new snow onto leeward slopes, causing both wind slabs and pockets of greater deposition. Most of these are sitting on old windcrusts or several inches of sugary recrystallized snow on a slab. Both are bad scenarios. These loaded pockets now have a moderate potential for human triggered slides on slopes steeper than 30 degrees. You'll find them primarily on northerly and easterly facing, at and above timberline terrain, with a few deposition areas on the downwind side of terrain features on south and west aspects. Right near the ridgelines, expect the hazard to be high over 35 degrees. At this point, most of the below timberline terrain continues to have a low or isolated potential for failure, but the new snow is loading up our widespread weak depth hoar. How much snow an area will hold is going to vary considerably, with some spots being depth hoar top to bottom, others with this sugar only in the mid and upper pack, plus many spots have a bit of a slab high in the old snowpack or suncrusts. Collapsing is already occurring in places, but for the most part the new snow will have to be a significant soft slab before the hazard is significant. Right now there is moderate potential on northerly facing open areas steeper than 35 degrees, but much more snow and it will become widespread.

Snowpack stability in the La Sal mountains, and in all of Utah's mountains, slowly began to decrease when the first snows in nearly a month arrived on the 7th of February. However, very little avalanche activity occurred in the first few days as the snow amounts were small. Avalanches were first observed in the

Wasatch Mountains on Feb. 11th, and on Feb. 12th an avalanche warning was issued by the Utah Avalanche Forecast Center for the Wasatch Mountains from Spanish Fork canyon north to Ogden canyon. This warning was expanded to all of Utah's mountains on Feb. 14, the first-ever statewide avalanche warning.

At the time of the accident, avalanche conditions were worsening throughout the western United States. As of the beginning of February there had been no avalanche fatalities, but by the end of the first week of March thirteen people had been killed in avalanches throughout the western states. By all accounts, it was one of the most deadly avalanche cycles of recent years.

Feb. 4	Cooke City, MT	1 snowmachiner killed
Feb. 11	Mt. Baldy, CA	2 out-of-bounds skiers killed
Feb. 12	La Sal Mtns, UT	4 backcountry skiers killed
Feb. 18	Vail, CO	1 backcountry skier killed
Feb. 23	Yellowstone, MT	1 snowshoer killed
Feb. 25	Mt. Sneffles, CO	1 backcountry skier killed
Feb. 29	Tetons, WY	1 snowmachiner killed
Mar. 1	Lost Lake, CO	1 snowshoer killed
Mar. 5	Red Mtn Pass, CO	1 highway worker killed

V. Avalanche Data

1. Type of slide(s) (classification): SS-AS-3

2. Dimensions width: 90 feet and 120 feet
length: 1080 feet
vertical: 540 feet

3. Crown height: Approximately 3 feet

4. Debris width: 150 feet
length: 450 feet
depth: 6-10 feet

5. Other comments: Because of the extensive avalanche activity which followed the accident, as well as the inexact accounts provided by the witnesses, it was impossible to determine exactly the dimensions of the avalanche or avalanches which struck the party. The data provided here is based on the location of the victims when finally retrieved, from topographic analysis, from knowledge of avalanche runout distances, and from what information the witnesses provided.

VI. Terrain Data

1. Elevation at crown: 11,640'
at toe: 11,100'

2. Aspect: NNE to NW

3. Slope angle in degrees, starting zone: 35-38 degrees

(estimated)
toe of debris: 23 degrees
(measured)
Alpha angle from toe to starting zone: 26.5 degrees

4. Vegetative cover (open, timbered, etc.): open

5. Shape of path (open slope, gully, etc.): open

6. Other comments: Talking Mountain cirque is a large alpine bowl entirely above timberline. Talking Mountain cirque is the furthest south of four large cirques in Gold Basin, and is also referred to as Cirque 3. Talking Mountain cirque is classic in shape, with a broad low-angle base and steep headwalls. The surrounding ridgelines are all above 11,800', and the peaks along the ridges rise to 12,400'.

The slope in the bottom of the cirque is long and gradual, and for nearly a quarter of a mile the slope angle is less than 25 degrees of steepness. At a distance of 800' from the ridge and 400' in elevation below it, the slope angle increases from 25 degrees up to 35 degrees in a distance of approximately 200'. The party was apparently at or within this slope transition when the avalanche occurred. The party had been climbing directly up the lower angled fan without the need for switchbacks, and Meleski had just begun the first switchback when the slide occurred. This indicates that the party was just beginning to climb up the steeper slopes that form the headwall.

VII. Conclusions and Recommendations

I would like to first look at the four main factors which create an avalanche accident. First of all, you need to have weather (1) which builds an unstable snowpack (2) which rests on a slope that is steep enough to cause an avalanche (3). Lastly, you need to have a person (4) in the way of the avalanche. There is no avalanche hazard until people are involved. Avalanches do not happen by accident, but rather for particular reasons, in particular places, at particular times. With the benefit of 20-20 hindsight we can analyze these four factors and their role in this accident.

1. The weather during the month preceding the accident resulted in the formation of a weak snowpack substructure which consisted largely of well-developed faceted snow. Starting on 2/7, snow began to accumulate gradually on top of this weak substructure, and by Feb. 12th 10" of snow containing .8" to 1.1" of H2O had accumulated at 9600'. More snow had accumulated at the higher elevations, as noted in the forecast of 2/11. Additionally, ridgetop winds through 6 days preceding the accident had been from the southwest, causing windloading of north and northeast facing slopes at the higher elevations.

Ten inches of snow with a water content of one inch spread out over 6 days would be an insignificant load were it to fall on a strong snowpack. However, this new snow fell on a very weak

snowpack, and each small increment of new snow brought the snowpack closer to critical instability. One inch of water weight is certainly a significant load on a weak snowpack, and that amount was reached by the morning of 2/12.

There does not appear to be any trend in the temperatures during the period that would have contributed significantly to the instability, and there is no other data to suggest that weather factors other than the recent snowfall and wind loading contributed to the accident. The weather on the day of the accident was generally fair and warm, and the weather at the time of the accident does not appear to have contributed to the instability. While the majority of avalanches happen during periods of stormy weather, a nearly equal majority of avalanche accidents happen during periods of fair weather, when people begin to venture into the mountains.

Weather data is hard to come by in the La Sal mountains, and this does make avalanche forecasting more difficult than in other mountain areas which are more-heavily instrumented and observed. Compared to the Wasatch Mountains of Northern Utah, which have over a dozen automated and modem-accessible remote weather stations and dozens of weather and avalanche observers, the La Sals are data-poor. The only sources of weather data for the La Sals are Soil Conservation Service (SCS) Snotel site at 9800' near the Geyser Pass trailhead and the La Sal Avalanche Forecast Center (LSAFC) weather station and snow study plots. The SCS site does provides maximum and minimum temperatures and reasonably good information on snowfall and water amounts, but Snotel sites are often unreliable and inaccurate. Unfortunately, at the time of the accident the LSAFC weather station was not in service and there was no available data on winds or temperature trends. Future operations would benefit by the installation of a modem-accessible weather station which provided reliable weather data from a representative location.

2. The snowpack prior to 2/7 was weak throughout the La Sal mountains, and forecasts from the La Sal Avalanche Forecast Center reflect the knowledge of that fact. It was also known, and accurately forecast, that any additional load of new snow would raise the instability dramatically. The forecast of 2/8 stated that the critical amount of snow was 6", while on 2/10 the amount was 5".

It appears that the rate at which new snow fell in the La Sals was deceiving. If the 10" of snow which had accumulated by 2/12 had arrived all at once, in one storm, instead of spread out over 6 days, this would have served as a red flag. As it was, the snowpack responded in the same way regardless of the rate of loading. Depth hoar does not respond to compressive stress by settling, but rather stores that stress until a critical level is reached and collapse occurs.

Collapse is one of the major indicators that a depth hoar snowpack has reached a critical level. The forecast of 2/11 notes that collapsing was already occurring, but the interpretation that the snowpack had not reached a critical level was incorrect. Collapsing of the snowpack was noted at several points along the

ski tour, but apparently was not considered important or relevant to the slopes the group was planning to ski.

There are other indications that the snowpack had reached a critical level. On 2/11 Jeremy Hopkins and Bret Sutteer had been skiing in Gold Basin and had experienced several large collapses of the snowpack. On the same day, 2/11, Hopkins had ski cut a short slope along the Gold Basin road, and this resulted in shooting cracks and a small fracture 12" deep and 10' long. The party skied past this slope on 2/12, and the party also noticed a recent avalanche high on the north face of Mt. Tukunukivatz.

The party did not dig any snowpits on 2/12, and after skiing a southwest facing slope into Gold Basin felt that the snow was stable. This southwest facing slope was later bombed with explosives on 2/14 and did not produce any avalanche activity, and in fact there was very little avalanche activity on any southeast, south, or southwest facing slopes. In many parts of the western U.S., south facing slopes have some of the stronger and more stable snowpacks because of the amount of solar radiation they receive. In the La Sal mountains, south aspects are often wind scoured as the prevailing winds are from the south and west.

One interesting comment that was made by Meleski is that as the party climbed into Talking Mountain Cirque the snow under the new snow was so hard and that this gave them some reassurance. It is likely that there was a hard windslab overlying the weak depth hoar. Snow that is quite hard on the surface is often mistaken as being stable, but it is not the strength of the strong layer that is critical but the weakness of the weak layer.

The party felt some collapsing of the snowpack soon after starting up from lunch, yet did not experience other collapses as they progressed up the bowl. It is possible that the party interpreted this fact as meaning that the collapsing was only occurring at the lower elevations, not in the wind-affected areas above timberline. This is sometimes the case, as strong winds effectively strip the weak snow away. However, in this instance, the majority of the snow on the ground consisted of cohesionless faceted crystals, and the wind had only put a cap of wind slab over this weak snow.

Collapsing is a potent mechanism for triggering avalanches, and is a progressive failure which travels through the snow in a process known as propagation. Collapsing of the snowpack occurs when the fragile substructure, consisting of porous and cohesionless grains, is overloaded to the point of failure. The failure is essentially a catastrophic compression of the pore space that exists between grains. On an inclined slope, this collapse has a resultant downslope vector which initiates shearing and loads the crown region with high tensile stresses. On a steep enough slope, the collapse will be the initial failure which starts the slab avalanche in motion.

A collapse travels through the snow as an advancing wave as adjacent regions are overloaded and collapse occurs. The rate of collapse propagation is not known, and is probably variable, but may exceed 100 feet per second. Collapses of the snowpack have been known to trigger avalanches at a distance of up to 1 mile from the original point of failure.

The party did experience a large collapse shortly before the avalanche started above them, and there is no question that this collapse triggered the avalanches that hit them and a third slide which did not. There seem to be no other extraneous factors which could have triggered the slide. The party did have time to comment on the collapse, and given that the slides started up to 1000' feet away, this lag time would be explained by the time necessary for the collapse to travel to the starting regions.

3. That the party was in avalanche terrain was known to most, if not all, of the members of the party. There are very few trees in Talking Mountain cirque, and those that are in the cirque and along the base show the signs of avalanche damage. The Avalanche Terrain Master Map created by the La Sal Avalanche Forecast Center labeled all the terrain in Talking Mountain cirque above the 11,000' level as having a High Avalanche Potential, while the base of the cirque down to 10,840' was labeled as having a Moderate Avalanche Potential. The party was at 11,300' when they were hit by the avalanche.

The slope the party was on at the time of the avalanche was not remarkably steep. The slope angle for the first 1600' of the climb into the cirque was 25 degrees or less. Avalanches are uncommon on slopes of 25 degrees or less, while they are most frequent on slopes of 30 to 45 degrees. If the entire slope had been no steeper than 25 degrees all the way to the ridge, it is very unlikely that there would have been an avalanche. It is likely that the party felt certain that they would not trigger an avalanche on a slope no steeper than 25 degrees, and they were not intending to go up onto the steeper slopes above them where the forecast for 2/11 accurately predicted the hazard was high. What the party did not realize is that they were connected to those slopes above them via the snowpack. It is likely that the party knew that avalanches could run to their position, but they did not expect that they could trigger a slide at such a long distance. The collapse they caused traveled through the snow to release the avalanches on the steeper slopes above.

Far more important than the angle of the slope you are standing on is the angle between you and steeper slopes above. This angle, which indicates the distance a avalanche can be expected to run, is called the alpha angle. Typical alpha angles are in the low to mid 20's, and in this case the alpha angle from the starting zone to the toe of the debris was calculated to be 26 degrees.

Because the party was on a low angle slope they were able to climb directly uphill without the need for switchbacks. This meant that the party members were nearly in a vertical line when the slide hit. The slide was not large relative to the whole bowl, but did not have to be to catch all of the party. It probably would not have mattered if there had been more distance between the members because they would still all have been in the same trajectory.

The question remains of what exactly triggered the collapse of the snowpack. Two answers are possible: either the person in the lead, or the group of three skiers close together. It is unlikely

that the second or last skiers would have triggered the collapse if they were climbing in the same track as the preceding party members. Likely either Meleski, in the lead, or the group of three of Turk, Hopkins, and Loveridge, with their combined stress on the snow in a small area, caused the collapse.

Traveling safely through large avalanche-prone areas is a difficult process, made more so by larger groups. Often even if you are spread out you are still in the same avalanche path. One of the most basic rules of thumb is to only expose one person at a time, but as the terrain size, and the group size, increases the problem becomes complex. Perhaps it would have been possible for one party member to remain at the base of the slope while the others climbed into the cirque. At least this would have left one person to initiate the search.

Incredibly, all six party members were buried, with no one to do the search. By the time Meleski had himself dug out, nearly 15 minutes had elapsed, and it took Meleski another 15-25 minutes to uncover Yates from 5' of snow. Bigler and Meleski were familiar with the use of their beacons and were proficient, yet by the time they had reached the others they had expired.

4. The victims of this avalanche accident typify the current trend in avalanche fatalities. A large percentage of recent avalanche victims have been experienced backcountry skiers, knowledgeable of and well-prepared for traveling in avalanche terrain. This party was certainly no exception. All were competent backcountry skiers, but were by no means were any of the group "extreme" skiers. All were equipped for traveling in avalanche terrain, carrying beacons and shovels. (Interestingly, Steve Meleski was using skis that had Voile releasable bindings on them, while the others were using cable or three pin bindings. Steve is the only person who's skis released in the avalanche, and he felt that this allowed him to stay near the surface of the avalanche.) All were members of a recently-formed Southeast Utah Winter Hasty Team. All of the party members had at least some knowledge that they were traveling in avalanche terrain. All of the party members were familiar with the terrain and some had skied in Talking Mountain cirque previously.

It is difficult to say exactly how group dynamics contributed to this accident. One subjective observation is that larger groups have a higher tolerance for risk, a phenomenon sometimes referred to as "risky shift". The larger the group the more likely that group is to do something individuals alone would not. Larger groups make communication more difficult and move more slowly through avalanche terrain. Group sizes of four or less are preferable for safe skiing in avalanche terrain.

Most troubling is that according to the survivors there was some disagreement regarding the stability of the snow and the chosen route. Several times while climbing up into the cirque the group discussed turning around, but the decision was made to continue. Apparently, at the time of the collapse failure the group was stopped and some of the party members were expressing their discomfort.

Perception is imperfect and is subjective. Rarely do we

perceive all the information available to us, and what we do pick up on is filtered by our beliefs and desires. What fits we accept, what doesn't fit we rationalize or reject. Seeing through "skier's eyeballs" leads us to interpret the data in a way that tells us the place we want to ski is safe. With "avalanche eyeball's" we see the data in a way that tells us whether the slope is likely to avalanche. For many avalanche victims, their skiing skills are better developed than their avalanche skills.

It is rarely possible to have all the information necessary to determine whether a slope will or will not avalanche. Avalanche forecasting is not a mystery, but it is an imperfect science. The human mind has a limited capacity to comprehend the complexity of the natural world, and avalanches are certainly complex. Humility and patience are very important to understanding the avalanche phenomena. It takes years to see all the different snowpack combinations that cause avalanches, and we are presumptuous to believe we understand them even after years of observation.

It is possible to determine patterns and trends that tell us when certain kinds of slopes may be likely to avalanche. It is possible to perceive clues to existing instability, such as recent snowfall, avalanches on similar slopes, wind drifted snow, collapsing sounds, and shooting cracks. Developing our senses to perceive these clues is a gradual process and one that is never complete.

Attachments:
Grand County and San Juan County Sheriff's Reports
Transcripts of interviews with Steve Meleski and Craig Bigler
Snow pit profiles
Soil Conservation Service Snotel data
La Sal Avalanche Center forecasts for 2/6 through 2/12/92
Newspaper articles
Terrain maps
Slope profile
Seasonal history chart
Death certificates