UNITED STATES **CAI-2000-18/19**
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION
UNDERGROUND COAL MINE EXPLOSIONS
JULY 31 - AUGUST 1, 2000

WILLOW CREEK MINE - MSHA ID. NO. 42-02113
PLATEAU MINING CORPORATION
HELPER, CARBON COUNTY, UTAH

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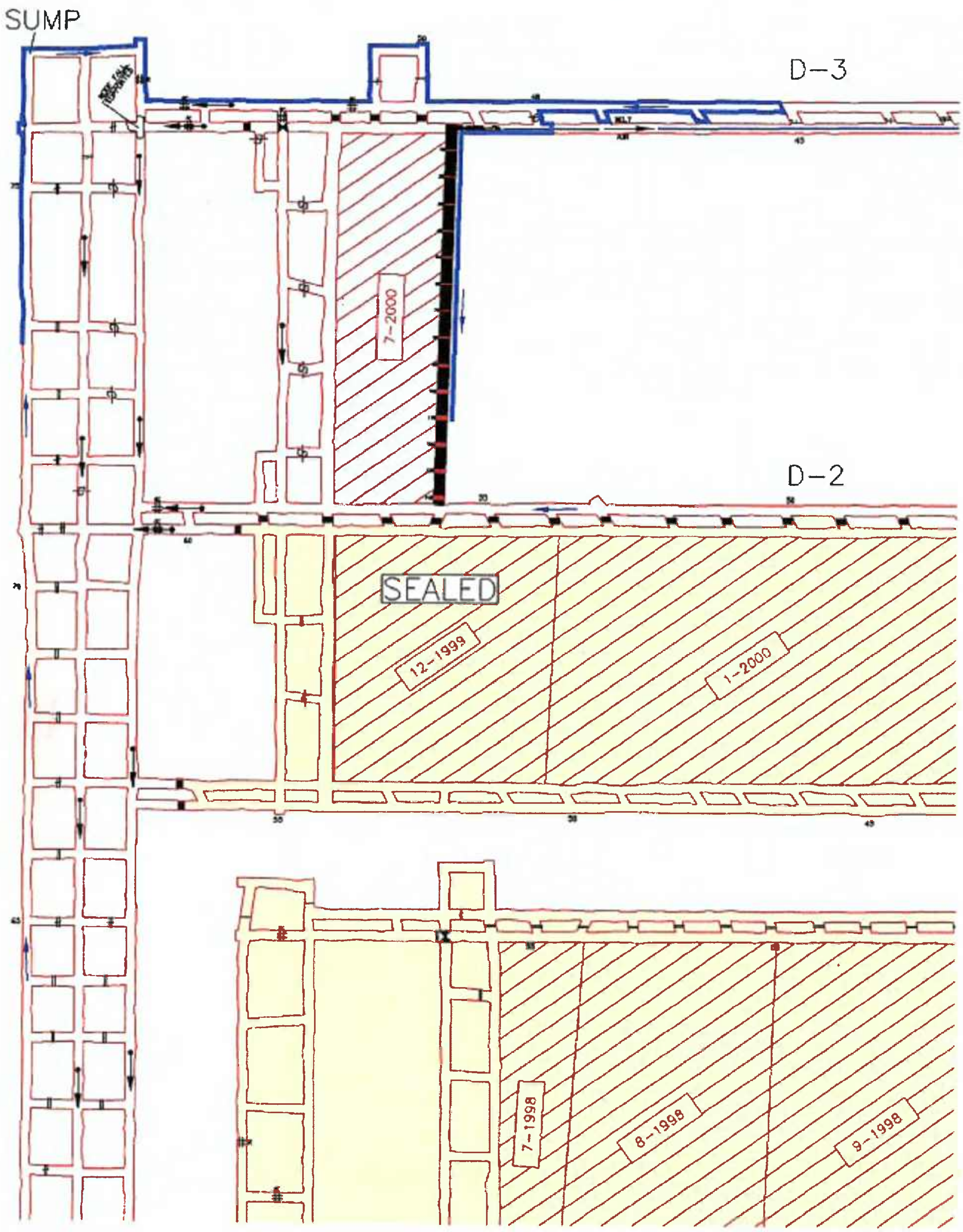
— IMMEDIATE AREA AFFECTED BY THE EXPLOSIONS



OVERVIEW

Beginning at 11:48 p.m. on July 31, 2000, a series of four explosions occurred in the Willow Creek Mine, an underground coal mine located in Carbon County, Utah. Most likely, a roof fall in the worked-out area of the D-3 longwall panel gob ignited methane and other gaseous hydrocarbons. This resulted in the first explosion and fire. Believing that a roof fall had occurred, personnel remained on the D-3 longwall section to extinguish a fire near the base of the shields on the headgate side of the longwall face. Eventually, liquid hydrocarbons became involved in the fire. Conditions worsened in the face area just prior to the second explosion. Two closely spaced explosions occurred at approximately 11:55 p.m. A fourth explosion occurred at 12:17 a.m. on August 1, 2000. Two fatalities occurred as a result of the second and third explosions. The fire provided the ignition source for these subsequent explosions. A mine rescue and recovery operation was conducted and all remaining survivors and the deceased were recovered by 4:00a.m. Appendix A is a list of the injured miners. Appendix E contains the accident data sheets.

The Mine Safety and Health Administration (MSHA) determined that the bleeder ventilation system did not adequately control the air passing through the worked-out area of the D-3 Panel. The system did not dilute and render harmless concentrations of methane and other gaseous hydrocarbons in the worked-out area where potential ignition sources existed.

The mine surface openings were sealed at approximately 10:30 a.m. on August 1, 2000. At present, there is no plan to reenter or reopen the mine. Accordingly, this report is based entirely on witness interviews and records obtained during the investigation. Should an underground investigation of the accident scene become possible in the future, an amended report may be issued.

GENERAL INFORMATION

The Willow Creek Mine is located along highway U.S. 191, four miles north of Helper, Carbon County, Utah. Beginning in 1996, the mine was developed from five drift openings by the room and pillar mining method into the Castle Gate "D" seam, which averages 20 feet in thickness. Mining heights ranged from 7 to 11 feet. The seam dips at 8 to 9 degrees toward the north. In 1999, RAG American Coal, Inc., purchased the property from Cyprus Western Coal Company, and operated the mine as Plateau Mining Corporation.

The mine had three operating sections which included two continuous miner sections and a longwall. The continuous miner sections were developing the right side of D Northeast Mains and the D-4 longwall headgate. Appendix I contains a copy of the mine map. Continuous miner sections utilized Joy 12CM-12 continuous mining machines, Joy 22SC and 32SC shuttle cars, and Fletcher CHDR17CH roof bolting machines.

The longwall section face equipment included a Joy 7LS double drum shearer, 142 Joy 2X920-UST shields, and a Joy M70976-9 face conveyor. The D-3 longwall panel was projected to be approximately 4200 feet long. The longwall face was approximately 815 feet wide. The orientation of this longwall panel was such that the inby headgate corner was the point of lowest elevation. The longwall section had commenced retreat of the D-3 panel on July 16, fifteen days prior to the accident. The top nine feet of the seam was being mined. The longwall had retreated approximately 250 feet at the time of the accident.

Conveyor belt haulage was used from each working section to the surface. Petitions for modification at the mine enabled two-entry longwall development. One of these petitions for modification permitted the use of belt entries as additional intake air courses to ventilate the longwall face during retreat mining. At the time of the accident, however, air in the longwall section belt entry was being coursed outby and was not being used to ventilate the longwall face. The longwall belt haulage entry was monitored for carbon monoxide (CO) by an atmospheric monitoring system (AMS).

The D-3 longwall panel was the third longwall panel mined. On November 25, 1998, an explosion and fire occurred in the worked-out area on the tailgate side of the D-1 longwall panel, the first longwall panel mined. All miners were evacuated safely and the mine was subsequently sealed at the surface. Recovery operations continued until November 15, 1999, when the longwall was recovered from the D-1 panel and the mine returned to normal operations. The ignition source for the November 25, 1998, event could not be determined with certainty because roof falls were discovered throughout the area where the initial event had occurred and this area was not recovered. However, the investigation concluded that the most likely source of the ignition was falling rock in the gob causing either a piezoelectric spark or a spark against a metal object (*see* MSHA Report of Investigation, Willow Creek Mine Fire, November 25, 1998). The Mine

Accident, Injury, and Illness Report Form 7000-1, filed by the operator, also stated that the 1998 fire was believed to have been caused by a roof fall in the gob which ignited hydrocarbons or methane.

After equipment recovery and sealing of the D-1 longwall panel, the D-2 longwall panel was successfully extracted. A flow-through bleeder system was utilized during extraction of the D-2 panel, whereas a wrap-around bleeder system had been used for the D-1 panel. The D-3 longwall panel was also ventilated with a flow-through bleeder system.

Through the first two quarters of 2000, the operator reported production of 1.1 million tons. During this period, an average of 227 miners were employed underground and 76 on the surface. Some of these miners were employed as contract employees. The longwall section produced coal during two 10-hour shifts, 7 days a week. Maintenance was performed between production shifts. Approximately once each week, a "double-up" day occurred during which twice the normal production personnel were present. Various non-production related work was conducted by the extra miners available during this time. The accident occurred during a "double-up" day. On the day of the accident, the additional personnel on the D-3 longwall section were performing the following tasks: removing the block stopping in Crosscut 48; retreating material and equipment; preparing for the construction of a seal in Crosscut 49; performing cleanup and rock dusting, and other related work.

The mine Non-Fatal Days Lost (NFDL) rate for January through June of 2000 was 7.86 while the industry average was 8.17. For the April through June quarter of 2000, the mine NFDL was 7.65 and the industry average was 8.60. The last complete regular inspection (AAA) by MSHA concluded on June 30, 2000. A regular inspection (AAA) had begun on July 1, 2000, and was in progress at the time of the accident. From January 1 through July 31, 2000, MSHA inspectors were onsite all but 15 days. MSHA inspectors were not onsite on July 31. Prior to the accident, MSHA inspectors initiated 256 enforcement actions during the year, as detailed on the chart below:

Type Enforcement Action	**Number Initiated 1/1/00 through 7/31/00**
104(a) non-S&S citation	50
104(a) S&S citation	183
104(b) order	3
104(d)(1) order	6
107(a) order	1
103(k) order	12
314(b) safeguard	1

DESCRIPTION OF ACCIDENT

The afternoon shift on July 31, 2000, started at 3:45 p.m. William Burton and Richard Callahan were the two afternoon shift supervisors. Burton oversaw the longwall operations and Callahan was responsible for the development operations.

Ernie Martinez, the regular afternoon shift longwall section foreman, had participated in mine rescue training on the day shift and did not work the afternoon shift. Burton assigned Roger McKinnon, continuous mining machine helper, to fill in for Martinez as a "Spellboss" for the shift. McKinnon was instructed to select three miners from the D-4 development section to perform outby work in the D-3 longwall section. He selected Charles Whitten, continuous mining machine operator; David Berdan, shuttle car operator; and Jas Mills, roof bolter helper. The longwall crew consisted of Wesley Ellner, tailgate shearer operator; Kyle Medley, headgate shearer operator; Tyson Hales, stageloader operator; Ronnie Gonzales and Shane Stansfield, longwall mechanics; and Cory Nielsen, propman. At approximately 3:50 p.m., the longwall crew, along with McKinnon, Whitten, Berdan, and Jas Mills, boarded the mantrip on the surface and traveled underground to the D-3 section.

Upon arrival on the D-3 section, the longwall face crew traveled inby to the face area. McKinnon spent about 15 minutes outby with Whitten, Berdan, and Jas Mills discussing their assignments before traveling to the longwall face. Mining commenced on the section with Ellner completing the tailgate cutout and then mining toward the headgate on the initial pass of the shift. During the shift, Ellner was to provide training to Nielsen on operating the tailgate drum of the shearer and Medley was to provide training to Ellner on operating the headgate drum.

After the shearer completed the headgate cutout, a wire rope was attached from Shield 1 to the shearer. The wire rope prevented the shield from tipping over when the pressure against the roof was released as the shield was advanced. This procedure was performed due to a mechanical problem with the anti-topple ram between Shields 1 and 2. After this operation was completed, Ellner gave the remote controls for the tailgate drum to Nielsen and observed Nielsen as he completed the clean-up pass from the headgate back to the tailgate.

As the shift progressed, Burton traveled into the mine and arrived on the longwall section at about 5:30 p.m. At approximately 6:00 p.m., McKinnon received a telephone call and was informed that the AMS indicated elevated levels of CO on the longwall belt. McKinnon left the face area and traveled on foot outby in the No. 1 belt entry searching for the source of the CO. He traveled to the box check at the mouth of the section but found no indication of CO. McKinnon returned to the longwall face at about 8.00 p.m. Burton advised McKinnon that the elevated CO levels were not associated with the longwall belt, but were in reference to a hot roller on Belt UG 3, which was repaired by outby personnel. About the same time, Vernon Marvidikis and Brent Howell, beltmen, began rock dusting the longwall belt from Crosscut 21 to Crosscut 47.

At approximately 9:00 p.m., Layne Willson, electrician, was instructed to take a wire rope into the D-3 section to replace one which had broken during an attempt to prevent Shield 1 from tipping over. Willson met Jas Mills several crosscuts outby and gave him the wire rope. Jas Mills delivered the wire rope to the face and Willson exited the mine. Burton had left the section and was outside by 9:30 p.m. where he talked to Henry Mills, midnight-shift maintenance foreman, and Kerry Hales, mine manager.

Ellner began the third clean-up pass from the headgate to the tailgate at approximately 9:40 p.m. As the shearer approached the tailgate, at 10:14 p.m., a sudden release of methane into the face area caused the shearer to de-energize. The longwall crew waited for methane levels to subside. When the methane did not clear readily, a washdown hose was utilized in an attempt to dissipate the methane, but this was unsuccessful. McKinnon arrived and instructed Gonzales and Medley to hang a piece of brattice to help sweep out the methane. It took approximately 42 minutes for the methane to clear. Although interruptions in production caused by methane were common, this was reportedly the longest interruption of the shift. Ellner completed the clean-up pass and the cutout at the tailgate.

Burton entered the mine around 10:45 p.m. and returned to the D-3 section. At Crosscut 47, he met Jas Mills and instructed him to bring a trailer from Crosscut 12 into the section. Burton went to the face and Jas Mills trammed the scoop outby toward Crosscut 12.

Medley and Ellner were in the process of mining the fourth cutting pass. Near Shield 35, Ellner gave his controls to Nielsen. McKinnon was at the tailgate with Gonzales washing down shields and making sure the tailgate panline was pushed to the face and the shields were advanced. McKinnon remained in the tailgate area until 11:30 p.m., when he began his preshift examination for the oncoming crew.

Nielsen completed the cutout at the headgate and the clean-up pass along the first eight shields. Shields 1, 2, and 3 were not advanced. The shearer was moved toward the headgate in preparation to attach the wire rope from Shield 1 to the shearer. Ellner was at Shield 8. Burton, Medley, Tyson Hales, and Nielsen were congregated in the headgate area. Stansfield was outby their location. Gonzales was shoveling at the tailgate and McKinnon was at mid-face taking an air reading. Whitten and Berdan had installed the check curtain in Crosscut 48. They were standing in the No. 1 entry at Crosscut 48. Jas Mills was hooking the trailer to the scoop in the No. 2 entry at Crosscut 12. Marvidikis was at Crosscut 8 in the No. 1 entry starting his preshift examination.

First Explosion

At 11:48 p.m., a methane explosion occurred on the headgate side of the D-3 gob. Outside in the mine office, Dean LaCotta, Jr., AMS attendant, observed that the system was reporting communication failures with many sensors surrounding the D-3 section. All of the miners on the D-3 section, and those in close proximity to the section, felt the forces of the explosion, but most miners interpreted the forces to be a result of a major cave in the gob. The physical effect of the explosion varied for each miner depending upon their proximity to the origin. Stansfield, probably located near Crosscut 49, was thrown by the forces and suffered rib injuries. Burton, located at Shield 3, was knocked down. Medley's hard hat was knocked off. Ellner felt a blast of air traveling from the headgate toward the tailgate and turned toward the face to shield his eyes from the suspended dust. When Ellner turned back toward the shield line, he observed sporadic blue flames in the toes of Shield 8. He shouted "fire" to alert the miners at the headgate. Medley and Ellner then observed flames at Shield 6.

McKinnon felt the air reverse direction briefly before returning to its normal direction. Gonzales also noticed an air change and heard a loud noise in the pillared area, originating from the headgate side of the gob. He called the headgate to inquire about the event and spoke with Tyson Hales. During their conversation, Tyson Hales became aware of a fire near the headgate and advised Gonzales of the situation. Gonzales immediately left the tailgate and traveled toward the headgate. He met McKinnon near mid-face. Gonzales suggested that they don their self-contained self-rescuers (SCSRs). McKinnon conducted an air quality test with a handheld detector and informed Gonzales there was no need for the SCSR. Following this conversation, McKinnon and Gonzales ran in the panline toward the headgate.

Jas Mills felt a slight overpressure at Crosscut 12. Assuming there had been a roof fall in the gob, he continued hooking-up the supply trailer and proceeded to take the trailer inby. Marvidikis felt a sudden burst of air at Crosscut 8 and also believed it was the result of a roof fall. He continued the preshift examination of the No. 1 entry. The forces caused Whitten to lose his hard hat and Berdan to be knocked to the mine floor. They traveled through Crosscut 48 and observed damaged SCSR units, the SCSR cache box, and other debris scattered in the No. 2 entry. In the face area, firefighting actions had commenced. Medley, using a washdown hose, and Nielsen, using a fire extinguisher, attempted to extinguish the fire along the shields. Ellner left the face to obtain additional fire extinguishers. Burton called outside to report a major roof fall in the gob and a small fire behind the shields. Burton also ordered evacuation of the continuous miner sections.

McKinnon and Gonzales reached the headgate area. McKinnon attempted to spray water with a washdown hose but the water would not reach the fire area. Additionally, the extinguishing agent dispersed by the fire extinguisher was observed suspended and moving very slowly along the face. Burton called to the surface again, and directed LaCotta to contact Jerry Dubois, second shift mine foreman. Dubois was instructed to send firefighting personnel and more fire extinguishers underground. Burton dispatched Gonzales and McKinnon to retrieve more fire extinguishers. Gonzales returned to the face and informed Burton that no more extinguishers were available on the section. Burton instructed Gonzales to bring rock dust to the area in order to fight the fire. Nielsen and Medley continued spraying water into the gob where the flames were visible. The fire would disappear when sprayed with water and reappear at other shields. The fire was migrating along the shield line.
Burton again called out and instructed LaCotta to call the mine rescue team and advise them that there was a fire at the mine.

Except for Medley and Nielsen, all of the other miners on the section were either obtaining fire fighting materials or preparing to evacuate the section. Ellner had backed the mantrip to between Crosscuts 48 and 49 where Stansfield, Gonzales, and Tyson Hales were located. Burton traveled through Crosscut 49 to the No. 2 entry and shouted that he needed fire extinguishers. He headed back toward the face. McKinnon picked up a bag of rockdust and headed toward the face. Whitten grabbed a fire extinguisher from the mantrip and followed. McKinnon reached the corner of the No. 1 entry, dropped the bag of rock dust, and turned to head outby to find another bag. Medley, at Shield 15, sensed that the situation was worsening. He observed that the fire was now burning more intensely in the gob and could hear the fire roaring behind the shields. Appendix H is a copy of the mine map detailing the D-3 longwall section showing the location of miners prior to the second explosion.

Second Explosion

At approximately 11.55 p.m., a second explosion occurred in the D-3 gob. The forces of the explosion threw Medley to Shield 6, where he ended up on his hands and knees in a pool of water and burning hydrocarbons. Nielsen, who was located on the shield line outby Medley, was thrown to Shield 4 and was asphyxiated as a consequence of carbon monoxide poisoning. The forces of the explosion threw Burton outby in the No. 1 entry and he ended up by the stageloader near Crosscut 49. McKinnon was thrown into Crosscut 49 facing the outby rib. He lost his cap lamp. Burton and McKinnon felt intense heat and each received burns and other injuries. Burton lost consciousness. McKinnon attempted to don his own personal SCSR. However, he dropped it and was unable to find it. Whitten was knocked down and thrown back into Crosscut 49 against the outby rib. He lost his hard hat, but not his cap lamp. Whitten made his way to the No. 2 entry where he saw Berdan.

Berdan was in No. 2 entry near Crosscut 49. Tyson Hales was nearby. Gonzales, Stansfield, and Ellner were located in the No. 2 entry close to Crosscut 48. Gonzales heard the explosion, felt slight forces and observed dust and debris coming out of Crosscut 49 into the No. 2 entry. Marvidikis, in the belt entry near Crosscut 25, felt a small rush of air and believed that it was another cave. He continued the preshift examination in the No. 1 entry, traveling inby.

Gonzales and Stansfield signaled the miners near Crosscut 49 to evacuate. Ellner was at the driver's door of the mantrip and was entering the vehicle. Gonzales opened the back door on the driver's side while Stansfield was preparing to enter the passenger side.

Third Explosion

At approximately 11.56 p.m., a third explosion occurred in the gob. The forces of the third explosion likely resulted in Stansfield being fatally injured. Tyson Hales was seriously burned and received a massive head injury. Ellner was injured when he was thrown into the dashboard of the mantrip and felt intense heat. Both Whitten and Gonzales were thrown past the mantrip by the force of the explosion. Berdan was apparently knocked unconscious. Gonzales, Whitten and Berdan received burns and abrasions from the explosion. McKinnon, in Crosscut 49, experienced difficulty breathing and passed out. Medley, on the face near Shield 6, felt debris pelting him. Burton was located in the No. 1 entry near the stageloader, still unconscious. Marvidikis, near Crosscut 24, was knocked down and rolled outby in the No. 1 entry about 10 to 15 feet, losing his hard hat. He traveled through a mandoor where he found a pager and called outside. LaCotta advised him that there was a fire on the face and that everyone was to evacuate. Jas Mills was between Crosscuts 15 and 20 when the explosion force blew his hard hat off. He observed that the air became dusty and seemed to reverse. He donned his respirator and waited until he felt the air begin to flow inby.

Ellner exited the mantrip and traveled outby a few crosscuts on foot until he came upon Burton's truck. Because Burton's truck was facing inby, Ellner backed it outby for several crosscuts until he found a location where he could turn the truck around. He traveled alone toward the mouth of the section. Although Gonzales had problems breathing and seeing, due to the dusty conditions, he struggled to his feet and started walking outby. Gonzales located the six-inch water line in the No. 2 entry and used it as a guide for traveling out of the section. He heard a back-up alarm from a vehicle and followed the sound outby for some distance. Whitten found himself along the rib line. His hard hat, cap lamp, and SCSR were missing. Whitten felt his way until he saw a faint light, which turned out to be the longwall transformer. He continued walking out of the section.

Ellner came upon Marvidikis near Crosscut 25, as Marvidikis was completing his phone call to the surface. Ellner shouted to Marvidikis that there had been an explosion and that he should get in the truck. Ellner continued driving outby with Marvidikis. Ellner collided with the scoop operated by Jas Mills as he attempted to pass. Ellner maneuvered around the scoop and told Jas Mills to get in the truck. Jas Mills decided to move the scoop so others coming out of the D-3 section would have clearance to pass the scoop. Ellner and Marvidikis changed positions in the truck and Marvidikis drove. As they got near the mouth of the section, they passed Willson and another miner, who were transporting fire extinguishers to the section. Ellner and Marvidikis continued to the surface where they arrived at approximately 12.12 a.m.

As Willson traveled inby, he passed Jas Mills and Gonzales. He came upon Whitten at Crosscut 39 and decided to turn around, pick up these three injured miners, and transport them to the surface. As they traveled outby, they met Henry Mills, Boyd Moosman, midnight shift maintenance foreman, and four other miners heading inby. Willson informed Henry Mills of their decision to exit the mine. Henry Mills and the others continued to travel inby. At Crosscut 46 or 47, it became apparent to Henry Mills and Moosman that there had been an explosion. At that moment, Henry Mills received a signal from his personal emergency device (PED), indicating that all miners should evacuate. They drove out, reaching the surface around 12:45 a.m.

The miners that were left on the section began to move from their locations and interact with each other. Medley, who had donned a 10-minute SCSR, crawled himself from the face to Crosscut 49. He saw a cap lamp on the mine floor. He felt his way along the cord to Burton, who was beginning to regain consciousness. Burton crawled toward the No. 2 entry. McKinnon also regained consciousness. He staggered over and sat next to Burton near the shop car, which had been blown more than 50 feet to a location outby Crosscut 49 in the No. 2 entry. Next to McKinnon were several SCSRs that had been scattered by the explosion. He retrieved two SCSRs and gave one to Burton. They each donned an SCSR. Berdan staggered to their location from outby. McKinnon gave a third SCSR to Berdan, but Berdan could not open it. McKinnon also attempted to open it, but could not because of the injuries to his hands. Medley crawled out of Crosscut 49 and continued toward the mantrip. Berdan walked to the mantrip. McKinnon went to start the mantrip and returned to Burton. He was unable to move Burton to the mantrip and it was decided that Burton should wait for assistance. Burton attempted to protect himself from additional injuries by positioning himself under the shop car.

As McKinnon walked to the mantrip, he saw Tyson Hales lying on the mine floor. McKinnon, due to his injuries, was unable to assist Tyson Hales. McKinnon, Berdan, and Medley traveled out of the mine. At this time, Tyson Hales, Burton, Stansfield, and Nielsen were the only miners remaining underground. McKinnon, Berdan, and Medley arrived on the surface at approximately 1:30 a.m. Appendix G shows a photograph of the truck used by McKinnon, Berdan, and Medley.

Fourth Explosion

Fan data indicated that a fourth explosion occurred at 12:17 a.m. Due to their condition and location, the few surviving miners remaining on the section do not recall this explosion.

RESCUE AND RECOVERY OPERATION

At approximately 11:53 p.m. on July 31, 2000, LaCotta received a telephone call from Burton. Burton requested that the company mine rescue teams be called to fight a fire in the mine. LaCotta secured a listing of Willow Creek Mine rescue team members and began calling those individuals at their homes. Willow Creek Mine rescue team members began receiving calls at approximately midnight and began to arrive onsite minutes later. MSHA personnel were notified at approximately 12:30 a.m. and began to arrive at the mine site at approximately 1:15 a.m.

Ray Haigler, mine rescue team captain, was one of the first to arrive. Mac Cook, mine rescue team trainer, arrived onsite at approximately 12:15 a.m. At the direction of Steven Rigby, maintenance manager, Haigler, along with Moosman, went to the mine return portals to monitor gases at approximately 1:00 a.m. After checking the three return portals, twice each, they returned to the command center to report their findings. Cook assisted Rigby with the outside activities as well as reviewing the gas monitoring results from the mine portals and the AMS system. Rigby assigned the monitoring duties to another employee and instructed Haigler and Moosman to prepare the mine rescue team breathing apparatuses. As of approximately 1:30 a.m., all but two members of the two Willow Creek Mine rescue team members had been contacted and were onsite.

A command center was established in the mine office. Senior company officials directing rescue operations included Charles Burggraf, general manager, and Rigby. MSHA officials included Irvin 'Tommy' Hooker, Gene Ray, Gary Frey, Larry Ramey, and Larry Keller.

At approximately 1 30 a.m., McKinnon, Medley, and Berdan exited the mine in the D-3 section mantrip. They provided information concerning at least two of the injured miners still underground. A decision was made to send a mine rescue team to the D-3 longwall section. Cook assembled a six man team consisting of Haigler, Moosman, Dave Wood, Lee Montoya, Zach Robinson, and Ken Powell. Cook briefed the team on what he knew of the events that had occurred in the mine, atmospheric conditions underground, on the location of injured miners, and on the need to communicate with the command center. The remaining Willow Creek team members were to remain on the surface as a back-up team. Several other mine rescue teams, although not officially called to the site, had arrived at the mine to offer assistance. They had been temporarily staying in nearby Price, Utah, preparing to compete in a mine rescue contest that was scheduled to be conducted on August 1.

The six team members entered the mine at approximately 2:00 a.m. They traveled in two vehicles, three team members in each, taking first aid supplies, fire extinguishers, water, stretchers, breathing apparatuses, and gas detection instruments. The team maintained communication with the command center by pager phones as they traveled into the mine. Conditions appeared normal until they approached Crosscut 43 of the D-3 longwall section. At that point, the team members began to observe scattered debris, such as a trash can and a lunch box, in the roadway. They traveled inby to Crosscut 44, which was the location of the longwall starter box. From there, Haigler called the command center to report their location and the conditions encountered. The air at that location was clear and was flowing in the proper direction. Haigler continued inby on foot, followed by the other team members in the two vehicles. He searched the crosscuts and under debris in the roadway for the remaining miners. Near Crosscut 45, the team encountered significant signs of an explosion in the form of soot, metal stopping panels, and larger items of debris. The team stopped at Crosscut 47, parked one truck in the crosscut, turned the other truck around, and parked it in the No. 2 entry.

All six team members assembled near the parked truck at Crosscut 47. They shouldered their breathing apparatuses, gathered a few first aid kits and stretchers, and proceeded bare-faced inby in the No. 2 entry. Conditions in the entry were very black and there was much debris strewn throughout the entire entry. Upon reaching Crosscut 48, the team encountered Tyson Hales. He was found near the center of the entry and was partially covered by a twisted metal stopping panel. Haigler examined him for injuries. A compressed airline, located above Tyson Hales, was open. The noise it created made communications difficult. After closing the valve, the team heard Burton calling from an inby location in the No. 2 entry. Haigler, Wood, and Moosman gathered first aid supplies and traveled inby.

Powell, Robinson, and Montoya remained with Tyson Hales to stabilize his condition and load him on a stretcher. Robinson proceeded outby and backed one of the trucks inby to Crosscut 48. Haigler, Wood, and Moosman found Burton in the No. 2 entry, halfway between Crosscuts 48 and 49 lying partially under a shop car. Burton was conscious, alert, and was able to describe his injuries to the team members. He also relayed to the team that he thought Stansfield was outby his location and that Nielsen was probably still inby him. They pulled Burton from under the shop car, stabilized his injuries, and loaded him on a stretcher. Burton was carried outby toward the truck at Crosscut 48 where Tyson Hales had just been placed onto the truck by Powell and Montoya.

In order to place Burton onto the truck, it was necessary to clear more space. The team members began to unload some of their equipment and while throwing fire extinguishers toward the rib, Moosman discovered another miner lying against the outby corner of Crosscut 48 in the No. 2 entry. The miner was identified as Stansfield. He was positioned against a timber set along the rib and was covered with brattice cloth. Powell determined that Stansfield had received fatal injuries.

At that time, the team split up. Robinson, Montoya, and Powell transported the two injured miners outside. Haigler, Moosman, and Wood proceeded to explore the rest of the section searching for Nielsen. They traveled from the No. 2 entry through Crosscut 48 into the No. 1 entry. From there, they traveled inby and encountered two hard hats, one of which was McKinnon's. They also found McKinnon's cap light at the outby corner of Crosscut 49. They traveled through Crosscut 49 toward the No. 2 entry and back to where Burton was found. The three members walked back through Crosscut 49 and went inby toward the longwall face. At the inby corner of Crosscut 49, in the No. 1 entry, the team encountered light smoke and 4.6 to 4.9 percent methane. At that point, the team members retreated to Crosscut 44 and reported their findings to the surface at approximately 2:40 a.m.

During this conversation, Haigler informed the command center that three team members were on their way out with Burton and Tyson Hales. He reported the conditions of the injured miners and that Stansfield's body had been located. Haigler also reported the atmospheric conditions found inby Crosscut 49. Rigby, after consulting with Burggraf, instructed the crew of three to go under oxygen and travel to the longwall face in search of Nielsen. The team found Nielsen at Shield 4. An examination of Nielsen revealed that he had received fatal injuries. Elevated methane concentrations and light smoke were present on the face; however, there were no visible flames. The team retreated to the telephone and contacted the command center to report their findings.

Rigby and Burggraf discussed the reported findings. Burggraf instructed Haigler to retrieve Nielsen from the face and bring both victims out of the mine. Haigler informed Burggraf that they would need additional help to remove Nielsen from the face. Burggraf told Haigler that the other three team members would return to the section. Haigler, Moosman, and Wood remained at the location of the telephone until the other three returned. Robinson and Powell prepared Stansfield for transport while Haigler, Montoya, Wood, and Moosman went to retrieve Nielsen from the face. While under oxygen, the team returned to the face to retrieve Nielsen. The four members removed Nielsen from the face and carried him to the vehicle. Team members called the command center to inform them that the recovery was complete and that the entire team was returning to the surface. All remaining miners arrived on the surface at approximately 4:00 a.m.

Upon reaching the surface, the team assisted placing Nielsen and Stansfield into ambulances. The ambulances left the mine site at approximately 4:05 a.m. A debriefing meeting was conducted in the mine office. Present were the six mine rescue team members, Burggraf, Ramey, Ray, and Frey. Haigler provided an account of the underground activities of the team. The meeting was concluded at approximately 5:05 a.m.

INVESTIGATION OF THE ACCIDENT

MSHA was notified of the accident at approximately 12:30 a.m. on August 1, 2000, and MSHA personnel began arriving at the site by 1:15 a.m. Preliminary information was obtained by MSHA District 9 personnel during the rescue and recovery operation. On August 1, the Administrator for Coal Mine Safety and Health directed that an investigation be conducted by a team consisting of personnel from MSHA Coal Districts 2, 3, 5, and 11, personnel from Coal Mine Safety and Health Headquarters, personnel from MSHA's Technical Support Division, and personnel from the Department of Labor's Office of the Solicitor. MSHA's District Manager from District 5 in Norton, Virginia, was assigned as the accident investigation team leader.

The investigation team members arrived onsite and began the investigation on August 2, 2000. Preliminary information, including records, were obtained from MSHA and the operator. Mine personnel were identified for interviews. Witness interviews began on August 7, 2000, at the Price, Utah, MSHA field office. Subsequently, 37 interviews were conducted with personnel working at the mine who had relevant knowledge. Other contacts were made and information was obtained from contractors and state and local authorities. All pertinent records were obtained and reviewed during the course of the investigation. Appendix C is a list of persons interviewed and Appendix D shows persons participating in the investigation.

DISCUSSION

Personal Emergency Device

A Personal Emergency Device (PED) system was in use at the mine. The system permitted text messages to be transmitted to key personnel underground. Miners provided with the receiving units included management officials as well as miners working in remote areas such as beltmen, examiners, and pumpers.

The use of the PED system was instrumental in alerting miners underground of the need to evacuate. Miners working in active and remote areas of the mine at the time of the explosion were notified through the use of the PED. These miners all safely exited the mine.

Self-Contained Self-Rescuers

The mine was operated under an approved SCSR storage plan. For the longwall section, 60-minute SCSR storage caches of 10 units each were maintained at both the headgate and tailgate areas. Mantrip vehicles were equipped with SCSR caches. Also, all miners carried 10-minute personal SCSR units on their belts. The 10-minute units carried by miners were Ocenco Model M-20. The 60-minute units stored in caches on the section and in the mantrip vehicles were Ocenco Model EBA 6.5. Although injured by the second explosion, Medley used a 10-minute unit in traveling from the longwall face to the No. 2 entry. It is possible that the atmosphere on the longwall face was irrespirable at this time. Some other miners, including McKinnon and Burton who were in Crosscut 49 after the third explosion, donned SCSR units.

Geology

Geology in the area surrounding and including the Willow Creek Mine includes formations prone to substantial methane liberation, as well as heavy bumps, bounces, outbursts, and liberation of hydrocarbons. Increased methane liberation sometimes accompanies bumps, bounces, and outbursts. Underground coal mines in close proximity to the Willow Creek Mine have operated with varying degrees of success over the past century. Mines have operated in the Sub 3, D, K, and A seams. The nearby Castle Gate No. 3 and No. 5 Mines, now closed, were characterized by violent bumps, and outbursts, as well as methane liberations, which frequently interrupted operations and resulted in accidents.

The Willow Creek Mine was developed in the D seam, which is one of nine seams in the 1000-foot thick Blackhawk formation. From the bottom to the top of the formation, seams are identified as Sub 3, 2, and 1, then A, B, C, K, D, and E seams. The D seam lies above the K-D interburden which consists mainly of sandstones and silty mudstones. The roof material above D seam consists of thin lenticular layers of mudstone, sandstone, and thin coal layers. A sandstone layer approximately seven feet thick is located 30 to 35 feet above the seam. The operator's geologist believed that this sandstone would break after approximately 400 feet of longwall retreat. The geologist had observed the D-3 gob caved approximately 20 to 40 feet high. The massive Castlegate Sandstone, approximately 500 feet thick, is located approximately 700 feet above the D seam. Overlying the Castlegate Sandstone are the Price River Formation, sandstones and mudstones, and the North Horn/Flagstaff Formation of interbedded mudstones, sandstones, thin limestones, conglomerates, and coal seams.

The Willow Creek Mine is located on the north end of the north-plunging axis of the San Rafael Swell Anticline. The mine is in a transition zone between three structural provinces: the Colorado Plateau, the Uinta Basin, and the Wasatch Plateau. The strike of the coalbed is east-west with the dip to the north at 8 to 10 degrees. Local dips of up to 15 degrees resulted from differential compaction. Overburden depth above the longwall face ranges from 2,800 to 2,900 feet.

Mine Ventilation

The mine used a blowing ventilation system. The main mine fan was a Joy M132-79-900 Axivane fan, which operated at 893 revolutions per minute (rpm). A second identical fan was arranged in parallel with the operating mine fan and was provided as a backup unit. Mine records indicated the average operating pressure of the main mine fan during the week preceding the accident was 9.7 inches water gauge (in. w.g.). The last recorded weekly air measurements, prior to the accident, revealed approximately 850,000 cubic feet per minute (cfm) of intake air being forced into the mine through the intake shaft. Airflow exhausted the mine through three return drift openings and the regulated belt drift opening. Intake air also leaked out of the mine through airlock equipment doors in the fifth drift opening.

At the time of the accident, separate splits of air ventilated three sections: the D-4 gate entry development, the right side of the D Northeast Mains development, and the D-3 longwall section. The left side of the D Northeast Mains development and the Sub Mains development located in the bleeder entries were not in operation at the time of the accident. These idle sections were not provided with separate air splits. Permanent stoppings, overcasts, and undercasts were used to provide the required separation between the various air courses.

Fan Pressure Recordings

The operating pressure of the main mine fan was recorded on both a Bristol pressure recorder seven-day fan chart and by an Allen-Bradley computer system. The fan chart had been changed at approximately 1:00 p.m. on July 31, 2000. Figure 1 (see Appendix F) shows the seven-day fan chart. Although the motion of the tracing arm for the main mine fan spanned approximately 1.5 in. w.g., the average operating pressure remained relatively consistent. Three distinct pressure spikes were visible; two near midnight on July 31, 2000, and another shortly after midnight on August 1, 2000. These pressure spikes were consistent with explosion forces.

Due to the sampling and recording intervals, the Allen-Bradley monitoring system did not record the first explosion pressure spike. The magnitude of the fan pressures recorded by the Allen-Bradley monitoring system differed from those recorded by the Bristol recorder. Figure 2 (see Appendix F) shows the Allen-Bradley monitoring system fan pressure data during the time of the accident. These pressure spikes were consistent with explosion forces. Decreases following the pressure spikes were likely the result of damage to underground ventilation controls.

Natural Ventilation and Barometric Pressures

Natural ventilation pressure (NVP) can affect the ventilation of mines. The magnitude and direction of NVP is determined by factors such as barometric pressure, air temperature and humidity, and elevation differences within the mine. NVP may assist or counter the effects of the mine fan. Slight fluctuations in fan operating conditions, due to NVP, are common. Barometric pressure information was obtained from the National Oceanic and Atmospheric Administration, U. S. Department of Commerce, for Price, Utah, for the period from July 16 through August 1, 2000. It appears that NVP did influence the fan operating pressure at the Willow Creek Mine. However, the effects of NVP do not appear to have been significant enough to contribute to the cause of the accident.

Changes in barometric pressure can also cause the expansion and contraction of accumulated gases within unventilated (sealed) and poorly ventilated areas of mines. The barometric pressure for Price, Utah, for 11:48 p.m. on July 31 was approximately 24.27 inches of mercury. The barometric pressure had been rising from 8:00 p.m. to 11:00 p.m., and was steady from 11:00 p.m. until the time of the accident. Changes in barometric pressure did not appear to significantly impact the conditions within the D-3 panel.

Ventilation Plan and Bleeder System

The ventilation plan in effect at the mine was initially reviewed and approved by the MSHA District 9 Manager on March 25, 1999. Six reviews were conducted and other amendments were approved. An amendment to the ventilation plan addressing longwall retreat mining in the D-3 longwall section, alternate seals, and other items was approved on July 7, 2000.

A flow-through bleeder system with multiple bleeder entries was used to ventilate the gob of the D-3 panel. Multiple ventilation configurations were approved for ventilation of the D-3 longwall section. The configuration described in the ventilation plan as "D-3 Longwall Start-up Head to Tail and Bleeder Ventilation with Tail Gate Intake" was being used at the time of the accident.

D-3 Ventilation

The ventilation plan required that 100,000 cfm of air be delivered to the intake of the longwall. This requirement was identified in the ventilation plan pursuant to Title 30 Code of Federal Regulations (CFR) Section 75.325(g)(2), and pertained to the minimum ventilating air quantity where multiple units of diesel-powered equipment were operated on working sections. The airflow directed onto the D-3 longwall face was required to be measured in the No. 1 entry between the last open crosscut and the face at measurement point location (MPL) #2. The required minimum airflow velocities on the longwall face at Shields 16 and 126 were 400 feet per minute (fpm) and 300 fpm, respectively. From

July 28 through July 31, 2000, the operator's records of preshift examinations showed face velocities ranging from 508 fpm to 830 fpm at Shield 16, and from 356 fpm to 703 fpm at Shield 126. The preshift report called out on July 31on the afternoon shift indicated 66,300 cfm at Shield 16 and 50,760 at Shield 126. The ventilation plan also required that face ventilation be increased 10 percent over the ventilation quantities in the approved ventilation plan when hydrocarbons were present. The operator's records of preshift examinations indicated that hydrocarbons were present on the D-3 longwall face during most days from July 17 to July 31, 2000.

Some of the D-3 intake airflow was not directed onto the longwall face. A portion of the airflow was directed inby the headgate side of the longwall face in the No. 2 entry toward the bleeder entries. This airflow was to be measured at MPL #3, just inby the last open crosscut. As shown in the configuration described in the ventilation plan as "D-3 Longwall Start-up Head to Tail and Bleeder Ventilation with Tail Gate Intake", intake air could be coursed through the D-3 belt entry either inby toward the longwall face or outby from the last open crosscut to a regulator at the front of the headgate panel. At the time of the accident, the D-3 belt airflow was coursed outby. In this scenario, the ventilation plan depicted the airflow ventilating the belt entry as part of the required 100,000 cfm intake airflow to the longwall face. The ventilation plan permitted replacement of the stopping in the second crosscut outby the face separating the D-3 intake from the D-3 belt with a curtain to facilitate belt structure removal.

Inlets to the Gob

The total airflow entering the gob of the D-3 longwall panel was to be measured at MPL #1, MPL #2, and MPL #3. The tailgate intake was to be measured at MPL #1, located in the tailgate entry just outby the longwall face. The tailgate intake split was directed into the gob from the tailgate entry. The ventilation plan required a minimum tailgate intake airflow of 30,000 cfm. All of the airflow directed onto the longwall face, measured at MPL #2, entered the gob. Some of the airflow at MPL #3 was directed into the inby setup entry at MPL #4. The regulator at MPL #4 was also identified as the mixing chamber regulator in the mine record books.

Outlets from the Gob

All airflow exited the gob through the two regulated tailgate bleeder connectors. These Nos. 1 and 2 entry tailgate bleeder connectors were identified in the ventilation plan as MPL #8 and MPL #7, respectively.

Bleeder Entries

At least one entry in the set of bleeder entries was required to be traveled in its entirety. MPLs were specified in the mine ventilation plan to determine the effectiveness of the system where the air entered and exited the bleeder entries. Measurements of methane and oxygen concentrations and air quantities and a test to determine if the air was moving in the proper direction were required at these MPLs. The ventilation plan also specified that the required weekly examination include traveling inby the longwall face in the headgate No. 2 entry and across the bleeder entries. Bleeder examination point locations were to be located at intervals of 1,000 feet inby the longwall face in the headgate entries. The plan also stated that the set-up rooms were not required to be traveled.

The portion of the airflow measured at MPL #3 which was not directed into the gob at MPL #4, entered the bleeder entries through two regulated headgate bleeder connectors. These D-3 Nos. 1 and 2 entry headgate bleeder connectors were identified in the ventilation plan as MPL #6 and MPL #5, respectively.

An intake split was directed into the bleeder entries inby the headgate bleeder connectors. The measured airflow where this split entered the bleeder airflow was identified in mine record books under the location "Return #3 Reg. 76 to 77 XC ". As shown in the configuration described in the ventilation plan as "D-3 Longwall Start-up Head to Tail and Bleeder Ventilation with Tail Gate Intake", the intake airflow in this split at the Return #3 Reg. 76 to 77 XC location was not to exceed 10% of the overall longwall intake.

The bleeder airflow ventilated the seals of the D-2 and D-1 gobs before it entered the main return from the D Seam Bleeders and the D-1 Tailgate entries. The total airflow exiting from the D Seam Bleeders and the D-1 Tailgate was measured at locations specified in the ventilation plan and shown in the plan drawing labeled, "Bleeder to Main Return MPL Locations". MPL B1 and MPL B2 were located between Crosscuts 6 and 7 in the D-1 Tailgate Nos. 1 and 2 entries, respectively. MPL B3 was located between Crosscuts 6 and 7 in the D Seam Bleeders No. 3 entry.

Atmospheric Monitoring System (AMS)

The mine had been granted petitions for modification of 30 CFR 75.350 and 75.352 which enabled two-entry development of longwall panels. The petition for modification of 30 CFR 75.350 and the mine ventilation plan required the use of diesel discriminating sensors (DDS) for CO and nitric oxide (NO) in the entries of the two-entry developments. CO/NO sensors were used in other beltlines in lieu of point-type heat sensors. The ambient CO level specified in the approved mine ventilation plan was 2 parts per million (ppm). The DDS action levels for longwall retreat and recovery were 8 ppm for alert and 12 ppm for alarm. The monitoring system had a 180 second delay to reduce nuisance alerts and alarms. The range of the CO sensors was from 0 to 50 ppm.

The ventilation plan amendment approved July 7, 2000, required AMS sensors at: MPL #1, tailgate intake to the longwall; MPL #5, headgate No. 2 entry bleeder connector regulator; MPL #6, headgate No. 1 entry bleeder connector regulator; MPL #7, tailgate No. 2 entry bleeder connector regulator; MPL#8, tailgate No. 1 entry bleeder connector regulator; and MPL B1, D-1 Tailgate No. 1 entry near the D Northeast Mains. The types of monitors at each location, action levels, and response to action levels were not specified in the ventilation plan. Methane, oxygen, CO, and velocity sensors were installed at MPL #5, MPL #6, MPL #7, and MPL #8. Methane, oxygen, and CO sensors were installed at MPL #1. Methane and CO sensors were installed at MPL B1.

The surface AMS attendant could monitor the gas concentrations at specific locations. A protocol had been established by the mine operator for methane concentrations at certain locations. The AMS attendants were instructed to notify the longwall section to stop production if the methane concentration reached 4 percent at any of the headgate or tailgate bleeder connectors (MPL #5, MPL #6, MPL #7, or MPL #8), reached 1.95 percent at MPL B1, or reached 0.9 percent in the longwall tailgate intake. Production could resume when the methane concentrations at those locations decreased to 3.7 percent, 1.75 percent, and 0.7 percent, respectively. The mine was to be evacuated and MSHA was to be notified if the methane concentration reached 4.5 percent at any of the headgate or tailgate bleeder connectors (MPL #5, MPL #6, MPL #7, or MPL #8) or reached 2.5 percent at MPL B1. The longwall section and shift foremen were to be notified if the methane concentration in the longwall tailgate intake was 1.0 percent or greater.

The AMS data for the period from July 16 through August 1, 2000, indicated that the overall trend of methane concentrations at MPL B1 had been increasing. In the days immediately preceding the accident, the trend was accelerated. The methane concentration at MPL B1 exceeded the operator's 1.95% action level twice on July 31. The first occurrence was at 2:48 a.m. and lasted approximately 11 minutes. The second occurrence was at 3:33 a.m. and lasted approximately 40 minutes. This indicated that the bleeder system was near its capacity.

Recorded Bleeder System Airflow Measurements

Two required weekly examinations of the mine had been completed since the beginning of retreat mining in the D-3 panel. The last weekly examination was conducted July 25 - 26, 2000. The recorded airflow at MPL #1 was 49,500 cfm, which was greater than the minimum required. Air quantities were not included in the record for the MPL #2 location either week. As shown in the configuration described in the ventilation plan as "D-3 Longwall Start-up Head to Tail and Bleeder Ventilation with Tail Gate Intake", the airflow at MPL #3 should be similar to the cumulative airflow at MPL #4, MPL #5, and MPL #6. However, the air quantity recorded for MPL #3 (113,000 cfm) was not consistent with the cumulative air quantities recorded at MPL #4, MPL #5, and MPL #6 (32,900 cfm in total). Testimony indicated that the measurements recorded for MPL #3 may not have been taken in the location indicated in the ventilation plan. The air quantity recorded for MPL #4 was 13,200 cfm. The air quantities recorded for MPL #5 and MPL #6 were 5,200 cfm and 14,500 cfm, respectively. The total recorded airflow exiting from the gob at MPL #7 and MPL #8 was 185,600 cfm (100,400 cfm and 85,200 cfm, respectively). The recorded airflow exiting from the D-1 Tailgate and the D Seam Bleeders at MPL B1, MPL B2, and MPL B3 was 331,600 cfm (60,300 cfm, 71,500 cfm and 199,800 cfm, respectively).

The airflow ventilating the D-3 panel decreased following the last completed weekly examination. The recorded face velocities measured on the longwall face showed a decreasing trend after July 26, 2000. Decreased face velocities indicated a decrease in the airflow ventilating the longwall face. Information from the velocity sensors positioned at MPL #5, MPL #6, MPL #7,and MPL #8 were also reviewed. The velocity sensor data for MPL #5, MPL #6, and MPL #7 did not appear to accurately represent the airflow at those locations. Therefore, that data was not used in determining whether airflow changes occurred at those locations. Velocity data from MPL #8 appeared accurate and also indicated that airflow at that location decreased from July 27 through 31, 2000. This condition commonly occurs after longwall start-up when roof falls first begin to significantly affect the resistance of airflow paths through a pillared area, often requiring increased ventilating pressure across the gob in order to maintain adequate ventilation. In such cases, adjustments to the bleeder system are often required at numerous locations in order to maintain control over airflow distribution within the worked-out area. Statements revealed that the regulators at the D-3 tailgate bleeder connectors were wide open and that no additional ventilating pressure was available at these regulators. In addition, the operator did not remove or adjust controls within the set-up rooms to affect airflow distribution within the worked-out area.

A split of intake air, approximately 65,400 cfm, was directed into the No. 1 entry of the D Seam Bleeders. This split of air was intended to ventilate a pump that had been installed at the inby end of the bleeder entries near the D-3 headgate bleeder connectors. The quantity of air that ventilated the pump, approximately 15,000 cfm, was coursed directly into the bleeder entries near the D-3 headgate entry bleeder connector regulators. The remainder of this air was either directed intentionally into the bleeder entries after ventilating other electrical installations or leaked through ventilation controls into the bleeder entries. The large volume of leakage reduced the methane concentration in the bleeder entry.

Bleeder System Ventilation Controls

The adjacent D-2 longwall panel was sealed prior to retreat mining of the D-3 panel. The seals in D-2 separated the D-2 panel gob from the tailgate entry of the D-3 panel. As the D-3 panel was retreated, the seals on the tailgate side inby the face became inaccessible.

The ventilation plan stipulated that seals were to be completed in the headgate between the gob of the D-3 panel and the D-3 No. 2 headgate entry in each crosscut, as the retreating D-3 longwall face passed the outby rib of the crosscut, except at the regulated opening at MPL #4. Seals had been completed in Crosscuts 50 through 52 and across the D-3 No. 1 entry between Crosscuts 53 and 54 in accordance with the approved plan. The plan required that sample points be provided through the seals on intervals of 1,000 feet as the longwall panel retreated. The locations were to be monitored weekly. Because the D-3 panel had not yet retreated 1,000 feet, the first sampling location had not been established.

Information gathered during the investigation revealed that ventilation controls had been installed in the D-3 set-up entries. The controls were constructed to facilitate the set-up of the D-3 longwall face and were left in place to assist in controlling the face airflow during start-up. An undercast was constructed in the intersection of the D-3 No. 1 headgate entry and the inby set-up entry at Crosscut 53. Framed check curtains were constructed in the crosscuts between the outby and inby set-up entries. A check curtain was also hung across a one-crosscut long dogleg entry located inby Crosscut 53. Testimony revealed the caved material was sufficient to control face airflow prior to the accident, making these check curtains unnecessary. The mixing chamber regulator was constructed under the top of the D-3 No. 1 headgate entry undercast in Crosscut 53. A few blocks were removed from the outby wall of the undercast to allow water entering the mine from the D-3 panel gob to drain through Crosscut 53 and flow to the sump at the back of the bleeder entries. The hole in the undercast was on the gob side of the mixing chamber regulator.

Testimony indicated that the mine operator did not travel into the setup room to make adjustments or to remove any controls after the longwall commenced operation. The failure to make adjustments or to remove controls affected the distribution of airflow in the gob. As installed, these curtains would have inhibited airflow between the headgate side of the gob and the inby set-up entry. These curtains, as well as the undercast, were not shown in the approved ventilation plan drawings for retreat mining of the D-3 panel. With these controls intact, airflow along the fringe of the headgate side of the gob would have been further restricted, increasing the potential for methane to accumulate in that portion of the gob.

Gob Ventilation Boreholes and Degasification Systems

Vertical and horizontal gob degasification boreholes were used to assist the mine ventilation system with the removal of methane from the gob areas. The vertical degasification boreholes vented methane directly to the surface. The horizontal degasification boreholes were connected to an in-mine methane collection system that was exhausted to the surface. The ventilation plan detailed information such as the design, operational procedures, and criteria concerning the gob ventilation boreholes and degasification system, and the horizontal degasification drilling and collection system. The ventilation plan also permitted the removal of methane from sealed gob areas through the in-mine methane collection system.

Vertical degasification boreholes were first used during retreat of the D-1 panel. They assisted the mine ventilation system in the removal of methane released from gob areas due to the fractures of the immediate roof and floor caused by longwall extraction. The vertical degasification boreholes were installed prior to the longwall extraction activities intersecting them. Many of the boreholes were directionally drilled from the same surface location. The ventilation plan permitted methane to free-flow from the boreholes. The ventilation plan also permitted the use of exhaust pumps to enhance methane removal. The minimum methane concentration in the borehole exhaust permitted by the ventilation plan was 25 percent. Retreat mining in the D-3 panel had not progressed sufficiently to intersect the D3-0 vertical degasification borehole nearest the start-up location. Intersection with the D3-0 vertical degasification borehole was expected within an additional 100 feet of retreat.

The horizontal degasification drilling and collection system included long horizontal holes drilled from the mine entries into the coal seam, roof and floor. Holes drilled into the roof strata are commonly referred to as crossmeasure holes. The holes were connected to the in-mine horizontal collection system that was routed to the surface. A centrifugal blower, located on the surface, provided negative pressure to the system to enhance methane drainage. The oxygen concentration within the collection system was monitored. The ventilation plan required the surface degasification pumps to automatically shut down when oxygen concentrations in the line exceeded 10 percent. The horizontal collection system was also connected through seals to transport methane from the sealed D-1 and D-2 gobs.

Two horizontal degasification holes (HD3R1 and HD3R2) were located in the roof coal of the D-3 panel outby the longwall face. Neither had been intersected. Drilling was in progress on one of the holes. Additional horizontal degasification holes were proposed. An existing inseam coal exploration hole had been drilled across the D-3 and D-2 panels. Horizontal degasification holes in both roof coal and floor coal were used near the end of the D-2 panel.

Samples were collected at vertical degasification holes located in the sealed areas during the week of July 23, 2000. The methane concentration at these holes ranged from 21.61% to 66.25%. A sample collected from the horizontal degasification system during the same week was 41.15% methane.

Interior Gob Ventilation

The primary airflow paths in a gob are generally those with the least resistance. In a longwall gob, they generally are the middle entries of the headgate and tailgate panels, the perimeter of the caved area, the set-up rooms, the open area behind the longwall face and the recovery faces. These primary airflow paths are critical to the successful operation of a bleeder system. In highly gassy mines, methane emanates from caved material and surrounding strata, or rubble zone, in concentrations close to 100%. Dilution of the methane must occur. The methane begins to dilute as it flows from the rubble into the primary airflow paths in the gob. Further dilution occurs as the methane-air mixture moves into the bleeder entries and out of the mine.

In a two entry system, the perimeter of the caved area becomes the primary airflow path for the headgate and tailgate fringes. The volume of airflow in these paths depends on many factors, such as the available ventilating pressure, the tightness of the fall in the rubble zone, and the resistance of the path to airflow. The resistance is affected by such factors as roof falls, roof support, water, and ventilation controls. In gassy mines, the use of a two entry system dictates that additional ventilation pressure, roof support and pillar design be considered in maintaining adequate airflow through primary airflow paths. In the D-3 panel, Can cribs (cylindrical steel roof supports filled with low density concrete) were installed in the tailgate entry. These Cans helped maintain the primary airflow path open in the tailgate side of the gob. In the headgate, Can cribs were installed behind the seals but not in the No. 1 entry. The primary airflow path in the headgate appears to have been more restricted due to additional caving. This would have reduced the airflow available to dilute methane as it was liberated from the rubble of the gob.

Generally, the typical primary airflow paths for a longwall gob are not fully established until the longwall is advanced a distance similar to its width. Until these paths are fully established, it is difficult to maintain adequate distribution of the airflow in the gob. Frequent changes or adjustments to headgate and tailgate regulators, ventilation controls adjacent to the longwall face, and controls in the worked-out area are often necessary as the initial falls occur. In the case of the D-3 panel, the majority of the air ventilating the pillared area was confined to a relatively narrow path, as compared to the width of the gob, flowing directly from the tailgate end of the face to the tailgate bleeder connector. Additionally, typical internal airflow paths were most likely not fully established in the D-3 panel as it was only retreated approximately 250 feet. This would have increased the potential for areas of varying restrictiveness to develop within the expanding pillared area. Such conditions can create short circuits of the airflow within the pillared area, leaving other areas isolated and inadequately ventilated. A means for determining if adjustments were needed to compensate for such conditions to maintain control of airflow through the pillared-area was not employed during the operator's evaluations of the D-3 bleeder system. Full establishment of the typical primary airflow paths wouldn't have been expected until after retreating about 825 feet.

Ventilation Surveys and Computer Simulations

A mine ventilation pressure-air quantity survey had been conducted in the mine by MSHA in October, 1998. Additional information was obtained during the investigation from other sources such as: the required mine record books; the interviews and discussions with MSHA enforcement personnel and the mine operator; and the ventilation simulations completed by the mine operator. This information was used to develop a model of the mine ventilation system prior to the events of July 31. The model demonstrates a number of weaknesses in the mine's ventilation system.

The airway paths through the gob become increasingly resistant as retreat mining progresses. These increases in resistance occur over the life of the longwall panel. Sufficient additional ventilating pressure differential is necessary to compensate for these increases in resistance if the same airflow is to be provided for ventilation of the worked-out area. If changes in contaminant liberation require additional airflow, even greater ventilating pressure is necessary. The design of the system was such that airflow passing through the worked-out area of the D-3 longwall panel was largely controlled through adjustment of regulators located in the tailgate bleeder connectors. The pressure differential that exists across a regulator is the reserve ventilating pressure at that point in the system. This reserve pressure is used to sustain, or increase, the ventilation through the worked-out area. The magnitude of that reserve pressure compared to the ventilating pressure applied to ventilate the worked-out area is a measure of the available capacity. Generally, the opening in the regulator is increased to transfer the reserve pressure. Statements revealed that the regulators in the tailgate bleeder connectors were fully opened. The other means to increase the system's ventilating capacity was through changes in operation of the main mine fan. Mine records indicated that the main mine fan was producing approximately 850,000 cfm at 9.7 inches of water. The fan blades were reportedly set at the 19.5 degree blade position. Mine management indicated that the motor for the fan was operating near its capacity and was monitoring motor amperage. This effectively limited further increases in ventilating pressure or airflow for the bleeder system. Therefore, the bleeder system had limited reserve capacity.

Airflow from the bleeder split ventilating the pillared portion of the worked-out area consistently contained methane in excess of 2.0 percent after July 29, 2000. Airflow from the regulator at the pump room and from MPL #5 and MPL#6 diluted the methane downwind of MPL #8. However, methane concentrations in the bleeder airflow continued to increase. These changes in conditions should have prompted an investigation to ensure that ventilation was adequate. Improved distribution and/or additional airflow through the pillared worked-out area was needed to dilute and remove the methane being liberated. However, as a result of the system's configuration and because the regulators near MPL #7 and MPL #8 were fully open, no additional capacity was readily available.

Computer simulations were developed to evaluate possible conditions in the mine after the first and third explosions. These simulations are based on the results of testimony taken during the investigation, on fan pressure recording information, and the results obtained from the AMS data. These simulations show that ventilation controls inby the longwall face in the headgate entries and in the D Seam Bleeders were likely to have been damaged after the first explosion. They also show that the effectiveness of the ventilation system for the D-3 longwall would have diminished significantly after the first explosion. This would have decreased the airflow within the primary airflow paths along the fringes of the gob and would have increased the volume of explosive gas along those fringes of the gob. The small magnitude of the second explosion did not materially affect the ventilation system. Therefore, no simulations were developed. The computer simulations also indicate that the third explosion probably caused additional damage to ventilation controls in the mine. They also show that the effectiveness of the ventilation system for the D-3 longwall would have further diminished. The fourth explosion probably caused additional damage to ventilation controls in the mine.

Methane Liberation

Excluding the degasification systems, and as determined through analyses of vacuum bottle air samples and air quantity measurements taken during an MSHA inspection on July 6, 2000, methane liberation was 2,832,000 cubic feet per day (cfd). The mine's measured total return airflow on that date was 732,000 cfm. The D-2 panel was not yet sealed and retreat mining in the D-3 panel had not begun as of July 6, 2000. Mine officials collected air samples for analysis at specific locations during regular weekly examinations. The results of the analyses of these samples and the air measurements taken during these weekly examinations provide information about the change in methane liberation from the bleeder system. Information collected on July 18 and 19, 2000, indicated that methane liberation from the bleeder system (at MPL B1, MPL B2, and MPL B3) was 2,519,000 cfd and total mine methane liberation in the main return entries was 3,235,000 cfd (an increase of 403,000 cfd from July 6 to July 19, 2000). The D-2 panel was sealed at that time and retreat mining in D-3 panel had just begun. Air samples collected on July 25 and 26, 2000, indicated methane liberation from the bleeder system (at MPL B1, MPL B2, and MPL B3) had increased to 6,338,000 cfd (an increase of 3,819,000 cfd from July 19 to July 26, 2000). By the night of July 31, 2000, methane liberation from the D-3 bleeder system had increased to over 7 million cfd.

Cut-outs on the tailgate and headgate routinely caused relief of stresses in the strata. The conditions on the tailgate resulted in sudden significant quantities of methane being released. The methane releases regularly caused production to cease because of resulting elevated methane concentrations on the face. Additionally, methane feeders were encountered at other locations on the face that resulted in production delays. Production resumed as the methane release decreased.

The methane concentration in the airflow exiting from the D-1 Tailgate No. 1 entry at MPL B1 was continuously monitored and recorded by the AMS. The system also monitored and recorded the methane concentration in the D-3 tailgate bleeder connectors (MPL #7 and MPL #8). Figure 3 (see Appendix F) shows the methane concentrations recorded by the AMS at MPL #5, MPL #6, MPL #7, MPL #8, and MPL B1. Fluctuations in methane concentrations at MPL B1 coincided with those at the tailgate bleeder connectors. However, during the last few days prior to the accident, the difference between methane concentrations at the tailgate bleeder connectors and those at MPL B1 widened, indicating that gob airflow constituted a smaller percentage of the airflow at MPL B1. Increasingly restrictive airflow paths developed within the pillared area as the longwall retreated, and resulted in decreased airflow through the bleeder connectors. The methane concentrations at the two headgate bleeder connectors were relatively stable during the entire time the D-3 panel retreated.

Methane liberation from the D-3 panel was significantly influenced by production rates as well as the increase in size of the gob area. Figure 4 (see Appendix F) shows the recorded methane concentrations at the tailgate bleeder connectors (MPL #7 and MPL #8) and the approximate number of passes mined each shift. Production reports were used to determine the approximate number of passes mined each shift. The methane liberated from the D-3 panel increased during production. Conversely, during the idle shift following the afternoon production shift and during idle periods on the production shifts, the methane concentration in the bleeder airflow decreased. It appears the production rate and methane liberation rate had somewhat stabilized prior to July 29, 2000. Beginning on July 29, the total number of passes mined each day increased. Also, on July 29, the methane liberation trend changed. The increase in methane liberation, combined with a decrease in airflow through the pillared area during the days prior to the accident, increased the methane concentrations in the gob at the time of the accident.

Hydrocarbons

Underground coal extraction at the mine results in the release of liquid hydrocarbons from the surrounding strata. Procedures to alleviate the health and safety concerns associated with the presence of these hydrocarbons were addressed in the longwall hydrocarbon procedure portion of the ventilation plan submitted by Plateau Mining Corporation. Personal protection, including jackets, gloves, and respirators, was required. Also, since the hydrocarbons are similar to diesel fuel, longwall personnel were required to review the Material Safety Data Sheet for diesel fuel. Hydrocarbons were to be directed away from work areas and equipment.

The ventilation plan also required that hydrocarbons be cleaned off equipment twice per shift. Where visible on the face, they were to be diluted with water. Ventilation quantities were to be increased 10% above approved quantities when hydrocarbons were present. A number of additional precautions were to be taken when hydrocarbons were present in the vicinity of welding/cutting activities.

The occurrence of hydrocarbons was not uniform throughout the mine. However, interviews of knowledgeable miners revealed that hydrocarbons were present on the longwall face of the D-3 longwall prior to and on July 31, 2000. As liquid hydrocarbons entered the mine, they dripped or flowed to the floor. The slope of the active D-3 section caused liquid hydrocarbons and water from the face area to flow inby to a sump in the bleeder entries. From this point, the liquid hydrocarbons and water were removed from the mine. Although information was not available concerning quantities at the time of the accident, about 1,200 gallons per day were being pumped outside at various times during 1998.

Data Chem Laboratories evaluated a sample of the liquid hydrocarbons and reported the results of their findings in a letter dated May 4, 1998. Their analysis noted that the composition of the sample was roughly equivalent to a mixture of 15% automotive gasoline, 35% kerosene (diesel fuel), and 50% light lubricating oil (motor oil). The sample contained measurable quantities of approximately 34 individual compounds. The volatile portion reportedly included isobutane, butane, pentanes, and hexanes in significant quantities. Toluene, benzene, and xylenes were also found.

Gases from the liquid hydrocarbons were released into the mine atmosphere in two ways as the hydrocarbons entered the workings. Primarily these gases were liberated as they entered the workings with the liquid hydrocarbons. This portion of the hydrocarbon gases was noticeably evident by the strong associated odors, not only throughout the section but occasionally also to the surface areas of the mine. The second manner of entry occurred as the volatile portion of the liquid entered the mine atmosphere as vapor. This process is exacerbated as the temperature increases, especially if the flash point of the liquid is exceeded.

If the flash point of the liquid hydrocarbons is exceeded, ignitable vapors are released. The flash point is the temperature at which a liquid begins to give off ignitable vapors. The flash point of hydrocarbons taken from the Willow Creek Mine was established to be approximately 97° F during an analysis conducted by Chevron in 1998. Although ignitable hydrocarbon vapors can occur at temperatures of 97° F or higher, the ignition temperature for those vapors is expected to be approximately 500° F. MSHA's Approval and Certification Center (ACC) received a sample of hydrocarbons from the mine. The sample was not fresh and a significant portion of the volatile content had previously been exhausted, causing any flash point and ignition temperature determinations to be inconclusive in relation to the hydrocarbons on the day of the accident. However, upon igniting a thin layer of the hydrocarbons, the flame reached nearly two feet in height and produced copious amounts of smoke.

In 1998 Data Chem Laboratories established the explosive range of the hydrocarbon gases to be between 1.03% and 5.36%. Methane, also a hydrocarbon, has a lower explosive limit of 5%. However, the combination of these gases would cause the lower explosive limit of the mixture to be less than 5.0%. Significant volumes of the hydrocarbon gases would not be expected to have been present, if adequate ventilation was maintained. Due to the volume of methane being liberated, methane was the more significant fuel source in the D-3 gob for the explosions of July 31 and August 1, 2000.

The first explosion ignited methane and likely ignited hydrocarbon vapors, resulting in fire around and behind the headgate shields. Parts of the fire remained inaccessible. Water was ineffective in fighting the accessible portion of the fire. An adequate supply of a suitable fire-extinguishing agent was not available. The fire continued to spread through inaccessible areas of the D-3 gob and provided an ignition source for subsequent explosions. Liquid hydrocarbons were eventually ignited.

Examinations

Mine examinations were conducted by various certified miners pursuant to the requirements of 30 CFR 75.360 through 75.364. Those miners included both salaried and hourly Willow Creek employees as well as contractor employees permanently assigned to the Willow Creek Mine. In general, section foremen would conduct preshift examinations and various outby personnel would conduct portions of the weekly examination. There were no miners designated solely as mine examiners.

The mine operated two, 10-hour longwall production shifts which began at 6:45 a.m. and 3:45 p.m., respectively. A maintenance shift began at 10:00 p.m. Preshift examinations were performed based upon three, 8-hour time periods not associated with the start of the production or maintenance shifts. For preshift examination purposes, the examinations were conducted within three hours of the following designated times: 2:30 a.m.; 10:30 a.m.; and 6:30 p.m.

Among the D-3 longwall shift foremen interviewed during the investigative process, there was confusion regarding the location of the air measurement required by 30 CFR

75.360(c)(2). That measurement, which was required to be taken immediately outby the longwall face to determine the volume of air reaching the longwall face, was often taken either outby the last open crosscut in the No. 2 headgate intake entry or in the last open crosscut. The air volume at those locations would have included airflow reaching the face, air exiting in the belt entry, and, in the case of the reading taken in the No. 2 entry, air traveling inby toward the D-3 setup rooms and the bleeder entries. The reviewed records and testimony indicated that some of the air measurements were not taken in proper locations. The examiners interviewed were not fully aware of the requirements of the regulation regarding the proper location of this required measurement.

Section 75.364(c)(1), 30 CFR, requires the examiner to determine the volume of air entering the main intakes and in each intake split. The air volume measurements were not conducted in the air course ventilating the idle belt of the D Seam Bleeders. This split was isolated by permanent ventilation controls and was functioning as a distinct intake air course before being regulated into the main return. The split was approximately 1,600 feet in length. The investigation revealed that the air volume was not determined in the belt air course during the weekly examinations and was not recorded in the record book.

Weekly examinations were routinely conducted during a two-day period, primarily during the day shift on Tuesdays and Wednesdays. Due to rotating shifts and varying work schedules, it was rare for the same miner to conduct any portion of the weekly examination for more than two consecutive weeks. This caused a lack of continuity in making a determination of changing conditions along the traveled routes. Several of the mine examiners voiced this concern to mine management prior to the explosions on July 31 - August 1. Management believed that regular examinations by the same miners could result in complacency. During testimony, some mine examiners could not explain discrepancies in the examination records.

Weekly examiners were provided a map and a listing of the designated locations requiring measurements for the weekly examination. The examiners traveled to those locations, took measurements, and recorded the information in the appropriate record book. However, when questioned during the interviews, the examiner who conducted the most recent weekly examination was unable to identify many of the locations where the recorded measurements were taken. Most of those locations were in the D-3 bleeder system. In addition, when presented with earlier conflicting measurements, another mine official was unable to provide an explanation.

The mine manager was responsible for countersigning and reviewing the examination records. It was his responsibility to make determinations as to the efficiency and adequacy of the ventilation system based upon his review of the records. The mine manager did not routinely correlate the measurements of the weekly examinations with previous examination results, or their locations in the mine, to determine whether any abnormalities were developing. The focus was on making sure that the examinations and records were completed. Many of these measurements were related to the ventilation of the D-3 longwall bleeder system.

Mine management implemented a mine examination system whereby the individual examiners had little responsibility for, or authority to act on, the results of the weekly examinations. The system provided for a management official, primarily the mine manager, to review, countersign, and evaluate the results of the weekly examinations. The requirements of the regulations corresponding to the weekly examinations were fulfilled with respect to the physical measurements and record keeping. However, the results were not used to identify trends or changes developing within the system.

Origin, Flame and Forces

On July 31, 2000, the afternoon shift began at 3:45 p.m., as the working crews traveled underground. The shift was to continue until 1:45 a.m. on August 1. Mining and related activities continued normally throughout the shift until the time of the first explosion.

First Explosion

Most likely, a roof fall in the headgate fringe area of the gob, between the longwall face and the longwall set-up rooms, ignited a small pocket of methane and other gaseous hydrocarbons. The flame traveled inby to a methane accumulation in the back of the gob near the longwall set-up rooms. The ignition of this methane resulted in the first explosion at 11:48 p.m. on July 31. Flame from the initial ignition also traveled toward the longwall face and ignited methane feeders and, eventually, the vapors from the liquid hydrocarbons.

Elevated CO readings occurred in the bleeder entries and in the D-3 No. 1 headgate entry. The monitors near the headgate bleeder connector regulators experienced a communication failure. Data from the CO monitors near the tailgate regulators at the bleeder entries indicated concentrations in excess of 50 ppm shortly after the explosion. Data from the CO monitor at MPL B2 showed that the concentrations began to increase approximately 21 minutes after the explosion and, within an additional two minutes, the readings were in excess of 50 ppm. Data from the CO monitors in the No. 1 headgate entry outby the face revealed that elevated concentrations of CO occurred at the monitor locations near the longwall face. Data from each outby sensor also showed elevated concentrations. This is consistent with the incomplete combustion of fuel during an explosion.

The miners working on the longwall section did not report seeing any flame or feeling any heat from the first explosion. The miners on the longwall face felt the pressure of the explosion followed by dusty conditions, but initially thought it occurred as a result of a massive roof fall in the gob. The reported effects of the explosion across the longwall face are consistent with pressures of less than 0.5 pounds per square inch (psi). The miners on the longwall face near the headgate immediately observed fire on the floor near Shield 8. The miners at Crosscut 48 of the headgate experienced a pressure wave that was propagating from the No. 2 entry. The reported effects of the explosion in this area are consistent with pressures of approximately 1 psi. The reported effects in the No. 2 entry are consistent with a pressure wave of about 2 psi. This pressure would have been sufficient to damage the regulator in the No. 1 entry inby Crosscut 51. Life-threatening injuries did not occur as a result of this first explosion.

The first explosion occurred in the No. 1 headgate entry of the D-3 section near the longwall set-up rooms. The explosion probably generated pressures of approximately 5 psi near the origin. However, obstructions prevented the full thrust of the explosion from propagating outby in the No. 1 entry. As little as 50 cubic feet of methane, diluted to about 6.5%, would be capable of generating this limited pressure. The 5 psi force would be sufficient to damage the undercast and regulator in the mixing chamber. The force exiting the headgate into the bleeder entries was approximately 3 psi. This pressure would be sufficient to severely damage both the headgate regulators and the nearby controls in the bleeder entries. These regulators were both nearly closed prior to the explosion. The force reaching the tailgate bleeder regulators was probably 2 psi. Both regulators were significantly open. This pressure may have been sufficient to damage both of these regulators.

The forces generated during an explosion can increase, decrease, or remain constant throughout an explosion zone, depending on the amount of fuel that continues to be available. In the absence of an underground investigation, firsthand facts pertaining to the propagation of flames and the resulting generation of explosion forces could not be confirmed by the investigators. However, it is reasonable to believe that limited forces could be maintained for significant distances. For example, pressures of less than 1 psi could have caused doors in outby areas of the bleeder entries to be forced into an open position.

Based on the expected generation of forces and statements from the witnesses, it is likely that the first explosion compromised the mixing chamber regulator, the undercast in the gob, and the regulators located in the headgate entries inby the face. Primary explosion forces propagated into the bleeder entries and outby in the No. 2 headgate entry toward the face. Because an underground investigation was not possible, the degree of involvement of coal dust, if any, and damage to the bleeder entries could not be ascertained. No miners traveled the bleeder entries after the explosion. However, it is believed that ventilation controls in the bleeder entries, in addition to those mentioned above, were significantly damaged or otherwise compromised due to the force of the first explosion.

Immediately after the first explosion, fire was observed in the vicinity of Shield 8 by one of the shearer operators. The liquid hydrocarbons were subjected to temperatures which exceeded both their flash point and their ignition temperature during the explosion. The fire was able to spread along the surface of the liquid hydrocarbons and along any available methane floor feeders. The fire continued to burn at least in the vicinity of Shields 3 to 8. Fire fighting activities were on-going with the use of 10-pound fire extinguishers and water. This effort had little effect on the overall fire due to the fact that much of the fire occurred in inaccessible areas behind the shields.

Second Explosion

The ventilation controls, compromised in the first explosion, resulted in a disruption of the ventilation of the gob. The area and volume of methane, between the rubble zone and the longwall face, increased. Shortly before the second explosion, fire was increasing in intensity, rolling behind the shields, indicating that additional methane accumulations were becoming involved. The second explosion occurred as a methane accumulation was ignited by the fire at approximately 11:55 p.m. on July 31. Primary explosion forces, although limited, propagated along the face toward the headgate and outby in the No. 1 entry.

The second explosion was not discernable on the fan chart and was not recorded by the monitoring system. Evidence indicates that forces generated during the second explosion were of a lower overall magnitude than those of the first explosion. However, injuries were more significant due to the proximity of miners to the origin of the second explosion. It is likely that fatal injuries occurred to Nielsen as a result of the second explosion. High levels of CO were present in and around the longwall face after this explosion.

Third Explosion

The area and volume of methane along the fringes of the gob continued to increase. Turbulence from the second explosion most likely caused high concentrations of methane from the fringes of the gob to mix with air. This accumulation along the fringes of the gob near the set-up rooms, was most likely ignited at approximately 11.56 p.m. The period of time between the second and third explosions was probably limited to less than one minute. Considering the burning rate of methane, it is conceivable that the third explosion was a continuation of the second explosion and not a separate event. The primary forces from this explosion propagated inby in the No. 1 entry and outby along the headgate fringe of the gob. Forces continued outby through Crosscut 53 and into the No. 2 entry. Forces also traveled into the bleeder entries. The fan pressure chart showed a spike in the pressure following this explosion. A sudden decrease in fan operating pressure resulted. It is likely that fatal injuries occurred to Stansfield as a result of the third explosion.

Considering all pertinent information, it is likely that the third explosion was the most powerful explosion. The miners working on the longwall section did not report seeing any flame or feeling any heat from the third explosion. The miners on the longwall face felt the pressure of the explosion but indicated that it was not as strong as the second explosion. The reported effects of the explosion across the longwall face are consistent with pressures of less than 1 psi. The miners near the mantrip in the headgate experienced a pressure wave that propagated outby in the No. 2 entry. The reported effects of the explosion in this area are consistent with pressures of approximately 2 psi. As with the first explosion, obstructions prevented the full thrust of the explosion from propagating outby along the headgate fringe of the gob.

Fourth Explosion

A pressure spike on the fan operating chart and the monitoring system indicated that a fourth explosion occurred at approximately 12:17 a.m. on August 1, 2000. No miners underground recalled the fourth explosion.

Potential Ignition Sources

A determination of the potential ignition sources is based on several factors. These factors typically include.

a) identification of the available fuels;
b) ignition temperatures and energies of the available fuels;
c) visual observations;
d) statements from witnesses and other persons with knowledge of the circumstances surrounding the explosion;
e) location of all ignition sources near the suspected origin;
f) the activities that were being conducted at the time of the explosion;
g) the location of all miners in the vicinity of the ignition; and
h) subsequent evaluations of ignition sources within the explosion zone.

The available fuels considered for the first explosion are methane, coal dust, and hydrocarbons. Methane was liberated from the mine and it did occur in significant quantities in the area of the mine where the series of explosions occurred. The ignition temperature for methane is approximately 1000•F. The energy necessary to ignite methane is approximately 0.3 millijoules. Methane is ignitable at concentrations between 5% and 15%. Coal dust layers can be ignited at temperatures as low as 320•F and coal dust clouds can be ignited at temperatures as low as 824•F. The energy necessary to ignite bituminous coal dust is about 60 millijoules. Layers of coal dust averaging only 0.005 inch thick can propagate an explosion, if suspended. Hydrocarbons from the Willow Creek Mine have a flash point of approximately 97•F. This is the temperature at which the hydrocarbons give off ignitable vapors. However, the ignition temperature for those vapors is approximately 500•F. Ignition energies are not well established for these particular hydrocarbons.

The fuel for the first explosion was most likely methane. Coal dust would not have been in suspension to the degree necessary for explosion propagation. Hydrocarbon vapors alone would not have been present in the volumes necessary to support a continuing explosion flame. However, the ignition of methane eventually resulted in prolonged burning of sporadic liquid hydrocarbon accumulations in the headgate fringe of the gob of the D-3 panel. This burning provided a continuing source of ignition for subsequent explosions propagating from the gob area.

Viable potential ignition sources must be capable of exceeding either the temperature or energy requirements of the fuel. Visual observations were not possible in this case because the mine was sealed and an underground investigation could not be conducted. However, the existence of potential ignition sources has been verified through the statements by witnesses and other persons with knowledge of the circumstances surrounding the initial explosion.

Witness statements and other information obtained during the investigation were used to identify an area in which the first explosion originated. This area includes the longwall face, the headgate entries inby the face, the fringe of the gob on the headgate side from behind the shields to the set up rooms, the headgate side of the set up rooms and the bleeder entries. All ignition sources within this area were considered in establishing the potential ignition sources for the first explosion.

The locations of miners underground and the activities that were being conducted are important in identifying the potential ignition sources. Very few ignitions have occurred over the past twenty years that did not directly involve the actions of those working underground at the time of the explosion. However, those extraneous sources were also considered and will be discussed in this section of the report.

Although equipment and other ignition sources are typically evaluated after an explosion, none were removed because an underground investigation was not possible. Therefore, laboratory testing was not used as a tool to eliminate or identify any particular source of ignition.

All of the available information concerning possible ignition sources for the first explosion was examined. The following ignition sources were considered:

a) roof fall inby face along the headgate fringe of the gob;
b) falling rock impacting on seams on Can cribs;
c) tensile failure of cable bolts or trusses;
d) operation of pumps in bleeder entries,
e) breaking of wire rope tied between Shield 1 and the shearer;
f) operation of face conveyor;
g) the operation to advance the shields;
h) operation of shearer;
i) shearer cutting roof or rib bolts;
j) cutting/welding operations;
k) material passing through crusher;
l) smoking;
m) spontaneous combustion;
n) lightning, and;
o) compression of air due to a large roof fall.

Roof falls occurred in the gob of the D-3 panel. Sandstone formations contain varied degrees of quartz. Quartz, which is a crystalline structure, is known to exhibit a "piezoelectric effect". Piezoelectricity is the development of electrical charges on the surface of the crystal. Sparking occurs when this electrical charge is dissipated. This sparking can provide the energy needed to ignite flammable gases and vapors. A roof fall is the most likely potential ignition source for the explosion.

The Cans used for roof support reportedly were constructed with welded seams. The mine operator indicated that roof falls impacting on the seams could generate sparks and that tape on the seams would minimize the hazard. However, the operator declined to provide information on tests conducted on these roof supports. Preliminary and informal tests had been performed by the National Institute of Occupational Safety and Health, formerly the Bureau of Mines, which indicated that sparks generated by rocks impacting the Cans were not likely to ignite methane. However, because formal testing was not conducted, conclusive results of testing on the incendive nature of these Cans was not available to the investigation team. Therefore, roof falls against exposed seams remains as a potential ignition source.

Recent testing of cable bolts has shown that their failure did not ignite methane. However, the tensile failure of cable bolts or trusses is theoretically capable of igniting methane, under certain conditions. Depending on their location and on the location of methane accumulations within the explosive range, tensile failures of either cable bolts or trusses may be a potential source of ignition for the explosion.

Pumps and their associated control boxes, located in the intake split adjacent to the bleeder entries, could have ignited methane. An evaluation of pumping equipment and an investigation of the surrounding area was not possible. An examination of the bleeder entries near the pumping equipment was conducted earlier in the shift on the day of the explosion. The pump was not operating at the time. Water had accumulated near the pump to within approximately 3 feet from the roof. It is possible that additional water inflow or a roof fall in the area of the water occurred which caused an interruption in the ventilation and allowed methane to accumulate. However, this is not likely because of the relatively short time period between the examination and the time of the explosion. Additionally, it is unlikely that an explosion initiating near the pump or its associated controls would result in an almost instantaneous fire at the longwall face. The pumping equipment is not considered as a potential source of the explosion.

Statements were made by witnesses that Shield 1 was not being advanced at the time of the first explosion. Therefore, the wire rope used in advancing Shield 1, immediately prior to the accident, had not experienced a tensile failure. It is not considered as a potential source for the explosion.

The operation of the face conveyor was considered as a potential ignition source. Although, methane can accumulate under the panline of face conveyors, miners were in the proximity of the panline and did not report methane or flames. Also, testimony indicated that the face conveyor was not operating immediately prior to the explosion. The operation of the face conveyor is not considered as a potential source of the explosion.

Frictional heating between the shields and the roof or roof supports would not be capable of generating the necessary temperatures for hydrocarbon or methane ignition. However, there could be sufficient energy generated during the process to ignite these gases. It is unlikely that ignitable gas concentrations existed at this location because of the volume of airflow in this area. Additionally, information was obtained during interviews to indicate that shields were not being moved at the time of the explosion. Therefore, the operation to advance the shields is not considered as a potential ignition source.

Although the operation of the shearer could ignite methane, the shearer was not cutting at the time of the explosion. Miners were in the immediate proximity of the shearer and did not state that methane was ignited at this location. The volume of airflow in the area was sufficient to prevent any accumulations of ignitable methane concentrations. Additionally, the recorded amperage used by the shearer had dropped to insignificant levels about four minutes prior to the event, further eliminating the shearer as a potential source for the explosion.

Although the cutting of roof or rib bolts by the shearer could ignite methane, it was not cutting at the time of the explosion. Therefore, the cutting of roof and rib bolts was not considered a potential ignition source.

There was no indication that cutting/welding operations were ongoing at the time of the explosion. Therefore, cutting/welding operations were not considered a potential ignition source.

Material passing through the crusher portion of the stageloader can create sufficient energy to ignite gas. Miners were working in the area and they did not report anything unusual in this area. The ignition of methane accumulations in the crusher portion of the stageloader would have caused flames to travel into the face area. Miners on the face did not report seeing flames at or near the stageloader prior to the first explosion. Therefore, material passing through the crusher is not considered a potential ignition source.

Investigators found no evidence to indicate that smoking was the ignition source. Therefore, smoking is not considered a potential ignition source.

There was no history of the occurrence of spontaneous combustion in the mine. The AMS did not record any elevated levels of carbon monoxide prior to the explosion. Therefore, spontaneous combustion is not considered a potential ignition source.

There were no reports of lightning at the time of the explosion. The report obtained from Global Atmospherics, Inc., shows that there were no lightning strikes in the area at or near the time of the explosion. Therefore, lightning is not considered a potential ignition source.

Heating of the atmosphere from the compression of air can only occur under extreme circumstances. A roof fall of a massive area would be necessary to cause such a condition. Mine maps revealed that there was not an open area in the D-3 panel large enough for this condition to occur. Miners on the face would have suffered fatal injuries associated with the resulting force of such a roof fall. However, the miners on the face did not experience injuries to this extent. Therefore, compression of air is not considered a potential ignition source.

The most likely ignition source for the first explosion is a roof fall. Two other potential ignition sources are roof falls against exposed seams of Can roof supports and the tensile failure of cable bolts. All three potential ignition sources were located in the headgate fringe area of the gob.

CONCLUSION

The bleeder ventilation system did not adequately control and distribute the air passing through the worked-out area of the D-3 Panel. The system did not continuously dilute and move methane-air mixtures and other gases, dusts, and fumes from the worked-out area away from active workings and into a return air course or to the surface of the mine.

Several factors adversely impacted the bleeder ventilation system prior to the accident. An increase of coal production on the longwall face and an expanding gob resulted in greater methane liberation into the gob. This increase in liberation was accompanied by a decrease in the total quantity of airflow within the gob. Although vertical degasification boreholes were drilled for the panel, the first vertical degasification borehole had not yet been encountered. In addition, the mine ventilation and bleeder system had limited reserve capacity and the availability of ventilation pressure and air quantity was further reduced by the intake air split adjacent to the D Seam Bleeders. The distribution of airflow in the gob was affected by the lack of fully established internal airflow paths as well as by ventilation controls, such as check curtains and an undercast, that were left intact in the worked-out area.

Most likely, a roof fall in the headgate fringe area of the gob, between the longwall face and the longwall set-up rooms, ignited a small pocket of methane and other gaseous hydrocarbons. The flame traveled inby to a methane accumulation in the back of the gob near the longwall set-up rooms. This resulted in an explosion and fire at 11:48 pm on July 31, 2000. An interruption of ventilation of the D-3 gob, caused by the explosion, prevented methane removal from the gob. Eventually, liquid hydrocarbons became involved in the fire. Fatal injuries did not occur as a result of the first explosion.

After the first explosion, personnel remained on the D-3 longwall section to extinguish a fire near the base of the shields on the headgate side of the longwall face. Conditions worsened in the face area just prior to the second explosion. The fire, resulting from the first explosion, ignited subsequent explosions. Fatal injuries likely occurred as a result of the second and third explosions.

Approved:

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Marvin W. Nichols, Jr.
Administrator

ENFORCEMENT ACTIONS

30 CFR 75.334(b)(1) *During pillar recovery a bleeder system shall be used to control the air passing through the area and to continuously dilute and move methane-air mixtures and other gases, dusts, and fumes from the worked-out area away from active workings and into a return air course or to the surface of the mine.*

Violation: During pillar recovery of the D-3 Longwall Panel, the bleeder system being used did not control and distribute air passing through the worked-out area in a manner which continuously diluted and moved methane-air mixtures and other gases, dusts, and fumes from the worked-out area away from active workings and into a return air course or to the surface of the mine.

The following factors impaired the bleeder system's effectiveness at controlling and diluting the air passing through the worked-out area: a limited mine ventilating potential; the configuration and distribution of airflow in the bleeder system and worked-out area; and temporary controls installed within the worked-out area which restricted airflow through the pillared area. As production increased and the pillared area expanded, methane liberation increased and airflow paths changed within the worked-out area. These changing conditions resulted in reduced airflow and elevated methane concentrations within the worked-out area at locations containing potential ignition sources and within close proximity to the active longwall face.

On July 31, 2000, an explosive concentration of methane-air mixtures and/or other gases, dusts, and fumes had accumulated in the worked-out area, within 250 feet of the working D-3 Longwall face. At approximately 11:48 p.m., a portion of the atmosphere in the worked-out area was ignited, resulting in an explosion which injured a miner working on the D-3 Longwall Section. The initial explosion created conditions which resulted in additional explosions within or near the worked-out area. The subsequent explosions resulted in fatal injuries to two miners located on the D-3 Longwall Section.

ENFORCEMENT ACTIONS (cont.)

30 CFR 75.370(a)(1): *The operator shall develop and follow a ventilation plan approved by the district manager. The plan shall be designed to control methane and respirable dust and shall be suitable to the conditions and mining system at the mine. The ventilation plan shall consist of two parts, the plan content as prescribed in §75.371 and the ventilation map with information as prescribed in §75.372. Only that portion of the map which contains information required under §75.371 will be subject to approval by the district manager.*

Violation: The approved mine ventilation plan was not being complied with in that ventilation devices used to control air movement through the D-3 worked-out area were left in tact after retreat mining commenced at locations not shown on the supplement to the mine ventilation plan titled, "D-3 LONGWALL START-UP HEAD TO TAIL AND BLEEDER VENTILATION WITH TAIL GATE INTAKE," approved July 7, 2000. Information obtained during the investigation of a fatal mine fire and explosion accident which occurred on July 31, 2000, established that the mine operator installed framed curtains across four of the six bleeder connectors at the inby end of the D-3 Longwall pillared area. Also, an overcast and check curtain were installed in the bleeder connector nearest the headgate side of the worked-out area, leaving one unobstructed bleeder connector which was located on the tailgate side of the worked-out area. However, the approved plan supplement did not show controls at these locations. These controls inhibited airflow on the headgate side of the worked-out area where the initial explosion and subsequent fire occurred on July 31, 2000.

Appendix A - List of Injured Miners

Name	Title	Nature of Injury
Shane Stansfield	Longwall Mechanic	Fatally Injured
Cory Nielsen	Propman	Fatally Injured
Tyson Hales	Stageloader Operator	Burns, Head Trauma
William Burton	Afternoon Shift Supervisor	Burns, Fractures, Smoke Inhalation
Roger McKinnon	Continuous Mining Machine Helper (Acting Spellboss)	Burns
Charles Whitten	Continuous Mining Machine Operator (General Laborer)	Burns
David Berdan	Shuttle Car Operator (General Laborer)	Cuts, Lacerations
Kyle Medley	Headgate Shearer Operator	Burns, Fractures
Ronnie Gonzales	Longwall Mechanic	Burns, Cuts
Wesley Ellner	Tailgate Shearer Operator	Burns, Cuts

Appendix B - Mine Rescue Team Members

Ray Haigler (Captain)

Boyd Moosman

Dave Wood

Lee Montoya

Zach Robinson

Ken Powell

Appendix C - List of Persons Interviewed

Name	Title
Robert Beasley	Electrical Coordinator
David Berdan	Shuttle Car Operator/Underground Coal Miner
John Borla	Manager of Technical Resources
Benjamin Brady	Shearer Operator
Charles Burggraf	Chief Operating Officer
William Burton	Shift Supervisor
Mac Cook	Heavy Equipment Operator/Mine Rescue Trainer
Jerry DuBois	Shift Foreman
Wesley Ellner	Shearer Operator
Dale Evans	Technician, Field Services (Resource Enterprises Inc.)
Victor Ewell	Outby Construction Foreman
Ray Haigler	Maintenance Foreman/Longwall Production Foreman, Mine Rescue Team Captain
Ronnie Gonzales	Longwall Shift Mechanic/Tailgate Operator
Kerry Hales	Mine Manager
Steven Jones	Staff Mining Engineer
Dean LaCotta, Jr.	AMS Attendant
Dennis Lake	Longwall Foreman
Vernon Marvidikis	Section Foreman
Joseph McCourt	Outby Foreman
Roger McKinnon	Continuous Mining Machine Helper/Spellboss
Kyle Medley	Headgate Shearer Operator
John Mercier	Geologic Supervisor
Henry Mills	Maintenance Foreman
Jas Mills	Scoop Operator (Rocky Mountain Miners/ Castle Valley Services)
Lee Montoya	Longwall Foreman
Boyd Moosman	Longwall Maintenance Foreman
John Pesarsick	General Mine Coordinator
Kenneth Powell	Beltman/Mine Rescue Team
Thomas Rice	Temporary Safety Coordinator
Steven Rigby	Maintenance Manager
Zachary Robinson	Roof Bolter/Mine Rescue Team
Steven Sheriff	Outby Utility Construction Man
Roger Tuttle	Mechanic/Electrician
Charles Whitten	Continuous Mining Machine Operator
Layne Willson	Electrician
David Wood	Outby Construction Man/Mine Rescue Team

Appendix D - Persons Participating in Investigation

Name	Title
Robert Beasley	Electrical Coordinator (Plateau Mining Corporation-PMC)
David Berdan	Shuttle Car Operator/Underground Coal Miner (PMC)
John Borla	Manager of Technical Resources (PMC)
Benjamin Brady	Shearer Operator (PMC)
Charles Burggraf	Chief Operating Officer (PMC)
William Burton	Shift Supervisor (PMC)
Mac Cook	Heavy Equipment Operator/Mine Rescue Trainer (PMC)
Jerry DuBois	Shift Foreman (PMC)
Wesley Ellner	Shearer Operator (PMC)
Dale Evans	Technician, Field Services (Resource Enterprises Inc.)
Victor Ewell	Outby Construction Foreman (PMC)
Ray Haigler	Maintenance Foreman/Longwall Production Foreman, Mine Rescue Team Captain (PMC)
Ronnie Gonzales	Longwall Shift Mechanic/Tailgate Operator (PMC)
Kerry Hales	Mine Manager (PMC)
Steven Jones	Staff Mining Engineer (PMC)
Dean LaCotta, Jr.	AMS Attendant (PMC)
Dennis Lake	Longwall Foreman (PMC)
Vernon Marvidikis	Section Foreman (PMC)
Joseph McCourt	Outby Foreman (PMC)
Roger McKinnon	Continuous Mining Machine Helper/Spellboss (PMC)
Kyle Medley	Headgate Shearer Operator (PMC)
John Mercier	Geologic Supervisor (PMC)
Henry Mills	Maintenance Foreman (PMC)
Jas Mills	Scoop Operator (Rocky Mountain Miners/ Castle Valley Services)
Lee Montoya	Longwall Foreman (PMC)
Boyd Moosman	Longwall Maintenance Foreman (PMC)
John Pesarsick	General Mine Coordinator (PMC)
Kenneth Powell	Beltman/Mine Rescue Team (PMC)
Thomas Rice	Temporary Safety Coordinator (PMC)
Steven Rigby	Maintenance Manager (PMC)
Zachary Robinson	Roof Bolter/Mine Rescue Team (PMC)
Steven Sheriff	Outby Utility Construction Man (PMC)
Roger Tuttle	Mechanic/Electrician (PMC)
Charles Whitten	Continuous Mining Machine Operator (PMC)
Layne Willson	Electrician (PMC)
David Wood	Outby Construction Man/Mine Rescue Team (PMC)

Appendix D - Persons Participating in Investigation (cont.)

R. Henry Moore	Esquire, Buchanan Ingersoll P.C. (Counsel for Plateau Mining Corporation)
Dennis A. Beiter	Supv. Mining Engineer (MSHA Technical Support)
William Crocco	Mining Engineer (MSHA Division of Safety)
Ray McKinney	District Manager (MSHA District 5)
Clete R. Stephan	Mining Engineer (MSHA Technical Support)
Joseph S. Tortorea	Supv. Mining Engineer (MSHA District 2)
John E. Urosek	Chief Ventilation Division (MSHA Technical Support)
Chris A Weaver	Mining Engineer (MSHA District 3)
Gary J. Wirth	Supv. Mining Engineer (MSHA District 11)

Appendix F

Figure 1 - Bristol Fan Pressure Recorder Chart

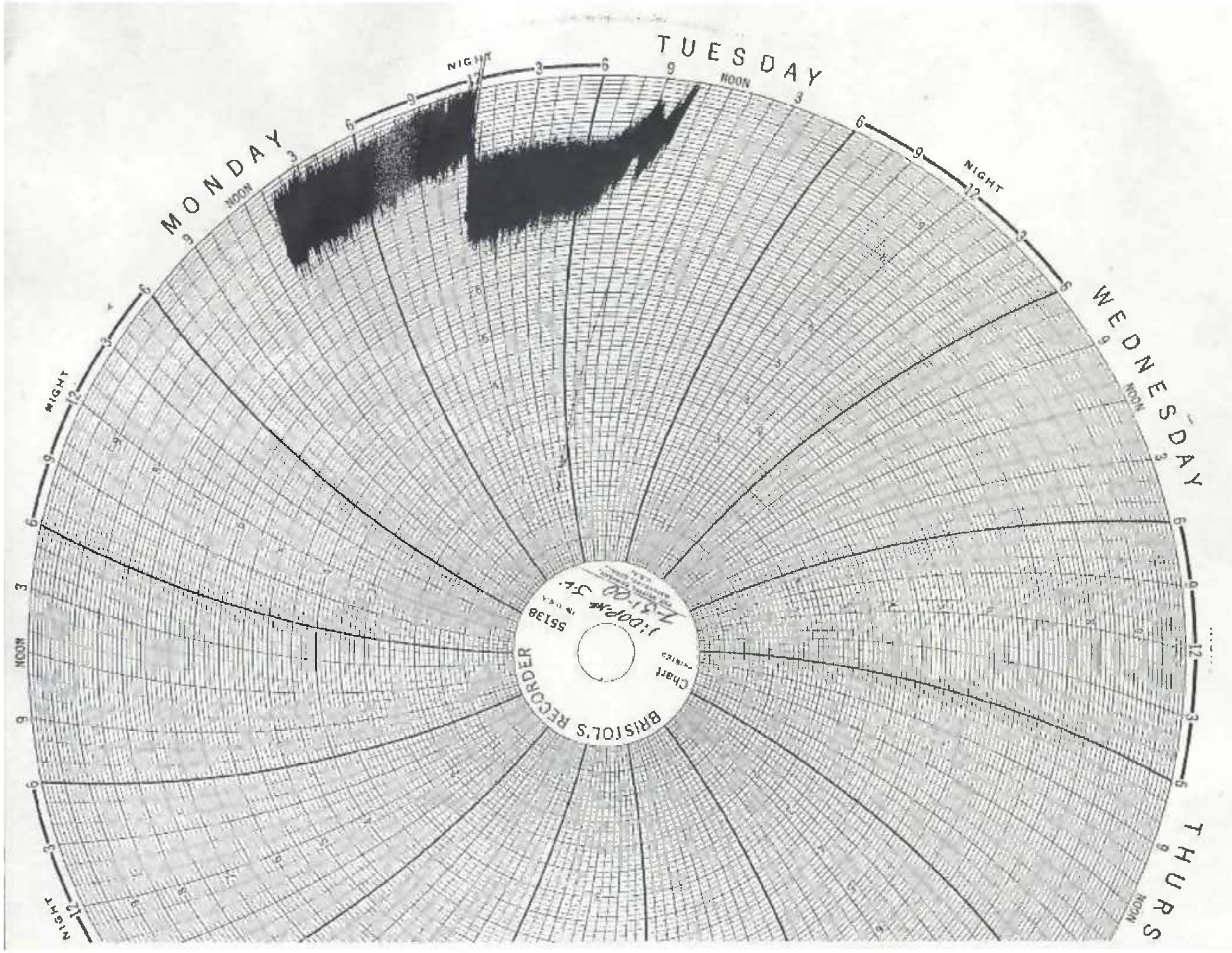


Figure 2 - Allen-Bradley System Fan Pressure

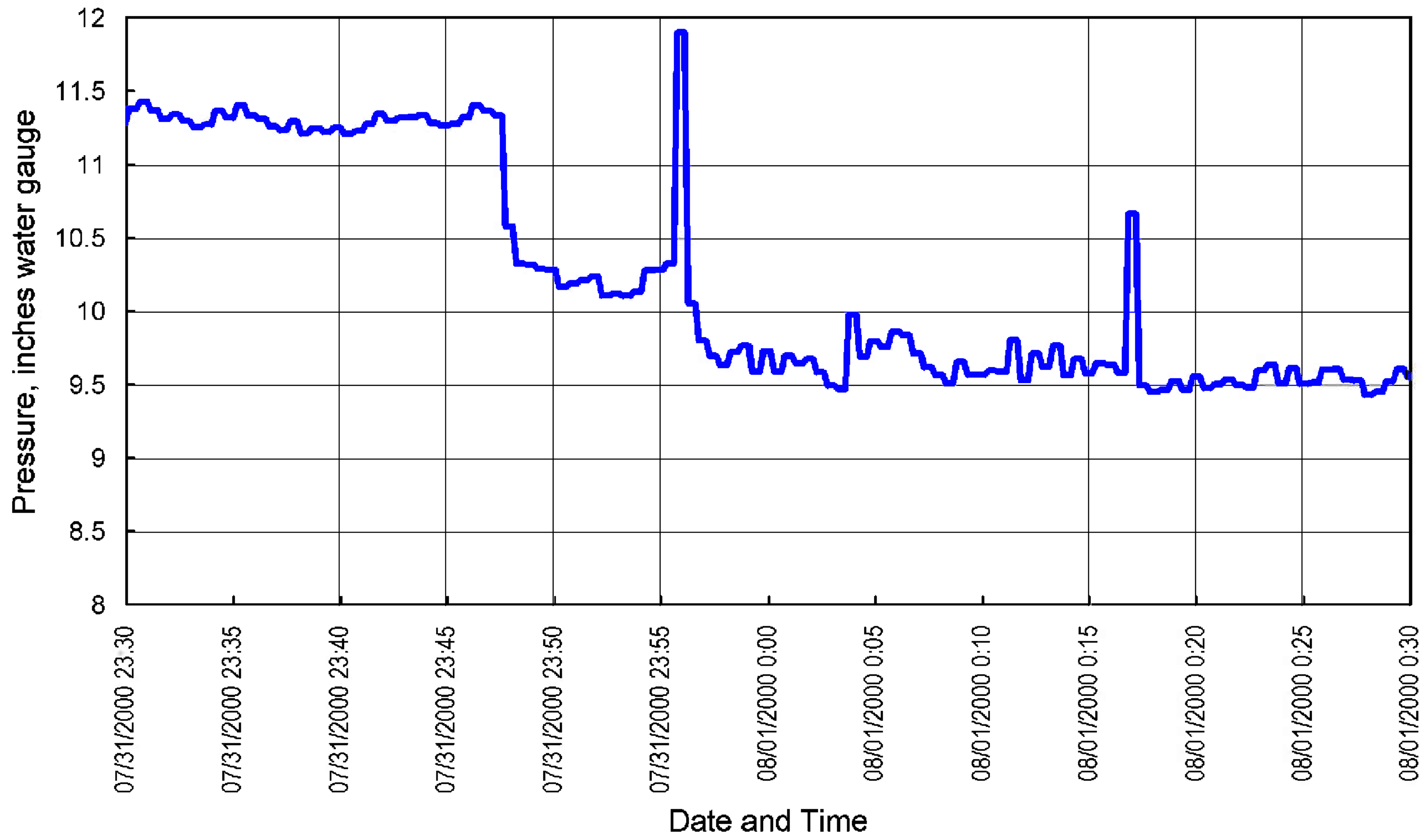


Figure 3 - Methane Concentration at Bleeder MPLs

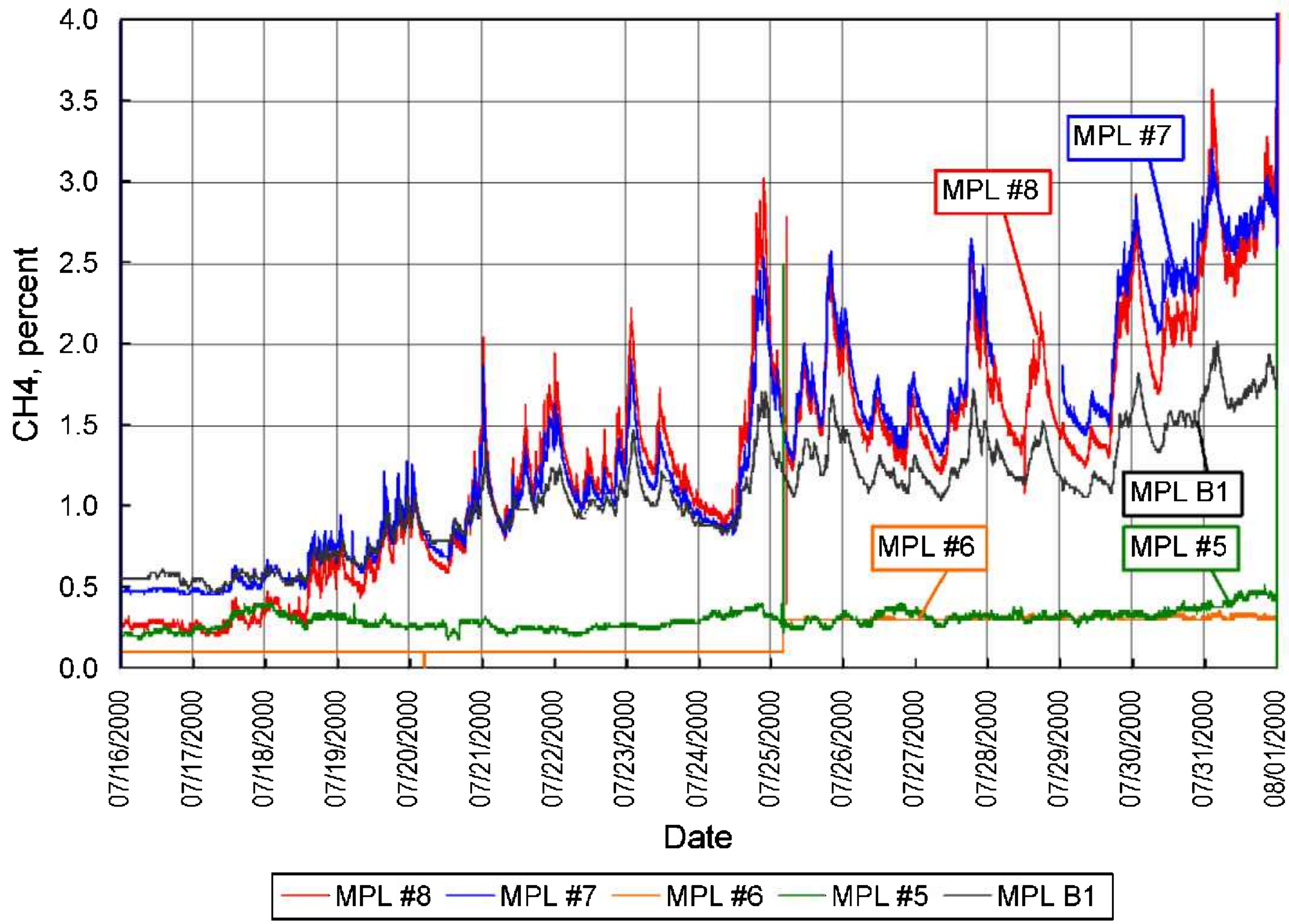
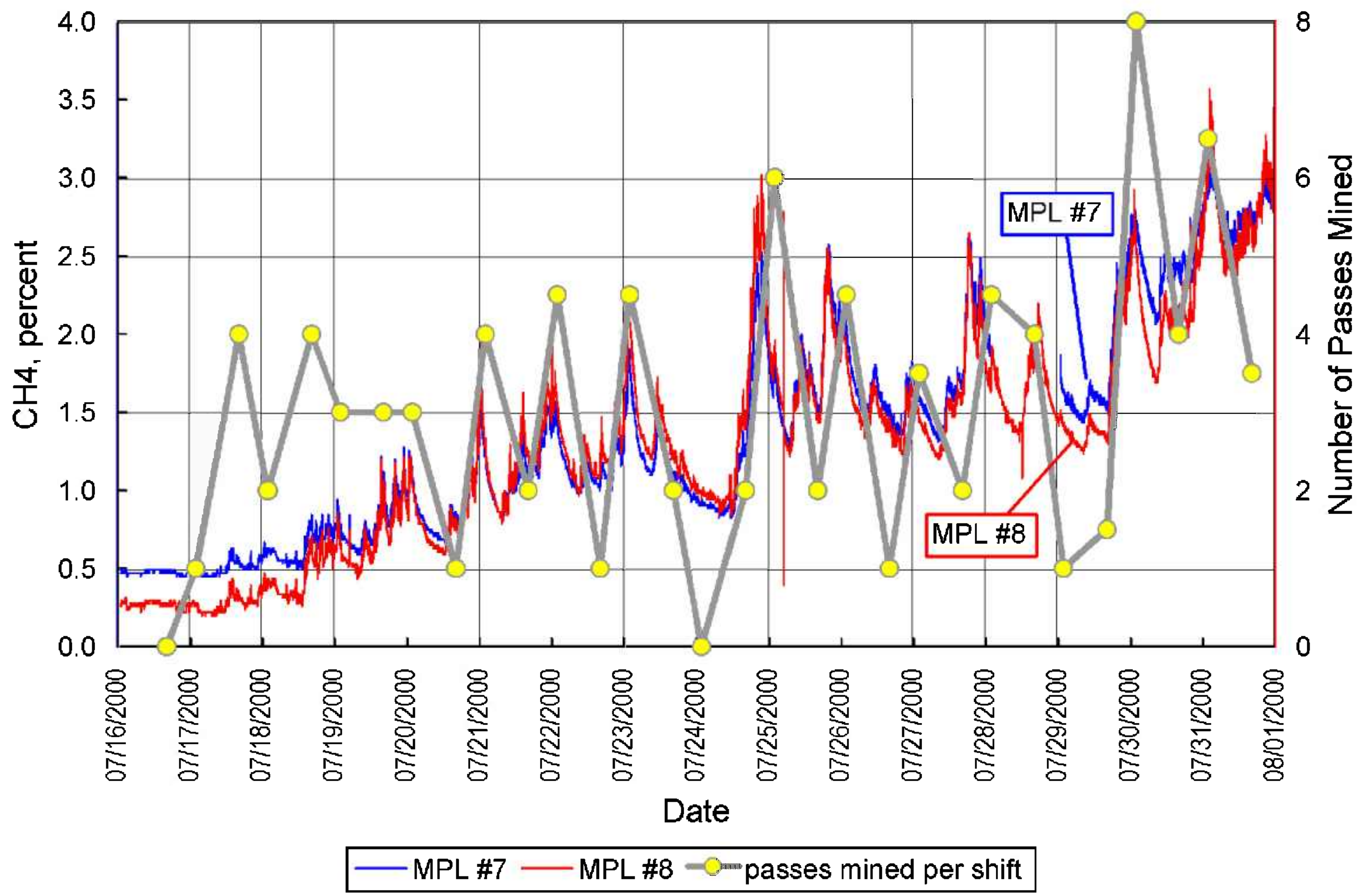


Figure 4 - Methane Concentration at Tailgate Bleeder Connector MPLs and Longwall Production



DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION
UNDERGROUND COAL MINE EXPLOSIONS
JULY 31 - AUGUST 1, 2000

WILLOW CREEK MINE - MSHA ID. NO. 42-02113
PLATEAU MINING CORPORATION
HELPER, CARBON COUNTY, UTAH

APPENDIX G

D-3 Section Longwall Mantrip showing extensive dust and soot deposits on white vehicle.

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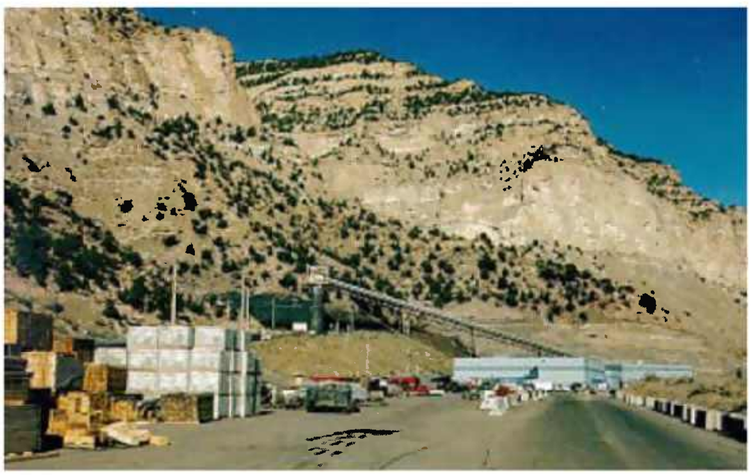
APPENDIX G



Mine Site offices, Shop and Highwall at lower right