



The Sago Mine Disaster

A preliminary report to Governor Joe Manchin III

J. Davitt McAteer
and associates

July • 2006

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JULY • 2006

Buckhannon, West Virginia

On January 12, 2006, West Virginia Senate President Earl Ray Tomblin (D-Chapmanville) and House Speaker Bob Kiss (D-Raleigh) appointed Senators Don Caruth (R-Mercer), Jeff Kessler (D-Marshall) and Shirley Love (D-Fayette) and Delegates Mike Caputo (D-Marion), Eustace Frederick (D-Mercer) and Bill Hamilton (R-Upshur) to conduct an inquiry into the Sago disaster. At the request of Governor Joe Manchin III, their inquiry was conducted jointly with our investigation. These legislators have worked diligently with us in seeking answers to this West Virginia tragedy.

This report, as well as additional related information, is available at:
www.wvgov.org and www.wju.edu

Front cover photo:

Memorial ribbons on the Sago Mine security fence, January 2006
Jeff Swensen / Getty Images

Back cover photo:

Mourners praying at the funeral of Jerry Groves, January 2006
Haraz Ghanbari / AP Images

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Letter of transmittal

Governor Joe Manchin III
State of West Virginia
1900 Kanawha Boulevard East
Charleston, WV 25305

Dear Governor Manchin:

I have the honor to submit to you this preliminary report on the Sago Mine disaster of January 2-4, 2006.

On January 9, 2006, when you appointed me as your special advisor on the disaster, you directed me to investigate and report on the causes; the rescue and recovery operation, including the miscommunication that caused the Sago miners' families such needless heartache; and the steps needed to improve mine safety and mine communications in West Virginia and across the nation.

This report seeks to address these concerns. My hope is that it honors the pledge you made to the victims' families when you stated: "These twelve lives will not be lost in vain. It is my goal to see that West Virginia is home to the safest mining operations in the nation."

I believe we can fulfill this pledge and accomplish this goal. But the task will require dedication, innovation, and vigilance on the part of all in the mining community.

For me, and for my associates in this investigation, it has been an inspiration to meet and work with the families of the lost miners. In their grief they have become tireless advocates for change. They have our deep respect and support.

The miners' families insisted that their loved ones be honored and remembered. They demanded that the disaster be investigated thoroughly and in the clear light of day. They were your strongest allies as you and the legislature moved with unprecedented speed to enact new mine safety legislation on January 23; they were full partners in the public hearings we conducted on May 2-4; and they became a vital presence in Washington, working with West Virginia's congressional delegation to pass the new federal legislation enacted by Congress in June. As we look to the future, miners' families have the most at stake and are the main reason why I can feel confident that real change is coming to the coal industry.

This is a preliminary report primarily because we do not yet have all the answers about the disaster's proximate cause. But in your initial charge to me you directed that if, during the course of the investigation, we were able to reach conclusions about improvements to mine safety and health which could be implemented along the way, we should make those conclusions available. We are doing so in this report, which includes numerous recommendations to improve mine safety and mine rescue.

We offer these recommendations in full awareness that more remains to be done. But that should not be a rationale for delay. There are technologies and equipment available today that could be making our coal mines significantly safer tomorrow — for example by improving communication and the ability to locate miners, and, when escape is not possible, improving miners' chances of surviving an explosion or fire by providing refuge chambers.

It has been suggested that some of this equipment is "unreliable," by which is meant that it may not work in all locations at all times. That criticism is misplaced.

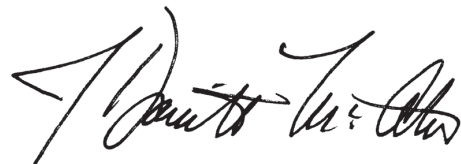
Underground coal mines are both similar and unique. The roughly 150 currently active underground coal mines in West Virginia are similar in purpose and function. They are different, even unique, in the geological, engineering, and other challenges that they represent. The similarities suggest that innovative technologies should be broadly applicable. The differences suggest that some technologies will need to be tweaked or modified in order to be made reliable in specific situations.

If we insist on waiting for perfect technological answers to the challenges facing us, we will wait forever. The unmistakable message of the Sago Mine disaster is that we cannot afford to wait. In this report we discuss technologies and techniques which are currently available, tested in underground mines in the United States and other mining countries, and which would immediately improve underground miners' chances to escape or be rescued in an emergency. Incremental improvements should be adopted immediately while the search for better technologies goes forward.

Because of your leadership, the leadership of the state legislature, and, at the national level, the leadership of Senator Robert C. Byrd and the entire West Virginia congressional delegation, West Virginia is poised to lead the coal mining industry of the United States in creating a far safer workplace, one worthy of the 21st century and the miners who do so much to power the nation's economy. My hope is that this report will help spur the kind of progress that miners have been waiting for.

The work of fulfilling our pledge to the Sago miners and their families is ongoing, and I expect to supplement this report as necessary.

Thank you for asking me to assist you in striving to make West Virginia the nation's leader in coal mine health and safety. I submit this report in the hope and belief that the Sago Mine disaster will be remembered as a turning point as well as a tragedy.

A handwritten signature in black ink, appearing to read "J. Davitt McAteer". The signature is fluid and cursive, with a large initial "J" and "M".

J. Davitt McAteer
Shepherdstown, West Virginia
July 19, 2006

We dedicate this report

to the families of the twelve good men
who lost their lives in the Sago Mine

January 2-4, 2006



Tom Anderson was a shuttle car operator on the Two Left section of the Sago Mine, moving coal from the area of the working face to the conveyor belt. He had 10 years in the mines. He lived in Rock Cave, Upshur County. Married to Lynda Hyre Anderson, he was the father of four sons, Caleb (deceased), Randy, Mitchell, and Thomas Isaac. He was 39.



James Bennett was a shuttle car operator with more than 25 years of mining experience. He lived in Volga, Barbour County. Married to Lily Foster Bennett, he was the father of a daughter, Ann Merideth, and a son, John. The eldest of the Two Left crew, he had been planning to retire in 2006. He was 61.



Marty Bennett was a continuous-miner operator, running the machine that cut coal from the face. He had 29 years of mining experience. He lived in Buckhannon, Upshur County. Married to Judy Ann Lantz Bennett, he was the father of a son, Russell, who also worked at the Sago Mine. He was 51.



Jerry Lee Groves was a roof bolter, with nearly 30 years of mining experience. He lived in Cleveland, Webster County. Married to Deborah A. Groves, he was the father of a daughter, Shelly Rose. He was 56.



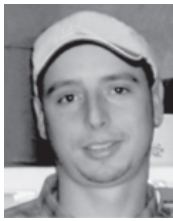
George Junior Hamner was a shuttle car operator, with 28 years of mining experience. He grew up on a farm near the site of the Sago Mine and owned a small cattle farm in Glady Fork, Upshur County. Married to Deborah Hamner, he was the father of a daughter, Sara Bailey. He was 54.



Terry Helms was a fireboss and beltman. He had 29 years of mining experience. He lived in Newburg, Preston County. The father of a daughter, Amber, and a son, Nick, from his previous marriage, he was engaged to be married to Virginia Moore. He was 50.



Jesse L. Jones was a roof bolter, with 16 years of mining experience. He lived in Pickens, Randolph County. He was the father of two daughters, Sarah and Katelyn. His brother, Owen, was the foreman of the One Left crew on the morning of January 2, and tried to reach Jesse after the explosion. He was 44.



David Lewis was a roof bolter, with about two years of mining experience. He lived in Thornton, Taylor County. Trained as a diesel mechanic, he went to work at Sago so that his wife, Samantha, could stay home with their three daughters, Kayla, Shelby, and Kelsie, while she completed a master's degree in health care administration. He was 28.



Martin Toler, Jr. was the section foreman on Two Left, with 32 years of mining experience. He lived in Flatwoods, Braxton County. Married to Mary Lou Toler, he was the father of a daughter, Courtney, and a son, Chris, who had worked with his father in another mine. He was 51.



Fred G. Ware, Jr. was a continuous-miner operator, with 37 years of mining experience. He lived in Tallmansville, Upshur County, just across the river from the Sago Mine. He was the father of a daughter, Peggy Cohen, and a son, Darrell. He was 59.



Jackie Weaver was the section electrician on Two Left, with 26 years of mining experience. He lived in Philippi, Barbour County. Married to Charlotte Poe Weaver, he was the father of a daughter, Rebecca, and a son, Justin. He was 51.



Marshall Winans was a utility man and scoop operator, with 10 years of mining experience. He lived in Belington, the Talbott Community, Barbour County. Married to Pamela Pharis Winans, he was the father of three daughters, Tiffany, Mandy, and Holly. He was 50.

We also dedicate this report to

the sole survivor of the Two Left crew,

Randal McCloy, Jr.

with best wishes for his continuing recovery

and

to the miners

who escaped the Sago Mine

on the morning of January 2, 2006:

Denver Anderson*

Paul Avington*

John Boni

Pat Boni

Gary Carpenter*

Ron Grall

Randy Helmick*

Eric Hess*

Fred Jamison

Owen Jones*

Hoy Keith*

Roger Perry*

Gary Rowan*

Joe Ryan*

Chris Tenney*

Alton Wamsley*

*One Left crew

and

to the miners

who courageously attempted to rescue the Two Left crew:

Jeff Toler

Vernon Hofer

Owen Jones

Al Schoonover

Dick Wilfong

1 Executive Summary

OVERVIEW

Twenty-nine coal miners went underground at International Coal Group's Sago Mine near Buckhannon in Upshur County, West Virginia, on the morning of January 2, 2006. At 6:26 a.m., a methane ignition in a recently sealed area of the mine triggered an explosion that blew out the seals and propelled smoke, dust, debris and lethal carbon monoxide into the working sections of the mine. One miner was killed by the blast. Sixteen escaped. Twelve were unable to escape and retreated to await rescue behind a curtain at the face of the Two Left section. Mine rescuers found the trapped miners approximately 41 hours later. By that time all but one had succumbed from carbon monoxide asphyxiation.

This is a report about what happened to the miners and why. It is also a report about why the explosion was not contained; why the Two Left crew was unable to escape; why the mine rescue effort took so long; why the trapped miners were sent no signal to tell them that help was coming; and why, after they were finally found, their waiting families were informed that all were alive — and celebrated that miraculous news for nearly three hours before being told the awful truth.

This is also a report about what the Sago

disaster has taught us and what we must do with what we have learned.

The staggering tragedy of the Sago Mine disaster — first the loss of the miners, then the appalling miscommunication to their families — shocked West Virginia and the nation. Governor Joe Manchin III pledged to the families that their loved ones would not die in vain. To make good on that pledge, he vowed to bring West Virginia to a position of national and international leadership in coal mine safety and health.

Action followed. As official investigations by the West Virginia Office of Miners' Health, Safety & Training (WVOMHST) and the federal Mine Safety and Health Administration (MSHA) got under way, the governor appointed a West Virginian and former MSHA chief, Davitt McAteer, as his special advisor. Then, on January 23, the governor introduced and the state legislature enacted — within the unprecedented span of a single day — legislation requiring rapid notification of and response to mine emergencies, storage of additional self-contained self-rescuers (SCSRs) underground, and installation of improved mine communication and tracking systems in order to be able to locate and maintain contact with miners in emergency situations.

Just four days previously, on January 19, the urgent need for action had been underscored by a fire that left two miners dead at Massey Energy's Aracoma Alma Mine in Logan County. Since that time, five more West Virginians have lost their lives in mine accidents, bringing to 19 the number of coal miners killed on the job in the state in the first six months of 2006 — compared to three in all of 2005. Nationwide, 34 coal miners have been killed on the job thus far this year, compared to 22 in all of 2005.

Governor Manchin pledged further action, announcing that public hearings would be held on the Sago Mine disaster and that Wheeling Jesuit University would host the first International Mining Health and Safety Symposium in April, to help spur adoption of improved technologies and equipment in West Virginia mines. WVOMHST issued an emergency rule on SCSRs, communication, and other mine safety improvements, and the governor appointed a six-person labor-management task force to assess the availability of the technologies covered by the new WVOMHST rule.

Meanwhile, at the national level, Senators Robert C. Byrd and John D. Rockefeller IV and Representatives Nick Rahall, Alan Mollohan, and Shelley Moore Capito introduced bills to enhance coal mine safety. Hearings were held in both the Senate and the House, and Representative George Miller of California convened a forum to hear testimony from the Sago miners' families as well as from family members of the 13 miners killed in an explosion at the Jim Walter Resources No. 1 Mine in Brookwood, Alabama, in 2001. Witnesses urged lawmakers to strengthen oversight and enforcement of the

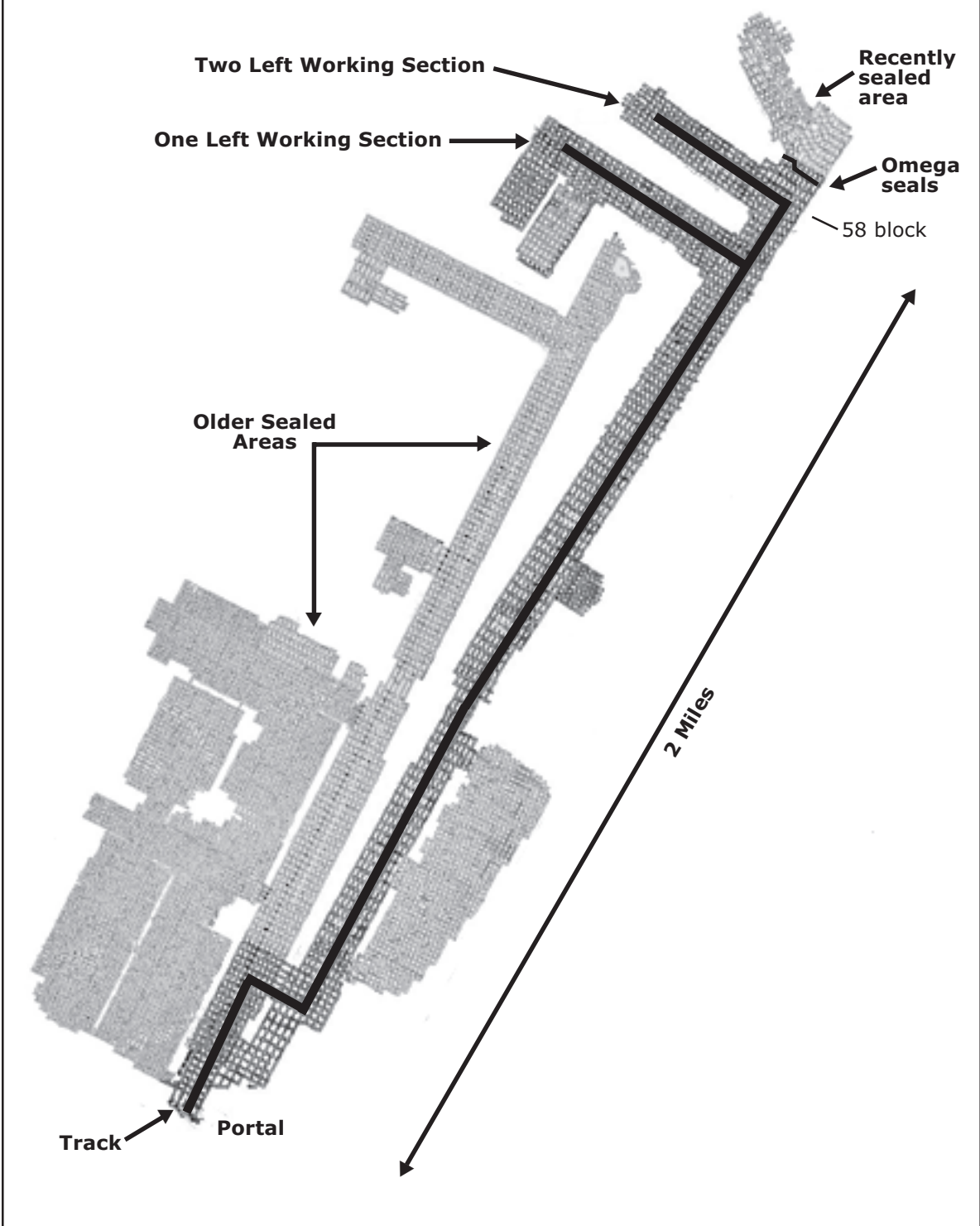
Federal Mine Safety & Health Act of 1977, require improvements in mine safety equipment and technologies, and improve mine rescue response strategies and management.

The public hearings promised by Governor Manchin, originally scheduled for March, were postponed at the request of the miners' families to allow more time for state and federal investigators to compile additional information on the causes and consequences of the Sago explosion. The international symposium on mine health and safety technologies went forward as scheduled and, among other accomplishments, demonstrated that technologies available today, in areas such as communications, tracking, and refuges, can be put into the mines of West Virginia on an accelerated basis to improve miners' chances of escaping or otherwise surviving an emergency.¹

Public hearings were convened at West Virginia Wesleyan College in Buckhannon on May 2, 2006. Over the course of the next three days, miners' family members, miners' representatives, West Virginia legislators and state and federal investigators heard detailed presentations and statements about the disaster. They closely questioned company, state, and federal officials about conditions at the mine prior to the disaster, the events of January 2-4, 2006, and the actions of the mine rescue command center where company, state, and federal officials shared decision-making responsibilities throughout the mine rescue operation.

For the first time in the history of coal mine disaster investigations in the United States, family members participated in a public hearing on an equal basis with state and

Sago Mine, January 2, 2006



federal investigators. The 1,263-page hearing transcript reflects both their grief and their determination to honor the memory of their loved ones.²

As John Groves, brother of disaster victim Jerry Groves, stated at the opening of the hearing: “Even though he’s gone now, he’s going to be helping people, because we’re going to be, through him, working to make sure that a disaster like this never happens again.”³

Other actions followed. On May 5, 2006, the West Virginia Board of Coal Mine Health and Safety filed a rule to establish two state-run mine rescue teams to enhance the largely company-based system currently and traditionally in effect. On May 12, 2006, WVOMHST Acting Director James M. Dean announced a statewide moratorium on the use of Omega blocks — the materials used to construct the seals at Sago — as alternative explosion-proof seals.

On May 22, 2006 — two days after an explosion at a Kentucky mine blew out seals constructed of Omega blocks and killed five miners — MSHA announced a nationwide moratorium on the use of alternative seals pending a reassessment of their ability to withstand explosions. On May 29, 2006, the West Virginia Mine Safety Technology Task Force issued its report. Among its other recommendations, the task force called for additional provision of SCSRs and improved training; emergency refuge shelters; and an August 2007 deadline for mine operators to submit plans for improved communication and tracking of miners underground.

On June 15, 2006, at a White House ceremony

attended by several of the Sago victims’ families as well as Governor Manchin and West Virginia’s congressional delegation, President George W. Bush signed into law the Mine Improvement and New Emergency Response (MINER) Act. Among other provisions, the new federal law requires underground miners to be supplied with two hours of emergency oxygen at their work sites, as well as additional oxygen cached in escapeways; requires mine rescue plans to be regularly updated and mine rescue teams to be within an hour’s travel time from the mine; and allows MSHA to seek injunctions to halt production at mines whose owners ignore outstanding fines.

Meanwhile, investigative work on the Sago Mine disaster continued, and a long-awaited interview with the sole survivor, Randal McCloy, Jr., eventually made possible by his remarkable recovery, was held on June 19, 2006.⁴ The release of this report, originally scheduled for July 1, 2006, was briefly postponed in order to allow more time to attempt to determine the proximate cause or causes of the Sago explosion and to follow up on concerns raised in the interview with Mr. McCloy, primarily about the failure of four of the SCSRs relied upon by the trapped miners and the failure of the command center to send signals to them to let them know that rescuers were on the way.

This report is being released now with the proximate cause of the Sago explosion still unsettled. There appears to be little doubt that an explosive mixture of methane and air ignited in the recently sealed area of the mine in by the Two Left section at 6:26 a.m. on January 2, and the belief is widespread that a powerful lightning strike was involved. As of

this writing, however, the means by which lightning may have entered the sealed area at that moment has not been determined.

Although various theories have been offered by International Coal Group consultants and others, definitive evidence has not yet been found or confirmed by state or federal investigators. Consequently this report does not purport to identify the proximate cause of the methane ignition — and, therefore, until definitive evidence becomes available, this report must be considered preliminary. Once the proximate cause has been identified, further work will be required in order to be able to make specific recommendations about the steps necessary to reliably protect underground mines and miners against a repetition of the Sago Mine disaster.

THE DISASTER: CAUSES AND CONSEQUENCES

It is important to make a clear distinction between what caused the *explosion* and what caused the *disaster*.

There would have been no disaster if the explosion had been contained by the supposedly explosion-proof seals. If that had happened, it is possible that all of the miners in the Sago Mine at the time of the explosion could have escaped safely and successfully.

There might have been no disaster if the miners on Two Left had been able to make all of their SCSRs work. Randal McCloy says that they could not. That left them little choice but to await rescue, which then came too late for all but one of them.

There would have been no disaster if it had been possible for rescuers to communicate

with the miners on Two Left. They could have been told that there was respirable air at the mouth of the section, not far from where they were. But the mine's phone system — an outmoded, vulnerable system typical of underground mines — was knocked out by the explosion.

There would have been no disaster if mine rescue teams had been sent into the mine sooner and allowed to advance to Two Left without being required to systematically assess post-explosion conditions throughout the mine on the way in. But there were delays in organizing the rescue, and the absence of a gas chromatograph for much of the first day meant that gases indicative of the presence or absence of a fire could not be accurately measured. The command center chose a cautious, time-consuming approach geared to protecting rather than risking the lives of the mine rescue team members. But that approach, whatever its merits, greatly diminished the chances of winning the race against deadly carbon monoxide.

There might have been no disaster if it had been possible to rapidly pinpoint the location of the trapped miners and drill a borehole down to them. But the seismic equipment theoretically capable of hearing their response to a prearranged signal was not brought to the mine. Even if it had been brought there, it would have taken too long to set up and operate to be of any value — but the trapped miners had never been told that. Consequently they had reason to hope that barricading themselves would work. Had they known the truth, they might have tried to make their way out of the mine, even though there was no certainty that they would have succeeded.

There might have been no disaster if there had been even a single stroke of good luck at Sago.

Because time is always the enemy, no mine rescue can succeed without a large measure of luck. Everything needs to go just right. At Sago, everything that could go wrong did go wrong. The explosion occurred on a federal holiday. Time was wasted trying to reach responsible officials, determining what had happened, organizing a response and calling in the most experienced mine rescue teams in West Virginia. Time was spent making educated guesses about whether there was a fire in the mine and whether it might trigger a second explosion. Time was spent trying to protect mine rescue teams against an undefined risk. All of that was time that the miners on Two Left did not have.

We do not find fault in this report with anyone who responded to the Sago Mine emergency. The failures we describe above and throughout this report were, in almost every instance, failures not of individual human beings but of *systems*: mine safety systems, mine emergency management systems, and mine rescue systems that are in desperate need of immediate help. One of the inescapable lessons of the Sago Mine disaster is that it could happen again tomorrow — and if it were to happen, the outcome next time might not be much different, regardless of who happens to be in the command center.

Next time, possibly, the seals would withstand the explosion. Possibly the SCSRs would work as expected. Possibly there would be no failure of communications. If miners did find escape to be impossible, possibly a rescue command center would be

rapidly operational and ready to deploy mine rescue teams within two or three hours after the explosion instead of six or seven. Possibly the command center would have better data to work with and might be inclined to take more risks. Possibly the miners would be brought out alive.

But, as we know, none of these hopeful possibilities came true at Sago, and they might not come true next time. It thus becomes a matter of great urgency to understand the reasons and to take corrective action as rapidly as possible.

Accordingly, the thrust of this report is directed toward what can be done *now* to get better safety technology, equipment, and strategies into the mines of West Virginia without further delay. We know that better technologies are on the horizon (they always are), but we do not consider it acceptable to wait for the perfection of technologies or equipment before improving the protection available to miners.

FINDINGS AND RECOMMENDATIONS

Based on the evidence available to us thus far, we do not believe that the Sago Mine disaster can be attributed to any specific actions on the part of International Coal Group (ICG), the federal Mine Safety and Health Administration (MSHA), or the West Virginia Office of Miners' Health, Safety and Training (WVOMHST). This does not rule out the possibility of further review — for example, if it is determined (as it has not been yet) that ICG's apparent failure to fully protect the mine's electrical and conductive infrastruc-

ture with the grounding and lightning arrestors required by regulations played a direct role in providing a path for lightning to enter the sealed area of the mine and trigger a methane ignition.

Similarly, it can be argued that a thorough review of the process by which MSHA and the National Institute of Occupational Safety and Health (NIOSH) tested and approved Omega blocks as “explosion-proof” seals within the meaning of federal regulations (discussed in section 5 of this report) may find that the testing protocols and the criteria upon which those protocols were based were inherently flawed and inadequate. If so, serious questions might be raised about the possibility of failure at the federal level. Pending such a review, however, it is premature to make any such charges or assumptions.

By the same token, the apparent failure of some of the SCSRs relied upon by the trapped Sago miners (discussed in section 6) raises questions about whether this particular unit can be counted upon to work in a crisis — or, alternatively, whether miners are being given sufficient training on what they should expect to experience while using any rebreathing device. Pending a nationwide audit of SCSRs, these questions and their potential implications cannot be addressed to anyone’s satisfaction. (On July 10, WVOMHST instructed all operators of underground mines in West Virginia to begin inventorying the estimated 10,000 SCSRs currently in use in the state, in order to facilitate a quarterly functional-status audit,⁵ and as this report goes to press a nationwide SCSR audit is expected.)

Although issues such as these are discussed throughout this report and cannot be ignored, we believe that it will be more productive and protective of miners’ safety to focus on what should be done immediately to address the largely systemic failures that unquestionably contributed to the tragic loss of life at the mine. While not ruling out the possible need for additional state or federal legislation at some point, this report does not call for more laws now. We find, rather, that West Virginia’s leaders and the state’s mining community have it within their power to implement all of the recommendations that we offer below.

The keys to immediate progress, in our view, are commitment, cooperation, and a willingness to pursue what we call ‘default options’ — that is, common-sense changes that can improve safety while we await the arrival of better technologies, equipment, and strategies. We have faith in miners’ ingenuity, and many of our recommendations are grounded in this approach. Four examples follow:

1. Strengthening underground communications We do not necessarily need new laws or more research in order to improve the odds that a mine phone system will survive an explosion. One possible ‘default option,’ at least in some mines, is to bury a phone cable under the floor or track and harden the phone handsets by placing them in military-grade housings and/or recessing them in the ribs of the mine. Few if any mine explosions have disrupted the mine floor at any significant distance from the source, and a recessed phone would stand at least a reasonable chance of surviving the pressures of an explosion wave traveling through an entry.

2. Improving SCSR reliability Pending the outcome of a national audit of SCSRs currently in service, we can improve the odds that a miner's SCSR will work when needed by making sure that miners receive thorough training in the actual use of an SCSR as opposed to the current regulatory requirement, which simply calls for being able to demonstrate the ability to open and activate an SCSR while going through the motions of donning it but not actually doing so. This gives the miner no sense at all of what it feels like to breathe through an SCSR. Without that experience, a miner trying to use an SCSR for the first time, in a frightening post-explosion or fire-threatened mine environment, may feel that breathing through the device feels constricted or even impossible. It is true that the SCSRs in use today need to be replaced by next-generation designs capable of supplying respirable air for longer than an hour, able to dock with replacement units without requiring removal from the user's face, and equipped with a comfortable half-face or full-face mask that also facilitates communication rather than the awkward, uncomfortable and speech-inhibiting mouthpiece, nose clips, and goggles currently supplied. But until the next-generation unit arrives in the marketplace — and unless a national audit finds serious and widespread failures among the many thousands of SCSRs now in service — the 'default option' should be to provide miners with the real-world training they need. SCSRs that are still functional but withdrawn from service because of being past their expiration dates represent an ideal and immediately available resource for training. As another part of the 'default option,' we must require random testing of SCSRs currently in service by asking miners to voluntarily don them and travel all or part way out of the mine while wearing them.

3. Emergency shelters Right now miners who survive an explosion such as the one at Sago have only two options: to escape or to retreat and barricade. Getting out, obviously, is every miner's first choice, by training as well as instinct, but it is not always possible. Debris or a fire may block the way, or the portal may be far away, or the miner may be injured and incapable of walking a great distance. But barricading means entering a race against time, against bad odds. After an explosion or in by a fire, carbon monoxide is almost always present in life-threatening concentrations. Only a completely impregnable barricade will suffice. Even if building one is feasible, the supply of respirable air behind it will be finite and will be drawn down and contaminated as it is breathed and rebreathed by the miners relying on it. Yet, as Sago shows so clearly and tragically, barricaded miners cannot count on being rescued within the limited time frame when life is still sustainable. An obvious solution is to require emergency refuge chambers or comparable shelters in underground mines. But — some will say — that could take years, until thorough testing of designs and structures has been completed and state and federal regulations have been promulgated. Possibly so. A viable 'default option' in the meantime, at least in some mines, may be to use mine engineering and machinery already in place to carve a rescue chamber into the coal seam. The next step would be to double-reinforce access to the chamber by building two concrete-block stoppings with offset doors, and then to supply the chamber with air and a phone line (through boreholes), water, food such as military meals-ready-to-eat (MREs), blankets, cots, first-aid supplies, and a chemical toilet. Miners should be able to survive in such a

shelter for days, and if no other exit option is available, a borehole large enough for a rescue capsule can be drilled down to the shelter. Is this just someone's vague notion of something that might or might not work? No. A refuge chamber of this type and design was successfully constructed in an Upshur County, West Virginia underground mine nearly 30 years ago, as described elsewhere in this report. Fortunately it never had to be used. The kind of 'default option' that was available to Upshur Coals then could be available to other West Virginia mine operators now. This is not to suggest that a one-size-fits-all approach would work, or that refuges can be constructed without due consideration of all the engineering and construction challenges that may be involved, but only to suggest that miners' ingenuity can be brought to bear on this topic as on so many others.

4. Emergency communications and tracking

It seems likely that in the near future we will be able to install and rely on robust, redundant two-way wireless communication systems capable of surviving explosions. But most such systems are now at the testing stage, and the process of actually getting them approved and into the mines could take longer than expected. In the meantime, there is a need to be able to locate miners and send messages to them in an emergency. A hardened mine phone system, as described above, may be one 'default option,' but it would not be wireless or able to locate miners missing in an emergency. An Australian manufacturer currently offers a wireless system capable of transmitting text messages to miners via a digital display on the top of the miner's cap lamp battery. The unit flashes the miner's cap lamp to alert him

or her to an incoming message. The same manufacturer offers a tracker unit, no bulkier than a pager or small cellphone, that can be carried by a miner (or mounted on mobile equipment) and that will tell the mine dispatcher where the miner (or equipment) is located. If the underground antenna for either system is knocked out, it can be replaced by an emergency antenna laid out on the surface above the mine. This 'default option' is available now and in widespread daily use as a productivity-enhancing tool — in Australia. A few mine operators in the United States are also using it successfully, and it has saved lives in this country — notably in the successful evacuation of 45 miners in 45 minutes during an underground fire at the Willow Creek mine in Utah in 1998.⁶ But many mine operators are reluctant to invest in such a system, because it may not work flawlessly in every part of the mine at all times, because it can only transmit one way, and because "something better" (wireless two-way voice communication) is on the horizon. Yes, but horizons can be deceptively distant. In the meantime, installing an interim system should be considered a 'default option' for safety-conscious West Virginia coal operators.

As these examples attest, significant improvements in mine safety may not have to wait for the perfection of new technologies. They do require financial outlays, but the costs pale in comparison to the costs of losing miners in disasters. In any case, it simply makes good sense to explore creative 'default options' while demand for coal is surging and prices are near or at all-time highs, as is the case today.

If cost is not an insurmountable barrier to adoption of 'default options' and the kinds of

safety improvements summarized below, then what stands in the way? The answer, it would seem, is inertia.

For a variety of reasons, some in the coal mining industry have never seen fit to put safety on a par with production. That must change — and, we believe, *is* changing. All that is needed now is the will to accelerate the momentum for change that began building in the dark hours after the outcome of the Sago disaster, when the governor of West Virginia pledged that the miners lost in that disaster would not be forgotten in the way that so many thousands of miners lost in the past have been forgotten. We wholeheartedly support that pledge and seek to help fulfill it.

The shock waves from the Sago Mine disaster are still being felt —most profoundly among

the grief-stricken families still struggling to understand how and why such a thing could have happened, but also among those in the mining community who know in their hearts that we can and must do much more to ensure that every miner who goes to a job in an underground mine in West Virginia can count on coming home alive and well at the end of the shift.

Underground mines are demanding and unforgiving environments. Mine safety is about improving the odds that the daily challenges of mining as well as emergencies will be met and mastered. We offer the recommendations that follow — and this entire report — in that spirit.

SOURCES

¹A summary of the Symposium is available at www.wju.edu/sago/def.asp

²The transcript of the May 2-4, 2006, public hearing may be accessed at www.wvminesafety.org/PDFs/SAGOhearing-CertifiedDay1.pdf
www.wvminesafety.org/PDFs/SAGOhearing-CertifiedDay2.pdf
www.wvminesafety.org/PDFs/SAGOhearing-CertifiedDay3.pdf

³May 2, 2006, public hearing, transcript, p. 78.

⁴A transcript of the June 19, 2006, interview with Randal McCloy, Jr. (as well as all of the interviews conducted by state and federal investigators in the course of the Sago investigation thus far) may be accessed at the WVOMHST website: www.wvminesafety.org/sagointerviews.htm

⁵More information is available from WVOMHST at: www.wvminesafety.org/PDFs/SCSRInventoryMemo.pdf

⁶For a description of the role of the PED system at the Willow Creek fire, see: www.msha.gov/minefire/wcreek2000/willowcreekfinal/willowcreekfinalrpt.pdf

2 Recommendations

1 Research, develop and adopt emergency measures to enhance protection against explosions from lightning entering underground mines and sealed areas; review and enhance equipment performance specifications for mine power stations.

2 Permanently ban the use of Omega blocks as seals, because the current 20-psi standard is inadequate and because they may not meet even that standard.

3 Require mine operators to strengthen existing alternative seals by preparing, within 90 days, a plan to construct solid concrete block or comparable seal structures in front of (outby) Omega block seals, or take other appropriate precautions such as ventilating or inerting gases in sealed abandoned areas, within reasonable deadlines clearly stated in the operator's plan for completing the task.

4 Evaluate the existing seal standards and consider, at a minimum, upgrading to the 50 psi standard adopted in other mining countries.

5 Require refuge chambers: Mine operators must develop a plan, by January 2, 2007, to purchase or construct refuge

chambers, subject to state and federal approval of the design, numbers, and locations of such refuges, with the aim of having refuge chambers installed by January 2, 2008.

6 Conduct a statewide review of all Self-Contained Self-Rescuers (SCSRs) currently in use to determine operability and detect damage, and require ongoing, in-mine testing of SCSRs by miners volunteering to don and breathe through them to assess performance.

7 Develop comprehensive emergency plans. Every West Virginia mine must have a *comprehensive* mine emergency plan integrated with federal, state and operator roles and tested periodically by the state for effectiveness.

8 Ensure that miners have two-way communications: Aggressively accelerate the testing, approval, and adoption of robust, redundant, wireless two-way communication systems in all underground mines.

9 Require implementation of tracking systems via the 'default option' of installing currently available one-way electronic personal emergency and tracking devices.

10 Undertake a comprehensive review of West Virginia’s mine rescue systems, including regulations, training, equipment and coordination with West Virginia’s Office of Homeland Security and Emergency Management.

11 Require installation of lifelines in all primary escapeways in underground mines, equipped with directional cones to guide miners to safety.

12 Expand research, development, and manufacturing opportunities in West Virginia to ensure that the state leads the nation in mine safety and health technology and equipment.

In addition to the above recommendations, we offer the following steps to enhance prevention, improve electrical safety, improve the safety of sealed areas, support escape in an emergency, advance mine emergency preparedness, strengthen the mine rescue system, and enhance cooperation among all mine health and safety stakeholders.

STEPS TO ENHANCE PREVENTION

Make risk assessment the top priority in planning, developing, and managing mines. Safety and health protection must be systematically engineered into all mining activities.

Adopt a ‘default option’ strategy. While awaiting availability of new technologies, systematically strengthen the ones we have now, such as hardening mine phone systems (by burying or otherwise shielding cables) to help protect against explosive forces.

Put safety on a par with production by expecting every mining company to employ adequate numbers of safety and health personnel reporting directly to top management and authorized to overrule production demands when inconsistent with safety practices.

Ask miners. Involve miners in all aspects of safety and health planning, design, management and enforcement as a basic requirement, not an afterthought.

Reinforce the state’s vital role in miners’ health and safety by expanding WVOMHST’s responsibilities, capabilities, and funding for risk management, education, training, and research, and providing competitive salaries for inspectors to recruit and retain them.

Build safety protection into all equipment design, from improving visibility and proximity protection to providing storage compartments for personal safety equipment, such as deploying safety equipment in longwalls.

Upgrade miners’ personal protective safety and health equipment and ‘tools of the trade,’ from brass identification tags to helmets, cap lamps, and self-rescuers, to evaluate their adequacy in a 21st-century-model West Virginia mining industry.

Urge mine operators to offer handheld gas detectors to every miner working underground. Miners choosing to carry them must be provided appropriate training and must have the right to report abnormal readings without fear of retaliation.

Maintain all safety equipment in top condition, from SCSRs to gas detection devices and communication systems.

Reject 'business as usual' attitudes. When a carbon monoxide sensor alarms, the response should *not* be simply to 'have someone check it out when they have time.' Safety protection must be the first order of business every day, not the last.

Modernize recordkeeping of preshift exam records, equipment serial numbers, and safety performance checks, using computer-based logs or templates developed by state and federal agencies.

Develop opportunities to accelerate safety technologies, evaluating and transferring technologies used in other industries and other countries.

STEPS TO IMPROVE ELECTRICAL SAFETY

Urge every mine operator to examine the mine's electrical system, to identify potential safety vulnerabilities.

Publicize lightning hazards: WVOMHST and MSHA should publish, post on their websites, and disseminate the latest available information on protecting mines' electrical systems and infrastructure against lightning strikes.

Improve information: Request researchers from within the United States and abroad to present papers addressing questions of lightning and protection of sealed areas at the 2nd International Mining Health & Safety Symposium in Wheeling in April 2007.

STEPS TO IMPROVE THE SAFETY OF SEALED AREAS

Require mine operators to assess and address the risk of allowing miners to work underground, or in certain areas underground, during the critical time period when methane in a sealed area is in the explosive range (5-15%).

Consider a mandatory requirement for a mining engineer to certify that a permanent seal was constructed according to specifications.

STEPS TO SUPPORT ESCAPE IN AN EMERGENCY

Require improved SCSR training for miners, by training miners to actually don and use breathable training-model SCSRs in a dark, smoke-filled environment (using available training modules and nontoxic smoke).

Involve miners in field-testing competing SCSR brands and encourage operators to be guided by miners' preferences when purchasing SCSRs.

Evaluate the existing 10-year shelf life allowed for SCSRs. Expired SCSRs should be retained and used for training.

Require mine operators to store sufficient numbers of SCSRs underground. The 'default option' is the state requirement of 3 hours per miner, increasing to 24 hours per miner if refuge chambers are not installed in 2007.

Review current SCSR storage requirements to ensure that SCSRs are not stored in environments likely to compromise the units' performance; reassess the adequacy and effectiveness of the currently required 90-day examination.

Conduct an independent evaluation of the current NIOSH protocol and procedures for examining SCSRs recovered in mine disasters.

Require SCSR manufacturers to improve reliability by redesigning SCSR temperature and moisture indicators to eliminate possible mis-indications of status.

Accelerate development of next-generation SCSRs by establishing an awards competition for a prototype full-face or half-face breathing apparatus for miners, capable of reliably providing respirable air for more than one hour and of docking with replacement units in order to facilitate multi-hour use without interruption or removal of the facepiece; and urge researchers and manufacturers to present papers on this topic at the 2nd International Mining Health & Safety Symposium in Wheeling in April 2007.

STEPS TO ADVANCE MINE EMERGENCY PREPAREDNESS

Improve mine-wide emergency preparedness by requiring much more rigorous education and realistic training.

Establish company-wide, centralized safety-systems control centers: Urge each mine operator with more than one operation to establish a centralized

center capable of monitoring safety systems on an ongoing basis and coordinating communications and rescue efforts in an emergency.

Require specialized training, conducted by WVOMHST and MSHA, for any management personnel who will be expected to serve in a position of responsibility in a mine emergency command center, and modeled on compulsory continuing education training required in other professions.

Provide liaison to families: In any rescue situation, the highest-ranking federal, state and company officials on site must be personally responsible to ensure that miners' families receive timely updates of accurate and confirmed information.

Reaffirm and strengthen the tripartite mine rescue model through which state, federal, and company officials share responsibilities under section 103(k) of the Mine Act, and develop and publicize information to ensure that all parties understand their authority and responsibility.

Improve WVOMHST's and MSHA's emergency management capabilities by enhancing the importance of mine rescue and making a mine rescue director part of top management.

Conduct mock-disaster drills to test the emergency preparedness of state and federal officials, mine operators and the community. Drills should be conducted for a range of emergency situations, from partial mine evacuations to full-scale major mine disasters, to test the effectiveness of communication systems, availability of personal

protective equipment, proficiency of key mine personnel, and coordination with local responders and government officials. Through post-drill evaluations, deficiencies in the emergency response plan should be identified and improvements made within specified deadlines.

Evaluate the inventory of available mine emergency operations equipment (such as gas chromatographs, robots, portable seismic) and the ability of such equipment to facilitate a rapid mine rescue; report results to the public. Retire unreliable or obsolescent equipment and replace with state-of-the-art as necessary.

Continually evaluate and enhance emergency equipment: At least annually, and under actual mining conditions, test all mine emergency operations equipment (such as robots and seismic), and report results to the public.

Support timely gas chromatography during a mine emergency by requiring every underground coal mine in West Virginia to include in its mine emergency preparedness plan a method to have a gas chromatograph on site within two hours after the onset of an emergency.

Require post-emergency medical examinations and treatment as necessary for any miner or rescuer exposed to toxic substances or other threats to life and health in the course of a mine emergency.

STEPS TO STRENGTHEN THE MINE RESCUE SYSTEM

Establish a West Virginia-based National Mine Rescue Committee made up of mine rescue team members and other experts, to systematically review the mine rescue system's structure, equipment, and response strategies, and to make recommendations to strengthen the system, in a report to be delivered at the 2nd International Mining Health & Safety Symposium in 2007.

Develop a skills-ranked or tiered scale for mine rescue teams, similar to what is used for other emergency response organizations.

Enhance mine rescue training to include in-mine drills. Veteran mine rescue teams should be canvassed to develop a 'wish list' for training and equipment that should become the basis for strengthening mine rescue training and deployment.

CONSOL ENERGY'S COMMUNICATION'S CENTER

Since 1969, CONSOL Energy has operated a communications center to provide comprehensive communications and monitoring services to its mining operations. The center operates on a 24/7 basis, enhancing safety and productivity of CONSOL's operations by supplementing mine-site monitoring of production, ventilation and fire prevention systems. The current communications center, located near their McElroy mine complex in Ohio County, West Virginia, plays an important role in preparing for and responding to emergency situations. Well-established relationships and procedures permit the rapid marshalling and coordination of emergency services, such as mine rescue teams, EMS, and fire and police departments.

Issue a mine rescue team member identification card, renewable annually, to expedite travel and admission to the mine property.

Retire the obsolete seismic system, and recall the hardhat stickers promising miners that help is on the way. Prompt implementation of robust two-way communications systems and tracking systems will make the current seismic system even more obsolete than it already is. Encourage research on next-generation seismic technology and equipment.

Invite the Incorporated Research Institutions for Seismology (IRIS) and other professional entities to participate in the 2nd International Mining Health & Safety Symposium in 2007 and to present information on the feasibility of applying seismology techniques and equipment to mine rescue.

STEPS TO ENHANCE COOPERATION

Provide updates on a regular basis to the Sago families and the public on progress made to improve mine safety and the mine rescue system in West Virginia.

Continue to host an international mine safety and health symposium annually or biennially to promote cooperation among mining countries and rapid advancement of new technologies and techniques.

Seek participation from the international community for a study group to evaluate lightning risk to underground miners. Participants would assess the incidence and travel paths of lightning strikes near mines and report their findings at the International Mine Safety & Health Symposium in April 2007.

Call upon International Coal Group (ICG) to lead the way in mine safety and health by making its mines and other resources available as laboratories for testing and improving technologies and training techniques in cooperation with state and federal agencies.

Examine methods to improve accident investigation protocols and procedures, such as appointing independent investigative committees and defining rights for victims' families; and design a data template to accompany or be incorporated into accident investigation reports to enhance their value to safety and health trainers and researchers.

Encourage voluntary cooperation and commitment as the preferred approach to get new equipment, technology, and best practices underground with all possible speed.

Abandon old myths and misinformation about the reliability of safety and health technologies and replace them with hard facts and science-based determinations.

3 A synopsis of the Sago Mine disaster

Note: The information in this synopsis is derived from numerous sources, primarily testimony provided to investigators. Transcripts are available on the website of the West Virginia Office of Miners' Health, Safety and Training at www.wvminesafety.org. The times shown (other than the time of the explosion) are in many cases approximate. Times, data, etc., may be subject to further investigation and verification.

MONDAY, JANUARY 2, 2006

3:00 am

Shortly after 3:00, firebosses Terry Helms and Fred Jamison enter the Sago Mine to conduct preshift examinations of the mine's two working sections, One Left and Two Left.

5:30 am

Between about 5:15 and 5:45, miners and supervisors arrive at the mine, change into their work clothes, check their lights and other gear, and chat with each other in and around the bathhouse and mine office. Meanwhile, the two firebosses report to Bill Chisolm, the mine dispatcher, that there are no major mechanical problems or safety violations on the two working sections. Terry Helms delivers his report over the mine's phone system; Fred Jamison delivers his report in person after exiting the mine to recharge the battery on his mine jeep.

6:00 am

Two crews of miners — One Left and Two Left, each consisting of 11 miners and a section boss (foreman) — enter the mine in two mantrips (battery-powered rail-traveling personnel carriers). The Two Left mantrip enters first, since it will be traveling inby (further in) to the Two Left section, past the point where the One Left crew will turn at a track switch to enter the One Left section. The One Left crew is briefly delayed while foreman Owen Jones, realizing that his mantrip is too small to accommodate his crew plus three other miners — two pumpers and a belt maintenance man — who will be traveling partway into the mine with him, goes back for a larger mantrip. The One Left crew, plus the pumpers and beltman, then follows the Two Left crew into the mine. Fred Jamison also re-enters the mine to work at a conveyor belt not far inby the portal. All told, 29 coal miners are at various locations inside the Sago Mine by about 6:15 am.

6:05 am

The computer console in mine dispatcher Bill Chisolm's office (a trailer separate from the mine office) indicates that a carbon monoxide (CO) monitor in the One Left section is either malfunctioning or detecting elevated CO levels. Based on the computer display (which flashes "malfunction" briefly before alarm-

ing), the dispatcher decides that the monitor is false-alarming and reportedly calls the One Left crew to ask the crew's electrician to check the fuse when he reaches the section.

6:26 am

As a severe, fast-moving thunderstorm sweeps across Upshur County, lightning bolts strike in the immediate vicinity of the mine. The mine dispatcher, who is on the phone with mine superintendent Jeff Toler at that moment, hears a loud pop on the phone and sees on his computer monitor that several conveyor belts, which he had previously powered up from the computer, are shutting down. The computer also alerts him — both visually and with an audible alarm — that the belts' CO monitors are detecting carbon monoxide. He reports this to Jeff Toler, who asks him to contact the One Left and Two Left crews on the mine phone, to tell them to check the CO monitors. At first, Toler and his maintenance supervisor, Dick Wilfong, assume that some fuses have blown, as has happened in previous storms.

(The time shown on the computer's clock was 6:31 am. In the course of the post-disaster investigation, state investigators performed a time correlation with an atomic clock and determined that the mine's clock was fast by 4 minutes 56 seconds. According to Vaisala, a nationwide lightning-monitoring service, two lightning strikes, one of which packed unusual power, occurred within a five-mile radius of the Sago Mine portal at 6:26. The explosion in the mine appears to have occurred at virtually the exact same moment.)

6:30 am

Dispatcher Chisolm gets no response from either of the two crews. He calls repeatedly on

the mine phone: "Inside, inside, inside!" Within an estimated three to five minutes, One Left foreman Owen Jones calls out to report that he and his crew have been caught in "a big rush of air that came from inby, toward the Two Left panel," as Jeff Toler remembers the report. Wilfong remembers Jones saying that he didn't know what happened. Jones recalls saying "We've had a mine explosion in here!" and adding: "Get a mine rescue team here now." Toler tells Jones to shepherd his crew into the escapeway.

In the mine, in the moments immediately following the explosion, the One Left miners struggle to see — some later describe the visibility as less than a foot at first — and to breathe in the dust-filled atmosphere. Seven of the miners don their self-contained self-rescuers (SCSRs); three later describe having had some difficulty using them, and one of the One Left miners subsequently testifies that SCSRs should be redesigned, but from their testimony to MSHA and WVOMHST investigators it appears that with one possible exception all of the SCSRs that were used by the One Left crew functioned properly.

6:45 am

Jeff Toler, safety director Al Schoonover, maintenance chief Dick Wilfong and assistant maintenance chief Vern Hofer enter the mine in a mantrip. On the way in, in the main track entry, they first encounter fireboss Fred Jamison and then pumper John Boni, both unharmed, and instruct them to exit the mine. They then stop at a mine phone near 25 block to call out to the dispatcher, to find out whether the Two Left crew has been heard from. The dispatcher reports that nothing has been heard. Meanwhile the One Left crew has been making its way on foot in the escapeway

toward the mine portal. The miners hear the sound of Toler's mantrip in the parallel track entry, and a crew member, Joe Ryan, sticks his head through a man door into the entry and calls to Toler to tell him where they are and that one of the crew, Hoy Keith, is having difficulty. Toler tells Ryan to bring the whole crew to the mantrip and instructs Wilfong and Hofer to take the crew out.

7:00 am

The One Left crew heads out of the mine on the mantrip. (In addition, beltman Pat Boni, after calling out to find out what has happened, has been instructed to exit the mine and is walking out, unharmed, in the escape-way.) One Left foreman Owen Jones, whose brother Jesse is on the Two Left crew, remains in the mine, further inby, at 41 block, trying to determine whether he can move toward Two Left. Jeff Toler, whose uncle, Martin Toler, Jr., is the foreman of the Two Left crew, asks Owen Jones to come back and stay by the mine phone near 30 block. Toler and Schoonover then explore inby, walking to 42 block, observing damage to ventilation stoppings, and using the phone at 41 block to call out to instruct Wilfong and Hofer to come back with curtains and other supplies to repair ventilation controls. Toler and Schoonover then walk back to rejoin Owen Jones.

Meanwhile, at about 7:00 am, the mine dispatcher phones ICG assistant safety director John Stemple at home to tell him that Sago has a problem — that there has been a severe lightning storm, power has been lost underground, and the One Left crew has called out to report trouble. Stemple, trying to understand the situation, asks to be patched through to Jeff Toler underground. They talk

at about 7:15. Toler tells Stemple that Dick Wilfong recommends contacting a mine rescue team and getting them started toward the mine.

7:20 am

The mantrip carrying the One Left crew arrives at the surface. Wilfong and Hofer load up supplies and head back underground.

Stemple begins trying to reach company, state, and federal officials. Initially he has no success: Phones are not answered, or his calls go to answering machines. In the case of WVOMHST inspector at large Brian Mills, he gets a message that Mills's phone has been disconnected.

7:45 am

Stemple leaves a voicemail message for WVOMHST inspector John Collins, who lives near the mine in Buckhannon. Collins returns the call at 7:50, learns of the incident, phones Brian Mills at 7:55 to notify him (Stemple had had an old phone number for Mills), and heads for the mine.

8:00 am

Stemple tries to phone the Barbour County Mine Rescue Team, which is under contract with ICG to provide emergency services. He discovers that the team's answering machine is turned off. Meanwhile, at about 8:00, Chuck Dunbar, general manager of ICG's Buckhannon division, arrives at the mine and discusses the situation with the mine dispatcher.

8:10 am

Wilfong and Hofer, heading back into the mine on the mantrip with supplies, meet Toler, Schoonover, and Jones at 32 block. They

repair blown-out stoppings and proceed via mantrip to 42 block, where their CO monitors begin alarming. Concerned about fire and the possibility of a second ignition, they disconnect the batteries on the mantrip and advance on foot inby, continuing to repair stoppings as they go. At 49 block, Toler goes into the track entry, and moves a phone and emergency first-aid supplies from the track entry to the intake entry.

8:15 am

Meanwhile, WVOMHST inspector John Collins arrives at the mine. He talks with members of the One Left crew about what they experienced. When two other state mine inspectors arrive, Collins asks them to take air readings at the return entry at the portal. They report the presence of carbon monoxide, although at low levels. Because the presence of CO is an indication of a possible mine fire or explosion, Collins decides to issue a control order under Title 36, series 19, section 7.1 of the West Virginia Administrative Regulations. The regulation states:

Unless granted permission by the Office of Miners' Health, Safety & Training, no operator may alter an accident site or an accident-related area until completion of all investigations pertaining to that accident, except to the extent necessary to rescue or recover an individual, prevent or eliminate an imminent danger, or prevent destruction of mining property.

Meanwhile, at about this same time, Stemple reaches a member of the Barbour County mine rescue team. He continues trying to reach MSHA officials but encounters answering machines at the District 3 office and at various officials' homes. Finally, at about 8:30, he reaches MSHA inspector Jim Satterfield at home.

8:30 am

About two hours after the explosion, at 8:32 am, MSHA inspector Satterfield issues a verbal 103(k) order by phone. According to Stemple, the inspector tells him that no one is to enter the mine or do any work at the mine.

Section 103(k) of the Federal Mine Safety & Health Act of 1977 states:

In the event of any accident occurring in a coal or other mine, an authorized representative of the Secretary [of Labor], when present, may issue such orders as he deems appropriate to insure the safety of any person in the coal or other mine, and the operator of such mine shall obtain the approval of such representative, in consultation with appropriate State representatives, when feasible, of any plan to recover any person in such mine or to recover the coal or other mine or return affected areas of such mine to normal.

At around 8:30, Ty Coleman, ICG safety manager for its West Virginia and Maryland operations, arrives at the mine.

A few minutes later, at 8:37, inspector John Collins briefs WVOMHST director Doug Conaway by phone.

Meanwhile, in the mine, Toler, Schoonover, Wilfong, Hofer and Jones continue to walk inby toward the Two Left turnoff, repairing damaged ventilation controls as they go, and pausing to let fresh air dissipate the carbon monoxide. As they proceed they notice that it is taking longer for the CO levels to drop and that the velocity of the fresh air coming in behind them seems to be diminishing. Because this could mean that the air is short-circuiting through damaged controls behind them, Toler asks Jones and Hofer to go outby, retrieve curtain, and check for damaged

controls. Then he, Schoonover, and Wilfong proceed inby to about 57 block, where they find the stopping damaged and hang a curtain. They then proceed to 58 block and find that the stopping there too is damaged. They also encounter dense, swirling smoke that does not appear to be dissipating. They discuss what to do, concerned that if there is a fire inby they should not be directing more air to it and possibly triggering another explosion. They decide, reluctantly, that the safest course — for the Two Left crew and for themselves — is to withdraw from the mine and let mine rescue professionals take over.

9:30 am

Toler phones the dispatcher from 58 block, reporting that the smoke is bad and that he, Wilfong, and Schoonover are walking out of the mine. They walk out in the intake escape-way. There, making their way out, they find Owen Jones and Hofer waiting for them, and the five men make their way toward the surface together.

10:30 am

Four hours after the explosion, MSHA personnel begin to arrive at the mine. The first to arrive are inspectors Jim Satterfield, Pat Vanover, and Ron Postalwait.

10:35 am

Toler, Schoonover, Wilfong, Jones and Hofer exit the mine. Collins and other state and federal personnel debrief them. They also describe the situation underground to ICG's Ty Coleman.

11:00 am

At about 11:00 am, more than 4 hours after the explosion, the first two mine rescue teams — the Barbour County teams under contract

to ICG — arrive on site and begin preparing to travel underground by noon. Meanwhile, MSHA has contacted Consol Energy, which has several experienced mine rescue teams, and requested that they be mobilized and sent to the mine. ICG, meanwhile, has chartered a plane to bring the rescue team from its Viper mine in Illinois.

ICG's John Stemple arrives at the Sago Mine at about 11:30. Sam Kitts, ICG's vice president for West Virginia and Maryland, arrives at the mine at about 11:45. Shortly before noon, according to Ty Coleman's recollection, Coleman has a command center set up and in operation at the mine offices; he is in charge of the rescue effort for ICG. Tim Martin, ICG's corporate safety director, arrives shortly after noon.

Late in the morning, ICG's Chuck Dunbar contacts Mike Ross, a local oil-and-gas developer, to locate a drilling rig in order to drill a borehole into the mine. Ross, in turn, contacts three drilling companies, one of which, Hyre Water in Buckhannon, is requested by ICG to bring a drill to the mine site.

12:00 noon

CO levels being measured at the return entry increase to 2,300 ppm. Elevated CO levels are also detected in the mine offices; MSHA issues an imminent danger order, requiring the offices to be temporarily evacuated. (However, as the evacuation is starting, CO levels decline, and the command center remains in operation.)

1:00 pm

ICG submits a plan, approved by MSHA and WVOMHST, to continue monitoring gases at the pit mouth. At 1:15 pm, personnel measur-

ing at the return record 500 ppm CO; 1.1% methane (CH₄); and 19.2% oxygen.

At about this time, the command center adopts a plan to drill a borehole from the surface into the Two Left section, based on the assumption that the Two Left crew, if alive, are most likely in by the mouth of the section. The borehole will help determine conditions on the section and presumably can be used to communicate with the miners if they are found alive. Surveying crews equipped with GPS instruments are sent out to determine a suitable location, but are hampered by unfavorable weather conditions, which cause difficulty and delays in getting accurate readings from GPS geosynchronous satellites orbiting the earth.

1:45 pm

The mine rescue team from Consol's Robinson Run mine arrives.

2:30 pm

The mine rescue team from ICG's Viper mine arrives. Several other mine rescue teams arrive in the course of the afternoon.

2:40 pm

Trapped miner Junior Hamner writes a note: "I'm still OK at 2:40 p.m. I don't know what is going on between here and outside. We don't hear any attempts at drilling or rescue. The section is full of smoke and fumes so we can't escape. We are all alive at this time."

2:45 pm

Trapped miner Jackie Weaver writes: "It's 2:45 pm — the fumes are getting terrible — everybody is still partially OK"

3:00 pm

A gas chromatograph from Consol arrives and is set up, facilitating bottle sampling of a wide range of gases.

3:07 pm

Trapped miner James Bennett writes: "The air is bad. I don't know how long we can last."

4:15 pm

Gas concentrations trend down.

4:22 pm

James Bennett writes: "Time is running out for us. We have not heard anything from the outside yet."

4:25 pm

James Bennett tries to write another note: "I love you..." He does not finish; it is his last note.

At some point, possibly later than this, Martin Toler, Jr., writes a note: "Tell all — I see them on the other side. Jr." On the right side of the sheet, he writes: "It wasn't bad I just went to sleep." Along the bottom, he writes: "I love you."

4:45 pm

More than 10 hours after the explosion, MSHA approves a plan to send mine rescue teams into the mine for initial exploration: Tri-State Team A is to explore the first 1,000 feet, stopping every 500 feet to cross three entries taking air readings. To eliminate conductivity hazards, the rail and belt structure will be broken and separated by the rescuers one break in by the pit mouth.

5:00 pm

A bulldozer is delivered to the mine site and begins to construct a 1,600-foot-long road down a hillside to the borehole drilling site. The bulldozer then excavates a pad 200 feet long and 90 feet wide to accommodate the drill. The process of surveying, road-building, excavation, and subsequent modification of the drill pad to facilitate precise borehole drilling takes about 13 hours. (Under normal circumstances, surveying, siting and drilling a borehole would take about two days.)

5:10 pm

At about 5:10, MSHA modifies the mine exploration plan to provide for the more experienced Consol Robinson Run team to enter instead of the Tri-State team.

5:25 pm

The Robinson Run team enters the mine in the intake entry through the fan housing. At 5:45, the team is given permission to stay in the track entry and move inby. At 5:50, the team is given permission not to break the track near the portal as originally planned, so that the track can be used for mantrip transportation if needed (the track is to be broken further inby).

6:00 pm

Between 6:00 and 7:00 pm — about 12 hours after the explosion — the Robinson Run team moves as far as 8 block, taking readings that indicate low levels of CO and no measurable methane. The team is told to hold at 9 block until the next team arrives. At 6:57, an accumulation of water is reported in the return entry at 21 block.

7:10 pm

ICG submits a plan, approved by MSHA, to

restore power to a dewatering pump so that the return airway can be kept open. At 7:30, permission is given to start the pump.

8:10 pm

The pump is started.

8:20 pm

MSHA approves a plan to send two mantrips operated by mine rescue personnel to the 17 block on No. 3 belt. One mantrip will be brought back to the surface by the exiting mine rescue team.

8:30 pm

Batteries are disconnected from a scoop and mantrip located at 17 block.

8:50 pm

Teams advance to the 32 block of No. 3 belt, where the mains reduce from 8 to 5 entries.

10:45 pm

The track is cut.

11:30 pm

On the surface, about 10 hours after surveying began for a suitable location to facilitate drilling a borehole into the Two Left section, the final coordinates are determined. Work begins to modify the drill pad to allow the drill to set up precisely on the coordinates so that it will drill into a mine entry and not into a coal pillar.

TUESDAY, JANUARY 3, 2006**12:25 am**

Consol's Robinson Run B team is to advance, with Consol's Blacksville team underground

for backup and the Barbour County team on the surface for backup.

2:45 am

The mine rescue teams have advanced to 34 block, about 9,400 feet from the portal, when they report seeing a red light and are given permission to approach it. They identify the light as a CO monitoring station, previously thought to have been de-energized. Because the monitoring station is a potential ignition source, they are instructed to withdraw from the mine until the system can be de-energized.

2:45 am

On the surface, the drill begins drilling the borehole toward Two Left.

3:40 am

The mine rescue teams reach the surface. In the command center, a decision is made to keep them outside until the borehole penetrates the mine.

4:00 am

The CO monitoring system's backup power source is successfully de-energized.

The borehole is drilled to a depth of 220 feet, about 38 feet above the roof of the mine.

5:00 am

MSHA approves a plan to load its V2 mine robot and operator and transport them to 31 block. The plan is for the robot to explore inby, followed by mine rescue personnel.

5:30 am

About 23 hours after the explosion, the borehole drill punches through into the mine, 258 feet below the surface, at a point in the

Two Left section about 300 feet from the face. Air samples from the borehole indicate CO at 1300 ppm (more than three times the maximum safe level for a one-hour exposure), negligible methane (.04%), and 20.7% oxygen.

5:50 am

The drilling equipment is shut down and a 10-minute quiet period is observed, in hopes of hearing a signal from the trapped miners. There is no signal. The drill steel is struck, to make noise underground; there is no response.

6:30 am

About 24 hours after the explosion, mine rescue teams are sent underground again, and a camera is lowered into the borehole. It shows no blast damage in the immediate vicinity, indicating that the explosion did not originate inby on Two Left and suggesting that it must have occurred in the sealed area beyond the mouth of Two Left.

7:00 am

Between 7:00 and 8:00, mine rescue teams travel to 31 block, No. 4 belt; the robot is transported into the mine at about 7:35; drilling of a second borehole into One Left gets under way; and the robot reaches 32 block, recording low CO levels (27 ppm).

8:50 am

The mine robot, encountering difficult terrain, is disabled.

10:20 am

About 28 hours after the explosion, the command center adopts a plan for the mine rescue teams to proceed to 48 block of One Left and examine the common return inby for six breaks. The teams are then to proceed inby

to the Two Left section via the intake entries. The teams will then examine the Omega block seals. Exploration will then proceed to 60 block, advancing intake air into the Two Left section, and will then proceed into the Two Left section.

1:30 pm

Mine rescue teams change places: Bailey and Loveridge advance, Tri-State going outside, Barbour County providing backup on the surface.

2:00 pm

Mine rescue teams are at 48 block in the track entry, near the One Left section return entry.

2:15 pm

Mine rescue teams find the mantrip abandoned by the One Left crew at 50 block, heading inby with its headlights still on.

4:30 pm

Mine rescue teams, using curtains to restore ventilation in damaged areas, establish a fresh air base at 57 block, No. 4 entry.

5:15 pm

MSHA mine rescuer Ron Hixson finds a miner's body in the track entry between 57 and 58 block. The victim is later identified as Terry Helms.

6:30 pm

36 hours after the explosion, mine rescue teams find that the Omega block seals beyond Two Left have been almost completely destroyed, with the pulverized seals blown in an outby direction, indicating that the explosion occurred in the sealed area. (The destruction is so complete that mine rescue team members at first walk past the entry into what had been the sealed area without realizing it.)

7:15 pm

Mine rescue teams begin exploring the Two Left section.

7:45 pm

Mine rescue teams find the Two Left mantrip at 10 block. Moving inby in the track entry, the teams find widespread damage to stoppings.

8:00 pm

Shortly after 8:00 pm, mine rescue teams exploring the Two Left intake escapeway find evidence of 12 SCSRs having been opened, and see footprints heading outby toward the seals.

9:00 pm

Mine rescue teams continue to advance into the Two Left section.

11:45 pm

Mine rescue teams have advanced 1,900 feet into the Two Left section. As rescuers advance to the face of the No. 3 entry, Jim Klug, captain of Consol's McElroy team, reports hearing sounds, and moments later he and other rescuers find the 12 trapped miners behind a curtain. The first report back to the command center, relayed by voice, walkie-talkie, mine rescue lifeline and mine phone, is that all 12 miners are alive. The command center erupts in celebration and then organizes to send in stretchers, blankets, water, SCSRs, first aid supplies and medical personnel. Word quickly reaches the miners' families waiting nearby in the Sago Baptist Church, and they celebrate the miraculous news: 41 hours after the explosion, their loved ones have been found alive.

WEDNESDAY, JANUARY 4, 2006

Midnight

Mine rescue team members, several of whom are certified emergency medical technicians (EMTs), determine that there is only one survivor. They place him on a stretcher, begin using a succession of SCSRs to give him air, and prepare to carry him back to their fresh air base and then to the nearest mantrip — nearly 3,000 feet in all, through difficult terrain. One of the mine rescuers, aware of the miscommunication, uses a walkie-talkie to try to radio back to the fresh air base, but cannot get through.

12:15 am

At 12:18 am, the command center receives a message from the mine rescue teams that they are leaving the Two Left section, and that they have one coming out on a stretcher and 11 “items.” The command center, concerned about communication leaks to the media, had earlier adopted a code by which the mine rescue teams would refer to bodies as “items,” and the teams were supplied an identification sheet with a number for each missing miner, to be used instead of names in radio and phone communications. ICG corporate safety director Tim Martin, remembering the code, asks for confirmation. The same answer comes back from underground. There is disagreement within the command center about its meaning. Martin tells the command center to drop the code and ask about survivors. At about 12:23 am the rescuers are asked: “Do you have 11 survivors and one on a stretcher?” The answer comes back: “No, it’s the other way around.” The command center is staggered by the news.

12:30 am

Mine rescue teams continue bringing the sole survivor out of the mine, reaching the surface at about 1:00 am. With his identity not yet determined, the survivor is rushed by ambulance to St. Joseph Hospital in Buckhannon. Meanwhile, all mine rescue teams have been ordered out of the mine.

1:45 am

At about 1:45 am, with the identity of the survivor still not yet known, ICG officials attempt to send a message to the families at the church via the state police, asking an officer to relay word to the clergy to the effect that the command center has conflicting reports on survivors and that the initial reports may have been too optimistic. The message is reportedly relayed but does not reach the families.

2:00 am

Shortly before 2:00 am, ICG’s Viper mine rescue team, which has 5 EMTs equipped with stethoscopes, is rushed back into the mine to confirm that the remaining Two Left miners are deceased.

2:30 am

Mine rescuers reach the face of No. 3 entry, reassess the victims, and report back that all 11 are deceased. Meanwhile, the command center hears from the hospital that the sole survivor is Randal McCloy, Jr.

A few minutes later, ICG president and CEO Bennett Hatfield, vice president Sam Kitts, and others make their way to the church and break the news to the families. Facing an outpouring of confusion, disbelief, grief, and outrage, the ICG officials are escorted out of

the church by state troopers and return to the command center.

5:00 am

At around 5:00 am, nearly 48 hours after the explosion, mine rescue teams carry out the task of identifying the victims, placing them in body bags, and using mine equipment (a scoop) to bring them out because of the difficulty of carrying them all out on stretchers and the risk that to do so could exhaust or otherwise endanger the rescuers. The

process of bringing the victims out of the mine continues for another 5 hours.

10:00 am

All victims are removed from the mine by about 10:00 am — nearly 52 hours after the explosion.

After the victims have been taken away in ambulances, the rescuers gather in a circle at the portal and say a prayer for the lost miners.

4 What caused the disaster?

Shortly before dawn on the morning of Monday, January 2, 2006, a severe thunderstorm swept across Upshur County, West Virginia. At 6:26 a.m., multiple lightning strikes, including one of much greater than normal power, were recorded within a five-mile radius of the portal of the Sago Mine, located about five miles south of Buckhannon, the county seat. At virtually the exact same instant, methane ignited in a recently sealed area of the mine just beyond the Two Left working section, blowing out the seals and filling the mouth of the section with smoke, debris, fumes, and lethal levels of carbon monoxide.

Twenty-nine miners were underground at Sago when the explosion occurred. Thirteen were in close proximity to the blast. As was subsequently learned, one miner was killed by the force of the explosion itself. Twelve others, after attempting to make their way out of the Two Left section, turned back and retreated behind a curtain hung diagonally across the No. 3 entry at the working face of the section in an attempt to barricade themselves against the smoke and carbon monoxide created by the explosion. There they awaited rescue — which, tragically, would come too late for all but one of them.

Meanwhile the other 16 miners, who were more distant from the ignition point and not seriously harmed by the explosion, were able to exit the mine safely with the aid of other miners, including the mine superintendent, who rushed into the mine and who then made a courageous but unsuccessful effort to reach the miners trapped in the Two Left section.

At this writing, the proximate cause of the methane ignition has not been determined with finality. Among the Sago miners who escaped (as reflected in their testimony to investigators), the belief is widespread that lightning somehow triggered the methane ignition. But the question of precisely how lightning may have entered the recently sealed area of the mine has not yet been resolved.

Multiple lightning strikes — at least two and perhaps three — are known to have occurred in the vicinity of the mine. The most powerful of the strikes registered at 101 kilo amps (kA), roughly three times the average peak current of lightning, and occurred at 6:26:35 a.m. at coordinate N.38.926 – W.80.233, approximately two miles from the sealed area of the mine but quite close to the 12 KV power lines owned by International Coal Group and

leading from the Allegheny Power substation at French Creek to the mine preparation plant, then branching off with a separate split to the mine offices and portal, where it supplied power underground.

Two other lightning strikes were recorded at 6:26:35 a.m., closer to the mine power line, preparation plant and portal but of normal lightning strength of 35 kA and 38 kA. These may actually have been a single strike, subject to differing interpretations as to location.¹

At the same instant — 6:26:35 a.m.² — the carbon monoxide (CO) monitor alongside the mine conveyor belt at block 57 spiked at 51 parts per million (ppm).³

These simultaneous events would seem to point to lightning as the probable cause of the methane ignition and subsequent explosion. However, investigators are still attempting to determine how lightning may have entered the sealed area.

One possibility is that lightning followed a path (still undetermined) from the surface downward into the sealed area, possibly involving a submerged pump, partially submerged pump cable, and wire roof mesh in finding its way to the site of the ignition. A de-energized and submerged pump was left in the area when the area was sealed, reportedly because crews were unable to remove it. The pump was reportedly connected to a length of cable which reached to near the ignition point.⁴ At this writing, the pump has been removed from the mine for further examination.

Another possibility is that lightning followed a path (also still undetermined) to the mine

portal, then traveling through the electric system, phone system, track, belt structure, and/or roof mesh, and thereby finding some way to and past the seals and into the sealed area to the point of the explosion.⁵

Since the sealed area had been abandoned in part because of a history of roof falls, there was some speculation early in the course of the investigation that a roof fall might have provided a frictional ignition source. Subsequent identification of the apparent ignition point and the forces emanating from that point suggested, however, that a roof fall probably was not the triggering mechanism, leaving lightning or spontaneous combustion as the alternative causes.

Since spontaneous combustion has been deemed unlikely by most investigators, they have focused on attempting to determine how lightning found its way into the sealed area. Although various theories have been advanced, the facts must drive the theory rather than the other way around, and some key facts have yet to emerge. Therefore, until the issue of the proximate cause has been definitively resolved, speculating is pointless.

That said, however, three questions clearly relevant to both the cause and the consequences of the explosion must be addressed:

- **Prevention:** Did the Sago Mine's owner, International Coal Group (ICG), do everything required by law and regulations to protect the mine against lightning strikes?
- **Containment:** Was the sealed area properly sealed, and were the seals used strong enough to contain a substantial explosion?

• **Propagation:** Was propagation of the explosion minimized by effective rockdusting outby the sealed area?

From testimony provided to investigators and at the public hearing in Buckhannon on May 2-4, 2006, it is clear that ICG failed to properly ground the mine's electrical power infrastructure in its entirety, and failed to install lightning arrestors at some key locations as required by federal regulations. Pending further investigation, the question of whether these failures directly contributed to the explosion and subsequent loss of life remains to be resolved, but there is no question that they represent serious failures of mine management.

As to the seals themselves, in the early stages of the investigation much attention was paid to the question of whether they were properly constructed. That question has not been entirely resolved and may never be, since most of the seals were pulverized. But to some extent the focus on this question had the effect of distracting attention from the larger and more relevant question, which is whether the Omega blocks that were used to construct the seals were, in fact, capable of withstanding a severe explosion originating inby the seals. Although this question is explored in more detail in section 5 of this report, it is important to note here that this question does not go to the adequacy of ICG's management of the Sago Mine. The mine operator installed, and relied upon, a type of seal approved for the purpose by the federal government.

Thus the crucial question with regard to the seals at Sago is whether the criteria used to determine the acceptability of Omega blocks as explosion-proof bulkheads were appropri-

ate and adequate. The evidence available at this point suggests that the test criteria were insufficiently comprehensive and failed to test the ability of Omega blocks to withstand and survive dynamic pressure from an explosion originating inby the seals. This leads to the conclusion that Omega blocks should never have been approved as explosion-proof seals, because it appears highly unlikely that, no matter how they were constructed, they could have contained an explosion such as the one that occurred in the Sago Mine on January 2.

Addressing the last of the three cause-related questions raised above, however — the question of whether propagation of the blast was effectively contained by adequate rockdusting outby the sealed area — it needs to be said that the explosion on January 2 might well have resulted in even greater loss of life but for the fact that investigators found the mine to have been well rockdusted prior to that date. Some investigators, in fact, consider Sago to have been exceptionally well rockdusted, apparently reflecting the efforts of mine managers to improve safety conditions at the mine in the wake of meetings held in late 2005 with MSHA representatives.

Rockdusting — the systematic application of powdered limestone to mine surfaces — suppresses coal dust, a substance even more explosive than methane. Deprived of coal dust as a mechanism to propagate the forces generated by the initial ignition, the explosion of January 2 had lost much (although certainly not all) of its power before it reached the One Left crew at their location further outby the sealed area. They experienced the blast mainly as a powerful rush of air and debris. A coal dust explosion, in contrast, might have engulfed the entire mine, killing

everyone or nearly everyone in by the portal. Moreover, deprived of coal dust, the explosion did not ignite a mine fire, which if it had spread could have made escape for the One Left crew problematic or impossible.

Accordingly, subject to development of additional and definitive evidence, we believe

that the question of what caused the Sago Mine disaster has a three-part answer:

- **Lightning probably caused the explosion.** More remains to be learned, however, about how lightning made its way into the sealed area where the methane ignition took place, and, depending on how that question is

LIGHTNING RELATED EXPLOSIONS IN COAL MINES (1993-2006)

An examination of the 9 known or suspected lightning strikes in 5 U.S. coal mines, since 1993, is an unsettling exercise. In contrast to other MSHA investigation reports which provide a measure of engineering certainty, these are more speculative, containing phrases like “probable cause was lightning” or “it is reasonable to conclude that lightning may have ignited methane.” We need prompt research on the role lightning plays in underground mine explosions and ways to prevent it.

Mine Name/ MSHA ID #	Operator & Location	Coal Seam & Depth	Date & Time of Explosion	Description of Seal	→
1 Mary Lee No. 1 01-00515	Drummond Company, Inc. Goodsprings, AL	Mary Lee Seam 600/700	8/22/93 4:30 P.M.	Cementitious foam	→
2 Oak Grove 01-00851	U.S. Steel Mining Company, Inc. Adger, AL	Blue Creek Coal Seam; 1100'	4/5/94 10:50 P.M.	5 solid block concrete, mortared; 33 cementitious foam seals	→
3 Gary No. 50 46-01816	U.S. Steel Mining Company, Inc., Pineville, WV	Pocahontas No. 3; 600/700'	6/9-6/16/95	TEK foam, 4 ft. thick seals	→
4 Oak Grove 01-00851	U.S. Steel Mining Company, Inc. Adger, AL	Blue Creek Coal Seam; 1100'	1/29/96	5 seals, 6 ft. thick; 38 cementitious foam by Celtite Div./Fosroc, Inc.	→
5 Mine No. 1 46-07273	Oasis Contracting, Inc. Quinlan, WV	Cedar Grove Seam;390'	5/15/96 4:00 A.M.	Micon 550, 6" solid concrete blocks as framing walls for 16" polymer grout and aggregate inner core	→
6 Mine No. 1 46-07273	Oasis Contracting, Inc. Quinlan, WV	Cedar Grove Seam;375'	6/22/96 8:00 P.M.	Micon 550, 6" solid concrete blocks as framing walls for 16" polymer grout and aggregate inner core	→
7 Oak Grove 01-00851	U.S. Steel Mining Company, Inc. Adger, AL	Blue Creek Coal Seam; 1100'	7/9/97 8:15 P.M.	Cementitious foam seals by Celtite Div./Fosroc Inc.	→
8 Gary No. 50 46-01816	U.S. Steel Mining Company, Inc. Pineville, WV	Pocahontas No. 3; 600/700'	5/18/01 5:09 P.M.	Micon 550	→
9 Sago 46-08791	International Coal Group, Inc., Tallmansville, WV	Middle Kittanning Seam;300'	1/2/06 6:26 A.M.	40" thick Omega block seal	→

answered, specific steps must then be taken to protect other underground mines and miners against the risk of lightning-related methane ignitions.

• **The seals that should have helped contain the explosion were not sufficiently explosion-proof and never should have been approved for that purpose.** The catastrophic failure of the Omega block seals clearly made the explosion far more lethal than would otherwise have been the case.

• **Effective rockdusting of the mine prior to January 2, 2006, helped contain the explosion and saved lives.** It is important to underscore this point, both to give credit where credit is due and to highlight the importance, on an industrywide basis, of guarding against mine emergencies by taking the kinds of basic preventive measures required both by law and by experience-based risk assessment and best practices.

(chart continues...)

→	Effect on Seals	Magnitude of Strike	Suspected Cause	Effect on Miners
→	2 seals blown out and fan shaft cap damaged	(-)21.7 ka	Explosion was a result of a lighting (electrification) strike at the vent pipe pipe on the cap of 70 North fan shaft	No personnel injured
→	2 seals blown out and 1 damaged	(+)84.8 ka	Lightning strike close to abandoned cased bore hole ignited methane	No personnel injured
→	No seals blown out	(-)90.2 ka; 7 strikes	Lighting strike could have caused explosion; no direct path identified	No persons in mine
→	5 seals destroyed with pieces blown 80' to 100'	(+)55.8 ka	Lightning strike near any wells could couple energy onto any of the metallic casings, travel down to an entry in the sealed areas	No personnel injured
→	3 seals blown out, 1 partially blown out. (Non-producing mine; seals leaked)	(+)59 ka	Probable cause was either lightning strike or friction/ignition from a roof fall	No persons in mine
→	Not reported	(-)50 ka	Probable cause was either lightning strike or friction/ignition from a roof fall	No persons in mine
→	3 seals destroyed and 1 severely damaged	(-)142.2 ka	Path into the sealed areas undefined	No personnel injured
→	Seals intact	Unknown	Lightning strike confirmed at time and vicinity of explosion; reasonable to conclude that methane ignition resulted when an explosive mixture was ignited by lightning	Force confined by seals; no loss of life
→	All 10 seals pulverized; no seal material attached to roof, rib or floor	(-)101ka	Lightning strike may have caused explosion; no path identified or confirmed	1 killed initially; 16 escaped; 12 trapped, eventually only one survivor.

Source: MSHA investigation reports, with the exception of the Sago entry.

SOURCES

¹ Monte Hieb, memorandum, 7/5/06.

² This event was originally thought to have occurred at 6:31 a.m. However, state investigators determined that the computer clock at the mine was 4 minutes 56 seconds fast. Adjusting the clock to Universal Time (atomic clock time), they found that the CO monitor alarmed at 6:26:35, precisely the same time that the lightning strikes were recorded by Global Positioning System (GPS) clocks, which are also set to Universal Time.

³ This reading appears to have actually exceeded the monitor's maximum level (50ppm). When it pegs at that level the monitor is designed to shut itself down and must be reset.

⁴ Monte Hieb, memorandum, 7/5/06.

⁵ Monte Hieb, memorandum, 7/5/06.

5 Why did the seals fail?

'The current seal construction regulations... assume that an explosion occurring in [a mined-out and abandoned area] will not be stronger than 20-psi pressure. However, if a large flammable gas volume exists in the [sealed area], the resulting explosion pressure can be >20 psi.'

— National Institute for Occupational Safety and Health, 2001¹

The explosion in the Sago Mine originated in a recently abandoned and sealed area. In theory, the seals constructed to isolate the abandoned area from the adjacent working sections of the mine should have withstood the blast — unless the ignition of methane in by the seals generated forces so powerful that no barrier, regardless of the materials used and the method of construction, could have contained the explosion.

That does not appear to have been the case. Instead, what appears to have happened is that the supposedly “explosion-proof” seals failed because they were constructed of a material — Omega blocks — that should never have been approved for the purpose of containing an explosion originating in a sealed area.

On May 12, 2006, Acting Director James M. Dean of the West Virginia Office of Miners' Health, Safety and Training imposed a state-wide moratorium on the use of Omega blocks as explosion-proof seals in underground

mines. Eight days later, on May 20, 2006, an explosion in the Kentucky Darby No. 1 Mine in Harlan County, Kentucky, blew out a seal constructed of Omega blocks, killing five miners in the explosion and its aftermath. On May 22, 2006, the federal Mine Safety and Health Administration imposed a temporary nationwide moratorium on the construction of alternative seals such as Omega blocks, requiring mine operators wishing to seal worked-out areas to revert to the practice of using solid concrete-block bulkheads, pending a reassessment of the structural integrity of alternative seals.²

West Virginia's decision to bar the use of Omega blocks as seals was appropriate and should be made permanent. Moreover, the state should join with the United Mine Workers of America, which has opposed the use of Omega blocks as seals for many years, and with other concerned parties to spur the appropriate agencies to conduct a comprehensive review of the entire history of the development of explosion-proof criteria for

seals used in the mines of the United States. These criteria appear to be severely inadequate and in urgent need of revision. In the meantime, Omega blocks should not be considered explosion-proof regardless of how they are constructed, and the current temporary nationwide moratorium on their use in underground mines for purposes other than as ventilation stoppings should be made permanent.

Although a comprehensive assessment of the development of the criteria currently governing the construction of explosion-proof bulkheads in U.S. mines is beyond the scope of this report, a brief discussion is warranted in order to explain the need for further investigation and action.³

The worst mine disaster in the nation's history occurred in 1907, when an explosion in a coal mine at Monongah, West Virginia, claimed 362 victims. In the wake of that catastrophe and several others that occurred over the next two years, Congress established the federal Bureau of Mines in 1910. Although the Bureau was initially given no enforcement authority (strong federal mine legislation was not enacted until 1969), the Bureau did have a mandate to investigate the causes of fatal accidents and to make recommendations for improvements in safety and health protection (which mine operators were free to adopt or ignore).

The Bureau's research on sealing abandoned mine areas dates back to 1914, when the agency began conducting explosion tests in its new experimental mine. Over the years, sometimes in cooperation with similar agencies in other mining countries such as Germany and the United Kingdom, the Bureau

undertook numerous studies of explosions and developed strategies to prevent and contain them.

Early on, experts were able to arrive at a consensus view regarding the basic standards needed to contain explosions. In 1921, for example, the U. S. government, in adopting criteria for explosion-proof bulkheads between coal mines on government-owned lands (the only sphere where the government had the power to regulate at the time), required that such stoppings be able to withstand an explosion generating a pressure of 50 pounds per square inch (psi).

Similarly, commissions investigating disasters in the United Kingdom in the 1930s and in 1960 concluded that mine explosions are likely to develop pressures ranging from 20 to 50 psi, and determined that a 50-psi standard would provide a reasonable margin of safety. Later studies of explosions in Poland and Germany led researchers there to conclude that bulkheads should be designed to withstand higher pressures, and that a 72-psi standard would be advisable.

Despite these findings, however — and despite subsequent adoption of 50 psi and in some cases more rigorous standards in mining countries such as Canada, Australia, and South Africa — the Bureau of Mines adopted a much lower standard for the United States.

The Federal Coal Mine Health and Safety Act of 1969 — enacted in the wake of the explosion that killed 78 miners at a Consolidation Coal Company mine near Fairmont, West Virginia, in November 1968 — required bulkheads to be “explosion-proof.” The

Bureau of Mines was then charged with developing appropriate standards to give that term meaning. Notwithstanding the increasing adoption of the 50-psi (or higher) standard elsewhere, the Bureau published a single report in 1971 that made the case for a 20-psi requirement — a standard subsequently adopted in federal regulations [30 CFR 75.335] that remain in effect today.

That 1971 report (*Explosion-Proof Bulkheads: Present Practices*, U.S. Bureau of Mines Report of Investigations 7581) makes for deeply disturbing reading in the wake of the Sago Mine disaster. The author of the report, the late Donald W. Mitchell, then Acting Supervisor of the Bureau's Pittsburgh Mining and Safety Research Center, briefly reviewed U.S. and foreign experience with mine explosions and noted that in test explosions in the Bureau's experimental mine, pressures had registered as high as 127 psi. He then stated, however, that pressures 200 feet or more from the origin of an explosion seldom exceed 20 psi. That statement, while not documented anywhere in the report, appears to be the rationale for his conclusion that bulkheads may be considered "explosion-proof" if they can withstand a static load of 20 psi.⁴

Mitchell's report makes no clear distinction between static and dynamic pressures, even though the differences can be important. Picture an explosion taking place at one end of a relatively long, narrow room. The explosion, propagating outward into the confined space, exerts static pressure on the walls parallel to the direction of travel, and dynamic pressure on the opposite wall. In this example, the opposite wall takes the greater hit. But from the evidence available it appears that Mitchell, in arguing for a 20-psi standard, gave little consideration to dynamic pressures.

The Bureau in its experiments appears to have tested materials for static pressure resistance only — that is, installing them as ventilation stoppings would be installed, typically in crosscuts parallel to the likely source of a blast, rather than as barriers built in the entry directly across its path. Consequently, the tests conducted over the years by the Bureau of Mines and its successor agencies — the Mine Health and Safety Administration and the National Institute for Occupational Safety and Health — to determine whether a given material and structure is "explosion-proof" as required by federal law do not seem to address the kind of explosion experienced at Sago.

It should be noted, and emphasized, that we have not yet had an opportunity to review the apparent limitations in the methodology of Mitchell's report with experts at MSHA or NIOSH, and we need to be open to the possibility of having missed something. However, unless that is the case, it is difficult to escape the conclusion that the 20-psi standard — adopted entirely as a result of that one 1971 report — provides none of the margin of safety that government explosion experts were sensibly advocating as far back as 1921, when they proposed 50 psi as a standard for seals survivability.

Why is this important now? It is important because Mitchell's 1971 report became, for the Bureau of Mines and then for MSHA and NIOSH, the standard reference which for the past 35 years has apparently guided the parameters for the testing and certification of allegedly "explosion-proof" seal designs and materials — including Omega blocks.

The Omega 384 block, manufactured by Burrell Mining Products, is a lightweight

fiber-reinforced block consisting of a mixture of cement, foam, and fly ash. Because a standard Omega block (16 inches by 24 inches by 8 inches) is three times the size of a single solid concrete block but weighs far less, the product has become popular in the mining industry, where it is widely used to construct ventilation stoppings. Omega blocks can be easily stored and transported into the mine on pallets, and stoppings made of the blocks can be built more easily and with considerably less risk of musculoskeletal injuries than when working with solid concrete blocks. Omega blocks can also be cut with a hand saw and are incombustible as well as moisture-resistant.

In 1990, MSHA was asked to approve Omega blocks as explosion-proof seals. Explosion tests were conducted in October 1990 at the Lake Lynn Experimental Mine. Burrell employees constructed four seals, each of which survived a pressure pulse of approximately 20 psi. However, as with previous “explosion-proof” tests, the testing was done with the seals constructed in crosscuts, as though they were ventilation stoppings, rather than built directly in front of and across the source of the blast. Thus the seals demonstrated only their ability to survive a powerful but glancing blow, rather than a full-force, head-on blow. In short, they were not subjected to the kind of test to which Omega blocks would be subjected at Sago nearly 16 years later. By way of analogy, think of an automobile being termed “collision-proof” on the basis of surviving a glancing blow at an intersection rather than a head-on crash at highway speeds.

Few in the mining industry — or, for that matter, in the ranks of mine safety enforce-

ment — were probably aware of the tests’ limitations. To most of us, the knowledge that the government will not sign off on something as “explosion-proof” unless it withstands an explosive force of 20 pounds per square inch has been good enough. What more would we need to know? And, prior to this year’s disasters at Sago and Darby, what we knew, essentially, was that MSHA had approved Omega blocks in 1992 as alternative seals, and that they were considered explosion-proof as long as the construction of the seals was done in accordance with the way they had been tested as well as in accordance with the specific, MSHA-approved ventilation plan for the mine installing them.

But in reality that was not good enough, because, as we now know, the tests themselves were not good enough. They did not test the ability of seals built of Omega blocks to survive a direct hit — a force of 20-psi or higher — from inby the seals.

In hindsight, it is difficult to understand why such tests were never conducted — never, that is, until mid-June 2006, six months after the Sago disaster. (In the latest tests, the Omega-block seals failed.) If the assumption was that explosions would not originate in abandoned and sealed areas because there would be no ignition sources in such areas, that is contradicted by long experience. For example, a roof fall in a sealed area could trigger a frictional methane ignition if it occurs while a methane buildup in the sealed area is in the explosive range (5 to 15 percent of the mine atmosphere). Moreover, evidence has been accumulating for several years that lightning can ignite methane in an abandoned and sealed area, triggering an explosion.

Between 1993 and 1997, seven explosions in abandoned areas of underground mines in Alabama and West Virginia were found to have been caused by lightning. MSHA investigators found that, in most cases, seals constructed of various materials had been partially blown out by the blasts. Fortunately, in all of these cases the lightning strikes occurred in remote areas of the mines; the explosions were not severe; and no miners were working directly in their path or in affected areas.

In the wake of these incidents, NIOSH issued a bulletin in 2001 to alert the mining industry to the apparent hazard of lightning-triggered ignitions, noting that in at least one case the force of the explosion clearly exceeded 20 psi. The bulletin further noted:

“The current seal construction regulations, which relate to all suitable underground seal designs, assume that an explosion occurring in the gob [mined-out and abandoned area] will not be stronger than 20-psi pressure. However, if a large flammable gas volume exists in the gob, the resulting explosion pressure can be >20 psi.”⁵

Unfortunately, NIOSH concluded that if lightning as a potential source of ignition could not be eliminated, the only alternative would be to eliminate flammable concentrations or reduce the volume of the flammable mixture present in the sealed area (by taking steps such as minimizing pressure differentials across seals to reduce air leakage). Other steps, such as eliminating wires or other conductors and removing potential ignition sources such as old batteries from sealed areas, were also recommended. But neither NIOSH nor MSHA, despite their acknowl-

edged awareness that sealed-area explosions could generate more than 20 psi, recommended reconsidering the 20-psi standard for “explosion-proof” bulkheads in the light of accumulating experience.

The decision by MSHA and WVOMHST in May 2006 to impose a moratorium on the use of Omega blocks as seals comes too late for the victims of the Sago Mine disaster. But it would seem to indicate a recognition, even if not explicitly acknowledged, that both the 20-psi standard and the explosion-proof testing regime are long overdue for reassessment. State and federal authorities must now work together — and must be willing to draw upon the experience of other mining countries and the more stringent standards they have long since adopted — to ensure that this urgent priority is addressed without further delay.

In the wake of the Sago Mine disaster, much attention was paid to the question of whether the Omega block seals at Sago were properly constructed. That would seem to be a largely irrelevant question, even something of a distraction, since the evidence strongly suggests that they would have been destroyed regardless of how they were constructed. The more basic problem is with a standard for “explosion-proof” that is clearly inadequate, both in terms of the standard itself — 20 psi — and the tests traditionally used to determine whether a given material can meet that standard.

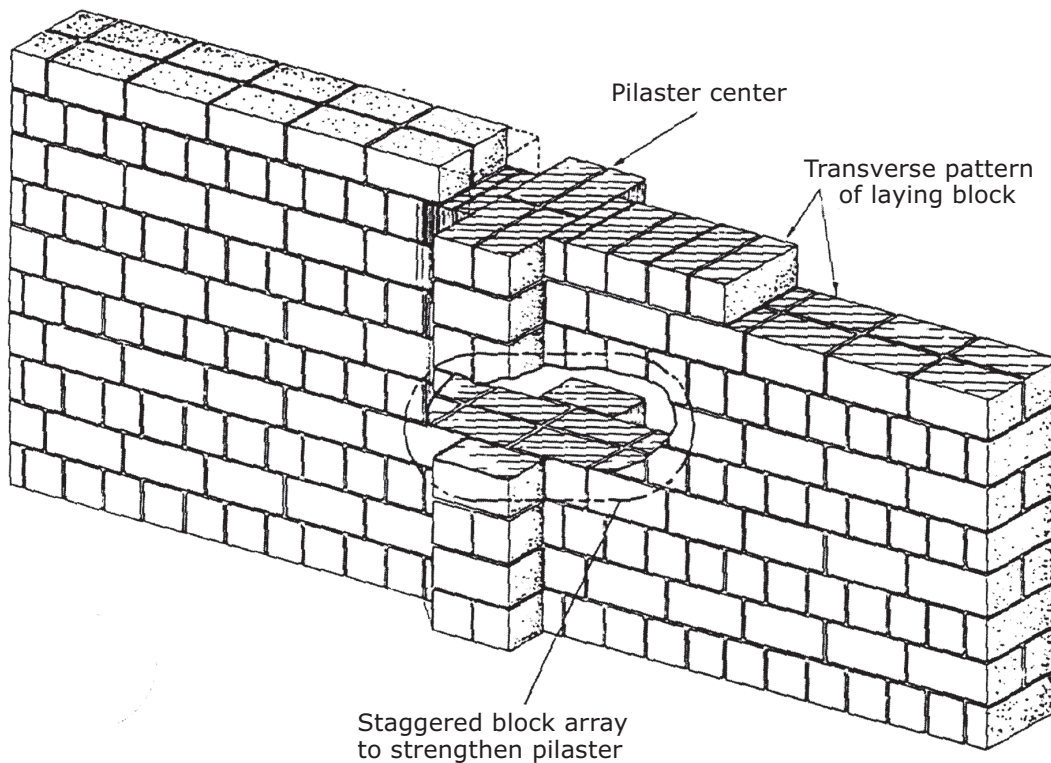
Standards for explosion-proof bulkheads in West Virginia and throughout the United States must now be brought into line with global standards, which suggests setting the bar at pressures significantly higher than 20 psi, and remedial steps must be taken to

ensure that all seals now in use are strengthened, if necessary, within a specific and enforceable timeframe.⁶ Where appropriate, on a case-by-case basis, boreholes should be drilled into abandoned areas to ventilate them. Other steps such as inerting sealed

areas by injecting nitrogen may also be warranted and should be explored with all deliberate speed.

For now, only seals constructed of solid concrete blocks (also known as Mitchell-

An explosion-proof seal



The diagram above shows a solid concrete block seal (also known as a Mitchell-Barrett seal). For extra strength the blocks are staggered — laid both lengthwise and crosswise — and all joints are mortared. To provide strength at the edges of the seal, the seal is hitched into the coal rib. When a seal is to be constructed above a specified height, it must be further strengthened by including a pilaster — an extra row of staggered blocks in the center as shown. Construction of such a seal is time-consuming, labor-intensive, requires masonry skills, and can involve risks such as musculoskeletal injuries while handling the heavy blocks and the possibility of being injured by a rib roll while hitching the rib. Consequently, alternative seals were developed and have become popular. Some, such as cementitious materials poured or pumped into frames filling the entire void between floor and roof, may have bulk and strength sufficient to withstand severe explosions. But Mitchell-Barretts should be thought of as the gold standard.

Barrett seals) or seals of demonstrated equivalent strength should be used for construction of seals in West Virginia and throughout the country. Mitchell-Barrett seals (see diagram) have successfully withstood explosions generating pressures far greater than 20 psi and offer a much higher level of protection than afforded by Omega blocks and other alternative seals.

In a related matter, research needs to be conducted to better understand the impact that variations in mining height and abrupt changes in the cross-sectional area of mine entries in a sealed area may have on the velocity of an explosion. At Sago, for example, bottom mining had been done in the area where the explosion occurred. We need to know the impact that bottom mining may have had on the strength, velocity, and direction of the explosive forces resulting from the methane ignition. As is well known, the velocity of water increases when it moves from a large pipe to a smaller pipe (an action known as the Venturi Effect). Because air acts in the same way as water, an explosive force which is initiated in a large space is then forced into a smaller space can be expected to result in a similar increase in velocity. In addition, turbulence that is created when a blast wave passes across entry obstructions or sudden mining-height changes increases

mixing of stratified mine gases and can enhance propagation effects.⁷

Computer modeling systems are available through institutions such as Sandia National Labs, Naval Surface Warfare Center, Army Corps of Engineers facilities, and others. Such tests should be funded and undertaken immediately in order to better understand the explosive forces which could be potentially created in coal mines by large and numerous changes in entry height due to bottom mining.

In addition to maintaining the current moratorium on the use of Omega blocks as seals, a comprehensive survey of the numbers and locations of Omega-block type seals currently in use should be completed, and plans to retrofit or otherwise accomplish the construction of explosion-proof seals within a specific timetable should be pursued, with each West Virginia mine operator responsible for developing plans subject to approval by the West Virginia Office of Miners' Health, Safety and Training.

Until measures such as these have been taken, every sealed area in every underground coal mine in West Virginia and throughout the United States should be considered a potential time bomb — and treated accordingly.

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6 Did the miners' SCSRs fail?

'... The mine filled quickly with fumes and thick smoke... The first thing we did was activate our rescuers, as we had been trained. At least four of the rescuers did not function. I shared my rescuer with Jerry Groves, while Junior Toler, Jesse Jones and Tom Anderson sought help from others. There were not enough rescuers to go around.'

— Randal McCloy, Jr.¹

When Randal McCloy, Jr., the only survivor among the miners trapped in the Two Left section of the Sago Mine on January 2, recovered to the point of being able to release a statement to the families of his co-workers on April 26, he delivered terrible news. The crew had survived the explosion, only to discover that their first line of defense — the self-contained self-rescuers (SCSRs) they carried into the mine with them every single working day — had failed them. They could not make all of their SCSRs work. Without enough fully functioning SCSRs to go around, there was no way, as they understood the situation, for all of them to make it safely out of the section and back to where there might possibly be respirable air.

When Mr. McCloy in his continuing recovery was able to be interviewed by state and federal investigators on June 19, he amplified on his earlier statement, explaining how he struggled with the non-functioning SCSRs and could not make them work. He described sharing his own SCSR with his roof-bolting

buddy, Jerry Groves, and how he struggled with Mr. Groves's SCSR: "I fought with it for I don't know how long, trying to mess with that valve, blow air through it or anything I could do, but nothing would work."²

The apparent failure of some of their SCSRs to generate oxygen may have doomed the miners trapped on Two Left. Without enough functioning SCSRs to go around, they could not have tried to walk out of the mine, knowing that they would be making their way through lethal concentrations of carbon monoxide and that any miner without a working SCSR would rapidly succumb. And it is impossible to imagine any of them, in that situation, simply walking away from their fellow miners.

Instead, according to Mr. McCloy, they tried to make their way together to where they had left their mantrip — yelling to keep track of each other in the blinding smoke — but had to abort that escape attempt when they encountered thick dust and swirling smoke

and what they believed was impassable debris. “We couldn’t escape the smoke,” Mr. McCloy recalled. “There was nowhere to go because it just lingered everywhere, you know, just everywhere you went.”³

So the miners returned together to the section face, where they hung a curtain as a barricade, began trying to signal their location to the surface by beating on roof bolts with a sledgehammer, and shared the limited number of SCSRs that did seem to be working.

Meanwhile the miners on the One Left crew, further out by the explosion, were making their way into the escapeway and out of the mine after being engulfed in a rush of air, dust, and debris. Seven of them donned their SCSRs. From their subsequent testimony to investigators it appears that, with one possible exception, all of their SCSRs worked, although at least two miners had some difficulty using them.

Mine Safety and Health Administration (MSHA) investigators subsequently recovered all of the SCSRs from the Sago Mine, including the Two Left section, had them tested by the National Institute for Occupational Safety and Health (NIOSH), and reported that all were in working order. This seems to raise the question: Who is right? The miners who believed that their SCSRs failed, or the laboratory technicians who examined those same units and found them to be operational?

That is the wrong question. The right question is not whether SCSRs work well under ideal conditions in a NIOSH laboratory. The question is whether they work *in the mine*, in an emergency, when they’re desperately needed.

To address that question, we must look first at how an SCSR is typically used, and then at the quality of the training provided to the miners who must rely on them.

The situation on Two Left in the moments immediately after the explosion tells us all we need to know about the kinds of conditions in which an SCSR is likely to be used. The mine suddenly fills with noise, smoke, and fumes. It’s pitch-black. The smoke and dust are dense and swirling. A miner’s cap lamp — much more powerful than an ordinary flashlight — cannot penetrate the murk. The mine atmosphere becomes terrifyingly foul and stays that way. Breathing immediately becomes difficult. Miners quickly lose contact with each other and can easily become disoriented. They know, instantly, that they are in a desperate life-and-death situation in which seconds count, and that the SCSRs they carry are their first and possibly last line of defense. So their first priority is to activate their SCSRs — under just about the worst kind of stress imaginable.

The Sago miners were equipped with the SR-100, an MSHA-approved SCSR manufactured by CSE Corporation in Monroeville, Pennsylvania. Like other SCSRs approved by MSHA, the SR-100 is rated to provide a minimum of one hour of breathable air while the user breathes under exertion, such as while escaping a mine, and in laboratory tests has provided approximately four hours of air at rest. The belt-wearable SR-100, which weighs about six pounds and costs about \$680 per unit, is currently the most widely used SCSR in U.S. mines.

Problems have been experienced with the SR-100 over the years. In 1998, for example,

MSHA issued an alert to the mining community after finding that some SR-100s emitted higher than normal levels of carbon dioxide in the air supplied to the user. Although the SCSRs still functioned, MSHA warned that miners using them might find themselves breathing uncomfortably fast and more deeply than expected, possibly causing them to become frustrated with the SCSR and discarding it. CSE suggested that the devices most likely to produce higher than normal carbon dioxide levels were those that had been exposed to excessive shock and vibration over an extended time.

Similarly, MSHA issued an alert in 1999 after finding that a small number of SR-100s manufactured from 1991 to 1993 had deteriorated hoses. CSE pledged to replace any such units, and subsequently modified the SR-100's hose design. MSHA urged mine operators to perform regular, thorough inspections of their SCSRs, remove from service any units with detectable damage, and replace older units. MSHA also advised placing extra SCSRs on each mining section.

Given the widespread use of the SR-100, however, problems have been relatively rare, and it has generally been considered a reliable unit. But general reliability is no comfort to a miner suddenly facing a life-threatening emergency. At that instant, the miner's only question is: "Can I get this thing on in a hurry and will it work?"

The answer to that vital question is not as simple as we would like. A number of variables are involved, the most important of which is the quality and frequency of the training that the miner may have received prior to needing the SCSR in an actual emergency.

Activating and donning the SR-100 requires practice and clear thinking. The miner removes the SCSR from its pouch. Holding it in his hand, he kneels on the ground and removes his hard hat so that he can shine his cap lamp on the area immediately in front of him. He opens the SCSR by lifting the latch on top, which supposedly allows him to remove both the top and bottom protective covers. In practice, removing the covers can be difficult, as the manufacturer acknowledges in its instructional materials. The miner then removes the safety goggles packed in the unit, looping them over his wrist so he won't lose them in the murk and mud. He takes the neck strap out and puts it over his head, taking care not to put the unit on backwards, which would make it difficult to use the mouthpiece and nose clips properly. He pulls an orange actuator tab downward to activate oxygen (the unit contains a small oxygen



Donning an SCSR is awkward and uncomfortable under the best of circumstances — let alone in a smoke-filled mine.

reserve to help inflate its breathing bag). He extends the breathing hose, removes a plug from the mouthpiece, and inserts the mouthpiece in his mouth, biting down hard on it to hold it in place. He pulls the two nose pads apart and affixes them to his nose, completely closing both nostrils. Although it is counterintuitive, he then exhales into the unit to get its rebreathing mechanism going. He puts on the safety goggles. He adjusts the neck strap so that the SCSR rests on his chest. He then fastens the waist strap tightly to keep the SCSR from swinging loose as he moves. He puts his hard hat back on his head, stands up, and starts planning his escape. (He can't voice-communicate with other miners while using his SCSR, so he must try to maintain physical or visual contact.) If everything goes perfectly, he gets his SCSR up and running in about 30 seconds.

It isn't easy, even if you've been thoroughly trained and are young and in great shape. If you're older, and not in such great condition, it's harder. If your training has been superficial, and if you haven't been retrained recently, it's harder still. If you wear eyeglasses and they've been blown away and you're blinded by smoke and grit, and you're choking, gasping, and at the brink of panic, it's harder yet. Several of the One Left miners discovered that they just about could not do it without help from other miners.

Moreover, the challenge doesn't end with donning the SR-100. It is possible to "overbreathe" the unit — in which case it will feel to the miner as though he is trying to suck air through a crimped drinking-straw instead of breathing through a hose. As ICG's assistant safety director, Johnny Stemple, ex-

plained while demonstrating an SR-100 at the May 2-4 public hearings in Buckhannon:

"The [SR-100] will provide oxygen at a certain rate. And you can overbreathe those rescuers. You can breathe faster than they can provide oxygen. If you're in a mode where you're moving very fast, very quickly, you can overbreathe those units. You have to slow your breathing rate down or slow your pace down to allow those units to produce oxygen at — or to allow your body to take in the oxygen as fast as [the] unit is producing the oxygen. It's not a unit that provides pressure, so when you activate the unit, there's not oxygen coming out of it. You have to breathe into it and breathe out of it, or suck out of it, to get oxygen. And you can outbreathe those units."⁴

Stemple's description, while accurate, does not mention another complication that can arise if a miner has not been thoroughly trained on the SR-100. In fact, the unit *does* generate oxygen very briefly when it is first activated — "a few puffs," as some trainers say — so it is possible to get the impression that it is working comfortably at first but then, after a couple of breaths, breathing may seem to become much more laborious. Someone thoroughly familiar with the unit would understand that it is still functioning, just differently — because, after those first few puffs, the unit needs to have the user actively exhaling into the rebreathing mechanism in order to be able to convert exhaled carbon dioxide into oxygen. However, someone who has never had to use the unit could easily get the impression that it has suddenly stopped working, or that breathing through it has suddenly become unnervingly difficult. Instead of making escape from a smoke-filled

mine easier, the SCSR is making it even harder — or so it may seem. At that point even a veteran miner might be tempted to make the potentially fatal decision to give up on using the SCSR, hoping somehow to get along without it.

We do not know whether this is exactly what happened to the miners on Two Left. But we do know what matters — that some of them were convinced that their SCSRs were not working. We do not for a moment believe that the miners trapped on Two Left were incompetent. We are sure, however, that they had not been adequately trained in the use of their SCSRs — and there is also the possibility that some of the SCSRs they relied on had been badly battered from long exposure to the rigors of daily transportation into and out of the mine.

From testimony provided to MSHA and state investigators and at the May 2-4 public hearing, we can be reasonably certain that those Sago miners who received SCSR training after International Coal Group acquired the mine were, in most instances, required only to demonstrate to an instructor that they knew how to don the unit, while in other cases they may have simply been shown how to do it. (And in at least one case a Sago miner testified that he was asked to sign a slip certifying that he had been retrained on the SCSR when in fact he had been absent that day.)⁵ It should be said, however, that the training provided by ICG was probably typical for the mining industry at this point in time.

The Sago miners did not actually breathe into a unit, because that is not part of the required training. And there can be no doubt that they

did not experience in training the kinds of challenges, including overbreathing, that they would face in a real crisis.

The reason why there can be no doubt about that is that ICG has not purchased the SR-T, a \$220 training unit marketed by CSE designed to “give the user a chance to experience the sensations that are common with the SR-100 [including] breathing resistance and temperature sensations.”⁶ As CSE notes in its marketing literature, a miner wearing the SR-T in a workplace setting can get a sense of what it is like to use the SR-100 under stress: “Higher work rates will increase breathing resistance and inspired temperature.”⁷ That would be valuable experience to store in memory.

Again, it should be noted that ICG is by no means alone in opting not to purchase this CSE training model. As far as we have been able to determine, CSE has sold few if any of these units to U.S. coal producers, who understandably prefer the less expensive approach of using old SR-100s as training models. (The SR-100 has a storage life of 10 years, after which units must be discarded or used for training.) The manufacturer reports, however, that the SR-T is in widespread use in Australia, not by government regulation but by a “duty of care” agreement within the mining industry that views thoroughly realistic SCSR training as a basic safety imperative.

We need that attitude in West Virginia and throughout the coal industry in the United States. Whether it would have saved the lives lost on Two Left is something we cannot know for sure. What we *can* say is that more thorough and realistic SCSR training — and at more frequent intervals than the annual

retraining required by the regulations that were in effect on January 2, 2006 — would improve the odds that a miner can count on his or her SCSR in a crisis. And improving the odds is a large part of what survival is all about.

The fact that four of the SCSRs relied on by the Two Left miners did not work for them — leaving them with not enough SCSRs to go around — is tragic. The fact that NIOSH’s subsequent tests found all of the SCSRs from Two Left to be in working order compounds the tragedy, because if those tests were accurate they can only mean one thing: that the Two Left miners, even though most of them were veterans, had not been sufficiently familiarized with the challenges of using an SCSR in an emergency setting.

Going forward, it will be necessary, *at minimum*, to do on an industrywide basis what a few companies already do: train miners in realistic settings, including special rooms or trailers that can be filled with (harmless) Hollywood smoke. Every miner needs and should have that level of SCSR training, repeated frequently enough to retain it in memory. As Joe Ryan, a veteran member of the One Left crew, described the experience of struggling with his SCSR on January 2: “We’ve heard it so many times, we could do it in our sleep. But then, when you have to do it, it’s a different — it’s really, really...”⁸ He didn’t finish the sentence; he didn’t have to.

In addition to immediately improving training, we need to address the urgent question of whether the SCSRs currently in service can be counted on to work in practice. The West Virginia Office of Miners’ Health, Safety and Training is attempting to address that ques-

tion by requiring mine operators to inventory SCSRs and report problems on a quarterly basis, effective August 15, 2006.⁹ This should be a useful development. However, SCSRs should also be field-tested. The best way to do that would be to give federal and state inspectors the authority to ask individual miners on working sections — at random, without forewarning, and on a voluntary basis — to don their SCSRs and walk out of the mine, or at least far enough to get a good feel for breathing through the unit. Since the unit will then have to be replaced, and because this safety exercise will also be seen as downtime and lost productivity, many coal operators can be expected to vigorously oppose this proposal. But some will surely recognize that as we absorb the lessons of the Sago Mine disaster — in which the initial explosion seems to have been followed by one tragedy after another — this is the very least we can do to prevent a recurrence. For those opting to invest in and use training-model SCSRs, the random testing requirement could be waived.

Another necessary step is to reduce the 10-year life expectancy currently permitted for SCSRs. That time period, we believe, is arbitrary and not based on any laboratory determinations. To create a greater margin of safety — including guarding against the risk of malfunction from the repeated wear and tear that SCSRs experience as they are transported in and out of mines daily — SCSRs should be withdrawn from use after a shorter period of service.

Moving beyond these interim measures, we must immediately take steps to accelerate development of the next-generation SCSR. The SR-100 and similar units produced by

other manufacturers represent technologies that are more than two decades old. Despite their obvious performance limitations and increasing obsolescence, there has been no serious effort to fast-track the research, development, and deployment of the next generation. MSHA and NIOSH have not gone much beyond workshop conceptual discussions, and no one has stepped forward to assist researchers, inventors and manufacturers interested in getting a 21st-century product into the hands of 21st-century miners.

This must change. Several next-generation concepts are worthy of support, including a hybrid SCSR which in less toxic environments can convert to functioning as an air-purifying respirator, and a dockable SCSR that would permit supplementary units to be docked to the main unit while in use, eliminating the need for the wearer to switch units. In addition, a prototype two-hour SCSR unit developed by OX-GEN Flexible Life Systems, Inc., and displayed at the International Mining Health and Safety Symposium in Wheeling, West Virginia, on April 20-21, 2006, shows promise and merits further support and testing. The unit can be stored in portable 48-unit caches kept within 50 feet of miners on working sections, and has a comfortable half-face mask, rather than a mouthpiece, with a

voice transmitter that allows communication while breathing. This represents an obvious advance that is worthy of further support.

While there is a clear need to push ahead with development and testing of next-generation SCSRs, there has been a vacuum of leadership at the national level. This, too, must change, but West Virginia does not need to wait for that to happen. The state has ample technology-transfer resources and its congressional delegation has often been able to channel federal R&D funds to projects of demonstrable importance. No R&D project could be of greater potential value to the state's most basic industry than the development of enhanced safety technologies such as next-generation SCSRs. Without some such stimulus, it could be many years — even another generation — before a next-generation SCSR is developed, tested for performance and reliability, approved by MSHA, and purchased by coal operators.

Miners working today do not have the luxury of waiting that long for the safety protection they need now. It should be a high priority for West Virginia, working with manufacturers, to take the lead in fast-tracking R&D and deployment of the next generation of SCSRs.

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7 Why did the mine rescue effort take so long?

There is no end to the heartbreak.

Think about James Bennett, writing a message on a scrap of paper as he and eleven other miners awaited rescue behind a curtain serving as a makeshift barricade at the face of the Two Left section of the Sago Mine. It was 4:25 on Monday afternoon, January 2, and they had been trapped and waiting for help for almost exactly ten hours. The air was foul with carbon monoxide. Three minutes earlier, at 4:22 p.m., carefully noting the time, he had written: “Time is running out for us. We have not heard anything from the outside yet.” Now he started another note: “I love you...” That was as far as he got.

4:25 p.m. At that hour, mine rescue teams were still waiting outside the mine, still waiting for permission to go in. It would be another hour, in fact, before the first teams were allowed to begin exploring the mine — exploring from the portal, more than two and a half miles from where the Two Left crew waited. And it would be more than another 30 hours before rescuers reached the face of Two Left, No. 3 entry; heard the sound of a miner gasping for breath; tore back the curtain being used as a barricade; and found the trapped miners. By that time — 41 hours after the explosion — all but Randal McCloy,

Jr., had succumbed to the carbon monoxide that permeated the mine atmosphere.

For the miners’ families, and for the miners of the One Left crew who survived the blast, and for the mine superintendent and the other men who tried so courageously to go to the rescue of the Two Left crew in the first chaotic hours after the explosion — for all of them, the unending nightmare of the Sago Mine disaster swirls around one central question about the rescue effort: *Why did it have to take so long?*

There is no satisfactory answer. The best we can do in this report is to look at what happened and try to understand, without unfairly second-guessing anyone after the fact, what the thinking was in the rescue command center. At this point in time, still awaiting the outcome of MSHA’s internal investigation, we have incomplete information about exactly how those decisions were made. Based on what we know thus far, however, we need to consider why the rescue effort largely failed and what must be done to improve the odds that the next mine rescue operation will be more successful.

The explosion occurred at 6:26 a.m. on January 2. As soon as he became aware that the

Two Left crew had not been heard from and was not responding to calls from mine dispatcher Bill Chisolm, mine superintendent Jeff Toler gathered maintenance chief Dick Wilfong, safety director Al Schoonover, and assistant maintenance chief Vern Hofer and headed into the mine. They were in such haste that they did not think to bring a two-way radio or gas monitor with them. They encountered some miners not far in by the portal and told them to exit the mine. Then, pausing near a phone to check in with the dispatcher, they were heard by the escaping One Left crew, who were making their way out of the mine in the parallel escapeway entry. When a One Left crew member poked his head through a man door, hollering to make the crew's location known, Toler instructed Wilfong and Hofer to take the men out of the mine on Toler's mantrip.

The One Left foreman, Owen Jones, whose brother Jesse was on the missing Two Left crew, refused to leave the mine. Jeff Toler, whose uncle, Martin Toler, Jr., was the foreman of the Two Left crew, asked Owen Jones to stay by a mine phone while he and Schoonover advanced in by on foot. About half an hour later, around 8:00 a.m., Wilfong and Hofer returned from the surface with radios, gas monitors, self-contained self-rescuers (SCSRs), and supplies to restore blown-out ventilation. The five men then advanced further into the mine on the mantrip. At 32 block they observed a blown-out ventilation stopping between the track and the intake escapeway and hung curtain material to keep the air flowing in by past them. They continued to advance in the track, hanging more curtain as they encountered more blown-out ventilation controls between 32 block and 42 block.

At 42 block, their handheld gas monitors alerted them to the presence of carbon monoxide (CO). They knew nothing about the condition of the mine atmosphere ahead of them. Worried about triggering another methane ignition, they de-energized the mantrip, disconnecting its batteries, and then proceeded on foot in the intake air entries. As they advanced, they encountered thickening smoke and higher CO levels, and found multiple ventilation stoppings blown out. Stopping to continue hanging curtain to advance the air flow, they had to wait for the CO levels to drop before moving ahead to hang the next curtain.

As they approached the outby end of the mouth of the Two Left section, continuing to hang curtain, they realized that the CO levels were taking longer to drop, and they found themselves getting into dense, swirling smoke. Thinking that the air flow must be short-circuiting somewhere behind them, Toler asked Jones and Hofer to go outby, retrieve curtain, and look for ventilation controls in need of repair. Then he, Schoonover, and Wilfong made their way to 58 block, at the mouth of the Two Left section. They could see nothing of the section from their position near the intake escapeway: the smoke was too thick.

Somewhere in there, they knew, the Two Left miners were likely to be trapped — if they were alive. A few times the three men heard sounds, and they yelled toward the sound, hoping it was someone coming toward them. But no one called back: most likely they were hearing distant falls of pieces of roof, jarred loose by the blast.

Toler, Schoonover, and Wilfong stood there for awhile at 58 block, hesitating, trying to decide what to do next. They thought that if they tried to restore ventilation into the section, they might be feeding fuel to a fire, or creating an explosive mixture of methane and air. If they donned their SCSRs, which would give them an hour of respirable air, they might make it to somewhere near the face of the section, roughly half a mile from where they were standing, only to run out of air on the way back.

Jeff Toler wanted to go in anyway. Dick Wilfong, who had been a mine rescue team captain and was a veteran of fires and other mine emergencies, worried about the risks.

“I didn’t think we could go any further,” Wilfong later testified. “One of us would go down... I knew we was going to have to put our self-contained self-rescuers on. And we didn’t have but a couple extras with us. And there was three of us there at that time... If we all put our rescuers on and tried to go in there with no line or no ways to communicate other than hollering at each other, that we would — somebody would — maybe all of us would perish... And even if we went in there and found somebody, what was we going to do then? Say if we would have found six men or five men or four men. Then you’ve got two rescuers and you’ve got one on yourself, you know. Who do you give them to, you know, if you’ve got more people than you’ve got rescuers? What do you do in a case like that?”¹

It was an agonizing decision. At about 9:30 a.m., roughly three hours after the explosion, Jeff Toler picked up the mine phone at 58 block and reported to the dispatcher that they

were abandoning their attempt to reach the Two Left crew and were coming out — walking, because they did not want to take chances by re-energizing their mantrip. Toler, Schoonover, and Wilfong made their way back into the intake escapeway, where, further outby, Jones and Hofer were waiting for them. The five men would emerge from the mine at around 10:30 a.m.

By that time the mine had been placed under a so-called (K) order. And because there has been controversy about what that meant, and how the imposition of the (K) order influenced the subsequent mine rescue effort, we should pause here to look at that question.

As described in the synopsis of events elsewhere in this report, International Coal Group’s assistant safety director, Johnny Stemple, began trying to reach federal and state authorities at about 7:30 a.m., roughly one hour after the explosion. It was a holiday and he initially had no success, encountering nothing but unanswered phones and voicemail recordings.

At about 7:50 a.m., Stemple reached John Collins, an inspector for the West Virginia Office of Miners’ Health, Safety & Training (WVOMHST). Collins, who lives nearby in Buckhannon, arrived at the mine at about 8:15 a.m. and issued a control order, which had the effect of barring entry to the mine except for mine rescue purposes (see the synopsis of events for the text of the order). He also issued instructions to begin monitoring carbon monoxide, methane, and oxygen levels in the air-return entry at the portal. (The mine had a blowing ventilation system, meaning that the mine fan forced air into the intake entry and that it then circulated

through the mine by means of an extensive network of aircourses and ventilation controls before exiting at the return entry.)

Then, at about 8:28 a.m., Stemple got through to Jim Satterfield, an MSHA inspection supervisor, and described what he knew about the situation at the mine: a possible explosion, two crews underground, one of the crews unaccounted for, five men trying to make their way toward Two Left. Satterfield reportedly told Stemple he would contact other MSHA officials. At 8:32 a.m., he issued a 103(k) order over the phone, instructing Stemple (as Stemple recalls the conversation) that no one was to enter the mine or do any work at the mine pending the arrival of MSHA personnel and approval of a mine rescue plan.²

Section 103(k) of the Federal Mine Safety & Health Act of 1977 reads as follows:

In the event of any accident occurring in a coal or other mine, an authorized representative of the Secretary [of Labor], when present, may issue such orders as he deems appropriate to insure the safety of any person in the coal or other mine, and the operator of such mine shall obtain the approval of such representative, in consultation with appropriate State representatives, when feasible, of any plan to recover any person in such mine or to recover the coal or other mine or return affected areas of such mine to normal.

A (K) order does not actually close a mine, nor does it mean that MSHA takes total control of the mine. The thinking behind Section 103(k) is that mine management knows the mine better than anyone else and should have the primary responsibility for putting a rescue plan into operation, but that MSHA and state mine safety agencies such as WVOMHST have a statutory responsibility to

ensure that the operator's plan is sound — and therefore, for the protection of miners, must have the authority to approve, disapprove, or require modifications of the plan. In theory, the imposition of a (K) order creates an orderly mechanism for shared decision-making — a way to expedite a well-planned mine rescue operation while sharing responsibility for managing the risks involved. Over the years it has often worked well.

In the aftermath of the Sago Mine disaster, however, there have been lingering concerns about how the (K) order was implemented and whether it had the effect of impeding the rescue operation. Satterfield was not physically present when he issued the order, as the Act requires. Pending completion of MSHA's internal investigation, it is not clear whether he was fully informed of conditions at the mine, including the fact that Toler's initial rescue effort had gotten to within less than 3,000 feet of where the trapped Two Left miners were thought to be — and that the rescuers had been able to proceed to that point barefaced (that is, without having to use their SCSRs), an indication that much of the mine atmosphere had not been severely impacted by the explosion and that the ventilating system was largely functional and could be quickly and easily repaired, at least as far as 58 block.

This has given rise to the view, widely held among the victims' families and by some of the other Sago miners, that MSHA, by issuing a (K) order, put the brakes on what otherwise might have become an aggressive and perhaps successful rescue mission — and one that could have saved precious hours by starting in the vicinity of 58 block rather than at the portal.

Given the long duration of the Sago Mine rescue operation and its outcome, this view is totally understandable. But there are several problems with it.

First, the imposition of a (K) order does not absolve anyone on the scene — MSHA, WVOMHST, or ICG — from responsibility for developing, agreeing upon, and implementing the most aggressive rescue operation that is deemed feasible under the circumstances.

Second, it is clear that the ICG personnel who went underground in hopes of finding the Two Left crew made their painful decision to withdraw based in part on their concern about triggering a second methane ignition and in part because neither they nor anyone else at the Sago Mine were equipped to explore the potentially lethal mine atmosphere inby 58 block.

ICG had no one on-site who was trained and properly equipped for such a mission. Although members of the One Left crew courageously volunteered to go back underground later that morning to search for the Two Left crew, a strong case can be made that it would have been criminally irresponsible to send them into a toxic, smoke-filled mine atmosphere equipped only with their SCSRs, unable to communicate to the surface from inby 58 block (because the mine phones inby had been knocked out by the explosion and their two-way radios had limited range), facing the possibility of encountering a fire and running the risk of triggering a second methane ignition.

Third, the evidence available to us thus far suggests that at no time during the rescue operation did ICG go to MSHA and

WVOMHST with a firm plan for a more aggressive rescue strategy than the one that appears to have evolved by some sort of consensus among those in the command center. Had ICG done so, and had MSHA and WVOMHST refused to consider such a plan, there might be more of a basis for criticism than now exists. While it may be reasonable to question whether the rescue strategy adopted by the command center was over-cautious, it is not correct to state that the imposition of the (K) order in and of itself thwarted the rescue effort, either at 8:32 a.m., when Satterfield imposed the order, or thereafter.

Like many mining companies, ICG had no trained mine rescue teams of its own at any of its operations in West Virginia, Kentucky, and Maryland. The nearest ICG team was at its Viper mine in Williamsville, Illinois, more than 600 miles away. Federal regulations in effect on January 2 required every mine to be provided emergency services by mine rescue teams located not more than two hours from the portal. For the Sago Mine, ICG had a contract with the Barbour County Mine Rescue Team, a volunteer association serving numerous mines in the area.

Stemple tried to phone the Barbour County team at about 8:00 a.m., only to discover, according to his subsequent testimony, that the team's 24-hour answering machine had been switched off.³ About 15 minutes later he succeeded in reaching one of the members of the team, who then notified the team's trainer, who called the others. After assembling their gear, the first of two Barbour County teams arrived between 10:40 and 11:00 a.m. (recollections and logs differ about the exact time), well over two hours after first being notified

and more than four hours after the explosion. About an hour later, around noon, the first team reported that it was ready to go into the mine. But mine rescue protocol requires having a backup team available, and the second Barbour County team did not arrive until about 12:30 p.m.

Meanwhile, MSHA and state inspectors, assisted by some of the Sago miners, had been taking gas readings at the return entry. The first readings, taken at around 8:30 a.m., were not highly elevated: carbon monoxide was recorded at 500 parts per million (ppm) and methane was measured at 1.1 percent of the mine atmosphere, well below the explosive range of 5 to 15 percent.

Toward noon, however, carbon monoxide levels at the portal suddenly spiked upward to 2,300 ppm, a development that increased concerns about the possibility of a fire in the mine. The spike also created confusion in the mine offices, where a rescue command center had just been set up, because the CO was making its way from the mine pit into the mine buildings. An MSHA inspector ordered the buildings evacuated. Some of the miners' family members had gathered at the mine offices, and they were escorted off the property (to the Sago Baptist Church, a few hundred yards away, where many of them would remain for most of the next two days). Then, as the evacuation proceeded, CO levels dropped and the command center was

EFFECT OF CARBON MONOXIDE POISONING AND COGNITION

Carbon monoxide (CO) poisoning and its relationship to adverse neurological symptoms is well established in the medical literature, and has been understood for decades by the public health and safety community. When a person is overexposed to CO, their carboxyhemoglobin (COHb) level rises. The higher the CO level, the more severe the neurological symptoms will be, including headache, dizziness, weakness, nausea, vomiting, confusion, disorientation, and visual disturbances.¹ This impairment to the neurological system can compromise a person's judgment, and make it difficult process information and make critical decisions. Because the brain is quite sensitive to the effects of CO,² these symptoms can emerge quite rapidly after exposure, especially at high levels occurring after a coal mine explosion when air flow is disrupted. It is reasonable to suspect that the miners trapped in the Sago mine had some degree of CO-induced neurological impairment which may have affected their judgment with respect to successfully finding an escape routes.^{3, 4} — Robert A. C. Cohen, MD

¹ Raub JA, Mathieu-Nolf M, Hampson NB, Thom SR. Carbon monoxide poisoning: a public health perspective. *Toxicology*. 2000; 145: 1-4.

² Kao LW, Nanagas KA. Carbon Monoxide Poisoning. *Med Clin N Am*. 2005; 89: 1161-1194.

³ Henz S, Maeder M. Prospective study of accidental carbon monoxide poisoning in 38 Swiss soldiers. *Swiss Med Wkly*. 2005; 135: 398-406.

⁴ Cohen RAC. Letter to J. Davitt McAteer, July 2006. Available at: www.wju.edu/sago/def.asp

reoccupied — only to be temporarily vacated again when the CO rose again, briefly, a few minutes later.

By 1:00 p.m., CO levels at the mine mouth were back down to 500 ppm, and methane was measured at 1.1 percent. But the command center considered the situation too volatile to let the Barbour County mine rescue team go in. Even after a more experienced team from Consol Energy's Robinson Run Mine arrived on site at around 1:45 p.m., the prevailing view in the command center seems to have been that there was a strong possibility of fire somewhere in the mine, and that to send any mine rescue teams in without knowing more about constituent trends — that is, what was happening over time to the mix of carbon monoxide, methane, other gases and oxygen in the mine atmosphere — would be irresponsible.

“We have a rich history of secondary explosions,” Ray McKinney, MSHA's Administrator for Coal Mine Safety and Health, often points out, and he is right. One of the examples that still haunts veteran mine rescue coordinators is the Scotia Mine in Letcher County, Kentucky, where an explosion on March 9, 1976, killed 15 miners — nine instantly, and six from carbon monoxide asphyxiation while awaiting rescue. Rescue teams recovered all of the victims within about 18 hours. Then, on March 11, while the roof was being rebolted to facilitate further exploration of the mine, a second and even more violent explosion occurred, killing 10 miners and three federal inspectors. Rescue teams had to be withdrawn because of the fear of still another ignition, and the mine was sealed. The victims of the second blast could

not be recovered until the mine was reopened about a year later.

A more recent disaster served to underscore McKinney's concern. On September 23, 2001, an explosion at the Jim Walter Resources No. 5 Mine in Brookwood, Alabama, injured four miners, including one who was too gravely hurt to move. The other three injured miners went to get help. The explosion had impaired the mine's ventilation system and methane was rapidly accumulating, but 12 miners bravely tried to rush to the aid of the injured miner. Fifty-five minutes after the first explosion, a second and more violent one occurred, killing 13 miners — the miner who had been injured in the first blast and those who had tried to come to his rescue (one of whom survived the second blast but later died of burns).

Because of nightmare scenarios such as Scotia and Brookwood (and there have been others), McKinney and other senior MSHA officials are understandably reluctant to send mine rescue teams into harm's way without knowing as much as possible about the conditions they are likely to encounter. And on the afternoon of January 2, MSHA was at a double disadvantage on that score.

MSHA owns two gas chromatographs — sophisticated instruments capable of measuring and analyzing multiple gases, including those most indicative of the presence of a fire. One is kept in Denver and the other in Pittsburgh. Hampered by the holiday, MSHA was slow in making arrangements to bring its Pittsburgh chromatograph to Upshur County, and it did not arrive at the mine until around 5:00 p.m., about two hours after a chromatograph owned by Consol arrived.⁴

Meanwhile MSHA was hindered in its ability to interpret the gas readings at the mine portal not just by the absence of a chromatograph but also because one of the agency's key people, the man probably most able to interpret gas chromatograph readings with assurance, was not at the mine — although through no fault of his own.

John Urosek, chief of the ventilation division of MSHA's technical support group, was in Colorado on January 2, monitoring a mine fire that had been burning for weeks (fortunately without loss of life) in an Arch Coal mine. After learning of the situation at Sago, he was in the process of trying to obtain an airline ticket when Tim Martin, ICG's corporate safety director, happened to call Arch Coal, hoping to track down a firefighting consultant, Ian Houlison. When Martin learned that both Houlison and Urosek were at the Colorado mine, he chartered a private plane to bring them both to Buckhannon. But it was close to 8:00 p.m. on January 2 — nearly 12 hours after the explosion — before a state police escort delivered them from the Clarksburg airport to the mine site. It was only after that point that Urosek could begin contributing his interpretive expertise to the mine rescue planning process.

Meanwhile, in late afternoon, Consol's chromatograph had begun augmenting the readings from handheld gas monitors. At 5:25 p.m., with CO readings at the portal declining, Consol's Robinson Run mine rescue team was finally authorized by the command center to enter the mine, through the fan housing, with instructions to explore the first 1,000 feet in by the portal. Mine rescue teams had been arriving at Sago throughout the afternoon, and the command center's first

plan had called for one of them, Tri-State, to make the initial exploration. But the Robinson Run team was given the task because Consol's mine rescue teams were the most experienced at the site.

At about the same time, a bulldozer went to work at the surface, building a rough road to permit drilling equipment to be moved to a site directly over Two Left. The command center's plan was to put a borehole down to assess the mine atmosphere in the area where the miners seemed most likely to be trapped if they had survived the initial blast.

Both projects — exploration of the mine and construction of the borehole — proceeded slowly as the evening wore on. On the surface, there were delays while surveyors using high-grade Global Positioning System receivers tried to determine precisely where to site the drill rig. Because of unfavorable weather conditions they were having trouble getting accurate readings from orbiting GPS satellites. Exploration underground, meanwhile, was slowed by the command center's instructions to the mine rescue teams to work systematically back and forth across the multiple entries of the mine as they advanced, taking multiple gas readings and thoroughly checking conditions before proceeding further.

That cautious and deliberate approach seems to have been intended primarily to ensure that the rescuers would not inadvertently proceed past a possible ignition source, and it made sense in the context of MSHA's fear of secondary ignitions. There is little doubt that the "rich history" was much on the minds of the MSHA officials in the command center, some of whom had been involved in the agency's investigation of the Brookwood

disaster. No one had to tell them to worry about the safety of the mine rescue teams exploring the Sago Mine.

On the other hand, there had to have been some concerns that the operation was proceeding too slowly. Everyone involved in mine rescue knows that time is the enemy when coal miners are missing after an explosion or in a fire. With every passing hour, the odds of finding anyone alive rapidly diminished. The command center must have been acutely aware of that, just as the mine rescue team members certainly were.

The dilemma, to be understood, must be seen as something like war. It is a maxim that generals tend to want to fight the last war, rather than the one in front of them, because the last war is the one they know. So they may be reluctant to try new strategies, even when the situation calls for fresh thinking. Mine emergencies pose a similar kind of challenge. Senior MSHA officials know all about Scotia, Brookwood, and other cases where things have gone terribly wrong. That awareness is drilled into their training and inevitably colors their thinking. Nobody wants to be remembered for having lost a mine rescue team. But history teaches some harsh lessons. Lincoln had to replace his cautious generals with men like Grant and Sherman, who are remembered today not for the losses they took but for getting the job done. The last-war analogy should not be pushed too far, but it should not be ignored.

As Mark Chewning, one of the captains of the Barbour County Mine Rescue Team, later told investigators: “You know, I’ve been doing this for, I think, 21 years now, and they should let the mine rescue people have a little more

leeway in what to do and what not to do... I mean, since we’re the ones being trained to do this, we should have a say in it somewhere — you know, say ‘Hey, you know, we’ll try it.’ We know the danger to begin with or we wouldn’t be in it... Like, these 12 guys in there — if we was willing to take the chance, to go try, I think we should have had the option to go try, if we sign a waiver or however you want to do it.”⁵

That view did not prevail in the command center. One result was that problems, as they arose, tended to have the effect of slowing the rescue operation or stopping it cold. For example, when water was encountered in the return entry, considerable time was spent restoring power to a pump, starting it, and waiting to let rescuers advance until the pump brought the water level down. Similarly, when rescuers spotted a red light near 34 block, and determined that it was a CO monitoring station that should have been de-energized when power was cut to the mine after the explosion, all of the rescue teams were pulled out of the mine while the problem (a battery backup power source that had to be disabled from the dispatcher’s computer) was dealt with. While actions such as these were definitely prudent, they also added time to the rescue operation when time was already at a premium.

On the surface, meanwhile, the drilling of the borehole got under way at about 2:45 a.m. on January 3, approximately 20 hours after the explosion. The command center, after pulling the rescue teams out of the mine, decided to keep them outside until the borehole had punched through into the Two Left section, because of concern that the drill might ignite methane. The drill punched through at about

5:30 a.m. Work stopped and the drilling equipment was shut down a few minutes later in order to listen for sounds from the mine. There were none. The drill steel was then struck in the hope that someone in the mine would hear the sound and send a signal back to the surface. No signal came. At about 6:30 a.m., while a video camera was being lowered into the borehole, rescue teams were sent back underground. The camera showed no signs of physical damage from an explosion, but it also showed no signs of the Two Left crew.

More than 24 hours had now passed since the explosion. The story of the second day is essentially one of continuing slow movement, punctuated by setbacks. For example, MSHA had brought a robot to the mine, and sent it in at around 7:30 a.m. on January 3 with the hope that it could accelerate the rescue operation by monitoring the mine atmosphere ahead of the teams. The robot was also equipped with a camera, and theoretically could travel up to 4,000 feet by remote control — meaning that it would be able to reach the mouth of the Two Left section from its starting point at 31 block. Instead, the robot functioned for only about an hour before getting stuck and becoming disabled on a muddy and uneven patch of the mine floor, where it stayed for the duration of the rescue and recovery operation.

Frustration — with the robot, with the pace of the rescue — seems to have been building in and around the command center. Later, ICG corporate safety director Tim Martin described it to investigators: “There was some high emotion there, obviously, that we have... 13 men unaccounted for and we need to get to those folks... [yet] they were actually using

a method almost like a mine rescue contest to tunnel across and back and just being extremely methodical about exploring and measuring the constituents.”⁶

According to Martin, who was near but not in the command center, he huddled with MSHA’s John Urosek and firefighting consultant Ian Houlison to talk about accelerating the mine exploration. They agreed, Martin said, that it would be feasible to advance more quickly by limiting readings to fewer entries closer to the intake. They discussed who should present this idea to the command center, and agreed that Urosek should do it, Martin recalled: “And it took about ten minutes but they finally accepted the idea, and that’s when the teams kind of picked up pace and started moving.”⁷

At about 2:00 p.m., rescue teams reached the mouth of the One Left section. At the command center, meanwhile, a decision was made to bypass exploration of One Left, other than the openings at the mouth of the section, since it was reasonably certain that there was no one there (the One Left crew had come out, and the assumption was that fireboss Terry Helms had left the section, on his way to Two Left, before the explosion occurred, because it was known that his lunch bucket had been left for him at the Two Left switch). About 15 minutes later, at 50 block, the teams found the One Left mantrip where the crew had abandoned it, with its headlights still on.

At about 4:20 p.m., the command center decided to have the rescue teams move their fresh air base up to 57 block. While some of the team members were hanging curtain out by the base site, to direct the air flow over it, others explored the entries between 57 and

58 block. At about 5:15 p.m., MSHA rescue team member Ron Hixson, working his way forward alone in the track entry on his way to join a Consol team as a backup man, came upon the soot-covered body of Terry Helms, lying across a rail near the coal rib. (A subsequent examination indicated that Mr. Helms had probably died instantly, after being caught in the direct path of the explosion.)

Shortly after 5:45 p.m., with the new fresh air base established, rescuers advanced toward the sealed area to check the mine atmosphere there. Not knowing that the seals had been almost completely destroyed, they actually walked through the pulverized rubble without realizing they had done so until they reported their location — and some very high CO readings — to the command center. They then retreated, working their way across the entire set of seals and confirming that the seals had been blown out by an explosion originating in the sealed area.

At this point — some 35 hours after the explosion — the command center finally had a clear sense of what had happened on the morning of January 2. Until this point, or at least until the borehole camera revealed the absence of damage on the Two Left section, there had been lingering speculation that the explosion might have originated near the face of the section, perhaps triggered by the Two Left crew, arriving and energizing equipment in the presence of an explosive methane-air mix that they had not detected. Now, with the realization that the crew most likely had not been killed outright by the explosion, there was a heightened sense of urgency about finding them.

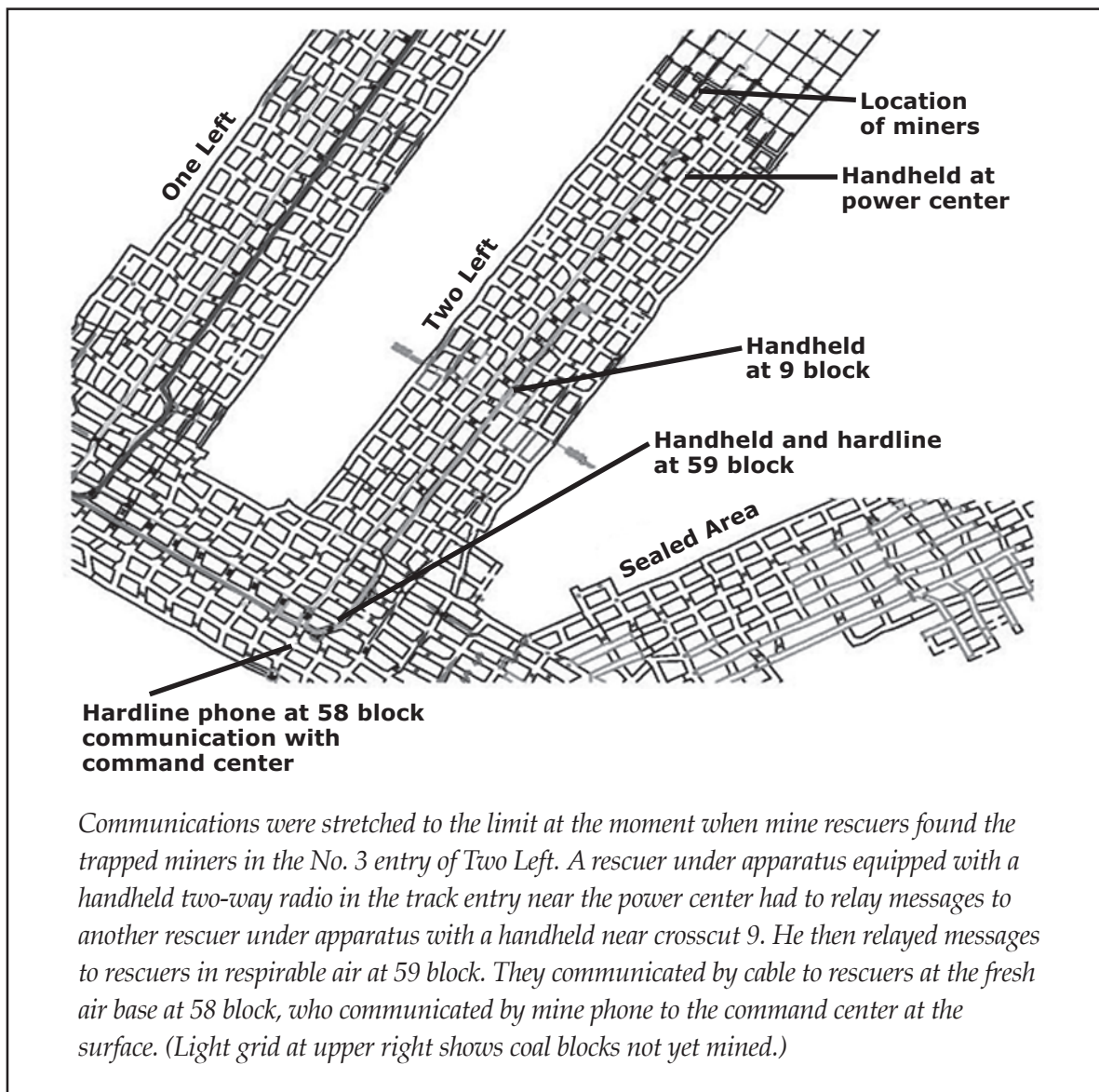
Advancing into the Two Left section, rescue teams found all of the ventilation controls in the primary escapeway damaged from the mouth of the section to crosscut 12, more than a third of the way toward the face. Then, at around 7:30 p.m., rescuers spotted the Two Left mantrip in the track entry at crosscut 10. Searching the area, rescuers found no one but reported to the command center that it appeared as though the crew had tried to use the mantrip to escape and had been forced to abandon the vehicle after encountering debris from the explosion across the tracks. Rescue team members found footprints in the intake escapeway, indicating that the Two Left crew had walked there from the abandoned mantrip, but the footprints disappeared — possibly lost in the mud and water — so there was no indication of how far the crew might have gone before turning back. (The command center was also concerned about the possibility that they had not turned back — that they had gotten disoriented in the smoke and stumbled past the destroyed seals into the abandoned area — but the rescue teams reported having seen no footprints there.)

Just after 8:00 p.m., rescuers exploring the intake escapeway found the top and bottom covers of 12 SCSRs at crosscut 11. That in itself did not indicate where the men were, but logic suggested that if they had been unable to make their way out of the mine in the mantrip, they most likely would have retreated in the other direction, toward the face. But it was also possible that they could have barricaded themselves somewhere else in the nearly half-mile-long section. The rescue teams, switching out according to protocol so that no team would become exhausted, needed nearly three hours to explore the entries from the mouth of the section to crosscut 15, just over halfway to the face.

At some point between 11:00 and 11:30 p.m. (the exact time is not shown in the command center's logs), the rescue teams were given permission to break with protocol and make a push to the face of the section. Normal mine rescue protocol would have required them to advance no more than 1,000 feet before establishing another fresh air base and hanging curtain to direct air to the new base. That process could have added another two hours or more to the exploration of Two Left. As Ron Hixson later testified: "Yes, we were

going to go further than 1,000 feet. The air quality was bad, but it wasn't a situation where you would die or anything if your apparatus failed or if you had a major problem. We felt the risk was worth taking and we had the radios to communicate back and forth, and we went for the face."⁸

But to push straight for the face meant that communication would be difficult. The mine phone system could be used to communicate between the command center and the fresh



air base at 58 block. Moving inby from the fresh air base, a couple of hundred feet into the neck of the Two Left section, rescuers equipped with a cable reel strung a cable that allowed them to stay in touch via headset with the rescuers manning the fresh air base. Because all of these mine rescue team members were working in respirable air, they were not wearing breathing apparatus, and so their hardline communications were reasonably clear and reliable.

But further into the section, where the CO levels were elevated, rescuers had to be under apparatus, communicating to each other through voice diaphragms in their face masks. Some also had handheld two-way radios, which when fully charged had an effective range of about 500 feet — as long as they were in direct line-of-sight with each other. That was feasible if two men stayed within 500 feet of each other in the same entry, but if one of the men was moving back and forth between entries, the other man was unlikely to be able to hear him clearly, if at all.

To help deal with the problem of stretched-out communications, one of the rescuers equipped with a two-way radio stayed in the track entry at crosscut 9, roaming a few yards inby or outby as necessary to pick up transmissions. He was theoretically able to relay messages from inby to the rescuers at the cable reel, who could then relay them by cable to the rescuers at the fresh air base, who could then relay them by mine phone to the command center. But this four-step communication linkup was inherently fragile, as would soon be demonstrated.

The push to the face was led by a team from Consol's McElroy Mine, accompanied by one

federal and one state inspector — MSHA's Ron Hixson and WVOMHST's Bill Tucker. The rescuers were grateful for the order to break with protocol. (As McElroy team captain Jimmy Klug said later: "By the way, whoever made that decision was a good person to do that.") They advanced rapidly in the track entry, knowing that the odds of finding anyone alive after so many hours were very slim — but carrying a dozen extra SCSRs with them, just in case.

At about 11:40 p.m., they reached the face, and split off, with Klug and Tucker exploring the entries to the left, Hixson and McElroy team members Mike Clark and Jim Smith exploring to the right. Making their way into the last open crosscut just outby the No. 3 entry, Klug and Tucker suddenly heard a deep gasping sound at about the same moment that they caught sight of a curtain hung diagonally across the entry.

As Klug pushed past the curtain, the beam of his cap lamp showed him that he had found the missing miners. Some were sitting against the coal rib. Some were lying down. All were silent and motionless, except for the miner who was the furthest inby, closest to the face. Klug heard him gasp again and ran straight to him.

The miner was in a sitting position. Another miner sitting next to him, a bigger man, had toppled across him. Klug struggled to pull the gasping miner free. Bill Tucker, hurrying into the entry just a step or two behind Klug, turned back into the crosscut momentarily to yell for help.

As Tucker later testified to investigators: "I was screaming, 'We need help! We need help!'

And I mean, when you first looked in, in my mind at that point, you know, I thought that most of them were dead. But I was hollering back for help and I said, 'They're over here! They're over here and they're alive!'"¹⁰

No one should ever blame Bill Tucker for miscommunicating the situation. At least one miner *was* alive, and in the instant of discovery there had not been time yet to check all of the others. However, as Hixson, Smith, and Clark responded to Tucker's call and rushed into the entry, it became obvious to them that the other miners were not alive. Klug later testified: "We all knew. I mean, I don't want to — we knew."¹¹

But they checked anyway. While Klug and some of the others moved the gasping miner onto his back, fearful that he was about to expire and hollering at him in a desperate effort to bring him back to consciousness, rescuers went from miner to miner, shaking them, calling out to them, feeling for pulses. The other miners were gone, all of them. For the rescuers there was absolutely no doubt about it.¹²

But that was not the message that made its way through the four strained links of the communication chain to the command center. It is still not clear how the word reached the rescuer with the two-way radio in the track entry at crosscut 9, but what he remembers is that someone transmitted from the face area: "We need help, we've found them, we found all the men, we need help... We need medical help. We've got two people we've got down, we've got to have stretchers, we need help."¹³

Hixson remembers how the confusion arose about a possible second survivor. As more

rescuers rushed forward to the face, responding to the first call for help, they too checked the lifeless miners, shaking them and calling out to them. One of the rescuers pulled one of the victims away from the rib, and when he did, as Hixson recalls, "I think it was just air trapped in his lungs, but he let out a load moan, and we thought we had a second man alive."¹⁴ It was only a matter of moments before the rescuers realized their error, but the message went back before they could cancel it.

Chris Lilly, captain of the Tri-State Mine Rescue Team, was at the fresh air base, communicating with the command center via the hardline mine phone, when word came from the next inby link of the communication chain — the rescuer at the cable reel, who in turn was relaying messages from the rescuer with the two-way radio at crosscut 9. Lilly remembers the message: "It may have been, 'We need supplies, oxygen, stretchers, 12 alive.' Or it was 'Twelve alive, we need oxygen and stretchers.' ... It was either supplies first or what they found first."¹⁵ Whichever it was, Lilly remembers asking for confirmation: "They confirmed it. And then we reported it outside to the control center."¹⁶

(Memories conflict on the question of confirmation. MSHA rescuer Frank Thomas was also at the fresh air base when the message came from the rescuer at the cable reel. He later testified: "The guy on the hard line [cable], the words came out of his mouth, 'Twelve alive.' The guy on the mine phone called out [to the command center], 'Twelve alive.' Nothing was confirmed before he called outside."¹⁷)

Although the situation at the face was chaotic, the evidence suggests that very little time elapsed before the rescuers got on their radios again to report what they all quickly understood — that there was just one survivor. Hixson, realizing they were going to need more people to help carry the survivor, got on his radio and called out: “Hey, we have all 12 guys accounted for. We have one alive, and we need help, and we need help now.”¹⁸

The rescuer with the relay radio at crosscut 9, running back and forth as he tried to maintain reception from inby, heard that message. In order to transmit it, he had to run a few yards outby in the entry. He remembers transmitting: “They’ve only got one person alive.”¹⁹ Ordinarily he would have waited for a response, but this time he didn’t — because he saw lights coming, realized it was the rescuers carrying the survivor, and “I just ran up to meet them, to help any way I could help.”²⁰

They needed help. Carrying anyone on a stretcher in a coal mine, stumbling over terrain illuminated only by cap lamps, is tough work. Carrying the sole survivor of the disaster was made even tougher by the fact that he was unconscious, perilously close to death, and in desperate need of oxygen. And the stretcher-bearers had to make their way through the rubble from the explosion in addition to stumbling through mud and water that was sometimes up to their knees.

In the entry, upon finding the survivor, Klug had broken open an SCSR and forced the mouthpiece between the survivor’s lips, but it was hard to keep the mouthpiece in place and even harder to get him to breathe through it. And once the survivor was on a stretcher and

being carried back toward the fresh air base, making the SCSR work for him became a major challenge. It meant running alongside the stretcher, holding the mouthpiece in the survivor’s mouth, holding the SCSR alongside him, peering at him constantly to see if he was breathing, avoiding falling toward him or away from him, and trying not to go faster or slower than the stretcher bearers — who were still under apparatus, their face masks fogging over with sweat, tiring rapidly as they stumbled and slipped. It was a nightmarish carry. If a man felt about to collapse, he would yell out and another rescuer would slide in to take his place, taking care not to let the stretcher drop, struggling to maintain the pace.

It was at about 12:15 that the rescuers bearing Randal McCloy, Jr. — they didn’t know his identity yet — reached fresh air at the neck of the Two Left section. By that point they had used three SCSRs in order to keep giving him the initial oxygen shot supplied by the small bottle within each CSE SR-100.²¹ Now, with the rescuers able to proceed barefaced in respirable air, they borrowed a rescuer’s Draeger BG-4 breathing apparatus and fitted it to McCloy’s face. The BG-4 is a positive pressure device, meaning that it supplies oxygen whether the user works at breathing or not. Soon the rescuers noticed that McCloy seemed to be breathing better — not normally by any means, but no longer taking a breath only every five seconds or so. Encouraged, they managed to keep moving rapidly as they carried him back to a mantrip at the mouth of the One Left section, and then, in the mantrip, headed out of the mine.

On their way out, they encountered an unexpected sight, coming toward them —

a motor pulling a supply car crowded with people. There was confusion as the rescuers hollered to clear the track so they could keep going with the survivor.²² The incoming miners — including mine superintendent Jeff Toler — wanted to know where the other survivors were. As Frank Thomas remembers the moment: “Someone gets out of the mantrip that was coming in and asked, ‘Where’s the rest of them?’ And in our bunch: ‘The rest of who?’ ‘The rest of the men, the other miners.’ ‘They’re all dead.’ Complete silence.”²³

The confusion had ramped up at 11:45, when the command center got the message from the fresh air base that all 12 miners were alive. Ty Coleman, International Coal Group’s safety manager for West Virginia and Maryland, was ICG’s man in charge in the command center throughout the rescue operation. As he later testified: “I was just basically listening to the mine phone and it came over the [speaker] phone... ‘We found 12 alive.’ And this was late in the hour. And I thought, you know, maybe I didn’t hear right. And the room got loud and I [can’t] remember who was next to me, and I said, ‘What did he say? Did you hear what I [heard]?’ He said, ‘Yeah, 12 alive.’...It was absolutely euphoric, the feeling there... But unfortunately I said, ‘You know, we got to confirm, you know, let’s clarify it.’ And the room erupted, but we were still doing business. And I had never seen so many old hairy guys cry in my life.”²⁴

There have been many accounts of the room erupting in celebration. And after all those anxious hours, it was only natural to celebrate. There is no evidence, however, that Coleman or anyone else in the room thought to request confirmation, despite their aware-

ness of the tenuous communication chain inside the mine and what has to have been their acute awareness of the odds against all of the miners surviving in bad air for such a long time. They did not follow basic emergency protocol requiring verification of all communications. Instead, reports of the miraculous discovery — “twelve alive!” — almost instantly reached the miners’ families waiting at the Sago Baptist Church.

Worse yet, it appears that one or more ICG employees may have taken it upon themselves to provide details to the families that simply could not have originated with the rescuers underground. For example, several family members vividly remember a company official telling them that as soon as the miners emerged from the mine they were going to come over to the church before going to get medical treatment.²⁵

That struck some of the family members as wildly implausible. As Amber Helms, daughter of Terry Helms, said: “Any man who is trapped underground for that long a time is not going to have a choice of whether they want to walk to a church. They’re going to be put in an ambulance and they’re going to take them immediately [to a hospital].”²⁶ But whatever doubts the families may have had were pushed aside by the apparent certainty of the reports from the mine and the sheer joy of hearing that their loved ones were alive.

No one cautioned them to wait for verification or further bulletins. Moreover, it appears that no one from MSHA or WVOMHST briefed the families at any time during the entire rescue operation — an appalling failure.

Meanwhile, at the command center, preparations got under way to send medical supplies into the mine and to summon ambulances to take the miners to the hospital. It was not until almost three-quarters of an hour later, at 12:25 a.m., that clarification came — to the command center, not the families — and even then the command center failed to understand at first.

When the rescuers carrying Randal McCloy reached the neck of the Two Left section, near their fresh air base, they had been met by other rescuers hurrying in by on the assumption that all 12 miners were alive. Realizing that the original miscommunication had taken on a life of its own, Jimmy Klug went to the mine phone at the fresh air base and called outside to the command center.

Earlier, before going underground, Klug and some of the other rescuers had been told to use a code to communicate with the command center in the event that they found anyone, because some of the people in the command center had become concerned that the news media were somehow eavesdropping on their communications. The code for “body” was “item,” and each of the missing miners was to be identified by a number. The rescuers had used the code when they found Terry Helms, reporting to the command center that they had found one “item” in the track entry. Now Klug used the code again, after realizing that the command center apparently did not know that all but one of the miners were dead. He recalls saying over the mine phone: “We have 11 items.”²⁷

The message didn’t seem to sink in, according to Tim Martin, ICG’s corporate safety director, who heard what Klug was saying. Martin had

had a role in coming up with the code. He remembers that the command center at that moment was “kind of full and the emotions were very high that they thought they had 12 miners alive. The word came across from [Klug] on the phone that ‘We have one on a stretcher and 11 items.’ And it just hit me like a ton of bricks that I knew what that meant. And I kind of stepped back for a minute — I just, you know, was in shock. But then I could see the rest of the room didn’t understand.”²⁸

Klug, as captain of a Consol team, was speaking with a Consol safety director, Rick Marlow. Martin remembers saying to Marlow and the others in the command center: “I think we got bad news here... You need to confirm that. And they argued with me for a short period of time that, ‘No, no, no... we got 12 people coming out’ ... And I had to kind of raise my voice pretty loud to get them to listen to me. I said, ‘Listen, he... just said we got 11 items.’ I said, ‘Have him repeat what we have as far as survivors.’ ... And the answer came back, ‘We have one on a stretcher and 11 items.’ And they turned to me and said, ‘See, we’re okay,’ or something to that effect. I said, ‘Listen, are you all forgetting about the code?’ I said, ‘Tell them to drop the code and just tell us what they’ve got as far as survivors.’ So they called back in and said, ‘Do you have 11 survivors and one on a stretcher?’ And they said, ‘No, it’s the other way around.’”²⁹

That message staggered the command center. Klug recalls Marlow telling him: “‘Forget the code. What do you mean?’ I said, ‘There’s 11 deceased people.’ And he just — he was speechless.”³⁰ Klug remembers that Marlow then told him: “Just bring everybody outside, we’re going to regroup and go back in.”³¹

The rest of the night's tragedy can be quickly told, in part because it dominated the next day's news stories and in part because it does not directly bear on this narrative of the mine rescue operation, which in reality came to an end at 11:45 on Tuesday night, January 3, with the discovery of the trapped miners and the realization that all but one were deceased.

Randal McCloy's rescuers brought him out of the mine at about 1:00 a.m. on Wednesday morning, January 4, after being briefly delayed when they encountered the incoming personnel, including a doctor — who, since they had no communication with the command center, were still under the impression, up to that moment, that they would be finding 12 miners alive. Mr. McCloy's removal from the mine marked the conclusion of the rescue effort — approximately 41 hours and 15 minutes after the Two Left miners first found themselves trapped by the smoke and debris from the explosion in the sealed area of the mine.

There are three lingering questions about the rescue operation that must be addressed:

- Why did the command center, after learning about the miscommunication from within the mine, take so long to communicate the truth to the miners' waiting families?
- Why did the command center have so much difficulty determining the facts in the first place?
- And, finally, what can be done to improve the odds that the next mine rescue operation — always a race against time — will not require nearly two full days to complete?

As previously noted, it was at about 12:30 a.m. on Wednesday when McElroy team captain Jimmy Klug succeeded in communicating to the command center that the rescuers were bringing out just one survivor on a stretcher and that the rest of the Two Left miners had died. The command center's response to that was to order everyone out of the mine — even though the mine rescue team from ICG's Viper Mine was underground at the time, assisting in the removal of Randal McCloy. Several members of the Viper team were certified emergency medical technicians (EMTs), fully capable of reassessing the condition of the other Two Left miners. But they were ordered out of the mine along with everyone else.³²

ICG president and CEO Bennett Hatfield, who was in the command center at the time, subsequently testified that the command center was informed that there "appeared" to be only one survivor and the other miners "appeared" to be deceased³³ — a statement not supported by the testimony of Klug and other rescuers, who do not appear to have had, or communicated, any ambivalence about the status of the miners. Nevertheless, Hatfield also testified: "The immediate reaction in the command center was that this report of only one survivor may be erroneous. Many participants in the command center clung to the fervent hope that the other 11 miners may be in some sort of comatose state."³⁴ If indeed they were clinging to such a hope, it is all the more difficult to understand why they ordered everybody out of the mine rather than immediately sending a team back to the face of Two Left.

The command center seems to have been in a state of general confusion at that point —

understandable given the level of fatigue and roiled emotions that everyone there must have been struggling with, but it continued to experience problems. For example, when rescuers brought the survivor to the surface at about 1:00 a.m., no one managed to determine his identity before sending him in an ambulance to St. Joseph Hospital in Buckhannon. It was not until more than an hour later that the command center learned which miner had survived, and in the meantime there was no information that could be transmitted to the families about his identity.

ICG's Viper team, exiting the mine with the other rescuers shortly after 1:00 a.m. on Wednesday, January 4, walked up from the pit to the command center. Team captain Pete Bryant later testified that no one debriefed them about what they and the other rescuers had seen in the mine.³⁵ However, when they encountered ICG corporate safety director Tim Martin, he told them, according to Bryant, to "get back in there and see if there were any folks still alive."³⁶ Someone then supplied the team with five stethoscopes and some first aid equipment, and they headed back into the mine — perhaps 20 minutes after exiting it, as Bryant recalls.³⁷

There is some confusion on that point. According to MSHA's log, all rescue personnel were out of the mine at 1:20 a.m. The log also shows that the command center, after deciding to send the Viper team back underground to reassess the condition of the Two Left miners and remove them from the mine, supplied the team with body bags as well as stethoscopes. The rescuers then re-entered the mine at 1:55 a.m, according to MSHA's log. At 2:35 a.m., they reported to the command center that they had reassessed the miners and that all were indeed deceased.³⁸

At that point — nearly three hours after rescuers had first determined, beyond any doubt in any of their minds, that only one of the miners in Two Left was alive, and more than two hours after the initial miscommunication had been cleared up — Hatfield and other ICG officials went to the Sago Baptist Church to deliver the horrific facts to the miners' families.

Hatfield subsequently testified that an attempt had been made at about 1:45 a.m. to send a message to the church that there were "conflicting reports" on survivors and that the initial reports might have been "too optimistic."³⁹ But by 1:45 a.m. there were no "conflicting reports" — none at all.

Subsequent interviews with the rescuers by federal and state investigators confirm that none of them, as they exited the mine, had any doubt whatsoever about the condition of the miners they had left behind — nor is it remotely imaginable that any of them would have been willing to leave the Two Left section if they had believed that any of the miners there were still alive. The only confusion on this point seems to have been in the command center. In any case, the message sent at 1:45 a.m., although reportedly relayed to the church by state police officers, never reached the families.⁴⁰

ICG officials have offered various explanations for the confusion in the command center, the failure to confirm information coming from underground, and the failure to hold that information within the confines of the command center. "Those of us involved in the rescue effort suffered from the same fatigue and range of emotions that everyone in the church did," Hatfield later testified.⁴¹

Ty Coleman, in charge of the rescue operation for ICG, testified that he was in the command center for the entire 40-plus hours of the rescue operation and “did not relinquish command responsibility” at any time from the morning of January 2 until the bodies of the miners were brought out of the mine on the morning of January 4.⁴²

That is a long stretch of time. Fatigue may well have played a part in the command center’s confusion, and it should be noted that — as MSHA is well aware — emergency management experts routinely caution against letting managers stay on station too long, to the point where sleeplessness and exhaustion can impair judgment and deci-

sion-making. No one should question the dedication of anyone in the command center, but if we are to learn anything from the Sago disaster it should be fair to point out that fatigue must be managed just like every other facet of an emergency.

As to the question of why the command center failed to control dissemination of the initial misinformation about finding 12 miners alive, Hatfield blamed the lapse on “cellphone communications,”⁴³ and ICG vice president Charles Snavely testified: “With all the people coming in and out of the command center, evidently people overheard this communication and reported that to the families at the church.”⁴⁴

Cellphones unquestionably played a role in the miscommunication to the families, and it should be noted that Sago was the first mine emergency to occur in this age of ubiquitous cellphones. Their omnipresence strengthens the case for ensuring that firm control of communications, preferably through pre-designated spokespersons, becomes part of any emergency management plan in the future.

On the other hand, throughout the rescue operation at Sago there appears to have been little if any control over who came and went at the command center, and little effort seems to have been made to keep critical information within its walls. At the moment when the command center heard that all 12 miners in Two Left were alive, ICG’s Tim Martin was outside, on his way back to the command center from the mine’s bathhouse, where he had been helping a mine rescue team stage its equipment in preparation for going into the mine. As he later testified, he heard “several

people” out in the open commenting on the “great news.”⁴⁵ Someone’s cellphone may have been used to get the news to the families, but that could not have happened if the news had been kept confidential until it was confirmed. The information could not have been “overheard” because no attempt was being made to guard it against *being* overheard. MSHA, the state, and the company share the responsibility for that failure.

MSHA rescuer Ron Hixson probably spoke for all of the rescuers when, while being interviewed later by federal and state investigators, he was asked if he had anything he wanted to add.

“The only thing I’d like to say is that... I know there was a lot of press and there was a lot went on with the communications,” Hixson said. “And as far as the guys underground, speaking for myself on down the line, I’m not blaming anybody... but we were in a very difficult situation. If that communications would have stayed where it was supposed to, at the command center, and not got out, none of that would have happened. And I feel as bad for those families — I mean, that was a terrible thing that they had to go through. I just think as far as mine rescue, you know, any time I’ve ever been involved in it, when we’re calling outside, that information is checked and double-checked and triple-checked before it’s ever written down, before it’s ever — you know, it’s verified. And it never had a chance to be verified this time.”⁴⁶

MSHA’s internal investigation, not yet completed as of this writing, may address some of the not yet answered questions about how the command center functioned. In the meantime, it is not our purpose here to question the

commitment of any of the individuals — federal, state, or corporate — who had the demanding and ultimately heartbreaking task of trying to organize a race against time. But there are questions, of course, about the initial delays in getting the mine rescue effort launched. And there is a larger question that will always hang over the Sago rescue operation:

Could precious time have been saved by starting the rescue at — or at least close to — 58 block, given that the mine outby that point had been at least partially explored, the air to that point was respirable, and gas measure-

ments were not showing exceptionally high or explosive elevations?

That is a hard question to answer with any certainty. Those conditions were known as of 9:30 a.m. on the morning of the explosion, when Jeff Toler, Dick Wilfong, and Al Schoonover were still at 58 block. But then, rightly apprehensive about a possible second explosion and further loss of life, they exited the mine. Once they were outside, however, no eyewitness accounts of conditions inby the portal were available to the command center. What if they had stayed at 58 block instead of exiting the mine? If they had been able to

SAGO AND ALMA

On Thursday, January 19, 2006, just 17 days after the Sago Mine disaster, a fire broke out in Massey Energy's Aracoma Alma No. 1 Mine in Melville, Logan County, West Virginia. Twenty-one miners were inside the mine when a carbon monoxide detector alongside a conveyor belt began sounding an alarm at about 5:35 p.m. Nineteen miners made it out of the mine safely. Two miners — Don Bragg and Elvis Hatfield — became separated from a crew of 10 others and did not escape.

Mine rescue teams entered the Alma mine at around 11:30 p.m., about six hours after the belt fire was discovered and while it was still burning. Rescue teams using water and foam suppressed the fire sufficiently to allow them to continue searching the mine. On Saturday, January 21, they found the bodies of the missing miners.

Today, more than six months after these tragedies, a question still haunts many of the Sago miners' families:

Why was it possible to send mine rescue teams into the Alma Mine, within just a few hours after the emergency began, and past a burning fire — when the command center at Sago had refused to let rescue teams go in for nearly 10 hours after the explosion, at a mine where there was no fire, and then kept them on a tight leash instead of letting them head straight for the Two Left section?

Part of the answer is that there are some important differences between the two emergencies. There was no explosion at Alma, and the mine liberated virtually no methane at all, so there was minimal risk of an explosion occurring while rescuers were in the mine.⁴⁹ The fire at the belt was not spreading out of control and therefore was not endangering either access or escape. Other than having to cope with smoke,

continue reporting conditions from the mine phone at 58 block, would it have been possible to rush properly equipped rescuers in to that point, taking the chance that the possibility of fire and/or a second explosion was low enough to justify the risk?

It would have been asking a lot to expect the three men to stay in the mine for many hours. Mine rescue teams were not on site in sufficient strength to launch an adequate rescue effort until about eight hours after the explosion. And with no gas chromatograph on site, accurately assessing the fire risk would have

been difficult if not impossible until fairly late in the day on January 2.

As for the risk of a second methane ignition, whoever was calling the shots in the command center would certainly have wanted to know as much as possible about how much methane the mine liberated. This was not as difficult as assessing the risk of fire. From each quarterly inspection, MSHA had a history of the mine's methane liberation. Sago liberated very little methane — so little, in fact (approximately 100,000 cubic feet per 24 hours⁴⁷), that when MSHA District 3 Manager

heat, and carbon monoxide, for which they were trained and equipped, the rescue teams were not imperiled by conditions in the mine. There was no reason to hold them back.

At Sago, in contrast, there was concern about what was not known. The gas readings obtained at the portal were subject to varying interpretations and the possibility that they might not reflect conditions further inby. After about 9:30 a.m. on January 2, there was no one inside the mine to provide first-hand reports on conditions. There was at least the possibility of a fire, and there was concern that the ventilation changes made in the first rescue attempt by mine superintendent Jeff Toler and others might have been pushing methane over such a fire, increasing the risk of a second explosion. Jeff Toler himself testified to his anxiety about that possibility.⁵⁰

So the two situations were not comparable. The rapid response at Alma does not necessarily mean that the more cautious response at Sago was fatally flawed.

But the Sago miners' families are still right to raise these questions, because there are reasons to be concerned about the differing responses.

What we know about human nature suggests that those in command at Alma (some of whom had also been at Sago), as they confronted another emergency less than three weeks after the tragic outcome of the year's first disaster, had to have been aware of the need to organize the most aggressive response that could be justified under the circumstances — and they appear to have done that.

Their actions did not save the lives of the two missing miners. But they did demonstrate the value of taking risks within reason. And that, in the end, is a large part of what mine rescue is all about.

Kevin Stricklin got the phone call telling him that the Sago Mine had had an explosion, he thought the caller must have misidentified the mine.⁴⁸

Knowing that the mine was not a big methane-producer, the command center might have figured that the initial explosion would have burned out most of the methane and that it would take a long time to build back up into the explosive range, even with the mine’s ventilation impaired. So the risk of sending mine rescuers in would have to be weighed against the advantage of sending them in as soon as possible — mainly to improve the odds of finding men alive, of course, but also to improve the odds of

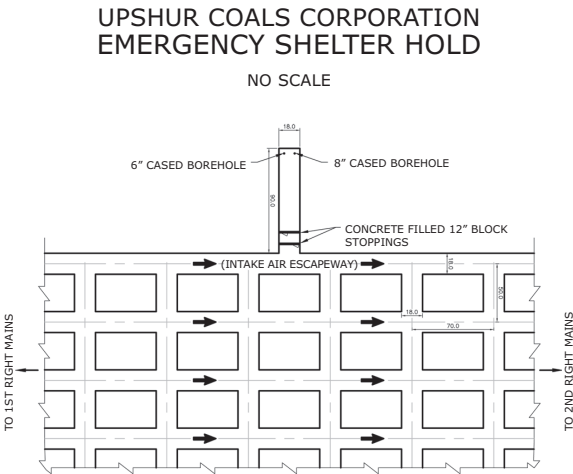
completing the mission before a methane buildup could imperil it.

It is possible — just possible — that such a scenario would have worked (even without eyewitness reports on conditions at the mouth of Two Left), and if everything had gone just right, mine rescuers might — *might* — have reached the Two Left crew at some point late in the afternoon on January 2, when some and perhaps all of the miners were still conscious, as we can tell from their notes and from Randal McCloy’s recollection. But a mine rescue launched in such a way would have put the rescue teams at high risk, no question about it. Although it seems certain that they would have been willing to

REFUGES: A NECESSITY, NOT AN OPTION

Although escape should always be a miner’s first choice in a mine emergency, miners should not have to choose between escape and barricading. They should have the option of safe refuge in a chamber capable of sustaining life for days if necessary.

Refuge chambers in coal mines are not a new or untried idea. In the 1970s, coal operators Frank and Dusty Williams operated a mine in Upshur County, not far from where the Sago Mine is today, and voluntarily built a rescue chamber in the mine. As the diagram shows, the chamber was excavated off the



intake air escapeway. It was 18 feet wide and roughly 90 feet deep. Two concrete-filled 12-inch block stoppings with offset doors provided blast protection. The doors were far enough apart so that a stretcher could be passed between them. The chamber was connected to the surface by two cased boreholes, one 6 inches in diameter and the other 8 inches, which could be used to supply air, food, and a phone line. Dusty Williams remembers that the chamber was a break-even cost proposition “because the coal paid for the work.”

One size does not fit all, in coal mining as elsewhere, so the refuge built by Upshur Coals should

take that kind of risk, it is unclear whether anyone in the command center seriously considered such an option or would have been willing to shoulder the personal and professional responsibility for its failure.

It is not easy to consider this question, even from a safe distance. Those who were in the command center on January 2 had to make life-and-death decisions based on limited information. Some might reject the idea that an accelerated rescue operation could have had any merit at all, recalling the rich history of secondary explosions in coal mine disasters and believing that no responsible mine emergency manager should ever willingly subject mine rescue teams to that kind of risk.

That view is understandable. But there is another possible response, one that will haunt anyone closely involved with the Sago disaster:

When a building is on fire and people are trapped inside, a fire chief must sooner or later make the gut-wrenching decision about whether to send in his firefighters — knowing that they have trained for the job and are willing to accept the risks, and knowing full well that delays will almost certainly cost lives. It is fair to ask why a coal mine should be any different.

not be thought of as anybody's ideal solution. It's just a good example of miners' ingenuity at work. There are other approaches. MineARC, an Australian manufacturer, custom-builds transportable steel refuge chambers capable of accommodating up to 20 miners and supporting life for up to 36 hours. At a Solid Energy underground coal mine in New Zealand, a transportable chamber is placed 300-600 feet from the face and is moved as coal is mined. Three other permanent chambers are installed in the mine, spaced about 3,000 feet apart, connected by lifelines with directional cones. If miners are unable to escape the mine, they can seek refuge in the chamber, communicate with the surface, replace their SCSRs if necessary, and then proceed to the next outby chamber using the lifelines. They can repeat the process, going to the next "changeover station," as the refuges are called, until they can safely exit the mine, or wait in one of the chambers for instructions from mine rescuers.

There are numerous other refuge chamber designs, including one manufactured by Mine Safehouse, LLC, that was shown at the International Mining Safety and Health Symposium at Wheeling Jesuit University in April. The Safehouse structure is said to be capable of resisting fire at temperatures exceeding 2000 degrees Fahrenheit and explosive forces up to 75 psi without conducting appreciable heat to the interior.

Obviously, careful consideration must be given to how and where a refuge chamber will be placed and how to ensure that it will truly provide a safe shelter when needed. Exhaustive testing and design refinements are a necessary part of getting refuge chambers into the underground mines of West Virginia. But after Sago there can no longer be any excuse for postponing the day when every miner can count on having a safe place to go to in an emergency if escape appears not to be an option.

SOURCES

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- ² Stemple, 2/22/06 testimony, p. 14.
- ³ Stemple, 2/22/06 testimony, p. 13.
- ⁴ Urosek, 5/3/06 public hearing, p. 571.
- ⁵ Chewning, 3/28/06 testimony, pp. 17-18.
- ⁶ Martin, 3/23/06 testimony, p. 23.
- ⁷ Martin, 3/23/06 testimony, p. 24.
- ⁸ Hixson, 3/27/06 testimony, p. 25.
- ⁹ Klug, 3/24/06 testimony, p. 12.
- ¹⁰ Tucker, 3/28/06 testimony, p. 12.
- ¹¹ Klug, 3/24/06 testimony, p. 24.
- ¹² Lilly, 3/23/06 testimony, p. 26.
- ¹³ Jolly, 3/26/06 testimony, p. 12.
- ¹⁴ Hixson, 3/27/06 testimony, p. 14.
- ¹⁵ Lilly, 3/23/06 testimony, p. 23.
- ¹⁶ Lilly, 3/23/06 testimony, p. 13.
- ¹⁷ Thomas, 3/27/06 testimony, p. 10.
- ¹⁸ Hixson, 3/27/06 testimony, p. 14.
- ¹⁹ Jolly, 3/26/06 testimony, p. 14.
- ²⁰ Jolly, 3/26/06 testimony, p. 14.
- ²¹ Lilly, 3/23/06 testimony, p. 27.
- ²² White, 3/28/06 testimony, p. 13.
- ²³ Thomas, 3/27/06 testimony, p. 12.
- ²⁴ Coleman, 2/21/06 testimony, p. 32.
- ²⁵ *Mine Safety and Health News*, 4/3/06.
- ²⁶ *Mine Safety and Health News*, 4/3/06.
- ²⁷ Klug, 3/26/06 testimony, p. 27.
- ²⁸ Martin, 3/23/06 testimony, p. 27.
- ²⁹ Martin, 3/23/06 testimony, p. 28.
- ³⁰ Klug, 3/26/06 testimony, p. 14.
- ³¹ Klug, 3/26/06 testimony, p. 14.
- ³² Bryant, 3/24/06 testimony, p. 20; federal and state logs.
- ³³ Hatfield, 5/2/06 public hearing, p. 224.
- ³⁴ Hatfield, 5/2/06 public hearing, p. 224.
- ³⁵ Bryant, 3/24/06 testimony, p. 21.
- ³⁶ Bryant, 3/24/06 testimony, p. 22.
- ³⁷ Bryant, 3/24/06 testimony, p. 22.
- ³⁸ MSHA log 1/4/06.
- ³⁹ Hatfield, 5/2/06 public hearing, p. 225.
- ⁴⁰ Hatfield, 5/2/06 public hearing, p. 225.
- ⁴¹ Hatfield, 5/2/06 public hearing, p. 226.
- ⁴² Coleman, 2/21/06 testimony, p. 37.
- ⁴³ Hatfield, 5/2/06 public hearing, p. 226.
- ⁴⁴ Snavely, 5/2/06 public hearing, p. 229.
- ⁴⁵ Martin, 3/23/06 testimony, p. 25.
- ⁴⁶ Hixson, 3/27/06 testimony, p. 27.
- ⁴⁷ Collins, 5/2/06 public hearing, pp. 160-161.
- ⁴⁸ MSHA presentation to miners' families, Buckhannon WV 3/9/06.
- ⁴⁹ Joseph W. Pavlovich, memorandum to Thomas N. Bethell, 7/4/06.
- ⁵⁰ Toler, 1/18/06 testimony, p. 15.

8 What happened to the three shots?

'I figured that they would bring that machine down and would have found us, would have drilled the hole in the right spot and would have took us out of there. That's what I expected. I was expecting to hear shots fired... on top, above, and didn't hear nothing. We banged and banged and banged, everyone did... but we never did know that I guess they... just didn't have that machine to do that task.'

— Randal McCloy, Jr.¹

Approximately three and a half years prior to the Sago Mine disaster, at about 8:45 p.m. on July 24, 2002, miners working in the Quecreek Mine, a small underground coal mine in southwestern Pennsylvania, accidentally broke through into an adjacent abandoned mine. Torrents of water rapidly flooded the Quecreek Mine, trapping nine miners. Three days later they were all brought out alive, after rescuers drilled 240 feet down to within a few feet of the miners' location and then lifted them out of the mine, through the enlarged borehole, in a rescue capsule. Because of nonstop television coverage, the miraculous rescue was seen by millions of Americans — including at least some of the 12 miners who became trapped in the Sago Mine on January 2, 2006.²

Tragically, the Quecreek rescue may help explain why there was such loss of life at Sago. If the trapped Sago miners had known that no one was going to save them in the way the Quecreek miners were saved, would they have abandoned their initial attempt to break out of the Two Left section on their

mantrip, after encountering debris from the explosion blocking the tracks? They were in smoke, probably disoriented, and four of their self-contained self-rescuers (SCSRs) would not work for them. Randal McCloy, the sole survivor of the crew, remembers their foreman, Martin Toler, Jr., saying, "We're going to have to hit the section"³ — head back toward the face, where they could hang curtain as a barricade and wait for the rescuers to listen for them and then drill down to them.

If they had known that no one would be listening, would they have scrapped that plan? We cannot know. What we do know, however, is that if they had been able to remove the debris from the ventilation overcast which had fallen and was blocking the tracks, the way out of the Two Left section would have been reasonably clear. It is true that without enough functioning SCSRs to go around, they might not have been able to remove the obstacles and then bull their way out in their mantrip through the smoke and carbon monoxide without some of them losing consciousness along the way —

but they might have tried, if they had not thought, perhaps unconsciously, that a Quecreek rescue scenario was possible.

But why *shouldn't* they have thought such a rescue was coming? No one had told them not to. The miners on Two Left did exactly what they had been told to do.

As every miner knows, miners are trained to respond to a mine fire, explosion, or other emergency by first trying to get out of the mine. If that fails, they are supposed to barricade themselves against smoke and toxic carbon monoxide and await rescue. As we know from the testimony of Randal McCloy, the miners on Two Left went by the book. Led by their foreman, who was driving their mantrip, they first tried to escape, and when they concluded that escape was not an option, they retreated to the safest place on the section — the face, as far removed as possible from the source of the smoke and fumes — to barricade themselves and await rescue.

The federal Mine Safety and Health Administration (MSHA) says it has distributed to every miner in the United States a three-inch-square adhesive sticker, to be placed inside the miner's hard hat. The instructions printed on the sticker are very clear:



The trapped Sago miners tried to follow the rules. Hearing nothing from the surface — no three shots — they used a sledgehammer to begin banging on a roof bolt, pounding hard as instructed, then resting for awhile before pounding again. It was exhausting work. They had to take their SCsRs out of their mouths in order to get enough air to keep pounding⁴ — but that also meant they were breathing carbon monoxide. Even so, for a long time they took turns pounding. But they never heard anything from the surface, let alone the five shots that were supposed to tell them that help was on the way.

Meanwhile, on the surface, representatives of International Coal Group were periodically briefing the miners' families on the status of the rescue operation. West Virginia State Delegate Bill Hamilton of Buckhannon, whose district includes the Sago Mine and who was a friend of one of the missing miners — Junior Hamner — was present for some of ICG's briefings. At the close of the public hearing on the disaster, he recalled that at one of the briefings "the question was asked, 'Have you heard the miners pounding on anything?' The answer, 'No.' The second question, from the same miner's family, was, 'Are you listening for sounds from the miners?' Question answered, 'Yes.' But in testimony... we know that wasn't true. They weren't listening."⁵

Nobody was listening. The explanation offered after the fact was that there was no *need* to listen, because the command center had a good idea of where the miners were. That is true up to a point, but only up to a point. It was likely that the trapped miners were somewhere on the Two Left section. But the section consists of multiple entries and is

more than half a mile in length from mouth to face. At the outset of the rescue effort it was not known that they were barricaded at the face. All that was known was that they were not within shouting distance of where mine superintendent Jeff Toler and other miners had hollered for them from the mouth of the section before being forced to abandon the first rescue attempt in the early morning hours of January 2. As the command center discovered many hours later — only after learning that the seals closing off the abandoned area of the mine had been pulverized — there was also a possibility that the Two Left miners, while trying to escape, might have lost their way and ended up wandering into the no-longer-sealed section, possibly barricading themselves a mile or more from the face of Two Left.

In other words, it would seem to have been a good idea to rush some seismic gear to Sago, set off the promised three shots, and listen for the miners. But MSHA's mobile Seismic Location System never left its base near Pittsburgh. Why?

In print and on its website, MSHA describes its system in these words: "The seismic location system is truck-mounted and is capable of detecting and locating the source of seismic vibrations produced by trapped miners. Miners may generate seismic signals by pounding on mine surfaces such as the roof, floor, or ribs. These signals are detected by sensors installed either on the surface or underground. The system is capable of detecting signals at a range of 1,500 feet, and can monitor approximately one square mile over most mines (depending upon terrain). Helmet stickers describing how to signal have been distributed to all miners in the United

States. The system is highly mobile, and can be airlifted."⁶

This description is inaccurate. In reality, as MSHA personnel know, the seismic system is old, outmoded, cumbersome and time-consuming to deploy, and it could not have been operational at Sago in time to be of any help to the trapped miners.⁷

Ty Coleman, the man in charge of the rescue operation for ICG, testified that he requested MSHA's seismic equipment at about 10:30 a.m. on January 2, four hours after the explosion, and was assured by MSHA officials that "We've got the package coming to you," as he recalled the conversation.⁸ If so, they misspoke. The system stayed where it was. And the tragic fact is that there were good reasons for leaving it there.

As MSHA officials know, setting up the system at Sago would have required extensive surveying above the mine, the construction of a road capable both of accommodating the seismic truck and allowing it to move freely from location to location above the mine, the determination of precise coordinates in order to site the truck, and then the firing of shots and — if no response was heard — the relocation of the truck to another site preparatory to firing off more shots.

The total elapsed time — from turning the key in the ignition of MSHA's parked 1970s-era truck until the first shots were fired — could easily have exceeded 15 hours.⁹ Even if the truck had left Pittsburgh at, say, 10:30 a.m. on January 2, when Coleman says he was told it was on its way — and even if construction of a road above the mine had started simultaneously — the system probably would not

have been able to be operational until well after midnight, long after many if not most of them had lost consciousness because of carbon monoxide asphyxiation. By that time they were far past the point of being able to respond to three shots, let alone listen for the five that would tell them that the promised help was on the way.

Much later — in fact not until more than a month after the May 2-4 public hearing on the Sago Mine disaster — MSHA acknowledged that, contrary to the upbeat information about its seismic system posted on the agency’s website, “MSHA’s experience has shown [that] application of the seismic technology is very limited.”¹⁰ That is an understatement. In fact, the system has been deployed only twice during the past 20-plus years, and it did not succeed in locating trapped miners on either occasion.¹¹ Although the system was transported to the Quecreek mine rescue site, it was not used even there, because other surveying and drilling strategies proved to be faster and more accurate and efficient.

In any case, the miraculous Quecreek rescue was made possible by a highly atypical situation. The Quecreek miners, although trapped, were not breathing carbon monoxide, because they had been trapped by a flood, not by an explosion or fire. They did not run out of respirable air while they waited for three long days to be lifted out of the mine. In the end they were saved by a good job of figuring out where they were and then pinpointing the location of a borehole, but that work took a long time. The Sago miners did not have the luxury of time.

MSHA’s seismic system, developed nearly four decades ago, has been made obsolescent

both by its inherent limitations and by the development of superior technologies. At Sago, for example, ICG arranged for the drilling of a borehole directly over the Two Left section using survey-grade Global Positioning System (GPS) instruments keyed to precise mine maps, with the entire process guided by cellphone by an engineering consultant who was in Atlanta at the time. A bulldozer built a road for a locally based drill while surveyors using wireless laptop computers in their pickup trucks determined the drilling coordinates. Nobody had to drive an old rig from Pittsburgh to Upshur County.

Even so, the process of getting the borehole drilled into the section was delayed by bad weather — making it difficult for the surveyors’ computers to pick up signals from multiple earth-orbiting satellites, as GPS surveying requires — and the task needed nearly a full day to complete. That was record time, compared to the more than two days normally required to survey and site a borehole, but it was still much more time than the Two Left miners had to spare. Moreover, difficult terrain prevented the surveyors from siting the drill so that it would penetrate close to the face of the section, where the trapped miners (if they had still been conscious and alert) might have heard or seen it.¹² Instead, the drill penetrated the mine with precision — punching into the middle of an entry rather than drilling into a solid block of coal as would have happened if the coordinates had been off by even a few feet — but it penetrated about 300 feet from where the miners were barricaded.

During the May 2-4, 2006, public hearing on the Sago Mine disaster, coal miner John Helms, who lost his brother Terry in the

disaster, questioned Kevin Stricklin, manager of MSHA's District 3, about the cap stickers MSHA distributes to all miners. "I've worked in the coal mines for 37 years," Mr. Helms said, "and got these little stickers where it said to barricade, beat on the roof, help will come. I better throw them away — hadn't we? We better come up with some other plan."

"I think we need to re-evaluate that, yes, sir," Mr. Stricklin said.¹³

That was an honest answer. We do need to re-think the training given to miners in light of the time likely to be involved in a mine rescue operation, even one that is conducted more aggressively and at greater risk to the rescuers than was the case at Sago. Perhaps even more importantly, we need to use the no-show failure of MSHA's seismic system to prod us into some fresh thinking about better ways to protect miners against a recurrence of what happened to the waiting Two Left crew.

First and foremost in importance, of course, is *prevention* — starting with taking the necessary steps to systematically assess risks and minimize the chances that an explosion will occur in the first place. If an area is to be sealed, the supposedly "explosion-proof" materials used to seal it must in fact be able to contain an explosion. It is equally urgent to ensure that miners will not be failed by the safety equipment that they carry or otherwise depend upon. That means, among other things, equipping them with ample quantities of SCSRs that work, and equipping mines with robust two-way communication systems capable of surviving explosions and fires. As discussed elsewhere in this report — and as recognized by new state and federal legisla-

tion — there is no good reason to delay any longer in getting such technology into the mines of West Virginia and the rest of the nation.

That leaves the question of whether to invest time and money in a next-generation seismic system with greater capabilities than the one that failed the Sago miners. It is a difficult question. We must always keep in mind that time is the enemy when miners are trapped and barricaded, and the time likely to be required to transport any MSHA-style centralized seismic system from a remote location, even in-state, argues against relying heavily on such a system. (In fact, based on the evidence, our view is that the present MSHA system should be mothballed. Inquiries made in the course of our investigation indicate that similar seismic technology has not been successfully deployed in South Africa, Australia, or Canada, reinforcing our belief that MSHA's system is unlikely ever to prove of value except, perhaps, in specific situations not yet identified.)

On the other hand, researchers should be encouraged to develop a totally different kind of seismic system capable of much more rapid deployment — such as a coiled-cable sensor system that could be laid out on the surface of a mine to detect vibrations from someone pounding underground. Equipment could be kept in each MSHA district (or, depending on price, required at every mine) and deployed quickly. Unless trapped miners can reach a refuge (discussed below and elsewhere in this report), pounding is all they can do — and there seems little doubt that a command center, hearing proof that trapped miners are alive, would be more likely to let rescue teams take some risks to reach them.

Unless better seismic technology becomes available, an alternative is to take maximum advantage of 21st-century mine surveying techniques. Given current GPS capabilities, for example, mine engineers know, as a mine advances, exactly what the surface coordinates are for the working sections underground. In an emergency, surveyors need only to be able to pick up geosynchronous signals from multiple satellites to be able to pinpoint the coordinates on the surface where a borehole should be drilled.

That solves only part of the elapsed-time problem, however, since a road would still have to be built to the site and a pad constructed to facilitate drilling. (Because of the need to construct a pad, airlifting drills by helicopter has limited applicability.) Therefore, even under the best circumstances, rescuing miners by borehole, as at Quecreek, should be thought of as a relatively remote possibility, not a promise.

This reinforces the case for requiring emergency refuges in mines as the primary alternative to escape — which should always be the first choice. Suppose, for example, that a refuge chamber had been available on the Two Left section — an explosion-hardened shelter with an air supply, water, rations, and communication to the surface. Or suppose, even, that such a shelter had been located at some distance, such as off of the main entries, equidistant between the One Left and Two Left sections.

With either of these scenarios, it is possible to imagine the miners of the Two Left crew emerging alive after even two or more days of awaiting rescue. Even in the second scenario, knowing what we know of their failed at-

tempt to break out of the section on their mantrip, it is at least possible to imagine that they would have struggled to remove the debris blocking the track, knowing that they did not have far to go to reach the safety of the refuge chamber.

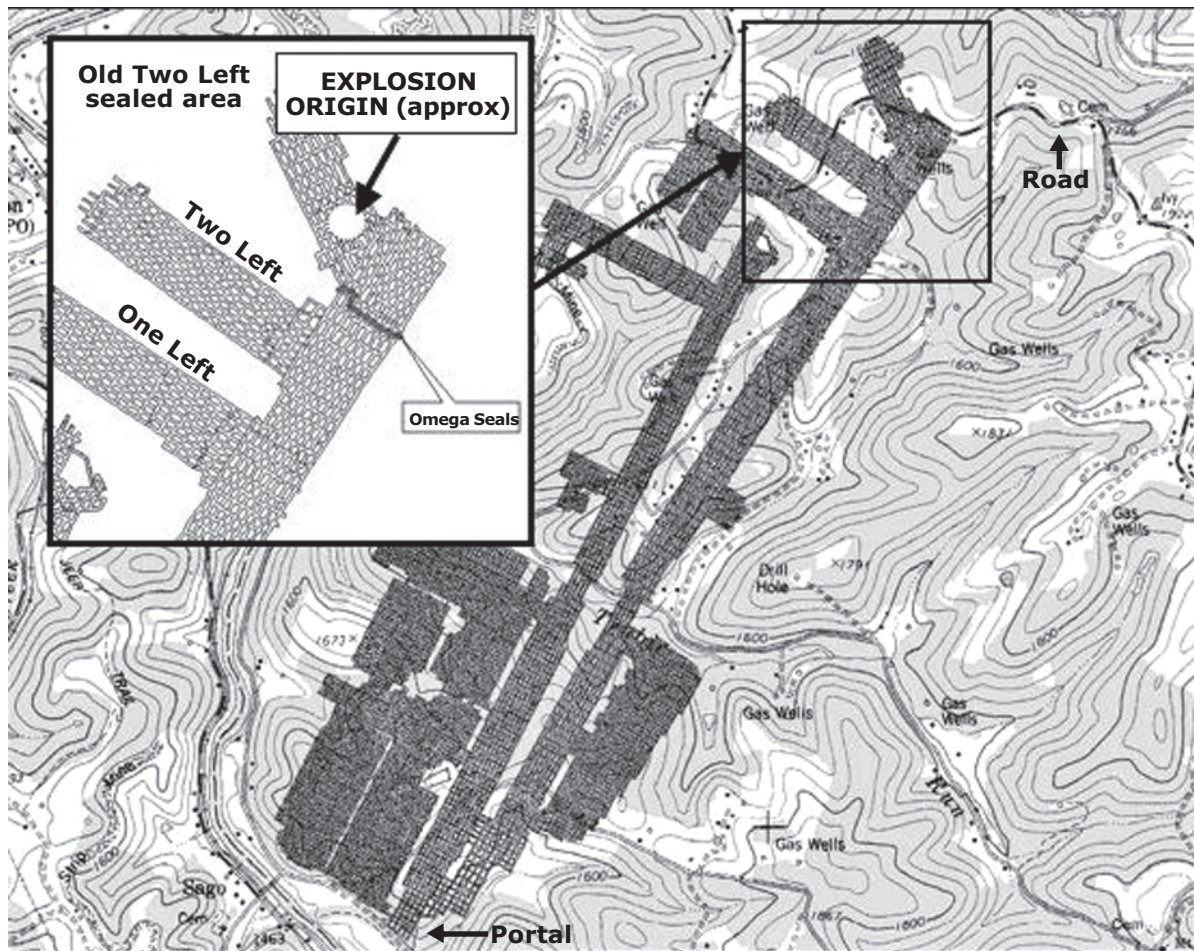
Instead, they had no idea what they were facing — and with no way of communicating to the surface, they could not find out. For all they knew, the explosion might have contaminated the emergency escapeways all the way to the portal, more than two miles from where they were. There was no way they would all have made it that far on foot, especially with four apparently nonfunctional SCSRs. So their choice was to risk losing some of the crew on the way out or to stick together and make for the section, as Junior Toler suggested. They stayed together.

Randal McCloy honored the memory of his foreman in these words: “He was, like, leading everything. He’s not the type of guy who’s pushy about anything, but he was concerned for everybody. He wanted to do the right thing. He didn’t want to, like, get us stuck out in the woods with no rations, something like that.”¹⁴

Junior Toler did the right thing — but he and his crew were failed by a mine rescue system that made promises it did not keep.

Above the mine, on the surface, a winding road runs directly over the Two Left section, at about its midpoint. If you park a truck there, get out, and walk cross-country in a westerly direction for a few hundred yards, you will be standing approximately above the face of the section, where Junior Toler and the Two Left crew waited for some sign of rescue.

Sago Mine, January 2, 2006



It is uneven terrain, and on January 2 it would have been slick with rain. But a surveyor or mine engineer could have walked the terrain, accompanying someone equipped with explosives. There are a lot of people in West Virginia — miners, construction workers, highway engineers — who know how to use explosives. If anyone in the command center had directed that three shots be set off above Two Left to let the miners know that help was coming, it could have been done.

But it was not done. And it is just not sufficient to say that the command center did not need to set off shots because the probable location of the miners was known, or to argue

that setting off three shots would have served no purpose since there was no system in place to listen for the miners' response. That misses the point.

Someone in the command center must have known that the miners, if alive, would do what they had been trained to do — and what all those cap stickers *told* them to do. But no one in the command center seems to have thought that it would be important to let them know that help was on the way.

If the command center had a good idea where the miners were, five shots could have been fired at the surface within, say, half an hour

after firing off the first three shots. The five shots would have told the miners they could stop pounding, preserve energy, and possibly prolong life by breathing as slowly and lightly as possible. But no such message was sent to them.

Is this just a case of 20-20 hindsight, made possible only by Randal McCloy's survival and his subsequent revelations about what his crew did while awaiting rescue? No.

Those in the command center should have been thinking about all the what-ifs. They did not. They failed in this regard, not because they are uncaring people — we do not believe that — but because they are part of an out-moded and inadequate mine emergency management system that is in desperate need

of an overhaul. The system has grown stale with disuse (and with the departure, partly through retirement, of some experienced mine emergency managers). Its immediate needs include greatly improved training requirements and rigorous emergency-simulation drills covering, among other things, how to communicate with trapped miners until the day comes when they can be reliably contacted by explosion-resistant two-way wireless communication systems.

The Sago tragedy leaves no doubt that the mine emergency management system must change, and fast. If another Sago disaster were to occur tomorrow, would the outcome be any different?

Right now, no one can be sure.

SOURCES

¹Randal McCloy, Jr., 6/19/06 interview with federal and state investigators, transcript, pp. 63-65.

²Del. William Hamilton, closing statement, May 2-4, 2006, public hearing, transcript, p. 1237.

³Randal McCloy, Jr., 6/19/06 interview with federal and state investigators, transcript, p. 21.

⁴Randal McCloy, Jr., "To the families and loved ones of my co-workers, victims of the Sago Mine disaster," 4/26/06 statement, p. 2.

⁵Del. William Hamilton, closing statement, May 2-4, 2006, public hearing, transcript, p. 1237.

⁶Jeffrey H. Kravitz and Robert G. Peluso, "The Mine Emergency Capabilities of the Mine Safety and Health Administration," undated, p. 5.

⁷See, for example, the testimony of Kevin Stricklin and John Urosek at the May 2-4, 2006, public hearing, transcript, p. 599 (Stricklin) and p. 637 (Urosek).

⁸Harrison Tyrone Coleman, May 2-4, 2006, public hearing, transcript, p. 456.

⁹J. B. Crawford, Letter to J. Davitt McAteer, re: Sago Mine Disaster Public Hearing, Additional MSHA Information and Documents, June 22, 2006.

¹⁰J. B. Crawford, Letter to J. Davitt McAteer, re: Sago Mine Disaster Public Hearing, Additional MSHA Information and Documents, June 22, 2006.

¹¹J. B. Crawford, Letter to J. Davitt McAteer, re: Sago Mine Disaster Public Hearing, Additional MSHA Information and Documents, June 22, 2006.

¹²Gary Hartsog, 3/28/06 testimony, p. 35.

¹³May 2-4, 2006, public hearing, transcript, p. 602.

¹⁴Randal McCloy, Jr., 6/19/06 interview with federal and state investigators, transcript, p. 86.

APPENDIX I: Synopsis of State of West Virginia and federal activities following the Sago Mine disaster

1/4/06

Federal Mine Safety and Health Administration (MSHA) announces its staff to investigate the Sago Mine Disaster.

1/9/06

MSHA announces it will conduct its investigation jointly with the West Virginia Office of Miners' Health, Safety and Training (WVOMHST)

1/9/06

Governor Joe Manchin III appoints J. Davitt McAteer as his special advisor on the Sago Mine disaster and promises a public hearing.

1/11/06

McAteer briefs U.S. Senator Robert C. Byrd on the disaster.

1/12/06

Governor Manchin announces Senators Caruth, Kessler, Love and Delegates Caputo, Frederick and Hamilton will serve on the state's investigation team to work in conjunction with McAteer's efforts.

1/15/06

Memorial service held for the Sago miners at West Virginia Wesleyan College.

1/17/06

MSHA and WVOMHST begin voluntary interviews of witnesses.

1/18/06

MSHA appoints staff to conduct an internal review of the agency's response to the Sago

disaster and its pre-accident enforcement at the mine.

1/19/06

Mine fire at Massey Energy's Aracoma Alma No.1 mine kills two: Donald Bragg and Ellery Hatfield.

1/20/06

U.S. Senators Rockefeller, Kennedy, Enzi, and Isakson meet with Sago families.

1/21/06

Investigators enter the Sago Mine to begin collecting physical evidence.

1/23/06

West Virginia Legislature passes mine safety bill SB-247.

1/23/06

U.S. Senate Appropriations Committee, Subcommittee on Labor, Health, and Human Services, chaired by Senator Arlen Specter holds hearing on Sago disaster, with Senator Robert C. Byrd leading the questioning.

1/24/06

MSHA seeks federal court order to grant United Mine Workers of America (UMWA) access to the investigation.

1/25/06

MSHA publishes in the *Federal Register* a Request for Information on emergency equipment and technology (e.g., communication, robotics, refuge chambers.)

1/25/06

MSHA announces investigation team for fatal Aracoma Alma fire.

1/26/06

Federal judge grants MSHA's request for an injunction against ICG to allow the UMWA to participate in the Sago investigation.

1/30/06

Esterhazy, Saskatchewan: 72 trapped Canadian potash miners survive 40 hours underground in a refuge chamber.

1/31/06

Richard Stickler, President Bush's nominee for Assistant Secretary of Labor for Mine Safety and Health, testifies at his Senate confirmation hearing.

2/1/06

Governor Manchin asks the state's coal mines to temporarily cease operations until emergency safety reviews are conducted, following three separate mining accidents, in which two miners were killed and another seriously injured.

2/1/06

Senators Byrd and Rockefeller and Representatives Rahall, Mollohan, and Capito introduce bills in their respective chambers of Congress to enhance coal mine safety.

2/6/06

MSHA requests mine operators to "Stand Down for Safety."

2/7/06

Doug Conaway resigns as director of WVOMHST.

2/8/06

Governor Manchin announces an International Symposium on Mine Safety and Health at Wheeling Jesuit University in April.

2/9/06

Governor Manchin appoints Jim Dean as acting director of WVOMHST.

2/10/06

WVOMHST asks the National Institute of Occupational Safety & Health (NIOSH) to conduct explosion testing on Omega blocks.

2/11/06

MSHA reports it has received about 50 proposals from manufacturers of underground communication and tracking devices; Consol Energy and Peabody Energy agree to assist in evaluating the devices.

2/13/06

Congressman George Miller (D-CA) holds a forum on mine safety, taking testimony from family members of miners killed in the 2001 Brookwood and 2006 Sago mine disasters.

2/15/06

MSHA announces plans to increase penalties; action is subject to formal rulemaking.

2/21/06

An explosion at a coal mine near San Juan de Sabinas, Mexico traps 65 miners.

2/24/06

MSHA and WVOMHST conclude initial interviews with witnesses.

2/27/06

WVOMHST files with the Secretary of State its emergency rule on SCSRs, communication and other mine safety improvements.

2/28/06

Governor Manchin appoints a six-person labor-management task force to assess availability of communication systems and other technologies contained in new WVOMHST rule.

3/1/06

House Committee on Education and the Workforce, Subcommittee on Workforce Protections, chaired by Charles Norwood (R-GA), conducts hearing on mine safety.

3/1/06

Governor Manchin announces that McAteer will chair a public hearing on the Sago disaster (originally scheduled for mid-March) at West Virginia Wesleyan College on May 2.

3/2/06

Senate Committee on Health, Labor and Pensions, chaired by Senator Michael Enzi (R-WY), holds an oversight hearing on mine safety.

3/8/06

U.S. Senate Committee on Health, Labor and Pensions approves Richard Sticker's nomination to be MSHA's Assistant Secretary.

3/9/06

MSHA publishes an emergency temporary rule in the *Federal Register* on mine evacuation procedures and equipment; provisions are similar to the rules issued earlier by WVOMHST.

3/13/06

MSHA holds a public meeting to receive information on communication and tracking technology, related to its January 25 request for information.

3/14/06

ICG meets with family members of the deceased Sago miners and provides findings of its on-site investigation, including the company's conclusion that "the explosion was ignited by lightning."

3/15/06

Sago Mine resumes production.

3/23/06

MSHA and WVOMHST resume interviews for the Sago investigation, expanding their inquiry to include the mine rescue effort.

3/27/06

NIOSH begins external and internal examination of SCSRs recovered from the Sago mine.

3/30/06

Randal McCloy, Jr. is released from the hospital and continues his rehabilitation at home.

4/11/06

Family members receive transcripts of witness interviews conducted by MSHA and WVOMHST.

4/15/06

NIOSH conducts the first in a series of explosion test of Omega block seals in its Lake Lynn Experimental Mine.

4/18/06

NIOSH and MSHA host a workshop on mine escape planning and emergency shelters.

4/20/06

Governor Manchin convenes the first International Symposium on Mining Health and Safety at Wheeling Jesuit University.

4/21/06

MSHA approves two handheld portable radios for use in underground mines, the first such devices approved by the agency in 10 years.

4/24/06

MSHA begins public hearings on its emergency temporary standard on mine evacuation procedures and equipment.

4/26/06

Randal McCloy, Jr. gives the Sago families a confidential letter describing his and his co-workers' experience while awaiting rescue.

5/2/06

Public hearing on the Sago mine disaster convenes at West Virginia Wesleyan College in Buckhannon, WV; provides 3 days of inquiry from family members, state and federal officials and miners' representatives.

5/5/06

West Virginia Board of Coal Mine Health and Safety files rule to establish two state-run mine rescue teams.

5/12/06

WVOMHST imposes a statewide moratorium on the installation of Omega block seals and begins a review of all alternative seals already in place.

5/22/06

MSHA announces a moratorium on alternative seals, a reassessment of the structural integrity of existing alternative seals, and requirements to test the atmosphere behind seals.

5/29/06

West Virginia Mine Safety Technology Task Force issues its report and recommendations.

6/8/06

MSHA provides an update on its testing and evaluation of communication and locating devices for underground miners.

6/9/06

WVOMHST files its emergency rule implementing recommendations of the Mine Safety Technology Task Force.

6/13/06

West Virginia adopts rule to establish two state-run mine rescue teams; takes effect July 13, 2006.

6/15/06

President Bush signs Mine Improvement and New Emergency Response (MINER) Act into law.

6/15/06

NIOSH conducts the second in a series of tests of Omega block seals in its Lake Lynn Experimental Mine.

6/19/06

MSHA, WVOMHST and McAteer interview Randal McCloy, Jr.

6/29/06

Comment period ends on MSHA's emergency temporary standard on mine evacuation procedures and equipment.

7/10/06

WVOMHST announces statewide SCSR inventorying and reporting system, effective August 15, 2006.

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As I noted in the transmittal letter on the opening pages of this report, we owe a deep debt of gratitude to the families of the victims of the Sago Mine disaster. They are a constant and continuing source of inspiration and motivation to press for changes in mine safety and the mining industry in the hope that other families will not have to suffer as they are suffering. We also express our thanks to Randal McCloy, Jr., the sole survivor of the Two Left crew, whose recollection of what he and his fellow miners experienced has been of great value to our investigation.

We thank the students of Wheeling Jesuit University, West Virginia Wesleyan College, West Virginia University, University of Charleston and Marshall University, who volunteered immediately following the disaster and in the months which followed. It makes me proud as a West Virginian that these young people stepped up to help.

We want to express our gratitude to the many individuals — whether in state and federal agencies, companies, professional or private life — whom we have called upon for advice, guidance and expertise in the preparation of this report. And we are grateful to the hundreds of individuals who have contacted us with ideas and suggestions about how to improve mine safety and health in West Virginia and across the nation.

This investigation has been supported by the State of West Virginia and its Governor, Joe Manchin, III. We thank Governor Manchin and his staff for their support and assistance during this investigation and preparation of the report.

The list of names that follows encompasses, we hope, most of those who have been involved in one way or another with our work over the past six months. Inevitably, however, there are bound to be omissions. We apologize for that, and hope that anyone whose name should have appeared here will be brought to our attention for future correction.

J. Davitt McAteer

Aimee Adams • Lynda Anderson and family • Jonathan Andrew • Kent Armstrong • Pamela Jubin Balch • Simon Barber • Richard D. Begley • Judy Bennett, Russell Bennett and family • Jason S. Bentley • Jamie Berg • Jodi Besenyei • Jacek Bielawa • Phil Bounds • Wojciech Bradecki • LeeAnn F. Brown • Melissa A. Brown • Tony Bumbico • U.S. Senator Robert C. Byrd • Brent Bodine • Premier Lorne Calvert • Pam Campbell • U.S. Congresswoman Shelley Moore Capito • State Delegate Mike Caputo • State Senator Don Caruth • Mary Ellen Cassidy • Elizabeth Chamberlin • Skye M. Chernicky • Gene Cilento • Kevin Cimino • Peggy and Aaron Cohen • Robert Cohen, MD • Doug Conaway • Kimberly A. Cottrell • Tammy Crites • Sean Daniel • Taylor A. Daugherty • James Dean • Christo de Klerk • Mary Doane • Jerry Donahue • Earl Dotter • Carol and Doug Duffield • Robert Edge • Chuck Edwards • Miranda Elkins • Susan Elliott • Yvonne Farley • Alan Fine • Mike Foletti • Brian France • State Delegate Eustace Frederick • Bruce G. Freedman, MD • Jimmy Joe Gianto • Richard T. Gillespie • Bobby Godsel • Michael Griffin • Cara J. Group • Wanda Groves and family • Father Joseph R. Hacala, SJ • State Delegate Bill Hamilton • Professor Vivian Hamilton • Debbie Hamner and family • Larry Harrah • Bennett K. Hatfield • William R. Hayden • Monte Hieb • Amber Helms and the Helms family • Jerry Henderson • F.W. Hermann • Justin Hershberger • David Hinkins • Brenda Hissam • Jessica L. Holley • Tad Hudkins • Craig Hyre • Justin Jack • Darwin F. Johnson • Yvonne Johnson • Shenna L. Johnston • Lula Bell Jones and family • Jarrod Jordan • State Senator Jeff Kessler • State House Speaker Bob Kiss • Sam Kitts • Jill Kriesky • Kimberly N. Leezer • Samantha Lewis • Pete Lilly • Alisa Lively • Tricia Lollini • Kathleen M. Long • Kathryn G. Lough • State Senator Shirley Love • Bernard Lown, MD • Joseph P. McAteer • Timothy O. McAteer • Randal and Anna McCloy • Professor Joyce McConnell • Pastor Ed McDaniels • Professor Marjorie McDiarmid • Professor Pat McGinley • Darrell V. McGraw, Jr. • Andrew Meek • Ann and Dan Merideth and family • David Michaels • Mine Safety and Health Administration • U.S. Congressman Alan B. Mollohan • Virginia Moore • Keith Moran • Thomas E. Moran • Christina Morgan • Zachery M. Morton • Paul Myles • Kraig R. Naasz • National Institute for Occupational Safety and Health • National Mining Association • Blaire Nuzum • James O'Dell • Thomas J. O'Neill • Carolyn Ostand, RN • Brenda Pinnell • Jennifer Powell • Andrea Pyles • U.S. Congressman Nick J. Rahall, II • Bill Raney • Paul and Cindy Rank • Katy Ratai • James Rau • Lawrence H. Roberts, MD • U.S. Senator John "Jay" Rockefeller • Joseph R. Romano • Shelly and Mike Rose • Chad Rosepappa • Neil Roth • Robert O Rupp • Allison E. Sharpe • Elizabeth H. Short • Bob Skinner • Malcolm Smith • Mayor Nicholas Sparachane • Catherine E. Squires • Duwane Squires • Ben Stout • David Stuart • Catherine E. Swigert • Tony Szwilski • Ryan A. Thorn • Mary Lou Toler and family • Senate President Earl Ray Tomblin • U.S. Department of Labor • United Mine Workers of America • Kyla R. Vala • Jesse J. Wagner, Sr. • Charlotte Weaver and family • Charlotte Weber • Suzanne Weise • Dusty Williams • Frank Williams, Jr. • Kimberly N. Williams • Ann Wilson • Pam Winans and family • Tom Wingler • WV Office of Miners Health Safety and Training • WV Board of Coal Mine Health & Safety • WV Coal Association • WV Department of Homeland Security • Wheeling Jesuit University Board of Directors • Evan M. Wolfe • Kevin G. Younkin • Gary Zamel • Paul Ziemkiewicz

