REPORT ON THE STATUS OF FIRES AT ABANDONED UNDERGROUND COAL MINES IN COLORADO

COLORADO DIVISION OF MINERALS AND GEOLOGY
STEVE RENNER, PROJECT MANAGER
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On the Cover:
Aerial Photograph of the Morgan Coal Mine Fire
Detail of map showing location of the Morgan Coal Mine Fire

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JANUARY 10, 2005

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This report is dedicated to my friend and colleague David Bucknam. Dave was an unceasing source of encouragement, motivation and friendship to myself and my comrades in the Colorado Inactive Mines Program.

Dave played a significant role in my career within the Inactive Mines Program by encouraging me to pursue my goals and interests and by providing moral support when the path became difficult. Dave offered counsel, advice, criticism, and exercised immeasurable patience.

Dave was my friend and mentor who has forever had an impact on my life, and to whom I am eternally grateful.

Steve Renner
December 17, 2004
Grand Junction, Colorado

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INTRODUCTION

Colorado is host to a rich mining history. Mining of both precious metals and coal helped establish the early economy of the State, dictated the location and importance of many of its towns and cities, and provided an important incentive for settlement of the West.

Coal mining was particularly important in the State's formative years. To a greater or lesser extent, almost every citizen, and every industry, was dependent on coal extraction. As a result of this dependence, large and small coal mines were established wherever coal formations were discovered. Today, there are approximately 1,736 known abandoned, inactive coal mines located throughout Colorado.

Fires in abandoned coal mines are relatively rare occurrences. Of the approximately 1,736 known abandoned coal mines in Colorado, 32 are known to be involved at some level of combustion. This equates to under two percent of the known abandoned coal mines being currently involved in a combustion event. In addition to the burning abandoned coal mines, there are three known actively burning coal outcrop fires, and one fire in a coal refuse pile in Colorado. Approximately 50 additional abandoned coal mines are documented to have been on fire since their closure. These additional mine fires appear to be dormant at this time.

This report details the status of the known active and dormant underground coal mine fires in Colorado. The status of the coal outcrop fires and the refuse pile fire are also discussed, so that a complete picture of the status of all known coal fires in Colorado is provided.

Terms

In order to clarify the status of these fires, a number of terms are used throughout the report to describe each site.

The term *inactive mine* is applied to any coal mine that was abandoned prior to August 1977, and where there is no continuing reclamation responsibility on the part of the former mine operator. A number of active mines, and at least one reclaimed mine where the operator is still responsible for reclamation, have caught fire since August 1977. However, these mines are not eligible for remedial actions by the Division of Minerals and Geology Inactive Mines Program, and are beyond the scope of this investigation.

The term *active fire* is used to describe a location where the combustion of coal causes an observable heating of the ground surface to a temperature exceeding ambient conditions at a similar, nearby site at the time of the field evaluation.

The term *dormant fire* describes a site where others had observed an active fire prior to the evaluation described in this report, but where indications of an active fire were not observed during the site evaluations conducted in 2002 and 2003. Coal combustion may be occurring underlying the ground surface, or conditions may not have been ripe for combustion at the time of the evaluation. Without obtaining site-specific subsurface data, it is difficult to confirm that any fire is extinguished. Others may use the term *inactive fire* to describe this same condition.

Research into production data yielded two terms that describe the coal extraction processes. *Drift mine* has been used to describe conventional room and pillar mining operations. The term as used in this report, describes a horizontal entry into a coal seam, with extraction resulting in open rooms devoid of coal, separated by pillars of coal left for roof and rib support.

The term *slope mine* has been used by others to describe any mine where the coal was accessed via an inclined, or sloping, entry, without necessarily implying a mining method. Frequently, slope mines used a room and pillar extraction technique. The term as applied here means that the coal was accessed by an inclined entry, and was extracted using room and pillar techniques.

Unfortunately, the term slope mine was also used to describe a mining technique employed in the Grand Hogback of Garfield County, and in other steeply dipping coal beds. The term *stope mine* is used in this report to describe a specific coal mining technique employed where the coal is steeply dipping. Using a stope mining technique, the steeply dipping coal was accessed either horizontally or on an incline. The entry, once it encountered the coal seam of interest, was driven horizontally into the coal, parallel with the strike of the seam. Coal extraction occurred overhead in long, stope-like rooms that followed the dip of the coal upwards. This resulted in finger-like areas of coal extraction extending upwards from the main entry. Blocks of supporting coal separated these long rooms.

The distinction between *slope* and *stope* mining is important because the different mining techniques appear to result in different fire characteristics. Stope mining results in a low-lying horizontal entry supporting a number of steeply pitched rooms from which coal was extracted. The rooms are bordered parallel with the entry by coal pillars. This combination of a low lying

entry with open, coal-bounded overhead rooms results in a chimney-like structure that is very efficient in moving air, and thus supports very active combustion.

A *refuse pile fire* is a fire occurring in the coal-bearing waste material extracted from an underground mine and deposited on the ground surface near the mine entry.

Outcrop fires are sites where in-place, un-mined coal is burning, generally as a result of natural processes, such as outcrop oxidation, ignition as a result of a wildfire or lightning strike. Outcrop fires resulting from human activities are not unheard of, but none are known to exist in Colorado at this time.

Site Observations

The observations detailed in this report are those obtained as a result of field evaluations of the surface characteristics of the subsurface fires. Inferences about the underlying fire were made as a result of these surficial observations. Because these inferences are not made on direct observation of subsurface conditions, actual conditions of the fire may vary from what is reported here. Drilling or other subsurface investigations are the only ways to obtain quantitative information about the nature of the fire itself. However, it is important to note that the surface characteristics of an underground fire such as subsidence features, fissures and fractures, elevated ground surface temperatures and unstable ground conditions are the factors that pose the greatest threat to human health and safety, and potentially a wildfire hazard.

In order to obtain a representative and reproducible data set, a field method was developed that contemplated collection of similar data at each site visited. Initially, each site was visually inspected from a distance in order to obtain a macro-scale characterization of the site. The perimeter of each site was walked to determine whether the area posed safety risks. Finally, the site was then walked to the extent that ground conditions permitted without taking undue risks. Individual fire related features were measured and logged using a hand held Global Positioning System instrument. Ground surface temperatures within or immediately adjacent to features were taken using a hand held infrared thermometer. Subsurface temperatures at refuse fires, and periodically at underground mine fires, were measured using a bi-metal ground temperature thermometer. This instrument was used to measure the ground temperature approximately eight inches below the surface, and within open vents. All temperatures presented in this investigation are reported in degrees Fahrenheit.

Observations of the fire related features were made to help quantify fire characteristics. Observations of thermal alteration of minerals, sulfur deposition and creosote deposition were made. Other observations such as alignment of features, positions of features relative to one another, growth of moss, ground stability, combustion smell and feature locations relative to vegetation were made.

Measurement of vent gas characteristics was attempted using a multi-gas meter suspended above venting features. Some data was produced using the meter, however a number of problems developed that ultimately suspended its use. A significant problem was that the temperature of the venting gas frequently surpassed the heat specifications of the meter, causing sensors to cease functioning. Another problem was that because the characteristics were measured at or near the point that the gas exited the ground, mixing with the atmosphere occurred, particularly on windy days. Therefore, the accuracy of the data was suspect to the point that, in some cases, it was deemed to be not useful. Vent gas characteristics data is provided in the report only from those sites where it appeared to be valid.

Qualitative assessments of the activity of the fires were made at most sites. These qualitative assessments included the relative activity of the fire, and its relative efficiency. Fires exhibiting a high degree of activity generally displayed active vents that vigorously produced combustion gasses. Some of the most vigorous vents dispel combustion gas with an audible exhausting sound. Less active fires predominately produced steam, rather than flue gas. Those fires termed efficient did not display a great quantity of precipitate at the vents, such as sulfur or creosote. The assumption was made that a hot, efficient fire would consume most of its fuel, and therefore would leave little residue at the ground surface. Conversely, it is assumed that an inefficient fire will display more significant deposition of combustion by-products.

Dormant Fires

In 1989, Rushworth et al, mapped approximately 54 mines as hosting "inactive" mine fires. These sites were observed from an aircraft during the winter of 2002 / 2003. The flights were made during the cold months because there is a higher probability of observing fire related features such as steam and smoke, and areas incapable of holding snow due to underlying heat. The vast majority of the sites were readily found. Three of the sites could not be located, even after extensive searching from the air. These were assumed to be no longer burning, and thus did not present any surface fire indicators. Each of the confirmed locations was photographed, and site observations documented. The observations recorded included the ability of the site to hold snow, vegetative changes observed and whether ground conditions

indicate signs of surficial instability. Five of the sites appeared to be somewhat anomalous, and therefore warranted a site investigation. Of these five sites, one was found to support an active fire.

Other Agency Coordination

Other governmental agencies have helped with this investigation by providing information and assistance. The agencies listed below have contributed to the Division's efforts at controlling some fires.

The Office of Surface Mining has provided grant funds to complete the field investigations and this report. OSM has also provided grant funds necessary to conduct drilling operations, fire suppression projects and related activities.

The Bureau of Land Management has provided matching funds for a coal outcrop subsurface fire investigation and mitigation project in Mesa County. The BLM has also been a resource in providing location information for mine fires in western Mesa and Garfield counties, and regarding outcrop fires in Moffat and Mesa counties.

The National Park Service has identified a coal outcrop fire located in Mesa Verde National Park. As a result of that information, a site evaluation was completed. A fire mitigation plan has been developed, and abatement activities are scheduled to begin in spring, 2005.

The City of Glenwood Springs has provided survey data, aerial photographs and historical information pertinent to work being undertaken at the South Canyon mine fires. Provision of these materials has saved the Division considerable time and resources.

ACTIVE UNDERGROUND FIRE EVALUATIONS BY COUNTY

Known active underground mine fires were visited throughout the State in an effort to document the activity at each site. The majority of these sites were evaluated in the 1988 publication, "Reconnaissance Study of Coal Fires in Inactive Colorado Coal Mines" by Rushworth, Haefner, Hynes and Streufert. That study documented 26 active mine fires, including one refuse pile fire. Three outcrop fires were also documented to be active. As of the date of this report, there are 32 known active coal mine fires in Colorado, including a refuse pile fire, and three active outcrop fires. This investigation revealed that three fires dormant at the time of the 1988 study are now active (Marshall Numbers 1 & 2, Slagle, Haas / IHI Number 2), one fire thought to have been an outcrop fire is actually a mine fire (Skull Creek), and two mine fires were not previously mapped (Oliver, Sunshine).

Table 1. Known Active Coal Mine Fires In Colorado

County	Mine Name
Boulder	Lewis No. 1 & 2
	Marshall No. 1 & 2
Delta	States
	Minnesota Creek
Fremont	Double Dick Vicinity
Garfield	Coryell
	IHI No. 3 (D & H)
	Elk Creek
	Gem (South Canyon No. 2)
	Haas (IHI No. 2)
	Harvey Gap
	New Castle No. 1
	Morgan
	New Castle No. 3
	Pocahontas No. 1 & 2
	South Cañon No. 1
	Sunshine
	Vulcan
Gunnison	Oliver
Jackson	Riach
Las Animas	Morley Waste Dump **
Mesa	Farmers Mutual
	Garfield
	Go Boy
Moffat	Streeter / Collom
	Wise Hill No. 3 (Hart)
Montezuma	McElmo
Ouray	Slagle (Bright Diamond)
Rio Blanco	Black Diamond
	Rienau No. 2
	Skull Creek
Routt	Kaspar

** Morley Waste Dump, a refuse pile fire, is included here for convenience.

A description of the known mine fires by county is provided below. Each description provides an overview of site conditions, general observations, a map and photograph. A brief table follows each site description. The table contains information pertinent to the mine when it was operated. The mine data contained in the table was obtained from Carroll and Bauer, 2002.

BOULDER COUNTY

Lewis Number 1 And 2 Coal Mine Fire

The Lewis Mine fire is located just north east of the intersection of Highway 170 (Marshall Road) and Cherryvale Road south of Boulder. The fire was visited in June 2002, and again in October 2003.

The fire occurs on private property that overlies an area of active subsidence. The owner of the property reports the fire has a cyclic nature, experiencing periods of activity and inactivity. The fire appears to have been relatively inactive for about ten years or longer, yet he has observed that the fire vents steam during the winter months.

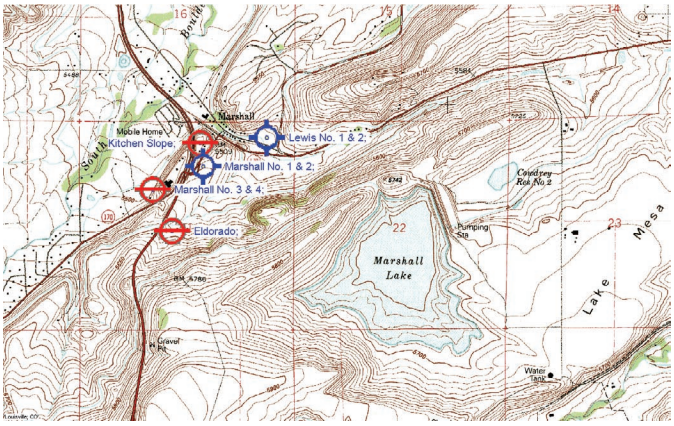
The ground surface at the fire zone is composed of intermixed coarse soil and sandstone outcrops. The area is characterized by extensive subsidence features, generally displayed as sunken areas bordered by ridges of ground not depressed by subsidence. Significant subsidence related fractures are observed within the subsidence features and along the margins of the boundary ridges in the sandstone outcrops.

The subsidence features, including depressions and ridges, generally exhibit a fairly obvious northerly to southerly trend. These features look characteristic of near-surface subsidence as a result of room and pillar extraction. Due in large part to the regular nature of the features, they do not appear to be fire related.

Few fire related features were observed at the site during the October 2003 evaluation. However, some fire related vents were observed to occur immediately south of a concrete lined irrigation ditch that crosses approximately east to west through the fire zone. Steam was visibly issuing from an approximately three feet by one foot vent located at 39° 57' 23.1"; 105° 13' 20.1". The ground surface temperature at the vent was 100° in contrast to ambient ground temperatures of 65° to 70°. The vent was partially obstructed by a rock, which displayed some moss growth on its underside. No creosote or sulfur development was observed, while smoke strains were also not present.

A few other small vents were found in the immediate vicinity of the vent discussed above; however, none of these could be considered a significant feature. Interestingly, the distinct smell of mine atmosphere could be detected periodically in the vicinity of some of these vents.

Lewis Number 1 and 2 Coal Mine Fire. View toward South.



Locations Marshall Numbers 1 & 2, and Lewis Numbers 1 & 2 active Mine Fires, and Marshall Numbers 3 & 4, Eldorado, and Kitchen Slope Dormant Mine Fires. North at top.

General Observations:

This is a very low activity fire, displaying limited surface activity. If this fire is not dormant, it is close to that stage of activity.

The fire apparently cycles between periods of activity and inactivity.

Subsidence phenomenon are pronounced throughout the area, and is the predominant surface effect of underground mining.

Subsidence activity likely controls the activity of the fire, as it may lead to either increased oxygen availability, or may serve to isolate portions of the fire from the atmosphere.

Wildfire risk is low, given the lack of surface heat and a paucity of overlying vegetation.

Human health and safety risk is low given the lack of significant surface fire features. The site is located on private property with no public access. The heat value of the small features observed is low.

Lewis Number 1 & 2 Coal Mine

Years Operated	Formation / Mined Seam	Strike	Dip	Mining Method	Total Production
1914–1942	Laramie / *	Unknown	4	Slope	164,057

* Not Reported

Marshall Number 1 & 2 Mine Fire. Highway 170 to left, Highway 93 to right. View to South.

Marshall Number 1 And 2 Coal Mine Fire

Rushworth et al, 1989, had mapped the Marshall Numbers 3 and 4 coal mines, which are located immediately south of the Marshall Number 1, as an inactive fire. Because significant subsidence is observable at the location of the Marshall Number 1, and because it is clear that the Marshall Number 1 is currently burning, it is theorized that this site was mistakenly identified in that report as the Marshall Numbers 3 and 4. The site is located approximately 300 yards north and east of the intersection of Highway 170 (Marshall Road) and Highway 93.

The Marshall Number 1 and 2 mine fire was visited in October 2003. A nearby resident reported smoke or steam emanating from the ground surface at this location during the winter months. This report prompted the site visit.

The Marshall Number 1 and 2 fire is a small site, with a surface expression observed at less than one-quarter acre. Not unlike the Lewis Numbers 1 and 2 mine fire, surface subsidence evidence is ample, with numerous depressions observable over a much larger area. Evidence of the fire is observable in tension fractures that border a ridge separating two subsidence depressions. The central portion of this ridge is located at 39° 57' 17"; 105° 13' 46". The subsidence features appear to be fairly active, as tension fractures bounding the east and south facing slopes are open, do not exhibit significant weathering, and do not support vegetation. The easterly fractures are linear, while the more northerly are concentric, opening toward the south, and apparently migrating toward the north.

The fractures on the east side of the ridge trend approximately north to south, as does the ridge itself. These north / south fractures are approximately 60 to 80 feet in length, and vary between four and eight inches in width. The smell of combusting coal was quite evident at a distance of over 20 feet from the fractures. Ground surface temperatures at the fractures were measured at 118° to 120°. Creosote development was observed to occur at this location. The south facing fractures are more conchoidal than linear, but trend approximately northwest to southeast. Each set of these approximately 20 feet long fractures serve as vents for the underlying fire. These features, the eastern margin of which are situated 20 feet west of the easterly fracture set, exhibit ground temperatures of 130°. No creosote deposition or other fire related alteration was observed at this location. A few scorched yucca roots were observed at the northerly fractures.

A large area surrounding the venting subsidence feature was traversed in an effort to locate other fire related features; however, none were discovered.

It appears that this fire is likely intermittently active. When it is active, the fire is probably relatively low intensity. It appears that the fire is responsive to oxygen inputs as a result of mine controlled subsidence activity.

General Observations:

Evidence of fire was located on the sides of a subsidence feature that appeared to be recently active.

Other nearby subsidence features did not exhibit fire related phenomena.

An intimate relationship between the subsidence feature and the fire vent exists.

Fire activity is likely controlled by subsidence activity, with subsidence capable of alternately providing oxygen to the fire, or of potentially isolating the fire from an oxygen source.

This fire is of low grade, and shows signs of being intermittently active in small areas;

Wildfire hazard is low, given the dispersed nature of surrounding vegetation, and the low surface temperatures at the vents. Re-activation of subsidence activity could cause an increase in ground surface temperatures, thus elevating the wildfire hazard.

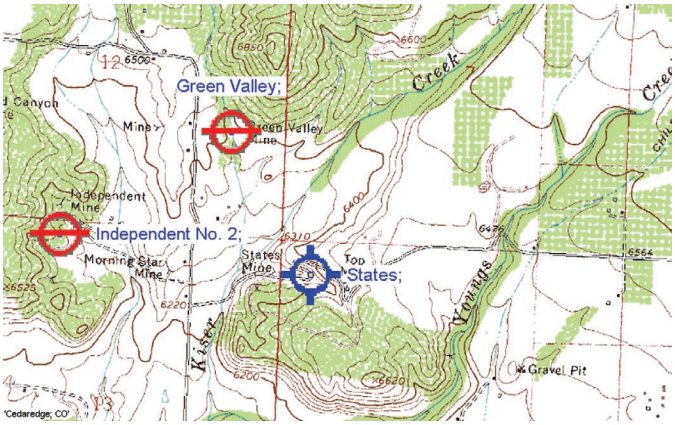
Public health and safety risk is low to moderate. The open nature of the area, and the apparently moderate activity level of the subsidence, could cause injuries should someone traverse the area.

Marshall Number 1 & 2 Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1863–1939	Laramie / *	Unknown	4	Drift	Unknown

* Not Reported

States Coal Mine Fire, view toward Southwest.



Location of States Mine Fire, and The Dormant Independent No. 2 and Green Valley Mine Fires. North at top.

DELTA COUNTY

States Coal Mine Fire

The States Mine Fire is located about two miles northwest of Cedaredge, in a small tributary to Kiser Creek.

The States Mine fire is located within a small east to west trending drainage. A county road accesses the base of the canyon and makes two switchbacks to climb out of the head of the canyon at its easterly margin. The mine fire is located on both the north and south facing slopes of the canyon, in the area of the two switchbacks. Annual grasses and weeds, and a few remaining pinyon pines, are located on the north-facing slope of the canyon, while vegetation on the south-facing slope is restricted almost exclusively to annual growth.

The States was the subject of an underground fire evaluation project conducted by the Division of Minerals and Geology in 1997. The purpose of the project was to drill into those portions of the mine that appeared to be most actively burning, based upon the surface expression of the fire. Drill holes were installed and completed to ensure communication between the mine and the atmosphere was minimized. Thermocouples were installed in the drill holes in order that underground temperatures could be monitored over time.

Five of these drill holes were found during a site visit in June 2002. The table on the next page summarizes the information from each drill hole.

The thermocouple data indicates that coal combustion at the location of the drill holes is minimal, at best; however, minor temperature elevation was noted at Drill Hole 4. This rise in temperature could be due to coal oxidation, or it could indicate that fire is occurring some distance from the well field, but is communicating with the fractures in the vicinity of this observation point.

Feature 1

Feature 1 is a series of parallel fractures located well above the canyon floor on the north-facing slope. These numerous fractures trend east to west, and are discontinuous over their length. The central portion of the fracture zone is located at 38° 55' 38.9", 107° 56' 54.9". Some of the fractures, which appear to be subsidence related, are greater than two feet in width by an undetermined depth. None of the fractures exhibited interior temperatures in excess of 80°. A small volume of moist air could be felt moving out of some portions of some of the fractures, apparently ventilating the underlying mine workings. Atmospheric measurements inside of one of the exhausting fractures showed oxygen at 9.6 percent, carbon monoxide at three parts per million, and methane at 0.2 percent.

Feature 2

Feature 2 is an eight inch diameter vent located at 38° 55' 40.7", 107° 56' 59.1", near the southwesterly portion of the surface expression of the fire. This vent exhibited a very strong odor of combustion, with creosote deposition around its margins. The exhaust was being displaced fairly rapidly, to the extent that an audible exhausting sound could be heard a short distance from the feature.

Feature 3

Feature 3 is a small set of subsidence fractures located on the north side of the canyon between the road switchbacks. Drill hole number 6 is also located here (38° 55'44.8", 107° 56'58.3"). These subsidence fractures trend east to west, but are much smaller and less numerous than those observed at Feature 1 on the south side of the canyon. The interior temperature of these fractures was measured at 110°. A faint combustion smell could be detected at this location, but no other evidence of exhausting combustion gas was observed.

General Observations:

This is a low activity fire, as evidenced by low surface temperatures at the features and drill holes.

It is probable that the Feature 1 fractures, because they are so extensive, provide some volume of air to the underlying mine.

The temperature of Drill Hole number 4 indicates that, at a minimum, oxidation, if not low level combustion, is occurring at or near this location.

Venting and creosote deposition at Feature 2 tends to support the heat data gleaned from Drill Hole number 4.

Human health hazard at this site is low to moderate, as the large subsidence fractures could cause injury to the inattentive hiker. However, the area is private property, and there are no cultural or natural features that would draw a person's interest to the site.

Wildfire hazard is moderate given the vast stand of annual grass. This is mitigated by the currently low surface heat values observed.

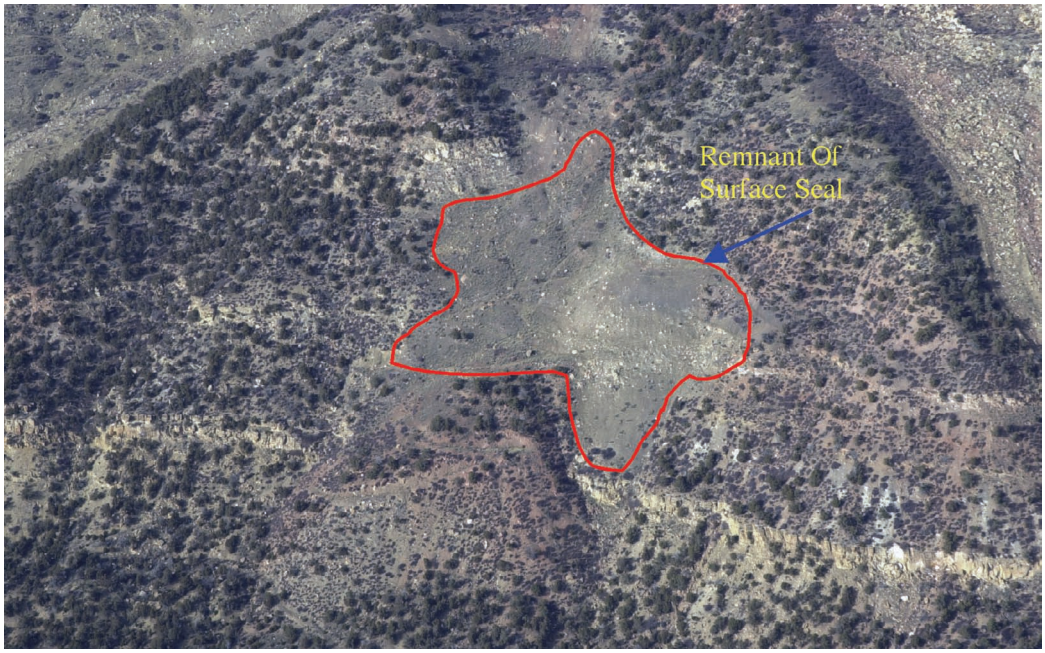
Drill Hole No..	Depth of Hole (Feet)	Thermocouple Depth / Temp.*	Comments
1			Could not locate
2			Could not locate
3	115	115' / 125°	"Thermo. at mine seam" written on cap
4	14	82' / 282°; 100' / 195°	Thermocouples (2) at different depths
5	135	No Measurement	Cap rusted in place
6	80	No Measurement	Cap rusted in place
7	63	Unknown / 80°	

* Degrees Fahrenheit

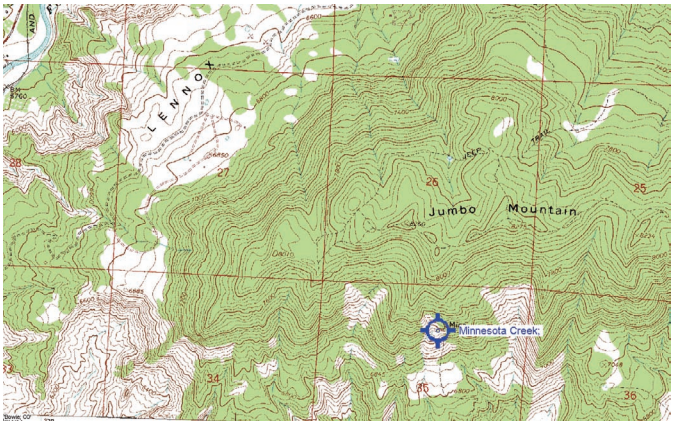
States Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1914 – 1951	Mesaverde / *	N 36 W	6	Drift	101,660

* Not Reported



Minnesota Creek Mine Fire. View to North.



Location of Minnesota Creek Mine Fire. North at top.

Minnesota Creek Coal Mine Fire

This site was visited on July 3, 2002. The fire zone is located east of Paonia, above Minnesota Creek on the south-facing flank of Jumbo Mountain. The fire zone, as seen from the County Road, located near Minnesota Creek, is characterized by a large, very apparent stand of dry annual grass or weeds. A few shrubs such as mountain mahogany and rabbit brush are present within the surface expression of the burn zone. Surrounding the fire zone is a healthy stand of piñon and juniper, interspersed with perennial shrubs. The property owner stated that the fire zone is the first area free of snow following a storm.

The fire zone is accessed by traveling across private property, using the old mine access road remnant. The road remnant roughly bisects the fire zone at about mid-slope, and is used to differentiate the upper and lower portions of the zone.

The Minnesota Creek fire was subjected to surface sealing efforts in the 1960's (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*). It is apparent that earth-moving operations on a large scale have significantly disrupted the land surface throughout the area. As a result, there is no evidence of the former location of the mine entries, and no evidence of coal on the ground. No subsidence features or other evidence of past mining activities was observed. Further, the mined outcrop is lost off-site as a result of spalling of overlying shale and sandstone sequences.

The lower portion of the burn zone is a steep slope approximately 400 feet parallel with contour, by about 300 feet perpendicular to contour. Ground temperatures within the lower portion of the burn zone varied from 125° to 150°. No vents or other fire related features were observed.

The upper area is similar, but less steep than the lower area. It is about 600 feet parallel with contour by 300 feet perpendicular to contour. This area characterized by a heavy stand of annual grass, with lesser amounts of shrubs within the burn zone. No vents were observed; however, a few small (four to six inches long) fractures were discovered. Temperatures within these fractures were measured at 160°. No other fire related features were found on the site.

General Observations:

The area has been highly disturbed by surface sealing operations. Thus, evidence of past mining activity is impossible to discern.

No significant fire related features were observed within the surface expression of the underlying fire.

No combustion smell was present, nor was sulfur or creosote deposition, or moss development observed.

This fire appears to be active, based upon vegetative changes and snowmelt observations, yet the level of activity is likely minimal.

Human health and safety hazard is low, given the lack of surface features.

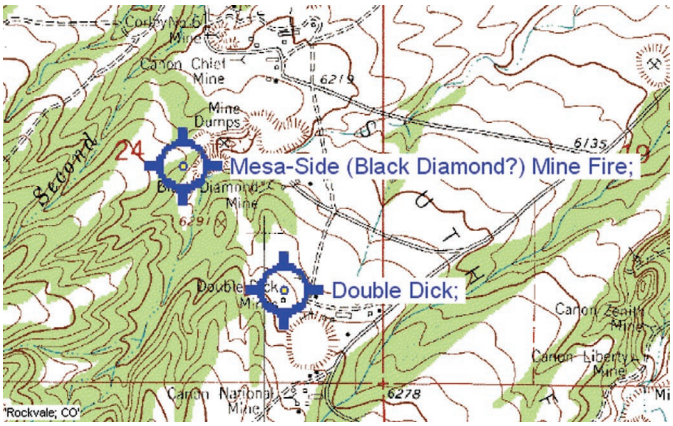
Wildfire potential is low, based upon the lack of surface venting and the lack of observable elevated surface temperatures.

Minnesota Creek Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1934–1936	Mesaverde / *	Unknown	Unknown	Unknown	Unknown

* Not Reported

Double Dick Mine Fire Vicinity. Features 1, 2, 3; from top to bottom. View towards North.



Location of Double Dick Mine Vicinity. North at top.

FREMONT COUNTY

Double Dick Vicinity Coal Mine Fire

The Double Dick Mine fire was visited on several occasions in 2002, 2003 and 2004. This fire is accessed by traveling south from Florence on Highway 67 to its intersection with Fremont County Road 15, then travel south on FCR 15 approximately 4.2 miles. The Double Dick site is located to the north of the county road on private property.

The Double Dick fire was noted as being active in 1982 (Rushworth et al, 1989). Control work was undertaken on a number of occasions by an adjacent mining company, and, in 1982 and 1984, by the Office of Surface Mining (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*). Generally, fire control work consisted of excavation of a trench that would serve as a barrier to fire progress. The initial trench was ineffective, as it was not constructed entirely in front of the fire, so combustion continued on both sides of the trench following its completion. Eventually, the trench was expanded. Post-construction evidence suggested that the fire still existed on both sides of the trench following the trench expansion work. Finally, a surface seal was constructed to help smother the fire.

During the field evaluations of the trench area, indications of underlying fire were observed. Two small fractures were observed to exist within the surface seal material; however, neither exhibits temperatures elevated above ambient conditions. These features are located at 38° 17' 26"; 105° 10' 04", and are seven to ten feet in length, by about two feet wide by about two feet in depth. Perhaps these fractures are a result of settlement resulting from the adjustment of burnt materials at depth. In February, 2004, a small subsidence-like feature located north easterly of the presumed trench location was observed to emit steam. A second, larger, subsidence feature was observed approximately 200 feet southerly of the small venting feature. This feature is located at 38° 17' 27.16"; 105° 10' 01.9". This feature, which measured approximately ten feet diameter by ten feet deep, was observed to discharge steam. Substantial moss development that occurs on the westerly side of the interior suggests that the feature has been open for some time. Ground surface temperatures within the feature were measured at about 95°.

A number of fire related features were observed to occur in the east facing side of a small mesa located immediately west of the trench area. Outward appearances suggest that portions of the east and the northeast sides of the mesa are cut features, possibly having been exposed during construction of the cutoff trench. The outslope of the mesa is characterized by loose gravel and cobble sized material. Although this material may have been dumped in this location, the coal that is burning beneath this

mantle is likely in-place, rather than dumped. The presence of mining-related subsidence features immediately west of the cliff face suggests that coal was extracted from beneath the mesa top. Therefore, it is assumed that the burning coal is related to the coal presumably extracted by the now-abandoned mining operation. Maps suggest that underground mining at this area may have been related to the Black Diamond Mine.

The fire zone is readily apparent as the mesa is approached from the east. The southerly portion of the mesa is defined by a gully or drainage that flows from the mesa toward the easterly cut or valley, and that separates the mesa from a larger upland area to the south. Vegetative growth on the mesa top at the vicinity of the fire related features is generally limited to small cactus and annual grasses and weeds.

Observable fire features on the mesa occur at its east face and the overlying crest. The characteristics of these features, moving from west to east are described below.

Feature 1

A set of small, discontinuous fractures that parallel the mesa crest are visible near the junction of the mesa top with the southerly gully or drainage. These southeast / northwest trending fractures have varying lengths and widths. The center of the fracture zone is located at 38° 17' 40.5"; 105° 10' 06.3". A discreet vent is located within the active fracture zone. Ground surface temperatures of about 100° were measured at the vent. Carbon monoxide was measured at four parts per million, with oxygen measured at 17.9 percent. An area of healing, and therefore presumably inactive, fractures is located immediately to the south. The appearance of the active fractures immediately north of and adjacent to the inactive fractures gives the impression that the fire is traveling in a northerly direction parallel with the coal outcrop.

Feature 2

Feature 2 is a small vent located at 38° 17' 41.0"; 105° 10' 04.7", which is about 125 feet north of Feature 1. This feature is also located immediately adjacent to the easterly facing crest of the mesa. This small and somewhat isolated vent had ground temperatures of about 114°.

Feature 3

Feature 3 is a series of parallel fractures located at a point where the mesa crest turns from an easterly to a northerly facing slope, approximately 95 feet north of Feature 2. At this point, a series of parallel fractures, measuring 50 feet in length by 15 to 20 feet in width, parallels the turn of the mesa crest. These features are parallel to the mesa crest, and proceed from just above the crest to below the crest. The southeasterly extent of these fractures exhibits significant creosote deposition, while the northwesterly margin did not. Ground surface temperatures through this area varied from 100° to 150°. The area appears to be unstable, as evidenced by elongation of the fractures and apparent down stepping of the features as they migrate down the slope of the mesa below its crest. It is not unreasonable to anticipate that a small scale slope failure will occur in this area.

Subsidence features located on the mesa in the vicinity of the fire related features were evaluated. These features, which are circular to rectangular, and occur both south of Feature 1 and due west of Feature 2, are closed, and do not exhibit elevated ground surface temperatures. It is presumed that these are mining related features, as opposed to fire related features.

General Observations:

Fire activity is observable on the east-facing crest of a small mesa located west of the cutoff trench. The northerly portion of the mesa appears to be a remnant of cut and fill activities associated with construction of the cutoff trench.

The fire appears to be low in activity, and fairly inefficient. It is possible that it is mainly located near the ground surface in the vicinity of the mesa crest.

All active fire related features were observed near the mesa crest, while subsidence features located on the mesa top did not exhibit fire related characteristics. This may indicate that the fire is located relatively near the mesa crest, and is not active further to the west.

Portions of the fire may become more active, particularly the Feature 3 area. This area appears to be unstable, and a small ground failure may occur at this location. If a failure occurs, fire activity may locally escalate as oxygen is more readily provided to the fire.

Limited indication of fire activity was observed in the presumed location of the cutoff trench located near Fremont County Road 15.

Human health and safety hazard is low, as the fire is located on private property behind a barbed wire fence.

Wildfire hazard is low, given low surface temperatures, and the lack of available fuels.

Double Dick Coal Mine

Years Operated	Formation/ Mined Seams	Strike	Dip	Mining Method	Total Production
1929–1968	Vermijo / Brookside	N 5 E	4	Drift	540,686

GARFIELD COUNTY

Thirteen fires at abandoned underground coal mines are known to be active in Garfield County. Each of these fires are burning in mines constructed in the Grand Hogback. The Grand Hogback is a regionally significant structural feature, which extends from about McClure Pass in Gunnison County northerly through central Garfield County to its terminus near Meeker in Rio Blanco County.

The Grand Hogback supported numerous underground mining operations. Coal varied in quality from anthracitic in the south to bituminous quality in the central and northerly mining areas. Currently, there are no active coal mines operating in the Grand Hogback.

The Grand Hogback is composed mainly of Cretaceous sediments, which have been severely uplifted on the northeast, creating a steep dip toward the southwest. Mine maps suggest that four or five seams were mined in the hogback. Some of the more significant mined seams were the U, Wheeler, D, and Allen seams. These four seams were the main coal producers in the Glenwood Springs to New Castle / Rifle mining district. Stratigraphic correlations have not been made for this report, and nomenclature is variable from area to area along the hogback. However, it is likely that these seams were the focus of most mining operations along the length of the hogback. Coal seam thickness varied across the hogback, thus dictating which seam(s) were mined at various locations. Thickness of any one seam can vary from a few feet to 15 feet or greater, with the Allen and Wheeler generally supporting a more consistent thickness of over 15 feet each.

Because the dip of the rock units within the hogback is severe, 55° dips are not uncommon. To compensate for these steeply pitched units, stope-mining techniques were utilized by early day operations. Many mining operations entered the coal seam low in a canyon, either directly or via a rock tunnel. Many of these mines were advanced along the strike of the coal, with rooms being developed up-dip. Pillars were left in place above the main entry, thus protecting the main, and allowing coal to be drawn from the overlying room for removal. This method of steep dip mining, which is similar to hard-rock stope mining methods, was common in the eastern Pennsylvania anthracite coal field. It is quite possible that miners with experience back east introduced this mining method to the Grand Hogback coal mines.

The stope-mining method presents almost ideal conditions to support underground abandoned mine fires. Stope subsidence creates numerous depressions and fractures at the land surface, generally parallel with the trend of the mine. When a fire is initiated in the main entry, the stopes act as chimney-like conduits for airflow, and thus heat. These stopes, once involved in fire, can permit the transmission of the fire to the overlying outcrop. Lateral spread of the fire through the outcrop is then possible. It is likely that this phenomenon has occurred at the South Cañon Number 1 mine, and most likely at the Sunshine, New Castle Number 1, Vulcan and Coryell mines.

Rifle Area Coal Mine Fires

Some confusion in nomenclature exists among four mines reported to have operated in the area. A canyon, locally known as Haas Canyon, bisects the Grand Hogback northeast of Rifle. Colorado Geological Survey data (Carroll and Bauer, 2002) indicates that the D & H, WH Canyon and IHI Number 3 coal mines were located on the westerly side of the canyon, while the Haas and IHI Numbers 1 and 2 and Black Raven coal mines were located on the easterly side of the canyon. Previous work by Rushworth and others, 1989, indicated that the Haas / IHI Numbers 1, 2 and 3, and the Black Raven coal mines were host to inactive underground fires. The same work indicated that the D & H and / or the IHI Number 3 mines were actively burning at the time of the field investigation.

Mine fires on the east and west sides of the canyon were visited as part of this study. In order to eliminate confusion, the westerly mine fire is referred to in this report as the IHI Number 3 coal mine fire. Because it was not possible to distinguish between the Haas and IHI Number 2, the easterly mine fire is referred to as the Haas (IHI Number 2) coal mine fire.

IHI Number 3 (D&H) Coal Mine Fire

The IHI Number 3 coal mine fire has been visited on a number of occasions since June 2002 for the purpose of gathering information for this report, and to evaluate site conditions.

This fire has been the scene of a number of abatement measures conducted by various governmental entities. Abatement activities have included blasting, surface sealing, and injection of foaming grout into the fire zone (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*). As a result of these activities, the land surface is highly disturbed, and bears little resemblance to its condition during mining activities.

The area is generally characterized by an approximately north / south trending ridgeline protruding perpendicularly from the trend of the Grand Hogback. The fire is located in this ridge. The central portion of the area is located at approximately 39° 37' 14.1"; 107° 44' 05.9".

Two distinct fire zones are observable at this site. The more significant zone is located on a bench located towards the westerly portion of the area. A smaller, east fire zone is located adjacent to the bench access road. Small vents from the east area are apparent adjacent to the road in sandstone outcrops, and, to a lesser extent, immediately below the access road.

West Fire Zone

A large bench has been constructed from which the active fire zone was penetrated by drilling operations. Numerous borehole casings are located on the bench and on the southerly facing bench outslope. Many of these casings have thermocouples installed; however, none of the thermocouples were operational during a June 2002 visit. A smaller road traverses the southerly side of the bench at its toe. Fire activity is expressed primarily along the margins and outslopes of the bench. Many zones of hot materials and some fracturing may be observed from the inside of the two lower access roads, along the bench outslope, trending west to northwest around the center of the bench to a sandstone outcrop immediately northwest of the westerly terminus of the bench.

Surface temperatures measured along the bench were:

Northwest on bench surface: 200° to 300°.

Northwest on outslope of bench; five to ten small (less than six to eight-inch diameter) vents: 300° to 400°.

Southerly bench outslope (fifty feet south of northwest corner of bench): 300° to 500°.

Northwest outslope of lower road cut: 150° to 500°.

East Fire Zone

As noted above, some fire features exist adjacent to the bench access road. These are located in sandstone outcrops westerly of the access road, and in fill material below the road and east bench area.

The vents at the road cut slope are approximately three feet by 18 inches by unknown depth. These appear to vent from fractures developed in the sandstone. A small subsidence feature, about two feet in diameter, is located immediately off the road, and about three feet higher in elevation. This feature vents at 250°. Below the road along the fill portion of the eastern section of the bench is a series of small, discontinuous fractures and vents. These features were measured to vent at 400°.

A relatively new subsidence feature has developed at a much lower elevation than the fire zone in colluvial material near the bottom of the canyon. This feature is located about three hundred feet west of the canyon road. The feature is approximately four feet deep by 20 feet in diameter. The feature, which is likely the result of a collapsing rock tunnel, does not exhibit elevated heat values. Potentially, this feature could act as a conduit to provide oxygen to the fire.

General Observations:

This is an active fire that is venting from a number of locations including near the access road, below the constructed bench and at the west side of the bench.

The westerly portion of the bench is very hot and active, as evidenced by greatly elevated surface temperatures and the large open vent in that area.

Portions of the fire are more efficient than others. Some vent areas are characterized by sulfur and creosote staining, while the hottest vents do not have such by-product deposition.

It appears likely that past abatement efforts have bifurcated the fire into separate, smaller subsurface burning zones.

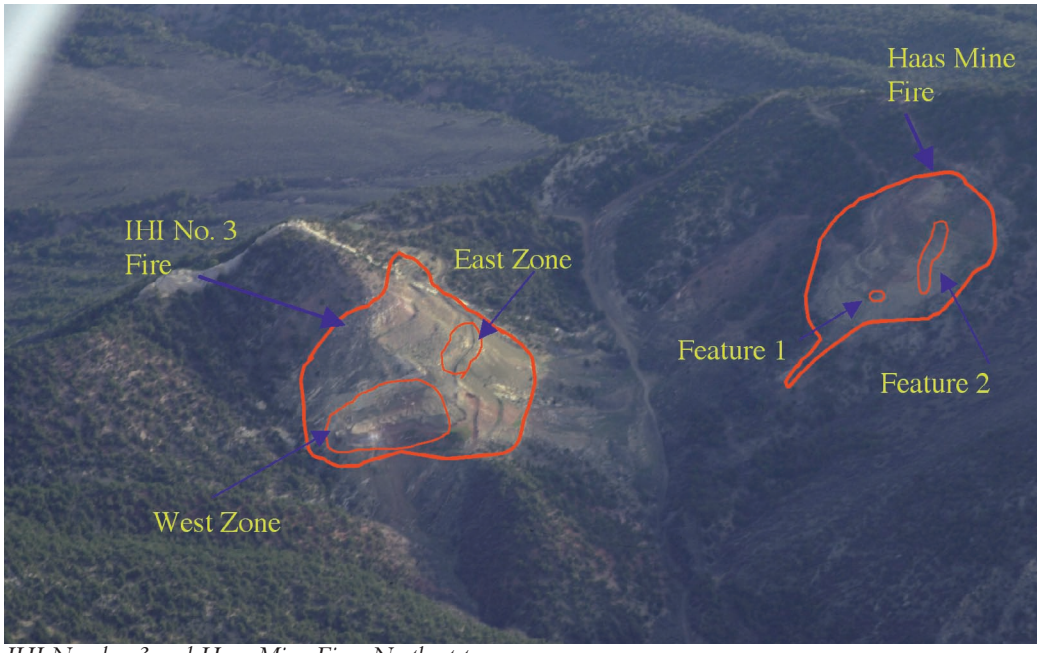
Surface disturbing efforts at fire abatement may complicate control efforts due to increased fracturing of the rock, allowing for increased oxygen availability as the surface cap is altered over time.

Wildfire hazard is moderate at this site, given the vent temperatures at the west side of the bench. Vegetation is sparse in the immediate vicinity of the fire.

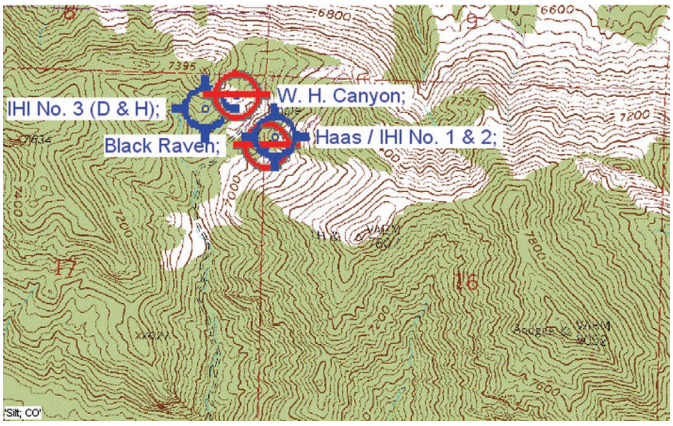
Public health and safety risk is high at this site given the relative ease of access, the high temperatures, and the open vent on the west side of the bench.

IHI No. 3 Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1953–1954	Mesaverde / Wheeler	N 75 W	57 SW	Stope	51,804



IHI Number 3 and Haas Mine Fires. North at top.



Locations of the IHI No. 3 and Haas active Mine Fires, and the Black Raven, W.H. Canyon and IHI Numbers 1 & 2 dormant coal mine fires. North at top.

Haas (IHI Number 2) Coal Mine Fire

This site was visited on March 7, 2003 for the purpose of investigating a fire previously mapped as being dormant. This site is located immediately east of, and across the canyon from, the IHI Number 3 Coal Mine Fire. The surface expression of this fire is located on a west to southwesterly facing flank of the Grand Hogback, approximately 300 feet above the canyon floor. The surface expression of the fire is estimated at three to five acres.

A road, discontinuous at times, traverses the east side of the canyon, eventually ending at the site. Mine fire features are located on the side of the canyon, roughly on a southerly facing bench, on or adjacent to the road system. It appears that the road system may have been constructed to provide access for heavy equipment for the purpose of constructing a surface seal over this fire. The ground surface above the fire is heavily disturbed, making interpretation of the mine features difficult.

Two important fire features were identified.

Feature 1

Feature 1 is a circular subsidence event approximately 15 feet in diameter located at 39° 37' 10.3"; 107° 43' 54.3". The smell of coal combustion is discernible in the vicinity of the feature. Within the feature, a white, incompetent material is visible. This material is reminiscent of rock ash, probably as a result of extremely elevated temperatures at one time. The feature is approximately four feet deep, with a single chimney vent located at its base on the west to south west side. The chimney ground surface temperature was measured at 280°.

This feature is on-strike with two other small step-like depressions or benches located approximately 100 and 150 feet, respectively, down slope of the feature. These features may be mine entries. They are on strike with a remnant wood tower / support / loadout structure located further down slope. If these are entries, it is possible that Feature 1 may be located over a main haulage way, and Feature 2 may be located down dip of the mined area, either on the subsidence angle of draw, or above the mine back on the main entry.

Feature 2

Feature 2 is an approximate 80 feet long by 15 feet wide subsidence feature with parallel fractures on either side. The feature trends northeast to southwest, parallel with the slope. The feature narrows at the uphill side to isolated, discontinuous one-foot diameter vents. The lower portion of the feature vents exhaust gasses at 280° to 400°, while the upper area vents at 60° to 80°

Satellite geometry did not allow for GPS location measurement; however this feature is approximately 200 feet east and 50 feet upslope from Feature 1.

The surface trace of the fire zone continues uphill about 200 additional feet from Feature 2 to the upper-most road trace. No significant fire-features were located in this area.

General Observations:

Diffuse surface heat, probably due to the steep dip of the hogback heating stratigraphically overlying materials.

No mineral, sulfur or creosote deposition was observed.

Ash deposit at side of Feature 1 indicates it was very hot and active at one time.

Appears to be low fire activity but fairly efficient.

Possible discrete burn zones underground.

Low surface fire hazard due to limited vents, low vent temperatures and sparse vegetation.

Low public safety hazard due to remoteness of the site, and lesser visibility than the IHI Number 3 site.

Haas Coal Mine (IHI No. 2)

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1946–1957	Mesaverde / Wheeler	N 75 W	57 SW	Stope	65,587

Grand Hogback North of New Castle

Three underground mine fires exist in the Grand Hogback roughly west and north of New Castle. Previous work by Rushworth el al, 1989, referred to these fires as Burning Mountain 1, 2 and 3 from south to north, respectively. In order to eliminate confusion, these fires are referred to in this report by the name of what appears to be the associated coal mine. The previously named Burning Mountain Number 1 fire is referred to as the New Castle Number 3 mine fires, the previously named Burning Mountain Number 2 is referred to as the Elk Creek Mine Fire, and the previously named Burning Mountain Number 3 is referred to as the Morgan Mine Fire.

New Castle Number 3 Coal Mine Fire

This site, visited on June 20, 2002, is located on the main ridgeline of the Grand Hogback, immediately west of the town of New Castle. As is typical with Grand Hogback mine fires, the surface expression of the fire is located on the flank of the hogback, in this case the easterly facing flank. Mine entries were located lower on the slope, apparently just above the elevation of nearby Highway 6 & 24. The Division of Minerals and Geology constructed a fence near the base of the hillslope to minimize access to the fire zone in the early 1990s.

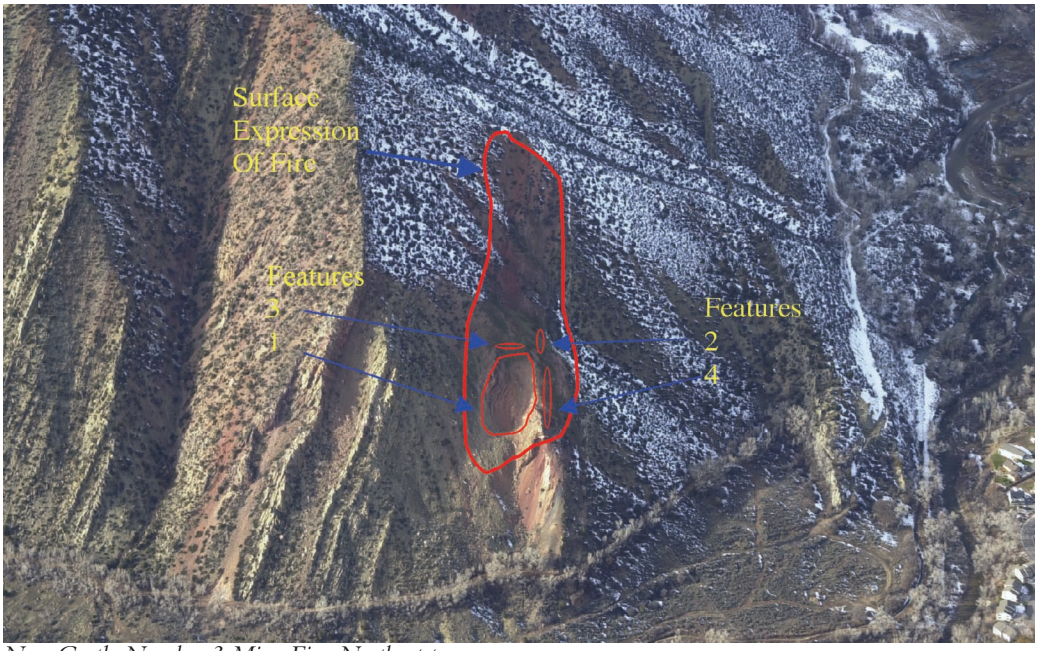
The site is readily visible from westbound Interstate 70, and appears as a very large, oblong shaped subsidence feature, characterized throughout by red clinker. The surface expression of the fire continues northerly along the hogback parallel with strike for approximately 300 feet. Little venting has been observed in this northerly area, but annual grasses and weeds predominate, with a few small low temperature steam vents present as well. Four significant fire related features were observed at the site.

Feature 1

This is the large, oblong subsidence feature visible from New Castle and Interstate 70. The estimated dimensions of the feature are 75 feet by 200 feet with the axis of the feature being perpendicular to the hillside contour.

Temperatures within the feature vary from 120° to 160°. The interior has a large fracture venting at the high end of the temperature values. This fracture is estimated to be 30 feet long, four feet wide and two feet deep. The fracture experiences areas of fill and collapse, and therefore appears discontinuous. The exterior, or perimeter, of the feature exhibits temperatures at the lower end of the scale.

Smaller fractures and vent zones are located north and south of the large subsidence feature. These exterior features are located at approximately the same elevation as the basal elevation of the large subsidence feature. The southerly most fracture in this area is 15 feet long, averages 20 inches wide, has an unknown depth, and trends north to south. Due to colluvial slough and intermittent healing, this system appears to be discontinuous. Ground surface temperatures along this feature vary from 160° at the southerly end, to 310° at the northerly end. The smell of combustion gas is very noticeable, even in a slight breeze.



New Castle Number 3 Mine Fire. North at top.

Feature 2

Feature 2 is a venting fracture 80 feet by two to four feet by an unknown depth. This feature trends northeast to southwest, and is located north of, and slightly higher in elevation than Feature 1. Ground surface temperatures at the southwest end of the venting fracture were measured at 500°. This feature has developed in altered shale materials. This feature is located at 39° 34' 23.4"; 107° 32' 37.7".

Feature 3

Feature 3 is another fracture system, located about 20 feet uphill and west to northwest of Feature 2, but at a slightly higher elevation. This system is located on the south-facing slope above Feature 1, approximately seven feet below the ridgeline. Ground surface temperatures at this location were measured in the 200° range.

Feature 4

Feature 4 is a series of very hot vents located at or immediately north of the ridge crest. These vents are visibly exhausting heat at a relatively high velocity. Ground temperatures at this location were measured at 360°. This feature is located at 39° 34' 23.8"; 107° 32' 37.9".

Little to no vegetation exists at the locations of these more severe vents. However, an annual grass community exists over the burning mine north of the ridgeline. No large vents were observed in this area, but a distinctive vegetative change is apparent in this area.

General Observations:

This is an active fire, and exhibits chimney development characteristics.

The most significant vents are located over an approximately one acre area.

Less significant heat values are observed at the annual grass covered area northwest of the main fire zone.

A relatively significant air intake may be located down slope, presumably near the former location of the mine entries.

Due to the steepness of the Hogback slope in this area, it is likely that only helicopter access would be available for future work.

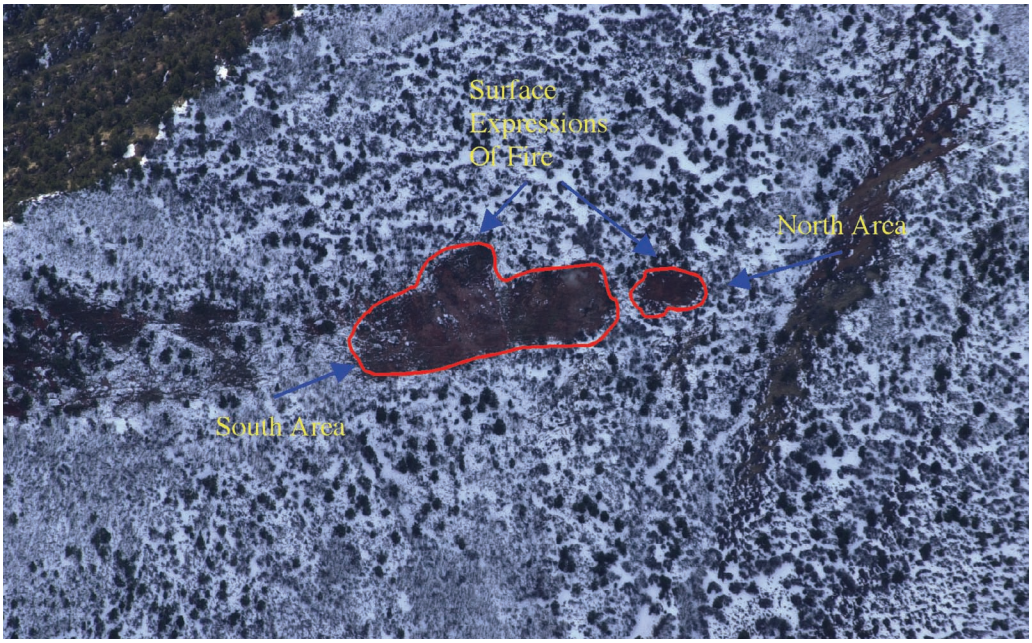
There is a moderate surface fire hazard due to the elevated surface temperatures and the stand of annual grass in the vicinity.

There is a low public safety hazard due to the relative inaccessibility of the site.

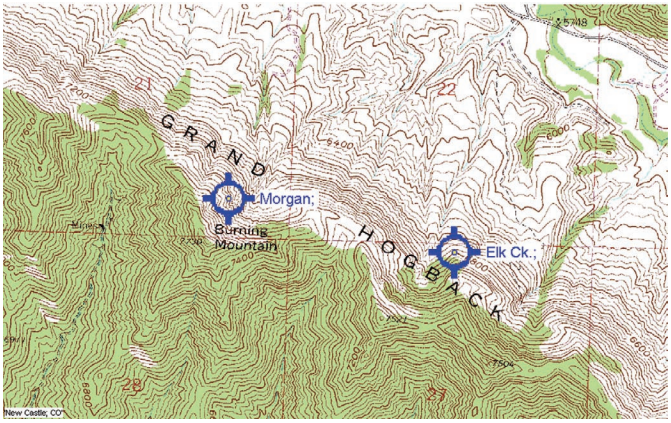
New Castle Number 3

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
No Data Found	Mesaverde / *	N 65 W	56 SW	No Data Found	No Data Found

* Not Reported



Morgan Mine Fire. View toward West.



Locations of Morgan and Elk Creek Mine Fires. North at top.

Morgan Coal Mine Fire

This site, located on the east flank of the Grand Hogback, approximately four miles north west of New Castle, was identified as the Burning Mountain Number 3 Coal Mine Fire by Rushworth, et al in the1989 report. This name was given to the site because no definitive evidence of a mine exists for the site. However, visual evidence suggests that this fire may be related to the Morgan / Silt / Llewellyn Mine(s). For clarity and to remove confusion caused by the name Burning Mountain, a name used locally to describe a specific area near New Castle, the site is referred to in this report as the Morgan Coal Mine Fire.

During the field investigation of this site, no evidence of mine related facilities were observed on the east side of the Grand Hogback in the vicinity of the site. However, mine remnants located in the westerly side of the hogback appear to correlate with the general location of this fire. These remnants appear to be that of the Morgan Mine. Therefore, it is assumed that the Morgan Mine is the origin of this event.

This site was visited on June 24, 2002. The fire is located below the crest on the east side of the Grand Hogback. The hogback is extremely steep in this area, and no roads are present in the vicinity of the fire zone. The area was accessed by hiking easterly over the hogback crest from a canyon on the west side of the hogback.

Fire activity is apparent in what appears to be a coal outcrop located on the east-facing portion of the Grand Hogback. The area is characterized by altered red to pink shale outcrops surrounded by annual grass. An oak brush community predominates off of the burn zone. The shale / scoria outcrops support the majority of the observable vents.

The fire zone is relatively small, at about two acres or less in size. The fire has two areas that support fire venting activity. A small area of inactivity separates these northerly and southerly areas. Vents located in the northerly portion of the area have temperatures of up to 150°. Some sulfur precipitate is observable at a few vents. The approximate center of the northerly area is located at: 39° 35’ 38.5”; 107° 36’12.2”.

A large, subsidence feature, estimated at 20 feet by five feet by four feet depth, is located immediately uphill of the northerly area. This feature appears to be an inactive vent that no longer displays elevated heat values.

The predominant vent located in the southerly portion of the area has a ground surface temperature of 140° degrees. Sulfur precipitate is present at this vent. This southerly vent is located at 39° 35’ 37.1”; 107° 36’ 10.7”.

General Observations:

This is a low temperature fire, probably smoldering, rather than aggressively burning.

The fire is slowly burning, and may be reaching the upper limits of the outcrop, and thus the end of its fuel source, unless it migrates parallel with the outcrop.

The fire is moderately inefficient, as witnessed by the sulfur deposition in both burn areas.

Surface fire hazard is low at this site, due to a lack of vegetative cover, and low surface heat values.

Because of its very remote location, the site poses a low public safety risk.

Morgan Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1929–1941	Mesaverde / Wheeler	N 70 W	53 SW	Stope	11,640

Elk Creek Coal Mine Fire

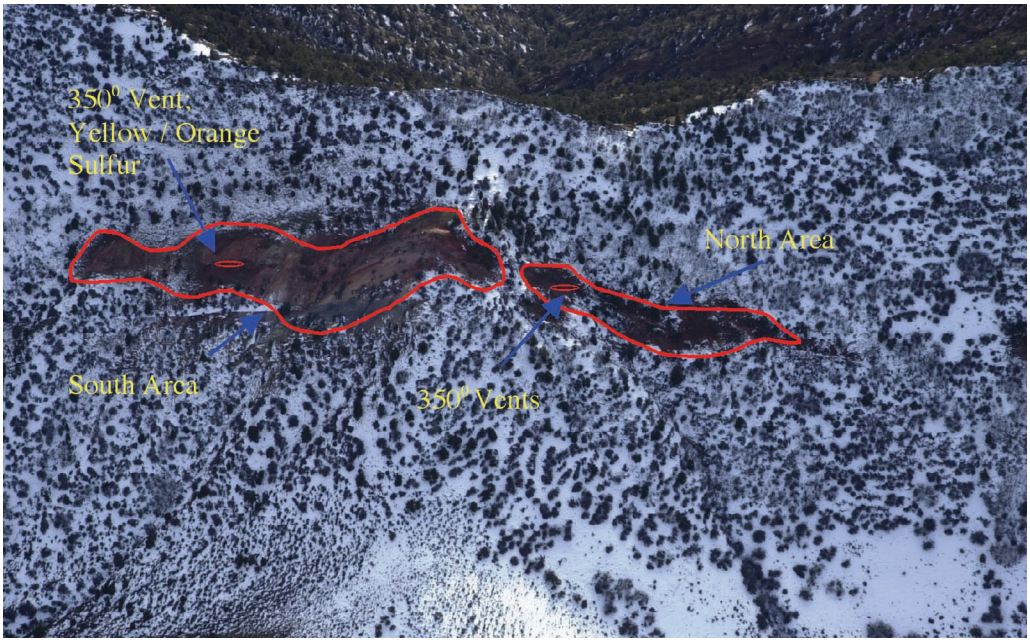
This site, located on the east side of the Grand Hogback about three miles north of New Castle, was identified as the Burning Mountain Number 2 Coal Mine Fire by Rushworth, et al in their1989 report. This name was given to the site because no definitive evidence of a mine exists for the site; however, anecdotal evidence suggests that this fire may be related to the Elk Creek Mine. For clarity and to eliminate confusion caused by the name Burning Mountain, a name used locally to describe a specific area near New Castle, the site is referred to in this report as the Elk Creek Coal Mine Fire.

During the field investigation of this site, no evidence of mine related facilities was observed on the east side of the Grand Hogback in the vicinity of the site. However, Carroll and Bauer, 2002, documented that the Elk Creek Mine was located within about one half mile of the observed location of the surface expression of this fire. For purposes of this report, a correlation between the mine and the fire is assumed.

This site was visited on June 24, 2002. The fire is located below the crest on the east side of the Grand Hogback. The hogback is extremely steep in this area, and no roads are present in the vicinity of the fire zone. The area was accessed by hiking over the crest of the hogback from a canyon located on the west side of the hogback, then following game trails from the surface expression of the Morgan Mine fire.

This fire is larger than the Morgan site, expressing itself over perhaps four acres. The fire zone trends parallel with the stratigraphy of the area, and likely vents in shales that overlay an unseen coal seam. From north to south, the fire area begins on the side of a small, transverse canyon near the crest of the Grand Hogback, and follows strike through a ridgeline into an adjacent transverse canyon. The portion of the fire zone within the canyon may be divided into a northerly and a southerly burn zone. The intervening areas are without elevated heat values.

Fire characteristics are first observed about 100 feet north of the ridgeline in the form of small vents and vegetative changes. The center of this area is located at 39° 35’ 21.9”; 107° 35’ 20.6”. The westerly portion of this area displays a significant amount of white, sulfur precipitate around active and abandoned vents. Vents in this area exhibit ground surface temperatures of about 190°. The easterly portion of the area is apparently more active and more efficient. No sulfur was observed in the east vent area, however ground surface temperatures of 350° were observed at some vents.



Elk Creek Mine Fire. View towards West.

Further to the south, a second set of vents occurs. These vents display ground surface temperatures of about 350°. The most significant vent in the area is an eight-inch diameter vent that extends horizontally into the Hogback. Yellow and orange sulphur precipitate was observed at this vent. More typical of the vents at this southerly area are ground temperatures in the 180° to 250° range. The approximate center of the easterly area is located at 39° 35' 20.1"; 107° 35' 15.9".

Vegetative cover near the southerly vent includes mountain mahogany, oak brush and cheat grass and low-lying forbs to within 50 feet of the fire zone. The northerly area is generally barren of vegetation.

General Observations:

This is a fairly active fire, as evidenced by the heat values registered at some of the vents in each burn area.

The fire is spatially intermittent, as suggested by the distinctive burn zones and intermediate relatively cool area.

The fire presents itself to be progressing northerly beyond the transverse ridge line.

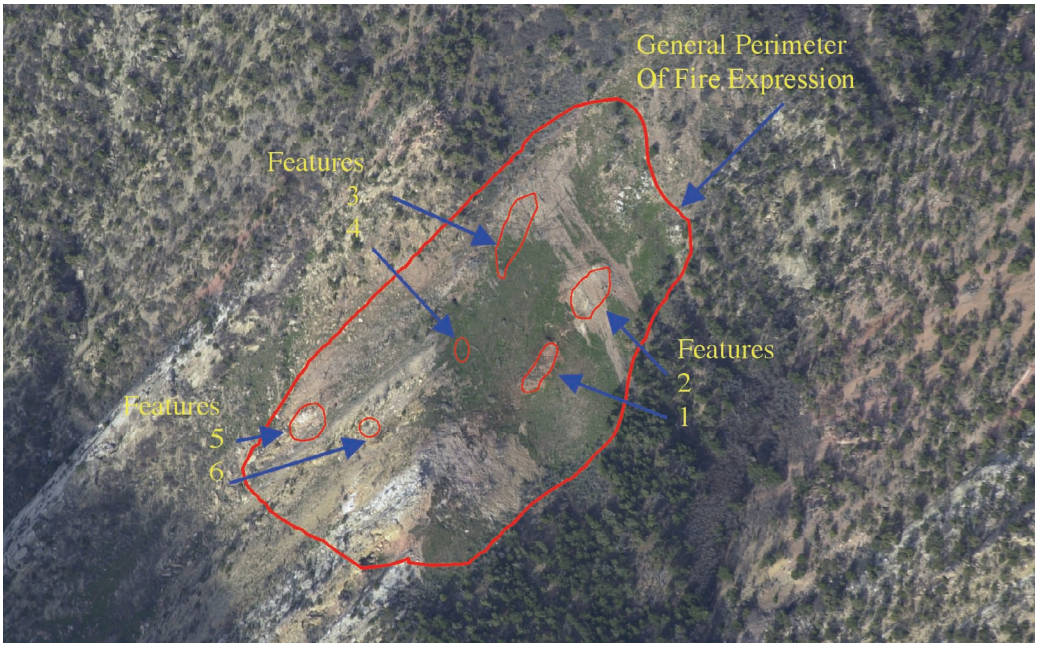
Wildfire potential is low because substantial growth is relatively far from the hot vents.

Public safety risk is low for this mine fire due to the difficulty in accessing the site, given the severity of the slopes in the area.

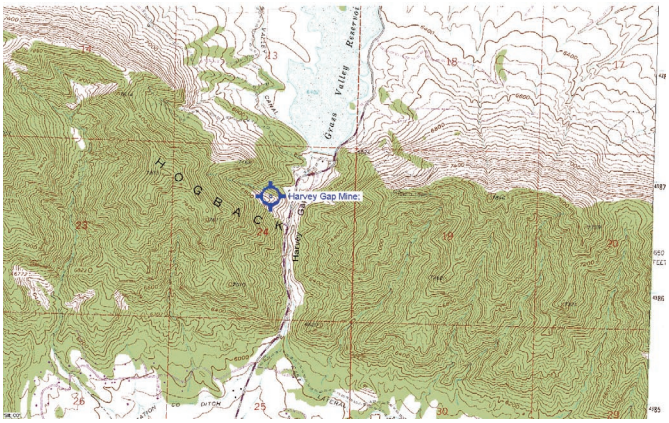
Elk Creek Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1896–1936	Mesaverde / *	N 73 W	54 SW	Drift	3,171

* Not Reported



Harvey Gap Mine Fire. View to Southwest.



Location of Harvey Gap Mine. North at top.

Harvey Gap Coal Mine Fire

The Harvey Gap Mine fire is located within a steep east to west trending ridge within the Grand Hogback, just south of the Grass Valley Reservoir. The site, located about four miles north west of Silt, can be accessed by driving north from Silt on the Grass Valley Reservoir Road.

The Harvey Gap mine apparently used multiple entries, generally located slightly above the current county road elevation, to gain access to two or three different coal seams. As a result of the multiple entries, the mines are tabulated on state records as the Harvey Gap Numbers 1, 2 and 3. Work by the Division of Minerals and Geology (Amundson, 2003) suggests that two mines and an intermediate rider seam are burning at this location.

The main surface expression of the underground fire exists on a north facing ridgeline. From the Grass Valley Reservoir dam, the burn zone appears to be an approximately three acre area of annual grasses that extends from just above the base of a small side canyon to the east west trending ridgeline. The stand of annual grasses is sharply contrasted by the surrounding piñon juniper forest. Venting of the underlying fire is generally observed to occur at the base of a steeply dipping sandstone that forms the ridge crest. Additional venting may be observed at two locations south of the ridgeline; one vent is located on the south facing side of this ridgeline, and another is located further south near the base of a small drainage that separates the venting ridgeline from a parallel, southerly ridgeline.

This site was visited on multiple occasions in 2002 and 2003. Subsequent to these visits, the Division conducted an abatement project in September and October 2003. The Harvey Gap Coal Mine Fire Project addressed two coal mine fires and a small outcrop fire located between the two mined seams. See the section of this report, titled "Status of Sites Where Underground Fire Control Work has Been Accomplished", for details regarding this project.

Feature 1

Feature 1, located about mid-slope on the north facing portion of the ridgeline, is situated at 39° 36' 04.0"; 107° 39' 54.3". This feature is an outcrop of altered sandstone and shale that is pale red in color, and measures 15 feet by 30 feet. Ground surface temperatures of the outcrop were measured at 220° to 350°. No open vents were observed at this location. No vegetative growth occurs at the outcrop.

Feature 2

Feature 2 is another altered sandstone and shale outcrop, located 50 feet west of Feature 1. The sandstone and shale material at this location is pale tan to buff in color. Heat values here did not exceed ambient conditions of 80° to 105°. Interestingly, mine

atmosphere could be detected at this location, apparently venting the underground workings. Depending on atmospheric conditions, this area could provide oxygen to the nearby fire.

Feature 3

Feature 3 consists of a series of parallel, discontinuous, low temperature vents located at the base of a sandstone outcrop. The center of this 50 feet long series of vents is located about 100 feet higher in elevation than Feature 1 at 39° 36' 08.5", 107° 39' 56.6". Ground temperatures at this series of vents varied between 125° and 150°. Steam was observed to exhale from these features, which were moist at the ground surface.

Feature 4

Feature 4 is an approximately three feet by four feet by unknown depth vent, located at the base of the steeply dipping sandstone, approximately 150 feet east of Feature 3. The ground temperature of this vent, located at 39° 36' 08.9", 107° 39' 56.6", was measured at 250°.

Further to the east, as the ridgeline begins to fall rapidly toward the Grass Valley Road, a number of subsidence features exist. These generally occur at the base of a sandstone outcrop. The further uphill features were observed to vent at temperatures to 150°. Those features located further downhill were not observed to exhibit elevated temperatures. It is unknown whether these features serve to ventilate the fire or not.

Feature 5

Feature 5 is a heat altered area located on the south facing side of the ridgeline at 39° 36' 08.6"; 107° 39' 55.4". This 40 feet (on strike) by fifteen feet (perpendicular to strike) area is located between a stratigraphically overlying white sandstone and an underlying buff sandstone. This area represents either a small rider seam, or a coal sequence accessed by another, southerly mine entry. The ground surface temperature in this area varied between 230° and 331°. An approximately eight-inch diameter, horizontal vent is located near the base of this area. The vent was observed to audibly exhaust very hot combustion gas. Significant sulfur deposition was present at the vent and in its immediate vicinity. The ground temperature at the vent was measured at 575°.

Feature 6

Feature 6 is a vent located near the groin of the drainage immediately south of the ridgeline. This area represents either a small rider seam, or a coal sequence accessed by another, southerly mine entry. Temperatures at this vent were measured at near 400°.

General Observations

It appears that three to four coal seams may be burning in this location. Some of the burning coal sequences may be small rider seams that over – or – under lie a mined seam.

The surface expression of the fire appears to be more localized, yet hotter, on the south side of the ridgeline. The fire(s) are likely better ventilated, and possibly located closer to the ground surface in this area.

The fire that is expressed near the ridgeline appears to be moderately active, and is likely located deeper within the ridge than are the more southerly fires.

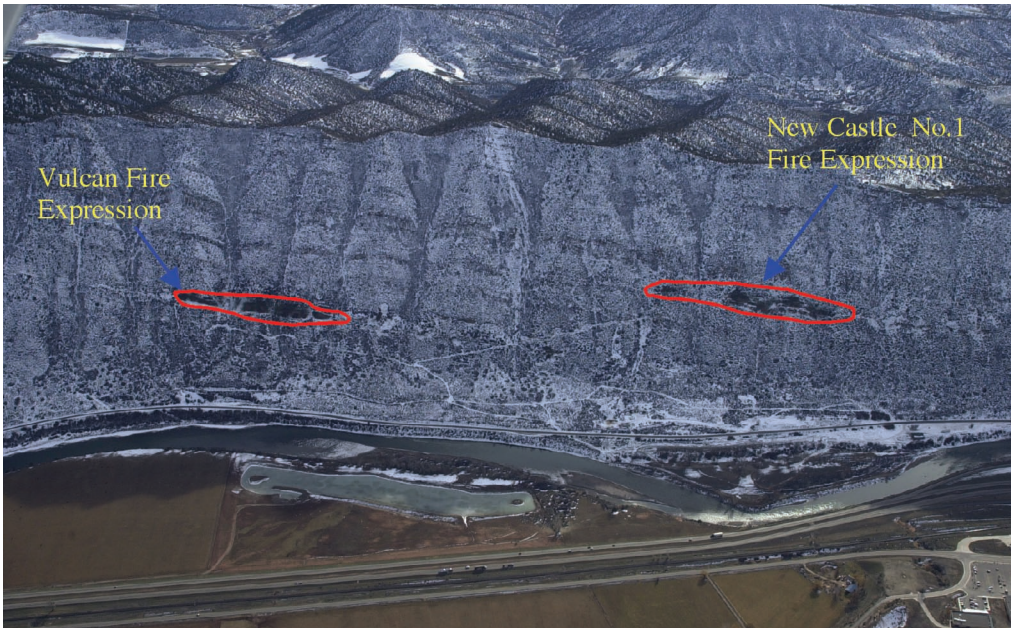
This area posses a moderate wildfire hazard due to the proximity of the ridgeline vents to adjacent vegetation and to annual weed growth.

The area poses a moderate human health and safety hazard, due to the hot surface temperatures at the southerly vents, and due to the open vent at Feature 4.

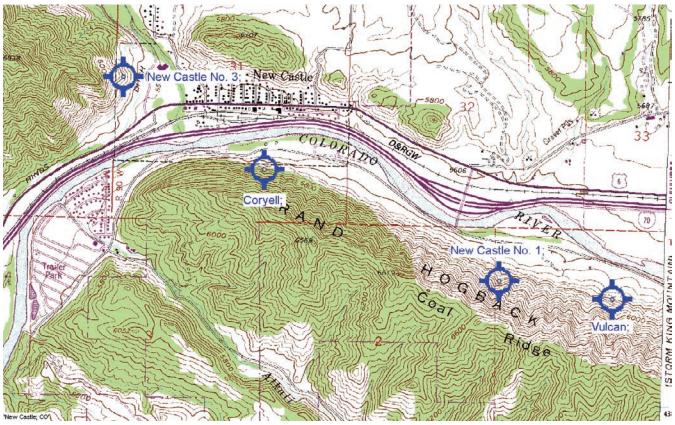
Harvey Gap Coal Mines 1, 2, 3 (Undifferentiated)

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1913–1968	Mesaverde / *	N 74 W	50 SW	Drift	84,109

* Not Reported



Vulcan and New Castle Number 1 Mine Fires. View toward South.



Locations of the New Castle Number 3, Coryell, New Castle Number 1 and Vulcan Mine Fires. North at top.

Grand Hogback, South Of Interstate 70

Possibly the best known sequence of underground coal mine fires are those located on the slope of the Grand Hogback, south of New Castle and the Colorado River facing Interstate 70. The fire zone is readily visible from Interstate 70 and is well known by highway travelers. The underground mine fires located along this portion of the Hogback provide a sufficient amount of heat to prevent snow from sticking in the winter, and to promote a healthy stand of bright green annual grasses in the spring. The annual grass growth, as does the absence of snow, provides a stark and visible contrast with the adjacent, unaffected areas.

Three mines appear to be burning in this area. From west to east, the mines that are burning are the Coryell, New Castle Number 1 and Vulcan. Historically, the McDonald Mine was thought to be burning, rather than the New Castle Number 1. However, Carroll and Bauer, 2002, indicate that the McDonald was an exploratory operation, and did not produce a significant amount of coal. The nearby New Castle Number 1 was a large operation that experienced a methane explosion in 1901. Due to the reported location of the New Castle Number 1 relative to the observed fire location, the volume of coal production and the 1901 underground explosion, it is presumed that the new Castle Number 1, rather than the McDonald, is burning at the mapped location.

Observation of the surface presentation of the fire indicates that two different seams are burning. It is presumed that the Allen seam is involved in fire at the Coryell and New Castle Number 1 mines, with the overlying Wheeler seam burning at the Vulcan.

Vulcan Coal Mine Fire

The Vulcan site was visited on June 19, 2002. The entire burn zone is easily distinguishable by the presence of dried cheat grass for much of the summer and early fall months. The westerly –most area exhibiting fire characteristics is located at 39° 33' 39.4"; 107° 30' 24.1". A small, closed subsidence feature may be found at this location. The periodic smell of coal combustion can be picked up near this westerly margin of the fire zone, although no vents were readily identified. Ambient ground temperatures of the fire zone were measured at approximately 115°. Temperatures measuring in the vicinity of 140° to 145° were observed within the subsidence feature.

Feature 1

Feature 1 is a narrow fracture about 50 feet long, three feet wide and two to three feet deep. The feature trends parallel with the contour. Ground surface temperatures within the fracture were measured at 150° to 180°. The smell of coal combustion was apparent at this feature site, which is located at 39° 33' 36.2"; 107° 30' 12.9".

Feature 2

Feature 2 is a large area located well upslope, and about 200 yards westerly of what appears to be the abandoned Vulcan Mine loadout. This feature presents itself as a barren area on the coal outcrop. A significant amount of white, sulfuric precipitate is present on the outcrop. This area is easily discernible from Interstate 70. This area appears to be a vent that displays a low level of activity. Surface temperatures were measured at 100° to 120°. Above average ground moisture indicates that some degree of vent activity exists. This feature is located at 39° 33' 33.3"; 107° 30' 02.5".

Feature 3

Feature 3 is located easterly of Feature 2 at 39° 33' 33.3"; 107° 30' 02.0". This feature consists of a series of three to five steaming, low temperature vents located just above, and parallel with, the coal outcrop. Ground surface temperatures were measured at 90° to 130°. Both sulfur and creosote were observed to be horizontally distributed along the face of this feature.

Feature 4

Feature 4 is similar to Feature 2 in that it presents characteristics of a low temperature area venting inefficient fire activity. Ground surface temperatures were measured at 105°. Interestingly, this vent area is likely fracture controlled, as the vents are vertically distributed, rather than occurring parallel with the outcrop. The area is generally barren of vegetation, with vents occurring in an altered shale outcrop. Minor sulfur deposition and some wet spots are observed here. This feature is located at 39° 33' 33.1"; 107° 29' 59.5".

No fire features were observed to occur beyond, or east of, Feature 4. Therefore, it is assumed that Feature 4 establishes the eastern margin of the Vulcan Mine Fire zone. However, a collapsed shaft / mine entry was observed at 39° 33' 30.5"; 107° 29' 51.8". It is unknown what, if any, relationship this feature may have with the Vulcan Mine, or with the fire.

General Observations:

The Vulcan Mine Fire is likely a diffuse, low temperature fire.

The mine is burning intermittently in distinct areas.

The fire may have migrated into the overlying seam.

Micro-fractures providing an air source are plentiful over the fire surface as a result of the numerous small subsidence features that are present.

Public safety hazards are low, given the low temperatures, and lack of large or open vents.

Wildfire hazard potential is low, given the low ground surface temperatures.

Vulcan Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1892–1918	Mesaverde / Wheeler (E, Allen?)	N 63 W	47 SW	Unknown / Shaft Entry	17,478

New Castle Number 1 Mine Fire

The New Castle Number 1 Mine Fire was visited on June 19, 2002. The New Castle Number 1 is located west of the Vulcan Mine fire. The New Castle Number 1 is apparently burning in the Allen coal seam. The easterly margin of the New Castle Number 1 fire zone is the first area west of the Vulcan presenting indicator vegetative changes. This presumed easterly margin of the fire is located at 39° 33' 38.7 "; 107° 30' 40.8". This location is within a draw on the flank of the Hogback at an altered shale outcrop. Ambient ground temperature at this location is 98° to 110°, with little evidence of immediately underlying fire presenting itself.

Feature 1

The ridgeline just west of the beginning of the New Castle Number 1 Fire zone is 75 feet to 100 feet wide area, exhibiting a series of small to almost imperceptible low temperature vents. These vents are generally discontinuous, exhibit moss growth, and are fairly wet. Ground surface temperatures at the vents are generally 125°, with temperatures reaching 140° to 150° at the westerly margin of the area. The central portion of Feature 1 is located at 39° 33' 39.5"; 107° 30' 44.4".

The westerly portion of the Feature 1 vent area is the site of a subsidence feature closure completed by the Division in May 2002. The subsidence feature was approximately 30 feet in diameter, and, excepting an active chimney at the western margin, was collapsed. The ground surface temperature at the active chimney was measured at over 250° before it was closed. This feature was closed by injecting high slump grout into the chimney until refusal, then constructing a concrete pad that overlaid the margins of the chimney by approximately 15 feet. Specially built concrete blocks were helicoptered to the site and were placed over the concrete cap. The concrete blocks and cap were then backfilled with dirt. The backfill was found to be intact at the time of the New Castle Number 1 Mine Fire evaluation. No evidence of

breach, venting or failure of the backfill was observed. Backfill ground surface temperature was measured at 110°, within the range of ambient ground surface temperatures.

Feature 2
Feature 2 is a one-foot diameter circular vent located about 50 feet west of the subsidence feature closed by the Division. This feature is located within the margins of a draw or gully. Subsidence characteristics within the gully are evident, including indications of circular failure patterns along the sides and a small lip that has developed at the vent location.

The vent, which is located at 39° 33' 39.9"; 107° 30' 46.7", is activly venting the mine fire. Ground surface temperatures at the vent were measured at 170°. The vent moves a significant volume of exhaust gasses, which can be felt exiting the feature. Interestingly, the smell of mine atmosphere predominates, with only a periodic scent of combustion present. Oxygen content just within the vent was measured at 11%, with carbon monoxide measured at 435 parts per million.

The westerly margin of the New Castle Number 1 Mine Fire is located at 39° 33' 43.2"; 107° 30' 54.7". Fire related vegetation exists from Feature 2 to this location, where the oak brush / mountain mahogany community predominates. At this interface, ground surface temperatures were measured at 95°, well within ambient conditions.

General Observations:

Small fire, somewhat diffuse toward its easterly margin.

Likely in the coal outcrop at the easterly margin.

The fire may be moderately efficient and more active at its westerly margin.

Feature 2 may indicate portions of the mine are not burning, and are somewhat discontinuous from burning portions.

Low public safety hazard due to lack of significant vents and elevated temperatures.

Low wildfire hazard due to low temperature vents and lack of persistent vegetative cover.

New Castle Number 1 Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1888–1954	Mesaverde / Allen	N 67 W	50 SW	Drift	1,345,461

Coryell Coal Mine Fire

The Coryell Mine Fire was visited on June 20, 2002. The Coryell is the furthest west of the three mine fires located south of Interstate 70 near New Castle, and is likely burning in the Allen coal seam. The features observed at this fire zone are numbered from west to east. The traverse began near the River Bend Subdivision, and proceeded east.

The beginning of the fire zone is presumed to coincide with a closed subsidence feature located at 39° 34' 06.2"; 107° 32' 09.1". Minor vegetative changes were observed to occur at this location, within the feature itself. The ambient ground surface temperature was measured at 850 to 900 at this location.

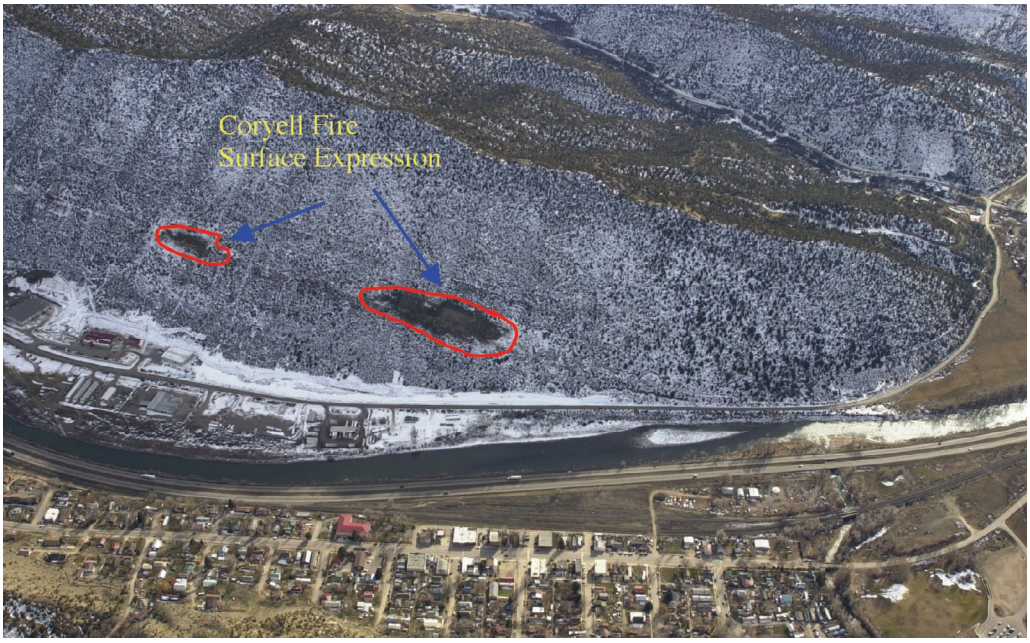
Feature 1
Feature 1 is an open subsidence feature located at 39° 34' 05.3"; 107° 32' 07.7". This is a recent feature that was sealed by the Division in November, 2004.

The feature was approximately 20 feet in diameter, and about 15 feet deep. A slight combustion smell emanates from the feature; however, interior ground surface temperature was measured at 95°.

Feature 2
Feature 2, located at 39° 34' 03.6"; 107° 31' 58.7", is a venting fracture within an area barren of vegetation. The area barren of vegetation begins at about 50 feet west of this feature. This is the first significant vegetative change observable as the traverse extends from the west to the east. The vent is semi-circular, and is approximately three feet long by six inches wide by 15 inches deep at the east end, with an unknown depth at the west end. Ground surface temperatures within the vent were measured at 155°. Carbon monoxide was measured at 145 parts per million at the west margin of the vent. Significant moss growth occurs in the area barren of vegetation, covering the ground surface more extensively at the vent.

Feature 3
Feature 3 is a series of three discontinuous vents measuring a total of five feet long by eight inches wide by unknown depth. These vents are semi-circular in shape, and begin in a draw located at 39° 34' 02.9"; 107° 31' 56.1". Ground surface temperatures were measured at 250°.

Numerous small, discontinuous vents are located in the vicinity of Feature 3, and throughout this area that is barren of vegetation. Many of the vents are likely longer than they present at the surface, but are healed or otherwise covered by active



Coryell Mine Fire. View towards South.

colluvial cover movement. It is assumed that other small vents are completely hidden by the colluvial cover. This venting zone extends generally from the location of Feature 3 to a ridgeline located at 39° 34' 03.1"; 107° 31' 54.5".

No indications of fire are observable on the ground between the easterly extent of the barren / vent zone near Feature 3 and a large area supporting a healthy stand of annual grass, located at 39° 33' 58.6"; 107° 31' 37.0". Ground surface temperature was measured at 110° at this location.

To this point, each of the numerous draws within the burn zone (s) has supported significant subsidence features. These are typically large (20 feet diameter), circular, rock filled depressions. None of these exhibit elevated ground temperatures, yet no subsidence features were observed at areas that do not exhibit fire characteristics. It is likely that these subsidence features, and thus the related burn zone, are coincident with upward stoping in the underlying mine. Ground surface temperatures between 120° and 145° are common.

Feature 4

Feature 4 is a vent located at 39° 33' 57.9"; 107° 31' 36.6". This vent is a circular, horizontal feature measuring about 4 inches in diameter. Ground surface temperature within the vent was measured at 170°. The area surrounding the vent exhibits many diffuse vents; with some sulfur precipitate noted in the general area.

Little evidence of fire characteristics, excepting small, discontinuous areas of annual grass exist for a distance of approximately 400 feet to the east of Feature 4.

Feature 5

Feature 5 is a small subsidence feature situated on ridge. Ground surface temperature within the feature was measured at 125°, with carbon monoxide measured at 128 parts per million, and oxygen at 16 percent. This low temperature vent and vent zone is very moist. Feature 5 is located at 39° 33' 50.6"; 107° 31' 16.4".

Feature 6

Feature 6 is a one-foot diameter, generally circular vent that appears to expand underground, parallel with contour. This feature, located at 39° 33' 49.7"; 107° 31' 13.6", exhibits a ground surface temperature of 140°. Numerous small vents are located in the immediate vicinity of this vent.

Intermittent annual grass and barren areas exist east of Feature 6; however, no venting was observed in any of these locations. An abandoned, closed mine entry was observed downslope of the presumed end of the Coryell Mine Fire zone at 39° 33' 49.4"; 107° 31' 12.6". No evidence of underlying fire presents itself from the east end of the Coryell survey to the west end of the New Castle Number 1 Mine fire survey.

General Observations:

The Coryell Mine fire is more active than either the New Castle Number 1 or Vulcan Mine fires.

The fire exhibits intermittent areas of activity and inactivity.

Fire activity is diffuse within areas of surface expression.

The Coryell is more prone to large subsidence events than the New Castle Number 1 or Vulcan Mines. This may be due either to the mine having less cover between the ground surface and the active mine, or perhaps different mining methods were being employed.

Surface expression of fire activity is related to subsidence events.

Fire is relatively hot, yet low in activity and intensity.

Public safety hazard is moderate due to the subsidence activity.

Surface fire hazard is low as a result of relatively low temperatures and intermittent vegetative cover.

Coryell Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1898–1909	Mesaverde / Allen	N 65 W	44 SW	Drift	484,511

SOUTH CANYON VICINITY

South Canyon, located west of Glenwood Springs, was host to at least four different coal mines. Mining was active in and near South Canyon from the mid-1880's until 1953.

There is some confusion about the names of the various mines at this location. State mining records indicate that the South Cañon Number 1 was the largest producer, and enjoyed the longest life. This mine is located on South Canyon Road, about one mile south of the Garfield County Landfill. Apparently because the mine extended to both sides of South Canyon Creek, parts or all of the mine has been known as South Cañon, New South Canyon, South Cañon Number 1 and South Cañon Number 2. To eliminate confusion, this mine is referred to as South Cañon Number 1 in this document. This name includes all mining activities conducted at this location.

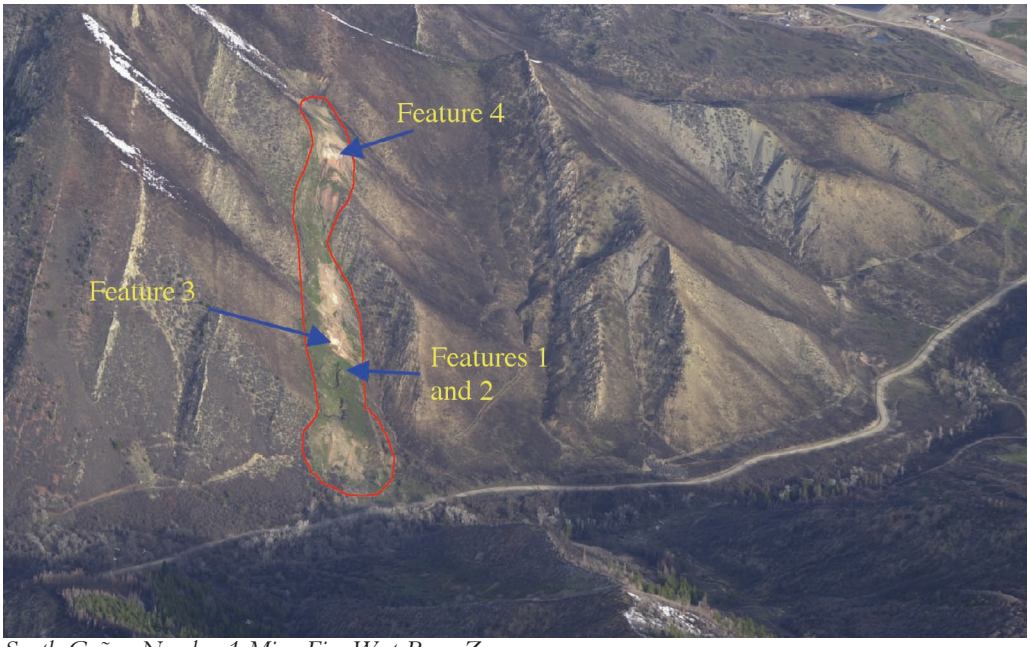
The U, Wheeler and D coal seams were mined at the South Cañon Number 1. Other mines in the vicinity include the Zemlock mine, located south of the South Cañon Number 1, and the Gem, also known as the South Cañon Number 2. The Zemlock probably mined the Allen seam. There is no indication of fire in the Zemlock. The Gem, which is burning, likely mined the Wheeler and D seams. The Gem Mine is located in a tributary canyon to South Canyon, south of the Garfield County Landfill.

South Cañon Number 1 Coal Mine Fire

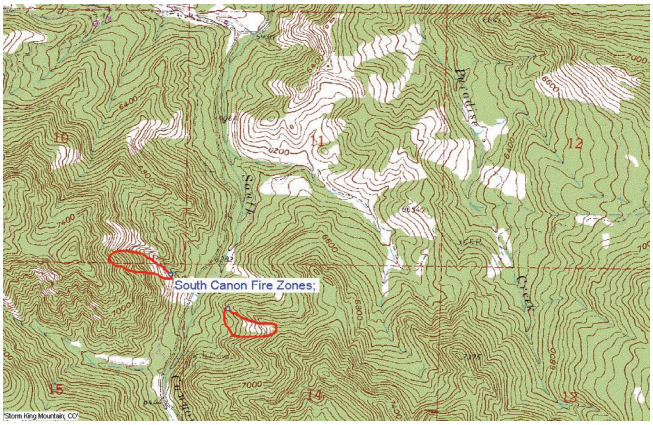
The South Cañon Number 1 Mine extracted coal from the Wheeler D and U seams. Mining of the Wheeler and D seams extended from east to west perpendicular to the strike of South Canyon Creek, beneath the creek and up two side canyons. Mine maps indicate that the mine entries were located east of South Canyon Creek, with an air entry located west of the creek. Field evidence suggests that at least one additional entry may have been located west of the creek.

Wildfire investigators have cited venting from the South Cañon Number 1 mine fire as the cause of the Coal Seam Wildfire of June 2002.

The Division has conducted a number of projects at the South Cañon mine fire in past years (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*). Three subsidence features and three adits have been closed in the past. All of the closure work has been for the purpose of protecting



South Cañon Number 1 Mine Fire, West Burn Zone.



South Canyon vicinity. North at top.

public health and safety. Two fences have also been constructed, one on the east side of the canyon, and one on the west side. The fences serve to minimize public access to the fire zones.

In order to describe the mine fire, the South Cañon Number 1 Mine fire area is divided into east and west burn zones, with South Canyon Creek forming the dividing line between the two areas. The location map shows the east and west burn zones. Preliminary investigations indicate that the two burn zones originated from the same fire, but are separated underground as a result of mine flooding in the vicinity of South Canyon Creek.

West Burn Zone

The westerly burn zone begins west of, and uphill from, South Canyon Road. The burn zone extends along the presumed coal outcrop westerly to near the canyon ridge. This is a north-facing slope extending from an east to west trending ridge to a parallel canyon. The most active areas within this larger area occur at the mid-point, and near the western extremity of the zone. During the late winter of 2002 / 2003, it was observed that the west side of the canyon held snow cover from the road to the location of Feature 1. This indicates that the active zone begins at Feature 1; and extends westerly from that area. A number of large subsidence features exist east of Feature 1, however, no elevated surface temperatures have been measured within these features. About half way up the burn zone within the canyon, rail iron and miscellaneous debris, as well as a barely perceptible depression, indicates the possible location of a collapsed mine entry. However, no entry has been portrayed on the mine maps at this location.

West Burn Zone Feature 1

Feature 1 is located near the mid to easterly portion of the west zone. It is believed by wildfire investigators to have been the point of ignition for the Coal Seam Wildfire in 2002. This area was evaluated on June 18, 2002, approximately six days after the wildfire began. The feature, located at 39° 32' 09.8"; 107° 25' 10.2", is situated immediately adjacent to a footpath that was walked in Spring 2002. At that time, no venting was occurring at this location.

The June 2002 evaluation revealed that the feature was conical in shape, and was estimated to be approximately 18 inches in height, with a basal diameter of four feet. The material was tan to buff in color, and consisted of fine grained rock ash, with periodic pebble occurrences. The ground surface temperature of the feature was 270°, but when the ash crust was broken and the interior was exposed, the temperature was measured to increase to 720°. The wind was blowing at the time of the site visit, but carbon monoxide was measured at 221 parts per million. It was observed that the carbon monoxide content increased as wind velocity increased, likely due to a drawing effect from the wind. Oxygen was consistently measured at 21.8 percent. This feature has been

observed on numerous occasions since the June 2002 evaluation. Observations made in 2003 indicate that the ground temperatures at this location do not exceed ambient, off-fire conditions.

Other small, cooler vents and fractures had developed in the immediate vicinity of Feature 1. These were observed to occur within about 20 feet of Feature 1, and generally on-strike to the west of this feature. Temperatures of these smaller vents did not exceed 180°.

West Burn Zone Feature 2

Feature 2 is an 18 inch diameter vent composed of rock ash. The material of the small vent is the same in color and texture as that at Feature 1. This feature is located about eight feet north of the fence corner that existed at the time of the site visit (the fence has since been extended to the west) at 39° 32' 10.2"; 107° 25' 10.6". The ground surface temperature of Feature 2 was measured at 500°.

Visits to these features since the initial inspection indicate that the vents have become less active. Temperatures of 200° to 300° have been measured at both locations. These vents appear to be off-strike with the main fire body, and thus may represent a localized movement of the fire from the mined coal seam to a small, underlying rider seam.

West Burn Zone Feature 3

Feature 3 is a relatively large, venting fracture zone located about 150 feet west of Feature 2, and about 50 feet higher in elevation. The fractures are located in what appears to be a highly altered shale outcrop that is present on a small transverse ridge. Temperatures within this complex vary from 175° to over 600°. The smell of coal combustion is noticeable, as is a large amount of a white precipitate. This material cannot be approached due to extremely unstable ground conditions, but it is assumed that this material is sulfur deposited throughout the vent zone. Numerous small vent areas as well as individual vents surround the Feature 3 vicinity. The area may also present stability issues, as suggested by the large scale fracturing and over-steepened slopes in the vicinity.

West Burn Zone Feature 4

Feature 4 is another zone feature, located at the far westerly extent of the west burn zone. This area is approximately 400 feet in length (parallel with contour) by an estimated average of 100 feet wide (perpendicular to contour). The area begins down-slope of a transverse ridge, and strikes across the ridge to its west side. The most active portions of the zone occur on the east-facing portion of the ridge. Although the entire area exhibits elevated ground temperatures, discrete vents are located on the east side. Vent temperatures of about 250° are common. The individual vents exhibit substantial creosote and sulfur deposition. From the base of the canyon, smoke is commonly observed to emanate from the area.

Viewed from the transverse ridge, the entire west side fire zone strikes north 500 west, directly in-line with a subsidence feature observable above the presumed mine entries on the east side of the canyon. Mine maps indicate the strike of the mine, and presumably of the D seam, to be north 570 west.

The west side of the transverse ridge exhibits moderately elevated ground temperatures of less than 250°, and less discrete individual vents. A large, closed subsidence feature observed to hold snow delineates the most westerly extent of surface features related to mining on the west side of South Canyon.

General Observations (West Burn Zone):

Feature 1 Vicinity:

New vents may have formed as a result of the fire moving into an underlying rider seam.

This area is intermittently active to very active, likely dependent upon oxygen availability.

The fire in this area is very hot, and very efficient.

The area exhibits stability problems that may result in a large scale subsidence, or surficial failure event.

Feature 2 Vicinity:

The fire in this area is active at this location, and appears to be consistently so over time.

The fire was hot at the time of the site visit, but may vary in efficiency, as evidenced by the large area of white precipitate noted there.

Some potential for slope failure exists at this location.

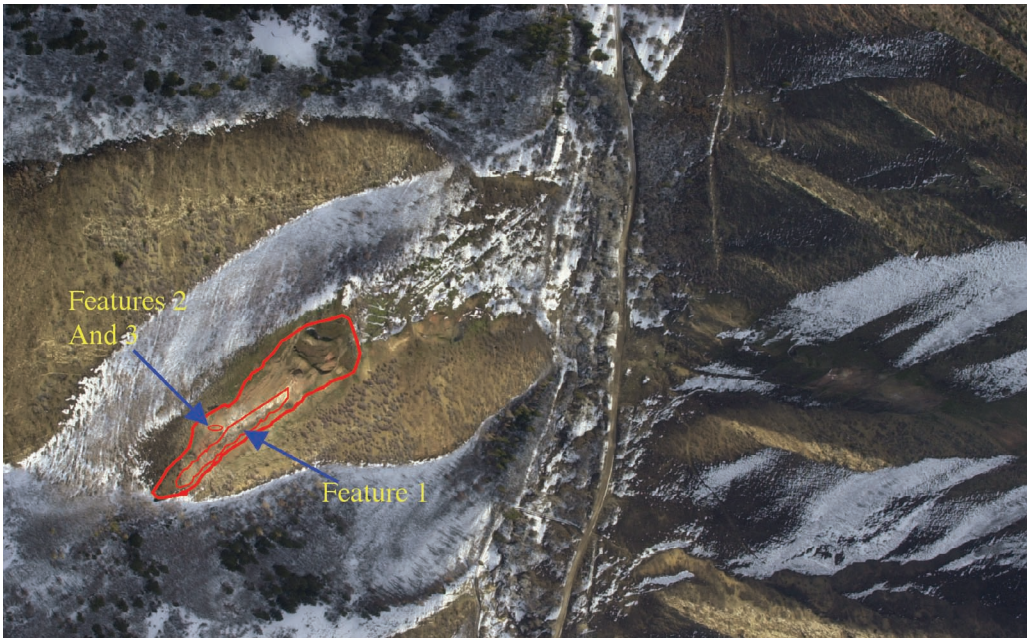
Feature 3 Vicinity:

This area appears to function as a low temperature chimney for the most westerly portion of the fire.

Fire is inefficient at this location as evidenced by creosote and sulfur deposition, and smoke occurrence.

The west side of the fire presents public safety issues. A fence and sign have been placed to minimize public use of the area.

Wildfire hazard is likely variable due to the active and migratory nature of the fire. The hottest portions of the fire are devoid of combustible materials.



South Cañon Number 1 Mine Fire, East Burn Zone.

East Burn Zone

The area east of South Canyon Creek is the location of the old mapped mine entry areas, mine facility remnants, numerous subsidence features, vents and an active burn zone. In terms of fire activity, a mid-slope road remnant, approximately parallel with an exclosure fence, separates the zone into a down-slope inactive area, and an upslope active area. The fence was constructed by the Division, and is in place at about the separation between the up-slope and down-slope areas. The fence serves to minimize public ingress to the active burn zone.

Down-Slope Area

The mine entry area, located just above creek level, defines the lower portion of the down-slope area. Above and east of the mine entries are many shallow, linear subsidence features. These appear to have formed along main haulage ways constructed either in rock, or, in some cases, in coal. Most of the features are collapsed, or have been closed by the Division. However, two open, active features were recently discovered near the mine entries. There is no indication of fire activity in this lower area. Elevated ground surface temperatures are not observed in this area. Snow cover persists in this area as well. It is possible, however, that due to the number and extent of subsidence features, and due to the presence of collapsed entries, the area may be an important factor in providing oxygen to the active fire zone further east.

Up-Slope Area

The active up-slope burn zone is estimated to be 150 feet wide (north to south) by up to 600 feet long in slope length. The area is a valley-like depression trending east to west. Parallel ridgelines form the north and south margins of the area. The area is characterized by denuded shale outcrops venting steam at lower elevations, and smoke from near the north ridge crest. Numerous lineal and circular depressions, generally tending east and west, exist in this area. Most of these are located adjacent to the base of the northerly ridge. Two recent features have developed near the base of the south ridgeline. About mid-slope on the north ridgeline iron, timber, steel, and miscellaneous debris, as well as a barely perceptible depression indicates the possible location of a collapsed mine entry. However, no entry has been portrayed on the mine maps at this location.

East Burn Zone (Up-slope area) Feature 1

Feature 1 is the long vent zone lying adjacent to the base of the northerly ridge. The feature begins down-slope at the east margin of a 30 feet diameter closed and cool subsidence feature. The zone strikes parallel with the base of the ridge, and runs uphill through vent zones exhibiting varying degrees of activity. This zone must be observed from the north ridgeline, as ground conditions within the zone are unstable and hazardous.

The various, discontinuous vents in the zone are generally fracture related. Venting may occur at almost any point within the long fractures. Ground surface temperatures vary from 150° to 300°. A dark precipitate, possibly creosote, and a white, sulfur-appearing precipitate, are observable at various locations. Interestingly, the sulfur precipitate becomes yellow at the up-slope area. The areas containing the dark precipitate exhibited ground surface temperatures at the higher end of the spectrum.

The upper-most extent of the zone occurs at the crest of the northerly ridge. Here the fire vents smoke that is usually apparent from South Canyon road. The vent at this location acts as a chimney for the underlying fire, venting high temperature (600° ground surface temperature) high sulfur, noxious smoke. Carbon

monoxide was measured about 60 feet north of the uppermost vent in a slight breeze at 62 parts per million. The upper extent of the zone is located at 39° 31' 58.5"; 107° 24' 41.7".

East Burn Zone (Up-slope area) Feature 2
Feature 2 is a circular, open subsidence feature estimated to be six to eight feet in diameter at the ground surface, but appears to expand to at least twice this dimension within a few feet of ground surface. This feature is located south of Feature 1 in the valley. Ground surface temperatures within the feature were measured at 470°. No creosote or sulfur was observed at this site.

East Burn Zone (Up-slope area) Feature 3
Feature 3 is a circular, open subsidence feature estimated to be eight to ten feet in diameter. The feature appears closed at four feet depth, however, a small very active chimney is observable near the east margin at the base of the feature. This is a new feature, having developed during the winter or spring of 2002 / 2003. Ground surface temperatures within the feature were measured to vary between 450° and 675°. No creosote or sulfur was observed at this site. This feature is located 30 feet down slope from Feature 2, and south of Feature 1 in the valley.

General Observations (East Burn Zone (Up-slope area):

Down-slope area

Subsidence events are a result of near-surface mining activity.

Subsidence still active near mine entries.

Subsidence features and collapsed mine entries may provide oxygen to fire.

Up-slope area

Fire active, near surface at lower most portion of area.

Fire more inefficient than west side of South Canyon.

Fire likely in Wheeler and D mines and in intermediate or overlying rider seams.

Public safety hazard is high due to active subsidence and unstable ground.

Wildfire hazard is low due to lack of fuels at the vent areas.

South Cañon Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1887–1951	Mesaverde / Wheeler, D, U, E,	N 60 W	53 SW	Stope	924,974

Gem (South Canyon Number 2) Coal Mine Fire

The Gem mine fire was visited on July 1, 2002. The surface expression of the fire is located on a north-facing slope. The site is accessed via an unimproved dirt road from the Garfield County Landfill. The westerly margin of the fire zone begins on a west facing ridgeline, and extends easterly across the nose of the ridge, through a small drainage, and onto the adjacent ridgeline. Approximately 70 percent of this two to three acre fire zone is located on the westerly ridge.

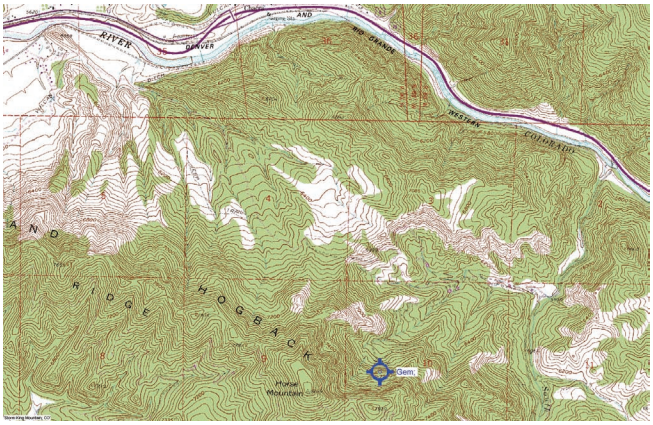
Feature 1
Feature 1 is a large, subsidence feature located on the west side of the westerly ridgeline. The feature is about four feet deep on the flank of the ridge above the westerly draw, and is incised into this flank. The feature is four feet deep on the low side, with a 20 feet tall backwall on the uphill side. It is oblong in shape, measuring 20 feet by 40 feet, and is closed. The feature, located at 39° 32' 25.2"; 107° 25' 55.4", is large enough that it is easily discernible in aerial photos.

The feature vents along the backwall side at numerous, small (four to six inch diameter), moss – supporting, low temperature vents occurring in a sandstone outcrop. The northeast portion of the feature supports small, almost imperceptible vents, which exhibit ground temperatures of 220°.

The intermediate ridge is characterized by "micro-hummock topography", which is reminiscent of a landslide body, without an upland scarp. The "micro-hummock topography" is a term given to a ground surface on a hillslope that contains a series of small steps, on the order of two to six inches of vertical relief each, separated by a steep slope that extends anywhere from a few inches to a foot in length, before transitioning to another step. The small vertical steps support very small vents or open fractures near the base of each. Plentiful moss growth and excessive moisture are present in this area. Ambient ground temperature across this area, which is located at 39° 32' 33.0"; 107° 25' 59.8", varies between 120° and 130°.

Feature 2
Feature 2 is a series of eight to ten vents that exhibit ground surface temperatures of 130°, with one vent measured at 180°. Feature 2 is located at the far eastern portion of the fire zone, about 50 feet south east of the central ridge. The central part of this area is located at 39° 32' 31.8"; 107° 25' 56.2". Some sulfur development was observed in this area, while none was observed in the westerly areas. The area surrounding this series of small vents supports substantial moss development, and significant available moisture. This area also supports the "micro-hummock topography" observed at the central ridge area.

Gem Mine Fire, view towards South.



Gem Mine Fire location. North at top.

Areas within the burn zone, but that are not significantly active, support a robust stand of annual grasses. The areas above and below the surface expression of the fire, and particularly in the intervening central draw, support a vigorous stand of Mountain Mahogany and Oak. No elevated heat values were measured in either the adjacent areas or in the central draw.

No evidence of the mine entry was located during the field reconnaissance. A landslide body located immediately to the west may have obscured the entry area.

General Observations:

This is a fire that exhibits low surface heat at vent locations.

The fire appears not to be very active near the ground surface. Possibly, the greatest amount of activity is located near the working face, rather than in the stopes.

The heat appears to be dispersed by geologic conditions, such as fractures and dip.

Venting is dispersed along the areas exhibiting "micro-hummock topography".

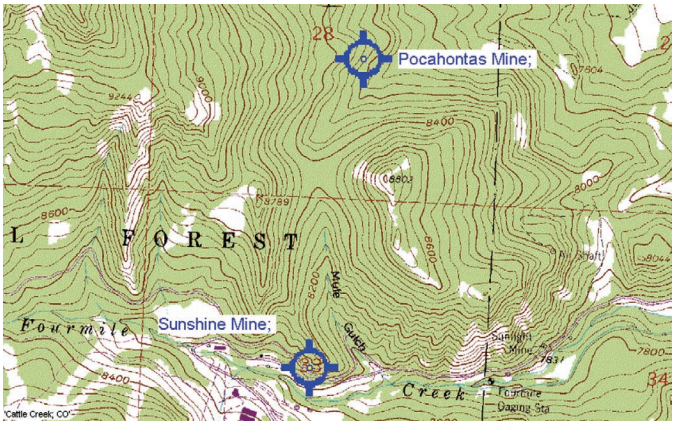
The fire presents a low surface fire potential due to the low heat values measured at the surface, and the fact that the hottest vents are located in non-vegetation bearing outcrops.

Public safety hazard is low due to the remote, and relatively inaccessible location of this fire.

Gem Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1938–1968	Mesaverde / Wheeler, E (U?)	N 53 W	57 SW	Stope	61,306

Pocahontas Mine Fire. View towards Southwest



Locations of Pocahontas and Sunshine Mines. North at top.

GRAND HOGBACK SOUTH OF GLENWOOD SPRINGS

Two coal mines on the Grand Hogback south of Glenwood Springs are known to be burning. These fires are unrelated to the South Canyon vicinity mine fires.

Pocahontas Number 1 And 2 Coal Mine Fire

This site was visited on July 1, 2002, and has been observed from the Four Mile Road on numerous occasions since the site visit. The Pocahontas Mine Coal Fire was accessed by walking toward the north along an abandoned dirt road from near the formerly permitted Sunlight Coal Mine located adjacent to Four Mile Road near the Sunlight Ski Area.

The site was readily visible from the abandoned road from a half-mile or more distance. The site exhibits the classic surface characteristics of an annual grass cover surrounded by oak and mountain mahogany. Intermittent red shale outcrops occur within the burn zone as well. From a distance, it appears that the site has two distinct areas that exhibit surface characteristics of underground fires. Each area is barren with annual grasses growing immediately above each.

The southerly area exhibits an eight feet diameter by four feet deep subsidence feature, which may be located at one of the entry areas. This closed feature is located at 39° 24' 40.7", 107° 19' 20.7". The temperature of the ground surface at this location was measured at 126° to 140°. These temperatures were marginally higher than the ambient ground temperatures that were measured to vary between 110° and 125°.

The northerly area also coincides with a closed feature that is reminiscent of a collapsed adit entry. The entry area is located at 39° 24' 43.1", 107° 19' 21.5". This area also exhibits barren red shale material at the elevation of the collapsed entry, with annual grasses growing immediately upslope. Ground temperatures at this area were measured at 135°.

The highest ground temperatures were noted at a point located at 39° 24' 41.9", 107° 19' 22.1". This area is about 40 feet west of and 15 feet upslope from the center of the southerly barren area. Ground temperatures were measured at between 150° and 165°.

No deposition of sulfur, creosote or other combustion by-products were observed anywhere on the site.

A number of subsidence features were observed upslope of the burn area. Most varied in size from about six by ten feet to 20 by 25 feet on a side, each being closed at five feet depth. A larger closed subsidence feature, approximately 20 by 40 feet by 15 feet deep was also observed. These features are all located upslope and

west of the surface expression of the underground fire. All exhibit mountain mahogany growth and other species atypical of heated soils, indicating that the fire is not present immediately below.

General Observations:

Fire appears to be centered between the two possible entry collapses, with heat apparent in the immediate vicinity of each entry and the intervening outcrop.

No mineral, sulfur or creosote deposition was observed.

No distinct or visible vents observed on site.

Fire may be relatively near surface.

Fire likely very low temperature.

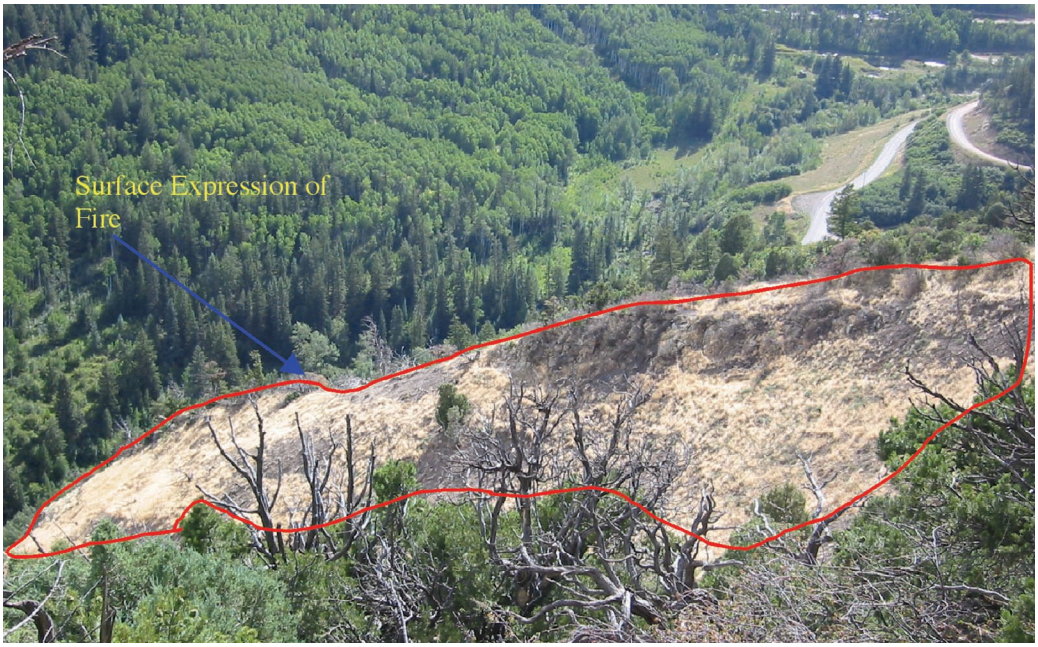
Low public safety hazard due to remoteness of the site, and lack of access.

Low surface fire potential due to the lack of vents and low observed surface temperatures.

Pocahontas Numbers 1 & 2 Coal Mine (Undifferentiated)

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1899–1951	Mesaverde (?)*	N 17 W	42 SW	Drift	176,222

* Not Reported



Sunshine Mine Fire. View toward West.

Sunshine Coal Mine Fire

This underground mine fire is burning at the historic Sunshine Mine, northeast of the Sunlight Ski Area, and immediately west of the recently reclaimed Sunlight Coal Mine. Rushworth, et al, 1988, did not report this mine as either burning or dormant. Indications are that this mine has been burning for an extended period of time; however, it is not known how long the fire has been active.

The Division of Minerals and Geology became aware of this fire as a result of a phone conversation with the Glenwood Springs City Planners Office. The City Planner reported that a resident of a condominium at the Sunlight Ski Area had observed smoke rising from a ridgeline northeast of the ski area. The Glenwood Springs Fire Department and a Bureau of Land Management helicopter evaluated the site and determine that the smoke was rising from the ground. Following that determination, the Division was notified of the fire, and asked to provide consultation services to the City.

The Sunshine Mine fire was visited on August 29, 2003 with staff from the Glenwood Springs Fire Department and City Planners Office. The location of the fire can be easily viewed from the parking lot of the condominiums located at Sunlight Ski Area. The fire-impacted area appears as a large annual grass dominated hillslope, surrounded by piñon juniper forest. When observed from the condominiums at the time of the site visit, no smoke or steam was observed to emanate from the Sunshine Mine fire.

Access to the site is provided via a very steep slope north of Four Mile Road. The surface expression of the fire is located along a westerly facing ridgeline that extends approximately parallel with the strike of the Grand Hogback. A number of venting fractures are present along the ridge, just west of its crest. These features strike approximately north to south, and appear to be related to a coal rider seam, presumed to be present at this location. Temperatures of the vents vary from 280° at the most down slope vent, to 370° at the furthest up-hill vent. These discontinuous fractures are generally one inch wide, and vary from six inches to ten feet in length. These vents and the presumed rider seam are strongly related to a sandstone crop located stratigraphically immediately above. In some areas, coal combustion near the ground surface is sufficiently hot to cause overlying pine duff to smolder. Evidence of burnt roots and dead and dying piñon pines were observed along the west facing side of the ridgeline.

Two other vents were observed off-strike from the parallel fractures, these being located about ten feet easterly of the ridge crest, on the east facing slope. These vents were located near the upper portion of the fire zone. These features are discontinuous, and are roughly circular in shape. The temperature of these features is about 200°. Condensate is apparent on the overlying rocks, and even on the thermometer surface when placed over the vents.

The size of the surface expression of the fire is difficult to ascertain. The vegetative cover over an area that includes the east side of the ridgeline is predominately annual grass. This change in cover generally indicates underlying heating. Excepting the two vents observed off-strike from the parallel fractures, no venting was observed to occur east of the ridgeline vicinity. Further, the rock units east of the ridge are stratigraphically lower than the strata that underlies the ridgeline and the ground west of the ridge. This is important because fire characteristics are generally observed in units stratigraphically higher than the burning seam. It is possible that radiation of heat is causing the vegetative change observed

east of the ridge, or perhaps heating from another, stratigraphically lower burning unit is occurring in this area, however no other evidence of an underlying fire was observed.

The total area that exhibits a predominantly annual grass cover is estimated to be 200 feet perpendicular with contour, by 500 feet parallel with contour. The area of active venting is estimated at 200 feet perpendicular with contour, by 100 feet parallel with contour.

General Observations:

It is likely that the long-abandoned Sunshine Mine is burning to a greater or lesser extent well below the ground surface.

Mine maps indicate that the stope extraction method was used to recover coal at this site.

It is possible that the underground fire in the Sunshine Mine is hottest along the westerly margin of the mine, thus causing heating and combustion of an overlying rider seam at the ground surface. It may be that the rider seam that is causing the venting and vegetative changes observed west of the ridge line.

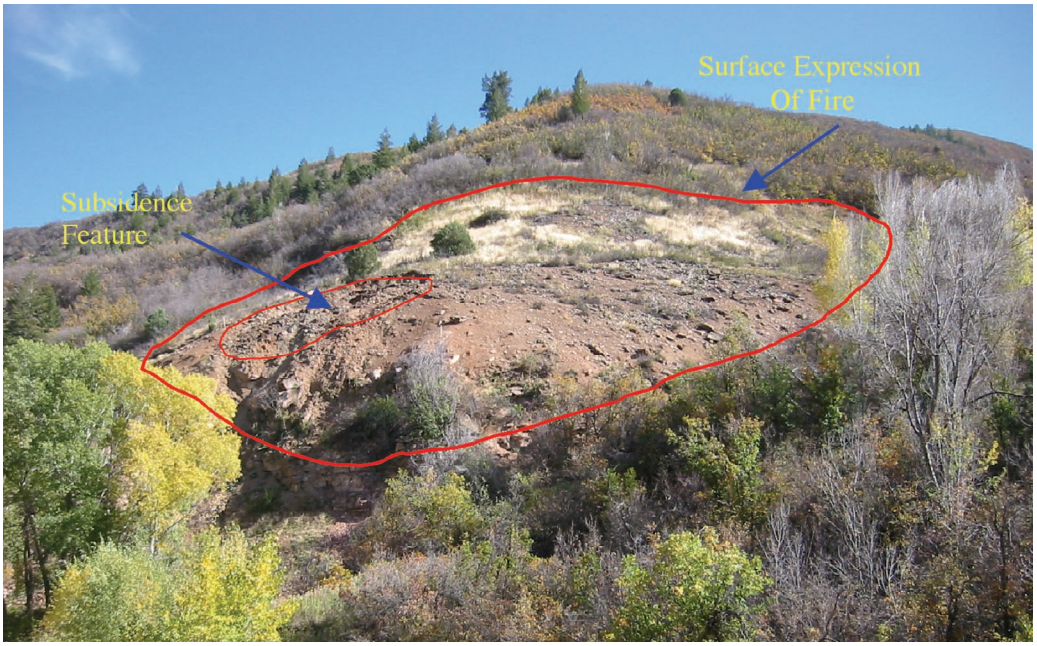
The underlying fire may be less intense, or the heat is dissipating more rapidly near the eastern margin of the mine. This would account for the vegetative changes observable east of the ridgeline, and for the lack of venting in this area.

The human health and safety risk at this site is moderate. The heat of the vents, and their apparent near-surface origin are cause for concern. However, the steepness of the slopes leading to the site, and the lack of visual fire clues ameliorate this concern.

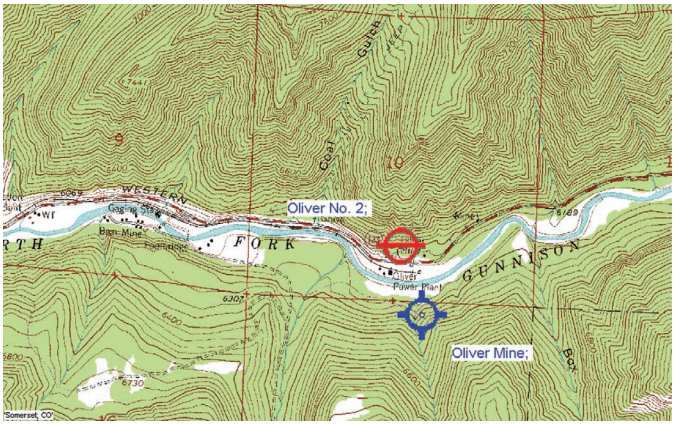
The wildfire risk from this fire is high. This is due exclusively to the west-of-ridge venting. These features appear to vent near surface combustion, and were observed in one instance to be hot enough to cause pine duff to smolder. The Glenwood Springs Fire Department and the Bureau of Land Management are aware of this situation, and have reportedly made contingency plans to deal with a wildfire should one occur at this location.

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1888–1900	Mesaverde / *	N 18 W	40 SW	Stope	434,911

* Not Reported



Oliver Mine Fire. View toward Southeast.



Locations of active Oliver Mine Fire, and Dormant Oliver Number 2 Mine Fire. North at top.

GUNNISON COUNTY

Oliver Coal Mine Fire

An active mine fire has been observed at a location which is presumed to be that of the Oliver Mine. Rushworth et al, 1989, indicates that the Oliver Number 2 Mine had, at one time, been burning, but mapped it as a dormant fire. The Oliver Number 2 Mine, as described by Carroll and Bauer, 2002, is located well north of the fire described here. Evidence suggests that the observed fire involves the Oliver Mine. This evidence is based upon an underground mine map of the Oliver Mine, which appears to be situated in the location of the observed fire. To eliminate confusion, the fire described here will be referred to as the Oliver Mine fire. The approximate center of the fire detailed in this report is located at 38° 55' 29.2"; 107° 25' 54.1".

There is some potential that this is the fire that was mapped as being dormant by Rushworth in 1989. Assuming this is correct, it is apparent that the fire has become active since that investigation. This change in condition is not atypical of the cyclic nature of underground fires at abandoned mines. In fact, it would not be unusual if some of the fires described as active in this investigation became dormant, or vice versa, over the next decade. For this reason, periodic field evaluations of underground fires are important to undertake.

The surface expression of the Oliver Mine fire occurs on a hillside on the south side of Highway 133 about five miles east of the town of Somerset. The fire zone is located at the mouth of a small canyon that trends approximately north to south. The fire is on the east side of the canyon, on a ridge that separates the canyon from the east to westerly trending hills that parallel Highway 133. The fire is readily visible during cold weather from the highway, as venting steam is a common occurrence.

Steam vents from altered shale and sandstone outcrops located about 25 to 30 feet above the elevation of the highway. The vents that appear in this material are very small, usually less than four inches in diameter, and are discontinuous. Each small vent generally displays a moderately significant growth of moss on adjacent rock particles and overhangs. These vents, which can be seen to exhaust small amounts of steam even during warm weather, display ground temperatures in the range of 80° to 100°. The vents occur along this scoria-like crop for a distance of perhaps 80 feet, moving from the canyon mouth towards the canyon head. After approximately 80 feet, colluvial slump material and the rising canyon floor cover the outcrop, eliminating observable venting.

The most significant feature at this fire is a large, relatively recent subsidence feature that is located on the ridge top at 38° 55' 29.2"; 107° 25' 54.1". This feature is horseshoe shaped, open at the northwesterly or downhill, margin. The feature is

approximately 70 feet long in the southeast to northwest direction, by about 40 feet in width. The head scarp shows vertical displacement of approximately four feet, with internal vertical displacement estimated at six feet or greater. The interior is hummocky, and does not present ground surface temperatures above ambient conditions of 65° to 75°.

The possible location of a mine entry was observed at the base of the hill within the canyon. Landslide activity, and possibly earthmoving activities related to highway construction, may have obscured the area, but the shape of the hill at this area suggests that this may have been where the entry was located. This area, located at 38° 55' 30.1"; 107° 25' 54.7", is located on strike with the large subsidence feature observed on the hill to the southeast.

The surface expression of the fire extends in a southerly direction from the subsidence feature, approximately parallel with the strike of the adjacent canyon, but on the side of the hill. Low diffuse heating and sparse vegetation characterize this area, estimated at about one to one and one half acres in size. No distinct vents were observed on the hillside above the scoria outcrop lower in the canyon.

Adjacent to the Oliver Mine is an active, permitted underground coal mine. Coal is reportedly extracted predominately by longwall mining techniques at this site from a coal seam that underlies the seam burning at the Oliver. Because longwall production facilitates subsidence of the overlaying strata, fracturing from the underlying operation into the Oliver could occur should extraction operations approach the footprint of the Oliver. Many factors bear upon the situation, however it is possible that combustion products could be drawn into the longwall operation if an interconnection between the two mines is established. Such a circumstance could potentially impact the health and safety of miners in the longwall operation. Therefore, fire delineation and abatement activities at the Oliver have received a high priority for future funding opportunities.

This fire, which has been casually and periodically observed since 1999, appears to be of low intensity, and not extremely active. There is some potential that the large subsided area may be helpful in controlling this fire in the future. If this feature is located in the main entry, it could be useful in helping to seal the mine along that corridor. It may be feasible to pressure grout the subsided material within the mine via holes drilled from the ground surface, then inject materials to smother or suffocate fire inby this location. Some degree of underground investigation will need to be accomplished in order to determine whether a two step approach to fire control is appropriate.

General Observations:

This appears to be a relatively low temperature fire, as evidenced by the low ground temperatures observed.

The fire appears to parallel the outcrop within the north / south trending canyon, and appears to have not developed very far to the southeast.

It may be possible to obtain some degree of control by smothering or suffocating the fire, particularly if it is a relatively near-surface event.

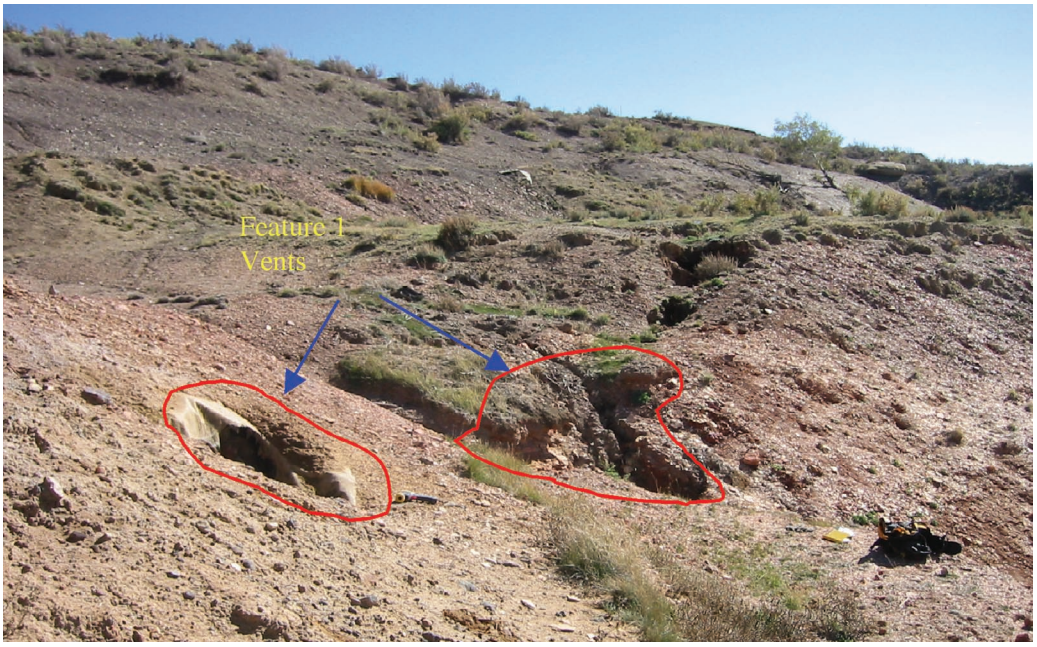
Public health and safety hazard is low, due to the lack of surface features, and the lack of significantly elevated heat values.

Wildfire risk is low, also as a result of relatively low surface temperatures, and due to a paucity of overlying vegetation.

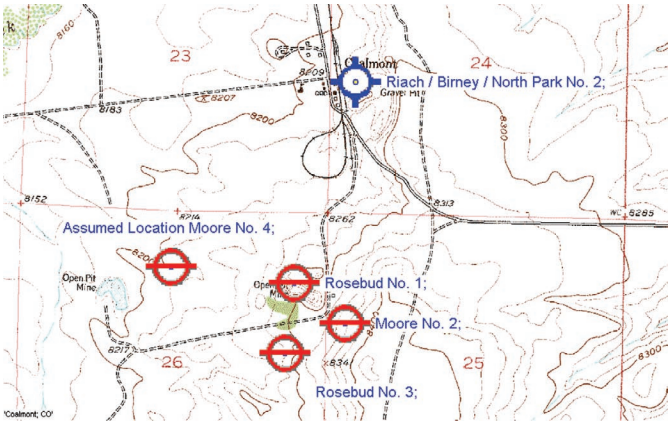
Oliver Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
Not Reported	Mesaverde / *	N 90 W	3 N	Not Reported	Not Reported

* Not Reported



Vents at the Riach Coal Mine Fire. View toward Southeast.



Locations of the active Riach Mine Fire, and nearby dormant mine fires. North at top.

JACKSON COUNTY

Riach Coal Mine Fire

The Riach Coal Mine fire is located approximately 16 miles south and west of Walden in west central North Park. The site can be accessed from Colorado Highway 14 by turning west on Jackson County Road 26 and traveling approximately 1.5 miles to an unimproved dirt road on a prominent ridgeline that overlooks the former town site of Coalmont. The dirt road is located opposite Jackson County Road 26A. Travel north on the unimproved dirt road approximately one quarter mile. The remnants of the Riach Coal Mine will be visible downslope to the west. The mine from this vantage point looks very similar to a surface strip coal mining operation. The area looks like a very large open pit with cut operation remnants visible as benches located on the west-facing slope. Rushworth et al, 1989, reports that this was an extensive room and pillar operation that caught fire in 1915 or 1916. The fire apparently burned for decades, causing massive subsidence, which has resulted in formation of a large subsidence pit. Surface sealing was undertaken in 1974 by the Bureau of Mines, when cut and fill operations were used to place four to eight feet of cover over the fire zone (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*) (Shellenberger, date unknown). This cut and fill operation resulted in slight enlargement of the pit to its approximately 12.5 acre configuration, and the creation of the many benches visible on the west-facing slope.

The fire was visited in June and in October of 2002. The October visit revealed that a fire is expressing itself on the west-facing margin of the pit.

Feature 1

Feature 1 consists of two vents located near the southeast margin on the west-facing slope of the large depression. The vents are located within about 30 feet of each other at 40° 33'37.4" 106° 26'22.5". The northerly vent is four feet by three feet, with a blockage at a depth of about three feet. Fractures within the sides of the vent trend nearly north to south, directly in-line with the southerly vent. The north vent exhibits substantial moss growth. The ground temperature within the vent was measured at 110°. Geotextile fabric, a remnant of a past slope stabilization project, drapes into the vent. This feature is situated on a bench created as part of the surface seal cut and fill activities. The second, or southerly, vent is situated in a small gully, also within the cut and fill area. It measures four feet by two feet by three feet in depth. Again, open interior fractures are visible. These trend north to south, and form a pattern toward the south that is expressed as a series of small, discontinuous open fractures that extend for at least 30 feet uphill toward the south.

The southerly feature and the fractures that extend from it toward the south are likely an extension of the northerly vent system along a subsidence fracture. The southerly feature, located within a gully, was probably encouraged to develop as a result of erosional processes prevalent during gully development.

Feature 2

Feature 2 is a 20 feet long by six feet wide by three feet deep depression located immediately uphill of Feature 1. This feature is likely a closed subsidence feature and, although not exhibiting elevated temperatures at the time of the site visit, could provide an indication of the direction of advance of the underlying fire.

Feature 3

Feature 3 is a series of lineal vents located approximately 100 feet south of Feature 1 on a cut terrace at about the same elevation as Feature 1. It is likely that this is another expression of the fracture system that the Feature 1 vents are using to communicate with the atmosphere.

Feature 3 is an approximately 12 feet long by eight to 18 inches wide, mostly discontinuous series of three vents located at 40° 33' 36.7", 106° 26' 22.5". The ground temperature at these vents varied from 65° to 75°.

Two closed subsidence features were observed in the immediate vicinity of Feature 3. One measured 40 feet in diameter by four feet depth, and one was approximately 20 feet in diameter. This second feature was located on the side of a terrace, so the low interior point was open to the west. No other fire features were observed on the west facing cut slope of the pit.

The crest of the west slope of the Riach Mine depression is at lower elevation than the east side, and exhibits much less terracing than that which is observed on the opposite wall. Great quantities of clinker were found throughout the west side area. Evidence suggests that at least a portion of this material is in place, but due to the great amount of earth moving that has occurred at the site, mechanical placement of this material cannot be ruled out. In any case, no evidence of fire related features was observed on the west side of the pit. However, the slight, periodic smell of burning coal and intermittent ground temperatures that vary from 80° to 90° indicate that some underlying heating may be occurring. The approximate center of the west side of the pit is located at 40° 33' 37.2", 106° 26' 26.9".

At least four large subsidence features are located on the mesa top, north east of the Riach Mine depression. These features are very large, varying in diameter from 20 to 75 feet. The depth of each is estimated to be approximately 20 feet; however, three of the features are filled with debris, so the bottom is not visible. No elevated heat values were detected in any of these features.

General Observations:

This is likely a low activity fire. No smoke or fire by-product was observed, only steam was emitted from vents.

The fire expresses itself over a relatively small area on the east side of the large pit, however, it may be more aerially extensive than the limited venting indicates, possibly evidenced by the degree of heat related vegetation present.

Possibly some low grade fire activity occurs on the west side of the Riach Mine; however, minimal evidence of such activity was observed.

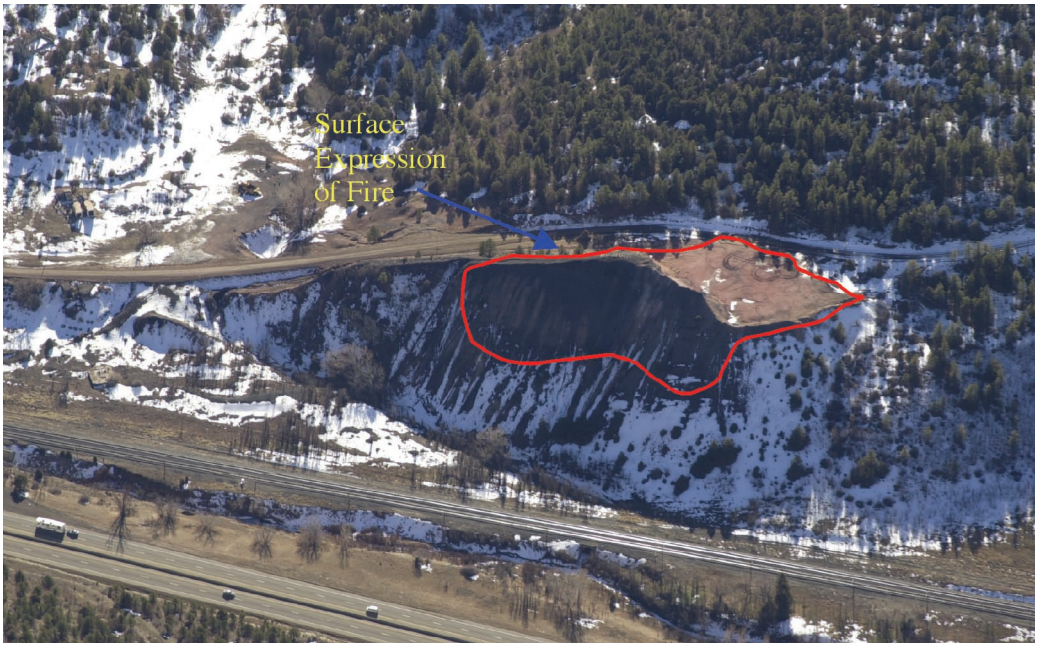
Wildfire hazard is low, due to the low heat values that were observed at the vents, and due to a lack of significant vegetative cover.

Human health and safety hazard is moderate, as the vents at Feature 1 are large enough to possibly cause injury should someone come into contact with them. The remoteness of the site however, mitigates this concern.

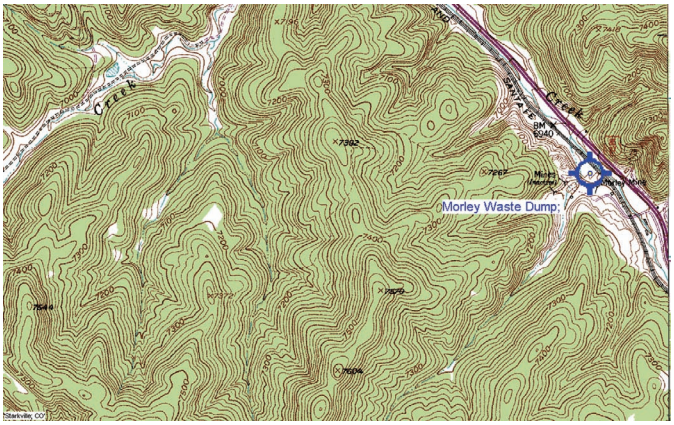
Riach Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1911–1912	Coalmont / *	Unknown	Unknown	Slope	30,475

* Not Reported



Morley Waste Dump Fire. View to West.



Location of the Morley Waste Dump Fire. North at top.

LAS ANIMAS COUNTY

Morley Waste Dump Fire

The Morley Waste Dump fire is somewhat unique because it occurs in a large coal refuse pile, rather than in an underground mine. A few other small coal refuse pile fires have been identified in the State, all in South Canyon, near Glenwood Springs, Garfield County. None of these approaches the size of the Morley Waste Dump. The South Canyon refuse fires were extinguished in 2002 and 2003.

The Morley waste dump fire was visited in June 2002. To reach the site, travel south from Trinidad on Interstate 25 for a distance of about 11 miles. Travel north on an improved dirt road to the old Morley town site. The site consists of one large coal refuse pile, or waste dump, and two smaller waste dumps.

The dump has a footprint of about five acres, and is approximately 30 feet tall. The waste material is red, black and white in color. The red and white indicate past heating. The northerly portion of the dump has been excavated to a flat lying bench, and exhibits little vegetation except some pine trees near the base of the dump in this location. The southerly portion of the dump supports some tree and brush growth. No vegetation exists on most of the north and central portions of the dump.

Coal combustion can be smelled when walking the northern and southern sides of the dump. No cracks, vents, smoke or areas exhibiting ground instability were observed. Ground temperatures on the north side of the dump varied from 92° to 110°. The ground surface in this area is light red in color, with periodic areas exhibiting white rock ash. A few small, isolated areas, generally less than 20 square feet in area, on the eastern side of the dump exhibited ground temperatures from about 90° to 99°. Temperatures slightly higher, at 110°, were observed at isolated areas near the southeastern portion of the dump. The central portion of the dump did not exhibit elevated temperatures. The two smaller dumps, situated southwest of the large dump, exhibited temperatures that varied between 80° and 116°.

General Observations:

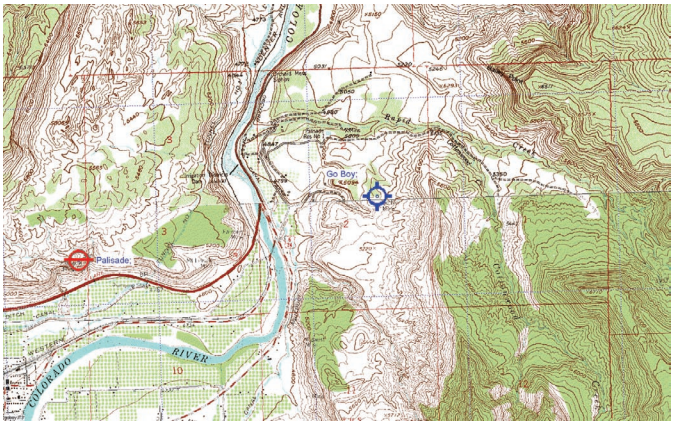
This is a very low activity fire, perhaps more similar to coal oxidation, than to combustion.

Many refuse piles will burn at high temperatures, due to the unconfined nature of the pile and the availability of oxygen. Perhaps as combustion occurs, the pile collapses on itself, reducing oxygen availability.

Human health and safety risk is low, given the apparent strength of the pile, and lack of fire related surface features. Construction of a fence may be prudent in the event that the fire were to become more active.

Wildfire hazard is low, given the low surface temperatures and lack of combustible vegetation on the pile.

Go Boy Coal Mine Fire. North to Left.



Location of the active Go Boy Mine Fire, and the dormant Palisade Mine Fire. North at top.

MESA COUNTY

Mesa County coal mines extracted coal from the Mesaverde Group, a sequence of sandstone, shale and coal seams. The Mesaverde Group forms the caprock of the Bookcliffs mountain range, which is visible north of Interstate 70. The Mesaverde Group typically dips gently to the north / northwest. Most mining was accomplished using room and pillar methods, with 50 percent extraction being common.

Go Boy Coal Mine Fire

The Go Boy Mine fire is located east of Palisade near the base of the Grand Mesa. This site had been the subject of a drilling and instrumentation program conducted by the Division in 1984 (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*).

The site was accessed on June 13, 2002, by walking up a box canyon and climbing up a coal waste pile located at the head of the canyon and below the mine entry area.

During the site visit, the entire area overlying the mine was walked to evaluate the surface expression of the underlying fire. Observations of the area overlying the mine did not yield any indication of active combustion. No subsidence features were observed, the smell of coal combustion could not be detected, and no indications of sulfur, creosote or alteration minerals were observed. No vent features of any type were observed to overlay the mine.

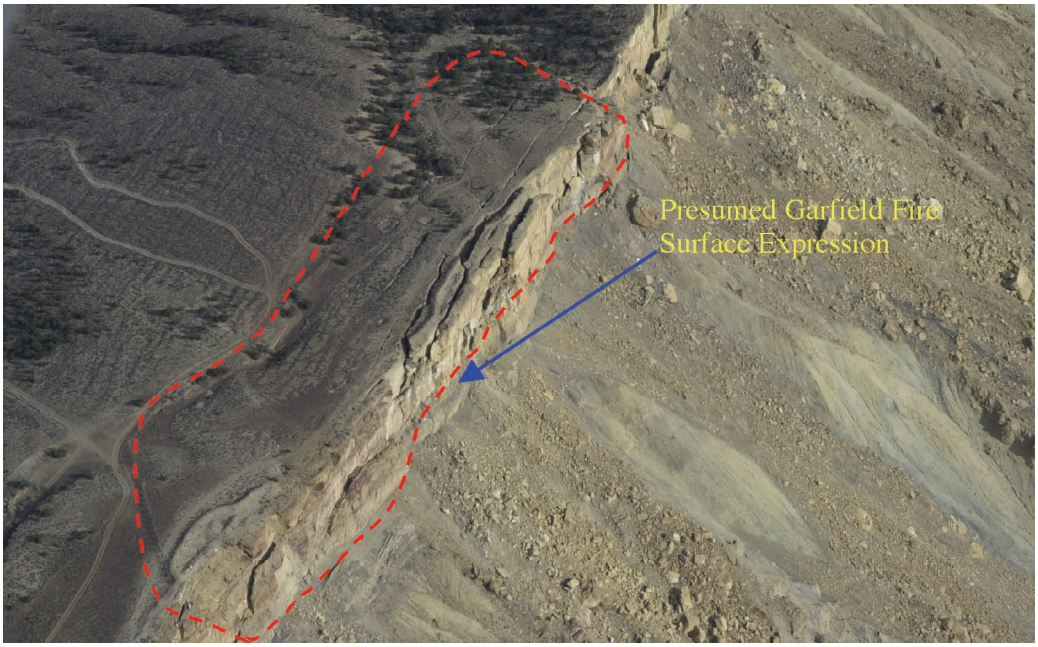
A number of cased boreholes were encountered during the site visit. These were installed by the Division as part of a 1984 investigation of the site. Many of the boreholes have been fitted with thermocouples for the purpose of evaluating subsurface temperatures. Records indicate that the drill holes were completed above the mined interval. No heat values were measured as it is unclear how the information is relevant.

General Observations:

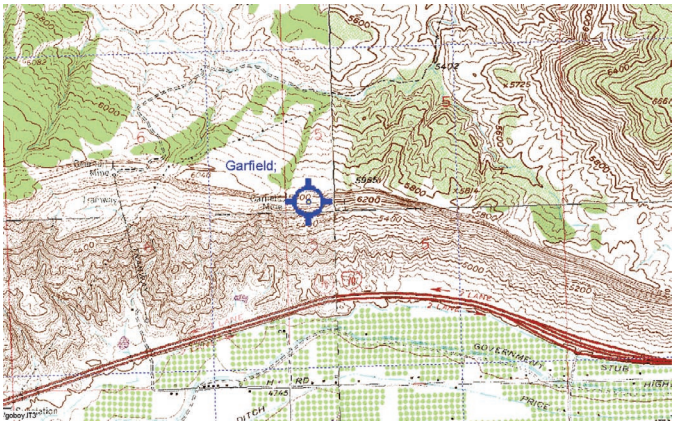
Surface evidence suggests that the fire is either dormant or close to it at this time. The lack of surficial fire indicators strongly suggests that this is the case. Subsurface information is required to make a definitive determination.

Go Boy Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1911–1968	Mesaverde / Cameo	N 65 W	2 N	Slope	22,765



Garfield Coal Mine Fire. North to Left.



Garfield Mine Fire location. North at top.

Garfield Coal Mine Fire

The Garfield Mine fire was visited on June 14, 2002. The site was accessed by driving west from Cameo up Coal Canyon to near the south facing edge of the Bookcliffs overlooking Palisade. A fence installed by the Division prevents vehicular access to the area overlying the mine.

The area is characterized by many deep, parallel fractures. These fractures begin well into the sandstone member that overlies the mined coal seam, and generally trend parallel to each other and the cliff face of the Bookcliffs. The fracture system begins at the cliff face, and can be observed to occur at more than 75 feet north of the cliff face. Some depression-like subsidence features are also observable near the more northerly fractures.

It has been assumed that the parallel fractures are a result of underground subsidence. This may be the case; however, the influence of assumed pre-existing jointing within the overlying sandstone member may be a significant factor in the depth, orientation and spacing of the fractures. Possibly, subsidence as a result of mining has triggered stress releases, causing the joint controlled features observable at the surface today.

The entire area within the fence line to the cliff face was evaluated during the field visit. The central portion of the area is located at about 39° 07' 37.8"; 108° 22' 52.7". The majority of the site assessment was spent observing individual fractures. This evaluation did not produce evidence of creosote, sulfur, moss, condensation or the smell of combustion at any location. Elevated heat values were not observed. No indication of fire activity was observed on the ground surface away from the fracture area.

General Observations:

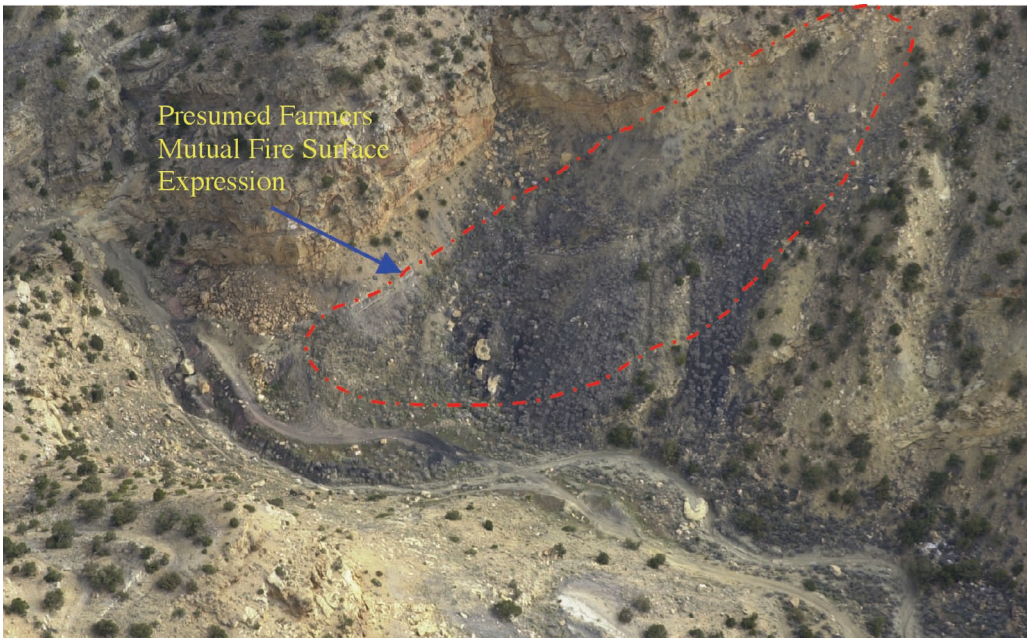
Surface evidence suggests that the fire is either dormant or close to it at this time. The lack of surficial fire indicators strongly suggests that this is the case. Subsurface information is required to make a definitive determination.

The fracture system is a public health and safety hazard due to the potential for falling into one of the features. The perimeter fence surrounding the area, and periodic warning signs, should discourage the public from entering the site. Additional downslope hazards from rock fall may also exist, but were not evaluated at this time.

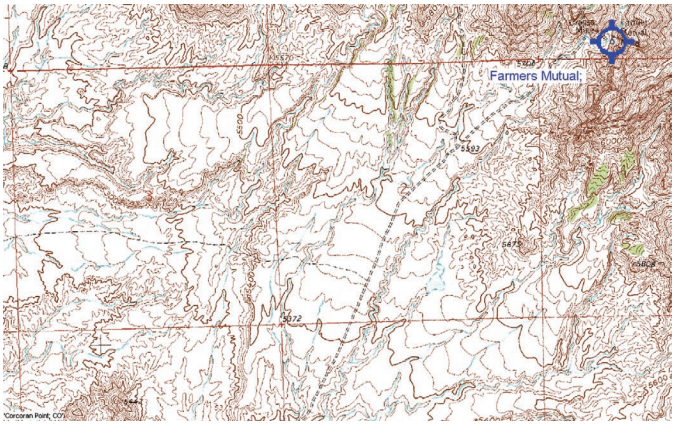
Wildfire hazard is low as a result of the lack of surface heat and fire related features.

Garfield Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1907–1948	Mesaverde / Palisade	N 70 W	11 N	Drift	288,097



Farmers Mutual Coal Mine Fire. North to left.



Farmers Mutual Mine Fire location. North at top.

Farmers Mutual Coal Mine Fire

The Farmers Mutual Mine fire has been visited on a number of occasions in 2001, 2002 and 2003. The site is reached by traveling north from Grand Junction on 27 Road to its terminus at the base of the Bookcliffs. The canyon within which the Farmers Mutual mine entry is located hosted at least two other coal mines, and as a result, a fair amount of coal waste and mining related debris is found in the canyon.

The Farmers Mutual site is characterized by a rock fall over the presumed location of the mine entry area. To the south east of the rock fall area is a relatively steep colluvial slope covered in annual weeds and grasses. An old road remnant traverses a portion of this slope.

During the first site visit, the smell of coal combustion and sulfur was apparent at the rock fall area. However, patches of snow existed on many of the rocks. No steam or smoke was observed to emanate from the rock or surrounding areas. Elevated temperatures were not observed.

The ridgeline overlying the rock fall / mine entry area was walked. No evidence of underlying fire, such as vents, fractures or mineral deposition or alteration was observed to occur.

On subsequent visits to the site, no further indication of fire could be found. In fact, the combustion smell detected on the first site visit was not apparent; however, this could be attributed to atmospheric pressure differences between visits. During one visit, a hiker who described himself as a frequent visitor to the canyon was interviewed. He stated that he had never smelled coal combustion, nor had he ever seen smoke or steam rising from the Farmers Mutual location.

The vegetation on the colluvial slope south east of the presumed mine entry area is noteworthy, however. The vegetation in this area appears to be slightly stressed. The growth is an uncharacteristic gray color, and has noticeably less shrub growth than nearby slopes of similar aspect. These factors may be an indication of an underlying heat source; however, no other definitive fire evidence has been recorded. Subsurface data is required in order to determine whether this fire is actively burning or not.

General Observations:

Other than the smell of coal combustion noticed during one visit, no specific surface indicators of an underground fire were observed.

A slight vegetative change on a slope southeast of the presumed mine entry area may signal an underlying heat source.

If there is a fire at the Farmers Mutual, it is likely of low heat and low activity.

Public health and safety hazard is low due to the lack of surface indicators of a mine fire.

Wildfire hazard is low due to the lack of surficial heat and overlying vegetation.

Farmers Mutual Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1908–1951	Mesaverde / Cameo	N 65 W	3 N	Slope	46,782

* Not Reported

Moffat County

There are two known coal mine fires burning in Moffat County. Both of these fires are very active, and both are located near active or recently active coal mining operations. The mine fires are burning in mines that extracted coal from the Williams Fork Formation. Records indicate that room and pillar methods were used to extract coal from each location.

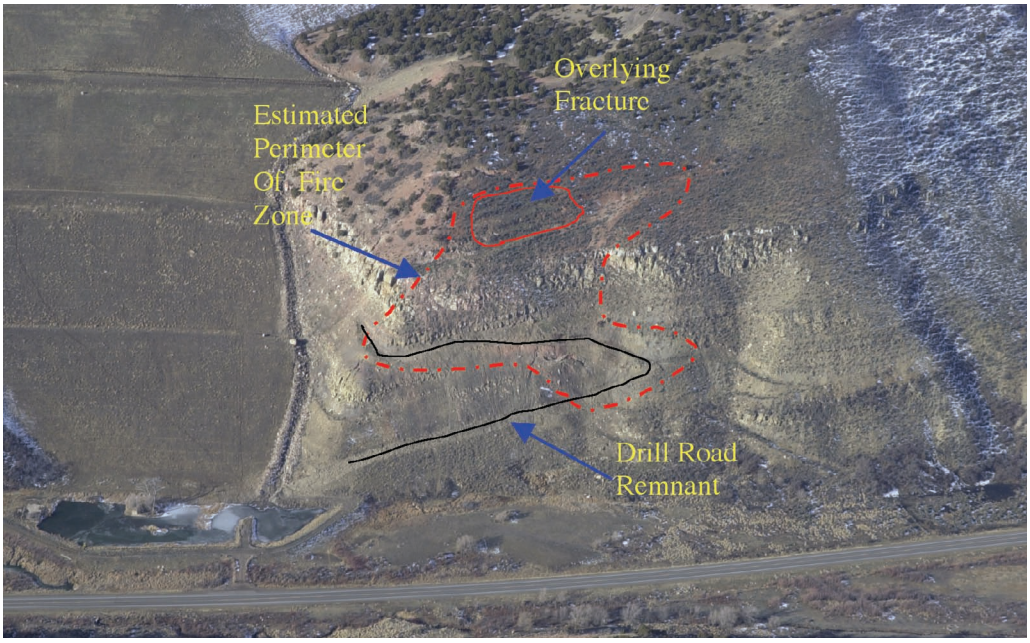
Streeter / Collom Coal Mine Fire

The Streeter / Collom, or Axial, Mine Fire is located near the old mining town of Axial, immediately adjacent to Colorado Highway 13 / 789 in southern Moffat County. The site is reached by driving either north from Meeker approximately 19 miles, or south from Craig, approximately 27 miles. The fire is situated mid-slope on an east-facing hillside just north of an excess overburden disposal area operated by the adjacent Colowyo Coal Mine.

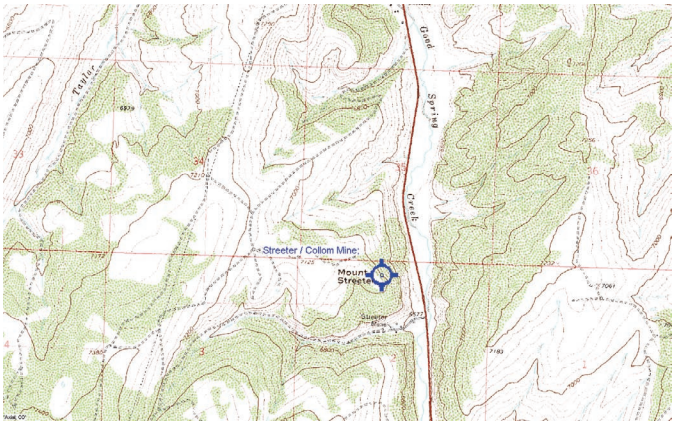
The fire is immediately adjacent to the now abandoned Redwing underground coal mine, and is relatively close to the active Colowyo open pit coal mine. This fire is generally very active, and has been the focus of a number of abatement activities (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*). Early abatement activity included the installation, maintenance and additional installation of a surface seal. This work occurred between 1962 and 1972 (Rushworth, et al, 1989). In the fall of 1998, the Division of Minerals and Geology accomplished subsurface investigations and limited grout injection. The Division completed a number of monitoring drill holes into the Redwing Mine in 2001, in order to determine whether the fire had migrated into that mine. Temperature data indicates that the fire had not progressed into the Redwing.

The surface expression of the fire is evident on the steep hillslope that overlooks Good Spring Creek and Highway 13 / 789. Steam plumes are visible from the highway during cold weather. Because the fire is extremely active near the ground surface, surficial sloughing, fracturing and failures are prevalent throughout the area.

The surface features of the fire are generally accessible via an abandoned drill rig access road that bisects the face of the hillslope and the fire zone. The lower portion of the road was reclaimed in the fall of 2001; however, the upper portion of the road is still in existence, and will likely remain so as it is too unstable to route reclamation equipment across. Because the features occur in close proximity to one another, individual numbers were not assigned to the features.



Streeter/Collom Coal Mine Fire. View toward East.



Streeter/Collom Mine Fire location. North at top.

The area where the underground fire expresses itself on the surface begins at the lower most extension of the remaining drill access road, and extends uphill in a south / southwesterly direction for an estimated distance of 250 feet. A large, circular, approximately 20 feet diameter, subsidence-like feature defines the lower portion of the zone. The base of the depression is closed. The feature is located on a hillside, so the lower portion is open to the down-slope side. The temperature of this feature is generally just above ambient conditions; however, this feature is significant because it denotes the furthest northeasterly extension of surface impacts from underground mining. From this point, the road traverses northward to a switchback, and then across the face of the hill in a southerly direction. Walking the road from north to south, beginning at the switchback a number of fire related features are encountered. The outside, or fill slope, of the switchback displays several short, north to south trending fractures that have ground temperatures of about 115° to 160°.

The inside, or cut slope of the switchback, displays several small venting fractures that display ground surface temperatures of 140°.

Immediately south is an area that displays massive fracturing on a scale significant enough to potentially cause localized slope failures. This area displays ground temperatures that vary from 100° to 315°. On the inside of the road immediately opposite of the potential ground failure area, is an approximately two feet diameter circular vent. This vent displays minor creosote deposition around its perimeter. Ground temperatures within the vent were measured at 530° to 560°. A fracture zone located about five feet east of the vent also displays creosote deposition and exhibits ground temperatures of 400°. The road cut immediately above these features displays significant creosote and sulfur deposition at a significantly reduced ground surface temperature of 125°.

Numerous fractures that intersect the road surface can be observed from the location of the circular vent to near the southerly extent of the road. In some places the fractures are limited to the road surface and the cut slope, but in some areas they are visible in the downslope fill area as well. Temperatures on the road surface and in the cut slope are generally in the range of 220° to 270°, while the fill slope temperatures are more typically in the 110° to 150° range.

Ground surface temperatures dissipate as the road ends about 200 feet south of the circular vent. At the end of the road, ground surface temperatures were not observed to exceed 90°.

A large fracture located near the crest of the hill immediately west of the fire features noted on the previous page is visible from the air. This 200 feet long feature is likely a subsidence related phenomenon, and could very well supply oxygen to the underlying fire.

General Observations:

This is a very active fire, as evidenced by substantial fracturing, slope instability and high near surface temperatures.

The fire is generally very efficient; few combustion by-products are observed across the site. However, near surface fire activity may be somewhat less efficient as a result of local ground (roof) failures, causing periodic oxygen starvation, and subsequent creosote and limited sulfur deposition.

The fire is probably well developed at depth within the abandoned mine.

Wildfire hazard is relatively low, as a result of the paucity of available fuels within the surface expression of the fire.

Human health and safety hazard is low due to the fence erected between the highway and the fire zone. Without this safeguard, the safety hazard would be rated as moderate to high.

Axial / Streeter / Collom Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1914–1944	Williams Fork	Unknown	2	Slope	3,475,360

Wise Hill Number 3 / Hart Coal Mine Fire

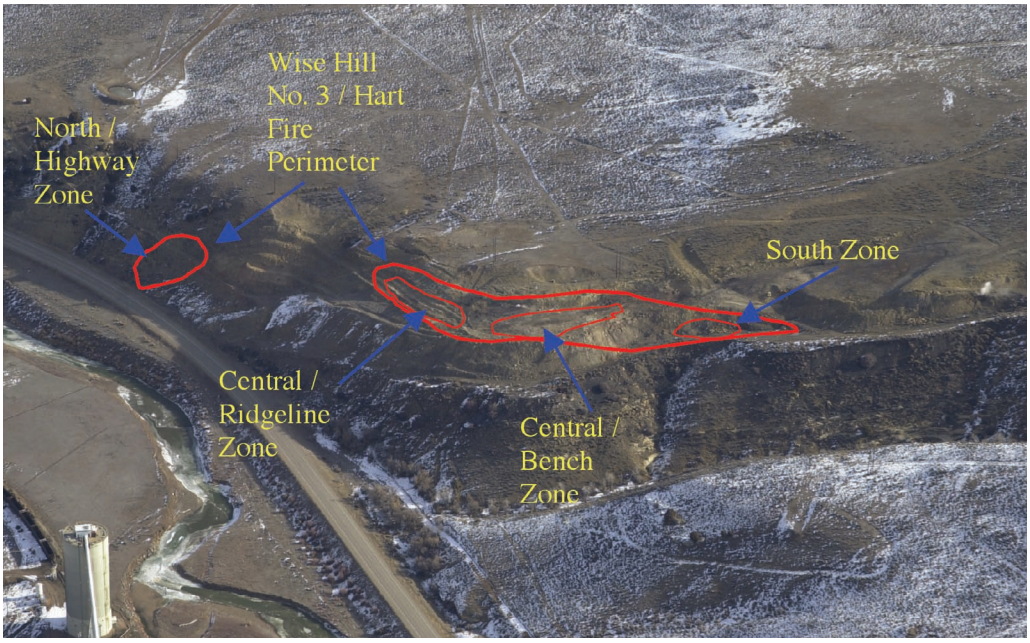
The Wise Hill Number 3 Coal Mine fire is located about five miles south of Craig adjacent to Highway 13 / 789 in Moffat County. This site appears on topographic maps as the Hart Mine. The site has been visited numerous times since 2001 as part of this evaluation, and as part of other on-going investigations.

A number of fire suppression activities have been accomplished at this site since 1976. Rushworth, et. al., 1989, reports that these activities included surface sealing efforts in 1976 and again in 1987 (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*). Drilling for purposes of monitoring the fire was accomplished in 1986. Drilling and grouting was accomplished about 1995. An attempt to flood the fire was initiated in 2004. None of the abatement activities has extinguished the fire. The Wise Hill Number 3 / Hart Mine fire is currently one of the more active fires in northwest Colorado.

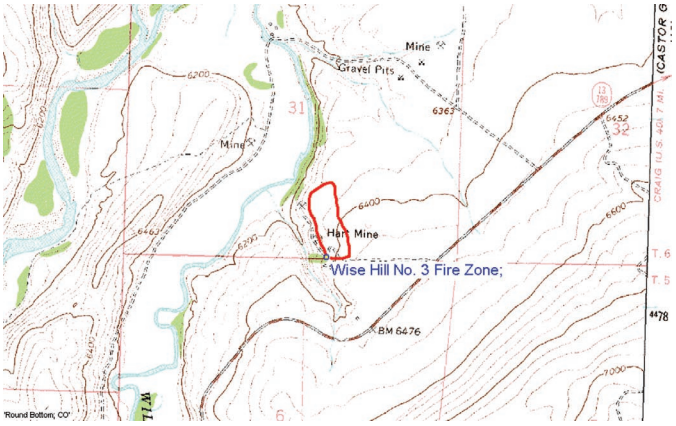
For discussion purposes, the fire can be divided into four distinct zones. From north to south, these zones are north / highway, central/ ridgeline, central/ bench and south. These areas are described as distinct zones based upon observations of fire characteristics. The ground surface, bore holes and fractures that separate the north / highway zone from the central / ridgeline are cool, and show no signs of active burning. It is possible that these locations are stratigraphically disparate; or if the same seam, they may be separated by mine collapse features or a large block of un-mined coal. Similarly, surficial evidence suggests a block of ground not involved in combustion between the central / ridgeline area and the central / bench area.

North / Highway Zone

This area is located adjacent to Highway 13 / 789, about eight feet above the highway elevation. This area is characterized by small slumps that open scarp-like fractures that vent the underlying fire. These venting fractures, located at 40° 25'54"; 107° 38' 45.6", produce small plumes of steam that are readily apparent in the winter months. Ground temperatures at the vents vary from about 102° to 125°. Carbon monoxide content immediately within the vents varies from 200 to 300 parts per million. Fractures and fracture remnants can be traced up the hill to just above mid-slope where a drill road crosses the slope. The fractures generally trend between north, 10° west and north, 20° east. None of the fractures above the lower set of vents exhibits elevated temperatures or other fire related characteristics. Drilling conducted by the Division in 1995 indicates that the fire in this area is relatively contained, and does not threaten the highway.



Wise Hill Number 3/Hart Coal Mine Fire. View toward Northeast.



Wise Hill Number 3/Hart Mine Fire location. North at top.

Central / Ridgeline Zone

This area is located on a point of land overlooking the highway to the west, and an unnamed canyon to the south. A bench has been constructed on the point near its southwesterly extent, which overlooks the confluence of the canyon with the highway. This bench supported past drilling operations. Fire features can be found on the bench, and on the relatively undisturbed slope immediately north of the bench.

A number of cased boreholes are located on the bench. The most northerly borehole located has an operable thermocouple installed. This thermocouple measured a subsurface temperature of 370° on May 17, 2002. Numerous venting fractures are located in this fire zone, generally located north and northeast of the drill hole. A fairly significant fracture is observable about 50 feet north of the instrumented drill hole. This fracture is discontinuous, due to surface bridging, but is discernible for at least 100 feet. The center of the fracture is located at 40° 25' 45.7"; 107° 38' 47.2". Open portions of the fracture are generally semi-circular, and measure about two feet by three feet. Temperatures within the fracture zone, as measured from south to north were measured at 125°, 165°, 200°, 600°, 135°. At the 600° vent, carbon monoxide measured 98 parts per million. Yellow and white sulfur precipitate is apparent at most of the vents along this fracture.

A large area to the north of the linear fracture is heavily disrupted by numerous parallel to sub-parallel venting fractures. These are generally located at the base of a deadman used to secure a double-pole transmission tower located slightly uphill of this area.

The fractures in this area generally trend north, 10° west. The fractures here support many active and inactive vents. The heat values tend to be in the 160° range, with higher values being observed near the southerly portion of the fracture system, as it approaches the linear feature described above.

Central / Bench Zone

This area lies immediately to the south east of the Central / Ridgeline Zone, and is characterized by a relatively flat bench area, backed to the north by a nearly vertical wall. A number of drill holes are visible on the bench area. Fire related features are prominent throughout this area.

The northerly vertical cut slope, and the overlying area, displays numerous parallel fractures, that appear to be joint controlled. These fractures, which are generally 40 feet or greater in length, by six to eight inches wide, trend about North, 35° West. These fractures do not exhibit elevated temperatures or other fire related characteristics. It is quite likely that these are subsidence features related to coal extraction, rather than coal removal by

combustion. If these features are connected to the underlying mine, they may become important ventilation pathways in the future as the fire approaches this portion of the abandoned mine.

Immediately adjacent to, and south of the vertical cut slope, is a bench from which at least eight boreholes were drilled. The surface expression of the fire is intermittent in this area, with only small vents observable. These vents are typically seen near the southern margin of the area, and exhibit low temperatures, generally less than 140°.

Ground surface temperatures near the eastern portion of the Central / Bench Zone have been measured in the 200° range. The bench area is well used by wintering cattle, as evidenced by an ample supply of cow manure covering the area. In June 2002, some of the manure on the bench area was smoldering in response to elevated ground surface temperatures.

Due to the fire hazard presented by the smoldering cow manure, the Division hired a contractor to scrape the manure from the Central / Bench Zone. The manure was removed from the area, soaked with water and mixed with dirt to eliminate the fire potential.

The northeastern most extent of the Central / Bench area exhibits a single vent located at 40° 25' 40.6", 107° 38' 43.2". This vent is small, measuring about four by eight inches, but exhibits temperatures measured at 525°. Oxygen emissions from the vent were measured at 11.2%, and carbon monoxide was measured at 435 parts per million.

The ground surface in the vicinity of the smoldering manure feels and sounds hollow when struck with a heavy object. This, in conjunction with the broad surface area of elevated temperatures gives the impression that the underlying fire is relatively near to the ground surface, and that it has significantly weakened the overlying rock.

South Zone

This area is south east of the Central / Bench Zone. The area consists of a bench sloping upward toward the east, and the remnants of two mine access roads. The roads are located on a cut slope below the elevation of the sloping bench, overlooking the adjacent canyon. The southerly burn zone is characterized by a few small vents located on the sloping bench, and a large, open vent located on the upper access road remnant. The cut slope between the large open vent and the smaller bench vents exhibits numerous conchoidal fractures, many of which vent the fire.

The cut slope venting fracture area, located at 40° 25' 37.0" 107° 38' 42.8", is about 40 feet in length, by about 12 feet high. The area exhibits ground surface temperatures of 125° to 160°. It is likely that the coal outcrop is involved in the fire at and near this location.

A large vent, measuring three and one half feet by two and one half feet is located on the road remnant about 25 feet due east of the slope fracture zone noted above. This vent exhausts visibly blue smoke, and is the site of significant creosote deposition. The ground temperature at the vent was measured at 225°, with oxygen content of the exhaust measured at 12.6% and carbon monoxide measured at 375 parts per million.

Significant conchoidal fracturing is observable in the road cut slope immediately south of this feature. These fractures vent combustion gasses, and exhibit temperatures of about 225°.

The large vent was backfilled by the Division of Minerals and Geology in June 2002 due to the safety hazard presented by the feature. It will be interesting to note how the adjacent fracture sets react to closure of the vent.

General Observations:

There appears to be as many as four distinct burn zones. These may be discontinuous as a result of the combustion of more than one coal seam, or as a result of roof falls or other underground impediments.

Alternatively, the appearance of discontinuity may be the result of surface venting rather than of actual spatial separation of underground burn zones.

Portions of this fire appear to be amenable to abatement activities.

The Central / Bench and South zones easterly areas may involve combustion of near surface rider seams.

The Highway zone appears to vent a relatively deeper fire than the more southerly areas. Drill data indicates that the fire does not present a hazard to the highway.

The Central / Ridge area appears to be the hottest and most active fire zone. This area is well vented and apparently burning rather vigorously as evidenced by the significantly elevated surface temperatures.

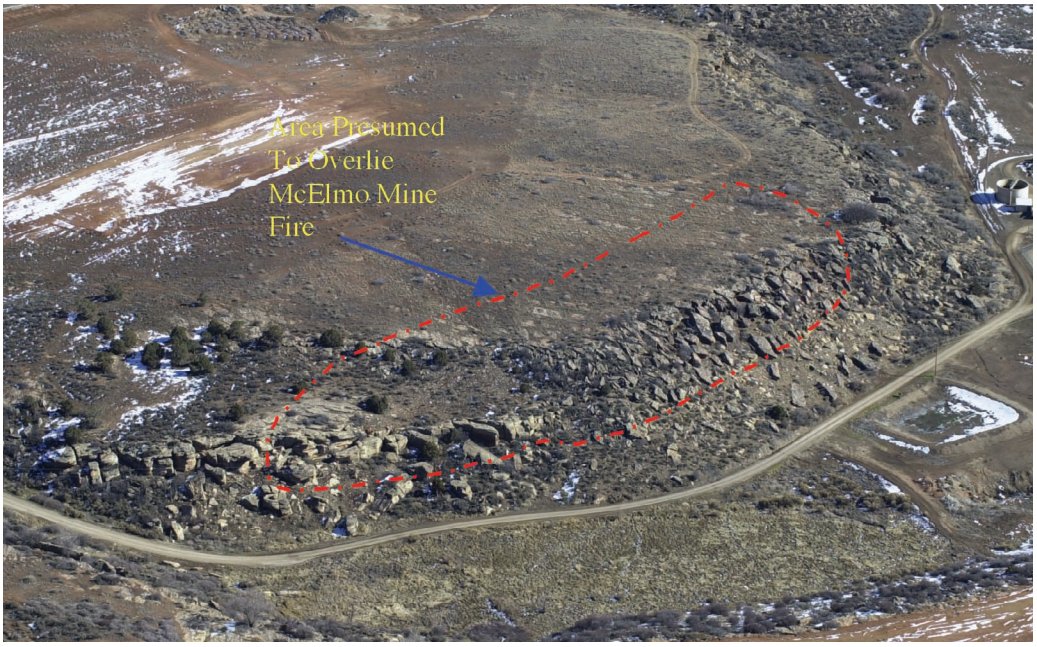
Wildfire hazard is variable because of the winter use of the Central / Bench Zone by wintering cattle. The manure left behind can combust, potentially resulting in an off-site wildfire. Other areas are generally barren of significant vegetation, resulting is a reduced fire hazard.

Public health and safety hazard of the area is moderate to high, due to the presence of elevated surface temperatures at some of the venting fractures, the potential of large vents opening, and due to apparently unstable ground at a portion of the Central / Bench Zone. An existing barbed wire fence constructed around the site ameliorates the hazard.

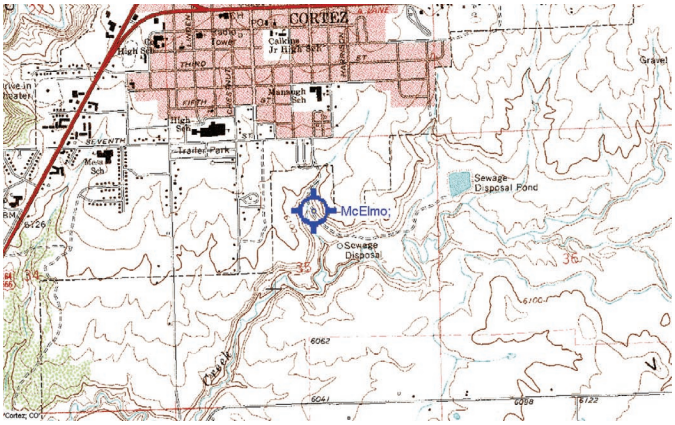
Wise Hill Coal (Silengo) Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1940–1970	Williams Fork / *	N 30 E	8	Drift	1,232,699

* Not Reported



McElmo Coal Mine Fire. View toward East.



McElmo Mine Fire location. North at top.

MONTEZUMA COUNTY

McElmo Coal Mine Fire

The McElmo fire is located south of Cortez in McElmo Canyon, just north of the city sewage treatment plant. The site is located about 200 yards south of the point where the sewage disposal facility access road drops into McElmo Canyon.

Rushworth, el al, 1989, indicates that the mine fire is located within the west-facing wall of McElmo Canyon. During the site visit of June 27, 2002, the entire west facing coal outcrop was inspected, as was the overlying mesa top. Very minor indications of past mining operations in this area were observed. Small quantities of coal were observed on the ground, and only intermittent debris was located. A portion of the overlying mesa top has been cleared of vegetation and has been graded, apparently in preparation for housing or other development.

The overlying mesa top is generally composed of a Dakota Formation sandstone member. This material is well jointed, displaying parallel fractures near the canyon edge. These fractures appear to be joint controlled, rather than being subsidence related phenomena.

No indications of an underlying fire were observed either along the outcrop, or on the mesa. No sulfur deposition, creosote, or other visual evidence of an underlying fire was observed. Because venting, if present, would likely occur from the fractures, temperature measurements were made at various fractures. Typically, temperatures varied from 80° to 85°. No anomalous measurements were made. Interestingly, a small area overlying the site does support a somewhat increased cover of annual grasses, as compared to surrounding areas. However, the cover difference is somewhat subtle, and is not by itself considered conclusive evidence of an underlying fire.

The west side of the canyon was also evaluated, as the Division had previously closed at least two abandoned mines in that area. These closed mine entries were easily located on the outcrop. No indication of a coal fire was observed at either entry area. The mesa overlying the top of these two mines was also evaluated. Portions of this area have been heavily disturbed by land clearing operations, apparently in preparation for housing or other development. No indication of an underlying fire was observed at either the disturbed or undisturbed area; however, the degree of disturbance was significant enough that earth work activities could have effectively buried fire indicators, if any.

General Observations:

The fire has been reported to occur on the east side of McElmo Canyon.

Few, if any, mining related artifacts were observed on the east side of the canyon.

No conclusive indications of an underlying fire were observed on the east side of the canyon.

Two closed mine entries were observed on the west side of the canyon, however no mining related features were observed on the overlying mesa.

If a fire is still burning in McElmo Canyon, it is of low intensity.

This fire may be dormant. However, subsurface data is required in order to accurately assess fire activity.

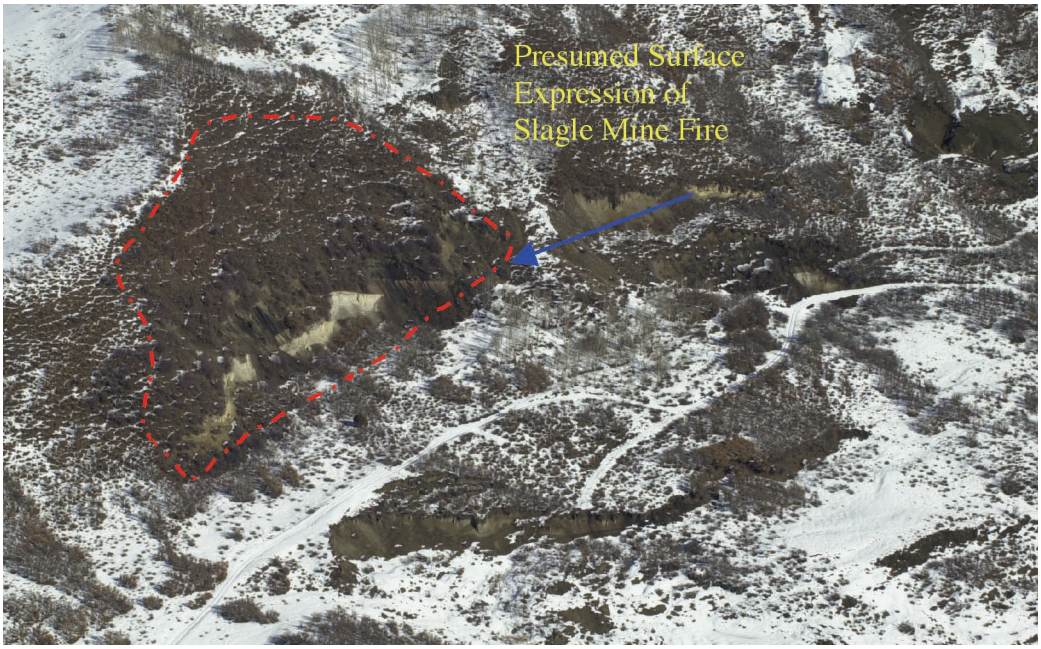
Public health and safety hazard at this site is low, due to the lack of fire related features.

Wildfire hazard is also low, again due to the apparent lack of elevated surface temperatures, lack of surface fuels and lack of fire related features.

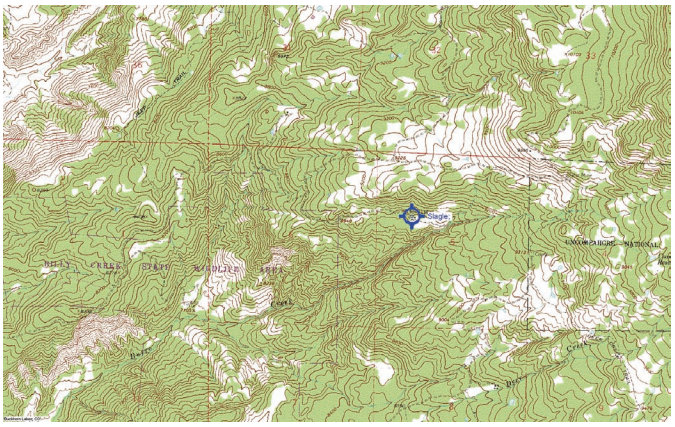
McElmo Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1914–1924	Dakota / *		4	Drift	7,124

* Not Reported



Slagle/Bright Diamond Coal Mine Fire. North to top.



Location of the Slagle/Bright Diamond Coal Mine Fire. North at top.

OURAY COUNTY

Slagle/Bright Diamond Coal Mine Fire, Ouray County

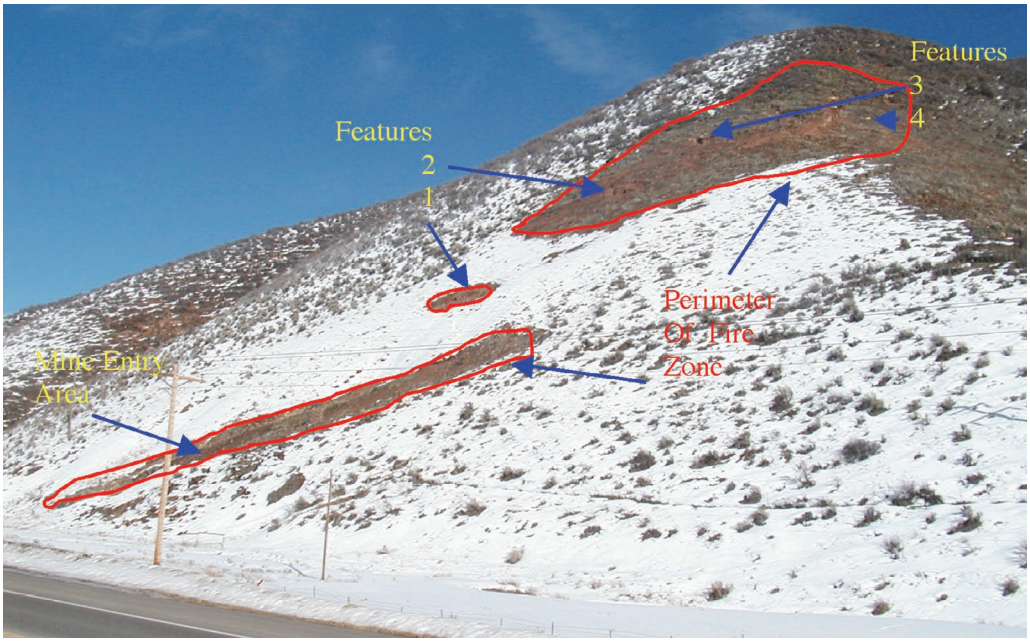
The Slagle Mine, also known as the Bright Diamond, had been evaluated by Rushworth et al as inactive, or dormant. As with the other coal mine fires thought to be dormant, the Slagle site was initially evaluated from the air. The aerial inspection revealed a steep hillside relatively barren of snow cover, while surrounding areas held snow. Generally, this pattern is a good indicator of underlying heat; however, a southerly aspect on a steep, dark colored slope can also display the same pattern.

The Slagle has been documented to be burning between 1939 and 1954. The U. S. Bureau of Mines constructed a surface seal over the fire by placing approximately eight feet of dirt over the fire area in 1954 (Shellenberger, date unknown).

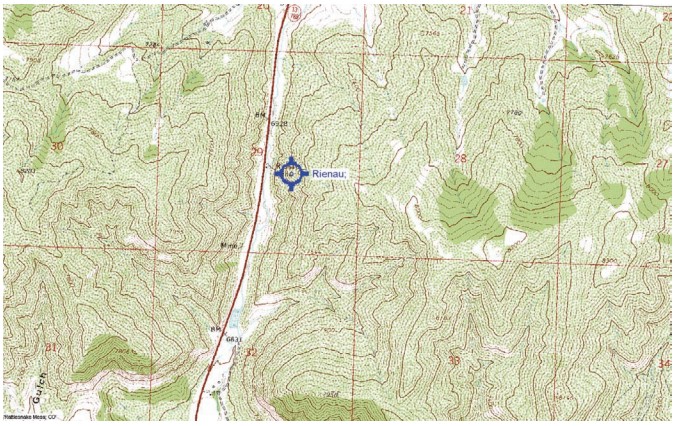
An attempt to visit the site was made in the fall of 2003. The landowner was contacted by phone, and indicated that he has observed smoke and steam issuing from the ground surface for some period of time. Unfortunately, the landowner did not allow access to the site at that time, so an on-site evaluation of the Slagle Mine has not been made. However, given the aerial observations, and the landowner account of smoke and steam issuing from the site, the Slagle Mine is classified as an active fire.

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1931–1938	Mesaverde / *	Unknown	Unknown	Drift	1,443

* Not Reported



Rienau Number 2 Coal Mine Fire. View toward Northeast.



Rienau Number 2 Mine Fire location. North at top.

RIO BLANCO COUNTY

Rienau Number 2 Coal Mine Fire

The Rienau Number 2 mine fire is located on a hill slope immediately east of Highway 13 / 789, about five miles north of Meeker. Due to the location of the fire, it is possible to drive to the base of the fire, park along the highway, and cross a field to reach the approximate location of the old mine entries.

The surface expression of the fire is readily apparent from Highway 13 / 789. The fire zone is an approximately three-acre area located on the side of a steep hill overlooking the highway. The vegetative change from native shrub land to annual grasses with intermittent shrubs is very dramatic. An observer positioned on the highway south of the mine will notice two large parallel fractures trending approximately west to east on the hillslope at the south end of the fire zone.

The surface expression of the burn zone is characterized by intermittent stands of annual grasses and weeds, and yellow sweet clover. A few perennial shrubs are present in the area, becoming more frequent near the upper margins of the area. Many large, barren areas also exist on the site.

Visitors to this site should be aware that a substantial population of large rattlesnakes occupy the mid to upper portions of the fire zone. The snakes are apparently attracted to the numerous warm fractures that occur at this portion of the area. The snakes were also observed to reside in some of the waist high shrubs located near the upper-most portion of the fire zone. Appropriate precautions should be taken when visiting.

The fire has been observed on a number of occasions in 2002 and 2003. Visits in 2002 indicated that the most active portions of the fire were located near the top of the hillside. However, in the spring of 2003, the Meeker Fire Department reported that a small brush fire had begun near the base of the hill, apparently as a result of the underground fire venting. A site visit two weeks following the wildfire indicated that an area located at the base of the hill, and previously relatively cool (temperatures of 130° to 150° in 2002), was now venting at temperatures between 300° and 450°. Within two months, the ground was no longer actively venting, and ground surface temperatures had declined to the 150° to 200° range. The wildfire was contained quickly, and thus impacted less than one half acre. However, this event is a good example of the sporadic nature of underground coal mine fire activity.

Feature 1

Feature 1 is a small vent located at 40° 06' 43", 107° 50' 46.4". This vent exhibits some moss growth and slightly elevated temperatures at about 180°. This vent is the terminus of a healing northeast / southwest trending fracture that terminates in a five feet by 12 feet closed subsidence feature.

Feature 2

Feature 2 consists of two sets of parallel fractures located about 50 feet north, and slightly uphill of Feature 1. The lower of the two fractures is about 150 to 200 feet long, with an average width of about one foot. The smell of combustion is slightly noticeable at this location. The upper fracture has similar dimensions as the lower, but the fracture appears to be healing, as it is bridging and filling in numerous locations.

Feature 3

A series of small, discontinuous vents that trend northeast / southwest forms Feature 3. This series of six to ten inch diameter vents generally exhibits ground temperatures of 150° to 200°.

Feature 4

Feature 4 is a long fracture that appears to be extending north over time. This fracture is located 125 feet uphill of Feature 1, is 15 feet in length and four feet wide. Sandstone and colluvial ledges disrupt the ability to view the bottom of the fracture. Ground temperatures within the fracture vary from 180° to 235°, with the hotter temperatures being observed at the further downslope portion of the fracture (40° 06' 43.7"; 107° 50' 45.5").

Three one-foot diameter vents are located about 20 feet north of the Feature 4 fracture. These trend north to south, and exhibit ground surface temperatures of 130° to 150°. Moss can be observed to be growing near these vents, but they appear to be minor features, overall.

Feature 5

Feature 5 consists of parallel fractures that are observable from the highway below. These two fractures trend northeast to southwest, are about 80 feet long and vary in width from two to four feet. These two fractures give the impression that they are subsidence features that serve as minor fire vents, as opposed to being primarily fire related features.

The northerly of the two fractures appears to be relatively active. The smell of combustion is apparent along the fracture. Ground surface temperatures within the vent vary between 150° and 175°.

The lower, or more southerly, of the two fractures appears to be inactive, and did not exhibit elevated temperatures, moss growth or combustion smell. It is possible that this southerly fracture serves as an atmospheric input to the fire.

General Observations:

The Rienau No. 2 Mine fire is a good example of the cyclic life of an underground fire at an abandoned mine. Periodic moments of activity, interspersed with periods of inactivity, occur at this site.

The fire appears to be of low intensity, yet is fairly efficient, as evidenced by a lack of combustion by-products at the various vents.

The fire appears to be located throughout the mine. This is evidenced by the large area surficially impacted by the heat of the combustion.

Likely in response to the steep slope of the hill, the area appears prone to significant fracturing, and slope displacements lower on the hill. These characteristics may help to ventilate the fire, and may ultimately be responsible for the periodic episodes of near surface activity.

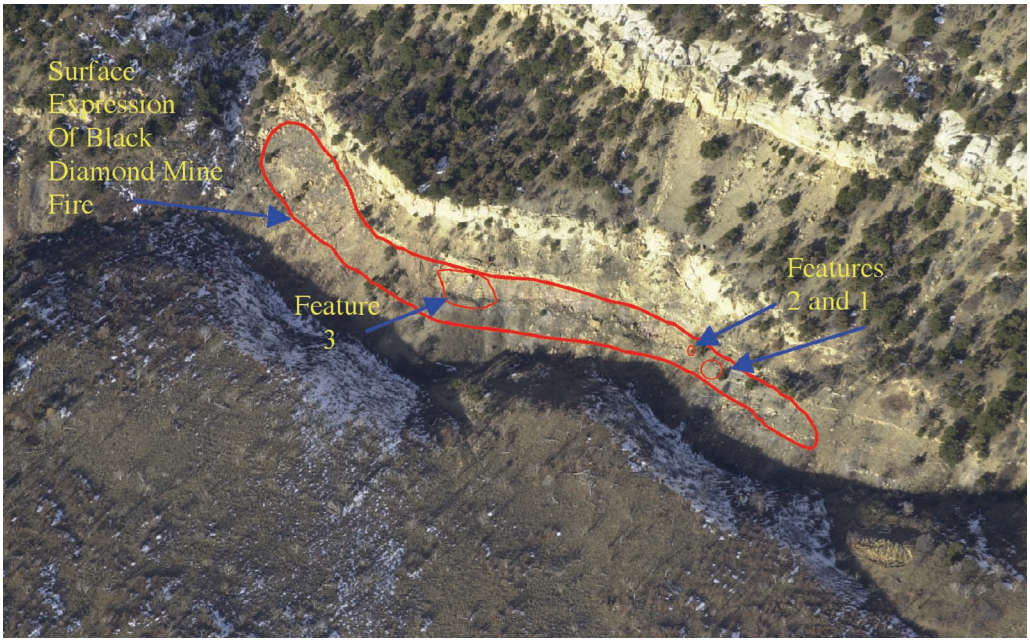
Wildfire hazard appears to be moderate, given the volume of plant growth over the area, and the heat generated during periods of activity.

Public health and safety risk is low, given the severity of the slopes in the area.

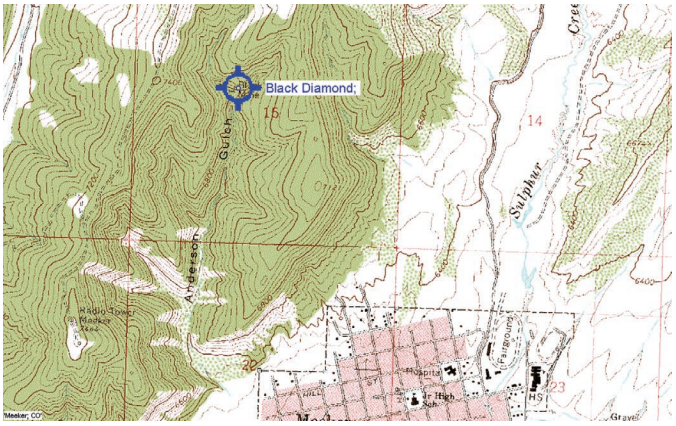
Rienau Number 2 Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1928–1965	Williams Fork / *	N 30 W	18 N	Drift	476,976

* Not Reported



Black Diamond Coal Mine Fire. North to top.



Black Diamond Mine Fire location. North at top.

Black Diamond Coal Mine Fire

The Black Diamond Mine is located about one mile northwest of Meeker in an unnamed tributary to Anderson Gulch. The mine fire was accessed by driving north on the East Fork of Lion Canyon Road, to the FAA radio tower, then hiking south cross-country to the mine. This site has been visited on a number of occasions in 2002 and 2003.

The mine fire is apparent on a south-facing slope immediately above the base of the unnamed tributary of Anderson Gulch. The remnants of an old mine access road delineates the base of the fire zone, while a talus covered slope hides the coal outcrop. Immediately above the slope is a competent, cliff forming sandstone. This sandstone displays significant jointing, some of which is likely enhanced by subsidence activity. A number of vents can be observed along the talus covered slope, and at the base of the overlying sandstone. Interestingly, the surface expression of the fire acts as a demarcation line for a relatively recent wildfire. Burnt trees are apparent on adjacent hillsides toward the southeast, and in the immediate vicinity of the Black Diamond. It is unknown whether the coal mine fire initiated the surface fire.

Feature 1

Feature 1 is a discontinuous fracture zone estimated at 15 feet in length, by six to eight inches in width. This feature, located at 40° 03' 27.8", 107° 55' 29.5", displays significant creosote deposition. Ground surface temperatures at the vent vary from 125° to 160°. This feature appears to occur in fill material caused by uphill sloughing of colluvial material over the coal outcrop.

Feature 2

Feature 2 is located west of Feature 1, and about 15 feet further uphill. This vent is located in a sandstone outcrop. The ground temperature of this vent was measured at 390°. Approximately 20 feet further to the west in the same sandstone outcrop are two more vents, each displaying ground temperatures of 340°. These more efficient vents do not display the creosote deposition so apparent at Feature 1.

About 20 feet further to the west of the westerly outcrop vent is a series of small venting fractures located over the colluvial-material-covered outcrop. These vents display ground temperatures of about 250°. Close examination of individual fractures reveals that smoldering coal is located relatively close to the ground surface.

Feature 3

Feature 3 is a highly fractured hillslope area that appears to be composed of surficial colluvial material over the coal outcrop. The fracture pattern at this area, located at 40° 03' 25.1", 107° 55' 31.7", is semi-circular, convex upward. It is possible that this area represents the old mine entry area. The convex fractures appear

to be fairly deep, and form free-standing ridges of colluvial material overlying sandstone and coal. The area appears to be very unstable, as witnessed by a fairly large debris pile at its base. Ground surface temperatures hover around 250° at this location.

Feature 3 marks the westerly extent of significant fire related features. The area immediately west of Feature 3, situated on-strike with the coal, is a colluvium covered slope supporting a moderately dense stand of annual grasses. The upslope sandstone cliff has contributed many boulders that are scattered on the slope. The stand of annual grasses in this area appears out of place, given the prolific, native-appearing adjacent vegetation. The vegetation here may indicate an underlying heat source.

General Observations:

The most active portion of the fire is located near the middle to eastern portion of the area, centered around Features 1 and 2.

The fire appears to be intermittently active toward the west, with some increased activity apparent at Feature 3. Fire activity at Feature 3 is resulting in surficial instability at this location.

The westerly annual grass area suggests an underlying heat source may be present.

Significant sediment contribution from the sandstone cliff above the westerly annual grass area may be a contributing factor in minimizing fire activity in this area, by providing a regenerating surface cover.

The site may experience short cycles of activity / inactivity as a result of slope instabilities causing periodic increases and decreases in oxygen availability.

The fire appears to be located relatively close to the outcrop.

Public health and safety risk is low, given the remoteness of the site.

Wildfire hazard is moderate given vent heat at Feature 2, and the association of nearby vegetation.

Black Diamond Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1916–1930	Williams Fork / *	N 30 W	18 N	Slope	30,818

* Not Reported

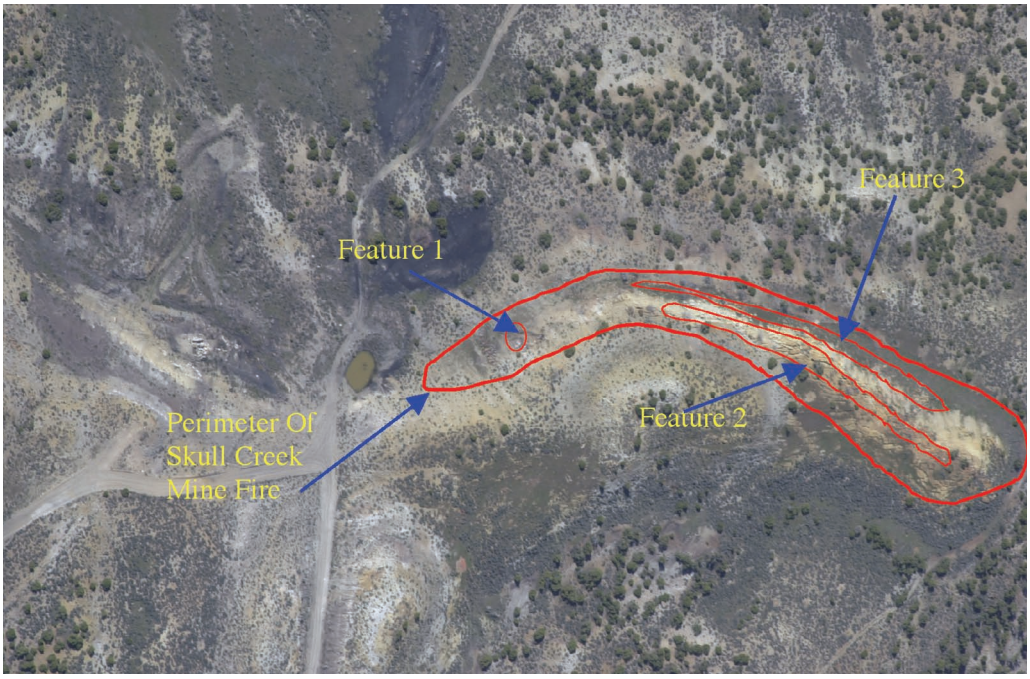
Skull Creek Coal Mine Fire

The Skull Creek Mine fire is located about seven miles northeast of Rangely, about halfway between Taylor Draw Reservoir and Highway 40 east of Dinosaur, Colorado.

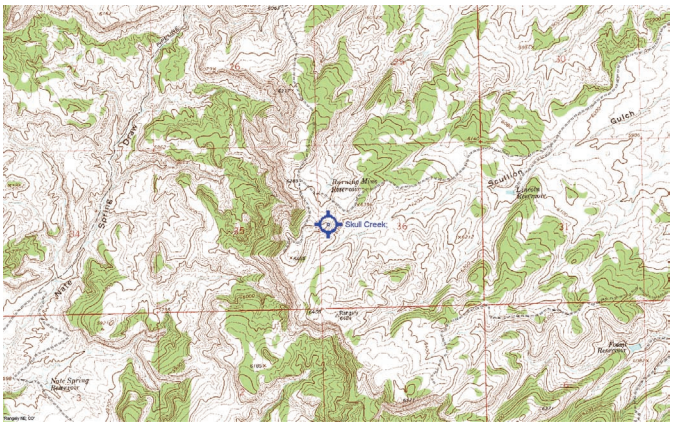
Skull Creek had previously been classified as an outcrop fire (Rushworth, el al, 1989), however, investigations at the site indicate that this is a coal mine fire. The area was severely disturbed by Bureau of Mines attempts to isolate the fire using heavy equipment in the 1960's (Shellenberger, date unknown) (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*), so it is difficult to ascertain the history of the site, given on-the-ground evidence. An area to the north of the fire appears to be a collapsed adit. This feature is located adjacent to a fairly large pile of coal waste, so the inference is made that mining activities were conducted here. Due to the lack of records and of mining related artifacts, it is assumed that this may have been a pick and shovel mine supplying local ranchers and homesteaders. By extension, it is assumed that the coal fire is a result of past mining activities, rather than being a product of outcrop spontaneous combustion as has been previously suggested. Other piles of coal are located on a flat area south of the fire zone. Given these site observations, the Skull Creek Fire will be classified as a mine fire rather than as an outcrop fire.

The fire is located under a fairly small ridge, which was bisected east of the fire zone by a dirt road. This road construction was apparently intended to help contain the fire, by depriving it of additional fuel to the east. The top of the ridge is composed of a significant, well jointed sandstone. Underlying the sandstone is a sequence of shale and coal measures. The coal outcrop is not visible due to sloughing of the shale, and to a minor extent, due to falling blocks of sandstone.

A small road or bench-like feature is located at the base of the ridge on its southern flank. The fire appears to be located below this bench, extending northerly under the face of the ridge so that it vents from the sandstone cap, and from the bench surface itself in a disseminated manner. No fire related features were observed on the north-facing flank of the ridgeline, which has also been exposed by road construction activities.



Skull Creek Coal Mine Fire. North to bottom.



Skull Creek Coal Mine Fire location. North at top.

Surface vegetation in the area has experienced a wildfire in the past, as evidenced by numerous burnt piñon and juniper trees in the area. It is unknown whether the fire originated as a result of the mine fire or not. The surface expression of the fire had been evaluated as a moderate wildfire risk due to the surface characteristics of the underground fire. The Bureau of Land Management was consulted about the possibility of conducting surface fire hazard reduction activities at the site. After a joint site visit in the spring of 2003, Bureau of Land Management representatives determined that this was an unnecessary activity given their management objectives for the area.

Feature 1

Feature 1 is a roughly circular subsidence-like depression. This feature is fairly active, having expanded by over ten feet in less than a years' time. In June 2002, the feature was about 40 feet in diameter. By April 2003, the feature had expanded to approximately 50 feet by 40 feet, and appears to be migrating toward the northwest. Temperatures vary across the feature from about 125° to 425°. The feature (40° 11' 12.1", 108° 47' 56.2") is located on a bench or road–like grade, and extends into the toe of the mesa located immediately to the north. The location of the subsidence feature indicates that the fire is located below the bench or road-like grade. This is contrary to the initial impression an observer of the site might have of the fire being located above this grade in a carbonaceous shale-to-coaly shale outcrop exposed above the grade in the cut slope of the mesa. This distinction is important because the casual observer will quickly discover that they are walking immediately above the fire, rather than walking to the side of the fire.

Feature 2

Feature 2 is a series of long, linear parallel fractures located on the crest of the mesa along its southerly margin. These fractures, which extend approximately 600 feet along the mesa crest, and northerly from the crest about 40 feet, trend northwesterly to southeasterly, and may well be joint controlled, rather than being subsidence related features. Some of the fractures vent the fire, but at temperatures just above ambient conditions. Venting is most evident as elevated moisture and resultant moss growth near the ground surface. Ground temperatures and temperatures within fractures along the south facing slope of the mesa vary from 125° to 165°. Periodically, creosote development near the top of a fracture or on the mesa side may be observed. A more apparent vent is located at 40° 11' 10.6", 108° 48' 10.3". This vent is located near the base of a tree near the far west margin of the mesa where it is bisected by an extension of the road / bench constructed around the base of the mesa.

Feature 3

Feature 3 is the bench-like road or grade on the south side of the mesa. Portions of the bench appear to overly the active fire zone. The temperature of the bench surface itself is elevated above ambient conditions, at 130° to 150°. The ground surface of the bench gives off a dead or "punky" sound when struck with a heavy object, giving the impression of low underlying strength. A number of small active vents also exist on the bench. The fire below the bench appears to be moderately active. This is evidenced by the generally elevated ground surface temperature, and by the presence of small ash cones. Small rock ash cones have been observed to develop over what is hypothesized to be small, robustly exhaling point-source vents. Two to three of these ash cones may be observed on the bench at each site visit. Generally, the ash cones have a circular ground surface footprint of 12 to 18 inches in diameter, and may be eight to ten inches tall. The cones are composed of rock ash, with silt to sand sized particles of burnt shale and sandstone predominating. The material is not compacted and is generally tan to rose color. This material appears to have been pushed out of the active burn zone by exhausting combustion gases, although significantly elevated temperatures were not observed within any dissected cone.

General Observations:

Evidence suggests that this was a small, pick and shovel mining operation.

The fire appears to be most active under the road like bench located south of the mesa, however, indications of fire within the south slope of the mesa immediately above the road / bench have been observed.

Venting is occurring from the long, parallel fractures located on the mesa top and from the road / bench area as well.

The fire appears to be fairly near surface, but possible discontinuous towards the west. The fire appears to be generally located at, or just south of, the southerly mesa crest.

The fire likely experiences periods of activity and relative inactivity, both spatially and over time.

During periods of activity, this fire is probably very active and hot.

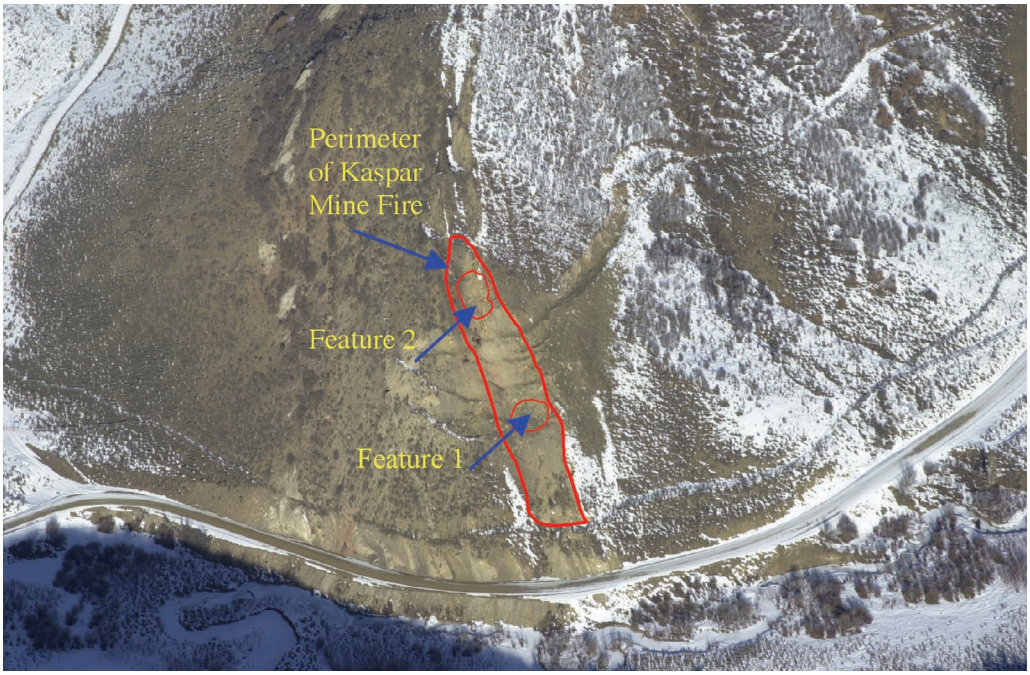
The ground surface at the road / bench area may be undermined or may have experienced a significant loss of underlying material due to removal by the fire.

The wildfire hazard has been evaluated as moderate, given the amount of vegetation in the area, and the relative degree of near surface heating observed at the bench / road area. However, the BLM has determined that pre-fire suppression activities would not be consistent with the management goals for this area.

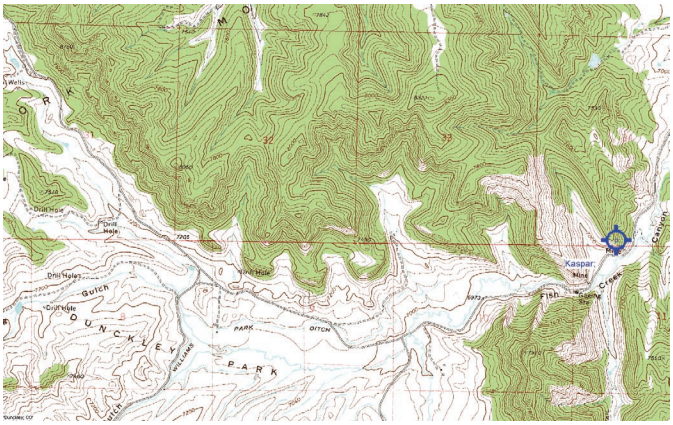
The human health and safety hazard at this site is minimal, given its remote location, and the presence of a fence around portions of the site.

Skull Creek Coal Mine

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
No Record	No Record	Unknown	4 N	No Record	No Record



Kaspar Coal Mine Fire. View toward West.



Kaspar Mine Fire location. North at top.

ROUTT COUNTY

Kaspar Coal Mine Fire

The Kaspar Mine Fire is visible on the south-facing nose of a ridge located immediately north of Fish Creek in Routt County. The site is accessed by traveling west from Oak Creek, or east from Hayden on County Road 27, to its intersection with County Road 37. The fire is located about two miles south of this intersection on the north side of County Road 37.

The fire apparently began in the late 1960's, or early 1970's. The mine fire initiated a wildfire in 1972. This event prompted the Bureau of Mines to construct a surface seal (Shellenberger, date unknown) later that year (see Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*).

When the site was visited on June 12, 2003, it was readily apparent that the surface expression of the fire zone was confined to an area extending up the nose of a narrow ridgeline. The ridge appears to be formed on-strike by high angle sandstone / coal / shale sequences. When walking the area, it is apparent that the coal formed the centerline of the ridge, with sandstone found on either side of the coal. These sandstones form slightly elevated outside margins of the ridge, with the softer coal forming a slightly depressed centerline of the ridge.

Evidence suggests that the mine entry was located at about road level, and that the mine advanced toward the northwest into the ridgeline following the strike of the steeply dipping coal.

The surface expression of the fire appears as a band of annual grasses and weeds that runs parallel with the ridge. Grasses and weeds thin upslope to an area where sandstone outcrop and weathering shale predominate. A six-strand barbed wire fence surrounds the fire perimeter.

The mine entry area appears to have either been backfilled or blasted shut, likely during the project conducted by the U. S. Bureau of Mines. No evidence of re-openings or venting was observed in this area. Further up hill, the ridgeline becomes very hummocky, possible as a result of the surface seal material sliding down hill. Some fracturing and venting can be observed in the hummocky area.

Feature 1

Feature 1 is a vent area located about mid-slope on the ridgeline located at 40° 20' 19.2", 107° 08' 08.2". This area is characterized by a number of small fractures, generally one to four inches wide by two feet in length, surrounded by un-fractured ground that displays creosote staining. Ground surface temperatures in this area were measured at 145°.

Feature 2

Feature 2 is a large, filled depression bordered by two abandoned vents. This feature is located uphill of Feature 1, on the steep ridgeline near the top of the surface expression of the underlying fire. The depression is either a collapsed subsidence feature, or, possibly, a collapsed or filled air shaft that was used to ventilate the mine. Two abandoned vents are located at the northwesterly margin of the cusp of the depression in a sandstone outcrop. These were both cold at the time of the site evaluation, but each displayed significant deposition of a very hard, tan to buff colored tar or creosote -like substance. The presence of this material was restricted to the immediate vicinity of the vents, and appears to be a cooled precipitate, so it is presumed to be a combustion by-product.

Immediately above Feature 2 the ridgeline begins to flatten near its crest. This flatter area appears to be the source of the surface sealing material used in 1972. The surface seal material borrow area has formed a large precipitation collection area, that channels snowmelt and rainfall down-slope onto the surface seal material. Quite likely, the contribution of concentrated water flow to the surface seal material, in combination with the severe slope angle of the ridge, contributed greatly to the failure of the seal.

General Observations:

This is likely a relatively low temperature fire that is laterally contained by stratigraphically higher and lower competent sandstones.

There is no surface evidence of fire uphill or westerly of the large surface depression. This could indicate that the feature that appears to be a backfilled pre-existing shaft, acts as a barrier to westerly movement of the fire.

The surface expression of the fire is limited to general ground warming and minor venting in one location.

Creosote deposition and lower surface temperatures indicate a relatively inefficient fire;

Wildfire hazard is regarded to be low, given the low surface heat values. However, there is substantial annual grass and weed growth over the lower half of the fire expression. Should elevated heat values occur, the wildfire hazard would be elevated.

Human health and safety risk is low, given the remoteness of the site, the steepness of the ridgeline, low surface temperatures and the lack of significant vents. A barbed wire fence surrounds the site, further reducing public safety risks.

Years Operated	Formation / Mined Seams	Strike	Dip	Mining Method	Total Production
1930's–1940's	Williams Fork / Wadge	N 40 W	28	Stope	215

Table 2. Active Coal Mine Fires By County*

County	Mine Name	Legal Description	Mining Method	Coal Rank	Mined Formation	Coal Thickness (ft.)
Boulder	Lewis No. 1 & 2	NE NE NE Sec. 21 T1S R70W	Slope	Sub-Bituminous	Laramie	5.5
	Marshall No. 1	SW NW NE Sec. 21 T1S R70W	Drift	Sub-Bituminous	Laramie	8
Delta	Minnesota Creek	NW NE Sec.35 T13S R91W	No Records	No Record	Mesaverde	No Record
	States	NE NW NW Sec. 18 T13S R94W	Drift	Sub-Bituminous	Mesaverde	6
Fremont	Double Dick	NW SE SE Sec. 24 T20S R70W	Drift	Bituminous	Vermijo (Brookside)	6
Garfield	Coryell	SW SE Sec. 31 T5S R90W	Drift	Bituminous	Mesaverde (Allen)	Unknown
	IHI No. 3 (D & H)	NE NE Sec. 17 T5S R92W	Stope	Bituminous	Mesaverde (Wheeler)	11
	Elk Creek	NW NE Sec. 27 T5S R 91W	Drift	Bituminous	Mesaverde	Unknown
	Gem (South Canyon No. 2)	NW SW Sec. 14 T6S R90W	Stope	Bituminous	Mesaverde (Wheeler, E, (U?))	Unknown
	Haas (IHI No. 2)	NW NW Sec. 16 T5S R92W	Stope	Bituminous	Mesaverde (Wheeler)	11
	Harvey Gap Nos. 1, 2, 3	SW NE Sec. 24 T5S R92W	Drift	Bituminous	Mesaverde	Unknown
	New Castle No. 1	NE NE Sec. 1 T6S R91W	Drift	Bituminous	Mesaverde (Allen)	8 - 42
	Morgan	SE SE Sec. 21 T5S R91W	Stope	Bituminous	Mesaverde (Wheeler)	Unknown
	New Castle No. 3	SW NW Sec. T5S R90W	No Records	No Record	Mesaverde	No Record
	Pocahontas No. 1 & 2	NW SE Sec. 27 T7S R89W	Drift	Bituminous	Mesaverde	Unknown
	South Cañon No. 1	NW NW Sec. 15 T6S R90W	Stope	Bituminous	Mesaverde (Wheeler, D, U, E)	6 - 17
	Sunshine	NW SE Sec. 33 T7S R89W	Stope	Bituminous	Mesaverde	8
	Vulcan	NW NW Sec. 1 T6S R91W	Shaft	Bituminous	Mesaverde (Wheeler)	6 - 18
Gunnison	Oliver	NW NE Sec. 15 T13S R90W	No Records	No Record	Mesaverde	No Record
Jackson	Riach	NW SW Sec. 24 T7N R81W	Slope	Sub - Bituminous	Coalmont	66
Las Animas	Morley Dump **	SE SE Sec. 36 T34S R64W	Waste (Refuse) Pile	Bituminous	Vermijo (?)	N/A
Mesa	Farmers Mutual	SE SW Sec. 36 T9S R100W	Slope	Bituminous	Mesaverde (Cameo)	3
	Garfield	SE SE Sec. 6 T11S R98W	Drift	Bituminous	Mesaverde (Palisade)	5
	Go Boy	SW NE Sec. 2 T11S R98W	Slope	Bituminous	Mesaverde (Cameo)	Unknown
Moffat	Streeter / Collom	NE NW Sec. 2 T3N R93W	Slope	Bituminous	Williams Fork	23
	Wise Hill No. 3 (Hart)	SW SE Sec. 31 T6N R91W	Drift	Bituminous	Williams Fork	16
Montezuma	McElmo	NE ¼ Sec. 35 T36N R16W	Drift	Sub-Bituminous	Dakota	4 - 10
Ouray	Slagle (Bright Diamond)	E ½ NW Sec. 5 T46N R7W	Drift	Sub-Bituminous	Mesaverde	25
Rio Blanco	Black Diamond	N½ S ½ Sec. 15 T1N R94W	Slope	Bituminous	Williams Fork	18
	Rienau No. 2	NW SE Sec. 29 T2N R93W	Drift	Unknown	Williams Fork	Unknown
	Skull Creek	SW NW Sec. 36 T3N R102W	No Records	No Record	No Record	No Record
Routt	Kaspar	N/2 NE Sec. 11 T4N R87W	Stope	Bituminous	Williams Fork (Wadge)	5

* Mining and Geologic Data from Carroll and Bauer, 2002

** Morley Waste Dump, a refuse pile fire rather than a mine fire, is included here for convenience

DORMANT UNDERGROUND FIRE EVALUATIONS BY COUNTY

Rushworth et al, 1989, provided a table of known fires at abandoned coal mines that had been characterized as "inactive". The term "inactive fire" as used in that publication was meant to describe an underground fire that did not display surface characteristics of an underlying fire. That term is synonymous with the term "dormant fire", that is used in this paper.

In order to evaluate these dormant mine fires, aerial inspections of each were conducted. The sites were studied from the air for signs of underlying fire indicators. These indicators included the presence or absence of fractures, creosote deposition, active subsidence, vegetative changes, venting, steam or smoke ground surface color changes or other anomalous ground conditions. Photos were taken to document the condition of each site. Any site that displayed characteristics of an active underground fire was scheduled for an on-site evaluation.

The following table lists by county underground mine fires that appear to be dormant and a brief description of observations made.

The aerial investigation indicated that five sites (Ramsey, Arrowhead, Slagle, Lou Creek, Engleville) displayed potential fire indicators, and thus warranted an on-site investigation.

Field investigations revealed that the Arrowhead had likely been an active fire at one time, but was dormant at the time of the field evaluation (October, 2003). The Ramsey site was evaluated; however, no indicators of an underground fire were observed during the field evaluation in October 2003. This fire will remain classified as dormant. The Engleville Mine was walked, but no fire indicators were observed on the ground. This fire will remain classified as dormant.

The Lou Creek area of Tongue Mesa, located in Ouray County, was visited in November 2003. Five different sites were visited during the field investigation. One site, possibly the Kennedy Mine, showed indications that the refuse located downslope of the mine entry had burned over a very small area at one time. The remnant ash did not appear to be recent, however, as it had become semi-consolidated. No indications of subsurface fire were observed at the Kennedy, Lou Creek or any of the other abandoned coal mines in this area. The Lou Creek Mine fire will remain classified as dormant.

The Slagle Mine is reported by the landowner to exhaust combustion gas and steam. This site is classified as an active fire, and is described in the *Active Underground Fire Evaluations by County* section of this report.

Table 3. Dormant Coal Mine Fires By County

County	Mine Name	Location *	Comments
Boulder	Eldorado	39° 56' 54.5"; 105° 14' 0.6"	No fire indicators visible
	Hi-Way	39° 57' 34.3"; 105° 05' 14.4"	No fire indicators visible
	Kitchen Slope	39° 57' 18.0"; 105° 13' 47.7"	No fire indicators visible
	Marshall No. 3 & 4	39° 57' 4.0"; 105° 14' 7.5"	No fire indicators visible
Delta	Blackburn	38° 55' 43"; 107° 31' 19.4"	No fire indicators visible
	Blossom	38° 55' 47"; 107° 58' 04.5"	No fire indicators visible
	Burnt Timber	38° 53' 22"; 107° 50' 38"	Could not locate mine in vicinity of coordinates provided
	Currant Creek	38° 56' 13"; 107° 50' 38"	Could not locate mine in vicinity of coordinates provided
	Dry Creek	38° 57' 08"; 107° 49' 35"	Could not locate mine in vicinity of coordinates provided
	Dugger – Rollins	38° 52' 53"; 108° 05' 49"	No fire indicators visible
	Fairview	38° 54' 39"; 108° 03' 16"	Of two reported locations, this appears to be correct; No fire indicators visible
	Green Valley	38° 56' 04"; 107° 57' 12"	No fire indicators visible
	Independent No. 2	38° 55' 47"; 107° 58' 0"	No fire indicators visible
	Red Canyon	38° 56' 06"; 107° 58' 01"	No fire indicators visible
	Rowland	38° 53' 36"; 108° 05' 31"	No fire indicators visible
Elbert	Barker Pit	39° 09' 55"; 1030 53' 40"	Holding snow; presumed not hot
Fremont	Beacon	38° 22' 15"; 105° 11' 57"	No fire indicators visible
	Brookside	38° 24' 38"; 105° 12' 14"	Could not locate mine in vicinity of coordinates provided
Garfield	Black Raven	39° 37' 09"; 107° 43' 56"	East side of Haas Canyon; No fire indicators visible
	Hot Point	39° 22' 35"; 108° 46' 14"	Bookcliffs; No fire indicators visible
	IHI No.'s 1 & 2	39° 37' 09"; 107° 43' 56"	East side of canyon; No fire indicators visible
	Loma & Mack Area	39° 27' 39"; 108° 57' 40"	Bookcliffs vicinity; No fire indicators visible
	Mack South Canyon No. 1	39° 28' 54"; 108° 53' 59"	Bookcliffs vicinity; No fire indicators visible
	Stove Canyon	39° 21' 54"; 108° 43' 28"	Bookcliffs vicinity; No fire indicators visible
	WH Canyon	39° 37' 14"; 107° 44' 05"	West side of Haas Canyon, near D & H Mine fire; No fire indicators visible
Gunnison	Owens Gulch		No location reported; site not found
	Oliver No. 2	38° 55' 39"; 107° 25' 58"	No fire indicators visible
Jackson	Birney	40° 33' 44"; 106° 26' 30"	Same location as Riach Coal Mine fire
	Moore No. 2	40° 33' 02"; 106° 26' 33"	No fire indicators visible
	Moore No. 4	40° 33' 11"; 106° 27' 12"	No fire indicators visible
	Rosebud No. 1	40° 33' 08"; 106° 26' 44"	No fire indicators visible
	Rosebud No. 3	40° 32' 56"; 106° 26' 46"	No fire indicators visible
La Plata	Hesperus No. 2	37° 17' 18.5"; 108° 02' 37"	Area obscured by landslide; No fire indicators visible
	Mountain	37° 13' 55"; 107° 52' 24"	No indication of mine observed in vicinity
Las Animas	Brodhead	37° 25' 59"; 104° 40' 49"	No vegetation at apparent crop line
	Engleville	37° 08' 42"; 104° 28' 34"	West facing slope free of vegetation; Field checked
	Royal		Reported coordinates do not exist, site not found
	Stevens	37° 08' 11"; 104° 30' 56"	Holding snow; presumed cold
Mesa	Coal Gulch	39° 21' 32"; 108° 42' 14"	No fire indicators visible
	Corcoran Point	39° 14' 28"; 108° 31' 31"	No fire indicators visible
	Fruita No. 1	39° 19' 54"; 108° 34' 0.9"	No mine located near provided coordinates
	Palisade	39° 07' 15"; 108° 20' 31"	No fire indicators visible
Moffat	Wisconsin	40° 30' 48"; 107° 52' 26"	No fire indicators visible
Ouray	Lou Creek	38° 13' 48"; 107° 36' 48"	Landslide at or near mine entry area; Field checked
Rio Blanco	Colthart	40° 03' 22"; 108° 47' 47"	No fire indicators visible
	Riley & Wesson	40° 07' 19"; 107° 45' 11"	No mine located near provided coordinates
	White River No.'s 1 & 2	40° 09' 25"; 108° 41' 51"	No fire indicators visible
Routt	Arrowhead	40° 20' 05"; 106° 57' 03"	Subtle vegetation changes, red outcrop; Field checked
	Ramsey	40° 25' 15"; 107° 15' 46"	Subtle vegetation changes, some barren ground; Field checked
	Slater	40° 59' 40"; 107° 17' 36"	No fire indicators visible

* Latitude and Longitude interpolated from legal descriptions contained in Rushworth et al, 1989.

STATUS OF SITES WHERE FIRE CONTROL WORK HAS BEEN ACCOMPLISHED

Federal and state agencies have intermittently attempted control of underground fires at inactive mines in Colorado for approximately 50 years. The United States Bureau of Mines attempted to quell active fires at approximately 22 locations in Colorado from about 1952 through 1974. Their work focused on accomplishing limited drilling to determine the extent of the burning coal. Following determination of the burning area, a cover of non-combustible earthen material was placed on the overlying ground surface. The purposes of the surface seals were to prevent oxygen from being introduced to the fire, and to seal vents to help smother the fire.

Records from 20 surface sealing projects were located. Of the 20 sites where a surface seal or other similar method was employed, eight appear to be dormant, 10 are active and two exhibit very low activity. Table 4, *Status of Sites Where Underground Fire Control Work Has Been Accomplished*, tabulates the sites where abatement work has been attempted.

The main problem that the surface seals appear to have experienced are fracturing and failure as a result of being compromised by surface erosion, or as a result of subsidence. In either case, a breach in the seal provides an opportunity for the fire to breath, and overcome the smothering effect of the seal. It appears that this method would be most useful at sites with low gradient slopes, little snow or rain fall, the ability to divert surface run-on, and that have limited opportunity for large scale subsidence. Regular inspections and the financial ability to accomplish periodic maintenance are vital components to an effective, long-term surface seal.

Table 4. Status of Sites Where Underground Fire Control Work Has Been Accomplished

County	Mine Name	Agency Attempting Control Project	Control Method Employed	Date Control Completed	Current Fire Status
Delta	Dugger-Rollins	Bureau of Mines	Surface Seal	1952	Dormant
	Minnesota Creek	Bureau of Mines	Surface Seal	1961	Low Activity
	States	Bureau of Mines, Division of Minerals and Geology	Surface Seal; Drilled And Instrumented	1950's, 1997	Active
Fremont	Double Dick	Office of Surface Mining	Surface Seal / Cut-Off Trench	1980's	Active West Of Trench
Garfield	Black Raven	Bureau of Mines	Surface Seal	1972	Dormant
	Harvey Gap	Division of Minerals and Geology	Water, Grout Injection	2003	Active; Subsurface Temperatures Being Monitored
	Haas	Bureau of Mines	Seal Entries; Surface Seal; Remove Coal,	1961	Active
	IHI No. 2	Bureau of Mines	Remove Coal; Backfill	1953	Dormant
	IHI No. 3 (D & H)	Bureau of Mines, Division of Minerals and Geology	Surface Seal; Barrier; Grout Injection	1973, 1995, 1999	Active
	New Castle No. 1	Division of Minerals and Geology	Safety Exclosure Constructed	1990	Active
	New Castle No. 3	Division of Minerals and Geology	Subsidence Feature / Vent Filled	2000	Active
	South Cañon No. 1	Division of Minerals and Geology	Entries Sealed, Safety Exclosure Constructed, Fire Characterization	1990; Ongoing	Active
	South Canyon Refuse Pile Fires (7) *	Division of Minerals and Geology (6), Office of Surface Mining (1)	Excavate And Quench	2002, 2003	Dormant
	W H Canyon	Bureau of Mines	Likely Surface Seal and Other Surface Method	1981	Dormant
Gunnison	Peanut Mine Refuse Pile*	Division of Minerals and Geology	Excavate And Quench	2001	Dormant
Jackson	Riach	Bureau of Mines	Surface Seal	1974	Active
	Rosebud No. 1	Bureau of Mines	Surface Seal	969	Dormant
	Rosebud No. 3	Bureau of Mines	Surface Seal	1963	Dormant
	North Park No. 1	Bureau of Mines	Trench And Barrier	1949	Dormant
Mesa	Farmers Mutual	Bureau of Mines	Surface Seal	1969	Assumed Active
	Garfield	Bureau of Mines, Division of Minerals and Geology	Surface Seal; Safety Exclosure Constructed	1969	Assumed Active
	Go Boy	Adjacent Active Mining Operation, Division of Minerals and Geology	Flooded Twice, Drilled And Instrumented	Presumed Early 1980's, 1985	Assumed Active
Moffat	Streeter / Collom	Bureau of Mines, Division of Minerals and Geology	Surface Seal, Grout Injection	1962 – 1972; 1998	Active
	Wise Hill / Hart	Bureau of Mines, Division of Minerals and Geology	Surface Seal, Seal Entries; Grout Injection, Irrigated	1976; 1997, 2004	Active
Ouray	Slagle	Bureau of Mines	Surface Seal	1954	Active
Routt	Kaspar	Bureau of Mines, Division of Minerals and Geology	Surface Seal; Safety Exclosure Constructed	1972	Active
Rio Blanco	Skull Creek	Bureau of Mines, Division of Minerals and Geology	Cut-Off Trench; Drill, Foam Injection	1951, 2004	Active
	Riley-Wesson	Bureau of Mines	Surface Seal	1954	Dormant

* Abated or extinguished coal refuse fires included here for ease of reference

The Division of Minerals and Geology has accomplished some abatement work at actively burning abandoned coal mines since about 1984. Some of the work has been directed toward preventing human interaction with the surface features of a fire. Exclusion fences have been constructed at some sites, such as South Canyon, New Castle Number 3 and Kaspar. Subsurface investigations of fire activity, surface sealing, mine flooding and grout injection have been attempted at other sites in an effort to control or contain subsurface fire activity. A brief summary of some of these abatement activities follows.

IHI Project

The IHI Project was accomplished at the D & H Coal Mine in Haas Canyon, north of Rifle in Garfield County by the Division of Minerals and Geology. See the Garfield County portion of the Active Fires Section of this report for a description of the site. The IHI Phase I and II Projects, completed in 1995 and 1999, respectively, attempted to control the D & H fire by applying a foaming grout product into the actively burning coal. This was done by drilling holes into the burning materials and injecting the foaming grout into the target zone. One of the properties of the grout is that it entrains air in micro-cells. These thousands of micro-cells act as insulation within the grout, thus cutting off the air supply to the burning material while suppressing heat transfer.

Initially, the Project was thought to have extinguished some portion of the fire, which has a large surface expression area. However, over time it has become apparent that the fire is active on a number of fronts within the burn zone. Likely, the fire was suppressed in some areas, generally the central portion of the burn zone. It is clearly active, exhibiting high surface heat values, at the margins of the affected area. This may indicate a bifurcation of the fire into westerly and southerly components.

Bovine Project

The Bovine Project was begun at Wise Hill/Hart Mine Fire in 2004. The goal of the project was to cool and potentially suffocate the fire. These goals were to be accomplished by providing water to the fire via the fractures located at the ground surface immediately above the fire. A series of small coffer dams were constructed using a dozer over the surface of the mine. Water, obtained from a nearby mining operation, was applied to the ground surface by a system of high volume sprinklers. Water addition continued at a pace so that the coffer dams were able to contain the volume of water applied, allowing the water to seep into the ground via natural percolation and through the fire and mining related fracture systems. The system was terminated for the winter months in the fall of 2004, with plans to resume operations in the spring of 2005.

Axial Project

The Axial Project was accomplished at the Streeter / Collom Coal Mine Fire by the Division of Minerals and Geology. See the Moffat County portion of the Active Fires Section of this report for a description of the site. The purpose of the Axial Project was to define the actively burning area and to then attempt to abate the fire. Drilling into the burning mine was accomplished to define the subsurface burn area, and to provide access for the foaming grout to be placed. The drilling portion of the project appears to have successfully delineated the aerial and vertical extent of the burn zone underground. Post-project reports indicate that the portion of the mine involved in the fire is extensive. The grouting portion of the project, the purpose of which was to isolate and cool portions of the fire, experienced many technical difficulties. This is not uncommon with a difficult technical problem in challenging topographic conditions.

Because the remaining thermocouples no longer function, it is difficult to determine what impact the project had on subsurface conditions. Surface activity, however, indicates that the subsurface fire is still extremely active.

Harvey Gap Project

The goal of this project, completed in the late summer of 2003, was to attempt to suffocate the fire by introducing large quantities of water and fly ash – based grout to the burning portions of the mine. Two burning mines and an intervening unmined, but burning, coal seam were treated during this project.

Water injection began on September 22, 2003, at a rate of approximately 100 gallons per minute, alternating from vent to vent. The pattern of steam indicated that there was no connection between the two coal seams mined, and the outcrop fire.

The amount of cement and fly ash utilized was approximately 95,700 pounds (47.9 tons) and 515,900 pounds (258 tons), respectively. These quantities, when mixed with water, made approximately 450 cubic yards of grout.

Table 5. Vent Temperatures* Measured at Harvey Gap Fire Before During and After Injection

Date Temp. Measured:	Feb.-24-03	May-09-03	Sep.-18-03	Sep.-25-03	Oct.-02-03	Oct.-07-03	Oct.-17-03	Oct.-23-03	Increase	Decrease
Vent Number 4	116	106	94	81	85	85	103	121	5	
Vent Number 5	692	716	715	575	423	325	477	500		-192
Vent Number 7	880	901	904	950	806	599	508	593		-287
Vent Number 9	781	824	811	852	909	737	715	843		-66
Vent Number 10	603	590	583	182	131	180	173	174		-429

* Temperatures in Degrees Fahrenheit

The overall result of the Harvey Gap Coal Mine Fire Project was cooling the fires and surrounding rock, closing the vents to prevent people from falling into or gaining access to, and smothering the fire by reducing the amount of air circulating through the fires.

The table on page 68 shows the effect of treatment at each vent. Immediately after beginning treatment, the temperature rises, only to fall, and then rise again. It appears that the temperatures will stabilize somewhere between 200° and 400° lower than the highest pre-project temperature.

States Mine and Go-Boy Mine Projects

The States Mine, located in Delta County, and the Go-Boy Mine, located in Mesa County, were both drilled and fitted with instrumentation by the Division of Minerals and Geology. This was done at both locations for the purpose of evaluating subsurface fire conditions over time. The timing of the Go – Boy Project coincided with the culmination of fire abatement activities undertaken by an adjacent active coal mining operation. No attempt at abating either of these fires was undertaken at the time of the drilling projects.

South Cañon Mine Fire Project

South Canyon, located about five miles west of Glenwood Springs in Garfield County, is host to one of the largest, and currently most active underground mine fires in Colorado. See the Active Mine Fires, Garfield County portion of this report for a site description. Since about 1992, the Division of Minerals and Geology has been involved in safeguarding the area so that the public does not come into contact with mine openings and the fire zone. Approximately five mine openings have been sealed, and fences have been erected near the County Road to exclude the public from the actively burning area. More recently, drilling has begun for the purpose of defining subsurface conditions in the various mines and intermediate coal rider seams. Drilling was completed on the east side of the canyon in the late spring of 2003, and began on the west side of the canyon in 2004. Initial abatement activities are scheduled to begin in 2006 and may continue for a number of years. These activities will likely include re-opening closed mine entries and some subsidence features and installing air tight seals to minimize oxygen supply to the fire. Other abatement activities are as yet undefined, pending completion of exploratory drilling operations. Likely, abatement would include injection of subsurface fire suppressant materials through drill holes.

South Canyon Coal Refuse Project

Seven historic coal refuse piles caught fire in South Canyon as a result of the Coal Seam Wildfire that occurred in 2002. These fires went largely undetected for a period of four to six months. As a result, some became fairly hot, and one grew to approximately one half acre in size. The others varied from a few hundred square feet to a few tens of square feet in aerial extent.

The Division of Minerals and Geology extinguished six of these fires between 2002 and 2003. The Office of Surface Mining extinguished one in 2003. Each was extinguished in a similar manner. A cut off trench was excavated around the perimeter of the fire to stop its ability to advance into un-burnt refuse. A large hole was excavated adjacent to the burning materials, and filled with water. The burning refuse was swept into the water filled trench using a track excavator. When the material had cooled to approximately 200 degrees, it was removed from the trench, and allowed to air-cool. It was then mixed with non-combustible materials and pushed back to approximate the original topography of the site.

Surface Fire Mitigation Project

The Surface Fire Mitigation Project was accomplished by the Division of Minerals and Geology in the spring and summer of 2003 at five mine fire locations. The original purpose of the project was to eliminate the cover of annual weeds and grasses at the eight sites where the risk of surface fires was evaluated at moderate or greater. Permission to complete the project was denied at three of these locations. As a result, the project was accomplished at the Rienau Number 2, Black Diamond, New Castle Number 3, Harvey Gap and South Cañon Number 1 mine fires.

The project was accomplished by using hand crews to remove the annual weeds and grasses from within a pre-defined perimeter. The cleared materials were generally tacked to the ground surface down hill of the cleared area to act as a natural sediment barrier. Following surface clearing, a pre-emergent herbicide was applied to the site in order to minimize the potential for weed seed germination. Approximately 15 acres were treated during the course of the project.

OUTCROP FIRE EVALUATIONS BY COUNTY

Three significant coal outcrop fires are known to exist in Colorado, one each in Mesa, Montezuma and Moffat counties. Each fire occurs on lands managed by the Federal government. Generally, these fires do not qualify for abatement funding by the annual grant that the State receives from the Office of Surface Mining, as these fires are unrelated to abandoned coal mines. Periodically, the Office of Surface Mining has funds available for the investigation or abatement of these fires; Colorado received one such grant in 2002. A portion of this grant was used to construct a surface seal at the Smokey Mountain Outcrop Fire in 2004. The remaining portion of the grant will be used to excavate the Horse Trap Outcrop Fire. This work is scheduled to begin in 2005.

Table 6. Coal Outcrop Fires By County

County	Outcrop Fire Name	Location	Estimated Surface Acreage Impacted
Montezuma	Horse Trap	37° 14' 53.6" North; 108° 24' 14.3" West	Less than 1 acre
Mesa	Smokey Mountain	39° 21' 02.7" North 108° 42' 21.2" West	15 acres estimated
Moffat	Sand Springs	40° 26' 38.5" North; 107° 47' 12.0" West	Less than 1 acre

Montezuma County

Horse Trap Outcrop Fire; Mesa Verde National Park

During the summer of 2002, the National Park Service discovered an underground coal fire within Mesa Verde National Park, located in Montezuma County, Colorado. In August of 2002, the Park Service contacted the Division of Minerals and Geology and requested that the Division evaluate the fire. The first site visit occurred in September, 2002, with subsequent visits in 2003 and 2004.

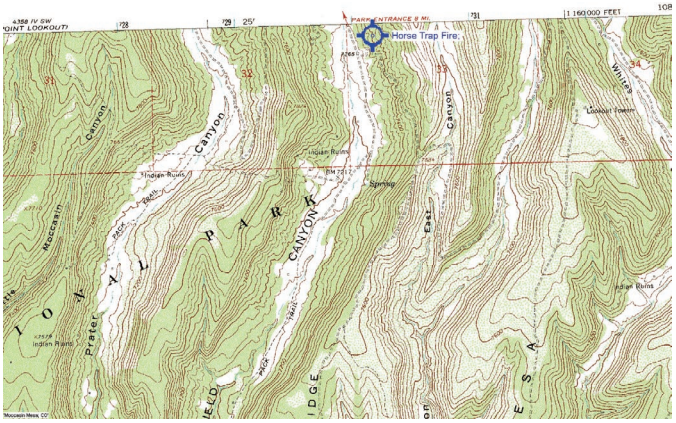
The fire is situated in an unnamed tributary drainage east of Morefield Canyon in the northerly portion of the Park. The center of the fire is located at approximately 37° 14' 53.6"; 108° 24' 14.3". The fire is readily accessed by foot from a dirt service road that approaches within approximately 450 feet of the burn zone.

The fire zone is located on the nose of a small intermediate east to west trending ridge situated between two ephemeral drainages. These small drainages are located immediately north and south of the ridge and burn zone.

The surface expression of the fire presents itself as a westerly facing scarp, an interior slump and an overlying fracture zone on the nose of the small ridge. The burn zone trends about north to south, is approximately 50 feet in width at its base, and is approximately six feet in height. An overlying, or uphill, semi-circular fracture pattern characterizes the burn zone. An interior facial surficial slump exists within the burn zone below the uphill fracture pattern. This slump disrupts the interior fractures, and separates the fire into northerly and southerly segments. An approximately two feet tall by 12 feet long backwall of fractured and broken sandstone is present at the northerly portion of the active burn zone. Discontinuous parallel fractures occur within the burn zone. These fractures were observed to act as vents at the most northerly and southerly portions of the area.

Parallel fractures occur within the active burn zone, and are pronounced immediately uphill of the fire activity. Within the burn zone, the fractures culminate in the facial slump and the two feet tall backwall. These appear to be fire related features, venting the underlying fire. A small vent is located at the most northerly portion of the lower fracture zone. This vent was observed to be exhaling steam at the time of the site visit from a fracture in sandstone material. The temperature of the ground surface at the vent was measured at 120°. The vent exhaust was sampled using hand held multi-gas meters. Oxygen content was 19.2 percent, carbon monoxide was 120 parts per million, and hydrogen sulfide was 3 parts per million.

Horse Trap Outcrop Fire. North to left.



Horse Trap Outcrop Fire location. North at top.

A second vent was observed near the southerly margin of the burn zone. This vent appears to be on-strike, but discontinuous from the other interior fractures. The ground temperature at this location was measured at 200°. The vent exhaust at this location contained an oxygen content of 17 percent, carbon monoxide content of 93 parts per million and hydrogen sulfide at 3 parts per million.

Approximately six feet up slope from the active burn zone is located another set of parallel fractures. These upper fractures trend about north 65° west. These appear to be tension fractures, which may have developed as a result of the slump failure, located downhill within the burn zone. These upper fractures are relatively cold, having temperatures matching ambient ground temperatures of about 58° to 60°. Venting from these fractures was not observed.

It is likely that the surficial slump was caused by a lack of structural support after the underlying coal had burned. It is possible that the slump has helped to mitigate fire activity in the center of the area. This may occur as a result of the sloughed material acting as a blanket to seal oxygen-supplying fractures in the central portion of the burn zone.

Site observations and temperature measurements indicate that the fire is most active in the central and southerly areas. Venting and ground temperatures from the northerly area indicate a cooler fire at that location.

Observations indicate that the underground fire is located relatively near surface, and is thus far relatively contained laterally. However, they also indicate that continued burning and subsequent subsidence could easily cause escalated fire activity as oxygen is provided to heated, but not yet combusting, coal materials located behind the active burn front.

Although the extent of the combusting coal was limited in the test hole, it is likely that the fire has burned deeper into the ridge near the central portion of the area. A fire, which has resulted in a more significant loss of coal, would explain the surface slump observed at the central portion of the burn zone.

General Observations:

This is a near surface event that is not supported into the hillside for a great distance. The outcrop involved in the fire is likely limited in thickness.

It is possible that thin shale partings exist within the coal, thus the fire is probably not prone to rapid progression through adjoining coal measures.

This is a low activity fire, exhibiting low surface temperatures.

Due to its proximity to the ground surface, the fire is moderately efficient. No creosote or sulfur mineral deposition was observed on the ground surface.

Exposure to oxygen will likely result in a rapid increase in local fire intensity.

Human health and safety risk is low, as the fire is small, and well away from areas frequented by Park visitors.

Wildfire potential is low, as surrounding vegetation has been subjected to wildfire in the recent past.

Mitigation activities are scheduled to begin in 2005.

MESA COUNTY

Smokey Mountain Outcrop Fire

The Smokey Mountain Outcrop Fire is located north of Loma in Mesa County. The site is situated on lands managed by the U. S. Bureau of Land Management, and has been visited on numerous occasions since January 2001.

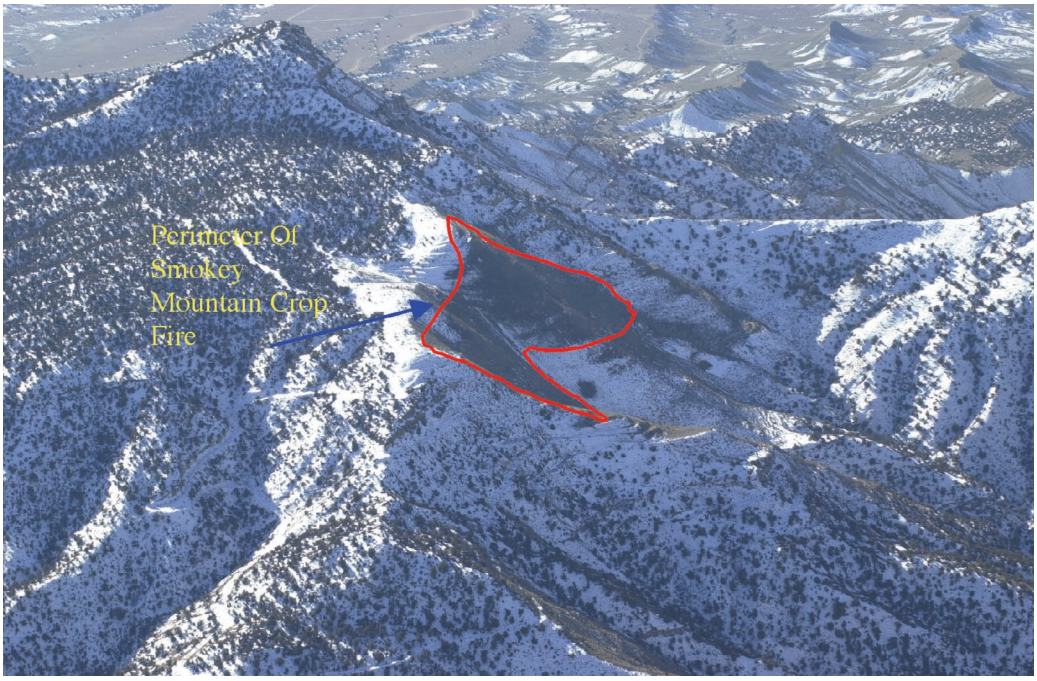
The fire is accessed by driving north from Highway 6 and 50 on 16 Road to Coal Gulch. An approximately one-mile hike or mountain bike ride toward the south from the Coal Gulch Road is required to reach the fire location.

Although there are several coal mines in the vicinity of Smokey Mountain, none appear to be connected to the fire. Anecdotal information indicates that a mine operating to the southeast of the Smokey Mountain fire encountered significant sections of burned coal as the mine advanced in the direction of the Smokey Mountain crop fire. Apparently, the mine had progressed approximately 800 feet underground mining a 22 foot thick coal seam. At this distance, the upper four feet of the seam was reduced to ash as a result of a pre-existing fire event. It is unknown whether the burnt coal is related to the Smokey Mountain crop fire, but there is some potential that the two events are related, given the proximity of the areas. This supports the theory that the Smokey Mountain fire has been burning for an extended period of time, and that it advances in discontinuous fingers as oxygen availability allows.

The surface expression of the fire is located in a north / south trending sub-canyon to Coal Gulch. The burn zone exists on a west-facing slope of this canyon from about mid-slope at the northern extent of the fire to near the canyon crest near the southeasterly extent of the fire zone.

The majority of the west facing canyon slope exhibits evidence of the underlying fire, generally due to vegetative changes from the surrounding piñon juniper forest. The canyon slope over the crop fire exhibits vegetative community dominated by annual grasses and weeds and grasses.

The area was subject to fire suppression activities in the 1960's. A surface seal was installed using cut and fill methods. Evidence of this activity includes at least two access road remnants and some benches from which material was generated to cover the fire zone.



Smokey Mountain Outcrop Fire. View toward Southeast.

Smokey Mountain Outcrop Fire location. North at top.

Three areas of venting present themselves at Smokey Mountain. The first is located near the northerly margin of the site, about mid-slope within the canyon. The second is located near the southeast margin of the canyon, higher on the canyon slopes. The third is located further south, at about the same elevation as the central area.

North Area

The active area at the northerly extent of the fire is a series of small circular vents and, more commonly, a series of venting fractures located at about 39° 21' 06.2"; 108° 42' 25.0". These features are all located in an area that was heavily disturbed by the surface sealing activities. The venting fractures are discontinuous, but can be traced over a distance of about 50 feet. These fractures have an average width of about six inches, and are generally eight to ten feet in length. These features trend north, 75° east. Vent temperatures consistently measure at 225° to 250° over time. These features appear to occur predominately in cut benches created during construction of the surface seal. A few small vents occur in the fill material immediately south of the larger linear features. The temperature of these vents varied between 95° and 180°. These features appear to have developed in fill material below the cut benches.

None of the vents exhibits any sulfur of creosote deposition. Neither has been observed to emit smoke or steam; however, coal combustion can be smelled on calm days.

Central Area

A single vent located higher on the canyon slope than the northerly area characterizes the central vent area. The vent, which is located at the base of a three-foot thick sandstone sequence, emits a large volume of water vapor. Condensate can be observed to drip from the overlying sandstone. This 125° vent is located at 39° 21' 02.7"; 108° 42' 21.2".

Southerly Area

The southerly area exhibits a number of vents and venting fractures. These generally exhibit cooler temperatures, and a greater degree of water vapor and combustion by-products than what is observed at the northerly vent area.

The southerly area is located higher on the canyon slopes than either the central or northerly areas. The area is characterized by a series of small vents and a few venting fractures. These are located at approximately 39° 20' 56.9"; 108° 42' 22.4". An upper (higher elevation) and lower set of vents exists in the immediate vicinity. The vents appear as a series of four, three inch diameter circular vents spread along an approximately 30 feet long alignment. Likely the intervening area between the circular vents is surficial

slough or partial healing of a fracture system. These vents are visible on a north, 15° west trend. The upper vents audibly exhale steam at a remarkable rate. These vents exhibit temperatures that vary from 160° to 210°, with visible steam.

Approximately 200 feet to the south west is an area approximately 75 feet long parallel with contour by 25 feet long perpendicular with contour that exhibits creosote deposition, with temperatures at less than 200°. Numerous small vents, generally one inch in diameter, are found throughout this area.

The Division of Minerals and Geology attempted to repair portions of the Bureau of Mines surface seal in 2004. Earthwork to bolster the seal and provide additional cover material was accomplished.

General Observations:

The northerly vent area appears to be venting from the underlying fire through the perimeter of the surface seal.

The north area appears to be relatively cool, possibly indicating that the fire is burning a great distance from the surface expression, and that the surface seal may be partially successful in reducing oxygen availability.

The central and upper portion of the southerly areas exhale a great volume of steam, perhaps indicating a more active and deeper fire near this location;

The lower part of the central area may be the remnants of a near surface rider seam fire that is either dormant, or inactive at this time.

The public health hazard is rated as low, given the relatively small nature of the vents, and the remoteness of the site. However, a nearby trail experiences some degree of hiker and mountain bike use. These users could be drawn to the area by the steam plume that rises from the central and southerly vents.

The wildfire hazard at this site is low, given the general lack of surface fuels in the area, and the relatively low temperatures of the vents.

MOFFAT COUNTY

Sand Springs Outcrop Fire

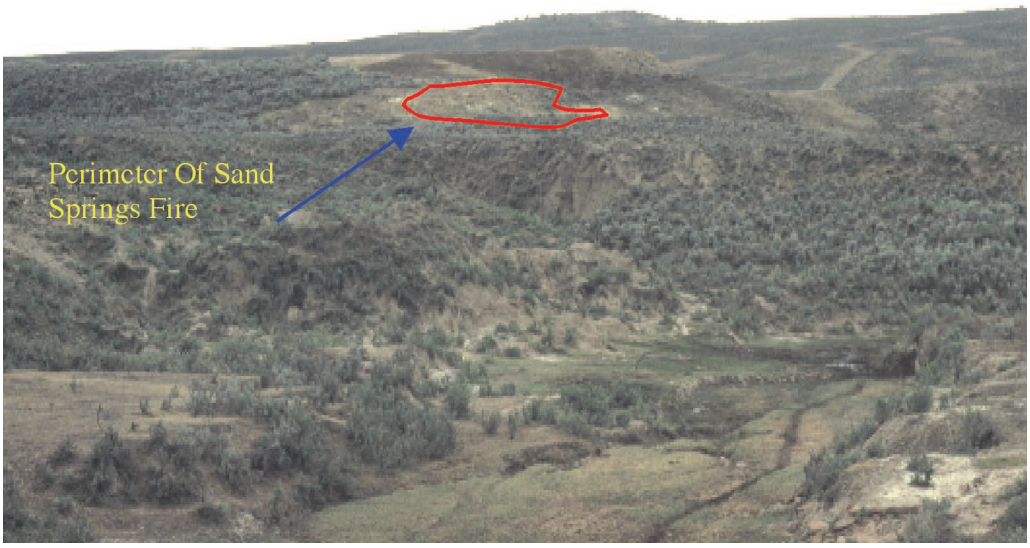
The Bureau of Land Management (BLM) requested that the Division evaluate an underground coal fire located approximately 12 miles southwest of Craig in Moffat County, Colorado. It was reported to the Division that the underground fire sparked a surface vegetation fire, which was suppressed by the BLM fire crew from Craig. The fire crew eliminated surface vegetation in the vicinity of the coal fire by burning an approximately one-acre area surrounding the underground fire.

The site was visited on August 7, 2002. The fire is accessed by traveling west from Craig to County Road 174, then south on County Road 90 to its end. Ranch roads provide access to within one mile of the fire. The fire was accessed by foot for the remaining mile.

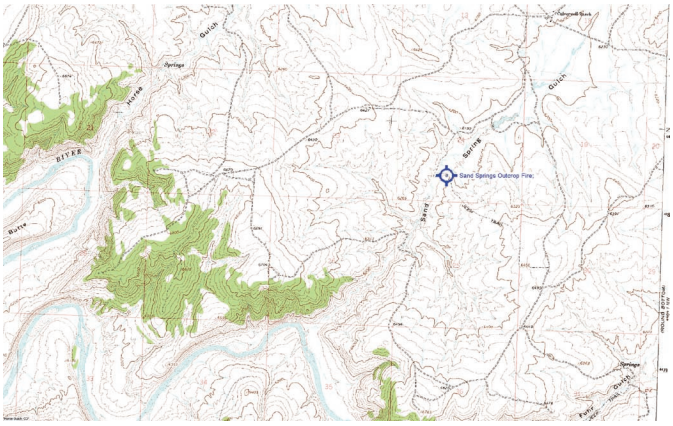
The surface expression of the underground fire occurs on a small north westerly facing ridge immediately east of Sand Springs Gulch. The fire zone is located at 40° 26' 38.5"; 107° 47' 12.0".

The surface expression of the fire zone is approximately 100 feet, north to south, by 75 feet, east to west. The fire zone is characterized by small, discontinuous subsidence fractures formed in a conical pattern uphill of what appears to be a small subsidence depression incised by a gully. These fractures generally trend easterly to westerly. The subsidence feature defines the westerly and most downhill extent of the fire zone. Additional fractures, generally oriented in a northwest to southeast pattern, were observed immediately north of the fire zone in a sandstone outcrop. Parallel jointing in the sandstone, rather than fire related subsidence, appears to be responsible for the fractures observed in this area.

Ground temperatures within fire related fractures were generally in the 1250° range. However, discreet vents within a few of the fractures were measured in the 180° range. These higher temperature vents were generally located further uphill of the subsidence feature. The smell of coal combustion was apparent near the northeast portion of the zone, coinciding with the location of the higher temperature venting. Smoke, steam, sulfur deposition, creosote deposition or thermal alteration of rock were not observed anywhere in the fire zone. Vegetative characteristics above and adjacent to the fire zone were not observed, as a result of the surface fires having removed these materials.



Sand Springs Outcrop Fire. View toward South.



Sand Springs Outcrop Fire Location. North at top.

A two to three foot thick coal outcrop occurs on the south westerly facing portion of the ridge. The coal appears to be of poor quality, is well oxidized, and exhibits low strength. It is assumed that this seam is that which is observed to be on fire, approximately three hundred feet to the north / north west of the outcrop. The outcrop is covered by colluvial debris in all other locations.

There is no indication of past mining activity in the vicinity of the outcrop, within the coal fire zone or on the hidden crop line. No coal or reject pile remnants, structures, open or collapsed entries or old roads or trails were observed in the area. These field observations lead to the conclusion that this is a coal crop fire that is unrelated to mining activities.

The original cause of the crop fire may have been a lightning strike or a surface fire passing over a then-exposed outcrop. It is somewhat difficult to explain how the underground fire may have ignited a vegetative fire, mainly because of the low surface temperatures observed. It may be possible that the fire sporadically exhibits more active behavior than that which was observed at the time of the field visit. A plausible scenario is that a surface fracture developed, allowing the fire to violently reactivate as a result of oxygen introduction. The reactivation may have produced sufficient heat to cause combustion of overlying vegetation, tumble weeds or other wind blown materials. Because the coal appears to be thin, near surface and of poor quality, the recurrence interval of such an event would probably be infrequent, and the duration of the event would likely be short.

General Observations:

The fire may be characterized as a small, likely near surface event, exhibiting low surface temperatures.

The lack of sulfur minerals and surface rock alteration, as well as the low observed surface temperatures, may be more indicative of coal properties than of fire efficiency.

The fire may periodically become very active, exhibiting surface temperatures capable of igniting nearby vegetation. If this occurs, it is likely a relatively rare event.

Human health and safety risk is low, as the site is very remote, surface temperatures are low and fractures are relatively small.

Wildfire hazard is low, because little vegetation is left on site. When or if the vegetation re-grows, the hazard may be elevated due to periodic increases in fire activity.

CONCLUSIONS

A systematic field investigation of known active and dormant fires at abandoned underground coal mines indicates that a greater number of coal mines are burning in Colorado than had been previously thought. This increase in numbers is a function of the cyclic nature of coal fires, and as a result of the systematic nature of this evaluation. Because fires at abandoned underground coal mines are dependent on available oxygen, and because the volume of available oxygen is variable over time as a result of subsidence activity and other factors, it is likely that in the future fires will develop at other abandoned mines, and that some currently burning mines will become dormant. Given the observations made in 2002 and 2003, it is possible that the Go Boy, Garfield, Farmers Mutual and McElmo fires will be dormant soon. Unfortunately, prediction of which mines will be host to new fire events is not possible. Therefore, continued periodic monitoring of known dormant and active fires is necessary.

It is not unlikely that other active fires exist in Colorado. As additional fires are documented, they will be included in the state inventory, and will be evaluated and monitored.

Comparison of earlier characterizations of individual fires to current conditions illustrates the cyclic nature of mine fire events. Some of the fires evaluated during this project exhibited increased activity compared to the level of activity documented in the mid-1980's. In contrast, others that were moderately active in the mid-1980's were clearly less active when evaluated in 2002 and 2003. The ability of a fire to draw an adequate and substantial supply of oxygen, all external influences aside, appears to be the determining factor in the level of activity experienced at an underground coal mine fire. Proximity of heated coal to an outcrop, the presence of water, and the nature and extent of subsidence phenomenon are likely key components in the ability of a fire to draw oxygen.

Garfield County is host to 13 of the 32 known active fires in Colorado. This striking percentage of coal fires is likely a direct result of the nature of the coal and, more strongly, the method of extraction employed in the Grand Hogback coal seams. Although records indicate that six of the 13 mines involved in Garfield County fires were mined by stope methods, it is thought that the actual number of mines employing this mining technique is greater than reported. This mining method is used exclusively in steeply dipping coal seams, which are generally found in the Grand Hogback coal mining district, which occurs roughly between Rifle and Glenwood Springs. This unique mining method results in a room and pillar-like mine arrangement; however, the rooms extend upwards at angles approaching 55 degrees or greater, as opposed to the typical situation of a nearly horizontal room. Record keepers who may have depended solely on maps when recording mining methods would be easily confused by the similarities of room and pillar and stope mining maps. The technique employed is an important distinction, as the stope mine creates chimney-like rooms of extracted coal that rise up-dip, toward the ground surface, from the main haulage way. These chimney-like stopes, or rooms, create conditions that are extremely conducive to fire propagation, and probably result in a more active and hotter fire situation. Understanding the mining method and ventilation system are important aspects of developing an abatement technique. Ultimately, the stope mine fires will probably require an abatement technique that is uniquely suited to this environment.

The qualitative evaluation of surface characteristics of an underground coal fire can provide an initial evaluation as to the hazards presented to the public and the environment. These factors are readily apparent as subsidence fractures or pits develop, and as smoke or steam escapes into the atmosphere. However, this qualitative assessment is not a comprehensive evaluation of the level of activity, or more importantly, the actual location of the subsurface fire. An evaluation of the surface expression of the fire is useful in making land use decisions based on actual and perceived threats to the population. These threats include health and safety issues resulting from recreation or other activities occurring over or near a fire, and the potential threat of a wildfire as a result of fire venting. The level of threat as a result of the underlying fire may also drive abatement decisions and techniques.

The qualitative assessment of fire activity at the ground surface at fires where previous abatement work has been accomplished is a good indicator of the success or failure of the abatement technology employed. It is important to note that each fire is unique. Very few fires share similar characteristics; mining methods, oxygen availability, overburden characteristics and topographic differences all play critical roles in the development and intensity of a fire. Therefore, no one technique is transferable to all fires. Because the fires are complex, and are probably more often than not discontinuous as a result of roof fall or subsidence collapse, a comprehensive understanding of the subsurface fire environment is a necessary component when devising an abatement technique.

Sealing of the ground surface over a fire was a favored abatement technology used extensively from the 1950's through the 1970's. This technique is generally the most economic; however, it is highly dependent upon maintenance of the seal, and upon the complete coverage of the ground surface overlying all fire related features to succeed. Failure of the surface seal as a result of a lack of long term maintenance is thought to be the most common reason why many of the surface sealed fires continue to burn.

Of the remainder that are still burning, it appears that the seal did not extend far enough away from the perimeter of the fire body, allowing an oxygen supply to reach the fire. Where the seal was placed extensively enough, and where it was not breached by erosion, the seal served to smother the fire. Fires at eight sites where the Bureau of Mines employed surface seals are now classified as dormant, and two others are nearly dormant.

Other abatement techniques, usually injection of grout or grout impregnated with foaming agents, have succeeded in accomplishing limited abatement in specific areas. Surface evaluation of the Wise Hill and IHI Number 3 fires indicates that the grout injection was successful in either bifurcating the fire, or perhaps to confining the fire to certain areas. It is evident that where these fires continue to burn, they are generally intense, very active and generally fairly efficient. This may indicate that the amount of material injected into the fire was not sufficient, that the placement location was less than optimal, or that the material did not effectively reach all of the intended targets.

RECOMMENDATIONS

As the population of Colorado continues to grow, and as the pressure the public puts on previously little used lands escalates, the likelihood of human interaction with a fire at an abandoned underground coal mine increases. This interaction may well be hazardous to those involved, regardless of whether it is a result of hot, open subsidence features, wildfire or noxious fumes. To help minimize the impacts of abandoned underground coal mine fires to Colorado, the following steps are recommended to take place:

(1) **Develop quantitative method(s) of evaluating fire activity via surface methods.** A quantitative evaluation of the mine fires would be based on data that can be duplicated and evaluated on a regular basis. This data would likely include obtaining and recording vent gas composition, heat values, photographic documentation and location information at significant vents and other surface features. The evaluation methodology could be developed over an approximately eight to 12 month period by Minerals and Geology, Inactive Mines Program staff.

(2) **Develop a quantitative method of assessing fire hazards as a mechanism to trigger abatement activities.** Measurable indicators of hazards presented by individual fires could be developed. These indicators would likely include an assessment of subsidence features, vent temperatures and locations, relationship of the fire to adjacent land uses, and proximity of the fire features to vegetation. If indicator values at a particular fire present a hazard rated as moderate or more severe, subsurface evaluation and abatement at an appropriate level would be proposed. Division of Minerals and Geology Inactive Mines Program staff would develop the assessment methodology over an approximately eight to 12 month period.

(3) **Evaluate fires on regular basis.** The status of all known active underground coal mine fires should be evaluated on a regular basis. An aerial assessment by Division of Minerals and Geology Inactive Mines Program staff using a hand held infrared imaging tool is a quick, economic and reliable method of evaluating surficial fire conditions. This, coupled with an annual comparison of previous year's data, would be a key mechanism to trigger an-on-the-ground follow up should anomalous data be recorded. Division of Minerals and Geology Inactive Mines Program staff could conduct a field evaluation of actively burning fires once every two years, unless the aerial investigation dictates that a more immediate site visit is warranted. This bi-annual evaluation would encompass use of the fire activity and fire hazard assessment tools developed in recommendations 1 and 2, above.

(4) **Develop or research methods of mapping subsurface burning areas via remote sensing.** If a reasonably reliable method of mapping subsurface burn fronts based on surface geophysical methods can be developed or adapted, the rate of burn front migration could be used as a tool to make land use and abatement project decisions. Division of Minerals and Geology Inactive Mines Program staff began initial work with this technology in the late spring of 2004. Additional investigations will be proposed for 2006. This work may be followed by drilling to confirm subsurface conditions. If the confirmation drilling indicates that surface geophysical methods are successful in delineating subsurface features of interest, additional investigative work at an active fire would be proposed for the 2007 construction season.

(5) **Data distribution system to land use planners, land owners and land management agencies.** The distribution of data and information to land owners, land management agencies and city and county officials is a critical step in minimizing the impact of underground coal mine fires to the citizens of the state. A GIS containing pertinent information relevant to active and dormant fires could be created and periodically updated. The development and distribution of a GIS containing pertinent information, updated as new data becomes available, is an effective and graphic method of information distribution. The GIS could be updated annually as a result of the aerial evaluation, or every other year as a result of the field evaluation discussed in recommendation 3, above.

(6) **Research and implement cost effective methods of minimizing impacts to the public and environment from underground coal mine fires.** The Division of Minerals and Geology should continue to attempt abatement of active underground coal mine fires, as funding is available, and as state and site priorities dictate. Other agencies, organizations, landowners and interested parties should be approached as cost – share partners to offset the tremendous costs of implementing an abatement program. The use of data sets generated as part of site-specific investigations, and the implementation of innovative techniques should be encouraged through abatement and investigation projects. Education, including interaction with specialists throughout the nation, should be encouraged so that new techniques are developed and implemented. These should be on-going activities appropriately funded by the Inactive Mines Program annual grant, and should be incorporated by Division of Minerals and Geology Inactive Mines Program staff into the annual work plan.

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