USDA Forest Service

Wildland Fire Origin and Cause Supplemental Incident Report

(Reference FSH 5309.11, Chapter 20)

Incident Number	22-02-IAIP002
Incident Date	12-30-21

LOCATION

Fire Name	Dispatch #	Account Code	Region	Forest	District	State	County
Marshall Fire-Marshall Mesa Trailhead	COBLX-995	PEPNR9	02	10	1	CO	13

Origin Location: geographical landmarks, highways, roads, trails, etc.	Township	Range	Section	¼ Sec	Meridian/Datum
Marshall Mesa Trailhead, Eldorado Springs Rd and Highway 93, Boulder, CO	T1S	R70W	21	NE1/4	WGS 84

Latitude (D – M' – S")			Longitude (D – M' – S")		
39	57	03	105	13	58

JURISDICTION

USFS Only	Identify Other Agency(s)	Lead Origin & Cause Investigator	Est. Suppression Cost	Injuries/Deaths
N/A	Boulder County Sheriff's Office	Special Agent Travis Lunders	Undetermined	2

EVENT SEQUENCE

Estimated Time of Ignition				Time Fire Reported				Time Origin Protected				Time Origin Released			
Mo.	Day	Year	HHMM	Mo.	Day	Year	HHMM	Mo.	Day	Year	HHMM	Mo.	Day	Year	HHMM
12	30	2021	1218	12	30	2021	1104	12	31	2021		03	25	2022	0900
Who	SA Henrichs			Who	Judith Demarest			Who	Boulder County SO			Who	Boulder County SO		

FIRE BEHAVIOR

Estimated Acres	Fuel Type @ Ignition Area Material First Ignited		Weather Observer (On Scene)	Date	Time	Temp	RH	Wind Dir	Wind Speed
6000	Grass		NA						
Slope %	Aspect: N E S W	Elevation	Weather Station	Date	Time	Temp	RH	Wind Dir	Wind Speed
Level	Flat	5,590	Boulder Southwest	Dec 30	1215	41.6 F	27.6%	247.9	50.9

CAUSE DETERMINATION CODE: (PS) = POSSIBLE, (PR) = PROBABLE, (EX) = EXCLUDED (EXPLAIN IN NARRATIVE)

EX	Lightning	(Detection Method)

Weather system associated with fire ignition did not contain lightning, commercial lightning detection services located no lightning strikes in the area.

EX	Equipment Use	(Exhaust, Brake Shoe, Mechanical, Friction, Aircraft, Vehicle Fire, Other)

No mechanized equipment was observed in or had access to general origin area at the time of ignition.

EX	Smoking	(Tobacco, Other)

Recent smoking material not located in area of general origin. Conditions not within parameters for a smoking ignition.

EX	Campfire	(Cooking, Warming, Ceremonial, Other)

Campfires not allowed on property where ignition occurred, no remnants of a campfire located within the general origin area.

EX	Debris Burning	(Land, Slash, Refuse, Other)

Debris burning was not being conducted at the time of ignition, no evidence of past or recent debris burning located in general origin area.

EX	Railroad	(Ignition Activities Associated with Railroad Companies)

No active railroads or trains in the general origin area.

EX	Incendiary	(Ignition Component / Material First Ignited)

Witnesses did not observe anyone in general origin area immediately prior to ignition, no ignition device located in general origin area. No arson history.

EX	Children	(Ignition Activities Associated with Children; 12- years and younger)

Winds limited access to general origin area, witnesses did not observe anyone in general origin area, no evidence of children located in general origin area.

PR	Miscellaneous	(Blasting, Structure, Fireworks, Welding, Cutting, Grinding, Pest Control, Power Line, Glass, Target Shooting, Spontaneous Combustion, Other)

Powerline conductor adjacent to general origin area had a mechanical failure, active underground coal seam fire in general origin area.

Cause Determined: State brief reason & explain in the narrative	Cause Undetermined: State brief reason & explain in the narrative
The most probable cause of the Marshall fire is Powerlines due to damage to the power lines from arcing in relation to the location of the SOA	

PREPARED BY		Date		Submitted to		Date	
ATTACHMENTS - IF INCLUDED	LE Incident Report ☐	Supplemental Reports ☐	Interviews ☐	Statements ☐			
	Fire Stat Report ☐	Sketches / Diagrams ☐	Maps ☐	Photographs ☒	Other ☒		

USDA Forest Service	**Wildland Fire Origin and Cause Supplemental Incident Report** **(Reference FSH 5309.11, Chapter 20)**	Incident Number	**22-02-IAIP002**
		Incident Date	**12-30-21**

(CODE: S – SUBJECT, W – WITNESS, V – VICTIM, RP – REPORTING PARTY, O – OTHER)

Name *(Last, First, Middle)*		Alias	DOB	Race	Gender
W	Tomasello, Joe		[redacted]		M
Address *(Home)*		Phone *(Home)*	Hair Color	Eye Color	SSN
		[redacted]			
Address *(Business)* *(Tax Identification Number if Required)*		Phone *(Work)*	Height	Weight	License / ID

Name *(Last, First, Middle)*		Alias	DOB	Race	Gender
W	Dewitt, William				M
Address *(Home)*		Phone *(Home)*	Hair Color	Eye Color	SSN
[redacted]					
Address *(Business)* *(Tax Identification Number if Required)*		Phone *(Work)*	Height	Weight	License / ID

Name *(Last, First, Middle)*		Alias	DOB	Race	Gender
W	Zoltowski, Michael		[redacted]		M
Address *(Home)*		Phone *(Home)*	Hair Color	Eye Color	SSN
[redacted]		[redacted]			
Address *(Business)* *(Tax Identification Number if Required)*		Phone *(Work)*	Height	Weight	License / ID

VEHICLE INFORMATION (CODE: D – DAMAGED, E – EVIDENCE, I – IMPOUND, S – SUBJECT W – WITNESS, O – OTHER)

	License Number	State	VIN	Year	Make	Style	Other Information
	License Number	State	VIN	Year	Make	Style	Other Information
	License Number	State	VIN	Year	Make	Style	Other Information
	License Number	State	VIN	Year	Make	Style	Other Information

INSURANCE INFORMATION (HOME, AUTO, LIABILITY, OTHER)

Insurance Company	Policy Number	Insurance Agent	Address	Phone Number

USDA Forest Service	**Wildland Fire Origin and Cause Supplemental Incident Report** (Reference FSH 5309.11, Chapter 20)	Incident Number	22-02-IAIP002
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SYNOPSIS (Date, Fire Name, Estimated Acres, Location, Jurisdiction); (Estimated Cost, Damage; Property / Resource); (Cause; Determined / Undetermined)

The Marshall Wildfire ignited on December 30th, 2021, at approximately 11:00 A.M. The origin area is located near the western boundary of 5329 Eldorado Springs Drive, Boulder, CO on what is referred to as the Twelve Tribes property. A second origin area was located south of the Marshall Mesa Trailhead on City of Boulder Open Space and Mountain Parks property which ignited at approximately 12:20 P.M. The initial origin of the Marshall Fire is reported on a separate report completed by USFS Special Agent Travis Lunders. The most probable cause of the second ignition at the Marshall Mesa Trailhead was determined to be powerlines.

DETAILS OF INVESTIGATION: (Initial Report, Initial Attack, Initial Investigation, Fire Behavior Analysis, Statements, Origin Examination, Cause Determination)

FORECASTED WEATHER

The National Weather Service had predicted mostly sunny skies with a high of 48˚ and an overnight low of 26˚ for the Boulder area for December 30, 2021. The forecast also called for winds of between 33 and 45 miles per hour with gust up to 65 mph. What developed over the area was a phenomenon called a "mountain wave" to include "rotors" as described by Paul Schlatter, a Science and Operations Officer at the National Weather Service Forecast Office in Boulder. The following in an excerpt from a report provided by Schlatter.

- The geography of the Front Range of Colorado is the primary reason extreme downslope windstorms are so common along and just east of the mountains. In particular, the CO-93 corridor from Boulder to Golden is notoriously capable of generating wind gusts well over 80 mph every year.

  Just west of the CO-93 corridor lies an unbroken ridge with an average elevation exceeding 12,000 feet, oriented roughly north to south, over 100 miles long. Weather patterns across the U.S. favor strong westerly flow aloft (i.e. winds blowing from west to east) in the winter months. Much like water in a river flowing over obstacles like boulders, the atmosphere behaves similarly when westerly winds flow over the Rocky Mountains and the 12,000+ ft ridge to the west of the Boulder area. Under the right conditions, strong west flow perpendicular to the ridge west of Boulder can get squeezed through a horizontal channel created by the terrain and a strong temperature inversion 1000s of feet above the top of the ridge. A temperature inversion is a layer of much warmer air aloft, creating an invisible but just as effective barrier or cap in the atmosphere that forces air through the narrow zone at ridgetop level. As the air emerges downwind of the ridge, i.e. in the foothills and adjacent plains in and around Boulder, it greatly accelerates the same way water crashes on the downstream side of a boulder in a stream.

  The strongest winds occur at the base of the foothills and along the CO-93 region from Lyons to Golden, though high winds can also occur further east. A "mountain wave" sets up that can last for hours (sometimes 6 or more hours), with continuous high winds occurring at the base of the foothills associated with the constant downslope acceleration of the winds flowing over the ridge west of Boulder. Standing waves occur in these specific meteorological conditions, and there comes a point downwind where a rotor forms.

  The rotor is a horizontal roll of wind, oriented parallel to the foothills, where wind flow reverses in response to the mountain wave.

Aside from the strong winds that developed in the area of the Marshall Fire on December 30, 2021, the area had been in a dry period that Schlatter also detailed in his report.

- Another factor that contributed to the rapid fire spread were the fuels in the area. First, Boulder was unusually wet from spring into mid-summer 2021. Grasses grew tall and thick. Then, the precipitation abruptly shut off, leading to the driest period on record along the Front Range from June through December. It was also the warmest such period on record, drying out the fuels significantly by December. The Boulder area went from no drought to level 3 (extreme, on a scale of 0-4) drought by December 2021. There had only been 2 light snows the entire season through December 30th. Normally snow does not remain on the ground along the CO-93 corridor for long even in December, but any amount of snow on the ground would have slowed or prevented the fire from spreading. Given record dryness and no snow on the ground for weeks prior to December 30th, the fuels were prone to rapid fire spread. Overall, the drought, extremely dry fuels that were thicker/taller than normal, and record warmth and dryness in the months leading up to December 30, combined to make a worst-case scenario for any fire that started along CO-93 in late December. **(Attachment 1, Schlatter Climatology and Meteorology Report)**

Information was gathered from several weather collection sites in the area. The most relevant to the ignition at the Marshall Mesa Trailhead may be the CO93-72 located near the intersection of Highways 93 and 72. The site is approximately 6 miles south of the trailhead and approximately 600 feet higher in elevation but is in a similar orientation to the mountains and foothills and presumably experiences similar wind conditions. The site reports that between 10:21 MST and 15:27 MST winds were sustained between 58 mph and 76 mph out of the west with peak gust reaching 109 mph at 11:23 MST. **(Attachment 2, Weather Details Compiled)**

INITIAL REPORT

Boulder County Sheriff's Office (BCSO) received the first reports of the Marshall Fire at 11:04 hours from the resident at 1568 Marshall Road who reported smoke in the area of S Foothills Hwy and Marshall Road. Rocky Mountain Fire and Boulder County District 6 are dispatched to the report **(Attachment 3, Dispatch Log)**. Rocky Mountain Fire arrived to find active fire at 5325 Eldorado Springs Dr. Firefighters provided photographs to BCSO of initial attack at the property to include at least one image that shows the fire apparatus on the property with a time stamp of 11:24 **(Attachment 4, Copy of Photo at 5325 Eldorado Springs Dr. maintained by BCSO)**.

INITIAL ATTACK

Initial attack of the Marshall Fire was directed at a property at 5325 Eldorado Springs Dr. Units begin responding to the area to assist with traffic control. At 11:10 hours City of Boulder Open Space and Mountain Parks (OSMP) Ranger Kelly McBride arrives in the area and pulls into the Marshall Mesa Trailhead, makes a loop through the parking lot, and turns around. McBride's park entrance and exit was photographed by a remote camera at the gate to the trailhead. **(Attachment 5, Copy of Photo of McBride maintained by BCSO)** McBride later stated that she did not see any fire in the area of the trailhead when she made her loop through the parking area. This demonstrates that fire was actively burning at the 5325 Eldorado Springs property while no fire existed at the Marshall Mesa trailhead.

INITIAL INVESTIGATION

Initial investigation of the Marshall Fire was focused on the property at 5325 Eldorado Springs Dr. in Boulder, CO where multiple reports by citizens and first responders identified a fire ignition. Ultimately the Marshall Fire was determined to have first ignited at this property. The resident of [redacted] Michael Zoltowski, was recording videos of the initial moments of the Marshall fire from the east side of his residence. One video shows fire burning to the north on the 5325 Eldorado Springs Dr property and in the basin to the east. Another video, IMG_3838 begins to the south and depicts an additional ignition burning from the southwest towards the northeast across OSMP land near the Marshall Mesa Trailhead **(Attachment 6, Screenshot from Zoltowski Video IMG_3838 maintained by BCSO)**. OSMP Ranger McBride can be seen blocking the roadway in the video after having left the park driveway.

In the early moments of the Marshall fire reports of a power line down near the intersection of Hwy 93 and Eldorado Springs Dr. were received. Responding officials were able to determine that the line was a communication line and not associated with a fire ignition. The area of the Marshall Mesa Trailhead was initially investigated by U.S. Forest Service Special Agent Hannah Nadeau on Monday January 3rd, 2022, to determine the relationship of the burn patterns on OSMP land and the nearby 5325 Eldorado Springs Dr. property. This examination was made prior to the discovery of the Zoltowski video. SA Nadeau made an arching sweep across the open space area generally identifying macro burn pattern indicators of advancing fire from southwest to northeast. SA Nadeau also noted down communication lines along the west side of the property, parallel to Highway 93.

On January 5, 2022, SA Travis Lunders and SA Aaron Henrichs made an examination of the powerline along the west side of the OSMP property, parallel to Highway 93. The powerline carried three conductors or phases, with a neutral line below the three conductors, and insulated communication lines below the electric power conductors. Aside from the communication line, damage was observed to the electric distribution system between Hwy 93 and the Marshall Mesa Trailhead. The damage appeared to consist of a neutral line that had become unlashed from an insulator on pole 188688. The unlashed neutral line then appeared to have pulled on an additional neutral wire that was attached to a transformer mounted on the pole while also causing an insulated conductor from the transformer to be severed **(Attachment 7, USFS Photos of Pole 188688)**. The next pole to the south, pole 101507, had a recloser mounted to the pole and insulated lines of communication between the recloser and recloser control box at the base of the pole had become unlashed from the support bracket and were dangling across the neutral line, which had pulled loose from the insulator, but was still retained to the pole by the metal insulator bracket **(Attachment 8, USFS Photos of Pole 101507)**. No other damage was immediately observed to the electrical system. Tire tracks through the burned area east of the powerline were observed from what appeared to be a large truck.

A snowstorm moved into the area that afternoon limiting access to fire burn pattern indicators and on scene investigation. Additional videos and photographs compiled by the Boulder County Sheriff's Office were reviewed. A motion activated Reconyx trail camera maintained by the Boulder County Sheriff's Office at the gate to the Marshall Mesa trailhead was retrieved and viewed. The timestamp on the camera is manually set and appeared to be one hour ahead, possibly having not been adjusted for daylight savings time. The camera was trained on the vehicle entry/exit to the trailhead, but also captured the power line along the west side of the trailhead as well as the open space land to the south. Several vehicles enter and exit the parking lot over the course of the morning as winds increased. An OSMP Ranger checks the parking lot at 08:35. A citizen is photographed removing a small tree that fell to the ground across the entry gate at 10:00. At 12:17 a photo captures the southern horizon, and no smoke is visible in the open space. The next photo where the horizon is visible is at 12:20 and smoke is visible in the open space just east of the pole MP2 **(Attachment 9, Screenshot from Reconyx camera video maintained by BCSO)**. The photo is triggered as a white Chevy pickup with Milo Construction enters the trailhead. By 12:30 the fire has covered the distance to the trailhead parking lot advancing to the north and reaches the camera location as the gate swings wildly.

On January 6, 2022, with approximately 2”- 4” inches of snow covering the ground SA Lunders and SA Henrichs inspected the Marshall Mesa Trailhead. SA Nadeau had become aware of an active coal seam fire under the general area of the trailhead. Several open holes or vents were found in the snow south of the parking area. No animal tracks were present to indicate that these holes had been opened or used by burrowing animals. These “vents” were generally clustered in two areas. The first in the large open space where in 2017 work was conducted to address subsidence of the land. The second cluster of vents were located farther south along a rock outcropping. One of the vents below a rock ledge had ice crystals forming possibly indicating moist air was escaping from the ground **(Attachment 10, USFS Photos of Vents)**. Upon further inspection the snow was found to be generally lighter across the 2017 reclamation area, with some small places melting off to bare soil. SA Nadeau located a report online entitled “Colorado Underground Coal Mine Fires 2018 Inventory Report” produced by the Colorado Division of Reclamation, Mining and Safety. The report described the Marshall mine fire site and activities undertaken to manage it. The report stated that in October of 2003 the smell of coal combustion was noted and the underground fire was found to be moderately active with ground temperatures ranging from 118˚F to 130˚F. In February of 2005 a recently constructed building suffered damage from ground subsidence. In December of 2005 a hot vent ignited a brush fire that was quickly contained. The origin of the fire was reported to be a vent measuring 373˚F. In January of 2006 aggregate was placed over the vents to reduce fire ignition potential. In 2016 work was conducted to address subsidence issues. During the work small vents were uncovered and exhaust air temperatures were recorded at 90˚F. The area was visited in 2018 but no new activity was detected. The report ranked the risk to public safety as limited and recommended monitoring and no further abatement stating the fire has behaved erratically in the past therefor annual monitoring for increased activity is recommended ***(Attachment* 11, Colorado Underground Coal Mine Fires 2018 Inventory Report*)*.**

On January 7, 2022, representatives of the Colorado Division of Reclamation, Mining and Safety met with investigators at the Marshall Mesa Trailhead to examine the site for evidence of coal seam fire activity. The vents located by SA Lunders and SA Henrichs were shown to the representatives. The area was searched for any old mine entrances that may have become open and allowed oxygen to be introduced into the existing underground coal seam fire. No such entrances were located. Colorado Division of Reclamation, Mining and Safety requested Tetra Tech, the contractor used to monitor underground coal mine fires, to respond and collect temperature and gas discharge data from the vents. Tetra Tech produced a report of the findings that generally found the gas concentrations and temperatures to be typical of closed mine atmospheres with minor venting and minor coal oxidation. All the temperatures sampled were near ambient air temperature with the exception of one vent that was 36˚F, 9.4˚F above ambient air temperature **(Attachment 12, Marshall Mine Fire Gas Analysis Memo 1/7/2022)**. On January 8, 2022, Tetra Tech conducted a drone flight over the area. The drone was equipped with a thermal camera and the flight produced similar results as the ground measurements **(Attachment 13, Marshall Mine Fire UAV Thermal Memo)**. Tetra Tech returned on January 14, 2022, to repeat the ground sampling. The results were similar to the January 7 sampling finding amounts of CO2 and O2, but no methane gas. The temperatures measured were also similar to those of January 8, 2022 **(Attachment 14, Marshall Mine Fire Gas Analysis Memo 1/14/2022)**. Finally, beginning February 21, 2022, Tetra Tech at the request of Colorado Division of Reclamation, Mining and Safety began boring holes into the area in order to identify any hot pockets of combustion beneath the surface and to identify any voids below the surface that would indicate material had combusted. A detailed report was produced that identified some elevated temperatures and combustion gases in the northern sample areas but did not locate any elevated temperatures or gas production in the southern area nearest to what would eventually become the Specific Origin Area (SOA) for the Marshall Mesa Trailhead ignition **(Attachment 15, Marshall Mesa Drill Preliminary Report).**

GENERAL ORIGIN EXAMINATION

By January 12, 2022, snow had sufficiently melted in the Marshall Mesa Trailhead area to attempt to conduct an examination of the general origin area determined from photographs, witness videos, and SA Nadeau's identification of macro burn pattern indicators. SA's Nadeau, Lunders, and Henrichs began by identifying macro burn pattern indicators around the general origin area. Clusters of macro burn pattern indicators were used to establish vectors of advancing fire indicated by red survey tape arrows constructed on the ground. Areas of lateral fire indicators were located and marked with lines of yellow survey tape. Investigators continued locating advancing fire indicators walking back and forth across the area. Eventually the general origin area was reduced to the area of reclamation south of the parking area extending west to the property edge at Hwy 93 and south to the area above the rock outcropping.

Due to the reclamation work in 2017, the area did not contain many features that would produce macro burn pattern indicators. The area had also been heavily impacted by the 80 to 100 mph winds that buffeted the area on December 30, 2021. Due to the winds and accompanying snow micro indicators were difficult to identify. The area contained many grass stems initially indicating that a backing fire had occurred. Upon closer examination it was found that the grass stems had been deposited by the wind across the area, showed no signs of having been burned, and were determined to be an unreliable fire indicator. The subsequent snow that fell across the general origin area matted down ash and fine burned fuels further complicating microscale burn pattern identification. Three possible specific origin areas were considered but the lack of microscale indicators and remaining snow fields hindered further investigation. Photographs of existing pin flags were taken and the area was documented with drone overflights.

Inv. Marci Lieberman with the Boulder County District Attorney's Office located the driver of the white Chevy Milo Construction pickup and identified him as Joseph A. Tomasello. In an interview Tomasello stated he was attempting to travel Hwy. 93 but it was closed so he pulled into the Marshall Mesa Trailhead to wait for the road to open. As soon as Tomasello pulled into the trailhead he said he saw the fire, east of Hwy. 93 "ripping west". Tomasello said he was initially unable to see what was burning when he pulled in as a small hill between his position and the base of the fire blocked his view. Tomasello did not see any power lines that were down **(Attachment 16, BCSO Tomesello Interview)**. The two videos provided by Tomasello show the fire already well-established moving towards the northeast and appearing to emanate from the south near the Hwy 93 border to the open space. In the video labeled IMG_6072 Tomasello pans from the fire to the south in the open space and around to the west. As Tomasello pans the camera the east conductor is visibley separated from the second braced power pole (MP2) and is bouncing in the wind **(Attachment 17, IMG_6072 Maintained by BCSO)(Attachment 18, Screenshots from IMG_6072 Maintained by BCSO)**.

Investigators returned to the photos captured by the Reconyx trail camera mounted at the entry to the Marshall Mesa Trailhead. Initially the photos were viewed with the focus of establishing the timeline and fire progression. With the focus now being the powerline and power pole MP2, a photo was located that showed a vehicle that exits the trailhead at 10:35 with the power line conductors in the original configuration. At 11:09 OSMP Ranger McBride is the next vehicle to enter the park but the view to the powerline conductors is blocked by the vehicle. When the OSMP Ranger McBride exits the park at 11:10 the east conductor on the second pole to the south with a support pole brace (labeled as MP2) is visibly sagging and unlashed from the crossmember **(Attachment 19 Screenshot from Reconyx camera video maintained by BCSO)**. This conductor was apparently remounted to the insulator in the days after the fire ignition. Detective Katie Tkach interviewed Kirk Schmidt with Golden Forensics who had been at the trailhead site on December 31, 2021. Schmidt provided Det. Tkach with photographs that depict the east conductor of pole MP2 being off the insulator and in contact with the support pole. Schmidt's photos also depict the neutral cable pulled loose from Pole MP1 with a large bolt attached to the cable. Schmidt confirmed that he labeled the poles MP1, MP2, and MP3 at that time. In April of 2022 Excel Energy stated in a letter to the Boulder District Attorney's Office that the east phase conductor of Pole MP2 was reinstalled on January 2, 2022 by lineman Dustin Lenser.

SPECIFIC ORIGIN EXAMINATION

On January 14, 2022, SA's Henrichs and Nadeau returned to continue the investigation of the general origin area. SA Henrichs followed the truck tracks from the parking area of the Marshall Mesa Trailhead south, through the burned area along the east edge of the powerlines, and into tall, unburned grass at the base of power pole MP2. In the grass at the end of the tire tracks and near the power pole were two short aluminum wires that appeared to be lashings used to attach conductors to insulators **(Attachment 20, USFS Photo of MP2 Lashings in Grass)**. SA Henrichs alerted BCSO of the items and they were collected by Deputy Jessica Yates as evidence items JY6.

With additional snow having melted the identification of indicators and placement of pin flags resumed. The northernmost possible specific origin area was eliminated through the identification of backing indicators that had previously been covered in snow. The area was very near the fence along the west boundary. Later, representatives from Excel Energy alerted investigators to a cigarette in that location. The cigarette was collected by BCSO detectives but appeared to be old and weathered. Two specific origin areas (SOA) were identified. The areas were identified as SOA 1 and SOA 2. A grid was established, and a detailed search was conducted of both SOA. Additional microscale burn pattern indicators were identified with pin flags within the grid lanes. After careful visual examination a magnet was used to attempt to locate ferrous metals in the grid lanes. Photographs of the grid lanes before and after examination were taken. A few large, thick pieces of broken Coca-Cola bottle glass were identified at the edge of SOA 2 but was not included in the area gridded. Nothing was located in the grid search to define an Ignition Area or identify a Point of Origin for the trailhead segment of the Marshall Fire.

CAUSE DETERMINATION

Lightning - Lightning is discharged static electricity associated with thunderstorm activity. Lightning is typically a series of short bursts approximately two inches in diameter, lasting for about one-half second. These lightning discharges include cloud-to-ground strikes which are in the range of 100 million volts, 200,000 amperes, and 54,000 °F. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 197, (2016). The circumstances indicating a possible lightning strike as a cause includes recent electrical storm (hours/days/weeks) activity in the area, the presence of indicators of sleepers and holdovers, scarring on trees or snags, precipitated sap, needle shower, ballistic penetration of adjoining vegetation by needles and small twigs or splinters, blow-holes at base of tree, fulgurites, and splintered wood or vegetation. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 197, (2016).

> *Earth Networks, a private company contracted to detect cloud to ground and cloud to cloud lightning, verified zero cloud-to-ground lightning strokes detected within a .8-mile radius of the GPS coordinates provided for the dates between 12/16/21 through 12/30/2021. No lightning scars were observed on any of trees or shrubs in the incident area. No blowholes or fulgurites were observed in the incident area. For these reasons, Lightning can be excluded as a possible cause.* **(Attachment 21, Earth Networks Inquiry Response)**

Equipment Use - Wildland fires resulting from the operation of mechanical equipment excluding railroads. Types of mechanical equipment range from heavy construction to small portable engines. Equipment use caused fires may be viewed in five parts; 1. Exhaust system particles, 2. Friction and sparks, 3. Fuel, lubricant, fluids, 4. Mechanical breakdown or other malfunction 5. Radiant or conductive heat transfer. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 215, (2016).

> *No evidence of equipment use was discovered in the GOA of the fire. Access to the area is fenced. Tire tracks discovered in the area were created after the fire. For these reasons, Equipment Use can be excluded as a possible cause.*

Smoking - Wildfires caused by smoking activities or accoutrements, including matches, cigarettes, cigars, pipes, illegal substances, etc. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 207, (2016). To effectively assess the probability of a cigarette as a competent ignition source, consider the following; physical characteristics of the cigarette, environmental factors, physical placement factors. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 207, (2016). Cigarette ignition factors are; 0% RH, Start Likely, 10% RH, Start Possible, 18% RH, Start Unlikely and 22% RH, No Start. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 208, (2016). Environmental factors include finely particulated fuel bed, loose fuel arrangement, fine dead fuel moisture (FDFM) less than 14%, 80 ˚F + ambient temperature, microclimate location (temperature at ground level vs. temperature at higher level), Relative Humidity (RH) of 22% or less. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 208, (2016).

> *Relative Humidity was measured at or near 22% at several weather stations in the area of the fire but temperatures at the time of ignition ranged from 39 to 45 degrees. The relative humidity range is unlikely to no start. According to the NWCG Handbook cigarette ignition cannot occur at temperatures 39 and 45 degrees. It would be unlikely for a person to be walking on the trail system in the weather conditions experienced on the day of the fire and the SOA not located on or near a trail. Smoking material tossed from a moving vehicle along Hwy 93 would be unlikely to travel over 125 feet to reach the SOA. No evidence of cigarettes or smoking was discovered in the SOA. For these reasons, Smoking can be excluded as a possible cause.* **(Attachment 2, Weather Details Compiled)**

Camp Fire - Any fire kindled for warmth, cooking, light, religious or ceremonial purpose. Campfires may occur at any location. Responsible parties may include hunters, campers, anglers, hikers or transients (homeless). Regulations often address attendance, clearance, and periods of use, suppression tools, and proper extinguishment. Violations of these regulations often result in escaped fires. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 202, (2016).

> *No evidence of a campfire ring, or any other evidence of recreational camping was observed in the GOA. The Marshall Mesa Trailhead is gated, and public use is limited. Camping beyond the gate and fenced area is not permitted. For these reasons, Camp Fire can be excluded as a possible cause.*

Debris Burning - Wildland fires caused by debris burning activities including residential (pile, barrel, hazard reduction) and industrial (logging operations, land clearing, agricultural, forestry, right-of-way hazard reduction, or other controlled burning). “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 211, (2016).

There was no evidence of debris burning or piles of debris in the GOA. Debris burning had occurred on a property 675 yards to the north but an ember traveling that distance upwind while retaining sufficient heat to cause an ignition is unlikely. For these reasons, Debris Burning can be excluded as a possible cause.

Railroad - Fires caused by any railroad operations, personnel, rolling stock and can include track and right-of-way maintenance. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 229, (2016). Railroad structures such as trestles, bridges, and ties, are included in this category of fire cause. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 229, (2016). General railroad ignition factors include exhaust carbon, brake shoe particles, track maintenance, right-of-way maintenance, dynamic grid failure, signal flares, wheel slip, wheel bearing failure (hotbox) and transients. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 230, (2016).

There are no known railroad operations in the vicinity of the Marshall Mesa Trailhead GOA. For these reasons, Railroad can be excluded as a possible cause.

Incendiary - Wildfires deliberately or maliciously set with the intent to damage or defraud. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 215, (2016). **Arson**: The intentional and wrongful burning of someone else’s property or one’s own property (as to fraudulently collect insurance). (Garner, 2009) “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 299, (2016). **Incendiary**: Deliberately and unlawfully set fire to property. (Garner, 2009) “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 299, (2016). These terms are often used interchangeably.

No evidence of arson or incendiary activity was discovered in the GOA. No incendiary devices; mechanical, chemical, or electrical were recovered. While the area is urban and experiences occasional arson activity, arson activity in this specific area is uncommon due to the popularity of the trailhead and the amount of people on the property at any given time. Boulder County Sheriff’s Office and City of Boulder Open Space Rangers were asked about outstanding arson reports in the area and could not recall any specific cases that would raise suspicion of an arson ignition. No modified fuel beds were observed in the GOA. None of the witnesses interviewed who were present at the trailhead near the ignition of the fire reported seeing anyone hiking in the area of the SOA. The SOA is not along a portion of the established trail system. Portions of the GOA were searched by Dawn Tollis of the Division of Fire Prevention and Control with her K9 JO-JO. JO-JO alerted to the presence of petroleum-based substances in 20 locations in the area of the coal seam vents. The samples were collected by Tollis for analysis. It is impossible for Jo-JO to determine the difference between naturally occurring petroleum products and products that may have been introduced to ignite a fire. Due to the fact petroleum products would be present in the area of a coal mine and no other information was located to support an arson/incendiary ignition, Incendiary can be excluded as a possible cause.

Children - Wildfires started by persons 12 years of age or younger. The child may be motivated by normal curiosity and use fire in experimental or play fashion. Matches or lighters are the most frequent ignition source. It often involves multiple children. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 243, (2016).

> *The area is a popular and highly utilized open space recreation area. Public access is allowed through a monitored access gate. No children were observed entering the area. Investigators did not observe or uncover any evidence of Children in the area. For these reasons, Children can be excluded as a possible cause.*

Miscellaneous - Wildfires that cannot be properly classified under other standard causes. Some of these are listed below but can include other ignition sources that are not listed. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 245, (2016).

Powerlines: The category of powerlines includes all electrical equipment associated with the production, transmission, and use of electricity. The electrical grid or system for the transmission, distribution, and service of customers forms a complex web and is governed by regulations. The transmission of electricity has long been recognized as having an inherent danger above and beyond typical hazards. Early electrical distribution systems caused numerous fires, better engineering and prevention efforts have reduced the number. Powerlines are an ignition source that can lead to major fires, as many of the conditions that contribute to system faults and failures coincide with extreme fire behavior. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 245, (2016).

> *After the confirmation of an additional ignition the area was revisited by investigators on January 5, 2022, where damage was observed to the electric distribution system between Hwy 93 and the Marshall Mesa Trailhead. The damage appeared to consist of a neutral line that had become unlashed from an insulator on pole 188688. The unlashed neutral line then appeared to have pulled on an attached neutral wire attached to a transformer mounted on the pole while also causing an insulated conductor from the transformer to be severed. Communication lines in this area were also severed, coming to rest on Hwy 93. Burn pattern indicators and video evidence do not support an ignition from this damaged section of the powerline.*
>
> *Video and photographic evidence indicate that the east conductor became unlashed from the insulator on the second braced power pole (MP2) south of the pole carrying the recloser (352885764). Aluminum lashings were found at the base of the power pole (MP2) that may have been the original lashings or scraps from repairs made when the conductor was reattached to the pole between December 30 and January 5, 2022. The lashings were located at the end of a set of tire tracks that paralleled the east side of the power line across the Marshall Mesa Trail open space. Excel Energy reported to Boulder County District Attorney’s Office that on January 2, 2022, the east conductor was in fact reinstalled to pole MP2 by PCSO lineman Dustin Lenser. On March 25, 2020 representatives of Excel Energy removed sections of the three conductors at Pole MP2. A brief examination of the conductors in the field revealed damage to individual cables and possible evidence of arcing on the center conductor* ***(Attachment 22, USFS Photo of MP2 Center Conductor).*** *The conductors were taken by representatives of Jensen Hughes, a firm contracted by Boulder County to provide electrical engineering expertise. Jensen Hughes examined the conductors in a lab and determined that the east conductor had evidence of arcing*

and as much as a few grams of the aluminum center conductor was missing and showed signs of arcing. SOA1 is 110.5' southeast of MP2 and SOA2 is 79.6' east of MP2. Jenson Hughes concluded that the amount of missing conductor, the speed at which the wind would have carried the hot conductor particles, and the heat retained in the particles would have been sufficient to ignite a fire in a receptive fuel bed. Jensen Hughes also analyzed data recovered from recloser 101-507on pole 352885764 and the 1161 circuit breaker at the Eldorado Substation. The circuit opened and closed several times over the course of the morning with the last recorded open and close cycle at 12:07, prior to the 12:20 fire ignition. The Jensen Hughes Marshall Mesa Trailhead Fire Investigation Report is retained by Boulder County.

Fireworks: Fireworks may be classified in several different ways depending upon the jurisdiction. Most fireworks will fall into one of three categories, ground based and hand-held, aerial, or explosive. Fireworks are known to cause major property damage annually including fires to both wildland and structures. Used in an unsafe manner, fireworks can discharge burning material into flammable vegetation. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 263, (2016).

There was no evidence of fireworks found in the GOA and SOA, including packaging, fuses, matches, mortar tubes or the remains of spent fireworks. There were no reports of fireworks being seen or heard in the area. For these reasons, fireworks can be excluded as a possible cause.

Firearms and Ammunition: Black powder discharge, tracer, incendiary, solid copper and copper jacketed and various types of ammunition are capable of causing wildfires through the discharge of hot materials or mechanical sparks caused when a bullet strikes a hard object and fragments, creating hot particles which land in the dry fuels. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 266, (2016).

There was no evidence of firearm use in or near the GOA or SOA. There was no ammunition packaging or targets found in the GOA and SOA. The area is a popular hiking area within city limits where firearms use is not allowed. For these reasons, firearms and ammunition use can be excluded as a cause.

Exploding Targets: Exploding targets detonate upon impact of the projectile, sending out hot particles. Exploding targets are typically a mixture of more than one compound which is generally not considered an explosive until combined. Exploding targets come commercially manufactured in either low or high velocity types. Homemade versions are also being used with similar effects. Once mixed, the compounds form an explosive device. Wildland fire investigators working a scene which may include an exploding target should use caution when handling, collecting, packaging and storing residue or devices. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 270, (2016).

There was no evidence of exploding targets being used in the GOA or SOA. The GOA and SOA are within Boulder city limits and are bordered by a highly traveled highway where exploding targets would have been noticed. No spent bullet casings or ammunition packaging were found in the SOA or GOA. For these reasons, exploding targets can be excluded as a cause.

Cutting, Welding, and Grinding: These types of ignitions are normally caused by an industrial or agricultural operation, but may also result from an individual or residential activity. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 274, (2016).

> *While a natural gas pipeline with above ground fixtures is near the GOA and SOA there is no evidence that work was occurring at any time around the ignition of the fire. There was no evidence of cutting, welding and/or grinding in the GOA or SOA. For these reasons, cutting, welding, and grinding can be excluded as a cause.*

Spontaneous Heating: Certain fuels will self-heat and ignite spontaneously when conditions support a combination of biological and chemical processes. This action is most likely to occur after periods of warm humid days in decomposing piles of organic material such as hay, grains, feeds, manure, sawdust, wood chip piles, and piled peat moss. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 277, (2016).

> *The materials and conditions required for a spontaneous heating ignition were not present. For this reason, spontaneous heating can be excluded as a cause.*

Coal Seam Fires: Coal seams may be ignited by lightning, wildfires, or other ignition sources. Fires typically burn slowly along the seam and may resurface when seam nears the surface which cracks, and oxygen is introduced to the burning seam. These fires are dangerous to investigate as the burning coal seam may lie just under the surface. Coal seam fires may be visible in the winter with steam plumes and random bare patches in the snow from underground heating. Patches of dead vegetation may also be a tip that underground heating from a coal seam fire is taking place. “NWCG Handbook”, PMS 412, NFES 1874, Chapter 6, page 282, (2016).

> *The Marshall fire occurred in the Denver Coal Region and the Marshall Mesa Trailhead is located above several abandon coal mines and two known active underground coal fires, the “Marshall and Lewis Fires”. It is believed these fires have been burning for decades and are only noticeable by occasional venting, slightly elevated surface temperatures, and land subsidence. In 2005 the Marshall coal fire was responsible for igniting a small brush fire when the origin of the fire was traced back to a 373 ˚F vent hole. On December 10 of 2012 Open Space and Mountain Parks photographed a vent in the GOA of the Marshall fire that had white residue around the edges and browning of grass at the hole’s perimeter. It is a hypothesis that the strong winds and the atmospheric low-pressure system that affected the region on December 30, 2021, infused oxygen into the existing underground coal fire and allowed for the venting of gases of sufficient temperature to support a wildfire ignition. Testing conducted on January 7, January 12, and February 21, 2022, by Tetra Tech does not support evidence of elevated underground fire activity and temperatures capable of an above ground fire ignition. The data collected does confirm the presence of coal oxidation or a very low activity, smoldering mine fire. At the request of the Boulder County District Attorney underground temperatures have continued to be monitored on days with excessive wind events and no significant increase in underground temperatures have been noted. Due to prior documented ignitions, coal seam fires cannot be totally excluded and must be* ***included as a possible cause, however not the most probable cause****.*

Electric Fences: Fires originating from electric fences used to contain domestic animals. Rapid electric pulse cycle does not allow fuel to cool down. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 283, (2016).

Electric fences used to contain domestic animals do not exist in any area of the Marshall Mesa Trailhead. There is no evidence of electric fences in the GOA or SOA. For this reason, electric fences can be excluded as a cause.

Refraction (Reflection): The sun's rays can be focused to a point of intense heat if concentrated by certain glass or shiny objects. This refraction or reflection process bends light rays, similar to that which occurs through a magnifying glass. The shiny, concave end of a metal-can may focus sunlight, but its short focal distance makes the potential as a possible cause highly unlikely. Fires started by these items are extremely rare occurrences; however, objects possessing these characteristics recovered from the specific origin Area may need to be carefully examined to determine their fire-starting potential. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 285- 286, (2016).

Small pieces of glass, remnants of a decades old Coke bottle, were observed just outside grid lanes 7-10 during the SOA examination. The glass was slightly opaque, and the sun was not particularly strong in the late December sky. No other glass or other light-focusing materials were found in the GOA or SOA. For these reasons, refraction (reflection) can be excluded as a cause.

Blasting: Fires started by flaming debris associated with blasting activities. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 286, (2016).

No blasting had been conducted in the vicinity of the Marshall Mesa Trailhead. For this reason, blasting can be excluded as a cause.

Flares: Fires resulting from commercial, industrial, or military flares. Compound is usually a mixture of sawdust, wax, sulphur, strontium nitrate, and potassium perchlorate. Flares burn at approximately 3600°F. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 287, (2016).

No burned-out flares, slag, plastic caps or other discarded parts of a flare were discovered in the GOA or SOA. There were no reports of aerial-type flares preceding the discovery of the Marshall fire. For these reasons, flares can be excluded as a cause.

Oil and Gas Fires: Fires associated with the recovery and pumping of oil and gas products in the wildland. Flare pit and stack fires are among some types of oil and gas fires which may be encountered in the wildland environment. Flare pit and stack operations are designed to burn off excess or unwanted petroleum by-products. Occasionally these will start fires from direct flame impingement, the igniter flare or stack particles. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 290, (2016).

Neither gas nor oil extraction operations exist in the vicinity of the Marshall Mesa Trailhead. A natural gas pipeline passes through the area to the south of the GOA and SOA but fire burn pattern indicators to not support an ignition from this location. For this reason, oil and gas fires can be excluded as a cause.

Flying Lanterns: Flying lanterns are miniature hot air balloons made from paper or plastic, bamboo or lightweight wood, and wire with a solid fuel package. Homemade lanterns may use plastic garbage sacks. Originating in Asia and called happiness balloons or wish balloons their use has spread around the world, and they are commonly used during weddings or other celebrations. Experimentation by young adults or teenagers is commonly associated to fires caused by flying lanterns, particularly if homemade. Manufacturers claim that the paper is treated with a fire retardant, but many are not. Flying lanterns can travel miles away from release site and are capable of reaching several thousand feet in altitude. Multiple lanterns may be released at a single time. Releases typically occur during nighttime hours for full visual effect but can also be deployed during daytime activities. Note: Oregon has classified flying lanterns as fireworks and banned them from use within the state. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 293, (2016).

> *No remains of a flying lantern were found in the GOA or SOA. There were no reports of flying lanterns being seen in the area prior to discovery of the fire. Flying Lanterns are uncommon for the area and would be difficult to impossible to launch in the strong winds of December 30, 2022 due to being unable to keep the fabric from collapsing as it collects the hot air needed to attain lift. For these reasons, flying lanterns can be excluded as a cause.*

Wind Turbines: Wind turbines use wind flow to generate electrical energy and are increasingly being placed into the wildland environment. Where more than one wind turbine is in the same area, the term wind farm may be used. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 295, (2016).

> *Wind turbines do not exist in the vicinity of the Marshall Fire. The nearest wind turbines are found 2.5 miles south of the fire. For this reason, wind turbines can be excluded as a cause.*

Home Outdoor Wood Burning Furnaces: Referred to as outdoor wood furnaces or outdoor wood boilers, these devices can be modern manufactured models or homemade. They can be used to heat a structure by way of connecting to a central heating unit and/or are used to provide hot water. Either way, the furnace operates by burning firewood and may be burning wood even in the warmer parts of the year if it is being used to heat water also. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 296, (2016).

> *No wood burning furnaces or boilers exist in the GOA or SOA of the Marshall fire. For this reason, home outdoor wood burning furnaces can excluded as a cause.*

Structures: Fire spreading to the wildland due to failures or activities associated with a structure. "NWCG Handbook", PMS 412, NFES 1874, Chapter 6, page 296, (2016).

> *Structures do not reside within the GOA or SAO of the Marshall Mesa Trailhead. For this reason, structures can be excluded as a cause.*

USDA Forest Service	**Wildland Fire Origin and Cause Supplemental Incident Report** (Reference FSH 5309.11, Chapter 20)	Incident Number	**22-02-IAIP002**
		Incident Date	**12-30-21**

Fire Name	**Marshall Fire**

Latitude	39	57	03	**Longitude**	105	13	58	**Datum**	WGS84

FIRE SCENE SKETCH (INCLUDE SCALE, TITLE, AUTHOR, NORTH ARROW, DATE AND TIME)

Marshall Fire

December 30, 2021

Boulder County, Colorado

Fire Perimeter and Associated Weather Observation Stations

Heal of Marshall Fire

Marshall Fire Perimeter

SCALE	NA	**AUTHOR**	HENRICHS	**DATE**	NA	**TIME**	NA

USDA Forest Service	Wildland Fire Origin and Cause Supplemental Incident Report (Reference FSH 5309.11, Chapter 20)	Incident Number	22-02-IAIP002
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SCALE	NA	AUTHOR	HENRICHS	DATE	NA	TIME	NA

USDA Forest Service

Wildland Fire Origin and Cause Supplemental Incident Report

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Fire Scene Sketch (Include Scale, Title,


[redacted]

Scale	NA	**Author**	Henrichs	**Date**	NA	**Time**	NA

USDA Forest Service	**Wildland Fire Origin and Cause Supplemental Incident Report** **(Reference FSH 5309.11, Chapter 20)**	Incident Number	**22-02-IAIP002**
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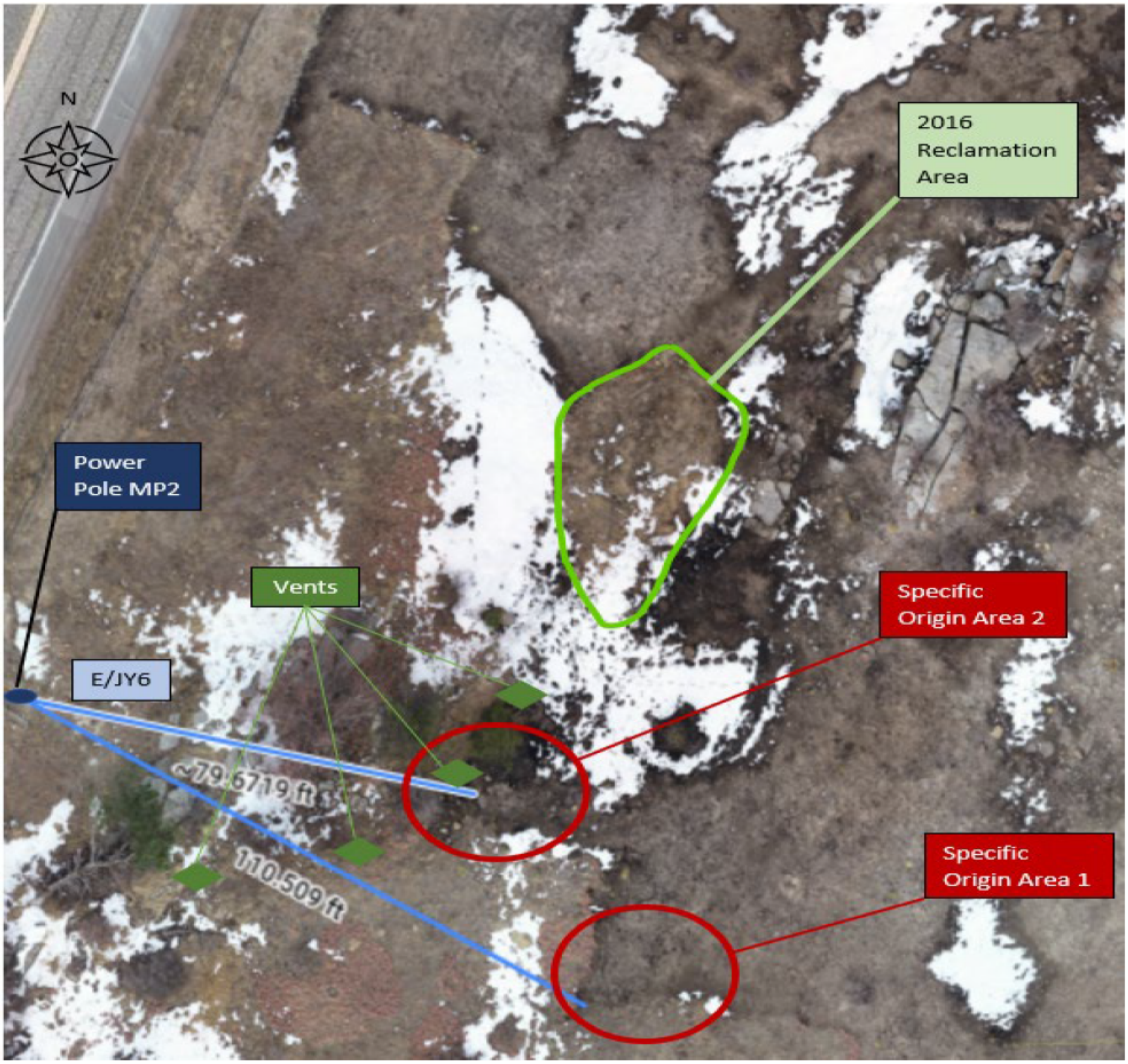

SCALE	NA	**AUTHOR**	HENRICHS	**DATE**	NA	**TIME**	NA

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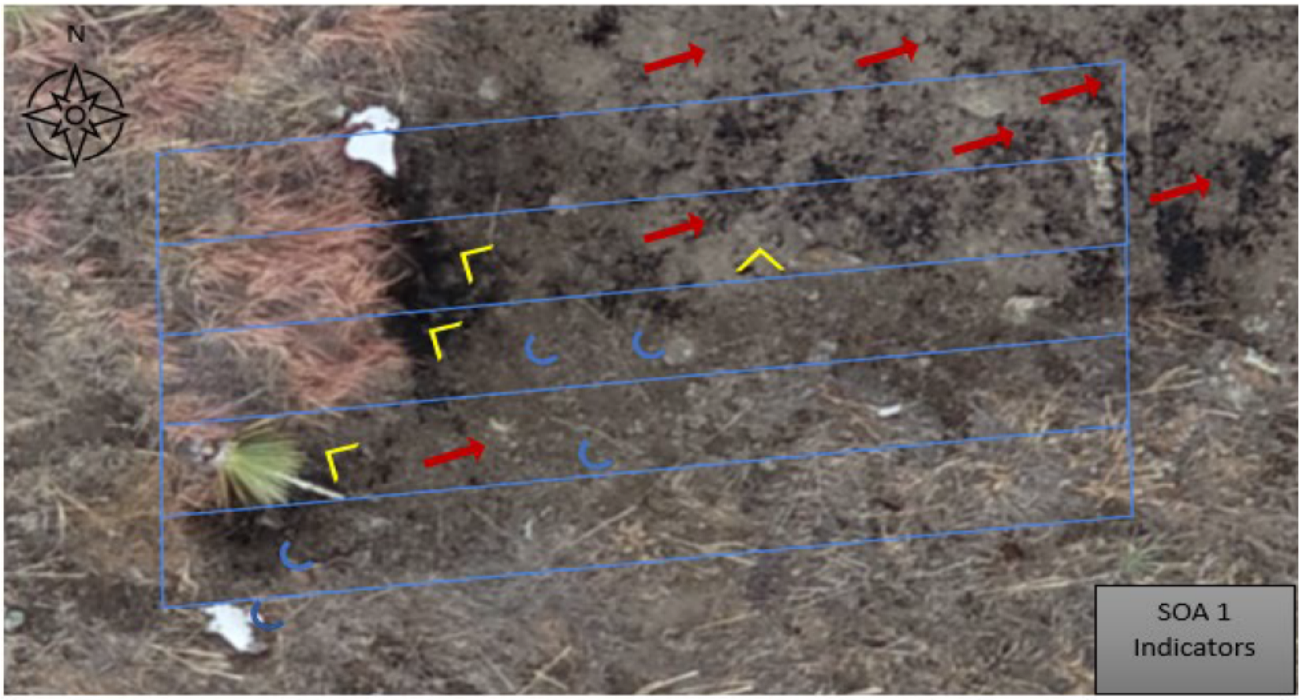

LEGEND

Advancing Fire Indicator	→	Advancing Fire Vector	➡
Lateral Fire Indicator	▶	Lateral Fire Vector	⚡
Backing Fire Indicator	☾	Item of Interest (Vent Clusters)	◆
Items of Evicence	E/#	Item of Interest (Individual Vent)	◆
Photographer viewpoint	👁		

SCALE	NA	AUTHOR	HENRICHS	DATE	NA	TIME	NA

USDA Forest Service

Wildland Fire Origin and Cause Supplemental Incident Report

(Reference FSH 5309.11, Chapter 20)

Incident Number	
Incident Date	

ATTACHMENT LIST

ATTACHMENT No.	DESCRIPTION	PAGE INTRODUCED
1	Schlatter Climatology and Meteorology Report	4
2	Weather Details Compiled	4
3	Dispatch Log	4
4	Copy of Photo maintained by BCSO of 5325 Eldorado Springs Dr.	4
5	Copy of Photo of McBride maintained by BCSO	4
6	Screenshot from Zoltowski video IMG_3838 maintained by BCSO	5
7	USFS Photos of Pole 188688	5
8	USFS Photos of Pole 101507	5
9	Screenshot from Reconyx camera video maintained by BCSO	5
10	USFS Photos of Vents	6
11	CDRMS Colorado Underground Coal Mine Fires 2018 Inventory Report	6
12	CDRMS Marshall Mine Fire Gas Analysis Memo 1/7/22	6
13	CDRMS Marshall Mine Fire Gas Analysis Memo 1/14/22	6
14	CDRMS Marshall Mine Fire UAV Thermal Memo	6
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17	IMG_6072 Maintained by BCSO	7
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Instructions for filling out the FS-5300-45, Wildland Fire Origin and Cause Supplemental Incident Report

LOCATION

Fire Name: The fire incident name assigned to the individual fire. If several fires have been combined into a Complex, use the individual name of the fire rather than the Complex name. There may be several independent investigations for the various individual fires within a Complex, each requiring an individual O&C report.
Dispatch #: The alpha-numeric designator used by dispatch for the State-County-Year-WildCad # (e.g. CO-MLX-2013-246)
Account code – the "P code" assigned to the fire.
REGION: Two digit Region identifier (e.g. 01)
FOREST: Two digit Forest identifier (e.g. 08)
DISTRICT: The single or two digit District identifier (e.g. 3 or 50)
STATE: Two letter alpha identifier of the State (e.g. AZ)
COUNTY: Spell out the county name.
ORIGIN LOCATION: Use common geographical names and road numbers that would allow the reader to locate the general fire location on a map.
TOWNSHIP/RANGE/SECTION/ ¼ SECTION: Example 39N, 1W, 18
MERIDIAN/DATUM: Enter the meridian used for the Township and Range reference and enter the datum used for the latitude and longitude reference (e.g. NMPM/NAD83)

JURISDICTION

USFS ONLY: Enter "yes" or "no" based on the land ownership burned by the fire. If the fire burned onto non-National Forest System land enter "no" and then fill in **"IDENTIFY OTHER AGENCY(S)"** with the State or local agency having concurrent jurisdictional responsibility for the fire investigation.
LEAD ORIGIN & CAUSE INVESTIGATOR: Title and name of the lead Forest Service O&C Investigator.
EST. SUPPRESSION COST: Estimated total suppression costs. This includes Forest Service and assisting agencies' costs. This information can generally be obtained from Incident Business Management Team or IC.
INJURIES/DEATHS: Number of serious injuries or deaths as a result of the fire.

EVENT SEQUENCE

ESTIMATED TIME OF IGNITION: An estimate based on factors such as the time of the initial report, the fire behavior, and the O&C investigation. The **"WHO"** is the name of the individual making the estimate.
TIME FIRE REPORTED: The time of the first report of the fire. The **"WHO"** is the name of the individual who first reported the fire.
TIME ORIGIN PROTECTED: The time and date the actual origin area was secured, either by fire crews or investigators.
TIME ORIGIN RELEASED: The time and date the actual origin area investigation was complete and the area was opened to the public or other investigators.

FIRE BEHAVIOR

ESTIMATED ACRES: Estimated total acreage at fire containment, or at time of report.
FUEL TYPE @ IGNITION AREA, MATERIAL FIRST IGNITED: e.g. grasses, pine needles, duff
WEATHER OBSERVER (ON SCENE): Name of the individual who took weather readings or weather observations at time closest to ignition of fire. Generally is a person with the initial attack crew.
SLOPE: Percent slope at the specific origin area.
ASPECT N E S W: Direction the specific origin area is facing.
ELEVATION: Elevation of the specific origin area.
WEATHER STATION: **DATE, TIME, TEMP, RH, WIND DIR, WIND SPEED**: Name of the closest Remote Automated Weather Station (RAWS) and the readings from the RAWS at the time closest to the estimated time of ignition.

CAUSE DETERMINATION

Use a two letter identifier for the level of certainty for each of the nine cause categories listed. The level of certainty is based on the definitions used in NFPA 921, 4.5.1. Explain the determination (PS, PR, EX) in detail for each of the nine categories. It is not necessary to go into detail on the ignition sources that are clearly not possible. This is based on the investigation results and/or the absence of the cause at the origin (e.g. no railroad in the origin area). The form expands to accept unlimited narrative in each of the nine cause categories blocks.

PS = POSSIBLE: At this level of certainty, the hypothesis can be demonstrated to be feasible but cannot be declared probable. If two or more hypotheses are equally likely, then the level of certainty must be "possible." Describe how you "tested" each hypothesis.

PR = PROBABLE: This level of certainty corresponds to being more likely true than not. At this level of certainty, the likelihood of the hypothesis being true is greater than 50%. Describe how you "tested" the hypothesis and arrived at a determination of probable.

EX = EXCLUDED: A determination of "excluded" should be used if the cause is not possible or probable.

CAUSE DETERMINED: Either this field or the "cause undetermined" field should be filled out; not both. State the actual cause and give a brief summary explaining the cause.

CAUSE UNDETERMINED: Give a brief summary of why the cause is "undetermined." An undetermined fire cause may later be changed to "cause determined" if new evidence becomes available.

SUBJECT/WITNESS/VICTIM/REPORTING PARTY/OTHER: Self-explanatory.

VEHICLE INFORMATION: Self-explanatory

EVIDENCE/PROPERTY INFORMATION:

Use evidence/property on form FS-5300-48 and FS-5300-49 and attached to FS 5300-45. (Law Enforcement and Investigation Inventory of Seized or Impounded Property).

INSURANCE INFORMATION:

The cost of fire suppression and resource damages can often be recovered by ASC-Claims through Homeowners, Automobile, or Umbrella policies of the individual or company who caused the fire. Include as much of this information as available.

SYNOPSIS:

(DATE, FIRE NAME, ESTIMATED ACRES, LOCATION, JURISDICTION); (ESTIMATED COST, DAMAGE; PROPERTY / RESOURCE); (CAUSE; DETERMINED / UNDETERMINED): Give a brief, one or two paragraph summary of the fire, including information on each of the items listed in this heading.

DETAILS OF INVESTIGATION:

(INITIAL REPORT, INITIAL ATTACK, INITIAL INVESTIGATION, FIRE BEHAVIOR ANALYSIS, STATEMENTS, ORIGIN EXAMINATION, CAUSE DETERMINATION: Provide a detailed write-up of the fire origin and cause investigation, including but not limited to how and when the fire was initially reported, who reported it, who it was reported to; provide details on who responded on the initial attack, both citizens and initial fire crew response, and describe the suppression actions they took that are relevant to the origin investigation.

Describe in detail the methodology used by the qualified fire investigator(INVF) for the investigation of the General Origin Area, the Specific Origin Area, and the Ignition Area of the fire. Also include details in this section about on scene weather data, lightning data, 911 call logs, and RAWS information as it relates to the origin and cause determination. Reference and attach documents, statements, and photographs as needed. Include information about the fire behavior as it relates to the ignition factors and origin determination. Attach the report of the Fire Behavior Analyst (FBAN) if used or referenced. Describe in detail the cause determination: how did the heat source come in contact with the materials first ignited, what were the ignition factors (e.g. windy conditions, burning without proper clearances, no screen on burn barrel, inadequate spark arrestor, etc.).

FIRE SCENE SKETCH

(INCLUDE SCALE, TITLE, AUTHOR, NORTH ARROW, DATE AND TIME): Insert the fire scene sketch or diagram on this page. The document can be scanned and inserted electronically at this location in the form.

PHOTO LOG

DATE: The date the photographs were taken.

CAMERA: The camera model used to take the photographs (e.g. Nikon D100).

PHOTOGRAPHER: The name of the person taking the photographs. If there are multiple photographers, consider us ding a separate page for the additional photographer(s).

IMAGE NO: Enter the original image number assigned by the camera (e.g. DSC_0171). If the image number is "renamed" by the author include that in the "Description" section.

DESCRIPTION: Enter a description of what the photograph is showing. If the photograph is showing a fire pattern indicator include the indicator category, the item depicted, and the fire vector (e.g. Protection, pine cone, Advancing).

DIRECTION OF PHOTO (COMPASS): Enter the compass direction the camera is facing when the picture was taken (e.g. N, ENE, SW, etc).

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 1

Schlatter Climatology and Meteorology Report

Report on The Climatology and Meteorology Associated with the Marshall Fire on December 30, 2021

Drafted by Paul Schlatter
Science and Operations Officer at the National Weather Service Forecast Office, Boulder, CO

<u>Overview:</u>

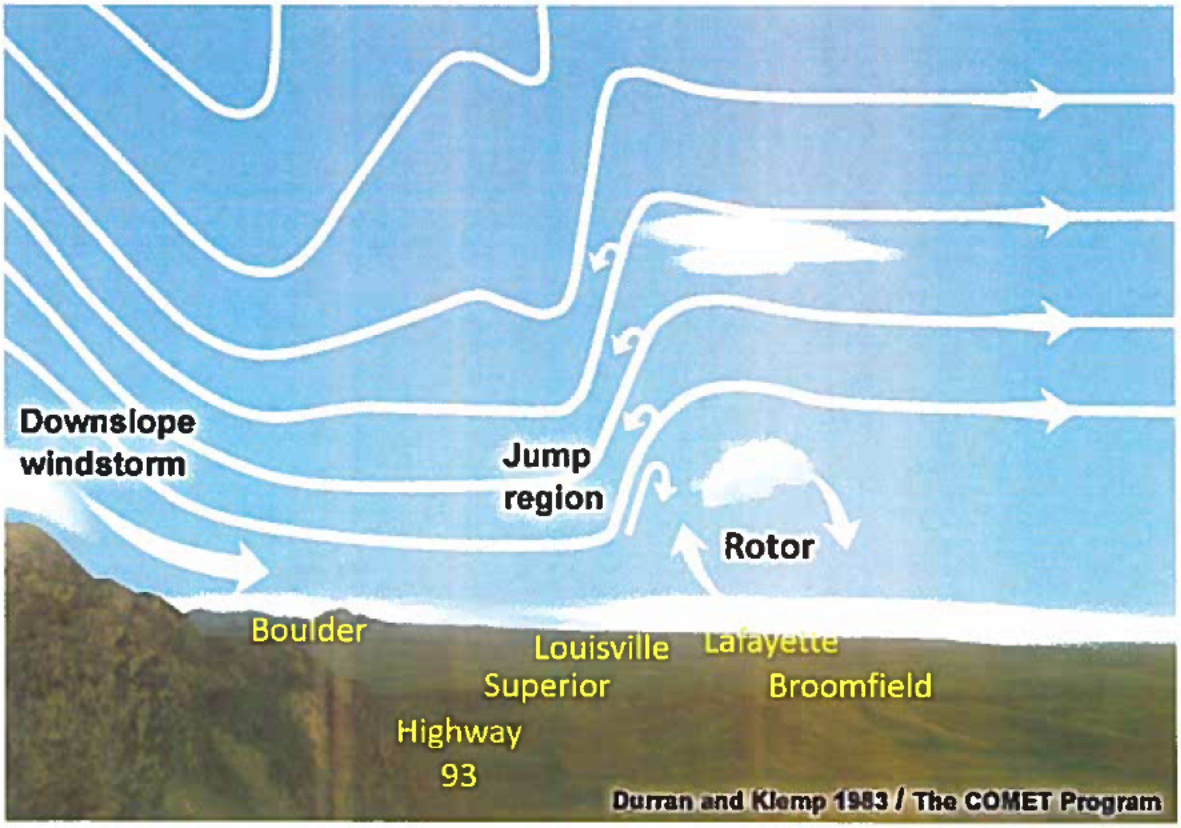
The geography of the Front Range of Colorado is the primary reason extreme downslope windstorms are so common along and just east of the mountains. In particular, the CO-93 corridor from Boulder to Golden is notoriously capable of generating wind gusts well over 80 mph every year.

Just west of the CO-93 corridor lies an unbroken ridge with an average elevation exceeding 12,000 feet, oriented roughly north to south, over 100 miles long. Weather patterns across the U.S. favor strong westerly flow aloft (i.e. winds blowing from west to east) in the winter months. Much like water in a river flowing over obstacles like boulders, the atmosphere behaves similarly when westerly winds flow over the Rocky Mountains and the 12,000+ ft ridge to the west of the Boulder area. Under the right conditions, strong west flow perpendicular to the ridge west of Boulder can get squeezed through a horizontal channel created by the terrain and a strong temperature inversion 1000s of feet above the top of the ridge. A temperature inversion is a layer of much warmer air aloft, creating an invisible but just as effective barrier or cap in the atmosphere that forces air through the narrow zone at ridgetop level. As the air emerges downwind of the ridge, i.e. in the foothills and adjacent plains in and around Boulder, it greatly accelerates the same way water crashes on the downstream side of a boulder in a stream.

The strongest winds occur at the base of the foothills and along the CO-93 region from Lyons to Golden, though high winds can also occur further east. A "mountain wave" sets up that can last for hours (sometimes 6 or more hours), with continuous high winds occurring at the base of the foothills associated with the constant donwslope acceleration of the winds flowing over the ridge west of Boulder. Figure one shows the important features that cause a mountain wave to develop, the general location of the strongest winds, and other features associated with the mountain wave. Note that in this graphic, the strongest winds typically occur in the Boulder to Louisville area just west of the "jump region", which is referring to a hydraulic jump, with weaker winds further east towards Lafayette and Broomfield. This is because a standing wave occurs in these specific meteorological conditions, and there comes a point downwind where a rotor forms.

The rotor is a horizontal roll of wind, oriented parallel to the foothills, where wind flow reverses in response to the mountain wave. It is important to note that not all mountain wave events result in the development of rotors. In this idealized graphic, the rotor is over Lafayette and is located just downwind (east) of the strongest winds at the surface. Air rises rapidly on the upwind (west) side of the rotor in the jump region, while winds under the rising branch of the rotor and just east of the rotor are much weaker, or even reverse flow from an easterly direction. This idealized situation is essentially what happened on 12/30/2021, when wind speeds in Louisville were 30 mph gusting to 40 mph, even as stronger winds continued in Marshall and Superior.

Plenty of video evidence shows the fire and smoke racing off the east, and at some point lifting upward. The rapid rise of the smoke plume is within the jump region, and clouds form on the eastern fringe of this, or on the rising portion of the rotor, shown in Fig. 1 and also in the videos linked below the graphic. As the strong winds continue east, additional waves form further downstream, just as additional ripples form in a stream below a boulder. These appear as alternating areas of clouds in the upward motion areas, and clear skies where the air is sinking.



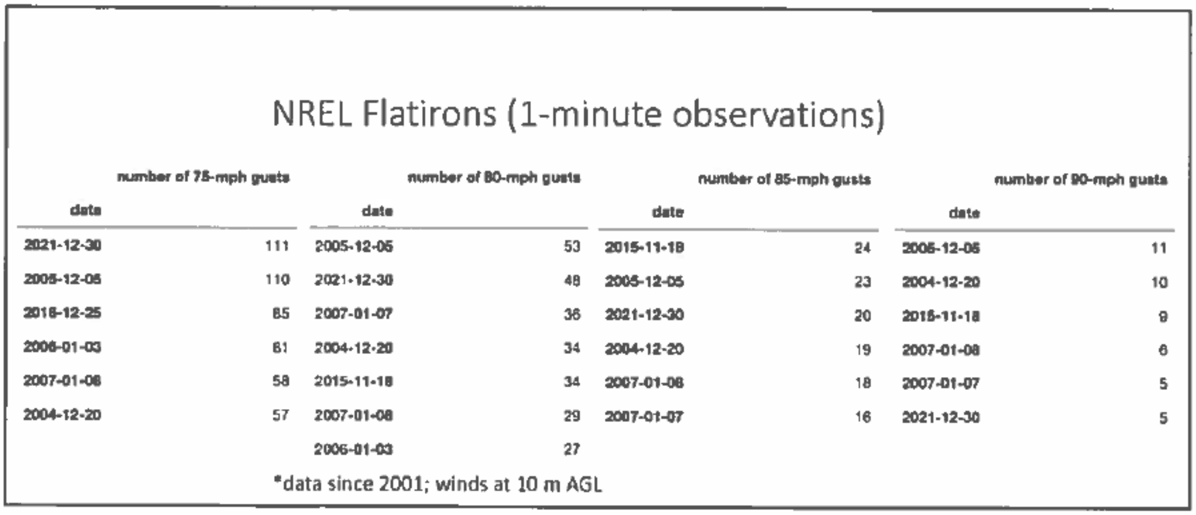
Durran and Klemp 1983 / The COMET Program

Figure 1: An idealized schematic of how downslope wind storms occur in the lee of the Rocky Mountains. The typical set up is shown, and the strongest winds occur along and west of the "Jump Region with locations shown in yellow. A rotor is shown over Lafayette, along with a rotor cloud.

- [redacted] This time lapse video is taken from the south of the fire, and shows the standing waves/rotors in the smoke plumes
- https://twitter.com/weatherdak/status/1476682724148539409 This is a satellite image showing the waves/rotors downstream of the fire. The red glow is the infrared retrieval from the fire as detected from 22,236 miles away in space.
- [redacted] This is a time lapse of the fire and smoke plume taken from quite a distance north of the fire, shows the wave/rotor downwind of the fire with rotor clouds and the upward vertical motion associated with the rotor downwind of the fire.
- https://rammb.cira.colostate.edu/templates/loop_directory.asp?data_folder=dev/lindsey/loops/dec2021_fires&loop_speed_ms=100 Satellite image from GOES-W of the smoke and fire

Climatology of Wind in the CO-93 Corridor:

Extreme winds are common along the CO-93 corridor. A thorough but not exhaustive summary of the high winds experienced in the Boulder area over the last 50+ years is available at this link: https://psl.noaa.gov/boulder/wind.html . A cursory look at the record of winds in the Boulder area shows that winds exceeding 80 mph occur nearly every year, with wind gusts exceeding 100 mph every couple of years. The maximum wind gust in the last 50 years has been an incredible 147 mph at the NCAR Mesa Laboratory, 3 miles northwest and over 500 feet higher from the Marshall fire ignition point. Needless to say, the winds on 12/30/2021 where the Marshall fire started and spread were extreme, but certainly not unusual. The National Wind Technology Center has a high quality surface observation, located about 2 miles south of the ignition area, and it is one of the best observations in the country for wind. Wind gusts for various thresholds were tabulated over the last 20 years in Figure 2, and it shows that for 75 mph gusts and stronger, the event on 12/30/2021 had the most. Examining Fig. 2, one can see that for higher magnitude gusts, there have been several events with more extreme gusts in the last 20 years.



NREL Flatirons (1-minute observations)

date	number of 75-mph gusts	date	number of 80-mph gusts	date	number of 85-mph gusts	date	number of 90-mph gusts
2021-12-30	111	2005-12-05	53	2015-11-18	24	2005-12-05	11
2005-12-05	110	2021-12-30	48	2005-12-05	23	2004-12-20	10
2016-12-25	85	2007-01-07	36	2021-12-30	20	2015-11-18	9
2006-01-03	61	2004-12-20	34	2004-12-20	19	2007-01-08	6
2007-01-08	58	2015-11-18	34	2007-01-08	18	2007-01-07	5
2004-12-20	57	2007-01-08	29	2007-01-07	16	2021-12-30	5
		2006-01-03	27				

*data since 2001; winds at 10 m AGL

Figure 2: National Wind Technology Center wind observations since 2001. Each occurrence of 1-min wind gusts exceeding the listed thresholds were counted by calendar day.

The wind event on 12/30/2021 occurred in the time of year that is normal for extreme wind events. December and January normally see the most extreme downslope windstorms along the CO-93 corridor.

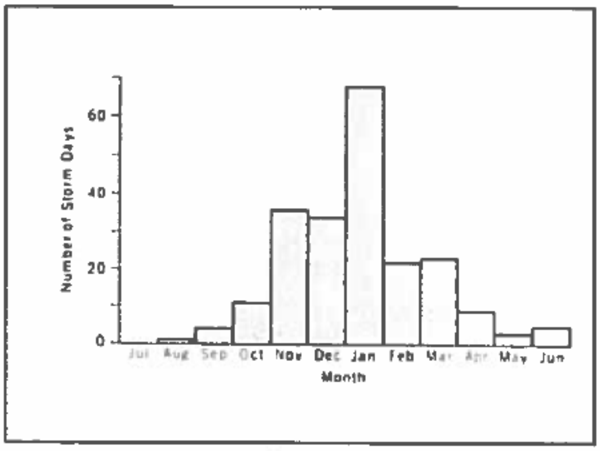


Figure 3: Taken from NOAA technical report Whiteman and Whiteman (1974). These are 151 identified wind storms in Boulder, defined as having at least one gust > 58 mph in the Boulder area during the period of study ending in 1974.

Figure 3 shows the peak occurring in the cold season and in particular in January. This graphic is from the 1970s but the trends are the same as today. An updated study looking at months with gusts greater than or equal to 70 mph from 1969-2021 in the Boulder area shows a similar trend to the dataset that ended in 1974. There is a distinct peak in the occurrence of extreme downslope wind in December and January. Here is the table of days by month with at least one wind gust > 70 mph across the CO-93 corridor from 1969-2021:

Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
2	1	2	2	11	19	49	57	21	19	13	4

Days with a Gust >70mph in the CO-93 Corridor, by month 1969-2021
Note that in the warm season (Apr-Sep) many/most of those events occurred with severe convective storms, rather than downslope winds.

Fuel Status on 12/30/2021: Another factor that contributed to the rapid fire spread were the fuels in the area. First, Boulder was unusually wet from spring into mid-summer 2021. Grasses grew tall and thick. Then, the precipitation abruptly shut off, leading to the driest period on record along the Front Range from June through December. Though Figure 4 only shows the Denver data, Boulder was close to the same situation. It was also the warmest such period on record, drying out the fuels significantly by December. The Boulder area went from no drought to level 3 (extreme, on a scale of 0-4) drought by December 2021.

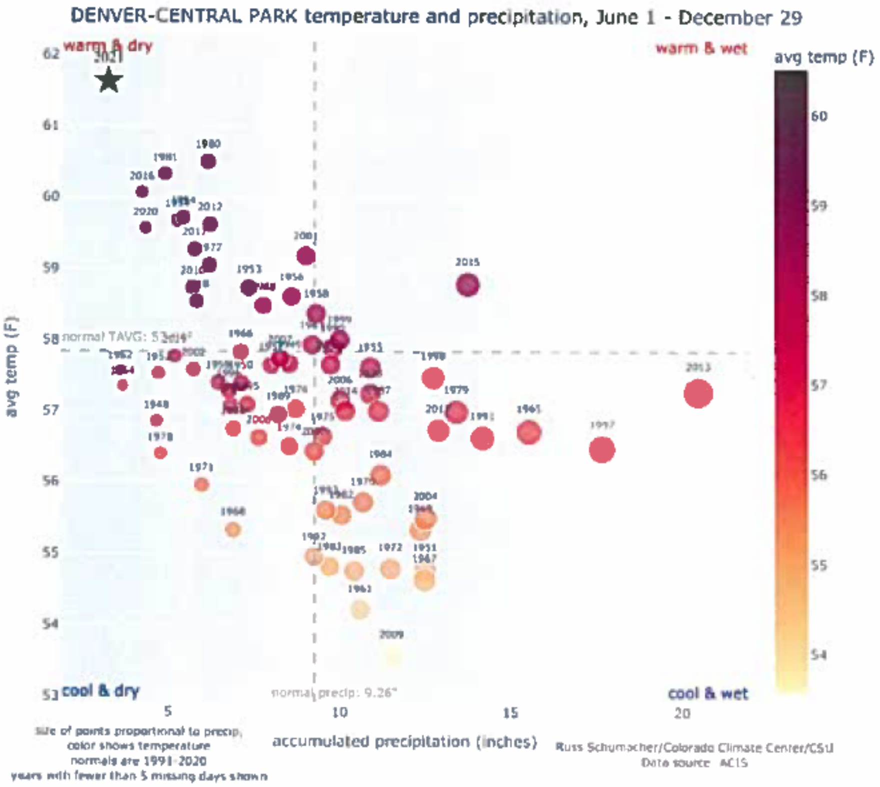


Figure 4: Climate data from Denver-Central Park that combines the effects of temperature and precipitation. Warmest/driest years on record appear in the top left, while cool and wet in the bottom right. 2021 was far and away the warmest and driest on record over the last ~75 years.

There had only been 2 light snows the entire season through December 30th. Normally snow does not remain on the ground along the CO-93 corridor for long even in December, but any amount of snow on the ground would have slowed or prevented the fire from spreading. Given record dryness and no snow on the ground for weeks prior to December 30th, the fuels were prone to rapid fire spread. A final graphic showing how dry the fuels were is included in Figure 5. Overall, the drought, extremely dry fuels that were thicker/taller than normal, and record warmth and dryness in the months leading up to December 30, combined to make a worst case scenario for any fire that started along CO-93 in late December.

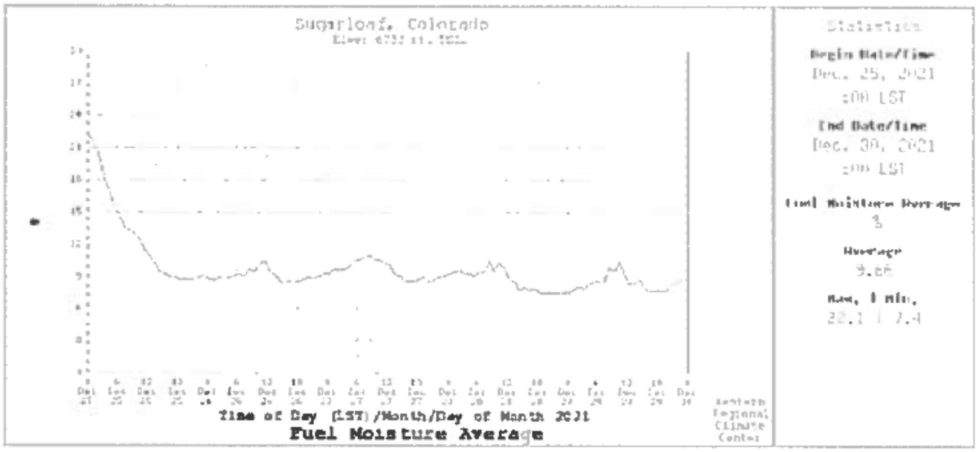
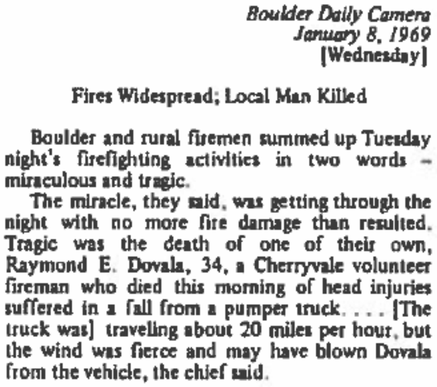


Figure 5: This is the fuel moisture trace for December, 2021 from Sugarloaf, Colorado, which is approximately 10 miles northwest of the Marshall fire ignition area. Fuels were near record dry at the end of December.

Fires Associated with Downslope Winds in Boulder's History: Fires associated with extreme downslope winds in the Boulder area are rare, but have occurred several times in the record. A significant fire occurred with an extreme mountain wave-induced downslope windstorm on January 11, 1972, when a trailer park in north Boulder caught fire and damaged/destroyed many of those homes. Another extreme event in January 1969 resulted in the death of a firefighter. Here's the excerpt from the Daily Camera, Boulder's local newspaper:



Boulder Daily Camera
January 8, 1969
[Wednesday]

Fires Widespread; Local Man Killed

Boulder and rural firemen summed up Tuesday night's firefighting activities in two words – miraculous and tragic.

The miracle, they said, was getting through the night with no more fire damage than resulted. Tragic was the death of one of their own, Raymond E. Dovala, 34, a Cherryvale volunteer fireman who died this morning of head injuries suffered in a fall from a pumper truck. . . . [The truck was] traveling about 20 miles per hour, but the wind was fierce and may have blown Dovala from the vehicle, the chief said.

A significant difference between the fire that occurred on 12/30/2021 and other fires in the Boulder area associated with downslope windstorms is the population increase, especially in the areas adjacent to grasslands. Another major difference that seems apparent on 12/30/2021 compared to other storms in the historical record is the sheer duration of the extreme west winds on 12/30, which were persistently gusting over 70 mph for over 5 hours. In most other downslope wind events in winter associated with mountain waves, the winds often weaken for brief periods, which could allow firefighting efforts to gain control of the fire before it spreads into a firestorm. The intensity and persistence of the extreme winds on 12/30/2021 did not allow firefighters to get control of the fire until winds weakened significantly in the early evening hours.

Meteorological Conditions Near the Marshall Fire Ignition Area: There are several high quality wind observations within a few miles of the ignition area. There are also several sites that shouldn't be used for analysis because they are sited improperly. Improper siting occurs if the observation is too sheltered to the wind, because the sensor is too low to the ground or placed in between trees or structures, or both. A properly sited anemometer should be at least 10 m off the ground, and this corresponds to the NWS definition for taking official wind measurements. The best observations to use near the ignition site are BLD01, which is next to Fairview High School in south Boulder, and the National Wind Technology Center (NWTC) observation which is in the northeast corner of Rocky Flats, just up the hill from the ignition site (same as Fig. 2). All other observations within 3-5 miles of the ignition point are not sited well enough to use for analysis.

The NWTC observation provides wind information at various heights (including 10 m) every minute. On 12/30/21, the winds increased significantly at the NWTC starting around 8 AM, in response to the mountain wave setting up with the strongest winds along the CO-93 corridor but not extending too far east yet. Gusts in the 8 AM hour were generally in the 40-65 mph range. By 10 AM, wind increased at NWTC with most gusts exceeding 70 mph. In general, wind gusts did not drop below 70 mph at NWTC until 4 PM. That's not to say high winds didn't continue, because they certainly did. Wind gusts exceeding 40-60 mph occurred until 7 PM, and gradually they weakened to less than 40 mph after 11 PM. The winds at the NWTC were likely a little stronger and lasted longer than what the wind conditions were at the ignition site, given local terrain differences.

Taking a look at the BLD01 observation, which is about 100 feet higher in elevation than near the ignition site and 1.5 miles to the northwest, winds also picked up after 8 AM, gusting to 60 mph. One thing to note is that BLD01 is sited at just over 6 m off the ground, so actual wind speeds at the preferred measurement height of 10 m may have been 10-20% higher than reported. A gust to 80 mph occurred at BLD01 just before 11 AM, and through 6 PM wind gusts generally remained above 60 mph. The strongest wind gusts in the ignition area occurred from 11 AM to 2 PM, with 80-100 mph gusts during this three hour window.

In terms of direction, NWTC is on top of a ridge without any terrain higher than it other than the Front Range Mountains to the west. Thus, wind direction at NWTC is not influenced by local terrain (other than the mountains to the west of course). The strongest winds from 10 AM - 2 PM, when gusts frequently exceeded 80 mph, had a wind direction of due west (270 degrees on a wind compass) or WNW (280 degrees on a wind compass). There were no significant fluctuations in wind speed or direction during the 10 AM to 2 PM window at NWTC. This implies that a standing mountain wave and rotor was always to the east of CO-93, and that the strongest winds associated with the mountain wave were focused right along CO-93. The BLD01 wind observation direction is influenced by local geography. The South Boulder Creek valley is just south of the observation, which runs from the southwest out of Eldorado Canyon, towards the northeast along the Davidson Mesa. Here, winds in a mountain wave are forced downward, as occurred on 12/30/21, and would tend to be more out of the west-southwest in the South Boulder Creek valley. BLDR01 winds from 10 AM - 2 PM, when they were strongest, indeed tended to be out of the west-southwest (250 degrees on a wind compass). A well-known meteorologist, Dr. Howie Bluestein, with expertise in downslope wind storms in the Boulder area, lives near Fairview High School. He took photos of the start of the fire from his vantage point on Shanahan Ridge around noon MST. He also noted the winds in his area. For the most part the strongest winds were out of the WSW and gusting 80-90 mph (his estimation), but occasionally he noted an abrupt shift to the N or NE, lasting several minutes, with weaker gusts. Then just as quickly, winds would shift back to the WSW and gust around 80-90 mph again. What explains what Dr. Bluestein experienced is the phenomena of rotors (refer back to Figure 1). If a rotor moves or oscillates a little west from it's position, in that area winds will shift quickly and reduce in magnitude, only to switch back if/when the rotor moves back, or when the mountain wave "reloads", meaning it reforms the standing wave once again after a brief, chaotic break in the flow over the mountains. Other wind observations from north and east of the ignition area support the presence of several rotors east of the Front Range, including weaker winds out of the east and northeast just downstream of them.

The strongest wind gust anywhere on 12/30/21 occurred just south of the NWTC, at the intersection of CO-93 and CO-72, where a gust of 110 mph was recorded at 11:12 AM MST. Note that a home weather station just east of CO-93/72 measured a gust to 115 mph around noon, but because the wind direction was listed as east-southeast, that gust measurement is suspect, and that particular observation is known to have potential issues with wind speed and direction. Wind gusts along the CO-93 corridor were strongest in the 11 AM to 1 PM range, with frequent gusts exceeding 90 and 100 mph.

Based on the evidence in the surface observational data, the eyewitness account of the wind in the area of the Marshall fire start, and incorporating my expert opinion of how extreme winds behave in mountain waves along the CO-93 corridor, here is what I believe the winds were doing near the ignition area along CO-93 near Marshall Road from 10 AM - 2 PM:

- West to west southwest winds (from 270-250 degrees on a wind compass) sustained at 50 mph with gusts reaching 90-100 mph at the 10 m height. The strongest winds were around between 11 AM and 1 PM MST, but gusts exceeding 80 mph were occurring from 10 - 2 PM.
- Occasionally an abrupt wind shift occurred, with winds shifting to the north or northeast for a few minutes (maybe as long as 10 minutes), associated with the mountain wave briefly "reloading" or the rotor moving slightly westward over the area.
- The NWTC winds did not capture any abrupt changes in wind direction in the high quality 1-minute data because the location of the rotor and mountain wave never shifted far enough west along that part of CO-93, probably due to an absence of local terrain effects.
- BLD01 also did not capture those brief and significant shifts in the wind because the data are only available every 15 minutes. Eyewitness accounts confirm these brief winds shifts occurred in the area. These abrupt changes in wind direction to north or northeast with speeds 30-50 mph occur near rotors (see Figure 1), and fit the eyewitness description from the area.
- Once the fire became very hot, it was able to locally modify the atmosphere around the fire, resulting in vortices and locally enhanced wind speeds, as well as rapidly shifting winds in and around the fire. These locally enhanced winds because of the heat of the fire occur on the order of 100s of m in space, and were not captured by any available

surface observing equipment. They were however captured by local Doppler radar, and they no doubt led to the erratic and extreme behavior of the fire as it raced to the east.

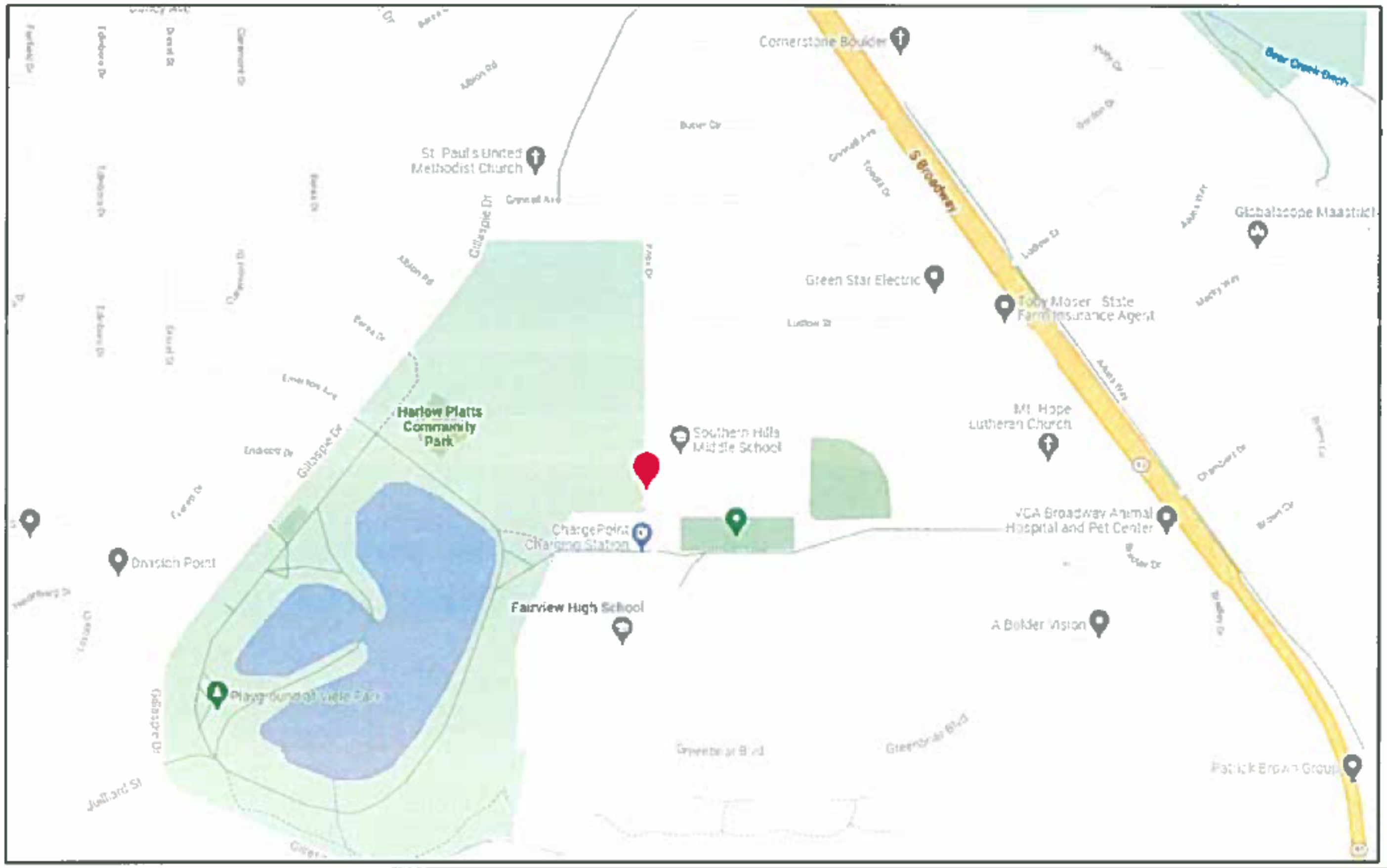
Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 2

Weather Details Compiled

Boulder South West

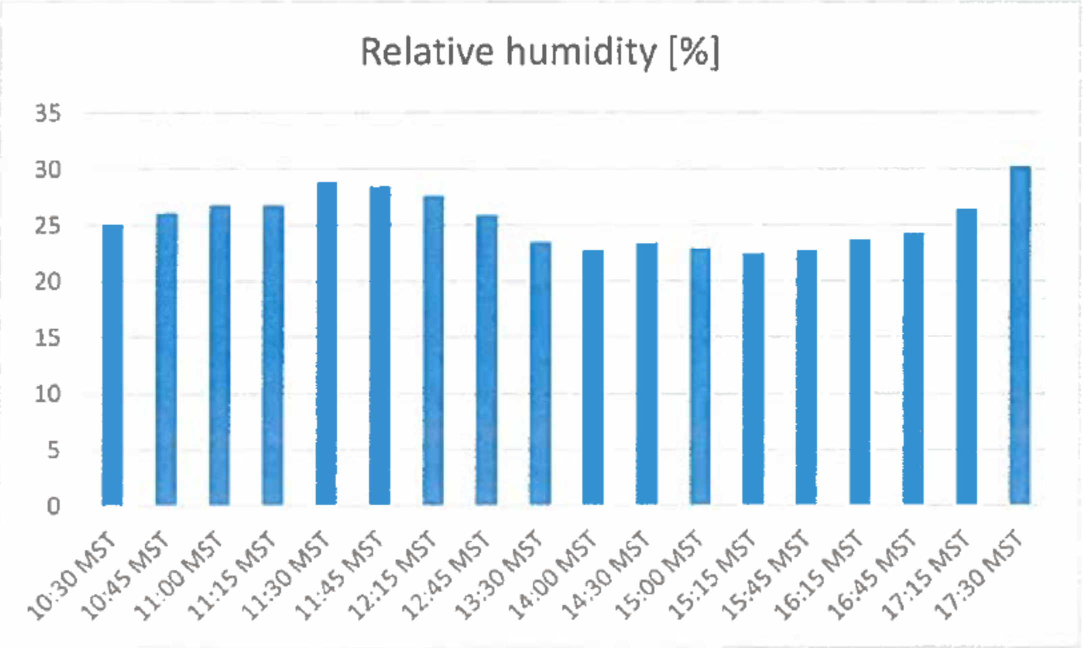


Station ID: BLD01
Station Name: Boulder South West
Mesonet ID: NORTHERN-WATER
Latitude: 39.97400
Longitude: -105.24600
Elevation (feet): 5515

County: Boulder
State: CO
Country: US
Timezone: Mountain
Local Region Category:
NWS Region: Central
NWS CWA: BOU - Denver/Boulder
NWS Zone: CO039 - Boulder And Jefferson Counties Below 6000 Feet/West Broomfield County

Boulder South West Weather Summary

Date and Time	Air Temperature	Relative Humidity [%]	Wind Speed [MPH]	Wind Direction	Wind gust [MPH]
12/30/2021 10:30 MST	41.43	25.1	40.35	249.6	66.49
12/30/2021 10:45 MST	41.4	26.1	46.45	247.8	79.28
12/30/2021 11:00 MST	41.22	26.8	49.7	250.9	81.4
12/30/2021 11:15 MST	41.36	26.8	46.63	248.8	83.99
12/30/2021 11:30 MST	41.02	28.8	47.76	249.4	79.86
12/30/2021 11:45 MST	41.18	28.5	48.7	250.8	84.7
12/30/2021 12:15 MST	41.61	27.6	50.96	247.9	89.4
12/30/2021 12:45 MST	41.86	25.9	44.44	250.6	67.08
12/30/2021 13:30 MST	42.6	23.5	44.3	244.9	75.7
12/30/2021 14:00 MST	43.02	22.8	47.15	249.6	91.39
12/30/2021 14:30 MST	42.93	23.4	46.03	247.3	82.3
12/30/2021 15:00 MST	43.2	22.9	44.6	249.4	86.4
12/30/2021 15:15 MST	43.38	22.5	46.94	245.6	78.99
12/30/2021 15:45 MST	43.48	22.8	40.2	246.1	70.94
12/30/2021 16:15 MST	43.11	23.8	41.36	245	81.9
12/30/2021 16:45 MST	42.78	24.3	39.37	245.4	64.96
12/30/2021 17:15 MST	42.37	26.5	37.32	241.5	66.34
12/30/2021 17:30 MST	41.49	30.2	36.92	246.3	61.16


Relative humidity [%]
35
30
25
20
15
10
5
0
10:30 MST
10:45 MST
11:00 MST
11:15 MST
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11:45 MST
12:15 MST
12:45 MST
13:30 MST
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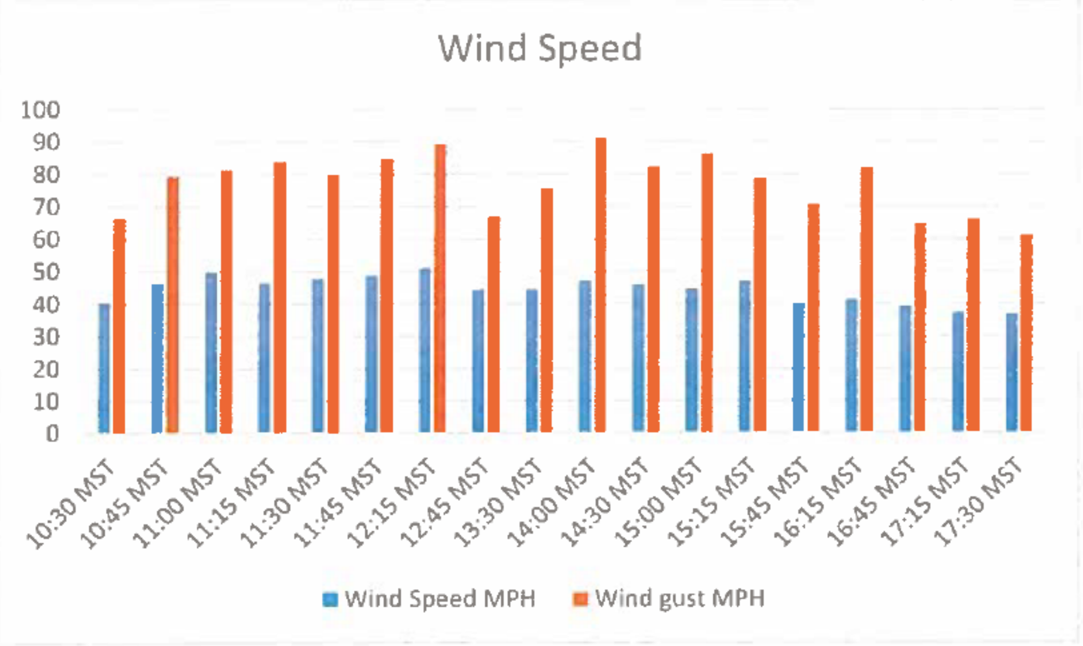
17:15 MST
17:30 MST


Wind Speed
100
90
80
70
60
50
40
30
20
10
0
10:30 MST
10:45 MST
11:00 MST
11:15 MST
11:30 MST
11:45 MST
12:15 MST
12:45 MST
13:30 MST
14:00 MST
14:30 MST
15:00 MST
15:15 MST
15:45 MST
16:15 MST
16:45 MST
17:15 MST
17:30 MST
Wind Speed MPH
Wind gust MPH

CO93-72

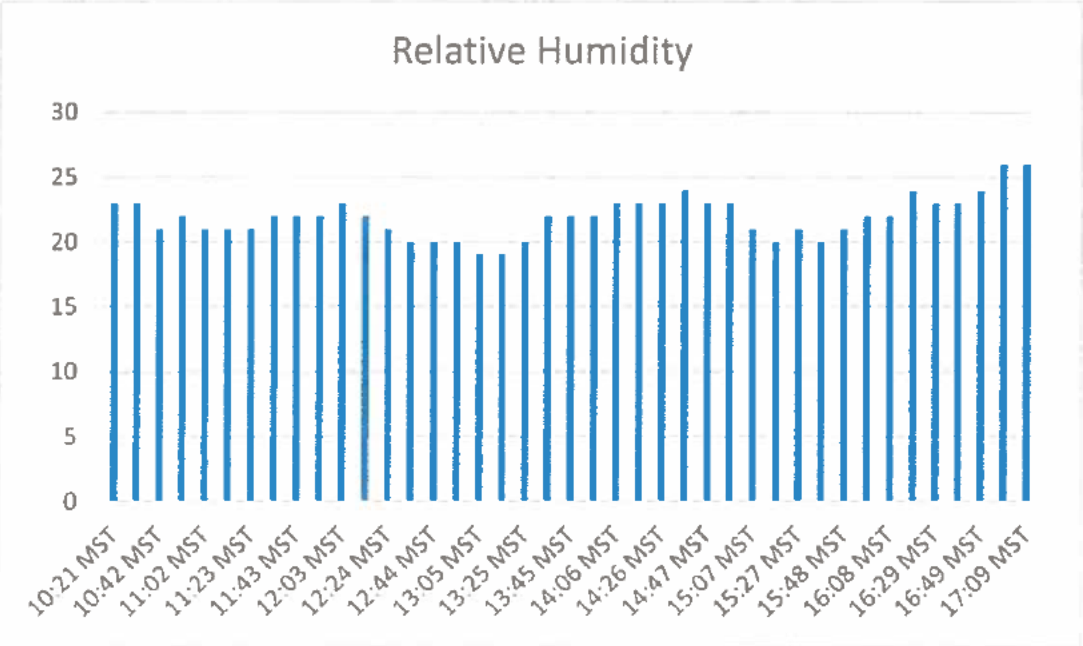
Station ID: CO109
Station Name: 093S00755RWS1SEC at Coal Creek Canyon Rd/CO-72
Mesonet ID: CDOT
Latitude: 39.86567
Longitude: -105.24060
Elevation (feet): 6250

County: Jefferson
State: CO
Country: US
Timezone: Mountain
Local Region Category: Metropolitan
NWS Region: Central
NWS CWA: BOU - Denver/Boulder
NWS Zone: CO036 - Jefferson and West Douglas Counties Above 6000 Feet/Gilpin/Clear Creek/Northeast

CO93-72 Weather summary

Date and Time	Air Temperature	Relative Humidity	Wind Speed MPH	Wind Direction Degrees	Wind Gust Speed
12/30/2021 10:21 MST	38.48	23	69.12	270	99.99
12/30/2021 10:32 MST	38.84	23	68.9	270	100.44
12/30/2021 10:42 MST	39.2	21	72.69	270	97.08
12/30/2021 10:52 MST	39.02	22	68.23	225	98.87
12/30/2021 11:02 MST	39.2	21	74.94	270	104.47
12/30/2021 11:12 MST	39.2	21	73.14	270	102.22
12/30/2021 11:23 MST	39.56	21	76.06	270	109.61
12/30/2021 11:33 MST	39.38	22	69.79	270	106.7
12/30/2021 11:43 MST	39.38	22	76.5	270	100.89
12/30/2021 11:53 MST	39.74	22	68.23	270	100.21
12/30/2021 12:03 MST	39.74	23	67.11	270	106.93
12/30/2021 12:14 MST	39.92	22	67.55	270	95.51
12/30/2021 12:24 MST	39.92	21	71.81	270	97.53
12/30/2021 12:34 MST	40.28	20	70.69	270	98.2
12/30/2021 12:44 MST	40.46	20	65.1	270	95.3
12/30/2021 12:54 MST	40.46	20	67.33	270	96.41
12/30/2021 13:05 MST	40.46	19	68.68	270	95.75
12/30/2021 13:15 MST	40.46	19	62.41	270	94.85
12/30/2021 13:25 MST	40.46	20	61.74	270	95.51
12/30/2021 13:35 MST	40.28	22	63.31	270	92.17
12/30/2021 13:45 MST	40.28	22	63.75	270	91.27
12/30/2021 13:56 MST	40.28	22	67.78	270	84.11
12/30/2021 14:06 MST	40.28	23	63.09	270	85.67
12/30/2021 14:16 MST	40.28	23	65.99	270	89.7
12/30/2021 14:26 MST	40.1	23	61.52	270	84.78
12/30/2021 14:36 MST	40.1	24	63.53	270	81.87
12/30/2021 14:47 MST	40.28	23	53.47	270	78.07
12/30/2021 14:57 MST	40.28	23	60.17	270	82.55
12/30/2021 15:07 MST	40.64	21	58.83	225	82.76
12/30/2021 15:17 MST	40.82	20	62.64	270	91.49
12/30/2021 15:27 MST	40.82	21	60.17	270	91.72
12/30/2021 15:38 MST	40.82	20	53.02	225	92.6
12/30/2021 15:48 MST	40.64	21	55.7	270	86.34
12/30/2021 15:58 MST	40.1	22	46.53	270	76.72
12/30/2021 16:08 MST	40.1	22	50.11	270	83.66

12/30/2021 16:18 MST	39.74	24	55.03	270	76.27
12/30/2021 16:29 MST	39.74	23	51.22	270	83.88
12/30/2021 16:39 MST	39.92	23	56.36	270	75.16
12/30/2021 16:49 MST	39.38	24	53.02	225	73.82
12/30/2021 16:59 MST	39.02	26	51	270	73.59
12/30/2021 17:09 MST	39.02	26	55.25	270	71.58


Relative Humidity
30
25
20
15
10
5
0
10:21 MST
10:42 MST
11:02 MST
11:23 MST
11:43 MST
12:03 MST
12:24 MST
12:44 MST
13:05 MST
13:25 MST
13:45 MST
14:06 MST
14:26 MST
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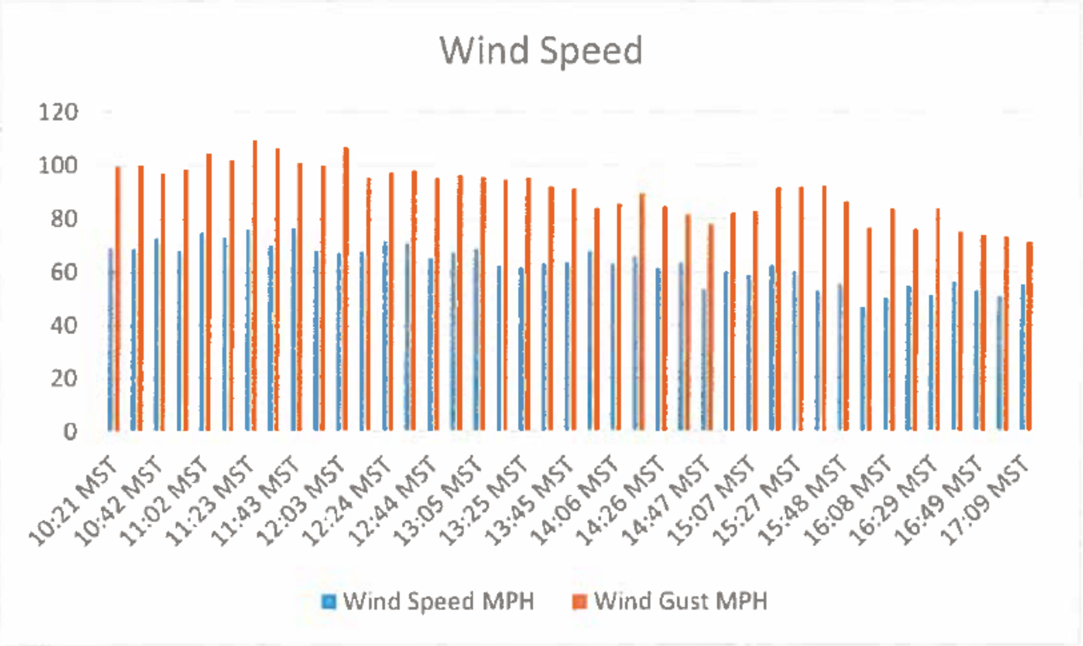
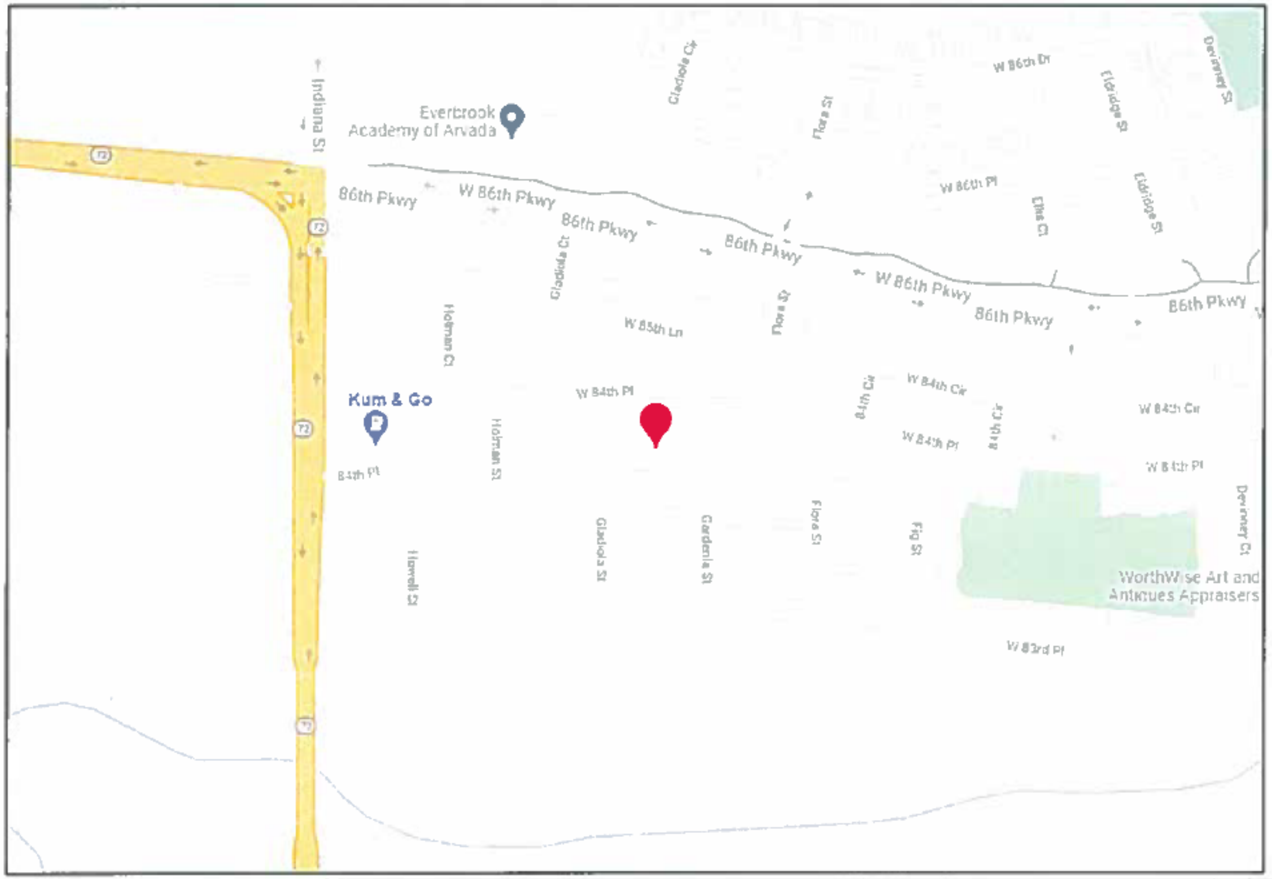
16:49 MST
17:09 MST


Wind Speed
120
100
80
60
40
20
0
10:21 MST
10:42 MST
11:02 MST
11:23 MST
11:43 MST
12:03 MST
12:24 MST
12:44 MST
13:05 MST
13:25 MST
13:45 MST
14:06 MST
14:26 MST
14:47 MST
15:07 MST
15:27 MST
15:48 MST
16:08 MST
16:29 MST
16:49 MST
17:09 MST
Wind Speed MPH
Wind Gust MPH

FW0869 Arvada

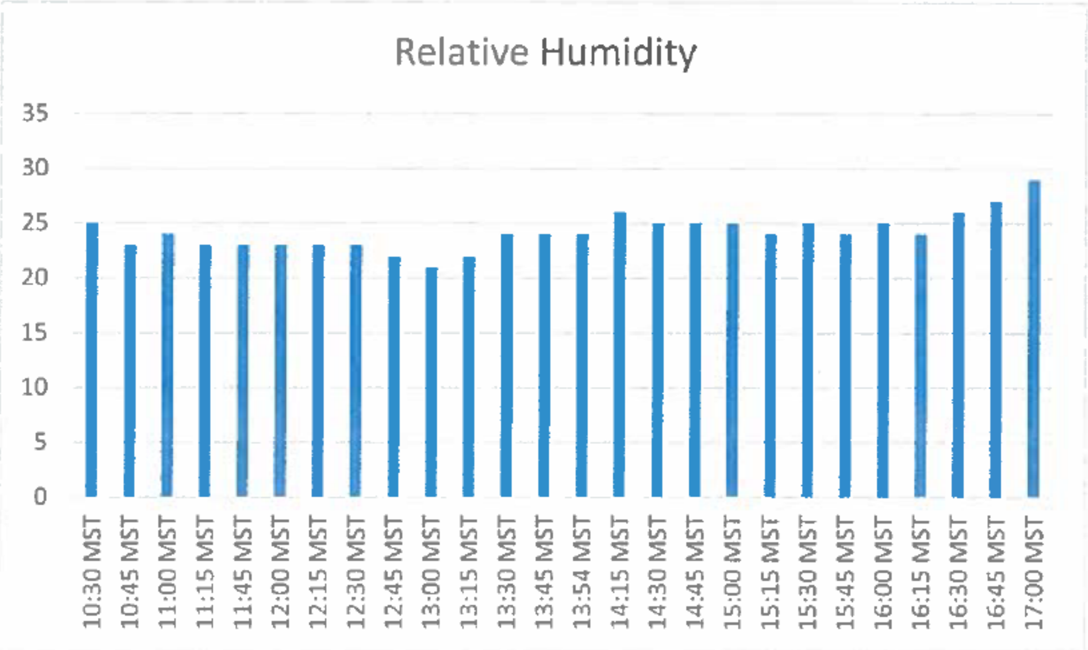


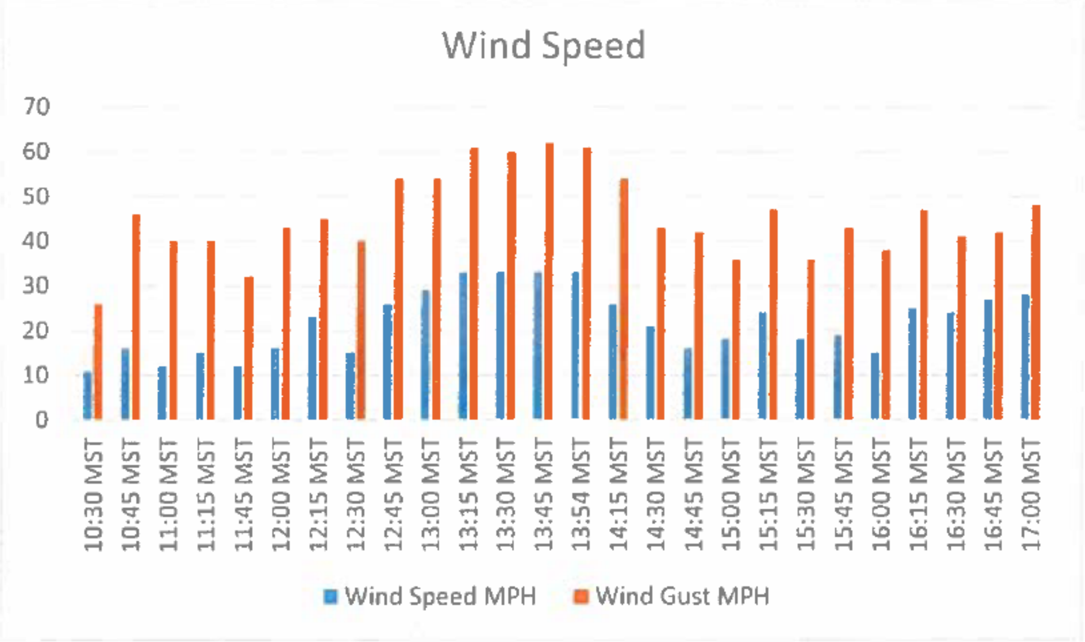
Station ID: F0869
Station Name: FW0869 Arvada
Mesonet ID: APRSWXNET/CWOP
Latitude: 39.84879
Longitude: -105.16221
Elevation (feet): 5708

County: Jefferson
State: CO
Country: US
Timezone: Mountain
Local Region Category:
NWS Region: Central
NWS CWA: BOU - Denver/Boulder
NWS Zone: CO039 - Boulder And Jefferson Counties Below 6000 Feet/West Broomfield County

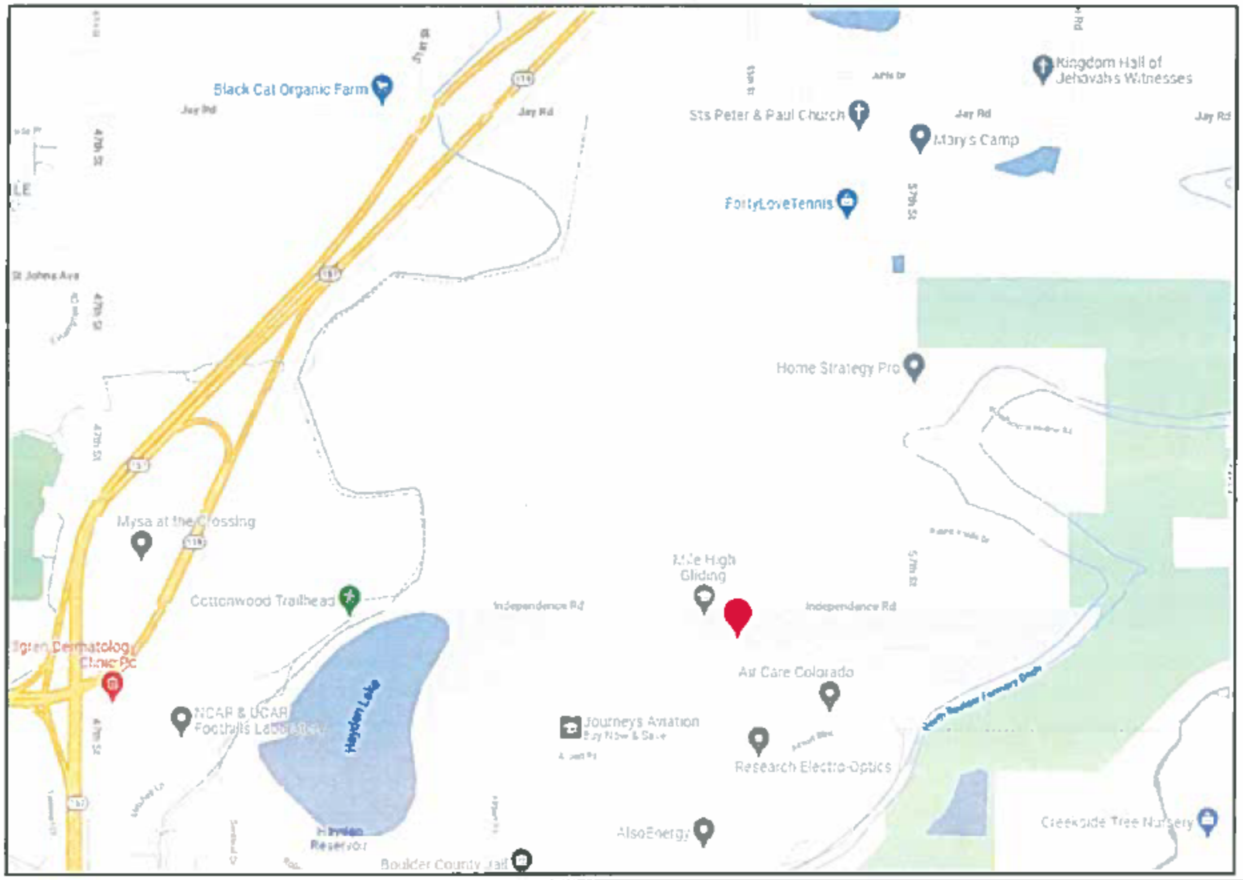
FW0869 Arvada Weather summary

Date and Time	Air Temperature	Relative Humidity [%]	Wind Speed MPH	Wind Direction Degrees	Wind Gust MPH
12/30/2021 10:30 MST	44	25	11	89	26
12/30/2021 10:45 MST	44	23	16	115	46
12/30/2021 11:00 MST	44	24	12	212	40
12/30/2021 11:15 MST	45	23	14.99	200	40
12/30/2021 11:45 MST	46	23	12	165	32
12/30/2021 12:00 MST	45	23	16	190	43.01
12/30/2021 12:15 MST	45	23	23	289	45
12/30/2021 12:30 MST	45	23	14.99	222	40
12/30/2021 12:45 MST	45	22	26	248	54
12/30/2021 13:00 MST	45	21	29	271	54
12/30/2021 13:15 MST	45	22	33	292	61
12/30/2021 13:30 MST	45	24	33	286	60
12/30/2021 13:45 MST	45	24	33	257	62
12/30/2021 13:54 MST	45	24	33	260	61
12/30/2021 14:15 MST	45	26	26	211	54
12/30/2021 14:30 MST	45	25	21	190	43.01
12/30/2021 14:45 MST	44	25	16	239	42
12/30/2021 15:00 MST	44	25	18	240	36
12/30/2021 15:15 MST	44	24	24	247	47
12/30/2021 15:30 MST	44	25	18	206	36
12/30/2021 15:45 MST	44	24	19	169	43.01
12/30/2021 16:00 MST	43	25	14.99	233	38
12/30/2021 16:15 MST	43	24	25	261	47
12/30/2021 16:30 MST	42	26	24	257	41
12/30/2021 16:45 MST	42	27	27	257	42
12/30/2021 17:00 MST	42	29	28	240	48


Relative Humidity


Wind Speed

Boulder Municipal Airport

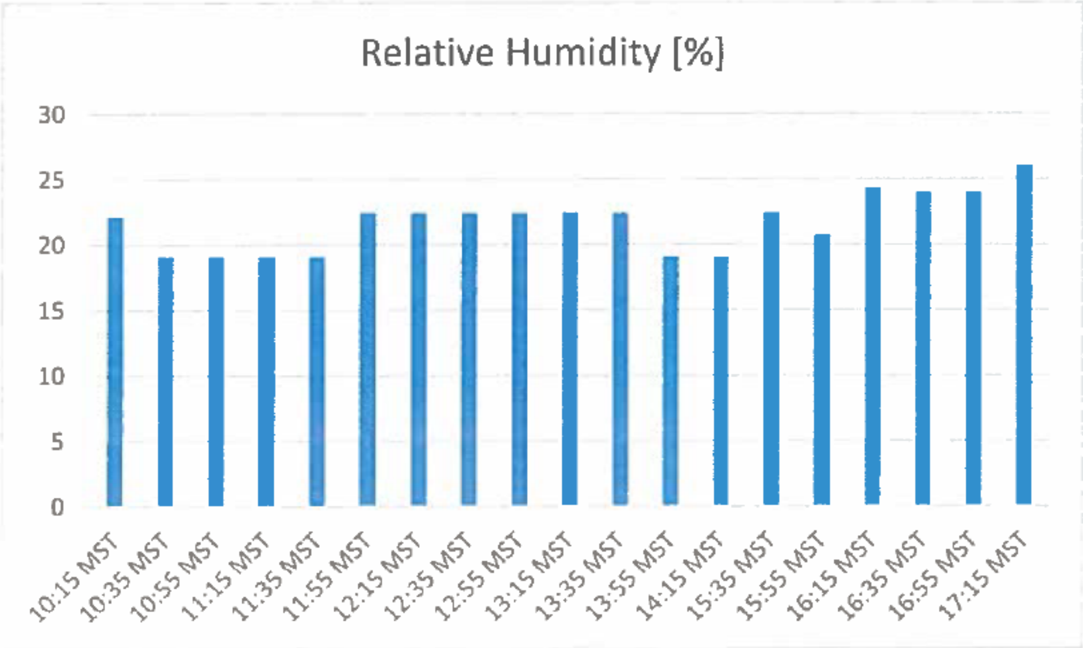


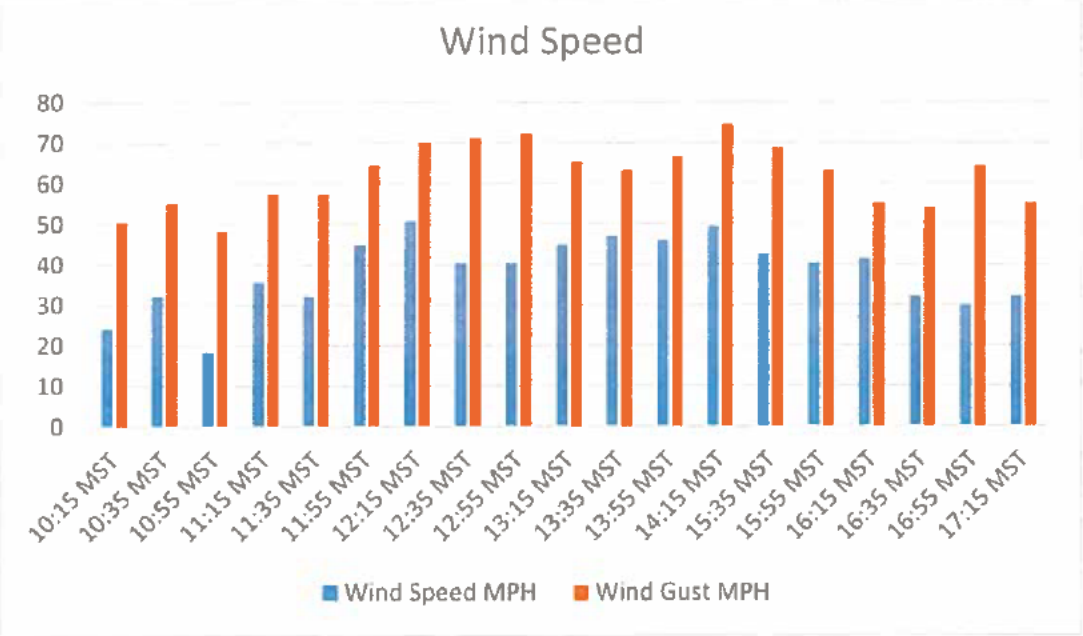
Station ID: KBDU
Station Name: Boulder Municipal Airport
Mesonet ID: NWS/FAA
Latitude: 40.0394297
Longitude: -105.2258217
Elevation (feet): 5288

County: Boulder
State: CO
Country: US
Timezone: Mountain
Local Region Category: Metropolitan
NWS Region: Central
NWS CWA: BOU - Denver/Boulder
NWS Zone: CO039 - Boulder And Jefferson Counties Below 6000 Feet/West Broomfield County

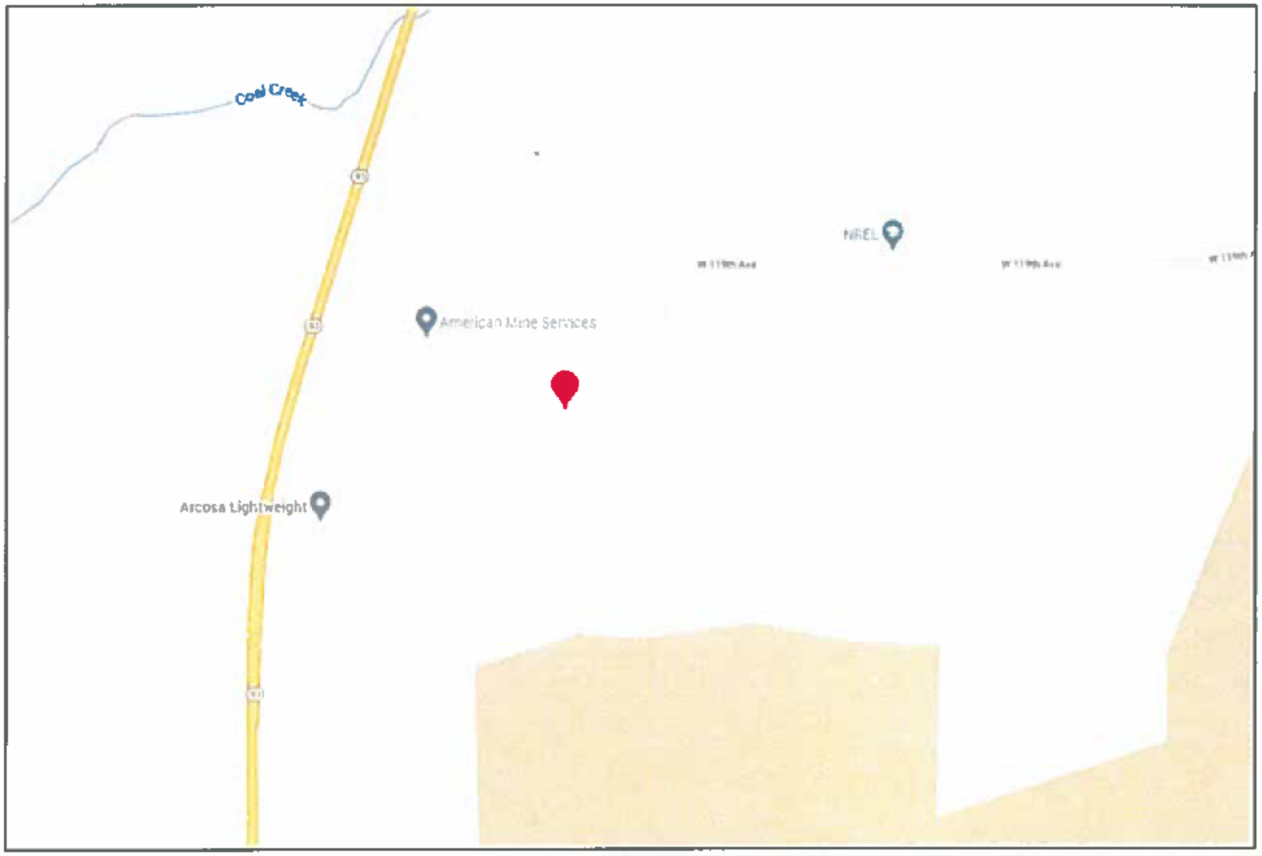
Boulder Municipal Airport
Weather summary

Date and Time	Air Temp	Relative Humidity	Wind Speed MPH	Wind Direction [Degrees]	Wind Gust MPH	Wind Direction [Cardinal]	Pressure	Sea Level Pressure
12/30/2021 10:15 MST	42.8	22.18	24.17	290	50.64	WNW	24.25	27.38
12/30/2021 10:35 MST	44.6	19.07	32.22	300	55.24	WNW	24.25	27.44
12/30/2021 10:55 MST	44.6	19.07	18.41	300	48.33	WNW	24.24	27.43
12/30/2021 11:15 MST	44.6	19.07	35.67	290	57.54	WNW	24.22	27.4
12/30/2021 11:35 MST	44.6	19.07	32.22	270	57.54	W	24.2	27.38
12/30/2021 11:55 MST	44.6	22.47	44.88	260	64.44	W	24.15	27.09
12/30/2021 12:15 MST	44.6	22.47	50.64	250	70.2	WSW	24.14	27.08
12/30/2021 12:35 MST	44.6	22.47	40.28	250	71.35	WSW	24.13	27.07
12/30/2021 12:55 MST	44.6	22.47	40.28	240	72.5	WSW	24.13	27.07
12/30/2021 13:15 MST	44.6	22.47	44.88	250	65.59	WSW	24.13	27.07
12/30/2021 13:35 MST	44.6	22.47	47.18	250	63.29	WSW	24.12	27.06
12/30/2021 13:55 MST	44.6	19.07	46.03	250	66.75	WSW	24.12	27.29
12/30/2021 14:15 MST	44.6	19.07	49.48	250	74.8	WSW	24.12	27.29
12/30/2021 15:35 MST	44.6	22.47	42.58	250	69.05	WSW	24.15	27.09
12/30/2021 15:55 MST	44.6	20.7	40.28	250	63.29	WSW	24.15	27.21
12/30/2021 16:15 MST	44.6	24.36	41.43	250	55.24	WSW	24.15	26.96
12/30/2021 16:35 MST	42.8	24.07	32.22	250	54.09	WSW	24.16	27.16
12/30/2021 16:55 MST	42.8	24.07	29.92	240	64.44	WSW	24.16	27.16
12/30/2021 17:15 MST	42.8	26.1	32.22	250	55.24	WSW	24.17	27.04


Relative Humidity [%]


Wind Speed

National Renewable Energy Laboratory (NREL)



NREL Flatirons Campus (M2)
Latitude: 39.9106o North
Longitude: 105.2347o West
Elevation: 1855 AMSL
Time Zone: MST
Elevation: 6085

The readings displayed are derived from instruments mounted on or near a 82 meter (270 foot) meteorological tower located at the western edge of the Flatirons Campus (formerly NWTC) and about 11 km (7 miles) west of Broomfield, and approximately 8 km (5 miles) south of Boulder, Colorado.

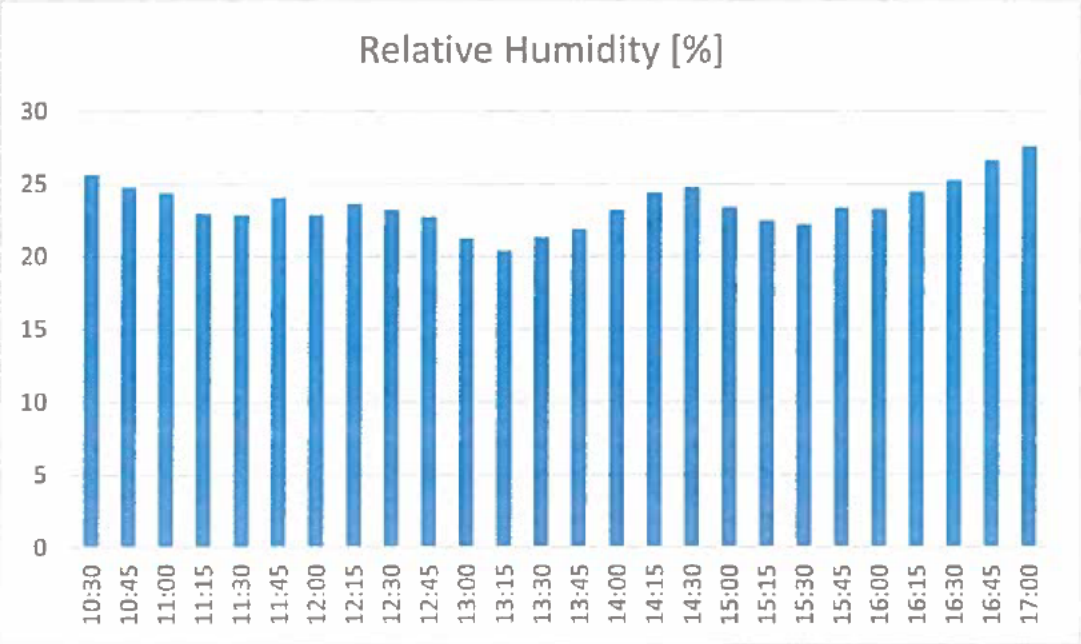
Jager, D.; Andreas, A.; (1996). NREL National Wind Technology Center (NWTC):

M2 Tower; Boulder, Colorado (Data); NREL Report No. DA-5500-56489.

https://midcdmz.nrel.gov/apps/sitehome.pl?site=NWTC

NREL Weather summary

DATE (MM/DD/YYYY)	Time (MST)	Relative Humidity [%]	10 m mph	10m Gust mph	Avg Wind Direction at 10m (degrees)	Wind Direction at peak wind speed (10m)
12/30/2021	10:30	25.63	54.4	72.2	266.7	264.1
12/30/2021	10:45	24.76	55.0	67.5	274.9	270.1
12/30/2021	11:00	24.36	64.7	85.2	272.4	259.9
12/30/2021	11:15	22.96	64.9	88.5	272.1	268.3
12/30/2021	11:30	22.85	65.8	84.6	275.3	279.6
12/30/2021	11:45	24.07	59.5	76.9	277.1	276.8
12/30/2021	12:00	22.83	59.4	80.3	280.5	284.5
12/30/2021	12:15	23.66	58.2	67.5	275.7	265.3
12/30/2021	12:30	23.22	49.7	69.6	269.3	263.9
12/30/2021	12:45	22.72	55.7	66.1	279.1	285.9
12/30/2021	13:00	21.23	66.9	84.7	273.8	263.8
12/30/2021	13:15	20.37	63.0	77.5	267.8	277.9
12/30/2021	13:30	21.33	58.2	67.9	272	285.6
12/30/2021	13:45	21.92	47.2	60.0	273.6	291.2
12/30/2021	14:00	23.19	58.5	70.9	271.4	275.4
12/30/2021	14:15	24.42	65.3	78.3	266	260.4
12/30/2021	14:30	24.78	46.2	58.0	262.5	268.7
12/30/2021	15:00	23.44	50.7	58.4	269.9	273.6
12/30/2021	15:15	22.48	52.4	66.7	262.1	257.8
12/30/2021	15:30	22.16	63.1	74.6	266.8	259.6
12/30/2021	15:45	23.4	51.7	67.9	273.1	277.8
12/30/2021	16:00	23.29	40.8	57.2	261.3	259.8
12/30/2021	16:15	24.52	45.3	60.6	254.9	253.7
12/30/2021	16:30	25.26	46.6	58.0	267.1	269.7
12/30/2021	16:45	26.62	43.7	56.3	263.2	264.8
12/30/2021	17:00	27.61	49.7	65.9	269.3	274.3


Relative Humidity [%]
30
25
20
15
10
5
0
10:30
10:45
11:00
11:15
11:30
11:45
12:00
12:15
12:30
12:45
13:00
13:15
13:30
13:45
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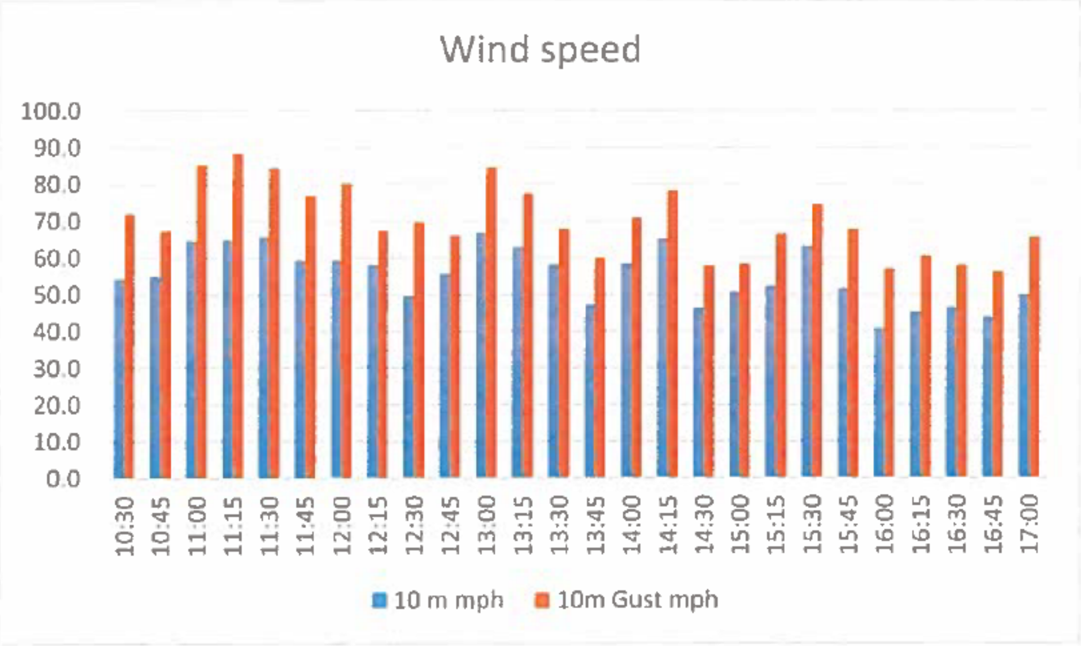
16:15
16:30
16:45
17:00


Wind speed
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
10:30
10:45
11:00
11:15
11:30
11:45
12:00
12:15
12:30
12:45
13:00
13:15
13:30
13:45
14:00
14:15
14:30
15:00
15:15
15:30
15:45
16:00
16:15
16:30
16:45
17:00
10 m mph
10m Gust mph

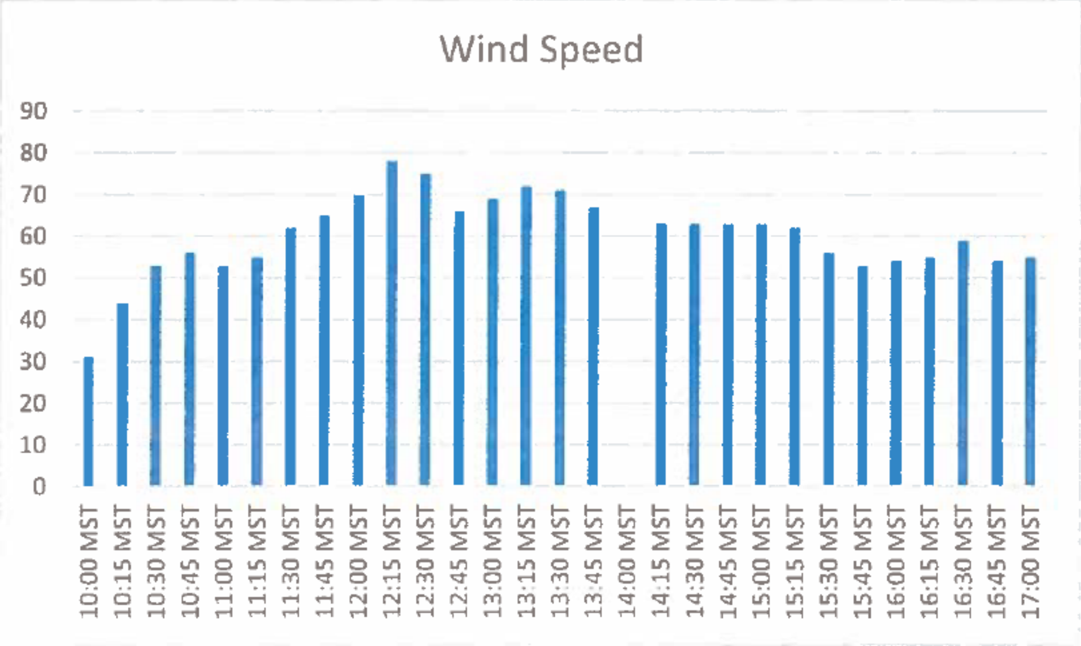
Rocky Flats - North

Station ID: RFN
Station Name: Rocky Flats - North
Mesonet ID: CDPHE
Latitude: 39.912799
Longitude: -105.188587
Elevation (feet): 5912

County: Jefferson
State: CO
Country: US
Timezone: Mountain
Local Region Category: Metropolitan
NWS Region: Central
NWS CWA: BOU - Denver/Boulder
NWS Zone: CO039 - Boulder And Jefferson Counties Below 6000 Feet/West Broomfield County

Rocky Flats- North Weather summary

Date and Time	Air Temperature	Wind Speed MPH	Wind Direction Degrees	Wind Direction (Cardinal)
12/30/2021 10:00 MST	39.3	31	292	WNW
12/30/2021 10:15 MST	39.6	43.99	283	WNW
12/30/2021 10:30 MST	39.9	52.99	278	W
12/30/2021 10:45 MST	40.4	56	278	W
12/30/2021 11:00 MST	40.9	52.99	280	W
12/30/2021 11:15 MST	41.4	55	281	W
12/30/2021 11:30 MST	41.5	61.99	281	W
12/30/2021 11:45 MST	41.6	65	279	W
12/30/2021 12:00 MST	41.6	69.99	279	W
12/30/2021 12:15 MST	41.7	77.99	282	WNW
12/30/2021 12:30 MST	41.6	75	282	WNW
12/30/2021 12:45 MST	42.3	66	279	W
12/30/2021 13:00 MST	42.5	68.99	274	W
12/30/2021 13:15 MST	42.7	71.99	273	W
12/30/2021 13:30 MST	42.7	70.99	271	W
12/30/2021 13:45 MST	42.8	67	271	W
12/30/2021 14:00 MST				
12/30/2021 14:15 MST	42.6	62.99	272	W
12/30/2021 14:30 MST	42.4	62.99	272	W
12/30/2021 14:45 MST	42.4	62.99	271	W
12/30/2021 15:00 MST	42.3	62.99	273	W
12/30/2021 15:15 MST	42.5	61.99	273	W
12/30/2021 15:30 MST	42.6	56	272	W
12/30/2021 15:45 MST	42.6	52.99	270	W
12/30/2021 16:00 MST	42.4	54	268	W
12/30/2021 16:15 MST	42	55	268	W
12/30/2021 16:30 MST	41.4	59	267	W
12/30/2021 16:45 MST	40.9	54	271	W
12/30/2021 17:00 MST	40.9	55	270	W


Wind Speed
90
80
70
60
50
40
30
20
10
0
10:00 MST
10:15 MST
10:30 MST
10:45 MST
11:00 MST
11:15 MST
11:30 MST
11:45 MST
12:00 MST
12:15 MST
12:30 MST
12:45 MST
13:00 MST
13:15 MST
13:30 MST
13:45 MST
14:00 MST
14:15 MST
14:30 MST
14:45 MST
15:00 MST
15:15 MST
15:30 MST
15:45 MST
16:00 MST
16:15 MST
16:30 MST
16:45 MST
17:00 MST

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 3

Boulder County Dispatch Log

12/30/2021 10:56:51 LPD	Longmont PD North	VICOGL-ViciousDog		544 Saint Andrews Dr	LONGMONT	303-772-9560	george lowenguth	537 st andrews
12/30/2021 10:57:12 BPD	BPD4	HAZARB-Hazard	jso	Meadowbrook Dr / Baseline Rd	BOULDER	720 378 5428	male passerby	
12/30/2021 10:57:41 BPD	BPD1	HAZARB-Hazard	Payback Collective	2775 Valmont Rd	BOULDER	256-313-4142	MELISSA	EMPLOYEE
12/30/2021 10:57:42 BCSO						(602) 410-9976		
12/30/2021 10:57:53 BCSO								
12/30/2021 10:57:59 BCSO								
12/30/2021 10:58:02 BPD								
12/30/2021 10:58:23 BPD						(303) 817-4087		
12/30/2021 10:58:12 BPD	BPD8	UNACCB-Unknown Injury Acc		Broadway / Baseline Rd	BOULDER	(303) 753-4985	T-MOBILE USA	
12/30/2021 10:58:11 BCSO								
12/30/2021 10:58:15 BPD	BPD	UNACCF-Unknown inj/unj acc		Broadway / Baseline Rd	BOULDER	(303) 753-4985	T-MOBILE USA	
12/30/2021 10:58:19 BPD								
12/30/2021 10:59:15 BCSO						(303) 776-1939		
12/30/2021 10:59:55 BCSO								
12/30/2021 10:59:49 BCSO								
12/30/2021 10:59:50 BPD	BPD4	FALAB-Fire Alarm	GOLD RUN CONDO BLD F 2850 (B1556)	2850 Sundown Ln	BOULDER	303 492 1429	alarm co	
12/30/2021 10:59:54 BCSO								
12/30/2021 10:59:55 BPD	BPD1	PWREQB-Public Works Request		1927 Pine St	BOULDER	303-875-7880	jennifer watson	
12/30/2021 11:00:28 BPD	BPD	FALAF-Fire Alarm	GOLD RUN CONDO BLD F 2850 (B1556)	2850 Sundown Ln	BOULDER		alarm co	
12/30/2021 11:00:14 BCSO								
12/30/2021 11:00:22 BCSO								
12/30/2021 11:00:38 BPD						(720) 352-5552		
12/30/2021 11:01:37 BPD	BPD1	ASSISB-Assist	jso	Broadway / Violet Ave	BOULDER	(303) 503-2264	female passerby	
12/30/2021 11:02:03 BPD								
12/30/2021 11:02:24 BCSO						(303) 919-5973		
12/30/2021 11:02:41 BPD	BPD1	AUNTB-Intrusion Alarm	boulder res ime interance	5545 N 51st St	BOULDER	303 444 2131	aa	
12/30/2021 11:02:59 BCSO								
12/30/2021 11:03:07 BPD	BPD1	PWREQB-Public Works Request	alley between 18th 19th	1832 18th St	BOULDER	303-652-7264	steven seder	aaa
12/30/2021 11:03:15 BPD						(316) 214-0918		
12/30/2021 11:03:31 BCSO	Erie PD District 2	ASSISS-Assist	Erie Police Department	1000 Telleen Ave	ERIE	970-443-7818	MARK, BCH	8AA
12/30/2021 11:03:31 BPD								
12/30/2021 11:03:45 BPD	BPD3	PWREQB-Public Works Request		19th St / Walnut St	BOULDER	303-482-7932	TA	VIA MOBILITY
12/30/2021 11:03:57 BCSO								
12/30/2021 11:04:19 LPD	Longmont PD South	FOLLOU-Follow-Up	c880	225 Kimbark St	LONGMONT		3106	
12/30/2021 11:04:22 BCSO						(720) 323-5605		
12/30/2021 11:04:49 BCSO								
12/30/2021 11:04:55 BCFD	**Rocky Mountain Fire**	**FWLR-Wildland/Grass Fire**	**LAW OPS COMMAND**	**S Foothills Hwy / Marshall Rd**	**BOULDER COUNTY**	**(720) 937-4172**	**JUDY**	**1562 MARSHALL RD**
12/30/2021 11:05:11 BPD								
12/30/2021 11:05:21 BPD	BPD3	PWREQB-Public Works Request		319 14th St	BOULDER	303-424-9043	ELLEN AIKEN	
12/30/2021 11:05:34 BCSO	BCSO District 5	FSMOS-Smoke Report		S Foothills Hwy / Marshall Rd	BOULDER COUNTY	720 937-4172	JUDY	1562 MARSHALL RD
12/30/2021 11:05:48 BPD						303 828 7787		
12/30/2021 11:06:22 BCSO								
12/30/2021 11:06:10 BPD								
12/30/2021 11:06:19 BCSO								
12/30/2021 11:06:52 BPD						720 607-0385		
12/30/2021 11:06:59 BPD	BPD2	WECHEB-Welfare Check	TARGET NS	2800 Pearl St	BOULDER	720-317-9546	ARMIN HALTMOVIC	MNGR
12/30/2021 11:06:59 BCSO								
12/30/2021 11:07:28 BPD								
12/30/2021 11:07:35 BPD	BPD5	FREAB-Fire Assist		4675 Ludlow St	BOULDER	(720) 607-0385	jackie fesco	5000 TABLE MESA DR
12/30/2021 11:08:01 BCSO	BCSO District 5	INFORS-Information		N Foothills Hwy / Plateau Rd	LEFT HAND U			
12/30/2021 11:08:04 BPD	BPD	FREAF-Fire Assist		4675 Ludlow St	BOULDER	(720) 607-0385	jackie fesco	5000 TABLE MESA DR
12/30/2021 11:08:31 BCSO								
12/30/2021 11:08:40 BPD	BPD3	HAZARB-Hazard		22nd St / Walnut St	BOULDER	303 919 8048	male homeowner	
12/30/2021 11:08:47 BCSO						(720) 240-8727		
12/30/2021 11:09:31 BCSO								
12/30/2021 11:09:37 BCSO								
12/30/2021 11:09:53 BCSO						(303) 246-7834		
12/30/2021 11:09:56 BPD						(720) 899-1922		
12/30/2021 11:10:04 BCSO						(303) 523-5025		
12/30/2021 11:10:07 BPD	BPD4	UNACCB-Unknown Injury Acc		Table Mesa Dr / Foothills Pkwy	BOULDER	(703) 975-0898	VERIZON	PASSER BY
12/30/2021 11:10:07 BPD						(856) 223-9372		
12/30/2021 11:10:22 BPD								
12/30/2021 11:10:48 BPD	BPD	UNACCF-Unknown inj/unj acc		Table Mesa Dr / Foothills Pkwy	BOULDER	(703) 975-0898	VERIZON	5000 TABLE MESA DR
12/30/2021 11:11:33 BPD						(303) 815-6571		
12/30/2021 11:11:49 BCSO								
12/30/2021 11:12:21 BPD								

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 4

Copy of Firefighter Photo from
5325 Eldorado Springs Dr.
At 11:24 Hours

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 5

Copy of Remote Camera Photo

OSMP Ranger Kelly McBride

Marshall Mesa Trailhead

At 11:10 Hours


2021-12-30 12:10:33 PM M 1/3
45°F
CITY OF BOULDER
RANGER

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 6

Screenshot from Zoltowski Video

IMG_3838


A6 IMG_3838

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 7

USFS Photo of Pole 188688

DSCN0296, 0312, 0307, 0316

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name	Case/File Number
Marshall Fire	21-02-IAIP002
Case Type	**Date of Incident**
Wildland Fire	12-30-2021

Photograph Number: DSCN0296

Date: 01-07-2022

Time: 11:16

Photographer: SA Nadeau

Subject:
Severed communication line and transformer on pole 188688

Photograph Number: DSCN0312

Date: 01-07-2022

Time: 11:37

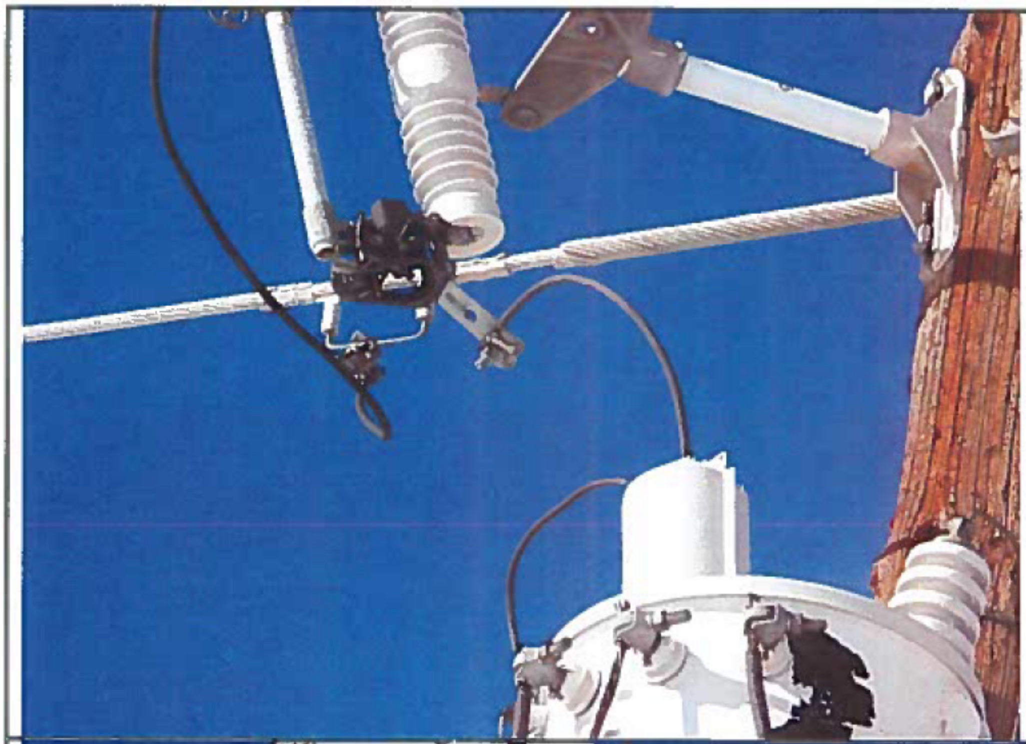
Photographer: SA Nadeau

Subject:
Transformer on pole 188688 with neutral line unlashed from insulator and severed insulated conductor

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name Marshall Fire	Case/File Number 21-02-IAIP002
Case Type Wildland Fire	Date of Incident 12-30-2021



Photograph Number: DSCN0307

Date: 01-07-2022

Time: 11:37

Photographer: SA Nadeau

Subject:
Intact fuse above transformer on pole 188688

Photograph Number: DSCN0316

Date: 01-07-2022

Time: 11:38

Photographer: SA Nadeau

Subject:
Transformer on pole 188688 with bare insulator and severed insulated conductor

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 8

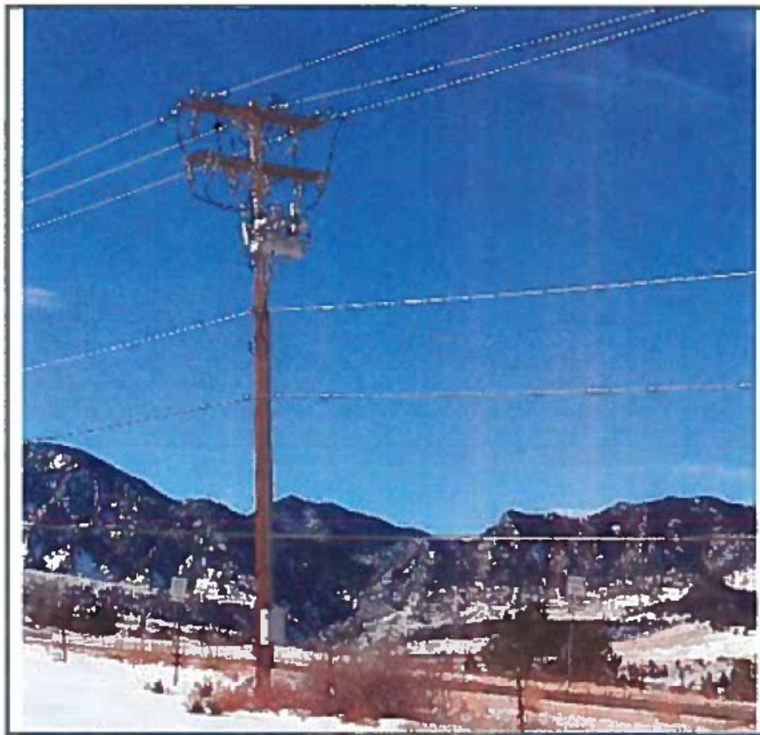
USFS Photo of Pole 101507

DSCN0361, 0378

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name Marshall Fire	Case/File Number 21-02-IAIP002
Case Type Wildland Fire	Date of Incident 12/30/2021



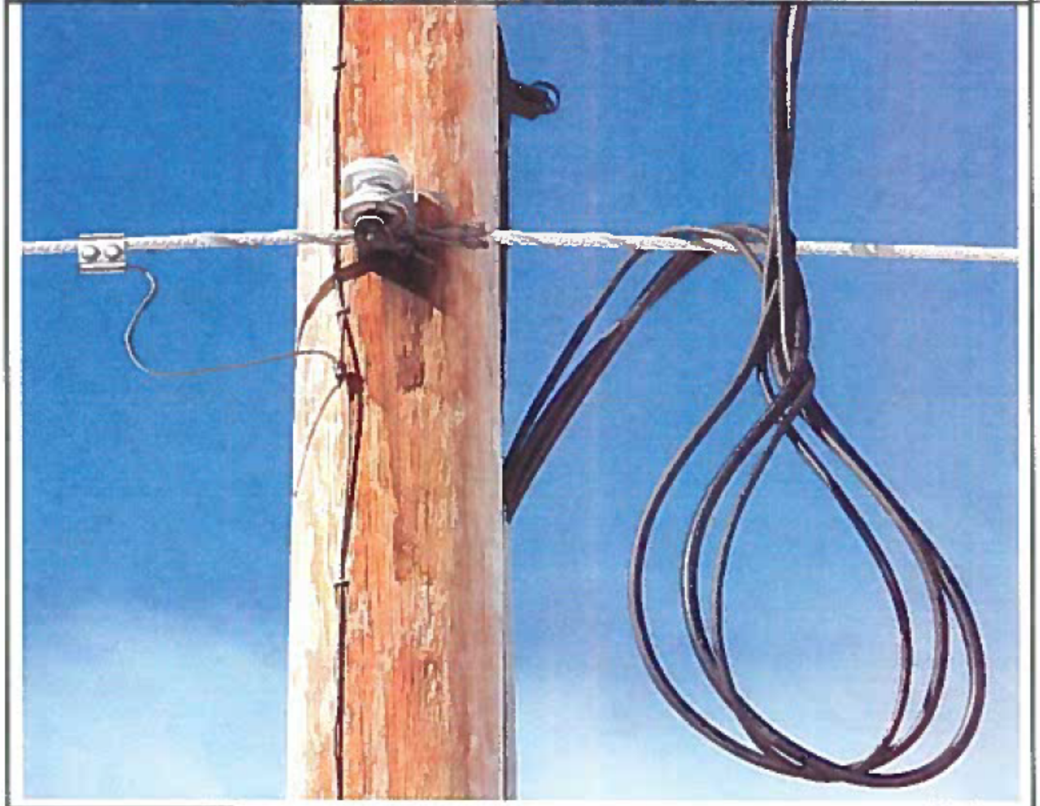
Photograph Number: DSCN0361

Date: 01/07/2022

Time: 11:49

Photographer: SA Nadeau

Subject: Pole 101507



Photograph Number: DSCN0378

Date: 01/07/2022

Time: 11:50

Photographer: SA Nadeau

Subject: Neutral Conductor and recloser communication cables of Pole 101507

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 9

Screenshot from Reconyx Camera Video

At Marshall Mesa Trailhead Entrance

12:17 and 12:20 hours

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name
Marshall Fire

Case/File Number
21-02-IAIP002

Case Type
Wildland Fire

Date of Incident
12-30-2021

[redacted]

Photograph Number: Trailhead Timelapse Video

Date: 12-30-2021

Time: 12:17

Photographer: Remote triggered camera

Subject:
Picture with no smoke visible on southern horizon from trailhead entrance

[redacted]

Photograph Number: Trailhead Timelapse Video

Date: 12-30-2021

Time: 12:20

Photographer: Remote triggered camera

Subject:
First picture with smoke visible on southern horizon from trailhead entrance

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 10

USFS Photos of Vents

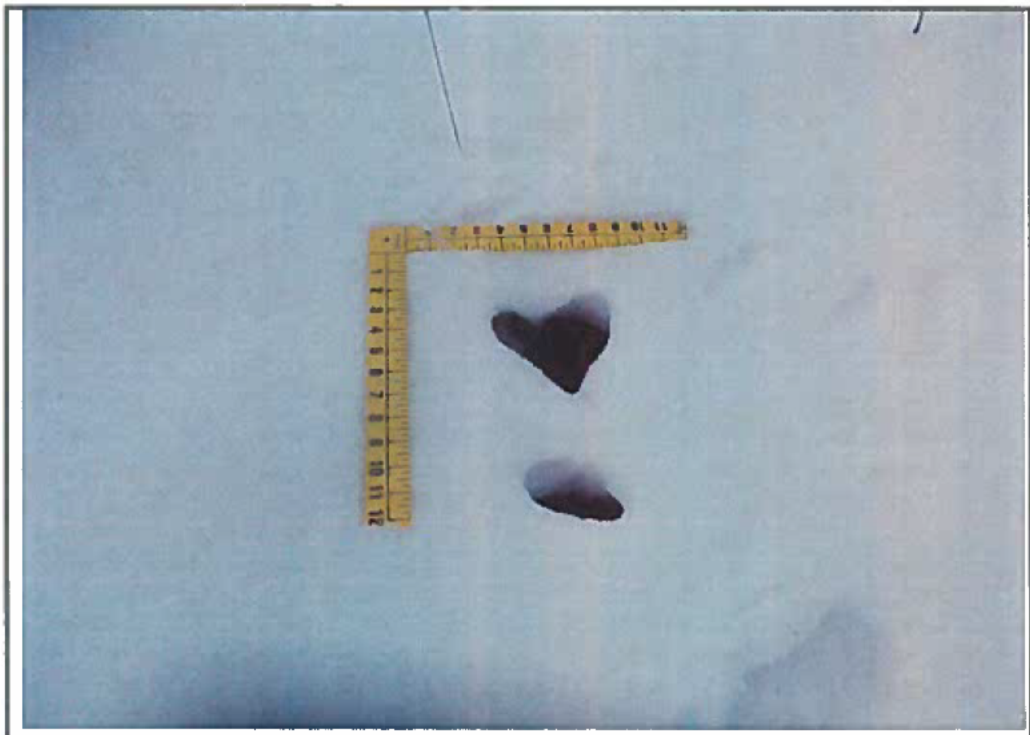
At Marshall Mesa Trailhead

DCSN 0047, 0043, 0052, 0053

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name	Case/File Number
Marshall Fire	21-02-IAIP002
Case Type	**Date of Incident**
Wildland Fire	12-30-2021



Photograph Number: DSCN 0047

Date: 01-06-2022

Time: 09:31

Photographer: A. Henrichs

Subject:
Holes created in the snow above visible holes and cracks in the rock

Photograph Number: DSCN 0043

Date: 01-06-2022

Time: 09:26

Photographer: A. Henrichs

Subject: Holes created in the snow above visible holes and cracks in the rock

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name Marshall Fire	**Case/File Number** 21-02-IAIP002
Case Type Wildland Fire	**Date of Incident** 12-30-2021

Photograph Number: DSCN 0052

Date: 01-06-2022

Time: 09:34

Photographer: A. Henrichs

Subject:
Possible vent created by escaping warm air from underground

Photograph Number: DSCN 0053

Date: 01-06-2022

Time: 09:35

Photographer: A. Henrichs

Subject:
Frost crystals on bottom of rock ledge

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 11

Colorado Division of Reclamation, Mining, and Safety

Colorado Underground Coal Mine Fires 2018 Inventory Report

COLORADO
Division of Reclamation, Mining and Safety
Department of Natural Resources

Colorado Department of Natural Resources
Division of Mining Reclamation and Safety
1313 Sherman Street, Room 215
Denver, Colorado 80203

Colorado Underground Coal Mine Fires
2018 Inventory Report

TETRA TECH

August 2019

TETRA TECH

Colorado Underground Coal Mine Fires

2018 Inventory Report

August 2019

PRESENTED TO

Colorado Department of Natural Resources
Division of Reclamation Mining and Safety
1313 Sherman Street, Room 215
Denver, Colorado 80203

PRESENTED BY

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Golden, Colorado 80401

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COLORADO
Division of Reclamation, Mining and Safety
Department of Natural Resources

EXECUTIVE SUMMARY

There are approximately 1,736 known abandoned coal mines in the State of Colorado. In 2017 and 2018, on behalf of the State of Colorado Department of Natural Resources Division of Mining Reclamation Safety (DRMS), Tetra Tech, Inc. inspected 38 coal mine fire sites across Colorado. Site conditions included highly active fires, low activity and dormant fires and sites that were previously reclaimed and confirmed as dormant/extinguished. Several coal waste piles were included in the inventory site visits. Several sites exhibit high-intensity indicators of coal combustion including ash, venting, and extremely hot temperatures at the surface. In some instances, the sites were visited on more than one occasion to collect additional data and identify trends in the state of the fires. In addition to coal mine fires, outcrop or paleo fires exist across the state.

As stated by Rushworth and others in the 1989 *Reconnaissance Study of Coal Fires in Inactive Colorado Coal Mines*, "Mine and coal crop fires and coal waste fires can all present a serious safety hazards to the public. Coal fires are dangerous due to instability of the ground surface and the possibility of toxic exhaust gases being trapped in hollows under certain atmospheric conditions." Time is also a critical factor in coal mine fires. Comparison of site conditions over the past three decades has shown that fires evolve and are subject to change at any time. Sites that appear dormant can become active again due to subsidence or other factors. The susceptibility of coal mine fires to change necessitates diligent monitoring and engineered safeguards to protect human health and the environment.

This report presents a summary of the findings for each of the coal mine fire sites visited during the 2017-2018 inventory. Data collected at each site includes aerial photography, thermal imagery, elevation data, emissions data, surface temperatures, and intake mapping where appropriate. Unmanned aerial systems (UAS) were used extensively to safely gather data in areas with substantial risk of exposure to toxic gases and unstable ground conditions.

The data presented in this report represents conditions at each of the coal mine fire sites at a specific moment in time and should serve as the basis for future comparisons to evaluate the overall changes in sites conditions at coal mine fire sites in Colorado. Routine monitoring of coal mine fire sites aids in the prioritization to best focus available funding to the sites with the highest risk factors.

Tetra Tech developed a multi-criterion decision analysis tool to aid in the prioritization of fire site reclamation efforts. Each site is scored subjectively for risk in the following areas: distance from populated areas, public accessibility and likelihood of trespassing, objective dangers at the site, risk of wildfire, emissions, public concern and visibility, and overall activity of the fire. After completing all the site visits, these values were assigned and a semi-quantitative ranking of the relative priority of the sites was determined (**Table ES-1**).

This report was authorized and funded by the Colorado Department of Natural Resources Division of Mining Reclamation and Safety under Contract CT-PKAA-1000-2018*1873 dated August 31, 2017.

Table ES-1 – Colorado Mine Fire Priority List

Rank	Fire	Score	Overall Risk	Comments
1	South Canyon West	8.3	High	Highly active. Vents up to 500°F. New vents forming. Near trail system.
2	South Canyon East	8.1	High	Highly active. Vents up to 678°F. CO emissions. Near trail system.
3	Sunshine	7.0	High	Vegetation near 300°F vent. Wildfire risk. Unstable ground. CO emissions.
4	Vulcan	6.8	High	Low activity but recent/ongoing subsidence. Near condominiums.
5	Axial	6.8	High	Temperatures as high as 860°F. Near highway. Developing fractures.
6	Haas /IHI No. 3	6.6	High	Vents up to 600°F. Near recreation area. Difficult firefighting access.
7	New Castle 3	6.4	Medium	Moderate activity. Publicly visible. Fractures and steep terrain.
8	Kaspar	5.4	Medium	Vents up to 300°F. Fire migrating. Some vegetation nearby.
9	Bear	5.3	Medium	Low-temperature vents. Steep, unstable slopes. Near town of Somerset.
10	Harvey Gap	5.0	Medium	Vents up to 310°F. Little vegetation. Not readily accessed by public.
11	Elk Creek	4.9	Medium	Vents up to 230°F. Little vegetation. Not readily accessed by public.
12	Black Diamond	4.7	Medium	Vents up to 237°F. Some high-CO vents. Near trail system.
13	New Castle 1	4.6	Low	Low temperatures. Private property. Steep terrain.
14	Morgan	4.5	Low	Moderately active. Not easily accessed by public. Little vegetation.
15	Coryell	4.5	Low	Low activity. No dangerous surface features. Near town of New Castle.
16	Gem	4.1	Low	Confined fire area but vegetation nearby. Moderately active.
17	IHI No. 2	3.8	Low	Low activity. Remote. Some subsidence.
18	North Coal	3.7	Low	Highly active but confined. Noxious emissions. Remote. Locked gate.
19	Marshall 1 and 2	3.6	Low	Low activity. In Open Space but off-trail.
20	McElmo	3.6	Low	Very low activity but high risk of trespassing.
21	Oliver	3.6	Low	Low activity but visible from highway. Methane exhaust.
22	Garfield	3.4	Very Low	Very low activity. Some unstable ground and risk of trespassing.
23	Lewis 1 and 2	3.1	Very Low	Low activity. Open Space property but no trail network.
24	Go Boy	3.0	Very Low	Low activity. Private property.
25	West Sopris	2.9	Very Low	Remediation planned or in progress.
26	Double Dick	2.9	Very Low	Low activity. Private property.
27	Davis	2.7	Very Low	No active vents. Private property.
28	States	2.7	Very Low	No active vents. Private property.
29	Minnesota Creek	2.7	Very Low	Low activity. Remote.
30	Wise Hill 3	2.7	Very Low	Abatement in progress. Revisit after abatement completed.
31	Slagle/Bright Diamond	2.5	Very Low	Remote. Only 1 low-temperature vent.
32	Riach	2.4	Very Low	Low activity. Remote. Partially remediated.
33	Farmers Mutual	2.4	Very Low	May be dormant.
34	Soda Springs	2.1	Very Low	Temperatures as high as 109°F. Locked gate. Remote. Little vegetation.
35	Pocahontas	2.1	Very Low	May be dormant.
36	Skull Creek	2.0	Very Low	May be extinguished.
37	Morley Waste Dump	2.0	Very Low	Abated and controlled.
38	Rienau Number 2	NA	NA	No landowner permission to access.

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
BGS	Below Ground Surface
BLM	Bureau of Land Management
BMP	Best Management Practice
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DRMS	Division of Mine Safety and Reclamation
°F	Fahrenheit
ft	Foot/Feet
H_2S	Hydrogen Sulfide
I-25	Interstate 25
I-70	Interstate 70
mya	Million Years Ago
O_2	Oxygen
UAS	Unmanned Aerial System

1. INTRODUCTION

Colorado's mineral resources played an important role in the development of the State. Coal mining started with the arrival of the first settlers and prospectors to Colorado's Front Range. At one point there were over 100 producing coal mines in Boulder and Weld Counties alone. As the population of Colorado grew and moved westward, the mining followed, with coal mining occurring in all of Colorado's coal fields at one point or another during the state's growth and development. As a result of the dependence on coal and availability around the state, there are approximately 1,736 known abandoned coal mines.

This report summarizes site conditions at the 38 known underground coal mine fires located in coal fields across the State of Colorado. An inventory of coal mine fires in the State of Colorado is completed every five years by the *Colorado Department of Natural Resources – Division of Reclamation Mining and Safety (DRMS)* to evaluate the mine fire activity, potential resource loss, and threat to public safety. Building upon the previous statewide inventory reports from 1989, 2005 and 2013, Tetra Tech visited each of the mine fire sites to gather current site condition data by using new tools and approaches, including: drone-based aerial photogrammetry and thermal imagery, emissions monitoring, remote seismological sensing, active seismic surveys, integrated 3D modeling, and deployment of remote monitoring stations.

Tetra Tech compared data collected in 2018 to observations reported in the 1989, 2005 and 2013 Coal Mine Fire Inventory reports, as well as other sources, to attempt to quantify the nature and extent of changes at each of the mine fire sites. Such changes range from subsidence, fracturing, and additional venting to the complete abatement of the fire.

In this report, the general geologic setting and characteristics of the eight Colorado coal region and numerous subfields therein are discussed in Section 2.0. Although the varying geologic settings across the state present individual challenges, there are overarching lessons to be learned and applied. The mine fire sites often share common features and characteristics despite the differences in geographical location and setting. Additionally, varying levels of background information were identified for each site. In some instances, there was a detailed mine map available as well as a knowledgeable landowner with direct experience with the mining operation on their property. In other cases, data available for a site was limited to what was visible at the surface, including: fractures vents, stressed vegetation, thermally altered rocks, gas contents, surface temperatures, or subsidence features that we could measure.

In Section 3.0, the tools and methods used to complete the mine fire inventory are described. The role and limitations of each dataset in the overall site characterization model are discussed. Safety was the number one priority during the site visits, and some of the key components of the safety program implemented for this project include gas monitoring and remote sensing of hazardous areas with unmanned aerial systems (UAS) or drones. The aircraft were modified to collect thermal data in addition to the data provided by the standard camera.

In Section 4.0, a summary of conditions observed at each site during the mine fire inventory inspections is presented. This section includes a brief history of the mine and fire when available, mine information, description of fire observations and data collected during the site visits, and directions to each site.

Section 5.0 summarizes the current priority ranking of all the mine fire sites across the state. A multi-criteria decision analysis (MCDA) tool was used to objectively determine which sites present the highest risk and help the State of Colorado prioritize funding.

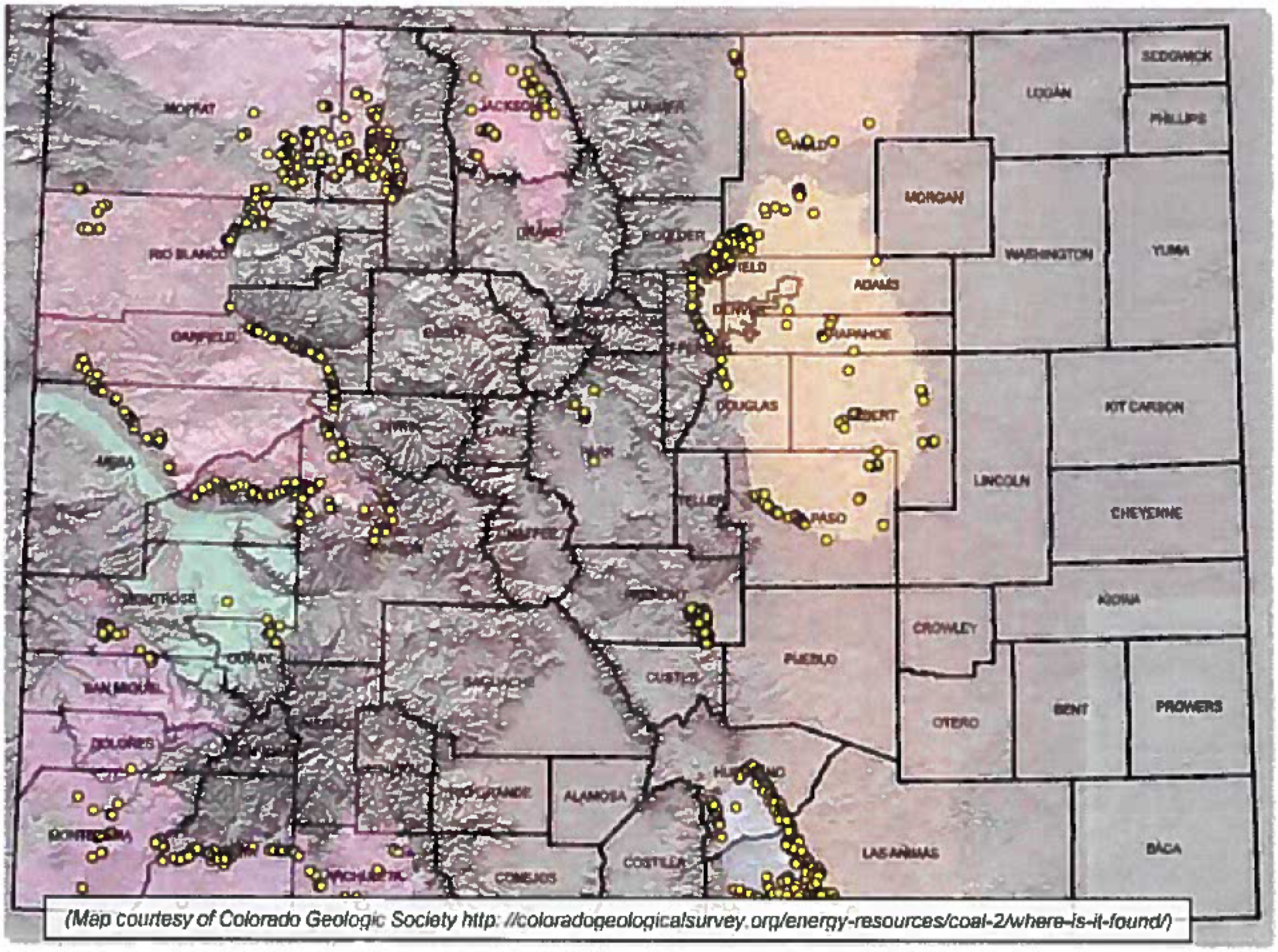
References used during the research and writing of this report are listed in Section 6.0.

The 2018 Colorado Underground Coal Mine Fire Inventory was completed for the Colorado Department of Natural Resources – Division of Reclamation Mining and Safety (DRMS) under contract CT-PKAA-1000-2018*1873 dated August 31, 2017.

2. COLORADO COAL FIELDS

2.1 Locations

There are eight distinct coal mining regions in Colorado identified and discussed in this report. Figure 2-1 shows the locations of these coal fields and areas within them, known to be undermined. The Green River Coal Region, Uinta Coal Region, and San Juan River Coal Region, all found on the Western Slope, account for most of the coal mining activity in Colorado. Smaller basins containing coal in the central part of the state include the North and South Park Coal Regions and the Cañon City Coal Region. Finally, the Denver Coal Region and Raton Mesa Coal Region lie along the I-25 Front Range corridor.



(Map courtesy of Colorado Geologic Society http: //coloradogeologicalsurvey.org/energy-resources/coal-2/where-is-it-found/)

Figure 2-1 – Colorado Coal Regions and Abandoned Mines

The Colorado Historical Society (Fell and Twitty, 2006) documents the history of mining in Colorado, including that of coal industries. The following is a summary thereof.

The Front Range hosted the first coal mines in Colorado. Riding the coattails of the Pike's Peak gold rush in 1859, coal mining began in Boulder County. The generally low-quality lignite was insufficient for smelting or steam production, however, and although the towns of Marshall, Erie, and Louisville were by far the most important in the state, production was seasonal because the coal was used almost exclusively for home heating. Higher-quality bituminous coal discovered near Cañon City fueled—both literally and figuratively—substantial expansion of railroads beginning in the 1870s, and coal production expanded to the Raton Mesa Region. Within a decade, metal mining was booming (most notably the silver-lead mines in Leadville), railroads were expanding, and demand for coal both to produce steam and to process ore soared. Towns from Trinidad to Walsenburg to Pueblo grew to fuel smelters and produce steel. Coal mining picked up in the greater Roaring Fork Valley near Crested Butte and Glenwood Springs, allowing ore from, for example, silver mines near Aspen to be processed more locally. For 30 years or so, coal production clipped along riding the waves of the metal, mineral, and overall national economy until the 1900s when the first heavy-gauge rail line overtopped the Continental Divide in central Colorado. The Denver Northern and Pacific left the capital (largely following the modern path of the Union Pacific), passing the coal mines at Leyden to South Boulder Creek and up to Rollinsville before a monumental crossing of the Divide into Middle Park near modern Winter Park. Now in the relatively benign Colorado River drainage, the railway could access the reserves of North Park and then the Green River and northern Uinta areas. As a result, production in the Green River Region especially skyrocketed.

A protracted decline in Colorado coal production began following World War I. Trains switched to petroleum, and houses to natural gas. Coal was primarily used for smelting, so mines producing coking-quality coal fared well through WWII, but the Denver Basin and Cañon City were especially hard-hit. The expansion of coal-fired power plants in the post-war years gave a boost to some parts of Colorado. In particular, several surface strip mining operations in the San Juan Uinta and Green River Regions served as on-site supply for power plants, with coal mined directly onto conveyors bound for the incinerator. At others, conveyors dumped coal directly into waiting trains that had only one cargo and only one destination: the power plant. Furthermore, the comparatively low sulfur content of Colorado coal made it increasingly attractive as environmental regulations were tightened to keep pace with development. These same regulations and the environmental movement in general may have been impediments to strip mines, but—coupled with improvements in mining equipment—spurred interest in underground, and especially longwall, mines in Colorado into the 1990s. Declining natural gas prices have put a squeeze on coal-fired plants in the past 10 years, and coal mining has steadily declined nationwide.

Integrated from 1864 to present, coal production is roughly evenly split between the Front Range (Denver and Raton Mesa) and the Western Slope (Uinta and Green River), with each contributing more than 350 million tons and each accounting for more than 45% of total statewide production. Cañon City has provided another 5%, and the remainder is split among the San Juan River basin and North and South Park.

Over the last decades, however, production has been dominated by the Western Slope. The Green River and Uinta Regions contributed 89% of all Colorado coal from 15 active mines (out of 21) in 1990. Four additional mines split between Raton and Cañon City provided another 10%. The San Juan River basin and North Park each hosted one operating mine, but no coal mines were active in Denver or South Park.

Following national trends, Colorado coal mines have become less active over the past several years, producing 1/3 of the coal produced as recently as 2007. Nevertheless, Colorado is the 11th leading coal producer in the United States (2.1% of national total). The most recent Colorado Geological Survey report (O'Keefe and Berry, 2016) describes eight active mines that account for 1,086 direct jobs and $500 million in product. Four are spread across the Uinta Region and account for 60% of statewide production. Two in the Green River Region contribute an additional 34%, and the final two in the San Juan Region provide the final 6%. No mines are active in Denver, Cañon City, Raton, or North or South Park.

2.2 Geology

Colorado coal was formed during the late Cretaceous and Paleocene Periods—approximately 55-100mya—in fresh-water swampy peat mires along coastal plains bordering the Western Interior Seaway. The process of burial by sediments, heat, and time transform peat into varying types of carbon-rich deposits such as lignite, bituminous coal, and anthracite.

Despite their common origin, modern coalbeds in Colorado comprise widely varying grades of coal, lie at varying depths beneath the surface, and have varying dips. As a result, mining methods vary between surface and underground mining. Over 90 percent of the coal mining in Colorado is underground, with some of the shallow mines in Moffat County being operated as open pit mines. The geology of each of Colorado's eight distinct coal regions are generally described below. Colorado Geological Survey Special Publication 36 (*1990 Summary of Coal Resources in Colorado*) provides extensive information on production, coal quality, and geology (Tremain et al., 1990). Much of our summary is drawn from this resource, but we have expanded focus on areas with mine fire sites. The locations of the regions described below are shown on Figure 2-1.

2.2.1 Green River Coal Region

Located in northwestern Colorado and southwestern Wyoming, the Green River Coal Region is bounded by the Park Range on the east, on the south by the White River Uplift, on the west by Uinta Uplift, and to the north by Sand Wash Basin and flank of the Axial Basin Anticline. The region is complicated structurally by folding, faulting, and late-Tertiary igneous intrusives in the southwest part of Sand Wash Basin and by the deformation of the Axial Basin Anticline (Collins, 1977).

The primary coal-bearing unit in the area is the Upper Cretaceous Mesaverde Group, which was deposited in a southwest-trending delta-plain/delta progression that extends across most of western Colorado. Both the Iles and Williams Fork Formations within the Mesaverde Group contain numerous thin coal seams. The Mesaverde Group consists of massive ledge-making sandstones, together with thinner-bedded sandstones, sandy shales, and coal beds. This group typically forms ridges because the sandstone members offer greater resistance to erosion than either the overlying or underlying shale units. Additional, but less substantial, coal seams also occur in the overlying (Cretaceous to Paleocene) Lance, Fort Union, and Wasatch Formations.

The two mine fires in this region are in the Yampa Coal Field in the coal beds of the middle group of the Williams Fork Formation (Rushworth, 1989). Yampa is the only named coal field in the region.

2.2.2 Uinta Coal Region

At present, the Uinta Coal Region is the most active in Colorado, and it also has the most mine fire sites. The coals of the Uinta Coal Region are also found in the Upper Cretaceous Mesa Verde Formation and were deposited in a deltaic sequence that progressed southeastward across western Colorado. This sequence is the same as discussed in the Green River Coal Region. The Axial Basin Uplift on the north side of the Uinta Coal Region separates it from the Green River Region.

The eastern boundary of the Uinta Coal Region is the Grand Hogback, a prominent monoclinal ridge extending south-southeast for about 125 miles from Rangely to Redstone. The Hogback hosts a high concentration of coal mines because it avails the opportunity for stope mining, which uses the near-vertical orientation of the coalbeds to an advantage for the mineral extraction. The monoclinal structure creates asymmetric basins, including the Piceance Basin, with more steeply dipping strata on the east side than the west, and north-northeast-trending axes. The Piceance Basin lies in the northern part of the Uinta Region and is one of the deepest basins in the state. The southern portion of the basin has been intruded by the West Elk and Elk Mountain igneous suites, baking and locally coking coal. At least eight coal fields have been described with the Uinta Region, and six of these have mine fire sites; these six fields are detailed below.

2.2.2.1 Book Cliffs Coal Field

The Books Cliffs Coal Field structure has relatively flat-lying rocks, dipping a few degrees to the northeast. It is located in the Piceance Basin, adjacent to the Uncompahgre Uplift. The Upper Cretaceous Mesa Verde Group are the home of the coal bearing sequences in the field, deposited by coastal on-lap/off-lap sequence. Coal in the Mt. Garfield Formation (roughly equivalent to the Lower Williams Fork Formation) is typically found in lagoonal deposits behind offshore sandstones (Young, 1955). Correlation of the coal bearing zones in the Book Cliffs Coal Field is complicated by the discontinuous nature of lagoonal depositional environments.

The Go Boy Mine was completed in the four- to six-foot Cameo bed in the Cameo Member of the Mt. Garfield Formation.

2.2.2.2 Grand Hogback Field

The Laramide Grand Hogback Monocline marks the eastern physiographic edge of the Colorado Plateau. The steeply dipping limb of the monocline contains the coal-bearing Mesaverde Group. The near-vertical seams are advantageous for stope mining. As a result, the Grand Hogback Field both is one of the most productive in the Uinta Region and hosts the most coal mine fire sites of any field.

Numerous seams are mined in the Grand Hogback Field. The most productive have been the Fairfield and South Cañon members of the lower Williams Fork Formation. Both the underlying upper Iles Formation (Black Diamond member) and overlying upper Williams Fork (Keystone member) are also mined.

2.2.2.3 Grand Mesa Field

The Grand Mesa Field lies on the southern edge of 10,000-foot Grand Mesa, a plateau capped by mostly mafic Tertiary-age volcanic flows. The coals in this field are found in the Mt. Garfield Formation of the Mesaverde Group. Numerous coal seams are known within the formation and the Cameo seam hosts several of the mines discussed in this report.

2.2.2.4 Somerset Field

The Somerset Field lies in the Gunnison River drainage, and mines generally target the Bowie and Paonia members of the Williams Fork Formation, part of the Mesaverde Group. Seams can reach thicknesses of 25-30 feet.

2.2.2.5 Danforth Hills Field

The Danforth Hills Field occupies the northeastern corner of the Uinta Region, situated against the Axial Uplift, which counterintuitively is a topographic low where the coal-bearing Mesaverde Group has been eroded away.

Both the Williams Fork and Iles Formations are present, availing numerous seams up to 20 feet thick. Strata are primarily flat-lying to gently dipping, so—unlike most of the Grand Hogback Field—surface mines are common. Several such mines have multiple benches to access multiple seams.

2.2.2.6 Lower White River Field

The final Field in the Uinta Region that contains mine fire sites is the Lower White River. This extensive region occupies the northwestern portion of the Uinta Region, including most of the western Piceance Basin and the Douglas Creek Arch and extending well into Utah. As with its eastern neighbor, Danforth Hills, both the Williams Fork and Iles Formations are present.

There is moderate structural complexity in the Lower White River. The most prolific portion of the region is where the Rangely Anticline is breached, and the resistant Mesa Verde sandstone beds acts as rimrock, exposing numerous seams beneath. (This same area and overall structure hosts the Rangely Oilfield, perhaps the largest in the state.)

2.2.3 San Juan River Coal Region

The San Juan River Coal Region extends over a broad swath of southwestern Colorado and contains numerous individual coal fields, generally sub-basins that are cut by the Uncompahgre and Gunnison Uplifts. Coal occurs in multiple Upper Cretaceous units: as many as four thin beds (a few feet thick) in the Dakota Sandstone, nine thin beds in the Menefee Formation (the local name for the middle member of the Mesaverde Group), and three more substantial beds in the Fruitland Formation.

2.2.3.1 *Durango Field (and Pagosa Springs Field)*

The Durango Field primarily lies in the San Juan Basin but also extends into the Red Mesa and Mesa Verde areas. The San Juan Basin is an asymmetrical syncline (thickening toward the northeast, generally) with a multi-phase structural history. The Paleozoic Ancestral Rockies orogeny formed the Uncompahgre Uplift to the northeast of the basin, specifically the Archuleta Anticlinorium. Roughly 200 million years later, the Hogback Monocline (which is distinct from the Grand Hogback farther north) grew early in the Laramide orogeny, creating the southwestern boundary of the basin. Subsequent growth of the Nacimiento and Zuni Uplifts to the east and south, respectively, tilted the basin down to the northwest.

Near the city of Durango, on the northern edge of the San Juan Basin, there is moderate structural complexity in the Upper Cretaceous units that is associated with the northeastern continuation of the Hogback Monocline. Thermal alteration in this area has locally upgraded coal seams to coking quality.

The Durango and Pagosa Springs Fields have been separated in some previous reports, but the difference is inconsequential in the context of this report.

2.2.3.2 *Tongue Mesa Field*

The Tongue Mesa Field occupies the northeastern corner of the San Juan River Region. Here, late Cretaceous and Tertiary volcanic rocks cap underlying coal-bearing Cretaceous units. Erosion has stripped away surrounding rocks, leaving the remnant high topography of Cimarron Ridge.

The coals in the Tongue Mesa Field are found on Cimarron Ridge in a 900-foot thick sequence correlative with the Kirtland/Fruitland/Pictured Cliffs Formations in the San Juan Basin to the south. Four coal seams are present. The largest—the Cimarron/Lou Creek—is 40 feet thick, in the lower Fruitland Formation.

2.2.3.3 *Nucla-Naturita Field*

The surficial geology of the western part of the San Juan River Region is dominated by modestly deformed Cretaceous sediments that have been extensively eroded and dissected along combinations of joints, salt dome collapse features, and Laramide faults. As a result, the landscape comprises complex topography of steep-sided mesas and narrow valleys, and coal-bearing units are absent in most places. Nevertheless, three seams in the Dakota Sandstone are locally persistent. Though thin (3-5 feet), these seams have been widely mined.

2.2.4 North Park Coal Field

The North Park Coal Field is situated in a high, intermontane basin in a Laramide syncline bounded by the Medicine Bow/Front Range Uplift to the east, the Rabbit Ears Volcanic Field on the south and southwest and the Park Range Uplift on the west. The coal beds in the North Park Coal Field occur in the late Paleocene to early Eocene age Coalmont Formation. The formation consists of terrigenous clastics, carbonaceous shales, and coals. The Coalmont Formation strikes west of north and dips 10 to 25 degrees to the northwest. Most of the productive seams, however, are found in local areas of structural complexity: dips often exceed 45 degrees, seams are often faulted and lenticular, and the coal is often upgraded by this tectonothermal history. Structurally, the area is dominated by a series of northwest trending normal faults associated with the downward warping of the basin (Rushworth, 1989), though secondary anticlinal structures are also present. In particular, the prominent Marr strip mine is located on the eastern flank of the McCallum Anticline.

2.2.5 South Park Coal Field

The South Park Coal Field is also located in an intermontane valley. The topographic valley reflects a large-scale synclinal structure bounded by the Mosquito Range to the west and the Front/Rampart Range to the east. The primary coal-bearing unit is the Upper Cretaceous Laramie Formation, which consists primarily of fine- to medium-grained sandstones and silty clays. The coal beds were deposited in a delta plain in swampy environment and are thickest in the lower portion of the unit, though thinner beds are found in the middle and upper portions as well.

The Laramie and other Paleozoic and Mesozoic units are exposed by myriad west-vergent, east-dipping thrust slices along the western half of the basin of Laramide age (Sterne, 2006). Coal seams outcrop in the northern portion of South Park around the flanks of the Michigan Syncline. In the northwestern part of the topographic and structural basin, the Laramie Formation dips steeply eastward, as much as 45 degrees, and was mined extensively in the latter third of the 19th century. No mines are currently active, however.

2.2.6 Raton Mesa Coal Region

The asymmetrical Raton structural basin is home to the Raton Mesa Coal Region. The axis of the basin is located near its western edge, close to the Sangre de Cristo and Culebra ranges, and plunges southward. Attendant to this structure, formations dip gently westward on the eastern edge of the basin—near I-25—and steeply eastward or are locally overturned near the mountain front. The basin formed as a result of Laramide thrust faulting of the Sangres and Culebras, but was subsequently intruded by the mid-Tertiary Spanish Peaks. Mainly radial dikes associated with these intrusions, as well as cogenetic high heat flow, have baked and in some places coked coal in the central portion of the Raton Basin. Coal appears in the Upper Cretaceous Vermejo shale and sandstone and the middle and upper members of the Paleocene/Cretaceous Raton Formation. The Raton Formation comprises a basal sandstone/conglomerate that unconformably overlies the Vermejo, a middle coal-bearing sandstone/shale/mudstone, and a sedimentologically similar upper coal-bearing member.

Raton Mesa has produced the most coal of any region in Colorado, approximately 31% of the statewide total. The majority of this coal has been mined on the east side of the basin from the lower portion of the Vermejo Formation (Tremain et al., 1990).

2.2.7 Cañon City Coal Field

The Laramide Cañon City structural basin is home to the Cañon City Coal Field, located in the southwest portion of the Denver Basin. The field itself is in a structural embayment bounded on the north by the Front Range Uplift, on the west and southwest by the Wet Mountains Uplift, and on the south by Apishapa Uplift. The Apishapa Uplift caused the removal of the coal-bearing sequences that were once continuous between Cañon City and Raton Basins (Murray, 1982).

Stratigraphically, the Cañon City Region is more similar to the Raton Basin than the Denver Basin. Late Cretaceous-age Vermejo Formation is the only coal-bearing sequence in the Cañon City Coal Field. The sequence is comprised of coals, claystones, siltstones, and sandstones deposited in delta plain settings. The coal beds formed parallel to major fluvial channels, with intermittent splays (Billingsley, 1978).

2.2.8 Denver Coal Region

The Denver Coal Region lies within the Denver structural basin, which was formed during the Laramide Orogeny. The basin is bounded on the south by Apishapa Uplift, the north by Wyoming, on the east by the Las Animas Arch, and on the west by the Front Range/Rampart Range Uplift. The synclinal axis is near the west edge of the basin (Rushworth et al., 1989). The Denver Basin is structurally complex. Two main sub-basins, Denver in the south and Cheyenne in the north, are separated by the Greeley Arch. These basins are further complicated by mainly northeast-trending grabens and half-grabens. Mining has occurred largely in graben areas where coal is thicker, generally five to ten feet and locally up to twenty feet (Weimer, 1977).

The important coal-bearing interval of the Denver Region is the Upper Cretaceous Laramie Formation, which consists primarily of fine- to medium-grained sandstones and silty clays. The Laramie Formation is nearly vertical near the western part of the region, but the dip decreases rapidly to the east. The coal beds were deposited in a delta plain in swampy environment and are found in the lower portion of the formation in a zone 50 to 275 feet thick. Individual seams are typically lenticular and are more abundant in the Denver than Cheyenne sub-basin (5-10 and up to 20 feet thick versus 3-7 feet).

In the Denver sub-basin only, the Laramie is overlain by the Denver Formation, an arkosic sandstone derived from the rising Rocky Mountains. Multiple local beds of coal occur in the central portion of the basin in the Denver Formation, likely reflecting two episodic Paleocene swamps (north and south) amid the alluvial plain draining the growing mountains to the west. The northern deposits are more abundant than the southern (10-30 and up to 50 feet thick versus 5-10 and up to 30 feet).

The earliest developed, the Denver Region was dominated by shaft rather than stope or drift mining. Shafts are or were typically 250-500 feet deep. Additionally, approximately the eastern half of the Laramie coals and almost all of the Denver Formation seams are within 200 feet of the surface, making them potential targets for surface mining.

2.3 Fires

The details of this report describe the current conditions of both active and dormant fires at abandoned coal mines in Colorado. In 2018, 38 active or dormant coal mine fires were documented in the state inventory. Additional, unknown, coal mine fires and outcrop fires are likely to exist.

Fires in this report are classified into one or more of four categories defined by Renner (2005): active fire, dormant fire, refuse pile fire and, outcrop fire, as described below:

1) **Active fire** describes a site at which the combustion of coal is causing measurable heating of the ground surface above ambient ground temperatures. Active fire sites also typically have vents on the ground surface producing exhaust.

2) **Dormant fire** sites are described as sites that were noted as active in previous reports, but at the time of the 2017-2018 site visits conducted by Tetra Tech and DRMS, no significant anomalies were measured at the surface or in previously installed borehole thermocouples. Underground coal combustion may still be present at these sites, but at the time of the inventory no data confirm the fire is active.

3) **Refuse pile fires** are related to the stockpiling and storage of coal refuse or coal waste material. Typically, these sites burn through oxidation, which occurs if introduction of oxygen to crushed coal causes heating, sometimes to the point of combustion.

4) **Outcrop fire** refers to the burning of unmined in-situ coal by means of oxidation or natural ignition (lightning strike, wildfire, etc.).

Coal mine fires described in this report are organized by county, and the fire locations across the state are summarized on Table 2-1 and shown on Figure 2-2.

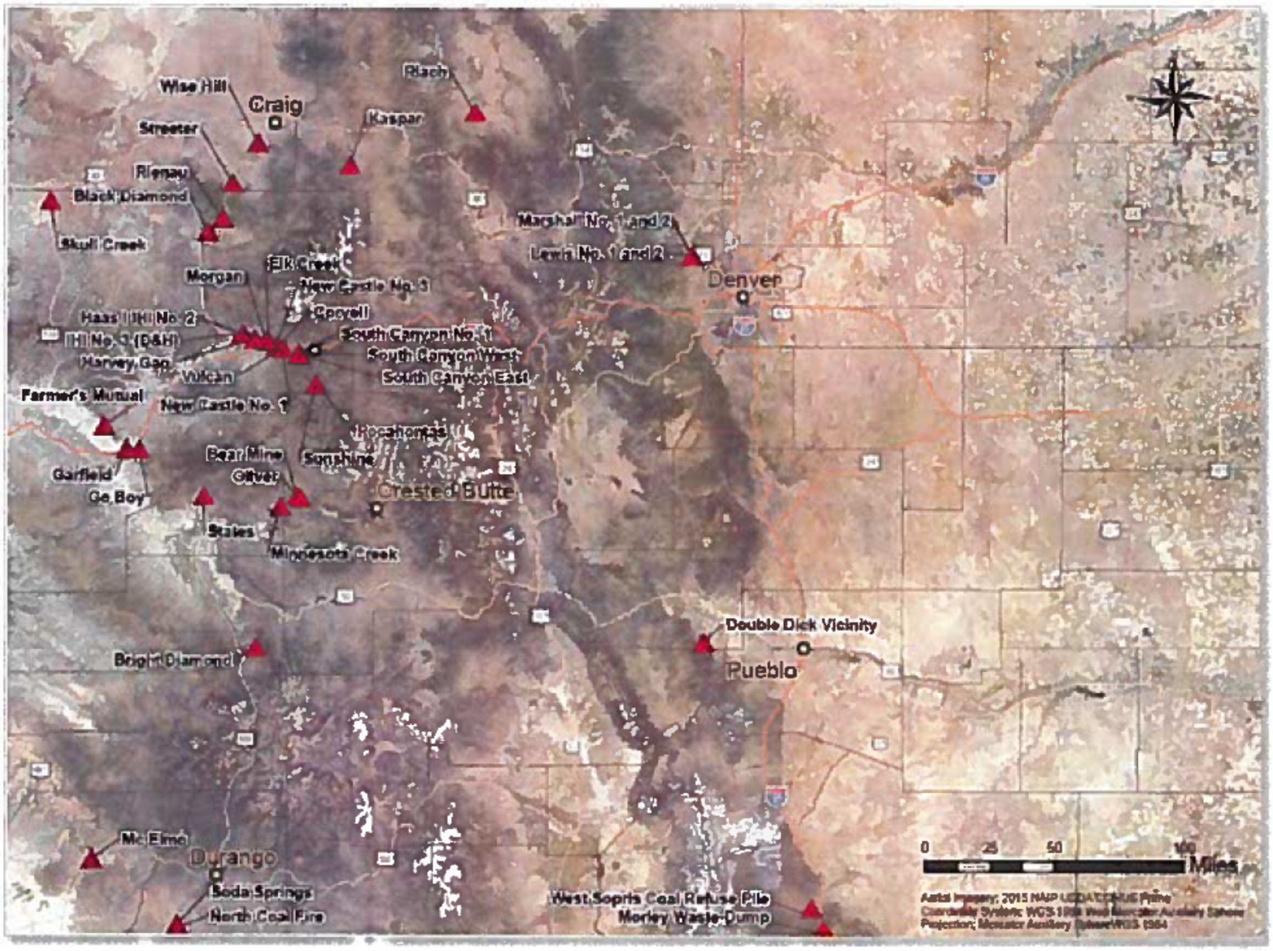


Figure 2-2 – Colorado Coal Mine Fire Locations

Table 2-1 – Mine Fire Information

County	Fire Name	Latitude (N)	Longitude (W)	Coal Field	Activity
Boulder	Lewis No. 1 and 2	39°57'23.04"	105°13'20.28"	Boulder-Weld	Very Low
	Marshall No. 1 and 2	39°57'16.92"	105°13'45.84"	Boulder-Weld	Very Low
Delta	Davis	38°55'49.41"	107°58'21.45"	Grand Mesa	Very Low
	Minnesota Creek	38°52'54.12"	107°31'23.88"	Somerset	Low
	States	38°55'33.96"	107°56'57.12"	Grand Mesa	Low
Fremont	Double Dick (vicinity)	38°17'26.88"	105°10'0.84"	Cañon City	Low
Garfield	Coryell	39°34'3.41"	107°31'58.47"	Grand Hogback	Low
	Elk Creek	39°35'22.11"	107°35'22.30"	Grand Hogback	High
	Gem	39°32'31.32"	107°26'2.04"	Grand Hogback	Moderate
	Haas / IHI No. 2	39°37'10.20"	107°43'54.48"	Grand Hogback	Low
	Harvey Gap	39°36'3.96"	107°39'54.36"	Grand Hogback	Moderate
	IHI No. 3 (D&H)	39°37'14.16"	107°44'6.00"	Grand Hogback	High
	Morgan	39°35'38.40"	107°36'12.24"	Grand Hogback	Moderate
	New Castle Number 1	39°33'39.60"	107°30'44.28"	Grand Hogback	Low
	New Castle Number 3	39°34'23.52"	107°32'37.68"	Grand Hogback	Moderate
	Pocahontas	39°24'41.60"	107°19'23.17"	Grand Hogback	Very Low
	South Canyon East	39°31'55.58"	107°24'49.02"	Grand Hogback	Very High
	South Canyon West	39°32'12.78"	107°25'20.84"	Grand Hogback	Very High
	Sunshine	39°24'6.02"	107°19'33.65"	Grand Hogback	High
	Vulcan	39°33'31.48"	107°29'59.85"	Grand Hogback	Moderate
Gunnison	Bear	40°25'44.31"	107°38'47.69"	Somerset	Low
	Oliver	38°55'28.40"	107°25'54.20"	Somerset	Low
Jackson	Riach	40°33'37.44"	106°26'22.56"	Coalmont	Low
Las Animas	Morley Refuse Pile	37°2'3.84"	104°30'27.00"	Trinidad	Very Low
	West Sopris Refuse Pile	37°7'45.66"	104°34'6.87"	Trinidad	Low
La Plata	North Coal Fire	37°2'8.88"	108°6'27.72"	Durango	Moderate
	Soda Springs	37°3'17.95"	108°5'44.83"	Durango	Low
Mesa	Farmer's Mutual	39°13'26.48"	108°30'18.70"	Book Cliffs	Very Low
	Garfield	39° 7'37.92"	108°22'52.68"	Book Cliffs	Very Low
	Go Boy	39° 7'33.24"	108°18'39.60"	Book Cliffs	Very Low
Moffat	Axial	40°15'45.00"	107°47'25.08"	Danforth	High
	Wise Hill Number 3	40°25'44.31"	107°38'47.69"	Yampa	Low
Montezuma	McElmo	37°20'18.96"	108°34'49.08"	Nucla-Naturita	Very Low
Ouray	Slagle / Bright Diamond	38°16'14.16"	107°39'43.92"	Tongue Mesa	Low
Rio Blanco	Black Diamond	40°3'26.43"	107°55'33.98"	Danforth	Moderate
	Rienau Number 2	40°6'43.21"	107°50'47.24"	Danforth	Moderate
	Skull Creek	40°11'4.92"	108°48'10.08"	Lower White River	Very Low
Routt	Kaspar	40°20'16.83"	107° 8'5.91"	Yampa	High

3. INVENTORY METHODS

3.1 Site Visits

Tetra Tech began the statewide Mine Fire Inventory project in October 2017 and completed visits to 38 coal fire sites by November 2018. Data collected during the site visits included: thermal imagery; spot temperature readings; exhaust gas composition readings; ground-based photography (when possible, site visits were coordinated to take advantage of snowfall and cold temperatures for thermal imaging and snowmelt photographs); and UAS imagery including aerial photos, thermal, and elevation data. This new data was integrated with existing site information to rank and prioritize coal mine fire sites across Colorado.

3.2 Safety

Because of remote and rugged terrain and often hazardous site features, the "buddy system," or minimum two-person team, was employed during site inspection activities. Each member wore standard field protective gear (hiking or steel-toed boots, high-visibility vests, hard hat when appropriate, and sun protection).

UAS drone flights were used to inspect hazardous site features while the team remained in a safe area. Known vents were approached from the upwind side. Ground temperatures around vents were checked using a laser infrared thermometer or FLIR thermal camera to insure a safe working area.

Inspection teams carried personal four-gas meters to monitor for concentrations of oxygen (O_2), methane (CH_4), hydrogen sulfide (H_2S), and carbon monoxide (CO). The personal four-gas air monitor is worn at or above chest level while working at the fire site. If the monitor's alarm sounds, the area is evacuated in the upwind direction until safe atmosphere is reached and the alarm turns off. Table 3-1 provides the alarm levels of the personal four-gas monitoring.

Table 3-1 – BW Honeywell GasAlert XL Factory Alarm Settings

	FACTORY ALARM SETTINGS			
	O_2	LEL	H_2S	CO
Alarm	% Vol	% LEL	PPM	PPM
Low	19.50	10.00	10	35
High	23.50	20.00	15	200
TWA	NA	NA	10	35
STEL	NA	NA	15	50

3.3 Mine Fire Emissions Monitoring

Tetra Tech quantified mine fire emissions by measuring gas concentrations at and calculating the flowrates of vents. The equipment used to measure the gas concentrations were the Landtec GEM 5000 landfill gas monitor and the Testo 350 combustion gas monitor. Table 3-2 presents the analysis capabilities of this equipment. Flowrates from the vents were determined by measuring the air speed using a Kestrel 1000 flowmeter and multiplying this speed by the cross-sectional area of the vent. The concentration data and flowrates were used to calculate annual emission rates in tons/year.

Table 3-2 – Emissions Analysis Equipment

Equipment	Measurement Parameter								
	CH_4	CO	CO_2	O_2	H_2S	SO_2	NO	NO_2	Gas Temperature
Landtec GEM 5000	X	X	X	X	X				
TESTO 350 XL		X	X	X		X	X	X	X

Vent cross-sectional area and velocity can be difficult to determine because of high gas temperatures and diffuse, complex fracture venting. In some cases, vents were inaccessible for monitoring because of unsafe ground conditions and toxic atmospheres. Because of these limitations, emissions from these areas of the mine fire are estimated in the field by analyzing gas concentrations of vents in the area to use as representative vent emissions and estimating the total cross-sectional area and average velocity of vents in the region. Although imperfect, this approach allows for the estimation of emissions for regions of the mine fire that otherwise could not be measured safely.

3.4 Infrared Temperature Monitoring & Thermal Imaging

Surface temperature measurements and mapping are key components of coal mine fire site inventories. Tetra Tech utilized a variety of handheld infrared thermometers and thermal imaging cameras to accurately characterize exhaust vent temperatures and the overall extents of heat at the surface. These instruments are also key components of the health and safety program, allowing field technicians the ability to identify and monitor hotspots near working areas.

3.5 Aerial Imaging

UAS drone data were a key element of the coal mine fire inventory project and provide a cost-effective and repeatable method for rapid evaluation of coal mine fire sites. Mission planning and management were essential components of the data acquisition at the various coal mine fire sites. UAS use dramatically reduced the time spent collecting ground survey data for large or hazardous areas, and the survey team was able to gather key data from safe locations.

3.5.1 Photogrammetry

In support of the inventory effort, Tetra Tech developed a drone program to add value to the types of data acquired for an inventory report. Photogrammetry provides survey-level measurements from a collection of georeferenced airborne photographs. The use of drone-based photogrammetry allows for near real-time assessment of a site and requires a low level of pre-survey work, making it an excellent tool for these remote sites. By establishing a baseline dataset for each site with aerial-based photogrammetry, Tetra Tech has provided the State with the ability to measure changes over time. The detailed maps generated by photogrammetry provide a metric for long-term monitoring of vegetation, erosion, deformation or subsidence, and risk management or encroachment. Tetra Tech suggests the following uses of this baseline drone data:

- Monitoring subsidence features over time
- Hi-resolution drone mapping and comparative analysis
- Surface feature mapping and measurements

Repeating site visits over time and repeating such analysis would provide a quantitative measure of fire progression and impact.

3.5.2 Aerial Thermal Photography

Thermal photography provides valuable insight into the measurable level of heat at the surface of a given site. By implementing this technology into the UAS program, Tetra Tech acquired more complete imagery than ground-based thermal surveys and provided more repeatable information at each mine fire site. Tetra Tech deployed the FLIR® DUO R thermal camera on the drone-based platform to coincide with the gimbal-regulated aerial photography. The dual-sensor FLIR® camera collects both thermal and visible light simultaneously, allowing for accurate positioning of the thermal data over a map of the site. Aerial temperature measurements can then be confirmed on the ground with IR thermometers. During the entire inventory project, Tetra Tech observed strong correlation between temperature data gathered with the drone and ground observations, validating the use of drone-based thermal photography for rapid assessment of large or hazardous areas.

3.5.3 Geomorphic Analysis

Tetra Tech uses photogrammetry and LiDAR based UAS systems to develop 3D models and contours of Abandoned Mine Lands sites. These 3D models allow engineers and scientists to evaluate the site for erosion and subsidence features and estimate quantities required for repair and maintenance. Collecting thermal imagery allows Tetra Tech to find vents and warm ground associated with underground coal mine fires far more efficiently and accurately than a typical site inspection alone. This survey then directs a targeted site inspection and helps delineate the fire expression area. High-resolution aerial imagery provides a point-in-time reference to allow for the tracking of reclamation performance.

4. 2018 COLORADO COAL MINE FIRE INVENTORY SITE SUMMARIES

During the 2017-2018 Inventory field investigations 38 coal mine fire sites were visited to document current site conditions. The mine fire sites and their location information are summarized on Table 2-1 and shown on Figure 2-2.

4.1 Boulder County

There are two known coal mine fires in Boulder County, Colorado. The Marshall and Lewis fires are in the southwestern part of Boulder County in an area with numerous abandoned underground coal mines in coal seams of the Upper Cretaceous Laramie Formation. The fire intensity at both locations has been observed to fluctuate over time as the fires burn, subsurface conditions change, and subsidence occurs. In 2018, the fires had very low activity and posed minimal risk.

4.1.1 Lewis Mine

Figure 4-1 – Lewis Mine Fire Looking North

FIRE DESCRIPTION

The Lewis mine fire site is located approximately 1 mile south of Boulder, CO on the northeast corner of the intersection of Marshall Road and Cherryvale Road. The mine fire is located on private and public property and accessed with permission of the landowner. The Lewis mine was a small production mine operating from 1914 to 1946. Evidence of the mine is apparent at the surface, with numerous north-south orientated subsidence features up to six feet deep. The subsidence features are related to the initial mining of a shallow coal seam, the small overburden thickness, and fractured nature of the roof material of the mine.

FIRE ACTIVITY

Very Low

FIRE HAZARD RANKING

23 of 38

LOCATION

Latitude: 39°57'23.04"

Longitude: 105°13'20.28"

Nearest Town: Boulder, Colorado.

Landowner: Private

MINE INFORMATION

Coal Field: Boulder-Weld

Seam: Unnamed

Strike and Dip: N45E & 4°

Mining Method: Drift

Years of Operation: 1914-1946

Production: 164,064 tons

DATA COLLECTION

2005 – Inventory

2013 – Inventory
- Magnetometer
- Fissure mapping
- Snowmelt mapping
- Coal outcrop mapping
- Mine maps

2018 – Inventory
- Snowmelt Pictures
- 3D surface mapping
- Orthophotography
- Aerial thermal mapping

In October 2003, it was reported that the fire showed very little activity; there was only one active vent, which had air temperatures 30 degrees above normal ground temperatures (Renner, 2005). By 2013, no vents were observed and only a small, 5ft x 10ft, patch of bare ground near the coal seam outcrop did not hold snow after a storm. During the 2013 inventory the fire was observed to be in a dormant state (Koveva Ltd, 2013).

FIRE OBSERVATIONS

The fire was visited on February 8, 2018 to collect aerial orthophotography and thermal images, 3D surface mapping, and analyze potential fire risks. No venting or elevated surface temperatures were observed at this time. Aerial thermal images showed substantial subsidence has occurred around and under a concrete aqueduct. A cavity approximately 3ft tall, 10ft wide, and 30ft long has developed underneath the concrete aqueduct (Figure 4-1). This is not believed to be related to the fire.

On February 12, 2018, the site was revisited to collect snowmelt pictures. One vent (Figure 4-2) was found at 39° 57' 31.93", 105° 13' 10.49". The gas temperature was slightly above ambient. The landowner mentioned that he has observed steam and snowmelt in the winter time in an area south of the lined irrigation ditch, but that area was not active at the time of this inventory.

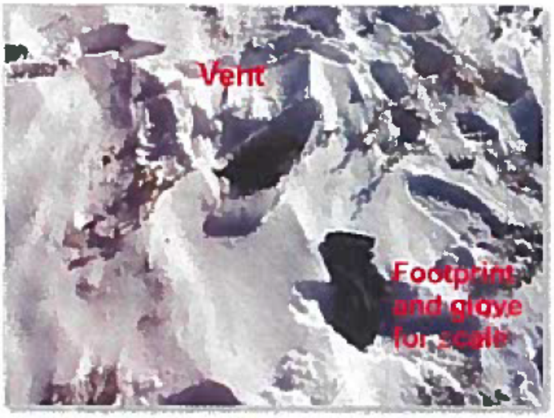


Figure 4-2 – Lewis Mine Fire Vent

FIRE RISK AND RECOMMENDATIONS

The fire's activity is very low and thus presents little public safety risk or potential to start a surface fire. While part of the fire is on City of Boulder Open Space, the parcel sees limited activity in the vicinity of the fire. No fire abatement work is recommended for the Lewis fire because of this low potential risk.

Figure 4-3 – Lewis Mine Fire Location Map

DIRECTIONS TO FIRE

From Boulder, CO, take Hwy 93 south to Marshall Rd and turn left (east). Stay on Marshall Rd for 0.5 miles, then turn left (north) onto Cherryvale. Fire is on the right (east) side of the road.

4.1.2 Marshall Mine

Figure 4-4 – Marshall Mine Fire Looking South

FIRE DESCRIPTION

The Marshall mine fire site is located approximately 1 mile south of Boulder, CO on the southeast corner of the intersection of Hwy 93 and Marshall Road. The mine fire is located on City of Boulder Open Space.

In October 2003, it was reported that the fire was moderately active with ground temperatures ranging from 118°F to 130°F. The smell of coal combustion was noted near the venting fractures (Renner, 2005).

In February 2005, a recently constructed building was inspected for damage caused by subsidence believed to be related to the Marshall Coal Mine. Vents and subsidence features were identified under and around the building (Amundson, 2005).

On December 20, 2005, a brush fire was started by a hot vent from the Marshall Coal Mine Fire. The fire was quickly contained and extinguished. The origin of the fire was traced back to a 373°F vent. In January 2006, fire abatement was undertaken by the Office of Surface Mining to fill in vents with small rock material to reduce the potential of starting another surface fire. 275 tons of unwashed aggregate was placed over the vent area to a total depth of 18 inches (Blackburn, 2006).

In 2016, two areas of trough subsidence were excavated, compacted, and backfilled to natural grade. Both areas, shown on Figure 4-4, were in areas where surface expression of the mine fire had been observed. During the subsidence mitigation work, a few small vents were uncovered in both locations. In all cases, the exhaust was warm, moist air with temperature less than 90°F. No new evidence of subsidence or other indicators of the coal mine fire were observed during the completion of the remedial activities. Gas monitoring during construction did not detect gases associated with coal combustion over the background levels.

FIRE ACTIVITY

Very Low

FIRE HAZARD RANKING

19 of 38

LOCATION

Latitude: 39°57'16.92"

Longitude: 105°13'45.84"

Nearest Town: Boulder, Colorado.

Landowner: Public

MINE INFORMATION

Coal Field: Boulder-Weld

Seam: Unnamed

Strike and Dip: N45E & 4°

Mining Method: Drift

Years of Operation: 1863-1939

Production: Unknown

DATA COLLECTION

2005 – Inventory

2013 – Inventory
- Magnetometer
- Fissure mapping
- Snowmelt mapping
- Coal outcrop mapping
- Mine maps

2018 – Inventory
- Snowmelt Pictures
- Surface Feature Mapping

FIRE OBSERVATIONS

The fire was visited October 2018 after one inch of snow fell the previous night. The fire area was inspected, and no signs of fire features or snowmelt were observed. Additionally, no coal combustion odors were noted during the site visit. The area was not imaged with a UAS due to City of Boulder Open Space restrictions. Drone perspective photographs were collected from outside the property boundary.

FIRE RISK AND RECOMMENDATIONS

The fire's activity is very low and thus presents little potential to start a surface fire. Although the fire is on City of Boulder Open Space and near the Marshall Mesa parking lot, the off-trail fire area sees little foot traffic, and there are no dangerous surface features. The fire poses limited risk to public safety.

No abatement is recommended. This fire has behaved erratically in the past, so it is recommended that it be monitored annually to check for increases in fire activity.

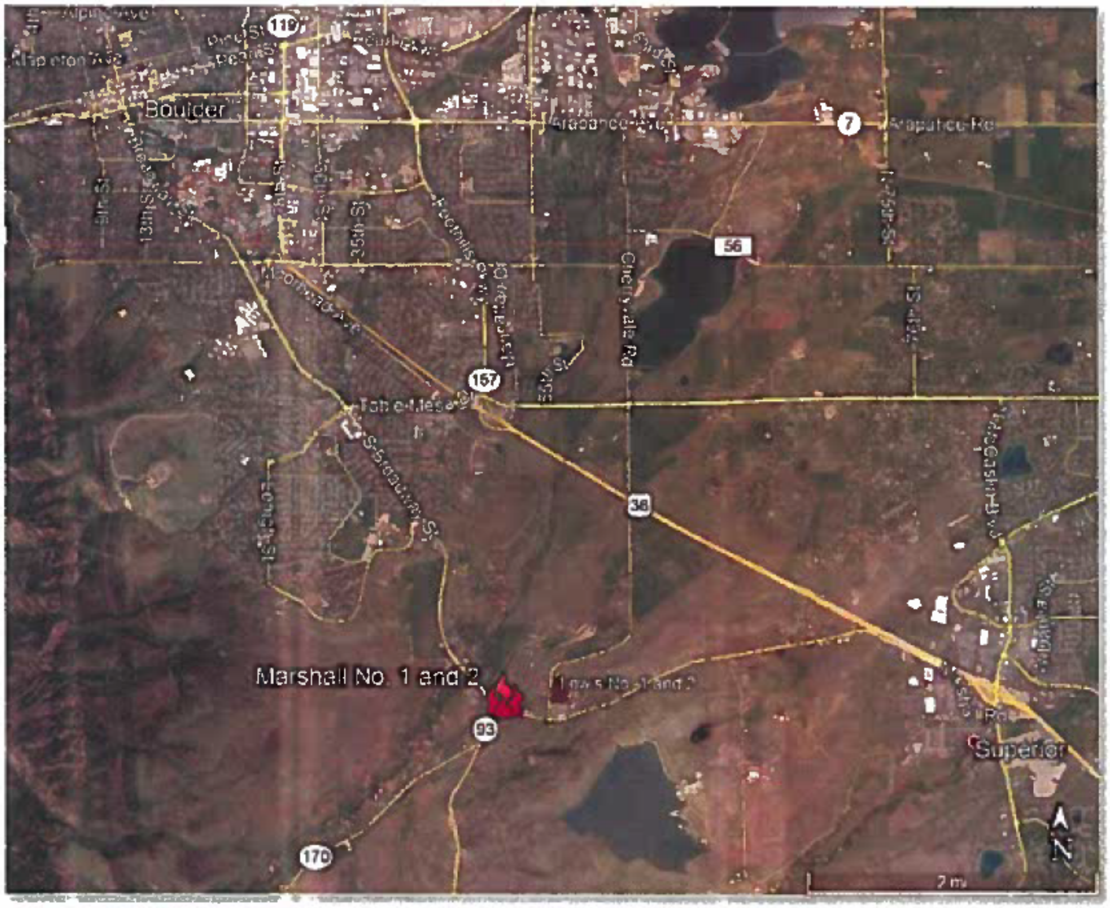


Figure 4-5 – Marshall Mine Fire Location Map

DIRECTIONS TO FIRE

From Boulder, CO, take Hwy 93 south to Marshall Rd and turn left (east). Take the immediate right (south) into the Marshall Mesa Open Space parking lot. The fire is to the northeast of the main parking lot.

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 12

Colorado Division of Reclamation, Mining, and Safety

Marshall Mine Fire Gas Analysis Memo 1/7/2022

TETRA TECH

MEMO

To:	Rachel Nickless – State of Colorado DRMS Erica Crosby – State of Colorado DRMS Tara Tafi - State of Colorado DRMS
From:	Max Johnson P.E. - Tetra Tech Jeff Nuttall P.G. - Tetra Tech
Date:	January 11, 2021
Subject:	Marshall Mesa Open Space Site Visit Jan 7, 2022 – Gas and Temperature Readings

On January 7, 2022, State of Colorado Division of Reclamation, Mining, and Safety (DRMS) requested Tetra Tech collect a gas and temperature readings on fractures and holes south of the Marshall Mesa trailhead between Hwy 93 and the Coal Seam trail. Tetra Tech arrived on site at 12:00pm with a FLIR Infrared (IR) thermometer, Trimble R2 GPS unit and a Landtec GEM 5000 gas analyzer with the capability to measure the constituents listed in **Table 1**.

Table 1. Landtec GEM 500 Gas Analyzer

Equipment	Gases Analyzed				
Landtec GEM 5000	Methane (%)	Carbon Dioxide (%)	Oxygen (%)	H2S (ppm)	Carbon Monoxide (ppm)

United States Forest Service representatives directed DRMS and Tetra Tech personnel to the locations of fractures and holes in question. The IR thermometer was aimed at the deepest part of the fracture or hole away from snow when possible, to take a reading representative of venting atmosphere/gas temperature. The gas analyzer's silicone inlet tube was inserted as far in the hole as possible in the direction of suspected air movement and the analyzer was turned on. The analyzer was run long enough (typically 1 to 2 minutes) to purge the suction line, for the gas reading to stabilize and to understand if there were short term fluctuations in gas concentrations. The factures and holes were numbered from south to north with MV1-MV9 being located in and along a southwest to northeast trending fractured rock outcrop. MV10 was located in an area of slightly mounded soil experiencing snow melt and was one of a few small holes trending in a line southwest to northeast. **Table 2** presents the gas concentration and temperature readings of each feature.

Table 2. Gas and Temperature Readings

Feature	Temperature Readings	GEM 500 Readings				
		CH4	CO2	O2	H2S	CO
	°F	%	%	%	PPM	PPM
Ambient	26.6	0	0.1	20.9	1	1
MV1	29.2	0	0.1-0.4	20.7	0	0
MV2	26.2	0	0.1-0.9	20.6	0	0
MV3	26.9	0	0.2	21.1	0	0
Ambient Check	26.9	0	0.1	21.0	0	0
MV4	26.9	0	0.1-2.2	21.0	0	0
MV5	26.6	0	0.1	20.9	0	0
MV6	25.9	0	0.0-0.1	20.8	0	0
MV7	26	0	0	20.9	0	0
MV8	27.1	0	0.4	20.6	0	0
MV9	23	0	0.2	20.8	0	0
MV10	36	0	10.7	11.9	1	528

Description of Typical Mine and Mine Fire Atmosphere

In general, unventilated underground coal mine atmospheres may contain increased concentrations of methane (CH_4) due to off gassing from the intact coal, increased carbon dioxide (CO_2) as a product of the coal oxidation process, and in some cases with active and prolonged coal oxidation, small concentrations of carbon monoxide (CO) may be present. Oxygen (O_2) concentrations can be reduced in these atmospheres as it is consumed in the oxidation process.

Underground mine fire atmospheres generally have increased CO_2 levels along with increased CO levels. O_2 levels are typically reduced as it is used up in the combustion process. It is also possible to have some increased levels of CH_4 and other hydrocarbons in mine fire atmospheres depending on the location of the measurement point in proximity to the burning front of the coal fire and O_2 availability. Typically, indicators of the presence of a mine fire are increased carbon dioxide readings along with high concentrations of CO. There are some situations where high concentrations of CO will not be detected as part of a mine fire atmosphere, but this typically occurs in long established mine fires with an ample supply of O_2 and high heat. Mine Fire atmosphere temperatures typically range from 80°F to greater than 1000°F depending on fire activity.

Observations

Locations MV1 through MV9 gas concentrations are typical of closed mine atmospheres with minor venting and minor coal oxidation (slightly increased CO_2 levels and slightly decreased O_2 levels). The temperatures are atypically low for venting mine atmospheres most likely due to minimal amount of venting flowrate and cooling and mixing with ambient air in the fractured rock outcrop. None of the fractures or vents had noticeable air venting from them. Fluctuation of gas readings from near ambient conditions up to the readings listed in the table also suggests low flowrate mine atmosphere air venting that is mixing with ambient air prior to the gas analyzer inlet. There was evidence of animal (rodents and rabbits) in some of the holes sampled, potentially using them as burrows. Hair can be seen on the moss around MV5 in Photo 5. This is supported by video taken during a UAV thermal flight on January 8, 2022 of a rodent running in and out of the fractures in the rock outcrop.

MV10 gas concentrations are typical of coal oxidation or very low activity, smoldering mine fire. Gas analyzer readings from this hole fluctuated from near ambient concentrations to the concentrations shown in Table 2. The MV10 feature temperature is atypically low for mine fires potentially due to the minimal amount of venting flowrate and cooling/mixing of the gases as they near the surface.

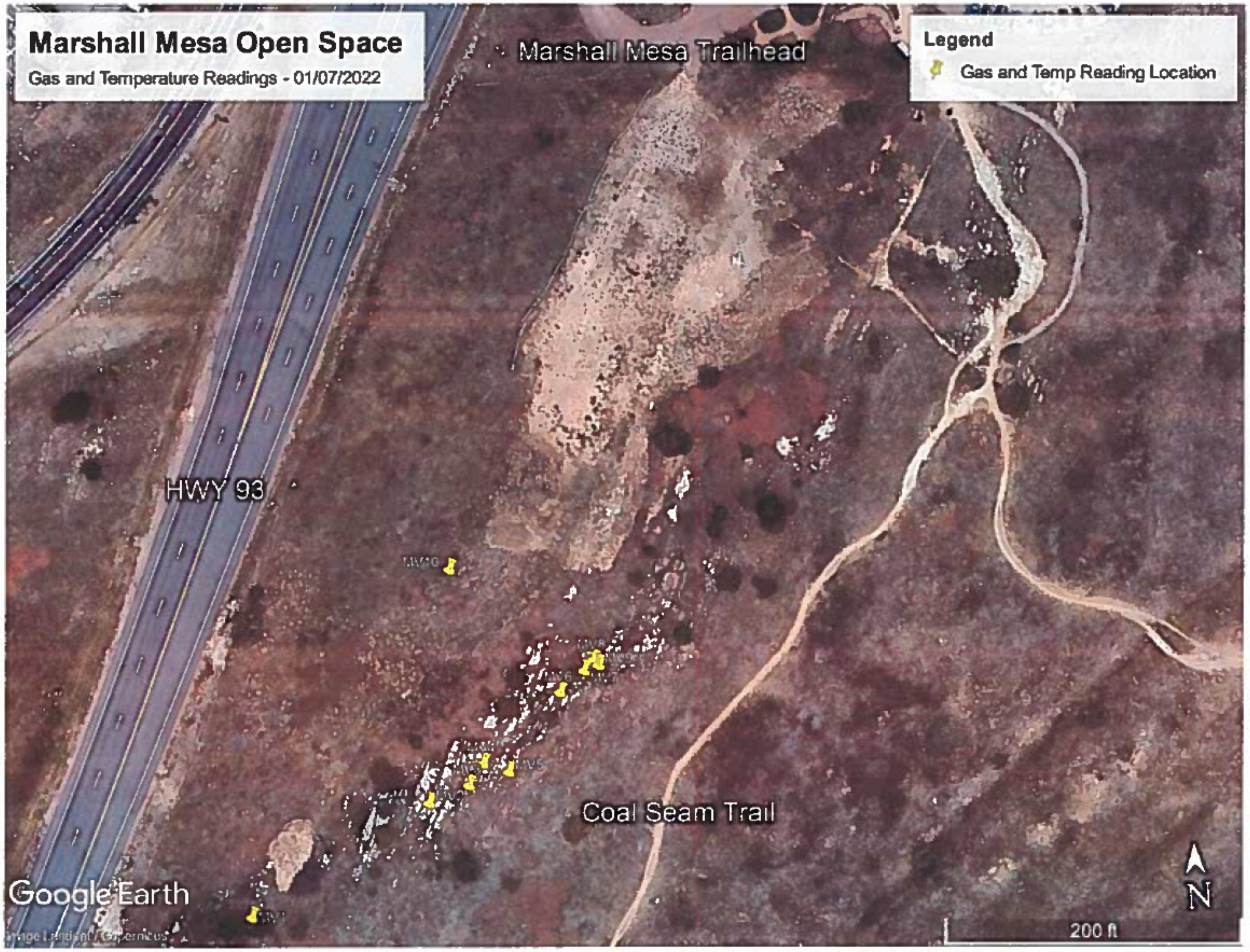


Figure 1. Map of Gas and Temperature Reading Locations

Photo 1. MV1

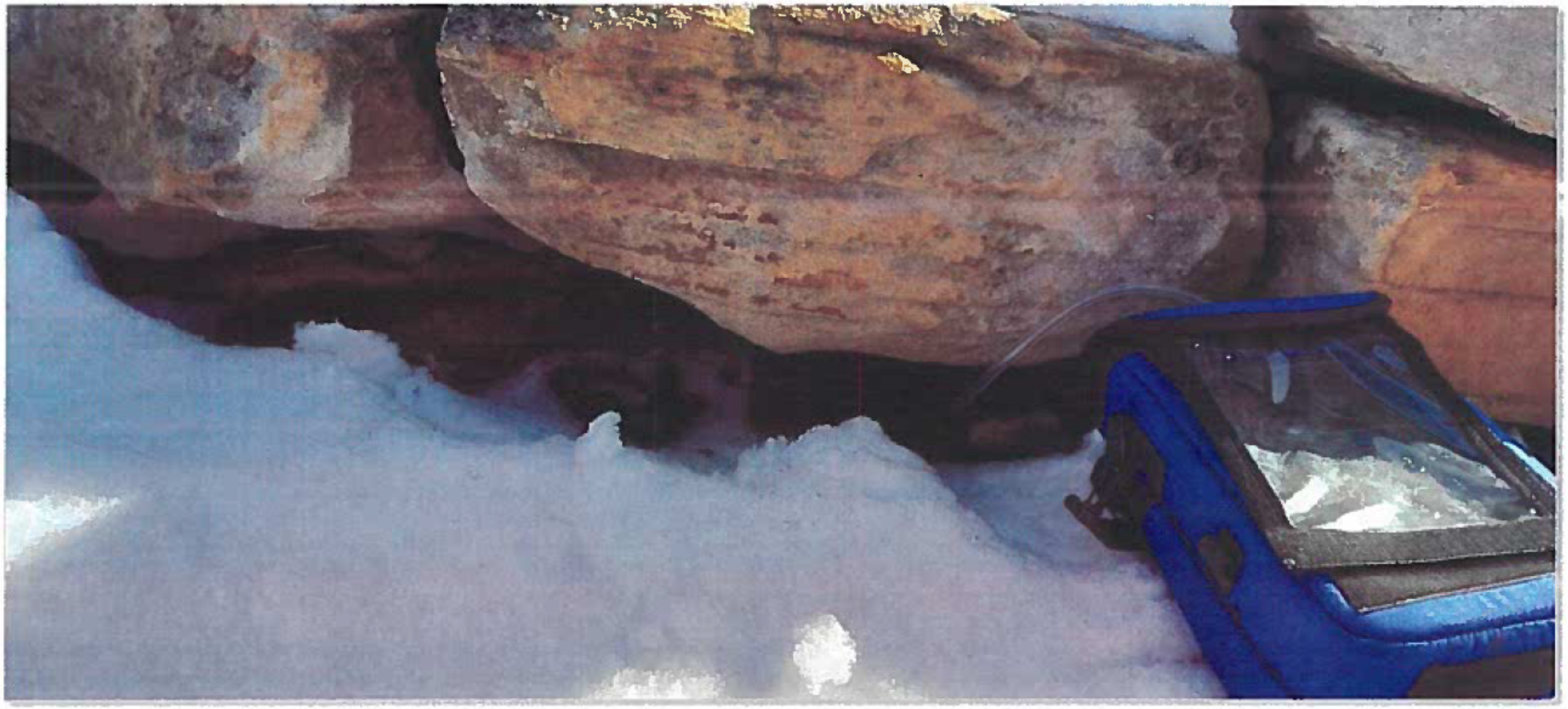


Photo 2: MV2.

Photo 3: MV3

Photo 4: MV4

Photo 5: MV5

Photo 6: MV6

Photo 7: MV7

Photo 8: MV9

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 13

Colorado Division of Reclamation, Mining, and Safety

Marshall Mine Fire UAV Thermal Memo 1/8/2022

TETRA TECH

MEMO

To:	Rachael Nickless – State of Colorado DRMS Erica Crosby – State of Colorado DRMS Tara Tafi - State of Colorado DRMS
From:	Max Johnson P.E. - Tetra Tech Jeff Nuttall P.G. - Tetra Tech
Date:	January 11, 2022
Subject:	Marshall Mesa Open Space Site Visit Jan 8, 2022 – Unmanned Aerial System Thermal Inspection

On January 8, 2022, State of Colorado Division of Reclamation, Mining, and Safety (DRMS) requested Tetra Tech to perform an Unmanned Aerial Systems (UAS) thermal investigation in the vinicity of the Marshall Mesa Open Space trailhead at the intersection of HWY 93 and Eldorado Springs Road. Specific areas for UAS inspection included the area south of the trailhead bounded by Hwy 93 to the west, Davidson Ditch to the south, and coal seam trail to the east up to the Davidson Ditch and west of Coal Seam trail, the area north of the Marshall Mesa trailhead up to Marshall Road, and a high level inspection of the Marshall Mesa Open space east of HWY 93 and south of Marshall Road within ¼ mile of the trailhead parking lot. This thermal inspection is a follow up to the feature inspection (gas and temperature readings) performed the previous day, January 7, 2022, on features south of the trailhead. Tetra Tech inspected the area using a DJI Matrice 300 UAS with high resolution thermal camera at 9:30pm on January 8, 2022. Weather conditions during the daylight hours on January 8 were cool and overcast meaning that residual solar heat in rocks would be minimal allowing for the collection of more informative data. Snow was present on the ground in areas.

The area south of the trailhead along HWY 93, which included the reclaimed surface of the 2017 DRMS project area and the fractures and holes immediately south of reclaimed area was flown to develop a surface thermal map. The area was also inspected at low altitude using video and perspective pictures. Besides those features no additional features of interest were noted besides those inspected on January 7, 2022. Fracture and hole temperatures south of the reclaimed area were between ambient (~18°F-22°F) and 29°F. Features on the reclaimed area present on the surface as periodic holes likely along a buried fracture. These features ranged in temperature between ambient and 33°F. The 33°F feature is location MV10 indentified during the January 7 site visit which was 36°F(measured using Infrared thermometer) and had measurable combustion gases.

The area north of the Marshall Mesa trailhead and south of Marshall Road was flown to create a surface thermal map. Some fractures with slightly elevated temperature were noted. These temperatures were between ambient and 30°F. These fractures appear in two areas of outcropping rock. No other thermal anomalies were observed from the UAS thermal flight in this area.

Finally, a high level flight was performed to inspect areas of Marshall Mesa Open Space within ¼ mile of the trailhead to look for any thermal anomalies. Nine hundred feet east-southeast of the trailhead near a project labeled "Marshall No. 3" in the CO DRMS brass cap Google Earth layer, several high temperature features were identified. A feature 220 feet north of the Marshall Valley Trail registered a temperature higher than the maximum that the UAS thermal camera can measure (302°F). The rest of the features identified lie along the Davidson Ditch approximately 150-250 feet south of the Marshall Valley Trail. These features measure, 75°F, 227°F, 53°F, and 55°F. It is recommended that these features receive follow up on-ground inspection.

It is important to note that while UAS thermal inspections can be very helpful in locating thermal anomalies that may be missed during on-ground inspections, it is possible for the UAS thermal camera to miss anomalies due to obstructions like trees and rocks, anomaly size and UAS flight altitude.

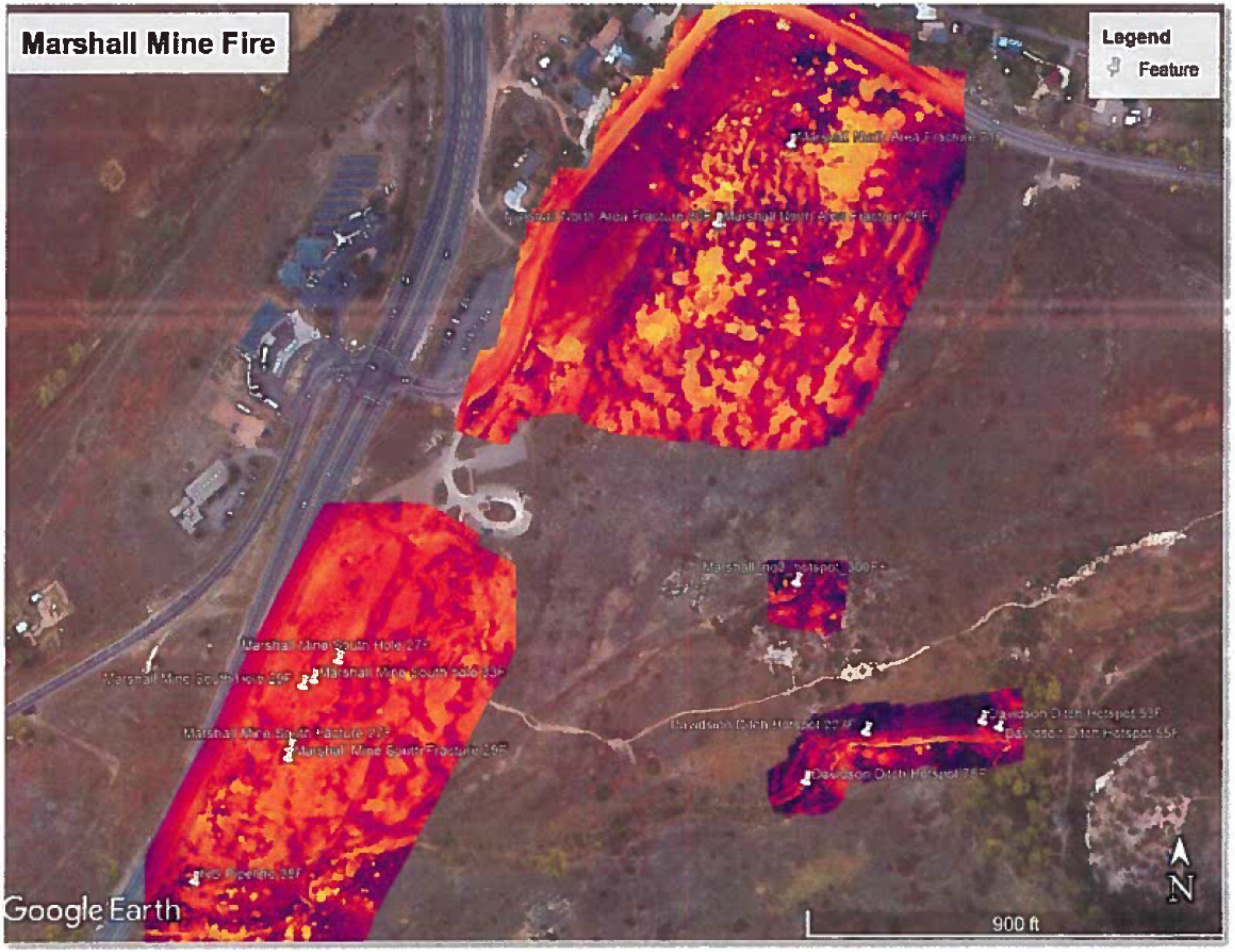


Figure 1. Overview of Thermal maps created from data collected 1/8/2022

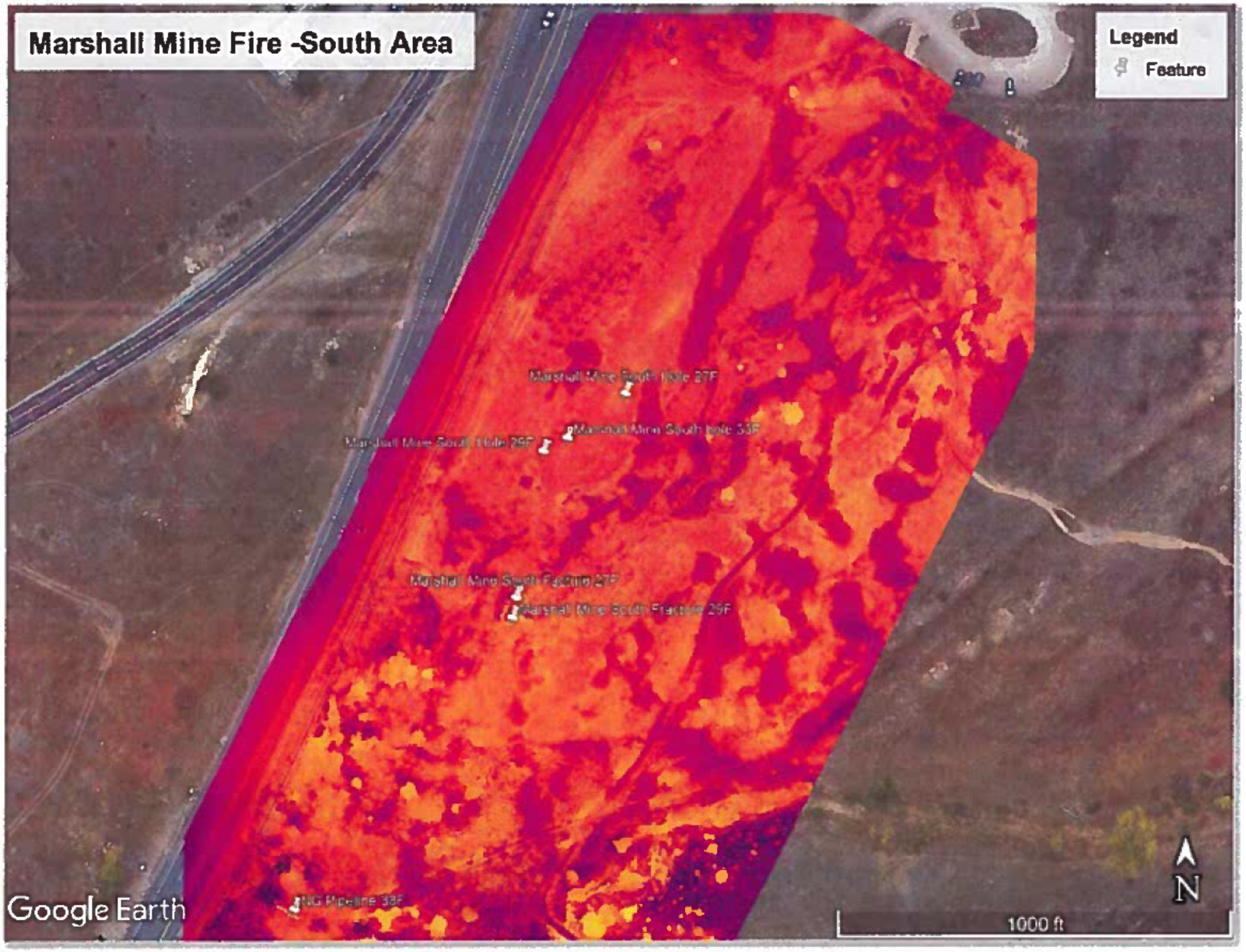


Figure 2 – Marshall Mine Fire – South Area Map

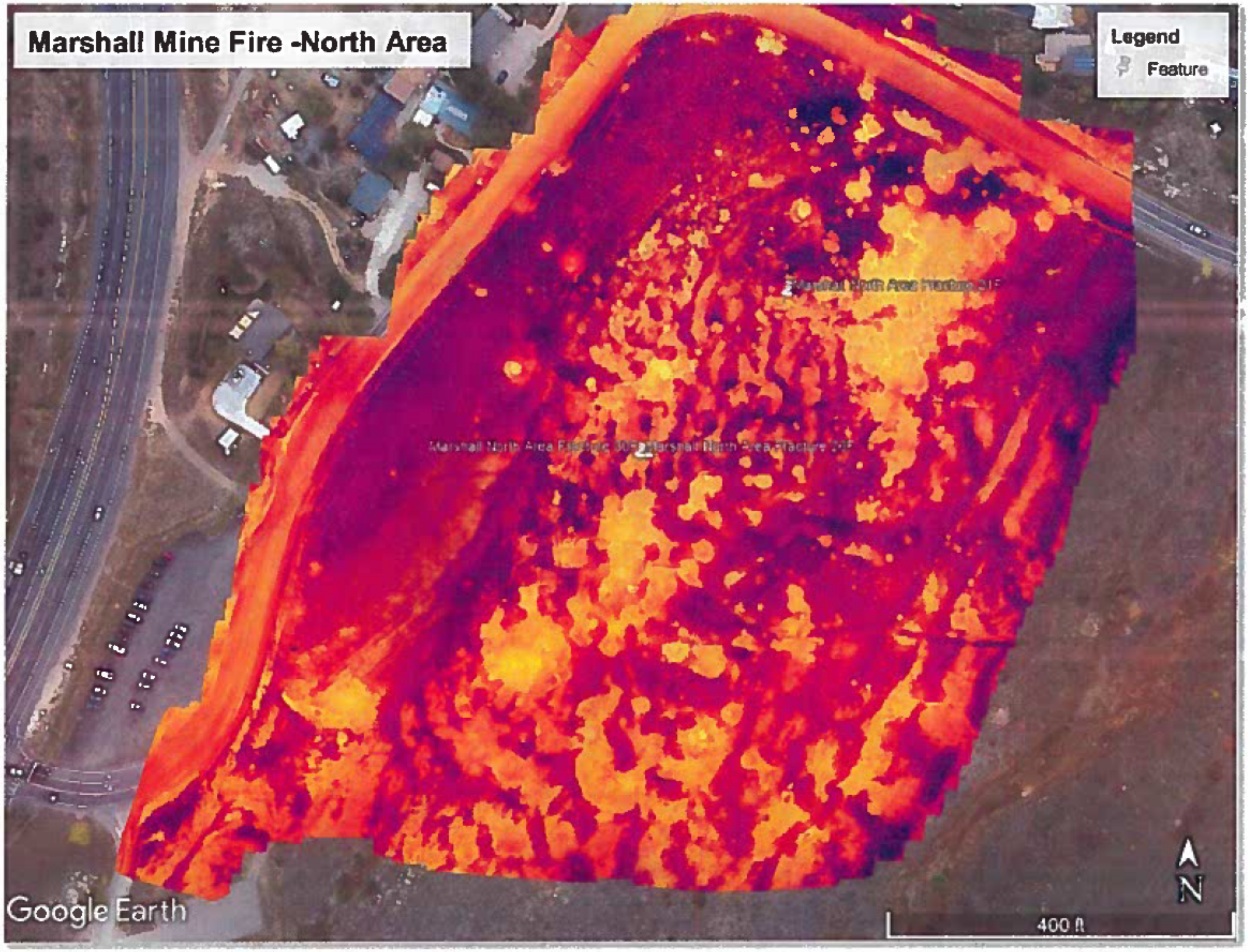


Figure 3 – Marshall Mine Fire – North Area Map

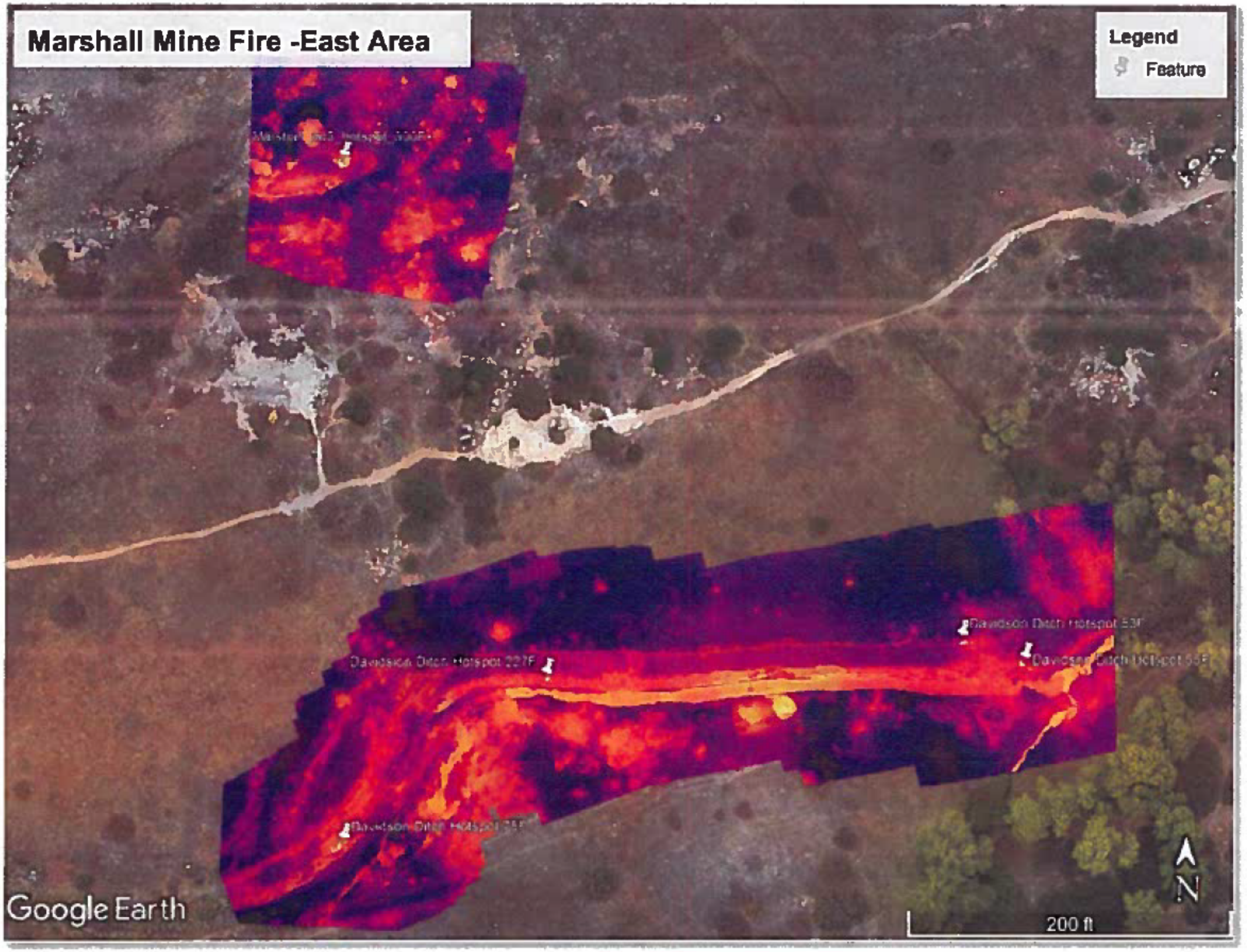


Figure 4 – Marshall Mine Fire – East Area

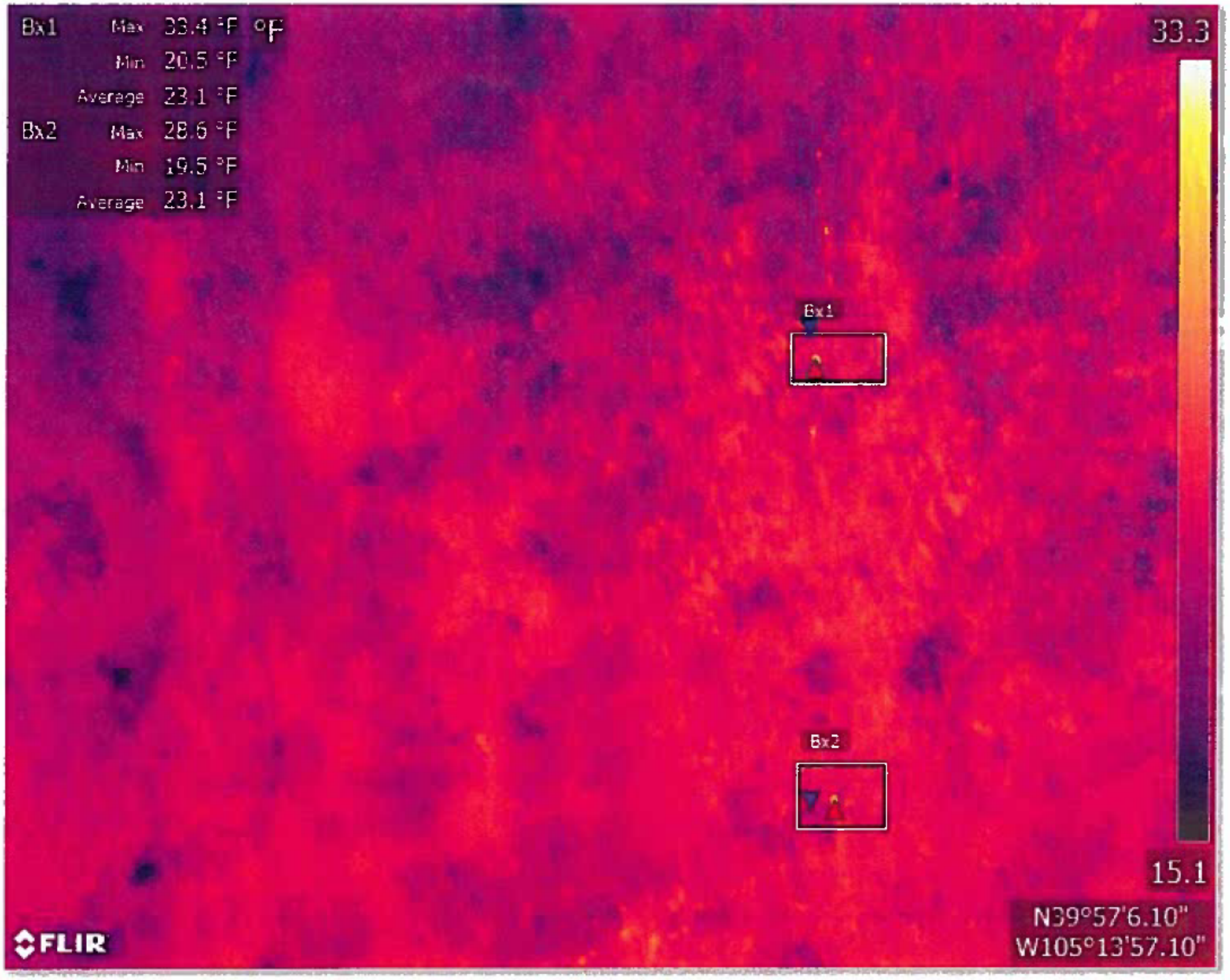


Photo S1 – Holes along buried fracture in Reclaimed Surface

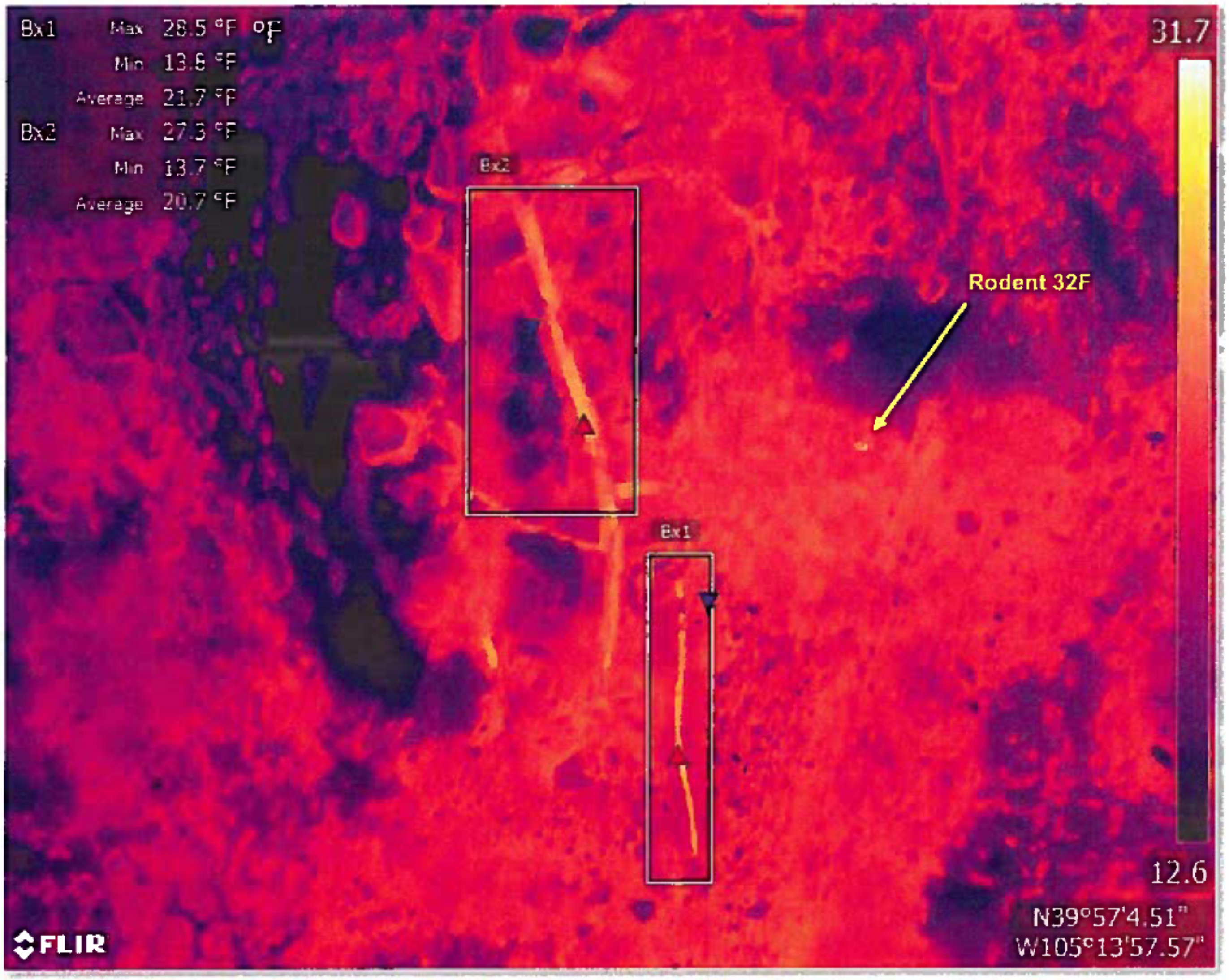


Photo S2 – Fractures in Outcrop South of Reclaimed Area

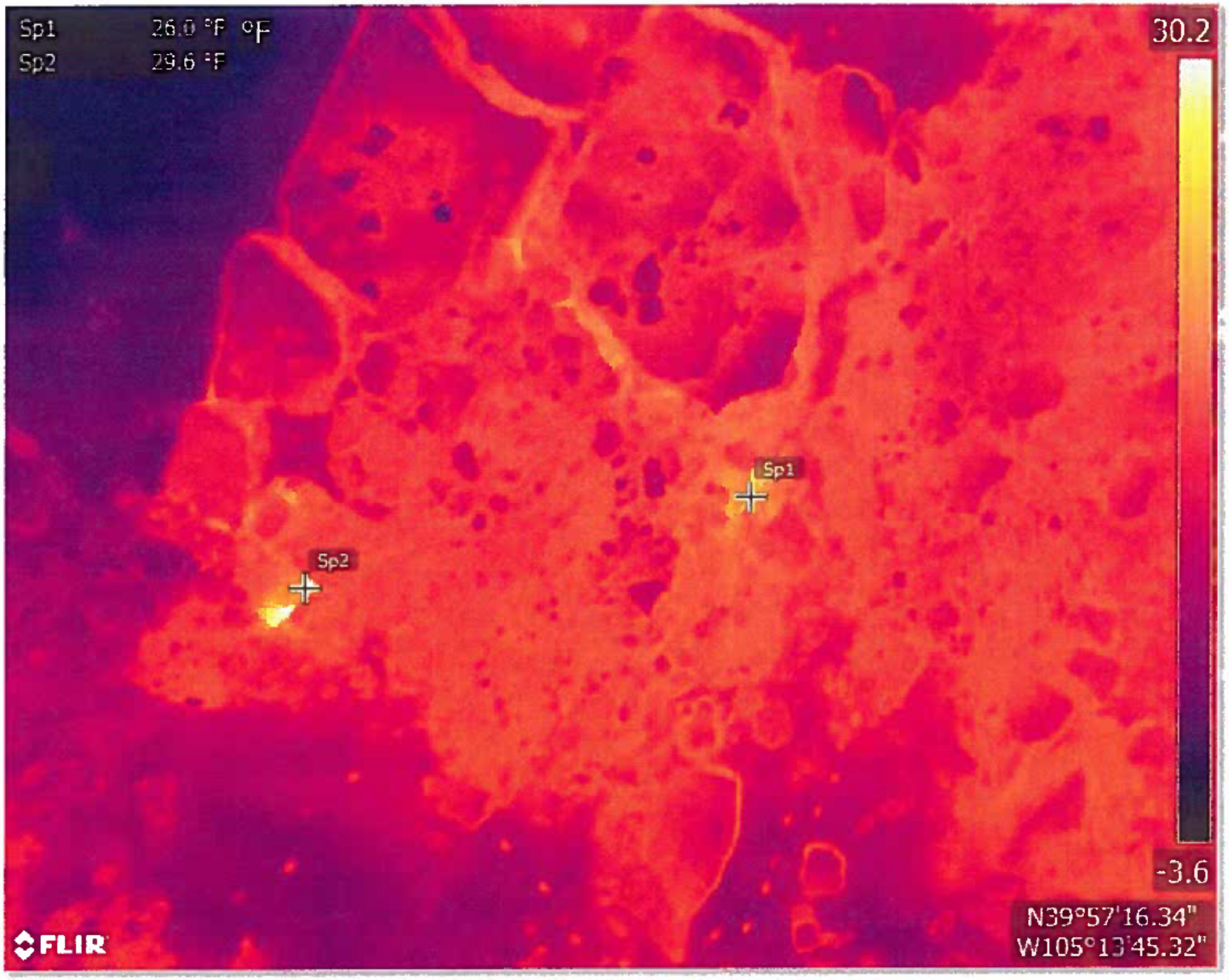


Photo N1 – Feature in Outcrop

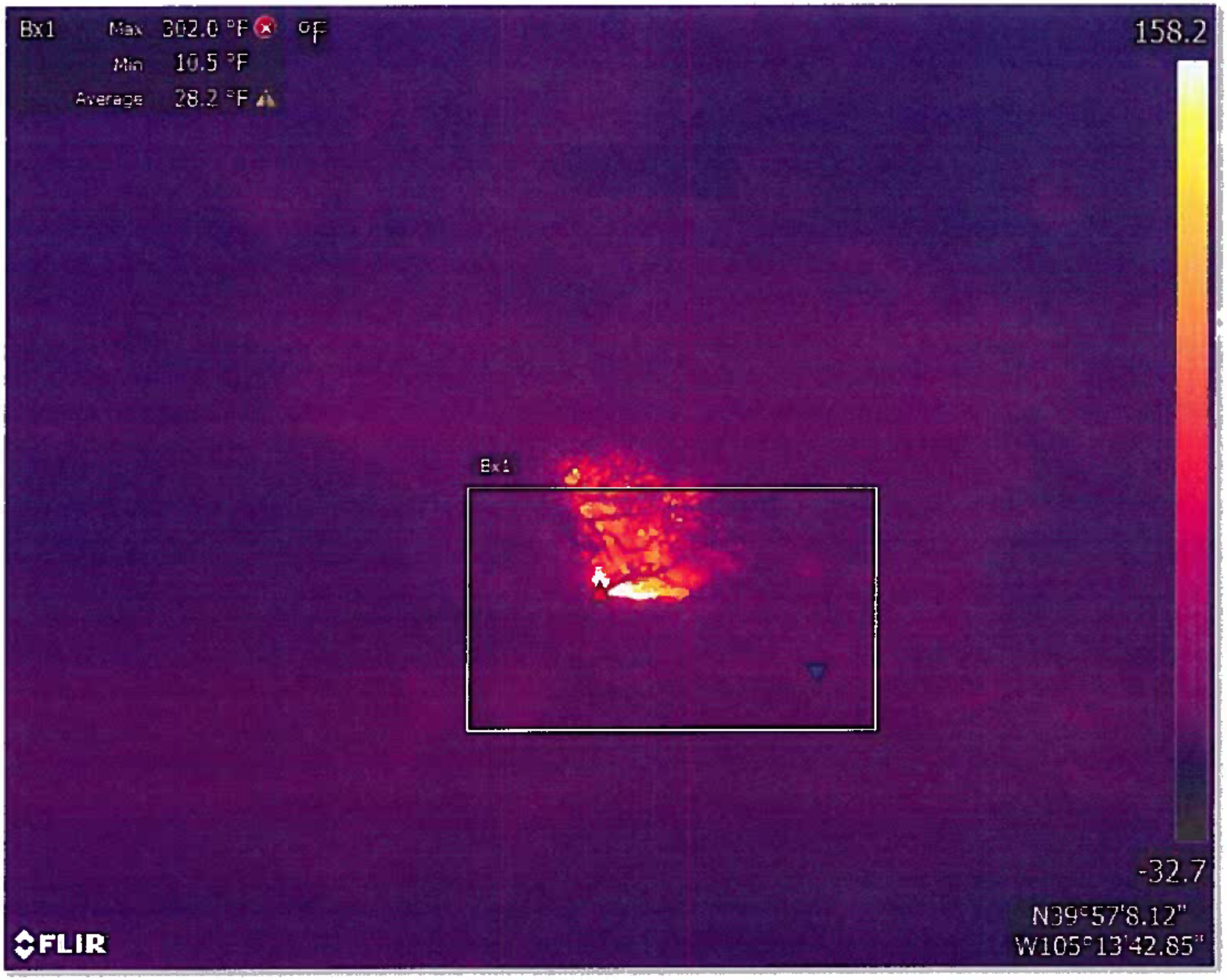


Photo E1 – >302F Hotspot North of Marshall No. 3

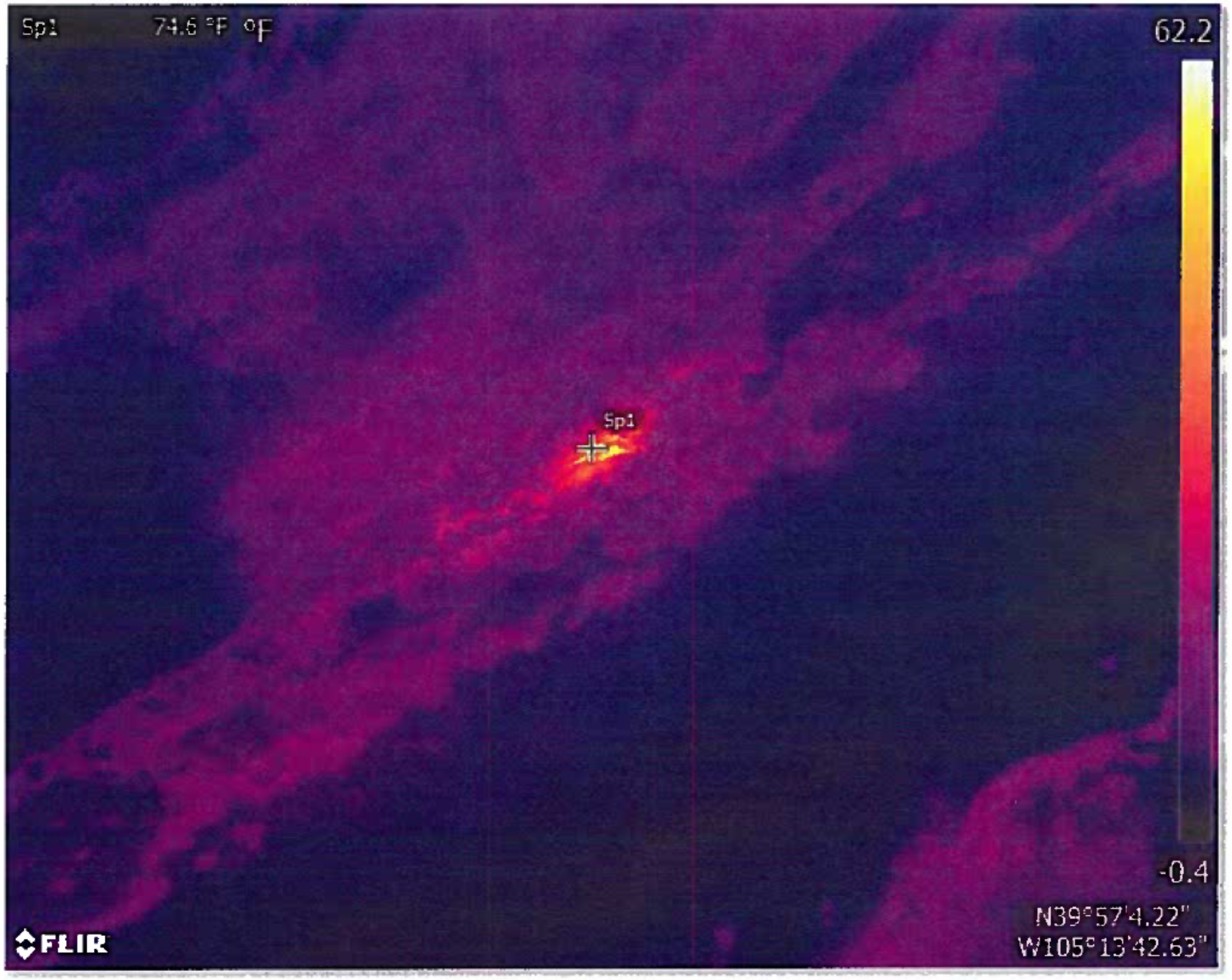


Photo E2 – Western Most Hotspot on Davidson Ditch

Photo E3 – 225F Hotspot on Davidson Ditch

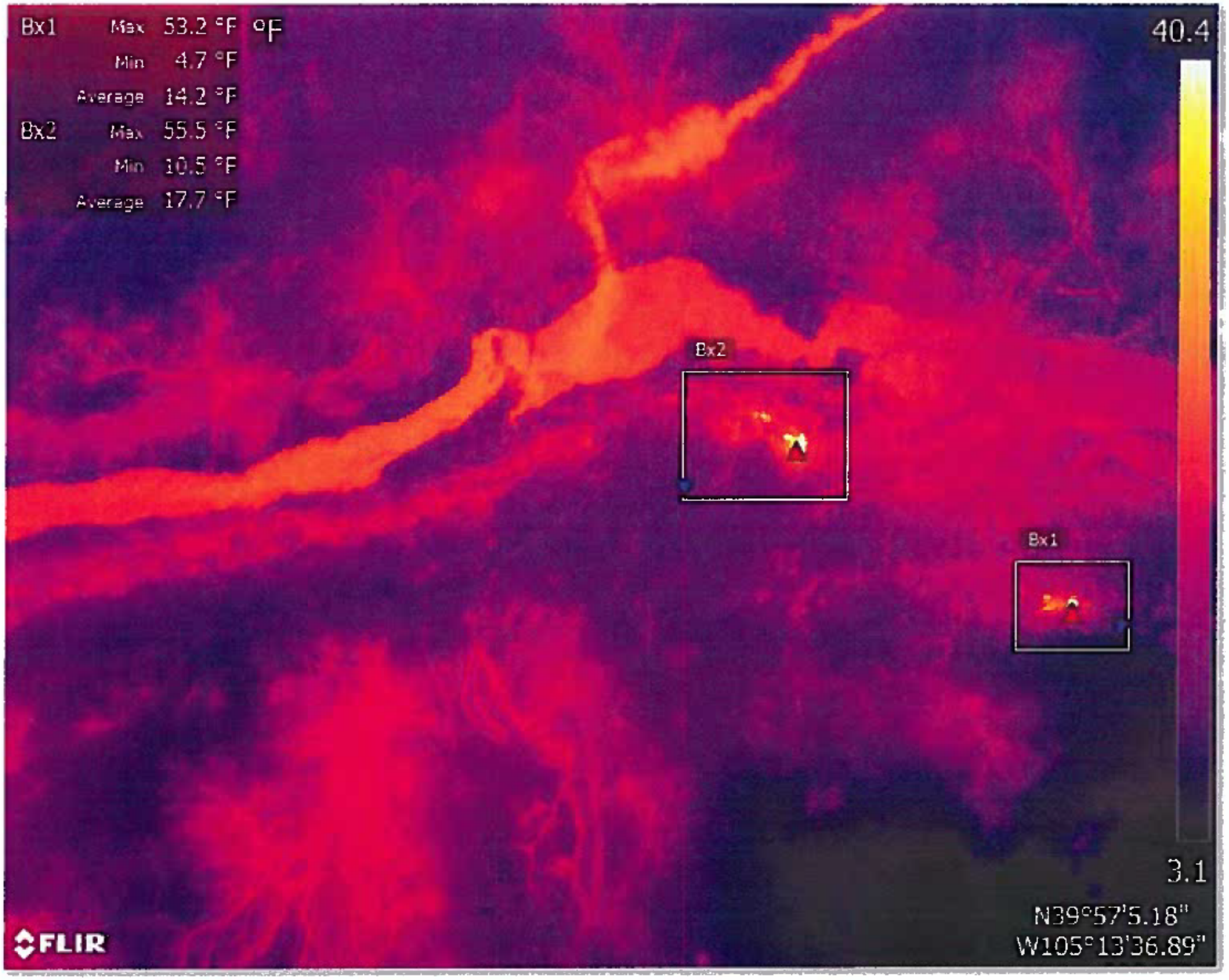


Photo E4 – Eastern Most Hotspots on Davidson Ditch

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 14

Colorado Division of Reclamation, Mining, and Safety

Marshall Mine Fire Gas Analysis Memo 1/14/2022

TETRA TECH

MEMO

To:	Rachael Nickless – State of Colorado DRMS Erica Crosby – State of Colorado DRMS Tara Tafi - State of Colorado DRMS
From:	Max Johnson P.E. - Tetra Tech Jeff Nuttall P.G. - Tetra Tech
Date:	January 25, 2022
Subject:	Marshall Mesa Open Space Site Visit January 14, 2022 – Gas and Temperature Readings

On January 12, 2022, State of Colorado Division of Reclamation, Mining, and Safety (DRMS) requested Tetra Tech collect a second round of gas and temperature readings on fractures and holes south of the Marshall Mesa trailhead between Hwy 93 and the Coal Seam trail as a follow-up to the first inspection performed on January 7, 2022. Tetra Tech performed the temperature and gas check at 1:00pm on January 14, 2022 with a FLIR Infrared (IR) thermometer, Trimble R2 GPS unit and a Landtec GEM 5000 gas analyzer with the capability to measure the constituents listed in **Table 1**.

Table 1. Landtec GEM 500 Gas Analyzer

Equipment	Gases Analyzed				
Landtec GEM 5000	Methane (%)	Carbon Dioxide (%)	Oxygen (%)	H2S (ppm)	Carbon Monoxide (ppm)

Tetra Tech used a Trimble R2 GPS survey antenna to find locations MV1-MV10 of the initial gas and temperature readings. As before, the IR thermometer was aimed at the deepest part of the fracture to take a reading representative of venting atmosphere/gas temperature. The gas analyzer's silicone inlet tube was inserted as far in the hole as possible in the direction of suspected air movement and the analyzer was turned on. The analyzer was run long enough (typically 1 to 2 minutes) to purge the suction line, for the gas reading to stabilize and to understand if there were short term fluctuations in gas concentrations. **Table 2** presents the gas concentration and temperature readings of each feature.

Table 2. Gas and Temperature Readings

Feature	Temperature	GEM 500 Original Readings				
		CH4	CO2	O2	H2S	CO
	°F	%	%	%	PPM	PPM
Ambient/Cal	33	0	0.1	20.9	0	0
MV1	33	0	0.1	20.9	0	0
MV2	35	0	0.5	20.7	0	0
MV3	36	0	0.8	20.4	0	0
MV4	36	0	0.1	20.9	0	0
MV5	35	0	0.3	21.0	0	0
MV6	32	0	0.1	21.3	0	0
MV7	32	0	0.1	21.4	0	0
MV8	30	0	0.1	21.4	0	0
MV9	28	0	0.1	21.0	0	0
MV10	40	0.1	12.9	8.5	0	218

Observations

Observations were similar to those of the first gas and temperature check performed on January 7, 2022. Fracture temperatures were around ambient temperatures with only MV10 being considerably (7°F) above ambient. No venting gases were detected.

Figure 1. Map of Gas and Temperature Reading Locations

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 15

Colorado Division of Reclamation, Mining, and Safety

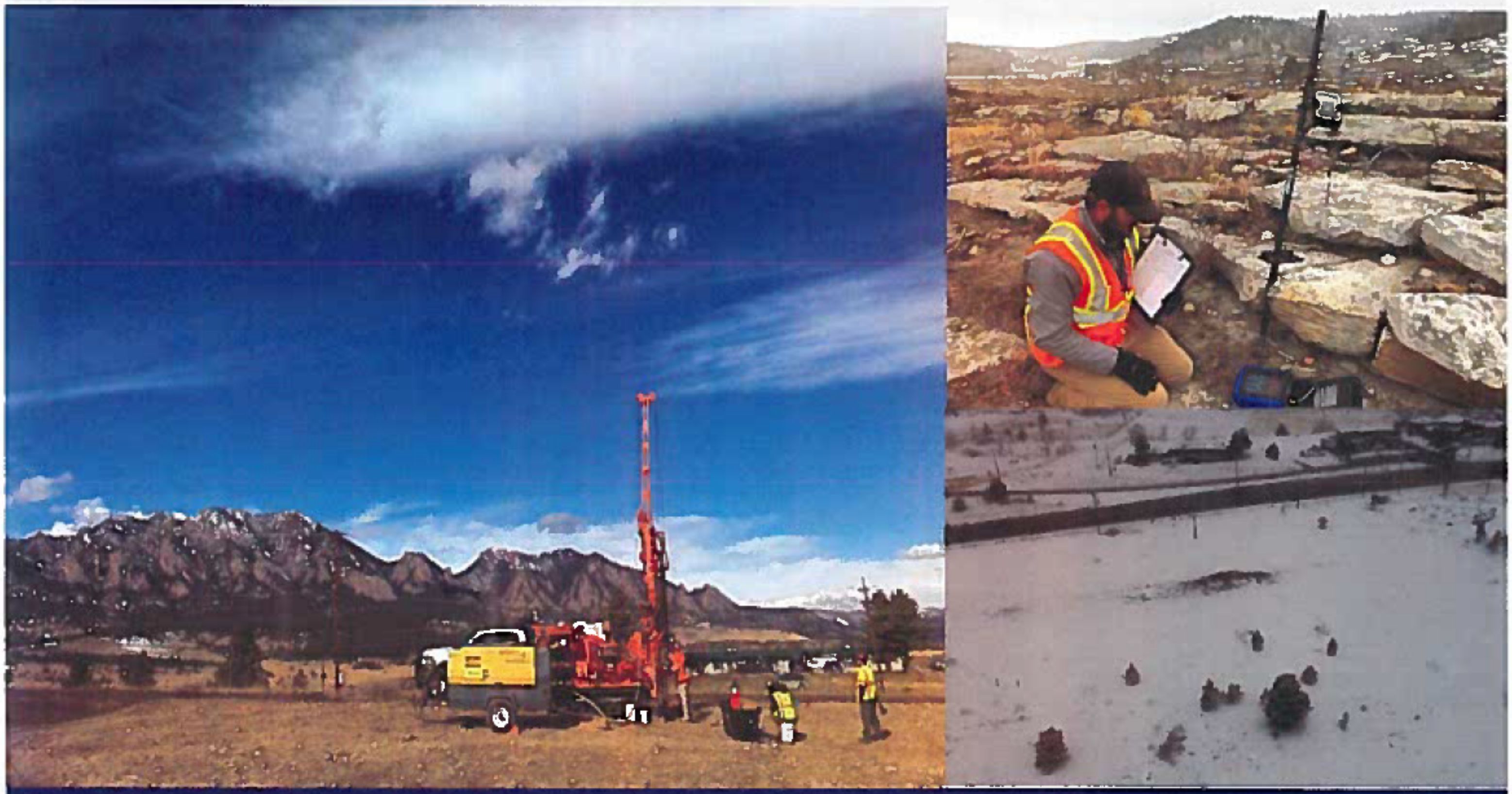
Marshall Mine Drill Preliminary Report

COLORADO
Division of Reclamation, Mining and Safety
Department of Natural Resources

TETRA TECH

Marshall Mesa Underground Coal Fire Investigation

Report of Preliminary Investigations



March 16, 2022

#114-910599

Report of Preliminary Investigations Marshall Underground Coal Fire

#114-910599
March 16, 2022

PRESENTED TO

Colorado Department of Natural Resources
Division of Reclamation, Mining, and Safety
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Disclaimer

The contents of this report do not necessarily represent the views or policies of the State of Colorado Department of Natural Resources, Division of Reclamation, Mining, and Safety, or United States Department of the Interior, Office of Surface Mining Reclamation and Enforcement. Subsurface conditions may vary from those depicted in this report. No warranty of geologic conditions is expressed or implied.

The site conditions and resulting recommendations presented in this document are based on conditions encountered at the specific underground coal mine location at the time of inspection. Due to the dynamic nature of underground coal mine fires, the complexity and variability of natural earth and rock formations and materials, significant variations may occur between and around these locations or with time. Because these data represent a very small statistical sampling of overall site conditions, it is possible that conditions may be encountered that are substantially different from those indicated. In these instances, modification and adjustment to the recommendations presented may be warranted.

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ACRONYMS/ABBREVIATIONS

Acronyms/Abbreviations	Definition
agl	Above ground level
AML	Abandoned Mine Lands
amsl	Above mean sea level
AOI	Area of Interest
bgs	Below Ground Surface
CO_2	Carbon Dioxide
CO	Carbon Monoxide
DRMS	Division of Reclamation, Mining and Safety
ft	Feet
°F	Degrees Fahrenheit
Hwy	highway
H_2S	Hydrogen sulfide
OSM	Office of Surface Mining
O_2	oxygen
No.	Number
UAV	Unmanned Aerial Vehicle or System

1. INTRODUCTION

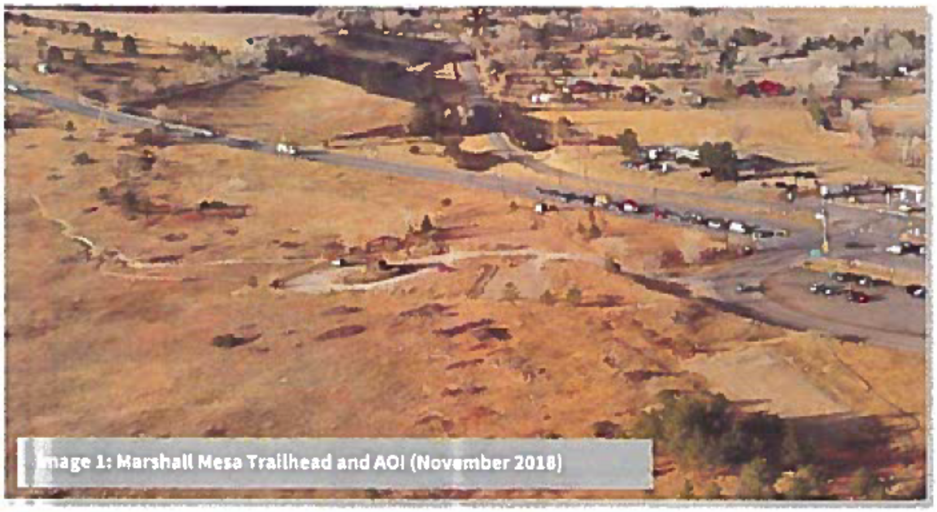
Following the Marshall Wildfire on December 30, 2021, Colorado Division of Reclamation, Mining, and Safety (DRMS) requested Tetra Tech complete a preliminary evaluation of the conditions across the southern half of the Marshall Underground Coal fire site which is located near the southwest corner of the Marshall Wildfire impacted area.

The preliminary evaluations included surface-feature temperature and combustion gas observations, unmanned aerial vehicle (UAV) based infrared thermal/visual scans, drilling investigation, and subsurface temperature monitoring. Initial site evaluation work was initiated in January and the drilling and thermocouple installations were completed by the end of February. Long-term coal seam temperature monitoring was initiated March 3, 2022. This report summarizes the findings of the initial evaluations, follow up inspections, drilling investigation, and initial subsurface temperature monitoring.

2. SITE DESCRIPTION

Location and Setting

The Marshall underground coal mine fire site is located on the City of Boulder, Colorado (Marshall Mesa Trailhead Open Space) property located south of Boulder, immediately southeast of the intersection of State Highway 93 (Hwy 93) and Eldorado Springs Road. The southern half of the of the Marshall Mesa Site or Area of Interest (AOI) for the investigations is undeveloped, open space land, owned and managed by the City of Boulder bounded by the Marshall Mesa trailhead parking area to the north, Coal Seam trail to the east, Davidson Ditch to the south, and Hwy 93 to the west (**Figure 1**).


mage 1: Marshall Mesa Trailhead and AOI (November 2018)

The site sits at an elevation of approximately 5,500 feet above mean sea level (ft amsl) and is generally flat with some hummocky areas due to suspected subsidence features related to historic coal mines. A sandstone outcrop cuts across the southern half of the AOI (at SW to NE trend). Vegetation is mostly grass with some shrubs and trees although much of the site burned during the Marshall Wildfire. **Figure 1** shows the perimeter of the Marshall Wildfire and impacted areas of the AOI.

Recent Site History

There is an extensive history of underground fires at Marshall Mesa documented through historical photographs, reports, and mine maps describing underground fires more than 100 years ago. As described in the 2018 Mine Fire Inventory report (Tetra Tech, 2019), the recent, 20-year, history highlights the dynamic, ever changing conditions at mine fire sites. During a site visit in October 2003, it was reported that the fire was moderately active with ground temperatures ranging from 118°F to 130°F. The smell of coal combustion was noted near the venting fractures

(Renner, 2005). These features were located in the northern portion of the Marshall Mesa site in a recently active subsidence feature.

In February 2005, a recently constructed building was inspected for damage caused by subsidence believed to be related to the Marshall Coal Mine. Vents and subsidence features were identified under and around the building (Amundson, 2005). The building was ultimately demolished after the property was acquired by the City of Boulder for construction of the Marshall Mesa Trailhead.

On December 20, 2005, a brush fire was started by a hot vent from the Marshall Mesa Coal Fire. The fire was quickly contained and extinguished. The origin of the fire was traced back to a 373°F vent in the northern portion of the Marshall Mesa site. In January 2006, fire abatement was undertaken by the Office of Surface Mining to fill in vents with small rock material to reduce the potential of starting another surface fire. 275 tons of unwashed aggregate was placed over the vent area to a total depth of 18 inches (Blackburn, 2006).

In 2016-2017, two areas of trough subsidence were excavated, compacted, and backfilled to natural grade. Both areas, shown on **Figure 1**, were in areas where surface expression of the mine fire had been observed. During the subsidence mitigation work, a few small vents were uncovered in both locations. In all cases, the exhaust was warm, moist air with temperature less than 90°F. No new evidence of subsidence or other indicators of the coal mine fire were observed during the completion of the remedial activities. Gas monitoring during construction did not detect gases associated with coal combustion over the background levels.

The site was visited in the morning following a small, overnight, snowstorm in October 2018. No signs of venting, heat, odors, or snowmelt were observed (Tetra Tech, 2019).

Regional Geology

The site lies in the late Cretaceous Laramie formation, west (on the footwall) of the east-dipping Fox Fault, which is the first major Laramide back thrust east of the Rocky Mountain Front Range (**Figure 2**). Units within the AOI dip six to twelve degrees to the southeast (e.g., Trudgill, 2015). Between the Fox Fault and the Gorham Fault some 500 meters southeast, multiple anastomosing fault strands create an elliptical anticlinorium elongated to the northeast.

Surface and bedrock units in the vicinity consist of late Cretaceous sedimentary rocks. The most prominent and youngest unit in the area is the Laramie Formation, a set of brackish to freshwater deposits up to 800 feet thick. The upper Laramie contains mainly clay and sandy shale, is highly variable laterally, and is easily eroded. Most surface rocks across Lake Marshall and Davidson Mesas are from the comparatively erosion-resistant shaly sandstones of lower 80–125 feet of the Laramie. A ubiquitous horizon of varnished, very durable ripple marks up to 1 inch deep at the top of the "C sandstone" member of the lower Laramie outcrops northeast of the site near Marshall Road, providing a stratigraphic marker.

In addition to the main, mapped faults (i.e., Fox, Pine Ridge, Peerless, Pittsburgh, South Gorham, and West Fox), there are a series of smaller faults present further complicating the site. The lower Laramie formation also contains nearly all of the coal seams mined in the area, with most activity concentrated in the three to eight-foot thick No. 3 Seam within the lower 40 feet of the formation, some 20 to 40 feet below the C sandstone. The underlying Fox Hills Sandstone varies from 80 to 250 feet across the Mesa because of depositional variations, inter-tonguing with the underlying shales, and duplication by faults **Figure 2**.

The Pierre Shale is an extensive clay to mudstone, though limestone and sandstone members are present at various locations and intervals within the unit's ~8,000-foot total thickness. In places, the Pierre is effectively water-soluble, spontaneously decomposing into suspended sediment and secondary settling silt and sand grains. The flat bottom of the South Boulder Creek plain in the vicinity of Marshall is entirely underlain by Pierre Shale.

Stratigraphy

The lower Laramie Formation below the C sandstone comprises alternating sandstone and shale with notable coal seams. Several coal seams have been mined in the lower Laramie in the area. At three to eight feet thick, the No. 3 coal seam is the thickest and most prominent. Near the site, this seam lies approximately ten feet below the top of the lower Laramie, underlying 17 feet of friable shaly and loose sandy material. This erodible unit is capped by up to ten feet of the "C" sandstone (Emmons, 1896) member, with its diagnostic oxide-varnished ripple-marked top and locally abundant oxidized concretions. Few members in this interval resist erosion, creating muddy flats with few outcrops. Erodible shales, sandstones, and some coal streaks in the lowest portion of the Laramie manifest as low-relief areas between the C sandstone and the massive grey sandstone at the top of the Fox Hills, in the swath from the C sandstone ridge southeast of the site.

Mine Maps

Coal mining started in the area as early as 1859 and continued through the 1950s. **Figure 3** shows the approximate extents of various coal mines in the immediate vicinity around the Marshall Mesa Trailhead. Historical maps identifying underground workings are only available for some of these mines, including the Marshall No. 3, Black Diamond, and Eldorado Mines. Others, including the Marshall No. 1 and No. 2, are known to exist to the north of the project areas, but mine maps are not currently available for these mines. The No. 3 Mine map shows workings to the south and east of the Marshall Mesa Trailhead, stopping just to the east of the project area. Two adits or airways are shown to extend west across the southern portion of the site to the slope west of Hwy 93.

It should be noted that the accuracy of available mine maps have not been confirmed and may not reflect the final extents and configuration of a given mine. Mine working extents and locations should therefore be considered approximate.

3. INVESTIGATION

As directed by DRMS, the preliminary investigation of the southern portion of the Marshall Mesa underground coal fire, was conducted in a phased approach utilizing a multi-disciplinary methodology for gathering background data, evaluating site conditions, and performing a targeted drilling investigation. The goal of the investigation was to quantify the extents of subsurface heat and extents of potential subsurface coal fire activity relative to the suspected ignition area of the Marshall Wildfire. The preliminary activities of the evaluation are summarized below.

Preliminary Site Inspection

Site Reconnaissance

The first part of data collection at the site included a reconnaissance of the project site as well as the surrounding areas. The No. 3 Mine map shows two adits potentially extending under Hwy 93 and daylighting out the slope to the west (**Figure 3**). This area was inspected January 7, 2022 and no signs of mine openings, recent subsidence, vents, or intakes were observed.

Surficial Fracture Gas and Temperature Observations

Two rounds of gas and temperature readings were completed January 7, 2022 and January 14, 2022 at ten discrete locations within the AOI shown on **Figure 4**. These locations were selected by DRMS to screen for potential connectivity between the surface and underground mine workings suspected to be present in the area. Tetra Tech performed temperature measurements and obtained gas readings at each location to screen for subsurface temperatures and combustion gases typically associated with oxidizing and/or burning coal. A FLIR Infrared (IR) thermometer, Trimble R2 GPS unit, and a Landtec GEM 5000 gas analyzer with the capability to measure Methane %, Carbon Dioxide % (CO_2), Oxygen % (O_2), hydrogen sulfide (H_2S), and carbon monoxide (CO) were used for the observations.

The Trimble R2 GPS survey antenna was used to survey the ten observation locations (MV1-MV10) identified during the January 7th, 2022 site activities. The IR thermometer was aimed at the deepest part of the fracture to take a reading representative of venting atmosphere/gas temperature. In most cases movement of air or gases in or out of the fractures was not apparent. The gas analyzer's silicone inlet tube was inserted as far in the hole as possible in the direction of suspected air movement and the analyzer was turned on. The analyzer was run long enough (typically 1 to 2 minutes) to purge the suction line, for the gas reading to stabilize and to understand if there were short term fluctuations in gas concentrations. **Table 1** presents the gas concentration and temperature readings of each feature.

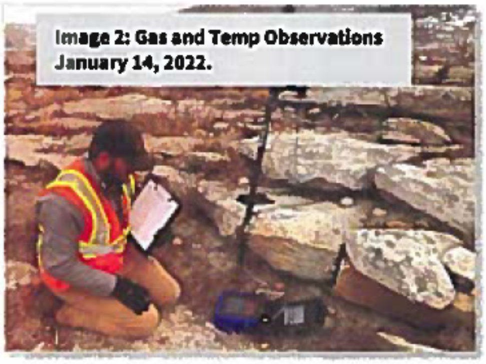


Image 2: Gas and Temp Observations January 14, 2022.

Table 1. Preliminary Gas and Temperature Readings

Feature	GEM 5000 Readings – January 14, 2022					
	Temp °F	CH_4 %	CO_2 %	O_2 %	H_2S PPM	CO PPM
Ambient	33	0	0.1	20.9	0	0
MV01	33	0	0.1	20.9	0	0
MV02	35	0	0.5	20.7	0	0
MV03	36	0	0.8	20.4	0	0
MV04	36	0	0.1	20.9	0	0
MV05	35	0	0.3	21	0	0
MV06	32	0	0.1	21.3	0	0
MV07	32	0	0.1	21.4	0	0
MV08	30	0	0.1	21.4	0	0
MV09	28	0	0.1	21	0	0
MV10	40	0.1	12.9	8.5	0	218

Tetra Tech noted slightly elevated temperatures and combustion gases at location MV-10 (**Figure 4**). The presence of CO without heat and CO_2 is typically associated with incomplete combustion or oxidation of subsurface coal. No other indications of mine fire activity were observed including odors, heat, venting gases, or intakes. Fracture temperatures at feature MV01 to MV09 were close to ambient (33°F) and no discernable airflow (intake or vent) was observed.

Site Imaging

Thermal Imaging

On January 8, 2022, Tetra Tech performed a UAV-based thermal inspection and mapping of the AOI within Marshall Mesa Open Space. A flight was performed to develop a thermal overlay of the AOI to map potential thermal anomalies, or features with sharp contrast, hot or cold, with the surrounding area (**Figure 5**). The color scale on the figure ranges from approximately 10-30°F with the darker blues and purples representing the cooler temps (~20°F) and the brighter colors representing the relatively warmer temps (25-30°F).

The warm circles (~28°F), primarily on the southern portion of the figure, are conifer trees that trap and hold warmer air. The area snowmelt area displayed a slightly elevated temperature (~1-2°F) above the surrounding area that was consistent with on the ground temperature observations. Low altitude video inspections were also performed to provide more detail of the fractures in question and actively search for thermal anomalies that may not be observed from higher altitude thermal mapping. No additional features were identified during the detailed imaging.

Site Mapping

On February 9, 2022, Tetra Tech completed a UAV-based visual photogrammetry flight of the property to develop baseline aerial imagery for the drilling program. The imagery was captured using a 45-megapixel survey-grade camera flown at approximately 200 feet above ground level (ft agl). The map was georeferenced using eight ground control points, surveyed using a Trimble R2 GPS antenna with precision RTX, and is used as the base imagery for **Figure 4** and **Figure 7.**

Snowmelt Imagery

With multiple snowfall events occurring in Boulder during January, February, and March 2022, Tetra Tech was able to visit the site several times to observe snowmelt patterns. During these visits an area was observed that consistently had snowmelt before the surrounding areas despite similarities in aspect and surface material or other factors that could influence differential melting patterns other than subsurface heat. **Image 3** and **Figure 6** show ground and perspective shots of the consistent snowmelt area during a recent storm and an outline of the consistent snowmelt area is shown on **Figure 4**. On the ground temperature observations with the handheld IR thermometer showed ground temperatures in the snow free areas were just above freezing at 34°F and only 1°F to 3°F warmer than background surface temperatures. No other areas of snowmelt were identified in the AOI.

Image 3: View to south of snowmelt in AOI, March 7, 2022.

North of the AOI, two suspected snowmelt areas were identified during the snowmelt imaging. These areas were not evaluated further since they are out of the scope of this investigation. Their locations were documented and recommendations for further evaluation are included in Section 4.2. **Appendix A** provides additional photographs of snowmelt areas at the site.

Microgravity Calibration Readings

A preliminary microgravity survey was completed across the AOI to evaluate the suitability of the method for the site, given the shallow coal mining, large extents of undermined areas, and extensive faulting. Results from the preliminary survey will identify areas These data will be calibrated with the preliminary drilling data and used to guide additional investigations.

Drilling Investigation

DRMS and Tetra Tech developed a borehole drilling program to quantify the extents of subsurface heat and/or fire in the AOI. Borehole locations were positioned to examine the main snow melt area and area to the south beneath the possible origin point of the Marshall wildfire. Drilling work was completed between February 21, 2022 and February 25, 2022 by Authentic Drilling based in Kiowa, Colorado. A track mounted CME-55 utilizing an ODEX casing advance system advanced the boreholes through the overburden and into competent rock. The boreholes were then completed to depth with an air-rotary tricone bit. Foam and water were pre-mixed and on standby in-case hot or burning conditions were encountered. A downhole camera was used to examine select boreholes and confirm the lithology and nature of the fractured/void zones. **Table 2** summarizes the borehole data and the boring logs are included as **Appendix B**. Borehole locations are shown on **Figure 4**.

Descriptions of the subsurface conditions observed, and select monitoring data, in each of the boreholes are summarized below:

1. **MM-01** - The location of borehole MM-01 in the middle of the primary snowmelt feature, was selected based on the snowmelt imaging and observed slightly elevated surface temperatures **Figure 6**. The borehole encountered 8.5 feet of backfill from the 2016 mitigation work, comprised of a brown, sandy, silty mixture with gravel and cobbles. Competent rock was encountered at 8.5 feet below ground surface (ft bgs), however circulation was lost shortly after. Drilling advancement was easy to 15 ft bgs and the ODEX casing was set at 13.5 ft bgs. The borehole began venting low temp (<90°F) gases with a strong, sulfurous coal combustion odor, typical of underground coal fires. Carbon monoxide concentrations fluctuated but were observed up to 1743 parts per million (ppm), H_2S was detected at 4.2 ppm, CO at 10 %, no methane was detected, and low oxygen conditions were present. A tri-cone bit was used to advance the borehole from 15 ft bgs through soft conditions and no circulation to 24 ft bgs, where solid rock was again encountered. From there the borehole was advanced through 9.5 ft of solid rock to a total depth of 33.5 ft bgs.
2. **MM-02** – Borehole MM-02 was located approximately 160 feet to the south of MM-01, at the southern end of surface heat documented with the snowmelt imagery. This borehole encountered a light-colored sandstone just below the surface which extended to a depth of approximately 15 feet where there was a transition to a dark brown shale with coal encountered from 17 to 24 ft bgs. No gases, heat or odors were observed. The borehole was covered, allowed to sit overnight, and was checked the following morning. CO was the only gas detected at a concentration of 199 ppm and the IR thermometer recorded a temperature of 89°F at the bottom of the borehole. A thermocouple was installed to 15 ft bgs and grouted in place.
3. **MM-03** – Sandstone, brown to reddish brown, with interbedded shale was encountered just below the surface at this location. From 12 to 17 ft bgs the color became redder and there was some bit chatter, likely indicating a fractured or disturbed zone (**Image 3**). Coal was encountered from 21 to 26.5 ft bgs, with a grey shale underlying the coal from 26.5 ft bgs to the total depth of 32.0 ft bgs. The borehole remained open overnight and the following morning venting, gases, odors, or heat were not observed. A thermocouple was grouted in the borehole to a depth of 21.5 ft bgs.

Image 4: Drilling MM-03 with reddish colored cuttings.

4. **MM-04** – Similar to MM-03, sandstone with some shale intervals were encountered from the surface to 20 ft bgs where the color became reddish and then circulation was lost at 22 ft bgs. From 22 to 31 ft bgs there was rig chatter and the bit was bouncing, indicating fractured conditions, possible faulting, rubble, or ash. The borehole drilled solid and smooth from 31 to 34.5 ft bgs, the total depth. Three-inch steel casing was installed to 34 ft bgs with a slotted interval from 24 to 34 ft bgs. The borehole was sealed from 20 ft bgs to 16 ft bgs with bentonite and then grouted to the surface. No odors, gases, or heat were observed during drilling or the casing installation. A thermocouple was hung in the steel casing to 23 ft bgs.

5. **MM-05** – MM-05 drilled solidly through interbedded, brown, sandstone and shales from the surface to a depth of 29.0 ft bgs where circulation was lost. There was soft drilling, with intermittent rig chatter from 29.0 to 39.0 ft bgs indicative of a fractured, fault, rubble, or ash zone. There was smooth, steady drilling from 39.0 to 50.0 ft bgs, the total depth of the borehole. The borehole was examined with a downhole camera and no obvious voids or coal were observed. Three-inch steel casing was installed to 50 ft bgs with a slotted interval from 30 to 40 ft bgs. The borehole was sealed with bentonite from 23 to 27 ft bgs and then grouted to the surface. A thermocouple was hung in the steel casing at a depth of 30 ft bgs. Venting, gases, odors, or heat were not observed following drilling or casing installation.

6. **MM-06** – This borehole was advanced through brown to grey, sandstones and shales from the surface to 11.0 ft bgs where coal was encountered. The coal seam extended from 11.0 to 22.0 ft bgs and was underlain by a competent grey shale. The total depth of the borehole was 24.5 ft and it was allowed to sit open overnight and the following morning venting, gases, odors, or heat were not observed, and a thermocouple was grouted in to 12 ft bgs.

7. **MM-07** – Borehole MM-07, located 50 feet west of MM-01, was advanced through interbedded sandstone and shale with intact coal encountered from 11 to 21.5 ft bgs. Grey shale was encountered from 21.5 to 24.5 ft bgs, the borehole's total depth. It sat open overnight and the following morning venting, gases, odors, or heat were not observed, and a thermocouple was grouted in to 12 ft bgs.

8. **MM-08** – This borehole encountered 3.5 feet of fill underlain by a brown sandstone with interbedded shale to a depth of 11.0 ft bgs. From 11 to 24 ft bgs there was interbedded, red to light tan, sandstones and shales. Coal was encountered from 24 to 28 ft bgs with a grey sandy shale extending from 28 to 35 ft bgs. Another coal interval was encountered from 35 to 41 ft bgs with grey shale from 41 to 49 ft bgs. Following completion of drilling and sitting of overnight, no venting, gases, odors, or heat were observed, however, approximately four feet of water was measured in the bottom of the open borehole. Three-inch steel casing was installed to 49 ft bgs with a slotted interval from 41 to 49 ft bgs to monitor the water level in the borehole. A thermocouple was grouted in the annulus between the steel casing and borehole wall at a depth of 24 ft bgs.

9. **MM-09** - MM-09 drilled very similarly to MM-06 and MM-07 with coal encountered from 10 to 20 ft bgs. The borehole was advanced through interbedded shales, sandstones, and a thin coal seam from 29 to 31 ft bgs. A grey, sandy shale was encountered from 31 to 54 ft bgs where the borehole was terminated. It was left open overnight. The following morning venting, gases, odors, or heat were not observed, and two thermocouples were grouted in borehole MM-09, one at 12 ft bgs and one at 29 ft bgs.

Table 2: Borehole Summary

Borehole ID	Date Drilled	Total Depth (ft bgs)	Top of Coal (ft bgs)	Bottom of Coal (ft bgs)	Venting	Casing	Screened Interval (ft bgs)	Thermocouple Depth (ft bgs)	Comments
MM-01	2/21/2022	33.5	-	-	yes	no	-	7	Warm venting borehole. 1743ppm CO. Casing installation failed due to collapsing borehole. Losing grout at 14 ft bgs. Needed 1yd of cement to backfill. Suspected coal interval 13.5 23.5 ft bgs.
MM-02	2/21/2022	24.0	17.0	24.0	slightly	no	-	15	Venting 199 ppm CO the day after drilling. No other gases detected. 89F in borehole.
MM-03	2/23/2022	32.0	21.0	26.5	no	no	-	21.5	Reddish overburdern and partial coal seam. No current fire activity.
MM-04	2/22/2022	34.5	-	-	no	yes	24-34	23	Reddish coloring above and circulation lost in anticipated coal interval. No signs of ongoing fire activity.
MM-05	2/23/2022	50.0	-	-	no	yes	30-40	30	Ciculation lost in suspected coal interval. Rubble or ash from 22-31 ft bgs. No current fire activty.
MM-06	2/24/2022	24.5	11.0	22.0	no	no	-	12	Solid borehole, no signs of coal mine fire.
MM-07	2/24/2022	24.5	11.0	21.5	no	no	-	12	Solid borehole, no signs of coal mine fire.
MM-08	2/24/2022	49.0	24.0	28.0	no	yes	41-49	24	~4 ft of water in the borehole 2/25/21 0830. Second coal interval from 35-41 ft bgs. No signs of coal mine fire.
MM-09	2/24/2022	54.0	10.0	20.0	no	no	-	12, 29	Thin coal seam ecountered from 29-31 ft bgs. No signs of coal mine fire.

Each of the boreholes was completed with a 12-inch, flush mount monitoring well cover that was cemented in place. The well covers were installed a few inches above the natural ground surface to promote drainage and prevent ponding on the well covers.

3.1.1 Borehole Emissions Observations

Emissions readings were taken during the drilling from the open boreholes once the boreholes were advanced to their total depth. To obtain emissions readings, the drilling rods were removed, equipment was switched off, and the boreholes sat open for a minimum of ten minutes prior to taking initial readings. Follow up readings were obtained in the morning after the boreholes sat overnight. Boreholes MM-01 and MM-02 were the only boreholes where combustion gases were detected during the initial or follow up readings with the findings from the follow up measurements presented below in **Table 3**.

Table 3: Borehole Gas Readings

Feature	GEM 5000 Readings – February 22, 2022					
	Temp °F	CH_4 %	CO_2 %	O_2 %	H_2S PPM	CO PPM
Ambient	5	0	0.1	20.9	0	0
MM-01	109	0	9.8	10.1	4	1743
MM-02	89	0	5.1	13.5	1	199

3.1.2 Thermocouple Installation

Type K thermocouples were installed in all the boreholes at or near the top of the coal seam interval. In boreholes MM-01, MM-04, and MM-05 where coal was not encountered, the thermocouples were installed at the top of the suspected coal interval. Thermocouples were installed by hanging the thermocouple wire in the open borehole and then grouting in place or by hanging the thermocouple wire down the inside of the steel casing installed in the borehole.

On March 9, 2022 thermocouple dataloggers were installed in the well monuments to record hourly temperature readings. This baseline data will be harvested monthly to allow DRMS to track potential changes in mine fire activity and correlate subsurface changes to weather events and variations in ambient conditions. **Table 4** summarizes the baseline thermocouple data collected prior to the installation of the dataloggers. The thermocouple in MM-06 was potentially damaged during installation and is not reading properly. No thermocouple data is available for this location.

Table 4: Downhole Thermocouple Temperature Data

Date	MM-01 7 ft bgs	MM-02 15 ft bgs	MM-03 21.5 ft bgs	MM-04 23 ft bgs	MM-05 30 ft bgs	MM-06* 12 ft bgs	MM-07 12 ft bgs	MM-08 24 ft bgs	MM-09S 12 ft bgs	MM-09D 29 ft bgs
3/3/2022	120.3	165.5	84.9	-	-	-	67.3	89.0	65.1	83.1
3/4/2022	119.0	166.2	62.3	82.3	78.6	-	67.1	69.5	64.3	83.1
3/7/2022	116.0	165.5	62.2	58.8	58.1	-	65.8	70.3	62.5	84.9
3/8/2022	117.9	165.3	61.0	60.4	58.3	-	66.7	69.7	62.9	82.8
3/9/2022	118.3	164.3	59.9	58.1	57.5	-	61.9	67.9	61.1	82.1

Notes: Thermocouples grouted in borehole MM-01, MM-02, MM-03, MM-06, MM-07, MM-08, MM-09S, MM-09D. Thermocouples in MM-04 and MM-05 are hanging in slotted steal casing. *Error message thermocouple likely damaged during installation.

Figure 7 presents an overview of the subsurface temperatures observed near the top of the upper coal seam as observed on March 9, 2022. Temperature observations from March 3 to March 9, 2022 remained relatively consistent.

4. SUMMARY OF FINDINGS

Findings

The findings of the investigation of the southern half of the Marshall Mesa Underground Coal Mine Fire AOI are summarized below:

- No surface heat, vents, intakes, or recent subsidence, indicative of changing subsurface conditions, were identified during site reconnaissance of the AOI and surrounding areas.
- One fracture (MV-10) was observed to have a slightly elevated temperature (40F vs 33F ambient) and low CO (199 ppm) readings.
- No heat anomalies were identified with UAV mounted thermal and visual cameras.
- A relatively small area of enhanced snowmelt, with surface temperatures a few degrees above background, was identified in the AOI. Two possible snowmelt areas were identified north of the project area but within the overall Marshall Mesa site.
- Two of nine boreholes (MM-01 and MM-02) encountered coal combustion gases and elevated temperatures (~90F).
    - Conditions encountered in boreholes MM-01 and MM-02 indicate that the underground conditions are hot in discrete locations that seem to correspond with observed snowmelt patterns but are below active burning levels and more indicative of a semi-dormant fire or intense oxidation of the fractured coal.
    - The discrete areas of oxidation and/or low-level combustion with heat are seemingly constrained by the flat lying geology, faulting, and relatively intact overburden in the areas currently exhibiting heat.
    - With no observed vents or intakes, there is currently little air flow to the warm areas of coal.

- Boreholes MM-03 through MM-09 showed no evidence of current fire activity. No heat, gases, or odors typically associated with mine fires were observed in these boreholes.
- No significant voids or mine workings were encountered by any of the boreholes. Circulation loses were attributed to fracturing, rubble, or ash zones based on bit chatter in these intervals when no resistance is typically encountered from open voids.
- Baseline thermocouple data show subsurface heat distribution consistent with borehole observations, snowmelt patterns, and site reconnaissance observations.

Recommendations

The southern portion of the Marshall Mesa underground coal mine fire that was the focus of this investigation is currently exhibiting the characteristics of a low activity, semi-dormant mine fire. No dangerous surface features or hazardous conditions related to the underground coal fire were observed. Given the extents of the historic behavior of the mine fire, observed site conditions, and remaining portion of the site to be investigated, Tetra Tech has the following recommendations.

1. Site Monitoring – The site should be visited on a regular basis to conduct snow melt observations (both north and south site areas), ground and UAV based thermal imaging, thermocouple readings, and record gas concentration measurements as appropriate. These data will be compared to weather data to establish if there is a relationship between atmospheric and subsurface conditions as well as document changes to fire activity.
2. Additional Investigations
    a. Geophysical Investigation – Preliminary microgravity data was collected across the AOI to calibrate for future investigations. The results of the calibration modeling show the methodology will provide useful results at the Marshall Mesa site. A sitewide microgravity survey modelled on the preliminary microgravity data and calibrated by the existing borehole data, would allow extrapolation and understanding of subsurface conditions, including faulting and mine workings, across the site away from the discrete borehole locations. This data would expand the understanding subsurface conditions across the site while helping to guide geotechnical drilling.
    b. Geotechnical Drilling - Additional drilling is recommended at the site to completely quantify the extents of the subsurface heat, confirm the orientation and offset of faults which could provide structural control on underground fire extents, and identify the extents of mine workings in proximately to current expressions of the underground coal fire at the Marshall Mesa site. Collection of core samples for detailed logging of stratigraphy should be considered as well as installation of additional thermocouples more comprehensive subsurface temperature monitoring.

5. REFERENCES

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FIGURES

Notes:
- Coordinate System: NAD 1983 UTM Zone 13N
- Projection: Transverse MercatorNorth American 1983
- World Imagery Basemap from ESRI, June 15, 2021

Legend

- ▭ Marshall Mesa North
- ▭ Marshall Mesa South
- ▭ Marshall Wildfire Impacted Area
- ▭ 2016 Mitigation Area - North
- ▨ 2016 Mitigation Area - South

0 250 500 1,000 Feet

TITLE

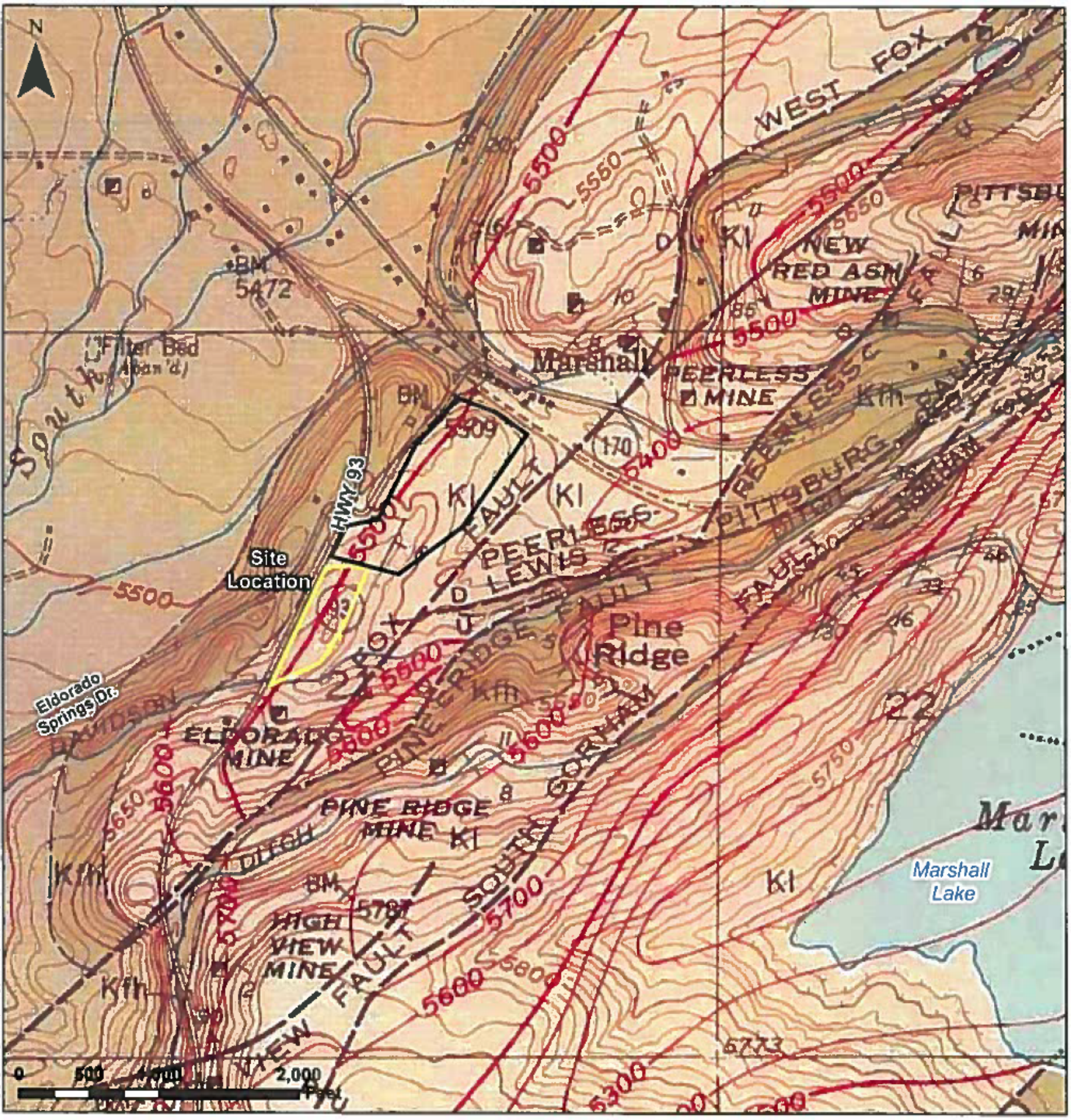
Marshall Mesa
Underground Coal Fire Investigation
Site Location Map

LOCATION

Marshall Area, Boulder, Colorado

APPROVED JN
DRAFTED CEC
PROJECT# 114-910409
DATE 03/16/2022

FIGURE 1



Legend

- ☐ Marshall Mesa North
- ☐ Marshall Mesa South
- Kl Laramie formation
- Kfh Fox Hills Sandstone
- Kp Pierre shale
- 60 Strike and dip of beds
- Strike and dip of overturned beds
- Mine Shaft
- Sand, gravel, or clay pit
- Structure contour *(top of the Fox Hills Sandstone) Contour Interval 100 ft*
- Contact (dashed where approx., dotted where concealed)
- High-angle fault, showing dip *(dashed where approx, dotted where concealed U, upthrown side, D, downthrown side)*
- —?— Doubtful or probable fault

Note:
Geologic Map from: Spencer, F. D., 1961, Bedrock geology of the Louisville quadrangle, Colorado. USGS Publications Warehouse, 10.3133/gq151, https://pubs.er.usgs.gov/publication/gq151

TITLE
Marshall Mesa
Underground Coal Fire Investigation
Geologic Map

LOCATION
Marshall Area, Boulder, Colorado

APPROVED	JN	FIGURE
DRAFTED	CEC	2
PROJECT#	114-810499	
DATE	03/16/2022	

Legend

⬛ Marshall Mesa North
🟨 Marshall Mesa South

Marshall Mine Workings (CO DRMS)

⬜	Big Tom Mine
🟦	Black Diamond
🟪	Eldorado 1939
🟥	Kitchen Slope
🟨	Lewis No 1 and No 2
🟩	Marshall No 1
🟧	Marshall No 3
🟦	Marshall No 5
⬜	Marshall No 7
⬛	Pine Cliff 1940

Notes
- Coordinate System NAD 1983 UTM Zone 13N
- Projection: Transverse Mercator North American 1983
- Mine features from CO DRMS
- World Imagery Basemap from ESRI, 6/15/21

Note: Subsurface conditions may vary from those depicted in this figure. No warranty of geologic conditions based on map interpretation is expressed or implied

TITLE

Marshall Mesa
Underground Coal Mine Fire Investigation
Mine Maps

LOCATION

Marshall Area, Boulder, Colorado

APPROVED	JN	FIGURE
DRAFTED	CEC, MRI	3
PROJECT#	114-910499	
DATE	03/16/2022	

Notes:
- Coordinate System: NAD 1983 UTM Zone 13N
- Projection: Transverse MercatorNorth American 1983
- Base UAV Aerial Imagery Collected by Tetra Tech on 2/9/2022
- Drilling occurred from 2/21-2/24/2022
- Snowmelt outlines provided by CO DRMS, created on 2/22/22
- World Imagery Basemap from ESRI

Legend

☐	Site Location
⊕	Borehole Locations
●	Gas and Temperature Readings (01/14/2022)
☐	Typical Snowmelt
☐	Additional Snowmelt Areas
☐	Marshall Wildfire Impacted Area

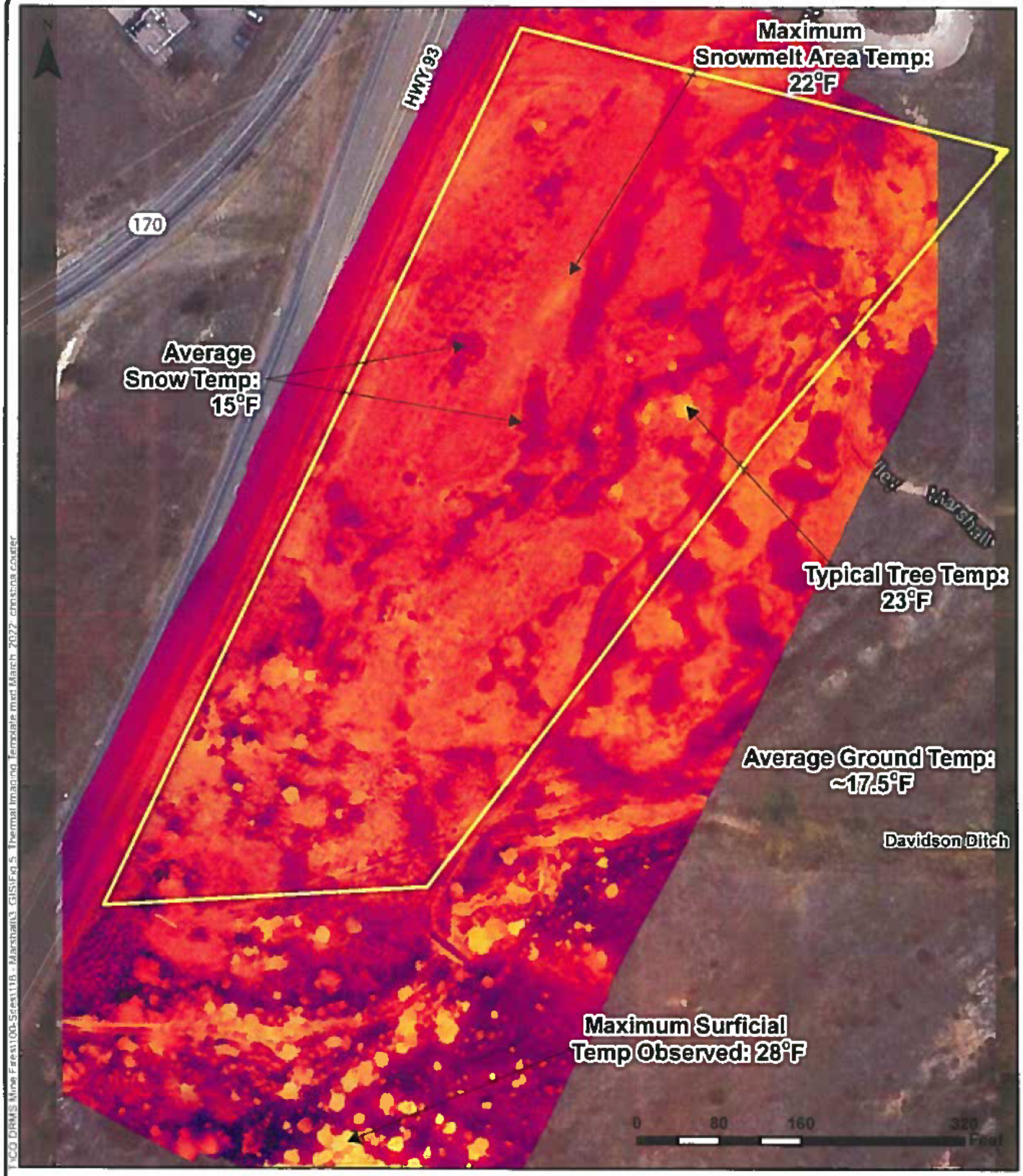
TITLE

Marshall Mesa
Underground Coal Fire Investigation
Site Investigation Locations and Features

LOCATION

Marshall Area, Boulder, Colorado

APPROVED	JN	FIGURE
DRAFTED	CEC	4
PROJECT#	114-910499	
DATE	03/14/2022	



T:\CO DRMS Mine Fires\100-Sites\118 - Marshall\3_GIS\Fig 5_Thermal Imaging Template.mxd March 2022 christina coulter

Legend

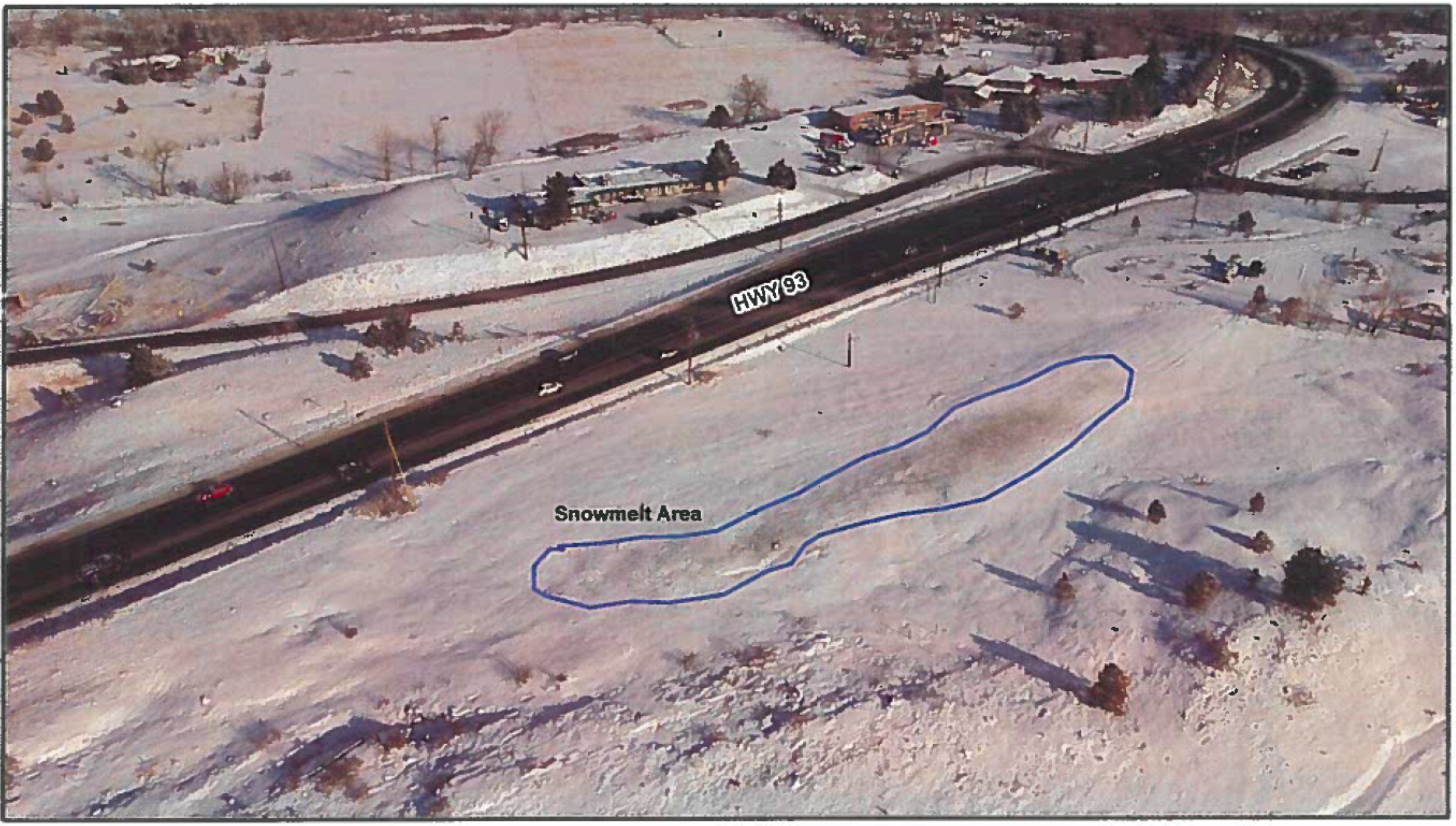
🟨 Marshall Mesa South

Notes:
- Thermal imaging performed by Tetra Tech on 01/08/2022.
- Ambient Temp. at 0600 was 34°F, light wind, cloudy.
- Max surficial Temp Oberved was 28°F (a tree in the southern portion of the site).
- World Imagery Basemap from ESRI, June 15, 2021.

TITLE
Marshall Mesa
Underground Coal Fire Investigation
Thermal Imaging

LOCATION
Marshall Area, Boulder, Colorado

APPROVED	JN	FIGURE
DRAFTED	CEC	5
PROJECT#	114-910499	
DATE	03/16/2022	



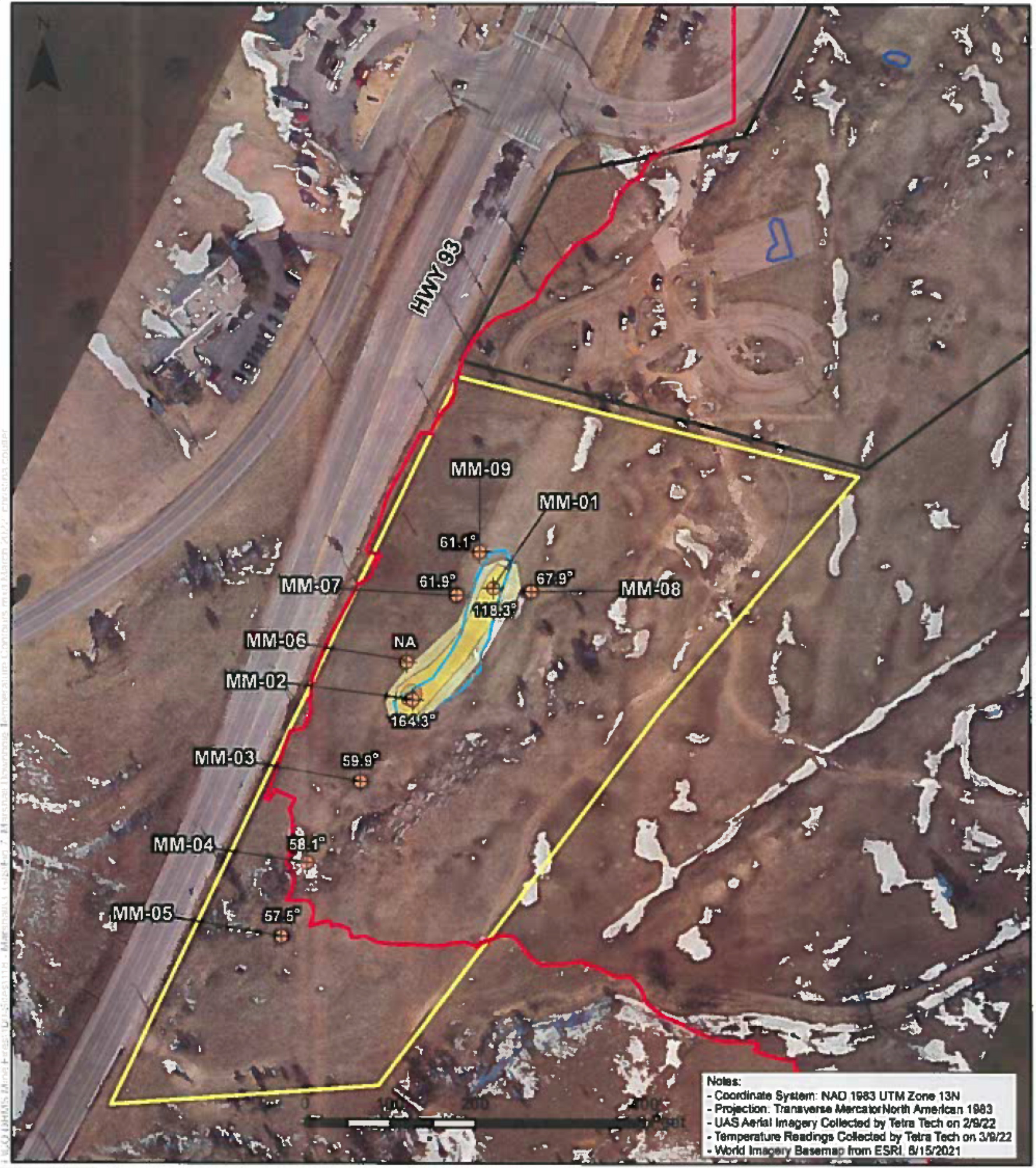
DRMS Mine Fires\100-Sites\118 - Marshall\3 GIS\Fig 6 Snowmelt Image.mxd March 2022 christina coulter

Notes:
- View to the northwest
- Photo taken by Tetra Tech on 3/10/2022

TITLE
Marshall Mesa
Underground Coal Fire Investigation
Snowmelt Image

LOCATION
Marshall Area, Boulder, Colorado

APPROVED	JN	FIGURE
DRAFTED	CEC	6
PROJECT#	114-910499	
DATE	03/18/2022	



Notes:
- Coordinate System: NAD 1983 UTM Zone 13N
- Projection: Transverse MercatorNorth American 1983
- UAS Aerial Imagery Collected by Tetra Tech on 2/9/22
- Temperature Readings Collected by Tetra Tech on 3/9/22
- World Imagery Basemap from ESRI, 6/15/2021

Legend

⊕ Borehole Locations
☐ Marshall Mesa North
☐ Marshall Mesa South
☐ Marshall Wildfire Impacted Area
☐ Southern Snowmelt Area
☐ Additional Snowmelt Areas

Temperature Contours (°F)
☐ 75°F
☐ 100°F
☐ 125°F
☐ 150°F

TITLE
Marshall Mesa
Underground Coal Fire Investigation
Top of Coal Seam
Temperature Contour Map - March 9, 2022

LOCATION
Marshall Area, Boulder, Colorado

APPROVED	JN	FIGURE
DRAFTED	CEC	7
PROJECT#	114-910499	
DATE	03/16/2022	

APPENDIX A: PHOTO LOG

Appendix A
Marshall Mesa Underground Coal Mine Fire Investigation Photolog
Boulder, CO

PHOTOGRAPH 1 02-17-2022 View of the snowmelt area to the south.

PHOTOGRAPH 2 02-17-2022 View to north across AOI with snowmelt visible.

PHOTOGRAPH 3 Fracture sample location MV07 with animal tracks entering/exiting.

PHOTOGRAPH 4 02-21-2022 Drilling MM-01

PHOTOGRAPH 5 03-06-2022 UAV Snowmelt looking South.

PHOTOGRAPH 6 03-10-22 Snowmelt looking to the south.

Boulder, CO

PHOTOGRAPH 7 03-06-2022 UAV snowmelt looking Northwest.

PHOTOGRAPH 8 02-22-2022 MM-03 Drilling

PHOTOGRAPH 9 02-24-2022 MM-06 Drilling through coal.

PHOTOGRAPH 10 02-24-2022 MM-01 Grouting

PHOTOGRAPH 11 03-06-2022 Possible snowmelt areas north of the AOI.

PHOTOGRAPH 12 03-09-2022 Parking lot possible snowmelt.

APPENDIX B: BOREHOLE LOGS

TETRA TECH

Tetra Tech Inc
3801 Automation Way, Suite 100
Fort Collins, CO, 80525
Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-01

PAGE 1 OF 1

CLIENT State of Colorado DRMS

PROJECT NAME Marshall Drilling 2022

PROJECT NUMBER 114-910599

PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/21/2022

GROUND ELEVATION: 5575 ft

METHOD: ODEX

CONSULTANT: Tetra Tech

LATITUDE: 39.952038 N

LOGGED BY: Jeffrey Nuttall

CONTRACTOR: Authentic Drilling

LONGITUDE: -105.232111 W

DRILLED BY: Jake

EQUIPMENT: CME 55

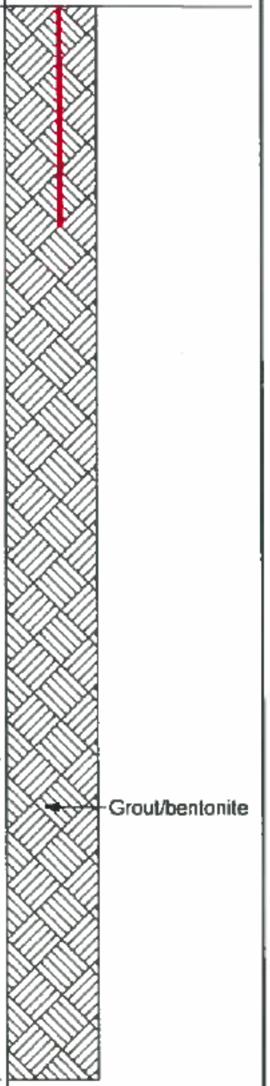
INCLINATION: Vertical

LOCATION: Marshall Mesa

DEPTH (ft)	SAMPLE TYPE	GRAPHIC LOG	MATERIAL DESCRIPTION	
0			**FILL** silty sand with cobbles (1"-6"), brown, dry	
5.0			**FILL** silty sand with cobbles and boulders, brown, dry Easy drilling	5569.7
8.5			**SANDSTONE** tan to brown, surface casing set at 13.5' drilling softer, lost returns 900ppm CO 4.2 H2S 13% O2 venting from casing Thermocouple wire installed to a depth of 7' Grout/bentonite tremmied from bottom of borehole to surface	5566.2
13.5			**RUBBLE** switch to tri-cone bit, no returns from 13.5' to 18.5' easy drilling, fill/rubble, coal, ash zone venting from casing at 13.5' little to no resistance from 18.5' to 23.5', ash pocket	5561.2
23.5			**SANDSTONE** tan to brown no returns, rig chatter from 23.5' to 28.5' solid drilling 24-33.5' Warm venting borehole 1700ppm CO	5551.2
33.5			-Borehole grouted from 14' to 33.5' -Pumped 2 batches but couldn't bring the level above 14'. -Concrete truck pumped 1 yard down the borehole to complete 0' to 14'	5541.2

Bottom of borehole at 33.5 feet.

Thermocouple Wire Completion



TETRA TECH

Tetra Tech Inc
3801 Automation Way, Suite 100
Fort Collins, CO, 80525
Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-02

PAGE 1 OF 1

CLIENT State of Colorado DRMS

PROJECT NAME Marshall Drilling 2022

PROJECT NUMBER 114-910599

PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/21/2022

GROUND ELEVATION: 5580 ft

METHOD: ODEX

CONSULTANT: Tetra Tech

LATITUDE: 39.951678 N

LOGGED BY: Jeffrey Nuttall

CONTRACTOR: Authentic Drilling

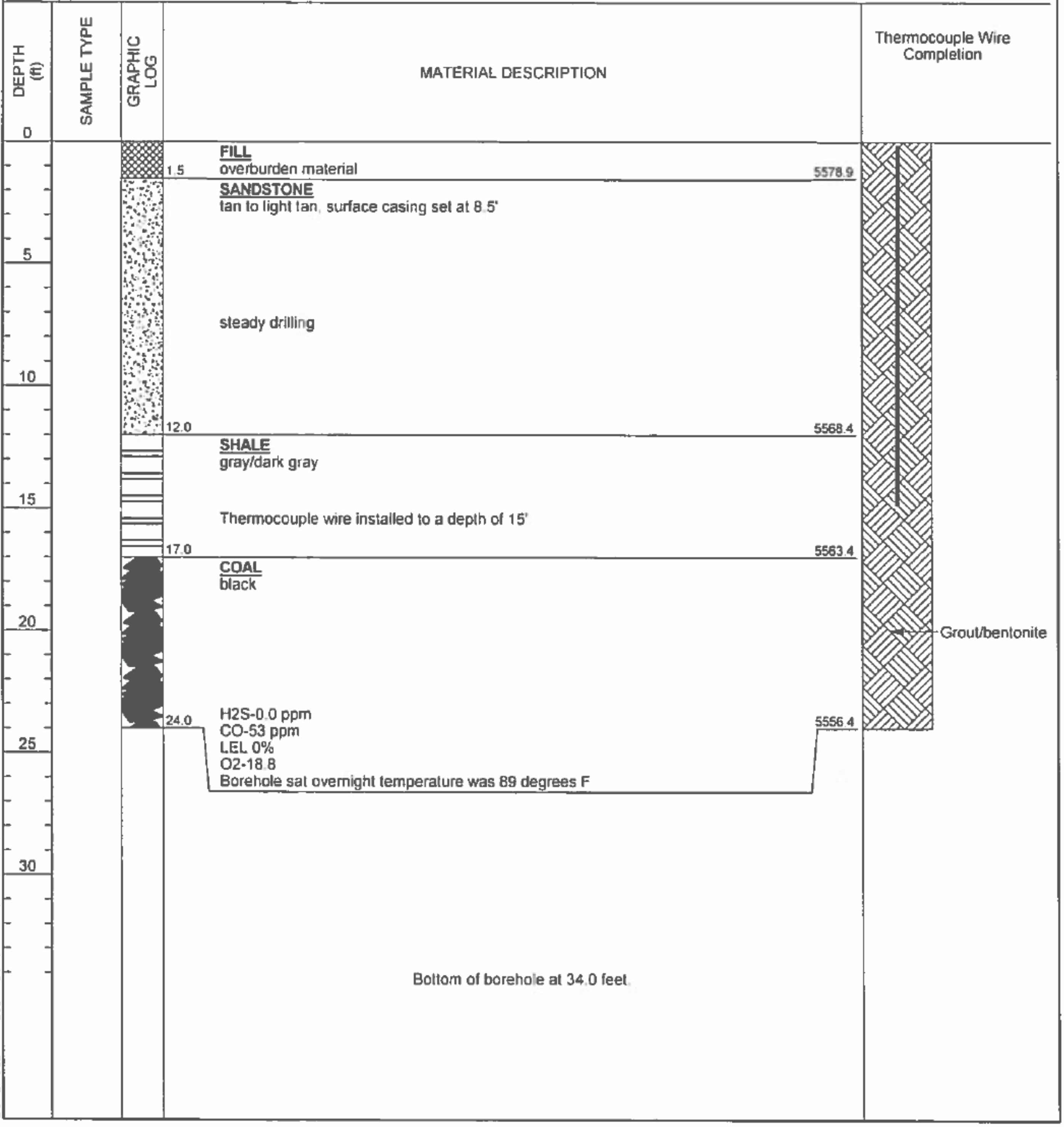
LONGITUDE: -105.232449 W

DRILLED BY: Jake

EQUIPMENT: CME 55

INCLINATION: Vertical

LOCATION: Marshall Mesa



Depth (ft)	MATERIAL DESCRIPTION	Elevation
1.5	**FILL** overburden material	5578.9
12.0	**SANDSTONE** tan to light tan, surface casing set at 8.5' steady drilling	5568.4
17.0	**SHALE** gray/dark gray Thermocouple wire installed to a depth of 15'	5563.4
24.0	**COAL** black	5556.4

H2S-0.0 ppm
CO-53 ppm
LEL 0%
O2-18.8
Borehole sat overnight temperature was 89 degrees F

Bottom of borehole at 34.0 feet.

TETRA TECH

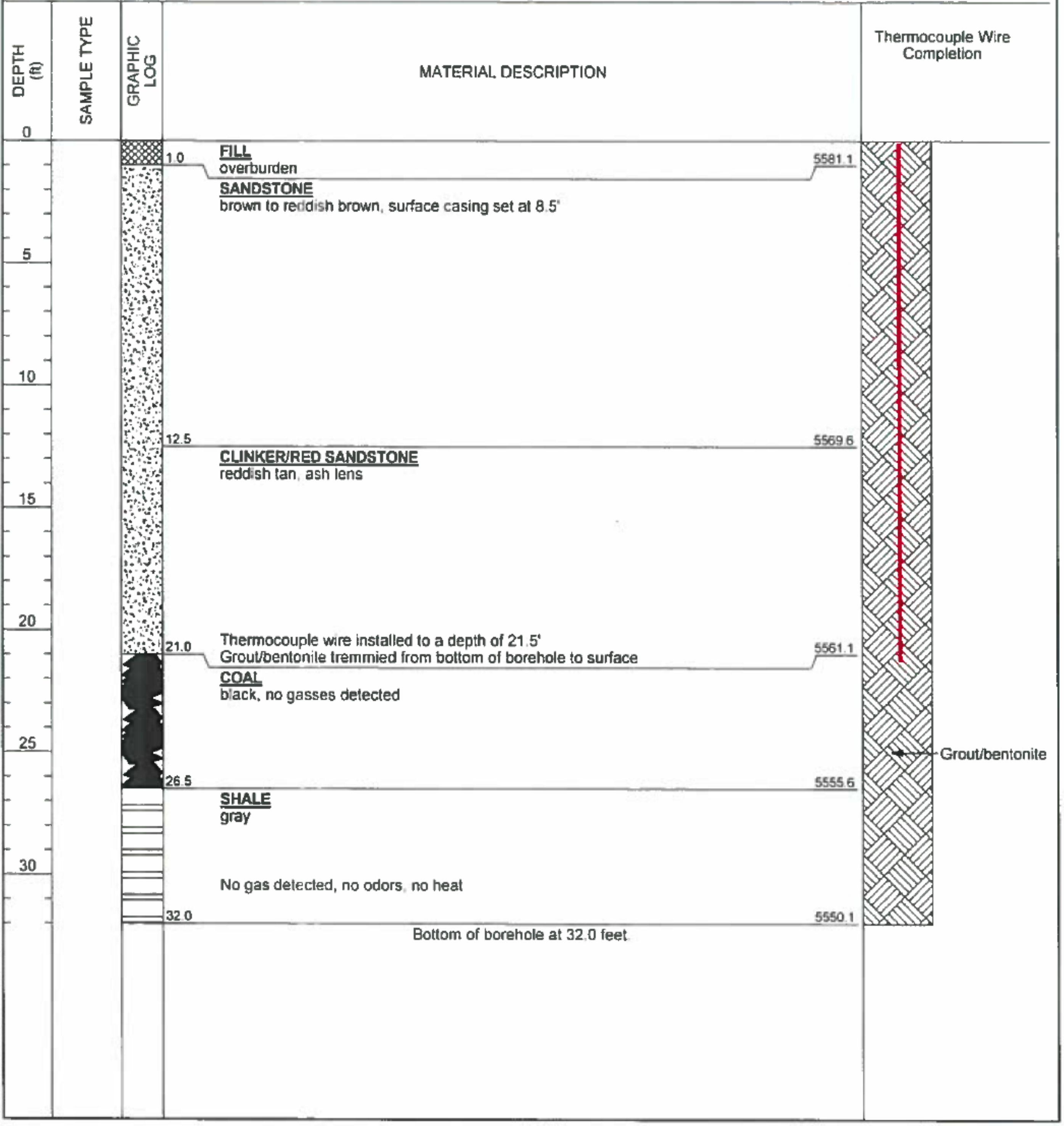
Tetra Tech Inc
3801 Automation Way, Suite 100
Fort Collins, CO, 80525
Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-03

PAGE 1 OF 1

CLIENT State of Colorado DRMS
PROJECT NAME Marshall Drilling 2022
PROJECT NUMBER 114-910599
PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/23/2022
CONSULTANT: Tetra Tech
CONTRACTOR: Authentic Drilling
EQUIPMENT: CME 55
GROUND ELEVATION: 5582 ft
LATITUDE: 39.951415 N
LONGITUDE: -105.232666 W
INCLINATION: Vertical
METHOD: ODEX
LOGGED BY: Jeffrey Nuttall
DRILLED BY: Jake
LOCATION: Marshall Mesa



DEPTH (ft)	MATERIAL DESCRIPTION	
1.0	**FILL** overburden	5581.1
12.5	**SANDSTONE** brown to reddish brown, surface casing set at 8.5'	5569.6
21.0	**CLINKER/RED SANDSTONE** reddish tan, ash lens Thermocouple wire installed to a depth of 21.5' Grout/bentonite tremmied from bottom of borehole to surface	5561.1
26.5	**COAL** black, no gasses detected	5555.6
32.0	**SHALE** gray No gas detected, no odors, no heat	5550.1

Bottom of borehole at 32.0 feet.

BOREHOLE/TP/WELL - VECTOR MARSHALL FILRE DRILLING 2022.GPJ ALL REPORTS JLR 2-14-11.GDT 3/11/22

TETRA TECH

Tetra Tech Inc
3801 Automation Way, Suite 100
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Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-04

PAGE 1 OF 1

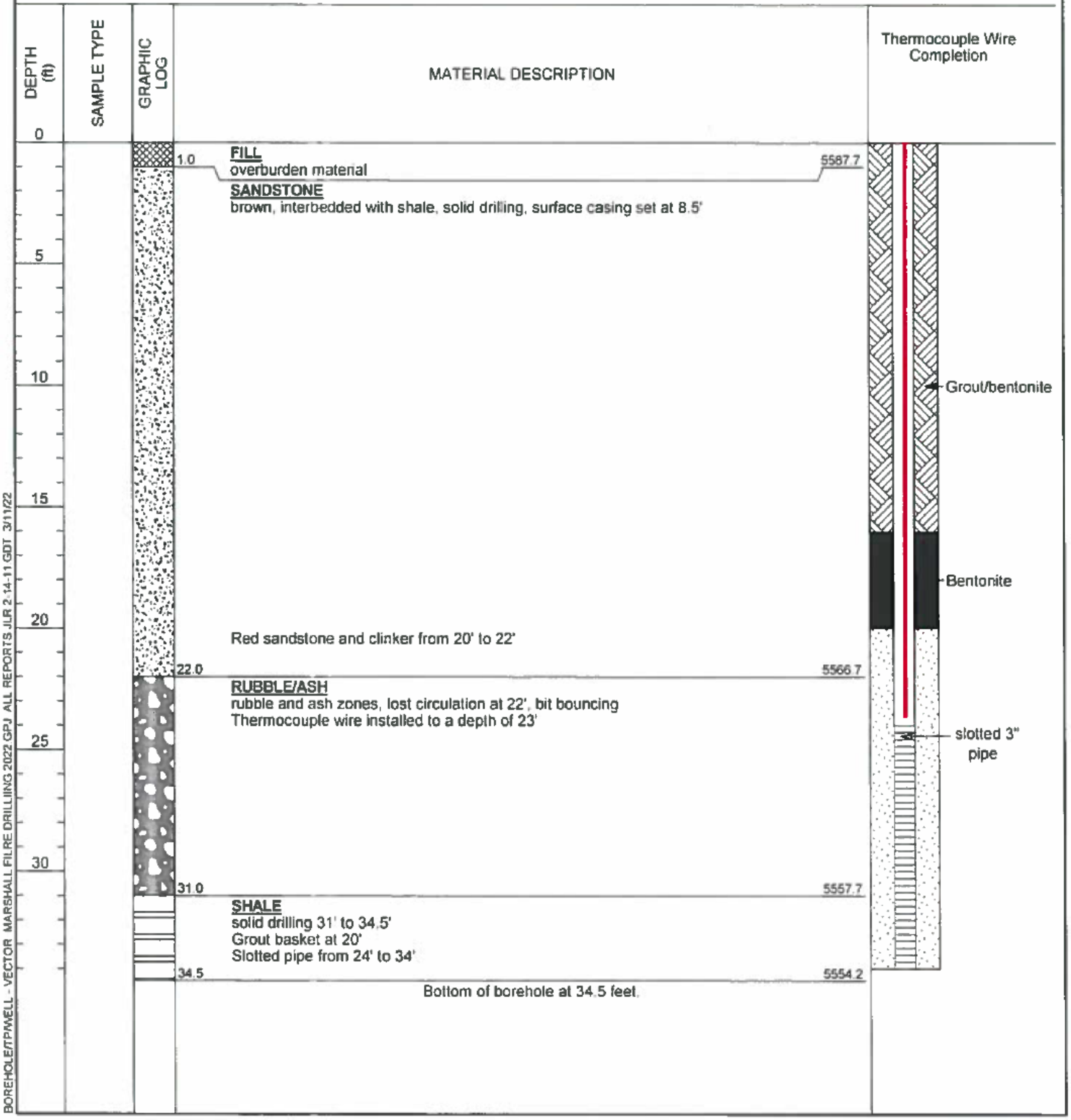
CLIENT State of Colorado DRMS

PROJECT NAME Marshall Drilling 2022

PROJECT NUMBER 114-910599

PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/22/2022
GROUND ELEVATION: 5589 ft
METHOD: ODEX
CONSULTANT: Tetra Tech
LATITUDE: 39.951154 N
LOGGED BY: Jeffrey Nuttall
CONTRACTOR: Authentic Drilling
LONGITUDE: -105.232891 W
DRILLED BY: Jake
EQUIPMENT: CME 55
INCLINATION: Vertical
LOCATION: Marshall Mesa



1.0 **FILL** 5587.7
overburden material

SANDSTONE
brown, interbedded with shale, solid drilling, surface casing set at 8.5'

Red sandstone and clinker from 20' to 22'

22.0 **RUBBLE/ASH** 5566.7
rubble and ash zones, lost circulation at 22', bit bouncing
Thermocouple wire installed to a depth of 23'

31.0 **SHALE** 5557.7
solid drilling 31' to 34.5'
Grout basket at 20'
Slotted pipe from 24' to 34'

34.5 5554.2

Bottom of borehole at 34.5 feet.

TETRA TECH

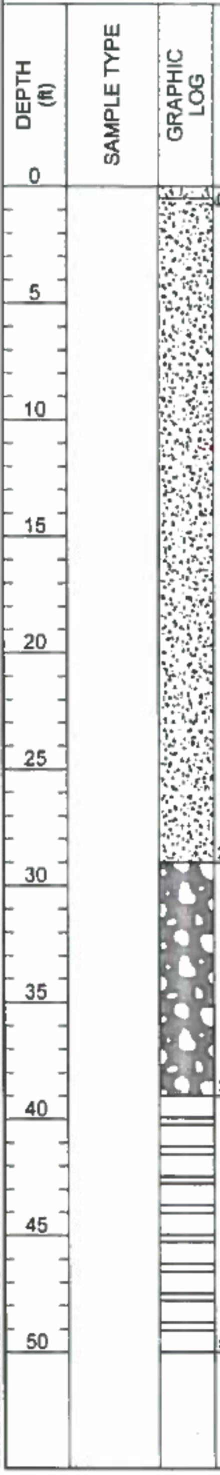
Tetra Tech Inc
3801 Automation Way, Suite 100
Fort Collins, CO, 80525
Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-05

PAGE 1 OF 1

CLIENT State of Colorado DRMS
PROJECT NAME Marshall Drilling 2022
PROJECT NUMBER 114-910599
PROJECT LOCATION Boulder County, CO

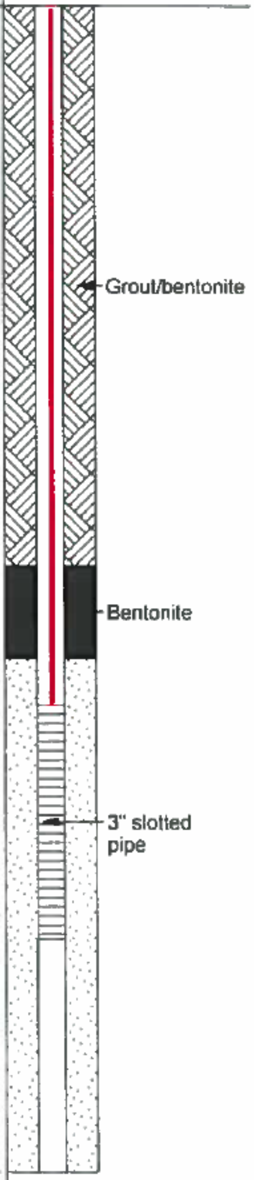
DATE(S) OF DRILLING: 02/23/2022
GROUND ELEVATION: 5595 ft
METHOD: ODEX
CONSULTANT: Tetra Tech
LATITUDE: 39.950918 N
LOGGED BY: Jeffrey Nuttall
CONTRACTOR: Authentic Drilling
LONGITUDE: -105.232997 W
DRILLED BY: Jake
EQUIPMENT: CME 55
INCLINATION: Vertical
LOCATION: Marshall Mesa



DEPTH (ft)	MATERIAL DESCRIPTION	
0.5	**OVERBURDEN MATERIAL** brown	5594.4
29.0	**SANDSTONE** brown, shale lenses, surface casing set at 8.5'	5565.9
39.0	**RUBBLE/ASH** soft, voids, rig chatter Lost circulation at 29'	5555.9
50.0	**SHALE** steady drilling, no returns No gas detected No heat detected Installed 3" steel casing Slotted pipe from 30' to 40'	5544.9

Bottom of borehole at 50.0 feet.

Thermocouple Wire Completion



BOREHOLE/TP/WELL - VECTOR MARSHALL FILRE DRILLIING 2022.GPJ ALL REPORTS.JLR 2:14:11 GDT 3/11/22

TETRA TECH

Tetra Tech Inc
3801 Automation Way, Suite 100
Fort Collins, CO, 80525
Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-06

PAGE 1 OF 1

CLIENT State of Colorado DRMS

PROJECT NAME Marshall Drilling 2022

PROJECT NUMBER 114-910599

PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/24/2022

GROUND ELEVATION: 5578 ft

METHOD: ODEX

CONSULTANT: Tetra Tech

LATITUDE: 39.951799 N

LOGGED BY: Jeffrey Nuttall

CONTRACTOR: Authentic Drilling

LONGITUDE: -105.232474 W

DRILLED BY: Jake

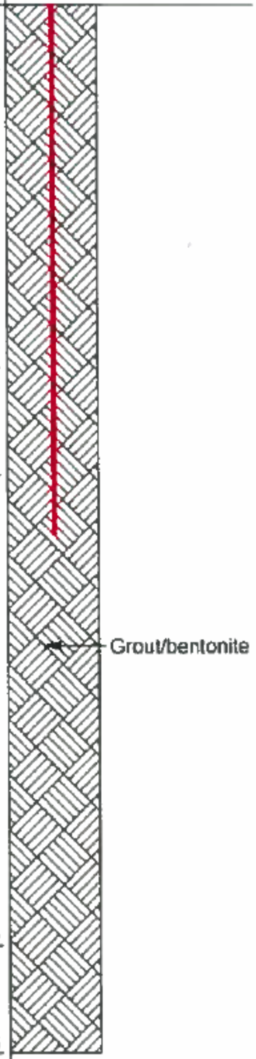
EQUIPMENT: CME 55

INCLINATION: Vertical

LOCATION: Marshall Mesa

DEPTH (ft)	SAMPLE TYPE	GRAPHIC LOG	MATERIAL DESCRIPTION	
0			**OVERBURDEN** sandy silt, brown	
1.5			**SANDSTONE** brown, dry, steady drilling, surface casing set to 8.5'	5576.5
8.5			Color changing to gray, shale increasing **SANDSTONE/SHALE** brown/gray	5569.5
11.0			**COAL** black Thermocouple wire installed to a depth of 12' Grout/bentonite tremmied from bottom of borehole to surface	5567.0
22.0			**SHALE** gray, steady drilling	5556.0
24.5			Bottom of borehole at 24.5 feet.	5553.5

Thermocouple Wire Completion



TETRA TECH

Tetra Tech Inc
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Fort Collins, CO, 80525
Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-07

PAGE 1 OF 1

CLIENT State of Colorado DRMS

PROJECT NAME Marshall Drilling 2022

PROJECT NUMBER 114-910599

PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/24/2022

GROUND ELEVATION: 5576 ft

METHOD: ODEX

CONSULTANT: Tetra Tech

LATITUDE: 39.952014 N

LOGGED BY: Jeffrey Nuttall

CONTRACTOR: Authentic Drilling

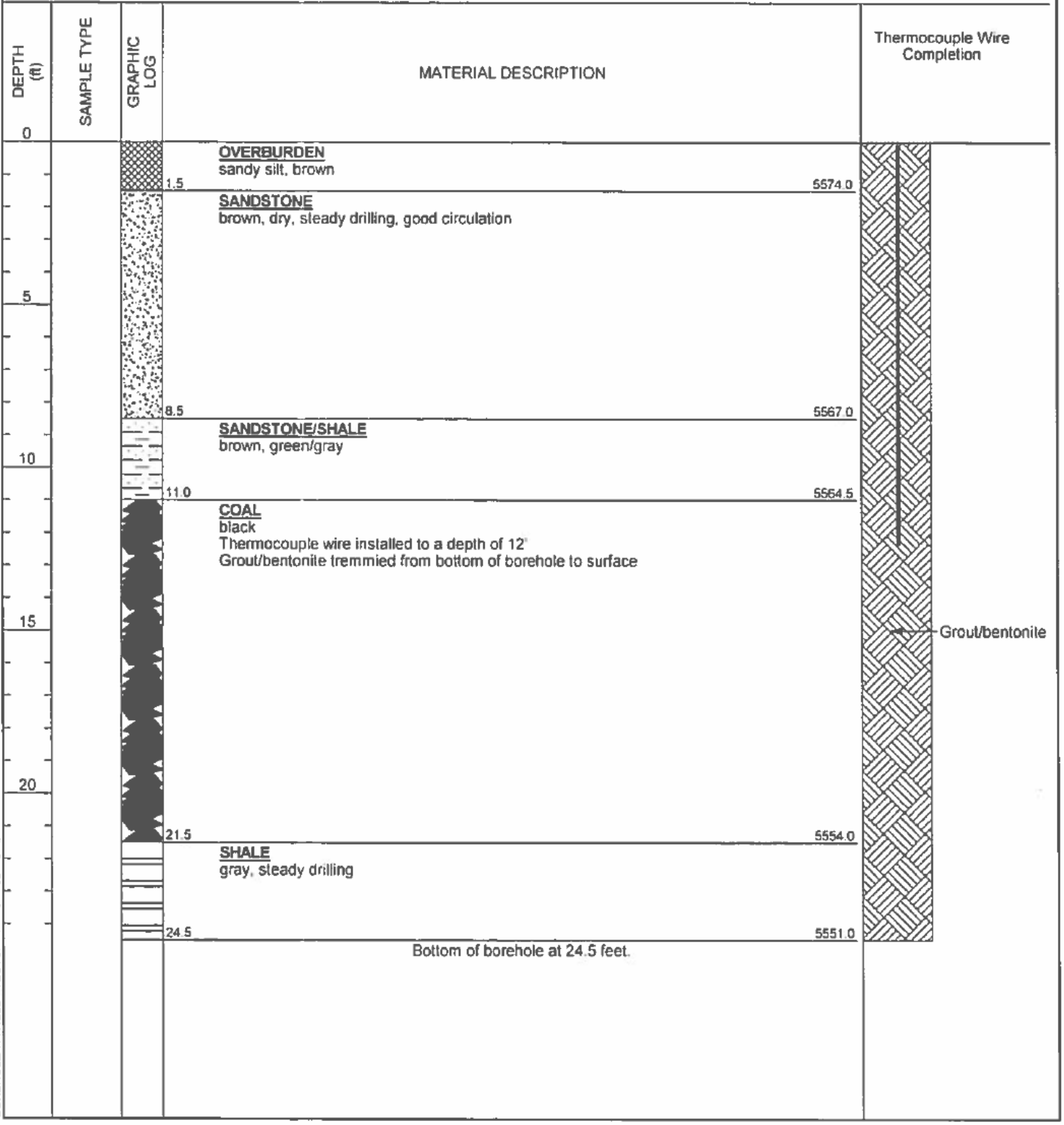
LONGITUDE: -105.232266 W

DRILLED BY: Jake

EQUIPMENT: CME 55

INCLINATION: Vertical

LOCATION: Marshall Mesa



1.5 **OVERBURDEN** sandy silt, brown 5574.0

8.5 **SANDSTONE** brown, dry, steady drilling, good circulation 5567.0

11.0 **SANDSTONE/SHALE** brown, green/gray 5564.5

21.5 **COAL** black
Thermocouple wire installed to a depth of 12'
Grout/bentonite tremmied from bottom of borehole to surface 5554.0

24.5 **SHALE** gray, steady drilling 5551.0

Bottom of borehole at 24.5 feet.

TETRA TECH

Tetra Tech Inc
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Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-08

PAGE 1 OF 1

CLIENT State of Colorado DRMS

PROJECT NAME Marshall Drilling 2022

PROJECT NUMBER 114-910599

PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/24/2022

GROUND ELEVATION: 5570 ft

METHOD: ODEX

CONSULTANT: Tetra Tech

LATITUDE: 39.952027 N

LOGGED BY: Jeffrey Nuttall

CONTRACTOR: Authentic Drilling

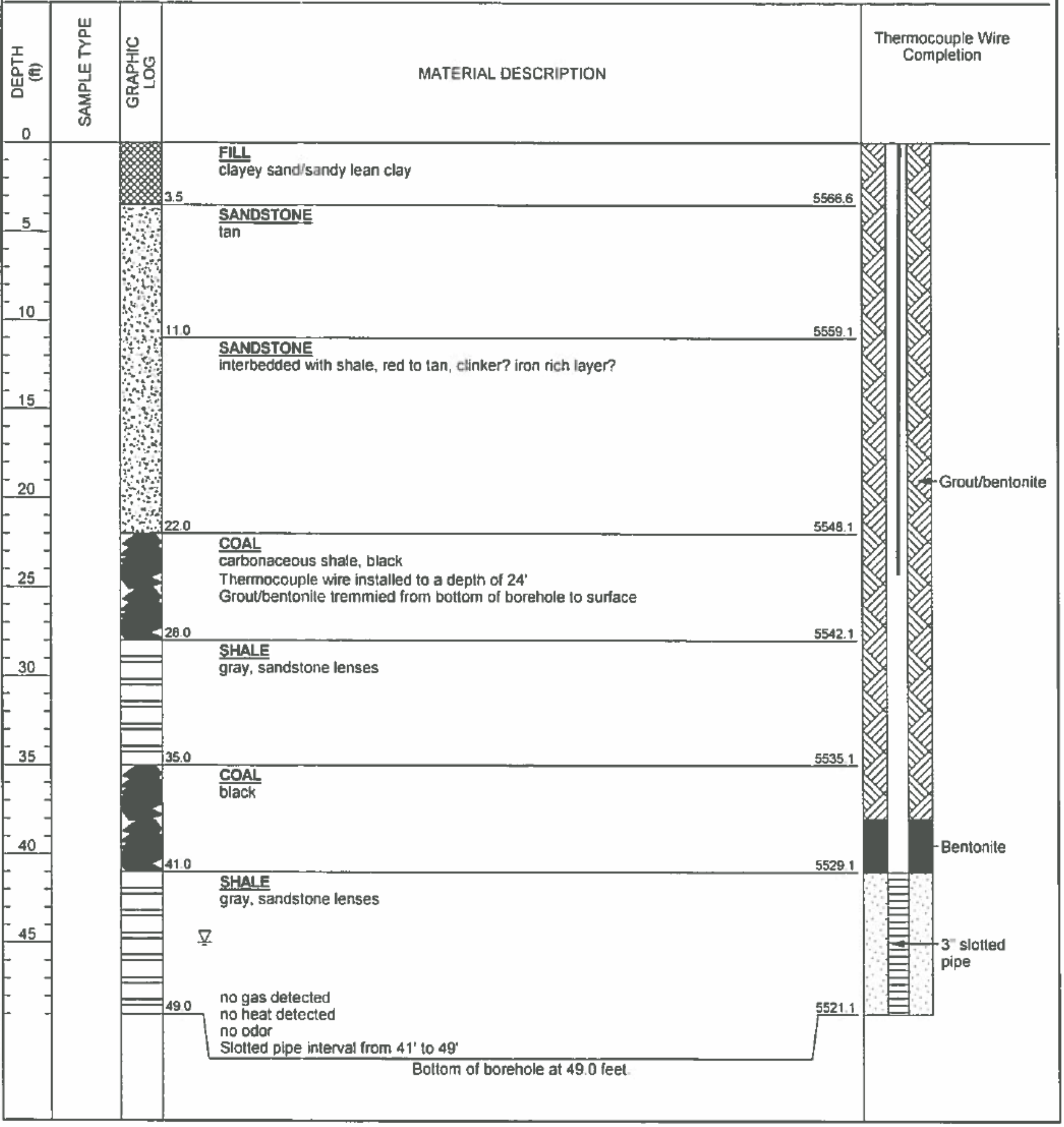
LONGITUDE: -105.231949 W

DRILLED BY: Jake

EQUIPMENT: CME 55

INCLINATION: Vertical

LOCATION: Marshall Mesa



3.5 **FILL**
clayey sand/sandy lean clay
5566.6

11.0 **SANDSTONE**
tan
5559.1

22.0 **SANDSTONE**
interbedded with shale, red to tan, clinker? iron rich layer?
5548.1

28.0 **COAL**
carbonaceous shale, black
Thermocouple wire installed to a depth of 24'
Grout/bentonite tremmied from bottom of borehole to surface
5542.1

35.0 **SHALE**
gray, sandstone lenses
5535.1

41.0 **COAL**
black
5529.1

49.0 **SHALE**
gray, sandstone lenses
▽
5521.1

no gas detected
no heat detected
no odor
Slotted pipe interval from 41' to 49'

Bottom of borehole at 49.0 feet.

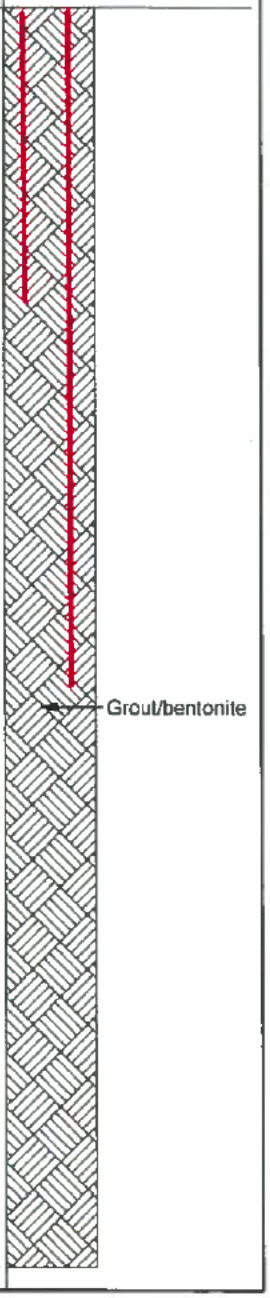
TETRA TECH

Tetra Tech Inc
3801 Automation Way, Suite 100
Fort Collins, CO, 80525
Telephone: 970-223-9600
Fax: 970-223-7171

BOREHOLE ID: MM-09

CLIENT State of Colorado DRMS
PROJECT NAME Marshall Drilling 2022
PROJECT NUMBER 114-910599
PROJECT LOCATION Boulder County, CO

DATE(S) OF DRILLING: 02/24/2022
GROUND ELEVATION: 5574 ft
METHOD: ODEX
CONSULTANT: Tetra Tech
LATITUDE: 39.952156 N
LOGGED BY: Jeffrey Nuttall
CONTRACTOR: Authentic Drilling
LONGITUDE: -105.232168 W
DRILLED BY: Jake
EQUIPMENT: CME 55
INCLINATION: Vertical
LOCATION: Marshall Mesa



DEPTH (ft)	SAMPLE TYPE	GRAPHIC LOG	MATERIAL DESCRIPTION		Thermocouple Wire Completion
0		1.5	**OVERBURDEN** brown/tan	5572.7	
		10.0	**SANDSTONE** brown, steady drilling, good circulation	5564.2	
		20.0	**COAL** good circulation Thermocouple wire installed to 12' Thermocouple wire installed to 29' Grout/bentonite tremmied from bottom of borehole to surface	5554.2	
		24.0	**SHALE** gray	5550.2	
		29.0	**SHALE/SANDSTONE** gray/tan, good circulation	5545.2	
		34.0	**COAL** changes to brown shale with depth	5540.2	
		54.0	**SHALE** brown to gray, sandstone lenses, good returns	5520.2	

Depth scale: 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50

Bottom of borehole at 54.0 feet.

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 16

Boulder County Sheriff's Office

Tomesello Interview

OFFICE OF THE DISTRICT ATTORNEY
TWENTIETH JUDICIAL DISTRICT
Michael T. Dougherty, District Attorney

Investigative Report

Investigator:	Marci Lieberman	Case Number:	22DA1 Supp 69
Date:	January 13, 2022	Marshall Fire Tip:	BCSO 2021-0105

WITNESS:

Name: Joseph Andrew Tomasello
DOB:
Res. Address:
Cell Phone: [redacted]

Bus. Address: Milo Construction
Bus. Phone: [redacted]

NARRATIVE:

On Thursday, January 6, 2022, I asked DA Investigator Chuck Heidel to follow up on Tip 105 and attempt to identify an individual whose vehicle was captured on game camera video from the Marshall Mesa Trailhead. The video showed a pickup truck driving into the area with "Milo Construction" badging on the side of the truck.

DA Investigator Heidel later provided me with the following information:

On January 6, 2022, at approximately 10:30 a.m., Investigator Heidel called Milo Construction and spoke to Kristen Robinson. Robinson identified herself as the Controller for Milo Construction. Investigator Heidel explained that we had identified a vehicle belonging to Milo Construction entering the Marshall Mesa Trailhead around the time of the fire on December 30, 2021, and we were trying to identify the employee who was driving the vehicle. Heidel gave Kristen the CO license plate number of the vehicle which is [redacted] Robinson stated she would identify the employee and have him call Investigator Heidel.

At approximately 11:00 a.m., Investigator Heidel received a call from a subject who identified himself as Joe Tomasello [redacted]. Tomasello did not want to provide his home address but gave his cell phone number of [redacted]. Tomasello told Investigator Heidel that on December 30, 2021, he was in his work truck and was heading west on "Road 28." He intended to turn left onto Highway 93, but the road was blocked for south-bound traffic. He decided to go north and got as far as the Marshall Mesa Trailhead where he decided to pull in and wait for Highway 93 to re-open. When he pulled into the parking lot through the gate, he turned to the right where there was a parking area for trailers. As soon as he pulled in, he saw "the fire starting right there off of 93." He said within five to eight minutes, the fire started "ripping west," and that was when he decided he had to get out of the area. He went south on Highway 93 to "Road 28," and drove east and then south on Indiana.

Tomasello further described the fire that he saw. He described the fire as being "east of 93," and that within five minutes was burning in the grass in front of his truck. Tomasello said he could not see what was burning when he initially saw the fire because there was a hill between him and the fire. Tomasello said he did not see any downed power lines in the area.

Investigator Heidel explained to Tomasello that from the vantage point of the game camera still shots, it appeared there was smoke directly slightly south and west of his location. Tomasello said he was certain the fire was on the east side of Highway 93.

Tomasello said he that he had taken video with his camera of the fire and he still had the footage. Tomasello said he would share the footage with us, but the files were too large to send by cell phone.

After learning this information from Investigator Heidel I notified BCSO Detective Yates and asked if Sgt. Connor Pontiakos could assign a deputy to meet with Tomasello and collect the video. I later learned this was not possible. On Monday, January 10, 2022, at approximately 9:33 a.m., DA Investigator Chris Merkle and I met with Tomasello at his job site located at 183 Taylor Avenue in Louisville, CO. Tomasello then airdropped two videos to my office issued iPhone. On this same date, I met with BCSO Crime Analyst Dave Rogers and emailed one video and airdropped the larger video file to his cell phone.

The associated digital evidence item number is TW46 for BCSO case 21-6301 (BCSO Supp 116).

1/13/22

Investigator

Date

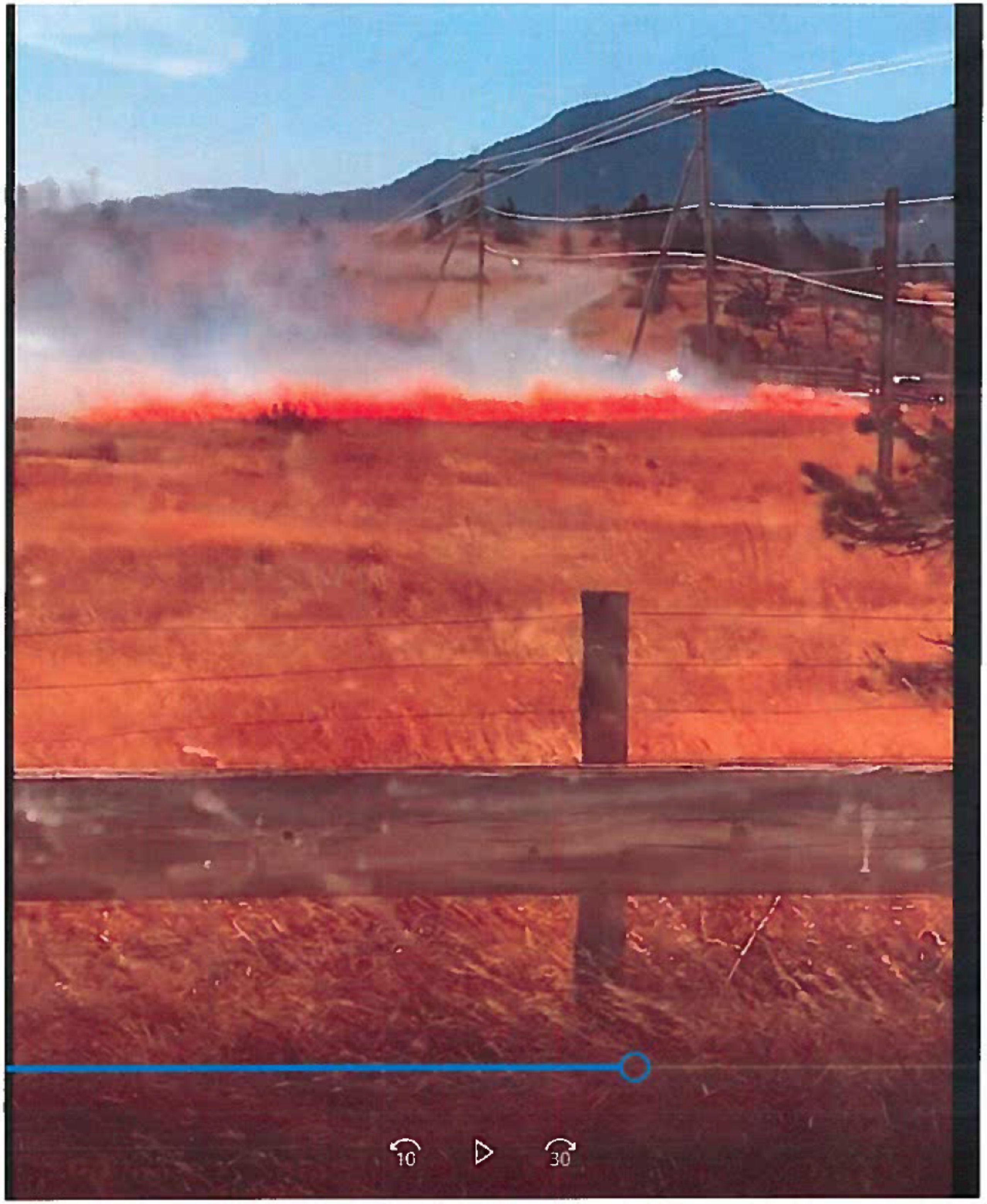
Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 17

Boulder County Sheriff's Office

Copy of IMG_6072


10
30

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 18

Boulder County Sheriff's Office

Screenshots of IMG_6072 Video

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name Marshall Fire	Case/File Number 21-02-IAIP002
Case Type Wildland Fire	Date of Incident 12-30-2021

Photograph Number: Tomasello Video

Date: 12-30-22

Time: Unable to determine (approximately 12:20)

Photographer: Joseph Tomasello

Subject:
Screeshot from Tomasello video shot from Marshall Mesa Trailhead parking area showing east conductor unlashed from power pole MP2

Photograph Number: Tomasello Video

Date: 12-30-22

Time: Unable to determine (approximately 12:20)

Photographer: Joseph Tomasello

Subject:
Screeshot from Tomasello video shot from Marshall Mesa Trailhead parking area showing east conductor sagging from MP2 but still lashed to MP3

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 19

Boulder County Sheriff's Office

Screenshot from Reconyx Camera

Marshall Mesa Trail Entrance

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name Marshall Fire	Case/File Number 21-02-IAIP002
Case Type Wildland Fire	Date of Incident 12-30-2021

Photograph Number: Motion Camera

Date: 12-30-22

Time: 10:35

Photographer: Motion Activated

Subject:
Screenshot from trailhead gate motion activated camera timelapse video

Photograph Number: Motion Camera

Date: 12-30-22

Time: 12:10

Photographer: Motion Activated

Subject:
Screenshot from trailhead gate motion activated camera timelapse video

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

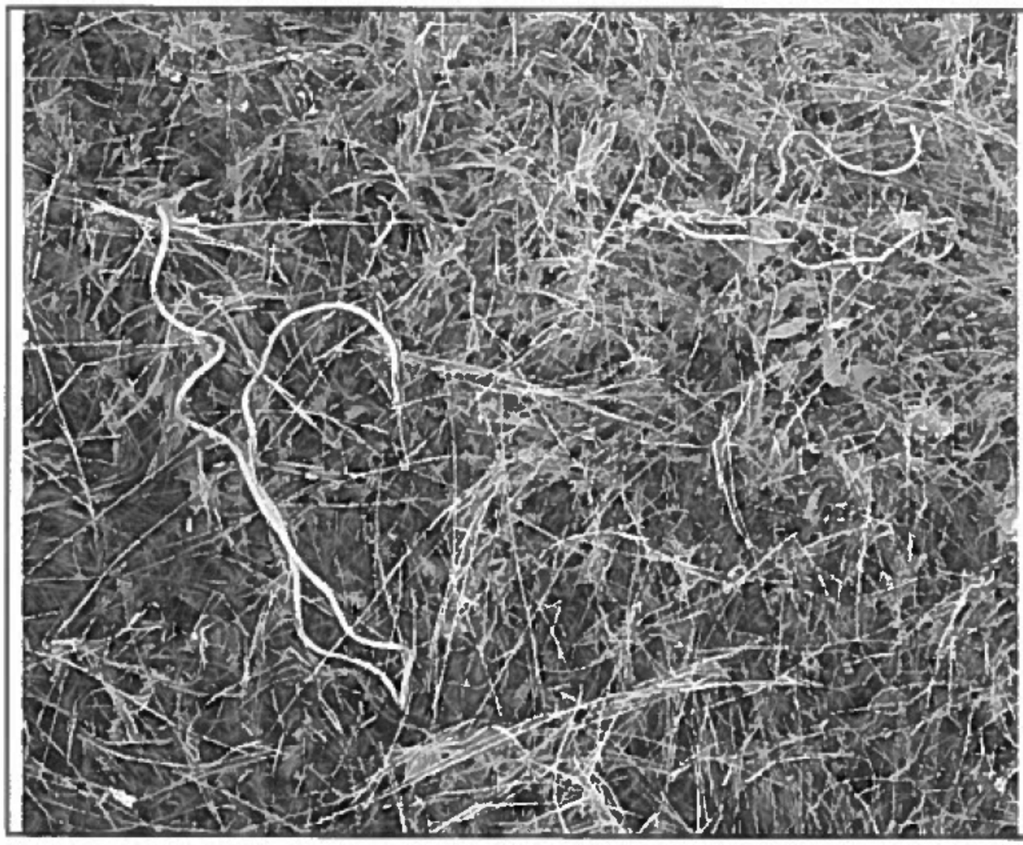
Attachment 20

USFS Photo of Powerline Lashings

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name Marshall Fire	Case/File Number 21-02-IAIP002
Case Type Wildland Fire	Date of Incident 12-30-2021



Photograph Number:

Date: 1-14-22

Time:

Photographer: SA Henrichs

Subject: Aluminum wire lashings in grass below conductors at Pole MP2

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 21

Earth Networks Lightning Inquiry Response

From: no-reply@earthnetworks.com <no-reply@earthnetworks.com>
Sent: Friday, January 14, 2022 4:58 PM
To: Lunders, Travis -FS <[redacted]>
Subject: [External Email]Lightning Archive - [Marshall Fire] - Success with No Results

Your report completed successfully. There was no lightning for the requested time and geographic area.

Name: Marshall Fire
Format: KMZ

Start Time: 2021-12-16 07:00 PM UTC
End Time: 2021-12-30 07:00 PM UTC

Lightning Type: Pulse
Stroke Type: Cloud to Ground
Additional Options: Location Accuracy

Area Definition type : Circle
Center: 39.9527, -105.2319
Radius: 0.7965 miles

Report ID: 7eae292d-13d8-41bf-b7bc-03683db3a33e

Marshall Fire

Marshall Mesa Trailhead Origin and Cause Report

Attachment 22

USFS Photo of MP2 Center Conductor

United States Department of Agriculture
Forest Service

Photograph Exhibit

Case Name Marshall Fire	Case/File Number 21-02-IA1P002
Case Type Wildland Fire	Date of Incident 12-30-2021

Photograph Number: 122135

Date: 03-25-22

Time: 12:21

Photographer: Henrichs

Subject:
Identifier tag placed on MP2 Center Conductor

Photograph Number: 122000

Date: 03-25-22

Time: 12:20

Photographer: Henrichs

Subject:
MP2 Center Conductor