Accident Prevention Analysis Report

Indians Fire
Los Padres National Forest
June 11, 2008

Pacific Southwest Region
July 24, 2008

Amended February 12, 2009 to include author's names in Appendix E

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Executive Summary

The Indians Fire reportedly started Sunday June 08, 2008 at around 12:35 pm in the Arroyo Seco drainage near the Escondido campground on the Los Padres National Forest (LPF) (Figure1). The fire began under foehn wind conditions that pushed the fire southeasterly, down slope, down canyon, and continued to do so for the next 4 days with the burned area generally doubling each day.

Figure 1. Vicinity map of Indians Fire.

The area had been experiencing recent warm and dry conditions and was in a long term drought. All time record low precipitation amounts in the previous three months resulted in extremely low dead fuel moisture levels.

On the morning of Tuesday, June 10th, little smoke was visible and the fire was fairly quiet. By that evening, the fire had moved into higher terrain (between 3000-4000 feet ASL). Conditions on the Indians Fire were forecast to become drier and windier but did not meet red flag criteria.

On June 11th, the fire was under an exceptionally dry north to northeast general wind flow and RH values remained extremely low, (around 10% during the overnight hours). Observed fire behavior was active but not extreme, with the main fire consuming brush (fuel model 4) on the slopes to the north of Milpitas Road. A burnout was occurring in cured and dried grass on alternately flat and gentle sloping terrain leading to the variegated hills, 40-60% slopes, with multiple aspects and intersecting drainages. The operation progressed well through the morning and early afternoon.

Approximately 1550 hours, firefighters along the east edge of the burnout operation were observing a large rotating fire plume that seemed to be paralleling the burnout operation. Video footage taken during this time clearly shows this rotation. (This video can be viewed at http://www.myfirevideos.net/?v=62.) Later interviews indicate that firefighters had observed such phenomena before, but did not perceive this event to be enough of a threat to safety to warn others.

Flames near the burn-out began to intensify and to be influenced by the rotating plume. Winds near the road increased to 20-30 mph from the west due to the proximity of the vortex. At approximately 1620, a spot fire ignited just south of the road and the crew of LPF Engine 71 moved west along the road to scout and extinguish the spot fire.

At approximately 1624, the crew was engulfed in thick smoke, strong winds, and continuous ground flames when the rotating plume crossed the road. Flame length is undetermined but flame height is reported to be “knee high” and ignites numerous spots that quickly grow together. The crew of Engine 71 attempted to withdraw from the area towards their engine, and in this process the hot temperatures caused them to deploy their fire shelters. Three of the crew successfully removed the shelters and wrapped them around their backs while continuing efforts to exit the area. The fourth crew member had difficulty deploying his shelter and continued running until he reached the engine. When he reached the engine, he and the Fire Engine Operator (FEO) did not know where the other crew members were and could not contact them, so they backed east out of the area. The Division Supervisor located the other three and drove them to safety. The three firefighters each sustained a range of superficial to serious burns during the burnover.

An entrapment occurred when the rotating plume that had developed over a 30-60 minute period crossed Milpitas Road. The rotating vertical plume appeared and behaved in many aspects like an F0 to F1 scale tornado, approximately 1000' in diameter at the base and 1000-1500' tall. Winds at the plume base are estimated at greater than 70 mph and resulted in extreme fire intensity and significant wind caused damage. Branches with base diameters as large as 18" were torn from trees and transported through the air. Fire spread virtually halted soon after the event, including last attempts to burn out.

One crew member with serious burns was flown to a burn center and two others were transported by ambulance to a local hospital. The most seriously injured crewmember remained in the burn center for more than a week. The two other crewmembers were treated and released.

Key Findings

- Three firefighters were not wearing full personal protective equipment (PPE).
- There were no posted designated lookouts by any resources in this portion of Division C.
- Although other resources observed the rotating vertical plume, there was hesitancy between crews to communicate the hazard.
- Crews underestimated the hazard of the plume.
- Firefighters in Division C had degraded situational awareness.

I Introduction

The Los Padres National Forest is located in central California along and near the coast of the Pacific Ocean. The terrain in this area is characterized by steep mountains in the Santa Lucia Range. Vegetation consists primarily of mature oak savanna in the interior valley bottoms with chaparral covering the mountain slopes.

The entrapment occurred along the Milpitas Road (also known to some as Del Venturi Road) (36.072°N x 121.340°W) on the north side of a roughly 1 mile wide valley plain covered with a mature white oak grass savanna. The road is located on the north side of the plain and the San Antonio River is on the south side of the valley. Immediately north of the road the terrain rises in highly variable foothills for approximately ¼ mile to the base of large steep slopes (40-80%) leading upward to the mountain peaks. The foothills are characterized by highly variable gulley and drainage orientation and are covered with chaparral shrub fuels that extend upward to the mountain peaks.

This incident qualifies as an entrapment according to FSM 5130.3 which states:

"Entrapments are situations where personnel are unexpectedly caught in a fire-behavior related, life threatening position where escape routes or safety zones are absent, inadequate, or compromised. An entrapment may or may not include deployment of a fire shelter. These situations may or may not result in injury and include near misses."

The USDA Forest Service Washington Office delegated the accident investigation to the Regional Forester, Pacific Southwest Region (R-5). The Regional Office initiated a systematic analysis of the circumstances related to the accident following the Accident Prevention Analysis (APA) process.

An Analysis Team was formed and reported to King City, California on June 13, 2008. The Analysis Team consisted of a Line Officer/Team Leader, Chief Investigator, Local NFFE representative, two peer Subject Matter Experts (Forest FMO and Hand Crew Squad Leader), a writer/editor and experts in personal protective equipment, fire behavior, incident meteorology, human factors and psychology.

The APA was conducted in the spirit of the "Foundational Doctrine" for fire suppression activities. The APA team looked at how firefighting principles were used to make sound assessments and reasonable decisions. The team sought to understand the situation in which the Incident Management Team (IMT), firefighters, and fire support personnel found themselves in early June in central California. The Team sought an understanding of not only what choices were taken, but why individuals made the decisions they did. The Team looked at the actions of the IMT and individual firefighters with this philosophy:

“Employees are expected and empowered to be creative and decisive, to exercise initiative and accept responsibility, and to use their training, experience, and judgment in decision making to carry out the leader’s intent” (Foundational Doctrine 2006).

The goal of this report is to provide an opportunity to learn from these incidents. “Safety is not a goal that an organization can reach, but is rather a continuously creative response by employees to risk. This is a challenging paradigm and has immense implications for how we should value operational accidents. A foundational principle of high-reliability organizing is the commitment to continuous learning. Learning from success is essential and learning from failure is critical. Fidelity to our values demands we treat accidents and near misses as precious learning opportunities and exploit their full value for enhancing system reliability” (APA Briefing Paper). Using this learning approach, the Indians Fire APA Team found that many employees were eager to openly report and share their individual lessons learned.

II Review Objectives

- Develop and complete a peer review (Accident Prevention Analysis/APA) of the Los Padres National Forest Engine 71 burnover that occurred on the Indians Fire Incident, on June 11, 2008. Issue a draft report within 45 days from arrival of the accident scene.

- Use the APA Guide to review the circumstances related to the accident.

- Contact the Regional Forester personally and immediately if there is identification of acts that the team believes constitutes a reckless and willful disregard for human safety or involve criminal misconduct.

- Maintain a high level of confidentiality regarding information obtained through interviews.

- Produce a 72 hour report using the 2005 Accident Investigation Guide.

- Upon completion of the APA report, schedule a presentation with the Regional Forester in compliance with Step 9 of the APA Guide.

III Methodology

The events and facts presented in this report were determined through a variety of methods. The analysis team conducted over 40 interviews with firefighters, fire support personnel, and fire management personnel to develop the general story of the incident. The review team conducted field reconnaissance and examined fire documents, weather records, maps, photographs, and videos.

Actual on-the-ground and aerial measurements were taken to determine relative distances, dimensions, and orientation of crewmembers, personal protective equipment, and vehicles immediately prior to and during the accident. A key factor in determining the chronological sequence of events was the many video and still photos that were collected by different firefighters and observers. Where conflicts exist in the chronology of events, they are based on different perspectives from different witnesses.

The team assumed that images collected by cell phones had the most accurate time stamp. Other video and still images were correlated with the cell phone time stamps to determine the actual time associated with the image files. Times listed in the report are based on a careful analysis of the various information sources. In most cases, the team was able to corroborate each action in the narrative with two or more sources.

As the day of the accident progresses, the time increments covered by the narrative become smaller. In the period from 1530 to 1700 on June 11, 2008, the observed fire behavior, the actions of crew members, and the movements of vehicles are described in time increments as detailed as minute-by-minute.

Satellite images were used to depict overall topography, vegetation, and fire progression. Information from specialists on the APA team, the IMET and FBAN on the IMT, and others, was used to understand the largely unrecognized physical mechanisms behind the development and propagation of the large scale rotating vertical plume.

Many of the primary participants in the fire operations on Division C of the Indians Fire on June 11, 2008, were working across several supervisory and operational responsibilities. For example, the Fulton IHC Superintendent had collateral duties in his role as a Hotshot Superintendent and his role as the Firing Boss. The Division C Supervisor had responsibilities in his role as Division Supervisor and also was functioning as a Dozer Boss some of the time. Each of these individuals is identified by their primary operational status and qualifications.

The story in the next chapter describes the events and actions of the primary parties that were involved in the accident or were working in the area where the accident occured. The story is told in the present tense to give the reader a sense of being there at the time with the individuals.

IV The Story of Forest Service Engine Crew 71

On Tuesday, June 10th, the crew of Engine 71 (E-71) returns to work after their two scheduled days off, working their normal shift of 0930 -1800 hours. Their work day consists of light duty, engine and equipment maintenance, and paperwork. Around 1930, the Engine Captain receives the dispatch call at home for an assignment to the Indians Fire. The dispatch resource order requests the crew report to the Indians Fire ICP at 0600 the next morning. The Captain accepts the assignment for the crew and thinks the crew should get on the road as soon as possible. The Engine Captain leaves home at this time and drives back to the station, approximately 85 miles away, arriving at 2200 hours. The rest of the crew lives in the general locale of the Ranger Station and is waiting for the arrival of the Captain. In the meantime, the crew is checking the engine for readiness for what could be a 14 day fire assignment. The Captain arrives and transfers his gear to the engine. They leave the compound at Lebec, California and travel to the Indians Fire, 18 miles west of King City, California.

The driving time to the Indians ICP is about 3 hours and 40 minutes and after a stop for fuel, the travel is closer to 4 hours. The FEO has prior experience driving to the ICP location and "knows the roads." While en route, all except the FEO take catnaps while someone remained awake to talk to the FEO to ensure his alertness. The E-71 crew arrives at ICP at 0200, throws their sleeping pads and bags on the ground, and they soon get some sleep. The crew rises at about 0530 and reports in at ICP at 0600.[1]

By that morning, June 11, the fire had burned approximately 5,000 acres. The Engine Captain and FEO both attend the 0600 overhead briefing and gather general fire and weather information and pick up an Incident Action Plan (IAP). After the overhead briefing, the Division C Supervisor conducts a short briefing for the division overhead and Crew Bosses, giving a general overview regarding the Division C's assignments, and indicating that resources should meet near the Division C/D break for a further briefing and assignments. Since E-71 is unassigned, they do not attend any Division breakouts and leave the briefing area looking for Operations and Plans to let them know they are available for assignment. E-71 is assigned to Division C. Their assignment is to drive to the Division C/D break and support a firing operation. The Captain and FEO rejoin their crew, eat breakfast, and then proceed to the staging area. [2]

The Engine Captain and FEO receive an IAP and use it to brief the crew. The weather forecast in the IAP indicates forecast temperatures and relative humidity will be similar to the previous day (north to northeast winds 8-18 mph at ridges becoming north 5-10 mph in the afternoon and north 10 mph in the valleys, becoming upslope and up canyon at 3-7 mph in the afternoon). Forecast fire

[1] See Appendix E, Decision Factor #1: Late Departure
[2] See Appendix E, Decision Factor #2: Sleep Deprivation

behavior is also similar to previous days with an emphasis on the potential for moderate fire behavior on the south and eastern perimeters that could test containment lines.

The IAP notes that firefighters should expect spotting and sustained runs. Due to minimal RH recovery, the fire burned actively through the previous night, tripling or quadrupling in size from June 10th (Figure 2).

One incident objective is to keep the fire north of the San Antonio River. According to the IAP, the organization on Division C includes a Division Supervisor, 3 Type 1 Crews, one Type II Crew, a Strike Team of Type III engines, including Engine 71, 4 Dozers, a Safety Officer, a Field Observer and 2 line Emergency Medical Technicians (EMTs).

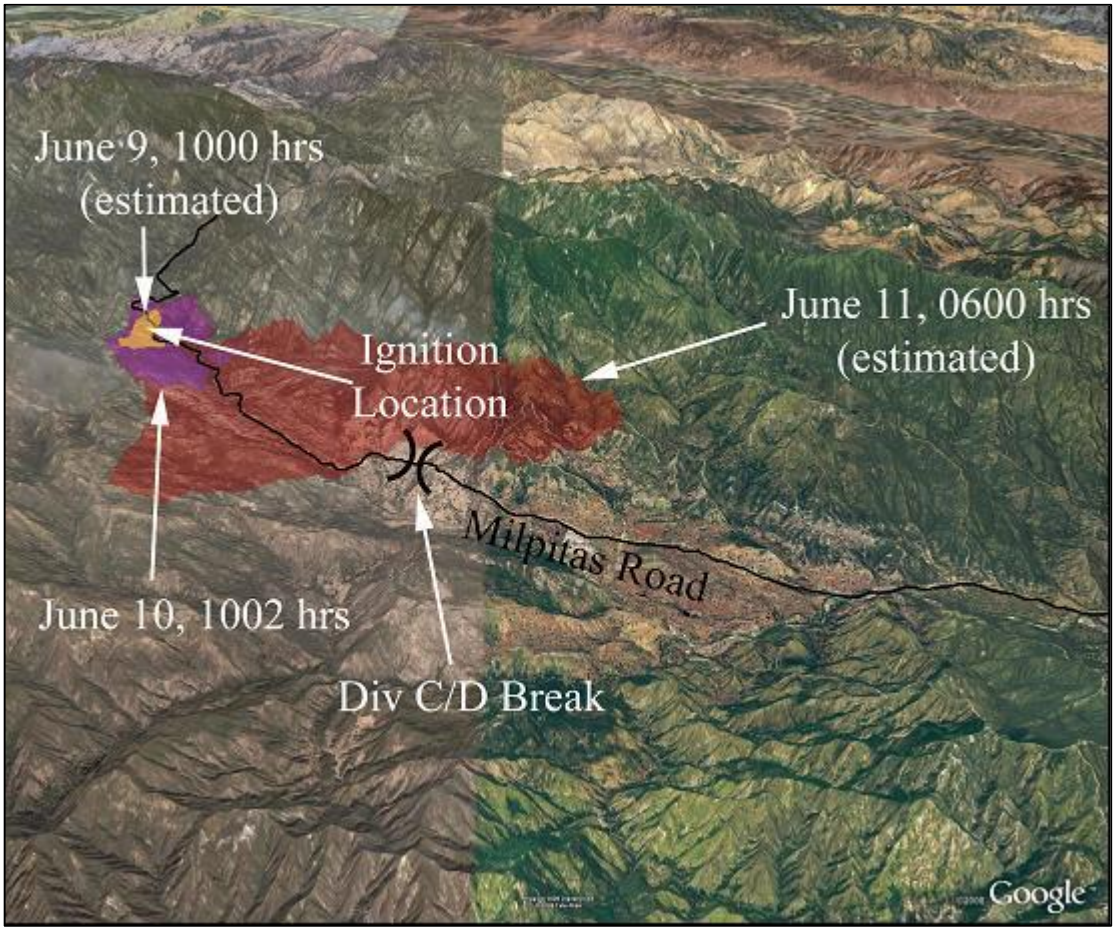

Figure 2. Fire progression map for period June 9 1000, through 0600, June 11, 2008.

E-71 leaves the ICP for the line at 0730 and arrives at the Division C/D break at about 0800. Once they arrive at the Division C/D break, the resources are told to stage here until the Division Supervisor and scouts come back to confirm tactics of the day.

Figure 3. Oak/grass vegetation along Milpitas Road.

Fuels along the Milpitas Road consist primarily of light dead grasses in the oak savanna (Figure 3). As the terrain rises above the valley floor, the vegetation changes abruptly to chaparral brush on the slopes to the north of the road (Figure 4). It remains the dominant fuel type on the upper slopes.

Figure 4. Chaparral vegetation, typical of slopes in Indians Fire.

The engines and crews wait at the C/D division break until the determination of the status of the main fire, how far it has burned through the night, fuel loadings, and general information needed to proceed with the tactics for the day (Figure 5). Once the Division Supervisor and scouts return to the C/D division break, a short briefing is conducted with final assignments for the day.

Between 0900 and 0930, a burnout begins and lasts until 1100 to establish a safety zone at or near the division break. Each engine on Division C works individually with a different hotshot crew to support the firing along their assigned sections of the road. This operation is to fire from the division break, east through Division C, firing off and to the north of Milpitas Road (also known to some as Del Venturi Road). The tactical goal of this action is to secure the

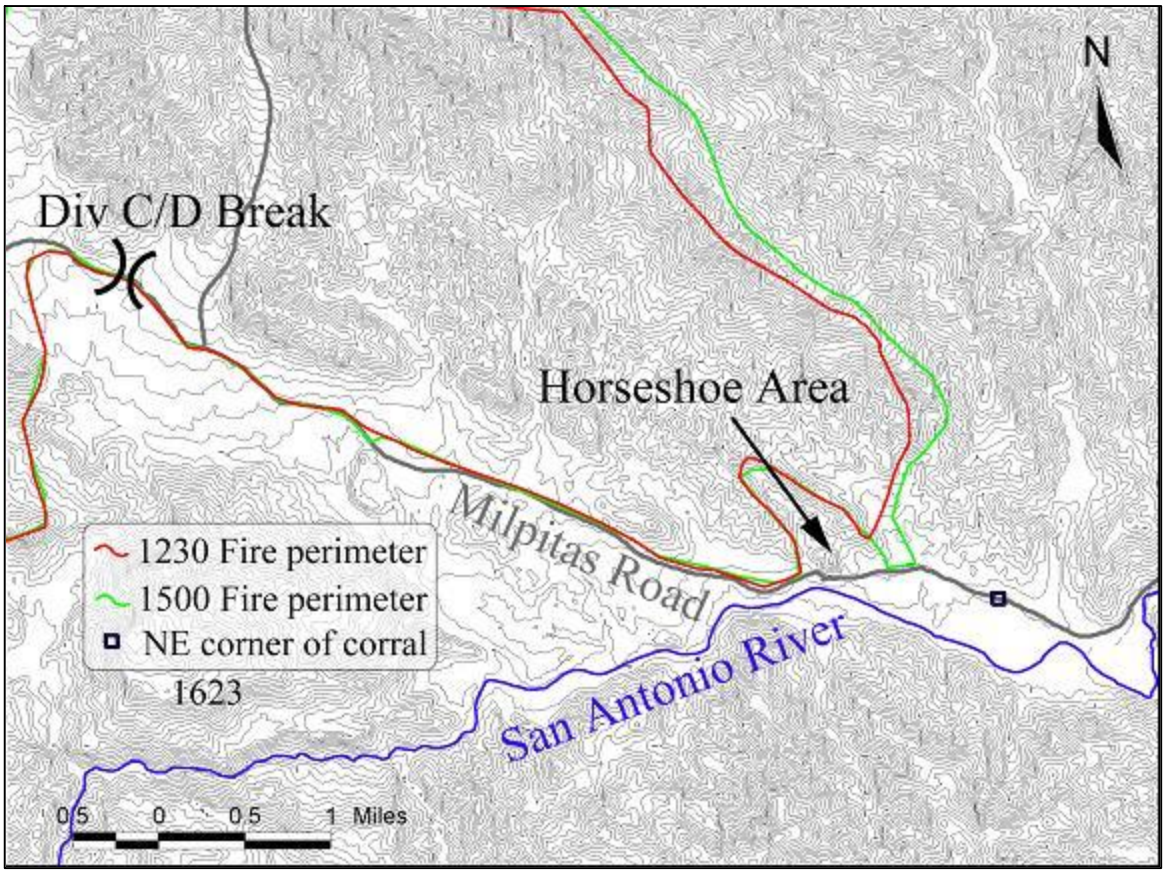

Figure 5. Vicinity map.

southern end of the fire. E-71 is being used as a holding crew for the burnout operation. Winds are from the north, consistent with the weather prediction. Initially, fire behavior in the grass fuels is low with limited success in the safety zone firing operation.[3]

Between 1200 and 1500, crews work to establish an interior control line between Milpitas Road and the main fire west of the C/D break. The area to be burned out is shaped like a horseshoe and is referred to as the "horseshoe area." An interior control line is used to reduce the visual fire impact along Milpitas Road. At this time fire intensity matches forecast levels, burning actively in the fine grassy fuels with nearly 100% consumption, driven north by the ground level winds drawing into the main fire further north. Between 1330 and 1430, several spot fires occur to the north of the Milpitas Road and south of the horseshoe area interior control lines, with one spot fire located 100 feet off of the road. The Kings River Interagency Hotshot Crew Superintendent directs helicopter bucket drops on spots. At this time, the FEO observes the column to be over their heads and states, "Fire is not ripping." At 1431, the FEO reports that a tree is torching on the

[3] See Appendix E, Decision Factor #3: Safety Zones

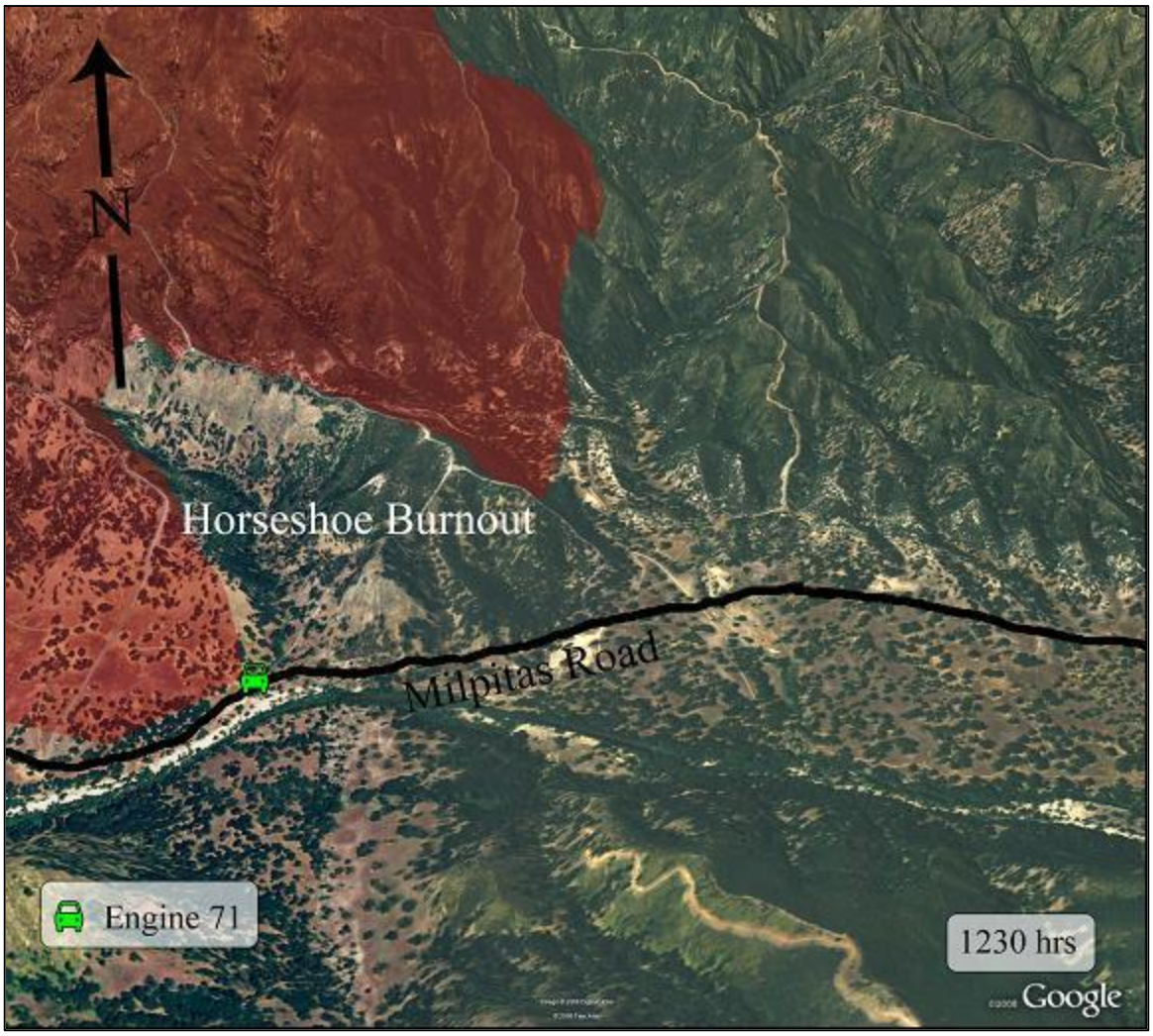

Figure 6. Approximate fire perimeter at 1230 on June 11, 2008.

north side of the road from the firing operation and he pulls up to it and cools it down. As a consequence of the spot fires south of the interior control lines, the firing operation is halted and crews fall back to firing off of Milpitas Road. E-71 and the Santa Barbara Engine support hotshot crews in the horseshoe area firing operation (Figure 6). After the horseshoe burnout, several members of the E-71 crew eat lunch. During this time, the Engine Captain sees a relatively small fire whirl to the north/northwest. The Engine Captain doesn't think much of this fire whirl other than it is an indicator of a slight change in fire behavior.

Between 1430 and 1500, a water tender tops off Engine 71 with water. At about this time, a Fulton Interagency Hotshot crewmember contacts E-71 requesting them to follow the crew as they leap frog east past other crews working along Milpitas Road as they begin burning again. The LPF Interagency Hotshots are brushing out the road ahead of the Fulton Hotshots and E-71.

As the day progresses, the fire and weather conditions are incrementally changing. An indicator of changing conditions is the occurrence of several spot fires and increased fire intensity between 1430 and 1500. The winds at this time are light, 0 to 5 mph from the north.[4]

By 1533, the Fulton Hotshots are moving the firing along Milpitas Road (Figure 7). One of the squad bosses from the crew is talking on a video indicating that the firing is commencing once again and he comments on a slowly rotating vertical plume north of the road.

At 1534, the Fulton Superintendent (Firing Boss) asks air attack for an aerial platform for "eyes in the sky" to perform as a lookout for spot fires to the south. The Fulton Crew is now firing well west of the corrals, with E-71 holding.[5]

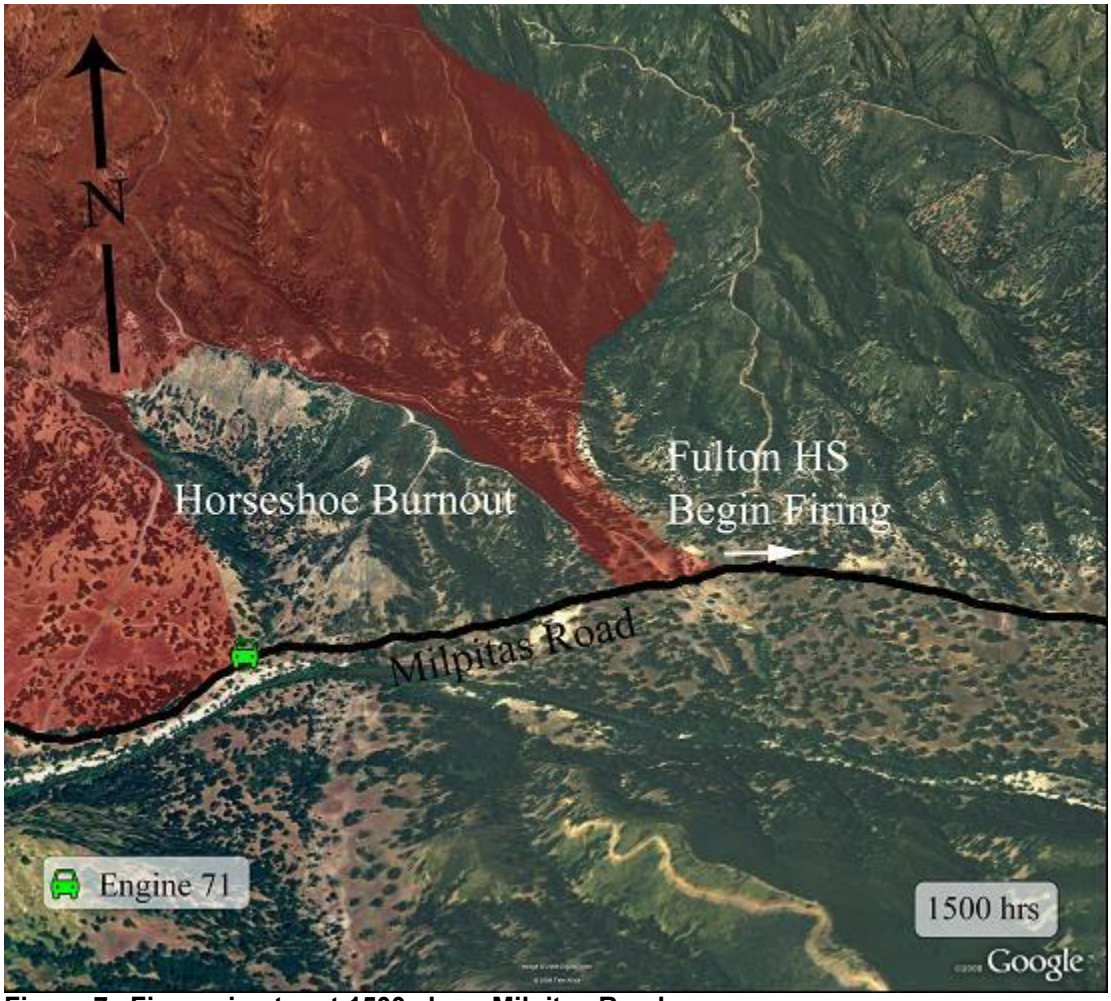

Figure 7. Fire perimeter at 1500 along Milpitas Road.

[4] See Appendix E, Decision Factor #4: Lookouts
[5] See Appendix E, Decision Factor #5: Escape Routes

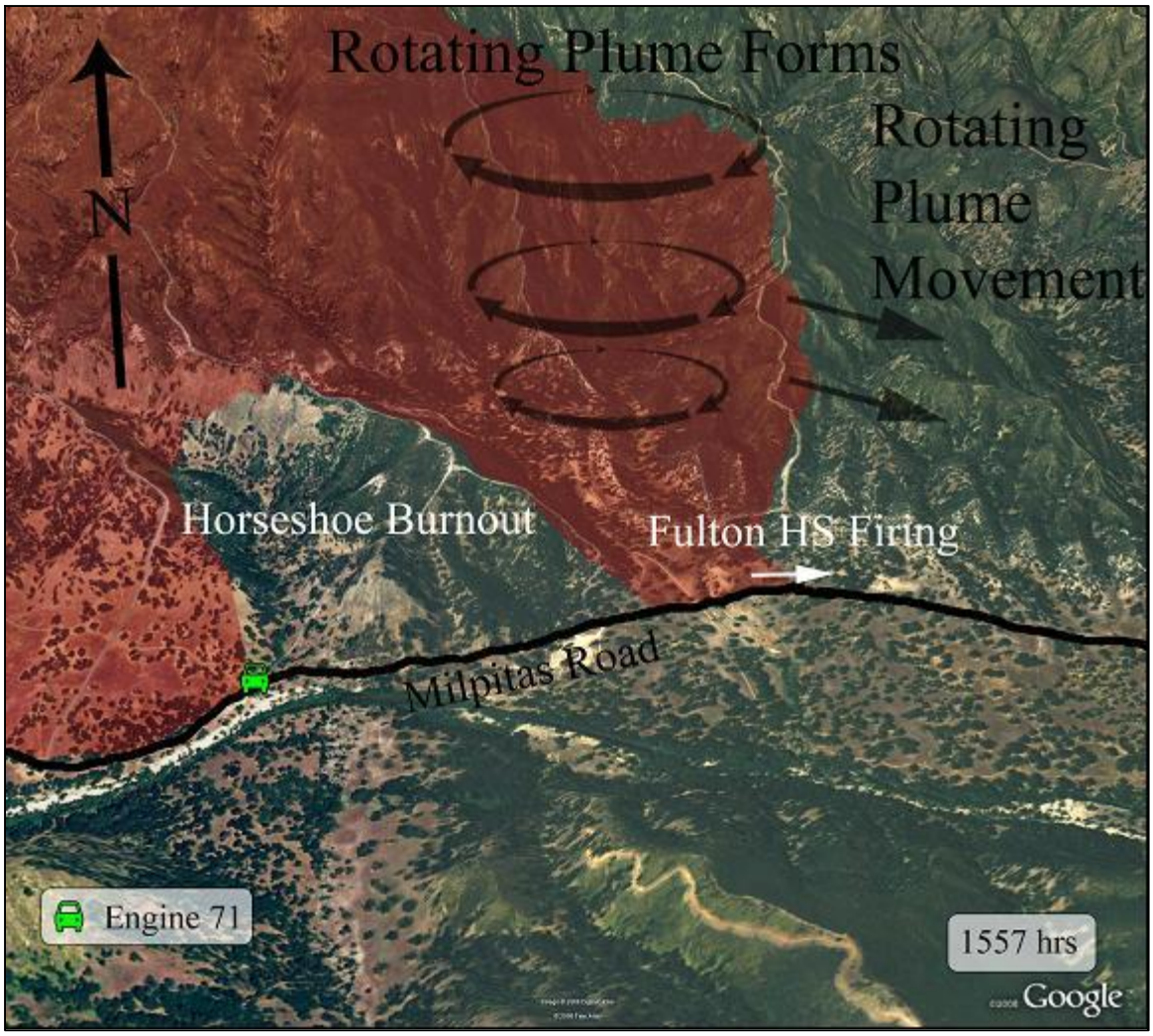

Figure 8. Fire perimeter along Milpitas Road at 1557 hours. Vertical rotating plume is clearly shown in video images at this time.

At 1547, the Fulton Superintendent and the LPF Superintendent are discussing the burning operation and the increasing fire conditions and severity. At 1600, Fulton continues to bring fire down the road, moving faster now, trying to hook around the main fire which is flanking to the east. The goal is to finish the firing and tie it off to an anchor point on the east side before the main fire can out flank them and threaten the Milpitas Road. A rotating vertical plume is recorded on video at 1601 north of the Milpitas Road (Figure 8).

At 1603, the June 11th night shift Division C Supervisor (Videographer #1), is gathering situational awareness of the division for night operations in the vicinity of the corrals, along the Milpitas Road and just east of the firing operation. He records several video clips of the rotating plume north of the road. The video demonstrates the size of the growing rotating plume. (View this video at <http://www.myfirevideos.net/?v=62>.) In one clip he states, “The rotating plume is paralleling the road.”

Figure 9. Photograph taken about 1607 on June 11, 2008 from a ridge south of Milpitas Road.

By now the rotating plume is also identified by the Hotshot Superintendents, Videographer #1, the LPF Hotshots, and others who are taking photos of the plume as it is developing and moving parallel to the Milpitas Road (Figure 9).

At this time, the engine crew does not seem to be aware of the vertical rotating plume, although it appears that several others in the division near the engine have been watching it for some time, and for some reason they aren't communicating to the engine crew or other firefighting resources. The rotating plume appears to be about 300 feet north of the corrals. The plume seems to have originated in the chaparral north of the firing operation. Witnesses state that rotation of the entire plume is visible intermittently and that it continues to parallel the firing operation. The diameter of the base of the plume is approximately 1,000 feet and is defined by smoke and intermittent burning (Figure 9).

At 1603, someone in the video says, "I think they'll make it now," indicating that the firing operation will be able to hook around the east end of the main fire. Videographer #1 says, "The firing operation is picking up fire whirls."

Approximately 1607, the Fulton Superintendent stops the burnout to reassess the status of the operation as it relates to the spread of the main fire (Figure 10). The Superintendent parks west of the corral where he has a good vantage point to view the fire and the firing crew.

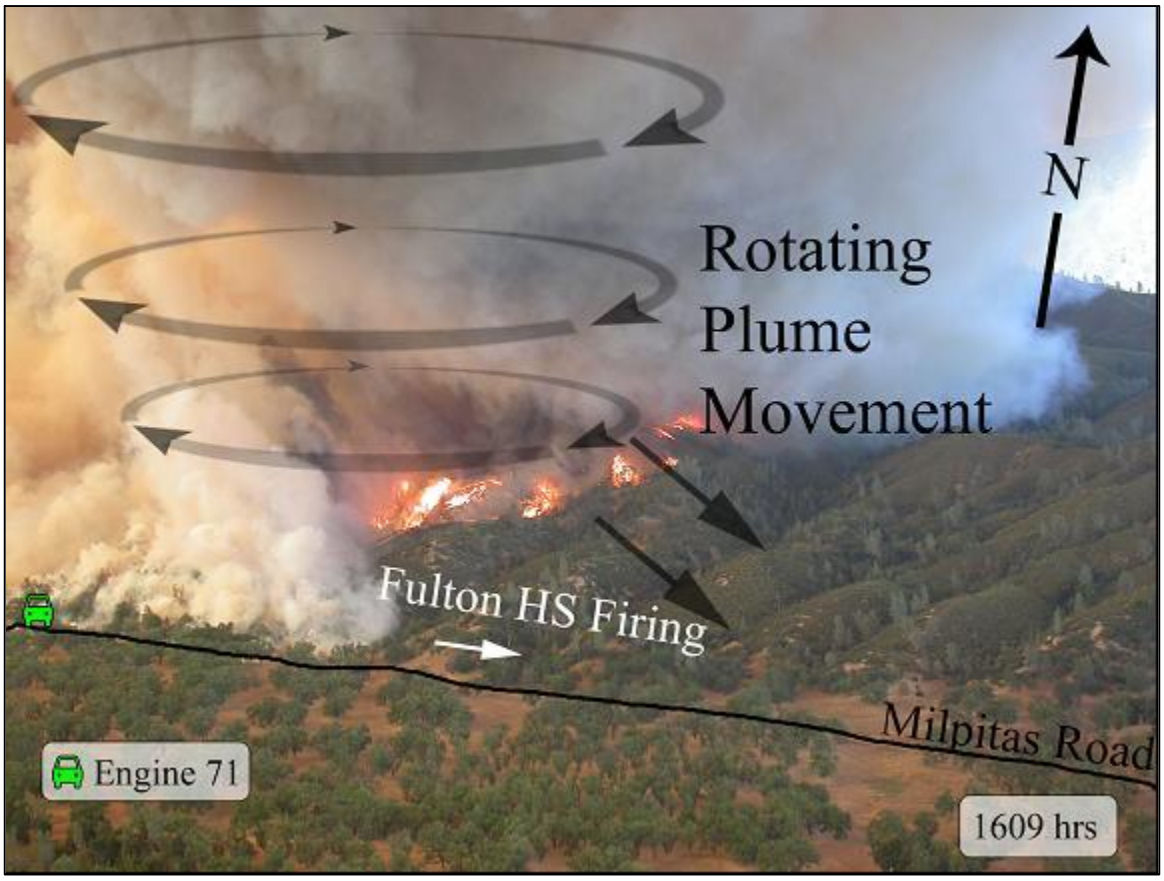

Figure 10. Photo of fire at 1609 hours.

At 1610, Videographer #1 takes a video from east of the corrals and has a good view of the rotating plume. He states, "It's like a freight train right now."[6]

Approximately 1611, the Division Supervisor stops and meets with Fulton Superintendent near the corrals to discuss his concerns that the firing operation is creating too much heat on the ground. Upon stopping his truck, he notices that the Superintendent has already ceased the firing operation.[7]

At 1614, the Superintendent feels that he needs to restart the firing operation before the main fire out flanks them.

At 1615, E-71 Crewmember #3 removes his gloves and is eating a sandwich in the engine when he hears over the radio the first report of a spot fire near the river to the south of the road.

At 1616, the Fulton Superintendent and Division C are still talking when the Fulton burners pass them.

[6] See Appendix E, Decision Factor #6: Communications
[7] See Appendix E, Decision Factor #7: Voicing Concern

Figure 11. Image from video footage captured near the corral along Milpitas Road. Winds are generally from the south, into the main fire.

The video record demonstrates that as the Fulton Hotshots continue to ignite along the road, the grasses are consuming very rapidly after ignition (Figure 11). The surface winds appear to be switching from blowing from the south to blowing from the east.

At the 1618 timestamp, a Fulton Crewmember (Videographer #2) takes a video clearly showing the vertical rotating plume and the rotation appears to be increasing in speed. It seems to be closer to the road and there are flames visible in the plume. Winds at the surface are flowing directly north into the plume base.

The Safety Officer assigned to this division says over the radio “Spot fire west of me” (referring to the spot fire near the river). About this time the Division Supervisor drives west, possibly after hearing about the spot fire. At this same time, based on the timestamp from the video, Videographer #1 states “There is s--- raining down on people.”

At 1619, Videographer #1 says, “The firing is nearly complete,” and then hears the same report of the spot fire near the river, 1000 feet off the road and “It’s

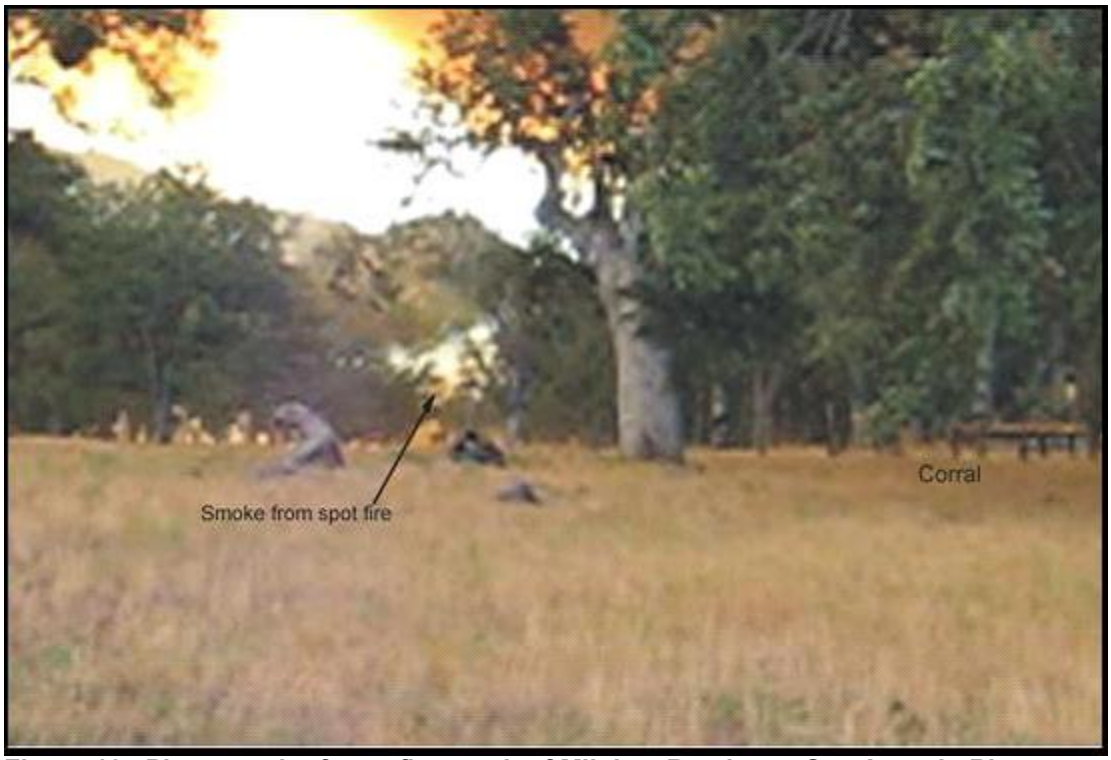

Figure 12. Photograph of spot fire south of Milpitas Road near San Antonio River.

taking off." At the same time, Videographer #2 states on the video, "It's crazy to see how much suction the fire whirl has, sucking it all in." The dozer that is building the contingency line, south of the road, turns around and is responding to the spot fire (Figures 12 and 13). A helicopter is requested to support suppression of the spot fire near the river.

The Fulton Superintendent asks for confirmation over the radio, regarding the spot fire near the river. Videographer #2 states on the video "Flames way up in the column" and "I think we just lost it."

At 1619, E-71 is parked west of the corrals, under a tree on the south side of the road, facing east. According to the FEO, "It seems like we are stopped here forever!" There is a slight lag time here and the Engine Captain takes this opportunity to roll up the mobile attack hose on the front bumper. In order to do this, he takes off his gloves and puts them in the box on the bumper.[8]

It appears that the plume is now closer to the road and the wind along the ground has definitely changed from a southerly flow to a strong flow from the east to the southwest that is visible in the lower portion of the plume. The Engine Captain remains unaware of the plume, and has not received any communication that the vertical rotating plume is present and increasing in size and velocity.[9]

[8] See Appendix E, Decision Factor # 8: PPE
[9] See Appendix E, Decision Factor #9: Crew Isolation

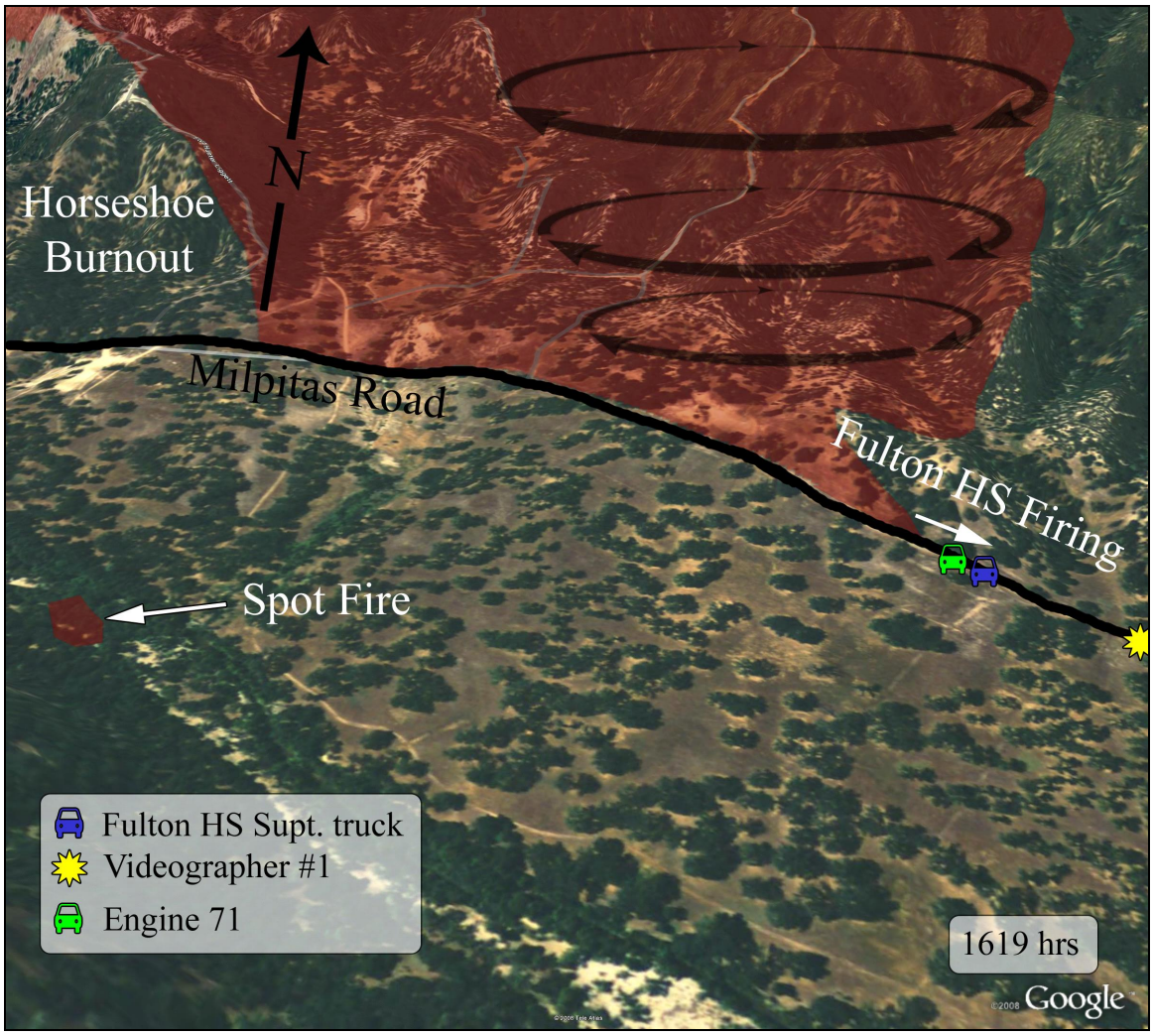

Figure 13. Approximate fire perimeter at 1619 hours.

At 1619, Videographer #1 states in the video, "It is pushing down and it is going to come down on Rio Bravo" (a later interview indicates he meant Fulton IHC burners).[10] At 1620, Videographer #2, states, "This is an old military base and there are live rounds going off."

The Division Supervisor returns to the Fulton Superintendent's location, west of the corral. He is trying to locate or make contact with the dozer that responded to the first spot fire near the river.

While E-71 is parked (see Figure 14), the Captain hears of a new spot fire adjacent to the south side of the road, about 350 feet west of E-71 (Figure 15). The Fulton Superintendent sees the new spot fire about the same time and says, "When I see the spot, the wind is from the east and it is clear, crystal clear, and this spot fire is a simple single spot."

[10] See Appendix E, Decision Factor #10: Hotshot Umbrella

Figure 14. Photograph of E-71 at approximately 1619 hours.

At 1621, based on video records, the Engine Captain tells the FEO to turn the engine around and to point it to the west. Engine Crewmember #1 helps the FEO back the engine up and then go forward several times in order to turn the engine around. While the engine is turning around, the Engine Captain and Engine Crewmembers #2 and #3 start walking along the road to the west towards the spot fire which is 320 feet from where the engine is parked. They do not take any tools with them and the Engine Captain leaves his gloves on the front bumper of the engine. Crewmember #3 also leaves his gloves on the back seat of the engine. The Engine Captain realizes he left his gloves and tools at the engine, and is thinking it is okay because he believes that the engine, once turned around, will be at the spot fire before the three of them arrive. According to Crewmember #3, "When we start walking to the spot, conditions seem the same as they have been all day."[11]

At 1622, the Division Supervisor is now driving back to the west along Milpitas Road to continue to search for the Dozer Operator who is not answering his radio. As he is driving west, he notices an engine backed in south off the road, appearing to be turning around to the west.[12]

[11] See Appendix E, Decision Factor #11: Crew/Engine Separation
[12] See Appendix E, Decision Factor #12: Situational Awareness

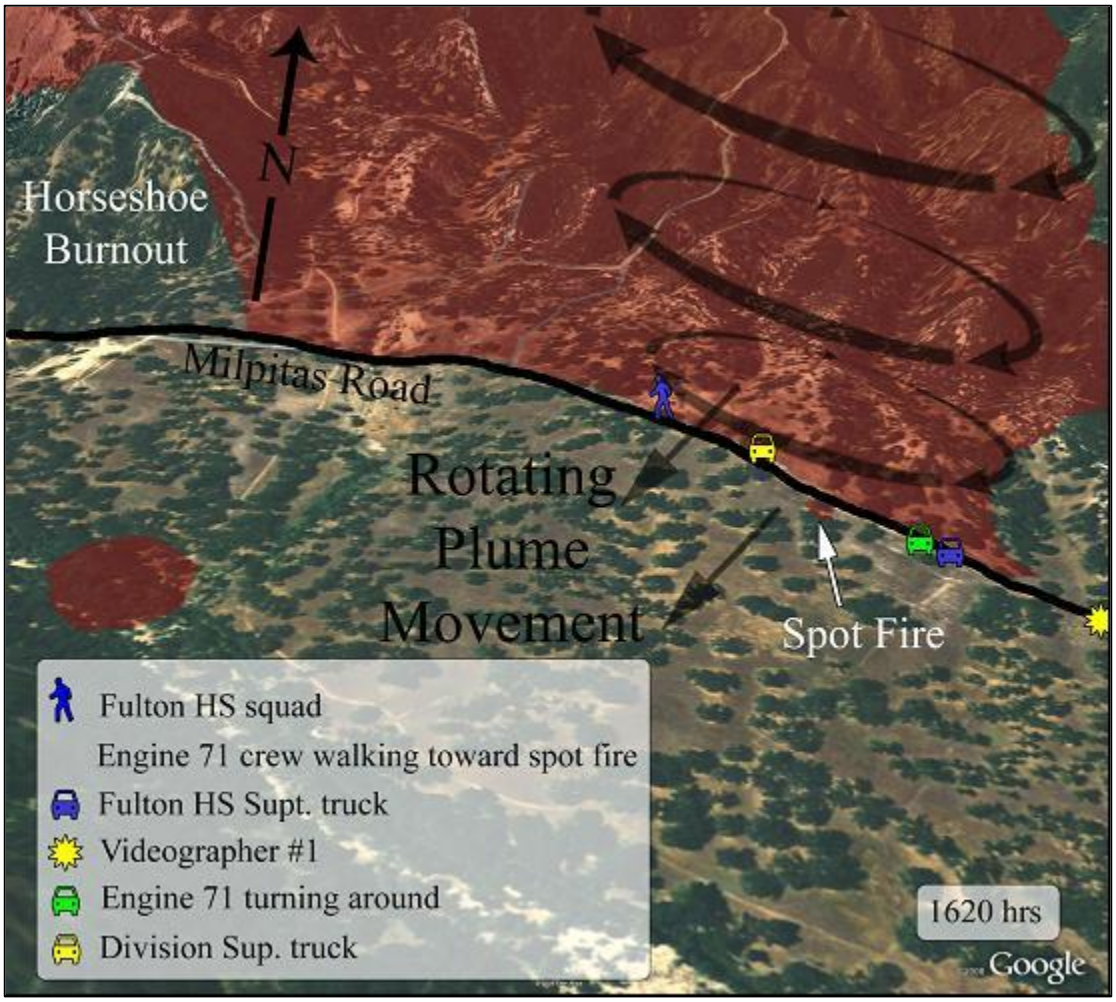

Figure 15. Schematic of crew, vehicle, and fire locations at 1620 hours.

After the engine is turned facing north ready to pull out to the west (Figure 16), Engine Crewmember #1 begins running down the road, towards the spot fire, to catch up with other crewmembers.

Video images of the rotating vertical plume show the southern edge is within a few feet of the road. The plume is rotating, behaving much like an F0 to F1 scale tornado with winds approximately 70 mph, and the tree canopies on both sides of the road are moving in the strong winds. The edge of the plume is defined by smoke and entrained embers with intermittent burning of surface fuels. The base is approximately 1000 feet in diameter.

At 1623, E-71 pulls onto the road following his crew to the west. The Fulton Superintendent walks south of the road into the grass without his fireline gear, pack, gloves, hardhat, etc. He is looking for the Dozer Operator who is not answering his radio. The Division Supervisor and the Fulton Superintendent are both concerned about the Dozer Operator's welfare. As the Fulton Superintendent is walking in the grassy field, he turns around with the wind blowing from east to west, propelling embers and debris all around him.

Figure 16. E-71 has just turned around and is beginning to pull out to head west after the crew.

His crew estimates that the winds near the corrals are 40-60 plus mph. The Superintendent says, “It seems that the ceiling is coming down on me. It appears to be at the tree tops and conditions are deteriorating fast.” The Fulton Superintendent is fighting to move north to his truck, holding the ball cap that he is wearing and covering his face (Figure 17).

The Fulton Superintendent knows that he has to get back to the road, and isn’t sure that he can. Videographer #1 states, “The winds east of the corrals feel like 30 plus mph and there are numerous spots.” Witness statements indicate winds increase close to the plume. Embedded in a Wizard of Oz environment, seeing all the debris flying in the air, the Fulton Superintendent expects, “At any moment, I will see a cow go spinning past.”

Figure 17. Photo of the spot fire to the south of Milpitas Road near the river. Fulton IHC Superintendent fighting through the wind to return to his vehicle.

The Fulton Superintendent is concerned that the crew is walking ahead of the truck (Figure 18). As he is returning to his truck, he hears a screech coming from the engine, notices the brake lights on E-71 come on, and the truck abruptly stops and a door opens. He states, "I interpret the truck stopping and a door opening to mean that the engine caught up with the crew and the crew is loading into the engine." His primary concern is finding the dozer.[13]

At 1624, a large oak limb breaks off a tree, crashing down onto the north side of the road causing an ember shower which blows embers everywhere. These embers, fanned by the increasing winds from the rotating plume, ignite many more spot fires. The branches from the limb strike Engine Crewmember #1 as he is running to catch up with the rest of the crew. He suffers some cuts, scrapes and bruises to his upper body. The high winds blow debris and golf ball size rocks through the air hitting Crewmember #1.

Engine Crewmember #1's instincts warn him to go back to the engine, but he is compelled to continue forward to link up with the crew. He continues running west towards the crew to warn them of the spot fire hazards.

[13] See Appendix E, Decision Factor #13: Narrow Focus

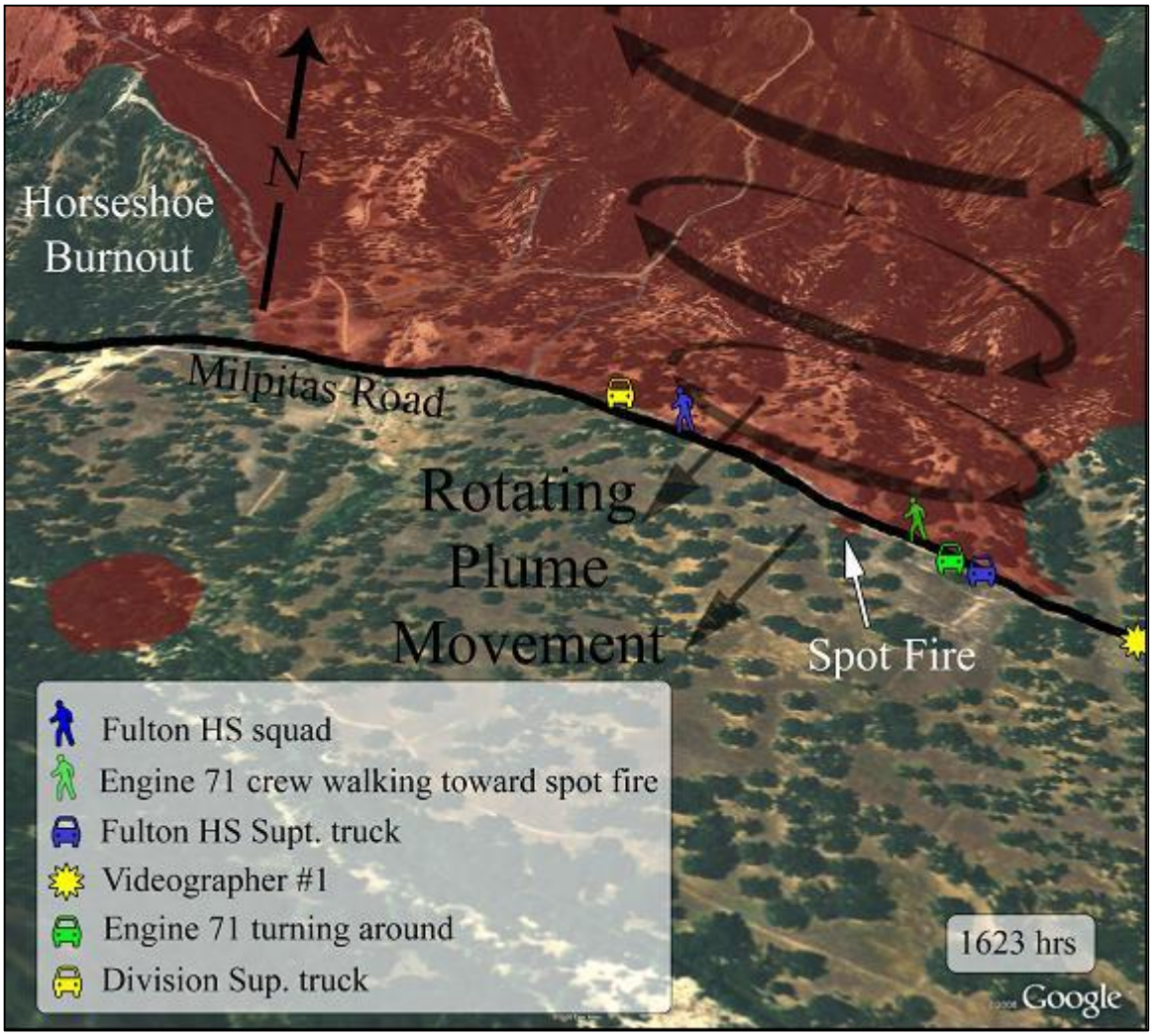

Figure 18. Schematic of crew, vehicle, and fire locations at 1623 hours.

At the same time, the FEO is driving slowly to the west and feels strong gusts of wind hit the engine from the east. He notices it is comparable to the 60-70 mph winds he feels when working on fires along the Interstate. He sees a limb fall west of his position, partially in the road. It seems to explode with embers blowing everywhere, (this was the same limb that hit Crewmember #1 as he was running to catch up with crew). The FEO is concerned for the well being of the engine crew and realizes they may need help. Embers from the fallen branch are igniting multiple spot fires on the south side of the road. Due to dense smoke, he can not see past the front of the hood on the truck. He radios the E-71 Captain, "Captain 71, Engine Operator 71, spot behind you." The FEO can't hear the radio due to the wind and flying debris, as well as the roar of the fires, and he realizes the Captain can't hear either. He hears loud popping and noise from debris hitting the truck. The FEO is thinking, "I am afraid."[14]

[14] See Appendix E, Decision Factor #14: Fear

At 1625, the E-71 crew is approximately 100 feet from the engine when the situation rapidly deteriorates (Figure 19). Seconds after the wind shifts to the west, a branch from a nearby oak tree breaks loose between the crew and the engine. When the crew hears the crash from the falling branch, they look to the east and see Engine Crewmember #1 running to join them. Suddenly, the air is filled with branches, embers, smoke, dirt, heat, and deafening sounds. Although no flames are observed, the rising air temperature is a cause of concern.

The Captain is under pressure to assess what is happening and what actions he and the crew should take. Looking back, he observes Engine Crewmember #3 with his eyes partially closed, moving away from them towards the southwest towards a large overhanging oak branch. Perceiving falling branches to be a danger, Crewmember #1 grabs Crewmember #3 and points him east towards the engine. The crew is gathered near the south edge of the road within 5 to 10 feet of each other. Things are now chaotic. Trying to see and hear is difficult with the dust, wind, fire intensity, and dense smoke. The Captain is trying to decide where to go and it seems hotter and darker to the west, so he thinks it is less risky to go back towards the east. At this time, it is hot enough to feel pain to exposed skin. As the Captain starts pulling out his shelter, he turns to yell to the others and they are reacting to their Captain's action and are starting to deploy too. Crewmember #1 is thinking, "Oh my gosh! I am actually doing this!" Crewmember #2 is thinking "Holy c…, this is really happening!"

At this time, the Captain notices that Crewmember #3, who had started to run away earlier, is now gone. The Captain is looking and inching to the west and does not see Crewmember #3 go west, so hopes and reasons that the missing crewmember has gone east towards the engine.[15] [16]

Prior to deploying his fire shelter, Engine Crewmember #1 indicates he smells a strong odor that makes him nauseas, and as a consequence, he reaches for his water bottle and takes a drink. He drops the bottle (Figure 20).

The Captain and Engine Crewmembers #1 and #2 deploy their fire shelters and use them in a crouching position to shield themselves from heat while they attempt to move backwards into the wind toward safety. At the time of the deployment, winds are estimated to be as high as 70 miles per hour and the firefighters are surrounded by smoke and blowing embers.

One of the firefighters does not have any difficulty deploying the fire shelter despite the wind and limited visibility. Another firefighter notices his red pull tab strip stretches before it separates from the PVC bag and he considers using a knife to open the bag. Eventually, he is able to open it.

[15] See Appendix E, Decision Factor #15: Narrow End of the Time Wedge
[16] See Appendix E, Decision Factor #16: Crew Cohesion

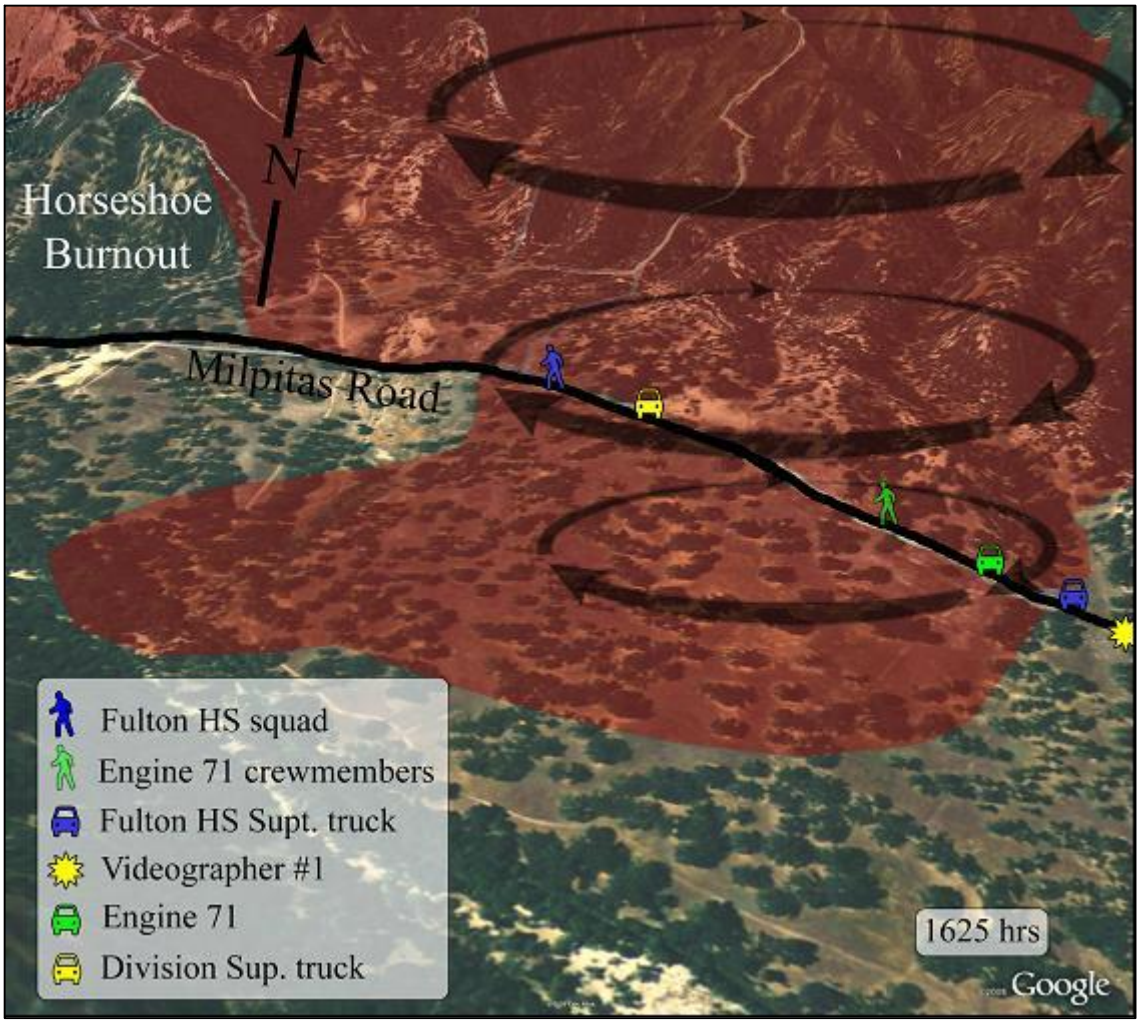

Figure 19. Approximate location of crew and vehicles at 1625.

Two firefighters have difficulty unfolding their fire shelters and struggle to maintain control of their shelters in the wind. The firefighters position the shelters to cover their backs, from their heads to their calves. With the additional protection of the shelters, they notice a marked decrease in temperature.

As they attempt to move, Crewmember #1 states, “It feels like we are trying to run and not going anywhere. It is like trying to run through waist deep water.” As a group, they continue struggling to move eastward, trying to stay near the road center and away from the oak trees.

As Engine Crewmember #3 runs eastward away from his crew, he attempts to deploy his fire shelter. He gets the flap of the horizontal fire shelter compartment on his field pack open and has difficulty removing the shelter from the pack. He is attempting to run eastward and is covering his face with his arm intermittently, while also trying to shield his hands under his arms. He encounters flying burning embers, smoke, and low flames blowing in many directions. He is thinking “I can’t

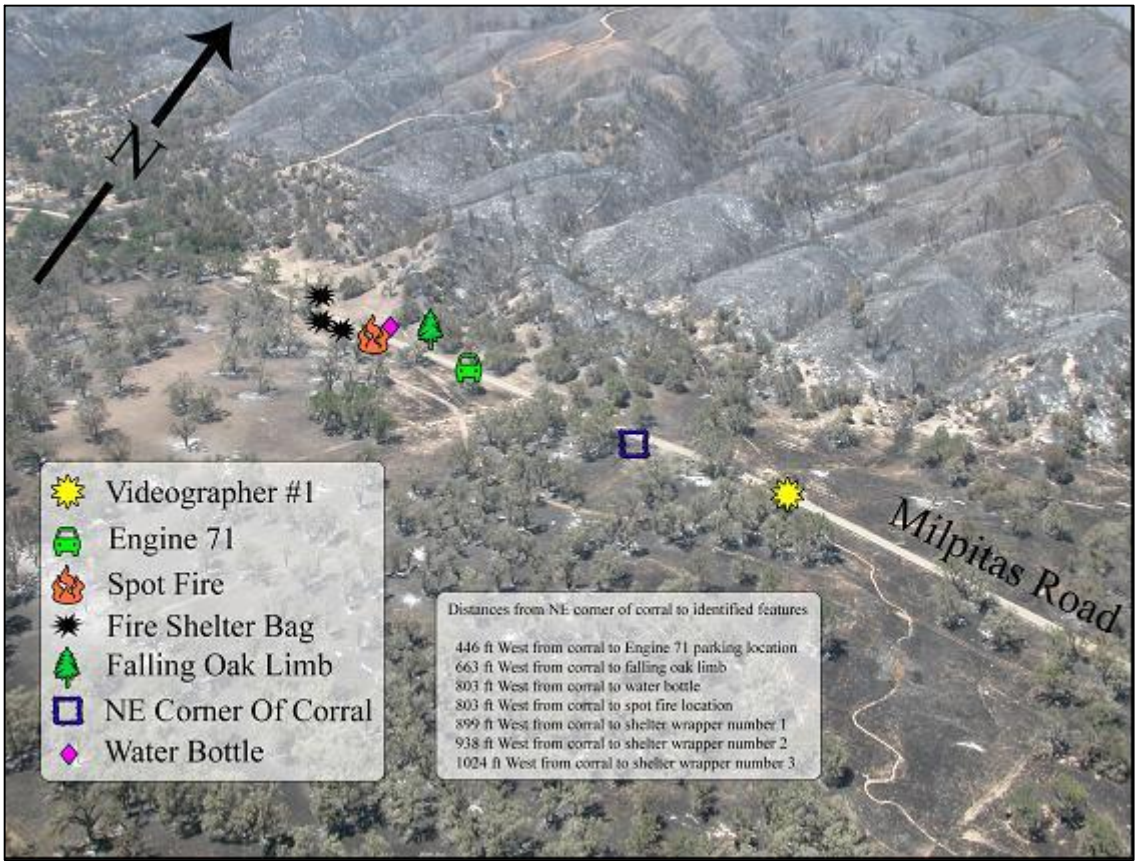

Figure 20. Aerial view of accident location with distances between crew, equipment, and other relevant points.

believe this is happening to me." He feels hot air in his throat and attempts to run while holding his breath. He tries removing one strap of his pack from his shoulder to reposition the pack for better access to the shelter. He is thinking, "If I can deploy my shelter, I will go into it on the road." Before he can remove the shelter, he sees the headlights of Engine 71. At this point, he abandons his attempt to deploy his shelter, runs to the engine, and enters the cab.[17]

As the FEO drives slowly forward, one of the E-71 crewmembers comes running towards him along the north edge of the road. The FEO sees a large branch fly past, just in back of and narrowly missing his crewmate. He stops and the crewmember gets into the engine. "Where are the others?" asks the FEO. The response is, "Right behind me." No one else comes out of the smoke, and with all the heat and debris, the FEO decides to move forward to the west. It is getting much darker to the west and the he thinks the others must have run to the west. After moving only a short distance, he decides to start backing out to the east (Figure 21).

[17] See Appendix E, Decision Factor #17: Realistic Shelter Training

Figure 21. Photograph taken from west of corral looking at area where rotating vertical plume has crossed the road. The Fulton Superintendent vehicle is shown in the photo.

At about this time, a squad from the Fulton Hotshots, approximately 300 feet west of the crew of E-71, is facing strong winds blowing west to east, the opposite direction to the winds faced by E-71. One witness states “It appears they are running in place as they attempt to move west away from the rotating vertical plume.” Debris consisting of rocks on the road and numerous broken oak branches are falling and covering the ground (Figure 22).

Crewmember #3, who just got into E-71, is very shaken up, and the FEO suspects the crewmember, who is breathing hard, may have sustained major injuries. The FEO does not stop to assess the crewmember as he shifts his attention and concern back to the three still missing. Getting out and getting help for the injured crewmember is a known problem and the fate of the others is speculation. The FEO chooses to act on the known reality and continues to back out of the smoke. Once out of the smoke, he stops the truck in the eastbound lane of the road (Figure 23).

At this time, further to the west, the Engine Captain is feeling increased heat and considers getting down on the ground at the side of the road. The Captain is reluctant to stay on the road due to the chance of being hit by a vehicle and he also recognizes the risk of being hit by flying debris.

Figure 22. Photograph of broken oak limb typical of those scattered all around the accident area.

He and the crew are crouching low, backing into the wind to reduce wind resistance and avoid letting hot air under their fire shelters.

Meanwhile, the Division Supervisor is looking for the dozer and has a compelling urge that he is needed east up the road. Driving eastward, the Division Supervisor finds it difficult to see in the dense smoke and blowing debris. He sees a flash (likely his headlights reflecting off the fire shelters). The flash alerts him to the possible presence of others. Before the Captain can make a decision about lying down, the Division Supervisor pulls alongside them in a utility truck. The Division Supervisor, seeing the firefighters immediately adjacent to his truck, stops and yells at the crew to get inside. Although the crew does not hear the horn honking, nor see the headlights, they can hear the Division Supervisor call out to them. When the crew gets inside the vehicle, the Division Supervisor asks if they know where the dozer is. It was a little later that the Division Supervisor realizes the three firefighters are injured (Figure 23).[18]

At approximately 1626, the Division Supervisor calls the E-71 FEO and asks how many are with the engine and the answer is “Two.” Now everyone is accounted for. Once the Division Supervisor and his passengers move further east out of the smoke they stop at E-71 and the three injured firefighters move from the Division Supervisor truck to the engine (Figure 24).

[18] See Appendix E, Decision Factor #18: Attachment to Mission

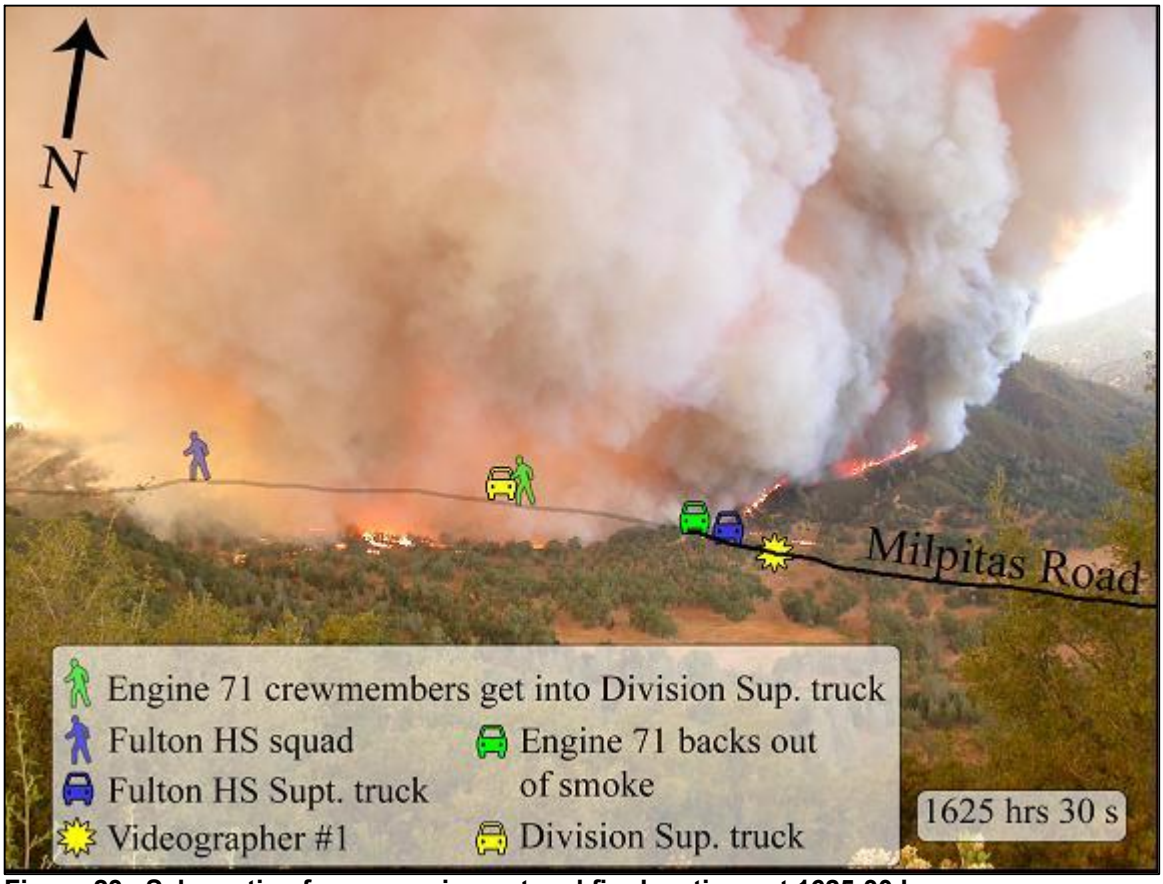

Figure 23. Schematic of crew, equipment and fire locations at 1625:30 hours.

Figure 24. Photo of crew moving from Division Supervisor truck to E-71.

Crewmember #1 gets into E-71 and Crewmember #2 assists in backing and turning the engine around. They then continue east to where the line EMT's are parked. The Captain walks east and is met by a paramedic and the night Division Supervisor who start medical treatment and transport the Captain further east where the rest of the crew of E-71 are being attended to by line EMT's.

In the meantime, the Fulton Superintendent receives a radio call from the Springville IHC Superintendent who reports that the dozer and operator are safe.

The rotating vertical plume dissipates within 5-10 minutes. At least a portion of the rotating vertical plume moved about 300 feet south of the road (Figure 25). In some areas temperatures and heating durations were well above levels needed for ignition (~600° F) and would have been very difficult to survive.

At approximately 1630-1640, the entire crew of E-71 is evaluated by line EMTs. The EMT's recommend immediate transport to the ICP medical unit. They ask several times if the FEO and crew want someone else to drive them to the ICP and the crew responds that they would rather drive together. The night shift Division Supervisor and paramedic offer to drive ahead of E-71 leading the way back to ICP.

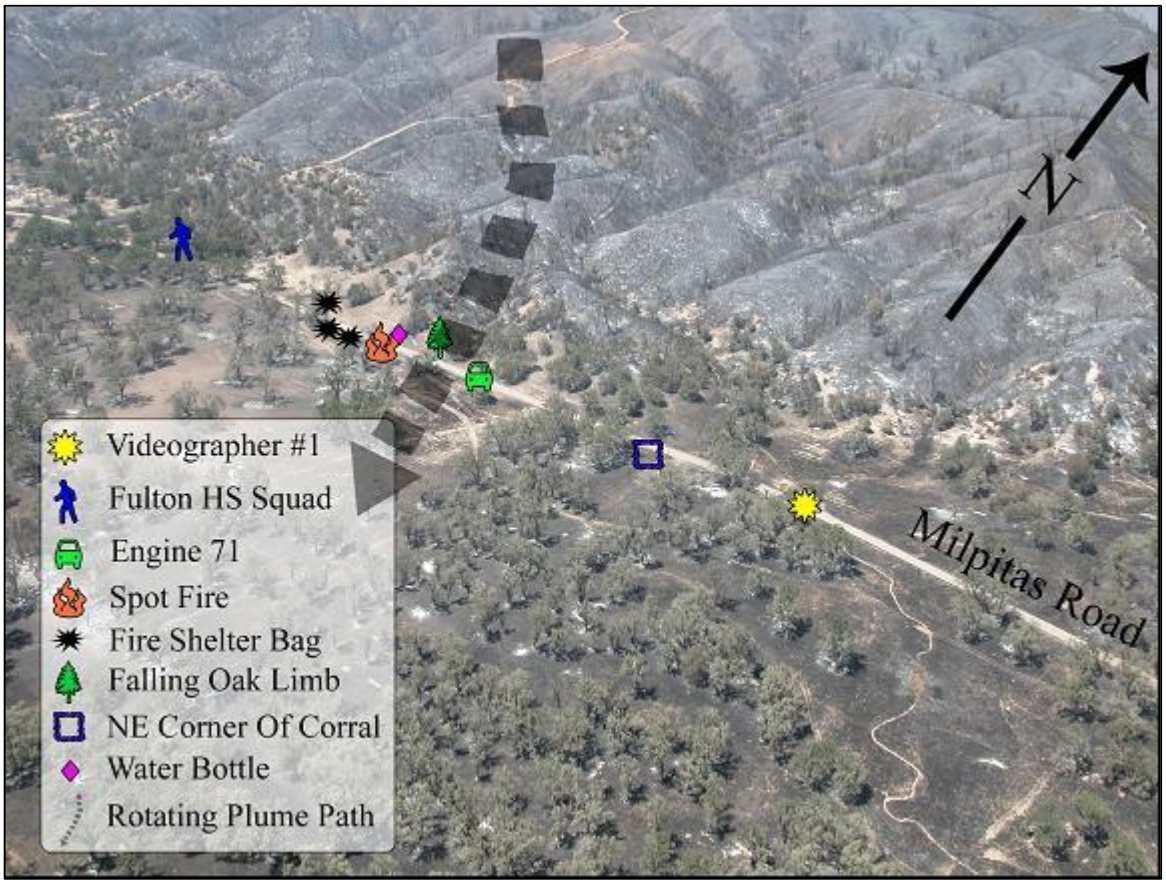

Figure 25. Estimated path of rotating vertical plume relative to accident site.

Up to this point, the FEO is very worried and concerned about Engine Crewmember #3, but when he sees the injury to the Captain's hands, he says, "I was really shaken up." When the EMTs are offering to drive them out, at first the FEO doubts his own mental state and capability to drive. He gets out to secure the front hose before departing. When he attempts this, he cannot remember how to secure the hose and another firefighter assists him. Doing a familiar task has a much needed calming effect. After that, he feels confident about driving back to the ICP. There isn't much talking on the drive to ICP, which helps the FEO stay focused on driving the engine.[19]

In the back seat, one of the crewmembers whose ears still feel like they are burning asks another crewmember, "Do I still have my ear?" He answers: "Yes, and what about my ears?"

At 1650, E-71 crew arrives at ICP medical unit. The medical personnel quickly provide what relief they can, and according to one crewmember, "Those burn pads felt so cool on my ears, heavenly!" At 1715, the E-71 Captain is transported to a burn/trauma center by air ambulance and Crewmembers #1 and #2 are transported to a local hospital by ground ambulance. Crewmember #3, though burned, declines treatment and stays at ICP.

The two E-71 crewmembers, still in camp, have no place to "get away" to de-stress. Both state they feel like they are in "a zoo or a fish bowl." After the evening briefing, they are the subject of whispering and speculation by firefighters returning from the briefing. Another firefighter, hereafter called the "Liaison," realizing the predicament of the two crewmembers, takes the initiative and helps them find a more peaceful location.

By 1800 that evening, the fire had largely cooled in the area of the entrapment (Figure 26).

Later, a call comes in that the two taken to the hospital by ambulance are now in need of a ride back. The Liaison offers to go with Crewmember #3 and the FEO to get the two crewmembers left at the hospital.

The IMT does not want them driving the engine and recognizes the need to have the engine inspected for damage and held as evidence. The Liaison and crew need to find a 6 passenger transport to pick up the other two crewmembers. The only available crew cab pickup is back to the west of the accident site. The E-71 FEO volunteers to drive when no readily available driver is found. He and the other crewmember do not want to go back and pass through the site two more times to get the vehicle, but it was the lesser evil compared to sitting around ICP until they can find someone else. The Liaison and the two crewmembers leave to retrieve the crew cab pickup.

[19] See Appendix E, Decision Factor #19: Mental Resilience

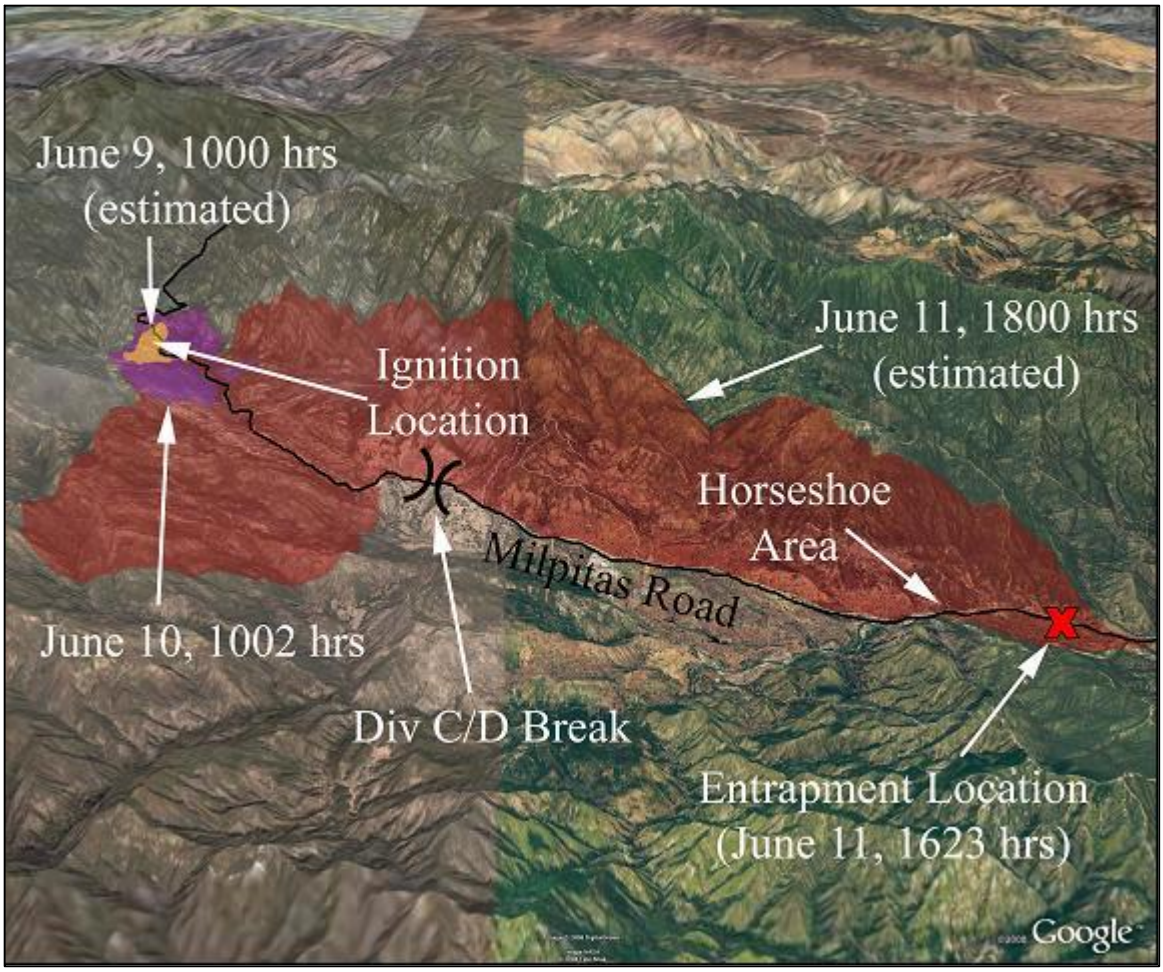

Figure 26. Estimated fire progression through 1800 hours June 11, 2008.

The FEO drives the vehicle back to ICP and the Liaison then drives all of them to the hospital where they pick up Crewmembers #1 and #2. Sometime around 2200 they get some take-out food and motel rooms for the night in Paso Robles. All sleep soundly except Crewmember #3 who is unable to sleep because he cannot stop thinking about the accident.[20]

On June 12th, the Liaison, FEO, and three crewmembers return to ICP to process their accident documentation and CA-1, 2 and 16 forms. The crew demobilizes and the Captain remains in the burn center.

The Liaison, FEO and three crewmembers stay in Fresno the night of June 12th. After they are evaluated by medical personnel at a Fresno hospital on June 13th, they return to their home unit.

One crewmember states “I never thought it would happen to me,” and the other says, “The only reason I survived is because of my training.”

[20] See Appendix E, Decision Factor #20: Critical Incident Stress Debriefing

V Lessons Learned by Firefighters

Each individual that had a significant role in the Indians Fire entrapment was interviewed. At the conclusion of an interview each person was asked a series of questions regarding what they learned for themselves from this accident and what they believe the greater wildland fire community needs to learn from it. The following is a list of their responses. These responses were edited to eliminate redundancy, personal references, and to improve clarity, but otherwise are not prioritized.

A. Environmental Factors

1. Column rotation changes everything and should be a watch out.
2. Immediately notify resources via radio or face to face communications in the area of a significant increase/change in fire behavior and/or weather.
3. Roads are no longer holding.
4. Driest March and April on record; have not seen runs like this.
5. Fires are no longer 2-sided and have become more complex.
6. Difficult to predict the degree and magnitude of recently observed extreme fire behavior (last 10 years).
7. Convey relevant and important information relating to fuel models (grass types).

B. Equipment Factors

8. Wear all PPE correctly.*
9. Have shrouds available.*
10. Wear gloves.*
11. Keep gloves readily available if removed.*
12. Wear eye protection.*
13. Chin strap on front of hard hat was conducive to ease of use.
14. Emphasize the importance of fire shelter training.*
15. Train with fire shelters multiple times throughout the season utilizing fans and different scenarios.*
16. Keep vehicle doors and windows closed to prevent ignition of vehicle.*

*These can also be categorized as Human Factors.

C. Human Factors

17. Maintain control of module, stay together, and keep support vehicles close.
18. As soon as you leave your vehicle have all your PPE on.
19. Command and supervisory positions need to continually monitor overall situation (big picture).
20. Identify and communicate tactics that are not successful and make adjustments.
21. Consider proper engine placement and direction.
22. Learning through trial and error used to be more forgiving. We are currently

operating in a much less forgiving environment.
23. Stress the importance of remaining calm.
24. Fire ground is becoming more complex.
25. Read the smoke, constantly assess and re-assess.
26. If you just warned your crew, it is time to warn adjoining resources.
27. Jewelry contributed to burn injuries.
28. Control breathing during entrapment situations, do not take large deep breaths.
29. Emphasize adequate rest.
30. Stay off road in reduced or limited visibility conditions.
31. Observe, read, and interpret body language.
32. Understand the difference between training and experience.
33. Avoid running when hot gases are known or suspected.
34. Learn and practice techniques that reduce stress, such as breathing exercises, mindfulness, and other meditations.
35. We need a way to better mentor our firefighters.
36. Changes are coming too fast with no incremental ramping up.

D. What firefighters said the greater wildland fire community needs to learn from this incident.

37. There are too many concurrent reviews occurring at inappropriate times impacting firefighters and causing distractions. This lesson has been identified before (i.e. Accountable Cost Management Team, NIMO Team, a new initiative to manage and assist with management of costs, Regional Forester's Representative, Chief's Principal Representative, Unified Command etc.). Due to the projected expenses and probable fire spread, these entities took a lot of Forest FMO, Forest Supervisor, and IMT attention for several days. Circumstantially, they showed up at the time that the fire was projected to threaten ICP.
38. Review procedures and protocols for all levels of management (Regional, Forest, District, IMT) relating to accident notifications, burned firefighter protocols, patient care and transport. The IMT and agency need to collaborate on developing a timely and accurate 24 hour accident report. (Roles and responsibilities for this could be identified in the Delegation of Authority). Identify the need and implement critical incident stress management within 48 to 72 hours. Each Forest or Dispatch Center should identify CISD providers throughout the region, so individual Dispatch Centers and Forests have that front loaded for when an incident

requiring their services occurs.

39. Adhere to SOP's regarding work/rest, driving and mobilization policies as per the Red Book, Chapter 7
40. All Incident Management Teams and Type III organizations need to review, discuss, and practice the incident within an incident protocol for their teams several times each year.
41. Use of a Liaison to support the injured firefighters was beneficial to the employees and the agency
42. Improve the understanding of the current OWCP-Compensations claims process and continue to stay informed on changes.
43. Know procedures and protocols for all levels of management (Regional, Forest, District, IMT) relating to accident notification, patient care and transport. Include timely and accurate 24 hour report and identify the need and implement critical incident stress management as required.
44. Utilize BLM DVD 2008 Fire Refresher Training including protocol for burned fire fighter patient care.
45. When firefighting resources check in with overhead, module experience should be matched to assignment/mission. Know your resources experience level.
46. Communications Unit needs to follow established protocols and document incident within an incident activities.

VI Lessons Learned Analysis

The Lessons Learned Analysis (LLA) is a display of relevant facts of the accident, and an analysis of the lessons learned by peers and management (IMT and Forest Management). It also includes the APA Team's analyses of the mental, cultural, and organizational faults or weaknesses that contributed to or were causal to the Indians Fire accident. The LLA assesses categories and factors germane and pertinent to each event: a) key issues, decisions and behaviors; b) related elements; and c) upstream causal and latent factors.

Minimum skill and quality experience is an issue of concern to the firefighters involved in any incident as well as a major focus of the APA Review Team. During this analysis, the Review Team had access to Incident Qualifications Certification System (IQCS) master records of the individuals interviewed. Qualifications were reviewed with no concerns by the Team, with confidence in the various levels of checks and balances embedded in the IQCS system.

Everyone directly involved appeared to be appropriately motivated and intentioned. The APA Team found no evidence of willful behavior that arose from recklessness. The decisions seemed reasonable to those involved at the time, based upon their understanding of the situation, their experience, and their expectations.

Throughout the investigative process, the Team performed a "substitution test," asking themselves "Could another employee or supervisor of the activity, meeting the agency's minimum competency standards, make the same decisions and have the same (or worse) outcome?" If the answer to this question is "Yes," then it is likely a similar or worse accident will occur again unless the latent causes are identified and mitigated (APA Guide, page 25).

In each of the following "Key Issues, Decisions, and Behaviors" analyzed, the determination of the Review Team was "**YES**" to the substitution test.

A. Analysis Methodology

The methodology of this LLA is based upon the weight of evidence including interviews, videos, photos, incident communications, resource orders, IAP's, etc. "At risk" behaviors, decisions, actions, active failures, causal and latent factors are compartmentalized into three groups. These categories are: Human Factors, Equipment Factors and Environmental Factors. Pertinent to each of these categories, the Team analyzed and grouped the risk management issues, behaviors, decisions, actions, failures, and lapses to determine causal and latent factors as well as recommendations into the following three subcategories:

1. Engaging in suppression operations without adequate situational awareness and fully established LCES (no posted lookouts and hesitancy in inter-crew and overhead to line communications).
2. Firefighters without full PPE while engaged in fire suppression activities.

3. Firefighters engaged in fire operations with fire whirls and a rotating vertical plume present.

What have been identified are issues, factors, and elements in one subcategory are also interrelated with factors or issues in another subcategory. For instance, under environmental and human factors, there are close links in having situational awareness and posting lookouts regarding the rotating vertical plume. Due to these interrelations between key issues, decisions, and behaviors, recommendations were combined into a single summary. The recommendations are pertinent to the causal and contributing factors of the accident, the “at risk” behaviors, any system failures or lapses, and cultural or organization upstream faults. Recommendations were developed to support accident prevention for the near term and long term, to help with risk management and mitigation over the next few weeks or months and into the future.

B. Equipment, Environmental and Human Factors

Equipment

There were no equipment issues that contributed to this accident. All equipment performed as designed and the fire shelters used likely provided life saving protection. There were several incidences of firefighters not using PPE and this behavior has been identified as a human factor.

Environmental

In the months prior to the fire, the Region was under moderate to severe drought conditions. March, April, and May were the driest ever recorded in this area. The Energy Release Components (ERC’s) for the local Remote Automatic Weather Stations (RAWS) were showing record levels for this time of year and fire behavior was extreme.

One thousand hour fuels (3”-9” diameter) were below 10% and all dead fuels were being completely consumed as a general rule. Live fuels were also below critical levels and being consumed, thus contributing to fire intensity. Highly flammable live and dead fuels, unstable atmospheric conditions, and low relative humidity led to the rapid formation of high intensity burning and the development of a large rotating vertical plume on the southern edge of the Indians Fire on June 11, 2008. The resultant fire behavior was unpredictable, unusual, and surprised numerous highly experienced firefighters.

The fire behavior and winds from the rotating vertical plume were contributing factors to the accident. Variable terrain contributed to enhanced combustion and channeling/blocking of inflow to the rotating vertical plume base. The channeling/blocking of the inflow may have been the source of rotation. The dry unstable atmospheric conditions enhanced vertical transport in the plume and increased plume rotational speed even further.

The combination of these factors resulted in a strong localized rotating vertical plume that appeared and behaved in many aspects like an F0 to F1 scale tornado, approximately 1,000 feet in diameter at the base and 1,000 to 1,500 feet tall. Winds at the plume base were estimated at greater than 70 mph and resulted in extreme fire intensity and significant wind damage (See Appendix C, Fire Behavior).

Human

Many of the causal and latent factors in the Indians Fire accident fall under the human factors umbrella. Human factors explain how humans become aware, make decisions, take actions, and make sense of situations and circumstances. In an APA, human factors are displayed in the listing of causal and latent factors. The human factors aspect of the LLA is closely associated with the Human Factors Report (Appendix E).

Development of causal factors and recommendations are based on lessons learned and the team analysis of key issues, decisions, and behaviors. With perfect hindsight, some of the risk management decisions displayed below may appear to arise from a lack of skill or experience. Minimum skill and quality experience is always of concern to firefighters involved in an incident, as well a major focus of an APA Review Team. Importantly, every person directly involved in this accident met or exceeded their agency's minimum qualifications for their position. Consequently, if an employee's error is due to a lack of experience, the root cause of that error isn't the employee's lack of experience; rather the causal factor could be that the agency's standard for experience is inadequate.

C. Causal Factors and Recommendations Based on Lessons Learned and Team Analysis of Key Issues, Decisions, and Behaviors

1. Engaging in suppression operations without adequate situational awareness and fully established LCES (no posted lookouts and hesitancy in inter-crew and overhead to line communications)

Division C of the Indians Fire operated throughout the day without optimal LCES. There were no posted lookouts. There was limited organizational information sharing and communication between various resources and overhead. There was very little information sharing over the radio between engines and Division Supervisor and with adjoining resources. This affected building and maintaining adequate situational awareness for and between division personnel.

Engine Crew 71 was engaged in attacking a spot fire at 1624 hours as the fire behavior was peaking. As extreme fire behavior began to occur, there was no committed lookout in position to alert firefighters of the inherent dangers. Engine Crew 71 was not fully engaged in their own LCES.

The fact that so many highly experienced firefighters were surprised by the rapid change and escalation of fire behavior indicates that this phenomenon must have

been a rapidly moving event. The past experiences of dozens of seasoned firefighters on Division C between 1600 and 1700 hours were inadequate to enable them to perceive the risks of the rotating vertical plume and the extreme fire behavior and then communicate that risk to others.

Related Elements

- June 11th, 2008 was the 3rd day of a firing operation in Division C. Through this time period there had been no significant operational problems. Overall, this resulted in a low to moderate operational tempo, casualness amongst firefighters, almost a passive versus active firefighter atmosphere, with no lookouts posted during this time.

- Lookouts are often better situated to notice the cumulative changes of fire behavior.

- Determined through several interviews with firefighters that were on Division C on June 11th, lookouts were not posted because the crews and Division Supervisor felt that there was constant traffic along the road, and that Crew Superintendents and Field Observers had located themselves in good vantage points to watch out for crews. Personnel could see north for a short distance towards the fire and could also look south for spot fires into the river valley. Depending on where the operation was any given time, dictated how much of a vantage point one had of the main fire and the valley to the south.

- At the time the rotating vertical plume was developing and growing, the Hunter Liggett Base Commander and Command Master Sergeant were one and a half miles to the south on a dirt road that ran along a major ridge above the valley and river basin. From this vantage point they could see most of the Division C firing operation and the main fire working its way down the ridge north of Milpitas Road. This was an ideal lookout location.

- There appeared to be no trigger points identified during the morning briefings to crews regarding the main fire coming down the ridge north of them or for any spot fires to the south. Failure to establish meaningful and relevant trigger points for withdrawal is a frequent and recurrent concern in accident and near-miss incidents.

- Several firefighters from crews and overhead on the line were taking videos and photos of the developing rotating vertical plume beginning at and around 1533 through 1557. Videos and photos of the rotating plume continued to be taken up to 1626 hours. Although these firefighters taking the videos stated they recognized the rotating plume as a potential hazard, they stated they did not recognize it as an imminent hazard at the

time. The Engine Crew said they were unaware of the plume. The Captain states, “Why didn’t someone tell us about it?” The first indicator of the rotating vertical plume was at 1533 hours but it was more pronounced at 1557. The rotating vertical plume built and leaned over the road at 1620 hours and the entrapment occurred at 1626. There were no radio communications warning crews of the potential danger. There appears to be no personal or cultural recognition of how fast this rotating vertical plume could change directions, move and expand. If firefighters had observed or been warned of such behavior through past experience or training, they would have recognized the rotating plume as a hazard and communicated it as such.

- From the interviews conducted, it was apparent to the APA Team that full situational awareness was lacking at many levels in the Division C organization. As a result, this partial lack of situational awareness may have created instances of confusion, incomplete information sharing, and casualness when the firing was going well into the afternoon and up to the time of the development of the rotating vertical plume.

- The APA Team has a concern about crew cohesion before and during the shelter deployment. Three members of the crew left the engine on foot, leaving one crewmember to help turn the engine around and then to run to catch up with the crew. This separation of the crewmembers from the engine, and walking towards the spot without full PPE, tools, and the engine, was an at-risk decision. Once the crew was entrapped Crewmember #3 fled from the rest of the crew. This was also a serious crew cohesion issue with concerns for firefighter safety.

- The Engine Captain and crew have the responsibility to manage their safety. *Look up, look down, look around!* A firefighter who has adequate situational awareness is a safer firefighter. Depending upon others to post lookouts is a big gamble. The Safety Officer spent most of his time on the west side of the Division and it appears he was unaware no lookouts were posted and situational awareness could be lacking for firefighting resources.

- At times on the fire line, engine crews, Type II crews, and even some overhead look to and defer to the more experienced Hotshots and there may exist a subconscious tendency to rely on Hotshots for a portion of LCES. As firefighters reflected back on the situation, they indicated in interviews that each resource needs to personally attend to their own LCES and assign their own lookouts. They also stated that individuals need to reach out and interact with adjoining resources.

2. Upstream Causal and Latent Factors

- The Incident Response Pocket Guide (IRPG) states LCES must be established and known to *all* firefighters *before needed***.** Standard Firefighting Principle number five states, "Post lookouts when there is possible danger." The word danger places a different emphasis on the use of lookouts. Some interpret the need for posting lookouts only when there is an imminent danger.

- A recurring organizational practice is that firefighters on the line may be assigned as lookouts, but many times they have collateral duties. Statements from interviews with engine crews and Captains identified, "R-5 engine crew SOPs are the FEO performs the duties of lookout for the crew." The danger of this can be characterized by what happened on the Indians Fire. The FEO was in a less than ideal location to see the rotating plume and if he would have seen it, chances are he would not have recognized it as a hazard other than a black plume inside the perimeter of the fire. Fire behavior was increasing with the development of the rotating vertical plume, and no one was talking to the Engine Captain over the radio or face to face regarding any potential dangers. If the crew was depending upon the FEO to alert them of the danger, he may not have had the vantage point, focus, or knowledge about the phenomenon. Many times the FEO may be fully engaged in running the pump, talking on the radio, working with other engines, or other tasks detracting from his or her ability to perform proper lookout duties.

- The Engine Captain and crew have the responsibility to manage their own safety. *Look up, look down, look around!* A firefighter who has good situational awareness is a safer firefighter. Depending upon others to post lookouts is a big gamble. The Engine Captain can't and shouldn't assume that other crews or overhead in the division would either post lookouts or would see hazards and communicate the hazards to all of the firefighters. If the Division Supervisor and other crews are not posting community lookouts, then the Engine Captain needs to assure that LCES is established and that gathering and maintaining situational awareness is being attended to personally or delegated. The Safety Officer spent most of his time on the west side of the Division and it appears that he was unaware that there were no lookouts posted and that situational awareness could be lacking for firefighting resources.

- There continues to be a cultural hesitancy to communicate between the various types of resources, more often between engines and Type I IHCs and between Type II crews and Type I crews. This has been observed before. This hesitancy to communicate has created safety issues in the past. During the Indians Fire, this hesitancy helped to contribute to the lack of situational awareness of the Engine Crew, who believed that there

were no unusual risks associated with their mission to engage in suppression of the spot fire.

- When assigned to be a holding resource the direction and expectations are to be looking for spots and slop overs in the green, and if firefighters are compelled to look to the black they are normally redirected to have eyes to the green. The engine crew has a responsibility to be aware of the changing conditions and the development of the rotating vertical plume looming above the road. When interviewed, the engine crew states their focus was to watch for spots on the south side of the road and they were not focused on the fire side of the road at that time. They are attending to the south side but not attending to the north side where the hazard may be coming from. The engine crew also had a responsibility to guard the Fulton Burners' back door, to watch for hazards in the black. Once the Fulton lighters stopped lighting the engine crew stopped looking for hazards to the north, thinking that the source of the hazard had been temporarily suspended.

- Within seconds, conditions changed, the operational tempo was increasing exponentially, and as the Engine Crew was walking to the spot, the environment changed, and the limb came crashing down behind them, leaving them no option to go back to the engine.

3. Firefighters without full PPE while engaged in fire suppression activities

Several members of Engine 71 module and other personnel in Division C were not wearing full PPE. Two crewmembers from Engine 71 received burn injuries to their hands. It is likely had they been wearing gloves, the burns would have been less severe. Four firefighters from Engine 71 received burns to the ears, neck and face. One firefighter had a shroud tucked inside his hard hat and did not use it. The other three did not have shrouds. Wearing shrouds may likely have lessened the severity of these burns.

Once members of the Engine Crew were entrapped by the fire, three out of the four members used their fire shelters to deflect heat while in a standing position and attempted to walk to safety. The fourth member of the Engine Crew fled from the other three crewmembers in search of the engine. This crewmember attempted to deploy his fire shelter and was unable to pull it out of his pack. He began to adjust his pack to bring the shelter within reach but quit trying once he saw the engine. He then ran to the engine and entered the cab.

No member of the crew dropped their pack, a recommended procedure. All but one pack had fusees in them. Fusees are a danger to carry in an entrapment because they can auto-ignite at 375° F, a temperature common in entrapment environments.

Related Elements

- Frequently, firefighters, including fire overhead, are in and out of their vehicles in the fire area. Often when they leave their vehicle, they are not wearing appropriate PPE because the cultural practice allows them to be more casual with PPE. For example, the Hotshot Superintendent who was overseeing the firing operation of Division C was away from the pickup without his line gear, helmet, and gloves searching for the missing dozer. When the winds of the rotating vertical plume hit him, he is in a highly dangerous position without all his PPE. Firefighters should maintain safety awareness and wear appropriate PPE while in the fire area.

- Many times the prudent action is to deploy a fire shelter in a prone position. During the fire shelter deployment, the crew decided to use the shelters as shields to aid in their escape. In making this decision, the firefighters considered that large limbs were falling from surrounding oak trees, the south side of the road was burning, the north side of the road was still hot and the road was likely to have vehicle traffic.

- The Engine Captain mentioned that the crew had trained with their practice fire shelters several times this spring, but Crewmember # 3 still had difficulty pulling the shelter out of his pack. Shelter training stresses removing the pack to deploy a shelter. This allows the firefighter to extract the shelter easily, rids the firefighter of possible fusees, saw gas, etc., and allows for an easier deployment by not having the shelter hang up on a firefighter's pack.

- Two of the firefighters said there were differences between their practice fire shelter deployments and this fire shelter deployment. For more realistic training, firefighters can use unserviceable fire shelters to practice deployments.

4. Upstream Causal and Latent Factors

- One firefighter took his gloves off to disconnect a hose and one of the firefighters had his gloves off because he was eating lunch. Two firefighters wore gloves through the deployment and suffered no burns on their hands. The current design of GSA firefighter work gloves meets all the requirements of the National Fire Protection Association (NFPA) 1977, including protection and dexterity. With any type of glove, as protection increases, dexterity decreases. A balance must be maintained. Missoula Technology and Development Center (MTDC) conducted a survey of firefighters in order to design gloves for a 2007 field trial. By next season the General Services Administration (GSA) Wildland Fire Equipment Catalog will carry redesigned firefighter work gloves as well as one,

possibly two additional types of wildland firefighter gloves that are also compliant with NFPA 1977 requirements.

- Crewmember #3 was running with his eyes partially closed because of dust, debris, and ash blowing into his eyes through the sides of his sunglasses. Wearing safety glasses or goggles would have afforded greater eye protection. Many times firefighters ignore wearing agency provided and approved eye protection and the rule is often not enforced.

- Shrouds are currently not mandated by the Forest Service, although there have been situations in which they have provided firefighters protection in burnover events. Wearing shrouds decreases the likelihood of firefighters being burned. On the other hand, wearing shrouds increases the likelihood of firefighters suffering from heat stress. Shrouds also close off the firefighters' stimuli receptors of exposed skin, which in turn decreases situational awareness. Many parts of the organization encourage firefighters to have shrouds available but not worn unfurled continuously throughout the operational period, due to increases in physiological heat stress.

5. Firefighters engaged in fire operations with fire whirls and a rotating vertical plume present

Over the past 8 years there have been multiple incidents in which large fire whirls or rotating vertical plumes have occurred: Fish Fire - 2001, Missionary Ridge Fire – 2002, New York Peak Fire - 2006, Fletcher Fire – 2007, Neola Fire - 2007 and now the Indians Fire - 2008. Fire behavior experts in the western United States have also identified several other incidents. Several of these fires have resulted in serious injuries or fatalities.

Review of several accidents caused by these phenomenon have uncovered that firefighters continue to engage in suppression activities as these phenomenon occur. Until further information is identified about how these phenomenon occur, chances are firefighters will continue to be caught off guard and accidents will continue due to increased fire behavior associated with increases in changing winds, increase in fire spread rates, and spot fire development.

Related Elements

- As long as there are unknowns regarding rotating vertical plumes with minimal information exchange about risks and hazards, there will most likely continue to be future events with associated risks and hazards to firefighters. There is recognition of the potential hazards but the risk is downplayed due to lack of awareness about how fast these phenomenons can move, change direction, or expand.

Upstream Causal and Latent Factors

- Firefighters are production oriented and will make all due efforts to manage wildland fires to protect life, property, and natural resources, utilizing the most appropriate management responses.

- Most firefighters have no pertinent mental slides for this phenomenon.

VII Recommendations

1. The APA Team recommends a region wide and agency wide analysis to identify current practices and subsequent recommendations concerning shortcomings in firefighting operational leadership, contributing to entrapments and burnovers. Over the past two years there have been a number of near misses, serious injuries, and fatalities sustained by firefighters across the country. Failures in judgment and faulty application of principles of fire suppression operations have been documented in review findings.

2. The APA Team recommends that Region 5 consider new ways to improve firefighter situational awareness. One opportunity currently being field tested in Regions 2 and 4 is a pilot training course called "Mindfulness Based Situational Awareness." Several hotshot crews, three helitack crews, five to ten engine modules, and several dispatch centers have participated in this training this year. Individuals will be working with these crews, captains and managers of each of these resources through the season and monitoring the value added to firefighter and manager situational awareness. Region 5's Risk Management Council Representative could learn more regarding the year end evaluation of the merits of this training.

3. Recommend that the Regional Forester develop a letter to Forest Supervisors and District Rangers with expectations for them to engage with individuals in mid-level fire management leadership positions and individuals assigned to operational leadership positions to increase emphasis and dialogue about line officer expectations. Increase on-site line officer monitoring of operational leadership in the fire environment. As crews train throughout the season, there should be added emphasis on LCES, situational awareness of fire environmental factors and human factors and sound application of the Risk Management Process. Crews should practice shelter deployment under adverse conditions with full PPE and line gear. Stress the importance of the basic requirements for PPE on the fireline.

4. The APA Team recommends the development of a power point presentation or video regarding the Indians Fire accident. If the Engine 71 crew is willing, have them talk about their experiences and their lessons learned. Include a short briefing of the fire weather phenomenon that occurred on the Indians Fire and consider other fires with similar phenomenon over the past 8 years or so. If this presentation can be developed in time for the Safety Stand Down, have the Region use this it to kick off the stand down and recommend that each forest base their safety discussions around it.

5. The APA Team recommends that R-5 make a national proposal/request to the Forest Service fire behavior research community to conduct further research into the physics driving the formation and propagation of rotating vertical plumes and large fire whirls. The goal would be to develop a research paper which identifies commonalities and characteristics, and develop trigger points for fire behavior analysts and Incident Meteorologists (IMETs) to use to brief IMTs and firefighters on the risks and consequences of these events. This should be a collaborative effort with the National Weather Service.

6. The Los Padres National Forest and Pacific Southwest Region should work with the Wildland Fire Safety Training Annual Refresher (WFSTAR) training group to integrate the Indians Fire story and Lessons Learned into the 2009 fireline refresher package.

7. The APA Team strongly supports the continuous work being done by MTDC on PPE. Encourage firefighters to try the new glove designs that will be available for purchase through GSA for the 2009 fire season. Provide feedback on the gloves and other components of PPE to MTDC directly or through the normal process of contacting the R-5 Equipment Specialist. Request from MTDC an evaluation of the current shroud design and determine the need for further development. One possibility is to redesign the nomex fire shirt with an oversize collar that could be flipped up as a shroud to protect neck, ears and a portion of the face.

8. The APA Team recommends that the Regional Forester direct all National Forests in the Region to have a "Safety Stand Down." Allow each National Forest maximum flexibility to pick a time within a designated timeframe for the Stand Down. The APA recommends a list of talking points with causal factors, decisions, actions taken or not taken, at-risk behaviors that occurred on and led to or contributed to the Indians Fire Accident.

   - Discuss situational awareness and the requirement for constant reassessment of conditions. Situational awareness needs to be emphasized on every wildland fire.
   - Discuss keeping an eye out for the 18 Watch-out Situations.
   - Discuss establishing operational/environmental limits (trigger points) ahead of time to help focus situational awareness, prompt re-assessment and re-evaluation of risks of current actions.
   - Discuss establishing and maintaining LCES. IMTs and overhead need to assure LCES is in place. When to post lookouts? What does communication mean in LCES?
   - Re-emphasize, "All firefighters have the responsibility to

communicate hazards, acknowledge messages and ask questions." When you alert your own crew of hazards, it is time to alert others.

- What processes are being developed on each Forest to assure firefighters are using PPE on the fireline?
- Discuss the Indians Fire scenario and the rotating plume phenomenon. Fireline supervisors to review incident response pocket guide, pages v –xi, for leadership principles. Visit the Leadership Development Program at http://www.fireleadership.gov/links.html. When does a crew separate from their engine? What does crew cohesion mean to you and your crew?
- Until other triggers are identified, when you see a plume start to rotate it needs to be communicated.

After conducting the Safety Stand Down, each National Forest will report back to the region and convey significant insights up, down, and throughout the Region.

VIII Summary

The APA process utilized for this accident was a viable method that facilitated accomplishment of all desired objectives. It provided an opportunity to evaluate individual decisions, actions, behaviors, issues and causal factors in terms of human, equipment, and environmental factors. The outcome of this process imparted much less stress and anxiety to firefighters interviewed, resulting in more open and candid discussions of the event. It also provided an opportunity to formalize a process that will help reduce future errors by correcting or reinforcing behaviors and providing a foundational basis for accelerating fire management organizational learning.

In an effective learning culture, mistakes, near misses, and accidents are framed, publicized, and exploited as opportunities to learn. Consequently, the focus of this analysis was not to document where employees went wrong, but instead to understand and display why what they did made sense to them at the time. Importantly, if their risky decisions made sense to them at the time, the same risky decisions will make sense again to other employees, given similar circumstances.

The analysis of this accident has yielded several warnings for the Agency.

- A critical lesson learned from this incident is that fires will behave in ways far outside of the expectations of experienced firefighters. Basing risk mitigation decisions on experienced-based fire behavior estimates alone is insufficient to ensure a safe working environment. With extreme fire behavior as the new norm, and the unexpected now common place, **it can happen to you!**

- By not having all LCES elements in place, as the fire activity increased, situational awareness was compromised. Situational awareness was degraded and understanding the fire environmental factors was inadequate. The lack of one or more LCES elements and degraded situational awareness led to a breakdown in the decision making process. Specifically, the risk management process (Situational Awareness, Hazard Assessment, Hazard Control, Decision Point and Evaluation) was poorly applied, if applied at all. In addition to failing to utilize several elements of LCES and to apply sound risk management, principles of suppression operations (Standard Firefighting Principles, Watch-out Situations, Look Up, Look Down, Look Around) as well as principles forming the USFS foundational doctrine for fire suppression, were not put into practice.

From a human factors standpoint (Appendix E, Human Factors Report), these warnings point toward two recurring errors:

1. Underestimating hazards, and using inadequate safety measures (i.e. inadequate application of LCES);

2. Failing to notice changing conditions and to adjust tactics accordingly.

The related elements uncovered through this analysis display a number of at risk behaviors ignored if not condoned by the agency and the culture. For example: fatigue management, specifically incident driving SOPs, the casualness of the organization towards the use of PPE on the fireline, and finally, mental training for firefighters on improving mindfulness based situational awareness.

The following is an excerpt from the Human Factors Report (Appendix E)

> *"The intention of learning must be at the forefront. At the heart of learning is challenging assumptions and expectations. If, after you read this, your thought is, "Boy did 'they' screw up, I would never do that," then we on the APA Team have failed in our responsibilities as storytellers, and you have failed in your responsibility as a listener to take advantage of this learning opportunity. By taking such a stance, you would in effect be enacting a defensive routine to protect your ego. You as a reader have a responsibility to learn and that can only happen by trying to put yourself in the place of the participants and see the world from their perspective, and try as best you can to avoid hindsight bias, which is pervasive and unavoidable. We need to find ways to constantly improve situational awareness and fireline communication. We also need to become students of practical drift and study why it occurs so we can respond appropriately."*

IX Commendation

The APA Team commends the Liaison for recognizing a need and providing support to the Engine 71 crew after their traumatic event. Noteworthy is his concern and compassion for the well being of the firefighters and his willingness to take action to assist them.

Three out of the five crewmembers were transported to a hospital. This left the remaining two crewmembers waiting to hear the status of their crewmates and wondering what the next steps were for them and the crew. These two firefighters were without a vehicle, support, and a friendly face, a distressing situation considering all they had experienced this day. The Liaison stepped up to provide this support. He helped locate a vehicle and drove the two crewmembers left in camp to pick up two of the crewmembers that had been treated at the hospital. He then took them for food and checked them into a local motel where they spent the night. The next day, the Liaison drove them back to ICP to fill out and process compensation and claims documents. He drove them to Fresno that afternoon where they spent the night and were evaluated by doctors at a Fresno Hospital the next day. The Liaison's contribution is commendable and made a positive difference in this difficult situation.

Thank you Liaison!

X Appendices

Appendix A
Indians Fire Entrapment Chronology

Date (all 2008)	Time	Identifier	Event
June 8	1235	IA Resources	Indians fire reported, Foehn winds pushing fire SE, down slope and down canyon.
June 8	1245	Arroyo Seco RAWS	89F, 11% RH, ENE winds 5mph gusting to 10.
June 8	1700	Arroyo Seco RAWS	95F, 10% RH.
June 8	N/A	E-71	Crew has day off.
June 9	N/A	E-71	Crew has day off.
June 9	1600	RAWS	102F high, 5% RH
June 10	0930	E-71	Crew begins normal workday on District.
June 10	1800	E-71	Crew ends normal workday on District.
June 10	1930	E-71	Receives call from dispatch at home.
June 10	2030	E-71	E-71 Captain leaves home for RS.
June 10	2045	E-71	Crew gets call at home to go to the Indians Fire.
June 10	2100	E-71	Crew reports to station.
June 10	2100	National Weather Service	Red flag warning issued for Bay Area Hills, Near red flag criteria over fire, forecast for hotter and drier.
June 10	2200	E-71 Captain	Arrives RS.
June 10	2210	E-71 Captain	Leaves RS.
June 10	2230	E-71	E-71 leaves station in route to Indians Fire.
June 11	0200	E-71	E-71 arrives at ICP, clocks off and soon go to sleep.
June 11	0500	E-71	E-71 crew wakes up.
June 11	0530	E-71	Crew wakes up.
June 11	0000	Fire	Burning actively all night--RH recovery did not occur--verified by Hunter Liggett RAWS.
June 11	0600	E-71	E-71 crew on clock and go to briefing.
June 11	0630	E-71	Crew goes to breakfast.
June 11	0730	E-71	E-71 crew left ICP for Div C.
June 11	0800	E-71	E-71 arrives at Division C/D break to work in Division C, assigned as strike team with E-2 as leader for safety zone burnout operation.
June 11	0830	FEO	E-71 moved up road by rock outcropping and set up in mobile attack mode.
June 11	900	E-71	Burnout started.
June 11	1100	FEO	SZ burnout ended.
June 11	1100	FEO	Winds from North, burn out as strip head fire. Finished burnout around 1100.
June 11	1100	FEO	Holding action for spot fires
June 11	1130	FEO	Went to spot where fire was backing downhill to road, Capt ahead of us talking to someone. Capt stopped us and told us to turn around.
June 11	1200-1300	E-71 and Fulton	Fulton Hotshots burning along road, heading east, E-71 patrolling for spots, no spots.
June 11	1200	E-71	Patrol for spots moving east along road, working with Santa Barbara Engine -37.
June 11	1230	E-71	Ate lunch.
June 11	1200	FEO	Start horseshoe burnout.
June 11		E-71 and Fulton	Burnout "horseshoe" area of road, Engine holding.
June 11	1330	E-71	Horseshoe burnout ended.
June 11	1330	E-71 Captain	After finished with horseshoe burn, noticed fire behavior column on main fire N-NW rotation, but seemed relatively small, nothing especially unique.
June 11	1430	E-71	Tender fills E-71 with water.
June 11	1430	E-71	Eat lunch on west side of 'horseshoe' burnout.

Date (all 2008)	Time	Identifier	Event
June 11	1500	E-71	At Horseshoe, watching for spots, eat lunch (informal munching, not together), refilled by water tender.
June 11	1500	FEO	Spot fires 100' off road, another much farther, burned 1/4 acre, helicopter called in to put it out.
June 11	1500	FEO	Pointed out another spot farther N of Capt. They (Capt +1) went in to direct water drops. Extinguished spot near rd. with Helicopter drops. Winds not strong - 0-5mph from north.
June 11	1500	FEO and Crewmember #3	Column seemed to be over our heads, it was not "ripping". He indicates that he did not see the vortex until later.
June 11	1500	FEO	Holding action here for awhile until we were called to patrol for spots along Road for next burnout operation.
June 11	1431	FEO	Operator for midpoint of Horseshoe burn, on cell phone photo.
June 11		FEO	I saw fire climb up tree, pulled up to put it out.
June 11	1500	E-71	Start burnout along road--moving east. LP brushing ahead of lighters.
June 11	1500	Fulton Superintendent	Fulton asked to join them as they started burning out the north side of the road, start burning within five minutes.
June 11	1515	E-71 FEO	E-71 bumped around Santa Barbara and followed Fulton igniters, monitoring for spots and high intensity fire.
June 11	1533	Fulton Crewmember	Talk on video indicates they are preparing to start the burnout, the plume is shown with some slow rotation. Alpha 5 coming down road--(squad of Fulton Hotshots?).
June 11	1534	Fulton Superintendent	Fulton Supt asking for aerial platform to be "eyes in sky."
June 11	1545	E-71 Crewmember #1	Stop near corral. Put away mobile equipment, watch for spots.
June 11	1547	Fulton Crewmember Videographer #2	Hotshot Supts (Fulton and Supt 4) seem to be discussing burning operation.
June 11	1557	Fire Overhead	Video 061108_15571.3gp2—video of plume.
June 11	1558	Fire Overhead	Video 061108_15581.3gp2-- video of plume.
June 11	1559	Fire Overhead	Video 061108_15591.3gp2-- video of plume.
June 11	1600	Fulton Crewmember	Fulton bringing fire down road to east, trying to get out in front of main fire (they seem to be referring to the rotating plume).
June 11	1601	Fire Overhead	Video 061108_16011.3gp2-- video of plume.
June 11	1601	Night OPS DIVS	Video footage of plume.
June 11	1601	Night OPS DIVS	Videographer #1 states that "it is one of the biggest fire whirls I have ever seen."
June 11	1603	Night OPS DIVS	Lighting crew shown in video about where spot fire occurred, Videographer says "they are about half way down" indicates that they will finish lighting ahead of fire whirl (1:40 into video clip). Also notes that fire whirl seems to be "paralleling the road."

Date (all 2008)	Time	Identifier	Event
June 11	1603	Night OPS DIVS	Rotating Plume seems to be roughly 100 yds north of the Corral. Scale of base diameter is 1000+ feet. LP shots east of videographer #1 and also a black truck. Someone in video says "I think they'll make it now" indicating that the firing operation will be able to hook around east end of main fire. Videographer states that "firing operation is picking up fire whirls."
June 11	1607	Fulton Superintendent	Fulton Supt holds ignition at location about 300yds west of corral.
June 11	1609	Fire Overhead	Cell phone video footage of plume.
June 11	1610	Night OPS DIVS	Video footage of plume.
June 11	1610	Fire Overhead	Taken from east of corral, good view of plume.
June 11	1610	Night OPS DIVS	Videographer states "It's like a freight train right now."
June 11	1611	Fulton Superintendent	Div C stops at corral to talk with Fulton Supt to discuss concerns about the intensity of the firing operation.
June 11	1614	Fulton Superintendent	Lighting crew start burning again from location about 300yds west of corral.
June 11	1615	Crewmember #3	E-71 crewmember #3 was eating when the call to put out spot fire came.
June 11	1615	E-71	First spot called in, too far away for E-71.
June 11	1616	Fulton Crewmember	Lighting crew about where branch fell on road. Grass fuels behind them are burning out within seconds of being ignited.
June 11	1616	Fulton Crewmember	Lighting crew finishes and walks east past Videographer #1. Wind to north, but seems to be switching to flow towards west along road. Videographer identifies the Fulton burners just passing him, nearly finished with firing operation.
June 11	1616	Fire Overhead	Rotating plume is clearly visible. Rotation seems faster compared to earlier images.
June 11	1618	Fire Overhead	Rotating plume is clearly visible. Rotation speed increasing.
June 11	1619	Fire Overhead	View of base of plume.
June 11	1618	Night OPS DIVS	Video of fire.
June 11	1618		Safety officer called out spot over radio, spot was to the west of me.
June 11	1618	Night OPS DIVS	Videographer #1 states it is raining "s---". Firing operation is still under way, but nearly completed. Heard on radio reporting spot fire across river approximately 1000 feet in and "it's taking off."
June 11	1618	Fulton Crewmember	"It's crazy to see how much suction is sucking it in." Report of spot about 300 yards comes over radio.
June 11	1619	Safety Officer	Heard on radio reporting spot fire across river approximately 300 yards in and "it's taking off."
June 11	1619	Fulton Crewmember	Fulton Superintendent asking for confirmation about spot across road--strong wind from east to west Videographer #2 states "flames way up in column." He states "I think we just lost it."

Date (all 2008)	Time	Identifier	Event
June 11	1620	Fulton Crewmember	Grass fuels largely burned out. Strong flow to west, E-71 truck parked on south side of road facing east. One firefighter in cab of E-71, four standing south of engine seem to be talking, one crew member in red hardhat (E-71 Captain) walking east toward Fulton Supt. Fulton Supt indicates that when he saw the spot the wind was from was blowing east to west and it was clear, crystal clear, simple single spot" Fulton concern was spots not necessarily the vortex.
June 11	1620	Night OPS DIVS	Videographer #1 states "It's pushing down, it's going to come down on Rio Bravo there" " is pushing hard down on those guys, there is a spot fire right there, they need to stop firing." "the only thing good is they already have it fired down there so they have a good enough buffer." Later states "If it gets up on that little ridge, forget it." Radio traffic on video talks about spot fire 1/4 mile across road. Firing operation is just completing. Visible flames approximately 40ft tall seems to be burning from north to south along north edge of rotating plume as shown in video. Winds seem to be changing from south to east. Rotating plume seems to have moved south closer to road and strong east to south and west flow visible in lower portion of plume.
June 11	1621	Fire Overhead	Taken east of corral, lighters have passed through. White ford explorer parked west of video position. Strong rotation in plume.
June 11	1621	FEO	25' hose attached to front of truck.
June 11	1621	FEO	The burners stopped across from corral, we caught up to them. I parked under tree then pulled out to park on south side of road facing east.
June 11	1621	FEO	Firing operation stopped.
June 11	1621	FEO	"Seems like we stopped here forever."
June 11	1621	Fulton Crewmember	Wind shown blowing hard from east to west, flames observed up in column. Videographer #2 states that he is hearing live rounds going off. Spot fire off to south.
June 11	1621	FEO	Captain said to turn the engine around. E-71 Captain leaves gloves on front bumper of truck.
June 11	1622	Videographer #2	Video of area.
June 11	1622	Videographer #1	Crew #1 and Operator turn engine around. When engine is facing north Crew #1 leaves to catch others, while Operator pulls out to follow.
June 11	1623	Fire Overhead	Large flames on hill in Chaparral north of road. Wind seems to blowing from north east to southwest, pushing flames across road in vicinity of corral, white ford explorer still parked, but occupants seem to be getting ready to leave. No visible view of Fulton SUPT truck or E-71.
June 11	1623	Night OPS DIVS	Video
June 11	1623	Night OPS DIVS	Video

Date (all 2008)	Time	Identifier	Event
June 11	1623	Night OPS DIVS	Fulton Supt moves south of road looking for dozer, when he turn around embers are moving from east to west and hitting him. His crew member estimates winds at 60+mph. Fulton Supt says it seemed that the ceiling was coming down on him, it appeared to be at the tree tops, conditions were deteriorating fast, " I knew I had to get to road, not sure if I could."
June 11	1623	Night OPS DIVS	Strong flow from north to south shown in video. White ford explorer departs to east. Videographer #1 states that wind feels like 30+mph. Multiple spots..
June 11	1623	Fulton Crewmember	Fulton Supt on south side of road fighting to move north to truck, holding hat and or covering face. E-71 is facing North and is just starting to pull out, Supt truck is facing east. E-71 marker lights are on.
June 11	1624	Fire Overhead	Large flames on hill, wind seems to be blowing from NE to SW. Two firefighters walking east. Seems to be image of Fulton Supt truck on south side of road 11 seconds into clip. White Ford Explorer is not in image.
June 11	1624	E-71	Saw a 4x4 ft spot fire 5 ft from green side of road.
June 11	1624	E-71	E-71 Captain, Crewmember #2 and CM #3 leave E-71 toward spot fire, Crew #1 helps Operator turn E-71 around. CM #3 states that when they started walking to spot, conditions seemed the same as they had been all day.
June 11	1624	E-71 Crewmember #3	Crewmember #3 says the wind was coming from everywhere, left, right, back and front, sticks and rocks blowing by.
June 11	1624	E-71	CM #1 leaves E-71 toward spot fire and 3 others.
June 11	1624	FEO	Operator feels very strong gust of wind hit his truck from the east. He says it was comparable to the 60-70mph winds he feels when working on fires along interstate.
June 11	1624	FEO	Operator sees limb fall west of his position in truck. He says it seemed to explode with fire--embers everywhere.
June 11	1624	E-71	Limb falls near Crewmember #1 on north side of road, 3 other crew members about 20 feet farther down road from CM #1.
June 11	1624	E-71	Wind increases, debris flying, smoke obscuring view.
June 11	1624	FEO	Operator starts west along road after crew, can't see past front of hood of truck, calls crew saying "Captain 71, Operator, Spot behind you." Realizes that he can't hear radio, so crew likely can't either. Sees multiple spot fires on south side of road. Loud popping and noise from debris hitting truck. Could only see 10' in front of truck. Flames 2-3" much bigger in interior. Wind seemed steady, but I was in the truck with windows closed. says "I was afraid." Could not hear radio. Supt. or patrol rig behind me.

Date (all 2008)	Time	Identifier	Event
June 11	1624	FEO	Operator sees embers moving south across road. He sees 5 spot fires south of road. Spot fires on south side seemed to coalesce. He can't see his crew through the smoke. There is a Supt or patrol rig behind me.
June 11	1624	E-71	Crewmember #1 sees more spots in green near him, moves toward other 3 crewmembers to warn them of spots and tree limb partially across road.
June 11	1625	Crewmember #3	Crewmember #3 started to turn back to engine, sees Capt turn toward him and say something, can't hear, but seemed to say run. CM #3 turns and runs down road. Can't see feet due to smoke.
June 11	1625	E-71	Crewmember #1 sees Crewmember #3 moving toward dangerous overhanging limb catches him and tells him to go toward E-71. CM #3 says there was fire all around us, I could see flames blowing across road on both sides, "We were running through fire" CM #3 says that if we could get his shelter out he was going to deploy on the road.
June 11	1625	FEO	When I passed the limb, Crewmember #3 comes running out of smoke on right side of truck, gets in and is nearly incoherent. Saying we have to get out. I decide to back out.
June 11	1625	FEO	Operator indicates that it feels as if the wind is pushing from SW in front of truck NE in rear of truck.
June 11	1625	E-71	Crewmember #1 feels like he's going to throw up, gets water bottle out and takes drink.
June 11	1625	FEO	Starts to back out, using flames along sides of road as guide. I was weaving due to poor visibility.
June 11	1625	E-71	E-71 Captain, Crewmember #2, and Crewmember #1 get shelters out of packs, shake out, and cover themselves while standing/making way toward E-71. Operator later states that the crew told him breathing was difficult due to hot air.
June 11	1625	Fulton Squad-west	Hotshot squad approximately 100m west of spot fire face extremely strong winds blowing from west to east. They have to bend over at the waist to move forward. One firefighter said it appeared as if they were running but not moving forward.
June 11	1625	E-71	As Crewmember #3 was running, and trying to remove shelter, he feels hot air, so holds his breath. He is covering his face with is arms and tucking hands in armpits. Gloves are in shirt pocket. Can't get shelter out of pack. Sees headlights ahead (20'). CM #3 makes it to E-71, gets in. States "I don't know why I didn't drop my pack, I should have ditched it!" CM #3 is burned by chain on his left wrist, leaves mark similar in appearance to tattoo with outline of chain links.
June 11	1625	E-71	E-71 Captain, Crewmember #2, and CM #1 get into Division C truck.
June 11	1625	Videographer #1	Spot south of road is relatively large in video.

Date (all 2008)	Time	Identifier	Event
June 11	1626	Videographer #1	Fulton Supt truck shown facing west ~100ft west of corral. Speaker on video states that "fire whirl is over." Later states "see that fire whirl" indicating to south of road. Still significant high intensity flaming north of road in chaparral.
June 11	1626	E-71	Engine backs out of smoke, Operator and Crewmember #3 onboard.
June 11	1626	E-71, DIVS-C	Division C truck drives out of smoke (pass downed limb on the way)
June 11	1626	E-71 Operator	Still in smoke when hear call on radio saying something like "E-71 how many people do you have?" Winds seem to be lower.
June 11	1626	Videographer #1	Fulton 5 alpha squad on west side of burnout face extremely strong winds blowing from west to east, they have to bend over and someone states it appears as if they are running in place trying to fight their way through wind to truck.
June 11	1626	Fulton Crewmember	E-71 crew get out of DIV C supt truck and get into engine. Looks like one crew member helps E-71 Captain take off his fire shelter pack. E-71 Captain is holding hands to sides.
June 11	1630	Arroyo Seco RAWS	86F, 14%RH, SW winds at 3 mph.
June 11		Videographer #1	Utility truck pulled up, Crewmember #1 and CM #2 get in Engine, profusely sweating, saying ears are hurting, E-71 Captain said "look at my hands" A guy w/ white hair 6'-2" tall maybe the Safety officer called ICP to say we are bringing guys with burn injuries in to ICP.
June 11	1640	E-71	Crew gets in E-71, moves short distance down road to meet EMT.
June 11	1640	FEO	Operator tries to put hoses away, but could not figure it out, someone came and helped him. This is something I have done many times.
June 11	1640	E-71	All 5 crew get in E-71 and drive to ICP. E-71 follows black truck to ICP.
June 11	1650	FEO	Crew arrives at ICP medical.
June 11	1706	IC	IC calls about entrapment.
June 11	1715	Hunter Ligget RAWS	90F, 5% RH, E wind at 6 mph.
June 11	1715	E-71	Some guy asked me the Operator at the ICP--It was 1715.
June 11	1747	Fulton Crewmember	"just shredded huge limbs" rocks up to 4" in diameter scattered on road.
June 11	1747	E-71	E-71 Captain driven in ambulance to helibase.
June 11	1747	Medical Unit Leader	Medical unit takes CM #3's blood pressure and then said he was alright. He goes outside trailer and sits at base of steps for 60-90 minutes.
June 11	1747	E-71crew#1-2	CM #3 and Operator stay at ICP.
June 11	1747	E-71 Captain	Captain medivac'd by helicopter to burn/trauma center.
June 11	1747	E-71crew#1-2	Driven in ambulance to hospital, enroute switch to another ambulance because original ambulance stationed on fire.

Date (all 2008)	Time	Identifier	Event
June 11	1830	FEO	CM #3 and Operator meet up with Advocate. Operator states it seems like they sat there 3 hours. Dave Crow talks to them about what might happen as far as an entrapment investigation.
June 11		FEO	CM #3, Operator and Advocate drive back along road, past entrapment site to get a 6 passenger truck. Operator drives the truck back to ICP where the three of them then leave to get CM #2 and CM #1 at hospital.
June 11		E-71 Captain	Arrive at burn center.
June 11		E-71crew#1-2	Arrive at hospital.
June 11	2100	E-71crew#1-2+Advocate	Advocate picks up CM #2 and CM #1 they all go to Paso Robles.
June 11		E-71 crew#3	CM #3 could not sleep at the hotel. Awake all night thinking about accident.
June 12		E-71 Operator, Crew #1,2,3, Advocate	Go to ICP to demob, fill out accident related paperwork.
June 13		E-71 Operator, Crew #1,2,3, Advocate	Crewmembers evaluated by medical personnel at Fresno hospital.
June 16		E-71 Operator, Crew #1,2,3	Crew interviewed at Mount Pinos Ranger Station
June 17		E-71 Captain	Interviewed at burn/trauma center.

Appendix B
Personal Protective Equipment Summary

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Tony Petrilli
Equipment Specialist
Missoula Technology and Development Center

This report is based on interviews of personnel and examination of personal protective equipment involved in the Indians fire entrapment on the Los Padres National Forest on June 11, 2008.

Summary

On June 11, 2008, four firefighters of a five person engine module were caught in an entrapment, while supporting firing operations on the Indians Incident on the Los Padres National Forest. All of the firefighters were carrying New Generation fire shelters. The Captain and crewmembers #1 and #2 deployed their fire shelters and used the shelters in a crouching and backing position to shield themselves from heat as they attempted to retreat to safety. These firefighters were picked up by the Division Supervisor in his vehicle. The fourth firefighter became separated from his crew and decided to deploy his fire shelter. He spotted the headlights of Engine 71 so he abandoned his attempt to deploy the shelter, ran to the engine, and entered the cab. He was driven to safety by the fifth firefighter, Engine 71's driver, who had driven into the deployment area following his fellow crewmembers. Four of the five firefighters received burns to their hands, ears, wrists, arms, and faces.

Injuries

The Captain received second and third degree burns to his hands and burns to his ears and face.

Crewmember #1 received burns to the wrist, both ears, and the left side of his nose.

Crewmember #2 received burns to his wrist, ear lobes, both sides of his nose, the right side of his face, and the back of his hands.

Crewmember #3 received second degree burns to his right forearm, left wrist, burns to both ears, and some light burns on his elbows.

The Deployment Site

The deployments occurred on Milpitas Road, Fort Hunter Liggett, Los Padres National Forest. Milpitas Road is a two lane paved road approximately 22 feet wide. All equipment was removed from the site prior to the arrival of the review team.

Fire Shelters

Shelter Types

The firefighters who deployed shelters were carrying regular size New Generation fire shelters (Revision C) manufactured under GSA contract in January 2005, by Anchor Industries Inc.

Shelter Deployment

The Captain and crewmembers #1 and #2 deployed their shelters and used them in a standing position to shield themselves from heat while attempting to retreat toward safety. The shelters were positioned to cover the firefighters' backs from their heads to their calves. At the time of the deployment, winds were estimated to be as high as 70 miles per hour and the firefighters were surrounded by smoke and blowing embers. One of the firefighters did not recall having any difficulties deploying the shelter despite the wind and limited visibility. Another firefighter noted his red pull tab strip stretched before it separated from the PVC bag and he considered using a knife to open the bag. None of the PVC bags or pull tab strips could be located for inspection as they had been removed from the site. Two firefighters had difficulty unfolding their shelters and struggled to maintain control of their shelters in the wind. The three firefighters who deployed their shelters noted a marked decrease in temperature once their shelters were deployed and wrapped around them.

The fourth firefighter became separated from the remainder of the crew and decided to deploy his shelter on or near Milpitas Road. He got the flap of the horizontal fire shelter compartment on his field pack open but had difficulty removing the shelter from the pack. He began removing one strap of his pack from his shoulder to reposition the pack for better access to the shelter. Before he could remove the shelter he saw the headlights of Engine 71. At this point he abandoned his attempt to deploy his shelter, ran to the engine, and entered the cab.

Shelter Inspection

The three fire shelters that were deployed were examined for signs of heat and mechanical damage on July 1, 2008 at Missoula Technology and Development Center. The shelters showed no signs of delamination or discoloration. Delamination of the shelter material begins at approximately 500 degrees F. No mechanical damage was found.

Shelter Training

According to the firefighters' interviews, all firefighters had received training with the New Generation fire shelter and had practiced shelter deployments with practice shelters.

Packs

The crew was equipped with Gear 911 Specialties packs. The packs were worn throughout the deployment. Three of the packs had horizontal fire shelter compartments while the fourth pack had a vertical shelter compartment. One firefighter had difficulty removing his fire shelter from the horizontal fire shelter compartment of his pack. The firefighter with the vertical compartment commented that the orientation of his fire shelter compartment allowed him to easily see and remove his fire shelter.

Two of the firefighters carried fusees on their packs during the burnover. None of the fusees showed signs of heat damage. Fusees can auto-ignite at approximately 375° F with the cap on.

Three of the four packs worn in the entrapment were inspected for indication of heat damage. One of the packs showed a few pin hole sized indications of melting, most likely due to hot embers. It is not known if the melting occurred during this incident or on a previous fire or prescribed burn. The remaining 2 packs were in good condition with no signs of heat damage.

PPE

According to the crew, they were equipped with proper flame resistant shirts and pants, boots, hardhats, and fire shelters. Two pairs of pants were examined for heat damage. One pair showed two small spots of discoloration, most likely from hot embers. The other pair showed heat damage near the bottom of the legs which the firefighter stated was from a previous prescribed burn. No other signs of heat were noted.

Two firefighters were not wearing gloves during this incident. One of the firefighters left his gloves at the engine after taking them off to disconnect a hose. This firefighter suffered second and third degree burns to his hands. The other firefighter was eating lunch at the time the spot fire was detected and left his gloves in the engine on the seat During the entrapment, he protected his hands by folding his arms and placing his hands under his armpits. With his arms in the folded position, a metal bracelet on his wrist was exposed, causing his wrist to be "branded" by the hot metal.

One firefighter used his chin strap to prevent his hard hat from blowing off in the wind. This firefighter mentioned that he was glad his chin strap was located on the front of his hardhat where he could easily reach it instead of on the back of the hard hat where he would have needed to remove the hard hat to access the chin strap.

One firefighter had a face and neck shroud rolled up under his hard hat but did not use it. Another firefighter wore a bandana on his head which he credits with preventing burns to the top of his ears. Two of the firefighters stated they would wear shrouds in the future. To provide easier access in an emergency, both firefighters said they would stow their shrouds on top of their hard hats when not in use instead of rolling the shrouds up inside of their hard hats.

Recommendations and Reminders

Firefighters should be aware of the increased risk of injury if they are not wearing or carrying personal protective equipment.

Getting rid of fire packs during a shelter deployment speeds escape, gets rid of dangerous fusees and saw gas, and makes it easier to get into the shelter.

While all of the firefighters were properly trained, there are elements that can create a more realistic deployment training scenario:

- Include removing the shelter and PVC bag from the fire pack as part of deployment practice.
- Get rid of the pack, or at least remove it from the back as part of the deployment practice.
- Firefighters should practice shelter deployments in high stress environments that include strong winds or fans, time constraints, and different positions (standing, kneeling and lying down).
- Firefighters should consider the risk of deploying a fire shelter on a road that may have vehicle traffic.
- As New Generation fire shelters become unserviceable they can be used to provide realistic practice.
- The use of shrouds would likely have prevented or reduced burn injuries to the ears of the firefighters. Shrouds should be stowed so they can be easily donned in an emergency.
- Chin straps should be located where they may be quickly accessed in an emergency without the need to remove the hard hat.
- Firefighters should be aware that metal jewelry can conduct heat to the skin which can increase the severity of burn injury. The use of metal jewelry should be kept to a minimum.
- Gloves need to be readily available, if firefighters remove them for some reason

Appendix C
Environmental Factors and Fire Behavior Summary

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Environmental Factors describes the weather, fuel, and topographical factors leading up to and during the high intensity fire behavior event that contributed to the entrapment of 4 firefighters on the Indians Fire Incident, June 11, 2008 (see Figure C27). The analysis suggests that a rotating vertical plume formed for a period of more than 30 minutes above the fire area and behaved much like an F0 to F1 scale tornado. A portion of the plume moved out of the burned area across the fireline and over the area where the crew from Engine 71 was working. When it passed near the crew, they were subjected to winds 60-70 mph or higher, flying burning debris, dense smoke, and high air temperatures. This fire behavior event is described, and the mechanism for the formation of the rotating fire plume is also discussed.

Local and Regional Climate Conditions

In the months prior to the fire, California was under moderate to severe drought conditions (see Figure C28); March, April, and May were the driest ever recorded in this area.

The fire began June 8th under Foehn wind conditions being pushed southeasterly, down slope, and down canyon. The fire continued moving south and east for the next 4 days. During the nighttime hours of June 8th and 9th, below 2500 ft., there was good RH recovery allowing the containment objectives to be met on most of the southern edge of the fire. The northern half of the fire burned in steep terrain generally above 2500 ft. and remained very dry and warm throughout the nights above the weak inversion.

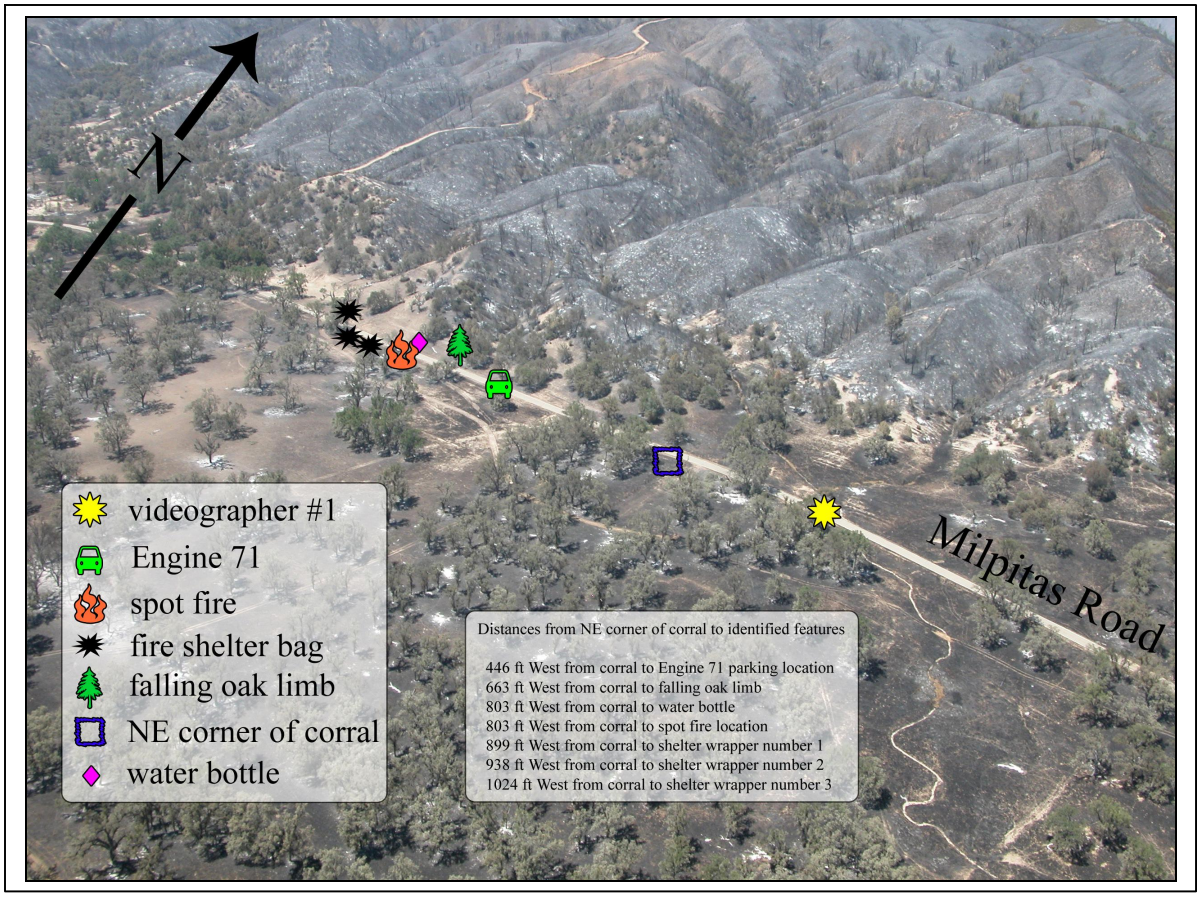

Figure C27. An aerial photograph of the area where four firefighters were entrapped and deployed their fire shelters (Latitude N 36.07113, Longitude W121.33814, elevation 1286 ft). Icons mark items relevant to entrapment site.

During the night of June 10, 2008, humidity did not exceed 10% in the lower elevations. On the day of the entrapment, June 11, 2008, conditions remained hot and dry over the entire fire area. The region around the Indians Fire was under an exceptionally dry north to northeast flow, established between strong upper-level high pressure ridging off the California coast, and a large upper-level low over the Northern Great Plains. Red Flag Warnings were issued for the region just north of the fire, but meteorologists did not issue a warning for the Indians fire because the forecast winds did not meet red flag criteria. Strong subsidence aloft was present, at levels between 6,000 and 12,000 feet, which caused the extremely low relative humidity's and very warm temperatures in the lower atmosphere. The Haines Index on June 11, 2008 was four, which is moderate to low. With the strong surface heating, clear skies, and a very warm air-mass, the lower levels of the atmosphere (surface to 5000-6000 feet) were very unstable. This would not have been reflected in the Haines Index, but it certainly would enhance vertical plume development. The lack of moisture in the lower atmosphere directly over the fire is indicated in the data collected from the Fort Hunter Liggett RAWS station (see Figure C29).

U.S. Drought Monitor

California

June 10, 2008
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	4.7	95.3	63.7	9.3	0.0	0.0
Last Week (06/03/2008 map)	4.8	95.2	63.7	9.3	0.0	0.0
3 Months Ago (03/18/2008 map)	44.5	55.5	34.3	13.3	0.0	0.0
Start of Calendar Year (01/01/2008 map)	8.9	91.1	84.7	58.0	14.6	0.0
Start of Water Year (10/02/2007 map)	0.0	100.0	92.6	64.6	33.8	0.0
One Year Ago (06/12/2007 map)	3.3	96.7	92.3	65.3	34.4	0.0

Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements

http://drought.unl.edu/dm

Released Thursday, June 12, 2008
Author: Mark Svoboda, National Drought Mitigation Center

Figure C28. Climate record for the region (source: National Weather Service).

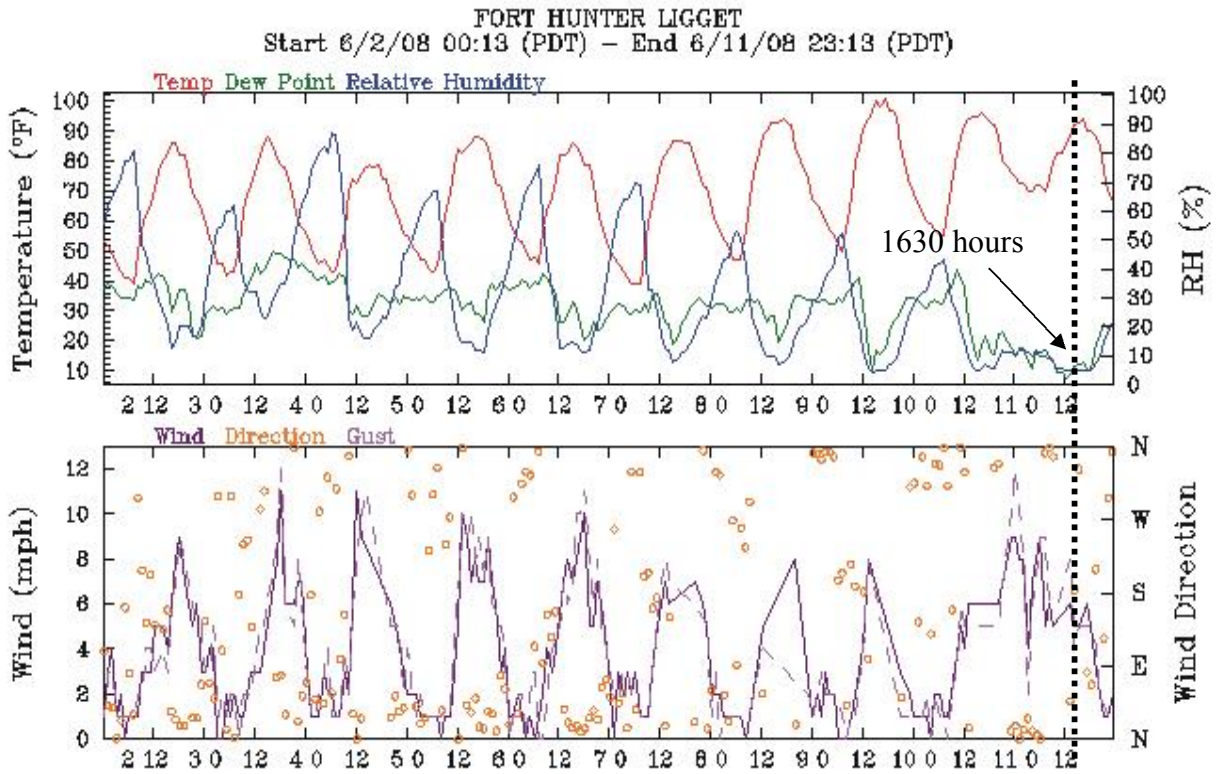

Figure C29. Data from Fort Hunter Liggett Remote Automatic Weather Station. Dashed line indicates approximate time of entrapment. Notice the poor humidity recovery on the night prior to the entrapment.

Fuels

Vegetation on the valley floor consisted of a mature white oak grass savanna with basal diameters from 1 to 4 ft (Fuel model 1-2, see Figure C30). As the terrain rises above the valley floor the vegetation changes abruptly to chaparral brush (Fuel model 4, see Figure C31) on the slopes to the north of Milpitas road. It remains the dominant fuel type on the upper slopes (Figure C32).

The hot, dry conditions in the months prior to the fire resulted in extremely low dead fuel moisture levels. A long term drought resulted in record high Energy Release Components (ERC's) for this time of year (see Figure C33) based on data collected from the local RAWS.

The burning reflected this. Larger diameter dead fuels (1,000 hour) were below 10% moisture content and generally all dead fuels were being completely consumed. Live fuel moisture content was also below critical levels and the bulk of the live shrub limbs below 3/4 inch diameter were consumed, thus contributing to fire intensity.

Firefighters indicated that fuels appeared to be burning as they typically do in August.

Figure C30. Photograph of oak woodland (savanna) characteristic of Indians Fire region.

Figure C31. Photograph of chaparral fuels characteristic of the Indians Fire region.

The combination of long-term drought and extremely low precipitation caused increased dead fuel load in the shrub fuels, a factor not reflected in National Fire Danger Rating System (NFDRS) index calculations. The Fire Behavior Analyst (FBAN) working on the entrapment team observed that it appears that greater amounts of live fuels may be contributing to the combustion process than is indicated by the sampled live fuel moistures.

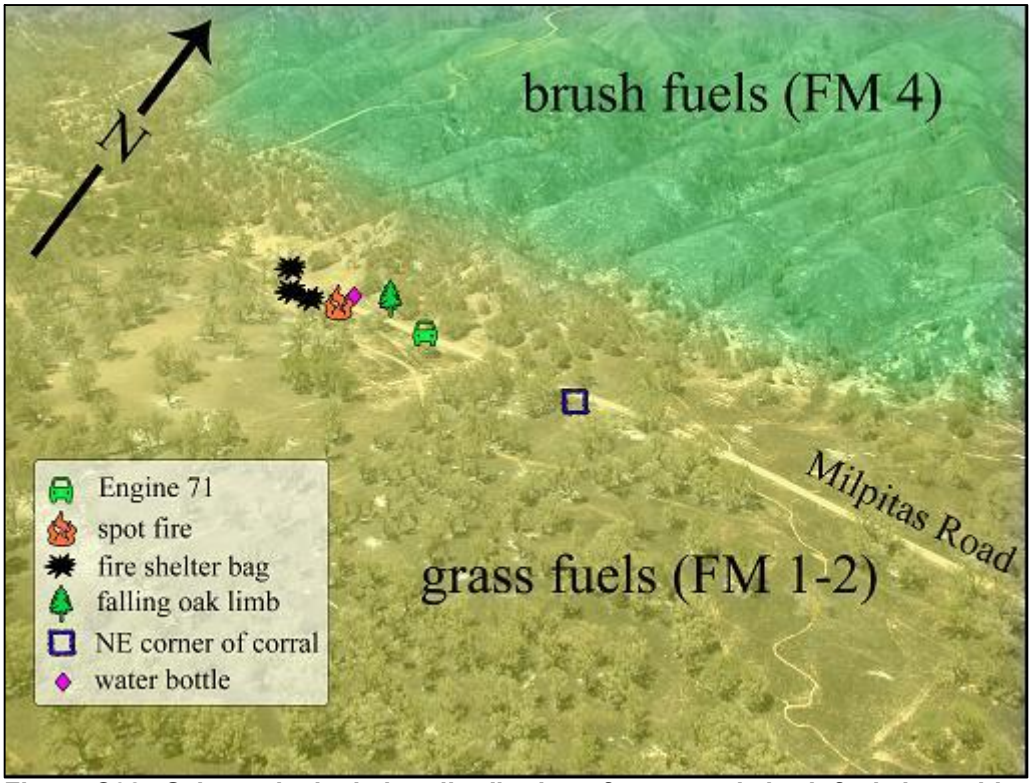

Figure C32. Schematic depicting distribution of grass and shrub fuels in accident area. Icons mark items relevant to entrapment site.

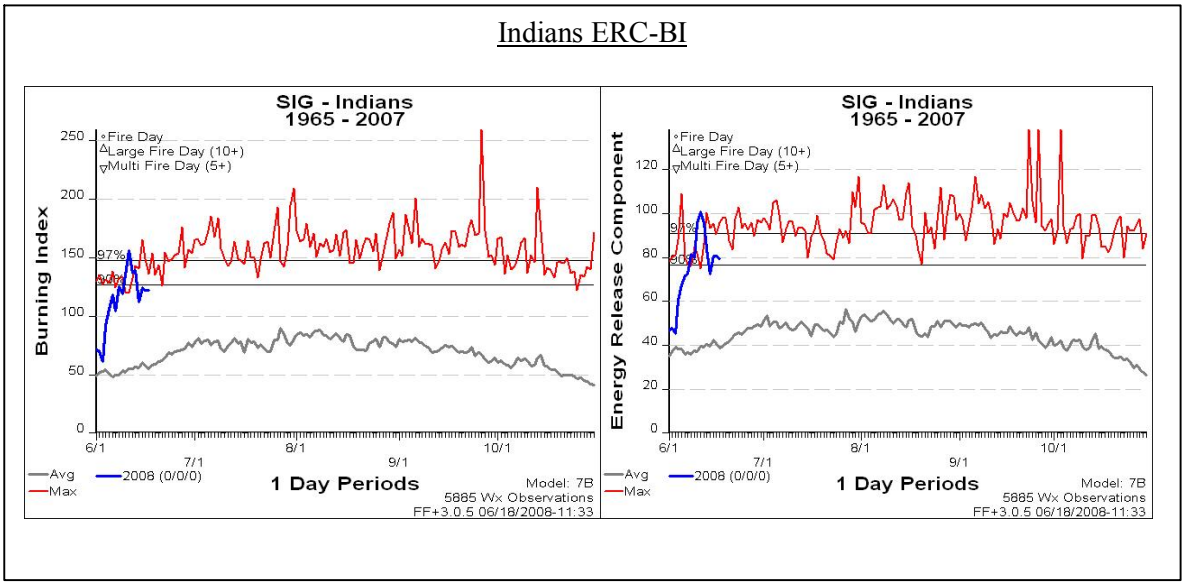

Figure C33. Indians Fire SIG was developed by the Incident FBAN in cooperation with the IMET. It utilizes 3 RAWS stations that were chosen and weighted to be as close a fit as possible to represent the area; 044301 Arroyo Seco 40%, 044317 Hunter Liggett %20, 044408 Santa Rita 40%. June 11 indices correspond to the peak value in the blue trace.

Topography

The Indians fire burned in the Santa Lucia Mountains of the Los Padres National Forest. The terrain in this area is characterized by steep coastal mountains with mature oak savanna in the interior valley bottoms and chaparral covered slopes.

The entrapment occurred along the Milpitas Road (36.072°N x 121.340°W) on the north side of a roughly 1/2 mile wide east-west oriented valley plain covered with a mature white oak grass savanna. The road is located on the north side of the plain and the San Antonio River is on the south side. Immediately north of the road, the terrain rises in highly variable foothills.

The foothills are characterized by highly variable gulley and drainage orientation and are covered with chaparral fuel types that extend upward to the mountain peaks. Approximately 1/4 mile north of the road, the terrain transitions to the base of large steep slopes (40-80% slopes) leading upward to the mountain peaks (Figure C34).

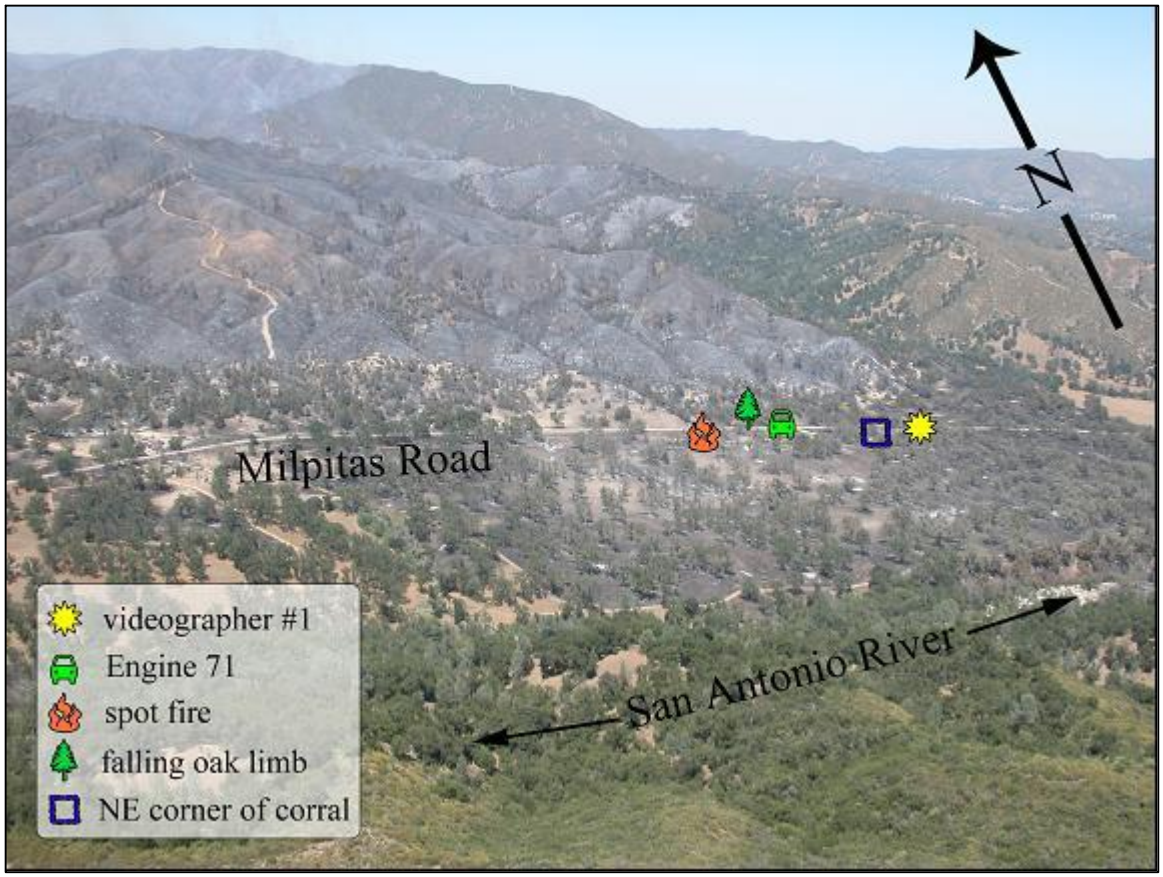

Figure C34. Photograph of topography in the area of the accident.

Fire History

While prescribed fire is widely applied in the area of the fire and on Fort Hunter Liggett, it appears that the specific area where the entrapment occurred has no recorded fire history. This may be due to lack of record and not lack of fire history. However, the fuels and terrain are typical of the inner coastal range and is a familiar fuel type to fire crews who have worked in the region.

Fire Behavior

The Indians Fire reportedly started Sunday June 08, 2008, at about 12:35 pm in the Arroyo Seco drainage near the Escondido campground on the Los Padres National Forest. At this time, the Arroyo Seco RAWS was reporting a temperature of 89° F with relative humidity (RH) at 11%, and east northeast winds at 5 mph, gusting to 10 mph. The temperature warmed to 95° F later that afternoon with RH of 10%. Figure C35 depicts the daily progression of the fire during the period June 8-12, 2008.

On the morning of Monday, June 9th, the fire was estimated to be 400 acres. The fire was burning in steep inaccessible terrain. A high temperature of 102° F was recorded with 5% RH during the afternoon. Winds were east northeast at 3-5 mph with gusts to

10-13 mph. Relative humidity in the valley floor reached 40% during the night with lows around 6-10% during the day.

By 0600 hours on June 10th, the fire had burned roughly 1100 acres. Fire growth was minimal the previous night. There was not much smoke visible from the fire that morning, and fire behavior was characterized as quiet.

Between 2 pm and 5 pm June 10th, the fire activity increased significantly due to the very warm temperatures (95° F) and dry conditions (~5% RH). A dry cold front was forecast to pass through the region during the night, with strongest winds located north of the fire area. Gusty north winds were to develop behind the cold front with warm and dry conditions forecast to persist for at least another 24 hours. No fire behavior forecast was developed.

By the evening of June 10th, the northern edge of the fire had moved into higher terrain (between 3000-4000 feet ASL) covered with dense mature chaparral fuels. At 2100 hours on June 10th, Red Flag Warnings went into effect across the Bay Area Hills, well to the north of the fire, for strong north winds and low humidity.

There were no Red Flag Warnings in effect over the Indians Fire area, but the conditions were forecast to become drier and windier. The air mass near the ground was very dry and consequently lower elevation relative humidity that night remained near or below 10% at the Fort Hunter Ligget RAWS (see Figure C29). Due to very poor humidity recovery, the fire burned actively all night.

By the morning of June 11th, the day of the entrapment, the fire had tripled or quadrupled in size from the prior morning, reaching approximately 5000 acres. The IAP weather forecast called for north to northeast winds 8-18 mph at ridges, becoming north 5-10 mph in the afternoon and north 10 mph in the valleys, becoming upslope and up canyon at 3-7 mph in the afternoon. Forecast fire behavior was also similar with an emphasis on the potential for moderate fire behavior on the south and eastern perimeters that would test containment lines. It was noted in the IAP that firefighters should expect spotting and sustained runs. Temperatures warmed quickly into the 90's F in the lower elevations (2000 ft. or lower) and RH's dropped to single digits (~5%) by early afternoon. Ridgetop winds remained from the northeast about 5 to 15 mph, while lower slopes and valleys had lighter, diurnal terrain winds. Fuels along the Milpitas Road consisted primarily of light dead grasses in the oak savanna. In the morning, fire behavior in the grass fuels was low, with limited success in a firing operation focused on expanding a safety zone.

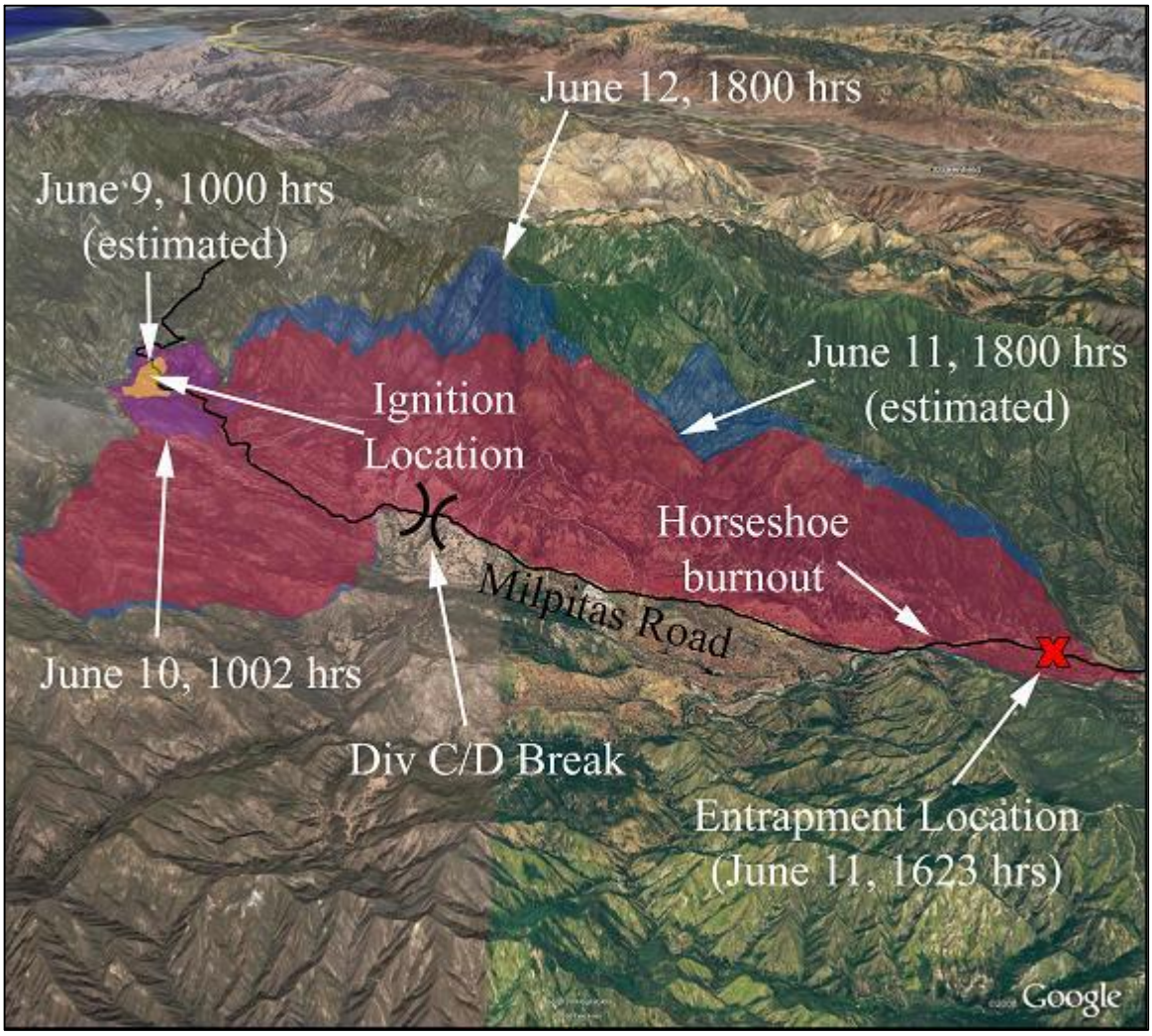

Figure C35. Schematic of daily fire growth for period June 8 to June 11, 2008 for the Indians Fire.

Around noon another firing operation was attempted. This time fire intensity matched forecast levels, burning actively in the fine grassy fuels driven north by diurnal winds and the ground level winds induced by the main fire further north. By 1400 hours, firefighters observed increased fire intensity as indicated by increased potential for lofting and ignition of new spot fires outside the containment lines, just as the FBAN had predicted.

The main fire was now moving east, flanking across the chaparral slopes and making runs up hill to the north of Milpitas Road. The plan was to burn out along the road, heading east and keeping up with the main fire. Photographs of fire behavior in the chaparral on the steep slopes show 20-40 ft. tall flames (see Figure C36). Post fire inspection indicates intense, nearly complete combustion of all vegetation smaller than ¾ inch in diameter. Large diameter dead fuels were

Figure C36. Photo of fire behavior in shrub and grass fuels on the Indians Fire.

totally burned to white ash. Fire intensity from the burnout near the road in the grass fuels was much lower, with 1-3 ft flame lengths (also seen in Figure C36). Although not as intense, the fire spread quickly through the grass fuels toward the main fire.

The firing operation moved from the west to the east and at approximately 1530 hours the smoke plume from the main fire on the slopes north of the road had begun to slowly rotate. By 1557, a large, intense, vertically-oriented, rotating smoke plume was clearly visible above the slopes north of the burnout operation. From video footage, wind speeds in the rotating plume are estimated at 50+ mph. We speculate that the vertical motion was enhanced by the combination of intense heat released from the chaparral fuels on the slopes and the hot, dry, unstable atmospheric conditions. Shear present in the near ground flow possibly due to the induced flow in the highly dissected terrain may have initiated the rotation. Photographs indicate by approximately 1600, the rotating plume was approximately 1000 feet in diameter at its base. The intense rotation would last for over 30 minutes. Video and camera images indicate that this rotating plume was part of the smoke column above the eastern portion of the main fire north of the firing operations being conducted along Milpitas Road (Figure C37). Witnesses state that the rotating column appeared to move east,

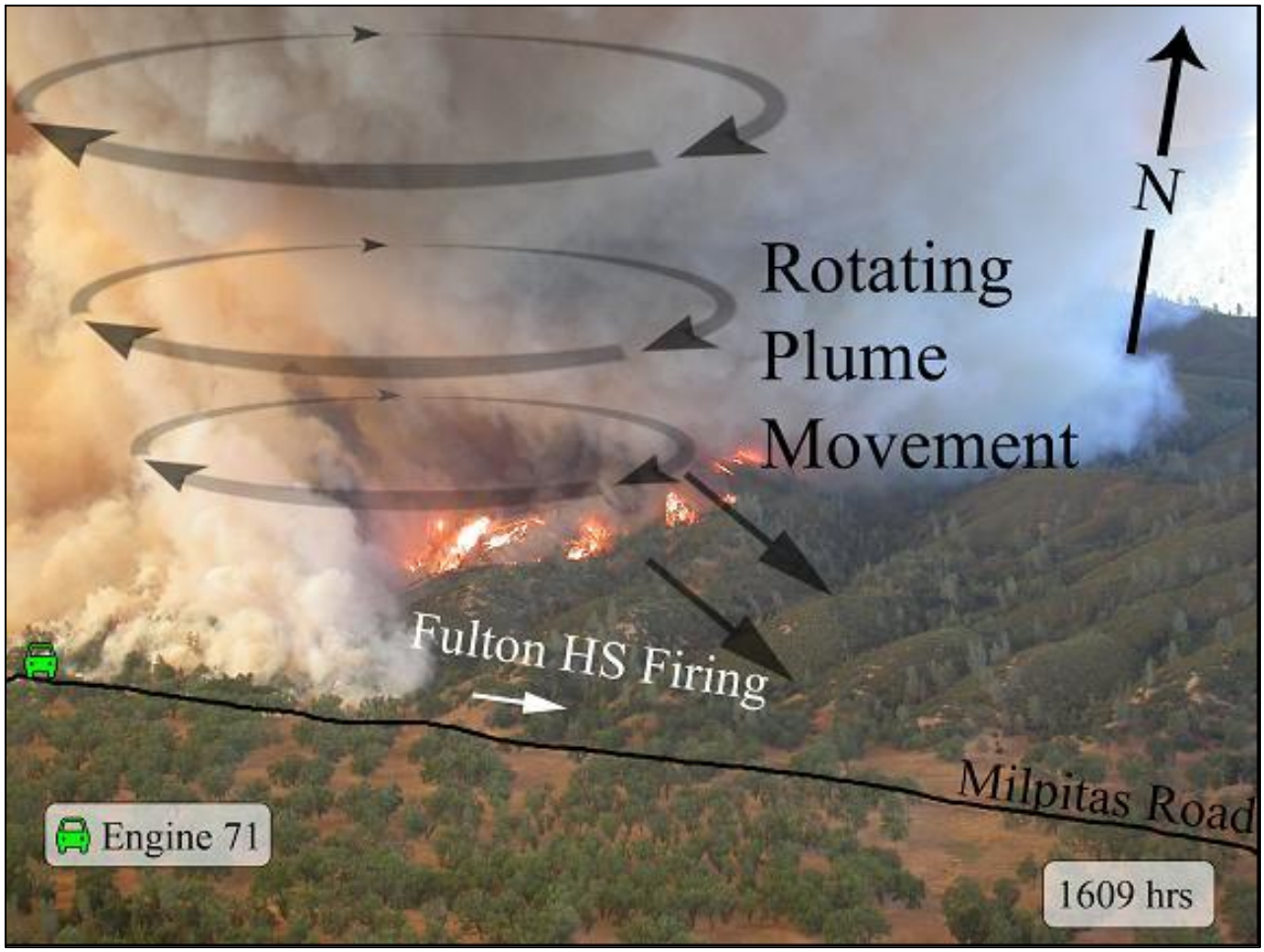

Figure C37. Image depicting rotation and location of rotating vertical plume. Photo was taken from a high point approximately 2 miles from the fire (courtesy of A.K. Davidson).

parallel to the firing operation and road. Firefighters at the eastern endpoint of the firing operation had been watching and photographing the large rotating fire plume (Figure C37). Some firefighters stated that they had observed large "fire whirls like that on several occasions," and did not perceive it to be any real threat to safety.

The winds along the road were now near the edge of the rotating plume and being significantly influenced by the rotation (Figure C38 and C39).

The fire plume had been standing mostly straight up, but now had a slight lean over the road high up in the column (as seen in video footage). At 1619 hours, a spot fire occurred south of the road near the San Antonio River (Figure C40).

Figure C38. Image showing rotating vertical plume in foothills north of Milpitas Road. Photo was taken looking northwest from Milpitas Road at the location of Videographer #1 in Figure C27.

At 1621 hours, the firing operation was stopped. About this time, the base of the rotating vertical plume had started to move toward Milpitas Road. Video images show the ground level winds near the road shifting from a southerly direction (drawing into the main fire) to an easterly direction. This change in wind direction was due to the rotating plume moving closer to the road.

The edge of the plume is defined by the smoke shown along the road (Figure C39). The winds also increased to around 20-30 mph. Video images show very rapid fire spread toward the west across any combustible matter near the road. Images of the fire further north of the road on the slopes indicated continued high intensity fire behavior. Firefighters were heard on the video records commenting about the size, intensity and noise of the rotating plume.

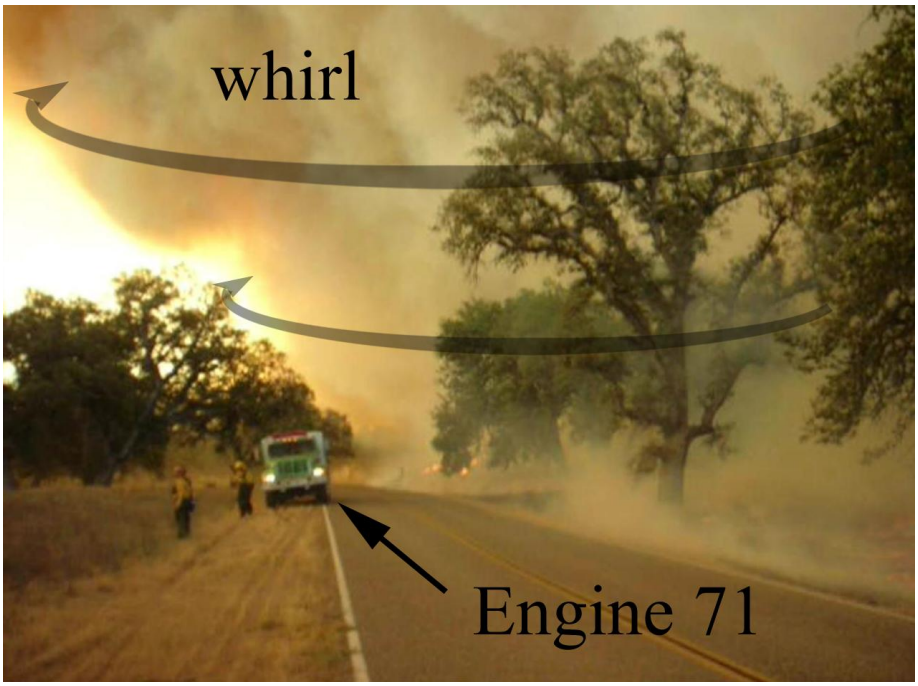

Figure C39. Image showing rotating vertical plume as it nears Milpitas Road. Photo was taken looking northwest from Milpitas Road at the location of Videographer #1 in figure C-27.

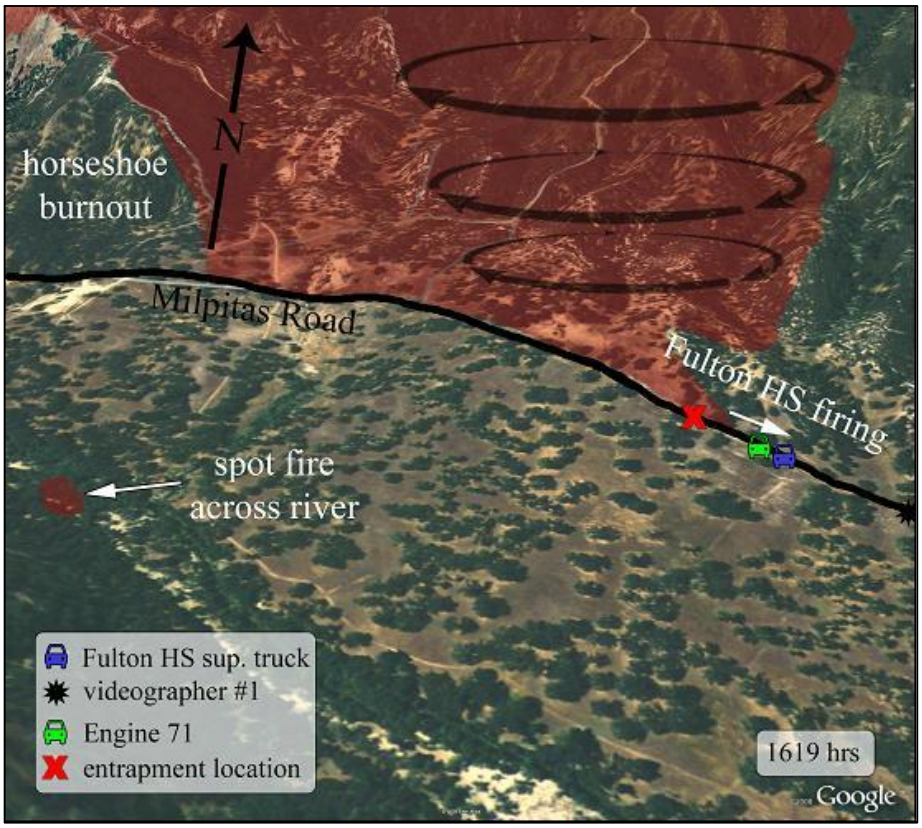

Figure C40. Image showing location of first spot fire near the San Antonio River. Rotating vertical plume is shown in the foothills north of Milpitas Road.

Also at 1621, Engine-71 saw another spot fire adjacent to the road only 320 feet west of their location. It was only about 5 feet by 5 feet in size. Three members of the engine crew walked west on the road toward the spot fire, while the other two turn the engine around. Once the engine is heading in the correct direction, one of the crew members joins the other three on foot and the driver begins to drive the engine toward the spot fire (Figure C41). Soon after, winds suddenly increase near the crew and engine. The edge of the rotating vertical plume has moved over them and the road (Figure C42). Additional spot fires ignite near the road. The 4 crewmembers on foot were enveloped in strong winds (estimated to be 60-70 mph), dense smoke, blowing embers and debris, flames blowing horizontally across the road, and highly variable wind direction and speed.

Flame length in the grass is undetermined, but flame height was reported to be “knee high” igniting any combustible surface fuels. Firefighters describe a “sheet of flame” over the ground. The spot fire located across the San Antonio River was drawn across the flats toward the main fire (Figure C43). Subsequent photos show active fire underneath the oaks, many of which sustained significant wind damage.

After moving onto the flat valley floor, the in-draft inside the vertical rotating plume scoured any loose material on the ground including pebbles and ash, leaving broad areas of only hard-packed earth. Once the edge crossed the road, the rotating plume soon dissipated and fire behavior decreased markedly.

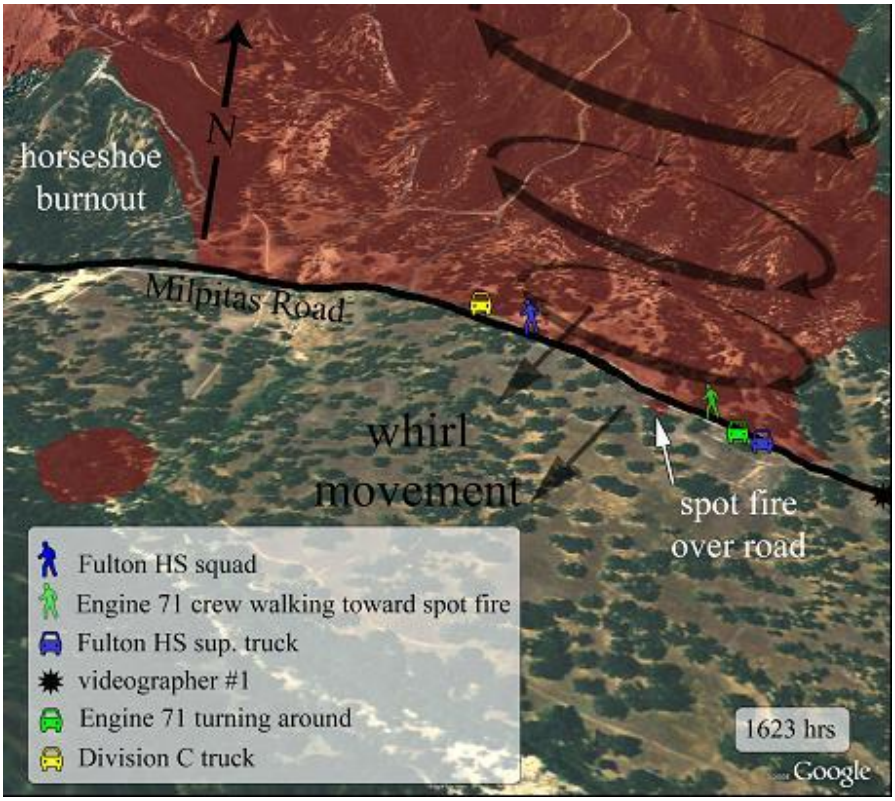

Figure C41. Image showing second spot fire near Milpitas Road that Engine 71 decided to move toward. Rotating plume location and movement is shown.

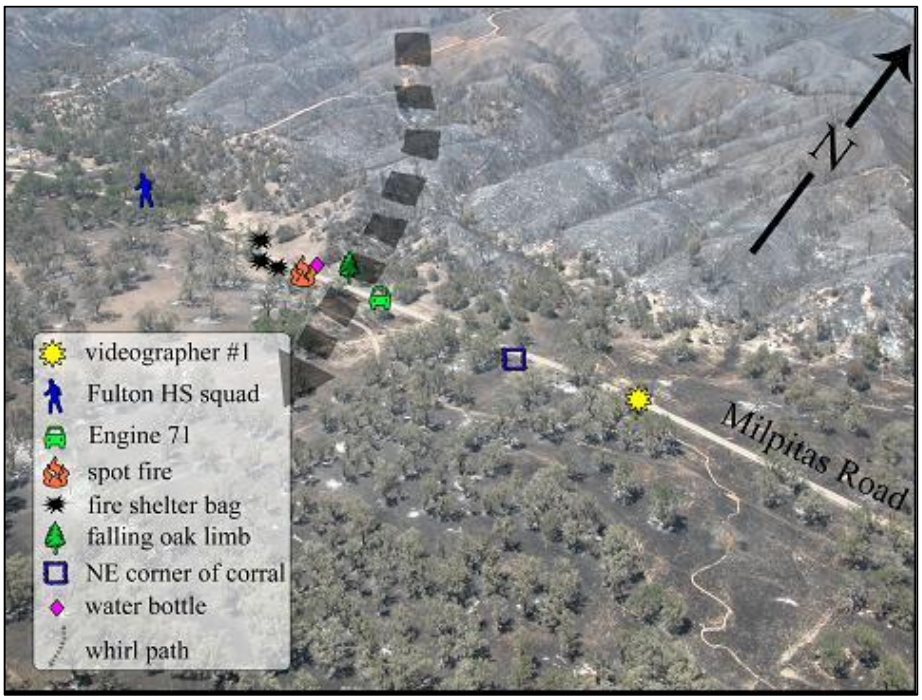

Figure C42. Approximate path of rotating plume.

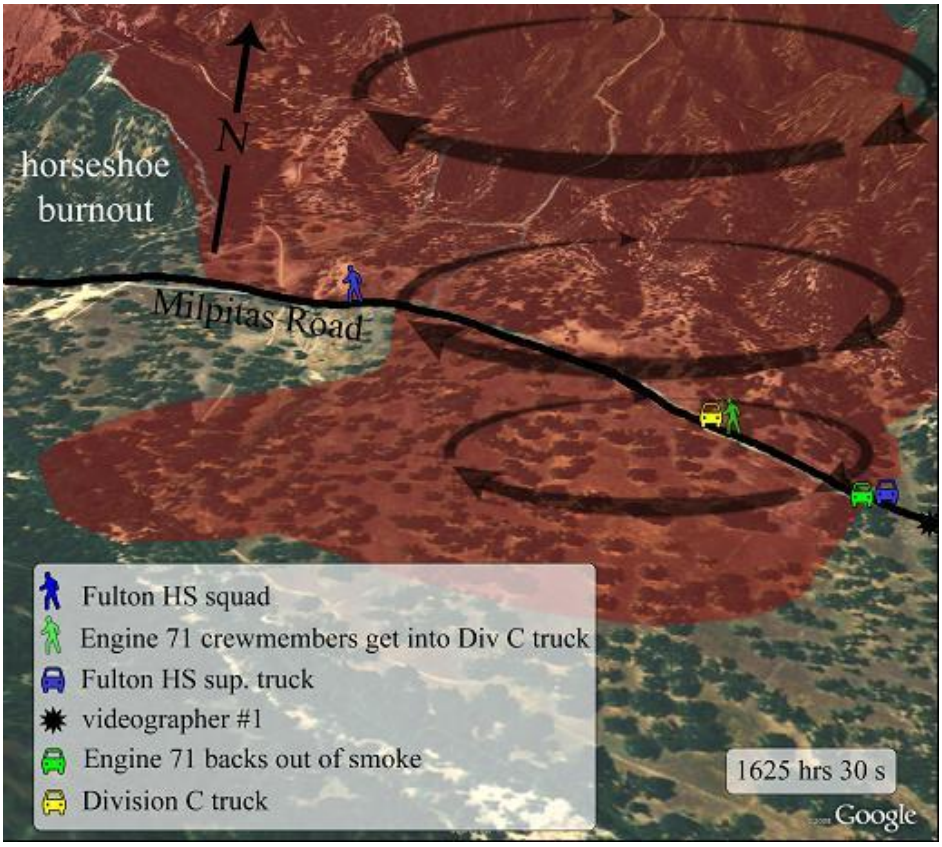

Figure C43. This images shows the location of the rotating plume as it crossed the road. It has drawn the spot fire near the river toward the plume.

Post fire examination of oaks in the area south of the road indicated significant wind blown charring of the stems up to 10 feet above the ground. Generally, the live canopies in the oak trees showed heat caused injury, but were not charred.

These data suggest the presence of high temperature (greater than 600° F), high velocity gases, and air near the ground.

Winds at the plume base are estimated at greater than 70 mph and resulted in extreme fire intensity and significant wind damage to the vegetation. White oak tree branches with base diameters as large as 18" were ripped off their parent trees and transported through the air (Figure C44).

Figure C44. Photo of typical vegetation damage due wind.

Firefighters that entered the area after the event report rocks as large as 5 inches in diameter scattered over the road. One firefighter from Engine-71was slightly bruised when hit by flying debris. Areas of the ground south of the road were scoured of any loose rocks or organic material, leaving only hard packed soil.

It is also possible that as the plume moved into new areas, unburned debris, char, and other organic materials drawn into its base, contributed to further energy release as they burned.

While it is likely impossible to determine if the burnout operation caused the formation of the rotating plume, video footage collected during the burnout operation indicates very short residence burning times in the light grassy fuels.

Therefore, it is doubtful that the light grassy fuels contributed substantially to its continued development.

Also, giving credibility to this idea, is the fact that the rotating vertical plume dissipated after moving into the less intensely burning grass fuels, indicating their heat release was not enough to sustain the rotating plume. The debris (consisting primarily of large oak branches), needle freeze, and bole charring patterns, indicate a highly variable wind direction on the ground with some rotation evident (see Figure C45).

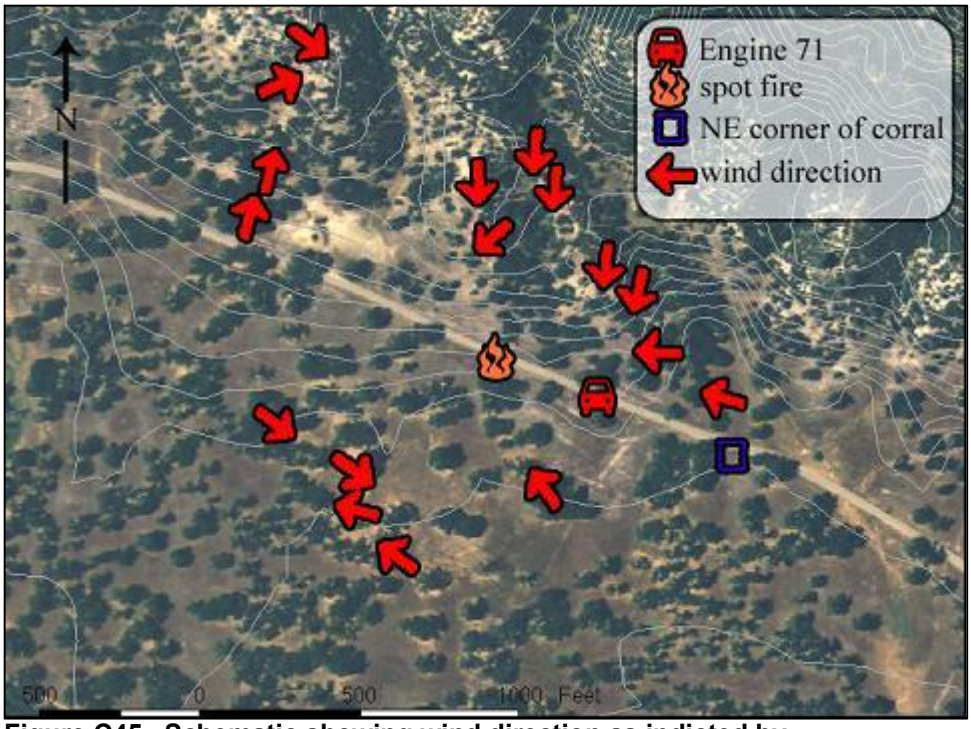

Figure C45. Schematic showing wind direction as indicted by post fire inspection of needle freeze and bole charring patterns.

The extent of the area covered by the debris indicates the path and size of the plume base (Figure C46).

By 1800 hours on June 11, the fire had burned more than 11,000 acres, growing by ten times over the past 36 hours. It is interesting to note that the fire did not spread to the south of the Milpitas Road at any other location between the accident site and the division C/D break, suggesting that the firing operation did halt southerly fire growth.

It had grown to more than 18,000 acres by 0600 on June 12th. Over the next few days it continued to cross control lines on the east and north perimeters.

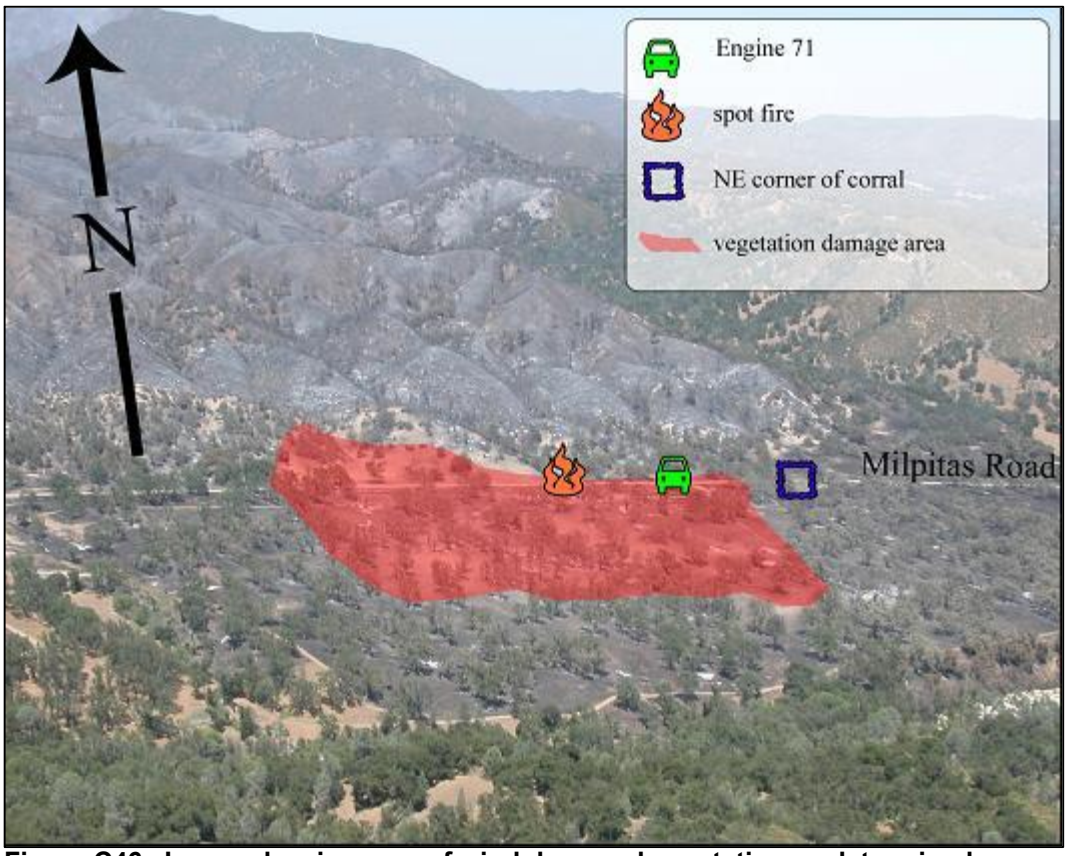

Figure C46. Image showing area of wind damaged vegetation as determined from post fire examination of accident site.

Rotating Plume Development

Tornadic events generated by large fires can be extremely dangerous, but apparently occur more often than one might initially think. A brief look into the scientific literature and discussions with veteran firefighters indicate several examples. The 2007 Fletcher Fire in Oregon damaged large trees. Many photos are available clearly showing a tornado-like structure that separates from the main column and moves at least a few hundred yards from the fire. The 2007 Neola Fire in eastern Utah produced similar vegetation damage and also tore the roof off of a nearby structure.

Three civilians were killed in what appears to have been a tornadic event similar to that observed on the Indians Fire. The 2002 Missionary Ridge Fire has video documentation of a large rotating vertical plume during which winds were strong enough to overturn vehicles and damage the roof of a building in the area. A 1977 wildland fire in Japan seriously injured firefighters when a rotating plume formed on the lee wind side of a mountain.

The 1871 Peshtigo, Wisconsin fire that killed up to 2,500 people was reported to contain a rotating plume that lifted a house off its foundations. In 1926, petroleum tanks near

San Luis Obispo, CA ignited and burned intensely for days, generating many large rotating vertical plumes. One was strong enough to lift a cottage located 1,000 yards from the tanks and move it 150 feet. The two occupants of the structure were killed.

Evidence exists describing a larger rotating fire plume that occurred during a city fire in downtown Tokyo, following an earthquake in 1923 that moved out of the city over a barren area where residents had gone for safety. This event ultimately killed an estimated 38,000 citizens within 20 minutes. Both the Hamburg, Germany and Hiroshima, Japan bombings during World War II also reportedly produced large, intense, damaging rotating plumes that appeared and behaved like tornados.

The main ingredients necessary for rotating vertical plumes of a large scale are a source of vorticity (rotation) and intense heat. The vorticity may come from flow channeling from variable terrain/drainage orientation, vorticity induced in the wake of a hill or ridge, or horizontally oriented vorticity present (due to shear near the ground) in the ambient atmosphere that gets tilted to the vertical by the heat source. In all cases of large rotating plumes, an intense heat source is necessary to concentrate the vorticity.

In the case of the Indians Fire, the drought had led to extremely dry live fuels and probably a buildup of dead fuels in the chaparral fuel types resulting in a highly flammable condition. The unstable atmospheric conditions promoted vertical transport in the plume. The variable terrain contributed to both enhanced combustion and channeling/blocking of in-flow to the plume base. The channeling/blocking of the in-flow may have been the initial source of rotation at the plume base.

However, once the rotation was initiated, the heat source concentrated the vorticity by stretching the plume in the vertical direction, reducing its diameter. This reduction in diameter forced the rotation to increase in speed to conserve angular momentum (just like a figure skater spins faster when her arms are held close to her body).

This concentrating mechanism allowed the rotating vertical plume to obtain high wind speeds and explains the dramatic increase in winds proximal to the plume base. The rotation also significantly reduces the diffusion of energy (both kinetic and thermal) from the rotating plume to its surroundings. The result was a rotating tornado like structure that was able to exist and move across terrain for some distance away from its heat source before dissipating.

Appendix D
IMET Weather Report

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Summary

The weather conditions at the Indians Fire on Fort Hunter-Liggett in Central California at the time of the entrapment on Wednesday, June 11, 2008, were near Red Flag criteria; winds were not quite strong enough to meet the criteria (see attached report from Roger Lamoni, NWS, Western Region Fire Weather Program Manager). The region was under severe drought conditions. The months of March, April, and May were the driest ever recorded in this area. A hot, dry period in May also dried fuels out earlier than usual and hence, ERC's were computed to be at record levels for this time of year.

The fire area on June 11, was under an exceptionally dry north to northeast general low to mid-level wind flow between strong upper-level high pressure ridging off the California coast, and a large upper-level low over the Northern Great Plains. This weather pattern, on the front side of a high pressure ridge, with a north to northeast general flow, produces strong subsidence, and hence extremely low relative humidities and very warm temperatures. The previous day in fact, had similar conditions and of some importance, so did the night before the entrapment. Tuesday night, 6/10/08, relative humidity recoveries were very low. On the slopes and ridges, they were only 10 to 20 percent, and active burning occurred through the night. Sustained winds on the upper slopes and ridgetops were from the northeast between 5 and 15 mph with gusts to 20 mph. During Wednesday the 11th, temperatures warmed quickly into the 90s in the lower elevations (2000 ft. or lower) by early afternoon. Relative humidity dropped into the 5 to 10 percent range by 1500. Ridgetop winds remained from the northeast about 5 to 15 mph, while lower slopes and valleys had lighter, diurnal terrain winds dominating. The Haines Index this day was only a 4, low. Strong subsidence aloft was present at levels between 6,000 and 12,000 feet, which caused extremely low relative humidities. With the strong surface heating, under clear skies with a very warm air-mass, the lower levels of the atmosphere (surface to 5000-6000 feet msl) would have been very unstable. This certainly would have been a factor in the development of the rotating plume which caused the entrapment. High fire intensity in these hot, dry, unstable (in the lower levels) conditions, combined with terrain and general wind flow interactions, caused the rotating plume, which was estimated at 1000 feet in diameter at the base, and 1500-2000 feet in height. Peak winds associated with the plume are estimated to have been at F0 to F1 tornado strength at approximately 70 mph, based upon eyewitness reports and surveys of broken and torn limbs from oak trees in its path that were 4 to 15 inches in diameter.

Discussion: Figures D1 and D2 below show the rotating fire column (or anti-cyclonically rotating vortice, as described by Dr. Warren Blier, Science and Operations

Officer, NWS Monterey) from two perspectives, looking north from a ridgetop 3-4 miles away, and west, along Milpitas road about a mile from it.

Figure D1. View of the rotating plume from ridgetop to the south.

Figure D2. Looking west at rotating plume from Milpitas Road.

The stability and temperature structure of the atmosphere at the time when the rotating plume formed are indicated by an upper-air balloon sounding data shown in Figure D3.

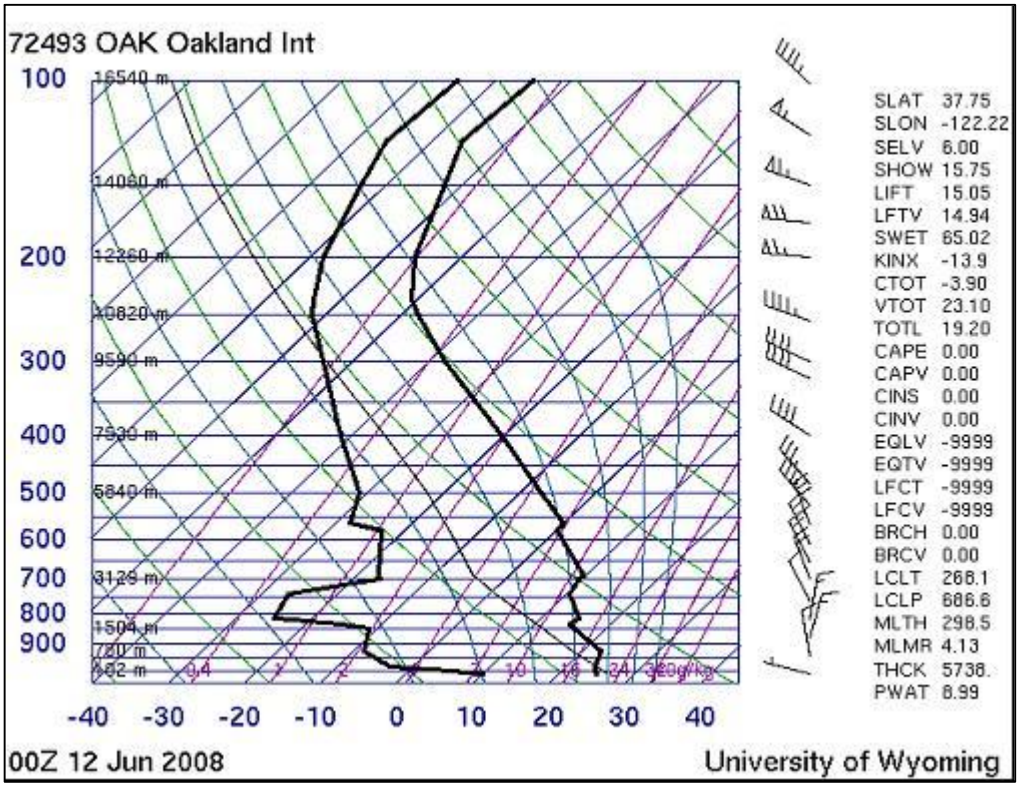

Figure D3. Upper-air sounding from Oakland, CA 4pm Wed 11JUN08

Note the very dry low-levels from about 900 millibars (about 1500 feet) to 700 millibars (10,000 feet) on the afternoon of June 11th. Dew-point temperatures are between -8C and -25C. In addition, note the presence of several strong subsidence inversions in Figure D3, the sounding from June 11th. These areas of subsiding air correspond with the extremely dry lower layers in that sounding.

How is the synoptic pattern at the time of the entrapment depicted? Figure D4, the surface analysis from the afternoon of Wednesday, June 11, shows the thermal trough extending north and west from the desert southwest over central and northern California. This trough marks the location of the warmest air near the surface, with higher pressure to the west, over the Pacific.

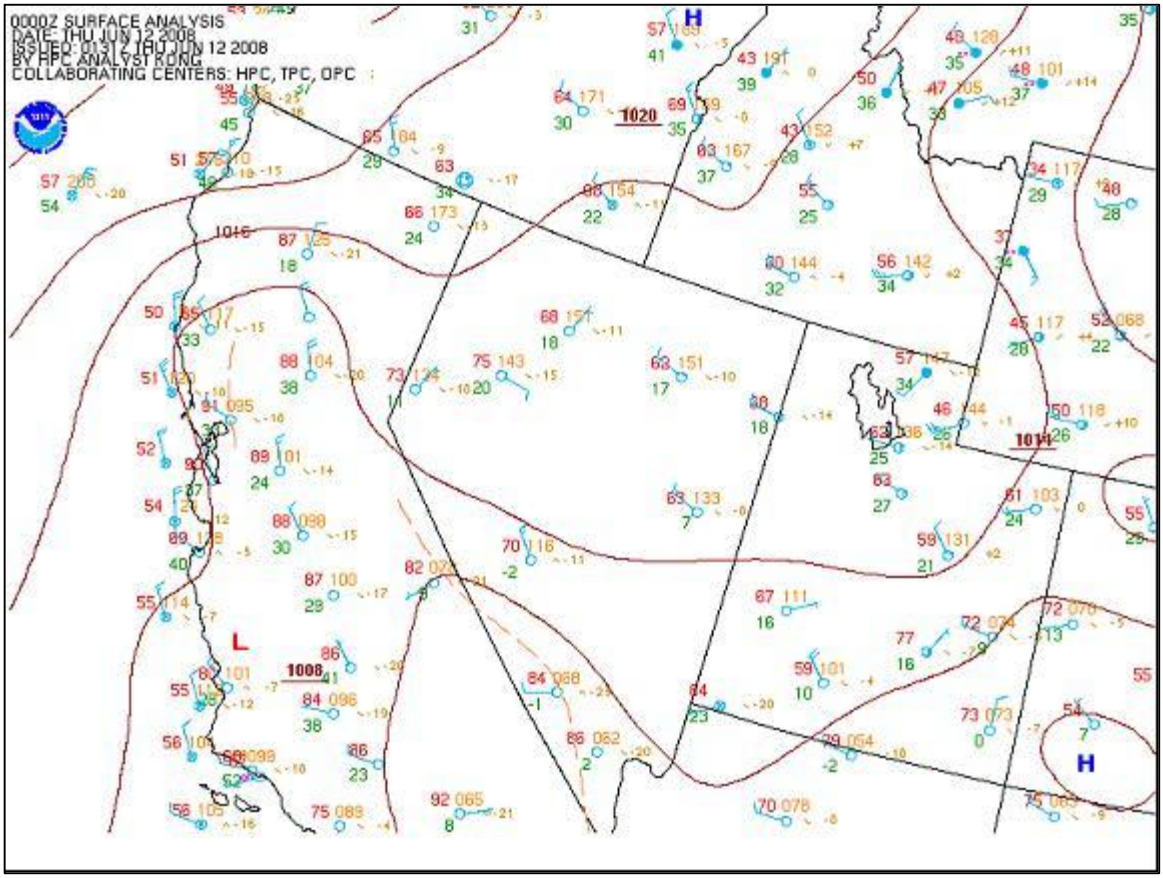

Figure D4. Surface analysis, 4pm Wed 11JUN08

Figures D5, D6, and D7 show the 850, 700, and 500 millibar analyses on the afternoon of June 11th. The very warm, dry northerly flow is very evident on all three; temperatures at 700 millibars (about 10,000 feet) were near 12C, or 55F. The strong high pressure ridge lies just offshore.

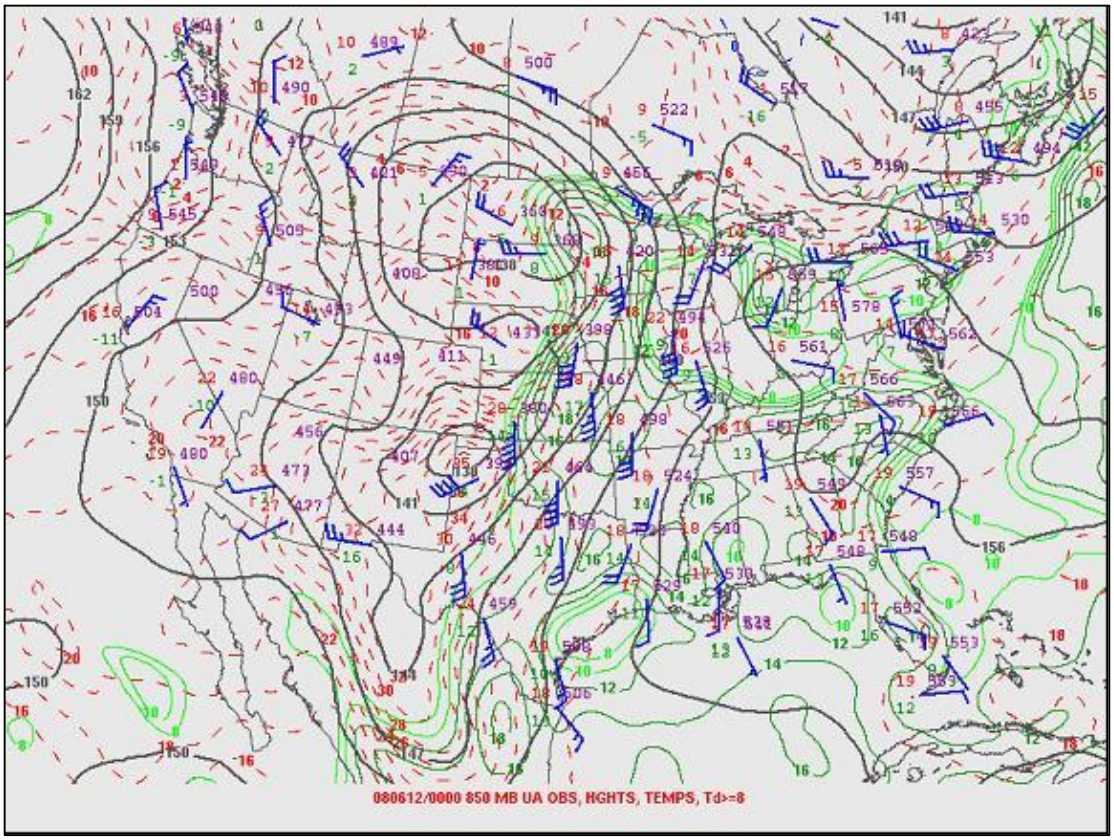

Figure D5. 850 millibar analysis, 4pm Wed 11JUN08

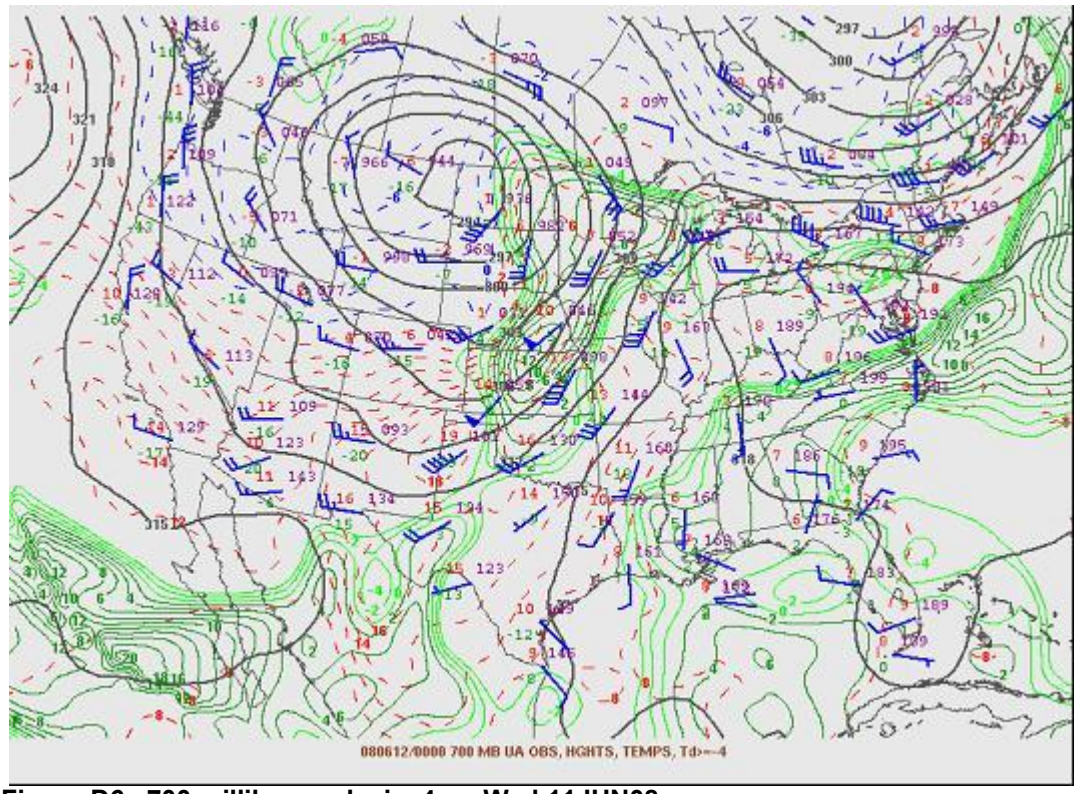

Figure D6. 700 millibar analysis, 4pm Wed 11JUN08

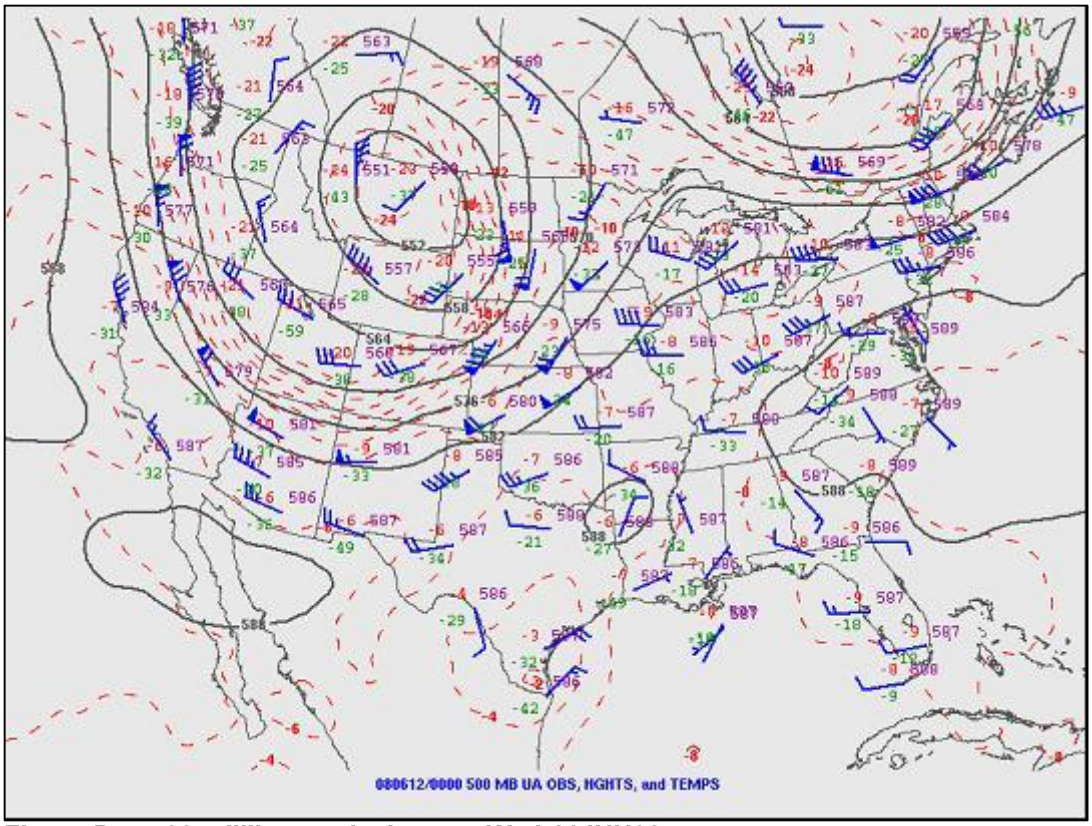

Figure D7. 500 millibar analysis, 4pm Wed 11JUN08

Figure D8 shows a GOES visible image from 1030 PDT on the 11th of June. The northerly flow is quite evident from the direction of smoke transport, as well as the smoke production from active burning. Figure D9 shows the terrain around the fire area, which is just to the north and east of Fort Hunter Liggett.

Note the northwest-southeast oriented hills and valleys, complex terrain with relief that varies from 1000 feet in the lower valleys to over 5800 feet on the highest ridgetop.

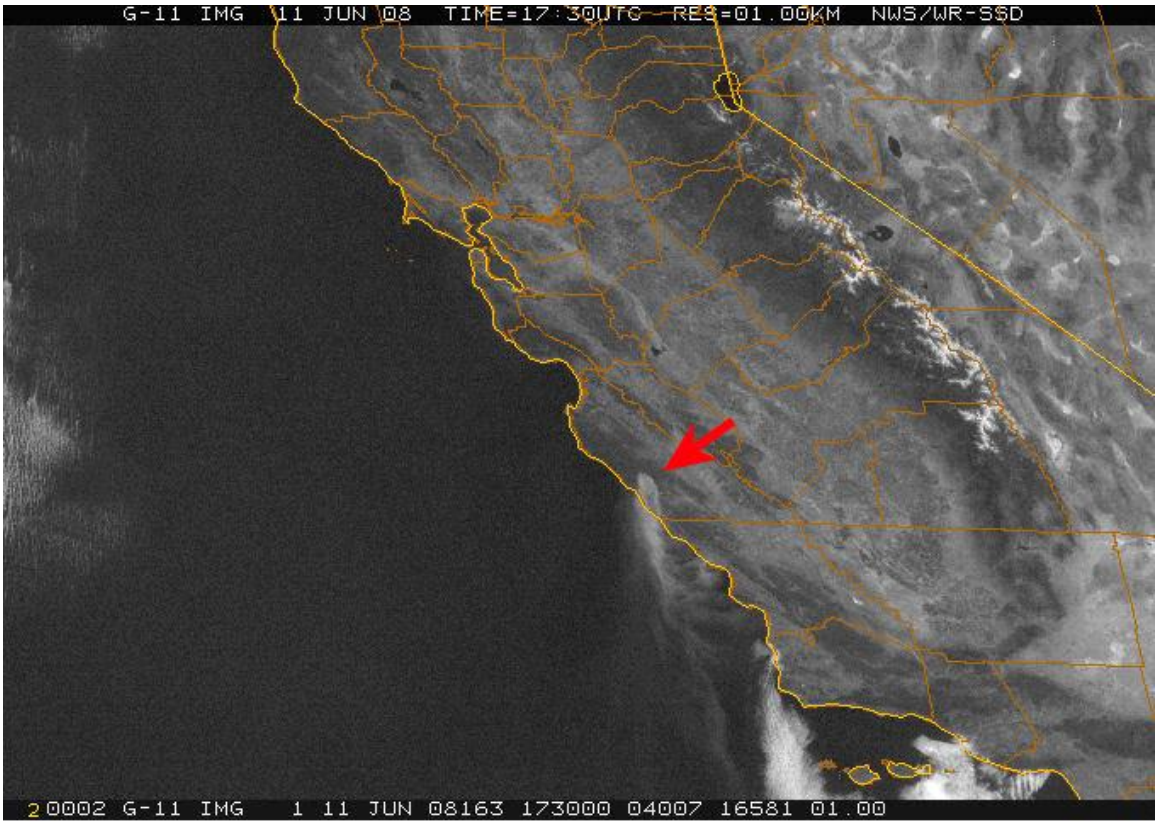

Figure D8. GOES visible imagery, 11JUN08, 1030 PDT.

Figure D9. Terrain around Indians Fire area.

With the synoptic pattern established, and an idea of the terrain in mind, now it is possible to estimate how the F1 tornado-like plume formed. As can be seen from Figure D1, the fire is actively and intensely burning on the southeast facing aspect in heavy fuels (chamise/chaparral with scattered Digger Pine and Valley Oak).

The light northerly general wind flow on the ridgetops and higher slopes would tend to push the fire south, while the up-valley afternoon wind flow would intersect the lower portions of the plume and induce a rotation. In addition, flow through many smaller side drainages that were present in the area could have also helped with this. The northerly general wind flow did help push the rotating plume south over the valley. It crossed the road and went over the flats, in the mile-wide valley.

The Milpitas road is along the north edge of this valley. The area of ripped and torn tree limbs extends across an area over a quarter-mile wide, just south of the road (Figure D10 and D11). The pattern of torn and downed tree limbs suggests that the vortice "danced" around, dipping down in some areas, and then rising again, much like a very small-scale fire whirl or dust-devil would. It is extremely fortunate that fire crews and civilians were not present off the road in the valley, where most of the downed tree limbs occurred.

Figure D10. Downed oak limbs near entrapment site.

Attachment

Red Flag Warning Analysis, Indians Fire Entrapment, 6/11/08, Roger Lamoni, Fire Weather Program Manager, NOAA/NWS, Western Region Headquarters, Salt Lake City, UT.

Comparing the [RFW (Red Flag Warning) criteria in the] CA AOP (Annual Operating Plan) and the RAWS data.

Ft. Hunter Ligget (FHLC1):

My thoughts are that wind did not meet RFW criteria during the periods of critical RH on June 10. Conditions were borderline between midnight (00) and around sunrise (06) on the morning of June 11, as RH was 10-15% (criteria is <31%) and wind was 4-9 mph (RFW criteria is 6-11 mph). However, the AOP also states that the winds should last for 8 hours or more to issue a warning.

Figure D11. Large downed limb near entrapment site.

Arroyo Seco (ASRC1):

Similarly, conditions did not meet RFW criteria on June 10. Conditions were borderline on the afternoon of June 11th, but again did not satisfy the 8 hour time requirement as listed in the AOP.

Based on the 24 hr and 72 hr reports, the incident occurred around 1630. Unless there were some fire RAWS nearby, Arroyo Seco may be the only local data.

Low RH in inland California is not at all unusual in the summer. Maximum temperatures in the 80s and 90s are not unusual either. Wind is the big factor and I don't see it as a driving force in the RAWS data in the fire area. Occasionally, the transition from an offshore flow to an onshore flow results in a strong and hazardous "sea breeze" for a few hours that offices have warned for, but that doesn't show up in the data either. To me, the RAWS data imply mostly local effects with a small amount of synoptic influence as the offshore flow just died off. Based on the very limited data I see here, and my knowledge of CA weather/climate, I would have leaned against issuing an RFW for this zone if I had been forecasting.

Having seen similar phenomena before (a 1/4 mile diameter rotating column killed several civilians in the Neola Fire in NE Utah last year), I'm curious about a local wind shift. Even if winds were light overall, local terrain could favor a small down slope wind speed increase that encountered an existing updraft boundary due to both the fire and highly contrasting albedo along the fire line. I have visited the area before and know that the terrain is very complex with many hills and small valleys and gullies containing oak groves and (now cured light tan) grassy slopes.

Appendix E
Human Factors

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Jim Saveland
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Introduction

The intent of a Human Factors Analysis is to better understand awareness, decision-making, actions, and sense-making from the perspective of those involved in an incident. Better understanding leads to learning and improved safe performance. The relevancy of human factors is paramount in identifying the mental, cultural, and organizational processes that occurred during events on the Indians Fire. Interactions between these factors are subtle and subjective, thus more difficult to retrieve and document compared to physical phenomena. Investigators are acutely aware of this and cultivate mutual trust between involved firefighters and themselves to identify these processes as they emerge during the incident. By noting what firefighters were attending to as they made decisions during the incident, an understanding of human factors unfolds.

Section 1: Decision Factors (Ted Putnam)

The Decision Factors listed below are the main findings of the Human Factors section of the report. The Decision Factors are sequentially numbered and footnoted to show in the Story where they demonstrate the event in focus. After the Decision Factors are presented, two discussions follow with background information pertinent to using and recognizing these factors. The first discussion is based primarily on latent *mental* causes and the second discussion is based primarily on latent *cultural and organizational* causes. Readers should note that mental, cultural, and organizational factors can be separated for discussion, yet are intricately woven together in the story and our lives.

Decision Factor #1: Late Departure

There is an SOP for incident operations driving, Chapter 07, page 07-7 of the Interagency Standards for Fire and Fire Aviation Operations, “to manage fatigue, every effort should be made to conduct off unit (excluding initial attack responses) mobilization and demobilization travel between 0500 and 2200 hours

Several levels of management must effectively disregard the 0500- 2200 SOP for the crew to leave at 2200, thus an example of organizational compliance drift. Consider the following: Given a choice, most firefighters will opt for the quickest departure for the extra pay, plus they are excited to leave. If the 0500-2200 SOP is to be strictly followed, then those doing the dispatching and ordering should stipulate that fire personnel are not to leave before 0500 the following day. Supervisors can ensure that fire personnel are aware of the restriction and see that it is followed. It is likely most of the crew got 4 hours total sleep at best, between cat-napping while driving and sleeping once at ICP. When reporting for assignment at 0600, the IMT now has the opportunity to ask the Captain how much sleep his crew has had. Before you ask a question if your mind senses a negative answer is likely, it may automatically erase the memory of the question and refocus on another issue. The IMT needs the engine crew it ordered so might not ask questions for which they may not like the corresponding answers. Questions would be more like “Did you get some sleep last night?” with an answer “Yes and we are raring to go.”

Decision Factor #2: Sleep Deprivation

Since the crew has arrived safely, the nighttime driving issue now shifts to will their four hours of sleep (or 4 hour loss) have a detrimental effect on situational awareness, clear thinking and appropriate decisions later in the day? The answer is that it will have a negative effect, though it should be small. Four hours sleep is enough to offset a truly detrimental effect but will accumulate if the crew doesn’t begin to get caught up. The crew would likely have had less sleep if they wait and depart at 0500 the next morning. Their sleep would be normal only if they leave at 0900 or later. Then there is the whole issue as to if you ever realistically can get caught up and maintain normal sleep in a fire camp environment. In fire camp and on the fire line, fatigue is a constant companion.

Decision Factor #3: Safety Zones

Resources, including E-71, staged near the C/D border on Milpitas Road. The first operation was to burnout remaining fuel in a large nearby field which would become a designated Safety Zone. Later, the main operation of the afternoon was to fire from the north side of Milpitas Road. Depending on the location along Milpitas Road, the mostly grassy areas became smaller Safety Zones as the crews “brought good black with them.” As the crews moved along Milpitas Road, possible smaller Safety Zones were likely available, but only if the crew noted their locations. When such alternates are identified, they should be securely signed or flagged as such. Obvious safety zone areas during burn out may be difficult to find later under smoky, stressful conditions.

Decision Factor #4: Lookouts

According to the Captain of E-71, many people left the staging area to conduct recons and the recon effort continued all day long. These recon firefighters were doing size-ups, planning, road locating, and prepping. The Captain assumed, to some degree, those engaged in this recon were informal lookouts. While conceptually there is quite a pool of roving eyes, they have other duties and are not formally assigned as lookouts, thus may or may not report their warnings and concerns generally to all the firefighters along Milpitas Road. This distance between assumption and reality opens a door best kept closed. We need to be careful when making assumptions, remain conscious of them and verify them when the opportunity arises.

There were no formally designated "lookouts" to watch for potential hazards from a vantage point away from the active burnout. Throughout the morning, the burnouts and backfire operations are pretty much picture book perfect, so there is little concern that a lookout is even needed. Keeping "eyes in the green," watching for spot fires south of the road was a crew priority. As fire severity increased to extreme, no one seemed to be alerting firefighters, in general, of the related inherent dangers. Is there a cultural reluctance to post designated lookouts?

Decision Factor #5: Escape Routes

The primary escape routes were to drive or walk east or west along Milpitas Road. The afternoon burnout operation was focused on keeping the fire north of Milpitas Road which kept the primary escape route open. The distance necessary to effectively escape the active fire areas remained stable since the crews were bringing the black with them. Areas of good black close to the head of the fire were not Safety Zones until they were out of reach of the wind driven rotating vertical plume, the column collapsing, or ember showers. Essential for LCES when burning out from a road, that is also your escape route, is the imperative to "stay tight with no separation," meaning keep your people together, near their engines and crew carriers, ready to roll once a trigger point is reached. Trigger points can prepare you for faster escape.

Decision Factor #6: Communications

Communications were effective with respect to the number of radios and the frequencies in use. There were no reports of overloaded channels or problems getting through to other firefighters. If there was a communications problem, it was more cultural in nature. There seemed to be a cultural hesitancy to communicate between the various types of resources. Some of this hesitancy is due to not wanting to get in the "collective face" of other resources, after all, would you want them in yours? However, it becomes a safety issue when no one gets on the radio and warns that the column has become a rotating vertical plume. There is a quiet casualness with respect to these potentially dangerous threats. "We see these all the time and they are seldom a problem." Or alternately that what we see is so obvious (from our perspective) that

everyone else must be aware of it too. Perspectives exist dependent on your locations and what you are currently attending to, and thus are not likely to be so obvious or known to all firefighters. If failure to note these changes can result in harm, then speaking up becomes a necessity for safety. Those in charge aren't likely timid folk. Perhaps they are overly preoccupied, so caught up in what they are doing that it becomes harder to withdraw and communicate; a cultural Attention Deficit Defect (ADD) Syndrome.

Decision Factor #7: Voicing Concern

By now, there have been many persons witnessing extreme fire behavior. There is growing concern about interactions between the burnout, the rotating vertical plume, and operational objectives. As the fire intensity increases, there is no corresponding ramping up of broadcasting this concern division-wide. When the Fulton Superintendent sees the beginning rotation, he contacts his crew and tells them "Stay tight, close to the buggies and ready to roll." When you warn your crew, is it time to warn nearby crews? What then was the trigger to warn others? Observers said that if the rotating vertical plume started towards the road, they would have sounded the alarm over the radio. For now, they continue to watch the plume. Vacillation has always been a weather vane trigger that you are now behind the proverbial eight ball. Our minds can only track changing environments linearly while the changes they are tracking are occurring exponentially. So vacillation means you need to assume the worst or simply put "start talking."

Decision Factor #8: PPE

The engaged firefighters for the most part had and wore their PPE. Some with face shields did not use them. However, the main concern is with the number of those in a recon mode who weren't wearing all their PPE. The cultural SOP is to leave one or more of your line gear, helmet or gloves in the vehicle when getting out and conducting a quick assessment. Safety degrades the longer you are out and the further you get from your vehicle, another "separation" issue. Due to the proximity of the rotating vertical plume, not wearing PPE is a concern. Too often, firefighters have been caught by fires while not wearing all their PPE. At issue is that firefighters are acting as if there is no immediate threat, only to be caught by a quick moving fire moments later. Routinely, firefighters continue taking little calculated chances and every year some of them pay the price.

When such casualness is observed, firefighters need first and foremost to keep up their own guard and mindfully remind themselves to "expect the unexpected," maintain safety awareness, and wear appropriate PPE. Along Milpitas Road, there was a need for mindful firefighters to remind their peers to wear their PPE. Check yourself and then quickly scan your crewmembers. No need for chastising so much as pointing to your helmet or gloves to remind the person what is missing. Fireline leaders should set the example, since Milpitas Road was an active fire zone. The observed failures here suggest individual, cultural and organizational laxity. New rules aren't needed so much

as to remind yourself that a habit of casual PPE use can leave you exposed when the unexpected pays a visit.

Decision Factor #9: Crew Personal Space

Each fire module tended to stay focused on *their* piece of turf, *their* crew, *their* present situation while losing *their* neighbors in the process. Concentration is necessary to stay focused on your task but must be balanced with mindfulness which keeps you in contact with other crews and the "big picture. " Said in another way, there are plenty of pictures and videos being taken, but little in the way of elevating the verbal warnings they're videotaping into a radio warning. The rotating vertical plume was recognized as only a "potential" hazard since it was moving parallel to the road. Along Milpitas Road, someone shouting over the radio that extreme fire behavior was about to impact firefighters in this area awaited the trigger of "starting towards the road."

The Fulton Supervisor said, "I see these things all the time and they are seldom a problem" and similarly "Attacking the spot fire is not a problem either" at this time. After witnessing the power, heat, and destruction of the rotating vertical plume, the Superintendent said, "If I ever see another one I will sound the alarm once it starts to rotate." So if a lookout had been posted, and that person called in to report the plume, it may have been "downsized" to "no problem." Before today, there has been a lack of respect for this "mother of all fire whirls" by some of our best firefighters. What is involved in this seeming discrepancy is a lack of appreciation, until after the fact, of how fast this column can move and change directions or expand to impact firefighters. In the future the Fulton Superintendent will call adjacent crews if he sees a similar plume beginning to rotate.

Decision Factor #10: A Hotshot Umbrella?

Since many crews lookup to and defer to the more experienced Hotshots, there may exist a subconscious tendency to rely on those same Hotshots for a portion of LCES. This suggests "If the hotshots aren't acting worried, i.e. talking on the radio and videotaping the fire, then everything must be ok." The firing operation along Milpitas Road is successful "so far, "and sends subtle signals that "firefighters are in control." This begs the question, "Do the Hotshots have an implicit responsibility for maintaining a "LCES umbrella," mentoring crews, and setting professional examples? Does casual PPE use and talking along Milpitas Road begin to seep into the unconscious awareness of other firefighters, inducing them to follow the lead? Has this collective casualness affected Hotshot situational awareness as well? Most of our decisions are made unconsciously, so subtle cues may be in control of later actions for most of these firefighters.

Decision Factor #11: Crew/Vehicle Separation

Separation can refer to the distance from your vehicle. Elsewhere, other crews were being reminded to "stay together, close to their vehicles and ready to roll." In the

language of engines, “Don’t go past the end of the hose you are carrying.” The engine was an element necessary along Milpitas Road to implement effective escape. When deciding to suppress the spot fire 300 feet away, the Captain didn’t discuss his plan with the crew before starting to walk towards it. His focus earlier was on the more distant spot, a mile away, but the new spot was “in the green,” on “their turf,” thus “their responsibility.” The dominant focus now is on this nearby, small, seemingly easy to suppress spot fire. There is a role shift here, from more passively guarding the Fulton burner’s back door to actively engaging the new spot fire, yet their passive mindset didn’t make the respective shift to active engagement. Are unconscious everyday habits leading this crew into a heedless action?

Decision Factor #12: Situational Awareness

About this same time, some of the firefighters, especially those further east and west of this spot, are observing a large rotating vertical plume 500-600 feet from the road above E-71’s location. The Captain said he and his crew were unaware of the plume, possibly due to a low rise on the north side of the road. His present concern was assessing the spot fire as part of their larger duty to keep “eyes in the green.” When asked if knowledge of the nearby rotating plume would have made a difference, he emphatically responded “Yes.” When asked if it would have altered his decision to go to the spot, he said he wasn’t sure. However, he would have got someplace to see the rotating vertical plume, assess the danger, and then take it into account. He said he may have posted one of his crew as a lookout to keep an eye on it or asked other resources with a better view to be lookouts.

The Captain stated that with knowledge of the rotating vertical plume, the entire crew would have driven to the spot fire as an extra precaution. As part of his situational awareness and decision to engage the spot fire, he had noted that the winds were still calm and in-drafting back into the main fire.

At the next window in time, the following fire indicators are observable:

- The main fire column is now leaning southwest, directly overhead
- The column is a rotating vertical plume
- Embers are falling
- Numerous spots are beginning to show up
- Wind direction is changing
- Wind speed is increasing
- The sky is darkening.

Once the Captain looks away, further decisions are based on the static memory or ”slide” he took, not the present wind and fire behavior that has already changed. It is crucial to note this distinction since as he takes actions to go to the spot fire, he checks the “slide” and not the present conditions. This isn’t a conscious ignoring of Situational Awareness, rather a natural property of how the mind functions, one object at a time, to the exclusion of other objects. The latent upstream cause is the mind itself, which is focused elsewhere.

Once the decision is made to Initial Attack the spot fire, events get stickier. There is an unconscious attachment or anchoring to our decisions and plans. Once attachment occurs, there is an unconscious defense of that decision and plan. If you next observe the wind picking up, it is incongruent with the decision you are “stuck to,” so the wind will be unconsciously ignored or erased from awareness.

Decision Factor #13: Narrow Focus

In a less hectic environment that wasn’t grabbing his immediate attention, the Fulton Superintendent may have taken the time to warn the engine crew. Remember the tendencies already apparent for avoiding just this type of contact. What may be missing is that on one scale we are separate modules, and on another scale, we are fire brothers and sisters, worthy of our concern with *heartfelt attention* as opposed to *habitual attention*. Acting on that concern, we are more likely to warn them. By this time, with quarter size embers pelting him, his focus is getting back to his truck.

Decision Factor #14: Fear

Here there is fear that rises directly proportional to the sinking reality of the stable world you thought you knew. The first moment of fear is a warning leading to arousal and instinctive reactions which can save your life, such as slamming on the brakes to avoid being hit by flying branches. However, if fear lasts beyond that moment, it clouds your mind. As fear arises, it competes for attention with an already overloaded mind which can lead to indecision. Both you and your crew’s lives are at risk, with full mental awareness and clear thinking needed for decisive action as you drive into an ominous storm.

Now is not a time for learning to face and approach your fears. The mental skills you bring to the fireline are the same as those you use all year long. The time for exploring fear in your mind is off season, under less hectic conditions where you can give full attention to the fear and how to effectively work with it.

Decision Factor #15: The Narrow End of the Time Wedge

According to the Fulton Superintendent, the time for awareness, appraisal, decision, and action has been compressed at the narrow end of the decision time

wedge. Witnesses commented that in the past few years, “Do not allow for trial and error learning,” “Fire is no longer a forgiving environment,” “We can no longer predict fire behavior,” and “Never saw this coming.” Engine crew comments include: “It seemed like a dream, can’t believe this is happening to us,” and “Don’t think this situation can be trained for.” Yet the wildland fire culture is now beginning to normalize extreme fire behavior. A relevant question is whether we need to rethink the way we view fire. Under the “new” normal conditions, “new” rules of engagement may be relevant, such as always post a lookout once we reach a certain level of ERC, FLI or BI. And wear all your PPE whenever you are not in a vehicle. If we can’t predict our environment, we must act as if the worst is already on the way

Decision Factor #16: Crew Cohesion

There have been three events that suggest this crew may be short on crew cohesion. In training, staying together has been strongly emphasized. Looking back when the Captain and two of his crew start walking towards the spot, they leave Crewmember #1 behind to assist the Engine Operator in backing up the engine. Once turned around Crewmember #1 runs to catch up with the three headed for the spot fire leaving the Engine Operator and engine behind. Still later, Crewmember #3 runs east back towards the engine. Only the last is unplanned separation, thus the most suggestive that crew cohesion is still tentative for this young crew.

Decision Factor #17: Realistic Shelter Training

This crew had a history of practicing shelter deployments under realistic conditions multiple times. Some firefighters seldom practice deployments while moving fast under outdoor conditions. Many practice indoors under unrealistic conditions. Attempts should be made to deploy outdoors in environments you are likely to be deploying in and under windy conditions when available. Firefighters need to practice reaching for their shelters while wearing their packs and other equipment to identify problems affecting deployment speeds, especially while moving fast.

Decision Factor #18: Attachment to Mission

Attachment or anchoring to plans, ideas, tasks, and missions are the norm. Once you attach, there is resistance to changing focus. This is not a conscious, deliberate focus, rather an automatic process. When the Division Supervisor asked about the dozer, this is natural as that has been his focus of awareness for some time now. He is slower to note these firefighters are injured, not due to lack of concern, but due to the automatic tendency to resist changing focus.

Decision Factor #19: Mental Resilience

Here the relevant process is a fundamental loss of a sense of reality. As we work through life, we all encounter rough times and learn to adjust. But rarely do we come up against the "perfect storm" that shakes up our sense of who we are to the core. However, the storms are only the proximal causes, not the deeper, latent causes. The real culprit lies in the nature of the minds of those involved. Most of us never take the time to explore and strengthen our minds to make them more resilient. When our thin veneer of reality is pushed to the limit, our "self" and "world views" begin to disintegrate. There are mental exercises that help keep our minds resilient but most of us decline to work on our minds because "There is nothing wrong with my mind," and "It will never happen to me." With extreme fire behavior as the new norm, and the unexpected now common place, it can happen to *you!* What's in your mind?

Decision Factor #20: Critical Incident Stress Debriefing

Since most people do not engage in mental resiliency exercises, deeper residual stress is a natural outcome of events such as that experienced by E-71 crewmembers. Here, the entire crew has come under critical incident stress. The Captain was questioned by a Health Care Professional to explore his need for prompt therapy by a mental health professional, but the other crew members were not. As a crew, the crewmembers chose to wait until their Captain came back to work to receive CISD counseling. Organizationally, we seem a bit slow to implement CISD Management, perhaps a reflection of our larger culture considering the high mental casualty rate of our soldiers. Often those hurting the worst decline counseling, feel it is their problem, and avoid talking about it which in turn can result in Post Traumatic Stress Disorder. Are we proactive enough?

Section 2: Latent Mental Factors (Ted Putnam)

Introduction

The APA process helps uncover human factors "beyond the edge of normality." By noting what firefighters were attending to as they made decisions during the incident, an understanding of human factors unfolds. The APA process is dependent on investigators paying "appropriate attention" to the witnesses and events. Investigators in turn, bring their own biases to an investigation. What follows is an analysis based on a blend of Eastern and Western psychology. The observations cited below are those that can be observed in your own mind by looking inward, thus experiential as opposed to theoretical, hypothetical, or academic. This is an invitation to explore the Indians Incident and your own mind.

It is useful to point out briefly how our minds work by noting five processes observable in your own mind:

(1). We can attend to only one object at a time. While we attend to one object, all other objects are excluded from awareness. An alternate way to say this is that attention to objects proceeds in a linear, sequential manner, one after the other. We switch attention many times per second giving us the perception of seeing and hearing at the same time, yet we still cannot truly multi-task. Firefighters can learn to work with their own mental processes to improve awareness in risky environments through “appropriate attention” to the immediate and expected hazards.

(2). Our cognitive processing capacity is limited. This can be shown by an example of driving a car. To drive a car mindfully in the safest manner, distractions need to be minimized. Talking or listening to the radio while driving reduces situational awareness. Using a cell phone while driving reduces driving awareness, resulting in accident rates similar to those of drunk drivers. Text messaging on cell phones is an even worse distraction and more likely to lead to fatalities than simply talking on a cell phone.

(3). Our minds automatically condition and habituate our actions and thinking unless we learn to observe and extinguish this process. This means almost all of our decisions are made on auto-pilot without reflection, and reflection is usually just another automated process. Said another way, we have a habit of distraction, continually avoiding the present moment. Only those who have taken the time to watch and understand how these processes unfold in their own minds become aware of their habitual ways of responding and learn to *stay* with the present moment. Roughly 95 percent of our thoughts and actions are habitual, automatic processes.

(4). Our mental routines go with us wherever we go. Because our mental routines are mostly unconscious, they are simply part of who we are. We do not suddenly become more aware and make better decisions in risky environments. We become worse due to all the added stresses associated with those environments. We routinely go off on mental “side trips” (such as daydreaming) throughout the day and seem surprised at our capacity to miss situational cues that can result in poor decisions in environments where the consequences are more severe. The underlying mental processes remain the same.

(5). There are three mental poisons that cloud your mind: Attachment, Aversion and Ignorance. Out of ignorance (of how our minds function) we attach to objects we find pleasant and avert or avoid objects we find unpleasant. Upon attaching to an object, it is only a matter of time until we experience a negative consequence from that attachment. Attachment to food we find pleasant can result in the overeating with downstream consequences of added pounds and increased health risks. The overeating can become routine if we are talking to someone

else (or ourselves), listening to the radio, etc. and lose track of how much we are eating. “Wise attention” is to taste and stay aware of the food, alert to note when the body tells us that it is “quite full.” Consider a life-threatening event under extreme pressure. To the degree we note or focus on the fire threat itself, it interferes with taking expedient action, such as getting into a fire shelter quickly. Averting and avoiding objects that arise are especially troublesome in risky environments. When elements of fear, self doubt, and confusion arise, they are usually ignored or erased from conscious awareness, often when clear awareness is a necessity for mitigating the immediate life threatening event.

These five processes will show up throughout the Indians Story as they do every day of our lives. Watch for them as you read the main story, where numbered footnotes alert you that decision factors may be present, usually functioning below conscious awareness. The decision factors are sequentially numbered. Additionally, the five processes listed above can be summarized as follows:

1. One object at a time; Decision Factors: 3,4,6,9,11,12,13,15,18; T=9
2. Limited cognitive capacity; Decision Factors: 2,4,5,6,7,13,15; T=7
3. Autopilot; Decision Factors: 1,2,4,6,7,8,9,10,12,15,16,17,18,19,20; T=15
4. Mental routines stay with us; Decision Factors: 1,2,5,6,8,10,14,16,19,20; T=10
5. The Three Poisons; Decision Factors:1,6,9,11,12,14,18,20; T=8After reading the story while following the decision factors located earlier in the Human Factors report, consider the following summary of mental factors.

Summary of Mental Factors

When analyzing accidents, the natural assumption for those of us looking over their shoulders, is that firefighters did what they did knowingly and deliberately. We then focus on what they did “wrong” rather than on what firefighters, from their perspective, were doing “right.” Looking back, we see only that events unfolded in the observed sequence and error in thinking the events are connected in a causal chain. We miss the multiplicity of choices available at each decision point and focus only on those actually acted upon. By looking closer at latent mental factors we can identify a number of factors that may have influenced the decisions and subsequent actions.

Almost all of our actions have subconscious determinants and so extra effort is needed to stay resilient and bring our own behavior under intentional control. The battle between conscious and unconscious control of behavior is the pivotal effort for increasing awareness and making wise decisions and actions under first routine, then with practice, under extreme conditions. Becoming more conscious of how our minds work is the best way to shift from trying to follow an unending number of rules to principal based actions. Principal based actions can reduce confusion and exert a force

that counters latent subconscious actions that if followed, even briefly, shift firefighters into higher risk actions under present situational pressures. Trigger points for these actions can reduce the amount of time and thinking to initiate appropriate actions and for noting when we are being overwhelmed and need to withdraw. Most firefighters use trigger points for outward events but few have similar trigger points for degrading mental processes. We can better understand and become more responsible for our minds by learning mindfulness meditation which generally enhances everything we do and specifically enables us to use information, training, and past experiences more efficiently while inviting new insights.

Studies of the health hazards of smoke show that smoke over the course of a summer depresses the immune system by about 7 percent. Meditation boosts the immune system by 7 percent or more and is a natural way for firefighters to deal with the health effects of smoke. With respect to improved immune systems and stress reduction, meditators have about a 30 percent reduction in illnesses and the associated medical and subsequent insurance costs. Therefore, learning meditation skills makes good economic sense as well. Upstream from organizations, cultures, and people, are human minds. When we quote the finding that human error accounts for 80% of all accidents and fatalities, we are referring to errors made by those very same minds. Research, past use by Hotshot crews, and worldwide personal practices, suggest that teaching meditation skills is a very effective way to improve awareness, decision making, and firefighter safety. To explore these benefits, a pilot program was started in 2008 in R-2 and R-4 to improve situational awareness by teaching mindfulness meditation. Course instructors were Jim Saveland and Ted Putnam.

Section 3: Latent Cultural and Organizational Factors on the Indians Fire

(Jim Saveland)

A human factors analysis reveals as much about the sense-making of the analysts as it does the actual events. We would like to think that there are simple facts out there for us to discover, and from those facts derive the underlying causes that contributed to an accident. Unfortunately, this is a pleasant fiction, known as the “myth of the given.” As Sydney Dekker, author of "The Field Guide to Understanding Human Error," has stated: “Facts do not exist without an observer wielding a particular theory that tells him or her, what to look for.” What follows is an analysis based on scientific, cultural, and organizational aspects of situational awareness, decision making and sense-making. This is an invitation to explore the Indians Incident with this emphasis.

Two particularly useful lenses to look through to see the world are recognizing the cognitive biases we all share, and recognizing that being able to see a dangerous situation unfolding is primarily a signal detection task.

When making decisions under uncertainty, people employ several cognitive biases. For the most part these biases are very effective in supporting rapid decision making.

However, they can lead to trouble if we are not aware of them. Some of these biases include overconfidence, availability, representativeness, anchoring, and hindsight. People tend to be overconfident in their predictions about the success of an operation. Certain information is more available to us for decision, especially recent information and information that is rich in personal meaning. Anchoring is very similar to attachment which is described above. Representativeness is the degree the current situation matches a familiar "slide" in our mind. Hindsight is the bias that comes from looking retrospectively at an event knowing the outcome, something we should all keep in mind as we read this report.

Another framework that is useful to keep in mind as you read the main story is signal detection. For the most part we are operating in a state that could be called "business as usual." This is carrying out what has been previously planned, events are unfolding according to expectations, and we are subject to complacency and operating on "auto-pilot." Next there is a period of uncertainty that may last from microseconds to minutes. In military operations, this level of ambiguity in situational awareness experienced by participants is called the "fog of war." The term is ascribed to the Prussian military analyst Carl von Clausewitz, who wrote: "The great uncertainty of all data in war is a peculiar difficulty, because all action must, to a certain extent, be planned in a mere twilight, which in addition, not infrequently, like the effect of a fog or moonshine, gives to things exaggerated dimensions and unnatural appearance." Next comes the moment of recognizing a life-threatening situation. A certain threshold of evidence that a threat exists must be crossed, otherwise people are concerned about "crying wolf" when there is no threat. With the crossing of the threshold and the recognition of threat, there is usually an almost immediate decision to take action (often an automatic reaction based on overtraining and experience). Finally, we take action to evade the threat and restore safe operations.

When we look at all the decision factors and ask ourselves why this event happened, there are three main elements: situational awareness, lateral voice, and practical drift.

Situational Awareness

With a limited understanding of situational awareness, we might be tempted to say that the engine crew "lost situational awareness." Such statements don't really tell us much, and some researchers are saying there is no such thing as "losing" situational awareness. We as humans always have some awareness of our surrounding environment. Situational awareness is increasingly seen as a complex, highly individual, dynamic balancing act between "cognitive fixation" (the ability to focus and concentrate) and "thematic vagabonding" (the ability to see the big picture, and switch attention to the multiple themes that comprise it). It is only with hindsight bias that we can conclude there was "inadequate" situational awareness. So the obvious question that arises is how was it that the engine crew wasn't aware (didn't detect the signals) of the large rotating vertical plume developing?

First of all we must keep in mind the **Local Rationality Principle**, which states that, "People are doing reasonable things given their point of view and focus of attention, their knowledge of the situation, their objectives, and the objectives of the larger organization they work for." Because of the local rationality principle, "the adequacy or accuracy of an insider's representation of the situation cannot be called into question."

As the large rotating vertical plume developed, four members of the engine crew are outside their engine. The engine is between them and the fire, blocking their view of the rotating column that is developing. What is obvious from a distance (seeing the rotating column develop), becomes less obvious the closer you get. The crew assumes there are informal lookouts and probably unconsciously expects to be notified of any pending threats to their safety. Many times, it is only with distance that we obtain perspective. For the crew to see the column, they would have to look directly overhead. The engine is running, dominating their sound scape and masking the sound of the fire. The high winds are extremely local, created by the in-drafts to the column, and diminish rapidly as you move away from the column. Up until this point, there have been no other challenging situations, and remember an overconfidence bias is always present. The crew's focus of attention is the spot fire burning adjacent to the road. Because it is burning away from the road, it is a backing fire and the fire behavior is benign. It appears to be a small spot that can readily and easily be extinguished. The question each of us needs to ask ourselves is, "How many times in our lives have we focused our attention on 'putting out the small spot fire' while losing sight of the main event?"

"Lateral Voice" or Speaking Up

Karl Weick and Kathleen Sutcliffe, Professors at the University of Michigan, School of Business have stated, "With every problem, someone somewhere, sees it coming. But those people tend to be low rank, invisible, unauthorized, reluctant to speak up, and may not even know they know something that is consequential." From the videos, we hear recognition of the fire being "lost" before the engine crew heads toward the spot fire and their entrapment. While there were several members of several crews watching the formation of the rotating vertical plume, there appears to have been very little communication between crews or up the chain of command about the growing threat to personal safety. The academic literature talks about the problems of "upward voice," people not raising issues of concern with those above them in a hierarchy. We need to also be concerned with what might be called "lateral voice," i.e. inter-crew communication. Each person on a fire has the responsibility to think of themselves as a lookout. They may be seeing something from their unique perspective that others are not. We can not assume that others are seeing the world we see. We need to cultivate a mind-set of collective sense-making and realize that developing good situational awareness is a team sport. Hotshot crew superintendents are notorious for keeping in contact with each other and engaging in this behavior of collective sense-making. We need to recognize the importance of this activity of collective sense-making and move it beyond the boundaries of hotshot crews, while not overloading already stressed communication channels.

Practical Drift

Practical drift is the uncoupling of local practice from policy and procedures. There are at least three cases of practical drift uncovered here: three firefighters not wearing personal protective equipment (PPE), inadequate LCES, and disregard for work/rest guidelines. The lack of gloves contributed to sustaining burns on the hands. One of the lessons learned from one firefighter was to always have the gloves nearby. Notice that he didn't say always wear them. The gloves were taken off in order to have the manual dexterity to complete necessary tasks. This suggests that we need to design gloves that afford protection while allowing for greater manual dexterity. If we are overly focused on production, or there is no apparent imminent danger, we may be tempted to ask, do we really need a lookout? Somehow we need to find a way to elevate the importance and maybe the necessity of the lookout position. Work/rest guidelines present an even thornier issue. We probably need to move our thinking beyond following work/rest guidelines to the concept of actively managing fatigue, and then move beyond that to the recognition of the importance of rest/recovery to optimal performance. In resistance training, working with weight tears down the muscle, while the recovery period builds the muscle. Tri-athlete training regimes always include at least one full day of rest a week and one week of light training per month. Rest & recovery needs to be recognized as a top priority in energy management for peak performance.

In the past, investigations often stopped with identifying "failure to follow procedure" and issuing some form of punishment. Such actions are increasingly seen as undermining the development of what James Reason, Professor of Psychology University of Manchester, refers to as a "reporting subculture" and a "just subculture." Organizations focused on high reliability tend to seek out and study practical drift rather than blindly impose punishment which ultimately serves to shut down reporting (for fear of punishment) and undermine justice (because punishment is inconsistent and unfair, i.e. only those people exposed in an investigation/analysis are punished). Ultimately, managers who impose punishment following the findings of a safety report, are also engaging in a defensive routine, protecting their ego from stepping into the shoes of the victims. As Karl Weick and Kathleen Sutcliffe have stated, "Executives often manage the unexpected by blaming it on someone, usually on someone else." Yet, turning a blind eye to misdeeds does not further the cause of justice either, so what can we do? Here are a couple of suggestions to consider.

The first step could be to grant immunity for any infraction uncovered in the course of a safety analysis. This will serve the development of a reporting culture. Second, we need to recognize that any infraction is an example of practical drift and thus we need to probe a little deeper and find out why this type of behavior is occurring. Next, management has a decision to make. Is this something that we need mandatory compliance for? If so, there needs to be some mechanism for wide-spread enforcement that is fair (all transgressors have an equal probability of getting caught). There are at least three options that can be considered here:

1) Peer Enforcement: This is somewhat of a self policing action where peers “keep each other honest.” For example, most crews have end of season parties. A person on a crew caught without appropriate PPE by another member of the crew would pay a “fine” that would contribute to the end of season party. Crews would need to develop what constitutes an infraction and the appropriate fine.

2) Hierarchical Enforcement: Here, policing action for certain behaviors is clearly specified in the roles and responsibilities of the position or through Commander’s intent. For example, we expect the Division Supervisor to issue warnings and citations for failure to wear PPE.

3) Police Force: Here, there is a creation of group of people (a police force) whose sole mission is enforcement of policy. They are assigned to the line to enforce policy. One word of caution here, do NOT put this role on Safety Officers.

Summary

The intention of learning must be at the forefront. At the heart of learning is challenging assumptions and expectations. If, after you read this, your thought is, “Boy did ‘they’ screw up, I would never do that,” then we on the APA Team have failed in our responsibilities as storytellers, and you have failed in your responsibility as a listener to take advantage of this learning opportunity. By taking such a stance, you would in effect be enacting a defensive routine to protect your ego. You as a reader have a responsibility to learn and that can only happen by trying to put yourself in the place of the participants and see the world from their perspective, and try as best you can to avoid hindsight bias, which is pervasive and unavoidable. We need to find ways to constantly improve situational awareness and fireline communication. We also need to become students of practical drift and study why it occurs so we can respond appropriately.

Appendix F

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