# Diamond Fire

## July 23, 2011

Serious Accident Investigation Report

*"How do we see the world, through what windows of language, story, and cultural practice? When Native Americans and European Americans peer out through the matrices of their beliefs and assumptions, do we all see the same world? If, despite our different practices, our worlds are really the same, how can that world be described without distorting or diminishing it? And if our worlds are different worlds, what are those differences, what do we make of them, how can we celebrate and honor them, what can we learn from them about how we ought to live?"*

V.F. Cordova

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# Diamond Fire

**July 23, 2011**

Serious Accident Investigation Report

Location:
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Whiteriver, Arizona

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## BACKGROUND

This incident is effectively two studies. The first study, and the reason the Serious Accident Investigation Team was assembled, was due to a fatality, which the autopsy later determined to have been caused by a heart attack. The team was not aware of the cause of death for over 4 weeks after the incident occurred. However, the observed and reported cases of heat stress symptoms, on the part of surviving members of the crew, made it necessary to fully explore the conditions surrounding heat illness. The second study was driven by the potential for additional loss of life, which existed in the multiple near miss situations of hyperthermia. High Reliability Theory suggests taking near misses as seriously as accidents, as they can provide insights into prevention.

The Serious Accident Investigation Team recognized the current agency fatigue and hyperthermia mitigation strategy was completely adhered to by the crew and yet was not enough to prevent fatigue and heat illness from affecting the crew. The Team commissioned a study of academic research, which is attached to this report. The facts uncovered in the investigation, coupled with this study, confirmed the complex nature of heat illness and the need to review current mitigation strategies. The following is an excerpt from that report:

> *"Wildland firefighters may be under more physical stress than almost any other class of worker or athlete. What other population performs on demand for long shifts, at high altitude, in the smoke and dust, and in temperatures that can reach high extremes?"*
> *Heat Illness and the Wildland Firefighter*, Vesel, C., (2011)

The stated intent of this type of investigation is to prevent reoccurrence and to learn from events. The premise unilaterally held by the team was, professional firefighters decide and react based on their experience and training to the best of their ability, given the information they had available to them at the time. This is consistent with modern science of incident analysis and supported by comments in the Fall 2011 online publication "Two More Chains".

The autopsy determined the fatality of Deon Classay was the result of a "heart attack exacerbated by environmental heat exposure."[1] The Classay family preferred to have Deon referred to in the report by his nickname, "Dino". To honor this request, we refer to Deon Classay as "Dino" throughout the report.

Firefighters are good at what they do, as evidenced by the small number of fireline fatalities, compared to the number of personnel who fight fire each year.[2] Though it may be disturbing, it is not surprising to see human fatalities arise from the complex environment of fire. The entire wildland fire community deeply feels no firefighting operation is worth the loss of a friend, colleague or family member.

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[1] Autopsy Report
[2] Verified by High Reliability Researchers, who recognize wildland firefighting as a High Reliability Organization - Weick, K, Suttcliffe, K (2007) Managing the Unexpected.

## EXECUTIVE SUMMARY

On July 23, 2011, Deon "Dino" Classay, Squad Leader on the Fort Apache Interagency Hotshot Crew (FAIHC) was hiking out of the Diamond Fire, a local initial attack fire on the home unit near Whiteriver, Arizona, when he separated from his crew, collapsed and subsequently died. Dino, a 43 year-old male, was nearing the end of his 22nd season as a wildland firefighter[3], he was a fully qualified Crew Boss (CRWB) and was acting in that capacity. The autopsy was completed and made available to the Team on August 16th. The autopsy identified the cause of death as a heart attack, stating, "Factors which contributed to death were environmental heat exposure and ischemic cardiomyopathy due to a previous myocardial infarction."[4]

Following the heart attack that claimed the life of Dino Classay on the Diamond fire on the White Mountain Apache Indian Reservation, the Bureau of Indian Affairs convened a Serious Accident Investigation Team.

The Team discovered that over 80% of the crew (not including the Dino) presented signs and/or reported symptoms of heat illness (crew interviews). Based on the reported signs of heat illness and the then unknown cause of death, the team determined the incident qualified as a near miss with regard to heat stress/illness. To better understand heat illness, the Team commissioned a study of existing research on heat illness and fatigue. Therefore the traditional accident investigation approach was augmented by research into causes, recognition and mitigations of heat related illness applicable to firefighters (see attached report, "Heat Illness and the Wildland Firefighter").

On the morning of July 23, the FAIHC began a normal workday with morning briefing at 0800, followed by physical training at their local softball field. The formally assigned Crew Superintendent had not worked with this crew for the month prior to the Diamond Fire. In his absence, his duties were informally deferred to the Assistant Superintendent. The crew leadership "back-filled" positions to cover for the absence of the FAIHC Superintendent.

Dino was in charge of 16 members of the crew who, at the beginning of the day, were assigned to do hazardous fuels reduction work. They arrived at the Bluegrass Fuels Project site about 1130, where they grabbed a quick bite to eat (snack) prior to starting work. At 1345, the Incident Commander (IC) of the Diamond Fire placed an order for the FAIHC to assist the Fort Apache helicopter module with initial attack on the Reservation.[5] The dispatch was received just prior to the crew's planned lunch break.

The FAIHC drove to a staging area and then were flown to a helispot, which was less than ¼ mile from the origin of the fire.

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[3] Incident Qualification and Certification System - Responder master record

[4] "[I]schemic cardio myopathy due to previous myocardial infarction" – Coronary heart disease due to heart damage from a previous heart attack

[5] Dispatch Log

Dino took a squad, augmented with members of the helitack crew, to the northeast section of the fire where they worked until shortly before 1800. The 1700 weather observation showed it was 82 degrees with a relative humidity of 27 percent. Several members of the FAIHC stated that they felt it was unusually humid that day compared to what they were accustomed to.[6]

The IC's original plan, at the end of shift, was to shuttle the crew from the lower helispot to the upper helispot, which was at the southwest end of Paddy Butte. Crew carriers and support gear were staged at the upper helispot. H553, the shared Fort Apache/San Carlos aviation resource, was scheduled to perform the shuttle. The plan changed when H553 experienced mechanical problems, which grounded the helicopter. The crew then hiked to the top of Paddy Butte in two groups (less than one mile and 1200 foot change in elevation).

On the way 13 of 16 firefighters reported symptoms of heat illness including a mixture of severe muscle cramps and/or exhaustion.[7] Some individuals required immediate intervention and narrowly averted serious medical complications or even death. This mitigation varied from stopping and resting to immediate cooling of the skin to reduce core temperature.

Prior to sunset (official sunset was 1926), fellow crewmembers saw Dino as they passed him on the hike; this, in itself, was unusual, but not a strong enough signal to prompt questioning. Dino was considered to be one of their strongest hikers.[8] Dino's last radio transmission took place about 30 minutes after the last time he was seen, sometime between 1900-1930 hours. Attempts to locate or contact him were repeated throughout the night. It gradually became apparent, "something was really wrong" (crewmember statement).

Upon recognizing an increase in mission complexity (2035 hours), associated with the Search and Rescue (SAR) and apparent incident-within-an-incident, Diamond IC duties were transferred to the most senior firefighter (M-81, the Acting Crew Superintendent). A search and rescue team was ordered from Tribal Game and Fish; however, due to the steep terrain and darkness, Game and Fish Officers and emergency medical personnel determined it was necessary to postpone the search until first light.

Shortly before sunrise, crewmembers searched for Dino in the location where he was last seen. At 0607, Dino's body was found by those crewmembers. Paramedics relayed their description of Dino to a physician and Dino was pronounced dead on the scene.

An autopsy and toxicology screening was performed. Results indicate Dino died of "acute myocardial infarction due to severe coronary artery atherosclerosis".

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[6] Crew Interviews
[7] EMT observed "physical collapse" condition – symptoms were reported during subsequent interviews
[8] Crew interviews

Contributing factors to the death were "environmental heat exposure and [sic] previous myocardial infarction" (a previous heart attack).[9] There was an indication during crew interviews that this was a possibility. One fellow crewmember, and close friend, told the Team that Dino mentioned having had chest pains a month or more before the Diamond Fire. During this dialogue the crewmember indicated that Dino pounded the left side of his chest with his fist indicating the source of the pain. The crewmember said, "I told him he should get that looked at." There is no indication that Dino sought medical attention or mentioned this to anyone else. This information was, in fact, a surprise to his family. The Team observed cultural, personal and organizational pressures placed on firefighters, which made self-reporting medical conditions difficult. The investigation found, these pressures included crew responsibilities exacerbated by prolonged crew leadership absence, time needed to go to a medical facility (given 4 back-to-back assignments) and personal financial concerns. (Crew interviews: See "Heat Illness, Heart Attack and Fatigue Training and Recognition Table" – Appendix 1)

Despite requests, Dino's medical records were never made available to the SAIT.


Map 1. Vicinity map with Reservation Boundaries.

[9] Autopsy finding

## NARRATIVE

### Crew History

From April to mid July 2011, the FAIHC worked 65 shifts, 46 of those were worked from May 22nd to July 16th (56 total days). During the same period, the crew spent 47 days on fire assignments, 28 of which were spent in spike camps.[10] In May the crew worked two tours assigned to the Miller Fire. The assignment required them to sleep in spike camps, and they hiked several miles each day to begin arduous line construction. The crew rested for two days and was then assigned to the Wallow Fire for another full tour (14 days).

The Wallow Fire burned up to the reservation boundary in early June, and with their homeland in jeopardy, the crew worked very hard, significantly contributing to approximately 40 miles of hand-line construction, burnout and point protection.[11] A review of dispatch logs showed the majority of the crew had a total of 4 days off in the month of June.[12]

| Date | Fire Name | Number of Shifts |
|---|---|---|
| 4/30- 5/05 | Abrams | 4 |
| 5/06 – 6/02 | Miller | 24 |
| 6/05 – 6/30 | Wallow | 19 |
| 6/30 - 7/01 | Stanley | 0 |
| 7/03 – 7/11 | Salt | 5 |
| 7/03 – 7/04 | Grindstone* | 2 |
| 7/03 – 7/04 | L-11* | 2 |
| 7/04 – 7/15 | Little Bear | 4 |
| 7/16 – 07/22 | Mixture of days off and project work | |

*The crew was split between these two fires.

Recognizing the crew had been significantly tasked over the previous two months, management offered to allow them to take leave, to rest and take care of personal business. Seven members of the crew voluntarily took leave between 7/17 and 7/19, Dino did not. (see Table above) This made the crew unavailable for National assignment.

The Team attempted to reconstruct the 72 hours preceding the event. The SAIT was only able to account for the workday (23 July), as no one was willing to discuss Dino's actions on his days off (which immediately preceded the day of the incident). The team was able to determine that official work rest policy had been adhered to. This raised questions regarding the duration of the workday and type of work conducted prior to the fire. For this reason the time line commenced with the start of the duty day.

Despite requests, Dino's medical records were never made available to the Team. The team reviewed the Medical Standards and Health Screening Questionnaires and found no mention of symptoms related to a heart condition.

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[10] Time and attendance and crew records
[11] Hand-line and burnout totals – Wallow Fire Geodatabase
[12] ROSS Assignment History

*INCIDENT TIMELINE*

*0730 crew members begin to arrive at the fire center*

*0800 – Crew Briefing*

*0800- 0940 Crew PT*

*1100-1130 IHC drives to fuels treatment area*

*1202 Fire reported to Show Low Dispatch, Fort Apache Helitack Crew (H553) is dispatched*

**July 23, 2011**

Mandatory rest requirements were met after the crew returned to work after two scheduled days off.

The crew came on at the usual time and held their morning briefing, which was conducted by the acting Crew Superintendent. Nothing was particularly unusual, except that Dino was a bit "quieter than normal;" He was known for his raucous sense of humor.

After morning briefing, the crew started physical fitness training (PT). This day, the acting Crew Superintendent chose to play the second semi-annual crew softball game.

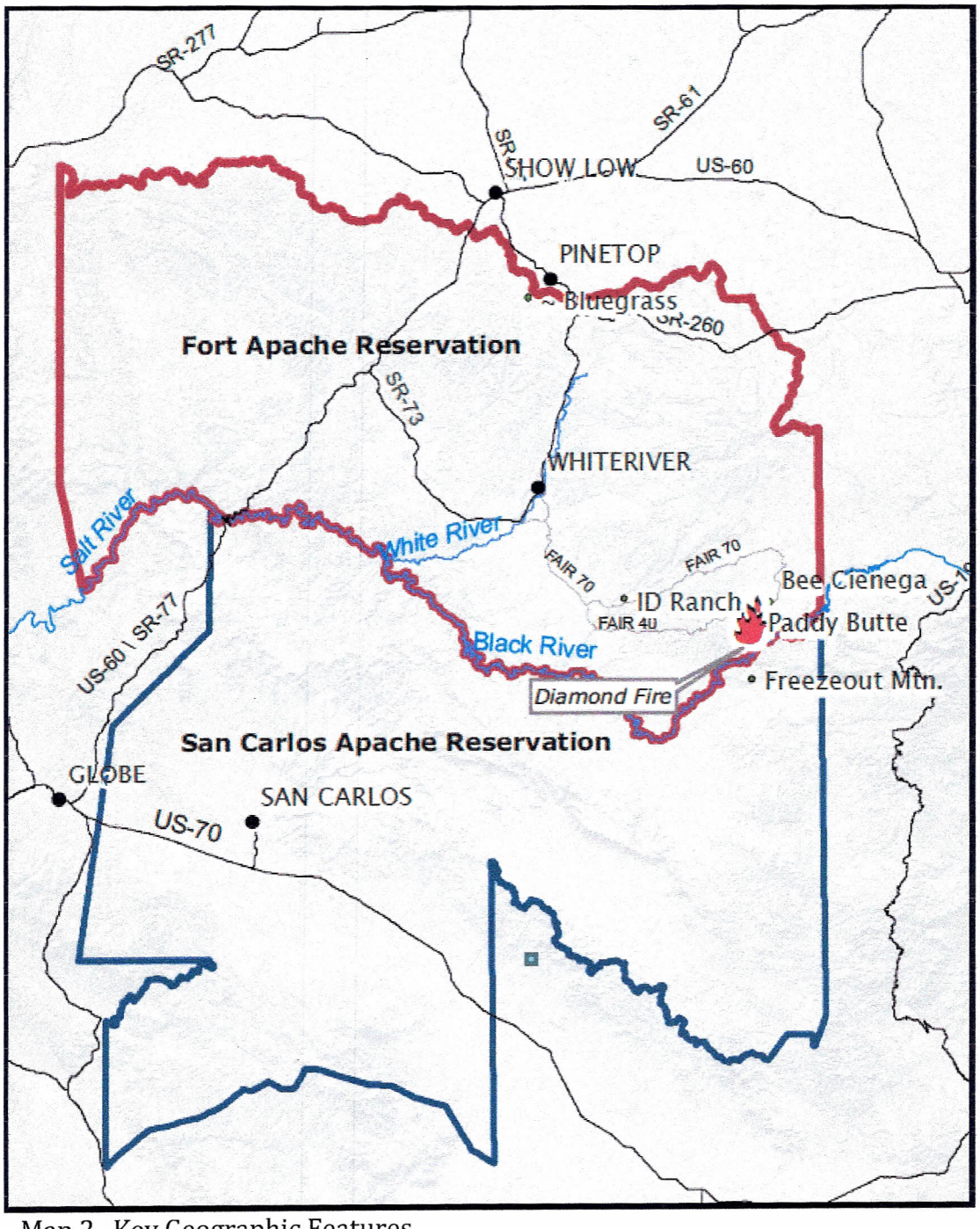
The crew was scheduled for fuels treatment work at the Bluegrass site. Given Dino's 21+ seasons of fire experience and Squad Leader designation, he was put in charge of the crew.

The Acting Crew Superintendent (M-81), Acting Assistant Crew Superintendent (M-82) and two IHC Crew Members remained at the fire center in Whiteriver, and did not participate in the fuels treatment work.

The helitack crew was dispatched to a reported smoke on Freeze Out Mountain, a full suppression response area on the San Carlos Apache Indian Reservation. There was confusion regarding the location of the fire, the initial response dispatch was sent to the Fort Apache Helitack Crew, as they were the closest resource. While en route the crew located the smoke and confirmed that the fire was actually on the White Mountain Apache Reservation. (See Map 2)

H553 Manager contacted the Fort Apache Duty Officer (DO) and dispatch to let them know the location of the fire. They were all on a common frequency. This facilitated simultaneous notification. The DO continued to monitor the frequency as the event unfolded. (DO Interview)

A small group of lightning strikes had started a few trees burning days before and now the fire was picking up a bit of momentum and began making small runs.



Map 2. Key Geographic Features

*1230 IC starts Incident Organizer Diamond Fire*

*1330 Smoke is located and confirmed to be on Fort Apache*

*1335 – Helitack overhead the fire - IC Gives Fire Size-up*

*1337-Dispatch Relays "take suppression action."*

*1337-DO confirmed order to suppress the fire.*

*1340-IC+1 on scene, IC requests remainder of Helitack crew, FAIHC and bucket drops*

*1345-Showlow dispatch orders FAIHC to the Diamond Fire*

The DO recalled, "The fire was growing and there had not been any rain." The Fort Apache Duty Officer relayed through dispatch that the IC should, "take suppression action" (Incident Organizer). This response was consistent with the Fort Apache Agency, White Mountain Apache Tribe Fire Management Plan 2004 (FMP).

*Fire size-up conducted by the IC*

*Estimated size: 25+ acres*
*Growth Potential: Moderate*
*Fire Behavior: Creeping*
*Slope: 10-20 Percent*
*Position on Slope: Canyon Bottom*
*Aspect: Flat*
*Fuel Type: Ponderosa Pine*
*Flame Length: 1-3 Feet*
*Wind: Northerly at 3-5 mph*
*Ignition Source: Lightning*

The Fire Management Plan (FMP) recommended suppression for an Energy Release Component (ERC) above 60 or, "Maximum allowable temperature of 80°F to be used after the start of monsoons". Prior to monsoons, temperatures $\leq$ 77°F, met suppression criteria. None of the FMP parameters contradicted suppression action. The SAI Team found no reason to question the decision to engage in initial attack based on the FMP.

The IC (qualified ICT4 and member of the helitack crew) requested additional resources and bucket drops to support suppression actions. Show Low dispatched the FAIHC to the fire to assist the local helitack (H553).

The fire was in a remote area; however, there was road access to the heel of the fire. This access road crossed the Black River several times. The upper reaches of the Black River watershed were burned over during the Wallow Fire. The road, although passible in a four-wheel drive vehicle, was considered difficult and dangerous due to flash flood potential, deep mud and standing water. The road had flooded several times and Game and Fish officers had fenced it off prohibiting recreational access.

The helicopter was being used to transport helitack crewmembers to the fire. Use of the helicopter to shuttle the IHC crew was a natural extension of this decision and determined to be the most efficient option, "there was pressure to get to the fire ASAP". The Helicopter shuttle ensured the crews could be on the fire before the peak burn period. (helitack, IC and IHC crew interviews)

*Approx. 1400- E5263 (Type 6 Engine) sent to Paddy Butte to serve as a radio repeater*

*1500 - First four Helitack crew arrive on H553 shuttle at the lower helispot*

*1515-Second load arrives with first members of IHC onboard*

*1530-Third load arrives*

*1540-Fourth load arrives with last IHC crewmembers*

*1545-Both IHC squads are engaged on North and South Flanks with Helitack crewmembers*

*1600-IC+1hike from lower helispot to North flank to tie in with Dino.*

*1605-North flank is tied into Black River*

M-81 called Dino on the phone to go over his expectation that Dino would continue to lead the IHC. They confirmed the plan to use the helicopter to shuttle crewmembers to the fire. Dino essentially took a role analogous to Operations and M-81 assisted the IC with logistics. The crew drove to "ID Ranch Helispot" and joined the helitack crew where they were shuttled to the fire by helicopter.

Use of the helicopter conserved crew energy, which could then be expended on the fire, as opposed to traversing the steep terrain required to access the fire. This was normal operation for the helitack crew, already engaged on the fireline. This crew appropriately asked for support that was locally available, the FAIHC.

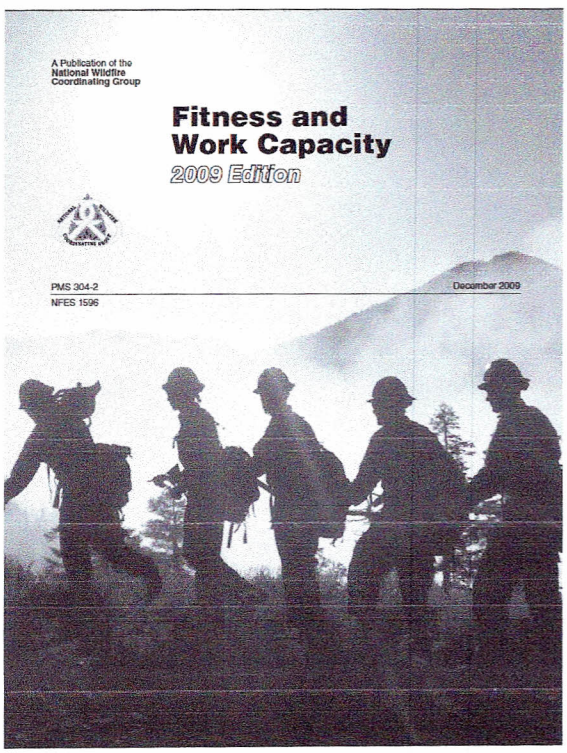
Four members of the helitack crew were in the first shuttle. Dino was in the second shuttle and was among the first of the hotshots to arrive at the lower helispot, which was adjacent to the fire and identified to be a safety zone. By the time most of the crew arrived, he was already scouting the fire, with the expectation that he would take over the fire the next day or if helitack needed to be released for IA.

Dino, M-85 (Squad Leader) and IC make the tactical decision to flank the fire on the North and South sides splitting the crew into two squads. Dino's role shifted from CRWB to FFT1, and he took squad one and started to work the North flank of the fire; M-85 took the South flank with squad 2, where they worked for the remainder of the day. Dino worked a section of line east of his squad and was not seen for most of the day; he did remain in radio contact throughout the day. Crewmembers assumed Dino was working part of the line by himself. He was heard on the radio coordinating several water drops with the helicopter, throughout the day. (See Map 3) Both squads were augmented by members of helitack crew.

M-81, M-82 +2 drive the crew carriers to a staging point above the fire, at the top of Paddy Butte. The location was selected due to the proximity to the upper helispot. The crew carriers held the gear to support a spike camp and the supplies to continue suppression action. (See Map 2)

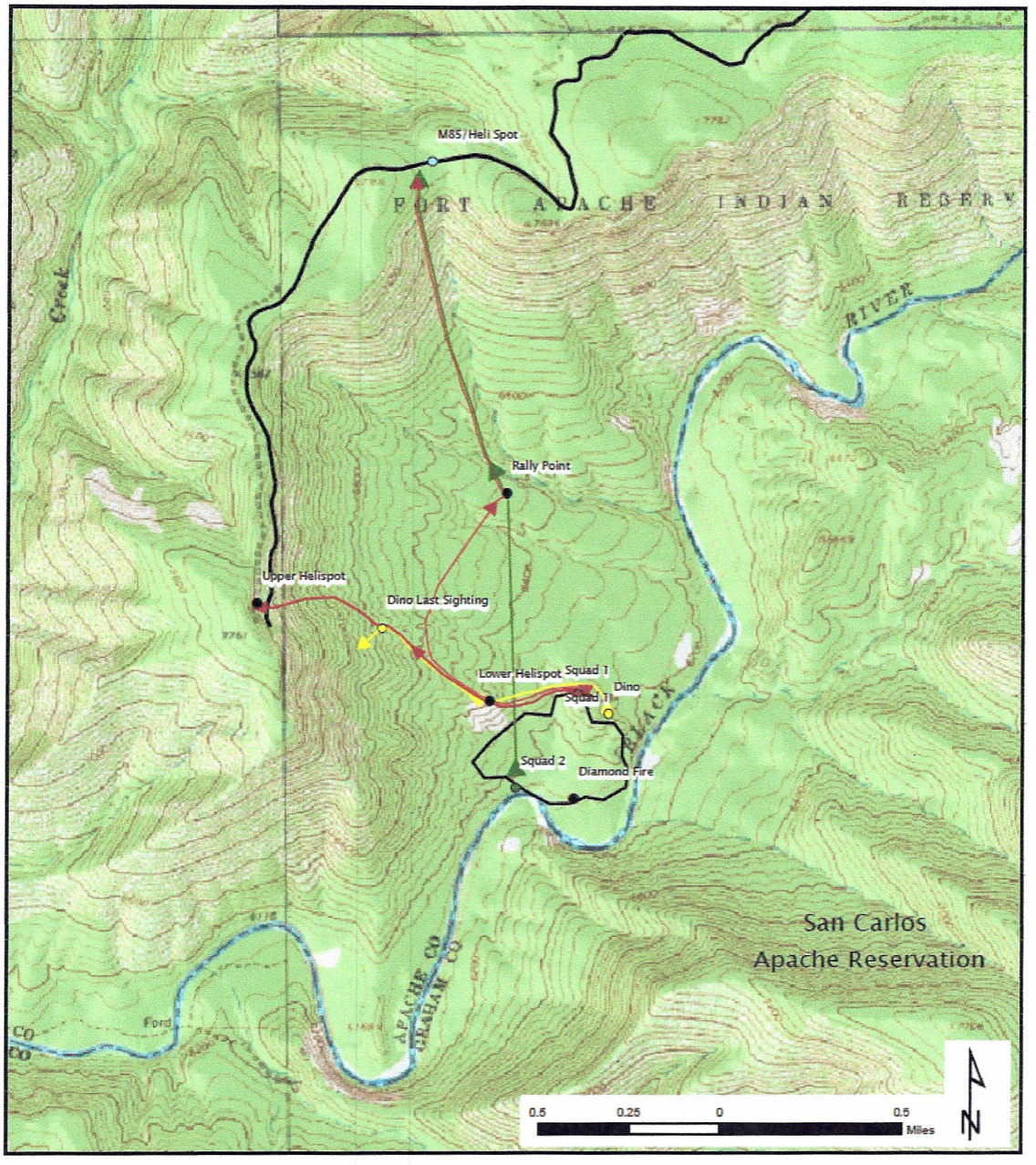
## WHILE WORKING ON THE FIRELINE, ONE FIREFIGHTER EXPERIENCED SYMPTOMS CONSISTENT WITH HEAT ILLNESS:

Although he did not recognize the symptoms of heat illness, one firefighter took intuitive intervention to stave off more serious results of heat stress. A fellow crewmember pointed out that his arms "didn't look right". Concerned about poison oak, he took off his gloves and noticed that his "hands were pruney, like they had been in water for a long time." He rolled his sleeves up and noticed his arms had white blotches all over them. Then he took his fire shirt off. Finally, he took his t-shirt off. Then he drank all his water and Gatorade quickly. Shortly thereafter he felt nauseous, in his words, "I felt on the verge of vomiting". He took a short break and when he felt better, he re-dressed and continued to work on the fire (personal account from crew interviews). This crewmember's inability to recognize heat illness in himself was confirmed during subsequent interviews. (See "Heat Illness, Heart Attack and Fatigue Training and Recognition Table" - Appendix 1)




*The symptoms mentioned above were described to a qualified Emergency Medicine and Intensive Care Unit Physician. <u>His conclusion was that this individual narrowly averted serious medical complications or even death</u>, pointing out that the onset of death can be as quick as minutes (research has shown that an individual experiencing symptoms of heat stress can die in as little as 10 minutes from the time that they start presenting symptoms).*

*This conclusion is supported by the National Wildfire Coordinating Group Publication, "Fitness and Work Capacity", 2009 Edition (see inset to the left)*




Map 3. Fire, trails and exit routes.

*1612-E263 arrives at Paddy Butte to serve as a radio repeater*
*H533 Begins bucket work*

*1700- E263 takes WX observation:*
*Dry: 82 Wet: ?*
*RH: 27% DP:44*

*1715-IC advises crew to hike to lower helispot to prepare for crew shuttle*

*1720-Radio call from Dino, "NE side is lined and secured"*

*1745-IC+2 Helitack Hike to lower helispot to prep for crew shuttle*

*1800-Dino arrives at lower helispot*

*1813-H533 reports Malfunction and out of service due to maintenance.*

*1815+- Dino leaves helispot moving toward Upper Helispot*

Each member of the crew carried at least six quarts of liquid (water and Gatorade) and the equipment needed to fight the fire. No plan was made to sling load supplies to the crew, although Meals Ready to Eat (MREs) were brought in during the crew shuttle. The plan was to shuttle the crew to the upper helispot, where their gear and equipment would be waiting. (See Map 3)

M-81 considered driving the crew carriers to the heel of the fire along the two-track (4WD) road that followed the Black River. This was discounted due to recent flooding of the Black River that rendered the road too dangerous to be traversed by the crew carriers.

M-81 and a mixed group of engine crew and IHC firefighters prepared the upper helispot and improved the road to make the transit for the crew carriers less hazardous.

The helicopter shuttle was planned to start at 1830. The helicopter pilot, who had been assisting the crew with bucket drops, observed a mechanical malfunction, which required maintenance attention and grounded the helicopter.

The IC +2 and Dino arrived at the lower helispot. The IC was there to prepare for the shuttle when the message came in that the helicopter was out of service. Shortly after hearing the news, Dino moved a few steps away from the IC and vomited 3 or 4 times, explaining he had inhaled "white smoke". He took a few puffs of a cigarette, put on his pack and then said he was going to scout a route to the top of Paddy Butte. He left the helispot alone. Dino was physically ill, but no one was aware (including Dino) of how serious his condition was. He explained this to the satisfaction of the IC, by saying he was scouting a route to the top. (Crew Member interviews and Dino's actions)

Dino, the most experienced firefighter on scene, became isolated from the crew when he walked alone toward the upper helispot[13].

[13] The coroner's report and subsequent interview, revealed nausea is a symptom of heart attack and Dino was already suffering the effects of the heart attack that ultimately killed him. During the interview the examiner stated, "It is likely he had been feeling the affects of the heart attack for most of the day."

Most of the firefighters were already on their way to the lower helispot when they found out the helicopter was grounded. The momentum of original planning, crew carriers and support equipment location and Dino's departure begin to determine the course of action, to walk out. Alternatives were not considered, as walking out is a normal part of firefighting operations and they saw no reason to stay. However the moral of the crew is best summed up by one firefighter who said, "My spirit was crushed when I heard the helicopter was out". (crewmember statement)

*1818-WX observation: Dry: 78 Wet: ? RH: 27% DP:? (? indicates no recording of data)*

Some firefighters grouped at the lower helispot, while M-85 and his squad prepared to leave directly from their fireline location once the last bit of line was tied into the Black River. M-85 was familiar with the area and knew about a game trail North of the fire. He announced his plan to use that trail over the radio, yet the hike to the top of Paddy Butte was not a fully coordinated event.

*1835-All firefighters are aware they will have to hike to the upper helispot*

At one point, M-85 paused to set up a rally point on a finger ridge. He tried to gather firefighters together for the hike (See Map 3) by announcing his intentions and shouting to crewmembers so they could find him.

M-81 was at the top of the butte improving the helispot with a chainsaw and started to experience possible heat illness related symptoms. M-81 recounted, "I started getting cramps in my arms and back" (this could also be associated with infrequent saw use). When he stopped running the chainsaw, he overheard Squad Leaders, including Dino, gathering the squads together over the radio. He told them, "Stay together and hike out." He could tell they were already split into two squads, and believed they were accounted for.

It is not uncommon for the Crew Boss or a Squad Leader to be the last out; in fact it could be considered the responsibility of the leadership to be last, to ensure that the other firefighters have reached their destination. However, it was unusual for anyone to pass Dino while hiking. (Crewmember Interviews)

M-85 who had been working the southwest side of the fire, gathered his squad and moved north across the black to a game trail that he knew. The area was familiar, having hiked there for recreation. He knew the route was longer but it was not as steep. He paused at a rally-point to gather crewmembers together. (See Map 3)

There was confusion as people tried to gather without knowing exactly where Dino or M-85 were. (Crewmember Interviews) Crewmembers gravitated to one of the two leaders for a variety of reasons. Some followed the sound of chainsaws, which "seemed very close". One squad leader had two firefighters with him who felt they could not keep up with M-85 and chose Dino's route rather than cross steep drainages to get to the rally point.

One crewmember reported, "The chainsaws being used to improve the upper helispot seemed very close." Dino may have been reacting to this same sound; his trail went straight from the lower helispot toward the upper helispot. Dino was also providing route information. He mentioned seeing two water bottles on the ground, as landmarks for the route he had selected. (Crew interviews)

The firefighters who chose Dino's route either saw or passed Dino. The last two people to see Dino reported <u>he</u> told them (in Apache) to go to the top and he would meet them there. They did as they were told. (Crew interviews)

M-85, who created the rally-point, made every attempt to gather as many firefighters as possible to his location. The terrain and the distances made this very difficult. M-85 communicated with Dino about the game trail and rally-point and asked Dino who was with him, thus accounting for all the personnel on the fire. With time running out before sunset, it was too difficult and perhaps too dangerous, to have Dino and the five firefighters who followed him traverse the rocky steep slope and get to the rally point. Instead, they continued on the direct route to the upper helispot.

When he was reasonably sure all firefighters were accounted for, M-85 hiked to the top with the firefighters who were with him. (M-85 interview)

*1926*
*Official sunset on 23 July*

*1956*
*End of Civil Twilight*

*2323*
*Moonrise with 44% visible moon*

The firefighters maintained radio contact with each other during the hike. In groups or in pairs, they helped each other to the top. Both routes required a climb of between 1140 to 1200 feet vertical relief (See Elevation Table).

After sunset the firefighters who were on an East-facing slope (Dino's Route) had to navigate very steep slopes; made slippery by loose pine needles, and rocks.
(See Elevation Table)

At the top of the climb, the slope is near vertical in places where a basalt outcrop forms the ridge defining the edge of Paddy Butte. "When I got near the top, it seemed like it was straight up. All I saw was sky" (Crewmember quote)

| *Distances follow Routes* | Elevation (Feet) | Elev Change (feet) | Distance |
|---|---|---|---|
| **Total Lower to Upper Helispot** | | **1,200** | **3,800** |
| Dino Last Sighting to Upper Helispot | 7,600 | 880 | 2,000 |
| Lower Helispot to Dino Last Sighting | 6,720 | 320 | 1,800 |
| | | | |
| **Lower Helispot** | **6,400** | | |
| | | | |
| Lower Helispot to Rally Point | 6,460 | 60 | 3,300 |
| Rally Point to M85/Helispot | 7,500 | 1,040 | 4,800 |
| **Total LH to M85** | | **1,100** | **8,100** |

Measurement by Chris English, 09/15/2011

Elevation Table

Dino radioed M-87 saying, "[*name of firefighter withheld]*, batteries". M-87 yelled back to Dino that he was on the next spur ridge. Dino yelled back, "Okay, copy." At this point M-87 continued uphill, believing Dino was following behind him. Later Dino was heard on the radio asking Engine 5263 to honk his horn, which they did.

As firefighters neared the top of Paddy Butte, those who had been working at the top to improve the road and the upper helispot, along with the engine crew (who served as a radio relay), started to assist the crewmembers that had been on the fire. Coming down part way to meet them, they were able to bring water, carry tools, and in some cases physically assist exhausted firefighters to the top of the ridge. (crewmember interviews)

All firefighters were accounted for, with the exception of Dino. Despite several attempts to establish radio contact with Dino, no contact was made. (IC and crewmember logs and interviews).

*1935-IC heard crewmembers trying to contact Dino on the radio with no response*

*2010-IC+3 last to reach the top of Paddy Butte*

*2030-Dispatch received notification of a missing person*

*2035-Fireline leaders discussed transfer of IC responsibilities due to increased complexity of an incident-within-an-incident*

*2035-IC duties are transferred to M81(Acting IHC Crew Superintendent)*

*2100-Dispatch records transfer of IC*

*2134-Dispatch orders Tribal Game and Fish to assist with Search and Rescue (SAR)*

*2202-New Incident Card created for SAR-Incident # 335*

Radio calls to Dino continued and additional crewmembers searched the ridge top on foot and in vehicles, optimistic he would "pop out on top". There was no flagging to mark a particular route to the top and there were game trails all along the slope, any one of which would take him to any number of places along the ridgeline.

Inquiry among the crew determined Dino was last seen shortly after 1830, when the last two crewmembers passed him on the hike.

When it became clear that Dino was missing, the IC notified dispatch of a missing person. He placed an order for Tribal Game and Fish, State Police Infra-red equipped helicopter and Navajo County Search and Rescue resources to assist.

A discussion among incident leadership took place to discuss the increasing incident complexity due to Dino's missing status. A unanimous decision was made to transfer command from the IC to M-81, the Acting Crew Superintendent. (Incident Organizer and crew interviews)

By the time they reached the top, 13 of 16 crewmembers had experienced signs of heat stress. "The crew was spent". (Crew interviews) One firefighter considered by leadership to the most physically fit among the crews said, "I wanted to go down [and look for Dino] that night, but I was too tired. I was too weak to go down. I was upset with myself for feeling tired, but I knew if I went down, I might go down [collapse] myself."

*Crewmembers have a self-interest in presenting themselves in a strong, fit condition. Heat exposure is a part of doing the job (something to be endured). As a result, firefighters rarely mention symptoms if they are observed. The general feeling expressed by firefighters is, if they are hydrated then, they don't have to worry about heat illness. (crew interviews).*

*2240-Dispatch attempts to contact Tribal Game and Fish Officers*

*2246-Tribal Game and Fish contacted and Officers dispatched to*

*2300- Dispatch contacts Navajo County requesting assistance with SAR*

M-81 solicited feedback from a group of 12 firefighters, consisting of leadership from all the resources present at the top of Paddy Butte and a cross-section of the FAIHC. They determined that the combination of darkness, loose rocks, crew fatigue and steep slippery terrain made it too dangerous to grid the slope below the upper helispot (multiple crewmember interviews).

> *One EMT recalled noticing that nearly the entire crew complained of muscle cramps and displayed signs of heat illness. During the crew interview, a survey was conducted to determine who had experienced symptoms of heat illness during the hike to the top of Paddy Butte. Of the 16 crewmembers, 13 of them reported having experienced significant symptoms of heat illness.*

Recognizing fatigue and wanting to mitigate risk, the IC bedded down the crew so they could get some rest. He then struggled to understand what Dino might have done. "He could have returned to the fireline. If he did, or if he was on the hill above the fire, and he had cramps, then he could be in real danger if the fire made a run." (IC Interview)

The moon did not rise until almost midnight and a thunderstorm was visible in the South. Concerned about a wind event and unsecured fireline, the IC determined it was too dangerous to extend the search beyond the top of Paddy Butte.[14]

[14] Crewmember interview

## July 24, 2011

Just after midnight, with the crews resting and thinking about the active fire, M-81 (IC) and M-82 (Acting Assistant Superintendent) went to check the fireline and look for Dino. They flagged a route, which a crew could follow. (See Map 4)

*0121 Tribal Game and Fish arrive along with ambulance and brush truck*

Tribal Game and Fish and a Fire Department Paramedics arrived sometime after midnight and confirmed it was too dangerous to launch a search, supporting the IC's decision. All agreed to delay the grid search in the steep terrain until first light. Paramedics concluded that the crewmembers they observed were extremely fatigued (Paramedic interview).

*0122 Weather Observation: Dry: 64 Wet: ? RH: 56% DP:? Winds N 0-5 Sky: No report*

*0241Game and Fish Officers request IR flight – UTF none available*

The requested infrared flight was not available from the Arizona Department of Public Safety (DPS). None of the requested Navajo County SAR K-9 units were available. However, Navajo County SAR was dispatched and was scheduled to arrive later in the morning.

At about 0200 hours, the M-81 and M-82 reached the fireline and started securing the East and North flanks. They checked for Dino, but did not see him near the fire. Concerned about fire potential and seeing that the fire had crept across the line in several places, they asked for a squad of volunteers to assist them. Seven firefighters volunteered and followed the flagged route to the fireline. A Paramedic was provided with PPE and went with the crew in case they found Dino. The plan was to start "gridding" the west side of the fire once the fireline was secured and there was enough light to conduct a search.

*0523-Grid Search Begins near lower helispot*

*Civil Twilight began @ 0456*

*0525 Sunrise*

*0606-Lifeflight placed on alert*

With an increasing sense of urgency, three firefighters (one who was among the last to contact Dino directly) took their own initiative to search for Dino. Near sunrise, they left the upper helispot to search the route they suspected that Dino had taken. They found Dino near the last place he had been seen.

*0607-Dino is found by crewmembers.*

The Paramedics were sent to the location. They relayed their description of Dino to a physician who pronounced Dino dead at the scene.

*0645-Dispatch is notified to change SAR to Recovery.*

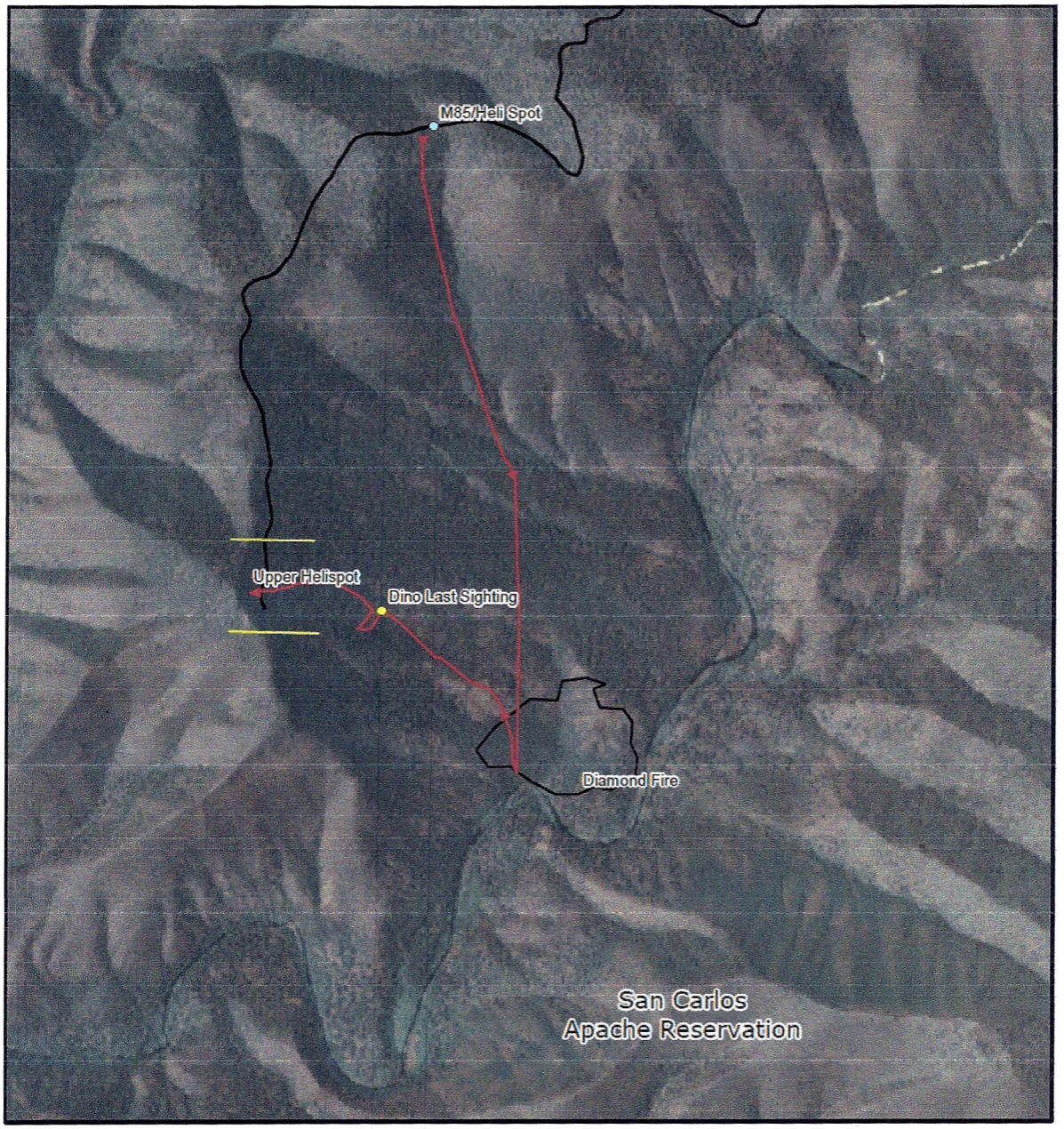
Even comparatively fresh crewmembers succumbed to the long-term fatigue and heat illness. One of the firefighters, who had driven the buggies to the top of Paddy Butte and had not been on the fire line the previous day, started hiking from the fire to where Dino was found. Along the way the Paramedic stopped him. The Paramedic insisted he needed an IV. It is reasonable to state that the Paramedic's intervention prevented a more serous outcome. (crew and paramedic interviews)

Law Enforcement officers, who were part of the recovery, stated Dino's radio was still receiving transmissions on the fire frequency. His gloves were on and his Nomex® was neat and buttoned. His headlamp and flashlights were still in his backpack, which was propped up next to the trail where he had apparently been sitting and leaning against it. His tool was next to his pack on the ground. They concluded he slipped out of his pack, stood up, walked five or six steps and then fell, where he was later found.

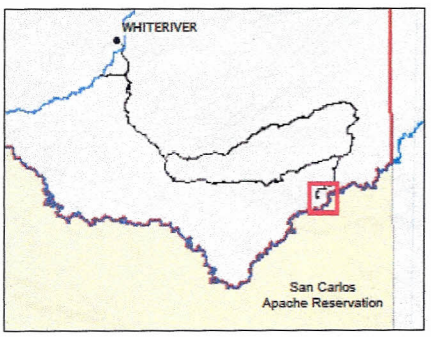
The autopsy revealed, Dino "had a previous myocardial infarction" months before. The cause of death was "an acute myocardial infarction, exacerbated by heat exposure." (Autopsy Report) The coroner indicated that Dino was most probably suffering from the onset of the second myocardial infarction as early "first thing in the morning. Hard work and heat exposure exacerbated the condition." "It is unlikely that any intervention short of advanced cardiac life support would have changed the outcome once he was seen throwing-up." (coroner interview).

## Team Observations

During interviews and visits to the Rick Lupe Fire Center, Fort Apache Agency, the Team noticed heat stress posters and awareness guidance in plain sight in the crew areas. The Fire Staff indicated they had reviewed the Risk Management Committee's Safety Alerts, including those related to hyperthermia. They also indicated an emphasis had been placed on hydration as a mitigation strategy for heat illness. It was also noted that all crewmembers were current on first aid training requirements.




**Location**




**Legend**

**Key Points**

**Squad Boss**

- Dino Approximate Last Sighting
- M81 - Rim
- M85

**Exit and Search Routes**

**Comments**

- Return to Fire and Search
- N. Edge Search Grid
- S. Edge Search Grid

Fire Perimeter

N

0.5 0.25 0 0.5 Miles

tca 20111207150O

Map 4. Search routes.

## TEAM OBSERVATIONS CONTINUED

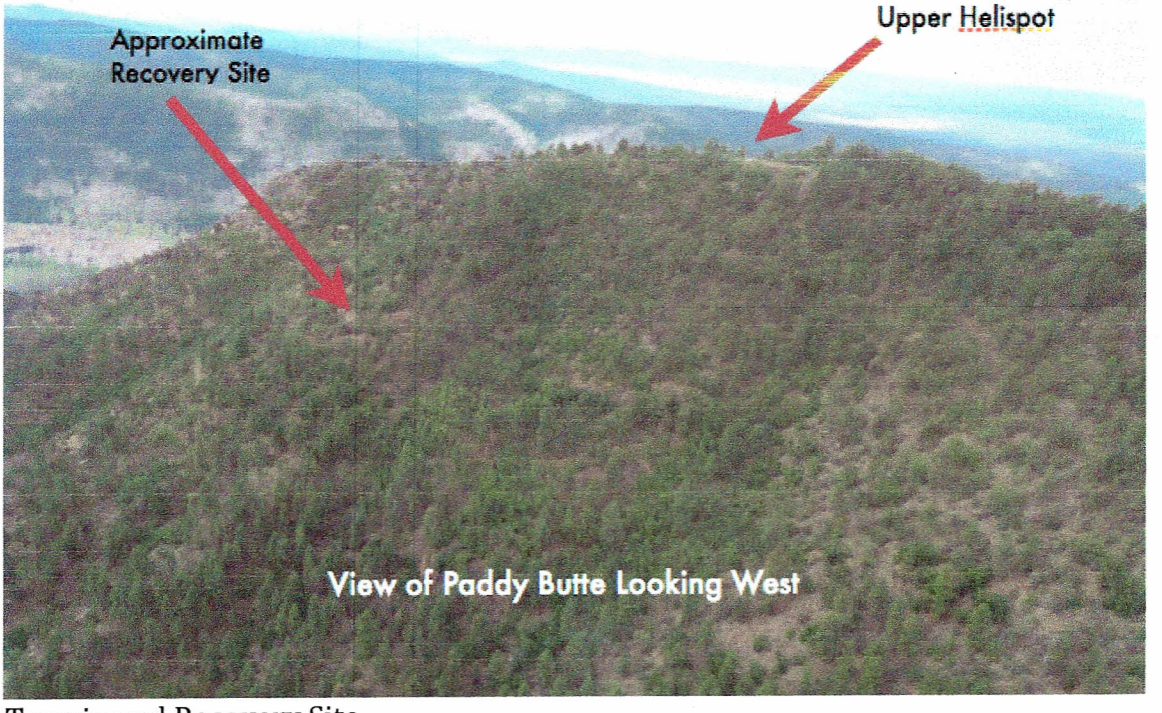
Developing information related to the near misses associated with heat illness became a prevalent part of the investigation. Several critical facts were observed regarding this:

> *"The effects of fatigue on safety critical work are actually difficult to measure or quantify [sic]. Fatigue itself can actually be difficult to pin down. Using people's self-reports or their judgments of colleagues is not very reliable. Fatigue actually impairs people's judgment about how fatigued they are and how it affects their performance."*[15]

Fatigue is normally the result of a number of *interactive* factors such as workload intensity, physical and/or psychological exertion, disruption of circadian rhythm, diet/nutrition, hydration, sleep depravation (lack of sleep), and/or sleep disturbances (being awakened or interrupted during sleep).[16] It can be fatal if not mitigated in as little as 10-15 minutes and it does not progress the same way from individual to individual.

> *"Acute sleep deprivation result[s] from missing a single night's sleep. However, more common are reductions in sleeping time over many days. This more insidious chronic sleep deprivation occurs when individuals repeatedly do not get 'a good night's sleep,' which creates a sleep deficit or debt. Research indicates that decreasing sleep time by one hour a night for seven consecutive nights is equal to staying up for 24 hours straight once a week."*[17]

The Team observed the common use of caffeinated energy drinks by the crew. Dino was reported to commonly bring energy drinks to fires and one was found in his locker.




Terrain and Recovery Site.

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[15] Dekker, S. W. A. (2006) "The Field Guide to Understanding Human Error", Ashgate Burlington, VT
[16] Dekker, S. W. A. (2006) "The Field Guide to Understanding Human Error", Ashgate Burlington, VT
[17] International Fire Chiefs, (2007) "Sleep Deprivation Report"

## INVESTIGATION PROCESS

The Investigation Team followed the standard process of considering human, environmental and material factors. All three factors were found to be present. The team found evidence to support causal relationships in the following categories:

| | |
|---|---|
| Human: | - "Because environmental heat exposure contributed to death, the manner of death is accident." (Autopsy Report)<br>- Pathologic diagnosis: Atherosclerotic cardiovascular disease and environmental heat exposure" (Autopsy Report)<br>- Heat illness symptoms were observed or reported by over 80% of the firefighters. |
| Environmental: | - The terrain is steep, rocky and heavily wooded in mixed Conifer. |
| Material: | - The helicopter used for crew shuttle became unavailable due to sudden mechanical failure. |

No single factor can be pointed to as causal with regard to the observed and reported symptoms of heat illness. This condition is commonly the result of many, otherwise independent, unrelated conditions and circumstances. These conditions and circumstances combined in a complex interaction, which manifested in varying degrees and symptoms of heat illness as reported by those on scene. The Coroner determined the cause of death to Myocardial infarction exacerbated by heat exposure.

The Team engaged in dialogue with the family and the local community in an attempt to understand cultural and personal details and to answer their questions and suppress rumors. There were a number of ethical, cultural, community and familial pressures, which made this contact necessary.

### VERIFICATION

Findings and conclusions were verified during dialogue with the Coroner who performed the autopsy and with an Emergency Medicine and Intensive Care Unit Physician. The coroner supported additional research regarding heat illness and the emergency Physician corroborated the Team's concern regarding the significance of the symptoms of heat stress observed and reported by the crewmembers.

The narrative was checked for accuracy during interviews with leadership from FAIHC and helitack crews. These individuals were given the narrative and asked to verify the contents with regard to accuracy of the depiction of the events.

### RESEARCH

Based on the short duration of time spent on the fire (3-4 hours) during the assignment, the comparatively mild temperatures, and the high incidence of heat stress symptoms exhibited by the crew, the Team determined the need for more information about heat stress. This prompted the commissioning of a review of available literature on the subject. The researcher noticed the relationship between many interactive factors leading to heat illness including heat exposure, caffeine use and fatigue. This is explained in detail in the companion report "Heat Illness and the Wildland Firefighter".

This paper provided the team with a wide array of factual data related to the incident and the ability to understand how this event could have happened. It also helped the team to understand how greater injury was averted by the crewmembers.

## FINDINGS

### HUMAN

The autopsy indicated "heat exposure" contributed to the heart attack. It also indicated that Dino was not dehydrated, suggesting the hydration strategies may be working. The autopsy indicated the only stimulant in Dino's system was caffeine. Research indicates the effects of caffeine increase the likelihood of heart attack and susceptibility to heat illness.

Over 80% of the firefighters engaged in the Diamond fire reported (during interviews) or were observed to exhibit symptoms of heat illness. The paramedics who arrived, close to midnight, confirmed this and added their observation that the crew was extremely fatigued. Personal accounts of fatigue level confirmed this observation.

During post incident interviews most of the crew stated they were aware of the symptoms of heat illness. They stated this was the result of organizational training programs and safety alerts. They were also aware of current organizational mitigation strategies (hydration and work-rest requirements). The crew was in compliance with all recommended and required mitigations related to fatigue (work-rest guidelines) and hydration (carried and drank the recommended amount and type of liquids). The crew demonstrated difficulty in recognizing the symptoms of heat illness in actual application (either in themselves or others). (See Table: Heat Illness, Heart Attack and Fatigue Training and Recognition Table (Appendix 1)

Medical experts concluded, heat stress treatment and innovative actions, including the EMT administering an IV, likely saved the lives of those demonstrating symptoms.

The crew did not recognize the symptoms of heart attack in Dino. He did not discuss symptoms with anyone on the crew, suggesting the possibility that he may not have recognized the severity of his own condition or did not want to acknowledge it. He physically moved away from other firefighters as they approached him during the hike out.

An elevated level of caffeine was present in the victims system.

The interaction between heat exposure, workload and rest cycles is not well understood by the field and work/rest guidelines do not appear to be enough to prevent heat stress incidents. The "Fitness and Work Capacity" (2009) publication recommends additional mitigations beyond those currently in practice.

Dino's medical records were not made available to the Team. The team reviewed the Medical Standards and Health Screening Questionnaires and found no mention of symptoms related to a heart condition.

## ENVIRONMENTAL

### Location:

The Diamond Fire was located on the White Mountain Apache Indian Reservation, Arizona (home unit). The original smoke report was thought to be on the San Carlos Apache Reservation. The fire was determined to be near the border of the Reservations on the White Mountain Apache Reservation.

Access to the fire was either a rugged 4-wheel drive road within the Black River corridor, marked closed due to recent flooding, or helicopter transport to a helispot 330 yards from the fire line. The helispot met the IC's criteria for a safety zone.

An upper helispot was located on Paddy Butte approximately one mile from the lower helispot. This was where the crew buggies were staged.

### Geographic

The fire was located in the lower third of the slope above the Black River. Slopes at the fire location averaged 20%. Slopes leading to the ridge top from the fire ranged from 32% to 44%.

| *Distances follow Routes* | Elevation (Feet) | Elev Change (feet) | Distance |
|---|---|---|---|
| **Total Lower to Upper Helispot** | | **1,200** | **3,800** |
| Dino Last Sighting to Upper Helispot | 7,600 | 880 | 2,000 |
| Lower Helispot to Dino Last Sighting | 6,720 | 320 | 1,800 |
| | | | |
| **Lower Helispot** | **6,400** | | |
| | | | |
| Lower Helispot to Rally Point | 6,460 | 60 | 3,300 |
| Rally Point to M85/Helispot | 7,500 | 1,040 | 4,800 |
| **Total LH to M85** | | **1,100** | **8,100** |

Measurement by Chris English, 09/15/2011

Elevation Table

### Weather

A gradual warming trend had taken place prior to the incident. Temperatures increased from the mid 70's two days before, to the high 80's on the day of the fire. The mid-day relative humidity prior to the fire and day of the fire was in the high 20's. Humidity recovery was in the 70% range the evening before the fire, otherwise humidity recovery was near 100% for the days prior to and after the fire.

Ambient air temperatures were moderate (at 1818, 78°F), yet the crew indicated, during interviews, that over 80% demonstrated symptoms of heat stress.

There was some question regarding the start of monsoon season. Some of those interviewed felt it had started, others were certain it had not. The information listed above supports the beginning stages of monsoonal flow. By the time the team was on scene, monsoonal activity was observed daily.

## MATERIAL

### Mechanical

The helicopter was used for crew shuttle and bucket work throughout the day. It was scheduled for a crew shuttle at 1830. During the flight, just prior to the evening crew shuttle, the pilot noticed a "blown fuse" on the "Oil Cooler Fan". When this occurs, the pilot is mandated to follow specific procedures. In this case, the procedure was to ferry the aircraft (re-locate without passengers) to a facility where more extensive inspection could be conducted. The flight manual states the pilot should, "Land as soon as practical".

This put the helicopter out of service until the maintenance inspection could be completed.

### Radio

Diamond Fire Overhead (including Acting Superintendent, IC and Squad Bosses) had fully functional radios and there were no transmission or receptions issues that prevented communications. The Incident Organizer delineated specific frequencies for Command, Dispatch/Support, Air-to-Ground and Air-to-Air. No one reported difficulty with radio transmission or reception.

Dino's radio was receiving fire communications when his body was located. A functional radio check was performed by a member of the Team in both transmit and receive modes. The radio was found to be fully functional.

### Personal Protective Equipment

Based on examination of the clothing Dino was wearing when he was found, the clothing had not been exposed to any heat or flames, was in new condition and met all Missoula Technical Development Center (MTDC) standards for wildland fire personal protective equipment.

No rips, tears, or burned areas were detected upon inspection. Small spots of blood were noticed near the area of the collar and manufacturers label. Dino was found wearing standard leather gloves and they appeared to be relatively new. Dino's full-brim hardhat was issued at the start of the 2011 field season. Inspection of the hardhat did not show any structural damage, indicating it was fully serviceable.

## Discussion

### Formal Process

Interviews provided a significant amount of information and understanding of what happened before, during, and after this incident. These interviews were conducted with crewmembers, paramedics, leadership and law enforcement, who were on scene as events unfolded. The SAIT also interviewed fire leadership at Fort Apache to understand their perspectives regarding the event. The Team also spoke with the Classay family to dispel rumors and to ensure that we were fairly representing Dino's actions. It was during this discussion that the family indicated their desire to see Dino referred to by name in the report.

Each of these interviews required the Team members to develop a level of trust with the participants. It should be noted that all the firefighters were eager to assist the team with this research and willingly met with the Team on several occasions.

The meetings with participants indicated the fact that there are at least two audiences for any accident analysis. One is the management of the affected organization and the other is the community of firefighters. Each of these has decidedly different needs to facilitate their ability to prevent the type of incident from reoccurrence. This may be why the process was originally divided into a main report and a Management Evaluation Report. It is the opinion of the team that the format of these reports be reviewed to ensure that both management's and the field's needs are met.

### Complex Interaction

This incident exemplifies the truly complex nature of the work firefighters do. Complex systems defy simple explanation. The SAIT made every attempt to understand actions/decisions in context, which include the social, cultural and situational pressures, felt by the crewmembers. Complex systems are defined as those having components, which are interactive, interconnected, diverse and adaptive.[18] To make sense of what happened in a complex system, we must first understand the interaction and interconnected nature of components. Without context it is not possible to fully understand the *facts*. Essentially, no single part of the report stands alone due to the interactive nature of the conditions and it is this interaction, which is causal.

The report addresses a number of complex interactions of these components, which put the firefighters in extreme situations. We attempt to place the components (observations) in context to present a view of the network of interactions.
One way was done was by placing a running timeline alongside the narrative, to allow the reader to place chronologic events in the context of the narrative. The reader is then able to better understand the interactions of the incident as it unfolded.

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[18] Page, S. E. (2011). *Diversity and Complexity,* Princeton, NJ: Princeton University Press.

## RECOMMENDATIONS

The following recommendations, developed by the Investigation Team, are the result of careful and thorough analyses of a multitude of human actions and decisions made within the context of normal work and framed by the roles of individuals and agency fire management staff.

Accordingly, these recommendations originate from the Investigation Team's understanding and commitment to discover, analyze, and develop recommendations that serve our firefighting community's goal to improve safety. Recommendations are intended to generate teaching, learning, and understanding of experiences. A natural outgrowth of this process will result in system improvement. We believe that other wildland fire programs may experience similar issues and needs. We wish to draw upon Diamond fire experiences to fulfill this need.

The recommendations can be generally classified into areas involving firefighter training and awareness, related to:

- Chronic fatigue and heat stress mitigation strategies
- Available trained emergency medical personnel on crew(s)
- Research regarding risks of caffeinated energy drink consumption by firefighters.

The recommendations highlight our interpretation and understanding of how changes to program operations and improved firefighter training, fitness, and awareness can prevent injuries and fatalities, as well as improving the responsiveness and resilience of the system. By "system" we refer to the interconnected nature of firefighters, supervisors, program policies, local community and families.

### PRESENTATION AND SUPPORTING INFORMATION

Recommendations are presented in a tabular format, followed by a more detailed explanation and supporting information and references where applicable.

## CONCLUSION & SUPPORTING INFORMATION

The intended and espoused purpose of any "accident investigation" is accident *prevention*. In order to practice prevention effectively, we have to be able to learn from the context of each event, regardless of outcome. The purpose of any report based on a tragic event is to protect our people from reoccurrence and further injury.

> *"In the static universe, nothing happens unless there is a cause. In the dynamic model of the universe, something is always happening without an agent having to cause anything, because that is what the universe, by its very nature, does."*
>
> *Viola Cordova, the first Native American to receive a PhD in Philosophy*

This simple quote is at the heart of understanding complex systems. We must be willing to open ourselves to new information, technology and philosophy to effectively understand and learn from the dynamic workplace common to wildland firefighting operations. In order to effectively practice accident prevention, we must challenge ourselves to question our assumptions and be willing to adapt and learn. Furthermore, there is a demonstrated need to add academic research to our toolbox for accident investigations. This additional research should start with an evaluation of existing literature in the topic areas specific to the incident.

Simple accident and incident analysis will not address these issues. Complex systems defy simple explanation. Simple "cause and effect models" will not suffice. A more comprehensive method based on dynamic inquiry, rather than categorical inspection, is needed and demonstrated by this report

Accidents in complex systems rarely involve "bad guys"; hence there is no one to blame. Catastrophic failures of material or machines did not occur and there was no negligence. Essentially nothing extraordinary occurred. This accident was the result of normal work - normal people behaving in normal ways in a normal organization. Further injury was prevented through adaptive and creative responses to unanticipated conditions and trained responses to recognized conditions.

## References and Further Reading


Woods, D., Dekker, S., Cook, R., Johannesen, L., & Sarter, N. (2010). *Behind human error.* Burlington: Ashgate Publishing Company.

Cordova, V. F. (2007). *How it is: The Native American philosophy of V.F. Cordova.* Tucson, AZ: University of Arizona Press.

Sharkey, B. (2009). *Fitness and work capacity.* Retrieved from http://www.nwcg.gov/pms/pubs/pms304-2.pdf.

Dekker, S. (2006). *The field guide to understanding human error.* Burlington, VT: Ashgate.

Page, S. E. (2011). *Diversity and complexity.* Princeton, NJ: Princeton University

Perrow, C. (1984). *Normal accidents: living with high risk technologies.* New York: Basic Books.Press.

Dekker, S. (2011). *Drift into failure: from hunting broken components to understanding complex systems.* Burlington: Ashgate Publishing Company.

Hollnagel, E. (2009). *The ETTO principle: efficiency-thoroughness trade-off; why things that go right sometimes go wrong.* Burlington: Ashgate Publishing Company.

Hollnagel, E., Nemeth, C. P., & Dekker, S. (2008). *Remaining sensitive to the possibility of failure* (Vol. 1). Burlington, VT: Ashgate Publishing Company.

Hollnagel, E. (2002). *Understanding accidents - From root causes to performance variability.* Paper presented at the IEEE 7th Human Factors Meeting, Scottsdale, AZ.

Heisenberg, W. (2007). *Physics and philosophy: the revolution of modern science.* New York, NY: HarperCollins Publishers.

Harbour, T. (2011, April 20). *Just Environment: Command Climate, Leadership, and Error.* Paper presented at the High Reliability Organizing Conference: Making HRO Operational, Washington, DC.

Flyvbjerg, B. (2001). *Making social science matter: why social inquiry fails and how it can succeed again.* Oxford, UK ; New York: Cambridge University Press.

Feyerabend, P. (1993). *Against method* (3rd ed.). London: Verso.

Reason, J. T. (1997). *Managing the risks of organizational accidents.* Brookfield, VT: Ashgate.

Ruby, B., Montain, S., Harger, S., Ham, J., & Gaskill, S. Water, electrolytes, and hydration. *Wildland Firefighter Health & Safety Report, 9*(Spring).

Sharkey, B. (2006). Heat stress. *Wildland Firefighter Health & Safety Report, 10*(Spring).

Sharkey, B. (2007). Intermittent feeding/shift food. *Wildland Firefighter Health & Safety Report, 11*(Winter).