

Serious Accident Investigation: Factual Report and Analysis

Fatality of NPS Arrowhead Interagency Hotshot Crew

Captain Brian Hughes

The Ferguson Fire on the Sierra National Forest, CA, July 29, 2018



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In Memory of Brian Hughes

August 1, 1984 – July 29, 2018



Captain Hughes is in the back row, left. The surviving members of the Arrowhead Interagency Hotshot Crew (IHC) have expressed sincere admiration for their fallen friend and leader.

“Fortitudo Vincimus”

By Endurance We Conquer
Arrowhead IHC motto

Serious Accident Investigation: Factual Report

Accident: Tree Strike of National Park Service (NPS) Arrowhead Interagency Hotshot Crew (IHC)
Captain Brian Hughes

Location: Ferguson Fire, Division-G, Sierra National Forest, near Yosemite West

Date: July 29, 2018

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Preface

The Serious Accident Investigation Team (SAIT) was delegated authority to organize, manage, and conduct the accident investigation in accordance with Departmental Manual 485 Chapter 7, NPS Reference Manual 50B Occupational Safety and Health Program, and Reference Manual 18 Wildland Fire Management, related to the July 29, 2018 accidental death of Brian Hughes. Hughes was Captain of the Arrowhead Interagency Hotshot Crew, duty stationed in Kings Canyon National Park, CA.

The purpose of the SAIT investigation, as stated by the team co-leads, is to provide management with information for accident prevention. Due to the interagency fire program involved in the incident, the SAIT was selected to reflect this interagency cooperation.

By reviewing these facts, the SAIT identified contributing factors that may help prevent similar accidents in the future.

The investigation team worked systematically and objectively to establish the accident chronology and identify findings based on the facts, weight of evidence, and relevant interviews. It analyzed the data to produce recommendations that will improve employee safety.

It is difficult to investigate the death of an NPS employee who made the ultimate sacrifice while performing his duty in service to his country. This team conducted the review and investigation with the utmost humility and sensitivity toward Hughes, his family, friends, crew, and co-workers. It was also mindful of other NPS employees who have suffered the tragic loss of one of their own. We hope to learn from Hughes' accident and trust what is learned will benefit all who follow in his footsteps.

*“Let us vow to learn from their tragedies and strive to prevent similar outcomes in the future.
May our fallen rest in peace and not have died in vain.”*

—Interagency Serious Accident Investigation Guide

Executive Summary

The NPS Arrowhead Interagency Hotshot Crew (IHC) was cutting down a hazard snag July 29, 2018 when it struck and killed Captain Brian Hughes, age 33. Hughes and his crew were working on the Ferguson Fire on the Sierra National Forest near Yosemite National Park in California at the time.

Captain Brian Hughes was born on August 1, 1984 in Hilo, Hawaii. He grew up near Akaka Falls and attended Hilo Union, Hilo Intermediate School, and Hilo High School. As a child, Brian loved running around and playing sports. He enjoyed swimming and surfing, and was most at peace in the ocean. He started his own yard business at age 13 with the hope of saving up to buy a car. The business was a booming success, leading Brian to set higher and higher goals for himself and to work hard at everything he set his mind to. He loved outdoor adventures and learned to be self-reliant in the wilderness. In high school, he was a star athlete in varsity soccer, track, and cross-country.

In 2010, Brian joined the Monterey hand crew on the Los Padres National Forest. His dream was to build the crew to hotshot status. After four years with the hand crew, he joined the Bureau of Land Management in Alaska as a specialist. During that year, he enthusiastically took on the tasks and details needed to achieve captain's qualifications.

Brian returned to California in 2015 and became a captain of the Arrowhead Interagency Hotshot Crew. As a captain, Brian was a trusted leader and mentor who led by example, inspiring others to train hard and develop their skills. His crew looked up to him and loved him as a brother.

The Ferguson Fire was reported late July 13. Investigators later determined it began when an unidentified vehicle's exhaust gases carried hot catalytic converter fragments into dry grass and leaf litter. The fire spread quickly through a drought-afflicted area of brush and beetle-killed trees, almost doubling in size each day for the first four days. It threatened the national park, nearby communities, and important historic, cultural, and natural resources, including threatened and endangered species.

On July 16, the U.S. Forest Service (USFS) Agency Administrator established a unified command including, USFS, CAL FIRE, and the Mariposa County Sheriff's Office, implemented through the South Central Sierra Interagency Incident Management Team.

The Arrowhead Hotshots arrived on scene July 16, having spent the previous month and a half working prescribed and wildland fires ranging from one to ten days long. The crew spent the next eight days working alongside other highly experienced hotshot crews to build and prepare a fire containment line for burnout operations designed to burn away the available fuel in a given area and keep the original fire from spreading.

By July 28, the day before the accident, the Ferguson Fire had grown to 53,657 acres and was burning across multiple jurisdictional boundaries. Hughes and IHC-1 Squad Leader were working along the edge of a spot fire on steep, rocky terrain in Division G and identified several hazard snags—dead trees that posed falling and fire risks. One stood out: a 57-inch wide, 105-foot tall ponderosa pine burning approximately 10 feet below its top and producing a steady stream of embers. With winds expected the next day, they agreed the snag posed a significant risk to keeping the fire contained and agreed it needed to come down.

The Arrowhead Hotshots lead sawyer started cutting the tree down on the morning of July 29 with help from Hughes, who temporarily stepped in for the sawyer's less-experienced swamper. The rest of the crew staged in an area safely uphill.

Hughes and the sawyer intended for the tree to fall uphill into an opening between trees. Instead, the tree fell downhill, hitting the ground approximately 145 degrees from the intended lay. It grazed another standing dead snag as it fell and then rolled and/or bounced farther downhill, coming to rest against other snags and brush.

Hughes and the sawyer had discussed the felling operation in detail. Warnings were issued prior to cutting. They also identified two escape routes in case something went wrong.

As the tree began to fall, the sawyer saw which direction it was going and instinctively ran directly downhill, escaping injury.

Hughes however, had moved about 20 feet downhill before the tree fell and then ran into the primary escape route as the tree started falling and was fatally struck. He was found lying underneath the tree in a space between it and the ground.

Efforts to save Hughes' life were made on scene by the sawyer, fellow firefighters, and paramedics on the ground and in the air. Despite these efforts, Hughes was pronounced dead as he was being flown to the Mariposa Helibase.

Factual Narrative

Ferguson Fire Background

July 13, 2018

Three 911 callers reported the Ferguson Fire at about 9:36 p.m. July 13, 2018. It was burning in brush and mixed oak and conifer forest in the Merced River Canyon along Highway 140 in Mariposa County, CA. The area is on Sierra National Forest land near Yosemite National Park, and affected surrounding communities.

Investigators later determined the fire was caused when a vehicle's exhaust ejected catalytic converter fragments into dry grass and leaf litter on the cut bank of the eastbound lane of Highway 140. The investigation is ongoing.

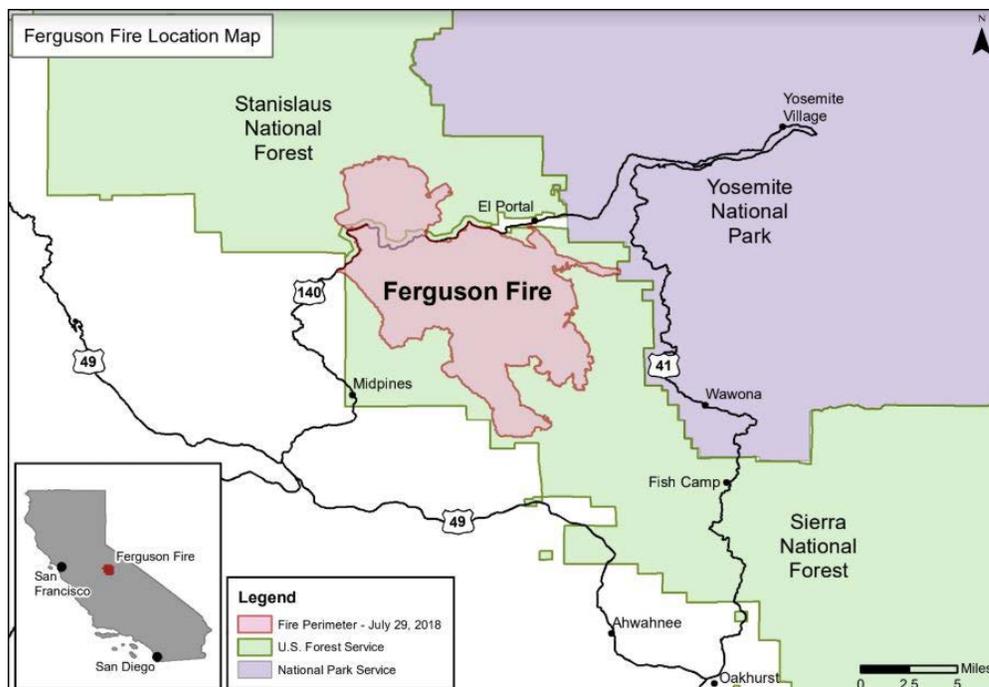


Figure 1: Map showing the general location of the Ferguson Fire on July 29, 2018 as well as the fire perimeter for that day.

July 14, 2018

A CAL FIRE bulldozer was operating on the Ferguson Fire in Mariposa County, CA. During the early morning hours, the CAL FIRE bulldozer experienced a rollover, causing fatal injuries to its Heavy Fire Equipment Operator (HFEO 1).

July 15, 2018

By the morning of July 15, the fire had grown to 4,000 acres. Officials issued the first evacuations that evening. The fire continued to grow rapidly, almost doubling in size each day for the first four operational periods. Rugged terrain remained a challenge for ground and aircrews, and there was little progress to contain the fire.

July 16, 2018

The USFS Agency Administrator established a unified command including, USFS, CAL FIRE, and the Mariposa County Sheriff's Office, implemented through the South Central Sierra Interagency Incident Management Team.

Pre-Accident Events

Arrowhead Interagency Hotshot Crew (IHC) Early Season

The crew started its 2018 season April 30, with 80 hours of required critical training. The crew was evaluated and certified during its annual readiness review. The crew was made available for assignment May 14, 2018, and spent the next month and a half on various prescribed fire and wildfire assignments that ranged from one to ten days in length. The crew's last day on assignment prior to the Ferguson Fire was July 13.

July 16-27, 2018

Arrowhead IHC arrived at the Ferguson Fire July 16. After getting to the Ferguson Fire, the crew worked for the next eight days alongside other IHCs to build and prepare a line for burnout operations on Division G (see Figure 2). Crews started the burnout¹ July 24 and Arrowhead IHC concluded it the morning of July 27, working a 32-hour shift to finish it. The crew took the remainder of the day and that night off.

The crew complied with current work/rest guidelines.

July 28, 2018

Arrowhead IHC returned to Division G, joining IHC-2 and IHC-1 to establish a direct containment line around the spot fire. The crew's objective for the day was to help keep the spot fire contained.

The IHC-1 squad leader notified Hughes via radio of snags that posed a risk to the fireline where Arrowhead IHC was working. Hughes joined IHC-1 Squad Leader to assess the snags. One stood out: a ponderosa pine burning approximately 10 feet below its top and producing a steady stream of embers. With winds expected the next day, the snag posed a significant risk to keeping the fire contained. Hughes and IHC-1 Squad Leader agreed it needed to come down, but it would have to wait until the next day.

¹ A tactic associated with indirect attack, setting fire inside a control line to widen it or consume fuel between the edge of the fire and the control line.

Day-of-Accident Events

The location of the accident was on the northeast flank of the fire. Crews were assigned to this area in order to establish and maintain containment lines, per the Incident Action Plan, in order to meet Agency Administrator's control objectives.

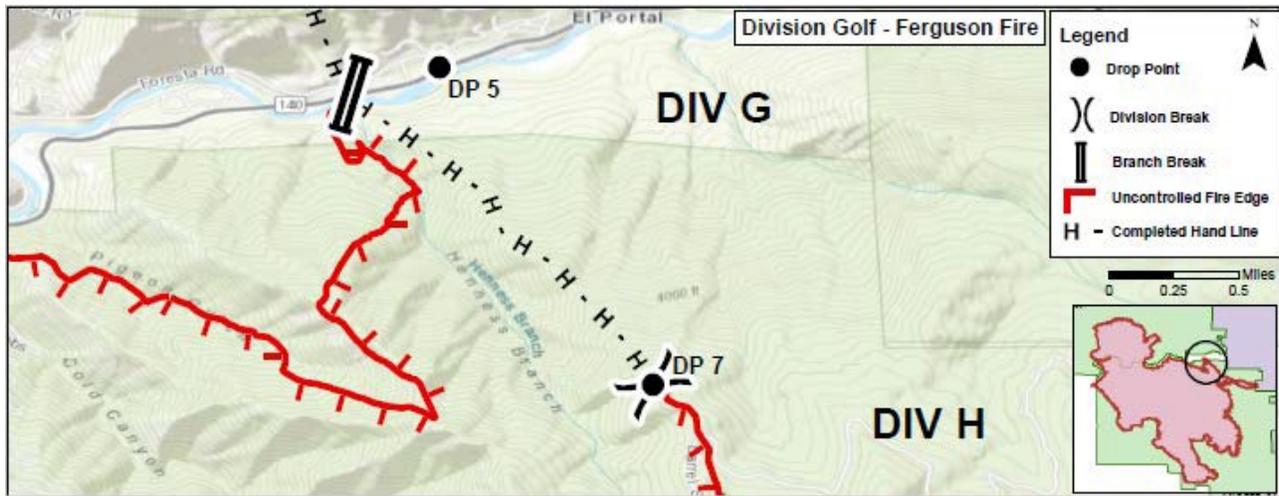


Figure 2: Map of Division G showing the handline that Arrowhead IHC was working along on July 28, 2018 as well as Drop Point 7 (DP 7) where Arrowhead IHC parked its crew carriers on July 29, 2018

July 29, 2018

Hughes woke the crew at 5:15 a.m. While the crew ate at Badger Camp, Arrowhead IHC's supervisors attended a morning briefing and then a breakout session with Division G personnel.

After the briefing, the crew drove to Drop Point 7 (DP 7) and Hughes went downhill to scout the area and check the snags he and IHC-1 Squad Leader identified the day before. Arrowhead IHC's lead saw team followed Hughes soon after.

The sawyer dropped his pack on the main ridge, uphill from the snag and walked down to talk to Hughes.

Hughes told the sawyer to start with the ponderosa pine snag since it was the tallest hazard in the area. By felling this snag first, the crew would be able to start working earlier.

It was decided that Hughes would serve as swamper for this snag as Hughes was more experienced than the sawyer's saw partner. The sawyer instructed his saw partner to serve as a lookout for falling debris hazards from a safe distance, uphill from the site. The lookout was also instructed to bring line packs and gear down to the site after the snag was on the ground in preparation for additional planned falling operations.



Figure 3: Photo of the ponderosa pine snag prior to falling operations.

The Size Up

Hughes and the sawyer assessed the snag together. It was still burning roughly 10 feet from its top. It was 57 inches in diameter at the cut point and about 105 feet tall. They judged the lean of the snag to be uphill and slightly sidehill, toward DP 7. Based on their assessment, they agreed the snag could be felled uphill and slightly left into an opening between trees. They also discussed other risks, including the steep terrain with loose rocks and boulders, and noted footing would be an issue.

The sawyer identified his tentative cutting sequence, which was based primarily on his ability to move away from the snag once it started to fall. He told Hughes where he envisioned starting his cuts, and where he planned to finish them. He also identified the finishing side of the falling snag, and where his primary escape route would be



Figure 4: Cutting area showing slope and terrain. Pie wedge was re-placed on the stump

when it fell. There were old burn scars on the snag's offside he planned to use as footholds to stand on while making his cuts. He said he referred to the offside as his danger side because it was downhill of the falling snag and had a large drop-off with big boulders he would have to work around (Figure 4). The sawyer said the finishing side, where he would initiate his final cut, had better footing. Hughes agreed with the plan.

The sawyer continued sizing up the snag. He used his falling axe to pound the snag, testing its structural integrity. He hit the snag three times and observed no visible limb movement or debris. Listening for audible signals, the sawyer felt the snag sounded like strong, solid wood.

Prior to beginning the cutting sequence, Hughes and the sawyer once again discussed their strategy and comfort level.

While the sawyer and Hughes sized up the snag, the rest of the Arrowhead IHC crew worked its way down the handline toward Drop Point 5 (DP 5). The crew staged itself approximately halfway between DP 7 and the felling operation, remaining a safe distance away from the lead saw team until it completed its work. As the crew waited, Fireline Medic 1, one of two fireline paramedics assigned to Division G, made his way down to the crew. He staged with the crew while Fireline Medic 2 staged at DP 7 for the day.

The Cutting Sequence

Hughes announced over the radio the sawyer was about to start working on the snag. The sawyer retrieved his saw, a Stihl 661 chainsaw with a 36-inch bar, and cleared the area around the base of the snag. Due to its size, the snag required a double cut². Then he began his cutting sequence. The sawyer followed standard procedures, sighting his saw to line up the face cuts with the opening he and Hughes identified earlier as the final target lay. The sawyer then completed the horizontal cut and sloping cuts, creating the face cut³.

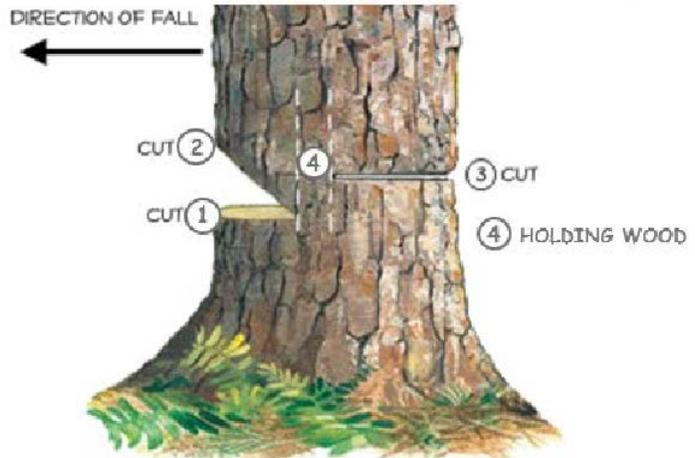


Figure 5: Illustration shows the terminology of the conventional cutting sequence, which is composed of the: 1) horizontal cut, 2) sloping cut, 3) back cut, and 4) the remaining holding wood.

The sawyer informed Hughes he was about to start his back cut. Hughes announced the sawyer's intent over the radio, and following standard procedure, the sawyer yelled out, "Back cut, tree going uphill," before restarting his chainsaw. The sawyer used the chainsaw to create a groove, tracing the finishing side of the snag to the back of the snag to serve as a guide to follow when he started his back cut on the snag's offside. The slope was steep and the back cut was approximately 69 inches from the ground, so the sawyer used an existing burn scar in the snag's offside to gain solid footing and to put himself at a comfortable height to cut.

The sawyer started cutting into the snag until he reached a point where he wanted his holding wood⁴. The cut was slanted and two inches below the face cut on the offside. The sawyer voiced this observation to Hughes.

The sawyer drove a wedge in the offside of the back cut with his falling axe. He moved to the finishing side of the snag, found the plane he had traced earlier, and worked on the finishing side of the back cut. Before the saw reached the desired holding wood thickness, the sawyer stopped and inserted a wedge into the back cut on the finishing side of the snag. The sawyer then finished his back cut.

² A technique used when the snag diameter is greater than the length of the chainsaw bar.

³ A notch, consisting of a sloping cut and horizontal cut, cut into a snag, to guide the direction of the snag fall and prevent splitting or kickback.

⁴ Section of wood located between the face and the back cut. Its purpose is to prevent the snag from separating from the stump until it has been committed to the face. It also helps direct where the snag will fall.

The snag did not fall. The sawyer put another wedge on the finishing side to help the snag fall toward the intended lay, to no effect. The sawyer said he noticed the snag didn't appear to be sitting back. He pounded the wedges in farther, but the snag did not fall.

Hughes walked over to the sawyer to discuss the situation. They agreed there was still a lot of holding wood left on the offside and more could be removed. After removing more of the holding wood on the back cut, the sawyer drove the wedges farther into the snag, but the snag did not fall.

The sawyer moved to the front of the tree to cut out the "guts" of the snag, leaving two holding wood hinges, completely severing the majority of the holding wood. He then moved to the back of the snag, where Hughes asked for the falling axe. Hughes used the axe to pound on the offside wedge.

The snag did not move.

Hughes moved to the finishing side of the snag and handed the falling axe to the sawyer. The sawyer told Hughes the snag was close to falling and he should move out of the cutting area. Hughes walked approximately 20 feet down their primary escape route. Once Hughes was watching the snag again, the sawyer began hitting the wedges on the finishing side of the snag. The sawyer heard a pop and saw the snag start to move.

The sawyer moved away from the snag toward Hughes and yelled, "Which way?" Hughes responded "This way." The two came together briefly. Hughes moved down the primary escape route, while the sawyer glanced up, saw the direction the snag was falling and immediately took a direct downhill path. It took approximately 10 seconds from when the snag began to fall until it came to rest in its final position.

The snag fell in the direction of the primary escape route, hitting the ground approximately 145 degrees from the intended lay and grazing another standing dead snag as it fell. The snag rolled and/or bounced farther downhill and came to rest against other snags and brush. Hughes was struck by the falling snag (Figure 6).

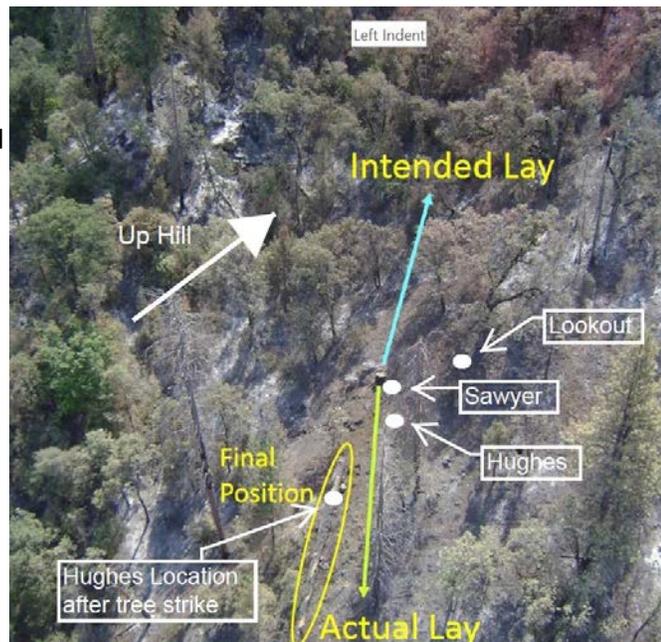


Figure 6: Aerial photograph of the accident site depicting the original location of the snag, the intended lay, and the actual lay and its final position.

Post-Accident Events

The sawyer used the lookout's radio to report the accident and then found Hughes lying face down in a space between the snag and the ground created by a boulder the snag was resting on. Hughes was unresponsive and the sawyer said he could not locate a pulse. The sawyer dug out the dirt from underneath Hughes' face because Hughes was not breathing and he was concerned the dirt was inhibiting Hughes' ability to breathe.

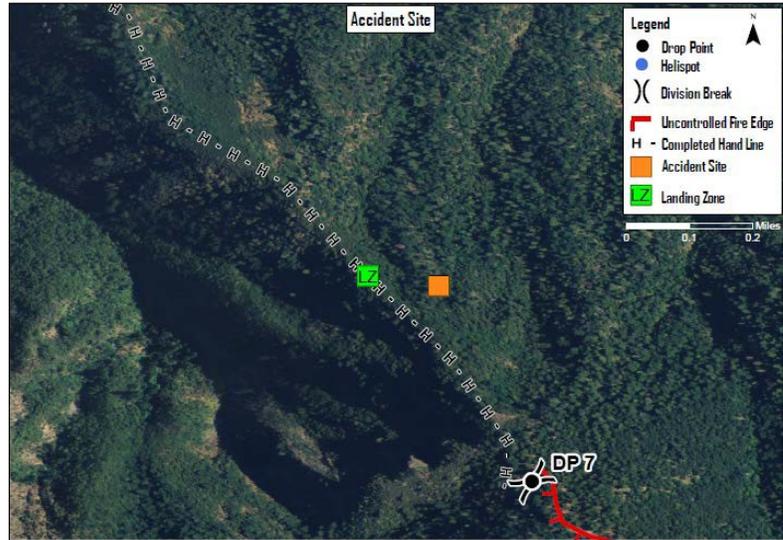


Figure 7: Map showing the location of the accident site and the helicopter landing zone.

Meanwhile, an Arrowhead IHC squad leader, relayed notification of the accident to the Division G supervisor trainee (DIVS(t)) and requested the two fireline paramedics and a helicopter. DIVS(t) contacted the fireline paramedics and instructed them to respond to the medical emergency. At 9:32 a.m., DIVS(t) notified the Incident Command Post (ICP) of an "Incident Within an Incident," (IWI) stating that Division G had a red priority medical emergency and requested the channel be cleared for emergency traffic.

The IHC-2 captain and three members of Arrowhead IHC arrived soon after. They helped the sawyer pull Hughes out from under the snag and initiated CPR. Shortly after, Fireline Medic 1 and IHC-1 Squad Leader arrived on scene. IHC-1 Squad Leader took control of the scene as the incident commander (IC) of the IWI. (see Figure 7 map for the location of the accident site and the helicopter landing zone.)

Fireline Medic 1 took over the medical response and began medical interventions. As members of IHC-2 arrived on scene with a Traverse Rescue Stretcher (TRS), Fireline Medic 1 requested Hughes be moved a short distance, slightly uphill, to an area that would provide a flat surface to work. Once he was secured in a litter, a process known as packaging, Hughes was moved to a flat bench closer to the ridge. During this time, a Rapid Extraction Module (REM)⁵ arrived on scene and set up rescue ropes to help transport Hughes in case there was a need to move him uphill to DP 7. Other members of the crew began cutting paths through the brush in case they needed to move Hughes uphill or sidehill. The medics applied an Automated External Defibrillator (AED) to Hughes' chest and continued compressions.

⁵ A team of two responders trained in technical rescue and ropes, with the purpose of affecting a rapid extraction of a downed firefighter, should the need arise.

Approximately 33 minutes into the medical response, NPS helicopter 551HQ arrived overhead, crewed by one NPS qualified park medic, one paramedic, one helicopter crew member, one helicopter manager, and a pilot. The helicopter's crew landed in a landing zone downhill of the medical response that they had assessed for viability in the days prior. As 551HQ set down, the crews began passing Hughes down to the landing zone.

Once 551HQ landed, its crew and pilot looked around to see where the rescuers were coming from. They saw the evacuation team about 600 feet from the landing zone passing Hughes hand-to-hand down the line in a "conveyor belt" fashion. The pilot realized the helicopter's main rotor would prevent the conveyor belt from entering the landing zone safely, so he took off and hovered to the east of the landing zone until Hughes could be carried down to the landing zone's lower side.

The crews reached the landing zone and 551HQ set down. Once Hughes was loaded into the helicopter, a helicopter crewmember took over medical treatment. 551HQ took off and navigated toward Mariposa Helibase, expecting to rendezvous with an air ambulance.

Although Hughes had been in traumatic arrest for 51 minutes, the crew agreed the ground medical response did not have full access to Advanced Life Support (ALS)⁶ interventions and decided to initiate care based on Traumatic Cardiac Arrest protocols. After CPR and several rounds of medications had been administered and all other interventions had been exhausted, the 551HQ park medic went through the Base Hospital Communication Failure Orders⁷ and ceased life-saving efforts at 10:44 a.m. on the way to Mariposa Helibase.

The medical examiner's report indicates Hughes died of multiple-system blunt force trauma.

⁶ A higher level of emergency medical care, usually provided by an EMT-intermediate or paramedics that extend beyond Basic Life Support (BLS). Typically, ALS includes invasive techniques such as IV therapy, intubation, and/or drug administration.

⁷ A set of orders outlined in the National Park Service's *Emergency Medical Services Protocols and Procedures* field manual (2015), that guide a park paramedic's actions when physician consultation is not available.

Saw Operations Analysis

This report analyzes the saw operations and tree felling procedures during the Ferguson Fire tree-felling fatality. The details of this report were derived from interviews with on-site crewmembers, witness statements, on-site observations, and analysis of the felling area, stump, bole, and specific saw operations. Please see the glossary at the end of document for definitions of terms.

All personnel involved in felling operations were performing within their qualifications and experience levels.

Physical Environment

Cutting operations were conducted as part of a multi-day effort to contain a spot fire. The area consisted of a mixed stand of conifers and hardwoods with a brush understory (Figure 8). Numerous standing dead conifers were also present in the area. The area was at an elevation of 4,030 feet and on a slope of 54 to 80 percent in very rough and rocky terrain (Figure 9). At the time of the accident, there was no report of any wind, with visibility approximately ½ mile.



Figure 8: Looking downhill at the accident scene with the stump and bole of the tree in its final resting place.



Figure 9: Cutting area showing slope and terrain. Pie cut is sitting on the stump.

Tree Size Up

The strike tree was a standing dead ponderosa pine (*Pinus ponderosa*), 57 inches in diameter at the cut and approximately 105 feet tall. The snag was reported to have had fire near the top and along sections of the bole on the day prior to the accident. The tree also had fire scars near the base from previous years.

Some bark and numerous dead limbs were still attached to the snag (Figure 10).

The diameter of the tree required cutting from both sides (double cut) to complete the face and back cuts. The intended lay for the tree was uphill and to the left (see Figure 11).



Figure 11: Photo of the strike tree before felling showing its top and dead limbs.



Figure 10: Photo along intended lay showing stump downhill.

Face Cut

On-site observations of the direction of the face cut matched the sawyer's description of the intended lay for the tree. The face cut was a conventional cut (flat horizontal cut with a downward sloping top cut). Depth of the face cut was approximately 35 percent of the tree diameter (Figure 12). The horizontal and sloping cuts met at the rear of the face cut with no Dutchman kerf left in the face.

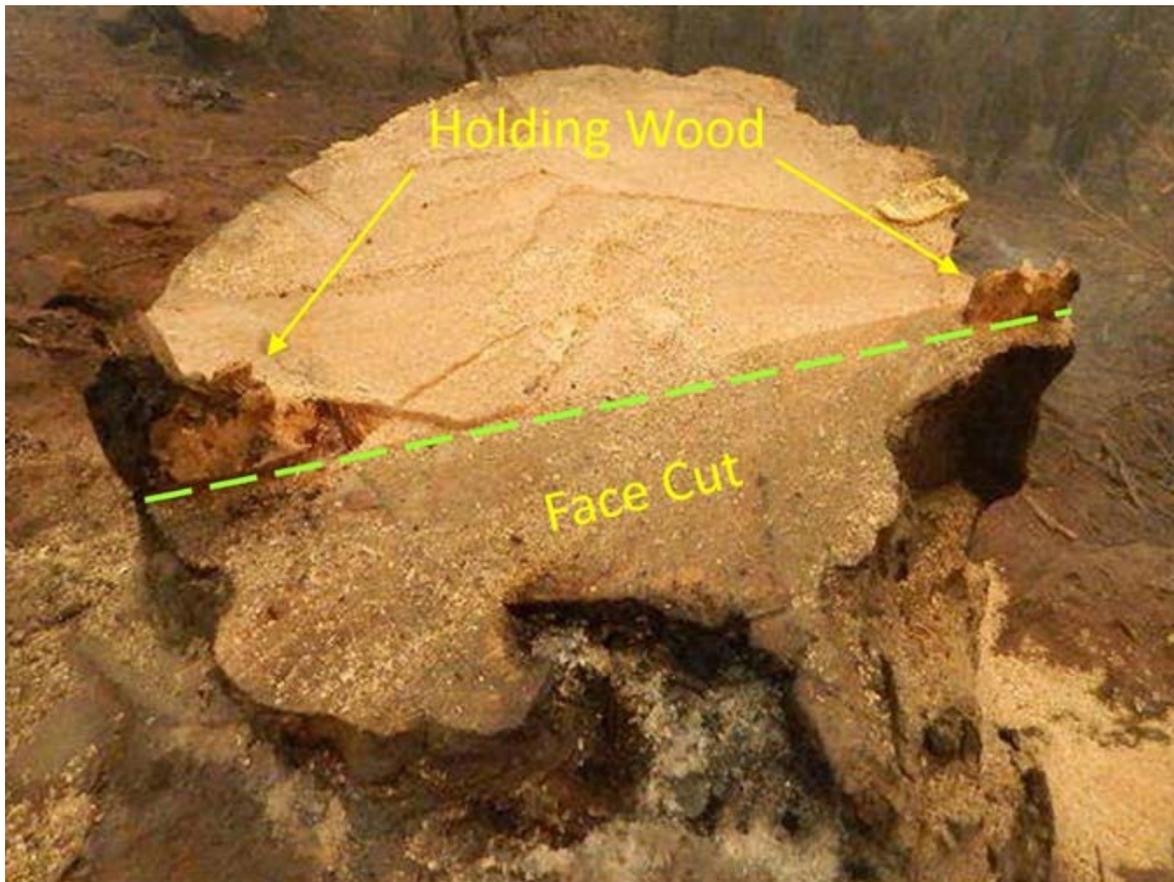


Figure 12: Stump showing face cut and holding wood posts (dashed green line).

Back Cut

Stump analysis and on-site observations showed numerous techniques used for the back cut. Just as the face cut, the diameter of the tree required double cutting to complete the back cut.

During the back cut sequence of operations, three felling wedges (8-inch, grooved plastic wedges) were placed and set around the back cut. These wedges were driven in with considerable force and left distinct indentations on the stump (Figure 13).

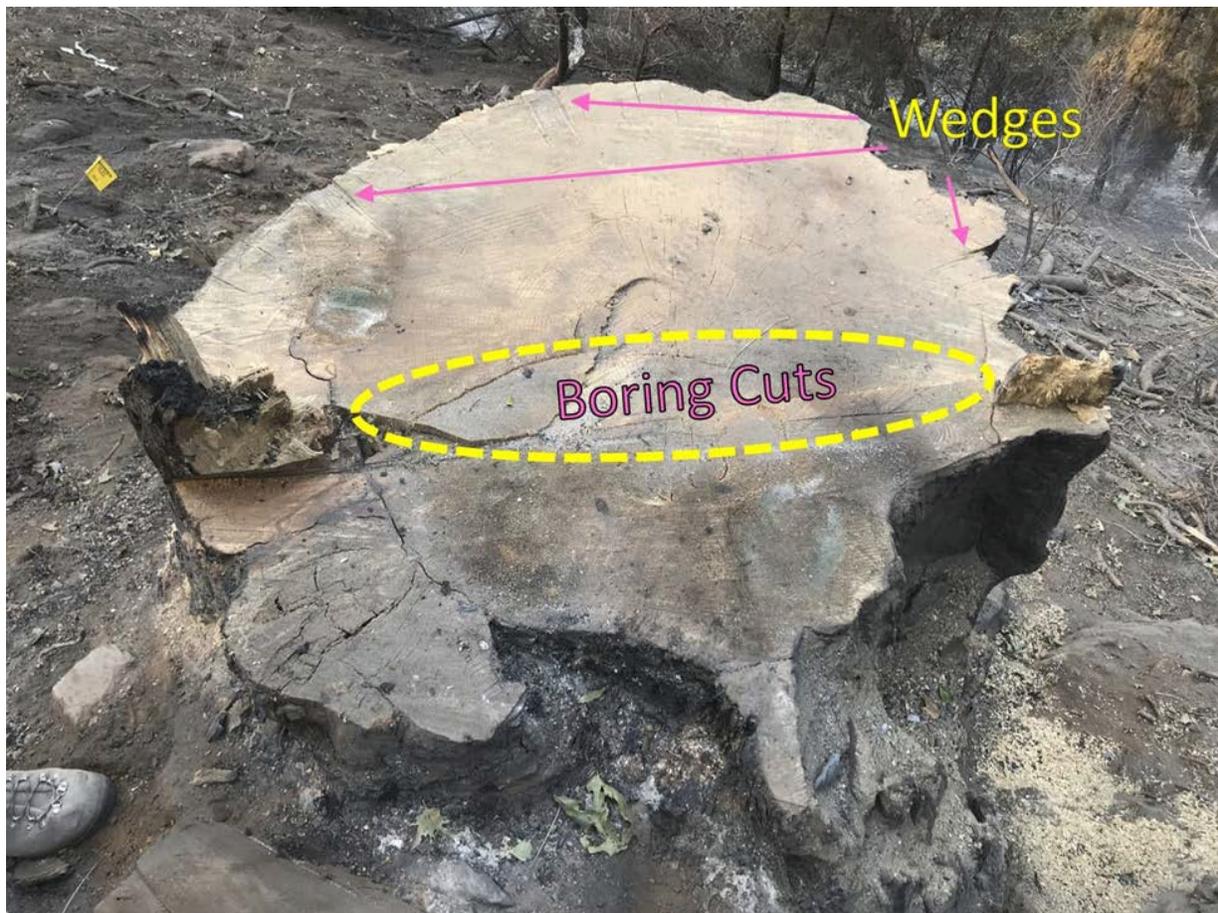


Figure 13: Stump showing area of holding wood boring cuts and position of felling wedges.

A series of cuts were used to reduce the depth of the holding wood. In addition, a separate series of cuts were used to bore out the center of the holding wood. These boring cuts left two holding wood corner posts (width of 4 inches and 9 inches, respectively). Figures 13 and 14 show the relative size, position, and depth of these corner posts.

Further stump analysis shows a sloping back cut with a maximum depth of two inches below the face cut (Figure 14). In addition, the offside holding wood was damaged and within an old fire scar. Figure 15 shows the old fire scar and bark inclusion within the corner post.



Figure 14: View of stump showing surface planes for the face and back cuts. Dashed line indicates the height difference between cuts on the offside.



Figure 15: Arrows indicate an old fire scar showing bark inclusion within offside holding wood corner.

Lay of the tree

All cuts were made and aligned for the intended lay of the tree to be uphill and slightly to the left. On-site observations and interviews placed the actual lay 145 degrees off the intended lay (Figure 16). The tree landed downhill, grazing another standing dead tree as it fell. The tree rolled and/or bounced farther downhill and came to rest against other trees and brush.

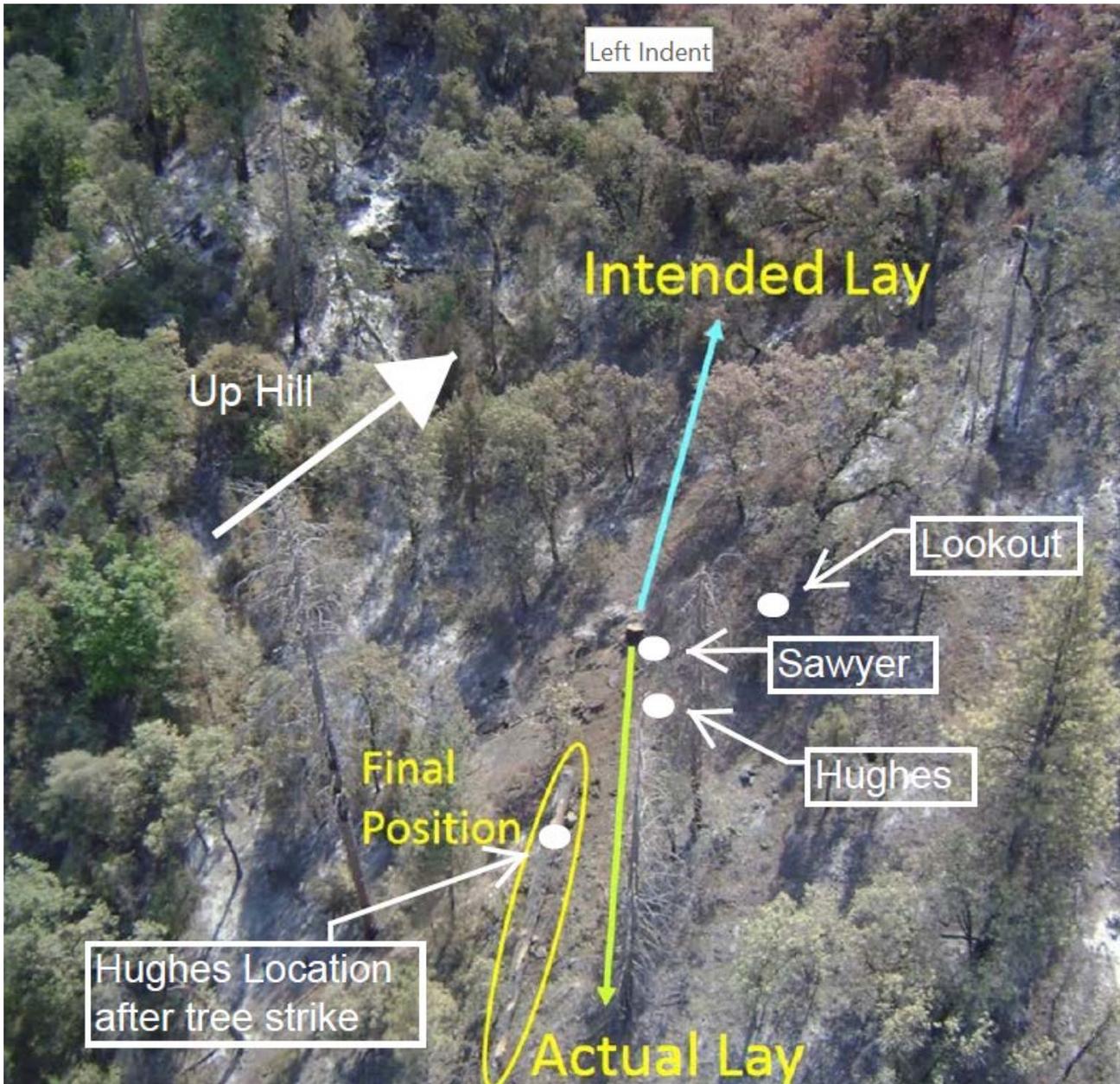


Figure 16: Aerial photograph of the accident site depicting the original location of the snag, the intended lay, and the actual lay and its final position.

Event Timeline

Arrowhead IHC work schedule prior to arriving at the Ferguson Fire:

6/3/18 – Ash Mountain Prescribed Fire, 1 shift

6/19-20/18 – Wheeler Fire, 1.5 shifts

6/25/18-7/5/18 – Lions Fire, 8 shifts

7/6-13/18 – Valley Fire, 7 shifts

7/16/18 – Travel to Ferguson Fire

Arrowhead IHC work schedule at the Ferguson Fire prior to the accident:

7/17/18 – First shift on Division H. Objective for division was to construct dozer line from Wild Dove Road to Forest Road 4S04C and to identify drop points. South Central Sierra Interagency Incident Management Team.

7/18/18 – Second shift on Division H. Objective for division was to continue dozer line operations to protect Yosemite West, access and protect structures, construct indirect handline from Pinoche Ridge to Merced River, and identify drop points. South Central Sierra Interagency Incident Management Team.

7/19/18 – California Interagency Incident Management Team 4 took command of the incident.

Third Shift. Branch 1 Division G. Objective for the division was to continue to construct indirect handline from Highway 140 to Pinoche Ridge and prepare for burnout.

7/20/18 – Fourth Shift. Branch 1 Division G. Objective for the division was to continue to scout and prepare control lines and prepare for firing operations. California Interagency Incident Management Team 4.

7/21/18 – Fifth Shift. Branch 1 Division G. Objective for the division was to continue to scout and prepare control lines, and to prepare for firing operations. California Interagency Incident Management Team 4.

7/22/18 – Sixth Shift. Branch 1 Division G. Objective for the division was to continue to scout and prepare control lines and prepare for firing operations. California Interagency Incident Management Team 4.

7/23/18 – Seventh Shift. Branch 1 Division G. Objective for the division was to prepare for firing operations. California Interagency Incident Management Team 4.

7/24/18 – Eighth Shift. Branch 1 Division G. Line photographer in division. Began firing operations midday. Arrowhead IHC was burning west on the ridge. California Interagency Incident Management Team 4.

7/25/18 – Ninth Shift. Branch 1 Division G. Midmorning discussion with Brian Hughes and IHC-1 Superintendent took place to decide how best to burn the line in Division G. Talked with Branch 1 Director later in the day about burning in Division G the next day if conditions were right. California Interagency Incident Management Team 4.

7/26/18 – Tenth Shift, 6:00am -12:00am: Arrowhead IHC was engaged in operations on Division H (on loan from Division G) holding burnout operations from High Point to DP 7 for IHC-1 and IHC-2 to one-third of the way down Incline Ridge handline in Division G. Firing operations were then passed off to Arrowhead IHC at 9:00pm.

7/27/18 – Eleventh Shift, 12:01am – 1200pm: Arrowhead IHC took fire down to the Merced River completing ignitions at approximately 6:00am. Arrowhead IHC engaged in one spot fire at approximately 8:00am and had it lined by 9:00am. The crew then crossed the Merced River via raft and headed to camp where they bedded down by 12:00pm. No food was available at the time so Arrowhead IHC woke for dinner at 6:00pm and was sleeping again by 8:30pm.

7/28/18 – Twelfth Shift, 6:00am – 10:30pm: Arrowhead IHC worked on the spot on Division G below DP 7. The crew anchored in off the indirect handline at the heel of the fire, building handline direct up the right flank where IHC-2 and IHC-1 were building handline down. Crew was bedded down by 9:00pm.

7/29/18 – Thirteenth Shift, Branch 1 Division G: Objective for the division was to use appropriate suppression actions to keep fire within current containment lines if necessary. California Interagency Incident Management Team 4. Fatality occurred.

Events the day of the accident

5:15 a.m. - Hughes wakes the Arrowhead Hotshot crew and they head to chow at Badger Camp.

6:00 a.m. - Arrowhead IHC supervisors attend operational briefing. Arrowhead IHC supervisors attend divisional break out meeting for Division G and the rest of the division resources at Badger Camp.

6:45 a.m. - The crew drives to DP 7 in Yosemite West and parks its vehicles there to head down the line for the day.

7:55 a.m. - Fireline Medic 1 arrives at DP 7. Arrowhead IHC has already departed DP 7.

8:45 a.m. - Sizeup and falling operations begin. Hughes scouts the area before the crew hikes down the ridge and stages at a safe distance from the burning snag. He is soon followed by the crew's lead sawyer and saw partner down to an area with several hazard trees that could impact the area the crew will be working on, some of which were on fire. Hughes and the sawyer discuss the falling operation, perform a sizeup of the burning snag for about 10 minutes, and clear their escape routes. Hughes and the sawyer work the strike tree together. The sawyer runs the saw and pounds wedges. Hughes pounds the wedges at times.

9:10 a.m. - Fireline Medic 1 leaves DP 7 down the line toward the spot fire area.

9:20 a.m. - Hughes moves down the escape route about 20 feet and turns to watch the tree. The sawyer continues pounding on the wedges to get the tree moving.

9:21 a.m. - The snag falls approximately 145 degrees from its intended lay.

9:22 a.m. - The sawyer calls for medical help and reports a tree strike on the crew channel.

9:24 - 9:28 a.m. - Radio traffic from Arrowhead IHC for code red emergency is logged on a tactical

channel and indicates that it was a tree strike. DIVS(t) calls into communications to stand by for a possible red medical. DIVS(t) requests medics, then notifies ICP of the incident within the incident and requests ground ambulance to DP 7.

- 9:32 a.m. - Red Priority medical is declared over the radio and the incident is named the Sevens Incident.
- 9:35 a.m. - Fireline Medic 1 and IHC-1 Squad Leader are on scene. IHC-1 Squad Leader begins working the radio as the IC for the IWI.
- 9:39 a.m. - Fireline Medic 1 stated that the patient is in traumatic full arrest.
- 9:40 a.m. - Request ambulance above and below incident to stand by. Air rescue requested as well.
- 9:44 a.m. - Helicopter 551HQ is dispatched with a crew of five, including a paramedic and park medic. The patient is being transported by foot from the accident site to the line that is downhill to the landing zone on the ridge. Ground ambulance en route to Fish Camp general store. Air ambulance is dispatched, en route to Batterson to evaluate and then head to Oakhurst to evaluate also. Air ambulance reaches Batterson but cannot land, Helibase Manager requests CHP helicopter to report to Mariposa Helibase.
- 10:05 a.m. - H551HQ and CHP H40 are flying in the area of the IWI. National Guard 823 stages at Mariposa airport to serve as relay or winch option if needed.
- 10:09 a.m. - 551HQ lands at the landing zone.
- 10:16 a.m. - Hughes is approximately 600 feet from the landing zone; is unconscious and not breathing.
- 10:17 a.m. - Helicopter is on the ground waiting for the patient at the landing zone midway between DP 5 and DP 7.
- 10:18 a.m. - Request for ground ambulance.
- 10:25 a.m. - Hughes is approximately 100 feet from the landing zone. 551HQ has to lift off in order to allow access to the site due to rotor clearance.
- 10:30 a.m. - Hughes loaded and lifted to Mariposa Helibase.
- 10:39 a.m. - Communications cleared, per Communications Unit.
- 10:44 a.m. - Paramedic and park medic on 551HQ terminate medical care.

Findings

These findings represent the Serious Accident Investigation Team's analysis based upon interviews, physical evidence, incident documentation, photographs, review of training curriculum and Standard Operating Procedures (SOPs).

Causal Findings

Finding 1: Based on observations by the SAIT, a combination of factors were present that likely contributed to the snag falling 145 degrees off its intended lay, including:

- The lean of the snag may have been misinterpreted.
 - The snag was not plumbed as described in S-212, Wildland Fire Chain Saws. The snag's lean was evaluated by visually sighting the snag from three different angles as described in Arrowhead IHC standard operating procedures, by two different people. S-212 Wildland Fire Chainsaws (2012) training curriculum states the following: "Evaluate the tree's lean. With a plumb bob or axe, project a vertical line up from the center of the tree's base and determine whether the tree's top lies to the right or left of the projected line."
 - The steep angle of the slope could make it difficult to interpret the lean by strictly visual means.
 - Absence of other conditions such as wind and limb weight distribution, the final resting position of the snag indicates a lean opposite of the intended lay.
- After initial face cuts, back cuts, and wedging failed to bring the snag down, approximately 78 percent of the snag's holding wood was removed.
 - Holding wood acts as a hinge, preventing the snag from separating until it has been committed to the face cut and helps direct where the snag will fall.
 - After the center of the hinge wood was bored out, two corner posts were left as holding wood (4 inches and 9 inches respectively).
 - Severe reduction of the holding wood can cause the snag to react in an unintended manner.
- The back cut was sloping at a downward angle and came in 2 inches below the face cut on the offside.
 - A back cut below the face cut highly increases the possibility of the tree sitting back on the stump.
 - A sloping or angled back cut can reduce the effectiveness of the hinge or holding wood.
 - Less than optimal footing and body positioning likely affected the sighting of the back cut.

Finding 2: Escape routes were identified following training and standard operating procedures at approximately 45-degree angles from the face cut.

- Hughes was struck while attempting to utilize the identified escape route.

Findings

Finding 1: The falling operation of the snag was conducted in line with the strategy and tactics identified in the Incident Action Plan, in order to meet Agency Administrator control objectives.

Finding 2: The snag's condition, including fire in its top, presented a threat to the fireline.

- The snag was a ponderosa pine, 57 inches in diameter at the cut point, and approximately 105 feet tall. It was burning about 10 feet from its top. The stump exhibited both old and new fire scars. Given the snag's proximity to the fireline, it presented a spotting hazard as well as being a hazard to firefighters working in the area.

Finding 3: The steep, rocky terrain limited the fireline and saw operations, including the ability to rapidly use the established escape routes.

Finding 4: Two days before the accident the Arrowhead IHC completed a 32-hour shift at 12:00 p.m. on July 27.

Finding 5: Hughes, the sawyer, and the lookout were current with training and certification for the positions they performed.

Finding 6: The National Wildfire Coordinating Group (NWCG) training curriculum lacks formal training for advanced fallers.

- NWCG S-212 (Wildland Fire Chain Saws) is the only course for chainsaw operators. No training pathway exists for advanced fallers (e.g. 300/400 series courses) to address and learn skills for complex hazards and techniques.

Finding 7: The Incident Management Team (IMT) assigned and staged appropriate medical and rescue resources throughout the division including a Rapid Extrication Module (REM) and paramedics on the fireline.

- The high level of fitness and wildfire experience of the paramedics allowed them to travel the rough terrain of the Division G fireline.

Finding 8: The fireline medics were well-integrated with the crews.

- The fireline medics established a rapport with the crews and worked with crews to identify where medics would be staged based on planned crew activities.

Finding 9: H-551HQ had the forethought to scope out the landing zone days before the accident.

Finding 10: Differences between Air Ambulance and Medivac terminology led to misunderstandings.

Glossary

Back cut: The last of the three cuts required to fell a tree. Located on the opposite side of the tree from the undercut and minimally 2 inches above the horizontal cut of the undercut. The two inches is referred to as stump shot and prevents the tree from kicking back over the stump toward the faller.

Base of tree: That portion of a rooted tree not more than three feet off the ground.

Bole: The trunk of a tree.

Boring: Method of using the bottom half of the guide bar nose to saw into the tree while felling or bucking.

Brush: A collective term that refers to stands of vegetation dominated by shrubby, woody plants, or low growing trees, usually of a type undesirable for livestock or timber management.

Control line: An inclusive term for all constructed or natural barriers and treated fire edges used to control a fire.

Conventional felling technique: One of the techniques commonly used to fell a tree. The undercut is at least 45 degrees, made up of one horizontal (gunning) cut and one sloping (matching) cut that meet each other without overlapping.

Direct attack: Any treatment of burning fuel, such as by wetting, smothering, or chemically quenching the fire or by physically separating burning from unburned fuel.

Dozer: Any tracked vehicle with a front-mounted blade used for exposing mineral soil.

Dozer line: Fireline constructed by the front blade of a dozer.

Dutchman: Results from the horizontal cut or the sloping cut, or both not meeting or extending beyond each other. Very hazardous. Can change the actual felling direction and cause loss of control of the tree.

Escape route: A preplanned and understood route a saw crew takes to move to a safety as a tree begins to fall.

Face: The side of the tree aligned with the predominant lean, the intended lay, or both. The side of the tree opposite from the back cut.

Face cut (Undercut): A minimum 45-degree section of wood sawn and removed from a tree base. Its removal allows the tree to fall to the intended lay. The undercut is comprised of two separate cuts, which have a constant relationship; the horizontal cut (gunning cut) must be of significant depth to allow adequate hinge wood; the sloping cut (matching cut) must be angled enough to allow a wide opening and the two cuts must meet each other without overlapping (Dutchman).

Faller: A person who fells trees. Also called a sawyer or cutter.

Finishing side: The side of a tree or snag where the final back cut is made when using a double cut technique.

Fireline: A linear fire barrier that is scraped or dug to mineral soil.

Fire perimeter: The entire outer edge or boundary of a fire.

Fuel: Combustible material. Includes, vegetation, such as grass, leaves, ground litter, plants, shrubs and trees that feed a fire (see Surface fuels).

Handline: Fireline constructed with hand tools.

Hazard tree – A tree that might burn or fall, creating a hazard.

Horizontal cut (Gunning cut): First of the two cuts required to undercut a tree. The depth of the gunning cut is generally 1/3 the diameter of the tree, and level.

Holding wood (Hinge wood or hinge): The uncut wood between the undercut and the back cut. Its purpose is to prevent the tree from prematurely slipping from the stump until it has been committed to the undercut. The hinge wood maintains the tree's alignment with the direction of fall. The hinge wood must never be completely sawn off.

Hotshot crew: Intensively trained fire crew used primarily in handline construction (Type 1).

Incident: A human-caused or natural occurrence, such as wildland fire, that requires emergency service action to prevent or reduce the loss of life or damage to property or natural resources.

Incident action plan (IAP): Contains objectives reflecting the overall incident strategy and specific tactical actions and supporting information for the next operational period. The plan may be oral or written. When written, the plan may have a number of attachments, including incident objectives, organization assignment list, division assignment, incident radio communication plan, medical plan, traffic plan, safety plan, and incident map.

Incident command post (ICP): Location at which primary command functions are executed. The ICP may be co-located with the incident base or other incident facilities.

Incident commander (IC): Individual responsible for the management of all incident operations at the incident site.

Incident management team (IMT): The incident commander and appropriate general or command staff personnel assigned to manage an incident.

Kerf: The slot in the wood made by the action of the saw chain cutters.

Lay: Refers to either the position in which a felled tree is lying or the intended falling place of a standing tree.

Lookout: An individual assigned to monitor fire conditions and saw or fire line operations for risks or hazards.

Offside: The opposite side of the tree from where the sawyer stands while bucking or felling.

Prescribed fire: Any fire ignited by management actions under certain, predetermined conditions to meet specific objectives related to hazardous fuels or habitat improvement. A written, approved prescribed fire plan must exist, and NEPA requirements must be met, prior to ignition.

Resources: 1) Personnel, equipment, services and supplies available, or potentially available, for assignment to incidents. 2) The natural resources of an area, such as timber, grass, watershed values, recreation values, and wildlife habitat.

Scar (Cat face): A scar or deformed section at the base of a tree caused by rot or fire.

Sizeup: A process used to assess the condition and lean of a tree or snag when planning a falling operation.

Sloping cut (Matching cut): The second of the two cuts required to undercut a tree. The matching cut must be angled sufficiently to allow a wide-mouthed undercut (at least a 45 degree) opening.

Snag: Any standing dead tree or remaining standing portion thereof.

Stump shot: The height difference between the horizontal (gunning) cut of the undercut and the back cut. The difference in height establishes an anti-kickback step that will prevent a tree from jumping back over the stump toward the faller. It is the undercut side of the holding wood.

Swamper: (1) A worker who assists fallers and/or sawyers by clearing away brush, limbs and small trees. Carries fuel, oil and tools and watches for dangerous situations. (2) A worker on a dozer crew who pulls winch line, helps maintain equipment, etc., to speed suppression work on a fire.

Sawyer: Chainsaw crew, may also include fallers who are qualified to cut down trees or snags, perhaps while the tree or snag is burning.

Unified command: In ICS, unified command is a unified team effort which allows all agencies with jurisdictional responsibility for the incident, either geographical or functional, to manage an incident by establishing a common set of incident objectives and strategies. This is accomplished without losing or abdicating authority, responsibility, or accountability.

Wedge (felling): A plastic or magnesium tool used by a faller to redistribute a tree's weight to a desired direction (lift) and to prevent a tree from sitting back. Also used to prevent the guide bar from being pinched.

Appendix - A: Investigation Process

Sunday July 29, 2018

The fatal accident was reported to the National Park Service's Fire and Aviation Management Office at the National Interagency Fire Center. NPS Fire and Aviation Division Chief Bill Kaage and NPS Wildland Fire Operations Program Leader Chad Fisher, assembled an investigation team. It was determined the investigation would be conducted by an interagency team based on the Memorandum of Agreement between Department of Agriculture, Forest Service and Department of the Interior signed in 2015. NPS Midwest Region Associate Regional Director for Operations Jim Loach was assigned as the Serious Accident Investigation Team (SAIT) Leader. USDA Forest Service Intermountain Region Director of Safety Randy Draeger was assigned as the Deputy Team Leader.

Monday July 30, 2018

The remainder of the team members were identified and notified to travel on Tuesday July 31. Deputy Team Leader Draeger arrived in Fresno late in the day.

Tuesday July 31, 2018

SAIT members in travel status. Deputy Team Lead Draeger, Investigator Murphy, Investigator Gregory, and Hotshot Superintendent Clem were able to connect with Sierra National Forest (Sierra NF) personnel and begin the process of identifying individuals the team would need to interview. The Sierra NF Forest Supervisor provided a conference room at the Forest Headquarters in Clovis, CA for the SAIT to operate.

Wednesday August 1, 2018

The SAIT had its first in-briefing at 7:30 a.m. A planning session was conducted to identify documentation to be collected and individuals to be interviewed. The team began the process of collecting and analyzing information. This process continued through the time the team was on site and beyond. When possible, interviews were conducted in person. In cases when individuals had already been released from the fire, telephone interviews were conducted. A 72-hour report was developed and delivered to NPS Fire and Aviation Division Chief Bill Kaage.

Thursday August 2, 2018

An interview with the sawyer was conducted at the Arrowhead Hotshot Base by Investigative Services Branch Special Agents, with SAIT Investigator Murphy present. Other SAIT members met with the crew and were briefed on the interview with the sawyer by Investigator Murphy and the ISB Special Agents.

Friday August 3, 2018

The process of conducting interviews and collecting information continued at the Ferguson Fire Incident Command Post.

Saturday August 4, 2018

SAIT members attended a memorial service for Captain Brian Hughes in Fresno, CA.

Sunday August 5, 2018

SAIT members continued collecting and analyzing information.

Monday August 6, 2018

Fire activity and weather conditions allowed team members to access the accident site. Photographs and measurements were taken.

Tuesday August 7, 2018

SAIT members continued collecting and analyzing information.

Wednesday August 8, 2018

SAIT Leader Loach, with SAIT members present, provided a briefing for NPS and USFS agency administrators. Some SAIT members demobilized.

Thursday August 9, 2018

The remaining SAIT members demobilized.

August 23 – October 22, 2018

SAIT members continued to analyze the information collected, conduct follow up interviews, develop findings, and prepare the factual report. Ten SAIT conference calls were conducted during this time frame.

November 14-15, 2018

The draft factual report was presented to the Board of Review (BOR). BOR members raised questions which necessitated follow-up interviews and further analysis of the information collected.

December 10, 2018

The final factual report was delivered to NPS Fire and Aviation Division Chief Bill Kaage.

End of Report