Cascade Complex

Three Days on the Boise

August 12 - 14, 2007

Intermountain Region
November 9, 2007

CASCADE COMPLEX
ACCIDENT PREVENTION ANALYSIS REPORT

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EXECUTIVE SUMMARY

Three events occurring on the Cascade Complex during August 12-14, 2007 are the subject of this report. These events are as follows:

- Entrapment of a fire support truck driver and passenger on the Warm Lake Road;
- Decision by the incident management team (IMT) to stay at the incident command post (ICP) location as the fire burned around the ICP;
- Decision by the IMT to remain at the ICP location during the smoke-filled days following the fire burning around the camp.

This report tells the story from the perspective of the review team and examines the social and organizational causes that led to the decisions and their outcomes.

Since the review included an entrapment incident, the Forest Service Washington Office delegated authority for the review to the Intermountain Regional Forester. The Regional Forester identified a review team and asked them to follow the Accident Prevention Analysis process while meeting the following objectives:

- Enable the reader of your report to understand the situation, the decisions that were made, and why they were made;
- With the input of those involved and the expertise of your team, articulate the organizational and cultural factors that led to unintended outcomes; and
- Based on your analysis of these events, recommend actions that you believe will enhance the safety and reliability of our organization in the future.

The review team consisted of a team leader, a lead investigator, a human factors specialist, a fire operations specialist, an NMAC representative, a fire behavior specialist, an occupational safety and health specialist, and a documentation specialist. The review team interviewed over 120 individuals including firefighters, fire support personnel, fire management personnel, and agency administrators. The review team examined fire documents, weather records, maps, Internet sites, photographs, videos, and did field reconnaissance.

This report consists of several parts:

- Narrative – a factual retelling of the events;
- Lessons Learned by Peers—a compilation of what those involved learned from their experience;
- Lessons Learned Analysis—a display of the decisions, related factors, latent or causal factors, and recommendations;
- Specialist Reports—Chronology of Events, Fire Behavior Analysis, Human Factors, and Health and Safety Analysis

The Accident Prevention Analysis (APA) was conducted in the spirit of the "Foundational Doctrine" for fire suppression activities. The APA team looked at how firefighting principles were used to make sound assessments and reasonable decisions. The team sought to understand the situation in which agency administrators, fire management teams, firefighters, and fire support personnel found themselves in mid-August in central Idaho. It was a rapidly changing environment with many competing demands for the attention of incident and management personnel. The APA team looked at the actions of Incident Management Teams and individuals with the philosophy that "employees are expected and empowered to be creative and decisive, to exercise initiative and accept responsibility, and to use their training, experience, and judgment in decision making to carry out the leader's intent" (Foundational Doctrine, 2006).

The objective of this report is to provide an opportunity to learn from these incidents. Safety is not a goal that an organization can reach, but is rather a continuously creative response by employees to risk. The Cascade Complex accident prevention analysis presents a provocative story with many opportunities for reflection, introspection, and, ultimately, organizational growth.

The review team has made several recommendations to address causal and latent factors in our organization. These recommendations include training and simulation, more broad application of risk assessments, review of policy regarding visits to the fireline,

consideration of LCES for those accessing fire areas, developing acute CO and smoke exposure guidelines, and better tracking of occupational illnesses on fires, among others.

A high reliability organization plans for the unexpected and embraces continuous learning. As many of those involved across the country in managing fires during 2007 realized, past experiences have not prepared fire managers for the situations in which they found themselves during this fire season. It is in the context of helping incident personnel and agency administrators recognize and plan for the unexpected that this report is offered.

PROLOGUE

Nationally, the 2007 fire season started with a bang in early March as the Southeast sustained record-breaking drought and extreme fire events. By the beginning of July, multiple geographic areas were reporting historically high fire indices along with drought conditions. Early onset of a severe western fire season caused the national Preparedness Level (PL) to transition from PL 2 to PL 5 in the short span between July 1 and July 19--Incident Management Teams (IMTs) quickly became highly committed and there was stiff competition for resources. By mid-July the Eastern Great Basin Preparedness Level had also elevated to PL 5, and the geographic area ranked as third national priority for resource allocation in the massive scope of significant fire activity.

Within the Eastern Great Basin, National Weather Service records show that the summer of 2007 was the third warmest summer in 142 years of record keeping in Boise, Idaho. Mountain snowpacks had been below normal, melted off early, and July 2007 was the warmest July on record for Boise. Precipitation for July and August measured only a few hundredths of an inch. Energy Release Components (the indices related to the amount of moisture in large, woody dead and downed material) in southeast Idaho hit the 97th percentile in mid-June and remained at that level, or above, for many weeks.

On July 17, 2007 a thunderstorm spread lightning and spotty rain widely across the mountains of central Idaho, starting more than 50 fires on the Boise National Forest, 25 of which were on the northern half. Before dark, the local dispatch was able to staff eight of these new fires; by the end of the next day, two thirds of the new starts were staffed and crews were making good progress. However, when it became apparent to Forest officials that some of these fires would exceed local capability, an order was placed for two Type 2 Incident Management Teams (IMT2s) and one Wildland Fire Use Management Team (FUMT). One IMT2 met with the Forest staff on July 19, and on July 20 took over what eventually became the Cascade Complex comprised of the Monumental, Mormon Creek, Bear Creek, and Riordan fires, as well as several other smaller fires. A second IMT2 was assigned to the Middle Fork Complex. At the same time, the Payette National Forest had assigned an IMT to the East Zone Complex which included the North Fork Fire also on the Boise National Forest

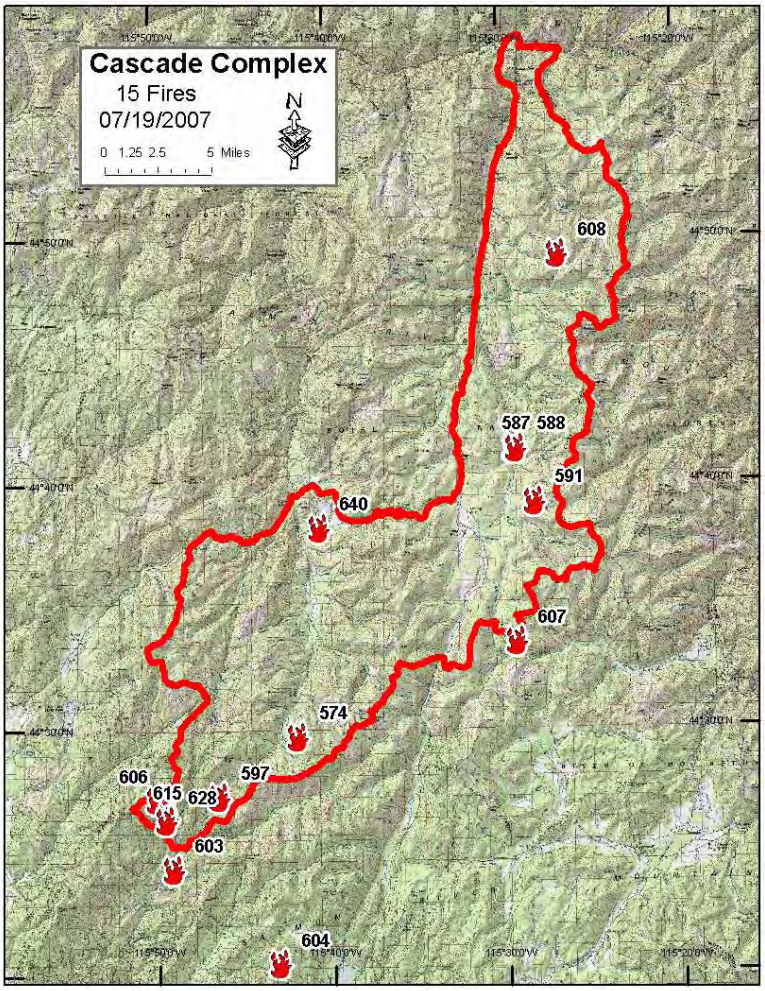


Figure 1 Initial boundary of the Cascade Complex

INTRODUCTION

The following story is focused on a 3-day period on the Cascade Complex during the middle of August 2007, where dedicated and experienced men and women were faced with developing and implementing a fire management strategy to deal with fires of an unprecedented nature in the rugged mountains of the Boise National Forest. The story recounts the decisions made and actions taken by agency administrators, fire management

personnel, and contractors during a 36 hour period that spanned three days in August, the 12th, 13th, and 14th. The story is told through the eyes of a review team commissioned in late September to use an investigative process called Accident Prevention Analysis (APA).

One of the events during the "36 hours" is an entrapment incident of two fire support contractors. The Intermountain Region had scheduled a "Facilitated Learning Analysis" (FLA) of other events that occurred on the Cascade Complex during the same time frame. The Regional Forester subsequently decided to combine the entrapment investigation with the FLA, through the APA process.

The three events to be examined through the review include the entrapment, the fire burning around the Cascade Complex Incident Command Post (Cascade ICP), and the decision to remain at that same ICP for 8 days afterward. Entrapment is defined by NWCG as "situations where personnel are unexpectedly caught in a fire behavior-related, life-threatening position where planned escape routes and safety zones are absent, inadequate, or have been compromised. Entrapments may or may not include deployment of a fire shelter for its intended purpose, and they may or may not result in injury."

While there is general agreement that the entrapment incident is an "accident," consideration of the other events in the context of an accident has been debated. The review team interpreted the definition of an accident, as incorporated in the 5100 section of the Forest Service directive system as applicable to all three situations. This definition is listed in the Interagency Standards for Fire and Fire Aviation Operations (NWCG, NFES 2724) handbook as an "unexpected occurrence in a sequence of events that produces an injury, death, or property damage." It is the team's intention that reflection on the actions taken and decisions made, in the context of cultivating a learning culture and a high reliability organization, will contribute to the prevention of unwanted outcomes in the future.

REVIEW OBJECTIVES

The objectives outlined by the Regional Forester in the Delegation of Authority to the Team Leader are as follows:

- Enable the reader of your report to understand the situation, the decisions that were made, and why they were made.
- With the input of those involved and the expertise of your team, articulate the organizational and cultural factors that led to unintended outcomes.
- Based on your analysis of these events, recommend actions that you believe will enhance the safety and reliability of our organization in the future.

INFORMATION SOURCES AND PROCESS

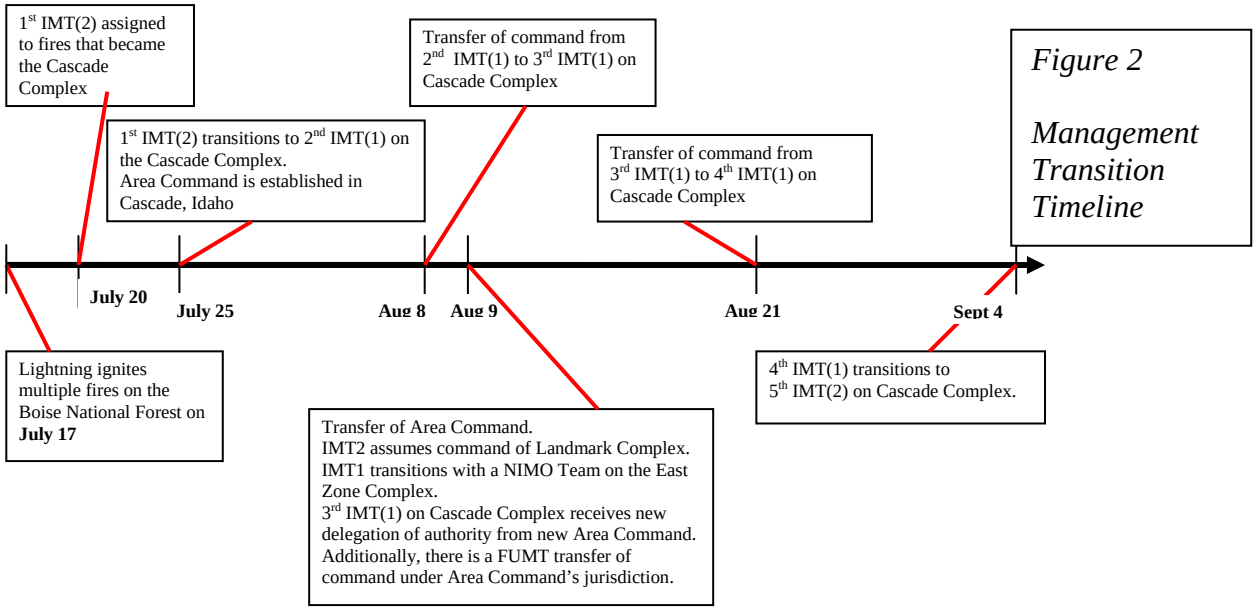
The review team interviewed over 120 individuals including firefighters; ICP support staff; Incident Management Team (IMT) personnel; Area Command Team personnel; Agency Administrators; and a Chief's Principal Representative (CPR). In addition, the team reviewed correspondence, Delegations of Authority, Wildland Fire Situation Analyses (WFSA), Fire and Aviation Safety Team (FAST) reports, unit logs, fire narratives, dispatch logs, forest land management plans, fire management plans, ICS-209s, fire behavior predictions, SAFENETs, videos, photographs, power points, websites, fire growth projections, resource orders, and other associated documents. As the reader may suspect, witnesses viewed similar events in very different ways. The team attempted to resolve differing accounts by factual data, professional knowledge, weight of evidence, and team members' experience and technical skills.

The process the team followed was to outline a chronology of events, write a factual story, compile lessons learned from interviews with fire personnel and other documentation, and develop a Lessons Learned Analysis with resulting

recommendations. It is hoped that the comprehensive review of documentation and extensive personal interviews have captured the essence of the situation confronting fire management personnel those three days in August.

SETTING THE STAGE

The stage will be set for the reader with fire activity, weather conditions, and decisions and actions by Agency Administrators and incident personnel prior to the unfolding of an eventful 36-hour period in the lives of the men and women who were living and working on and around the Cascade Complex from August 12 through August 14, 2007. The story should provide opportunities for reflection, introspection, and ultimately, organizational growth in the context of a mature, learning environment. As the reader progresses through this narrative, he/she should be mindful of the unprecedented situation in which the agency administrators and incident personnel were working. The fire situation was evolving exponentially in some cases, Agency Administrators and incident personnel were reacting to this dynamic environment to the best of their abilities. This account is not intended to criticize or place value judgments on decisions made or actions taken, but rather to transport the reader to the context of the decisions and actions.



On July 19, a Delegation of Authority (DoA) from the Forest Supervisor to the 1st IMT on the Cascade Complex identified the Cascade District Ranger as the Agency Administrator's Representative. Management objectives outlined in this DoA and the accompanying Wildland Fire Situation Analysis (WFSA) included the following:

1. IMT will report to Landmark Airstrip and establish an Incident Command Post (ICP).
2. Maintain firefighter and public safety at all times.
3. Implement "confine and contain" strategies seizing opportunities to either fully suppress or confine new starts within the Maximum Management Area (MMA).
4. Provide protection emphasis in the community of Yellow Pine, structures along Johnson Creek, Warm Lake, Landmark Historic Ranger Station, and Stolle Meadows cabins.
5. Manage an area closure, including roads and trails, with incident personnel.

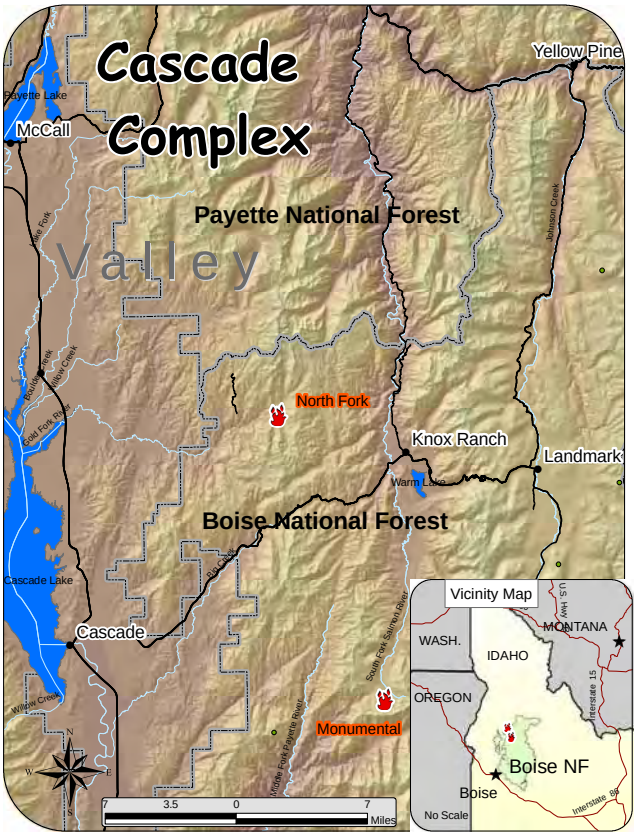


Figure 3

Cascade Complex Vicinity Map

The operational objectives were straightforward, but after assessing drive times, road construction, fire threat, operational support options, etc., the Incident Commander (IC) requested that he be allowed to use Knox Ranch as ICP instead of the Landmark Airstrip. Knox Ranch, near Warm Lake, is part of the Boise National Forest and consists of a large (33 acre) meadow and four historic structures located just inside a "stringer" of timber on the south edge of the meadow. The Agency Administrator and his staff concurred with the request. This IMT had used this location as ICP on previous assignments on the Boise National Forest and felt comfortable there. The helibase was located on the widest part of the meadow on the east end. Co-locating the helibase adjacent to ICP, however, limited the area in which camp facilities could be located. Providing adequate space for parking and crew sleeping was a continual challenge.

Photo 1

Cascade Complex ICP on west end of meadow (wide end had been used as the helibase). Picture taken after fire had burned around camp on 8/13/07

Meeting Agency Administrator expectations that the IMT would manage road and area access in cooperation with the Valley County Sheriff's Office also became a challenge.

The Warm Lake and Johnson Creek Roads are county roads under jurisdiction of the County Sheriff. One Security Manager (SECM), and four Security Assistants (SEC2s) were ordered but by the time the first IMT demobilized on July 25 only one SEC2 position had been filled. The SEC2 was stationed at the checkpoints on Road #474 (South Fork Salmon River Road) south of Cascade ICP. The IMT recruited a volunteer near Johnson Creek Guard Station to manage the checkpoints along Road #413 (Johnson Creek Road.). Ability to fill orders for security personnel remained a problem for the life of the Cascade Complex, but IMTs were able to adequately staff the checkpoints they felt were necessary.

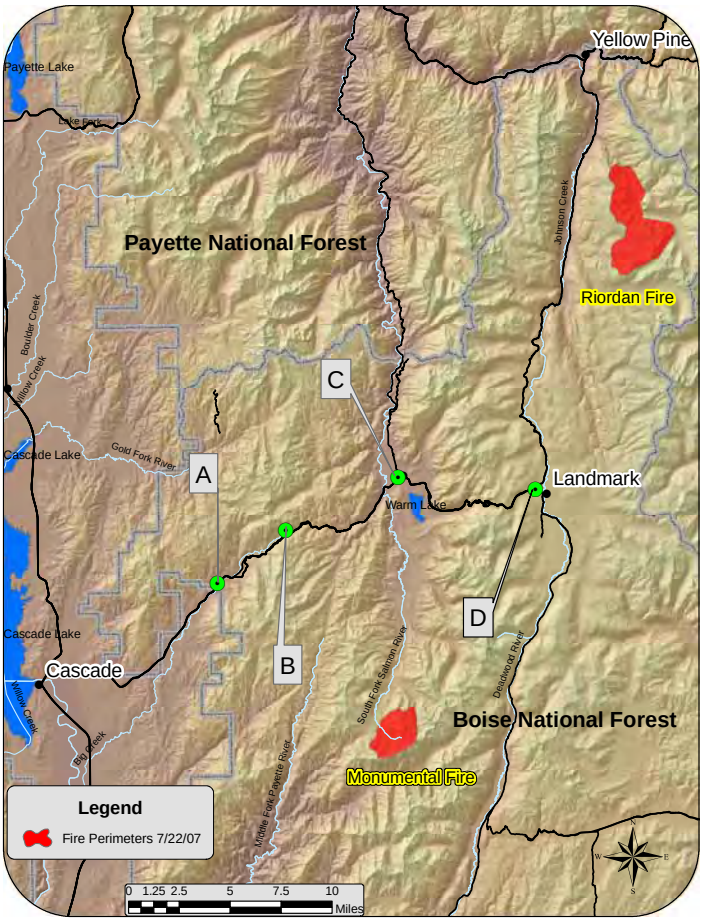


Figure 4

Checkpoints:

A = Forest Boundary

B = Big Creek Summit

C = Weed Wash Station near Knox Ranch

D = Johnson Creek Road

On July 22 the Monumental Fire exhibited extreme fire behavior. A massive convection column developed over the fire as it burned into the Mormon Creek Fire. Similar fire behavior was exhibited on the Riordan Fire when it burned into the Bear Creek Fire. On July 23 a spike camp was established at the Johnson Creek Guard Station near Yellow Pine to reduce driving times to the values at risk near the Riordan Fire. By July 24 the Sandy fire was added to the Cascade Complex.

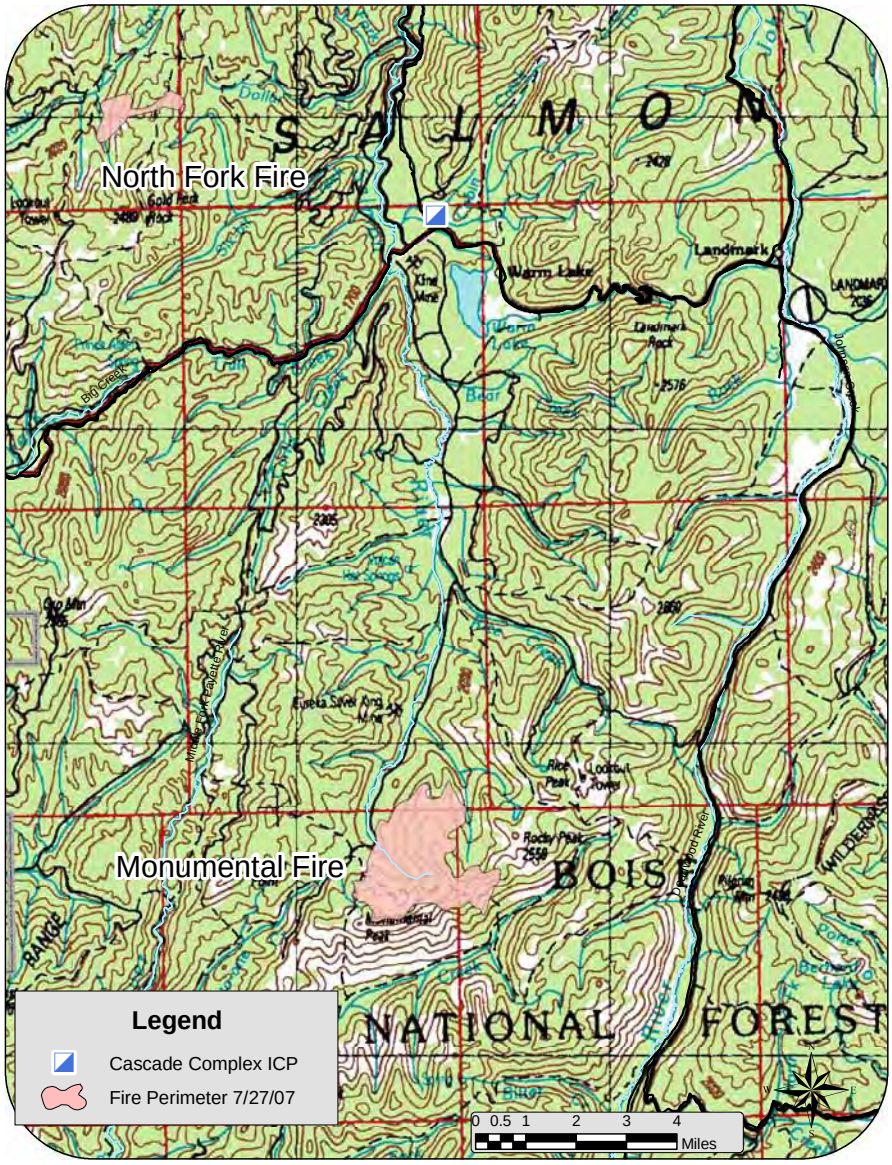


Figure 5

Monumental and North Fork fire perimeters in proximity to Knox Ranch ICP on July 27, 2007

As large fire activity continued unabated on several national forests in central Idaho, the involved Agency Administrators ordered an Area Command Team to be based in the town of Cascade. The purpose of the Area Command Team was to reduce the impact on Agency Administrators and other forest personnel, and improve oversight and coordination of the multiple IMTs assigned to fires in central Idaho. The Area Command Team took control on July 24.

At their closeout on July 25th, the 1st IMT included the following recommendations in the documentation of their tenure on the Cascade Complex:

1. Limit fire traffic on roads under construction (the Warm Lake Highway between Cascade and Big Creek Summit).
2. Continue to work with the local Sheriff's Office to effect management of travel corridors to local communities.
3. When smoke inversions persist, watch for increased cases of respiratory ailments.
4. Establish ICP/Spike Camps as close to the fire as logistically practicable to avoid driving hazards and traffic congestion with local communities.
5. Avoid camp locations where inversions occur and are greater than two hours travel time from the caterer.
6. Ensure that all people accessing the fireline are equipped with required personal protective equipment (PPE).

Increase in complexity of the fire situation resulted in the need for the 2nd Cascade Complex IMT to be Type 1 qualified. At the time of transition, the Area Command Team provided the 2nd IMT with a DoA that did not significantly deviate from the original drafted by the Forest, other than directing the location of ICP to remain at Knox Ranch. Concerns about sharing the ICP location with the helibase continued, but another suitable location for the helibase could not be found. Additionally, the previous IMT had pulled their team's trailers into Knox Ranch to house support personnel and took their trailers with them upon demobilization. The 2nd IMT was forced to place newly ordered trailers on the far west end of the meadow to provide enough separation between the camp facilities and the helibase. Camp facilities were placed close to the trees surrounding the meadow on the west end, resulting in a poor traffic pattern and a lack of parking and tent space. The six new trailers were blocked up, had stairs installed, and the tractor that pulled the trailers returned to the vendor home base. This semi-permanent installation reduced IMT flexibility to relocate the trailers in the future.

On July 26 conditions forced the Forest to modify the existing Cascade Complex WFSA, acknowledging the potential for the fires to become very large. The WFSA instructed the Area Command Team to prioritize fires by the threats posed, with the community of Yellow Pine and private in-holdings in Johnson Creek as the primary concerns.

On July 25 the total acres burned for all fires on the Complex were reported at just under 12,000 acres. Three days later, increasing winds and decreasing relative humidity resulted in significant fire behavior that continued for two more days. The Sandy and Riordan Fires produced huge columns of smoke and made significant runs. On July 31, the Yellow Fire was discovered within the Cascade Complex area of initial attack responsibility and grew rapidly, eventually burning into the Monumental Fire. By August 1, the fires within the Cascade Complex had grown to 30,600 acres in size.

On August 1 the Forest again modified the Cascade Complex WFSA, continuing to recognize significant fire acreage gains. This new WFSA placed the major focus on minimizing large fire spread toward communities, roads, and specific topography under a confine and contain strategy.

Also on August 1, a Fire and Aviation Safety Team (FAST), under the auspices of the Eastern Great Basin Multi-Agency Coordinating Group, visited the Cascade ICP and discussed the fire situation with the Command and General staff. The FAST shared with the 2nd IMT their concerns about the camp location and predicted a high likelihood that the North Fork Fire (part of the East Zone Complex at that time) may force the evacuation of the ICP within the next 48 to 72 hours. The FAST also discussed driving hazards with the IMT, particularly that drivers were subjected to a confusing system of road closures. The Cascade Complex Incident Status Summary (ICS-209) for August 1 and 2 consequently stated as major problems and concerns "the Yellow Fire has now become a large fire and is threatening the Warm Lake area, including the ICP. The North Fork Fire in the East Zone Complex is also threatening Warm Lake and the ICP." Responsively, the 2nd Cascade IMT developed an evacuation/relocation plan for the Cascade ICP. Three perimeters depicting trigger points for evacuation were identified and shared with security personnel. The plan estimated that it would take eight hours to complete the evacuation.

At an emergency meeting of the Valley County Board of Commissioners on August 2, the Commissioners decided to close the South Fork of the Salmon River drainage to

public access. Warm Lake Road #22 was closed at the Boise National Forest boundary east of Cascade to all public travel. On the same day, Boise National Forest officials issued an order closing the north half of the Cascade Ranger District to public use.

The ICS-209 for August 3 and 4 stated that "the North Fork Fire has reached the second established trigger point for the potential relocation of the ICP". Similar wording appeared in the ICS-209 for August 5. By then, the majority of the helicopter operations had been moved from Knox Ranch to the Scott Valley helibase.

A fire spread probability model (FSPRO) run on August 3 for the Monumental Fire showed less than 1% probability of fire reaching Warm Lake by August 10. For the North Fork fire, the probability of fire reaching ICP, as projected by FSPRO, was less than 60% by August 10.

On August 3, the 1st Area Command Team met with officials from the Intermountain Region, and the Boise and Payette National Forests to discuss upcoming team transitions for both Area Command Team and IMTs. Redistribution of fires and Complexes were addressed, as well as the appropriate mix of Type 1, Type 2, and Wildland Fire Use teams. The Area Command Team proposed to schedule IMT transitions over several days. The Agency Administrators, however, voiced a desire for a transition plan that would "reduce the number of moving parts" over time by compressing IMT transitions into the shortest period possible. The Agency Administrators also favored a strategy that would increase the likelihood of Great Basin IMTs being assigned to the fires on the Boise. In the words of one witness, "they were adamant that Great Basin IMTs be assigned to the Cascade and [new] Landmark Complexes". The transition schedule was adjusted accordingly to result in five management transitions over a 36-hour period.

The Landmark Complex was then spun off of the Cascade Complex and consisted of the Sandy and Riordan fires. An IMT2 took over management of the Landmark Complex on August 8 (there was no identification of an ICP location in the DoA to the Landmark IMT). They initially co-located an ICP at Knox Ranch to facilitate transition with the 2nd

Cascade IMT, intending to relocate to Landmark Airstrip. Landmark Complex ICP was actually relocated several times in the following days, but access to each location was via either Warm Lake Highway through the Cascade Complex or Lick Creek Road through the East Zone Complex.

The situation at Cascade ICP continued to build as recorded in the Cascade Complex ICS-209s for August 6-8, stating that there were smoke incursions at Cascade ICP. Also mentioned were "the lack of resources to fully staff the Monumental and Yellow Fires will likely result in those two fires merging together [to] threaten Warm Lake and ICP", as well as "the continued spread of the North Fork fire continues to threaten the Cascade Complex ICP." A Forest Service Washington Office (WO) employee made a visit to the Cascade ICP with a Forest staff officer during the final day of the 2nd Cascade IMT command. The WO employee recalls that the staff officer predicted the fires would burn around Knox Ranch in a week or two.

By August 7, when the 2nd IMT had reached the end of their 14-day command, total acreage burned on all fires had increased to nearly 70,000 acres. The Monumental Fire alone jumped from just under 3,000 acres to almost 17,000 acres—nearly a six-fold increase. During the initial briefing of the 3rd IMT by the Area Command Team and the Agency Administrator, the Agency Administrator stated his strategy to contain the fires and his desire for the IMTs to limit the spread of the fires to the north and east. The primary focus of suppression operations would be to protect the infrastructure and commercial properties around Warm Lake. The Forest staff officer recalls making the point at the briefing that the IMT should be mindful of the many watch out situations and the extreme fire behavior that was occurring all across central Idaho.

The Cascade Complex was redefined to include the North Fork (previously part of the East Zone Complex), Skunk, Yellow and Monumental Fires. DoA from the 1st Area Command Team was issued on August 7 to the 3rd Cascade IMT to assume command of the Cascade Complex on August 8 at 8:00 p.m. The DoA did not specify a location for ICP. The 2nd Cascade IMT transitioned with the 3rd Cascade IMT on August 8.

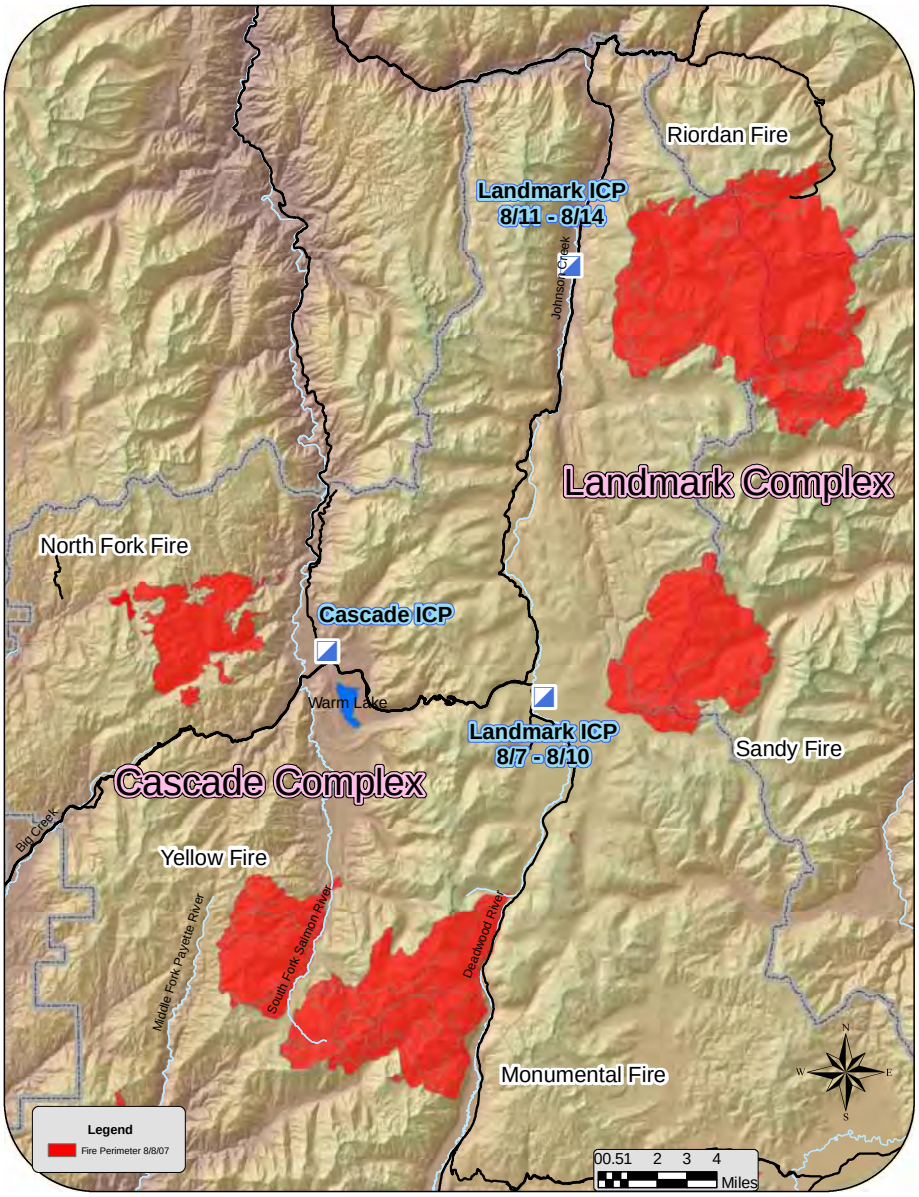


Figure 6

Cascade Complex and Landmark Complex fire perimeters on August 8.

The fire narrative produced by the 2nd Cascade IMT included the following observations:

1. The IMT felt that communications and coordination with the Valley County Sheriff's Office [were] excellent.
2. Cascade District Ranger provided valuable input, information, and feedback to the Team.
3. Analysis revealed trends toward higher frequency and more debilitating injuries.
4. The IMT was successful at containing and escorting traffic along the Warm Lake Road.

5. Smoke inversions impacted aviation missions and prevented aerial delivery of food to spike camps.
6. Communications [were] difficult between the different IMTs assigned under the Area Command.
7. It was challenging to develop a common understanding of objectives that met confine and contain strategies across multiple jurisdictions [with] multiple agency representatives.
8. Multiple transitions by multiple teams [were] implemented too fast. A slower transition plan implemented over several days would result in less confusion for IMTs and assigned resources.

In the meantime, a transition between the 1st Area Command Team and the 2nd Area Command Team was occurring in Cascade. Command was transferred to the 2nd Area Command Team on August 8 at 6:00 a.m. The new DoA was not significantly different from the original but placed more emphasis on coordination of the road, trail, and area closures. The 2nd Area Command Team continued daily conference calls with Agency Administrators, ICs, Dispatch, and other interested participants at 7:00 a.m. and 7:00 p.m. A daily call was also conducted at 11:00 a.m. with the Finance and Logistics Section Chiefs within the area command to coordinate issues, including road management.

One of the first items of discussion as the 3rd Cascade IMT began their command was the ICP location. They earnestly considered the following factors in the decision to remain at the Knox Ranch location:

- Exposure to driving hazards (construction, heavy machinery, fire activity, etc.)
- Defensibility of the site, including fuel treatments completed in previous years in the vicinity of Knox Ranch
- Cost of relocating
- Proximity to implementing their protection objectives; and
- No deference for camp personnel regarding smoke impacts.

The IC directed his SOF1(T) (the 3rd IMT's fully qualified SOF1 did not arrive until August 12) to update the camp safety plan, including the Stay-in-Place plan previously

drafted by the 2nd IMT. The IC requested that each of the unit leaders discuss the plan with employees in their unit. He also asked them to query their employees and identify those who did not wish to remain in camp if the camp was threatened by fire. Fourteen camp crew members expressed a preference to be evacuated.

On August 9, relative humidity readings were in the single digits. The Monumental fire made two major runs. One run was five miles to the northeast, the other run was to the north for a mile and a half. As the Deputy Agency Administrator and a Forest staff officer were returning from a meeting in Cascade on that same day, the Deputy Agency Administrator remembers seeing the large column of smoke from the Monumental fire as they drove south on Highway 55. He remembers the Forest staff officer making the comment that he thought the fire would at some point "bump" the ICP location.

Photos 2 & 3

Smoke Columns on the Cascade Complex

In the Cascade Complex ICS-209s for August 9 and 10 the following statements were made: "Fires are exhibiting extreme fire behavior. North Fork fire is moving [east] toward Knox Ranch…The North Fork Fire progression remains as a concern to the Cascade Complex ICP…The North Fork fire has moved [east] to proposed containment line 1.5 miles from the ICP…*In the next 24 hours*: N.Fork: Fire well established in Two Bit, Six Bit, and Dollar Ck with potential moving [northeast] towards 474 road and threaten ICP…*In the next 48 hours*: N. Fork: Dollar Ck fire should begin to slow fire spread to the [north], but [south] flank will continue to threaten ICP…*In the next 72 hours*: Monumental: Potential threat to Landmark ICP."

On August 11, a strong inversion held over the fire area until 3:00 p.m. Once the inversion lifted, fire activity increased. The North Fork fire made a run to the northeast

skirting around the 1989 Dollar Ck burn and crossing the South Fork Salmon River road north of Cascade ICP. This cut off a potential evacuation route from ICP to the north. In anticipation of the Monumental fire reaching Warm Lake, Cascade Branch II completed a 60-acre burnout around the Kinney Point cabin group. Logistics activity continued to increase in support of the Cascade and Landmark Complexes. The Landmark IMT decided to relocate the Landmark ICP, from the Landmark Airstrip to Cox Ranch near Johnson Creek Guard Station, "due to fire danger" from the Monumental fire to the southwest. At the same time, the Cascade Complex 3rd IMT was in the process of establishing and supporting their own spike camp at Landmark Airstrip.

The Landmark Complex fire narrative states "communication between the Cascade Complex and the Landmark Complex concerning road closures was a problem." The narrative continues by stating, "We had problems determining when locals and fire traffic were able to use the roads." During a review team interview, the East Zone Complex IC recalls discussing road management with the Area Command Team shortly after management transitions on August 7 and 8 had taken place. He described road management as a critical coordination issue with only two supply and evacuation routes winding through three adjoining complexes.

On August 12, the Forest completed another modification of the Cascade Complex WFSA, continuing with a "confine and contain" strategy. The WFSA identified protection of the community of Warm Lake and Warm Lake Highway as high priorities for resource allocation. There were many old burns in the area that under typical fire seasons would be expected to stop or slow fire progression. Earlier in the 2007 season, the old burns had indeed been effective barriers to fire spread. The strategies employed by the IMTs under Area Command in August included identifying and using some old burns to confine portions of the fires.

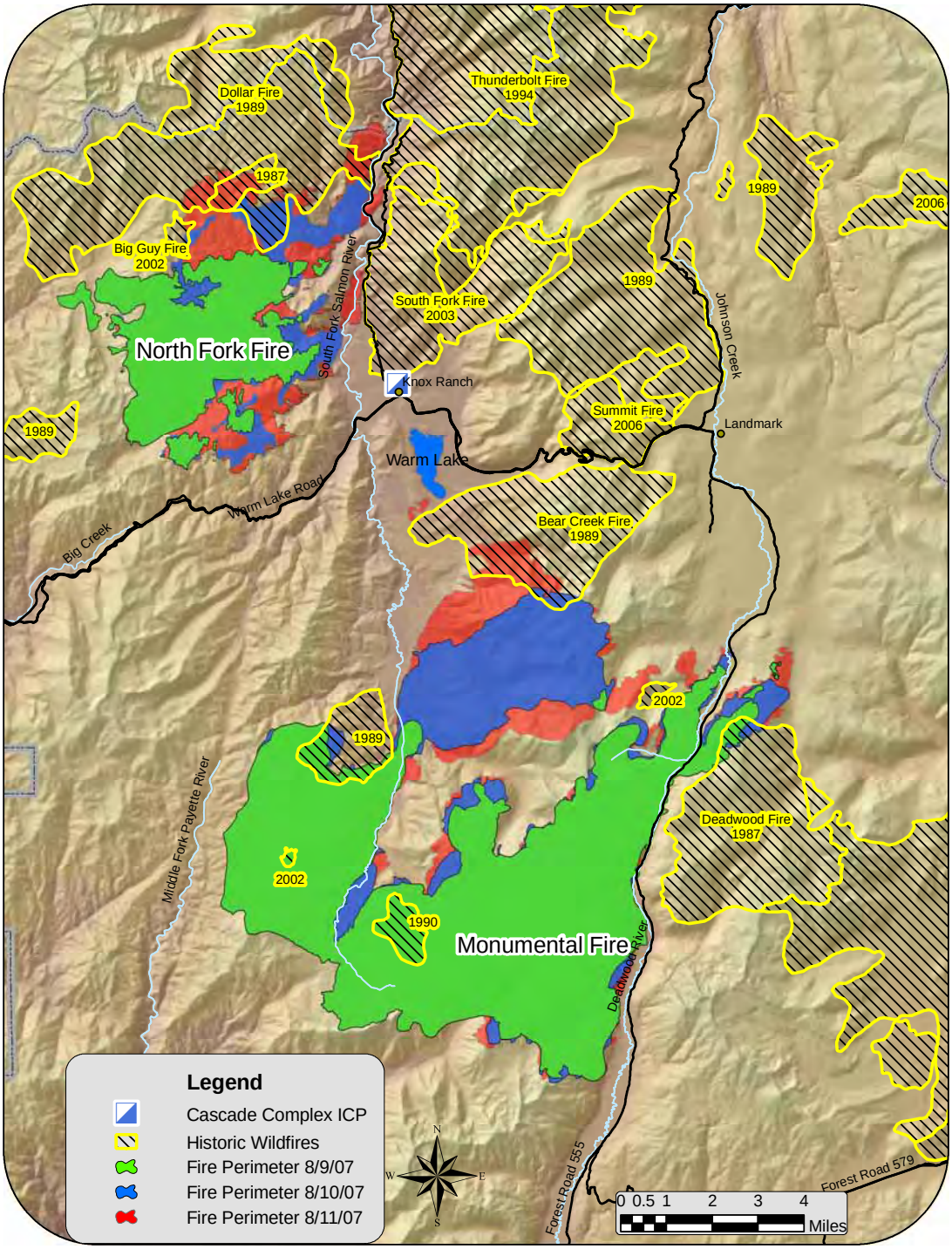


Figure 7 *Cascade Complex August 9-11 Fire Perimeters and Historic Wildfires.*

As part of the logistics required for support of ongoing fire management efforts, a resource order was placed by the Landmark IMT to remove two roll-on dumpsters from the abandoned ICP at the Landmark Airstrip. With this order, the 36-hour story begins.

THE STORY

Early in the morning of August 12 a truck, owned by the contractor who had placed the dumpsters at Landmark, left Challis, Idaho to fill the resource order placed on August 9. The driver, a 57-year old male, was an experienced truck driver and retired Forest Service road crew employee. He was accompanied by a 51-year old female companion who often joined him on long trips. The couple had made this trip before and had hoped that they could save some time by reaching the Landmark Airstrip via the Deadwood Road. However, that road was closed because of fire activity and they were forced to travel the long way around, through the town of Cascade. Around 12:00 to 12:30 p.m. they arrived at a checkpoint located on the Forest boundary (Checkpoint A) just east of Cascade on the Warm Lake Highway (Road #579). They were asked about their business by the road guard, explained that they were ordered to pick up dumpsters at the Landmark Airstrip, and departed for the airstrip. Neither was wearing personal protective equipment (fire shirts, pants, shelter, etc.) nor had access to it inside the cab. At the Big Creek Summit checkpoint (Checkpoint B) they were again stopped. They were told to go through the weed wash station and then proceed to Landmark.

The inversion lifted around 11:00 a.m., and the fires quickly became active. To meet the incident objectives of holding the Monumental fire east of Roads 474 and 427 and south of Warm Lake, Cascade Branch II began firing along these roads to the south from the previous day's burnout to Stolle Meadows. To the southeast of Warm Lake, and south of the Warm Lake road, was the 1989 Bear Creek burn. Since August 9, this old burn had been an effective barrier to the Monumental fire's spread to the north toward the Warm Lake road.

Between Warm Lake and Landmark is a steep adverse grade with an infamous history for vehicles that travel too fast for conditions. (Near the bottom of the grade is a well-known memorial for occupants of a grey water truck that were killed when the truck careened off the road on August 21st, 1998 during another active fire season.) In post-event documentation sent by the occupants of the garbage truck to their Congressman, the

driver and his passenger reported that they arrived at the Landmark Airstrip and proceeded to load one of the full roll-on dumpsters. Another contractor who was watering the airstrip remembers seeing the garbage truck pull in around 2:00 or 3:00 p.m.

Firefighters near the dumpster location were asked by the driver where the full dumpster might be stored while the garbage truck returned for the second dumpster. The driver was told that he could off-load the dumpster at Stolle Meadows transfer station. The driver then told a firefighter that they would leave it at the transfer station and return in an hour or so to pick up the second dumpster. Once the dumpster was loaded, the truck left the Airstrip and began driving back west toward Warm Lake.

At the junction of the Johnson Creek Road (Road #413) and the Warm Lake Highway was another checkpoint (Checkpoint D). This checkpoint was operated by the Landmark IMT to control traffic going north on the Johnson Creek Road through the Riordan fire area. The guard acknowledged the garbage truck as it proceeded west on the Warm Lake Highway, but the guard was not controlling traffic going in that direction. By the time the truck reached the top of the grade, the inversion had lifted and fire activity on the Monumental fire had picked up substantially. As the driver crested the summit and started down the long, winding grade toward Warm Lake, he observed fire on the hill to the south of the highway. About a mile or so below the summit, with the fire intensity picking up, he and his passenger decided to turn around and return to Landmark. As he tried to shift to a lower gear he was unable to engage the transmission, and the truck began rolling faster and faster down the steep grade. He made it through a couple of hairpin turns by hard braking, but the brakes became soft at the next turn. He decided to drive the truck off the road to stop it by running up the slope. As the truck careened off the road, it rolled on its side and slid across the dirt and brush before coming to rest in a small clump of trees. The driver sustained a bleeding head injury, lost consciousness and fell onto the passenger. After a few minutes, though, the driver regained consciousness and the two occupants were able to climb out a window of the overturned truck.

In the recap of their experience provided to the Congressman, the occupants stated that the crash occurred around 1:30 p.m. However, in the documentation package provided by the Cascade SOF1(T), two Training Specialists (TNSPs) returning from Landmark ICP were traveling down the same grade around 3:00 p.m., and do not recall seeing an overturned truck or two individuals on the road. The TNSPs did observe fire across the Warm Lake Highway and reported that to Operations (OSC1) when they arrived at Cascade ICP around 3:15 p.m. At 3:35 p.m., Cascade OSC1 told the Cascade SECM to shut down the Warm Lake Highway to all traffic due to the fire situation. The only checkpoints that the Cascade SECM had established to control access on the Warm Lake Highway were west of the Landmark grade at the junction of the South Fork Salmon River Road (Checkpoint C) and at Big Creek Summit (Checkpoint B).

On the morning of August 12 the Cascade Complex IC signed the final ICP Stay-in-Place plan and preparations around ICP in the form of pumps, hose lays, and sprinklers were in place to wet down the fuels on a continuous basis. The Cascade Complex IC left Knox Ranch with the intent to visit the Landmark ICP near Johnson Creek Guard Station but changed plans and instead touched base with OPBD Branch III on the Deadwood Road around 3 p.m. About 40 minutes later, as he was driving north towards Landmark Airstrip, he heard on the radio that the Warm Lake Highway was closed due to fire activity. He passed the guard at the junction of Warm Lake Highway and Johnson Creek road and drove to the top of the Landmark grade. As he peered down into the Warm Lake basin, the smoke was ominous. Not wanting to risk driving the grade, he turned around and returned to the Landmark Airstrip where he met the Cascade OPBD Branch III again. He does not recall seeing a garbage truck on the road or at the airstrip. The IC and Branch III discussed the increase in fire activity and decided that they would pull all the Branch III firefighters off the line and hold them at the airstrip. The IC remembers talking with the road guard at the Johnson Creek Road around 5:30 or 6:00 p.m. to advise him of the fire activity that might be heading his way. The IC checked to see if he could get back to Cascade ICP via Lick Creek summit, but the East Zone Complex had closed that road due to fire activity, so after dinner at Landmark ICP he returned to Deadwood with the District Ranger and waited for the fire activity to subside. Eventually he was

able to return to Cascade ICP via the Deadwood road, arriving at Cascade ICP just after midnight.

Meanwhile, after climbing out of their wrecked garbage truck, the driver and passenger discussed their predicament. The passenger grabbed her purse and began walking up the hill toward Landmark, but she did not get far before the driver hollered at her to turn around. Recalling his years of fire training in the Forest Service, the driver told her it was not smart to try to outrun a fire going uphill. At their wrecked vehicle, they collected some personal belongings, including a coat, shirt, and stocking cap before starting down the road toward Warm Lake. As they walked, the terrain blocked their view of the fire to the south and west. Once they rounded a corner, about a third of a mile below the wrecked truck, the fire came into view. They turned around, spotting a concrete culvert catch basin against a steep cutbank with very little vegetation where they could take cover.

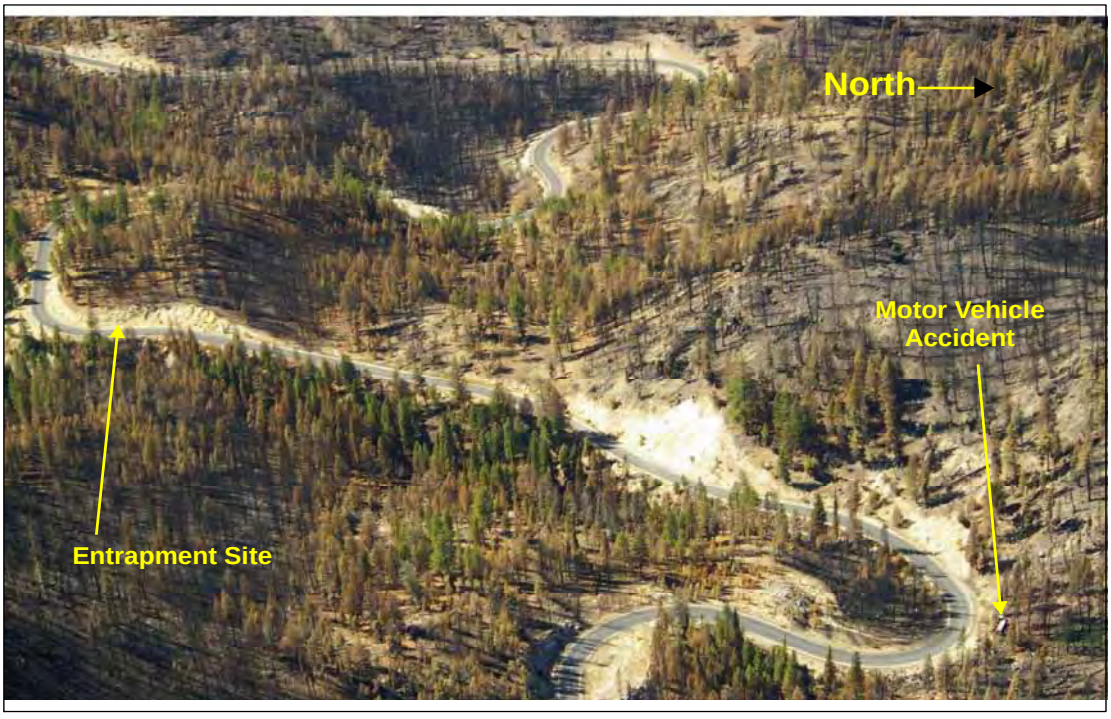


Photo 4 *Aerial view of accident and entrapment sites*

The road was wider at this point and had a pull-off on the active-fire side of the road opposite the catch basin. They crouched in the catch basin and covered their heads with a coat while wrapping a shirt over their noses and mouths. The fire made several runs up the drainage opposite their location, spotting across the road in many places. Luckily, they were able to breathe fresh air coming through the culvert. Several times the driver would stick his head up to assess their situation and the fire activity surrounding them. He recalls heavy smoke, heat, and embers falling all around. After an hour to an hour and a half, he felt that the main fire pulse had moved on, and it was safe to get out of the catch basin. They had survived a crash and a burnover and were still alive. They took stock of their injuries—the driver's bloody face, some cuts and scrapes, a few burn holes on their jacket, and a minor burn on the passenger's arm.

Photo 5

The culvert catch basin where the garbage truck occupants reported taking shelter as fire approached them.

Unsure what to do next, they walked back up to the truck and saw that the fire had burned intensely around it, consuming nearly everything flammable including the garbage and tires. The driver washed the blood off his face in a nearby stream. They debated again

which direction to go, thinking that somebody would eventually come looking for them, remembering that they had told the firefighters at Landmark Airstrip that they would be back in an hour. Finally, they decided to head downhill toward Warm Lake.

After walking approximately two miles, they saw lights and heard pumps running down below them. Around 9:30 p.m. two fallers, who were driving through the fire area on their way to Landmark ICP, stopped when they saw the driver and passenger on the road. They ferried them back down to an engine that was working along the edge of the fire near Warm Lake. At 9:39 p.m. the engine captain radioed to his Task Force Leader (TFLD) that he had two individuals that had been involved in a motor vehicle accident and needed medical treatment. The TFLD arrived at their location at 9:42 p.m. and a few minutes later contacted Cascade OPBD Branch I regarding the situation. The driver and passenger of the garbage truck recounted their story of how they had been ordered to pick up garbage at Landmark, crashed their truck, and had been overrun by the fire. At 9:51 p.m., Branch I and two EMTs arrived at the injured parties' location. At 9:54 p.m., Cascade Complex ICP communications logged a call from Branch I reporting two parties injured in a motor vehicle accident and that they had been burned over by the fire. ICP Communications called Valley County Dispatch to request an ambulance at 9:56 p.m.

The two injured parties were taken to Cascade ICP and assessed by EMTs in the Medical Unit tent. The female passenger complained of abdominal pain. She again recounted her experience to the EMTs. (The Medical Unit log states the passenger related that she and the driver "got trapped in the fire, pick[ed] up a dumpster, heading to Landmark, got over run by fire, truck burned, [two firefighters] hiked out, called EMTs." The Medical Unit log also documented what the driver said, including "tipping over in truck, she's yelling at me. We get the hell out. Went into culvert. Fire all around us. Walked a mile or two. Gears went out, brake started to go so headed for a tree.")

The Medical Unit Leader (MEDL), suspecting internal injuries to the female passenger, asked Communications to order a life flight helicopter to transport her to a hospital. Communications placed this order at 10:50 p.m. right after the ambulance from Cascade

arrived. SOF1(T) also took notes on comments the two injured parties were making but does not recall them mentioning that they were burned over by the fire. He also does not recall if they appeared to have soot on their clothes or smelled of smoke--it appeared to him that they were victims of a traffic accident and nothing more.

Around 11:15 p.m., the ambulance left Cascade ICP to transport the injured driver to the hospital in Cascade. Around 11:30 p.m., the Life Flight helicopter contacted Cascade Communications to report that they could not land due to the thick layer of smoke. The Deputy Incident Commander (DPIC) and the SECM were able to make radio contact with the helicopter and arrange vehicles with their headlights on to help direct the helicopter to a safe landing at ICP. A few minutes after midnight, Life Flight departed for a hospital in McCall with the injured female passenger on board.

In response to the existing contain/confine strategy, a burnout was concurrently taking place along the southeast flank of the North Fork fire (west of Cascade ICP). The intent of the burnout was to contain the southeast flank of the North Fork fire and to buffer the threat of a head fire running toward ICP. The burnout operation continued through most of the night of August 12 and into the early morning hours of August 13. Approximately 1.7 miles of indirect fireline were burned.

The ICS 209 for August 12 stated "fire behavior is extreme with wind driven runs on both the Monumental and North Fork fires. Both the Monumental and North Fork fires [became highly active] at 15:30 overriding the red flag winds…The southern flank of the North Fork fire remains a concern to the Cascade Complex ICP." The North Fork fire increased in size by over 2,100 acres, and the Monumental fire grew by more than 4,200 acres during that burning period.

On August 13 on the 7:00 a.m. AC/IC conference call, the Cascade DPIC reported a successful burnout operation had been conducted, and that there had been a motor vehicle accident with 2 injuries the night before involving a garbage truck assigned to the Landmark Complex. He was unaware that the occupants of the garbage truck had been

burned over by the Monumental fire. The IC and DPIC had agreed that the Cascade Complex would initiate documentation of the motor vehicle accident and had directed SOF1 (T) to begin collecting information at the scene. The SOF1 (T) then traveled to the site and began documenting the accident. At 7:45 a.m. the Cascade District Ranger called the Area Command Team requesting information about the garbage truck accident. The District Ranger said that she would contact the Valley County Sheriff.

After the AC/IC call, the Landmark Complex IC, having heard that the truck was assigned to his incident, directed his SOF2 to look into the situation. When the Landmark SOF2 arrived at the accident scene, he and the Cascade SOF1(T) discussed their conflicting direction. The Landmark SOF2(T) stated that he did not have enough staff to complete the accident documentation, so the Cascade SOF1(T) continued collecting information. By mid-morning, Cascade SOF1 (T) also radioed Cascade ICP to recommend that the Warm Lake Highway should be closed due to rolling material and falling snags.

In an Idaho Vehicle Collision Report filed by the Valley County Sheriff's Office, the reporting officer stated that the Sheriff's Office was notified of the accident at 9:56 p.m. on August 12. A Deputy Sheriff arrived at Cascade ICP at 10:29 a.m. on August 13 to conduct an investigation. He was told that the road was too dangerous for him to travel to the scene of the accident. The collision report stated that the deputy met with the SOF1(T) and discussed how to complete the investigation. The officer then received a dispatch to another incident and was not able to visit the accident site that day.

The inversion lifted in the Warm Lake Basin in the early afternoon of August 13. As the relative humidity dropped, fire activity began to rapidly increase. The North Fork fire spotted across the South Fork of the Salmon River near the junction of the South Fork Road and Warm Lake Highway. The road guard located at that checkpoint (Checkpoint C) radioed Cascade ICP that he was returning to camp due to fire activity. From his air platform, the Cascade Air Tactical Group Supervisor (ATGS) radioed Branch I to recommend evacuation of Knox Ranch because the fire was approaching, but followed

with the report that the only remaining evacuation route (the Warm Lake road west to Cascade) was compromised by the North Fork fire. A 2500-gallon fuel tender did a precautionary move from a fueling location near Warm Lake Highway into the middle of the meadow at Knox Ranch.

Increased fire activity in the vicinity of ICP triggered the Cascade Complex IC's decision to implement the ICP Stay-in-Place plan at 3:45 p.m. Command and General staff met outside the communications tent to coordinate the plan's implementation. All camp personnel were instructed to put on fire pants and fire shirts and to report to the area outside the communication tent for a briefing. The IC and OSC1 relayed the imminent fire threat to the camp and calmly described what those in camp would experience as the fire approached. They discussed the sounds that would be heard, the heat and embers they would feel, and the flames they would see. The IC then asked that fireline qualified individuals disperse around the camp perimeter and patrol for spot fires. Those that were not fireline qualified were told to sit in chairs near the center of ICP. Of the previously identified fourteen that wanted to be evacuated, four had been reassigned to Landmark Spike and the ten that remained were told to board a bus. The bus was unable to leave the camp, however, because fire activity had compromised the exit routes. Those on the bus were then told to join their fellow employees in the chairs near the center of camp.

The North Fork fire burned towards camp in three separate pulses. The first pulse burned along the south side of Cascade ICP. About an hour later the second pulse burned along the west side of ICP. After another hour, the third and final pulse burned along the north and west edge of camp. As the fire approached the camp, Branch I mobilized two hand crews and three engines to patrol the camp perimeter. In addition, ATGS directed two Type 1 helicopters to make repeated water drops along the camp perimeter until smoke reduced the visibility and they returned to the helibase.

A computer technician captured much of the activity on his digital camera as the fire burned around the camp. Approximately thirty minutes of fire and camp activity were recorded and downloaded onto a computer. Many of those in camp also chronicled fire

scenes on their cell phones and digital cameras. A National Interagency Fire Center (NIFC) video crew happened to be on site to film footage for a training video and they, too, recorded some of the fire activity.

Photo 6 View from within the meadow of Knox Ranch ICP as fire approached the camp.

As the event continued, Logistics personnel hauled propane heaters out of tents while embers were falling to prevent them from exploding if the tents were to catch fire. The heaters were then placed under fireproof wrap along with other flammables. One yurt burned and some of the tents in camp sustained burn holes from the ember showers. One vehicle, parked and locked near the edge of the meadow, had a melted grill and a blister in the paint. A row of portable toilets partially melted in the intense heat. A fire whirl moving along the edge of camp was captured by the video. The historical ranch building

adjacent to the meadow, which was being watered with sprinklers, caught fire from embers in the attic and burned to the ground.

The IMT expected the main North Fork fire to burn to the northeast, but instead the smoke column tilted to the east resulting in a heavy ember shower and intense fire activity on several fronts around camp. Many of those interviewed felt that the fire burning around the camp was much more severe than they had anticipated. Many interviewees expressed only minor concern over the event, but many others experienced a wide range of alarm. Some of those interviewed felt that non-arduous fire support personnel should not be subjected to "fire line" conditions. Others felt that the event was well managed and provided an element of excitement to their routine.

At 8:00 p.m. the Command and General staff conducted their planning meeting to develop the next day's Incident Action Plan (IAP). By 9:00 p.m. most of the fire activity around camp had subsided and the caterer served dinner. A 9:30 p.m. AC/IC update call was conducted with the report that all was well at Cascade ICP, and there had been only minor damage to some tents and toilets but the historic building was a total loss.

The Cascade Complex ICS 209 for August 13 stated "ICP is threatened by the southern flank of the North Fork fire…Due to extreme growth a defensive strategy is in place for ICP." The 209 continued with the following: "The Stay-in-Place Plan was implemented at Cascade ICP at 16:00… Some infrastructure and two historical cabins were lost in the Knox Ranch/ICP area…Prior to the camp incident, two civilians attached to another fire were in a vehicle accident and transported to a medical facility." Fire information reports for August 13 indicate that the North Fork fire gained nearly 17,400 acres, and the Monumental fire also grew over 17,000 acres. These fires increased nearly 50,000 acres during the three-day period of August 11 through 13.

In this age of instant information technology, the Forest Public Affairs Officer provided the NIFC Training Unit video, showing destruction of the historic cabin and the fire activity around the camp, to several local TV stations and several excerpts from the

videos were aired on late news shows on August 14. The Cascade Complex TNSP (T) prepared and e-mailed a PowerPoint for his family and friends, containing several dramatic pictures of the fire activity with captions intended to lighten the situation. Additionally, a 150-second clip from the computer technician's 30 minute recording was downloaded a few days later on Youtube.com. The individuals who released the videos and PowerPoint reported an earnest intent to illustrate the Stay-in-Place plan as well thought out, well implemented, and to demonstrate that despite the intensity of the fire around the camp, everyone remained calm.

As people awoke and ventured from their tents on August 14, the smoke was so thick they could not see across camp. The inversion would not lift until late afternoon. The IC had requested the night before that an assessment be done of the need for camp personnel to undergo critical incident stress debriefing (CISD) as a result of the previous day's fire activity. The Forest Safety Officer was assigned the task and after talking with several people in camp he determined that a CISD was not necessary. While there, he also took readings from a handheld carbon monoxide (CO) monitor. He recorded readings of up to 38 parts per million (*for further information see Appendix D, Health and Safety Analysis*) near the ICP on August 14.

Photos 7 & 8

Smoke inversion on the Cascade Complex

Recognizing a need to better control access to the Cascade Complex from the east on the Warm Lake road, Cascade OSC1 discussed the issue with Landmark OSC2. The Cascade OSC1 suggested that the Landmark Complex road guard located at the junction of Warm Lake road and Johnson Creek road could provide traffic control for traffic headed east on the Warm Lake road as well as traffic control for the Landmark Complex on the Johnson Creek road. Landmark OSC2 responded that the issue was created by the Monumental fire (part of the Cascade Complex) and that Cascade had more resources with which to address the issue than did Landmark Complex. The issue of uncontrolled

and uncoordinated traffic heading east from Landmark persisted when the Landmark Complex ICP was relocated from Cox Ranch to a field near the town of Cascade. Cascade OSC1 said he was surprised to see Landmark Complex logistical support traffic moving east through the Cascade Complex active fire area on the afternoon of August 15.

Also around August 15, people on the host unit were inquiring about the motor vehicle accident and a potential entrapment. Incomplete follow-up on this issue resulted in the driver and passenger of the garbage truck elevating their experience to their Congressman, who, in turn, passed it along to the Agency Administrator.

EPILOGUE

As had been the case for several weeks, smoke continued to impact the Cascade ICP location and other areas downwind for several days following the fire burning around the camp. The Agency Administrator visited Cascade ICP with the Chief's Principal Representative on August 15. Both recall that the smoke was heavy. The Area Commander and his Logistics Chief stopped at Cascade ICP on August 16 on a tour of the fires under his command. They discussed smoke conditions and mitigations with the IMT. The Cascade Complex IC responded that the location still provided the best support for line operations and that he would consider moving once structure protection objectives had been accomplished at Warm Lake, believing that this might be possible within the next three or four days.

Figure 8

Satellite image of smoke from Idaho and Montana fires on August 13

Over the next few days, medical unit visits made a significant jump from the level prior to the fire burning around the camp. Records indicate significant numbers of referrals to the medical clinic in Cascade on the days following August 14. Most of the visits to the clinic were for respiratory ailments, including bronchitis and pneumonia. One individual was hospitalized for three days with bacterial pneumonia.

The Cascade MEDL recalled that the IC visited the medical tent and remarked at how busy they were. The Incident Business Adviser (IBA) recalls asking the MEDL about relocating camp due to the illnesses attributed to smoke but that the MEDL responded that it would cost too much to relocate. The IBA also expressed a concern that the "pulse-ox" monitors and nebulizer being ordered were strong indicators to her that camp should be relocated. She also voiced concerns to the SOF1(T) that treatments for smoke

were only good for as long as a patient remained in the medical tent, and that the effectiveness disappeared once the patient returned to the smoky environment.

For those Cascade Complex personnel who were referred to physician visits in Cascade, the attending physician noted on his patient evaluation forms that the patients he was seeing had seriously compromised immune systems due to smoke exposure and that the situation was leading to bacterial pneumonia. He frequently recommended to the patients with respiratory ailments to move out of the smoke.

A member of the Area Command Team visited Cascade ICP for the morning briefing on August 15. He reported seeing his son, a squad boss on a 20-person hand crew, looking like "death warmed over." When asked how he and his crew were doing, the son replied that the whole crew was sick and that the "smoke has knocked everyone on their ass."

Early demobilization was offered by the Cascade IMT to anyone uncomfortable remaining at Knox Ranch following the fire burning around the camp. A few individuals elected to accept that offer and went home early. Crews with the option to spike out chose to sleep outside of the inversion whenever possible. Numerous individuals provided the review team with stories of the effects of these events and conditions at the Cascade Complex ICP.

A Resource Advisor (READ) assigned to the camp recalls hearing the SOF1 (T) comment at a morning briefing that smoke and carbon monoxide created an intoxicated feeling. The READ said that stuck in his mind because he had awakened in the middle of the previous night feeling like he was rolling over and over and couldn't stop.

A hotshot crew superintendent said that smoke issues were his biggest concern and that in 30 years this was the worst he had seen. Two days after the fire burned around Cascade Complex ICP, he moved his crew to Big Creek Summit to sleep. Most of the crew was sick.

Around August 14, it became obvious to the 3rd IMT that the current confine/contain strategy was no longer an effective strategy for these rapidly expanding fires. They initiated discussions with Area Command and Agency Administrators about alternatives for managing the fires. Area Command pulled together the Agency Administrators and ICs, where they discussed and developed the concept of a "mega WFSA," to include approximately six million acres of the Boise, Payette, and Salmon-Challis National Forests. On August 16, the Agency Administrators adopted this strategy and identified for Area Command and IMTs the values they felt were important to protect. The IMTs then developed management action points to focus their tactics to protect those values. Containment actions were no longer indicated for the individual fire perimeters.

Before leaving Cascade ICP the 3rd IMT conducted an After Action Review of the Stay-In-Place event. Many operational items were incorporated into the team's camp safety plan for future Stay-In-Place incidents. The 3rd IMT received an excellent performance evaluation from the 2nd AC for their assignment on the Cascade Complex and an excerpt from that performance rating included the following: "Your management and pre-planning associated with the fire coming into your ICP and Base camp are excellent examples of your focus and commitment to the Safety of all personnel." The 3rd IMT transitioned with the 4th IMT on August 21.

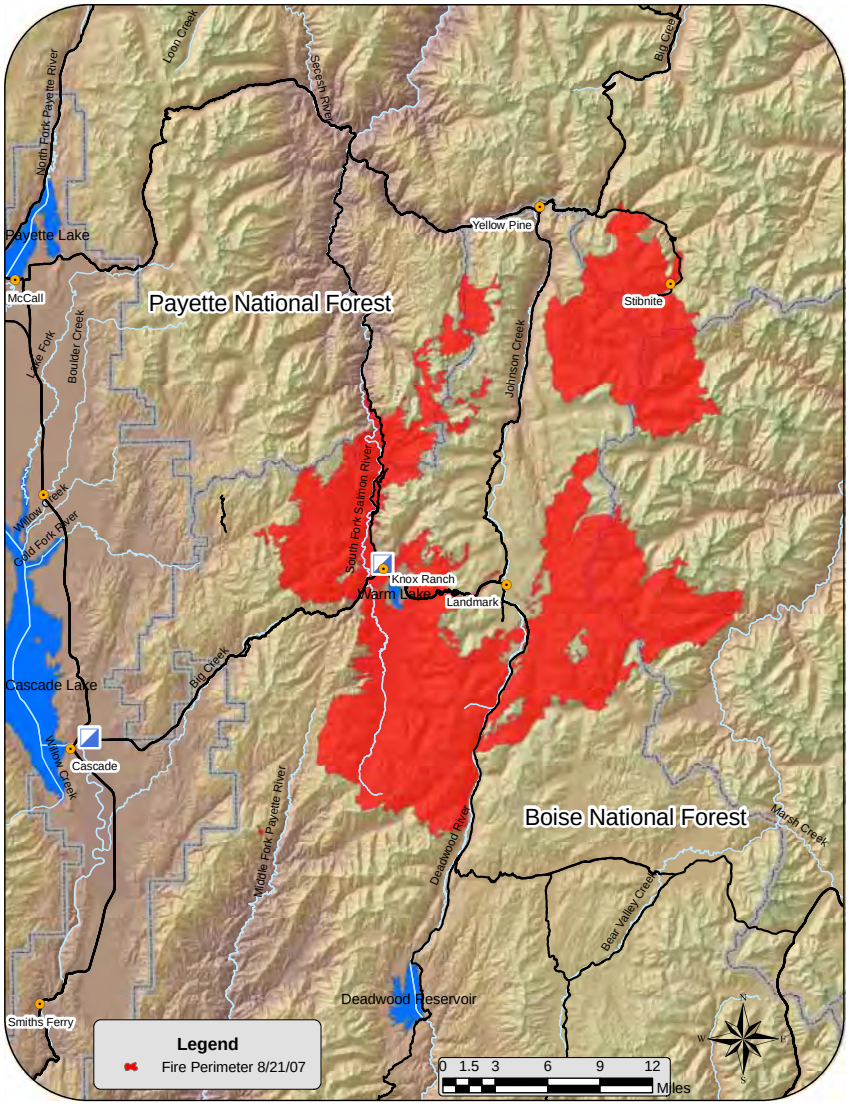


Figure 9 Cascade Complex on August 21. Knox Ranch ICP moved to Davis Ranch east of Cascade.

The 4th IMT assumed management of both the Landmark Complex and the Cascade Complex. The Knox Ranch ICP was demobilized and resources were relocated to the Landmark Complex ICP that had been established just east of Cascade. During discussions between the Area Command and the 4th IMT it was decided to use the existing Landmark ICP location near Cascade as the combined Cascade/Landmark ICP due to operational considerations as well as the health risks due to smoke exposure (*see Appendix D Health and Safety Analysis)* associated with the ICP at Knox Ranch.

The release and unofficial widespread distribution of the PowerPoint and the Youtube.com video led to many discussions among those outside the decision process regarding the Stay-in-Place plan. Postings with a wide array of viewpoints rapidly appeared on www.wildlandfire.com/theysaid.htm. Interviewees used the term "chatter" to describe the significant number of conversations regarding whether a decision to stay or evacuate was the appropriate decision. On August 18 the 3rd Cascade Complex IC distributed a revised PowerPoint and discussion document titled "Cascade Complex ICP Stay-in-Place Event Discussion Document" to the National Multi-Agency Coordination Group for posting on the Lessons Learned website. The revised PowerPoint and discussion document reflected the IC's perspective that staying in camp was the right decision, and that it was well planned and well executed.

As mentioned above, in the days following the fire burning around Cascade ICP a significant number of people working at the ICP reported experiencing adverse health effects due to the smoke exposure, including headaches, nausea, eye irritation, trouble sleeping, and increased respiratory distress to the point where many sought treatment at the Medical Unit and/or Agency Provided Medical Care at the clinic in Cascade. For more information on health effects associated with these complaints, see Appendix D (the Cascade Complex Health and Safety Analysis).

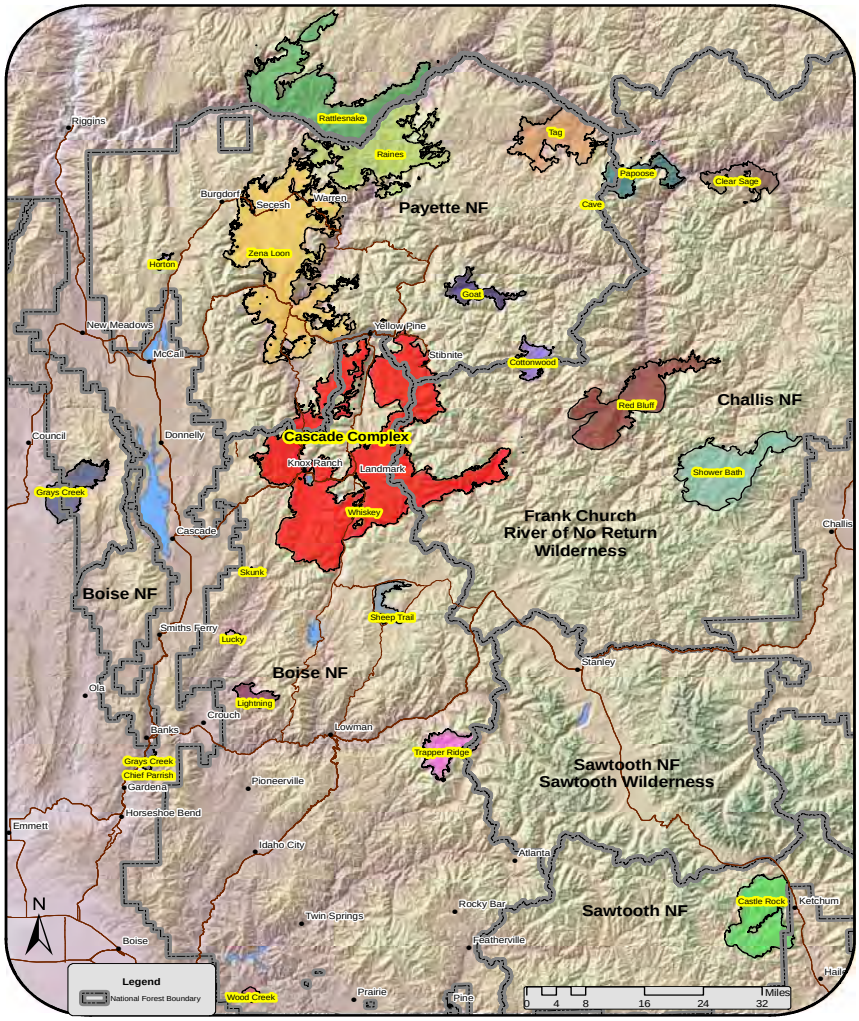


Figure 10

Final fire perimeters 2007

The active fire season continued for several more weeks in central Idaho. On the Cascade Complex, the 4th IMT transitioned after 14 days to a Type 2 IMT that managed under the mega-WFSA until a season-ending event occurred in late September.

As the early snows began to fall on the mountains of central Idaho, an unprecedented fire season was coming to a close and firefighters relished the much-needed rest. The dedicated men and women engaged in this historic season merit recognition for pioneering the adaptive management approach that led to an overall outstanding safety record for 2007 and, integrating lessons learned, will shape fire management for the future.

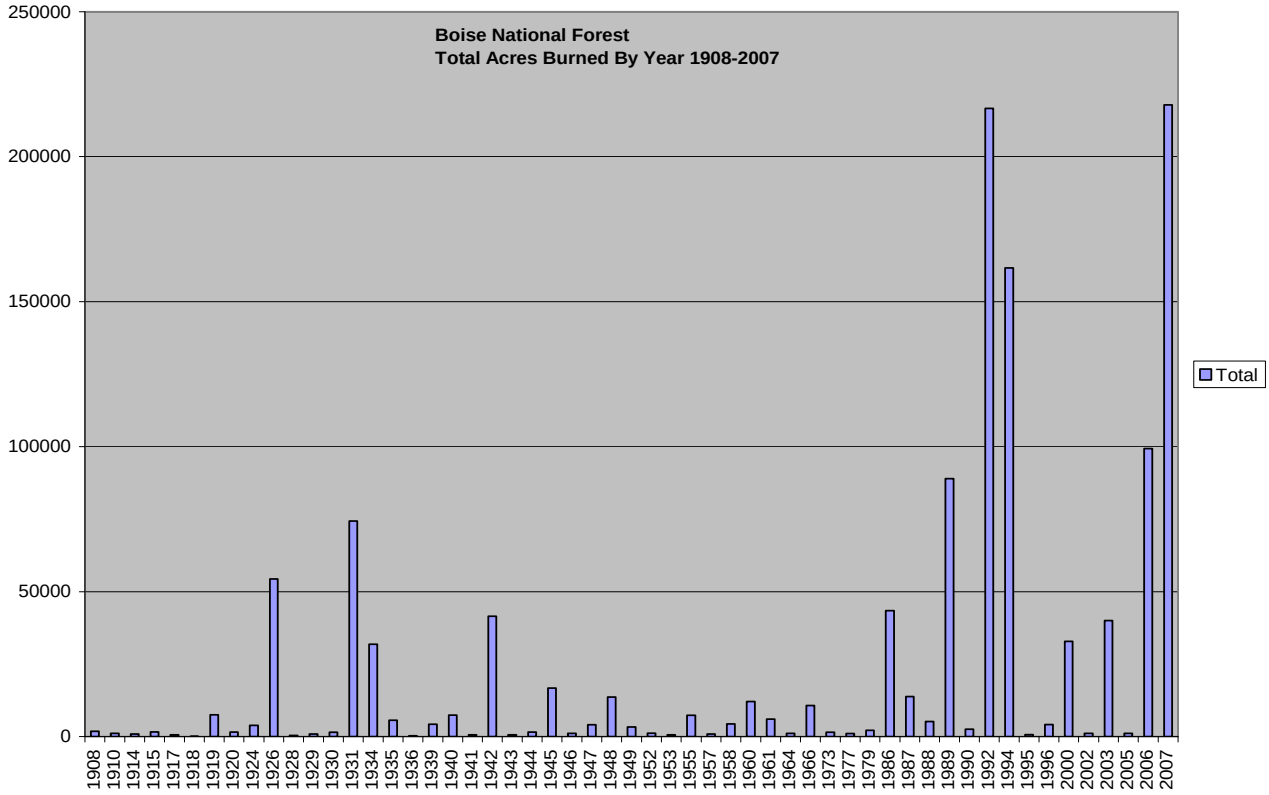


Figure 11 Boise National Forest Total Acres Burned by Year from 1908-2007

LESSONS LEARNED BY THE PEERS

During interviews with personnel directly involved in the events of this Accident Prevention Analysis, the interviewees identified the following lessons they learned from their experiences.

Entrapment

Equipment

- Require Personal Protective Equipment (PPE) for all personnel passing through check points into fire closure areas.
  - Contractors
  - Supply vendors
  - Support personnel

Human

- Clarify road management responsibilities for ingress and egress when major supply lines support multiple incidents and pass through fire closure areas.
  - Staff roadblocks in a professional manner
  - Require identification for ingress and egress
  - Keep log of vehicles entering and exiting
  - Provide escorts for convoys of vehicles when appropriate
  - Clarify who has authority and responsibility to close road access due to fire activity
  - Establish communications capability and protocols between Security Managers (SECMs) on adjacent incidents

- Provide liaisons between IMTs for road closures associated with burnouts and other tactical operations.

- Clarify accident investigation/management roles and responsibilities in delegations of authorities to area commands and incident commanders.
  - Provide for positive hand-off of accident reporting and investigative responsibilities
  - Report critical events via phone or face-to-face discussions rather than via e-mails
  - Close loops on critical incident follow-ups (upward reporting and initiating investigations)

- Consider the potential impacts on major supply lines when establishing Fire Complex boundaries.

- Stagger multiple Incident Management Team (IMT) transitions for incidents in close proximity of each other to improve inter-incident coordination. Avoid multiple transitions happening simultaneously or in a condensed period of time.
  - Ensure mitigation of critical coordination issues occurs, such as road access and management.

Environmental

1. Prior to August 12, meadows and old burned areas such as the 1989 Bear Creek Burn had live fuel moistures that inhibited fire spread or at least moderated the fire spread. A tipping point occurred, live fuel moistures went down from August 12 on. These features no longer restricted or moderated fire behavior.

Stay-In-Place (SIP) and Resulting Property Damage

Equipment

- Ensure all personnel remaining at ICP/Camp have appropriate PPE at least one operational period prior to expected implementation of the SIP Plan.

- Secure all critical computer systems and databases by relocating to a safe location or to a vehicle with a designated driver.

- Prepare ICP/camp for possible wildfire threats by:
  - Moving all tents and trailers away from areas of high risk
  - Secure all flammable liquids (propane, gas, diesel) away from any threat of ignition
  - Move vehicles to predetermined areas, with keys left in vehicles and windows rolled up
  - Stage fire fighting equipment (back pack pumps & fire extinguishers) at strategic locations for spot fire control

Human

- Validate the inclusion of a Stay-In-Place strategy in a Camp Safety Plan, considering:
  - Long term incidents
  - Suppression strategies
  - Long term area and road closures
  - Alternatives for ICP and camp locations where SIP will not be an issue

- Develop a standard template for a SIP Plan to include the following elements:
  - Alternatives including evacuation and relocation
  - Trigger points for SIP implementation, including repositioning of equipment and facilities
  - Cost analysis (moving camp to a new location versus potential consequences of SIP implementation)
  - Description of the worst case scenario
  - Contingency resources necessary to protect the camp under various scenarios
  - Tactical plan for the expected suppression actions
  - Evacuation of personnel not essential to the defense of the camp
  - Fire behavior analysis
  - Fuels reduction measures
  - Removal of flammable fuels such as fuel tenders and propane tanks
  - Protection of infra-structure
  - Radio communication plan
  - Contingency plans for emergency medical evacuations
  - Control of access into the area and direction to road guards

- Consider the following when implementing a SIP plan:

  - Provide personnel an opportunity to voice concerns and challenge the SIP strategy
  - Brief all personnel (including contractors and vendors) on roles and responsibilities associated with SIP
  - Advise local dispatch center to halt all incoming resources including service and supply traffic
  - When possible evacuate all non-firefighting personnel prior to imminent threats from wildfire and the implementation of defensive fire suppression actions
  - Coordination with adjacent IMTs when applicable

- Consider the following:
  - All personnel in camp have not had firefighter refresher training
  - Not everyone is a trained firefighter
  - There are no physical fitness requirements for camp and support overhead personnel
  - The need for daily reminders and briefings on the status of SIP plan implementation
  - Be aware of the mental impacts (such as increased stress) of a complex incident like the Cascade Complex.
  - Engage non-firefighter personnel in the process.

- Improve Agency Administrator, Area Command, and IMT training to address long term incidents and mega fire issues:
  - Intra-incident coordination between IMTs
  - Long term physical effects on personnel

Environment

- Assess sites for ICPs/base camps that offer the most overall benefits. If ICPs will be located in proximity to firelines to provide optimal support for operations, then camps should be set up in the best defensive orientation, for example the widest part of a meadow.

Remain in Place and Resulting Personal Illnesses

Equipment

- Provide tents with oxygen-enriched air when camps are in chronic smoke conditions

- Execute continuous 24 hour CO monitoring, check the charts and recordings several times a day to determine conditions and trends.

- Use monitoring devices to determine particulate levels.

Human

- Consider more than fire suppression objectives and operations when making decisions to operate camps in smoky environments. Other considerations should include:
  - Social ramifications
  - Political ramifications
  - Economic impacts such as OWCP claims
  - Share decision criteria with safety staff for use in the risk management analysis.

- Be aware of thresholds, and provide respites from smoke and carbon monoxide when thresholds are exceeded.

- Be alert for mental and behavioral effects of CO and smoke intoxication in incident personnel.

- Minimize the number of people required to remain in smoky conditions, especially support personnel

- Provide physician assistants or mobile medical clinics in smoke impacted camps

- Area Command training should include tactical situations when command authority should be exercised, such as when to provide direction to move camp locations.

- Situational awareness can be compromised with exposure to heavy smoke and CO

- Don't let the Incident Action Plan (IAP) operational objectives impact decisions regarding employee health and safety

- Learn from hindsight (such as, the ICP and base camp probably should have just been moved).

Environmental

- Consider installing "smoke eaters" in confined workspaces

- Provide air quality monitoring with thresholds for smoke and CO exposure that would trigger considerations for camp relocation.

LESSONS LEARNED ANALYSIS

The Lessons Learned Analysis (LLA) is a display of relevant facts of the accident, an analysis of the peer lessons learned and the APA team's analysis of the cultural and organizational faults or weaknesses that contributed or were causal to the following three separate accident events: **1)** the entrapment of two individuals; **2)** the stay in place event resulting in property damage as the fire reached and burned around the ICP and base camp; and **3)** the remain in place which resulted in significant increases in occupational illnesses. The LLA assessed categories and factors germane and pertinent to each event: **a)** key issues, decisions and behaviors; **b)** related elements; and **c)** "upstream causal and latent factors"[*]*.

Minimum skill and quality experience is an issue of concern to the firefighters involved in any incident as well as a major focus of the APA review team. During this analysis the review team did not have access to the various agencies' IQCS master records of individuals interviewed because there is currently no established process by which to do so. Qualifications were reviewed as opportunities presented themselves, but the team relied mainly on high confidence in the various levels of checks and balances embedded in the IQCS system.

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

> Throughout the investigative process the team should be performing a "Substitution Test" – this is asking: could another employee (or supervisor of the activity) meeting the agency's minimum competency standards make the same decisions and have the same (or worse) outcome? If the answer to this question is "yes" then it is likely a similar or worse accident will occur again unless the latent causes are identified and mitigated. (*APA Guide, page 25)*

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

An issue was identified by the APA team regarding mobilization of the 3rd IMT without a qualified SOF1, but with a SOF1(T). Based upon the initial review of the team roster for the 3rd IMT's mobilization (documented in ROSS) it appeared that all Command and General Staff positions were filled with fully qualified personnel per NMG 63.1. During

[*] Causal Factors are the underlying (latent) organizational and cultural factors (the upstream factors) that enabled human errors to produce an unintended outcome, factors that are failing to manage at-risk behaviors or normalization of deviance at the organizational level. Causal factors do not include omissions or deficiencies such as fatigue, inappropriate actions, failure to comply with the standard firefighting orders, etc.

the analysis process of the Cascade Complex, it was discovered that there were two SOF1 trainees and an absence of a fully qualified SOF1. The Incident Management Team recognized the critical need to have a fully qualified SOF1 and ordered this position during mobilization. This position order was filled and the fully qualified SOF1 arrived on scene 4 days after mobilization, on August 12.

I. Accident: Entrapment

Key Issues, Decisions and Behaviors.

1) From July 19 through August 16, the WFSA strategies for the Monumental Fire were to contain the fire and *"limit the fire's spread to the north and the east"*. On August 16 this fire was only 18% contained.

2) Area Command, with Agency Administrator concurrence, established a new complex on the east side of Cascade and East Zone Complexes, indirectly creating a need for IMTs to have to coordinate on common travel routes.

3) Road coordination and management by the affected IMTs within the fire area was not fully effective, as evidenced by:
   - No checkpoint to control and track traffic headed west from Landmark.
   - Absence of procedures and protocols and only minimal coordination between IMTs using the same road system for fire related traffic.
   - Key Command and General (C & G) staff individually attempted to resolve road management issues, but unresolved issues were not elevated to the Incident Commander (IC) or Area Commander (AC) to resolve.
   - IMTs did not coordinate the removal of dumpsters at Landmark airstrip.

4) Risk assessment did not take into account the hazards of access into the fire area because the Monumental fire was not expected to reach the Warm Lake Road on August 12.

5) Individual IMT members were aware of significant issues or events that were not communicated to the rest of the IMT for resolution or coordination.
   a) Fire trapping two individuals on Warm Lake highway
   b) Responsibility for traffic management on Warm Lake highway

Related Elements

2. The IMT expected the Monumental Fire's northern spread to be checked by the Bear Creek Burn of 1989. Prior to August 12, live fuel moistures in grasses and shrubs had inhibited spread.

3. The IMT had several significant concerns including: **1)** the burnout operations on the southeast flank of the North Fork fire to secure the Warm Lake Highway focused the IMT's attention on the segment of the Warm Lake Road between Knox Ranch and the Big Creek Summit; and **2)** the Monumental Fire threat to structures and recreational facilities in the Warm Lake and Deadwood areas.

4. As a result of these concerns, and the assumption that the Bear Creek Burn of 1989 would limit the northern spread of the Monumental Fire, the IMT did not plan for the unexpected and did not see the imminent threat to the Warm Lake highway between Knox Ranch and Landmark.

5. The standard operating procedures at the IMT level appeared to be inadequate to ensure an appropriate level of communication and coordination between members of the IMT.

Upstream Causal and Latent Factors

1. The need for IMTs to coordinate with other IMTs is not an uncommon scenario in the real world. Currently, S-420 and S-520 do not train for and/or evaluate team member ability to accomplish this coordination.

2. Traveling by motor vehicle through a fire area is a high frequency activity with a low assessed risk of being adversely impacted by the fire. Consequently, motor vehicle travel routes are routinely overlooked in IMT planning meetings for hazard identification and risk mitigation (LCES) needs.

3. Interpretation of the Red Book's guidance on "Visits to The Fire Line"; "Escorted" and "Non-Escorted Visits" are generally not viewed as applicable to service contractors, vendors and others that are not directly assigned to operations.

4. There are no IQCS standards for personnel staffing road checkpoints. Most are not trained in doctrinal principles and there are no standard operating procedures and protocols for checkpoints.

Recommendations:

1). The Regional Forester should recommend that the National Fire and Aviation Executive Board amend the Interagency Standards for Fire and Aviation Operations, ISFFAO ("Red Book") as follows:

A) Expand the context of *"Visits to the Fire Line"* to include service and support personnel entering hazardous fire areas.

B) Adopt doctrinal principles, protocols and/or develop team SOPS for tracking and managing access on trails and roads into or through high-risk closure areas.

2). The Regional Forester should recommend that the National Wildfire Coordinating Group (NWCG) review this report and evaluate if additional training is needed to address the causal and latent factors associated with risk management in "mega" fire situations and to provide tools and principles to assist IMTs in planning for the unexpected.

II. Accident: Stay-In-Place

(Property damaged as fire reached and burned around the ICP and base camp, including historic structures, yurts, a dumpster and private firefighter property; and exposure of non-firefighting personnel to fire.)

Key Issues, Decisions and Behaviors

1) The 1st IMT established their ICP at Knox Ranch. The 2nd IMT was directed by the 1st Area Command to retain Knox Ranch as their ICP. The 3rd IMT decided to retain Knox Ranch as ICP based on:

- Mitigation of driving time and hazards for operational personnel, and support personnel servicing spike camps (including heavy machinery and delays associated with road construction on the Warm Lake highway)
- Proximity to operational objectives
- The convenience of the existing camp infrastructure at Knox Ranch.

As the threat of fire reaching the ICP increased, the IMT remained steadfast in their decision to retain Knox Ranch as ICP in order to accomplish mission objectives. A major factor was the team's confidence that Knox Ranch was a good safety zone.

2) The 1st Area Command's transition plan for replacing Area Command and IMTs was accelerated due to pressure from one of the host units to reduce the number of "moving parts" and to take advantage of current availability of familiar Great Basin IMTs. As a result five teams, including Area Command, were replaced within a 36-hour period.

3) The 3rd IMT involved in planning the Stay-In-Place underestimated the severity of the fire burning around the Cascade Complex ICP. Property damage resulted from limited preparations within the ICP for a potential burn around, (such as moving property located near the timber line further into the meadow, burning out around the

ICP prior to the event, or conducting fuels mitigation efforts around the ICP. The IMT perceived Knox Ranch was a safe location with minimal risk.

4) The 3rd IMT initiated burn out operations northwest and to the south of ICP on August 10 through the early morning hours of August 13. This was to contain the southeast flank of the North Fork fire, thereby reducing the threat to ICP. The burnout likely contributed to the burn around of ICP on August 13.

5) Property damage claims to date total approximately $17,000 with other significant claims pending.

Related Elements

1. The Fire Behavior Analyst (FBAN) was not involved in the decision to retain the ICP location at Knox Ranch, nor was he involved in developing the Stay-in-Place Plan.

2. On the first day of the 3rd IMT's assignment to the Cascade Complex, the team decided to retain the Knox Ranch location as ICP. Subsequent reassessments of that decision continued to validate the original decision with consideration of:

- Familiarity with the site and the known safety zone.
- A strong impetus to reduce driving hazards associated with road construction, as well recognition of the history of driving accidents on the Warm Lake highway.
- Proximity to values at risk.
- Strong Agency Administrator direction to minimize fire spread toward Warm Lake.
- Maintaining a presence for private property owners in area.
- Costs associated with moving ICP.

3. Planning for the Stay-In-Place did not include a risk assessment. If a risk assessment had been completed, it may have led to better preparation of the ICP and base camp for the advent of fire burning around the ICP, one objective would have been to minimize property damage. Such an assessment may have led to a reaffirmation of the team decision to remain at Knox Ranch.

4. The complete turnover of five incident management organizations within the Cascade Area Command in a 36-hour period resulted in critical information not being shared. An example of this is the Fire and Aviation Safety Team (FAST) documented recognition of the imminent fire threat to the Cascade Complex ICP from the North Fork Fire.

5. The 3rd IMT had several significant concerns during the 12th and 13th, including: **1)** the burnout operations on the southeast flank of the North Fork fire to secure the Warm Lake Highway, and **2)** the Monumental Fire threat to structures and recreational facilities in the Warm Lake and Deadwood areas. These concerns focused IMT attention on the segment of the Warm Lake Road between Knox Ranch and the Big Creek Summit. As a

result, the IMT did not fully recognize the imminent threat that the North Fork fire posed to the ICP and did not plan for the unexpected.

Upstream Causal and Latent Factors

1. Organizationally and culturally we have embraced the notion of risk assessment but we rarely apply it to non-fireline situations.

2. A wildland fire burning around an ICP is not viewed in the same context as a wildland fire burning around a safety zone where "visit to the fireline" protocols would have been implemented for non-line qualified support personnel. (For example, a spike camp in a large safety zone typically houses non-fireline qualified personnel but they are trained and equipped with full PPE, including fire shelters.)

Recommendations:

1). The Regional Forester should recommend that the Lessons Learned Center post this report for the widest possible distribution.

2). The Regional Forester should recommend that the National Multi-Agency Coordinating Group distribute this report to all Type 1 and 2 Incident Commanders with a cover letter requesting they read and discuss this report with their respective team members.

3). The Regional Forester should request the National Fire and Aviation Executive Board amend the ISFFAO ("Red Book") "Visits to the Fire Line" section to include all areas hazardous to support personnel within the fire area.

III. Accident: Personal Illnesses From 8/13 to 8/21, Following Fire Burning Around the Camp.

(There was chronic (8 + days) exposure of camp personnel to heavy smoke, and elevated carbon monoxide levels, resulting in numerous cases of respiratory illnesses, including bacterial pneumonia, and possible diminished cognitive skills.)

Key Issues, Decisions and Behaviors

1. The 3rd IMT decided to remain at Cascade Complex ICP in spite of heavy smoke and elevated levels of carbon monoxide.

2. Prior to fire burning around the ICP, medical unit visits were approximately 50 per day. After the event, medical unit visits averaged over 300 per day. The IMT made no strategic change to mitigate the trend. Nothing was mentioned in the Safety or Medical Unit narratives regarding smoke effects and health impacts at ICP.

3. The 3rd IMT weighed the risks and cost of moving camp versus remaining in place to facilitate accomplishment of operational goals and elected to remain in place.

4. The 3rd IMT ordered specialized medical equipment and vitamins to treat physiological effects of smoke.

5. The IMET for the 3rd IMT forecasted the smoke inversions would be short-lived after the fire burned around the camp, which created expectations that conditions would be improving soon.

Related Elements

1. There is no standard applied to smoke exposure for fireline/non-fireline incident personnel. (*See Appendix D Health and Safety Analysis for NIOSH and EPA standards*).

2. There was no monitoring of the smoke exposure to include carbon monoxide and particulate matter at ICP. In addition, the IMT did not have protocols in place to recognize the significance of smoke effects.

3. The Area Commander recognized the smoke issues and facilitated discussions with the Incident Commander regarding moving the ICP, though the base camp remained at Knox Ranch.

4. Members of the IMT were preoccupied with developing responses to unauthorized public distribution of information (i.e. powerpoint presentation) following the ICP burn around event.

5. Refer to Human Factors Analysis (Appendix C) on effects of CO on cognitive skills. Refer to Smoke Exposure Safety write up and Smoke Exposure Report (Appendix D).

6. Reference “Group Think” in the Human Factors Analysis (Appendix C).

Upstream Causal and Latent Factors

1. Organizationally and culturally, illnesses do not have the same status as personal injury or motor vehicle accidents.

2. Organizationally and culturally, smoke exposure is not viewed as a health hazard worth mitigating. There is an ingrained cultural acceptance that breathing smoke by all incident personnel, no matter how intense, is part of the job.

3. Wildland fire agencies have not embraced research findings on the acute (short-term) adverse effects of smoke on human health including compromised immune system and diminished cognitive abilities (see Appendix C, Human Factors Analysis and Appendix D Smoke Exposure Safety write up).

4. The Wildland fire community has not adopted the established processes for tracking personal illnesses, or for establishing thresholds to trigger mitigation actions (including training to mitigate smoke).

5. Area Commanders are taught, and perhaps even selected for, facilitative skills as opposed to using direct command authority to change a course of action.

6. Organizationally there is no training to improve the very mind itself, to the end of increased awareness and improved decision-making.

Recommendations:

1. The Regional Forester should recommend that NWCG incorporate scenarios into Area Command and Agency Administrator training, emphasizing when command authority should be exercised.

2. The Regional Forester should recommend that NWCG develop protocols and thresholds for acute (short-term) smoke exposure to minimize respiratory infections and the cumulative effects of CO and that NWCG sponsor research to determine these thresholds to better define effects of mitigations for smoke exposure and CO.

3. The Regional Forester should recommend that NWCG establish protocols for reporting personal illnesses on ICS-209's, similar to the reporting requirement of personal injuries, for incident illness tracking.

4. The Regional Forester should recommend that NWCG develop guidance to evaluate occupational illnesses for the purposes of assessing medical trends (and OSHA recordables) that would trigger mitigation actions.

SUMMARY OF RECOMMENDATIONS

The following recommendations are from the Lessons Learned analysis:

1. The Regional Forester should recommend that the National Fire and Aviation Executive Board amend the Interagency Standards for Fire and Fire Aviation Operations ("Red Book") as follows:

   A) Expand the context of *"Visits to the Fire Line"* to include service and support personnel entering hazardous fire areas.

   B) Adopt doctrinal principles, protocols and/or develop team SOPS for tracking and managing access on trails and roads into or through high-risk closure areas.

2. The Regional Forester should recommend that the National Wildfire Coordinating Group (NWCG) review this report and evaluate if additional training is needed to address the causal and latent factors associated with risk management in "mega" fire situations and to provide tools and principles to assist IMTs in planning for the unexpected.

3. The Regional Forester should recommend that the Lessons Learned Center post this report for the widest possible distribution.

4. The Regional Forester should recommend that the National Multi-Agency Coordinating Group distribute this report to all Type 1 and 2 Incident Commanders with a cover letter requesting they read and discuss this report with their respective team members.

5. The Regional Forester should request that the National Fire and Aviation Executive Board amend the ISFFAO ("Red Book") "Visits to the Fire Line" section to include all areas hazardous to support personnel within the fire area

6. The Regional Forester should recommend that NWCG incorporate scenarios into Area Command and Agency Administrator training, emphasizing when command authority should be exercised.

7. The Regional Forester should recommend that NWCG develop protocols and thresholds for acute (short-term) smoke exposure to minimize respiratory infections and the cumulative effects of CO and that NWCG sponsor research to determine these thresholds to better define effects of mitigations for smoke exposure and CO.

8. The Regional Forester should recommend that NWCG establish protocols for reporting personal illnesses on ICS-209's, similar to the reporting requirement of personal injuries, for incident illness tracking.

9. The Regional Forester should recommend that NWCG develop guidance to evaluate occupational illnesses for the purposes of assessing medical trends (and OSHA recordables) that would trigger mitigation actions.

APPENDIX A

CHRONOLOGY OF EVENTS

Date (2007)	Time (all times approximate)	Event
July 17	evening	Monumental and 24 other new fires ignited by lightning.
July 20	0600	IMT2 assumes command of Garden Valley Complex, later named Cascade Complex, and establishes ICP at Knox Ranch.
July 25	0600	Area Command is established in Cascade area.
July 25	0600	IMT1 assumes command of Cascade Complex.
July 31		FAST report states that Knox Ranch ICP may be threatened by fire within 48-72 hours and there may be a need to evacuate.
Aug 1		FAST out-briefed with Cascade Complex IMT1.
Aug 3		FAST out-briefed with Forests and Area Command.
		Area Command 2 makes decision to reconfigure Complexes, adds North Fork fire to Cascade Complex and Riordan to Landmark Complex.
Aug 8	2000	Transfer of IMT1 command on Cascade Complex.
Aug 9	0600	Transfer of Cascade Area Command.
	0600	IMT2 assumes command of Landmark Complex.
	0600	IMT1 on Cascade Complex receives new delegation of authority from new Area Command.
		Transfer of command on East Zone Complex from IMT1 to NIMO team.
		Decision by Cascade Complex Command and General staff to develop Stay in Place strategy.
Aug 10	0900	Per the AC/IC call, the Warm Lake road is closed to all but fire traffic.
Aug 11		Per Fire Narrative, District Ranger closed Warm Lake highway and ordered evacuation of Warm Lake.
		Cascade Complex Operations makes decision to set up a spike camp at Landmark airstrip (Airstrip Spike).
		"Stay in Place" Plan is circulated for comment by Cascade Complex SOF1 (T).
	1830	Per ICS 209, firing operations are initiated on the Monumental fire at the south end of Warm Lake.
	1830	Per ICS 209, the North Fork fire progression remains a concern to Cascade ICP.
Aug 12	1125	Cascade Complex Division M begins firing operations from Warm Lake south.
	1330-1400	Per District Ranger, Zone AFMO was at Landmark Airstrip, did not see garbage truck.
	1400-1430	Garbage truck departs Airstrip Spike (Landmark).
	1330-1600	Motor Vehicle Accident (actual time not validated yet).

Date (2007)	Time (all times approximate)	Event
Aug 12	1400-1500	Contractor witnessed garbage truck pull into Landmark Airstrip and load dumpster.
	1500	Cascade Complex TNSP and passenger travel Warm Lake road, observe multiple spots across the road but no vehicle wreckage.
	1515	Spot fire detected north of Warm Lake highway, northeast of Drop Point 32.
	1535	Security told to shut down highway due to running fire.
	1900-2000	Garbage truck driver and passenger leave culvert catch basin to walk back to truck.
	2139	E-41 Engine Operator notifies a Cascade Complex TFLD of 2 injured individuals.
	2142	TFLD talks with injured individuals.
	2145	TFLD informs Cascade Complex OPBD Branch 1 of injured individuals.
	2151	OPBD Branch 1 and 2 EMTs arrive on scene of injuries.
	2154	Communication from OPBD Branch 1 to ICP: 2 injured—got burned over by fire.
	2156	Cascade ambulance dispatched to Knox Ranch ICP.
	2227	Cascade Complex DPIC to Landmark Communications—MVA, need to get the IC ASAP.
	2245	Cascade ambulance arrives at ICP.
	2250	Cascade IMT1 orders Life Flight.
	2350	Life Flight on the ground at ICP.
Aug 13	0008	Life Flight leaves ICP.
	0112	Cascade ambulance arrives at hospital.
	0500	Begun in the night on August 12, 1.7 miles are burned out south of 2 Bit Creek on North Fork fire.
	0700	Landmark SOF2 arrives at accident scene, talks to Cascade Complex SOF1 (T).
	0700	Cascade Complex DPIC reports to Area Command that a trash truck on its way to Landmark ICP had an MVA and didn't make it to camp--1 female life-flighted and 1 male transported by ground to hospitals.
	Mid-morning	SOF2 radios to Landmark ICP that the road is unsafe for travel, no traffic.
	Late morning	Forest Zone FMO reports to Forest AFMO that a garbage truck was wrecked when fire overtook them, they were able to crawl out of the wrecked vehicle and took refuge in a culvert till the fire passed by.
	Early afternoon	Inversion lifted; RHs rapidly and significantly decrease, North Fork fire jumped South Fork road, threatening Knox Ranch (Cascade ICP).
	1530-1600	Per phone call to Forest AFMO, Cascade Complex DPIC reports that “Stay in Place” is being initiated. Had to hang up phone to deal with fire surrounding the camp.

Date (2007)	Time (all times approximate)	Event
	1545	Cascade Complex Incident Commander used PA system to tell personnel to report to the Communications Tent as the 'Stay in Place' is to be implemented.
	1545-2000	North Fork fire burns around Cascade ICP.
	1645	Cascade Complex tells Expanded Dispatch in Boise to stop everything going to the Complex as there is a "possibility of burn over at ICP".
	1711	Per WildCad log, Cascade Complex ATGS radios to Cascade Complex OSC1, advises evacuation of ICP as the fire was threatening camp.
	1730	Per ICS 209: running crown fire enveloped ICP.
	1900	Cascade Complex IC requests on Area Command call to "go first" since there was a "burn-by" happening. On the same call, it is also reported that the burnout along Warm Lake Road was lost, and the south and west flanks of ICP were jeopardized.
	2130	Area Command call to obtain update on status at Cascade ICP.
Aug 14	1700	Smoke inversion lifts for a period at Cascade ICP.
Aug 15		Cascade Complex personnel burn out the eastern, and a portion of the northern flank of Cascade ICP.
		Decision is made to change AMR strategy from confinement to point defense. Efforts to burnout or build direct line have proved to be generally ineffective with the lack of Type 1 crews.
		Per District Ranger, County Sheriff handed a report on the MVA to the Forest Supervisor at Knox Ranch ICP.
	1020	Local Dispatch center manager e-mails to Expanded and Initial Attack dispatchers requesting follow-up information on investigation of garbage truck MVA and burnover.
	1300	Inversion lifts, Monumental fire becomes active on several fronts, Monumental merges with Sandy fire.
	1520	Local Dispatch center manager e-mails Forest FMO and AFMO requesting follow-up information on garbage truck MVA and burnover.
	1900	Per AC/IC call, Cascade Complex IC reports "another" trash truck rollover from Landmark, and also that it is "still hot at ICP".
Aug 16		"Mega" WFSA prepared.
Aug 18	1810	Forest AFMO forwards Dispatch center manager e-mail to Cascade District Ranger and others for follow-up information.
Aug 19		Per Cascade Complex SOF1(T), 7 copies of the MVA report are distributed to the Forest, Area Command, etc….

Date (2007)	Time (all times approximate)	Event
	1730	Cascade District Ranger e-mails reply to Forest AFMO describing the garbage truck MVA and states the truck was burned over in the fire and the two occupants “were not caught in the fire”.
Aug 21	1800	Transfer of IMT1 command on Cascade Complex.
		Relocation of ICP from Knox Ranch to Cascade begins.
Aug 29		Congressman’s office sends Forest Supervisor an e-mail with garbage truck occupants’ statement and requests follow-up information as well as a report on the actions taken.
Sept 4	0735	Forest Supervisor e-mails reply to Congressman’s office promising follow-up and forwards message to the Deputy Forest Supervisor, Fire Staff Officer, and Forest Safety Officer.
	1900	On the AC/IC call, Forest FMO shares the "entrapment" story with the ICT1 who had command at the time.

APPENDIX B Fire Behavior Specialist Report

This summary interprets the fire environments for the Monumental Fire on August 12, 2007, as it relates to the entrapment of two individuals following a motor vehicle accident; and the North Fork Fire on August 13, 2007, as it relates to the burn around of the Knox Ranch ICP. The summary covers the topography, fuel conditions, and weather related factors that influenced fire behavior on these two days.

Topography: Both fires occurred in mountainous terrain ranging from steep, rugged canyons to the comparatively flat Warm Lake Basin along the South Fork Salmon River. Elevations ranged from 5,000 feet to over 8,500 feet. The alignment of the major river basins is in a north/south orientation with tributaries in an east/west orientation, and generally aligned with prevailing southwest winds.

The entrapment site occurred on a southern aspect at an elevation of 6,200 feet in the upper third of Warm Lake Creek; a WSW to ENE orientated drainage with slopes of 40-100%. The ground is steep and broken, requiring several sharp switchbacks in order for the highway to climb over Summit Pass towards Landmark.

Photo 1. Warm Lake Highway climbing over the summit to Landmark

Knox Ranch ICP was located on a gentle SW aspect at 5,200 feet within the Warm Lake Basin near the South Fork Salmon River and Warm Lake. The basin lies in a north/south orientation between the North Fork Range to the west and Salmon River Mountains to the east. Slopes within the basin range from 0-20%.

Photo 2. Warm Creek Basin and Knox Ranch ICP.

Fuels: At the entrapment site along Warm Lake Creek, mixed conifers were the primary fuel type with open ponderosa pine/fir over story and grass/shrub understory with moderate fuel loadings. Across the drainage on a northern aspect were denser stands of spruce/fir with heavier fuel loading. The lower south side of Warm Lake Creek burned in 1989 and was in varying stages of succession, ranging from seven foot "dog-hair" lodgepole pine near Warm Lake to open slopes of grass/elk sedge/bear grass with mountain shrub. There were numerous dead and down logs further up in the drainage. There were several unburned islands of trees scattered throughout the 1989 burn area.

Around Knox Ranch ICP, from South Fork Salmon River east to the camp location, the primary fuel type was lodgepole pine mixed with scattered sub-alpine fir. Riparian areas north, south and west of camp contained mostly herbaceous species, and grass with some decadent scattered aspen. The lodgepole pine surrounding ICP varied in size from saplings, to poles, to mature trees with a dead and down component that carried fire and

was receptive to spotting. Within the basin numerous fuels treatments had been completed since 1996 with over 8,000 acres of prescribed burning and 750 acres of mechanical treatments. All treatments focused around developments near Warm Lake, and no treatments were accomplished around the ICP location. North of the ICP, the old South Fork Fire, which burned in 2003, contained lodgepole pine seedlings, grass/sedge and dead and down logs.

Fuel moistures were at critical levels through the period and contributed significantly with weather conditions to produce extreme fire behavior. Live foliar moistures measured in early August, (lodgepole pine--106%, Douglas-fir--113%, elk sedge--108%), yielded values traditionally representative of late August, or three weeks ahead of normal. 1000-hr fuels measured 6-9% (3-6% below average), setting new minimum fuel moistures for the area. Many of the mountain shrub species were showing signs of drought stress (moistures around 100%) and were expected to contribute to fire spread by mid-August according to the Long Term Analysis completed around August 10. It was during the fire run on August 12 that meadows and riparian areas (normally "green" fuels) were observed to be no longer an effective barrier to slowing or stopping fire spread as they had cured to the point of carrying fire.

At Bearskin, a National Fire Danger Rating System (NFDRS) Remote Automated Weather Station (RAWS) located 21 miles SSE of the fires at an elevation of 6,950 feet, had calculated fuel moisture values on August 12 of 1-hr 2%, 10-hr 2%, 100-hr 3% and 1000-hr 7% and on August 13 of 1-hr 1%, 10-hr 2%, 100-hr 3% and 1000-hr 6%. According to the Long Range Assessment and the local experts, Bearskin was the best representative of area climatological weather for the fires.

The Energy Release Components (ERC), an index related to how hot a fire could burn at the flaming front based on fuel loading and live and dead fuel moistures, set new record highs. Beginning in mid-June for Bearskin, values climbed above average quickly to near maximum values before moderating slightly in mid July through July 27, when values exceeded the 90th percentile and climbed above the 97th percentile by August 1. New maximum ERC values were set during August 12-13.

In addition to extremely dry live and dead fuel moistures, the amount of lichen in tree canopies provided an additional fuel ladder, carrying surface fire into the canopies under even mild wind conditions. The lichen effectively lowered the crown base height even in mature lodgepole pine with typically high crown base heights.

The area had numerous old fire scars that under normal fuel and weather conditions typically slowed or stopped fire movement. As mentioned above, it was observed on August 12 that the fuels in these older burns had cured to the point of carrying fire. In addition there was a heavy dead and down fuel component that was very receptive to spots, facilitating log-to-log spread and enabling fire movement. More recent burns however (eight to ten years old), had lighter fuels that under all but extreme wind events did provide a slowing affect on fire movement. Overall, the extreme fuels conditions made direct tactical operations very difficult.

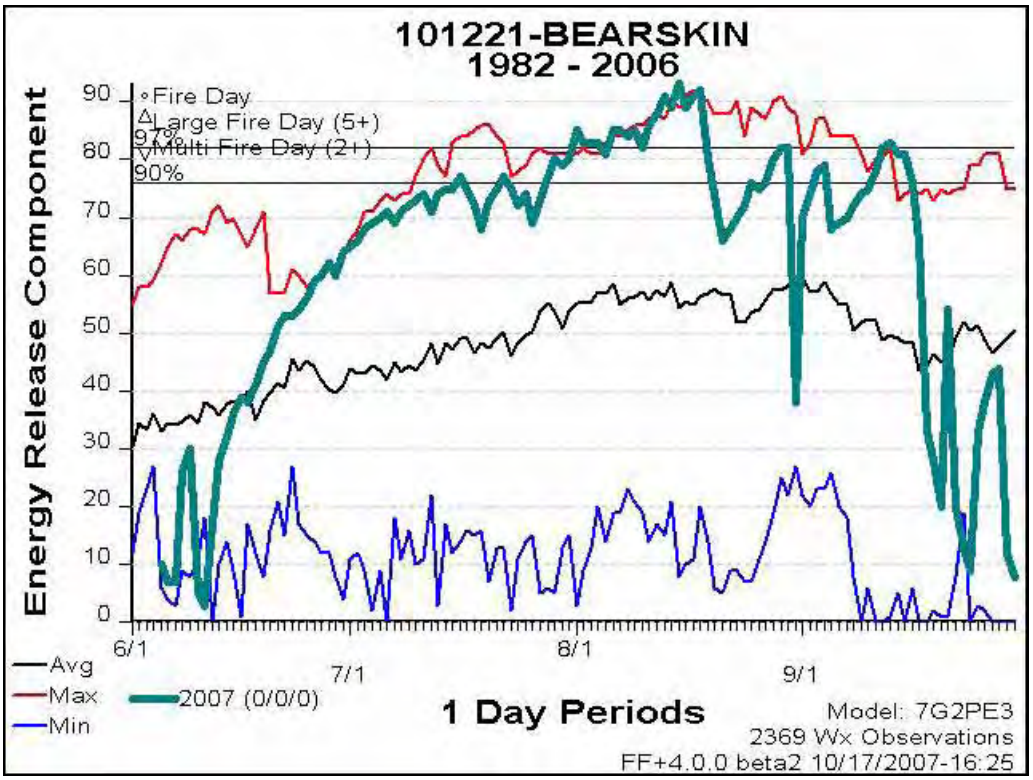


***Figure 1**. Average and maximum ERC values for Bearskin RAWS past 24 years compared to 2007 ERC values.*

Weather: The 2006/2007 winter snowpack and spring precipitation was well below normal, fluctuating between 25-70% of normal until July when it dropped to 5-25%. Temperatures were 2-6° above average from February through June, increasing to 6-8° above normal for July and the first portion of August.

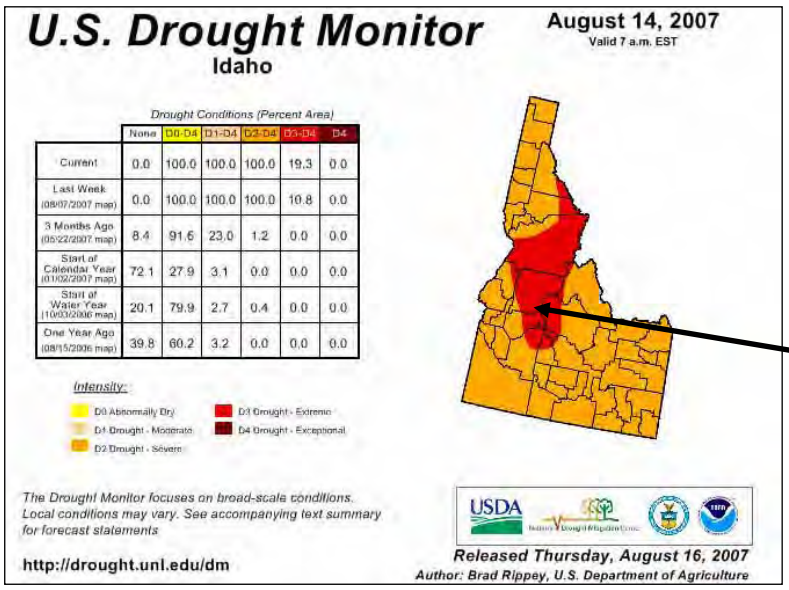


Figure 2. Idaho Drought Monitor

The weather pattern from August 8-15, 2007 was driven by southwest flow aloft, a result of high pressure to the southeast and a low-pressure trough over the Pacific Northwest. As a result of southwest flow, very warm and dry air from the desert southwest moved over the fire area causing single digit relative humidity's (RHs) during the days, poor recovery at night, and longer, very active burning periods. On August 12, a Red Flag Warning was issued for low relative humidity and strong winds.

Valley inversions were common each day and tended to limit fire behavior at lower elevations until around noon, or early afternoon, when they mixed out followed by increased fire activity. Above the inversion, portions of fires remained active well into the night and early morning, and picked up activity earlier in the mornings than fire in the valleys.

Two portable RAWS were set up near the fires. Warm Lake, FRWS#25, 4 miles SSW of Warm Lake at an elevation of 5,200 feet and North Fork, FRWS#37, 12 miles NW of Warm Lake at an elevation of 7,430 feet. The two stations provided an adequate weather observation platform for the fire area that could be monitored remotely by the Incident Meteorologist. (The Warm Lake RAWS was ultimately burned over by the Monumental Fire on August 17.)

The Incident Action Plan (IAP) fire weather forecasts for August 12 and 13 are included in Figures 3 and 4. On August 12, the fire weather forecast verified well with actual weather conditions, save the RH that turned out to be 7% less than predicted. On August 13, the fire weather forecast again under-predicted RH by 6-7%. A weather update issued at 12:45 p.m. updated the RH expectation to be near 10%, and warned of dramatic changes in fire behavior as the inversion lifted due to southwest winds aloft mixing down to the surface around 10-15 mph and gusting to 20 mph.

Fire Behavior, General: Both Monumental and North Fork Fires started from lightning on July 17. While the Monumental Fire was located soon after ignition, the North Fork Fire was detected 8 days later on July 25. From the time of ignition, the fires were growing in a predominately northeast direction.

Fire behavior was primarily fuels and wind driven. Fire movement was primarily through individual, group torching and running crown fires that resulted in lofting embers and establishing spots ahead of the main fire that would eventually burn together with surface spread. Spot fires 1-2 miles ahead of the main fire were not uncommon with some spots observed up to 4 miles.

Fire growth during this time period was extreme with large acreage gains during periods of extreme weather conditions (Figure 5). It was not uncommon for the fire to move 3-5 miles during a burning period of 4-8 hours. A local Fire Behavior Analyst (FBAN) estimated 80% of fire spread was a result of spotting that allowed the fire to spread more quickly through normally slower fuel models with sparser fuels.

In younger timber stands and particularly areas with fuel treatments, fire generally changed behavior by dropping out of the crowns and becoming a less intense surface fire. The best indicator of active fire behavior was the probability of ignition (PI). When PI was above 60%, active fire behavior would begin, and above 90% extreme fire behavior with extreme growth was expected.

Since ignition of both fires, strategies to protect developments around Warm Lake were developed that included direct attack as weather and resources allowed, use of existing fire scars to slow or stop spread, and indirect tactics using roads and indirect firelines with burnout.

FIRE WEATHER FORECAST

FORECAST NO. 22

NAME OF FIRE: Cascade Complex

PREDICTION FOR: Sunday

UNIT: Boise National Forest, Cascade R.D.

SHIFT DATE: Aug 12, 2007

TIME AND DATE FORECAST ISSUED: 2000 Saturday 8/11/07

SIGNED: _____

Incident Meteorologist

********** **RED FLAG WARNING TODAY** **********

WEATHER DISCUSSION: It will be dry and windy today. Compared to yesterday, the inversion will break much earlier between 1000 and 1200 noon. Just as quickly as the smoke lifts, Southwest winds will increase with strong gusts of 30 to 40 mph that will continue through the afternoon hours. Temperatures and humidity will be similar to yesterday

TODAY ... SUNDAY: Mostly sunny and windy.
MAXIMUM TEMPERATURES: 85 to 90 degrees 5000 ft to 6000 ft, 80 to 85 degrees from 6000 to 7000 ft, around 75 from 7000 ft to 8000 ft and 70 to 75 degrees above 8000 ft.
MINIMUM RELATIVE HUMIDITY: 12 to 16 % after 1400 hours.
EYE-LEVEL WINDS:
RIDGETOP: Southwest winds 20 to 30 mph with gusts 35 to 40 mph in the afternoon.
SLOPE/VALLEY: Upvalley 10 to 15 mph with gusts 20 to 30 mph.
CHANCE OF WETTING RAIN (≥ .10") : 0%.
LIGHTNING ACTIVITY LEVEL: 1
STABLITY/INVERSION: Inversion breaking after 1000 hours.
HAINES INDEX: 5 (Moderate).

TONIGHT: Warmer with poor humidity recovery.
MINIMUM TEMPERATURES: Lows 45 to 50 in the valleys to 60 degrees in the thermal belt above midslope.
MAXIMUM RELATIVE HUMIDITY: 25 to 35%.
EYE-LEVELWINDS:
RIDGETOP: Southwest winds 8 to 10 mph.
SLOPE/VALLEY: Light downslope 2 to 4 mph becoming downvalley after 2200 hours.
CHANCE OF WETTING RAIN (≥ .10"): None.
LIGHTNING ACTIVITY LEVEL: 1.
STABLITY/INVERSION: Not much inversion.
HAINES INDEX: 5 (Moderate).

TOMORROW ... MONDAY: Partly cloudy and not so breezy. High temperatures 75 to 85. Minimum RH around 15 %. Southwest winds 5 to 10 mph with gusts around 15 mph. Haines 4.

OUTLOOK FOR TUESDAY AND WEDNESDAY: Slight chance of afternoon and evening thunderstorms both days. Temperatures will continue to range from the mid 70s to mid 80s with relative humidity 15 to 20 %. Wind will be terrain-driven in the valleys with Southwest ridge winds 10 to 15 mph.

Figure 3. Fire weather forecast for August 12, 2007

FIRE WEATHER FORECAST

FORECAST NO. 23

NAME OF FIRE: Cascade Complex **PREDICTION FOR:** Monday

UNIT: Boise National Forest, Cascade R.D. **SHIFT DATE:** Aug 13, 2007

TIME AND DATE
FORECAST ISSUED: 2000 Sunday 8/12/07 **SIGNED:** _____
Incident Meteorologist

WEATHER DISCUSSION: High pressure will continue to build into the area from the Great Basin this week while a trough of lower pressure will remain over the Pacific Northwest. This will provide warmer temperatures today but winds will be less strong. By late afternoon cloud cover will increase.

TODAY ... MONDAY: Increasing clouds in the afternoon.
MAXIMUM TEMPERATURES: 85 degrees 5000 ft to 6000 ft, 82 degrees from 6000 to 7000 ft, around 77 from 7000 ft to 8000 ft and 75 degrees above 8000 ft.
MINIMUM RELATIVE HUMIDITY: 12 to 16 %.
EYE-LEVEL WINDS:
RIDGETOP: Southwest winds 10 to 20 with gusts to 30 mph in the afternoon.
SLOPE/VALLEY: Upvalley around 10 mph with gusts near 20 mph.
CHANCE OF WETTING RAIN (≥ .10") : 0%. **LIGHTNING ACTIVITY LEVEL:** 1
STABLITY/INVERSION: Weak inversion breaking after 1100 hours. **HAINES INDEX:** 5 (Moderate).

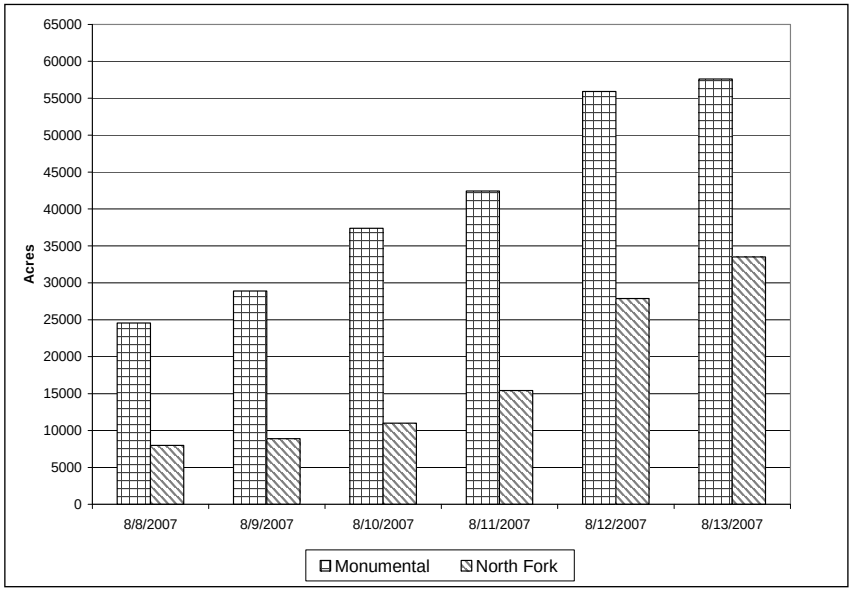
TONIGHT: Partly cloudy and cooler.
MINIMUM TEMPERATURES: Lows near 40 in the valleys to 60 degrees in the thermal belt above midslope.
MAXIMUM RELATIVE HUMIDITY: 35 to 40 % midslope to ridge, but around 60 % in the valleys.
EYE-LEVELWINDS:
RIDGETOP: Becoming light downslope 2 to 4 mph.
SLOPE/VALLEY: Light downslope 2 to 4 mph becoming downvalley after 2200 hours.
CHANCE OF WETTING RAIN (≥ .10"): None. **LIGHTNING ACTIVITY LEVEL:** 1.
STABLITY/INVERSION: Inversion setting up after 2200 hours. **HAINES INDEX:** 4 (Low).

TOMORROW ... TUESDAY: Partly cloudy and warmer. High temperatures Upper 80s valleys and near 80 above midslope. Minimum RH 10 to 15 %. Southwest winds 5 to 10 mph with gusts around 15 mph. Haines 4.

OUTLOOK FOR WEDNESDAY through FRIDAY: Pockets of monsoonal moisture will rotate northward into the Cascade Complex through the period.. This will team up with warm temperatures and instability for a slight chance of thunderstorms, but no appreciable moisture. Temperatures will continue to peak in the mid to upper 80s with relative humidity in the teens each afternoon. Wind will be terrain-driven in the valleys with Southwest ridge winds 10 to 15 mph. By Thursday thunderstorm possibilities will increase with an approaching cold front that will be relatively dry. The cold front Friday will allow winds become West to Northwest with gusts to 25 mph.

Figure 4. Fire weather forecast for August 13, 2007.

Figure 5. August 8-13 fire growth



To assist fire managers with making short and long term strategic decisions, several analyses were completed prior to the entrapment and burn around of ICP.

A Long Term Analysis was completed on or about August 10 to access the seasonal outlook, seasonal trend, probability of large fire growth, season ending event and the probabilities of the fire reaching high value areas at Warm Lake and Landmark. In addition FARSITE was used to project fire growth over a 5-day period from August 6-10 on the North Fork and Monumental Fires. An FSPRO model was also run for the time period of August 12 -19, on Monumental, North Fork, Sandy and Riordan to examine the probabilities of the fires joining one another as well as the probabilities of Monumental and North Fork affecting Warm Lake.

A summary of the Long Term Analysis is as follows:

Large fire growth –Based on early season conditions, there was a 17% probability of any fire start becoming a large fire even without a significant weather trigger during the months of July, August and September. These conditions were present and predicted to remain so for 7 days. In combination with the existing dry fuel conditions, there was a high risk of large fires exhibiting rapid growth.

Season ending event – The analysis calculated a 50% probability of a season ending event by September 5 and 80% probability by October 2.

Using RERAP and based on a normal fire season, the probability of the Monumental/Yellow Fire reaching Warm Lake before a season ending event was 24%; by August 15 - 1%; August 31- 4%; with the greatest risk period September 1-15. Since 2007 conditions were not considered "normal" but extreme, the climatological probabilities were adjusted to reflect these conditions and a re-calculated probability of the fire reaching Warm Lake before a season ending event was 92%; by August 15 - 54%; August 31 – 92%; with the greatest risk period of August 1 -15.

The RERAP analysis was validated by the fire progression map which showed the fire burning to the south end of Warm Lake by August 12 (although fire movement towards Warm Lake was attributable to burnout operations). If burnout tactics had not been used, it is highly likely that the fire would have burned to Warm Lake on its own in the next couple of days given fire history and conditions.

The 5-day FARSITE projection for the North Fork Fire was more aggressive with fire growth than actual growth although direction of spread was consistent to the northeast for both. The projection on August 10 showed fire perimeter reaching the head of Fourmile Creek on the Payette National Forest and in actuality the fire spread to this point on August 14, but in a very similar pattern as the projection. The projection did not consider the influence burnout actions had on bringing the fire perimeter further south (to the Warm Lake Highway on Curtis Creek) and did not show any perimeter growth that would threaten ICP at Knox Ranch. Given the projected growth that was simulated, an

additional assessment showing the affect of the burnout operation would likely have shown fire spreading around the ICP.

The FARSITE projection for Monumental and Yellow fires was also fairly accurate where it showed the fires joining around August 10-11, and in actuality they joined on August 9-10. In addition, the projection showed continued growth northeast toward Landmark in a very similar pattern and time period as the reality. The projection did show growth towards Warm Lake but not to the extent that actually occurred. The actual growth can be attributed to a situation similar to the North Fork Fire where burnout operations, used as an indirect tactical tool, brought fire closer to Warm Lake each time it was used. The model only assumed fire environment influence on growth without additional suppression actions.

The FSPRO analysis showed all four fires had less than a 5% probability of growing together prior to August 19. The fires actually grew together around September 7 with pattern of growth shown in the analysis very nearly matching reality.

In addition to the FSPRO analysis completed for the Long Term Analysis, a number of other FSPRO analyses were completed for different lengths of time and changing fire perimeters. Below is a summary of the runs completed prior to the entrapment and ICP burn around.

- On Monumental Fire, a run on August 3 predicted fire movement WNW with less than 0.2% probability (rare event) of fire moving north in the next 7 days. There was no projected movement toward Warm Lake Highway and entrapment site.

- On August 8, the Monumental run predicted less than 0.2 % probability (rare event) of fire reaching the highway in the next 7 days. Another run predicted less than 40% probability of the fire reaching the highway in the next 30 days.

- On August 10, the Monumental run predicted less than 80% probability of the fire reaching the highway in the next 30 days considering the change in fire perimeter from the previous run.

- On North Fork Fire, the August 3 run predicted fire movement to the NNE with less than 60% probability of fire burning to the ICP and less than 80% probability of the fire burning to Warm Lake Highway along Curtis Creek within the next 7 days.

- On August 9, the North Fork run predicted less than 40% probability of fire burning to the western shore of Warm Lake, less than 20% probability of fire burning north of Warm Lake, 100% probability of fire reaching Warm Lake highway along Curtis Creek and less than 60% probability of fire burning to ICP at Knox Ranch in the next 10 days. The highest burn probability was to the northeast, east and southeast. In addition, another run on the August 9 predicted

less than 80% probability of the fire reaching ICP and Curtis Creek along Warm Lake Highway in the next 30 days.

All of the long-term models assume no suppression action and that fire is at the will of the fire environment (i.e. fuels, weather and topography). It was observed by several people that the affect each fire had on one another is difficult to model. A couple of examples were when a fire column shaded fires to the east it decreased the shaded fire's intensity; and also that significant column development would modify surface winds as thermal in-drafts would flow toward the column, a phenomenon noticed on the North Fork Fire on August 13.

Specific Fire Behavior Relative to the Entrapment and the Burn around of ICP.
Daily weather observations for August 9-13 as well as hourly weather observations for the August 12 -13 from the closest RAWS are attached at the end of the document.

Friday August 10:
Monumental Fire activity increased significantly as fire crossed FSR 474 and made a significant northeast five-mile run. Area RAWS showed SW winds of 12-16 mph gusting to 30-40 mph. The northeast flank of the fire ran about ½ mile into the southern flank of the 1989 Bear Creek Fire. According to the infrared flight, the fire burned 8,513 acres for the day with the fire size estimated at 37,409 acres.

On the North Fork Fire the initial strategic plan to decrease risk to the Warm Lake developments and highway was primarily to use indirect tactics. The Six Bit Road (FSR 493) had been prepared along the eastern flank of the fire with a burnout, started mid afternoon from Six Bit Creek south toward the Warm Lake Highway. The burnout was completed to Two Bit Creek with a small slop-over near the beginning of the burn near Six Bit Creek. The northeast flank continued growing to the northeast, burning to the South Fork Salmon River as well as slowly growing south to within ¾ miles of Warm Lake Highway east of Big Creek Summit. The fire was within 1¼ miles of the Cascade Complex ICP. According to the infrared flight the fire burned over 2,000 acres for the day with the fire size estimated around 9,000 acres.

Saturday August 11 – There was active fire behavior throughout the night above the inversion. The daily maximum temperature was 85°, minimum relative humidity 12%, winds were lighter from the SW averaging 10-15 mph and gusting to 20-30 mph in mid afternoon. Hot/dry conditions led to rapid transition from surface to crown fire after a strong inversion lifted around 1400-1500 hours.

On Monumental Fire, shortly after the inversion lifted the fire made a two-mile run to the northeast, burning one mile into the old Bear Creek Fire. A 60-acre burnout near the Kinney Point cabin group two miles ahead of the main fire was started at 1630 hours and completed by 2130 hours to remove fuels between the cabin group and the fire. The burn tied FSR 474 into the Bear Creek fire scar. Burnout along FSR 474 continued north approximately one mile, keeping ahead of the main fire around Stolle Meadows.

According to the infrared flight, the fire burned 5,023 acres for the day with the fire size estimated at 42,432 acres.

The North Fork Fire continued burning north and east in Dollar Creek and crossed east of South Fork Salmon River. Slop-over from the previous day crossed the river, burning to FSR 401 forcing closure of the road north of Cascade ICP. Burnout along FSR 493 continued south toward the highway with another slop-over to the east, north of Two Bit Creek. With the current perimeter 1.1 miles west of ICP, fire threat to the ICP was projected to be within the next 24 hours according to the ICS-209. According to the infrared flight, the fire burned 4,427 acres for the day with the fire size estimated at 15,423 acres.

Sunday August 12 – A Red Flag Warning for low humidity and strong winds was issued. Both fires exhibited extreme fire behavior and growth. The Monumental Fire entrapped two fire support contractors following a Motor Vehicle Accident along the Warm Lake highway east of Warm Lake. The inversion lifted around 1100 hours with rapid escalation of fire behavior. Maximum temperature was 81°, minimum relative humidity 7%, winds were from the SW 9-13 mph gusting to 33 mph. Strong winds near Warm Lake reportedly snapped several large green trees in the early afternoon. Southwest winds began increasing around 1000-1100 hours, mixing out the inversion and causing the Monumental Fire to become active quickly. The increase in activity prompted firing operations to begin around 1130 hours, from the Kinney Point burnout completed the previous night, south along FSR 474 toward the fire (Map 2). The Bear Creek Fire area east of the burnout was expected to confine and/or slow fire spread to the north and east. Initially the burnout was within lodgepole regeneration but as the burnout progressed south out of the old burn, into more continuous mature lodgepole pine, the fire from the burnout gained momentum as it made upslope runs in alignment with increasing southwest winds. Both the burnout and the main fire merged together and carried through the old burn to the Warm Lake Highway. During the afternoon it was reported that fire intensity was so extreme that resources were pulled off portions of the fire as it made a four and one half mile northeast run up Warm Lake Creek (Photo 3). The previously unburned interior timber islands in the old burn, near the ridge south of the highway, appeared to have torched out, lofting embers over a mile to the north, starting spot fires across the Warm Lake Highway around 1500 hours. Within 10 minutes the spots were reported at greater than 200 acres. By 1530 hours fire was burning on both sides of the highway, running up drainage toward the individuals involved in the Motor Vehicle Accident.

Photo 3. Monumental Fire getting active south of ICP around 1330 hours.

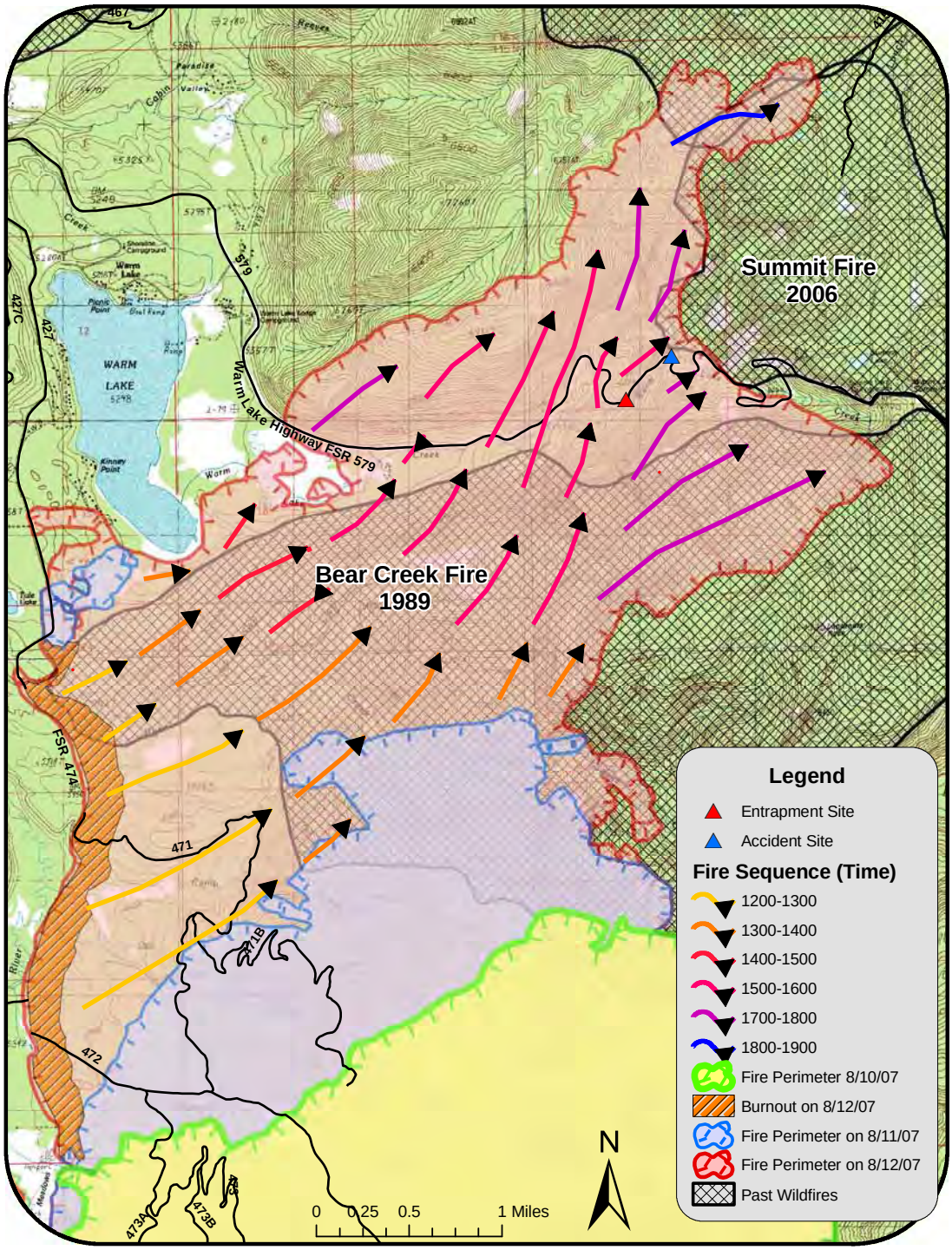
The location where the individuals sought refuge during the entrapment was a concrete headwall (Photo 6) around a culvert, against the highway cut slope. The area above the headwall to the top of the road cut was 15 feet high and mostly devoid of vegetation. In this location they were able to survive the next couple hours as the fire burned around them. The individuals recall ember showers during the course of the fire burning near their location.

The location of the headwall and culvert provided excellent protection to the two individuals with only light to moderate radiant heat impingement from the area above the cut slope (Photo 7) as it burned intensely. There was no evidence that convective heat impacted their location, as the area below them and across the highway (Photo 5) sustained a significantly less intense fire with scattered surface spots and isolated torching. The vegetation around their place of refuge showed no signs of any heat impingement.

When the fire crossed the highway in its initial run around 1500 hours, topography and slope were in alignment for fire to run up northern side of Warm Lake Creek (northern fork west of the entrapment site), in effect pulling much of the fire and heat up the chimney away from the entrapped individuals. This would partially explain the less intense fire that occurred across the highway from them. The highway wraps around a "knob" below the culvert location, which in combination with brokenness of the topography, provided a barrier as the fire spotted over it and ran up a chute with less resistance as it continued its run toward the accident site and beyond.

According to the infrared flight the fire burned 13,481 acres with an estimated fire size of 55,913 acres.

Photo 4. Entrapment site and surrounding area along Warm Lake Highway.



Map 2. Fire progression sequence for the entrapment.

Photo 5. South across the highway from the entrapment site.

Photo 6. Concrete headwall and culvert the individuals sought refuge in.

Photo 7. Fuels above entrapment site.

The North Fork Fire made a significant four-mile run northeast through the 1989 Dollar Creek Fire, burning on both sides of the South Fork Salmon River, crossing South Fork Salmon Road at 1530 hours and burning onto the Payette National Forest. The burnout along Six Bit Road continued from Two Bit Creek toward the highway with holding difficulties as fire continued spotting east of the road. With the current perimeter still 1.1 miles from ICP, the fire was projected to threaten ICP within next 48 hours per the ICS-209. According to the infrared flight the fire burned 12,470 acres with an estimated fire size of 27,893 acres.

August 13 – Both fires remained active most of the night above the inversion, due to poor humidity recovery--particularly on the North Fork fire with a recovery of 18-22%. Once the inversion lifted at the lower elevations, humidity dropped from 26% to 9% in 30 minutes. Knox Ranch ICP had the North Fork Fire burn around the camp between 1730-1900 hours. Between 1630 and 1830, the convection from both fires produced micro scale winds that were gusty and erratic, drawing winds from every direction and affecting fire behavior around the ICP.

Photo 8. Burnout operation along Two Bit Six Bit Road seen from ICP around midnight.

The Monumental Fire continued to be active, creating a significant column northeast of Warm Lake (Photo 9). According to the infrared flight the fire burned 1,695 acres with an estimated fire size of 57,608 acres.

The North Fork Fire burnout (Photo 8) along Six Bit Road continued throughout the night, to the highway and west on the Warm Lake Highway approximately 0.7 miles. Holding resources reported numerous spots east of the road that were caught during the night. In the morning, resources patrolled and continued mopping up additional spots. Fire activity was minimal due to heavy smoke inversion.

Around 1230 winds started increasing, with gusts of 11 mph, starting to mix out the inversion layer. The IMET issued the following weather update at 1245 hours: "The RAWS stations indicate relative humidity of 9 percent with winds gusting to 14 mph. The

inversion is lifting and will allow winds at other locations on the fires to increase rapidly. This will result in dramatic changes in fire behavior. During the next 30 minutes, SW winds aloft will begin to mix down to the surface for gusts around 20 mph on the ridges and 10-15 mph in the drainages with humidity near 10 percent. Please notify field personnel of this weather update and keep posted for additional information."

At 1300 hours, a dramatic change in fire behavior was observed with winds gusting to 20 mph. On the eastern aspect of FSR 493, trees begin torching from the previous night's burnout as well as the main fire higher on the slope. Individuals working the spots noticed ridge top winds starting to push the column down toward the South Fork Salmon River, lofting embers that started numerous spot fires below FSR 493 near the river. Crews were initially successful picking up the spots, but by 1400 hours spot fires were observed across the South Fork Salmon River, 100-150 feet north of the Warm Lake Highway Bridge. With help from heavy helicopters, crews attempted to catch the spots but quickly determined it was hopeless and pulled back to the highway to keep fire north of the highway.

As ground resources pulled off the spot fires, fire jumped the highway in several locations both east and west of the highway bridge across the South Fork Salmon River and began to run east along the highway. It was during this initial spread of the North Fork fire across the highway that the Monumental Fire was also making a significant run (Photo 9) in upper Chipmunk Creek (east of Knox Ranch ICP), and the in-draft into that column may have influenced surface winds in the vicinity of the North Fork Fire. The IMET and FBAN, as well as others, mentioned that they observed a northeasterly wind for a period of time that appeared to be feeding the Monumental Fire.

Once the fire became established south of the highway on the northern aspect of Kline Mountain, the heavily timbered slope carried an intense crown fire on an alignment adjacent with the powerline corridor to the east toward Knox Ranch ICP. This initial wave of fire that affected the ICP burned along the southern flank the camp (Photo 10).

North of the highway between ICP and the South Fork Salmon River were several roads, a wide riparian area along Warm Lake Creek and a very different fuels situation due to previous fuel treatments. Due to this variation in fuel continuity an active crown fire could not be sustained. The slower fire spread from the river to the camp in the second wave encroaching ICP was a combination of surface fire within the fuel treatments and riparian areas moving into untreated areas that torched and spotted into other untreated areas (Photo 12).

Photo 9. Monumental Fire column develops east of ICP around 1500.

Photo 10. 1st wave of the fire goes south of ICP around 1730-1800. Heavy helicopter dropping water along southern edge of camp.

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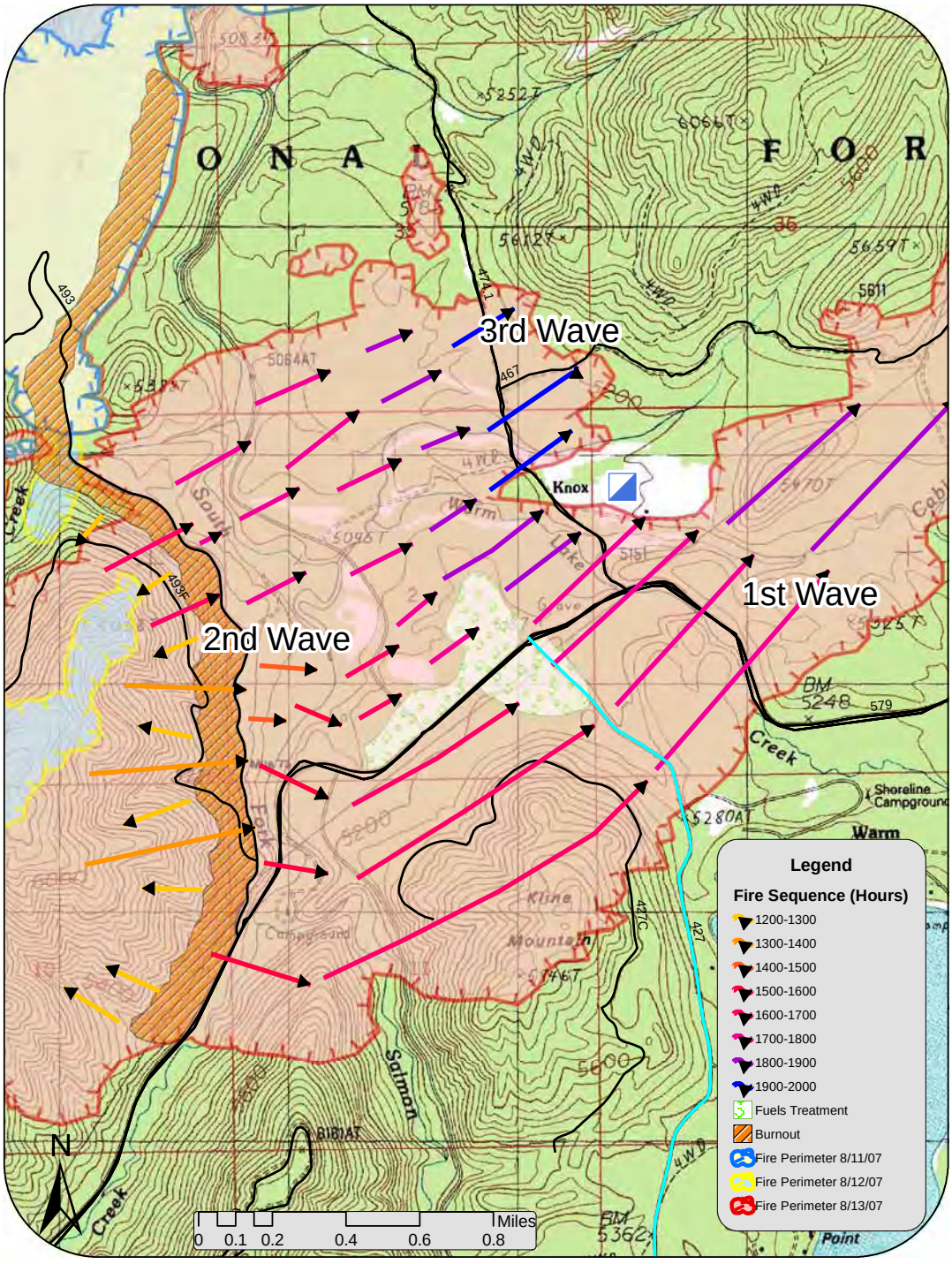


Map 3. Fire progression sequence for ICP burn around.

Photo 11. 2nd wave of fire approaching SW corner of ICP near camp entrance around 1800 hours.

Photo 12. The 2nd wave of fire hits the SW corner of camp around 1830-1900 hours.

Photo 13. Fire torching trees along northwestern side of camp from 2nd wave of fire.

A third and final wave of fire eventually impacted the northwestern side of Cascade ICP around 1900-2000 hours as the fire ran through more continuous fuels into the riparian area north of camp and the South Fork burn.

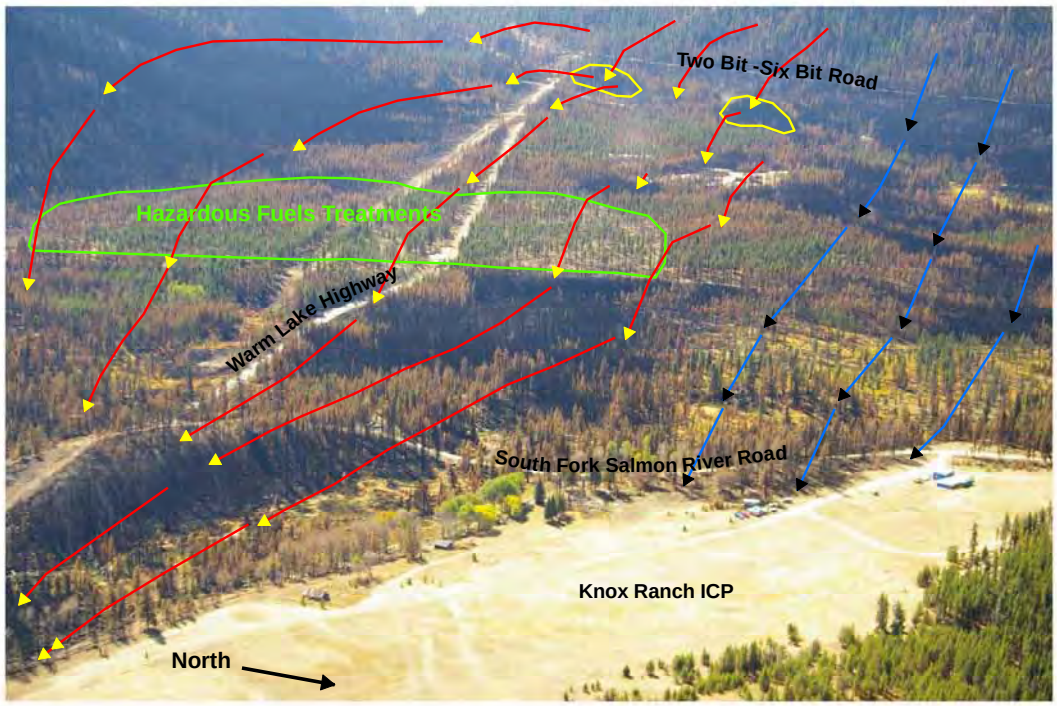


Photo 15. Knox Ranch ICP showing the 1st and 2nd wave of fire that burned around camp. Red is the 1st wave, blue is the 2nd wave. Notice the effect of the fuel treatments and riparian areas on fire intensity.

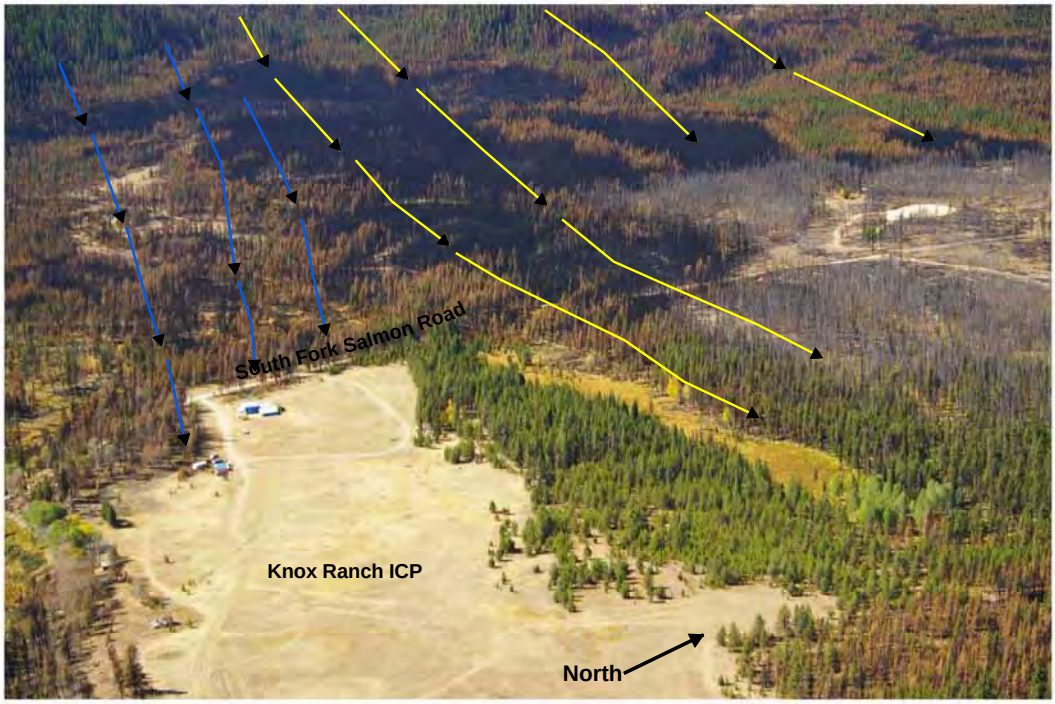
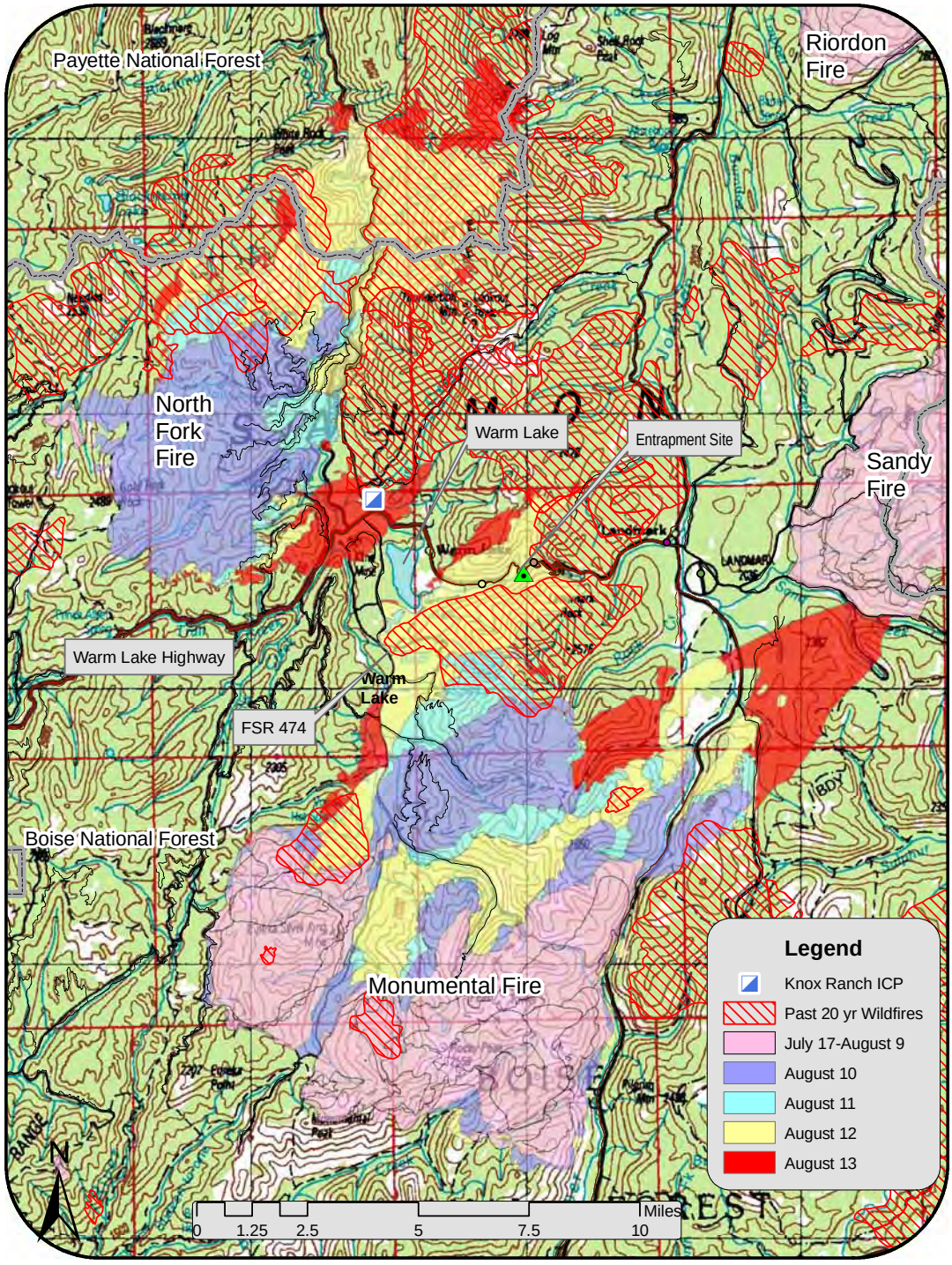


Photo 16. Knox Ranch ICP showing 2nd and 3rd wave and 2003 South Fork burn north of camp. Blue is the 2nd wave and yellow is the 3rd wave. The burned area in the lower right corner was from a burnout operation on August 15-16 to secure this portion of the camp from further fire threat.

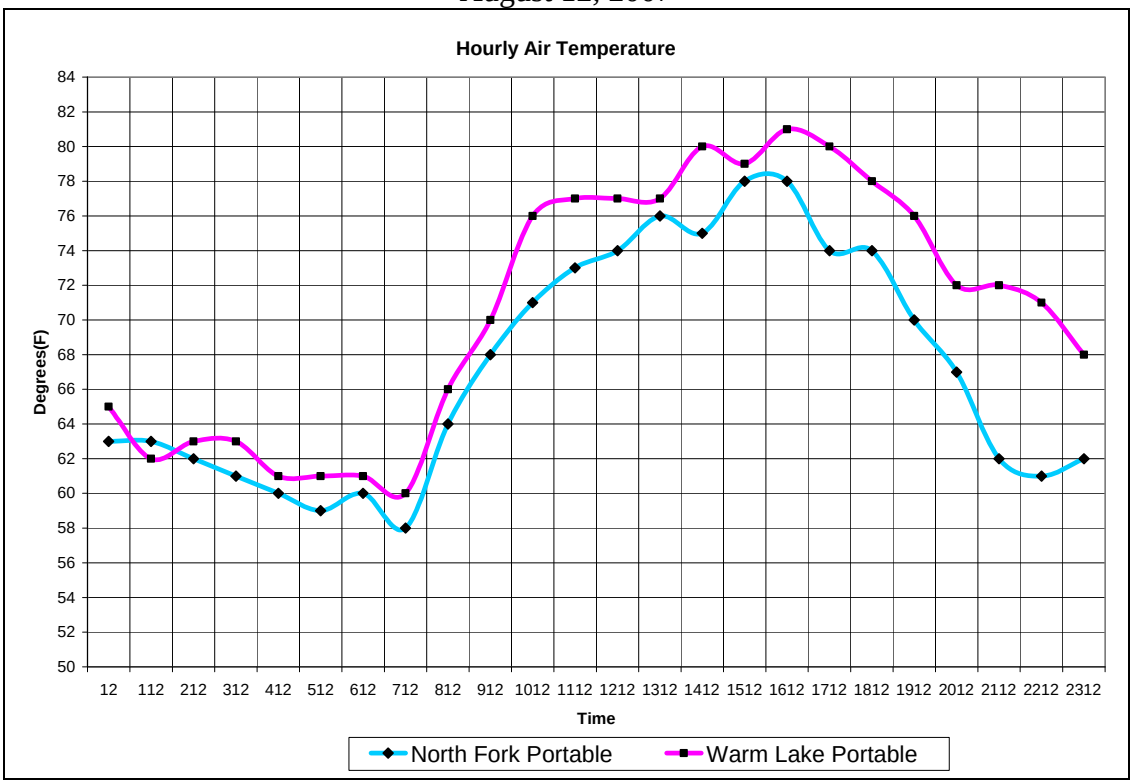
August 14 – On the 14th a strong inversion held smoke in Warm Lake Basin persisting until around 1700 hours resulting in a short burning period. High pressure with light winds was responsible for holding smoke in the valley's over the next few days until the 16th when a low pressure system moved into the region bringing slightly stronger winds that mixed out the smoke by early afternoon.

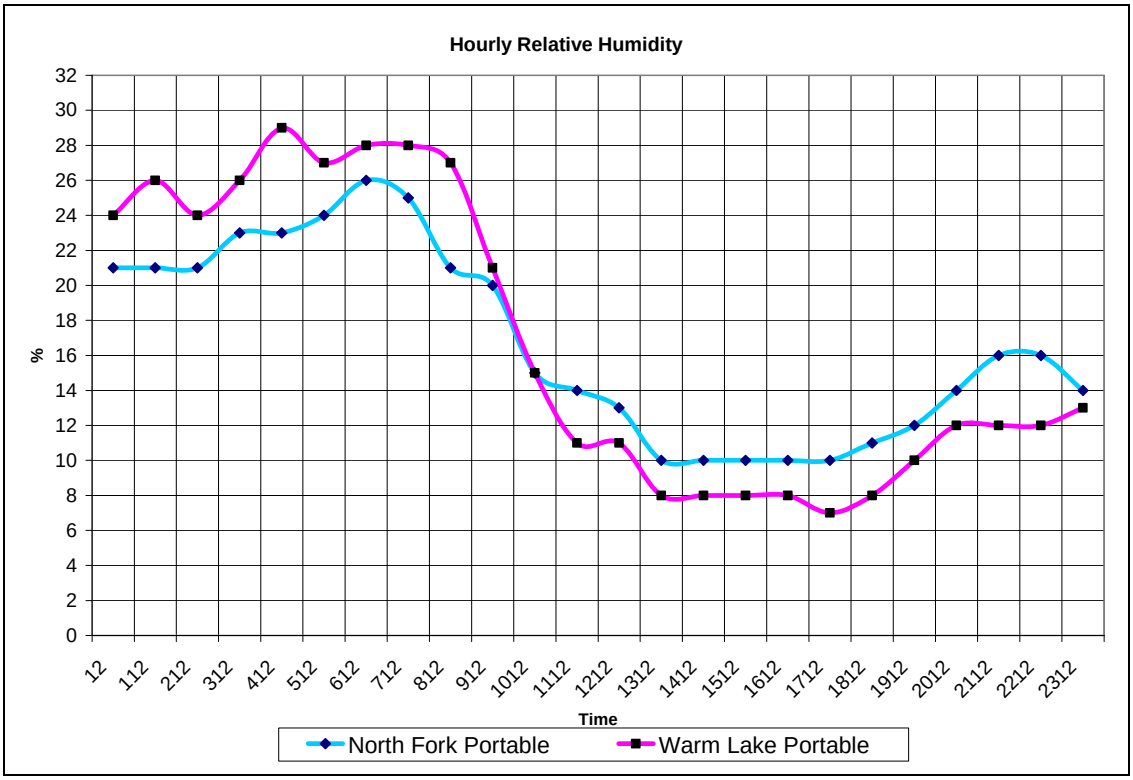


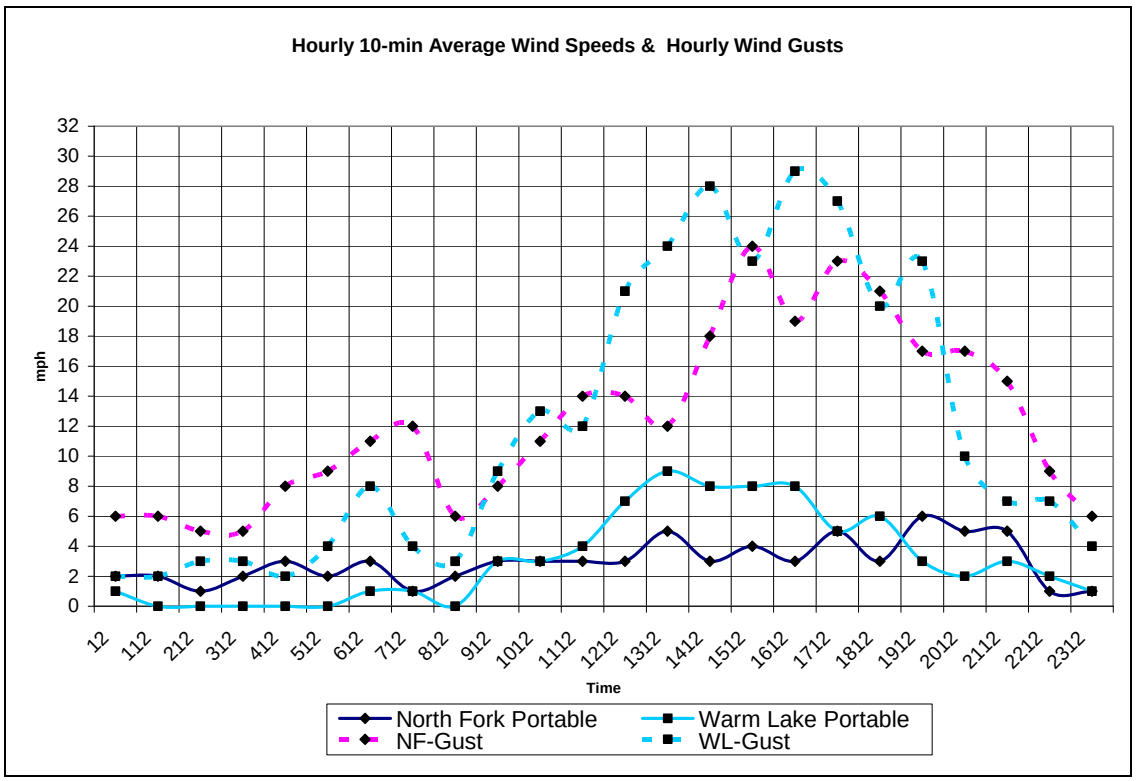
Map 1. Progression Map for August 10-13, 2007

Weather Summary
RAWS Weather Observations August 12-13, 2007

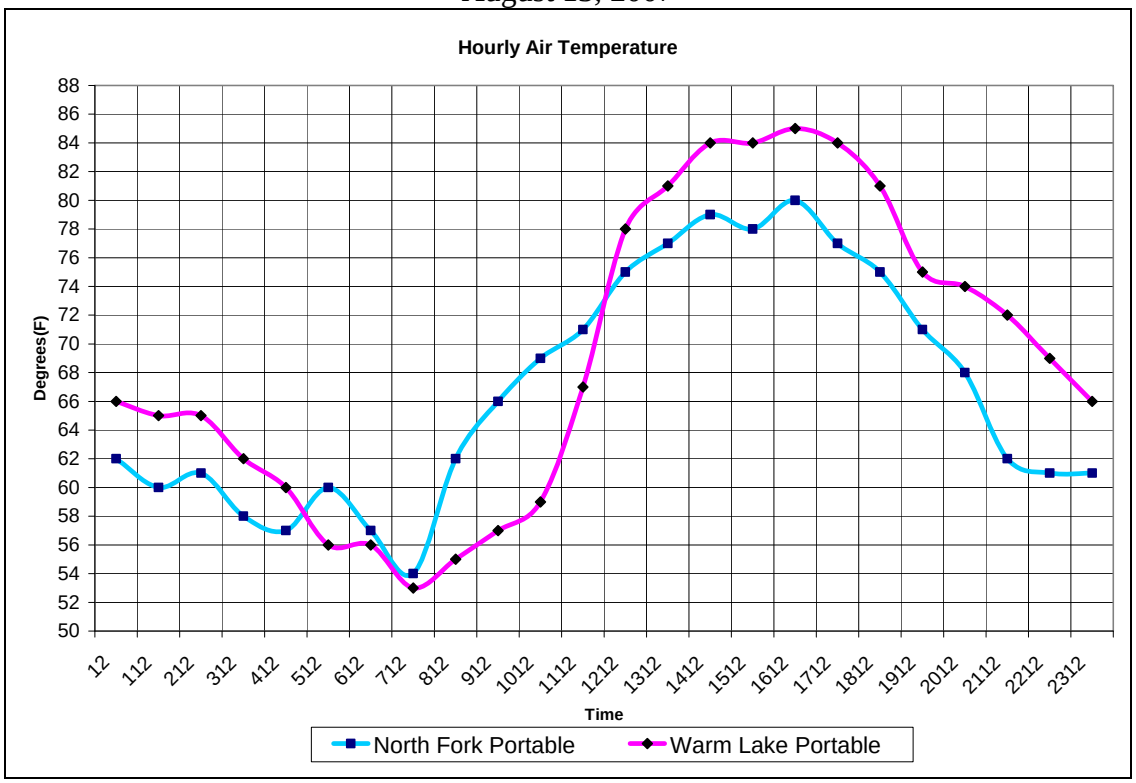
August 12, 2007

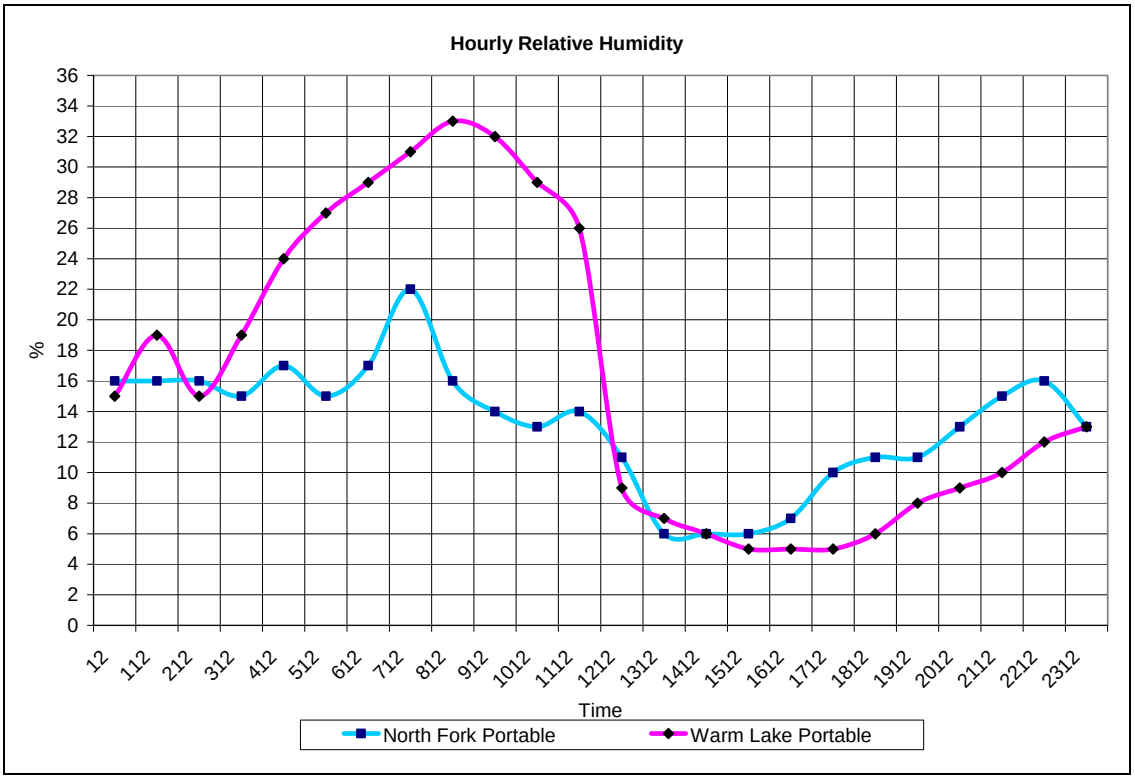


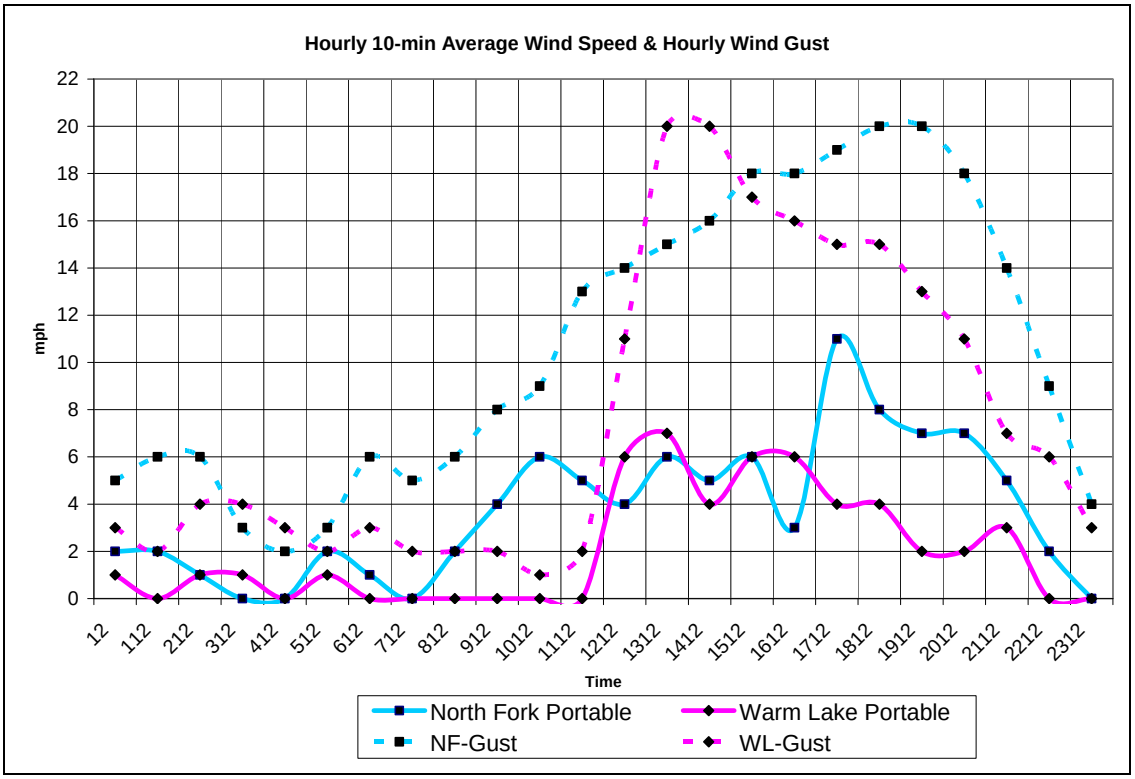




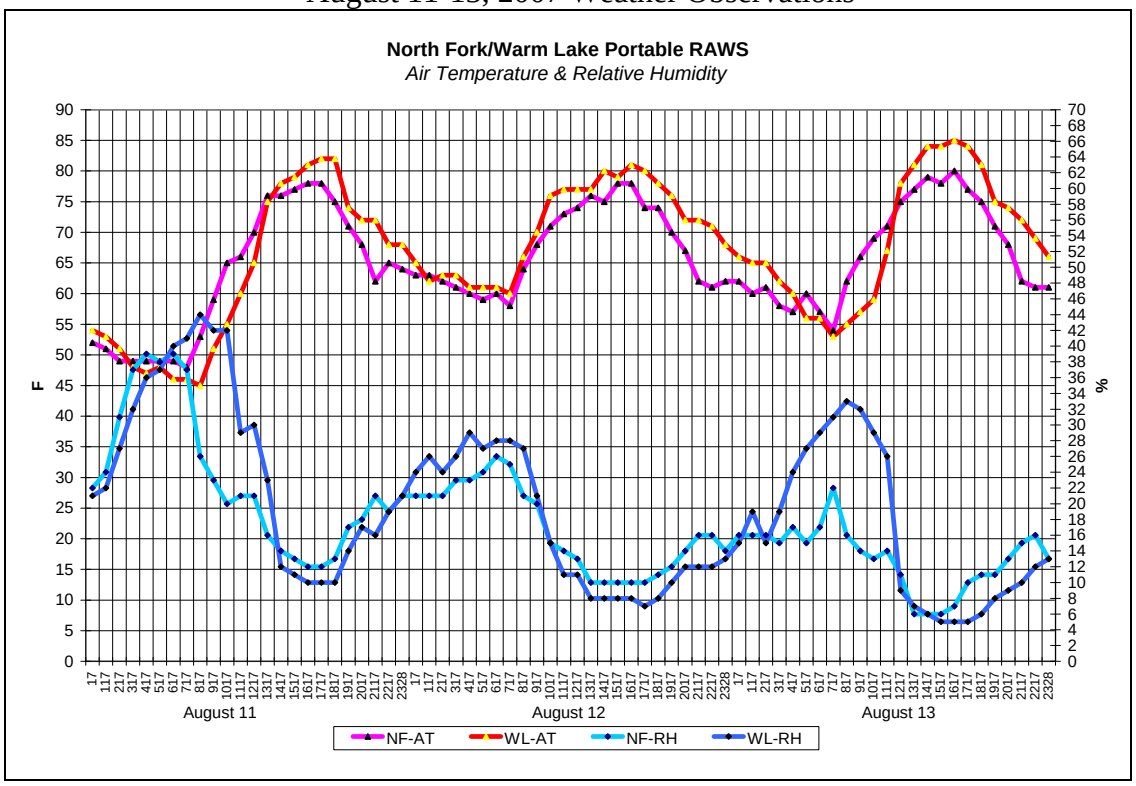
August 13, 2007

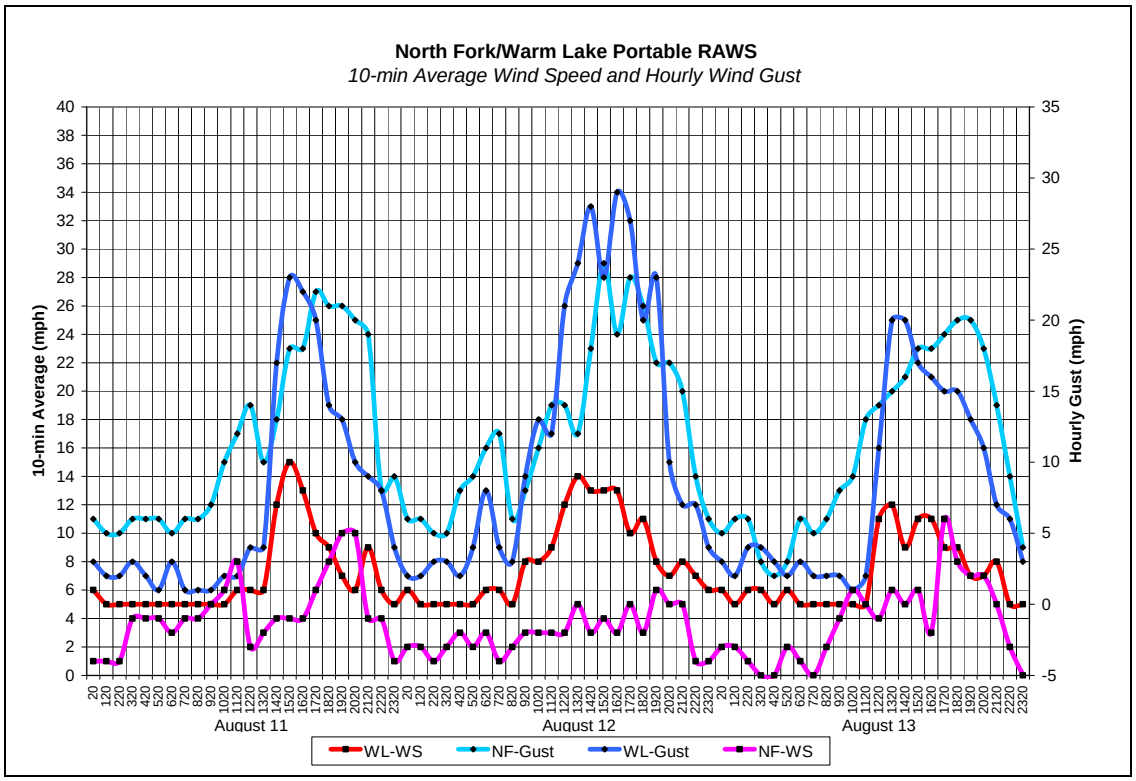



Hourly Relative Humidity
%
Time
North Fork Portable
Warm Lake Portable


Hourly 10-min Average Wind Speed & Hourly Wind Gust
mph
Time
North Fork Portable
Warm Lake Portable
NF-Gust
WL-Gust

August 11-13, 2007 Weather Observations





APPENDIX C

A Human Factors Analysis of the Cascade Complex

OVERVIEW

This analysis focuses on complex interactions of some of our best fire resources as they apply their skills in a hostile, perhaps even alien, fire environment. As IMT's, AC's and AA's integrated to accomplish mission goals they reported: "Every day brought extreme conditions and fire behavior challenging us to accomplish our objectives with the limited resources available and the skill levels we all arrived with." There are time pressures to "do it quick" because windows to implement decisions are slamming shut even quicker. This effort reflected operating beyond the edge. In 2007, throughout the country, firefighters described the fire season as "beyond extreme" or "mega-extreme" to convey what they were dealing with and witnessing. Historically, old behaviors are inadequate and new behaviors emerge when people are operating "beyond the edge of normality."

Within this context, three events will be reviewed to understand operating under these new "mega-extreme" conditions: (1) an accident-entrapment, (2) a burn around by fire of the Cascade Complex Incident Command Post (ICP), and (3) the continuing decision to remain at that same ICP location for 8 more days. While following the story content of the main report the intent of the Human Factors Analysis is to better understand decisions, from the perspective of those making the decisions, with the associated mental factors. When sections of the story are copied from the report, they are referenced as "Story", followed by the page number, i.e. "Story-14". A corresponding analysis with observations is labeled a Decision Point, or "DP".

The relevancy of human factors is paramount in identifying the mental, cultural and organizational processes that occurred during events on the Cascade Complex. Interactions between these factors are subtle and subjective, thus more difficult to retrieve and document compared to physical phenomena. Investigators are acutely aware of this and cultivate mutual trust between involved firefighters and themselves to identify these processes as they emerged during the incident. The APA process helps accomplish this joint willingness to derive the human factors "beyond the edge of normality."

Firefighters interviewed were encouraged to account for events prior, during and after the three events in their own words from beginning to end without interruption. They were encouraged to include observations, thoughts, feelings, expectations, concerns and frustrations. These initial accounts took between 20-40 minutes. Next interviewers asked specific questions to further prompt personnel involved to recall mental and physical events. The interviewees were then asked for their suggestions for what they learned personally, and what they would recommend to improve future fire operations based on their experiences at the Cascade Complex. Many were asked for their

observations on the interview process itself. What follow is based on their observations. By noting what they were attending to as they made decisions during the incident, understanding of human factors is developed

It is useful to point out briefly how our minds work by noting five processes:

(1). We can attend to only one object at a time. While we attend to one object, all other objects are excluded from awareness. An alternate way to say this is that attention to objects proceeds in a linear manner, one after the other. We can change attention many times per second giving us the perception of seeing and hearing at the same time, yet we still cannot truly multitask. Firefighters should learn to guide their own mental processes to stay focused in risky environments through "appropriate attention".

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

(3). Our minds automatically condition and habituate our actions and thinking unless we learn to extinguish this process. This means almost all of our decisions are made automatically without reflection, and reflection is usually just another automated process. Only those who have taken the time to watch and understand how these processes unfold in their own minds become aware of their habitual ways of responding.

(4). Our mental routines go with us wherever we go. Because they are basically unconscious, they are simply part of who we are. We do not suddenly get to be better decision makers when in risky environments, we become worse due to all the stresses associated with those environments. We routinely make bad decisions throughout the day (such as overeating) and seem surprised at our capacity to make bad decisions in environments where the consequences are more severe.

(5). There are three mental poisons that cloud your mind: Attachment, Aversion and Ignorance. Out of ignorance (of how our minds function) we attach to objects we find pleasant and avert or avoid objects we find unpleasant. Upon attaching to an object it is only a matter of time until we experience a negative consequence from that attachment. Attachment to food we find pleasant can result in the overeating with downstream consequences of added pounds and increased health risks. The overeating can become routine if we are talking to someone else (or ourselves), listening to the radio, etc. and begin to miss the taste of what we are eating or how much we eat. "Appropriate attention" is to taste the food and to listen for when the body tells us that it is "quite full".

These five processes will show up throughout this analysis as they do every day of our lives. Watch for them in the digestion of this report.

Investigations are initiated after a judgment is made that an event had a "bad" consequence. Accident investigators are normally tasked to determine the details of these "bad" events by focusing on incorrect actions, flawed decisions and inaccurate perceptions, even though such 'flaws" were not influential or obvious to the involved parties. The Serious Accident Investigation guide tends to look for <u>what</u> happened by focusing on what <u>wasn't</u> attended to. The Accident Prevention Analysis looks at <u>why</u> event s occurred by focusing on the underlying processes and what the firefighters themselves focused on as the events were emerging. Consider a life-threatening event under extreme pressure. To the degree we note or focus on the fire threat itself, it interferes with taking expedient action such as getting into a fire shelter quickly. The APA process is dependent on investigators with "appropriate attention" as well.

ALONG THE DECISION ROAD

Story-12: On August 3, the 1st Area Command Team met with officials from the Intermountain Region, and the Boise and Payette National Forests to discuss upcoming team transitions for both Area Command Team and IMTs. Redistribution of fires and Complexes were addressed, as well as the appropriate mix of Type 1, Type 2, and Wildland Fire Use teams. The Area Command Team proposed to schedule IMT transitions over several days. The Agency Administrators, however, voiced a desire to consider a transition plan that would "reduce the number of moving parts" over time by compressing IMT transitions into the shortest period possible. The Agency Administrators also favored a strategy that would increase the likelihood of Great Basin IMTs being assigned to the fires on the Boise. In the words of one witness, "they were adamant that Great Basin IMTs be assigned to the Cascade and [new] Landmark Complexes". The transition schedule was adjusted accordingly to result in five management transitions over a 36 hour period.

DP: Given their current fire situation, it's not surprising that the Forest AAs insisted that IMTs and ACs most familiar with their Forest's terrain, fuels, roads, fire behavior, etc. be brought in to fight the ongoing fires. This is positive in that if ACs and IMTs are already familiar with the fire ground, they have less learning to come up to speed and can "hit the ground running." The fires certainly aren't waiting and are getting increasingly more active. It is also more likely that the "home court" IMTs and ACs know the Forest and District personnel and have previously established an element of cohesion with them. With less to learn about the local environment and people, more time and effort can be spent on the fire itself. However, such familiarity can also be a source of trouble. They are more likely to do all the same actions that worked in the past <u>out of habit</u>, not realizing fast enough that such actions may not be effective when conditions this extreme have never been experienced before. Perhaps the best result is a local IMT with the resilience to quickly identify when normal actions aren't working and look for novel solutions to the novel fire behaviors being observed.

Story-15: One of the first items of discussion as the 3rd Cascade IMT began their command was the ICP location. They earnestly considered the following factors in the decision to remain at the Knox Ranch location:

- Exposure to driving hazards (construction, heavy machinery, fire activity, etc.)
- Defensibility of the site, including fuel treatments completed in previous years in the vicinity of Knox Ranch
- Cost of relocating
- Proximity to implementing their protection objectives; and
- No deference for camp personnel regarding smoke impacts.

The 3rd Cascade IMT inherited an ICP at Knox Ranch and chose to stay there. ICPs are usually situated on flat ground and require plenty of room. Large meadows with water nearby are ideal providing they are close logistically to the fire being managed but not so close they may be compromised by the fire. There is an obvious tradeoff here between the desire to keep travel times short and the inconvenience of being so close that a smoky environment is inevitable, not to mention the possible necessity to relocate if the fire approaches. Balancing fire and smoke risks against travel risks and convenient support for firefighters was a central theme on the Cascade Complex.

DP: The 3rdIMT chose to stay at Knox Ranch although fire projections indicated it was just a matter of time (days) for the fire to encroach upon the ICP. The IMT drafted a plan and felt they could manage the risks associated with staying at Knox Ranch in order to provide better support for operations and the line-going firefighters. Driving on the local roads was historically hazardous and thus balanced some of the fire risk to ICP. Indeed, more fire personnel are killed in accidents than in burnovers. Additionally, there was ongoing road construction between the town of Cascade (the alternate ICP location) and Knox Ranch, creating slower driving times and risks associated with meeting heavy machinery on the road. Knox Ranch was located near Warm Lake, where protecting structures at Warm Lake and the Warm Lake Road itself were primary objectives and further reasons for staying nearby. The 3rd IMT was familiar with Knox Ranch and all the surrounding roads so it was like "coming home" to a familiar place. This definitely biased them to keep the ICP at the Knox Ranch—had they been new to the area they may have been more open to moving ICP. The decision to stay at Knox Ranch was not solely that of the IMT. Either the AC or the Forest Supervisor could have directed the IMT to move and did not do so, thus effectively concurring with the decision. For the three parties involved, it would have been easiest to move during the transition as it is much harder to move, mentally and logistically, once entrenched. The three parties evaluated the risk of the ICP location but likely did not factor in their own biases toward that risk as part of their calculations.

***DP:** Many injuries and fatalities result from attaching to and thus sticking with (or more literally "sticking like glue" to) initial IAPs based on expected fire behavior at the time. If the expected fire behavior is "extremely compromised" there is often no corresponding change in the tactics. Clinging to the outdated plans seems necessary to validate the efforts already expended and mentally preferable to pulling out and dealing with doing it*

all over again up the road. It is necessary to evaluate the associated risks and make a decision, but it is not necessary to attach to that same decision. Attachment to objects is a routine daily reality that can prove fatal on the fireline. Recognizing the inherent "stickiness" of mental and physical objects is best done in times of quiet reflection rather than in the heat of the fire. Just like with heavy packsacks, ICPs can be dropped when safety is at stake-- when there is no mental attachment and the mind is resilient. A person must make an effort under daily conditions to see the attachment effect in their own mind to be alert for it under stressful conditions. A way around our mental resistance to change is to set trigger points now for when to move. It is easier cognitively to recognize the trigger to move later when overwhelmed by pressing matters at hand. This is how to make a good decision from a mental perspective. The IMT made a good decision regarding the camp location based on what they considered. By possibly attaching to that decision, they did not determine trigger points for when to move the location before their assignment was up.

In contrast, the Landmark IMT did not have an established ICP to move into or a location picked out. They decided to set up initially at the Landmark airstrip on August 9. Due to the increasing activity of the Monumental Fire on August 11, they moved their ICP to Cox Ranch, which was further to the North. As the Monumental Fire continued to move northward, the Landmark IMT decided to move the ICP again. They moved their ICP to Cascade on the afternoon of August 15, resulting in a move every few days. One of the Landmark drivers, however, went off the road on August 15, demonstrating the associated road risks. While changing ICP location minimized smoke and other fire risks, such moves involved driving risks. Disrupting IMT operations and logistical moves are also generally stressful by nature.

Both teams were trying to manage the risks of many variables in their rapidly changing environments with different consequences that kept both teams on the run. Once relocated in Cascade, the Landmark ICP was in less smoke and could stay in place with consequently longer drives for some members but a less stressful location for clearer thinking. The Cascade Complex 3rd IMT cited costs as a reason not to move to the larger end of the meadow, or to the town of Cascade, yet the Landmark IMT moved twice. Cost containment was a serious upper management concern passed down to IMTs, yet these teams demonstrated two views of "moving costs" and associated risk analysis of moving along the same road. Additionally, the Landmark IMT moved as an example to encourage Yellow Pine residents to move out of the fire's path. The Cascade Complex 3rd IMT stayed at Knox Ranch to show their determination to protect Warm Lake structures. These opposite outcomes show concern for local residents as a major decision factor.

There is one more factor with possible upstream consequences operating out of conscious sight. Once the ICP location was accepted, a plan was written and signed for protecting the ICP for when the fire burns around it. Once formulated, the risk appears to have been mitigated because they "had a plan." Thereafter the risk disappears into the background since the plan became most noted in the foreground. Meanwhile as the risk was increasing, the plan was static.

Story-17: The Landmark Complex fire narrative states "communication between the Cascade Complex and the Landmark Complex concerning road closures was a problem." The narrative continues by stating, "We had problems determining when locals and fire traffic were able to use the roads." During a review team interview, the East Zone Complex IC recalls discussing road management with the Area Command Team shortly after management transitions on August 7 and 8 had taken place. He described road management as a critical coordination issue with only two supply and evacuation routes winding through three adjoining complexes.

Although this situation existed prior to August 7 it continued with the new IMT's and seems to capture their "road" relationship as well.

DP: At this time the Cascade Complex and Landmark IMTs inherited the road problem. In part it was due to how the AC had reconfigured the Complex boundaries thus creating the road conflicts without resolving them. In this situation giving a Cascade Complex radio to the Landmark road guards seems the simple solution but the Landmark IMT did not want the added responsibility of keeping track of the Monumental Fire with the associated communications obstacles. Landmark personnel should have been checking with the Cascade Complex IMT to see if the road was open but report that they did not do so due to the radio difficulties and since they considered it "their" road too. The other solution was for incident personnel to keep raising the issue with their own ICs until a workable solution was found. Cascade Complex personnel didn't raise their concerns since their perception was that the old Bear Creek burn of 1989 would stop the Monumental Fire and not impinge upon the Warm Lake road. In the end, during this very busy fire season, it may have been easier to do nothing and hope their tours would end before further problems arose. In a dynamic interactive world leaving a door open often invites unwelcome guests.

THE STORY

Story-19: Early in the morning of August 12, a truck owned by the contractor who had placed the dumpsters at Landmark left Challis, Idaho (about 200 miles away though Lowman) to retrieve the dumpsters at the Landmark Airstrip. The driver, a 57 year old male, was a retired Forest Service road crew employee. He was accompanied by a 51 year old female companion, who often joined him on long trips. The couple had made this trip before and had hoped that they could save some time by reaching Landmark via the Deadwood Road. However, that road was closed due to fire activity, and they were forced to travel the long way around through the town of Cascade.

DP: Why contract with someone out of the area? It is approximately a 5 hour drive to get from Challis to Landmark, predisposing the driver to pick up the dumpsters during the heat of the day when the fires were most active. The set-up also encourages the cultural solution of speeding to get there quicker to get the job done: "time is money." Speeding may be even more likely for someone who also plans to return to Challis later the same day. If so, long days mean increasing fatigue. Garbage trucks have a history of speeding

in this area, thus a deviant norm. Locals would've known the hazards of the road better and the Warm Lake Road has a history of accidents and fatalities. The Challis contractor was likely the low bidder but there are often downstream risks from upstream cost savings. Then again, a fire season with scarce fire resources usually translates into scarce local resources.

Story-20: At the junction of the Johnson Creek Road (Road #413) and the Warm Lake Highway was another checkpoint. This checkpoint was operated by the Landmark IMT to control traffic going north on the Johnson Creek Road through the Riordan fire area. The guard waved at the garbage truck as it proceeded west on the Warm Lake Highway.

DP: Although the garbage truck was physically stopped twice on the way to Landmark by Cascade Complex road guards, at the Landmark end of the Warm Lake Road a simple wave sufficed. In part this may have been due to the garbage truck picking up garbage for the Landmark Complex, sending "our" truck down "our" road, which was the established habit.

Story-20: By the time the truck reached the top of the grade, the inversion had lifted and fire activity on the Monumental fire had picked up substantially. As the driver crested the summit and started down the long, winding grade toward Warm Lake, he observed fire on the hill to the south of the highway. About a mile or so below the summit, with the fire intensity picking up, he and his passenger decided to turn around and return to Landmark. As he tried to shift to a lower gear he was unable to engage the transmission, and the truck began rolling faster and faster down the steep grade.

DP: Being unable to downshift into a lower gear can result from going too fast down the hill to begin with. A driver needs to get into the correct lower gear before starting downhill with a heavy load for this reason. The garbage truck driver may have been speeding either to get though before the fire got to the road, or maybe due to preoccupation watching the fire activity in the distance rather than the gauge in front of him (one object at a time).

Story-20: He made it through a couple of hair pin turns by hard braking but the brakes became soft at the next turn. He decided to drive the truck off the road to stop it by running up the slope. As the truck careened off the road, it rolled on its side and slid across the dirt and brush before coming to rest in a small clump of trees.

Story-21: Per the recap of their experience provided to the Congressman, the occupants stated that the crash occurred around 1:30 p.m. However, in the documentation package provided by the SOF1(T), two Training Specialists (TNSP) returning from Landmark ICP were traveling down the same grade around 3:00 p.m., and do not recall seeing an overturned truck or two individuals on the road. The TNSPs did observe fire across the Warm Lake Highway and reported that to Operations (OSC1) when they arrived at Cascade ICP around 3:15 p.m. At 3:35 p.m., Cascade OSC1 told the Cascade SECM to shut down the Warm Lake Highway to all traffic due to the fire situation. The only

checkpoints that the Cascade SECM had established to control access on the Warm Lake Highway were west of the Landmark grade at the junction of the South Fork Salmon River Road (Checkpoint C) and at Big Creek Summit (Checkpoint B).

DP: The accident time of 1330 is out of synch. In the hand written note from the couple dated August 12, 2007 they say they got to the first guard station as they drove from Cascade towards Warm Lake as late as 1230. Earlier testimony is almost always more accurate than later testimony. Considering the distance to Landmark, the road construction and the delay at the weed washing station would put their arrival time into Landmark around 1430 and departure from Landmark around 1500 hours.

If so, the times are in alignment. Furthermore the couple says "We started down the grade at least two switchbacks and saw the fire coming not far away." For it to be not far away they must have been going down the grade about 1500 to 1515 hours. When the road was shut down at 1535 only the traffic from the Cascade side was affected, leaving the road open at the Landmark end. The Landmark road guards belonged to the Landmark IMT and therefore did not get the message, but by this time the couple had already passed through the Landmark checkpoint anyway. The Cascade 3rd IMT had expected the old Bear Creek burn to stop the Monumental Fire from reaching the road. They were focused on continuing a burnout operation to protect the Warm Lake structures and were late to note the fire advance to the road.

Story-26: In response to the existing contain/confine strategy, a burn out was concurrently taking place along the southeast flank of the North Fork fire (west of Cascade ICP). The intent of the burn out was to contain the southeast flank of the North Fork fire and to buffer the threat of a head fire running toward ICP. The burn out operation continued through most of the night of August 12 and into the early morning hours of August 13. Approximately 1.7 miles of indirect fireline were burned.

DP: On August 12 the North Fork Fire had reached the 3rd IMT's previously identified trigger point for taking this action. The FBAN and IMET had both participated in the burnout planning and remained up with the burnout crews, giving them updated forecasts every half hour. The burnout fire was active throughout the night and occasionally spotted outside the control line. The expectation was that this burnout would burn back into the North Fork fire and create a buffer between the fire and the Cascade Complex ICP at Knox Ranch. It is likely that this burnout also triggered the burn around of the ICP on the 13th. Had the burnout not taken place at this time the North Fork would probably have burned into the ICP a day or two later. The IMT had expected the burnout to be pulled to the NE by the North Fork Fire but conditions changed overnight and in the early morning.

DP: The burnout location is west of the ICP and local winds historically push fires towards the Northeast or East. For this reason, the Burnout Operation should have been tightly coupled with the Stay-In-Place Plan, i.e. implement one, implement the other at the same time.

Story-27: In an Idaho Vehicle Collision Report filed by the Valley County Sheriff's Office, the reporting officer stated that the Sheriff's Office was notified of the accident at 9:56 p.m. on August 12. A Deputy Sheriff arrived at Cascade ICP at 10:29 a.m. on August 13 to conduct an investigation. He was told that the road was too dangerous for him to travel to the scene of the accident. The collision report stated that the deputy met with the SOF1(T) and discussed how to complete the investigation. The officer then received a dispatch to another incident and was not able to visit the accident site that day.

DP: The accident investigation technically was under the jurisdiction of the County Sheriff. The County Sheriff was also responsible for road blocks but did not engage in that function on the Warm Lake Road due to lack of budget and personnel, as well as the number of roads in question. There was reluctance on the part of the County to accept their responsibility to come back and investigate the accident. The IMT was right to assume the Sheriff would do the investigation but should have upped the ante by calling the Sheriff daily until the investigation took place. A pattern was developing, of people and organizations pushed to their limits and unable to respond to normal daily, routine expectations. What was collectively missed by the Cascade 3rd IMT was that the garbage truck driver and passenger had also undergone a fire entrapment. The couple had trouble getting out of the truck after the accident and the words "trapped" and "entrapped" were thought to refer to the difficulty of getting out of the vehicle rather than a later fire event. The IMT and the Sheriff's department both had overflowing plates and lots of other concerns that possibly precluded asking more questions and accepting responsibility to do a more thorough investigation. The couple was rescued late in the day and decision-making is notoriously worse at night. After the Deputy left on the morning of the 13th, the IMT soon had more serious events to occupy their limited awareness.

Story-28: The North Fork fire burned towards camp in three separate pulses. The first pulse burned along the south side of Cascade ICP. About an hour later the second pulse burned along the west side of ICP. After another hour, the third and final pulse burned along the north and west edge of camp. As the fire approached the camp, Branch I mobilized two hand crews and three engines to patrol the camp perimeter. In addition, ATGS directed two Type 1 helicopters to make repeated water drops along the camp perimeter until smoke reduced visibility and they returned to the helibase.

DP: It was expected by OPBD Branch I that the overnight burnout would heat up when the inversion lifted and be pulled toward the closer fire, the North Fork. This was expected to drive their burnout toward the Northeast and bump the camp on the west side. However the Monumental fire heated up quicker and more forcefully and pulled the burnout column east toward the ICP and with it an associated ember shower. Instead of the best outcome, a worst case scenario from their planning effort occurred: multiple fire runs and an ember shower. The IMT had underestimated the fire spread and intensity. This is not surprising since people think linearly and fire grows exponentially. The rule of thumb here is that the more intense the fire behavior, the more likelihood of under-planning. In these situations computers may have provided better projections, dependent on the program and quality of data input. People are excellent at estimating

the levels of intensities, but computers are much better at predicting what combining those levels means. The computer models had been on track up until August 12, at which time they under-predicted fire spread. The IMT may not have taken into account the additional fire they were putting on the ground when inputting data into the computer models. Whether by computer or by the processes of the mind, the result was to under-predict.

Story-29: The historical ranch building adjacent to the meadow, which had been watered with sprinklers but had not been fully wrapped, caught fire and burned to the ground.

DP: Protecting the historic Knox Ranch cabin was a high priority of the AA representative. Thinning was not implemented around the cabin or the other buildings and they were not fully wrapped with fire shelter fabric, which could have significantly increased their survival chances. The IMT felt the AA representative had expressed views to spare the nearby trees, thus tying their hands. However, the AA representative had expected the buildings would be wrapped like a previous IMT had done at Stolle Cabin earlier. There are three issues here: first there are three AA contacts without common agreement about structures; second, the IMT and the AAs are not on the same page; third, with the prediction that the ICP would soon be overrun by fire, wrapping the buildings should have been done well before the burn around. The 3rd IMT could have prepared the area around the camp better to reduce property damage. Though the plans and contingencies existed, the evidence suggests the burn around was not expected the day it arrived. The burnout and the Monumental Fire growth the day before likely started the pattern of heavier nighttime smoke at the ICP. Visibility would have hindered fire observations until the inversion lifted and thus delayed the warning that the burn around would occur later that same day.

Story-30: At 8:00 p.m. the Command and General staff conducted their regularly scheduled planning meeting to develop the next day's Incident Action Plan (IAP). By 9:00 p.m. most of the fire activity around camp had subsided and the caterer served dinner. The 9:30 p.m. AC/IC update call was conducted with the report that all was well at Cascade ICP with only minor damage to some tents and toilets. However the historic building was a total loss.

DP: At the end of the day was everything "okay"? The plans, and implementation of those plans, were successful for the most part. But melted toilets, a burnt-out yurt and pin-holed tents suggest a closer call. Their plan did not forecast the resultant damage as acceptable losses in the cost containment environment, so if the damage had been anticipated, why not send mobile structures to a safer area (like the larger end of the meadow that the ICP was situated in)? During the burn around an ember shower preceded the flames, resulting in the trees on the edge of the meadow torching out individually and in clumps. If the fire had approached the ICP as a wind driven crown fire, the overall consequences could have been more severe. The IMT did have a provision for people to move to the wider end of the meadow if the fire got more intense--a crown fire may have only resulted in increased property damage as a consequence. The Stay-In-Place plan, while successful up front, could have been worse with stronger winds

or whirlwinds bringing more heat into the ICP. The Stay-In-Place Plan did not keep pace with the changing environmental realities.

Story-31: As people awoke and ventured from their tents on August 14, the smoke was so thick they could not see across camp. The inversion would not lift until late afternoon. The IC had requested the night before that an assessment be done of the need for camp personnel to undergo critical incident stress debriefing (CISD) as a result of the previous day's fire activity. The Forest Safety Officer was assigned the task and after talking with several people in camp he determined that a CISD was not necessary. While there, he also took readings from a handheld carbon monoxide (CO) monitor. He recorded readings of up to 38 parts per million near the ICP on August 14th (This value falls within OSHA guidelines).

DP: We cannot conclude that everyone worked within OSHA guidelines only that the few readings taken were within the guidelines. For example, CO and smoke effects would have been worse at night when the smoke settled into the Warm Lake area. No CO readings were taken at night, but people there reported they felt worse at night. Monitoring CO and smoke are not required culturally or organizationally, so the "seat of the pants" decision was subject to habitual ways of responding.

EPILOGUE

Story 32: As had been the case for several weeks, smoke continued to impact the Cascade ICP location and other areas downwind for several days following the fire burning around the camp. The Agency Administrator visited Cascade ICP with the Chief's Principal Representative on August 15. Both recall that the smoke was heavy. The Area Commander and his Logistics Chief stopped at Cascade ICP on August 16 on a tour of the fires under his command. They discussed smoke conditions and mitigations with the IMT. The Cascade Complex IC responded that the location still provided the best support for line operations and that he would consider moving once structure protection objectives had been accomplished at Warm Lake, believing that this might be possible within the next three or four days.

DP: Essentially, the IMT was saying they would stay in place until after Warm Lake and the Warm Lake Road were no longer in fire danger due to continuing to confine and control the fire. They were trying to provide the best support for the line-going firefighters even if those at the ICP must endure more smoke than the firefighters in order to accomplish those goals. However this conflicted with other goals. Was working under these increased smoke levels safe? Culturally, safety is oriented more toward fire operations rather than ambient environmental conditions, so IMTs are likely to see smoke effects as something "you put up with" rather than something to minimize.

Story-33: Over the next few days, medical unit visits made a significant jump from the level prior to the fire burning around the camp. Records indicate significant numbers of referrals to the medical clinic in Cascade on the days following August 14. Most of the

visits to the clinic were for respiratory ailments, including bronchitis and pneumonia. One individual was hospitalized for three days with bacterial pneumonia.

DP: The above shows a significant increase in illnesses. In fire camp most personnel were aware of the increasing number and severity of illnesses. The IMT felt they were observing the usual, ordinary, "camp crud" increasing, perhaps at the extreme end of ordinary, and therefore something we culturally endure. How we label phenomenon says a lot about how we plan to react to them. From the IMT's perspective the illnesses alone were not sufficient criteria to move camp, even if all personnel, including themselves, were getting sicker. Rather, they perpetuated the "cowboy up, we have bigger problems!" approach. In reality, the estimated 200 plus people staying at ICP each night were, in effect, exposed to more smoke than the estimated 800 firefighters in spike camps away from the ICP. Camp personnel are also more likely to be susceptible to effects of smoke due to lower fitness standards.

Story-33: The Cascade MEDL recalled that the IC visited the medical tent and remarked at how busy they were. The Incident Business Adviser (IBA) recalls asking the MEDL about relocating camp due to the illnesses attributed to smoke but that the MEDL responded that it would cost too much to relocate. The IBA also expressed a concern that the "pulse-ox" monitors and nebulizer being ordered were strong indicators to her that camp should be relocated. She also voiced concerns to the SOF1(T) that treatments for smoke were only good for as long as a patient remained in the medical tent, and that the effectiveness disappeared once the patient returned to the smoky environment.

DP: The concern here is that the symptoms were being treated and not the cause. When asked what level of illness would prompt moving the ICP, the IMT had no quick answers. When "people can no longer work" or when "we begin to lose enough people it affects whole crews" capture some possible trigger points. The SOF1 and MEDL implemented firmer trigger points: "if an illness was serious enough to require a visit to the clinic or hospital, the patient had 24 hours to improve or be sent home." At the time the special equipment was being ordered, the MEDL and SOF1 both began to discuss the rise in medical tent visits with the LSC1 and the DPIC but may not have realized the magnitude of the change. Noticing things "getting worse" is not as attention-grabbing as seeing an increase visually in a graphic display. With respect to the above illness trigger points if a person or a crew stops working the IMT says it takes the situation seriously. However, if the same person or crew gets worse and shows up for work they "just have a bad case of the crud." Individual personnel were given opportunities to leave the ICP for a respite out of the smoke, or full demobilization if preferred. Within a few days of the fire burning around the camp, scattered showers reduced the smoke in camp. Both the MEDL and SOF1 noted a decline in medical tent visits, but the decline was short lived as the visits increased again for three more days before hitting a steady decline. The reduction in smoke and tent visits may have been interpreted as "our medical efforts are working and we can tough it out a few more days".

The IMT encouraged all personnel to visit the medical tent for relief of symptoms, and took positive measures to keep the "crud" from spreading. In the fire culture there are

no clear triggers for when to move a camp due to smoke issues. Also there is no requirement, together with procedures and equipment, to monitor the health hazards of smoke so related decisions are subjective. "Seat of the pants" decisions are precariously susceptible to other pressures.

One such pressure reported was the possible embarrassment of the IMT for getting "burned around" by the fire. Getting burned around was a known and accepted risk by the 3rd IMT when the decision was made to stay at Knox Ranch, even though the event was not expected on the day it happened. To leave once the burn around occurred might have suggested the initial decision, perceived as the best option at the time, may not have been the best option in the end. A PowerPoint presentation of the burn around which was posted on the internet on August 14, was replaced by the "formal" release of an amended version from the Incident Commander four days later. It was important to the IC to correct the shortcomings of the first version, but this effort likely took the IC away from other fire duties and effectively created an "incident within an incident" for him. Unconsciously, this could also have been a cost of having previously attached to the ICP location and the Stay-In-Place plan, with respect to the "three poisons". Once an attachment is formed to a place or a plan there is an unrealistic optimism about them and any disruption to that optimism will be experienced within an emotional range from irritation to anger. The three poisons are cyclic-- the IMT may have attached to the new PowerPoint so that any criticism to the revised presentation would have generated more irritation, and so on. We should practice skillfully noting events without attachment to extinguish these cycles.

It is common for many of us go to work at our regular jobs with similar illness symptoms. They aren't caused by smoke, yet our response mirrors that of the IMT and firefighters at Knox Ranch. Most of us don't have our own trigger points for going to the doctor, and we often don't go until we have "toughed it out" on our own or when it is otherwise convenient for us to leave work. These personal habits are embedded in our minds that we take with us wherever we go and therefore it is not all that unusual for the 3rd IMT to have responded the way they did.

BEYOND THE STORY BOOK ROAD

Some unusual behaviors were reported after being in the smoky environment following days of exposure after the burn-by. However, neither the MEDL nor SOF1 recalled any such behaviors. Their rule of thumb for taking action upon observing unusual behavior was similar to that for illnesses: once noted the person was referred to counseling and if they improved they were allowed to continue with work. If not, they were sent home for further assistance. So there were triggers for taking action regarding some illnesses and personnel problems, but not generally for smoke related illnesses. Being "unable to work" was a more potent criterion than the "sheer number of illnesses."

If CO becomes high enough, particularly in the late evening or during the night it begins to affect both the body and the mind. This is thought to be rare under wildland fire

conditions, but the conditions encountered in 2007 were also rare. Measured CO levels recorded on only one day weren't high enough to explain the reported behaviors and no measurements were taken at night. Just being in a smoky environment, however, can lessen cognitive skills, and lead to feelings of discomfort (or even panic) similar to being disoriented in fog. Simply being sick leads to cognitive decline, and more so if the sickness is a head cold. Most of us avoid making significant decisions when we're ill for that reason. Mind and body effects float both ways. Crucial IMT functions often have air conditioned trailers for similar cognitive reasons. In short, we are more aware and make better decisions in comfortable, less stressful environments.

It is well known that firefighters are willing to take more risks when homes are involved. Homes used to be "just another type of fuel" to wildland firefighters, and not worthy of risking lives to protect. Protecting structures has increasingly become associated with higher risk operations, and a corresponding increase in accidents and fatalities in the wildland urban interface (such on the Esperanza Fire). Without being aware of the escalation of risk as it arises in our own minds, we will not be aware of it in high risk environments where we operate more on instincts and habits. We have good risk assessment tools for the fireline situations we observe, but seldom apply risk assessment to illnesses let alone to our own minds. In light of the above, take a second look at the emphasis on structure protection at Warm Lake and the associated extra risk of staying at the Cascade Complex ICP during the burn around (and for the eight ensuing days). These events beg the questions: Do you recognize risks associated with your current mental state and beliefs as easily as assessing risks "out there"? Do you have mental triggers for when your mind starts to "brown out" to warn you of diminished mental capacity for assessing risk?

In a "normal" extreme year the IMT actions would be considered "safe" actions, whereas in 2007 those normally safe actions occurred on the "edge of normality", or the edge of the mega-extreme, and likely did not work quite as planned. If the three events investigated at the Cascade Complex are viewed as accidents, then they meet the criteria that "accidents occur at the confluence of people functioning on the border of the ordinary." The difference in 2007 is that Mother Nature's response to fireline actions came back more quickly than the firefighters had ever seen before. Linear thinking struggles in an exponential environment. When we lob our ball over the net with linear thinking, Mother Nature fires back an exponential curve ball. With mental training the operant skills are to calm the mind, negate autopilot, and then apply appropriate attention to what is occurring at that moment and, in effect, jump ahead to the present situation.

Group Think or a Good Team?

During the interview process itself the IMT answered questions with similar phrases and with similar examples. Most if not all insisted they made the best decisions possible and would make the same decisions again. Perhaps, a few said, they should have moved the ICP after the fire burned around it. Not because staying wasn't a good decision, but simply because it resulted in criticism from some of those who weren't subject to the situational conditions at the time of the decisions. This could be "circling the wagons" to protect the team image with everyone giving "team" answers in interviews. Pat answers

interfere with understanding interactive decision processes at the Cascade Complex both for us and for the IMT. It can also be an instance of "Group Think", which is not resilient to new solutions since everyone thinks alike. Gary Klein once studied an IMT and found them to be very robust because of their group cohesion and that they all knew each other so well they could communicate effectively with fewer words and common phrases. So the IMT may just be very good at what they do with common, agreed upon goals.

SUMMARY

When analyzing accidents, the natural assumption for those of us looking over their shoulders, is that firefighters did what they did knowingly and deliberately. We then focus on what they did "wrong" rather than on what fire fighters, from their perspective, were doing "right." Almost all of our actions have subconscious determinants and so extra effort is needed to stay resilient and bring our own behavior under intentional control. The battle between conscious and unconscious control of behavior is the pivotal effort for increasing awareness and making appropriate decisions and actions under first routine, then with practice, under extreme conditions. Becoming more conscious of how our minds work is the **only** way to shift from trying to follow an unending number of rules to principal based actions. Principal based actions can reduce confusion and exert a force that counters latent subconscious actions that if followed, even briefly, shift firefighters into higher risk actions under present situational pressures. Trigger points for these actions can reduce the amount of time and thinking to initiate appropriate actions and for noting when we are being overwhelmed and need to disengage. Most firefighters use trigger points for outward events but few have similar trigger points for degrading mental processes.

A Story was utilized to bring focus to what the involved fire fighters were focused on. The extreme weather, dry fuels and fire behavior are keys to understanding the complexities and time pressures that arriving fire fighters were brought into. Another general factor was the low level of experience of many crews that limited tactics, and often meant ending or modifying operations under intense conditions demanding more skill.

When looking at this incident and accepting the overall conditions that they were embedded in, there are at least three key points contributing to the "accidents". **First** were the issues regarding road controls; **Second** was being caught off guard by burning conditions and projections, or at the very least by the timing of the fire burning around the ICP, resulting in a last minute effort to protect the ICP; and **Third** was that there were no trigger points to consider for relocating Cascade Complex ICP for health reasons. Otherwise, these "accidents" do not reach convergence on the edge of the ordinary.

The evaluation of actions concerning the ICP can take on an interesting mental twist. When we look into our own minds we have the equivalence of an ICP. We normally call it our ego, self, me, mine and so forth. Buffered in our mental ICP we fail to see that

grasping, aversion, and ignorance are consuming everything in sight. The resulting "clouds" obscure our awareness and thinking. In truth very few people realize these mental dangers because they never see that they are on autopilot. We do nothing to extinguish these "mental rings of fire" because after all they are the very nature of our self essence.

If we return to the perennial observation that 80 percent of causal factors are due to human error and thus mental in origin, then it is reasonable to say training, such as meditation, to improve the mind is long overdue. Such training is inherently different from filling the mind with still more information that can lead to overload. Meditation or mental training enables us to use information, training and past experience more efficiently. It has been determined in studies of the health hazards of smoke, that smoke over the course of a summer depresses the immune system by about 7 percent. Meditation boosts the immune system by 7 percent or more and is a natural way for firefighters to deal with the health effects of smoke. With respect to improved immune systems and stress reduction in meditators, meditators have about a 30 percent reduction in illnesses and the associated medical and subsequent insurance costs. Therefore learning meditation skills makes good economic sense as well. Meditation is a skill with both mental and physical benefits for firefighters, and financial benefits to organizations.

Fire organizations and fire cultures are populated by individual fire fighters, leaders and managers. Upstream from organizations, cultures, and people, are human minds. When we quote the finding that human error accounts for 80% of all accidents and fatalities we are referring to errors made by those very same minds. To re-emphasize--upstream of errors are minds. Studies suggest that teaching meditation skills would be a very effective way to improve awareness, decision making and improve firefighter safety.

APPENDIX D HEALTH AND SAFETY ANALYSIS

Smoke Exposure at Cascade Complex ICP

Introduction

Smoke exposure to wildland firefighters is inevitable on the line, however those fire personnel on the line are physically fit, have been through medical testing and red carded at the appropriate level. In the case of the Cascade Complex ICP burn around, multiple personnel with less than arduous duty qualifications were exposed to arduous duty conditions for multiple operational periods. After the burn around event, many line personnel only returned to camp to eat and/or go to briefings, and then overnight at spike camps with improved air quality.

There are two occupational health concerns that are directly related to the smoke exposure at Cascade Complex ICP. Carbon Monoxide exposure over extended periods of time resulted in flu like symptoms (headache, dizziness, nausea, vomiting and disorientation and/or cognitive skills) and the exposure to particulate matter resulted in significantly increased number of upper respiratory illnesses.

In a review of medical records, personal interviews, literature review, and a smoke exposure analysis (see safety appendix D(1) it is believed that personnel in the Cascade Complex ICP after the burn around event were exposed to high levels of residual smoke that led to exposure of Carbon Monoxide (CO) and Particulate Matter (PM). In reviewing medical records from the medical tent, Agency Provided Medical Care (APMC) forms, and CA 1 & 2's, there appears to be a correlation between smoke exposure in the ICP and increased visits to the medical tent. The effects of this prolonged acute exposure of the concentrations of smoke at ICP more than likely exceeded Permissible Exposure Limits (PEL's) established by OSHA (Safety Appendix 1).

Upper Respiratory Illnesses

Smoke from wildfires is a mixture of gases and fine particles from burning trees and other plant materials. Smoke can effect eyes, irritate the respiratory system, and worsen chronic heart and lung diseases. (CDC Factsheet)

People who have heart disease might experience, chest pain, rapid heartbeat, shortness of breath, and fatigue. Smoke may worsen symptoms for people who have pre-existing respiratory conditions, such as respiratory allergies, asthma, and chronic obstructive pulmonary disease (COPD) in the following ways; inability to breathe normally, cough with or without mucus, chest discomfort, wheezing and shortness of breath. (CDC Factsheet) Even healthy people may experience some of these symptoms.

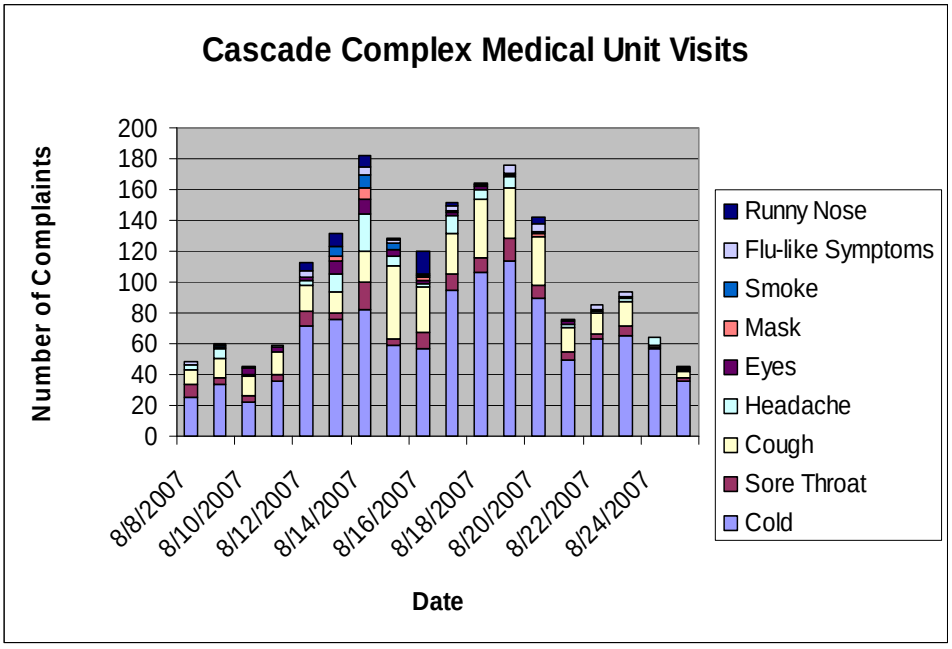
As of August 8th, there was documentation that "camp crud" was present at the Cascade Complex. Between August 8th - 12th, the Medical Unit averaged 50-60 visits. After the

burn around event on August 13th, the numbers of medical tent visits increased to around 300 per day.

As a result of prolonged acute exposure to the concentrations of smoke at ICP, Cascade Complex personnel already ill with "camp crud" experienced an exacerbation of symptoms as a result of exposure to the particulates that are a toxic component of smoke. There is evidence in literature linking smoke exposure to compromised immune systems. (See Safety Appendix 1). Visits to the medical tent, for complaints related to upper respiratory and flu-like symptoms, the day after the burn around rose from 59 (August 12) to 182 (August 14).

Previously non-symptomatic personnel later developed upper respiratory symptoms after the smoke exposure. On August 19, a spike in medical unit visits, for upper respiratory and flu-like symptoms, increased to 176 visits. This spike in respiratory symptoms correlates with known health effects associated with acute smoke exposure.

Prevalence of significant upper respiratory illnesses following the burn around required the medical unit to obtain physician protocols to provide specialized medical treatment beyond normal medical unit operations. These included administration of oxygen and nebulizer treatments which required the medical unit to procure specialized medical equipment. In addition, a request was made and approved through the Incident Business Advisor (IBA) to obtain and distribute immune boosting supplies.



Number of Medical Unit Visits for health complaints related to Upper Respiratory and flu-like symptoms.

Carbon Monoxide

Carbon monoxide is life-threatening to humans, as inhaling even relatively small amounts of it can lead to hypoxic injury, neurological damage, and possibly death. The most common symptoms of CO poisoning are headache, dizziness, weakness, nausea, vomiting, chest pain, and confusion. The initial symptoms of CO Poisoning are similar to the flu, but without the fever. Many people with CO poisoning mistake their symptoms for the flu or are misdiagnosed by physicians (Consumer Product Safety Commission). Unless suspected, CO poisoning can be difficult to diagnose because the symptoms so closely mimic other illnesses.

When carbon monoxide is inhaled, it takes the place of oxygen in hemoglobin, the red blood pigment that normally carries oxygen to all parts of the body. Because carbon monoxide binds to hemoglobin several hundred times more strongly than oxygen, its effects are cumulative and long-lasting, causing oxygen starvation throughout the body.

The main medical treatment for carbon monoxide poisoning is breathing 100% oxygen via a tight fitting oxygen mask. Oxygen hastens the dissociation of carbon monoxide from hemoglobin, improving tissue oxygenation by reducing its biological half-life.

On August 14th – 15th, 10 "M" numbers were issued for illnesses related to nausea, vomiting, dizziness, and headaches, all of which are classic symptoms of CO poisoning. In addition, Cascade Complex personnel displayed disoriented and/or confused behaviors in multiple instances. CO measurements were not taken, however based on analysis of photos taken during and after the burn around, CO is estimated to have been at levels far exceeding the OSHA Permissible Exposure Limits once adjusted for multiple contaminants and the duration of the exposure (See Safety Appendix 1). The personnel in the camp were never able to fully recover from the effects of CO exposure because prolonged exposure to fresh air (or pure oxygen) is required for the CO-tainted hemoglobin (carboxyhemoglobin) to clear. Cascade Complex personnel experienced continuous exposure to CO and lack of fresh air until, they were either demobed and/or the camp was moved when the 4th IMT took command on August 22, 2007.

How quickly the carboxyhemoglobin builds up is a factor of the concentration of the gas being inhaled (measured in parts per million or PPM) and the duration of the exposure. Compounding the effects of the exposure is the long half-life of carboxyhemoglobin in the blood. Half-life is a measure of how quickly levels return to normal. In an article review from, Fire *Engineering* by Mike McEvoy, the half-life of carboxyhemoglobin is between 2 to 6.5 hours. This means that for a given exposure level, it will take anywhere between 2 and 6.5 hours for the level of carboxyhemoglobin in the blood to drop to half its current level after the exposure is terminated.

After reviewing the medical unit information, APMC, CA-1's&2's and comparing them with medical studies and literature review there appears to be a link between the flu-like symptoms and the confusion/disorientation with the exposure levels and length to over

exposure to CO. It is believed cognitive functions were at least somewhat affected in Cascade Complex personnel by the acute smoke exposure after the burn around.

As can be seen from the above information, the symptoms vary widely based on exposure level, duration and the general health and age on an individual. Note the one recurrent indicator that is most significant in the recognition of carbon monoxide poisoning- is headache, dizziness and nausea. These 'flu like' symptoms are often mistaken for a real case of the flu and can result in delayed or misdiagnosed treatment. When experienced in conjunction with the sounding of carbon monoxide these symptoms are the best indicator that a potentially serious buildup of carbon monoxide exists. It is also important to address the issues of confusion and disorientated behaviors that were not the norm in Cascade Complex personnel. In a study reported in the Archive of Neurology, Vol. 55 June 1998, *Neuropsychological Impairment from Acute Low-Level Exposure to Carbon Monoxide,* the authors determined that "cognitive impairment resulting from low-level exposure to carbon monoxide may involve memory, visuomotor coordination, visuospatial functioning, construction skills, temporospatial orientation, and attention to concentration." This effect could lead to a determination that with the lack of pure oxygen exposure to clean out all CO in the blood systems, there is a high probability that CO exposure from the residual smoke could have played a part in not only the flu-like symptoms, but also the reports of cognitive and behaviors that seemed out of the norm.

Conclusion

From August 8 – August 21, Medical Unit visits totaled over 2400 during the time IMT #3 was in place at Cascade Complex and there were a total of 131 Agency Provided Medical Care or "M" numbers issued. 104 of those were respiratory related and 91 of those were issued in the time frame after the burn around event. In addition, to IMT #3's M numbers, IMT #4 issued 66, 45 were respiratory related and 29 of those were direct documentation links related to the smoke exposure from the burn around event. There were also 24 "precautionary" CA-2's filed as a result of burn around event. There is also documentation from the treating Physician at the local medical clinic that states that in his professional opinion the high number of pneumonia cases was directly related to the extended smoke exposure of already sick personnel.

As an employer there is a responsibility to provide every employee with a place of employment that is free from recognized hazards that are causing or are likely to cause death or serious physical harm. Under the OSHA 1960 General Duty Clause this obligation is an open-ended one because it is designed to protect employees in situations where there are no established standards.

OSHA also addresses identified hazardous activities or conditions through specific standards applicable to those hazards. The general duty clause and a specific OSHA standard address an identical hazard, there is a requirement to comply with the specific standards (which are generally more stringent). However, complying with specific requirements that apply to known hazards is far easier than anticipating and correcting hazards that have yet to be officially identified. In any event, the General Duty Clause

highlights the value of developing workplace safety plans in order to identify potential hazards that are unique to the workplace.

Using this concept, then it would be of utmost benefit to the Wildland fire agencies to consider, address, and adopt the recommendations in the Lessons Learned Analysis and the Smoke Exposure Analysis Report (safety Appendix D-1). Because Cascade Complex was not a unique situation and other ICPs have, in the past have been severely impacted by smoke, wildland fire agencies create and be proactive assessing and mitigating risks of acute smoke exposure.

Geomatrix

November 7, 2007

Mr. Roger Ottmar
USDA Forest Service
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Subject: Preliminary Cascade Complex Smoke Exposure Analysis and Recommendations

Dear Roger:

Geomatrix Consultants, Inc. (Geomatrix) has been tasked to support the USDA Forest Service (Forest Service) with a retrospective occupational health and safety analysis of potential respiratory hazards to wildland fire incident command post camp personnel during a sustained smoke exposure event. In July-August, 2007, the Cascade Complex series of wildfires occurred approximately 60 miles northeast of Boise, Idaho. As we understand the facts, a Type 1 Incident Management Team (IMT) in command of the incident was actively managing the fire response when the fire forced the IMT and camp occupants to prepare to "Stay in Place" (SIP) for at least one operational period where their means of egress would be blocked by the fire. The IMT had selected a relatively safe, defensible location for the fire camp, at a site known as Knox Ranch.

Our task objectives were to have a Certified Industrial Hygienist (CIH) expert in wildland fire smoke exposure: 1) estimate the potential exposure that fire camp personnel might have experienced, 2) summarize expected adverse health effects associated with similar smoke exposures, and 3) recommend appropriate preventive measures that fire managers should consider in the event of similar circumstances in the future. We base our analysis on the available documentation provided by the Forest Service, which was very limited with respect to the actual smoke conditions, camp occupant locations and tasks, and adverse health outcomes experienced up to and during the SIP event and the subsequent days. Therefore, our summary is a preliminary analysis and cannot be considered a definitive estimate of what the actual exposures were or the associated adverse health outcomes.

Summary:

Ambient smoke exposures at the Cascade Complex incident command fire camp were reconstructed based on available photographs of smoke conditions and limited data on the chronology of events. Our analysis indicates that exposures among camp personnel may have exceeded permissible exposure limits established by OSHA, once adjusted for multiple contaminants and the duration of exposure. OSHA standards are applicable to personnel in any workplace situation, as the fire camp was, and are orders of magnitude higher than EPA's National Ambient Air Quality Standards, which are much lower to prevent adverse health effecst among sensitive non-workplace populations, such as children, the elderly and persons with cardiovascular and other diseases. The health effects of smoke components, at the projected exposures, are consistent with anecdotal reports in the limited documentation we have received. The adverse health effects known to be associated with smoke are mostly fast-acting and

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might last for days or a few weeks. Anecdotal reports of impacts on individuals are consistent with both carbon monoxide and respiratory irritant exposures. The available literature does not support long-term adverse health effects, though this is an area of ongoing research. We make four recommendations to better manage smoke exposure in fire camps: 1) Site fire camps where smoke is less likely to accumulate; 2) Measure indicators of smoke exposure to provide objective hazard data; 3) Move camps or implement exposure controls when smoke exposures exceed permissible exposure limit criteria; and 4) Prepare camps to withstand smoke inversion conditions through the use of engineering controls.

The following sections summarize our analysis methods, results and recommendations.

Exposure Estimate: Because no measurements of smoke exposure were obtained during the events, any estimate of exposure must be considered an educated guess and cannot substitute for actual measurements of exposure to toxic and hazardous substances according to the regulatory compliance requirements of the U.S. Occupational Safety and Health Administration (OSHA). With this caveat, we have selected the best available method for estimating the potential exposures. We have reviewed a chronology of events and available photography of the fire camp prior, during and after the SIP event.[1-2] To reconstruct the potential exposures among fire camp personnel due to ambient smoke levels, we first estimated the duration of smoky conditions from the chronology of events and our past experiences under similar inversion conditions at wildland fires in the region. We then estimated the smoke intensity at the camp from the available photographs and applied past research results correlating similar visual estimates of smoke intensity at western wildfires with actual inhalation smoke exposures among wildland firefighters.[3] Those correlations between visible estimates of smoke exposure and actual exposures were derived in the late 1990s in very similar relative humidity regimes, fuels and ambient temperatures. We have chosen the mean relationships derived from those data. We recognize that incident light angles relative to the smoke, the effects of relative humidity, steam or fog, and other factors can bias the results higher or lower than actual concentrations.

The visual estimate system we adopted for this task had applied independent ratings by fire research experts of the smoke intensity in a variety of photographs of wildland firefighters in various work situations. Those researchers ranked each photograph into one of five smoke intensity classes (none, light, medium, heavy and very heavy smoke concentrations). The authors developed linear regressions between measured inhalation smoke exposures among firefighters and trained observer estimates of the smoke intensity at the time of the measurements, using the same classification system. The analysis was

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[1] Author unknown. "Appendix ? Chronology of Events: Chronology Appendix SIP RIP", Oct. 9, 2007, U.S. Department of Agriculture, Forest Service. Transmitted by Roger Ottmar, Research Forester, Pacific Northwest Research Station, Seattle, WA, Oct. 23, 2007.

[2] Author unknown. "Cascade Complex ICP Burn-By", Oct. 1, 2007, U.S. Department of Agriculture, Forest Service. Transmitted by Roger Ottmar, Research Forester, Pacific Northwest Research Station, Seattle, WA, Oct. 23, 2007.

[3] Reinhardt, Timothy E., and Roger D. Ottmar. Smoke Exposure at Western Wildfires. Research Paper PNW-RP-525, U.S, Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR. July, 2000, pp. 44-48.

developed for 46 to 70 samples of three of the major health hazards in wildland fire smoke: carbon monoxide (CO), respirable particulate—particles with a mass median aerodynamic diameter of 3.5 microns (PM3.5), and formaldehyde, with coefficients of determination (r^2) that ranged from 0.6 for PM3.5 to about 0.4 for CO and formaldehyde.

By applying this basic system relating observers' visual estimates and measured smoke exposures among wildland firefighters to the photographs and time series of events, we have developed rough estimates of the general ambient smoke exposures that might have been expected at the Cascade Complex. The estimates are based on very limited data—they may certainly be improved with further input by persons present at the Cascade Complex. There is no method to address differences in exposure that would occur due to performing fire suppression tasks, nor differences in exposure based on proximity to emissions as might be expected among personnel located in different areas of the camp. Table 1 (attached) presents the results of this simple analysis. For three days (August 13 through 15, 2007), we have divided the day into periods based on the chronology of events and observer's notes on smoke levels and diurnal inversion conditions. For each period of the day, we have estimated the associated smoke conditions and specified the basis for the estimate. The visual estimates are presented for CO, PM3.5 and formaldehyde, along with the mixture exposure for the latter two irritants. Because they both adversely affect the eyes and respiratory system, the mixture exposures to all irritants must be considered. This formula uses a simple additive sum of the ratios of exposures to PM3.5 and formaldehyde to their respective permissible exposure limits (PELs), to approximate the total adverse health effects from exposure to the mixture of irritants via a respiratory irritant index, (E_m). The formula for this is provided under OSHA regulations at Title 29, Code of Federal Regulations, Part 1910.1000(d)(2). The individual OSHA PELs are:

Pollutant	**8-hour OSHA PEL**
Carbon monoxide (CO)	50 parts per million (ppm)
Respirable particulate (PM3.5)	5 milligrams per cubic meter (mg/m^3)
Formaldehyde	0.75 ppm
Acrolein	0.1 ppm

In contrast, U.S. EPA National Ambient Air Quality Standards (NAAQS) are 9 parts per million for CO (8-hour average) and 35 micrograms per cubic meter for fine particulate (PM2.5) over 24 hours (0.0035 mg/m^3—note that PM2.5 is of slightly smaller diameter than PM3.5). The EPA NAAQS are much lower than PELs to prevent adverse health impacts among sensitive populations, including children, the elderly, and persons with significant health problems such as serious cardiovascular impairment.

Table 1 presents estimated time-weighted average (TWA) exposures to CO and respiratory irritants for each 24-hour period. Because the camp personnel were not able to get relief from the smoky conditions when sleeping or otherwise off duty in the camp, we recommend that an adjusted PEL for 24-hour exposure to CO apply in this situation. The adjustment, by the simple method specified in the OSHA Compliance Officer's Field Manual, reduces the PEL for CO downward from 50 to 17 parts per million

(ppm).[4] According to this and other guidance documents for industrial hygienists, the PELs for PM3.5 and formaldehyde should not be adjusted for extended duration work shifts, because they are based on irritant effects which are essentially immediate and not time-dependent. Thus the respiratory irritant exposures are directly compared with the 8-hour mixture PEL of 1.0 (a unitless ratio).

The 24-hour exposure estimates in Table 1 indicate that fire camp personnel may have been exposed to a 24-hour average CO exposure that ranged from 33 to 38 ppm, more than double the adjusted PEL of 17 ppm. The respiratory irritant exposures were estimated to average 0.9 to 1.1, approximately at or above the mixture PEL of 1.0. We included no exposure estimate for the smoke component acrolein, because the visual estimate system of Reinhardt and Ottmar[3] had insufficient data for that potent respiratory irritant. Past measurements at western fires indicate that acrolein levels average roughly 15% of formaldehyde levels in wildland fire smoke.[5] The PEL for acrolein is established at about 13% of the PEL for formaldehyde (0.1 ppm vs. 0.75 ppm). Therefore, based on typical past data and the ratio of PELs for these two aldehydes, we might expect acrolein to add an additional 30% to the total respiratory irritant exposures, making the combination of PM3.5, formaldehyde and acrolein at an E_m of roughly 1.2 to 1.4—in any case above the PEL of 1.0.

With more information about the camp conditions, we might improve upon our estimates. However, the estimates are adequate to estimate what the associated adverse health impacts might have been. We strongly doubt that actual exposures among general camp employees were an order of magnitude higher or lower than our estimates. If they had been higher, the health effects would have been much worse than the limited anecdotal information we have received, and there would have been few adverse health impacts if they had been substantially lower. Because the actual exposures are likely well within an order of magnitude of our estimates, the available options to manage exposures are unlikely to change.

Summary of Potential Health Effects: No objective data have been made available to us on cardiovascular and respiratory distress medical visits, but anecdotal reports have been received of adverse health effects among many of the fire camp personnel[6], including:

- headache,
- inability to concentrate on complex tasks and apply normal mental acuity,
- an increase in eye, nose and throat irritation, and
- an increased incidence of colds and flu-like respiratory diseases after the initial exposures.

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[4] U.S. Occupational Health and Safety Administration, Compliance Officer's Field Manual, 1979.
[5] Reinhardt, Timothy E., and Roger D. Ottmar, "Baseline Measurements of Smoke Exposure Among Wildland Firefighters", *Journal of Occupational and Environmental Hygiene*, 1:593-606, Sept. 2004.
[6] Ottmar, Roger. Research Forester, Pacific Northwest Research Station, Seattle, WA. Personal Communication on October 22, 2007.

The first two symptoms are consistent with exposure to CO; the remaining symptoms are consistent with exposure to respiratory irritants PM3.5, formaldehyde and acrolein. Naeher, et al, have recently summarized the literature with respect to the adverse health effects of wood smoke from biomass combustion worldwide, including wildland fire smoke.[7] Among their conclusions:

- Though wood smoke is mutagenic and possibly carcinogenic, it is less so than coal smoke.
- Animal studies indicate exposure to smoke results in significant impacts on the respiratory immune system—by interfering with normal macrophage activity, smoke reduces resistance to diseases such as colds and flu—and the impacts are most strongly associated with the particulate phase of smoke (e.g., PM3.5).
- Upper and lower respiratory tract illnesses, including asthma, respiratory symptoms, and temporarily decreased lung function are noted in major biomass smoke exposure episodes.
- One study in Southeast Asia during the large fires of a few years ago indicated a relationship with increased cardiopulmonary mortality.

Many of the human health and epidemiological studies reviewed by Naeher, et al, were among general public populations exposed to lower concentrations of smoke, where respiratory irritants were the major hazard to public health and CO exposure was a lesser concern. Studies of occupational exposures to higher levels of smoke at wildfires have also identified CO as a significant hazard in smoke due to chemical asphyxiation from the displacement of oxygen from blood hemoglobin by CO, forming carboxyhemoglobin (COHb). Interestingly, as COHb levels increase, the body increases blood flow to the brain to compensate; limited data indicate that this may also increase transport of other air pollutants to the brain, which presumably could include other neurotoxic chemicals that are present in smoke.[8]

Table 2 summarizes the formation rate of COHb at 35 ppm CO exposure, and lists some adverse neurobehavioral health effects of CO exposure from past studies. These effects include reductions in visual perception, manual dexterity, learning, driving performance, and attention level. Though COHb levels of 5% have long been the threshold to be avoided, recent re-evaluation of the literature has concluded that behavioral effects at levels below 10% are widely varying and contradictory among some studies, and that COHb levels of 15-20% would need to be reached before a 10% reduction would be observed in measurable behavioral or visual effects.[9] Despite difficulty in comparing past studies, carbon monoxide's neurobehavioral health effects are not inconsistent with anecdotal reports of multiple persons in the camp exhibiting symptoms of "spaciness" in communications with others. These effects,

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[7] Naeher, L.P., M. Brauer, M. Lipsett, J.T. Zelikoff, C.D. Simpson, J.Q. Koenig and K.R. Smith. "Woodsmoke Health Effects: A Review", *Inhalation Toxicology*, 19:67-106, 2007.

8 U.S. Environmental Protection Agency. Air Quality Criteria for Carbon Monoxide, EPA 600/P-99/001F. National Center for Environmental Assessment, Office of Research and Development, U.S. EPA, Research Triangle Park, NC. June, 2000.

[9] Raub, J. A. AND V. A. Benignus. Carbon Monoxide and the Nervous System. *Neuroscience And Biobehavioral Reviews* 26(8):925-940, (2002).

even when mild, may be of concern when critical decisions are being made by the incident command staff under high smoke exposure conditions.

Finally, although wood smoke has been shown to be mutagenic and has carcinogenic components, cancer is typically associated with long durations of exposure rather than isolated incidents. We have published a human health risk assessment that calculated the risk of cancer among wildland firefighters.[10] That work estimated an excess cancer risk from a career of firefighting that ranged from 1.4 to 220 excess cancers per million, depending on exposure group. The highest estimates were for firefighters in the reasonable maximum exposure group, Type I crews who worked 97 days per year at wildfires and 17 days per year at prescribed burns, with the assumption of maximum exposure estimates at each. We could apply similar risk assessment calculations to the 3-day exposure, but expect the incremental additional cancer risk would be negligible because of the relatively short duration of exposure (several days), in contrast to our career firefighter health risk assessment which assumed a reasonable maximum career of 25 years.

In summary, the adverse health effects noted in the anecdotal reports we have received are consistent with those effects expected from smoke exposure. Individuals vary in their susceptibility to all toxic components in smoke, and some will experience adverse health effects long before others. Just as it cannot be concluded that significant adverse health effects will be experienced by all Cascade Complex personnel, we cannot conclude that none of the personnel were adversely affected. The facts support a conclusion that many were adversely affected during the event and likely for the short term afterwards, if nothing else due to lingering viral diseases such as colds and flu. Long-term health consequences are not clearly linked to relatively short-term exposures to wood smoke, but definitive epidemiological work has not yet been done. Naeher, et al, have called for more research in this area.

Recommendation for Future Events: Clearly the evidence indicates that smoke exposures experienced in the Cascade Complex camp at Knox Ranch caused short-term adverse health effects among many personnel. Our reconstruction of potential exposures resulted in estimated concentrations that may have exceeded: 1) the OSHA PELs for CO, when adjusted for a 24-hour exposure; and 2) the E_m mixture PEL for the respiratory irritants PM3.5 and formaldehyde (and qualitatively, acrolein), when summed according to the OSHA formula for irritants. These estimated exposures are open for debate, but whatever the actual exposures were, if they rose to a level that warrants action, the management strategy would be similar across a wide range of exposures.

To manage smoke exposure in fire camps, we recommend that the Forest Service and other wildland fire agencies adopt a strategy of basing command decisions on objective smoke exposure data and implementing the following specific tactics with respect to fire camps:

[10] Booze, T.F., T.E. Reinhardt, S.J. Quiring, and R.D. Ottmar. A Screening-Level Assessment of the Health Risks of Chronic Smoke Exposure for Wildland Firefighters. *Journal of Occupational and Environmental Hygiene*, 1:296-305. May, 2004.

1. **Site fire camps where smoke is less likely to accumulate**, either under prevailing wind patterns or under inversion conditions. The logistical requirements for fire camps limit the options available to incident teams, and smoke is reportedly one of the factors considered, but it cannot be emphasized enough that avoidance is the simplest solution.

2. **Measure indicators of smoke exposure to provide objective hazard data** when smoke is impacting fire camps. Past recommendations that wildland fire agencies conduct routine monitoring of smoke exposure among firefighters has evidently not been implemented, despite data documenting overexposures in approximately 5-10% of work shifts. Data on fire camp exposures have shown high levels, but are not routinely obtained. There are a number of readily available direct-reading instruments on the market, and some are reportedly available in the NIFC fire cache system. Either the existing Safety or Meteorology staff at most fires would be well-suited to deploy and interpret results from these instruments. Many instruments exist for both CO and various size ranges of airborne particulate (we recommend PM3.5 or PM4 inlets because these match the size range for comparison with the PEL, but PM2.5 or PM10 inlets would be reasonable approximations). If not yet in the fire cache system, they can be rented on a daily, weekly or monthly basis from many vendors of rental instruments. Most are simple to deploy and a setup, operation and interpretation protocol could be developed for the standardized models that are made available. With real data in-hand, the hazard to camp can be objectively evaluated and actions can be based on relevant and appropriate data.

3. **Move camps or implement exposure controls when smoke exposures exceed criteria** that indicate unacceptable levels. We recommend adherence to the adjusted PELs we presented here, but if there was interest, we could refine the criteria further via application of more sophisticated PEL adjustment methods for nonstandard work shifts that should be acceptable to OSHA and applicable state occupational safety agencies. Clearly the Cascade Complex IC team considered moving the camp, but concluded that staying put gave them the best chance at controlling the fire. Similar decisions will surely occur at future incidents because there is usually only one best choice from a logistical standpoint, and considerable investment occurs in developing the camp once the location is selected. This presents an inertial impediment to moving the camp. Due to the reasonably good correlations among wildland fire smoke pollutants, measuring one indicator such as PM3.5 or CO can be used to estimate exposure to the other pollutants.[11] One or two action levels should be established—a lower trigger level to relocate nonessential personnel and take other administrative actions and a higher action level to either move the camp or implement engineering controls.

4. **Prepare camps to withstand smoke inversion conditions** by providing enclosed operational and sleeping spaces with air filtration systems to remove the hazardous components of smoke. If

[11] Reinhardt, Tim E., Roger D. Ottmar, and Michael R. Hallett, Guide to Monitoring Smoke Exposure of Wildland Firefighters, General Technical Report PNW-GTR-448, March 1999.

the camp cannot be moved, reduce exposures within the camp via engineering. Such an engineering solution should be fully investigated before resorting to personal protective equipment. We do not recommend supplemental oxygen for routine (non-life threatening) use—oxygen poses significant hazards and must be kept away from combustible liquids such as gas and diesel fuels, which are present in every fire camp. The correct engineering solution should involve air conditioning equipment that supplies existing trailers and available (nearly-airtight) group tents. The air filtration needs to consider the fresh air needs of the anticipated occupant load (expressed in air changes per hour) and provide the minimum delivery rate in a reliable fashion. System failure alarms are recommended to alert sleeping personnel. The air delivery system must provide filtration for respirable particulate (e.g., HEPA), aldehydes (e.g., carbon or combination carbon/acid gas media), and carbon monoxide. Each of these components of smoke can be removed by readily-available air pollution removal/industrial gas conditioning equipment. The engineering required to integrate the system components at least cost while maximizing reliability and efficiency is straightforward, and because the individual components already exist, suitable systems may already be on the market. We recognize these controls will be costly. However, along with the agency's duty to protect the health of employees and contractors, there are regulatory compliance requirements to control smoke exposures, and each fire management agency may want to contrast the cost of effective controls versus the total costs of staff time and the medical, workman's compensation and legal activities driven by required followup to employee and contractor overexposures to smoke.

In closing, we believe that our analysis is the best that can be done given the limited data. We are certain that a number of steps can be taken to improve smoke management at fire camps, and offer our engineering and industrial hygiene capabilities to help conceptualize, pilot test, and implement them. Please call at (206) 838-8464 or email me at treinhardt@geomatrix.com if you have any questions about our findings or recommendations, or if you need further assistance with resolving this important issue.

Sincerely yours,
GEOMATRIX CONSULTANTS, INC.

T Reinhardt

Tim Reinhardt, CIH
Senior Scientist

CC: Jim Russell—USDA Forest Service, Region 6 Headquarters

Enclosure

Table 1--Estimated Smoke Exposures at Cascade Complex Incident Command Fire Camp

						Estimated Smoke Concentrations			
Date	Time Period	Event	Estimated Conditions	Estimate Basis	Estimated Duration (hours)	CO (ppm)[a]	PM3.5 (mg/m^3)[b]	Formaldehyde (ppm)	Irritants Mixture Index[c] (unitless)
08/13/07	0000-1300	Burnout of 1.7 miles, south of 2-Bit Creek	medium smoke	Nighttime and notes of inversion lifting in early afternoon (Ref. 1)	13	30	3	0.15	0.8
08/13/07	1300-1530	Lifting inversion, drop in RHs	light smoke	Notes of inversion lifting (Ref. 1), photo of spot fires from camp in slide 7 (Ref. 2)	2.5	15	2	0.1	0.5
08/13/07	1530-1700	Increasing smoke events and frequency	medium smoke	Notes of burn-by (Ref. 1), photos of stay-in-place briefing and initial pulses of fire in slides 8-11 (Ref. 2); assume weighted average of "medium" conditions	1.5	30	3	0.15	0.8
08/13/07	1700-2359	burn-by, with erratic winds, alternating light to very heavy smoke	heavy smoke	Notes of burn-by (Ref. 1), photos of smoke conditions and fire runs in slides 12-23 (Ref. 2); assume weighted average of "heavy smoke" conditions	7	44	5	0.2	1.3
				Estimated 24-Hour Time-Weighted Average Inhalation Exposures 8/13/2007:	**24**	**33**	**3.5**	**0.2**	**0.9**
				OSHA-Adjusted Permissible Exposure Limits:		**17**			**1.0**
08/14/07	0000-1500	Inversion, assumed with heavy smoke	heavy smoke	Notes of Smoke Inversion condition lifting at 1700 (Ref. 1), photos of smoke conditions the morning of 14th--slides 24 and 25 (Ref. 2); assume weighted average of "heavy smoke" conditions during the strongest inversion period.	15	44	5	0.2	1.3
08/14/07	1500-1700	Inversion lifts at 1700, assume lighter in last two hours	medium smoke	Notes of Smoke Inversion condition lifting at 1700 (Ref. 1), photos of smoke conditions the morning of 14th--slide 24 (Ref. 2); assume weighted average of "medium smoke" conditions during the inversion breakup period.	2	30	3	0.15	0.8
08/14/07	1700-1900	Assume air clears somewhat after inversion lifts but before sundown	light smoke	Notes of Smoke Inversion condition lifting at 1700 (Ref. 1), photos of smoke inversion conditions on 14th--slide 25 (Ref. 2); assume weighted average of "light smoke" conditions after the inversion breakup period and before inversion rebuilds during evening hours.	2	15	2	0.1	0.5
08/14/07	1900-2359	Assume inversion settles in after sundown again	medium smoke	Notes of Smoke Inversion condition lifting at 1700 (Ref. 1), photos of smoke inversion conditions on 14th--slide 25 (Ref. 2); assume weighted average of "medium smoke" conditions after the inversion breakup period and increasing smoke during evening hours.	5	30	3	0.15	0.8
				Estimated 24-Hour Time-Weighted Average Inhalation Exposures 8/14/2007:	**24**	**38**	**4.2**	**0.2**	**1.1**
				OSHA-Adjusted Permissible Exposure Limits:		**17**			**1.0**
08/15/07	0000-1100	Inversion conditions and burn out of camp flanks	heavy smoke	Notes of Smoke Inversion condition lifting at 1300 (Ref. 1), photos of smoke inversion conditions on 14th--slide 25, and lost resources-assumed to be on 15th (Ref. 2); assume weighted average of "heavy smoke" conditions during the inversion.	11	44	5	0.2	1.3

Table 1--Estimated Smoke Exposures at Cascade Complex Incident Command Fire Camp

					Estimated Smoke Concentrations				
Date	Time Period	Event	Estimated Conditions	Estimate Basis	Estimated Duration (hours)	CO (ppm)[a]	PM3.5 (mg/m^3)[b]	Formaldehyde (ppm)	Irritants Mixture Index[c] (unitless)
08/15/07	1100-1300	Inversion lifts at 1300, assume lighter in last two hours	medium smoke	Notes of Smoke Inversion condition lifting at 1300 (Ref. 1), photos of smoke inversion conditions on 14th--slide 25 (Ref. 2), and lost resources--assumed to be on 15th (Ref. 2); assume weighted average of "medium smoke" conditions during the inversion breakup period.	2	30	3	0.15	0.8
08/15/07	1300-2359	Assume air clears somewhat after inversion lifts but before sundown	medium smoke	Notes of Smoke Inversion condition lifting at 1300 (Ref. 1), photos of lost resources--assumed to be on 15th--slide 26 (Ref. 2); assume weighted average of "medium smoke" conditions after the inversion breakup period.	11	30	3	0.15	0.8
				Estimated 24-Hour Time-Weighted Average Inhalation Exposures 8/15/2007:	**24**	**36**	**3.9**	**0.2**	**1.0**
				OSHA-Adjusted Permissible Exposure Limits:		**17**			**1.0**

[a]parts per million

[b]milligrams per cubic meter of air

[c]The irritants mixture (E_m) is the sum of each respiratory irritant (PM3.5 and formaldehyde) divided by its PEL, and accounts for the fact that these both affect the eyes and respiratory system.

Reference 1: "Appendix ? Chronology of Events: Chronology Appendix SIP RIP", Oct. 9, 2007, USDA Forest Service (author unknown.) Transmitted by Roger Ottmar, Research Forester, Pacific Northwest Research Station, Seattle, WA.

Reference 2: "Cascade Complex ICP Burn-By", Oct. 1, 2007, USDA Forest Service (author unknown.) Transmitted by Roger Ottmar, Research Forester, Pacific Northwest Research Station, Seattle, WA.

Table 2—Estimated Carboxyhemoglobin Levels and Possible Mental Effects of Carbon Monoxide Exposure

Exposure Duration at 35 ppm CO (hours)	Carboxy-hemoglobin (COHb) levels during light work (%)	Examples of Potential Neurobehavioral Effects in Humans[a,b]
1	2.6	Measurable impairment of ability to estimate length of brief sounds (0.7-1.3 seconds) and length of 30-second time intervals, but not 10-second time intervals.
2	3.8	
3	4.7	
4	5.2	12% reduction in ability to see changes in red light brightness; Significant increase in errors in complex behavioral test response (e.g., response to color changes, arithmetic solving, recognizing plural nouns in text). Measurable impairment of control precision (e.g., compensatory tracking) and multiple limb coordination.
5	5.5	
6	5.8	
7	5.9	
8	6.0	
24	6.2	Up to 28% reduction in vigilance (at 6.6% COHb)

[a]Data and examples from: Criteria for a Recommended Standard: Occupational Exposure to Carbon Monoxide. National Institute for Occupational Safety and Health, U.S. Department of Health, Education and Welfare, Health Services and Mental Health Administration. Washington, D.C. 1972.

[b]Note—There are conflicting data among studies, and further research in this area is recommended by U.S. EPA.

APPENDIX E

Accident Prevention Analysis Team Members:

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