Paper presented at the International Technical Rescue Symposium, 5-7 November 1999, Fort Collins, CO

"Recognition" as a Component of Emergency Response[1]

by

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1. Introduction.

An important, but frequently overlooked, component of response to a natural disaster is the *recognition* that a disaster is actually taking place. This seemingly simple step can lag the onset of life-threatening events by a significant period of time. As an example, we will look at the Fort Collins, Colorado flash flood of July 28, 1997. A flash flood occurs when heavy rain persists over a single drainage, particularly when soils have been saturated in advance. In such cases, catastrophic events evolve quickly.

2. Rain and Topography.

Regions in and around mountainous terrain are susceptible to weather effects that don't occur in other parts of the world. Varying topography can modify both airflow, and water runoff. Such is the case for Fort Collins -- a city of more than 100,000 people situated along the eastern foothills of the Rocky Mountains in north central Colorado. The elevation rises gradually by more than 2,000 feet from the eastern Colorado border to the city center. Easterly low-level winds (called upslope flow) can bring what is typically more moist air from Kansas and Nebraska westward, right up to the base of the mountains. Warm, moist, rising air is one key ingredient for thunderstorms. If atmospheric instability is present, strong storms are the result.

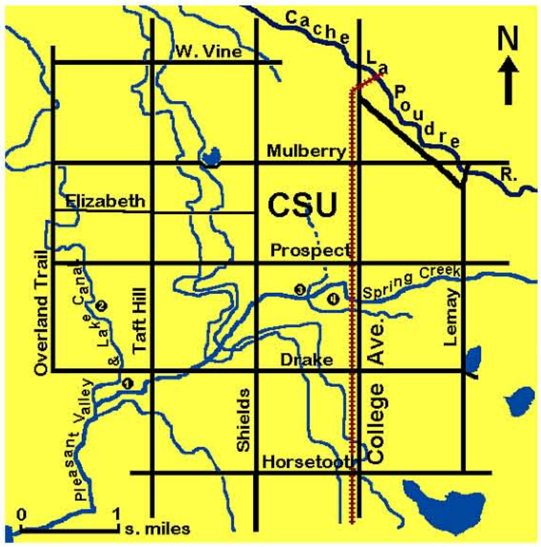

Figure 1. Map of Fort Collins. CO with principal roads, canals and creeks. The Pleasant Valley & Lake (PV&L) canal and Spring Creek as indicated. "CSU" marks the main campus of Colorado State University.

As with most cities on the high Plains, Fort Collins has its own unique set of runoff and drainage problems. In addition to the Cache La Poudre River which crosses through northern Fort Collins, the urban area is

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1 Most of the material for this manuscript is taken from an article by the author which appears in the September 1999 issue of Fire Chief magazine (see acknowlegements). Also, for a more detailed account of 9-1-1 dispatch difficulties during this disaster, see the January-February 2000 issue of 911 Magazine.

crisscrossed by a series of creeks and irrigation ditches running both east-to-west, and north-to-south.

Rivers, creeks, and irrigation canals are not the only hydrological factors affecting the area. The elevation along the western edge of Fort Collins averages around 5,200 ft. Six miles to the east, on the other side of town, the average elevation is just under 4,900 ft. This apparently gentle 300 ft drop in terrain from west-to-east across the city, makes for a significant difference in various weather situations. Western Fort Collins generally gets more "upslope precipitation," and from a drainage standpoint, the sloping terrain means persistent runoff from west-to-east during heavy rains. To complicate matters further, the runoff terrain is not flat across the city. Water drains into broad, shallow, "drainage basins" which channel the runoff as it moves through the urban area.

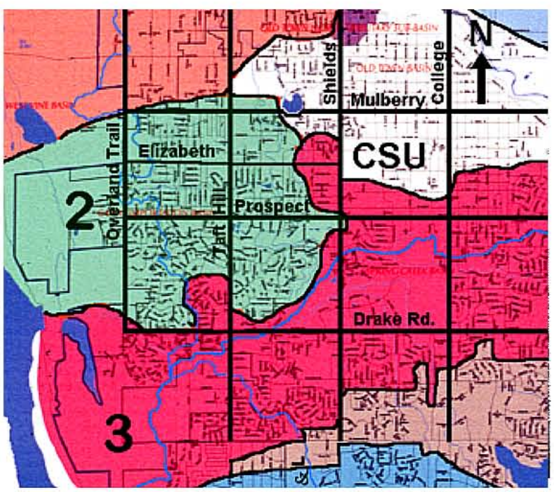

Figure 2. Some of the principal drainage basins in Fort Collins. Number 2 is the Canal Importation Basin, number 3 is the Spring Creek Basin. North-South winding line is the PV&L canal, east-west line in basin 3 is Spring Creek.

3. The Event.

On Sunday, July 27th, the passage of a cool front put Fort Collins into a strong upslope flow pattern. The front passed through the area just before noon, and rain began at around 4:30 p.m. Heavy showers continued throughout the night, bringing rainfall totals as high as 3 - 4" to western parts of the city by noon the following day. This is a lot of water for a city whose average annual rainfall is 15", but similar events do occur every few years in the region. Thus, reports of flooded fields and nearly full irrigation canals were not far enough outside the normal to worry the emergency response community.

The National Weather Service (NWS) recognized the potential for trouble when it issued a Flash Flood Watch at 5:00 p.m. on Monday evening. In their discussion, forecasters warned that the atmosphere over northern Colorado was saturated, and that heavy thunderstorm rains were likely. But a "Watch" is just a forecast based on potential, and at the time no plans were in place to deal with potential.

Heavy rain began again just after 5:00 p.m. This time the action was centered over western Fort Collins. A series of individual rain cells formed southwest of the city, then moved off slowly toward the north-northeast. The cells brought periods of extremely heavy rain, mixed with shorter periods of drizzle. Residents say that the noise from the rain was so loud that it interfered with normal conversation indoors. However, post-event interviews conducted with nearly 300 people traveling through, and living in, the affected areas found an overall lack of concern at this point. Drivers continued about their business, slowing somewhat as they drove into heavier downpours, but, in general, people reported being either pleased to see the rain, or irritated by the fact that driving times were slower. Between 5:00 p.m. and 7:00 p.m., not many seem to have recognized the situation as dangerous.

By 7:30 p.m., flags were beginning to go up for people in specialized professions. Police officers began to report more intersections under water. E-911 dispatch began to get reports of electrical short circuits and automatic fire alarms, all due to water. Firefighters were kept busy responding to these types of calls.

The NWS issued an Urban and Small

Stream Flood Advisory at 7:36 p.m. for eastern Larimer county, and specifically mentioned Fort Collins. It warned of small creek and stream flooding, and noted that the ground was already saturated from the previous evening's rain.

Despite the ominous signs of a growing threat, *no one* as yet saw the situation as becoming deadly. The NWS did not issue an actual Flash Flood Warning. This "highest-level-of-alert" would have triggered scroll bars on major television stations to mobilize both the general public, and the city's emergency staff. Forecasters were having difficulty justifying taking this important step. The airmass was actually *so* warm, that hail concentrations normally found in the upper reaches of the storms were missing, and Doppler radars (calibrated locally to the "normal" storm) were understating rain amounts by as much as fifty percent. Also, no eyewitness reports were reaching the Weather Service. Local spotters perceived the event as "heavy rain," but did not recognize it as particularly threatening. At 7:30 p.m., the heaviest storms were far too transient for any pattern to emerge

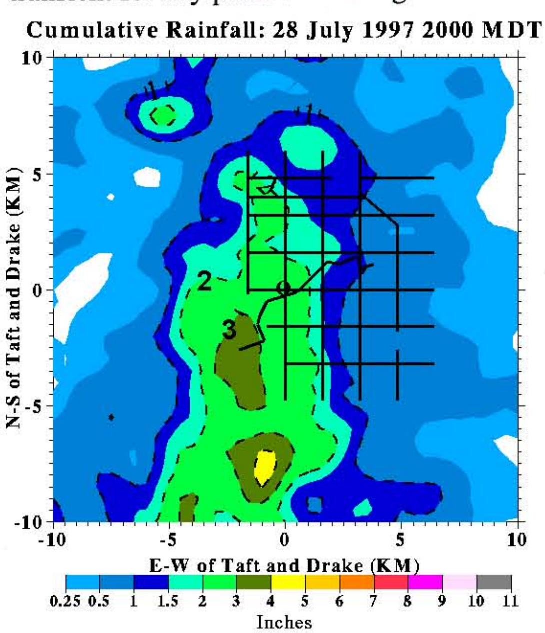

Figure 3. Rainfall accumulation between 5:00 p.m. and 8:00 p.m. MDT on 28 July 1997. "O" is centered at the intersection of Drake and Taft Hill. By 8:00 p.m., 2 ½ " had fallen there.

Just before 8:00 p.m., 9-1-1 dispatch began sending firefighters out to a few houses to help with pumping. This was not unusual. Flooded basements happen in Fort Collins with every extreme rain event, and the Poudre Fire Authority offers help on a non-emergency basis, whenever possible. Local traffic volumes on city streets remained near normal, and interviewees in my post-event survey report feeling nothing more than a minor irritation as they continued with their evening activities.

However, some rather bizarre behavior did begin around this time. The northern half of the Canal Importation Basin drains onto the campus of Colorado State University at the intersection of Elizabeth Street and Shields Avenue. At roughly 8:15 p.m., several students were seen (by police officers and the city emergency manager) riding "boogie boards" and inner-tubes down Elizabeth Street on sheets of one-foot-deep water, toward the Shields intersection where the water was about two-feet-deep. There they were met by friends in high-centered pickups, and driven back west for another "run." In other parts of town, the volume of traffic on the roads *increased*, as residents with large pickups and sport utility vans came out to test their vehicles in the high water.

E-911 activity really began to liven up about this time. The total call volume (9-1-1 plus non-emergency police lines) increased sharply, going from just 9 calls in the fifteen minutes between 7:45 and 8:00, to 28 in the next 15-min. period. Several calls concerned the PV&L canal overflowing into houses. What wasn't known at the time was that a major backup in the canal's flow was occurring just north of Spring Creek where three-foot-deep runoff swept across a ten-to -twelve acre open space. It was running *across the top of the PV&L canal* in a place where the canal ran west for several hundred yards, and in a direction *opposite to that of the underlying flow*.

The general runoff, plus the canal's diverted water now roared toward Spring Creek. One of the early E-911 calls was from the Town and Country Stables (No. 1, figure 1) which sat in a lowland area right in the path of this overflow. Firefighters came on scene at a little after 8:30 p.m., to find water depths ranging from six-to-twelve feet, and spent a harried 30 min. getting horses to safety. A quarter mile downstream, other rescuers began a 2½ hour odyssey which involved trying to find a way to pull a woman and her son from a tree half submerged in fourteen foot deep, raging water.

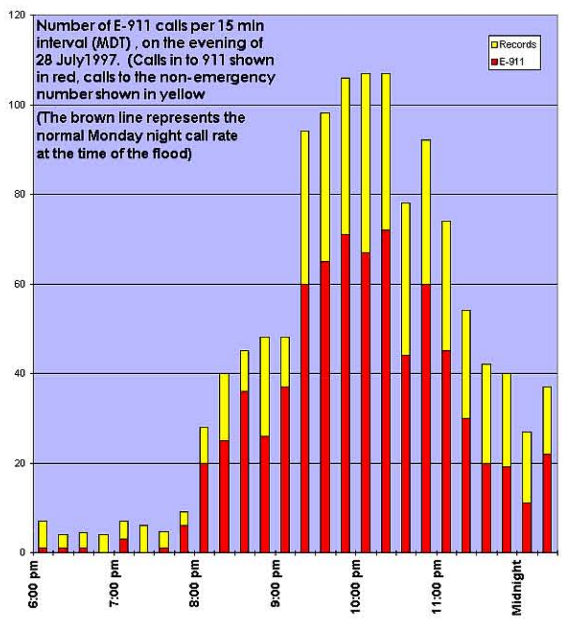

Figure 4. Incoming 9-1-1 (dark) and police (light) phone calls in 15-min increments. Times in Mountain Daylight (24-hr clock).

Closer to the center of town, the southern half of the Canal Importation basin had reached its capacity, and calls began to come in about flooded basements, and floating cars. Many of the second variety included reports of vehicles floating east in four-foot-deep water with people trapped inside. Down at the end of a small lowland cul-de-sac, the banks of the PV&L canal overtopped, and began to erode away (No. 2, figure 1). Water which had previously been held back by the canal embankments now poured into houses, soon reaching levels as high as the ceilings of the first floor. An engineer who'd gone down to check on the canal was caught by this event, and nearly drowned before grabbing onto a passing tree. Water swept down streets and through a local drainage channel at 1,750 cubic ft per second (cfs), heading east where the flow spilled out across main north-south streets. There it trapped other drivers who failed to recognize the deadly nature of the situation.

The incoming call rate was now nearly one call every 20-sec., and the city's emergency manager called for *all* off-duty firefighters, ambulance staff, police officers, and dive rescue personnel to be paged-out. Emergency responders had at this point recognized the unusual nature of the storm(s).

Then came the final, ironic touch of the evening. A large storm some 40 miles to the east produced a massive dome of dense, rain-cooled air. The warm winds on its northern side were deflected and accelerated by nearly 50%. A narrow, intense jet of moist air began feeding into the Spring Creek Basin. What had been a series of slow moving cells suddenly became a single, large and very intense tropical rain storm that virtually stalled over southwest Fort Collins. Rain rates nearly doubled.

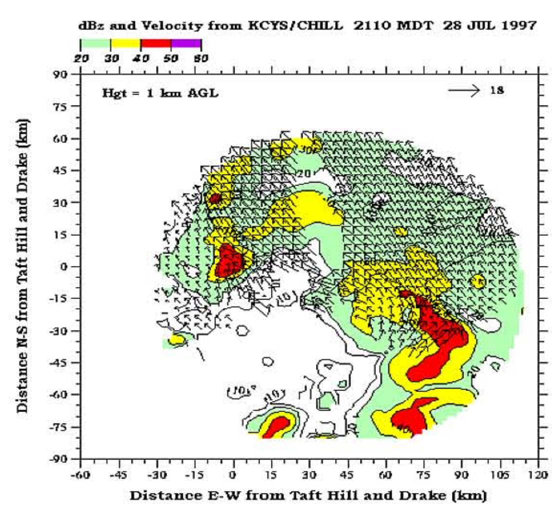

Figure 5. Low-level wind vectors computed by combining Doppler radar velocities from the CSU CHILL Doppler with those from the NWS Doppler in Cheyenne, Wyoming. The large core at (0,0) is near Taft Hill Road and Drake in Fort Collins.

Now the call-rate spun out of control. Radio frequencies jammed with traffic, and dispatchers had trouble keeping track of where fire, police, and ambulance units were in the chaos of trying to prioritize calls. Response times were doubled, or even tripled, as routes became blocked by the deep, fast flowing water. In several cases, firefighters were blocked from reaching one call, and diverted on their own to rescue trapped people they encountered elsewhere. Often it would take five minutes or more to get through to the dispatch center to inform them of the change of mission. Fort Collins was now "behind the curve," and many firefighters and police officers began searching for, and rescuing, citizens on their own.

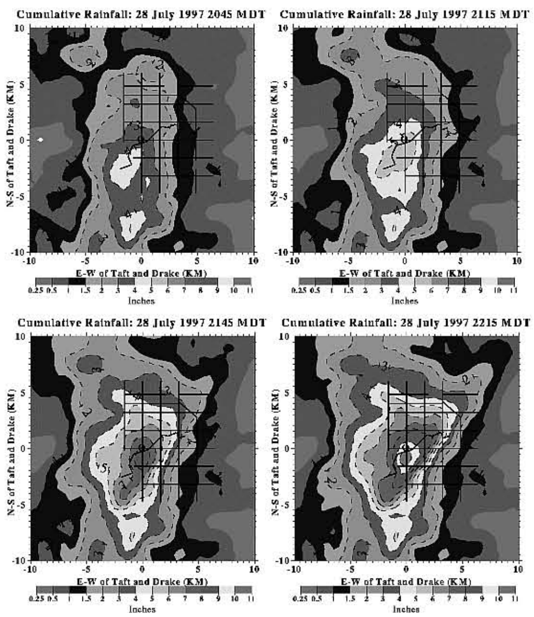

Figure 6. Rainfall accumulation in 1/2 hr increments beginning at 8:45 p.m. MDT on 28 July 1997. 10.5" fell near Taft Hill and Drake.

Along many city streets, boogie boarders were toppled into the furiously flowing water, and had to be rescued. Dozens of automobile drivers were pulled from cars that tumbled along in deepening water. The water washed onto the campus of Colorado State University (marked "CSU" on city map), flooding the campus police and dispatch center, smashing through large picture windows in the Morgan Library, and inundating the massive student center complex. A man who'd been trying to squeegee trickles of water from the west entrance of the student center left just seconds before four-to-five foot deep flow smashed through the double glass doors. In the basement of the library, workers who were mopping up water in a large storage area heard a wall "groan," and ran for the stairs less than 30-seconds before the wall caved in. Nearly a half million books were destroyed. Many people that had been in both buildings missed being killed or injured by minutes.

Back to the south, Spring Creek raged east with flow rates of more than 6,000 cfs. This water was joined by 1,350 cfs exiting the southern end of the Canal Importation Basin, and 850 cfs coming in from south of the main channel. Along both routes houses flooded, basement walls collapsed, and motorists were washed into deep, whitewater rapids. At the confluence of the three flows, trucks, vans and sport utility vehicles were swept into a pile at the end of Wallenberg Drive (No. 3, figure 1), which is the lowest street in the region. A two-car garage was torn off its foundations, nearly dragging some of the fleeing drivers (wading through chest deep water) along behind it.

The combined flow sent 8,250+ cfs of water directly into a 50-acre lowland area (No. 4, figure 1) that had been designed to be a massive detention pond. On the north, west, and south sides of the region, the terrain slopes gently downward toward the center. The eastern side is bordered by a 19 ft. high railroad embankment. Several culverts had been engineered into the birm that were designed to allow huge quantities of excess water, to move east in a more controlled fashion. The entire detention facility had been designed to collect and hold *nearly double* the predicted 500-year flood overflow. Its total capacity of more than 16,000,000 cu. ft. was nearly reached by 10:45 p.m., at a time when the incoming call rate from the western part of the city was running one call every 8.5 seconds. No stream or depth gauges had been installed in the lowlands, so the buildup went unmonitored. Also, since the area is large, unlit, and free from human habitation, there was virtually no way for anyone to observe the potentially deadly situation.

The first sign of the final phase of the disaster came when several people to the east of the railroad tracks noticed that Spring Creek was running exceptionally high between the railroad bed and College Avenue – the main north-south street through the city. Nearby houses were starting to flood. Calls from this area began to filter into the overworked dispatch center. Only one engine was available in reserve, and it headed down College at 10:44 p.m. While it was still on its way, and while most rescuers worked furiously in a three-to-four sq. mi. area to the west, severe turbulence and enormous water pressure caused the 12' x 14' culvert under the railroad bed to fail catastrophically.

Figure 7. Failed culvert, 9:00 a.m. on the morning of 29 July 1997. Compacted dirt had all been washed away, and the 80 ft. long, 36 in. diameter pipe broken into pieces.

A few minutes after the culvert failed, the deepening water (which continued to rise despite the sudden release of 3,300 cfs through the culvert) overtopped the railroad bed. Unfortunately, a freight train had started across this section of tracks between the two events. The combined flow from the culvert and the overtopping surged into two trailer parks situated next to the tracks on the east. Several witnesses who'd driven through the parks just twenty minutes before report having seen only rain dampened roads, and normal activity. By 11:00 p.m., eight-foot-deep raging waters were floating trailers, and sweeping victims into the twelve-foot-deep Spring Creek channel. Broken gas lines had ignited three mobile homes which burned fiercely in the middle of the flood waters. The passing train was derailed, and a nearby store exploded. Sixty-two people were in the process of being injured and five ladies had already drowned.

The total rainfall in southwest Fort Collins for the six hour period from 5:00 through 11:00 p.m. was 10.5 inches. In eastern and northern Fort Collins, residents looked out their windows at what for them would be an inch or two rainfall, and went to bed where they enjoyed a peaceful night's sleep.

Figure 8. Entrance to the Johnson Mobile Home Park, 1799 S. College Ave. at about 8:30 a.m. on the morning of 29 July 1997.

4. Concluding Remarks.

The Fort Collins flood of 28 July 1997 brought with it a number of lessons for the local response community and emergency management staff -- especially with regard to the issue of recognition. First is that emergency managers must be aware of every type of natural disaster to which their area is prone. Second, emergency staff must be trained to be more alert to their daily environment than is the general public. Third, a system must be in place to facilitate information and environmental cues which will help those in charge of emergency will help those in charge of emergency response to more quickly recognize a developing catastrophe. And fourth, all emergency responders should be prepared to not only live with, but welcome "false alarms" as an *important* and *useful* component of their job. Part of any success in "planning for the worst" is an up front acknowledgment that the "worst" by definition is so unusual that recognition can often be the most difficult step in the plan.

The City of Fort Collins Office of Emergency Management has now formed a working partnership with the National Weather Service. The goal is to streamline two-way information exchange on "threat" days to help both agencies carry out their responsibilities more effectively. The city has installed an Emergency Manager's Weather Information Network (EMWIN) site, which allows the NWS to directly transmit text messages to city computers or pagers. Additional rain and stream flow gauges are being installed throughout the city; especially within the more flood-prone areas. Data from these sites will be transmitted directly to the Weather Service via a new system call the Local Data Acquisition and Display (known by its acronym, L-DAD).

A low-power, AM radio station has been set up (530 AM) to help keep the public constantly informed during disasters. With proper management and advertising, this radio site will be a place where the public will turn both in times of local natural disasters, as well as during more routine situations such as school closings, and etc. Broadcasts during natural disasters will also include instructions concerning when, and when *not*, to use the Emergency 9-1-1 phone lines.

Natural disaster information cards, in a format resembling standard EMD cards, have been designed to help dispatchers carry out their duties more effectively. These cards contain quick and accurate advice for a number of weather-related emergencies and are set up to be used both in real-time and for in-service training. Copies of these cards may be obtained at:

http://www.ci.fort-collins.co.us/c_safety/oem/overview_ndic.htm

Finally, many city workers are being trained to think of themselves as emergency responders in natural disasters. They, too, are becoming more "weather-alert" through training and experience, and will facilitate a more effective response. In the case of future flooding, for example, Stormwater Utility staff plan to be part of a large observing network that will help the Emergency Manager intelligently assess the general threat, and identify localized problems.

There are large number of other steps in progress all of which are designed to facilitate education, mitigation, observation, and recognition of critical threat when disaster next strikes.

5. Acknowledgments

Most of the material for this manuscript is taken from an article by the author which appears in the September 1999 issue of Fire Chief magazine, published by Intertec Publishing Corp., P.O. Box 12901, Overland Park, KS 66282-2901.

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