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Lessons from an Extreme Event

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Abstract

The July 28, 1997 flood disaster in Fort Collins, Colorado is generally called a "500-year event" and offers insight into the causes and impacts of extreme urban flooding. Although it hurt and traumatized many people, the flood provided valuable lessons for civil engineers, managers of government agencies, political leaders, counselors, and citizens. Representing several disciplines and entities, the authors present a cross-cutting view of the flood emergency and its lessons. The paper also includes a synthesis of a post-flood conference at Colorado State University which featured reports from all major entities involved in the flood. The remarkable storm that caused the flood produced the heaviest rains ever documented to have fallen over an urbanized area in this state in the recorded history of Colorado. The storm occurred in stages, and dropped 10 to 14 inches in 31 hours in a large area around Fort Collins. The heaviest hourly precipitation occurred at the storm's end, which is different from most storms, and may have exacerbated the flooding. Runoff was dramatic and some peak discharges greatly exceeded projected 100-year and 500-year flows. The City Manager's report showed five people dead, 54 people injured, loss of about 200 homes, and 1500 homes and businesses damaged throughout the City. Fort Collins was more prepared than most cities because it has a nationally-recognized Stormwater Utility and good emergency response capabilities, but it still learned much from the event. Damages at Colorado State University were unusually severe, totaling in the range of $100 million, including building damages, about 425,000 library volumes inundated, loss of a semester's textbooks in the bookstore, and many other losses—both personal and professional. Although the university was surprisingly vulnerable, it responded well with no delay in opening school a month later, but only as a result of tremendous efforts. Emergency response in the City by the Poudre Fire Authority was outstanding, and although the flood had tremendous impacts on the community, not one firefighter or police officer was injured. Within three months after the flood, the local paper, the Coloradoan, had published 282 stories about the flood, and the event received broad coverage in the

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United States and abroad. After the flood, Fort Collins has tried to focus beyond the physical issues to recognize the multi-faceted losses and the ensuing grief experienced by many people. Lessons are presented in the paper about complacency, protecting vulnerable areas, flood frequency analysis, stress and trauma, the importance of organizational mobilization, the vulnerability of universities, growth management in a hazardous environment, mitigation versus response, communicating risk to officials and the public, and handling large influxes of donations.

Introduction

On the evening of July 28, 1997, an extreme flood disaster hit the Colorado community of Fort Collins, Colorado. The storm produced the heaviest rains ever documented to have fallen over an urbanized area in this state in the recorded history of Colorado. The disaster will be remembered as one of the most memorable events of the 20th Century in the City, and was quickly labeled a "500-year event," regardless of whether the term applies. This urban flood event differed markedly from other famous floods in Colorado, such as the Big Thompson River flash flood disaster that hit near Fort Collins in 1976, and, based on media coverage, was certainly one of the major urban floods of recent years in the United States.

This paper is offered as a post-flood analysis to provide a comprehensive view of the causes, consequences, and lessons of this remarkable flood event. Rather than an in-depth technical analysis of a single aspect, such as rainfall, runoff, or damages, the paper takes a cross-cutting view of the flood emergency and provides a narrative, a data base, and a set of "lessons learned." It includes the results of the seven authors' own studies and analyses of the flood and a synthesis of information from the Flood '97 Conference, an event held on November 4, 1997 by Colorado State University's Water Center.

The questions that we will raise and attempt to answer about the flood fall within the different fields of the authors, and include several different ways to look at flooding. For example, in the realms of hydrology and hydraulics, the event was characterized as a "500-year flood," but what is the basis for such claims, are they true, and is such a characterization useful for planning for extreme urban floods such as this? In the realm of risk, dollar damage during the flood was extraordinarily high, especially on the Colorado State University campus. Given that previous large floods had occurred, how did so much damage occur in an urban flooding situation, and can similar damages be prevented in other places? From the viewpoint of emergency response, how effectively did the community respond to the event? Were systems for emergency preparation and response adequate? How could they be improved? What flood mitigation programs took effect? How did they work? In terms of public involvement and citizen responses, what were the emotional impacts of the flood? Did they affect the community in surprising ways? If so, what were the surprises? Finally, what lessons can civil engineers and flood specialists learn from such a severe flood event?

Figure 1: Location Map

The Storm That Caused the Flood

In the weeks leading up to the flood, Fort Collins and vicinity experienced a six-week period of predominantly hot and very dry weather. A total of just 0.36 inches of rain had fallen from June 15 through the afternoon of July 27. But in that last week of July, the humidity increased as moist tropical air drifted northward. Widely scattered afternoon thundershowers developed in parts of Colorado each day. On July 27, a fairly strong cold front moved southward into the region. This cold front served as the trigger to help initiate numerous storms over northern Colorado late that afternoon. As the front pushed southward across eastern Colorado, southeasterly surface winds developed that brought even more humid air from Kansas into the region. The combination of a tropical air mass with light winds aloft (above mountain top level), the extremely moist near-surface air from the east and the air mass boundary to help trigger storm development provided the ingredients needed for copious Front Range rainfall.

As this weather pattern developed, many meteorologists noted the strong similarity with weather conditions associated with previous flash floods – the Rapid City storm of June 9, 1972, and the Big Thompson flood of July 31, 1976, for example. The potential certainly existed, yet no one knew exactly where or if a similar storm would develop.

The first round of storms late on Sunday afternoon (July 27) were not unusual. Small, localized storms, complete with crashing thunder and gusty winds, brought torrents of rain to areas in the lower foothills just west and northwest of Fort Collins between 5:00 and 6:00 PM MDT. After dropping as much as 2.4 inches of rain near the south end of Horsetooth Reservoir, the storms quickly diminished and brought only a light shower to most of the city. But instead of clearing off after dark – the normal summer weather pattern, moist southeasterly winds strengthened. Low, dark clouds hugged the foothills. Late at night, rains developed again, but this time with a different character. Steady, drumming rains without the accompaniment of lightning or thunder expanded along the base of the foothills. Areas two or more miles east of the foothills again received relatively light rains, but at the immediate base of the foothills, heavy rainfall was noted. A gloomy dawn July 28 brought a temporary break in the rainfall, but then the downpours began again, this time even more localized. While most of Fort Collins had a cloudy, cool morning, rain poured along the base of the foothills from 8:00 AM to noon.

A detailed time history of the storm is given by Doesken and McKee (1998) as they analyzed rainfall reports gathered from more than 300 locations in and near Fort Collins. Unknown to most residents of Fort Collins, six to 10 inches of rain had already fallen by midday July 28 from the north end of Horsetooth Reservoir to northwest of the small town of Laporte (Figures 2 and 3). Areas west and southwest of Fort Collins received two to four inches of rain. Flooding was severe during the day in and near Laporte.

Figures 2 and 3

Rainfall abated across the region Monday afternoon (July 28). However, high humidity air continued in place with dewpoint temperatures in the low 60s Fahrenheit, unusually high for this part of the country. Around 6:00 PM MDT, bands of heavy showers began again (Figure 4). Once more, the heaviest showers were concentrated near the foothills. A few rumbles of thunder accompanied the rain, but lightning activity was not remarkable. As the evening progressed, rains increased. Winds were surprisingly light, and temperatures remained very mild. Many residents noted the unusually warm rain and the lack of any hail. Around 8:30 PM, after more than two hours of heavy rain, the rains diminished east and southeast of the city. At this same time, the storm's intensity increased in western portions of Fort Collins. From 8:30 to 10:00 PM, the heaviest sustained rainfall in memory, with rainfall rates occasionally reaching six inches per hour over southwest Fort Collins, inundated the city and sent huge volumes of runoff flowing downhill across the city from west to east. After this awesome crescendo of rainfall, the rains ended mercifully and abruptly between 10:00 and 10:30 PM in southwest Fort Collins with lighter rains continuing north of town until after 11:00 PM. When the evening storm was over, more than 10 inches of rain had fallen in the Spring Creek basin in southwest Fort Collins (Figure 5) with five to eight inch totals widespread over the western half of the city. Remarkable rainfall gradients were noted southeast of the storm center with less than two inches of rainfall over most of southeast Fort Collins. In fact, many of the citizens were unaware of the raging flood waters heading eastward.

Figures 4, 5, 6, 7

The official Fort Collins weather station is on the Colorado State University main campus and has been measuring precipitation daily since 1889. It received very heavy rains from this storm system but was approximately 3 miles northeast of the center of heaviest precipitation. As measured on campus, the 1997 storm dropped 6.35 inches of rain in approximately 30 hours. While not unique in terms of total rainfall at that location, only two other storms in history have produced comparable rainfall. Analysis of hourly rainfall totals show the 1997 storm to be even more remarkable. Since hourly data were first published in 1940, there have been several storms with large one-hour rainfall totals in excess of two inches. However, most intense storms in this area have relatively short lives, and no six hour period has ever come close to dropping so much rainfall on campus as the 5.3 inches that fell from 6:00 PM to 10:30 PM July 28, 1997.

Figure 8, Table 1

Meteorological radar, a remote sensing tool for precipitation detection, offered another perspective on this storm. Three radar observed this storm. National Weather Service WSR-88D weather surveillance radar from Cheyenne, Wyoming and Denver, Colorado monitored the storm. The Colorado State University CHILL research radar, managed by the Departments of Atmospheric Science and Electrical Engineering, and located north of Greeley was closest to the storm. Data from the CHILL radar were used together with gauge measurements to help formulate rainfall estimates in the areas immediately west of Fort Collins where precipitation reports were few.

From an operation forecaster's perspective, the Fort Collins storm was neither eye-catching nor spectacular. Based on satellite and radar signatures, several storms July 28 attracted more National Weather Service attention. The Fort Collins storm was small in area extent and was not accompanied by unusually tall clouds or by excessive lightning. Fortunately the WSR-88D radar display algorithms successfully detected the large rainfall accumulations associated with this nearly stationary storm. Although the radar underestimated storm rainfall over Fort Collins by nearly 50 percent, it did alert forecasters to a potential problem and contributed to the issuance of a Flash Flood Warning for the city at 9:40 PM while the storm was still in progress and before most of the worst damage and fatalities had occurred. A report on this will be issued by the National Weather Service team working on the storm.

In summary, 10 to 14.5 inches of rain fell over an approximately 30 hour period in a band extending along the base of the foothills from southwest Fort Collins northward to northwest of Laporte. Rainfall of this intensity is rare, but storms of similar magnitude like the Big Thompson flood of July 1976 have been observed roughly once every ten to twenty years somewhere in Colorado with a distinct preference toward being in or near the eastern foothills of the Rocky Mountains (McKee and Doesken, 1997). During the recorded history of Colorado, the Fort Collins storm produced the heaviest rains ever documented to have fallen over an urbanized area in this state.

The Runoff

While the storm was remarkable, the runoff was at least as dramatic, and some peak discharges exceeded estimated 100-year flows by a factors of ten.

Hydraulically, the two main flow paths that caused greatest damage during the flood were along Spring Creek and through the Colorado State University campus (Figure 1). Spring Creek begins in the foothills west of Ft. Collins. When Horsetooth Reservoir was constructed in the early 1950's, it intercepted about half of the Spring Creek drainage basin. Now, the urban portion of Spring Creek begins below Spring Canyon Dam at Horsetooth Reservoir, then flows generally from west to east through Ft. Collins. Spring Creek terminates at the Poudre River to the east off of the map. The total drainage area from below Horsetooth Reservoir to the confluence with the Poudre River is approximately 12 square miles. Generally, Spring Creek flows with a small discharge representing snowmelt, small spills from irrigation canals, groundwater seepage, and local stormwater. As Spring Creek nears College Avenue, it flows through a large detention area behind the Burlington Northern Railroad embankment and just upstream of the trailer park. In 1989, numerous improvements were made to the stormwater system in this area. A 14' X 12' box culvert leading to the trailer park area was plugged with compacted fill and Spring Creek was rerouted to the south to pass through three 84" pipes. Also the Burlington Northern Railroad embankment was reinforced and stabilized and designed to withstand the 500-year flood.

Table 2 shows estimated discharges as compared to previously-established 100-year and 500-year flow estimates. Note that all along Spring Creek estimated flows exceeded the previously-established levels by factors of two or more. The most dramatic flow measurement was the "combined flow below the Canal Importation Channel" on Spring

Creek. The July 28, 1997 discharge was 8,250 cfs while the FEMA 500-year discharge was 3,325 cfs, an exceedance factor of 2.48. This is the water that ponded behind the Burlington Northern railroad embankment, swept four rail cars off the tracks, and overtopped the tracks, resulting in flooding of the trailer park to the east. Downstream of College Avenue, the discharge decreased to about 5000 cfs. This was because of the storage behind the railroad embankment. Even with the storage, at Mathews Street, the estimated flow exceeded the previously-established 500-year level by a factor of 2.98. The 500-year flood at the railroad trestle was supposed to be 2,920 cfs, but the estimated flow was 5,860 cfs, a factor of 2.01. Some of the tributary urban flows shown on Table 1 show even greater exceedance factors.

Table 2

The storm greatly exceeded the design capacity for stormwater facilities in the City. By 8:30 p.m., when more than 3 inches of rain had fallen, the detention ponds began overtopping. The additional six inches of rain that fell in the next hour and a half did not have anywhere to go. To further complicate matters, trailers jammed up against the College Avenue bridge blocking the bridge opening. In addition, many arterial streets were overtopped and damaged.

On the Colorado State University campus, Ayres Associates had prepared drainage plans and was able to compare simulation models with the actual event. As shown on Figure 6, water generally flows from west to east across campus. The main confluence is near the intersection of Elizabeth and Shields Streets, and several other streets contribute as well. During a minor event, most water is captured by the storm sewer system and does not affect the campus; but in larger events, water ponds and begins to overflow.

Figure 9

The drainage area that contributes to the campus begins at the foothills. Canals normally capture small runoff, but large events on the order of 25-year larger begin to overtop these canals. Two channels from the foothills, the West Plum Channel and the Clearview Channel, bring water into the canals and in large events tend to spill water from the lower canal (Larimer #2 Canal), and the overflow concentrates near City Park and West Elizabeth Street. Water then enters the campus near the Moby Gym and, after overtopping the Arthur ditch, it flows into the Library parking lot and north into the Lagoon. In very high water, additional drainage also comes from the South part of campus. Then, the Lagoon area starts to overtop, water flows into the Engineering lot, which ponds and then releases overflows into the Oval. Water ponds in the Oval, floods the Heating Plant, and eventually flows through a pedestrian underpass at the railroad track. Water then flows past the gym, and ultimately overtops College Avenue and goes down Locust Street to the east.

In 1996, Ayres identified potential damage areas on the campus and estimated water surface elevations for frequencies up through the 100-year event. This was done using a modified version of the Stormwater Management Model (SWMM). The study identified the vulnerable areas, including individual buildings. While one of the proposed mitigation measures was to use the athletic fields to create a large detention area to keep water from the area behind the Library and the Student Center, that plan has not been implemented.

Water levels on campus significantly exceeded the estimated 100-year water levels. At the College Avenue Gym, at the east border of campus, the 1997 water levels were 1.3 feet higher than the 100-year event. At the heating plant, the water levels exceeded the 100-year elevations by 5.2 feet and up to 7.2 feet at the building entrance. At the Engineering parking lot, the flood elevation was 2 feet higher than the projected 100-year level. The water level in the Lagoon area west of the Lory Student Center and Morgan Library was 2.7 feet higher than the 100-year elevation.

Using rainfall data from the 1997 event, Ayres used a model to calculate discharges at various points on the campus. On the west side at Elizabeth and Shields Streets, the estimated peak discharge was 1890 cfs, compared to a projected 100-year value of 490 cfs, The estimated flow from the Lagoon area into the Engineering parking lot was 930 cfs, compared to a projected 100-year value of 50 cfs. The estimated flow through the railroad embankment near the heating plant was 320 cfs, compared to a projected 100-year flow of 40 cfs.

Figure 6 shows the areas of campus that were flooded and the buildings receiving damage. The map also shows estimated flows from the SWMM model for the 1997 event and the 100 year event. Note that actual 1997 flows (as estimated after the flood) exceeded modeled 100-year flows by large factors, such as 18.6 from the Lagoon area into the Engineering parking lot.

Actions by the City of Fort Collins

Emergency response. Emergency response in the City was overseen by Glenn Levy (1997), a Battalion Chief for the Poudre Fire Authority (PFA) with experience and training in emergency response. According to Levy, the night of July 28th was very busy for the emergency response team. Normally, heavy rain causes traffic accidents and also automatic fire alarms to go off due to the rain, basements get flooded, but there is also a city to run with other fire calls, medical emergencies, traffic accidents, and other demands. So when the flood occurred, it created a tremendous impact on services.

The night of July 28 began with heroic rescues. From 8:30 until about 10:45 p.m., 15 minutes before the flood in the trailer park, firefighters rescued over 200 people from cars, from buildings, and from areas that were flooded, such as by pushing them through intersections. CSU's Police Department had to relocate to the City because their building was flooded. In the 911 dispatch center, there was a call every 16 seconds for a period of time (Figure 10). A building exploded from natural gas, a train derailment occurred in the center of town with four cars derailed, and the PFA heard that one of the cars had deadly chlorine gas. Luckily, the rail car with the chlorine gas did not derail. The Poudre Fire Authority broke into businesses to get life jackets to deal with the flooding. The last rescue occurred somewhere around 2:10 the next morning. Then, on the next day, July 29, there were still 172 people missing, and all of them had to be accounted for. Levy reported that the flood had tremendous impacts on CSU and the greater community, but not one firefighter or police officer was injured. He said that while event taxed our system, and was tragic, some good came in its wake.

Figure 10

City Manager's Perspective. According to City Manager John Fischbach (1997), the City's incident command system worked extraordinarily well; but as with other floods, the full impact of the event was not immediately apparent. When the City Manager was called about 10:00 p.m., he told his deputy to take care of the event because it did not appear to be a big problem. The deputy called about an hour later, and told the City Manager "We have a major flood down in the trailer park, we have a train that's overturned, we have fires, and buildings are burning." The City Manager then went outside, and it wasn't even raining, but as he drove toward town, he ran into flooded streets and could not get through. When he arrived at the Police Department's Command Center, everything was in turmoil.

Then, the City Manager went to the trailer park, and he reported that "it was horrible, absolutely horrendous." All of the trailers in the trailer park were lost. During the recovery process, the City declared it a "nuisance," and eventually cleared out the entire park. It was a tragic experience for the residents. The City worked with the residents as much as possible to recover whatever they could, but some of them never found their belongings. The City's cost to clear the park was about $221,000. Now, the area looks like a quiet, idyllic place with few hints of what it was like that evening of July 28.

The City spent about $5 million on flood recovery. The City Council originally appropriated $2.5 million to provide an account to spend from, the City expects to get a large amount back from the federal government and insurance, so the flood will end up costing the City about $800,000 to cover physical losses.

The City Manager's report ultimately showed five people dead, 54 people injured, 200 homes destroyed, and 1500 homes and businesses damaged throughout the City. Although the focus was on the trailer park, there were other parts of town with frightening experiences and intense damage. The city is considering memorializing the deaths at the flood site. Four of the five were residents in the trailer park, and one was a resident downstream, near the trailer park.

Performance of Storm Drainage System. Fort Collins was more prepared than most cities, because it has a nationally-recognized Stormwater Utility with several program areas, but it still learned a great deal from the flood about the operation of the storm drainage system. In the Utility, System Repair and Maintenance manages detention ponds and culverts across town and these facilities continuously need repair and maintenance. System Construction handles the larger projects. Development Review is a vital component because every development has to go through a review process, including storm drainage, and meeting FEMA and City flood plain criteria. Flood Plain Administration oversees FEMA and City regulations and provides information to the community about flood hazards. Water Quality studies watersheds and works with the schools to teach kids about water quality and flooding. Master Planning takes a long term view of solutions to problems in the different basins.

The Stormwater Utility has divided the city into 11 basins for the purpose of planning and management (Figure 11). The basins most impacted by the July 1997 flood were Spring Creek, the Canal Importation Basin, the Old Town area, which includes the CSU campus, and the West Vine Basin to the north.

Figure 11, 12

The damages at the trailer park show that normal stormwater planning will not handle extraordinary hazards and that there are many features in a stormwater system other than culverts, pipes, and detention ponds. Near the trailer park, the railroad embankment was designed to hold back the 500-year flow, but the ponded area behind the embankment exceeded the 500-year design, and the culverts under the embankment, which were designed for the 100-year flow, could not handle this particular storm, and the water overtopped the embankment. Railroad ties were pushed out of place, there was severe erosion on the downstream face of the embankment, and some ballast was eroded as water spilled into the trailer court from the ponded area.

Blockages were a primary problem with the storm drainage system, and College Avenue just downstream of the trailer park was the worst case. Debris from homes and cars floated all over town, and cars were found a week later upside down in a box of one of the bridges.

Since 1989, over $5 million has been spent on storm drainage improvements in the Spring Creek basin, including acquisition and relocation of structures, channelization projects, storm drainage improvements, reinforcement of the railroad embankment, and bridge improvements. In that period, thirty trailers, two homes and a business were removed, and Creekside Park was developed.

In many cases Fort Collins goes beyond federal regulations in flood mitigation work. One example is restrictions on homes built in the flood plain. Other measures include using developed flows rather than current hydrology to size facilities. Land use planning and zoning are also emphasized.

In spite of Fort Collins' preparation, damages were significant, including the CSU campus, flooding in the trailer park, fires, gas explosions, a train derailment, and many individual losses.

Flood Documentation. The City was very concerned about documenting the flood, and on the morning after the disaster, volunteers from local engineering firms and several state and federal agencies were organized to help document the high water marks. Teams were sent to all the major drainage basins in town and used flagging and spray paint to mark the high water lines. For each high water mark, the volunteers filled out a field form to describe the mark and also took a photo of each mark. The field marks and photos have been organized and can be used to reconstruct the marks for future reference. In addition, the City is placing signs along the Spring Creek bicycle path to identify the high water mark at several key locations. These will hopefully help educate the public about the 1997 flood and remind them that floods do happen in Fort Collins and that we must all learn from the past.

The discharge measurements discussed earlier were the result of work by several local consulting firms, the Colorado Water Conservation Board, and the US Geological Survey. Each organization made their measurements independently. The amazing thing about this effort was the close agreement between the different measurements despite uncertainty inherent in these type of measurements. This fact has resulted in all of the agencies being confident in the discharge data for the flood.

Figure 13

Predisaster Mitigation and Floodplain Management

The Federal Emergency Management Agency (FEMA) had formally recognized Fort Collins in December 1996 for developing a comprehensive Floodplain Management Program and its Class 6 rating in the Community Rating System (CRS). As part of the local program, the City has collected and evaluated a large amount of hazard information and implemented a broad range of mitigation activities. In light of the recent floods and the wealth of useful mitigation information, the recent flood disaster provides an opportunity to use actual hazard and risk data as the basis for demonstrating that loss of lives and property can be reduced through cost-effective mitigation measures.

The effectiveness of local floodplain management and mitigation efforts in reducing flood damages and loss of life can be demonstrated from the cumulative loss of buildings and lives in the July 28th flood and buildings (and lives) that were positively affected by pre-disaster mitigation projects. The latter represent potential losses if mitigation had not been implemented. This section summarizes the mitigation efforts implemented and funded by the City and attempts to quantify the relative reduction of loss of life and property that pre-disaster mitigation accomplished.

Natural hazard mitigation is defined as a sustained action taken to reduce or eliminate the long-term risk to people and property from natural hazards and their effects. Mitigation against the effects of natural disasters is a locally-based initiative that considers the long-term view. It requires the cooperation of Federal, state, and local governments, as well as businesses and residents of the community. Mitigation relies on recognition of the risks of natural disasters and the development and implementation of methods to reduce these risks. The use of a case study such as Fort Collins provides an example of a successful mitigation effort being implemented that clearly demonstrates that loss of lives and property can be reduced through cost-effective mitigation measures.

Fort Collins' population increased from 1,376 residents in 1880 to over 100,000 in 1997. The number of people and structures located in the floodplain also increased greatly. Recognizing the potential for loss of life and personal property, the Fort Collins Stormwater Utility utilized management tools such as outreach projects to increase public awareness of the hazard and flood protection measures, establish local policy and ordinances to regulate floodplain development, adopt design criteria for structures located in the floodplain, implement flood preparedness and warning activities, acquire floodplain land, provide informational services such as map determinations for property buyers and sellers, maintain drainage systems, and maintain scientific information available on local flood and erosion hazards. As a result of these activities, the potential for loss of life and property has been substantially reduced.

In addition to entering the National Flood Insurance Program (NFIP) in 1979, Fort Collins entered into the federally-designated Community Rating System (CRS) in 1990 as part of the City floodplain management program. The CRS Program provides an incentive for communities to do more than just regulate construction of new buildings to minimum National Flood Insurance Program standards. It gives credits (reductions) on flood insurance premiums to local policy holders in return for the community's adoption of more effective measures to reduce flood and erosion damages. The amount of the premium credit is tied to the estimated reduction in flood and erosion damage resulting from the measures that exceed the minimum NFIP standards. As of 1996, Fort Collins has a CRS Class 6 rating which results in a 20% discount on flood insurance premiums. The City is ranked in the top 10 communities nationally out of about 1000 communities participating in the CRS.

It is unlikely that any of the families affected by the disaster would call the event a "success story," but the scenario without the City's self-funded floodplain management program and initiative in hazard identification and risk assessment must also be recognized.

Structures that were acquired in the Spring Creek floodplain include: 30 mobile homes in an area that is an open space park, 9 residential homes, 1 retirement home that could have housed more than 15, and 1 business also located in the park. The acquired structures were generally located in the very high hazard areas of the Spring Creek floodplain and floodway.

Table 3 provides estimates of the potential number of lives and dollar amount of property damage that were positively affected by pre-disaster mitigation activities implemented by the City of Fort Collins.

Table 3

In addition to the acquired structures, approximately 45 residential and/or commercial structures were removed from the regulatory floodplain as a result of structural flood control measures. This could have resulted in an estimated additional $5,625,000 to $9,000,000 in damage reduction attributable to pre-disaster mitigation, assuming worst case, total loss of the structure. In total, the "worst-case" scenario presented here, that "could have happened" without pre-disaster mitigation is an additional 98 lives lost and additional $8,400,000 to $14,550,000 in property damage.

The damage loss figures above assume total loss of the structure (contents not included) and are only estimates based on assumed values to make a point. In addition, the estimates only consider structures mapped within the 100-year regulatory floodplain. Since the July 28th flood is estimated to exceed the 500-year event, potential damage estimates may be even higher. Regardless of the actual number of lives or dollars stated in Table 1 the point is that pre-disaster mitigation was a success. The five lives the were lost and millions of dollars in property damage and down business time that did occur is a disaster.

The City of Fort Collins is also involved in many city-wide floodplain mitigation activities that cannot be so readily quantified in terms of potential reduction in loss of life or property damage. It is unclear how many additional lives and/or property may have been positively affected by these additional activities implemented by the City such as public outreach activities, acquisition of floodplain land and open space preservation, enforcement of regulatory standards that exceed minimum NFIP standards, and far-sighted land use planning.

For example, the City's annual "Flood Awareness Week" was held May 12-18, 1997. One of the many outreach projects done during Flood Week included a mass mailing pertaining to local flood hazards to all residents who live in or near the floodplain. Of the 2,823 acres of total floodplain area in the City, approximately 958 acres have been preserved as Open Space. The City's master plans and floodplain regulations exceed minimum NFIP criteria for design freeboard, cumulative substantial improvements, protection of critical facilities, future condition hydrology, floodway requirements, and mapping erosion hazards.

The successes and failures of past attempts to deal with floods have brought a fuller understanding of the need to manage floodplain areas. It is clear that society will continue to place demands on floodplain lands, therefore it is necessary to approach floodplain management from a variety of perspectives. In order to reduce the effects of natural disasters, mitigation must be a locally based initiative that considers "wise-use" over the long-term. It requires a cooperative decision making process between Federal, State, and local governments, as well as businesses and residents of the community that balances competing uses and evaluates alternatives.

Damages and Response: Colorado State University

At Colorado State University, major state university with over 20,000 students, damages were unusually severe, including many buildings damaged, about 425,000 library volumes inundated, loss of a semester's textbooks in the bookstore, and many other personal and professional losses. The university responded well, and there was no delay in opening school a month later, but only as a result of tremendous dedication.

Impact on campus was reported by John Morris (1997), Manager of Facilities Operations.

- over 200 faculty, staff, students heavily impacted (for some it was their lifetime work)
- over 60 graduate students, some with families, lost possessions and were displaced from the International Center where they lived on the west side of campus.
- over 40 buildings had some damage, especially support systems which tend to be in the basements
- all the textbooks for the Fall 1997 semester were destroyed
- over 425,000 volumes of library books were destroyed
- hundreds of thousands of work hours were required to get the campus back into condition
- total damage was well over 100 million dollars (about a third for the library collection, another third for facilities, and a third in areas such as loss of business, relocation costs, contents of buildings, personal loss of individuals)
- $2.25 million in time and effort spent on flood recovery for cleanup, relocations, replacements, security, and similar items (through February 6, 1998, telephone conversation with Janice Lenihan, Business and Financial Services)

CSU had to respond rapidly during the flood, such as dealing with an ongoing student conference with 3,500 participants, but the major work came later. Morris reported that from his initial phone call, for the next three to four weeks, sleep was a precious commodity. During the first week the Facilities Department was frantic to get a student conference group out and another group in. Within a week the university was able to hold another conference for about 5,000 students.

Facilities instituted an emergency management team. As the originally planned site for the Control Center had been destroyed, another had to be organized. Five immediate priorities were established: protect health and safety; respond to personal and professional losses of staff and faculty; resume classes as soon as possible (the university only missed about two days of summer semester); help clean up; and prepare for (and minimize the disruption to) the Fall Semester.

The morning after the flood, Facilities began the major effort of draining water and restoring the functionality of buildings. It took two or three days to start bringing down the water level within some buildings. Facilities estimated that they pumped well over five million gallons of water. They had to verify the structural integrity of the buildings, (fortunately, there were no structural problems other than a floating floor in one building that was easy to repair). They had to determine not only cost estimates of the damage, but essential systems such as heating, ventilation and air conditioning, electric systems, elevators, and building alarms. A basic level of security was required. Document recovery was important and one safe with well over $1.5 million in promissory notes had to be rescued.. Packing the library books became critical because the books would deteriorate biologically until frozen. The university anticipates recovering about 80 percent of the books that were lost but it will take two to four years, and it is still unknown what the success rate will be. A new book costs $70-90 dollars, and a book can be restored for about $30. Rapid clean up and disinfection was critical because mold will start growing and air quality becomes a concern for people with asthma. Facilities continued to monitor the buildings because reports of concern continued to be filed.

Publicity and accurate information is critical in flood recovery management. The university was on national news, and worried that students would not come, but that did not turn out to be the case. Updates were continuously available through the university's home page on the Web. Communication with the campus community was important, especially on health and safety.

Organization was a critical factor. Documentation to work with FEMA and insurance agents was essential, and a team to work with FEMA had to be organized. Working with occupants to assess status, damages, access, and salvage took much time. Assessing documents to recover was a tremendous task. Financial aid and registration for students required new work on computers systems. Some buildings were scheduled to be upgraded, so work with capital improvement process had to be accelerated. To start academic programs required a campus emergency management team which evolved to become a disaster recovery team. Staff were under much stress, and a stress management program was required for them. After all the initial work was done, we had to make long term plans, including implementing storm mitigation plans, and improving emergency management plans. Financial and contract management required much time and attention. Financial committees and a cash management team to work with firm and insurance agents was required. Many consultants were required, including some to manage flood contractors (there were 1,000 people cleaning up the campus) and to help rebuild.

Role of media in flood response and recovery

In the management of flood emergencies, the role of the media is crucial. David Greiling, Executive Editor of the Coloradoan, Fort Collins' daily newspaper, described this role at the November 4 conference.

The event received broad coverage in the United States and abroad. A sampling of many, newspapers covering it included the New York Times, USA Today, the Associated Press, Reuters, the LA Times, and last but not least, the Saigon Times Daily. Television network staffers from the major networks were on the scene, and the story made national news for a day or two. The national media then go on to other stories, but the local media stays for the long haul.

By November 4, or some 90 days after the flood, the Coloradoan had published 282 stories that dealt in some way or another with the event. In those stories are answers to questions like where do you go for help when you have lost everything, what the economic and psychological impacts on the community, on individuals, and on businesses are, how you mop up the mess, how much rain we got, who will pay, what kind of aid is available from the state and federal governments, and who will help the flood victims.

From the standpoint of the local paper, the main impression was that to cover the event meant to go full speed until it is over. The paper had to place a limit on the number of hours staffers could work each day. There are more stories than any news organization could every hope to cover, no matter how big the staff.

Many reporters were affected personally by the flood and also had to cover the story. Greiling quoted from the paper: "We kept ourselves going with caffeine and sugar and that adrenal buzz that each journalist gets when there's a job to do that requires grace under pressure, but even with the excitement the newsroom was unusually quiet. Newsrooms are typically very sarcastic places, just a notch above a pool hall." "To an outsider they must seem vulgar and disrespectful. We are often faced with death and destruction daily and making jokes about it is how we cope, but there were no jokes about this tragedy. Our reporters and photographers were sent into a mess of twisted metal and tears, and it showed on their faces when they returned. No matter how many years of journalism you have under your belt, it never gets any easier to look into swollen, tearful eyes and ask a stranger to bare his or her sole to you. This storm touched us all; it touched this community and will be with us forever."

Aftermath of the Flood: Grief: A Normal Reaction

As communities depend on those with many technical skills to help re-build following a natural disaster, it is crucial to keep in mind the many emotional issues that are also tied to such an event. Community members collectively experience a great number of losses, including such things as: loss of life, physical spaces, belongings, resources, dreams, etc..

If the Ft. Collins community, for example, is truly to recover from the July 28th disaster, we have to look well beyond the more obvious physical issues; the many multifaceted losses following the flood triggered significant grief reactions. Grieving is a common and healthy reaction and must be "normalized" so that those who do grief are not left to feel that something is "wrong" with them, that there is something "strange" about their feelings. It is crucial that the community give support- and give it for the long term. If such assistance and understanding is not provided, there is a risk of disenfranchising those individuals who have already suffered a great deal.

Grief is much longer lasting than many persons understand - regardless of the type of loss. We know that grief goes through phases, not simply the five stages that many people read about in the popular literature. Rather, we need to understand that there is an *acute* phase of grief that lasts for days or even weeks immediately after a loss. This is the time when feelings are likely to be most intense and most overwhelming. Following the acute phases is a much longer period of time that has no easily definable end of date or stage and that is what we would call the *chronic* phase of grief.

It is evident that the flood has had a significant impact already; further, there will be ongoing reminders that will bring back thoughts and trigger emotions that the flood survivors believed were already over and dealt with. For example, children in this town were frightened in the days after the flood as the rains continued to fall. A world that they had thought was safe and secure, no longer was; they didn't understand. Adults were also having uneasy reactions to the ongoing heavy rainfall. Given a phenomenon known as an *anniversary reaction*. Many feelings related to a loss are felt quite strongly once again, as July 28th draws near.

Grief is much more than the simple word "sadness." That is a part of it, but grief is a multi-faceted, complicated phenomenon; although there are many common manifestations, it is ultimately unique to a given individual. Immediate reactions to grief are typically denial and shock. Additionally there is often a strong physical component to a grief response. Many may have experienced an absolute sense of exhaustion. Part of the exhaustion in this community was the cleanup, part of the exhaustion was likely a grief response. Individuals also might experience some level of eating disorders, sleep disorders, things such as headaches, increased susceptibility to illnesses because of the stress.

There is clearly an emotional response to grief, and that's often what we think of. Sadness is typically at the very core of the grief response. Other psycho-emotional components are anger., a sense of frustration, feelings of guilt. A number of people in this town shared that they actually feel guilty because they were not directly impacted by the flood reflective of a phenomenon called *survivor guilt*. Further, there are many psychological responses to grief. They include an inability to concentrate, mental exhaustion, feeling distracted, focusing over and over on the loss event and its aftermath. Many times, individuals deal with grief differently than those around them - they define the loss itself differently, have different reactions, have different coping styles. These variations may put stress on relationships that had been quite stable earlier as people find themselves angry at persons they wish were more understanding and supportive. It is also important to understand that grief is not a linear response, with a clear cut beginning or end; rather grief is more like a roller coaster ride and it is much more complex than many people understand.

Some are left to wonder why they are even grieving - (i.e., those who did not personally know a person who died or did not personally lose any belongings). Regardless of personal knowledge or experience, many may grieve the loss of those who did die, for they were neighbors, a part of the community. Even without knowing them, we had every right to grieve their passing. This is tied to a phenomenon termed *vicarious grief*.

Grief reactions are often magnified by certain factors that define the flood. For example, the loss and bereavement literature identifies many variables that have an impact on the grief response in terms of intensity and duration of reactions, as well as special challenges to be faced following a particular type of loss. Many of these variables would be relevant to the study of loss following an unexpected natural disaster, such as the Ft. Collins flood. These variables include such things as the suddenness of the event (therefore there is no time to prepare for the loss); questions of preventability of the loss (tied to difficult questions of "why" did this have to happen and also possibility of increased sense of anger - which is a normal part of a grief reaction); likelihood of multiple losses (increased possibility of bereavement overload); ambiguity of the loss (inability to predict actual magnitude of loss or likely outcome); disenfranchisement of the bereaved (larger society's not fully understanding significance of loss or individuals "right" to grieve).

Another issue to reflect on relates to a subset of our community. There is a fairly new specialty area in the study of grief, called *traumatic grief.* There are certain situations where the loss is so overwhelming that there is cross cutting of post-traumatic stress disorder, as well as a grief response. When there is an intermingling of such events as water rising, currents rushing and flames encircling - as there were for persons in the mobile home park and for the emergency personnel - there is an element of the "horrific"- an element we would hope human being should not have to deal with. I believe, then, that some of our community members will be impacted differently than many of us; I would suspect that many are actually now dealing with something a long the lines of post-traumatic stress disorder.

It is important to understand that there are two sides of grief. I want to stress, that for all the pain and anguish that many have experienced as a result of their grief, there are also positive outcomes of losses and of the ensuing grief experiences. These may include a stronger sense of community, re-designed buildings, and much more. Regardless, , of the many positive outcomes that will develop as a result of the flood, there will continue to be much emotional pain. Ongoing support is absolutely needed. For without this support, many important members of our community may ultimately feel disenfranchised from those that they feel simply do not understand their experience, or - worse yet- do not seem to care.

Lessons from the Past

Fort Collins is susceptible to flooding from the Cache La Poudre River, Spring Creek, Dry Creek, Fossil Creek and Boxelder Creek. In addition, flooding in the urban areas often occurs from localized thunderstorms and irrigation canals overflowing. Some the most notable past floods in Fort Collins' history include 1864, 1891, 1902, 1904, 1938, 1951, 1977, and 1992. In fact, the original settlement, a military post called Camp Collins, was moved a few miles from its location near Laporte to our present city site after the flood of 1864. Two people died during the 1904 flood. Spring Creek experienced considerable flooding as a result of the 1951 event.

A review of floods presented by Wayne Charlie (1997) at the conference covered the floods of 1902, 1938, 1951, and 1997. In addition, there had been several minor floods with enough water to flood some CSU buildings. In 1902, about 6.2 inches of rain fell in 48 hours between September 20th and the 21st. The City had a significant amount of damage, but the campus had few buildings and did not suffer much. By 1938, however, the campus had become more vulnerable, and on September 2-3, 1938, 4.6 inches of rain in about 48 hours caused five buildings on the Oval to flood, with 10 to 11 feet of water in the Heating Plant. The Library, which was then located on the Oval in what is now the Music Building, had 5 feet of water in the basement and books damaged. In 1951, on

August 3rd, 6.06 inches of rain fell in 27 hours, with 3 inches in 3 hours. Again, buildings on the Oval flooded, with 5.5 feet of water in the Heating Plant. Officials noted that a large storm sewer was needed to drain the area and to remove the hazard caused by the limited opening under the railroad tracks. A number of improvements were completed, including a storm sewer from the Oval and two additional storm sewers to take water from west part of campus to Spring Creek. Several regional detention ponds were also constructed. Suffice it to say that none of this helped much during the flood of 1997 because the flood was simply too large..

Another historical lesson is from the August, 1976 flash flood on the nearby Big Thompson River. This flash flood killed 139 people in the space of a few hours (McCain, 1979). The Big Thompson is a mountain stream with headwaters in Rocky Mountain National Park near Fort Collins. The storm that occurred on July 31-August 1, 1976 was extraordinary, to say the least, and poured 6 to 10 inches of storm rainfall over a wide area of the basin. The estimated peak discharge was more than four times the previous maximum during 88 years of record. However, prior floods on several other streams in the foothills have approximately equaled the Big Thompson experience.

Analysis and Conclusions

Although it hurt and traumatized many people, the July 28, 1997 flood in Fort Collins provided valuable lessons for civil engineers, managers of government agencies, political leaders, and citizens. We would like to suggest a few of the lessons and offer suggestions for further research and work in these areas.

Complacency. The event showed that people tend to become complacent about such extreme events. This flood showed that you need to plan for extreme events, especially in vulnerable areas.

Vulnerable areas. Planners need to give special consideration to vulnerable areas, perhaps going beyond economic benefit-cost data. Consideration should be given to the possible need to design for events in excess of the 100-year event in some areas.

Flood frequencies. Engineers and planners need to give careful study to flood frequency. While the Fort Collins flood is called by some "a 500-year event," establishing this parameter is not at all certain. For example, flooding on the campus greatly exceeded the 100-year event. The precipitation recorded at the campus rain gage was the largest 6-hour rainfall event in over 100 years of record.

Stress and trauma. There is evidence of great stress and emotional trauma having been elicited. Research has been initiated on the emotional impacts of the flood, and it will be interesting to determine if policy or procedural changes will result from the studies. Without ongoing support, many survivors may experience a complicated grief reaction.

Importance of organizational effectiveness. The City of Fort Collins, Colorado State University, and the Poudre Fire Authority responded well to the flood. Lessons they learned can be valuable to other communities who might suffer similar trauma. Research might show how these lessons can be transferred effectively.

Vulnerability of university. Colorado State University was extremely vulnerable to the flood. Although the university responded and recovered well, study of its preparation for such a flood might help universities in their facility planning. Critical facilities such as faculty offices, heating plants, utilities and libraries may need more than 100-year protection.

Growth management in a hazardous environment. Fort Collins is a rapidly-growing community. The flood hit in older parts of town, but if it had hit in newer developments, it would have provided a test of land-use and urban facilities planning. Lessons might show how to build a sustainable community that is resilient to natural hazards.

Mitigation versus response. Fort Collins had made substantial investments in flood mitigation. A study of the yields from these investments, compared to the effectiveness of the flood responses, shows clearly that mitigation is very effective in reducing flood losses. Pre-disaster mitigation is highly desirable, as an alternative to disaster response, and it is necessary to promote floodplain management, hazard identification and risk assessment to build disaster resistant communities, a current goal of the Federal Emergency Management Agency.

Communicating risk to public officials and citizens. Officials in Fort Collins and at Colorado State University were shocked at the severity of the flood. Although the City had made significant investments in storm drainage improvements, the impact on citizens was dramatic, and some citizens wondered what their money had gone for. The flood reminded us of the continuing challenge in educating the public and officials about flood risk.

Handling large influxes of donations. A remarkable discovery was the extraordinary generosity of donors. Officials stated that they were surprised by the large influxes of donations, both for the city and university. Should modifications to response plans be made to accommodate donations?

Perhaps the best summary of the overall impact of the flood was by Mayor Ann Azari who said at the conference: "...you can talk about data... My perception is all about people...of trailers in the middle of College Avenue, of families scared to death, of people not knowing where someone else was, of children still afraid to go to sleep at night for fear they're going to be in water, of organizations trying to figure out how we're going to help those families..." "My perception of the flood is that it may be very microscopic in the history of ... Fort Collins ..." "It might show up on some red line on somebody's graphs..." "My perception is we have to do as good a job as we can and learn to live on the high plains of Colorado."

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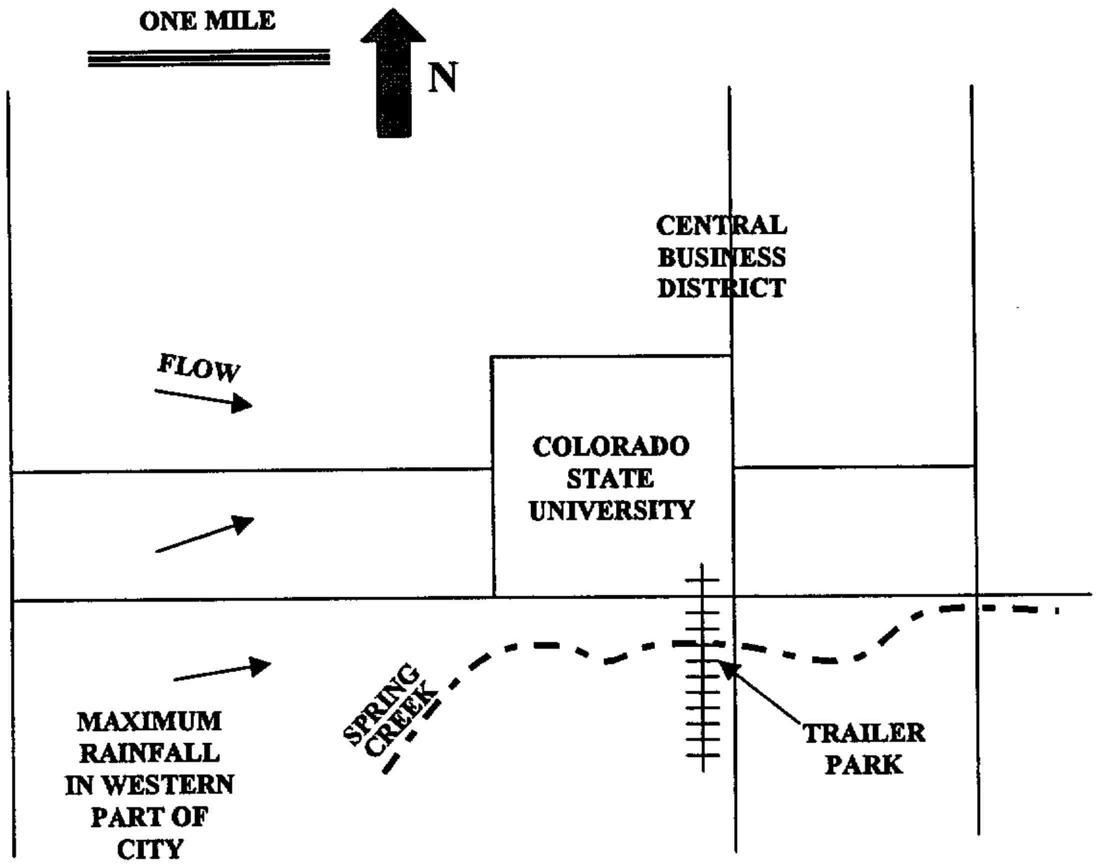
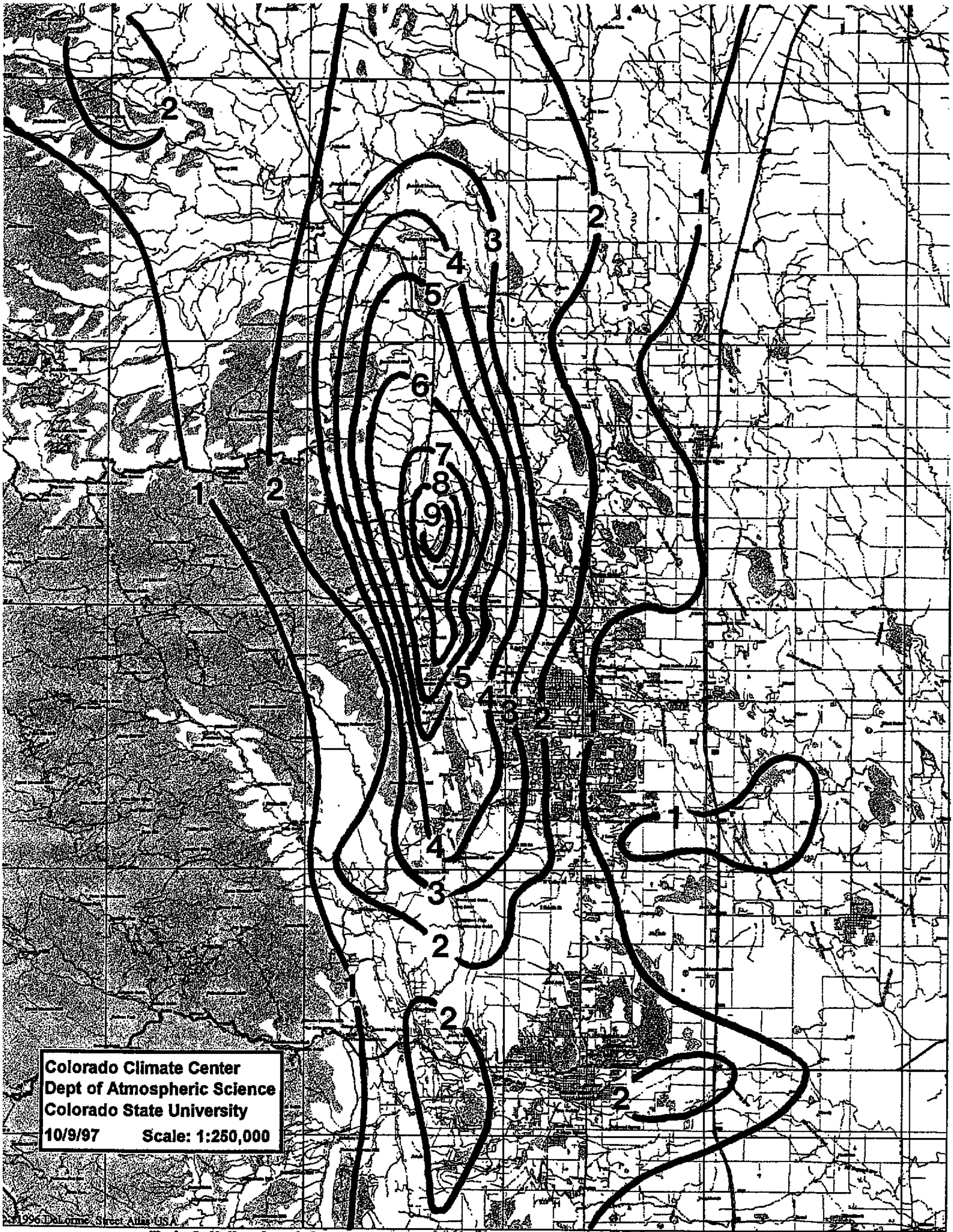
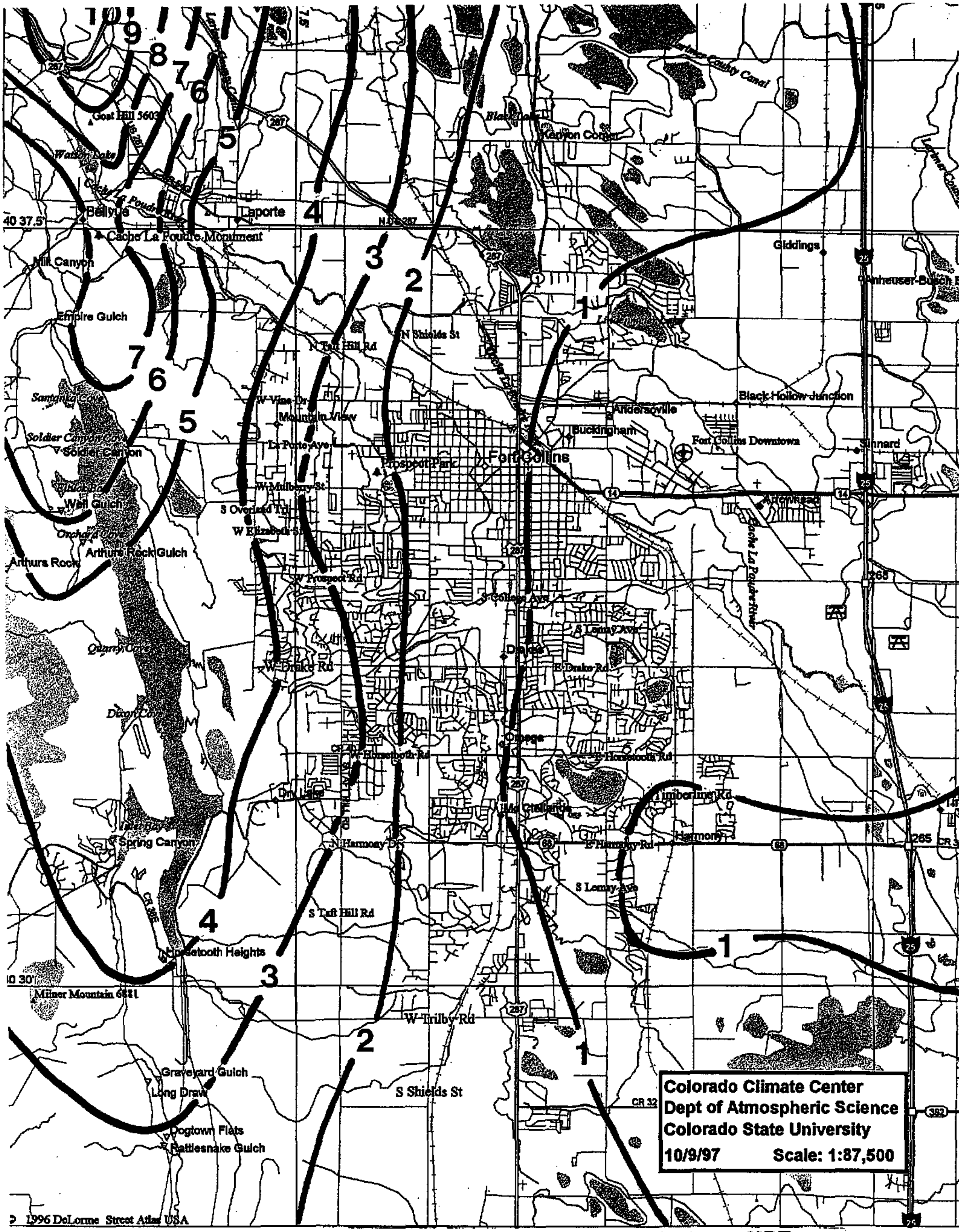

ONE MILE
N
CENTRAL
BUSINESS
DISTRICT
FLOW
COLORADO
STATE
UNIVERSITY
SPRING
CREEK
TRAILER
PARK
MAXIMUM
RAINFALL
IN WESTERN
PART OF
CITY

Fig 1



Rainfall (inches) for eastern Larimer County, Colorado, for 4:00 p.m. MDT July 27, 1997 through 1:00 p.m. MDT July 28, 1997

Fig. 2



Rainfall (inches) for Fort Collins, Colorado, for 4:00 p.m. MDT July 27, 1997 through 1:00 p.m. MDT July 28, 1997

Fig 3

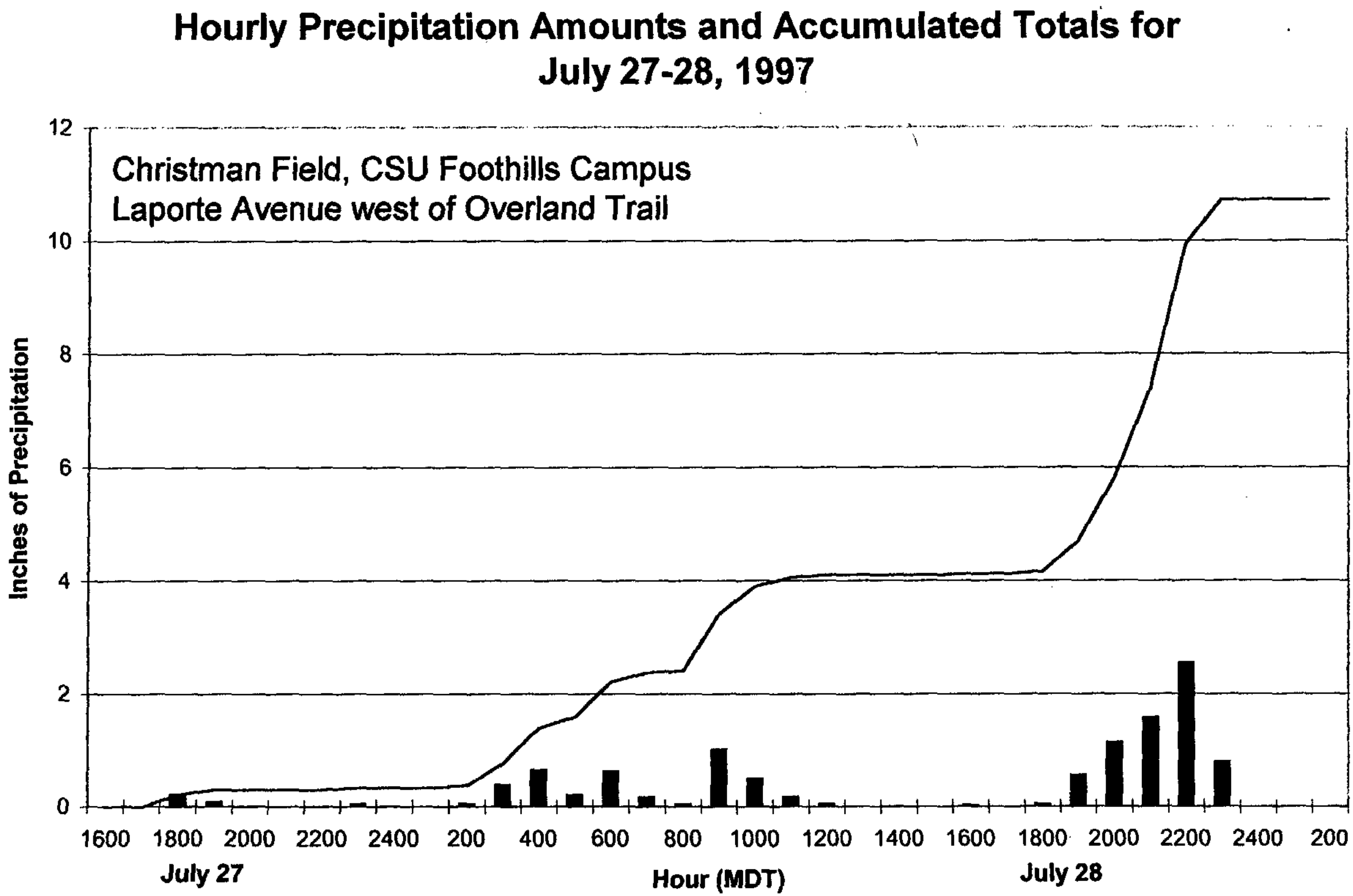
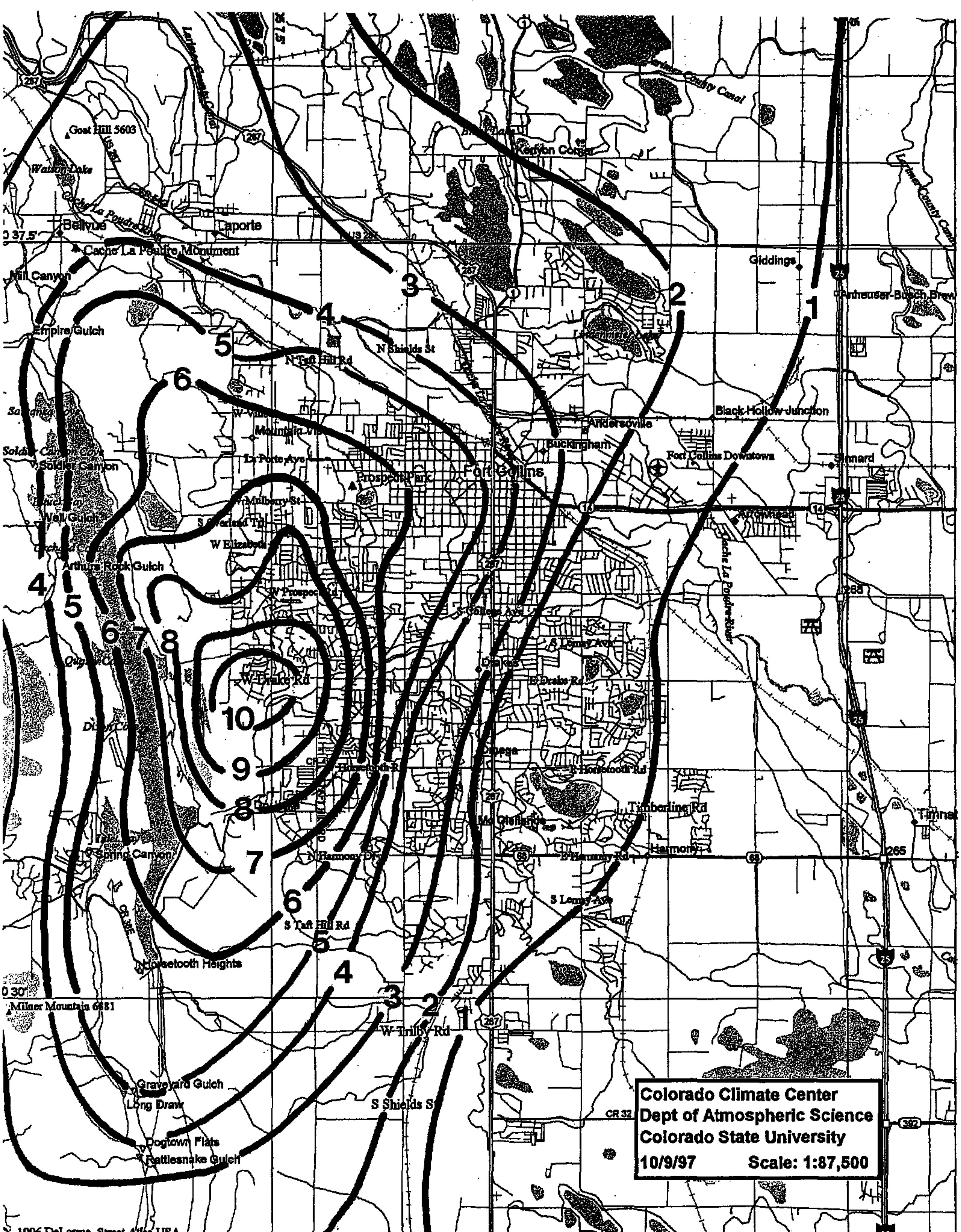
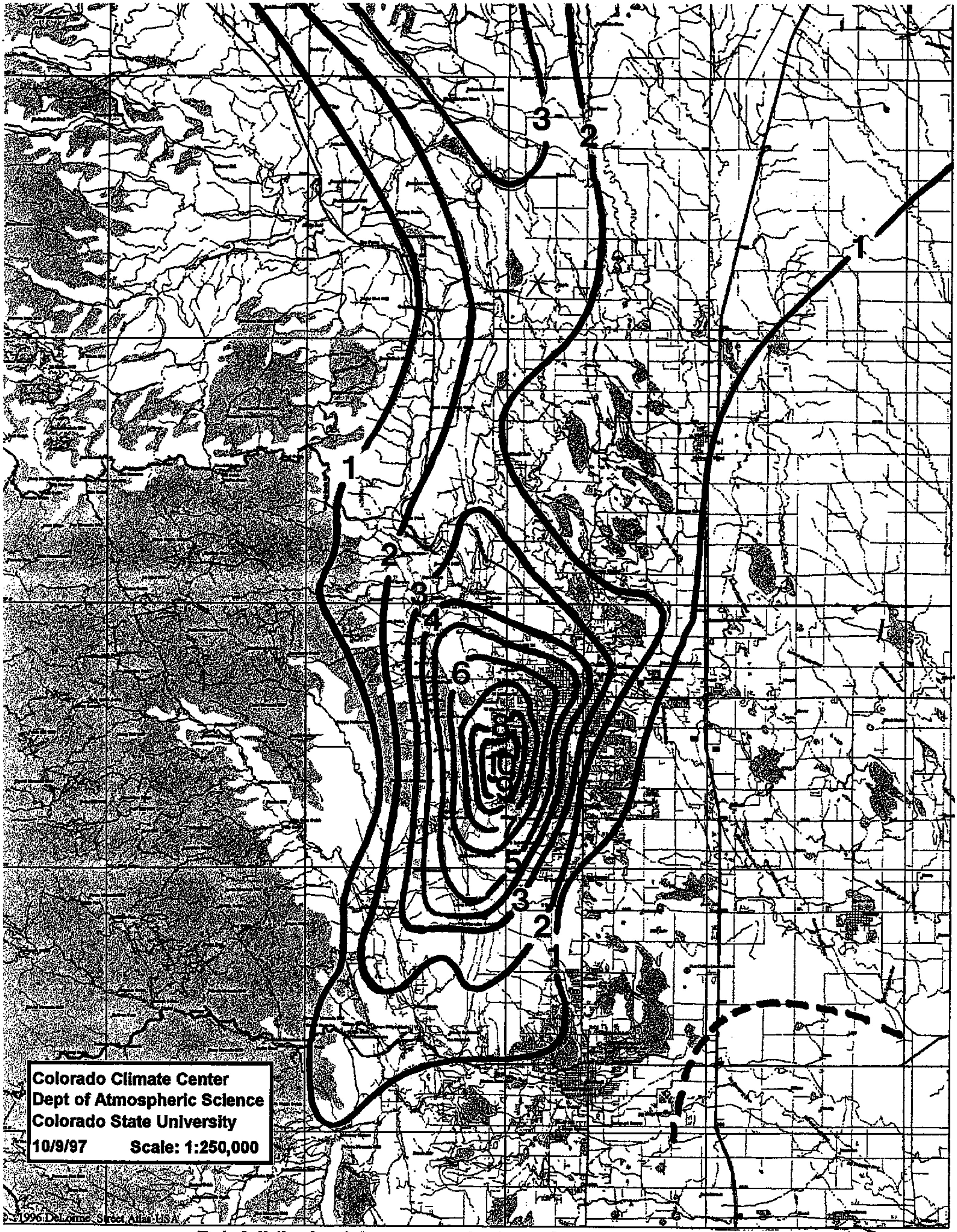

Hourly Precipitation Amounts and Accumulated Totals for
July 27-28, 1997
Christman Field, CSU Foothills Campus
Laporte Avenue west of Overland Trail
Inches of Precipitation
12
10
8
6
4
2
0
1600 1800 2000 2200 2400 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 200
July 27
Hour (MDT)
July 28

Fig 4



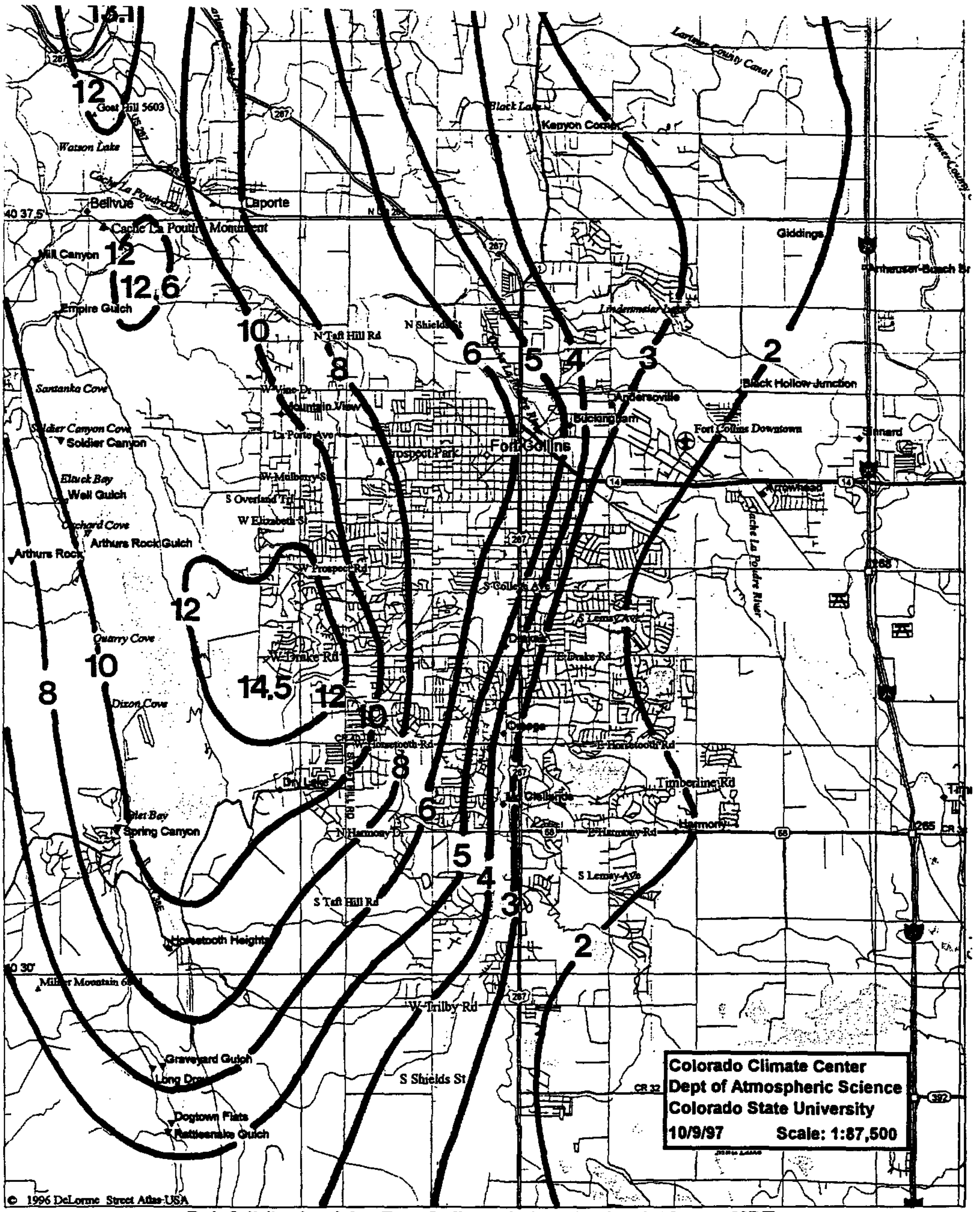
Rainfall (inches) for Fort Collins, Colorado, for 5:30-11:00 p.m. MDT for July 28, 1997

fig 5



Rainfall (inches) for eastern Larimer County, Colorado, for 5:30-11:00 p.m. MDT for July 28, 1997

Fig 6



Rainfall (inches) for Fort Collins, Colorado, for 4:00 p.m. MDT July 27, 1997 through 11:00 p.m. MDT for July 28, 1997

Fig. 7

Yearly Maximum 1-day Precipitation
Fort Collins, CO

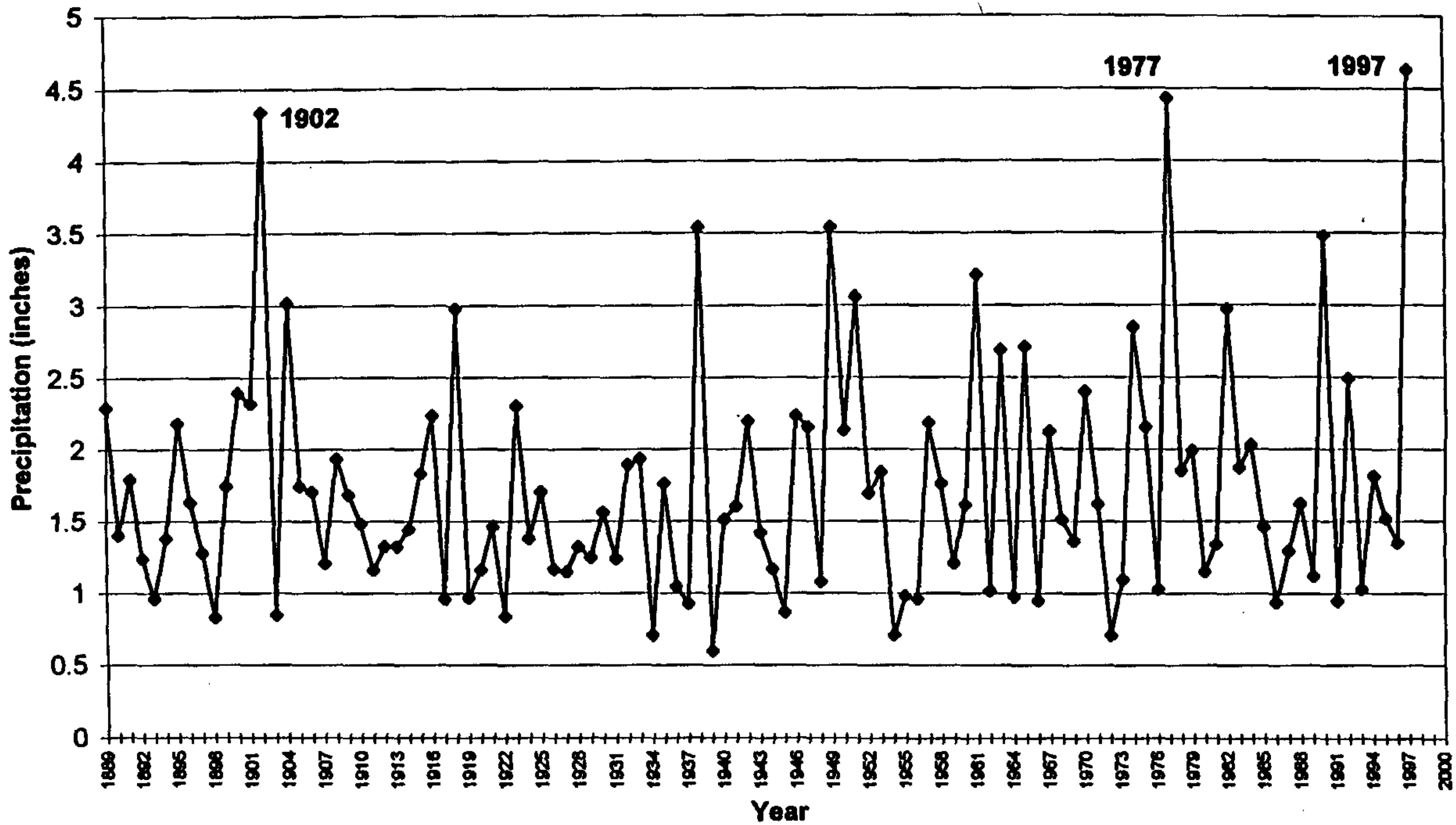


Fig 8

Chronologic List of Extreme Rain Events on the "Front Range" during the 20th Century*

(* from Colorado Extreme Storm Precipitation Data Study, Climo Rept 97-1)

Storm	Date	Maximum Precipitation
Livermore/Boxelder	May 20-21, 1904	8"
Pueblo/Penrose	June 2-6, 1921	6-12"
Savageton, ***WY***	Sept 27-29, 1923	17"
Cherry Creek/Hale	May 30-31, 1935	12-24"
N. Colo Front Range	Sept 2-3, 1938	6-10"
Rye (S. Colo Front Range)	May 18-20, 1955	6-13"
Gibson Dam, ***MT***	June 6-8, 1964	16"
Plum Creek	June 16-17, 1965	14-16"
Big Elk Meadows	May 4-8, 1969	6-14"
Rapid City, ***SD***	June 9, 1972	15"
Big Thompson	July 31, 1976	12"
Frijole Creek	July 2-3, 1981	8-16"
Fort Collins	July 27-28, 1997	14.5"
Pawnee Creek	July 29-30, 1997	15.1"

Table 1

Table 1 PRELIMINARY DISCHARGE ESTIMATES

Location	July 28, 1997 Discharge (cfs)	FEMA 100-year Discharge (cfs)	FEMA 500-year Discharge (cfs)	Estimate made by
Spring Creek				
Taft Hill Road	3,900	1,492	2,347	Lidsone & Anderson
Downstream of Taft Hill	3,300	1,492	2,347	Ayres
Drake Road	4,200	1,635	2,575	Lidsone & Anderson
Downstream of Drake Road	3,700	1,635	2,575	CWCB
DS Shields above Canals	5,200	1,955	3,090	CWCB
Combined flow below Canals	8,250	2,135	3,325	USGS
Drop Structure – Channel	6,100			USGS
Overflow to South	850			USGS
Wallenberg	1,300			USGS
Indian Meadows Condos		1,528	1,846	Lidstone & Anderson
Indian Meadows Condos	5,000	1,528	1,846	Ayres
Mathews	5,500	1,528	1,846	CWCB
Edora Park	6,000	2,187	2,920	Ayres
RR Trestle	5,860	2,187	2,920	USGS
Fairbrooke				
Willow Lane Townhomes	425	260	420	Lidstone & Anderson
Fairbrooke/Dorset Drive Combined	1,750	326		USGS
Fairbrooke Channel	530			USGS
Dorset Drive	1,220			USGS
Clearview				
Clearview Channel-Taft Hill	2,400	532	670	Lidstone & Anderson
Clearview Channel-Avery Pk	2,500	532	670	USGS
Plum				
Culvert -Jefferson Commons	370	356(developed)		USGS
Fossil Creek				
LeMay Ave – Southridge	1,800	2,520		USGS

Estimates as of 1/16/98

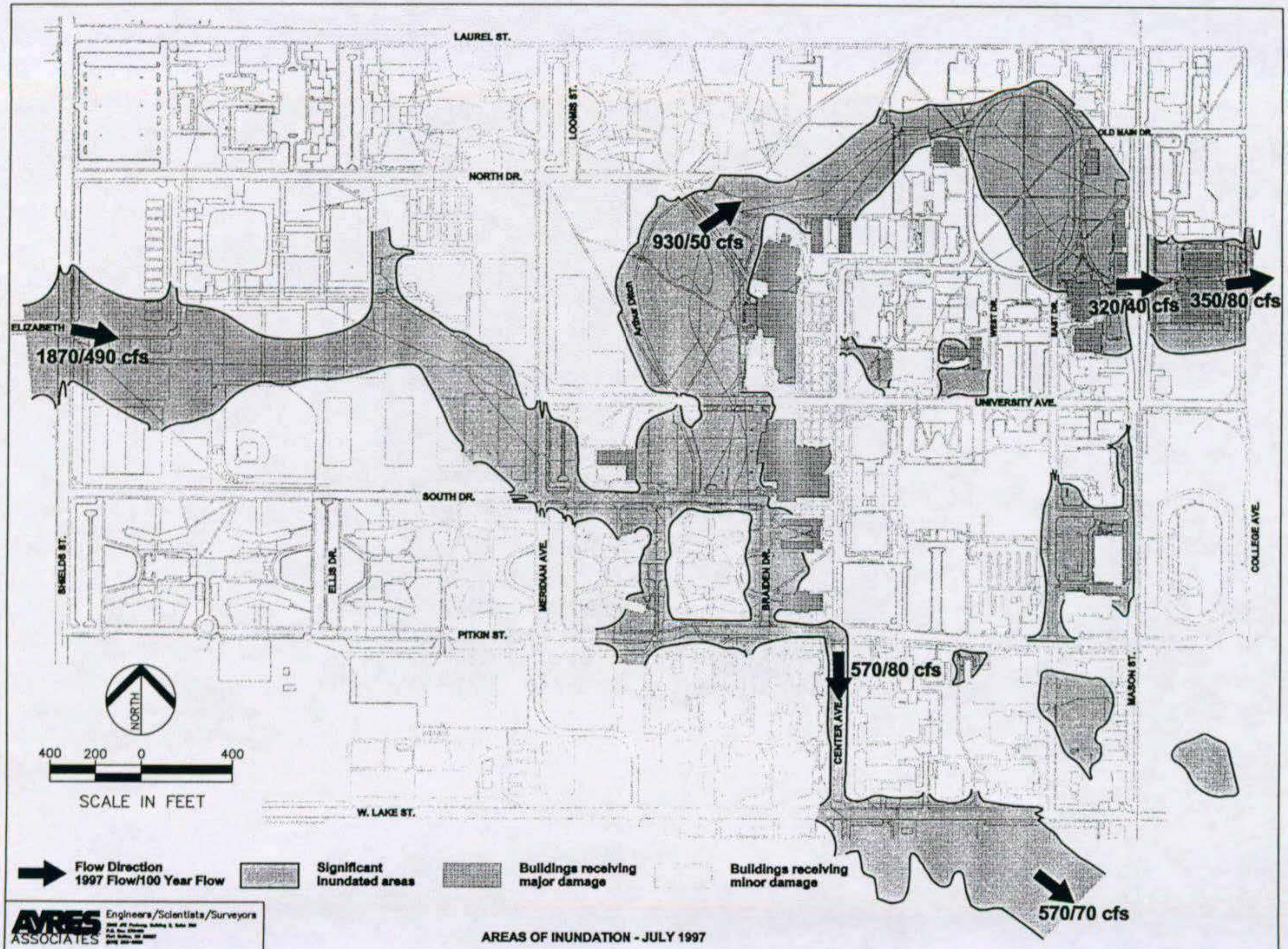


Figure 3

Fig 9

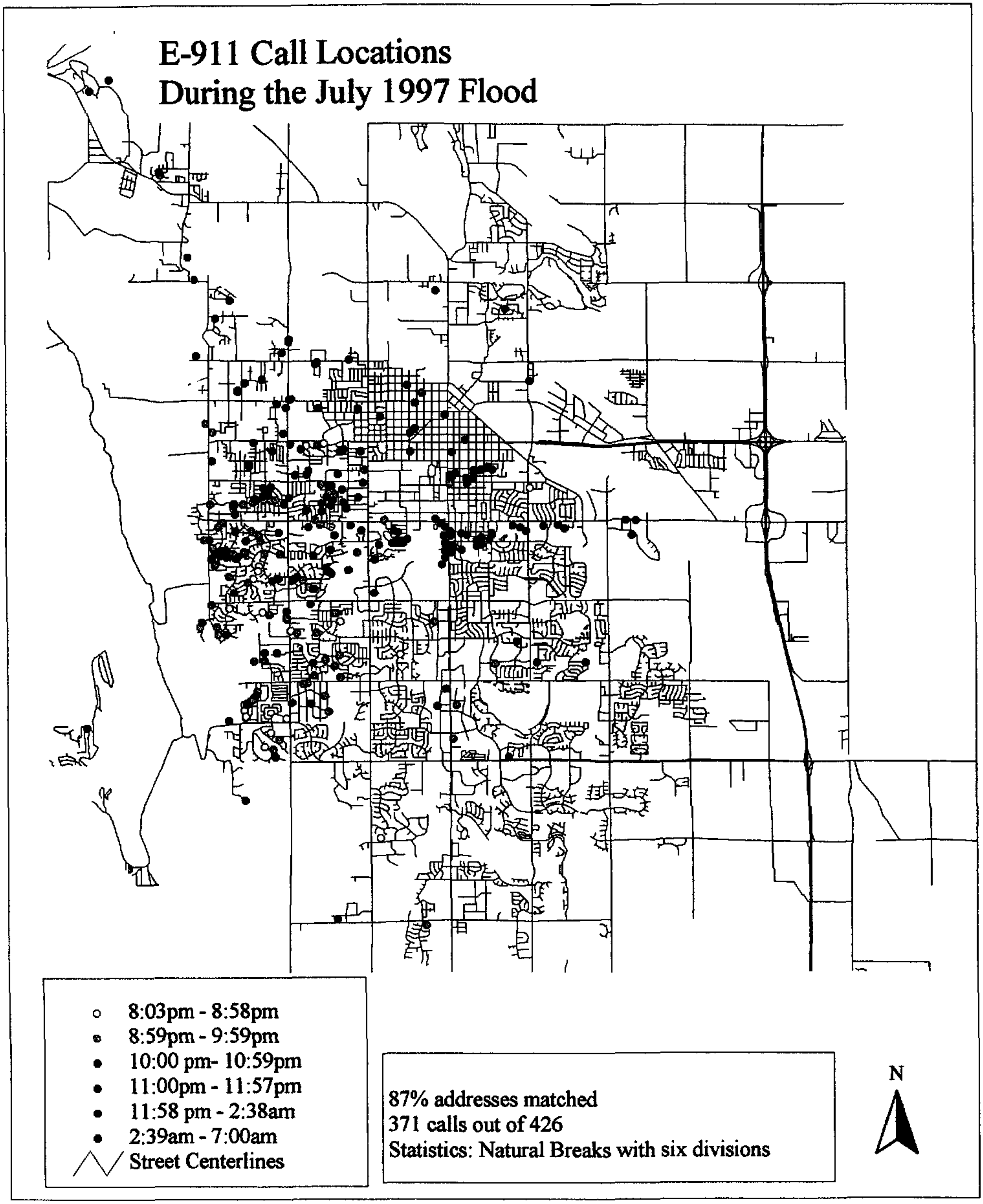
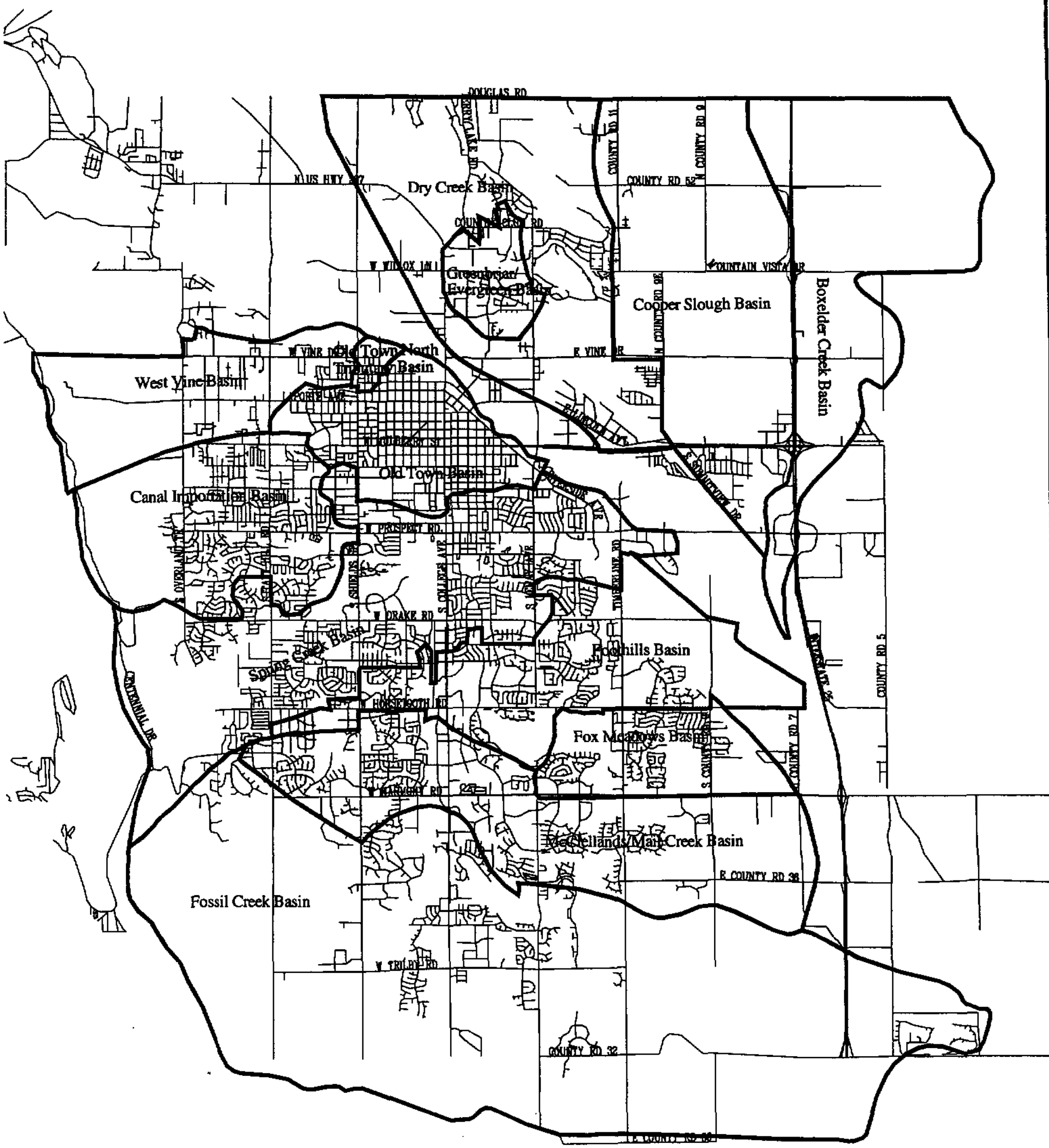

E-911 Call Locations
During the July 1997 Flood
8:03pm - 8:58pm
8:59pm - 9:59pm
10:00 pm- 10:59pm
11:00pm - 11:57pm
11:58 pm - 2:38am
2:39am - 7:00am
Street Centerlines
87% addresses matched
371 calls out of 426
Statistics: Natural Breaks with six divisions
N

Fig 10

CITY OF FORT COLLINS

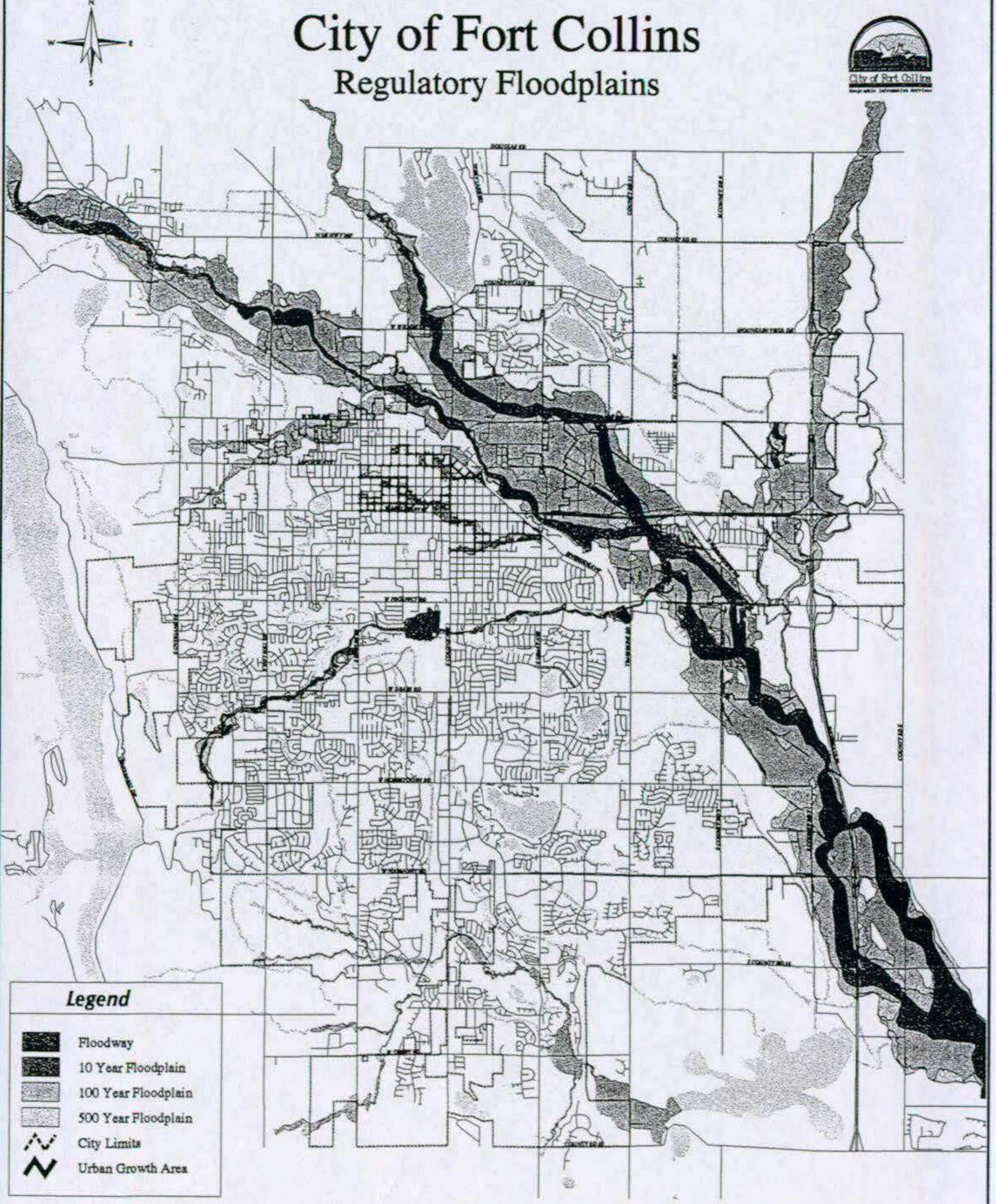
Stormwater Basins



Not To Scale

January 08, 1998

City of Fort Collins
Regulatory Floodplains



Red outlined floodplains indicate city designated floodplain.
Black outlines indicate FEMA designated floodplains.

Fig 12

Not To Scale

January 08, 1998

July 1997 Flood

Discharge Estimate Locations

City of Fort Collins

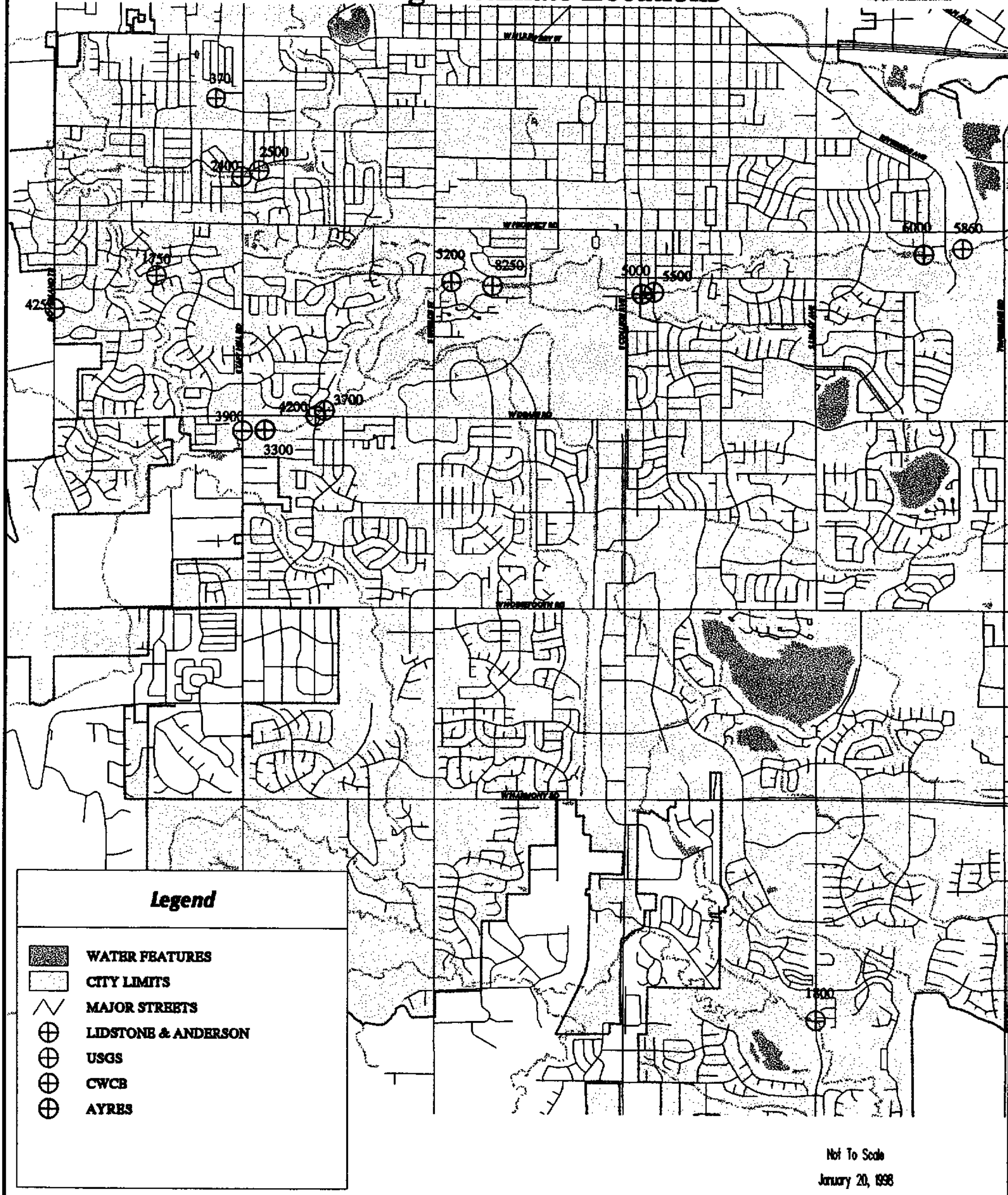


Table 2. Estimated number of lives and property positively affected by pre-disaster mitigation.

Structure Type	Number of structures affected	Range of value assumed per structure, does not include contents	Number of people assumed affected per structure	Estimated direct mitigation savings	Estimated lives saved
Mobile Home	30	$40,000-100,000	2	$1,200,000 to $3,000,000	60
Residential	9	$125,000-200,000	2	$1,125,000 to $1,800,000	18
Critical Facility	1	$150,000-250,000	15	$150,000 to $250,000	15
Commercial	1	$300,000-500,000	5	$300,000 to $500,000	5
TOTAL				**$2,775,000 to $5,550,000**	**98 lives**