An Evaluation of the Boulder Creek Local Flood Warning System

Eve Gruntfest, Kim Carsell, and Tom Plush
Department of Geography and Environmental Studies
University of Colorado at Colorado Springs

Prepared for
Urban Drainage and Flood Control District
Boulder City/County Office of Emergency Management

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Eve Gruntfest, Kim Carsell, and Tom Plush
Department of Geography and Environmental Studies
University of Colorado at Colorado Springs
PO Box 7150
Colorado Springs, CO 80933
(719) 262-4058
ecg@uccs.edu

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May 2002

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ACKNOWLEDGEMENTS

We appreciate the opportunity provided by Kevin Stewart of Urban Drainage and Flood Control District who had the courage and perseverance to initiate and support this research. We thank Larry Stern of the Boulder City/County Office of Emergency Management for his encouragement, support, and inspiring charisma.

Thanks to those who assisted with the development of the survey.

- Tom Carney, CU Department Of Public Safety
- Sylvia Dane, CU Natural Hazard Research And Applications Information Center
- John Handmer, Centre For Risk Community Management, RMIT University, Australia
- Ricky Martinez, CU Student Family Housing
- Dennis Mileti, CU Natural Hazard Research And Applications Center
- John Sorensen, Oak Ridge National Laboratory
- Gilbert White, Professor Emeritus, Geography, University Of Colorado

We appreciate those who spent time providing information about their various organizations

- Luli Bevis, CU Family Housing Children's Center
- Sam Hartman, Boulder Library
- Randy Heizarman, Millennium Hotel
- Marsh Hilmes-Robinson, Fort Collins Stormwater Utility
- Dale Hobbs And Bob Martin, Boulder Valley School District
- Steve Waters, Maricopa County Flood Control District
- Amy Wayne And Lisa Richie, Naropa University

Thanks to the 319 Boulder residents who participated in our survey and provided information on their perceptions of flash floods and their flash flood preparedness activities. Thanks also to the 21 MACS committee members who participated in our online survey.

EXECUTIVE SUMMARY

This report was a cooperative effort between Urban Drainage and Flood Control District (UDFCD), the Boulder City/County Office of Emergency Management and many other agencies and individuals.

The report has six parts:

1. A state of the art review of flood warning literature;
2. A brief overview of the Boulder warning system;
3. A review of detection and warning practices from communities with innovative flash flood warning operations;
4. A survey of Multiple Agency Coordinating System (MACS) members to gauge their confidence in the warning system;
5. An in-depth survey of floodplain residents along Boulder Creek;
6. A review of the flash flood plans for several non-residential Boulder floodplain occupants.

Boulder Creek has high flash flood vulnerability, not only because of physical/hydrologic factors, but also because so many people work and live along the floodplain. Even if all aspects of the warning system work perfectly, a flash flood might take many lives.

Accurate and timely flash flood warning is difficult. The warning process includes many components beyond issuing an accurate message. People must respond quickly and appropriately. UDFCD and the Boulder City/County Office of Emergency Management are recognized national leaders in flash flood warning and preparedness. Also, Boulder has a pro-active, multi-agency, multi-jurisdictional committee, MACS, that meets regularly to maintain high levels of coordination and preparedness. However, the complex process of warning with such short lead-times means that numerous processes must all work quickly and smoothly to reduce loss of life and property in flash floods. Successful warnings are challenging and require continuous vigilance.

The most important aspect of our study is the contribution of baseline data. This is the first study in Colorado since Waterstone's report in 1977, following the deadly Big Thompson flood that identifies what floodplain residents know and don't know about flash floods, preparedness, and response to warnings. Waterstone interviewed Ralston Creek and Lena Gulch floodplain resident. He found that public education provided by UDFCD did heighten awareness of flash flood risk and motivated floodplain residents to mitigate their risk. Waterstone also identified key factors that seemed to determine awareness of flash flood hazards. The current research follows up on Waterstone's 1977 work, but evaluates a new society. The population-at-risk in 2002 is vastly different from 1977. How do new technologies, new sources of information, and new views of government affect how and who

responds to warnings? The information in this report may help UDFCD, Boulder City/County Office of Emergency Management and other responsible entities by allowing them to more deeply understand the knowledge base, warning preferences, and existing evacuation plans (or lack thereof) of their constituents.

Since this report is the first examination of the perceptions of Boulder's floodplain residents, it is hard to judge whether these findings are encouraging or disheartening. For example, 57% of the respondents who own their own homes indicate they have flood insurance. Flood insurance is required for all federally insured home mortgages for floodplain properties. Is 57% a disappointing number? What percentage constitutes good news? Is 30%, 50%, or 70% a high or low expectation?

Methodology

The most complex aspect of this research included a survey of floodplain residents along Boulder Creek. A total of 319 respondents participated in the study, which is a 44% response rate. These residents consisted of two populations:

- Population A: those living on Boulder Creek in the 100-year floodplain
- Population B: University of Colorado Student Family Housing residents along Boulder Creek in the 100-year floodplain.

A 60-question survey was developed and mailed to floodplain residents as a tool to evaluate the flash flood knowledge and risk perception of those living along Boulder Creek. Every household in population A receives a public information brochure provided by UDFCD at the beginning of flash flood season. Every household in population B receives a similar public education brochure from CU Student Family Housing at the beginning of flash flood season.

A smaller, 12-question survey was administered via the Internet to members of the MACS committee. Committee members were notified via e-mail and asked to participate in the study. A total of 21 committee members participated. The findings listed in this report represent perceptions of only those MACS committee members who participated and should be considered a snapshot in time.

One other important aspect of this research is a cursory look at flash flood response plans for business and public agencies in the Boulder Creek Floodplain. Those chosen for inclusion in the study were the Boulder Public Library, Boulder High School, University of Colorado Student Family Housing, University of Colorado Children's Center, Naropa University, and the Millennium Hotel. Interviews were conducted with appropriate personnel by telephone or in person.

Findings and Recommendations

UDFCD and the Boulder City/County Office of Emergency Management are nationally recognized leaders in flash flood preparedness and warning. Other communities take different directions with their choice of public education and

warning procedures. Some of these examples might also have promise for Boulder. Our project recommendations fall into three categories:

1. Public Education – We recommend conducting new education campaigns marketed to specific audiences as outlined by our demographic findings and to parents of Boulder High School students. The Internet and e-mail may be one avenue to do this.

   Public education *cannot* reduce the flash flood threat, nor can it assure that everyone at risk receives and responds to a warning during flash floods. However, educating the public may allow people to understand their own risk and may empower them to act appropriately during hazardous events. The link between awareness and action is not clear, but we believe that public education campaigns are worthwhile.

2. Using new technologies and education techniques – We recommend a study of how UDFCD and Boulder can capitalize on new technologies and education techniques currently being used by other flood control organizations. The technologies that might be considered include, but are not limited to, enhanced GIS capabilities including flood inundation mapping, small scale GIS maps for basin or gauge location, and unique public education such as billboards as used by Clark County FCD.

   We also strongly recommend a review of the current paging system as several MACS participants indicated the system could be better.

   We recognize that more technology does not necessarily translate into reduced losses. However, different tools may assist before, during, and after an event. We encourage UDFCD and Boulder City/County Office of Emergency Management to investigate these resources.

3. Involving local businesses and schools in the warning system, including the annual drill – We recommend education of the local business and schools along Boulder Creek as these business owners/managers/administrators/teachers represent an educated and semi-permanent population that may be depended upon by employees and constituents during a flash flood event.

Findings and Recommendations from Public Survey

1. Most of our respondents do know that they are in the floodplain. The residents surveyed all live in the Boulder Creek floodplain. Respondents indicated that 70% *know* that they live in the floodplain.

2. The majority of respondents do not know/remember basic flash flood information. We asked four basic questions to determine what knowledge Boulder Creek floodplain residents had about flash flood terminology. All residents (or their addresses) received a flood hazard education brochure either from UDFCD or from CU Family Housing. Those residents who have lived on the floodplain for more than one year should have received the flyer before we contacted them.

   Our questions were based specifically on information from the UDFCD brochure. Although we recognize that there is no standard to indicate what percent of correct answers is an acceptable level of knowledge, our findings may be perceived as disappointing. Our sample population has received a brochure and has heard the siren sound each month during flash flood season, they should have perhaps a higher awareness.

   Respondents were asked the definition of a 100-year flood, flash flood watch, flash flood warning, and if they though their residence was in the 100-year floodplain. Only 30% of survey participants answered all four questions correctly.

   Recommendations: Current public education efforts should continue. UDFCD and Boulder should consider changing and augmenting the annual brochure with additional ways to communicate risk to the public and to improve the public's retention of flash flood knowledge.
   - Examine other popular resources such as the Internet to distribute public education.
   - Examine the potential and possibly adopt a non-threatening flood-warning mascot to be used in schools and at community events.
   - Replace the term 100-year flood with something more appropriate.
   - Consider public education campaign used by Clark County FCD.

3. Knowledge of flash flood information and perceptions of risk varied by demographic groups. Answers to several questions were evaluated using demographic groups. Findings show that certain residents need more help than others in understanding flash flood risk. For example, floodplain residents not living in the family housing population scored higher than those who lived in family housing. Other low scoring groups included women living at CU Family Housing and residents living in the community for less than one year. Males under the age of 36 scored the lowest for understanding that their life may be at risk from flash flooding. Other interesting demographic findings can be gleaned from the data. For example, women are more likely to delay their evacuation because of pets and women are more aware of the potential loss of life from flash floods while men are more aware of the risk to their homes.

   Recommendations: This data should be useful to UDFCD and other appropriate organizations in marketing future public educational pieces to select publics.
   - CU Family Housing needs to find additional ways to communicate flash flood information.

- Flash flood educational items should be provided to new residents. Perhaps information can be provided when new residents add utilities or phones?
- Increase public education to people less than 35 years old.

4. Residents are aware of risk to property, but are only somewhat aware of risk to life and are not taking ownership of the risk or appropriate actions to reduce their risk.
   When asked to rate the risk of loss of life and loss of property, more respondents acknowledged the risk to their residence (73%) than they did their risk to life (44%). This suggests that they may be underestimating the power and suddenness of a flash flood.

   Mileti and Fitzpatrick (1992) found that ownership of risk could be predicted based on whether or not the population-at-risk is actively seeking additional information. The majority of participants in this survey are not seeking additional information about flash flood risk, do not talk to their neighbors about flash flooding, have not made flash flood preparation such as emergency planning or flood mitigation efforts for their homes, and do not have flood insurance. Does this mean that residents are not receiving enough information via UDFCD publications and other traditional methods such as the newspaper? How can we increase the number of people who prepare for a flash flood?

   Recommendations:
   - The possibility of death from a flash flood must be communicated, but perhaps can be communicated in a non-threatening manner.
   - Education about flood insurance to homeowners and renters should be provided to residents in the 100-year floodplain.
   - CU Family Housing should provide information about property protection insurance (both for regular renters insurance and flood insurance).

5. The majority of residents prefer to be warned by sirens. Boulder has an extensive siren system. We asked how people prefer to be warned at different times of the day: 2:30 AM, 11:00 AM, and 5:00 PM. An overwhelming number of respondents (88%) listed sirens as their preferred method of warning, regardless of the time of day. Other preferred warning types were the television, a phone call, and a personal knock on the door. Few people wanted to be warned via pagers (3%) or NOAA Weather Radio (4%), but several wished to be warned via e-mail (28%) during the daytime hours.

   Recommendations:
   - Consider e-mail as a viable warning dissemination device for Boulder residents.
   - Determine if there may be a way to reach residents by knocking on doors, similar to the “Neighborhood Watch” program.

- Warning through pagers is not preferred. Even people with pagers did not want to be warned in this manner.

6. More flash flood warnings are acceptable. Prior research in the natural hazard field has shown that, contrary to conventional wisdom, false alarms for natural hazards may not have negative impacts on the community. The survey was developed to look at the perception of false alarms and overwarning. Most respondents, 78%, would rather be overwarned than underwarned. Only 35% indicated that a few false alarms would reduce their confidence in future warnings. We also asked if they would find it helpful to have an automatic road barrier (like a railroad crossing) to warn of dangerous driving conditions. Over half of the respondents said they would find a warning device like this helpful.

   Recommendation:
   - Adopt an understanding that the public may not be negatively impacted by false alarms to the degree that conventional wisdom may suggest, especially if an educational effort follows any false warning.

7. Many residents know what appropriate action to take and are willing to take it. The survey included five mini-scenarios to gauge to what degree the population-at-risk know what to do and if they will do it. Questions concerned issues including driving in deep water, response to an automated call, response to sirens at the library, and perceived parental response to a flash flood warning (at Boulder High and CU Family Housing Children's Center). The appropriate actions were selected for each question by over 50% of the respondents.

   Many people still plan to drive away from the flash flood threat. However, 55% said they would wait until conditions improved if they noticed that the streets were flooded at quitting time and 66% said they would go five minutes out of their way to avoid a flooded intersection. However, when asked what they would do if they received a call from the emergency manager to go ten feet higher, at least 1/4 said they would leave in their cars. More people said they would go upstairs or walk to higher ground but a significant percentage still feel their car is a safe choice.

   Recommendations:
   - Adopt public education techniques aimed at reducing the number of people who will drive during a flash flood.
   - Increase public signage such as "climb to safety."

8. Communication technology preferences and availability are better known. Television (75%) is the most important news source for weather. Internet (56%), The Weather Channel (56%) and the newspaper (51%) are other popular choices. Radio (3%) was selected less often. More of our respondents have Internet access at their homes (84%) than have cable television access (79%).

This finding shows the Internet to be an effective dissemination tool, before, during and following major and minor flash flood events.

Nearly everyone has at least one phone line (91%). Few know about the emergency call back system (30%). Only 35% of our respondents have a cell phone.

Recommendation:

- Consider using the Internet for dissemination before, during, and following major and minor flash flood events.

Findings and Recommendations From MACS and Other Agencies

1. MACS participants have high confidence in the warning system, but not in public response. When asked to rank their confidence level in various aspects of the warning system such as detection of a hazard and response of personnel, MACS responded that they are mostly confident of the system (averages on a scale of 1-10 were 7-9, respectively). However, when asked to rank their confidence level to public responses, MACS responded that they have low expectations (4) of the public to take protective action. Any system is only as strong as its weakest link. The MACS survey indicates that the weak link in the Boulder Creek Warning System is public response.

   Recommendations:

   - MACS should formulate ways to increase the likelihood of the public taking protective action during a flash flood.
     - More public education provided by UDFCD (MACS suggestion).
     - Examine and potentially adopt a "Neighborhood Watch" program (MACS suggestion).

2. Some MACS participants expressed concern over the current paging system. One participant indicated that historically the pagers never operate 100% during drills and then are never retested. Since this is the main avenue of communication to alert responsible personnel to early flood potentials, it is *imperative* that this system works seamlessly.

   Recommendations:

   - Conduct a comprehensive review of the paging system.
   - Test the pagers every month during flood season, the same day/time as the siren test (MACS suggestion).
   - Have pagers serviced by an on-site technician every six months and establish a regular maintenance schedule (MACS suggestion).

3. MACS participants ask for two additional services from UDFCD.
   - Host a workshop or seminar in which staff and emergency personnel can be further educated about a response plan.
   - Be more pro-active and financially supportive in the warning and public education side as part of a coalition of Red Cross, local OEM, institutions, and neighborhood watch/CDE/CERT programs.

4. Other floodplain regulatory agencies are using newer technology and unique public education techniques.

   Recommendations: Examine and possibly incorporate or enhance the following new technology:
   - GIS as used by Maricopa County FCD to show specific location of cities, basins, and gauges. UDFCD has GIS maps; however, more small-scale maps may prove useful.
   - Cutting edge detection, notification, and GIS as used by Fort Collins Utilities-Stormwater. Boulder uses a mired of detection and notification systems but may benefit from adding new materials or software.
   - Public education campaign as used by Clark County FCD.

5. Major non-residential floodplain occupants have acknowledged the flash flood risk and have made flash flood plans. All of the non-residential floodplain organizations we interviewed have a flash flood plan. One example is the Millennium Hotel. The Millennium Hotel has a flash flood plan, and personnel will be warned via a Plectron radio system. However, there was some doubt as to whether the Plectron system was operational as it had been some time since anyone had heard a warning on the system.

   Recommendations: Educating business owners and managers along Boulder Creek may be one way to disseminate flash flood response information to an educated and semi-permanent population. These people have employees and/or constituents in their businesses, and during an event, might be looked to for advice.
   - Develop a plan to train and update business owners about warning systems, techniques, and responses.
   - Involve businesses in the annual drill to test their Plectron system and other communication and response systems prior to flash flood season.
   - Consider providing some type of economic incentive to encourage participation from local business.

6. Parents of Boulder High School Students not likely to drive to school during a flash flood. There is a perception that parents will flock to the high school to pick up their children during a flash flood event. However those parents indicating their child knew what to do during a flash flood event said they *would not* go to pick the students up. Greater public awareness of effective plans in place may

reduce confusion when flash flood warnings are issued. The benefit possibilities for educating constituents should be well worth the effort. For example, an inexpensive flyer sent to Boulder High School parents may reduce the number of people driving into danger in a flash flood situation.

Recommendations:

- Educate Boulder High School parents about the schools flash flood plans and why the school has adopted these plans. A simple flyer may be enough.
- Educate students about the danger of driving in deep water. This could be done in association with the annual flash flood drill.
- Boulder High School might consider developing a box of supplies to be used in the event of a flash flood like CU Student Family Housing has done.
- The Boulder School District should develop and keep up-to-date a series of media statements to broadcast during a flash flood event regarding the safety of Boulder High School students and informing parents not to go to the school.
- Recognize that many people will be calling the school for additional information and that phone lines will be jammed.

SECTION I: LITERATURE REVIEW

BOULDER CREEK DRAINAGE BASIN AND FLOOD HISTORY

The Boulder Creek basin begins at the Continental Divide at approximately 13,409' above mean sea level and encompasses 132 square miles upstream from the City of Boulder sitting at approximately 5,385'. The basin is oriented in a generally west to east direction and includes the major tributaries of North Boulder Creek, Middle Boulder Creek, and Fourmile Creek. Many glaciers exist at the Continental Divide and numerous small lakes occur in the higher portions of the basin. Barker Reservoir, owned by the City of Boulder, is located along Middle Boulder Creek near Nederland up-stream from the City of Boulder. The Boulder Creek basin is predominantly mountain and foothills, characterized by steep rock and gravel bed streams that slope between 2.5% -10% (UDFCD 2001).

Because of the steep slopes and generally elongated basins, Boulder Creek and its principal tributaries are susceptible to flash floods caused by high intensity, short duration thunderstorms which generally occur from May through September. Rainfall rates from such storms can exceed the infiltration capacity of the surface soil, producing large runoff in short periods of time. When high runoff converges on a stream, it generally exceeds the carrying capacity of the normal channel, resulting in flooding of the adjacent floodplain (UDFCD 2001).

Fast moving water from a flash flood has the ability to pick up and carry debris such as boulders, trees, and cars which in turn may clog normal stream channels and reroute the flow into neighboring streets and property. Flash floods occur swiftly and are difficult to warn for. A flash flood on Boulder Creek could have disastrous consequences for the City and County of Boulder, both in property damage and loss of life. The state geologist has listed Boulder Canyon as one of the most dangerous canyons in Colorado as far as the potential for loss-of-life from flash flooding (UDFCD 1992). The City of Boulder is located at the base of Boulder Canyon. Thousands of people live and work on the Boulder Creek floodplain. Buildings in jeopardy from a flash flood include Boulder High School, Boulder Library, City of Boulder administration buildings, businesses along Broadway, Arapahoe, Folsom & 28th Street, CU family housing and homes in the Goss-Grove neighborhood (Boulder County 2000).

Six major flash flooding events have occurred on Boulder Creek since 1864. A brief synopsis of each follows, additional information can be obtained from UDFCD Boulder Creek Flood Warning Plan and Boulder County Emergency Operation Plan 2000.

- **1874, May 21-23,** large flood inundates the area swelling Boulder Creek in many places to 1½ miles wide.

- **1894, May 29-June 2**, heavy rainfall between 4.5 – 6 inches falls in the mountains. This rainfall and the snowmelt from a heavy snowfall create a record flood on Boulder Creek, roaring down the valley during the evening of May 30. All bridges were swept away in Boulder Canyon, destroying the highway and railroads as far up the canyon as Fourmile Creek. Estimates calculated 18 years after determined the flow rate ranged from 9,000 to 13,000 cubic feet per second (cfs). The floodwater in Boulder covered the entire area between Water Street (now called Canyon Boulevard) and the University Hill with water as deep as eight feet. Many people were trapped and needed rescuing from their homes. Agricultural losses included the loss of livestock, crops, pastures, fences, roads, and deposition of sand and silt on the floodplain. This flood was estimated as 100-year flood (a flood that has a 1% chance of occurring in any given year).

- **1914, June 1-2,** heavy rains in the mountains that accelerated melt on a snowpack, which was estimated to be 50% above normal, produced a large flood on Boulder Creek. Many roads and bridges in the mountains were damaged or destroyed and Boulder's water supply system was damaged.

- **1921, June 2-7,** rainfall totaled 3.36 inches in Boulder throughout these six days. A peak discharge was recorded at 2,500 cfs approximately 3 miles above Boulder at the U.S. Geological Survey's Orodell gauge.

- **1938, September 4**, flood occurred with a maximum discharge of 4,410 cfs recorded.

- **1969, May 4-8**, four days of continuous rainfall combined with snowmelt in the mountains produced a flood causing damage estimate at $325,000. Total precipitation for the storm amounted to 7.60 inches at Boulder and 9.34 inches at the Boulder Hydroelectric Plant located about three miles up the canyon from Boulder. Estimated discharge at the Orodell gauge indicated a peak of 1,220 cfs. The discharge at Broadway in Boulder was estimated to be between 2,500 to 3,000 cfs. Large areas were flooded downstream from Boulder (UDFCD 2001, Boulder County 2000).

INTEGRATED WARNING SYSTEM

The literature review was a useful starting point for the evaluation of Boulder's warning system. We looked for a definition of a comprehensive warning system. Prior to the 1970s, warning efforts focused solely on the detection and forecasting of meteorological events. The addition of social science to the equation began with Mileti (1975) and McLuckie (1974) and has been drawn on extensively over the years. Mileti (1975) proposed an integrated warning system that makes clear all parts of the warning process as well as the links between them.

An integrated system is composed of three basic processes:

1. *<u>Evaluation</u>, detection, measurement, collation, and interpretation of threat data (typically referred to as prediction and forecast);*

2. *Dissemination, decision to warn, message formulation (when warning is not accomplished by purely technical means such as sirens), and message conveyance; and*
3. *Response by those who receive the warnings* (Mileti 1975, 11).

Later research has elaborated on the definition of the warning system and redefined the three components – detection, management, and response subsystems (Mileti and Sorensen 1990). The detection subsystem consists of routine monitoring of the environment. Like the evaluation process described by Mileti (1975), this subsystem collects and analyzes information and makes forecasts about potential disasters. The detection subsystem then disseminates the forecasts to the management subsystem. The management subsystem evaluates the information received and determines if the risk is sufficient enough to make a public warning. If the risk meets predefined criteria, a public warning is issued. The final step in the warning process is the public response subsystem. Adequate response subsystems should have prearranged multiple channels of communication, comprehensive messages to the public, and should be monitored during public action (Mileti and Sorensen 1990).

> *A warning system is a means of getting information about an impending emergency, communicating that information to those who need it, and facilitating good decisions and timely response by people in danger* (Mileti and Sorensen 1990, 2-1).

Recent literature has similar definitions. "*Warning systems detect impending disaster, give that information to people at risk, and enable those in danger to make decisions and take action"* (Sorensen 2000,1). "*Flood warning systems need to be seen as providing (a) forecasts of floods, (b) warnings to those at risk, and (c) in-between arrangements for disseminating warning messages to those who need the information as a basis for their response*" (Penning-Rowsell *et al.* 2000, 7).

CHALLENGES IN THE WARNING PROCESS

Most agree that flood warning systems are complex because they incorporate many disciplines and organizations from meteorology to engineering, government, media and finally to the public (Sorensen 2000, Penning-Rowsell *et al.* 2000, Mileti and Sorensen 1990, Mileti 1975, McLuckie 1974). Warning systems are designed for rare events; therefore, those individuals involved in any aspect of the warnings system, such as forecasters, may be experiencing an event for the first time (Doswell *et al*. 1996). The warnings system is often "tested" during real events where lives are at risk (Handmer 2000). One often-overlooked aspect is that of monitoring public reaction and making changes to the warning message (Mileti and Sorensen 1990). More attention needs to be given in the design of the warning system to match the needs of the public (Penning-Rowsell *et al*., 2000).

The literature does not have an adequate definition of what makes a successful warning. Perhaps this varies between agencies depending on their perspectives

and expectations. Some feel that a successful warning should include the public's response.

> *"Ensuring response by the public to the warnings which it receives should be just as much the responsibility of the agencies concerned as is their more traditional role in flood forecasting and their new-found task of warning dissemination"* (Penning-Rowsell *et al.* 2000, 13).

Others, however, believe that this is too strong of a definition since those in the warning system cannot control the actions of individuals at risk (Handmer 2000). Despite these and other inadequacies, flash flood warning systems do provide a truly valuable asset to society (Handmer 2000).

PUBLIC RESPONSE

A large part of this project is based on furthering an understanding of the response subsystem. Many advances have been made in the detection and forecasting of meteorological and hydrological events, but the social science understanding of why some people respond accurately and timely to warnings while others do not has not improved. Mileti and Sorensen (1990) determined that adequate public response requires:

- hearing the warning,
- understanding the contents of the warning message,
- believing the warning is credible and accurate,
- personalizing the warning,
- confirming the warning, and
- responding by taking protective action.

Other studies have provided some understanding of public behavior. Drabek (2001) suggests that the first reaction of the population-at-risk when warned of an impending disaster is that of disbelief. Dow and Cutter (1998) suggest that the population-at-risk seeks information from a variety of sources beyond official forecasts and evacuation notices. This finding differs from Baker's finding (1995) that the population-at-risk relies solely on advice of emergency managers.

Improvements in communication and technology have changed the way in which society is now warned of impending disasters. For example, The Weather Channel has been cited as an important source of emergency weather information before and during hurricanes (Drabek 2001, Dow and Cutter 1998).

Many sources of information are now available to the public at the same time they are available to officials. The advent of cell phones, pagers, and real-time data availability have also altered the warning process.

Societal changes are not limited to technological advancements. Differences in languages, individual priorities, and in risk understanding affect perspectives. Some people have an aversion to authority and do not take protective action even when

they understand the risks (Handmer 2000). Dow and Cutter (1998) have noted an increasing population that will not evacuate when told to do so.

In developing the tools to determine the hazard perceptions and warning preferences of Boulder residents, many other research projects were reviewed. Table 1 lists the studies, methods, and relevant finding used in developing tools to measure the public response aspect of the Boulder warning system.

Table 1:
Important Studies of Public Perception/Response

Researcher	Date	Research Topic	Methods	Major Findings
Drabek	2001	Disaster Warning and Response by Private Business Employees	In person interviews; mail surveys	First response to disaster warnings is disbelief; public looks to many different sources for disaster information, but mainly looks to the medias.
Carsell	2001	Understanding Public Perception of a False Alarm	Public survey conducted orally in public areas	False alarms can provide an opportunity for learning how to and how not to respond to warnings. The public is not desensitized by all false alarms.
Gruntfest and Carsell	2000	Understanding Perceptions of False Alarms from Organizational Users of the Warning System	Internet and paper survey	Forecasters and organizational users believe the public is desensitized by false alarms and sometimes hesitate in issuing warnings.
Dow and Cutter	1998	Response to Repeat Hurricane Evacuations in South Carolina	Public survey conducted orally in public areas	Public not negatively effected by repeat evacuations; public considers a variety of sources and factors prior to making evacuation decisions.
Baker	1995	Public Understand of Hurricane Probability Forecasts	In home interviews	The public can understand probability-based forecasts; the public looks to emergency managers for evacuation information.
Sanders and Westergard	1995?	Citizens' Understanding and Use of Weather Information and Forecasts	Focus groups	Citizens seek additional information to support weather forecasts; Citizens feel emergency weather warnings issued during non-emergencies creates public confusion and disruption.
Mileti and Fitzpatrick	1992	Risk Communication in Parker Earthquake Prediction	Mail survey	Risk information reinforcement important; Public's seeking additional information about risk is of major importance related to taking protective action.
Waterstone	1978	Flash Flood Hazard Perception	Structured telephone interviews	Public perception of flash floods; risk awareness; mitigation efforts and ownership of risk; evaluation of UDFCD brochure.

SECTION II: BOULDER WARNING SYSTEM

Since the scope of this research project has primarily been public perception, and since information on the Boulder warning system can be found elsewhere, limited details are provided here. Further information is contained in the Boulder Creek Flood Warning Plan located at the City/County Office of Emergency Management or can be accessed via the Internet (http://www.co.boulder.co.us/sheriff/eop.htm).

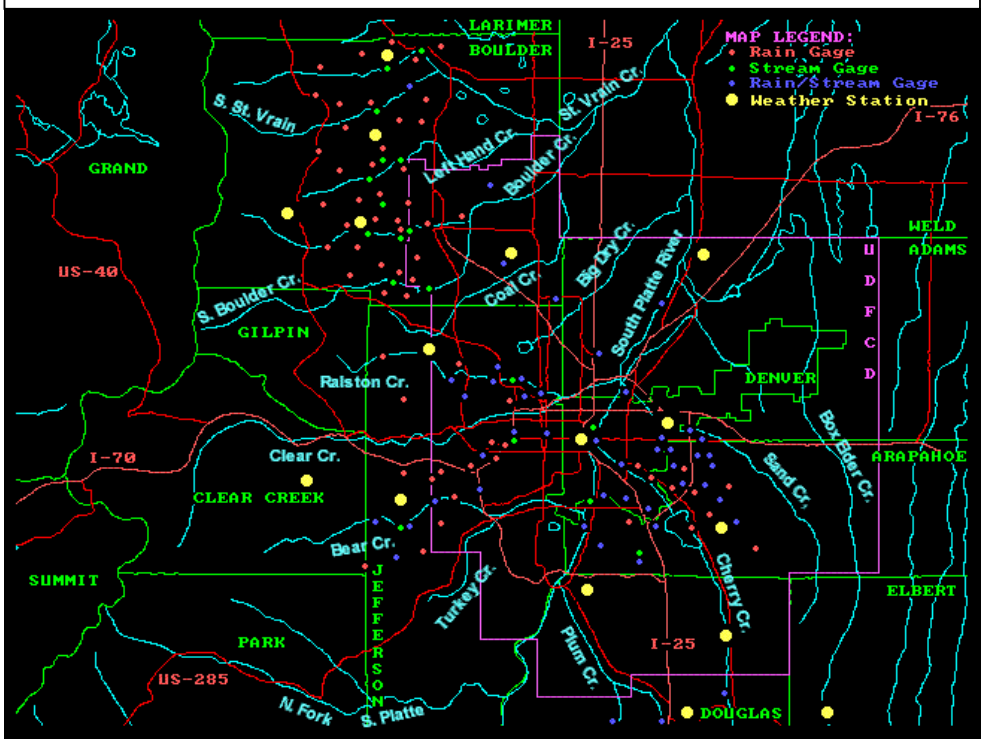
Methodology

The Boulder warning system was studied by examining a plethora of documents provided by UDFCD and the Boulder City/County Office of Emergency Management. We interviewed Kevin Stewart of UDFCD and Larry Stern, Emergency Manager in Boulder, CO. Internet resources were utilized as well.

Detection Subsystem

ALERT System: ALERT is the District and Boulder City/ County Office of Emergency Management's online system for dispensing information such as rainfall measurements, stream/reservoir levels, and weather data as it pertains to potential flood events. ALERT has been updated to enable Internet access at (http://alert.udfcd.org) while continuing to support dial-up access to authorized users. Currently the District supports a total of 145 ALERT stations and additional stations are added periodically. The web server that supports the primary system along with DIADVISOR (Storm Watch) is a 2-node LAN base located in the District office and is designed for automatic emergency failover operations should either PC malfunction.

Figure 1:
UDFCD ALERT Gages



There are 6 ALERT stream gauges along Boulder Creek and South Boulder Creek. The stations are located at:

- South Boulder Creek below Gross Reservoir
- South Boulder Creek at Eldorado Springs
- Boulder Creek below Boulder Falls
- Boulder Creek at Orodell
- Fourmile Creek at Salina
- Boulder Creek below Fourmile

Meteorological Support: The Boulder City/County Office of Emergency Management receives meteorological support from two primary sources 1) private meteorologist provided by UDFCD during flash flood season and 2) the National Weather Service (NWS) year round.

HDR Engineering, Inc. provided the private meteorological service in 2001. HDR supplies the District and local governments with flash flood prediction services. This program is entitled the Flash Flood Prediction Program (F2P2). The goal is to give local government users a sufficient lead-time to prepare appropriate responses before flooding events. Once flooding potential is recognized, it is communicated via telephone, fax, and the District's Internet-based bulletin board (EBB) to the local governments likely to be affected. Two primary services provided by F2P2 are Metwatch and Internal Alert (Henz 2000).

1. Metwatch: Analysis and observation-based monitoring of weather factors capable of producing urban, foothills, and/or catastrophic flash flooding events.

- Heavy Precipitation Outlooks (HPO) issued daily prior to 11:00 AM consisting of general discussion on the heavy rain potential of the atmosphere and a table containing more specific guidance on a county basis. This is communicated by fax and EBB.

2. Internal Alert: Internal alerts are issued whenever the F2P2 meteorologist determines there is flash flooding potential. Four types of alerts can be produced, messages A-D, Quantitative Precipitation Forecasts (QPF), StormTraks, and specialized forecasts.

- Messages A-D (1-4 for other District users) provide detailed flooding potential forecasts. Criteria for issuing these messages have been developed using the known hydrologic response of basins, streams, and urban areas to rainfall intensities and amounts. (See Table 2).

- Quantitative Precipitation Forecasts (QPF) provide detailed basin-specific predictions of the amount and time predicted for storms. Issued when forecast's exceed locally developed criteria.

- StormTraks provide the forecast track of storms or storm systems which have the potential to produce message level rainfall. Issued with a 30-60 minute lead-time.

- Specialized forecasts such as fire weather forecasts are provided, if possible, when requested.

Table 2:
F2P2 Messages to Boulder County

Message	Definition	Criteria	Red Flag
A	(internal alert): Advisory message meant to inform keep people that weather conditions are such that flood producing storms could develop later in the day.	.50”/10 minutes or 1.00/60 minutes	>1.00”/30 minutes and occurrence is imminent
B	(flash flood watch): Indicates that the NWS has issued a flash flood watch and/or that F2P2 feels the risk is high that a life-threatening flood may occur later in the day.	NWS issues FF Watch or F2P2 predicts 3.00”/60minutes	Lead-time is 3 hours or less
C	(flash flood warning) Indicates that the NWS has issued a flash flood warning and/or F2P2 feels that a life-threatening flood is imminent.	NWS issues FF Warning or F2P2 issues for specific basin	
D	(all clear) Cancels the flood potential status.		
Message Update	Issued to update any previous messages as additional information becomes available.		

Modified from Henz, 2000

Other Detection: Other detection systems used by Boulder City/County Office of Emergency Management and UDFCD include *DIADVISOR* (StormWatch), which (among other things) can send notification of gauge alarms via pager; *Riverwatch*; and NWS radar.

MANAGEMENT SUBSYSTEM

The emergency manager and the Boulder Communications Center personnel use the information provided from the ALERT network, private meteorological services, field observations, and pre-determined gauge/flow information to assess the flood threat. The emergency manager has the ability to access this information from home via the Internet and contact with the Communications Center. Tasks for each alarming gauge level and each flood emergency action mode have been documented in detail and are located at the emergency operations center; one copy is with the emergency manager at all times.

Multiple Agency Coordinating System (MACS): An organization that bridges the political jurisdictions and response agencies in Boulder County. It acts as an information and resource service to facilitate the use of limited resources between jurisdictions. The MACS group is activated upon receiving information of a possible disaster. Monthly meetings keep the members up-to-date with institutional and personnel changes and recent events.

Emergency Operations Center (EOC): The EOC is established as the central point to which essential reports and information concerning the disaster will flow, enabling the City Manager, Board of County Commissioners and other key officials to obtain the information needed for decision-making and for the management of resources. It also serves as the center for the maintenance of an overall status board, and, through the Board of Directors, issuance of resolutions and/or proclamations concerning the disaster and advising the general public of the situation. The EOC is located on the 2nd floor next to the Communications Room in the Public Safety Building at 1805 33rd Street, Boulder, Colorado. The EOC is to be staffed by:

Boulder County Commissioners
City of Boulder City Manager
City of Boulder Mayor
Boulder County Sheriff
City of Boulder Police Chief
Emergency Management Director
City of Boulder Public Works Director
Boulder County Transportation Director
Radiological Officer
Amateur Radio

Boulder Creek Flood Warning Plan: This plan is updated and exercised once per year at the beginning of the flash flood season. The exercise involves several agencies throughout Boulder and allows warning and response personnel to review and refine procedure. One aspect of the flood warning system that needs to be identified is the use of modes to communicate level of risk.

- Mode 1: The meteorological potential of a flood-producing storm has been observed.
- Mode 2: The possibility of flooding exists.
- Mode 3: Flooding is probable.
- Mode 4: Flooding is occurring (UDFCD 2001, Boulder County 2000)

Public Information: Many forms of public education are used in Boulder. Samples of these are to follow.

<u>UDFCD Brochure</u>: UDFCD sends out a brochure to all residents and businesses in the 100-year floodplain at the beginning of flood season. This brochure is specific to the creek

by which the resident lives. These brochures explain that the resident is living in or near to a 100-year floodplain, explain the probability of a flash flood, and what residents can do.

Boulder City Telephone Line: The City provides an information line for residents to call for current flash flood information.

Media: Media sources such as the *Boulder Daily Camera* are used during the beginning of flash flood season to distribute flood safety information.

Kiosk: A flash flood kiosk is located along the Boulder Creek bike path. The kiosk provides a variety of information on historical flash floods and what to do and not to do in the event of a flash flood. A picture of the "Climb to Safety" sign is shown on the kiosk.

Figure 2
Climb to Safety Sign

Climb to Safety Signs: Climb to Safety signs are located in Boulder Canyon as a means to remind visitors and commuters what to do in a flash flood.

Flood Protection Handbook: The County has published a handbook for residents living in Boulder detailing how to prepare their property for a flash flood (http://www.co.boulder.co.us/transportation/pdf_files/fld_protect.pdf).

WARNING METHODS

Emergency Alert System (EAS): Alert tone issued via radio to warn the population-at-risk. Tone is followed by message.

Outdoor Warning Sirens: A warning method to alert the population-at-risk of an emergency situation. There are 27 sirens located in Boulder County in the cities of Boulder, Lafayette, Louisville, Longmont, Lyons, and Erie. The City of Boulder has 10 fixed sirens, 9 of which have voice capability. Operation of the siren system is located in the Communications Center. A backup system is located at CU Police Department Communications Center. The siren system is tested at the beginning of each month during flash flood season, April – September.

Citizen Alert System: A warning system consisting of a number of Plectron boxes located at various businesses in Boulder such as nursing homes, banks, and schools. These boxes were in two of the non-residential structures included in this study – the Boulder High School and the Millennium Harvest House Hotel.

Metropolitan Emergency Telephone System (METS): A telephone system used to instantly alert law enforcement, response agencies, and the media of emergency situations.

Voice Over-Ride Cable Television: A warning method used by communications center personnel to voice over-ride all City of Boulder TCI cable programming for emergency messages. All radio and TV stations receive emergency information.

Automated Emergency Call System: A warning method using existing 9-1-1 services and an Xcel database of telephones numbers to call home and business telephone numbers in order to issue warnings. This system is housed at the communications center and is operated by the emergency manager or "warning point supervisor." Warnings can be issued to pre-programmed numbers (including pagers to appropriate city/county personnel), pre-defined geographic boundaries, or geographic boundaries defined during an event. This system has been used several times in the past few years for various hazards such as the 2001 Walker Ranch Fire. There is a .20 charge for each number called using this system (Stern 2002).

When the CU Police Department Communications Center receives a warning via the automated emergency call system, the warning is sent to selected CU numbers. One select group is Student Family Housing residents. The call time is slower through this system. Eventually, the system will be programmed to issue warnings in a variety of languages up-to-date with the primary language spoken by each student-housing unit.

NOAA Weather Radio: A service of the National Oceanic and Atmospheric Administration (NOAA) the National Weather Service provides 24-hour coverage of local weather information/forecasts. During severe weather, the National Weather Service forecasters can broadcast warning messages. The radios have the ability to sound an audible alarm when warnings are issued. Reception of the NOAA broadcast is not available in canyon areas. Only one non-residential structure, the library, and 14 survey participants indicated they had a NOAA Weather Radio (11 participants indicated they had it plugged in).

Emergency Vehicles: Sirens and public address systems on police and fire vehicles can be used to provide additional warning coverage.

SECTION III: CASE STUDIES

An investigation of other advanced warning systems was conducted for comparison to Boulder's warning system. The other warning systems investigated included:

- Flood Control District of Maricopa County, Arizona
- Utilities, Stormwater Department, Fort Collins, Colorado
- Clark County Regional Flood Control District, Nevada

FLOOD CONTROL DISTRICT OF MARICOPA COUNTY (FCDMC)
Maricopa County (Phoenix metro and surrounding areas), Arizona
Interview with Steve Waters (http://www.fcd.maricopa.gov/).

The FCDMC encompasses 27 cities and approximately 13,000 square miles in Maricopa County. FCDMC has the second largest ALERT System in the United States (FCD 2001). Current population for Maricopa County is 3,072,149 (Census 2000).

Detection Subsystem: FCDMC has 265 ALERT stations. Two hundred fifty-five (255) stations measure and record rainfall, 118 measure and record water level information, and 18 are complete weather stations measuring temperature, barometric pressure, solar radiation, wind speed / direction and humidity. The flood monitoring room has three computers dedicated to ALERT and three illuminating boards illustrating activity at these gauges. District staff can also check other data such as USGS gauges and activity on large rivers by accessing the Arizona Flood Warning System at (www.afws.org).

The District has a private meteorologist on staff. Weather products consist of daily rainfall forecast, which includes general weather forecast, percent chance of rain, expected time period, and expected rainfall totals for 13 forecast zones. This forecast is sent to clients and published on the web. Clients also receive messages 1-4 to communicate severity of threat: 1) threat higher than usual, 2) threat higher than 1, but no immediate threat to loss of life and/or property, 3) imminent flooding, and 4) all clear. These messages are sent electronically to clients. Clients receive the messages as e-mail or fax, depending on the client's preferences. FCDMC also issues severe weather warnings for recreational lakes within the county.

Management Subsystem: FCDMC has preset alarm criteria on each ALERT gauge and relies heavily on these alarms. When a gauge reaches the preset alarm level, an alarm sounds on the flood-warning console. If it is not picked up at the office, the computer dials a list of numbers until someone is contacted. The two people on call have home computers that can be used. Most of the operations can be run from a home location. As of 2001 the on-call person still travels to the office (approximately a 30 minute drive) during an event.

Flood control staff consults an emergency response manual during a flood event. One of the first steps listed in the manual is to notify operations and maintenance so

that observation teams can be dispatched to predetermined locations to monitor flood conditions at streams and dams. Teams are sent to storage dams when the dam is at 25% capacity. The operations and maintenance teams report conditions hourly. Flood control staff can communicate via county radio system, over the telephone (US West and County system), and by e-mail/fax. E-mail and fax communication can easily be sent to individuals or to predetermined groups or zones.

When necessary, the Flood Control staff advises the NWS of conditions in the district. FCDMC also advises emergency managers or public safety personnel of when and how to evacuate from a flood event. FCDMC provides this service to assist clients, but it is not necessarily their responsibility.

The FCDMC also develops or works with consultants to develop flood response plans to assist local governments. Response plans have been developed for the cities of Wickenburg, Fountain Hills, and Glendale (http://156.42.96.39/alert/special.html). A unique project, Skunk Creek, has presented an unusual warning plan. An updated hydrologic study found that 17 homes are in the Skunk Creek floodway. These properties are being bought out, but in the meantime, warning residents in the floodway has been an issue. Since there is not enough time to warn residents the traditional way, through emergency management, FCD hired a consultant to develop a warning plan for the residents. Each household has been provided with a warning pager (if there are two adults, two pagers are provided) and a NOAA weather radio. Messages can be sent directly to the pagers provided to the residents during a flood event. A written warning plan has been given to each household explaining pager messages and illustrating evacuation routes. The warning plan consists of three modes, green, orange, and red to communicate the severity of flooding. Pager messages tell the resident which mode the flood event is in and advises them to consult the warning plan. Pagers are tested every Wednesday. This is a temporary arrangement that will end before 2004.

Public Information: FCDMC has two public information officers to work with the media and public. In addition, they have an extensive Internet site that is accessed regularly by the public. Many members of the public must access the site for rainfall and weather information as visits to the Internet site triple during a storm event (approximately 500 hits during a dry week, 1,000 on a rainy day). Many of the users come from the Phoenix metro area.

The ALERT section (http://www.fcd.maricopa.gov/alert/alert.htm) offers the following:

- Rainfall
    - Raw Data
    - Statistical Reports
    - Contour Rain Maps
    - Low Resolution Rain Maps
    - High Resolution Rain Maps

- Stream flow
    - Daily water sensor reports
    - Real-time and historic water level reports (per gauge)
    - Real-time and historic stage sensor reports (groups of gauges)
    - Graphical display of real-time and history water level (per gauge)
    - Statistics and complete records of each gauge (picture, map, current conditions, rating curve, rating table, gauge cross section plot, and site data such as water year peaks). Still being developed.
- Weather
    - Raw data
    - Statistical reports
    - Trend charts
    - Weather Maps (current readings, temperature/humidity/dewpoint vs. elevation, desert floor temperature, dewpoint temperatures, trends for select stations)
- Publications
    - Annual hydrology report for precipitation, water surface, and weather sensors
    - Storm event reports (http://156.42.96.39/alert/102000/storms_2000.htm)
- Custom
    - Daily precipitation reports
    - Daily surface water reports
    - Daily rainfall forecasts
    - Lake Pleasant weather station report
    - Real-time and historic graph data maps and tables
    - Alert station location maps
    - On-line flood response plans, Wickenburg, Fountain Hills, Glendale, Phoenix dams
    - Additional information such as
        - Meta Data Lists
        - Links
        - ALERT Map
        - Unique features such as “gauge of the month”

FORT COLLINS, CO. – UTILITIES, STORMWATER DEPARTMENT
Fort Collins, Colorado Interview with Marsha Hilmes-Robinson (http://fcgov.com/stormwater/).

The flood warning system in Fort Collins, CO is a shared responsibility between the city of Fort Collins Office of Emergency Management (OEM) and the City Utilities - Stormwater Department.

Detection Subsystem: The Fort Collins detection subsystem uses 21 streamflow gauges and 28 rainfall gauges strategically located throughout the city. *Watchdog*, a

customizable computer program that monitors gauges and sends notification when gauge thresholds have been exceeded, monitors gauge activity. Each gauge in Fort Collins has a predetermined level of acceptable activity. Once the level of activity at a streamflow or rainfall gauge is met, *Watchdog* sends information via pagers, e-mail, and text messaging to appropriate personnel. *Watchdog* allows an emergency plan to be in place for each gauge, this includes a to-do list for Stormwater and for the Office of Emergency Management.

Notification: Two people are on call every night: a Stormwater engineer and an emergency manager. The Stormwater person on call has a laptop computer to use for monitoring purposes if necessary. The on-call person keeps both the laptop and a procedure book overnight. Other select Stormwater personnel have pagers to notify them as necessary.

Management Subsystem: The City of Fort Collins has many avenues for notifying the population-at-risk. Unlike Boulder, they have not installed warning sirens because they fear that people will associate the wailing sirens with tornado sirens and respond by going to their basements. Other drawbacks of siren notification are that siren systems are expensive and many times they cannot be heard by the population-at-risk during periods of heavy rainfall, when inside their homes, or out of the siren range.

Figure 3
Emergency Radio Station

Two interesting avenues of notification are the use of radio and cable television. Fort Collins has one radio station 530 AM dedicated to emergency information during an event. During non-emergency events, this station rebroadcasts the NOAA weather radio and covers community and public education information. This can be accessed by the population-at-risk in homes, offices, or cars to get real-time storm information. One cable television channel, channel 27, is a dedicated City channel. The Emergency Manager can display either a crawler or a scroll of text informing the population-at-risk of what the conditions are and how they should or should not respond. The benefit of channel 27 is that people can check often to see if the information has changed. The office of emergency management can interrupt all cable television channels with a message about the expected conditions and refer people to 530 AM and channel 27. Cable interrupt initially only had voice capability, but the office of emergency management now has the ability to include crawling text.

Like the Boulder Warning System, Fort Collins has the ability to call select groups of people using their automated dialer. The auto dialer will call all of the phone numbers within the area identified by the OEM. A message, either pre-recorded or real-time, is delivered to all of the phone numbers. The auto dialer keeps track of the number of messages delivered to people and to answering machines. It can send a message to the hearing impaired through an alpha pager, fax, or TDD/TTY.

If a phone number is busy, the auto dialer recycles the number and calls again later. It also has an option for people to replay the message and to respond when the message has been understood. Phone numbers within city limits are updated every few weeks.

Finally, Fort Collins is using a geographic information system (GIS) based program that incorporates information from all of the gauges and from other programmed sources to show flooding in real-time.

Fig. 4

Public Information: The city uses many forms of public information to get the message about flood safety out to the population-at-risk. An all hazard brochure about notification was developed to inform residents about what to expect and how to prepare for an emergency. The same type of information was designed to be included along with utility bills. Other public information sources consist of articles regarding seasonal hazards in the newspaper, public service announcements, mailers to all floodplain residents and property owners, mailers to the board of realtors, insurance agents and lenders telling them where they can get floodplain information. Real-time information from the City's stream and precipitation network is available to the public on the City's website. Finally, a sign has been posted on Spring Creek along a popular trail to show the high water level of the 1997 flood.

CLARK COUNTY REGIONAL FLOOD CONTROL DISTRICT
Clark County, Nevada (http://www.ccrfcd.org/).

The Clark County Regional Flood Control District (CCRFCD) was established in 1986. Clark County (Las Vegas) is one of the fastest growing areas in the national and has an unusually high number of tourists and conventions.

Detection Subsystem: CCRFCD Flood Threat Recognition System consists of hydrometrological data collected from 121 strategically located field stations. These stations report data from more that 250 sensors in real-time to computerized basestations. Rainfall, temperature, humidity, and wind data are collected by 24 stations. Rainfall and water level information are collected by 56 stations, and 41 stations report only rainfall data.

Public Information: The District is engaged in a multi-level public information process. They conduct advertising campaigns to educate the public about the risk of flash flooding by using outdoor billboard advertising, radio, print and broadcast media, and training by educators. There are 8 billboards to warn about flash flood risks. In the past, a dairy company has provided a panel on milk cartons to advertise about the dangers of flash floods.

Figure 5
Clark County Regional Flood Control District Billboard Advertising

CCRFDC produces *The Flood Channel* television program, which is shown on two local television stations. The District also talks to over 20,000 students each year by speaking in school classrooms. They have developed a curriculum for teachers and a flash flood coloring book for students, which is available as an interactive game as well (http://www.ccrfcd.org/kidsgames/cbook1.html).

The public can find both historic and real-time rain and weather data on the District's web page. The web page also offers several downloadable reports and other innovative educational information. The advertising campaign shows how a regional flood control district can become more proactive in public education.

SECTION IV: MACS COMMITTEE

Boulder has developed an innovative way to keep various hazard agencies (emergency management, detection, response, public service) in constant communication prior to, during, and after an emergency event. The Multiple Agency Coordinating System (MACS) meets once per month to discuss the warning procedure and address any concerns. Each agency and individual involved in MACS represents an area of expertise. MACS committee members are intimately familiar with their area of the Boulder warning system; therefore, they were included in this research regarding the evaluation of the warning system.

METHODOLOGY

A 12-question survey was developed and posted on the Internet at (http://web.uccs.edu/geogenvs/macs.htm). Survey questions were developed to gauge the level of confidence the MACS committee members had in various aspects of the warning system. MACS members were sent several e-mail messages requesting their participation. A total of 21 members participated.

FINDINGS AND DISCUSSION

Detection:

Q1. On a scale of 1-10, (1 being the lowest and 10 being the highest), please indicate your confidence in the existing flash flood detection and early notification system as a whole. Median score: 7.4 (n=21)

Participants were asked to indicate confidence to the following parts of the detection system, taking into consideration detection and transmission of information (See Figure 6.) n= number of participants responding to each question. Responses "don't know" and those that were left blank are not included in n value.

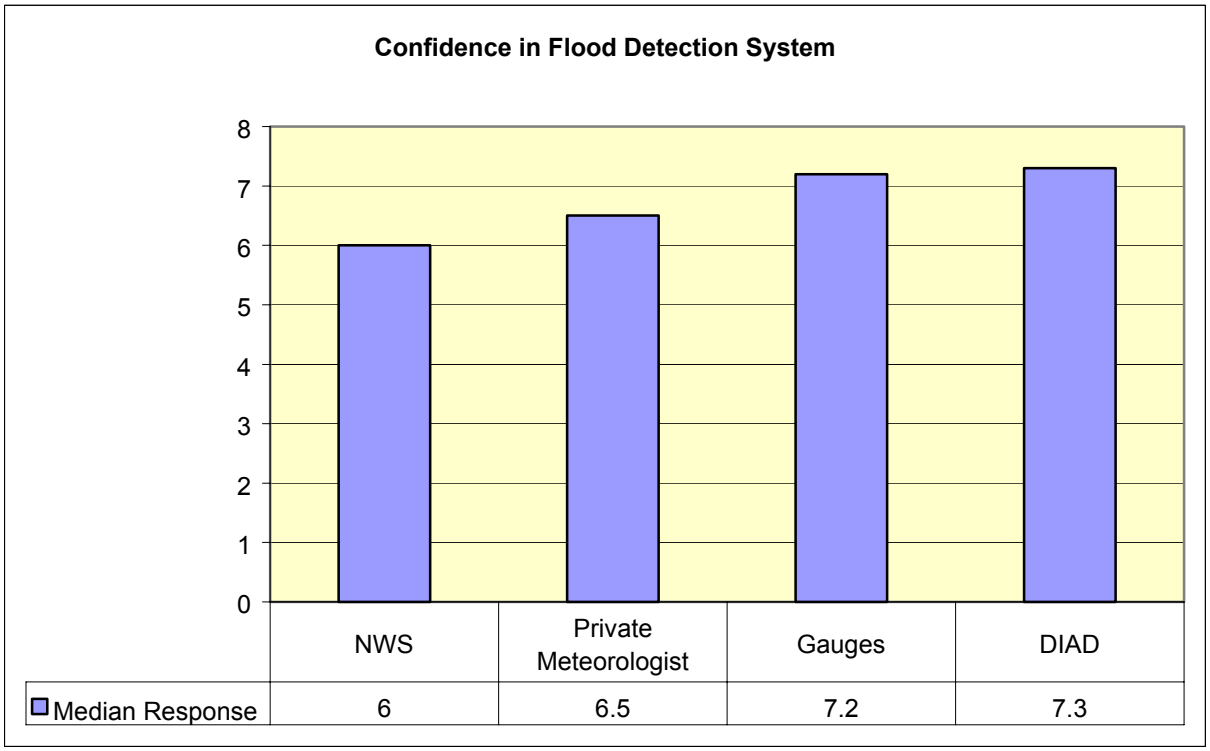
National Weather Service (NWS): Median score**:** 6 (n=21)

Private Meteorologist: Median score: 6.5 (n=17)

Stream/Rain Gauge Network: Median score: 7.2 (n=19)

DIADVISOR (formerly STORM Watch by DIAD): Median score: 7.3 (n=13)

Figure 6



There were several comments from MACS participants indicating that the private meteorologist and the gauge detection network were good additions to the Boulder Warning system instead of relying solely on the NWS. Only two participants scored the detection and notification system below 5. Many participants chose "not applicable" for the question regarding DIAD. See Appendix B for complete scores. Overall, MACS participants have good confidence in the detection system in place for Boulder City/County.

Notification of MACS Committee:

Q2. On a scale of 1-10, (1 being the lowest and 10 being the highest), please indicate your confidence in the system/procedure in place to notify you and other important people regarding flood modes. Median score: 7.1 (n=20)

Several MACS participants expressed concern about the current paging system. One indicated the pagers typically have some problems during the annual drill, but that they are never retested. One participant rated the notification system under 5. MACS participants recommended 1) Test the pagers every month during flood season, the same day/time as the siren test and 2) Have pagers serviced by an on-site technician every six months and establish a regular maintenance schedule

Notification of Public:
Q3. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate your confidence in the system/procedure in place to notify the public of an imminent flash flood (mode 3). Median score: 6.5 (n=21)

Several MACS participants expressed concern about gaps in the siren coverage. Other concerns were expressed such as reliance on technology using power, especially since many buildings and homes do not have backup generators; use of automated calling system when phone lines are clogged, and that many people have cordless telephones which rely on power. There were five respondents who scored the public warning system below 5.

Public Response:
Q4. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate your confidence in the public to take protective actions when notified of an imminent flash flood (mode3). Median score: 4 (n=21)

Many MACS participants responded to this question. Concerns exist about whether the public will respond appropriately or not. One respondent said, "This is the area which is the greatest weakness". Many expressed their interest in continuing to educate the enhancing education to the public. There were 12 participants who rated their confidence in public response under 5. Recommendations from MACS participants included more public education and funding for education by UDFCD and an examination of how the "Neighborhood Watch" has worked for King County Washington.

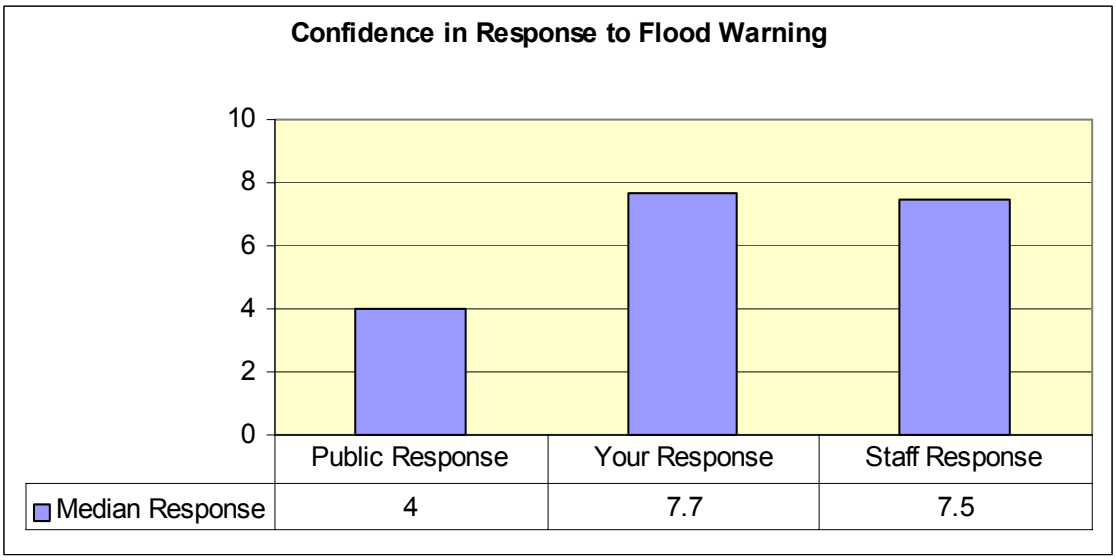
Confidence in Your Ability:
Q5. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate your confidence in your ability to perform your predetermined duties during a flooding event. Median score: 7.7 (n=20)

MACS participants have indicated that they have a strong confidence level in their ability to perform their duties during a flash flood event. There was one participate that ranked their ability below 5. Most responses were 9s.

Confidence in Staff Ability:
Q6. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate your confidence in your staff's ability to perform their predetermined duties during a flood event (or if they are not to perform flash flood related duties, their ability to take protective action during a flash flood). Median score: 7.5 (n=20)

MACS participants also have a high confidence level in their staff's ability to perform duties (or take protective action) during a flash flood event. One respondent ranked confidence in staff ability under 5.

Figure 7



Flow of Communication from Detection to Response:
Q7. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate your confidence in the flow of communication from early notification of threat to detection to response. Median score: 6.9 (n=19)

One participant indicated that the "regular, established relationship and use of the system" makes him/her more confident. Two participants ranked confidence in the flow of communication under 5.

Concerns:
Q8. "What portions of the warning plan do you have concerns about?"

Responses to this question fell into four categories: public awareness and response issues, detection issues, emergency service and response issues, and notification issues.

Seven participants indicated that they were concerned about the level of public awareness and response. Concerns listed included public apathy, ability to evacuate, lack of knowledge regarding how to take protective actions, people who are outside of building and don't know where to go, and lack of risk awareness. Several comments were made about seeing people ignore the sirens during a test, even on a rainy day after the Fort Collins flood.

There was one participant who expressed concern about streams and creeks that are not monitored but still can generate devastating flash floods.

Three participants expressed concern about emergency services and response. The concerns included emergency access routes, coordination & communication

between entities, and organizing response of emergency services. One participant said, "Specific response actions need to be re-emphasized".

Eight participants listed concerns regarding notification. Concerns consisted of not enough time to do job, notifying the public, siren coverage, warning those in commercial buildings and businesses, pager messages and reliability, city HOTLINE not being updated, overloading phone systems, lack of redundancy in technological systems.

Suggestions:
Q9. "What suggestions do you have that could be used to make the warning plan more effective?"

Responses were categorized into three sections, public awareness and response issues, notification issues, and emergency service and response issues.

There were five participants who had suggestions for improved public awareness and response issues. Suggestions consisted of continued education/outreach, regeneration of "flood watch," participation of supervisors at organizations, and public education programs such as those used in King County.

Three participants wrote suggestions regarding notification issues. Suggestions included consistent pager messages, regular maintenance of pagers, adding additional sirens. One participant suggested more practical exercises.

UDFCD Services:
Q10. "What additional services could UDFCD provide or what current services could they do better?"

Two suggestions were made for improved and/or additional services from UDFCD. Suggestions included hosting a workshop or seminar in which staff and emergency personnel could be further educated about the response plan and to be more "pro-active and financially supportive" of public education as part of a group of likeminded organizations.

See Appendix B for complete comments and suggestions from MACS participants.

SECTION V: RESIDENTIAL FLOODPLAIN OCCUPANTS

A comprehensive survey was conducted to measure the needs, perceptions, and risk awareness of the population living in the Boulder Creek floodplain.

METHODOLOGY

Two populations were selected. Population A consisted of residents of the Boulder Creek 100-year floodplain not including University of Colorado Student Family Housing residents. Population B consisted *only* of residents of University of Colorado Student Family Housing. Although both populations A and B resided within the 100-year floodplain, the populations were separated based on

1) differing reasons and length of time occupying the floodplain,
2) possible differences in public education (type and frequency) about flash floods,
3) differing types of aid in an emergency situation, and
4) diversity of ethnicity and language.

Participants of population A were selected based on a floodplain address mailing list provided by UDFCD. The list contained both business and residential addresses. Business addresses were identified and eliminated. The remaining residential addresses were mixed randomly and a stratified random selection was performed. Population B participants were selected in a similar fashion from a list of residential addresses provided by CU Family Housing staff. There were 400 addresses selected for each population.

Questionnaires were developed and sent to the populations . Development of the questionnaires was based on an accumulation of surveys used by other researchers, suggestions from hazard experts and local warning officials, and by following an outline presented by Dillman (1978). Hazard experts and local warning officials who reviewed and/or provided suggestions for the questionnaire included

- Tom Carney, Public Safety, University of Colorado at Boulder
- Sylvia Dane, Editor, *Natural Hazard Observer*, Natural Hazard Research and Applications Information Center, University of Colorado at Boulder
- John Handmer, Director, Centre for Risk Community Management, RMIT University, Australia
- Ricky Martinez, Family Housing, University of Colorado at Boulder
- Dennis Mileti, Director, Natural Hazard Research and Applications Center; Chair, Department of Sociology, University of Colorado at Boulder
- Kevin Stewart, Information Systems & Flood Warning Program Manager, Urban Drainage and Flood Control District
- Larry Stern, Emergency Manager, Boulder County
- John Sorensen, Director, Emergency Management Center, Oak Ridge National Laboratory
- Gilbert White, Professor Emeritus, Geography, University of Colorado

Questions for the two populations were mostly identical. Some variation was added to account for the needs of each population. For example, population A contained a question specific to Boulder High School while population B contained questions regarding the CU Family Housing Children's Center. Questionnaires sent to populations A and B were individually numbered so that responses could be correlated to addresses.

Following a modified strategy presented by Dillman (1978), population A received three mailings (See Table 3). The initial mailing consisted of an explanatory letter, the questionnaire, and a postage-paid return envelope. A second mailing, a postcard, was sent to those who had not initially responded, and a third mailing, another complete packet, was sent to those who had not responded to the first two mailings. Population B received only two mailings, a postcard announcing the study followed by a survey packet with a letter, the questionnaire, and a postage-paid return envelope. Population B was provided an incentive to participate in the study. CU Student Family Housing offered to hold a gift certificate drawing for all those who responded. A family housing newsletter contained a note asking residents to respond.

Table 3:
Survey Mailings

	Survey Packet	Postcard	Monetary Incentive	Advertising
Population A	2	1	0	0
Population B	1	1	1	1

SURVEY RESPONSE RATE

Of the 800 surveys mailed, 319 (44%) were returned completed. A total of 35 (4%) were returned marked vacant and a total of 33 (4%) were returned because of incorrect addresses. Population A had a greater number of vacancies and incorrect addresses than did population B (See Table 4). Recognizing that the high turnover rate of the population, the length of the survey, and survey

Table 4:
Survey Response Rate

Population	**Number Mailed**	**Number Completed**	**Number Vacant**	**Number Incorrect Addresses**	**Response Rate**
A	400	163 (34%)	29 (7%)	27 (7%)	163 of 344 (47%)
B	400	156 (39%)	6 (2%)	6 (2%)	156 of 388 (40%)
Total	800	319 (36%)	35 (4%)	33 (4%)	319 of 732 (44%)*

*Response rate does not include surveys returned due to vacancy or incorrect addresses.

literature (Dillman 1978, National Research Center 2001), the goal was to obtain a 30% response rate. The Boulder Citizen Survey 2001 reported a response rate of 34% (National Research Center 2001). This project received a 47% response rate from population A and a 40% response rate from population B, for a total response rate of 44%, which met and exceeded our goal.

DEMOGRAPHICS OF PARTICIPANTS

The majority of respondents were 1) female, 2) ages 18-35, 3) renters living at their currently address 1-3 years and planning on staying there another 1-3 years, 4) had obtained various level of college education, 5) speak English, 6) and were CU Students.

Note: This data is biased and only represents those who chose to participate in the survey and those who live in the two populations selected for inclusion in this study. Less represented persons such as those over 75 years of age and non-English speakers may not have elected to participate for obvious reasons.

Gender: There is an almost equal number of male and female respondents in population A, 48% and 51% respectively. Population B had a larger contingency of female respondents, 55% (See Table 5).

Table 5:
Gender Division of Participants

	Population A Number (%)	**Population B** Number (%)	**Total** Number (%)
Male	79(48%)	71(45%)	150(47%)
Female	84(51%)	85(55%)	169(54%)

Age: The majority of participants, 75%, were between the ages of 18-35. Population A respondents were younger than population B as 58% of population B were between 26-35 years of age (See Table 6).

Table 6:
Age Division of Participants

	Population A Number (%)	**Population B** Number (%)	**Total** Number (%)
18-25	58(36%)	40(26%)	98(31%)
26-35	47(29%)	91(58%)	138(44%)
36-45	16(10%)	19(12%)	35(11%)
46-55	21(13%)	4(3%)	25(8%)
56-65	8(5%)	1(1%)	9(3%)
66-75	6(4%)	0	6(2%)
76+	6(4%)	0	6(2%)

Tenure: Respondents were predominantly renters, with only 28% owning their homes. The majority of population A and B had lived at their current address for 1-3 years, 36% and 51% respectively. A total of 23% of the respondents had lived at their current address 0-6 months, 15% had lived there 6-11 years, and 7% had lived there 4-6 years. Population A reported 21% who had lived at their current address 7+ years, while only 1% in population B had done so (See Table 7).

Table 7:
Tenure of Participants

		Population A Number (%)	**Population B** Number (%)	**Total** Number (%)
Ownership				
	Own	47 (28%	N/A	N/A
	Rent	118 (72%)		
Length of time at current address				
	<6 months	38 (23%)	36(23%)	74(23%)
	6-11 months	22(13%)	25(16%)	47(15%)
	1-3 years	60(36%)	80(51%)	140 (44%)
	4-6 years	11 (7%)	11(7%)	22(7%)
	7+ years	34(21%)	2(1%)	36 (11%)
Length of time planning to stay at current address				
	<6 months	26 (15%)	16 (10%)	42 (13%)
	6-11 months	41 (24%)	36 (23%)	77 (24%)
	1-3 years	60 (35%)	96 (62%)	156 (49%)
	4-6 years	9 (5%)	8 (5%)	17 (5%)
	7+ years	37 (21%)	0	37 (12%)
What type of home do you live in				
	House	51 (31%)	N/A	N/A
	Apartment	97 (59%)		
	Mobile home	1(1%)		
	Condo	6 (4%)		
	Townhouse	2 (1%)		
	Duplex	8 (5%)		

Education Level: Population A showed that 34% had obtained some college, while 23% had obtained a Bachelor's degree, and 27% had some graduate studies. There are a few people in population A, 6%, who had not graduated high school, and a few more that have completed high school, 9%, but have not gone on to college. Not surprisingly, the majority of population B respondents, 69%, have some graduate studies. A total of 29% have either some college or have obtained a

Bachelor's degree. There are no participants in population B who did not graduate from high school and only 2% who have graduated from high school, but have not gone on to college (See Table 8).

Table 8: Highest Education Level Obtained by Participants			
Education Level	**Population A** Number (%)	**Population B** Number (%)	**Total** Number (%)
Some high school	11 (6%)	0	11 (3%)
Completed high school	15 (9%)	3 (2%)	18 (6%)
Some college	58 (34%	26 (17%	84 (27%)
Bachelor's Degree	40 (23%)	19 (12%)	59 (19%)
Graduate Studies	46 (27%)	108 (69%)	154 (49%)

English Speaking: The majority of both populations claim that everyone at their residence speaks English. Population B had a slightly lower number of English speakers than population A, 93% and 96%, respectively (See Table 9).

Table 9: English Spoken by Everyone in Household			
	Population A Number (%)	**Population B** Number (%)	**Total** Number (%)
Yes	156 (96%)	145 (93%)	301 (96%)
No	6 (4%)	11 (7%)	17 (5%)

CU Association: The majority of population A respondents, 64%, are not associated with CU as faculty/staff or students, while the majority of population B respondents, 86% are associated with CU (See Table 10).

Table 10: University of Colorado Affiliated			
Association	**Population A** Number (%)	**Population B** Number (%)	**Total** Number (%)
Student	50 (32%)	112 (72%)	162 (51%)
Faculty/Staff	6 (4%)	22 (14%)	28 (9%)
Neither	90 (58%)	19 (12%)	109 (35%)
Other	9 (6%)	3 (2%)	12 (4%)

PARTICIPANT DEMOGRAPHICS COMPARED TO OTHER ENUMERATIONS
Our populations are not representative of either Boulder County or of Colorado according to the Census 2000. Compared to the census, our participants are 1) younger, 2) more educated, 3) and rent rather then own; therefore, are not representative of Boulder in general. Note: Census 2000 does not count those living in group quarters; thus, only population A should be compared to Census data.

Some categories used in this study are different from those of the Census, so slight errors may be present.

Data from this study was also compared to that of the Boulder Citizen Survey 2001 (National Research Center 2001). Data from our survey and the Boulder Citizen Survey is closely matched in age, education level obtained, and student affiliation (See Table 11). Therefore, participants of this study are more representative of those electing to participate in surveys in the City of Boulder, than those participating in the mandatory Census data collection.

Table 11:
Warning Study Demographics
Compared to Census 2000 and City Survey 2001

Group	Variable	Warning Study		Census 2000			Boulder Citizen Survey 2001	
		Population A	Population B	*Variable changes*	Boulder	Colorado		City
Gender								
	Male	48%	45%		50%	51%		50%
	Female	51%	55%		50%	49%		50%
Age*	18-25	36%	26%	18-24	13%	14%	18-24	30%
	26-35	29%	58%	25-34	22%	22%	25-34	19%
	36-45	10%	12%	35-44	24%	24%	35-44	21%
	46-55	13%	3%	45-54	20%	20%	45-54	14%
	56-65	5%	1%	55-64	10%	9%	55-64	7%
	66-75	4%	0%	65-74	7%	6%	65-74	5%
	76+	4%	0%	75+	5%	5%	75+	4%
				(based on total population 18+) * note category differences				
Education Level**	Some High School	6%	0		5%	10%		1%
	High School Graduate	9%	2%		17%	25%		5%
	Some College	34%	17%		27%	31%		20%
	Bachelor's Degree	23%	12%		31%	30%		35%
	Graduate Studies**	27%	69%	Graduate Degree**	19%	9%	Graduate Degree**	39%
				(based on total population 18+) **note category differences				
Tenure								
	Own	28%	0%		64%	67%		53%
	Rent	72%	100%		36%	33%		47%
Households	W/ persons under 18	9%	42%		32%	35%		
CU Affiliate	Student	32%	72%		--	--		31%
	Faculty/Staff	4%	14%		--	--		--

FINDINGS AND DISCUSSION

Survey questions were written and analyzed for specific findings (See Table 12).

Table 12: Survey Questions Used in Analysis	
Finding	Survey Questions
Knowledge of location in 100-year floodplain	#2
Knowledge of flash flood Information	#1, 2, 3, 4
Risk awareness	#6, 20, 21,15
Ownership of risk	#9, 13, 14, 16, 22
Preferred warning methods	#17, 31, 32,
Overwarning vs. underwarning	#18, 19, 28
Perceived action in flash flood event	#23, 24, 25, 26, 27, 29
Where and how often respondents seek weather information	#8, 10, 11, 12, 41
Avenues of communication	#33, 35, 37, 39, 40
Other noteworthy findings	#5, 43, 60

Knowledge of Location in 100-Year Floodplain

Survey question #2: "Is your residence in the 100-year floodplain?"

A total of 71% of respondents chose "yes" to this question. Population A respondents selected "yes" more than population B respondents (See Table 13).

Table 13: Residence in Floodplain			
Is your residence in the 100-year floodplain?	**Population A**	**Population B**	**Total**
Yes	124 (77%)	101 (65%)	225 (71%)
No	14 (95)	1 (1%)	15 (5%)
Don't know	22 (14%)	53 (34%)	77 (24%)

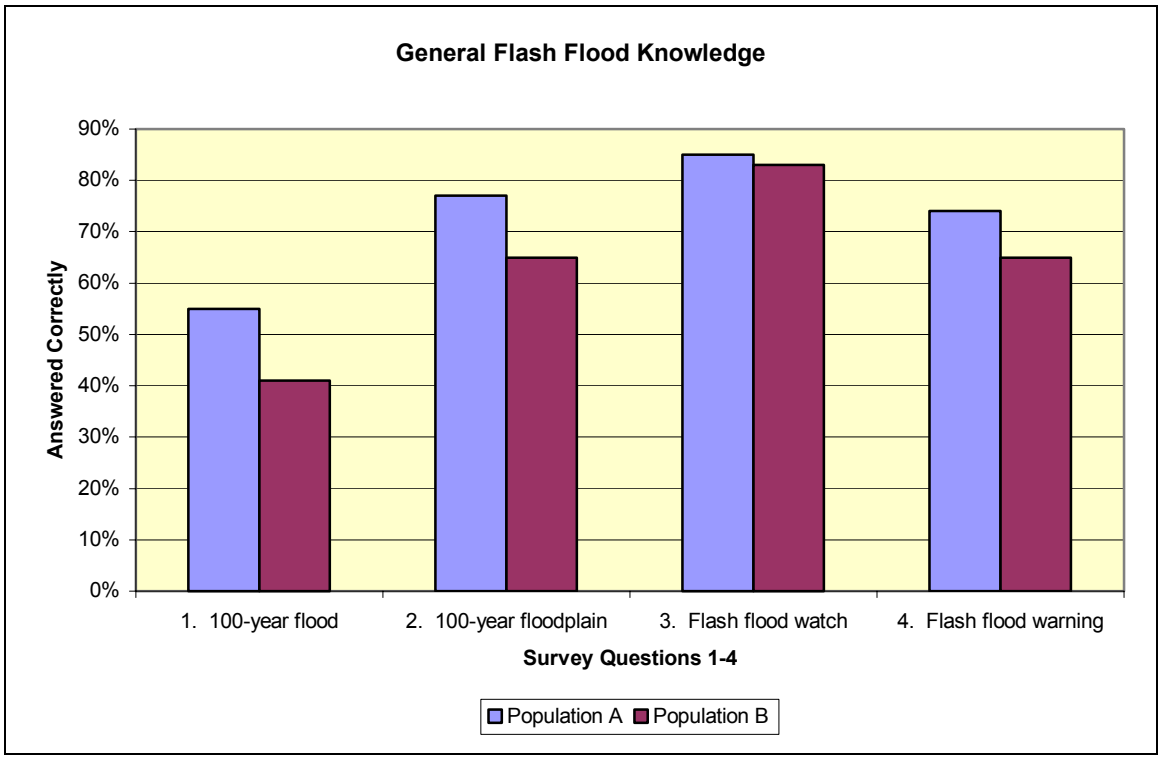
A look at sub-demographics shows that population A residents who have lived in the area under one year chose "yes" less frequently than other groups.

Discussion: The term, "100-year floodplain" needs to be replaced with a term that is more accurate and easier for the public to understand. Population A residents living in the area less than one year scored noticeably lower to this question. They are less likely to know that they live in the Boulder Creek floodplain. Perhaps this is because they had not yet received the UDFCD brochure.

Knowledge and/or Retention of Flash Flood Information
A series of questions asked how much participants knew and/or remembered about flash flood terminology (See Figure 8). Results are based on the number of people per population who correctly answered all four questions. The four questions are

Survey question #1: "What does the term "100 year flood" mean to you?"
Survey question #2: "Is your residence in the 100-year floodplain? "
Survey question #3: "What does a flood watch mean?"
Survey question #4: "What does a flood warning mean?"

Figure 8



Overall, 30% of the participants answered all four of these questions correctly. The following information provides insight as to who does and who does not know the answers to these basic questions regarding flash flood terminology. Respondents with any of these characteristics are most likely to have answered these questions correctly:

1) population A,
2) males,
3) ages 36+, and
4) those living in the area the longest time.

Populations: The percentage of non-housing residents (population A) who answered these questions correctly is higher than CU family housing residents (population B).

Gender: The percent of males who answered these questions correctly is higher than females. There were significantly fewer population B women answering the flash flood watch/warning question correctly.

Age: The percentage of residents aged 36+ who answered these questions correctly is higher than those under 36 for both population A and B.

Tenure: There is a clear correlation between length of residence and basic flash flood knowledge for population A. Correct responses increased progressively from those living in the area less than six months to those living in the area more than four years. Population B residents who have lived in the area less than six months score higher than those living there between six months to three years. Residents living in the area less than six months aside, there a progressively correct response level from less than six months, one-to-three years, and more than four years.

CU Associated: Of the respondents from both populations who are associated with CU the percentage of correct answers from faculty/staff was higher than CU students in their perspective populations. However, population A students scored higher than population B Faculty/Staff.

Discussion: The answers to these four questions have been provided annually in brochure form from UDFCD to population A and from CU Student Family Housing for population B. This measurement may be one way to determine whether participants have received, read, and retained the flash flood information sent to them each year.

Since only 30% correctly answered all of the questions, perhaps UDFCD and CU Student Family Housing might consider alternative methods to their public education measures. This finding should be useful for marketing flash flood information effectively. Many surveys were returned with incorrect addresses. UDFCD should review their database for Boulder County to be sure to account for accurate apartment numbers. We realize that public education is a small part of the UDFCD's mission. With help from Boulder City and County this issue should be closely revisited.

Several designs for updating and redesigning the brochure should be tested. Perhaps the District can adopt a friendly flash flood mascot to interest readers and children. For example, "Ready Freddy" is used by the Bureau of Reclamation in Ventura, CA. "Ready Freddy" is a black lab rescue-dog that wears a "grab and go" backpack. This mascot is used as a non-threatening way to educate residents about preparedness (Carsell 2001).

Figure 9

Ready Freddy

We also recommend that the City/County of Boulder provide information to new residents (perhaps copies of the UDFCD brochure) so that there is no lapse in time from move in until the next UDFCD brochure is mailed. This mailing could be coordinated through the Utilities department and sent to new residents when their utility service is activated. This method is used in Fort Collins, CO and in Orting, WA (Carsell 1998).

Risk Awareness

One question specifically measures the degree to which Boulder Creek floodplain residents viewed their risk to flash flood. The hypothesis was that participants would feel their homes were more at risk than their lives, but that there would still be a high awareness of their personal risk.

Survey question #6: "To what extent do you agree or disagree with the following statements: 'my home is at risk from a flash flood' and 'my life is at risk from a flash flood.' Respondents were to choose between

"strongly agree,"
"agree,"
"neither agree nor disagree,"
"disagree," and
"strongly disagree" for each statement.

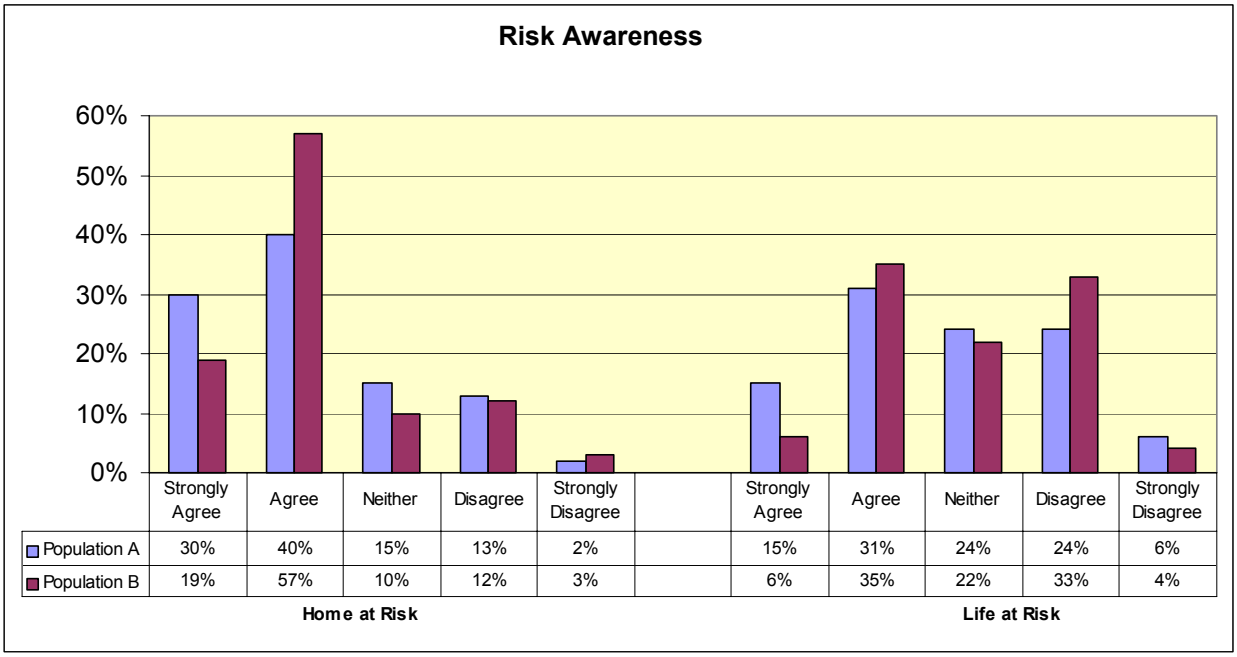
Sub-populations who rate highest for risk awareness were of one or more of the following groups:

a. population A,
6. male for home at risk and female for life at risk,
7. age groups 35+,
8. residents at same address for 4+ years, and
9. CU Faculty (compared to students).

Sub-populations who answered negatively to these questions, and who might need some additional flash flood education were in one or more of the following groups:

1) population B,
2) male (life at risk),
3) age group 18-25,
4) residents at same address for under 6 months (especially for life at risk),
5) those with Bachelor's degrees, and
6) CU Students (compared to faculty).

Figure 10



Population: Both populations either strongly agreed or agreed that their homes were at risk. The category of "agree" that homes were at risk received the most responses with 40% of population A and 57% of population B. Very few respondents "strongly disagree" that their home was at risk, 2% and 3% for populations A and B respectively.

The number of "strongly agree" and "agree" responses were lower when answering "my life is at risk". The agree category receive more responses, 31% for population A and 35% for population B (See Figure 10).

More respondents from population A selected "strongly agree" to homes and life being at risk from a flash flood. Affirmative responses to "home at risk" were higher for population B, 76%, than population A, 70%. Affirmative responses to "life at risk" was under 50%, 46% for population A and 41% for population B. These responses only slightly exceeded negative responses to "life at risk", 30% for population A and 37% for population B.

Gender: More male respondents than female respondents selected "strongly agree" to homes being at risk, while more female respondents selected "strongly agree" to life at risk. Men chose "disagree" to home at risk and "strongly disagree" to life at risk than women did.

Age: Age group 36-55 selected "strongly agree" to both their homes and their lives being at risk much more frequently than did other groups. All in age group 56+ selected "strongly agree" or "agree" to home being at risk, with "strongly agree"

selected more frequently than “agree.” Age group 56+ also selected “strongly agree" often for home at risk. Age group 18-25 is less concerned about home at risk, and strongly disagree that their lives are at risk.

Tenure: Respondents who have lived at their address for 4+ years selected “strongly agree” for both home at risk and life at risk much more frequently than did other groups.

Those living in the area less than 6 months selected “disagree” to home at risk more and “strongly disagree” to life at risk more than other groups. Respondents living in the area 6-11 months chose “strongly disagree” to home being at risk more frequently than other groups.

CU Association: Faculty associated with CU selected “strongly agree” and “agree” to both home at risk and life at risk than CU Students. Students selected “disagree” and “strongly disagree” to life at risk much more frequently than faculty did.

Three additional questions were asked to determine the population’s knowledge of local flash flood risk:

Survey question # 20: “Have you ever seen the sign “Climb to Safety in Case of Flash Floods?”

> 84% of population A and 71% of population B indicated they have seen the Climb to Safety sign.

Survey question # 21: “Have you heard about the “Big Thompson Flood” in Colorado?”

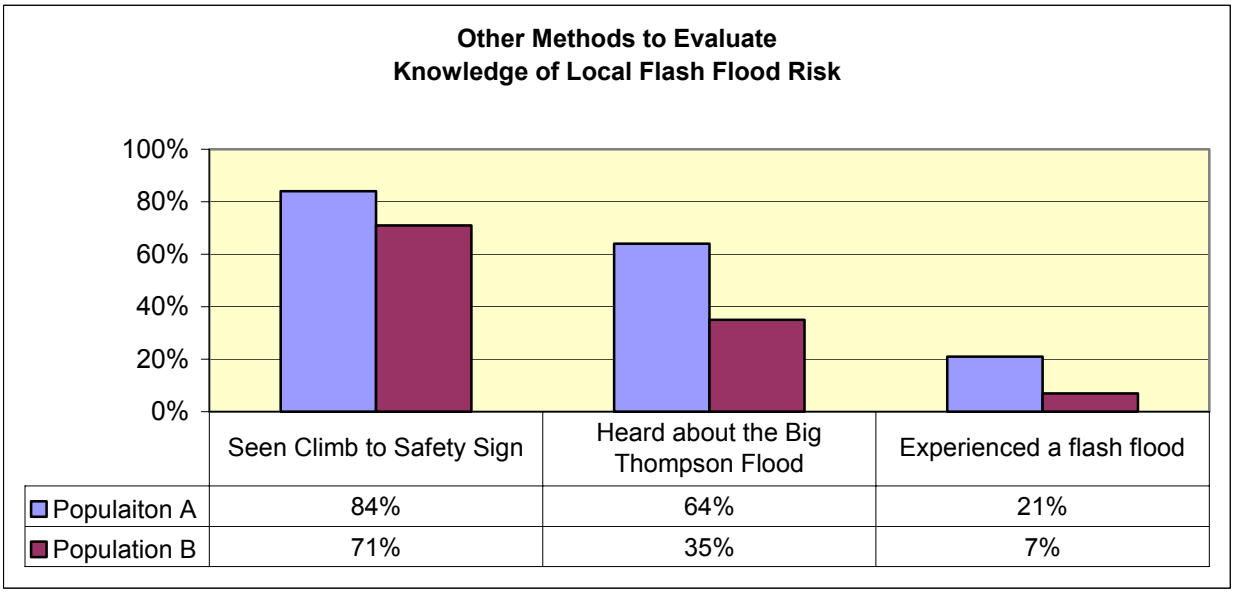
> 64% of population A and 35% of population B indicated they have heard of the Big Thompson Flood.

Survey question #15: “Have you ever experienced a flash flood?”

> 21% of population A and 7% of population B have had previous experience with flash floods.

Population A answered these three questions positively more frequently than did population B, showing that population A has a higher knowledge of the risk (See Figure 11).

Figure 11



Discussion: The strongest correlations to risk awareness of both home and life are those who have lived here 4+ years and those 35+.

We recommend more education to CU students. Population B feels more secure about both home and life than population A. Population B might not realize that a flash flood could be life threatening. In addition, we recommend a strategy to inform the younger population (18-25), as well as new Boulder residents, that lives could be in jeopardy during a flash flood.

Interesting findings that we don't yet understand: 1) Men are more concerned than women about their home being at risk. 2) Those with the least and those with the most education are the most concerned. Perhaps this is not due to education as much as other factors. However, there is a group of residents with some high school education who are feeling vulnerable to flash floods.

Ownership of Risk

Several questions were included in the survey in order to evaluate whether Boulder floodplain residents are taking appropriate steps to mitigate their risk to flash floods. Mileti and Fitzpatrick (1992) found that people who seek additional information about the hazards are taking ownership of the risks. Other factors that equate to ownership of risk are talking to neighbors about flash flooding, purchasing flood insurance, developing a family emergency plan, and making structural changes to property.

Survey question #9: "Have you ever looked for additional information (other than what has been sent to your home) about flooding?"

Only 16% of population A and 12% of population B indicated they had looked for additional information.

Survey question #13b (population A only): "Do you have flood insurance now?"

Only 27 of 47 (57%) homeowners indicated they did currently have flood insurance.

Survey question #14B (population B only): "Do you have renter's insurance?"

Twenty-eight percent (28%) indicate they do have renter's insurance. We did not specifically ask if they had flood insurance; however, the number must be substantially lower.

Survey question #14A (population A only): "Have you made any changes to your home to prepare for a flash flood?"

Only 8 of 47 (17%) homeowners indicated that they have made changes to their homes.

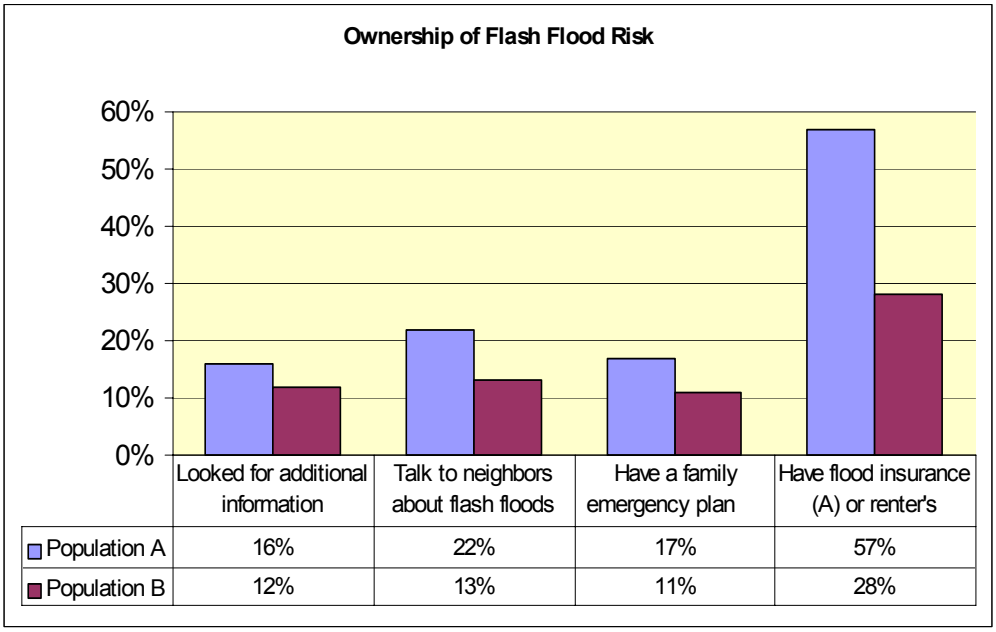
Survey question #16: "Do you have a family emergency plan for flash floods such as you might have developed for fire safety?"

Seventeen (17%) of population A and 11% of population B indicated they did have a family emergency plan.

Survey question #22: "Have you had discussions with your neighbors about the threat of flash flooding?"

Respondents answering "yes" totaled 22% for population A and 13% for population B.

Figure 12



Discussion: Population A respondents selected positive answers more frequently than population B respondents (See Figure 12).

Once again, are these numbers encouraging or discouraging? We would expect that a population that has received many sources of public education, and one in which 70% knows they live in a 100-year floodplain would have answered these questions more correctly than they did.

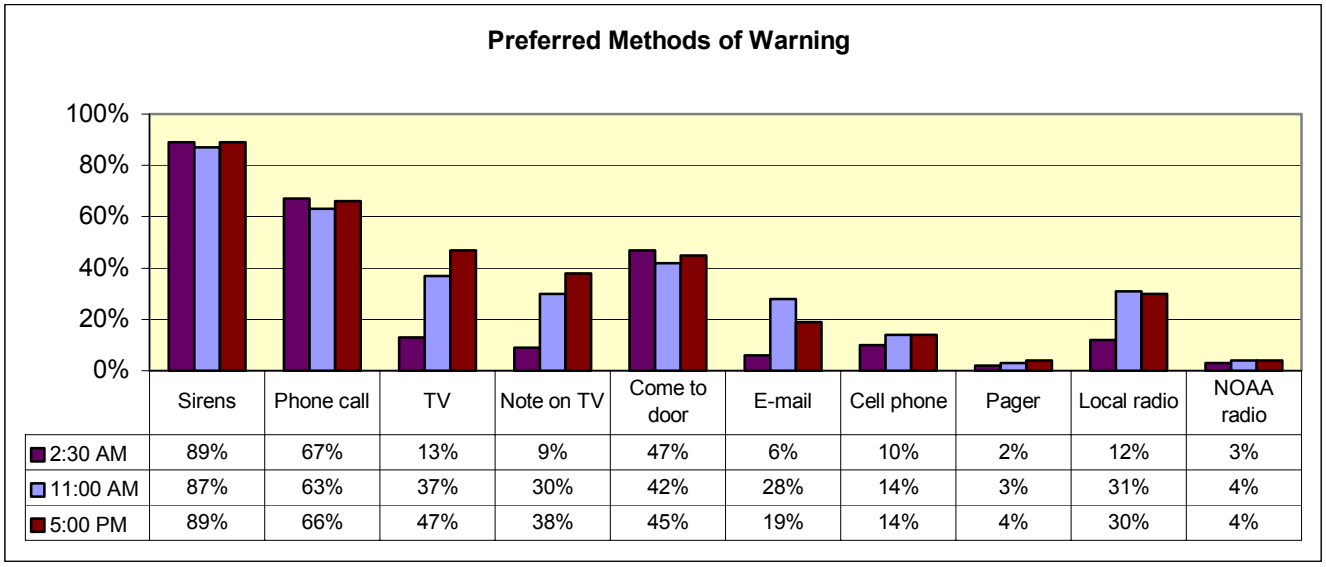
How to Warn about Imminent Flash Flooding

Survey question #17: "What would be the best way to contact you at the following time (2:30 am, 11:00 am, 5:00 pm). Respondents could choose multiple answers, thus totals do not equal 100%. (See Figure 13)

89% of respondents selected "sirens" for 2:30 am and 5:00 pm
87% of respondents selected "sirens" for 11:00 am
Respondents selected "call me" 67%, 63%, and 66%, respectively
Respondents selected "come to my door" 47%, 42%, and 45%, respectively

Sirens and phone calls are preferred over other warning methods at all times. Respondents accounted for the different times in their answers to these questions: few chose television, radio, and e-mail at 2:30 am. Many respondents indicated they would like personal knocks on the door. Requests for notification via e-mail during daylight hours were surprisingly high and by pager almost non-existent.

Figure 13



	Sirens	Phone call	TV	Note on TV	Come to door	E-mail	Cell phone	Pager	Local radio	NOAA radio
2:30 AM	89%	67%	13%	9%	47%	6%	10%	2%	12%	3%
11:00 AM	87%	63%	37%	30%	42%	28%	14%	3%	31%	4%
5:00 PM	89%	66%	47%	38%	45%	19%	14%	4%	30%	4%

Population Preferences: Population A relies more on local radio and NOAA radio than population B. Population B relies more on sirens, phone calls, and someone coming to their door than Population A does.

Survey question # 31: "Prior to this survey, did you know Boulder has a warning siren along Boulder Creek to warn about emergencies including flash flooding?"

69% of population A and 75% of population B knew the siren system existed.

Survey question # 33: "Prior to this survey, did you know Boulder has an automated emergency call system that will call your home in the event of a neighborhood emergency such as a flash flood?"

39% of population A respondents and 22% of population B respondents knew about the automated emergency call system.

Discussion: Some emergency managers choose not to use siren systems to warn the public. We found 89% of the respondents responded that they want to be warned by sirens. Also, the majority of respondents know about the siren system. A telephone call was the second most frequently selected response. Not many respondents knew about the existence of the automated call system. Respondents ranked having someone come to their door as the third out of the possible answers. Do residents *expect* this type of warning? How realistic is a personal contact as a warning?

Warnings via e-mail, cell phones, and pagers are not currently a part of the Boulder warning plan. Perhaps the Boulder City/County Office of Emergency Management could use this finding to decide future warning communication sources. Most people do have email access but very few have pagers.

Overwarning vs. Underwarning

Several survey questions were written to learn how the public perceives warnings, whether they want more warnings or fewer warnings.

Survey question #18: "Realizing it is difficult to accurately predict flash floods, which would you prefer?" "More warning with the possibility of false alarms" "Fewer warnings with the possibility of missing an event"

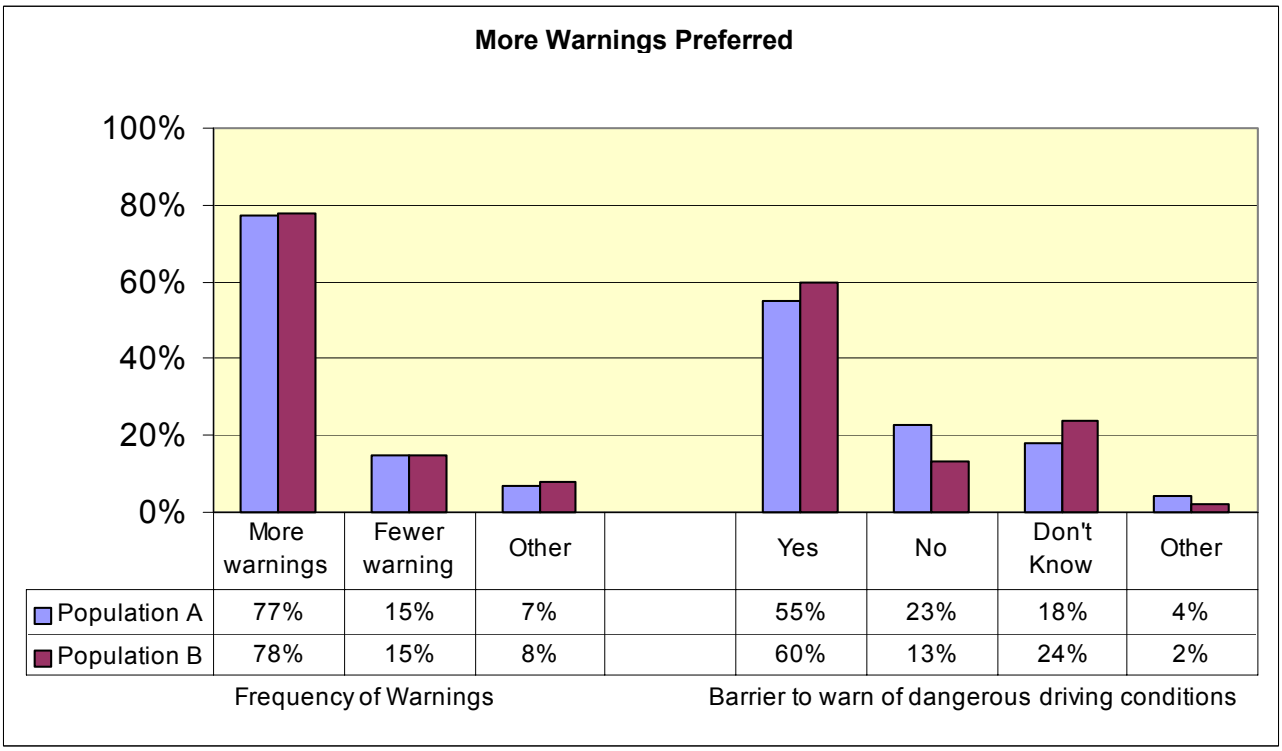
77% of population A and 78% of population B selected more warnings.

Survey question #28: "Would it be helpful to have an automatic road barrier at the intersection of Broadway and Canyon (like at a railroad crossing) to warn about dangerous driving conditions due to flash flooding?"

55% of population A and 60% of population B selected yes.

23% of population A and 13% of population B selected no.

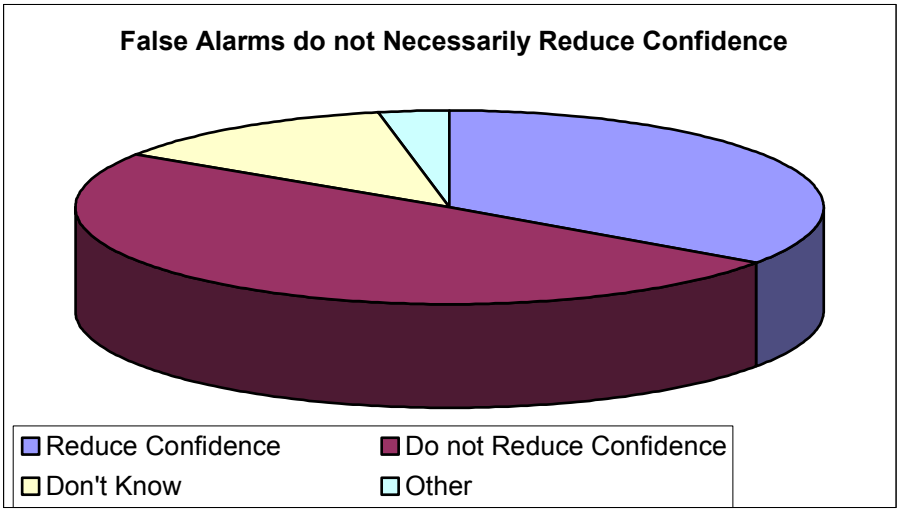
Figure 14



Survey question #19: "Do you think 1 or 2 false alarms for flash flooding would reduce your confidence in future warnings?"

53% of population A and 46%of population B indicated that 1 or 2 false alarms *would not reduce* their confidence in future warnings.

Figure 15



Discussion: Conventional wisdom of false alarms indicates that "crying wolf" will lead people not to believe future warnings. Research suggests that this is not necessarily true (Carsell 2001, Gruntfest and Carsell, 2000; Dow and Cutter, 1998). Likewise, if the population-at-risk is faced with receiving a warning or not receiving a warning on a borderline situation, they prefer to be warned with the possibility of a false alarm than not warned. If the population-at-risk is overwarned, we, along with other social scientists (Mileti and Peck 2000) suggest that by explaining the situation and the difficulty of warning, the population will understand. Furthermore, studies show that false alarms or overwarnings can be a learning opportunity (Carsell 2001; Gruntfest and Carsell 2001; Mileti and Peck 2000; Breznitz, 1984).

Potential Response in Flash Flood Event

Five scenario-based questions were asked to develop an understanding of how much residents know about taking appropriate actions in the event of a flash flood.

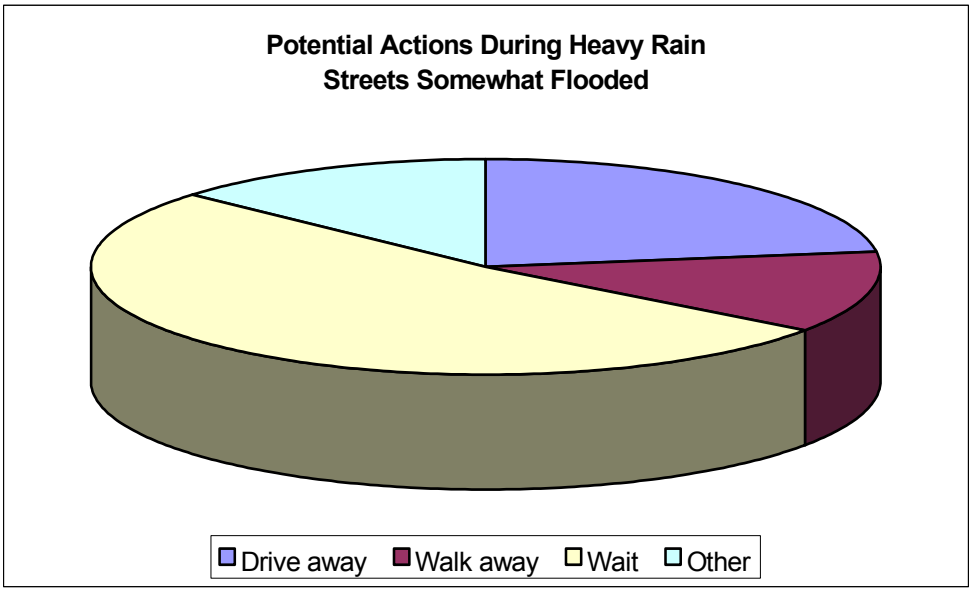
Survey question #23: "You are at the Boulder Public Library and hear the sirens saying that flash flooding is imminent, what do you do?"

Respondents selected "seek information from library staff" most frequently, "go to top floor" second, and "leave immediately and walk away" third most frequently (See Boulder Public Library Section VI).

Survey question #24: "You are at work and it is quitting time. It is raining hard and you see the streets are somewhat flooded, what do you do?"

The majority of respondents (55%) indicated they would wait until conditions improved. Nearly ¼ of respondents (24%) indicated they would leave and drive away.

Figure 16



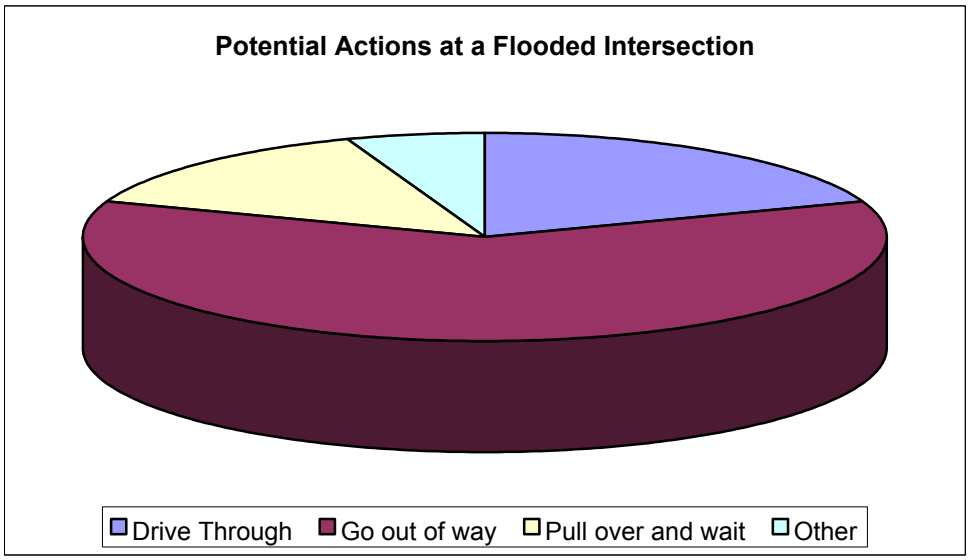
Survey question #25: "You have a child at Boulder High School (population A) / CU Family Housing Children's Center (population B) and you think a flash flood is going to occur, what do you do?"

Respondents selected "call the school", "assume the school has a plan", and "go pick up child" most frequently. Closer inspection of those who actually have students Boulder High show that none of Boulder High parents chose to go pick their student (See Boulder High School and CU Family Housing Children's Center in Section VI).

Survey question #27: "You are driving and come to an intersection covered in water up to the middle of your tires, what do you do?

66% of the population selected the option "go 5 minutes out of the way"
21% selected "drive through"
15% selected "pull over and wait for conditions to improve
Population A selected "pull over and wait" more than population B
Population B selected "go 5 minutes out of way" more than population A

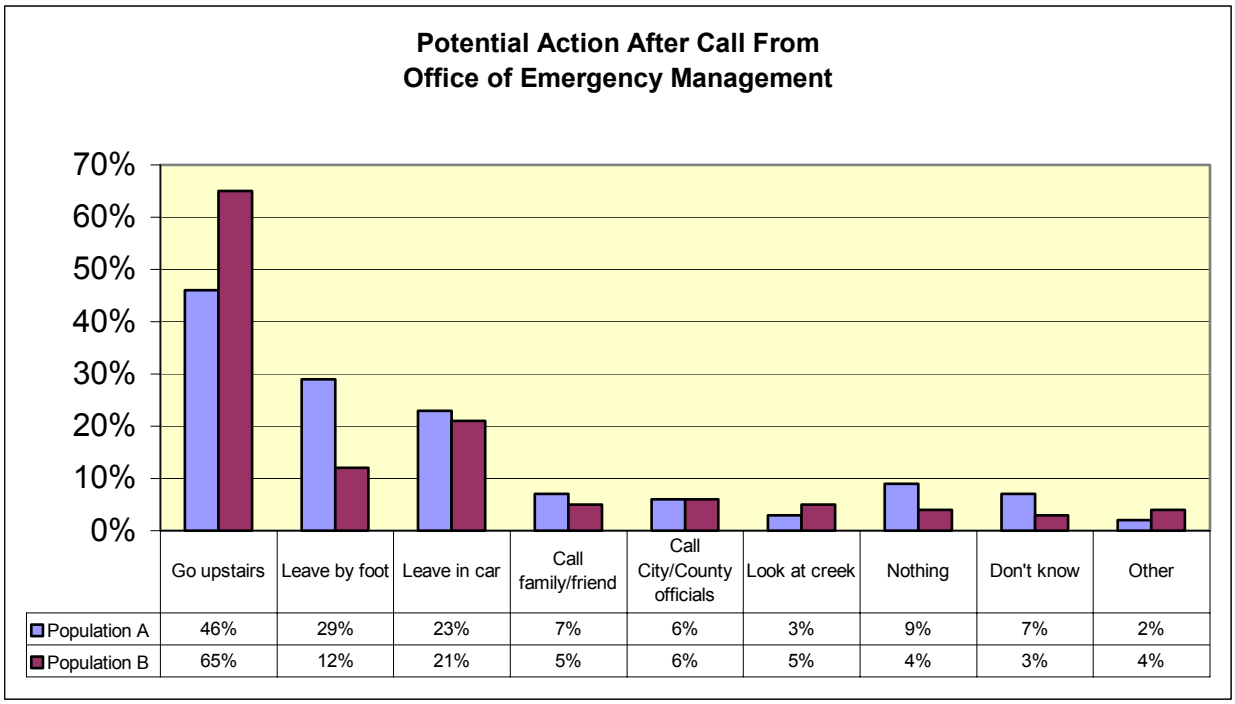
Figure 17



Survey question #29 "If you received a call from the Boulder City/County Office of Emergency Management that told you flash flooding is imminent and to 'get 10 feet higher than you are now' what would you do?" Respondents could choose more than one answer.

Top three choices were "go upstairs in home/to a higher apartment", "leave and travel by foot", and to leave and travel by car".

Figure 18



	Go upstairs	Leave by foot	Leave in car	Call family/friend	Call City/County officials	Look at creek	Nothing	Don't know	Other
Population A	46%	29%	23%	7%	6%	3%	9%	7%	2%
Population B	65%	12%	21%	5%	6%	5%	4%	3%	4%

Discussion: The majority of respondents selected appropriate actions to the five scenarios. These actions may save lives. This shows that most of Boulder's population-at-risk knows what to do and is willing to do it. A high number of respondents indicated they would drive away from the situation. Over 50% of flash flood deaths occur while driving. The question remains, how do we get people out of their cars? These figures give emergency officials some understanding of what behaviors to expect from Boulder Creek floodplain residents.

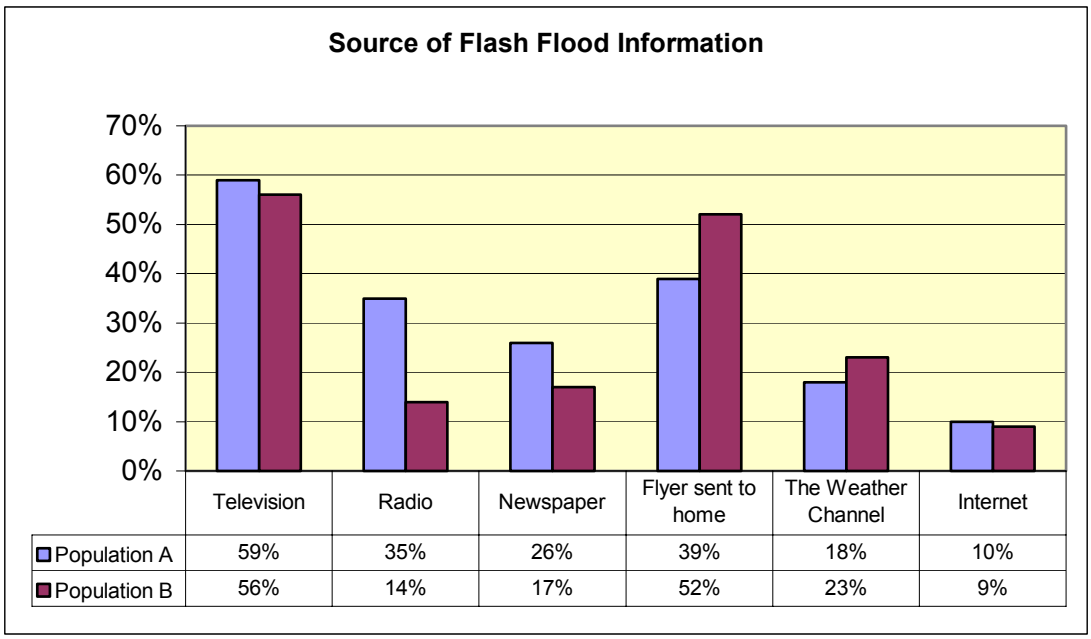
Weather and Flash Flood Information

Survey question #8: "From where have you obtained information about flash floods?"

Respondents from population A selected "television", "flyer sent to home", and "radio" 59%, 39%, 35%, respectively. Respondents could select more than one answer, so answers exceed 100%.

Respondents from population B selected "television", "flyer sent to home", and "The Weather Channel", 56%, 52%, 23%, respectively.

Figure 19



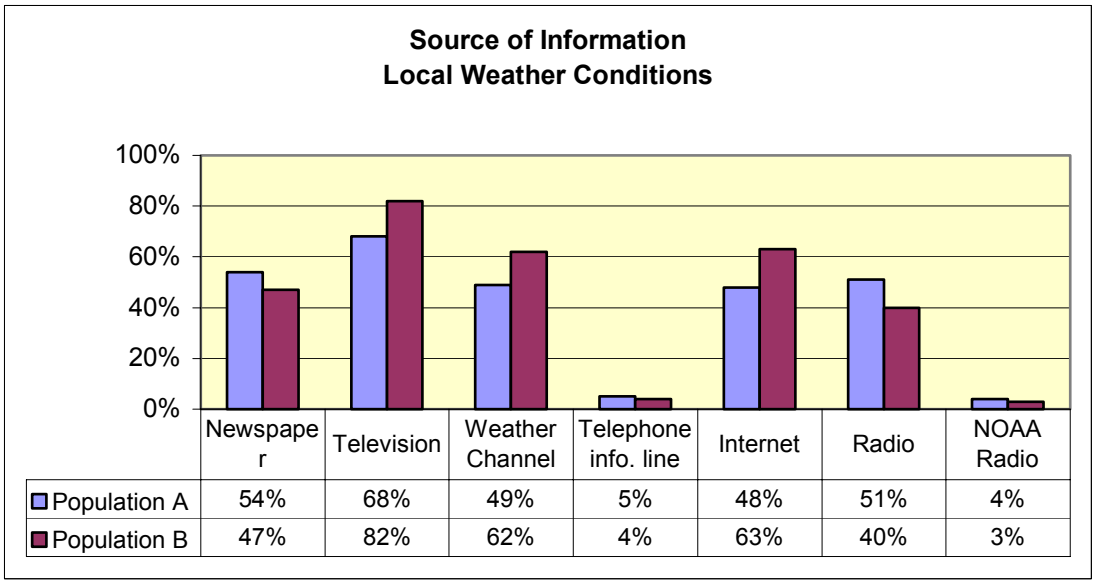
	Television	Radio	Newspaper	Flyer sent to home	The Weather Channel	Internet
Population A	59%	35%	26%	39%	18%	10%
Population B	56%	14%	17%	52%	23%	9%

Survey question #10: "Where do you look for local weather conditions?"

Respondents selected "television", "The Weather Channel", and "Internet" as the top thee sources.

Selection of "telephone information line" and "NOAA weather radio" were low.

Figure 20



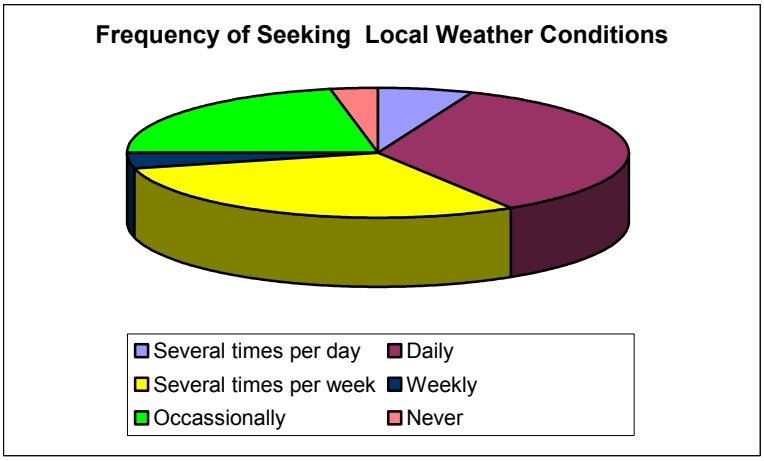
	Newspaper	Television	Weather Channel	Telephone info. line	Internet	Radio	NOAA Radio
Population A	54%	68%	49%	5%	48%	51%	4%
Population B	47%	82%	62%	4%	63%	40%	3%

Survey question #11: "How often do you look for local weather forecasts?"

Respondents selected "daily", "several times per day", and "occasionally", 35%, 30%, and 22%, respectively.

Options "several times per day", "weekly", and "never" were lowest, 6%, 4%, and 3%, respectively (See Figure 21).

Figure 21



Survey question #41: Do you use the Internet to check for weather information?"

71% of population A and 57% of population B indicated they did use the Internet to check for weather information.

Discussion: The Internet has become an important source of weather information, particularly for people in Boulder. More people in population B and an almost equal amount in population A rely on the Internet for weather information more than they do on radio or, in the case of population B, the newspaper. Respondents seem to check weather conditions either daily or more than once per week. Their sources of information regarding flash floods have predominantly been the television or flyers sent to their home. This can help determine what resources should be used to disseminate flash flood information. For example, since so many people use the Internet to check weather forecasts, these resources should be exploited for local flash flood information.

Communication Technologies

This information was included to provide an overview of the types of communication systems the Boulder Creek floodplain residents have.

Survey question #33: "How many telephone lines are at this address?" (not including cell phones)

91% of respondents have one phone line
4% do not have a telephone (all in population A)
5% have more than one phone line

Survey question #35: "How many people at this address have a cell phone?"

55% did not have a cell phone
35% indicated one person had a cell phone
10% indicated more than one person had a cell phone

Survey question #37: "How many people at this address have a pager?"

98% of respondent do not have a pager

Survey question # 39: "Is there currently cable or satellite service at your address?"

79% of respondents indicated they have cable

Survey question #40: "Is there Internet access at this residence?"

71% of population A indicated they had Internet access
97% of population B indicated they had Internet access

Discussion: Home telephones, Internet, and cable television are the most common types of communication services for Boulder Creek floodplain residents. Approximately 1/3 have a cell phones and few have pagers. This finding can help identify how best to contact the population-at-risk.

Other Noteworthy Findings

Survey question #5: "Do you pay attention to environmental factors that may indicate a flash flood?"

70% of population A and 68% of population B indicate they do pay attention to environmental conditions.

Survey question #15: "Have you ever experienced a flash flood?"

21% of population A and 7% of population B said they had experienced a flash flood; however, close examination showed that this experience did not necessarily mean that they scored correctly on questions 1-4.

Survey question #30: "Would your pet(s) delay evacuation or cause you not to evacuate your home?"

26% of population A and 4% of population B selected "yes". The majority of those selecting "yes" were women.

Survey question #43: "Do you have a radio that has NOAA weather ability?"

Only 5% of population A and 4% of population B indicated they do have a NOAA radio. Of those, all but 3 respondents had their radio plugged in.

Survey question #48: "Does everyone at your residence speak English?"

96% of population A and 93% of population B selected "yes".

Survey question 60: "Is there anyone at this address who would have trouble hearing or comprehending a flood warning?

10% of population A and 17% of population B selected "yes".

SECTION VI: NON-RESIDENTIAL FLOODPLAIN OCCUPANTS

METHODOLOGY

Occupants selected for inclusion in this part of our study include several businesses and organizations in the Boulder Creek floodplain. These consist of Boulder High School, Boulder Public Library, Millennium Harvest House Hotel, Naropa University, CU Student Family Housing, and CU Family Housing Children's Center.

BOULDER HIGH SCHOOL

1604 Arapahoe. Interviews with Bob Martin, Assistant Principal and Dale Hobbs, Boulder Valley School District

Notification: Boulder HS has a Plectron box that will issue an alarm and message in the event of an emergency. The alarm is issued by the Boulder Communication Center and can be used for a variety of hazards such as tornado, wildfire, and chemical spills. All schools in the Boulder School District have a Plectron box, but Boulder HS is the only school within a floodplain. The school district security office also has a Plectron box and monitors it at all times, so they contact the high school as well. At least one person at the school district has a pager issued by the Boulder OEM. This person receives all messages regarding flash flood modes and will contact the high school as needed.

Emergency Plans: The school has developed a "shelter in place" strategy, meaning that all students and staff will stay within the school building but will relocate to the second and third floors. When the flash flood mode 3 message (flash flooding is probable) is issued, all students will be sent to the higher floors. Each section of the school (language, arts, auditorium, gym and weight room, cafeteria, library, science/art wing, and band) has a corresponding location where students will relocate on the upper floors. For example, students in the library will relocate to the second level social studies area. Each teacher is responsible for the students in the class and is expected to talk in advance with any handicapped students that may need help.

Teachers with classes on the second and third floors are to assist students arriving from the first floor. Several staff members are assigned to a "station" which they report to immediately. Prior to relocation on the top floors, all teachers who do not have a class report to the office and are assigned an area to monitor. All exits from the building will be monitored in order to discourage and advise students not to leave the building. A record of any students who does leave the building will be kept to inform their parents if necessary.

Once everyone is safely on the top floors, attendance will be taken and compared to the attendance record for the day to account for all students. All administrative staff have portable radios to stay in contact with each other. The school has five

telephone lines, and several phones on the top floors from which they can answer incoming or make outgoing calls.

After the flood, and when it is safe, the students will be relocated to another school building. The location of that building will be determined based on variables that cannot be predicted in advance. School busses will be used to transport the students and arrangements have been made with the Boulder OEM.

Preparedness: The school practices a flash flood drill once per year, usually in April or May. Emergency Flood Plans are posted in each classroom and are also available in the administrative offices. Boulder HS has received extensive landscaping work aimed at directing floodwaters from the school. The new engineering efforts should allow the school building to withstand the impacts of a flood.

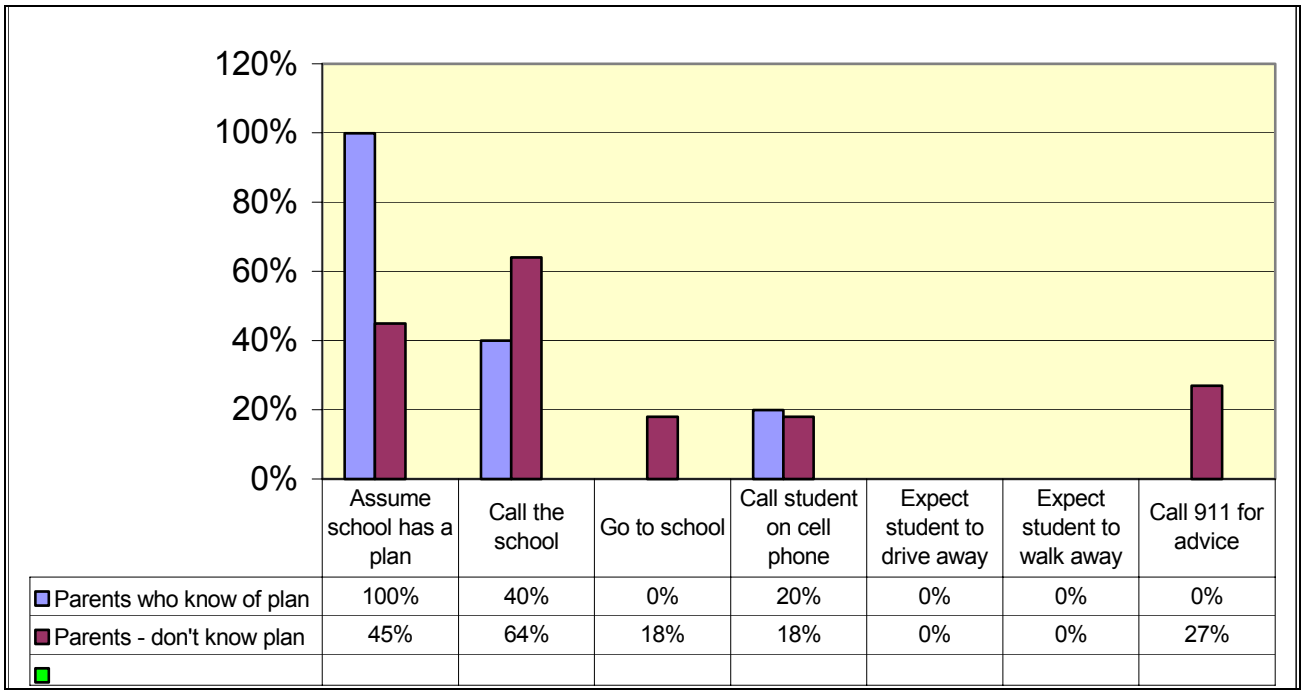
Survey data: Survey question 25 specifically addressed what actions Boulder HS parents would take in the event of a flash flood warning (population A respondents only). Sixteen (16) respondents indicated they did have a student at Boulder HS. Of the 16, five (31%) indicated that their student would know what to do. A closer look at the demographics of these five respondents showed that all five had lived in Boulder four or more years and were in the age group 26-55. All five had previous knowledge of the flood warning system and 4 of the 5 (80%) agreed that their property and lives were at risk from a flash flood.

This question also asked what actions respondents would take regarding students if they thought a flash flood was imminent. Respondents could select multiple answers from the following options: Assume the school has a plan, Call the school, Go pick up child, Call child on cell phone, Expect child to drive to safety on own, Call 911 for advice. We compared responses from parents who knew about the plan, parents who did not know of the plan, and responses from all of population A (See Figure 22).

Recommendations: Hazard researchers are concerned that parents will attempt to pick up their children during a flash flood event or that the high school students will elect (aside from staff recommendations) to evacuate the school and either try to drive or walk out of the inundation zone. Any of these scenarios could result in higher loss of life and/or higher need for rescue personnel to reach parents/student in cars or on foot when the floodwaters inundate the area. An attempt should be made to educate both students and parents about the “shelter in place” strategy and the reasons why this strategy has been chosen. This data shows that parents whose student knows of the school’s flash flood plans *did not choose* the incorrect answer of going to the school to get their students. Perhaps if parents are pre-educated and not caught totally unawares, they will be more likely to take the appropriate actions. Also, a press release should be developed in advance urging parents <u>not</u> to attempt to reach their children. This would allow the Boulder Valley School District to immediately get the correct information to the media who could in

turn inform parents and guardians of Boulder High School students. The school might also consider accumulating emergency supplies such as water, blankets, flashlights, candles, etc. on the 2nd and 3rd floor (see CU Student Family Housing).

Figure 22



	Assume school has a plan	Call the school	Go to school	Call student on cell phone	Expect student to drive away	Expect student to walk away	Call 911 for advice
Parents who know of plan	100%	40%	0%	20%	0%	0%	0%
Parents - don't know plan	45%	64%	18%	18%	0%	0%	27%

BOULDER PUBLIC LIBRARY DISTRICT
100 Canyon Boulevard. Interview with Sam Hartman, Research Associate

Notification: Notification of possible flood threat to the Boulder Public Library will be disseminated via, pager, e-mail, and the automated dialer system.

Pagers are issued to the reference desk at each of the library branches. The Boulder City/County Office of Emergency Management issues pages. The city's communications department will send e-mail notification to all city employees once the communications department has received pertinent information. Notification via the automated dialer (911 callback system) has not been tested at the library location, but the library anticipates receiving any calls that are sent.

Historically, the library had several NOAA weather radios. Most of these have been taken out of the library as they report conditions outside of Boulder. If the NWS issued alerts, watches, and warnings for Boulder County only, the library would reinvest in these radios. At least one NOAA weather radio remains at the library, with the alarm off.

Emergency Plans: The library has two different sets of actions outlined for flash flood modes 2 and 3 – one for weekdays and one for evenings and weekends.

During mode 2 (flash flooding possible), the north building and bridge are closed to the public. All staff and patrons move to the south building. Volunteers and special needs staff go home. A public address announcement is made and patrons are asked, but not required to leave the library. With the activation of mode 3 (flash flooding probable), a public address will be made to patrons announcing an immediate evacuation to the CU Recreation Center at 20th and Baseline. Patrons are told not to cross the creek or to go to cars in the parking lot. During evenings and weekends, because the library has less staff available, the closing of the library occurs more rapidly, during mode 2 instead of mode 3.

Preparedness: The library district participates in a yearly countywide flash flood drill organized by the Boulder City/County OEM. Participation is limited to library staff. The staff has developed several tools to assist them in responding quickly and correctly in an emergency situation. One tool is a small file box containing categorized index cards. A series of detailed index cards lists all responsibilities related to hazardous meteorological conditions such as flash floods and tornadoes. Sections for flash flood modes 1, 2, and 3 are included. Another tool is a script book with pre-written text in the event that a verbal or written announcement needs to be made. These two tools are kept together on a shelf in the administration offices.

In addition to the flash flood box, library staff has developed a one-page list of primary actions to be taken in a flash flood situation. This has been developed because of the realization that the index cards in the flash flood box may contain too much information. This quick list of actions is location dependent for the different branches of the library. The text is displayed on bright green paper, is well categorized, and is posted in key areas in the library such as in administration, reference, and circulation.

In an effort to reach parents of children frequenting the children's library, the library has a flood emergency handout discussing what procedures the library would take in a flash flood emergency.

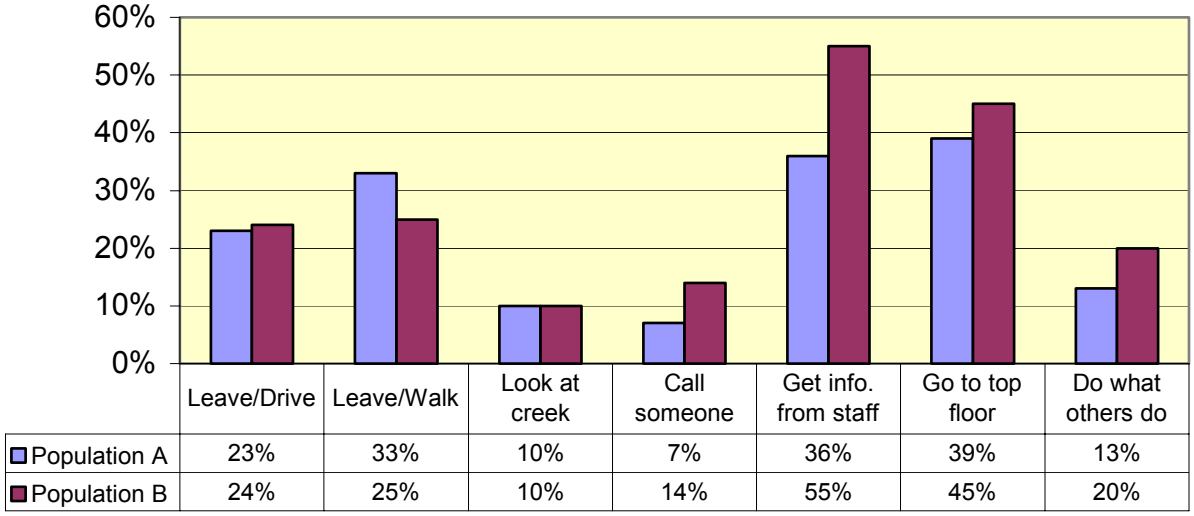
Survey data: Survey question 23 specifically addressed perceived response while at the library.
Q. You are at the Boulder Public Library and hear the sirens saying that flash flooding is imminent, what do you do? (Respondents could check multiple answers):

- Leave immediately and drive away
- Leave immediately and walk away
- Go look at the creek
- Call someone
- Seek information from the library staff
- Go to top floor
- Do what others are doing

Twenty-four percent (24%) of the answers were “leave immediately and drive away,” which is a dangerous action to take, especially since the parking lot is one of the areas directly in the floodplain and since a few extra minutes to get into a car could make the difference between life and death.

The most selected option in response to this question was “seek information from the library staff” and “go to top floor” (see Figure 23). Population B selected these two choices more frequently than did Population A. Population A indicated “leave and walk” more than population B respondents.

Figure 23



	Leave/Drive	Leave/Walk	Look at creek	Call someone	Get info. from staff	Go to top floor	Do what others do
Population A	23%	33%	10%	7%	36%	39%	13%
Population B	24%	25%	10%	14%	55%	45%	20%

Recommendations: We commend the library staff for their vigilance in making and updating flash flood plans. Our only immediate recommendation would be to consider monitoring stream gauge activity for Boulder Creek during flash flood season. This may help certain staff members who are nervous about receiving warning information via the methods outlined above. Boulder Creek stream gauge activity can be monitored via the UDFCD’s Internet site at (http://www.udfcd.org/FWP/alert.htm). Also, it is clear that library patrons will look to library staff during a flash flood event, so it is important to keep all staff up-to-date on emergency plans.

MILLENNIUM HARVEST HOUSE HOTEL
1345 28th Street. Interview with Randy Heizarman, Engineering

Notification: In the event of a flash flood situation, the Millennium Hotel has an emergency radio located by the PBX operator. When a flash flood warning is issued on the Plectron box the operator broadcasts a message to all staff via two-way radio. There are at least three engineers with radios at any given time. Other staff with radios includes housekeeping and banquet offices. The emergency sirens can be heard in many areas of the hotel, and will serve as a backup warning to the emergency radio. In addition, hotel staff keeps a close watch on Boulder Creek when the creek is running at a high level.

Emergency Plan: The hotel has an emergency plan written for flash floods. The plan shows areas of the hotel that need to be evacuated to higher floors in the building. Specifically, all first floor guests and staff are immediately evacuated to the second floors, especially those located in the South Wing. The hotel owns three cabins that are located along the south side of Boulder Creek. These cabins are close to the creek and the emergency plan for the employees in the cabins is to evacuate to higher ground at the University. They are told not to cross the creek to reach the main hotel. The hotel closes access to the fish observatory near the hotel when the water begins to run near the top of the observatory wall.

Preparedness: Employees are given information about emergency plans. The information contains procedures to take during a flood as well as what not to do. For example, the information packet discusses the dangers of driving in water, and that travel to the south of the hotel property would be likely be blocked by Boulder Creek and that travel to the north of the hotel would likely be blocked by other flooding creeks. Periodically the engineering depart reviews flash flood plans. There are a few earthen berms around the hotel property built to divert the flow of water.

Recommendations: We recommend that a representative from the Millennium Hotel participate in the Annual Flash Flood Exercise. At the time of this research, there was question as to whether or not the Plectron box was still located near the PBX operator and if it was functioning correctly. Participation in the annual exercise would reacquaint Millennium staff with flash flood procedures and perhaps could serve as a test of the Plectron box. We also suggest the Millennium consider a simple display at the front desk informing guests of weather conditions and/or any NWS issued watches/warnings/advisories.

NAROPA UNIVERSITY
2130 Arapahoe. Interviews with Amy Wayne, Human Resource Director and Lisa Richie, Facilities Management

Notification: Naropa depends on a variety of options to be notified of flash flood activity. They can hear the emergency sirens in most of the buildings and they look to the media, local television and radio, for additional information. They have learned to pay close attention to the weather and activity of Boulder Creek.

Emergency Plans: Once a flash flood watch has been issued, the staff is on alert. They can send out e-mail messages and broadcast phone messages to all Naropa staff. In the event of a flash flood warning, Facilities is responsible to notify the staff immediately. All students and staff proceed to the 2nd floor of the Old Lincoln building or to the new Nelanda Hall building.

Preparedness: Once per year Facilities sends a message reviewing the emergency plans. This message is send via e-mail and is also included in a newsletter.

Recommendations: We urge Naropa University to educate their students about the potential dangers of flash floods. We also suggest collecting emergency supplies such as water, blankets, flashlights, and candles, and storing them on the 2nd floor to use in the event of a flash flood.

CU STUDENT FAMILY HOUSING
Athens, Newton, Marine, Smiley Courts, Faculty and Staff Apartments
Interviews with Tom Carney and Ricky Martinez

Notification: CU Emergency Manager notifies Family Housing staff by e-mail during modes 1, 2, and by phone during Mode 2 and Mode 3. Residents will be notified by sirens and by the reverse call system during Mode 3. The reverse call system dials into one University number and the University switchboard sends the call out to all residents. Since there is a high contingency of foreign languages at the Family Housing facilities, the University switchboard will eventually have the ability to send flood messages in the native language of each resident.

Emergency Plans: CU Family Housing has adopted a shelter-in-place strategy in the event of a flash flood on Boulder Creek. Shelter points are located in specified areas on the second and third floor apartments. Resident Managers (RM) will work with housing office staff during a flash flood and have designated responsibilities.

During Flash Flood Modes 1 and 2, the office staff communicates with the children's center, College Inn, and RMs. When Mode 2 is reached, RMs are called in. RMs open shelter points, ensure all equipment is accessible, and begin to notify residents of increased awareness. RMs have pagers to receive messages from Housing

Staff. During Mode 3, RMs direct residents to the shelter locations (second and third floors). If there is enough time, RMs will go door-to-door. Maintenance staff and Hall Directors will assist in notifying residents. RMs have master keys to the apartments and the flood boxes.

Staff operations move to shelter points when Mode 3 is activated. A pre-recorded emergency message will be placed on the switchboard. Both RMs and staff will have lists of residents with them at the shelter points so that residents can be tracked. Staff will have access to regular phone lines, cell phone, pagers, and maintenance staff radios.

Preparedness: All Family Housing staff and RMs are trained and participate in a flash flood drill at the beginning of the flood season (during the county-wide drill if possible.) Lists of responsibilities are given to staff and RMs, and are kept in a secure location.

An informative flash flood brochure is distributed to residents each year. The brochure addresses the location of shelter points and what to do (and not to do) during a flash flood. During the past, Family Housing has also placed information regarding flash floods in their monthly newsletter.

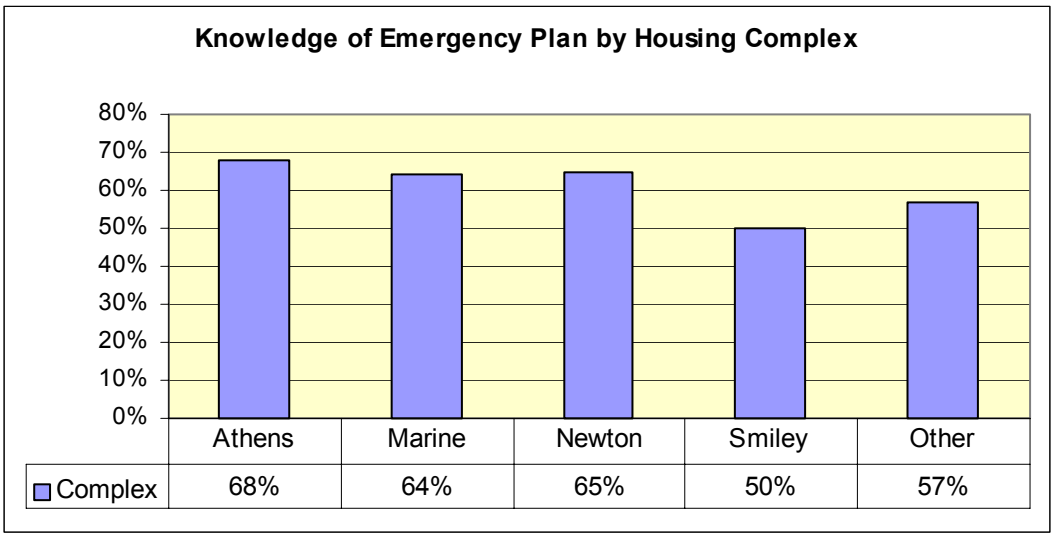
Large plastic flood boxes have been prepared and are kept at shelter points. These flood boxes are restocked at the beginning of flood season and contain the following supplies.

- Water – three day supply per person,
- Ready to eat canned meats, fruits, vegetables, juices,
- Can opener, knife, pliers, flashlight, paper and pencil
- Toilet paper, paper towels, and plastic garbage bags, diapers, soap,
- First aid kit, two rain ponchos, clipboard with a form to list who is at that site
- List of RM responsibilities, emergency preparedness instructions.

Survey data: Sixty-one (61%) of Population B respondents indicated that they knew CU Family Housing had an emergency plan in place. More women (59%) than men (41%) selected “yes” to this question. The majority of responses came from those aged 26-35 and those that had lived at their residence 1-3 years.

There is no real correlation between knowledge of an emergency plan and family housing complex. Except, that residents in Smiley Court selected “yes” less frequently (See Figure 24).

Figure 24



CU FAMILY HOUSING CHILDREN'S CENTER
Smiley and Newton Locations, Interview with Luli Bevis, Director

The CU Family Housing Children's Center has two locations within the Family Housing property, Newton and Smiley. Although the Newton location has a higher chance of involvement in a flash flood, both locations have prepared and practice an evacuation plan.

Notification: The children's center will be notified by several different sources if flash flood conditions warrant notification. The CU Police Department notifies them by phone, the Family Housing offices notify them, and they can hear the sirens. During the 2001 season, CU Police notified them several days that flash flooding was possible. Several of those calls were made early on sunny days, but the center knows that conditions can change rapidly.

Emergency Plans: If there is a lot of time to prepare for a flood, parents will be notified and asked to pick up their children. The children's center staff, however, realized that there may not be time for such action. The evacuation plan calls for the children's center at Smiley to relocate to a second floor of one of the housing buildings. Evacuation plans for the center at Newton are to relocate to the 3rd floor (2nd story) of Naropa's Lincoln building. Emergency flood boxes have been prepared and placed at the relocation sites. The flood boxes are similar to those at other family housing sites. The boxes contain emergency supplies such as first aid kits, blankets, food, water, and flashlights.

Family Housing staff will come to assist the children's center in an evacuation. Some teachers have wagons to help transport the children. Each teacher is

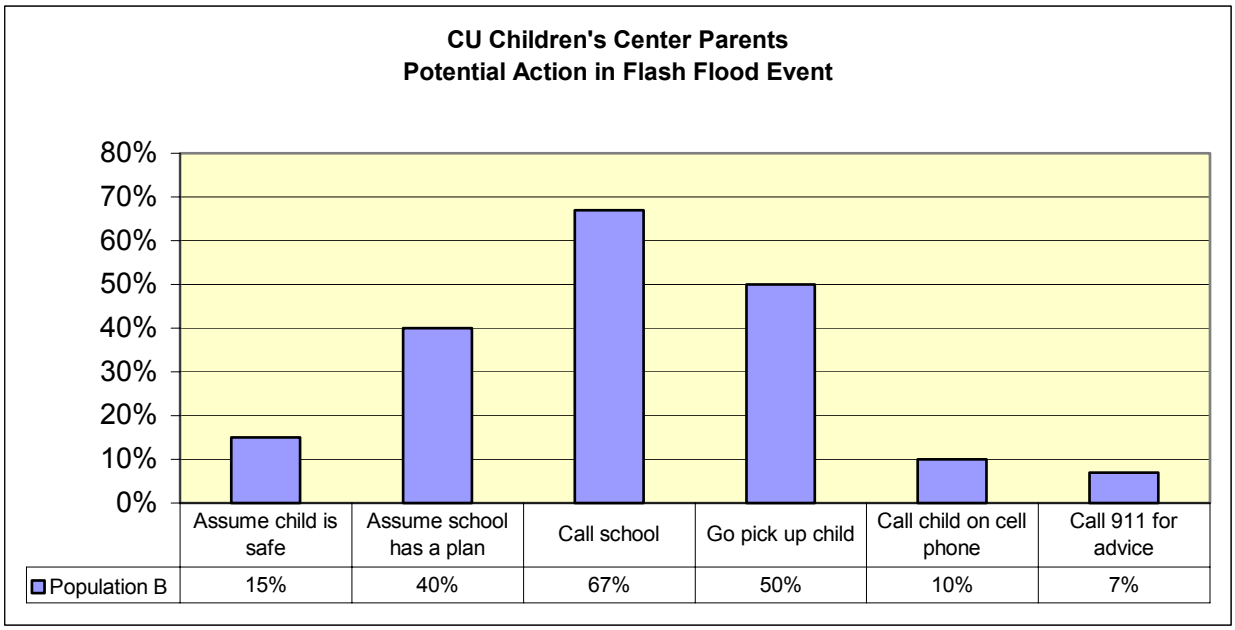
responsible for the children in his/her class. Teachers are required to take along the daily sign-in sheet as well as an emergency backpack. Emergency backpacks contain first-aid supplies and other essentials that vary depending on the age of the children they are caring for. For example, if the class has children in diapers, supplies will include diaper-changing materials.

Preparedness: Evacuation plans are practiced during the OEM siren test on the first Mondays of April - October. These drills allow both staff and students to become familiar with the evacuation plan. The evacuation drills are timed at approximately 8 minutes for staff and children to reach their designated safety location. During drills, the teachers of each classroom are to take care of the students in their classroom. Each teacher is responsible for taking along the daily sign-in sheet and the emergency backpack.

Prior to the beginning of the flash flood season, new teachers are informed of the procedure either in a teacher training in January, a staff meeting in February, or informally by the lead teacher. Since many teachers have been with the center for several years, the usual procedure is to remind them via a memorandum that drills for the flash flood season begin in April.

Survey data: Survey question 25 (for population B respondents only) asked: "You have a child at CU Family Housing Children's Center and you think a flash flood is going to occur, what do you do?" Respondents could check multiple answers from the following: Assume he/she is safe, assume the school has a plan, call the school, go pick up the child, call child on cell phone, and call 911 for advice. Respondents chose "call school" more frequently than other options.

Figure 25



Recommendations: We commend CU Family Housing Children's Center on their preparedness efforts, and especially on the monthly evacuation drills during flash flood season. We recommend educating parents of children at the center about when it would be and when it would not be appropriate to attempt picking up their children in the event of a flash flood. We also strongly encourage further negotiations with Naropa University, if it has not already been done, regarding use of their new building during the flash flood as the new building is nearer to the children's center.

SECTION VII: SUGGESTIONS FOR FUTURE RESEARCH

Cultivating and maintaining public awareness is an ongoing process. As this report shows the Boulder Creek floodplain population is a technologically sophisticated group with a limited knowledge of flash flood potential. The measures currently being used may or may not be the best and most effective method of increasing awareness and preparedness. There are ways to target particular segments of the population that may be less expensive, more localized, and more effective. The evaluation of the efficacy of the public education measures should be included annually as an integral part of the public education campaign. This means that every year a portion of the budget should be set aside to follow up by measuring perceptions and levels of understanding.

Use these findings as baseline data for follow up efforts to evaluate whether the population is becoming more or less informed. The raw data as well as the findings are available for further analyses. There are several Master's theses possible based on this initial study. For example, there are more questions about the demographics of warning preferences, the opportunities for businesses to be better prepared, carefully assisting the University Family Housing with a targeted public education campaign, to name a few possibilities.

Boulder has several floodplains. This study does not show that Boulder Creek residents are representative of the residents along all of the local floodplains. It would be valuable to conduct the same effort along other floodplains in Boulder, elsewhere in and outside the District.

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APPENDIX A: MACS SURVEY

Internet based survey
available at (http://web.uccs.edu/geogenvs/macs.htm)

Dear MACS Committee Members:

We are in the process of wrapping up our study on the perceptions of Boulder floodplain residents. Before we finalize the report however, Kevin and Larry wanted to complement the survey results from the public with perspectives of those directly involved with the warning process.

Please take a few minutes to participate in this brief survey. The answers you provide will be included in the report in aggregated format so that responses cannot be linked to individuals, so please be candid. We would like to have all responses by March 15.

If you would rather talk to one of us regarding these questions, please feel free to e-mail or call us.

Thanks in advance for your participation.

Eve Gruntfest (719) 262-4058

Kim Carsell (719) 229-0627

1. On a scale of 1-10, (1 being the lowest and 10 being the highest), please indicate **your confidence in the existing flash flood detection and early notification system as a whole**.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Indicate your confidence to the following parts of the detection system. Take into consideration detection and transmission of information.

National Weather Service

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Private Meteorologist

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Stream/Rain Gauge Network

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

DIADVISOR (formerly STORM Watch by DIAD)

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Please provide any comments you may have related to this question.

2. On a scale of 1-10, (1 being the lowest and 10 being the highest), please indicate **your confidence in the system/procedure in place to notify you and other important people regarding flood modes**.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Please provide any comments you may have related to this question.

3. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate **your confidence in the system/procedure in place to notify the public of an imminent flash flood (mode 3)**.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Please provide any comments you may have related to this question.

4. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate **your confidence in the public to take protective actions when notified of an imminent flash flood (mode3)**.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Please provide any comments you may have related to this question.

5. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate **your confidence in your ability to perform your predetermined duties during a flooding event**.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Please provide any comments you may have related to this question.

6. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate **your confidence in your staff's ability to perform their predetermine duties during a flood event** (or if they are not to perform flash flood related duties, their ability to take protective action during a flash flood).

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

7. On a scale of 1-10 (1 being the lowest and 10 being the highest), please indicate **your confidence in the flow of communication from early notification of threat to detection to response**.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ Don't Know

Please provide any comments you may have related to this question.

8. What portions of the warning plan do you have concerns about?

9. What suggestions do you have that could be used to make the warning plan more effective?

10. What additional services could UDFCD provide or what current services could they do better?

11. Please indicate what your role and your staff's role will be during a flash flood event.

12. Please use this space for any additional comments you may have.

Submit Form | Reset Form

We appreciate your help.

APPENDIX B: RESPONSES FROM MACS PARTICIPANTS

Respondents	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	AVE
Questions																						
1. Detection	9	3	9	9	2	10	7	9	9	7	7	7	8	6	8	8	9	8	8	8	5	**7.4**
NWS	8	8	6	6	2	7	4	7	9	9	7	8	6	2	5	5	3	9	8	6	7	**6**
HMS	9	NA	7	9	NA	6	5	7	NA	9	7	6	6	5	NA	5	8	8	4	9	7	**6.5**
GAUGE	9	4	9	9	NA	9	6	10	9	6	6	8	8	6	NA	8	7	9	6	9	6	**7.2**
DIAD	9	NA	9	NA	NA	8	7	NA	9	NA	NA	NA	8	6	5	8	7	9	NA	9	8	**7.3**
2. NOTIFICATION	10	5	7	10	2	9	8	10	NA	8	7	7	8	4	8	10	9	9	6	8	5	**7.1**
3. NOTIFY PUBLIC	9	4	8	10	2	8	6	8	8	4	8	7	7	4	3	10	9	9	6	8	5	**6.5**
4. PUBLIC RESPONSE	3	2	6	1	4	5	4	5	6	5	4	5	5	3	2	7	4	7	3	3	3	**4**
5. YOUR RESPONSE	10	6	NA	10	8	9	7	10	9	9	9	9	8	6	9	9	10	9	7	5	3	**7.7**
6. STAFF RESPONSE	NA	6	10	8	8	9	8	10	9	9	9	9	8	2	9	10	8	9	5	5	6	**7.5**
7. COMMUNICATION	8	3	10	9	BL	7	9	10	7	8	6	7	7	4	7	BL	9	9	5	7	6	**6.9**

Individual surveys are listed under each letter; thus "A" is one response.
Averages do not include "NA's" or "BL's" (BL was a response left blank)

Comments to question 1: "confidence in the existing flash flood detection and early notification system as a whole."

?? The National Weather Service has generally been proactive in issuing warnings, but sometimes they lack the technology/capability to predict/detect sudden onset local impacts, and/or to interpret possible local phenomena such as isolated area flash flooding, tornadoes, etc. In 1997 NWS was unable to detect a small tornado that occurred in Boulder County causing minor damage, and by the time they became aware of it's existence, the event had already subsided. Only people visibly spotting the funnel cloud and calling 9-1-1 were responsible for initiating a warning. Stream gauges and the DIAD system offer somewhat better analysis provided the storm cell is affecting those tributaries that are monitored. The Fort Collins flood of 1997 did not have any technological detection or warning since it occurred right over the city and not from stream tributaries in the foothills.

?? A private meteorologist is a good way to stay on top of local developments regarding weather. The NWS, in my experience, does not have the manpower or systems in place to keep track of local weather and its impacts on the Boulder Valley. And I know that, apart from severe storm notification for the plains, they are way behind the curve.

?? According the folks in Fort Collins, the Weather Service did not issue a warning for the 1997 Fort Collins flood because the storm cell was so small that it didn't look as dangerous on the radar as it turned out to be in reality. I have attended the City of Boulder annual spring flood exercise and seen a demonstration of DIAD and have regularly viewed the data from the stream gage network that is monitored by UDFCD. These data provide a more focused and accurate measure of rainfall in the mountains west of Boulder that will allow, in my opinion, a longer warning time than the city would get from the Weather Service alone. Because I haven't had much contact with private meteorologists for nearly 20 years, I don't have much more confidence in their forecasts than I do with the Weather Service. It was my experience then that they simply used the forecasts from NWS, but were paying a little more attention to local conditions.

Comments to question 2: "confidence in the system/procedure in place to notify you and other important people regarding flood modes."

?? My confidence in the system is situational. If I'm in town, I have a relatively high level of confidence if I were near a phone or outside in an area where I could hear the sirens. If I were inside a store or driving with the radio off, it would be more difficult and time-consuming to reach me with a warning. If I were at home and the emergency dial-up warning system was able to function (assuming no lines are down, etc.), I'd feel extremely confident in receiving a warning. But, if I were driving home in the canyon, my radio would have to be on and tuned to the right station to get a warning, since radio and cell phone reception can be iffy in many locations.

?? Interpretation and dissemination of advanced threat probability information to MACS and CU's corollary organization, EMOG, then to local emergency communications centers has generally been quite reliable (especially those from the STORM and private meteorological services under contract to emergency management). The weakness of such systems, is analogous to the Fort Collins Flash flood of 1997, in that there is no technology in place for a "point site" flash flood which occurs right over a populated area and results in unanticipated buildup of water in natural terrain "reservoirs" such as roadbeds, railroad berms, buildings/structures, damming and diversion due to debris, etc., which then give way and create undetectable flash floods with no prior warning. Regrettably there is little that can be done to anticipate and mitigate these issues without considerable study and analysis of such risks.

?? Pager does not always work correctly and the Groupwise e-mail system has to be working to receive the Mode e-mail, which is not always the case. Need to have the pagers serviced by an on-site tech every six months and a regular maintenance schedule.

Comments to question 3: "confidence in the system/procedure in place to notify the public of an imminent flash flood (mode 3)."

?? There are still some gaps in siren coverage. I realize that sirens are not our only method of notification but there should be equitable coverage.

?? Dr. Mileti has suggested that in a flash flood with "worst case" scenario (e.g., minimal advanced warning time flash flood of Boulder Creek, at 2:00 AM, from a sudden onset massive storm cell, or a catastrophic dam failure) where floodwaters would reach Boulder in less than an hour, it is probable that the loss of life along the flood path could be quite high. This is probably almost unavoidable despite the best warning technology possible or even currently anticipated. Certainly enhanced warning systems, and extensive public education can mitigate these consequences, but I am not optimistic that those "in harm's way" will have as much survival probability as we would like to hope for. Statistically, this is the least likely scenario, but certainly the most deadly. The outdoor warning sirens are generally disregarded by the public even when they are outside. At the present time, I am not at all confident that people would follow the presumed directive to tune to radio or television for updated information when they hear warning sirens/pa announcements. I have personally witnessed folks blatantly ignoring the sirens during tests, and many just seem to assume that there is a test even during an actual emergency (e.g., Tornado warning of 1997) and don't even bother to check TV or radio. At night, when people are asleep, or even inside buildings, outdoor warning sirens and pa announcements cannot generally be heard, nor were they intended to be, so are only minimally effective for folks outside. Those in cars may or may not hear them either, so unless there is a way to activate a warning on car radios, this is another "hole" in the warning methodology that needs to be addressed. Even when folks are outside, echoes and acoustics often impair audibility of warning siren voice messages. Conversely, the EWE/EPN telephone fan-out warning system has been demonstrated to be considerably

more effective for those inside buildings, where phones are available. Once phone numbers in locations that are determined to be "in harm's way" are called by the EPN system, with a credible message, surveys have shown that most citizens understand that there is a credible threat and are less likely to "deny" and therefore ignore the threat or seek further time-consuming confirmation before taking action. So long as wired telephone service is operational, this is probably the single most effective warning tool. A multi-faceted approach needs to be taken however, to issue the same consistent warning throughout the affected area via TV/cable interrupt, radio, broadcast radio/TV, low-power am radio local transmitters at 530 kHz, fan-out telephone warning system (EPN), etc. There are still many additional technological possibilities that could be implemented such as a future enhancement of EAS that would turn on a radio or television at night when residents are sleeping to issue a warning. Satellite based radio telemetry warning receivers would also be another option. All options need to be battery powered and otherwise redundant in the event of power failure. Cell phone notification is a serious concern, because the EWE/EPN system does not yet have the capability to alert cell phones. Moreover, it is predicted that the use of cell phones will become about 80% of the market share in the next five to ten years, and that wired phone use will remain constant or even diminish. The advent of cellular phase 2 for 9-1-1 (providing automatic number and location identification or ANI/ALI) is essential to the ability of EWE/EPN to select wireless (cellular) telephones in operation in the affected area. This also presumes that the wireless phone is powered up and detected by the trunking system. So some technology may need to be addressed that alerts wireless phones that are not powered up to "turn on." Currently, it is unlikely that full implementation of wireless phase 2 will be any sooner than three to five years or more so this is a major "deficit" in the warning system.

Comments to question 4: "confidence in the public to take protective actions when notified of an imminent flash flood (mode 3)."

?? I'm really not sure how people would react. I've seen people continue walking along Boulder Creek when a warning siren was sounded during a heavy rainstorm the day after the Fort Collins flood.

?? This community is very complacent and does not heed warnings.

?? I don't think people in general are prepared for emergencies - floods, fires, etc.

?? It is important to continue to educate people because most tend to not believe that they will be involved in a flood.

?? This is the area which is the greatest weakness. Community disaster education research shows that in areas where disasters typically are infrequent, there is less preparation and anticipation of a need for rapid response. Public education efforts are quite minimal in these areas, and for the lack of any recent history of flash flooding (more than 100 years ago), no one takes the threat seriously. Few know what to do and those in harm's way would have very little time to react and respond, especially at night when most flood deaths occur. I would predict that those in the flood path would be in great danger due to insufficient warning time, confusion as to what they should do (shelter in place or evacuate?) and the typical denial response which results in seeking verification/confirmation before taking action. In a flash flood, there is no time for these luxuries and thus lives can be lost due to delay. Moreover, there is the element of non-English speaking international students and visitors/aliens who do not understand the danger, cannot understand or interpret the warnings (which are only in English at the present time) even if they get them, or have no concept of how to respond appropriately and either take no action or inappropriate actions. Much more attention needs to be paid to multi-lingual public education and messaging to meet these ever-increasing numbers of non-English speaking populations. Involvement of those communities in the warning effort becomes essential.

Comments to question 7: "confidence in the flow of communication from early notification of threat to detection to response."

?? Communications will always be a problem; but I feel more confident due to our regular, established relationships and use of the systems in place.

Comments to question 8: "What portions of the warning plan do you have concerns about?"

Public awareness and response issues

?? General public apathy and ignorance; we continue to work on the problem and just have to accept we will never get everyone up to speed.

?? The concern that I have is related to the ability to evacuate the area if needed.

?? The public's lack of knowledge regarding how to respond to a flood emergency and, ultimately, how they will respond to a flood emergency (i.e., will they seek high ground, will they try to get across town to be with other family members, driving or traversing through inundations with high flow velocities.)

?? Creating a level of concern and seriousness in the minds of people so they will be motivated to participate in drills and that learning transferred into appropriate actions at a time when needed.

?? Worried about those who are outside in areas like the city's Central Park area who may not know where to go, even though they hear the sirens sounding.

?? Concerned about the public reacting appropriately.

?? The public's response is largely unpredictable or measured, and especially for the Boulder area, there is a significant lack of awareness or concern for the probable life-threat of a rapid-onset flash flood (or any other natural or man-made hazard) by the public. Little is widely disseminated by the media about threats, or public education as to how warnings will be issued, and what appropriate responses should be, unless and until there is an actual event. During the siren tests, from April through August, some media attention is given, but it is limited and probably needs to be augmented at a "grass-roots" level through other programs such as CDE/CERT. It is essential to proactively and widely disseminate such information in advance of such events.

Detection issues

?? Streams and creeks NOT monitored. Urbanized basins are very small basins, but will generate short, quick, high run-off. Little detection time.

Emergency service and response issues

?? Emergency access routes and coordination & communication between entities, agency staff and the public during an emergency situation.

?? Specific response actions need to be re-emphasized.

?? Advising the public, organizing response of emergency services.

Notification issues

- ?? I have concerns about being given enough notice too…
- ?? Public notice and safety/evacuation message.
- ?? There are still one or two small areas that do not have siren coverage.
- ?? I think it will be more difficult to warn those in commercial buildings and businesses, particularly large stores. One phone call to the store doesn't necessarily mean the information will be adequately communicated to customers and employees.
- ?? Pager messages have not been communicated in a timely manner. 2. Pager messages are hit and miss 3. Pager messages are not specific and simple (do not always state mode, so not state specific location information, rarely provide updates or cancellations) 4. E-mail communication about mode and mode updates or cancellations erratic. 5. City Phone HOTLINE usually not updated.
- ?? The current EWE/EPN system relies on a "calling partner" that is located in another state. Thus the system depends on access to long distance lines into local central offices. Generally these are reliable, but in the event of a widespread emergency or multiple initiations of warnings in multiple areas, delays in delivering warnings could be experienced. Technological breakdowns could also affect reliability. A more localized or otherwise redundant fan-out calling system might offer greater reliability. PBX (private business telephone exchange) systems such as the University of Colorado are also limited on the number of inbound trunks available to receive calls from the EWE/EPN system. Only 300 inbound trunks can receive calls at a given time, so a high-speed notification to affected telephone numbers could be "choked" down from a delivery rate of 2000 per minute to only about 300 per minute. This also competes for lines that are already in use, so during an ordinary business day, if 30% of the lines are in use while a warning is activated, then only about 200 inbound lines would be available for warning purposes. Some method needs to be devised to override or bypass this limitation to permit a larger volume of warning calls to be delivered in a finite time period.
- ?? General lack of sufficient redundancy in technological systems. Most of our warning methodology is entirely dependent on technology. Yet, if there is a catastrophic failure of any of a series of components, one or more of the warning systems could be significantly impaired or rendered useless (e.g., a failure due to flooding or cable interruption of a major telephone switching center could effectively render the EWE/EPN System useless for the affected area). Similarly, failures of various public safety radio communications systems/networks could also be compromised by a natural or man-made hazard, thus having fully redundant/stand-alone backup systems in place should be critically addressed at all levels to ensure appropriate fail-safes are available. Power failure is a pivotal concern in that all of the technology relies on uninterrupted delivery of power to various warning systems, and to the technology (e.g., radios, TV, phones) by which the public receives the warnings. Telephone service is generally independent in that most phones operate from power supplied by the telephone line. However, more and more local phones are using "cordless" phones that require AC power and will not function if power is cut off. Even local telephone central offices and substations have battery power supplies and generators that usually will activate to maintain telephone service in the event of power failure, but some decentralized "hubs" of telephone service, such as PBX systems at the University may not have UPS (uninterruptible power supply) capability.

So a "top to bottom" evaluation and resultant "hardening" of such systems needs to be critically pursued and engineered. Then testing of such possibilities should be conducted before the "real thing" occurs.

?? Still other concerns include "overloading" of local telephone switching systems during an emergency which would result in a virtual shut down of normal telephone communications even for emergency services agencies. Most telephone systems are engineered to function with only about 20 % of the users actually on the system at any given time. If larger percentages attempt to use the system, as they most certainly will during a disaster, it becomes overloaded, and users do not get "dial tone" so calls do not go through, emergent or non-emergent. If warnings from EWE/EPN are being initiated during this time, they too will not be received by local residents if a system overload is already in effect at the local central office. There is no priority "override" currently in place with this technology that supercedes local calls already in progress, or if a central office switch is in "overload" status. This phenomena is similarly true of cell phones, and was graphically experienced during the 9-11 attacks where public and public safety communications was largely paralyzed due to overloading and failure of critical switching centers adjacent to the attack site. Only those systems that had governmentally owned and controlled simple analog technology and redundant backup engineering, continued to function. Commercial services were largely inoperative. Most "digital trunked" public safety radio and private sector paging systems became overloaded and failed due to either overloading or complex technology with a lack of sufficient redundant engineering that anticipated such loading. The less complicated the technology, the more likely it is to continue to operate reliably. This is also why amateur "ham" radio support of public safety in emergencies becomes so important to supplant failed/overloaded normal systems.

Comments to question 9: "What suggestions do you have that could be used to make the warning plan more effective?"

Public awareness and response issues

?? Continue public education / outreach, continue regular siren tests. Perhaps regenerate "Flood Watch" and educational materials if time / assets allow.

?? Ask that supervisors at organizations give focus to the program by asking for employees to discuss their role and knowledge about the appropriate steps to take during a flood event. This assumes that the supervisor is aware of their plan. As for citizens, do some random sampling of people on the street in various areas near the areas identified as having the potential for flooding. Identify areas with signage that have the potential for flooding and on the sign ask thought provoking questions about "What If's" that would give information and at the same time cause people to think about the appropriate steps they would want to take at the time of encountering a flood situation.

?? I'd work as closely with businesses in the flood area to help them know how to respond correctly to a major flood or other emergency. I think it would also help to hear from them about their concerns and let them know about how public officials will respond.

?? Standardized pager messages would be a help. 2. For every pager message that goes out, City Hall should send out a citywide e-mail 'translating' the pager message into simple jargon.

?? Community Disaster Education programs could be much more widely implemented such as in Seattle/King County Washington, in which Community Emergency Response Teams (CERT) are formed similar to "neighborhood watch" programs where "block captains" and teams are organized, trained, and given responsibility for their various neighborhoods or work places. They are thus empowered and have the credibility to go

"door to door" and enlist the support and involvement of the local residents. The preparedness aspects of these teams combines the Red Cross Community Disaster Education presentations with CERT training to first educate the citizens of probable hazards, and appropriate response techniques, and then to train them in the various urgently necessary skills of light duty rescue, first aid, sheltering, light duty fire suppression, assembling and storing family disaster supplies kits, emergency water, battery powered radio/TV, and most of all educating families and workers how to respond when normal emergency services are unavailable or overwhelmed (e.g., fire, rescue, law enforcement, emergency medical services, et al). Those communities that have implemented the combined CDE/CERT programs have had remarkable success in dealing with actual emergencies/disasters due to much greater empowerment and education of citizens than would normally occur. As Dr. Mileti has suggested, the "bottom line" is that if folks aren't sensitive to the risks, and don't know what to do if they are suddenly faced with an emergency, all the finest warning technology and plans in the world will not be very effective. Moreover, it has to be on-going and continuous because as the advertising professionals already know, a message has to be repeated at least 3 to 10 times before some folks finally "get it." And then you have to anticipate that a continuous flow of new people will always be coming in that haven't previously "heard the message."

Emergency service and response issues

- More practical exercises.

Notification issues

- Need to have the pagers serviced by an on-site tech every six months and a regular maintenance schedule.
- Need for additional sirens

Comments to question 10: "What additional services could UDFCD provide or what current services could they do better?"

- Host a workshop or seminar in which staff and emergency personnel can be further educated about a response plan.
- UDFCD does a good job in the detection and hazard assessment area, but if they could be more pro-active and financially supportive in the warning and public education side as part of a coalition of Red Cross, local OEM, institutions, neighborhood watch/CDE/CERT programs, that would be money very well spent.

Comments to question 12: "any additional comments you may have?"

Public awareness and response issues

- The public is in a "window of opportunity" mode for increased knowledge and preparedness as a result of the terrorist attacks of 9-11. While natural hazards do not rise to the level of concern of terrorism currently, the general emphasis on homeland security can be used as a "springboard" to fit in preparedness for all hazards (natural and man-made) and thus the "carpe diem" approach should be capitalized while the interest levels and funding possibilities remain relatively high. As threats subside, so too does interest and thus financial resources to support and promulgate training and information, until the "next" disaster when lives may be needlessly lost due to complacency and lethargy following previous events. No one likes to think about the possibility that they could be directly affected by various hazards, and again "denial" sets in which changes priorities to

more enjoyable pursuits. This complacency, and denial always seems to result in unnecessary and easily preventable tragedy for which there is no recourse.

Detection issues

?? A private meteorologist is a good way to stay on top of local developments regarding weather. The NWS, in my experience, does not have the manpower or systems in place to keep track of local weather and its impacts on the Boulder Valley. And I know that, apart from severe storm notification for the plains, they are way behind the curve.

Emergency service and response issues

?? I think the people who will respond to a flood in this community are very dedicated and will do their best. However, I think there is far too little participation by public works departments and land use planning officials. One land use planner from Boulder County told me they were still using FEMA flood maps from 1976. And, my experience with land use officials has been that they are far more involved with growth control and the color of buildings. They work very hard at enforcing Boulder's strict codes, but seem to lack an understanding of why they exist. Both the county and city Public Works departments do not devote adequate resources to planning for and responding to such an event, and need to do more to train their employees and get them involved in helping to implement emergency response to such events. Their heavy equipment and the personnel who can operate such machines are going to be desperately needed when a flood occurs, and they need to do some tabletops, etc. to become more aware of their role in such an event.

?? I know that local officials have done a great deal of preparation for a flood. I have a tremendous amount of faith in their abilities and their readiness to respond. They pay a lot of attention to the information about flood mode and act accordingly.

?? Boulder is lucky or I guess unlucky in how you look at it. We are fortunate that we have not had to deal with a 100-year flood event, although we are in the window for such an event. The damage and potential human impact is huge for Boulder considering the vast number of people within Boulder Canyon. On the flip side, we have not had to try our emergency response capabilities to see where there could be gaps or problems. Larimer County I think has a leg up on us since they have had several floods to deal with and I imagine the roles of the different players has been well defined.

Notification issues

?? Historically, there have always been pager problems during the annual drill. However, there is never a follow-up test to see if the problems have been corrected. Testing the pagers every month during flood season, the same day/time as the Siren Test, makes a lot of sense.

?? The reverse 911 system has done a lot to improve the notification element of the plan. That, combined with the sirens and the recently distributed Flood Protection Handbook produced by the Boulder County Transportation Department all add up to a strong, proactive education campaign and notification system. I would say that it is one of the best I've seen.

APPENDIX C: DATA FROM BOULDER WARNING SYSTEM SURVEY

	Pop A	Pop B	Total
1. What does the term "100 year flood " mean to you?			
Flood that has a 1% chance of occurring in any year	88(55%)	63(41%)	151(48%)
Flood that occurs every hundred years	58(36%)	69(45%)	127(40%)
Don't Know	12(8%)	18(12%)	30(10%)
Other	2(1%)	5(3%)	7(2%)
			(n=315)
2. Is your residence in the 100-year floodplain?			
Yes	124(77%)	101(65%)	225(71%)
No	14(9%)	1(1%)	15(5%)
Don't Know	22(14%)	53(34%)	77(24%)
Other	0		0
			(n=317)
3.What does a "flash flood watch" mean to you?			
Flash flooding is possible	138(85%)	129(83%)	267(85%)
Flooding occurring or is imminent	18(11%)	17(11%)	35(11%)
Don't know	7(4%)	9(6%)	16(5%)
Other	0	0	0
			(n=318)
4. What does a "flash flood warning" mean to you?			
Flash flooding is possible	39(24%)	50(32%)	89(28%)
Flooding is occurring or is imminent	120(74%)	101(65%)	221(70%)
Don't know	3(2%)	3(2%)	6(2%)
Other	0	1(1%)	1(1%)
			(n=317)

	Pop A	Pop B	Total
5. Do you pay attention to environmental factors that may indicate a flash flood?			
Yes	113(70%)	106(68%)	219(69%)
No	37(23%)	37(24%)	74(23%)
Don't know	11(7%)	6(4%)	17(5%)
Other	0	6(4%)	6(2%)
			(n=316)
6. Do you agree with the following? "my home is at risk form a flash flood"			
Strongly agree	48(30%)	29(19%)	77(24%)
Agree	64(40%)	89(57%)	153(49%)
Neither	24(15%)	15(10%)	39(12%)
Disagree	21(13%)	19(12%)	40(13%)
Strongly Disagree	3(2%)	4(3%)	7(2%)
"my life is at risk from a flash flood"			
Strongly agree	24(15%)	10(6%)	34(11%)
Agree	50(31%)	54(35%)	104(33%)
Neither	38(24%)	34(22%)	72((23%)
Disagree	39(24%)	52(33%)	91(29%)
Strongly disagree	10(6%)	6(4%)	16(5%)
			(n=316)
7.Which is a more serious flood event?			
100-year flood	80(51%)	68(44%)	148(47%)
20-year flood	28(18%)	34(22%)	62(20%)
Don't know	50(32%)	54(35%)	104(33%)
			(n=314)

	Pop A	Pop B	Total
8.From where have you obtained info about flash floods? (check all that apply)			
Television	95(59%)	88(56%)	183(58%)
Radio	57(35%)	21(14%)	76(24%)
Newspaper	42(26%)	26(17%)	68(22%)
Flyer sent to your home	63(39%)	81(52%)	144(46%)
The Weather Channel	29(18%)	36(23%)	65(21%)
Internet	16(10%)	14(9%)	30(9%)
Other	26(16%)	41(26%)	67(21%)
(Pop B -Family Housing Material 16(10%))			(n=319)
9.Have you ever looked for additional information (other than what has been sent to your home) about flooding?			
Yes	26(16%)	18(12%)	44(14%)
No	134(83%)	138(88%)	272(86%)
Don't know	1(.5%)	0	1(0)
Other	1(.5%)	0	1(0)
			(n=319)
10. Where do you look for local weather conditions? (Check all that apply)			
Newspaper	87(54%)	74(47%)	161(51%)
Television	109(68%)	128(82%)	237(75%)
The Weather Channel	79(49%)	96(62%)	175(56%)
Telephone information line	9(5%)	6(4%)	15(5%)
Internet	77(48%)	99(63%)	176(56%)
Radio	81(51%)	62(40%)	143(45%)
NOAA Radio	7(4%)	4(3%)	11(3%)
Other	19(12%)	3(2%)	22(7%)
(POP A -conditions outside 7 – 4%)			(n=319)

	Pop A	Pop B	Total
11. How often do you look for local weather forecasts?			
Several times per day	14(9%)	4(3%)	18(6%)
Daily	54(34%)	55(35%)	109(35%)
Several times per week	40(25%)	56(36%)	96(30%)
Weekly	11(9%)	2(1%)	13(4%)
Occasionally	34(21%)	34(22%)	68(22%)
Never	7(4%)	3(2%)	10(3%)
Other	7(4%)	2(1%)	9(3%)
			(n=323)
12. How often do you watch the weather channel?			
Several times per day	6(4%)	1(1%)	7(2%)
Daily	10(6%)	14(9%)	24(18%)
Several times per week	17(11%)	36(23%)	53(17%)
Weekly	8(5%)	7(4%)	15(5%)
Occasionally	59(37%)	64(41%)	123(39%)
Never	61(38%)	33(21%)	94(30%)
Other	3(2%)	1(1%)	4(1%)
			(n=320)
13. (Population A only) Have you ever purchased flood insurance?			
Yes	30(18%)		
No	127(78%)		
Don't know	4(2%)		
Other	2(1%)		
	(n=163)		
If yes, do you have flood insurance now?			
Yes	27(17%)		
No	44(27%)		
Don't know	3(2%)		
Other	89(55%)		
	(n=163)		

	Pop A	Pop B	Total
13. (Population B only) To your knowledge, does CU Family/Staff Housing have an emergency plan in place in the event of a flash flood on Boulder Creek?			
Yes		95(61%)	
No		6(4%)	
Don't know		53(34%)	
Other		2(1%)	
If yes, Please tell us what the plan consists of?			
Have some idea		74(47%)	
Don't know		82(53%)	
		(n=156)	
14. (Population A only) Have you made any changes to your home to prepared for a flash flood?			
Yes	8(5%)		
No	149(91%)		
Don't know	4(2%)		
Other	2(1%)		
	(n=163)		
14. (Population B only) Do you have renters' insurance?			
Yes		44(28%)	
No		95(61%)	
Don't know		17(11%)	
		(n=156)	
15. Have you ever experienced a flash flood?			
Yes	35(21%)	11(7%)	46(15%)
No	124(76%)	145(93%)	269(84%)
Don't know	2(1%)	0	2(1%)
Other	2(1%)	0	2(1%)
			(n=319)

	Pop A	Pop B	Total
16. Do you have a family emergency plan for flash floods such as you might have developed for fire safety?			
Yes	27(17%)	18(11%)	45(14%)
No	131(80%)	129(83%)	260(83%)
Don't know	0	4(3%)	4(1%)
Other	4(2%)	4(3%)	2(1%)
			(n=311)
17. What would be the best way to contact you at the following time; (check all that apply)			
2:30a.m.			
Sirens	136(83%)	144(92%)	280(89%)
Call me	94(58%)	117(75%)	211(67%)
Television	19(12%)	21(14%)	40(13%)
Message at bottom of tv screen	12(7%)	16(10%)	28(9%)
Come to my door	75(46%)	72(46%)	147(47%)
E-mail	9(6%)	9(6%)	18(6%)
Cell phone	22(14%)	11(7%)	33(10%)
Pager	4(2%)	3(2%)	7(2%)
Local radio	26(16%)	12(8%)	38(12%)
NOAA Weather radio	6(4%)	3(2%)	9(3%)
Don't want to be warned	1(1%)	1(1%)	2(1%)
Other	5(3%)	0	5(2%)
			(n=319)

	Pop A	Pop B	Total
11:00a.m.			
Sirens	132(81%)	141(90%)	273(87%)
Call me	91(56%)	109(70%)	200(63%)
Television	63(39%)	55(35%0	118(37%)
Message at bottom of tv screen	44(27%)	49(31%)	93(30%)
Come to my door	57(35%)	75(48%)	132(42%)
E-mail	31(19%)	57(37%)	88(28%)
Cell phone	20(12%)	23(15%)	43(14%)
Pager	5(3%)	5(3%)	10(3%)
Local radio	64(39%)	35(22%)	99(31%)
NOAA Weather radio	10(6%)	4(3%)	14(4%)
Don't want to be warned	1(1%)	0	1(0)
Other	6(4%)	0	6(2%)
			(n=319)
5:00p.m.			
Sirens	138(85%)	141(90%)	279(89%)
Call me	96(59%)	112(72%)	208(66%)
Television	72(44%)	75(48%)	147(47%)
Message at bottom of tv screen	53(33%)	68(44%)	121(38%)
Come to my door	63(39%)	79(51%)	142(45%)
E-mail	19(12%)	40(26%)	59(19%)
Cell phone	20(12%)	23(15%)	43(14%)
Pager	8(5%)	4(3%)	12(4%)
Local radio	61(37%)	34(22%)	95(30%)
NOAA Weather radio	9(5%)	4(3%)	13(4%)
Don't want to be warned	1(1%)	0	1(0)
Other	7(4%)	0	7(2%)
			(n=319)

	Pop A	Pop B	Total
18. Realizing it is difficult to accurately predict flash floods, which would you prefer?			
More warnings	125(77%)	121(78%)	246(78%)
Fewer warnings	24(15%)	23(15%)	47(15%)
Other	12(7%)	12(8%)	24(8%)
			(n=317)
19. Do you think 1 or 2 false alarms for flash flooding would reduce your confidence in future warnings?			
Yes	54(33%)	56(36%)	110(35%)
No	86(53%)	72(46%)	158(50%)
Don't know	16(10%)	25(16%)	41(13%)
Other	7(4%)	3(2%)	10(3%)
			(n=319)
20. Have you ever seen the sign "Climb to Safety in Case of Flash Flood"?			
Yes	137(84%)	111(71%)	248(79%)
No	20(12%)	41(26%)	61(19%)
Don't know	2(1%)	2(1%)	4(1%)
Other	4(2%)	2(1%)	6(2%)
			(n=319)
21. Have you heard about the "Big Thompson Flood" in Colorado?			
Yes	105(64%)	54(35%)	159(50%)
No	54(33%)	96(62%)	150(48%)
Don't know	1(1%)	3(2%)	4(1%)
Other	3(2%)	3(2%)	6(2%)
			(n=319)
22. Have you had discussions with your neighbors about the threat of flash flooding?			
Yes	36(22%)	21(13%)	57(18%)
No	124(76%)	134(86%)	258(82%)
Don't know	4(1%)	1(1%)	5(1%)

	Pop A	Pop B	Total
23. You are at the Boulder Public Library and hear the sirens saying that flash flooding is imminent, what do you do? (check all that apply)			
Leave immediately and drive away	37(23%)	38(24%)	75(24%)
Leave immediately and walk away	53(33%)	39(25%)	92(29%)
Go look at the creek	16(10%)	15(10%)	31(10%)
Call someone	11(7%)	22(14%)	33(10%)
Seek information from the library staff	59(36%)	86(55%)	145(46%)
Go to top floor	64(39%)	70(45%)	134(43%)
Do what others are doing	21(13%)	31(20%)	52(17%)
Nothing	0	0	0
Other	9(6%)	3(2%)	12(4%)
			(n=319)
24. You are at work and it is quitting time. It is raining hard and you see the streets are somewhat flooded, what do you do?			
Leave and drive away	37(23%)	40(26%)	77(24%)
Leave and walk away	15(9%)	25(16%)	42(13%)
Wait for conditions to improved	91(56%)	82(53%)	173(55%)
Other	27(17%)	16(10%)	43(14%)
			(n=319)

	Pop A	Pop B	Total
25. (Note: Population A is Boulder High, Population B is CU Family Housing Children's Center) You have a child at Boulder High/CU Family Housing Children's Center and you think a flash flood is going to occur, what do you do? (check all that apply)			
Assume he/she is safe	17(10%)	23(15%)	40(13%)
Assume the school has a plan	67(41%)	62(40%)	129(41%)
Call the school	83(51%)	104(67%)	187(59%)
Go pick up child	25(15%)	78(50%)	103(33%)
Call child on cell phone	25(15%)	15(10%)	39(12%)
Expect child to drive to safety on own	3(2%)	0	3(1%)
Expect child to walk to safety on own	15(9%)	0	15(5%)
Call 911 for advice	17(10%)	17(11%)	34(11%)
Other	22(13%)	7(4%)	29(9%)
			(n=319)
26. If you do have a child at Boulder High, does he/she know what to do?			
Yes	5(3%)	8(5%)	13(4%)
No	11(7%)	27(17%)	38(12%)
Don't know	6(4%)	9(6%)	15(5%)
Does not apply	137(84%)	112(72%)	249(79%)
			(n=315)
27.You are driving and come to an intersection covered in water up to the middle of your tires, what do you do?			
Drive through	34(21%)	31(20%)	65(21%)
Go 5 minutes out of the way	94(58%)	105(67%)	209(66%)
Pull over	28(17%)	18(12%)	46(15%)
Other	12(7%)	6(4%)	18(6%)
			(n=319)

	Pop A	Pop B	Total
28. Would it be helpful to have an automatic road barrier at the intersection of Broadway and Canyon (like at a railroad crossing) to warn about dangerous driving conditions due to flash flooding?			
Yes	90(55%)	94(60%)	184(58%)
No	38(23%)	21(13%)	59(19%)
Don't know	29(18%)	38(24%)	67(21%)
Other	6(4%)	3(2%)	9(3%)
			(n=319)
29. If you received a call from the Boulder City/County Office of Emergency Management that told you flash flooding is imminent and to "get 10 feel higher than you are now," what would you do? (check all that apply)			
Go upstairs in your home	32(20%)		
Go upstairs to a higher apartment	42(26%)	102(65%)	144(46%)
Leave and travel by foot	48(29%)	18(12%)	66(21%)
Leave and travel by car	37(23%)	33(21%)	70(22%)
Call a friend/family member to ask for advice	12(7%)	8(5%)	20(6%)
Call City/County offices to ask for advice	10(6%)	10(6%)	20(6%)
Look at creek before making a decision	5(3%)	8(5%)	13(4%)
Nothing	14(9%)	6(4%)	20(6%)
Don't know	11(7%)	5(3%)	16(5%)
Other	4(2%)	6(4%)	10(3%)
Call resident advisor 31(20%)			(n=319)
30. Would your pet(s) delay evacuation or cause you not to evacuate your home?			
Yes	42(26%)	6(4%)	48(15%)
No	39(24%)	31(20%)	70(22%)
Don't know	6(4%)	5(3%)	11(3%)
N/A	82(50%)	114(73%)	196(62%)

	Pop A	Pop B	Total
31. Prior to this survey, did you know Boulder has a warning siren along Boulder Creek to warn about emergencies including flash flooding?			
Yes	113(69%)	117(75%)	230(73%)
No	52(32%)	39(25%)	91(29%)
			(n=321)
32. Prior to this survey, did you know Boulder has an automated emergency call system that will call your home in the event of a neighborhood emergency such as a flash flood?			
Yes	63(39%)	34(22%)	97(31%)
No	112(69%)	121(77%)	233(72%)
			(n=330)
33. How many telephone lines are at this address? (not including cell phones)			
0	13(8%)	0	13(4%)
1	133(82%)	153(98%)	286(91%)
2	11(7%)	3(2%)	14(4%)
3	6(3%)	0	6(2%)
			(n=319)
34. How many telephone lines have voice mail or an answering machine?			
0	16(10%)	21(13%)	37(12%)
1	136(83%)	135(86%)	271(86%)
2	5(3%)	0	5(1%)
3	4(2%)	0	4(1%)
35. How many people at this address have a cell phone?			
0	78(48%)	96(62%)	174(55%)
1	67(41%)	44(28%)	111(35%)
2	15(9%)	16(10%)	31(10%)
3	7(4%)	0	7(2%)

	Pop A	Pop B	Total
36. Do one or more of these cell phones have the ability to check the weather forecast?			
Yes	11(7%)	11(7%)	22(7%)
No	41(25%)	31(20%)	72(23%)
Don't know	41(25%)	25(16%)	66(21%)
N/A	70(43%)	89(57%)	159(50%)
Other	2(1%)	0	2(1%)
			(n=321)
37. How many people at this address have pagers?			
0	156(96%)	152(97%)	308(98%)
1	7(4%)	4(3%)	11(3%)
2	1(1%)	0	1(0)
3	2(1%)	0	2(1%)
			(n=322)
38. Can one or more of these pagers check the weather forecast?			
Yes	1(1%)	1(1%)	2(1%)
No	8(5%)	21(13%)	29(%)
Don't know	8(5%)	4(3%)	12(4%)
N/A	146(90%)	130(83%)	276(86%)
Other	2(1%)	0	2(1%)
			(n=321)
39. Is there currently cable or satellite service at your address?			
Cable	101(62%)	149(96%)	250(79%)
Satellite	4(2%)	1(1%)	5(1%)
Neither	57(35%)	5(3%)	62(20%)
Don't know	1(1%)	2(1%)	3(1%)
Other	3(2%)	0	3(1%)
			(n=323)
40. Is there Internet access at your this residence?			
Yes	115(71%)	151(97%)	266(84%)
No	48(29%)	5(3%)	53(17%)

	Pop A	Pop B	Total
41. Do you use the Internet to check for weather information?			
Yes	115(71%)	89(57%)	204(66%)
No	48(29%)	57(37%)	105(34%)
			(n=309)
42. Do you or others at this address use the Internet at other locations such as at work or at school?			
Yes	117(71%)	152(97%)	269(85%)
No	35(21%)	4(3%)	39(12%)
Don't know	9(5%)	0	9(3%)
Other	4(2%)	0	4(1%)
			(n=321)
43. Do you have a radio that has NOAA weather ability?			
Yes	8(5%)	6(4%)	14(4%)
No	71(43%)	66(42%)	137(43%)
Don't know	85(52%)	83(53%)	168(53%)
Other	1(1%)	1(1%)	2(1%)
			(n=321)
If yes, is it plugged in?			
Yes	7(4%)	4(3%)	11(3%)
No	4(2%)	2(1%)	6(2%)
Don't know	7(4%)	0	7(2%)
Other	147(89%)	150(96%)	297(94%)
			(n=321)
44. Is anyone at this address a ham radio operator?			
Yes	1(1%)	0	1(0)
No	153(93%)	150(96%)	303(96%)
Don't know	10(6%)	6(4%)	16(5%)
Other	1(1%)	0	1(0)
			(n=321)

	Pop A	Pop B	Total
45. Does at this residence have a police/fire scanner?			
Yes	6(4%)	0	6(2%)
No	155(94%)	152(97%)	307(97%)
Don't know	2(1%)	4(3%)	6(2%)
			(n=319)
46. How often do you have the radio on when driving?			
Always	32(20%)	33(21%)	65(21%)
Most of the time	51(31%)	50(32%)	101(32%)
Sometimes	43(26%)	39(25%)	82(26%)
Rarely	10(6%)	20(13%)	30(9%)
Never	9(6%)	5(3%)	14(4%)
Other	18(11%)	10(6%)	28(9%)
			(n=320)
47. (Population A only) Do you own or rent your residence?			
Own	47(28%)---		
Rent	118(72%)	---	
	(n=165)		
48. Does everyone at your residence speak English?			
Yes	156(96%)	145(93%)	301(96%)
No	6(4%)	11(7%)	17(5%)
			(n=318)
49. What is your gender?			
Female	84(51%)	85(55%)	169(54%)
Male	79(48%)	71(45%)	150(47%)
			(n=319)
50. What is your age group?			
18-25	58(36%)	40(26%)	98(31%)
26-35	47(29%)	91(58%)	138(44%)
36-45	16(10%)	19(12%)	35(11%)
46-55	21(13%)	4(3%)	25(8%)
56-65	8(5%)	1(1%)	9(3%)
66-75	6(4%)	0	6(2%)
76 +	6(4%)	0	6(2%)
			(n=317)

	Pop A	Pop B	Total
51.Are you a CU student or faculty/staff?			
Student	50(32%)	112(72%)	162(51%)
Faculty/staff	6(4%)	22(14%)	28(9%)
Neither	90(58%)	19(12%)	109(35%)
Other	9(6%)	3(2%)	12(4%)
			(n=311)
52.What is your highest education level?			
Some high school	11(6%)	0	11(3%)
Completed high school	15(9%)	3(2%)	18(6%)
Some college	58(34%)	26(17%)	84(27%)
Bachelor's	40(23%)	19(12%)	59(19%)
Grad studies	46(27%)	108(69%)	154(49%)
			(n=326)
53. How long have you lived at your present address?			
Under 6 months	38(23%)	36(23%)	74(23%)
6-11 months	22(13%)	25(16%)	47(15%)
1-3 years	60(36%)	80(51%)	140(44%)
4-6 years	11(7%)	11(7%)	22(7%)
7 + years	34(21%)	2(1%)	36(11%)
			(n=319)
54. How long will you continue to live at this address?			
Under 6 months	26(15%)	16(10%)	42(13%)
6-11 months	41(24%)	36(23%)	77(24%)
1-3 years	60(35%)	96(62%)	156(49%)
4-6 years	9(5%)	8(5%)	17(5%)
7 + years	37(21%)	0	37(12%)
			(n=329)
55. (Population A only) What type of home do you live in?			
House	51(31%)		
Apartment	97(59%)		
Mobile home	1(1%)		
Condo	6(4%)		
Townhouse	2(1%)		
Duplex	8(5%)		
	(n=165)		

	Pop A	Pop B	Total
55. (Population B Only) What floor do you live on?			
1st		60(38%)	
2nd		56(36%)	
3rd		34(22%)	
4th		6(4%)	
		(n=156)	
56. (Population B Only) What complex do you live in?			
Athens		34(22%)	
Marine		22(14%)	
Newton Court		51(33%)	
Smiley		42(27%)	
Other		7(4%)	
		(n=156)	
56.How many people live at this address?			
1	75(46%)	14(9%)	89(28%)
2	55(34%)	80(51%)	135(43%)
3	15(9%)	33(21%)	48(15%)
4	12(7%)	22(14%)	34(11%)
5	2(1%)	7(4%)	9(3%)
6+	5(3%)	0	5(2%)
			(n=319)
57.How many people at your address are over 18?			
1	81(49%)	21(13%)	102(32%)
2	62(37%)	135(87%)	197(62%)
3	7(4%)		7(2%)
4	7(4%)		7(2%)
5	3(2%)		3(1%)
6+	6(4%)		6(2%)
			(n=319)

	Pop A	Pop B	Total
58.What is your usual mode of transportation?			
Bike	30(18%)	41(26%)	71(22%)
Walk	70(42%)	88(56%)	158(50%)
Bus	43(26%)	38(24%)	81(26%)
Car	83(50%)	74(47%)	157(50%)
SUV	16(10%)	5(3%)	21(7%)
Truck	8(5%)	3(2%)	11(3%)
Motorcycle	9(5%)	2(1%)	11(3%)
Other	1(1%)	0	1(0)
			(n=319)
59. How often are you around Boulder Creek in the summer?			
Several times per day	23(14%)	47(30%)	70(22%)
Daily	49(30%)	41(26%)	90(29%)
Several times per week	35(21%)	41(26%)	76(24%)
Weekly	19(12%)	8(5%)	27(9%)
Occasionally	28(17%)	18(11%)	46(15%)
Never	5(3%)	1(1%)	6(2%)
Other	5(3%)	0	5(2%)
			(n=320)
60. Is there anyone at this address who would have trouble hearing or comprehending a flood warning?			
Yes	16(10%)	27(17%)	43(14%)
No	148(90%)	128(82%)	276(87%)
Don't know	1(1%)	1(1%)	2(1%)
			(n=321)