After Action Report

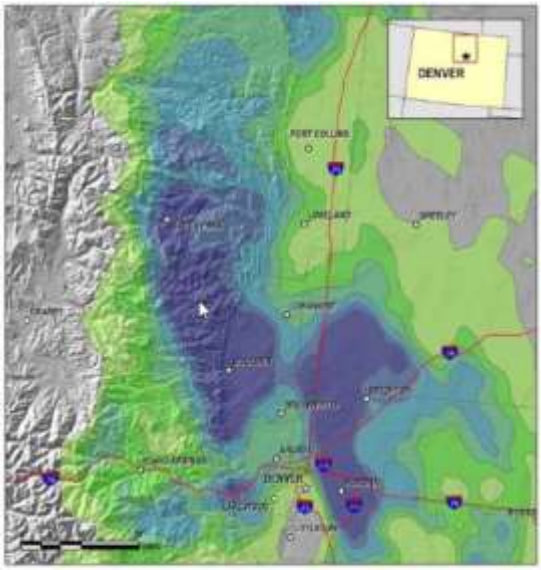
NAME OF INCIDENT: Colorado Flooding 2013

AGENCY: Colorado Department of Natural Resources, Division of Water Resources, Dam Safety Branch (DSB)

SITUATION:
The State of Colorado had been experiencing varying levels of drought prior to the week of September 9. The U. S. Drought Monitor stated that "The combination of ample Gulf and Pacific tropical moisture (in part from Tropical Storms Manuel (Pacific) and Ingrid (Gulf) which inundated Mexico), stalled frontal systems, and up - sloping conditions produced the widespread rainfall along Colorado's Front Range.

The northern Colorado flood not only brought unusual rainfall, it came at an unusual time. On average, April and May are the wettest months, with precipitation totals of 2.45 and 3.04 inches, according to the Desert Research Institute. Precipitation amounts drop slightly in the summer months, but remain relatively high as the North American Monsoon takes hold sometime between June and August. Monsoon winds carry moisture from the Gulf of Mexico northward over the American Southwest. Monsoon storms can bring strong afternoon and evening thunderstorms to the state. Although not the driest month of the year, September is usually much more arid, with average total precipitation of 1.61 inches.

During the week starting on September 9, a slow - moving cold front stalled over Colorado, clashing with warm humid monsoonal air from the south. This resulted in heavy rain and catastrophic flooding along Colorado's Front Range from Colorado Springs north to Fort Collins. The situation intensified on September 11 and 12. Boulder County was worst hit, with 9.08 inches recorded September 12 and up to 17 inches of rain recorded by September 15, which is comparable to Boulder County's average annual precipitation (20.7 inches).

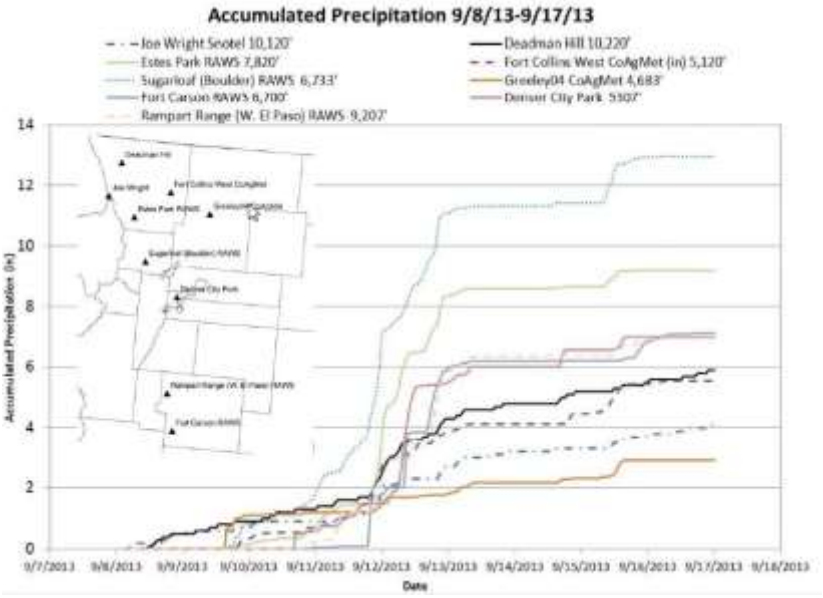


Colorado Flood Event, 9-16 September 2013
Annual Exceedance Probabilities (AEPs) for Worst Case 7-day Rainfall

Hydrometeorological Design Studies Center
Office of Hydrologic Development, National Weather Service
National Oceanic and Atmospheric Administration

By September 12, everything had changed. Flood conditions stretched about 150 miles, from Colorado Springs north to Ft. Collins. Saturated soils left water with no place to go, and puddles turned to ponds throughout the densely populated Colorado Front Range. Rainwater swelled rivers and creeks, overtopped dams, flooded basements, and washed out roads. By September 16, authorities had confirmed six deaths, and more than 1,000 people remained missing.

By September 13, the rain was starting to ease around along the Front Range. But a multitude of damaged or destroyed buildings, waterlogged vehicles, and washed - out roads and bridges meant that Colorado residents would be mopping up for months after the skies cleared.



Amongst the hardest - hit communities was Boulder, located on the northwestern end of the Denver metropolitan area. Boulder's Daily Camera reported that heavy rains started on the evening of September 11 and continued through the following morning. The National Weather Service recorded rainfall amounts exceeding 8 inches in Boulder on September 12, and amounts exceeding 4 inches the next day. Similarly high rainfall totals occurred in other spots along the Front Range. Colorado State University concluded that the precipitation in Boulder County and other parts of the state qualified as a 1,000 - year event, meaning that any one year has just a 1 - in - 1,000 chance of experiencing such heavy precipitation.

Three deaths have been confirmed in Boulder County. Over 1,600 were evacuated, with 262 homes destroyed and nearly 300 more damaged. Nearly 900 square miles were damaged by flooding. Roads suffered extensive damage in Big Thompson Canyon and Buckhorn Canyon, with some sections completely washed away.

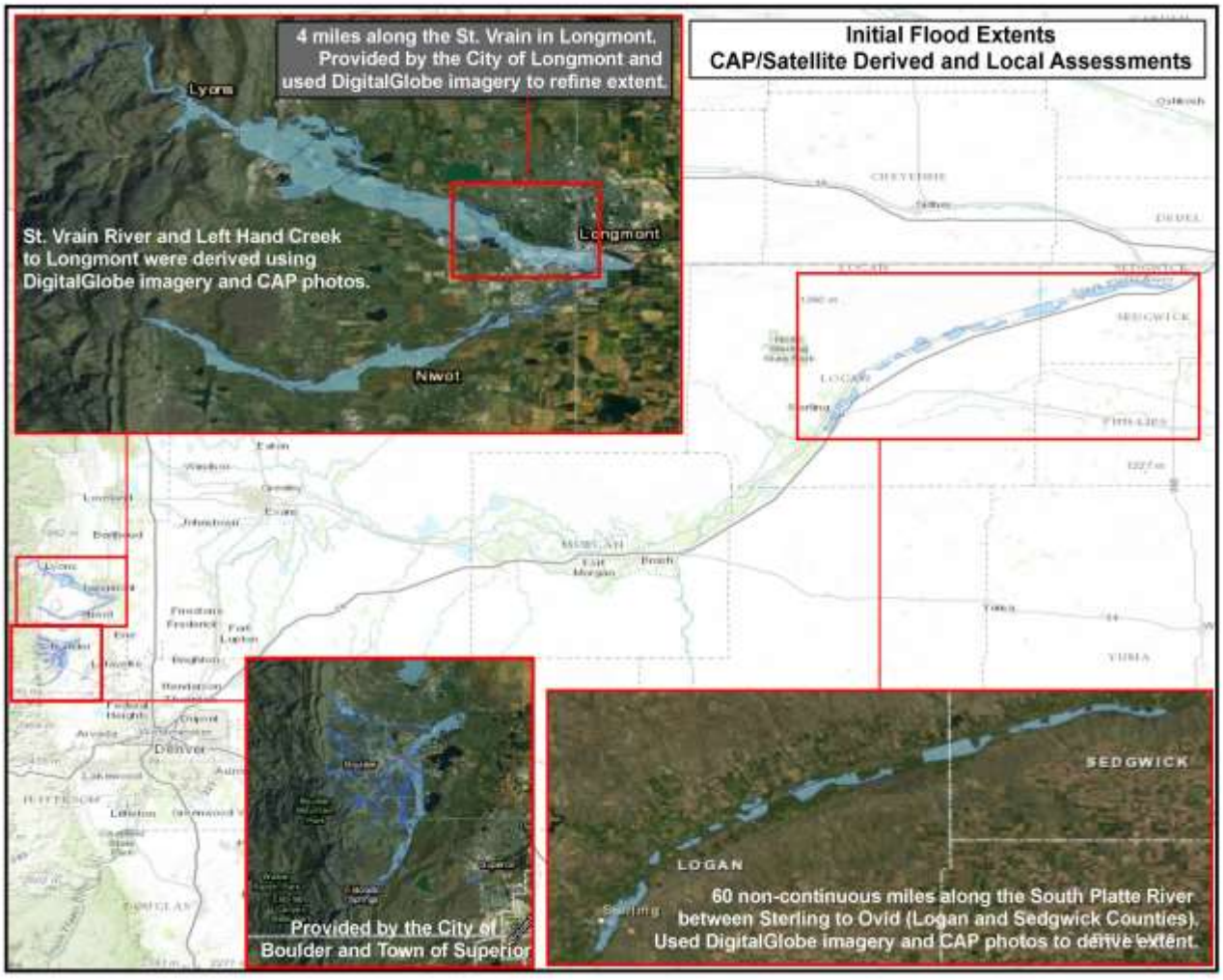
On September 12, the Boulder Creek, which flows roughly eastward through town, crested in downtown Boulder at 7.78 feet - the highest water level observed at that location since 1894. The main highway running through Boulder was partially closed southeast of town, and partially destroyed northwest of town, isolating the nearby mountain community of Lyons. Thousands of residents faced power outages and evacuation orders in the Denver - Boulder area as officials called in the National Guard to assist rescue efforts. Schools, businesses, and government offices closed. Many roads remained closed and impassable for weeks, so multiple mountain communities remained isolated. And the rain kept falling.

Larimer County was also hit hard, with 1,120 square miles affected by flooding, and 1,500 homes and 200 businesses destroyed. An additional 4,500 homes and 500 businesses are estimated to be damaged. Extensive road damage in Big Thompson Canyon completely cut off road access to the communities of Drake, Glen Haven, and Cedar Park. Three dams also failed in the county. Both U.S. Route 36 and U.S. Route 34, the major routes into the tourist town of Estes Park, were severely damaged. Hundreds of Estes Park residents were also isolated by the

destruction of sections of Fish Creek Road and all nine crossings across Fish Creek. Damaged sewer lines dumped raw sewage down the creek and into the Big Thompson River.

Weld County, in northeast Colorado, was flooded by the overflow of the South Platte River. Flooding in Weld County affected 3,000 homes, over 350 commercial properties, and 2,377 agricultural parcels. One hundred twenty-two bridges were damaged and 654 lane - miles of road in Weld County were either damaged by flooding or under standing water. Portions of Greeley, the county seat, were under mandatory evacuation, and whole neighborhoods in Greeley and nearby Evans were submerged after days of flooding. The shutdown of a wastewater treatment facility in Evans put remaining residents on restrictions including not to flush their toilets, do laundry, or bathe.

In Morgan County, the communities of Goodrich, Orchard, and Weldona were placed under an immediate evacuation order the morning of September 14.



In total, early 20,000 homes have been damaged, and at least 1,852 have been destroyed. The Colorado Department of Transportation estimates that at least 30 state highway bridges have

been destroyed and an additional 20 are seriously damaged, with repairs for damaged bridges and roads expected to cost many hundreds of millions of dollars. Miles of freight and passenger rail lines were washed out or submerged.

At least ten deaths have been reported, with the last body being found 27 days later. At one point, there were 1,000 individuals unaccounted for across the entire incident area. More than 18,000 have been evacuated. The town of Lyons in Boulder County was isolated by the flooding of St. Vrain Creek, and several earth dams along the Front Range burst or were over - topped. On September 12, Boulder Creek was reported to have exceeded 5,000 cubic feet of water per second. Boulder Creek regularly flows around 150 - 200 cubic feet per second. This caused serious damage to buildings along the creek and the creek path such as Boulder High School.

Hundreds of oil and gas wells were shut down in the Denver Basin, many of which were under rushing water, and reports of broken lines and storage tanks swept away by the flood waters raised concerns of contamination. A spill from flood - damaged storage tanks in Milliken was reported September 18, which released 5,250 US gallons of crude oil into the South Platte River.

Lower - lying agricultural land in northeast Colorado was affected as flood waters surged down rivers and creeks, inundating fields and pastures. Significant crop damage is expected from standing water that had no way to drain from fields.

As the incident evolved from response to recovery, seventeen counties were impacted under FEMA Individual Assistance / Public Assistance criteria, with an additional two counties being adjudicated. At least 1,750 people and 300 pets have been rescued by air and ground. Rescue efforts were hampered by continuing rain and a low cloud ceiling, which grounded National Guard helicopters. In total twenty shelters were opened with an occupancy of 1,000. The amount of roads damaged / destroyed included 2,500 miles of roadways and highways along with 250 bridges. At the height of the incident electric / natural gas outages were summarized as 10,000 homes without electrical power and 7,500 without natural gas. Isolated communities (defined as: a need for specialized vehicles in order to access the location i.e. high – water, off – road, or via air) totaled 15 three weeks after the height of the flooding. Debris estimated at 50 thousand tons.

DAM SECTOR SPECIFIC SITUATION

Specific for the dam sector of this incident, a total of 207 dams were within the incident area, 27 of which were damaged, with nine (low hazard) failed between Larimer and El Paso counties.[1] No high or significant dams failed throughout this incident. All of these damaged dams will require repair work which will necessitate a lowering of water levels before work can be started. Due to damages to the road network, some dams were inaccessible to ground level inspection for several days and even longer.

[1] Carriage Hills #2 Lower (Larimer County), Emerald Valley Lower Dam (El Paso County), Emerald Valley Upper Dam (El Paso County), Havana Street (Adams County), Meadow Lake (Larimer County), Mirror Lake (Larimer County), Rainbow Lake (Boulder County), Sunset Lake (Boulder County), and Willow Lake Dam (Boulder County).

A total of eleven Emergency Action Plans[2] were activated to facilitate the notification process of downstream jurisdictions. Typically, after the emergency level has been determined, people on the applicable emergency level notification flowcharts shall are notified in order. Level C is for a non – emergency incident; unusual event; slowly developing situation. Level B is for a potential dam failure situation; rapidly developing. Level A is urgent; dam failure is imminent or in progress.

The remaining dams performed as designed. Some of the difficulties that occurred involved the amount of debris that flowed into the reservoirs subsequently clogging intakes and spillways.

A total of 226 dam owners were contacted resulting in Dam Safety Engineers (DSEs) performing 152 immediate dam assessments and performing nine forensic investigations. DSEs were also positioned to support four State / local emergency operation centers.

Emergency Dam Inspection Program		
Inspectors form	Number	Comments
Engineering Consultant Firms	27	Front Range
Federal Agencies	4	FERC, NRC, USACE, USBR
State Agencies	1	Wyoming
Volunteer Engineers	113	All Colorado P.E.

Emergency Dam Inspection Status			
Condition Assessment Categories	Definition	Number	Percent of Total
Response Level 0	Safe for normal operations	128	62%
Response Level 1	Functional, some repairs needed, due to dam safety concerns	65	31%
Response Level 2	Potential dam safety issue exists, needs immediate evaluation	14	7%

[2] Baseline – Northwest (Boulder County), Baseline (Boulder County), Blunn (Jefferson County), Evergreen (Jefferson County), Gaynor (Boulder County), Great Western (Jefferson County), Left Hand Valley (Boulder County), Leyden (Jefferson County), Meadow Lake (Larimer County), Upper Gates (Larimer County), and Windsor Lake (Weld County).

Response Level 3	Urgent, failure is imminent or in progress, notify 911 immediately	0	0%
		207	**100%**

DISCUSSION

Background: In mid-November, the Dam Safety Branch team assembled for a retreat that include a facilitated After-Action Review. General comments from team members are summarized in the following pages, along with capturing strengths, weaknesses and take-aways identified by the group.

As the situation developed, many of the DSEs were notified by some dam owners and in some cases by a local emergency operations center. Internal branch communications were problematic because many of the staff's cell phones had been turned off during non – business hours. It was not until later that day that the magnitude of the event was starting to be understood.

Actions taken on the first full day involved contacting dam owners, watching the news, and attempting to glean information from any source. Additional notifications were further distributed to the Branch leadership. It has been recommended that a formalized notification system to internal staff to alert them to impending developments be acquired. This could take the form of an automated system that would pass a message to the staff via telephone, text, and e – mail.

Gaining situational awareness is always challenging. Besides internal Branch information, it would have helped if there had been daily updates from the dam owners / caretakers as well as the local emergency operation centers. In some situations, contact could not be made with the owners of dams that were in remote areas.

One of the more critical aspects of this incident is that the Branch needs to build upon its existing relationships with local jurisdictions (not exclusively, but primarily with offices of emergency management) and other federal agencies that have dam-related roles and responsibilities. This will help the agency in the immediate short – term in providing that subject matter expertise aspect for a single or multi – dam failure incident. If these relationships are maintained, it will help in the long – term when another such incident happens (likely years from now) when the current staff has retired a new set of DSEs are faced with a large – scale incident.

The Division of Water Resources and the Dam Safety Branch needs to do a better job of outreach to local governments, the media, and the general public. During this incident there was one case where an impacted county contacted the U.S. Army Corps of Engineers requesting assistance / guidance. Also, there were several news stories that contained inaccurate information. The Division / Branch were unaware of the actual source of that information and thus were unable to correct the false information.

Besides the issue of internal communications, there is also the challenge of communicating out in the field. Many of the regulated dams are physically located in remote areas of the State. In some of these areas there is no cellular coverage thus requiring the need for satellite telephone,

800MHz (digital trunked radio system – DTRS), and VHF radios. Need to research the availability of acquiring these types of radios either through direct purchase, leasing, or borrowing.

Finally, we must not lose sight of the need to take care of each other. During situations like this (during and afterwards) everyone deals with stress in their own way. Some can handle it better than others. The staff needs to be aware of the people around them and be able to recognize when they and others may need a break. The staff is very dedicated and has the drive to work through all situations. However, it order to successfully accomplish this, sometimes it is better to walk away for one day per week just to refresh and gain the ability to refocus on the problem.

TIMELINE OF EVENTS:

Sep 12 12:50am	First WebEOC posting regarding flash flooding
Sep 13	All dam owners in affected area contacted
Sep 13	First of four Governor's disaster declarations
Sep 14	Immediate dam assessments begin
Sep 15	DSEs located in multiple EOCs
Sep 15	Need for emergency inspections of dams identified
Sep 16	Presidential disaster declaration issued
Sep 18	Scope of Work sent to consultants for emergency inspections
Sep 19	DSEs from western slope mobilized
Sep 21	Emergency inspections begin
Sep 23	Inspection reports are being received
Sep 24	Forensic field inspection begin by DSEs
Sep 24	Inspections of inaccessible dams begin
Sep 26	Compilation of emergency dam inspection data
Sep 27	Emergency inspections completed

STRENGTHS:

1. The DSB Team was able to pull together through professional, technical competency, and dedication to assist on another and bounce ideas off of each other.
2. Establish and maintain relationships with owners, local / state emergency management officials, and other agencies.
3. Internal communications evolved over time, to include occasional conference call to update everyone.
4. Management of volunteer consultant engineers and to develop on – the – fly plans to get them actively involved.
5. Arrangements for getting to inaccessible dams for inspection / forensics.
6. Knowledge of the area impacted.
7. Ability to prioritize tasks to make the most use of limited time.
8. Google drive for coordination.
9. The leadership provided by Bill McCormick.
10. Coordination at the emergency operations center level in getting access to WebEOC (both virtually and in the centers. This improved over time.

11. Responsiveness to owner / media concerns and questions.

WEAKNESSES:

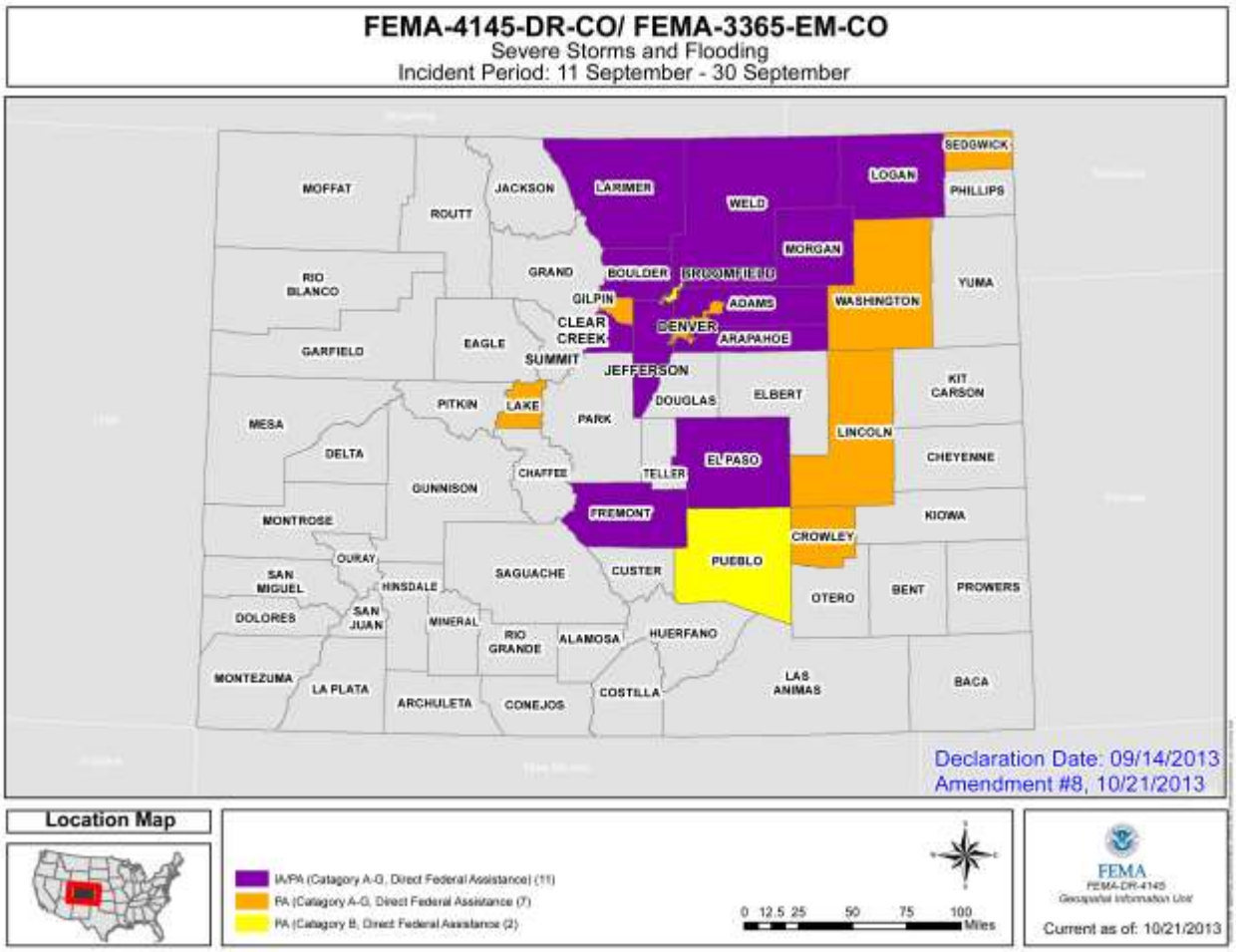
1. Not enough knowledge of the EOC process and how to become integrated in to it. This also includes a specific definition of DSE roles and responsibilities in these situations as well as the role and responsibilities of an emergency manager.
2. Lack of enough / relevant of an internal emergency response organization, notification of staff protocol, and the ability to get the big picture during the event. Twelve engineers running around, but what was the overall sense of how we were responding.
3. As a whole, engineers tend to be a little "territorial" and not want to let go of their areas of responsibility. There is also a reluctance to rely / ask for help.
4. Pre – planning needs to improve. Should not concentrate on only one dam failure at a time. Inherently this also includes improving the availability of dam construction information, inundation flows, converting hardcopy information to digital. Familiarity with available resources (people and materials) for emergency response.
5. Coordination, face - time, and emergency situation training and exercises with emergency managers as well during non-emergencies.
6. Too much responsibility on Bill. Need to be able to rapidly reassign duties (such as Public Information Officer) as the situation develops.
7. Site access – authority / official capacity.
8. Could have had a stronger presence in some of the critical areas.
9. Delayed deployment of DSEs.
10. Internal communications poor at time of event (i.e. I'm here, but not sure what to do).
11. Need to do a better job of eliminating mis – information.
12. Integration with EOCs: Positive is once integration people in the EOC knew who to go to. Negative was feeling underutilized at EOC.
13. Development of volunteer consultant database.

TAKE – AWAYS:

1. Increase awareness of our organization's capabilities. Resources are available and we need to know the process for garnering these. Division education – broaden EOC role to hydrography.
2. Foster relationship between emergency managers (local and state) and owners. Keep on hand current list of emergency managers. Need for local emergency management involvement / communication.
3. Develop method for internal emergency notification and guidelines for availability (e.g. phone on 24 hours, etc).
4. Develop and keep a current WebEOC knowledge.
5. Every DSE keep a current dam owner contact list with them.
6. Increase and keep current understanding of emergency management functions and our role.
7. Develop list of potential available resources.
8. Establish communication lines with US Army Corps of Engineers, US Bureau of Reclamation, etc.
9. Each DSE provide Scott with list of balls going to drop this year.

10. Develop emergency management response plan (ERP). Develop understanding of when and how to activate different support networks, procure resources, and emergency response training. Develop roles and responsibilities for emergency response activities, and activate those as soon as possible.
11. Small dams are a big deal!
12. Central information coordination (Google Drive).
13. Understandable vocabulary for the public and news agencies.
14. Department education – Bob Randall, "We need GOGCC to stand up in EOC like dam safety.
15. Develop internal communication protocols during events and flow of information.
16. Familiarize dam owners with their EAPs.
17. Real time monitoring. Radar overlay on basins. Compare to design event.
18. Have a "go kit" at home with muck boots, flashlights, and other field tools.
19. Emergency manager integration: WebEOC training and getting face time with local and State emergency managers. Could invite them to inspection of high hazard dams.
20. Update contacts in database for non – jurisdictional dams and work on capturing "illegal" or "non – rostered" dams.
21. More regional exercises and discussion, coordination for regional events.
22. Development of permanent volunteer consultant database, certification, implementation process, etc.
23. Coordination of EAP training for dam owners, EMs, OEMs and first responders in my area.

The map below illustrates the counties that were recognized, under two federal declarations, as disasters. The color coding reflects the different federal programs they were eligible for assistance.


FEMA-4145-DR-CO/ FEMA-3365-EM-CO
Severe Storms and Flooding
Incident Period: 11 September - 30 September
SEDGWICK
PHILLIPS
LOGAN
MOFFAT
JACKSON
LARIMER
WELD
ROUTT
MORGAN
RIO BLANCO
GRAND
BOULDER
BROOMFIELD
YUMA
GILPIN
ADAMS
WASHINGTON
CLEAR CREEK
DENVER
ARAPAHOE
GARFIELD
EAGLE
SUMMIT
JEFFERSON
KIT CARSON
PITKIN
LAKE
DOUGLAS
ELBERT
MESA
PARK
LINCOLN
DELTA
EL PASO
CHEYENNE
CHAFFEE
TELLER
GUNNISON
FREMONT
KIOWA
MONTROSE
CROWLEY
OURAY
PUEBLO
SAN MIGUEL
SAGUACHE
CUSTER
HINSDALE
OTERO
BENT
PROWERS
SAN JUAN
DOLORES
MINERAL
RIO GRANDE
ALAMOSA
HUERFANO
MONTEZUMA
LA PLATA
ARCHULETA
CONEJOS
COSTILLA
LAS ANIMAS
BACA
Declaration Date: 09/14/2013
Amendment #8, 10/21/2013
Location Map
IA/PA (Catagory A-G, Direct Federal Assistance) (11)
PA (Catagory A-G, Direct Federal Assistance (7)
PA (Catagory B, Direct Federal Assistance (2)
0 12.5 25 50 75 100
Miles
FEMA
FEMA-DR-4145
Geospatial Information Unit
Current as of: 10/21/2013