A THOUSAND YEARS IN THE MAKING: A LESSON IN RESILIENCE

Author and Presenter: Tony Urquhart

ABSTRACT

In September 2013 a one in one–thousand year rainfall event drenched Boulder, Colorado in the United States. Ten people across the state died in the flooding. Meteorologists used terms like 'biblical' and 'epic' in their description of the flood which affected hundreds of thousands of people, and was the biggest airlift rescue operation undertaken in the US since Hurricane Katrina, damaging 19000 homes and destroying 2500 homes state-wide. Living in the direct path of the storm and having spent nearly five years of my early career as a municipal storm-water engineer in Auckland, I will share my perspective and lessons learned as one of those directly affected by the flood.

KEYWORDS

Flood, resilience, storm, Colorado, Boulder, 2013, rainfall, FEMA.

PRESENTER PROFILE

Tony has been closely involved in assisting the utility and municipal industry with the development of strategic asset management plans, asset management and operational audits, asset valuations, utility business plans and risk management strategies, and is recognised as a global thought leader in the area of utility and municipal asset management.

He has acted as the leader of numerous award winning asset and utility management projects for public and private sector infrastructure owners, utilities, city & state governments, and industry regulators. He is a widely published author on the subject of best practice utility management, investment planning and business transformation having had presented at conferences and published papers in industry journals in Australia, New Zealand, Europe and the United States.

INTRODUCTION

September is usually one of the driest and sunniest months along Colorado' Front Range, making it perfect for outdoor activities such as golf, running, kayaking and hiking. Most residents will tell you the weather in Colorado is one of the reasons they love living there.

September 2013 started out as one would expect. The first eight days of the month offered sunny skies and warm temperatures, and residents of the Front Range took full advantages of the late summer weather. No one expected – not even the meteorologists – that the next seven days would bring rainfall that would exceed the average annual precipitation for an entire year. Boulder has an

annual precipitation (rain and melted snowfall) of just over 500mm, and in the next six days would see close to that amount. The records are especially noteworthy because, prior to September 9, Colorado was sweltering in record heat and long term drought conditions.

A HISTORY OF FLOODING

In the mountains, foothills, and deserts of Colorado, flash flooding can be a serious matter and floods in Boulder and the wider state of Colorado are not unexpected. Nestled against the front range of the Rocky Mountains to the west, Boulder sits at the mouth of three canyons and their associated streams. The mountains are steep and primarily rock with limited vegetation. While most Colorado thunderstorms are not big precipitation producers by Midwest or Eastern standards, even a thunderstorm producing only 20mm of rain in a concentrated area may produce a serious flash-flood, thanks to Colorado's steep topography and thin soils. If a severe storm with ample moisture "parks" in single location and delivers copious amounts of rain, an epic flash flood can occur. An example of this was the 1976 Big Thompson Canyon flood west of Loveland that was one of the deadliest floods in US history, claiming the lives of 140 people.

Boulders nearby mountains are also susceptible to wildfires and in September 2010 fires in the foothills destroyed 26 square of vegetation in the mountains to the east of Boulder and destroyed 169 homes. This is noteworthy because the lack of vegetation from wildfires increases runoff and silt.

A PERFECT STORM

The September 2013 event was not the typical thunderstorm driven localised flash flood. On the morning of Monday, 9 September a cold front dropped into northeast Colorado and the rains began.

A nearly stationary low pressure system to the south-west started pulling a vigorous plume of tropical moisture from the Pacific Ocean and Gulf of Mexico. Blocking it all in place was a high pressure system parked to the west.

On Tuesday, 10 September just over 25mm of rain fell in Boulder saturating the usually dry and arid soils. Stationary low pressure system to the west and high pressure system to the east was driving the moist tropical air against the Front Range foothills, lifting up, cooling, and producing pounding rain over the region. The next 36 hours saw the storms greatest fury as the funnel of moist air continued to be squeezed between the low to the southwest and the high to the west.

By 9pm on 11 September 50mm per hour of rain was falling and in the 24 hour period ending 6 pm on Thursday 230mm of rain had fallen – nearly doubling the previous 24 hour record. The National Weather Service warned of "biblical" rainfall noting "things are not looking good".

The storm had lost its intensity on Friday, 13 September and continued through Sunday 15 September, but flooding continued for many days more. What had seemed like nothing more than an unusual stretch of rainy days transformed into a historic, week -long weather disaster, ravaging homes, cutting off

communities and ultimately claiming 10 lives. The National Weather Service reported that in some locations rainfall had reached a 1 in 1000-year intensity.

Over the course of the flood, tens of thousands of people were directly affected by the flooding, and the number of helicopter rescues was the most since Hurricane Katrina, with over 1750 people airlifted to safety. Official estimates put the number of homes damaged or destroyed at 19,000 state-wide, with over 30 bridges destroyed and another 20 damaged.

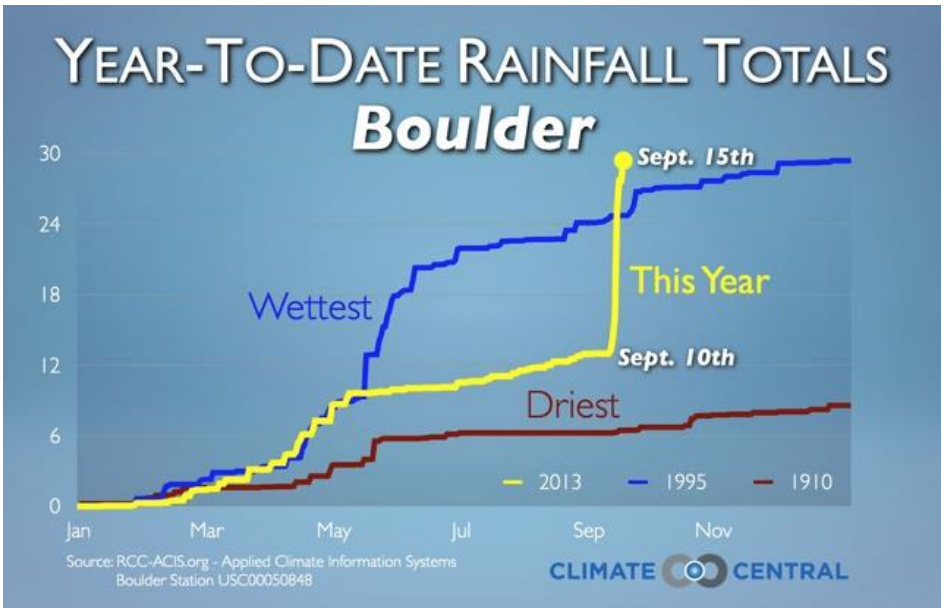

Figure 1: Rainfall 2013

WHAT DID I LEARN

While the buried stormwater network performed well overland flow paths were often compromised because of failure to keep the paths clear. There was significant public misunderstanding of overland flow paths and their purpose given there were stormwater pipes in the ground Many people used sandbags and other material to divert flow paths away from their property, creating significant downstream issues.

Silt and erosion was a significant problem. Once lower grades were reached the silt and large rocks deposited in pipes eventually becoming blocked, compromising the stormwater system

Road culverts were a system weak-point. They often became overloaded and inlet and outlet structures were inadequate to prevent erosion. In many cases the flow path was across the road surface above the existing culvert. High velocities meant that in many cases the road pavement completely washed out and the whole culvert was washed away. Cars then drove into the washouts causing loss of life on some occasions.

Social media was the main source of communication. The power to communicate on a large scale through the digital network was powerful. Facebook, twitter and text messaging were powerful and reliable communication tools.

Crowdsourced flood mapping was an effective means of data gathering. The City of Boulder launched a "Community Flood Assessment" crowd sourced mapping application. Users were encouraged to submit flood reports via a website or smartphone.

Infrastructure dependencies were crucial. With much of the power and telecommunications buried these were simply washed away in the flood. Sewers and water supply supplies were destroyed in many smaller towns. Major highways were destroyed and many arterial roads impassable. 120 bridges required replacement or structural repair. Scour around bridge piers was considerable issue and foundations of many bridge abutments were exposed. Floating debris often caused significant damage.

From a personal viewpoint the Federal Emergency Management Agency (FEMA) was impressive. Within one day of registering FEMA officials were at my own home assessing costs of damage and money to assist with recovery was in my bank account that day. In the two months since heavy rains brought flooding, Colorado survivors received more than $117.4 million in state and federal assistance and low-interest loans and an additional $35.1 million in FEMA's National Flood Insurance Program (NFIP) pay-outs. The FEMA housing inspectors were on the ground quickly and were efficient in capturing data and providing assistance.

CONCLUSIONS

This paper has discussed my personal observation of a devastating storm that had a significant impact on flood protection, stormwater and other infrastructure of Boulder, Colorado, USA, with an emphasis on meteorological aspects and impact on infrastructure.

The importance of designing stormwater infrastructure to take into account scour, silt and potential landslides in extreme rainfall events is an area that needs more emphasis and planning.

Overland flow-path maintenance (and understanding of the purpose by those who live near them) is an important aspect of stormwater management. Many people diverted overland flow paths during the storm using a variety of methods, often compromising the stormwater system.

The use of social media via cellular/wireless networks as a highly effective communication tool during a flooding emergency is an area that many organisations could benefit from. Existing wired communication networks are extremely prone to flood damage.

A GIS/spatial crowdsourcing platform is a powerful tool for rapidly assessing damage in an event such as the 2013 Colorado flood.

REFERENCES:

Martin, B. et al, 2013, Colorado Floods Test Endurance, Skill of Utility Personnel, AWAA Opflow, Volume 39, No.12

Yail M, Kim et al, 2014, Assessment of infrastructure devastated by extreme floods; a case study from Colorado, USA, Proceedings of the Institution of Civil Engineers, November 2014 Issue CE4

Prairie Mountain Publishing, 2013, A Thousand Year Rain: The Historic Flood of 2103 in Boulder and Larimer Counties