

The Great Flood: Alberta's "biblical" deluge of 2013

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Summary

On June 21st 2013 more than 100,000 people were evacuated from their homes in Alberta. Over the following week significant portions of Calgary (and other southern Albertan communities) were inundated by what was variously described as a "biblical" or 100 year flood. The result was Canada's costliest ever disaster, estimated at \$1.7 Billion in insurable damage alone. In other southern Albertan localities, such as High River, where all 13,000 residents were evacuated, hundreds of people remain in temporary accommodation.

One of the main causes of the flooding was traced back to a weather system trapped over a small catchment basin some 80 km to the west of Calgary. Four days of torrential rain poured more than 250 mm of water, in addition to snow melt, into Cougar Creek. The "creek" should more correctly be described as an alluvial fan, and demonstrated this as huge boulders and trees were mobilized across a vast gravel plain. The resulting flows destroyed all access to Canmore and Banff, washing away both the Trans Canada Highway and Highway 1A.

The mass of water flowed towards Calgary, bolstered by heavy rains along its length. It burst its banks in many areas, flooding much of downtown Calgary. The Bow River demonstrated to the city planners that rivers will be rivers, depositing tons of sediment and eroding up to 60 m into its banks. The flooding had a large impact on the city infrastructure which is gradually being repaired. Significant crevasse splay deposits (including manmade debris and sediment) were deposited, and studied in detail in a locality downstream from the city.

The previous "100 year flood" had occurred in 2005, after a hiatus of 70 years. Studies based on earlier floods suggested that there was a potential for a flow of 2400 m³/second in peak flood conditions, which is a concern as the maximum velocities seen in 2013 were only around 1740 m³/second. Yet this was more than three times the flow seen in 2005. Reasons for this may include changes in ground conditions, weather patterns, or is it simply that the worst is yet to come? The likelihood of another flood like that of 2013, and the periodicity of flooding, will be examined.

Introduction

The 2013 flood in Alberta had a huge impact on the lives of everyone living in the southern part of the Province. No one will forget the incredible spirit shown by Albertans in helping to clear up the resulting flood related damage, leading to commendations and justified praise. Many questions regarding the flooding remain unanswered, which encouraged the author to start collecting data.

The Bow Basin covers an area of around 25,000 square kilometres. The Bow River rises at the Bow Glacier and runs eastwards joining the Oldman River to the west of Medicine Hat. Several rivers feed into the Bow River, notably the Elbow and Highwood Rivers. Peak flow rates have been recorded for the Bow River in and below Calgary since 1911. The water feeding the rivers is sourced from the Pacific Ocean, and falls as rain and snow, ranging from 300 to 600 mm annual average precipitation heading mountainward. Up to 50% of the average annual rainfall fell in less than 24 hours along the Foothills on June 20th 2013, as a giant low pressure system became trapped over the mountains. Flooding was exacerbated by a number of contributing factors including sodden ground, poor flood defences and the stationary weather pattern.

Over the following few days the flooding had an enormous impact on the communities across southern Alberta. While High River was the worse affected, this paper will concentrate on Canmore, where much of the flood waters were amalgamated, and Calgary, where the author resides. Canmore was completely cut off from Calgary, after both the TransCanada Highway and Highway 1A were washed away within a day of the commencement of flooding. The catchment area for Cougar Creek, on the north side of Canmore, pushed a vast amount of water through the lower Cougar Creek, washing away houses and the Highway. In Calgary over 30 communities were evacuated, and a mandatory no-go zone was imposed on the downtown area. Large parts of the city were flooded along the Bow and Elbow Rivers. Both communities are still recovering from the fall out from the flooding. Damage across the Province is estimated at \$1.7 Billion, but this is only insured damage, so the real figure may be two or three times this amount, making it Canada's costliest disaster, probably more expensive than the damage caused by Hurricane Katrina.

There was a huge impact on Canmore, on Calgary and on other communities. People and wildlife alike suffered and were forced to relocate. Transit systems were destroyed, whole communities flooded, and a vast clean up operation was required. Many bridges were closed or washed away. Repairs continue to be made to pathways and houses, and the final cost of this disaster is likely to exceed \$3 Billion. Little appears to have been changed in terms of planning for the next flood, should one occur.

Method

A variety of data sources were examined ranging from the internet to magazine articles, newspapers and more. Many of the images copied from the internet were from newspaper websites, supplemented by local council websites and by photographs taken by friends and by the author. Several published documents were downloaded which examined the flooding history of Calgary, as well as estimating the risk of flooding going forward. The author acknowledges the vast array of public data sources used to pull together the conference presentation and this extended abstract.

Initiation and Impacts of the Flood

River systems

The Bow Basin covers an area of around 25,000 square kilometres. The Bow River rises at the Bow Glacier and flows downstream through Calgary and on to the confluence with the Oldman River to the west of Medicine Hat. The distance from Bow Glacier to Calgary is around 200 kilometres. Feeding into the Bow River above Calgary are waters from Lake Minnewanka, from the Spray Reservoir, via Cougar Creek and the Kananaskis River (amongst others), and the Elbow River joins the Bow at their confluence by Fort Calgary. Below Calgary the flow volume is supplemented by the Sheep and Highwood Rivers, and by other rivers further downstream. Peak flow rates on the Bow River have been recorded since 1911. Most of the water feeding these rivers is originally sourced from above the Pacific, and is transported by weather systems to fall as rain and snow. Snowfall makes up 50% of the yearly average of 600 mm precipitation in the mountains, and around 25% of the 300 mm average precipitation on the eastern prairies.

Weather and flood records

The weather was clearly a major factor in creating the flood. A giant low pressure system came over the Rocky Mountains and became mired in a loop of the Jet Stream, leading the system to become stalled and spinning over the Foothills. A high pressure system in northern Alberta also blocked its passage. The low pressure system sucked in water from the United States, the Gulf of Mexico and Saskatchewan, and the rain started falling on the evening of June 19th, continuing for more than 24 hours. As a consequence on June 20th to 21st the area between Banff and to the west of Lethbridge, along the Rocky Mountain front, experienced extremely high rainfall, with up to 50% of the average yearly rainfall, or up to 300 mm, in less than two days. Easterly winds helped to pump humidity onto the rising slopes of Rocky Mountain foothills. The runoff was exacerbated by saturated ground, partly as a result of recent snow melt. It is telling that most of Calgary's historical floods have occurred in June and early July, probably for much the same reason.

Looking back at weather records dating back to the 1800's, a series of floods are recorded from 1879, 1897, 1902, 1929 and 1932. There is then a significant hiatus in flooding events until 2005, followed by the 2013 flood. During the hiatus there was a change in weather patterns, with a lack of cyclonic storms. It would appear that the weather has reverted to one prone to such

cyclones, which may well affect the likelihood of further flooding. The 1929 and 1932 events both resulted from heavy rain in the Foothills, while the 1902 flood event was due to a very wet summer with saturated ground.

In terms of maximum peak discharge, estimates for the 1879 and 1897 floods suggest a figure of around 2249 m³/second. This compares to the 2013 values of 1740 m³/second, which would suggest that the so-called 100 year flood of 2013 was only flowing at a peak rate of some 77% of the possible flow rate. Of course changes have been made to the river system since the earlier floods. It is estimated that there has been a reduction in storage in the Bow River system of 13% since the 1932 flood. There have also been a series of dams constructed, beginning in 1910. These reduced channel movement, braiding and island occurrence. Three further dams were constructed in the 1930s, and another five in the 1950s. These can be operated to control flooding, but clearly they have their limitations.

Several studies have looked at the potential maximum discharge rates. The Monenco 1968 study indicates a potential maximum discharge of 2830 m³/second every 100 to 150 years; the 1977 study suggested 2265 m³/s every 70 years; the 1983 study indicated a 100 year estimate of 1980 m³/second; and the Golder and Associates study in 2010 predicted 1700 m³/second every 100 years. What do these figures suggest? All the values exceed the 2013 value except for the most recent study, so there seems a high probability that the 2013 value will be eclipsed within the next 50 years (based on the fact that two of five floods exceeded 2200 m³/second in the 53 years between 1879 to 1932). It should be noted that maximum peak discharge rates outside the city may exceed those within the city by more than 500 m³/second.

Impact on Canmore

Canmore suffered disastrous flooding, with a State of Emergency declared as early as the morning of June 20th. Much of the flood waters flowed through Cougar Creek, located on the northeast side of the city. Cougar Creek is a steep mountain watercourse between Mount Lady Mac and Grotto Mountain. The creek should more correctly be termed an alluvial fan, which was "channelised" by the city in the 1960s. Prior to this Cougar Creek flowed unrestrained over an alluvial fan, and the channel shifted laterally across the fan in response to high flow events. Since channelization the creek continues to attempt to shift laterally resulting in periodic episodes of bank erosion. The catchment area for the Creek is a paltry 42 square kilometres, but on June 20th it received some 300 mm of rain, all of which had to pass through the 23 m gap in the lower reaches of Cougar Creek. As a result the Creek formed a braid plain that swept houses aside and ended up cutting through the Transcanada Highway, before flowing alongside what remained of the highway. In the neighbourhood of the Highway the Creek transported a slurry of mud, trees and boulders, some of them several metres in diameter. The Creek also flooded parts of downtown Canmore. A 1980s engineering report correctly stated that Cougar Creek had "catastrophic flood potential".

Impact on Calgary

On June 21st approximately 75,000 Calgarians were evacuated. It is estimated that less than 10% of the evacuees had to be provided shelter by public authorities, as the rest were housed by friends and volunteers. Downtown was declared a mandatory evacuation area to allow relief workers to begin the clean up process. Parts of the transit services were flooded and tracks warped, necessitating extensive repairs. The Stampede Grounds were completely flooded, yet still managed to host the Stampede events less than two weeks later. The Saddledome was flooded to the ninth row of seats, and reopened for business in October. Bonnybrook Bridge collapsed due to scour of one of the concrete supports by the Bow River, and repairs continue. Apart from the city infrastructure, thousands of homes were flooded, many due to sewerage back up, including entire communities, such as Bowness, Sunnyside and several more along the Elbow River. There were very few reports of looting, and thousands of volunteers were quick to help people clear up their properties after the flooding receded.

Impact on wildlife

The zoo suffered catastrophic flooding with damage estimated at \$52 Million. Parts of the zoo later had to be knocked down. A newspaper report suggested that the hippos might have been able to escape into the Bow River, and many of the animals were flooded in their cages, although very few died (a peacock and a few piranhas only). One apocryphal story alleged that the zoo planned to use the holding cells at the Calgary Court Centre to house the lions, tigers and leopards, but this was not actually true. Many wild animals were forced from their riverside homes, with beavers spotted on decks and sheltering on the river banks with their kits. The fish population plummeted, although there were stories of residents catching fish in Bridgeland and on Elbow Drive. Insect populations are also likely to take years to recover.

Sedimentology of the flooding

Some interesting depositional features have been recorded associated with the flooding in the city of Calgary and in the reaches below. Of some significance is the increase in the size and relief of braid bars within the city limits, particularly around the 10th Street bridge and in the Inglewood area. However it remains to be seen whether the return to lower, Fall flow rates will gradually eat away at the braid bars, restoring their former morphology. Extensive bank erosion occurred, sweeping away some 31 kilometres of river paths, with the worst affected area also being located in Inglewood, close to the Bird Sanctuary. Here the river ate back 60 m into the cut bank. On the inner bends many point bars, such as Bowness and Inglewood Golf Course, were extensively flooded. Indeed a friend of the author remarked that as a result of the flooding he finally appreciated exactly what the word "floodplain" really meant.

With the flooding came tons and tons of mud. Fleets of trucks were employed by the city to remove the mass of mud that the flood waters left behind. However, taking a walk around the city today, an observer would have trouble identifying any overbank flood deposits. While much has been cleared manually, it appears that the preservation potential of these crevasse splay deposits is very low. One feature that remains obvious is the fallen trees and shrubs along the riverbanks. However in the longer term it is expected that these will rot away leaving little trace. More extensive flood deposits were examined at Sandy Point, around 100 kilometres north of Medicine Hat on the South Saskatchewan River, where up to 50 cm of sediment was deposited. The mud (actually a fine grained silt) dried out and formed deep mud cracks, while trenching through the muds showed dominantly horizontally stratified deposits, with some climbing ripples. It is planned to revisit these deposits in 2014 to see whether they have been preserved.

Flood mitigation following the 2013 flood.

Little seems to have been done since the flooding. In Canmore a debris net and steel mesh have been installed on the banks of Cougar Creek. These are designed to catch sediment upstream and minimise deposition of gravel and sand in the inhabited zones adjacent to the Creek. The mesh should prevent bank erosion, hopefully stopping houses from being undermined. In Calgary, the government announced it would buy out flood zone properties in communities where the flooding occurred, and ban new development in those areas. Houses located in the adjacent floodways would not be entitled to flood insurance.

Conclusions

The Alberta flooding of 2013 was a disaster the scale of which had not previously been seen in Canada. The final cost may dwarf that of Hurricane Katrina. However there is little evidence to support the much bandied term "biblical" or even 100 year flood, as statistical data suggests that it is very likely to be repeated within the next 25 years. Few convincing preventative measures seem to have been taken by the cities that suffered in the flooding. The depositional features associated with the flood seem to have little preservation potential, which has implications for those features, such as crevasse splays, that are preserved in the fossil record.

Acknowledgements

I would like to thank everyone who has published photographs of the flooding on the internet. The level of reporting by the press was also excellent, and I have drawn freely on their published material. I would also like to pay tribute to all of those who volunteered and helped with the clean up of the city. It was amazing to see the city fathers having to turn volunteers away, repeatedly, due to the overwhelming numbers. Calgarians received a special Commendation for Outstanding Service from the Governor General of Canada as a result.

References

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