Flood hydrology of the Storms River tubing accident

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In March 2000, 13 people died in a tubing accident on the Storms River. The reasons given in the media for the accident were 'freak flood' and 'flash flood in side kloof', which were considered to be acts of God. A study of the hydrology of this river and the surrounding rivers found this to be untrue. The rainfall records indicated significant widespread rainfall over the whole Tsitsikamma area during the accident period. The historic rainfall records indicated that rainfall of the magnitude experienced over the accident period had a recurrence interval of three times a year on average. The water-level records from three nearby gauging stations showed a good correlation between them and are a good indication of the water level in the Storms River during the accident period. The historic records of these gauges indicated that a flood of the magnitude experienced during the accident was likely to occur two to three times a year on average. An understanding of the hydrology of the river may have resulted in the river guides making a different choice when confronted with the flood in the major tributary, thereby saving many lives.

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Floating down a beautiful river on a tube is a wonderful experience especially popular these days at company team-building breakaways. A typical scene of tubers on the river is shown in figure 1. However, it can also lead to disaster. On the evening of 25 March 2000, the media reported the unfolding drama of a number of people missing, feared dead, in a tubing accident on the narrow Storms River gorge in the Tsitsikamma mountain range, on the border between the Eastern and Western Cape Provinces. In total, thirteen people lost their lives, turning a fun company breakaway into a tragedy.

The reasons given in the media for the accident were 'freak flood' and 'flash flood in side kloof', which were considered to be acts of God (*Eastern Province Herald, Eastern Cape Weekend*).

With the death of so many people, the question that must be posed is, could this accident have been foreseen and prevented? Was it, in fact, a freak flood or flash flood, as suggested in the media? More importantly, it must also be asked, could an accident like this happen again?

A study of the flood hydrology of the Storms River during this accident period, when compared with a longer historic record, helps to put the accident into perspective and may provide answers to these questions.

THE ACCIDENT

A schematic layout of the Storms River catchment is shown in figure 2. The river rises in the Tsitsikamma Mountains, cuts deeply into the coastal plateau, across which the N2 national road is constructed, discharging into the Indian Ocean at the popular Storms River Mouth resort. A large tributary of the Storms River, the Witteklip River, also rises in the Tsitsikamma Mountains and joins the Storms River fairly near the sea.

River tubers traditionally enter the river at the Old Road bridge, as shown in figure 2,

Figure 1 Tubers enjoying the Storms River (Photo by Euan Waug)

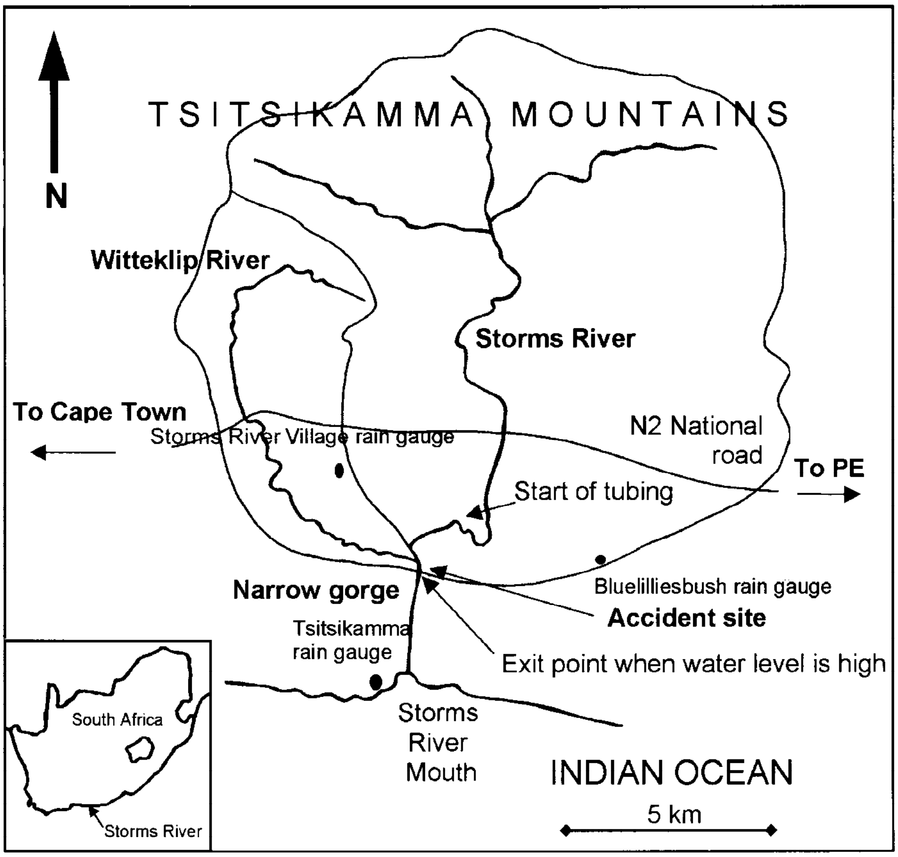

Figure 2 Layout of Storms River catchment

Figure 3 Tubers in narrow section of gorge during low flow conditions (Photo by Gill Manley)

and continue down through the narrow gorge section, ending at the river mouth. If the water level is high, the narrow gorge section is extremely dangerous and tubing down the river is prohibited. However, if the water level is considered 'medium high', the commercial company which uses river guides to take inexperienced tubers down the river, is allowed to go down the river as far as the emergency exit or escape route, which is just before the dangerous narrow gorge section, and about 500 m below the confluence with the Witteklip River.

On the morning of 25 March 2000, three large groups of rafters were booked to go down the river with the commercial company. Heavy rain had fallen in the early hours of that morning, and there was some debate as to whether to continue with the planned river trips. Finally, all three groups did enter the river, the final group leaving relatively late in the morning, despite the continual rain. In spite of the rain, the water level in the river was not considered abnormally high at that stage. The first two groups successfully completed tubing the river, exiting at the escape route. The final group, however, somewhat slower than the other groups, found on reaching the confluence with the Witteklip River, that the tributary was significantly flooded, noticeably swelling the water in the Storms River. Instead of taking the inexperienced tubers off the river at this stage, the guides opted to continue the last half a kilometer to the emergency exit where arranged transport was waiting for them. Unfortunately from that point on, the water level in the Storms River itself apparently rose rapidly and significantly, with the result that the river guides were unable to control the group of inexperienced tubers, and a number of tubers and guides were swept into the dangerous narrow gorge section, where most died (*Eastern Province Herald*). Figure 3 shows what the narrow section of the gorge looks like when the water level is low.

RAINFALL DATA

Rainfall over the accident period

Rainfall is the basis of any hydrological analysis. Rainfall was recorded at a number of stations in the Storms River area over the 24–26 March 2000 period, namely at the Lottering, Witelsbos, Bluelilliesbush, Storms River Village, and Tsitsikamma stations (South African Weather Bureau). The Storms River Village rainfall station is on the plateau near the Tsitsikamma mountains and lies between the Lottering and Witelsbos / Bluelilliesbush rainfall stations, while the Tsitsikamma station is located at the Storms River Mouth on the coast. The positions of the rainfall stations, closest to the Storms River can be seen in figure 2. The Storms River Village station is the closest gauge to the upper catchments of the Storms River, as there are no rain gauges in the mountains.

Based on the rainfall data from Storms River Village station, 25 mm of rain fell on Friday/ Saturday to 8am Saturday 25 March, and a further 51,2 mm fell on Saturday/Sunday to 8am Sunday 26 March. The total recorded rainfall for the period 24–26 March was 76,3 mm. According to the Storms River Forestry Officer, most of the 25 mm of rain that fell in the Friday/Saturday to 8am period, fell in the early hours of Saturday morning (Report on the Storms River Tubing Accident, Storms River Forestry Officer). A similar rainfall record was recorded at the Tsitsikamma station, with 13,8 mm of rain recorded on Friday/Saturday to 8am Saturday 25 March, and a further 54 mm fell on Saturday/Sunday to 8am Sunday 26 March. The total rainfall for the period 24–26 March was 80,5 mm. The corresponding rainfall records for Bluelilliesbush, Witelsbos, and Lottering showed that 71,9 mm*, 66,6 mm*, and 73 mm* of rain respectively fell over the combined period 24-26 March to 8 am. (* Indicates only cumulative rainfall was recorded over the period 24–26 March at these stations.)

It can therefore be appreciated that there is a good correlation between all the rainfall records, indicating that the rainfall was widespread over the period and of a similar intensity, in the order of 70–80 mm over the two-day period. (It is necessary to consider the two-day records as rainfall was only recorded over the period 24–26 March at some of the gauges.*)

Records also show that the previous rainfall in the area during the period 13–17 March was sporadic light rain, measuring in total 20,7 mm at Storms River Village, 19,6 mm at Tsitsikamma, 16,7 mm at Witelsbos, 23,3 mm at Bluelilliesbush, and 35 mm at Lottering. For the period 18–24 March the records showed that no rain fell in this area. This means that the ground was not saturated

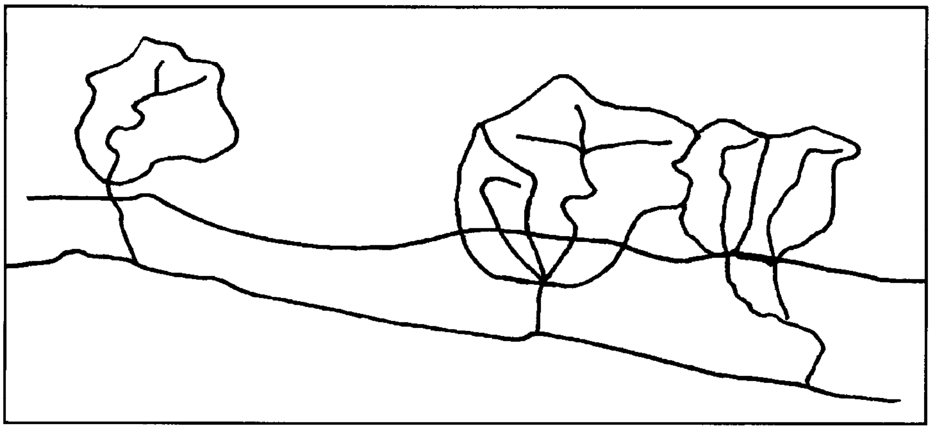

Figure 4 Locality plan of river catchments

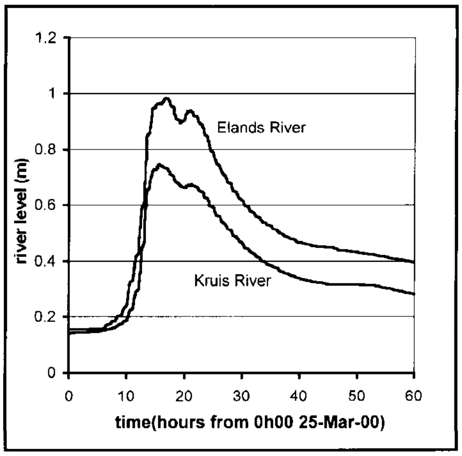

Figure 5 Water level record in Elands and Kruis rivers during accident period

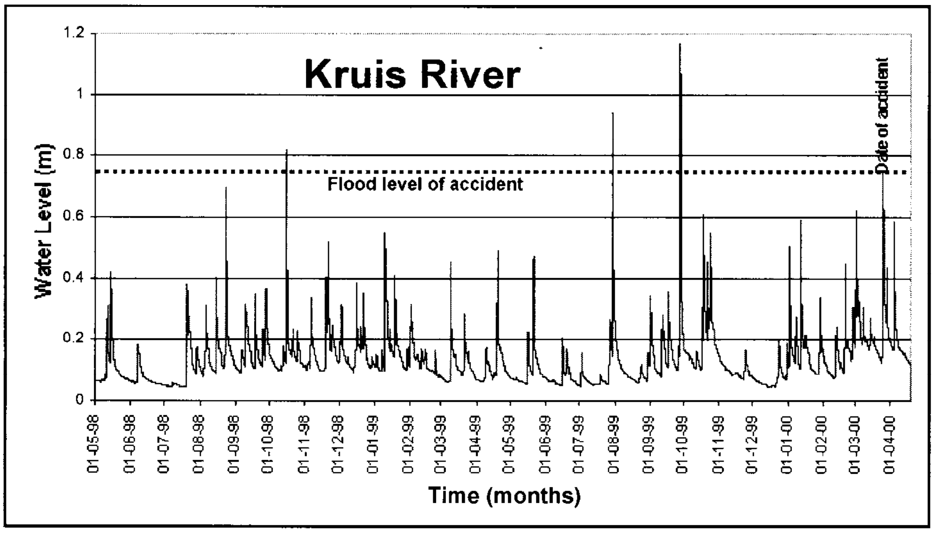

Figure 6 Water level record in Kruis River over period 1 May 1998 to 18 April 2000

from a previous rainfall before the rainfall on 24–26 March occurred. However, the rain falling in the early morning of 25 March would have wet the ground significantly, but may not have resulted in a noticeable rise in water level in the Storms River, and would have had the overall effect of increasing the runoff from rain falling later in the day.

Historic data

Historic rainfall records were obtained for the Storms River Village, Bluelilliesbush and Tsitsikamma rainfall stations (South African Weather Bureau). As the Storms River Village and the Bluelilliesbush rainfall stations are closest to the source of the Storms River in the Tsitsikamma Mountains, records from these stations were considered to be representative of the rainfall in the catchment of the river and were analysed statistically.

The record for the Storms River Village station indicated a high number of rainfall events of magnitude greater than the 51,2 mm recorded on Saturday 25 to 8am Sunday 26 March 2000, namely 123 occurrences in 41 $^1/_2$ years, for the period May 1958 to 31 December 1999. This represents an average recurrence of three times in a year. Thus, a rainfall of the magnitude experienced during the accident period, or greater, can be expected to occur three times a year on average.

In the period June 1950 to 31 December 1999 (49 years), the Bluelilliesbush station revealed a similar pattern, with 149 events greater than the 72 mm recorded over the two-day period. This also represents a recurrence of about three times in a year on average.

Thus it can be stated that the rainfall event of Saturday 25 to 8am Sunday 26 March 2000 was not an unusual rainfall event at all and represents an average recurrence of three times in a year, or less than a '1-in-1-year recurrence'.

RUNOFF DATA

Recorded runoff during the accident period

The Department of Water Affairs (DWA) has a number of water-level weir-gauging stations located on rivers around the country. Three such gauging stations are located in the vicinity of the Storms River, namely on the Bloukrans, Kruis and Elands rivers. The Bloukrans River is 25 km west of the Storms River, while the Kruis and Elands rivers are the next two adjacent river catchments to the east, respectively nine and 13 km east of the Storms River. The catchments of these stations are shown in figure 4. There is no gauging station on the Storms River. From the DWA data (Department of Water Affairs and Forestry, Cradock, Department of Water Affairs and Forestry, Western Cape Region) it was observed that all three gauges recorded a flood peak in the afternoon of 25 March 2000, in line with the widespread rainfall recorded, as discussed above.

Based on this DWA water level recorder data, at about 2.30pm on 25 March, the Bloukrans River showed a sudden increase in water level of about 0,58 m over a short time period. The flood peak (1,07 m) occurred at 5pm on the 25 March, about 0,11 m higher than that recorded at 2.30pm. The total rise in water level for the event was therefore 0,85 m between 12 noon to 5pm. The peak runoff recorded in the Bloukrans River was 23,8 m^3/s.

The Elands and the Kruis rivers recorded similar rises in water level, (approximately 1 m in Elands and 0,75 m in Kruis) although over a longer time period of about eight hours, starting at approx 8am with the peak at 4pm. The steepest rise was from 12am to 2pm in both rivers. The peak runoff recorded in the Kruis and Elands rivers was 17,7 m^3/s and 17,9 m^3/s respectively. The rise in water level in the Elands and Kruis rivers over the period 25–27 March 2000 can be seen in figure 5. Note the very steep rise in water level over the accident period, 1–2pm on 25 March.

Since the catchments of these three rivers and that of the Storms River all lie in the Tsitsikamma Mountains, are climatically very similar and have similar catchment characteristics, it can be expected that a similar flood peak with a similar rapid rise in water level would have been experienced in the Storms River in the afternoon of 25 March 2000.

The catchment area of a river has a significant influence on the amount of runoff experienced as a result of the rainfall. The catchment of the Storms River is about 120 km^2, compared to the Bloukrans of 57 km^2, Kruis of 25,5 km^2, and the Elands River of 34,5 km^2. This would indicate a larger runoff would be experienced in the Storms River, although not necessarily a higher rise in water level, as this would depend on the cross-sectional area of the river channel. No accurate cross-sectional area of the accident site is available to determine the extent of the rise in water level during the accident period, but based on the other rivers in the area, a rise in water level, possibly in the order of 0,7–1,0 m or higher was probably experienced.

Historic recorded events

In a study of the Elands and Kruis River gauging station records for the period October 1990 to January 2001 (the last ten years) (Department of Water Affairs and Forestry, Cradock), flood events of the magnitude of that recorded on 25 March 2000 or greater, have occurred 27 times in the Elands River and 34 times in the Kruis River. This is in the order of two or three times a year on average for both these rivers. Figure 6 shows the water level record from the Kruis River for the period 1 May 1998 to 18 April 2000 and illustrates this high frequency of floods. A similar occurrence occurred in the Bloukrans River (Department of Water Affairs and Forestry, Western Cape Region), with 24 flood events of the magnitude recorded on 25 March 2000 or greater, during the period January 1990 to December 2000. This is also in the order of two or three times a year on average. There is a good correlation of flood events between these three rivers and it can be expected that a similar recurrence of flooding would have been experienced in the Storms River, which lies between these rivers, ie floods of this magnitude may be expected in the Storms River twice or thrice in each year, on average. It can be seen in Figure 6 that the rise in water level is always rapid, and that floods greater than or equal to the magnitude experienced during this accident, occur frequently.

These records indicate that the flood experienced in the Storms River during the accident period was not a freak flood. It was in fact a fairly common flood, occurring probably in the order of two or three times a year on average.

FLASH FLOOD IN SIDE TRIBUTARY

The tubers experienced a significant flood of water when they arrived at the confluence of the Witteklip River, giving rise to speculation in the media that a flash flood in the side tributary was the probable cause of the accident, and that the guides could not have anticipated this flood. An isolated flash flood in this side tributary alone seems unlikely in view of the significant widespread rainfall recorded over the accident period. However, an understanding of the overall hydrological mechanisms of the Storms and the Witteklip rivers sheds new light on the accident.

The catchments of the Storms and the Witteklip rivers have similar characteristics, except that the catchment area of the Storms River is about 70 km^2 while that of the Witteklip is only 22 km^2. Since the volume of storm runoff is proportional to the catchment area, this means that a flood experienced in the Storms River will be significantly larger than that experienced in the Witteklip River, for a similar rainfall. Furthermore, the time taken from the start of a storm until the peak runoff is recorded (time of concentration) at the confluence of the two rivers, is in the order of four hours (after infiltration losses) in the Storms River, while it is only about two and a half hours in the Witteklip River. This means that if both catchments are experiencing similar rainfall, the flood in the Witteklip River will arrive at the confluence of the rivers first. So the flood in the Witteklip River experienced by the tubers was not an isolated flash flood, but a warning of a greater flood soon to be experienced in the Storms River itself. Possibly, if the guides had had this hydrological knowledge they may have immediately taken all tubers off the river when they encountered the flooded Witteklip River, saving many lives.

COULD IT HAPPEN AGAIN?

Floods of the magnitude experienced during this accident period will definitely happen again. The question is, can a similar accident be prevented? An understanding of the hydrological mechanisms of the Storms and Witteklip rivers, as explained in this article, and an accurate reading of nature's signs will go a long way towards preventing another accident. The establishment of an automatic rain gauge in the mountain catchment, or a water-level gauging station some distance upstream of the sections to be tubed, linked to a telemetry system to relay this data immediately to the Controlling Bodies of the river, would be a costly but effective early warning system.

CONCLUSION

The study of the hydrology of the Storms River during this accident period on 24/25 March 2000 shows that the flood experienced in the Storms River was not an unusual event, or even a flash flood, as suggested in the media. In fact, in hydrological terms, it was a common, minor flood, with similar floods in all the other rivers in the whole Tsitsikamma mountain range.

From a hydrological point of view, rainfall produces runoff and it was the increase in the runoff which led to a rise in water level, which was ultimately the cause of the accident. Based on the rainfall experienced on the morning of the 25 March 2000, the guides could have expected a rise in water level and a flooding in the Storms River later in the day. It seems that the accident may have been avoided if the guides had had an understanding of the hydrology of the river. As such a flood event is likely to happen again, the evidence discussed above suggests that steps should be taken by the controlling bodies to ensure that the river guides fully understand the hydrology of the river, and to install an early warning system based on the upstream water level in the river, otherwise a tragedy such as this could occur again.

My condolences go to the loved ones of those who died in the accident.

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