RESPONDING TO A 100 YEAR STORM – AN ACTUAL EXAMPLE IN AUCKLAND

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ABSTRACT

A short duration, high-intensity storm, hit northern Auckland on 3rd July 2012. The 10-30 minute duration intensities reached 1% AEP. This storm caused the worst flooding experienced in northern Auckland since 2000 and resulted in 70 buildings being flooded.

This paper outlines the actions taken by Auckland Council's Stormwater Operations Group in responding to this heavy storm and their field observations. The focus of this paper is as follows:

- Brief analysis of the storm event based on actual rainfall records
- Council's response to this storm
- Causes of the reported flooding problems based on field observations

This paper also suggests actions to enable improvements in the work practices of people working in the stormwater and building industries and how to avoid similar problems of this nature in future.

KEYWORDS

Rainfall intensity, short duration, overland flow path, popping manholes

PERSONAL PROFILE

Frank Tian is presently Auckland Council's Northern Stormwater Operations Manager. He has 20 years of experience in many aspects of stormwater management and has previously held positions in the public sector, private sector, and in research. He received his PhD in 1997 by studying stormwater related environmental issues from the University of Waikato and is a Chartered Professional Engineer.

1. INTRODUCTION

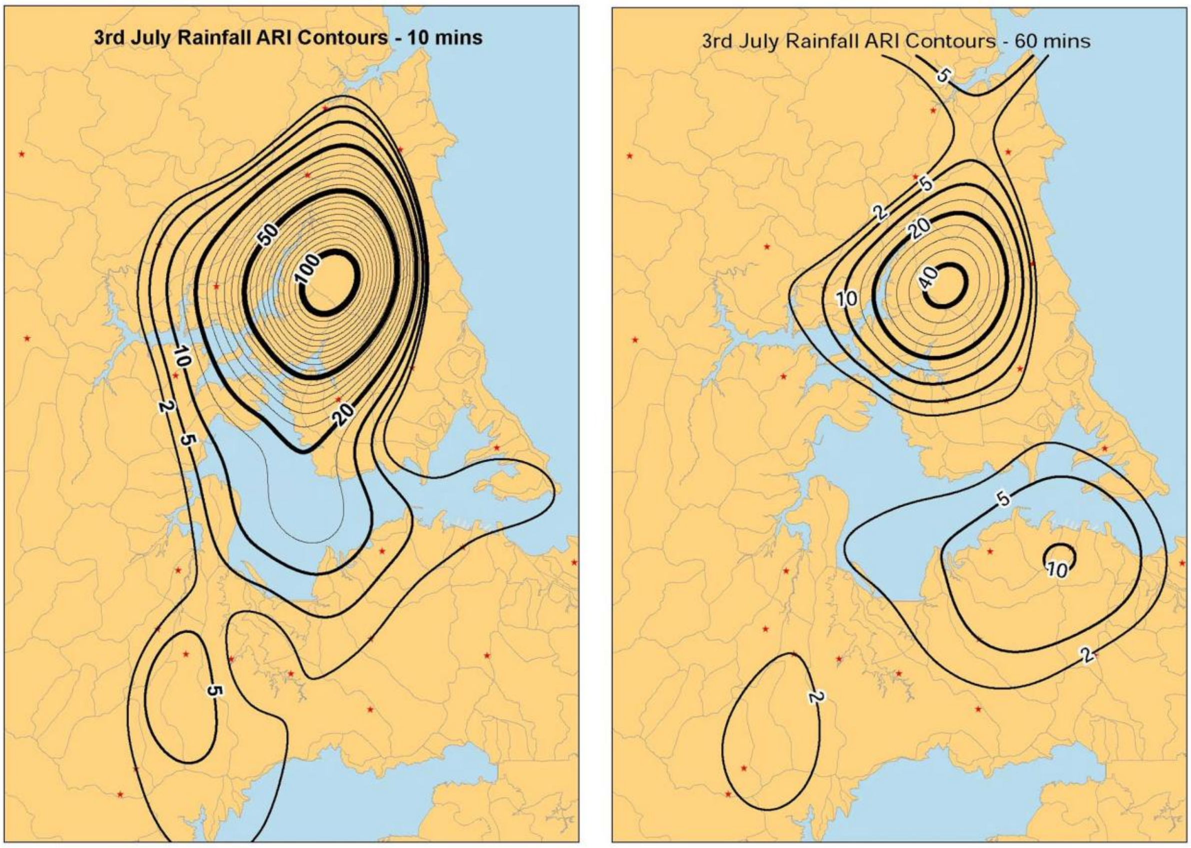
On 3rd July 2012, a heavy storm hit Auckland. The entire storm event lasted for less than two hours and the total cumulative rainfall was only 49 mm in the worst hit (Albany) area,. However, as was widely reported by the media, this storm caused extensive damage to properties in northern Auckland, resulting in 70 flooded buildings (27 habitable and 43 non-habitable) and 37 manholes having popped their lids. This was the worst flooding in northern Auckland since 2000 in terms of the number of flooded buildings and popped manholes.

- Why did this storm cause such widespread property damage and so many popped manhole lids?
- How did the Auckland Council's Stormwater Operations Group respond to such an event?
- What did we observe during field investigations?
- What lessons should we learn from mistakes of the past?

This paper endeavours to answer these questions. It also recommends some actions to enable improvements in the work practices of personnel working in the stormwater and building industries and makes recommendations on how to avoid similar problems in the future.

2. THE NATURE OF THIS STORM

As discussed in detail by Carter (2013) and Irvine (2013), a narrow band of rain moved onto the Auckland area from a northwesterly direction at approximately 12:30 pm on 3rd July 2012. The entire rainfall process lasted for less than 120 minutes and the heaviest period was shorter than 30 minutes. The worst hit area was around Albany in northern Auckland, and the 10 minute duration intensity was about 1% AEP. Figure 1 shows the distribution of 10 and 60 minute duration rainfall intensity over the northern Auckland area.



(A) 10 minute (B) 60 minute

Figure 1 Rainfall intensity of 10 (A) and 60 (B) minute duration

3. RESPONSE TO THIS STORM BY AUCKLAND COUNCIL'S STORMWATER OPERATIONS GROUP

A region-wide Stormwater Incident Response Plan was prepared and tested before the amalgamation of the Auckland region on 1 November 2010 (Blackburn-Huettner *et al,* 2011). Since then, particularly taking learnings from the two significant rain events in January 2011, the Plan was reviewed and improved (Tian *et al,* 2012). These improvements focused on escalation, reporting and communication and the improved Plan provides the framework for responding to any stormwater-related incident, including a region-wide heavy storm.

A Thunderstorm Watch status was issued by New Zealand MetService on the morning of 3 July 2012. All Stormwater Operations staff and their contract managers are in the distribution list of MetService's Severe Weather Warning System.

Rain radar images were regularly monitored by Stormwater Operations staff during the morning. By 13:00 Council received the first flooding report from the north western area. At this time, senior management of the Stormwater Operations Group decided to activate the emergency response procedure as defined in the Incident Response Plan. These procedures and actions included:

A. All major maintenance contractors, including those whose area had not yet been affected by the heavy storm, were informed of the possible heavy storm and instructed to be ready to handle the possible high volume of service requests and/or support other areas if necessary.
B. The Customer Response Coordinators from the four major area offices collated and filled in a common, shared, Excel database, which was prepared as part of the Incident Response Plan review process. The latest information was then sent to the Communication Coordinator employed by Auckland Council and Auckland Transport. The Coordinator collated and compiled all information from Council, Auckland Transport and the Joint Transport Operations Centre (a joint venture between NZTA and Auckland Transport) every three to four hours and sent regular updates to the relevant stakeholders.
C. Liaison with Council's Civil Defence and Emergency Management team.
D. Liaison with the Stormwater Planning and Projects groups within the Stormwater Unit, to obtain extra staff for the required investigation.
E. Assigning of investigation tasks among Operations staff and the support staff from other stormwater groups.
F. Liaison with NZ Fire Service to obtain from them, a list of properties which had reported actual or potential flooding problems to them directly.

As the Stormwater Operations Group and its contractors were well prepared and organised, 70% of the urgent service requests were responded to within one hour, although 39 urgent service requests were received for the northern area within seven hours after the storm hit. Most reported problems were investigated within a few days. Seven compliments from our customers for our quick response were received.

4. FIELD OBSERVATION

A total of 127 service requests were received for the northern area, mainly around the Albany and East Coast Bays areas in relation to this heavy storm (including 60 service requests referred to the Operations Group directly from the NZ Fire Service). All reported flooding problems and popped manholes were investigated within a few days after the storm event. During our field investigations, we observed the following:

1. Location of flooded buildings and areas

As this storm was a high-intensity, short-duration event, most flooded buildings and land areas were located in the upstream or middle area of the affected catchments. Building flooding and water ponding in streets was mainly due to blocked catchpits or inlet structures, exceedence of pipe capacity (this is an overdesign event) and building in an overland flow path, rather than increased water levels in streams. Figure 2 shows a flooded street in the Albany area.

Figure 2 A flooded street in the Albany area

2. Overland flow path

In Auckland, GIS models were used to identify overland flow paths, with some field validation. Our field investigation indicates that, of the 70 flooded buildings, about 80% of them were located in a previously identified overland flow path. The following is a typical example.

Modelling results indicate there is a significant overland flow path running through the Mairangi Bay town centre and a number of commercial buildings are very close to the modelled overland flow path. Photos taken during the heavy storm around this area verified the modelling results. Figure 3 shows the modelled overland flow path. The photos taken during the storm (see Figure 4) show the significant overland flow, which flooded three nearby commercial buildings and damaged a car, at two locations in the modelled overland flow path.

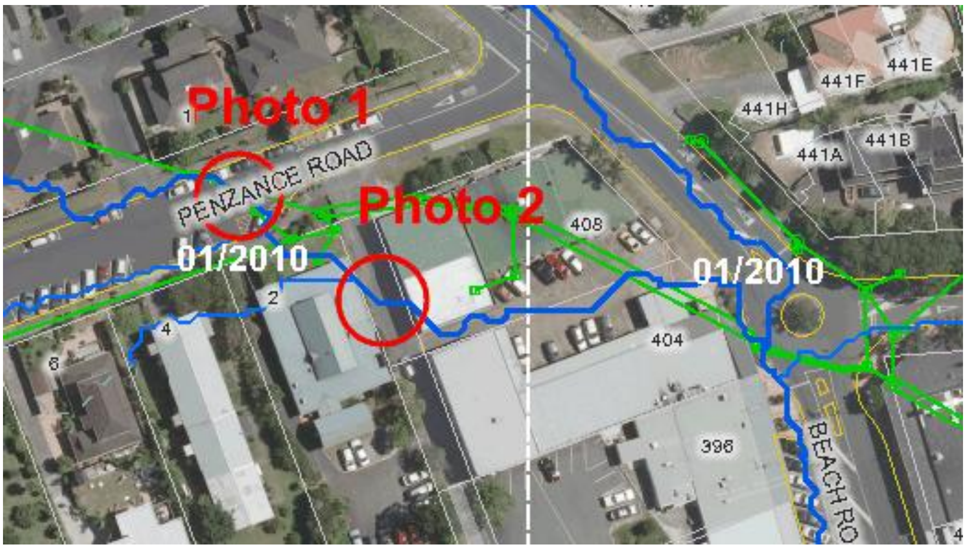


Figure 3 The modelled overland flow path around the Mairangi Bay town centre.

Further detailed investigation indicated that such a large volume of overland flow was formed due to:

A. The short duration rainfall intensity in this area exceeding the design capacity of the twin downstream culverts (1500 mm and 1200 mm in diameter); and

B. Two large water supply pipes (100 mm and 375 mm respectively), which ran through the big twin culverts (refer to Figure 5) and intercepted a large piece of timber, resulting in a significant proportion of the culverts being impeded.

Watercare has relocated the 100 mm pipe and is in the process of relocating the larger (375 mm) water supply pipe.

Figure 4 Significant overland flows along the modelled overland flow path which flooded three nearby commercial buildings

Figure 5 A large water supply pipe running through the big twin culverts

The current District Plan for northern Auckland requires a resource consent if a building is to be built in an overland flow path. Most building consent officers are fully aware of this requirement, and the District Plan requirement is being implemented properly. However, 2,000 m^2 was used as the minimum area threshold for overland flow path identification due to technical reasons. Any overland flow path from a catchment smaller than 2,000 m^2 has not been identified.

Our field investigation revealed that a few flooded houses were built in minor overland flow paths. As their contributing catchment is less than 2,000 m^2, these flow paths were not identified by the modelling process and not shown in GIS. However, these houses were flooded due to the following reasons:

A. The height difference between the inside floor level and outside ground level, does not comply with the current building code,

B. Low vehicle crossings resulted in road runoff flowing down to houses via driveways,

C. Landscaping works around these houses were not carried out properly and as a result, encouraged runoff flowing into houses,

D. Heavy reliance on private piped drainage systems. Unfortunately, the design capacity of private stormwater drainage systems allows them to cope with a maximum of 10 year storms,

E. Inadequate overland flow path provision, and

F. Inlets of private stormwater drainage systems are normally quite small. It is much easier for them to be blocked than is the case for larger inlets.

3. Inlet blockage

Due to historical reasons, many of Auckland's watercourses (natural streams or man-made channels) have been partially piped, resulting in many watercourses being of an open-piped-open-piped nature. Due to safety concerns, some inlets must be fitted with safety grilles to prevent children entering the downstream pipes. Blockage of some inlets, particularly those with safety grilles, is another major reason for flooding. Our field observations confirmed that not only are smaller inlets easily blocked, but that even larger inlets can be completely blocked. Figure 6 shows a blocked 1.8 m diameter inlet. Due to the blockage of this inlet the majority of a large recreational reserve was inundated.

Note that this inlet was fitted with a safety grille to prevent children entering the downstream pipes. The gap between each steel bar is approximately 180mm. Requests from local residents for Council to reduce the gap between steel bars have been received in the past. The safety issue for children, in relation to stormwater inlets is of serious concern to the Council. Unfortunately, it is not a simple issue and a balanced approach to resolving this problem is required. If the gap between steel bars is significantly reduced, the grille can be more easily blocked by debris. A blocked inlet may result in property flooding and popped manhole lids within the catchment which may expose the public to further hazards. Furthermore, a child falling into an open watercourse may be trapped in front of the grille by the force of water, even if the grille is not blocked. Considering these factors, we did not reduce the gap between the steel bars. Figure 6 shows that even with a wider gap a large inlet could still be entirely blocked, causing extensive upstream flooding.

4. Popped manholes

A total of 37 manholes popped their lids in northern Auckland due to this heavy storm. Hydraulic analysis indicates that about 80% of these popped manholes were caused by inadequate capacity of the downstream pipes (<10 year capacity). The main reasons for this include:

A. Some pipes were designed and installed many years ago and low design standards may have been used, and

B. The coverage of impervious surfaces from the contributing catchment may have been lower when the downstream pipes from these popped manholes were designed.

Aside from the capacity problem of the downstream pipes, we also observed the following phenomenon. Figure 7A shows a popped manhole in the middle of a flooded cul de sac. This manhole popped again on 3 September 2012 when a two year short-duration storm hit the northern Auckland region. The outgoing pipe was renewed several years ago, with the designed pipe capacity higher than 5 years. CCTV inspection also indicated that there was no blockage in the downstream pipe.

Why did this manhole pop twice? Further investigation revealed that this is a standard size manhole (1050 mm in diameter) which receives runoff from three, 300 mm diameter steeply graded pipes (Figure 7B). Fast flows from the three steep pipes result in strong turbulence in the manhole and in water levels rising in the manhole. Figure 8 shows another popped manhole which has seven incoming pipes and one outgoing pipe.

Figure 6 A totally blocked 1.8 m diameter inlet and the flooded, large recreational reserve resulting from that blockage

Figure 7 (A) A popped manhole in the middle of a flooded cul de sac; and (B) the incoming and outgoing pipes to and from this manhole

5. FUTURE IMPROVEMENT OPPORTUNITIES

During the process of responding to this heavy storm, we identified the following improvement opportunities:

Opportunity 1 - Improving procedures for handling urgent stormwater service requests during a significant storm event.

Our normal procedures for handling an urgent stormwater service requests are as follows:

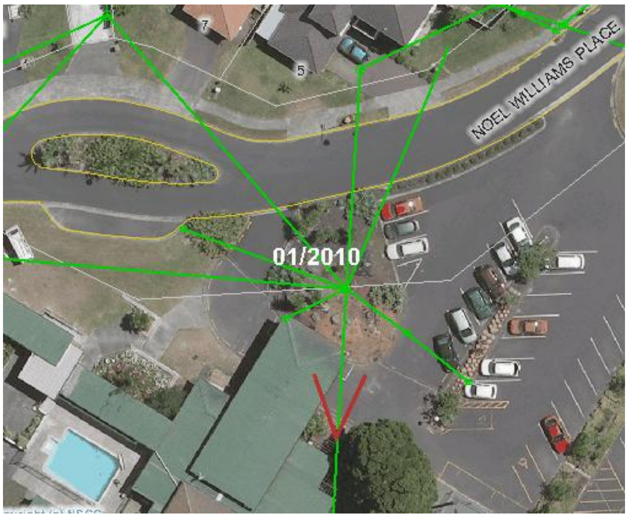


Figure 8 A popped manhole which has seven incoming pipes

After receiving an urgent service request, Council's call centre records the request and a work order is automatically sent to the relevant contractor through the Asset Information Management System (several systems are currently in use across the region). To ensure that Council's contractors pick up the service request promptly, the call centre staff must call the contractor immediately after they send the service request.

On 3 July 2012, between 13:30 and 15:30, Council's northern call centre received more than 30 flooding-related urgent service requests. The call centre staff made more than 30 phone calls to our contractor within two hours. This resulted in the contract manager and administrator spending much of their time, answering phone calls from Council. We now have modified this procedure. When we are dealing with a significant storm event, we will inform our contractor that due to the likely high volume of urgent service requests for the next 5 hours (for example) we will not call them, with the expectation that a contractor is frequently checking their job receiving system. In this way our contract managers and administrators can focus solely on the critical tasks of job dispatch and coordination.

Opportunity 2 – Improvement of communication with NZ Fire Service.

Many residents report their actual or potential flooding problems to the Fire Service directly. We had no direct access to the Fire Service's database to interrogate it for reports of flooding. As a result we do not have a complete understanding of what actually happened during the storm. Obtaining flooding-related information promptly from NZ Fire Service, is an area we need to improve upon. After discussions with NZ Fire Service, Council's Civil Defence and Emergency Management unit has been granted direct access to NZ Fire Service database and hence all of their reported flooding problems. This will enable us to get a full picture during and immediately after a heavy storm. It will also speed up our field investigations and response.

Opportunity 3 – Proactive inspections of critical assets.

As discussed in Section 4.2, the two large water supply pipes running through the large, twin downstream culverts at Mairangi Bay, contributed to the significant overland flow which flooded three nearby commercial buildings and damaged a car. If the problem was identified and resolved proactively at an early stage, the overland flow might cause less damage. The Stormwater Operations Group is currently implementing an identification and inspection programme so that the critical assets, such as these twin culverts, can be identified, inspected and proactively maintained.

To avoid mistakes such as those we observed during our field investigation, the following actions are suggested:

A. The Infrastructure Design Manual should be modified so that we can avoid the installation of manholes with multiple steep incoming pipes. In cases where multiple inlet pipes cannot be avoided, the following factors should be carefully considered to minimise the probability of manhole lid popping: the diameter of the manhole riser, diameter and inlet form of the downstream pipe and the angles between inlet and outgoing pipes.

B. A balanced approach must be given to safety concerns raised by the public in relation to inlet grilles.

C. Identification and publication of overland flow paths has proved to be a very useful tool. The relevant Council departments should pay adequate attention to a completed development site, particularly the vehicle crossing, landscaping and legal requirements regarding ground levels surrounding a house. This should include any development in, or adjacent to, a very minor overland flow path with a contribution catchment of only several hundred square meters (based on on-site visual assessment), although a resource consent is not required for such a development under the current district plan rules.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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