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Flood Hazards to the Water Supply Infrastructure

FOR FURTHER INFORMATION

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1. Introduction

The purpose of this report is to give an overview of the potential types of impact on the security and integrity of the water supply system that could arise from high rainfall and flood events. The actual impact would be in a variety of ways. This includes submergence, erosion, landslip, deposition, scouring, etc. The expression *flooding hazard* will be used as a general term for all these effects.

The report does not give specific work programmes to reduce risks but gives a way forward by which these risks can be identified, prioritised and mitigated.

2. Background

The effects of seismic activity on the water supply system have been well documented and significant physical work has been undertaken to create a more resilient system. Much of this work relates back to the 1991 Centre for Advanced Engineering Project Report *Lifelines and Earthquakes - Wellington Case Study*. However, there has not been anywhere near the same emphasis on the risks arising from extreme rainfall events.

Recognition of flooding risks has been built into some facilities, for example, the electrical control hut for the Gear Island wellfield built nearly 30 years ago was raised above a nominal flood level and the Gear Island and Waterloo Pumping Stations were designed with the motors on raised platforms. Piers and abutment supports and pipes buried beneath stream beds have been designed to accommodate scour.

The reason why precipitation induced hazards has not been a key part of the water supply design philosophy is hard to understand. For earthquake design, a 1 in 500 year return period is usually the objective but for flooding a much shorter return period has been used, if a return period has indeed been considered. It may be because the seismic effect on a structure can be analysed and the structure designed to carry the induced loads in an appropriate way. Flood hazards are harder to identify, the analysis is far less proscriptive and much more weight is placed on the designer's experience, especially at the micro level, when individual sites are considered. Also the design solutions for protection against flooding are less rigorous. Flood impact on the water supply infrastructure is generally localised.

In addition, in the wider community there is a greater fear of earthquakes as against flooding, perhaps because of their instantaneous effect without the warning which usually occurs in a flood situation.

In recent years the general perception is that there has been an increase in the frequency of localised extreme precipitation events. As climate change continues, apparently these types of events may become more commonplace.

Greater Wellington Regional Council's (GWRC) surface water collection areas are in mountainous country, where fast rivers with high bed loads and steep unstable hillsides are commonplace.

With Wellington's topography, reservoirs are often served by rising mains traversing steep hillsides.

3. Recent Events

3.1 General

In recent years there have been a number of events that have impacted on the water supply system. In the listing below I have attempted to define each case as an example of a general situation and tried to analyse in retrospect the mitigation that could have been carried out.

3.2 Orongorongo Rainfall - 30/31 March 2005

Very high rainfall in the lower part of the Orongorongo Catchment occurred over these two days. Significant amounts of material were mobilised, from the active scree slopes on the eastern side of the Orongorongo River. There was a huge amount of bed load transported past the intake, causing the bed to rise by 3 m to 4 m at the height of the flood. Consequently, water flowed through the Little Tunnel and, when exiting, scoured the track away and removed the support of the pipeline. The land scoured away appeared to be solifluction deposits from an adjacent run-off channel which may have been built out further as a tip site for tunnel excavated material when the tunnel was originally constructed.

This is a classic case of a secondary flow path impinging on an unprotected fill. Mitigation could have been achieved by building an impervious apron at the tunnel exit, so that the secondary flow would not erode the fill. Additionally, if water had been prevented from entering the tunnel, the drop-out would not have occurred. The east end of the tunnel could have been blocked by a door or solid wall. Note that there were reports that water had flowed through the Little Tunnel on at least one previous occasion.

In this event a major gravel fan inflow from Boulder Creek, and North Boulder Creek, downstream from the intake, has dammed the main river, and diverted the flow through the valley side vegetation. If a similar quantity of gravel had come from Ryan Creek, which is a similar unstable gully upstream of the intake, it could well have been that the whole intake structure could have been buried in gravel. As it was, the downstream side of the weir was buried.

3.3 February 2004 Flood - Wainuiomata

This event - which was about a 25 year return period - caused significant damage to the Wainuiomata facilities. The 1050 mm concrete pipeline from the intake to the treatment plant was undermined and washed out for about 30 m. When the pipeline had been laid, the river channel had been moved away from the pipeline route and the new embankment given some armouring. In the files an armouring system for a 100 year flood had been designed but an examination on the ground indicated that the protection work did not include all the features of the design. Better bank protection work would have prevented this failure.

Also the intake pipeline was not valved off at the intake, so a large flow would have gone down the pipe after failure, causing even greater erosion at the failure point.

In the same flood the central pier of the treatment plant access bridge was scoured out, causing the bridge to drop by about 300 mm at the central pier. The deck of this bridge had been modified and strengthened on several occasions but it appeared that the central pier had not been founded or underpinned at a safe depth below the scour level for this 25 year flood.

3.4 Takapu Road 750 mm Pipeline

In February 2005 it became apparent that a length of this pipeline had been exposed and was being undermined by the Takapu Stream. Vegetation had deviated the stream, so it was attacking the support for the pipeline. This situation had been building up over some time but got to a state that there was a risk to the integrity of the pipeline and remediation work was necessary.

3.5 Duck Creek, Whitby

The Porirua branch pipelines cross Duck Creek in Whitby. Work has been done on previous occasions to secure the pipe from undermining of the headwalls. A flood event in 2002 required extensive underpinning and support for the pipelines.

A long-term solution would be to relay the pipes underneath the stream in a concrete encasement.

4. General Event Situations

The following is a list of the types of event that could cause damage to the infrastructure.

- Waterway eroding under the pipe and removing support at a crossing [Duck Creek]
- Scouring of abutment and headwalls for pipeline crossings or bridge structures [Wainuiomata Water Treatment Plant bridge]
- Secondary flow path bringing water to areas that were not designed to pass the water [Little Tunnel, Orongorongo]
- Riverbed level increases that could bury facilities [Orongorongo intake structure]
- Rain induced slips causing drop-outs and removing pipe support [Old Haywards Road]
- Rain induced slips blocking access to or burying facilities [Kaitoke weir]
- Coastal erosion from storm surge or tsunami [Petone Foreshore]

- Flooding and submergence of facilities, especially electrical equipment [Randwick Pumping Station]

- Inadequate provision for surface run-off causing scour [Tunnel Grove]

- A muddy slip in the catchment affecting raw water quality [East branch of Hutt River]

5. Locations of Risk

In the catchment areas, gradients are steep, rainfall high, stream velocities high, and access difficult. Also the pipelines and other facilities are not under constant watch, as they are in an urban setting.

In rural areas, where the pipelines traverse open country, the local landowner will be generally aware to the changes to flow patterns of streams and would probably contact Greater Wellington Water (GWW) if there is a major change to the stream course.

In the urban areas, the territorial authority drainage staff would be monitoring the situation. However, there are locations where reservoir inlet mains cross steep inaccessible slopes, out of the public view - for example, Messines Road and Ngaio Reservoir inlet mains.

The overall impact of a failure will depend on the availability of alternative supplies. For example, a failure of the Messines Road inlet would have a greater impact than a failure of the Orongorongo supply.

6. Current Situation

Up to now flood hazards were handled in an ad hoc manner in both the design and maintenance of water supply assets. Culverts under catchment roads have been traditionally built with any old pipes available, rather than from a review of the likely subcatchment run-off rates, and normally no great consideration has been given to secondary flow paths.

In the catchments, there has been no major effort put in river protection work. However, the gabions that were built at the base of a major scree slip on the Orongorongo River upstream of the intake some years ago appears to have performed satisfactorily in the latest event.

7. Issues to be Handled

An assessment should be carried out of the exposure to flooding hazards for all GWW facilities. This would include the following:

- Identify where the pipelines are close to waterways

- Enter into a dialogue with GWRC Flood Protection staff for an on-the-ground assessment of areas that could be vulnerable if waterways change course in major events, including access to critical facilities, including buried valves

- Maintain contact with territorial authority drainage staff for run-off patterns which may impact on the urban sections of the network

- Identify where pipelines cross potentially unstable slopes within the urban areas

- Identify all urban off-road pipelines

- General geological assessment of the stability of our catchments to build up a risk profile

- The GWRC Hazard Section could give information on slopes that could become unstable during high rainfall or seismic events

8. Design Standards

One of the difficulties in a flood hazard assessment such as this is the decision on the flood design level. As mentioned earlier, seismic design is generally on a 1 in 500 year return period. The GWRC Flood Protection Department generally design to a return period flood of 100 years. However, when the Ewen Floodway was constructed in the Hutt River, a 440 return period was adopted.

Because the damage to infrastructure from flooding is likely to be localised, and with dispersed sources and pipelines, a 1 in 100 year return period is probably an appropriate parameter to be adopted.

Scouring and changes in alignment of waterways is probably the biggest risk, so an assessment of pipe support relative to scour depths must be carried out.

9. Proposed Areas to Investigate

I have carried out an overall preliminary assessment of the infrastructure and my first cut of areas worthy of a more detailed investigation is as follows:

9.1 Orongorongo Catchment

Assess the Orongorongo Catchment for further potential gravel deposition and whether any toe stabilisation or other measures would assist in holding scree slopes. This has some importance, because of the proposal to put more reliance on the Orongorongo supply for off-river storage for the Wainuiomata Water Treatment Plant. The vulnerable areas to inundation by gravels are the intake and also the potential for the main river to be dammed adjacent to the main tunnel, causing a secondary flow path through the tunnel. This assessment would need to be carried out by a geotechnical consultant.

9.2 George Creek Catchment

The Wainuiomata intake pipeline crosses this creek near the connection/ pressure reducing valve area. Following the decommissioning of Morton Dam, the creek bed in this location is now degrading. The potential scour depth relative to the pipeline support piers and monitor bed levels should be checked. The piers are founded 10 m below the pipeline invert.

9.3 Wainuiomata Pipeline at Richard Prouse Park

The pipeline crosses the Wainuiomata River twice in this area. Assess potential scour depth and possible changes to river alignment relative to the pipe support piers and abutments, and monitor bed levels.

9.4 Kaitoke Weir Access

The slip face adjacent to the weir face should be assessed by a geotechnical consultant and, if necessary, stabilisation measures constructed.

9.5 Pipe between No. 2 Tunnel and Te Marua Water Treatment Plant

In this section the pipeline crosses Benge Creek in several locations. An assessment of potential scour depth needs to be made and pipe supports underpinned if found necessary.

9.6 Landslip at Stuart Macaskill Lake 1

An investigation needs to be carried out into the stability of the hillside above Lake 1.

Adjustments to drainage patterns may be made, to enhance long-term stability.

9.7 Kaitoke Pipeline at Mangaroa

The proposal to realign State Highway 2 and reroute the pipeline in this area has now been deferred by Transit New Zealand.

An assessment of the potential for the Hutt River to scour the riverbank and undermine the pipeline should be made, using expertise of the GWRC Flood Protection Department. Bank protection work may be required.

9.8 Kaitoke Pipeline at Silverstream Bridge

Although the bridge is scheduled to be strengthened, there is still vulnerability to flooding and damage to the pipe at the bridge abutments. We need to assess, in conjunction with the Flood Protection Department, the potential for erosion of support in high flows.

9.9 Ngaio and Onslow Inlet Main

Assess the stability of the pipeline route from Ngaio Gorge Road to Ngaio Reservoir, in particular run-off patterns and potential for slippages.

9.10 Karori and Kelburn Inlet Mains

These two inlet mains traverse the steep side slopes of the Kaiwharawhara Stream valley. Stability and run-off patterns should be assessed.

For the Karori rising main, an alternative proposal was made to Wellington

City Council for an emergency inlet from a small pumping station to this zone at Whitehead Road.

9.11 Emergency Materials

An overall assessment needs to be made of the location of emergency replacement materials and equipment, and the access routes that would be available to these stockpiles.

10. Conclusion

It may well be that the water supply system is at greater overall risk of interruption from flooding than from earthquake. This has certainly been the case in the last two years.

The task of carrying out a flood hazard assessment and consequent mitigation measures must be put in hand, with the aim that exposure from this cause is reduced to an appropriate level.

The initial list of locations to be investigated detailed above will be confirmed and expanded, if necessary, following discussions with Operations staff.

11. The Way Forward

The proposal is that this report would become the basis of a report to the Utility Services Committee. The Committee would be asked to confirm that a 1 in 100 year flood return period become the guideline for the design of water supply facilities. It is recognised that, if this guideline indicated the need for major projects, specific direction would be sought from the Committee.

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