Debris Flow Risk, Awatarariki Catchment - Early Warning System Work stream

Introduction

Jeff Farrell of Whakatane District Council (WDC) asked GNS Science to provide information relating to the design of a debris flow early warning system for the Awatarariki catchment above the township of Matata. In 2004, a large debris flow occurred in this catchment, which damaged homes and infrastructure in Matata.

Risk assessments have been carried out by Tonkin and Taylor and the assessed annual individual fatality risk to dwelling occupants in the area affected by debris flow hazards has been assessed as being intolerable, by WDC and most of the local community.

The purpose of the debris flow early warning system is to warn users of the council reserve land, road and rail users and any dwelling occupants who choose to remain after the retreat, of the possible imminent hazard of a dangerous debris flow in the area.

This email provides preliminary information relating to the development of a debris flow early warning system. This potential design of a system might follow the "Components of an Effective Early Warning System" developed by GNS Science (see attached). The main components would comprise:

1) Roles and responsibilities of the various stakeholders and GNS Science
2) The effectiveness of debris flow early warning systems
3) The design of a potential early warning system
    a. Alert and warning thresholds
    b. Hardware, installation, software and communication
    c. Annual review of the alert and warning thresholds
    d. Peer review
    e. Maintenance
4) Planning, communication, education, participation and exercises

1. Roles and responsibilities

GNS Science: to establish the alert and warning thresholds, scope the hardware and install the monitoring and data transfer equipment (from site to office). Analyse the collected data from the installed instruments and review the thresholds on an annual basis. We would also work with WDC and Environment Bay of Plenty (EBoP) to help with the planning, communication, education and participation, components of the warning system. GNS Science could also provide technical maintenance of the equipment.

WDC and EBoP: to operate the warning system, and lead the planning, communication, education and participation components of the system. WDC and EBoP would also issue the alerts and warning.

NZTA: To action the alerts and issue warnings to road users, and possibly operate barriers/warning lights to prevent access to the section of road affected by debris flow hazards.

KiwiRail: To action the alerts and issue warnings to rail users, and possibly operate barriers/warning lights to prevent access to the section of road affected by debris flow hazards.

2. The effectiveness of debris flow early warning systems

Given the velocity and volume of potential debris flows in the Awatarariki catchment and the risk to residents and road and rail users, it is unlikely that an early warning system based on detecting a debris flow once it initiates would be effective. This is because there would be little notification time between: i) the identification of a debris flow, ii) a warning being issued and acted upon, and iii) the debris reaching the at-risk people and infrastructure. Therefore the system would need to be based on debris flow triggering rainfall intensity/duration thresholds, rather than trip wires and stream flows alone.

However, even if such a system, based on rainfall thresholds were to be installed, it is still possible that the warnings once issued, may not be received by those affected in time for them to take protective action. It is, therefore possible that should a debris flow initiate, not everybody in the affected area will be able to evacuate, possibly resulting in deaths. Therefore it should not be assumed that a debris flow early warning system would be infallible.

In order to ensure that a debris flow does not occur without a warning being given, it is necessary that there will be false warnings given where no debris flow occurs. This must not be allowed to undermine the credibility of the system and would need to be managed by WDC. Experience from Japan suggests that false warnings (where a warning is given and no debris flow occurs) happen between 40 and 50% of the time. This must be balanced against the consequences of a failure to warn, which may have more legal consequences than does failure to act on a warning, once given.

3. The design of a potential debris flow warning system.

Alert and warning thresholds: An alert indicates that something significant has happened or is likely to happen. A warning typically follows an alert and provides more detailed information indicating what protective action should be taken.

In Japan and Taiwan, typical debris flow alerts and warnings arise when:

1) Alert: Rainfall of a given intensity/duration and amount (that exceeds the threshold) is expected to occur in the catchment.
2) Alert: Rainfall in the catchment is approaching the thresholds where debris flows may initiate
3) Warning: Rainfall in the catchment has exceeded the threshold when debris flows initiate, and warnings are issued in multiple ways, including social media.

At the Awatarariki catchment the, the alert and warning thresholds would be based on precedence, i.e. what rainfall intensities and amounts have in the past triggered landslides in the area, and not just in the Awatarariki catchment. These thresholds would form the basis of the monitoring system.

Although no soil moisture data is currently available locally for the catchment, over time, soil moisture conditions (rather than its proxy of antecedent rainfall), would be used to refine the alert and warning thresholds. In Japan, the lack of such data (at the site scale) is thought to be the cause of many of the false warnings.

Once the thresholds are set, Metservice would issue rainfall warnings to WDC and EBoP (as currently happens), and discussions with them should be undertaken at the earliest time to ensure collaboration and that the correct information is provided at the scale needed. There should be discussions around the uncertainties of these predictions.

Hardware, installation, software and communication: It is anticipated that: i) rainfall, ii) soil moisture and iii) stream flow would need to be monitored within the catchment. These instruments would need to be able to record the data at the correct temporal resolution and be able to transmit the data in real time remotely to locations where it can be plotted, displayed, and alert and warnings given and the data analyzed and interpreted by the end user.

Annual review of the alert and warning thresholds: would need to be carried out to assess what has happened within the catchment during the monitoring period, using the data collected from the instruments and any local observations. The thresholds may then be revised based on these observations. In Japan, thresholds are fixed and do not change. This is believed to have led to many false warnings being issued.

Peer review: the thresholds and system will need to be independently peer reviewed.

Maintenance: is needed on an "as needed" and periodic basis. Often-requiring immediate response if equipment malfunctions. Redundancy must be built into the system to ensure a robust warning system.

4. Planning, communication, education, participation and exercises

These components are essential to any warning system. GNS Science social scientists could work with WDC and EBoP to develop these. GNS Science has a much experience with this i.e. the Tongariro warning system and ERLAWS Crater Lake warning system.

Approximate cost of the early warning system components

Establish alert and warning thresholds: $20K
Design the system: $10K
Purchase, Install and establish the hardware (based on three field stations: i) soil moisture, ii) rain and iii) stream flow): $70-90K
Reporting: $40K
Peer review (GNS only): $10K

Total $150K to 170K

Items 1, 4 , the annual review and developing the software required to receive and plot the data, alert the responsible people, and issue the warnings are not included in this cost. This cost would depend on how and whether EBoP could incorporate such a system into their current hazard management process, e.g. flood management processes.

Maintenance is also not included in the cost and is largely uncertain. This will depend on how the equipment performs.

24/7 monitoring of incoming data (by WDC or EBOP) is not included in the cost