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Numerical modelling of tsunami inundation for Whangarei Harbour and environs

NIWA Client Report: CHC2010-133
April 2011
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Jade Arnold
Philip Gillibrand
Julian Sykes

NIWA contact/Corresponding author

Philip Gillibrand
Jade Arnold

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National Institute of Water & Atmospheric Research Ltd
10 Kyle Street, Riccarton, Christchurch
P O Box 8602, Christchurch, New Zealand
Phone +64-3-348 8987, Fax +64-3-348 5548
www.niwa.co.nz

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Reviewed by:

David Plew

Approved for release by:

Graham Fenwick

Executive Summary

Northland Regional Council contracted NIWA to undertake an initial study on the risk of tsunami inundation facing communities in the Northland Region. The following credible sources were identified:

- Remote source: South American origin. Return period 50-100 years. This represents the most probable tsunami risk in the next 100 years.
- Local/regional source: Tonga Kermadec. Two events were modelled, Moment magnitude scale (M_w) 8.5 and M_w 9.0. The return period of these events is much longer (500-2000 years) but these represent a worst-case scenario for a tsunami striking the Northland coast.

The current study investigated tsunami propagation into the Whangarei Harbour, including inundation at six communities, for each of the above scenarios using computer simulation. Inundation modelling was performed assuming that the tsunami arrives at Mean High Water Spring (MHWS) at current sea levels and for a mean sea level elevated by 50 cm, representing the 100 year projection of sea level rise by the IPCC Fourth Assessment Report.

The simulation results presented here cover the likely range of tsunami that might be expected in Whangarei Harbour, from the relatively common, generally smaller South American tsunami to the largest likely event emanating from the Tonga-Kermadec subduction zone (TKSZ). This report provides information on the likely range of impacts on which to base local contingency planning.

The South American tsunami source caused the greatest inundation, in particular to Marsden Cove and Whangarei. Other areas inundated include Otaika, Oakleigh, Takahiwai and Whangarei Head. These six areas were also inundated, to a lesser extent, by the TKSZ M_w9.0 scenario, and less again by the TKSZ M_w8.5 scenario. When the effect of sea level rise is included, the extents of inundation increased for each of the scenarios. With sea level rise, the South American source again produced the greatest level of inundation followed by TKSZ M_w9.0, and TKSZ M_w 8.5 scenarios. The TKSZ M_w 8.5 source with sea level rise included (MHWS + 0.5 m) inundates more than the South American scenario at current MHWS. The Bercich Drain was not inundated in this study. A dynamic analysis of flow within the culvert may be required to determine if water entering the culvert at the seaward end will spill into the refinery. Finer resolution of the Bercich Drain grid area in future studies would permit more accurate modelling of this aspect.

In this study, results are summarised and recommendations for improving the modelling and reducing the uncertainty in the results are made. In previous modelling, the TKSZ sources produced the greatest inundation in most areas. This study found that, within Whangarei Harbour, the South American scenario had the greatest effect. The modelling study is dependent on, and therefore limited by, the initialisation of the tsunami for each earthquake source, the quality of the LiDAR topographic data and also the quality of bathymetric data in inshore waters. A lack of knowledge of the effects of buildings and land features on wave drag also adds uncertainty to the simulations. Despite these limitations, we believe that the current modelling exercise provides the best possible estimate of inundation in Northland from remote and regionally sourced tsunamis available to date.

Caveat

This report is based on state-of-the-art knowledge and modelling capabilities of tsunamis and tsunami inundation. While every effort is made to provide accurate information, there are many uncertainties involved, including knowledge of potential sources, source characteristics, bathymetry and topography. In addition, while RiCOM captures much of the physics involved in tsunami propagation and inundation, it also includes some simplifying assumptions, as with all models. The information provided in this report is technical in nature and should be viewed with the above limitations in mind.

1. Introduction

Northland Regional Council contracted NIWA to undertake a modelling-based assessment of tsunami hazard for the Whangarei Harbour region. Previously, three studies have modelled inundation in 32 Northland communities. In the present study, potential inundation of six communities in the Whangarei Harbour is investigated.

From Goff et al's. (2006) study, tsunami from two sources were identified as likely to cause significant inundation of the areas of interest:

- Distant, eastern: South America (Chile). A distant tsunami comparable to either the 1868 Peru (now Chile) earthquake (M_w9.0) event or the 1960 Chile Earthquake (M_w9.5) event (note that, although the 1960 event was larger, its tsunami was directed more to the north of New Zealand, whereas the 1868 event was an almost direct hit on New Zealand). This represents the most probable tsunami in the 50-100 year timeframe.

- Regional, eastern source: Tonga-Kermadec Trench. Two tsunamigenic earthquakes were studied: a M_w 8.5 subduction zone event located just to the north of the Rapuhia Scarp (i.e., in the central portion) and a M_w9.0 subduction zone event in the central and southern portion. These are identified as worst -case scenarios.

For each of these events, NIWA modelled wave propagation up to the Northland shoreline and inundation of the following communities in Whangarei Harbour:

1) Marsden Bay
2) Takahiwai
3) Oakleigh
4) Otaika
5) Whangarei
6) Bream Head

Inundation modelling at the above locations was performed assuming that the waves arrive at Mean High Water Spring (MHWS) at present day sea level and also with a sea level rise scenario of 50 cm, which represents the 100 year projection defined by the IPCC Fourth Assessment Report (2007).