Executive Summary

Introduction

As one of the outputs from the Transfund Research Project *Standardisation of Design Flows and Debris Control Intake Structures*, the purpose of this report is to provide further information for the bridge and culvert designer on hydrological approaches that are appropriate to the estimation of design flows in low-lying coastal catchments.

Currently, approaches can vary a great deal between practitioners. Even when the same procedures are used, design flows can differ substantially because selecting a single parameter, such as the runoff coefficient C used in the Rational Method, can be subjective. Ideally, for Transit New Zealand to set up standard designs for their flow structures and debris control intake structures for their state highways and other roads in New Zealand, a single approach should be used where standards are based as much as possible on research relevant to New Zealand. This will enable more relevant and consistent culvert and bridge design for waterways.

Study methods

Research was undertaken in 2001-2004 for the project based on rainfall-runoff analysis of two small catchments in low-lying coastal zones in New Zealand

Two study sites were used in two distinct coastal catchments undergoing rapid residential growth. One was the Mazengarb Catchment on the Kapiti Coast, near Wellington, and the second was a series of catchments around the Papamoa Drain near Tauranga, Bay of Plenty. In each case these catchments are dominated by a mixture of coastal dune and peat swamp soils, which have been highly modified as part of modern development earthworks practice. For each of these sites a series of sub-catchments were identified which represented a range of land uses.

Methods for calculating design flows

Our research and this report describes possible methods for the calculation of design flows in smaller urban coastal catchments. Currently these catchments would typically be assessed using the Rational Method, which is a simplistic equation for calculating peak flow using rainfall intensity, catchment area and a runoff coefficient as follows:

$$Q = 0.278\ C.I.A$$

where: Q = peak flow (m^3/s)
C = runoff coefficient
I = rainfall intensity for the duration equal to the time of concentration (mm/h)
A = catchment area (ha) (NZIE 1980)

A second method, the Regional Flood Frequency Formula (RFFF), was developed in New Zealand to combine gauged runoff data from throughout the North and South Islands as one regional model. Most of the catchments used for this regionalisation were medium to

large-sized inland hill catchments, and as such coastal zones were typically not well represented. Other limitations include:

- Within the model, *"small catchments (A<10 km^2) have large prediction errors for the mean annual flood and q^{100}".*
- The regional approach also *"seriously underestimates Q for urban basins".*

For these reasons the RFFF is not recommended for use for small catchments in coastal zones or any urban catchments. Also a comparison of the research results with the RFFF results will lead to substantial variation.

Alternate calculation methods

Comparisons were drawn with unit hydrograph techniques. The development of regionalised Unit Hydrograph procedures would have some substantial benefit for the culvert and bridge designer. This benefit would be greater in those areas which lack long-term historical rainfall data, such as small coastal watersheds with increased residential development.

Development in 1999 of an Auckland-based regional model for the development of unit hydrographs has shown that the Rational approach is practical, achievable and useful.

However coastal rainfall–run-off research would have to be extended by bridge and culvert designers to provide enough information for the development of a regionalised Unit Hydrograph model in these areas. The research that has been completed to date has been particularly limited by a lack of extreme events.

Suggested amendments to Bridge Manual

The hydrological section of the Transit Bridge Manual (2002 version) should be rewritten (insertions are underlined italics) as follows:

> *The following two methods replace the methods outlined in section 3 of the Austroads Waterway Design Manual (1994) …*
>
> ***Rational Method***
>
> *The Rational Method is only applicable to small catchments, because of its inability to account for the effects of catchment storage in attenuating the flood hydrograph. The recommended maximum size of the catchment to which the method should be applied is 25 km^2 in urban catchments, and between 3 and 10 km^2 for rural catchments. The Rational Method is described in "Australian Rainfall and Runoff" (AIE 2001) and the "Handbook of Hydrology" (Maidment 1992).*
>
> *NZIE coefficient charts shall be used for the definition of 'C' within the Rational Method equation (see appendix X). It should be assumed that all design events have high antecedent conditions (i.e. addition of 0.1 to the calculated coefficient as outlined in the notes of this NZIE Chart).*

Regional Method

"Flood frequency in New Zealand" (McKerchar & Perarson 1989) is a regional method suitable for all rural catchments except those in which there is snowmelt, glaciers, lake storage or ponding. It should be used for rural catchments greater than 10 km^2. The Regional Method can also be used for rural catchments between 3 km^2 and 10 km^2, but should be checked against the Rational Method, particularly in coastal zones.

Regionalised unit hydrograph-based model

While these changes to the wording of the Bridge Manual will provide greater level of consistency, a regionalised unit hydrograph-based model would be the most flexible design tool for assessing culvert and bridge waterway requirements in the long term. This approach would also allow simple analysis of modern low-impact design-based stormwater solutions.

Such a model has already been developed and calibrated for the Auckland Region, and a similar project has also been recently been completed in Kapiti. Expanding these models to cover all major urban zones may be the most practical long-term solution.

Research and monitoring

Continued research within coastal urban catchments would help to add weight to the preliminary findings of the research project, which are that coastal runoff coefficients may be overestimated for large event storms.

A continuation of monitoring programmes in the existing study catchments would be of great value, with collection of storm data over a longer period of time likely to provide 'design storm' rainfall runoff data.

Abstract

This report provides further information for the bridge and culvert designer on hydrological approaches that are appropriate to the estimation of design flows in low-lying coastal catchments.

Currently, approaches can vary a great deal between practitioners. Even when the same procedures are used, design flows can differ substantially because selecting a single parameter, such as the runoff coefficient C used in the Rational Method, can be misleading. Ideally, to set up standard designs for flow structures and debris control intake structures for state highways and other roads in New Zealand, a single approach should be used where standards are based as much as possible on research relevant to New Zealand. This will enable more relevant and consistent culvert and bridge design for waterways.

Research was undertaken in 2001-2004 based on rainfall-runoff analysis of two small catchments in low-lying coastal zones of the North Island, New Zealand, where rapid urban development is occurring, i.e. Kapiti Coast near Wellington and Papamoa near Tauranga, Bay of Plenty. Results and recommendations are presented.