

# TEKAPO CANAL CONDITION ASSESSMENT AND MITIGATION CONCEPTS



## THE PROBLEM

In 2008, a dive inspection unexpectedly observed extensive erosion of the earthen canal lining, above a culvert extending beneath the Tekapo Canal. This led to urgent mitigation measures to stabilise the canal over the short term. As a result the owner wanted to better understand conditions along the entire 26km long Tekapo Canal and identify any additional deficiencies that needed to be addressed. Mitigation concept options were developed in areas assessed as deficient.

## ENGINEERING STUDY

A comprehensive study of Tekapo Canal was performed. First, the regulatory and owner's operational criteria were interpreted in relation to the canal. Next, the potential failure modes were determined. Internal erosion under static and earthquake loading were the primary failure modes. Overtopping was generally not considered a risk, except at a very large fill section under extreme seismic shaking. This condition was studied using numerical modelling and analyses by experts. Then the canal was divided into segments having similar engineering conditions. Design and construction information from each segment was collated. Next, a quantitative risk assessment was performed via a series of workshops, that identified foreseeable failure mechanisms at each segment, and calculated the risk of failure and incidents needing major repair. Finally, risks of failure and major repair were assessed against the regulatory and owner's operational criteria to determine deficiencies.

Repair concepts were developed for the deficiencies identified. Concepts were evaluated by risk analysis to determine their risk reduction. Concepts had to meet an established tolerable level of risk. Those that did were evaluated further for concept design, constructability assessment, construction methodology, programme, cost estimate and canal outage time. Multiple repair concept options were presented for some deficiencies.

## Engineering Solution

Three areas were identified as deficient, each with unique characteristics requiring unique solutions.

Where the canal lining has eroded beneath a culvert the embankment needed to be stabilised, and the canal relined with a membrane lining system. Options for remove and replacement or compaction grouting were developed for stabilizing the embankment

Where lining defects were dispersed over a 1.1km section of canal a composite solution was developed. This consisted of groundwater dewatering, cofferdams, canal dewatering, inspection and repair of defect areas, relining with a membrane lining system, and drainage buttresses.

At a fill embankment up to 45m high, the canal embankment was built with filters that do not extend up to the canal water level. Here several options were developed to raise the filter. Repair options consisted of: 1) degrading the exterior embankment and reconstructing with a filter; 2) a secant pile granular filter; or 3) a biopolymer filter trench.

## Client

Meridian Energy Ltd

## Location

Tekapo, New Zealand

## The Canal

Tekapo Canal was constructed between 1971 and 1977 to link Lakes Tekapo and Pukaki as part of the Upper Waitaki Power Scheme. The 26 km long earth lined canal has a capacity of 130m<sup>3</sup>/sec and maximum flow velocity of 1m/sec.



## Canal Features

- Approx. 26km in length
- Traverses undulating, glacial terrain through cut, fill and siding with a 1:8500 invert gradient
- Normal operating flow of approx. 130m<sup>3</sup>/sec
- Maximum embankment fill height approx. 45m at Maryburn Fill
- Stilling Basin at canal terminus designed and constructed as a 'ring dam' and feeds water into penstocks to Tekapo B Power Station.

## Background

Tekapo Canal was the first canal designed and constructed as part of the Waitaki Power Scheme. The initial stages of construction were especially challenging. During the multi-year construction period earthworks specifications and equipment changed and were improved. Several design changes were also implemented during the construction period. Thus, conditions vary along the canal's length. Tekapo Canal has been in operation since 1977. Some areas have leaked since commissioning. Water samples from leaks indicate many are canal water, rather than groundwater.

## Project Objective

Seepage problems at Tekapo Canal have necessitated assessing the risks of potential failure of the canal or major interruption of operation to repair damage to the canal. Canal conditions have been assessed against current applicable criteria, and provide repair concepts for identified canal deficiencies.

## Services

- Geotechnical, geophysical and groundwater investigation of canal conditions
- Dam safety instrumentation and data interpretation
- Canal specific Geographic Information System (GIS)
- Detailed characterisation of site conditions from geologic, topographic, design and construction information
- Quantitative risk analysis
- Numerical finite difference modelling of canal fill embankment deformations subject to earthquake loads
- Evaluating repair construction methodology and constructability
- Concept design
- Cost estimating
- Canal dewatering study
- Surveillance planning

