IDENTIFICATION AND MITIGATION OF RISKS IN AN AUCKLAND TUNNELLING PROJECT

Isabella Merschdorf

Aurecon New Zealand Limited, 139 Carlton Gore Road, Newmarket, Auckland, +64 9 520 6019

ABSTRACT

A thorough understanding of ground conditions and associated risks is one of the primary roles of geologists on engineering projects, and allows clear communication and mitigation of potential risks. A wide spectrum of risks was encountered on the St Marys Bay and Masefield Beach Combined Sewer Upgrade project, consisting of 3 shafts, a storage tunnel, and a marine trench and outfall in a high-profile suburb of central Auckland. Although much of the terrestrial alignment is expected to be constructed in good East Coast Bays Formation rock, key ground risks include lenses and layers of harder volcaniclastic conglomerate in the marine environment and an alluvial channel and sources of contamination along the main storage tunnel. A further challenge is the communication of the risks to a concerned and influential public and the fact that parts of the project area are close to or within sites of significance to local Maori tribes. Existing infrastructure dating back to the middle of last century and documentation of design and as-built structures pose another potential risk in the project area. A review of historical data, combined with 2 phases of ground investigation, lab testing and hydrogeological analyses, all visualised in a 3D model, has enabled us to represent and communicate a range of complex risks and aid in their mitigation.

1 INTRODUCTION

The waterfront area of St Marys Bay near the Auckland Harbour Bridge is frequently subjected to wastewater overflows, particularly after rainfall events, due to the combined stormwater-wastewater pipes dating back to the early settlement in this area. Local residents and visitors use the harbour for recreational purposes and it was therefore of importance to the local council to make significant water quality improvements.

The project now known as the St Marys Bay and Masefield Beach Water Quality Improvement Project, led by Healthy Waters of Auckland Council, investigated a number of options through which the combined sewer overflows could be reduced or mitigated altogether. This project will reduce the amount of sewage overflowing into the harbour by over 90%.

Working closely with the client and wider project team, Aurecon has been involved from the start of the project, initially looking at the option of building a large storage tank, a treatment plant for the overflows, separating the stormwater and wastewater pipes, and then considering the option of a retention tunnel. Aurecon is now carrying out the detailed design of this tunnel.

Figure 1: Project overview; Source: Aurecon

Figure 1 shows the current design, which includes the main storage tunnel (green), two shafts and the pump station, from which a trench will connect back into the main sewer line (red) and another trench will go out to sea and serve as the overflow for the few times a year when an extreme rainfall event might still trigger an overflow (yellow).

A desktop study to investigate the historical records and data was followed by two stages of ground investigation, including a total of 18 boreholes and six cone penetration tests along the alignment on land and three marine boreholes along the proposed outfall. This drilling programme was followed by a comprehensive lab testing schedule to determine the parameters required by the tunnel engineers.

Numerous, partly competing, factors constrain various aspects of this project and pose possible risks. These have been identified and solutions developed to help facilitate the best possible outcome for the project and community.

2 KEY RISKS TO THE PROJECT AND MITIGATION MEASURES

2.1 HARD ROCK IN MARINE ENVIRONMENT

Parnell Grit is the local term for volcaniclastic conglomerates found in lenses and layers around Auckland. It was formed in the Waitemata Basin during the early Miocene in the form of submarine debris flows resulting from large-scale sector collapse from terrestrial or shallow marine stratovolcanoes or gravitational failure of volcaniclastic ring plain deposits in coastal settings [Shane, 2010].

Parnell Grit was encountered in an outcrop in the shallow marine area of the proposed outfall. It was identified in boreholes and during a site walkover during a very low tide. The outcrop is visible on current and historic aerial photographs, as can be seen on Figure 2.

Figure 2: Parnell Grit outcrop visible in recent aerial image on the left (Source: Google Earth) and in aerial image from 1955 on the right (Source: Whites Aviation)

The proposed construction method for the marine trench foresees the use of a digger on a barge. This is a viable option for the largely soft marine sediment but a different method would need to be applied in areas of Parnell Grit beds.

This particular hard rock outcrop is also of significance to local Maori tribes, who refer to it as Te Routu ō Ureia, the place at which the Taniwha Ureia came to scratch its back on the hard, spiky outcrop. A Taniwha, in Maori tradition, is a supernatural creature closely associated with the natural environment, often living in deep water [Keane]. They could be terrifying or protective, but either way, care is taken not to upset them and their natural environment, such as this outcrop.

Working closely with the local Iwi is a significant focus on this project and the level of cultural sensitivity is very high. Areas of cultural significance have been avoided unless absolutely necessary and permissions where sought from Iwi before conducting invasive investigations on such land.

The route of the marine trench was thus chosen so that it would avoid the hard rock outcrop known as Te Routu ō Ureia. A slight adjustment of the originally proposed alignment of the trench now means that the same construction method can be applied for the whole trench and areas of cultural significance aren’t disturbed.

2.2 ALLUVIAL CHANNEL

A large part of the park known as St Marys Bay Reserve, in which the intermediate shaft is proposed, is land of significance to Iwi. Conducting invasive investigations in this part of the park was thus initially avoided during the first stage of investigation. However, a historical borehole log from within this area was discovered which showed young alluvium to a depth of almost 12 metres below ground level. This varied significantly from all our nearby boreholes, in which we encountered fill material directly overlying a wave-cut platform, with no or minimal alluvial deposits.

Based on a regional geological understanding, the alluvium in the historical borehole could be explained as paleochannel deposits of a channel running from the higher ground down to the coast with an approximately NE-SW oriented channel axis. The next step was to determine the extent and deepest point of the channel. This was achieved through relatively closely spaced Cone Penetration Tests (CPTs) perpendicular to the channel axis. The extent and maximum depth of the channel in the area of the proposed tunnel was thus determined and the material confirmed with a borehole at the deepest part of the channel.

Confirming the presence and extent of the channel was important in terms of choosing a suitable location for the shaft and to inform the tunnel engineers regarding the variability of rock types that will be encountered by the tunnel boring machine.

2.3 CONTAMINATION

The intermediate shaft is to be constructed in St Marys Bay Reserve. Today a popular recreational area for joggers and dog-owners (Figure 4), this area was once coastal marine with jetties and ramps for industrial use, as can be seen in Figure 3 A and B.

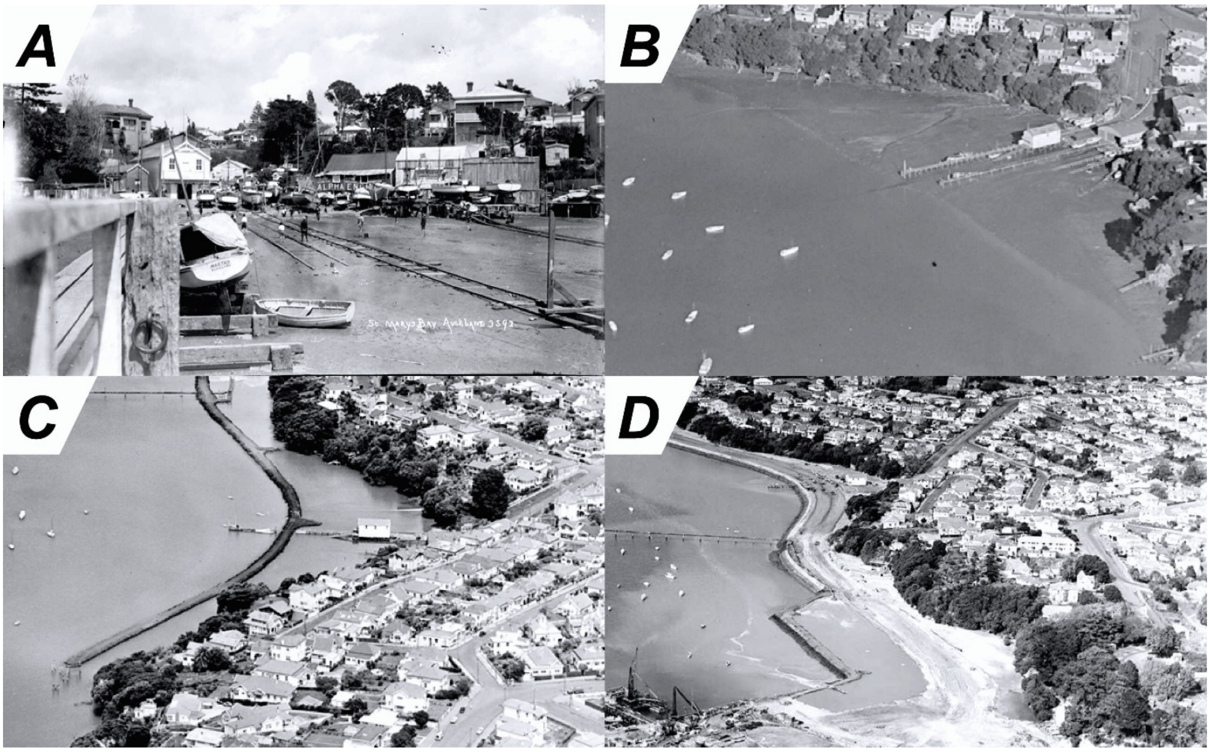

Figure 3: Historical Images of St Marys Bay area; A - 1914; B - 1950; C - 1956; D - 1958. Source: Whites Aviation

In the 1950's a seawall was constructed and the area behind it reclaimed. Much of the materials and waste were simply left in place and covered with dredged marine sediments and other fill material (Figure 3 C and D). Most of this reclaimed area is therefore contaminated, with high levels of lead and the presence of asbestos having been identified in the environmental samples taken from the boreholes in this area.

Figure 4: St Marys Bay Reserve, 2016. Source: Aurecon

Disposing of contaminated fill material is a costly endeavour and disturbing it can lead to exposure of the field- and construction staff and residents if, for example, asbestos fibres are present in soil that dries and becomes airborne. The initially proposed cut-and-cover construction method through the park was thus considered to be too much of a health and safety risk with expensive mitigation requirements with the consequence that this part of the alignment is now also going to be tunnelled and shaft secant piled.

2.4 EXISTING INFRASTRUCTURE

A thorough search of available historical data was carried out as part of the desktop study component of this project, yielding a number of very crucial pieces of information. The compilation of data and every piece of information that could be relevant to the project is of course continuous and does not end with the issue of the desktop study report. And it was thus that a crucial piece of information was collected that turned out to be of major consequence to the project.

It was a historical paper which stated that the piles supporting the Shelley Beach Flyover were not in fact constructed as they had been designed and documented, namely founded in the underlying bedrock, and suggested that they go deeper. This was not enough information to go on but led to further investigation by bridge engineers who were then finally able to determine how exactly the piles had been constructed. The original tunnel alignment would have passed through the zone of influence of these existing bridge piles, as can be seen in the model in Figure 5.

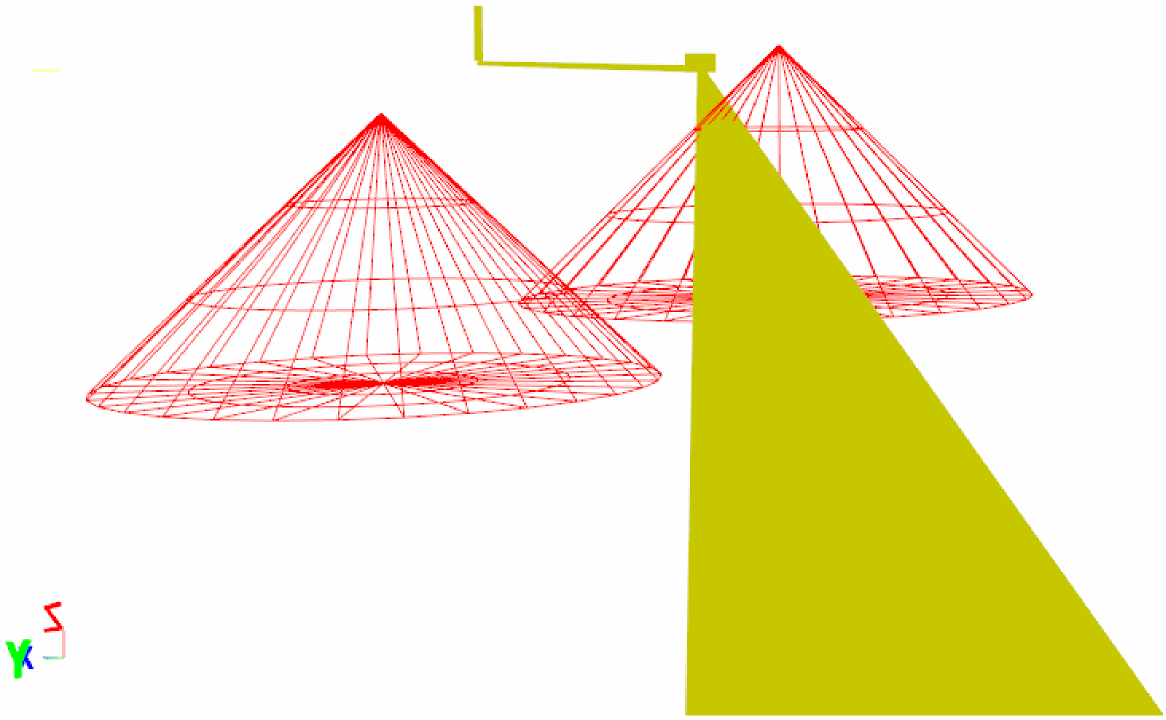

Figure 5: 3D Model showing that the original tunnel alignment would have passed through the zone of influence of the Shelley Beach Flyover South Abutment Piles. Source: Aurecon

On the basis of this new information, the tunnel design was adapted slightly to avoid this area. A representation of how the new tunnel alignment will now avoid the zone of influence is shown in Figure 6.

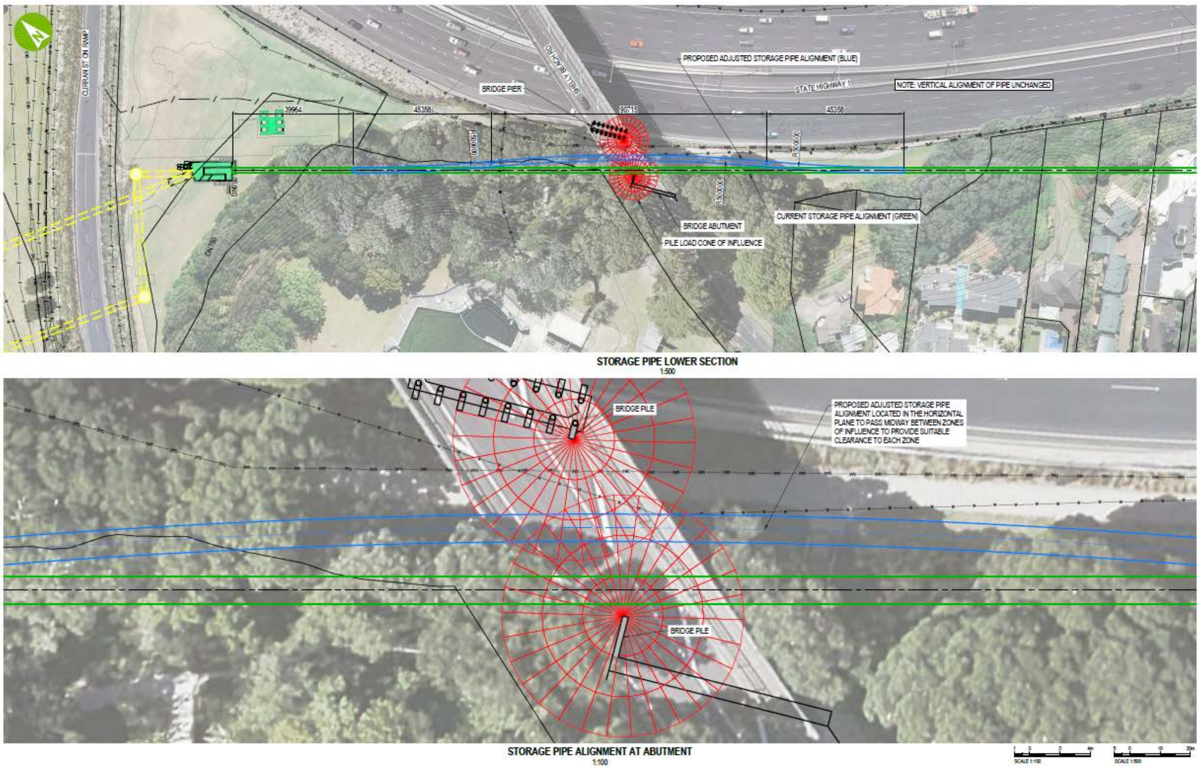

Figure 6: The new tunnel alignment bends slightly to avoid influencing the piles of the Shelley Beach Flyover. Source: Aurecon.

2.5 COMMUNITY CONCERNS

Parts of the alignment pass under residential properties along the St Marys Bay cliff top. The tunnel is situated in good ECBF rock, at depth, below the properties. From vibration modelling, and our experience on similar tunnelling projects, we expect negligible effects at the surface.

However, this cliff line is a historic erosion feature and the cliff crest supported by relatively weak residual soils. Council records show that this stretch of cliff has experienced several landslides associated with high rainfall events in the last few decades, and a number of properties already exhibit some evidence of damage, presumably from instability.

Landowners are understandably concerned about any possibly effects of the tunnel on land stability. The project has proposed extensive baselining of existing structures, groundwater and ground levels, together with construction monitoring of vibration.

This approach was recently applied during the construction of a tunnel in the Auckland CBD and showed the vibration effects of the tunnelling works to be barely detectable even though the instrumentation was sensitive enough to register the vibration of the Kaikoura Earthquake in November 2016 (some 1000 km distance from the tunnelling work).

A number of events have been hosted for the public to attend, pose questions and discuss their concerns with the leaders of the project team. A geological 3D Model proved to be a very useful means of communication. The 3D Model was constructed based on all available data, including current and historic borehole data, topography, bathymetry, geophysical sections and geological sections. The geological units were modelled and the proposed structures, including shafts, pump station and tunnel sections, were also imported into the model. The result has been an accurate virtual model of the project area, which is added to and adapted as new information and data becomes available. This model has been an invaluable tool for communication, both between the disciplines of the project team and to the public. It was used incorporated with a groundwater model, with technical studies for consents, with detailed design schematics and to extract property-specific sections for landowners. Figure 7 shows an overview of the project area in the Leapfrog 3D geological model.

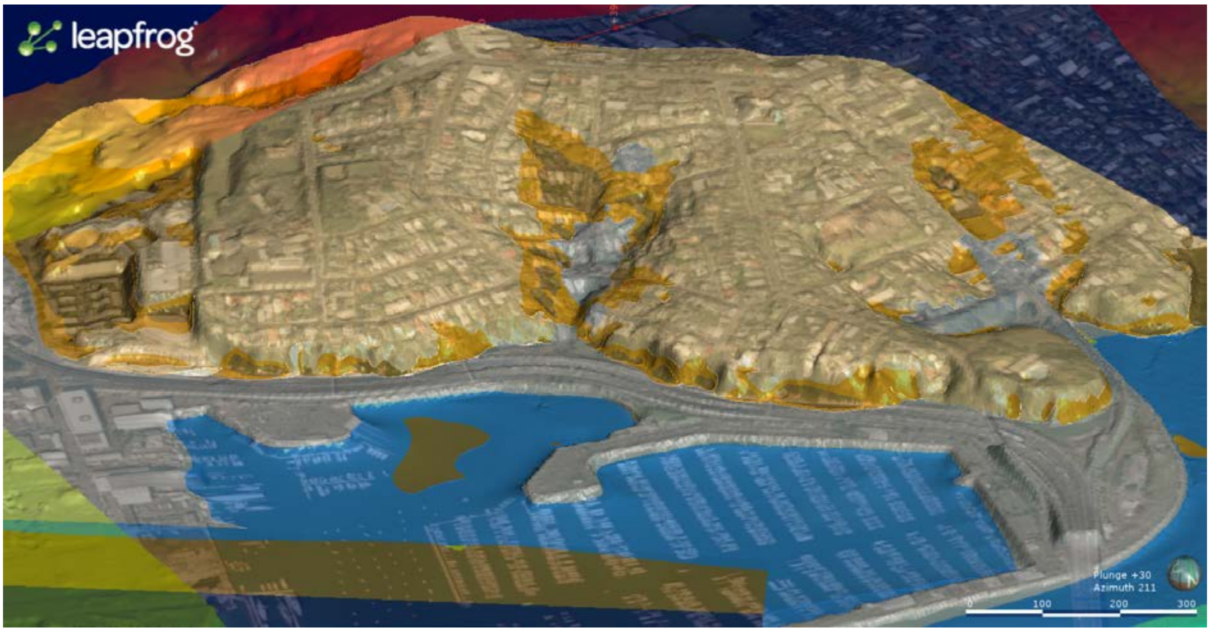

Figure 7: Overview of project area in Leapfrog 3D geological model. Source: Aurecon

3 CONCLUSION AND OUTLOOK

The St Marys Bay and Masefield Beach Water Quality Improvement Project has been a fast-paced and exciting project that only covers a relatively small geographical area. Within this area, the project team has needed to identify and manage has key project risks as described. The thorough, multi-disciplinary project team has identified and managed these risks, working closely with residents and Iwi to make sure concerns are understood and addressed, drawing on the extensive experience of the technical staff as well as historical data and maintaining communication across the project team and with community stakeholders.

Currently the project is in the phase of awaiting the outcome of the Resource Consent Application and, if all goes to plan, construction will start as early as 2019.

Keane, B. Taniwha. The Encyclopedia of New Zealand. http://teara.govt.nz/en/taniwha/print (accessed 22nd June 2018)

Shane, P., L. J. Strachan, and I. Smith (2010). Redefining the Waitemata Basin, New Zealand: A new tectonic, magmatic, and basin evolution model at a subduction terminus in the SW Pacific. Geochem. Geophys. Geosyst., 11, Q04008, doi: 10.1029/2009GC002705.