Memo

To	Peter Murray - DCE Information and Knowledge Services
Cc	Preserving the Nation's Memory Governance Board Rob Stevens, Project Director Rosie Perez, Project Manager
From	Liana Lloyd-Simpson, Senior Project Manager
Date	15 February 2018
Subject	PtNM Project: Board Action Item AP118 Climate Change Impact

Purpose

1. This memo addresses action item AP118 from Preserving the Nation's Memory (PtNM) Governance Board meeting held on 12 October 2017. This action item responds to the Board's request for the *Mulgrave Street Hazard Assessment Report* (Milestone 43) to include an analysis on the impact of climate change and rising sea levels on the 10 Mulgrave Street facility.

Recommendations

2. It is recommended that you:
    - **Note** that the updated *Mulgrave Street Hazard Assessment Report* includes analysis on climate change and the possible impact from rising sea levels to the Mulgrave Street facility and the Thorndon Precinct
    - **Note** that the key update is located in section 5.3 Climate Change, with only minor edits to sentences in other sections to ensure alignment with section 5.3
    - **Note** the risk of coastal inundation on low lying ground is predicted to be significantly exacerbated over the next 50 years by rising sea levels; and there is an increased risk of flooding due to increased rainfall, particularly affecting the existing lower elevation of the Mulgrave Street facility.

Governance Board open action item

3. At the 12 October 2017 Board meeting the *Mulgrave Street Upgrade: Land Hazard Assessment Report* (milestone 43) was formally accepted. The Board requested for additional analysis on the impact of climate change and possible increase in sea levels to the 10 Mulgrave St facility.

Updated Mulgrave Street Hazard Report

4. Opus Engineering Consultants, the authors of the report, undertook additional analysis and updated the report with section 5.3 – Climate Change (attached at Appendix 1).

Climate change – sea level rise and hydrological hazards

5. The report acknowledges the effects of climate change and the changing risk and uncertainty on coastal erosion and rising sea levels as a result. Risk management and planning is strongly recommended.

6. The report notes that sea levels will rise however it is unknown when this will happen. The report has modelled a number of scenarios that describe the potential impact of a range of rising sea levels on Wellington harbour (refer Table 4 on page 18). As an example, over the next 50 years:

    - If a 30cm sea level rise occurs, the consequences would be that, what is currently a 1%AEP event (annual exceedance probability for 1 in 100 year event) would be expected to occur at least once a year.

    - If the sea level rises 50cm, the consequence of this would be that the current 1%AEP event, would occur approximately twice per month.

7. The report also identifies extreme weather and rainfall events as most likely to impact Archives Wellington and the Thorndon Precinct in the future, as climate change is expected to impact on the volume and frequency of rainfalls in New Zealand. This may increase the risk of flooding of the existing Mulgrave Street facility as storm water pipes will need to cope with the increased volume of rainfall.

8. The report notes that the risk of coastal inundation on low lying ground is predicted to be significantly exacerbated over the next 50 years by rising sea levels; and there is an increased risk of flooding due to increased rainfall, particularly affecting the existing lower elevation of the Mulgrave Street facility

9. The PtNM project has calculated whole-of-life costs for 25 years. The business case timeline indicates the completion of the redeveloped Mulgrave Street facility in 2026, if the assumption is a building life expectancy of 50 years, this would take the building life span to 2076.

Peter Murray
DCE Information and Knowledge Services
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Appendix 1: PtNM 10 Mulgrave Street Hazard Assessment report

OPUS

Department of Internal Affairs

Preserving the Nation's Memory

10 Mulgrave Street Hazard Assessment

Department of Internal Affairs

Preserving the Nation's Memory

10 Mulgrave Street Hazard Assessment

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Contents

Executive Summary

As part of the Preserving the Nation's Memory (PtNM) project, the Department of Internal Affairs (he Department) has engaged Opus International Consultants (Opus) to consider the exposure of their existing Archives New Zealand facility to natural and anthropogenic hazards. The assessment includes whether the exposure to hazards is consistent across the whole building and specifically the two entrances, located on Mulgrave Street (west) and Thorndon Quay (east). Similarly, the Department wish to understand whether the nearby 'Thorndon Precinct' area is also subjected to the same exposure to hazards. A number of Government organisations already occupy buildings within the Thorndon Precinct, including the National Library and the Ministries of Justice and Defence. A summary of the hazard exposure for the Archives New Zealand building and the Thorndon Precinct is presented in Table 1.

Table 1 Hazard Exposure Summary to Archives New Zealand and Thorndon Precinct

Hazard	Archives New Zealand	Thorndon Precinct	Preferred Location
Fault Rupture	0.65 km from Wellington Fault.	0.5 km from Wellington Fault. Mapped adjacent to poorly constrained Lambton Fault.	**Similar**
Ground Shaking	Atop a number geological units which have soft layers which can amplify ground shaking.	Atop old alluvium. Less exposure to amplified ground shaking.	**Thorndon Precinct**
Liquefaction and cyclic softening	Known soft layers through marine deposits and young alluvium are potentially liquefiable.	Localised areas of potentially soft layers with low potential for liquefaction in older alluvium.	**Thorndon Precinct**
Tsunami	Within self-evacuation zone	Not considered to be exposed to tsunami hazards.	**Thorndon Precinct**
Flooding	Close to mapped flooding zone	Less exposed to flood hazards	**Thorndon Precinct**
Storm surge	Low exposure given distance from coastline.	Not considered to be exposed to coastal hazards	**Similar**
Urban fire	Exposed to urban fire potential (less neighbouring buildings)	Exposed to urban fire potential (higher concentration of buildings)	**Similar**
Contaminated land	Noted as a contaminated site (at least partially). Adjacent to train station and rail yards.	Potential for small fuel storage tanks for buildings at various sites.	**Thorndon Precinct**
Petroleum storage	Not in near vicinity to known large petroleum storage	Not in near vicinity to known large petroleum storage	**Similar**
Transportation incidents	Adjacent to Thorndon Quay (critical arterial route with heavy vehicles)	Between city streets	**Thorndon Precinct**

The Wellington Region is exposed to a high level of seismicity and has a number active faults capable of generating large earthquakes of magnitude 7.5 to 8+. The Wellington Fault is a principal seismic source and is located in close proximity to the Thorndon area.

The level of ground shaking experienced in an earthquake is considered one of the most important seismic hazards, as it is a source for other seismically induced ground damages effects such as liquefaction and settlement. Seismic hazards at the Archives New Zealand and the wider Thorndon area could be expected to be significant due to the potential for strong ground shaking. This shaking may be further amplified by deep soils in the vicinity of the building and basin edge effects. Observations from the 2016 Kaikoura Earthquake

indicate that higher levels of ground shaking were experienced within marine deposits and young alluvium, underlying the eastern side of the Archives New Zealand building, than the older alluvium underlying the western side of the building and the Thorndon Precinct area.

Exposure to liquefaction hazards is expected to be more localised, due to the variable nature of the marine and alluvial deposits and possible reclamation fill which underlie a large area of Thorndon and a portion of the Archives New Zealand building. Historical logs for the Archives New Zealand facility indicate that there are potentially liquefiable layers and soft peats which could lead to settlement. However, there is not adequate geotechnical data to confirm the level of liquefaction hazard and site specific investigation and analysis is required to quantify and liquefaction effects. The Thorndon Precinct area is expected to be much less vulnerable to liquefaction and settlement given the older alluvium present in this area.

The eastern (Thorndon Quay) side of the Archives New Zealand is more exposed than the western side or the Thorndon Precinct area to storm and tsunami hazards, given the closer proximity to the shoreline and the low lying nature of the reclaimed ground surface. The Archives New Zealand building is located on the cusp of two tsunami evacuation zones. It is recognised that due to climate change, there is both a changing risk exposure from coastal storm and erosion events and also a level of uncertainly regarding future rates of sea-level rise. The effects of which will likely increase the exposure to storm and coastal hazards, particularly at the existing Archives New Zealand facility.

Anthropogenic hazards are generally more localised than natural hazards, however they can also lead to building or infrastructure damage and potential loss of life. Exposure to anthropogenic hazards such as urban fire, explosion from hazardous substances or contaminated land is generally similar across the Archives New Zealand and Thorndon Precinct areas, as both areas are in close proximity to other buildings (including their relevant electrical and mechanical services), are highly populated (during business hours) and are all in the vicinity of potential zones of soil contamination. The exception is the eastern (Thorndon Quay) side of the Archives New Zealand which is potentially more exposed to transportation hazards. This is due to Thorndon Quay being a critical arterial route for Wellington City and therefore has a higher volume of heavy vehicle traffic and as it is also adjacent to the railway yard and train station, which exposes it to rail incidents.

1 Introduction

As part of the Preserving the Nation's Memory (PtNM) project, the Department of Internal Affairs (the Department) wish to assess the exposure of their existing Archives New Zealand facility and the Thorndon Precinct area to hazards.

The Department has engaged Opus International Consultants (Opus) to undertake an assessment to:

- Determine the hazards that could affect the facility;
- Determine whether there is any difference in exposure to hazards to the various entrances of the building (Mulgrave Street and Thorndon Quay) and;
- Assess the 'Thorndon Precinct' area to determine whether there are any locations in the immediate vicinity which are exposed to a lower level of hazards than the Archives New Zealand at10 Mulgrave Street.

This assessment encompasses both natural hazards, which are naturally occurring physical phenomena such as earthquakes or flooding, and anthropogenic hazards, which occur as a result of human influence such as hazardous substances fire or explosions.

This report presents the findings of this hazard assessment of the Archives New Zealand facility and the Thorndon Precinct.

2 The Site

2.1 Site Location

The Archives New Zealand building is located at 10 Mulgrave Street, Thorndon (see Figure 1). There are two entrances to the building; the main public entrance on Mulgrave Street near the intersection with Aitken Street and the loading bay entrances on Thorndon Quay. The Thorndon Quay entrance is low lying on reclaimed land and is two storeys lower than Mulgrave Street which marks the edge of an alluvial terrace.

The ground surface at the two entrances has an elevation difference of approximately 9 m. The Mulgrave entrance is ~11 m above sea level and Thorndon Quay at ~2 m above sea level, see Illustration 1 (WCC, n.d.).

The Archives New Zealand is located in close proximity to an area described as the 'Thorndon Precinct'. This area encompasses the National Library and a number of other Government occupied buildings such as the Ministry of Defence and the Ministry of Justice, see Figure 1.

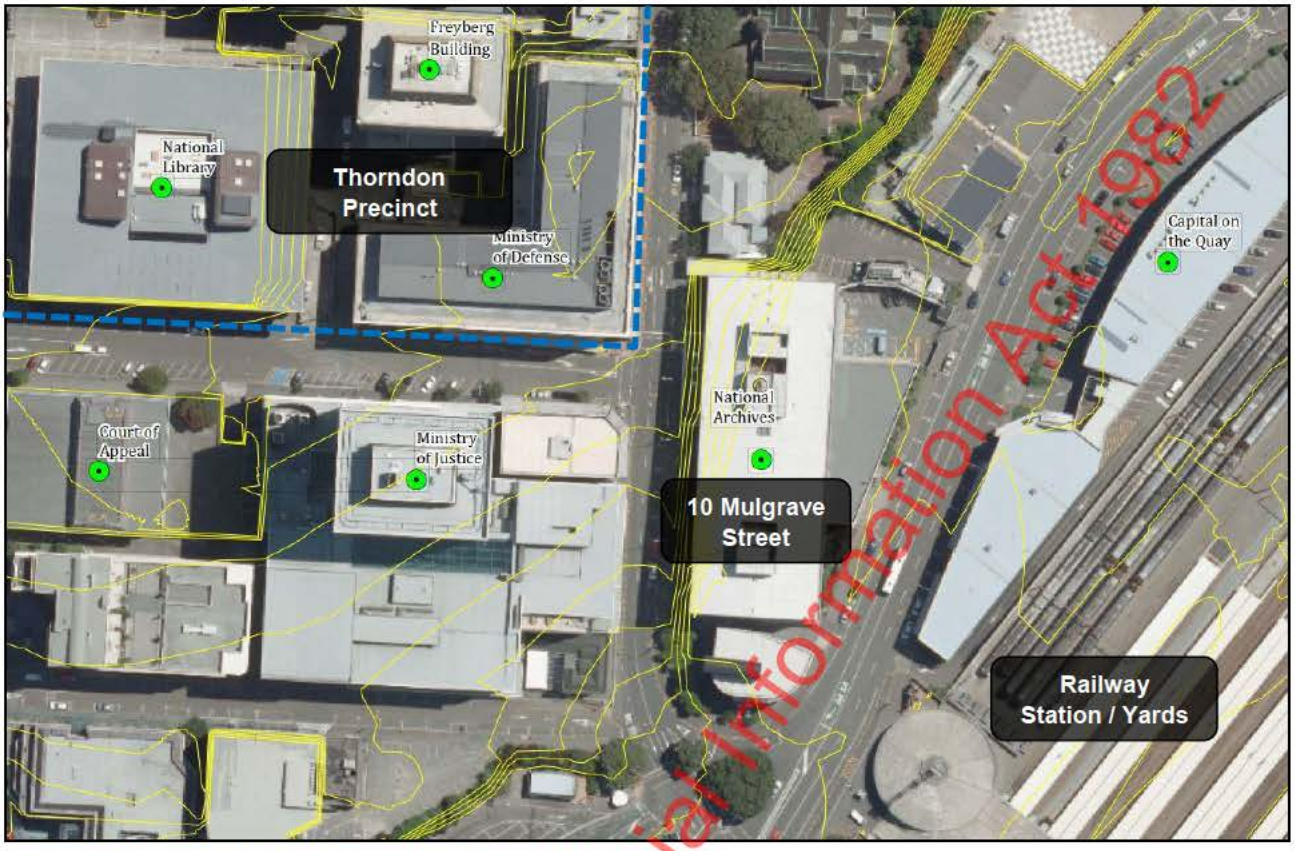

Illustration 1 Contour Map of Archives New Zealand (WCC, n.d.)

2.2 Geology

The geology of the Wellington Region has been mapped by the Institute of Geological and Nuclear Sciences at 1:25,000, 1:50,000 and 1:250,000 scales (DSIR, 1974 and IGNS 1996 and 2000). These maps show that the Archives New Zealand facility has been built straddling an old sea cliff between an older alluvial terrace to the west and lower lying marine deposits to the east. The building is underlain by three geological units, see Illustration 2.

Along Thorndon Quay, the surface geology has been characterised as reclaimed land. Areas around the Wellington Harbour have been progressively reclaimed between 1852 and 1973, see Figure 2. The composition of the reclaimed land varies between quarried rock and hydraulically placed marine silts and sands and the depth varies up to 17 m (Murashev and Palmer, 1998). The fill in nearest proximity to the archives is the 'H zone' and is noted as 'rock fill' by the Wellington Harbour Board (1936), see Figure 2. This fill is further described as gravel with some sand and gravelly silt, with a thickness of 1.2 to 2.5 m in the vicinity of the Archives New Zealand (MOW, 1961 and T&T, 1994). The Wellington Harbour reclaimed land is generally flat with ground surface levels ranging between 1 and 3 m above mean sea level.

Adjacent to the reclamation fill, a narrow zone of marginal marine sediments are mapped (IGNS, 1996). Borehole information in the wider area indicate these units primarily consist of beach sand and extend beneath the 'H zone' of reclaimed land to the east towards the present harbour coastline. The thickness of the material is variable but is indicated to be of the order of 2.0 – 5.0 m (T&T, 1994 and Wellington Harbour Board, 1936).

The third geological unit in the vicinity of the Archives New Zealand are alluvial deposits of the Whiteman Formation (DSIR, 1974). These deposits comprise gravels, sands, silts and peat and are preserved as a terrace. The edge of this alluvial terrace is likely to account for the elevation difference between Mulgrave Street and Thorndon Quay and marks the historical shoreline prior to reclamation of the land further east.

Illustration 2 Geology of Thorndon Area (IGNS, 2000)

Notes 1.This map was originally 1:250,000 scale and does not depict the marginal marine deposits shown in the IGNS 1996 1:50,000 map.

2. Due to the scale of this map (1:250,000) the boundary of these units should be considered to be accurate to ±250 m.

2.3 Ground Conditions

There is only one borehole in the vicinity of the Archives New Zealand that has confirmed the depth to bedrock. The borehole is located approximately 70 m to the northwest, at the northern end of the Ministry of Defence building at 2 Aitken Street, and indicates bedrock is at 114 m depth. A study that compiled bedrock contours for the wider Thorndon area shows that the depth to bedrock increasing to the east towards Wellington Harbour. The depth to bedrock at the Archives New Zealand is indicated to be of the order of 150 m depth, see Illustration 3 below (Semmens, 2010).

Geotechnical investigations carried out by the Ministry of Works (MOW, 1961) indicate that the building is underlain by variable layers of sand, silt and clay with lesser deposits of peat and gravel to a minimum of 25 m depth. This indicates that the building has been founded on marginal marine and alluvial deposits. No strength or in-situ tests were carried out as part of this investigation.

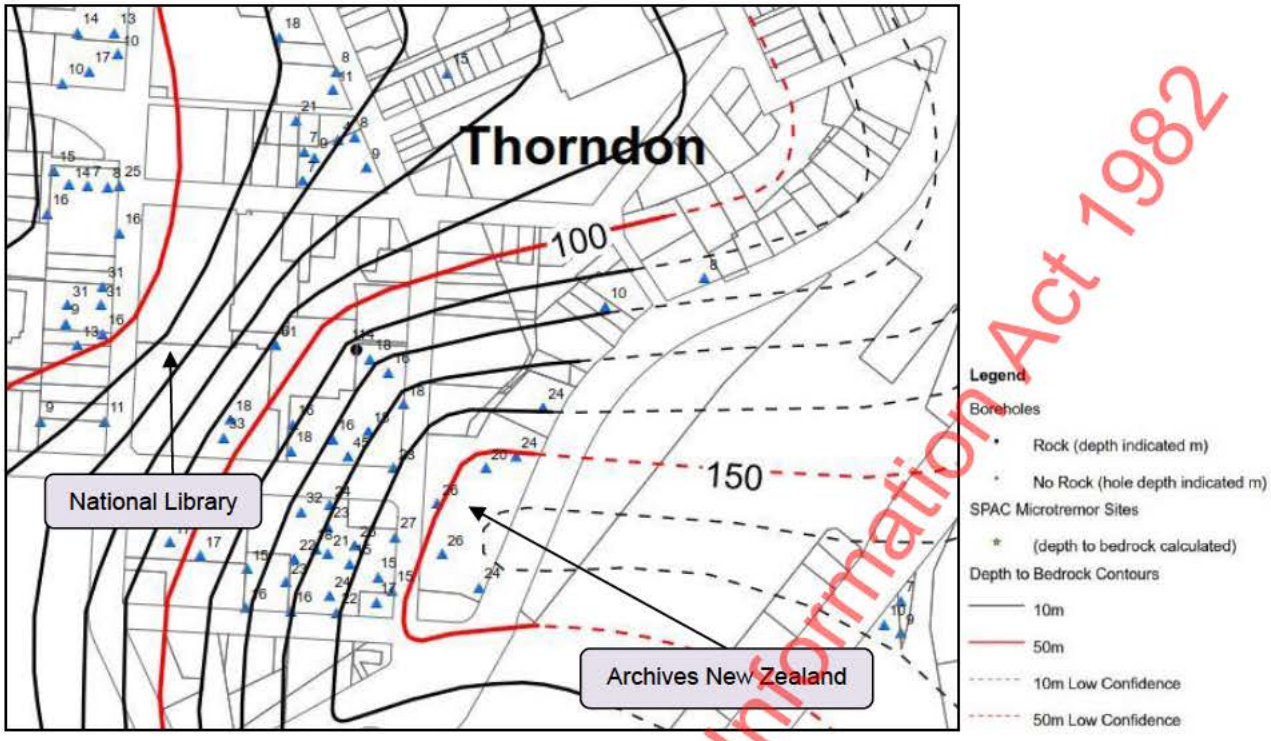

Illustration 3 *Bedrock Contours in the Thorndon Area (Semmens, 2010)*

2.3.1 Groundwater

There are no site specific records of groundwater levels for the Archives New Zealand building. However measurements taken across the wider Thorndon area provide an indication of the hydrological setting.

To the east of the Archives New Zealand, groundwater levels have been noted between 2.0 – 3.5 m depth (T&T, 1994 and Cubrinovski et al., 2017).These levels are expected to be consistent throughout the reclaimed land between Thorndon Quay and the harbour.

West of the Archives New Zealand, the groundwater has been measured up to 4 m below ground level. Due to the variability of alluvium, the groundwater levels are expected to be more locally variable. It has been noted that groundwater levels show a variation between 1.5 - 2.0 m in depth across the same site (Semmens, 2010).

2.4 Site Class

The ground conditions indicating deep soil deposits suggests the site class, in accordance with NZS 1170.5, is Class D, or potentially Class E if the underlying soils are very soft. This suggests the potential for amplification of earthquake motion leading to strong ground shaking.

3 Hazards

3.1 Hazards Considered

To consider the exposure of the Archives facility to risk from hazards, the hazards have been categorised into two types; natural hazards, which are naturally occurring physical phenomena such as earthquakes or flooding, and anthropogenic hazards, which occur as a result of human influence such as hazardous substances fire or explosions. A list of the hazards considered in this assessment is provided below:

3.2 Natural Hazards

A. Seismic hazards
    a. Fault rupture
    b. Ground shaking
    c. Slope failure
    d. Liquefaction
    e. Tsunami
B. Storm hazards
    a. Flooding
    b. Storm surge and coastal inundation
C. Volcanic hazards

Natural sea cliff slopes in the vicinity of the Archives New Zealand facility accommodate an elevation difference of ~9 m between Mulgrave Street and Thorndon Quay, with the slope faces bound by retaining structures. Consequently, earthquake and storm induced slope instability is not considered as an issue for the building, however the performance of these walls in a seismic event could be critical to performance of the building.

Volcanic hazards have not been considered in this assessment as they are not regarded as a significant hazard in the Wellington Region. The nearest volcanic centre is the Central Plateau and any far reaching effects that may occur from a volcanic event here are not likely to significantly impact the Wellington region. Any effects (eg ash fall) that do affect the region are considered to be consistent across the wider Thorndon area including the Archives New Zealand building and the Thorndon Precinct.

Wild fire is not considered in this assessment as the Archives New Zealand and Thorndon Precinct areas are both within an urban area where wild fire is not considered as a hazard.

Cyclones are more common in higher latitudes of New Zealand as they originate from the tropics (Sinclair, 2002). As they advance poleward, the can ose characteristic hurricane features and for this reason, can be considered less of a hazard for the Wellington Region. It is expected that adverse weather effects that could affect the Archives facility will have a consistent impact across the wider Thorndon area. Consequently, cyclones have been excluded from this assessment.

3.3 Anthropogenic Hazards

D. Urban fire
E. Petroleum and hazardous substance storage
F. Transportation incidents (road, rail, air)
G. Contaminated land

Military hazards are not considered in this assessment as there are no known military facilities in the vicinity of the Archives New Zealand building. However, it is noted that a Ministry of Defence office building is located within the Thorndon Precinct area, and close to the Archives New Zealand building at 10 Mulgrave Street.

Security issues have been omitted from this assessment. It is considered that the Department will already have information detailing security issues regarding their existing facilities in the area (Archives New Zealand and Library) and the exposure to potential security hazards will be consistent across the wider Thorndon area.

Detailed descriptions of these hazards considered are provided in the following sections.

4 Seismic Hazards

4.1 Seismicity

The Wellington region is exposed to a high level of seismicity. It has a number of major active faults and a subduction zone associated with the active plate boundary between the Pacific and Australian plates. These structures are capable of generating large earthquakes of magnitude 7.5 to 8+, and together these represent earthquake sources that contribute significantly to the seismic hazard in the Wellington region. The principal active faults within 20 km of the site are summarised in Table 2 below.

Table 2 Active fault summary table

Fault	Characteristic Event Magnitude	Recurrence Interval (years)	Distance from site	Direction
Wellington Fault	7.5	610 – 1100	0.65 km	North west
Ohariu Fault	7.1 – 7.5	2,200	5.4 km	North west
Wairarapa Fault	8.0 – 8.3	1,200	20 km	East

Source: GNS Science (2008); Heron et al. (1998); Langridge et al. (2011); Litchfield et al. (2004, 2006, 2010); Little et al. (2009, 2010); Schermer et al. (2004); Stirling et al. (2012).

In addition, the subduction interface between the Pacific and Australian plates has the potential to generate very large magnitude earthquakes (Mw 8.2-8.6) that would generate strong ground shaking in the Wellington region (Holden and Zhao, 2011).

4.2 Fault Rupture

Fault rupture refers to displacement of the ground. Fault movements can occur underground without breaking the surface, but are more hazardous to infrastructure when the rupture reaches the ground surface. Where a building is constructed in this zone, the rupture has the potential to cause significant structural damage.

The Wellington Fault is the closest known active fault to the Archives New Zealand, see Illustration 4. The fault has a recurrence interval of 610 to 1,100 years and ruptures in large earthquakes of magnitude 7.5 with typical coseismic displacements of the ground surface of 5 m horizontally and 1 m vertically (Little et al., 2010). The Archives New Zealand and the Thorndon Precinct are located ~650 m and ~500 m respectively from the trace of the Wellington Fault. Given this separation, fault rupture is not considered as a significant hazard for these sites.

The Lambton Fault is located in close proximity to the Archives New Zealand and Thorndon Precinct (Illustration 5) however is considered less active and is thought to not have moved in the past 100,000 years (DSIR, 1974 and GNS, 2017). It is mapped (at 1:25,000 scale) to pass through the Thorndon area west of Molesworth Street, approximately 250 m from the Archives New Zealand. It is unlikely that the Archives New Zealand site is exposed to fault rupture hazard from the Lambton Fault. Sites in the vicinity of Molesworth Street may be exposed to potential fault rupture hazards but based on the map, the Thorndon Precinct is just outside of the Lambton Fault.

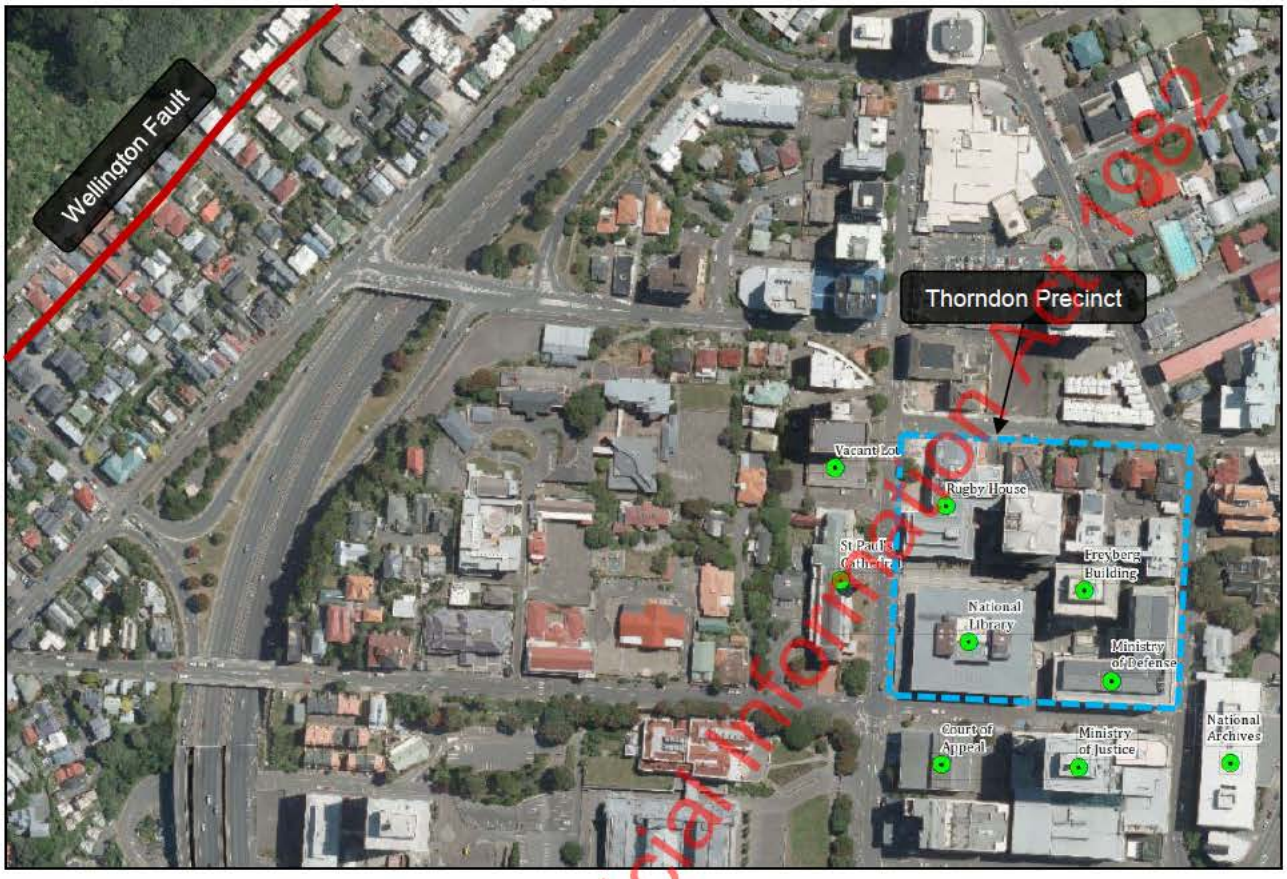

Illustration 4 Wellington Fault Location – (IGNS, 2000)

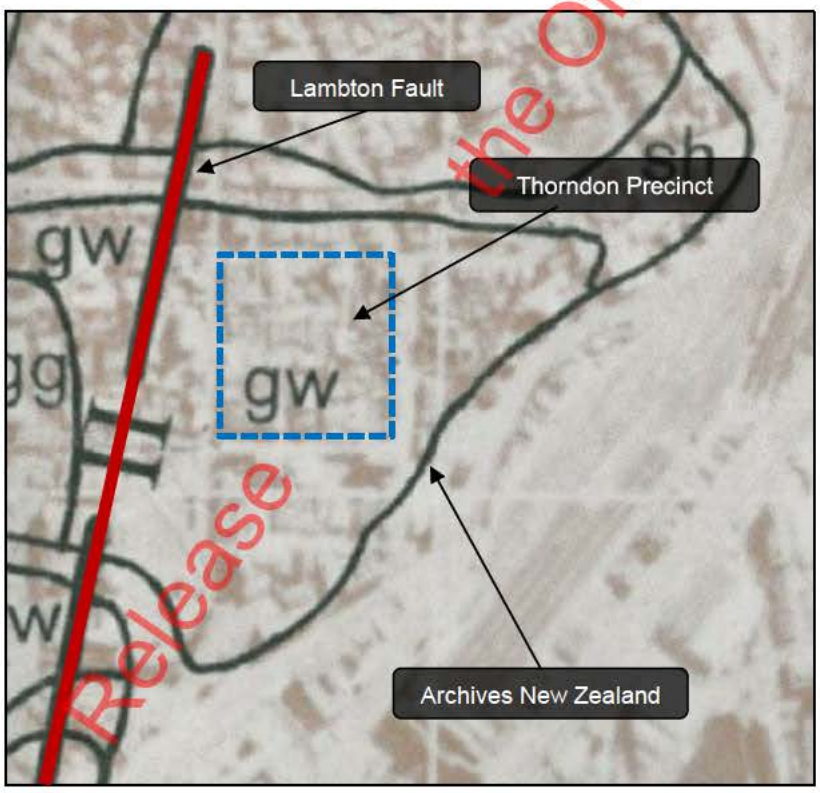

Illustration 5 Lambton Fault location in Thorndon (DSIR, 1974)

4.3 Ground Shaking

Ground shaking is the intensity of shaking that is experienced during an earthquake. It varies across regions as it is influenced by topography, geology and the earthquake source. Intensive ground shaking can cause buildings and infrastructure to collapse or be significantly damaged. Ground shaking can be considered as the most important seismic hazard as it is the source for a number of other earthquake hazard phenomena.

According to Semmens (2010), the Archives New Zealand facility and surrounding area in Thorndon has a moderate potential for ground shaking amplification. This is because it is underlain by >150 m of soil deposits. Sites underlain by soils, as opposed to sites located on rock, tend to damp out high frequency motion and amplify long period motion. When the amplified period is close to the natural period of a structure, the ground motion can cause severe damage.

Ground shaking can also be amplified through basin edge effects. The Thorndon Precinct and Archives New Zealand are located in close proximity to the edge of the Thorndon Basin, which is bound by the Wellington Fault. When the seismic waves reach the basin edge they can be reflected and result in amplification of ground shaking. The Archives New Zealand facility is also located along a sea cliff which marks the boundary of older terrace alluvium with softer recent alluvial and marine deposits and reclamation fill. These younger, softer sediments along Thorndon Quay may experience more locally amplified shaking compared to the older terrace where the Thorndon Precinct is located.

Evidence of amplified ground shaking in the Thorndon area was observed during the M_w7.8 Kaikoura Earthquake which occurred in November 2016. The peak ground accelerations (PGA) measured within soil sites in the Thorndon Basin where significantly higher comparatively to sites underlain by rock. Strong ground shaking was experienced along Thorndon Quay at the Thorndon Fire Station building which is representative of the situation of the Archives New Zealand facility (Geonet, 2016).

4.4 Liquefaction

4.4.1 Available Geotechnical Information

An overview of the potential exposure to liquefaction hazards has been undertaken by reviewing geotechnical information available for the Archives New Zealand and the surrounding area. Intrusive geotechnical information was predominantly retrieved from our records, the Wellington City Council archives and public databases. Historical geotechnical logs were reviewed for the following buildings (Figure 1):

- 34 Thorndon Quay - Capital Gateway complex
- 10 Mulgrave Street – Archives New Zealand
- 19 Aitken Street – Ministry of Justice (also known as Vogel House)
- 2 Aitken Street – Defence House
- Corner Aitken and Molesworth Street – Court of Appeal, Ministry of Justice
- 20 Aitken Street – Freyberg House
- 70 Molesworth Street – National Library
- 61 Molesworth Street – Vacant building site

It is important to note that while a number of borehole logs were reviewed in this assessment, no geotechnical analysis was undertaken. The historical logs available for the Archives New Zealand were undertaken circa 1961 and do not include any in situ testing or groundwater data. As such, the exposure to liquefaction hazards discussed in the following section is based on the soil descriptions provided and is a qualitative assessment only.

4.4.2 Liquefaction Potential

Liquefaction occurs when saturated sediments are subjected to ground shaking, which causes the soil to act as a fluid and is forced to the surface under pressure. Lateral spreading is an associated effect where soil moves laterally towards free surfaces. Both liquefaction and lateral spreading can lead to significant structural damage.

A regional-level study of the susceptibility of liquefaction has previously been undertaken for the wider Wellington region (Brabhaharan, 1994). This study indicates that the potential for liquefaction along Thorndon Quay is considered moderate and in the area of the Thorndon Precinct is considered as negligible (WRC, 1993). Other studies describe the reclamation fill area has having a high liquefaction potential and the Thorndon Precinct area as having a variable liquefaction potential, ranging from low to high (Semmens, 2010).

Historical logs for the Archives New Zealand building are available form 1961. One of the boreholes was undertaken adjacent to Thorndon Quay and may comprise ~0.5 m of fill or reclamation fill, however the deposits are not characterised. The thickness of the reclamation fill along Thorndon Quay and is noted to be up to 2 m thick and was placed in 1876 (Semmens, 2010).

Underlying the fill deposits, the borehole logs indicate up to 25 m of variable deposits of sand, silt and clay with lesser deposits of peat and gravel which are likely to be marine and alluvial deposits. The marine sediments are thought to be of the order of ~ 1.5 m in thickness and consist of medium gravel, shell fragments and sand.

Within the alluvial deposits there are localised layers of silt and sandy silt that may be susceptible to liquefaction. These layers are more common at the southeast end of the Archives New Zealand building than along Mulgrave Street where the soils become more clayey and gravelly. The liquefaction susceptibility of these silty soils will depend on the density and the plasticity properties, however in-situ testing data of this material is not available. As the thickness of the layers are variable across the site, liquefaction or softening of the soils during earthquakes could lead to differential settlements across the building footprint.

It is noted that no liquefaction manifestation was observed at this site during the Kaikoura earthquake which only led to low to moderate ground shaking in Wellington.

The Thorndon Precinct area is underlain by older alluvial deposits. Boreholes from the wider area indicate these deposits are dominated by sandy gravel in a clay or silt matrix. There are also localised zones of soft peats, silts and sands. These alluvial deposits are generally not susceptible to liquefaction except where these localised zones of soft or loose deposits are encountered.

4.4.2.1 Lateral Spreading

Lateral spreading is a major seismic hazard for sites located near a free face such as a river bank. The Archives New Zealand building is located on sloping ground, and the higher ground of older alluvium has a low potential for liquefaction. It is considered that the Archives New Zealand and Thorndon Precinct area is not exposed to lateral spreading hazards.

4.5 Tsunami

A tsunami is a natural phenomenon consisting of a series of waves generated when a large volume of water in the sea or a lake is rapidly displaced. They can affect long stretches of coastline and extend inland for hundreds of metres to kilometres in low lying areas. The effects of tsunamis can be controlled by the topography, geomorphology, bathymetry, beach slope, coastal orientation, configuration and the characteristics and direction of arising waves and the built environment within the tsunami run-up zone.

Indicative evacuation zones for tsunami hazards have been mapped for the Wellington Region (GWRC, 2010). These zones correspond to different threat levels and are characterised into red (shore exclusion zone), orange (CDEM evacuation zone) and yellow (self evacuation zone) zones.

The Archives New Zealand building is within the yellow self-evacuation zone for tsunami risk, as shown on Illustration 6. This zone is designated for large return period waves (2500 year return period), with a wave height of >10 m. Immediately adjacent to the Archives New Zealand building, along Thorndon Quay is characterised as the orange CDEM evacuation zone. This zone is for a distant or locally sourced tsunami with a return period of 500 years. This zone may be evacuated by Civil Defence for a large local earthquake or one sourced within the Pacific (eg. South America). This area is more exposed to tsunami hazards than the yellow self-evacuation zone. The characteristics of these zones are summarised in Table 3 below.

Table 3 Tsunami Evacuation Zones for Wellington Harbour

Evacuation Zone	Return Period (years)	(84%) Wave Height (m)
Yellow	2,500	12.3
Orange	500	3.6

Source: GNS, 2008

The Thorndon Quay side of the Archives New Zealand building is more exposed to tsunami hazards due to the lower elevation. This is where the loading bays to the archive storage area are located. The Thorndon Precinct has a very low exposure to tsunami hazards as it is located outside of the tsunami evacuation zones.

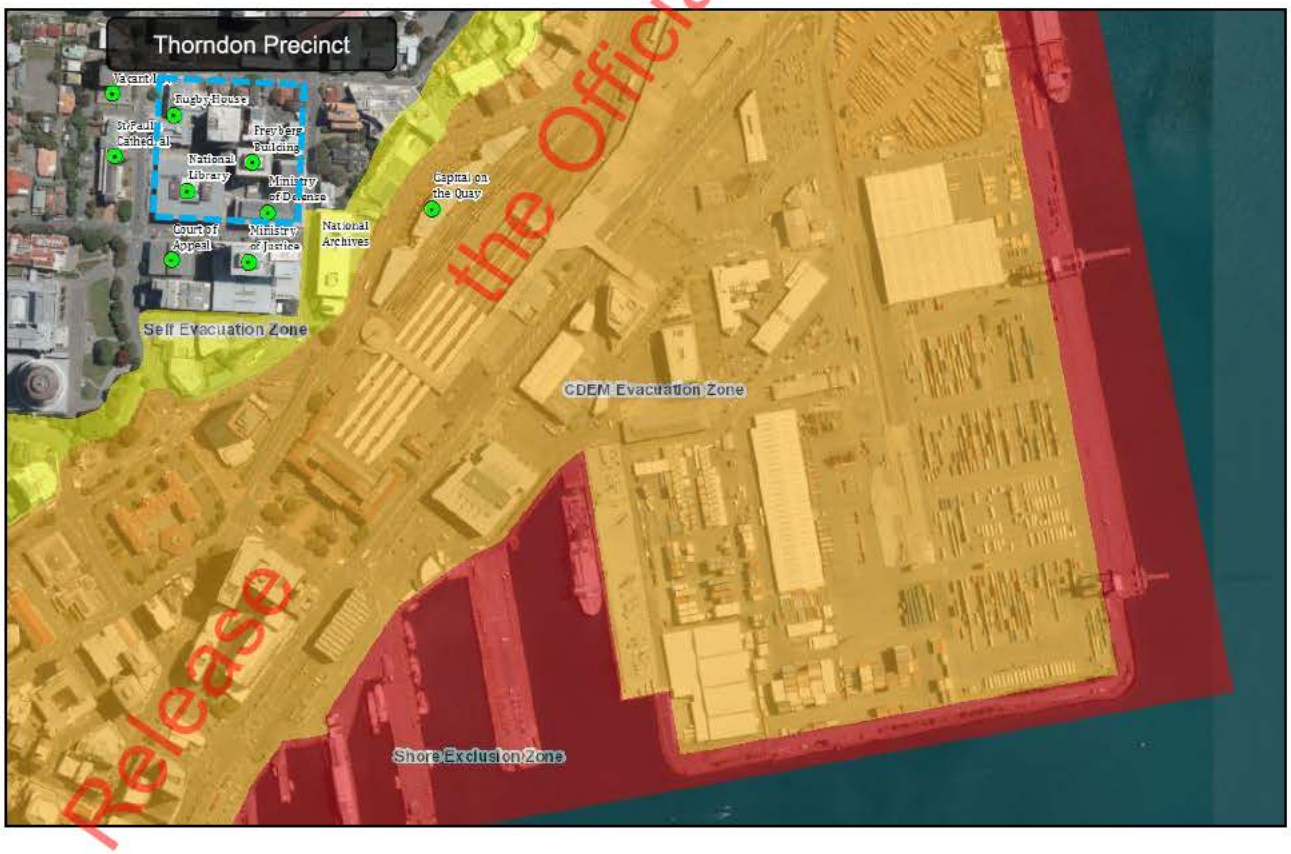

Illustration 6 Tsunami Evacuation Zones (WREM, 2017)

5 Storm Hazards

5.1 Flooding

Flooding is most commonly caused by heavy or prolonged rainfall. It generally occurs over a short period of time and affects localised areas.

Greater Wellington Regional Council have produced flood hazard maps (GWRC, 2016). These maps indicate that there are a number of low lying areas in the vicinity of the Archives New Zealand that are exposed to flooding hazards, see Illustration 7. These areas, including the train station and associated rail yard opposite the Archives New Zealand facility, are mapped to have 2% probability of a flood occurring within any given year which is classed as a 'high likelihood' area (GWRC, 2016). Predicted flooding depths for specific sites are based on factors such as the wider catchment area, land use and storm water services and would require detailed assessment.

Illustration 7 Flooding Hazards

Although these maps do not present the Archives New Zealand facility as being exposed to flood risk, the low-lying elevation on the Thorndon Quay is consistent with the railway yard (2 m above mean sea level). Given this it is reasonable to expect that flooding hazards can also be expected across Thornden Quay and along the base of the Archives New Zealand facility. This is of particular importance for the loading bay area and the basement levels of the building. It is noted that the loading bays are 1.2 – 1.5 m above the road level and hence have a greater level of protection. The basement level is potentially exposed to flooding if the flooding extends from the rail yards across Thorndon Quay, but the likelihood is low based on the flood hazard maps.

Flooding can inundate buildings, cause foundation damage and contribute to degradation of the building and its contents. Flood inundation of a building is likely to cause significant damage to stored materials.

The Thorndon Precinct is not shown to be exposed to flooding hazards in the GWRC modelled scenario. This indicates there is less than a 2% probability of a flood occurring within any given year.

5.2 Storm Surge and Coastal Inundation

Storm surge is a coastal hazard which can induce flooding when storms affect a coastline. Sea level rises as a result of falling atmospheric pressure and strong winds can push water up against the coast. Coastal inundation can occur when high tides, storm surge and/or large waves occur at the same time. As storm surge induces flooding, the likely consequences are described as above in the flooding assessment.

The Thorndon Quay side of the Archives New Zealand facility is on low lying ground which may be exposed to flooding hazards, as described in Section 5.1 above. However, the facility is 300 m from the existing Wellington Harbour coastline, with a number of buildings and infrastructure located in between. Given this, the Archives New Zealand is not considered to be exposed to storm surge and coastal inundation hazards.

The Thorndon Precinct is further inland and at a higher elevation than the Archives New Zealand facility and is also considered to not be exposed to storm surge and coastal inundation hazards.

5.3 Climate Change

The earth's climate is changing, predominantly due to emissions of greenhouse gases from human activities, such as burning fossil fuels, agriculture, and deforestation. These greenhouse gases warm the earth and one of the major and most certain consequences of warming, is sea-level rise (MfE, 2017b). Climate change and sea-level rise may compound coastal hazards already occurring naturally. The exact nature of the change has some uncertainty and it is therefore important to understand the range of future potential scenarios, and the impact they might have, on the existing Archives New Zealand facility and the Thorndon Precinct.

5.3.1 Sea Level Rise

Hydrological risks such as coastal inundation, coastal erosion or pluvial flooding can be exacerbated by rising sea level. The nature and frequency of these potentially damaging or disruptive coastal hazards is likely to increase. With a modest 30 cm rise in sea levels in the next 50 years or so, the current 1%AEP event (a 1 in 100 year event) will be expected to occur at least once a year in Wellington Harbour (Parliamentary Commissioner for the Environment, 2015). With a sea-level rise of 50 cm, the current 1%AEP event (a 1 in 100 year event) would occur approximately twice a month (Parliamentary Commissioner for the Environment, 2015).

Table 4 shows a range of sea-level rise increments that could be reached in New Zealand and the approximate timeframe they could be reach for the four scenarios modelled in New Zealand (MfE, 2017a).

- The low-emission scenario (RCP2.6) assumes an 'aggressive emissions' reduction in the emission fossil fuels.
- The two middle scenarios (RCP4.5 and RCP8.5) should be considered equally in assessments along with the range between them (MfE, 2017a). The RCP4.5 scenario assumes a reduction in emissions whereas the RCP8.5 scenario assumes little to no reduction.
- The RCP8.5H+ scenario was added to reflect a world where a high rate of rise may be experienced in the latter part of the century (i.e. faster polar ice sheet melt). This scenario could be used to assess the adaptability of major infrastructure, and timing of decision points (MfE, 2017a).

Table 4 Approximate years when specific sea-level rise increments could be reached for the four scenarios of sea-level rise in NZ (from MfE, 2017a).

SLR (metres)	Year achieved for RCP8.5 H$^+$ (83%ile)	Year achieved for RCP8.5 (median)	Year achieved for RCP4.5 (median)	Year achieved for RCP2.6 (median)
0.3	2045	2050	2060	2070
0.4	2055	2065	2075	2090
0.5	2060	2075	2090	2110
0.6	2070	2085	2110	2130
0.7	2075	2090	2125	2155
0.8	2085	2100	2140	2175
0.9	2090	2110	2155	2200
1.0	2100	2115	2170	>2200
1.2	2110	2130	2200	>2200
1.5	2130	2160	>2200	>2200
1.8	2145	2180	>2200	>2200
1.9	2150	2195	>2200	>2200

The earliest year listed is based on the RCP8.5 (83rd percentile) or H+ projection and the next three columns are based on the New Zealand median scenarios in figure 27, with the latest possible year assumed to be from a scenario following RCP2.6 (median). Note: the year for achieving the sea-level rise is listed to the nearest five-year value.

The uncertainty associated with Table 4 is not 'whether it will happen' but rather 'when will it happen' i.e. a 1.5 m sea level rise is predicted to occur in al four pathways, however the predicted year of occurrence ranges between 2130 for a PRC8.5 scenario and >2200 in a RCP4.5 scenario. Risk management and planning must therefore recognise there is both a changing risk exposure from coastal storm and erosion events and also a high level of uncertainly regarding future rates of sea-level rise (MfE, 2017a).

The Thorndon Quay side of the Archives New Zealand facility is on reasonably low lying ground. While the facility is 300 m from the existing Wellington Harbour coastline, with a number of buildings and infrastructure located in between, a 1.5 m rise in sea levels will cause this low lying area to be inundated (Illustration 8) (T+T, 2013). However, considering the area expected to be inundated is part of Wellington's business hub, it is possible that mitigation techniques such as sea walls will be employed and thus, limit inundation. The Thorndon Precinct is not modelled to be inundated with a 1.5 m rise in sea levels, however will have a higher exposure to storm surge and coastal inundation hazards (Illustration 8).

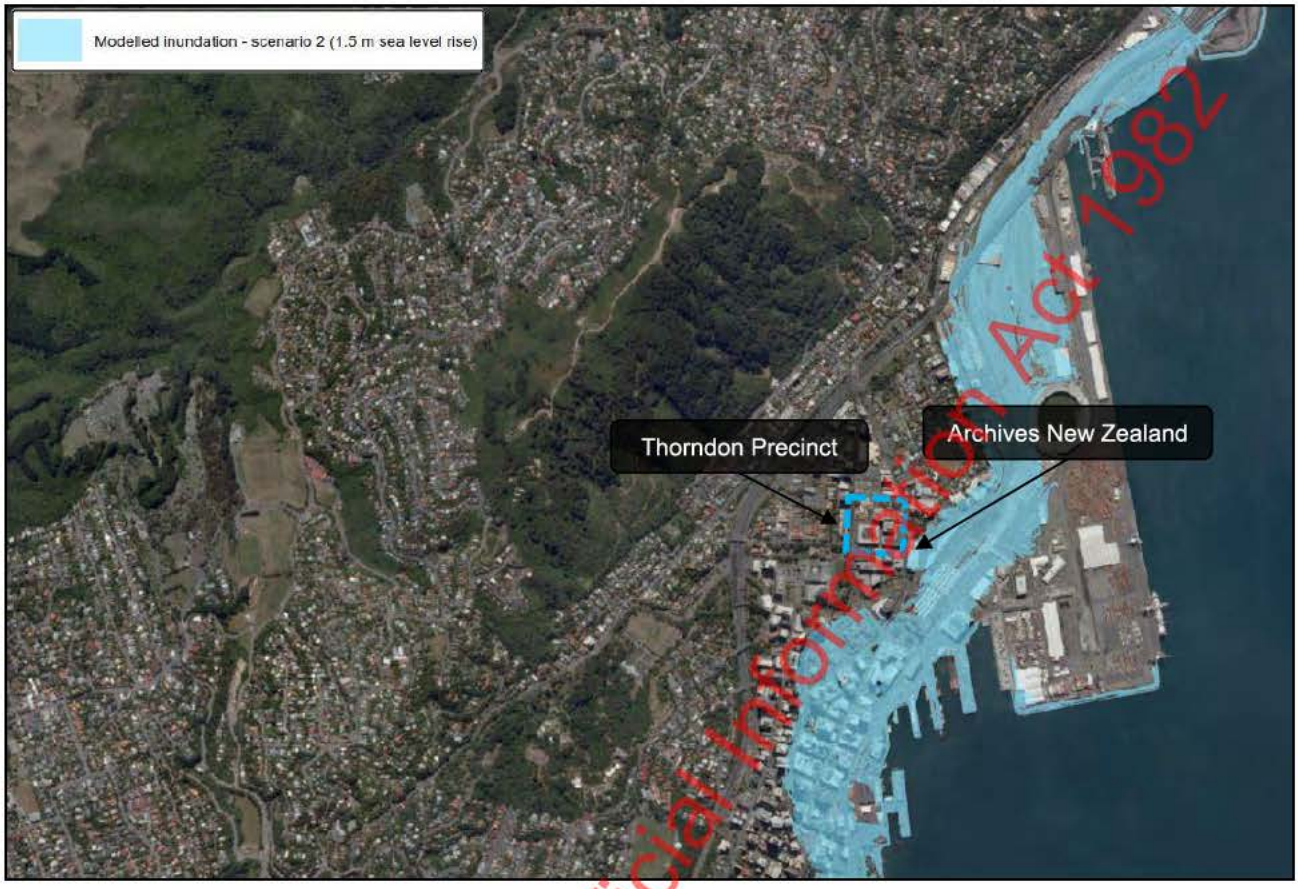

Illustration 8 1.5m sea level rise modelled scenario assuming no mitigation (i.e. sea walls) (from T+T, June 2013).

5.3.2 Other Hydrological Hazards

Besides-sea-level rise, coastal environments will also be affected by changes in weather-related coastal-hazard drivers, such as storm surge, waves, winds, and the frequency and intensity of storms. Any changes in impacts from these drivers have implications for coastal erosion, coastal inundation, and groundwater and drainage levels (MfE, 2017a).

Considering the National Archives and the Thorndon Precinct locations are currently inland, there is a low risk of coastal erosion or wave ove topping at these locations, even with increased probabilities due to climate change. However, cl mate change is expected to have an effect on rainfall patterns and amounts around New Zealand. The biggest change is expected to come from the changes to extreme rainfall. Both frequency and intensity of rainfall is expected to increase, mostly because a warmer atmosphere can hold a greater amount of water (MfE, 2010). An increase in the intensity and frequency of large rainfall events will likely have a regional scale effect encompassing both existing Archives New Zealand facility and the Thorndon Precinct.

However given the lower elevation of the existing Archives New Zealand facility, increased rainfall could increase the flooding risk as stormwater pipes need to be able to convey a greater volume of water. As sea level rises, the discharge locations of stormwater pipes could become underwater at high tide or during storm events. This becomes problematic when rainfall events occur and the discharge location is underwater meaning the pipes cannot discharge and become backed-up, increasing the risk of flooding at the site.

6 Anthropogenic Hazards

6.1 Urban Fire

Urban fires can be caused maliciously, by accident, or as the result of an unpredicted ignition (eg. electrical, mechanical, or chemical fault). Fires can also result from natural causes such as earthquakes or lightning. Fire can engulf and destroy buildings as well as risking human life. A large fire could significantly damage stored material at the facility or destroy it completely.

There is a greater level of exposure to urban fire hazards in more highly and densely populated areas. In such areas, there are generally more sources for fire ignition (land use and building and infrastructure service pipelines) and fire can more easily spread between closely spaced, flammable buildings - from both human ignition and following large natural hazard events such as earthquakes or tsunamis.

The central Thorndon area, where the Archives New Zealand and Thorndon Precinct are located, is primarily occupied by other government and commercial organisations. The surrounding buildings are multi-storeyed and are likely to be densely populated during business hours, but are likely to be constructed of less flammable materials.

The Archives New Zealand building is bounded on two sides (east and west) by roads and two sides by other buildings. Exposure to urban fire hazards is moderated by the presence of Mulgrave Street and Thorndon Quay along the long axis of the building but the close proximity to the Tramways Building (south) and Anglican House (north) mean the site is potentially exposed to a significant fire hazard.

By contrast, the Thorndon Precinct area is similarly prone to fire hazards as there are a number of large, densely populated and closely spaced buildings within the area. These range between commercial premises, government organisations and residential buildings, a number of which have timber exteriors.

As a result, it is considered that the wider Thorndon area is exposed to fire hazards. The highest levels of exposure are those in the centre of the precinct area which are bound by multiple buildings, and those adjacent to timber buildings.

6.2 Petroleum and hazardous substance storage

Substances classed as hazardous may be explosive, flammable, corrosive or toxic. This could include petroleum or other fuel, gases such as LPG, acids and alkalis, industrial solvents and other chemicals. Where such substances are stored, the exposure to potential fire, explosion hazards or toxic atmosphere hazards is heightened. Storage sites can be classed in the following four categories (Opus, 1999):

- Major bulk storage tanks (eg. tank farms)
- Intermediate bulk storage (eg. service stations and airports)
- Small storage sites (eg tanks with capacity less than 40,000 litres)
- Pipelines

The nearest known large petroleum storage site to the Archives New Zealand, is the northern end of the railway yard and the pipelines which connect Kaiwharawhara to Aotea Quay. However, any storage of petroleum or other hazardous substances at the railway yard is likely to be located north of Westpac Stadium, away from the train station, which is a significant distance from the Archives facility (>750 m). The pipelines are located at a greater distance. Given this, the Archives New Zealand is not considered to be exposed to petroleum storage hazards from these facilities.

There is potential for smaller storage sites to be in a closer proximity to the Archives New Zealand and Thorndon Precinct area. As aforementioned in Section 6.4, a number of sites have been cited on the Selected Land Use Register due to the presence of fuel storage tanks, however the presence and function of

these tanks is unknown. The nearest known service station is located approximately ~450 m to the south and not considered to expose the facility to petroleum hazards.

6.3 Transportation incidents

Transportation incidents are commonly occurring events, particularly along the road network. A transportation incident has the potential to cause structural damage or induce fire or explosion hazards.

A study of petroleum transportation hazards in the Wellington Region has previously been undertaken (Opus, 1999) and provides a base to identify the main areas of potential transportation hazards within the Thorndon area. The study identified Aotea Quay and State Highway 1 as the primary transportation routes in Thorndon, as well as the NIMT railway. Aotea Quay and State Highway 1 are located approximately 200 m and 500 m respectively from the Archives New Zealand, indicating that the facility is likely to have a lower exposure to transportation hazards.

The Archives New Zealand building is bound on two sides by Mulgrave Street and Thorndon Quay. Thorndon Quay is considered as a secondary route as it links the industrial portion of Thorndon and Kaiwharawhara to central Wellington and provides an alternative to SH1 to reach Ngauranga and the northern suburbs. Thorndon Quay carries heavy and industrial vehicles than Mulgrave Street and hence a higher exposure to transportation incidents which could affect the Archives New Zealand facility. Although the northern end of Mulgrave Street is an exit from SH1, there are numerous traffic lights which slow traffic and decrease the likelihood of incidents.

The railway is in the near vicinity to the Thorndon Quay side of the Archives New Zealand. Although rail incidents are uncommon occurrences, a significant event (such as a train derailment) could expose the Archives New Zealand building to fire and explosion hazards.

In addition to Mulgrave Street, the Thorndon Precinct area is also adjacent to Molesworth Street. It is considered that the exposure to transportation hazards is even lower along Molesworth Street, as it has a low speed environment and is not a favoured route for large vehicles to service the surrounding industries.

The Thorndon area is not in the direct flight path for Wellington Airport and hence the hazard from aircraft incidents is low.

6.4 Contaminated Land

Greater Wellington Regional Council has compiled the Selected Land Use Register of sites that have accommodated, or currently accommodate, activities or industries detailed on the Ministry for the Environment's hazardous activities and industries list (HAIL) (MfE 2011). This register indicates that there are a number of HAIL sites within the vicinity of the Archives New Zealand, see Illustration 9. Potentially contaminated land is not likely to adversely affect a building structure but may cause adverse effects to the environment or human health such as the exposure to contaminated soils or the build of up toxic gas.

It is noted that the Selected Land Use Register lists sites that have a history of hazardous activities or industries but in many cases, does not detail whether the hazardous activity is applicable to the current land use, whether contamination is confirmed at the site or whether any remedial works have been undertaken.

The Archives New Zealand facility is registered as a site with a verified history of hazardous activity or industry, cited to have storage tanks for fuel, chemicals or liquid waste. However, a report was produced in 2009 confirming that fuel storage tanks have been removed from the site (MWH, 2009). The report details soil validation testing following the removal of two fuel storage tanks and identified that a sample retrieved from the tank site returned chemical concentrations above MfE guidelines. The report detailed that the contamination was contained within concrete bunding and no significant risks were identified.

A number of other buildings in the near vicinity are also registered and cited to have storage tanks for fuel, chemicals or liquid waste. These are Defence House, the Freyberg Building, the National Library, the vacant lot at 61 Molesworth Street and the Ministry of Justice building at 32 Aitken Street (see Illustration 9). There is limited information regarding whether the tanks noted are still in operation or have been removed and whether any contamination has been confirmed.

Illustration 9 Thorndon HAIL sites

7 Conclusions

A summary of the hazard exposure for the Archives New Zealand building and the Thorndon Precinct is presented in Table 5 and is further discussed below.

Table 5 Hazard Exposure Summary to Archives New Zealand and Thorndon Precinct

Hazard	Archives New Zealand	Thorndon Precinct	Less exposed location
Fault Rupture	0.65 km from Wellington Fault.	0.5 km from Wellington Fault. Mapped adjacent to poorly constrained Lambton Fault.	**Similar**
Ground Shaking	Atop a number geological units which have soft layers which can amplify ground shaking.	Atop old alluvium. Less exposure to amplified ground shaking.	**Thorndon Precinct**
Liquefaction and cyclic softening	Known soft layers through marine deposits and young alluvium are potentially liquefiable.	Localised areas of potentially soft layers and low potential for liquefaction given older alluvium.	**Thorndon Precinct**
Tsunami	Within self-evacuation zone	Not considered to be exposed to tsunami hazards.	**Thorndon Precinct**

Flooding	Close to mapped flooding zone	Less exposed to flood hazards	**Thorndon Precinct**
Storm surge	Low exposure given distance from coastline.	Not considered to be exposed to coastal hazards	**Similar**
Urban fire	Exposed to urban fire potential (less neighbouring buildings)	Exposed to urban fire potential (higher concentration of buildings)	**Similar**
Contaminated land	Noted as a contaminated site (at least partially). Adjacent to train station	Potential for fuel storage tanks at various sites.	**Similar**
Petroleum storage	Not in near vicinity to known large petroleum storage	Not in near vicinity to known large petroleum storage	**Similar**
Transportation incidents	Adjacent to Thorndon Quay (critical arterial route)	Between city streets	**Thorndon Precinct**

Discussion:

- The Archives facility is located on the edge of an alluvial terrace which marks the historical Wellington Harbour shoreline. The eastern side of the building is underlain by reclamation fill and marginal marine deposits, however the boundary between these deposits beneath the Archives New Zealand is not well defined. The western side of the building and the Thorndon Precinct is underlain by older alluvium.

- The nearest active fault to the Thorndon area is the Wellington Fault which is located 0.5 km and 0.65 km from the Thorndon Precinct and Archives New Zealand respectively. Neither site is considered to be exposed to fault rupture hazards, however the wider area is likely to experience significant and potentially damaging ground shaking in a seismic event due to the presence of deep soils and the position of the Thorndon area on the edge of a basin.

- There is not enough site specific information to quantify the liquefaction potential and associated ground damage at the Archives New Zealand site. However, from the information available, it should be considered that the site is exposed to liquefaction hazards. Site specific geotechnical investigations and detailed liquefaction analysis would be required to confirm the level of hazard and quantify the liquefaction effects. The Thorndon Precinct is considered to be considerably less exposed to liquefaction hazards (WRC, 1993).

- The Thorndon Precinct area is not mapped to be exposed to tsunami or flooding hazards. The eastern side of the Archives New Zealand is more exposed to tsunami and flooding hazards due to its low elevation and proximity to the coast. As a result of climate change, the exposure to storm and coastal hazards, particularly at the existing Archives New Zealand facility, is expected to increase.

- The Archives New Zealand and the wider Thorndon area is exposed to urban fire hazards given the population density during business hours, number of potentially ignitable service networks and the close proximity of buildings to each other. The hazard also depends on the fire suppressions systems in the building.

- There are no known significant petroleum or hazardous substance storage facilities in the immediate proximity to the Archives New Zealand or Thorndon Precinct.

- The eastern side of the Archives New Zealand adjacent to Thorndon Quay is more exposed to transportation hazards. This is due to Thorndon Quay is due to Thorndon Quay being considered as a critical arterial route for Wellington City and is therefore likely to have a higher volume of traffic and as it is also adjacent to the railway yard and train station, where it is exposed to potential rail incidents.

- There are a number of sites within the wider Thorndon area which have potentially contaminated land. The Archives New Zealand is listed as a HAIL site due as fuel storage tanks were previously stored on the site.

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Figures

Legend

- St Paul's Cathedral
- National Library
- Freyberg Building
- Ministry of Justice
- Ministry of Defense
- Rugby House
- Vacant Lot
- Court of Appeal
- Westpac Stadium
- Capital on the Quay

Scale:
1:5,000
0 0.05 0.1 0.15 0.2 0.25 km

Title:
Location Plan

Project:
Preserving the Nation's Memory

Prepared For:

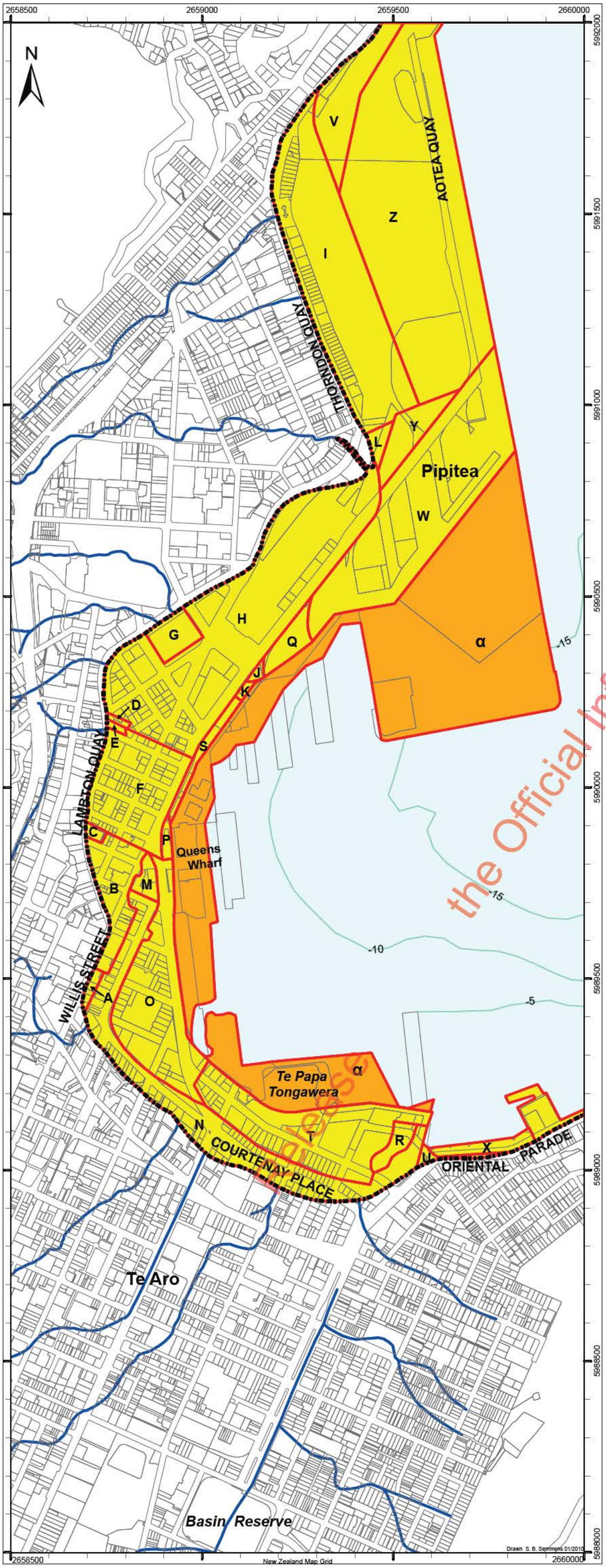
Prepared By:

Date:	*Project No:*	*Figure:*
Sept 2017	5-C3448.00	1

Document Path:

Figure 2
Wellington City Waterfront Reclamations (Semmens, 2010)

Map shows the location and construction dates of waterfront reclamations in Wellington City based on:
Wellington Harbour Board (WHB) 1936. Historical plan of reclamations in the port of Wellington (Port Nicholson) - Fill zones A to Z.
Wellington Waterfront Limited (WWL) 2009 - Fill zone α.
Bastings L. 1936. A subsoil survey of Wellington City - Former stream and shoreline locations.



Legend

- 1852-1932 WHB Fill Zones
- 1965-1972 Reclamation
- Bathymetric Contours (5m)
- Former Streams (Bastings)
- Shoreline (pre European settlement)

Reclamation Zones by Construction Date

Reclamation No.	Date	Source
A	1852	WHB
B	1857-1863	WHB
C	1859	WHB
D	1864	WHB
E	1865	WHB
F	1866-1867	WHB
G	1875	WHB
H	1876	WHB
I	1882	WHB
J	1882	WHB
K	1882	WHB
L	1884	WHB
M	1886	WHB
N	1886	WHB
O	1889	WHB
P	1893	WHB
Q	1893-1901	WHB
R	1895	WHB
S	1901-1903	WHB
T	1901-1914	WHB
U	1902-1925	WHB
V	1904	WHB
W	1904-1916	WHB
X	1906	WHB
Y	1910-1913	WHB
Z	1924-1932	WHB
α	1965-1972	WWL

This map provides a guide to the reclamations around the waterfront in Wellington City, but does not replace the need for professional consultation and site specific investigations.

0 125 250 500 750 1,000
Metres

1:10,000 Scale (at A3 presentation size)

Semmens S 2010. An engineering geological investigation of the seismic subsoil classes in the central Wellington commercial area. Unpublished thesis, University of Canterbury, Christchurch, New Zealand.

Figure 2

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