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24 December 2025

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Dear Peter,

## **Thickness of aquifer cover in the Lower Wairau Plain**

### **1.0 Purpose**

This report assesses aquifer cover thickness in the Lower Wairau Plain and Blenheim areas for Marlborough District Council (MDC), following previous work in the Lower Wairau Plain (White et al. 2016). This work was funded by the Ministry of Business, Innovation & Employment under Envirolink Grant 2607-MLDC179. MDC well logs are used to derive three dimensional (3D) models of sedimentary facies, which include permeable gravel aquifers and fine-grained, less-permeable, cover sediments (e.g. estuarine and overbank deposits) in the Lower Wairau Plain. Then, cover thickness is calculated in ancillary datasets for the use of MDC.

### **2.0 Background**

Wairau Plain communities depend on groundwater as a water supply, like many coastal populations in New Zealand (White 2001). Groundwater resources in the Wairau Plain coastal groundwater system are, commonly, the sole water supply for the human population, for agriculture and for industry, and provide water to important amenities, such as spring-fed streams (White et al. 2016). The geology of the Wairau Plain includes shallow aquifers and aquicludes (Davidson and Wilson 2011).

#### **DISCLAIMER**

This report has been prepared by the New Zealand Institute for Earth Science Limited (Earth Sciences New Zealand) exclusively for Marlborough District Council and for the specific purpose stated ('Purpose'). It is based on available information and professional judgment at the time of preparation, and is subject to any limitations or assumptions set out in the report. Unless otherwise agreed in writing by Earth Sciences New Zealand, Earth Sciences New Zealand provides no warranty as to the use of the report other than by Marlborough District Council for the Purpose and Earth Sciences New Zealand will not be liable for any loss, damage or expense (whether direct, indirect or consequential) arising from use of or reliance on this report or its contents by any person other than to Marlborough District Council for the Purpose.

Aquifers are typically found in gravels. The main aquifer is in shallow Wairau River gravels deposited in the Holocene period (Brown 1981). Relatively fine sediments form aquicludes, e.g. estuarine and overbank sediments deposited with Holocene sea level rise.

These sediments can form a cover to the aquifer. Generally, cover sediments are important in coastal aquifer systems because they reduce vertical outflow from artesian aquifers and can provide a barrier to the inflow of pollutants from overlying land use.

However, vertical upflow from artesian aquifers can become a problem when cover sediments are removed, e.g. for building construction, with a result of increased maintenance costs, e.g. dewatering (Markham 2024). Removal of cover by quarrying can result in risks to groundwater quality (Mitchell 2016) and cover thickness above an aquifer has been used to define zones that aim to protect shallow groundwater quality in the Christchurch coastal groundwater system (Weeber 2008).

In the Wairau Plain, naturally occurring, horizontal confining layers extend inland from the Cloudy Bay coast to the western outskirts of Blenheim and from the north of Blenheim to the vicinity of State Highway One. These layers act as a natural barrier preventing land-surface contaminants from entering the aquifer from above. Should this layer be punctured, then pressurised groundwater will escape upwards from the Wairau Aquifer to possibly flow at the ground surface. Uncontrolled flows from the aquifer are a waste of a precious resource and may impact on construction conditions (requiring in-construction dewatering) and possibly influence future building operations (requiring permanent de-watering or monitoring). In addition, pollutants may enter the aquifer.

Groundwater protection areas (GPAs) were implemented in the Marlborough Environment Plan (MEP) in 2016 to manage land uses and excavations that could potentially puncture the confining layer and pollute groundwater for municipal supply. However, GPAs are not defined everywhere a bridge, deep excavation or a tall building with deep foundations could be located.

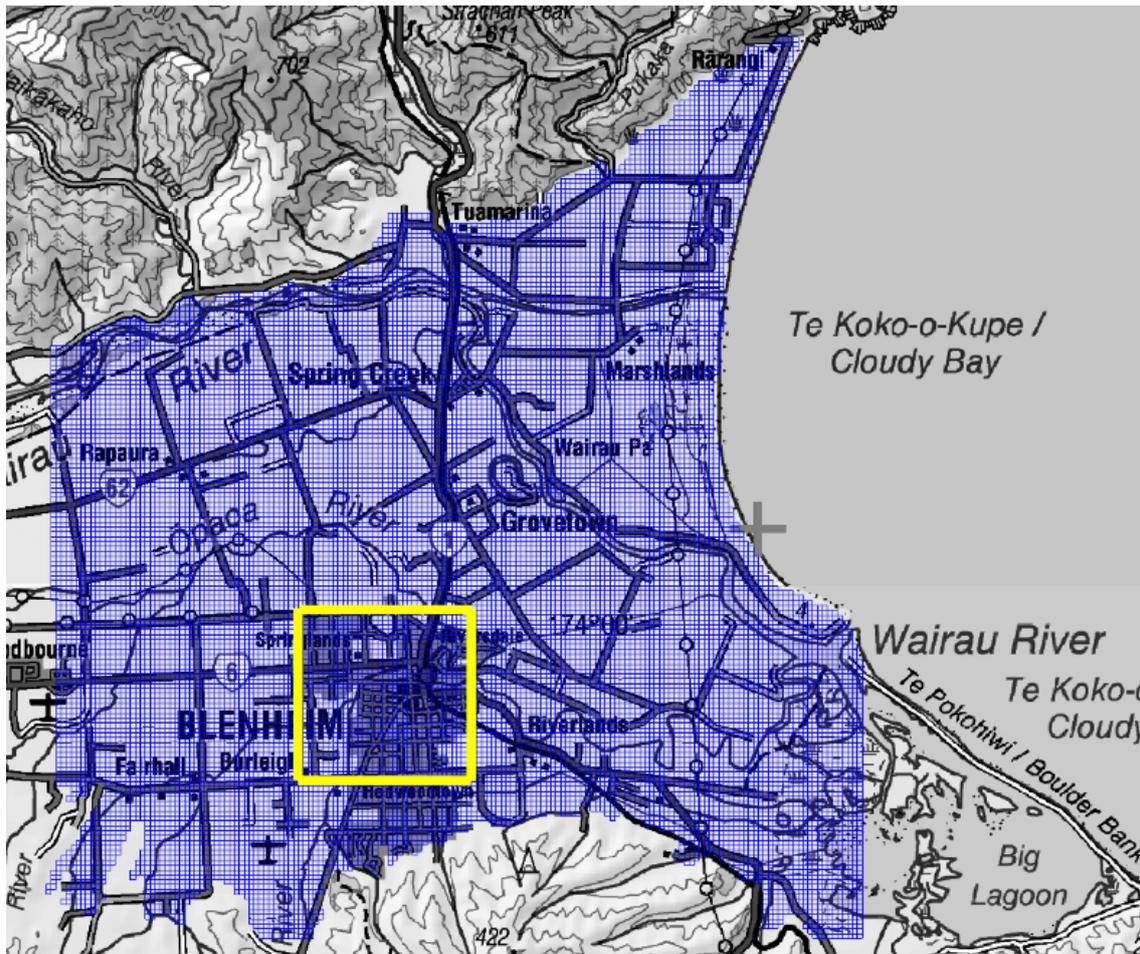


Figure 2.1 The location of Lower Wairau Plain aquifer cover thickness calculations (blue) and the Blenheim area (yellow square).

### 3.0 Methods

Firstly, well log locations in the Lower Wairau Plain are identified from the MDC well log database (Figure 3.1). Then, depositional facies are identified from well log descriptions based on Boolean operators (White et al. 2023) (Figure 3.2). These facies represent significant depositional units in the Lower Wairau Plain relevant to groundwater flow, which are:

- Aquifers:
  - Braidplain gravel – the main aquifer in the Lower Wairau Plain.
  - Beach gravels – a local aquifer in the vicinity of Rarangi.
- Aquicludes:
  - Overbank – riverine silts associated with rivers and partially infilling the Holocene Wairau estuary.
  - Estuarine – sediments that partially fill the Holocene Wairau estuary.
  - Swamp – peat (etc) that was deposited in the Holocene Wairau estuary as sea levels rose.
  - Shallow marine – offshore marine deposits.
  - Dune – dune sediments possibly associated with Holocene high-stand sea levels.

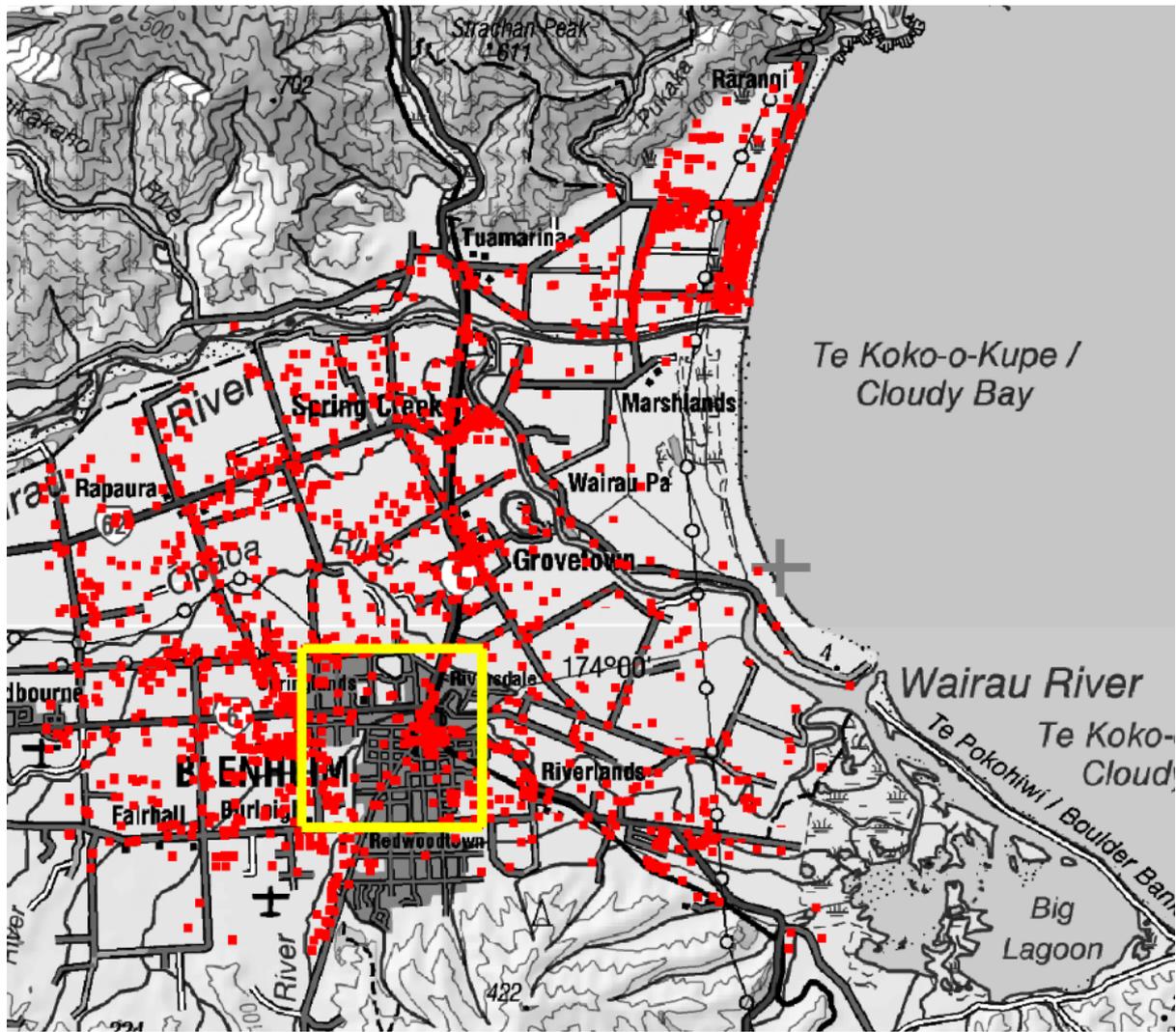


Figure 3.1 The location of MDC well logs in the Lower Wairau Plain (red squares).

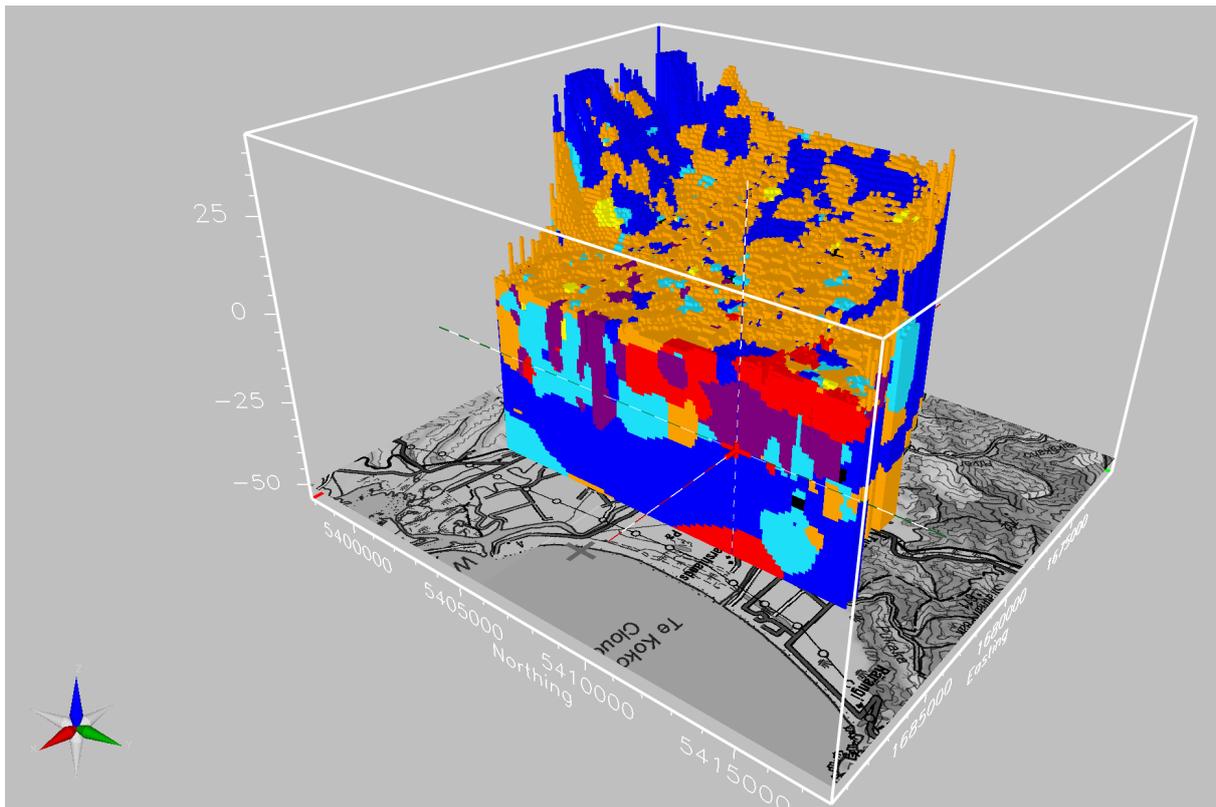


Figure 3.2 Wairau Plain 3D facies model, viewed from the north east: braidplain gravel (royal blue); beach gravels (red); overbank (ochre); estuarine (teal); shallow marine (purple) and dune (yellow). The 3D marker is set at -20 m below mean sea level. The Z exaggeration for the Wairau Plain model view and following cross-sections is 125.

These facies demonstrate that Holocene aquiclude sediments form a wedge that thickens towards the coast and is approximately 20 m thick near the coast (Figure 3.2).

Then, these facies were modelled in 3D using EarthVision software, see White et al. (2016) for the general method. In addition, static groundwater elevations measured in wells were modelled in 3D as an update to the current model (White et al. 2016). The 3D model was calculated with a cell size of 100 m, 100 m and 1 m (in the x, y and z dimensions, respectively) in the Lower Wairau Plain and a cell size of 50 m by 50 m by 1 m in the Blenheim area (with EarthVision script files: *wairau\_ev0.sh*, *wairau\_ev1.sh*, *wairau\_ev2.sh* and *wairau\_grid\_merge.sh*).

Cover thickness values are calculated in each model cell as follows:

- Cover thickness is 0 m where braidplain gravels are modelled at the ground surface (script files: *wairau\_cover1.sh*, *wairau\_cover1\_export.sh* and *wairau\_grav\_grd.sh*).
- Cover thickness is calculated where braidplain gravels are not at the ground surface by:
  - Identifying occurrences, in the 3D model, of cover above braidplain gravel facies.
  - Cover facies are defined as all facies other than braidplain gravel.
  - Cover facies thicker than 2 m that sit on 3D braidplain gravel cells are identified as ‘cover thickness picks’ (*wairau\_cover\_subsurface1.sh*) (Figure 3.3, Figure 3.4 and Figure 3.5).
  - Commonly, multiple sets of cover facies and braidplain gravel cells are identified in the cell column. Therefore, the ‘shallowest cover picks’ identified in the cell column are selected (*wairau\_cover\_thick\_all.sh*, *wairau\_cover\_thick\_all\_sort.sh*).

For example, cover is thin, or absent, in much of a cross section near Woodbourne and is thick near the coast (Figure 3.3 and Figure 3.5, respectively).

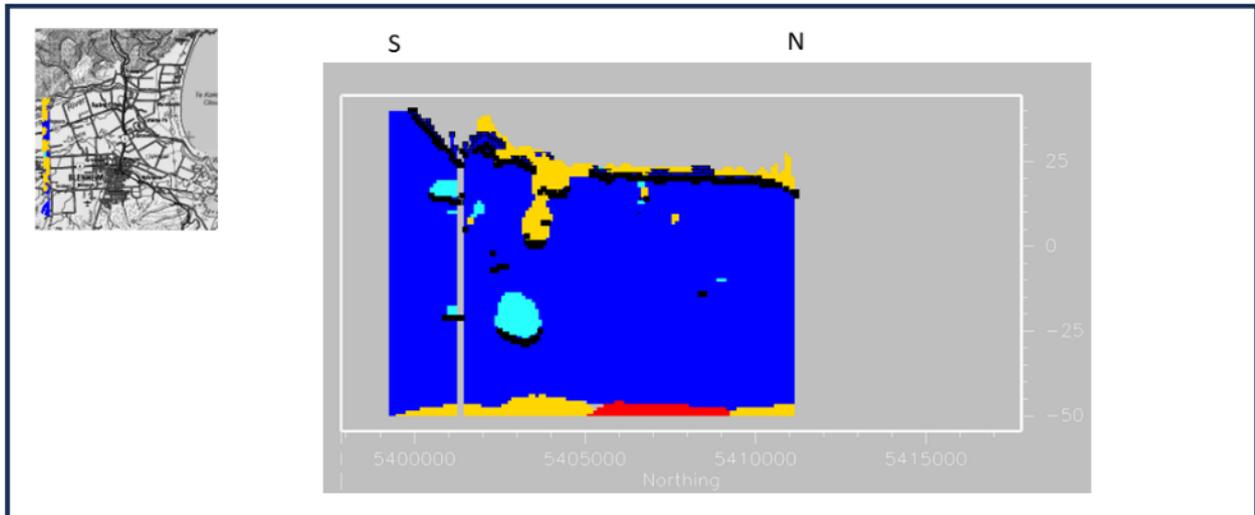


Figure 3.3 Cross section of 3D facies (colours as Figure 3.2) and 'cover thickness picks' near Woodbourne (black).

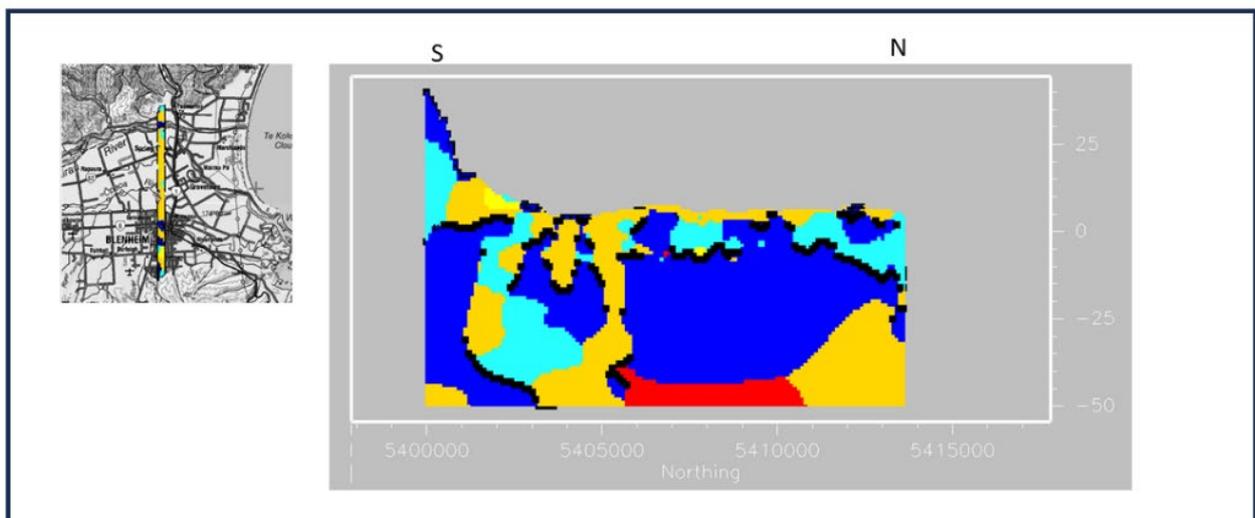


Figure 3.4 Cross section of 3D facies (colours as Figure 3.2) and 'cover thickness picks' through Blenheim (black).

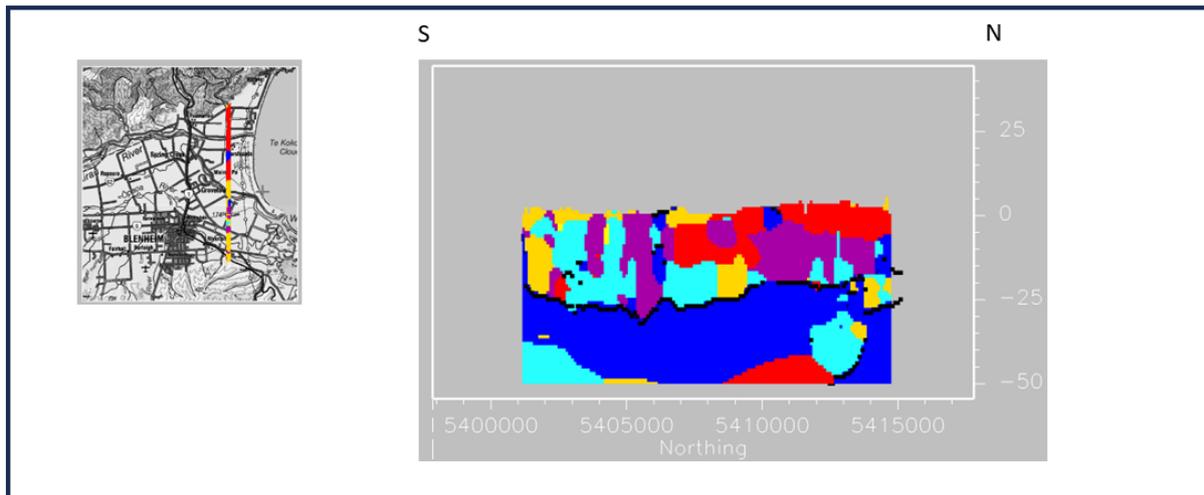


Figure 3.5 Cross section of 3D facies (colours as Figure 3.2) and ‘cover thickness picks’ near the coast (black).

The ‘shallowest cover picks’ are mapped in 2D and plotted as oblique images in the Lower Wairau Plain and Blenheim areas.

## 4.0 Results

### 4.1 Lower Wairau Plain Cover Thickness

Cover thickness is calculated over the Lower Wairau Plain (Figure 4.1). Generally, cover thickness increases towards the coast. In the far west, cover thickness is typically less than 1 m (Figure 4.2). West of Blenheim, cover thickness is typically less than 5 m (Figure 4.3). Cover thickness is greatest, i.e. more than 50 m, at the southern coast (Figure 4.4).

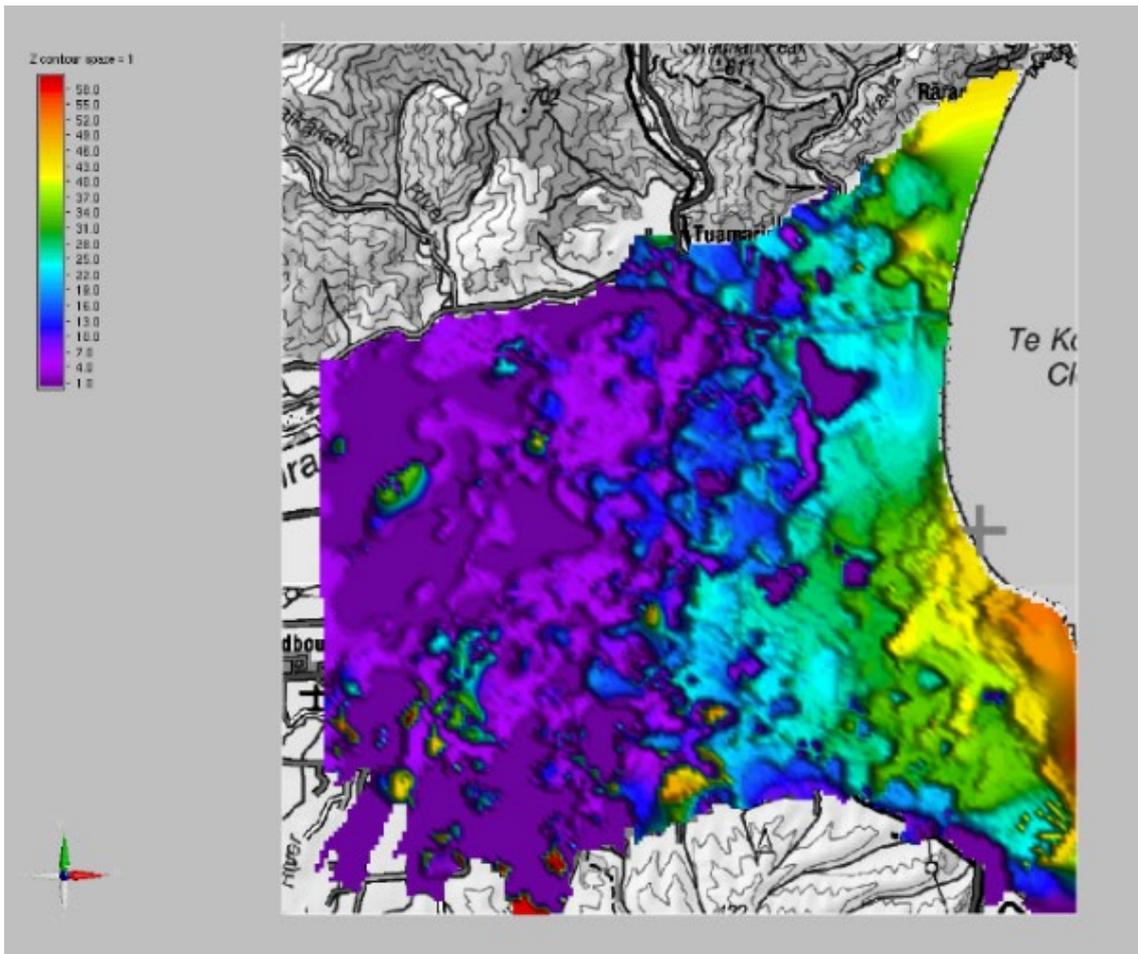


Figure 4.1 The Lower Wairau Plain cover thickness (m).





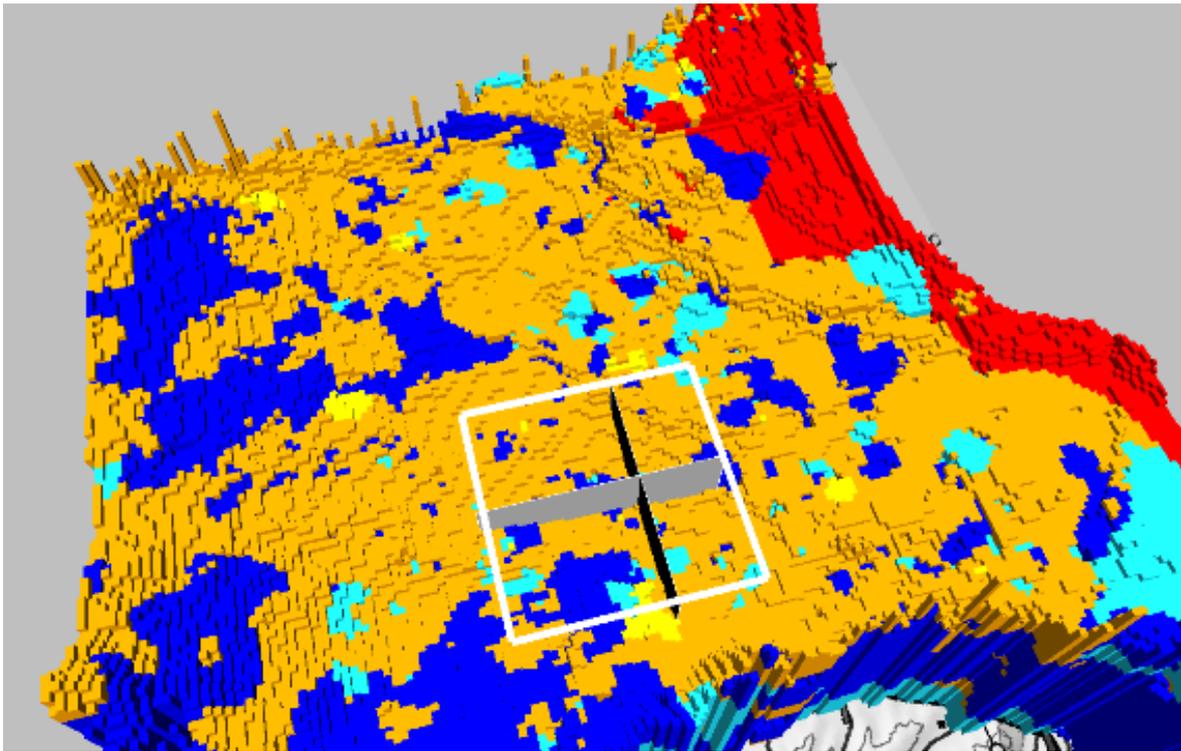


Figure 4.5 Location of the Blenheim area (square) and two cross sections (see Figure 3.2 for facies names and colours).

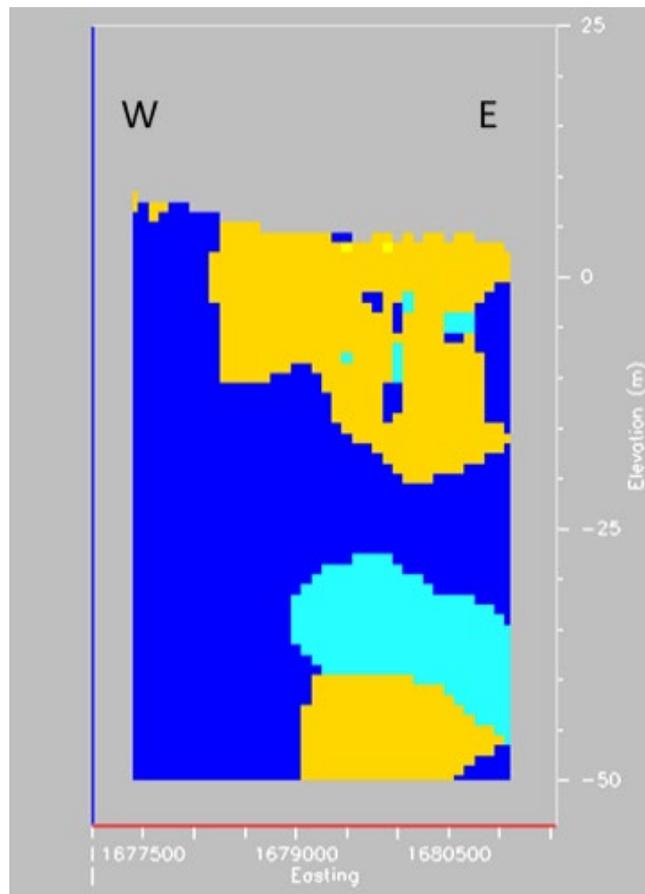


Figure 4.6 Blenheim facies west–east section (see Figure 3.2 for facies names and colours).

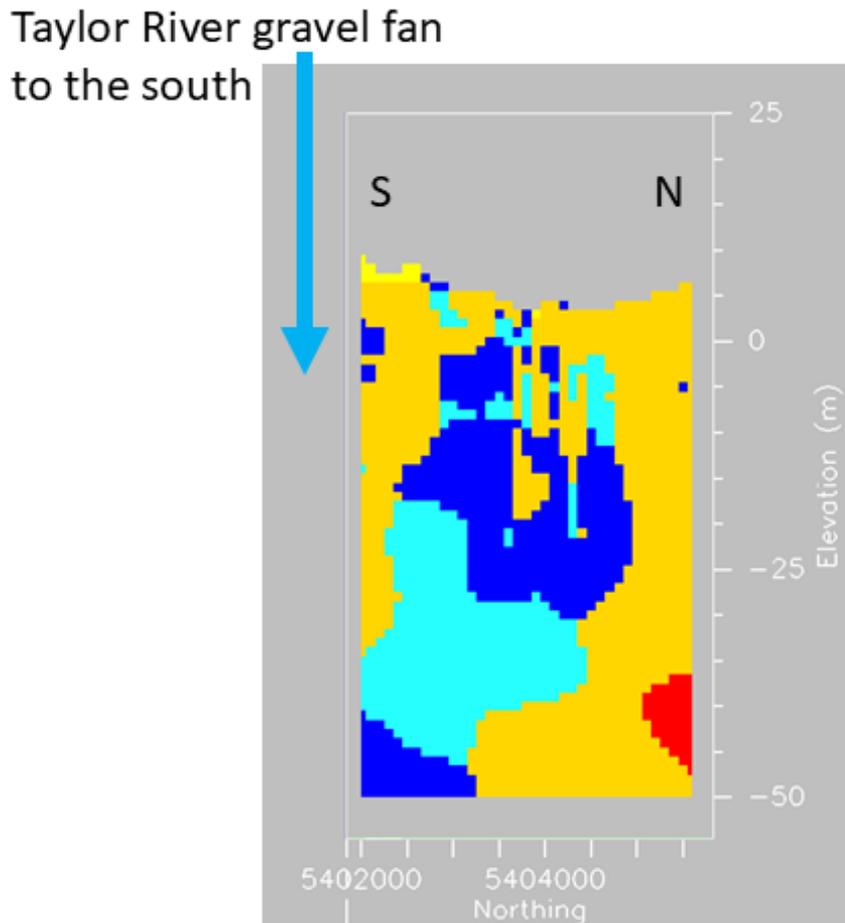


Figure 4.7 Blenheim facies south–north section (see Figure 3.2 for facies names and colours).

### 4.3 Blenheim Cover Thickness

In the west Blenheim area, cover thickness is typically less than 1 m (Figure 4.8 and Figure 4.9). Eastern Blenheim has cover thickness that is commonly greater than 5 m (Figure 4.10). In the Blenheim area, an apparent ‘interfingering’ of three gravel lobes is associated with cover that is thinner than 5 m (e.g. Figure 4.11). Cover thickness is generally greater than 20 m in the east (Figure 4.12).

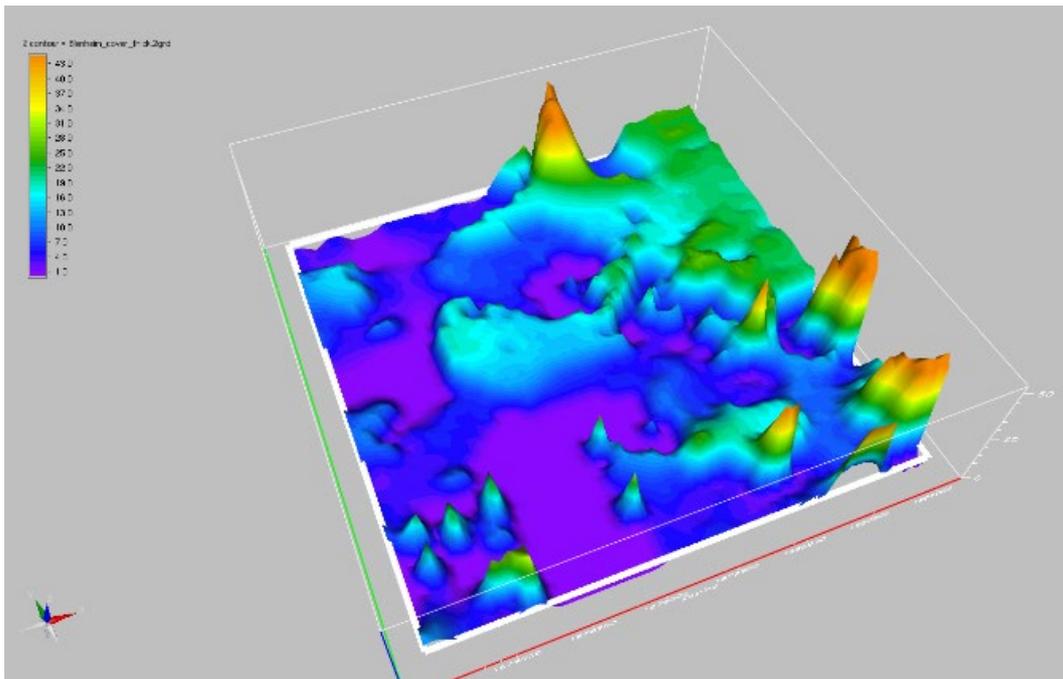


Figure 4.8 Blenheim cover thickness (m).

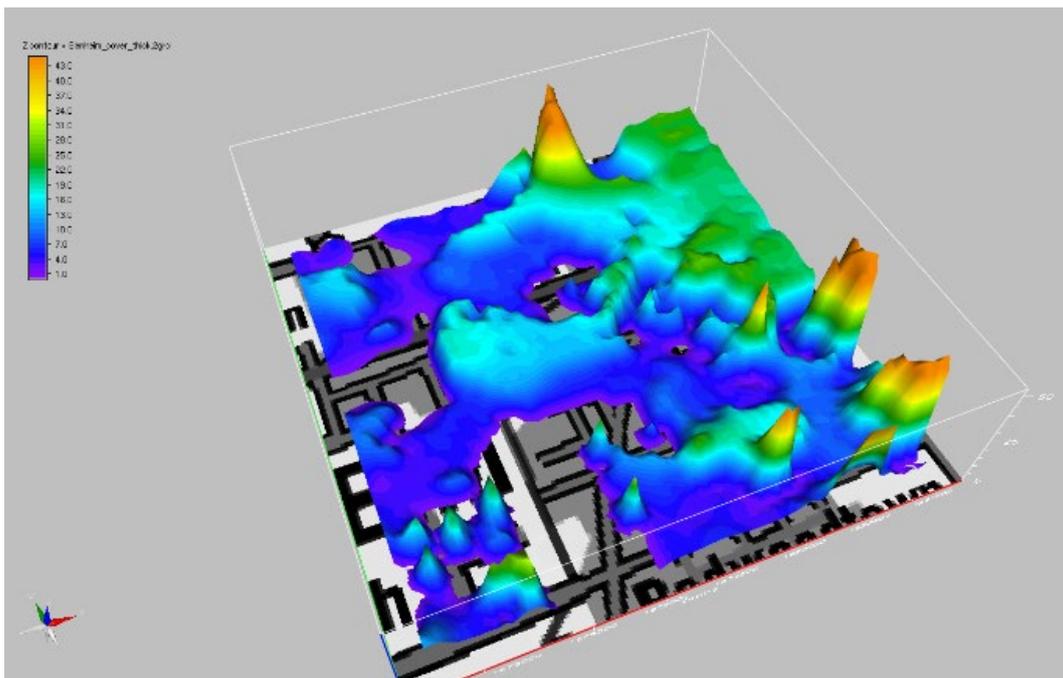


Figure 4.9 Blenheim cover thickness greater than 1 m.

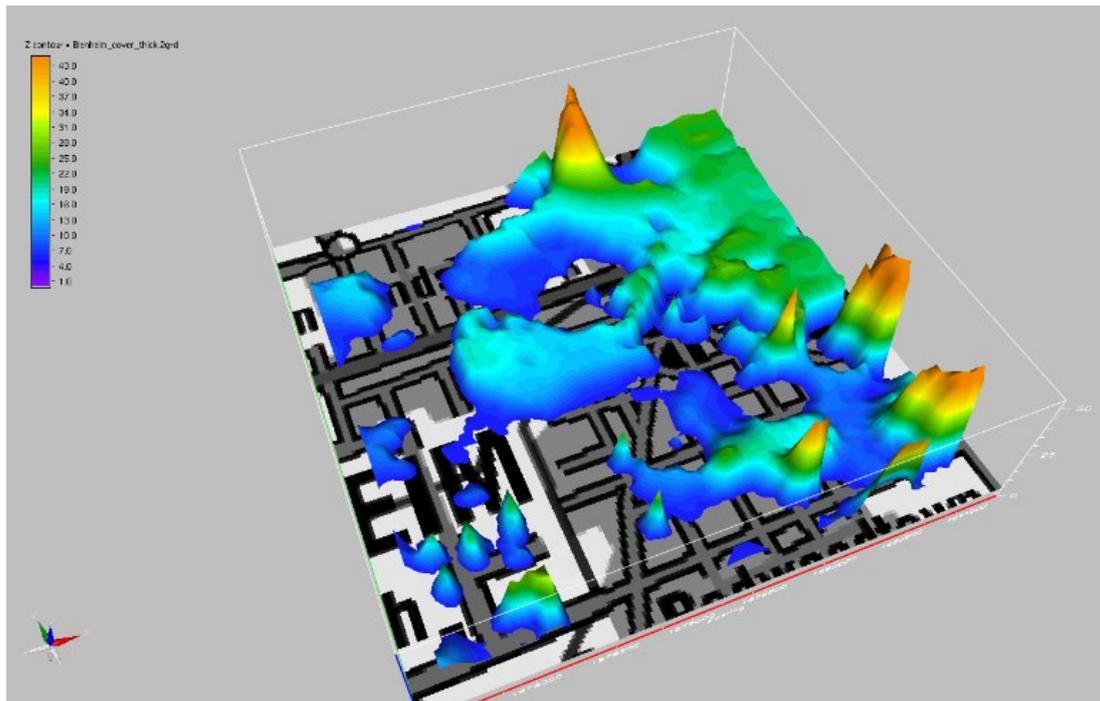


Figure 4.10 Blenheim cover thickness greater than 5 m.

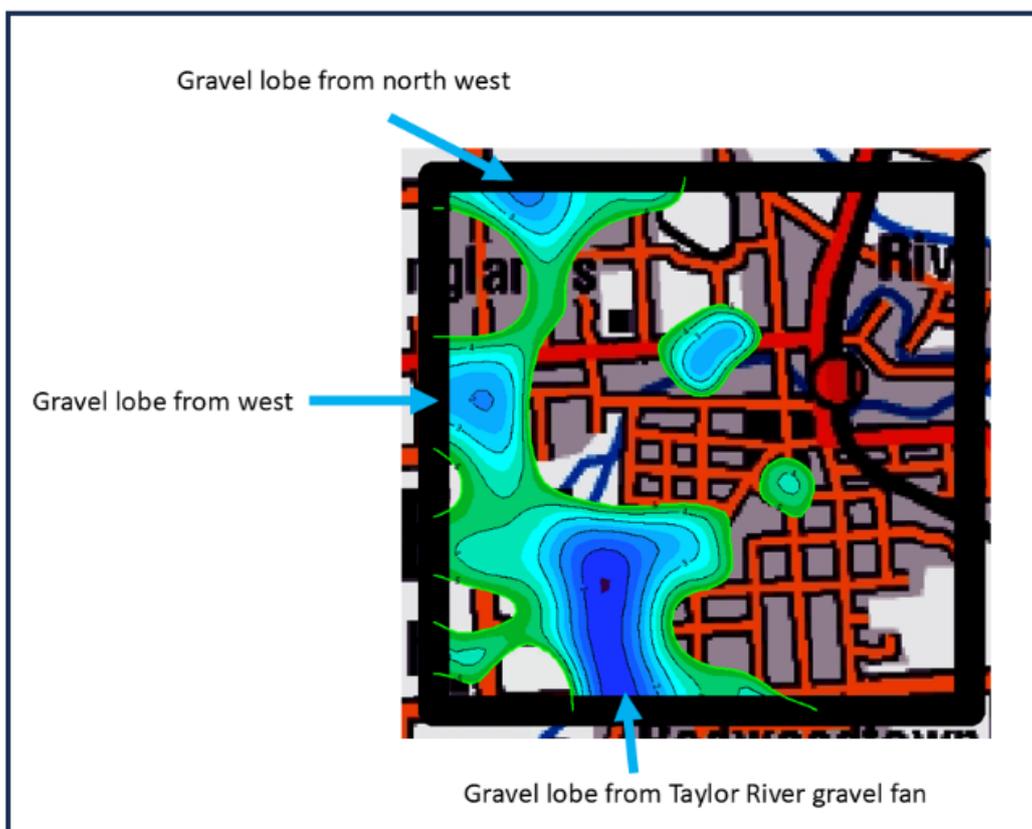


Figure 4.11 Blenheim cover thickness less than 5 m, with locations of three proposed gravel lobes.

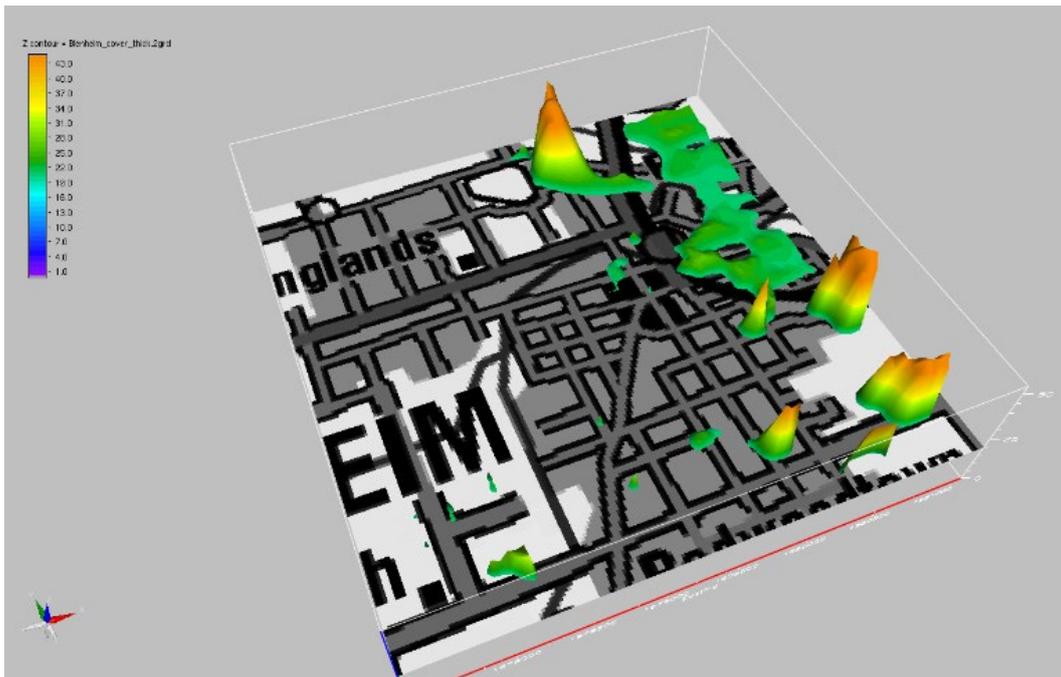


Figure 4.12 Blenheim cover thickness greater than 20 m.

## 5.0 Summary

Sedimentary cover overlies aquifers in New Zealand's coastal aquifer systems. This cover generally reduces vertical outflow from artesian aquifers and protects aquifers from pollution by land use. However, vertical upflow from artesian aquifers and pollution risk can become problems when cover sediments are removed or punctured. This report, funded by the Ministry of Business, Innovation & Employment under Envirolink Grant 2607-MLDC179, aims to model cover thickness in the Lower Wairau Plain for MDC.

Marlborough District's Wairau Plain communities depend on groundwater as a water supply, like many coastal populations in New Zealand (White 2001). The Wairau Plain aquifer provides the sole water supply for the human population on the Plain, much water for agriculture and for industry and for amenities such as spring-fed streams (White et al. 2016).

MDC well logs were used to derive a 3D model of sedimentary facies in two classes, i.e. the gravel aquifer and cover sediments. Cover sediments are typically fine-grained sediments with permeabilities that are much less than the aquifer. These sediments were generally deposited in the Wairau Holocene paleoestuary formed as sea level rose in the current interglacial period and include terrestrial overbank deposits. Then, a 2D model of cover thickness was calculated from the 3D model and results presented as cross sections, two-dimensional maps and oblique views of the Lower Wairau Plain and Blenheim areas.

Generally, cover in the Lower Wairau Plain is thin in the west, typically less than 1 m, because braidplain gravels are located at, or very close to, the ground surface. Cover thickness increases towards the coast. For example, thickness is greatest, i.e. more than 50 m, at the southern coast.

In the Blenheim area, cover thickness is typically less than 1 m in the west. Three sub-surface gravel lobes, including a lobe sourced from the Taylor River, are associated with cover that is thinner than 5 m. Cover thickness is generally greater than 20 m in the east.

## 6.0 Disclaimer

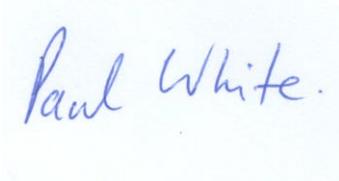
The datasets described in this report have been prepared by Earth Sciences New Zealand for MDC. In compiling the dataset, inferences have been made based on borehole observations, and assumptions have been made about geological structures. Experience and an appreciation of the limitations of the information is needed by persons using the dataset as an element in their decision making over access to and use of groundwater resources.

All reasonable effort has been made to ensure that the dataset is as accurate as practicable. However, because of the necessary inferences and assumptions that have been made in compiling the dataset, there is uncertainty inherent in the information, and it is therefore provided without warranties of any kind, including accuracy, completeness or fitness for any particular purpose. MDC and Earth Sciences New Zealand, their employees and any external suppliers of data to the dataset, exclude to the full extent permitted by law, liability for any loss or damage, direct or indirect, and however caused, whether through negligence or otherwise, resulting from any data user's use or reliance on the data.

## 7.0 Acknowledgements

I would like to thank Peter Davidson, MDC for arranging this Envirolink project and providing the well logs on which this work is based.

Yours sincerely,



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## 8.0 References

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