

**Environment Canterbury  
Groundwater Resources Section**

# Annual Groundwater Quality Survey 2010



**Environment  
Canterbury**  
Regional Council  
*Kaunihera Taiao ki Waitaha*

# 1 Introduction

**What is the annual groundwater quality survey?**

Each year in the springtime, Environment Canterbury collects groundwater samples from over 300 wells in the region. The samples are analysed for a range of water quality parameters.

**Why do we carry out an annual survey?**

The survey provides data for evaluating long-term, regional-scale changes in groundwater quality. It also provides an annual snapshot of groundwater quality in the Canterbury region.

**Why springtime?**

The composition of the groundwater can vary over the year. Springtime is when we generally see contaminant concentrations at their highest.

**What do we do with the data?**

We use data from the annual surveys to determine the state of the groundwater resource and to assess changes in groundwater quality. We also use the data as a baseline of the local groundwater conditions for other investigations.

We also send the data to the Ministry for the Environment when it compiles national statistics on the state of the environment in New Zealand.

We have used the results from the past year's survey to compile a snapshot of Canterbury's groundwater quality in spring 2010, which we present in this report.

All the data we collect are stored in our water quality database and are publicly available. We are working on systems to make our data more easily accessible over the Internet.

**What terms do we use in this report?**

**Coastal confined gravel aquifer system** means the confined gravel aquifer system located between the Ashley River/Rakahuri and the Rakaia River as defined in Environment Canterbury's Natural Resources Regional Plan (NRRP). Four principal aquifers, composed of water bearing gravels and separated by low permeability sediments, have been identified.

**Unconfined aquifer** means an aquifer that lacks an overlying layer of fine sediment, and is not under pressure. The water level in a well is the same as the water table outside the well.

**Semi-confined aquifer** means an aquifer confined by a layer of sediment that is significantly less permeable than the aquifer itself but still sufficiently permeable to allow vertical leakage of water into or out of the aquifer.

**Nitrate nitrogen** refers to the concentration of nitrate in water calculated based on the mass of nitrogen in the nitrate anion. Nitrate is a common contaminant in Canterbury groundwater, which occurs in the form of highly soluble, negatively charged nitrate anions.

**Denitrification** refers to a series of microbially assisted chemical reactions in which the nitrate anion is converted to other forms of nitrogen such as nitrous oxide or nitrogen gas. It occurs primarily in environments where there is no dissolved oxygen (anoxic groundwater).

**MAV** (Maximum Acceptable Value) of a chemical parameter in drinking-water is the highest concentration of a parameter in the water that, on the basis of present knowledge, is considered not to cause any significant risk to the health of the consumer over 70 years of consumption of that water (MoH, 2008).

**GV** (Guideline Value) of a chemical parameter sets a threshold above which objectionable aesthetic effects may be observed, such as odour, taste, corrosion or staining problems. The GV is not a health-based limit.

**Median**, in statistics, is the numerical value separating the higher half of the sample population from the lower half. The median of a finite list of numbers is found by arranging all the observations from lowest value to highest value and picking the middle one. We use the median value to represent “average” water quality, because the arithmetic mean may be biased by samples with very high or very low concentrations.

## 2 The 2010 annual survey

From September to December 2010, we sampled 322 wells across the Canterbury region.

### Survey coverage

Figure 1 shows a map of the well locations. The annual survey covered nine out of the ten Canterbury Water Management Strategy (CWMS) zones. The exception is Banks Peninsula, which uses mainly surface water resources. The Selwyn-Waihora and Ashburton zones are heavy users of groundwater and these two zones together account for more than 40% of the wells in the survey.

### Aquifer types

Most of the wells we sample are in unconfined alluvial aquifers on the Canterbury Plains and in inland alluvial basins. Just under 10% of the wells tap groundwater from the Coastal Confined Gravel Aquifer System.

### Well depths

Most wells in the Canterbury region are relatively shallow and about half of the wells sampled in our survey (140 wells) are less than 20 m deep. We sampled 50 wells with depths between 50 and 100 m and another 26 greater than 100 m deep. The deepest well sampled was drilled to just over 250 m.

### Methods

When collecting the samples, we followed Environment Canterbury's standard procedure for the collection of groundwater quality samples, which is consistent with national groundwater sampling protocols (MfE 2006). These include purging at least three well volumes before sampling, filtering samples for metal cations in the field and keeping the samples chilled during transport to the laboratory. We measured the depth to water before purging the well and the field parameters (groundwater temperature, dissolved oxygen concentration, pH and conductivity) after purging, immediately before taking each sample.

Our groundwater samples were analysed by Environment Canterbury's water laboratory for major ion chemistry (sodium, potassium, calcium, magnesium, alkalinity, chloride and sulphate), ammonia and nitrate nitrogen, iron, manganese, silica, pH, conductivity and indicator bacteria (*E. coli* and total coliforms). Samples from ten wells with historic arsenic detections were also tested for arsenic.

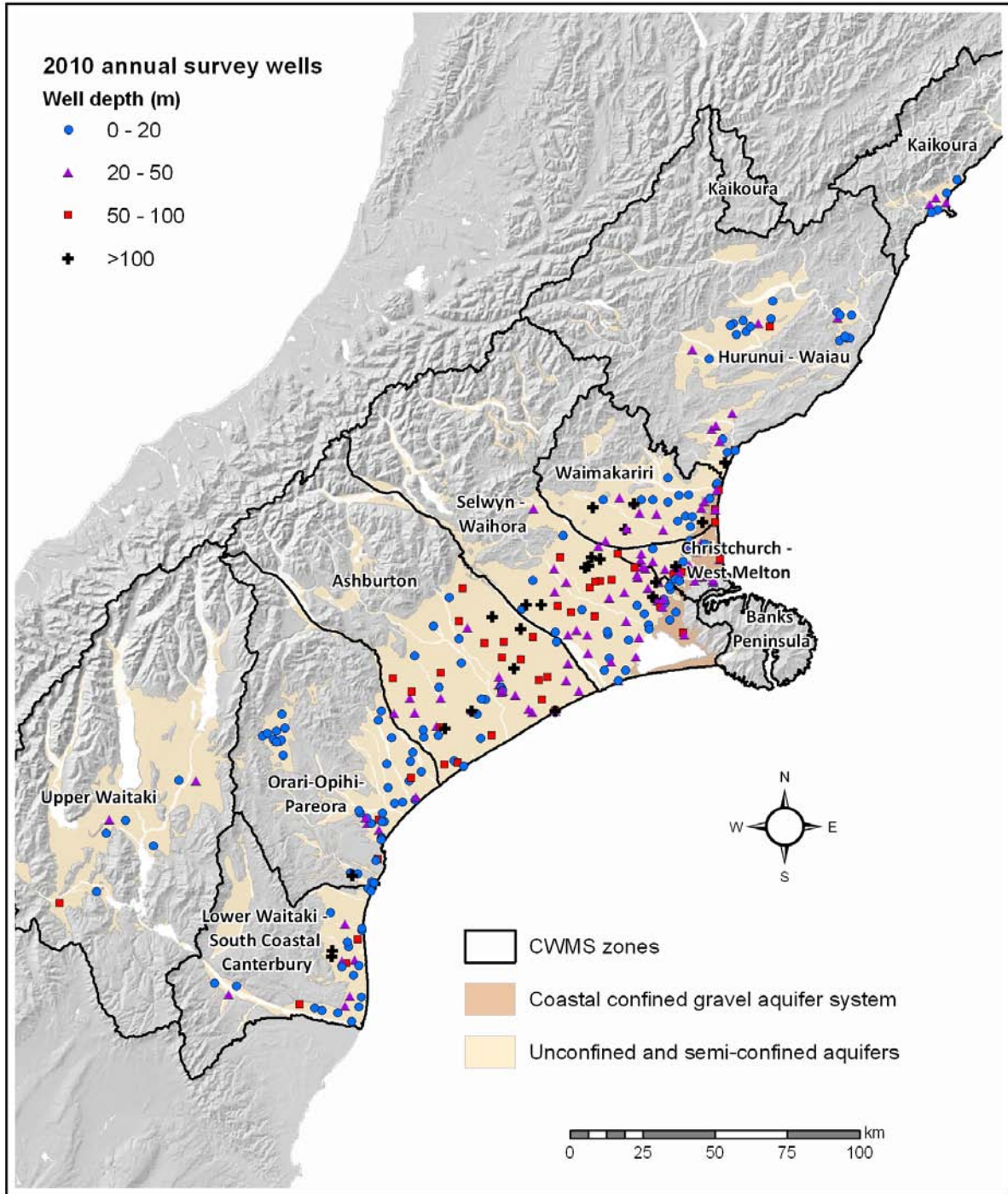


Figure 1: Locations and depths of wells sampled in the 2010 annual survey

### 3 Regional summary

Table 1 presents a summary of our results for the whole Canterbury region in 2010.

**Table 1: Groundwater quality indicators measured, summary of 2010 annual survey results and median values by aquifer type.**

| Water Quality Parameters               | Units     | 2010 Annual Survey<br>(322 wells) |              | Un/semi-<br>confined<br>(287 wells) | Coastal<br>confined<br>(35 wells) |
|----------------------------------------|-----------|-----------------------------------|--------------|-------------------------------------|-----------------------------------|
|                                        |           | Median                            | Range        | Median                              | Median                            |
| <b>Microbiological indicators</b>      |           |                                   |              |                                     |                                   |
| <i>E. coli</i>                         | MPN/100mL | <1                                | <1 to 980    | <1                                  | <1                                |
| Total Coliforms                        | MPN/100mL | <1                                | <1 to >2400  | <1                                  | <1                                |
| <b>Major anions</b>                    |           |                                   |              |                                     |                                   |
| Nitrate nitrogen                       | mg/L      | 4.0                               | <0.1 to 24.5 | 4.7                                 | 0.5                               |
| Alkalinity (as HCO <sub>3</sub> )      | mg /L     | 58                                | 9 to 571     | 57                                  | 75                                |
| Chloride                               | mg/L      | 8.9                               | 0.4 to 680   | 9.4                                 | 8.1                               |
| Sulphate                               | mg/L      | 9.9                               | <0.1 to 94   | 10                                  | 3.1                               |
| <b>Major cations</b>                   |           |                                   |              |                                     |                                   |
| Calcium                                | mg/L      | 18                                | 0.2 to 89    | 18                                  | 17                                |
| Magnesium                              | mg/L      | 4.9                               | 0.68 to 95   | 5                                   | 3.2                               |
| Sodium                                 | mg/L      | 11                                | 2.3 to 230   | 11                                  | 11                                |
| Potassium                              | mg/L      | 1.1                               | 0.1 to 23    | 1.1                                 | 1.0                               |
| Iron                                   | mg/L      | <0.03                             | <0.03 to 3.6 | <0.03                               | <0.03                             |
| Manganese                              | mg/L      | <0.01                             | <0.01 to 3   | <0.01                               | <0.01                             |
| Ammonia nitrogen                       | mg/L      | 0.012                             | <0.005 to 25 | 0.012                               | 0.018                             |
| <b>Other</b>                           |           |                                   |              |                                     |                                   |
| Conductivity (Lab)                     | mS/m      | 20                                | 3.6 to 240   | 21                                  | 17                                |
| Dissolved Oxygen                       | mg/L      | 6.7                               | <0.1 to 17   | 6.9                                 | 2.1                               |
| Total Hardness (as CaCO <sub>3</sub> ) | mg/L      | 67                                | 8 to 556     | 69                                  | 54                                |
| pH (Lab)                               |           | 7.4                               | 6 to 8.9     | 7.4                                 | 7.8                               |
| Silica (as SiO <sub>2</sub> )          | mg/L      | 16                                | 5 to 48      | 15                                  | 18                                |
| Temperature                            | °C        | 12.4                              | 9.3 to 17.2  | 12.3                                | 13.4                              |

Samples from the coastal confined gravel aquifer system have lower median concentrations of nitrate nitrogen and dissolved oxygen than those from unconfined and semi-confined alluvial aquifers.

## 4 Drinking water quality

Canterbury groundwater is widely used as a source of untreated drinking water. We used the New Zealand Drinking-Water Standards (MoH 2008) to assess the groundwater quality. Table 2 summarises the number of wells in each CWMS zone, and in the region as a whole, which did not meet the standards.

Nitrate nitrogen and faecal contamination (indicated by *E. coli* bacteria counts) pose the most common health-related threats to our groundwater. Manganese and iron concentrations are not health threats, but high concentrations can cause aesthetic problems like staining of laundry.

**Table 1: Number of samples not meeting drinking-water standards for the 2010 annual survey, grouped by CWMS zone**

| Water quality parameter and drinking-water standard                                             | Canterbury Region | Summary by CWMS zone |                          |              |          |                                        |                    |                |               |             |  |
|-------------------------------------------------------------------------------------------------|-------------------|----------------------|--------------------------|--------------|----------|----------------------------------------|--------------------|----------------|---------------|-------------|--|
|                                                                                                 |                   | Ashburton            | Christchurch West Melton | Hurnui Waiau | Kaikoura | Lower Waitaki South Coastal Canterbury | Orari Ophi Pareora | Selwyn Wainora | Upper Waitaki | Waimakariri |  |
| Number of wells sampled:                                                                        | <b>322</b>        | <b>64</b>            | <b>36</b>                | <b>29</b>    | <b>7</b> | <b>29</b>                              | <b>47</b>          | <b>69</b>      | <b>8</b>      | <b>33</b>   |  |
| <b>Health-based Maximum Acceptable Value (MAV) - number of wells that exceeded the MAV for:</b> |                   |                      |                          |              |          |                                        |                    |                |               |             |  |
| <i>E. coli</i> <1 MPN/100 ml                                                                    | <b>27</b>         | 5                    | 0                        | 4            | 1        | 3                                      | 6                  | 5              | 0             | 3           |  |
| Nitrate nitrogen 11.3 mg/L                                                                      | <b>34</b>         | 18                   | 0                        | 3            | 0        | 1                                      | 6                  | 4              | 0             | 2           |  |
| Manganese 0.4 mg/L                                                                              | <b>8</b>          | 0                    | 3                        | 2            | 1        | 0                                      | 1                  | 0              | 0             | 1           |  |
| Arsenic (10 wells) 0.01 mg/L                                                                    | <b>3</b>          | 0                    | 1                        | 1            | 1        | 0                                      | 0                  | 0              | 0             | 0           |  |
| <b>Aesthetic-based Guideline Value (GV) - number of wells that exceeded the GV for:</b>         |                   |                      |                          |              |          |                                        |                    |                |               |             |  |
| Ammonia nitrogen 1.2 mg/L                                                                       | <b>4</b>          | 0                    | 3                        | 0            | 0        | 0                                      | 1                  | 0              | 0             | 0           |  |
| Chloride 250 mg/L                                                                               | <b>2</b>          | 0                    | 1                        | 0            | 0        | 1                                      | 0                  | 0              | 0             | 0           |  |
| Hardness (as CaCO <sub>3</sub> ) 200 mg /L                                                      | <b>10</b>         | 0                    | 3                        | 4            | 0        | 2                                      | 1                  | 0              | 0             | 0           |  |
| Iron 0.2                                                                                        | <b>25</b>         | 2                    | 4                        | 6            | 1        | 3                                      | 1                  | 4              | 0             | 4           |  |
| Manganese 0.04                                                                                  | <b>31</b>         | 2                    | 6                        | 6            | 1        | 5                                      | 4                  | 1              | 0             | 6           |  |
| pH 7.0 to 8.5                                                                                   | <b>60</b>         | 15                   | 1                        | 3            | 1        | 9                                      | 21                 | 4              | 0             | 6           |  |
| Sodium 200 mg/L                                                                                 | <b>1</b>          | 0                    | 1                        | 0            | 0        | 0                                      | 0                  | 0              | 0             | 0           |  |
| Sulphate 250 mg/L                                                                               | <b>0</b>          | 0                    | 0                        | 0            | 0        | 0                                      | 0                  | 0              | 0             | 0           |  |

## 5 Nitrate nitrogen

Figure 2 shows the distribution of nitrate nitrogen concentrations in Canterbury groundwater measured in the 2010 annual survey. Although some laboratories will report the concentrations of the nitrate anion itself, the nitrate nitrogen concentrations we report are calculated based on the mass of nitrogen in the nitrate anion.

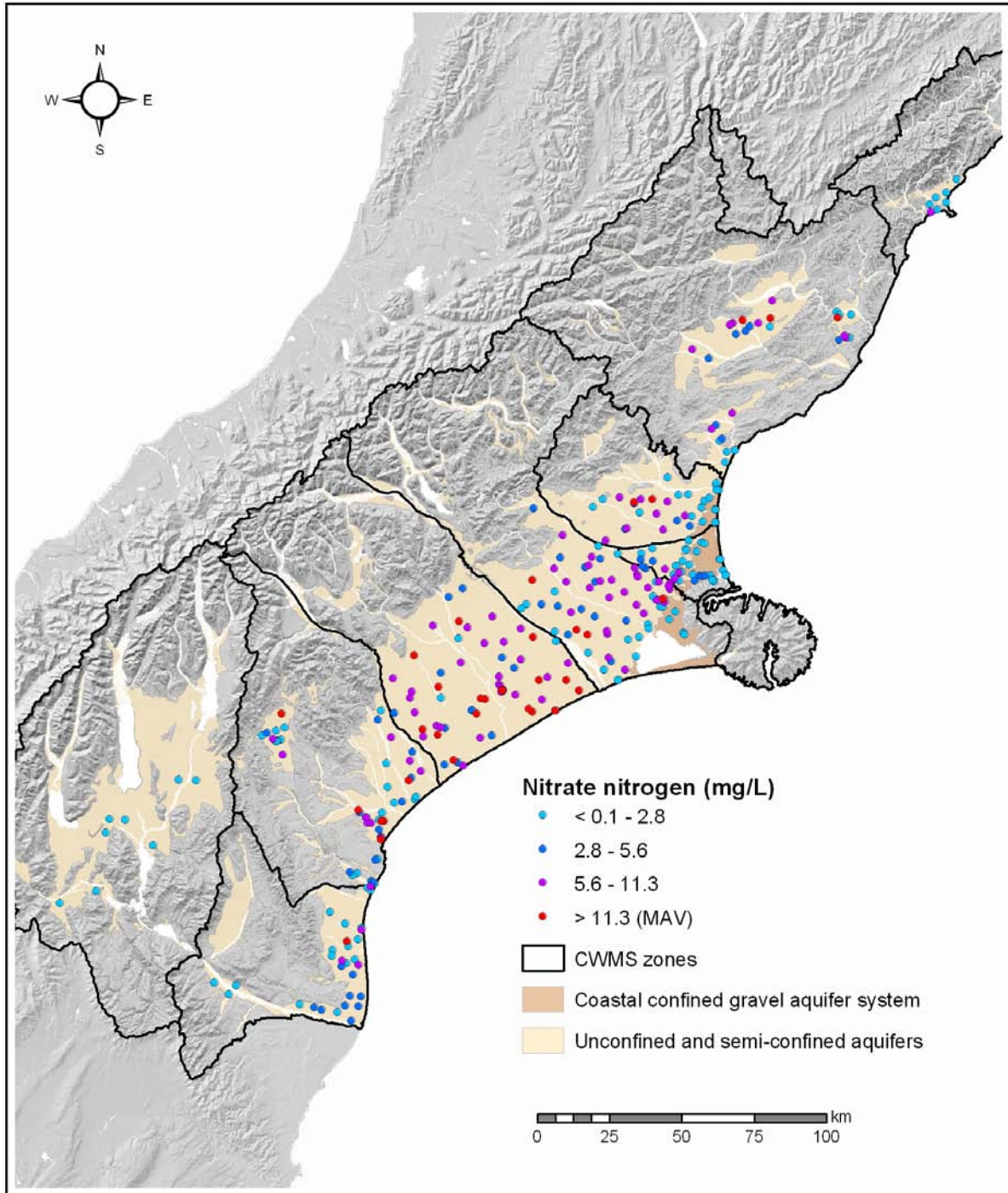


Figure 2: Nitrate nitrogen concentrations recorded in the 2010 annual survey

**Nitrate nitrogen concentrations in Canterbury groundwater in the 2010 annual survey:**

- Just over 40% of the wells have low nitrate nitrogen concentrations, around what we would expect for natural background (shown by light blue dots).
- In some places, concentrations of nitrate nitrogen leached from the soils are decreased by dilution (especially adjacent to the major rivers) or by denitrification.
- Areas of intensive agricultural land use tend to have higher nitrate nitrogen concentrations in the groundwater.
- Red dots show the 10% of groundwater samples with nitrate nitrogen concentrations above the drinking water standard.

## **5.1 Trends in nitrate nitrogen concentrations**

Each year Environment Canterbury conducts a statistical analysis of the long-term nitrate nitrogen data from our annual survey wells. Hanson (2002) provides detail on the Mann-Kendall test that we use for the trend analysis. The results for a 10-year trend analysis on the data collected each spring from 2001 to 2010 are shown in Figure 3.

**Nitrate nitrogen trends in Canterbury groundwater:**

- Over the past 10 years, nitrate nitrogen concentrations have been increasing in about one third of the wells we sampled. The Selwyn Waihora, Ashburton and Orari Opihi Pareora zones have the highest proportion of wells with increasing nitrate nitrogen trends.
- Only 6 wells showed decreasing concentrations and most of these already had low concentrations of nitrate nitrogen.
- Two-thirds of the wells in the annual survey have no decreasing or increasing trend in nitrate nitrogen concentrations.

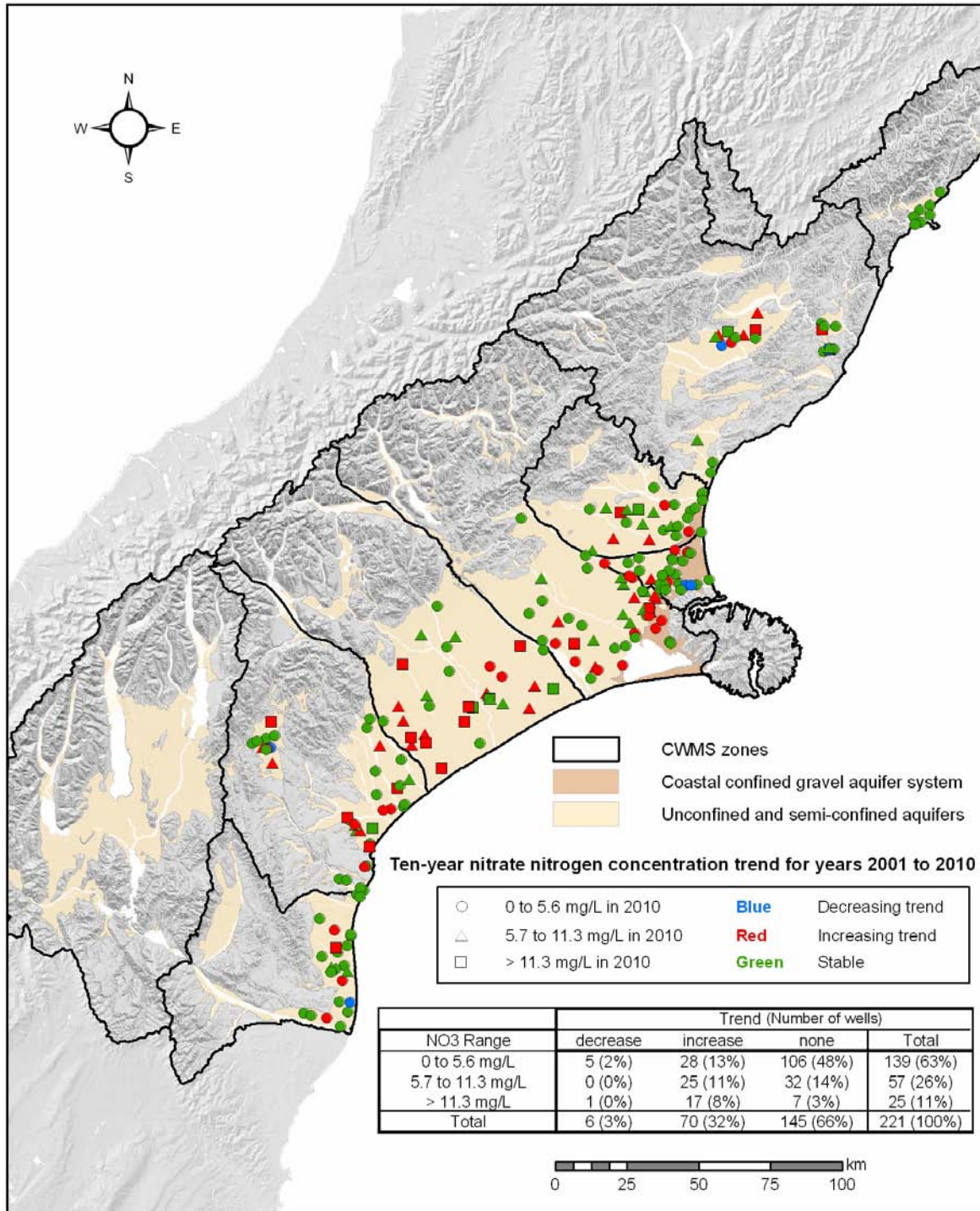
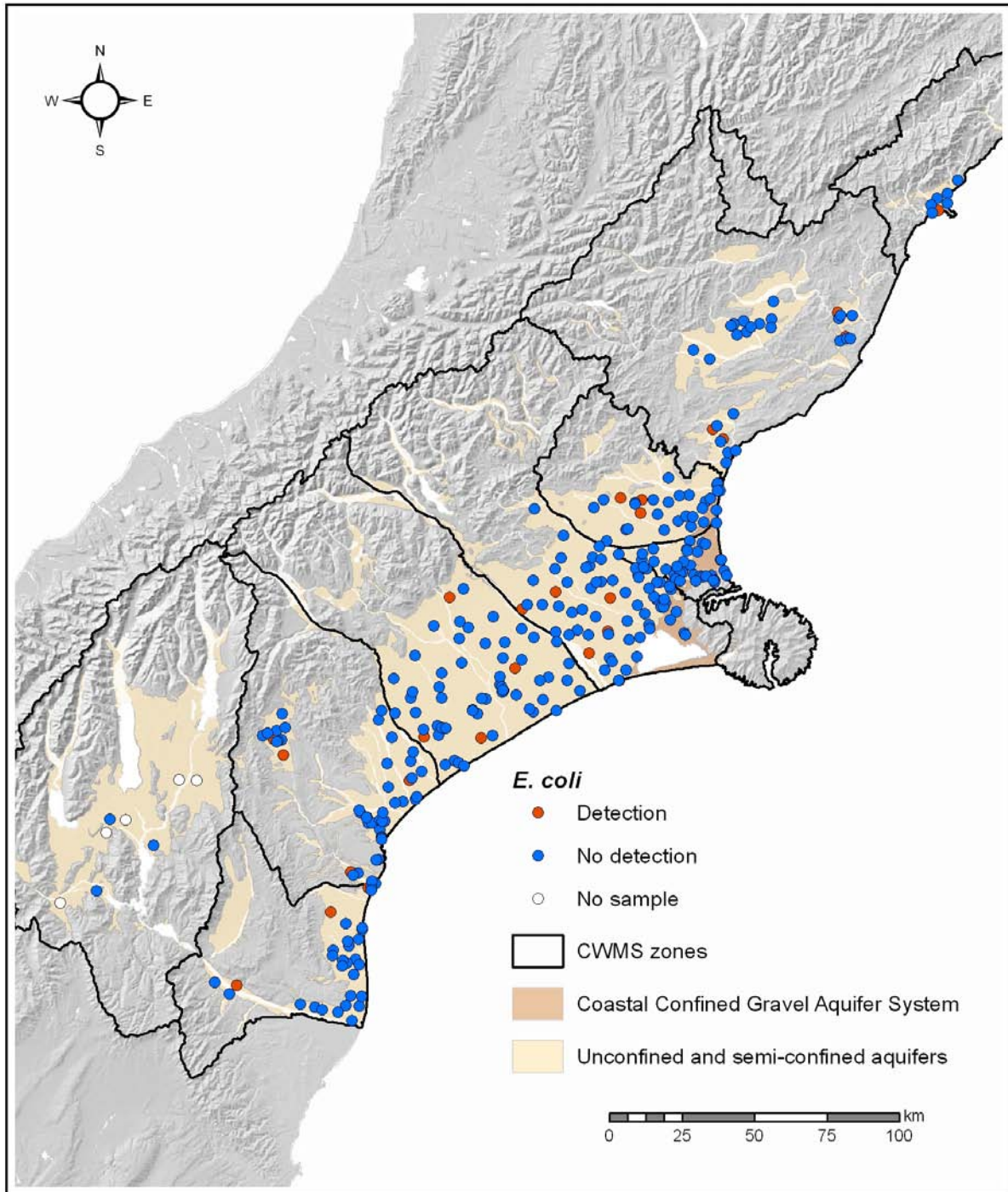


Figure 3: Ten-year trend in nitrate nitrogen concentrations in annual survey wells

## 6 *E. coli*

Figure 4 shows the wells where *E. coli* bacteria were detected in groundwater samples.



**Figure 4: Location of wells sampled for *E. coli* in the 2010 annual survey**

The distribution of samples from the unconfined aquifers containing *E. coli* has no geographical pattern. *E. coli* were not detected in annual survey wells in the coastal confined gravel aquifer system.

**Well depth and *E.coli* detections:**

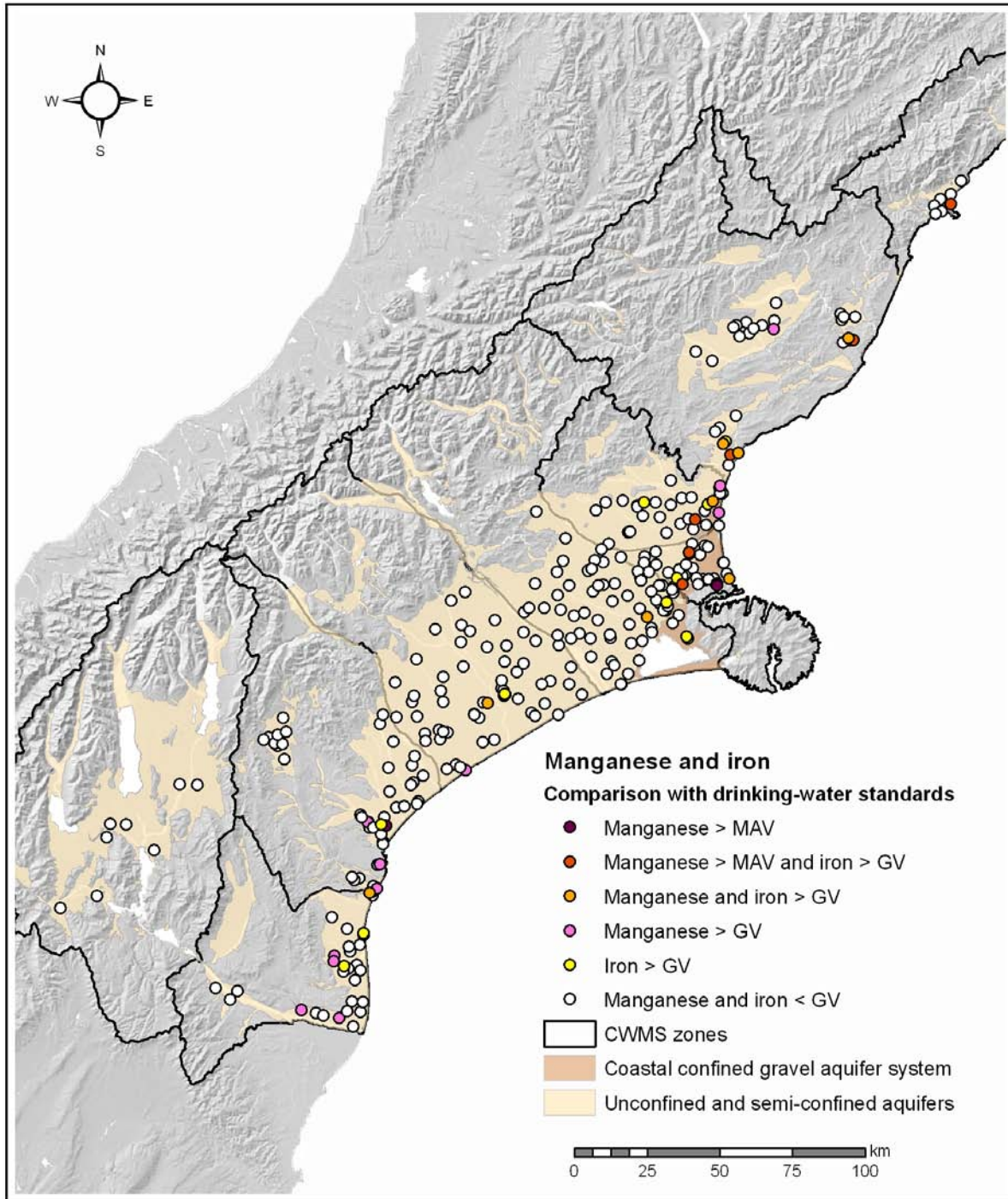
- A higher proportion of the shallow wells is affected by *E.coli* contamination than deep wells.
- *E.coli* were present in 14% of the samples from wells less than 20 m deep and 7% of samples from wells between 20 and 50 m deep.
- Only one well more than 50 m deep had *E.coli* present in the sample and the bacteria count was low (4 MPN/100 ml).

## 7 Manganese and iron

Figure 5 highlights the 42 wells where the concentrations of one or both of these metals in groundwater exceed the limits set by the New Zealand Drinking-Water Standards (MoH 2008).

### **Manganese and iron concentrations in Canterbury groundwater in the 2010 annual survey:**

- Most of the wells in the annual survey yield samples with undetectable or very low concentrations of manganese and iron.
- Higher concentrations tend to be more frequent near the coast than in inland areas.
- Samples from eight wells had manganese concentrations above the health-based MAV.
- Thirty-four other wells had manganese and/or iron concentrations above guideline values.



**Figure 5:** Wells in the 2010 annual survey with manganese or iron concentrations that exceed drinking-water standards (MAV = maximum allowable value and GV = guideline value, MoH 2008)

## References

- Hanson, C., 2002. *Nitrate concentrations in Canterbury groundwater – a review of existing data*. Environment Canterbury technical report R02/17.
- MfE, 2006. *A national protocol for State of the Environment groundwater sampling in New Zealand*. Published by the New Zealand Ministry for the Environment, Wellington. 52 pages.
- MoH, 2008. *Drinking-Water Standards for New Zealand 2005 (revised 2008)*. Published by the New Zealand Ministry of Health, Wellington. 163 pages.