CANTERBURY REGIONAL COUNCIL
Kaunihera Taiao ki Waitaha

Annual Groundwater Quality Survey

2023

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Introduction

What is the annual groundwater quality survey?

Each year, Environment Canterbury (Kaunihera Taiao ki Waitaha) collects groundwater samples from wells across the region. The samples are analysed for a range of water quality parameters. We generally conduct the survey in the springtime, during the months of September to December.

Why do we care about groundwater quality?

Communities in Canterbury need access to safe drinking-water sources and healthy waterways. Groundwater is the major source of drinking-water supply in Canterbury and provides the baseflow to streams and lakes.

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.

The wells we sample are a mix of public and privately-owned wells used for a range of purposes. They give us an indication of the quality of *untreated* source water and baseflow to surface water across the region. We don't specifically monitor drinking-water supplies – this is the responsibility of the water supplier.

How do we conduct our annual groundwater quality survey?

Every year, Environment Canterbury field officers visit over 300 wells across Canterbury to collect water samples. For the most part, we return to the same wells year after year, but there are also a few changes every year, usually due to access constraints or adjustments to our monitoring network (Groundwater Science Section, 2023). We sample in the spring and early summer months (September to December), after the higher groundwater recharge which generally happens over winter.

We collect samples according to Environment Canterbury's standard procedure for the collection of groundwater quality samples, which is consistent with the National Environmental Monitoring Standard for groundwater quality sampling (NEMS, 2019).

The process includes purging wells by pumping out at least three well volumes or by pumping the well at a low flow rate with the pump intake at the level of the well screens. We take the samples using our own pump, or from a sampling tap as close to the wellhead as we can get when the well is already equipped for pumping.

As we are purging the well, we measure various properties of the purge water, such as temperature, pH, electrical conductivity and dissolved oxygen concentrations. When these parameters reach a steady state, we are confident that the well has been purged and the sample is representative of the local groundwater. Our groundwater samples are tested by an IANZ-accredited laboratory for nutrients (ammonia-nitrogen, nitrate-nitrogen, nitrite-nitrogen and dissolved reactive phosphorus), major ion chemistry (alkalinity, calcium, chloride, magnesium, potassium, sodium, and sulphate), iron, manganese, reactive silica, pH, electrical conductivity, hardness, bicarbonate and indicator bacteria (*E. coli* and total coliforms). In the 2023 survey we also included aluminium as a one-off measurement.

What do we do with the data?

All the data we collect are stored in our water quality database and are publicly available on Environment Canterbury's website via the Well Search or Water Quality Data functions.

In addition to analysing and presenting the data in reports like this one, we also send the data to the Ministry for the Environment (Manatū Mō Te Taiao) when the ministry compiles national statistics on the state of the environment in New Zealand. Some of these data (chloride, dissolved reactive phosphorus, *E. coli*, electrical conductivity, and nitrate-nitrogen) are available on the groundwater quality module on the LAWA website – Land, Air, Water Aotearoa. Our monitoring also supplements results from other investigations and is used to inform resource management decisions, such as regional planning and processing resource consent applications.

Glossary

Ammonia-nitrogen

This refers to the concentration of ammonia in water, calculated based on the mass of nitrogen in the ammonia molecule. Our standard convention is to record the concentration of ammonia-nitrogen in milligrams of nitrogen per litre of water (mg/L).

Baseflow

Baseflow is sustained low flow in a river during dry or fair-weather conditions, contributed mainly by the discharge of groundwater in springs.

CWMS zone

A water management zone in the Canterbury Region of New Zealand. There are 10 water management zones mapped in the Canterbury Water Management Strategy (Canterbury Mayoral Forum, 2009).

Denitrification

Denitrification refers to a series of microbially assisted chemical reactions in which the nitrate anion is converted to other forms such as nitrous oxide or nitrogen gas. It occurs primarily in environments where there is very low available oxygen (such as anoxic groundwater).

AV

AV stands for '*Aesthetic Value*'. It has been set by Taumata Arowai – the Water Services Regulator under the Water Services Act 2021, as a threshold above which objectionable aesthetic effects may be observed, such as odour, taste, colour, corrosion, or staining problems (Taumata Arowai, 2022). The AV is not a health-based limit.

MAV

MAV stands for '*Maximum Acceptable Value*'. These values have been set by Order in Council (Water Services (Drinking Water Standards for New Zealand) Regulations 2022) under section 47 of the Water Services Act 2021, to define water suitable for human consumption and hygiene. The MAV for most chemical parameters is the highest concentration at which, based on present knowledge, drinking 2 litres per day for 70 years does not pose a significant health risk to the consumer.

For two of the parameters that we test, nitrate-nitrogen and *E. coli*, the MAV has been set a bit differently. For nitrate-nitrogen, the MAV is a short-term exposure limit established to protect bottle-fed infants against blue baby syndrome. For *E. coli*, a concentration above the MAV may indicate a significant risk of contracting a waterborne disease.

Median

In statistics, the median is the middle value in an ordered list of numbers. We use the median rather than the arithmetic mean (average) to summarise water quality because the mean may be biased by samples with very high or very low concentrations.

Nitrate-nitrogen

This refers to the concentration of nitrate in water, calculated based on the mass of nitrogen in the nitrate anion. Our standard convention is to record the concentration of nitrate-nitrogen in milligrams of nitrogen per litre of water (mg/L).

Vadose Zone

The vadose zone is the term used to describe the zone between the ground surface and the groundwater table. It includes the soil and any unsaturated aquifer material/sediment.

The 2023 annual survey

From September to December 2023, we collected samples from 349 wells across Canterbury.

Survey coverage

Figure 1 shows the locations of the wells we sampled. They cover the areas in Canterbury where groundwater is used. The annual survey covered nine out of the ten Canterbury Water Management Strategy (CWMS) zones. The exception was Banks Peninsula, where there is not much groundwater resource potential and water supplies are derived mainly from surface water resources. The Selwyn-Waihora and Ashburton CWMS zones are heavy users of groundwater, and these two CWMS zones together account for 35% of the wells in the survey.

Well depths

We sample groundwater from a range of depths and locations (Figure 1). Most of the wells draw groundwater from the upper part of the groundwater system near the water table. The shallowest well in our network is 3 m deep and the deepest is 294 m deep.

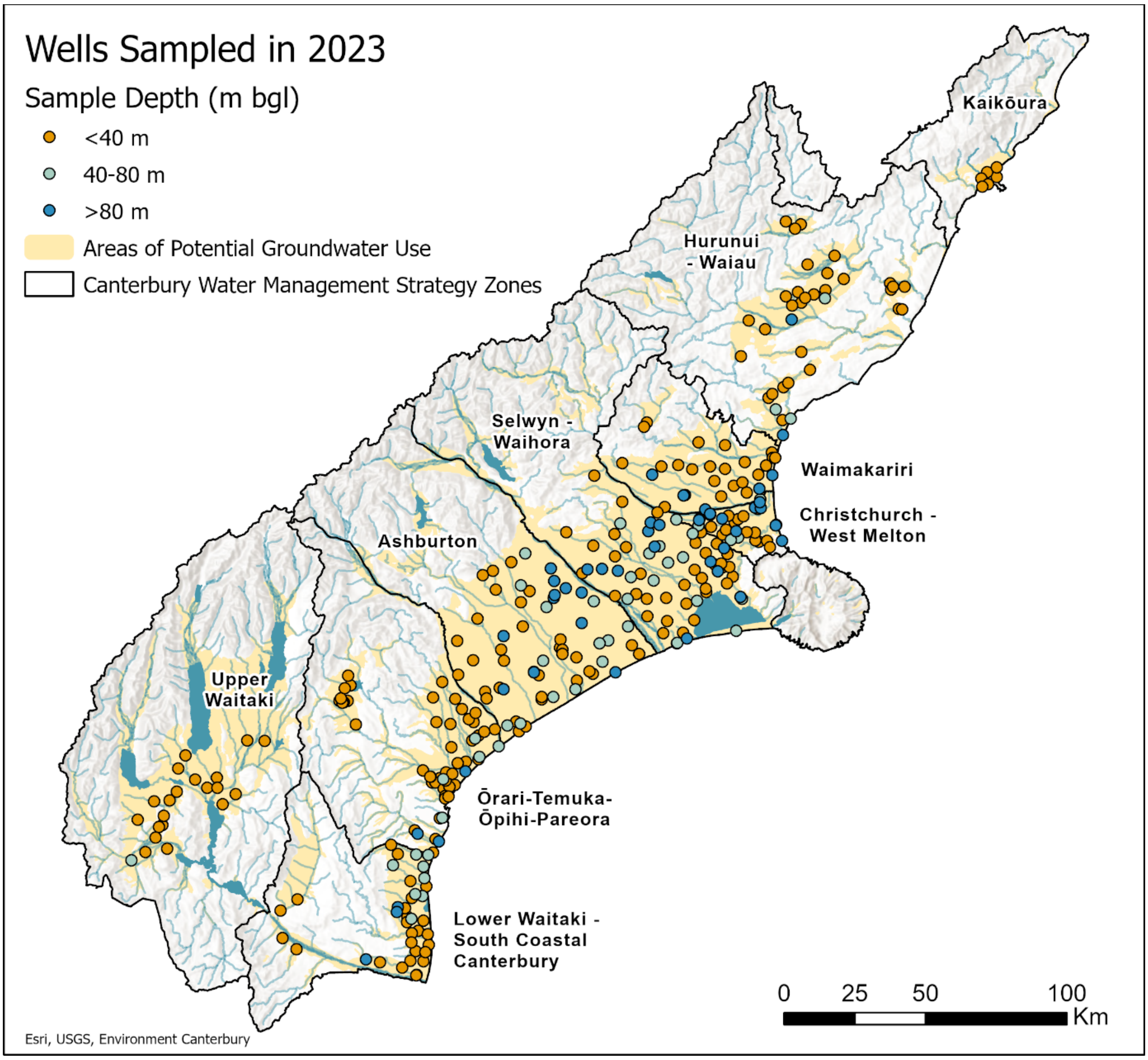

Figure 1: Locations and depths of groundwater samples in the 2023 annual survey

Regional summary

Table 1 below is a summary of the water quality statistics from groundwater samples collected at all 349 wells in our 2023 survey.

Table 1: Summary of groundwater quality parameters collected in the 2023 annual survey

Water Quality Parameters	Units	Median	Range
Microbiological indicators			
E. coli	MPN/100mL	<1	<1 to >2420
Total coliforms	MPN/100mL	<1	<1 to >2420
Nutrients			
Nitrate-nitrogen	mg/L	3.4	<0.002 to 31
Nitrite-nitrogen	mg/L	<0.002	<0.002 to 0.039
Ammonia-nitrogen	mg/L	<0.01	<0.01 to 3.3
Dissolved reactive phosphorus	mg/L	0.006	<0.001 to 1.52
Cations (dissolved metals)			
Total hardness (Ca + Mg as $CaCO_3$)	mg/L	73	8.3 to 340
Calcium	mg/L	19.9	2.2 to 100
Sodium	mg/L	10.8	1.12 to 181
Magnesium	mg/L	5.0	0.25 to 28
Potassium	mg/L	1.33	0.22 to 9.3
Iron	mg/L	<0.02	<0.02 to 8.9
Manganese	mg/L	0.0012	<0.0005 to 3.4
Aluminium	mg/L	<0.003	<0.003 to 1.25
Anions			
Bicarbonate alkalinity (as HCO_3^-)	mg/L	64	11.3 to 320
Chloride	mg/L	8.9	<0.5 to 210
Sulphate	mg/L	9.2	<0.5 to 200
Other parameters			
Electrical conductivity at 25°C (lab)	mS/m	20.4	2.1 to 103
pH (lab)	Unitless	7.5	6.0 to 8.5
pH (field)*	Unitless	6.5	5.1 to 9.3
Temperature (field)	°C	12.6	6.3 to 18.5
Oxidation Reduction Potential (field)	mV	195	-276 to 415
Dissolved oxygen (field)	mg/L	6.7	0 to 14.7
Reactive silica (as SiO_2)	mg/L	16.3	4.7 to 45

** Based on our results, the pH of a sample usually increases due to loss of dissolved gases when it is removed from the ground and transported to the lab.*

Comparison to New Zealand Drinking-water Standards

Canterbury groundwater is widely used as a source of untreated drinking water. We used the Water Services (Drinking Water Standards for New Zealand) Regulations 2022 and the Aesthetic Values for Drinking Water Notice (Taumata Arowai, 2022) to assess the groundwater quality. Table 2 summarises the number of wells in each CWMS zone, and in the whole region, that did not meet the standards.

Table 2: Number of wells not meeting the drinking-water standards for 2023 annual survey

Water quality parameter and drinking-water standards		Canterbury Region	CWMS Zone								
			Kaikōura	Hurunui-Waiau	Waimakariri	Christchurch-West Melton	Selwyn-Waihora	Ashburton	Ōrari-Temuka-Ōpihi-Pareora	Lower Waitaki-South Coastal Canterbury	Upper Waitaki
Number of wells sampled		349	6	37	32	38	63	60	55	37	21
Health-based maximum acceptable value (MAV) - number of wells that did not meet the standard											
Nitrate-nitrogen	11.3 mg/L	35	0	2	0	0	6	22	1	4	0
***E. coli* [1]**	< 1 MPN/100 ml	32	0	1	3	1	2	5	15	5	0
Manganese	0.4 mg/L	9	1	4	0	2	0	1	0	1	0
Arsenic [1]	0.01 mg/L	4	1	2	0	1	-	-	-	0	0
Aluminium	1 mg/L	1	0	0	0	0	0	1	0	0	0
Aesthetic-based guideline value (AV) - number of wells that did not meet the standard											
pH (lab)	7.0 – 8.5	56	0	7	6	0	3	13	21	6	0
Manganese (staining threshold)	0.04 mg/L	37	1	7	4	7	2	5	3	8	0
Manganese (taste threshold)	0.1 mg/L	22	1	7	2	2	1	2	1	6	0
Iron	0.3 mg/L	27	1	5	6	6	2	3	1	3	0
Hardness (measured as $CaCO_3$)	200 mg/L	12	0	4	0	0	0	0	4	4	0
Ammonia-nitrogen	1.2 mg/L	3	0	2	0	1	0	0	0	0	0
Aluminium	0.1 mg/L	5	0	1	1	0	0	1	1	1	0
No wells exceeded the aesthetic guideline values for Chloride (250 mg/L), Sodium (200 mg/L), or Sulphate (250 mg/L).											

[1] We tested 346 of the samples for *E.coli* and 15 samples for arsenic. Dash indicates no wells tested in the zone.

Drinking water quality

E. coli

Groundwater is vulnerable to contamination by human and animal faeces, especially after heavy rainfall. Bacteria and viruses in faecal material can cause diseases. We test for the presence and quantity of *E. coli* bacteria in water as an indicator of faecal contamination in groundwater. Any detection of 1 or more *E. coli* bacterium per 100 mL exceeds the drinking water standards for New Zealand.

Current state of *E. coli* in groundwater (2023)

Groundwater throughout the region is vulnerable to faecal contamination. Detections of *E. coli* are found in all CWMS zones. They show no strong geographical pattern from year to year, but they are most common in shallower wells.

- *E. coli* were detected in 32 (9%) out of 346 wells we tested in spring 2023. The proportion of wells in which *E. coli* were detected varies from year to year, but 2023 was slightly below average for all the years we have been testing for *E. coli*. We typically find higher concentrations in groundwater if we collect a sample after there has been some heavy rain.

- 27 samples with *E. coli* detections came from groundwater sampled less than 20 m below ground, three samples between 20 and 40 m below ground, two from between 40 and 80 m below ground. There were no *E. coli* detections from groundwater sampled greater than 80 m below ground.

Figure 2 shows wells where *E. coli* were detected in this year's sampling. Although most of the monitoring wells where *E. coli* were detected are not used for drinking water, if people were to consume untreated water from these wells, they would have a higher risk of contracting a water-borne infection from their water supply.

We also plotted the *E. coli* detections by groundwater sample depth below ground level in Figure 3. Because faecal bacteria are carried to groundwater from the surface and are filtered out or die-off over time as they travel through the vadose zone and aquifer, it is common that we see more detections in shallower wells.

We recommend that all owners of private water supply wells test their water regularly for *E. coli*, especially after heavy rain. If *E. coli* are detected, all water for consumption should be boiled or disinfected. Please visit Our Drinking Water webpage for more information about protecting your private water supply.

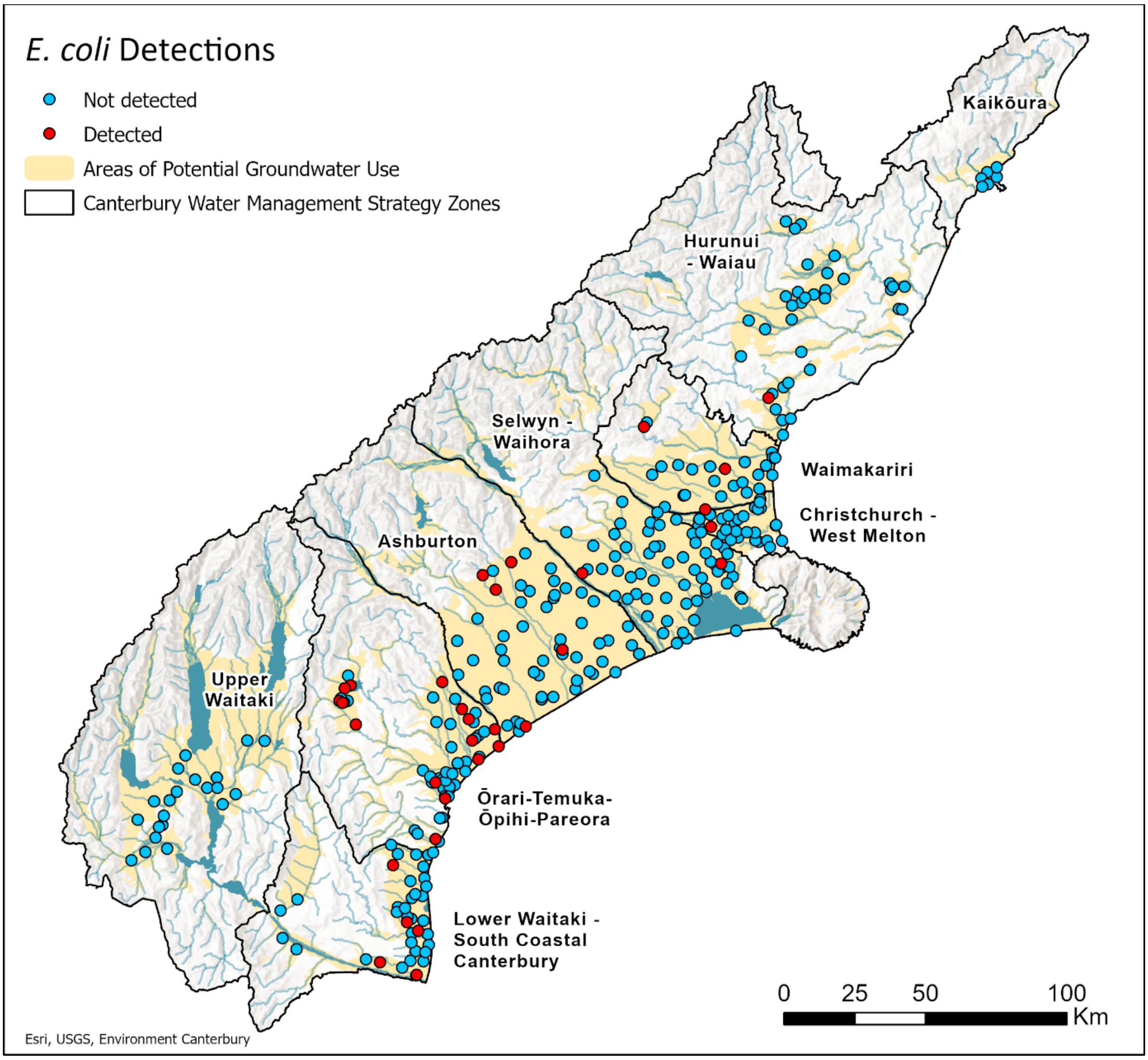

Figure 2: ***E. coli* detections in wells sampled in the 2023 Annual Survey**

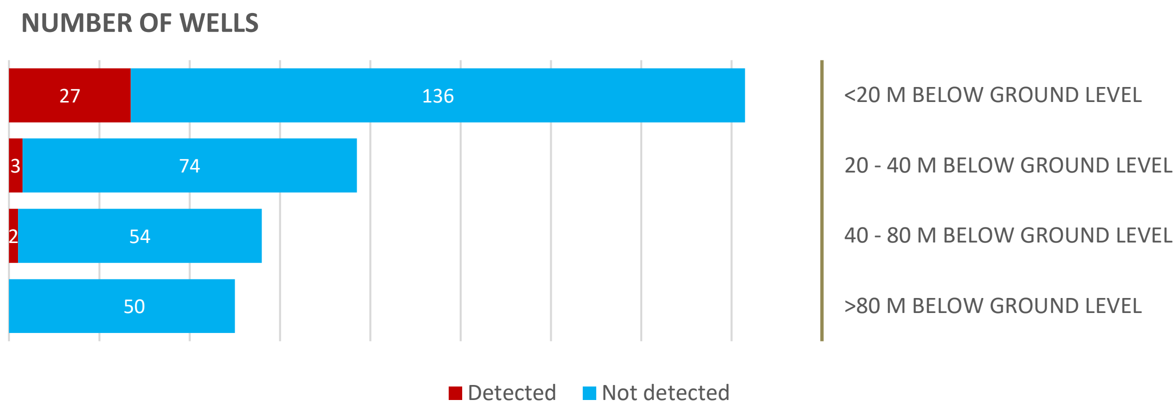

Figure 3: ***E. coli* detections by groundwater sample depth in the 2023 Annual Survey**

Nitrate-nitrogen

Nitrate-nitrogen in groundwater can affect its suitability for drinking-water supply. The Maximum Acceptable Value (MAV) for nitrate is 50 mg/L (equivalent to nitrate-nitrogen of 11.3 mg/L), based on a risk to bottle-fed babies. The Ministry of Health (Manatū Hauora) recommends applying this value to protect bottle-fed babies less than six months old and pregnant women.

Current state of nitrate-nitrogen in groundwater (2023)

Figure 4 summarises the nitrate-nitrogen concentrations found in our 2023 groundwater quality survey by CWMS zone. The concentrations are grouped into four categories, using the same categories that are used on the LAWA website – Land, Air, Water Aotearoa.

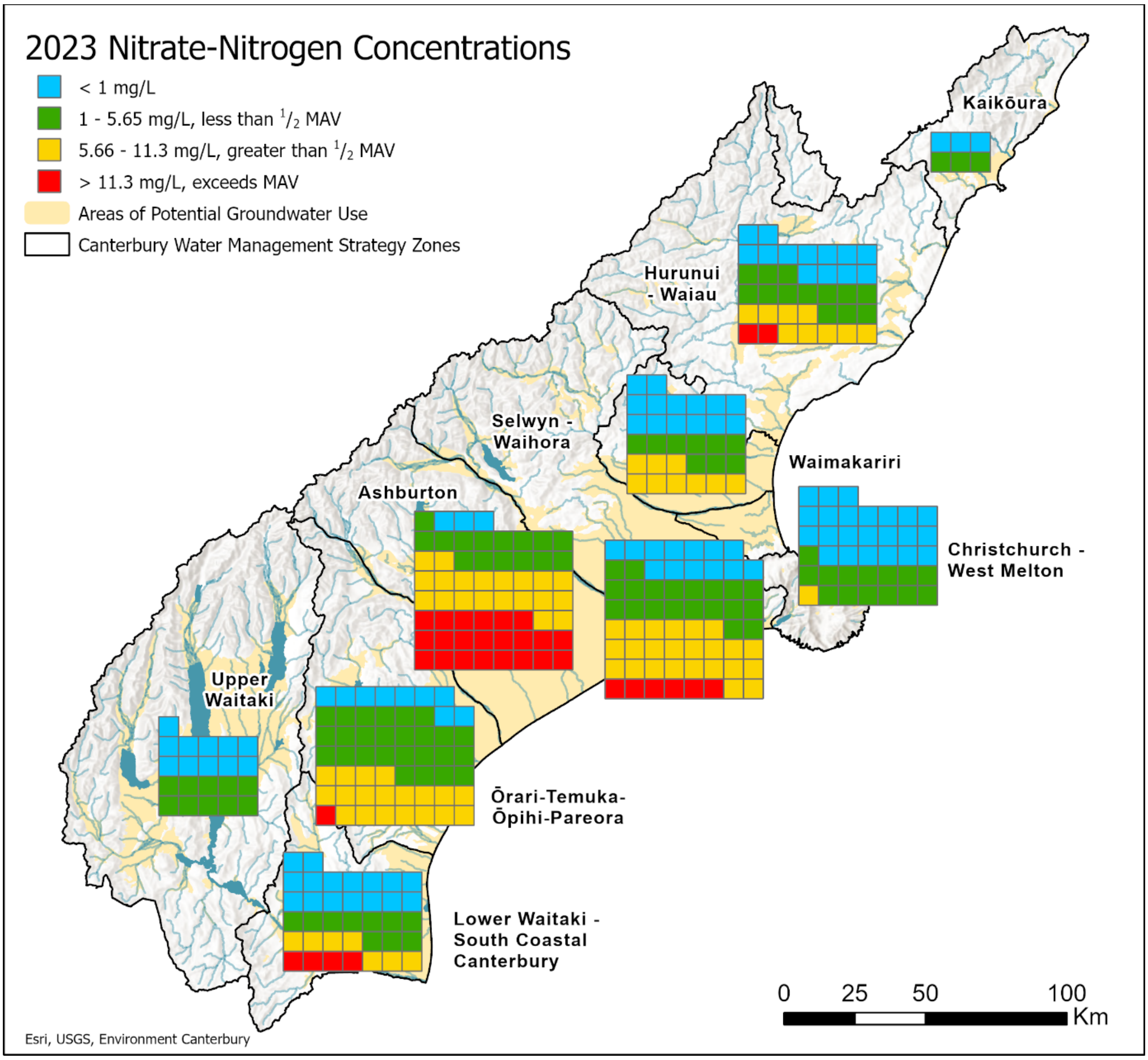

Figure 4: **Summary of nitrate-nitrogen concentrations sampled in the 2023 annual survey for each CWMS zone. One square represents one well**

Areas around and downstream of intensive agricultural land use tend to have higher nitrate-nitrogen concentrations in the groundwater than other areas. In some places, concentrations of nitrate-nitrogen leached from the soils may be lower as a result of natural dilution (especially adjacent to the major rivers) or by denitrification.

In the 2023 annual survey we found:

- the samples from 105 wells (30% of the wells we sampled) had nitrate-nitrogen concentrations below 1 mg/L (shown by blue squares).
- the samples from 120 (34%) wells had nitrate-nitrogen concentrations greater than or equal to 1 mg/L but less than half of the MAV (5.65 mg/L; shown by green squares).
- the samples from 89 (26%) wells had nitrate-nitrogen concentrations above half of the MAV (5.65 mg/L) but less than or equal to the MAV (11.3 mg/L; shown by yellow squares).
- the samples from 35 (10%) wells had nitrate-nitrogen concentrations above the MAV (> 11.3 mg/L; shown by red squares).

The proportion of samples exceeding the MAV (10%) is lower than the 13% found in 2022.

Long-term trends in nitrate-nitrogen in groundwater (2014 – 2023)

Environment Canterbury conducts a statistical analysis each year to look for long-term trends in nitrate-nitrogen concentrations. Our trend analysis followed the methodology developed by Snelder *et al. (*2021) which is also used for the groundwater quality module on the LAWA website. Details of this methodology can be found on the LAWA website. The results are mapped in Figure 5. Where necessary, the approximate location has been used to prevent symbols overlapping.

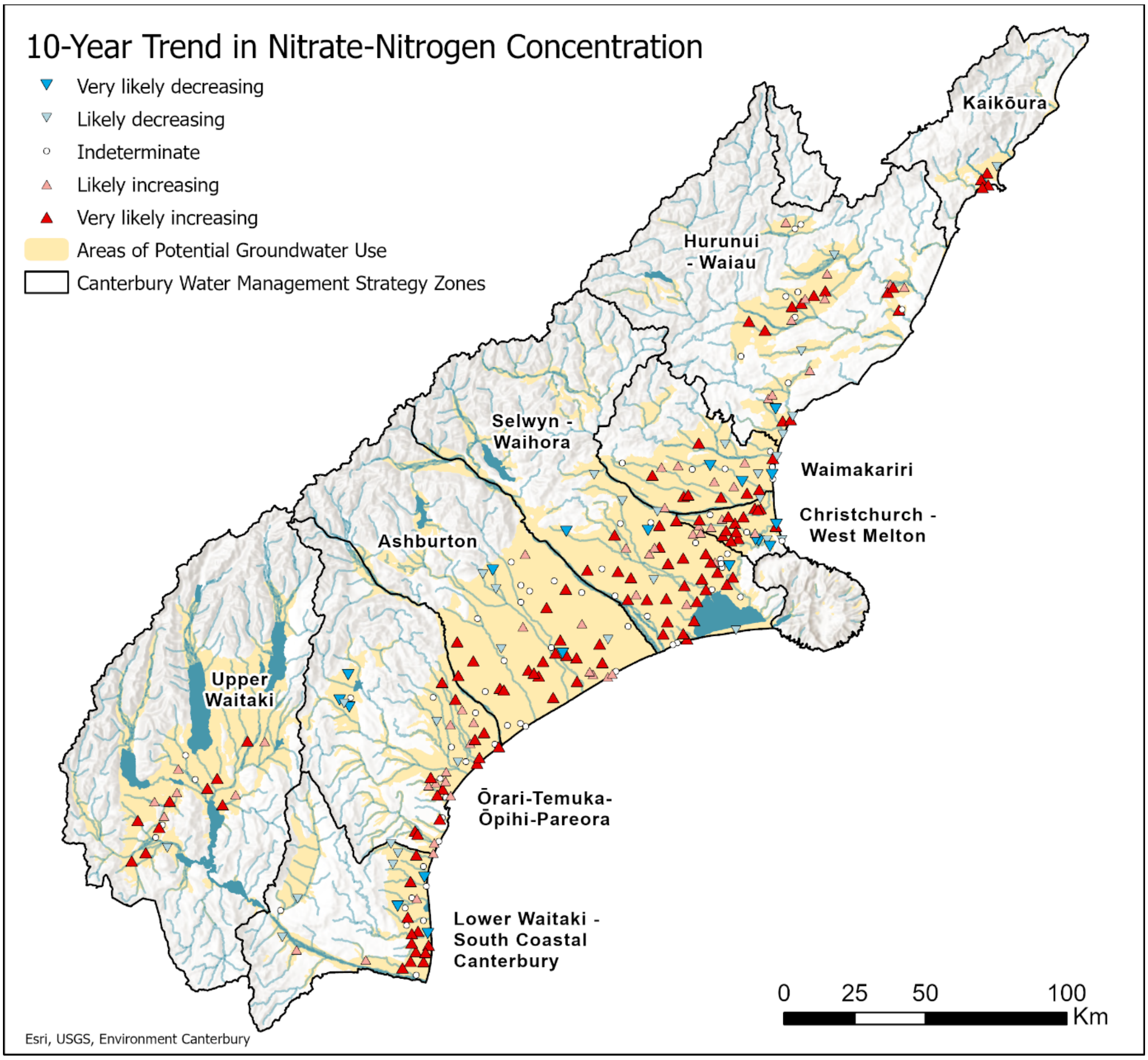

Figure 5: **Ten-year trends (2014 to 2023) in nitrate-nitrogen concentrations in annual survey wells**

In 2023, 287 of the 349 wells sampled had enough data to analyse trends (at least 8 samples over the last ten years).

From the 2014 to 2023 annual surveys, we found:

- 115 wells (40%) showed 'very likely increasing' trends in nitrate-nitrogen concentrations
- 55 wells (19%) showed 'likely increasing' trends in nitrate-nitrogen concentrations
- 30 wells (10%) showed 'likely decreasing' trends in nitrate-nitrogen concentrations
- 19 wells (7%) showed 'very likely decreasing' nitrate-nitrogen concentration trends
- 68 wells (24%) had no decreasing or increasing trend (labelled as indeterminate) in nitrate-nitrogen concentrations.

There are some differences between our results and those shown on LAWA, even though the analytical method is the same. There are two key reasons for this:

1) *different time periods*: in this report, we present trends calculated over the period 2014-2023, whereas LAWA presents trends calculated over the period 2013-2022.
2) *different sampling frequencies*: the trends in this report are based on annual data, whereas LAWA trends were calculated using quarterly data. About a third of the wells in our annual survey are sampled four times a year. Those quarterly results are available on LAWA but we do not report them here.

The greatest difference between them is the number of wells analysed. For this report, we had sufficient data (at least 8 samples) to calculate trends for 287 of the 349 wells in our survey. In contrast, LAWA only has 92 quarterly wells that meet their data requirements for trend analysis. A second difference is that because LAWA uses quarterly data, it has more data points and therefore increases certainty in the trend. This means that some sites that show ‘no trend’ or a ‘likely’ trend in this report have a ‘very likely’ trend on LAWA.

Other contaminants

Manganese

Figure 6 shows the results for manganese graded by aesthetic (AV) and health-based (MAV) concentrations in 2023. Pink dots indicate wells where the manganese concentrations are high enough to cause potential staining of laundry (above 0.04 mg/L) and dark purple indicates potential health risks from long-term consumption of water with manganese above 0.4 mg/L. There is also an aesthetic value of 0.1 mg/L set as a threshold for objectionable taste (Taumata Arowai, 2022).

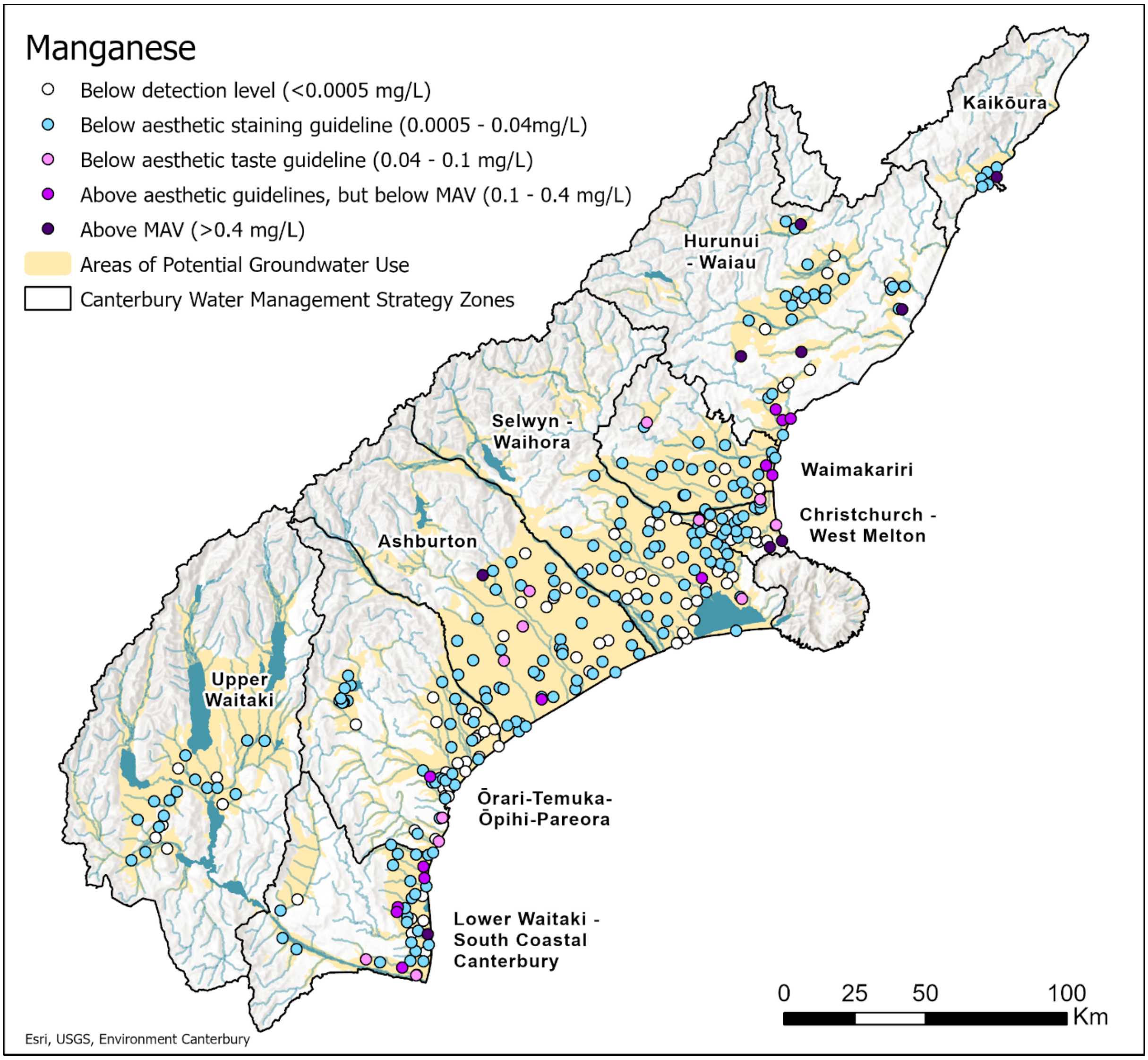

Figure 6: **Manganese concentrations in groundwater from the 2023 annual survey assessed relative to drinking-water standards**

Arsenic

This year, we sampled 15 wells for arsenic based on detections found in the 2022 survey. Seven wells were sampled in Hurunui-Waiau, four wells in Christchurch West-Melton, and one well each in Kaikōura, Lower Waitaki-South Coastal Canterbury, Waimakariri, and Upper Waitaki zones. Arsenic is also known to be present in other localised areas (Pearson, 2022). The red circles in Figure 7 show four wells with arsenic levels exceeding the MAV of 0.01 mg/L in the 2023 survey.

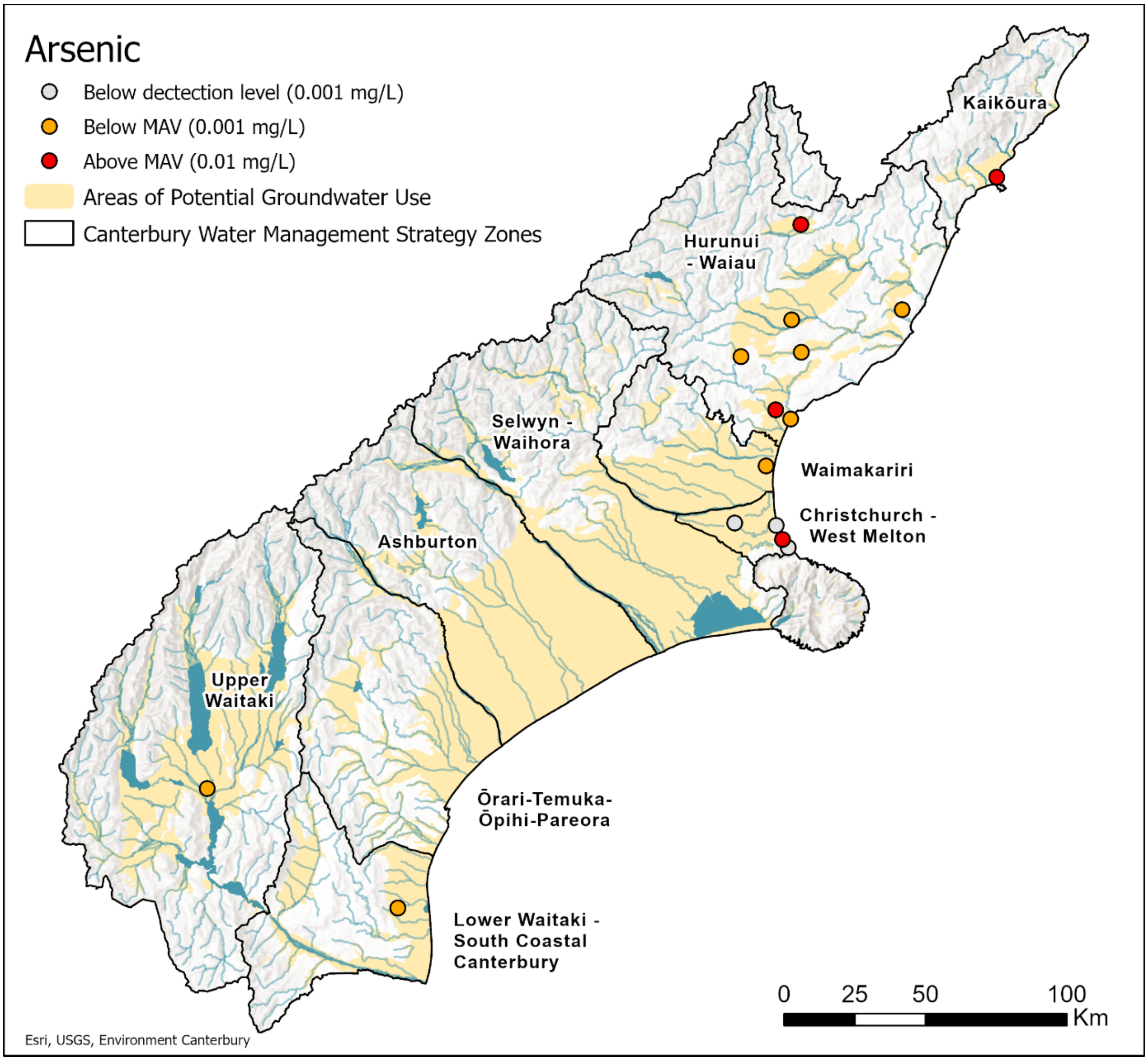

Figure 7: **Arsenic concentrations in groundwater from the 2023 annual survey assessed relative to drinking-water standards**

Aluminium

In 2023, we included dissolved aluminium in our parameter list as a one-off test. Aluminium can be present naturally in groundwater due to the weathering of rocks and minerals that contain aluminium. However, certain human activities and products can introduce additional aluminium into the environment which can make their way into groundwater. Figure 8 shows the results for Aluminium graded by aesthetic (AV) and health-based (MAV) values for the 2023 survey.

From the 2023 annual survey, we found:

- 1 well (0.3%) exceeded the drinking-water MAV of 1 mg/L
- 5 wells (1%) exceeded the drinking-water AV of 0.1 mg/L

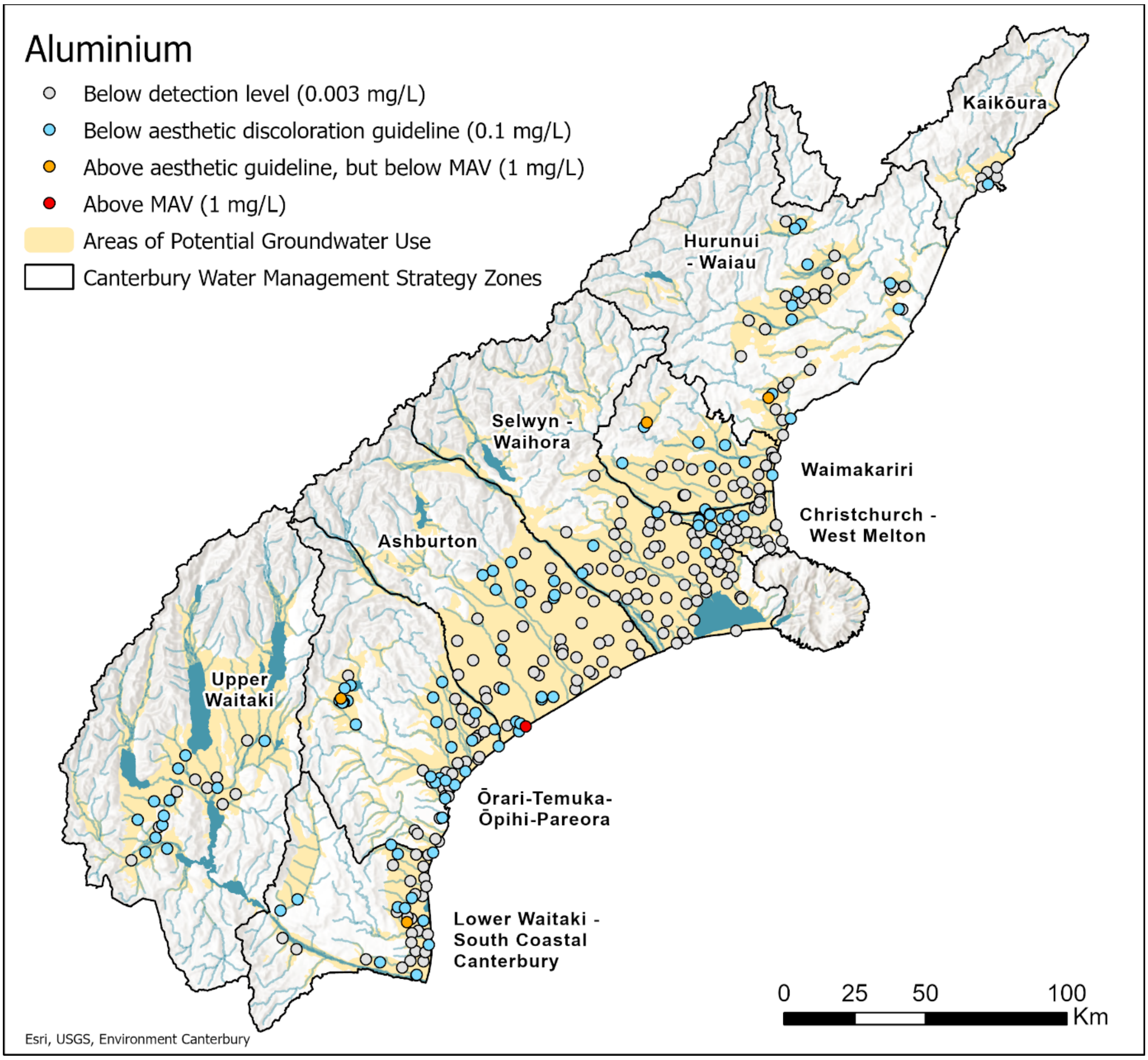

Figure 8: **Aluminium concentrations in groundwater from the 2023 annual survey assessed relative to drinking-water standards**

Aesthetic properties

The samples from some wells did not meet guideline values for contaminants that affect the aesthetic properties of the water, including pH, iron, manganese, ammonia, aluminium, and hardness (see Table 2). Except for the one-off testing for aluminium, these results were very similar to previous surveys. These contaminants do not pose a health risk, but they may be a nuisance because of corrosiveness, staining, poor taste, scale build-up or scum formation with certain types of soaps.

pH is the most common parameter that does not meet drinking-water guideline values. The pH of most Canterbury groundwater is mildly acidic. This is a natural effect from dissolved gases in the recharge and the low buffering capacity of our aquifer sediments. Water with a pH below 7 can pose a risk of dissolving metals from plumbing pipes (which the drinking-water standard refers to as *plumbosolvency*).

Healthy waterways

Many of our streams and lakes are fed by groundwater. Dissolved nutrients (nitrogen and phosphorus) transported via groundwater pose a threat to the health of these waterways. Nitrate can be directly toxic to fish or, together with phosphorus, can cause the growth of plants and algae that deplete oxygen in waterways.

To assess our groundwater monitoring results in this context, we have used nitrate-nitrogen and dissolved reactive phosphorus attribute bands for ecosystem health in rivers from the National Policy Statement for Freshwater Management (NPS-FM, MfE, 2020). We must note, though, that for surface water, these thresholds are based on median concentrations. Our groundwater results are based on single samples that do not capture the true median value across the year, so they can only indicate potential effects on rivers. These results are most relevant for rivers and streams where groundwater is the dominant source of flow in the river.

We identified a subset of 135 wells from our annual survey that are located in areas where groundwater may be discharging to surface water. This includes wells with a sample depth less than 20 m deep and water levels less than 6 m below ground level. For both nitrate-nitrogen and dissolved reactive phosphorus, we used the NPS-FM band classifications to categorise the concentrations we found in these 135 wells.

Nitrate-nitrogen

The NPS-FM classifies nitrate concentrations in rivers into four bands, based on toxicity and the potential effects on aquatic life. An annual median nitrate-nitrogen concentration of greater than 2.4 mg/L in rivers exceeds the NPS-FM 2020 National Bottom Line for ecosystem health.

In Figure 9 we have displayed the measured nitrate-nitrogen concentrations in the 135 wells used in this analysis. The yellow and orange symbols indicate areas where our sampling shows nitrate-nitrogen concentrations in groundwater that could be contributing to the risk of surface waterways exceeding the National Bottom Line for nitrate toxicity under the NPS-FM 2020.

In the 2023 annual survey we found:

- Samples from 36 wells (27%) had low nitrate-nitrogen concentrations (≤ 1.0 mg/L), shown by dark green circles. In rivers, an annual median nitrate-nitrogen concentration below 1.0 mg/L would be classed as band A in the NPS-FM – unlikely to cause effects even on sensitive species.
- Samples from 16 wells (12%) were in the range of 1.0 to 2.4 mg/L of nitrate-nitrogen, shown by light green circles. In rivers, an annual median nitrate-nitrogen concentration in this range would be classed as band B in the NPS-FM – some growth effects on up to 5% of species.
- Samples from 41 wells (30%) had concentrations in the range of 2.4 to 6.9 mg/L, shown by light yellow circles. In rivers, an annual median nitrate-nitrogen concentration in this range would be classed as band C in the NPS-FM – growth effects on up to 20% of species, mainly sensitive species.
- Samples from 42 wells (31%) had nitrate-nitrogen concentrations greater than 6.9 mg/L, shown by the orange circles. Annual median nitrate-nitrogen concentrations of greater than 6.9 mg/L in rivers would be classed as band D in the NPS-FM – could have potential impacts on the growth of multiple aquatic species.

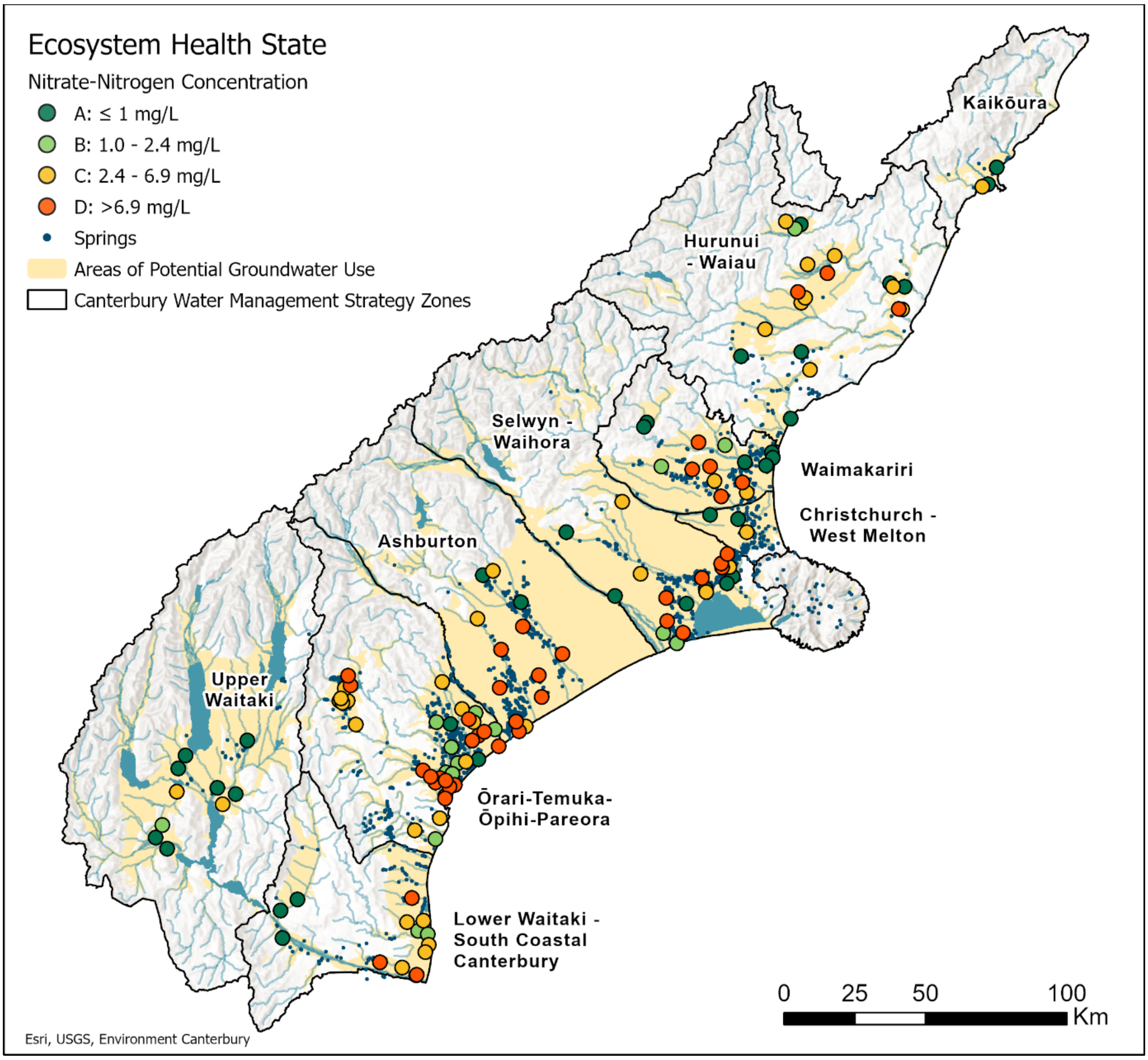

Figure 9: **Groundwater nitrate-nitrogen concentrations from the 2023 annual survey.** Concentrations are shown for wells in areas where groundwater potentially discharges to surface water. They are grouped by NPS-FM attribute band thresholds

Phosphorus

To assess our groundwater monitoring results for dissolved reactive phosphorus (DRP), we used the NPS-FM attribute bands.

High concentrations of nutrients in surface water bodies can cause excessive plant growth rates. With the exception of Banks Peninsula rivers, and possibly the Waipara and Pareora catchments, phosphorus is considered the main limiting nutrient for aquatic plant growth in Canterbury rivers (Hayward *et al.*, 2009). Surface runoff is widely recognised to be the major source of phosphorus in rivers, but where groundwater contributes to stream flow, the phosphorus concentration in the groundwater has the potential to affect the concentration in the stream. Phosphorus in groundwater could be coming from several sources, either natural or from human activities such as farming or discharge of effluent.

The NPS-FM classifies DRP into four bands, based on potential effects to aquatic life. In Figure 10, we apply this classification to the same subset of 135 shallow wells as used for the nitrate analysis in Figure 9.

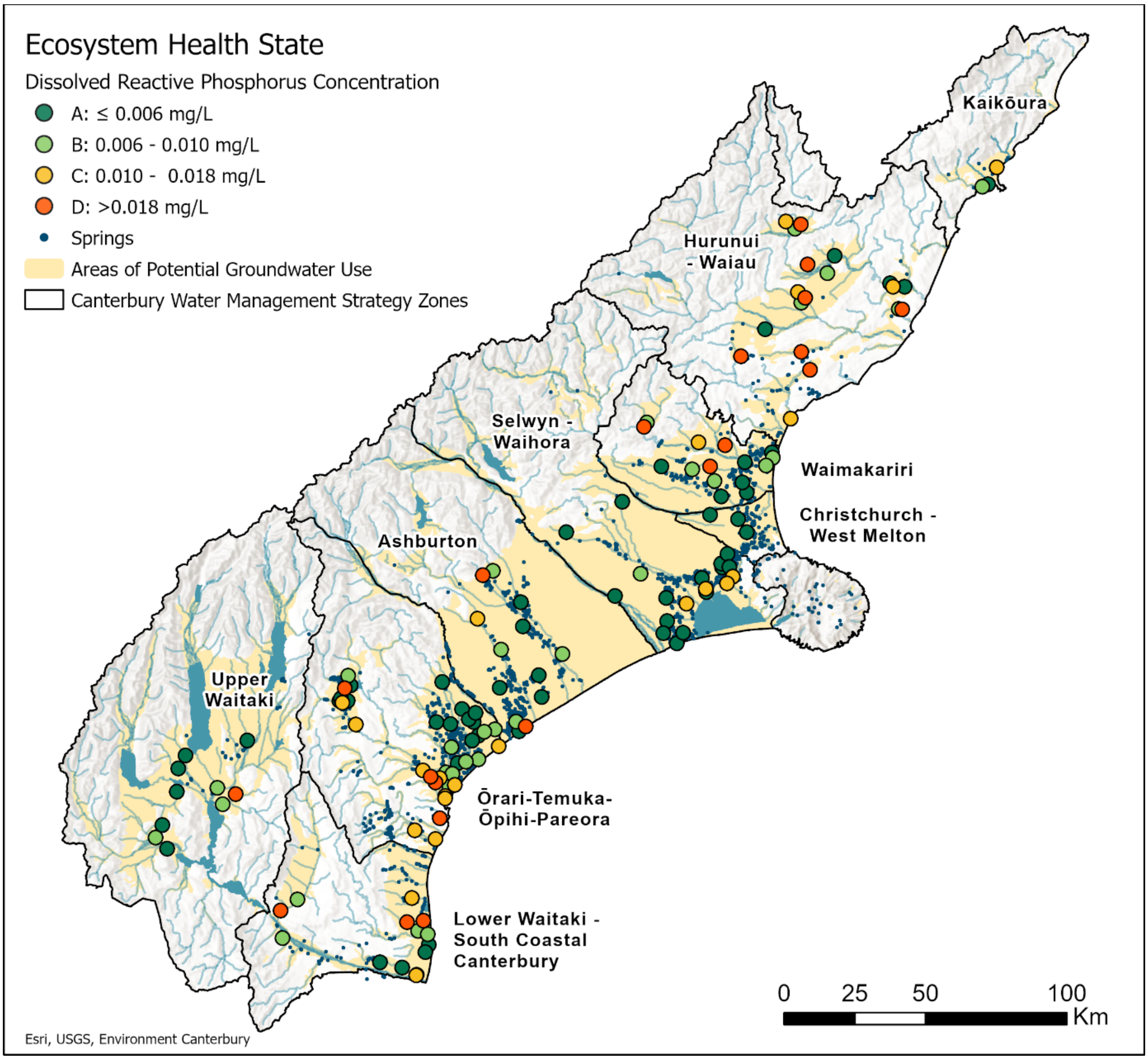

Figure 10: **Groundwater DRP concentrations from the 2023 annual survey.** Concentrations are shown for wells in areas where groundwater potentially discharges to surface water. They are grouped by NPS-FM attribute band thresholds

In the 2023 annual survey we found:

- Samples from 60 wells (44%) in areas of potential connection to surface water had low DRP concentrations (<0.006 mg/L). These are shown by the dark green circles. In rivers, a median DRP concentration below 0.006 mg/L would be classed as band A – no adverse effects from DRP enrichment are expected.
- Samples from 31 wells (23%) had DRP concentrations in the range of 0.006 – 0.010 mg/L, shown by light green circles. In rivers, a median concentration in this range is classed as band B, which can result in the loss of sensitive macroinvertebrate taxa.
- Samples from 24 wells (18%) had DRP concentrations of 0.010 – 0.018 mg/L, as shown by the yellow circles. In rivers, median concentrations in this range are classed as band C, which can result in the loss of sensitive macroinvertebrate and fish taxa.
- Samples from 20 wells (15%) had DRP concentrations greater than 0.018 mg/L, shown by the orange circles. In rivers, median DRP concentrations of greater than 0.018 mg/L are classed as band D, with potential impacts on the growth of multiple aquatic species, and significant changes in the macroinvertebrate and fish communities.

High DRP concentrations in some of the wells are probably from phosphorus-bearing rocks or sediments, especially in the Hurunui-Waiau CWMS zone and the downlands of South Canterbury (Scott & Wong, 2016).

Summary and conclusion

- We sampled groundwater from 349 wells across the Canterbury region in our 2023 annual groundwater quality survey.

- The samples from 35 wells (10%) had nitrate-nitrogen concentrations above the health-based Maximum Acceptable Value (MAV). This was lower than the previous year's survey (44 wells or 13% of sampled wells).

- We found increasing trends in nitrate-nitrogen concentrations in 59% (40% very likely, 19% likely) of the wells with enough data to analyse trends over the past ten years. This is a greater than the 53% in the previous year's survey. The concentrations in 24% of the wells showed no trend, and 17% of the wells showed decreasing trends (7% very likely, 10% likely).

- *E. coli* were detected in the samples from 32 wells (9%), which was slightly lower than the previous year's survey (35 wells or 10% of sampled wells had *E. coli* detected in 2022).

- In areas where there is likely high connectivity with surface water, more than half (61%) of the groundwater samples (83 out of a total of 135 samples) had nitrate-nitrogen concentrations greater than 2.4 mg/L. Baseflow from such groundwater could contribute to some lowland rivers failing to meet the National Bottom Line concentration (of 2.4 mg/L annual median nitrate-nitrogen).

- Samples from 20 (15%) of the wells sampled in areas where there is likely high connectivity with surface water had dissolved reactive phosphorus (DRP) concentrations above 0.018 mg/L. Baseflow from this groundwater could contribute to some lowland rivers being given a D band classification for DRP (>0.018 mg/L annual median concentration).

- The samples from some wells did not meet the Aesthetic Value (AV) for hardness, iron, manganese, pH, aluminium, and ammonia. These results were very similar to previous surveys.

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