April 2017

GROUNDWATER TECHNICAL REPORT

Fonterra Edgecumbe - Medium Strength Wastewater Irrigation Expansion

Submitted to:
Fonterra Limited
Edgecumbe

Report Number: 0978204_316_001_R-Rev0

REPORT

Table of Contents

TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Fonterra Limited operates a dairy manufacturing site on the corner of Awakeri and Eastbank Roads, Edgecumbe in the eastern Bay of Plenty and which is located adjacent to the Rangitāiki River. Fonterra holds resource consent 65800 for the discharge of treated dairy manufacturing wastewater to land and associated discharge of contaminants into the air, the consent being issued on 27 May 2010 for a term of 24 years (expiry 31 December 2034).

The consent enables the discharge of medium strength wastewater (MSW) onto land located approximately 4 km to the west of the Edgecumbe manufacturing site, a total load area as described in Schedule 1 of the consent of 290 ha. Fonterra's farm, commonly referred to as the Omeheu farm comprises 104 ha with the balance being third party owned farms.

Fonterra proposes to expand the land area onto which the medium strength wastewater up to a total area of 500 ha. A 'consent area' has been identified by Fonterra as shown in Figure 1, further referred to as the 'envelope'. The potential effects from the irrigation of MSW onto land on groundwater and surface water need to be assessed for the resource consent application.

Consent 65800 also enables the discharge of high strength wastewater (HSW) onto land through four irrigation schemes (Putiki, Awakeri, Angle Road and Omeheu extension), utilising small travelling irrigators onto approximately 26 third party owned farms. Truck spreading of both MSW and HSW can be undertaken onto land within the Rangitāiki Plains.

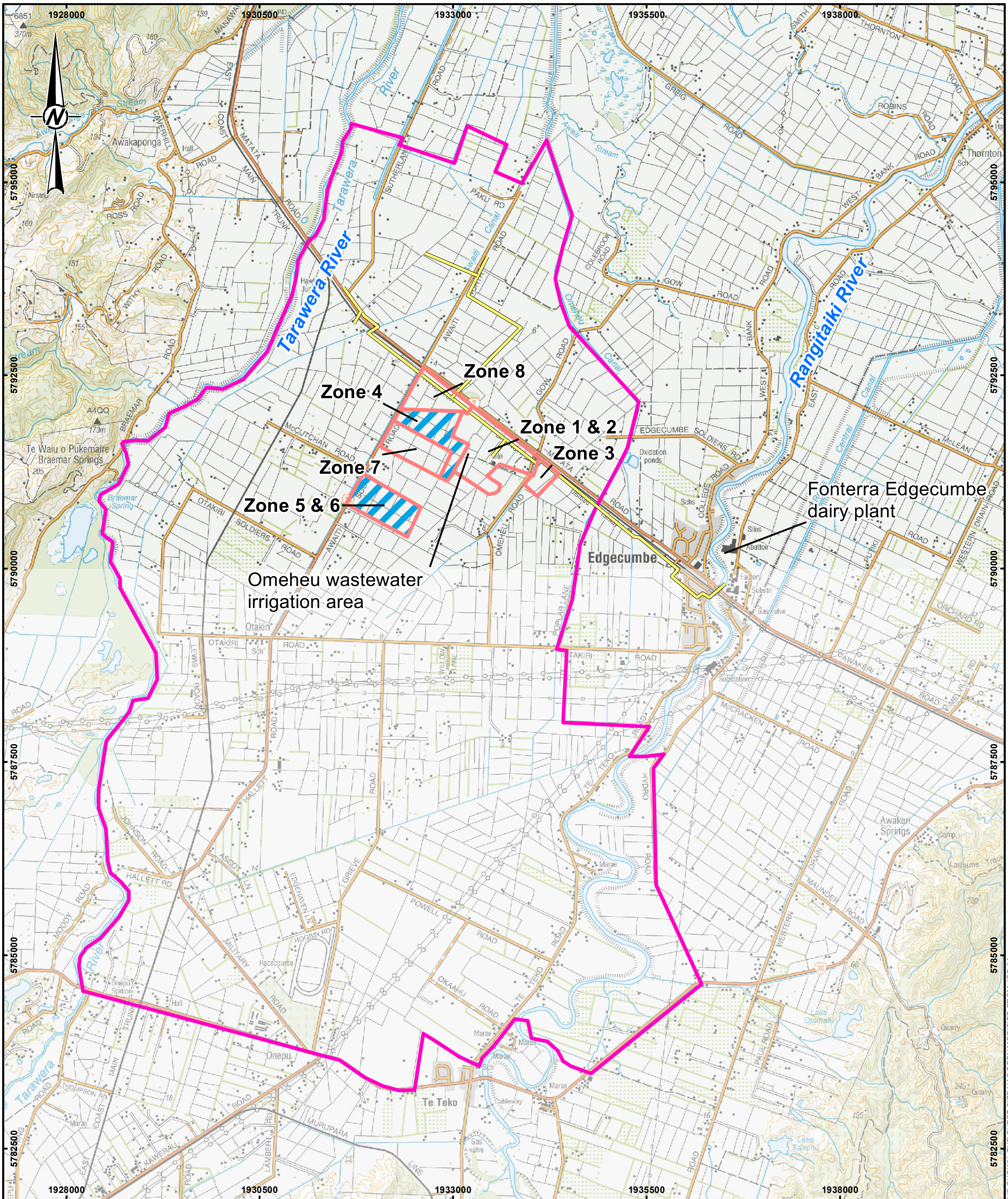
This consent application relates only to the irrigation of MSW onto land. This report has been prepared for Fonterra Limited by Golder Associates (NZ) Limited (Golder) to provide additional information in relation to a request from Bay of Plenty Regional Council (BOPRC) for additional information in relation to Resource Consent Application CH16-00294. This document provides an overview of:

- The regional groundwater system and of groundwater flow paths.
- Current groundwater quality and long term changes in groundwater quality over time.
- The implications of groundwater use if abstracted.
- An indication of expected water quality effects of the proposed expansion of wastewater irrigation areas, based on the current and proposed practices.

2.0 DESCRIPTION OF PROPOSED ACTIVITY

Fonterra currently irrigates treated dairy factory wastewater to land onto paddocks west of the Edgecumbe township under the Bay of Plenty Regional Council (BOPRC) resource consent number 65800 (Figure 1), namely medium strength wastewater onto the Omeheu and Brophy farms comprising a total of 104 ha and high strength wastewater onto a total of six privately owned farms (total area 489 ha). The HSW farms are generally located to the west of the Omeheu and Brophy farms between Awaiti Roads and the Tarawera River.

Medium strength wastewater from Fonterra's dairy manufacturing site at Edgecumbe is pumped approximately 4 km via two wastewater pipelines to the Omeheu wastewater silo compound and irrigation area (Figure 1). This irrigation of wastewater to land uses the soil microbes and plants to assimilate the organic content and nutrients thereby providing additional treatment, before the wastewater reaches the groundwater resources and subsequently, through groundwater flow, the surface water resources.



LEGEND

- Wastewater irrigated areas
- Previous in-ground irrigation
- Wastewater pipe line
- Envelope

0 1 2

Kilometres

REFERENCE SCALE: 1:70,000 (at A4)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

NOTES

1. Map image: LINZ NZTopo Series, CC-BY-3.0-NZ.
2. WW irrigated areas are sourced from map sent by Leigh Old dated 16 February 2017.
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

CLIENT
FONTERRA

PROJECT
FONTERRA EDGECUMBE - WW IRRIGATION AREA EXPANSION

TITLE
ENVELOPE (I.E., SEARCH AREA) FOR NEW WASTEWATER IRRIGATION PADDOCKS NEAR FONTERRA EDGECUMBE

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-03-31
PREPARED	EVN/KC
REVIEWED	RK
APPROVED	PK

PROJECT NO.	REPORT	REV.	FIGURE
0978204316	001	0	01

PATH: K:\GIS\Projects-Numbered\2009\09782x\04xxx\0978204_316_Fonterra_AssessDischargesToRiver\MapDocuments\2017\0978204316-001-R-F001-A4P.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A4

25mm

Medium strength wastewater irrigation has been undertaken at Omeheu and also onto a privately owned McLeans farms for over 30 years. The MSW scheme is operated in ‘zones’ with Omeheu being zones 1, 2, 3, Brophy farm zones 7 and 8, and McLeans farms comprising zones 4, 5 and 6. A change in farming management on McLeans farm has meant MSW irrigation ceased on zone 4 in May 2012 (end of the 2011/12 dairy season) and on zone 5 and 6 in May 2014 (end of 2013/14 dairy season).

The discharge of medium strength wastewater, by consents issued by BOPRC, allowed up until June 2010 a nitrogen loading of up to 760 kgN/ha/yr. While these consents contained nitrogen loading performance standards no phosphorus loading rate applied but typical loadings have been greater than 300 kgP/ha/yr. A full summary of nutrient and mineral element loadings was contained in the consent application July 2009. Since July 2010 the nitrogen loadings have been limited to a maximum of 550 kgN/ha/yr and a further decrease to 400 kgN/ha/yr takes effect from 1 July 2018.

The Omeheu and Brophy farms were operated as stand-alone dairy farms until approximately 1999 and 2008 respectively, after which time they were grazed by dairy cows, however since 2014 the Omeheu and Brophy farms have been used typically for dairy support and grass cut-and-carry operations.

The historical wastewater and farming operations of the last ten years have been considered in this assessment of effects on groundwater. The time period for groundwater quality trend analysis has targeted the relatively stable conditions over the ten year period since 2007 which is considered to represent the current effects.

Fonterra will reduce the discharge of low strength wastewater to the Rangitāiki River by expanding the wastewater irrigation area, within the identified envelope area, up to a total of 500 ha. It is considered that the net effect of the expanded irrigation operation will be a reduction of Fonterra Edgecumbe’s contribution to the total catchment load of nutrients, thus providing a net positive effect.

3.0 GROUNDWATER RESOURCES

3.1 Introduction

In this section an overview of the groundwater resources and their interaction with surface water beneath the area covered by the envelope is provided. This section also includes a description of groundwater flow paths and provides an indication of relevant groundwater quality processes.

3.2 Geology and Hydrogeology

The Lower Rangitāiki – Tarawera catchment is located within the “Whakatane Graben”, which is an actively subsiding basin. Several faults cross this area in north-easterly direction following the faulting trend of the Taupo Volcanic Zone (Pang 1994 and GNS 2010). The area is infilled with clay, peat, silt, sand, pumice and gravels formed by the Tauranga Group to a depth of approximately 70 m. Matahina Ignimbrite underlies the unconsolidated deposits and has been encountered at 70 m to ~400 m depth. These are underlain by greywacke basement rock. Bay of Plenty Regional Council (Pang 1994, BOPRC 2004) identify two aquifer systems in the area:

- **Shallow system (0 to 70 m deep):** Alluvial and marine sediments, pumice sands. Largely unconfined, but local clay, peat and silt layers form local semi-confined conditions. The top 30 m of sediments do not contain any gravels and consist of meandering river deposits. In the middle of the area are peat deposits of up to 4 m in thickness. The hydraulic conductivity is estimated to be 27 to 59 m/day.
- **Deep system (70 to 400 m deep):** Layers of low permeability (peat, silt and clay) form confining conditions for the underlying Matahinga ignimbrites on the Rangitāiki plains. GNS (2010) also states

that the top of the Matahinga ignimbrites (i.e., the deep aquifer system) forms a relatively impervious surface across a wide area based on density differences derived from seismic profiling of the area and therefore hydraulic connection with the overlying Quaternary deposits (i.e., the shallow aquifer system) is small. In the surrounding hills the Matahinga ignimbrites are unconfined. The aquifer is formed by alluvial silts, sands and gravels and ignimbrites. Groundwater levels in this deep system are generally artesian on the Rangitāiki plains. Hydraulic conductivity is approximately 10 m/day, however, local faulting has resulted in considerable higher conductivities locally.

The groundwater in the shallow aquifer system is considered to be replenished by four sources:

- Infiltrating rainwater and irrigation water that falls on the farmland in the plains between the Tarawera and Rangitāiki rivers.
- Lateral flow from the Kawerau Geothermal Field to the south of the plains.
- Vertical upward seepage from the deeper aquifer system.
- Losses from the Tarawera River.

It is likely that all of the groundwater in the shallow aquifer system flows out into the Rangitāiki Drainage Scheme, the lower Rangitāiki River or the sea. There is no groundwater flow from the shallow aquifer system to the deeper aquifer system (Figure 2).

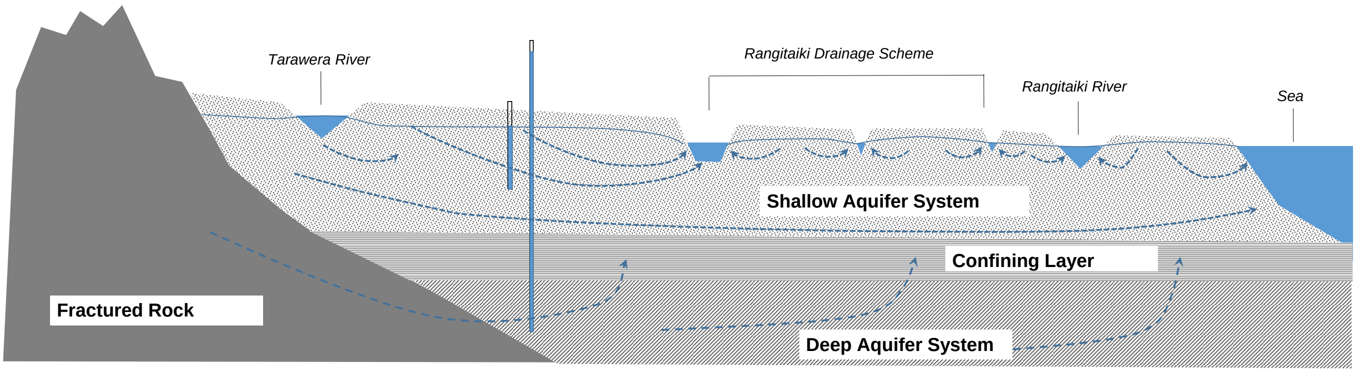


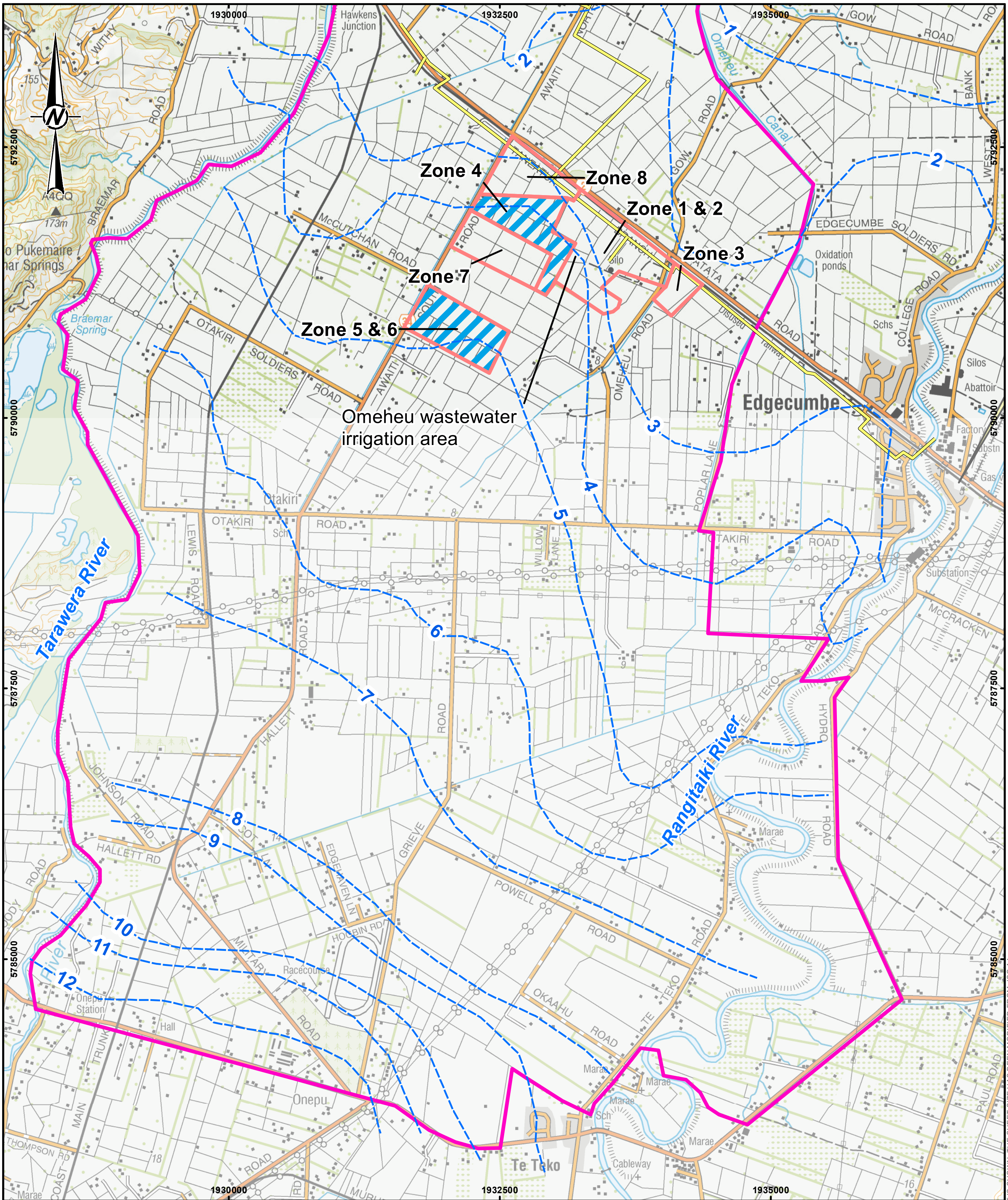
Figure 2: Schematic representation of groundwater flow in Lower Rangitāiki - Tarawera catchment (indicative).

The groundwater flow system as described above is reflected in the groundwater and surface water quality. Based on statistical analysis of water quality data, Pang (1994) identifies a difference between deep aquifer groundwater quality, which is generally low in mineral content and relatively uniform, and shallow aquifer groundwater which is more mineralised and variable.

The Kawerau Geothermal Field has influenced the shallow aquifer water quality causing high boron levels, which makes the use of the shallow aquifer in some areas unsuitable for potable water supply.

3.3 Groundwater Levels and Recharge

Groundwater recharge to the shallow aquifer system is mainly from rainfall and estimated to be approximately 30 % of the total rainfall, which amounts to 600 mm/year for this area (Pang 1994). The groundwater contours of the shallow aquifer system as recorded in April 1989 are shown in Figure 3. There is a general groundwater gradient (and thus a groundwater flow) from southwest to northeast towards the coast in the shallow aquifer system. The groundwater contours are strongly influenced by nearby surface water bodies such as the main rivers and the Rangitāiki Drainage Scheme (see Section 3.4).



LEGEND

- Groundwater contours in 1989 (after BOPRC 1991)
- Wastewater pipe line
- Envelope
- Wastewater irrigated areas
- Previous in-ground irrigation

0 1 2 Kilometres

REFERENCE SCALE: 1:50,000 (at A4)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

NOTES

1. Map image: LINZ NZTopo Series, CC-BY-3.0-NZ.
2. WW irrigated areas are sourced from map sent by Leigh Old dated 16 February 2017.
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

CLIENT
FONTERRA

PROJECT
FONTERRA EDGECUMBE - WW IRRIGATION AREA EXPANSION

TITLE
GROUNDWATER CONTOURS IN SHALLOW AQUIFER SYSTEM IN APRIL 1989 (AFTER BOPRC 1994)

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-04-27
PREPARED	EVN/KC
REVIEWED	RK
APPROVED	PK

PROJECT NO.	REPORT	REV.	FIGURE
0978204316	001	0	03

South of the envelope lies the Kawerau Geothermal Field. This geothermal area is considered to discharge into the shallow aquifer system. The deep aquifer system is recharged in the surrounding hills through rock fractures and faults (BOPRC 2004).

Groundwater levels in the shallow aquifer system vary from 3 to 7 m below ground level (m bgl) in the southwestern part of the envelope to near the surface in the northeast. Fonterra has recorded groundwater levels approximately four times per year since 1997 in monitoring bores near the Fonterra Edgecumbe dairy plant and the Omeheu wastewater irrigation area (Figure 1). Groundwater level graphs for the Omeheu wastewater irrigation area are included in Figure 4 and Figure 5. Seasonal fluctuations of up to 1 m are observed in some bores with the lowest levels occurring in summer.

The groundwater flow direction on the currently irrigated site is roughly divided between the eastern and western sides of the irrigated area. Groundwater on the eastern side moving towards the north and groundwater on the western side moving towards the north east as shown in Figure 6. These groundwater flow lines are based on the 1989 groundwater contours from Pang (1994) and indicate that bore McLeans 604 is up-gradient from bore McLean 412 and that bore McLeans 8 is up-gradient from bore Sturme. These bores are used in the effects assessment described in Section 4.0.

Hydraulic heads of the deep aquifer system are above ground level and are therefore flowing artesian. The deep aquifer hydraulic head varies from approximately 18 m above ground level in the southwest of the area to approximately 2 m above ground level in the northeast. Major springs are present in the Lower Tarawera Catchment, which are used for public water supply. These are the Braemer Spring, Holland Spring, Pumphouse Spring and Jennings Spring. These are fed from the Matahina Ignimbrites (i.e., the deeper system). Pang (1994) suggests the groundwater gradient in the deeper aquifer system is southwest to northeast.

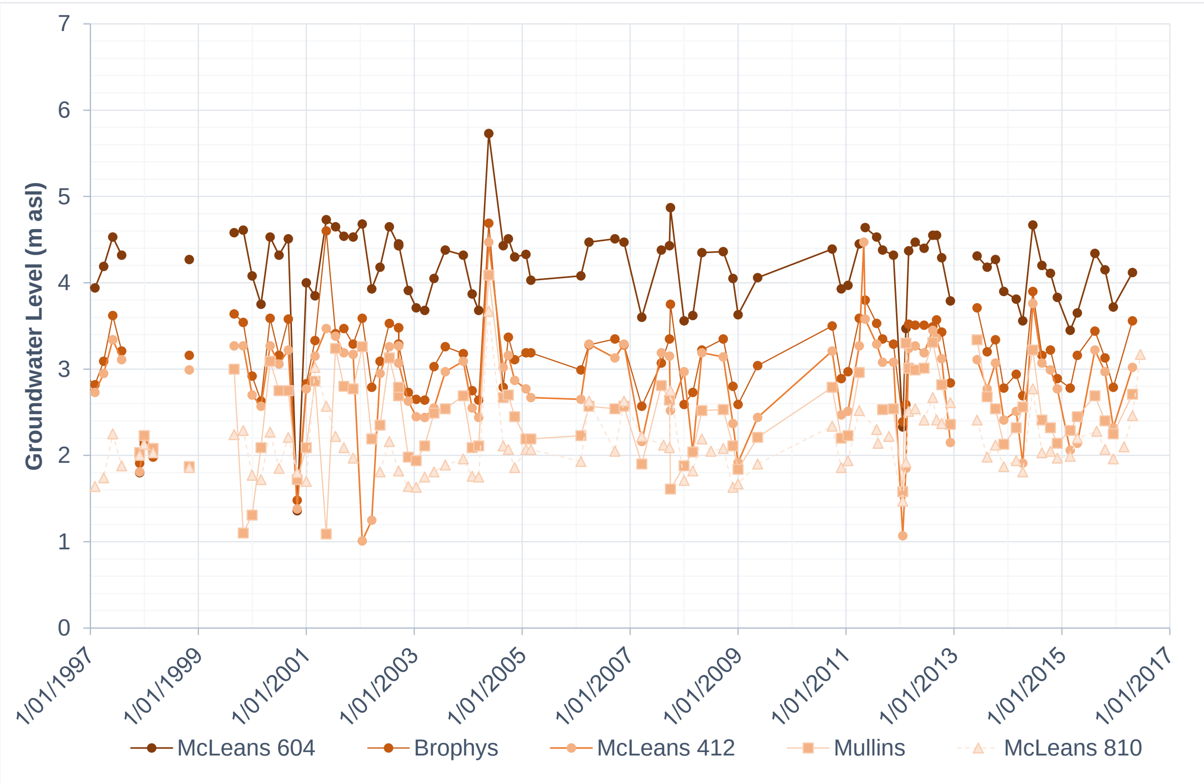


Figure 4: Groundwater levels recorded on western side of the Omeheu wastewater irrigation area.

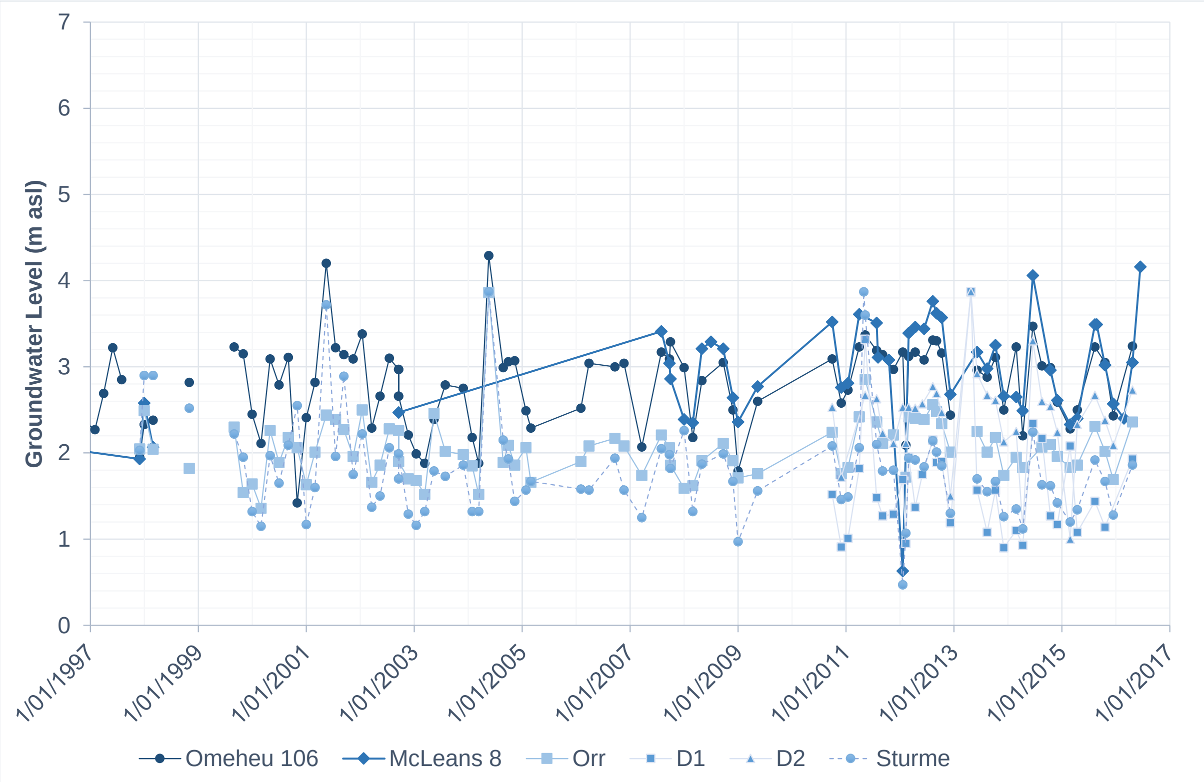


Figure 5: Groundwater levels recorded on eastern side of Omeheu wastewater irrigation area.

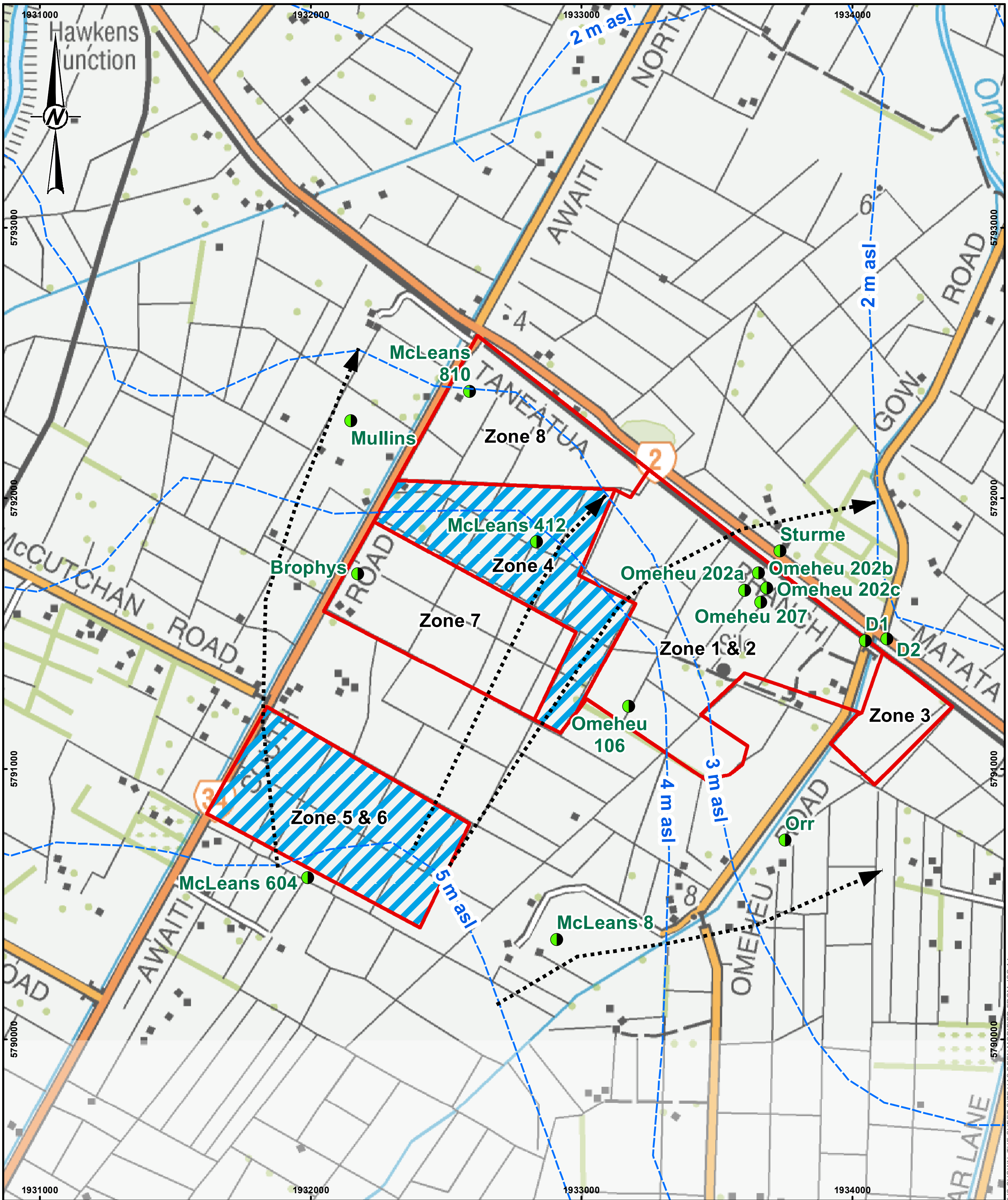
3.4 Surface Water and Groundwater Interaction

The plains area in the middle of the Lower Rangitāiki – Tarawera catchment consisted largely of wetlands before European settlement began in 1890 (BOPRC 2012). Agricultural development in the area required drainage of the land and a drainage scheme was established. The Rangitāiki Drainage Scheme is a network of channels and drains that allow groundwater and surface water to drain from the surrounding land. The area controlled by the drainage scheme is approximately 29,200 ha.

The drainage scheme drained initially largely under gravity, but after the Edgecumbe earthquake of 1987 large areas subsided and the drainage scheme could no longer drain those areas under gravity. Since that time, pumping schemes were established. The scheme is designed to maintain a water table at 600 mm below ground surface, sufficient for pasture growth.

The Rangitāiki Drainage Scheme captures most of the groundwater in the shallow aquifer system and therefore receives drainage water from the surrounding farmland. The shallow groundwater contours in 1989 (Pang 1994) as shown in Figure 3 bend towards the Rangitāiki River downstream of McCracken Rd and groundwater flows towards the river north from that point. The lower Rangitāiki River is therefore considered to be groundwater receiving. Some shallow groundwater from areas east of the Omeheu Canal will flow into the Rangitāiki River. Of the groundwater originating from within the envelope only areas generally to the east of Te Teko Road will potentially flow to the Rangitāiki River.

The Tarawera River forms the western boundary of the envelope area. The Tarawera River is considered to be a recharge source to the local aquifer (Pang 1994). GNS (2010) confirms the Tarawera River predominantly loses water to groundwater.



LEGEND

- Groundwater flow lines - Omeheu Wastewater irrigated areas
- Groundwater monitoring bores
- Groundwater contours in 1989
- Wastewater irrigated areas
- Previous in-ground irrigation

0 250 500 METRES

REFERENCE SCALE: 1:20,000 (at A4)

PROJECTION: NZGD 2000 New Zealand Transverse Mercator

NOTES

1. Map image: LINZ NZTopo Series, CC-BY-3.0-NZ.
2. Bore locations and monitoring sites are sourced from Fonterra map "Groundwater monitoing bore locations" dated 08 November 2016 drawn by M McKenzie Rev 1.
3. Schematic only, not to be interpreted as an engineering design or construction drawing.

CLIENT
FONTERRA

PROJECT
FONTERRA EDGECUMBE - WW IRRIGATION AREA EXPANSION

TITLE
GROUNDWATER AND SURFACE WATER MONITORING SITES NEAR OMEHEU WW IRRIGATION SITES

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-03-31
PREPARED	EVN/KC
REVIEWED	RK
APPROVED	PK

PROJECT NO.	REPORT	REV.	FIGURE
0978204316	001	0	06

3.5 Summary

All nutrient-enriched shallow groundwater that originates from farmland on the Rangitāiki Plains in the Lower Rangitāiki – Tarawera catchment will remain within the shallow aquifer system (up to 70 m deep). Most of this shallow groundwater will flow out into the drains and channels of the Rangitāiki Drainage Scheme. The shallow aquifer is considered to be naturally unsuitable for potable water supply because of high boron levels. No shallow groundwater within the envelope will be discharged to the lower Rangitāiki River even though the Rangitāiki River does receive local groundwater in its lower reaches below the envelope. The drainage system canals restrict the flow of shallow groundwater within the areas proposed to be irrigated.

The deeper aquifer system below 70 m will not receive any shallow groundwater as this aquifer is under substantial flowing artesian pressure (hydraulic head approximately 20 m above ground level) throughout the area and is replenished in the surrounding hills through rock fractures and faults. Bores screened in this deep aquifer are considered unaffected by existing and proposed MSW irrigation within the envelope.

4.0 GROUNDWATER QUALITY EFFECTS ASSESSMENT OF CURRENT IRRIGATION

4.1 Overview

The water quality effects of the current treated wastewater irrigation practices provide an indication of expected effects when the wastewater irrigation is expanded. The groundwater quality data from groundwater monitoring sites in the vicinity of the Omeheu treated wastewater irrigation sites (Figure 6) has been reviewed to assess current groundwater quality changes. This assessment has been utilised in Section 5.0 of this report to examine the potential effects of the proposed expansion of wastewater irrigation within the envelope.

4.2 Monitoring Sites and Summary Statistics

Water quality in groundwater and surface water bodies near the Omeheu wastewater irrigation area and the wastewater irrigation areas east of the Rangitāiki River, is monitored as part of the compliance monitoring required by consent 65800. Data collected by Fonterra between 1997 and 2017 has been used. The available groundwater quality monitoring sites are listed in Table 1 below. Note that different name conventions have been used in the past and the names shown in Table 1 are consistent with the groundwater monitoring report prepared by Golder (2014). A list of different name conventions is included in Appendix A. The location of the monitoring bores of the Omeheu wastewater irrigation sites are shown in Figure 6.

There have been various historical changes to MSW irrigation on the currently irrigated area as outlined in Section 2.0. These historical changes will have resulted in temporal variations in the local groundwater quality. In order to assess the effect of the relatively current application rates and areas only data collected since 2007 has been used in the analyses in this report. The summary statistics for the monitoring bores over the 2007 – 2017 period are summarised in Table 2. The listed parameters are considered the most relevant to assess the effects of the wastewater irrigation practices; electrical conductivity (EC), dissolved reactive phosphorous (DRP), total phosphorous (TP), nitrate-nitrogen (NO_3) and total nitrogen (TN).

Monitoring bores Omeheu 202a, 202b, 202c and 207 were installed to assess the groundwater quality effects associated with the high nitrate concentrations historically observed in bore 2 and an attempt to determine if this was associated with the wastewater irrigation or some other root cause. These monitoring bores have been excluded from further analysis as they are not considered to represent the effects of the wastewater irrigation practices, which is the purpose of this study.

Table 1: Fonterra Edgecumbe groundwater quality monitoring bores within the Omeheu wastewater irrigation area.

Bore Name	Easting (NZTM)	Northing (NZTM)	Ground level (m asl, Moturiki datum)	Total Bore Depth (m)
McLeans 604	1931989	5790599	5.73	4.90
Mullins	1932148	5792287	4.09	5.70
McLeans 412	1932833	5791839	4.47	3.50
McLeans 8	1932909	5790370	5.52	5.70
Sturme	1933733	5791805	3.87	5.70
D1	1934048	5791474	-	-
D2	1934128	5791481	-	-
Brophys	1932174	5791721	4.69	5.70
McLeans 810	1932587	5792396	3.67	5.70
Omeheu 106	1933174	5791232	4.29	5.70
Omeheu 202a	1933603	5791661	4.20	5.88
Omeheu 202b	1933653	5791725	4.20	5.80
Omeheu 202c	1933684	5791668	4.20	5.00
Omeheu 207	1933661	5791616	4.20	5.00
Orr	1933751	5790737	3.86	5.72

Table 2: Summary statistics Omeheu wastewater irrigation sites monitoring bores for 2007 – 2016 period.

Bore	Variable	Sample size	Minimum	Median	Mean	Maximum
McLeans 604	EC (mS/m)	44	17	29.1	32.01	73
McLeans 604	DRP (g/m^3)	29	0.002	0.1	0.32	3.1
McLeans 604	TP (g/m^3)	43	0.001	0.6	1.02	13.9
McLeans 604	NO_3 (g/m^3)	42	0.001	0.05	1.46	15
McLeans 604	TN (g/m^3)	43	0.05	5.9	6.72	26
Mullins	EC (mS/m)	43	7.5	24.9	25.60	48.4
Mullins	DRP (g/m^3)	28	0.01	0.03	0.09	1.4
Mullins	TP (g/m^3)	42	0.06	0.3	0.99	24
Mullins	NO_3 (g/m^3)	41	0.003	0.8	1.86	6.7
Mullins	TN (g/m^3)	42	0.052	1.9	3.57	19.2
McLeans 412	EC (mS/m)	45	9.43	29.2	29.27	47
McLeans 412	DRP (g/m^3)	30	0.002	0.02	0.04	0.4
McLeans 412	TP (g/m^3)	44	0.015	0.09	0.71	13.9
McLeans 412	NO_3 (g/m^3)	43	0.008	2.1	3.33	27
McLeans 412	TN (g/m^3)	44	0.82	3.45	4.82	30.1
McLeans 8	EC (mS/m)	47	10.1	19.3	23.85	66
McLeans 8	DRP (g/m^3)	33	0.012	0.04	0.05	0.4
McLeans 8	TP (g/m^3)	46	0.04	0.14	0.70	11.4
McLeans 8	NO_3 (g/m^3)	45	0.001	3.6	3.44	8.4
McLeans 8	TN (g/m^3)	46	0.007	4.7	4.68	10

Bore	Variable	Sample size	Minimum	Median	Mean	Maximum
Sturme	EC (mS/m)	86	10.5	30.7	35.37	88
	DRP (g/m^3)	58	0.008	0.05	0.06	0.4
	TP (g/m^3)	84	0.027	0.08	0.39	24
	NO_3 (g/m^3)	82	0.003	4.6	4.38	11.2
	TN (g/m^3)	85	0.48	5.2	6.04	80.6
D1	EC (mS/m)	32	0.72	9.7	11.55	46.9
	DRP (g/m^3)	30	0.002	0.005	0.06	0.4
	TP (g/m^3)	33	0.01	1.3	1.34	3.5
	NO_3 (g/m^3)	32	0.01	0.05	0.50	4.6
	TN (g/m^3)	33	0.011	0.4	1.28	8.8
D2	EC (mS/m)	32	5.5	9.95	11.23	36
	DRP (g/m^3)	28	0.002	0.04	0.07	0.9
	TP (g/m^3)	31	0.007	0.77	1.16	7.1
	NO_3 (g/m^3)	30	0.05	0.84	0.70	1.93
	TN (g/m^3)	31	0.05	1.36	2.98	51.3
Brophys	EC (mS/m)	45	29.5	52	56.39	111
	DRP (g/m^3)	31	0.012	1.4	1.26	4.3
	TP (g/m^3)	45	0.001	2.1	3.54	60
	NO_3 (g/m^3)	44	0.001	0.05	1.38	15.4
	TN (g/m^3)	45	1.4	4.7	7.60	82.2
McLeans 810	EC (mS/m)	46	22	82.45	76.64	129
	DRP (g/m^3)	30	0.002	0.07	0.31	1.68
	TP (g/m^3)	46	0.001	1.55	2.02	8.9
	NO_3 (g/m^3)	45	0	0.05	0.92	8.4
	TN (g/m^3)	46	0.96	6.65	9.15	78.2
Omeheu 106	EC (mS/m)	46	10	89.3	91.08	130
	DRP (g/m^3)	31	0.001	0.02	0.12	2.9
	TP (g/m^3)	45	0.032	0.18	1.07	35
	NO_3 (g/m^3)	44	0.001	0.08	0.44	4.6
	TN (g/m^3)	45	0.05	4	5.80	84.9
Orr	EC (mS/m)	85	9.3	39.7	41.54	78
	DRP (g/m^3)	57	0.004	0.05	0.16	2.8
	TP (g/m^3)	85	0.001	1.32	2.21	65
	NO_3 (g/m^3)	83	0.001	0.65	1.09	8.3
	TN (g/m^3)	85	0.16	6.1	7.25	67.1

Note: exceedance of New Zealand drinking water standard (2005 rev 2008) of 11.3 g/m^3 is indicated in red.

4.3 Water Quality Type Analysis

The assessment of water quality data from the Omeheu monitoring bores identified three significantly different water types. A notable difference in the monitored electrical conductivity (EC) values. As mentioned in Section 3.2, the groundwater in the shallow aquifer is of variable quality with different degrees of mineralisation. Electrical conductivity results may relate to the origin of the groundwater encountered in a monitoring bore. There are various reasons for the different water quality signatures seen in the shallow on-site monitoring bores. The water may be sourced from a more distant recharge area or have a component sourced from deeper groundwater sources that are upwelling in the area. In either case the bores with higher mineral content may not fully represent groundwater recharged through the local soil (i.e., with irrigated wastewater).

Box plots for EC recorded in Fonterra Edgecumbe monitoring bores are shown in Figure 7. This figure shows that monitoring bores Brophys, McLeans 810, Omeheu 106 and Orr receive a significantly different water type than the other bores of the Omeheu wastewater irrigation sites. Median EC of these four bores between 40 and 89 mS/m and is significantly higher than EC values of nearby bores with an EC range of 10 to 31 mS/m. However, median values of nitrate-nitrogen show the reverse, with the lowest values recorded in the four bores with high EC levels, and highest values in the bores potentially influenced by wastewater irrigation (i.e., local recharge source) (Figure 8).

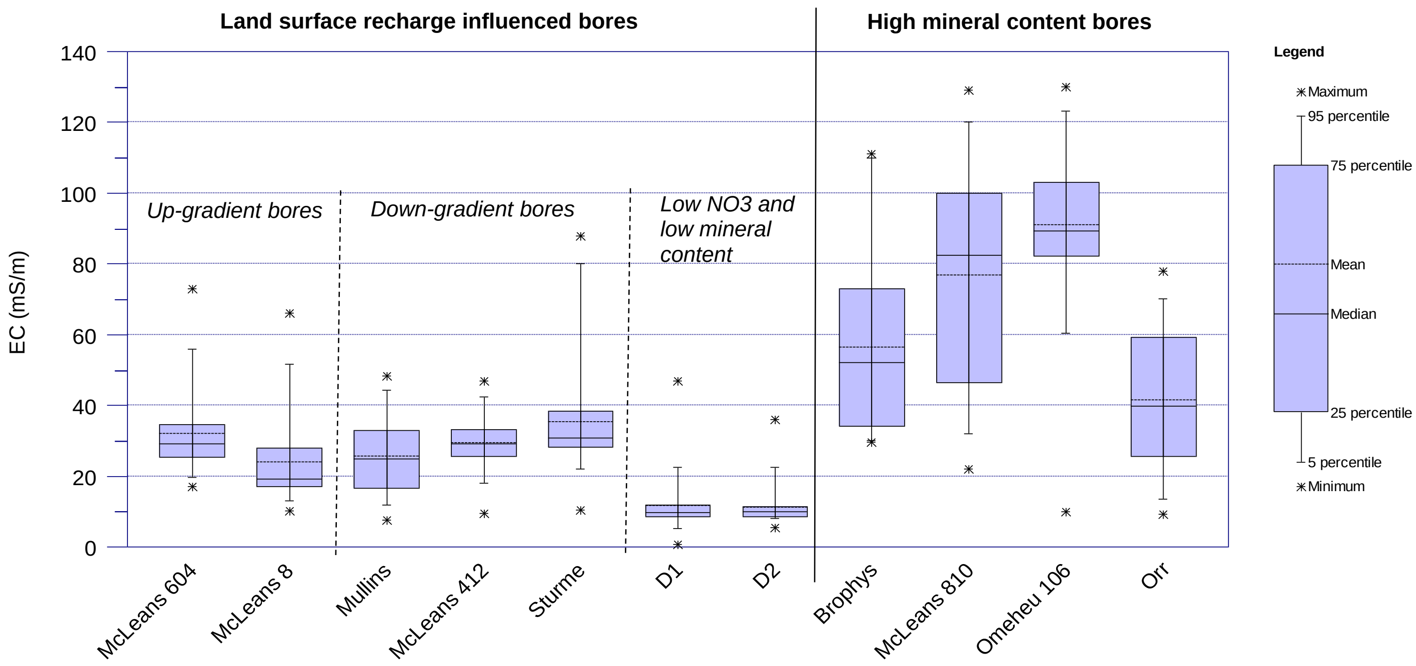


Figure 7: EC box plots for groundwater monitoring bores in Omeheu wastewater irrigation area (2007-2017).

The chemical composition of the different water types was examined using cluster analysis (refer to Appendix B). The analysis identified two different overarching water quality types and three sub-types:

1) High mineral content bores (Brophys, Omeheu 106, McLeans 810)
2) Land surface recharge influenced bores
   a. Western bores (McLeans 604, Mullins and McLeans 412)
   b. Eastern bores (McLeans 8 and Sturme)
   c. Low nitrate-nitrogen and low mineral content bores (D1 and D2)

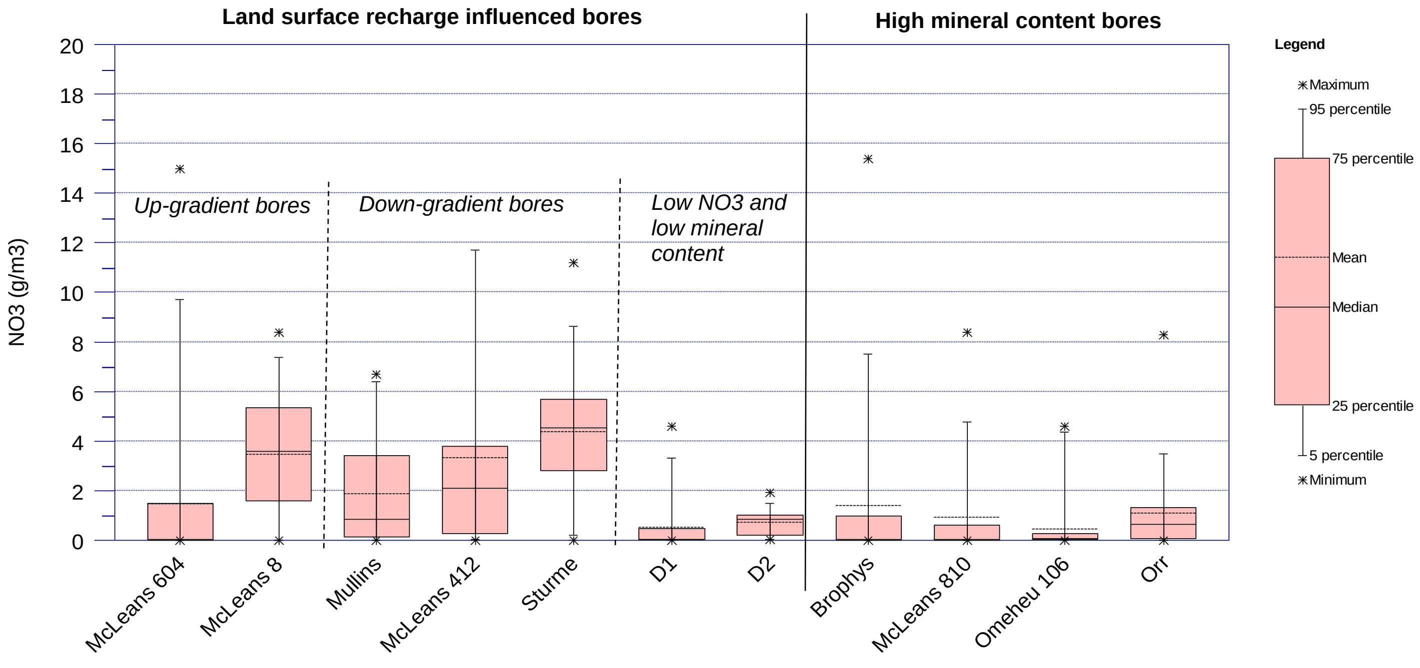


Figure 8: Nitrate-nitrogen box plots for groundwater monitoring bores in Omeheu wastewater irrigation area (2007-2017).

Monitoring bores D1 and D2 show both low EC and low nitrate-nitrogen concentrations and are considered to represent shallow groundwater that may be influenced by denitrification (Section 4.4.5). The Orr bore appears to be a mix of the two overarching water quality types listed above.

The local groundwater flow directions have been taken into consideration when assessing the appropriate up-gradient bores for each of the down-gradient bores. The bores have been divided into the western and eastern sides of the currently MSW irrigated areas as described in Section 3.4.

4.4 Water Quality Effects Assessment

4.4.1 Introduction

In this section, the observed groundwater composition of monitored bores associated with Fonterra's current irrigation of medium strength wastewater are assessed to describe the following:

- Change in nutrient levels from up-gradient to down-gradient of activities: this provides an indication of the individual effect of Fonterra Edgecumbe's wastewater irrigation to land practices.
- Long-term trends in nutrient levels: provides an indication of the long-term water quality effects of wastewater irrigation to land, if any.
- Abstractive uses affected by current nutrient levels: indicates the current state of nutrient levels in groundwater in relation to guidelines/standards for groundwater quality such as the New Zealand Drinking Water Standards (MoH 2008), and guidelines/standards for use of water for stock use ANZECC (2000).

As described earlier, wastewater irrigation will affect shallow groundwater beneath the Omeheu wastewater irrigation sites and all the monitoring bores are screened over the typical seasonal variability of groundwater level and at levels to intersect the shallow groundwater.

4.4.2 Up-gradient versus down-gradient

A change in water quality between groundwater and surface water monitoring sites up-gradient as compared with down-gradient of Fonterra's activities may indicate the influence of these activities and land management practices. Observed changes in water quality have been reviewed as described below for nitrate-N and DRP. The bores have been considered in terms of eastern and western bores as outlined in Section 3.3. It is noted that the Mullins site is irrigated with HSW and the flow direction is considered to be towards the north.

Nitrate-nitrogen

Observed changed in nitrate-N concentrations up-gradient and down-gradient from Fonterra's activities are as follows:

- Monitoring bore McLeans 604 is located up-gradient from the bores Mullins and McLeans 412. The median nitrate-nitrogen concentration is 0.05 g/m^3 in the up-gradient bore (McLeans 604) and increases to 0.8 g/m^3 (Mullins) and 2.1 g/m^3 (McLeans 412). The increase in nitrate-nitrogen concentration in the downstream direction is therefore considered to be up to 2 g/m^3.
- Monitoring bore McLeans 8 is located up-gradient from Sturme. The median nitrate-nitrogen concentration is 3.6 g/m^3 in the up-gradient bore (McLeans 8) and is higher in the Sturme bore (4.55 g/m^3). The increase in nitrate-nitrogen concentration is therefore up to 2 g/m^3.
- Monitoring bores D1 and D2 show a median nitrate-nitrogen concentration of 0.05 g/m^3 and 0.84 g/m^3 respectively. These suggest that the up-gradient monitoring bore McLeans 604 represents background nitrate-nitrogen levels.

DRP

Observed changed in DRP concentrations up-gradient and down-gradient from Fonterra's activities are as follows:

- Monitoring bore McLeans 604 is located up-gradient from monitoring bores Mullins and McLeans 412. The median DRP concentration is 0.124 g/m^3 in the up-gradient bore (McLeans 604) and decreases to 0.032 g/m^3 (Mullins) and 0.018 g/m^3 (McLeans 412). Therefore a decrease in DRP concentration occurs of some 0.1 g/m^3.
- Monitoring bore McLeans 8 is located up-gradient from monitoring bore Sturme. The median DRP concentration is 0.036 g/m^3 in the up-gradient bore (McLeans 8) and increases to 0.05 g/m^3 (Sturme). This would suggest an increase in DRP concentration is therefore some 0.01 g/m^3.
- Background monitoring bore D1 and D2 show a median DRP concentration of 0.005 g/m^3 and 0.041 g/m^3 respectively. These suggest that up-gradient monitoring bore McLeans 8 represents background DRP levels.

A clear increase of some 2 g/m^3 in nitrate-nitrogen levels is observed between up-gradient and down-gradient monitoring bores. The available data shows no clearly identifiable changes in DRP when up-gradient and down-gradient bore DRP is compared.

4.4.3 Trend analysis

Time Trend software (NIWA and Jowett Consulting 2015) provides a tool to undertake a Kruskal-Wallis seasonality test on the data set. Seasonal fluctuations are generally not obvious in the nitrate-nitrogen concentrations in groundwater and accounting for seasonal trends is not required. Therefore the Mann-Kendall statistical test has been used to assess the long-term groundwater quality trends. Note that a significance level of 5 % is used (i.e., P <0.05). The detailed results and graphs are included in Appendix C. Table 3 provides a summary of the results which are statistically significant (i.e., P <0.05).

The following trends are observed:

- EC levels are increasing in up-gradient bore McLeans 604, but decreasing in down-gradient bore Sturme and background monitoring bore D2. This is likely a reflection of the change in groundwater flow regime since 2007.
- A general increase in TN, TP and DRP concentrations are observed in the up-gradient monitoring bore McLeans 604. TN and nitrate-nitrogen levels are decreasing in the down-gradient bore McLeans 412, but TP and DRP levels are increasing. The increase in the down-gradient bore is less than observed in the up-gradient bore.
- The monitoring bore D1 shows in increase in TN and nitrate-nitrogen levels, but no trend observed in TP or DRP. In bore D2 TP levels are rising, but DRP, TN and nitrate-nitrogen levels are falling.

Table 3: Mann Kendall groundwater quality trend analysis for statistically significant results (2007-2017).

Site	Variable	Samples used	Sampling period	P	Median Sen slope (annual)	Percent annual change
McLeans 604*	EC (mS/m)	44	21/3/07-22/4/16	0.002	1.066	3.7
	TP (g/m^3)	43	21/3/07-22/4/16	0.017	0.062	10.5
	TN (g/m^3)	43	21/3/07-22/4/16	0.043	0.364	6.2
	DRP (g/m^3)	29	30/11/10-22/4/16	0.035	0.076	61.6
McLeans 412	TP (g/m^3)	44	21/3/07-22/4/16	0.002	0.018	20.5
	NO3 (g/m^3)	43	21/3/07-22/4/16	0.000	-0.778	-37.0
	TN (g/m^3)	44	21/3/07-22/4/16	0.000	-0.578	-16.8
	DRP (g/m^3)	30	30/11/10-22/4/16	0.000	0.006	33.8
Sturme	EC (mS/m)	86	21/3/07-22/4/16	0.000	-1.754	-5.7
D1	NO3 (g/m^3)	32	1/5/10-22/4/16	0.015	0.038	76.0
	TN (g/m^3)	33	1/5/10-22/4/16	0.043	0.187	44.6
D2*	EC (mS/m)	32	30/9/10-22/4/16	0.001	-0.724	-7.3
	TP (g/m^3)	31	30/9/10-22/4/16	0.009	0.251	32.7
	NO3 (g/m^3)	30	30/9/10-22/4/16	0.001	-0.187	-22.4
	TN (g/m^3)	31	30/9/10-22/4/16	0.000	-0.319	-23.5
	DRP (g/m^3)	28	30/11/10-22/4/16	0.025	-0.009	-22.6
Brophys*	TP (g/m^3)	45	21/3/07-22/4/16	0.001	0.283	13.5
Omeheu 106*	EC (mS/m)	46	21/3/07-22/4/16	0	-5.035	-5.6
	NO3 (g/m^3)	44	21/3/07-22/4/16	0.003	0.018	23.4
	TN (g/m^3)	45	21/3/07-22/4/16	0	-0.287	-7.2
Orr*	TP (g/m^3)	85	21/3/07-22/4/16	0.04	-0.084	-6.3
	DRP (g/m^3)	57	30/11/10-22/4/16	0	-0.026	-47.5

* **Note**: These bores are not considered to be influenced by local recharge at the site (i.e., not influenced by Fonterra wastewater application).

4.4.4 Abstractive uses

Drinking water

Summary statistics of the concentrations of EC and nutrients recorded in the monitoring sites are provided in Table 2. It is noted that the New Zealand Drinking Water Standards (2005) nitrate-nitrogen limit of 11.3 g N/m^3 is on occasion exceeded (when the maximum concentrations are compared) in several groundwater monitoring bores both up-gradient and down-gradient from the current wastewater irrigation site. However, most of the time there are no nitrate-nitrogen exceedances in the shallow groundwater influenced by the wastewater irrigation practices.

It is noted that the groundwater in the shallow aquifer is considered unsuitable for drinking water consumption in the absence of wastewater irrigation. The upward gradient, caused by the artesian pressure in the deeper aquifer, prevents any shallow groundwater influenced by the wastewater irrigation practices to flow towards the deeper aquifer. It can therefore be concluded that no potable water supply bores are affected by Fonterra Edgecumbe's wastewater irrigation practices.

Stock water

ANZECC (2000) provides information on water quality requirements to ensure water is suitable as stock water. The ANZECC guidelines provide a range of interim trigger values (both chronic and acute) to protect stock from poor water quality. Water quality better that the ANZECC (2000) trigger values provides an indication that the water quality poses little risk of adverse effects on stock health if consumed. The only relevant guidance is that for nitrate-nitrogen. The ANZECC (2000) trigger value of 339 gN/m^3 is well above that present in groundwater near the Omeheu wastewater irrigation area.

4.4.5 Denitrification potential

The low nitrate concentrations in some of the on-site monitoring bores (e.g., D1 and D2) could be interpreted as potentially being due to denitrification processes. Microbiological processes can reduce the nitrate-N levels in groundwater and surface water if sufficient organic matter is present. This process is referred to as denitrification. This process occurs under reduced (anaerobic) conditions (Stenger et al. 2015).

Insufficient data is available to confirm whether denitrification processes are significant in the shallow aquifer beneath the Rangitāiki Plains. However, significant peat layers (consisting of organic matter) are present and very low nitrate-nitrogen levels (less than 1 g/m^3) have been observed in the up-gradient bore McLeans 604 and in background monitoring bores D1 and D2. All three of these bores represent shallow groundwater originating from nearby paddocks. Considering that the farmland on the Rangitāiki Plains has significant number of dairy farms, a much higher nitrate-nitrogen level might be expected. Shallow groundwater influenced by dairy farming typically have levels above 2 g/m^3 or much higher in other dairy catchment in New Zealand (catchment near Fonterra Kapuni in Taranaki has nitrate-nitrogen levels of approximately 8 to 10 g/m^3 and typical nitrate-nitrogen levels in the catchment near Fonterra Pahiatua has nitrate-nitrogen levels of approximately 2 to 4 g/m^3). The low nitrate-nitrogen levels in the up-gradient bore McLeans 604 and in background monitoring bores D1 and D2 indicate the potential occurrence of denitrification.

4.5 Summary

Fonterra's wastewater irrigation practice is considered to cause a small increase of up to 2 g/m^3 in the nitrate-nitrogen concentration down-gradient of the irrigated sites. This follows approximately 30 years of irrigation at the site.

It is considered likely that localised denitrification is actively reducing nitrate-nitrogen levels in some areas down-gradient from the wastewater irrigation paddocks. In general, there is no indication that Fonterra's current wastewater irrigation activities cause an on-going increase in nutrient concentrations in groundwater over time.

Whilst drinking water guidelines for nitrate-nitrogen are exceeded on occasion in some of the monitoring bores, it is noted that the shallow aquifer is considered by BOPRC to be not suitable for drinking water consumption.

The water quality of the deeper consumptive aquifer is not influenced by Fonterra's irrigation practices.

5.0 GROUNDWATER EFFECTS OF PROPOSED IRRIGATION EXPANSION

5.1 Controls on Groundwater Effects

The effects of the proposed expansion of wastewater irrigation on groundwater quality will be controlled by the on-site irrigation management. The projected effects are expected to be similar to those observed under the current wastewater irrigation sites.

Wastewater irrigation practices have improved since wastewater irrigation began at the current site in 1985. The effects of wastewater irrigation on groundwater are highly controlled by irrigation management and as management practices improve through time the effects on groundwater will lessen. The effects on groundwater quality can be minimised by controlling the wastewater application rates and concentrations appropriate to the soil conditions. Monitoring bores established on each new site will provide the ability to assess the local effects.

5.2 Variations in Hydrogeology

When proposed wastewater irrigation moves into southern areas of the envelope there are slightly different hydrogeological conditions (Section 3.3). Water-table levels in the southern areas of the envelope are deeper and the hydraulic gradient is expected to be downwards to deeper layers within the shallow aquifer. These areas are considered to be recharge sites for the shallow aquifer (to an estimated depth of 70 m). Water recharged in this southern area may move through the aquifer and discharge eventually to the sea. In the northern areas the shallow groundwater is considered to discharge relatively quickly to local drainage networks. This difference in hydrogeology will be taken into consideration in design of the monitoring bores for any new irrigation areas through the Property Irrigation Plan.

5.3 Drinking Water Supply Bores

In order to check that nearby bores are not being used for drinking water purposes a bore survey is recommended as part of the preparation of the Property Irrigation Plan. The survey should include BOPRC registered bores within 1 km down-gradient of the proposed irrigation area. The results of the survey will be assessed by a suitably qualified hydrogeologist to determine potential effects on drinking water supply. In addition boron concentrations will be tested in one of the on-site monitoring bores prior to irrigation starting to identify suitability of the local shallow aquifer for drinking water supply.

5.4 Monitoring

In accordance with condition 9.3 of consent 65800 Fonterra will submit for BOPRC approval a recommendation of proposed additional groundwater monitoring bores to enable characterisation of groundwater up and down-gradient of the proposed irrigation properties. Bores are recommended to be a similar depth to the existing bores at the Omeheu site (5 to 6 m deep or at least 2 m below the water table) and to be established prior to irrigation starting at the site.

The development of appropriate groundwater monitoring sites will be needed to ensure that irrigation management is appropriate at each property. As outlined in this report the “water type” source to each monitoring bore controls how representative it is for assessing the local effects of wastewater irrigation.

Monitoring shall be undertaken in accordance with conditions 9.5 and 9.6 of consent 65800 and for those parameters identified in Schedule 5, and an evaluation of the monitored data undertaken every two years. In addition the following is also recommended:

- To identify the water type in each new monitoring bore groundwater sample testing should be carried out on a full suite of major cations and anions (Ca, Mg, K, Na, Mn, Fe, SO_4, Cl, CO_3, HCO_3), nutrients (NO_3, NO_2, NH_4, TN and DRP), full suite of field parameters (temperature, DO, redox potential, pH, EC, TDS), total organic carbon (TOC) and boron (B) prior to irrigation and again every five years.
- Routine monitoring in between the five yearly testing should include a subset of the nutrients (i.e., NO_3, NO_2, NH_4, and DRP) and a subset of the field parameters (temperature, EC, DO and pH). It is recommended that total suspended solids (TSS) and ammoniacal-nitrogen be added to the routine monitoring parameter set.

5.5 Changes in Irrigation and Loadings

5.5.1 Current irrigation areas

The effects of irrigation have been assessed using the AgResearch Overseer Model (Version 6.2.3) by Fonterra. Modelling was carried out for the Omeheu site: a nitrogen loading of 530 kgN/ha/yr, to reflect the wastewater nitrogen loading that has occurred over the last five years, and a loading of 400 kgN/ha/yr to reflect the long term nitrogen loading sought in this consent application.

The modelling was undertaken assuming a highly developed ryegrass-clover pasture with low clover activity. Because the Overseer model treats dairy processing wastewater as whey the fertiliser inputs were split 50:50 between the whey and urea components in the model (Table 4).

Table 4: Overseer nitrogen leaching results for current and future irrigation scenarios at a currently irrigated farm.

	Current	Proposed	Change
Wastewater (kg N/ha/y)	530	400	-25 %
Leached (kg N/ha/y)	93	67	-28 %

The modelling shows that currently 18 % of the applied nitrogen in the MSW is lost to shallow groundwater. Under the 400 kg N/ha/yr loading rate (the consent limit), the loss is 17 %. This assessment does not account for nitrogen removed through farm cut and carry.

Overall, the increase in irrigation footprint will result in:

- A 25 % reduction in the nitrogen load irrigated on each hectare of pasture within the envelope
- A 28 % decrease in the amount of nitrogen leaching to shallow groundwater.

The consequence of the increased irrigation area on the current irrigation area should be a relative reduction in the nitrate-nitrogen reaching shallow groundwater. The reduced leaching (28 %) should be reflected long term in a reduction in the concentration of total nitrogen seen in shallow groundwater. Based on the relative change in load, theoretically an in-ground change in concentration of 2 g/m^3 TN would on average be expected to decline to 1.4 g/m^3.

Significant reductions in the load of total phosphorus will occur with the reduction of phosphorus in site cleaning chemicals. This reduction should assist in reducing overall down-gradient groundwater concentrations. Given that current long term average difference in phosphorus (between up-gradient and down-gradient sites) are not significant it is not expected that a decrease in groundwater phosphorus concentration will be measureable.

5.5.2 New irrigation areas

The change in groundwater nitrate-nitrogen concentrations under new irrigation areas will be controlled by current land practices compared with proposed MSW irrigation applications. To calculate the expected nitrogen changes in the envelope six example farms have been modelled by Fonterra using Overseer. The example farms cover a variety of farming and soil conditions within the envelope. The resulting Overseer nitrogen leaching results and projected drainage volumes have been used to calculate the expected change in nitrogen concentration in shallow groundwater underlying the properties. A simple mass mixing model has been used based on calculated through flows under the farms. The following parameters have been used in the assessment of groundwater through-flow:

- A groundwater mixing depth of 4 m below the water table.
- Relevant hydraulic gradients under each farm based on Pang (1994) (Figure 3), ranging from 0.0016 m/m to 0.0005 m/m.
- A hydraulic conductivity range from 27 m/day to 59 m/day.

The projected increase in nitrogen leaching for each farm was calculated from the Overseer results by using the difference between the leaching under current farming system and under a MSW application rate of 400 kg N/ha. The projected increase in leaching rates varied from 8 kg N/ha/y to 34 kg N/ha/y. The projected drainage volume for each farm was calculated using the Overseer calculated drainage depth (mm/year). The drainage depths ranged between 760 mm/y and 1,100 mm/y.

The resulting projected increases in groundwater nitrogen concentrations under the example farms was between 0.4 g/m^3 and 2.7 g/m^3. The median increase for the six example farms was 1.3 g/m^3. These results are within a similar range to the observed change in nitrate-nitrogen concentration under the current irrigation areas (2 g/m^3) and expected concentrations under proposed lower nitrogen loading (1.4 g/m^3) as detailed in Section 5.5.1.

5.6 Summary

The effects of the proposed expansion of wastewater irrigation on groundwater quality will be controlled by the on-site irrigation management, and can be minimised by controlling the wastewater application rates and concentrations appropriate to the soil conditions. Monitoring bores established on each new site will provide the ability to assess any local effects and should there be any environmental concerns the conditions of consent can be reviewed in accordance with consent condition 16.1. The following matters will need to be considered when developing the groundwater monitoring programme for new wastewater irrigation areas within the envelope:

- The southern areas of the envelope have slightly different hydrogeological conditions and this must be taken into consideration in design of the monitoring bores for any new irrigation areas through the preparation of the Property Irrigation Plan.
- A bore survey 1 km down-gradient is recommended as part of the Property Irrigation Plan, to assess whether nearby bores are being used for drinking water purposes.

In current irrigation areas the proposed long term reductions in nitrogen loading by 25 % to 400 kgN/ha/yr or less should be reflected in lower average in-ground concentrations of total nitrogen downstream. In new areas of irrigation the projected increases in nitrogen leaching will depend on current land practices. However, in general it is expected that similar or lower groundwater nitrate-nitrogen concentration changes will be observed compared to those seen at the current MSW irrigation site.

6.0 SUBMISSIONS

Few of the submissions received in relation to the resource consent application contained specific reference to groundwater quality. One submission made specific reference to ensuring that there was “additional groundwater monitoring and bores”. Monitoring associated with the expanded irrigation land area includes additional monitoring as follows:

- Section 7 below, presents the recommended resource consent conditions that relate to groundwater monitoring.
- It is intended that additional groundwater monitoring bores will be installed upstream and downstream of new irrigation areas.
- The existing monitoring programme has had some changes made to add additional water quality parameters and to add additional monitoring and that is included in the Schedule 6 information presented below.

7.0 CONDITIONS

Set out below are proposed resource consent conditions relating to groundwater monitoring (Additions to the existing schedule are shown in blue and underlined, while any deletions are shown in strikethrough)

9 Groundwater Monitoring

9.1 The consent holder shall construct any new groundwater monitoring bores as per New Zealand Standards for drilling of soil and rock (NZS 4411:2001) and maintain the groundwater monitoring bores (identified in Schedule 3 of this consent) to the satisfaction of the Chief Executive of the Bay of Plenty Regional Council or delegate.

9.2 The consent holder shall notify the Chief Executive of the Bay of Plenty Regional Council or delegate within one week of detection of an issue (such as damage) that makes a monitoring bore unusable for monitoring purposes. Any bores that cannot be used for monitoring purposes (for example due to damage) shall be repaired or replaced within three months (unless otherwise agreed to in writing by the Chief Executive of the Bay of Plenty Regional Council or delegate).

9.3 Prior to commissioning the additional medium strength wastewater irrigation areas proposed in the application (which are marked with an asterisk in Schedule 1, Table 2 to this consent, and as proposed under the “Property Irrigation Plan”, Condition 3.2A), the consent holder shall submit proposed locations of additional groundwater monitoring bores and any changes required to the location of current monitoring bores to enable characterisation of groundwater quality up and down gradient of the additional and existing irrigation areas. Where two properties are adjacent bore locations may be proposed to provide groundwater information for the combined area. The additional irrigation areas shall not be commissioned until the Chief Executive of the Bay of Plenty

Regional Council or delegate has approved the location of the additional monitoring bores. (See Advice Notes 1, 7 and 8).

9.3 The consent holder shall investigate possible locations for installing one groundwater monitoring bore between the areas of irrigation to the east of the Rangitāiki River and the Rangitāiki River for the purpose of intercepting any groundwater flow from the irrigation areas to the river. The consent holder shall supply a report on this investigation and a recommendation as to the preferred location of the groundwater monitoring bore to the Chief Executive of the Bay of Plenty Regional Council or delegate for approval of the proposed bore location within 6 months of the granting of this consent. If approval is granted the consent holder shall, within 6 months of approval being given, install the bore at the approved location. If installed this groundwater monitoring bore shall be added to the groundwater monitoring wells listed in Schedule 3.

9.4 The groundwater monitoring bores specified in conditions 9.1, 9.3 and 9.4 shall be levelled to Moturiki Datum.

9.5 The consent holder shall undertake groundwater monitoring in accordance with the monitoring programme attached as Schedule 5 to this consent, in order to characterise the nature of any effects on groundwater resulting from the irrigation operations authorised by this consent.

9.6 The consent holder shall engage a suitably qualified and experienced person to compare the groundwater quality data collected to background groundwater quality, current drinking water standards and historic groundwater data at least once every two years. The consent holder shall submit a report to the Chief Executive of the Bay of Plenty Regional Council or delegate that includes, but is not limited to:

a) A description of groundwater quality trends;

b) Any exceedances of the drinking water standards and an explanation for those exceedances; and

c) What (if any) action is required to avoid, remedy or mitigate adverse effects on groundwater quality resulting from the irrigation activities, or to refine the monitoring programme to ensure that potential effects are identified.

Schedule 5 of the current resource consent sets out the required groundwater monitoring requirements. The Schedule has been updated to include (additions to the existing schedule are shown in blue and underlined, while any deletions are shown in strikethrough).

1 The water level, corrected to the Moturiki datum, in the groundwater monitoring bores shall be measured and recorded at least once in February, April, June, August, October and December of each year.

2 A representative sample of water from each of the groundwater monitoring bores shall be collected at least once in February, April, June, August, October and December of each year and analysed for the following constituents:

Parameter	Units
Total suspended solids	mg/L
Conductivity	mS/m
Total nitrogen	mg/L
Nitrate-nitrogen	mg/L
Nitrite-nitrogen	mg/L

Ammoniacal-nitrogen	mg/L
~~Total phosphorus~~	~~mg/L~~
Dissolved reactive phosphorus	mg/L
Sodium	mg/L
Potassium	mg/L
Calcium	mg/L
~~Total BOD_5~~	~~mg/L~~
pH	unitless

3 The representative sample of water from each of the groundwater monitoring bores in February every five years shall also be analysed for the following additional parameters:

Parameter	**Units**
Dissolved calcium	mg/L
Dissolved magnesium	mg/L
Dissolved potassium	mg/L
Dissolved iron	mg/L
Dissolved sulfate	mg/L
Dissolved chloride	mg/L
Carbonate and bicarbonate	mg/L

4 The consent holder shall undertake the monitoring required by condition 2 of this Schedule, within 24 hours of the soil moisture measuring equipment required to be installed by condition 11.2 of this consent indicating field capacity has been exceeded. This monitoring shall be undertaken up to 3 times per year, and if possible 2 of these monitoring events being undertaken in the winter and spring periods. The consent holder shall by 30 November notify the Bay of Plenty Regional Council if soil moisture conditions in the winter and spring periods have not exceeded the soil field capacity.

5 Sample collection, storage, analyses and reporting of results shall be carried out in accordance with sections 1 and 10 of the Australian/New Zealand Standard AS/NZS 5667:1998 Water Quality – Sampling (unless otherwise agreed to in writing by the Chief Executive of the Bay of Plenty Regional Council or delegate).

8.0 CONCLUSIONS AND SUMMARY

Groundwater flow direction and hydrogeology

All nutrient-enriched shallow groundwater that originates from farmland on the Rangitāiki Plains in the Lower Rangitāiki – Tarawera catchment will remain within the shallow aquifer system (up to 70 m deep). Most of this shallow groundwater will flow out into the drains and channels of the Rangitāiki Drainage Scheme. The shallow aquifer is considered to be naturally unsuitable for potable water supply because of high boron levels.

The deeper aquifer system below 70 m will not receive any shallow groundwater as this aquifer is under substantial flowing artesian pressure (hydraulic head approximately 20 m above ground level) throughout the area and is replenished in the surrounding hills through rock fractures and faults. Bores screened in this deep aquifer are considered unaffected by existing and proposed dairy factory wastewater irrigation within the envelope.

Effects of current irrigation

Fonterra's wastewater irrigation practice is considered to cause a small increase of up to 2 g/m^3 in the shallow groundwater nitrate-nitrogen concentration. No clear indication of changes in DRP concentration were observed down-gradient of the irrigated sites. This follows approximately 30 years of irrigation at the site. Localised denitrification will reduce nitrate-nitrogen levels in some areas down-gradient from the wastewater irrigation paddocks. In general, there is no indication that Fonterra's current wastewater irrigation activities cause an on-going increase in nutrient concentrations over time.

Suitability for drinking water

Whilst drinking water guidelines for nitrate-nitrogen are exceeded on occasion in some of the monitoring bores, it is noted that the shallow aquifer is considered by BOPRC to be not suitable for drinking water consumption and the water quality of the deeper consumptive aquifer is not influenced by Fonterra's irrigation practices.

Suitability for other uses

Shallow groundwater downstream of areas where medium strength irrigation has occurred is considered suitable for other uses (e.g., stockwater).

Effects of irrigation expansion

The effects of the proposed expansion of wastewater irrigation will be controlled by the irrigation management practices. In the currently irrigated areas, reductions in nitrogen loads applied are proposed. Nitrogen loadings will be reduced (to 400 kgN/ha/yr or less) from 1 July 2018. The expected reduction equates to a 25 % lower loading rate. This reduction should overtime be reflected in lower average downstream concentrations of nitrogen in shallow groundwater. As such, the improvements may potentially see nitrate-nitrogen concentrations reducing from the current up-gradient to down-gradient difference of up to 2 g/m^3 to 1.4 g/m^3.

The effects of MSW irrigation on new properties on groundwater nitrate-nitrogen concentrations will depend on the current farming practices and soil conditions. Modelling of the projected changes in groundwater nitrate-nitrogen concentrations under six example farms gave a range of results similar to the observed effects under current irrigation areas (0.42 g/m^3 to 2.65 g/m^3 with a median of 1.34 g/m^3).

Significant reductions in the load of total phosphorus will occur with the reduction of phosphorus in site cleaning chemicals. This reduction should assist in reducing overall down-gradient concentrations. Given that current long term average difference in phosphorus are not significant it is not expected that a decrease in groundwater phosphorus concentration will be measureable.

Monitoring

Appropriate groundwater monitoring bores will be established to confirm the assessment conclusions at each of the proposed new irrigation areas.

It has been recommended that every five years an expanded water quality constituent set is examined during the February summer sampling round. For on-going monitoring, it is recommended the current parameter list delete monitoring for total phosphorus and total BOD_5 but with the addition of nitrite-nitrogen, ammoniacal nitrogen and total suspended solids.

Overview

Irrigation of MSW is permitted under Consent 65800. Monitoring of shallow groundwater quality has been carried for about ten years at a number of sites as required by the consent. The sites include locations upstream and downstream of areas of irrigation. The monitoring has shown that on average the irrigation results in an increase in the down-gradient nitrate-nitrogen concentration of up to 2 g/m^3. It is proposed that the area of MSW irrigation be increased but while doing that, the load of nitrogen applied per hectare is to be reduced. Using land treatment as the preferred method of treatment of the MSW, results in the uptake of nutrients and mineral elements from the wastewater as it passes through the pasture and soil. Based on Overseer modelling, the proposed benefit from the land treatment is a nett balance of 82 % removed / 17 % leaching of total nitrogen to shallow groundwater.

Irrigation of new properties within the proposed envelope is expected to result in similar increases in groundwater nitrate-nitrogen concentration as observed in monitoring at the current irrigation site (approximately 2 g/m^3). The degree of change in concentration will depend on current farming practices and soil conditions.

Whilst drinking water guidelines for nitrate-nitrogen are exceeded on occasion in some of the monitoring bores (at times), it is noted that the shallow aquifer is considered by BOPRC to be not suitable for drinking water consumption.

The water quality of the deeper consumptive aquifer is not influenced by Fonterra’s irrigation practices.

9.0 REFERENCES

ANZECC 2000. Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council.

BOPRC 2004. Regional Plan for the Tarawera River Catchment, Chapter 16 - Groundwater Quality and Quantity. Bay of Plenty Regional Council Environmental Publication 2003/24, ISSN: 1175-9372.

BOPRC 2012. 2 011/2012 Rivers and Drainage Schemes Asset Management Plan – June 2012. Bay of Plenty Regional Council.

BOPRC 2015. Memorandum from Paul Sholes (Environmental Scientist) to Jessica Hunter-Smith (Pollution Prevention Officer): Technical review – Fonterra – Discharge treated dairy manufacturing wastewater to land, 20 July 2015. Bay of Plenty Regional Council file rev. 1370 65800.

GNS 2010. Groundwater Resource Investigations of the Rangitāiki Plains Stage 1 – conceptual geological model, groundwater budget and preliminary groundwater allocation assessment, GNS science consultancy report 2010/113, project number 631W0603.

MoH 2008. Drinking Water Standards for New Zealand 2005 (Revised 2008). Wellington: Ministry of Health.

Pang L 1994. Groundwater Resources of the Lower Tarawera Catchment. Bay of Plenty Regional Council Environmental Report 94/3, 11 July 1994.

Stenger R, Clague J, Woodward S, Morgenstern U, Clough T 2015. Multi-pronged approach to elucidate nitrate attenuation in shallow groundwater.

APPENDIX A

Groundwater Monitoring Bore Name Conventions

Golder Name[1]	Fonterra (2017)[2]	BOPRC (2017)[3]	Fonterra (2012)[4]	Fonterra (2009)[5]	Fonterra (2004)[6]	BOPRC (2009)[7]
McLeans 810	Bore 1	Bore No 1	McLean 810	Bore 1	1	Bore 1
Omeheu 202a	Bore 2A	Bore No 2	Omeheu 202 (not further specified)	Bore 2	2	Bore 2A
Omeheu 202b	Bore 2B	-	Omeheu 202 (not further specified)	2B	2b	Bore 2B
Omeheu 202c	Bore 2C	-	Omeheu 202 (not further specified)	2C	2c	Bore 2C
Omeheu 207	Bore 2D	-	Omeheu 207	2D	2d	Bore 2D
McLeans 412	Bore 3	Bore No 3	McLean 412	Bore 3	3	Bore 3
Brophys	Bore 4	Bore No 4	Brophy's Cowshed	Bore 4	4	Bore 4
Omeheu 106	Bore 5	Bore No 5	Omeheu 106	Bore 5	5	Bore 5
McLeans 604	Bore 6	Bore No 6	McLean 604	Bore 6	6	Bore 6
Sturm	Bore 7	Sturme 21747	Sturm-Cowshed	Bore 21747	Sturme	Sturme 21747
Mullins	Bore 8	Mullins 21800	Mullins/Shake Cowshed	Bore 21800	Mullins	Mullins 21800
McLeans 8	Bore 9	McLean 8	-	Bore 21852	McLean	-
Orr	Bore 10	Orr	Orr-Cowshed	Bore 21854	Orr	Orr 21854
Hydro Rd	Bore 11	Ngati Awa - Hydro Rd	-	-	Skilling	Ngati Awa (Skillings)
Awaroa	Bore 12	Awaroa - Cowshed	-	-	Awaroa	Awaroa
D2	Bore 13	D2 - Smits	Bore D1	-	-	Bore D2
D1	Bore 14	D1- Omeheu	Bore D2	-	-	Bore D1
Reeves	Bore 15	Reeves	-	-	-	-

1. Groundwater report from Golder (2014)
2. Water quality spreadsheet from BOPRC for 1997-2016 (Rangitaiki Fonterra bore data.xlsx)
3. Survey map provided by Fonterra in 2017
4. Water quality data spreadsheet from Fonterra for 2012 (F12 Wastewater discharge to land by Irrigation 65800.xlsx)
5. Fonterra 2009, Groundwater Composition - Omeheu Irrigation Area, J.M. Russell, Report No. 2009-j01
6. Water levels spreadsheets from Fonterra for 2004 (MOTURIKIlevel.xls)
7. BOPRC 2009, Resource Consent 68500

APPENDIX B

Groundwater Quality Cluster Analysis

Euclidean distance and nonmetric multidimensional scaling (NMDS) was used to construct a map of similarity between sampling sites. These statistical analyses use relationships between the water quality parameters between the different sampling locations. This method allows for the identification and classification of different water types. The method systematically groups and ranks water samples based on similarities between the water quality parameters of each site. The results are shown in the cluster tree (Euclidean distance) shown below, which illustrates the degree of separation between sampling sites. This gives a visual representation of the similarity between sampling sites.

The analysis identified two different overarching water quality types and three sub-types:

1) High mineral content bores (Brophys, Omeheu 106, McLeans 810)

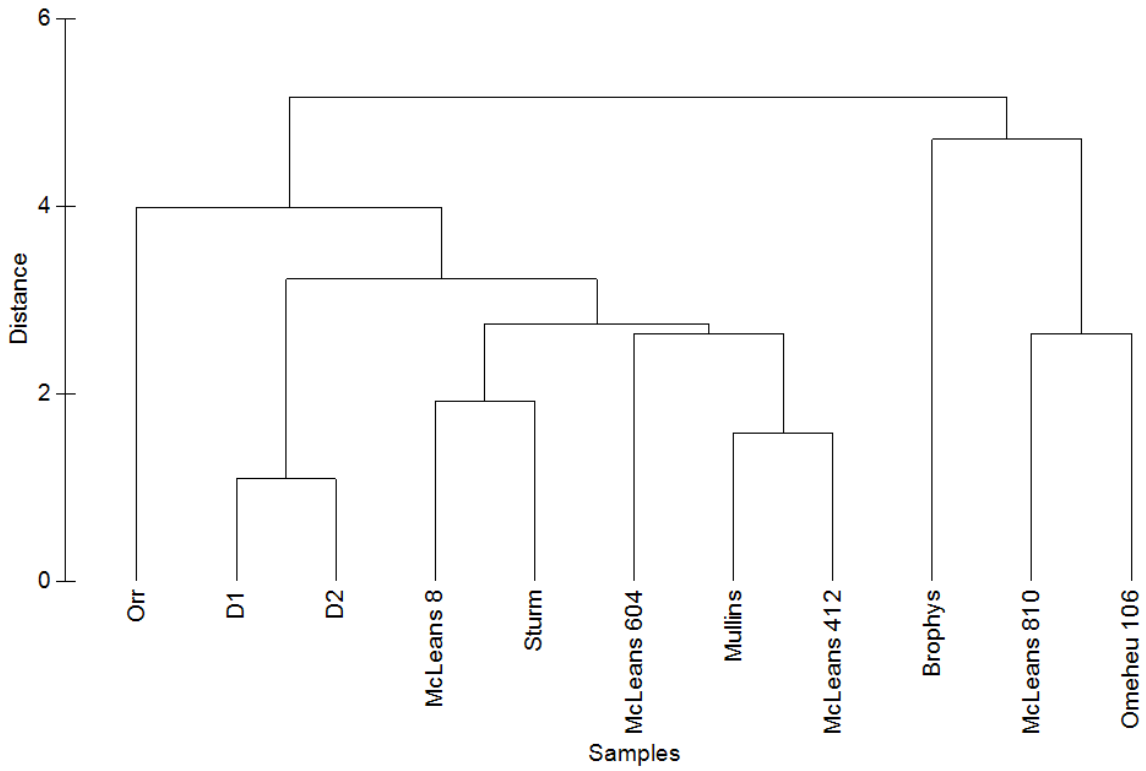
2) Land surface recharge influenced bores

   a. Western bores (McLeans 604, Mullins and McLeans 412)

   b. Eastern bores (McLeans8 and Sturme)

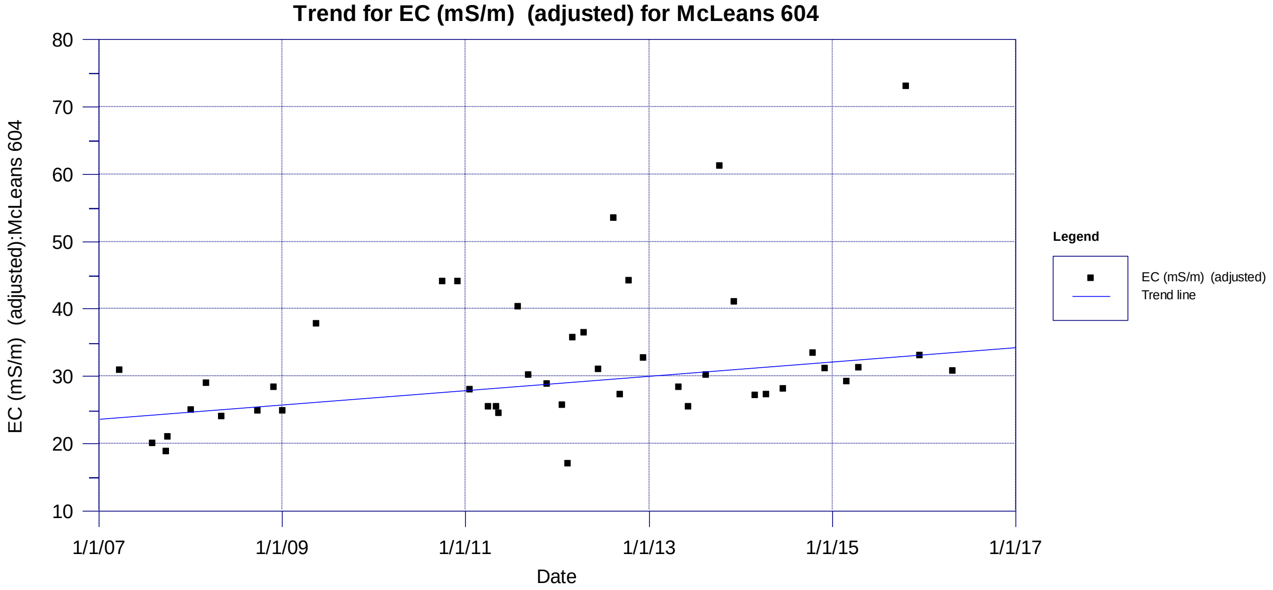
   c. Low nitrate-nitrogen and low mineral content bores (D1 and D2)

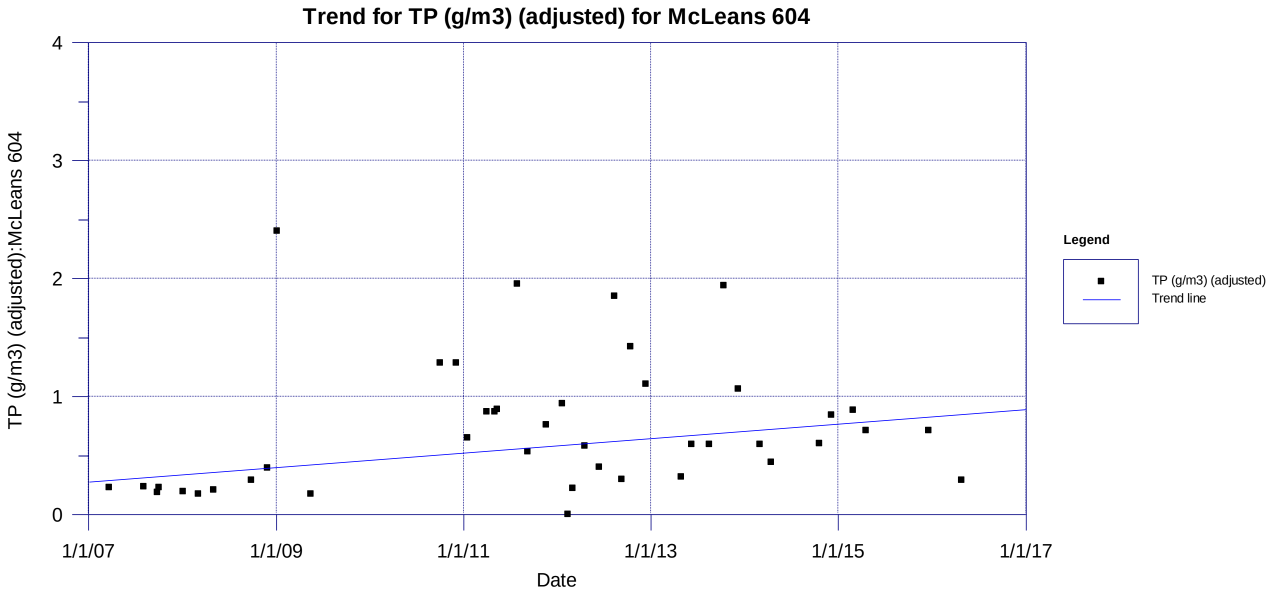
The Orr bore appears to be a mix of different water quality types.

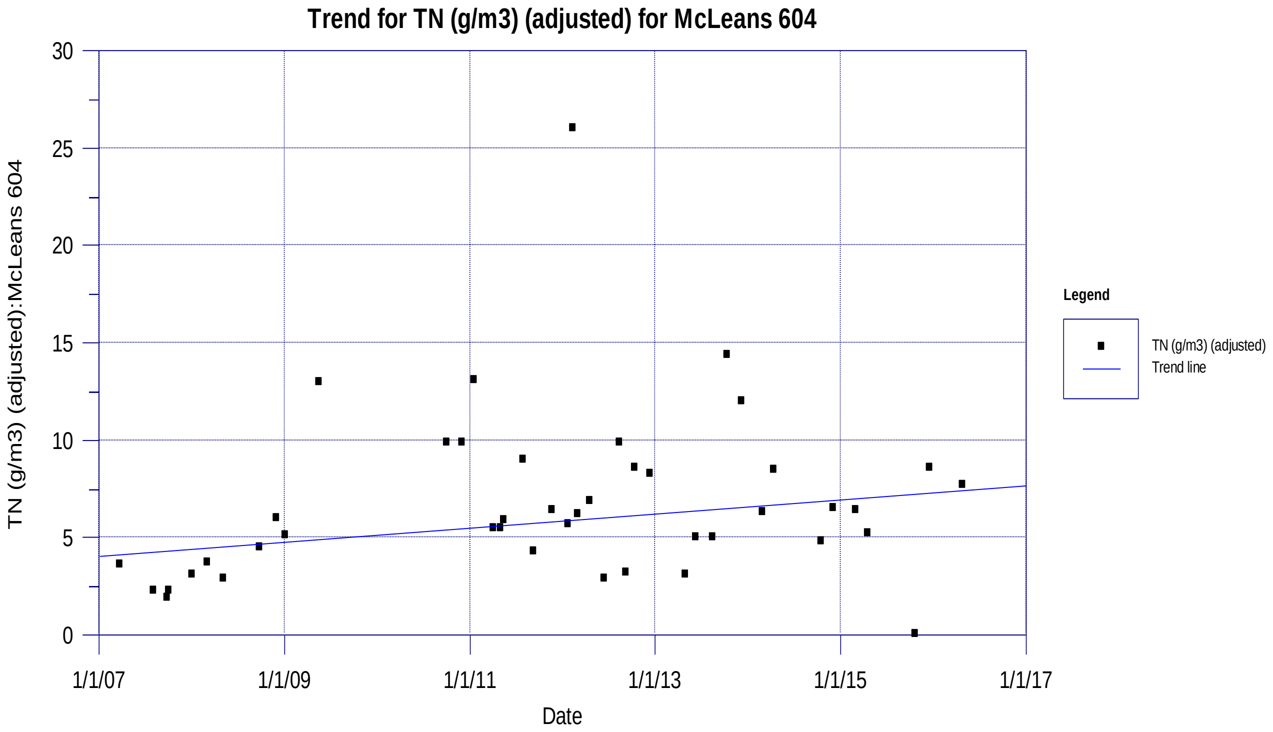


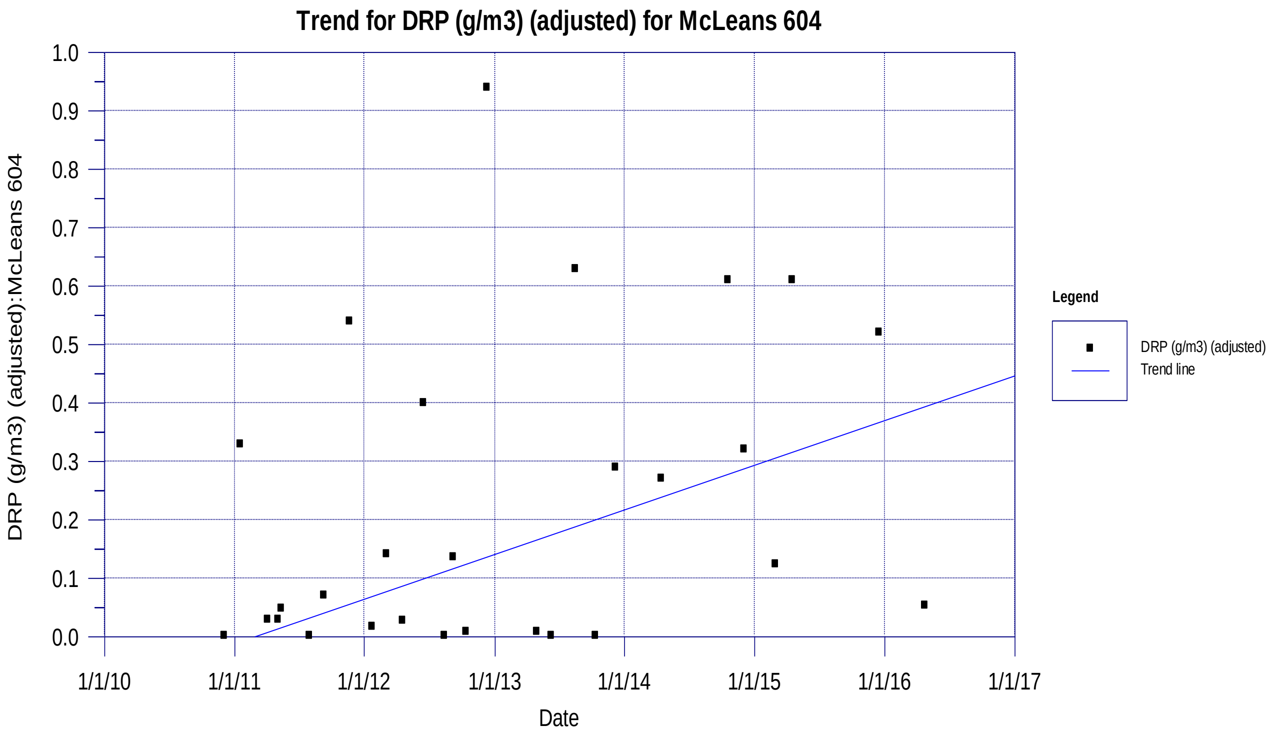
APPENDIX C

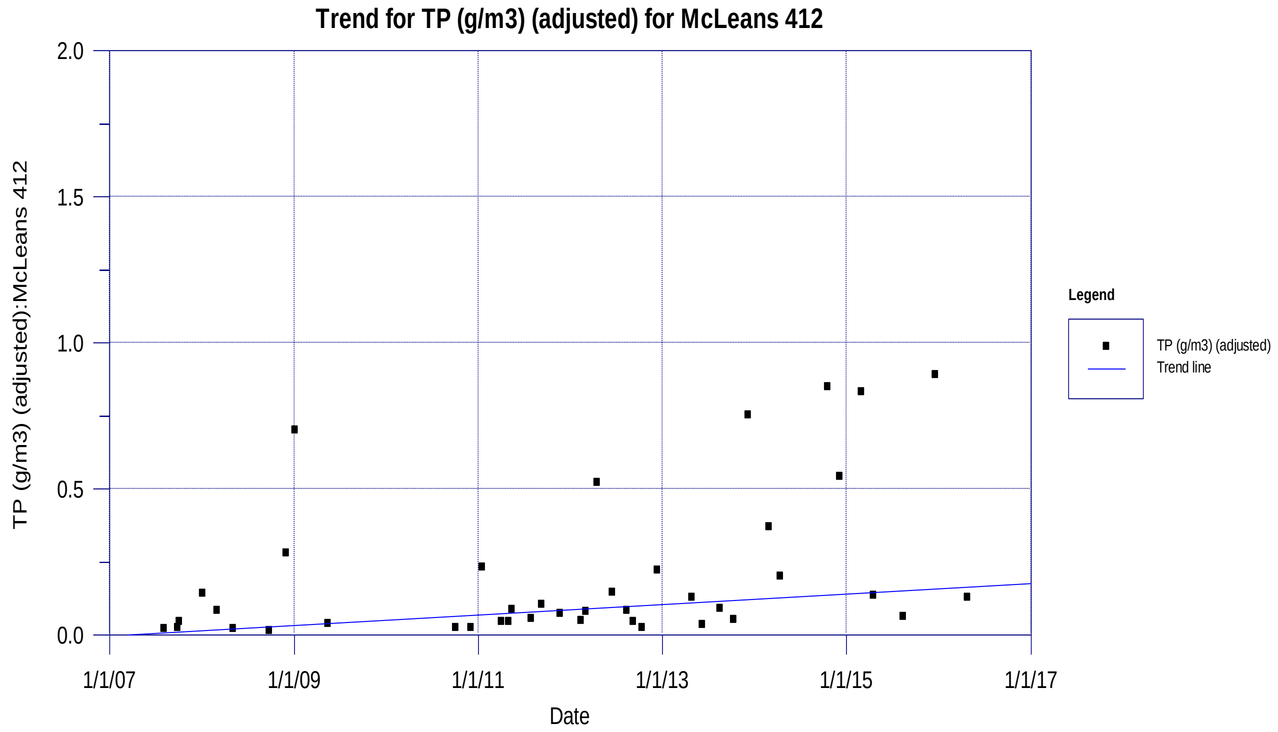
Groundwater Quality Trend Analysis Results

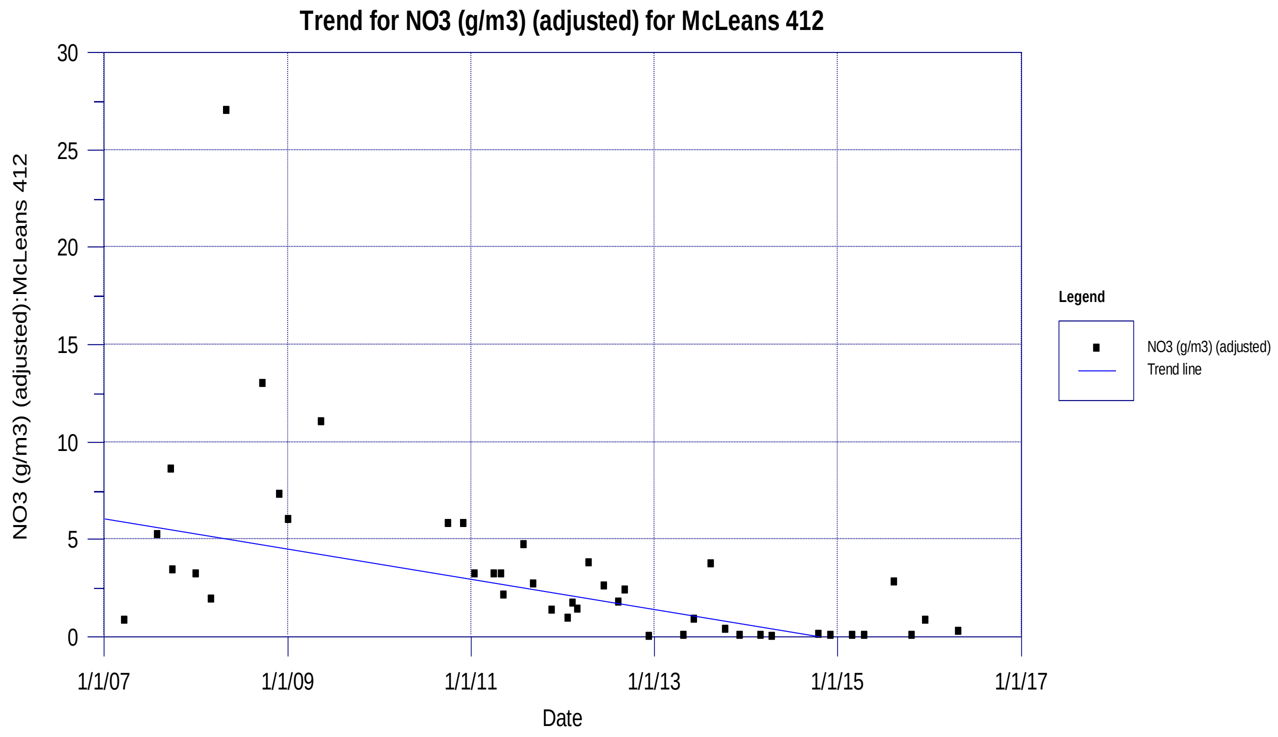

Trend for EC (mS/m) (adjusted) for McLeans 604
EC (mS/m) (adjusted):McLeans 604
80
70
60
50
40
30
20
10
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
EC (mS/m) (adjusted)
Trend line

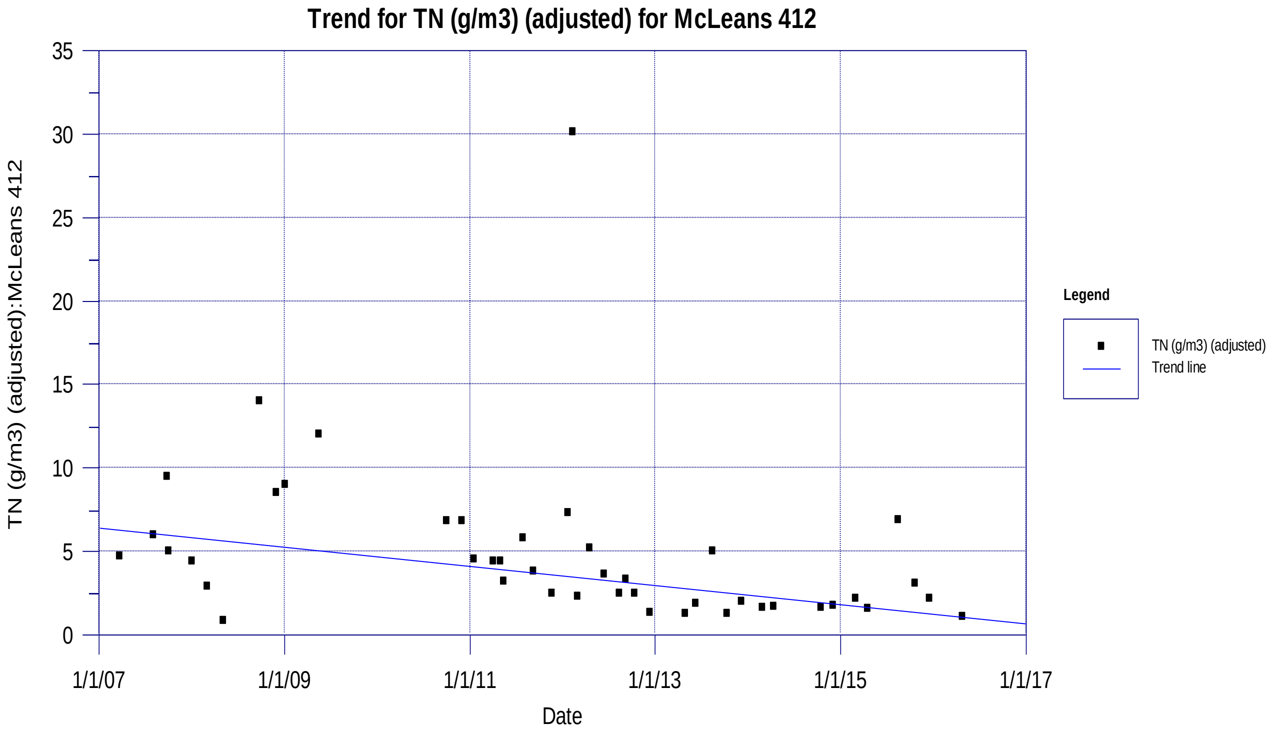

Trend for TP (g/m3) (adjusted) for McLeans 604
TP (g/m3) (adjusted):McLeans 604
4
3
2
1
0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
TP (g/m3) (adjusted)
Trend line

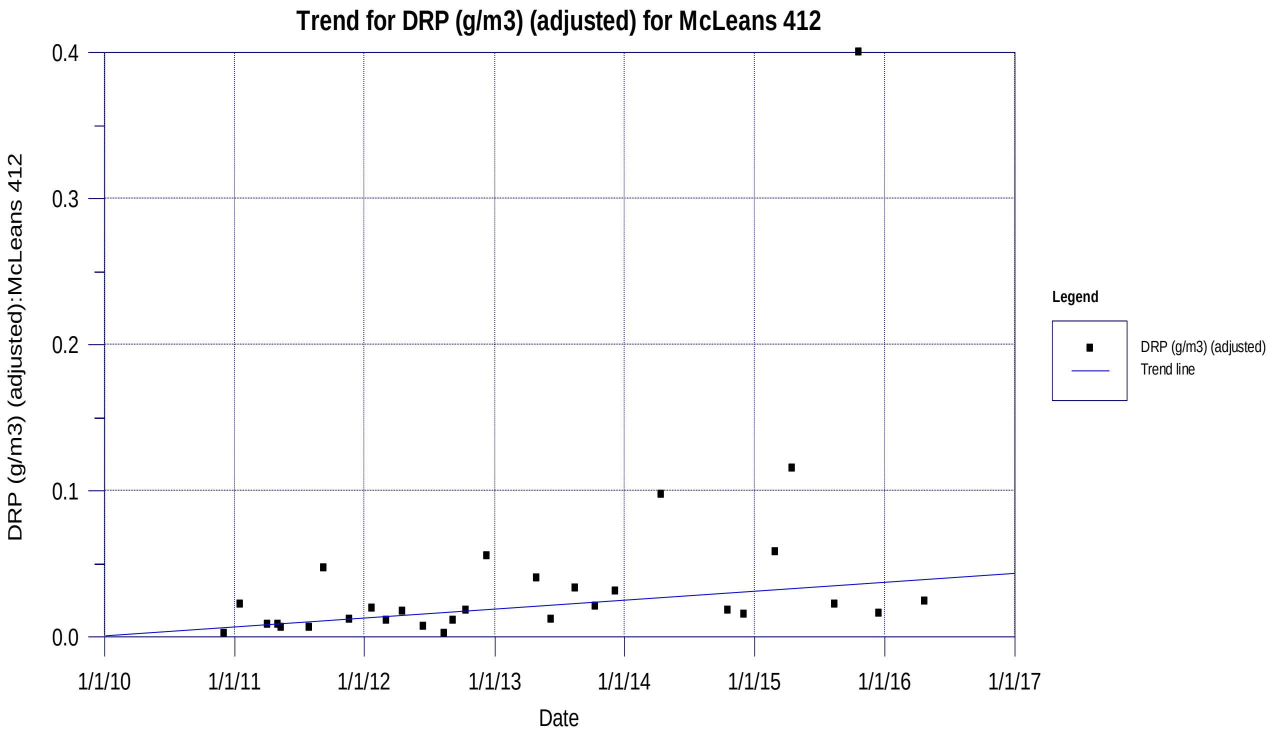

Trend for TN (g/m3) (adjusted) for McLeans 604
TN (g/m3) (adjusted):McLeans 604
30
25
20
15
10
5
0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
TN (g/m3) (adjusted)
Trend line

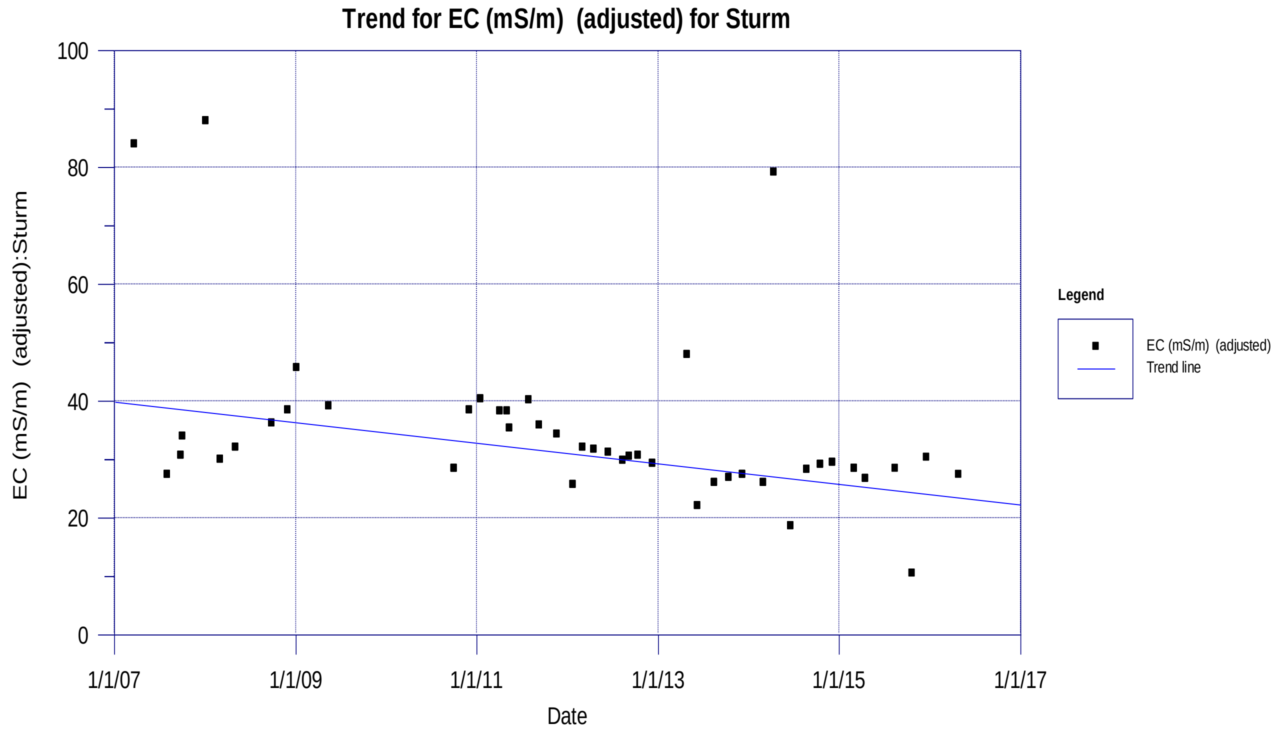

Trend for DRP (g/m3) (adjusted) for McLeans 604
DRP (g/m3) (adjusted):McLeans 604
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
DRP (g/m3) (adjusted)
Trend line

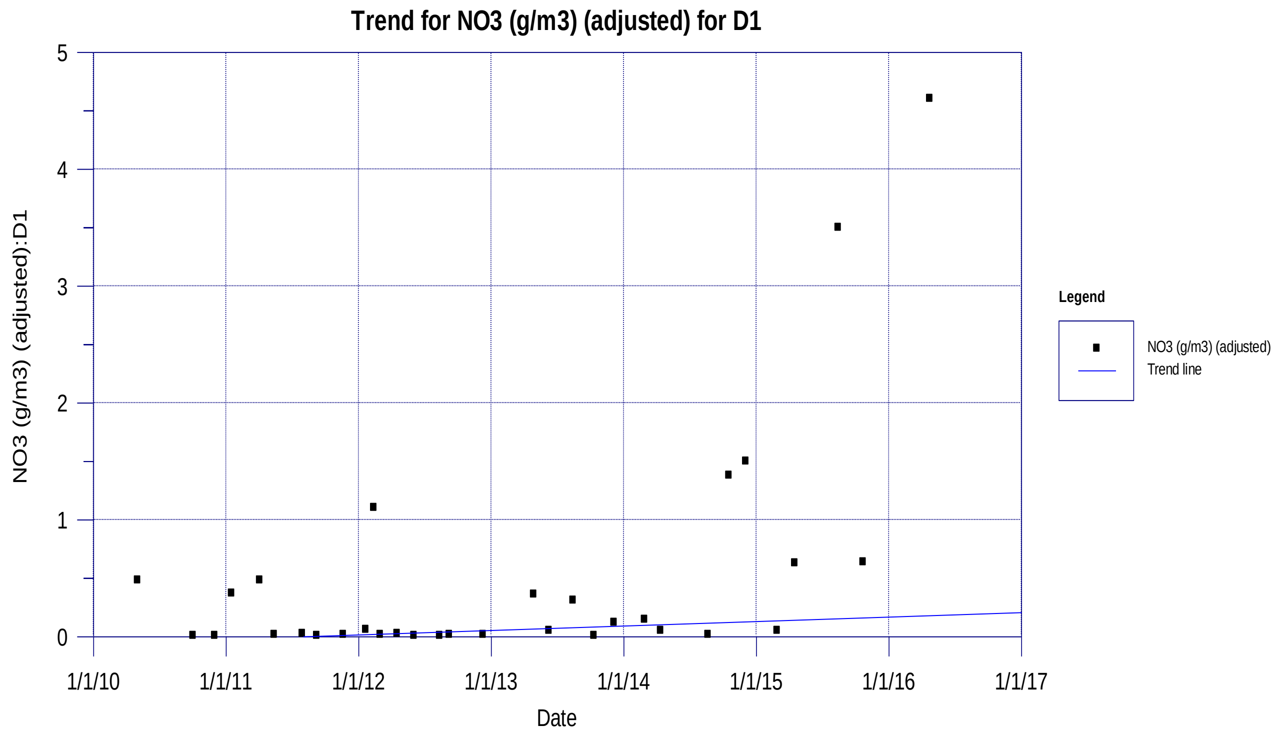

Trend for TP (g/m3) (adjusted) for McLeans 412
TP (g/m3) (adjusted):McLeans 412
2.0
1.5
1.0
0.5
0.0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
TP (g/m3) (adjusted)
Trend line

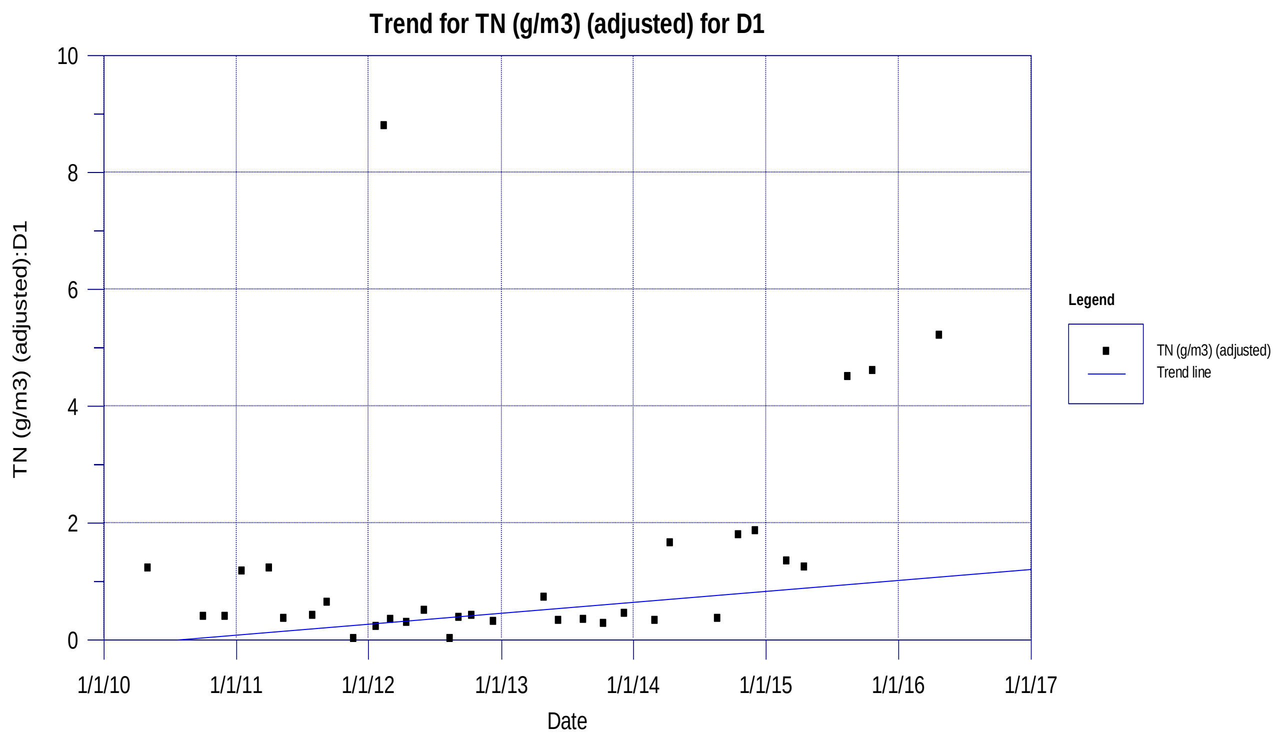

Trend for NO3 (g/m3) (adjusted) for McLeans 412
NO3 (g/m3) (adjusted):McLeans 412
30
25
20
15
10
5
0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
NO3 (g/m3) (adjusted)
Trend line

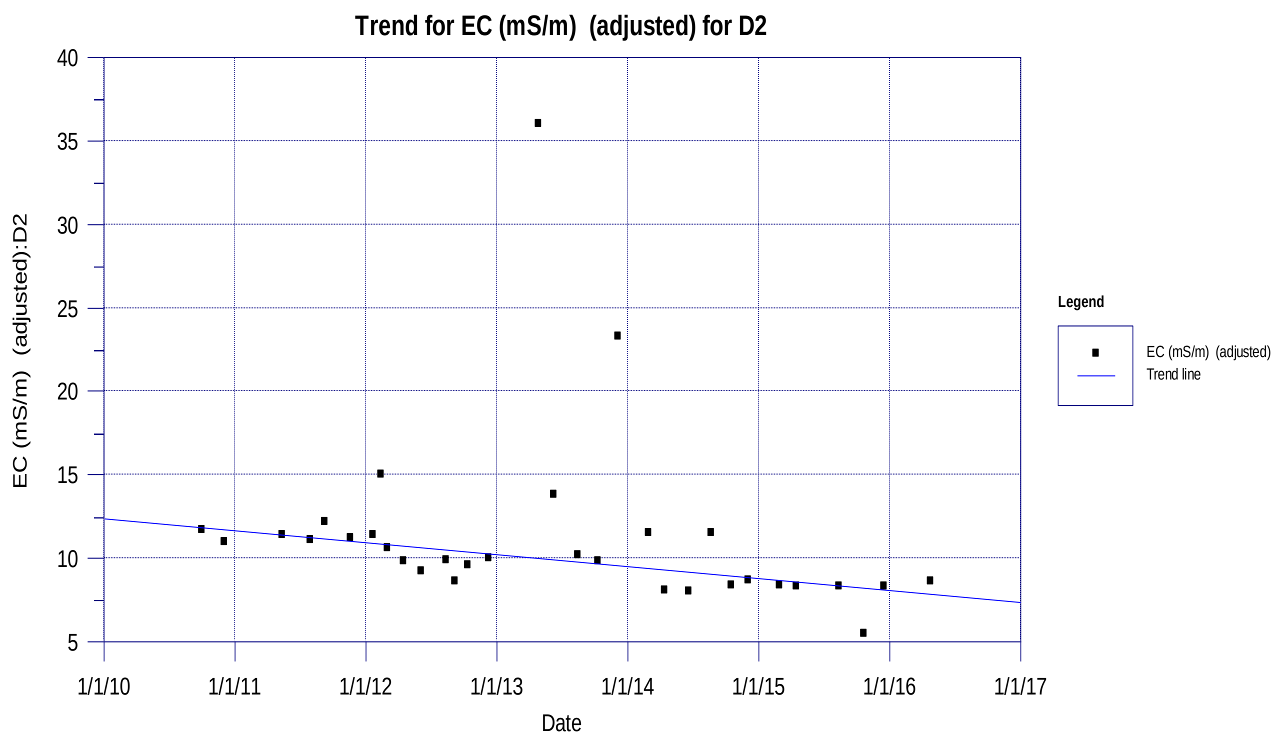

Trend for TN (g/m3) (adjusted) for McLeans 412
TN (g/m3) (adjusted):McLeans 412
35
30
25
20
15
10
5
0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
TN (g/m3) (adjusted)
Trend line

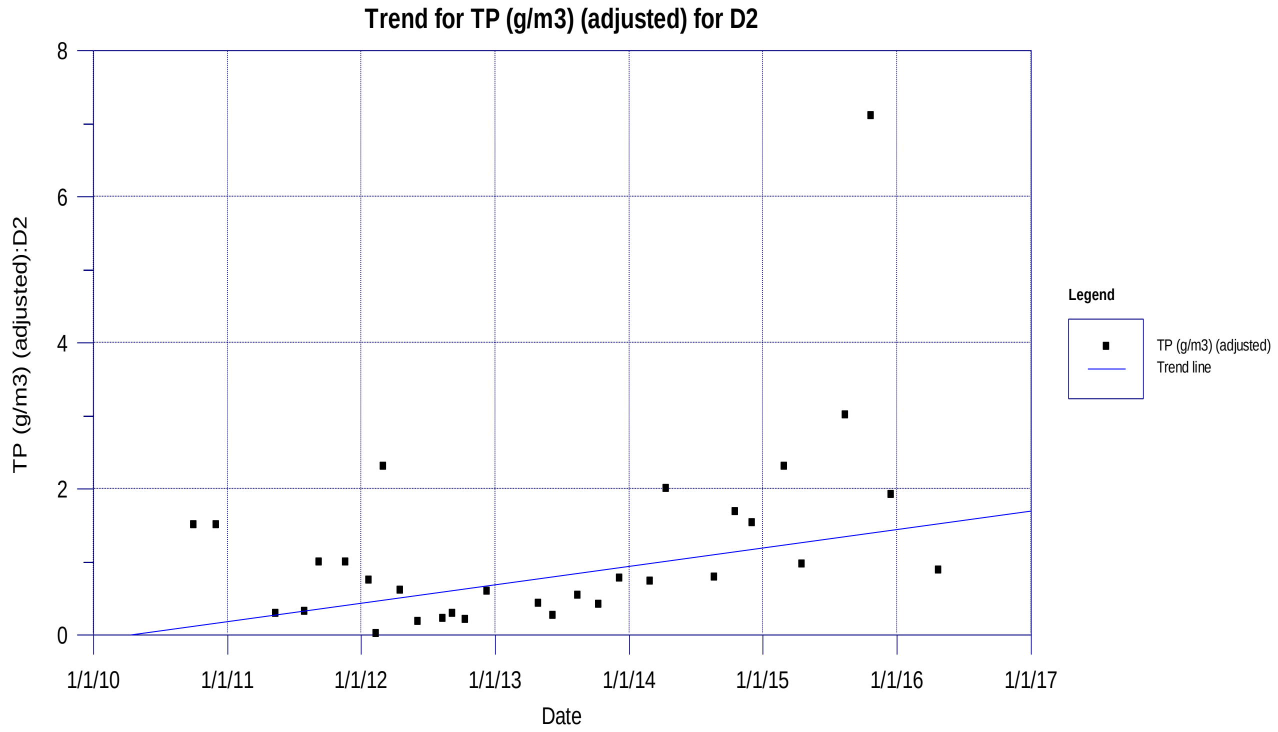

Trend for DRP (g/m3) (adjusted) for McLeans 412
DRP (g/m3) (adjusted):McLeans 412
0.4
0.3
0.2
0.1
0.0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
DRP (g/m3) (adjusted)
Trend line

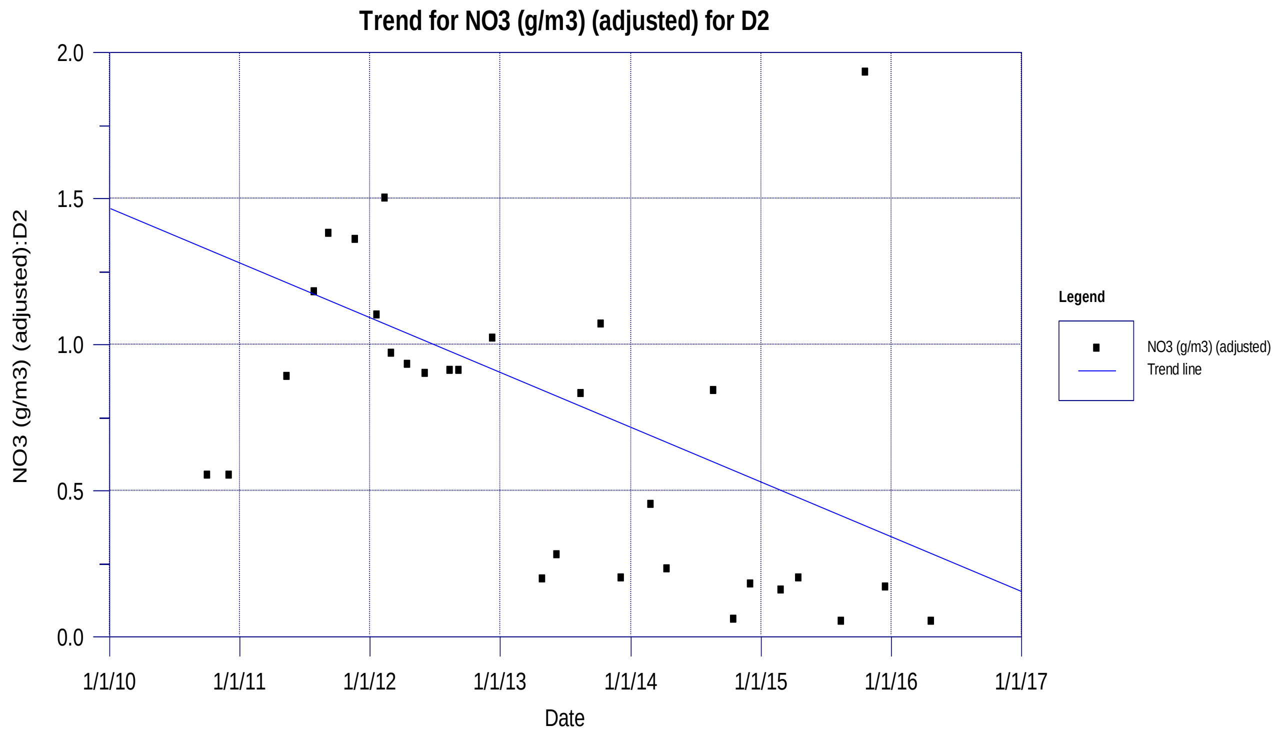

Trend for EC (mS/m) (adjusted) for Sturm
EC (mS/m) (adjusted):Sturm
100
80
60
40
20
0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
EC (mS/m) (adjusted)
Trend line

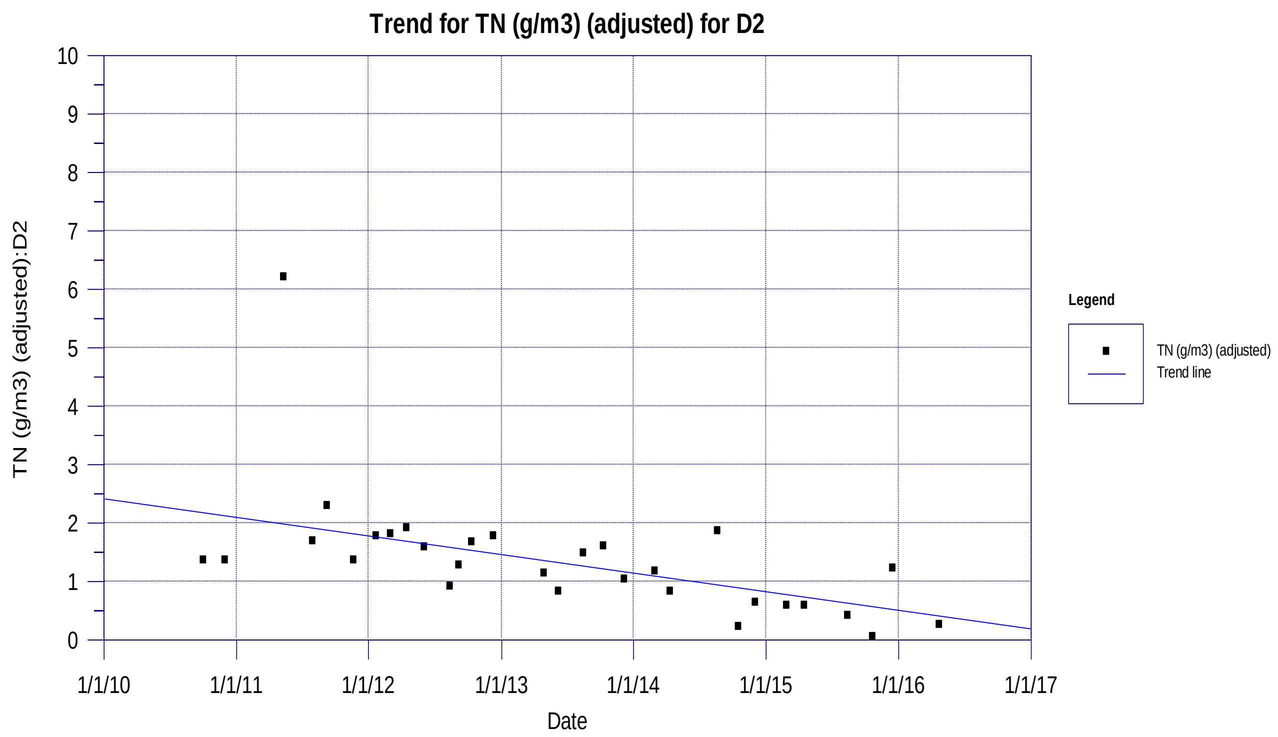

Trend for NO3 (g/m3) (adjusted) for D1
NO3 (g/m3) (adjusted):D1
5
4
3
2
1
0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
NO3 (g/m3) (adjusted)
Trend line

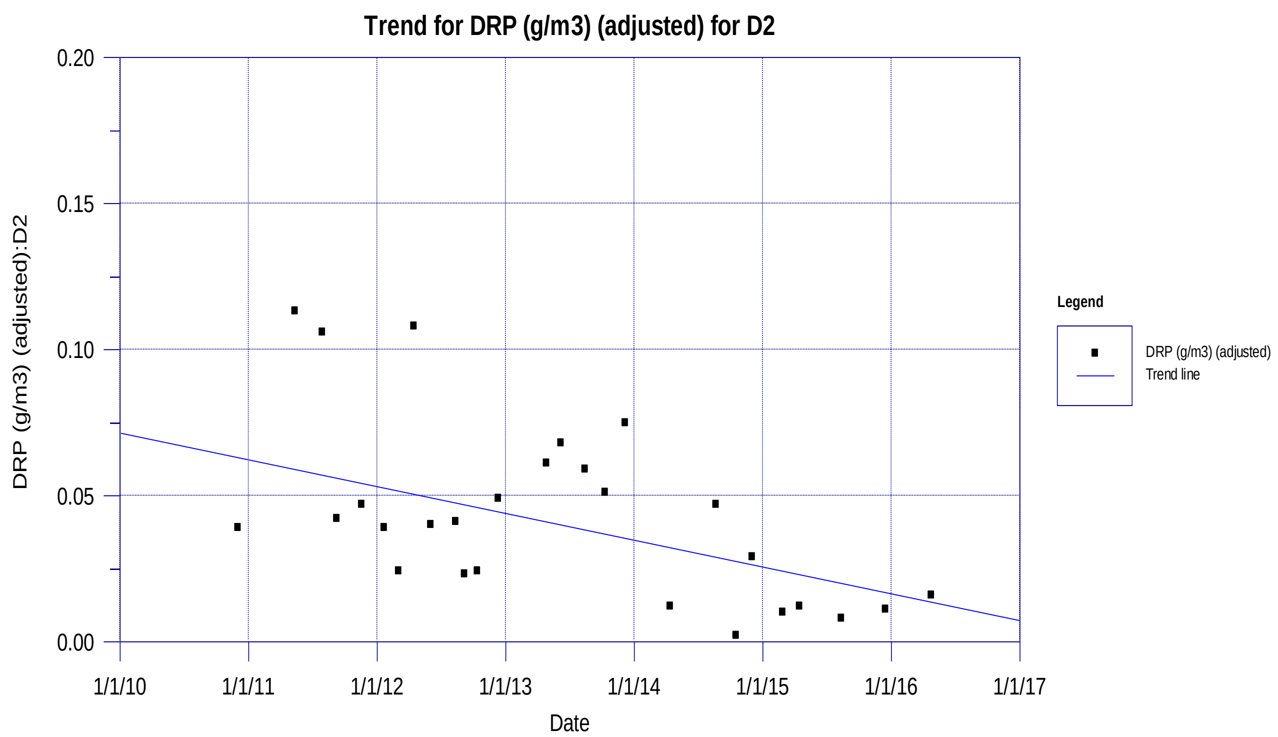

Trend for TN (g/m3) (adjusted) for D1
TN (g/m3) (adjusted):D1
10
8
6
4
2
0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
TN (g/m3) (adjusted)
Trend line

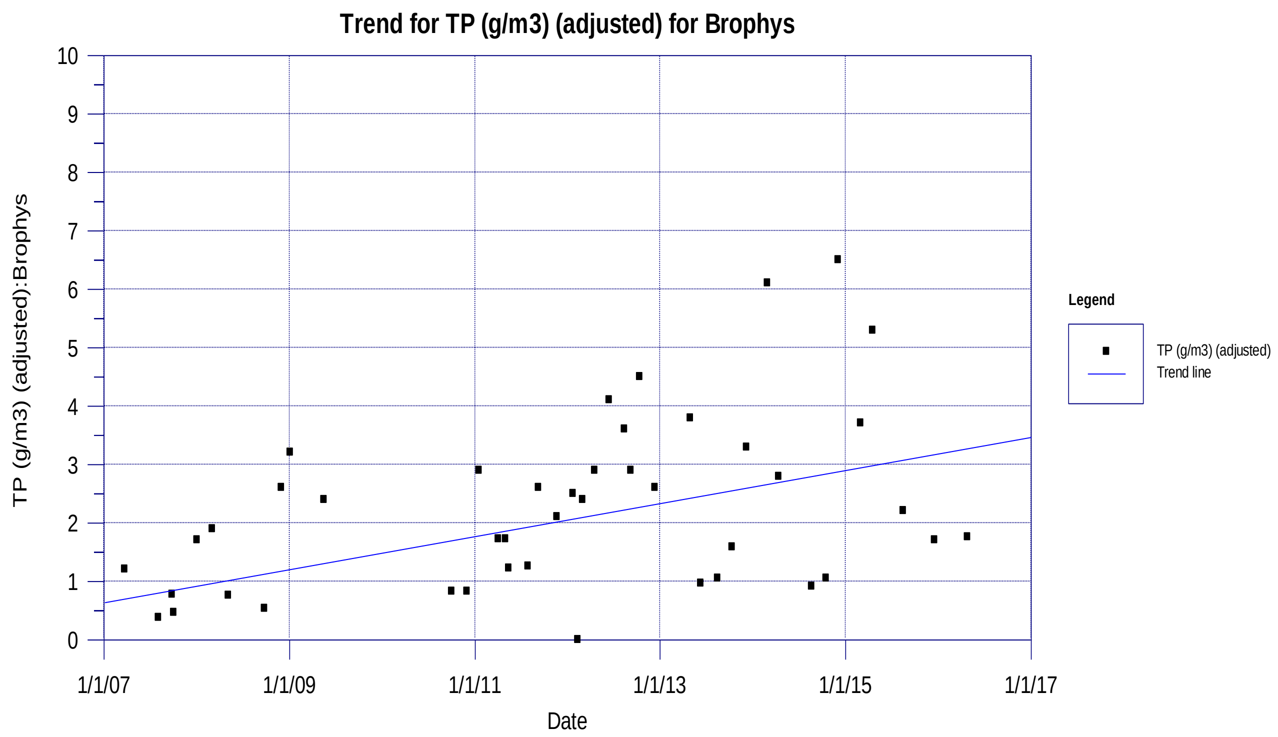

Trend for EC (mS/m) (adjusted) for D2
EC (mS/m) (adjusted):D2
40
35
30
25
20
15
10
5
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
EC (mS/m) (adjusted)
Trend line

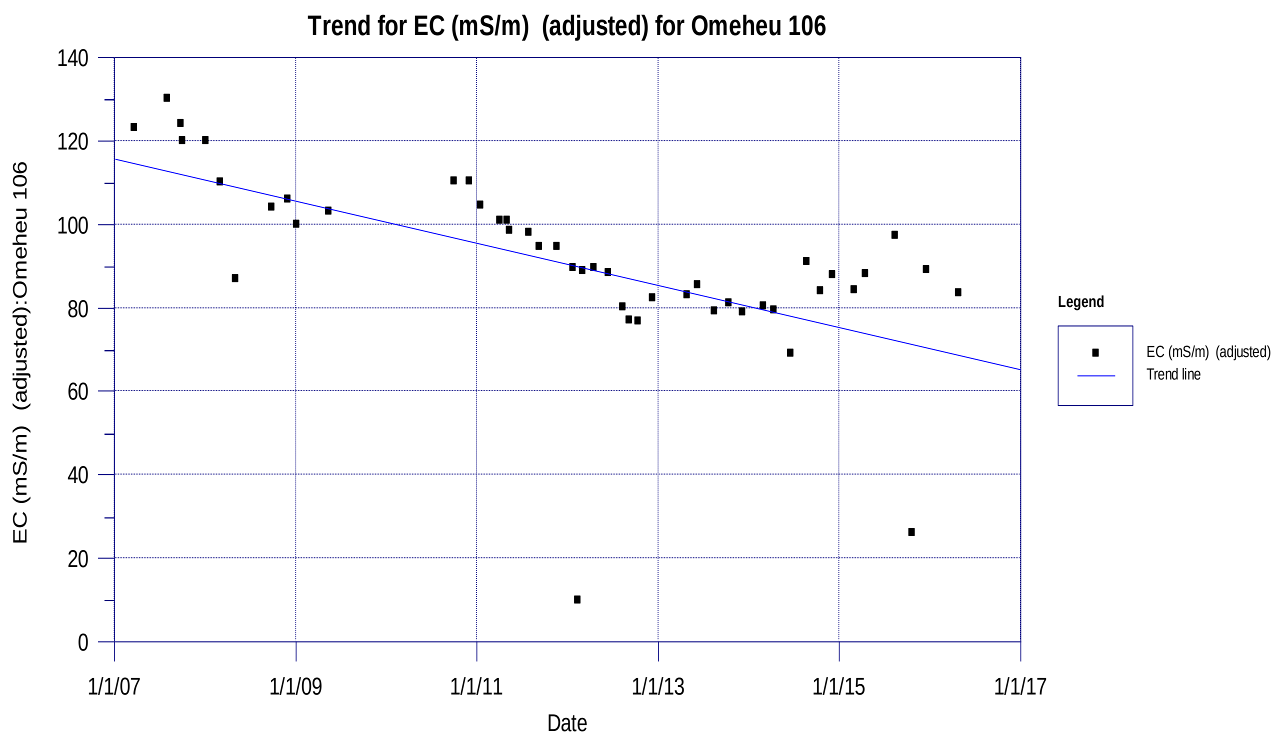

Trend for TP (g/m3) (adjusted) for D2
TP (g/m3) (adjusted):D2
0
2
4
6
8
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
TP (g/m3) (adjusted)
Trend line

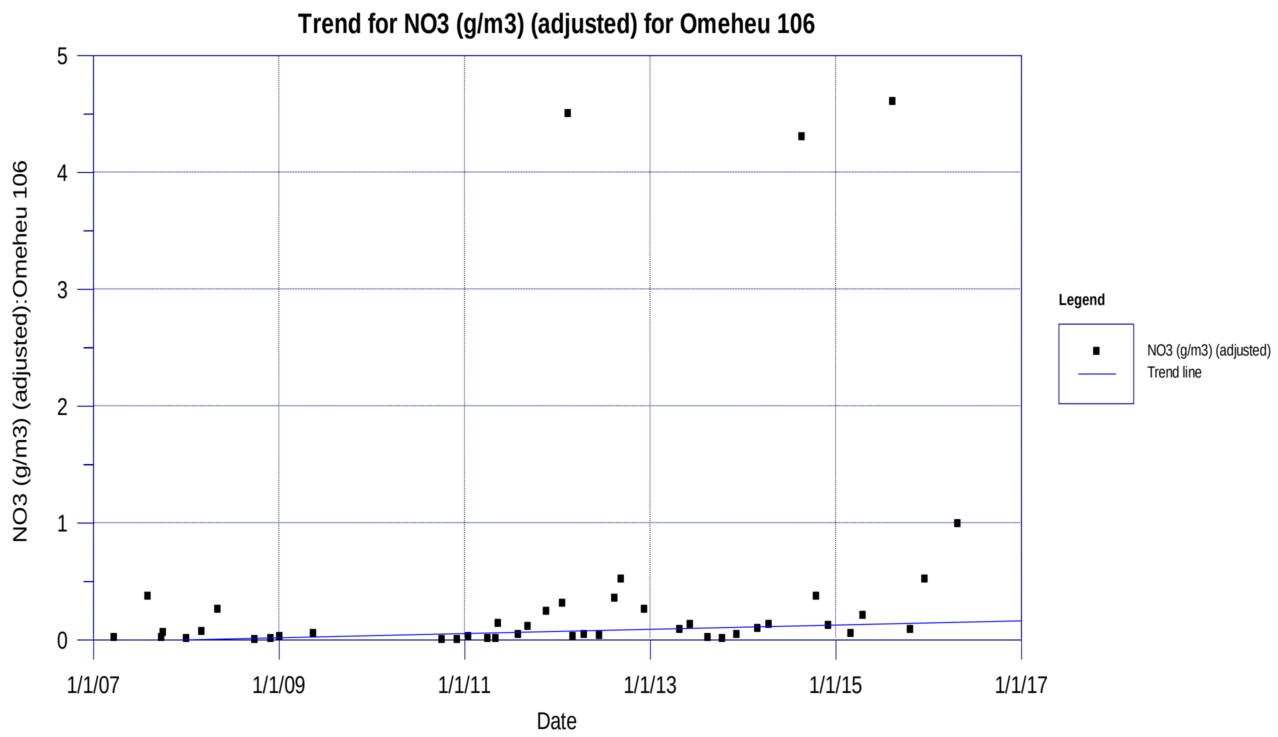

Trend for NO3 (g/m3) (adjusted) for D2
NO3 (g/m3) (adjusted):D2
0.0
0.5
1.0
1.5
2.0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
NO3 (g/m3) (adjusted)
Trend line

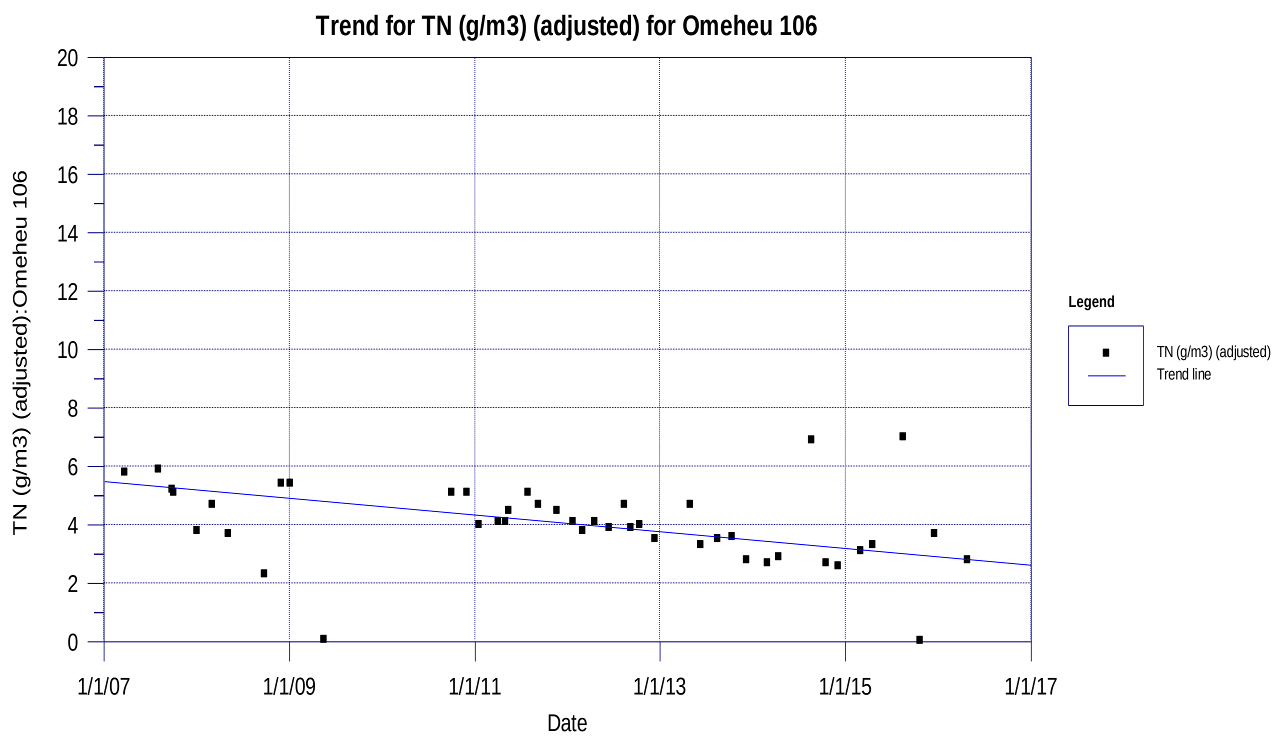

Trend for TN (g/m3) (adjusted) for D2
TN (g/m3) (adjusted):D2
10
9
8
7
6
5
4
3
2
1
0
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
TN (g/m3) (adjusted)
Trend line

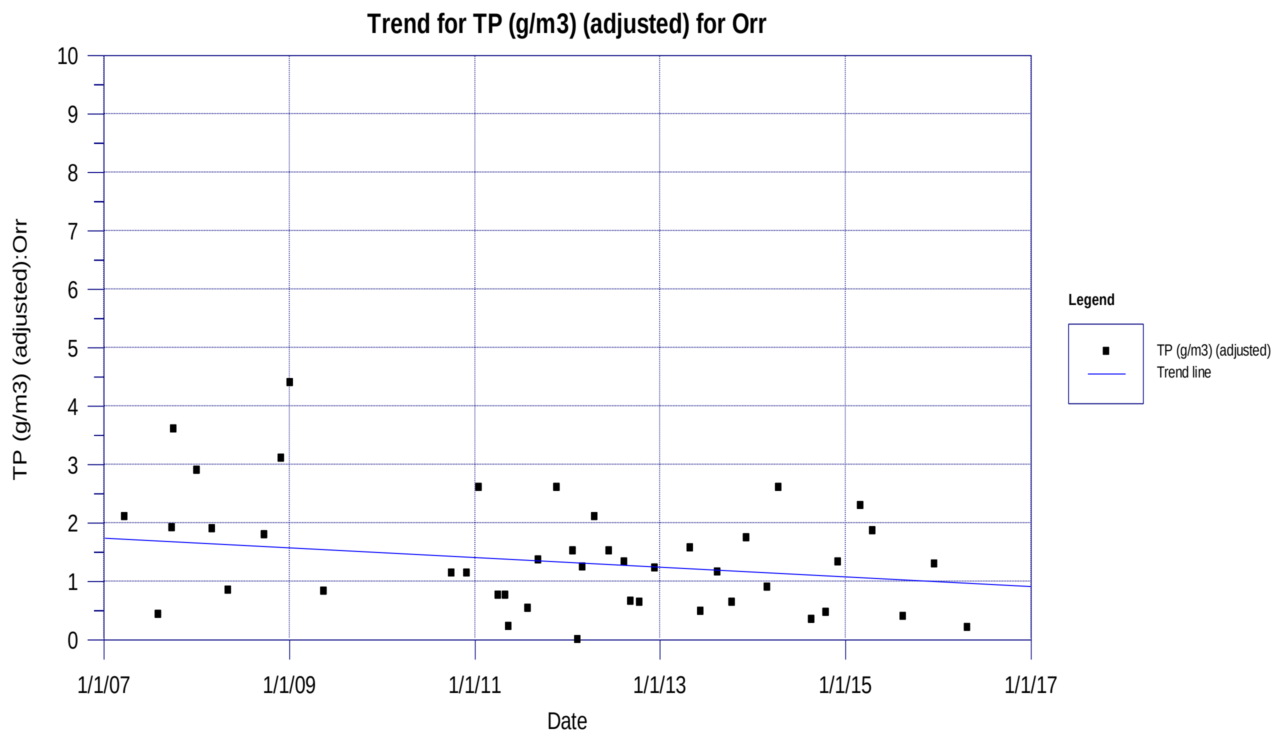

Trend for DRP (g/m3) (adjusted) for D2
DRP (g/m3) (adjusted):D2
0.20
0.15
0.10
0.05
0.00
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
DRP (g/m3) (adjusted)
Trend line

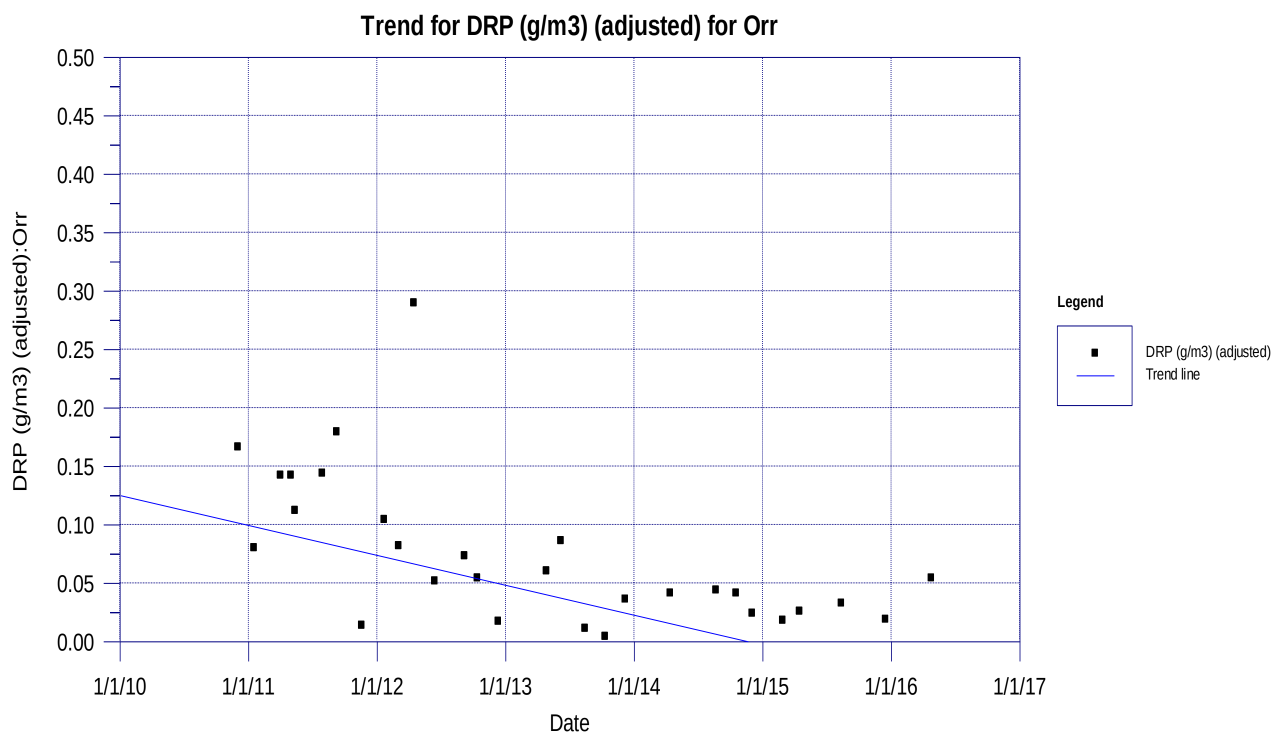

Trend for TP (g/m3) (adjusted) for Brophys
TP (g/m3) (adjusted):Brophys
10
9
8
7
6
5
4
3
2
1
0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
TP (g/m3) (adjusted)
Trend line


Trend for EC (mS/m) (adjusted) for Omeheu 106
EC (mS/m) (adjusted):Omeheu 106
140
120
100
80
60
40
20
0
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
EC (mS/m) (adjusted)
Trend line


Trend for NO3 (g/m3) (adjusted) for Omeheu 106
NO3 (g/m3) (adjusted):Omeheu 106
0
1
2
3
4
5
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
NO3 (g/m3) (adjusted)
Trend line


Trend for TN (g/m3) (adjusted) for Omeheu 106
TN (g/m3) (adjusted):Omeheu 106
0
2
4
6
8
10
12
14
16
18
20
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
TN (g/m3) (adjusted)
Trend line


Trend for TP (g/m3) (adjusted) for Orr
TP (g/m3) (adjusted):Orr
0
1
2
3
4
5
6
7
8
9
10
1/1/07
1/1/09
1/1/11
1/1/13
1/1/15
1/1/17
Date
Legend
TP (g/m3) (adjusted)
Trend line


Trend for DRP (g/m3) (adjusted) for Orr
DRP (g/m3) (adjusted):Orr
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
1/1/10
1/1/11
1/1/12
1/1/13
1/1/14
1/1/15
1/1/16
1/1/17
Date
Legend
DRP (g/m3) (adjusted)
Trend line

At Golder Associates we strive to be the most respected global company providing consulting, design, and construction services in earth, environment, and related areas of energy. Employee owned since our formation in 1960, our focus, unique culture and operating environment offer opportunities and the freedom to excel, which attracts the leading specialists in our fields. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees who operate from offices located throughout Africa, Asia, Australasia, Europe, North America, and South America.

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australia & NZ	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

AUCKLAND

Tel +64 9 486 8068
Fax +64 9 486 8072

Level 2
Nielsen Centre
129 Hurstmere Road
Takapuna
Auckland 0622

PO Box 33-849
Takapuna 0740

WELLINGTON

Tel +64 3 377 5696

Level 1
93 The Terrace
Wellington 6011

PO Box 5234
Wellington 6145

HAMILTON

Tel +64 7 859 2356
Fax +64 9 486 8072

Room 31 in the Homestead
Ruakura Research Centre
10 Bisley Road
Hamilton 3214

PO Box 19-479
Hamilton 3244

NELSON

Tel +64 3 548 1707
Fax +64 3 548 1727

Level 1
105A Montgomery Square
Nelson 7010

PO Box 1724
Nelson 7040

CHRISTCHURCH

Tel +64 3 377 5696
Fax +64 3 377 9944

Level 1
214 Durham Street
Christchurch 8011

PO Box 2281
Christchurch 8140

DUNEDIN

Tel +64 3 479 0390
Fax +64 3 474 9642

Level 7B
John Wickliffe House
265 Princes Street
Dunedin 9016

PO Box 1087
Dunedin 9054

Golder Associates