Waikato Regional Council Technical Report 2018/32

Groundwater field investigations over the 2014-15 summer in support of the Healthy Rivers project

www.waikatoregion.govt.nz
ISSN 2230-4355 (Print)
ISSN 2230-4363 (Online)

Waikato
REGIONAL COUNCIL
Te Kaunihera ā Rohe o Waikato

Prepared by:
John Hadfield

This report was commissioned by the Technical Leaders Group for the Healthy Rivers Wai Ora Project
Report No. HR/TLG/2015-2016/1.5B

For:
Waikato Regional Council
Private Bag 3038
Waikato Mail Centre
HAMILTON 3240

September 2015

Document #: 3350891

Peer Reviewed by:
Bryce Cooper
(NIWA) Date December 2015

Approved for release by:
Mike Scarsbrook Date December 2018

Disclaimer

Acknowledgement

The author would like to acknowledge the contributions of Zara Rawlinson and her team from Geological and Nuclear Sciences, Ralph Ostertag from WildImpacts Ltd, University of Waikato Students Hannah Surgeoner and Jacob Steen, and John Hughey of Waikato Regional Council. Their input to the field work enabled the large task to be undertaken effectively in a very short period of time.

Table of Contents

List of Figures

List of tables

Executive Summary

This report describes short-term groundwater related field investigations undertaken in the summer of 2014-15 in support of the Healthy Rivers Project (Waiora He Rautaki Whakapaipai). This work adds an increment, most notably in respect to groundwater lags, to the substantial body of information already available. The report aims to document data provision and hence provides very limited analysis. Information was made available to collaborating investigators (e.g. modellers) as it became available. A summary reporting of information with references to datasets was produced in June (doc 3425899).

The summer field investigations included: a flow confirmation survey, low flow gauging, well information surveys, water chemistry sampling, groundwater level surveying, investigation of redox conditions in groundwater, radon surveys and water age dating. The large flow confirmation survey involved observations of surface flow along designated routes throughout the Waipa catchment and Waikato catchment north of Karapiro. This was to confirm low flow contribution from a substantial number of selected sub-catchments for water budget analyses. Flow, or lack of, was confirmed at a total of 484 locations. To further substantiate flow estimates, low flow gaugings were undertaken throughout the Healthy Rivers study area at 170 locations and included 'simultaneous' linear gauging. Both the low flow gauging and flow confirmation survey information was provided to GNS Science Ltd (GNS) for contracted water budget analyses.

Some field investigation to obtain additional well information was also part of the summer program. A total of 90 sites were visited to add information to the approximately seventeen thousand records held in the Council database. These surveys targeted particularly areas of interest to modellers.

The field investigations in the Waikato catchment (upper, middle and lower) included collection of 68 samples for analysis of chemistry. The chemical determinands included nitrate-N, dissolved reactive phosphorous, iron, manganese, reactive silica, pH, ammoniacal-N and others relevant for characterisation and determination of land-use influence.

Nearly 35% of all wells sampled in the study area this summer showed some contamination of nitrate-N (i.e. > 1 ppm) probably related to land-use activities (doc 3431809). Recent groundwater sampling in the Reporoa area showed the nitrate-N concentration varied from less than 0.05 (non-detect) to 12.8 ppm (almost at the drinking water guideline of 11.3 ppm), with a mean of 2.5 and median of 0.75 ppm. Aerobic conditions are indicated at about a 36% of these sites, anaerobic at about 32% with the remaining third being indeterminate.

Static groundwater levels were recorded in about 95 wells, including 27 measured by GNS Science in the Waipa catchment. Relative levels of selected sites were surveyed to Moturiki datum (mean sea level). This information was provided to contractors for numerical modelling and construction of piezometric surfaces.

Surveys of radon concentration were undertaken along the Pokaiwhenua and Little Waipa Streams, comprising 10 sites in each, to identify areas of groundwater inflow. Radon is a radioactive gas which can be used as a tracer of groundwater input to surface waters given it is present in aquifers but readily dissipates in air. Flow and water quality were also measured at the same time.

The radon results show considerable variation, ranging from non-detect (<0.01) to 5.4 Bq L^{-1} in the Pokaiwhenua and from 0.2 to 28.1 Bq L^{-1} in the Little Waipa. The highest concentrations were associated with springs. The results reflect the importance of fracture flow through these Upper Waikato catchments which are dominated by

fractured ignimbrite geology. Water age dating also undertaken showed the notable spring inflows to be of similar age to the streams consistent with their baseflow domination.

Investigation was undertaken at selected sites to determine the depth to the redoxycline (where groundwater changes from aerobic to anaerobic condition). This was achieved by core testing. Drilling and piezometer construction was undertaken at four selected sites adjacent to the Upper Waikato hydro-lakes. At two of these sites (Little Waipa Reserve and Bulmer Landing) the redoxycline was found to be within four metres of the water table. The redoxycline was not encountered at the other two sites within 6 m and 11 m below the water table (Epworth Park and HoraHora Domain respectively). The opportunity was also taken to test core from 18 holes drilled in the Hamilton Basin for monitoring wells by Opus International Consultants Ltd for Transit New Zealand Ltd. Although the depth to anaerobic conditions below the water table was highly variable (ranging up to 50 m), it occurred almost half the time within five metres. Groundwater quality was also tested at the sites selected and nitrate-nitrogen concentrations were confirmed to be either very low or non-detect where anaerobic conditions were indicated.

Water was sampled for age dating throughout the Healthy Rivers study area and comprised 25 groundwater samples, three springs and 21 other surface water samples. The previous year 13 surface water samples from the Upper Waikato were analysed for tritium with only two being available before that. Groundwater age estimates, by contrast, were already available from 85 groundwater wells in the study area (~160 regional-wide). The most recent groundwater samples included 10 from wells in the Waipa catchment and all were analysed for CFCs, SF_6 and tritium. Groundwater samples were also taken from either side of the redoxycline from two sites adjacent to the Waikato River south of Karapiro and one in the Hamilton Basin.

Apart from the Upper Waikato streams, the age of surface waters (expressed as mean residence time) are generally less than 15 years and average about 10 years. The base-flow dominated Upper Waikato sub-catchment streams are older with an average measured mean residence time of about 52 years (median 35 years; flow weighted mean of about 47 years). The Upper Waikato main stem water age is younger (about 12 years at Karapiro) due to the influence of Lake Taupo which provides two thirds of the flow.

The age of groundwater throughout the study area is highly variable with mean residence times often much older than surface waters (mean and median residence time estimated from the summer monitoring results are about 114 and 95 years respectively). The mean and median of the previously available groundwater age analyses was about 68 and 48 years respectively. Although the relationship between groundwater age and depth is not significant, age is generally expected to increase with depth in a recharging regime. Similarly there is no simple linear relationship between age and nitrate-N concentration in wells. Typically, however, there is a wedge shaped distribution showing groundwater older than the significant development of farming is low in nitrogen, whereas younger groundwaters range in concentration dependent on land-use influence and attenuation.

Field investigations undertaken in the Waipa catchment by GNS are not reported here but information is available in Rawlinson et al., 2014 (doc 3410503). The results were made available to collaborators and provide additional information for the calibration of a proposed Waipa numerical groundwater model. It is noted that some preliminary data visualisation work undertaken by one of the students trialling ‘Leapfrog’ software (doc. 3297495) is also not reported here.

1 Introduction

1.1 Background

The Waiora He Rautaki Whakapaipai project (Healthy Rivers - Plan for Change), will establish limits and targets for nutrients, sediment and *E. coli* in waters of the Waikato and Waipa catchments. The technical leaders of this project consider it important to seek a greater understanding of nitrate loads and transport times from the land, via groundwater to streams, and the extent of attenuation processes within aquifers and riparian zones. This is to assist the development of policy to equitably restore and protect the Waikato and Waipa Rivers to meet community's desired outcomes.

The technical leaders group approved work briefs including that for the summer field investigation provided below. It should be noted that the proposed work represents an increment to the substantial body of information already available. This notably includes information about groundwater age from the dating of about 110 wells regionally, numerical groundwater flow and contaminant transport modelling of the Upper Waikato involving Aqualinc already in its fifth phase (doc 3199217), Waipa conceptual model development by GNS (doc 3208380), collaborative work on nitrogen assimilation involving ESR and Lincoln Agritech, and regional groundwater quality information from regular long-term monitoring. This is as well as numerous other investigations into groundwater resources including characterisation at Tokoroa, Hamilton Basin, Pukekohe and Ohinewai.

This report describes the groundwater related field investigations undertaken in a very tight timeframe over the summer of 2014-15 in support of the Healthy Rivers Project. References to the detailed datasets are included along with an overview of the programme showing how the various components link to other work. It is not intended to provide detailed analyses here but some description is provided along with comment about how the data is intended to be used. A summary reporting of information with reference to datasets was produced in June (doc 3425899).

1.2 Work brief

The work brief developed with the technical Leaders groups was to undertake an extensive field programme during the 2014/15 summer to provide additional information on basic hydrology, hydrogeology, regional piezometric levels, water chemistry (especially N), and ground water/surface water age and age distribution. The work brief is as included below.

A summer field work programme will be undertaken to improve the understanding of the state of equilibrium between current land use intensity and river water quality. The field programme will be guided by desktop reviews of current hydrogeological information. The additional information will support other aspects of an integrated programme of work to understand and model N attenuation and transport from land to surface water including developing robust conceptual models of the ground water systems in the Waikato and Waipa catchments and enhancement of the regional surface water quality estimation tool developed by NIWA. The information will also help define the changes in land use intensity required to restore and protect the Waikato and Waipa rivers and define the costs of achieving those changes.

Information required:
At selected and agreed locations the following types of information are required

a) basic hydrology, including low flow gauging and stream head elevations associated with low flow conditions, aquifer pumping tests for T, S and k if available, ground water levels, surveyed regional piezometric levels and ground water flow paths;
b) groundwater chemistry (especially N) and silica, also N_2 gas and radon where justified
c) groundwater/surface water (springs) age and age distribution (over a range of flow conditions)
d) geological and redoxycline information from well logs and shallow drilling in critical parts of the region.

Method:
Establish a 2014 summer field programme to provide the additional information identified. Agree the sites and information necessary in selected sub-catchments with groundwater experts involved in developing the conceptual ground water models and water quality models that this project contributes to. Previously sampled sites will be re-sampled and new monitoring sites will be established.

Performance measures:
The location of sampling sites and other observations and tests as agreed by the client and other groundwater experts before beginning the programme.
Sampling and other observations undertaken using standard hydrogeological methods.
Waikato Regional Council's HS&E policies adhered to.

Timelines and milestones:
Information for this investigation collated and agreed with client by 19 Dec 2014
Field work completed by 20 March 2015
Results and observations forwarded to modellers immediately they become available
Draft report completed by 28 May 2015
Final report completed by 26 June 2015

It is noted that a summary report was requested and supplied, describes and references the various datasets derived (doc 3425899). Greater detail was subsequently requested which would directly include more detailed field data.

1.3 Approach

The scale of this study and its extremely short timeframe required it to be broken into components with the involvement of contractors (GNS Science and WildImpact Ltd) and University of Waikato student input. A substantial part of the investigations in the Waipa catchment was undertaken by GNS Science. Investigations throughout the study area were managed, and contributed to, by Waikato Regional Council groundwater staff. The extent of the study area is illustrated in Figure 1 within sub-catchments labelled.

As well as the field work described, the routine summer monitoring of 110 regional wells and 90 community water supplies also contributed information which was made available to the Healthy Rivers project.

In parallel with the field investigations there were also other contracted works as part of the Healthy Rivers project to investigate unsaturated 'groundwater' flow within the study area by Lincoln Agritech and to produce conceptual hydrogeological models, piezometric surfaces, water balance and water quality information by GNS Science Ltd. A considerable amount of field derived information was made available to all relevant contractors and researchers by Council.

Figure 1: Healthy Rivers study area showing sub-catchments

The field collection of general hydrogeological information in the Waikato and Waipa catchments are described below, although for a substantial part of the latter the reader is referred to a report by GNS Science (Rawlinson et al., 2015 in doc 3410503). The following sections describe a flow confirmation survey, low flow gauging, well information surveys, water chemistry sampling, groundwater level surveying, investigation of redox condition in groundwater, radon surveys and water age dating.

2 Flow confirmation survey

2.1 Method

This work was undertaken by University of Waikato students and involved driving a series of selected routes to check where there is flow in 'streams'. These were essentially where blue lines crossed the road on topographic maps, although any other significant flows were noted. This primarily involved checking at culverts and bridges for any flow and depending on circumstances making an approximation of flow. The information gathered included a series of GPS waypoints with at least two photos at each site to show the flow and setting. Date, time and GPS location were noted and flow described. Comment on the location was also made, such as bridge, culvert number or stream name (if available). In respect to flow, it was noted whether: there was flow; flow was gaugeable or could be estimated using a bucket or cross-section and velocity approximation.

2.2 Data obtained

The flow confirmation survey undertaken extended throughout the Waipa catchment and Waikato catchment north of Karapiro (Figure 2). Flow, or lack of, was confirmed at a total of 484 locations. These comprised 179 in the Waipa, 59 in the 'Middle Waikato', 246 in the Lower Waikato (north of Ngaruawahia). The summary of the data collected is listed in Table 1. Further descriptive information is also archived in doc 3261460 and photographs of each site are available in G:/RIG/Environmental Monitoring/Healthy River/Gaugings Healthy River/Flow Confirmation photos Healthy Rivers. The codings for flow are:

N – no flow
E – estimated
G – gaugeable
M – gauged
U - ungaugeable

This flow confirmation information was provided to GNS Science to provide context for sub-catchment water budget and flow estimation.

3 Low flow gauging

3.1 Method

A substantial number of low flow gaugings were undertaken throughout the Healthy Rivers study area by WildImpact Ltd. The total of 170 gaugings carried out included 31 in the Waipa catchment, 68 in the Reporoa area (including repeats), five on the Pokaiwhenua Stream and 66 gaugings in the Lower Waikato. The low flow gauging sites are mapped in Figure 3. Some of this work involved simultaneous linear gauging.

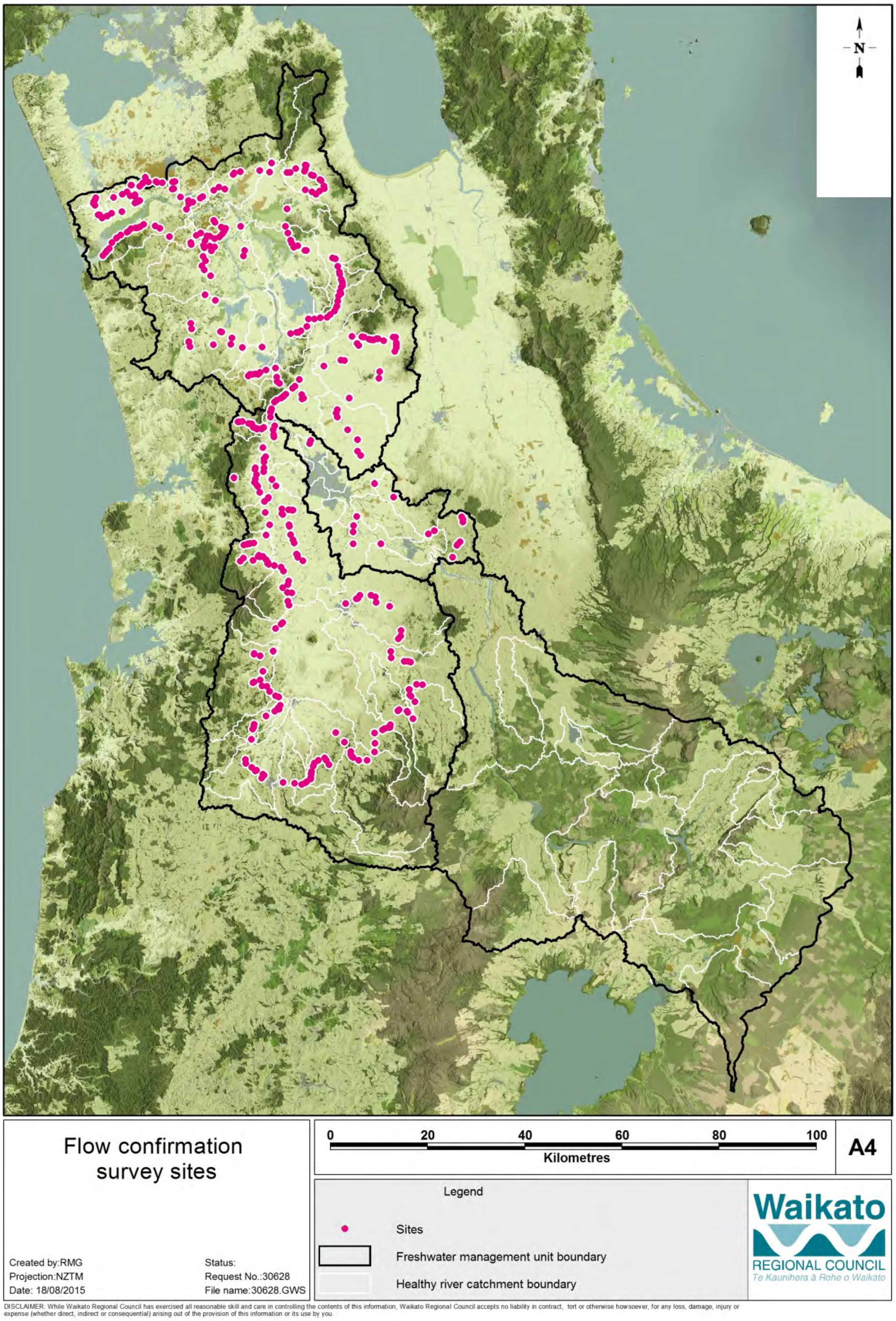


Figure 2: Map of the flow confirmation survey sites

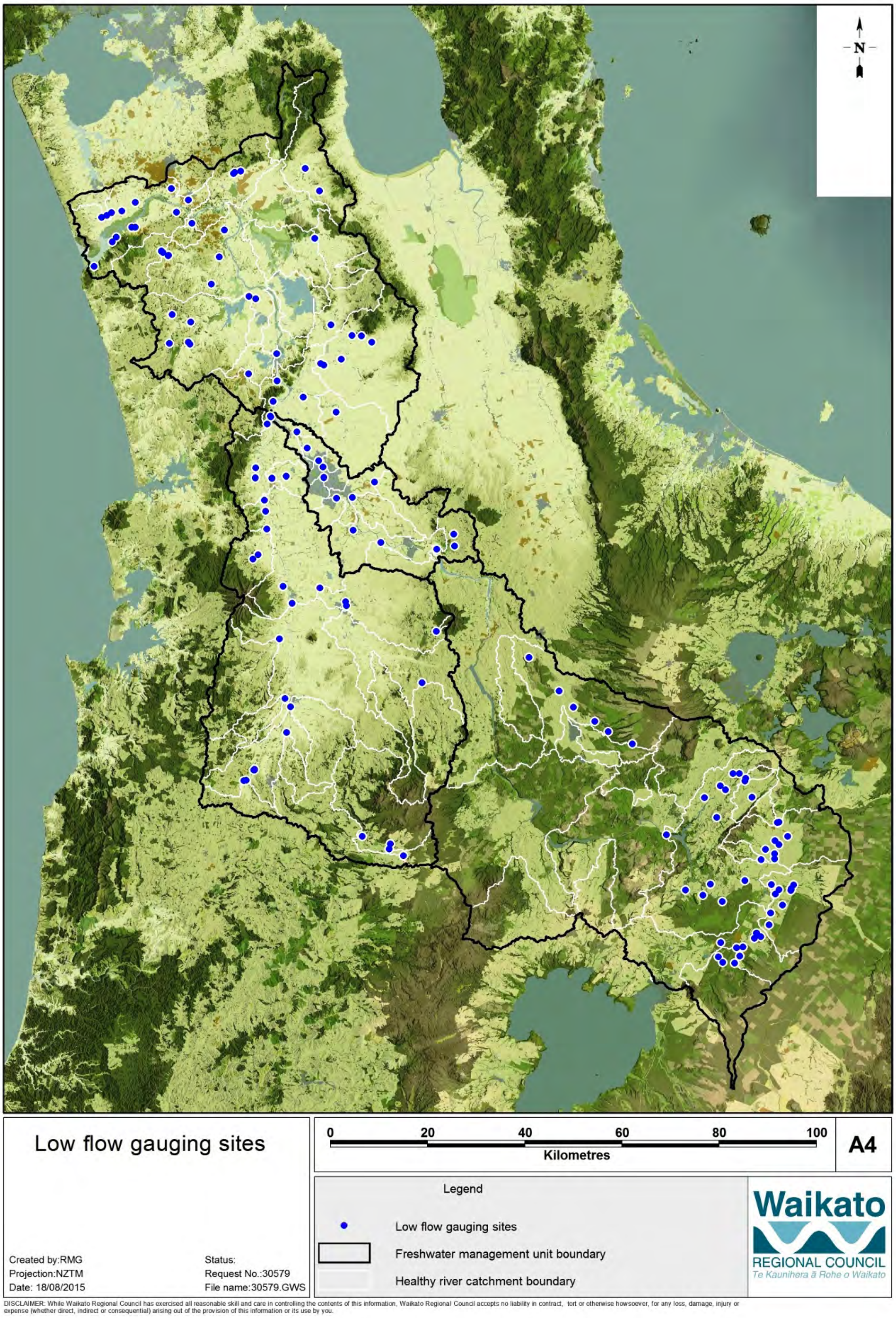


Figure 3: Map of the low flow gauging sites

Three different types of flow meters were used to gauge stream flows in the Waikato/Waipa catchment. For wade-able streams the following two current meters were used, depending on availability:

1. Seba Universal Current Meter (propeller type), mounted on a top setting rod. As a logging device a Glogger from Scott Technical Instruments was used and associated glog software to calculate the discharge

2. Sontec Flowtracker Handheld (Acoustic Doppler Velocimeter), mounted on a top setting rod. This has an integrated logger and discharge calculation software.

For streams with a width of greater than two metres 20 verticals were measured across the stream, for smaller streams the distance between verticals was usually no less the 0.1m.

For larger streams or rivers a Teledyne Streampro ADCP (Acoustic Doppler Current Profiler) was used to measure the discharge. The instrument was mounted on a floating device and tethered across the water body using a remote controlled traveller along a fixed tag line. Win River software was used to record and calculate the discharge according to WRC standard procedures.

3.2 Data obtained

Gauging information is provided in Appendix II. Full reporting is available in documents 3298785 (Waipa), 3298789 (Upper Waikato) and 3298794 (Lower Waikato) and otherwise in G:\rig\environmental monitoring\healthy rivers.

Both the low flow gauging and flow confirmation survey information was provided to GNS for consideration as part of water budget analyses. Comment is not provided here on the subsequent use of this information.

4 Well information surveys

4.1 Method

Well information surveys were programmed as part of the summer student field programme to obtain information additional to that already held for about seventeen thousand wells in the Council database. This work targeted areas of interest to modellers such as for the Reporoa, Upper Waikato (more generally), and Lake Maratoto areas (where there are exiting models). Te Kowhai was also of interest to substantiate the location of Waipa catchment divide. The Mangatangi area was also targeted as a potential lower catchment case study area.

The opportunity was also taken to inspect recently constructed wells (over the last two years) in areas of interest (a function not currently undertaken by Council). Wells of interest, particularly for water level and water quality were generally preferentially selected. Similar work was undertaken by GNS Science in the Waipa catchment.

Given occupational safety and health and access considerations, the students worked in pairs and only obtained samples where the owner was prepared to assist. No dismantling of pumping equipment was undertaken. Some of this work was subsequently undertaken by Council staff. Similarly water levels were frequently not able to be measured due to access problems or pumping in the particularly dry summer conditions in which the field-work was undertaken. Permission could not be gained to access some of the wells of interest and occasionally wells were found to have been abandoned (an aspect also not controlled by, or notified to, council).

4.2 Results

A total of 90 wells were surveyed through the summer. Example site survey sheets, including photographs, are attached in Appendix III. They include, where available, information about the following: name, location (easting and northing), address, contact person, phone contact, survey date, aquifer geology, topography, land-use, water use, level probe access, static water level, water quality comment, site number, number of wells on the property, driller's log availability, year of well construction, well depth, casing diameter, casing depth, casing type, screen diameter, depth and type, pump details, well yield, drawdown, whether there is hydraulic testing information and whether the well is used for potable supply. Similar information gathered by WIldImpact Ltd in the Mangatangi area was gathered using a different format. The remaining site sheets are available in the documents listed by number in the following table along with the related map references and area.

Table 1: List of documented well information

Well No.	Document No.	Area	Easting	Northing
70_741	3279550	Maritoto	1804156	5805186
72_8016	3279500	Maritoto	1804404	5804234
72_8051	3279469	Maritoto	1804291	5804673
72_7156	3279324	Maritoto	1802508	5803470
72_3609	3279319	Maritoto	1801802	5804268
72_1648	3279305	Maritoto	1802122	5804385
72_7157	3279285	Maritoto	1802491	5805006
72_309	3279262	Maritoto	1803299	5804762
72_7158	3279215	Maritoto	1803635	5804532
70_1182	3279200	Maritoto	1804050	5804535
70_525	3279171	Maritoto	1804107	5803987
72_7051	3279155	Maritoto	1803159	5803574
72_4696	3279135	Maritoto	1802655	5802309
72_1176	3279095	Maritoto	1804126	5804137
72_4511	3279067	Maritoto	1804181	5804113
72_7820	3291701	Waotu	1837458	5776539
72_7821	3291696	Whakamaru	1848566	5761846
72_7835	3291690	Taupiri	1793137	5833224
72_7837	3291689	Gordonton	1810944	5831350
72_7838	3291687	Gordonton	1804692	5830232
72_7836	3291685	Gordonton	1803656	5829430
72_7844	3291677	Gordonton	1796283	5833584
72_7839	3291683	Arapuni	1827654	5777728
72_7840	3291655	Orini	1807112	5839179
72_7844	3291677	Gordonton	1796283	5833584
72_1779	3291653	Taupiri	1803977	5834088
72_3525	3291650	Waotu	1840772	5770953
69_354	3291647	Te Kowhai	1790960	5819696
62_115	3291644	Te Kowhai	1794838	5820854
72_7126	3259835	Karapiro	1826419	5800732
72_7775	3259803	Karapiro	1823870	5800618
72_7775	3259777	Karapiro	1822721	5801268
72_1480	3259738	Reporoa	1883726	5748034
72_6843	3259738	Reporoa	1883726	5748034
68_9	3252956	Reporoa	1886604	5738147
72_1502	3252622	Reporoa	1887116	5737217
72_3022	3249386	Reporoa	1900918	5736261
72_1147	3249386	Reporoa	1900918	5736261
72_1498	3243110	Reporoa	1888438	5738757
72_1501	3243049	Reporoa	1887096	5737197
72_7964	3243049	Reporoa	1887096	5737197

66_35	3238957	Reporoa	1891603	5742995
72_4618	3238945	Reporoa	1887902	5741351
72_3036	3238928	Reporoa	1887751	5726346
72_7834	3290306	Taupiri	1805340	5840374
72_3741	3287465	Tokoroa	1848980	5774796
72_7842	3287326	Tokoroa	1849972	5774933
72_4797	3283646	Te Kowhai	1788347	5819611
69_724	3283644	Te Kowhai	1792965	5819703
72_7444	3283637	Te Kowhai	1793120	5820733
72_5979	3259840	Cambridge	1831313	5799573
72_7367	3269819	Cambridge	1826172	5795836
72_7943	3269778	Cambridge	1830524	5790704
72_3984	3258651	Reporoa	1895796	5736466
72_4142	3258651	Reporoa	1895796	5736466
73_3538	3252825	Reporoa	1895796	5736466
72_6153	3258651	Reporoa	1893552	5730702
66_32	3249269	Reporoa	1901605	5736221
72_4457	3249183	Reporoa	1903620	5736364
66_60	3249146	Reporoa	1904381	5736490
72_1148	3248948	Reporoa	1898187	5736788
72_1882	3243106	Reporoa	1893283	5734364
72_5198	3238986	Reporoa	1896577	5742571
72_1480	3238950	Reporoa	1890141	575100
72_5445	3238919	Reporoa	1896448	5742731
69_2044	3386300	Mangatangi	1795144	5880575
72_2866	3386282	Mangatangi	1796842	5881278
72_2166	3386300	Mangatangi	1794038	5883573
72_5637	3386300	Mangatangi	1794159	5875491
69_836	3386282	Mangatangi	1797344	5880679
72_6501	3386300	Mangatangi	1795053	5875574
69_2088	3386300	Mangatangi	1798749	5877981
72_553	3386300	Mangatangi	1796653	5875577
61_663	3386300	Mangatangi	1797038	5883679
72_175	3386300	Mangatangi	1794944	5880374
72_54	3386300	Mangatangi	1795143	5880875
69_745	3386282	Mangatangi	1800157	5873983
69_2085	3386300	Mangatangi	1798655	5874780
72_3749	3386300	Mangatangi	1802060	5873425
72_6500	3386300	Mangatangi	1800055	5874683
72_3745	3386300	Mangatangi	1800493	5873503
69_1018	3386300	Mangatangi	1803764	5870189
72_7034	3386282	Mangatangi	1795694	5880627
72_4472	3386282	Mangatangi	1798533	5886382
72_4912	3386300	Mangatangi	1792144	5879869
69_836	3386300	Mangatangi	1797446	5880420
61_444	3287780	Mangatangi	1789388	5880801
72_6599	3386282	Mangatangi	1790908	5878379
72_6601	3287780	Mangatangi	1790342	5878819
72_6627	3287780	Mangatangi	1791697	5893220

5 Groundwater chemistry

5.1 Method

Sampling for water quality was carried out as described by the New Zealand national protocol for the state of environment sampling (Daughney et al., 2006) with minor exceptions, notably that pH was not measured in the field. Samples were only collected when access was provided by the land-owner. Samples were taken as close as possible to the wellhead. Students were not permitted to dismantle pipe-work or plant which constrained access and required some follow-up by Council staff.

Samples were taken after a sufficient volume of groundwater had been purged to ensure the removal of annular water. This was aided by coincident substantial pumping of many wells over the dry summer provided this could be confirmed. Conductivity, temperature and dissolved oxygen were measured in the field and samples were only taken after these measurements became stable. Samples were kept cool with ice in chilly bins until delivered to Hill Laboratories for analyses.

Samples were analysed for the following determinands: pH, alkalinity, free carbon dioxide, total hardness, electrical conductivity, total dissolved salts, total boron, total calcium, total copper, total iron, total magnesium, total manganese, total potassium, total sodium, total zinc, chloride, ammoniacal-N, nitrate-N, sulphate, dissolved iron, dissolved manganese, dissolved reactive phosphorus and reactive silica. The analytical methods used are listed in Appendix IV as well as an example results sheet.

5.2 Results

Water chemistry sampling was undertaken at 68 wells throughout the Upper, Central and Lower Waikato catchments. The results are listed in Appendix IV. About 60 surface water quality samples were also analysed as part of the summer programme, associated predominantly with water age dating and radon surveys. These results are not discussed here although there is related comment in section eight of this report. A further 48 groundwater wells were sampled by GNS Science in the Waipa catchment.

About 35 % of all wells sampled in the study area this summer show some contamination of nitrate-N (i.e. > 1 ppm) probably related to land-use activities (doc 3431809). Recent groundwater sampling in the Reporoa area showed the nitrate-N concentration varied from non-detect to 12.8 ppm (almost at the drinking water guideline of 11.3 ppm), with a mean of 2.5 and median of 0.75 ppm. Aerobic conditions are indicated at about 36% of these sites, anaerobic at about 32% with the remaining third being indeterminate.

The chemistry data obtained was provided to GNS Science Ltd as an increment to the much larger existing dataset for contracted analyses of results. As a consequence no further analyses is provided here and it would be outside the scope of this work. An indication of the nitrate distribution is, however, provided in the map of the larger dataset (Figure 4).

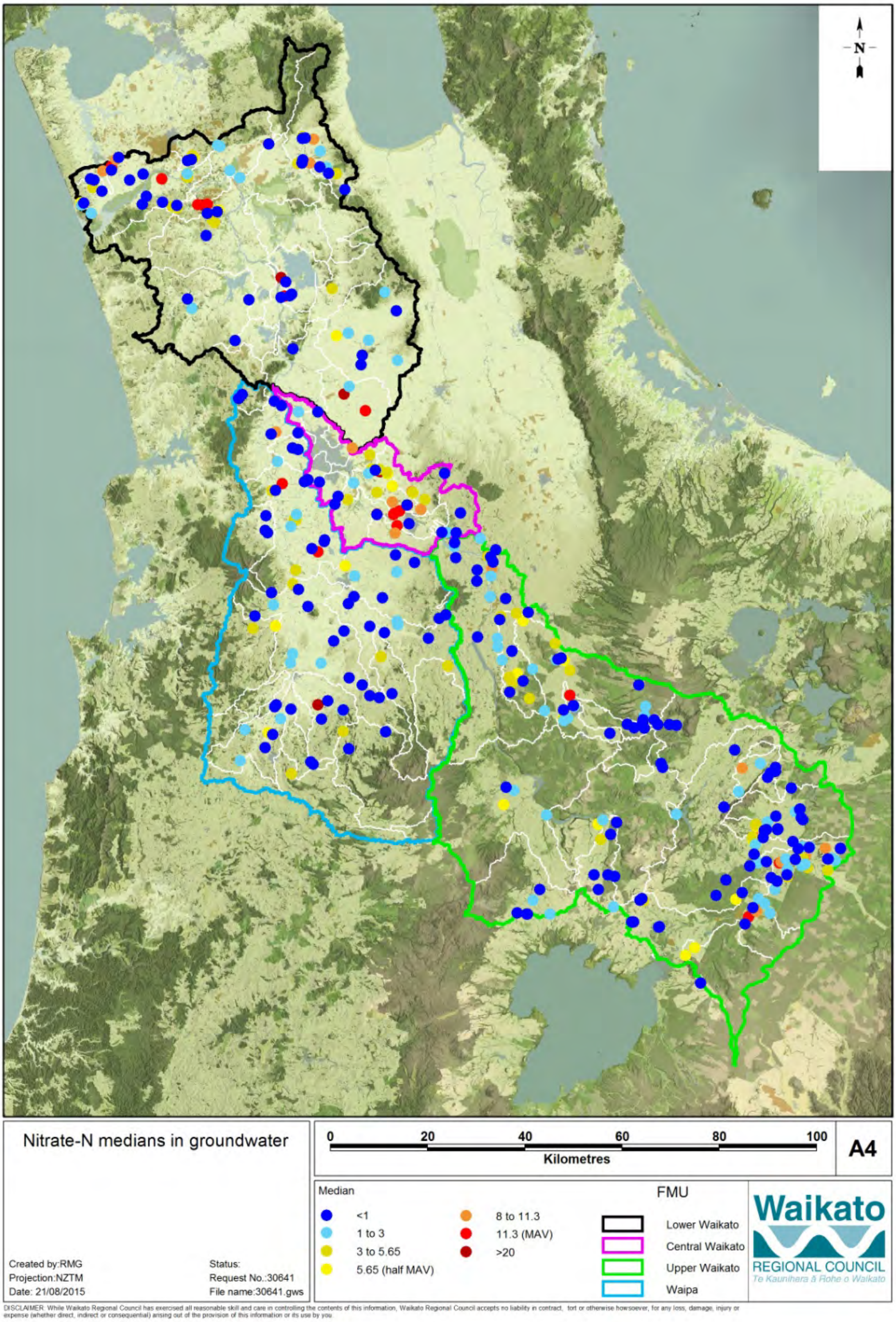


Figure 4: Groundwater nitrate-N medians in the Healthy Rivers study area

6 Groundwater level surveying

6.1 Method

Groundwater levels were obtained wherever possible from all wells surveyed and sampled. Manual water level probes were lowered to detect the water level where access could be obtained down the annulus from the wellhead. Water levels were checked over time to determine if they were in a static condition. Many wells were being pumped during the hot summer constraining the ability to gather static readings. Where it was possible the depth was noted along with the point of reference for the measurement taken. This was typically the casing head flange.

Subsequent surveying to Moturiki datum was undertaken to determine the relative height above a common mean sea level reference. A range of techniques was used. These included line of sight surveying (for close benchmarks) and RTK GPS surveying. The calibration method and accuracy is dependent on the availability and accuracy of benchmarks. Although higher accuracies are from individual techniques are possible, overall confidence taking into account the range of benchmarks is about 100 mm. The points of measurement on the bore-heads are corresponding with the mark used to measure the groundwater level. These marks are described in the site file of each bore.

6.2 Results

Groundwater levels were measured in 95 wells in the Healthy Rivers study area during the 2014-15 summer. Of these 27 were measured by GNS Science in the Waipa catchment and are not included here. The measured static water levels (from doc. 3502580) are listed in Table 2.

Information gathered was made available to modellers and contracted hydrogeologists to construct piezometric surfaces and calibrate numerical models. Some of this work focused on the Reporoa, Upper Waikato and Lake Maritoto areas where there were existing numerical models.

Table 2: Measured groundwater levels and well elevations

Well No.	Easting	Northing	Date	Depth to SWL	Elevation	SWL (masl)
61_444	1789442	5881064	5/02/2015	2.46		
62_115	1794838	5820854	9/02/2015	2.53		
66_32	1901669	5736209	12/12/2014	67.39	529.78	462.39
66_35	1891564	5742992	4/12/2014	1.83	297.26	295.43
66_60	1904380	5736493	12/12/2014	> 160	546.04	<386.04
69_2085	1798655	5874780	9/04/2015	9.155		
69_354	1790960	5819696	9/02/2015	3.27		
69_724	1792965	5819703	9/02/2015	7.5		
69_836	1797344	5880679	13/04/2015	4.89		
70_1182	1804050	5804535	2/02/2015	3.66		
70_525	1804107	5803987	2/02/2015	10.57		
70_526	1822684	5801200	17/02/2015	4.01		
72_1176	1804126	5804137	2/02/2015	10.93		
72_1483	1896155	5744453	20/01/2015	17.09		
72_1486	1895255	5743901	20/01/2015	2.48		
72_1488	1888403	5740487	30/04/2015	41.04	349.46	308.42
72_1489	1888954	5740564	30/04/2015	28.73	336.62	307.89
72_1498	1888438	5738757	9/12/2015	0.14		
72_1502	1887113	5737218	16/12/2014	6.25	331.05	324.80
72_1648	1802122	5804385	2/02/2015	1.88		
72_1882	1893284	5734366	1/05/2015	2.8	306.44	303.64
72_2067	1891672	5740441	15/01/2015	2.06	295.73	293.67
72_3022	1900918	5736261	12/12/2014	>160		
72_3036	1887751	5726346	4/12/2014	23.94		
72_309	1803299	5804762	2/02/2015	10.74		
72_3538	1895778	5736474	19/02/2015	44.97	358.66	313.69
72_3609	1801802	5804268	2/02/2015	3.9		
72_3741	1848956	5774764	1/01/2008	40.3	249.33	209.03
72_3745	1800458	5873483	9/04/2015	19.96		
72_3749	1802058	5873386	9/04/2015	5.11		
72_3984	1895775	5736434	20/01/2015	45.58	357.71	312.13
72_4061	1897033	5737008	20/01/2015	114.73	442.08	327.35
72_4511	1804181	5804113	2/02/2015	15.9		
72_4618	1887881	5741255	4/12/2014	38.95	348.31	309.36
72_4696	1802655	5802309	2/02/2015	19.59		
72_4797	1788347	5819611	9/02/2015	2.6		
72_6153	1893553	5730706	29/01/2015	13.3	316.23	302.93
72_6155	1890354	5730592	15/01/2015	2.5		
72_6501	1795053	5875574	9/04/2015	4.485		
72_7126	1826403	5800527	23/12/2014	4.42	90.90	86.48
72_7142	1818946	5843688	17/12/2014	4.36		
72_7156	1802508	5803470	2/02/2015	3.55		
72_7367	1826342	5795496	5/05/2015	28.65	106.90	78.25
72_7444	1793120	5820733	9/02/2015	3.18		
72_7774	1826051	5798580	28/01/2015	13.85		
72_7775	1823439	5800685	5/05/2015	46.55	79.30	32.75

72_7776	1822718	5801053	28/01/2015	60.34	80.37	20.03
72_7820	1837458	5776539	12/02/2015	10.59		
72_7821	1848567	5761853	5/05/2015	14.52	350.14	335.62
72_7834	1805340	5840374	17/02/2015	18.67		
72_7837	1810944	5831350	18/02/2015	6.58		
72_7838	1804692	5830232	18/02/2015	2.53		
72_7839	1827565	5777763	5/05/2015	50.54	180.69	130.15
72_7840	1807112	5839179	17/02/2015	12.65		
72_7842	1849970	5774931	12/02/2015	35.4	243.89	208.49
72_7844	1796283	5833584	17/02/2015	5.48		
72_7911	1830749	5779427	8/04/2015	1.93		
72_7912	1830737	5779426	8/04/2015	2.77		
72_7913	1830717	5779437	8/04/2015	2.31		
72_7919	1830747	5779425	8/04/2015	1.84		
72_7920	1833256	5787607	8/04/2015	3.43		
72_7921	1833275	5787602	8/04/2015	4.12		
72_7922	1833311	5787601	8/04/2015	4.75		
72_7943	1830496	5790512	5/05/2015	57.98	252.93	194.95
72_796	1886575	5738773	9/12/2014	14.77	360.50	345.73
72_7964	1887096	5737197	9/12/2015	14.77		
72_7981	1886604	5738147	30/04/2015	42.47	363.40	320.93
72_8016	1804404	5804234	2/02/2015	10.09		

7 Investigation of redox conditions

7.1 Method

Determining the distribution of anaerobic zones in groundwater is an important precursor to estimating the extent and distribution of denitrification. Previous investigation by the author (predominantly in the Lake Taupo catchment) and reported in literature (e.g. Korom, 1992), shows that nitrogen is essentially absent in anaerobic conditions below the redoxycline (where groundwater changes from aerobic to anaerobic condition). Rates of denitrification are influenced by the availability of electron donors and microbial populations to mediate the process. Investigation here, however, was limited to determining the depth to the redoxycline at selected sites.

Determining the depth to the redoxycline was achieved by drilling at selected sites and testing the core recovered using the Childs' test. Childs (1981) described the use of dipyridil in ammonium acetate solution as an indicator of ferrous iron in soils. This solution when sprayed onto drill core will produce a red colour in the presence of ferrous ions. Redox conditions in formation are often indicated by the oxidation state of iron with ferrous irons indicating anaerobic conditions. This testing also enables changes in redox condition to be accounted for in subsequent monitoring well design. Piezometers were construction to facilitate sampling to confirm groundwater chemistry.

7.2 Results

Drilling and piezometer construction was undertaken at four selected sites adjacent to the Upper Waikato hydro-lakes. At the Little Waipa Reserve (E1833678 N5792689) and Bulmer Landing (E1830696 N5779425) sites the redoxycline was found to be within four metres of the water table. The redoxycline was not encountered at the Epworth Park site (E1833427 N5791778) within the drilling depth of six metres below the water table. Similarly there was no redoxycline encountered at HoraHora Domain (E1796661 N5831635) within a depth of 11 m below the water table. An example drill log for monitoring well 72_7922 is provided in Figure 5.

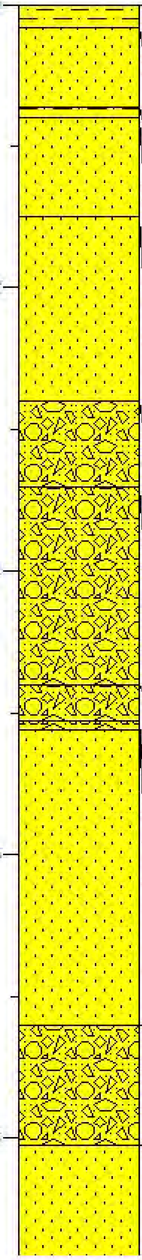
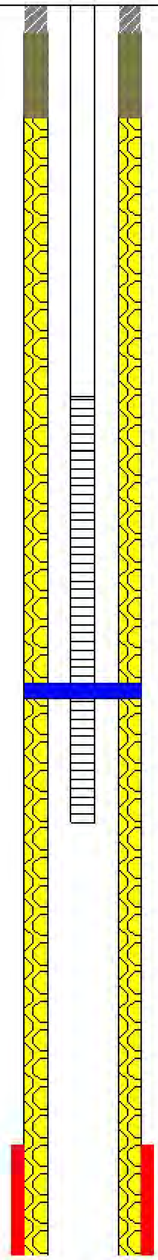
The opportunity was also taken to test core from 18 holes drilled in the Hamilton Basin for site investigation and monitoring purposes under the supervision of Opus International Consultants Ltd for Transit (NZ) Ltd. Although the depth to anaerobic conditions below the water table was highly variable (ranging up to 50 m), it occurred almost half the time within five metres. (doc 3411845).

Groundwater quality from the hydro-lakes and selected 'Transit' wells was also analysed. This confirmed that nitrate-nitrogen concentrations were either very low or non-detect where anaerobic conditions were indicated. The information gained regarding the redox conditions at the sites investigated was provided to collaborators to inform the consideration of denitrification within the respective sub-catchments.

ENVIRONMENT WAIKATO

3 Cook St
Hamilton East, NZ

Drillhole	72_7922 Little Waipa Reserve Inland	**Project**	River Transects
Map Reference	E1833678 N5792689	**Date Commenced**	24/3/2015
Location	Little Waipa Reserve	**Date Completed**	24/3/2015
Elevation	NA	**Contractor**	Brown Bros
Logged by	John Hadfield	**Rig**	Geoprobe

Depth (m)	Lithology	Lithologic Description	Formation	Well Construction	Additional Observation
0		0 - 0.16m Silt Loam: light brown, loose organic, soft	Tauranga Group		grout sealed and locked
		0.16 - 0.72 m Silty sand (ash): light yellow brown, pumiceous, very fine			
		0.72-0.8 m Slightly gravelly, sandy, silt: brown, slightly pumiceous, soft occ. rhyolite gravel to 10 mm, mod. rounded			bentonite seal 0.2 to 0.8 m
2		0.8 - 1.5 m Slightly gravelly sand: Light brown grey, predom. coarse to very coarse, occ. rhyolite gravels to 5 mm, mod. rounded, mod. sorted			
		1.5 - 2.8 m Slightly gravelly sand; very light grey & occ. tan iron stained, consistent, well sorted, mod. rounded, siliceous, minor grey lithic rhyolite			gravel pack 0.8 to 7 m 100 mm drill-hole
4		2.8 - 3.4 m Very sandy gravel; light fawn & common tan iron stained pumiceous, indistinct bedding, occ. lithic rhyolite, mod. sorted, mod. rounded, predom very coarse sand & gravel to 6 mm			
		4.8 - 5.05 m Very sandy gravel, light grey/cream & common tan iron stained, predom pumice to 30 mm, poor-mod rounded, mod sorted			
		4.8 - 5.05 m Gravelly sand; Light slightly yellow grey, siliceous ~40% pumice, occ. tan iron stained, v coarse with occ. gravel to 40 mm			SWL 4.8 m
6		5.05 - 5.12 Gravel; cream & tan, pumiceous iron stained, mod rounded			
		5.12 - 7.2 m Gravelly sand; light grey, pumiceous, gravels to 15 mm mod. rounded, consistent indistinct bedding, appearance of reworked ignimbrite			50 mm PVC screen from 2.77 to 5.79 m
		7.2 - 8.05 m Sandy gravel; light grey fresh pumice, occ. rounded, poor - mod. sorted (reworked ignimbrite)			
8		8.05 - 10.05 m Very gravelly sand; light grey pumiceous, fine to v coarse & gravels to 10 mm & occ. 40 mm, sub-mod. rounded, poorly sorted, heavy trace charcoal at 8.5 m			anaerobic (positive

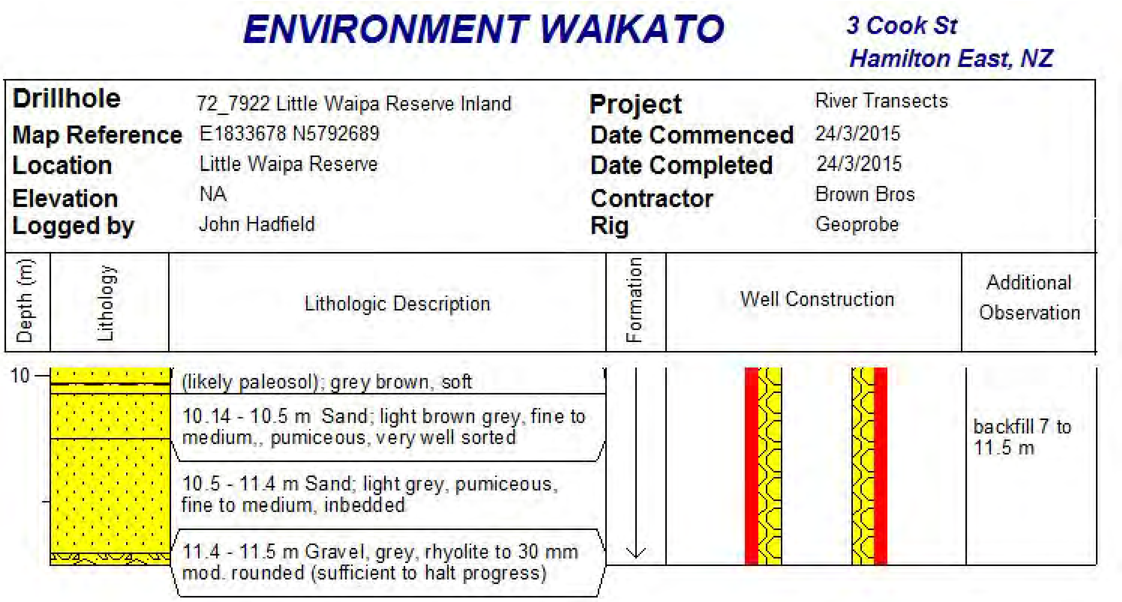


Figure 5: Example drill log from the Little Waipa Reserve (the vertical red lines indicates the presence of ferrous iron).

8 Radon

8.1 Method

Two surveys of radon concentration were undertaken to identify longitudinal groundwater inflows into the Pokaiwhenua and Little Waipa streams comprising ten sites along each stream (Figure 6). The Pokaiwhenua survey was undertaken on the 18th (first four sites) and 19th of March 2015. The Little Waipa survey was carried out on the 16th of April 2015.

Radon is a relatively dense, radioactive, colourless, odourless, tasteless noble gas, occurring naturally as the decay product of radium. Its most stable isotope, ^{222}Rn, has a half-life of 3.8 days. Atmospheric concentrations of radon are very low and it is readily volatilised from water on exposure to air. Radon is continuously produced by radioactive decay of ^{226}Rn present in formation and hence groundwater generally has higher concentrations of ^{222}Rn than surface water. It can therefore be used as a tracer of groundwater input to surface waters.

Given radon's short half-life, samples are required to be analysed within a few days. Samples were taken by submerging duplicate glass bottles underwater and expelling any air. The samples were sent to the GNS Science Ltd Water dating lab in Wellington for analysis. Radon is measured by liquid scintillation counting using Quantulus low-level counters. The presence of significant groundwater discharge is indicated by radon concentrations above c. 0.5 Bq L^{-1}. A higher radon concentration indicates a higher groundwater contribution. The detection limit for radon is approximately 0.1 Bq L^{-1}. The becquerel (symbol Bq) is defined as the activity of a quantity of radioactive material in which one nucleus decays per second.

Groundwater quality samples were taken at the same time for analyses by Hill Laboratories for a total of 22 determinands listed in Table 3. Temperature, conductivity and dissolved oxygen were also measured at each site, GPS location noted and a photograph taken (doc. 3325163). Flow was also gauged at selected locations on the Pokaiwhenua Stream. Some of the sites were also used for water age dating using tritium.

8.2 Results

The radon concentration results are presented in Tables 3 and 4. They are highly variable, ranging from non-detect to 5.4 Bq L^{-1} in the Pokaiwhenua and in the Little Waipa from 0.2 to 28.1 Bq L^{-1}. The highest two concentrations were from the Huihuitaha (trout hatchery) Spring and the Hodderville Spring. The results generally indicate discrete input of groundwater at specific locations (or springs). This reflects the importance of fracture flow contribution in these Upper Waikato catchments (doc 3341680). These streams are base-flow dominated and flow through catchments dominated by fractured ignimbrites.

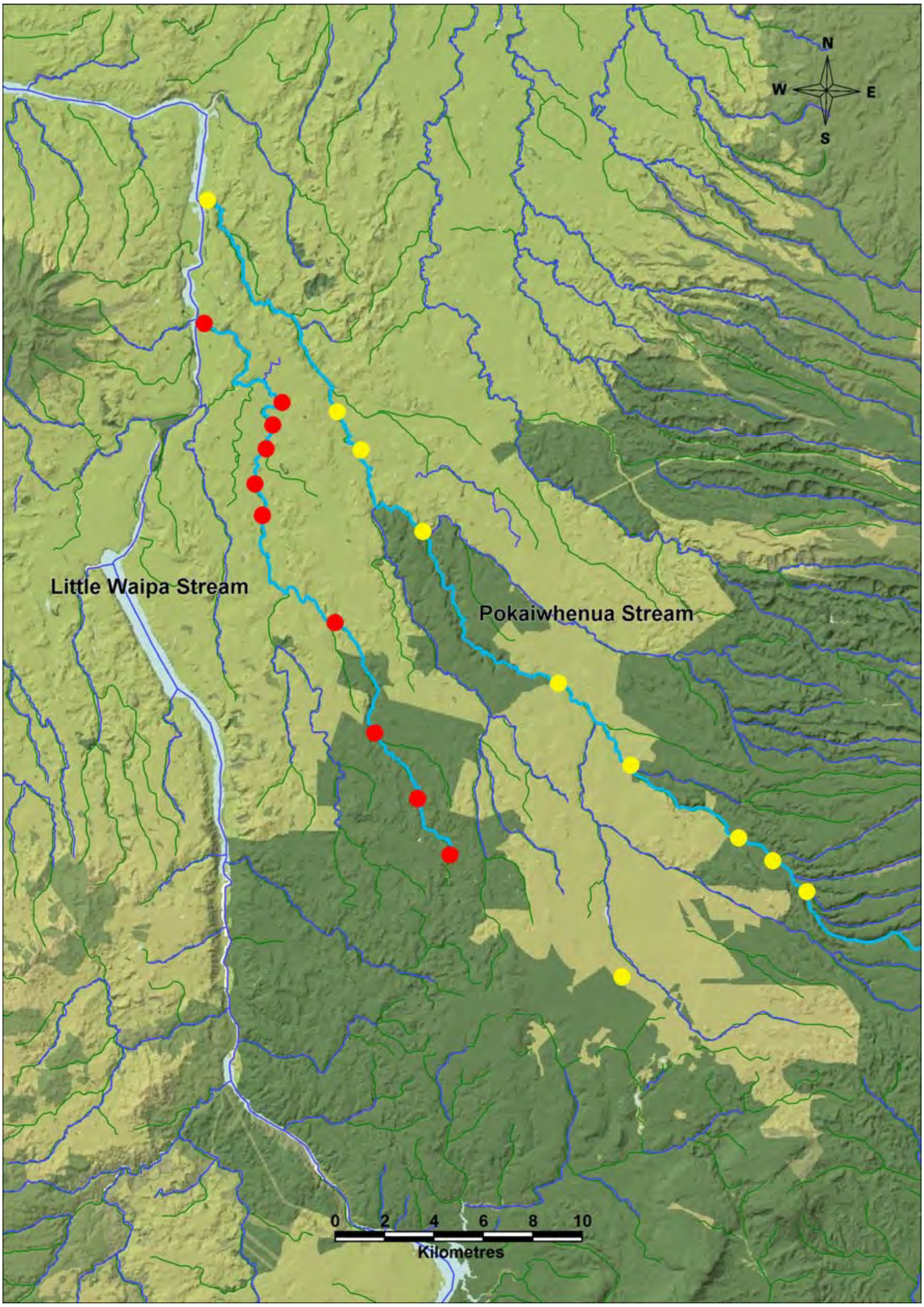


Figure 6: Radon survey sites on the Little Waipa and Pokaiwhenua Streams

Table 3: Radon and water quality analyses from the Pokaiwhenua Stream (units are mg l^{-1} unless otherwise specified)

Site	Key Rd	Shrew Rd	Weir	Bridge	SH1	Wiltsdown Rd	Mullaine Rd	Woutu Rd	Arapuni Rd	Mouth
Easting	E1850242	E1857633	E1856264	E1854911	E1850589	E1847710	E1842287	E1839802	E1838859	E1833678
Northing	N5761650	N5765046	N5766286	N5767198	N5770098	N5773384	N5779462	N5782695	N5784250	N5792689
Radon (Bq L^{-1})	**0.2**	**0.5**	**0.2**	**0.1**	**<0.1**	**<0.1**	**0.1**	**5.4**	**3.1**	**0.2**
Free Carbon Dioxide	2.2	2	4.6	3.6	1.6	1.7	1.4	5.4	2	2.6
Approx Total Dissolved Salts	42	45	44	44	43	67	74	72	69	72
Total Phosphorus	0.009	0.042	0.035	0.038	0.038	0.21	0.173	0.14	0.123	0.129
Chloride	5.8	5.2	5	5.1	5	7.8	9.1	8.6	8.6	8.9
Total Ammoniacal-N	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	0.011	< 0.010	0.012	< 0.010
Nitrate-N	0.06	0.24	0.3	0.29	0.28	1.47	2.1	1.71	1.48	1.6
Dissolved Reactive Phosphorus	< 0.004	0.03	0.026	0.024	0.024	0.17	0.145	0.106	0.088	0.099
Reactive Silica	41	56	60	59	59	55	53	59	59	59
Sulphate	< 0.5	0.6	0.8	0.8	1.1	3.3	3	2.5	3	2.4
pH (pH units)	7.4	7.4	7.1	7.2	7.5	7.6	7.6	7.1	7.5	7.4
Electrical conductivity (mS cm^{-1})	6.3	6.7	6.5	6.6	6.5	10.1	11.1	10.7	10.4	10.8
Total Alkalinity	25	26	28	26	25	30	30	31	31	31
Total Hardness	12.6	12.5	11.3	11.1	11.3	20	22	21	21	22
Total Boron	< 0.0053	0.0059	< 0.0053	0.006	0.0058	0.0107	0.0096	0.01	0.0101	0.0093
Total Calcium	2.7	2.5	2.4	2.4	2.4	4.7	5	4.4	4.4	4.6
Total Copper	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053
Total Iron	0.43	0.26	0.22	0.3	0.28	0.37	0.19	0.146	0.188	0.153
Total Magnesium	1.44	1.49	1.31	1.28	1.32	2.1	2.4	2.5	2.5	2.5
Total Manganese	0.025	0.0151	0.0126	0.0154	0.0125	0.021	0.0094	0.0083	0.0108	0.0098
Total Potassium	2.3	2.7	2.7	2.8	3	4.1	4	3.9	3.7	4.1
Total Sodium	7	7.7	7.5	7.5	7.9	12	12.2	12.3	11.7	12.7
Total Zinc	< 0.0011	0.0014	0.0012	0.0017	0.0014	0.0051	0.0023	0.0016	0.0014	0.0018
Flow (l s^{-1}) 18,19/03/2015	18	426		404	467	839	1522		2750	
Temperature ^{o}C	11.3	12.5	12.6	12.5	11.8	13.3	15.3	12.19	16.3	16.5
Conductivity (*u*S cm^{-1})	60.1	64.4	62.5	62	62.5	96.2	106.7	102.9	99.7	103.4
D.O. (mg L^{-1})	9.9	9.72	9.75	9.93	10.35	10.61	10.76	16.1	11.71	9.9

Table 4: Radon and water quality analyses from the Little Waipa Stream (from doc 3341680; units are mg l^{-1} unless otherwise specified)

Site	Mouth	Arapuni Rd	Pearson Rd	Old Taupo Rd	Hatchery Spring	Off Huihuitaha Rd	Hodderville Spring	Wiltsdown Rd	Plimmer Rd	Cole Rd
Site #	335_16	335_1	335_4	335_3	335_8	335_17	336_10	335_6	335_18	335_19
Easting	1833534	1836644	1836275	1836014	1835574	1835866	1838764	1840356	1842074	1843365
Northing	5787770	5784618	5783705	5782747	5781338	5780092	5775800	5771379	5768754	5766520
Radon (Bq L^{-1})	0.2	4.6	8.7	3.4	28.1	0.2	13.6	0.8	0.3	0.2
Free Carbon Dioxide	3.2	4.6	12	3.7	20	2.4	8.8	20	3.1	3.5
Approx Total Dissolved Salts	68	67	67	71	68	70	64	68	46	47
Chloride	8.5	8.4	8.2	9.6	7.5	10.1	7.5	7.5	8	8.2
Total Ammoniacal-N	0.011	0.015	0.017	< 0.01	< 0.01	< 0.01	<0.01	< 0.01	< 0.01	0.011
Nitrate-N	1.41	1.38	1.44	1.65	1.6	1.61	1.72	1.6	0.13	0.05
Dissolved Reactive Phosphorus	0.06	0.062	0.064	0.059	0.073	0.073	0.061	0.073	0.029	0.004
Reactive Silica	64	67	67	63	68	52	61	68	48	50
Sulphate	2.2	2	1.7	2.3	1.8	2.8	1.6	1.8	2.8	2.9
pH (pH units)	7.3	7.1	6.7	7.2	6.5	7.3	6.8	6.5	7	7
Electrical Conductivity (*m*S cm^{-1})	10.2	10	9.9	10.6	10.2	10.5	9.6	10.2	6.9	7
Total Alkalinity	29	29	29	28	31	26	28	31	17.4	17.7
Total Hardness	19.4	19	18.6	21	20	20	19.3	20	9.7	8.9
Total Boron	0.0081	0.0079	0.0084	0.009	0.0088	0.0092	0.0073	0.0088	0.0074	0.0081
Total Calcium	4	3.9	3.9	4.3	4.1	4.2	3.9	4.1	2.2	2.1
Total Copper	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	< 0.00053	<0.0053	< 0.00053	0.0006	< 0.00053
Dissolved Iron	0.05	0.04	0.03	0.08	< 0.02	0.12	<0.02	< 0.02	0.43	0.48
Total Iron	0.072	0.074	0.066	0.12	< 0.021	0.175	<0.021	< 0.021	1.59	2.1
Total Magnesium	2.3	2.2	2.1	2.5	2.4	2.4	2.3	2.4	1	0.91
Dissolved Manganese	0.0046	0.0036	0.0035	0.0045	< 0.0005	0.003	<0.0005	< 0.0005	0.0048	0.26
Total Manganese	0.0074	0.0061	0.0058	0.0068	< 0.00053	0.0063	<0.0053	< 0.00053	0.0159	0.34
Total Potassium	4.6	4.4	4.4	5	4	5.4	3.5	4	4.3	4.3

Site	Mouth	Arapuni Rd	Pearson Rd	Old Taupo Rd	Hatchery Spring	Off Huihuitaha Rd	Hodderville Spring	Wiltsdown Rd	Plimmer Rd	Cole Rd
Total Sodium	10.9	10.7	10.8	11.2	11.5	10.6	10.7	11.5	8.4	8.6
Total Zinc	< 0.0011	< 0.0011	< 0.0011	< 0.0011	< 0.0011	0.0011	< 0.0011	< 0.0011	0.0012	0.0014
TKN	0.15	0.12	0.14	0.21	< 0.05	0.37	<0.05	< 0.05	0.25	0.29
Turbidity	1.94	1.13	1.53	1.54	0.44	2.3	0.81	0.44	4.5	5.6
Temperature (^{o}C)	12.5	12.2	12.8	12.6	14.3	12.5	14.1	9.5	7.9	9
Conductivity (*u*S cm^{-1})	97.1	95.1	94.9	103	97.9	99.4	90.6	62	47.5	50
D.O. (mg L^{-1})	10.7	10.21	10.02	10.96	9.12	12.16	8.49	9.1	10.51	9.34
	~50m upstream of mouth	at bridge	~100m upstream of bridge	~50m upstream of bridge	at spring outlet	down race across bottom paddock	at spring rhs below p.s.			

There was a progressive increase in flow down the Pokaiwhenua and a noted degradation in water quality down-stream of Wiltsdown Rd (and Lichfield). The nitrate-nitrogen concentration, for example, increased from an average 0.23 mg l^{-1} above that point to 1.67 mg l^{-1} below. The water dating data showed the spring inflows to be of similar age as the streams reflecting baseflow domination of the latter. The estimated mean residence times (MRT) for the Huihuitaha Spring and Hodderville Spring were 60 and 35 years respectively. These compare with 31 years MRT for the Pokaiwhenua at Puketurua and 51 years MRT for the Little Waipa at Arapuni-Putararu Rd.

9 Water age

9.1 Method

Samples were collected from surface waters and springs for tritium analyses and from groundwater for tritium, chlorofluorcarbons (CFCs) and sulphur hexafluoride (SF_6). Tritium is naturally produced in the atmosphere by cosmic rays, but large amounts were also released into the atmosphere in the early 1960s during nuclear bomb tests, giving rain and surface water a high tritium concentration. Surface water becomes separated from the atmospheric tritium source when it infiltrates into the ground, and the tritium concentration in the groundwater then decreases over time due to radioactive decay. The tritium concentration in the groundwater is therefore a function of the time the water has been underground.

As a result of the atmospheric tritium "bomb" peak in the 60s, ambiguous ages can occur with single tritium determinations in the age range 15-40 years (i.e. the tritium concentration can indicate any of several possible groundwater ages). This ambiguity can be overcome in groundwater samples by using a second tritium determination after about 2-3 years, or combining the tritium data with CFC data. CFC concentrations in the atmosphere have risen linearly over that time.

CFCs are entirely man-made contaminants. They were used for refrigeration and pressurising aerosol cans, and concentrations in the atmosphere have gradually increased. CFCs are relatively long-lived and slightly soluble in water and therefore enter the groundwater systems during recharge. Their concentrations in groundwater record the atmospheric concentrations when the water was recharged, allowing determination of the recharge date of the water. CFCs are now being phased out of industrial use because of their destructive effects on the ozone layer. Thus rates of increase of atmospheric CFC concentrations slowed greatly in the 1990s, meaning that CFCs are not as effective for dating water recharged after 1990.

Tritium is a conservative tracer in groundwater. It is not affected by chemical or microbial processes, or by reactions between the groundwater, soil sediment and aquifer material. Tritium is a component of the water molecule and age information is therefore not distorted by any processes occurring underground. In CFC age interpretation, however, care has to be taken. A number of factors can modify CFC concentrations in the aquifer, including microbial degradation of CFCs in anaerobic environments (CFC-11 is more susceptible then CFC-12), and CFC contamination from local anthropogenic sources (CFC-12 is more susceptible to this. CFC ages do not take into account of travel time through unsaturated zones.

SF_6 is primarily anthropogenic and is stable in the atmosphere and groundwater. Manufacturing of SF_6 for electrical switches beginning in the 1960s resulted in steadily increasing atmospheric concentrations. Natural occurrences can occur in some volcanic fluids. SF6 is a useful tracer for post-1970s groundwater.

The sampling carried out for age dating was consistent with the GNS Water Dating Laboratory protocol. This included using specific bottles, generally excluding excess air and ensuring there were no effects on tritium results from fluorescent watches. Groundwater wells were purged before sampling as described in section. Analysis of tritium for age estimation is time consuming with results becoming available approximately three months after sampling. Tritium is measured by electrolytic enrichment and liquid scintillation counting using Quantulus low-level counters (Morgenstern & Taylor, 2009).

9.2 Results

A total of 21 surface water sites were sampled for tritium analysis from selected sub-catchments. The previous year 13 surface water samples from the Upper Waikato were analysed for tritium with only two being available before that. Groundwater was sampled from 25 wells and three springs (doc 3427209). The distribution of sites sampled is illustrated in Figure 7 below. The groundwater samples include 10 from wells in the Waipa catchment. Groundwater samples included those taken from either side of the redoxycline from two sites adjacent to the Waikato River south of Karapiro and one in the Hamilton Basin. The results and site locations (from doc. 3427209) are listed in Tables 5 and 6. For simplicity only the tritium results and estimated mean residence times (MRT) are tabulated. One TR (Tritium Ratio) corresponds to one tritium atom per 10^{18} hydrogen atoms. The radioactivity equivalent for one TR in one kg of water is 0.118 Bq. The detection limit is approximately 0.025 TR.

A combined exponential and piston flow model was used to estimate the MRT with input function from the Kaitoke record being used for tritium interpretation. The MRT estimates in the tables assumed 80% used was exponential flow.

Table 5: Surface water and spring age dating results

	Site No.	Easting	Northing	TR	MRT
Springs:					
Reporoa spring	1315_6	1887996	5746055	1.080	11
Huihuitaha Spring	336_2	1835518	5781410	0.480	60
Hodderville Spring	336_10	1838793	5775800	0.664	35
Surface Water:					
Whangapoa at confluence	1303_4	1868375	5752035	0.760	29
Orakonui at Ngatamariki	672_1	1876904	5731831		95
Pokaiwhenua at Puketurua	786-2	1838866	5784259	0.701	31
Waipa River	1191-10	1793489	5791255	1.200	6
Waipa River	1191-12	1793417	5770550	1.378	2
Kaniwhaniwha	222-16	1788267	5806351	1.051	9.5
Mangapu	443-3	1793118	5770149	1.141	7
Mangapiko	438-3	1799086	5794363	0.912	14
Mangaonua	421-10	1810258	5815986	0.970	12
Mangaone	417-7	1805661	5812778	0.896	15
Puniu	818-2	1801295	5788365	0.876	16
Waitomo	1253-5	1792015	5771848	1.277	4
Mangauika Stm	477-10	1787592	5788646	1.128	7
Mangaokewa Stm	414-6	1789636	5754541	1.091	8
Lake Waikare	326_10	1795485	5857672	1.350	2.5
Whakapipi	1282-8	1770704	5874826	0.868	16
Parker Lane	739_4	1769350	5875727	0.888	15
Mangatangi	453-6	1793779	5875482	1.185	6
Whangamarino	1293-9	1798066	5865561	1.016	10
Waikato at Rangariri	1131_117	1788389	5855059	1.012	10
Mangawara	481-7	1798115	5840673	0.920	14

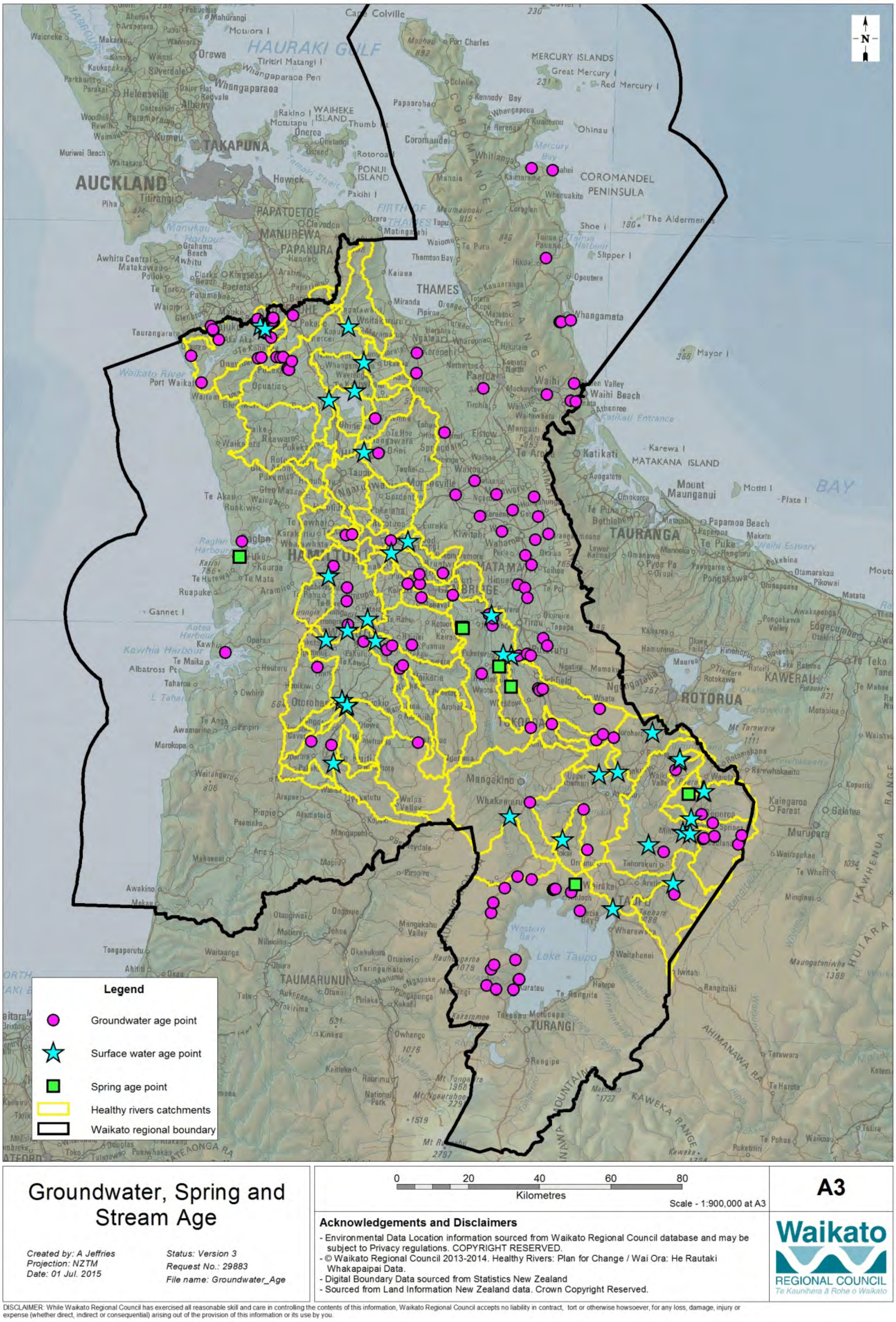


Figure 7: Water age dating sites

Table 6: Groundwater age dating results

Site No.	Well depth	Easting	Northing	TR	MRT
72_5034	38	1808894	5781614	0.021	>250
70_632	57.9	1793409	5799433	0.060	235
72_4014	24.6	1789678	5809205	0.082	225
72_6408	81	1793179	5817787	0.004	>250
72_5103	66	1798073	5788285	-0.013	>250
72_7021	31	1804441	5786117	0.272	120
72_5009	89	1813181	5760312	0.146	190
62_96	26	1794886	5818013	-0.009	>250
72_5433	30	1785192	5781194	1.012	11
71_3	26	1783525	5760572	1.026	10
61_54	19.8	1773105	5876816	0.939	13
61_245	14.5	1769666	5867027	1.257	4
70_526	5.82	1822687	5801166	1.599	2
72_7776	120	1822696	5801067	0.013	>250
61_280	23.2	1773947	5867124	1.008	10
72_7919	5.68	1830754	5779387	0.872	17
72_7911	2.79	1830734	5779408	1.496	5
72_7922	5.8	1833678	5792689	pending	pending
72_8065	12	1833678	5792688	pending	pending
70-1187	38.1	1814000	5800457	0.327	95
70-453	17.07	1813431	5806866	1.089	9
70-1164	74.3	1811400	5787379	0.173	165
69-1902	90.2	1801199	5850080	0.832	18
72_8099	23.5	1805583	5816309	pending	pending
72_8115	8.5	1805583	5816309	pending	pending

Apart from the Upper Waikato streams, the age of surface waters (expressed as mean residence time) are generally less than 15 years and average about 10. Upper Waikato sub-catchment streams are older with an average measured mean residence time of about 52 years (median 35 years; flow weighted mean of about 47 years). The Upper Waikato main stem water age is younger (about 12 years at Karapiro) due to the influence of Lake Taupo which provides two thirds of the flow.

The age of groundwater throughout the study area is highly variable with mean residence times often much older than surface waters (mean and median from the latest monitoring results of about 114 and 95 years (MRT) respectively. The mean and median of the previously available age analyses was about 68 and 48 years respectively (*n*=85). Although the relationship between groundwater age and depth is not significant (Figure 8), age is generally expected to increase with depth in a recharging regime. Similarly there is no simple linear relationship between age and nitrate-N concentration in wells. Typically, however, there is a wedge shaped distribution showing groundwater older than the significant development of farming is low in nitrogen, whereas younger groundwaters range in concentration dependent on land-use influence and attenuation.

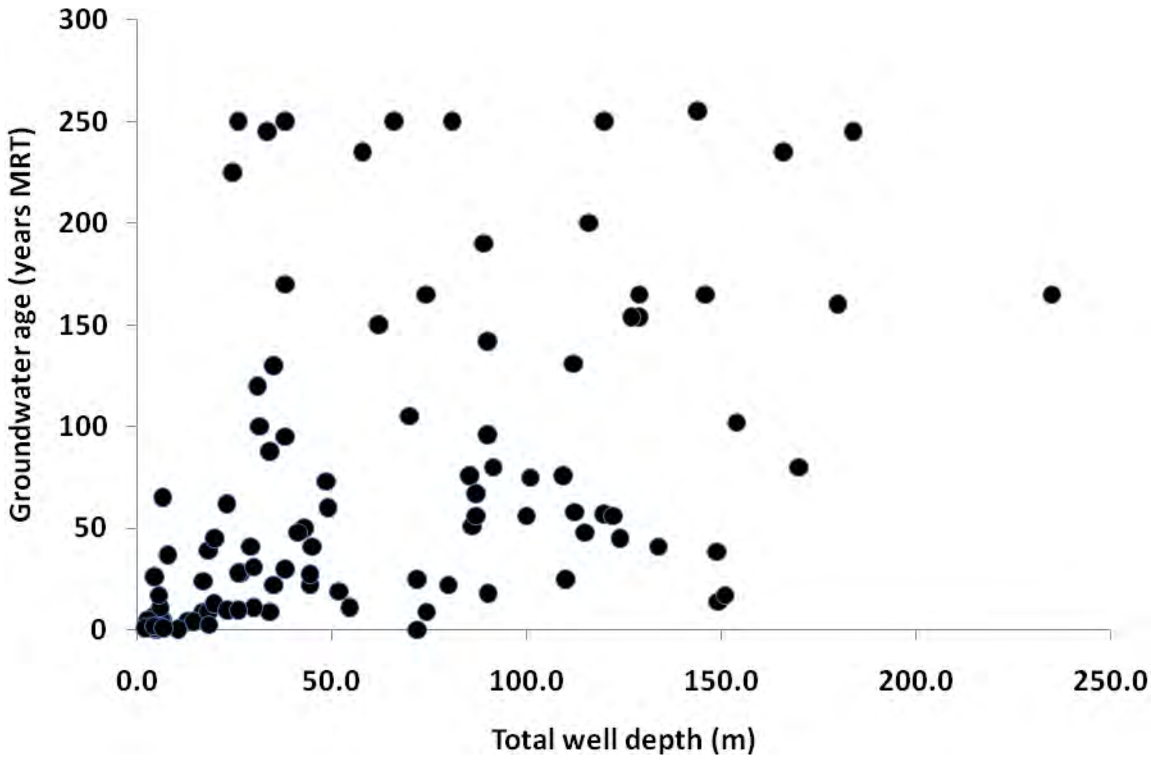


Figure 8: Groundwater age versus well depth for the Healthy Rivers area

The following Figure 9 shows the surface water ages measured within the Healthy Rivers area with the freshwater management units (FMUs) designated the project management group illustrated. Figure 9 similarly illustrates the measured groundwater ages with well depth indicated.

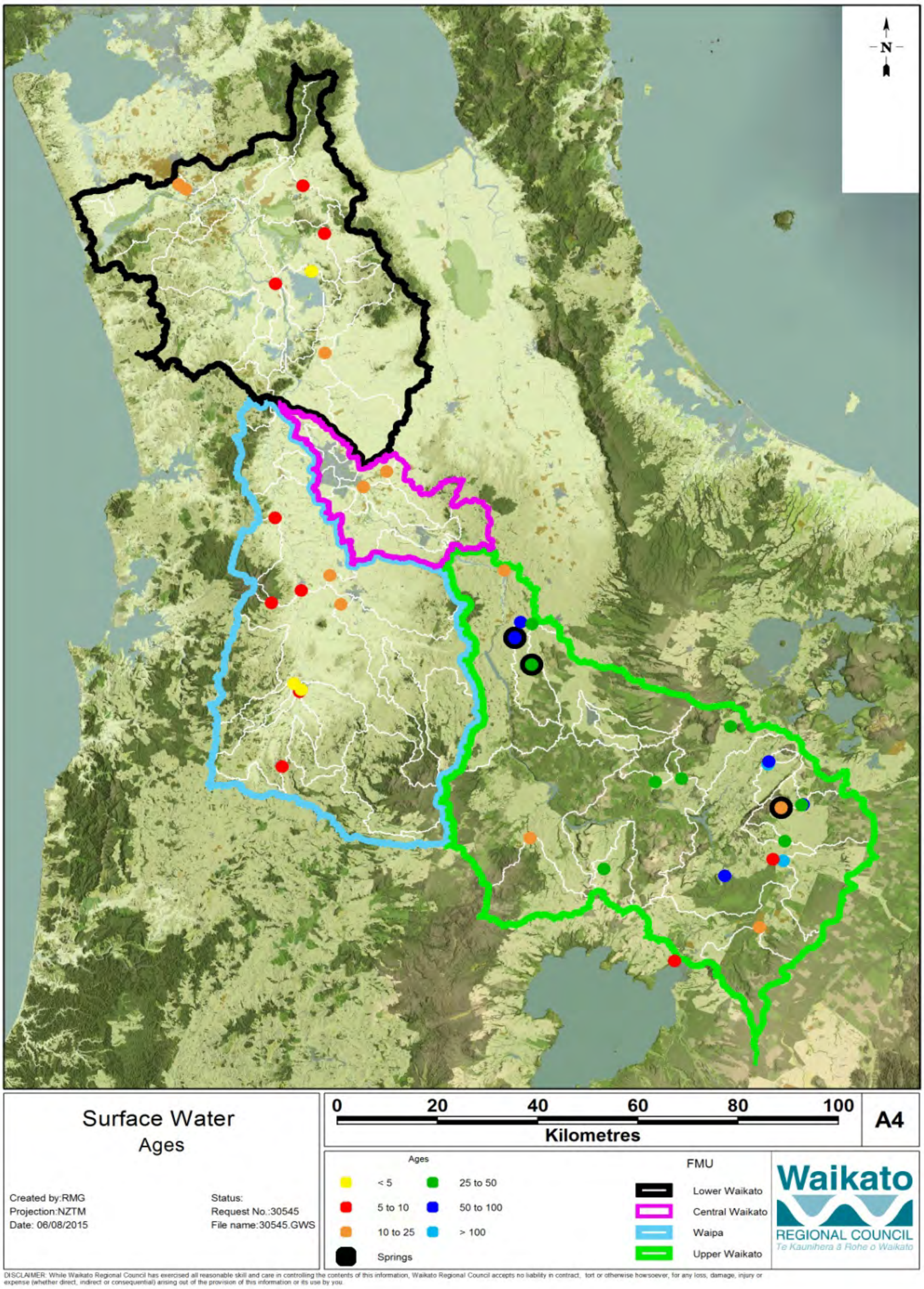


Figure 9: Surface water ages in the Healthy Rivers area

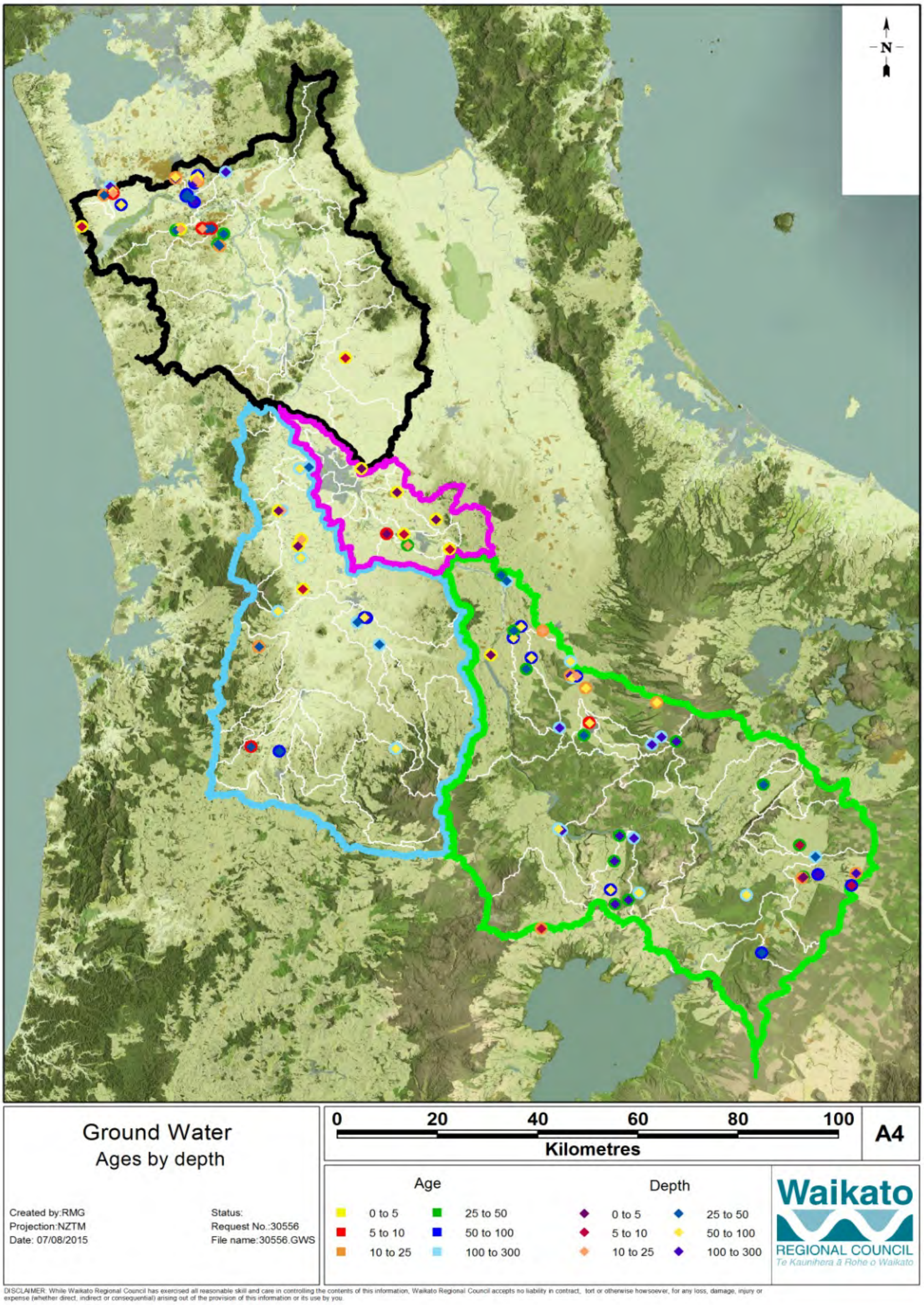


Figure 10: Groundwater age with well depths in the Healthy Rivers area

References

Rawlinson, Z, Riedi, M.A., Schaller, K., and Bekele, M., 2015. Short term field investigation of groundwater resources in the Waipa River Catchment January – April 2015. GNS Science Consultancy Report 2015/54.

Childs, C.W., 1981. Field tests for Ferrous Iron and Ferric-Organic Complexes (on Exchange Sites or in Water-soluble Forms) in Soils. *Australian Journal of Soil Research 19:175-180.*

Korom, S.F., 1992. Natural denitrification in the saturated zone: a review. Water Resources Research 28 (6), 1657–1668.

Appendix I: Flow confirmation survey results

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
WP1	Whatawhata-Pirongia	5/01/2015	11:30	1788634	5813054	N	0
WP2	Whatawhata-Pirongia	5/01/2015		1788535	5812893	N	0
WP3	Whatawhata-Pirongia	5/01/2015		1787850	5812191	M	65
WP4	Whatawhata-Pirongia	5/01/2015	12:30	1787966	5810002	M	1346
WP5	Whatawhata-Pirongia	5/01/2015		1788846	5807494	E	1
WP6	Whatawhata-Pirongia	5/01/2015	13:00	1788172	5805417	G	
WP7	Whatawhata-Pirongia	5/01/2015		1785675	5803802	E	0.4
WP8	Whatawhata-Pirongia	5/01/2015		1784952	5803660	G	
WP9	Whatawhata-Pirongia	5/01/2015		1784803	5803653	E	12
WP10	Whatawhata-Pirongia	5/01/2015		1784560	5803607	E	6
WP11	Whatawhata-Pirongia	5/01/2015		1784259	5803549	G	8
WP12	Whatawhata-Pirongia	5/01/2015	14:00	1783677	5803348	G	
WP13	Whatawhata-Pirongia	5/01/2015		1782929	5800101	G	
WP14	Whatawhata-Pirongia	5/01/2015	14:15	1783521	5800718	E	0.2
WP15	Whatawhata-Pirongia	5/01/2015		1785509	5800256	M	176
WP16	Whatawhata-Pirongia	5/01/2015		1786554	5801076	E	150
WP17	Whatawhata-Pirongia	5/01/2015		1786689	5801264	G	
WP18	Whatawhata-Pirongia	5/01/2015		1786979	5800994	E	0.25
WP19	Whatawhata-Pirongia	5/01/2015		1787514	5801009	E	4.5
WP20	Whatawhata-Pirongia	5/01/2015	16:00	1788154	5800421	E	0.3
WP21	Whatawhata-Pirongia	5/01/2015		1788462	5799892	E	6
WP22	Whatawhata-Pirongia	5/01/2015		1788433	5799559	G	approx 150
WP23	Whatawhata-Pirongia	5/01/2015	16:30	1788718	5799429	G	approx 200
WP24	Whatawhata-Pirongia	5/01/2015		1789850	5799162	G	approx 30-50
WP25	Whatawhata-Pirongia	5/01/2015		1791233	5798836	E	8
WP26	Whatawhata-Pirongia	5/01/2015		1791690	5798031	N	
KP1	Karakariki-Pirongia	6/01/2015	11.13	1785974	5819056	E	> 1
KP2	Karakariki-Pirongia	6/01/2015	11.27	1785858	5818731	M	228
KP3	Karakariki-Pirongia	6/01/2015	12.1	1786237	5817693	N	
KP4	Karakariki-Pirongia	6/01/2015	12.46	1785997	5816800	G	28
KP5	Karakariki-Pirongia	6/01/2015	12.53	1785848	5816078	N	
KP6	Karakariki-Pirongia	6/01/2015	15.59	1786276	5815500	N	
KP7	Karakariki-Pirongia	6/01/2015	13.03	1786422	5815318	E	1.1

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
KP8	Karakariki-Pirongia	6/01/2015	13.15	1786879	5814074	N	
KP9	Karakariki-Pirongia	6/01/2015	13.47	1792721	5796021	E	>1
KP10	Karakariki-Pirongia	6/01/2015	13.53	1792573	5795312	E	>10
KP11	Karakariki-Pirongia	6/01/2015	14.07	1793398	5793681	G	
KP12	Karakariki-Pirongia	6/01/2015	14.23	1792789	5791110	G	
KP13	Karakariki-Pirongia	6/01/2015	14.32	1792541	5791953	E	30-50
KP14	Karakariki-Pirongia	6/01/2015	14.49	1792523	5793738	G	
KP15	Karakariki-Pirongia	6/01/2015	14.56	1791551	5794686	M	224
OP1	Otorohanga-Pirongia	6/01/2015	11:45	1790687	5772487	G	
OP2	Otorohanga-Pirongia	6/01/2015	12	1790075	5772724	N	
OP3	Otorohanga-Pirongia	6/01/2015	12:15	1788849	5773583	U	
OP4	Otorohanga-Pirongia	6/01/2015	12:30	1788299	5774662	G	
OP5	Otorohanga-Pirongia	6/01/2015	12:33	1787362	5774709	G	
OP6	Otorohanga-Pirongia	6/01/2015	13:11	1785698	5775547	E	1
OP7	Otorohanga-Pirongia	6/01/2015	13:23	1785476	5775407	G	
OP8	Otorohanga-Pirongia	6/01/2015	13:40	1786974	5775968	G	
OP9	Otorohanga-Pirongia	6/01/2015	13:45	1787528	5777747	U	
OP10	Otorohanga-Pirongia	6/01/2015	14:00	1789577	5781799	G	
OP11	Otorohanga-Pirongia	6/01/2015	14:13	1786914	5780823	U	
OP12	Otorohanga-Pirongia	6/01/2015	14:25	1785700	5781299	U	
OP13	Otorohanga-Pirongia	6/01/2015	15:07	1790096	5786415	U	
OP14	Otorohanga-Pirongia	6/01/2015	15:13	1791206	5787260	N	
OP15	Otorohanga-Pirongia	6/01/2015	15:19	1791502	5787605	G	
OW1	Otorohanga-Waitomo caves	7/01/2015	11:24	1791035	5770793	N	
OW2	Otorohanga-Waitomo caves	7/01/2015	11:33	1789928	5769630	G	
OW3	Otorohanga-Waitomo caves	7/01/2015	11:38	1790781	5770030	N	
OW4	Otorohanga-Waitomo caves	7/01/2015	11:43	1790656	5770308	E	0.7 (approx)
OW5	Otorohanga-Waitomo caves	7/01/2015	12:11	1788111	5768659	E	0.25
OW6	Otorohanga-Waitomo caves	7/01/2015	12:20	1785720	5766975	E	9
OW7	Otorohanga-Waitomo caves	7/01/2015	12:44	1785628	5766355	N	
OW8	Otorohanga-Waitomo caves	7/01/2015	12:50	1785434	5765997	G	
OW9	Otorohanga-Waitomo caves	7/01/2015	12:55	1785185	5763881	G	
TKO1	Te Kuiti- Otorohanga	7/01/2015	11:40	1787297	5756037	E	0.45
TKO2	Te Kuiti- Otorohanga	7/01/2015	12:10	1787722	5756549	E	
TKO3	Te Kuiti- Otorohanga	7/01/2015	12:15	1787551	5756692	N	
TKO4	Te Kuiti- Otorohanga	7/01/2015	12:20	1787475	5756808	N	
TKO5	Te Kuiti- Otorohanga	7/01/2015	12:24	1786196	5757575	E	0.5
TKO6	Te Kuiti- Otorohanga	7/01/2015	12:34	1786003	5757458	N	

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s⁻¹
TKO7	Te Kuiti- Otorohanga	7/01/2015	12:50	1785240	5758143	G	
TKO8	Te Kuiti- Otorohanga	7/01/2015	12:58	1784070	5759004	E	2
TKO9	Te Kuiti- Otorohanga	7/01/2015	13:09	1783949	5759768	E	0.5
TKT1	Te Kuiti- Tahaia bush rd. Group 1	7/01/2015	14:12	1793955	5754954	G	
TKT2	Te Kuiti- Tahaia bush rd. Group 1	7/01/2015	14:30	1796075	5755008	E	0.2
TKT3	Te Kuiti- Tahaia bush rd. Group 1	7/01/2015	14:35	1797206	5755834	E	0.1
TKT4	Te Kuiti- Tahaia bush rd. Group 1	7/01/2015	14:38	1797303	5756730	G	
TKT5	Te Kuiti- Tahaia bush rd. Group 1	7/01/2015	14:50	1797390	5757363	E	0.4
TKT6	Te Kuiti- Tahaia bush rd. Group 1	7/01/2015	14:58	1797981	5759032	G	
TKT7	Te Kuiti- Tahaia bush rd. Group 2	7/01/2015	14:06	1791568	5755146	N	
TKT8	Te Kuiti- Tahaia bush rd. Group 2	7/01/2015	14:17	1795385	5754752	E	0.1
TKT9	Te Kuiti- Tahaia bush rd. Group 2	7/01/2015	14:30	1796429	5755251	N	
TKT10	Te Kuiti- Tahaia bush rd. Group 2	7/01/2015	14:34	1797275	5756103	E	0.02
TKT11	Te Kuiti- Tahaia bush rd. Group 2	7/01/2015	14:43	1797310	5756974	E	0.6
TKT12	Te Kuiti- Tahaia bush rd. Group 2	7/01/2015	14:55	1797723	5758428	E	0.1
TKT13	Te Kuiti- Tahaia bush rd. Group 2	7/01/2015	15:03	1798725	5759617	G	
TATK1	Te Awamutu- Te Kuiti	9/01/2015	10:04	1806495	5792438	G	
TATK2	Te Awamutu- Te Kuiti	9/01/2015	10:10	1806678	5792549	N	
TATK3	Te Awamutu- Te Kuiti	9/01/2015	10:12	1806829	5792549	N	
TATK4	Te Awamutu- Te Kuiti	9/01/2015	10:18	1807244	5793127	N	
TATK5	Te Awamutu- Te Kuiti	9/01/2015	10:24	1809456	5793164	N	
TATK6	Te Awamutu- Te Kuiti	9/01/2015	10:29	1810387	5792857	G	
TATK7	Te Awamutu- Te Kuiti	9/01/2015	10:35	1810482	5791745	G	
TATK8	Te Awamutu- Te Kuiti	9/01/2015	10:48	1813258	5790871	G	
TATK9	Te Awamutu- Te Kuiti	9/01/2015	11:02	1815550	5785975	E	7
TATK10	Te Awamutu- Te Kuiti	9/01/2015	11:14	1815532	5784860	G	
TATK11	Te Awamutu- Te Kuiti	9/01/2015	11:20	1815045	5784334	E	9
TATK12	Te Awamutu- Te Kuiti	9/01/2015	12:00	1813510	5781765	E	
TATK13	Te Awamutu- Te Kuiti	9/01/2015	12:16	1813604	5780421	G	
TATK14	Te Awamutu- Te Kuiti	9/01/2015	12:34	1816244	5779745	N	
TATK15	Te Awamutu- Te Kuiti	9/01/2015	12:38	1816936	5779745	N	
TATK16	Te Awamutu- Te Kuiti	9/01/2015	12:40	1817533	5779605	N	
TATK17	Te Awamutu- Te Kuiti	9/01/2015	13:00	1819901	5775005	G	
TATK18	Te Awamutu- Te Kuiti	9/01/2015	13:10	1818730	5775101	E	25
TATK19	Te Awamutu- Te Kuiti	9/01/2015	13:15	1817239	5774059	N	
TATK20	Te Awamutu- Te Kuiti	9/01/2015	13:24	1817208	5774059	E	6.8
TATK21	Te Awamutu- Te Kuiti	9/01/2015	13:34	1817344	5772918	E	1.2
TATK22	Te Awamutu- Te Kuiti	9/01/2015	13:37	1817555	5772618	U	

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate $l\ s^{-1}$
TATK23	Te Awamutu- Te Kuiti	9/01/2015	13:44	1818411	5771520	N	
TATK24	Te Awamutu- Te Kuiti	9/01/2015	13:52	1817964	5768082	N	
TKTA1	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	10.38	1800056	5760067	E	1
TKTA2	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	10.46	1800340	5759635	E	0.28
TKTA3	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	10.56	1800905	5758701	N	
TKTA4	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	11.18	1802291	5765271	N	
TKTA5	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	11.30	1804079	5763301	E	10
TKTA6	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	11.45	1805389	5761354	E	12
TKTA7	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	11.58	1805349	5760859	N	
TKTA8	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.01	1805464	5760621	N	
TKTA9	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.03	1805640	5760335	E	49.5
TKTA10	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.09	1805873	5760163	G	
TKTA11	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.15	1806973	5759614	G	
TKTA12	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.20	1808666	5759596	G	
TKTA13	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.31	1810158	5761287	E	1-2
TKTA14	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.43	1810297	5763066	E	200
TKTA15	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	12.55	1810189	5765178	E	512.5
TKTA16	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.08	1811770	5765848	E	150
TKTA17	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.13	1812169	5766087	E	20
TKTA18	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.21	1812946	5766263	N	
TKTA19	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.27	1813331	5766264	G	
TKTA20	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.32	1813441	5766880	N	
TKTA21	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.37	1814941	5769695	E	40
TKTA22	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.43	1815186	5769901	G	
TKTA23	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.50	1816796	5769617	E	
TKTA24	Te Kuiti (start bush rd)- Te Awamutu	9/01/2015	1.54	1816917	5769373	E	40
HP1	Hamilton- Paterangi	9/01/2015	1355	1793644	5810488	E	
HP2	Hamilton- Paterangi	9/01/2015	1405	1793414	5810487	E	<1
HP3	Hamilton- Paterangi	9/01/2015	1407	1792741	5810501	E	1-2
HP4	Hamilton- Paterangi	9/01/2015	1420	1791347	5810727	N	
HP5	Hamilton- Paterangi	9/01/2015	1430	1791382	5809749	N	
HP6	Hamilton- Paterangi	9/01/2015	1435	1791544	5809561	N	
HP7	Hamilton- Paterangi	9/01/2015	1450	1792838	5807481	E	10-15
HP8	Hamilton- Paterangi	9/01/2015	1500	1792919	5807155	G	~30
HP9	Hamilton- Paterangi	9/01/2015	1505	1793137	5805479	E	<10
HP10	Hamilton- Paterangi	9/01/2015	1510	1793600	5804409	N	
HP11	Hamilton- Paterangi	9/01/2015	1520	1793868	5803781	E	<10
HP12	Hamilton- Paterangi	9/01/2015	1535	1794352	5801519	E	10-20

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
HP13	Hamilton- Paterangi	9/01/2015	1545	1794496	5801326	G	
HP14	Hamilton- Paterangi	9/01/2015	1550	1794570	5800863	N	
HP15	Hamilton- Paterangi	9/01/2015	1555	1795630	5800173	E	<1
HP16	Paterangi -Te Awamutu	12/01/2015	1029	1804305	5791440	G	
HP17	Paterangi -Te Awamutu	12/01/2015	1039	1084615	5790708	G	
WGM1	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1122	1790147	5815381	E	6
WGM2	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1130	1789363	5816708	G	
WGM3	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1138	1781601	5817075	N	
WGM4	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1145	1787636	5818268	E	<10
WGM5	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1151	1787783	5819078	N	
WGM6	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1157	1787738	5820252	N	
WGM7	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1206	1787705	5820884	E	<1
WGM8	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1209	1788038	5821347	N	
WGM9	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1225	1787469	5823146	G	~60
WGM10	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1238	1789722	5825326	N	
WGM11	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1245	1789651	5825810	N	
WGM12	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1251	1789612	5826780	E	<5
WGM13	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1256	1789955	5827561	N	
WGM14	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1323	1787687	5827236	E	<2
WGM15	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1337	1787257	5826969	E	<1
WGM16	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1338	1787275	5826982	E	<1
WGM17	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1342	1786472	5826987	N	
WGM18	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1346	1786391	5826966	N	
WGM19	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1350	1786220	5826945	E	12
WGM20	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1402	1785899	5827153	E	<1
WGM21	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1413	1785593	5827253	E	6
WGM22	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1417	1785392	5827512	E	1.5
WGM23	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1426	1785256	5828019	E	60
WGM24	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1440	1784608	5828102	G	40 (estimate)
WGM25	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1445	1783359	5828464	E	<10
WGM26	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1455	1782706	5828411	E	<5
WGM27	Whatawhata-Ngaruawahia-Glen Massey	12/01/2015	1457	1782400	5828363	G	20 (estimate)
HCH1	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	12:22	1806555	5809129	U	
HCH2	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	12:38	1811479	5803585	G	
HCH3	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	13:13	1826026	5800881	E	130
HCH4	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	13:24	1826928	5803257	N	
HCH5	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	13:29	1827120	5803545	E	0.54
HCH6	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	13:40	1827532	5804001	N	

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
HCH7	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	14:00	1828151	5808020	G	
HCH8	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	14:05	1828099	5808638	E	30
HCH9	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	14:08	1827894	5809052	E	10
HCH10	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	14:23	1822304	5806275	E	1
HCH11	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	14:28	1821144	5805640	E	3
HCH12	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	14:51	1814064	5813118	E	45
HCH13	Hamilton-Karapiro-Taupiri-Matangi-Hamilton	12/01/2015	15:00	1810192	5815883	G	
HCH14	Hamilton-Karapiro (re-visited)	27/01/2015	11:12	1805843	5803582	E	200
HCH15	Hamilton-Karapiro (re-visited)	27/01/2015	11:37	1805843	5806010	N	
HCH16	Hamilton-Karapiro (re-visited)	27/01/2015	11:47	1805889	5807354	N	
HGTTH1	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:00	1807368	5821546	N	
HGTTH2	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:03	1806709	5822412	N	
HGTTH3	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:10	1806709	5824743	E	80
HGTTH4	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:19	1804723	5826758	G	
HGTTH5	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:27	1802588	5829346	E	30
HGTTH6	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:33	1802400	5830119	G	
HGTTH7	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:36	1802619	5830880	E	8
HGTTH8	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:44	1805022	5833192	E	60
HGTTH9	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	10:55	1808451	5036516	E	100
HGTTH10	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	11:00	1811057	5837224	N	
HGTTH11	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	11:05	1811251	5838623	N	
HGTTH12	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	11:35	1814270	5842710	N	
HGTTH13	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	11:48	1814573	5843411	N	
HGTTH14	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	11:50	1814617	5843934	N	
HGTTH15	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	11:52	1814611	5844147	E	30
HGTTH16	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	11:54	1814606	5844481	E	40
HGTTH17	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:04	1814430	5845634	G	
HGTTH18	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:10	1813955	5845563	N	
HGTTH19	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:13	1812022	5844854	E	80
HGTTH20	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:21	1810883	5845260	N	
HGTTH21	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:24	1810558	5845255	N	
HGTTH22	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:27	1810030	5845021	N	
HGTTH23	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:30	1809589	5845015	N	
HGTTH24	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:33	1809295	5845125	N	
HGTTH25	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:39	1809033	5845219	N	
HGTTH26	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:41	1808072	5845569	N	
HGTTH27	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:43	1807594	5845705	E	300
HGTTH28	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:48	1805598	5845754	G	

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s[-1]
HGTTH29	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:53	1806628	5844298	G	
HGTTH30	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	12:55	1806932	5843898	E	2
HGTTH31	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:07	1804090	5840847	N	
HGTTH32	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:14	1803346	5840930	G	
HGTTH33	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:23	1799923	5839707	E	180
HGTTH34	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:33	1794932	5836959	E	1
HGTTH35	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:39	1794036	5835608	N	
HGTTH36	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:42	1793568	5835192	U	
HGTTH37	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:48	1795375	5833902	U	
HGTTH38	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:55	1795760	5833232	N	
HGTTH39	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:55	1795760	5833232	E	240
HGTTH40	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	13:59	1795553	5833102	N	
HGTTH41	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	14:02	1795471	5833056	N	
HGTTH42	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	14:17	1797217	5824643	E	150
HGTTH43	Hamilton-Gordonton-Te Hoe-Taupiri-Hamilton	13/01/2015	14:19	1797035	5823980	N	10
HK1	Huntly-Kopuku	14/01/2015	10:34	1793160.3	5846312.6	E	0.6
HK2	Huntly-Kopuku	14/01/2015	10:44	1794300.2	5846530.6	E	
HK3	Huntly-Kopuku	14/01/2015	10:48	1794516.2	5846530.9	E	0.5
HK4	Huntly-Kopuku	14/01/2015	10:52	1794723.2	5846561.3	E	0.2
HK5	Huntly-Kopuku	14/01/2015	10:55	1795202.8	5846860.1	E	
HK6	Huntly-Kopuku	14/01/2015	11:03	1796400.5	5847748.4	E	0.0125
HK7	Huntly-Kopuku	14/01/2015	11:11	1796748	5849266.2	N	
HK8	Huntly-Kopuku	14/01/2015	11:17	1797999.2	5849263.4	U	
HK9	Huntly-Kopuku	14/01/2015	11:20	1799162.9	5849582.4	N	
HK10	Huntly-Kopuku	14/01/2015	12:00	1800533.1	5849612.8	N	
HK11	Huntly-Kopuku	14/01/2015	12:03	1801194.3	5850206.1	N	
HK12	Huntly-Kopuku	14/01/2015	12:07	1802046.2	5850945.7	N	
HK13	Huntly-Kopuku	14/01/2015	12:08	1203045	5850233	N	0.05
HK14	Huntly-Kopuku	14/01/2015	12:10	1802444.9	5851713.5	N	
HK15	Huntly-Kopuku	14/01/2015	12:14	1802572.5	5851979.8	N	
HK16	Huntly-Kopuku	14/01/2015	12:17	1802735	5852882.3	E	0.2
HK17	Huntly-Kopuku	14/01/2015	12:26	1802845.2	5853926.7	G	
HK18	Huntly-Kopuku	14/01/2015	12:30	1803375.4	5854461.8	N	
HK19	Huntly-Kopuku	14/01/2015	12:33	1803272.4	5854461.6	N	
HK20	Huntly-Kopuku	14/01/2015	12:34	1803168.5	5854946.5	G	
HK21	Huntly-Kopuku	14/01/2015	12:38	1803424.2	5855723.2	N	
HK22	Huntly-Kopuku	14/01/2015	12:40	1803659.6	5856083.6	E	12
HK23	Huntly-Kopuku	14/01/2015	12:47	1803689.5	5856167.7	E	2

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
HK24	Huntly-Kopuku	14/01/2015	12:49	1803658.7	5856618.8	U	
HK25	Huntly-Kopuku	14/01/2015	12:51	1803568.1	5856923.7	N	
HK26	Huntly-Kopuku	14/01/2015	12:55	1803430.3	5857376.5	G	
HK27	Huntly-Kopuku	14/01/2015	12:55	1803095.4	5858394.2	N	
HK28	Huntly-Kopuku	14/01/2015	12:56	1803009.5	5858873.1	N	
HK29	Huntly-Kopuku	14/01/2015	12:57	1802736.5	5859985.9	G	
HK30	Huntly-Kopuku	14/01/2015	13:07	1802202.7	5861510.3	N	
HK31	Huntly-Kopuku	14/01/2015	13:10	1801697.3	5861654.4	U	
HK32	Huntly-Kopuku	14/01/2015	13:30	1796328.5	5863201.1	N	
HK33	Huntly-Kopuku	14/01/2015	13:33	1796051.5	5863197.6	N	
HK34	Huntly-Kopuku	14/01/2015	13:38	1794577.5	5864171.2	E	8
HK35	Huntly-Kopuku	14/01/2015	13:40	1793770.9	5863850.7	E	3
HK36	Huntly-Kopuku	14/01/2015	13:43	1793366.4	5864643.1	G	
HK37	Huntly-Kopuku	14/01/2015	13:47	1793155.2	5865329.8	E	1
HK38	Huntly-Kopuku	14/01/2015	13:54	1792566.5	5866752	N	
HK39	Huntly-Kopuku	14/01/2015	13:56	1792119.9	5868140.4	N	
HK40	Huntly-Kopuku	14/01/2015	14:03	1792373.6	5871674.4	U	
NgN1	Ngaruawahia-Naike (via Huntly)	14/01/2015	10:17	1789022	5829357	G	
NgN2	Ngaruawahia-Naike (via Huntly)	14/01/2015	10:31	1788996	5830353	E	0.6
NgN3	Ngaruawahia-Naike (via Huntly)	14/01/2015	10:43	1789161	5830715	E	3
NgN4	Ngaruawahia-Naike (via Huntly)	14/01/2015	10:56	1789267	5831044	E	3
NgN5	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:11	1789799	5832379	G	
NgN6	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:23	1790297	5832818	N	
NgN7	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:26	1791176	5833251	E	<1
NgN8	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:31	1791492	5833438	E	1-2
NgN9	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:41	1791646	5833565	E	<1
NgN10	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:48	1791713	5833636	N	
NgN11	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:51	1792145	5834041	N	
NgN12	Ngaruawahia-Naike (via Huntly)	14/01/2015	11:58	1790872	5836182	E	2.5
NgN13	Ngaruawahia-Naike (via Huntly)	14/01/2015	12:16	1790388	5836623	G	
NgN14	Ngaruawahia-Naike (via Huntly)	14/01/2015	12:23	1790295	5837449	N	
NgN15	Ngaruawahia-Naike (via Huntly)	14/01/2015	12:35	1790080	5839313	E	1-2
NgN16	Ngaruawahia-Naike (via Huntly)	14/01/2015	12:47	1788158	5838911	N	
NgN17	Ngaruawahia-Naike (via Huntly)	14/01/2015	12:54	1786939	5838417	N	
NgN18	Ngaruawahia-Naike (via Huntly)	14/01/2015	1:00	1786879	5838383	G	
NgN19	Ngaruawahia-Naike (via Huntly)	14/01/2015	1:06	1786498	5838044	N	
NgN20	Ngaruawahia-Naike (via Huntly)	14/01/2015	1:13	1785949	5838116	E	2-4
NgN21	Ngaruawahia-Naike (via Huntly)	14/01/2015	1:20	1785427	5838026	N	

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
NgN22	Ngaruawahia-Naike (via Huntly)	14/01/2015	1:30	1784869	5838007	N	
NgN23	Ngaruawahia-Naike (via Huntly)	14/01/2015	1:56	1784490	5837756	G	
NgN24	Ngaruawahia-Naike (via Huntly)	14/01/2015	2:13	1787302	5843615	N	
NgN25	Ngaruawahia-Naike (via Huntly)	14/01/2015	2:21	1753332	5843510	N	
NgN26	Ngaruawahia-Naike (via Huntly)	14/01/2015	2:26	1780956	5844186	G	
NgN27	Ngaruawahia-Naike (via Huntly)	14/01/2015	2:37	1781243	5845467	G	
NgN28	Ngaruawahia-Naike (via Huntly)	14/01/2015	2:52	1779169	5846663	G	
NgN29	Ngaruawahia-Naike (via Huntly)	14/01/2015	2:57	1778856	5846767	N	
NgN30	Ngaruawahia-Naike (via Huntly)	14/01/2015	3:05	1777427	5844056	E	7
NgN31	Ngaruawahia-Naike (via Huntly)	14/01/2015	3:29	1772718	5843693	G	
NgN32	Ngaruawahia-Naike (via Huntly)	14/01/2015	3:33	1772470	5844548	G	
NgN33	Ngaruawahia-Naike (via Huntly)	14/01/2015	3:37	1772460	5844732	E	5
KM1	Kopuku-Mangatawhiri	15/01/2015	12:37	1796122	5875530	N	
KM2	Kopuku-Mangatawhiri	15/01/2015	12:44	1797451	5875083	N	
KM3	Kopuku-Mangatawhiri	15/01/2015	12:46	1798293	5874647	N	
KM4	Kopuku-Mangatawhiri	15/01/2015	12:48	1799046	5875257	G	
KM5	Kopuku-Mangatawhiri	15/01/2015	12:51	180006	5875602	N	
KM6	Kopuku-Mangatawhiri	15/01/2015	12:57	1800004	5875803	N	
KM7	Kopuku-Mangatawhiri	15/01/2015	12:58	1799877	5876250	N	
KM8	Kopuku-Mangatawhiri	15/01/2015	12:59	1799857	5876312	N	
KM9	Kopuku-Mangatawhiri	15/01/2015	13:01	1799332	5877418	N	
KM10	Kopuku-Mangatawhiri	15/01/2015	13:02	1799223	5877496	N	
KM11	Kopuku-Mangatawhiri	15/01/2015	13:03	1799186	5877526	N	
KM12	Kopuku-Mangatawhiri	15/01/2015	13:04	1799100	5877592	N	
KM13	Kopuku-Mangatawhiri	15/01/2015	13:07	1797808	5878399	U	
KM14	Kopuku-Mangatawhiri	15/01/2015	13:15	1797284	5878543	N	
KM15	Kopuku-Mangatawhiri	15/01/2015	13:18	1795975	5879295	N	
KM16	Kopuku-Mangatawhiri	15/01/2015	13:23	1796095	5879741	E	240
KM17	Kopuku-Mangatawhiri	15/01/2015	13:25	1796337	5880492	N	
KM18	Kopuku-Mangatawhiri	15/01/2015	13:27	1796085	5880566	N	
KM19	Kopuku-Mangatawhiri	15/01/2015	13:32	1794162	5879868	N	
KM20	Kopuku-Mangatawhiri	15/01/2015	13:36	1793072	5879068	G	
KM21	Kopuku-Mangatawhiri	15/01/2015	13:41	1792439	5879101	N	
KM22	Kopuku-Mangatawhiri	15/01/2015	13:46	1788870	5879124	N	
KM23	Kopuku-Mangatawhiri	15/01/2015	13:50	1786897	5879491	G	
KM24	Kopuku-Mangatawhiri	15/01/2015	13:54	1789278	5880981	G	
KM25	Kopuku-Mangatawhiri	15/01/2015	14:02			U	
KM26	Kopuku-Mangatawhiri	15/01/2015	14:11	1782953	5879222	E	20

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s[-1]
KM27	Kopuku-Mangatawhiri	15/01/2015	14:16	1781730	5878973	E	120
KM28	Kopuku-Mangatawhiri	15/01/2015	14:18	1781481	5878674	E	120
MR1	Mangatawhiri (SH2 Sawmill)- Rangariri	16/01/2015	10:31	1779759	5875670	U	
MR2	Mangatawhiri (SH2 Sawmill)- Rangariri	16/01/2015	10:45	1783834	5863233	N	
MR3	Mangatawhiri (SH2 Sawmill)- Rangariri	16/01/2015	10:49	1783592	5862070	N	
Pk1	Pukekawa	19/01/2015	11:38	1775573	5863744	E	10
Pk2	Pukekawa	19/01/2015	12:12	1776704	5864093	N	
Pk3	Pukekawa	19/01/2015	12:23	1775791	5865192	N	
Pk4	Pukekawa	19/01/2015	12:42	1776146	5866217	E	1.5
Pk5	Pukekawa	19/01/2015	12:47	1776717	5866132	E	3
Pk6	Pukekawa	19/01/2015	12:59	1777728	5865608	E	1-2
Pk7	Pukekawa	19/01/2015	13:21	1779704	5867209	U	
Pk8	Pukekawa	19/01/2015	13:22	1779919	5867692	N	
Pk9	Pukekawa	19/01/2015	13:48	1777779	5868911	U	
Pk10	Pukekawa	19/01/2015	14:50	1775433	5864241	N	
PkN1	Pukekawa to Naike	20/01/2015	11:46	1775569	5863746	N	
PkN2	Pukekawa to Naike	20/01/2015	11:51	1775386	5861975	N	
PkN3	Pukekawa to Naike	20/01/2015	11:56	1775799	5861115	N	
PkN4	Pukekawa to Naike	20/01/2015	11:58	1775096	5860105	N	
PkN5	Pukekawa to Naike	20/01/2015	12:04	1775603	5859244	N	
PkN6	Pukekawa to Naike	20/01/2015	12:10	Map grid	86.6 20.2	N	
PkN7	Pukekawa to Naike	20/01/2015	12:12	1776863	5858032	N	
PkN8	Pukekawa to Naike	20/01/2015	12:17	1777039	58563252	G	
PkN9	Pukekawa to Naike	20/01/2015	12:23	1775763	5854222	N	
PkN10	Pukekawa-Naike	20/01/2015	12:30	1777831	5853094	U	
PkN11	Pukekawa-Naike	20/01/2015	12:50	1772852	5848423	G	
PkN12	Pukekawa-Naike	20/01/2015	12:57	1773038	5847258	E	9
PkPw1	Pukekawa-Port Waikato	21/01/2015	12:38	1768533	5866005	N	
PkPw2	Pukekawa-Port Waikato	21/01/2015	12:43	1766620	5867757	N	
PkPw3	Pukekawa-Port Waikato	21/01/2015	12:47	1765637	5868177	E	24
PkPw4	Pukekawa-Port Waikato	21/01/2015	12:52	1763284	5868498	N	
PkPw5	Pukekawa-Port Waikato	21/01/2015	12:56	1762583	5868005	N	
PkPw6	Pukekawa-Port Waikato	21/01/2015	12:58	1782973	5868125	E	4
PkPw7	Pukekawa-Port Waikato	21/01/2015	13:03	1761995	5867799	N	
PkPw8	Pukekawa-Port Waikato	21/01/2015	13:05	1761603	5867784	E	40
PkPw9	Pukekawa-Port Waikato	21/01/2015	13:09	1760749	5867642	E	
PkPw10	Pukekawa-Port Waikato	21/01/2015	13:13	1760115	5867114	N	
PkPw11	Pukekawa-Port Waikato	21/01/2015	13:15	1759933	5866916	E	1.5

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
PkPw12	Pukekawa-Port Waikato	21/01/2015	13:20	1758646	5866350	N	
PkPw13	Pukekawa-Port Waikato	21/01/2015	13:28	1757774	5865729	E	4
PkPw14	Pukekawa-Port Waikato	21/01/2015	14:04	1755011	5862129	E	11.25
PkPw15	Pukekawa-Port Waikato	21/01/2015	14:09	1755536	5862784	N	
PkPw16	Pukekawa-Port Waikato	21/01/2015	14:11	1755787	5863159	E	2
PkPw17	Pukekawa-Port Waikato	21/01/2015	14:14	1756328	5863588	E	
PkPw18	Pukekawa-Port Waikato	21/01/2015	14:19	1756884	5864846	E	
PkPw19	Pukekawa-Port Waikato	21/01/2015	14:21	1757791	5865756	E	16
PkPw20	Pukekawa-Port Waikato	21/01/2015	14:26	1759931	5866927	N	
PAaO1	Pokeno-Aka Aka-Otaua	22/01/2015	11:02	1778540	5876118	E	40
PAaO2	Pokeno-Aka Aka-Otaua	22/01/2015	11:06	1777563	5875409	N	
PAaO3	Pokeno-Aka Aka-Otaua	22/01/2015	11:22	1774781	5873871	N	
PAaO4	Pokeno-Aka Aka-Otaua	22/01/2015	11:23	1774856	5873919	E	
PAaO5	Pokeno-Aka Aka-Otaua	22/01/2015	11:34	1775262	5874170	-	
PAaO6	Pokeno-Aka Aka-Otaua	22/01/2015	11:40	1773249	5873003	N	
PAaO7	Pokeno-Aka Aka-Otaua	22/01/2015	11:43	1772447	5872728	U	
PAaO8	Pokeno-Aka Aka-Otaua	22/01/2015	11:47	1771973	5871584	N	
PAaO9	Pokeno-Aka Aka-Otaua	22/01/2015	11:55	1772350	5873365	G	
PAaO10	Pokeno-Aka Aka-Otaua	22/01/2015	12:00	1770747	5874086	G	
PAaO11	Pokeno-Aka Aka-Otaua	22/01/2015	12:13	1769383	5875738	E	20
PAaO12	Pokeno-Aka Aka-Otaua	22/01/2015	12:18	1769106	5875687	E	0.01
PAaO13	Pokeno-Aka Aka-Otaua	22/01/2015	12:30	1769625	5877234	E	0.01
PAaO14	Pokeno-Aka Aka-Otaua	22/01/2015	12:32	1769489	5877200	N	
PAaO15	Pokeno-Aka Aka-Otaua	22/01/2015	12:34	1769278	5877139	N	
PAaO16	Pokeno-Aka Aka-Otaua	22/01/2015	12:37	1769201	5877096	E	4
PAaO17	Pokeno-Aka Aka-Otaua	22/01/2015	12:45	1767061	5876946	N	
PAaO18	Pokeno-Aka Aka-Otaua	22/01/2015	12:49	1766048	5877078	N	
PAaO19	Pokeno-Aka Aka-Otaua	22/01/2015	12:50	1765822	5877177	N	
PAaO20	Pokeno-Aka Aka-Otaua	22/01/2015	12:55	1764244	5877092	E	50
PAaO21	Pokeno-Aka Aka-Otaua	22/01/2015	13:05	1762508	5873378	N	
PAaO22	Pokeno-Aka Aka-Otaua	22/01/2015	13:19	1762097	5873107	U	
PAaO23	Pokeno-Aka Aka-Otaua	22/01/2015	13:22	1761821	5873001	N	
PAaO24	Pokeno-Aka Aka-Otaua	22/01/2015	13:23	1761554	5872895	N	
PAaO25	Pokeno-Aka Aka-Otaua	22/01/2015	13:34	1758845	5871084	G	
PAaO26	Pokeno-Aka Aka-Otaua	22/01/2015	13:40	1758888	5871081	N	
PAaO27	Pokeno-Aka Aka-Otaua	22/01/2015	13:44	1756766	5870759	E	40
PAaO28	Pokeno-Aka Aka-Otaua	22/01/2015	13:52	1755873	5870208	N	
PAaO29	Pokeno-Aka Aka-Otaua	22/01/2015	13:55	1755801	5870200	G	

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
PAaO30	Pokeno-Aka Aka-Otaua	22/01/2015	14:00	1754830	5869815	G	
OPu1	Otaua-Puni	23/01/2015	11:29	1754828	5869818	G	
OPu2	Otaua-Puni	23/01/2015	11:38	1754568	5870103	G	
OPu3	Otaua-Puni	23/01/2015	11:47	1754383	5870482	E	0.1
OPu4	Otaua-Puni	23/01/2015	11:52	1754000	5870482	N	
OPu5	Otaua-Puni	23/01/2015	11:55	1753416	5872382	N	
OPu6	Otaua-Puni	23/01/2015	11:58	1753067	5872804	N	
OPu7	Otaua-Puni	23/01/2015	12:02	1753129	5873091	N	
OPu8	Otaua-Puni	23/01/2015	12:04	1753374	5873516	N	
OPu9	Otaua-Puni	23/01/2015	12:06	1753566	5873894	N	
OPu10	Otaua-Puni	23/01/2015	12:14	1757149	5874031	U	
OPu11	Otaua-Puni	23/01/2015	12:19	1758983	5874622	E	0.05
OPu12	Otaua-Puni	23/01/2015	12:21	1759749	584479	G	
OPu13	Otaua-Puni	23/01/2015	12:25	1760537	5874333	N	
OPu14	Otaua-Puni	23/01/2015	12:30	1761500	5874156	E	250
OPu15	Otaua-Puni	23/01/2015	12:32	1759894	5875091	E	30
OPu16	Otaua-Puni	23/01/2015	12:38	1760808	5876512	E	0.4
OPu17	Otaua-Puni	23/01/2015	12:40	1760754	5876490	N	
OPu18	Otaua-Puni	23/01/2015	12:47	1761501	5874389	E	20
OPu19	Otaua-Puni	23/01/2015	12:49	1761492	5874570	N	
OPu20	Otaua-Puni	23/01/2015	12:54	1762524	5876283	N	
OPu21	Otaua-Puni	23/01/2015	12:57	1763074	5876784	E	0.2
OPu22	Otaua-Puni	23/01/2015	13:00	1763153	5876967	E	6
OPu23	Otaua-Puni	23/01/2015	13:03	1763645	5878112	E	60
	Pukekawa	19/01/2015	11:30	1777043	5863166	N	
	Pukekawa	19/01/2015	11:38	1775573	5863744	E	10
	Pukekawa	19/01/2015	11:54	1777728	5863949	E	6
	Pukekawa	19/01/2015	12:12	1776704	5864093	N	
	Pukekawa	19/01/2015	12:23	1775791	5865192	N	
	Pukekawa	19/01/2015	12:42	1776146	5866217	E	1.5
	Pukekawa	19/01/2015	12:47	1776717	5866132	E	3
	Pukekawa	19/01/2015	12:59	1777728	5865608	E	1-2
	Pukekawa	19/01/2015	13:08	1778666	5865941	N	
	Pukekawa	19/01/2015	13:17	1779199	5866524		
	Pukekawa	19/01/2015	13:18	1779455	5866833		
	Pukekawa	19/01/2015	13:21	1779704	5867209	U	
	Pukekawa	19/01/2015	13:22	1779919	5867692	N	
	Pukekawa	19/01/2015	13:40	1779083	5867965	E	<5

No.	Route	Date	Time	Easting	Northing	Flow No, some or gaugeable	Flow Estimate l s-1
	Pukekawa	19/01/2015	13:48	1777779	5868911	U	
	Pukekawa	19/01/2015	13:51	1777554	5869356	N	
	Pukekawa	19/01/2015	14:04	1774905	5866721	N	
	Pukekawa	19/01/2015	14:08	1773969	5866308	G	
	Pukekawa	19/01/2015	14:14	1772823	5864801	N	
	Pukekawa	19/01/2015	14:20	1772969	5864457	N	
	Pukekawa	19/01/2015	14:50	1775433	5864241	N	

Appendix II: Low flow gauging results

Located Key	Name	Easting	Northing	Date	Discharge ($m^3 s^{-1}$)
411_9	Mangaohoi @ Maru Rd	1822707	5785494	16/01/2015	0.076
1191_5	Waipa @ above Otamarua confluence	1813126	5741182	21/01/2015	0.127
3125_1	Otamarua @ above Waipa confluence	1813126	5741182	21/01/2015	0.102
1191_19	Waipa @ Waipa Valley Bridge	1807670	5743810	21/01/2015	0.506
3126_1	Wharekiri @ Horokino Farm Bridge	1816085	5739838	21/01/2015	0.012
2057_3	Okurawhanga @ Allen Rd Bridge	1813424	5742234	21/01/2015	0.144
1253_5	Waitomo @ SH31	1792015	5771848	28/01/2015	0.515
443_3	Mangapu @ SH3	1793118	5770149	28/01/2015	1.738
461_10	Mangatea @ Oparure Rd Bridge	1785795	5757297	23/12/2015	0.015
818_40	Puniu @ Wharepapa Rd Bridge	1819868	5775028	23/12/2014	3.389
818_40	Puniu @ Wharepapa Rd Bridge	1819868	5775028	4/02/2015	2.028
818_40	Puniu @ Wharepapa Rd Bridge	1819868	5775028	5/03/2015	1.202
818_40	Puniu @ Wharepapa Rd Bridge	1819868	5775028	1/04/2015	1.321
443_7	Mangapu @ Gatsby Rd	1783634	5755134	23/12/2014	0.897
1391_1	Mangarama @ Gatsby Rd	1784134	5755235	23/12/2014	0.220
443_10	Mangapu @ Oparure Rd Bridge	1785647	5757285	23/12/2014	1.250
443_11	Mangapu @ d/s Mangatea Confluence	1785829	5757450	4/02/2015	0.628
443_11	Mangapu @ d/s Mangatea Confluence	1785829	5757450	5/03/2015	0.328
443_11	Mangapu @ d/s Mangatea Confluence	1785829	5757450	1/04/2015	0.326
444_4	Mangarapa @ Railway Bridge	1792349	5764943	27/01/2015	0.186
444_4	Mangarapa @ Railway Bridge	1792349	5764943	5/03/2015	0.159
444_4	Mangarapa @ Railway Bridge	1792349	5764943	1/04/2015	0.176
438_3	Mangapiko @ Bowman Rd	1799086	5794363	16/01/2015	0.770
438_3	Mangapiko @ Bowman Rd	1799086	5794363	28/01/2015	0.618
438_18	Mangapiko @ SH3	1804292	5791570	16/01/2015	0.296
438_18	Mangapiko @ SH3	1804292	5791570	28/01/2015	0.229
411_20	Mangaohoi @ Rosegarden	1804493	5790770	16/01/2015	0.299

Located Key	Name	Easting	Northing	Date	Discharge ($m^3 s^{-1}$)
411_20	Mangaohoi @ Rosegarden	1804493	5790770	28/01/2015	0.244
222_16	Kaniwhaniwha @ Wrights Rd	1788267	5806351	28/01/2015	0.762
553_3	Moakurarua @ Farm Bridge	1790899	5783950	28/01/2015	3.866
553_3	Moakurarua @ Farm Bridge	1790899	5783950	11/03/2015	1.371
553_3	Moakurarua @ Farm Bridge	1790899	5783950	2/04/2015	1.196
1008_8	Te Pahu Stream @ Limeworks Loop Rd Bridge	1785491	5800263	5/01/2015	0.178
1008_9	Te Pahu Tributary @ Limeworks Loop Rd	1786549	5801087	7/01/2015	0.157
1191_6	Waipa @ Ngaruawahia	1789132	5829156	28/01/2015	14.537
124_8	Firewood Creek @ Waingaro Rd Bridge	1788353	5827726	17/12/2014	0.360
124_8	Firewood Creek @ Waingaro Rd Bridge	1788353	5827726	29/01/2015	0.177
124_8	Firewood Creek @ Waingaro Rd Bridge	1788353	5827726	26/02/2015	0.124
124_8	Firewood Creek @ Waingaro Rd Bridge	1788353	5827726	31/03/2015	0.16
228_2	Karakariki @ Karakariki Rd culvert	1785974	5816831	7/01/2015	0.028
430_2	Mangaotama @ Karakariki Rd culvert	1786047	5818849	6/01/2015	0.229
430_2	Mangaotama @ Karakariki Rd culvert	1786047	5818849	29/01/2015	0.127
1191_20	Waipa @ Pirongia	1793489	5791255	28/01/2015	11.682
484_2	Mangawara @ O'Shea Rd culvert	1791584	5794653	6/01/2015	0.224
734_5	Paratawa @ Te Pahu Rd Bridge	1787850	5812191	5/01/2015	0.068
1150_7	Waikoha @ Te Pahu Rd Bridge	1788061	5809951	7/01/2015	1.346
624_1	Ohote @ Blackett Rd	1789351	5816754	29/01/2015	0.065
624_3	Ohote @ Laxon Rd	1792251	5817159	29/01/2015	0.009
398_1	Mangakotukutuku @ above culvert at Sandford Park	1802500	5812597	10/02/2015	0.057
571_1	Mystery Creek @ Mystery Creek Rd Cuvert	1805876	5806114	10/02/2015	0.184
488_1	Mangawhero @ Kaipaki Rd Bridge	1811463	5803602	10/02/2015	0.222
230_5	Karapiro @ Hickey Rd Bridge	1822825	5802233	10/02/2015	0.209
1103_1	Waiarumu @ Whitehall-Quarry Rd Bridge	1826400	5802864	10/02/2015	0.031
230_4	Karapiro @ French Pass Rd Bridge	1826285	5805275	10/02/2015	0.054
230_4	Karapiro @ French Pass Rd Bridge	1826285	5805275	10/02/2015	0.058
417_7	Mangaone @ Annebrook Rd Bridge	1805677	5812795	11/02/2015	0.488

Located Key	Name	Easting	Northing	Date	Discharge ($m^3 s^{-1}$)
421_10	Mangaonua @ Hoeka Rd Bridge	1810180	5815912	11/02/2015	0.278
1236_2	Waitawhiriwhiri @ Edgecumbe Str. Park	1799910	5816904	11/02/2015	0.123
253_3	Kirikiriroa @ River Rd Bridge	1798867	5820260	11/02/2015	0.083
47_1	Bankwood Stream @ Donny Park	1799717	5818954	11/02/2015	dry
1132_68	Waikato Tributary @ River Rd (Golf Course)	1796481	5822838	11/02/2015	0.030
1132_99	Waikato Tributary @ River Rd (near Lake Rd Junction)	1794401	5826160	11/02/2015	0.010
258_10	Komakorau @ Whitikau Rd Bridge	1802363	5830117	11/02/2015	0.197
445_9	Mangarata @ Hakarimata Rd Culvert	1789025	5829318	26/02/2015	0.008
353_7	Maire @ SH22	1772836	5848532	2/03/2015	0.120
353_6	Maire @ Waikaretu Valley Rd	1769114	5850046	2/03/2015	0.024
665_4	Opuatia @ Onewhero Rd Bridge	1768374	5862125	4/03/2015	not gaugable
3131_1	Poporo Stream @ Ponganui Rd	1766915	5862889	4/03/2015	<0.005
666_7	OpuatiaTributary at Ponganui Rd	1767207	5862626	4/03/2015	<0.005
3000_2	Mitimiti Stream @ Ponganui Rd	1768282	5862040	4/03/2015	<0.010
665_5	Opuatia @ Ponganui Rd	1766922	5862941	4/03/2015	0.139
665_6	Opuatia @ SH22	1777041	5856253	4/03/2015	not gaugable
890_1	Rotongaro Canal @ Glen Murray Rd	1786091	5853255	25/02/2015	dry
3125_1	Otamarua @ above Waipa Confluence	1813126	5741182	21/01/2015	0.102
2057_3	Okurawhanga	1813424	5742234	21/01/2015	0.144
3126_1	Wharekiri @ Horokino Farm Bridge	1816085	5739838	21/01/2015	0.012
960_1	Tararoa @ Churchill Rd	1778676	5861743	26/02/2015	0.008
572_1	Naike @ Woodleigh Rd	1768505	5844124	2/03/2015	0.038
436_1	Mangapiko @ SH22	1772405	5844431	2/03/2015	0.015
1132_9	Waikato Tributary @ Hakarimata	1789627	5832357	26/02/2015	0.007
39_11	Awaroa @ Sansons Bridge	1784617	5837950	25/02/2015	0.085
158_2	Haumapu @ SH22	1772706	5844031	2/03/2015	0.039
83_1	Clark Rd Stream @ Clark Denize Rd	1779666	5867245	26/02/2015	0.011
612_9	Ohaeroa @ SH22	1773063	5868633	26/02/2015	0.084
1319_7	Whauwhautahi @ Port Waikato- Tuakau Rd	1761595	5867797	23/03/2015	0.023

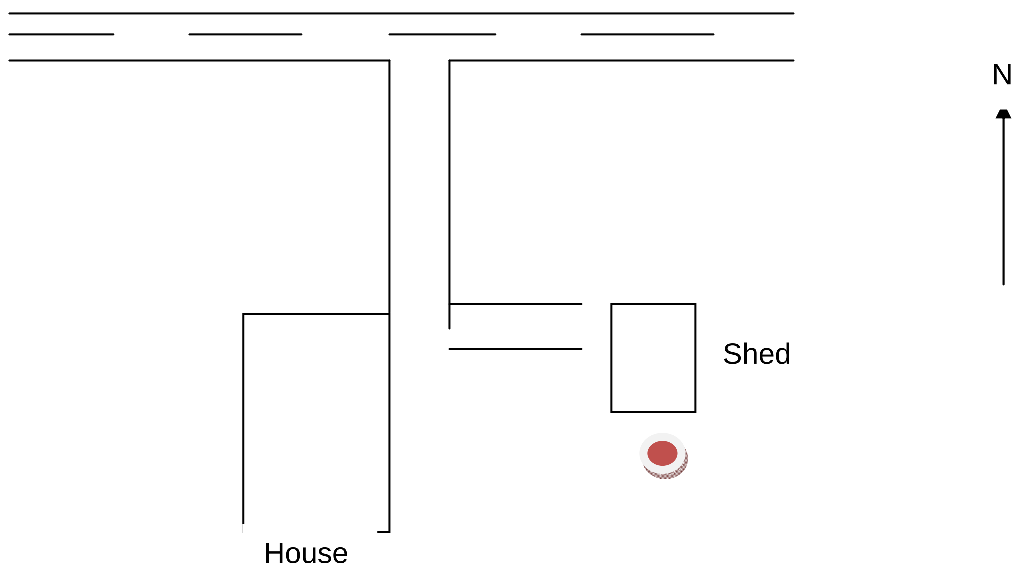
Located Key	Name	Easting	Northing	Date	Discharge ($m^3 s^{-1}$)
1132_18	Waikato Tributary @ Port Waikato Rd	1760864	5867811	23/03/2015	0.006
720_1	Pakau @ Port Waikato Rd	1757767	5865760	23/03/2015	0.004
508_1	Maraetai @ Waikaretu Rd	1753255	5859859	23/03/2015	0.008
1131_229	Waikato Tributary @ Port Waikato Rd	1756895	5864840	23/03/2015	0.002
211_5	Kaipo Flats @ Port Waikato Rd	1769927	5870877	23/03/2015	0.026
1407_2	Mangakawa @ Orini Rd	1799920	5839736	24/03/2015	0.085
966_15	Tauhei @ Orini Rd	1803416	5840950	24/03/2015	0.192
461_5	Mangatea @ Te Hoe	1805580	5845764	24/03/2015	0.115
3129_1	Mangawara Tributary @ Tahuna Rd	1807565	5845711	24/03/2015	0.008
481_2	Mangawara @ Jeffries Recorder	1809611	5844393	24/03/2015	0.235
1293_9	Whangamarino @ Jeffries Rd End	1798066	5865561	24/03/2015	0.177
473_2	Mangatoketoke @ Kerie Rd	1795708	5833222	24/03/2015	0.035
272_6	Koteruato @ Monument Rd	1799009	5875232	25/03/2015	0.035
894_3	Ruaotehuia @ Monument Rd	1796112	5879753	25/03/2015	0.036
1214_2	Waipunga @ SH2, Grattens Bridge	1782961	5879218	25/03/2015	0.009
1214_3	Waipunga @ Mc Anulty's Brdige, SH2	1781816	5878987	25/03/2015	0.016
1214_1	Waipunga @ Graham's Bridge SH2	1781521	5878770	25/03/2015	0.040
739_4	Parker Lane Stream @ Parker Lane Bridge	1768944	5875713	25/03/2015	0.017
214_5	Kairoa @ SH22	1772375	5873339	25/03/2015	0.020
1188_1	Waioteatua @ Riverview Rd	1790430	5836546	26/03/2015	0.041
516_22	Matahuru @ Myjers	1801347	5847910	26/03/2015	0.274
481_4	Mangawara @ McConnell Bridge	1799216	5840075	26/03/2015	0.701
1097_1	Waahi Stream @ Ohaki Rd Bridge	1790311	5842060	19/01/2015	0.180
1302_1	Whangape Stream @ Glen Murray Rd Bridge	1784690	5853752	19/01/2015	0.434
786_7	Pokaiwhenua @ Key Str	1862548	5762631	18/03/2015	18
786_13	Pokaiwhenua @ Shrew Rd	1857647	5765070	18/03/2015	426
786_	Pokaiwhenua @ Farmbridge beside Ken Rd	1854900	5767193	18/03/2015	404
786_10	Pokaiwhenua @ SH1	1850596	5770094	19/03/2015	467
786_18	Pokaiwhenua @ Wiltsdown Rd Bridge	1847690	5773399	19/03/2015	839

Appendix III: Groundwater site information

Regional Groundwater
Site Sheet

Site Name:	-	Site (Hydrol) No: 72_7126	
Map Reference:	T15:366-621	Wells on property:	1
Address:	212 Karipiro Road, Waikato	Bore log available?	Yes
		Driller:	Brown Bros Ltd
Person to contact:	-	Year of Construction:	25/09/2013
Location: (NZTM)	5800732 1826419	Bore Depth (m):	72 m
		Casing Diameter (mm):	100 mm
Survey Date:	23/12/2014	Casing depth (m):	56.5 m
Aquifer geology:	N/A	Casing type:	Steel
Drastic Index:		Screen diameter (mm)	
Topography:	Flat	Screen depths (m)	70 m
Land Use:	Dairy Farm	Screen type:	
Water Use:	Dairy Shed	Pump details:	Submersible
Level probe access (y/n)	y	Well yield (m^3d^{-1})	4 m3/hr
Static water level (m chf)	4.42 m	Drawdown for above	34 m +
Water quality comment:		Aquifer test info (y/n)	n
Water quality sampled	No	Water supply?	

Site Map



Comments

Bore located beside water tanks and farm shed. Has large concrete lid on it.

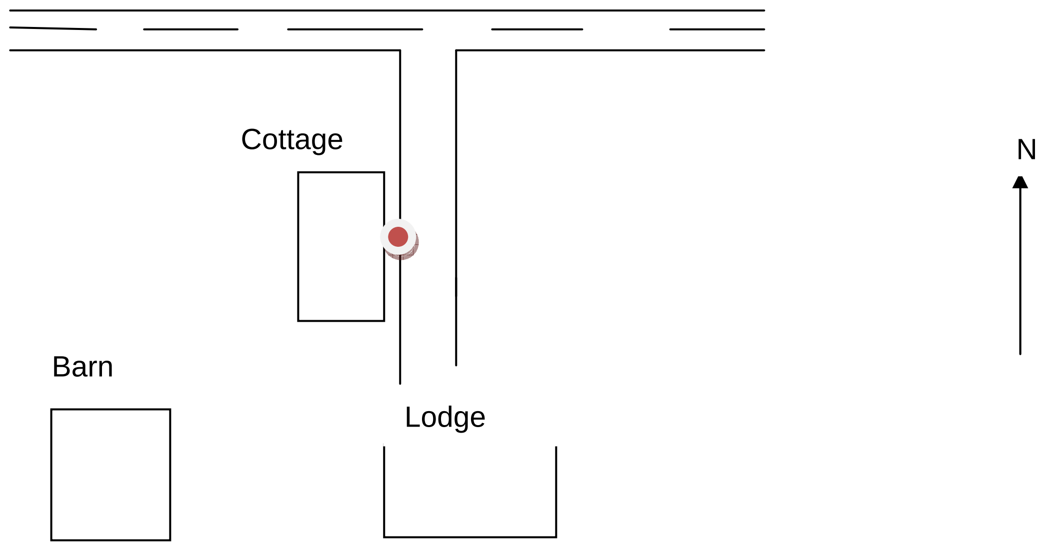
OSH Hazards Identification

Large concrete lid. Take care when lifting/moving.

Regional Groundwater
Site Sheet

Site Name:	-	Site (Hydrol) No: 72_7776	
Map Reference:		Wells on property:	1
Address:	518 Tirau Road	Bore log available?	Yes
		Driller:	Unknown
Person to contact:	-	Year of Construction:	2014
Location: (NZTM)	5801268 1822721	Bore Depth (m):	120
		Casing Diameter (mm):	100mm
Survey Date:	23/12/2014	Casing depth (m):	74
Aquifer geology:	N/A	Casing type:	Galv. Casing
Drastic Index:		Screen diameter (mm)	
Topography:	Flat	Screen depths (m)	
Land Use:	Horse Lodge/Stables	Screen type:	
Water Use:	Residential/Animals	Pump details:	Submersible Pump
Level probe access (y/n)		Well yield (m^3d^{-1})	42
Static water level (m chf)	62.4	Drawdown for above	.8
Water quality comment:		Aquifer test info (y/n)	No
Water quality sampled	No	Water supply?	

Site Map



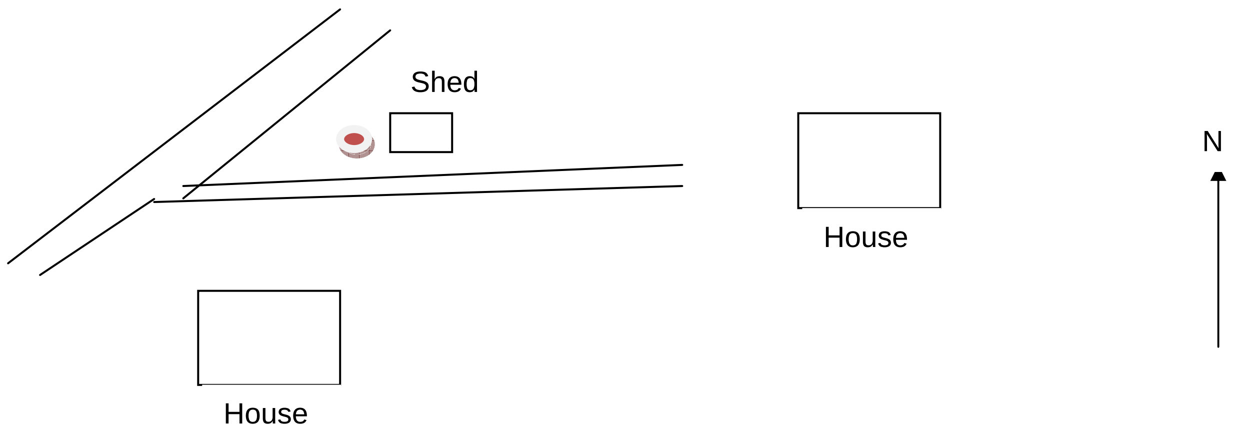
Comments
Bore located by the driveway, outside cottage. Unsure where a water sample could be easily obtained.

OSH Hazards Identification

Regional Groundwater Site Sheet

Site Name:	430 Te Kopai Road	Site (Hydrol) No: 72_6843	
Map Reference:	U16:982-137	Wells on property:	1
Address:	430 Te Kopai Rd, Waikite Valley	Bore log available?	No
		Driller:	Carlyle
Person to contact:	-	Year of Construction:	2013
Location: (NZTM)	5748034, 1883726	Bore Depth (m):	96
		Casing Diameter (mm):	100mm
Survey Date:	19/12/2014	Casing depth (m):	75
Aquifer geology:	ignimbrite	Casing type:	Steel
Drastic Index:		Screen diameter (mm)	
Topography:	Flat	Screen depths (m)	
Land Use:	Dairy Farm	Screen type:	
Water Use:	Residential	Pump details:	Submersible Pump
Level probe access (y/n)	y	Well yield (m^3d^{-1})	3500
Static water level (m chf)	Not static (12.1 in 2013)	Drawdown for above	
Water quality comment:	Clean	Aquifer test info (y/n)	
Water quality sampled	No	Water supply?	

Site Map



Comments

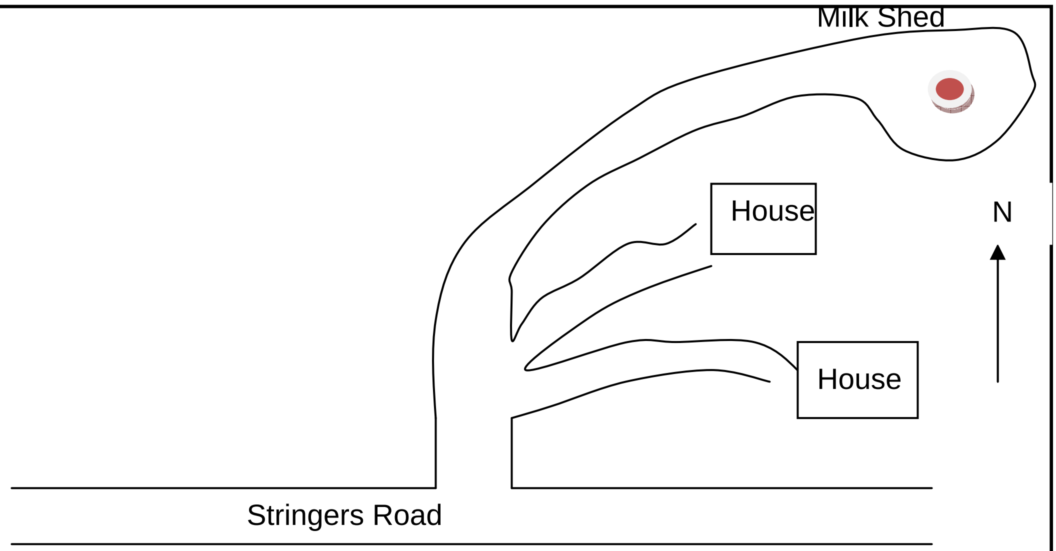
Well located in paddock between main road and top house. Could not turn pump off.

OSH Hazards Identification

Regional Groundwater
Site Sheet

Site Name: -		Site (Hydrol) No: 72_3525	
Location: E:N	1840772 5770953	Wells on property:	1
Address:	110 Stringers Road	Bore log available?	
		Driller:	Ken Garnett Drilling LTD
Person to contact:	-	Year of Construction:	30/07/2007
ph:		Bore Depth (m):	157
		Casing Diameter (mm):	150
Survey Date:	12/2/2015	Casing depth (m):	105
Aquifer geology:		Casing type:	PVC and steel
Drastic Index:		Screen diameter (mm)	
Topography:		Screen depths (m)	
Land Use:	Farming	Screen type:	
Water Use:	Water supply domestic	Pump details:	
Level probe access (y/n)	?	Well yield (m^3d^{-1})	
Static water level (m chf)	Probe depth to 2.49 m, would not go any further and appeared to be hitting the screen/pump.	Drawdown for above	
Water quality comment:		**Aquifer test info (y/n)**	
Water quality sampled		Water supply?	

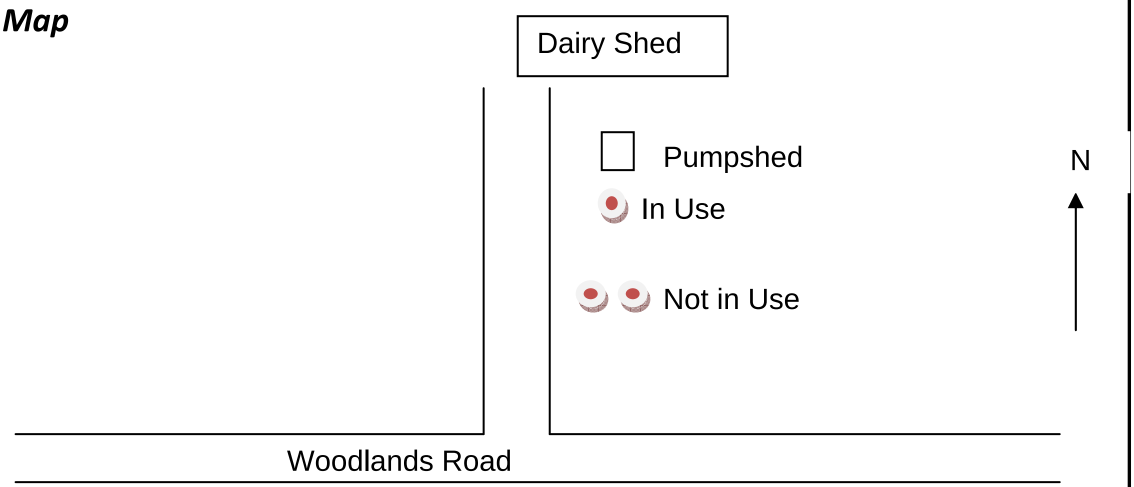
Site Map



Regional Groundwater
Site Sheet

Site Name:	-	Site (Hydrol) No:	72_7836
Location: E:N	1803656 5829430	Wells on property:	3
Address:	129 Woodlands Road	Bore log available?	no
		Driller:	Benton and Sons Ltd
Person to contact:		Year of Construction:	2014
ph:		Bore Depth (m):	16.5
		Casing Diameter (mm):	100
Survey Date:	18/02/2015	Casing depth (m):	13.5
Aquifer geology:	Sand/silts	Casing type:	PVC
Drastic Index:		Screen diameter (mm)	100
Topography:	Flat Farmland	Screen depths (m)	3
Land Use:	Dairy Farm	Screen type:	PVC
Water Use:	Milk cooling and washing down shed	Pump details:	
Level probe access (y/n)	y	Well yield (m^3d^{-1})	64.8
Static water level (m chf)	7.05 (recovering)	Drawdown for above	Approximately 3m
Water quality comment:	Poor	Aquifer test info (y/n)	N
Water quality sampled	no	Water supply?	n

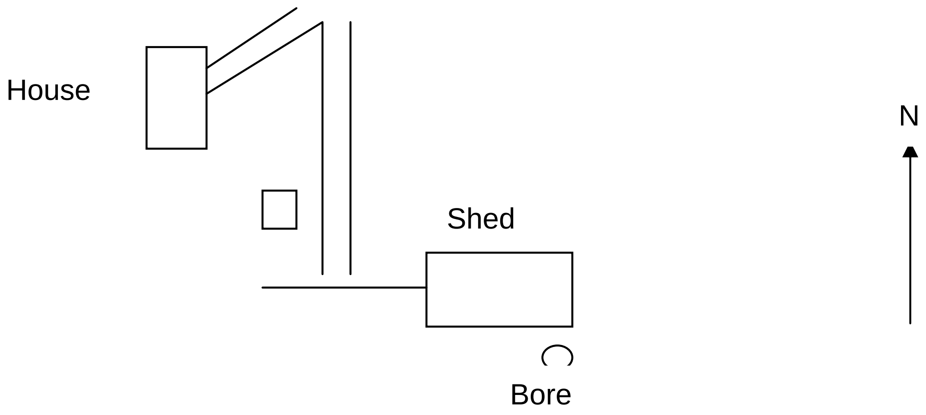
Site Map



Regional Groundwater
Site Sheet

Site Name:	-	Site (Hydrol) No: 66_35	
Map Reference:	U17:017-045	Wells on property:	1
Address:	159 Wharepapa Road Reparoa	Bore log available?	Yes
		Driller:	Warmington Welldrilling
Person to contact:	-	Year of Construction:	1992
Location: (NZTM)	1891603, 5742995	Bore Depth (m):	16
		Casing Diameter (mm):	100
Survey Date:	4/12/2014	Casing depth (m):	13
Aquifer geology:	Clay, Sand	Casing type:	Galv. Casing
Drastic Index:		Screen diameter (mm)	
Topography:	Flat	Screen depths (m)	
Land Use:	Small Dairy Farm	Screen type:	
Water Use:	Spa Pool (thermal)	Pump details:	
Level probe access (y/n)		Well yield (m^3d^{-1})	
Static water level (m chf)	1.83	Drawdown for above	
Water quality comment:		Aquifer test info (y/n)	No
Water quality sampled	No	Water supply?	Yes

Site Map



Comments
Bore located at the rear of the shed. Spanner/wrench required for access.

OSH Hazards Identification
Active electric fences. Geothermal waters, 70 degrees Celsius minimum. Take caution when accessing bore head.

Appendix IV: Groundwater chemistry (units are mg l^{-1} unless otherwise specified)

Well No.	Easting	Northing	Date	Alkalinity	Boron	Calcium	Chloride	Copper	D.O.	DRP	Conductivity (mS cm^{-1})	Diss. Iron	Tot. Iron	Free CO2	Hardness	Potassium
61_444	1789442	5881064	5/02/2015	128	0.2	22	38	0.0076	4.6	0.064	37.2	0.19	1.6	16.9	87	3.5
62_96	1794950	5818063	19/02/2015	80	0.0144	7	19	< 0.00053		0.172	21.3	0.82	2.9	46	45	5.2
65_53	1787695	5786146	1/04/2015	42	0.0076	7.8	7.3	< 0.00053		0.052	10.8	< 0.02	< 0.021	8.1	36	1.12
66_60	1904380	5736505	15/01/2015	33	< 0.0053	3.3	3	0.0029	11	0.062	7.6	< 0.02	< 0.021	8.9	13.6	3.5
69_1018	1803764	5870189	9/04/2015	153	0.022	30	29	< 0.00053	1.6	0.068	38	0.03	0.45	10.4	128	2.2
69_1668	1782233	5827845	10/04/2015	26	0.014	3.6	13.5	0.0023		0.11	10.6	< 0.02	0.129	29	15.9	2.7
69_2044	1795144	5880575	13/04/2015	14.9	0.0114	1.02	13.4	0.027	5.9	< 0.004	8.5	0.32	0.92	13.9	6.1	3.2
69_2082	1782233	5827845	1/04/2015	11	0.0111	1.9	12.7	0.0027		< 0.004	9.4	< 0.02	1.11	6	14	1.74
69_2085	1798655	5874780	9/04/2015	176	0.077	45	27	< 0.00053	3.1	0.004	41.3	< 0.02	0.082	5.2	158	1.25
69_2088	1798749	5877981	17/04/2015	184	0.034	52	35	0.0021	1.3	0.008	47.2	< 0.02	4.1	8.4	168	2.1
69_2140	1808612	5839627	17/02/2015	94	10.5	29	310	0.00146		< 0.004	122.2	< 0.02	12.3	11.9	94	4.2
69_836	1797344	5880679	13/04/2015	88	0.0146	18.5	22	< 0.00053	0.2	0.054	30.8	4.2	4.7	50	97	2.4
70_484	1791061	5810555	11/03/2015	18.8	0.0134	14.9	19.2	< 0.00053		0.024	22	0.07	0.23	24	60	5.7
70_526	1822684	5801200	17/02/2015	28	0.0111	7.8	6.4	< 0.00053	9.5	0.016	12	< 0.02	0.04	15.9	34	4.8
70_632	1793378	5799457	19/02/2015	22	0.0133	2.1	8	< 0.00053		0.048	7.8	< 0.02	< 0.021	13.7	9.6	3.1
70_796	1799580	5798765	10/04/2015	24	0.0134	8.6	16.2	< 0.00053		< 0.004	33.8	41	43	42	43	4.8
72_1148	1898185	5736779	29/01/2015	35	0.0103	12.3	9.3	< 0.00053	10.5	0.03	19.4	< 0.02	< 0.021	9.1	45	6.5
72_1480	1890141	5751792	3/12/2014	25	0.0098	4.6	6.3	< 0.00053	6.3	0.022	10.8	< 0.02	< 0.021	29	19.9	6
72_1483	1896155	5744453	20/01/2015	113	0.0119	5.1	51	0.027	1.9	< 0.004	39.9	< 0.02	9.2	4.7	21	11.6
72_1485	1896165	5744513	20/01/2015	27	0.0086	3.5	3.8	< 0.00053	6.3	0.1	8.2	< 0.02	0.032	3.9	17.2	2.1
72_1486	1895255	5743901	20/01/2015	26	0.0091	2.5	2.7	< 0.00053	9.3	0.13	6.4	< 0.02	0.023	2.6	12.3	1.82
72_1498	1887474	5739387	14/01/2015	20	0.0077	5.3	6.6	< 0.00053	9.9	0.02	12.5	< 0.02	< 0.021	9.4	25	4.6
72_1501	1887096	5737197	14/01/2015	20	0.0081	1.19	8.1	< 0.00053	9.6	0.106	12.3	0.03	0.037	5.4	4.4	2.2
72_1502	1887116	5737217	9/12/2014	27	0.0064	5.2	10.9	0.00055	8.6	0.054	17.4	< 0.02	< 0.021	18.4	21	4.3
72_1511	1901358	5736532	15/01/2015	27	0.0081	6.4	7	< 0.00053	10.8	0.03	12.5	< 0.02	< 0.021	5.6	24	4.8
72_1576	1891095	5728154	14/01/2015	27	0.0083	2.8	2.9	< 0.00053	11.1	0.08	6.4	< 0.02	< 0.021	4.1	13.3	2

Well No.	Easting	Northing	Date	Alkalinity	Boron	Calcium	Chloride	Copper	D.O.	DRP	Conductivity (mS cm^{-1})	Diss. Iron	Tot. Iron	Free CO2	Hardness	Potassium
72_1882	1893283	5734364	14/01/2015	50	0.0136	3.6	2.7	< 0.00053	9.6	0.3	10.6	0.18	0.181	2.3	18.6	0.43
72_2067	1891668	5740433	15/01/2015	52	0.043	5.4	3.5	0.0023	5.4	0.042	11.4	0.68	5.1	36	20	1.74
72_2389	1825991	5797603	22/01/2015	78	0.086	11.1	15	0.0063	7.6	< 0.004	20.1	< 0.02	10.4	40	52	5.3
72_2732	1790937	5826358	12/03/2015	19.1	0.0129	1.52	14.7	< 0.00053		0.008	10	< 0.02	< 0.021	22	7.4	4.4
72_2874	1817792	5794490	21/01/2015	108	0.021	20	13.8	< 0.00053		0.055	25.5	< 0.02	< 0.021	12.4	82	1.06
72_2915	1789238	5752941	26/02/2015	310	0.075	123	11.1	< 0.00053		< 0.004	68.1	< 0.02	0.116	31	340	2.3
72_3022	1900918	5736261	15/01/2015	40	0.0063	4.6	3	< 0.00053	10.3	0.058	9	< 0.02	< 0.021	15.4	18.2	3.4
72_3538	1895900	5736652	15/01/2015	24	0.0065	2.9	3.5	< 0.00053	10.3	0.068	6.7	< 0.02	< 0.021	8.6	12.4	2.5
72_3706	1789435	5827256	11/03/2015	18.9	0.0197	3.7	17.7	0.00151		0.084	14.1	0.03	0.05	39	22	4.3
72_3745	1800458	5873483	9/04/2015	118	0.0196	23	23	< 0.00053	0.2	0.075	30.4	0.43	1.08	13.3	92	2.2
72_3749	1802058	5873386	9/04/2015	133	0.021	28	35	< 0.00053	0.6	0.078	36.7	0.07	0.4	26	123	2
72_3984	1895913	5736656	29/01/2015	23	0.0088	2.2	2.6	< 0.00053		0.088	5.6	< 0.02	< 0.021	1.9	10.2	1.84
72_4014	1789663	5809153	12/02/2015	69	0.0101	5.8	14.4	< 0.00053		0.34	18.2	8.2	8.6	30	37	4.5
72_4070	1798325	5765655	10/02/2015	48	2.2	5.7	240	< 0.00053		< 0.004	92.5	< 0.02	< 0.021	< 1	15.2	0.77
72_4159	1888729	5738740	14/01/2015	42	0.0138	3.2	2.8	< 0.00053	10.7	0.088	10.3	2.6	2.6	5.6	16.1	1.5
72_4235	1793971	5804258	1/04/2015	37	0.0199	19.6	31	0.0022		0.058	36.2	< 0.02	< 0.021	16.4	87	28
72_4280	1802823	5768161	28/01/2015	56	0.0153	6	7.6	< 0.00053		0.109	14	< 0.02	< 0.021	11	35	2.8
72_4320	1808405	5783273	29/01/2015	46	0.0113	6.7	9.5	< 0.00053		0.116	13.2	< 0.02	< 0.021	18.2	29	2.2
72_4742	1789523	5765244	24/02/2015	111	0.0094	43	9.6	< 0.00053		0.05	26.2	< 0.02	< 0.021	3.2	116	1.55
72_4759	1792712	5774150	4/03/2015	92	0.46	117	750	< 0.0011		0.023	259	< 0.02	0.167	2.1	380	4
72_4788	1792825	5764748	24/02/2015	85	0.058	11.4	10.1	< 0.00053		0.044	20.1	< 0.02	< 0.021	1	35	1.53
72_4805	1787574	5801048	12/03/2015	23	0.021	2.9	12.8	< 0.00053		< 0.004	10	< 0.02	0.84	23	13.7	5.1
72_4819	1800309	5778461	4/03/2015	80	0.026	12.3	13.9	< 0.00053		0.042	20.3	< 0.02	< 0.021	14.3	50	3.9
72_4998	1803888	5793870	18/03/2015	19	0.0134	2.3	8.8	< 0.00053		0.136	7.5	< 0.02	< 0.021	8.1	9.9	4
72_5009	1812036	5760170	28/01/2015	25	0.0072	2.9	7.9	< 0.00053		0.073	8	< 0.02	< 0.021	8.8	14.1	3
72_5019	1798283	5796663	18/03/2015	8.6	0.0161	3.7	14.1	0.00152		< 0.004	12.3	< 0.02	< 0.021	37	20	2.1
72_5034	1808807	5781573	18/02/2015	24	0.0102	2.4	7.6	< 0.00053		0.014	7.7	< 0.02	< 0.021	3.7	10.7	3.5
72_5042	1822910	5783193	18/03/2015	20	0.0165	7.8	20	0.00059		0.06	21.5	< 0.02	< 0.021	39	43	8.3
72_5048	1814508	5781881	4/02/2015	20	0.0118	2	7.1	< 0.00053		0.14	7.3	< 0.02	< 0.021	5.4	8.9	3.7

Well No.	Easting	Northing	Date	Alkalinity	Boron	Calcium	Chloride	Copper	D.O.	DRP	Conductivity (mS cm-1)	Diss. Iron	Tot. Iron	Free CO2	Hardness	Potassium
72_5049	1804520	5770864	3/02/2015	31	0.02	3.6	9.2	< 0.00053		0.125	9.9	< 0.02	< 0.021	6.4	15.8	3.2
72_5053	1807222	5769667	21/01/2015	32	0.0125	4.8	9.5	< 0.00053		0.22	11.9	< 0.02	< 0.021	6.9	24	4.4
72_5062	1793110	5776051	26/02/2015	63	0.76	194	990	< 0.0011		< 0.004	327	11.9	18.8	36	500	3.5
72_5103	1797995	5788260	12/02/2015	94	0.0196	11.6	18	< 0.00053		0.102	23.9	< 0.02	< 0.021	7.5	75	0.91
72_5197	1903336	5734075	16/12/2014	21	0.006	2.5	3.3	< 0.00053		0.093	6.7	< 0.02	< 0.021	2.7	10.5	3
72_5200	1896780	5742347	3/12/2014	28	0.0102	3.6	3.6	< 0.00053	7.2	0.081	8.4	< 0.02	< 0.021	14	19	1.83
72_524	1799680	5799066	18/03/2015	39	0.0132	3.9	11.7	< 0.00053		0.046	11.8	< 0.02	< 0.021	15.1	19.7	4.8
72_5253	1810727	5767071	28/01/2015	30	0.0102	11.5	12.8	0.00074		0.083	14.3	< 0.02	< 0.021	12.8	40	1.16
72_5289	1824624	5773491	28/01/2015	49	0.0084	4.4	7.7	< 0.00053		0.2	12.1	< 0.02	< 0.021	15.4	29	1.51
72_5300	1813227	5767875	29/01/2015	24	0.0093	2.6	6.9	< 0.00053		0.15	8.1	< 0.02	< 0.021	5.2	14.9	3.5
72_54	1795143	5880875	17/04/2015	99	0.033	9.2	17	< 0.00053	2.3	0.34	24.2	4	5.7	17.2	52	8.6
72_5433	1785102	5781141	24/02/2015	38	0.0085	8.8	9.8	< 0.00053		0.034	12.1	< 0.02	< 0.021	4.1	39	1.27
72_5442	1893649	5732286	3/12/2014	38	0.21	8.2	6.3	< 0.00053	7	0.064	16.4	< 0.02	< 0.021	22	38	1.33
72_5445	1896448	5742731	14/01/2015	28	0.033	10.9	11.8	< 0.00053	10.1	0.052	19.2	< 0.02	< 0.021	26	49	5.6
72_5469	1792941	5751645	17/02/2015	51	0.0165	11.8	11.8	< 0.00053		0.04	16.4	< 0.02	< 0.021	15	53	1.07
72_5490	1799055	5762789	10/02/2015	31	0.021	4	7.3	0.00093		0.028	9.4	< 0.02	< 0.021	8.2	17	1.9
72_5503	1796839	5754050	17/02/2015	31	0.0123	7.9	10.1	< 0.00053		0.074	13	< 0.02	< 0.021	11.2	35	1.35
72_553	1796653	5875577	9/04/2015	54	0.0109	7.2	21	0.00174	0.1	0.084	18.1	1.48	4.6	59	38	2.3
72_5569	1814275	5792556	29/01/2015	19.5	0.0151	11.5	25	< 0.00053		0.046	24.7	< 0.02	< 0.021	25	51	8.5
72_5637	1794159	5875491	13/04/2015	39	0.022	5.8	23	< 0.00053	5.2	0.054	16.6	2.6	2.6	49	21	3.2
72_5979	1831290	5799312	22/01/2015	99	0.021	26	13.4	< 0.00053	2	0.015	23.6	< 0.02	< 0.021	2.1	88	1.58
72_6153	1893623	5730719	29/01/2015	320	0.0159	5.7	13.8	0.0179		< 0.004	74.6	< 0.02	19	13.4	37	62
72_6155	1890354	5730592	15/01/2015	24	0.139	23	17.2	0.0033	9.9	0.012	31.7	< 0.02	< 0.021	14.5	78	17.7
72_6180	1787844	5821553	12/03/2015	24	0.02	7.3	12	< 0.00053		0.036	15.4	< 0.02	< 0.021	16.4	37	6.8
72_6408	1793150	5817760	12/02/2015	61	0.014	4.3	25	< 0.00053		0.146	19.4	6	6.2	28	29	4.9
72_6474	1817741	5827702	28/01/2015	96	0.0147	9.8	17.9	0.00132	4	0.022	24.5	5.5	6.1	73	50	5.6
72_6500	1800055	5874683	9/04/2015	183	0.026	50	25	< 0.00053	0.7	0.019	41.9	< 0.02	0.92	8.4	163	2.1
72_6501	1795053	5875574	9/04/2015	96	0.034	27	18.5	0.00158	1	0.151	25.4	0.85	2.5	9.8	85	1.74
72_6514	1793191	5790154	4/03/2015	65	0.0148	4.4	8.5	< 0.00053		< 0.04	14.8	10.4	25	35	23	3.4

Well No.	Easting	Northing	Date	Alkalinity	Boron	Calcium	Chloride	Copper	D.O.	DRP	Conductivity (mS cm^{-1})	Diss. Iron	Tot. Iron	Free CO2	Hardness	Potassium
72_6680	1845792	5810369	17/12/2014	116	0.093	12.2	34	0.0039	8.9	0.018	32.9	2.3	5.9	33	65	5.3
72_7003	1804587	5756680	26/02/2015	27	0.0103	4.9	6.4	< 0.00053		0.084	9.3	< 0.02	< 0.021	2.8	24	1.01
72_7021	1804476	5786128	18/02/2015	34	0.0118	4.9	10.6	< 0.00053		0.104	13.4	< 0.02	< 0.021	14.7	28	4.6
72_7107	1788203	5760013	17/02/2015	146	0.024	51	7.5	< 0.00053		0.008	32.5	< 0.02	< 0.021	4.5	154	1.16
72_7126	1826398	5800525	22/01/2015	39	0.021	3.8	10.2	0.00054	9.3	0.06	11.6	< 0.02	0.03	13.8	18.9	4.3
72_7142	1818946	5843688	17/12/2014	70	0.0107	11.2	19.1	0.0025	3.6	0.09	21.4	< 0.02	0.28	15.7	49	2.5
72_7232	1794246	5820762	28/01/2015	75	0.024	5.1	14.5	0.0058	3.6	0.164	19.5	10.3	11.1	42	29	2.9
72_730	1794393	5789056	8/04/2015	18.2	0.0097	1.8	9.3	< 0.00053		0.004	7.2	< 0.02	< 0.021	11.2	7.9	3.9
72_7747	1833762	5788254	16/01/2015	29	0.0123	4	9.2	< 0.00053	5.3	0.136	11.4	< 0.02	< 0.021	5.4	25	4.7
72_7772	1834430	5797085	22/01/2015	49	0.0139	5.7	9.7	< 0.00053	7.7	0.158	14.6	< 0.02	0.037	16.3	35	3.3
72_7773	1830524	5790710	22/01/2015	32	0.0115	4.4	6.8	< 0.00053	8.8	0.081	9.3	< 0.02	0.029	16.4	22	3.7
72_7774	1826051	5798580	28/01/2015	102	1.49	4	12.2	< 0.00053	2.2	< 0.004	25.1	< 0.02	13.9	< 1	15.6	3
72_7775	1823870	5800618	28/01/2015	46	0.158	6.7	19	< 0.00053	2.7	0.008	16.7	< 0.02	2.6	25	40	5.2
72_7776	1822696	5801067	28/01/2015	54	0.169	5.1	9.6	< 0.00053	1.8	0.34	14	< 0.02	0.036	11.4	28	3.9
72_7782	1825938	5797712	17/02/2015	96	0.03	14	9.2	0.00073	8.4	0.21	21.1	3.1	3	7.3	63	3.3
72_7799	1812521	5760349	23/01/2015	17.4	0.0098	1.88	5.6	0.025		0.074	6.6	< 0.02	0.027	2.6	8.6	4.2
72_7838	1804692	5830232	18/02/2015	40	0.0111	14.2	31	0.0042	5.8	0.004	25.2	0.16	0.99	5.7	67	5.7
72_7911	1830749	5779427	8/04/2015	28	0.0109	9	8.7	0.0091	7.2	0.004	12	< 0.02	5.1	23	32	5.9
72_7912	1830737	5779426	8/04/2015	25	0.007	6.7	16.6	0.0029	4.7	< 0.004	14.9	0.37	2.9	17.6	30	6
72_7913	1830717	5779437	8/04/2015	19.3	0.009	9.9	15.5	0.0118	8.7	0.009	15.8	0.03	9.3	7.7	42	8.2
72_7919	1830747	5779425	8/04/2015	30	0.0053	5.4	17.6	0.0037	4	< 0.004	14.3	3.2	12.4	25	25	6.1
72_7920	1833256	5787607	8/04/2015	40	0.0121	10.1	17.7	0.0029	6.1	0.014	17.7	0.26	1.41	26	40	6.5
72_7921	1833275	5787602	8/04/2015	41	0.0099	11	14.2	0.0032	7.8	0.011	17.1	0.14	2.5	41	42	5.9
72_7922	1833311	5787601	8/04/2015	35	0.0084	12.1	17.9	0.0033	8.4	0.004	17.5	< 0.02	3.6	13.8	43	6.2
72_796	1886603	5738847	14/01/2015	21	0.0087	11.8	13.6	0.0023	9.4	0.016	21.4	< 0.02	< 0.021	10.1	49	4.1
72_7981	1886497	5739696	16/12/2014	97	0.036	1.42	3.4	0.00078		0.139	21.4	0.02	0.69	< 1	4	0.33
72_8065	1833308	5787509	28/05/2015	45	0.0081	6.8	8.9	0.03	0.23		12.2	1	25	15.4	28	6.4
72_8092	1795211	5826256	19/06/2015	126	0.047	14.9	18.3	0.0066	0.4	0.011	34.6	11	29	155	62	5.6
72_8096	1798564	5824526	19/06/2015	80	0.023	13.1	23	0.0021	0.2	<0.004	24.2	7.5	12.1	46	44	5.8

Well No.	Easting	Northing	Date	Alkalinity	Boron	Calcium	Chloride	Copper	D.O.	DRP	Conductivity (mS cm^{-1})	Diss. Iron	Tot. Iron	Free CO2	Hardness	Potassium
72_8097	1802583	5821125	19/06/2015	30	0.0114	6.8	25	0.0046	1.2	0.006	31.9	34	39	54	42	3.9
72_8098	1803263	5819780	19/06/2015	35	0.02	8	40	0.0021	0.2	0.004	29.5	23	41	41	31	4.5
72_8099	1805583	5816309	19/06/2015	40	0.0094	7	22	0.0096	0.2	0.03	19.9	7.4	10	30	36	4.2

Well No.	Magnesium	Diss. Manganese	Total Manganese	Sodium	Ammoniacal-N	Nitrate-N	pH (pH units)	Reactive Silica	Sulphate	TDS	Zinc	Temperature (°C)
61_444	8	0.28	0.3	48	0.098	< 0.05	7.2	50	5.4	250	0.038	16.6
62_96	6.7	1.61	1.69	24	0.04	< 0.05	6.5	93	< 0.5	143	0.008	16.5
65_53	4.1	< 0.0005	< 0.00053	7.5	< 0.01	0.22	7	50	1.4	72	0.0022	14
66_60	1.28	< 0.0005	0.00129	8.6	< 0.01	0.2	6.9	75	0.9	51	0.0116	14.6
69_1018	12.7	0.182	0.194	34	< 0.01	< 0.05	7.5	59	6.2	250	0.0069	17
69_1668	1.71	0.0045	0.0044	12.3	< 0.01	0.2	6.3	54	3.2	71	1.93	17.9
69_2044	0.86	0.0191	0.0178	12.1	< 0.01	0.33	6.3	84	2.9	57	0.42	18.1
69_2082	2.2	0.033	0.031	11.8	0.015	3.2	6.6	23	1.5	63	0.171	15.4
69_2085	10.9	0.051	0.053	29	0.29	< 0.05	7.8	43	6.8	280	0.046	16.7
69_2088	9.1	0.36	0.37	41	0.05	< 0.05	7.6	48	11.7	320	0.0115	15.8
69_2140	5.3	0.49	0.51	220	0.27	< 0.05	7.2	51	0.6	820	0.0142	
69_836	12.3	0.55	0.52	23	0.018	< 0.05	6.6	76	31	210	0.0044	17.9
70_484	5.6	0.154	0.158	15.4	0.187	6.4	6.2	58	28	147	0.0019	15.6
70_526	3.4	< 0.0005	0.00179	7.7	< 0.01	3	6.6	54	6.9	80	0.0015	16.1
70_632	1.07	< 0.0005	< 0.00053	10.7	< 0.01	0.08	6.5	88	3.2	53	0.0198	15.9
70_796	5.3	0.7	0.66	16.6	0.31	< 0.05	6	71	106	230	0.0049	16
72_1148	3.4	< 0.0005	< 0.00053	16.7	< 0.01	6.6	6.9	77	15.2	130	0.0025	13
72_1480	2.1	< 0.0005	< 0.00053	10.8	< 0.01	2.4	6.2	85	6.5	73	0.0036	14.3
72_1483	2	0.046	0.062	57	7.3	< 0.05	7.7	1.12	< 0.5	270	0.62	16
72_1485	2.1	0.0027	0.0028	9.4	0.029	0.92	7.2	77	2.9	55	0.0017	16.9
72_1486	1.48	< 0.0005	< 0.00053	7.7	0.021	0.12	7.3	77	1.8	43	0.0029	17.5
72_1498	2.9	0.0012	0.00124	10.7	< 0.01	1.86	6.6	82	18.4	84	0.0026	15.8
72_1501	0.36	0.0008	0.00097	22	< 0.01	4	6.9	79	10.7	82	0.0025	15.9

Well No.	Magnesium	Diss. Manganese	Total Manganese	Sodium	Ammoniacal-N	Nitrate-N	pH (pH units)	Reactive Silica	Sulphate	TDS	Zinc	Temperature (^oC)
72_1502	1.97	< 0.0005	< 0.00053	23	< 0.01	7.3	6.5	79	10.9	117	0.0033	16.2
72_1511	1.85	< 0.0005	< 0.00053	11.4	< 0.01	4.2	7	75	5.2	83	0.0015	15.8
72_1576	1.57	< 0.0005	< 0.00053	7	< 0.01	0.09	7.1	78	1.3	43	0.0014	14.9
72_1882	2.3	0.26	0.26	16.5	0.119	< 0.05	7.6	68	2.1	71	< 0.0011	14.2
72_2067	1.69	0.42	0.44	14.9	0.25	< 0.05	6.5	89	< 0.5	76	0.0062	20
72_2389	5.9	0.69	0.71	22	0.015	< 0.05	6.6	44	0.7	135	1.62	27.5
72_2732	0.88	0.0011	0.001	16	0.012	0.9	6.2	93	2.8	67	0.0069	16.5
72_2874	7.7	< 0.0005	< 0.00053	22	< 0.01	0.22	7.2	44	3.7	171	0.0139	17
72_2915	7.7	0.0036	0.0037	19.6	0.084	0.11	7.3	16.1	52	460	0.012	15.6
72_3022	1.62	< 0.0005	< 0.00053	9.6	< 0.01	0.34	6.7	77	1	60	< 0.0011	12.6
72_3538	1.23	< 0.0005	< 0.00053	7	< 0.01	0.75	6.7	77	2	45	< 0.0011	12.5
72_3706	3	0.0031	0.0032	17.5	< 0.01	2.1	6	72	11	94	0.0084	16.7
72_3745	8.3	0.31	0.33	31	< 0.01	< 0.05	7.2	65	6.3	200	0.0059	16.7
72_3749	12.8	0.064	0.067	32	< 0.01	< 0.05	7	61	7.1	250	0.76	16.4
72_3984	1.13	< 0.0005	< 0.00053	6.7	< 0.01	0.16	7.4	74	1.3	38	< 0.0011	
72_4014	5.5	0.58	0.56	18.4	0.119	< 0.05	6.7	82	0.5	122	< 0.0011	16.1
72_4070	0.22	< 0.0005	< 0.00053	171	0.193	< 0.05	9.2	19.4	< 0.5	620	< 0.0011	17.1
72_4159	1.98	0.5	0.48	14.3	0.05	< 0.05	7.2	91	6.3	69	< 0.0011	21
72_4235	9.3	0.0006	< 0.00053	17.7	< 0.01	11.1	6.7	63	41	240	0.0148	16.2
72_4280	4.9	< 0.0005	< 0.00053	13.6	< 0.01	0.52	7	80	2.1	94	0.0012	16.2
72_4320	3.1	< 0.0005	< 0.00053	15.3	< 0.01	1.02	6.7	67	2.1	89	< 0.0011	16.8
72_4742	1.93	< 0.0005	< 0.00053	7.5	< 0.01	1.55	7.8	29	3.2	176	0.0042	15.7
72_4759	21	0.088	0.095	390	0.66	0.06	8	16.2	1.2	1740	0.145	16.4
72_4788	1.55	< 0.0005	< 0.00053	29	< 0.01	0.15	8.2	20	3.3	135	< 0.0011	18.2
72_4805	1.55	0.045	0.045	12.6	0.028	1.13	6.3	84	1.8	67	0.0014	15.9
72_4819	4.7	< 0.0005	0.00055	24	< 0.01	0.23	7	84	3	136	0.0012	16.1
72_4998	0.98	0.0015	0.00104	9.4	< 0.01	0.42	6.7	87	3.2	50	0.0053	16.4

Well No.	Magnesium	Diss. Manganese	Total Manganese	Sodium	Ammoniacal-N	Nitrate-N	pH (pH units)	Reactive Silica	Sulphate	TDS	Zinc	Temperature (°C)
72_5009	1.67	0.0012	0.00108	8.8	< 0.01	0.26	6.8	67	1.8	54	0.0071	14.4
72_5019	2.6	0.0092	0.0092	14.3	0.017	6.8	5.7	30	1.2	82	0.026	15.7
72_5034	1.15	< 0.0005	< 0.00053	9.9	< 0.01	0.09	7.1	89	1.9	52	0.0014	16.4
72_5042	5.8	0.0037	0.0038	19.5	0.021	12.2	6	83	1.8	144	0.03	15.5
72_5048	0.93	< 0.0005	< 0.00053	9	< 0.01	0.3	6.9	101	2.9	49	< 0.0011	15.5
72_5049	1.64	< 0.0005	< 0.00053	12.9	< 0.01	0.42	7	85	2.4	67	0.0013	17.1
72_5053	2.9	< 0.0005	< 0.00053	11.3	< 0.01	1.68	7	88	4.3	80	0.0026	16.8
72_5062	2.5	0.49	0.51	470	1.2	< 0.05	6.5	52	< 0.5	2200	0.0035	15.8
72_5103	11.1	0.0033	0.004	23	< 0.01	0.08	7.4	40	3.8	160	0.0167	18.8
72_5197	1.02	< 0.0005	< 0.00053	7.7	< 0.01	1.45	7.2	78	1.1	45	0.164	
72_5200	2.4	0.0009	0.00098	9.9	< 0.01	1.41	6.6	79	3.1	57	< 0.0011	13.6
72_524	2.4	0.0075	0.0085	14.9	< 0.01	0.38	6.7	87	2.6	79	0.007	17.6
72_5253	2.8	< 0.0005	< 0.00053	10.8	< 0.01	2.5	6.7	35	8.8	96	0.0019	16.3
72_5289	4.4	0.031	0.03	12.6	< 0.01	0.28	6.8	86	2.3	81	0.0089	16.4
72_5300	2.1	0.0009	< 0.00053	7.8	< 0.01	0.53	7	79	2.7	54	< 0.0011	14.8
72_54	7	1.18	1.18	28	0.175	< 0.05	7.1	81	< 0.5	162	0.53	19.2
72_5433	4.1	< 0.0005	< 0.00053	7.5	< 0.01	1.64	7.3	37	1.5	81	0.15	15.6
72_5442	4.4	< 0.0005	< 0.00053	18	< 0.01	4.4	6.5	79	14.2	110	0.0063	13.6
72_5445	5.2	< 0.0005	0.00056	13.4	< 0.01	5.2	6.3	76	21	129	0.0016	14.8
72_5469	5.8	0.0024	0.0024	12.2	< 0.01	1.9	6.8	32	6.8	110	0.24	15.7
72_5490	1.72	0.0019	0.00197	11.7	< 0.01	0.21	6.9	56	4	63	0.0017	17.5
72_5503	3.7	< 0.0005	< 0.00053	11.4	< 0.01	4.5	6.7	39	1.2	87	0.0011	15.5
72_553	5	0.5	0.54	22	0.031	< 0.05	6.3	64	4.3	121	0.185	15.7
72_5569	5.5	0.0012	0.00135	21	< 0.01	12.8	6.2	94	2.7	165	0.0108	16.5
72_5637	1.68	0.033	0.029	21	0.09	< 0.05	6.2	96	5	111	0.0068	17.5
72_5979	5.4	0.046	0.046	16.3	< 0.01	< 0.05	8	33	3.5	158	< 0.0011	19.4
72_6153	5.6	0.072	0.171	12.9	55	0.05	7.7	2.4	< 0.5	500	0.73	17.3
72_6155	5.1	0.0013	0.00182	14.2	< 0.01	10.5	6.5	64	52	210	0.0116	16

Well No.	Magnesium	Diss. Manganese	Total Manganese	Sodium	Ammoniacal-N	Nitrate-N	pH (pH units)	Reactive Silica	Sulphate	TDS	Zinc	Temperature (°C)
72_6180	4.6	0.0033	0.003	11.7	< 0.01	4.9	6.5	57	11.1	103	0.66	16.3
72_6408	4.3	0.172	0.178	25	0.045	< 0.05	6.6	93	< 0.5	130	0.0083	17.5
72_6474	6.1	0.57	0.54	26	0.021	< 0.05	6.4	91	2.2	164	0.056	19.1
72_6500	9.1	0.39	0.43	29	0.034	< 0.05	7.6	64	5.7	280	0.194	16.1
72_6501	4.4	0.195	0.21	19.7	0.074	< 0.05	7.3	56	5.9	170	< 0.0011	17
72_6514	2.8	0.84	0.87	12.2	0.73	< 0.05	6.6	78	< 0.5	99	0.0012	15.6
72_6680	8.3	0.31	0.3	41	0.56	< 0.05	6.8	92	< 0.5	220	0.0032	16.8
72_7003	2.8	< 0.0005	< 0.00053	9.2	< 0.01	1.96	7.3	37	1.5	62	0.009	14.2
72_7021	3.8	< 0.0005	< 0.00053	13.6	< 0.01	3.4	6.7	89	1.9	90	0.26	15.9
72_7107	6.7	< 0.0005	< 0.00053	10.1	< 0.01	0.17	7.8	16.9	15.2	220	0.079	14.9
72_7126	2.3	0.0007	0.00092	15.5	< 0.01	0.34	6.8	94	1.9	78	0.041	17.5
72_7142	5.2	0.0053	0.005	23	< 0.01	0.19	7	87	7.2	143	0.12	21
72_7232	4	0.37	0.36	26	0.7	< 0.05	6.6	93	< 0.5	131	0.002	19.8
72_730	0.83	0.0014	0.00158	8.8	< 0.01	0.31	6.5	78	1.6	48	0.0078	15.4
72_7747	3.5	0.0006	0.00087	9.9	< 0.01	2.1	7	82	5	76	0.054	15.8
72_7772	5.2	0.0006	0.0006	14.9	< 0.01	1.4	6.8	85	2.8	97	0.22	17.5
72_7773	2.7	0.0015	0.00159	8.2	< 0.01	0.59	6.6	82	1.7	62	1.02	15
72_7774	1.36	< 0.0005	0.09	49	< 0.01	< 0.05	9.8	0.15	< 0.5	168	0.155	20
72_7775	5.6	0.0134	0.0143	15.4	< 0.01	0.2	6.6	83	5.2	112	0.002	17.1
72_7776	3.6	0.023	0.022	16.2	< 0.01	< 0.05	7	88	1.9	94	0.39	17.4
72_7782	6.8	0.28	0.3	22	< 0.01	< 0.05	7.4	62	0.8	141	0.0013	16.9
72_7799	0.94	0.0015	0.00149	7.2	< 0.01	1.09	7.1	77	1.6	45	0.028	14.8
72_7838	7.7	0.57	0.56	19.3	0.157	2.8	7.2	73	21	169	0.021	
72_7911	2.4	0.123	0.36	10.8	0.015	2.7	6.4	68	6.3	80	0.023	17
72_7912	3.2	0.4	0.45	14.1	0.033	1.08	6.4	72	15.5	100	0.0138	16.1
72_7913	4.1	0.074	0.169	13.8	0.011	4.5	6.7	79	13.5	106	0.042	17.1
72_7919	2.7	0.49	0.52	12.6	0.189	< 0.05	6.4	78	8.5	96	0.0167	15.7
72_7920	3.5	0.32	0.4	15.9	< 0.01	1.6	6.5	77	11.5	119	0.038	16.6
72_7921	3.5	0.67	0.84	13.9	0.046	2.2	6.3	74	10.3	115	0.058	16.6

Well No.	Magnesium	Diss. Manganese	Total Manganese	Sodium	Ammoniacal-N	Nitrate-N	pH (pH units)	Reactive Silica	Sulphate	TDS	Zinc	Temperature (°C)
72_7922	3.2	0.76	0.81	14.3	0.012	2.7	6.7	67	10.9	117	0.0171	16.8
72_796	4.7	< 0.0005	< 0.00053	17	< 0.01	12.8	6.6	79	11	143	0.0108	19
72_7981	< 0.021	0.0036	0.0054	49	0.031	< 0.05	8.9	21	11	143	3.9	
72_8065	2.7	0.171	0.28	15	0.16	0.07	6.8	73	< 0.5	82	0.194	15.5
72_8092	5.9	0.87	0.91	27	4.5	<0.05	6.2		<0.05	220	0.0194	16.4
72_8096	2.9	0.68	0.67	19.2	2	<0.05	6.5		<0.5	162	0.0052	16.1
72_8097	6	0.4	0.39	18.7	0.187	<0.05	6		74	210	0.011	16.4
72_8098	2.7	0.51	0.51	18.7	0.84	<0.05	6.2		31	190	0.014	15.6
72_8099	4.4	0.22	0.24	15.6	0.21	<0.05	6.4		12.2	124	0.0193	15.3