Environment Bay of Plenty State of the Environment: Groundwater Level and Quality

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LIST OF ABBREVIATIONS

General

AMD	Above Moturiki datum
BGL	Below ground level
Calc	Calculated
CBE	Charge balance error
CD	Compact disk
DWSNZ2005	Drinking Water Standards New Zealand 2005
EBOP	Environment Bay of Plenty
GNS	GNS Science
GV	Guideline value (for DWSNZ2005)
GW	Groundwater or ground water
ID	Identification
m/year	metres/year
MAD	Median absolute deviation
MAV	Maximum acceptable value (for DWSNZ2005)
mg/L	milligrams/liter
mS/m	milli-Siemens/meter
NERMN	Natural Environmental Regional Monitoring Network
NGMP	National Groundwater Monitoring Program
p value	Probability value
r^2	Coefficient of determination
SWL	Static water level
TOC	Top of casing
uS/cm	micro-Siemens/centimetre

Water Chemistry Variables

Br	Bromide
Ca	Calcium
Cl	Chloride
COD	Chemical oxygen demand
Cond	Conductivity
E. Coli	Escherichia coliform bacteria
Fe	Iron
HCO_3	Bicarbonate
K	Potassium
Mg	Magnesium
Mn	Manganese
Na	Sodium
NNN	Nitrite plus nitrate nitrogen or total oxidized nitrogen
NO_3-N	Nitrate-nitrogen
^oC	Degrees Celsius
pH	Logarithm of the reciprocal of the hydrogen ion activity
PO_4-P	Phosphate-phosphorus
SO_4	Sulphate
TDS	Total dissolved solids
Temp	Temperature
TP	Total phosphorus

EXECUTIVE SUMMARY

Environment Bay of Plenty (EBOP) request GNS Science (GNS) analyse and review its existing groundwater level and quality databases. The databases to be utilized in performing this work were provided by EBOP in March 2006 via compact disk. The methods used in performing this work and the results from it are delineated in this report.

Water level data from 77 wells at 67 locations was reviewed. Fifteen of these wells with open intervals at different depths were installed at five locations to provide vertical profile gradient data. The following conclusions with regard to EBOP water level data were reached:

1. The water level data exhibits substantial variation. The primary sources of this variability are apparently such factors as climate-related annual cycles and data outliers. These are most evident in the case of wells in which data loggers were installed. The database for these wells included mean daily values. Water levels in other wells were manually measured on a quarterly basis. Some of the variability may be a result of measurements being made when the installed well pump was in operation.

2. There are apparent outliers in the data for most wells. These may be a result of extreme events, erroneous measurements, data entry errors, or measurements being made when the installed well pump was in operation.

3. There are few indications of real water level trends (i.e., consistent rising or falling water levels over time). Linear lines of best fit to time series plot data indicated substantial trends for 23 or 77 wells. However, further assessment of the plots indicates that for only about half of these wells was the trend likely to be real. The two major reasons initially indicated trends were rejected were: (1) the presence and timing of outliers; and (2) a bifurcated dataset. These conditions have the ability to indicate trends that are not supported by a reasonable assessment of the data.

Water quality data from 62 wells was reviewed. National Groundwater Monitoring Program NGMP) data for which there were 20 variables were used for six of these wells. EBOP data for which there were 36 variables were used for the other 56 wells. The following conclusions with regard to water quality data were reached:

1. The quality of groundwater sampled in EBOP monitoring wells is generally good. Although Drinking Water Standards for New Zealand 2005 (DWSNZ2005) are not strictly applicable to ambient groundwater quality in the EBOP region, they serve as a convenient gage for comparison. In most cases, results for variables analysed in samples from these wells indicated quality better than DWSNZ2005 maximum acceptable (MAV) or guideline (GV) values.

2. Water quality in the region generally does not appear to be changing over time. Trend analysis found relatively few variables having statistically significant changes over time (with the earliest available data being in the early-1990s). Increasing trends

were calculated for 38 variables in samples from 19 wells and decreasing trends were calculated for 46 variables in samples from 16 wells out of a maximum potential of 36 variables in 62 wells. Further review of these data using time series plots led to further reductions in apparent trends. As with water level data, the presence and timing of outliers and database bifurcation were factors leading to this reduction. The frequency of sampling, total number of samples, and data gaps were additional considerations. It was finally concluded that there were convincing indications of trend with regard to only four wells. Increasing trends were evident for three of these and a decreasing trend was evident in the fourth. Three of these wells are located near the coast (one of which is deep) and three of these wells have relatively shallow open intervals. Sea water intrusion may be the causative factor for the case of one of these wells with an increasing trend for conductivity and major ions may. Causes in the other three cases are not immediately evident.

3. Groundwater is generally sodium bicarbonate type. Deviation from this general case involves calcium as the predominant cation or chloride as the predominant anion.

4. Although a rigorous evaluation of data quality was not possible as a part of this project, review of outliers and charge balance errors indicates that data quality may be generally acceptable but is better for NGMP than for other EBOP wells. Reasons for this include consistent analysis and checking of reported results with reanalysis, if necessary, prior to entry into the database.

As a result of this review, the following recommendations were made with respect to water level and water quality data:

1. Water level –

   a. The EBOP water level database should be reviewed and adjustments made for future use. Level data should represent static water level conditions. Therefore, water level measurements known to have been made when the installed pump was in operation should be deleted. The database should include information on the height above datum of the reference point for water level measurements and the depth below the reference point of the open interval of the well.

   b. All manual water level measurements should be made with an electric tape water level indicator maintained in proper working order. Checks should be made by field personnel to ensure that the installed pump of a well is not in operation when the measurement is made. Field crews should compare measurements with historic data on level and level variability and take extra precautions when an initial measurement indicates the level is higher or lower than three standard deviations from the median historic water level for the well. These additional checks should be documented.

   c. Water level data should be carefully checked in the office at the time of entry into the database to ensure they are consistent with historic data or, if not, that the measurement is accurate. The use of historic statistics and/or time series plots are appropriate for this purpose. If necessary to resolve questions, the measurement should be repeated. Field and office checks are important to maintaining the integrity of the database.

2. Water quality –

   a. The EBOP water quality database should be reviewed and adjustments made for future use. Consistency regarding variables being analysed, uniformity in data entry, and inclusion and identification of values less than detection limits are important in this regard.

   b. All analytical data reported by a laboratory should be checked for data quality at the time of receipt and when being entered into the database to ensure consistency with historic data or, if not, that the measurement is accurate. If necessary and the sample is still within holding time, it can be reanalysed. If the sample is out of holding time, data quality problems may require resampling. Field and office checks are important to maintaining the integrity of the database.

   c. Data for NGMP wells in the EBOP database should be checked for consistency with the NGMP database and any problems resolved.

   d. Wells having high groundwater temperatures should be checked for geothermal influences and, if verified, flagged in the database as such.

   e. Well 3272 had extreme levels of sodium, chloride, and other major ions making it unsuitable as a source of drinking water or agricultural uses. The owner/users of this well should be notified of that circumstance.

   f. Well 3470 had a high level of arsenic making it unsuitable as a source of drinking water. Fifteen other wells or sites (including Braemer Springs) had at least some samples with arsenic concentrations exceeding the DWSNZ2005 MAV. The owners/users of these wells and Braemer Springs should be notified of that circumstance.

   g. Reasons for the exceedance of ammonia-nitrogen GV in 15 wells and the nitrate-nitrogen MAV in two wells should be further reviewed.

   h. Owners of the 17 wells having positive results for bacteria should be notified of that circumstance and encourage to take corrective measures to eliminate sources of such contamination if possible.

   i. The data for wells 0001, 1393, 2707, and 3301 indicated significant trends. The circumstances of these wells should be studied in further detail to determine, if possible, what the reason(s) for these trends may be. In the case of well 2707, its location near the coast, shallow construction, and variables with increasing trends are consistent with seawater intrusion. The increasing trends in the first three of these wells have priority for this study. The slight decreasing trends with regard to well 3301 are unlikely to be of any consequence.

1.0 INTRODUCTION

Environment Bay of Plenty (EBOP) requested that GNS Science (GNS) analyse and review its existing groundwater level and quality databases. The databases to be utilized in performing this work were provided by EBOP in March 2006 via compact disk (CD). This CD included the following Microsoft Excel workbook files:

1. Water level data –
   a. “Well Level Sites” – Two worksheets with lists of wells monitored to obtain water level data including EBOP well identification (ID) numbers and owner names, addresses, and phone numbers.
   b. “Natural Environmental Regional Monitoring Network (NERMN) Level Sites” – One worksheet with a list of wells monitored to obtain water level data including EBOP well ID numbers, owner names and addresses, location by map reference and coordinates, bore total depth, an unidentified static water level (SWL), and an unidentified temperature. Unidentified in this context means the dates for the data were not specified.
   c. “NERMN Groundwater” - One worksheet with a list of wells used for monitoring both groundwater levels and quality. In addition to the well ID, map references, and coordinates, this spreadsheet has two other columns. These indicate the general area of EBOP the well is located in and whether it is used for water level or water quality monitoring only or for both.
   d. “GW (groundwater) Level Data Up To February 2006” – Worksheets for 67 well locations identified by well ID numbers and providing time series water level data. At five of these locations, multiple wells are installed with open intervals at different vertical depths below ground level (BGL).
2. Water quality data –
   a. “Well Chemistry Sites” – One worksheet with tabulated information relevant to wells sampled for water quality including well ID numbers, owner names, addresses, and phone numbers, and unidentified depth, temperature, and conductivity values. Unidentified in this context means what depth was intended is not identified. It is presumed to be total depth.
   b. “NERMN Chemistry Sites” – One spreadsheet with information identical to that found file listed above at 1.b with regard to water level data only for wells monitored to obtain water quality data.
   c. “NERMN Groundwater” – This is the same spreadsheet listed in item 1.c above.
   d. “NERMN” GW chem. Data” – One spreadsheet with groundwater chemistry data for a number of variables in a number of wells.
   e. “Methods” – A worksheet listing information on methods used in analysing water quality samples.

This document provides a report of the analysis and review of the EBOP groundwater level and quality databases conducted. With the exception of editing of water level and quality data as identified in Sections 2 and 3 of this report, all data provided by EBOP was assumed correct and consistent and were relied on for analysis and presentation as received. The groundwater level analysis and review is presented in Section 2 and the groundwater quality analysis and review is presented in Section 3. Conclusions and recommendations are provided in Section 4.

2.0 GROUNDWATER LEVEL

2.1 Data

A noted in Section 1.0, four Excel files with information identifying wells used for water level monitoring or providing such water level monitoring data were received from EBOP. The wells identified in each of these files are listed in Table 2.1. It can be seen from Table 2.1 that there are differences between these; however, most of the differences appear to be a result of the 10 wells listed in the two columns on the far right side of the table having been taken out of service for the reasons indicated.

The wells identified in the “Current Well Data” columns are those currently in service for which EBOP provided data through February 2006 to be analysed. The water level data were provided in the form of an Excel spreadsheet for each of the listed wells. One or more data points were subsequently obtained for the 10 out of service wells, but because of the status of those wells these data were not analysed.

Locations of wells monitored by EBOP for water level data are indicated in Figure 2.1. Figure 2.1 is a map provided by EBOP. It may not be completely up to date but was considered sufficient for the purposes of this report. Information on each of the wells currently monitored to obtain water level data is presented in Table 2.2. Because multiple wells screened at different depths exist at some locations, there are 77 wells at 67 locations. Well IDs 2519 through 2523 involve 15 wells with vertically different open zones at five locations. This includes the identification of the well (by EBOP well ID number and the name of owner), the location of the well (by town, area within EBOP, map reference, and coordinates), and available well data (well top of casing or TOC elevation above the Moturiki datum or AMD used to represent sea level, well total depth, the interval of the well open to the aquifer, and the geology the well is located in). The open interval was assumed to be from the bottom of the casing to the well total depth. As is evident from Table 2.2, there were substantial gaps in available well data.

Water level data were provided in the following two formats:

1. For most wells, water level measurements were manually made from the TOC. In these cases, the spreadsheet has six columns of information. These are labelled:
    a. Piezo;
    b. Date;
    c. Time;
    d. Level;
    e. Pumped; and
    f. Comment.

In most cases, the "Piezo" column contained a "1" indicating that all measurements were obtained from one well. Where multiple wells screened at different depths were involved at the same location, they were identified by additional numbers. This is the case for well IDs 2519 through 2523. The open interval being monitored in each of those cases is indicated in Table 2.2. The date column was used but the time column was ignored. This is reasonable since water level measurements were normally made on a monthly or quarterly basis. Levels were listed in m below the TOC reference point. Information in the "Pumped" and "Comment" columns was used to censor data that was obtained when the well's pump was in operation. This was accomplished by removal of any data point where there was a "1" in the pumped column, indicating the pump was running when the measurement was taken (Naude, 2006) or where there was a notation in the comment column to the same effect.

2. Data loggers are installed in a selection of wells. The spreadsheets for these wells have three columns of information. These are date, time, and elevation in mm with reference to the Moturiki datum. All of the times are 24:00 and all of the data points are daily means. Some data points were listed with question marks. All of these were assumed to be questionable and removed.

The number of deleted data points and the number of remaining data points analysed for each well and the year range of the data period are listed in Table 3. The general case was quarterly water level monitoring. However, there were many wells with missing dates in their record. This circumstance could effect data analysis and was considered qualitatively during visual assessment of time series graphs.

2.2 Data Analysis

Water level data were analysed in the following three ways:

1. Summary statistics (i.e., minimum, median, mean, maximum, and standard deviation values) for the data from each well were calculated using Microsoft Excel 2002.

2. Time series graphs of the data were prepared for each well using Version 5 of the Golden Software Grapher computer program. Data for locations with multiple wells screened at different depths were plotted on the same graph to facilitate graphical comparisons. The plot for each well also shows the linear line of best fit produced by Grapher. Time series water level data are not expected to closely follow a linear trend, but the slope and coefficient of determination (r^2) values obtained from linear regression provide a useful means of evaluating the overall temporal trends.

3. Visual assessment of time series graphs. The graphical plot for each well was visually assessed and qualitative determinations were made regarding slope, outliers, and other relevant aspects. In the absence of any evident trend, the trend was classified as horizontal. A positive slope that appears to be valid is classified as a "Falling" water level trend for manually measured wells (depth below TOC increasing over time) and an "Rising" water level trend for data logger wells (water elevation increasing over time). A negative slope that appears to be valid is classified as an

"Rising" water level trend for manually measured wells and a "Falling" water level trend for data logger wells. If outliers are evident (i.e., data points that don't appear to be consistent with the general trend of measurements) they are noted as being either "Deep" (i.e., below the general trend) or "Shallow" (i.e., above the general trend). Additional comments as appropriate are listed in the final column of the table. These include the relative location of outliers on the plot that might influence slope (e.g., a late high outlier could result in a negative slope for manually measured wells) and data which appear to be in some way bifurcated (e.g., apparent differences between earlier and later year periods).

2.3 Results

Summary statistics for the data from each well are presented in Table 2.3. These indicate the range of measurements for each well (from minimum to maximum), central tendency (median and mean), and variability. Considerable variability is evident in the data with median and average standard deviations of 0.78 and 1.75 m, respectively. For example, if the data were normally distributed, approximately 95% of the data would be expected to be within two standard deviations of the mean. This would cover a range on the order of 3.1 to 7 metres.

Time series plots are presented in Appendix A. Twelve locations are plotted on each page. Where a single well is shown in a plot, the circular data points are joined by a solid black line. Discontinuities in the record are indicated by breaks in the line. The linear line of best fit for the data as a whole is shown as a dashed red line. The slope of this line and its coefficient of determination are listed in Table 2.3. Also presented in Table 2.3 are the qualitative judgements based on visual assessment of these plots including comments on the trend of the data (horizontal or falling or rising water levels), whether or not there are apparent outliers and in what direction, and other relevant comments.

The graphical plots show that there are seasonally-related cycles in the data. This is particularly apparent in the case of wells with data loggers. Such cycles would be expected with water levels rising in response to precipitation during the wetter part of the year and falling in response to lack of precipitation during the dryer part of the year. Whether or not these cycles coincide in time with actual wet and dry seasons depends the nature of the connection between the surface and aquifer involved. In some cases (e.g., well 0461) it appears that water levels fall in the summer and rise in the winter while in others (e.g., well 2504) the reverse is sometimes evident.

Based on the slope of the linear line of best fit, there are a number of wells with substantial long term water level trends of either rising or falling water levels (i.e., trends with a magnitude of 0.1 m/year or larger). Of the 77 wells, 23 are in this category. However, when the graphical plots were visually assessed it was found that there were often reasons the calculated trend did not appear to be an accurate description of the situation. The two major apparent reasons for this were the bifurcated nature of some of the data plots and the presence and timing of outliers.

It was apparent for some wells that early and late time data points were different in substantial ways. This phenomenon is referred to herein as bifurcation. For example, in the case of well 0090 the best linear fit for the data as a whole (1986-2006) indicates a substantial rising water level trend (i.e., a large magnitude negative slope of – 0.5114 m/year). However, visual assessment shows that the early time data (roughly between 1987 and 1992) differs from the latter time data (roughly between 1993 and 2006). Summary statistics for these two periods are as follows:

Statistic	1987-1992	1993-2006
Minimum	29.87	26.97
Median	35.87	28.48
Mean	36.53	28.63

Statistic	1987-1992	1993-2006
Maximum	43.51	34.95
Standard Deviation	4.00	1.40

Further analysis of the groups of data from these two periods indicates that they are significantly different (by Mann-Whitney, Student's t, and parametric or nonparametric analysis of variance) and that there is no significant trend for either group (by Mann-Kendall with very small Sen's slopes on the order of 0.02 and 0.01 m/year for the later and earlier periods, respectively).

The situation with regard to outliers is similar. For example, in the case of well 0094 the best linear fit for the data as a whole (1990-2006) indicates a substantial rising water level trend (i.e., a large magnitude negative slope of – 0.2324 m/year) and a relatively high coefficient of determination (i.e., 0.0988). However, visual assessment shows that there were three high data points near the end of the monitoring period (2004 and 2005). These were in the range of 2 to 3 m compared to the median for the database as a whole of 17.27 m. Analysis indicates that these three points are statistical outliers. If they are removed, the best linear fit for the data becomes nearly horizontal with a very small positive trend of 0.005683 m/year and a relatively small coefficient of determination of 0.000391.

Taking these visual assessments into account, of the 77 wells for which there are water level monitoring data, there is no trend indicated for 64. Five show falling and eight show rising trends. The bulk of these, all but two, are in the Tauranga or Te Puke-Maketu areas of the Region. These are nearly evenly split between falling and rising categories (five and six, respectively). Small rising trends are indicated for one well each in the Rangitaki Plain (well ID 2541) and Galatea Plain (well ID 2913).

3.0 GROUNDWATER QUALITY

3.1 Data

As noted in Section 1.0, three Excel files with information identifying wells used for water quality monitoring or providing such water quality monitoring data were received from EBOP. The wells identified in those files are listed in Table 3.1. It can be seen from Table 3.1 that there are differences between these lists; however, there is considerable overlap.

The wells listed in the "Current Well Data" columns are those for which EBOP provided water quality data. Although most of these wells are apparently still in service, some are evidently no longer being sampled (see further information relevant to this comment below). Water quality data were provided in the form of an Excel spreadsheet listing results for 699 samples for one or more of 78 columns of variables from 62 wells (including one spring). This spreadsheet was labelled "NERMN GW chem. data." Locations of wells monitored by EBOP for water quality are indicated in Figure 3.1. Figure 3.1 is a map provided by EBOP. It may not be completely up to date but was considered sufficient for the purposes of this report. Six of the wells were National Groundwater Monitoring Program (NGMP) wells. These are listed at the end of the far right column in Table 3.1 by their NGMP designation and earlier in the "Current Well Data" columns with a parenthetical note of that designation after the EBOP well identification number.

Information on each of the 62 wells for which water quality data were provided is presented in Table 3.2. This includes the identification of the well (by EBOP well ID number with, in six cases, a parenthetical note of the NGMP designation and the name of the owner), the location of the well (by town, area within EBOP, map reference, and coordinates), and available well data (the open interval of the well and the geology the well is located in). The open interval was assumed to be from the bottom of the casing to the well total depth. As is evident in Table 3.2, there are substantial gaps in available well data.

The general case, with one exception, was that these EBOP wells were sampled on an annual basis. That exception to that general case was that the six NGMP wells were normally sampled on a quarterly basis. However, there were many wells with missing dates in their record or for which not all variables were analysed on a given sample date. A notable gap in the sampling program was that many of the EBOP wells were not sampled in the 1999 through 2001 or 2002 period (e.g., wells 925, 2362, and 3039). The water quality data file provided by EBOP was edited in a number of ways in order to obtain a useable database for statistical analysis. After editing, the input database consisted of data for 36 variables. The following is a summary of the edits that occurred:

1. There was a column listing water levels. It contained 14 data points. This column was deleted as not being directly relevant to this section of the statistical analysis.

2. The numbers "142," "2806," and "2902" were deleted as temperature values for three different sites (well IDs 3045, 2362, and 3272, respectively). In looking at other values for those wells, those values may have been data entry errors for real values on the order of 14, 28 and 29 ^{o}C, but this could not be confirmed.

3. Two columns of data were provided labelled "Alkalinity." In most cases, there was only data in one or the other of these columns. It was apparent from the values where data was listed in both columns that one was total alkalinity as calcium carbonate and the other was the bicarbonate ion concentration. These columns were merged into one for bicarbonate with alkalinity as calcium carbonate being converted to bicarbonate ion concentrations. This was accomplished by multiplying the conversion factor of 1.22 (the ratio of equivalent weights) times the total alkalinity as equivalent calcium carbonate (Sawyer and McCarty, 1978). A separate column labelled "bicarbonate" had only one value in it and was deleted. This may result in minor errors in the 12 samples from two wells (well IDs 2829 and 3301) where pHs marginally exceeded 8.3 units and, therefore, a small amount of the alkalinity would be in the carbonate form. Most of these pHs were 8.4 or 8.5 but the highest was 8.8 units.

4. Units of conductivity were converted from mS/m to uS/cm.

5. The column labelled salinity was deleted. It contained 4 data points. Salinity is measured with a conductivity bridge calibrated with standard seawater. Salinity is not normally a major consideration with respect to groundwater and where it is can be indicated by conductivity.

6. A column labelled turbidity was deleted. There were no data points in it.

7. A column labelled COD was deleted. There were 42 data points in it. The highest of these was 38.7 mg/L. COD is not normally a consideration with respect to groundwater unless contamination by wastewater is of concern.

8. Multiple columns were listed for a number of elements. Nearly all of these data were in columns identified as being the "soluble" form. By definition, "soluble" indicates that the sample was filtered using a 0.45 micron filter in the field at the time of collection and, therefore, what has been determined was in solution rather than associated with solids.. Columns labelled "total" or "total reactive" were deleted. "Total" indicates that the sample was digested using strong acid(s) and high temperatures prior to analysis. When such samples have not been filtered, reported concentrations are likely to be influenced by the presence of any solids in the sample and may be substantially elevated beyond what was actually in solution in groundwater.

9. In the case of calcium, there were two columns: (1) one labelled "Calcium;" and (2) one labelled "soluble" calcium. In general, data were in one column or the other. In the few cases where data were in both columns for the same sample results appeared to be similar. In many cases, data were in one column for some years and the other column for other years for the same well. In these cases, results were also similar. There were nearly 300 data points in each column. Calcium is a major ion which tends to be predominantly soluble under normal conditions. Because of the evident similarity, these columns were merged to produce one column of calcium data. The cases for magnesium, potassium, and sodium were similar.

10. In the case of mercury, there were 54 values listed under the "soluble" column. All of these values were 0.000040 mg/L. All of these were deleted because the data were too sparse to be useful (usually not more than one or two data points per well). Additionally, a level of 0.00004 mg/L appears to be similar to the level of the detection limit for this element. Therefore, it is considered likely that 0.000040 was the detection limit and that those values were being reported as less than it but that the "less than" distinction was not made in the database used.

11. In the case of silica, there were seven columns with varying labels: (1)silica; (2) SiO_2; (3) reactive silica; (4) soluble silica; (5) total silica; (6) total reactive silica; and (7) dissolved silica. The number of total data points appeared to be fairly evenly split between these seven columns. Where there were values in common for the same wells, it was apparent that two of these columns were substantially different. Values in the column labelled total reactive silica were in the range of 0.2 to 1.4 mg/L while values in all other columns were much larger (with median values for all but one column in the approximately 74 to 82 mg/L range). The one different column was labelled soluble silica. Values in that column were approximately half of those any of the other five columns. Therefore, the columns labelled total reactive silica and soluble silica were deleted and values in the other five columns were combined and simply labelled silica.

12. In the case of phosphorus, there were three columns: (1) one labelled "dissolved reactive phosphorus;" (2) one labelled "total dissolved phosphorus;" and (3) one labelled "total phosphorus." The dissolved reactive phosphorus column was assumed to represent phosphate-phosphorus. There were only nine values in the total dissolved phosphorus column and in each case there was a value for that sample in the dissolved reactive phosphorus column. Therefore, the total dissolved phosphorus column was deleted

13. There were two columns labelled "nitrate-nitrogen" and one labelled "total inorganic oxidized nitrogen" or "NNN." Most of the data points were either in the column labelled NNN or the first of the two nitrate-nitrogen labelled columns and in many cases there were values in both of these two columns for the same sample. Comparison of data in all three columns indicated similar magnitudes. Because nitrite is a transient intermediate species during nitrification, nitrite levels are usually small in comparison with nitrate when both are measured in the same sample. Therefore, all three of these columns were merged into one with precedence being given to the first nitrate column when there were data in more than one.

14. There were three columns with microbiological data: (1) one labelled "E. Coli;" (2) one labelled "Enterococcus;" and (3) one labelled "Faecal Coliform." Because of the sparsity of data in that column (seven data points) data in the E. Coli column were deleted.

15. Data for the six NGMP wells were provided as part of the EBOP database. When these data where compared with data for the same wells in the NGMP database, substantial differences were noted. These included differences in sampling dates

and differences in data for the same sampling date. Priority was given to the NGMP database and the EBOP database for these wells was replaced with it. This resulted in the replacement of EBOP data for 197 samples with NGMP data for 213 samples. This changed the resulting data base from a total of 699 samples for 62 wells to a total of 715 samples for the same wells. The NGMP database included arsenic, chromium, and copper data for two of the 213 samples. These were too sparse for statistical analysis and were deleted. This left 20 variables for NGMP wells compared to 36 for the EBOP database.

16. It appeared that some results in the EBOP database were probably at the detection limit and may have been originally reported at less than their respective detection limits (e.g., in the case of mercury). There was no way to positively identify this as being the case. Results less than the detection limit are reported that way in the NGMP database.

3.2 Data Analysis

Water quality data were analysed in the following ways:

1. The data were input into the NGMP Calculator. This is an Excel spreadsheet program developed by GNS for automatic processing of water quality data (Daughney, 2005). This program is capable of producing the following output for each variable in the database for each well:

    a. Distributional parameters –

        1) Median
        2) Mean
        3) Median absolute deviation
        4) Interquartile range
        5) Standard deviation

    b. Temporal trends –

        1) Trend evaluation by seasonal Mann-Kendall test with calculation of the "p value." p values less than 0.05 are the criterion for statistical significance (i.e., 95 % confidence level).
        2) Trend magnitude in units/year (both by linear regression and Sen's slope estimator).

2. Excel was also used to select the maximum value for each variable in the database for each well.

3. For those analytes having statistically significant increasing or decreasing trends, time series graphs of the data were prepared for each well using Version 5 of the Golden Software Grapher computer program. Data for locations with multiple wells screened at different depths were plotted on the same graph to facilitate graphical

comparisons. The plot for each well also shows the linear line of best fit produced by Grapher. To facilitate plotting, results reported below detection limits were changed to one-half the detection limit.

4. Visual assessment of time series graphs. The time series plot for each well was visually assessed and qualitative determinations were made regarding slope, outliers, and other relevant aspects. A positive slope that appears to be valid is classified as an increasing concentration and a negative slope that appears to be valid is classified as a decreasing concentration. If outliers are evident (i.e., data points that don't appear to be consistent with the general trend of measurements) they are noted as being either "low" (i.e., far below the general trend) or "high" (i.e., far above the general trend). Additional comments as appropriate are listed in the final column of the table. These include the relative location of outliers on the plot that might influence calculated slope (e.g., a late high outlier could result in a positive slope despite the rest of the data indicating no discernible trend) and data which appear in some way to be bifurcated (e.g., apparent differences between earlier and later time periods).

5. Median values for major ions were analysed using Version 5 of AquaChem to determine water type and to produce two types of major ion plots. The two types of plots were: (1) Piper; and (2) pie map. Because of the relatively large number of samples, plots were produced by regional area groupings. These areas are identified in Table 3.2. Charge balance error (CBE) was calculated by AquaChem using these data as were values for total dissolved solids (TDS).

3.3 Results

Results are most readily considered in terms of the analysis conducted (i.e., summary statistics, trend, and other factors such as water type and geographic distribution). Therefore, they are discussed below in those general categories.

3.3.1 Summary Statistics

The presentation of statistical results, such as summary statistics, is awkward for a database of this size. With 36 variables for 62 wells, there could be 2,232 groups of statistics (the actual number of groups was less because there was not data for all variables in all wells). Presenting results for summary statistics alone under this circumstance (i.e., minimum, median, mean, maximum, standard deviation, and median absolute deviation) would require a table with nearly 14,000 entries. Therefore, tables of results for median and maximum values only are presented in this report. They are shown in Tables 3.3 and 3.4, respectively. This gives some indication of central tendency and maximum levels that can be compared to suitable criteria.

Median results are presented in three sections in Table 3.3. The three sections used were: (1) field variables, major ions, and silica; (2) minor/trace elements; and (3) nutrients and bacteria. The maximum level for any variable in any well was similarly presented in Table 3.4. In the absence of other criteria, maximum levels are also compared with Drinking Water

Standards New Zealand 2005 (DWSNZ2005) in Table 3.4 (Ministry of Health, 2005). This was not intended to imply that those standards were applicable in any strict sense but was done to allow results to be placed in some type of context.

Results for maximum values in Table 3.4 indicate that, with a few exceptions, levels of variables reported in ground water samples from EBOP monitoring wells have generally been less than DNSNZ2005 maximum acceptable values (MAVs) and/or guideline values (GVs). Further discussion and substantial exceptions are as follows:

1. pH – Maximum values in three of 62 wells exceeded the high pH criterion of 8.5 units while minimum values in 49 of 62 wells were less than the low pH criterion of 7.0 units in DWSNZ2005. Altogether, pHs for all samples were within the DWSNZ 2005 pH range criteria in only 11 of the 62 wells sampled. However, it should be noted that although pHs in the range of 6.0 to 7.0 units were outside of the DWSNZ2005 criterion range, they are well within the range of natural groundwater systems (Hem, 1985) as well as drinking water standards used by many other countries (USEPA, 1992 and WHO, 2003). Drinking water standards in general use historically specified a pH range of 6.0 to 9.0 units. More recently, the bottom end of this range has been narrowed to 6.5 units in many parts of the world (USEPA, 1992 and WHO, 2003). The reason for this narrowing was to reduce corrosion of metal plumbing fittings rather than having anything to do with health or other intrinsic factors. A pH less than 6.0 was reported in samples from only five of the 62 wells.

2. Temperature – 16 of the 62 wells had temperatures that were judged to be elevated above what would be expected for cold fresh groundwater (i.e., in excess of 25 ^{o}C). The highest reported temperature was 54.7 ^{o}C (well ID 0951). Such a temperature greatly exceeds that characteristic for water supplies and indicates geothermal influences.

3. Major ions – Eight of 62 wells had sodium concentrations in excess of the 200 mg/L GV. In most of theses cases, chloride was also in excess of its 250 mg/L GV (a total of six wells were in that category). The highest sodium and chloride concentrations were in the same well (well ID 3272). In this case, they were at levels of 5,010 and 10,600 mg/L, respectively. Concentrations of other major ions were also high in well 3272 (e.g., sulfate at a level of 1,070 mg/L). This was also the only well in which hardness (i.e., levels of the divalent cations calcium and magnesium) clearly exceeded DWSNZ2005 GVs.

4. Minor/trace elements –

    a. With the exception of arsenic, fluoride, iron, and manganese, there were only a handful of results for minor/trace elements in excess of DWSNZ2005. These are listed in Table 3.4b and include three for aluminium, four for boron, one for copper, three for lithium, one for nickel, and two for zinc.

b. In the case of arsenic, maximum levels exceeded the DWSNZ2005 MAV of 0.01 mg/L in 15 wells of 62 wells. Only one of these was a very substantial exceedance of more than an order of magnitude (i.e., 0.29 mg/L in well 3470).

c. Although levels for fluoride only exceeded the DWSNZ2005 MAV of 1.5 mg/L in five of 62 wells, several were greater than 10 mg/L and one was as high as 44.9 mg/L (well ID 0925). However, the highest fluoride concentrations recorded in the data base (9.3, 11.4, 19.5 and 44.9 mg/L for samples from wells/sites Braemer Springs, 0466, 0845 and 0925) were for samples taken on the same date and presumably sent to the same laboratory for analysis. These results are outliers with respect to the all other values for those wells with no other values exceeding 1 mg/L (except an earlier value of 1.7 mg/L for well 0466) and median values of 0.60, 0.63, 0.26, and 0.13 mg/L, respectively.

d. Iron and manganese – The DWSNZ2005 GV for iron of 0.2 mg/L and GV of 0.04 mg/L for manganese were exceeded in 31 each of 62 wells. Additionally, the GV of 0.10 mg/L for manganese was exceeded in 28 of 62 wells. In most cases these iron and manganese exceedances occurred in the same wells (see Table 3.4b). Iron and manganese are commonly reported at substantial levels in groundwater samples. This circumstance in EBOP monitoring wells is therefore not unusual.

5. Nutrients and Bacteria –

a. The only nutrients for which there are DWSNZ2005 criteria are nitrogen compounds. Of the three nitrogen compounds, results indicated that the major problem was with respect to ammonia-nitrogen. Samples from 15 wells exceeded the 0.3 mg/L GV and samples from four wells exceeded the 1.5 mg/L GV. There were no exceedances of the nitrite-nitrogen long and short term MAVs of 0.2 and 3 mg/L, respectively, and only two marginal exceedances of the nitrate-nitrogen MAV of 11.3 mg/L. However, it should be noted that research has found that nitrate-nitrogen levels over 1 mg/L are indicative of anthropogenic impact in New Zealand aquifers (Burden, 1982 and Daughney and Reeves, 2005) and that in addition to the two marginal exceedances of the MAV there were samples from 15 wells less than the MAV but greater than 1 mg/L.

b. Positive results were reported for samples from 15 of 62 wells for both enterococci and faecal coliform bacteria. Positive results were also reported for faecal coliform bacteria in samples from another three wells.

3.3.2 Trend Analysis

Trend analysis results produced by the Excel NGMP calculator program are shown in Table 3.5 for all variables in any well having statistically significant increasing or decreasing trends. There were 38 variables in 19 wells for which increasing trends were indicated and 46 variables in 16 wells for which decreasing trends were indicated. It is noteworthy that just over half of these trends occurred for variables in NGMP wells. It is normally considered necessary to have at least eight samples available to confidently analyse data for trend (Yue, et al., 2002). Since NGMP wells are sampled quarterly and other EBOP monitoring wells are only sampled annually and same data were missing, the available data for most EBOP monitoring wells is thin with regard to trend analysis. Nevertheless, the result indicates a relatively low incidence of statistically significant trends considering the total number of variables and wells (i.e., an incidence of approximately 4% assuming the suite of possibilities is defined by 20 variables in six NGMP wells and 36 variables in the other 56 wells or 2,136).

In order to assist in data visualization, time series plots were produced for those wells having statistically significant increasing or decreasing trends for three or more variables. Copies of these time series plots are presented in Appendix B. Multiple variables were plotted on each graph. Where necessary to fit these plots on the same graph, additional vertical scales were utilized for some variables. Raw data points are indicated by various shaped features (e.g., circles, triangles, plus signs, and squares) joined by a black line. Discontinuities (i.e., missing quarterly sample dates) in the record are indicated by breaks in the line. Values reported as less than the detection limit were estimated at one-half of that limit in order to facilitate plotting. The linear line of best fit for the data as a whole is shown as a dashed red line for each variable in each well. The slope of this line and its coefficient of determination are listed in Table 3.6. The higher the coefficient of determination, the greater the indication of a relationship between the two factors being plotted (in this case, concentration as a function of time). A coefficient of determination greater than 0.7 was considered a reasonably strong indicator of a relationship for these data. Also presented in Table 3.6 are the qualitative judgements based on visual assessment of these plots including comments on the trend of the data (horizontal indicating no trend or increasing or decreasing water concentration trends), whether or not there are apparent outliers and in what direction, and other relevant comments. It is noteworthy that over two-thirds of the entries in Table 3.6 are for variables in NGMP wells.

When the time series plots were visually assessed it was found that there were often reasons the calculated trend did not appear to be an accurate description of the situation. As with water level data, the two major reasons for this were the bifurcated nature of some of the data plots (i.e., in some cases the data appeared substantially different between two periods of time with no trend or conflicting trends in each period) and the presence and timing of outliers (e.g., early time high outliers or late time low outliers could result in the appearance of a decreasing trend not indicated by the main body of data while late time high outliers or early time low outliers could result in the appearance of an increasing trend not indicated by the main body of data). In contrast with water level data, detection limits were an additional factor. Since EBOP's database did not specifically indicate any data in this category, it was only possible to take this factor into consideration when analysing data from the NGMP database for the six NGMP wells. Additionally, in some cases, the fact that a substantial fraction of the data base were missing also affected consideration of the trend.

Based on the data, slope of the linear line of best fit, and coefficient of determination (r^2), four wells appear to have substantial increasing and five wells appear to have substantial decreasing trends for two or more variables.

These wells and the variables involved are as follows:

		Well	Variable
1.	Increasing trends –		
	a.	**0001**	SO_4, Fe (high SO_4 r^2)
	b.	1393	HCO_3, PO_4-P, TP (all r^2 high)
	c.	2707	Cond, Ca, Mg, K, Na, Cl, SO_4 (mostly high r^2)
	d.	**4007**	Mg, Cl (very slight)
2.	Decreasing trends –		
	a.	**0001**	Cond, pH, Ca, Mg, HCO_3, Mn (slight and outliers)
	b.	0490	HCO_3, NO_3-N, PO_4-P (substantial missing data)
	c.	2303	Temp, TP (substantial missing data)
	e.	**3301**	Cond, Ca, Mg, K, Na, HCO_3, Cl, SO_4, Br, NO_3-N (missing data and slight trends but five high r^2)
	f.	**4364**	Na, HCO_3, Cl, SO_4, Mn (slight or very slight)

The bolded well numbers above indicate an NGMP well is involved. For the above variables in the indicated wells, the increasing trends in the first three wells appear to be substantial but not the fourth. With regard to decreasing trends, with the exception of well 3301, most appear to be very slight to slight and influenced by substantial missing data or outliers. Well 3301 is the only one of the five for which some of the variables had a relatively high coefficient of determination. Well 0001 had both increasing trends for two variables and decreasing trends for six variables.

Taking these visual assessments into account, of the 62 wells for which there are water quality monitoring data, only three appear to have substantial and significant increasing trends for two or more variables and only one appears to have substantial and significant decreasing trends. The wells with convincing trends are:

	Well ID	Town	Area	Depth (m)	Geology
Increasing -					
1.	0001	Awakeri	Rangitaki Pl.	12.1	-
2.	1393	Katikati	Tauranga B.	247.5-326.1	Ignimbrite
3.	2707	Papamoa	Coastal Pl.	8-10	Gravel
Decreasing -					
1.	3301	Ohope	Coastal Pl.	12	-

Because of its proximity to the coast, shallow depth, the variables involved, and the magnitude of the increases in conductivity and major ion concentrations (e.g., sodium and chloride), the case of well 2707 suggests sea water intrusion. There is no obvious cause with regard to the other two cases of wells with increasing and one case of a well with decreasing concentrations. Three of the wells involved are relatively shallow and one is deep while three of the wells involved are near the coast. With regard to proximity to the coast, this includes the deep well (1393) but not one of the shallow wells (0001).

3.3.3 Water Type

The type of water, charge balance error (CBE), and calculated total dissolved solids ("Calc TDS") produced by AquaChem from median values for major ions from each well are presented in Table 3.7. Data presented in Table 3.7 are grouped by area. Also shown in Table 3.7 are the town, well coordinates, information on geology in the vicinity of the well (where available), and identification of the primary cation and anion in the water as indicated by median values. This information makes it clear that sodium and bicarbonate are the predominant ions for groundwater in the EBOP region. Of the 62 wells, these were the major cation and anion in the majority of cases. Groundwater from only seven wells had a different dominant cation (calcium) and in only nine wells did the groundwater have a different dominant anion (chloride). In eight of the nine cases where chloride was the dominant anion, the location of the well was near the coast (the exception was for well 4001 near Rotorua). This included all three cases where calculated TDS exceeded 1,000 mg/L as well as well 2707 where, as noted above, circumstances suggest seawater intrusion.

Piper and pie map plots of median major ion data for all wells by area produced by AquaChem are presented in Appendix C. Copies of these are provided in Appendix C. These plots are generally consistent with the information in Table 3.7 as discussed above. Although AquaChem does not label the well locations shown, review of these plots along with Figure 3.1 and the coordinates provided in Table 3.7 allows their identification.

3.3.4 Data Quality

It is not possible to rigorously evaluate sample data quality as a part of this project. That would require a review of suitable quality control and assurance data at the time of sample collection and analysis. However, there are two indications of data quality that can be considered: (1) the presence of outliers; and (2) CBE results.

The Excel NGMP calculator uses a modified z-score to identify outliers (Daughney, 2005). The setting is controllable. In this case, a conservative approach was used of a factor of four times the median absolute deviation (MAD). In this case, 241 outliers were identified by the program for the 213 NGMP samples analysed and 1,481 outliers were identified by the program for the total of 715 samples analysed (see Table 3.8). These figures yield mean outlier rates of 1.13 and 2.07 outliers/sample for NGMP samples only and for all samples combined. For the potential 20 NGMP and 36 EBOP variables, if all variables were actually determined in all samples the outlier rate in both cases would be approximately the same at about 6%.

In addition to Excel NGMP calculator results, outliers are qualitatively evident in the time series plots for wells having three or more variables with statistically significant increasing and decreasing trends in Appendix B. For example, in the plot of iron data for well 2509 (with plots for wells having increasing trends) the values of 4.9 and 4.6 mg/L near the right hand side of the plot are clearly outliers compared to surrounding iron levels at or near the detection limit of 0.02 mg/L and it is equally clear in the plot of data for six variables for well 4364 (with plots for wells having decreasing trends) that there are no outliers for any of them.

The Excel NGMP calculator also determines the CBE for each analysis and whether it's within acceptable limits or not. The precise limit varies with concentration but is typically around 3%. As can be seen from Table 3.8, of the 715 samples there were sufficient data to calculate CBE for 572 or 80% of the samples. Of these, 458 or 80% were classified as acceptable and 114 or 20% were classified as outside of the criterion. It should be noted that there may be substantial quality differences between laboratories in this regard. NGMP samples are analysed by the GNS water and gas laboratory at Wairakei. For the 213 samples from six NGMP wells, there were sufficient data to calculate CBEs for 152. In all cases, the CBE was acceptable.

Daughney (2005) notes that a CBE criterion of plus or minus 5% is commonly used as the definition of what is acceptable. Using this more lenient criterion and applying it to the CBEs shown in Table 3.7 calculated by AquaChem for median values of major ions, results consistent with the Excel NGMP calculator are obtained. CBEs would be outside that limit for 13 of the 62 wells or approximately 21%.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

Review of groundwater level and quality from a combination of the EBOP database for water level (77 wells in 67 locations) and the EBOP and NGMP databases for water quality (62 wells including six NGMP wells) results in the following conclusions:

1. Water level –

   a. **Water level data exhibits substantial variability** - In general, there is substantial variability in the EBOP water level data. The primary sources of the variability are apparently such factors as climate-related annual cycles and data outliers. Climate-related cycles are difficult to discern when reviewing the time series plot of quarterly monitoring data that form the bulk of the database, but are very apparent with the daily mean values available for wells with data loggers installed. Some of the variability may be a result of measurements being made when the installed well pump was in operation. All measurements should be of static water level. There are two columns in the existing EBOP database for water level measurements that may be used to indicate if the pump was in operation or not. However, it is uncertain if they were accurately used in all cases. Measurements flagged as having been taken with the pump in operation were deleted from the database used in this analysis.

   b. **There are apparent outliers in the data for most wells -** These may be a result of extreme events, erroneous measurements, data entry errors, or measurements made when the installed well pump is in operation.

   c. **There are few indications of real water level trends -** Linear lines of best fit to time series plot data indicate substantial trends (i.e., rising or falling water levels at a rate of 0.1 m/year or larger) for 23 of 77 wells. However, further assessment of the plots challenges that indication for roughly half of the wells involved. The two major reasons for this are: (1) the presence and timing of outliers; and (2) a bifurcated database. Further review of the data shows that the presence and timing of outliers (e.g., one or more uncharacteristically high water levels late in the record causing a rising water level trend calculation) can imply a trend that is not consistent with the rest of the data (e.g., well 0094). It was also found that there were some wells having bifurcated datasets in which early time data was for some reason substantially different from late time data (e.g., well 0090). After visual assessment, it was concluded that in the case of most wells (64 out of 77) there was no trend indicated. For the remaining 13 wells, the data indicate long term falling trends for five and rising trends for eight. Most of these are near the coast in the Tauranga or Te Puke-Makeu areas of the Region. Two are at inland locations, one each in the Rangitaki Plains and Galatea Plains area of the region.

1) **Wells with falling water level trends were**:

	Well	Slope (m/year)
1)	Well 1386	0.1380
2)	Well 1586	0.0255
3)	Well 2520-1	0.2387
4)	Well 2521-1	0.3031
5)	Well 2822	0.0610

2) **Wells with rising water level trends were**:

	Well	Slope (m/year)
1)	Well 2520-2	- 0.1994
2)	Well 2521-2	- 0.6523
3)	Well 2522-2	- 0.0204
4)	Well 2522-3	- 0.0223
5)	Well 2522-4	- 0.0402
6)	Well 2541	- 0.0617
7)	Well 2838	- 0.1357
8)	Well 2913	- 0.0999

Wells 2522-2, 2522-3, and 2522-4 are the three shallowest wells of a four well nest with open intervals at different vertical depths.

Long term trends in groundwater levels would be expected to be a reflection of the stability of the climate. Although short term trends might occur as a result of drier or wetter climate conditions in some locations, absent major long term changes in climate they would be expected to even out over a longer period of time. For most of the wells involved in this analysis, the period of record was approximately 20 years. From a climate change standpoint, that is not a long period of time.

2. Water quality –

   a. **The quality of groundwater sampled in EBOP monitoring wells is generally good -** DWSNZ2005 are not an applicable regulatory standard for ambient groundwater. However, they do serve as a convenient gage for comparison. The fact that most variables in most samples from most wells were better than DWSNZ2005 MAVs or GVs indicates generally good water quality. Several exceptions to this general case are noteworthy –

      1) pH – Samples from 49 of 62 wells had less than the minimum pH GV of 7.0 units. However, only five of these were less than 6.0 units and three had more than the maximum GV of 8.5 units. However, pH levels in the 6.0 to 7.0 range are well within normal for natural waters and only five wells had samples with pHs less than 6.0 units.

      2) Temperature – Temperatures measured in samples from 16 of 62 wells were high enough to indicate geothermal influence. The extreme value reported was 54.7 ^{o}C in well 0951. However, the median temperature for all sample measurements from this well was only 24.8 ^{o}C. The well with the highest median temperature was 3044 at 41.8 ^{o}C. Groundwater with high temperatures would not be suitable for drinking water or agricultural uses.

      3) Major ions – There were samples from several wells where major ion levels were elevated above GVs of 200, 250, 250, and the maximum of 300 mg/L for sodium, chloride, sulfate, and hardness (as CaCO3 for calcium and magnesium), respectively. Extreme levels of sodium and chloride were 5,010 and 10,600 mg/L, respectively, for well 3272. Groundwater with major ion levels this high would not be suitable for drinking water or agricultural uses. High levels of major ions in groundwater are commonly a result of natural mineralization or sea water intrusion.

      4) Minor/trace elements – In most cases, concentrations of minor/trace elements were within DWSNZ2005 criteria. Noteworthy exceptions were arsenic, fluoride, iron, and manganese –

         a) Arsenic - Arsenic exceeded the 0.01 mg/L MAV in samples from 15 of 62 wells and reached an extreme of 0.29 mg/L in well 3470. Such high levels of arsenic would not be safe to drink.

         b) Fluoride - Fluoride exceeded the 1.5 mg/L MAV in samples from five of 62 wells. High levels of fluoride would not be safe to drink. However, these levels appear to be erroneous. The highest fluoride concentrations recorded in the data base (9.3, 11.4, 19.5 and 44.9 mg/L for samples from wells/sites Braemer Springs, 0466, 0845 and 0925) were for samples taken on the same date and presumably sent to the same laboratory for analysis. These results are outliers with respect to all other values for those wells with no other values exceeding 1 mg/L (except an earlier value of 1.7 mg/L for well 0466) and median values of 0.60, 0.63, 0.26, and 0.13 mg/L, respectively.

c) Iron and manganese - Concentrations of iron and manganese exceeded their respective GVs in about half of the wells. This is not unusual for these elements in groundwater.

5) Nutrients - Concentrations of ammonia-nitrogen in samples from 15 of 62 wells exceeded the GV of 0.3 mg/L while in four of 62 wells they also exceeded the GV of 1.5 mg/L. However, concentrations of nitrate-nitrogen only marginally exceeded the GV of 11.3 mg/L.

6) Bacteria - Enterococci and faecal coliform bacteria were reported in samples from 15 of 62 wells. Positive results for faecal coliform bacteria were also reported in samples from three other wells.

b. **Water quality is generally remaining unchanged –** Trend analysis found relatively few variables having significant trends (38 variables in samples from 19 wells with increasing trends and 46 variables in samples from 16 wells with decreasing trends out of a maximum of 36 variables in 62 wells). Further review of time series plots for those wells from this set involving three or more variables provided substantiating information in a much reduced number of cases (14 variables in samples from four wells with increasing trends and 26 variables in five wells with decreasing trends). After visual assessment, these numbers were reduced and it was concluded that there were convincing increasing trends for two or more variables in only three wells and decreasing trends in only one. Three of these four wells were shallow ones and three were located near the coast (including a deep well). These wells were 0001, 1393, and 2707 (increasing trends) and 3301 (decreasing trends). In the case of well 2707, the increasing trends are for conductivity and major ions. Considering the location of this well, these trends are consistent with increased seawater intrusion over time. There was no evident explanation with regard to the other three wells with apparent trends. Two of the four wells are NGMP wells (0001 and 3301).

The following factors are noteworthy complications with regard to trend analysis of these data –

1) Sample frequency and number of samples - In general, NGMP wells are sampled quarterly while other EBOP wells are sampled annually. However, there are substantial gaps for most wells. The most significant gap is the 1999-2001 or 2002 time period. NGMP wells were sampled during this period but not most other EBOP wells. Trend analysis is best conducted with routinely sampled data and with a database of more than eight samples for each well. There were a relatively large number of samples in the database for all six NGMP wells (between 27 and 44) but only a marginal number of samples were in the database for most other EBOP wells (between one and 12).

2) Outliers – Statistical analysis and time series plots indicated a number of outliers in the data (241 outliers for 213 samples from the six NGMP wells and 1,268 outliers for 502 samples from other EBOP wells). Outliers can be legitimate data but they can also indicate errors in the sampling and analysis process or in data entry. Outliers can have an inordinate impact on trend analysis. For example, a high outlier late in the time period can indicate an increasing trend that is not consistent with the rest of the data.

3) Bifurcation – In some cases, plots indicated the data were bifurcated with substantially different data for one period of time compared to the rest of the data. Such bifurcation can be a result a result of real changes in water quality or some type of sampling and analysis bias. Bifurcation can impact trend analysis in the same manner that outliers can.

c. **Groundwater is generally sodium bicarbonate type** – In only seven of the 62 wells was the dominant cation different than sodium (calcium) and in only nine of the 62 wells was the dominant anion different than bicarbonate (chloride). With regard to the dominant anion, in eight of the nine cases where chloride was the dominant anion the wells involved were near the coast. All wells with calculated TDS values in excess of 1,000 mg/L and well 2707 with increasing trends for conductivity and major ions are part of this category.

d. **Data quality may be generally acceptable but is better for NGMP than for other EBOP wells** – It is not possible to rigorously evaluate data quality as a part of this project as there is insufficient information to conduct a comprehensive data quality review. However, the incidence of outliers and results for CBE indicate that while data quality may be generally acceptable it is better for NGMP wells than for other EBOP wells. Samples from NGMP wells are normally analysed by the GNS Science water and gas laboratory at the Wairakei Research Centre. NGMP data is also checked by GNS Science and, if necessary, reanalysis is conducted prior to entry into the database.

4.2 Recommendations

As a result of this analysis and the above conclusions, the following recommendations are made:

1. Water level -

   a. The EBOP water level data base should be reviewed and adjustments made for future use. This includes deletion of data for wells at times when it is known that the installed pump was in operation. Additional information should also be added to the database for each well including the height above datum of the reference point for water level measurements and the depth below the reference point of the open interval of the well (e.g. from the bottom of the casing to total well depth).

   b. To minimize the potential for errors in water level measurements, all measurements should be made with electric tape water level indicators that are in proper order and properly maintained. Static water levels are required. For wells with installed pumps, field crews should carefully check to ensure the pump is not in operation at the time of measurement. Field crews should also carry and refer to historic data on the level and variability of water levels for each well. If a measurement is more than three standard deviations higher or lower than the median water level for that well, additional checks of pump status and the measurement should be made and a notation put in remarks indicating such checks did in fact occur.

c. Water level data should be carefully checked in the office at the time of entry into the database to ensure they are consistent with historic data or, if not, that the measurement is accurate. If necessary to do so, the measurement can be repeated. Comparison with historic data using statistics and/or time series plots is helpful in checking. Field and office checks of data quality prior to final entry into the database are important to maintain the integrity of the database as it is often not possible to subsequently conduct such checks with the same efficacy.

d. Review of the groundwater level monitoring network with regard to its suitability and coverage. As a part of such a review, a comprehensive database of information on the wells forming the network should be put together (including well details and aquifer characteristics). To the extent possible, it is most efficient to monitor the same wells for both water levels and quality. In addition, there are questions of spatial coverage of the region in order to obtain representative information for all important areas and for more in-depth consideration of data by such as the contouring of groundwater elevations to produce potentionmetric surfaces that can be used for various purposes including visualization of groundwater flow paths. Broader questions such as the appropriate number of wells in the network, their monitoring frequency, and cost-effectiveness of continuous versus periodic monitoring or some combination of the two should also be considered.

2. Water Quality –

a. The water quality database should be reviewed and adjusted as appropriate for future use. This includes consistency as to the precise variable being analysed, uniformity in data entry, and inclusion and identification of values less than the detection limit.

b. All analytical data being reported by a laboratory should be checked for data quality at the time of receipt from the laboratory and when being entered into the database to ensure they are consistent with historic data or, if not, that the measurement is accurate. If necessary to do so and the sample is still within holding time, the analysis can be repeated. Comparison with historic data using statistics and/or time series plots is helpful in checking. Field and office checks of data quality prior to final entry into the database are important to maintain the integrity of the database as it is often not possible to subsequently conduct such checks with the same efficacy.

c. Data for NGMP wells in the EBOP database should be checked for consistency with the NGMP database. Dates of sampling and data for each sample date should be the same. If there are valid differences, they require explanation.

d. Wells having high groundwater temperatures (i.e., greater than 25 ^{o}C) should be checked for geothermal influences and if verified flagged in the database as such.

e. Well 3272 had extreme levels of sodium, chloride, and other major ions making it unsuitable for a source of drinking water or agricultural uses. The owner/users of this well should be notified of that circumstance.

f. Well 3470 had a high level of arsenic making it unsuitable as a source of drinking water. Other sites with values for arsenic exceeding the DWSNZ2005 MAV were 0066, 0643, 0951, 1104, 1319, 1686, 2076, 2093, 2303, 2728, 2829, 3044, 4001, 120045, and 180071 (Braemer Springs). The owners/users of these wells and Braemer Springs should be notified of that circumstance.

g. Reasons for the exceedance of ammonia-nitrogen GVs in samples from 15 of 62 wells and the nitrate-nitrogen MAV in two of 62 wells should be further reviewed to determine if these situations represent some source of nitrogen contamination or natural conditions.

h. Owners of the 17 wells having positive results for bacteria should be notified of that circumstance and encouraged to take corrective measures to eliminate sources of such contamination if possible.

i. The data for wells 0001, 1393, 2707, and 3301 indicated significant trends. The circumstances of these wells should be studied in further detail to determine, if possible, what the reason(s) for these trends may be. For example, well 2707 is a shallow well located near the coast and the trends in it are consistent with seawater intrusion. The priority in this regard belongs with the first three wells for which the trends were increasing. The slight decreasing trends with regard to well 3301 are unlikely to be of any consequence.

j. Review of the groundwater level monitoring network with regard to its suitability and coverage. As a part of such a review, a comprehensive database of information on the wells forming the network should be put together (well details and aquifer characteristics). To the extent possible, it is most efficient to monitor the same wells for both water levels and quality. In addition, there are questions of spatial coverage of the region in order to obtain representative information for all important areas and for more in-depth consideration of such as issues potential sources of contamination. In the case of wells showing trends for variables, this would include assessment of the reasons for those trends and could reasonably include such things as age-dating of groundwaters and delineation of capture zones. Broader questions such as the appropriate number of wells in the network, their monitoring frequency, and cost-effectiveness of continuous versus periodic monitoring or some combination of the two should also be considered.

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Table 2.1 Water Level Data Wells/Files

Water Level Data Wells/Files									
								Wells Out of Service[5]	
Well Level Sites[1]		NERMN Level[2]		NERMN GW[3]		Current Well Data[4]		Well ID	Status
0051	2829	0051	2822	0051	2520	0051	2847	0307	Well removed 1996
0090	2838	0090	2829	0090	2521	0090	2913	0643	Well buried 2004
0093	2843	0093	2838	0093	2522	0093	3020	1074	Well removed 1998
0094	2847	0094	2843	0094	2523	0094	3026	2043	Well sealed 2003
0410	2913	0307	2847	0307	2524	0410	3032	2393	Well removed 2004
0490	3020	0410	2913	0410	2533	0461	3034	2722	One 1987 data point
0547	3026	0490	3020	0461	2541	0547	3036	2843	Well buried 2004
0643	3032	0547	3026	0466	2707	0845	3038	3462	Well removed 2002
0845	3034	0643	3032	0490	2728	0851	3043	3464	Well tiled over 2005
0851	3036	0845	3034	0547	2822	0921	3272	3465	Access lost 2005
0921	3038	0851	3038	0643	2829	0951	3460		
0932	3272	0921	3036	0845	2838	1018	3463		
0951	3301	0932	3272	0851	2843	1319	3467		
1018	3460	0951	3301	0921	2847	1386	3469		
1319	3462	1018	3460	0932	2913	1468	3470		
1386	3463	1319	3462	0951	3020	1520	4000		
1468	3464	1386	3463	1018	3026	1535	4003		
1520	3465	1468	3464	1074	3032	1561	4004		
1535	3467	1520	3465	1319	3034	1566	4005		
1561	3469	1535	3467	1386	3036	1586	4006		
1566	3470	1561	3469	1520	3038	1605	4007		
1586	4000	1566	3470	1535	3272	1670			
1605	4003	1586	4000	1561	3301	1686			
1670	4004	1605	4003	1566	3460	1690			
1686	4005	1670	4004	1586	3462	2024			
1687	4006	1686	4005	1605	3463	2060			
1690	4007	1687	4006	1670	3464	2068			
2024		1690	4007	1686	3465	2083			
2043		2024		1687	3467	2328			

Water Level Data Wells/Files						
					Wells Out of Service[5]	
Well Level Sites[1]	NERMN Level[2]	NERMN GW[3]		Current Well Data[4]	Well ID	Status
2068	2043	1690	3469	2330		
2083	2068	2024	3470	2334		
2303	2083	2043	4000	2344		
2330	2303	2060	4003	2504		
2334	2330	2068	4004	2509		
2344	2334	2076	4005	2519 (1-3)		
2393	2344	2083	4006	2520 (1-3)		
2509	2393	2088	4007	2521 (1-3)		
2518	2509	2328		2522 (1-4)		
2519	2518	2330		2523 (1-2)		
2520	2519	2334		2533		
2521	2520	2344		2541		
2522	2521	2393		2707		
2523	2522	2504		2728		
2707	2523	2509		2822		
2728	2707	2518		2829		
2822	2728	2519		2838		

1. *List of well identification numbers (well IDs) in "Well Level Sites" Excel file.*
2. *List of well IDs in "NERMN (Natural Environmental Regional Monitoring Network) Level Sites" Excel file.*
3. *List of well IDs in "NERMN Groundwater" Excel file*
4. *List of well IDs for wells currently in service and for which data were provided in "Groundwater Level Data Up To Feb 2006" Excel file. Wells IDs 2519-2523 involve well nests monitoring multiple depths.*
5. *Well IDs of former wells no longer in service but for which some data exists (Naude, 2006).*

Table 2.2 Water Level Well Information

Water Level Well Information[1]										
				NZMS 260	NZMG Coordinates					
Well ID	Surname	Town	Area	Map Reference	Easting	Northing	TOC AMD	Total Depth	Open Interval	Geology
0051	Hewson	Welcome Bay	Tauranga Basin	U14: 9408, 8207	27940800	63820700	10.00	67.	38.7-67	Ignimbrite
0090	Shaw	Athenree	Tauranga Basin	U13: 7166, 1275	27716600	64127500	26.37	329.2	249.9-329.2	Volc Rock
0093	Lowes	Te Puna	Tauranga Basin	U14: 8206, 8689	27820600	63868900	-	460.2	350.5-460.2	Ignimbrite
0094	Cain	Te Puna	Tauranga Basin	U14: 8029, 8757	27802900	63290000	20.00	164.6	130.1-164.6	Rhyolite
0410	Bowyer	Paengaroa	Te Puke - Maketu	V15: 1110, 6700	28111000	63670000	-	196.6	118-196.6	Pumice
0461	Byford	Thornton	Rangitaki Plain	V15: 4750, 5670	28475000	63567000	0.14	12.5	-	Sand
0547	Whakatane Golf Club	Whakatane	Coastal Plain	W15: 5610, 5650	28561000	63565000	4.48	11.6	5.5-11.6	S&G
0845	Bonner	Awakeri	Rangitaki Plain	W15: 5225, 5233	28522500	63523300	3.48	173.	161.6-173	Pum Sand
0851	Cook	Katikati	Tauranga Basin	T14: 6880, 9490	27688000	63949000	20.10	97.5	75.3-97.5	Volc Rock
0921	Schlepers	Whakatane	Rangitaki Plain	W15: 5804, 5123	28580400	63512300	3.38	28.5	26-28.5	Pum Sand
0951	Paengaroa North K Trust	Paengaroa	Te Puke - Maketu	V14: 1090, 7120	28109000	63712000	-	114.3	86.3-114.3	Rhyolite
1018	Brawn	Maketu	Te Puke - Maketu	V14: 1200, 7448	28120000	63744800	-	359.	-	Ignimbrite
1319	Ngati Manawa Tribal Lands	Murupara	Galatea Plain	V17: 3508, 9687	28350800	62968700	198.36	51.8	39.6-51.8	Ignimbrite
1386	18th Avenue Motel	Tauranga	Tauranga Basin	U14: 8831, 8299	27883100	63829900	-	466.3	335.3-466.3	Ignimbrite
1468	Haddad	Matua	Tauranga Basin	U14: 8513, 8807	27851300	63880700	-	420.6	234.6-420.6	Ignimbrite
1520	Tapsell Family Trust	Maketu	Te Puke - Maketu	V14: 1478, 7411	28147800	63741100	-	74.	50-74	Pum Grav
1535	Tuhurangi Marae Ladies Comm.	Rangiuru	Te Puke - Maketu	U14: 0686, 7372	27068600	63737200	-	32.	19.81-32	Pum Sand
1561	Dunroamin Nursery	Hamurana	Rotorua	U15: 9291, 4590	27929100	63459000	295.00	73.1	63-73.1	Rhyolite
1566	Egglestone	Apata	Tauranga Basin	U14: 7364, 9011	27736400	63901100	29.90	163.1	85-163.1	Rhyolite
1586	Crawford	Te Puke	Te Puke - Maketu	U14: 0428, 7342	27042800	63734200	-	30.5	28-30.5	S&G
1605	Penetito Lands Trust	Te Teko	Rangitaki Plain	V15: 4513, 4095	28451300	63409500	20.62	61.	51-61	Pum Grav
1670	Te Hua Whenua Trust	Welcome Bay	Tauranga Basin	U14: 9968, 8331	27996800	63833100	-	103.6	84.4-103.6	Ignimbrite
1686	Western Bay Golf Club	Omokoroa	Tauranga Basin	U14: 7730, 9119	27773000	63911900	-	182.9	111.6-182.9	Pum Grav
1690	Mangatarata Orchards Ltd	Maketu	Te Puke - Maketu	V14: 1028, 7474	28102800	63747400	-	97.5	72.5-97.5	Ignimbrite
2024	Eleos Ltd	Te Puke	Te Puke - Maketu	U14: 0723, 7125	27072300	63712500	-	118.5	98-118.5	Ignimbrite
2060	Signal	Te Teko	Rangitaki Plain	V1545304420	28463000	63442000	14.01	61.3	-	Boulders
2068	Van den Broek	Onepu	Rangitaki Plain	V15: 4024, 4569	28402400	63456900	14.28	10.	-	-
2083	Brownless	Awakaponga	Rangitaki Plain	V15: 4341, 5861	28434100	63586100	1.49	12.	-	-
2328	Duncan	Katikati	Tauranga Basin	T14: 6640, 9660	27664000	63966000	21.24	454.2	246.89-454.2	Ignimbrite
2330	Noble	Kauri Point	Tauranga Basin	U13: 7292, 0544	27729200	64054400	-	118.87	65.53-118.87	S&G
2334	NZ CCS Tauranga	Tauranga	Tauranga Basin	U14: 8887, 8355	27888700	63835500	-	506.	347.47-506	Ignimbrite
2344	Voss	Oropi	Tauranga Basin	U14: 8638, 7339	27863800	63733900	-	123.4	39.32-133.4	Volc Rock
2504		Otumoetai	Tauranga Basin	U14: 8720, 8850	27872000	63885000	3.72	140.	-	Rhyolite
2509	Eternal Spring Mineral Water	Otakiri	Rangitaki Plain	V15: 4093, 4889	28409300	63488900	8.59	319.5	295-319.5	Pum Grav
2519-1	Sampson	Katikati	Tauranga Basin	T14: 6570, 9910	27657000	63991000	50.06	452.	99.7-102	Ignimbrite
2519-2	Sampson	Katikati	Tauranga Basin	T14: 6570, 9910	27657000	63991000	50.06		66.2-68.5	Ignimbrite
2519-3	Sampson	Katikati	Tauranga Basin	T14: 6570, 9910	27657000	63991000	50.06		38-44	Ignimbrite
2520-1	Henry	Katikati	Tauranga Basin	T13: 6660, 0160	27666000	64016000	41.53	353.	228-240	Silty Sand
2520-2	Henry	Katikati	Tauranga Basin	T13: 6660, 0160	27666000	64016000	41.53		109.5-121.5	
2520-3	Henry	Katikati	Tauranga Basin	T13: 6660, 0160	27666000	64016000	41.53		44-50	
2521-1	Cole	Katikati	Tauranga Basin	T13: 6824, 0565	27682400	64056500	36.47	157.4	151-157	
2521-2	Cole	Katikati	Tauranga Basin	T13: 6824, 0565	27682400	64056500	36.47		53.5-86	
2521-3	Cole	Katikati	Tauranga Basin	T13: 6824, 0565	27682400	64056500	36.47		42-46	Silty Sand
2522-1	Hardy	Katikati	Tauranga Basin	T13: 6974, 0160	27697400	64016000	9.42	245.6	233.8-236	
2522-2	Hardy	Katikati	Tauranga Basin	T13: 6974, 0160	27697400	64016000	9.42		103-109	
2522-3	Hardy	Katikati	Tauranga Basin	T13: 6974, 0160	27697400	64016000	9.42		42-48	Silty Sand
2522-4	Hardy	Katikati	Tauranga Basin	T13: 6974, 0160	27697400	64016000	9.42		24.5-30.5	Silty Sand
2523-1	Matthew	Kauri Point	Tauranga Basin	U13: 7049, 0585	27704900	64058500	37.94	196.	154-160	
2523-2	Matthew	Kauri Point	Tauranga Basin	U13: 7049, 0585	27704900	64058500	37.94		52.5-58.5	Silty Sand
2533	Edmonds	Te Puna	Tauranga Basin	U1479258901	27792500	63890100	3.45	247.5	97.5-247.5	-
2541	Zink	Otakiri	Rangitaki Plain	V15: 3910, 5100	28391000	63510000	8.24	-	-	Ignimbrite
2707	Hickson	Papamoa	Coastal Plain	U14: 0752, 7944	27075200	63794400	-	10.	8-10	S&G
2728	Steiner	Papamoa	Tauranga Basin	U14: 0283, 8140	27028300	63814000	-	81.	69-81	S&G
2822	Winters	Pongakawa	Te Puke - Maketu	V15: 1622, 6811	28162200	63681100	-	121.9	104.85-121.9	Ignimbrite

Water Level Well Information[1]										
				NZMS 260	NZMG Coordinates					
Well ID	Surname	Town	Area	Map Reference	Easting	Northing	TOC AMD	Total Depth	Open Interval	Geology
2829	Bagshaw	Waihi Beach	Tauranga Basin	U13: 7065, 1414	27706500	64141400	-	216.41	-	Rhyolite
2838	Higgs	Katikati	Tauranga Basin	U14: 7268, 9697	27726800	63969700	7.60	304.8	-	Volc Rock
2847	BOPRC 3B	Mt Maunganui	Coastal Plain	U14: 9237, 8799	27923700	63879900	3.99	5.2	3.2-5.2	Sand
2913	Muller	Galatea	Galatea Plain	V17: 4345, 0725	28434500	62072500	208.48	22.	20-22	Gravel
3020	BOPRC 4	Papamoa	Coastal Plain	U14: 9992, 8430	27999200	63843000	3.70	-	-	-
3026	Norfork Trust	Te Puke	Te Puke - Maketu	U14: 0163, 7138	27016300	63713800	-	103.6	-	Volc Rock
3032	Lockyer	Waihi Beach	Coastal Plain	U13: 7068, 1730	27706800	64173000	-	6.	-	-
3034	Brawn	Maketu	Te Puke - Maketu	V14: 1197, 7460	28119700	63746000	-	8.5	-	-
3036	Brooklyn Farms Ltd	Opotiki	Opotiki Plain	W15: 8872, 4266	28887200	63426600	-	30.	-	-
3038	Young	Opotiki	Opotiki Plain	W15: 8654, 4090	28865400	63409000	-	12.	-	-
3043	Stewart & Sons Ltd	Maketu	Te Puke - Maketu	V14: 1190, 7480	28119000	63748000	3.74	10.	-	Pumice
3272	Dickson	Mt Maunganui	Tauranga Basin	U14: 9428, 8822	27942800	63882200	-	375.	300-375	-
3460	Barnes	Otumoetai	Tauranga Basin	U14: 8727, 8844	27872700	63884400	-	213.36	-	-
3463	McIntosh	Otumoetai	Tauranga Basin	U14: 8635, 8865	27863500	63886500	-	274.32	225.55-274.32	-
3467	Glenmur Imports Ltd	Tauranga	Tauranga Basin	U14: 8883, 8755	27888300	63875500	-	329.2	-	Volc Rock
3469	Nelson	Kaharoa	Rotorua	U15: 9122, 4670	27912200	63467000	-	124.66	80.16-124.66	-
3470	Lepper	Ngongotaha	Rotorua	U15: 9135, 4310	27913500	63431000	-	-	-	-
4000	Webster	Rotorua	Rotorua	U15: 0264, 4340	27026400	63434000	-	26.	-	-
4003	Pickernell	Rotorua	Rotorua	U15: 0253, 4342	27025300	63434200	-	26.	-	-
4004	Webster	Rotorua	Rotorua	U15: 0305, 4338	27030500	63433800	-	26.	-	-
4005	Geiss	Rotorua	Rotorua	U15: 0330, 4014	27033000	63401400	-	180.	167-180	-
4006	Field	Ngongotaha	Rotorua	U15: 9101, 4397	27910100	63439700	-	85.3	-	-
4007	Pemberton	Ngongotaha	Rotorua	U15: 8936, 4472	27893600	63447200	-	-	-	-

1. *Information obtained from various EBOP database files. "TOC AMD" is the elevation of the well top of casing listed in the EBOP database in m above the Moturiki datum. The Moturiki datum is used by EBOP to represent mean sea level interval. "Total Depth" indicates well total depth in m. "Open Interval" means the depth interval of the well open to the aquifer. This was assumed to be from the bottom of the well casing to the well total depth (both in m). Where the bottom of the well casing was unknown, the only indication of the open interval is well total depth. "Geology" is the reported geology the well open interval is located in.*

Table 2.3 Summary Water Level Statistics

Summary Water Level Statistics														
									Linear Fit[4]		Visual Assessment[5]			
												Outliers		
Well ID[1]	Deleted[2]	Count[2]	Data Period[2]	Min[3]	Median[3]	Mean[3]	Max[3]	Stdev[3]	LR Slope	r^2	Trend	Deep	Shallow	Comments
0051	0	57	1990-2006	4.51	5.28	5.65	10.52	1.15	0.0086	0.00133	Horizontal	X		
0090	1	89	1986-2006	25.90	30.28	32.32	43.51	4.89	-0.5114	0.375	Horizontal	X		Bifurcated
0093	0	57	1990-2006	16.20	18.41	18.41	19.70	0.54	0.0313	0.0819	Horizontal	X	X	
0094	0	57	1990-2006	2.06	17.27	16.59	23.99	3.61	-0.2324	0.0988	Horizontal	X	X	Late high outliers
0410	0	20	1998-2006	35.40	35.99	35.98	36.69	0.38	-0.0218	0.0161	Horizontal			
0461	-	6,174	1988-2006	-0.92	-0.63	-0.62	0.04	0.10	0.0031	0.0229	Horizontal		X	
0547	5	64	1988-2006	1.89	3.49	3.52	5.33	0.56	0.0341	0.108	Horizontal	X	X	
0845	1	63	1988-2006	-3.16	-2.35	-2.27	-0.97	0.43	0.0143	0.0266	Horizontal	X	X	
0851	1	91	1987-2006	14.89	15.23	15.60	23.94	1.60	-0.0225	0.00666	Horizontal	X		
0921	2	78	1987-2006	0.94	2.29	2.28	4.71	0.55	-0.0246	0.066	Horizontal		X	
0951	1	55	1990-2006	9.08	9.90	10.10	13.85	0.84	-0.0452	0.0683	Horizontal	X		
1018	5	39	1993-2006	2.81	3.23	3.71	10.60	1.65	-0.1229	0.103	Horizontal	X		Early low outliers
1319	20	31	1991-2006	2.18	7.66	7.50	8.80	1.20	0.0150	0.00526	Horizontal		X	
1386	0	21	1999-2006	31.31	31.76	31.93	33.89	0.66	0.1380	0.163	Falling	X		
1468	2	59	1995-2006	12.60	14.71	14.69	19.43	0.79	0.0150	0.00436	Horizontal	X		
1520	0	56	1990-2006	13.18	26.77	26.56	29.90	1.89	0.0569	0.0226	Horizontal	X	X	
1535	1	55	1990-2006	6.47	7.20	7.16	7.77	0.32	-0.0130	0.0412	Horizontal			
1561	0	28	1995-2006	14.62	15.05	15.03	15.37	0.22	0.0323	0.358	Horizontal			Bifurcated
1566	0	93	1987-2006	24.92	31.92	31.88	33.20	0.78	-0.0463	0.118	Horizontal		X	
1586	2	54	1990-2006	5.75	6.39	6.38	6.76	0.25	0.0255	0.270	Falling			
1605	2	84	1986-2003	7.70	8.73	8.82	10.88	0.65	0.0152	1.26E-06	Horizontal	X		
1670	6	51	1990-2006	14.22	14.89	15.41	31.06	2.39	0.1103	0.0535	Horizontal	X		Late low outlier
1686	1	57	1990-2006	3.24	5.36	7.20	27.32	4.44	0.2514	0.0781	Horizontal	X		Late low outliers
1690	8	49	1990-2006	2.21	2.69	2.96	6.65	0.86	-0.0299	0.0334	Horizontal	X		
2024	7	49	1990-2006	16.19	16.89	16.96	18.53	0.46	-0.0225	0.0639	Horizontal	X		
2060	-	6,192	1988-2006	9.99	11.34	11.35	12.44	0.39	-0.0040	0.00264	Horizontal			
2068	1	83	1987-2006	0.23	1.38	1.34	2.80	0.56	-0.0246	0.0641	Horizontal			
2083	0	85	1987-2006	1.06	1.64	1.60	1.95	0.16	0.0221	0.00641	Horizontal			
2328	-	6,096	1987-2006	21.95	32.96	32.69	42.46	4.65	0.3018	0.127	Horizontal			Bifurcated
2330	1	89	1987-2006	29.67	30.17	30.81	55.00	3.01	-0.0354	0.00460	Horizontal	X		
2334	1	20	1990-2006	0.15	3.02	16.76	44.15	17.74	-6.9460	0.573	Horizontal			Bifurcated
2344	1	54	1990-2006	18.50	20.51	21.67	38.76	4.18	0.3895	0.217	Horizontal	X		Late low outliers
2504	-	7,353	1983-2006	-0.04	0.85	0.86	1.77	0.30	-0.0062	0.0178	Horizontal			
2509	0	23	1996-2006	-29.80	-17.30	-16.34	-10.50	4.02	0.5099	0.222	Horizontal		X	Early high outlier
2519-1	0	101	1984-2006	2.04	2.93	3.16	6.67	0.73	-0.0230	0.0396	Horizontal	X		
2519-2	0	103	1984-2006	1.69	3.10	3.27	6.67	0.72	-0.0299	0.0642	Horizontal	X		
2519-3	2	102	1984-2005	3.19	3.84	4.05	7.65	0.73	-0.0290	0.0596	Horizontal	X		
2520-1	0	102	1986-2006	13.59	15.31	16.11	18.52	1.59	0.2387	0.854	Falling			
2520-2	0	102	1986-2006	25.04	26.82	26.85	29.00	1.32	-0.1994	0.871	Rising			
2520-3	0	102	1986-2006	17.80	26.74	26.44	28.84	1.75	-0.1245	0.192	Horizontal		X	Late high outlier
2521-1	0	77	1984-2006	15.71	22.94	21.97	25.60	2.79	0.3031	0.482	Falling			
2521-2	0	103	1984-2006	14.63	20.56	21.13	29.72	4.37	-0.6523	0.840	rising	X	X	
2521-3	0	102	1986-2006	21.60	24.28	26.87	42.66	6.15	-0.4387	0.191	Horizontal	X		Bifurcated
2522-1	0	100	1986-2006	-0.04	3.28	3.11	4.66	1.07	0.1047	0.366	Horizontal		X	Bifurcated
2522-2	0	92	1984-2006	5.49	6.67	6.70	7.95	0.35	-0.0204	0.130	Rising			
2522-3	0	102	1984-2006	5.45	6.66	6.72	7.97	0.41	-0.0223	0.116	Rising			
2522-4	0	102	1984-2006	5.41	6.75	6.77	8.54	0.46	-0.0402	0.292	Rising			
2523-1	1	98	1984-2006	1.21	33.85	31.44	48.16	7.22	-0.0510	0.215	Horizontal	X	X	Bifurcated
2523-2	0	100	1984-2006	18.01	29.46	29.67	34.40	1.61	-0.0510	0.0377	Horizontal			
2533	-	5,583	1990-2006	1.48	2.43	0.41	2.89	0.17	-0.0076	0.0409	Horizontal			
2541	-	6,311	1986-2006	14.60	26.89	26.83	0.59	1.12	0.0617	0.995	Rising	X		

Summary EBOP Water Level Statistics

Well ID[1]	Deleted[2]	Count[2]	Data Period[2]	Min[3]	Median[3]	Mean[3]	Max[3]	Stdev[3]	Linear Fit[4] LR Slope	Linear Fit[4] r^2	Visual Assessment Trend	Outliers Deep	Outliers Shallow	Comments
2707	0	53	1990-2006	3.39	4.49	4.46	5.10	0.44	-0.0126	0.0188	Horizontal			
2728	0	56	1990-2006	3.79	4.63	4.94	10.07	1.24	0.0497	0.0397	Horizontal	X		
2822	0	57	1990-2006	5.94	7.43	7.55	9.52	0.77	0.0610	0.153	Falling			
2829	3	80	1988-2006	21.57	23.80	26.25	52.70	6.33	0.3064	0.0749	Horizontal	X		Late low outliers
2838	0	88	1987-2006	1.57	3.65	3.89	11.10	1.89	-0.1357	0.180	Rising	X		
2847	0	164	1975-2006	0.78	1.91	1.89	3.86	0.32	0.0114	0.110	Horizontal	X		Late low outlier
2913	10	41	1990-2006	5.88	10.58	10.66	13.70	1.83	-0.0999	0.0796	Rising			
3020	0	56	1990-2006	1.52	2.00	2.06	5.81	0.54	0.0167	0.0235	Horizontal	X		Late low outlier
3026	0	57	1990-2006	50.35	61.15	60.97	62.82	1.66	-0.1011	0.0903	Horizontal			Late high outlier
3032	0	58	1990-2006	2.00	2.50	2.58	3.97	0.44	0.0235	0.0672	Horizontal			
3034	0	57	1990-2006	2.99	4.46	4.34	5.13	0.49	-0.0217	0.0465	Horizontal			
3036	0	52	1990-2006	1.24	2.05	2.59	22.84	2.95	0.2001	0.113	Horizontal	X		Late low outlier
3038	0	52	1990-2006	0.65	1.81	1.86	3.18	0.65	0.0139	0.0116	Horizontal			
3043	-	5,534	1990-2006	0.82	1.37	1.41	2.58	0.02	0.0095	0.0176	Horizontal			
3272	1	50	1996-2006	1.78	3.19	3.14	3.80	0.30	-0.0057	0.00417	Horizontal			
3460	7	53	1995-2006	0.12	0.90	0.87	1.43	0.32	-0.0463	0.210	Horizontal			
3463	1	61	1995-2006	1.09	1.98	1.95	2.62	0.36	0.0015	0.00020	Horizontal			
3467	2	60	1995-2006	0.13	0.53	0.56	0.92	0.18	-0.0114	0.0433	Horizontal			
3469	0	26	1996-2006	25.48	50.80	49.78	52.93	5.11	-0.1750	0.0135	Horizontal		X	Late high outlier
3470	1	26	1996-2006	1.64	2.07	2.12	3.29	0.33	0.0106	0.0129	Horizontal	X		
4000	0	32	1995-2006	6.31	7.42	7.63	8.86	0.72	0.0590	0.100	Horizontal			
4003	1	31	1995-2006	20.50	21.66	21.95	26.33	1.22	0.0947	0.0917	Horizontal	X		
4004	1	31	1995-2006	10.94	11.78	12.12	18.38	1.32	-0.0160	0.00218	Horizontal	X		
4005	0	32	1995-2006	15.55	16.52	16.70	22.89	1.31	0.0358	0.0111	Horizontal	X		
4006	0	32	1995-2006	15.98	16.73	16.70	17.26	0.38	0.0536	0.292	Horizontal			
4007	0	33	1995-2006	26.01	52.52	51.57	53.42	4.66	-0.2095	0.0273	Horizontal		X	Late high outlier
Median								0.78	-0.0057			36	16	
Mean								1.75	-0.0909					

1 Well identification (ID) number from EBOP database.

2. Obtained from review of EBOP water level database. "Deleted" means number of data points deleted due to indication in database that pump was in operation during measurement (i.e., "1" in "Pumped" column or relevant comment in "Comment" column). Question marks accompanying the data point from a data logger were also deleted. "Count" means number of remaining data points after deletions. Relatively large counts (i.e., counts greater than 1,000 data points) indicate measurements obtained by data loggers. In those cases, each value is a daily mean. "Data Period" means period covered by data points after deletions.

3. Descriptive statistics calculated using Microsoft Excel 2002 spreadsheet. "Min," "Max," and "Stdev" are minimum, maximum, and standard deviation, respectively. Values in m.

4. Linear line of best fit determined using Version 5 of Golden Software computer program Grapher. "LR Slope" is the slope of the linear regression line in m/year. "r^2" is the accompanying coefficient of determination.

5. Qualitative judgements based on visual assessment of water level graphical plots. A "Horizontal" trend indicates relatively unchanging water levels over time while falling and rising describe the trend in the water level over time. Falling means depth from TOC is increasing for manually measured wells and the opposite for data logger wells and vice versa for rising. Deep and shallow outliers are indicated by an "X" in the respective column. Additional comments relevant to interpretation of the data plots are also provided.

Table 3.1 Groundwater Quality Files

Groundwater Quality Files					
NERMN Chemistry Sites[1]		NERMN GW[2]		Current Well Data[3]	
0001	4000	0001	3045	0001 (20)	3301 (55)
0051	4001	0051	3272	0049	3470
0196	4002	0066	3301	0066	3505
0410	4003	0068	3470	0068	3566
0466	4007	0094	3566	0094	4000
0490	4364	0196	4000	0196	4001
0643	4582	0400	4001	0410	4002
0845		0410	4002	0466	4003
0851		0490	4007	0490	4007 (58)
0925		0643	4364	0643	4364 (57)
0951		0707	4571	0845	4582
1018		0845	4582	0851	4968
1104		0851	4586	0925	120045
1319		0925	120045	0951	180065
1393		0951	180071	1018	180071
1520		1018		1104	NGMP-20
1561		1104		1319	NGMP-21
1586		1319		1393	NGMP-55
1605		1393		1520	NGMP-56
1686		1520		1561	NGMP-57
1690		1561		1586	NGMP-58
2076		1586		1605	
2093		1605		1686	
2118		1686		1690	
2303		1690		2076	
2330		2093		2093	
2342		2118		2303	
2344		2303		2330	
2362		2330		2342	
2393		2342		2343	
2509		2343		2344	
2707		2344		2362	
2728		2362		2393	
2822		2393		2509 (56)	
2829		2509		2707	
2840		2707		2728	
2847		2728		2729	
2913		2822		2822	
3034		2829		2829	
3036		2840		2847	
3039		2847		2913	
3044		2913		3034	
3045		2957		3036	
3272		3034		3039	
3301		3036		3044	
3470		3039		3045 (21)	
3566		3044		3272	

1. *"NERMN Chemistry Sites" Excel file.*
2. *"NERMN Groundwater" Excel file*
3. *"NERMN GW Chem Data" Excel file plus National Groundwater Monitoring Program (NGMP) database for six EBOP sites (last six entries). NERMN listing includes NGMP wells. These wells are indicated by parenthetical notations using NGMP well numbers after each.*

Table 3.2 Water Quality Well Information

Water Quality Well Information[1]								
				NZMS 260	NZMG Coordinates		Casing-Bore	
Well ID	Name	Town	Area	Map Reference	Easting	Northing	Depth	Geology
0001 (20)	G.F & A.J. van Beek [NGMP-20]	Awakeri	Rangitaki Plain	W15:5360-5190	2853600	6351900	12.1	-
0049	Parker	-	Rangitaki Plain	V15:4410-5670	2844100	6356700	-	-
0066	P.E & L.J. Sargent	Apatha	Tauranga Basin	U14:7180-9230	2771800	6392300	199.9-618.7	Ignimbrite
0068	Lindemann Orchard Ltd.	Katikati	Tauranga Basin	T13:6640-0270	2766400	6402700	57-275.8	Ignimbrite
0094	G.D. Cain	Te Puna	Tauranga Basin	U14:8020-8750	2780200	6387500	130.1-164.6	Rhyolite
0196	I.Taylor	Galatea	Galatea Plain	V17:3830-0510	2838300	6305100	19	-
0410	W & H Bowyer	Paengaroa	Te Puke - Maketu	V15:1120-6700	2811200	6367000	118-196.6	Pumice
0466	I.B.Rogers	Awakeri	Rangitaki Plain	V15:4910-5110	2849100	6351100	16.8	-
0490	V & A.Muller.	Awakaponga	Rangitaki Plain	V15:4040-5720	2840400	6357200	73	-
0643	A & S Wakefield	Pukehina	Coastal Plain	V14:1960-7160	2819600	6371600	7-9	Sand
0845	A.Bonner	Awakeri	Rangitaki Plain	W15:5230-5230	2852300	6352300	173	-
0851	T & A Cook	Katikati	Tauranga Basin	T14:6880-9490	2768800	6394900	75.3-97.5	Volc Rock
0925	NM Gardner	Edgecumbe	Rangitaki Plain	V15:4440-5040	2844400	6350400	32	-
0951	Paengaroa North K Trust	Paengaroa	Te Puke - Maketu	V14:1090-7120	2810900	6371200	86.3-114.3	Rhyolite
1018	D & J Mockford (Black Rose Orc)	Maketu	Te Puke - Maketu	V14:1200-7460	2812000	6374600	359	Ignimbrite
1104	D.E Haley	Rotorua	Rotorua	U16:0120-3662	2801200	6336620	61	-
1319	Ngati Manawa Trust	Murupara	Galatea Plain	V17:3510-9780	2835100	6297800	51.8	-
1393	C & M. Babington	Katikati	Tauranga Basin	T13:6860-0470	2768600	6404700	247.5-326.1	Ignimbrite
1520	W.Tapsell	Maketu	Te Puke - Maketu	V14:1470-7380	2814700	6373800	50-74	Gravel
1561	Dunroamin Nurseries	Hamurana	Rotorua	U15:9290-4600	2792900	6346000	73.1	-
1586	K.J & G. Crawford	Te Puke	Te Puke - Maketu	U14:0430-7350	2804300	6373500	28-30.5	Alluvium
1605	Penetito Trust	Te Teko	Rangitaki Plain	V15:4520-4090	2845200	6340900	61	-
1686	Western Bay Golf Club	Omokoroa	Tauranga Basin	U14:7750-9140	2777500	6391400	111.6-182.9	Gravel
1690	Mangatarata Orchard	Maketu	Te Puke - Maketu	V14:1050-7470	2810500	6374700	72.5-97.5	Ignimbrite
2076	Whakatane Airport	Whakatane	Rangitaki Plain	W15:5460-5670	2854600	6356700	-	-
2093	Dominion Salt Co.	Mt Maunganui	Coastal Plain	U14:9130-8870	2791300	6388700	6	-
2303	A. Harris	Katikati	Tauranga Basin	U14:7020-9900	2770200	6399000	114.8-262	Ignimbrite
2330	D.W. Noble	Kauri Point	Tauranga Basin	U13:7280-0530	2772800	6405300	65.8-118.87	Sediment
2342	Faith Bible College	Welcome Bay	Tauranga Basin	U14:9580-8210	2795800	6382100	78.33-194.5	Ignimbrite
2343	L & H Duggan	Tauranga	Tauranga Basin	U14:7540-9060	2775400	6390600	98.45-153.9	Rhyolite
2344	Waimapu Packhouse	Oropi	Tauranga Basin	U14:8640-7350	2786400	6373500	39.32-123.4	Volc Rock
2362	P.A.Bell	Matapihi	Tauranga Basin	U14:9160-8420	2791600	6384200	99.67-210.3	Rhyolite
2393	M.Thompson	Bethlehem	Tauranga Basin	U14:8440-8510	2784400	6385100	128.02-146.3	Rhyolite
2509 (56)	Eternal Springs [NGMP-56]	Otakiri	Rangitaki Plain	V15:4090-4900	2840900	6349000	319.5	-
2707	E.K. Hickson	Papamoa	Coastal Plain	U14:0760-7950	2807600	6379500	8-10	Gravel
2728	R.S & S.R Steiner	Papamoa	Tauranga Basin	U14:0280-8140	2802800	6381400	69-81	Sand
2729	Ngapeke Orchard	Welcome Bay	Tauranga Basin	U14:9410-8210	2794100	6382100	13-15	Pumice
2822	RW & S Winters	Pongakawa	Te Puke - Maketu	V15:1620-6810	2816200	6368100	104.85-121.9	-
2829	R & S Bagshaw	Waihi Beach	Taurnaga Basin	U13:7060-1420	2770600	6414200	216.41	-
2847	BOPRC 3B. MOT Testing Station	Mt Maunganui	Coastal Plain	U14:9240-8810	2792400	6388100	3.2-5.2	Sand
2913	A & D Muller	Galatea	Galatea Plain	V17:4340-0730	2843400	6307300	22	-
3034	D & J Mockford (Black Rose Orc)	Maketu	Te Puke - Maketu	V14:1190-7460	2811900	6374600	8.5	-
3036	Otara Orchard	Opotiki	Opotiki Plain	W15:8890-4280	2888900	6342800	30	-
3039	Riverloch Farms	Opotiki	Opotiki Plain	W16:8570-3970	2885700	6339700	30	-
3044	Fernland Spa	Tauranga	Tauranga Basin	U14:8570-8370	2785700	6383700	244	-
3045 (21)	G.S.R. Allen [NGMP-21]	Te Puke	Te Puke- Makatu	V14:1100-7430	2811000	6374300	5.48	Pumice
3272	Drake	Mt Maunganui	Tauranga Basin	U14:9435-8815	2794350	6388150	300-375	-
3301 (55)	Ohope Golf Club [NGMP-55]	Ohope	Coastal Plain	W15:7270-4890	2872700	6348900	12	-
3470	J.W Lepper	Ngongotaha	Rotorua	U15:9133-4310	2791330	6343100	-	-
3505	Rerewhakaaitu School	-	Rotorua	V16:1560-1470	2815600	6314700	-	-
3566	G & D Thacker	-	Te Puke- Makatu	V15:1660-6620	2816600	6366200	70-122	-
4000	P & G Ludgate	Rotorua	Rotorua	U15:0240-4300	2802400	6343000	26	-
4001	Rotoma Holiday Camp	Rotoma	Rotorua	V15:2140-4500	2821400	6345000	55	-
4002	Opotiki Holiday Park	Opotiki	Opotiki Plain	W15:8620-4660	2886200	6346600	60	-
4003	Pickernell Bore	Rotorua	Rotorua	U15:0253-4342	2802530	6343420	26	-
4007 (58)	D & R Pemberton [NGMP-58]	Ngongotaha	Rotorua	U15:8935-4700	2789350	6347000	-	-
4364 (57)	Fernland Spa [NGMP-57]	Tauranga	Tauranga Basin	U14:8570-8368	2785700	6383680	-	-
4582	T & M Mclean	Welcome Bay	Tauranga Basin	U14:9385-8105	2793850	6381050	350	-
4968	G & D Thacker	Pongakawa	Te Puke- Makatu	V15:1740-6510	2817400	6365100	10	-
120045	Waitapu Spring (Barlows Sp.)	-	Rotorua	U16:8600-3920	2786000	6339200	-	-
180065	Te Ngae Nursery Bore	-	Rotorua	U15:0224-4089	2802240	6340890	-	-
180071	Braemar Springs	-	Rangitaki Plain	V15:3870-5260	2838700	6352600	-	-

1. *Information obtained from various EBOP data files. "Samples" indicates number of groundwater quality samples in database through file provision in March 2006. "Casing-Bore Depth" indicates depth range of well open to the aquifer in m below top of well casing. Where there is only one number listed, it is the total depth. "SWL" is representative static water level listed in database file in m below top of well casing. "Geology" is the geology intercepted by the well open interval.*

Table 3.3a Median Water Quality Values

Median Water Quality Values[1]														
	Sample		Field Variables[2]				Major Cations[3]				Major Anions[3]			
Well ID	Count	Data Period	Cond	DO	pH	Temp	Ca	Mg	K	Na	HCO_3	Cl	SO_4	Silica[3]
0001 (20)	43	1991-2005	372	1.3	7.40	16.7	27.5	10.9	3.8	31.0	157.0	22.0	29.0	67.5
0049	7	1991-1996	885	0.3	6.89	16.0	105.0	11.4	9.7	93.0	537.4	36.4	0.3	ND
0066	6	1991-1996	362	1.1	7.33	32.1	2.9	1.1	5.4	64.3	128.3	35.0	2.0	ND
0068	11	1991-2005	148	6.0	7.59	21.5	5.0	2.3	2.0	22.3	75.6	8.7	1.8	89.2
0094	6	1991-1995	198	3.4	7.25	25.0	5.1	4.7	3.2	31.0	96.4	16.4	2.6	ND
0196	11	1991-2005	118	3.1	6.95	14.9	6.8	4.2	2.2	10.0	59.8	5.6	2.9	65.4
0410	7	1994-2005	205	ND	6.80	15.3	5.5	3.4	3.4	24.0	102.5	10.0	6.6	76.5
0466	10	1991-2004	497	0.3	7.20	16.9	35.4	5.0	3.8	24.5	309.9	10.3	0.3	72.8
0490	12	1991-2005	105	1.6	6.90	14.3	3.1	2.1	1.5	14.8	51.1	7.7	1.6	80.9
0643	10	1991-2004	435	0.5	6.60	16.3	15.9	10.2	5.7	59.3	234.9	28.1	14.4	73.0
0845	12	1991-2005	618	0.8	7.30	28.1	23.1	10.3	5.1	102.5	385.5	17.1	0.4	99.9
0851	10	1991-2004	164	3.2	6.75	19.8	6.6	5.8	4.1	14.9	79.7	10.5	2.2	83.0
0925	11	1991-2005	689	0.3	6.05	19.1	23.7	9.4	3.8	81.3	353.8	44.9	0.3	108.0
0951	11	1991-2005	493	4.4	6.90	24.8	28.6	10.4	2.6	63.5	289.1	21.6	0.3	93.1
1018	11	1991-2005	637	0.8	6.70	32.4	16.2	11.5	8.8	105.0	346.5	40.5	0.9	137.0
1104	2	1997-1998	139	ND	6.45	19.3	3.6	3.3	2.6	18.5	45.1	13.0	9.3	101.0
1319	11	1991-2005	228	3.1	7.20	15.9	13.8	6.6	3.7	22.4	126.9	9.8	0.3	65.8
1393	11	1991-2005	165	1.3	8.00	26.5	0.3	0.1	2.6	34.9	83.1	9.0	1.4	111.0
1520	10	1991-2005	313	4.5	6.55	22.1	8.0	6.1	7.9	48.6	133.0	26.8	2.2	98.0
1561	11	1991-2005	84	6.9	6.60	13.6	3.0	2.0	2.6	9.4	39.5	5.1	1.3	70.1
1586	11	1991-2005	107	0.9	6.35	17.4	3.1	2.0	3.5	12.3	35.7	8.6	5.0	89.3
1605	10	1991-2004	92	2.4	6.50	16.1	2.5	1.6	2.9	11.3	35.4	8.0	3.1	80.0
1686	10	1991-2005	378	1.0	7.66	26.8	1.3	1.4	3.8	74.5	114.7	56.0	5.0	99.8
1690	10	1991-2005	421	3.0	6.95	26.5	17.1	8.2	6.2	59.0	241.0	19.1	0.4	100.8
2076	11	1991-2005	163	6.9	6.95	19.6	6.8	3.1	3.3	12.8	34.8	9.3	6.9	73.3
2093	7	1991-2002	1,198	1.4	6.50	18.1	25.0	2.9	7.7	233.0	92.7	310.0	32.0	40.1
2303	11	1991-2005	490	0.2	7.45	35.5	1.0	0.5	14.1	108.0	290.4	12.2	0.8	109.5
2330	11	1991-2005	178	4.1	6.40	18.4	6.0	2.4	5.5	20.9	53.7	23.4	5.0	85.0
2342	11	1991-2005	197	7.3	7.00	22.0	8.3	6.0	4.2	19.1	75.3	20.5	4.6	91.5
2343	11	1991-2005	106	7.6	6.70	18.9	4.6	1.6	3.0	13.0	42.7	10.0	2.3	66.9
2344	11	1991-2005	86	6.5	6.12	17.0	2.8	1.5	5.0	9.6	34.0	7.1	2.5	89.4
2362	11	1991-2005	210	0.4	6.95	30.8	6.7	3.2	5.1	28.0	96.3	16.7	3.4	115.0
2393	8	1991-1998	228	3.9	7.20	28.9	5.2	4.5	5.2	33.0	100.1	19.6	2.5	97.0
2509 (56)	32	1996-2005	94	7.9	6.74	17.8	2.8	1.6	2.9	11.4	35.0	6.7	3.4	82.0
2707	11	1991-2005	926	2.8	7.75	16.1	81.5	14.8	5.3	66.8	157.4	170.0	48.6	36.2
2728	11	1991-2005	574	1.3	6.70	21.4	9.1	4.0	10.8	79.7	133.0	84.3	12.4	84.0
2729	6	1991-1996	193	4.4	6.65	19.8	8.6	4.6	3.6	22.0	82.0	16.8	3.9	ND
2822	11	1991-2005	341	3.2	6.60	18.1	7.9	7.7	4.2	49.5	178.1	19.8	0.6	91.2
2829	11	1991-2005	232	5.2	8.40	31.1	0.3	0.3	3.7	47.7	103.5	18.3	4.0	70.5
2847	12	1991-2005	232	0.2	5.80	19.7	18.5	7.5	7.8	29.6	59.8	55.0	24.0	42.0
2913	10	1991-2005	110	9.6	6.80	12.7	7.7	3.3	2.4	8.1	49.6	6.3	4.5	43.5
3034	11	1991-2005	292	2.8	6.50	18.2	2.8	1.4	7.1	47.5	65.5	20.3	20.0	84.7
3036	10	1991-2005	190	0.9	6.80	15.4	13.3	6.2	2.3	14.3	97.5	11.9	1.4	37.6
3039	11	1991-2005	103	4.9	6.50	14.9	9.6	2.5	1.2	6.0	42.7	5.8	6.5	25.0
3044	15	1991-2005	1,771	0.4	7.40	41.8	12.2	7.3	12.6	260.0	255.0	398.5	0.3	83.0
3045 (21)	44	1991-2005	260	4.0	6.39	15.8	12.6	5.6	9.2	22.2	67.0	33.0	7.7	81.0
3272	4	1997-2005	27,300	ND	6.85	35.9	546.0	616.0	267.0	4,460.0	100.5	9,790.0	995.0	94.0
3301 (55)	27	1996-2005	300	3.5	8.12	16.1	15.3	9.3	3.5	30.0	94.5	37.0	9.8	35.0
3470	6	1997-2005	98	ND	6.80	12.8	2.2	1.6	1.9	11.9	49.8	4.3	0.3	40.2
3505	1	2002	163	ND	6.00	12.4	8.6	3.0	ND	11.2	74.9	12.2	9.7	81.6
3566	5	1997-2005	185	ND	6.90	15.1	7.1	3.3	7.1	15.8	34.0	15.7	4.0	84.6
4000	8	1991-1998	132	8.8	6.30	15.4	7.2	2.3	5.8	10.3	30.9	9.4	8.9	82.6
4001	10	1991-2005	1,409	0.7	5.80	39.1	14.3	7.8	21.8	228.5	189.1	322.0	38.8	164.0
4002	11	1991-2005	837	4.3	6.90	16.5	42.1	12.0	7.8	85.3	122.0	188.4	24.9	41.1
4003	2	2003-2004	109	ND	7.00	14.6	5.7	2.2	4.3	9.7	29.9	4.7	11.8	84.0
4007 (58)	33	1996-2005	87	8.4	6.56	12.9	3.2	1.9	1.7	10.0	31.4	5.2	1.4	66.0
4364 (57)	34	1996-2005	912	0.5	7.47	36.7	9.6	7.2	7.2	147.0	136.0	197.0	0.2	79.5
4582	4	1997-2005	211	ND	6.75	23.9	8.3	4.9	4.1	23.5	83.4	22.3	4.0	107.0
4968	3	2002-2005	212	ND	6.60	16.4	7.5	3.3	3.5	18.5	25.9	20.1	6.3	88.4
120045	6	1996-2005	66	ND	6.50	11.2	2.3	1.4	2.8	9.3	27.1	4.5	1.5	64.1
180065	5	1997-2005	118	ND	6.60	14.2	6.3	2.3	2.9	11.4	34.2	6.3	10.9	79.2
180071	5	1997-2005	101	ND	6.80	17.0	3.6	1.5	3.5	11.5	29.8	9.0	8.2	75.3

1. *Median levels calculated by Excel NGMP calculator program (Daughney, 2005) for 36 variables from 715 samples taken from 62 wells. "ND" indicates fewer than two results and value not determined.*
2. *Units for "Cond" (conductivity), "DO" (dissolved oxygen), pH, and "Temp" (temperature) are uS/cm, mg/L, units, and ^{o}C, respectively.*
3. *Units for major cations and anions and for silica are mg/L.*

Table 3.3b Median Water Quality Values

Median Water Quality Values[1]																	
	Minor/Trace Elements[2]																
Well ID	Al	As	B	Br	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	Zn
0001 (20)	-	-	-	0.0292	-	-	-	-	0.1800	3.5000	-	-	0.2300	-	-	-	-
0049	0.0012	0.0008	1.1700	ND	0.0000	ND	0.0001	0.0002	0.2900	0.0800	0.0000	ND	0.3350	ND	ND	0.0005	0.0018
0066	0.0049	0.0328	1.5600	ND	0.0000	ND	0.0001	0.0006	0.3500	0.0050	0.0006	ND	0.0300	ND	ND	0.0005	0.1380
0068	0.0015	0.0030	0.0170	ND	0.0000	0.0001	0.0034	0.0003	0.1100	0.0100	0.0000	0.0216	0.0003	0.0003	0.0003	0.0005	0.0581
0094	ND	ND	ND	ND	ND	ND	ND	ND	0.3300	ND	ND	ND	ND	ND	ND	ND	ND
0196	0.0015	0.0045	0.0585	ND	0.0000	0.0001	0.0003	0.0003	0.2700	1.9850	0.0000	0.0088	0.3340	0.0007	0.0003	0.0005	0.0125
0410	0.0015	0.0030	0.0415	ND	0.0002	0.0008	0.0003	0.0003	0.2800	0.2850	0.0006	0.0293	5.0900	0.0012	0.0003	0.0005	0.3690
0466	0.0015	0.0005	0.0890	ND	0.0000	0.0001	0.0003	0.0003	0.5950	0.0600	0.0000	0.0346	0.3290	0.0001	0.0004	0.0005	0.0028
0490	0.0030	0.0005	0.0145	ND	0.0000	0.0001	0.0003	0.0003	0.1800	1.0550	0.0000	0.0224	0.1280	0.0001	0.0003	0.0005	0.0126
0643	0.0070	0.0296	0.1490	ND	0.0000	0.0008	0.0002	0.0032	0.3300	8.7550	0.0000	0.1630	12.7000	0.0012	0.0005	0.0005	0.0027
0845	0.0015	0.0005	0.5325	ND	0.0000	0.0001	0.0004	0.0003	0.6300	0.3350	0.0000	0.2310	0.1230	0.0001	0.0003	0.0005	0.0039
0851	0.0015	0.0005	0.0120	ND	0.0000	0.0001	0.0002	0.0003	0.0900	4.9150	0.0001	0.0057	0.1480	0.0002	0.0005	0.0005	0.0258
0925	0.0015	0.0005	1.7100	ND	0.0000	0.0001	0.0006	0.0003	0.2600	24.4000	0.0008	0.4200	1.0300	0.0001	0.0004	0.0005	0.0193
0951	0.0015	0.0102	0.1835	ND	0.0000	0.0001	0.0003	0.0003	0.2600	0.7800	0.0000	0.1260	1.7500	0.0006	0.0003	0.0005	0.0096
1018	0.0015	0.0005	0.5050	ND	0.0000	0.0001	0.0003	0.0003	0.3500	1.8000	0.0001	0.2215	0.2745	0.0007	0.0004	0.0005	0.1280
1104	0.0015	0.0160	0.0540	ND	ND	0.0001	ND	0.0016	0.2800	0.0250	0.0003	0.0846	0.0015	0.0005	0.0005	ND	0.0245
1319	0.0015	0.0440	0.1375	ND	0.0000	0.0001	0.0003	0.0006	0.3400	0.4250	0.0000	0.0138	0.7985	0.0012	0.0003	0.0005	0.0082
1393	0.0263	0.0100	0.0560	ND	0.0000	0.0001	0.0003	0.0009	0.3500	0.0200	0.0004	0.0418	0.0045	0.0019	0.0004	0.0005	0.0387
1520	0.0023	0.0010	0.2310	ND	0.0000	0.0001	0.0003	0.0004	0.1500	0.0100	0.0003	0.0369	0.0004	0.0004	0.0004	0.0005	0.0244
1561	0.0015	0.0010	0.0085	ND	0.0000	0.0001	0.0003	0.0013	0.0800	0.0150	0.0000	0.0122	0.0030	0.0001	0.0003	0.0005	0.0631
1586	0.0015	0.0005	0.0160	ND	0.0000	0.0001	0.0003	0.0003	0.1350	0.0225	0.0000	0.0029	0.1840	0.0006	0.0003	0.0005	0.0800
1605	0.0080	0.0010	0.0365	ND	0.0000	0.0001	0.0003	0.0003	0.1800	0.0175	0.0000	0.0076	0.0003	0.0002	0.0005	0.0005	0.0075
1686	0.5800	0.0190	0.4980	ND	0.0000	0.0002	0.0003	0.0010	0.5900	0.6200	0.0017	0.0966	0.0454	0.0104	0.0003	0.0005	0.0292
1690	0.0015	0.0010	0.2160	ND	0.0000	0.0001	0.0003	0.0003	0.3500	0.8900	0.0000	0.1145	0.6020	0.0009	0.0005	0.0005	0.0011
2076	0.0031	0.0145	0.0230	ND	0.0000	0.0001	0.0002	0.0025	0.1200	0.0175	0.0005	0.0197	0.0007	0.0003	0.0005	0.0005	0.1215
2093	0.0015	0.0220	0.0560	ND	0.0000	0.0001	0.0001	0.0005	0.0650	0.0250	0.0009	0.0035	0.0030	0.0013	0.0005	0.0005	0.0027
2303	0.1220	0.0340	0.0810	ND	0.0000	0.0001	0.0003	0.0010	0.5350	0.0900	0.0002	0.1120	0.0751	0.0009	0.0005	0.0005	0.0010
2330	0.0100	0.0010	0.0160	ND	0.0000	0.0001	0.0016	0.0011	0.0600	0.0400	0.0004	0.0052	0.0013	0.0001	0.0003	0.0008	0.1250
2342	0.0015	0.0005	0.0200	ND	0.0000	0.0001	0.0004	0.0003	0.0750	0.0100	0.0004	0.0130	0.0015	0.0001	0.0003	0.0005	0.0335
2343	0.0015	0.0005	0.0130	ND	0.0000	0.0001	0.0003	0.0003	0.0600	0.0175	0.0002	0.0085	0.0003	0.0001	0.0005	0.0005	0.2785
2344	0.0250	0.0005	0.0110	ND	0.0000	0.0001	0.0003	0.0005	0.0750	0.0250	0.0000	0.0074	0.0020	0.0001	0.0003	0.0005	0.0230
2362	0.0015	0.0042	0.0785	ND	0.0000	0.0001	0.0003	0.0003	0.2200	0.2200	0.0000	0.0392	0.5520	0.0007	0.0003	0.0005	0.3395
2393	0.0015	0.0040	0.1490	ND	0.0000	0.0001	0.0001	0.0004	0.2300	0.0250	0.0004	0.0528	0.0003	0.0015	0.0005	0.0005	0.0630
2509 (56)	-	-	-	0.0233	-	-	-	-	0.1500	0.0006	-	-	0.0001	-	-	-	-
2707	0.0015	0.0005	0.0335	ND	0.0000	0.0001	0.0003	0.0003	0.0275	0.0100	0.0000	0.0060	0.0275	0.0001	0.0005	0.0033	0.0112
2728	0.0021	0.0100	0.1010	ND	0.0000	0.0001	0.0003	0.0003	0.1350	7.7300	0.0001	0.0105	0.2200	0.0014	0.0004	0.0005	0.1300
2729	0.0016	0.0006	0.0160	ND	0.0000	ND	0.0001	0.0018	0.2100	0.0700	0.0000	ND	0.0021	ND	ND	0.0005	ND
2822	0.0015	0.0035	0.2170	ND	0.0000	0.0006	0.0003	0.0003	0.3850	4.6600	0.0000	0.1930	0.9490	0.0003	0.0003	0.0005	0.0146
2829	0.0775	0.0140	0.1250	ND	0.0000	0.0001	0.0003	0.0009	0.1900	0.2600	0.0009	0.0110	0.0119	0.0024	0.0006	0.0005	0.0200
2847	0.2940	0.0011	0.0590	ND	0.0000	0.0002	0.0004	0.0006	0.0800	6.8250	0.0002	0.0007	0.1748	0.0001	0.0005	0.0005	0.0741
2913	0.0015	0.0005	0.0320	ND	0.0000	0.0001	0.0003	0.0012	0.2300	0.0100	0.0002	0.0078	0.0007	0.0003	0.0004	0.0005	0.0220
3034	0.0065	0.0005	0.1460	ND	0.0000	0.0001	0.0003	0.0003	0.1600	0.0100	0.0000	0.0048	0.0008	0.0005	0.0004	0.0005	0.0015
3036	0.0015	0.0040	0.0360	ND	0.0000	0.0001	0.0003	0.0003	0.2000	1.4700	0.0000	0.0045	0.3300	ND	0.0003	0.0005	0.0574
3039	0.0015	0.0005	0.0330	ND	0.0000	0.0001	0.0003	0.0003	0.0800	0.0275	0.0000	0.0015	0.0011	0.0001	0.0003	0.0005	0.0095
3044	0.0040	0.0230	9.5100	0.3800	0.0000	0.0001	0.0003	0.0008	1.0500	0.3700	0.0000	0.7440	0.2815	0.0050	0.0003	0.0005	0.0035
3045 (21)	-	-	-	0.0600	-	-	-	-	0.1000	0.0400	-	-	0.0110	-	-	-	-
3272	0.0070	0.0005	0.8570	ND	ND	0.0008	0.0025	0.0031	0.0700	4.3000	0.0006	1.4300	5.4003	0.0027	0.0025	ND	0.0400
3301 (55)	-	-	-	0.1200	-	-	-	-	0.1100	0.0490	-	-	0.0000	-	-	-	-
3470	0.0015	0.2445	0.0130	ND	0.0000	0.0001	0.0003	0.0003	0.3100	5.3800	0.0000	0.0187	1.0800	0.0001	0.0003	0.0005	0.0112
3505	0.0015	0.0005	0.0100	ND	ND	0.0001	0.0003	0.0003	ND	0.4300	0.0000	0.0054	0.0117	ND	0.0003	ND	0.0760
3566	0.0085	0.0010	0.0180	ND	0.0000	0.0001	0.0003	0.0005	0.1850	0.0250	0.0000	0.0072	0.0009	0.0004	0.0003	ND	0.0240
4000	0.0033	0.0005	0.0070	ND	0.0001	0.0001	0.0001	0.0045	0.0500	0.0250	0.0001	0.0038	0.0024	0.0001	0.0005	0.0005	0.2610
4001	0.0040	0.0805	2.2550	ND	0.0001	0.0005	0.0003	0.0003	0.5600	9.7150	0.0000	1.7900	2.9200	0.0003	0.0003	0.0005	0.0100
4002	0.0015	0.0020	0.0515	ND	0.0000	0.0001	0.0003	0.0003	0.2000	0.4750	0.0000	0.0177	0.2840	0.0004	0.0003	0.0005	0.0027
4003	0.0015	0.0005	0.0090	ND	ND	0.0001	0.0003	0.0008	0.0575	0.0250	0.0004	0.0045	0.0067	ND	0.0274	ND	0.0990
4007 (58)	-	-	-	0.0011	-	-	-	-	0.0234	<0.05	-	-	0.0050	-	-	-	-
4364 (57)	-	-	-	0.6600	-	-	-	-	0.4500	0.5700	-	-	0.5100	-	-	-	-
4582	0.0015	0.0005	0.0200	ND	0.0001	0.0001	0.0003	0.0003	0.1000	0.0300	0.0003	0.0182	0.0042	0.0002	0.0005	0.0005	0.3990
4968	0.0060	0.0040	0.0620	ND	0.0000	0.0001	0.0003	0.0003	0.1300	0.0400	0.0000	0.0137	0.0010	ND	0.0003	0.0005	0.0400
120045	0.0015	0.0005	0.0105	ND	0.0000	0.0001	0.0003	0.0003	0.0800	0.0100	0.0000	0.0078	0.0012	0.0001	0.0003	0.0005	0.0050
180065	0.0015	0.0090	0.0130	ND	0.0000	0.0001	0.0003	0.0009	0.1450	0.0100	0.0000	0.0211	0.0038	0.0002	0.0005	0.0005	0.0080
180071	0.0050	0.0180	0.0240	ND	0.0000	0.0001	0.0003	0.0003	0.1300	0.0100	0.0000	0.0205	0.0003	0.0004	0.0003	0.0005	0.0005

1. *Median levels calculated by Excel NGMP calculator program (Daughney, 2005) for 36 variables from 715 samples taken from 62 wells. "ND" indicates fewer than two results and value not determined.*
2. *Units for minor/trace elements are mg/L.*

Table 3.3c Median Water Quality Values

Median Water Quality Values[1]							
	Nutrients[2]					Bacteria[3]	
Well ID	NH_3-N	NO_2-N	NO_3-N	PO_4-P	TP	Entero	F_Coli
0001 (20)	1.100	0.002	0.001	0.034	ND	ND	ND
0049	1.920	ND	0.189	0.312	1.330	260	2547
0066	0.144	ND	0.013	0.118	0.117	ND	ND
0068	0.004	0.001	0.060	0.116	0.111	ND	ND
0094	0.008	ND	0.561	0.113	0.109	ND	ND
0196	0.083	0.001	0.004	0.317	0.669	1	1
0410	0.070	0.001	0.004	0.008	0.009	ND	ND
0466	3.510	0.001	0.007	0.044	1.070	1	1
0490	0.091	0.001	0.008	0.099	0.183	ND	ND
0643	0.105	0.001	0.009	0.409	0.425	18	4
0845	0.486	0.001	0.002	0.551	0.609	ND	ND
0851	0.029	0.002	0.002	0.126	0.134	ND	ND
0925	0.622	0.006	0.005	0.219	0.267	ND	ND
0951	0.152	0.001	0.001	0.116	0.325	ND	ND
1018	0.108	0.001	0.009	0.140	0.186	ND	ND
1104	0.012	0.001	0.001	0.623	0.651	ND	ND
1319	0.530	0.001	0.037	1.324	1.430	1	1
1393	0.005	0.001	0.036	0.161	0.173	ND	ND
1520	0.004	0.001	1.782	0.071	0.073	ND	ND
1561	0.007	0.001	0.534	0.085	0.093	ND	ND
1586	0.019	0.001	0.222	0.037	0.037	1	1
1605	0.005	0.001	0.100	0.119	0.127	ND	ND
1686	0.012	0.001	0.002	0.218	0.217	ND	ND
1690	0.189	0.001	0.007	0.064	0.209	ND	ND
2076	0.007	0.001	1.100	0.082	0.073	1	1
2093	0.092	0.003	1.760	0.034	0.037	1	1
2303	0.500	0.003	0.002	2.580	2.420	ND	ND
2330	0.005	0.001	0.075	0.024	0.021	ND	ND
2342	0.004	0.001	0.116	0.080	0.079	ND	ND
2343	0.003	0.001	0.083	0.064	0.062	ND	ND
2344	0.003	0.001	0.180	0.026	0.018	ND	ND
2362	0.139	0.001	0.018	0.225	0.279	ND	ND
2393	0.005	0.001	0.198	0.090	0.098	ND	ND
2509 (56)	0.000	<0.005	0.180	0.064	ND	ND	ND
2707	0.009	0.009	2.180	0.018	0.018	1	1
2728	0.350	0.001	0.009	0.018	0.027	ND	ND
2729	0.005	ND	0.117	0.174	0.183	ND	ND
2822	0.032	0.001	0.005	0.183	0.244	ND	ND
2829	0.005	0.001	0.112	0.215	0.242	ND	ND
2847	1.590	0.011	0.010	0.008	0.015	1	1
2913	0.007	0.002	0.286	0.074	0.074	1	1
3034	0.007	0.001	4.895	0.174	0.190	1	1
3036	0.173	0.001	0.009	0.267	0.350	ND	ND
3039	0.007	0.001	0.502	0.020	0.022	ND	ND
3044	0.191	0.001	0.001	0.089	0.099	ND	ND
3045 (21)	0.002	0.005	0.560	0.010	ND	ND	ND
3272	1.004	0.005	0.030	0.015	0.054	ND	ND
3301 (55)	0.010	ND	1.900	0.100	ND	ND	ND
3470	0.864	0.001	0.004	0.257	0.334	ND	1
3505	0.010	0.002	4.790	0.014	0.009	ND	ND
3566	0.010	0.001	9.250	0.172	0.172	6	1
4000	0.005	0.002	3.320	0.045	0.034	1	1
4001	0.403	0.006	0.012	0.224	0.244	ND	ND
4002	0.066	0.001	0.005	0.029	0.087	ND	ND
4003	0.027	0.001	2.675	0.041	0.043	ND	ND
4007 (58)	0.020	<0.005	1.500	0.070	ND	ND	ND
4364 (57)	0.020	ND	0.070	0.085	ND	ND	ND
4582	0.035	0.001	0.104	0.172	0.159	ND	ND
4968	0.020	0.001	5.115	0.157	0.156	ND	ND
120045	0.005	0.001	0.504	0.083	0.087	1	1
180065	0.010	0.002	2.240	0.149	0.150	ND	1
180071	0.005	0.001	0.620	0.074	0.077	ND	1

1. *Median levels calculated by Excel NGMP calculator program (Daughney, 2005) for 36 variables from 715 samples taken from 62 wells. "ND" indicates fewer than two results and value not determined.*
2. *Units for nutrients are mg/L as nitrogen ammonia, nitrite, or nitrate) or phosphorus (phosphate or total identified as "TP").*
3. *Units for bacteria are #/100 mL. "Entero" indicates enterococci and "F_Coli" indicates faecal coliform.*

Table 3.4a Max Concentrations

Max Concentrations[1]													
		Field Variables[2]				Major Cations[3]				Major Anions[3]			
Well ID	Samples	Cond	DO	pH	Temp	Ca	Mg	K	Na	HCO_3	Cl	SO_4	Silica[3]
NZDWS	-	TDS 1000	-	7.0-8.5	Cool	100-300 as $CaCO_3$		-	200	-	250	250	-
0001 (20)	43	970	3.95	6.10-7.70	22.5	36.9	15.7	14.7	208.0	622.0	36.8	58.0	85.4
0049	7	980	0.30	6.70-7.00	16.1	230.0	34.0	17.0	250.0	624.6	41.3	1.0	-
0066	6	1,408	1.10	7.00-7.70	39.7	8.8	1.6	26.4	290.0	522.2	164.0	3.9	-
0068	11	166	6.80	7.10-7.90	22.3	6.6	2.5	3.0	24.2	79.3	12.8	2.9	93.0
0094	6	221	3.80	7.00-8.20	27.0	6.2	5.1	3.7	36.0	101.3	23.0	3.2	-
0196	11	187	5.80	6.40-7.30	15.1	12.3	5.9	3.6	15.6	101.3	8.0	5.0	77.7
0410	7	213	0.00	6.60-7.20	15.9	7.5	4.0	7.3	25.4	103.8	11.2	6.8	76.8
0466	10	518	1.80	7.00-7.50	17.2	72.0	5.5	6.4	32.8	318.4	12.3	1.8	74.6
0490	12	112	2.20	6.80-7.30	15.9	4.3	2.3	1.9	18.4	58.6	11.0	15.0	84.9
0643	10	577	0.60	6.40-6.80	16.7	26.7	14.9	9.0	65.7	247.7	37.2	44.9	76.0
0845	12	638	1.00	7.10-7.80	29.1	29.9	11.7	6.0	147.6	422.1	20.0	1.3	106.0
0851	10	192	6.20	6.50-6.90	20.5	7.8	6.2	5.5	18.1	93.9	11.5	3.0	85.3
0925	11	1,010	0.30	5.80-6.45	20.1	27.0	10.3	110.9	109.6	653.9	100.0	1.9	119.0
0951	11	613	8.10	6.70-7.40	54.7	62.0	21.0	5.4	150.0	312.3	47.5	4.5	139.0
1018	11	650	0.85	6.50-6.80	34.1	19.4	13.0	*	115.0	361.1	45.5	4.3	144.0
1104	2	140	0.00	6.30-6.60	19.9	3.6	3.4	2.7	19.3	45.1	13.6	10.5	102.0
1319	11	239	4.50	6.90-7.60	16.2	14.6	8.4	5.6	27.3	138.3	11.3	1.7	72.4
1393	11	176	1.30	7.50-8.10	29.3	2.5	0.7	4.3	37.9	90.0	11.2	3.5	124.0
1520	10	427	4.90	6.30-7.00	23.3	11.2	8.3	11.0	73.3	207.4	33.0	5.7	108.0
1561	11	88	8.00	6.30-7.00	16.2	3.7	2.2	4.0	10.7	42.7	7.4	4.0	74.3
1586	11	148	1.00	6.10-6.60	17.8	4.6	2.8	5.6	19.2	42.5	23.6	6.4	94.8
1605	10	93	2.60	6.40-7.10	16.7	3.5	1.8	4.1	14.2	36.8	9.8	4.1	85.0
1686	10	385	1.60	7.10-7.80	27.8	51.0	2.1	8.0	89.3	119.6	63.6	7.4	102.0
1690	10	448	6.00	6.80-7.50	27.1	21.0	9.1	10.7	63.4	255.0	26.3	0.9	104.0
2076	11	373	7.10	6.50-8.00	21.5	11.7	5.2	3.9	15.4	114.3	38.0	11.8	74.2
2093	7	1,980	1.40	6.30-6.65	20.2	42.0	7.2	17.0	319.0	157.4	497.0	70.0	43.2
2303	11	575	0.20	6.80-7.70	37.5	5.6	1.6	22.0	148.9	330.6	16.2	4.0	137.0
2330	11	252	6.00	6.30-8.80	23.0	23.8	2.6	9.1	25.8	100.9	26.8	7.6	91.9
2342	11	224	8.10	6.90-7.30	22.0	9.9	6.4	6.3	21.2	79.3	22.8	6.2	95.2
2343	11	121	7.70	6.50-6.80	19.1	5.6	1.7	4.2	15.6	111.4	12.8	3.3	68.6
2344	11	94	6.80	6.00-6.30	17.8	23.0	1.6	6.6	11.0	36.6	78.0	4.6	93.3
2362	11	223	0.55	6.90-7.50	31.7	8.6	3.6	8.6	31.5	103.6	38.3	4.9	122.0
2393	8	235	4.40	7.10-7.40	29.5	6.8	4.8	7.4	35.0	103.7	22.9	3.0	98.0
2509 (56)	32	140	9.15	5.92-7.29	18.7	3.2	1.8	3.7	12.2	36.2	7.7	5.3	90.0
2707	11	2,660	4.10	7.40-7.90	16.5	138.0	40.9	10.7	274.0	194.0	794.0	92.1	37.3
2728	11	664	1.70	6.50-7.20	22.0	38.0	8.6	12.0	111.0	252.5	115.0	26.0	102.0
2729	6	196	4.80	6.40-6.80	21.2	9.9	4.8	3.9	26.7	86.6	18.0	12.2	0.0
2822	11	358	6.10	6.30-7.00	18.2	10.5	8.2	5.6	52.7	191.5	23.2	4.0	93.4
2829	11	255	5.80	8.20-8.80	32.2	3.0	0.5	9.7	59.7	106.1	21.8	6.4	76.2
2847	12	685	0.30	5.60-6.10	22.8	33.8	12.0	15.0	47.5	95.3	88.0	128.0	119.0
2913	10	116	9.80	6.60-7.10	14.3	8.7	3.6	3.2	10.0	53.6	8.9	6.8	45.7
3034	11	459	3.30	5.90-6.90	22.4	6.5	2.1	12.3	86.0	185.4	31.8	31.0	98.5
3036	10	213	1.00	6.50-7.30	15.8	14.4	7.0	22.1	16.3	112.2	14.7	3.6	42.2
3039	11	117	5.20	6.30-7.00	16.0	11.1	2.9	10.6	19.9	51.4	6.7	10.1	26.2
3044	15	2,752	0.60	7.30-7.80	44.1	18.7	7.6	19.0	417.0	292.8	653.0	5.4	92.6
3045 (21)	44	290	6.10	6.10-6.92	17.8	15.3	6.5	9.8	25.0	81.0	42.0	28.0	91.1
3272	4	27,700	0.00	6.70-8.10	36.0	553.0	627.0	289.0	5,010.0	119.0	10,600.0	1,070.0	96.0
3301 (55)	27	420	7.90	7.47-8.58	16.5	20.3	12.7	4.1	33.0	103.0	53.0	13.7	38.0
3470	6	121	0.00	6.60-6.80	14.2	2.4	1.7	2.8	13.6	62.5	5.3	1.6	61.4
3505	1	163		6.00-6.00	12.4	8.6	3.0		11.2	74.9	12.2	9.7	81.6
3566	5	224	0.00	6.20-7.10	16.8	10.0	4.7	8.9	19.2	46.7	19.5	10.9	97.0
4000	8	139	9.00	6.20-6.70	16.0	8.3	4.0	7.3	12.6	33.1	15.1	10.1	85.2
4001	10	1,470	1.00	5.50-6.30	40.1	18.0	10.1	30.7	259.0	256.2	606.0	47.9	177.0
4002	11	1,866	5.00	6.60-7.30	16.7	122.2	22.8	301.0	122.0	161.0	572.9	65.6	43.2
4003	2	110	0.00	7.00-7.00	15.0	5.9	2.3	4.3	9.8	30.5	5.2	12.4	84.1
4007 (58)	33	909	9.25	6.22-7.06	13.3	4.1	2.3	2.0	10.7	34.0	6.7	1.6	74.0
4364 (57)	34	1,081	3.20	6.74-7.73	37.7	10.6	7.6	8.3	162.0	139.0	208.0	0.3	89.0
4582	4	228	0.00	6.50-6.80	26.7	8.4	5.2	4.3	23.9	93.9	27.5	6.8	112.0
4968	3	215	0.00	6.30-6.70	16.6	8.7	4.1	8.0	25.9	53.8	21.6	7.6	92.6
120045	6	4,567	0.00	6.40-6.70	16.0	3.4	3.3	2.9	18.5	34.8	9.5	3.5	95.2
180065	5	121	0.00	6.50-6.70	15.5	6.4	2.4	3.0	11.8	36.5	7.3	12.6	83.6
180071	5	105	0.00	6.50-6.90	17.1	3.6	1.5	3.6	11.9	31.7	9.3	9.8	78.9
Total	715	4	-	51	16	1	1	-	8	-	6	1	-

1. *Maximum levels determined by Excel for 36 variables from 715 samples taken from 62 wells. "-" indicates no data. Shaded values indicate level outside of "DWSNZ2005 (Drinking Water Standards for New Zealand 2005) maximum acceptable value (MAV) or guideline value (GV). Although there is no criterion for "Cond" (conductivity), there is a GV for total dissolved solids (TDS) of 1,000 mg/L, which would roughly be equivalent to 2,000 uS/cm. The GV for pH is in the range of 7.0 to 8.5 units. There is no GV for temperature other than "acceptability" and a notation that consumers like "cool" water. Neither is there a GV for Ca or Mg individually. However, there is a GV for hardness of 200 mg/L due to scale and for combined Ca and Mg of 100 to 300 mg/L as CaCO3 due to taste.*
2. *Units for "Cond" (conductivity), "DO" (dissolved oxygen), pH, and "Temp" (temperature) are uS/cm, mg/L, units, and ^{o}C, respectively.*
3. *Units for major cations and anions and for silica are mg/L.*

Table 3.4b Max Concentration

Max Concentrations[1]																	
	Minor/Trace Elements[2]																
Well ID	Al	As	B	Br	Cd	Co	Cr	Cu	F	Fe	Pb	Li	Mn	Mo	Ni	Se	Zn
NZDWS	0.1	0.01	1.4	-	0.004	-	0.05	1/2	1.5	0.2	0.01	1	0.04/0.10	0.07	0.02	0.01	1.5
0001 (20)	-	-	-	0.0600	-	-	-	-	0.2300	6.1000	-	-	0.3300	-	-	-	-
0049	0.0012	0.0008	1.1700	-	0.0000	0.0000	0.0001	0.0002	0.3500	0.0800	0.0000	-	0.3350	-	-	0.0005	0.0018
0066	0.0049	0.0328	1.5600	-	0.0000	0.0000	0.0001	0.0006	0.6700	0.0050	0.0006	-	0.0300	-	-	0.0005	0.1380
0068	0.0050	0.0030	0.0200	-	0.0000	0.0001	0.0060	0.0003	0.3500	0.0250	0.0002	0.0238	0.0005	0.0003	0.0005	0.0005	0.2260
0094	-	-	-	-	-	-	-	-	0.3500	-	-	-	-	-	-	-	-
0196	0.0015	0.0060	0.1790	0.0000	0.0000	0.0063	0.0003	0.0052	0.3500	8.0200	0.0002	0.0108	0.7830	0.0007	0.0005	0.0005	0.0530
0410	0.0015	0.0040	0.0840	0.0000	0.0003	0.0009	0.0003	0.0020	0.3300	3.3700	0.0016	0.0326	6.1700	0.0012	0.0005	0.0005	4.2500
0466	0.0015	0.0010	0.0920	0.0000	0.0000	0.0001	0.0003	0.0003	11.4000	5.8200	0.0000	0.0357	0.3350	0.0001	0.0005	0.0005	0.0330
0490	0.0081	0.0010	0.0340	0.0000	0.0000	0.0001	0.0003	0.0006	0.9000	1.4500	0.0001	0.0259	0.1740	0.0001	0.0005	0.0005	0.0310
0643	0.0090	0.0390	0.1600	0.0000	0.0000	0.0042	0.0003	0.0120	0.4100	10.8000	0.0006	0.1840	15.4000	0.0012	0.0005	0.0005	0.0390
0845	0.0030	0.0005	0.5950	0.0000	0.0000	0.0001	0.0007	0.0003	19.5000	0.5500	0.0002	0.2490	0.1390	0.0001	0.0005	0.0005	0.2330
0851	0.0030	0.0005	0.0140	0.0000	0.0000	0.0001	0.0003	0.0004	0.3500	7.3200	0.0001	0.0063	0.1600	0.0002	0.0005	0.0005	0.0710
0925	0.0015	0.0005	1.8500	0.0000	0.0000	0.0011	0.0015	0.0009	44.9000	56.5000	0.0160	0.4710	1.0500	0.0001	0.0005	0.0005	2.6900
0951	0.0015	0.0120	0.8020	0.0000	0.0000	0.0001	0.0003	0.0003	0.3500	3.2600	0.0000	0.3690	2.0100	0.0006	0.0005	0.0005	0.0190
1018	0.0050	0.0006	0.5780	0.0000	0.0000	0.0001	0.0005	0.0003	0.4100	3.9900	0.0004	0.2300	0.2950	0.0007	0.0005	0.0005	0.2040
1104	0.0015	0.0160	0.0560	0.0000	0.0000	0.0001	0.0000	0.0016	0.2800	0.0250	0.0003	0.0885	0.0016	0.0005	0.0005	0.0000	0.0280
1319	0.0015	0.0490	0.1810	0.0000	0.0000	0.0001	0.0003	0.0006	0.3900	0.7300	0.0002	0.0149	0.9610	0.0012	0.0005	0.0005	0.0190
1393	0.0430	0.0100	0.0660	0.0000	0.0000	0.0001	0.0017	0.0010	0.4100	0.0250	0.0006	0.0474	0.0069	0.0019	0.0005	0.0005	0.0920
1520	0.0043	0.0030	0.2600	0.0000	0.0000	0.0001	0.0003	0.0009	0.3500	0.0250	0.0004	0.0461	0.0009	0.0004	0.0005	0.0005	0.1400
1561	0.0015	0.0010	0.0290	0.0000	0.0000	0.0001	0.0003	0.0023	0.5700	0.0250	0.0000	0.0139	0.0036	0.0001	0.0005	0.0005	0.1430
1586	0.0110	0.0008	0.0450	0.0000	0.0000	0.0001	0.0003	0.0007	0.3500	0.0300	0.0002	0.0034	0.2470	0.0006	0.0005	0.0005	0.1590
1605	0.0089	0.0011	0.0370	0.0000	0.0000	0.0001	0.0004	0.0006	0.9000	0.0250	0.0000	0.0077	0.0003	0.0002	0.0005	0.0005	0.0239
1686	0.6530	0.0200	0.6230	0.0000	0.0001	0.0003	0.0003	0.0590	0.7400	0.7400	0.0022	0.1060	0.0789	0.0104	0.0005	0.0005	0.1060
1690	0.0015	0.0020	0.2290	0.0000	0.0000	0.0003	0.0005	0.0127	0.3700	19.7000	0.0012	0.1210	0.6680	0.0009	0.0017	0.0005	0.0380
2076	0.0050	0.0190	0.0420	0.0000	0.0000	0.0001	0.0003	0.0035	0.7900	0.0250	0.0010	0.0226	0.0020	0.0003	0.0005	0.0005	1.3400
2093	0.0015	0.0240	0.0900	0.0000	0.0000	0.0001	0.0001	0.0008	0.0800	0.0750	0.0018	0.0038	0.0375	0.0013	0.0005	0.0005	0.0080
2303	0.1780	0.0600	0.1570	0.0000	0.0001	0.0001	0.0005	0.0017	0.7200	0.1300	0.0003	0.1510	0.0754	0.0009	0.0011	0.0005	0.0640
2330	0.0405	0.0030	0.0260	0.0000	0.0000	0.0001	0.0031	0.0021	0.3500	0.2700	0.0031	0.0062	0.0117	0.0001	0.0005	0.0010	0.5320
2342	0.0030	0.0010	0.0300	0.0000	0.0000	0.0001	0.0006	0.0120	0.3500	0.0250	0.0008	0.0145	0.0052	0.0001	0.0005	0.0005	0.1210
2343	0.0100	0.0006	0.0370	0.0000	0.0000	0.0001	0.0003	0.0111	0.3500	0.0700	0.0003	0.0088	0.0040	0.0001	0.0010	0.0005	0.4540
2344	0.0470	0.0005	0.0150	0.0000	0.0000	0.0001	0.0003	0.0007	0.3500	0.1200	0.0001	0.0081	0.0058	0.0001	0.0005	0.0005	0.0620
2362	0.0030	0.0050	0.0880	0.0000	0.0000	0.0001	0.0003	0.0006	0.3500	0.4000	0.0002	0.0448	0.6180	0.0007	0.0005	0.0005	0.5370
2393	0.0015	0.0040	0.1540	0.0000	0.0000	0.0001	0.0001	0.0005	0.3500	0.0250	0.0005	0.0532	0.0050	0.0015	0.0005	0.0005	0.1280
2509 (56)	-	-	-	0.0400	-	-	-	-	0.5000	4.9000	-	-	0.1200	-	-	-	-
2707	0.0023	0.0010	0.0630	0.0000	0.0000	0.0001	0.0003	0.0006	0.3500	0.0250	0.0008	0.0072	0.0652	0.0001	0.0022	0.0060	0.0370
2728	0.0040	0.0180	0.1150	0.0000	0.0000	0.0002	0.0003	0.0006	0.3500	13.1000	0.0006	0.0155	0.4800	0.0014	0.0005	0.0005	0.1890
2729	0.0016	0.0006	0.0160	0.0000	0.0000	0.0000	0.0001	0.0018	0.3500	0.0700	0.0000	0.0000	0.0021	0.0000	0.0000	0.0005	0.0000
2822	0.0015	0.0063	0.3350	0.0000	0.0000	0.0006	0.0003	0.0031	0.4400	5.0800	0.0001	0.2010	1.0400	0.0003	0.0005	0.0005	0.1760
2829	0.0973	0.0160	0.1620	0.0000	0.0001	0.0001	0.0004	0.0010	0.3500	0.4200	0.0010	0.0117	0.0200	0.0024	0.0008	0.0005	0.0300
2847	0.5310	0.0030	0.0830	0.0000	0.0000	0.0007	0.0009	0.0008	0.3500	12.7000	0.0005	0.0218	0.2900	0.0001	0.0011	0.0005	1.1400
2913	0.0015	0.0005	0.0420	0.0000	0.0000	0.0001	0.0003	0.0023	0.3500	0.0250	0.0005	0.0081	0.0008	0.0003	0.0005	0.0005	0.0330
3034	0.0200	0.0005	0.2080	0.0000	0.0000	0.0001	0.0003	0.0006	3.5000	0.0250	0.0001	0.0056	0.0045	0.0005	0.0005	0.0005	0.0090
3036	0.0015	0.0060	0.0410	0.0000	0.0000	0.0002	0.0003	0.0006	0.8000	8.6600	0.0005	0.0057	0.4910	0.0000	0.0005	0.0005	0.8340
3039	0.0015	0.0005	0.0350	0.0000	0.0000	0.0001	0.0003	0.0005	0.8000	0.1000	0.0000	0.0020	0.0032	0.0001	0.0005	0.0005	0.0139
3044	0.0150	0.0390	20.5000	0.3800	0.0000	0.0010	0.0003	0.0025	1.5600	0.4600	0.0050	1.4700	0.5400	0.0050	0.0050	0.0005	0.0270
3045 (21)	-	-	-	0.1100	-	-	-	-	0.1400	0.1800	-	-	0.1200	-	-	-	-
3272	0.0110	0.0050	0.9200	0.0000	0.0000	0.0010	0.0025	0.0050	0.0900	15.1000	0.0006	1.5300	10.8000	0.0027	0.0070	0.0000	0.2000
3301 (55)	-	-	-	0.1400	-	-	-	-	0.1400	1.2000	-	-	0.0290	-	-	-	-
3470	0.0015	0.2900	0.0530	0.0000	0.0000	0.0060	0.0003	0.0155	0.3400	12.1000	0.0001	0.0283	1.4800	0.0001	0.0005	0.0005	0.0270
3505	0.0015	0.0005	0.0100	-	-	0.0001	0.0003	0.0003	-	0.4300	0.0000	0.0054	0.0117	-	0.0003	-	0.0760
3566	0.0290	0.0050	0.0570	0.0000	0.0000	0.0001	0.0003	7.5000	0.2200	0.0600	0.0001	0.0168	0.0016	0.0004	0.0005	0.0000	0.0920
4000	0.0050	0.0008	0.0070	0.0000	0.0001	0.0001	0.0001	0.0047	0.3500	0.0250	0.0001	0.0040	0.0025	0.0001	0.0005	0.0005	0.6620
4001	0.0050	0.0900	2.5400	0.0000	0.0001	0.0005	0.0003	0.0005	0.7900	10.3000	0.0002	2.2300	3.0300	0.0003	0.0005	0.0005	0.0330
4002	0.0070	0.0030	0.0540	0.0000	0.0000	0.0001	0.0003	0.0003	0.8000	6.7400	0.0000	0.0246	0.3810	0.0004	0.0005	0.0005	0.0060
4003	0.0015	0.0005	0.0090	0.0000	0.0000	0.0001	0.0003	0.0013	0.0900	0.0400	0.0004	0.0046	0.0067	0.0000	0.0473	0.0000	0.1410
4007 (58)	-	-	-	0.0600	-	-	-	-	0.0500	-	-	-	0.0050	-	-	-	-
4364 (57)	-	-	-	0.7900	-	-	-	-	0.5100	0.6500	-	-	0.5700	-	-	-	-
4582	0.0040	0.0010	0.0210	0.0000	0.0001	0.0001	0.0003	0.0003	0.1300	0.0800	0.0003	0.0243	0.0044	0.0002	0.0005	0.0005	0.4070
4968	0.0070	0.0050	0.0810	0.0000	0.0000	0.0009	0.0003	0.0035	0.1600	1.0300	0.0008	0.0278	0.0010	0.0000	0.0003	0.0005	1.1700
120045	0.0070	0.0170	0.0540	0.0000	0.0000	0.0001	0.0003	0.0016	0.1400	0.0250	0.0002	0.0851	0.0020	0.0001	0.0005	0.0005	0.0660
180065	0.0015	0.0090	0.0140	0.0000	0.0000	0.0001	0.0003	0.0025	0.1600	0.0250	0.0017	0.0225	0.0112	0.0002	0.0012	0.0005	0.0090
180071	0.0060	0.0180	0.0300	0.0000	0.0000	0.0001	0.0003	0.0009	9.3000	0.0250	0.0000	0.0219	0.0006	0.0004	0.0005	0.0005	0.0200
Total	3	15	4	-	0	-	0	1	5	31	0	3	31/28	0	1	0	2

1. *Maximum levels determined by Excel for 36 variables from 715 samples taken from 62 wells. "-" indicates no data. Shaded values indicate level in excess of "DWSNZ2005 (Drinking Water Standards for New Zealand 2005) maximum acceptable value (MAV or guideline value (GV). In the case of Mn, shaded value is GV for staining of 0.04 mg/L. Bolded box outline for Mn indicates value also in excess of MAV of 0.4 mg/L for taste.*
2. *Units for minor/trace elements are mg/L.*

Table 3.4c Max Concentrations

Max Concentrations[1]							
	Nutrients[2]					Bacteria[3]	
Well ID	NH_3-N	NO_2-N	NO_3-N	PO_4-P	TP	Entero	F_Coli
NZDWS	0.3/1.5	0.2/3	11.3	-	-	<1	<1
0001 (20)	1.250	0.014	6.700	0.250	-	-	-
0049	4.500	-	0.703	0.905	3.480	500	5000
0066	0.277	-	0.045	0.142	0.141	-	-
0068	0.161	0.001	0.179	0.149	0.129	-	-
0094	0.029	-	0.693	0.128	0.286	-	-
0196	0.407	0.001	0.015	0.444	2.340	1	13
0410	0.120	0.002	0.090	0.028	0.028	-	-
0466	4.100	0.001	0.214	0.415	1.200	1	2
0490	0.107	0.001	0.082	0.169	0.504	-	-
0643	1.300	0.001	0.960	0.502	0.515	27	91
0845	0.505	0.001	0.094	0.603	1.120	-	-
0851	0.054	0.002	0.018	0.164	0.140	-	-
0925	0.896	0.018	0.045	0.292	0.281	-	-
0951	0.180	0.011	0.034	0.301	0.345	-	-
1018	0.145	0.001	6.848	0.209	0.223	-	-
1104	0.020	0.001	0.001	0.631	0.662	-	-
1319	0.650	0.002	0.119	1.500	1.600	1	1
1393	0.043	0.001	0.059	0.294	0.299	-	-
1520	0.024	0.001	2.670	0.166	0.158	-	-
1561	0.014	0.001	0.992	0.121	0.121	-	-
1586	0.152	0.001	0.458	0.097	0.062	1	1
1605	0.013	0.001	0.152	0.144	0.137	-	-
1686	0.020	0.001	0.024	0.260	0.229	-	-
1690	0.232	0.001	0.082	0.197	0.232	-	-
2076	0.052	0.001	3.140	0.402	0.414	1	1
2093	2.120	0.003	4.860	0.050	0.356	5	3
2303	0.572	0.004	0.053	2.930	3.040	-	-
2330	0.020	0.001	0.299	0.176	0.350	-	-
2342	0.032	0.001	0.266	0.106	0.084	-	-
2343	0.016	0.009	0.110	0.083	0.090	-	-
2344	0.016	0.001	0.203	0.054	0.293	-	-
2362	0.170	0.001	0.208	0.279	0.380	-	-
2393	0.012	0.001	0.218	0.119	0.115	-	-
2509 (56)	0.020	-	0.430	0.120	-	-	-
2707	0.028	0.015	9.900	0.023	0.044	11	1
2728	0.764	0.001	0.052	0.034	0.037	-	-
2729	0.016	0.000	0.150	0.186	0.197	-	-
2822	0.050	0.008	0.245	0.272	0.257	-	-
2829	0.021	0.001	0.347	0.282	0.310	-	-
2847	4.780	0.021	1.340	0.201	0.181	10	39
2913	0.052	0.002	0.390	0.096	0.084	1	1
3034	0.026	0.001	12.300	0.222	0.215	100	1
3036	0.282	0.001	0.152	0.748	0.782	-	-
3039	0.055	0.001	0.790	0.036	0.032	-	-
3044	0.260	0.001	0.155	0.134	0.169	-	-
3045 (21)	0.040	0.015	4.100	0.026	-	-	-
3272	1.100	0.009	1.020	0.092	0.114	-	-
3301 (55)	0.010	-	3.900	0.140	-	-	-
3470	1.020	0.005	0.545	0.522	0.829	-	1
3505	0.010	0.002	4.790	0.014	0.009	-	-
3566	0.021	0.001	11.500	0.242	0.247	11	1
4000	0.018	0.003	4.310	0.061	0.039	1	1
4001	0.418	0.011	0.936	0.252	0.266	-	-
4002	0.129	0.001	0.046	0.094	0.108	-	-
4003	0.034	0.001	3.130	0.057	0.054	-	-
4007 (58)	0.020	-	2.700	0.100	-	-	-
4364 (57)	0.050	-	0.070	0.156	-	-	-
4582	0.040	0.001	0.123	0.173	0.198	-	-
4968	0.026	0.001	10.200	0.245	0.247	-	-
120045	0.023	0.001	0.540	0.114	0.664	1	2
180065	0.034	0.002	2.300	0.162	0.163	-	1
180071	0.028	0.008	0.640	0.106	0.092	-	1
Total	15/4	0	2	-	-	15	18

1. *Maximum levels determined by Excel NGMP for 36 variables from 715 samples taken from 62 wells. "-" indicates no data. Shaded values indicate level in excess of "DWSNZ2005 (Drinking Water Standards for New Zealand 2005) maximum acceptable value (MAV) or guideline value (GV).*
2. *Units for nutrients are mg/L as nitrogen ammonia, nitrite, or nitrate) or phosphorus (phosphate or total phosphorus identified as "TP"). Two GVs exist for ammonia (one at 0.3 mg/L related to possible effects on chloramine formation and a potential odor threshold at 1.5 mg/L). Shaded value for ammonia indicates in excess of the 0.3 mg/L GV. Bolded box for ammonia indicates also in excess of the 1.5 mg/L GV. Two MAVs exist for nitrite (one at 0.2 mg/L for long term and one at 3 mg/L for short term health effects).*
3. *Units for bacteria are #/100 mL. "Entero" indicates enterococci and "F_Coli" indicates faecal coliform.*

Table 3.5 Groundwater Quality Trends

Groundwater Quality Trends[1]																
			Trend	Slope							Trend	Slope			
Well ID	Variable	Median	p Value	Sen's	LR	Area	Samples	Well ID	Variable	Median	p Value	Sen's	LR	Area	Samples
INCREASING TREND								DECREASING TREND							
0001 (20)	K	3.8	0.01195	0.03347	0.20685	Rangitaki Plain	31	0001 (20)	Cond	371.55	0.01333	-7.56458	-15.05796	Rangitaki Plain	34
0001 (20)	SO4	29.	9.74E-10	2.20791	2.82957	Rangitaki Plain	31	0001 (20)	pH	7.4	0.00658	-0.03501	-0.06160	Rangitaki Plain	31
0001 (20)	Fe	3.5	0.00001	0.20166	0.23880	Rangitaki Plain	30	0001 (20)	Ca	27.5	0.00014	-0.98397	-0.98017	Rangitaki Plain	30
0001 (20)	NO3-N	0.001	0.00433	0.00146	0.28413	Rangitaki Plain	31	0001 (20)	Mg	10.9	3.14E-06	-0.45273	-0.44647	Rangitaki Plain	30
0068	pH	7.59	0.01675	0.04401	0.02618	Tauranga Basin	11	0001 (20)	Na	31.	0.00178	-0.32168	-2.26284	Rangitaki Plain	31
0466	Cond	497.	0.03957	5.60408	5.90669	Rangitaki Plain	10	0001 (20)	HCO3	157.	6.35E-10	-8.34712	-16.05646	Rangitaki Plain	31
0851	Cond	164.5	0.01221	1.74727	2.25798	Tauranga Basin	10	0001 (20)	Mn	0.23	0.00004	-0.00530	-0.00562	Rangitaki Plain	26
1018	Mg	11.5	0.00913	0.20074	0.16973	Te Puke - Maketu	9	0490	HCO3	51.118	0.00932	-0.45910	-0.45114	Rangitaki Plain	11
1393	HCO3	83.082	0.03751	0.70684	0.69334	Tauranga Basin	11	0490	NO3-N	0.008	0.00359	-0.00359	-0.00349	Rangitaki Plain	11
1393	PO4-P	0.161	0.04094	0.01492	0.01483	Tauranga Basin	8	0490	PO4-P	0.099	0.02813	-0.01059	-0.00920	Rangitaki Plain	9
1393	TP	0.173	0.04094	0.01503	0.01545	Tauranga Basin	8	0845	Mg	10.25	0.03957	-0.13791	-0.12618	Rangitaki Plain	10
1520	pH	6.55	0.04249	0.03868	0.02891	Te Puke - Maketu	10	0845	NO3-N	0.002	0.02337	-0.00199	-0.00294	Rangitaki Plain	11
1520	SO4	2.2	0.03957	0.24104	0.18321	Te Puke - Maketu	9	1605	Temp	16.1	0.04249	-0.02424	-0.01018	Rangitaki Plain	10
1561	Cond	84.	0.03171	0.74897	0.85817	Rotorua	11	2076	Mg	3.065	0.04094	-0.26967	-0.36872	Rangitaki Plain	8
1690	Cond	421.5	0.03171	4.13837	2.98712	Te Puke - Maketu	10	2303	Temp	35.5	0.02213	-0.77199	-0.71591	Tauranga Basin	11
2343	pH	6.7	0.03751	0.02145	0.01827	Tauranga Basin	11	2303	NH3-N	0.5	0.00913	-0.01707	-0.02482	Tauranga Basin	9
2344	NH3-N	0.003	0.03957	0.00070	0.00091	Tauranga Basin	9	2303	TP	2.42	0.01966	-0.14693	-0.14691	Tauranga Basin	9
2509 (56)	Cl	6.65	0.00028	0.04988	0.06050	Rangitaki Plain	24	2344	Ca	2.795	0.01700	-0.05332	-0.50537	Tauranga Basin	10
2509 (56)	Br	0.023	0.02056	0.00297	0.00260	Rangitaki Plain	22	2344	HCO3	34.038	0.03751	-0.16931	-0.17821	Tauranga Basin	11
2509 (56)	F	0.15	0.02651	0.00397	0.01341	Rangitaki Plain	21	2509 (56)	Ca	2.8	0.00291	-0.03855	-0.03742	Rangitaki Plain	23
2509 (56)	Fe	0.001	0.04962	0.00079	0.18152	Rangitaki Plain	24	2728	NO3-N	0.009	0.01966	-0.00364	-0.00287	Tauranga Basin	9
2707	Cond	926.	0.00087	133.87974	139.15136	Coastal Plain	11	2829	HCO3	103.456	0.00932	-0.29680	-0.28470	Tauranga Basin	11
2707	Ca	81.55	0.00418	4.07371	3.66618	Coastal Plain	10	3034	pH	6.5	0.04249	-0.05955	-0.05409	Te Puke - Maketu	11
2707	Mg	14.8	0.00866	1.86210	1.89627	Coastal Plain	10	3036	K	2.3	0.02747	-0.09683	-0.42417	Opotiki Plain	9
2707	K	5.3	0.01700	0.40232	0.45216	Coastal Plain	10	3045 (21)	Cond	260.45	0.00959	-4.59118	-3.54886	Te Puke - Maketu	26
2707	Na	66.75	0.00192	18.81855	19.15691	Coastal Plain	10	3045 (21)	HCO3	67.	0.00025	-0.96837	-0.74243	Te Puke - Maketu	37
2707	Cl	170.	0.00087	38.87699	45.76490	Coastal Plain	11	3045 (21)	Br	0.06	0.01312	-0.00335	-0.00382	Te Puke - Maketu	19
2707	SO4	48.55	0.00192	4.03591	4.74241	Coastal Plain	10	3045 (21)	NH3-N	0.002	0.01526	-0.00036	-0.00170	Te Puke - Maketu	22
2829	NO3-N	0.112	0.00396	0.02651	0.02636	Tauranga Basin	9	3045 (21)	NO3-N	0.56	2.91E-06	-0.09209	-0.14795	Te Puke - Maketu	37
2847	Temp	19.7	0.00627	0.12606	0.15681	Coastal Plain	12	3301 (55)	Cond	300.15	0.00122	-15.79952	-17.61431	Coastal Plain	22
2847	PO4-P	0.008	0.00498	0.00392	0.00759	Coastal Plain	11	3301 (55)	Ca	15.3	0.00010	-0.88868	-0.85247	Coastal Plain	20
3045 (21)	SO4	7.7	3.59E-10	1.19633	1.33414	Te Puke - Maketu	37	3301 (55)	Mg	9.3	0.00071	-0.50884	-0.49163	Coastal Plain	21
3045 (21)	Fe	0.04	0.04924	0.00264	0.00270	Te Puke - Maketu	37	3301 (55)	K	3.5	0.00018	-0.07082	-0.06813	Coastal Plain	22
3301 (55)	Fe	0.049	0.01952	0.00981	0.04793	Coastal Plain	21	3301 (55)	Na	30.	0.00094	-1.00711	-0.95498	Coastal Plain	22
4007 (58)	Mg	1.9	0.04863	0.02481	0.01891	Rotorua	21	3301 (55)	HCO3	94.5	0.00042	-2.34670	-2.17794	Coastal Plain	22
4007 (58)	Cl	5.2	0.01101	0.10240	0.09776	Rotorua	22	3301 (55)	Cl	37.	0.00001	-1.99589	-1.80676	Coastal Plain	21
4007 (58)	F	0.023	0.02303	0.00336	0.00323	Rotorua	17	3301 (55)	SO4	9.8	0.00063	-0.76128	-0.67176	Coastal Plain	22
4364 (57)	K	7.2	0.00291	0.13257	0.11919	Tauranga Basin	23	3301 (55)	Br	0.12	0.03420	-0.00493	-0.00534	Coastal Plain	20
								3301 (55)	NO3-N	1.9	0.00063	-0.18851	-0.19449	Coastal Plain	22
								4002	K	7.8	0.03957	-0.46275	-5.66802	Opotiki Plain	10
								4364 (57)	Temp	36.7	0.00686	-0.07727	-0.06043	Tauranga Basin	33
								4364 (57)	Na	147.	0.00015	-3.22258	-3.06221	Tauranga Basin	23
								4364 (57)	HCO3	136.	0.01375	-0.33377	-0.43806	Tauranga Basin	23
								4364 (57)	Cl	197.	0.01822	-0.99419	-1.20160	Tauranga Basin	23
								4364 (57)	SO4	0.15	0.02392	-0.01317	-0.00959	Tauranga Basin	23
								4364 (57)	Mn	0.51	0.00102	-0.00982	-0.00928	Tauranga Basin	23

1. Variables with increasing or decreasing trends in each well (identified by well ID) as calculated by Excel NGMP calculator (Daughney, 2005). Units for median values are uS/cm for "Cond" (conductivity), units for pH, ^{o}C for "Temp" (temperature), and mg/L for all others. "Trend p Value" indicates statistical significance of result (all p values in this table are less than 0.05, indicating statistically significant at the 95 percent confidence level). "Slope" in units/year appropriate to the variable indicates magnitude of annual change over the of record. Values for both Sen's slope estimator and "LR" (linear regression) are listed. "Area" indicates area of region involved. "Samples" indicates number of sample values used in calculations.

Table 3.6 Time Series Plots

Time Series Plots							
		Linear Line of Best Fit[1]		Visual Assessment[2]			
		Slope			Outliers		
Well ID	Variable	units/year	r^2	Trend	High	Low	Comments
Increasing Trend							
0001 (20)	K	0.2067	0.079	Horizontal	X		Several late outliers, missing data
0001 (20)	SO4	2.828	0.769	Increasing	X	X	One earlier low and several late high outliers, missing data
0001 (20)	Fe	0.2143	0.411	Increasing			Very slight trend, missing data
0001 (20)	NO3-N	0.2839	0.291	Horizontal	X		Several late outliers, missing data
1393	HCO3	0.6909	0.782	Increasing			Substantial missing data, slight trend
1393	PO4-P	0.01511	0.808	Increasing			Substantial missing data
1393	TP	0.01582	0.777	Increasing			Substantial missing data
2509 (56)	Cl	0.06044	0.365	Horizontal			-
2509 (56)	Br	0.002601	0.301	Horizontal			Large fraction <DLs, substantial missing data
2509 (56)	F	0.01340	0.194	Horizontal	X		Several late outliers, substantial missing data
2509 (56)	Fe	0.1814	0.155	Horizontal	X		Large fraction <DLs, two late outliers
2707	Cond	139.1	0.922	Increasing			Substantial missing data
2707	Ca	3.665	0.629	Increasing			Substantial missing data
2707	Mg	1.895	0.807	Increasing			Substantial missing data
2707	K	0.4515	0.876	Increasing			Substantial missing data
2707	Na	19.14	0.957	Increasing			Substantial missing data
2707	Cl	45.70	0.888	Increasing			Substantial missing data
2707	SO4	4.738	0.764	Increasing			Substantial missing data
4007 (58)	Mg	0.01890	0.143	Increasing			Very slight trend
4007 (58)	Cl	0.09771	0.245	Increasing			Very slight trend
4007 (58)	F	0.003232	0.641	Horizontal			Bifurcated, substantial missing data, possible <DLs

1. *Linear line of best fit determined using Version 5 of Golden Software computer program Grapher. "Slope" means the slope of the linear regression line in units/year. Units are uS/cm for "Cond" (conductivity), ^oC for "Temp" (temperature), and mg/L for all other variables. "r^2" is the accompanying coefficient of determination.*
2. *Qualitative judgements based on visual assessment of water level graphical plots. A "Horizontal" trend indicates relatively unchanging concentration over time while increasing and decreasing describe the trend in concentration over time. Increasing means variable concentration. High and low outliers are indicated by an "X" in the respective column. Additional comments relevant to interpretation of the data plots are also provided.*

Time Series Plots							
				Visual Assessment[5]			
		LR Slope			Outliers		
Well ID	Variable	units/year	r^2	Trend	High	Low	Comments
Decreasing Trend							
0001 (20)	Cond	- 15.04	0.143	Decreasing	X	X	High early outlier, substantial missing data
0001 (20)	pH	- 0.06153	0.377	Decreasing		X	Several late outliers
0001 (20)	Ca	- 0.9797	0.362	Decreasing			Very slight trend
0001 (20)	Mg	- 0.4460	0.524	Decreasing			Very slight trend
0001 (20)	Na	- 2.261	0.077	Horizontal	X		High early outliers, very slight trend
0001 (20)	HCO3	- 16.05	0.389	Decreasing	X		High early outliers
0001 (20)	Mn	- 0.005617	0.419	Decreasing			-
0490	HCO3	- 0.4515	0.515	Decreasing			Substantial missing data
0490	NO3-N	0.003513	0.423	Decreasing			Substantial missing data
0490	PO4-P	0.009329	0.670	Decreasing			Substantial missing data
2303	Temp	- 0.6997	0.590	Decreasing			Substantial missing data
2303	NH3-N	382.9	0.626	Horizontal			Substantial missing data, large fraction probably <DLs
2303	TP	0.1472	0.527	Decreasing		X	Substantial missing data, low late outlier
3045 (21)	Cond	- 3.546	0.157	Horizontal			Bifurcated, some early data missing
3045 (21)	HCO3	- 0.7420	0.333	Horizontal			Possibly very slight trend
3045 (21)	Br	- 0.003814	0.264	Horizontal			Large fraction <DLs
3045 (21)	NH3-N	- 0.001697	0.350	Horizontal	X		Large fraction <DLs
3045 (21)	NO3-N	- 0.1479	0.414	Horizontal	X		Bifurcated
3301 (55)	Cond	- 17.66	0.508	Decreasing		X	Late low outlier, missing data
3301 (55)	Ca	- 0.8545	0.817	Decreasing			Missing data
3301 (55)	Mg	- 0.4924	0.716	Decreasing			Missing data
3301 (55)	K	- 0.06851	0.424	Decreasing			Missing data
3301 (55)	Na	- 0.9556	0.752	Decreasing			Missing data
3301 (55)	HCO3	- 2.183	0.761	Decreasing			Very slight trend, missing data
3301 (55)	Cl	- 1.810	0.707	Decreasing			Very slight trend, missing data
3301 (55)	SO4	- 0.6720	0.645	Decreasing			Missing data, slight trend
3301 (55)	Br	- 0.005391	0.361	Decreasing			Very slight trend, missing data
3301 (55)	NO3-N	- 0.1952	0.544	Decreasing			Missing data
4364 (57)	Temp	- 0.06037	0.112	Horizontal			-
4364 (57)	Na	- 3.060	0.672	Decreasing			Slight trend
4364 (57)	HCO3	- 0.4376	0.338	Decreasing			Very slight trend
4364 (57)	Cl	-120.1	0.368	Decreasing			Slight trend
4364 (57)	SO4	- 0.009581	0.148	Decreasing			Very slight trend
4364 (57)	Mn	- 0.06037	0.112	Decreasing			Very slight trend

Table 3.7 Water Quality Sample Summary

Water Quality Sample Summary[1]										
		CBE	Calc TDS			Coordinates		Primary[2]		
Well ID	Water Type	(%)	(mg/L)	Town	Area	Easting	Northing	Cation	Anion	Geology
0643	Na-HCO3	-1.37	536	Pukehina	Coastal Plain	2819600	6371600	Na	HCO3	Sand
2093	Na-Cl	3.78	785	Mt Maunganui	Coastal Plain	2791300	6388700	Na	Cl	-
2707	Ca-Na-Cl-HCO3	-0.57	619	Papamoa	Coastal Plain	2807600	6379500	Ca	Cl	Gravel
2847	Na-Ca-Mg-Cl-HCO3	1.40	295	Mt Maunganui	Coastal Plain	2792400	6388100	Na	Cl	Sand
3301 (55)	Na-Mg-Ca-HCO3-Cl	1.58	271	Ohope	Coastal Plain	2872700	6348900	Na	HCO3	-
0196	Na-Mg-Ca-HCO3	-0.82	225	Galatea	Galatea Plain	2838300	6305100	Na	HCO3	-
1319	Na-Ca-Mg-HCO3	-0.46	317	Murupara	Galatea Plain	2835100	6297800	Na	HCO3	-
2913	Ca-Na-Mg-HCO3	-1.43	169	Galatea	Galatea Plain	2843400	6307300	Ca	HCO3	-
3036	Ca-Na-Mg-HCO3	-2.52	224	Opotiki	Opotiki Plain	2888900	6342800	Ca	HCO3	-
3039	Ca-Na-Mg-HCO3	-1.72	125	Opotiki	Opotiki Plain	2885700	6339700	Ca	HCO3	-
4002	Na-Ca-Cl-HCO3	-5.59	566	Opotiki	Opotiki Plain	2886200	6346600	Na	HCO3	-
0001 (20)	Ca-Na-Mg-HCO3	-0.30	421	Awakeri	Rangitaki Plain	2853600	6351900	Ca	HCO3	-
0049	Ca-Na-HCO3	3.58	796	-	Rangitaki Plain	2844100	6356700	Ca	HCO3	-
0466	Ca-Na-HCO3	-20.77	539	Awakeri	Rangitaki Plain	2849100	6351100	Ca	HCO3	-
0490	Na-HCO3-Cl	-3.70	245	Awakaponga	Rangitaki Plain	2840400	6357200	Na	HCO3	-
0845	Na-HCO3	-1.64	745	Awakeri	Rangitaki Plain	2852300	6352300	Na	HCO3	-
0925	Na-HCO3	-11.16	760	Edgecumbe	Rangitaki Plain	2844400	6350400	Na	HCO3	-
1605	Na-HCO3-Cl	-3.47	225	Te Teko	Rangitaki Plain	2845200	6340900	Na	HCO3	-
2076	Na-Ca-Mg-HCO3-Cl	10.53	225	Whakatane	Rangitaki Plain	2854600	6356700	Na	HCO3	-
2509 (56)	Na-HCO3-Cl	-0.17	228	Otakiri	Rangitaki Plain	2840900	6349000	Na	HCO3	-
180071	Na-HCO3-Cl	-2.02	218	-	Rangitaki Plain	2838700	6352600	Na	HCO3	-
1104	Na-Mg-HCO3-Cl	0.33	298	Rotorua	Rotorua	2801200	6336620	Na	HCO3	-
1561	Na-Mg-HCO3	-2.53	204	Hamurana	Rotorua	2792900	6346000	Na	HCO3	-
3470	Na-HCO3	-3.51	160	Ngongotaha	Rotorua	2791330	6343100	Na	HCO3	-
3505	Na-Ca-HCO3-Cl	-22.78	288	-	Rotorua	2815600	6314700	Na	HCO3	-
4000	Na-Ca-HCO3-Cl	6.12	243	Rotorua	Rotorua	2802400	6343000	Na	HCO3	-
4001	Na-Cl-HCO3	-4.15	1,164	Rotoma	Rotorua	2821400	6345000	Na	Cl	-
4003	Na-Ca-HCO3-SO4	4.42	239	Rotorua	Rotorua	2802530	6343420	Na	HCO3	-
4007 (58)	Na-Ca-Mg-HCO3	5.29	188	Ngongotaha	Rotorua	2789350	6347000	Na	HCO3	-
120045	S	6.95	178	-	Rotorua	2786000	6339200	Na	HCO3	-
180065	Na-Ca-HCO3-SO4	3.14	235	-	Rotorua	2802240	6340890	Na	HCO3	-
0066	Na-HCO3-Cl	0.46	240	Apatha	Tauranga Basin	2771800	6392300	Na	HCO3	Ignimbrite
0068	Na-HCO3	-2.29	296	Katikati	Tauranga Basin	2766400	6402700	Na	HCO3	Ignimbrite
0094	Na-HCO3-Cl	-1.22	160	Te Puna	Tauranga Basin	2780200	6387500	Na	HCO3	Rhyolite
0851	Na-Mg-Ca-HCO3	-2.68	295	Katikati	Tauranga Basin	2768800	6394900	Na	HCO3	Volc Rock
1393	Na-HCO3	-1.70	354	Katikati	Tauranga Basin	2768600	6404700	Na	HCO3	Ignimbrite
1686	Na-HCO3-Cl	-1.05	458	Omokoroa	Tauranga Basin	2777500	6391400	Na	HCO3	Gravel
2303	Na-HCO3	0.31	647	Katikati	Tauranga Basin	2770200	6399000	Na	HCO3	Ignimbrite
2330	Na-HCO3-Cl	-3.18	287	Kauri Point	Tauranga Basin	2772800	6405300	Na	HCO3	Sediment
2342	Na-Mg-Ca-HCO3-Cl	-1.80	321	Welcome Bay	Tauranga Basin	2795800	6382100	Na	HCO3	Ignimbrite
2343	Na-Ca-HCO3-Cl	-1.51	211	Tauranga	Tauranga Basin	2775400	6390600	Na	HCO3	Rhyolite
2344	Na-HCO3-Cl	-0.47	242	Oropi	Tauranga Basin	2786400	6373500	Na	HCO3	Volc Rock
2362	Na-HCO3-Cl	-3.85	391	Matapihi	Tauranga Basin	2791600	6384200	Na	HCO3	Rhyolite
2393	Na-HCO3-Cl	-1.40	365	Bethlehem	Tauranga Basin	2784400	6385100	Na	HCO3	Rhyolite
2728	Na-Cl-HCO3	-2.87	510	Papamoa	Tauranga Basin	2802800	6381400	Na	Cl	Sand
2729	Na-Ca-Mg-HCO3-Cl	-1.46	142	Welcome Bay	Tauranga Basin	2794100	6382100	Na	HCO3	Pumice
3044	Na-Cl-HCO3	-9.24	1,114	Tauranga	Tauranga Basin	2785700	6383700	Na	Cl	-
3272	Na-Cl	-3.38	16,973	Mt Maunganui	Tauranga Basin	2794350	6388150	Na	Cl	-
4364 (57)	Na-Cl-HCO3	-0.94	665	Tauranga	Tauranga Basin	2785700	6383680	Na	Cl	-
4582	Na-Ca-HCO3-Cl	-3.46	365	Welcome Bay	Tauranga Basin	2793850	6381050	Na	HCO3	-
2829	Na-HCO3-Cl	-2.16	319	Waihi Beach	Taurnaga Basin	2770600	6414200	Na	HCO3	-
0410	Na-HCO3	-6.01	314	Paengaroa	Te Puke - Maketu	2811200	6367000	Na	HCO3	Pumice
0951	Na-Ca-HCO3	-1.74	605	Paengaroa	Te Puke - Maketu	2810900	6371200	Na	HCO3	Rhyolite
1018	Na-HCO3	-2.20	806	Maketu	Te Puke - Maketu	2812000	6374600	Na	HCO3	Ignimbrite
1520	Na-HCO3-Cl	3.20	431	Maketu	Te Puke - Maketu	2814700	6373800	Na	HCO3	Gravel
1586	Na-HCO3-Cl	0.48	249	Te Puke	Te Puke - Maketu	2804300	6373500	Na	HCO3	Alluvium
1690	Na-HCO3	-2.61	555	Maketu	Te Puke - Maketu	2810500	6374700	Na	HCO3	Ignimbrite
2822	Na-HCO3	-2.71	456	Pongakawa	Te Puke - Maketu	2816200	6368100	Na	HCO3	-
3034	Na-HCO3-Cl	7.59	339	Maketu	Te Puke - Maketu	2811900	6374600	Na	HCO3	-
3045 (21)	Na-Ca-Mg-HCO3-Cl	1.95	320	Te Puke	Te Puke- Makatu	2811000	6374300	Na	HCO3	Pumice
3566	Na-Ca-HCO3-Cl	9.24	266	-	Te Puke- Makatu	2816600	6366200	Na	HCO3	-
4968	Na-Ca-Cl-HCO3	11.96	267	Pongakawa	Te Puke- Makatu	2817400	6365100	Na	Cl	-

1. *Median values from monitoring data provided by EBOP and, for six wells, NGMP database entered into Version 4 of AquaChem computer program. "CBE" column indicates charge balance error and "Calc TDS" indicates total dissolved solids calculated by AquaChem from median values. Shading of "CBE" value indicates level exceeds 5%. Shading of "Calc TDS" value indicates level exceeds 1,000 mg/L.*
2. *Shading indicates primary cation not sodium (i.e., Ca) and primary anion not bicarbonate (i.e., Cl).*

Table 3.8 Quality Control and Assurance Indications

Quality Control and Assurance Indications							
ID	Total Samples Current Site	# Samples with CBE OK	# Samples with CBE Low	# Samples with CBE High	Number of Outliers	Outliers/Sample	Percent CBE Exceedance
0001 (20)	43	30	0	0	71	1.65	0
0049	7	2	0	2	9	1.29	50
0066	6	4	0	1	15	2.50	20
0068	11	8	2	0	39	3.55	20
0094	6	3	1	0	6	1.00	25
0196	11	6	2	2	30	2.73	40
0410	7	1	0	1	34	4.86	50
0466	10	4	5	0	31	3.10	56
0490	12	7	2	0	27	2.25	22
0643	10	7	1	0	20	2.00	13
0845	12	6	1	2	28	2.33	33
0851	10	5	2	1	21	2.10	38
0925	11	4	5	0	34	3.09	56
0951	11	9	0	1	42	3.82	10
1018	11	6	3	0	26	2.36	33
1104	2	2	0	0	0	0.00	0
1319	11	9	1	0	21	1.91	10
1393	11	9	0	0	17	1.55	0
1520	10	9	0	0	14	1.40	0
1561	11	7	3	0	24	2.18	30
1586	11	8	0	2	30	2.73	20
1605	10	6	1	0	17	1.70	14
1686	10	5	0	3	28	2.80	38
1690	10	8	1	0	26	2.60	11
2076	11	6	0	1	15	1.36	14
2093	7	4	0	1	21	3.00	20
2303	11	7	1	1	27	2.45	22
2330	11	9	0	1	44	4.00	10
2342	11	9	1	0	40	3.64	10
2343	11	7	2	0	25	2.27	22
2344	11	8	1	1	30	2.73	20
2362	11	6	4	0	34	3.09	40
2393	8	6	1	0	17	2.13	14
2509 (56)	32	23	0	0	42	1.31	0
2707	11	6	1	3	26	2.36	40
2728	11	7	1	1	18	1.64	22
2729	6	4	0	0	7	1.17	0
2822	11	9	1	0	31	2.82	10
2829	11	8	0	1	21	1.91	11
2847	12	7	1	2	29	2.42	30
2913	10	6	3	0	16	1.60	33
3034	11	5	2	2	24	2.18	44
3036	10	6	2	1	23	2.30	33
3039	11	7	2	1	19	1.73	30
3044	15	5	4	2	21	1.40	55
3045 (21)	44	37	0	0	38	0.86	0
3272	4	3	0	0	19	4.75	0
3301 (55)	27	20	0	0	36	1.33	0
3470	6	3	0	3	25	4.17	50
3505	1	0	0	0	0	0.00	0
3566	5	4	1	0	12	2.40	20
4000	8	3	2	2	16	2.00	57
4001	10	3	4	1	30	3.00	63
4002	11	5	3	2	26	2.36	50
4003	2	2	0	0	0	0.00	0
4007 (58)	33	19	0	0	45	1.36	0
4364 (57)	34	23	0	0	9	0.26	0
4582	4	3	0	0	11	2.75	0
4968	3	1	1	1	12	4.00	67
120045	6	3	1	2	30	5.00	50
180065	5	5	0	0	19	3.80	0
180071	5	4	1	0	13	2.60	20
Min						0.00	0
Median						2.32	20
Mean						2.32	23
Max						5.00	67
Stdev						1.12	19
Total	715	458	70	44	1481		

1. 12 variables analyzed in each NGMP sample.
2. Maximum possible 32 variables analyzed in EBOP samples.

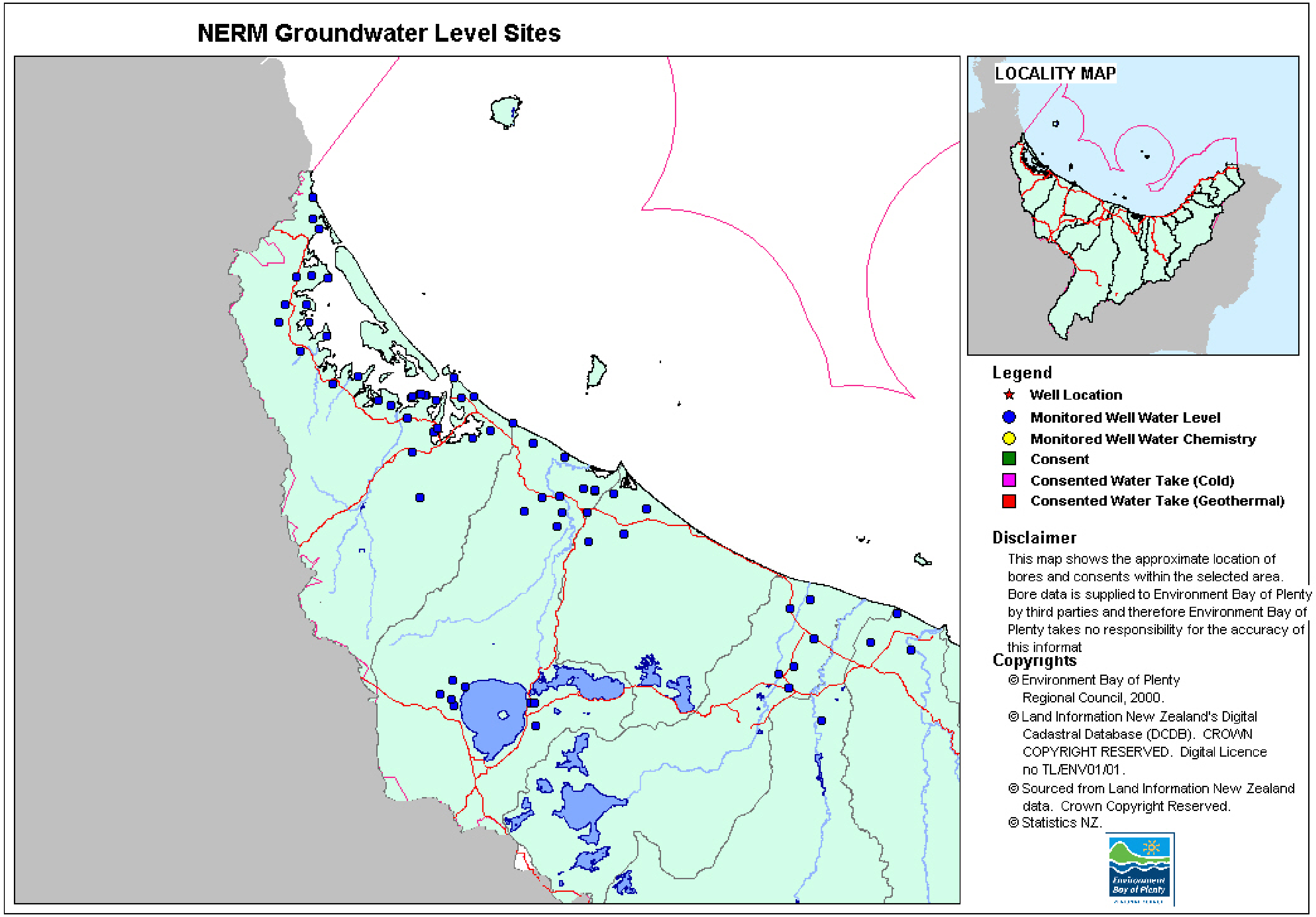


Figure 2.1 NERM Groundwater Level Sites

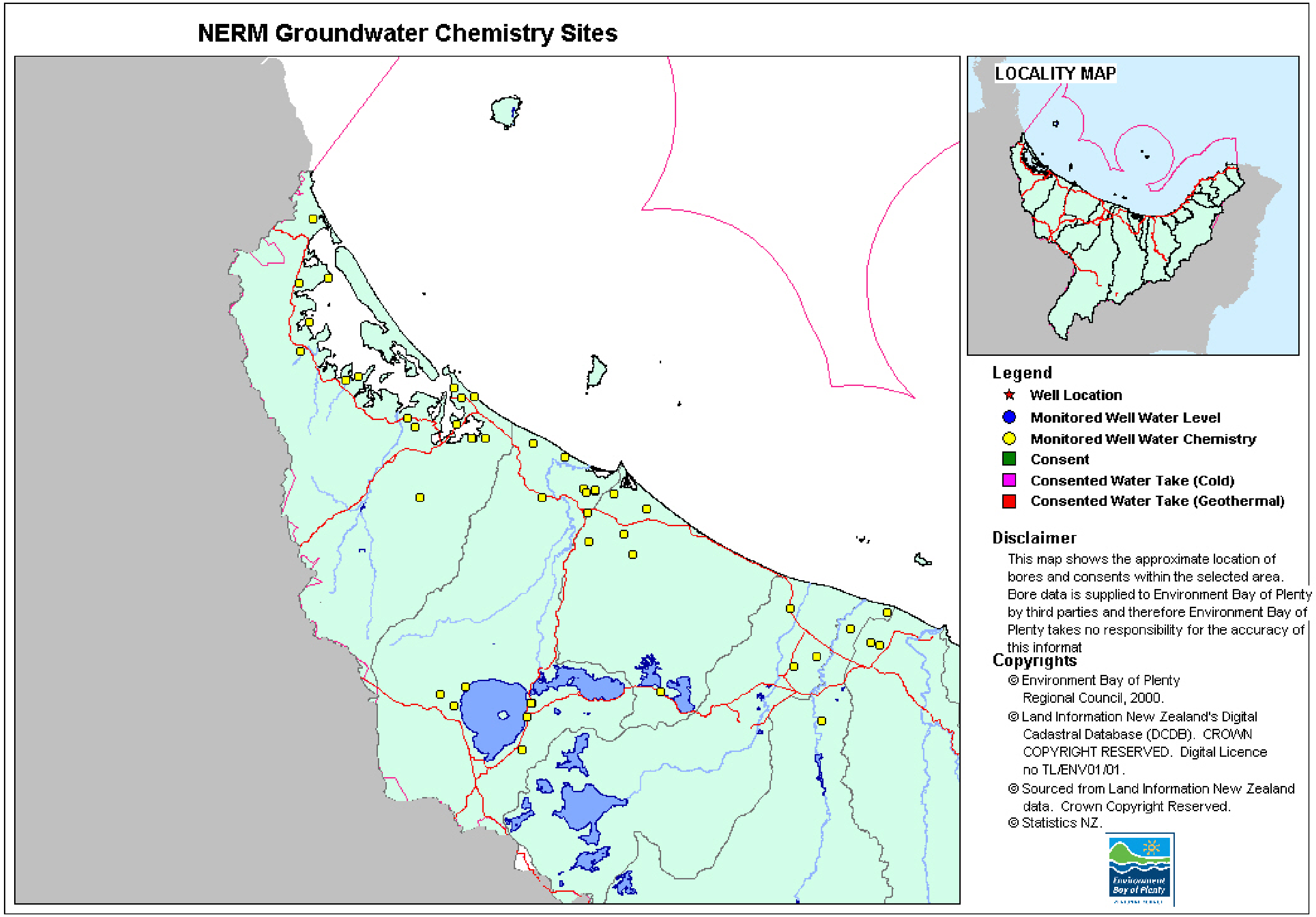
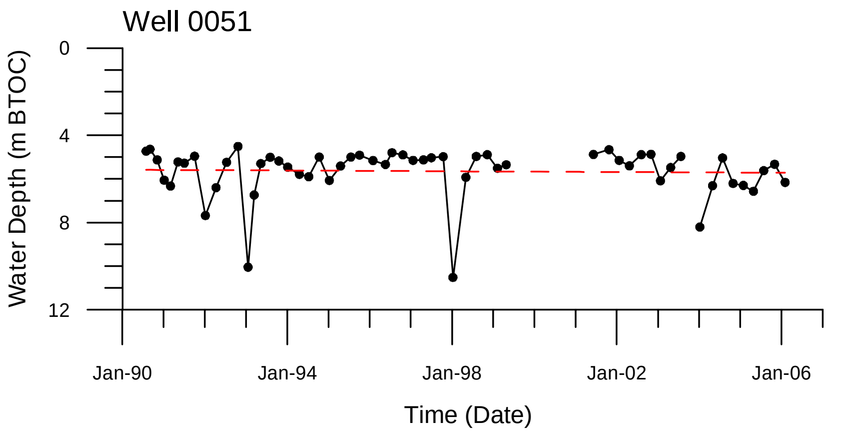
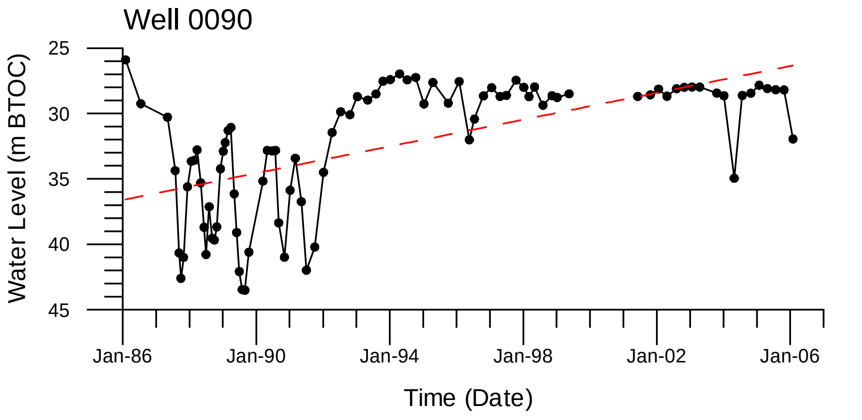
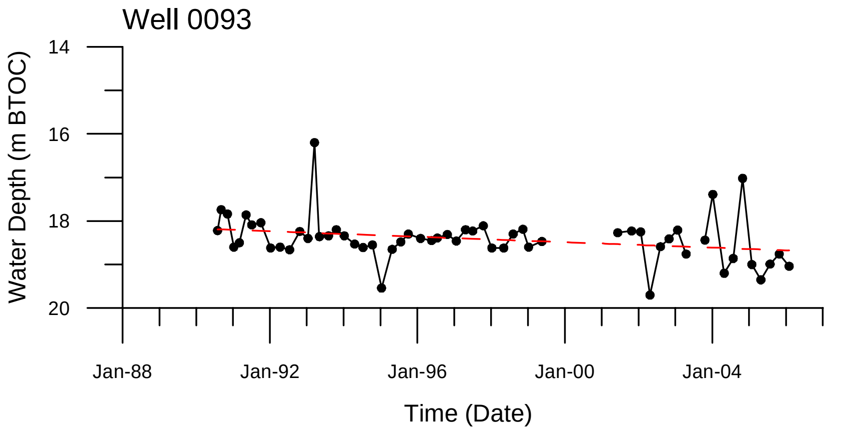


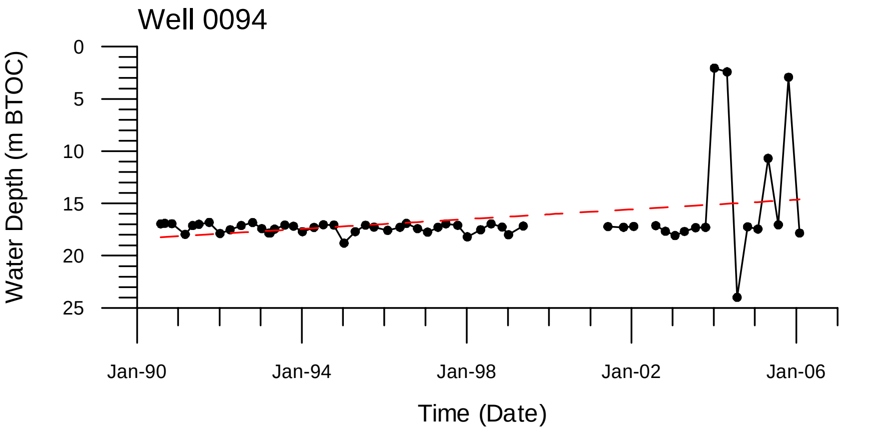
Figure 3.1 NERM Groundwater Chemistry Sites

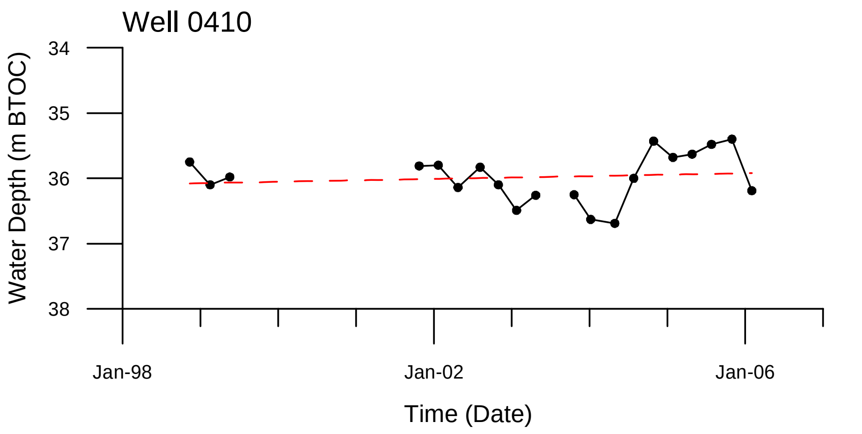
APPENDIX A – WATER LEVEL DATA TIME SERIES PLOTS

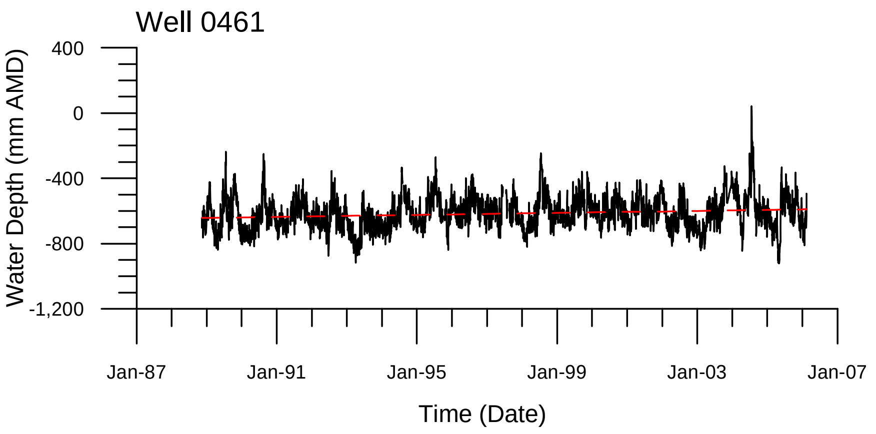

Well 0051
Water Depth (m BTOC)
0
4
8
12
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

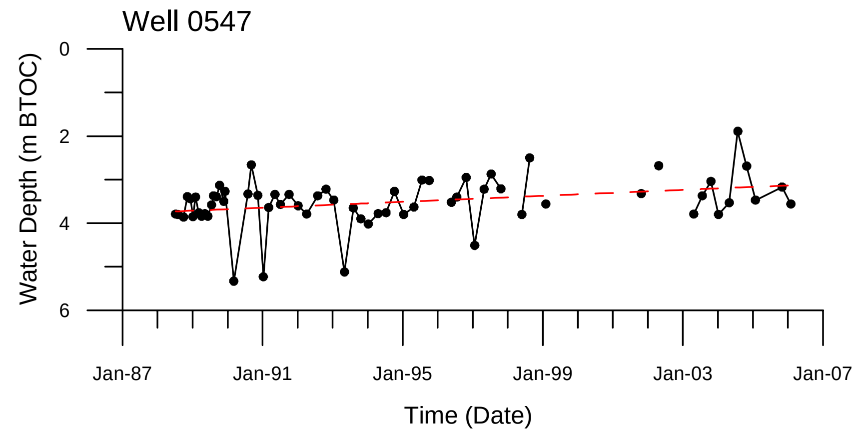

Well 0090
Water Level (m BTOC)
25
30
35
40
45
Jan-86
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

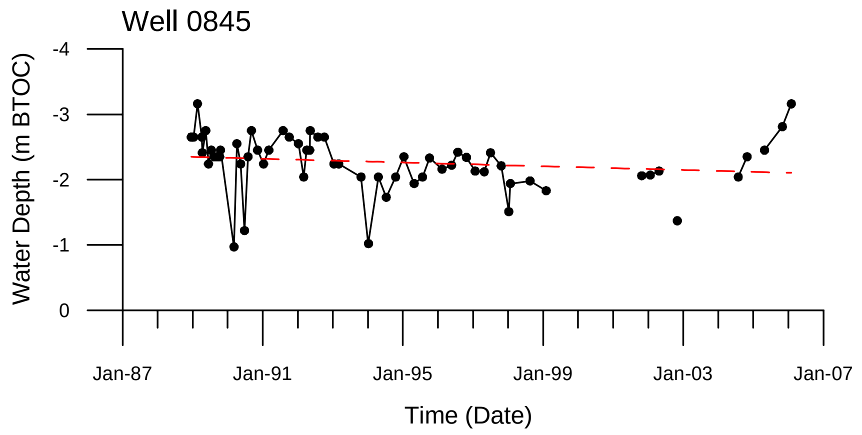

Well 0093
Water Depth (m BTOC)
14
16
18
20
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
Time (Date)

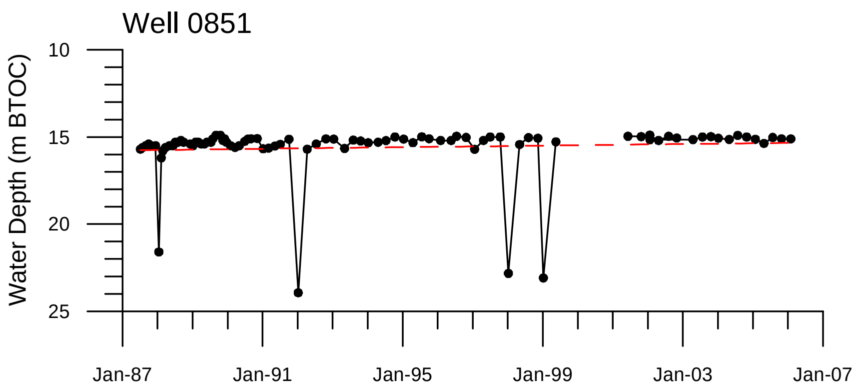

Well 0094
Water Depth (m BTOC)
0
5
10
15
20
25
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

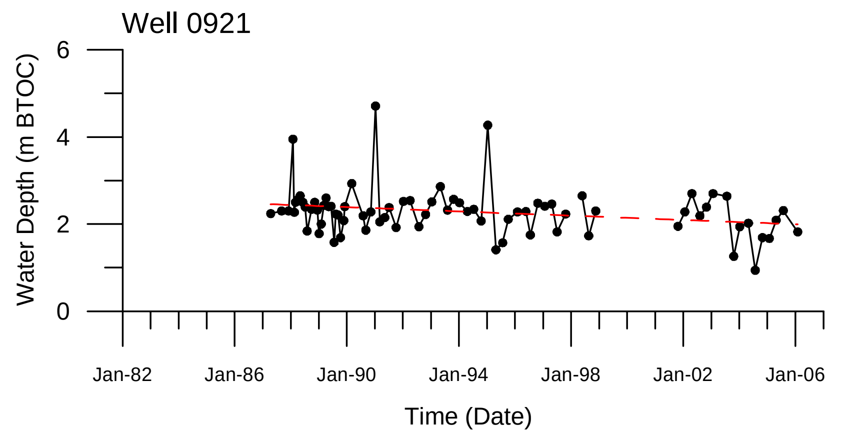

Well 0410
Water Depth (m BTOC)
34
35
36
37
38
Jan-98
Jan-02
Jan-06
Time (Date)

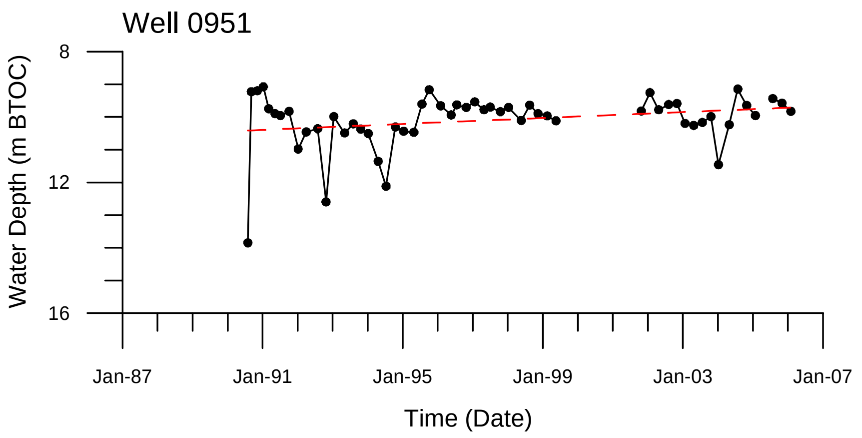

Well 0461
Water Depth (mm AMD)
400
0
-400
-800
-1,200
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

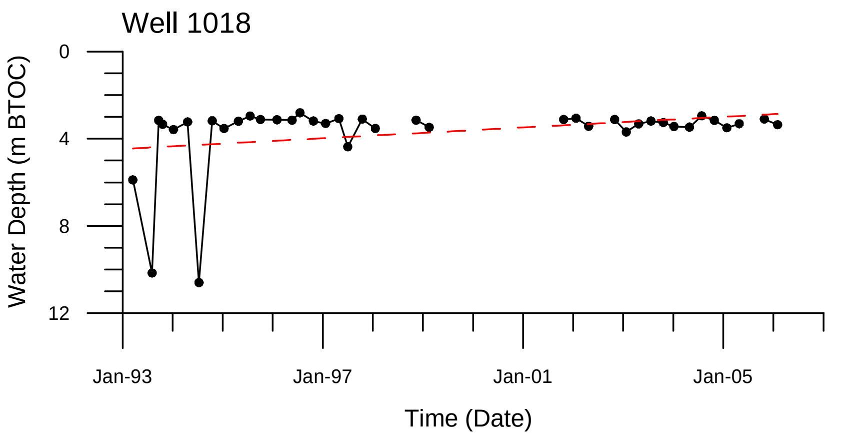

Well 0547
Water Depth (m BTOC)
0
2
4
6
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

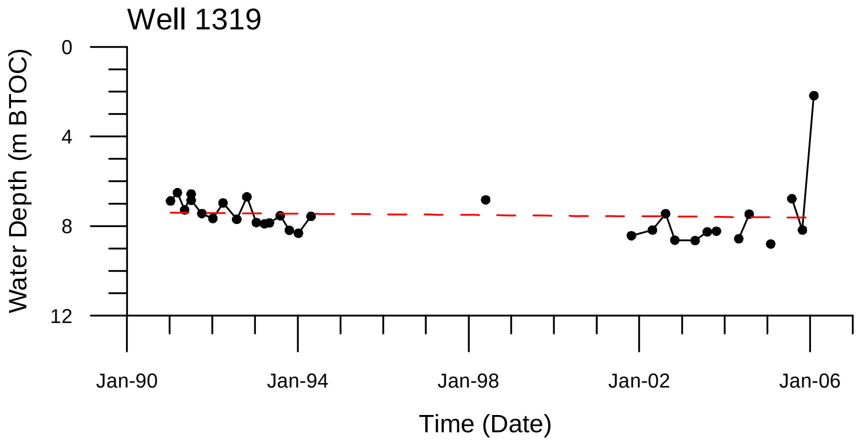

Well 0845
Water Depth (m BTOC)
-4
-3
-2
-1
0
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

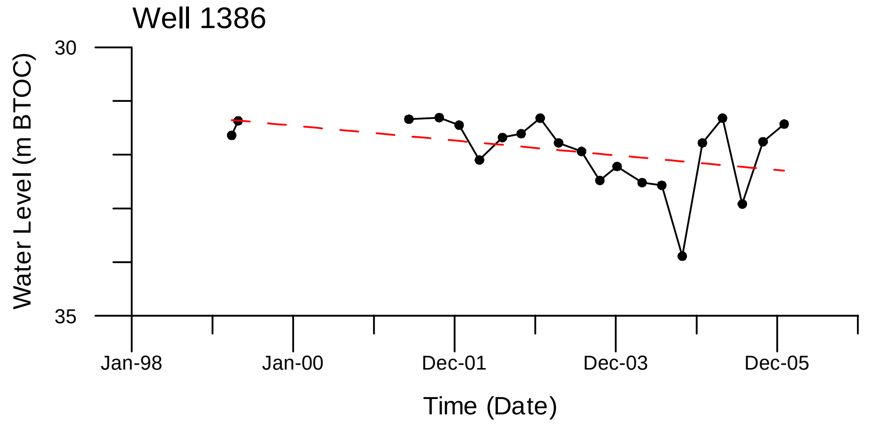

Well 0851
Water Depth (m BTOC)
10
15
20
25
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07

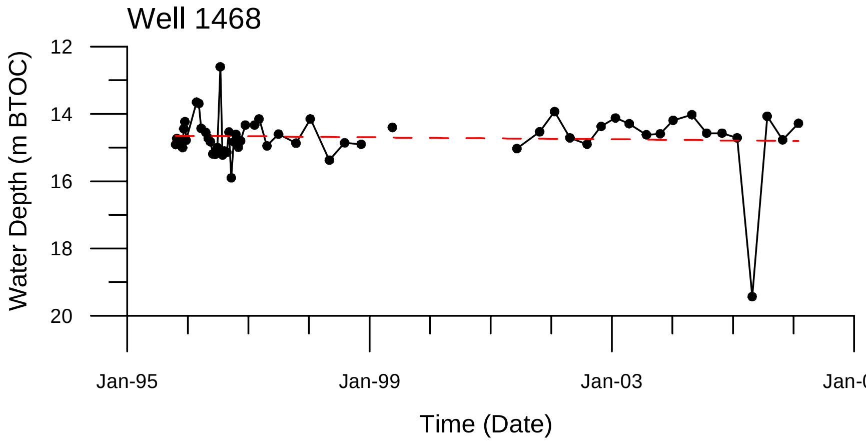

Well 0921
Water Depth (m BTOC)
6
4
2
0
Jan-82
Jan-86
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

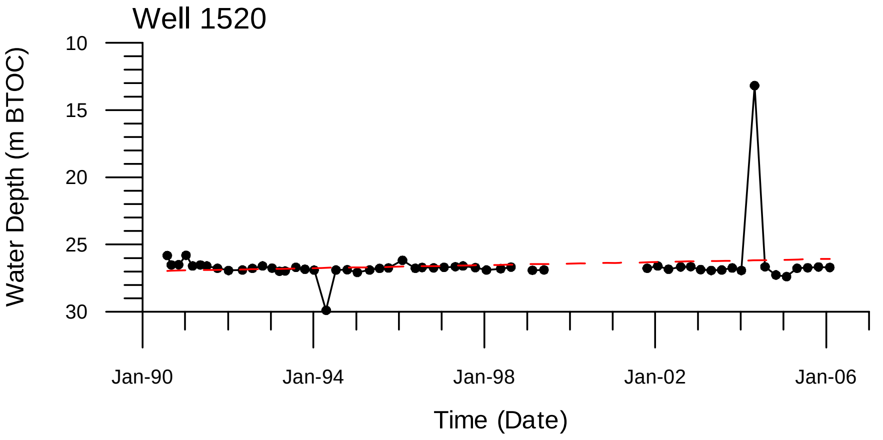

Well 0951
Water Depth (m BTOC)
8
12
16
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

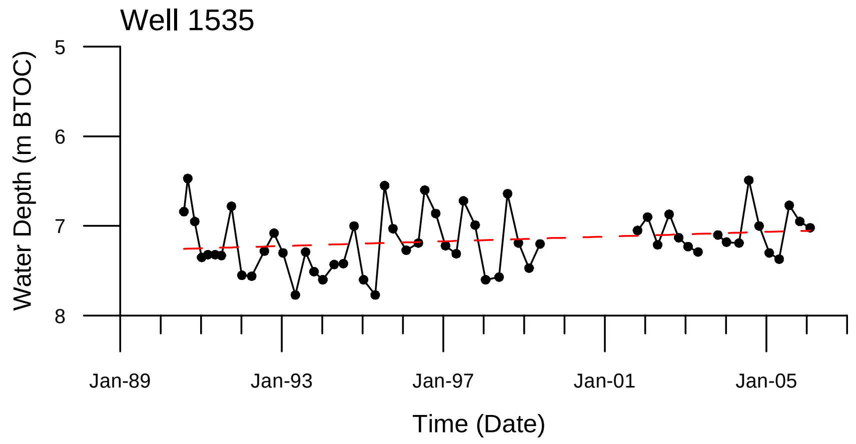

Well 1018
Water Depth (m BTOC)
0
4
8
12
Jan-93
Jan-97
Jan-01
Jan-05
Time (Date)

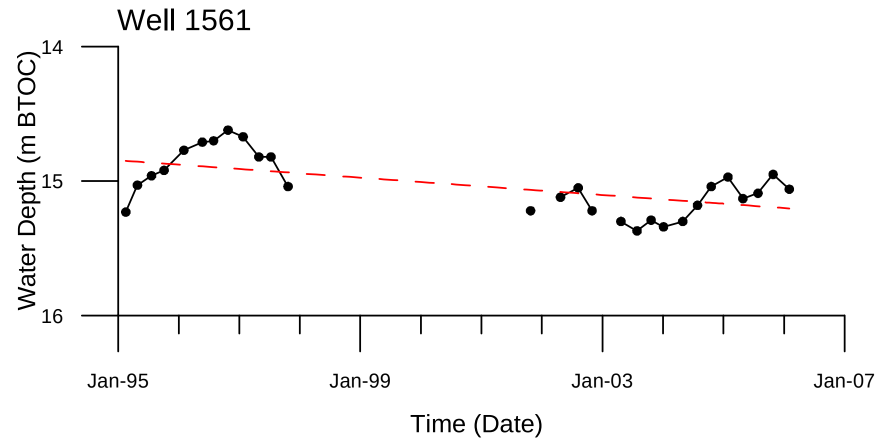

Well 1319
Water Depth (m BTOC)
0
4
8
12
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

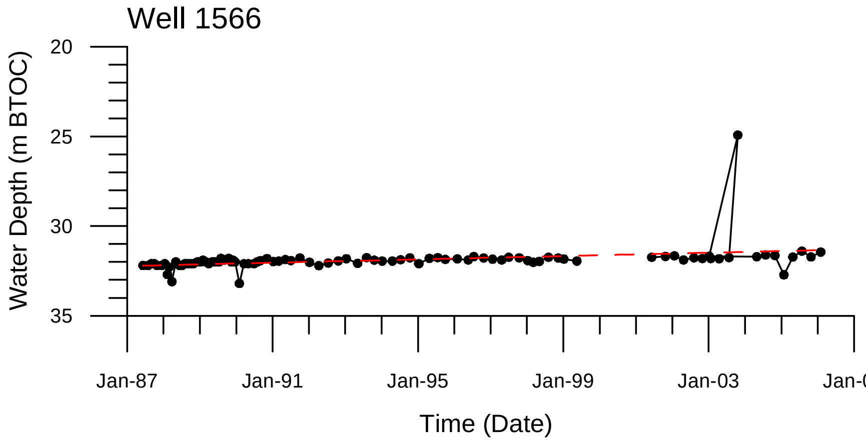

Well 1386
Water Level (m BTOC)
30
35
Jan-98
Jan-00
Dec-01
Dec-03
Dec-05
Time (Date)

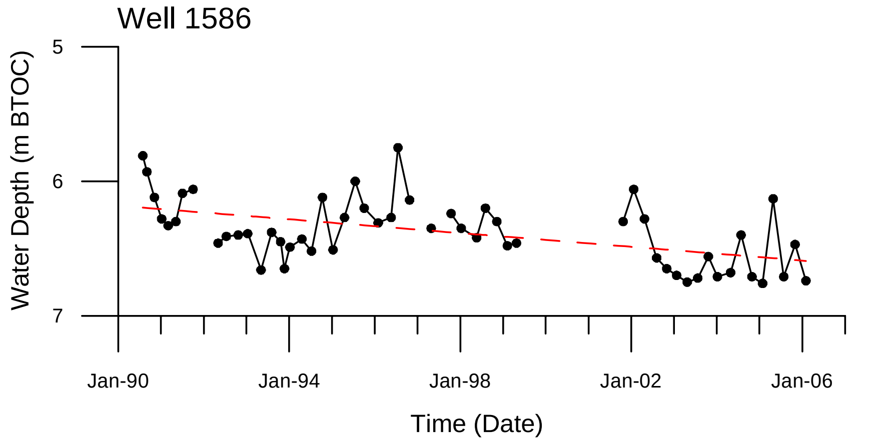

Well 1468
Water Depth (m BTOC)
12
14
16
18
20
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

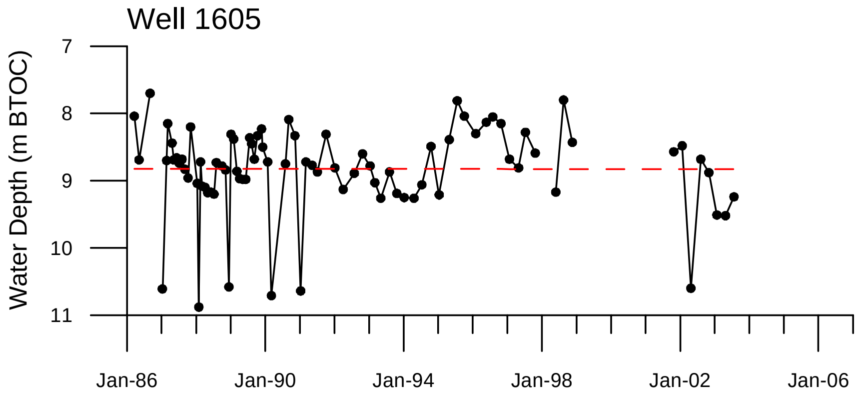

Well 1520
Water Depth (m BTOC)
10
15
20
25
30
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

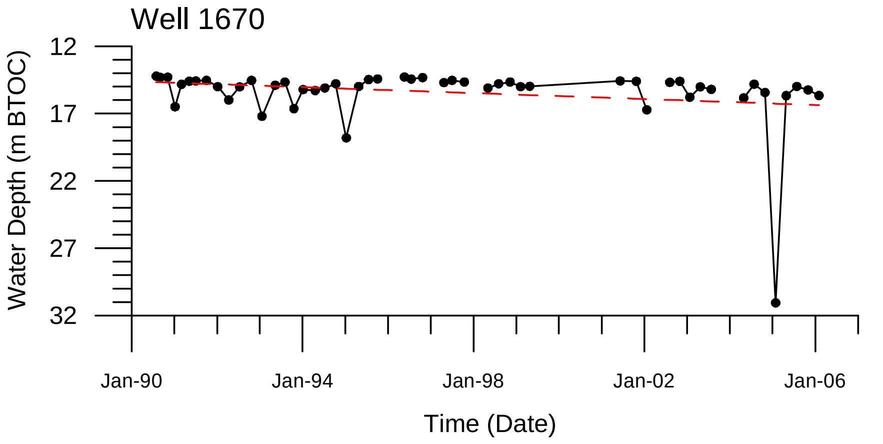

Well 1535
Water Depth (m BTOC)
5
6
7
8
Jan-89
Jan-93
Jan-97
Jan-01
Jan-05
Time (Date)

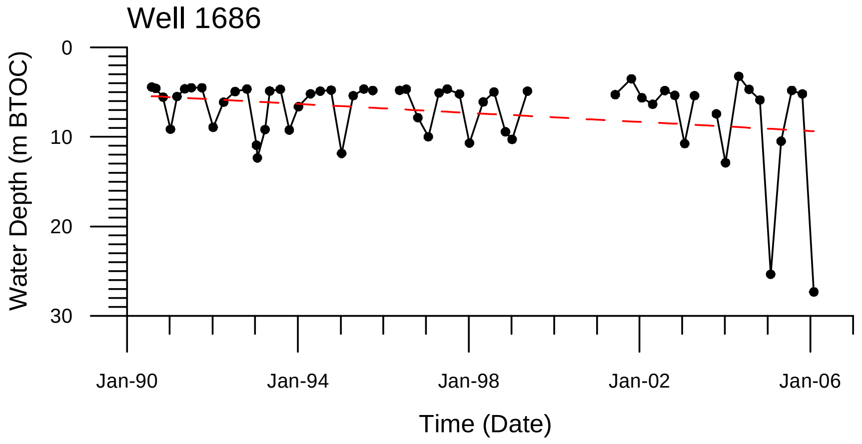

Well 1561
Water Depth (m BTOC)
14
15
16
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

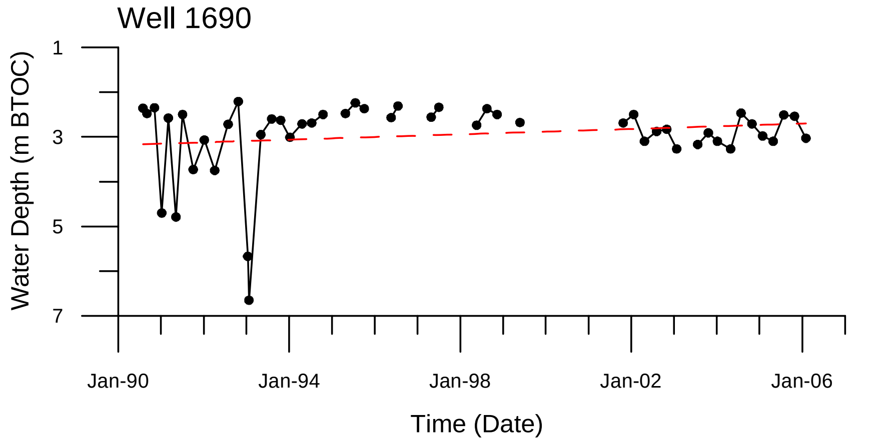

Well 1566
Water Depth (m BTOC)
20
25
30
35
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

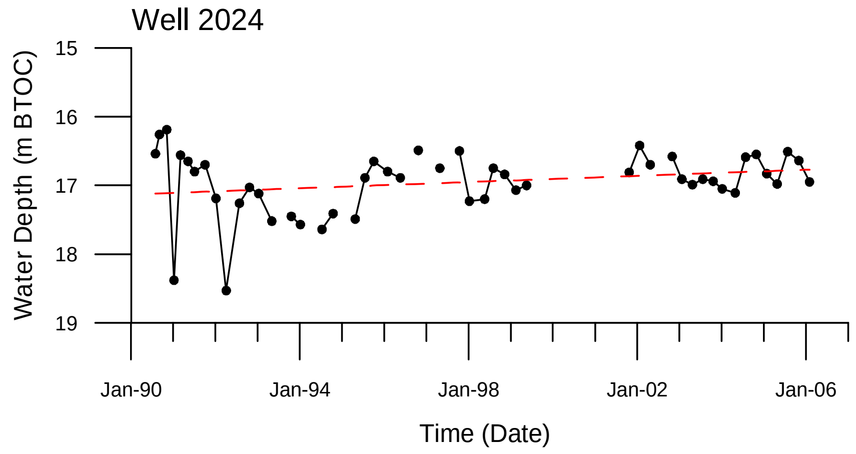

Well 1586
Water Depth (m BTOC)
5
6
7
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

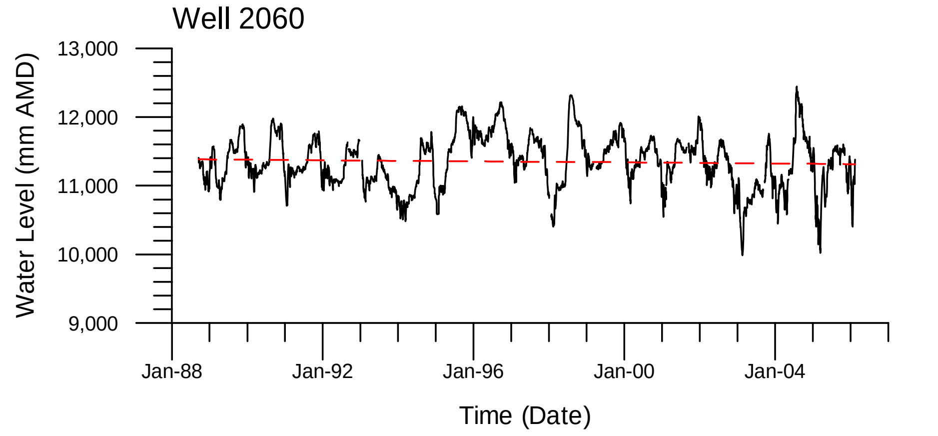

Well 1605
Water Depth (m BTOC)
7
8
9
10
11
Jan-86
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06

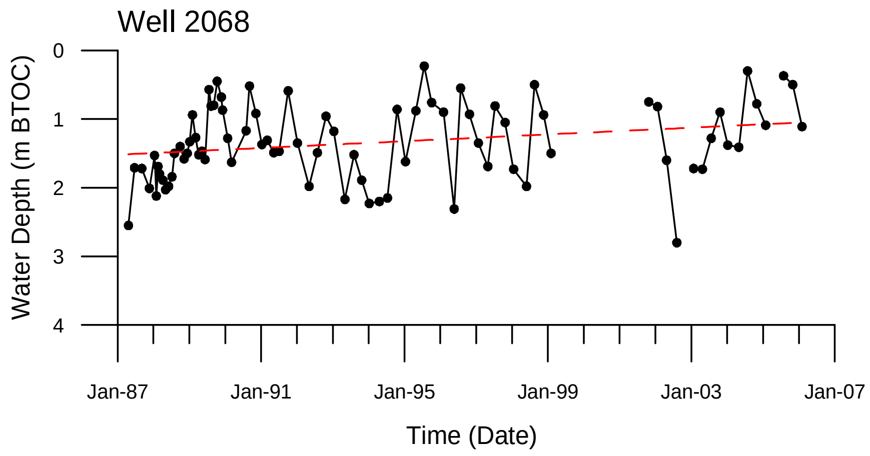

Well 1670
Water Depth (m BTOC)
12
17
22
27
32
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

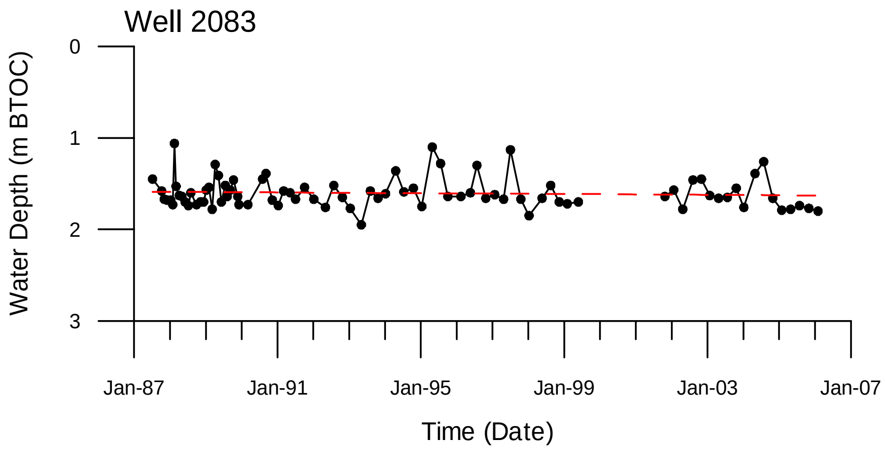

Well 1686
Water Depth (m BTOC)
0
10
20
30
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

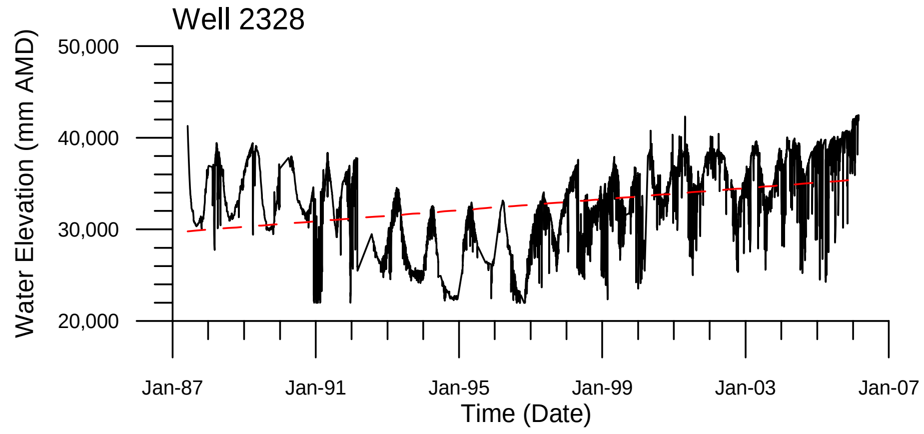

Well 1690
Water Depth (m BTOC)
1
3
5
7
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

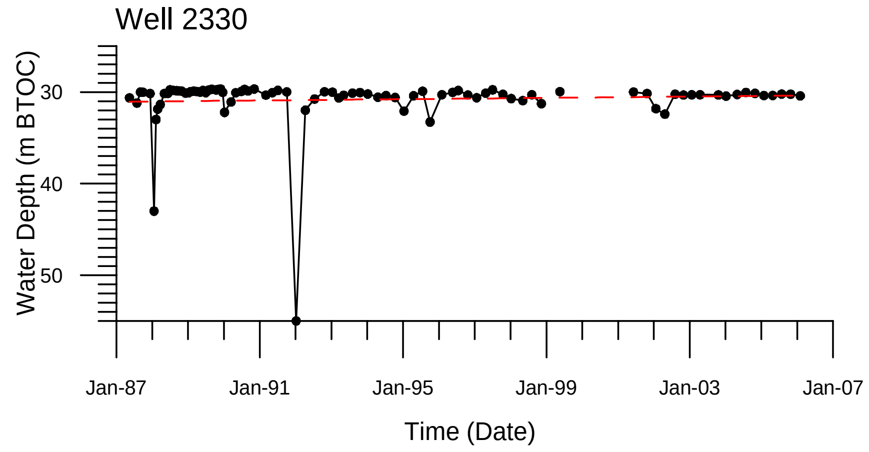

Well 2024
Water Depth (m BTOC)
15
16
17
18
19
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

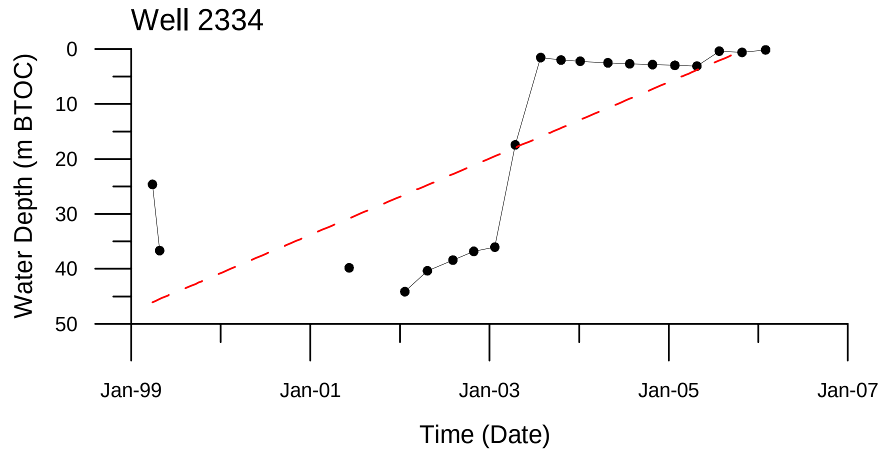

Well 2060
Water Level (mm AMD)
13,000
12,000
11,000
10,000
9,000
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
Time (Date)

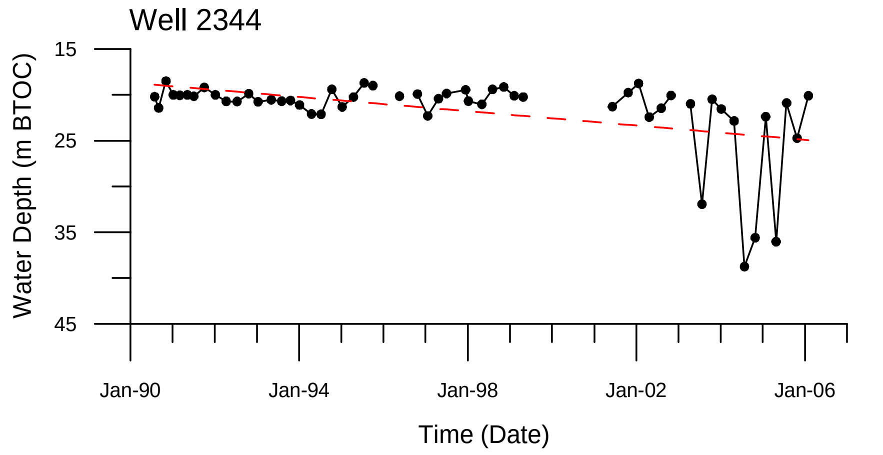

Well 2068
Water Depth (m BTOC)
0
1
2
3
4
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

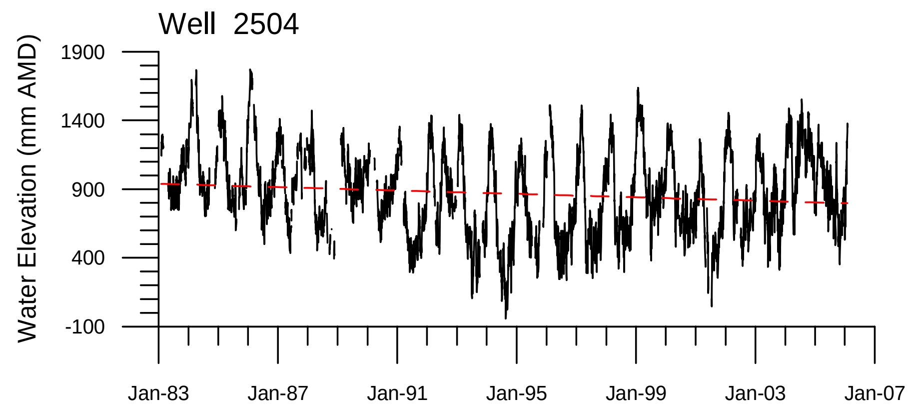

Well 2083
Water Depth (m BTOC)
0
1
2
3
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

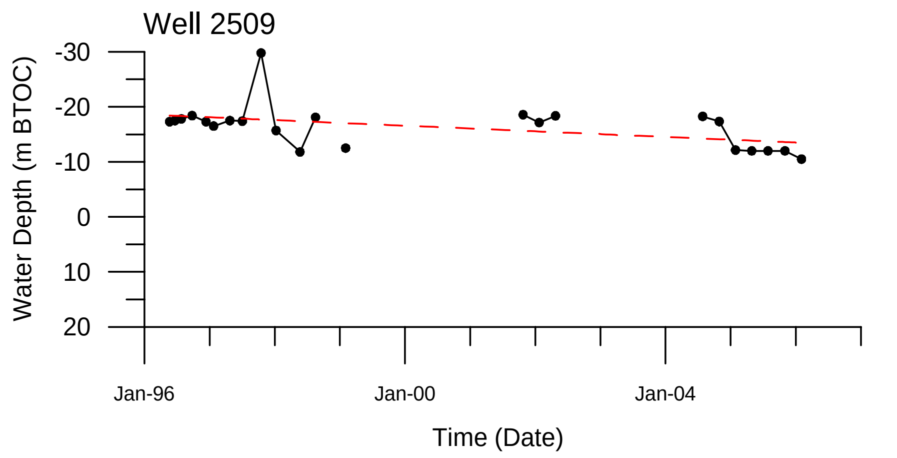

Well 2328
Water Elevation (mm AMD)
50,000
40,000
30,000
20,000
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

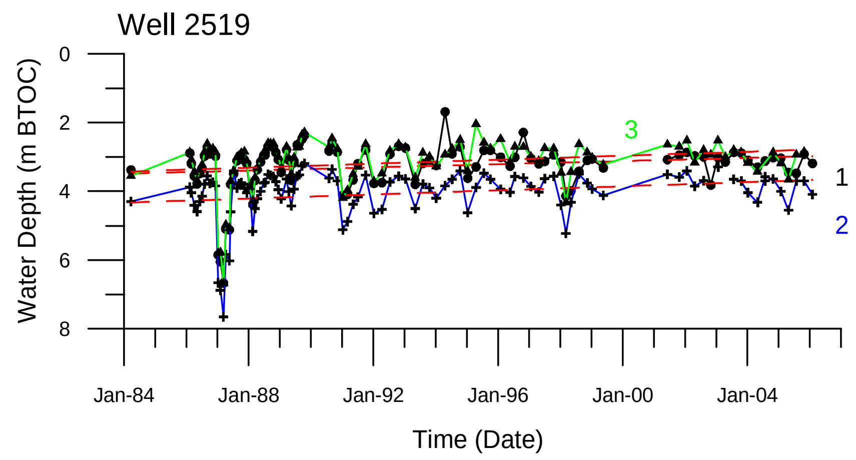

Well 2330
Water Depth (m BTOC)
30
40
50
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

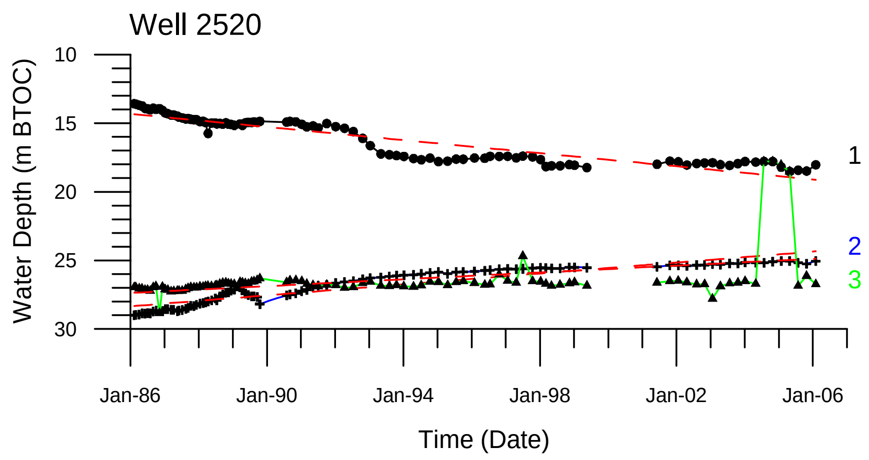

Well 2334
Water Depth (m BTOC)
0
10
20
30
40
50
Jan-99
Jan-01
Jan-03
Jan-05
Jan-07
Time (Date)

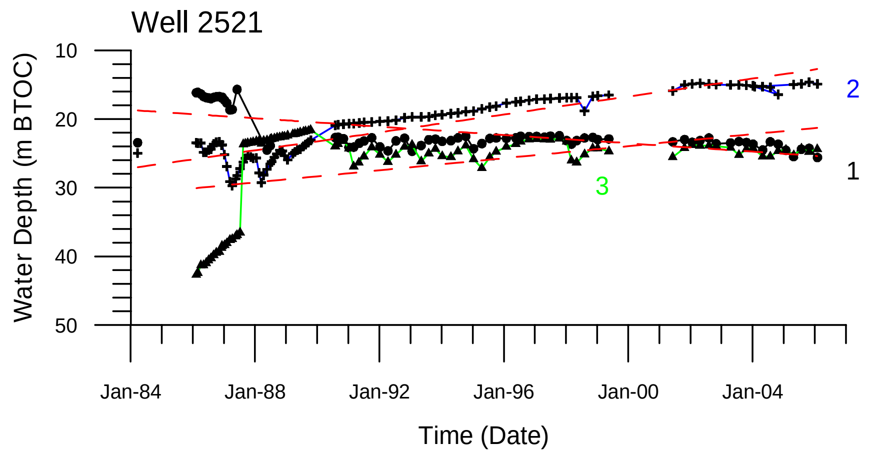

Well 2344
Water Depth (m BTOC)
15
25
35
45
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

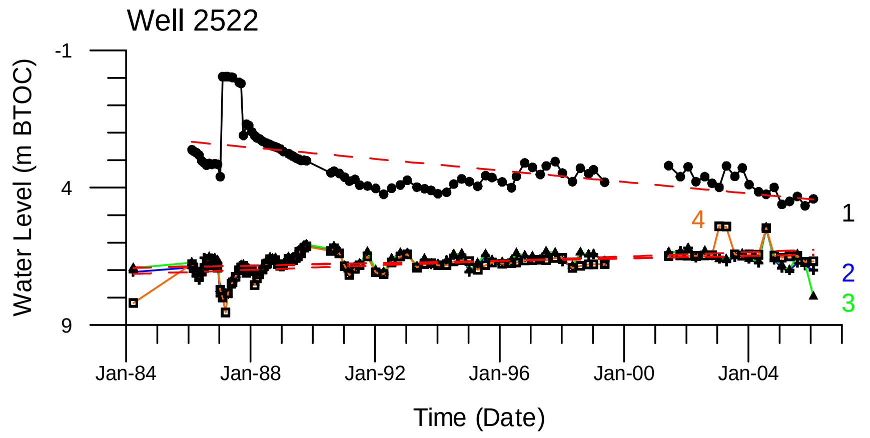

Well 2504
Water Elevation (mm AMD)
1900
1400
900
400
-100
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07

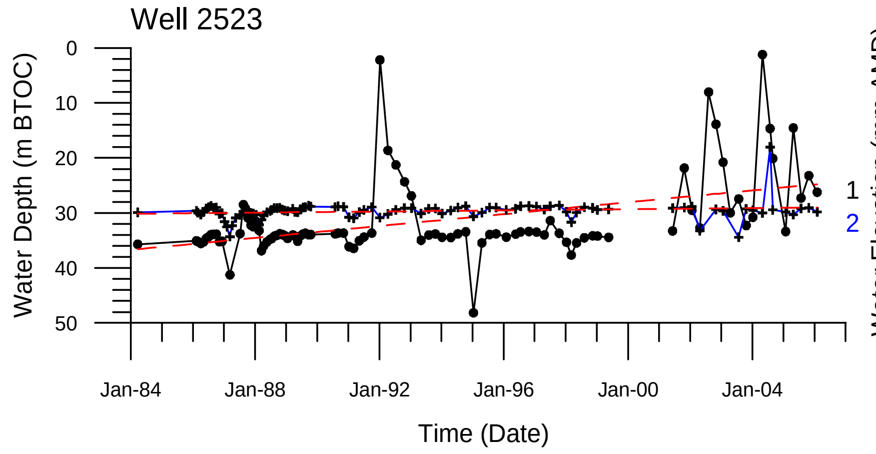

Well 2509
Water Depth (m BTOC)
-30
-20
-10
0
10
20
Jan-96
Jan-00
Jan-04
Time (Date)

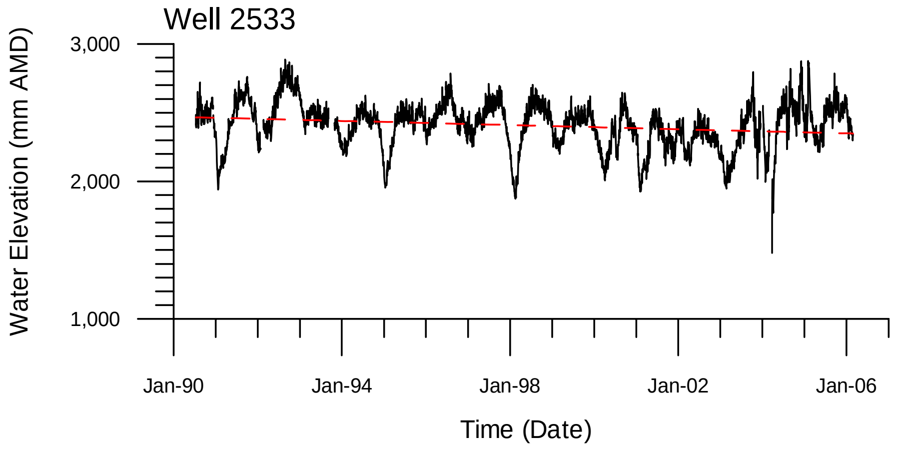

Well 2519
Water Depth (m BTOC)
0
2
4
6
8
3
1
2
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
Time (Date)

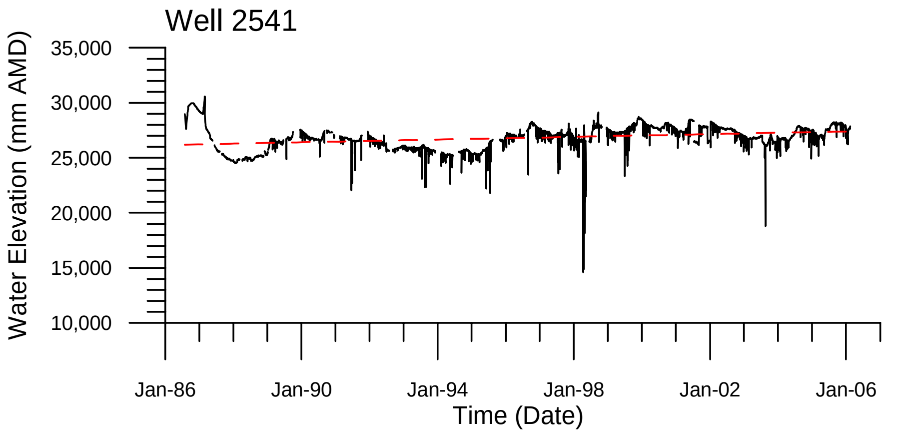

Well 2520
Water Depth (m BTOC)
10
15
20
25
30
1
2
3
Jan-86
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

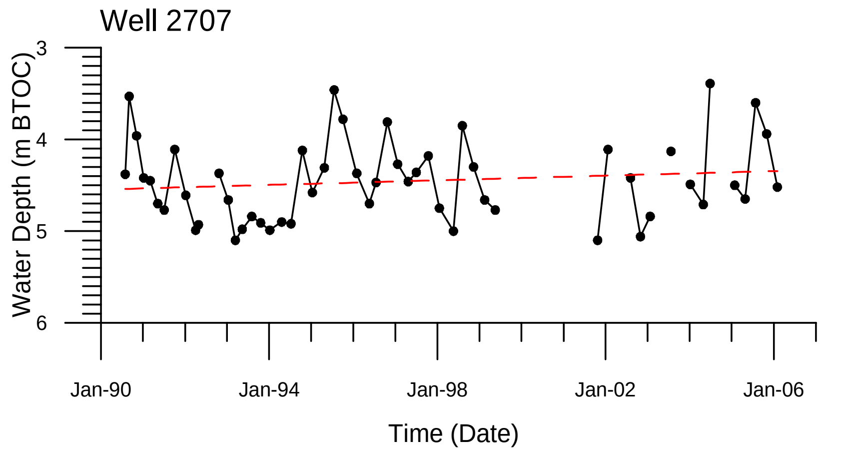

Well 2521
Water Depth (m BTOC)
10
20
30
40
50
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
Time (Date)
1
2
3

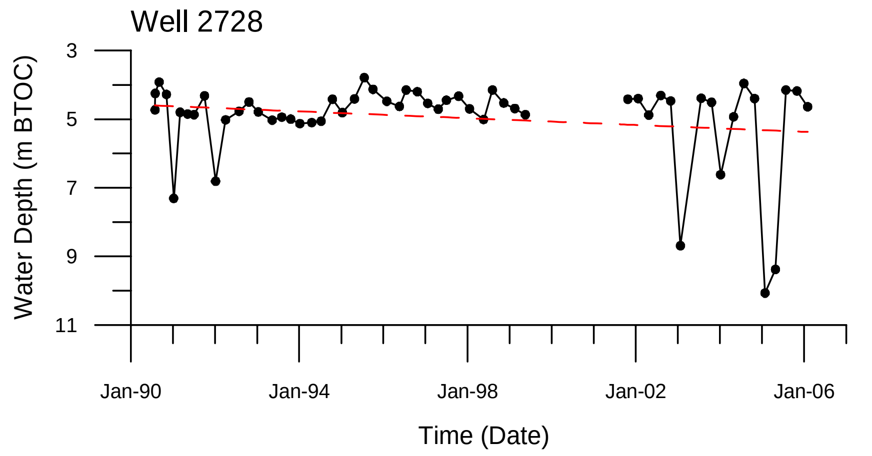

Well 2522
Water Level (m BTOC)
-1
4
9
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
Time (Date)
1
2
3
4

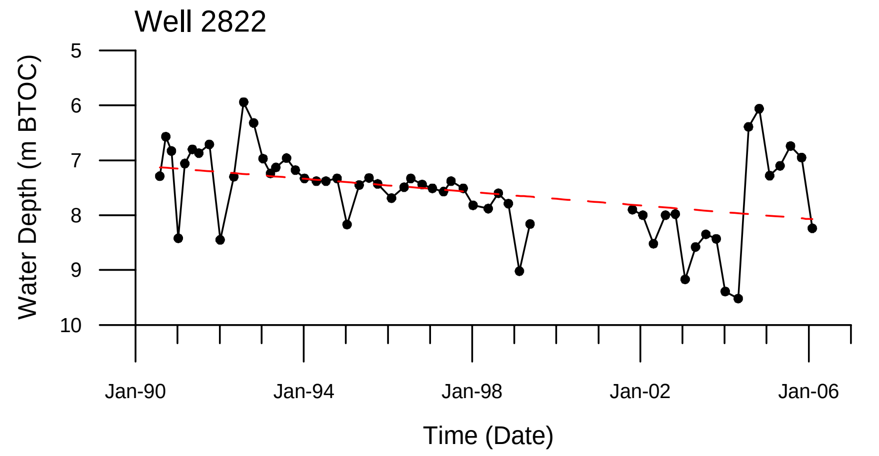

Well 2523
Water Depth (m BTOC)
0
10
20
30
40
50
Jan-84
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04
Time (Date)
1
2

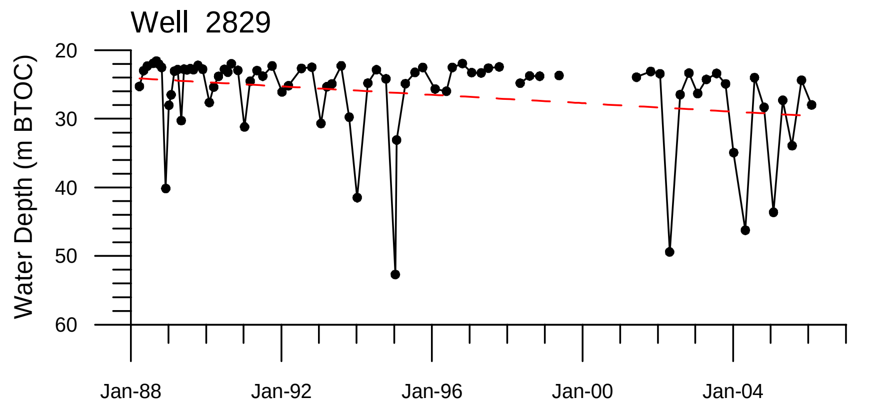

Well 2533
Water Elevation (mm AMD)
3,000
2,000
1,000
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

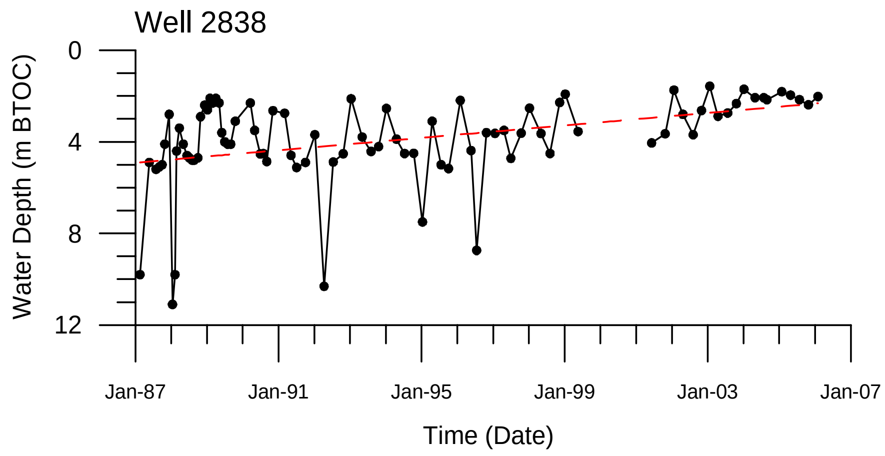

Well 2541
Water Elevation (mm AMD)
35,000
30,000
25,000
20,000
15,000
10,000
Jan-86
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

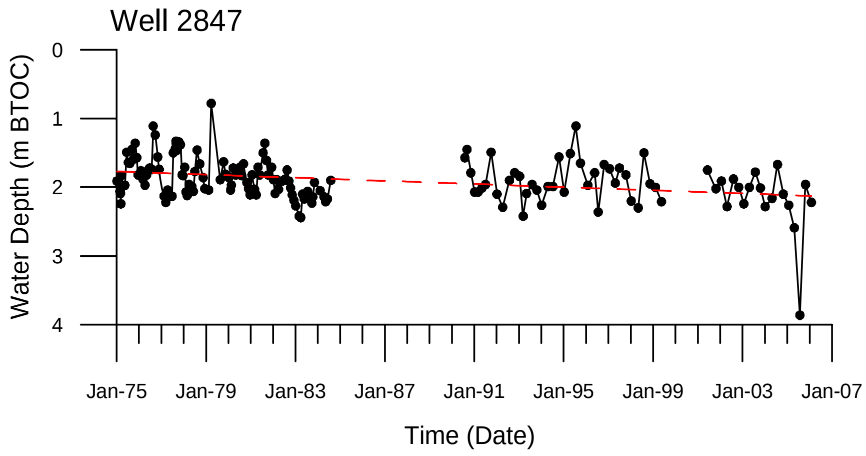

Well 2707
Water Depth (m BTOC)
3
4
5
6
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

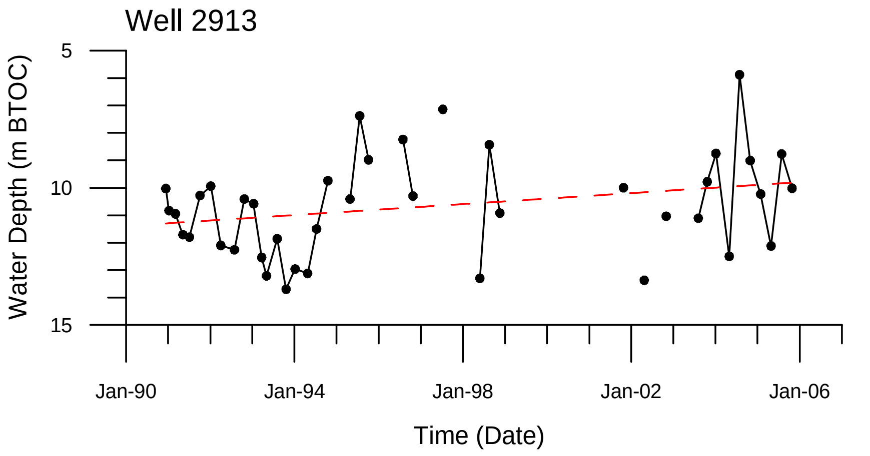

Well 2728
Water Depth (m BTOC)
3
5
7
9
11
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)


Well 2822
Water Depth (m BTOC)
5
6
7
8
9
10
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

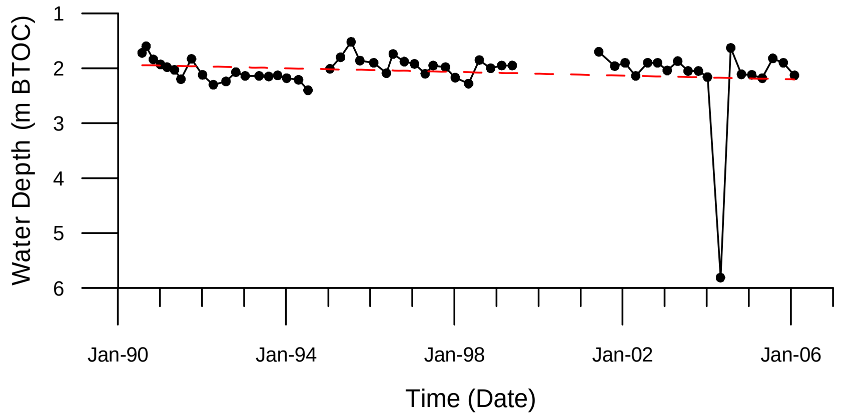

Well 2829
Water Depth (m BTOC)
20
30
40
50
60
Jan-88
Jan-92
Jan-96
Jan-00
Jan-04


Well 2838
Water Depth (m BTOC)
0
4
8
12
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

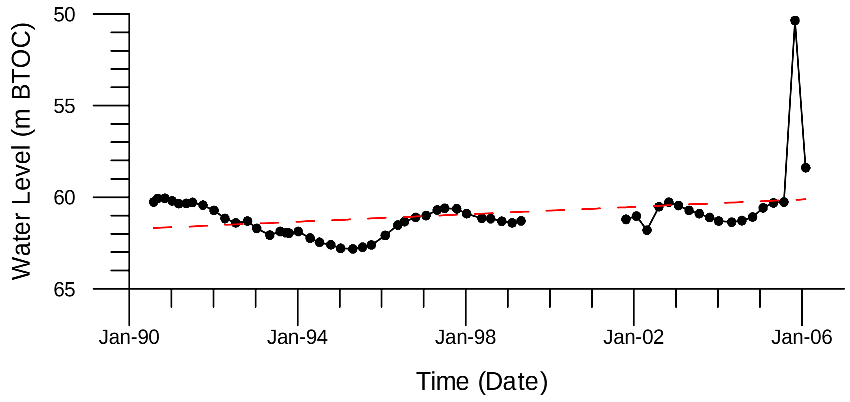

Well 2847
Water Depth (m BTOC)
0
1
2
3
4
Jan-75
Jan-79
Jan-83
Jan-87
Jan-91
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)


Well 2913
Water Depth (m BTOC)
5
10
15
Jan-90
Jan-94
Jan-98
Jan-02
Jan-06
Time (Date)

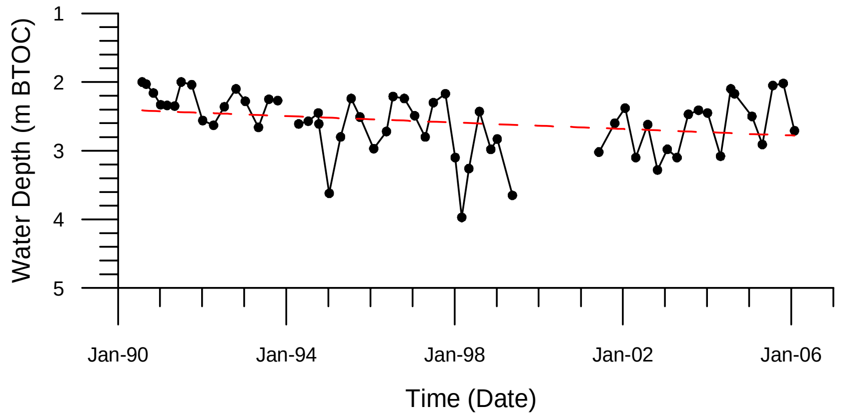
Well 3020



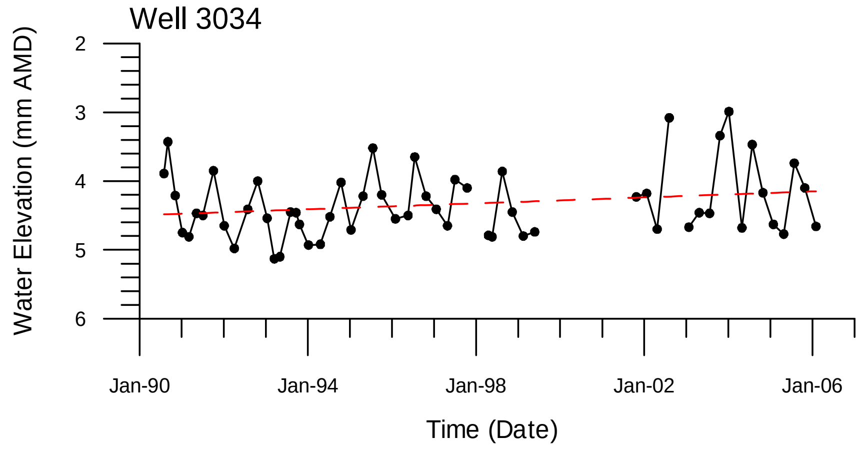
Well 3026



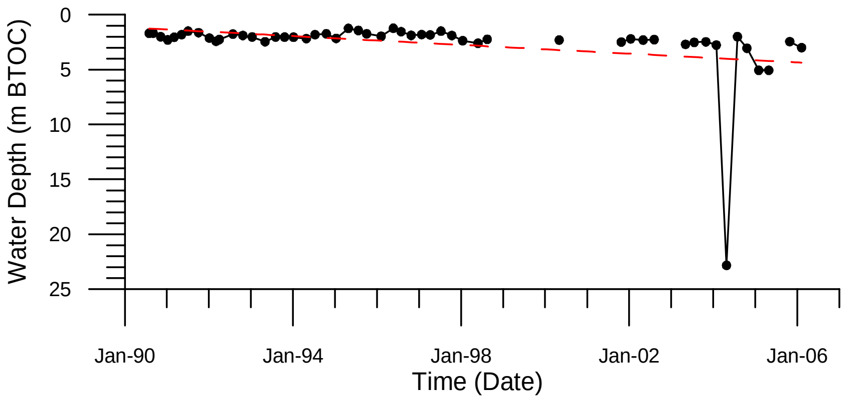
Well 3032



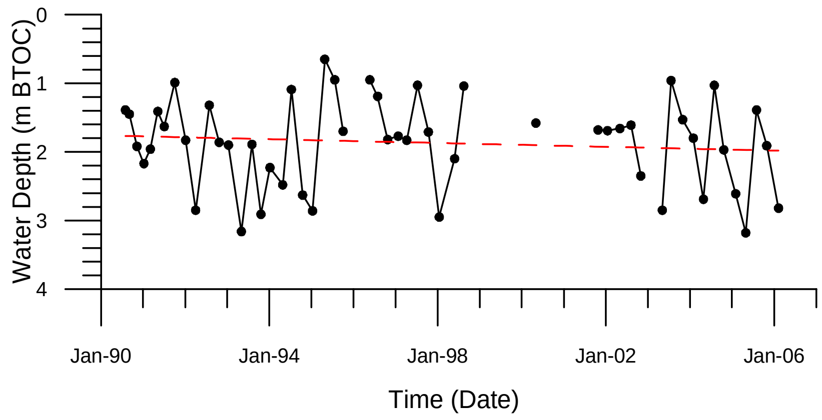
Well 3034



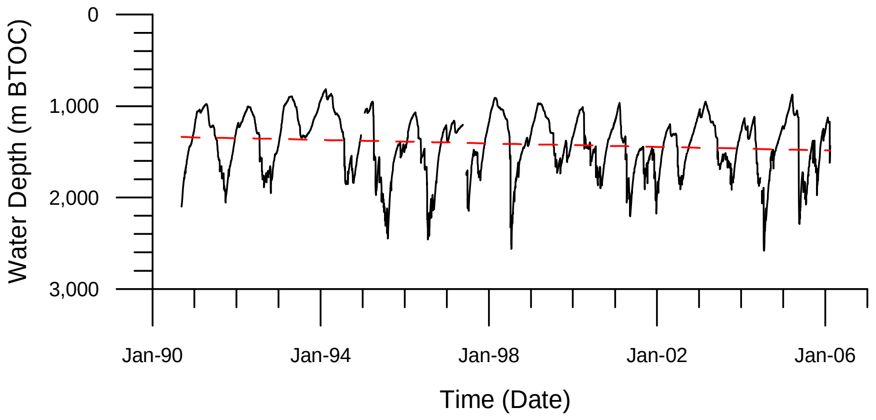
Well 3036



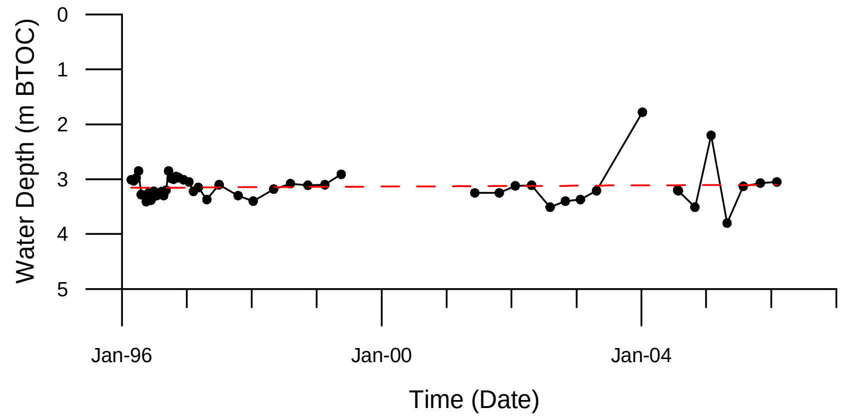
Well 3038



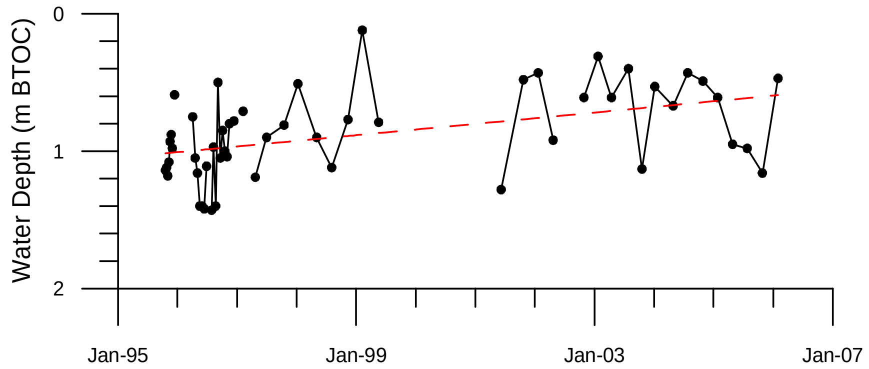
Well 3043



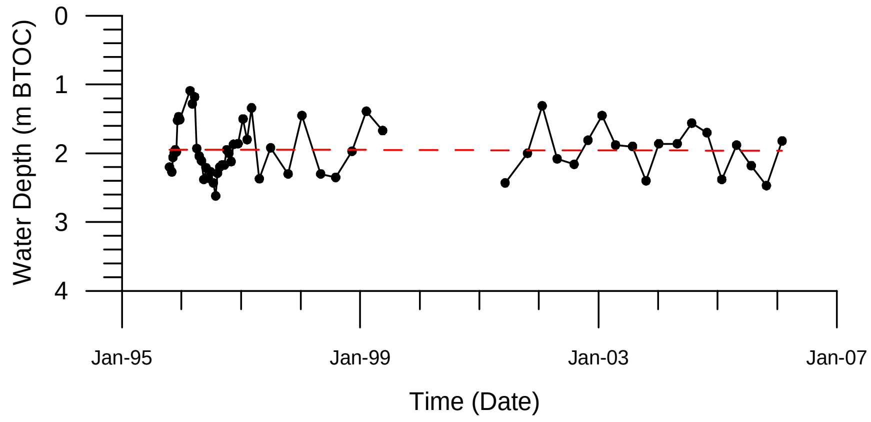
Well 3272



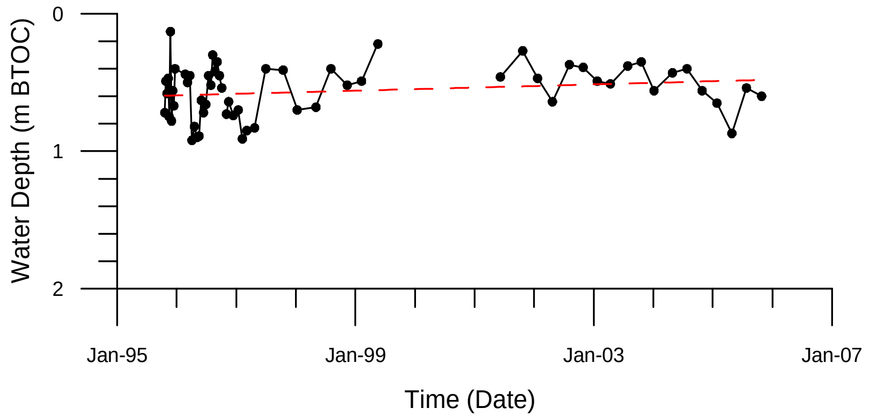
Well 3460



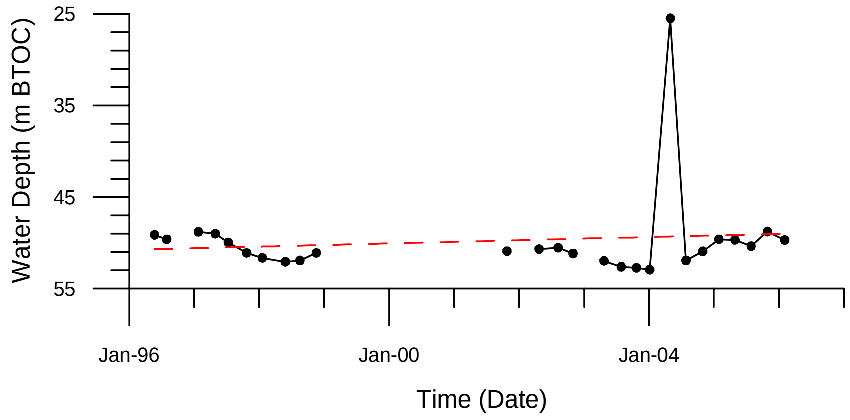
Well 3463

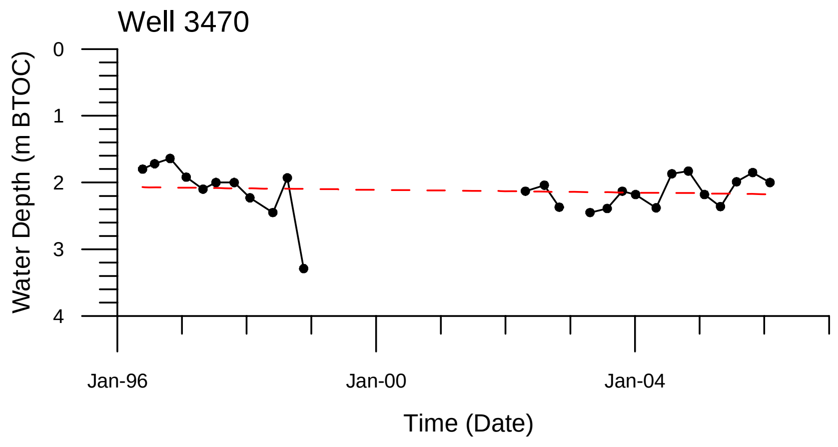


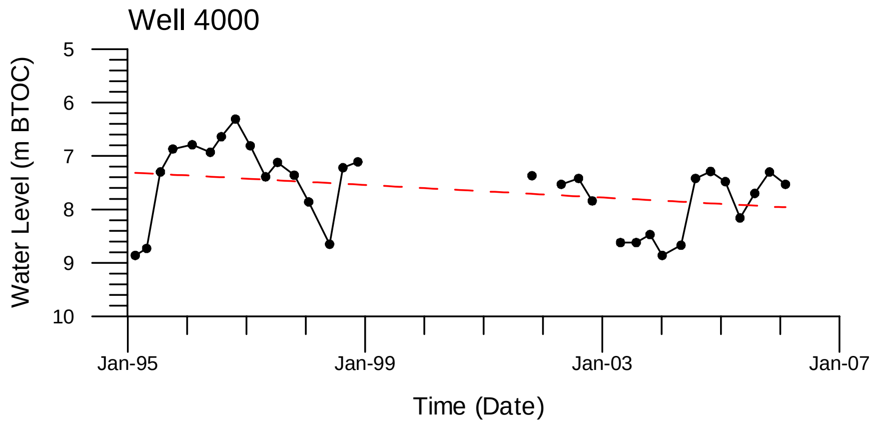
Well 3467

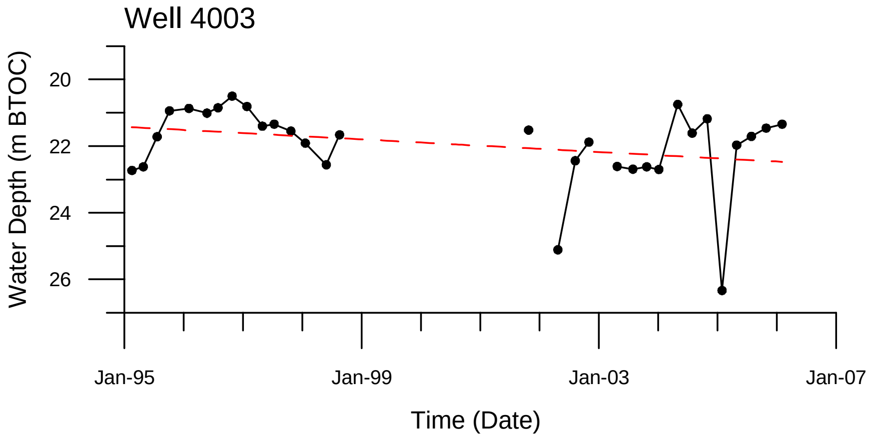


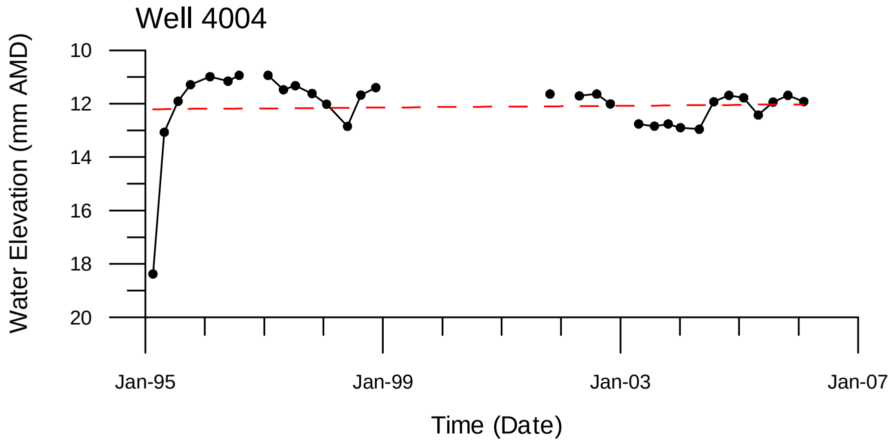
Well 3469

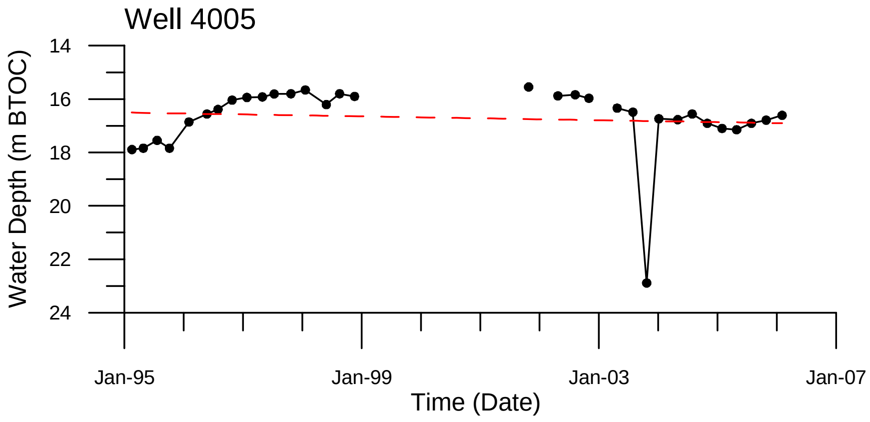


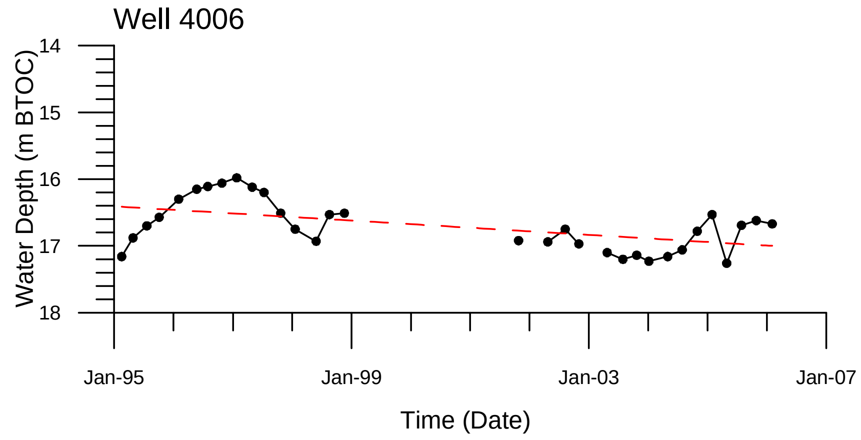

Well 3470
Water Depth (m BTOC)
0
1
2
3
4
Jan-96
Jan-00
Jan-04
Time (Date)

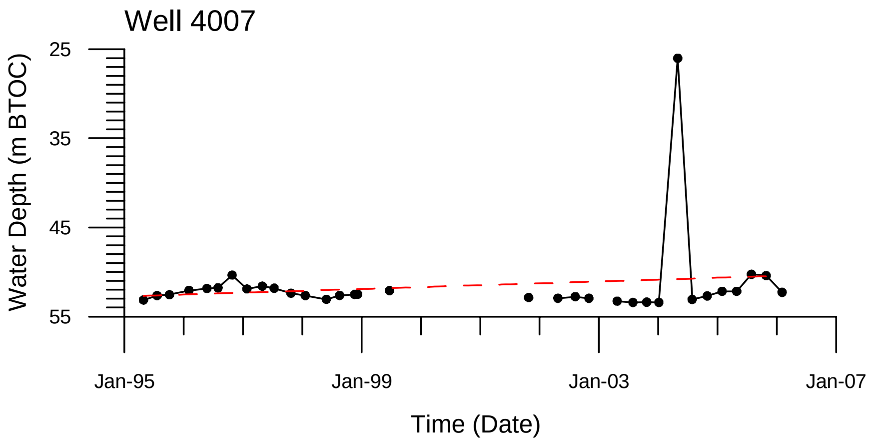

Well 4000
Water Level (m BTOC)
5
6
7
8
9
10
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)


Well 4003
Water Depth (m BTOC)
20
22
24
26
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)


Well 4004
Water Elevation (mm AMD)
10
12
14
16
18
20
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

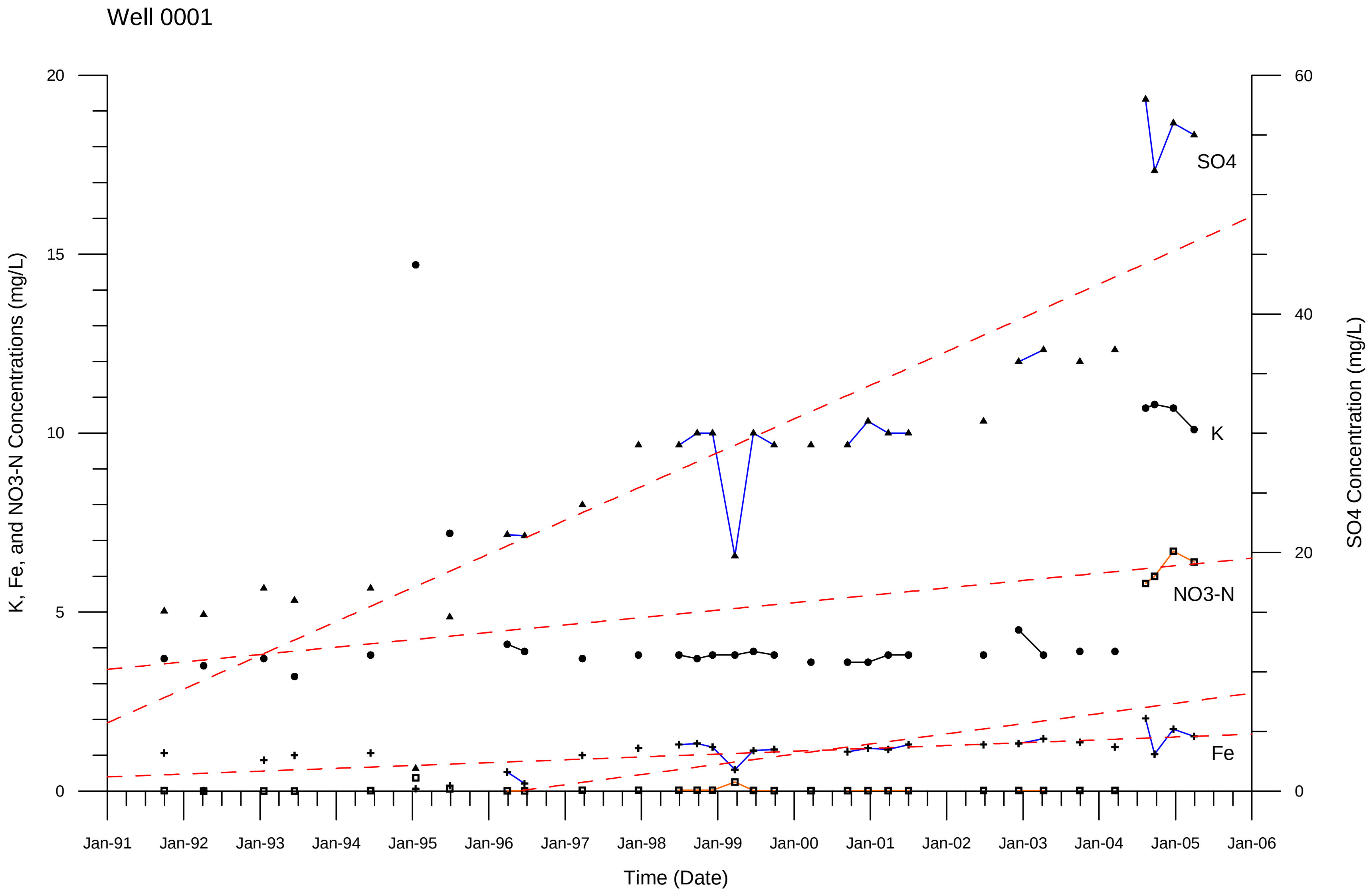

Well 4005
Water Depth (m BTOC)
14
16
18
20
22
24
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

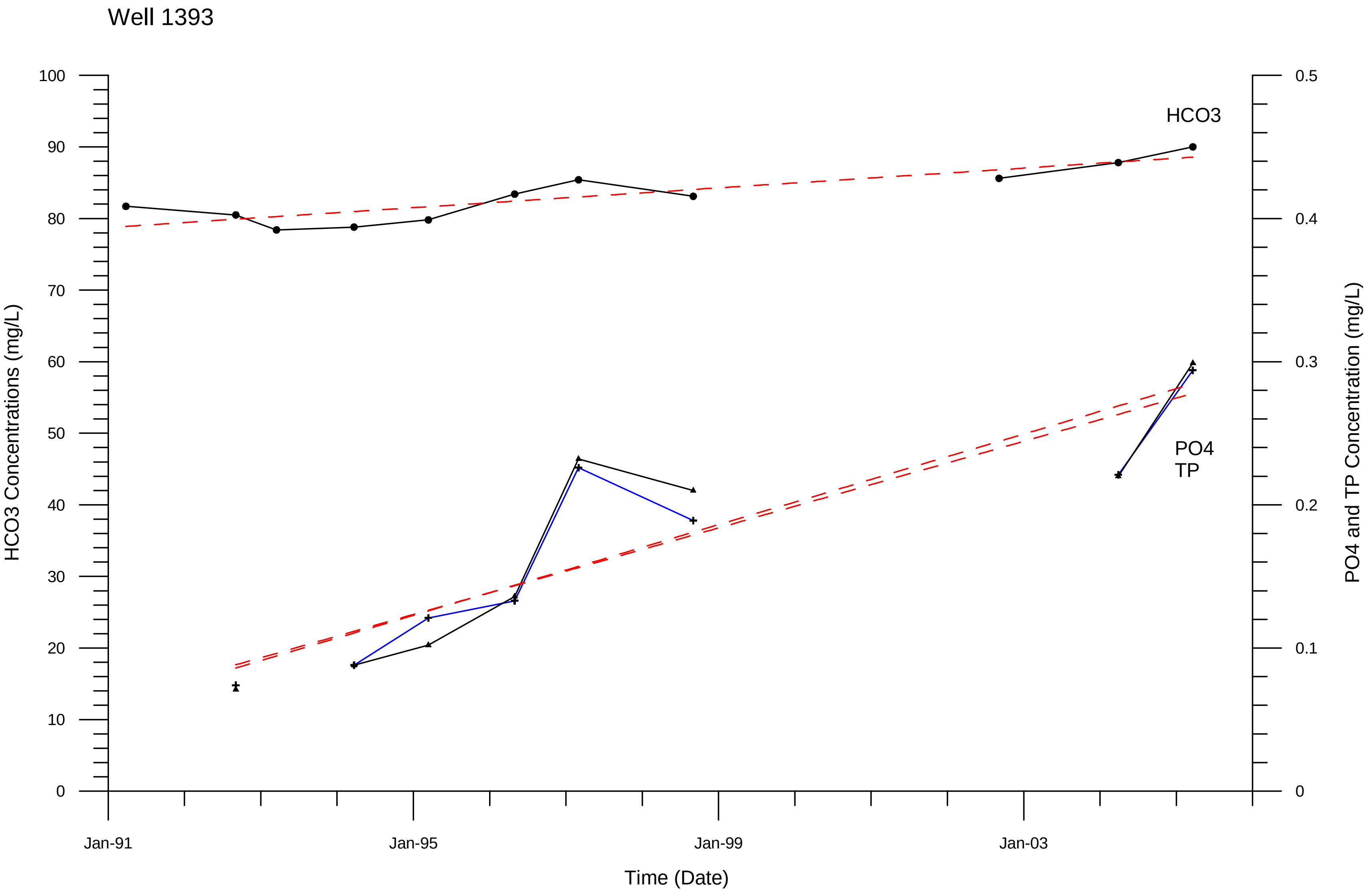

Well 4006
Water Depth (m BTOC)
14
15
16
17
18
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

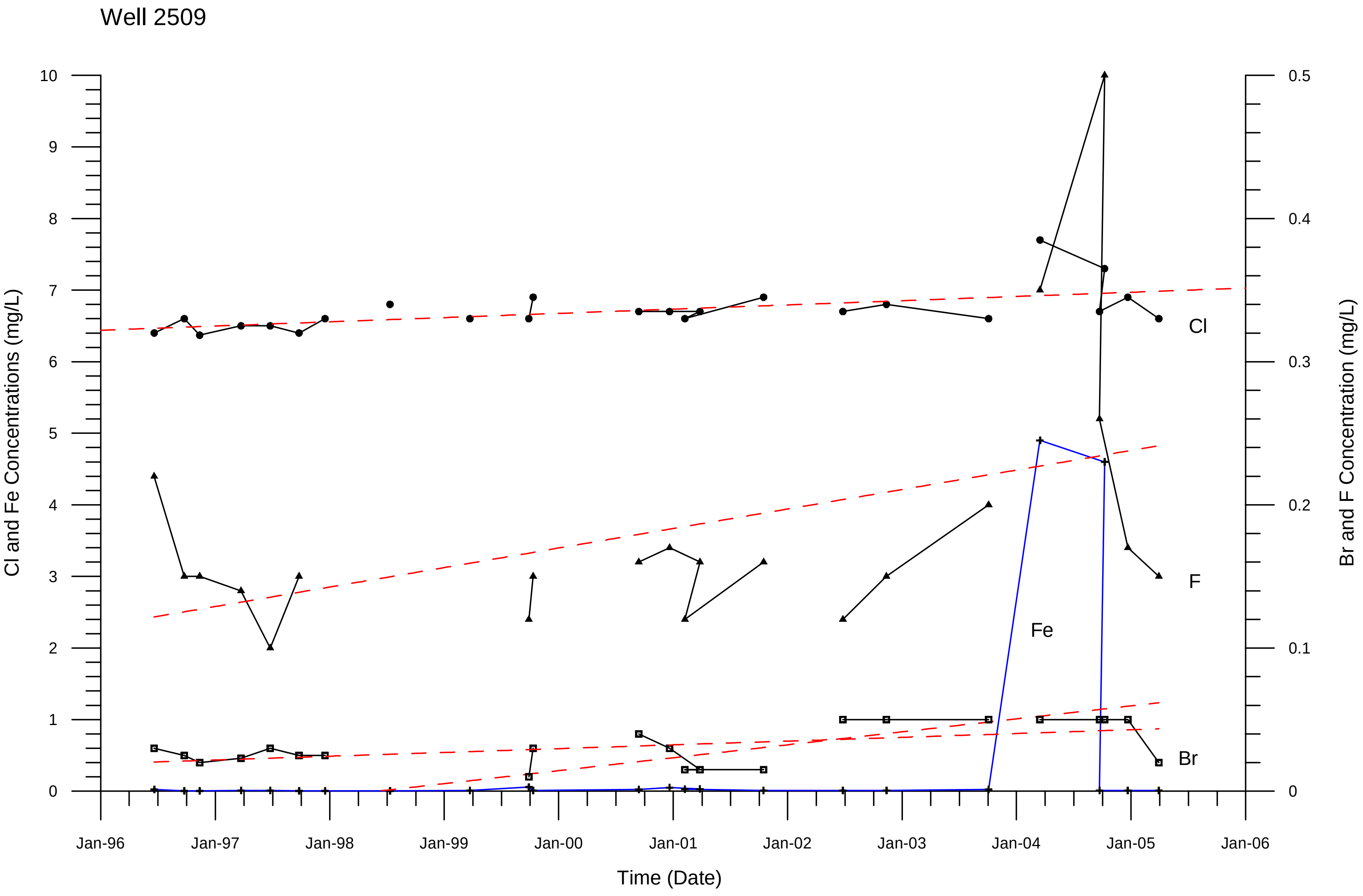

Well 4007
Water Depth (m BTOC)
25
35
45
55
Jan-95
Jan-99
Jan-03
Jan-07
Time (Date)

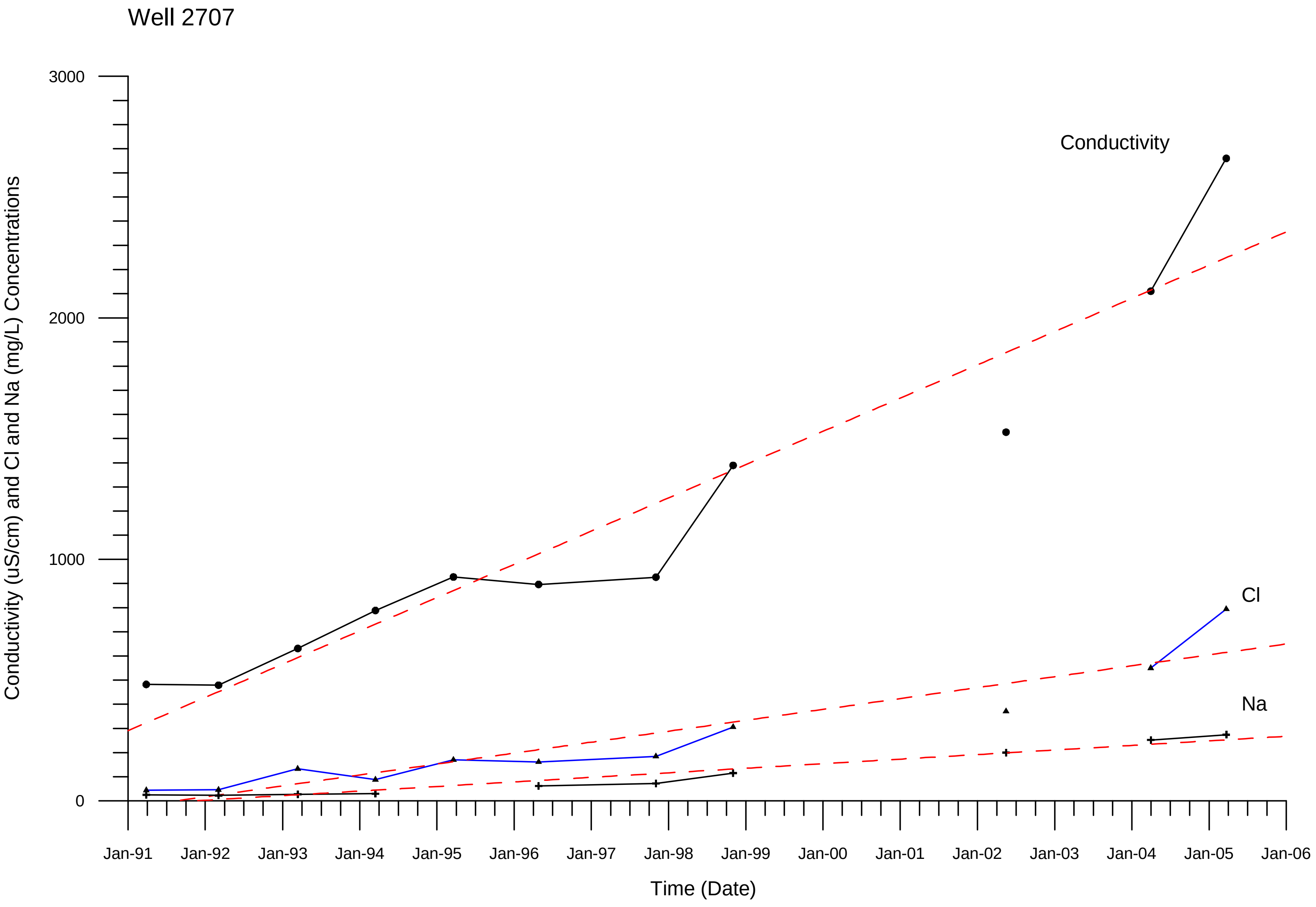
APPENDIX B - GROUNDWATER QUALITY TREND PLOTS

B1: Increasing Trend Plots (Wells 0001, 1393, 2509, 2707, and 4007)

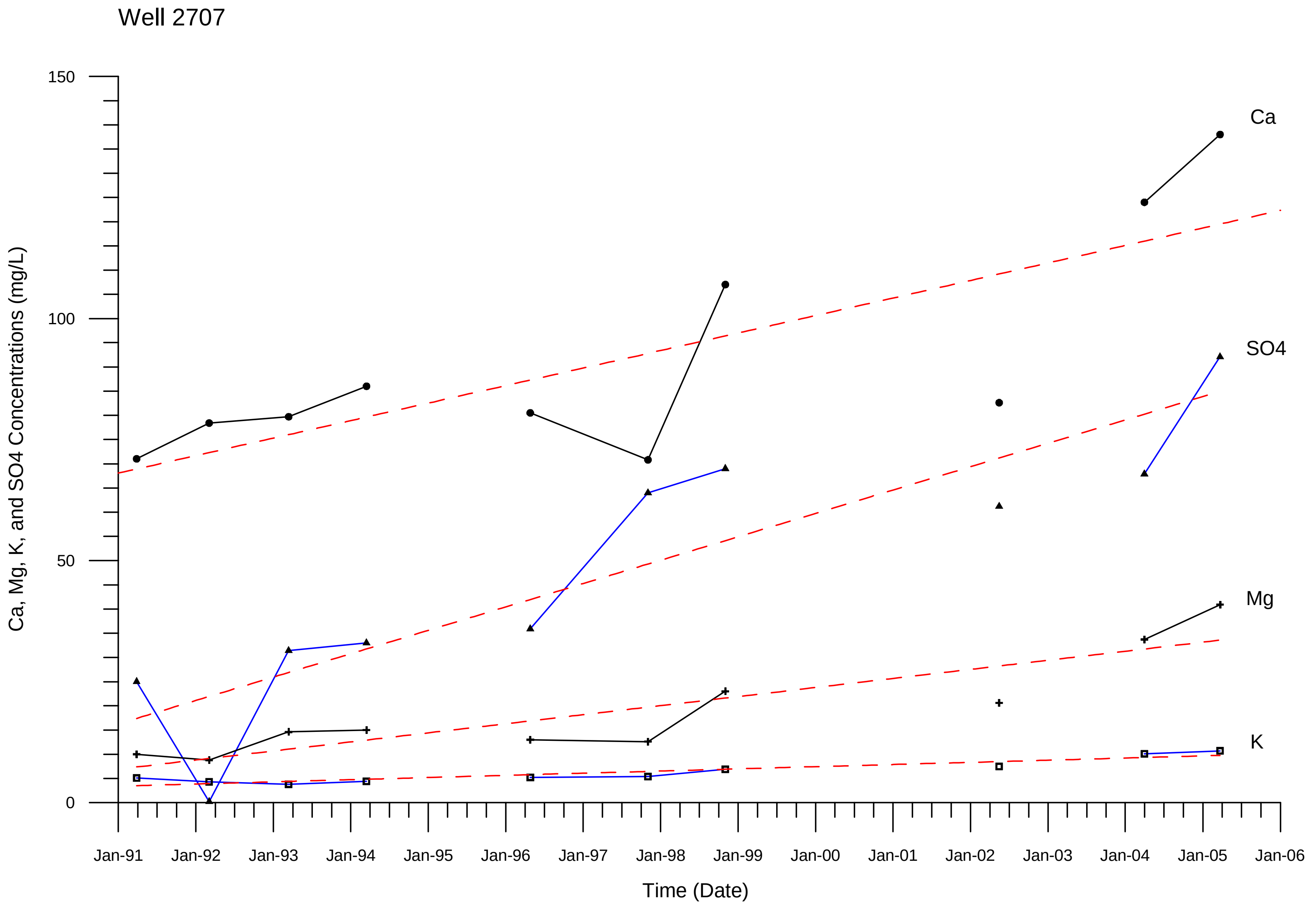

Well 0001
20
15
10
5
0
60
40
20
0
K, Fe, and NO3-N Concentrations (mg/L)
SO4 Concentration (mg/L)
SO4
K
NO3-N
Fe
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

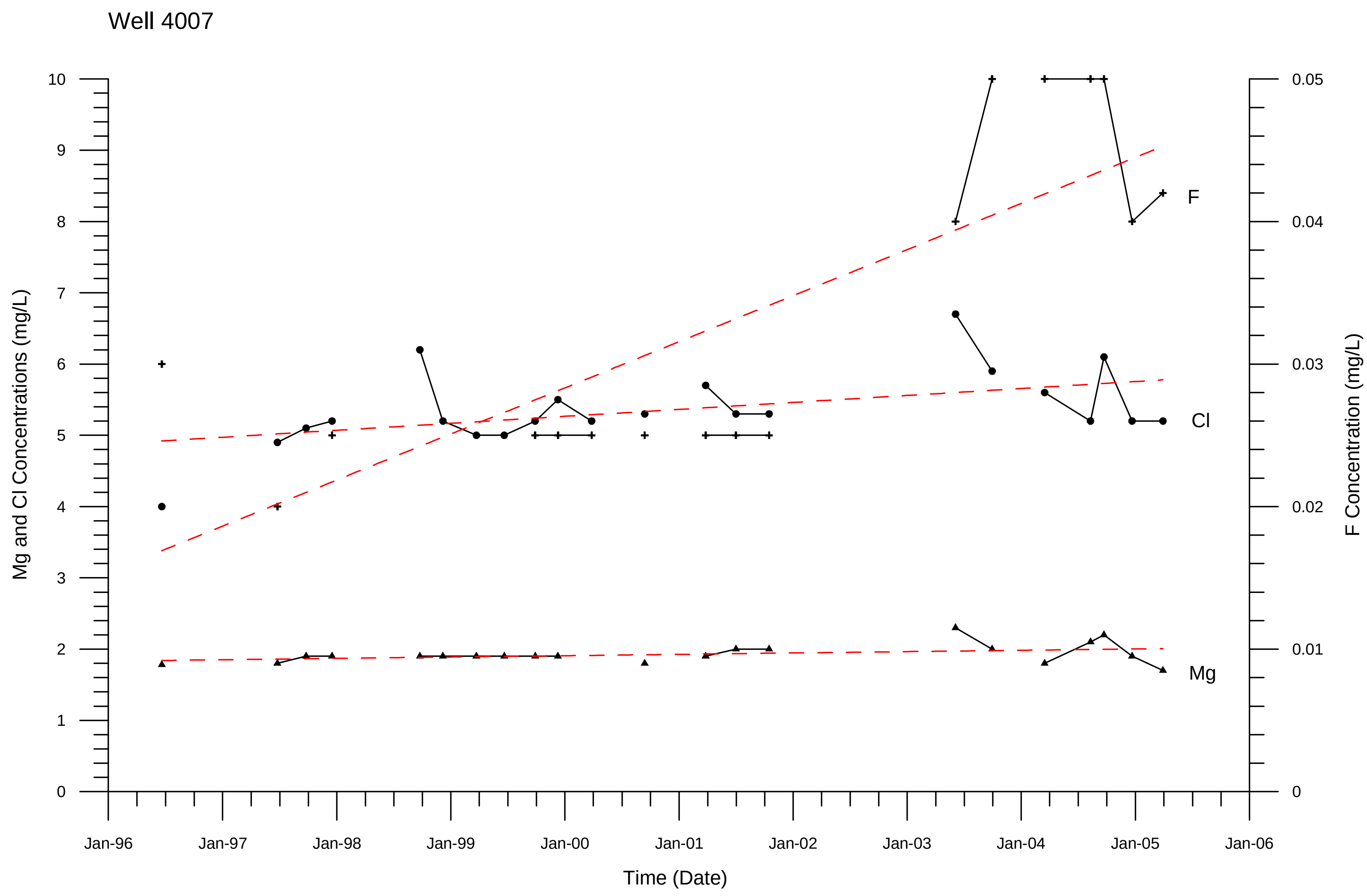

Well 1393
100
90
80
70
60
50
40
30
20
10
0
0.5
0.4
0.3
0.2
0.1
0
HCO3
PO4
TP
HCO3 Concentrations (mg/L)
PO4 and TP Concentration (mg/L)
Jan-91
Jan-95
Jan-99
Jan-03
Time (Date)


Well 2509
Cl and Fe Concentrations (mg/L)
10
9
8
7
6
5
4
3
2
1
0
Br and F Concentration (mg/L)
0.5
0.4
0.3
0.2
0.1
0
Cl
F
Fe
Br
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)



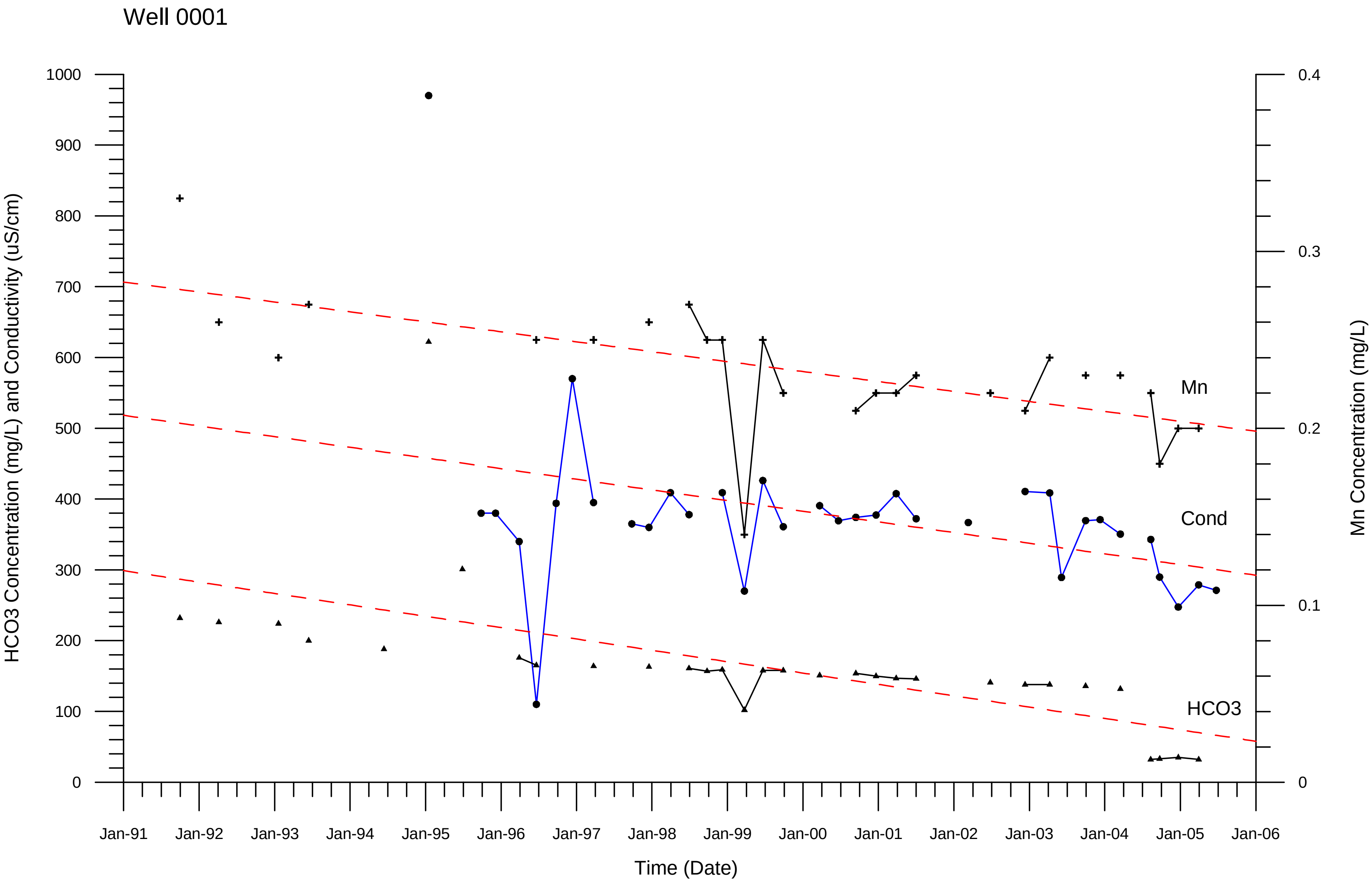
Well 2707
Conductivity
Cl
Na
3000
2000
1000
0
Conductivity (uS/cm) and Cl and Na (mg/L) Concentrations
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

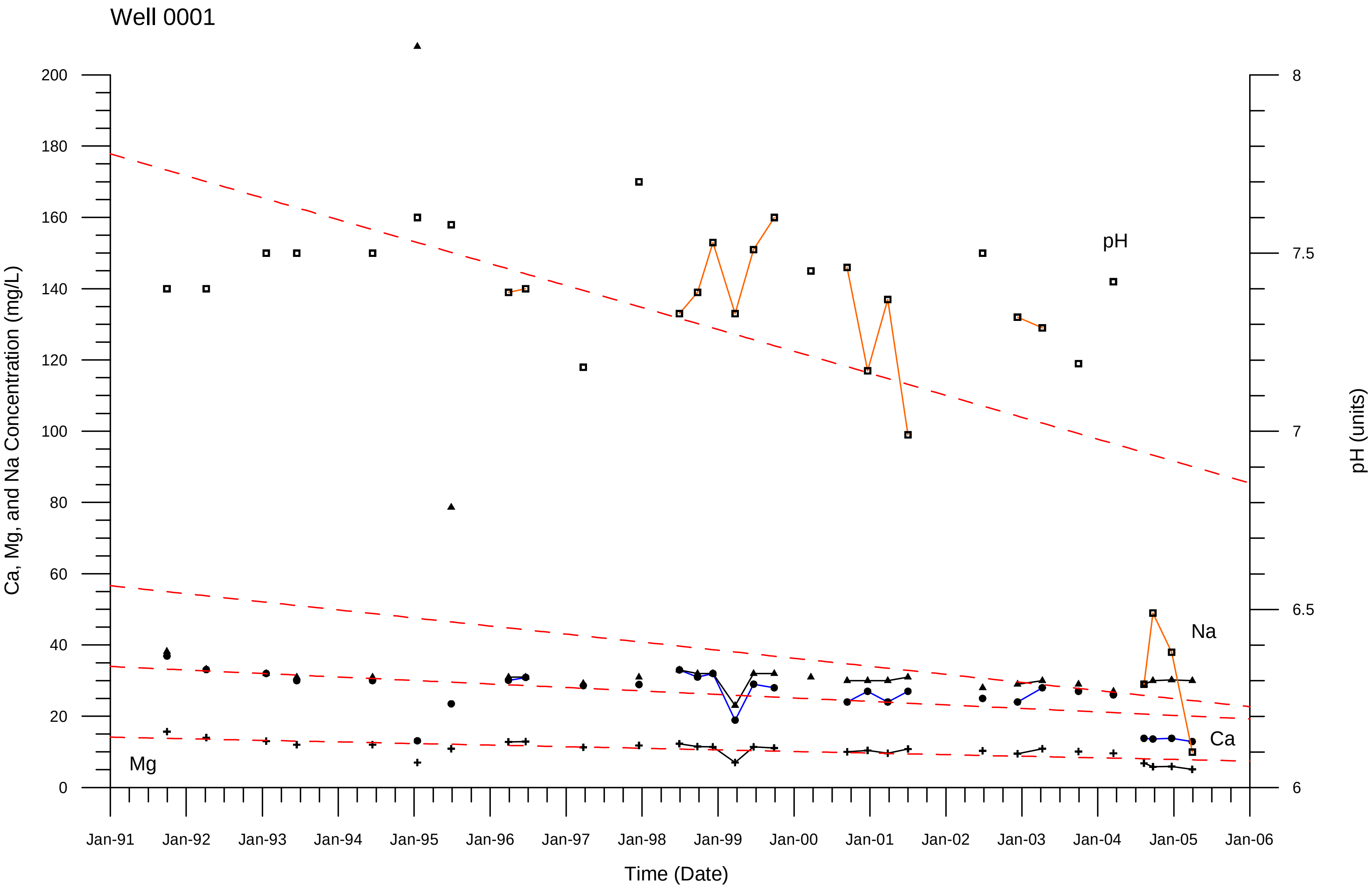

Well 2707
150
100
50
0
Ca, Mg, K, and SO4 Concentrations (mg/L)
Ca
SO4
Mg
K
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

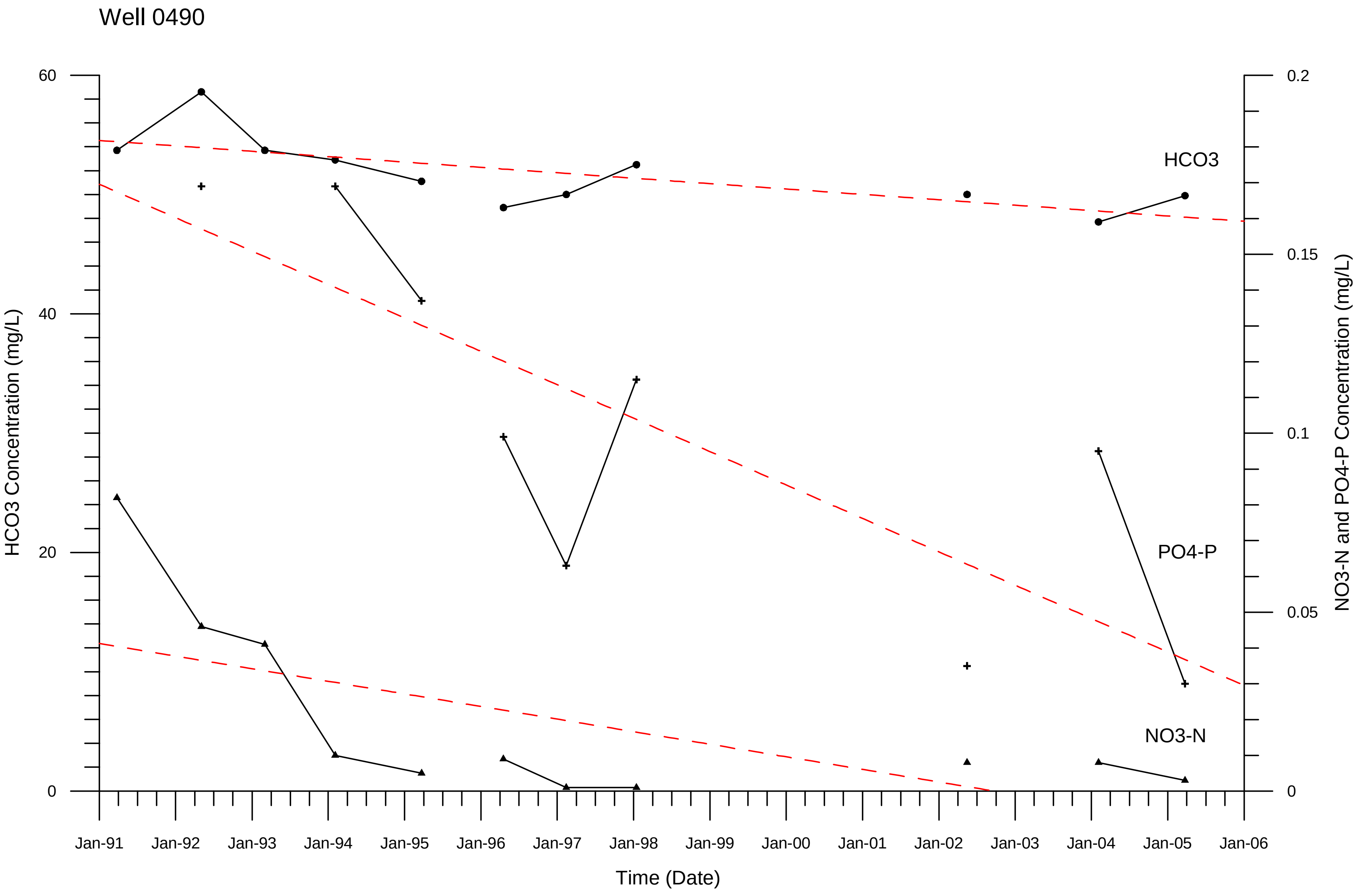

Well 4007
Mg and Cl Concentrations (mg/L)
F Concentration (mg/L)
Time (Date)
10
9
8
7
6
5
4
3
2
1
0
0.05
0.04
0.03
0.02
0.01
0
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
F
Cl
Mg

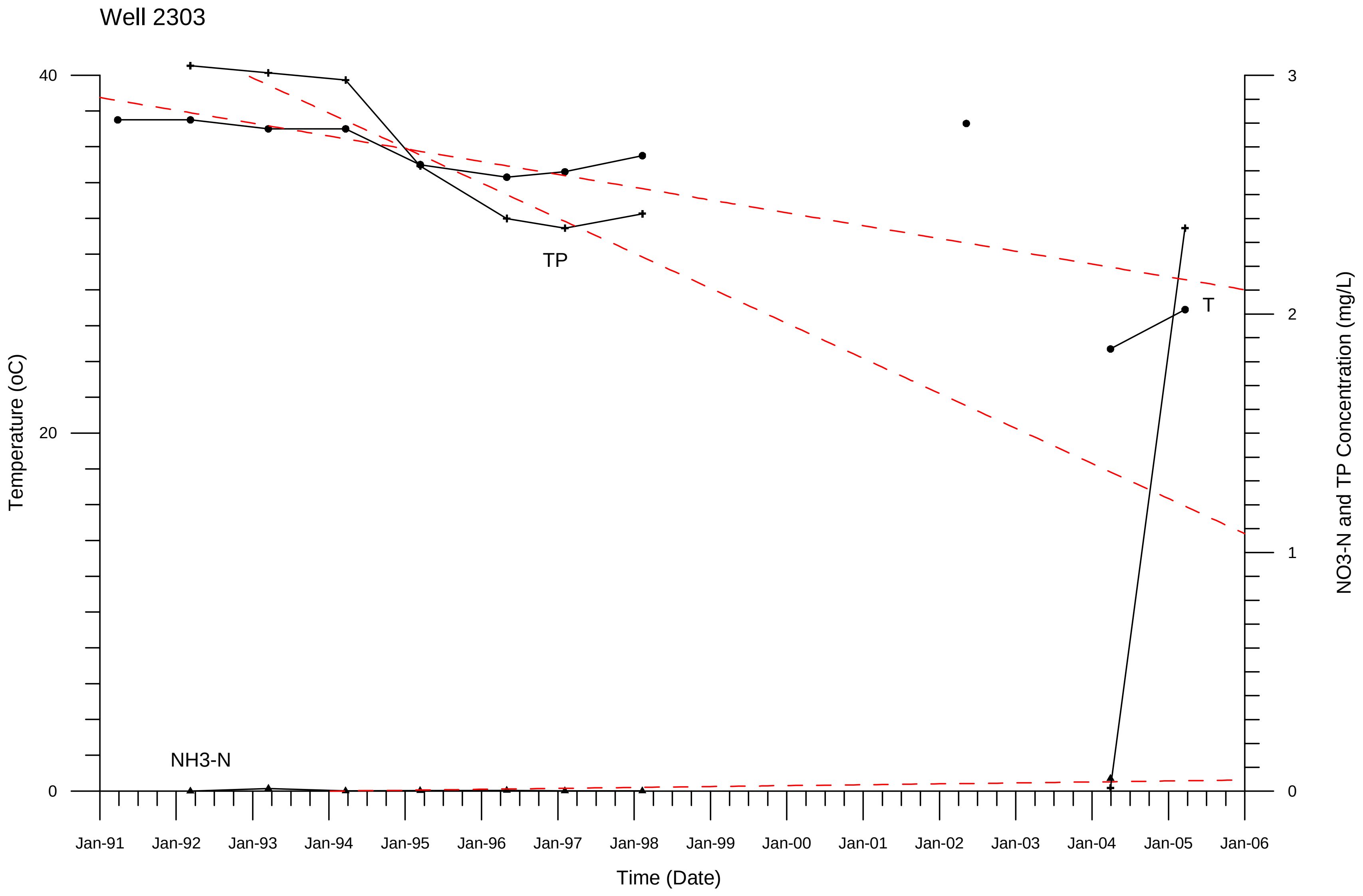
APPENDIX B - GROUNDWATER QUALITY TREND PLOTS

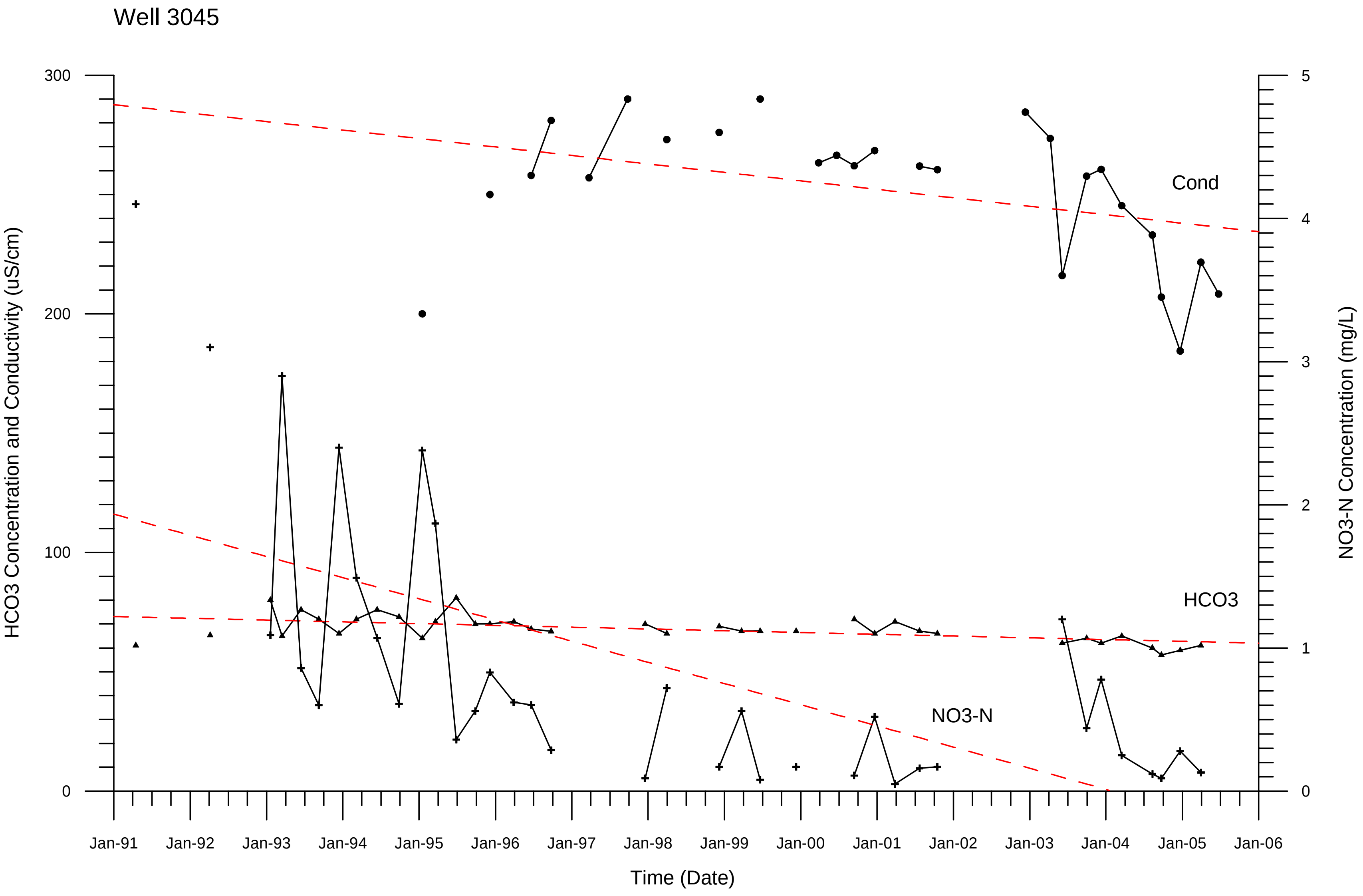
B2: Decreasing Trend Plots (Wells 0001, 0490, 2303, 3045, 3301, and 4364)

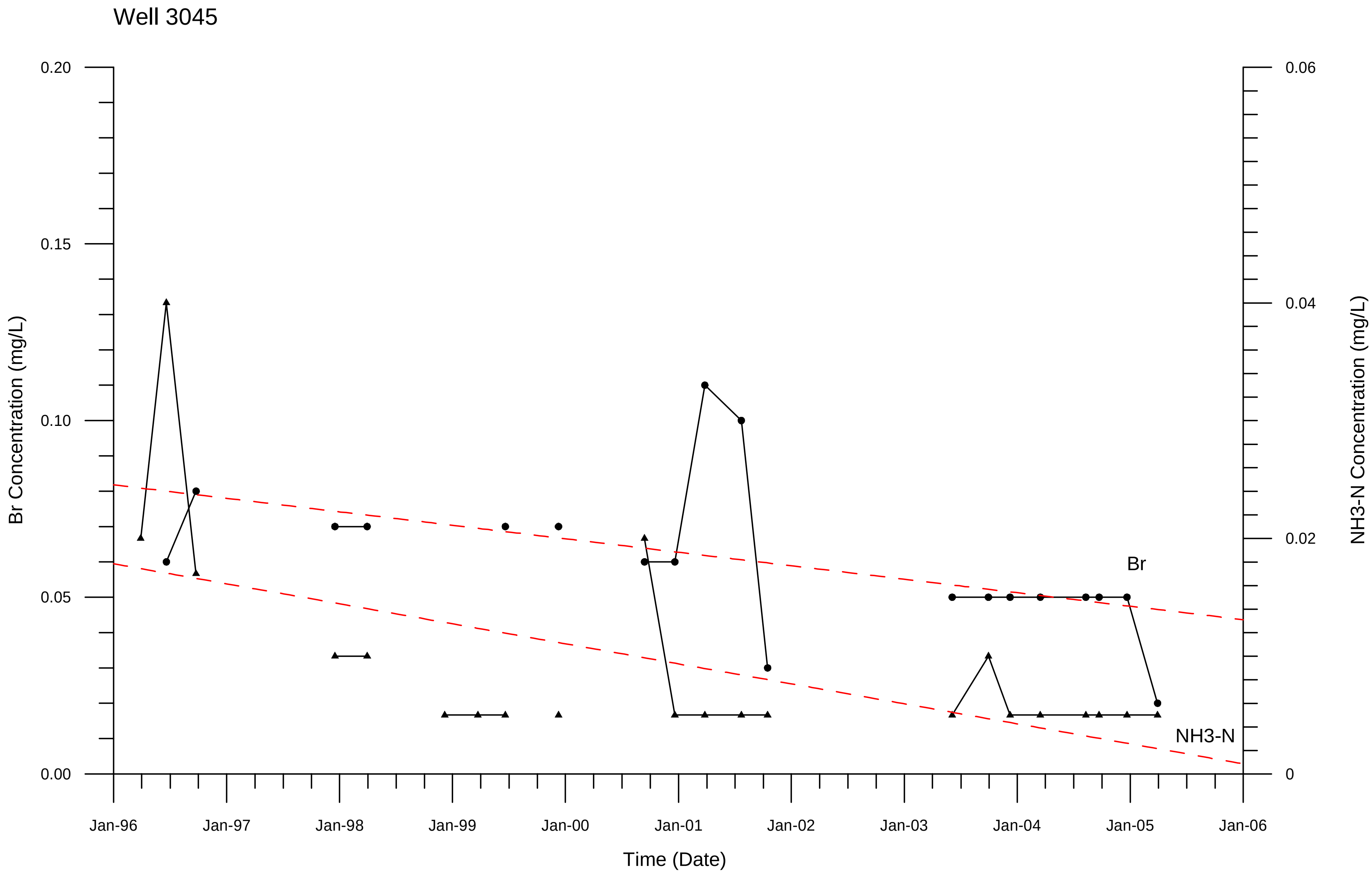

Well 0001
HCO3 Concentration (mg/L) and Conductivity (uS/cm)
1000
900
800
700
600
500
400
300
200
100
0
Mn Concentration (mg/L)
0.4
0.3
0.2
0.1
0
Mn
Cond
HCO3
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)


Well 0001
Ca, Mg, and Na Concentration (mg/L)
200
180
160
140
120
100
80
60
40
20
0
pH (units)
8
7.5
7
6.5
6
pH
Na
Ca
Mg
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

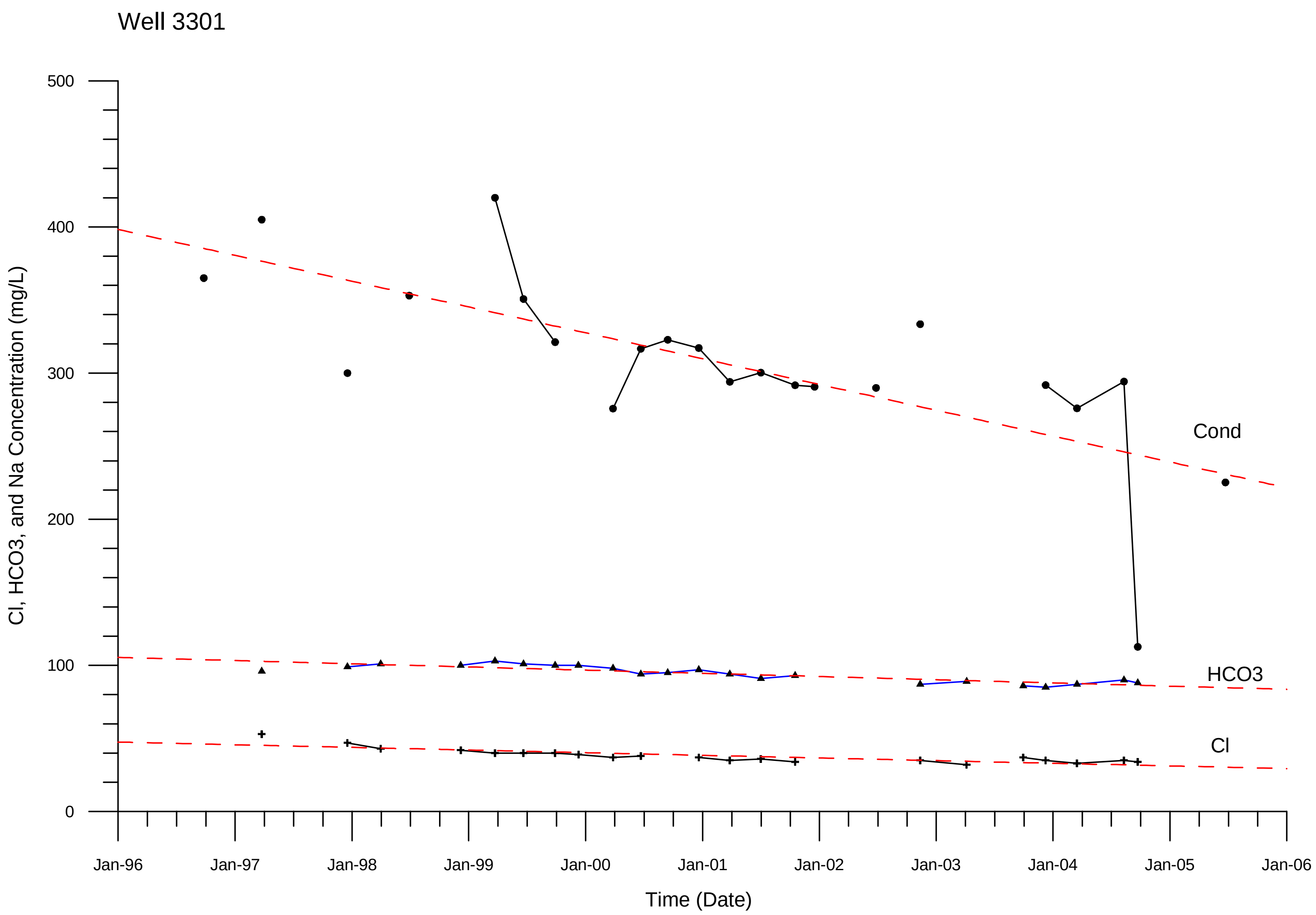

Well 0490
HCO3 Concentration (mg/L)
NO3-N and PO4-P Concentration (mg/L)
Time (Date)
HCO3
PO4-P
NO3-N
60
40
20
0
0.2
0.15
0.1
0.05
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06

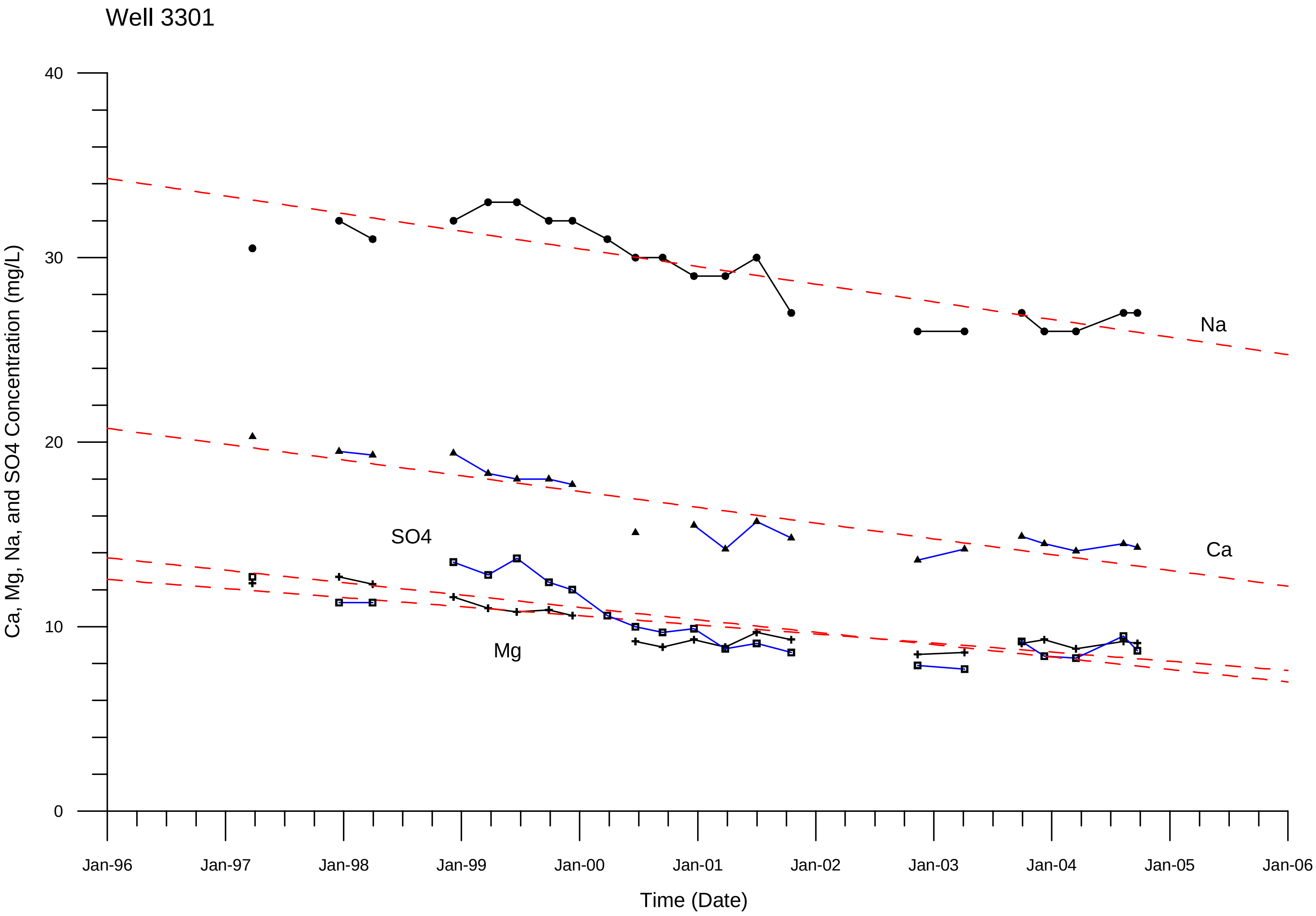

Well 2303
40
20
0
Temperature (oC)
TP
T
NH3-N
3
2
1
0
NO3-N and TP Concentration (mg/L)
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

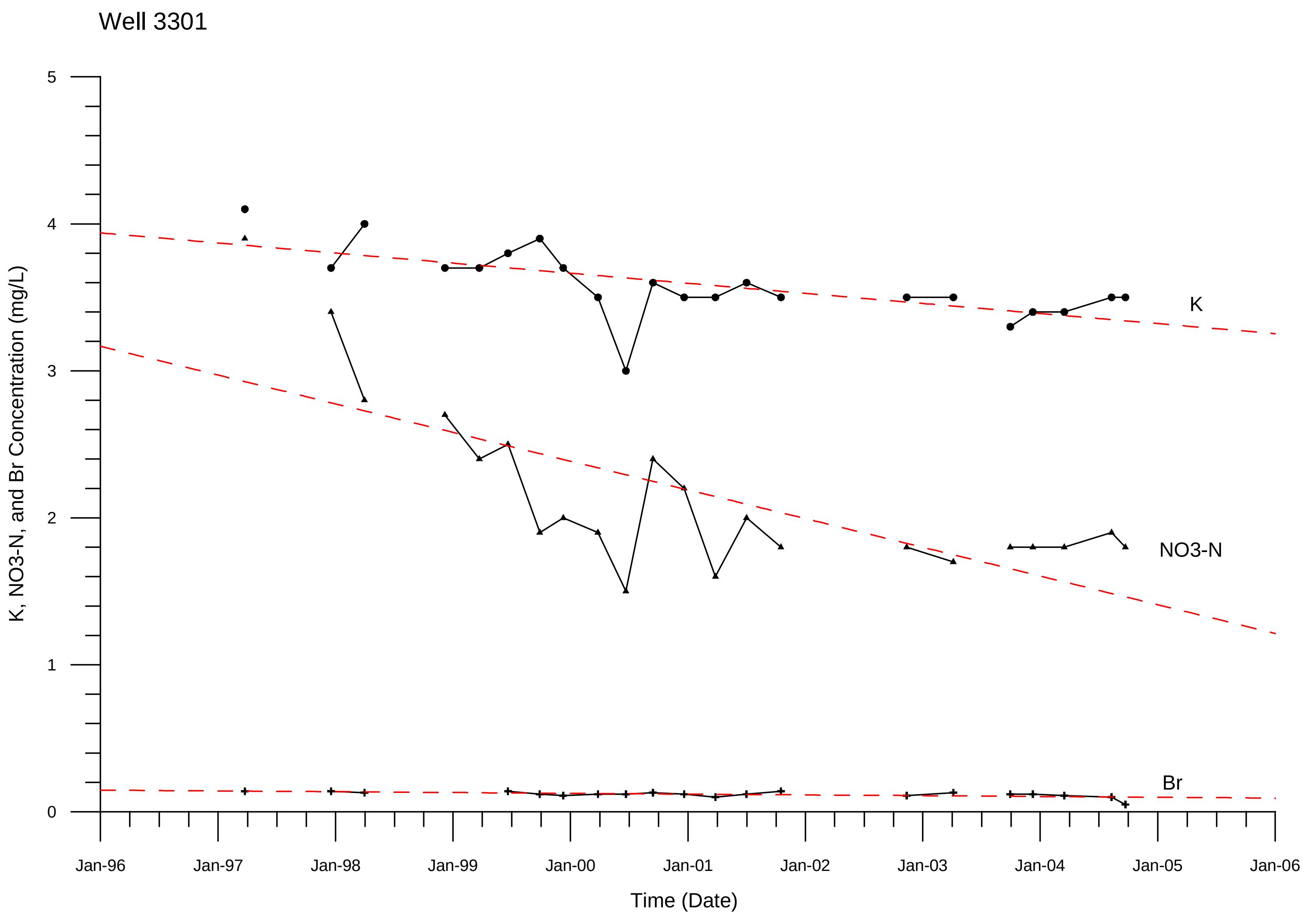

Well 3045
HCO3 Concentration and Conductivity (uS/cm)
NO3-N Concentration (mg/L)
Time (Date)
Cond
HCO3
NO3-N
300
200
100
0
5
4
3
2
1
0
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06

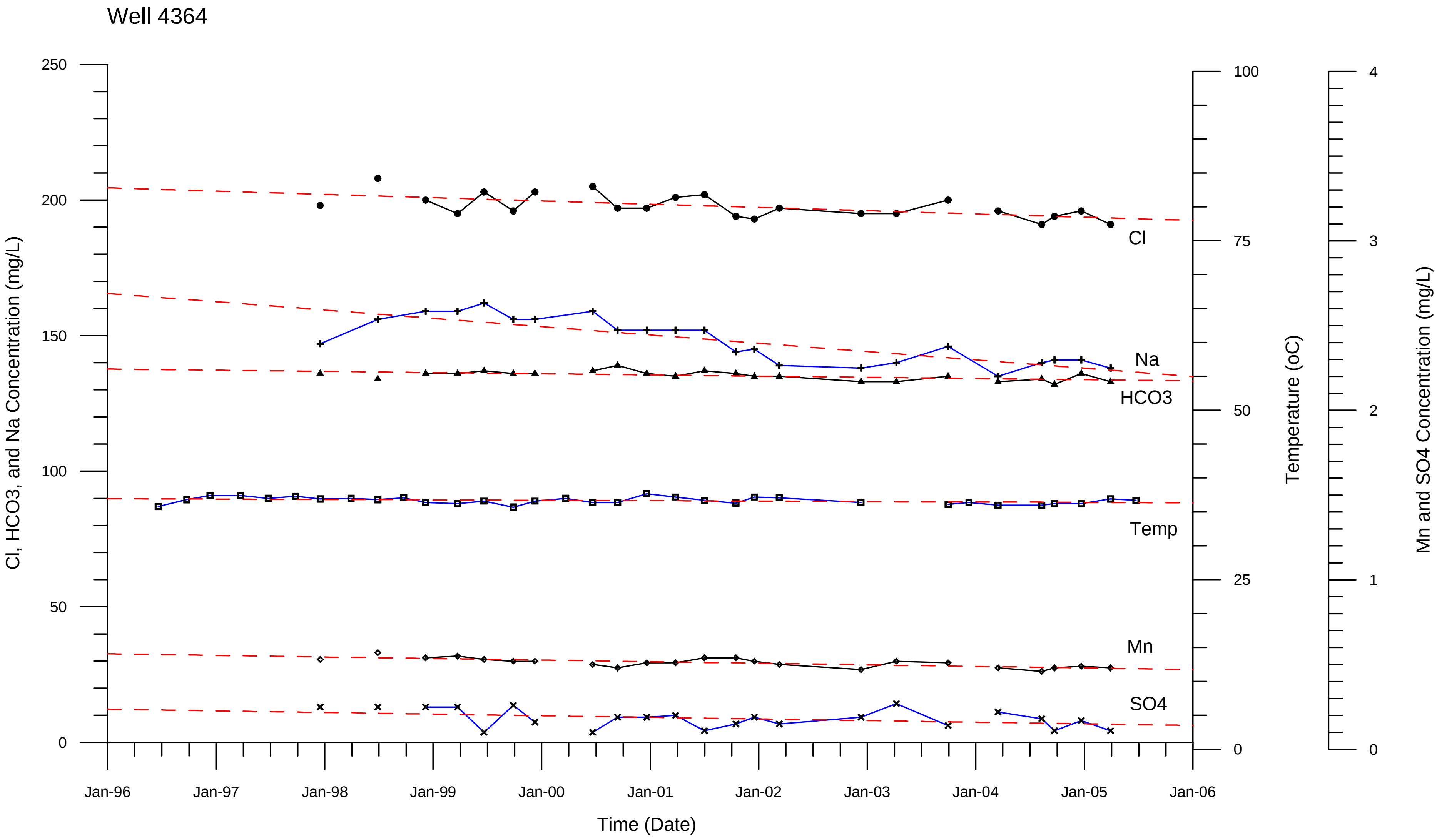


Well 3045
0.20
0.15
0.10
0.05
0.00
Br Concentration (mg/L)
0.06
0.04
0.02
0
NH3-N Concentration (mg/L)
Br
NH3-N
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

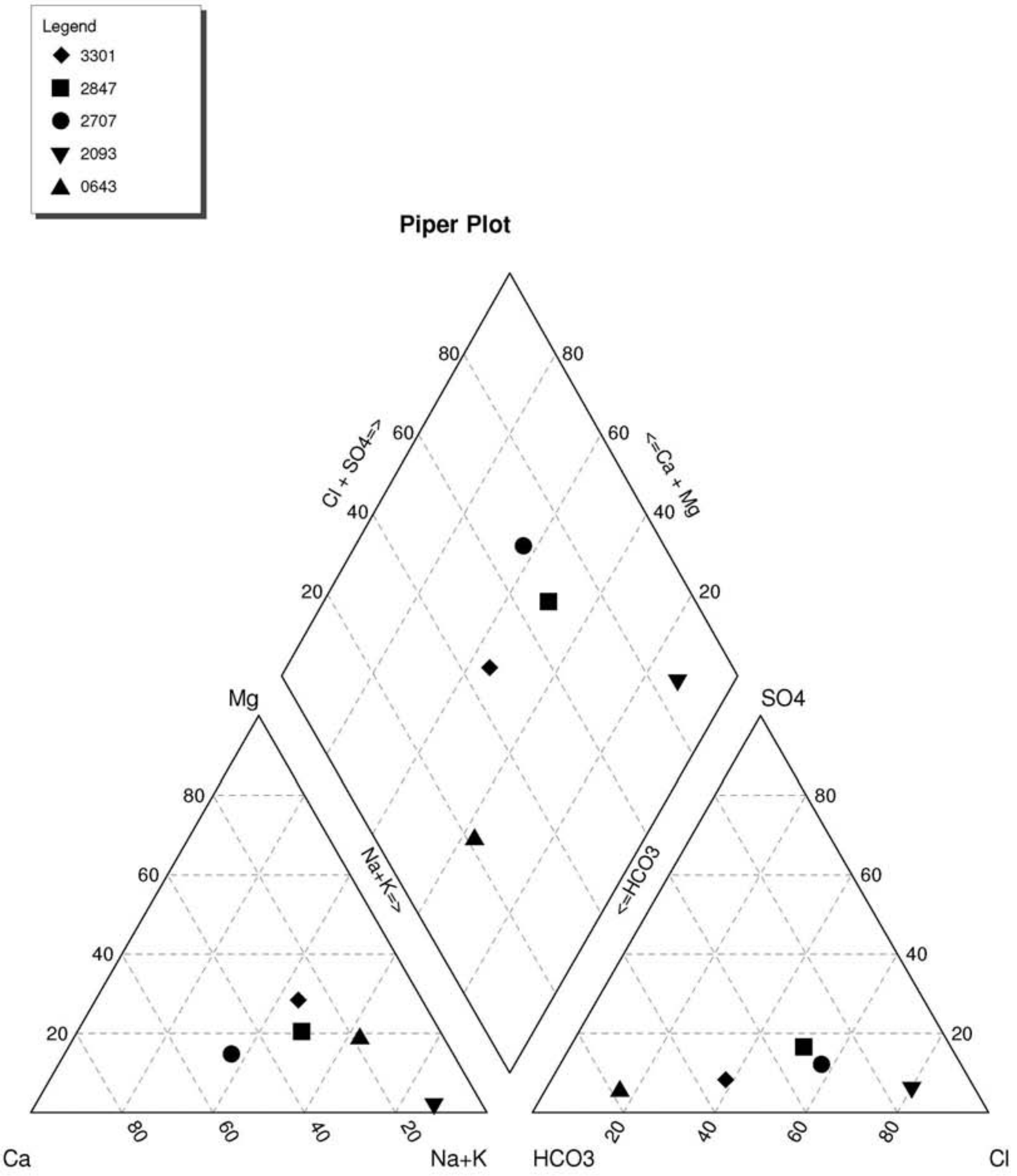

Well 3301
500
400
300
200
100
0
Cl, HCO3, and Na Concentration (mg/L)
Cond
HCO3
Cl
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)


Well 3301
40
30
20
10
0
Ca, Mg, Na, and SO4 Concentration (mg/L)
Na
Ca
SO4
Mg
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

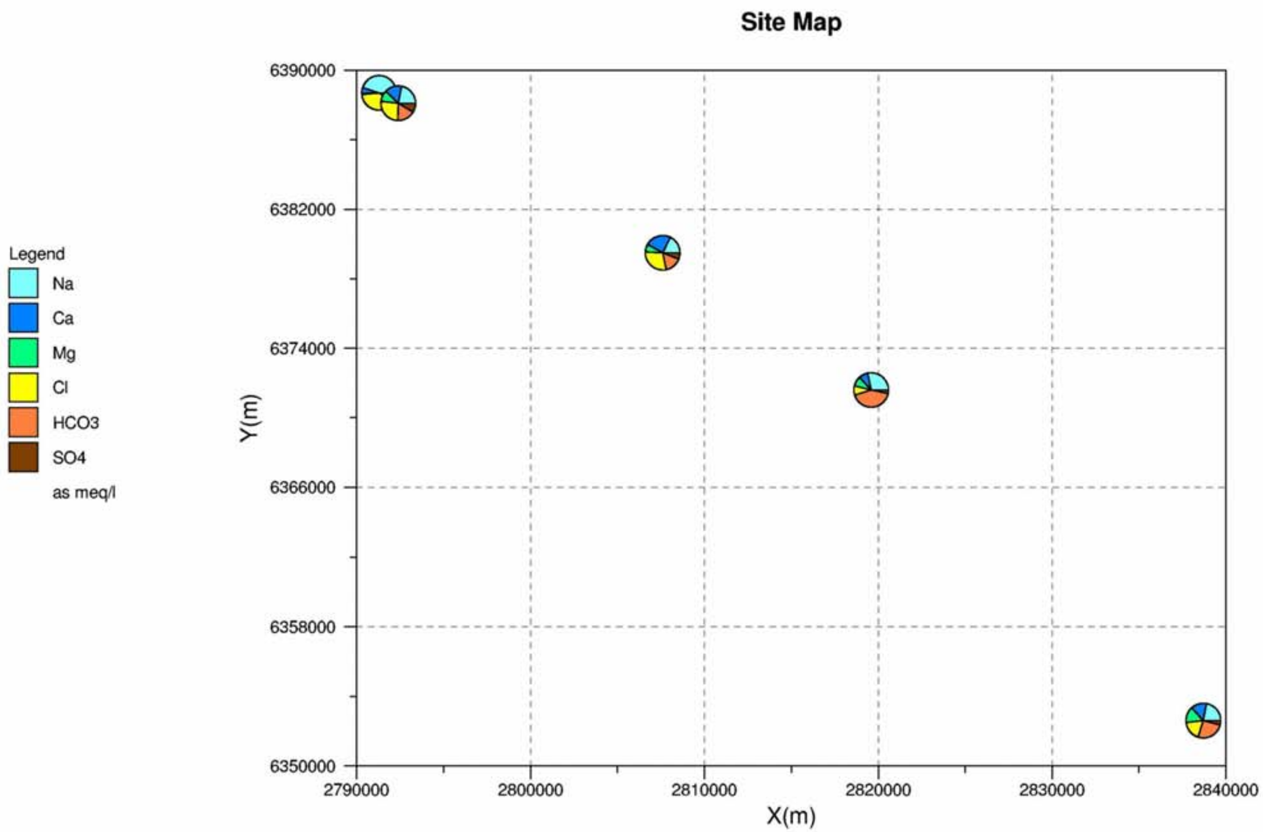

Well 3301
5
4
3
2
1
0
K, NO3-N, and Br Concentration (mg/L)
K
NO3-N
Br
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)


Well 4364
Cl, HCO3, and Na Concentration (mg/L)
250
200
150
100
50
0
Temperature (oC)
100
75
50
25
0
Mn and SO4 Concentration (mg/L)
4
3
2
1
0
Cl
Na
HCO3
Temp
Mn
SO4
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06
Time (Date)

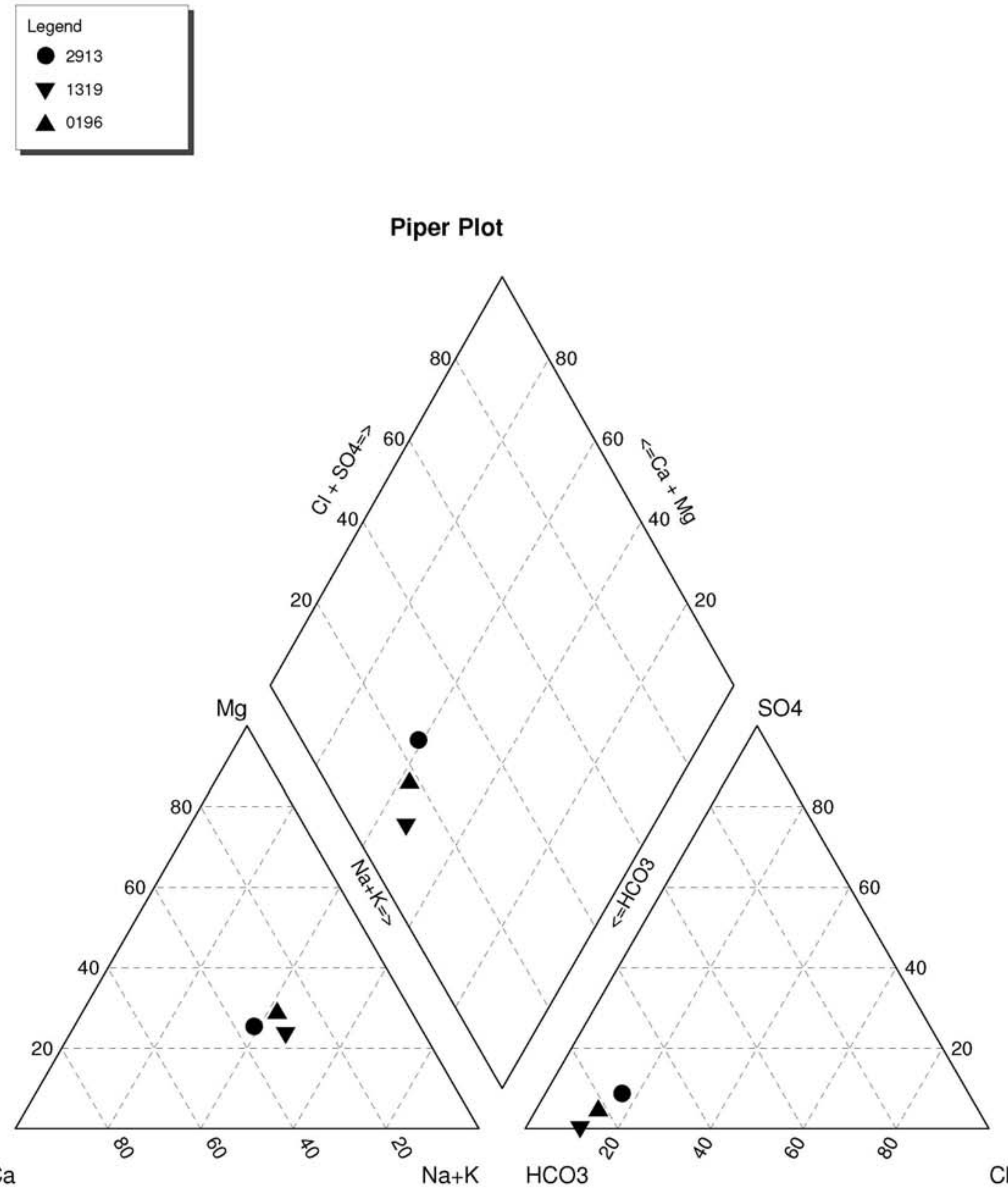
APPENDIX C – GROUNDWATER QUALITY PIPER AND PIE MAP PLOTS



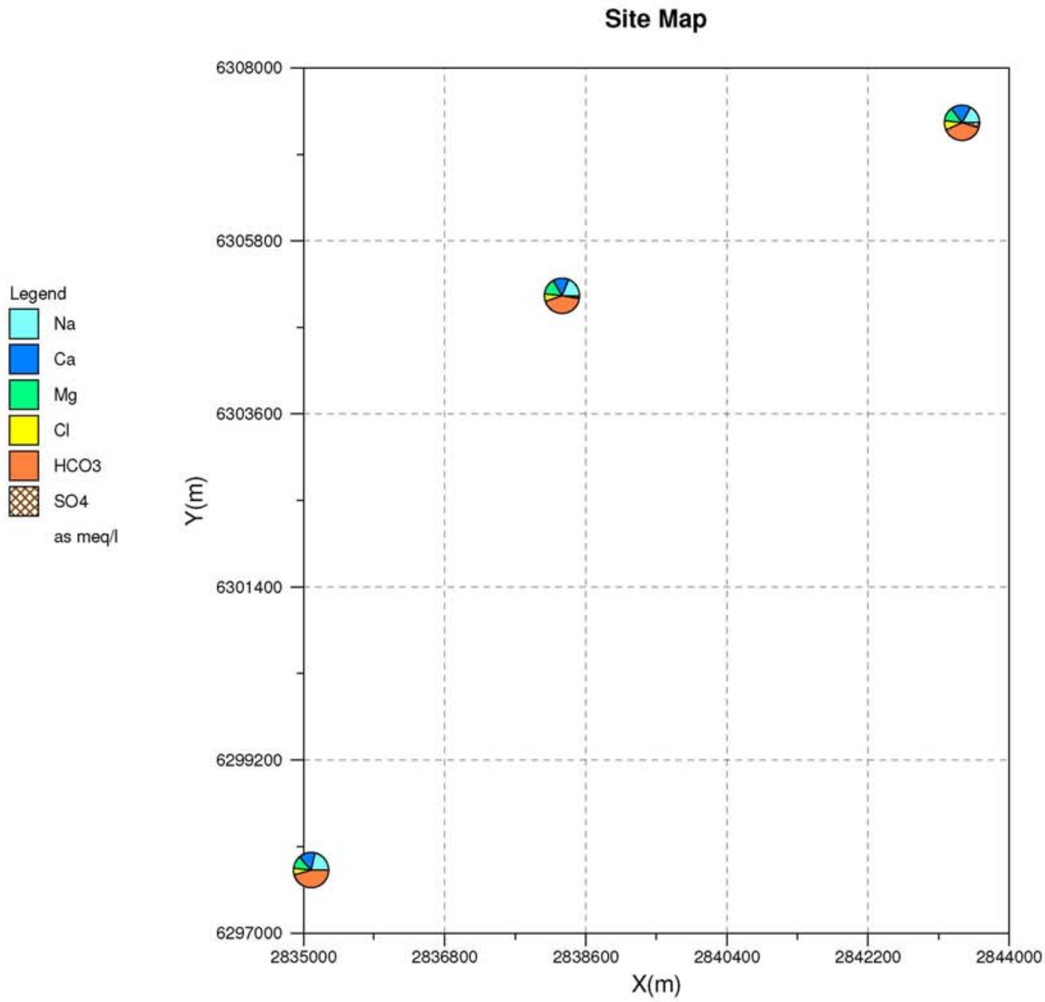
DESCRIPTION: Appendix C Figure 1P: Coastal Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



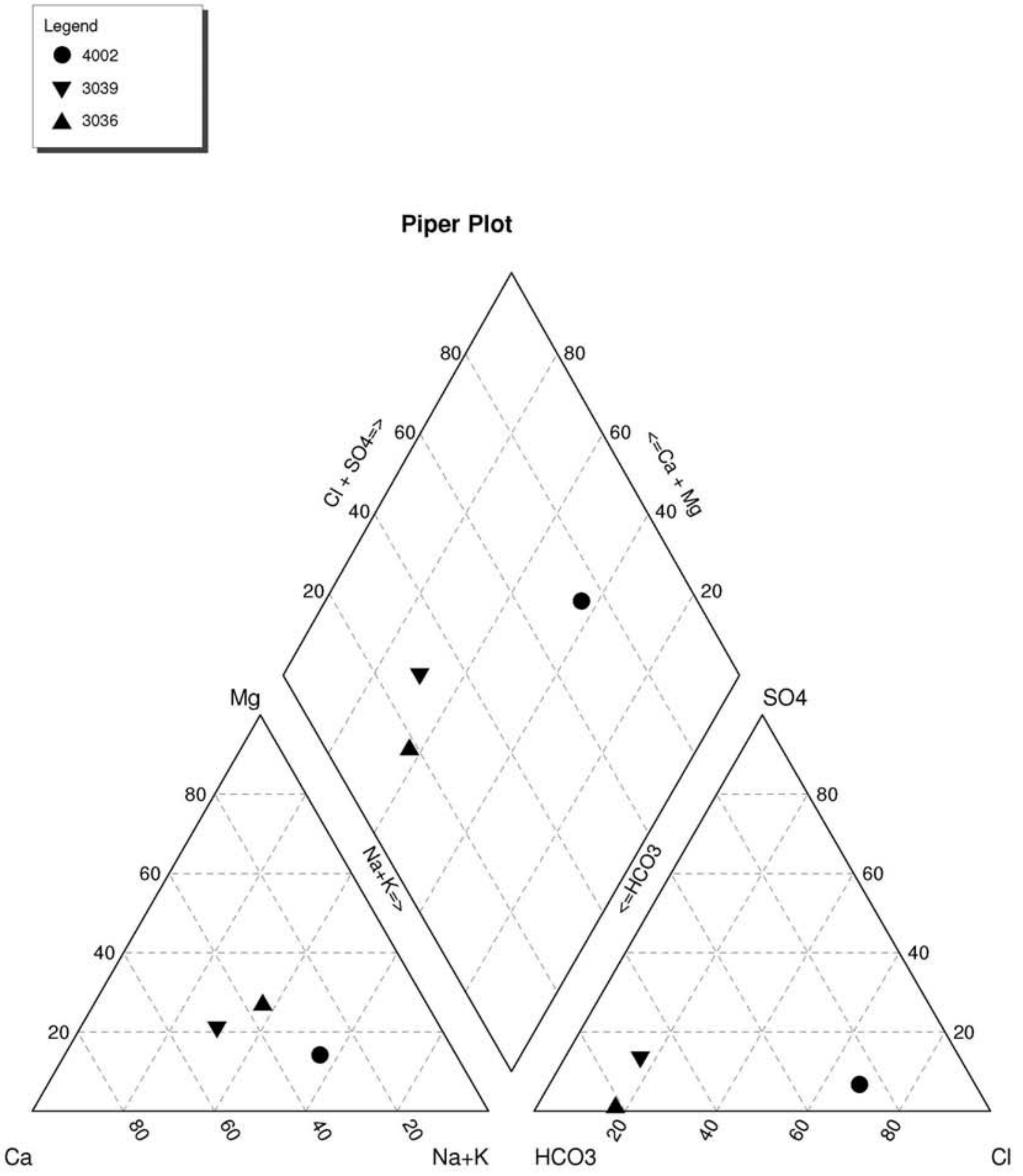
DESCRIPTION: Appendix C Figure 1M: Coastal Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



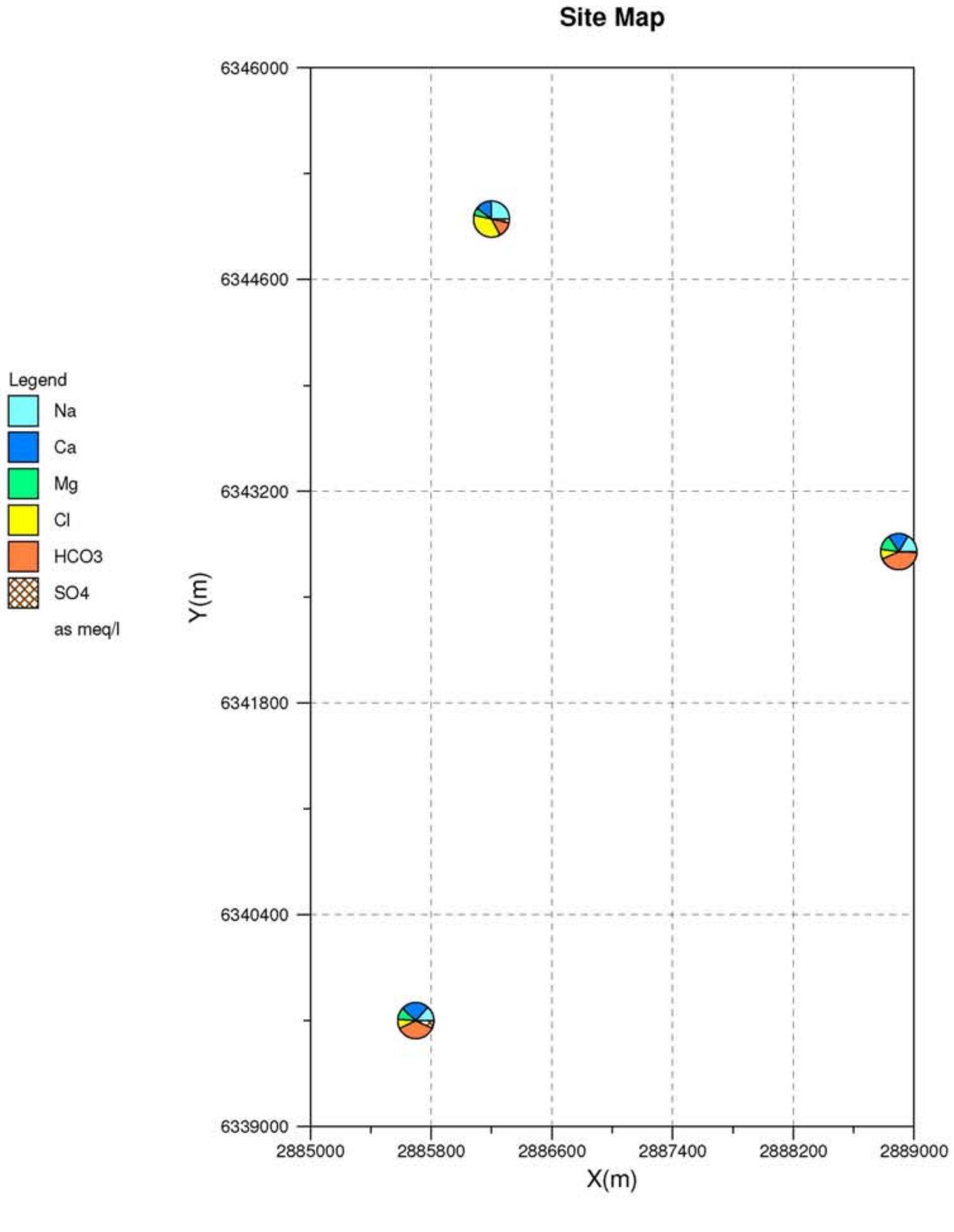
DESCRIPTION: Appendix C Figure 2P: Galatea Plain Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



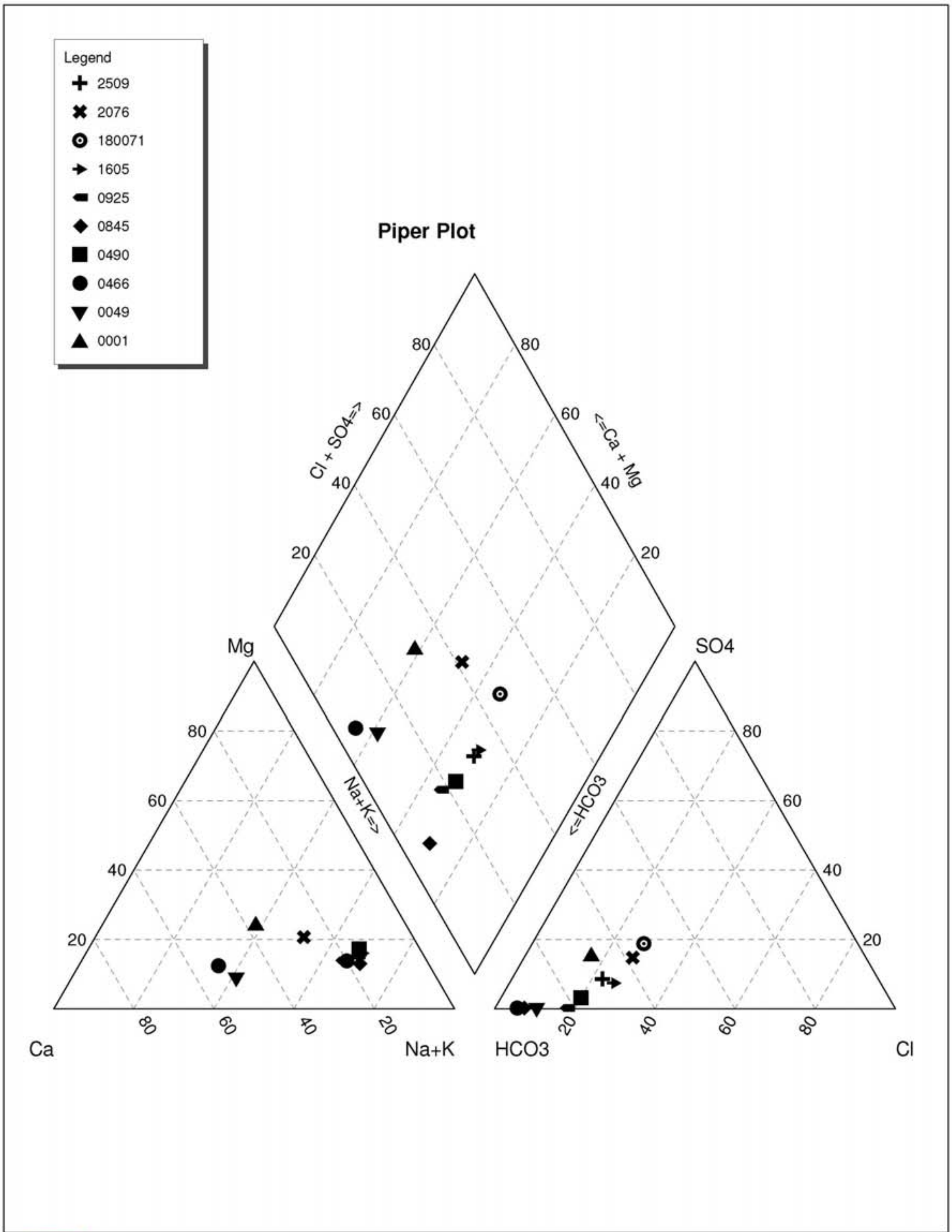
DESCRIPTION: Appendix C Figure 2M: Galatea Plain Area		
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127	
CLIENT: EBOP	DATE: Jun 06	



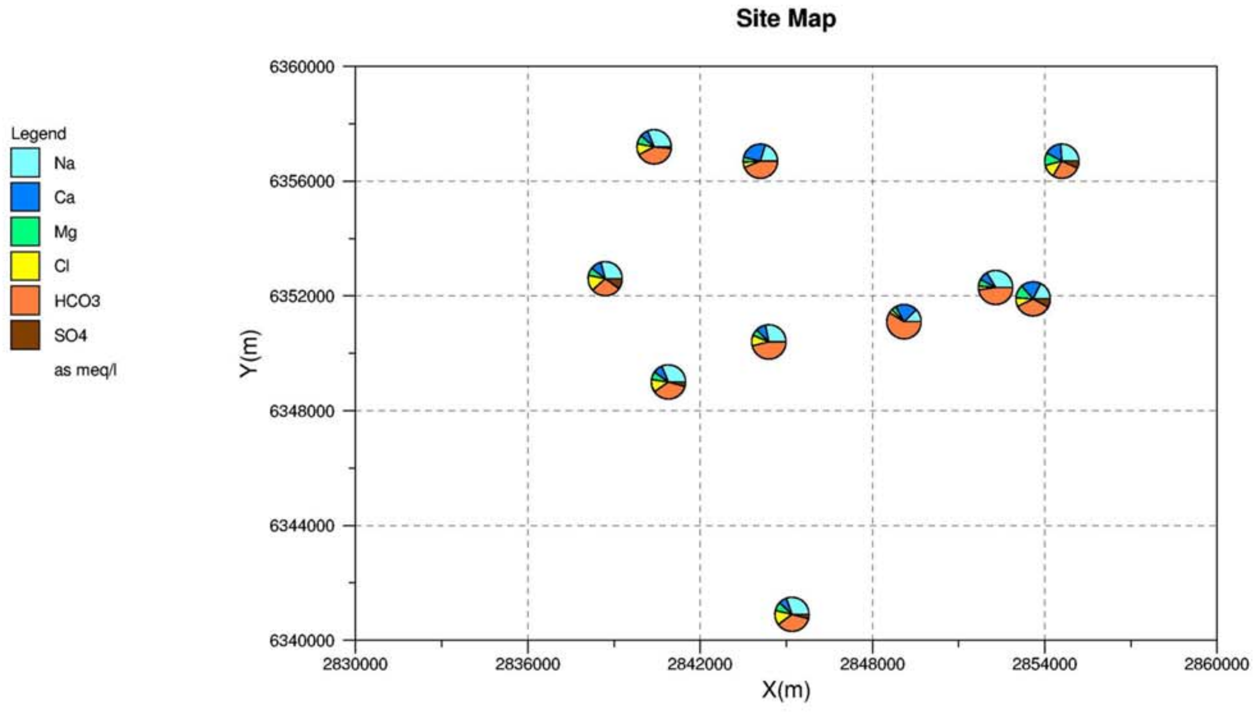
DESCRIPTION: Appendix C Figure 3P: Opotiki Plain Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



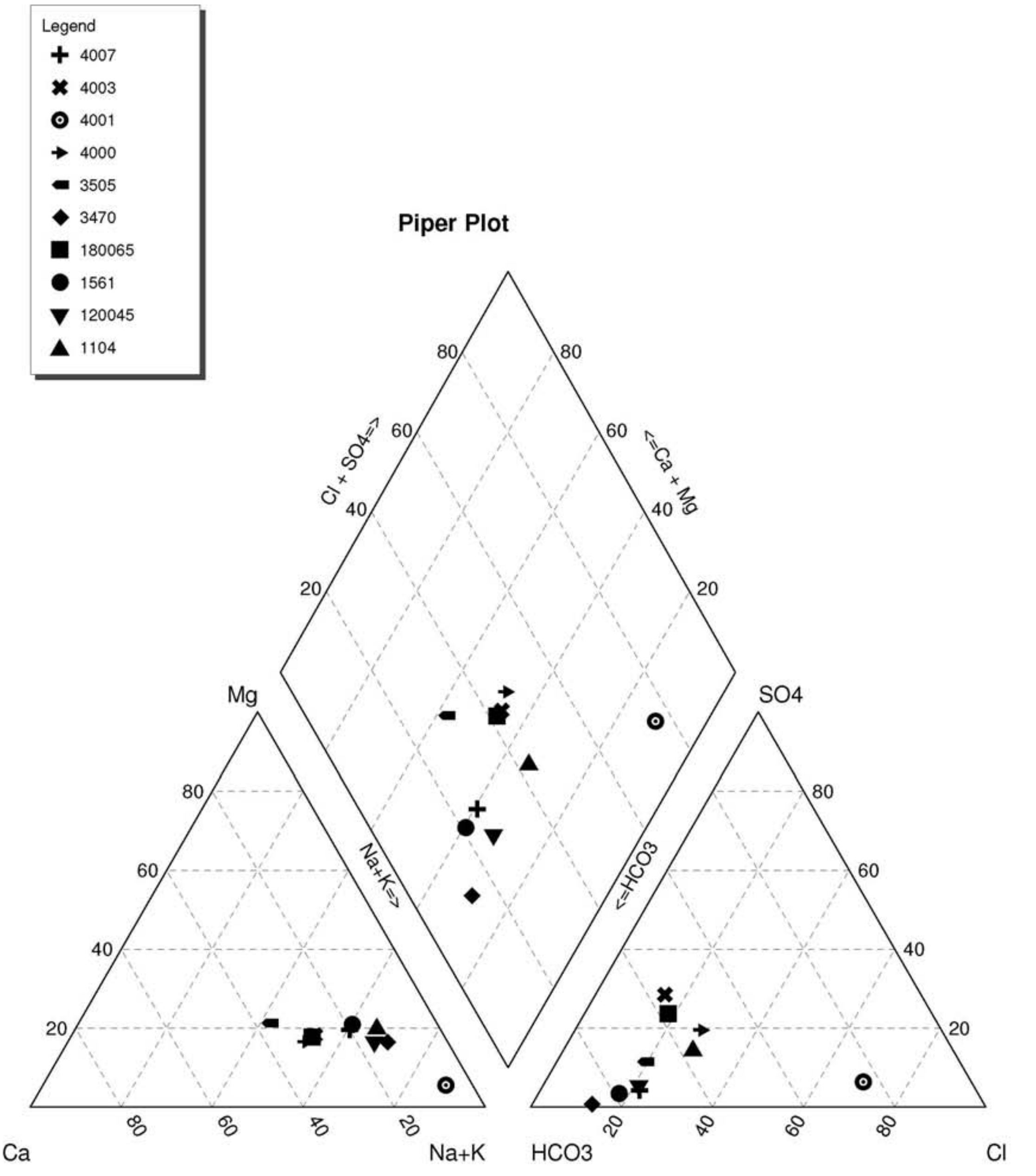
DESCRIPTION: Appendix C Figure 3M: Opotiki Plain Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



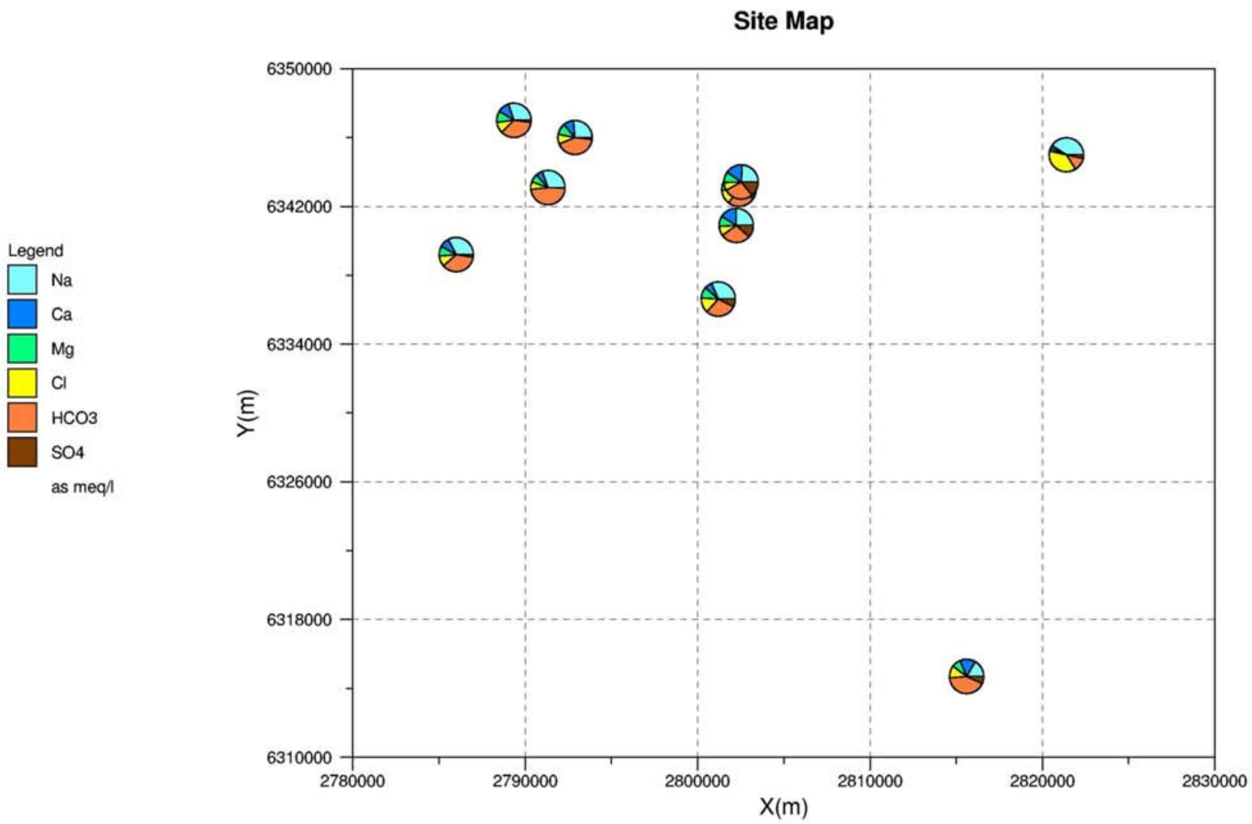
GNS SCIENCE TE PŪ AO	DESCRIPTION: Appendix C Figure 4P: Rangitaki Plain Area	
	PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
	CLIENT: EBOP	DATE: Jun 06



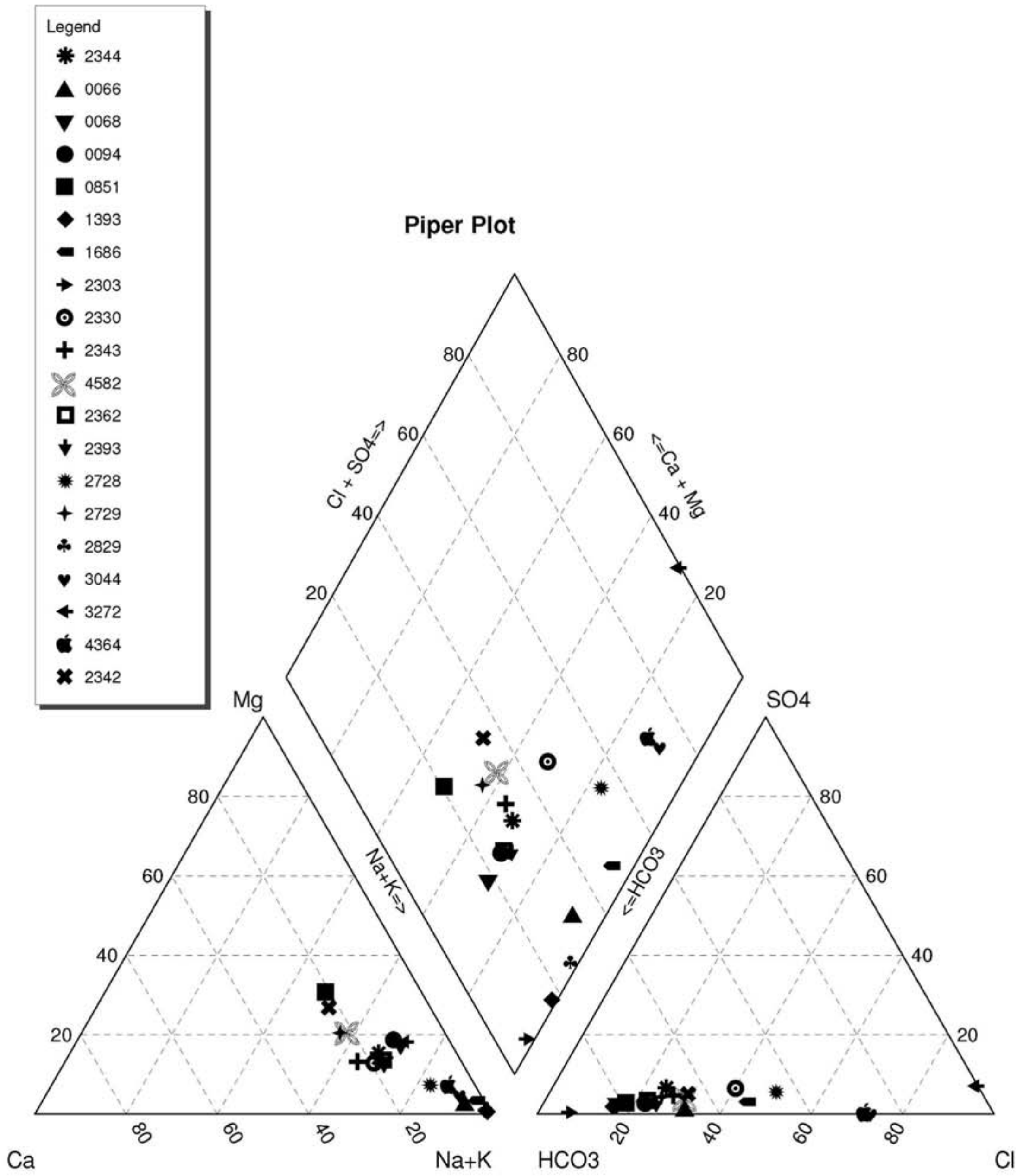
	DESCRIPTION: Appendix C Figure 4M: Rangitaki Plain Area	
GNS SCIENCE TE PŪ AO	PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
	CLIENT: EBOP	DATE: Jun 06



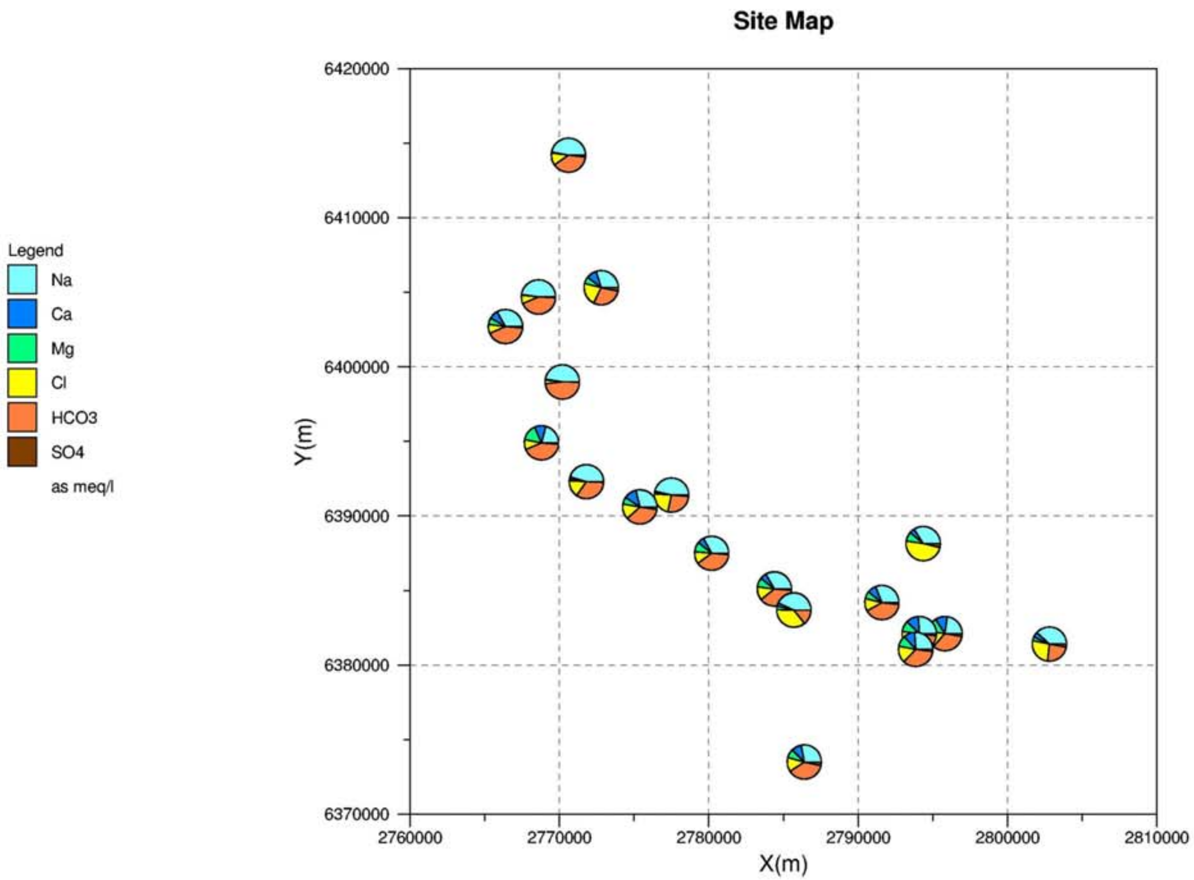
DESCRIPTION: Appendix C Figure 5P: Rotorua Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



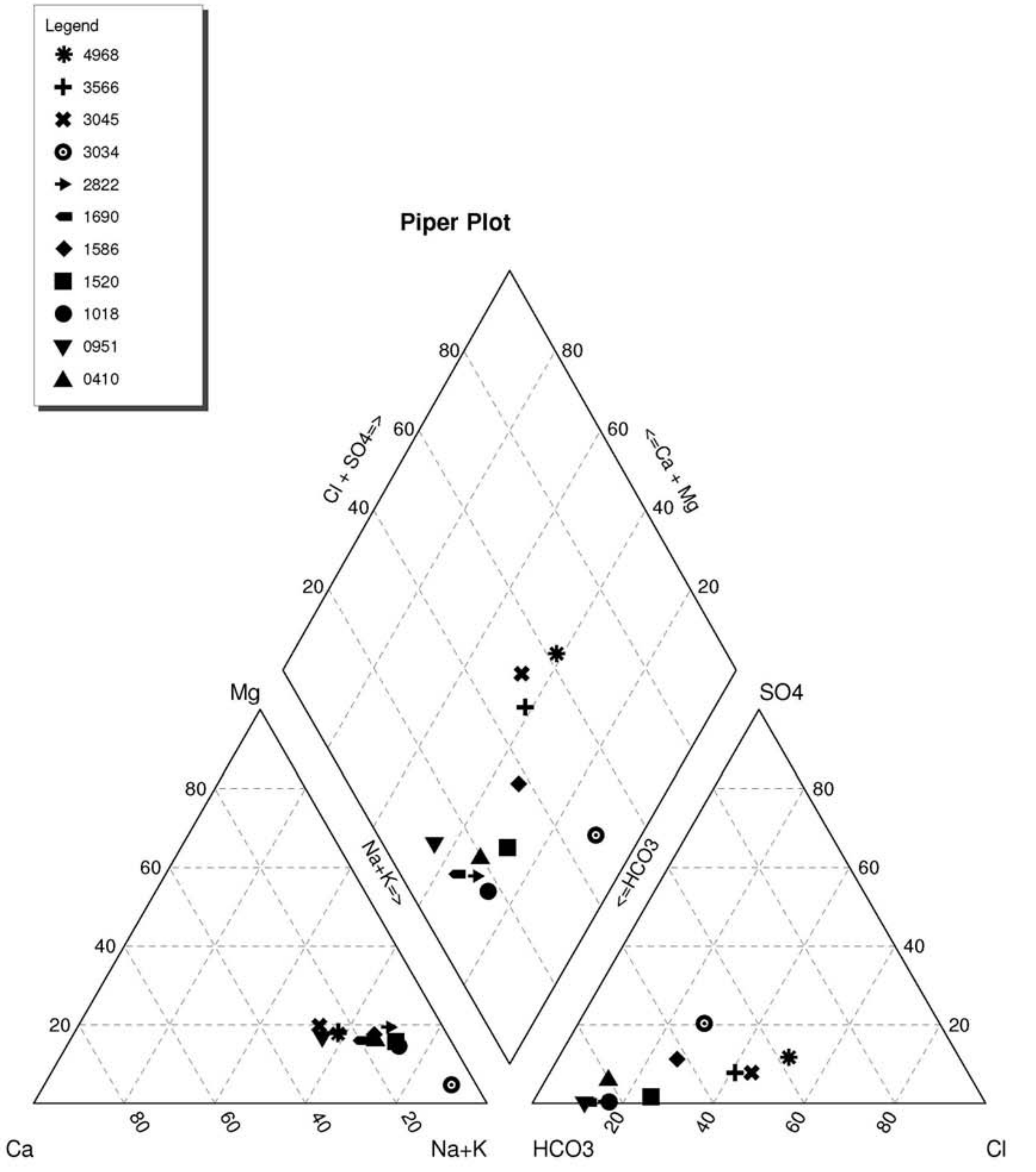
DESCRIPTION: Appendix Figure 5M: Rotorua Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Ju 06



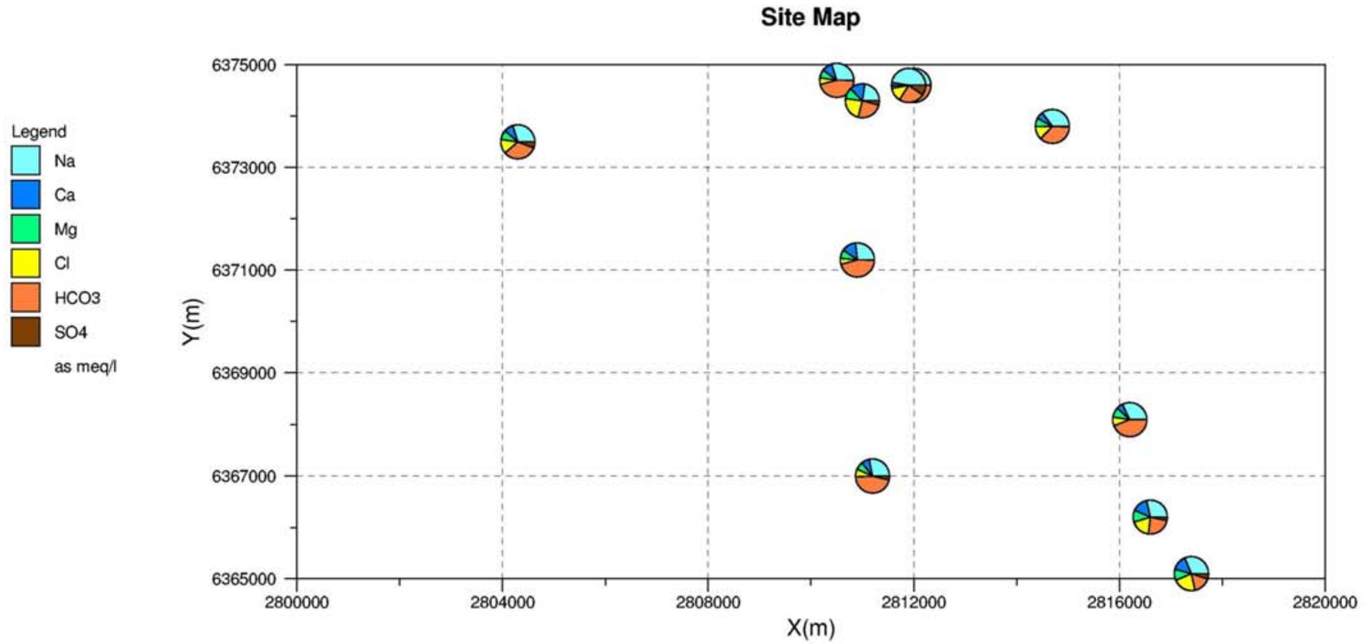
GNS SCIENCE TE PŪ AO	DESCRIPTION: Appendix C Figure 6P: Tauranga Area	
	PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
	CLIENT: EBOP	DATE: Jun 06



DESCRIPTION: Appendix C Figure 6M: Tauranga Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



DESCRIPTION: Appendix C Figure 7P: Te Puke - Maketu Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06



DESCRIPTION: Appendix C Figure 7M: Te Puke-Maketu Area	
PROJECT: EBOP State of the Environment	PROJECT NO: 520W2127
CLIENT: EBOP	DATE: Jun 06

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