Detecting mineralisation with hydrogeochemistry in western Victoria, Australia

by

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Summary

The discovery of shallow mineral deposits has slowed, the challenge for mineral exploration is now to find more deeply buried deposits, frequently beneath sedimentary rocks and the groundwater table. Groundwater has the potential to be a powerful exploration tool in this search due to the release of pathfinder elements during mineral dissolution, the ability to detect low concentrations of pathfinder elements in groundwater and the use of computer aided interpretations that facilitate the utilisation of larger datasets.

This study applies the above techniques to an area with thin sedimentary cover, numerous observation bores and proven potential for three mineralisation types: porphyry Cu-(Au-Mo), intrusion-related gold and orogenic gold. principal component analysis of data demonstrate associations between pathfinder elements and mineral occurrences as wells as spatial associations between geology and major ion ratios.

Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

1. Introduction

The field of hydrogeochemistry studies water-rock interactions for both surface and groundwaters. Water-rock interaction can result in a chemical signature that reflects interaction with specific minerals and/or rock types. Various elements show associations with specific types of mineralisation, these elements can be used as pathfinder elements to vector in on prospective rocks that are buried beneath groundwater bearing sedimentary rocks.

Associations between pathfinder elements and various mineralisation types have been demonstrated in Australia and the around world the (see e.g. Arne & Giblin, 2009; Eppinger, et al., 2013; Gray, et al., 2018; Leybourne & Cameron, 2010 and Wallace, et al., 2018). These associations are largely interpretive and without statistical validation. Statistical validation is complicated by ambient groundwater chemistry effecting the concentration of pathfinder elements. Associations with electrical conductivity (EC), pH, dissolved oxygen (DO), oxidation-reduction potential (redox) are common. Results from the hydrogeochemical survey are segmented into associations with mineralisation and associations with ambient groundwater chemistry through the application of principal component analysis (PCA).

The study area is located within the Grampians-Stavely zone, western Victoria, Australia, Figure 1. Multiple phases of mining and mineral exploration have occurred within the Grampians-Stavely zone including the Moyston and Mafficking Goldfields in the 1800's, Thursdays Gossan in the 1970's, and Stavely in 2010's (Schofield, et al., 2018). Three mineralisation types are known to be present in the region: porphyry Cu-(Au-Mo), intrusion-related Au and orogenic Au. Mineral exploration to date has been concentrated in areas of outcrop whilst the clear majority the mineralised rock is buried beneath thin cover and alluvial aquifers. An increasing appetite to explore under cover in combination with an improved ability to use hydrogeochemistry analysis for exploration mean that it is now a good time to test these methods within the Grampians-Stavely zone.

This report describes the methodology employed and analytical results of a hydrogeochemistry orientation survey in the study area. The main objectives of this study are to:

1. Collect a comprehensive hydrogeochemistry database collected from the existing observation bore network and surface water bodies.
2. Apply principal component analysis to the data to analyse and assess the association between groundwater processes and trace element chemistry and to assess the relevance of published mineral pathfinder elements in the Grampians-Stavely zone and any geologic/geographic associations to trace element chemistry.
3. Incorporate the findings from PCA into the interpretation of geology, mineral occurrences and hydrogeochemistry.

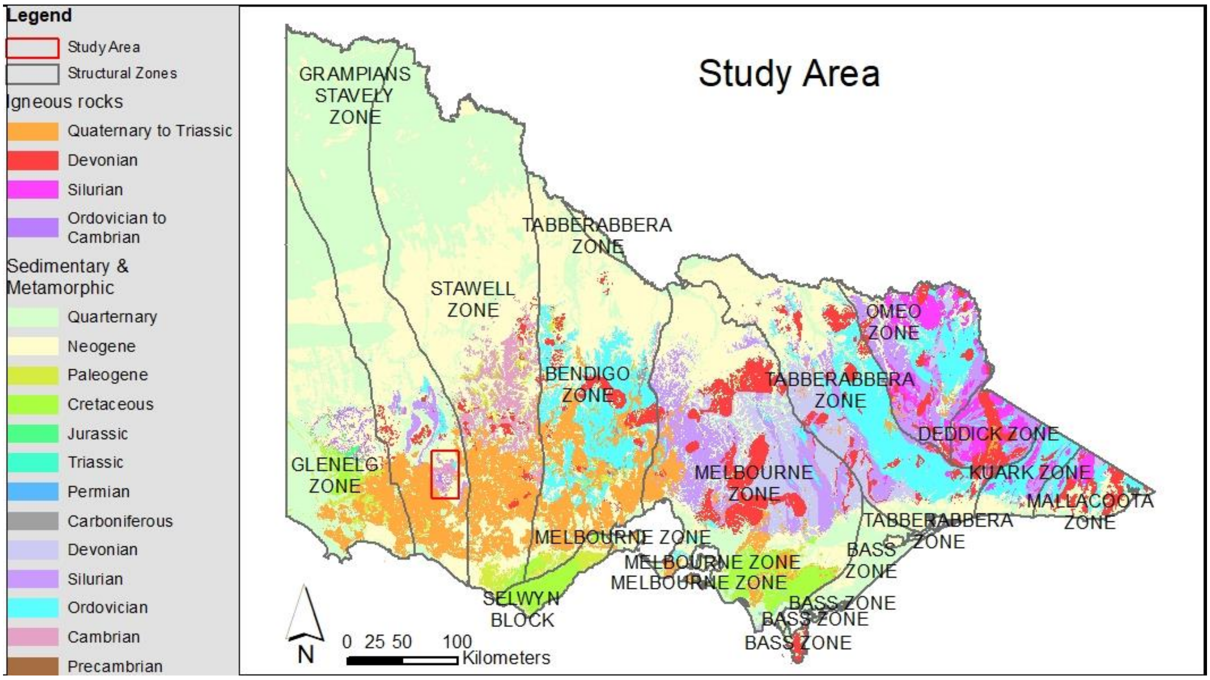


Figure 1. Geological map of Victoria, Australia showing the Study Area (red rectangle) and the structural zones (black lines). The study area is located within the Grampians-Stavely Zone, in western Victoria, Australia. The structural zones control the types of mineralisation present. Geology after (Welch, et al., 2011). Structural zones after (Vandenberg, et al., 2000).

1.1. Study Area

The study area is in the southeast of the Grampians-Stavely zone, western Victoria, Australia. The area is 65 km from north to south, and 35 km from east to west, Figure 2. Groundwater observation bores are located throughout the study area where they are used for monitoring groundwater levels and salinity by the Department of Environment, Land, Water and Planning.

The study area is bound by Lake Bolac to the east, the Grampians Ranges to the west, the township of Moyston to the north and Caramut to the south. The major land uses are mixed agricultural cropping and livestock. The climate is Mediterranean, with dry summers and wet winters. Average annual precipitation is about 600 mm, precipitation decreases northwards and in the rain shadow east of the Grampians ranges (BOM, 2019). Groundwater salinity is a prominent feature driven by evapotranspiration exceeding precipitation in the rain shadow and to the north. Elevation ranges from 150 m in the south to 400 m.AHD the north with sporadic peaks reaching higher including the Grampians Ranges reaching up to 1168 m.AHD to the west, Figure 6.

The study area contains (poorly) exposed Cambrian bedrock, including prospective rocks of the Stavely Arc, known mineral occurrences for base metals and precious metals, historical gold workings, multiple aquifers, state government observation bores and active surface water drainage. This makes the study area suitable for delineating mineral occurrences with hydrogeochemistry. The thickness of alluvial sedimentary cover increases to the north and south of the study area. There are numerous mineral occurrences in outcropping crystalline basement and potential for more discoveries beneath sedimentary cover, Figure 2.

Eighty-seven groundwater and surface water samples were collected during 2016 & 2017 in association with the Victorian Geological Survey (O'Neill, et al., 2018). The groundwater samples were obtained from State Observation Bores and surface water samples were collected from the baseflow in streams after a period of no rain. They may collectively reflect the hydrogeochemical signature of groundwater at various distances from mineral occurrences and within unaltered surrounding rock. The data set contains field chemistry (Appendix A), major ions (Appendix B), trace elements (Appendix C), precious metals (Appendix D) and interpretations of crystalline basement geology (Appendix A).

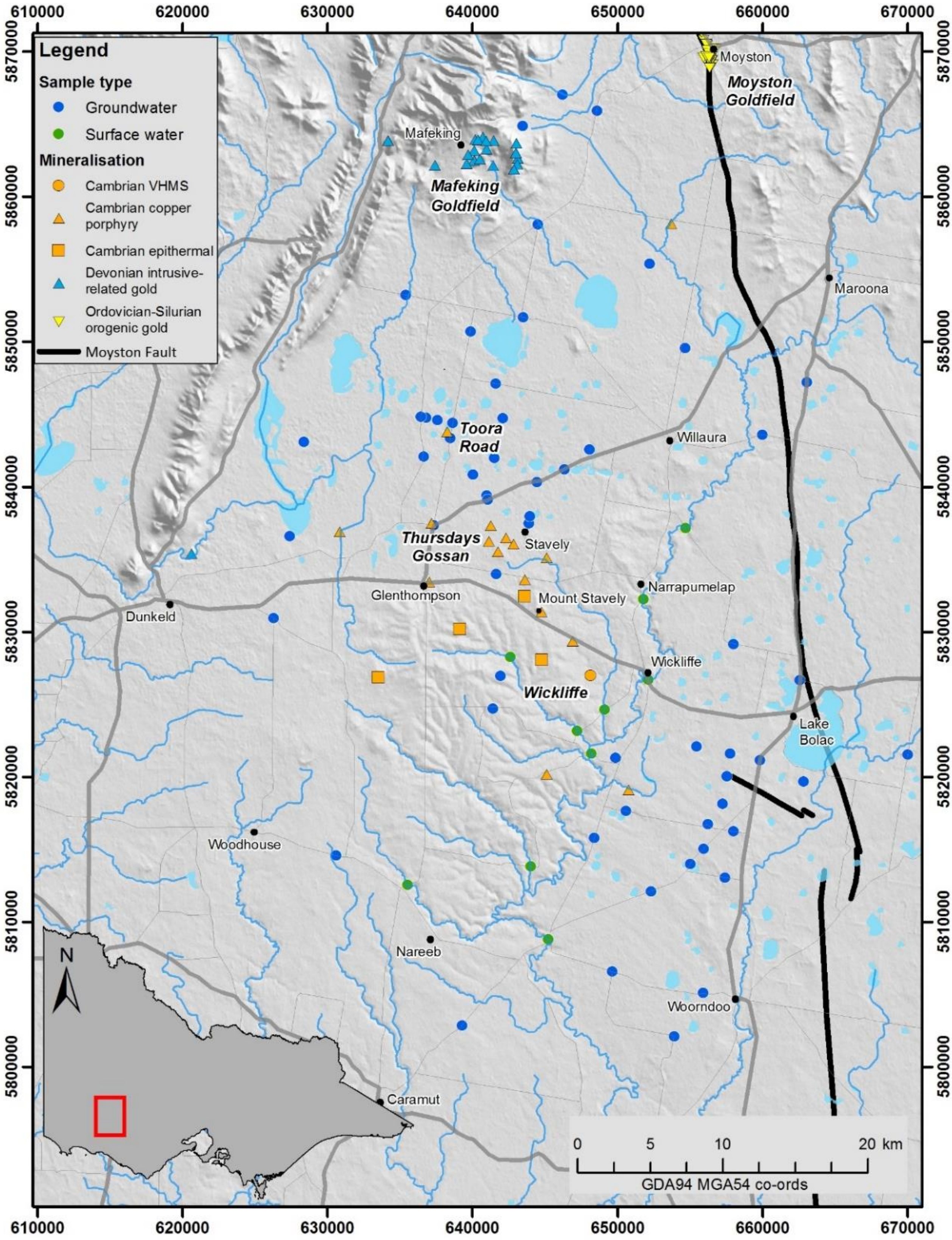


Figure 2. Location map for the study area within the Grampians-Stavely zone. Surface water and groundwater sample points are indicated in green and blue. Mineral occurrences in the study area after (Schofield, et al., 2018). Mineral occurrences labelled for geographic reference include the Moyston Goldfield, Mafeking Goldfield, Toora Road Prospect, Thursdays Gossan Prospect and the Wickliffe Prospect.

2. Background

2.1. Hydrogeochemistry

The groundwater flow regime influences the dispersion of pathfinder elements with the area of dispersion, typically larger, than the area of mineralisation. Some pathfinder elements are more mobile and disperse more readily, while other elements may adsorb more strongly to aquifer material and are immobile. Mobile elements such as SO_4^- and Cl^- can be detected several km down flow of the source (Caritat & Kirste, 2005). Elements such as arsenic (As) and molybdenum (Mo) can also travel long distances but become too dilute for detection due to their naturally lower concentrations and are detected near the mineral source (Caritat & Kirste, 2005). Proximal elements such as Cu and Pb are detected closer to the mineral source as they readily bond with colloidal matter and are naturally low in concentration (Caritat & Kirste, 2005).

Weathering of minerals is typically required to release trace elements into groundwater. This can occur effectively through oxidation in shallow oxygen rich groundwaters, however, dissolution reactions which release pathfinder elements may also occur under anoxic conditions. Examples are the reduction of iron oxides under progressively reducing conditions or the oxidation of pyrite under progressively oxidising conditions. Thus, local groundwater flow and redox conditions can significantly influence the concentration of trace elements in groundwater.

2.2. Geology

2.2.1. Palaeozoic

The regional geology and mineralisation of the Grampians-Stavely Zone and surrounds, including the Stavely Arc, is most recently summarised in Schofield et al., (2018) with a regional 3D geological model presented in Cayley, et al., (2018).

The Grampians-Stavely Zone is a diverse range of volcanic and intrusive rocks associated with the Stavely Arc, Figure 3. The Stavely Arc is a Cambrian magmatic arc system which developed on the eastern margin of the Delamerian Orogen (Schofield et al., 2018)

The Stavely Arc includes nineteen discrete but discontinuous steeply-dipping Cambrian-aged volcanic belts, 2 to 5 km wide and up to 150 km long, Figure 3. The present-day distribution of the nineteen volcanic belts is the product of multiple deformation events.

Volcanic belts of the Stavely Arc are separated by Cambrian metasedimentary rocks of the Nargoon Group and Glenthompson Sandstone (Cayley et al., 2018 & Schofield et al., 2018). The volcanic belts outcrop poorly but are exposed in the middle of the study area near Willaura. The narrow, north-trending, fault-bound volcanic belts typically comprise mafic to felsic volcanic and intrusive rocks collectively assigned to the Mount Stavely Volcanic Complex (Schofield et al., 2018). Around 500 Ma the Stavely Arc, and associated metasedimentary rocks were folded, faulted, and locally tilted to sub-vertical during the Delamerian Orogeny (Cayley et al., 2018 & Schofield et al., 2018).

The Cambrian bedrock is viewed as the major prospective exploration target with younger rocks being emplaced post mineralisation. Younger rocks include: sediments of the Ordovician to Silurian Grampians Group, Devonian granite intrusions and the associated felsic volcanic rocks of the Rocklands Volcanic Group.

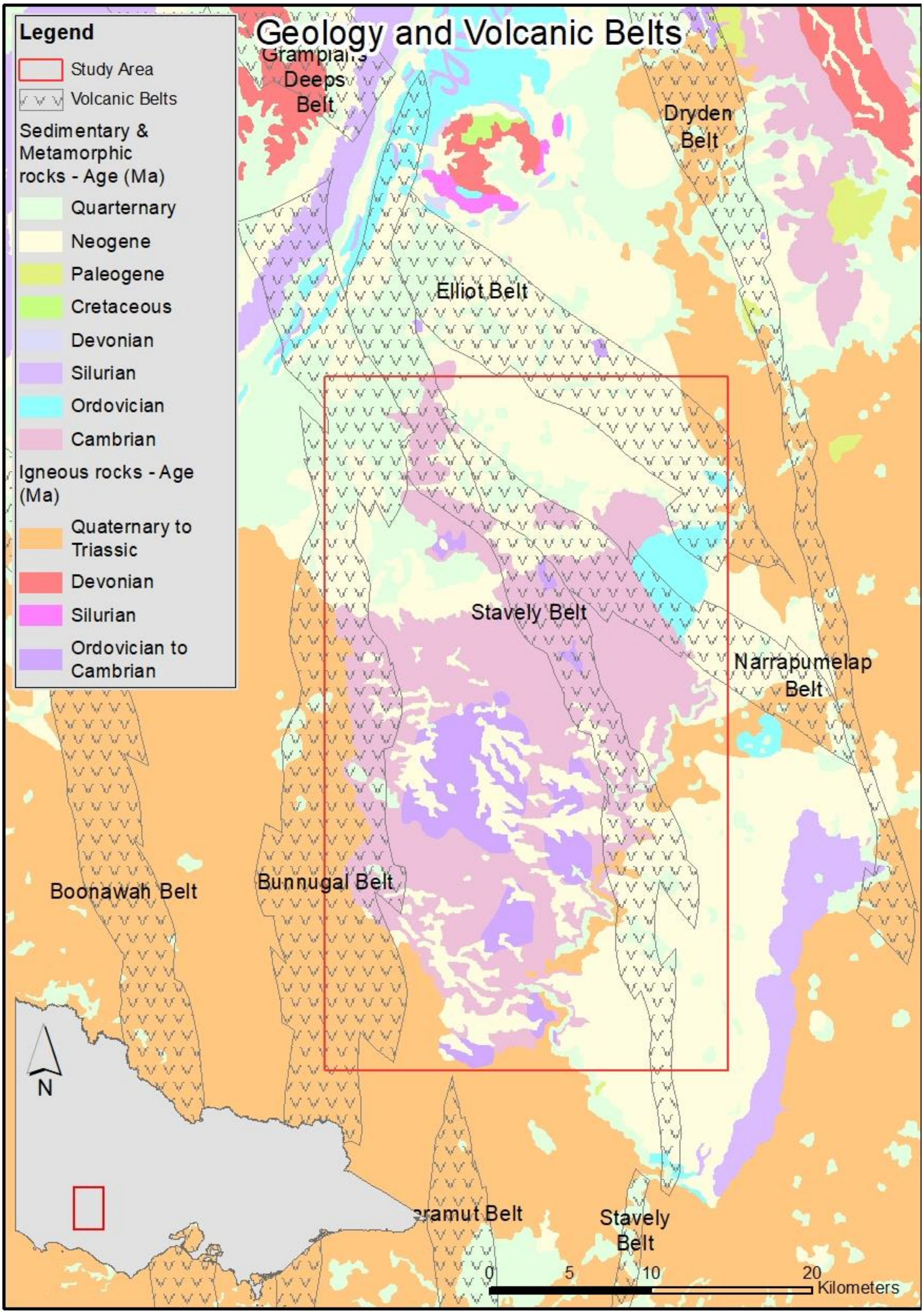


Figure 3. Surface geology for the study area with the interpreted extent of the Stavely Arc outlined by the V hatch. Note the limited extent of outcropping Stavely Arc (purple) and the significant extent of Stavely Arc buried beneath Cainozoic cover. Surface geology is 1:250,000 Seamless Geology (Welch, et al., 2011). The Stavely Arc after (Skladzien, 2018).

2.2.2. Cenonozoic

Aquifer bearing lithologies are dominantly Cainozoic. These include unconsolidated fluvial to shallow marine Cainozoic sediments of the Murray and Otway basins, Neogene to Quaternary basalt flows and up to a 10 m thick veneer of recent alluvial and colluvial cover. The Cainozoic thickness varies from 0 to 100 m within the study area. The geology of the Murray Basin to the north is summarised in Brown and Stephenson (1991) and the Otway Basin to the south in Woolands and Wong (2001). Generalised stratigraphy and hydorstratigraphic units are depicted below Figure 4.

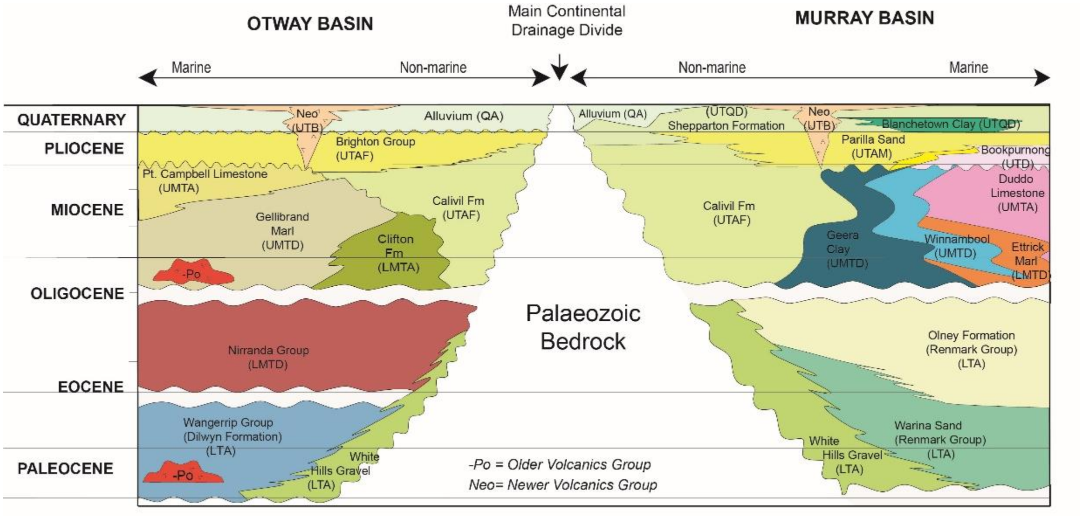


Figure 4. Generalised Cainozoic stratigraphy for the study area after (Cayley & Taylor, 2001) with hydrostratigaphic units defined by (GHD, 2012).

2.3. Hydrogeology

The four main aquifers present within the study area are the: Quaternary Alluvium, Upper Cainozoic Basalt, Upper Cainozoic Fluvial Aquifer and Lower Cainozoic Aquifer. The extent of these aquifers is presented in Figure 5. All four aquifers onlap Cambrian basement at various points and all four have tested positive for pathfinder elements.

2.3.1. Quaternary Alluvium (QA)

The QA contains low salinity groundwater at the foot slopes of the Grampians Ranges, this water is utilised by Grampians Wimmera Mallee Water and local domestic users for supply purposes. Down gradient and in groundwater discharge sites the EC can increase to 22,000 µS/cm.

2.3.2. Upper Cainozoic Basalt (UCB)

The UCB groundwater varies in EC from 2,500 – 25,000 µS/cm. It is freshest near outcropping basalt cones and becomes saltier down gradient.

2.3.3. Upper Cainozoic Aquifer Fluvial (UCAF)

The UCAF groundwater is widely used for stock and domestic bores. Groundwater salinity and yield varies. In general, groundwater salinity increases downgradient as water flows away from the catchment divide and the Grampians Ranges. In the study area typical groundwater EC ranges from <1000 µS/cm to 30,000 µS/cm near groundwater discharge lakes.

2.3.4. Lower Cainozoic Aquifer (LCA)

The Lower Cainozoic aquifer groups together with the White Hill Gravel, Dilwyn Formation and Renmark Group. In the study area it is distinguished by fine to large sand lithologies with minor coal bands and clay. Regionally, groundwater salinity increases downgradient from the catchment. In general, groundwater in the study area ranges in EC from 1,800 µS/cm to 10,500 µS/cm down gradient and yield varies.

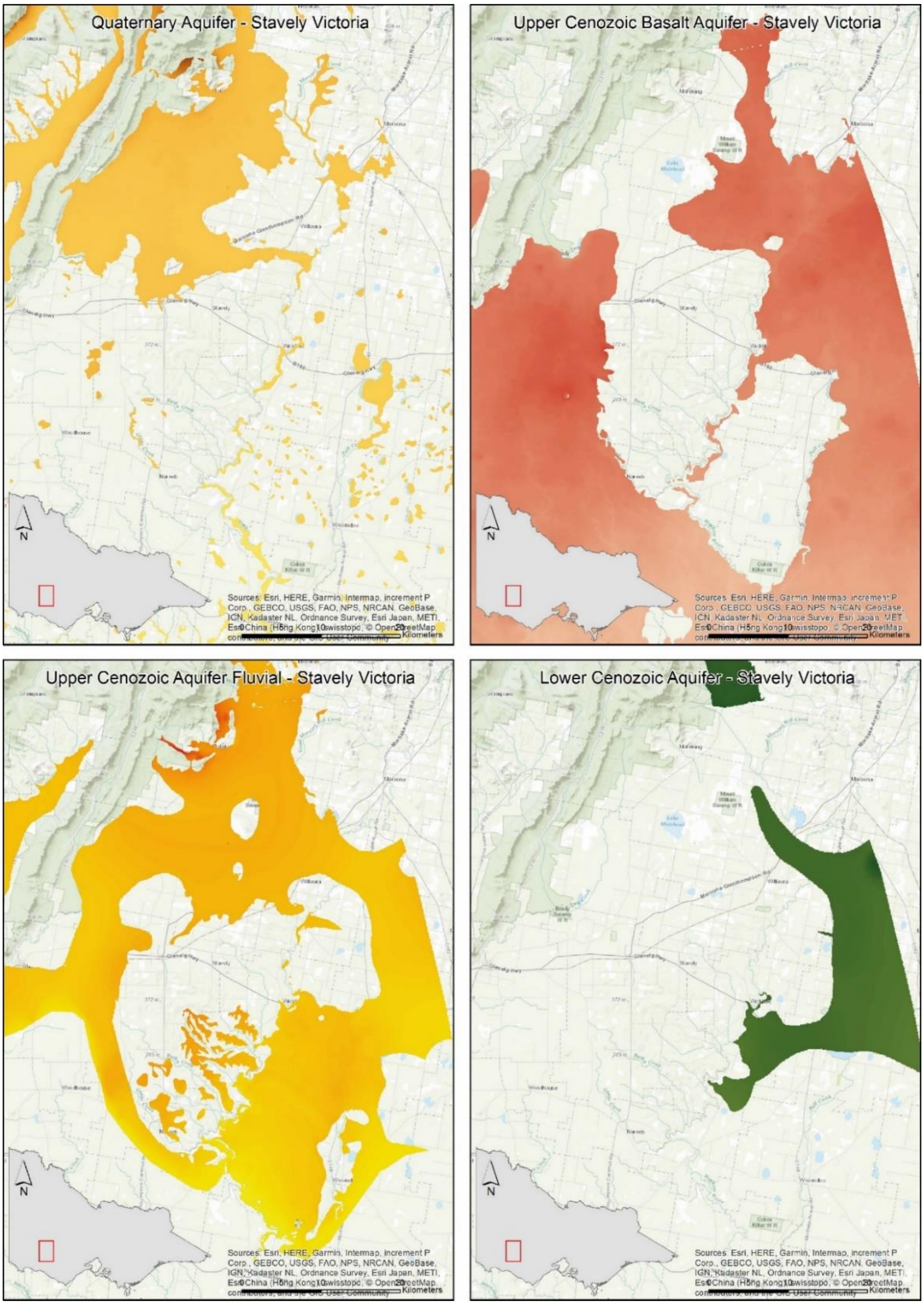


Figure 5. Aquifers sampled during the study. Clockwise from top left: Quaternary Aquifer, Upper Cainozoic Basalt, Upper Cainozoic Aquifer Fluvial, Lower Cainozoic Aquifer. Aquifers extent defined by (GHD, 2012).

2.4. Mineralisation

A summary of the main mineralisation types in the study area is presented below. A review of hydrogeochemistry work relating to these mineralisation types is also provided. Key pathfinder elements for each mineralisation type are provided in Table 1.

2.4.1. Porphyry Cu-(Au-Mo)

Several porphyry Cu-(Au-Mo) prospects occur centrally in the study area. The two most well-known are Thursday's Gossan and the Junction prospect (Cairns, et al., 2018 and Schofield et al., 2018).

Prior work

A pilot research project examined hydrogeochemical outliers associated with the Spence porphyry Cu deposit in Chile. Concentrations of As, Se, Re and Mo were elevated in groundwater 2 km down flow of the deposit (Cameron et al., 2002; Cameron & Leybourne, 2005; Leybourne & Cameron, 2006).

More recent studies detected outliers of Cu, Mo, and Ag concentrations within ponds, seeps and streams using HR-ICP-MS (Eppinger et al., 2013). Samples were collected proximal to near surface sulphide-bearing mineralised rocks at the giant Pebble porphyry Cu-(Au-Mo) deposit in Alaska. The concentration of pathfinder elements decreased in association with increasing sedimentary cover thickness.

2.4.2. Orogenic gold

Orogenic Au mineralisation in the east of the study area include the quartz reefs at Moyston and eroded products that have been deposited within the White Hills Gravels (Cayley and Taylor 2001)

Prior work

Arne and Giblin (2009) collected over 1100 water samples throughout central Victoria, Australia with the aim of identifying orogenic Au mineralisation. Water samples were collected from bores, mineral exploration holes and surface water bodies. Analysis for pathfinder elements included Ag, Au, As and Sb. Gold was found to be the best pathfinder element for orogenic gold mineralisation and an association was suggested for Au with As.

The study focussed on the Stawell and Bendigo zones to the east of the current study area. Eight water samples were collected from the current study area and these are concentrated around the Moyston Fault which hosts the orogenic Moyston goldfields. Porphyry Cu-(Mo-Au) and intrusion-related Au mineral occurrences were not tested.

Arne & Giblin (2009) suggested outlier values for the Stawell zone of 50 ng/l for Au and 3 µg/l for As. It is not apparent that these values apply to the study area due to the differing styles of mineralisation.

2.4.3. Intrusion-related gold

Intrusion related Au mineralisation is present at Mafeking in the northwest of the study area and is likely related to the Early Devonian Mafeking Granodiorite (Cayley & Taylor, 1997). The Nekeeya Gravel, now considered the equivalent of the White Hills Gravel (Cayley pers comms, 2018), hosts alluvial Au that appears to be sourced from the Mafeking Granodiorite (Cayley & Taylor, 1997).

Molybdenum and other base metals are associated with some of the other Early Devonian intrusions (and volcanics) in the region (see Cairns et al., 2018 for a summary of known prospects).

Prior work

Studies elsewhere have shown hydrogeochemical outliers associated with intrusion-related Au deposits (Carey, et al., 2003 & Mueller, et al., 2003). Outliers include: Au (10–52 ng/l) at the St. Ives camp, Western Australia (Carey et al., 2003) and As 3.5 – 7.7 µg/l and Sb. – 4.1 µg/l at the Donlin Creek Gold Deposit, Southwest Alaska (Mueller et al., 2003).

At the St Ives camp, groundwater was sampled on a 1 km grid from boreholes intersecting transported cover. At Donlin Creek, water samples were taken from surface water bodies, seeps and bores.

Table 1. Summary of key hydrogeochemical pathfinder elements from the literature for styles of mineralisation targeted in the study area.

Deposit type	Main pathfinders	Secondary pathfinders	Reference(s)
Porphyry Cu ± Au ± Mo	Distal – As, Mo, Re, Se Proximal - Cu	Pb, Zn	(Leybourne & Cameron, 2010)
Porphyry Cu ± Au ± Mo	Distal – As, Mn, Mo, V Proximal - Cu	Low detection – Ag, In, Sb, Th, U and W.	(Eppinger, et al., 2013)
Orogenic Au & Intrusion-Related Au	Au, Ag, As Bi, Te, Se, As, Sb,	As, Bi,	(Arne & Giblin, 2009), (Carey, et al., 2003) (Mueller, et al., 2003)

2.5. Topography

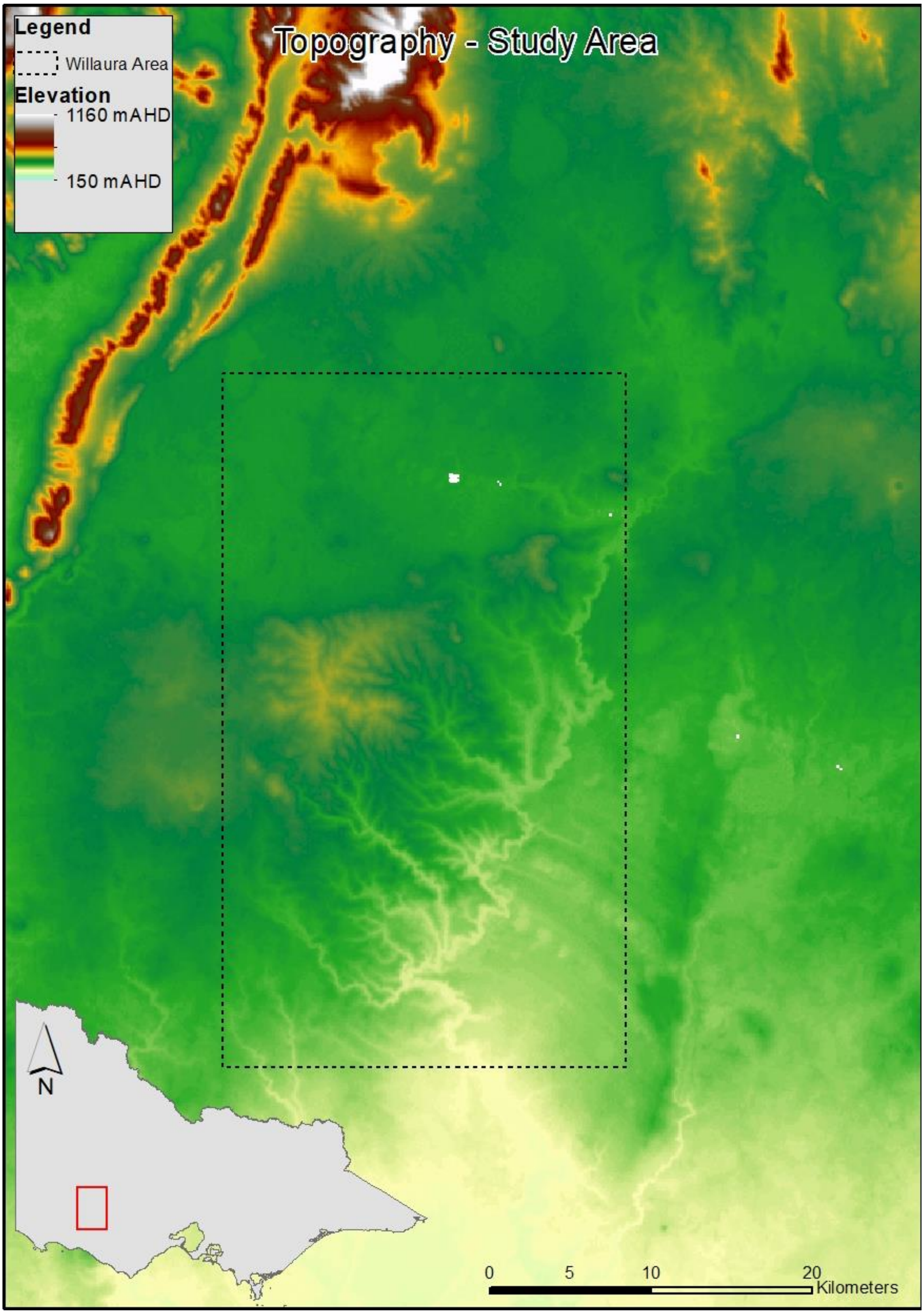


Figure 6. Topography for the study area. Note the general decrease in elevation from northwest to south. Elevation reaches a maximum of 1160 m.AHD in the Grampians ranges in the north and drops to 150 m.AHD in the south of the field area. Digital elevation model produced from SRTM3 satellite data at a 90m cell size.

2.6. Principal Component Analysis

PCA is a multivariate statistical method which captures the essence of a large data set. This helps to reveal hidden patterns that humans find difficult to comprehend due to the number of variables. PCA is particularly useful for finding associations within datasets with numerous variables and obscured correlations.

The hydrogeochemical characteristics of groundwater reflect various groundwater processes. These processes include evapotranspiration, DO, redox pH, host geology (Gray, et al., 2016) and reactive transport (Caritat & Kirste, 2005). PCA has been in groundwater analysis to identify the hydrological processes that have caused a specific hydrogeochemical characteristics, see (Cloutier, et al., 2008; Guan, et al., 2013; Guler, et al., 2002 and Mrklas, et al., 2006).

In this study PCA is used to segment the numerous variables that can alter pathfinder element concentration and elucidate which variables are associated with mineralisation of the rock body and which variables are associated with other hydrogeological processes such as redox, DO and evapotranspiration. This study uses the version of PCA developed by (Guan, et al., 2013)

To establish if a pathfinder element is useful for mineral exploration we must first establish if the concentration of a pathfinder element is elevated and that the elevated concentration is not due to common catchment hydrological processes.

This concept is demonstrated by elemental Arsenic. Arsenic is a recognised pathfinder element for porphyry Cu-(Au-Mo) mineral systems. It is also a common component of some sedimentary basins and readily mobile in neutral groundwaters as arsenate. PCA provides the potential to understand which factors are associated with a high As concentration in a groundwater sample.

3. Methods

3.1. Sample collection

Low flow groundwater sampling from government owned groundwater monitoring bores has provided a geographically diverse overview sample suite of hydrogeochemical parameters. Monitoring bores were prioritised because the bore construction details and aquifer information were generally available.

Every bore was cleared of sediment prior to sampling. All equipment was decontaminated with Decon 90™ and potable water between each site. The collection of groundwater samples followed guidelines by Sundaram, et al., (2009), where each bore was sampled using low flow sampling methods. Four field chemistry parameters (pH, EC, redox and temperature) and standing water level were recorded during purging until three consecutive 10 litre readings showed an adequate degree of consistency (approx. +/- 10%) and no trending. A double piston Bennett pump ™ was the preferred method to collect groundwater samples and sample collection was based on the Victorian Groundwater Sampling Guidelines- Sampling Device Matrix (EPA, 2000). In instances where low flow pumping could not be used (e.g. excess sediment, low yield, less than 50 mm diameter bore) a mechanical inertia pump with 25mm hose was used. Inertia pumps yield a sample with higher Eh as shown by Leybourne and Cameron (2007).

Flowing streams (no stagnant water) were used to collect surface water samples, after two weeks of no rain to ensure the sample was primarily groundwater base flow.

Preferred sample density spacing varies with the target pathfinder element and local conditions. Various distances have been suggested by other studies: 2000 m Leybourne & Cameron (2007), 100-2000 m (Caritat & Kirste, 2005) and 500 m Cidu, et al., (1995). Sample density was determined by the availability of roadside state government groundwater bores and surface water sample points. In this study, water samples were generally more widely spaced than any of the above studies suggest. For example, 87 groundwater samples over a 2,275 km^2 area which equates to approximately 26 km^2 spacing. Potential exists to increase the sample density through the utilisation of private bores and unsampled government bores but was outside the scope of this study.

3.2. Sample preparation

Four water samples were collected from each site: anions, cations, alkalinity and precious metals. Cations and anions were filtered through 0.45 µm filter paper in the field and stored in 125 ml high density polyethylene (HDPE) bottles. Alkalinity was unfiltered and stored in 125 ml HDPE bottles. Precious metals had 10 g of laboratory grade sodium chloride and a carbon sachet added. They were stored in 1000 ml HDPE bottles. The work flow is illustrated in Figure 7.

Water was filtered to standardise the colloidal content, thereby allowing more repeatable comparison of dissolved ions between water samples, however, it also reduces the concentration of many cations that may sorb to larger colloidal matter.

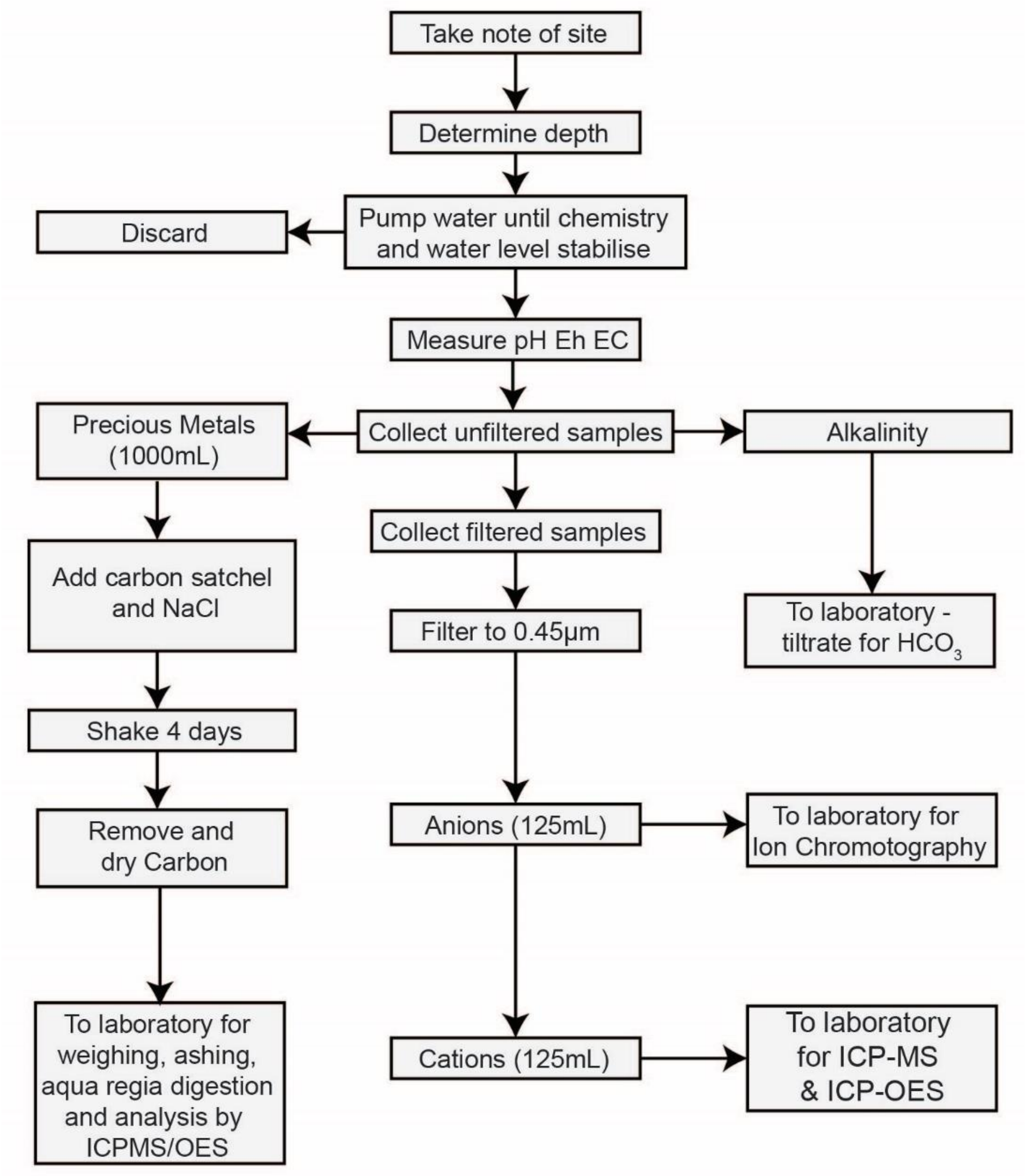


Figure 7. Flow diagram of water sample collection method and preparation for laboratory analysis. Modified from (Noble, et al., 2011).

3.3. Sample analysis

Field chemistry including EC, DO, pH, redox and temperature (T) were all measured using a TPS meter and recorded on field sheets. Depth to water table was measured using a dip-meter and pumping rates was calculated by timing 10 L volumes of from the flow cell.

Alkalinity was titrated at CSIRO laboratories in Adelaide.

Anions were analysed for using Ion chromatography at CSIRO laboratories in Adelaide.

Cations were analysed using ICP-OES for major ions (mg/l) and ICP-MS for trace elements (µg/l). Some elements were analysed using both techniques. In these instances, the relevant technique for the concentration was used.

Precious metals were analysed for by ashing the carbon sachet and undertaking an aqua regia digest on the ash. The resulting liquid was analysed for precious metals using ICP-MS at Bureau Veritas Minerals in Perth and the results are presented as (ng/l) due to the concentration of metals onto the carbon sachet.

3.4. Principal Component Analysis

In PCA, observations are standardised into variables that preserve relative order over absolute value. The variables are plotted into a range of uncorrelated axis, that are orthogonal to one another. Each axis represents a PC and the relationship between a particular PC and a particular variable is characterised by the PC coefficient (Woodcay & Walton, 2008). Variables that share a high PC coefficient with a particular PC are responding to similar processes. The first PC (PC 1) is associated with the most data variance and as such represents the dominant groundwater process. Each succeeding PC is associated with a smaller amount of data variance and a less dominant groundwater process. Eigenvalues represent the amount of variation that is represented by each PC.

PC’s, eigenvalues and PC coefficients were calculated with MATLAB© embedded functions. For each analysis the number of PCs produced was equal to the number of variables, however, only PC’s representing more than 5% of total data variation were retained for analysis. In this study variable with a coefficient greater than 0.5 or less than -0.5 are considered to be associated with the relevant PC.

Principal component analysis was undertaken for variables from 87 water sampling sites. Variables included major ion ratios, trace element concentrations, geographic co-ordinates, basement geology and proximity to mineralisation. A smaller subset of 58 water samples were also analysed as they included precious metal concentrations. The data were formatted as a matrix (X) with columns representing variables and rows representing measurements. Variables were represented as concentrations (mg/L, µg/L, ng/L), major ion ratios, geographic co-ordinates and presence or absence of the Stavely Arc.

Null values were used in the place of Au and Ag values when values weren’t available. Trace elements that were below detection levels were replaced with a random value between zero and the low detection value.

4. Results & Discussion

4.1. Water Chemistry

The detection limits for trace elements varied between water samples and the element analysed. This is due to interference patterns between certain elements within a solution. A table of polyatomic Interferences in ICP-MS has been compiled by (May & Wiedmeyer, 1998).This interference impacted water samples that were more saline and elements that are at lower concentrations. This resulted in a high number of analytes being below the detection limit for certain trace elements. These are referred to as being censored within this publication.

4.1.1. Anions

Eighty-seven water samples were analysed for the anions listed in Table 2. All anions were above detection limits.

Table 2. Anions analysed for using ion chromatography, detection limit and the number of water samples that were below the low detection level for that element.

Element/ Compound	Method	Detection limit (mg/l)	Number censored
Br (mg/l)	IC	0.10	0
Cl (mg/l)	IC	10.0	0
F (mg/l)	IC	0.01	0
SO_4 (mg/l)	IC	3.50	0

4.1.2. Cations

All 87 water samples were analysed for the cations listed in Table 3. Notable elements with high censorship rates included: Cu, Cr, Fe, Pb and Sb. Some highly censored elements, such as Fe, are relatively common groundwater species. However, these elements have a strong affinity to sorb to colloidal matter which is filtered during sample preparation. Other elements, such as Cu and Sb, are less common and also have a strong affinity to sorb to colloidal matter.

Table 3. Cations analysed for using ICP-MS and ICP-OES, detection limit and the number of water samples that were below the low detection level for that element.

Element/ Compound	Method	Detection limit range	Number censored
Ag (µg/l)	ICP-MS	0.1 – 0.5	86
Al (mg/l)	ICP-OES	0.002-3	85
As (µg/l)	ICP-MS	0.2 - 3	41
B (mg/l)	ICP-OES	0.1-5	65
Ba (µg/l)	ICP-MS	0.01-0.5	0
Ca (mg/l)	ICP-OES	0.1	0
Cd (µg/l)	ICP-MS	0.01 – 0.5	77
Ce (µg/l)	ICP-MS	0.01 – 0.5	87
Co (µg/l)	ICP-MS	0.01 - 1	44
Cr (µg/l)	ICP-MS	0.01 - 3	69
Cu (µg/l)	ICP-MS	0.01 - 3	68
Fe (mg/l)	ICP-OES	0.004 – 2.5	81
Ga (µg/l)	ICP-MS	0.01 - 1	83
Ge (µg/l)	ICP-MS	0.1 - 3	81
In (µg/l)	ICP-MS	0.05 – 0.5	87
K (mg/l)	ICP-OES	0.08 – 0.2	0
La (µg/l)	ICP-MS	0.01 – 0.5	79
Li (µg/l)	ICP-OES	0.01 – 0.1	0
Mg (mg/l)	ICP-OES	0.04 – 0.2	0
Mn (µg/l)	ICP-MS	1.0	7
Mo (g/l)	ICP-MS	0.01 – 3	62

Na (mg/l)	ICP-OES	6.0	0
Nb (µg/l)	ICP-MS	0.1 - 5	87
Nd (µg/l)	ICP-MS	0.01 - 5	81
Ni (µg/l)	ICP-MS	0.01 – 5	25
Pb (µg/l)	ICP-MS	0.01 – 2	71
Pr (µg/l)	ICP-MS	0.02 - 1	83
Rb (µg/l)	ICP-MS	0.01 - 4	4
Sb (µg/l)	ICP-MS	0.01 - 4	85
Sc (µg/l)	ICP-MS	0.1 - 1	47
Se (µg/l)	ICP-MS	0.1 - 4	32
Si (mg/l)	ICP-OES	0.5 – 12.5	12
Sm (µg/l)	ICP-MS	0.05 - 1	83
Sn (µg/l)	ICP-MS	0.01 - 2	56
Sr (mg/l)	ICP-OES	0.008 - 5	4
Te (µg/l)	ICP-MS	0.2 - 6	86
U (µg/l)	ICP-MS	0.01 – 0.5	28
V (µg/l)	ICP-MS	0.05 – 0.5	33
Yu (µg/l)	ICP-MS	0.05 – 0.5	72
Zn (µg/l)	ICP-MS	2 - 10	16
Zr (µg/l)	ICP-MS	0.1 - 1	80

4.1.3. Precious Metals

Fifty-eight water samples were analysed for the precious metals listed in Table 4. Gold and Ag appear ubiquitous; however, laboratory blanks can yield up to 3 ng/l Au and 300 ng/l Ag (Christ, 2017). Results above 4 ng/l and 300 ng/l are interpreted to be an indication of elevated Au and Ag. Seven water samples are above 4 ng/l for Au and five are above 300 ng/l for Ag. Bismuth was detected in ten water samples with two high concentrations at ~15 ng/l.

Table 4. Precious Metals analysed for using ICP-MS and ICP-OES, detection limit and the number of water samples that were below the low detection level for that element.

Element/ Compound	Method	Detection limit (ng/l)	Number censored
Ag (ng/l)	Carbon ICP-MS	16	2
Au (ng/l)	Carbon ICP-MS	0.1 – 0.2	2
Bi (ng/l)	Carbon ICP-MS	0.1 – 5	39

4.2. Statistics

The concentration of an element in a ground water sample can only be considered high or low relative to the concentration of the same element in surrounding groundwater samples. This means that an element that appears to be low in concentration can actually be high if that element is not detected elsewhere. Such elements often have high censorship rates. This produces a range of problems for the use of high censorship elements in statistical analysis. Two methods are used to minimise this problem:

- A value of fifty percent of the relevant detection limit was used to replace censored values for cumulative frequency plots.
- A random value between 0 and the relevant detection limit was used for censored values in PCA.

4.3. Major ion ratios

Major ion ratios were calculated because groundwater chemistry in the study area is strongly influenced by evapotranspiration. Major ion ratios are designed to compare the ratio between two major ions in a water sample with those same two ions in seawater. This provides insight into how local factors have changed the composition of groundwater. Major ion ratios were calculated for selected elements that could be influenced by weathering of a mineral body. This calculation follows the methodology outlined in Gray, et al., (2016) and uses the following formula:

$KNaSW$	$= [2 \times (K - 0.0363 \times Na)]/ [0.0363 \times (Na + 500)]$	$Na < 500$ mg/L
	$= [K - 0.0363 \times Na]/ [0.0363 \times Na]$	$Na > 500$ mg/L
$MgNaSW$	$= [2 \times (Mg - 0.1194 \times Na)]/ [0.1194 \times (Na + 500)]$	$Na < 500$ mg/L
	$= Mg - 0.1194 \times Na]/ [0.1194 \times Na]$	$Na > 500$ mg/L
$CaNaSW$	$= [2 \times (Ca - 0.0381 \times Na)]/ [0.0381 \times (Na + 500)]$	$Na < 500$ mg/L
	$= [Ca - 0.0381 \times Na]/ [0.0381 \times Na]$	$Na >500$ mg/L
$MgCaSW$	$= [2 \times (Mg - 3.14 \times Ca)]/ [3.14 \times (Ca + 20)]$	$Ca < 20$ mg/L
	$= [Mg - 3.14 \times Ca]/ [3.14 \times Ca]$	$Ca > 20$ mg/L
$SrCaSW$	$= [2 \times (Sr - 0.0195 \times Ca)]/ [0.0195 \times (Ca + 20)]$	$Ca < 20$ mg/L
	$= [Sr - 0.0195 \times Ca]/ [0.0195 \times Ca].$	$Ca > 20$ mg/L
$RbKSW$	$= [2 \times (Rb - 0.306 \times K)]/ [0.306 \times (K + 20)]$	$K < 20$ mg/L
	$= [Rb - 0.306 \times K]/ [0.306 \times K]$	$K > 20$ mg/L
$SO4ClSW$	$= [2 \times (SO4 - 0.1396 \times Cl)]/ 0.1396 \times (Cl + 500)]$	$Cl < 500$ mg/L
	$= [SO4 - 0.1396 \times Cl]/ [0.1396 \times Cl]$	$Cl > 500$ mg/L

4.4. Cumulative Frequency plots

The concentration of an element can only be considered low or high relative to samples taken from a similar environment. Cumulative frequency plots have been used to characterise the distribution in concentration for elements. The distribution may tell us something about the population and help us to identify outliers. In this study outliers are defined by interpretation of cumulative frequency plots. Attention is focussed on bi-modal and right bias plots Figure 8. The area's circled in red are considered outliers in this study.

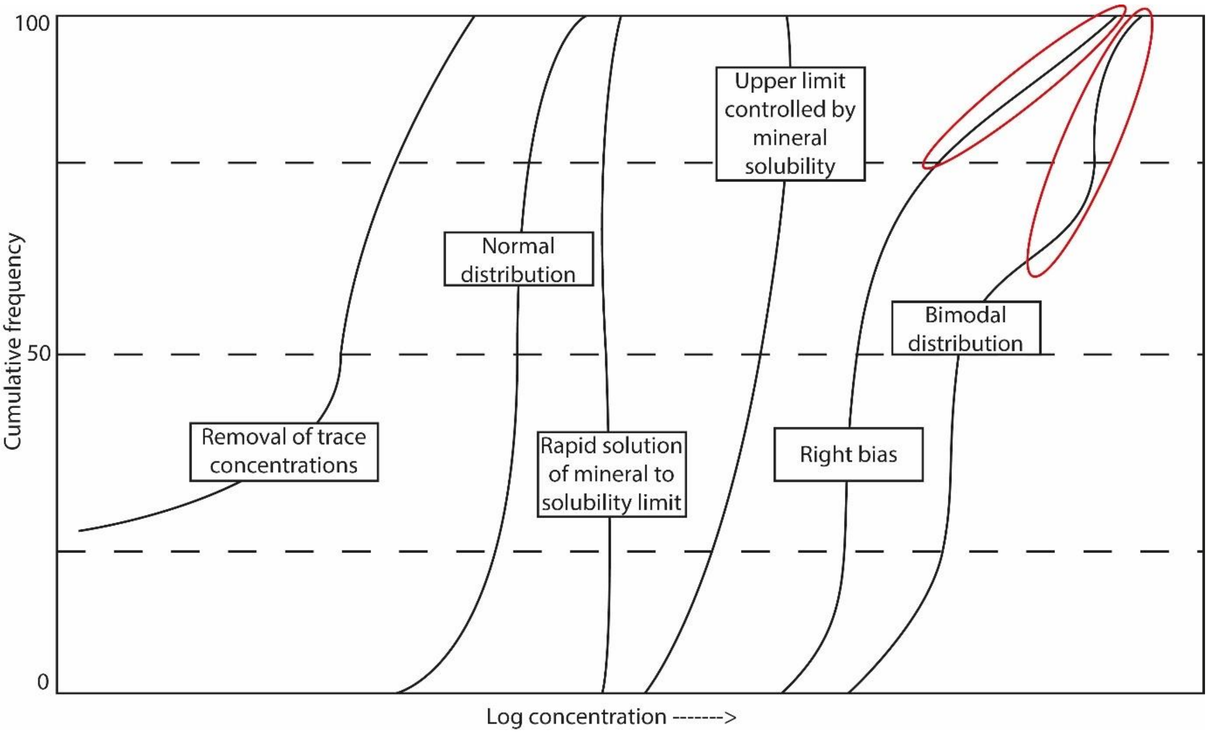


Figure 8. Cumulative frequency plots and potential mechanisms for the population distribution. Data points identified as being potential outliers are circled in red. Modified after (Reimann, et al., 2005).

Cumulative frequency plots for pathfinder elements and sulphate chloride ratios are available in Appendix E. This interpretation method is valuable when looking at water samples from similar host geology which are sampled and analysed in a comparable manner. More information on this technique is available from Reimann, et al., (2005). Elements have been grouped according to their cumulative frequency distribution Table 5. Major ions typically follow a normal distribution conversely many trace elements and precious metals follow a right bias or bi-modal distribution. Right bias and bi-modal distributions are exacerbated by populations with large numbers of censored data.

Table 5. The population distribution of major ions, trace elements and precious metals have been interpreted according to Cumulative Frequency distribution and are categorised below.

Distribution type	Elements
Normal Distribution	Ca, Na, K, Mg, Li
Right Bias	Ag, Au, Bi, Mo, Sn
Bi-Modal	As, Cu, Ni, Rb, Sc, Se, SO_4, U, V, Zn
Upper limit controlled by mineral solubility	Mn, Si, Co

4.5. Porphyry Cu-(Au-Mo) pathfinder elements

Porphyry mineralisation pathfinder elements including As, Mn, Mo, Se and V were all detected in water samples in the study area.

Arsenic has a bi-modal distribution with a step change in concentration at 2.6 µg/l and a peak at 15 µg/l. Eight water samples are interpreted as outliers. Outlier water samples were collected from bores screened in transported cover and weathered Cambrian rocks. Two were collected from bores screened in weathered outcropping Stavely Arc, proximal to the Toora Road Prospect. The remainder were collected from bores screened in the Cainozoic cover above Cambrian sediments Figure 9.

Copper has a high censorship rate with only 18 detections. The distribution is bi-modal suggesting two populations, one with elevated copper and one without elevated copper. Six samples at 2 µg/l represent moderately elevated Cu. Four samples between 3 and 5 µg/l represent outlier concentrations. Two samples at 13.9 and 16 µg/l were collected from in situ pumps and probably represent contamination from copper pipes. Outlier water samples were collected from bores screened in transported cover and one from weathered outcropping Stavely Arc, 2km from the Drysdale Cambrian Cu porphyry prospect Figure 9. Three were collected from bores screened in transported cover.

Moderately elevated Cu concentrations were apparent at two points within the Hopkins River. Samples were collected above the Stavely and Narrapumelap Belts. Three were collected from bores screened in transported cover and one from a bore screened in weathered Stavely Arc.

Molybdenum has a bi-modal distribution with steps higher in concentration at 3 µg/l and 5 µg/l. Outlier water samples were all collected from transported cover. One each from the sediments above the Elliot and Narrapumelap Belts and three from above Cambrian sediments Figure 9.

The frequency distribution plot suggests that manganese concentrations are limited by the rate of mineral dissolution. There are steps at 1068 µg/l and 1568 µg/l. Seven water samples are outliers and all were collected from transported cover. One was sourced from above each of the Dryden, Narrapumelap and Stavely Belts. Four were sourced from above Cambrian sediments down flow of the Stavely Arc.

Selenium has a bi-modal distribution with steps at 30 µg/l and 86 µg/l. Eight water samples have a Se concentration greater than 32 µg/l. These water samples were collected from transported cover and two were collected from weathered outcropping Stavely Arc. The samples from transported cover included two from above the Dryden Belt, one from above the Narrapumelap Belt and three from above Cambrian sedimentary rocks. Four of the seven were collected in the area between Toora Road and Thursdays Gossan.

Vanadium has a bi-modal distribution with a step higher in concentration at 4.8 µg/l and 10 µg/l. Outlier V clusters between the Toora Road and Thursdays Gossan Prospects.

4.6. Orogenic gold pathfinder elements

Silver, Au, Bi, As, Sb, Se and Te were all detected in water samples from the study area see Figure 10.

Gold is above 4 ng/l in 10 percent of water samples. These water samples were collected from transported cover and one from outcropping Stavely Arc. The samples from transported cover included two from above the Dryden Belt, two from above the Narrapumelap Belt, one from above the Elliot Belt and one from above Cambrian sedimentary rocks.

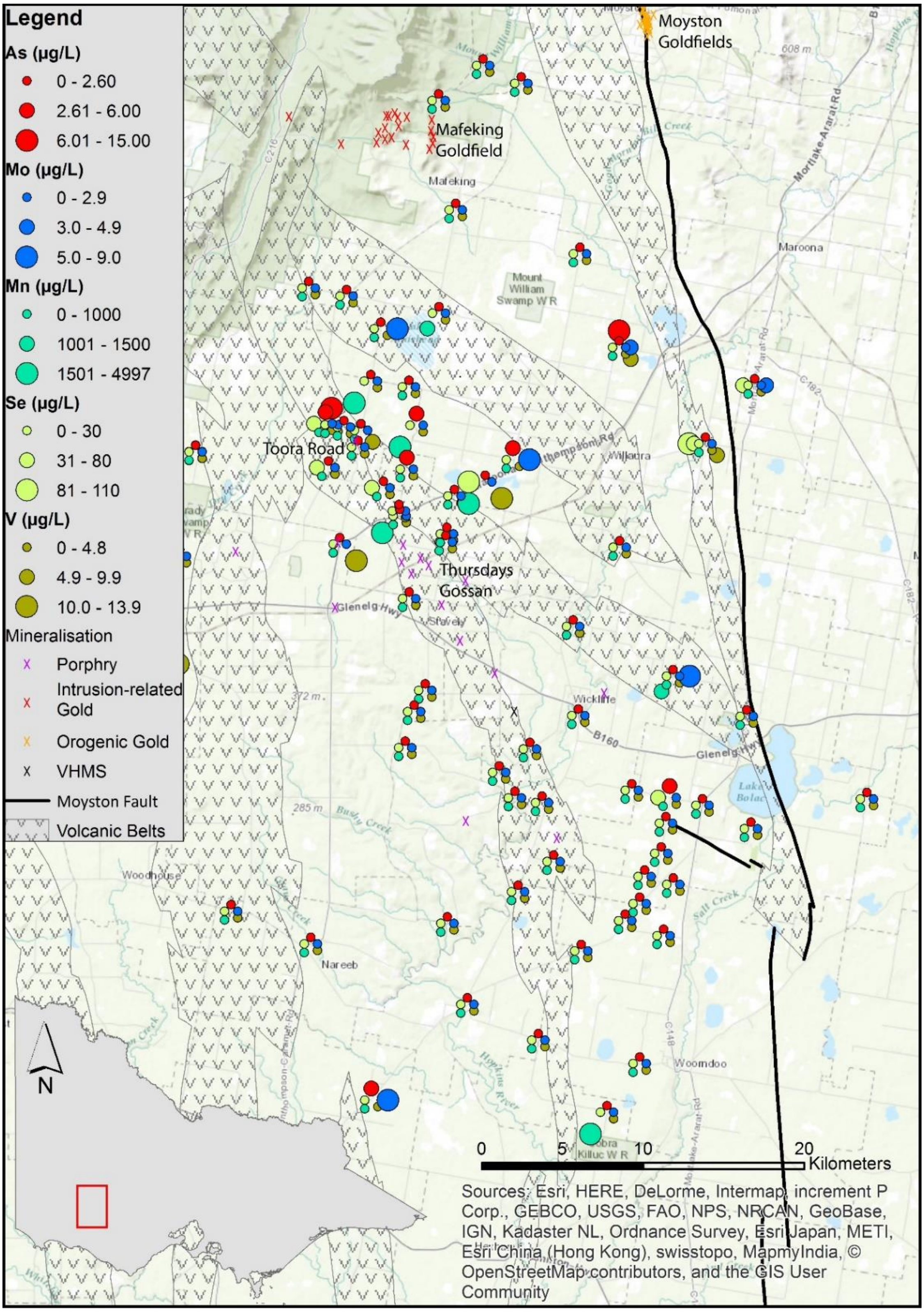
Silver is above 400 ng/l in 7 percent of water samples. These water samples were collected from transported cover and outcropping Stavely Arc. The samples from transported cover include one from above the Elliot Belt, one from above the Stavely Arc and two from above Cambrian sedimentary rocks.

Antinomy is above 0.8 µg/l in two water samples collected from outcropping Stavely Arc and in association with the Toora Road Prospect.

Bismuth is above 14 ng/l in two water samples. Both were collected from transported cover and neither are from above the Stavely Arc. One is located 4 km from known mineralisation at Mafeking and the other from southwest of Lake Bolac Figure 10.

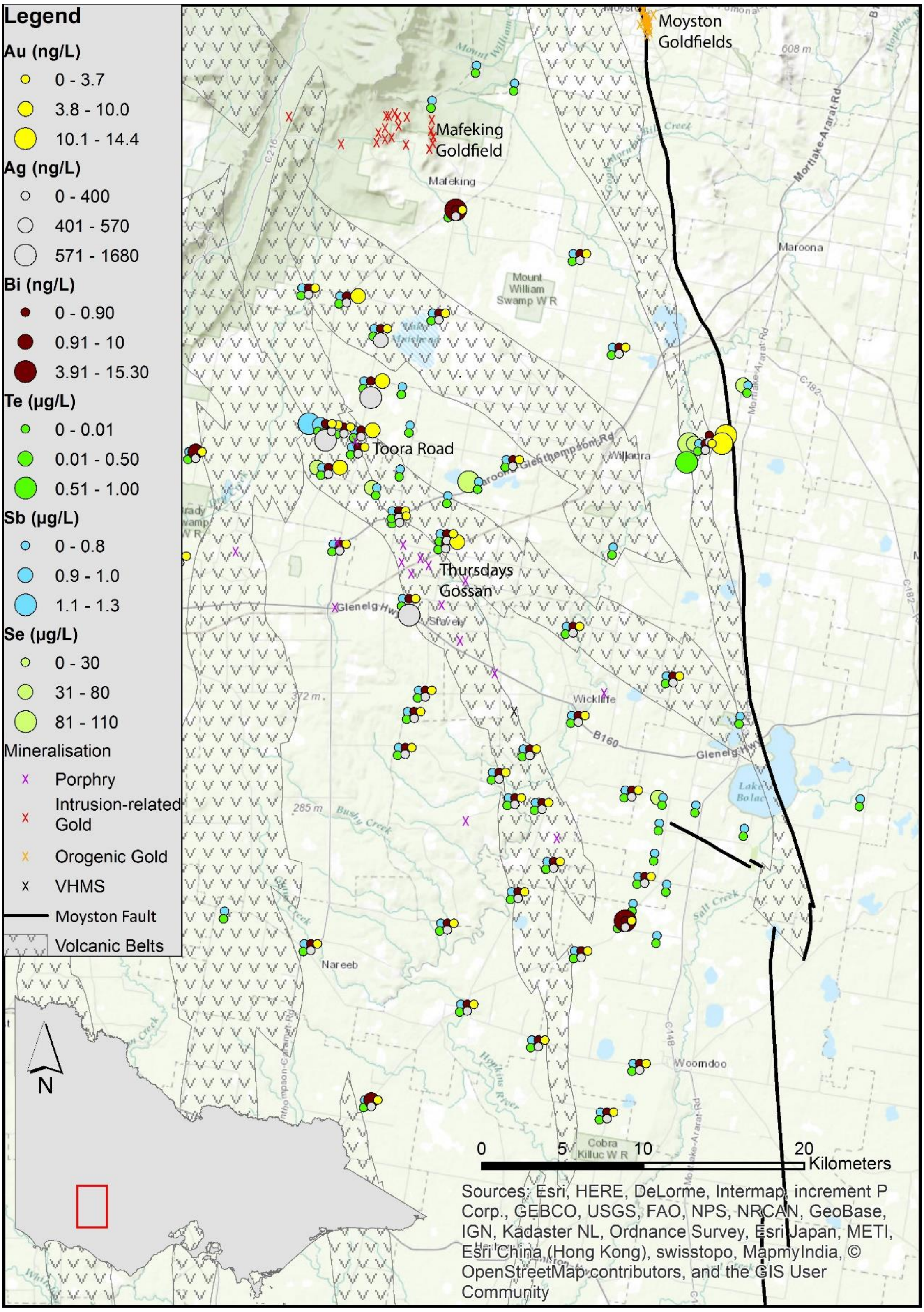
Selenium has a bi-modal distribution with 8 water samples considered to be anomalous. These water samples were collected from transported cover and outcropping Stavely Arc. Water samples collected from transported cover included two from above the Dryden Belt, one from above the Narrapumelap Belt and two from above Cambrian sedimentary rocks.

Tellurium was detected in one water sample collected from above the Dryden Belt in association with Au outliers.



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 9. Hydrogeochemical pathfinder elements for porphyry Cu-(Au-Mo) mineralisation. The Toora Road and Thursday's Gossan porphyry Cu-(Au-Mo) prospects and the Moyston Goldfields are labelled for geographic reference. The Volcanic is represented by V thatch in foreground.



Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 10. Hydrogeochemical pathfinder elements for Au mineralisation. The Toora Road and Thursday's Gossan porphyry Cu-(Au-Mo) prospects and the Moyston Goldfields are labelled for geographic reference. The Stavely Arc are represented by V thatched in foreground.

5. Principal Component Analysis

PCA was applied in three ways to test its applicability in answering the following questions: 1) Are the same groundwater processes associated with both major ion chemistry and trace element chemistry; 2) Are published mineral pathfinder elements relevant in the Study area zone; 3) Are there any geologic or geographic associations with pathfinder element concentrations.

5.1. Groundwater processes

5.1.1. Conceptual framework – Groundwater processes

PCA analysis was conducted to improve our understanding of groundwater processes. Variables added include: field chemistry, major ions, trace elements, sample locations and the absence or presence of the Stavely Arc. The aim is to define the major groundwater processes and asses the association between these processes and major ion or trace element chemistry. If a trace element concentration is linked to the same process as a major ion chemistry, the utility of the trace element concentration is diminished.

5.1.2. Results and Discussion – Dominant Processes

The results show that there are four important variables: EC, pH, DO and the presence of the Stavely Arc. The distribution of principal components and dominant variables are displayed in Table 6. The dominant variable loading is above 0.6 for PC1 – PC4. There are no clear dominant variables for PC5 – PC11.

The most dominant groundwater process (PC1) is associated with 19.1% of data variance. This process is very strongly aligned with EC with a variable loading of 0.91. Salinity driven by evapotranspiration is apparent in the region and this is the likely groundwater process associated with PC1. All the major ions are strongly associated with PC1 with variable loadings ranging from 0.88 to 0.98, with Na being the highest. Selenium is the only trace element associated with PC1 with a variable loading of 0.74. This suggests that Se is concentrated by the same processes as major ions, but the process is less efficient and there is another variable influencing Se concentration.

The second most dominant groundwater process (PC2) is associated with less than 10% of data variance. This process is moderately aligned with high pH with a variable loading of 0.61. No other variables are associated with PC2 with a variable loading greater than 0.5. Weak associations are apparent for areas to the south, being within 2km of a volcanic belt and the trace element Sc.

The third most dominant groundwater process (PC3) is associated with 7.3% of data variance. This process is moderately to strongly aligned with DO with a variable loading of 0.67. No other variables are associated with PC3 with a variable loading greater than 0.5. Weak associations are apparent for Cu and Cr.

The fourth most dominant groundwater process (PC4) is associated with 6.1% of data variance. This process is moderately to strongly aligned with the Stavely Arc with a variable loading of 0.66. Shallow groundwater samples are weakly associated with the depth of sample having a variable loading of -0.5.

Numerous unidentified groundwater processes are apparent through PC5 – PC11. The highest variable loading for many trace elements is within PC5 – PC11. Removal of major elements from the data set and an increased number of variables may be able to identify more processes that are associated with these trace elements.

Table 6. PCA analysis for groundwater processes. A strong association is represented by a PC coefficient above 0.5, these are in bold. Components analysed include: geographic locations, bore depth, proximity to a volcanic belt, field parameters (DO, EC, pH, redox), major ion chemistry and trace element chemistry.

	PC1	**PC2**	**PC3**	**PC4**	**PC5**	**PC6**	**PC7**	**PC8**	**PC9**	**PC10**	**PC11**
Data variance	19.1%	9.7%	7.3%	6.1%	5.9%	5.1%	4.3%	4.1%	3.7%	3.4%	3.1%
Eigenvalues	7.1	3.8	2.7	2.3	2.2	1.9	1.6	1.5	1.4	1.3	1.2
Dominant variable	EC	pH	DO	Volcanic Arc	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Variable Loading	0.91	0.61	0.67	0.66							
Easting	0.03	**-0.46**	-0.30	-0.29	0.19	0.09	0.22	0.28	0.22	-0.22	-0.27
Northing	0.07	0.41	0.07	0.32	-0.25	-0.35	0.12	-0.12	0.07	0.31	-0.02
Depth (m)	-0.36	0.27	-0.02	-0.50	-0.20	0.39	-0.19	0.19	-0.20	-0.08	-0.16
Volcanic Arc	0.22	0.22	-0.01	**0.66**	0.19	-0.07	0.18	0.25	-0.05	-0.30	-0.21
Volcanic Arc (<2km)	0.33	0.47	0.01	**0.59**	0.05	0.11	-0.04	0.13	-0.09	-0.24	0.04
DO (mg/L)	0.32	-0.44	**0.67**	-0.10	0.08	-0.02	-0.15	0.06	0.10	0.00	0.16
EC (µS/cm)	**0.91**	0.05	-0.07	0.15	0.08	0.11	0.08	-0.08	-0.03	-0.02	-0.05
pH	0.12	**0.61**	0.23	-0.32	0.43	-0.03	0.11	0.10	0.07	-0.07	0.15
Redox (mV)	-0.02	-0.60	0.26	0.30	0.23	-0.10	-0.07	-0.13	-0.14	0.12	-0.08
Alkalinity (mg/l)	0.10	0.36	0.10	-0.10	0.49	0.21	-0.08	-0.10	-0.15	0.11	0.11
Ca mg/L	**0.95**	0.05	-0.09	0.00	-0.11	-0.03	-0.02	-0.09	0.00	0.00	-0.03
K mg/L	**0.88**	0.02	-0.09	-0.25	-0.10	-0.10	-0.12	0.08	-0.05	0.09	0.01
Mg mg/L	**0.95**	0.04	-0.05	-0.10	-0.13	-0.10	-0.10	-0.02	-0.02	0.00	-0.02
Na mg/L	**0.98**	0.00	-0.05	-0.04	-0.11	-0.02	-0.06	-0.02	-0.01	0.02	-0.03
S mg/L	**0.96**	-0.03	-0.01	-0.04	-0.11	-0.07	-0.04	0.01	0.03	-0.01	-0.04
As (µg/L)	-0.02	0.04	-0.09	0.00	0.42	0.01	-0.01	-0.01	-0.09	**0.61**	-0.45
Co (µg/L)	-0.08	-0.41	-0.43	0.38	-0.28	0.05	-0.26	-0.06	-0.13	0.15	0.05
Cu (µg/L)	-0.11	-0.20	0.49	-0.02	-0.30	-0.17	-0.14	-0.05	0.22	-0.06	-0.22
Cr (µg/L)	0.07	-0.22	0.49	0.09	-0.03	0.01	0.05	0.22	0.26	0.22	0.01
Li (µg/L)	0.41	0.17	0.12	0.07	-0.09	0.67	0.12	-0.09	0.11	-0.04	-0.16
Mn (µg/L)	0.32	0.21	-0.15	0.14	-0.30	0.46	0.09	-0.24	0.33	0.13	0.15
Mo (µg/L)	-0.07	0.16	-0.21	0.13	0.53	-0.13	-0.40	0.05	0.39	0.12	-0.16
Ni (µg/L)	0.04	0.03	-0.31	0.11	0.16	-0.09	-0.41	0.18	**0.64**	-0.14	0.11
Rb (µg/L)	0.34	-0.26	-0.56	-0.35	0.00	0.02	-0.07	0.16	-0.27	-0.19	-0.08
Ba (µg/L)	-0.23	0.41	-0.31	0.09	-0.21	0.04	-0.19	-0.02	-0.02	0.21	0.44
Pb (µg/L)	0.15	-0.47	-0.35	0.33	0.16	0.18	-0.07	-0.27	-0.08	0.11	-0.09
Sb (µg/L)	0.03	0.07	0.08	-0.05	0.02	0.48	0.14	**0.53**	0.05	0.44	0.11
Sc (µg/L)	-0.21	0.41	-0.06	-0.15	-0.22	0.09	-0.27	-0.30	0.05	0.00	-0.11
Se (µg/L)	**0.74**	-0.06	0.08	-0.06	-0.03	-0.16	0.08	0.39	0.00	0.15	0.08
Sn (µg/L)	0.05	-0.57	0.09	0.01	0.09	-0.06	0.17	0.01	-0.03	-0.05	**0.50**
Te (µg/L)	-0.19	0.01	-0.04	0.31	-0.28	0.03	-0.29	**0.62**	-0.18	0.04	0.04
Th (µg/L)	0.11	-0.11	-0.32	-0.25	-0.05	-0.15	0.47	-0.17	0.34	0.15	0.07
Tl (µg/L)	0.00	-0.22	-0.35	-0.22	0.18	-0.01	-0.36	0.04	0.12	-0.03	0.14
U (µg/L)	0.28	-0.07	0.37	0.11	0.42	0.45	-0.21	-0.20	-0.01	-0.24	0.12
V (µg/L)	0.36	0.11	0.35	-0.25	0.03	-0.23	-0.47	-0.13	-0.23	0.14	0.02
W (µg/L)	0.03	-0.40	-0.20	0.07	0.33	0.26	0.03	-0.05	-0.17	0.17	0.21
Zn (µg/L)	-0.11	-0.48	0.24	0.00	-0.42	0.38	-0.22	-0.04	0.18	0.02	-0.16

5.2. Mineralisation

5.2.1. Conceptual framework

PCA analysis was used to test for associations with porphyry Cu-(Au-Mo) and intrusion-related Au mineral occurrences. Associations with orogenic Au mineralisation were not tested due to the small number of samples collected proximal to orogenic mineralisation. Analysis was conducted on a range of variables including pathfinder elements, major ion ratios and spatial references. The aim was to: 1) Test spatial associations between and pathfinder elements; 2) Test associations between individual pathfinder elements; 3) Test associations between mineral occurrences, the Stavely Arc rock and major ion ratios.

To focus the PCA analysis on mineralisation a smaller subset of variables relevant to more subtle groundwater processes were used. Major ions were removed because they are strongly associated with evapotranspiration and major ion ratios were included because they filter out the impacts of evapotranspiration. Trace elements were limited to As, Cu, Mo, Mn, Sb, Se, and V as they are suggested as pathfinder elements for porphyry Cu-(Au-Mo) (Leybourne & Cameron, 2007). Precious metals were added because an association between Ag and porphyry systems is suggested by Eppinger et al, (2013) and Au is a likely pathfinder element for intrusion-related Au (Cidu, et al., 1995).

Because the observations included references to potential groundwater processes such as EC for evapotranspiration and distance to mineral occurrence for trace element concentration, it is possible to associate the PC with a hydrogeological process. For example, if a trace element is strongly associated with distance to a known mineral occurrence it possible to suggest that there is an association between a mineral occurrence and that trace element. However, if the trace element is strongly associated with DO it is possible to conclude the presence of oxygen is associated with that trace element being present. Thus, PCA can potentially separate hydrogeochemical signals that relate to mineral dissolution from hydrogeochemical signals that relate to oxidation.

5.2.2. Results and Discussion

Data Variance

The results show data variance is concentrated within the first 8 principal components, Table 7. Principal component 1 is associated with 15.6% of data variance and the Volcanic Arc. Principal component 2 is associated with 14.8% of data variance and Do and distance to mineralisation.

Spatial Associations

There is a spatial association between the Stavely Arc illustrated in PC 1, Table 7. The association is greater for the Stavely Arc (0.70) that it is for the 2km buffer around the Stavely Arc (0.60). This suggests that the Stavely Arc are influencing hydrogeochemistry in a quantifiable way. There is also a negative association with the Stavely Arc illustrated in PC 6. This association is much weaker suggesting there are more influences on hydrogeochemistry outside of the Stavely Arc.

There is a spatial association between proximity to porphyry Cu-(Au-Mo) and intrusion-related mineralisation illustrated in PC 2. The association is greater for intrusion-related mineralisation (-0.53) than it is for porphyry Cu-(Au-Mo) (-0.20). This suggests that proximity to mineralisation is influencing hydrogeochemistry and potentially that intrusion-related mineralisation is having a greater impact, however, the data set is likely to be too small to be conclusive. There are stronger associations with distance away from porphyry Cu-(Au-Mo) mineralisation (0.62) in PC 3 and intrusion-related mineralisation (0.52) in PC 6. Neither PC 3 nor PC 6 are associated with pathfinder elements. This suggests that the lack of pathfinder elements distal to mineralisation is statistically more robust than the presence of pathfinder elements close to mineralisation. This could mean false negatives are more common than false positives.

There is a strong (0.82) spatial association with Easting illustrated in PC 3. The association is with the east of the field area and could represent two things: 1) Distance from the main recharge point, the Grampians Ranges in the west; 2) Deeper groundwater bores in the east.

Pathfinder Element Associations

There is a pathfinder element association between Mn and the precious metals Ag and Au illustrated in PC1, Table 7. The association is moderate for Mn (0.62) and weak for Ag (0.53) and Au (0.55). There is also a strong association with EC (0.77). There are fewer samples for Ag and Au which may explain the weaker association for the precious metals. It is possible that Mn is accumulating in groundwater through evapotranspiration and that precious metals are more likely to be mobilised by more saline water. The precious metals are also weakly associated with PC6 which is not associated with EC.

There is a pathfinder element association between Cu and V illustrated in PC2. The association is moderate for Cu (0.66) and weak for V (0.51). Selenium is most strongly associated with PC 2 however that association is weak (0.47). PC 2 has a strong association with DO (0.84) and moderate association with redox (0.62). There is also the association between PC 2 and proximity to mineralisation. This could suggest that for Cu and V to be elevated in groundwater, they require high DO levels, high redox potential and the presence of mineralisation.

There is a pathfinder element association between As and Mo illustrated in PC 4. The association is weak for As (0.51) and Mo (0.54). PC 4 has a weak to moderate association with pH (0.58) and weak negative associations with both DO and redox potential. This suggest that As and Mo are potentially more detectable under reducing groundwaters typical of deeper aquifers. There is a weak positive association between distance to mineralisation and PC 4.

There is no strong association between Sb and any of the principal components. This is likely due to the high number of censored data points. Antinomy was detected in two water samples. One sample was also elevated in Ag and the other elevated in As and V.

Major Ion Ratio Associations

There are major ion ratio associations with PC1, PC2 and PC 5, Table 7. The associations are weak with Rb: K (-0.52) associated with PC 1, SO4: Cl (0.54) associated with PC2 and Sr: Ca (-0.50) associated with PC 5. Although the associations are weak they demonstrate potential. Rubidium is low relative to K in PC 1 which is also associated with the Stavely Arc. The Stavely Arc are more mafic then the surrounding rocks and more likely to be weathering K feldspars. Sulphate is elevated relative to Cl In PC 2. The weathering of pyrites within mineralisation could contribute excess sulphate to groundwater and PC 2 is associated with mineralisation. Strontium is reduced relative to

Ca in PC 5. Gray et al, (2018) suggests low Sr: Ca ratios are associated with mafic geologies and PC 5 is weakly associated with being within 2km of a volcanic belt.

Table 7. PCA analysis for mineralisation. variable loadings and processes. Strong associations above 0.5 are highlighted in bold. Components analysed include: field chemistry, precious metals, trace element concentrations, major ion ratios, co-ordinates and geologic references.

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8
Data variance	15.61	14.08	10.77	8.99	7.19	6.68	5.78	5.58
Eigenvalues	3.59	3.24	2.48	2.07	1.65	1.54	1.33	1.28
Easting	-0.03	-0.05	**0.85**	-0.18	-0.25	0.10	-0.14	-0.05
Northing	0.37	-0.19	-0.37	0.42	-0.13	0.03	**-0.51**	-0.35
Distance to intrusion- related mineralisation	-0.08	**-0.53**	0.41	0.14	0.05	0.52	-0.29	0.08
Distance to porphyry mineralisation	0.02	-0.20	0.62	0.23	0.38	0.38	-0.01	0.28
2km from volcanic Arc	**0.60**	-0.14	-0.09	0.24	0.50	-0.13	0.27	0.26
Above volcanic Arc	**0.70**	-0.08	0.28	0.05	0.32	-0.34	-0.09	-0.19
DO (mg/L)	-0.17	**0.84**	0.12	-0.19	0.16	0.27	-0.15	0.08
Redox (mV)	-0.41	**0.62**	0.04	-0.32	0.11	0.24	0.22	-0.16
Ph	0.02	0.34	0.05	**0.58**	-0.06	0.00	0.10	0.09
EC (µS/cm)	**0.77**	0.23	0.16	-0.29	-0.11	0.02	0.18	-0.10
As (µg/L)	-0.12	0.04	0.23	**0.51**	-0.37	0.16	0.39	-0.31
Cu (µg/L)	-0.10	**0.66**	-0.02	0.20	-0.07	-0.25	-0.24	0.29
Mn (µg/L)	**0.62**	-0.16	-0.23	-0.28	-0.40	0.18	0.12	0.35
Mo (µg/L)	0.09	0.08	0.14	**0.54**	0.00	0.20	0.51	0.00
Sb (µg/L)	0.00	0.34	-0.20	0.30	-0.38	0.36	-0.29	0.24
Se (µg/L)	0.24	0.47	0.08	-0.12	0.27	0.03	-0.24	-0.21
V (µg/L)	-0.13	**0.51**	-0.35	0.08	0.21	0.27	0.07	-0.28
Au (ng/L)	**0.55**	0.15	0.21	0.13	0.14	0.16	-0.32	-0.06
Ag (ng/L)	**0.53**	-0.04	-0.37	-0.26	-0.29	0.35	0.07	0.25
K: Na	-0.43	0.09	-0.02	0.36	0.00	-0.39	-0.15	0.49
Sr: Ca	0.41	0.31	0.28	0.26	**-0.50**	-0.27	-0.04	-0.22
Rb: K	**-0.52**	-0.33	0.32	-0.26	-0.29	-0.21	-0.03	-0.08
SO4: Cl	0.32	**0.54**	0.51	-0.17	-0.14	-0.24	0.09	0.24

5.3. Porphyry Cu-(Au-Mo)

PCA validated the association between Cu, V, proximity to porphyry Cu-(Au-Mo) mineralisation and a high SO4: Cl ratio within the study area. This association is based on relatively few data points for Cu due to the high censorship rate. Alternative methods for Cu analysis may enhance the detection rate. The association agrees with Leybourne and Cameron (2010) who identified Cu as a proximal pathfinder element and V as a distal pathfinder element.

Arsenic and Mo are associated with each other and weakly with proximity to porphyry Cu-(Au-Mo) mineralisation, again in agreement with Leybourne and Cameron (2010) who identified As and Mo as distal pathfinder elements.

Gold shows an association with Ag and Mn and the Stavely Arc but not with distance to porphyry Cu-(Au-Mo). As PCA is sensitive to scaling of the data the reduced number of Ag and Au samples and the large number of censored Cu results may be impacting the statistical association between Au, Ag, Mn and distance to mineralisation. Further investigation of water samples that returned detectable levels for Cu and Au show a positive association with an R^2 value of 0.68, Figure 11.

Selenium and Ag have been detected within the study area but not verified as being related to porphyry Cu-(Au-Mo) mineralisation. PCA of spatial features suggest that the Stavely Arc and porphyry Cu-(Au-Mo) mineralisation both have an important effect on hydrogeochemistry but that they are not necessarily linked.

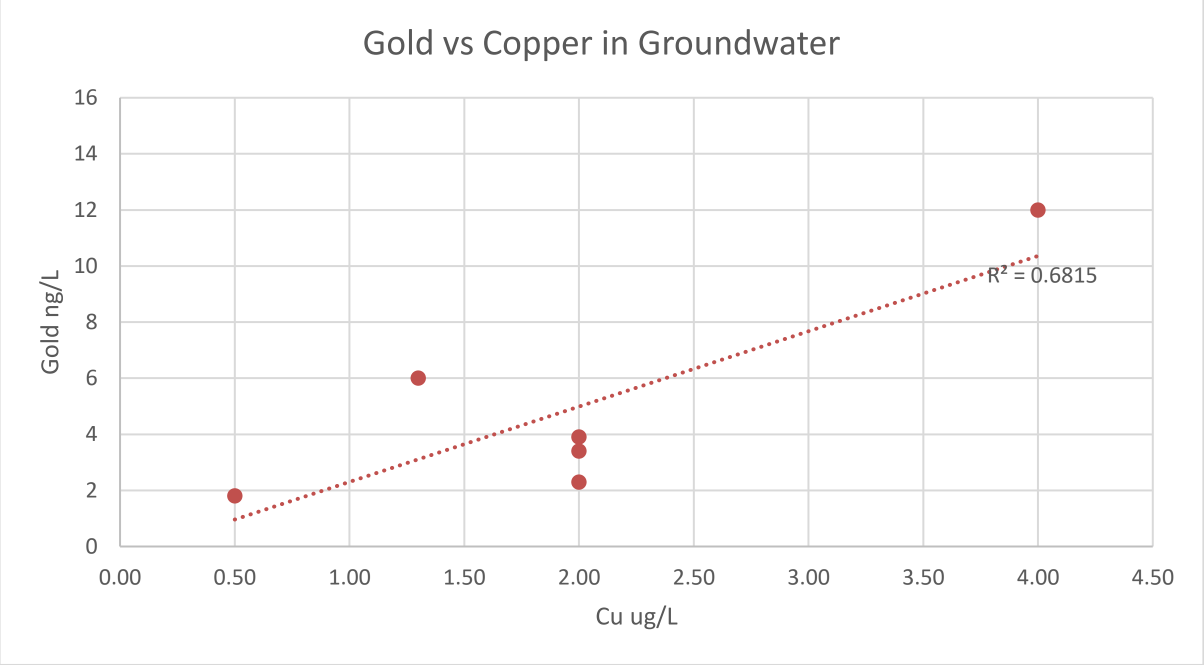


Figure 11. Plot of groundwater concentrations for Gold vs Copper. Groundwater samples that were censored for either Cu or Au have been removed.

5.4. Intrusive-Au related mineralisation

PCA suggests a moderate to strong association between Cu, V, SO4: Cl and proximity to intrusion-related mineralisation within the study area. However, Cu and V were not suggested as pathfinder elements by either Carey et al, (2003) or Mueller et al, (2003).

Suggested pathfinder elements (As, Ag, Au, Bi, Se and Sb) have all been detected but have not been shown by PCA to be associated with known intrusion-related mineral occurrences. Two potential reasons for this discrepancy are: The proximity of porphyry Cu-(Au-Mo) mineralisation impacting the statistical analysis; potential for unidentified intrusion-related mineral occurrences producing anomalies that aren’t proximal to recognised intrusion-related mineralisation. The second reason is supported by intrusion-related pathfinder elements being associated with each other. These include Ag and Au by PCA and Ag with Sb by direct association, with the highest Sb result coming from the same water sample as the third highest Ag result. The number of censored results for Cu and Sb may have be reduced alternative methods of chemical analysis.

Selenium has been detected in the study area but not verified as being related to intrusion-related mineralisation. Bismuth was not included in PCA because only two results weren’t censored however the highest Bismuth result was proximal to the Mafeking Goldfield.

Reasons for the lack for stronger associations with intrusion-related mineral occurrences could be that the sampling density proximal to intrusion-related mineralisation is too low with no groundwater samples being collected within two kilometres.

6. Geological interpretation

Two maps have been created, each represents a mineralisation type found in the study area. They are porphyry Cu-(Au-Mo), orogenic and intrusion-related Au. Trace elements have been grouped into the appropriate pathfinder elements for each of these mineralisation types. Groupings are based upon the observation published in the literature (Arne & Giblin, 2009, Eppinger, et al., 2013 & Leybourne & Cameron, 2010). Interpretations have been made to determine if there are hydrogeochemical signatures associated with known mineral occurrences.

6.1. Porphyry Cu-(Au-Mo)

Nine bores with elevated pathfinder elements are clustered within an area 10 km by 5 km running parallel to the Stavely Arc between porphyry prospects at Toora Road and Thursdays Gossan Figure 12. Pathfinder elements include As, Cu, Mn, Se and V. The Stavely Arc is cropping out and the Narrapumelap Belt is under thin cover in this area. Bores sampled within the cluster ranged in total depth from 10 m to 28 m. These bores are generally either above the or down gradient of the Stavely Arc. This hydrogeochemical signature could be representative of what to expect around porphyry deposits in the study area. However, this signature relates to mineral occurrences that are not buried or buried beneath thin cover. The signature can be expected to change as cover thickness increases and oxygen fugacity decreases.

Five outliers for As and Mo can be seen outside of the main cluster. These are either associated with the Elliot and Narrapumelap Belts or are in proximity to the interpreted extent of these belts. These outliers were sampled from bores that are generally deeper (13 m - 72 m) and more likely to be screened in reducing environments.

Copper outliers were sampled from both oxidised and reduced environments that ranged from surface waters to a bore that was 100 m deep. The concentration of Cu is generally low due to the rarity of the element and the affinity for Cu to sorb to colloidal matter which was filtered from samples. The association of Cu with Au and or Ag outliers in groundwater samples throughout the field area suggests a similar source for these metals. Leybourne & Cameron, (2010) consider Cu to be a proximal indicator of mineralisation and Ag and Au to be relatively immobile.

The cluster of both Au and Ag near the Toora Road prospect suggests that they are potentially useful pathfinder elements for porphyry Cu-(Au-Mo) in study area. Antimony was also elevated in the cluster to the north of Toora Road and represents another potential pathfinder element.

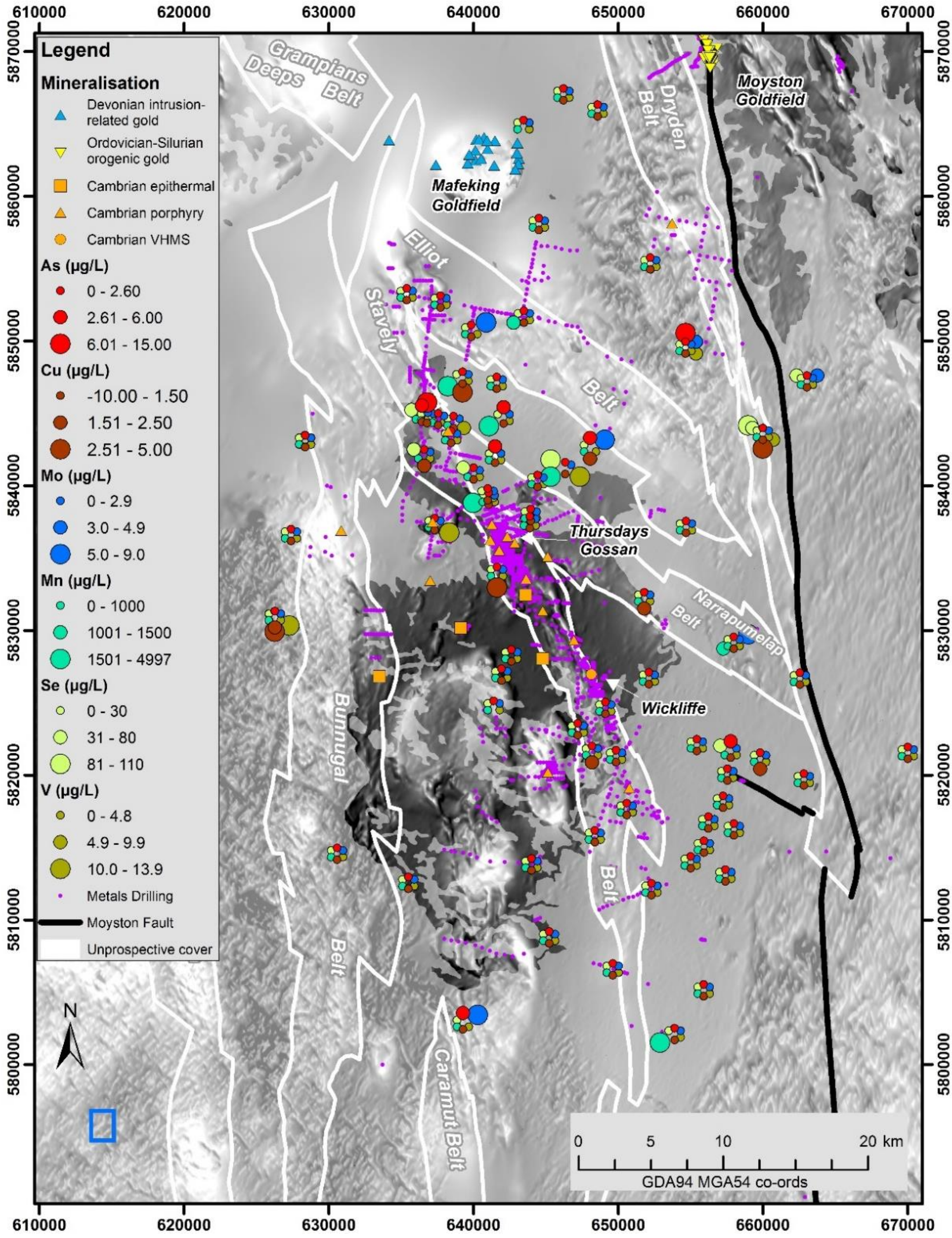


Figure 12. Hydrogeochemical pathfinder elements for porphyry mineralisation. The Toora Road and Thursday's Gossan prospects are central within the study area and are labelled for geographic reference. Background is TMI (RTP) greyscale. The Moyston Goldfield is located on the Moyston Fault in the northeast of the study area.

6.2. Orogenic Au.

The Moyston goldfields are the orogenic Au mineralisation target within the study area. Mineralisation is located within the Moyston fault at Moyston, but mineralisation is possible at other locations along the fault as shown by Arne & Giblin (2009) who identified numerous Au outliers proximal to the Moyston Fault. In this study bores were sampled proximal to the Moyston Fault, but none were available to be sampled within the Moyston goldfields.

The two highest Au concentrations detected during the orientation survey, (ID: 111696 & 111968) were both from one nested site 1.5 km west of the Moyston Fault, Figure 13. The site also sits above the volcanic Dryden Belt. The cover thickness in this location is 74 m. According to the drillers log (ID: 111698) the bore is screened within the Newer Volcanics at 8 m and (ID:111696) is screened within coarse sand with coal bands at 45 m. The coarse sand is unlikely to represent the White Hills Gravel; however, it is possible that alluvial Au from the Moyston fault is present.

These outliers could represent orogenic Au (Moyston Fault), porphyry Cu(-Au-Mo) (Dryden Belt) or intrusion-related Au. Associated hydrogeochemical outliers include Se, Te and a notable absence of Ag. Selenium is also elevated proximal to the porphyry Cu-(Au-Mo) cluster Figure 12. Selenium could also be interpreted as an indication of the presence of sulphides. Tellurium is more common in orogenic Au (Duncan pers comms, 2018) and is absent elsewhere in the study area. The lack of a silver anomaly is common in alluvial Au deposits within the White Hills Gravel. If there is mineralisation in the Moyston Fault at this location alluvial Au could have been transported towards the nested site.

6.3. Intrusion-related Au.

The Mafeking goldfields are the intrusion-related Au mineralisation target within the study area, although Devonian granites are also present elsewhere. Two bores were sampled within 3km of the Mafeking granite. They were outliers for Bi and Zn but not for Au, Ag, Te or Se.

A stronger suite of intrusion-related pathfinder element outliers is apparent within ~2.5 km of the Toora Road Prospect Figure 13. These pathfinder elements (Ag, Au, As, and Sb), were collected from weathered Stavely Arc and as such are likely to be close to the source. Extensive drilling has been undertaken within this cluster targeting porphyry Cu(-Au-Mo) mineralisation. There are additional bores in this region that could be sampled to further define the extent of this anomaly.

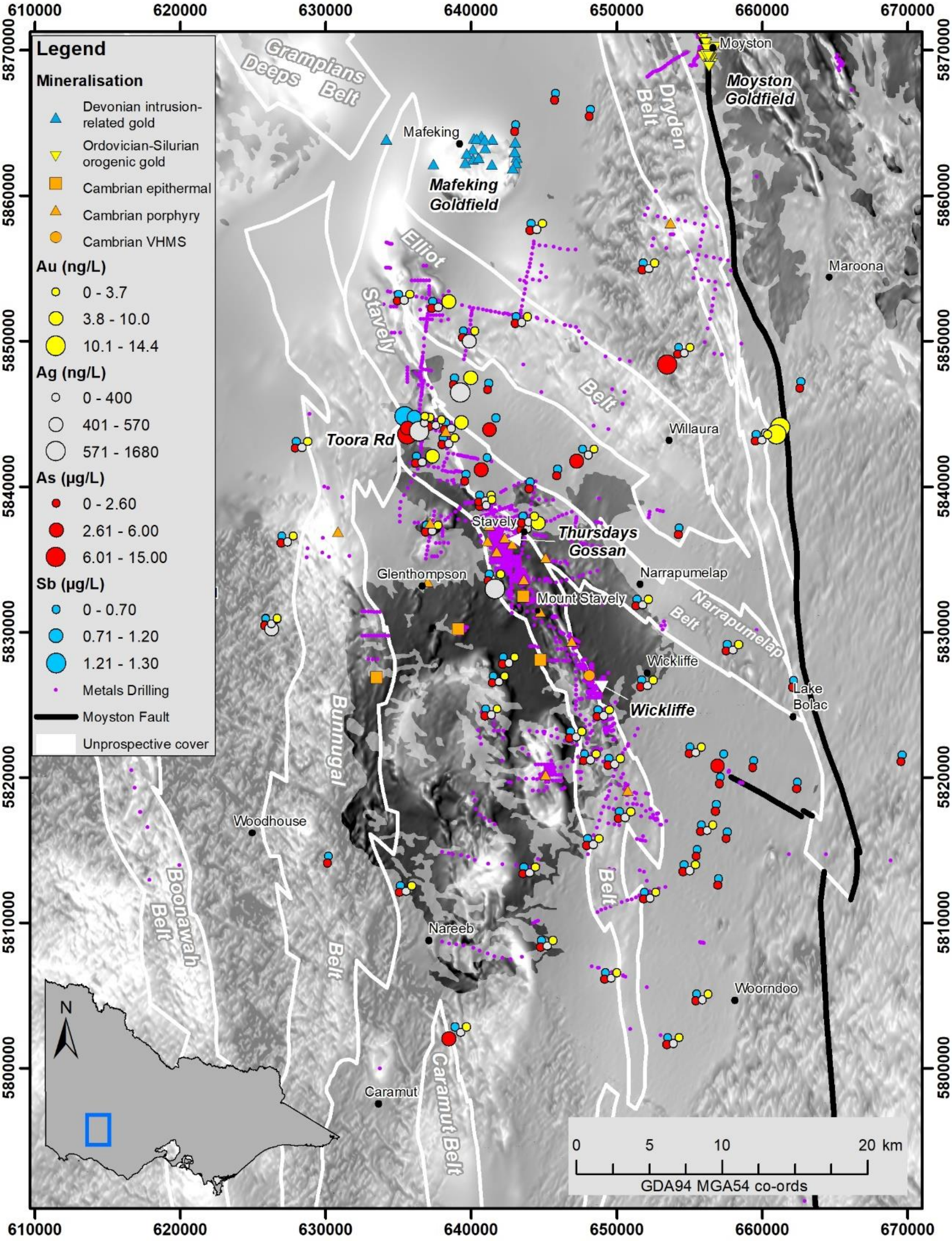


Figure 13. Hydrogeochemical pathfinder elements for orogenic and intrusion-related Au. The Moyston Goldfield is located on the Moyston Fault in the northeast of the study area. The intrusion-related Mafeking Goldfield are in the north of the study area and are associated with a known intrusive exposure and an associated geophysical feature. Background is TMI (RTP) greyscale.

7. Conclusions

A comprehensive hydrogeochemistry database has been collected from the state observation bore network and surface water bodies within the study area. Further infill sampling around areas of interest would be possible using unsampled state observation bores and private landholder bores.

Evapotranspiration is validated by PCA as being the dominant groundwater process in the study area. Additional identified important processes include: mineral occurrences, pH, DO, redox and the Stavely Arc. Major ion concentrations were dominated by evapotranspiration. Pathfinder element concentrations are associated with a range of processes including proximity to mineralisation, basement geology and physiochemical parameters. Some pathfinder elements are partially associated with DO, pH and redox but also require an additional variable such as proximity to mineralisation to explain their presence.

The interpretation of a proximal hydrogeochemical signature for porphyry Cu-(Au-Mo) mineralisation has been validated with PCA. The signature comprises elevated concentrations of Cu, V and an elevated SO4:Cl ratio. These pathfinder elements were detected in both ground and surface waters. A distal hydrogeochemical signature (As, Mo, Mn and Se) is interpreted and weakly associated with proximity to porphyry Cu-(Au-Mo) for As and Mo. Direct associations between Au and Cu suggests Au may also be considered a pathfinder element in the study area. Elevated concentrations for all pathfinders are apparent within 3km of known porphyry Cu-(Au-Mo) mineralisation at Thursdays Gossan, Toora Road and Junction Prospects.

Porphyry Cu-(Au-Mo) observations agree with those of Eppinger, et al., (2013) and Leybourne & Cameron, (2010). The extent to which weathering of mineralisation under deep cover occurs is unknown. However, elevated concentrations of Au, Ag, As, Cu, Mn, and Mo were all detected within reducing environments.

An interpreted hydrogeochemical signature for intrusion-related gold includes elevated concentrations of Ag, Au, As, Sb, and Se. Elevated pathfinders were detected in groundwaters but not surface waters. The presence of Bi near the Mafeking granite suggests potential for Bi as a pathfinder element. The interpreted hydrogeochemical signature for intrusion-related Au mineralisation has not been validated by PCA. This may be due to a lack of water samples collected within 2km of recognised intrusion-related Au mineralisation. PCA validation may have also been complicated by Au, Ag and As also being pathfinder elements for porphyry Cu(-Au-Mo).

Elevated concentrations of Au, As and Se are apparent within 2km of the Moyston fault which has potential for orogenic Au mineralisation. This supports the numerous Au anomalies detected by Arne & Giblin (2009) proximal to the Moyston Fault. The absence of groundwater bores within the Moyston goldfields limits the potential to validate an orogenic Au signature using PCA. However, the results of this study are nonetheless encouraging for the potential to detect the relevant pathfinder elements i.e. Ag, Au, Bi, Se and Te.

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Appendix A Sample location, field chemistry and geospatial references

Bore ID	Easting	Northing	Total Depth (m)	EC (µS/cm)	pH	DO (mg/L)	Redox (mV)	Volcanic belt	Volcanic Belt 2>km	Nearest Epithermal	Nearest Porphyry
102411	635394.90	5853227.00	28	5.1	6.12	0.11	-62	1	1	22336.63737	9881.278116
102412	643470.10	5851672.70	18	7.96	6.73	-0.04	-119	1	1	19223.10577	9468.648927
103096	657977.90	5829154.10	56	9.16	7.17	-0.04	-145	1	1	13260.20808	11052.33185
103097	657977.90	5829154.10	15.75	10.51	6.95	0.56	-70	1	1	13260.20808	11052.33185
103101	655421.50	5822076.60	45	14.48	7.17	0	-161	0	0	12229.38149	5525.812448
103336	648041.20	5842577.30	12.95	10.49	7.57	2.19	110	0	1	11060.33	8041.917292
104928	655905.80	5805124.40	85	5.35	5.84	4.35	104	0	0	25509.42434	14894.2729
104929	655007.00	5813985.00	63	3.58	6	0.18	116	0	0	17417.67553	6648.0804
104930	655005.00	5813980.00	15	7.04	6.73	1.86	-11	0	0	17420.54333	6650.654855
104961	656221.50	5816726.60	37	5.36	6.2	2.68	164	0	0	16124.99772	5952.443466
110104	639277.40	5802850.50	46	10.43	7.87	-0.16	-168	0	1	24686.27453	18285.38387
110516	641479.50	5841996.90	23.5	18.86	6.82	1.12	79	1	1	9778.478402	3678.490269
110517	640975.40	5839394.60	15.5	31.1	6.63	0.11	-190	1	1	7422.248535	2105.713447
110736	669999.00	5821532.00	111	6.79	7.61	0.07	-160	0	0	26070.37955	19387.76073
111689	652210.00	5855357.00	60	8.18	7.55	-0.12	-198	0	0	24473.432	3138.317065
111690	652208.00	5855357.00	45	9.38	7.92	0	-268	0	0	24472.72805	3139.275394
111691	644510.00	5858076.00	52.8	3.8	6.97	-0.01	-54	0	0	25642.33026	9203.070412
111692	644506.00	5858076.00	23	7.54	5.61	0.88	-71	0	0	25642.18784	9207.070381
111693	648573.40	5865932.40	41	1.845	5.14	0.45	-28	0	1	33850.48857	9358.105808
111695	637733.00	5852728.00	43	9.02	7.05	0.15	-197	1	1	21108.29998	8974.252615
111695 Dup1	637733.00	5852728.00	43	4.69	6.73	1.57	-191	1	1	21108.29998	8974.252615
111696	659981.30	5843579.00	78	10.39	7.23	-0.06	-294	1	1	19808.2172	15827.18149
111696 Dup1	659981.30	5843579.00	78	11.44	7.27	4.11	-265	1	1	19808.2172	15827.18149
111696 Dup2	659981.30	5843579.00	78	11.44	7.3	0.68	-294	1	1	19808.2172	15827.18149
111697	659980.80	5843582.00	37	12.6	7.2	-0.05	-180	1	1	19809.48928	15824.22879
111698	659981.90	5843583.00	9	25.1	7.44	6.92	101	1	1	19810.96112	15823.74634
111698 Dup1	659981.90	5843583.00	9	25.14	7.37	0.92	-154	1	1	19810.96112	15823.74634
111698 Dup2	659981.90	5843583.00	9	27.1	7.5	1.14	72	1	1	19810.96112	15823.74634
111699	663034.00	5847204.40	41	8.49	7.42	1.03	251	0	0	24404.24226	14347.70988
111700	663035.30	5847201.40	21	14.06	7.64	1.38	64	0	0	24403.46422	14350.83516
117418	659806.00	5821139.00	20	1.269	5.08	6.57	578	0	0	16564.25549	9268.390367
117420	657763.00	5821614.00	15	18.41	6.23	3.33	263	0	0	14516.15824	7435.800024

117424	657540.00	5820038.00	16	12.49	6.01	1.43	135	1	1	15093.25588	6840.204748
117426	657240.00	5818155.00	16.8	6.6	5.32	1.63	284	0	0	15938.24143	6545.01948
117428	657990.00	5816243.00	17	13.88	3.74	2.41	652	0	0	17744.90259	7771.401161
117430	657398.00	5813060.00	11	363	7.71	10.28	154	0	0	19621.38163	8973.728601
117435	655915.00	5815051.00	17	0.462	5.5	0.8	492	0	0	17143.79798	6553.739772
117438	650579.00	5817658.00	18.71	12.48	7.08	3.1	5	0	0	11927.61745	1456.794426
117440	652289.00	5812110.00	16.83	10.79	6.05	2.39	156	0	1	17646.79149	7157.351046
45807	626275.80	5830920.90	57	7.06	7.01	2.07	103	0	1	8287.887273	7528.854219
45808	626274.00	5830930.00	101.3	8.6	7.09	2.75	97	0	1	8293.92796	7522.733612
45815	627396.00	5836590.00	77	3.36	7.65	-0.1	-169	0	1	11491.97115	3476.317736
45816	627392.40	5836589.30	40	5.34	7.9	0.05	-149	0	1	11493.28897	3479.965179
52348	641381.40	5824716.60	45.1	0.119	7.35	7.85	82	0	0	4762.400206	5881.545402
53514	636608.90	5842086.10	20	15.21	7.17	5.66	43	1	1	11902.10135	2354.801652
53515	638460.10	5843359.40	20	20.8	6.79	1.58	230	1	1	12057.45439	457.634101
53516	637320.20	5837339.50	28	8.12	6.98	5.37	98	0	0	7385.410408	196.257204
53517	640014.00	5840840.00	13.1	14.35	7.4	6.73	149	1	1	9122.262928	3416.078977
53518	628367.70	5843082.30	72	0.912	7.38	0.56	-128	0	1	16798.22101	6670.954398
53519	628374.00	5843076.00	56	0.773	6.55	0	-127	0	1	16789.34811	6662.758363
5464	662817.00	5819690.00	10	16.47	6.53	3.36	-16	0	1	19905.38083	12067.28545
55506	653892.20	5802105.60	85	14.02	7.46	6.81	-67	0	1	27523.85419	17282.85978
55521	649621.50	5806576.60	61	7.45	6.91	0.1	-57	0	1	22036.87754	12578.3943
70920	654645.00	5849545.00	72	4.36	7.41	0.05	-74	0	0	20355.38074	8617.546809
70921	654641.00	5849546.00	40	7.81	7.46	5.27	30	0	0	20354.04952	8616.120937
74021	646338.00	5841206.00	35	-2222	6.91	7.02	-136	0	1	9175.597256	6204.815066
74035	641035.40	5839098.20	37	25.1	6.85	0.57	-53	1	1	7123.911524	1804.12882
74037	644421.40	5840326.70	12.5	13.03	7.3	3.04	-286	0	1	7919.933071	4378.358625
74039	643887.80	5837474.40	9	13.42	6.73	2.61	374	1	1	5032.924319	1786.284748
74041	643951.00	5837974.00	10.2	16.2	6.61	3.02	811	1	1	5535.459511	2213.122003
8003551	643444.00	5864860.00	49	0.237	5.63	4.67	226	0	0	32410.35176	12287.71195
82181	646208.00	5867040.00	34.50	85	6.22	1.2	-198	0	0	34688.5553	11663.3704
83676	641924.50	5826948.80	38.1	8.44	6.48	2.48	6	0	0	3051.350372	5247.115864
87751	639856.60	5850697.40	26	14.19	6.77	0.36	-186	1	1	18626.41247	7110.882288
87752	638627.80	5844402.40	11.5	9.48	6.45	4.98	647	1	1	12943.45169	734.459529
87753	637569.20	5844597.60	10	17.04	7.1	2.13	767	1	1	13560.03139	1076.230552
87754	636804.20	5844746.60	16	22.8	7.08	2.15	702	1	1	14047.11131	1750.264266
87755	636436.20	5844812.60	18	23.2	6.6	5.41	-2222	1	1	14285.73751	2097.801945
87756	639241.00	5847460.00	25	21.98	6.52	0.67	-148	0	1	15628.73687	3820.170939
87756 Dup1	639241.00	5847460.00	25	21.06	6.87	2.85	-151	0	1	15628.73687	3820.170939

87757	641597.20	5847107.60	28	15.35	7.11	1.64	-280	0	1	14793.12146	4723.332235
87781	662544.30	5826664.70	55	7.2	6.72	0.18	290	1	1	17837.82142	13998.38473
88257	630574.50	5814569.20	80	5.65	7.72	1.11	-220	0	0	12623.28677	15589.99946
96478	648371.50	5815776.60	45	15.18	7.02	0	-131	1	1	12813.30409	4097.437395
SW001	643992.00	5813827.00	0	16.77	8.35	7.9	555	0	0	14264.79709	6449.58456
SW002	645224.00	5808792.00	0	15.72	8.01	4.87	-2222	0	0	19284.53487	11385.46591
SW003	635512.00	5812550.00	0	26.6	7.62	6.95	-2222	0	1	14441.54732	12268.00758
SW004	649103.00	5824633.00	0	9.41	8.05	7.66	-2222	1	1	5537.519752	5178.375904
SW005	647198.00	5823177.00	0	17.38	8.35	7.01	-2222	0	1	5466.747845	3648.825702
SW006	654678.00	5837145.00	0	12.61	8.11	6.36	-2222	1	1	12036.44109	9787.384584
SW007	652105.00	5826701.00	0	7.95	8.08	5.61	-2222	1	1	7469.708763	5808.084452
SW008	648182.00	5821597.00	0	14.6	7.96	4.04	-2222	1	1	7321.821904	3374.332675
SW009	651781.00	5832234.00	0	17.5	8.02	4.51	-2222	0	1	8160.694211	5655.344375
SW010	642615.00	5828269.00	0	10.5	8.12	7.56	-2222	0	0	2156.110619	3765.851431
WRK958119	642077.00	5844712.00	27.44	16.72	7.12	1.16	-189	0	0	12355.60472	3935.643531
WRK962452	641621.00	5833976.00	18	20.83	6.42	4.4	-2222	1	1	2495.06553	1554.699328
WRK985194	649850.00	5821307.00	36	12.67	7.09	0.01	707	1	1	8464.008507	2386.003353

Appendix B Major ions

Bore ID	Ca (mg/l)	K (mg/l)	Mg (mg/l)	Na (mg/l)	S (mg/l)	Al (mg/l)	B (mg/l)	Fe (mg/l)	P (mg/l)	Si (mg/l)	Sr (mg/l)	Cl (mg/l)	Br (mg/l)	SO4 (mg/l)	Alkalinity HCO_3 (mg/l)
102412	184.0	14.7	211.0	1450.0	102.0	-0.5	-1.0	-0.5	-1.0	9.6	2.4	2682.0	10.1	309.4	286.8
103096	256.0	25.9	349.0	1450.0	171.0	-0.5	-1.0	-0.5	-1.0	3.4	2.6	3101.0	12.2	525.0	290.9
103097	228.0	26.1	307.0	1820.0	166.0	-0.5	-1.0	-0.5	-1.0	4.5	2.3	3604.0	13.8	510.3	249.2
103101	115.0	45.6	276.0	2860.0	197.0	-0.5	1.1	-0.5	-1.0	3.8	2.2	4974.0	19.5	635.4	513.7
103336	236.0	35.3	357.0	1730.0	128.0	-0.5	-1.0	-0.5	-1.0	9.4	4.3	3855.0	14.5	409.3	395.7
104928	87.0	9.6	123.0	874.0	61.0	-0.3	-0.3	-0.5	-1.0	5.2	0.7	1780.0	5.3	213.7	54.6
104929	58.1	12.6	94.0	703.0	46.2	-0.1	-0.2	-0.1	-0.2	12.5	0.8	1434.0	5.5	154.4	90.1
104930	107.0	15.5	166.0	1260.0	83.3	-0.5	-1.0	-0.5	-1.0	8.6	1.4	2288.0	8.7	260.3	169.4
104961	79.6	13.7	118.0	948.0	82.1	-0.5	-1.0	-0.5	-1.0	13.7	0.9	1747.0	6.9	258.7	133.4
110104	112.0	21.8	390.0	1930.0	174.0	-0.5	-1.0	-0.5	-1.0	6.1	1.5	3731.0	13.6	537.8	325.5
110516	757.0	44.0	916.0	4637.0	322.0	-0.5	1.1	-1.0	-2.0	5.9	17.6	-333.0	-333.0	-333.0	5.5
110517	583.0	43.9	1070.0	6170.0	610.0	-2.5	-5.0	-2.5	-5.0	-12.5	13.8	11845.0	43.5	1836.4	221.8
110736	87.0	30.0	228.0	1110.0	80.0	-0.3	-0.3	0.8	-1.0	15.0	1.3	2274.0	6.7	291.5	345.2
111689	177.0	13.9	272.0	1260.0	80.4	-0.5	-1.0	-0.5	-1.0	12.7	2.8	2614.0	9.5	248.0	360.9
111690	318.0	22.0	318.0	1320.0	101.0	-0.5	-1.0	-0.5	-1.0	7.1	4.0	3182.0	12.1	313.2	96.3

111691	96.3	5.1	85.5	505.0	11.0	-0.1	-0.2	-0.1	-0.2	15.4	0.8	1107.0	3.6	36.4	253.9
111692	98.4	6.6	274.0	1130.0	31.9	-0.5	-1.0	6.1	-1.0	28.2	1.5	2677.0	7.7	108.5	4.5
111693	44.0	6.0	79.0	186.0	5.5	-0.1	-0.1	-0.1	-0.2	14.0	0.3	654.0	1.8	26.0	13.0
111695	98.5	9.5	366.0	1620.0	115.0	-0.5	-1.0	-0.5	-1.0	4.0	1.4	3242.0	12.9	361.3	431.0
111695 Dup1	123.0	9.0	467.0	1682.0	149.0	-0.5	-0.5	-1.0	-2.0	9.1	1.7	-333.0	-333.0	-333.0	311.7
111696	190.0	21.5	351.0	1710.0	152.0	-0.5	-1.0	-0.5	-1.0	7.7	3.7	3699.0	14.2	495.5	333.9
111696 Dup1	201.0	23.0	378.0	1728.0	168.0	-0.5	-0.5	-1.0	-2.0	7.9	3.7	-333.0	-333.0	-333.0	253.3
111697	214.0	27.8	464.0	2080.0	200.0	-0.5	-1.0	-0.5	-1.0	21.8	3.7	4669.0	18.1	657.4	361.3
111698	802.0	124.0	2220.0	9070.0	1070.0	-1.0	-2.0	-1.0	-2.0	25.6	14.9	9876.0	39.0	1668.2	412.2
111698 Dup1	413.0	65.0	1258.0	4605.0	615.0	-0.5	1.0	-1.0	-2.0	12.0	6.9	-333.0	-333.0	-333.0	417.3
111699	78.0	17.0	257.0	1470.0	120.0	-0.3	0.4	-0.5	-1.0	5.3	1.2	3491.0	10.8	532.1	309.0
111700	141.0	35.0	533.0	2440.0	284.0	-0.5	0.8	-1.0	-2.0	12.0	2.5	5585.0	18.9	1143.6	242.9
117418	178.0	21.0	374.0	1810.0	220.0	-0.1	0.4	-0.1	-0.2	13.0	2.5	3551.0	16.1	755.5	29.5
117420	386.0	41.0	432.0	3590.0	367.0	-0.5	0.9	-1.0	-2.0	6.3	4.6	8123.0	27.5	1608.6	197.3
117424	211.0	22.0	300.0	2320.0	205.0	-0.5	-0.5	-1.0	-2.0	6.5	2.2	3808.0	10.6	583.6	101.6
117426	84.0	14.0	139.0	1140.0	133.0	-0.3	-0.3	-0.5	-1.0	13.0	1.0	2187.0	6.2	496.8	70.7
117428	229.0	18.0	367.0	2600.0	168.0	-0.5	-0.5	-1.0	-2.0	15.0	2.5	5409.0	14.2	621.0	18.7
117430	5.4	2.0	10.1	37.7	3.6	-0.1	-0.1	-0.1	-0.2	6.0	-0.1	-333.0	-333.0	-333.0	23.5
117435	3.4	0.6	5.7	104.0	9.9	-0.1	0.1	-0.1	-0.2	7.8	-0.1	70.0	0.3	33.1	65.8
117438	278.0	35.4	312.0	2360.0	246.0	-0.5	-1.0	-0.5	-1.0	3.3	3.6	4678.0	17.9	792.8	347.2
117440	162.0	20.8	267.0	2090.0	159.0	-0.5	-1.0	-0.5	-1.0	11.4	2.2	4042.0	14.6	504.6	109.4
45807	114.0	5.5	284.0	1090.0	49.8	-0.5	-1.0	-0.5	-1.0	20.8	1.2	2372.0	7.5	162.8	533.3
45808	138.0	7.6	334.0	1360.0	64.1	-0.5	-1.0	-0.5	-1.0	21.0	1.7	3012.0	9.2	211.5	492.5
45815	72.2	6.9	93.6	479.0	22.7	-0.1	-0.2	-0.1	-0.2	8.0	0.9	996.0	3.8	76.9	332.8
45816	141.0	10.3	211.0	764.0	50.1	-0.5	-1.0	-0.5	-1.0	8.1	1.9	1705.0	6.1	157.9	454.5
52348	7.1	3.1	8.3	62.1	12.2	3.5	-0.2	0.8	-0.2	6.9	0.1	38.0	0.1	22.5	61.3
53514	269.0	19.6	351.0	3160.0	302.0	-0.5	-1.0	-0.5	-1.0	6.3	3.6	6230.0	25.1	999.7	154.8
53515	431.0	48.7	620.0	3520.0	269.0	-0.5	1.4	-0.5	-1.0	6.5	12.3	-333.0	-333.0	-333.0	345.5
53516	187.0	7.4	229.0	1240.0	110.0	-0.5	-1.0	-0.5	-1.0	27.1	1.6	2676.0	9.8	344.8	176.3
53517	160.0	22.0	256.0	2885.0	318.0	-0.5	1.1	-1.0	-2.0	6.2	3.7	-333.0	-333.0	-333.0	424.5
53518	63.1	8.4	13.6	96.6	-0.2	-0.1	-0.2	-0.1	-0.2	10.5	0.5	183.0	0.8	0.0	238.1
53519	37.4	5.3	16.5	88.3	-0.2	-0.1	-0.2	0.9	-0.2	7.4	0.3	164.0	0.7	0.5	168.4
5464	234.0	40.0	424.0	3220.0	334.0	-0.5	1.2	-1.0	-2.0	17.0	4.0	5775.0	15.2	1170.6	285.8
55506	189.0	19.7	366.0	2800.0	156.0	-0.5	-1.0	-0.5	-1.0	4.3	2.0	4950.0	18.7	517.3	640.5
55521	166.0	27.5	201.0	1240.0	128.0	-0.5	-1.0	-0.5	-1.0	9.0	1.4	2511.0	9.9	398.7	180.5
70920	111.0	9.2	105.0	642.0	42.9	-0.1	1.0	-0.1	0.3	12.2	2.5	1353.0	5.0	141.8	332.2
70921	190.0	32.8	295.0	1160.0	115.0	-0.5	-1.0	-0.5	-1.0	23.1	2.7	2527.0	10.0	356.5	434.1
74021	1766.0	497.0	4712.0	21855.0	2228.0	-0.5	6.3	-1.0	-2.0	11.0	53.0	47600.0	194.2	7360.0	142.2

74035	443.0	32.1	637.0	4560.0	394.0	-1.0	-2.0	-1.0	-2.0	-5.0	10.4	9204.0	34.3	1247.9	252.0
74037	444.0	65.0	813.0	5347.0	441.0	-0.5	1.4	-1.0	-2.0	5.1	9.9	-333.0	-333.0	-333.0	194.1
74039	207.0	21.0	378.0	2210.0	208.0	-0.5	-1.0	-0.5	-1.0	2.5	3.7	-333.0	-333.0	-333.0	410.3
74041	411.0	31.6	624.0	2300.0	259.0	-0.5	-1.0	-0.5	-1.0	3.9	6.8	-333.0	-333.0	-333.0	425.2
8003551	0.7	2.0	1.5	10.0	0.9	-0.1	-0.1	-0.1	-0.2	5.2	-0.1	23.0	0.1	3.5	6.6
82181	0.6	2.3	1.1	9.3	0.5	0.6	-0.1	2.9	-0.2	4.5	-0.1	-333.0	-333.0	-333.0	300.6
83676	177.0	17.1	324.0	1270.0	85.2	-0.5	-1.0	-0.5	-1.0	24.4	0.9	3039.0	9.7	266.0	140.5
87751	253.0	12.1	477.0	2310.0	227.0	-0.5	-1.0	-0.5	-1.0	12.6	4.0	5018.0	21.2	738.3	503.2
87752	212.0	36.4	365.0	1330.0	177.0	-0.5	2.0	-0.5	-1.0	5.5	5.2	-333.0	-333.0	-333.0	663.0
87753	290.0	27.1	437.0	2830.0	219.0	-0.5	-1.0	-0.5	-1.0	-2.5	5.8	-333.0	-333.0	-333.0	212.5
87754	342.0	35.2	471.0	4140.0	322.0	-0.5	1.7	-0.5	-1.0	2.8	6.3	-333.0	-333.0	-333.0	334.8
87755	417.0	25.8	490.0	4250.0	402.0	-0.5	1.0	-0.5	-1.0	3.4	7.0	-333.0	-333.0	-333.0	65.7
87756	434.0	18.5	579.0	4200.0	386.0	-1.0	-2.0	-1.0	-2.0	5.3	5.9	8485.0	33.6	1246.4	108.1
87756 Dup1	477.0	20.0	650.0	4311.0	438.0	-0.5	0.5	-1.0	-2.0	7.5	5.9	-333.0	-333.0	-333.0	126.2
87757	487.0	28.0	682.0	3808.0	356.0	-0.5	0.7	-1.0	-2.0	4.7	7.0	-333.0	-333.0	-333.0	96.5
87781	109.0	24.0	252.0	1120.0	89.0	-0.3	0.3	-0.5	-1.0	20.0	1.8	2454.0	7.7	323.4	286.4
88257	86.0	7.0	309.0	862.0	39.0	-0.5	-0.5	-1.0	-2.0	20.0	1.0	-333.0	-333.0	-333.0	104.2
96478	382.0	41.8	381.0	2570.0	208.0	-0.5	-1.0	-0.5	-1.0	22.1	4.7	5555.0	21.0	675.0	224.5
SW001	175.0	31.8	578.0	2650.0	241.0	-0.5	-1.0	-0.5	-1.0	-2.5	2.6	5488.0	22.0	763.3	446.4
SW002	176.0	29.5	553.0	2450.0	223.0	-0.5	-1.0	-0.5	-1.0	-2.5	2.5	5066.0	20.0	708.4	460.9
SW003	529.0	16.6	966.0	4000.0	391.0	-0.5	-1.0	-0.5	-1.0	5.5	6.9	9577.0	35.1	1313.3	481.6
SW004	207.0	12.2	412.0	1680.0	90.3	-0.5	-1.0	-0.5	-1.0	-2.5	2.0	4064.0	13.4	288.2	306.9
SW005	194.0	32.3	607.0	2700.0	250.0	-0.5	-1.0	-0.5	-1.0	-2.5	2.8	5827.0	23.2	812.5	427.6
SW006	210.0	12.7	433.0	1720.0	79.6	-0.5	-1.0	-0.5	-1.0	-2.5	2.3	4201.0	14.4	251.6	303.6
SW007	155.0	5.4	286.0	1090.0	58.8	-0.5	-1.0	-0.5	-1.0	2.6	1.5	2448.0	8.2	186.0	521.7
SW008	218.0	21.4	498.0	2310.0	174.0	-0.5	-1.0	-0.5	-1.0	-2.5	2.7	5201.0	19.0	564.6	385.7
SW009	217.0	30.2	609.0	2700.0	233.0	-0.5	-1.0	-0.5	-1.0	-2.5	3.0	5889.0	22.9	757.9	424.6
SW010	159.0	13.6	337.0	1570.0	66.1	-0.5	-1.0	-0.5	-1.0	-2.5	1.7	3504.0	11.4	211.5	327.5
WRK958119	368.0	142.0	544.0	2807.0	8.9	-0.5	0.6	-1.0	-2.0	13.0	6.6	-333.0	-333.0	-333.0	1571.5
WRK962452	275.0	18.9	447.0	3530.0	311.0	-0.5	-1.0	-0.5	-1.0	-2.5	4.2	-333.0	-333.0	-333.0	107.8
WRK985194	292.0	22.4	345.0	1900.0	136.0	-0.5	-1.0	2.4	-1.0	15.6	3.1	4278.0	17.3	432.7	150.2
Blank001	0.2	0.2	0.3	4.4	-0.2	-0.1	-0.2	-0.1	-0.2	-0.5	-0.1	0.0	0.0	0.0	7.5
Blank002	0.1	-0.2	-0.2	1.6	-0.2	-0.1	-0.2	-0.1	-0.2	-0.5	-0.1	0.0	0.0	0.0	7.2

Appendix C Trace elements

Bore ID	As µg/L	Ba µg/L	Cd µg/L	Ce µg/L	Co µg/L	Cr µg/L	Cu µg/L	Er µg/L	Eu µg/L	Ge µg/L	Ga µg/L	Li µg/L	Mn µg/L	Mo µg/L	Nb µg/L	Ni µg/L	Rb µg/L	Sc µg/L	Se µg/L
102411	-2	196	-0.5	-0.5	11	-1	-2	-0.5	-0.5	-1	-1	12	744	-3	-5	23	6	5	-1
102412	-1	109	-0.3	-0.3	24.1	-0.5	-1	-0.3	-0.3	-0.5	-0.5	20.2	1096	-2	-3	4	3	3.3	0.5
103096	-1	84	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	1.5	302	-2	-3	4	63	1.9	-0.5
103097	-2	160	-0.5	-0.5	21	-1	-2	-0.5	-0.5	-1	-1	3	1062	8	-5	1426	29	2	9
103101	-1	43	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	81.8	495	-2	-3	3	86	1.7	-0.5
103336	6	67	-0.3	-0.3	1	-0.5	2	-0.3	-0.3	-0.5	-0.5	12.6	163	9	-3	6	12	2.7	2.6
104928	-0.2	101.9	-0.05	-0.05	4.1	-0.1	-0.5	-0.05	-0.05	-0.1	-0.05	3.9	66	-0.1	-0.1	1.6	20.1	-0.2	1.5
104929	1.1	98	0.5	-0.1	-0.2	0.3	0.5	-0.1	-0.1	-0.2	-0.2	11	5	-0.6	-1	10	55.2	2.7	1.8
104930	-2	73	7.1	-0.5	3	-1	-2	-0.5	-0.5	-1	-1	7	670	-3	-5	488	30	3	1
104961	1.8	49	-0.1	-0.1	0.4	-0.2	-0.4	-0.1	-0.1	-0.2	-0.2	3.8	6	-0.6	-1	10	35.5	3.3	3.9
110104	4.6	37	-0.1	-0.1	-0.2	-0.2	-0.4	-0.1	-0.1	-0.2	-0.2	29.2	167	5.5	-1	2	10.2	2.8	-0.2
110516	3.3	50.2	-0.5	-0.3	2.6	-3	-3	-0.3	-0.3	-0.5	-0.5	92	313	-3	-3	5	56.5	-2	11.7
110517	-2	33	-0.5	-0.5	3	-1	-2	-0.5	-0.5	-1	-1	56	4127	-3	-5	6	10	2	-1
110736	1.4	94.1	-0.1	-0.1	-0.2	-0.2	-1	-0.1	-0.1	-0.2	-0.1	6.1	121	1.6	-0.2	-1	60	-0.4	-0.2
111689	-1	103	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	42.9	408	-2	-3	-3	19	4	-0.5
111690	-2	122	-0.5	-0.5	-1	-1	-2	-0.5	-0.5	-1	-1	25	419	-3	-5	-5	23	3	-1
111691	-0.2	127	-0.05	-0.05	1.2	-0.1	-0.2	-0.05	-0.05	0.2	-0.1	58.1	492	-0.3	-0.5	2.4	12.4	3.3	-0.1
111692	-0.4	193	-0.1	13	92.3	-0.2	-0.4	0.3	0.1	0.3	1.3	22.2	229	-0.6	-1	36	11.2	6.5	-0.2
111693	-1	213	0.5	-0.3	41.2	-0.5	-3	-0.3	-0.3	-0.5	-0.3	14	507	-0.5	-0.5	49	22.8	-1	-0.5
111695	2	46	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	21.1	854	-2	-3	15	4	2.1	-0.5
111695 Dup1	1.5	46.4	-0.5	-0.3	5.4	-3	-3	-0.3	-0.3	-0.5	-0.5	28	502	-3	-3	-5	3	-2	9.4
111696	0.6	65	-0.1	-0.1	-0.2	0.4	-0.4	-0.1	-0.1	0.2	-0.2	38.4	97	-0.6	-1	3	25.2	2.4	-0.2
111696 Dup1	0.7	65.2	-0.2	-0.1	-0.1	-1	-1	-0.1	-0.1	-0.2	-0.2	31.9	99.9	-1	-1	12	24.8	-0.8	41.9
111697	-1	56	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	0.7	-0.5	25.1	190	-2	-3	4	16	5	-0.5
111698	-2	93	-0.5	-0.5	-1	1	4	-0.5	-0.5	-1	-1	21	10	-3	-5	21	28	4	13
111698 Dup1	1.5	94.4	-0.5	0.4	-0.3	-3	-3	-0.3	-0.3	-0.5	-0.5	20	4	-3	-3	32	26.7	-2	108.3
111699	0.9	47.7	-0.1	-0.1	0.4	-0.2	-1	-0.1	-0.1	-0.2	-0.1	2.7	44	3.2	-0.2	4	8.5	-0.4	0.2
111700	-1	32	-0.3	-0.3	-0.5	1.6	-3	-0.3	-0.3	-0.5	-0.3	4.8	14	1.6	-0.5	-3	11.1	-1	30.5
117418	-0.4	37.7	0.3	0.2	1.8	4.5	2	-0.1	-0.1	-0.2	-0.1	39	39	-0.2	-0.2	13	2.4	-0.4	15.1
117420	4	28	-0.3	-0.3	1.9	0.5	-3	-0.3	-0.3	-0.5	-0.3	1.2	8	1.9	-0.5	-3	48.1	-1	34.3

117424	2	44	1	0.5	68.7	-0.5	-3	-0.3	-0.3	-0.5	-0.3	1.7	273	0.7	-0.5	7	68.9	-1	8.2
117426	1.7	32.7	0.1	0.3	5.4	-0.2	-1	-0.1	-0.1	-0.2	-0.1	2.3	22	-0.2	-0.2	-1	60	-0.4	8.6
117428	1	37	-0.3	12.6	116.1	0.8	-3	1.5	0.6	0.9	1.4	21.8	52	-0.5	-0.5	21	54.7	-1	1.5
117430	0.6	8.1	0.1	-0.05	0.32	-0.5	-0.5	-0.05	-0.05	-0.1	-0.1	1.7	31.1	-0.5	-0.5	3	1.5	-0.4	1.2
117435	1.2	1.5	-0.05	-0.05	-0.1	0.2	-0.5	-0.05	-0.05	-0.1	-0.05	1	-1	-0.1	-0.1	-0.5	0.7	-0.2	1.8
117438	-1	38	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	5.9	20	-2	-3	-3	29	1.5	6.6
117440	-1	43	-0.3	-0.3	1.3	-0.5	-1	-0.3	-0.3	-0.5	-0.5	15.1	56	-2	-3	-3	30	3.1	-0.5
45807	-0.4	93	-0.1	-0.1	-0.2	0.3	2	-0.1	-0.1	-0.2	-0.2	4.7	2	-0.6	-1	5	3.8	5	1.4
45808	0.8	70	-0.1	-0.1	-0.2	0.6	2.9	-0.1	-0.1	-0.2	-0.2	4	-1	-0.6	-1	28	9	5.4	1.6
45815	1	133	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	2.5	285	-2	-3	-3	12	1.7	-0.5
45816	-0.4	238	-0.1	-0.1	-0.2	-0.2	-0.4	-0.1	-0.1	-0.2	-0.2	4	253	-0.6	-1	1	19.6	2.3	-0.2
52348	0.8	8.3	0.12	0.51	0.2	2	13.9	-0.05	-0.05	-0.1	0.5	0.8	1	-0.3	-0.5	1.7	2.6	1.6	0.8
53514	-1	12	0.4	-0.3	1.6	-0.5	2	-0.3	-0.3	-0.5	-0.5	23.1	51	-2	-3	21	4	2.1	35.6
53515	-2	36.1	-0.3	-0.3	-1	-1	-1	-0.3	-0.5	-1	-1	21	25	-0.5	-0.3	6	37	-1	-1
53516	-0.4	4	-0.1	-0.1	-0.2	0.7	-0.4	-0.1	-0.1	-0.2	-0.2	25.6	7	-0.6	-1	7	-0.4	6.1	4.2
53517	0.7	19.3	-0.5	-0.3	-0.3	6	-3	-0.3	-0.3	-0.5	-0.5	57	9	-3	-3	19	3.8	-2	30.8
53518	-0.4	411	-0.1	-0.1	-0.2	-0.2	0.5	-0.1	-0.1	-0.2	-0.2	4.6	67	2.6	-1	3	10	2.3	-0.2
53519	-1	301	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	1.6	240	-2	-3	-3	8	1.5	-0.5
5464	2	36	-0.3	-0.3	0.9	-0.5	-3	-0.3	-0.3	-0.5	-0.3	18.8	187	2.7	-0.5	-3	25.8	-1	10.4
55506	-2	82	-0.5	-0.5	-1	-1	-2	-0.5	-0.5	-1	-1	212	1670	-3	-5	12	7	3	-1
55521	-2	41	-0.5	-0.5	6	-1	-2	-0.5	-0.5	-1	-1	47	684	-3	-5	6	16	2	-1
70920	15	89	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	35.4	239	3	-3	4	18	2.9	-0.5
70921	-0.4	53	-0.1	-0.1	-0.2	0.8	-0.4	-0.1	-0.1	-0.2	-0.2	15.2	-1	1.1	-1	1	28.7	5.4	14.1
74021	-3	39.7	-3	-1	3	-10	-10	-1	-1	-3	-3	82	1568	-10	-10	122	83	-10	97
74035	-1	32	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	36.7	274	-2	-3	4	10	2.2	1.6
74037	-1	51.9	-1	-0.5	0.5	-5	-5	-0.5	-0.5	-1	-1	21	19	-5	-5	12	14	-4	11
74039	-2	41.3	-0.3	-0.3	-1	-1	-1	-0.3	-0.5	-1	-1	8	79	-0.5	-0.3	-3	6	-1	2
74041	-2	32.3	-0.3	-0.3	-1	-1	-1	-0.3	-0.5	-1	-1	23	42	0.9	-0.3	-3	8	-1	3
8003551	-0.4	15.6	-0.1	-0.1	0.3	-0.2	16	-0.1	-0.1	-0.2	-0.1	1	4	-0.2	-0.2	-1	10.5	-0.4	-0.2
82181	0.4	7.22	-0.1	1.65	0.34	1.4	-0.5	0.12	0.06	0.2	0.2	0.6	25.7	-0.5	-0.5	2	6.7	1.3	0.2
83676	-1	99	-0.3	-0.3	2.7	-0.5	-1	-0.3	-0.3	-0.5	-0.5	41.3	427	-2	-3	34	10	5.4	-0.5
87751	-1	35	-0.3	-0.3	-0.5	-0.5	-1	-0.3	-0.3	-0.5	-0.5	42.5	20	7	-3	9	-1	3.6	2.8
87752	0.8	43.1	-0.1	-0.1	-0.4	1.1	1.3	-0.1	-0.2	-0.4	-0.4	17.2	17	1	-0.1	2	10	-0.4	9.9
87753	-2	153.3	-0.3	-0.3	-1	-1	-1	-0.3	-0.5	-1	-1	22	125	-0.5	-0.3	9	12	-1	1
87754	10	104.6	-0.3	-0.3	-1	-1	-1	-0.3	-0.5	-1	-1	45	2130	1.3	-0.3	4	10	-1	7
87755	4	31.6	0.7	-0.3	9	-1	-1	-0.3	-0.5	-1	-1	96	311	1.1	-0.3	23	-4	-1	46

87756	-2	103	-0.5	-0.5	13	-1	-2	-0.5	-0.5	-1	-1	93	4997	-3	-5	18	5	3	4
87756 Dup1	1.1	107.5	-0.5	-0.3	0.7	-3	5	-0.3	-0.3	-0.5	-0.5	78	2960	-3	-3	53	4.6	-2	20
87757	-0.5	105.1	-0.5	-0.3	-0.3	-3	-3	-0.3	-0.3	-0.5	-0.5	35	646	-3	-3	23	53.9	-2	24.5
87781	0.4	83.8	-0.1	-0.1	-0.2	-0.2	-1	-0.1	-0.1	-0.2	-0.1	27.8	147	2.3	-0.2	-1	36.6	-0.4	-0.2
88257	1.9	23.05	-0.1	-0.05	0.06	0.6	-0.5	-0.05	-0.05	-0.1	-0.1	3.5	64.6	0.5	-0.5	5	16.8	-0.4	1.9
96478	1	53	-0.3	-0.3	4.8	-0.5	-1	-0.3	-0.3	-0.5	-0.5	94.4	312	-2	-3	4	33	5.6	-0.5
Blank001	-0.2	-0.5	-0.05	-0.05	-0.1	0.7	0.5	-0.05	-0.05	-0.1	-0.1	0.1	1.3	-0.3	-0.5	2.3	0.3	-0.1	-0.1
Blank002	-0.2	1.1	-0.05	-0.05	-0.1	0.1	0.6	-0.05	-0.05	-0.1	-0.1	-0.1	1.8	-0.3	-0.5	0.6	-0.2	-0.1	-0.1
SW001	2.2	84.2	-0.3	-0.3	0.4	-3	-2	-0.05	-0.05	-3	-0.3	16.1	3	1.6	-0.5	-5	18.7	-1	-4
SW002	1.8	77.3	-0.3	-0.3	-0.3	-3	-2	-0.05	-0.05	-3	-0.3	12.9	-3	1.6	-0.5	5	15.5	-1	-4
SW003	1.6	122.2	-0.3	-0.3	-0.3	-3	-2	-0.05	-0.05	-3	-0.3	27.5	-3	-0.5	-0.5	9	4	-1	-4
SW004	0.7	139.9	-0.1	-0.1	-0.1	-1	-0.8	-0.02	-0.02	-1	-0.1	24.6	1	-0.2	-0.2	-2	3	-0.4	1
SW005	1.9	91.6	-0.3	-0.3	0.3	-3	-2	-0.05	-0.05	-3	-0.3	18.1	6	1.3	-0.5	-5	18.3	-1	-4
SW006	0.7	157.4	-0.1	-0.1	-0.1	-1	1.1	-0.02	-0.02	-1	-0.1	55.6	-1	-0.2	-0.2	-2	3	-0.4	2
SW007	2.6	75.1	-0.1	-0.1	0.4	-1	1.1	-0.02	-0.02	-1	-0.1	7.3	2	1	-0.2	3	3.2	-0.4	2
SW008	1.8	134.2	-0.3	-0.3	0.3	-3	2	-0.05	-0.05	-3	-0.3	24.1	36	-0.5	-0.5	-5	8.6	-1	-4
SW009	2.3	110.2	-0.3	-0.3	-0.3	-3	2	-0.05	-0.05	-3	-0.3	20.8	3	0.9	-0.5	-5	15.5	-1	5
SW010	0.8	121.1	-0.1	-0.1	0.2	-1	1.2	-0.02	-0.02	-1	-0.1	23.2	82	-0.2	-0.2	-2	4.4	-0.4	3
WRK958119	4.1	129.6	-0.5	-0.3	6.3	-3	-3	-0.3	-0.3	-0.5	-0.5	6	2285	-3	-3	46	54.6	-2	11.5
WRK962452	-2	27	-0.3	-0.3	-1	-1	5	-0.3	-0.5	-1	-1	30	5	-0.5	-0.3	3	-4	-1	24
WRK985194	1.2	50.4	-0.3	-0.3	0.4	-3	-2	-0.05	-0.05	-3	-0.3	70.8	396	-0.5	-0.5	-5	20.3	-1	5

Bore ID	**V µg/L**	**Y µg/L**	**Zr µg/L**	**Gd µg/L**	**Hf µg/L**	**Ho µg/L**	**In µg/L**	**La µg/L**	**Nd µg/L**	**Pb µg/L**	**Pr µg/L**	**Sb µg/L**	**Sn µg/L**	**Sm µg/L**	**Te µg/L**	**Ta µg/L**	**Tb µg/L**	**Th µg/L**	**W µg/L**	**Zn µg/L**
102411	-0.5	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	40
102412	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	6
103096	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	6
103097	-0.5	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	-10
103101	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	0.9	13
103336	4.1	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	-5
104928	-0.1	0.2	-0.1	-0.05	-0.05	-0.05	-0.1	-0.05	-0.05	-0.2	-0.05	-0.5	1.4	-0.1	-0.2	-0.2	-0.05	-0.2	-0.2	87
104929	0.8	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	-0.2	20

104930	-0.5	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	48
104961	0.6	0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	-0.2	19
110104	-0.1	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	-0.2	4
110516	2.1	0.3	-3	-0.3	-3	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.5	-0.5	-0.3	-3	-0.5	-0.3	-0.3	-3	8
110517	-0.5	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	14
110736	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0.4	-0.1	-1	1.3	-0.2	-0.4	-0.4	-0.1	-0.4	-0.4	111
111689	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	-5
111690	-0.5	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	6
111691	-0.05	-0.05	-0.1	-0.05	-0.1	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.4	-0.2	-0.05	-0.6	-0.1	-0.05	-0.1	-0.1	1
111692	-0.1	9.9	-0.2	0.7	-0.2	-0.1	-0.1	13.5	3.2	-0.1	0.9	-0.8	-0.4	0.4	-1	-0.2	-0.1	-0.2	-0.2	40
111693	-0.5	-0.5	-0.5	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-1	-0.3	-3	-1	-0.5	-1	-1	-0.3	-1	-1	55
111695	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	7
111695 Dup1	1.2	0.4	-3	-0.3	-3	-0.3	-0.5	0.6	-0.3	-0.3	-0.3	-0.5	-0.5	-0.3	-3	-0.5	-0.3	-0.3	-3	9
111696	0.3	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	-0.2	-2
111696 Dup1	1.2	-0.1	-1	-0.1	-1	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1	-1	-0.2	-0.1	-0.1	-1	-1
111697	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	20
111698	2.3	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	25
111698 Dup1	4.9	0.7	-3	-0.3	-3	-0.3	-0.5	-0.3	0.3	-0.3	-0.3	-0.5	0.8	-0.3	-3	-0.5	-0.3	-0.3	-3	4
111699	0.6	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0.4	-0.1	-1	1	-0.2	-0.4	-0.4	-0.1	-0.4	-0.4	23
111700	2.6	-0.5	-0.5	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-1	-0.3	-3	3	-0.5	-1	-1	-0.3	-1	-1	12
117418	0.3	0.5	-0.2	-0.1	-0.1	-0.1	-0.2	0.2	-0.1	1.1	-0.1	-1	1.3	-0.2	-0.4	-0.4	-0.1	-0.4	-0.4	146
117420	3.6	-0.5	-0.5	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	2	-0.3	-3	4	-0.5	-1	-1	-0.3	-1	5	21
117424	-0.5	0.5	-0.5	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-1	-0.3	-3	2	-0.5	-1	-1	-0.3	-1	3	28
117426	0.6	0.3	-0.2	-0.1	-0.1	-0.1	-0.2	0.2	-0.1	-0.4	-0.1	-1	0.8	-0.2	-0.4	-0.4	-0.1	-0.4	1.4	47
117428	-0.5	32.5	-0.5	3.1	-0.3	0.5	-0.5	20	13.8	3	3.3	-3	3	2.4	-1	-1	0.4	-1	-1	66
117430	0.41	-0.05	-0.5	-0.05	-0.5	-0.05	-0.1	-0.05	-0.05	0.05	-0.05	-0.1	6.1	-0.05	-0.5	-0.1	-0.05	-0.05	-0.5	5.8
117435	0.4	-0.1	-0.1	-0.05	-0.05	-0.05	-0.1	-0.05	-0.05	-0.2	-0.05	-0.5	0.3	-0.1	-0.2	-0.2	-0.05	-0.2	-0.2	11
117438	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	0.4	-0.3	-2	2	-0.3	-3	-0.5	-0.3	-0.5	-0.5	36
117440	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	7
45807	3.7	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	1.6	-0.1	-1	-0.2	-0.1	-0.2	-0.2	5
45808	13.9	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	0.2	60
45815	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	-5

45816	-0.1	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	-0.2	-2
52348	2.02	0.22	2.1	0.05	-0.1	-0.05	-0.05	0.27	0.3	0.32	0.05	-0.4	1.2	0.06	-0.6	-0.1	-0.05	0.2	-0.1	38
53514	0.4	1.9	-0.5	-0.3	-0.5	-0.3	-0.3	0.9	0.6	-0.3	-0.3	-2	1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	29
53515	1.6	-0.3	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	1	-0.3	-0.5	1.4	-0.3	-2	-0.3	-0.3	-0.3	-0.5	51
53516	11.2	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	-0.2	25
53517	1.9	-0.3	-3	-0.3	-3	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.5	-0.5	-0.3	-3	-0.5	-0.3	-0.3	-3	5
53518	-0.1	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	0.8	-0.1	-1	-0.2	-0.1	-0.2	0.3	2
53519	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	-5
5464	3.1	-0.5	-0.5	-0.3	-0.3	-0.3	-0.5	-0.3	-0.3	-1	-0.3	-3	-1	-0.5	-1	-1	-0.3	-1	-1	19
55506	0.8	-0.5	2	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	2	82
55521	-0.5	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	43
70920	0.5	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	-5
70921	5.8	-0.1	-0.2	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	-0.8	-0.4	-0.1	-1	-0.2	-0.1	-0.2	-0.2	5
74021	10	-1	-10	-1	-10	-1	-3	-1	-1	-1	-1	-3	-3	-1	-10	-3	-1	-1	-10	10
74035	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	28
74037	2.7	-0.5	-5	-0.5	-5	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-1	1	-0.5	-5	-1	-0.5	-0.5	-5	-5
74039	0.4	-0.3	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.7	-0.3	-0.5	1.9	-0.3	-2	-0.3	-0.3	-0.3	-0.5	14
74041	0.4	-0.3	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	1.4	-0.3	-0.5	-0.5	-0.3	-2	-0.3	-0.3	-0.3	0.6	26
8003551	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	-0.4	-0.1	-1	1	-0.2	-0.4	-0.4	-0.1	-0.4	-0.4	150
82181	3.3	1.03	2.3	0.23	-0.5	-0.05	-0.1	0.53	1.01	0.23	0.21	-0.1	0.4	0.25	-0.5	-0.1	-0.05	0.81	-0.5	9.2
83676	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	11
87751	2.6	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	21
87752	7.2	-0.1	0.04	-0.1	-0.1	-0.1	-0.1	-0.1	-0.1	0.4	-0.1	-0.2	2.4	-0.1	-0.6	-0.1	-0.1	-0.1	-0.2	61
87753	0.8	-0.3	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.6	-0.3	-0.5	1.6	-0.3	-2	-0.3	-0.3	-0.3	-0.5	11
87754	3.7	-0.3	0.2	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.5	-0.3	0.8	-0.5	-0.3	-2	-0.3	-0.3	-0.3	-0.5	10
87755	0.5	0.7	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.8	-0.3	1.3	-0.5	-0.3	-2	-0.3	-0.3	-0.3	0.6	13
87756	-0.5	-0.5	-1	-0.5	-1	-0.5	-0.5	-0.5	-0.5	-0.5	-0.5	-4	-2	-0.5	-6	-1	-0.5	-1	-1	108
87756 Dup1	2.7	-0.3	-3	-0.3	-3	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.5	2.3	-0.3	-3	-0.5	-0.3	-0.3	-3	36
87757	1.5	-0.3	-3	-0.3	-3	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.5	3.1	-0.3	-3	-0.5	-0.3	-0.3	-3	-3
87781	-0.2	-0.2	-0.2	-0.1	-0.1	-0.1	-0.2	-0.1	-0.1	0.4	-0.1	-1	0.9	-0.2	-0.4	-0.4	-0.1	-0.4	-0.4	9
88257	4.76	-0.05	-0.5	-0.05	-0.5	-0.05	-0.1	-0.05	-0.05	-0.05	-0.05	-0.1	0.6	-0.05	-0.5	-0.1	-0.05	-0.05	-0.5	1.2
96478	-0.3	-0.3	-0.5	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	-2	-1	-0.3	-3	-0.5	-0.3	-0.5	-0.5	-5
Blank001	0.11	-0.05	-0.1	-0.05	-0.1	-0.05	-0.05	-0.05	-0.05	0.05	-0.05	-0.4	-0.2	-0.05	-0.6	-0.1	-0.05	-0.1	-0.1	3

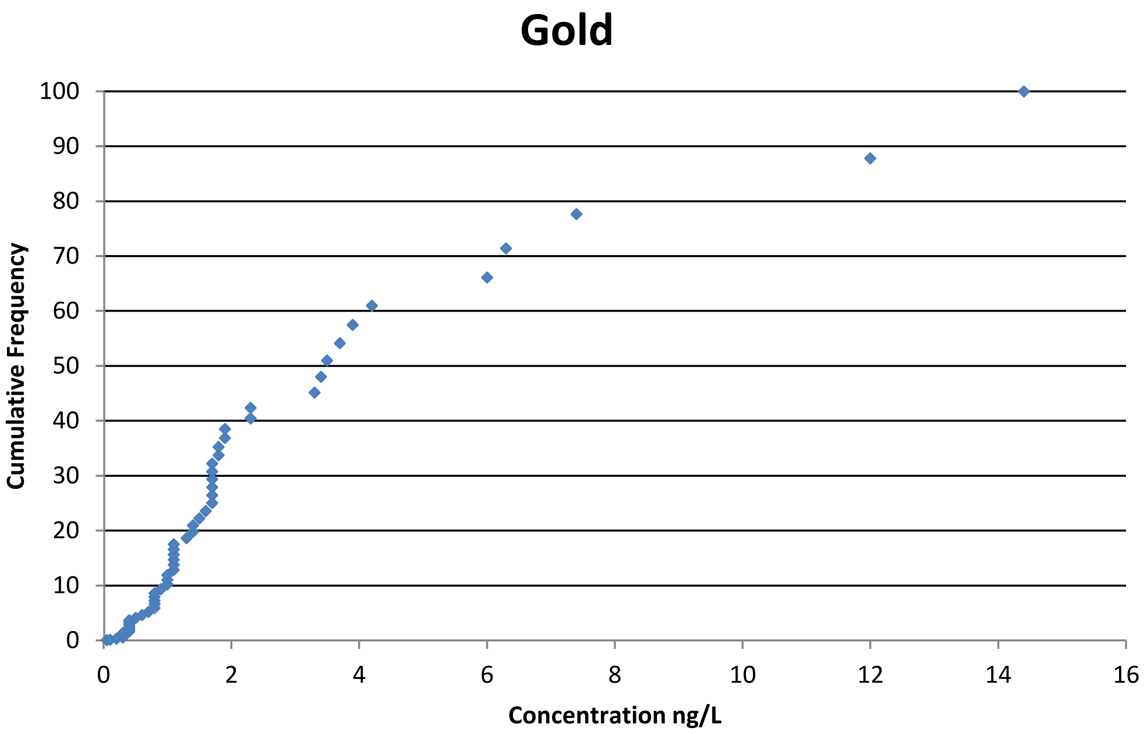
Blank002	0.07	-0.05	-0.1	-0.05	-0.1	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.4	0.2	-0.05	-0.6	-0.1	-0.05	-0.1	-0.1	3
SW001	2	-0.3	-0.3	-0.05	-0.3	-0.05	-0.3	-0.3	-0.3	-2	-0.05	-2	-2	-0.3	-1	-0.5	-0.05	-0.5	-1	3
SW002	2	-0.3	-0.3	-0.05	-0.3	-0.05	-0.3	-0.3	-0.3	-2	-0.05	-2	-2	-0.3	-1	-0.5	-0.05	-0.5	-1	2
SW003	3	-0.3	-0.3	-0.05	-0.3	-0.05	-0.3	-0.3	-0.3	-2	-0.05	-2	-2	-0.3	-1	-0.5	-0.05	-0.5	-1	5
SW004	1.3	-0.1	-0.1	-0.02	-0.1	-0.02	-0.1	-0.1	-0.1	-0.8	-0.02	-0.8	-0.6	-0.1	-0.4	-0.2	-0.02	-0.2	-0.4	1.2
SW005	3	-0.3	-0.3	-0.05	-0.3	-0.05	-0.3	-0.3	-0.3	-2	-0.05	-2	-2	-0.3	-1	-0.5	-0.05	-0.5	-1	-2
SW006	1.4	-0.1	-0.1	-0.02	-0.1	-0.02	-0.1	-0.1	-0.1	-0.8	-0.02	-0.8	-0.6	-0.1	-0.4	-0.2	-0.02	-0.2	-0.4	2.3
SW007	1.5	-0.1	0.2	-0.02	-0.1	-0.02	-0.1	-0.1	-0.1	-0.8	-0.02	-0.8	-0.6	-0.1	-0.4	-0.2	-0.02	-0.2	-0.4	1.3
SW008	3	-0.3	-0.3	-0.05	-0.3	-0.05	-0.3	-0.3	-0.3	-2	-0.05	-2	-2	-0.3	-1	-0.5	-0.05	-0.5	-1	-2
SW009	3	-0.3	-0.3	-0.05	-0.3	-0.05	-0.3	-0.3	-0.3	-2	-0.05	-2	-2	-0.3	-1	-0.5	-0.05	-0.5	-1	-2
SW010	1.4	-0.1	0.1	-0.02	-0.1	-0.02	-0.1	-0.1	-0.1	-0.8	-0.02	-0.8	-0.6	-0.1	-0.4	-0.2	-0.02	-0.2	-0.4	4.1
WRK958119	2.2	-0.3	-3	-0.3	-3	-0.3	-0.5	-0.3	-0.3	-0.3	-0.3	-0.5	0.7	-0.3	-3	-0.5	-0.3	-0.3	-3	3
WRK962452	-0.3	-0.3	-0.1	-0.3	-0.3	-0.3	-0.3	-0.3	-0.3	0.5	-0.3	-0.5	0.6	-0.3	-2	-0.3	-0.3	-0.3	-0.5	34
WRK985194	2	-0.3	-0.3	-0.05	-0.3	-0.05	-0.3	-0.3	-0.3	-2	-0.05	-2	4	-0.3	-1	-0.5	-0.05	-0.5	-1	8

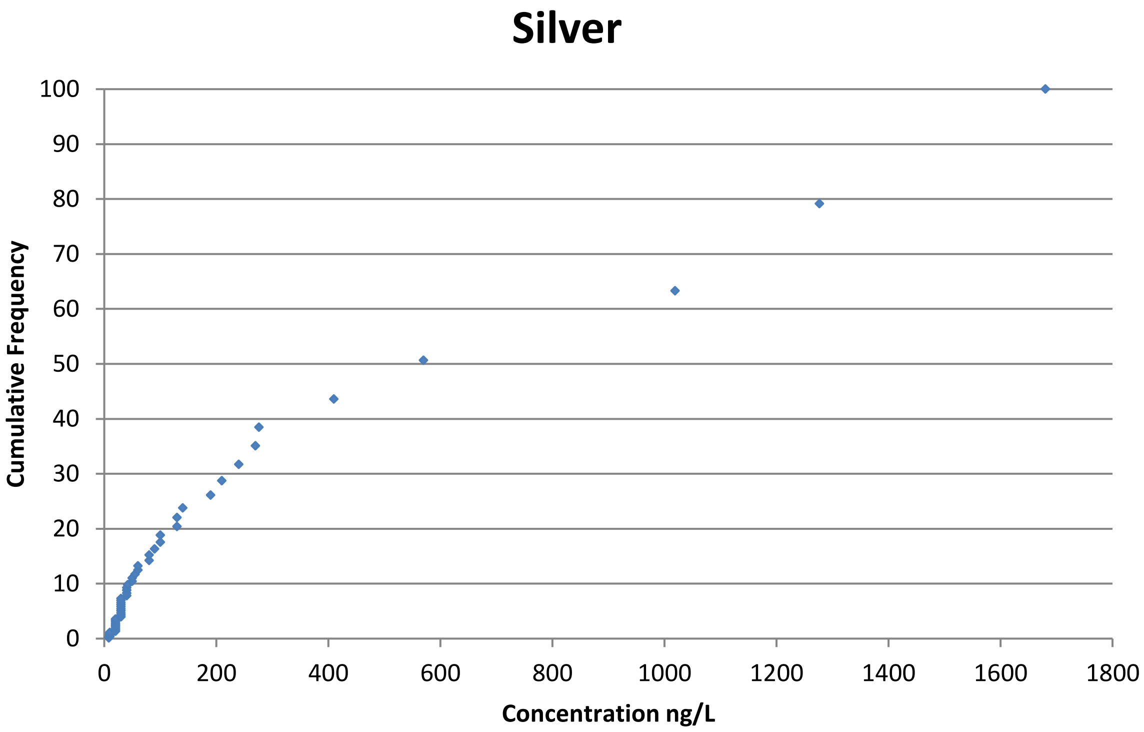
Appendix D Precious Metals

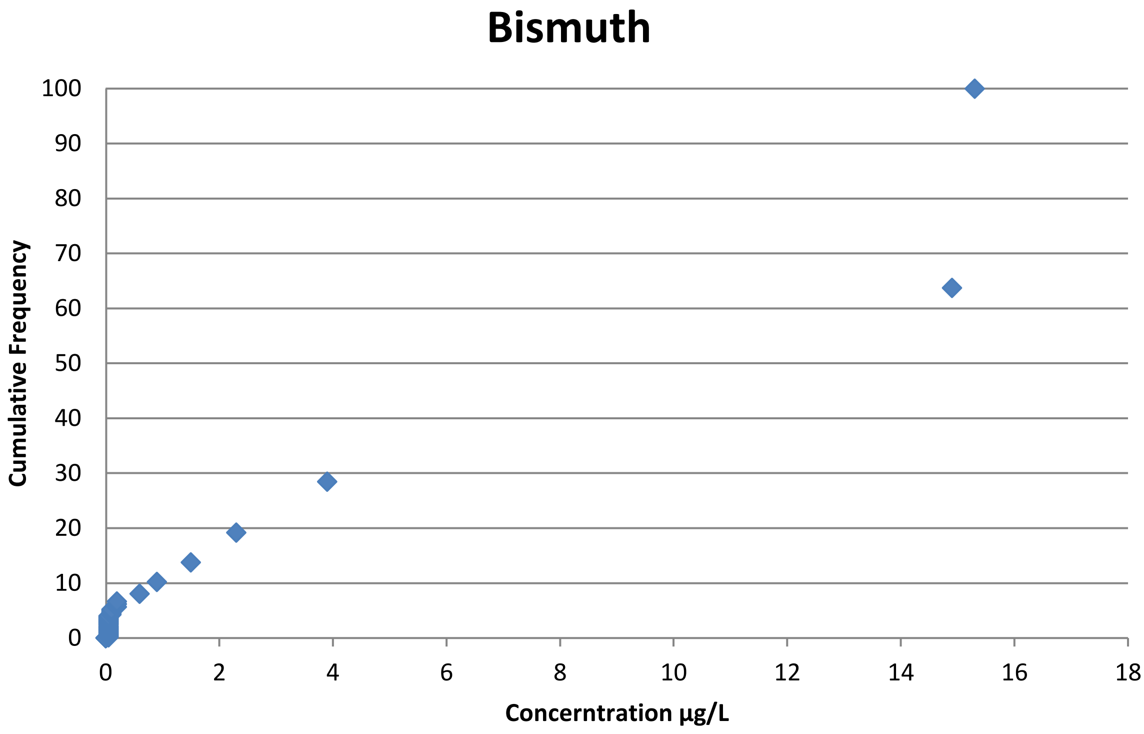
Bore ID	Au (ng/L)	Ag (ng/L)	Bi (ng/L)	Bore ID	Au (ng/L)	Ag (ng/L)	Bi (ng/L)	Bore ID	Au (ng/L)	Ag (ng/L)	Bi (ng/L)
111696	14.4	10	-0.1	117438	1.7	50	-0.1	96478	0.8	30	-0.1
111698	12	80	-0.1	74035	1.7	40	-0.1	SW008	0.8	20	-0.1
111695	7.4	100	0.2	87754	1.7	210	-333	SW005	0.7	40	-0.1
87756	6.3	1680	-0.1	102412	1.6	30	-0.1	103101	0.6	20	-0.1
87752	6	55	-333	70921	1.5	30	-0.1	87753	0.5	-16	-333
74039	4.2	276	-333	111692	1.4	80	-0.1	103096	0.4	30	-0.1
53514	3.9	130	-0.1	55506	1.4	30	-0.1	53519	0.4	10	1.5
83676	3.7	60	0.2	74041	1.3	42	-333	SW001	0.4	10	-0.1
87751	3.5	570	-0.1	111697	1.1	10	-0.1	SW003	0.4	50	0.9
103336	3.4	90	-0.1	45808	1.1	40	-0.1	SW007	0.4	20	-0.1
53516	3.3	100	-0.1	45815	1.1	30	-0.1	SW009	0.4	10	-0.1
110517	2.3	270	-0.1	55521	1.1	40	-0.1	SW010	0.4	10	-0.1
45807	2.3	410	-0.1	WRK962452	1.1	1277	-333	103097	0.3	60	0.6
70920	1.9	20	-0.1	WRK985194	1.1	20	-0.1	104928	0.3	20	-333
SW004	1.9	20	-0.1	104930	1	190	14.9	104961	0.3	20	-0.1

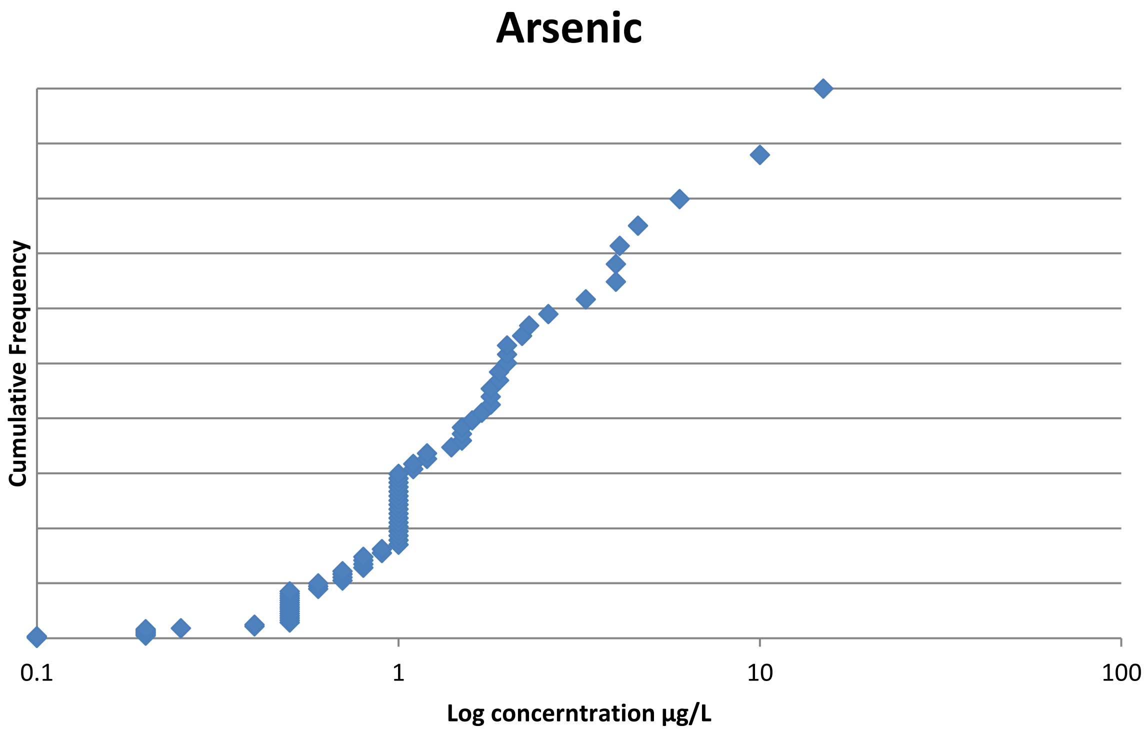
117440	1.8	130	0.2	87755	1	1019	-333	111690	0.3	10	-0.1
53518	1.8	20	3.9	45816	0.9	30	-0.1	SW002	0.2	20	-0.1
104929	1.7	30	-0.1	111689	0.8	30	-0.1	102411	-0.1	140	-0.1
110104	1.7	20	2.3	111691	0.8	240	15.3	53515	-0.2	-16	-333
117438	1.7	50	-0.1	52348	0.8	30	-0.1				

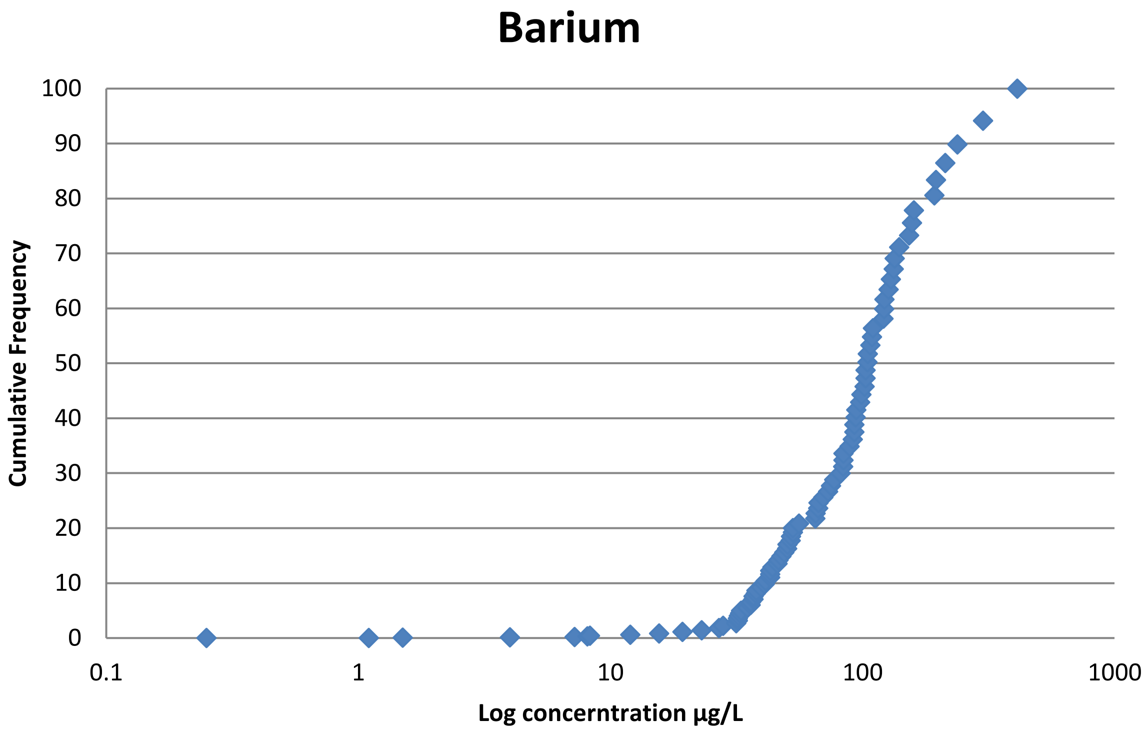
Appendix E Cumulative frequency plots

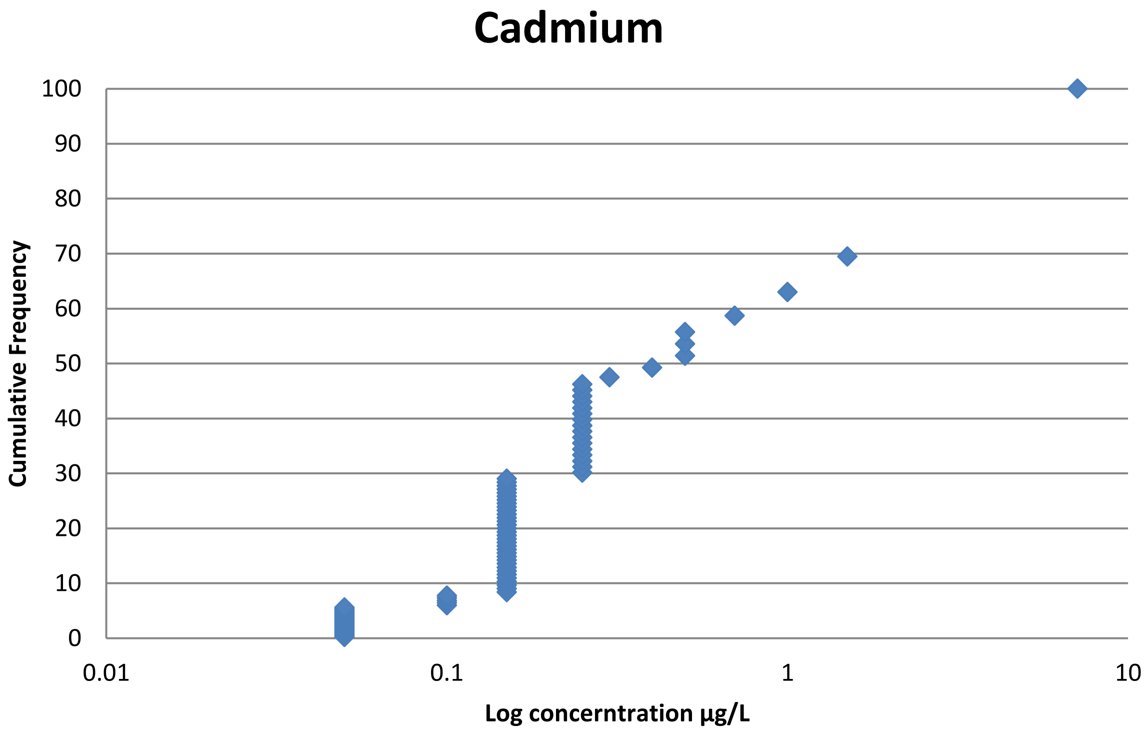


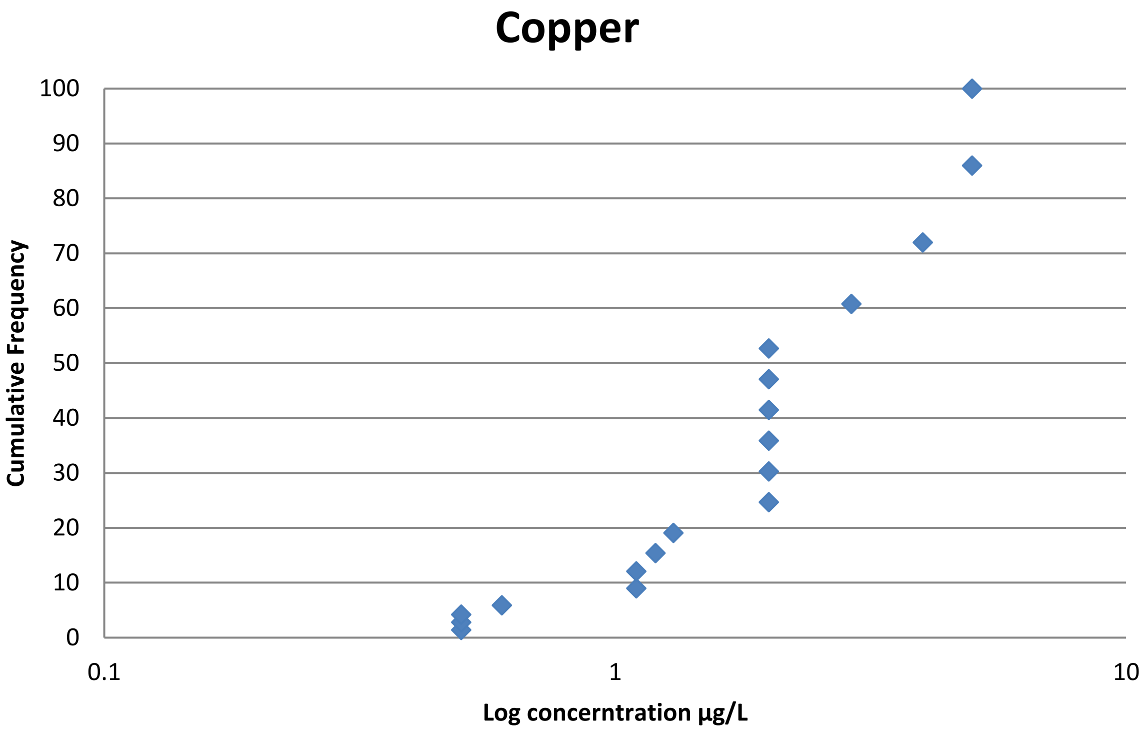


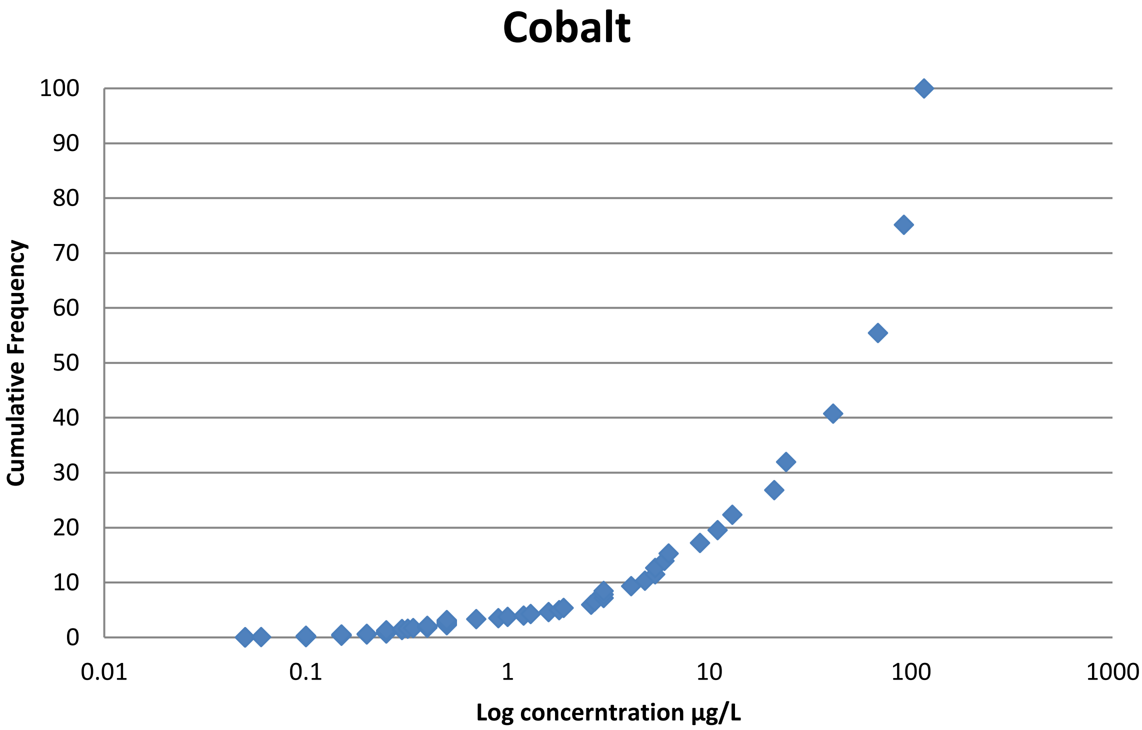

Bismuth
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0
2
4
6
8
10
12
14
16
18
Concerntration µg/L

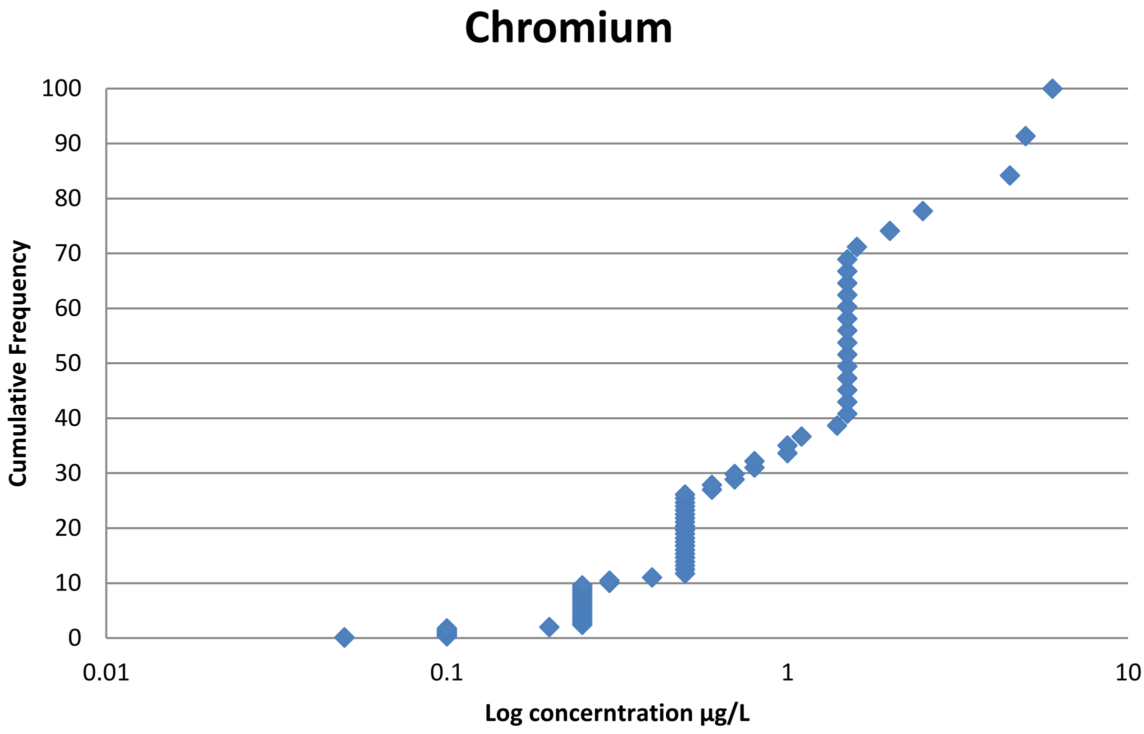

Arsenic
Cumulative Frequency
0.1
1
10
100
Log concerntration µg/L

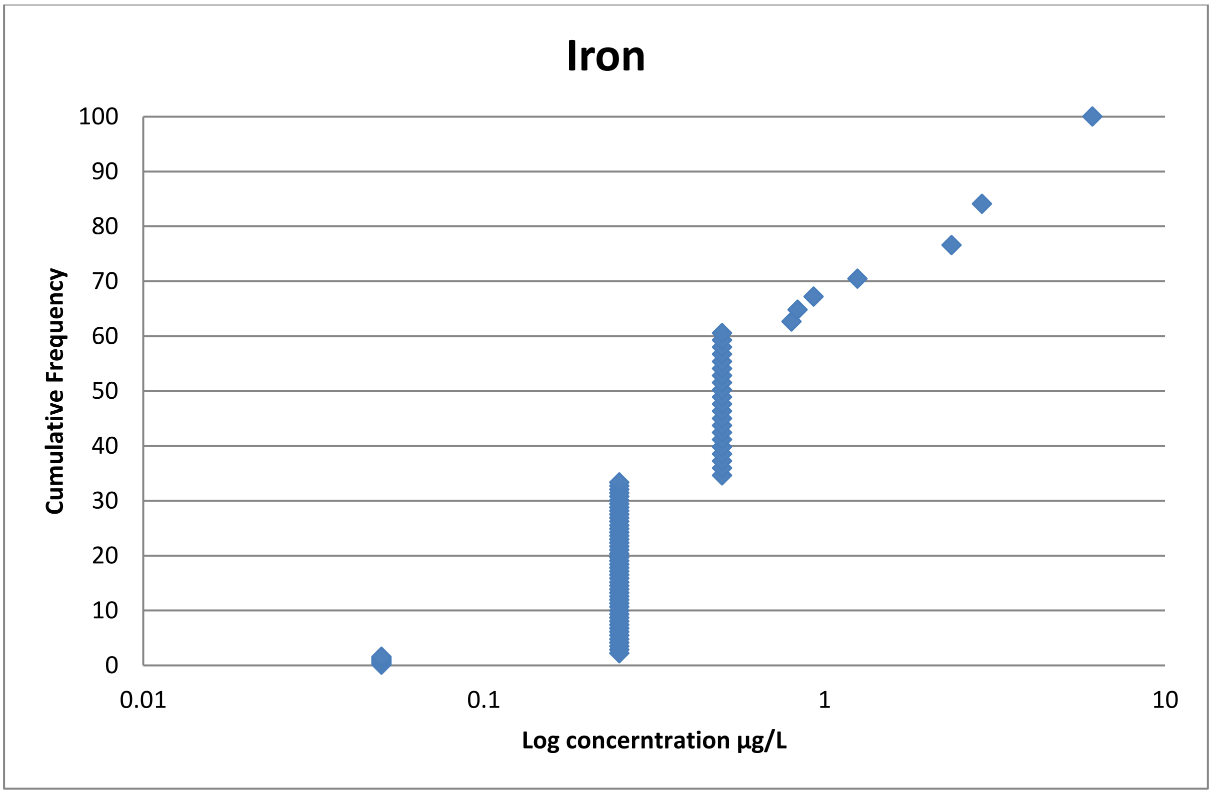

Barium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
100
1000
Log concerntration µg/L

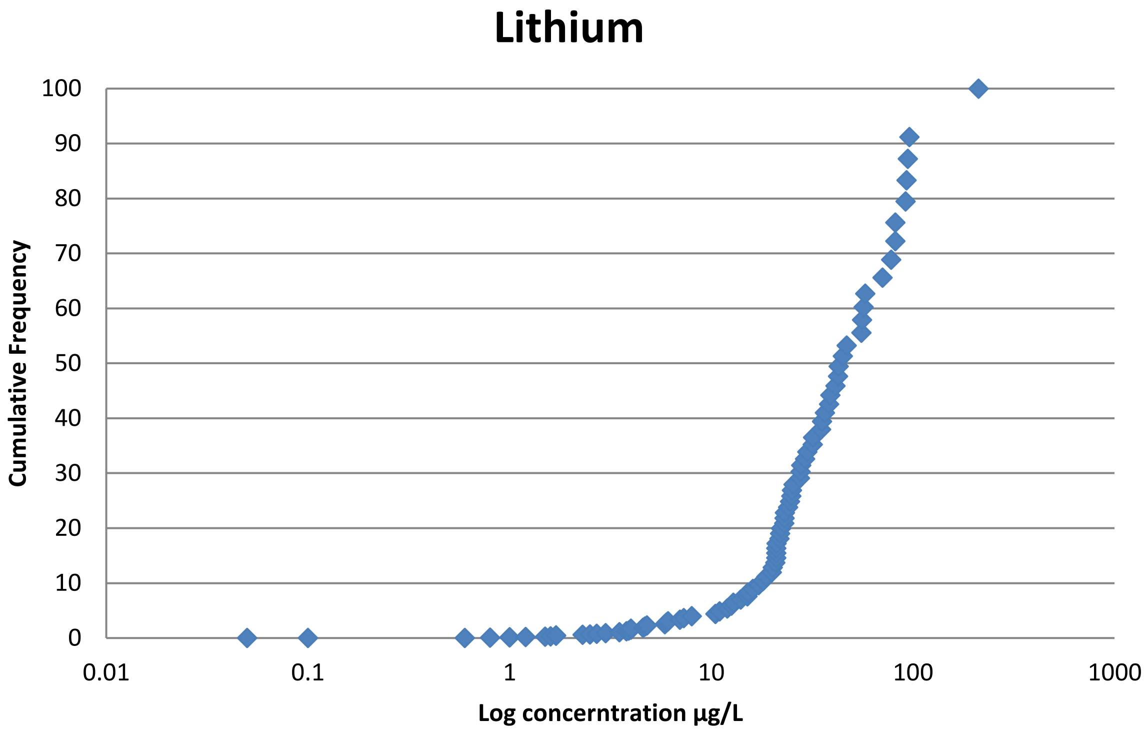

Cadmium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
Log concerntration µg/L

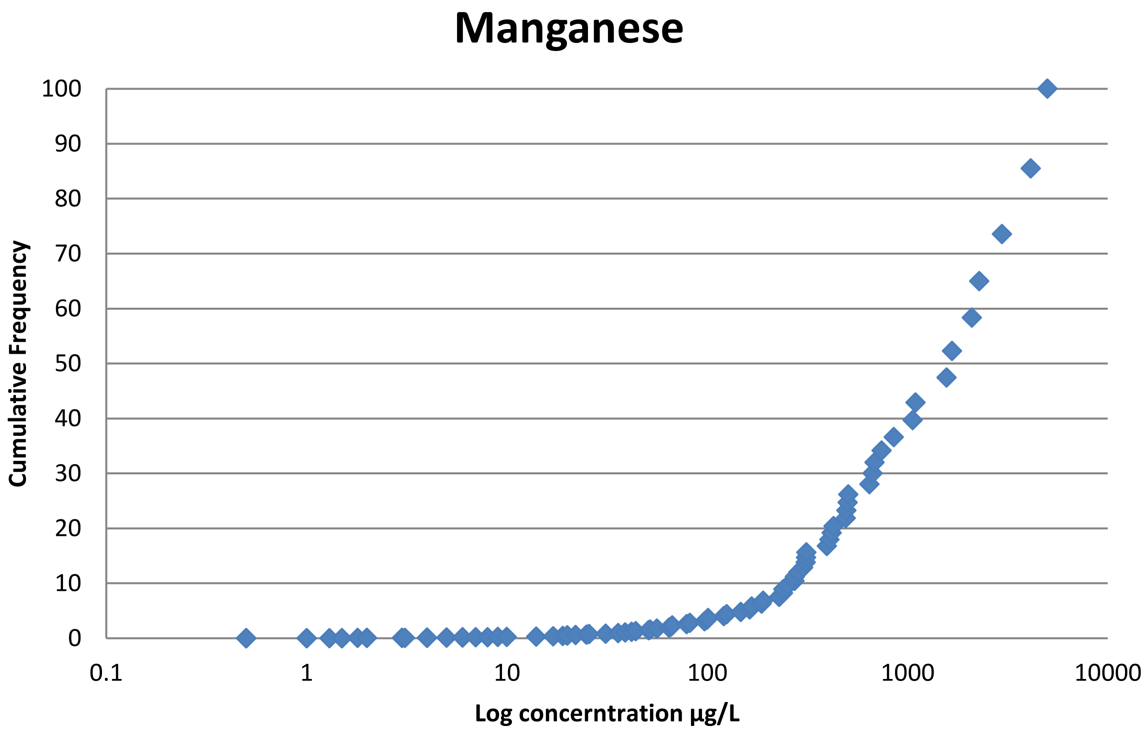

Copper
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
Log concerntration µg/L

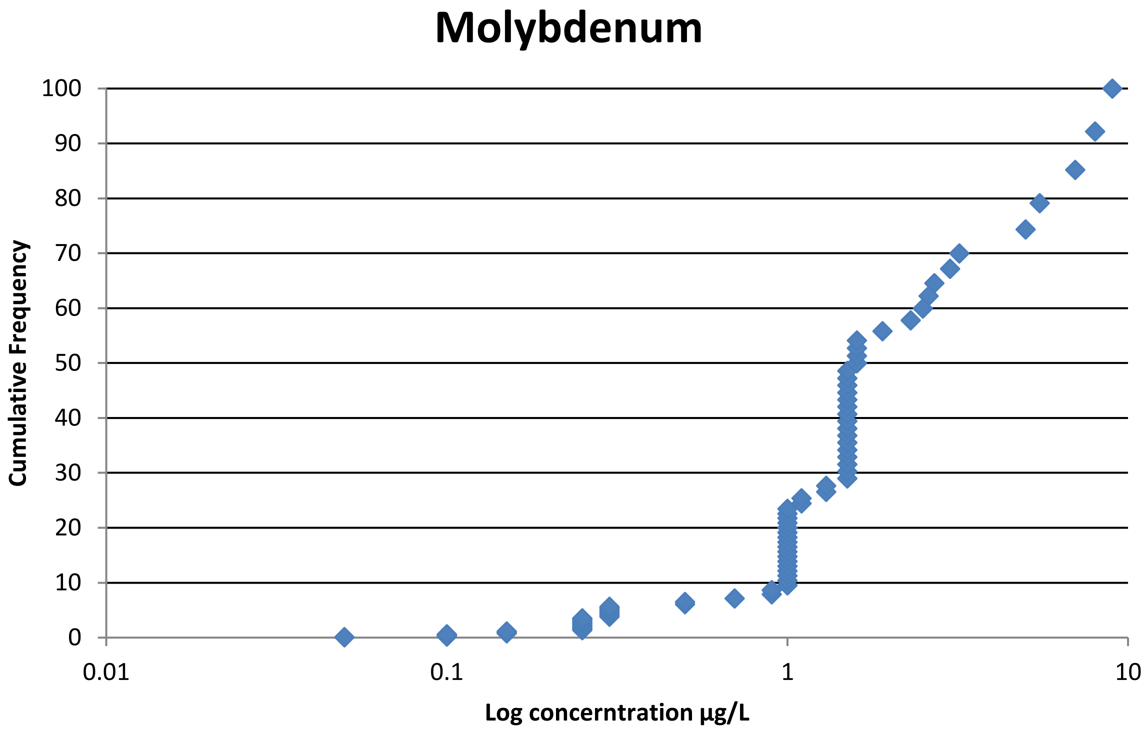

Cobalt
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
Log concerntration µg/L

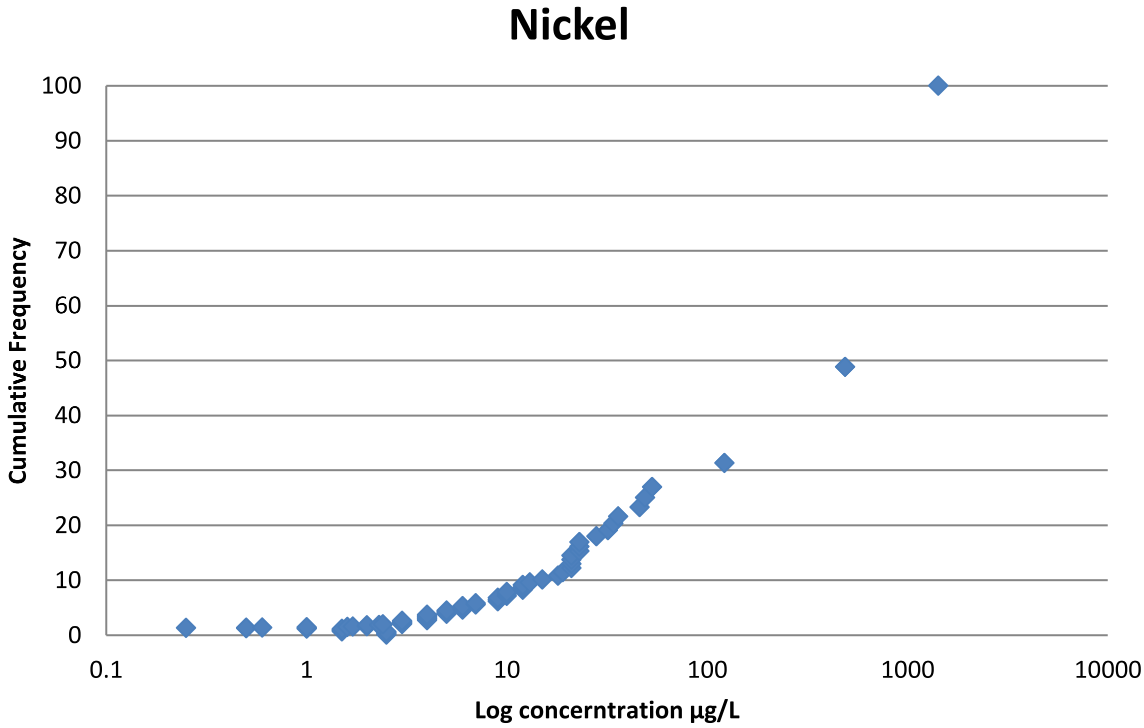

Chromium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
Log concerntration µg/L

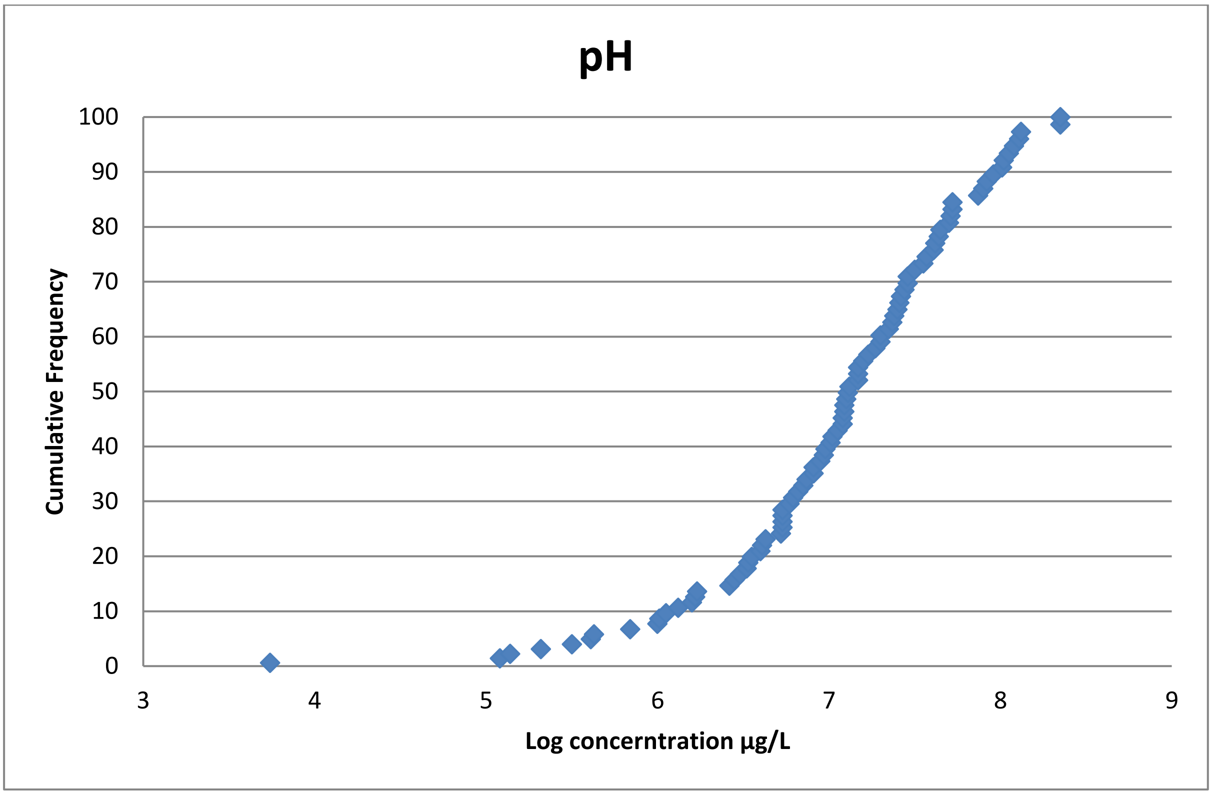

Iron
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
Log concerntration µg/L

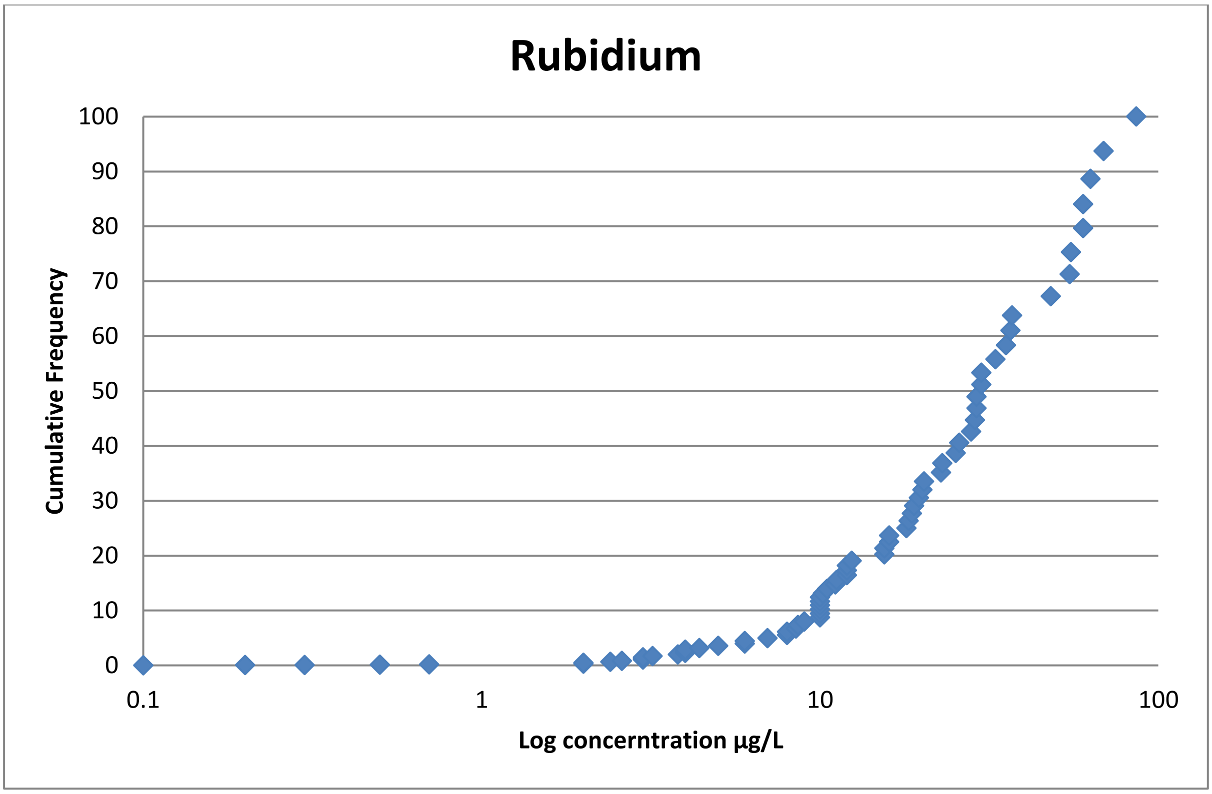

Lithium
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
Cumulative Frequency
Log concerntration µg/L

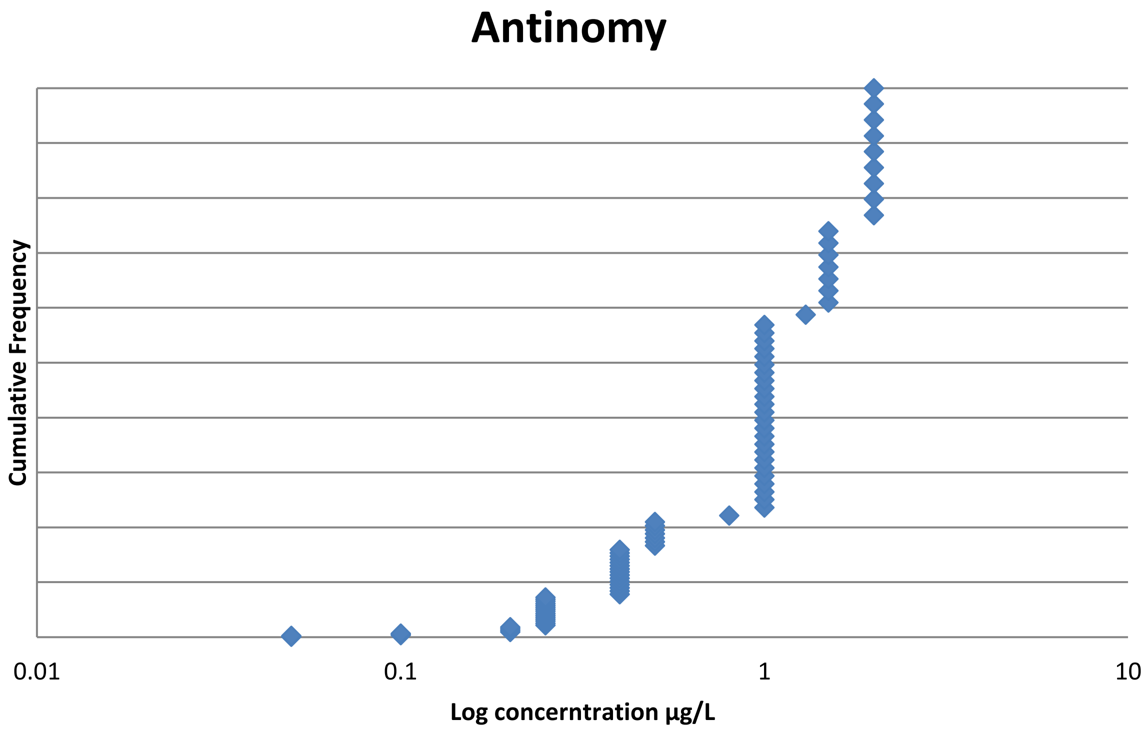

Manganese
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
100
1000
10000
Cumulative Frequency
Log concerntration µg/L

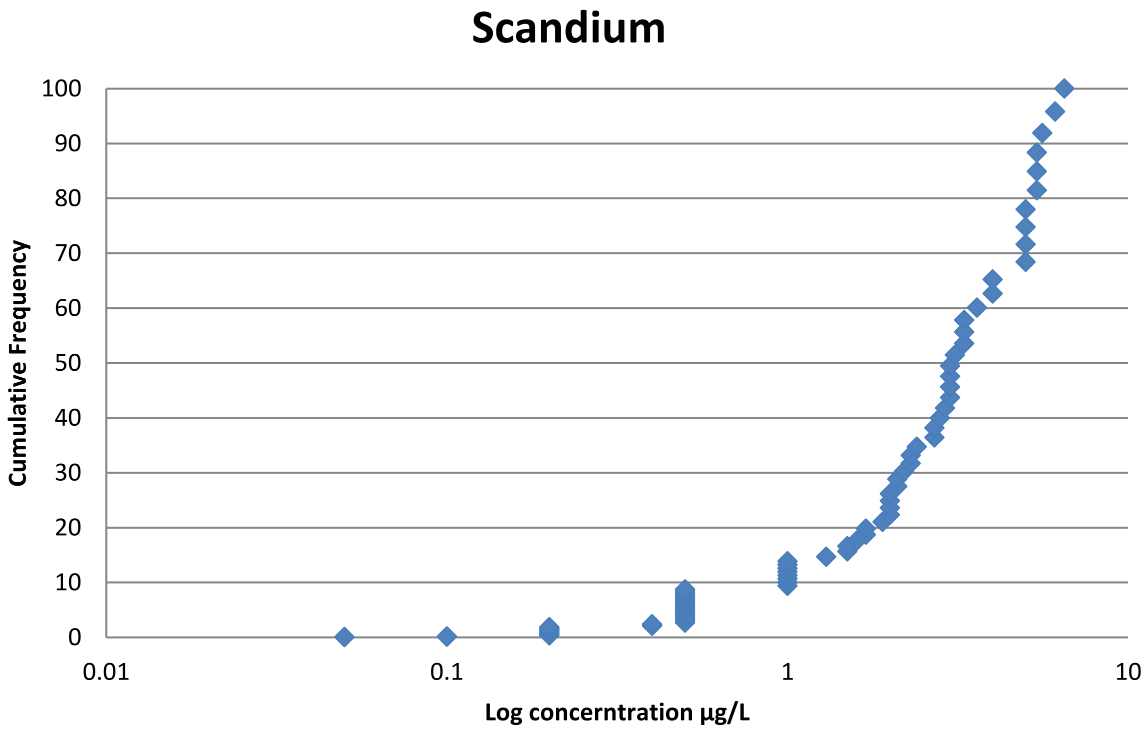

Molybdenum
100
90
80
70
60
50
40
30
20
10
0
Cumulative Frequency
0.01
0.1
1
10
Log concerntration µg/L

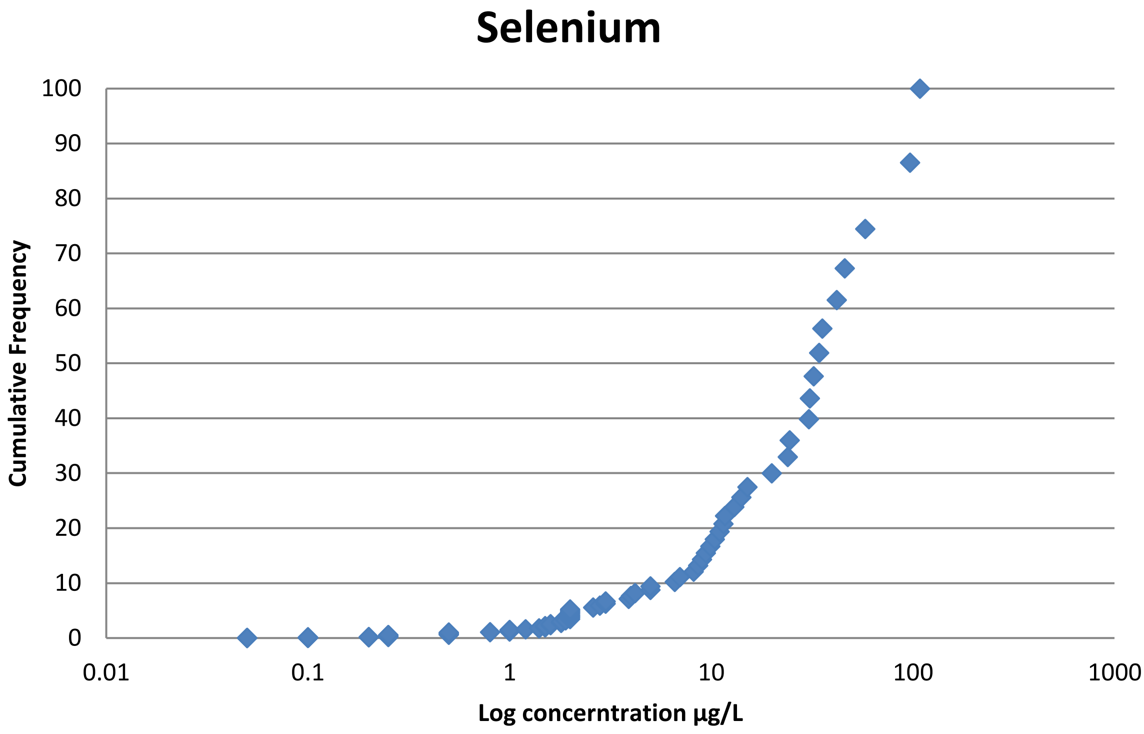

Nickel
100
90
80
70
60
50
40
30
20
10
0
Cumulative Frequency
0.1
1
10
100
1000
10000
Log concerntration µg/L

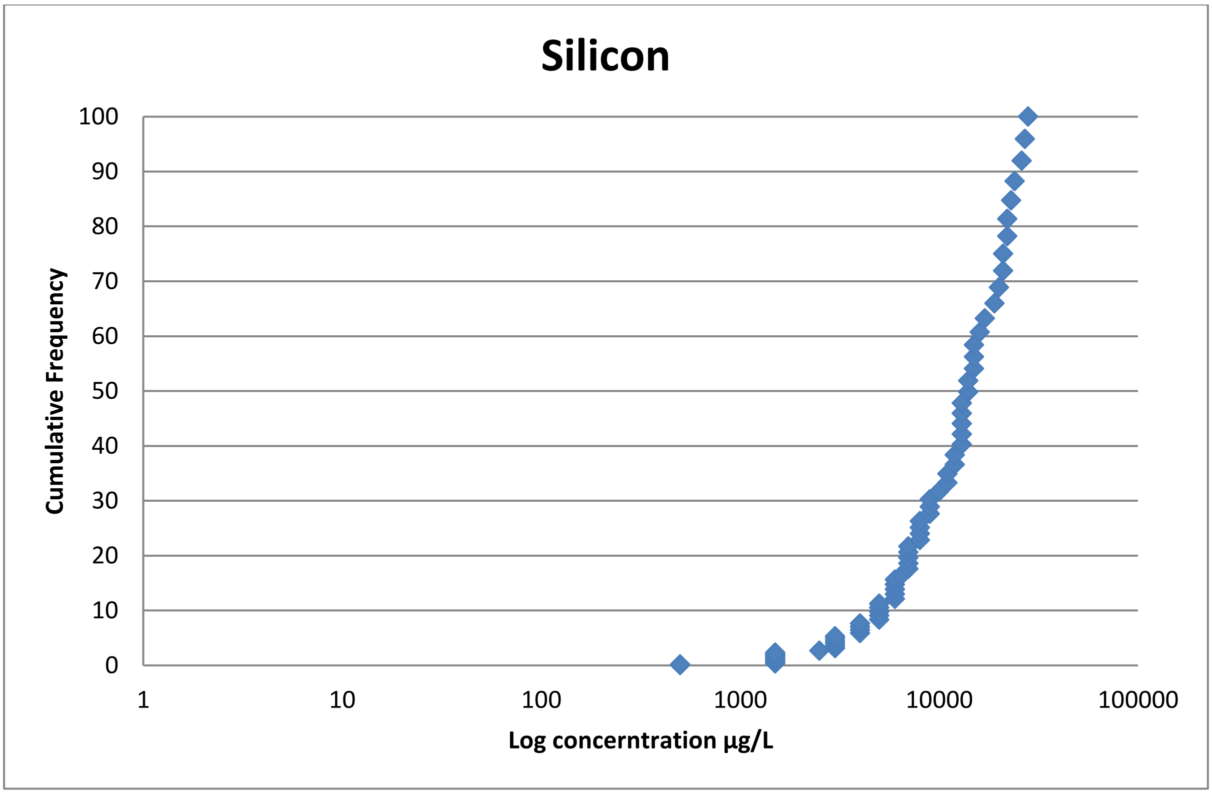

pH
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
3
4
5
6
7
8
9
Log concerntration µg/L

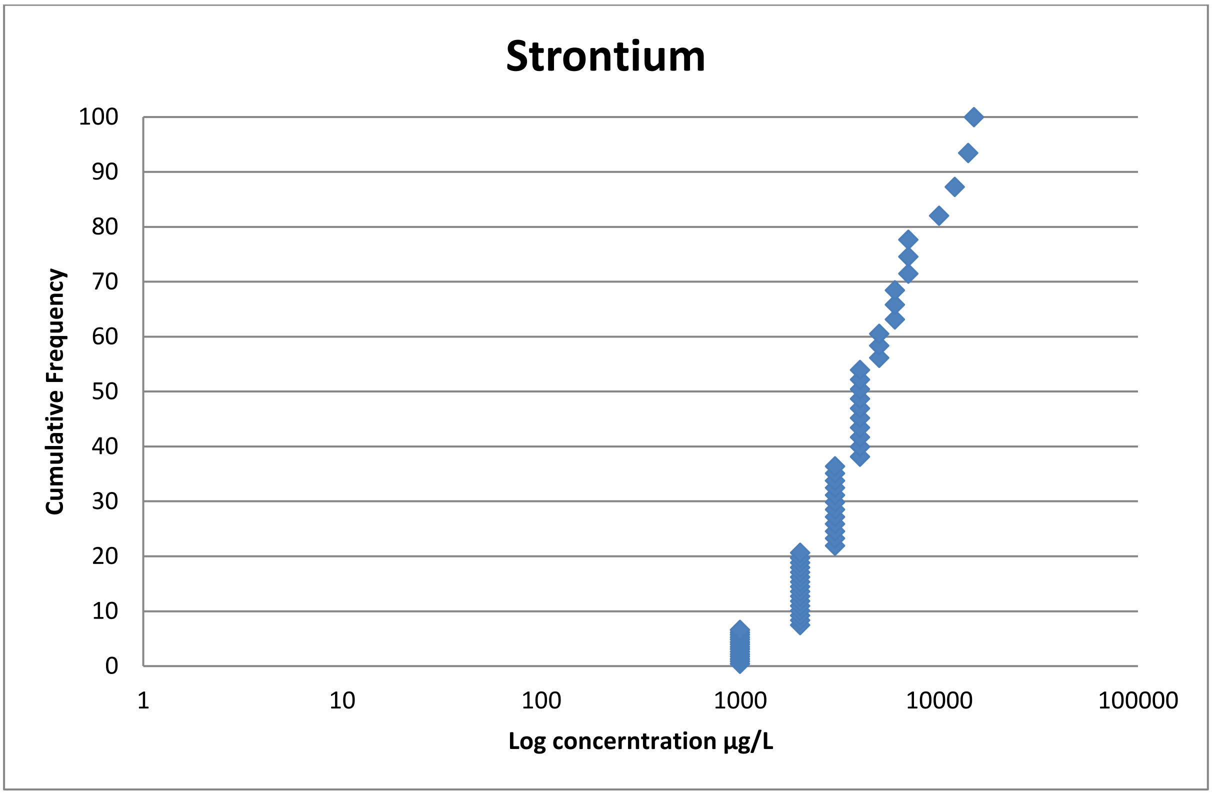

Rubidium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
100
Log concerntration µg/L

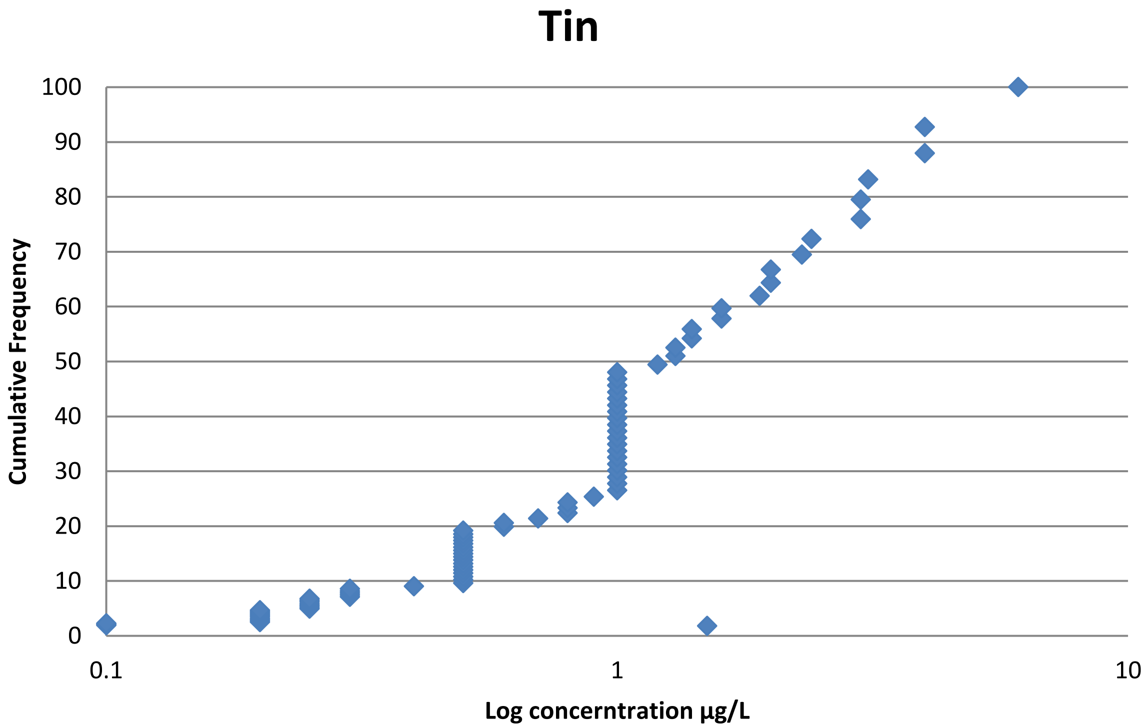

Antinomy
Cumulative Frequency
0.01
0.1
1
10
Log concerntration µg/L


Scandium
100
90
80
70
60
50
40
30
20
10
0
Cumulative Frequency
0.01
0.1
1
10
Log concerntration µg/L

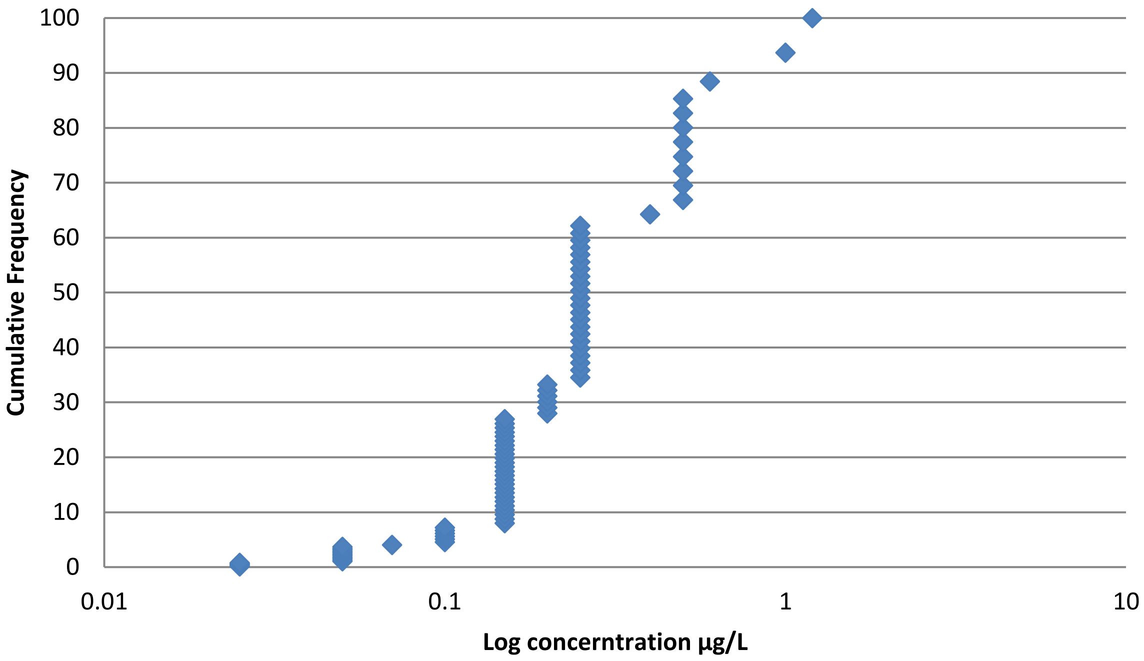

Selenium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.01
0.1
1
10
100
1000
Log concerntration µg/L


Silicon
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
100000
Log concerntration µg/L

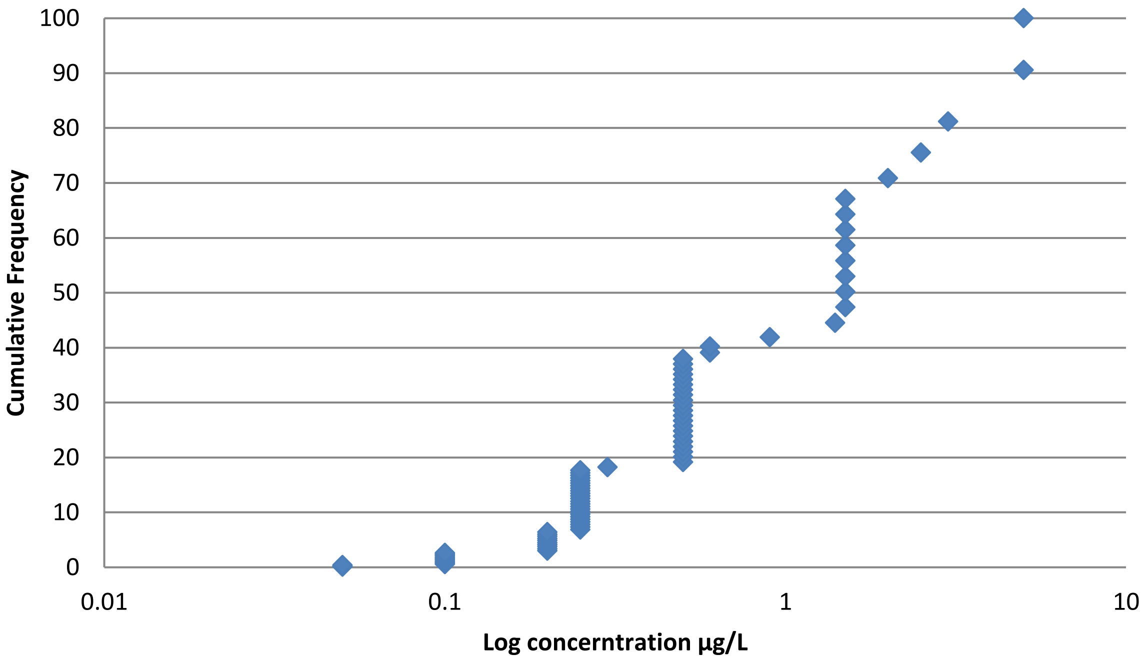

Strontium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
100000
Log concerntration µg/L

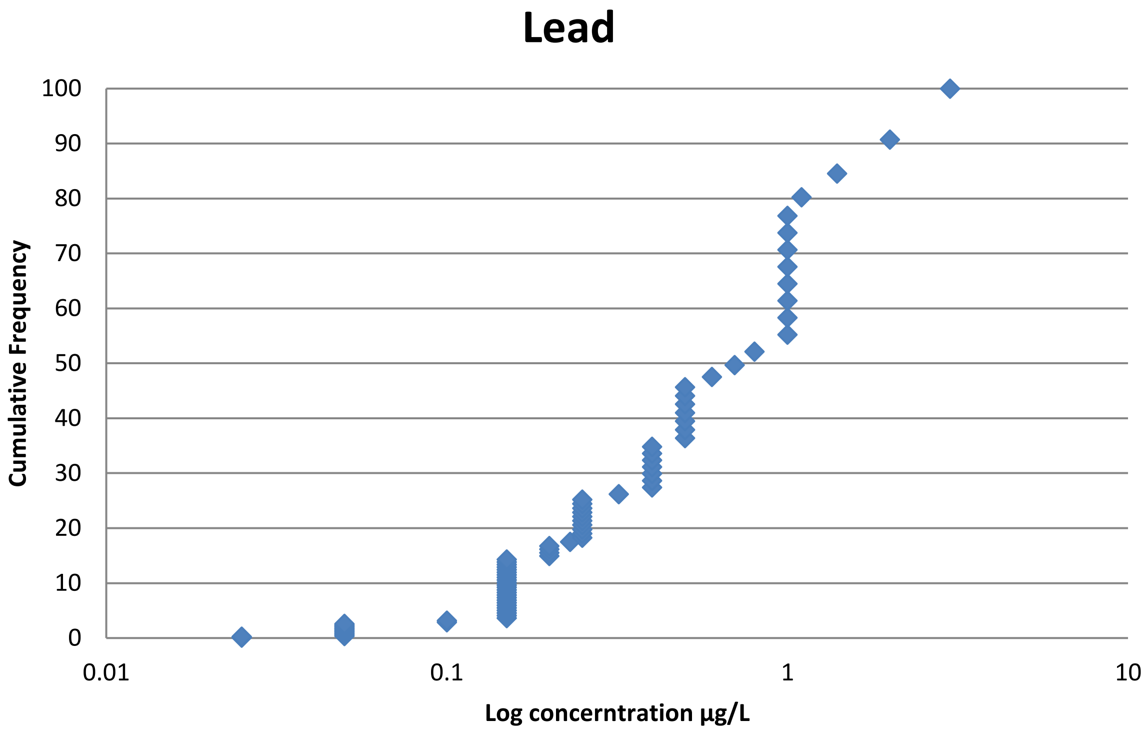

Tin
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
Log concerntration µg/L

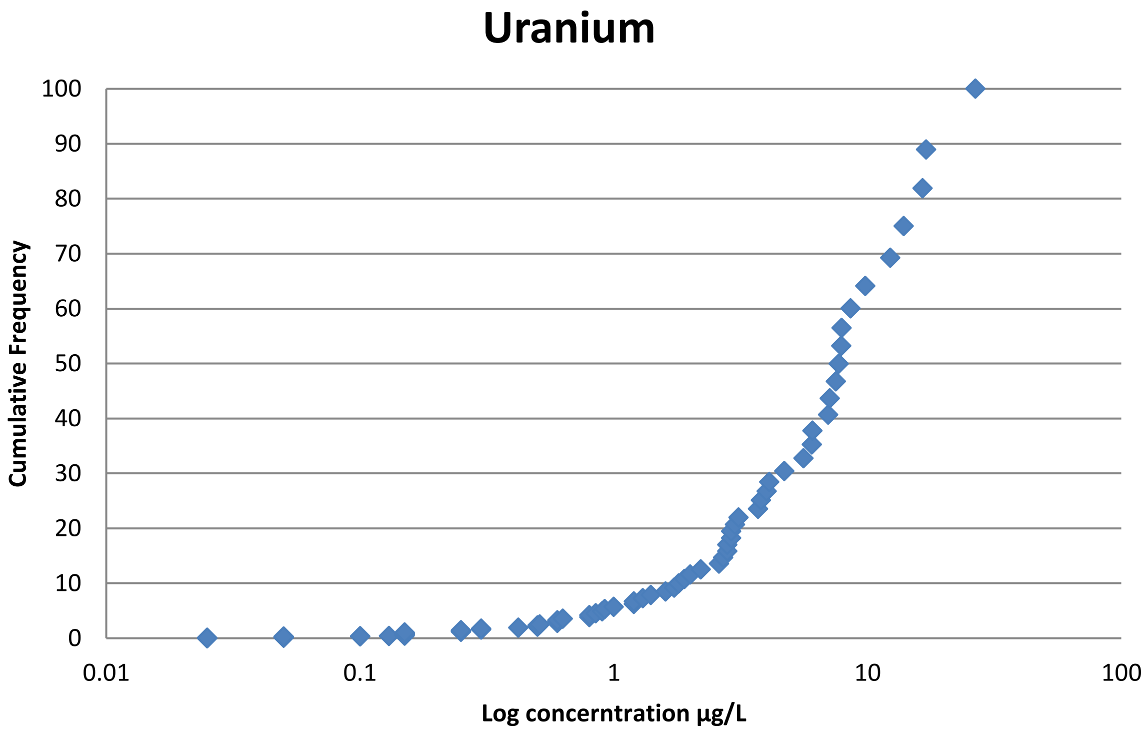
Thallium

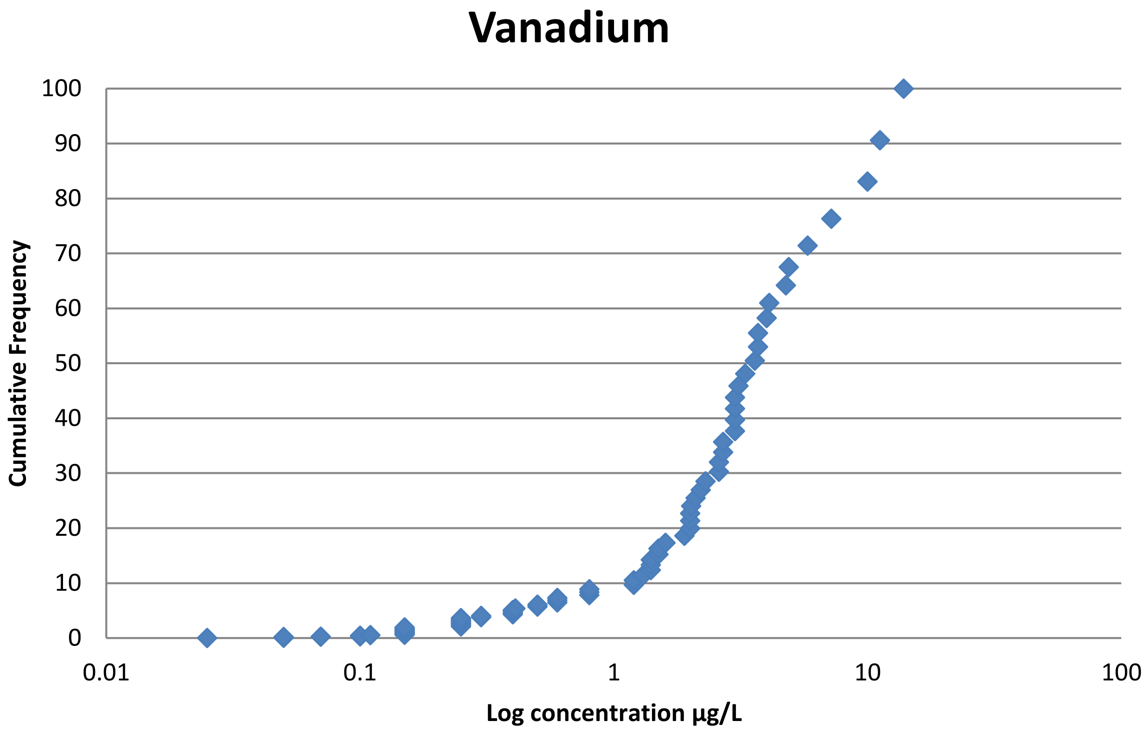


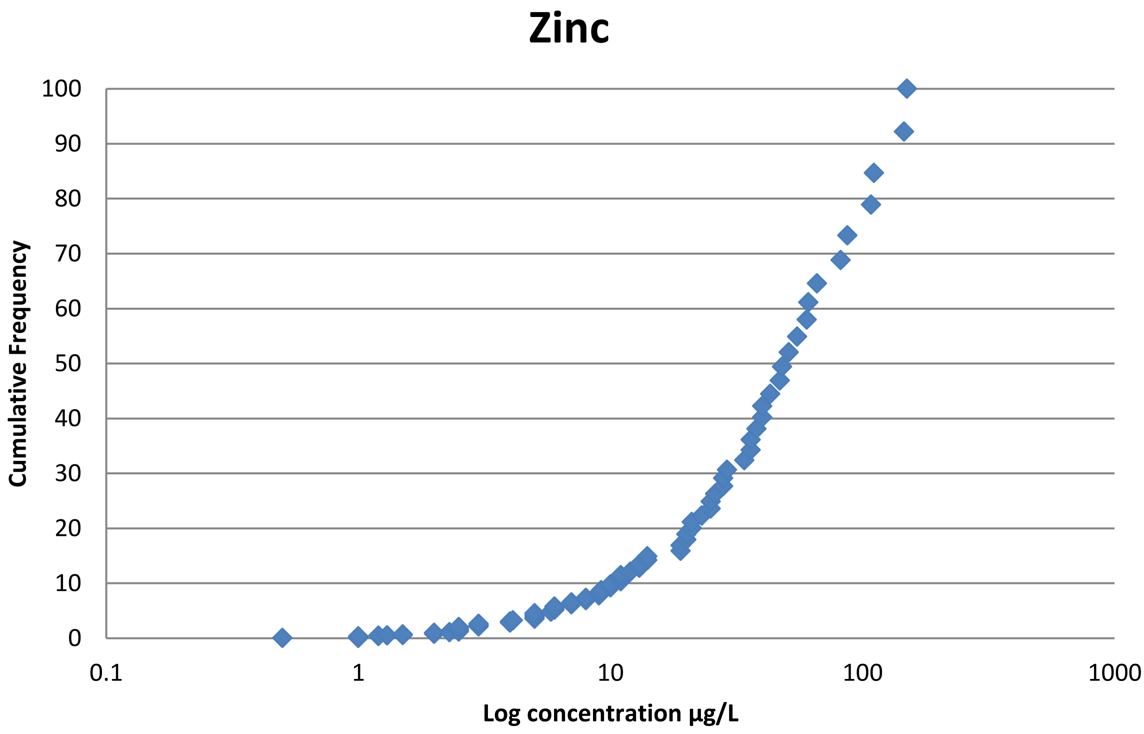
Tungsten

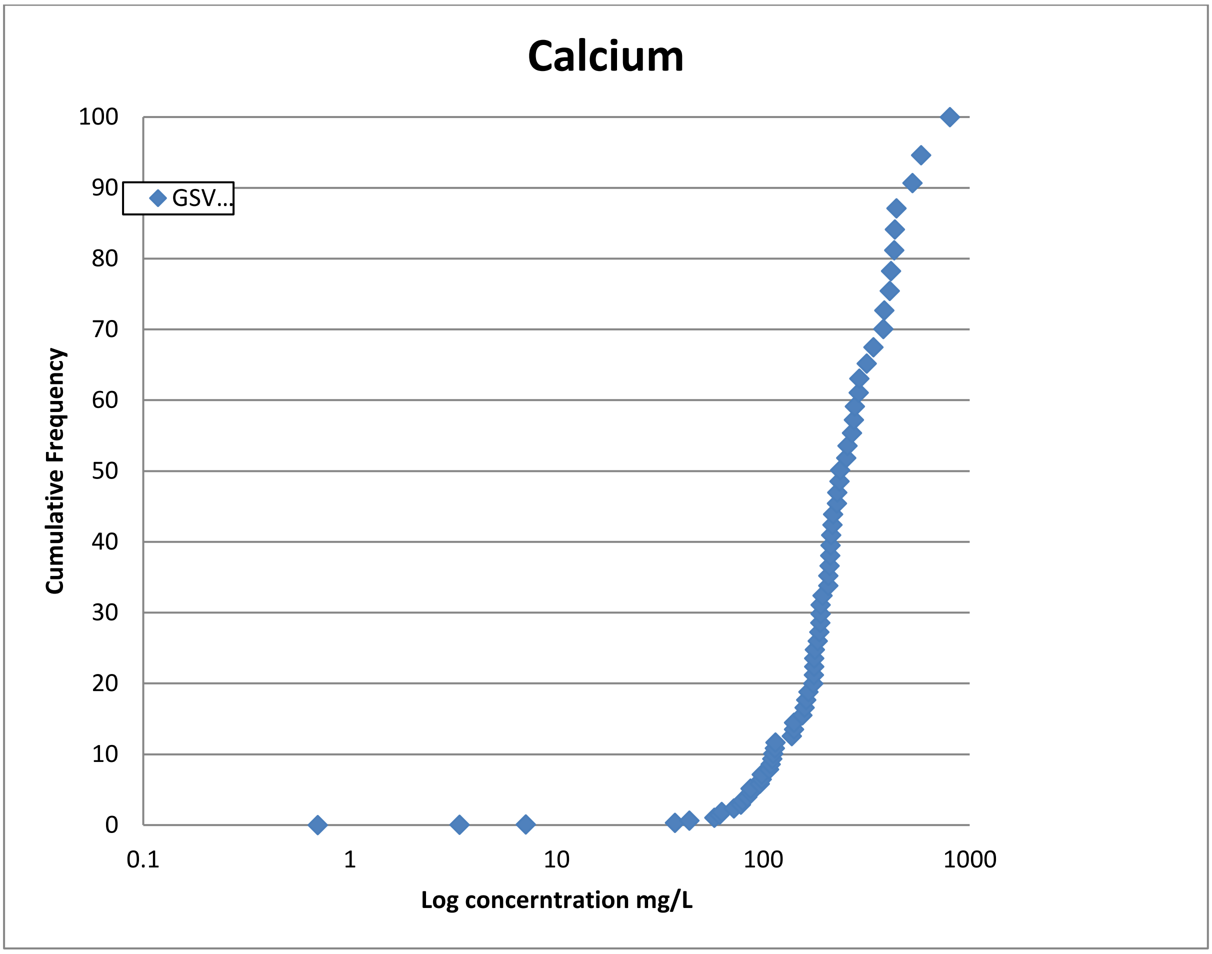


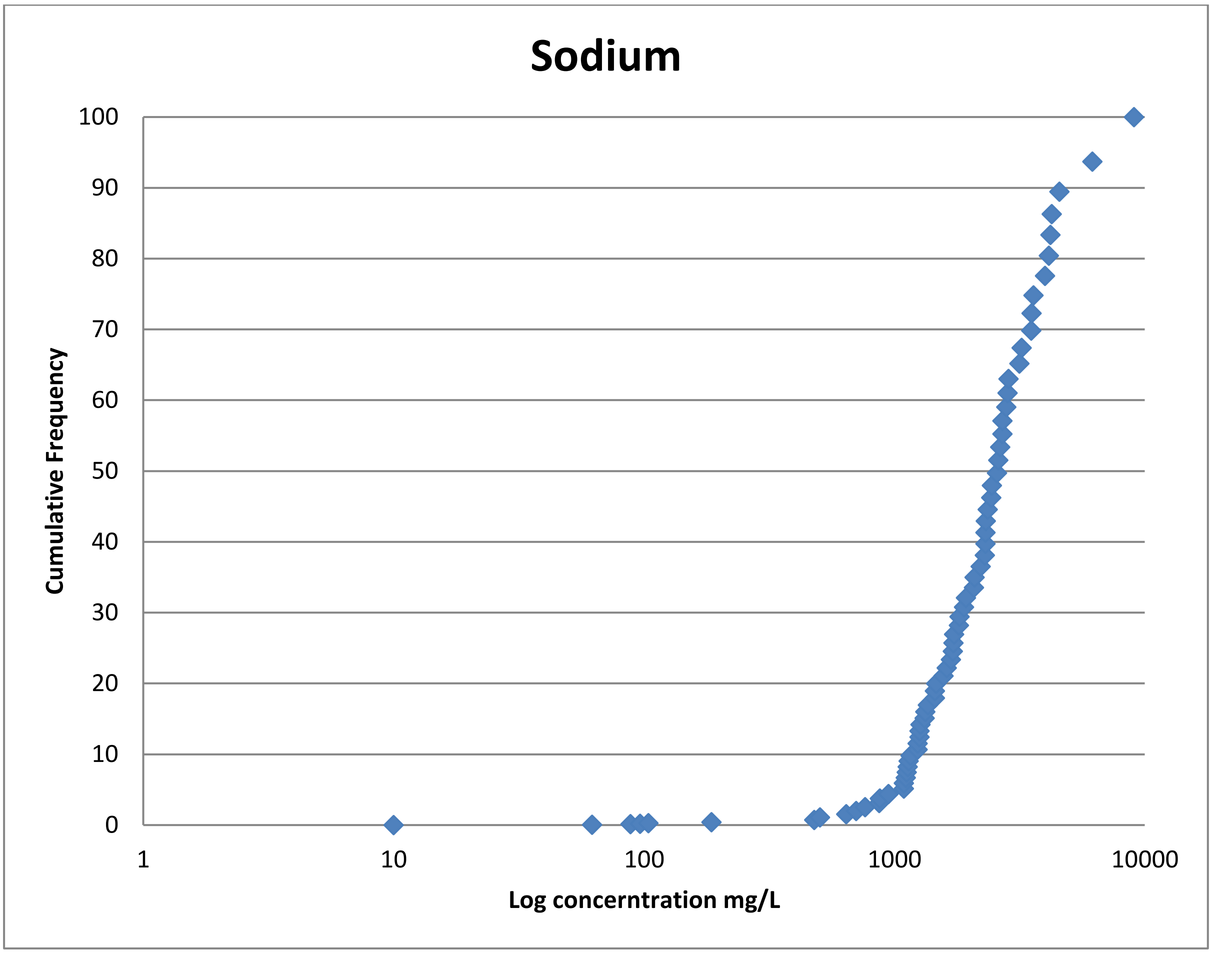

Lead
100
90
80
70
60
50
40
30
20
10
0
Cumulative Frequency
0.01
0.1
1
10
Log concerntration µg/L

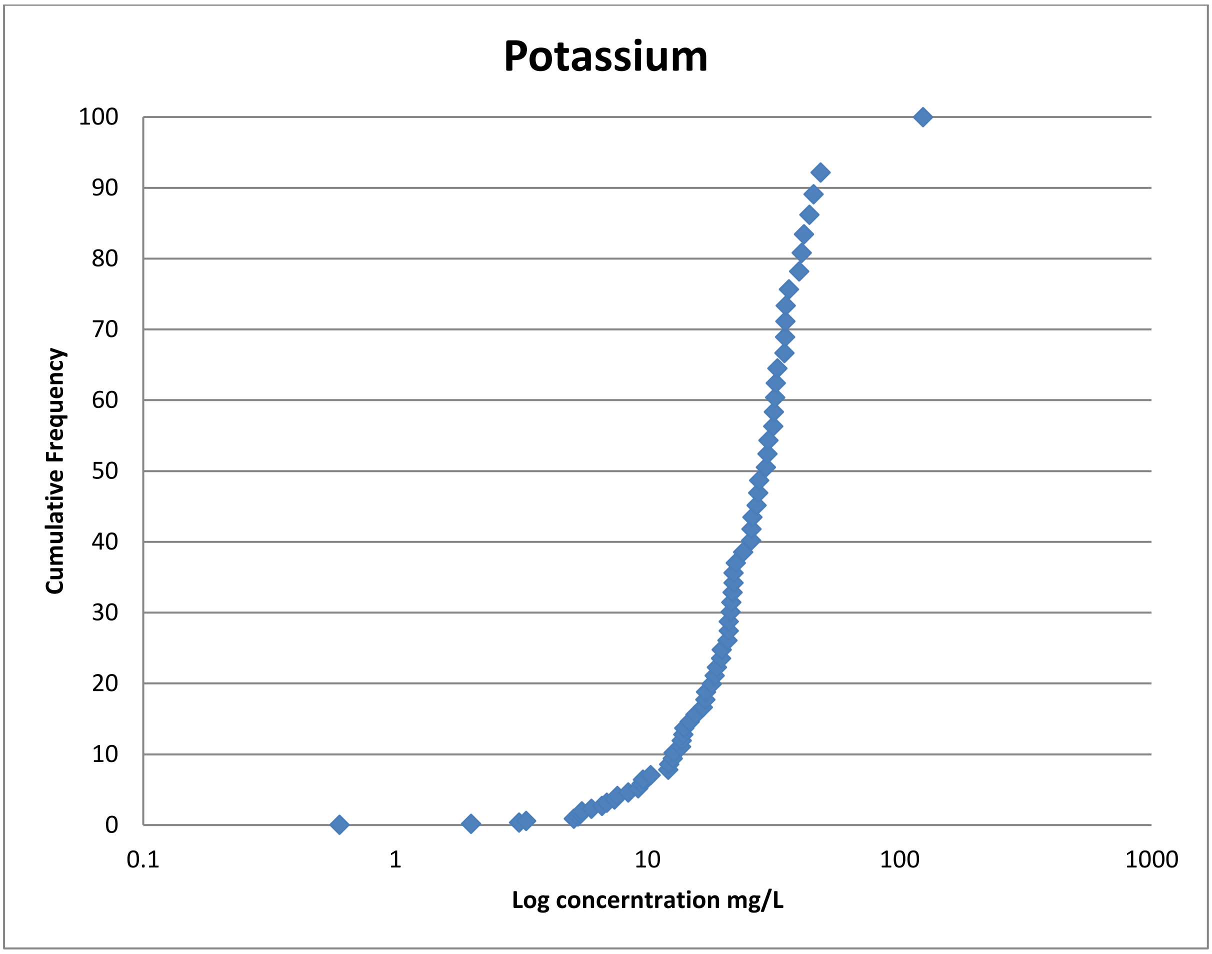

Uranium
100
90
80
70
60
50
40
30
20
10
0
Cumulative Frequency
0.01
0.1
1
10
100
Log concerntration µg/L

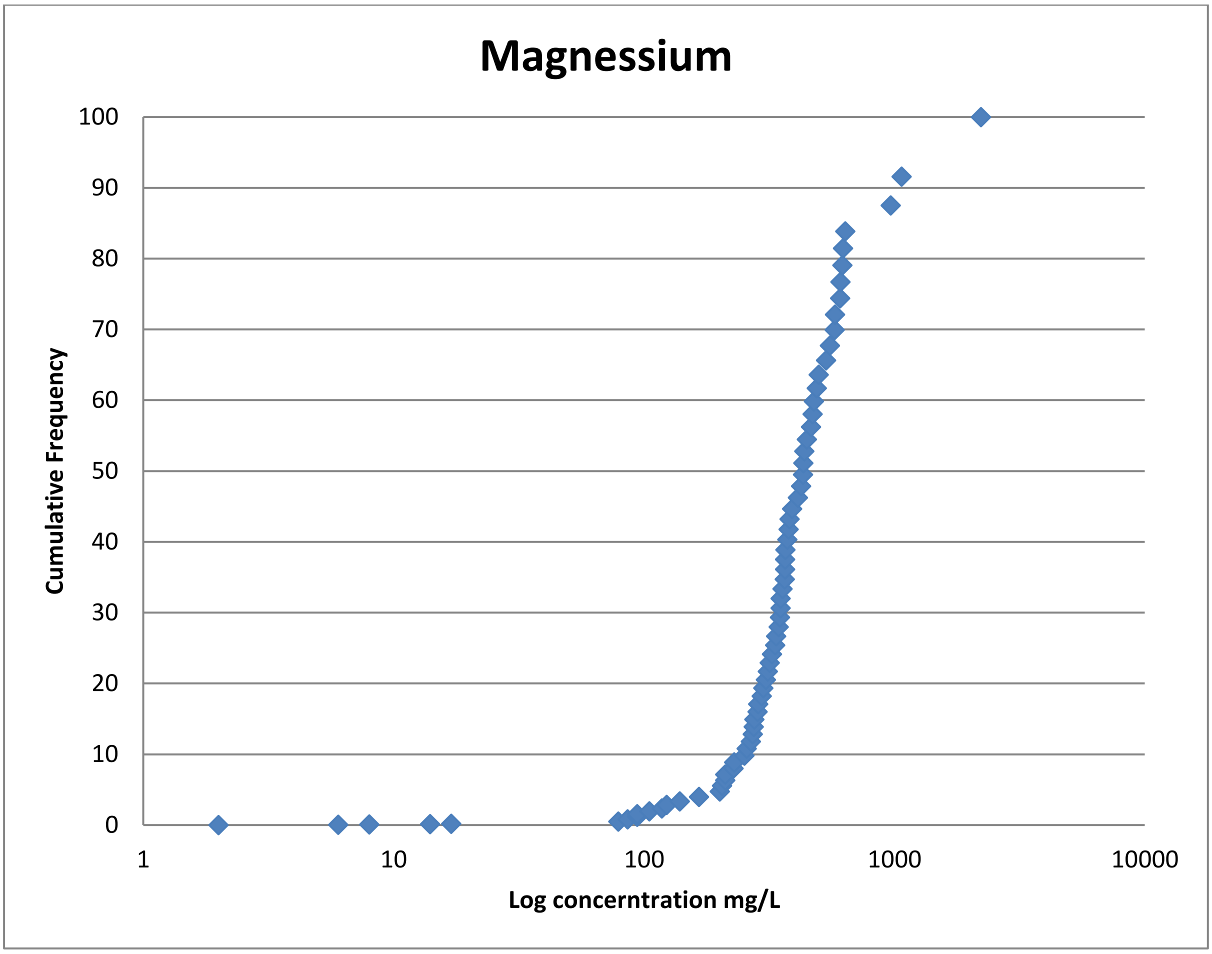

Vanadium
100
90
80
70
60
50
40
30
20
10
0
Cumulative Frequency
0.01
0.1
1
10
100
Log concentration µg/L

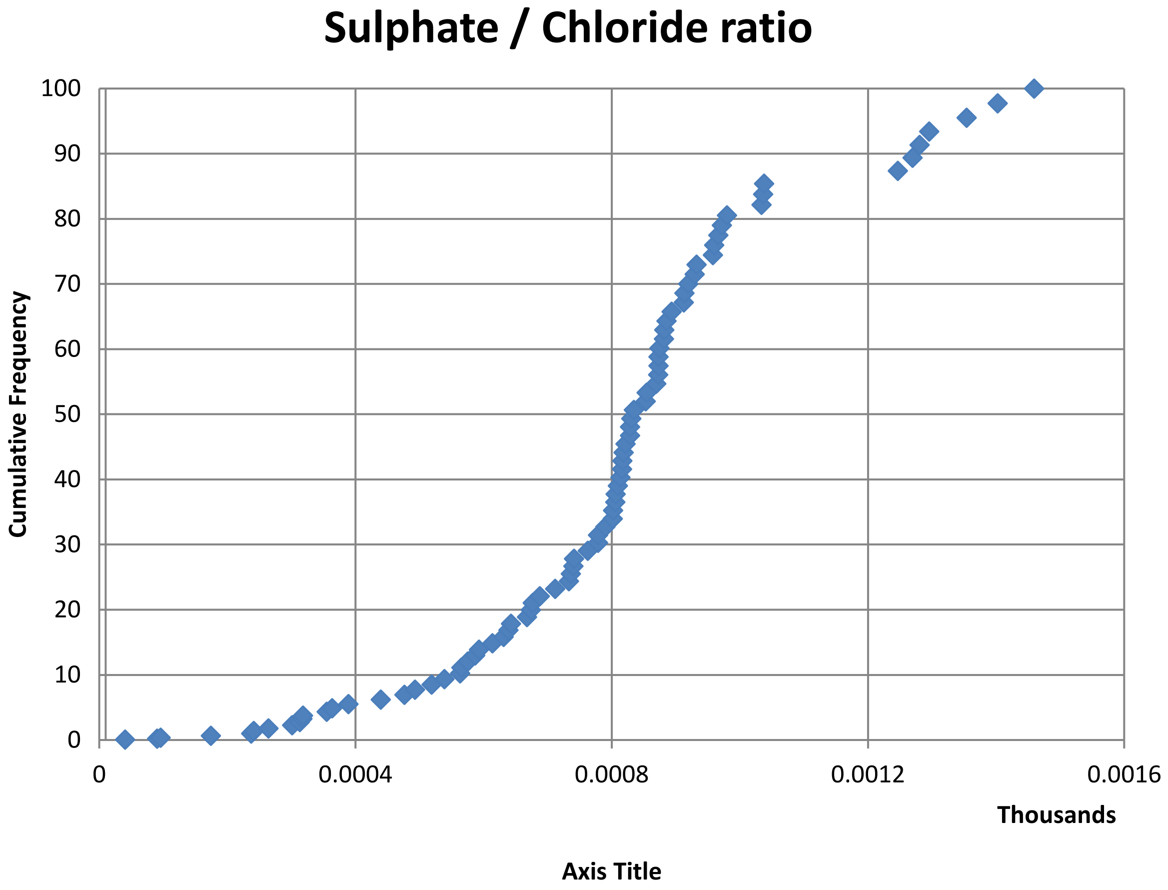

Zinc
100
90
80
70
60
50
40
30
20
10
0
Cumulative Frequency
0.1
1
10
100
1000
Log concentration µg/L


Calcium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
◆ GSV...
0.1
1
10
100
1000
Log concerntration mg/L


Sodium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
Log concerntration mg/L


Potassium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0.1
1
10
100
1000
Log concerntration mg/L


Magnessium
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
1
10
100
1000
10000
Log concerntration mg/L


Sulphate / Chloride ratio
Cumulative Frequency
100
90
80
70
60
50
40
30
20
10
0
0
0.0004
0.0008
0.0012
0.0016
Thousands
Axis Title