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**GROUNDWATER GEOCHEMISTRY AND THE GENESIS AND
DISTRIBUTION OF GROUNDWATER FLUORIDE
IN THE BOLGATANGA AND BONGO DISTRICTS,
GHANA**

by

W BRAIMAH APAMBIRE, B Sc.(Hons)

A thesis submitted to
the Faculty of Graduate Studies and Research
in partial fulfilment of
the requirements for the degree of
Master of Science
Ottawa-Carleton Geoscience Centre
and
Department of Earth Sciences

Carleton University

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**GROUNDWATER GEOCHEMISTRY AND THE GENESIS AND
DISTRIBUTION OF GROUNDWATER FLUORIDE
IN THE BOLGATANGA AND BONGO DISTRICTS,
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submitted by W. Braimah Apambire, B.Sc.(Hons)
in partial fulfilment of the requirements
for the degree of Master of Science

Thesis Supervisor

Chairman, Department of
Earth Sciences

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ABSTRACT

Geological, geochemical and groundwater data were used in order to describe the physical flow of groundwater, groundwater geochemistry and the genesis and distribution of groundwater fluoride in the Bolgatanga and Bongo Districts of Ghana.

Groundwaters of the study area are low in mineral content. There is a good positive correlation between calcium, magnesium, sodium and bicarbonate ions and electrical conductivity. The source of the major ions in the groundwaters is probably dissolution of feldspars and ferromagnesian minerals. Groundwater types in the study area are CaMgHCO_3 and CaNaHCO_3 , which is typical of groundwaters from crystalline rocks of igneous and metamorphic origin.

Concentrations of groundwater fluoride in the study area range from 0.11 to 4.60 ppm, with the highest concentrations found in the fluorine enriched Bongo Granites. The depth variability of groundwater fluoride in the Bongo Granite indicates that the mean fluoride concentration decreases with depth. Eighty-five wells have fluoride concentrations above the World Health Organization (WHO) recommended maximum guideline value of 1.5 ppm and may cause dental fluorosis in children drinking the water. Nitrate levels ranged from 0.02 to 211.00 ppm with 19 water samples exceeding the WHO recommended limit of 45 ppm. The sources of nitrate pollution are suspected to be anthropogenic with the highest concentrations found in the towns and sizable villages.

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Chapter 1

INTRODUCTION

1.1 BACKGROUND

This study was undertaken as part of a joint Canadian International Development Agency (CIDA) and Government of Ghana (GOG) project that involves the provision of safe and potable water supplies to the people of the Upper Regions of Ghana (see Figure 1). The CIDA/GOG project was initiated in 1974 and to date about 2,700 drilled wells, equipped with hand pumps, have been provided in about 100 communities in the two Upper Regions of Ghana.

The first phase of the project focused on the construction of wells, while the second phase emphasized the repair and maintenance of hand operated water pumps. The current phase of the project, the Community Water Project (COWAP), involves the Ghana Water and Sewerage Corporation (GWSC) and CIDA replacing over 2,000 hand pumps with the Afridev and Nira pumps. These pumps are said to meet the requirements of the "Village Level Operation and Maintenance" (VLOM) concept for rural water supplies. They are less costly and easier to repair.

Figure 1. Location Map (Study area shaded)

The emphasis of the Community Water Project is on transferring the operation and maintenance responsibilities to the communities by motivating and empowering the villagers, especially the women, to take charge of the repair and maintenance responsibilities. Also planned in the project is the creation of new water supply systems by constructing 90 boreholes and 600 hand-dug wells.

In the project, provision was made to support a variety of research activities through the Action Research Fund (ARF). The Action Research Committee, which administers the Fund, evaluated and approved a research proposal to conduct hydrogeological field work in the Bolgatanga and Bongo Districts for this M.Sc thesis

The issue of high fluoride in the study area groundwaters was reported in December 1994 and a request was made by Cowater International Inc, the CIDA/COWAP executing agency, to incorporate this problem into the hydrogeological study

The major aim of this thesis is to aid in the understanding of groundwater geochemistry issues in the Upper Regions of Ghana. It is also hoped that, in the area where high fluoride levels in groundwater affect domestic supplies, the thesis will provide information about the distribution of fluoride in groundwater.

1.2 OBJECTIVES

The primary objectives of the study were:

1. to determine the physical flow of groundwater in the study area;
2. to characterize the groundwater geochemistry;
3. to investigate the possible sources of groundwater fluoride; and
4. to describe the distribution of fluoride in relation to geology and well depth

To achieve the above objectives, documentation and analysis of geology, hydrogeology and geochemical data collected during a field program were undertaken.

1.3 THE STUDY AREA

The study area comprises the Bolgatanga and Bongo Districts of the Upper East Region of Ghana (see Figure 1). The area belongs to the two northern-most regions of Ghana (Upper East and Upper West Regions), formerly called the Upper Region. It is bordered to the north by the Republic of Burkina Faso, in the east by the Bawku West District, in the West by the Builsa and Kassena-Nankana Districts and in the south by the Northern Region of Ghana. The area lies within latitudes 10° 30' N to 11° 00' N and longitudes 0° 30' W to 1° 00' W and has a total area of about 1700 sq. km. Figure 2 shows the major towns and villages of the study area.

Figure 2. Major towns, villages and roads in the study area.

The study area, which falls under the continental or interior savanna climatic region, is characterized by one rainy season that begins normally in May and ends in September, with most of the rain falling in July and August. The pattern of rainfall within the year is closely related to the north and south movements of the Inter-Tropical Convergence Zone (ITCZ) (Dickson and Benneh, 1970). The ITCZ is the zone between the moisture laden South West monsoons (maritime air masses) and North East trade winds (continental air masses), known locally as the Harmattan. The mean annual rainfall is approximately 1000 mm. The rainfall period is followed by a marked dry season for the rest of the year.

The study area falls under the Sudan and Guinea climatic zones. The mean maximum and minimum monthly temperatures are 32°C and 25°C in April and August, respectively. The yearly mean temperature is about 28°C.

The population of the area is estimated to be 184,770 in the Bolgatanga District and 120,020 in the Bongo District, with about 85% living in rural communities. The people belong to the Frafra tribe, about 90% of which are subsistence farmers, producing mainly millet, guinea corn, groundnuts and rice. In a few places, dry season vegetable farms are established using water from surface sources. Animal rearing (cattle, sheep and goats) is predominant in the area. In the recent past, small scale gold mining activities in part of the study area have been a good source of income for the inhabitants.

1.4 HISTORY OF RURAL WATER DEVELOPMENT

In Ghana, groundwater supply systems have proven to be the most cost effective and appropriate option for water supply to the rural populations. Through the joint effort of the Ghana Government, rural communities, and international organizations, about 10,500 drilled wells and over 60,000 hand-dug wells have been constructed in the country. With even these seemingly high numbers, about 55% of the population is still not served by safe and potable water. Thus, groundwater development will continue to be a major activity in the area.

Traditionally, water supply has been through streams, ponds and hand-dug wells. Between 1920 and 1945, the then colonial government, in an attempt to alleviate the perennial water problem in the north, established the Rural Water Department in the northern territories. This department, which was an offshoot of the Gold Coast Geological Survey Department, was charged with the responsibility of constructing hand-dug wells.

Before 1973, 350 boreholes located in small to medium towns, and in schools and hospitals were drilled by the Ghana Water and Sewage Corporation. Some of these were mechanized and powered by diesel engines.

The joint Canadian International Development Agency/Ghana Water and Sewage Corporation-Upper Region Water Supply Program (CIDA/GWSC-URWSP) was the first substantial attempt by GWSC to supply rural dwellers with potable water.

World Vision International has drilled 16 wells in the Upper East Region. The Catholic Diocese of Navrongo-Bolgatanga sponsored the drilling of wells in the Navrongo area. Rural Aid, a local Non-Governmental Organization (NGO) and Water Aid (United Kingdom) have helped in the construction of about 400 hand-dug wells in the Upper East Region. Through the support of the United Nations Children's fund, GWSC is encouraging communities to sink hand-dug wells. It is reported that about 568 boreholes equipped with hand pumps and over 800 dug wells are in the study area.

1.5 SCOPE OF WORK

The field program in Ghana was conducted between January and April 1995. The activities that were covered include.

- 1) Survey of water supply locations using Global Positioning System (GPS) receivers, measurement of the water supply site elevations using an altimeter, and observation of the geology, structural features, topographic setting and hydrologic indicators in the research area.

Figure 3 shows the sites that were surveyed during the field program;

Figure 3. Locations of sampled wells in the Study Area.
Numbers denote sample numbers.

- 2) Collection of water and rock samples for chemical analysis, and investigation of potential fluoride sources. The parameters that were measured on site were pH, electrical conductivity and temperature; and
- 3) Acquisition of data relevant to geology and hydrogeology of the study, such as: maps, reports, borehole logs, pump test data and verbal information.

1.6 OUTLINE OF THESIS

The rest of this thesis is divided into 6 chapters. Chapter Two deals with the geology and hydrogeology of the study area while Chapter Three discusses the geochemistry and medical aspects of fluoride. In Chapter Four, the methodology adopted to achieve the objectives of this study are discussed while Chapter Five presents the general results and discussion. Fluoride results and discussion are given in Chapter Six. The conclusions and recommendations of this thesis can be found in Chapter Seven.

Chapter 2

GEOLOGY AND HYDROGEOLOGY

2.1 REGIONAL GEOLOGY

The study area is located in Precambrian metamorphic and igneous rocks of the West African Craton (Figure 4). The Craton has suffered no major orogenic deformation since the Lower to Middle Proterozoic (Wright *et al.*, 1985). Four main tectonic events are thought to have created or affected the rocks and have been recognized by Wright (1985) as follows:

- 1) Liberian > 2500 Ma The last major event that affected the Archean Cratonic nucleus found in Guinea, Sierra Leone and Liberia. There is evidence of an earlier event, the Leonian. However, it is obscured by the Liberian orogeny.

- 2) Eburnian 1850 ± 250 Ma This event was responsible for the deformation, metamorphism and tectonic stabilization of the Birimian Formation which makes up most of the West African Craton. Emplacement of granite at about 1800 Ma.

Figure 4. Geology of West Africa (after Wright et al., 1985)

- 3) Kibaran 1100 ± 250 Ma. This orogeny may have been associated with the formation of the Volta Basin in Ghana, Togo and Burkina Faso

There was a glaciation period at about 700 Ma, which was followed by the opening of an ocean. This is evidenced by the occurrence of ophiolitic sequences sandwiched between the Birimian Formation and the Pan African Rocks

- 4) Pan-African 550 ± 100 Ma The last tectonic event that affected the West African Craton.

The oldest rocks in the study area belong to the Birimian Formation. The name derives from the original type locality of these rocks, the Birim River Valley of Ghana. The Birimian in Ghana is subdivided into the Lower Birimian, dominated by metasediments, and the Upper Birimian, dominated by greenstone-type metavolcanics. Junner(1935), indicated that this subdivision is by no means comprehensive and ambiguities do occur.

The lowest parts of the Birimian succession are primarily phyllites and greywackes. These change upwards to weakly metamorphosed tuffs, greywackes and feldspathic sandstones. The sequence appears to pass conformably into the Upper Birimian, although a local unconformity has been recorded in places. The Upper Birimian Formation consists chiefly of metamorphosed basaltic and andesitic lavas. Rocks of sedimentary origin also occur in places.

The Upper Birimian Formation has been folded and in some places assimilated by granitoid bodies. The folding is intense, tight to isoclinal, with dips commonly in the order of 70° - 90° along a NE-SW orientation (Kesse, 1985). The metamorphism has generally been termed "low-grade" greenschist facies.

Faulting usually trends perpendicular to the folds. Jointing in these rocks has many orientations but is commonly parallel to fold and fault directions and in a north-south direction. A study carried out by Blay (1977) showed shear-joint planes at approximately 310° with longitudinal joints in roughly a $30^{\circ}/210^{\circ}$ orientation. These patterns are consistent with the WNW-ESE principal stresses (Kesse, 1985).

The Birimian Formation has been intruded by two main granitic groups: large syntectonic batholithic granites designated the Cape Coast granites (G1) and generally smaller late-tectonic to post-tectonic granites designated the Discove granites (G2). The age of the granites is about 1800 Ma.

A rare type of porphyritic, hornblende-microcline granite occurs in the study area. The granites are also foliated, faulted and fractured. Pegmatite and quartz veins are common in the granites.

2.2 GEOLOGY OF THE STUDY AREA

The most detailed mapping of the study area was done by Murray (1960) at a scale of 1:125,000. He divided the rocks underlying the study area into 3 major categories: Bongo granite, granitoids associated with the Upper Birimian Formation, and the Upper Birimian rocks (Figure 5). The Lower Birimian Formation mentioned in section 2.1 does not occur in the study area. Table 1 also summarizes the rock types present (modified after Murray, 1960):

Table 1. Geological stratigraphy in the study area

1) Bongo Granite

Pink microcline-hornblende-quartz syenite and granite with biotite subgroup

2) Granitoids associated with the Birimian

Altered hornblende granodiorite, biotite granodiorite

Gneissic tonalite, biotite- hornblende granodiorite.

Hornblende-biotite granodiorite, and biotite granodiorite.

Biotite gneiss and migmatite

3) Upper Birimian

Greenstone-Andesites, rhyolites, porphyries, tuffs, hornblende and actinolite schists.

Argillaceous-Phyllites and schists

Arenaceous-conglomerates, grits, greywackes, quartz-muscovite schists

Figure 5. General geology of the study area (Modified from Murray, 1960).

It was observed by Murray (1960) that the folded, complex, steeply dipping, metamorphosed rocks of the Upper Birimian could not be delineated and mapped as separate units, except in a most general fashion. On this basis, the Birimian Formation has been subdivided into a dominantly metasedimentary argillaceous and arenaceous group, and a dominantly volcanic group with intermixed argillaceous bands, though the relative ages are obscure (Murray, 1960). In the area, even though the term granite has been used, the proportion of true granites is very small.

2.2.1 The Upper Birimian

The Upper Birimian rocks occupy up to 30 percent of the study area. The main belt is 10 miles wide, trends NE-SW and lies between the villages of Sekoti and Zuarungu (Figure 5). Smaller belts occur to the southwest, to the northeast between Bongo and Arabe, and in the north western corner of the study area.

The argillaceous group of the Upper Birimian Formation consists of phyllite, chlorite schist, biotite schist, greywacke and quartzite. The dominantly arenaceous series consists of conglomerate, greywacke and quartz-muscovite schist. The arenaceous group outcrops in the southeast of Bolgatanga, east of Yorogo, north of Nangodi, and southeast of Datoko. A well exposed conglomerate outcrop was observed near Sherigu.

The volcanic group consists of greenstone, andesite, actinolite schist, hornblende schist, amphibolite, tuff and phyllite. The best exposures of the volcanics are found in the Nangodi Hills where andesites, greenstones, meta-basalt, and tuff occur (Murray, 1960).

2.2.2 Granitoids Associated With the Upper Birimian

The plutonic rocks associated with the Birimian include a foliated biotite-hornblende granodiorite suite, altered hornblende granodiorite and biotite granodiorite, biotite gneiss, and migmatite. Foliated biotite-hornblende granodiorite outcrops in a northeast southwest trending belt. These rocks are cut off in the southwest by the Bongo granite and occur along the western margin of the Bongo granite (Figure 5). The two areas of granodiorite would appear originally to have formed a continuous body which has been offset by faulting prior to the intrusion of the Bongo granite (Murray 1960). The granodiorite is medium to coarse-grained grey and black in color; mafic minerals constitute hornblende and biotite. More basic tonalites (quartz-diorite) also outcrop in places. According to Murray(1960), these rocks are more gneissic and migmatitic in some places.

Like the foliated granodiorite, the altered hornblende granodiorite outcrops in a northeast southwest trending belt. The belt stretches from the southwestern corner of the study area to the northeast. Near Bolgatanga, the Bongo granite cuts these rocks and at Tongo, they are intruded by the Tongo granite. The most well developed members of the group are exposed in Zuarungu and Tongo (Murray, 1960). These rocks are grey in color. A mylonitized zone of

altered granodiorites can be traced for several miles from the southwest to Adaboya. Most of the rocks in this zone are severely cracked by shearing (Murray, 1960).

Another large outcrop of the altered hornblende granodiorite, is the Sekoti granodiorite which underlies the eastern margin of the study area. The outcrop occurs as an elliptical shaped mass trending almost north-south. These outcrops are well jointed and from field evidence they are very similar to the Bongo granites (Murray, 1960). Biotite is the major mafic mineral. Outcrops are composed of rocks which range in composition from microcline and plagioclase bearing granodiorite to adamellite.

Coe (1953) was of the opinion that the Sekoti granodiorite falls within the Bongo granite suite.

However, this opinion was refuted by Murray (1960) who based his argument on results of chemical and modal analyses of the rocks. The results showed the sodium-rich nature of the Sekoti granodiorite as compared with a predominance of potassium in the Bongo granite suite

2.2.3 The Bongo Granite Suite

The Bongo granite suite, is a distinctive type of granite in Ghana which occurs only in the study area. Coe (1953), who gave the name Bongo granite to these rocks, was the first to map their boundaries. Two main masses of the granites have been mapped. The largest, which is also the type rock, extends northward from Bolgatanga to Bongo and to the border with the Republic of Burkina Faso at Yuwa (Figure 5). A smaller mass forms the Tongo hills in the south.

The Bongo granite outcrops as a rock mass 4 km wide striking almost northeast. About 4 km north of Yorogo, the outcrop changes strike to the northwest. The width of the outcrop at this place is about 8 km. Outcrop is well developed between Bolgatanga and Bongo, and about 4 km NNW of Bolgatanga. It becomes finer grained towards the margins of the intrusive. Close to the boundaries, the granitic body contains less quartz, and locally develops into a hornblende syenite or biotite-hornblende syenite (Murray, 1960). In hand specimen, the typical Bongo granodiorite is a pink coarse-grained rock with well developed euhedral to subhedral microcline phenocrysts up to one cm in length, euhedral amphibole crystals, granular interstitial quartz, plagioclase and a little biotite (Murray, 1960). The Bongo granite suite contains high proportions of alkalis which indicates that they are an alkaline granite suite (Murray, 1960). The difference between the big mass and Tongo granite is that the latter contains more quartz and a higher proportion of plagioclase feldspar than the former.

Porphyritic microgranites of the Bongo granite suite occur at Adaboya. The microgranites contain large phenocrysts of microcline. Two dykes traverse the area; one from Bongo to Feo and the other about 7 km northeast of Bongo. These dykes are identical to the Adaboya microgranites.

2.3 HYDROGEOLOGY

The study area is within the crystalline Basement aquifers of Africa. Basement aquifers occur within the weathered and fractured rock, thus, groundwater occurrence in these areas is controlled by the thickness of the overburden, the degree of decomposition, and the intensity of fracturing of the rocks. The thickness of the weathered zone or regolith is dependent on the type of rock, intensity of fracturing, and the climatic conditions. The decomposed zone is thicker where numerous fractures, quartz-veins and pegmatites occur. In most Basement terrains, although extensive outcrops occur, large areas are covered by a more or less continuous weathered layer with a maximum thickness of over 100m but generally less than 30m

Wright(1992) has described Basement aquifers as having two components. First, the weathered Basement consists of a more or less homogenous cover, ranging from clay to clayey sand, with generally high porosity and low permeability, thus having a predominantly reservoir function. The second component is due to fractured bedrock having low porosity and high permeability, thus it is strongly conductive. There is, however, a hydraulic link between the two components.

About 95% of the wells in the Upper Regions were completed within overburden. A typical profile for a weathered granitic or gneissic rock consists of the following horizons: A: surficial soil containing sand, clay and organics; B: lateritic zone; C: highly decomposed zone characterized by quartz, partially altered minerals and rock fragments, fractures are common;

D: moderately decomposed and fractured zone; E: poorly decomposed zone, contains fractures in many cases; and F: fresh basement rock. However, there are variations to this profile. Horizon B may outcrop in certain places, and in other places, where the weathering conditions do not favour further decomposition of clay minerals into various forms of aluminum and iron oxides, it may be absent. In the granite and migmatite terrains profiles over weathered granite and granodiorite are more uniform than those over migmatites.

The well yields are quite variable because of the complex geology (CIDA/GWSC, 1980). In many parts, the well yields are low (2-5 Igpm), but are sufficient for the installation of handpumps. In some places, where overburden is thick, capacities of wells may range from 20 to 30 Igpm in the granites, and from 20 to 50 Igpm in the Birimian rocks. The coarse-grained granites and granodiorites are more productive than the fine-grained mica-hornblende rich granodiorites.

The static water levels range from 0.98 m to 17.67 m and average 6.39 m. In a network of 54 observation wells in the Upper Regions, the average water level rise during the rainy season, measured over a three year period, was 1.8 m. The highest recorded level was 5.4 m and the lowest was 0 m. The highest water level rise during the same period was 3.7 m and the lowest was 0.1 m. The average rise was approximately equal to the regional average of 1.8 m. The highest levels were recorded in the Kongo-Nangodi area.

Bannerman and Ayibotele (1984) determined the average water level change over a 20-year period in aquifers of the Upper Regions and concluded that the change is considerably smaller than the seasonal fluctuations of water levels. They suggested, therefore, that there is no significant decline in water levels anywhere in the two regions over the 20-year period. However, there have been reports of declining borehole yields in certain parts of the two Upper Regions.

From pumping test results, Quist (1976) found the transmissivities of the Basement rocks in Ghana to be from less than $1 \text{ m}^2/\text{day}$ to $60 \text{ m}^2/\text{day}$. In the Bawku well field, the storativity for the aquifers was calculated to be 0.014 and the transmissivity was $17.2 \text{ m}^2/\text{day}$. Banoeng-Yakubo (1989) determined the transmissivity values for 54 wells in the Upper Regions to be from 1.10 to $98.30 \text{ m}^2/\text{day}$.

2.4 GROUNDWATER RECHARGE, DISCHARGE AND FLOW SYSTEMS

Previous geochemical and isotopic groundwater studies in the Upper Regions indicate that some areas are characterized by groundwaters of recent age, suggesting that active groundwater circulation and significant recharge occurs. Other areas seem to contain significantly older groundwaters (Akiti, 1976).

CIDA (1980) indicated that the amount of recharge into the aquifers is small but significant. Using incomplete data, CIDA(1980), calculated the recharge into the Wa well field to be 4% of the annual rainfall, corresponding to about 40 mm/yr. Similarly, the average total recharge into the Bawku well field was also estimated to be 3 to 4 percent of the annual rainfall.

Groundwater flow has not been researched in detail. However, Sommen *et al.* (1988) found that the regional groundwater flow is from north to south in the Basement aquifers of Burkina Faso.

2.6 GROUNDWATER GEOCHEMISTRY

In Ghana, studies into groundwater geochemistry have been directed more towards water quality issues than to the understanding of the aqueous geochemistry related to the various rock types. Thus the chemical interactions that occur within various aquifers and the geochemical evolution of groundwaters are not well understood

Generally, the chemical quality of groundwater in Ghana has been regarded as being acceptable for human consumption. Up until the late 1970's, except for high iron and manganese which occur in high concentrations due to weathering of lateritic rocks, most water quality parameters have been found to be within the acceptable limits of the WHO guidelines for drinking water.

For a total of 64 wells in the Upper Regions, the pH values were found to range from 5.4 to 7.3 with an average value of 6.40 (CIDA, 1980). The waters are thus slightly acidic and many are potentially corrosive. Silica content in the analyzes was found to be high (mean value of 40 ppm) and the electrical conductivity values for the 64 wells ranged from 170 to 925 $\mu\text{S}/\text{cm}$ with an average of 350 $\mu\text{S}/\text{cm}$. In a few of the wells, iron was found to be in excess of the GWSC limit of 1.0 ppm. Nitrate levels were found to range from 1.0 to 74.0 ppm, with an average value of 6.6 ppm.

The Ghana Institute of Aquatic Biology of the Council for Scientific and Industrial Research (IAB/CSIR, 1978) carried out field sampling and fluoride analyses of groundwaters in the region. Fluoride concentration levels ranged between 0.11 and 5.00 ppm. Information contained in the final hydrogeological report by Wardrop and Associates (1980) to CIDA indicated that in the above study, six (6) wells in the Bongo area were found to contain fluoride in excess of the GWSC allowable limit of 1.5 ppm.

Akiti (1982) investigated the levels of nitrate concentrations in the Upper Regions and concluded that the high concentrations were attributed to production of nitrogen by certain plants and human activities. Using water chemistry data for 11 wells in the Upper Regions, Banoeng-Yakubo (1989) found that the waters are $\text{HCO}_3 + \text{CO}_2$ and $\text{Ca} + \text{Mg}$ dominated.

In 1994, a British hydrogeological team, in conjunction with the Water Resources Research Institute (WRRI), carried out a chemical survey of groundwaters. Fluoride concentrations up to 4 ppm occurred in a localized area and the authors associated the anomalous values with the Bongo granite. In that same study, iodine levels were found to be generally low in the area. The Bolgatanga area is said to suffer from endemic goitre.

Chapter 3

GENESIS OF FLUORINE AND HEALTH EFFECTS OF FLUORIDE

3.1 GEOCHEMISTRY OF FLUORINE

Fluorine belongs to the halogen group of elements and it is the lightest element of the group (Lalonde, 1973). It is the most electronegative element and thus is one of the most chemically reactive elements known (Boyle, 1976). It has a valency of one, mass number of 19.00 and rarely occurs in the neutral state. Fluorine forms ionic stable bonds with over 30 elements including H, Li, Na, Mg, Fe and Ca (Boyle, 1976). It may form complexes under certain conditions with Al and some rare earth elements (Boyle, 1976).

3.1.1 Fluorine in Minerals

Fluorine has an ionic radius of 1.33 Å and, therefore, under favourable conditions may substitute for the OH⁻ and O²⁻ ions because these ions have similar ionic radii of 1.40 Å (Lalonde, 1973). It is the fourteenth most abundant element in the earth's crust (Lalonde, 1973). In igneous rocks, it ranks twelfth in abundance (Rankama and Samata, 1950). During the intrusion of magmas, the highest accumulation of fluorine is found in the residual fractions of melts as well as in aqueous and vapour phases. Therefore, fluorine is

strongly associated with pegmatitic, hydrothermal, and pneumatolytic stages as well as with the main stage of magmatic differentiation (Boyle, 1976).

The occurrence of fluorine in magmatic rocks is high where silica and alkalis (Li, Na, K, Rb, Cs) are present in high concentrations. In sedimentary rocks, fluorine is concentrated in micaceous and phosphatic minerals.

The principal fluorine-bearing minerals are fluorite, micaceous minerals, apatite (phosphate), amphiboles, pyrochlore (oxide group), bastnaesite (carbonate), and villiaumite, topaz and cryolite (fluoride group) (Koritnig, 1972). Due to the similarity between the ionic radius of F, OH and O, silicate minerals (which contain OH and/or O ions) invariably contain fluorine in either trace or major amounts (Boyle, 1976).

The amount of fluorine that can be incorporated into a silicate mineral depends on the conditions under which the mineral was formed. Silicates that form under pegmatitic, pneumatolytic, hydrothermal and metasomatic conditions generally contain more fluorine than their basaltic rock-forming counterparts (Boyle, 1976).

The mica group of minerals (biotite, muscovite and phlogopite) have a great affinity for fluorine during both primary magmatic activities and secondary weathering processes (Boyle 1976). Among the micas, biotite has the highest potential to concentrate fluorine, followed respectively by phlogopite and muscovite. Clay minerals also contain fluorine,

with levels dependent on the origin of the clay and the secondary processes to which it has been subjected. The amphiboles (hornblende), aegirine, zugite and some accessory minerals like tourmaline, and sphene also concentrate fluorine due to F-OH and F-O substitution.

3.1.2 Fluorine in Igneous Intrusive Environments

In magmatic environments, fluorine has a tendency to be concentrated in the Earth's crust rather than the mantle. Because it has atmophilic characteristics, there is a strong correlation between fluorine and the silica content of igneous rocks.

Fluorine concentrations (range and mean) in igneous intrusive environments are given in Table 2 (after Boyle, 1976). From the table, it can be observed that there is a positive correlation between F, SiO_2 , and alkali content. The range of fluorine for the rock types in each of these four groups is not distinct and there is much overlap in the data.

In magmatic systems the correlation between fluorine and SiO_2 is enhanced by the depolymerizing effect of F on Si-O bonding to form Si-F bonds. This implies that as magmas become enriched in SiO_2 through differentiation, the fluorine content will increase in the residual melt (Tauson, 1967, Greenland and Lovering, 1966).

Table 2. Fluorine Concentrations in Intrusive Environments (after Boyle, 1976).

ROCK TYPE	RANGE (ppm)	MEAN (ppm)
A. ACID-BASIC GROUP		
Ultramafic rocks	tr. - 2,000	130 (37)
Gabbros	50 - 11,000	430 (47)
Diorites	300 - 1,300	665 (20)
Granites & Granodiorite	20 - 30,000	810 (182)
B. TRANSITIONAL GROUP		
Syenites & monzonites	20 - 4,000	1,360 (26)
C. ALKALINE GROUP		
Alkali-ultramafics	tr. - 3,800	1,400 (41)
Alkali-syenites	100 - 25,800	1,800 (249)
Alkali-granites	670 - 12,400	5,500 (20)
D. LATE DIFFERENTIATES AND DYKE ROCKS		
Carbonatites	200 - 24,000	8,100 (96)
Kimberlites	520 - 2,500	1,310 (42)
Diabase(Dolerite)	198 - 500	420 (14)
Lamprophyres*	tr. - 3,700	1,500 (63)
Pegmatites	800 - 9,000	4,320 (6)

tr. = trace

* includes alkali-lamprophyres

Numbers in brackets indicate number of measurements used to calculate the mean

This process is further enhanced as a result of the inability of most rock-forming minerals to accept appreciable amounts of fluorine in their lattices, resulting in a considerable amount of residual fluorine in later magmatic stages. Thus high concentrations of fluorine are found in residual melts such as those which form pegmatites.

It can be observed in Table 2 that granite and granodiorites have the highest fluorine concentrations in the acid-basic group (810 ppm). The principal fluorine-bearing minerals in granitic rocks are muscovite, hornblende, apatite, topaz, fluorite and tourmaline. In granitic terrains, where the concentration of these minerals is above the normal ranges, fluorine concentrations will correspondingly be higher (e.g., the topaz granites of Nigeria). Conversely, a low concentration of fluorine-accessory minerals will yield low concentrations of fluorine.

It has been established that there is a marked correlation between the fluorine content of igneous rocks and their trace and rare earth element contents (rare earth elements, Sn, Ta, Nb, Be, Li, Cs, Tb, U, B). For granitoids, Odikadze (1971) has shown that an increase in fluorine concentration is accompanied by an increase in the concentration of Li, Rb, Cs, Ta, Nb, Sn and other rare elements. This positive correlation which exists with granitoids also exists with pegmatite. Kimberlites and carbonatites have high fluorine contents as well as high rare earth element concentrations. Conversely, ultrabasic and basic rocks have low rare element concentrations and are also low in fluorine.

3.1.3 Fluorine in Volcanic Environments

With few exceptions, the fluorine content of extrusive rocks shows the same relationship with the SiO_2 and alkali contents as that shown by intrusive rocks (Boyle 1976). The concentration of fluorine during the volcanic phase is controlled by the melt and gas phases. Generally, there is a much lower fluorine content in the extrusive rocks than in

their intrusive equivalents as a result of degassing of melts during eruption. Noble *et al.*(1967) have discussed the loss of halogens from recrystallized and glassy silicic volcanic rocks, noting that up to half of the fluorine originally present is lost through degassing. Basalts, andesites and rhyolites have mean fluorine concentrations of 375, 250 and 610 ppm, respectively (Boyle, 1976).

3.1.4 Fluorine in Sedimentary Environments

Fluorine is generally concentrated in the sedimentary environment as a result of water movement. It enters the sedimentary environment through a number of processes: as a component of resistant minerals such as topaz, tourmaline, and to a small extent apatite, fluorite, and the micas; as an absorbed ion; and as an aqueous complexed ion.

The highest concentrations of fluorine in clastic sediments are formed in clay-bearing rocks (shales, siltstone and mudstone, average of 790 ppm) with a majority of the fluorine tied up in micas and to a lesser extent, apatite (Boyle, 1976). Sandstones and greywackes have comparatively lower fluorine contents (average of 180 ppm). The high content of fluorine in shales, siltstones and mudstones, as compared to sandstones and greywackes, is due to the fact that the former have a higher clay content. Among the biogenic and chemical sediments, phosphate rock has the highest concentration of fluorine (average of 30,500 ppm).

3.1.5 Fluorine in Metamorphic Environments

During metamorphism, two important processes can be recognized; regional and contact metamorphism. The latter process plays a more significant role in the concentration of fluorine than the former. The range and mean of fluorine contents for various metamorphic rock types, resulting from both regional and contact metamorphism, is summarized in Table 3 (Boyle, 1976).

As a result of high temperature and pressure during metamorphism, fluorine minerals become unstable and thus fluorine migrates along the chemical potential gradient until it reaches favourable sites (a zone of low pressure, low concentration, low temperature), where it escapes from the metamorphic system. This implies, therefore, that the level of fluorine in metamorphic rocks is lower than in their protoliths. This can be illustrated by comparing the mean fluorine content of schists (250 ppm) with that of shales, sandstones and mudstones (790 ppm). The principal carriers of fluorine in regional metamorphic rocks are biotite, amphibole and apatite.

During contact metasomatism, volatiles and solutions containing fluorine and other elements escape from crystallizing igneous bodies into the country rocks forming contact metasomatic deposits. The formation of hydrothermal deposits may result in the deposition of fluorine-bearing minerals around the alteration zones of many types of intrusions, veins, and pipes.

Table 3 Fluorine Concentrations in Metamorphic Environments (after Boyle, 1976)

Rock Type	Range (ppm)	Mean(ppm)
A. REGIONAL METAMORPHIC ROCKS		
Meta-Gabbro	99-140	120(2)
Schists	60-580	250 (48)
Hornblende hybrid	400-930	620 (4)
Amphibolite	140-1,400	740 (10)
Gneiss	240-2,800	1,030 (14)
B. METASOMATIC ROCKS		
Hornfels	260-7,800	1,630 (957)
Skarns (Regional metamorphic origin)	90-4,500	1,200 (10)
Skarns (contact origin)	700-43,500	9,780 (28)
Greisens and greisenized granites	1,600-20,400	9,800 (26)
Kaolinized granites	800-7,400	2,800 (21)
Fenites	Tr.-600	400 (3)

Numbers in brackets indicate number of measurements used to calculate the mean

3.2 FLUORINE IN SOILS

The extent to which fluorine is leached from soils depends on how resistant the fluorine-bearing minerals are in the parent rocks. For soils which contain fluorite and micas, fluorine is easily leached. The mobility of fluorine is further enhanced in soils which contain a low colloid and clay mineral content. For environments in which fluorine is held

in resistant minerals such as topaz, tourmaline, and apatite, fluorine will in general not pass into the aqueous phase.

It has been found by Samson (1952) and Larsen *et al.* (1971), that aluminium hydroxides are better adsorbers of fluorine than clay minerals. Of the clay minerals, kaolinite possesses a greater adsorption capacity than montmorillonite (Boyle, 1976). The adsorption capacity of the clay minerals is pH dependent. Pluger and Friedrich (1972) found that there is a decrease in the anion adsorption capacity of clays with increasing pH.

When the Ca content exceeds the solubility limit for apatite and fluorite, fluorine is precipitated as fluorapatite or fluorite, thus fluorine becomes immobile in soils. On the other hand, fluorine is relatively mobile in soils which have solutions rich in the alkaline elements (K, Na) such as those over alkaline igneous rocks. This is due to both the high solubility of K and Na fluorides and the fact that K and Na increase the solubilities of fluorite and apatite.

It has been reported by Robinson and Edgington (1946), Vinogradov (1959), and Michael and Blume (1952) that there is an increase in fluorine concentration with increasing soil depth. However, there have been other studies which produced contrary results. Boyle (1976) found that in the Bancroft area of Canada, the A horizon of soils developed over pegmatites show a marked enrichment in fluorine compared with the B horizon. In the vicinity of the fluorite deposits of the Madoc area in Canada, Lalonde (1973) also found

high enrichments of fluorine in the A horizon. It was concluded by Boyle (1976) that in areas where soils are developed over rocks in which fluorite is the primary fluorine-bearing mineral, the A horizon will be more enriched in the element.

Another source of fluorine in soils is through the use of agricultural fertilizers containing large quantities of phosphatic material. Less than 10% of the fluorine added through fertilization is normally removed by groundwater leaching and harvesting (Oelschlager and Hohenheim, 1971). Therefore, a large accumulation of fluorine is expected in soils which are intensively fertilized.

3.3 BIOGEOCHEMISTRY OF FLUORINE

There are two mechanisms which enhance the uptake of fluorine by plants: plant roots absorbing fluorine directly from soil solutions, and the decomposition of fluorine-bearing minerals near the root-soil interface. Fluorine is absorbed by almost every plant species in detectable amounts. The highest concentration levels are found in the leaves and roots of plants. The fluorine content in plants on a dry weight basis may vary from a trace to as much as 8,200 ppm. The highest concentrations are found in the tea plant (*Theacea elegans*) and may vary from 100 ppm to a maximum of 8,200 ppm fluorine (Boyle, 1976). In animals, fluorine builds up in the skeletal tissues as fluorapatite.

3.4 HYDROGEOCHEMISTRY OF FLUORINE

Fluorine occurs in almost all waters from trace to very high concentrations. Its occurrence in natural waters depends on such factors as temperature, pH, total ionic strength, presence or absence of complexing or precipitating ions or colloids, solubility of fluorine-bearing minerals, the size and type of geological formations traversed by water and the amount of time in which the water is in contact with a particular formation.

The level of fluorine in groundwater invariably correlates with its concentration in the rocks that the water is traversing. The concentration of fluorine in groundwater traversing different kinds of geological terrains have been compiled by Boyle (1976) and displayed in Table 4. The overall range of groundwater fluoride for these rocks is from trace to 35.1 ppm and the range of average fluoride contents is 0.02 to 8.7 ppm.

The most important minerals which have a direct effect on the aqueous chemistry of fluoride are fluorite, apatite, the micas, amphibole, and villiaumite. Among these minerals, fluorite is the main mineral affecting groundwater fluoride geochemistry. This is because fluorite is the most soluble fluorine-bearing mineral. Apatite, the micas and amphibole have extremely low solubility and thus fluorine is leached from these minerals only under strongly acid (dissolution) or alkaline (F-OH exchange) conditions.

The amount of fluoride released by the dissolution of fluorite in water with low ionic strength is of the order 8 to 10 ppm (Boyle, 1996). However, the concentrations of Ca

Table 4 Fluorine Content of Waters from Identified Rock Types (after Boyle, 1976)

TYPE OF ROCK	NO. OF SAMPLES	F CONTENT(ppm)	
		RANGE	AVERAGE
Granitic (810)	78	n.d.-9.0	1.4
	14	n.d.-3.4	0.9
	14	0.06-0.2	0.1
	31	0.03-0.25	0.11
Alkalic (1,800)	77	0.70-35.1	8.7
Basaltic (750)	44	n.d.-0.5	0.1
	11	n.d.-0.4	0.2
Ultrabasic (130)	11	0.02-0.04	0.07
Andesitic (250)	4	n.d.-0.04	0.07
Sandstones and quartzites (180)	69	n.d.-2.7	0.1
	16	n.d.-1.9	0.4
Shales and clays (790)	80	n.d.-1.8	0.2
	16	n.d.-2.8	0.6
	15	0.07-0.2	0.1
Limestone (220)	14	n.d.-0.9	0.3
	116	n.d.-1.8	0.3
	123	n.d.-1.8	0.12
Dolomites (260)	21	n.d.-0.3	0.02
	5	n.d.-1.7	0.5
Marbles	27	0.03-0.2	0.1

and Na, the pH of the waters, and the concentrations of co-complexing ions can alter the above concentration range of fluoride.

Due to the common ion effect, the dissolution of fluorite is suppressed when the concentration of Ca is above the limit for the solubility of fluorite. Various studies (Voroshelov, 1966; Edmonds, 1971; Boyle, 1976 and 1992) have indicated a strong negative correlation of Ca with F in groundwaters that contain Ca in excess of that required for the solubility of fluorite. Voroshelov (1966) has shown that Ca in excess of that contributed by fluorite seriously affects the concentration of fluoride at levels of 0.5 to 3.0 ppm. This concentration range is well below the levels of fluoride (8 - 10 ppm) produced by the dissolution of fluorite in water of low ionic strength. Because of this, a majority of groundwaters are greatly undersaturated with respect to fluorite (Boyle, 1976). For 'hard' groundwaters (low Na) the fluoride content is generally in the range 0.02 to 3.00 ppm.

Sodium exhibits a positive correlation with fluorine in many types of groundwaters, especially those having low concentrations of calcium. Thus, Na dominated groundwaters favour the concentration of fluoride. High concentrations of Na lead to an increase in the solubility of fluorite and apatite.

The formation of complex ions between fluoride and cations such as Al, H, Fe, B and Si are other factors that affect the concentration of fluoride in waters. The formation of such complexes is dependent on the pH of the water.

The base exchange softening process is another phenomenon which can lead to high levels of fluorine in groundwaters. The base exchange softening process leads to severe depletion in Ca, significant enrichments in Na, anion exchange of OH for F from solid phases, and increased solubility of F-bearing minerals such as fluorapatite. In the New Brunswick region of Canada, the occurrence of high levels of fluorine has been attributed to the base exchange softening process whereby Ca, Mg and to a lesser extent H, are exchanged on solid phases for Na thus producing strong Na-HCO₃ waters (Boyle, 1992). The base exchange softening process begins at a depth of 15 m and there is a strong positive correlation between fluoride, pH, Na, and HCO₃.

3.5 EFFECTS OF FLUORIDE ON HUMAN HEALTH

It is generally considered that fluoride in small amounts (0.5 to 1.5 ppm) is required for the prevention of dental caries and better bone development and that if ingested in high doses (> 4.0 ppm), ailments known as skeletal or dental fluorosis may occur. Therefore, fluoride, as with many other trace elements (e.g. iodine), can be considered as harmful or beneficial to humans depending on the amount ingested.

Based on different research results, the recommended beneficial daily dosage of fluoride is estimated to be 1.3 to 3.3 mg while the contribution of fluoride from food has been estimated to be about 0.2-0.5 mg. The chief source of fluoride for humans is, therefore, drinking water. The beneficial range of fluoride in drinking water is generally between 0.5-2.0 ppm depending on average ambient temperatures, which control fluid intake and thus total dose/day (WHO,1970).

Generally, ingestion of water, having a fluoride concentration above 1.5 ppm, may lead to dental mottling (fluorosis), which is characterized by opaque white patches on the teeth with eventual staining. In advanced stages of dental fluorosis, teeth display brown to black staining, and pitting of teeth surfaces may even occur. The degree of mottling depends largely on the amount of fluoride ingested. With increasing concentrations of fluoride, the effects become progressive, so that at about 6 ppm the incidence of mottling is 100% WHO(1970). The age for high manifestations of dental fluorosis is said to be from 0 to around 12 years.

Skeletal fluorosis occurs when fluoride concentrations in drinking water exceed 5-8 ppm. Skeletal fluorosis leads to an increase in bone densities, thickness of long bones and calcification of ligaments. The disease may be present in an individual at sub-clinical, chronic, or acute levels of manifestation (Teotia and Teotia, 1988). Symptoms of the ailment range from mild rheumatic or arthritic aches, pains in joints and muscles, to severe pain in the cervical spine region along with stiffness and rigidity of the joints. Crippling

skeletal fluorosis can occur when a water supply contains more than 10 ppm (Weatherell and Weidmann, 1959).

Acute stages of skeletal fluorosis were first described by Moller and Gudjonsson (1932) and studied by Roholem (1937) among cryolite workers in Denmark. These workers inhaled dust containing fluoride (14 to 68 ppm) over a period of 20 to 38 years. Toxic effects that were reported include severe gastric pains and abnormalities in bone density and growth.

Skeletal fluorosis has been reported in many countries of the world. Notable in Africa are countries such as Morocco, Tunisia, Algeria, Sudan, South Africa, Kenya, Senegal, Nigeria and Tanzania (Bohne, 1958; Ockerse, 1946; Nadosi, 1989). In Europe, it has been reported from England, Spain, Italy, Greece, Russia and Denmark (Awinsworth, 1933; Roholem, 1937). Other countries are the United States, Canada, Mexico, Denmark, China, India, Pakistan and the former Soviet Union.

The highest level of fluoride recorded in the world is in the East Africa Rift System (Tanzania and Kenya) where groundwater fluoride levels may reach 57 ppm, while the soda lakes of the region may contain up to 2,800 ppm (WHO, 1970). In Canada, extremely high levels of fluoride (up to 28 ppm) in groundwaters occur in the Maria, Quebec region of the Maritime Carboniferous Sedimentary Basin (Boyle and Chagnon, 1995).

In the 1960s, evidence derived from studies in the USA indicated that under American diets, the prolonged ingestion of fluoride at up to 8 ppm in drinking water did not produce harmful physiological effects in humans except for dental mottling (Leone *et al.*, 1954). An objectionable degree of mottling was observed only when fluorides were consumed during the ages of 0 - 12 years at levels in excess of 2 ppm. However, recent evidence suggests that bone cancer in young males is much greater in fluoridated areas of the USA than in non-fluoridated areas (Colquhoun, 1993).

The differences in epidemiological results on fluoride intake suggest that there are highly varying degrees of fluoride intoxication in different parts of the world. This has led to the inference that there are factors peculiar to each country, which influence the effect of fluoride in drinking water (WHO, 1970).

It is reported by some researchers that climate is a very important factor in fluoride intoxication because the amount of water (and consequently the amount of fluoride) ingested by children is primarily influenced by air temperature. This relationship was first studied and reported by Galagan (1953), Galagan *et al.* (1953) and Galagan *et al.* (1957). Further studies into this relationship were conducted by Richards *et al.* (1967).

The WHO has set a guideline limit for drinking water fluoride at 1.5 ppm. This limit may, however, change depending on local conditions. The Indian Council for Medical Research has fixed desirable limits for fluoride in drinking water at 0.6 to 1.2 ppm (ISI, 1983). The highest desirable and maximum limits (especially for places where there is no better alternative water

source) have been prescribed respectively as 1.0 and 1.5 ppm. In India, dental fluorosis has been reported in communities that have fluoride concentrations as low as 1.0 ppm and skeletal fluorosis exists in some communities where fluoride concentrations are about 3.00 ppm and the water was consumed for about 8 to 10 years.

China has set optimum concentrations of fluoride in drinking water at 0.5 to 1.0 ppm. Kenya implements guideline limits of 0.7 to 1.5 ppm (Gaciri *et al.*, 1993).

Brouwer *et al.*, (1988) found the WHO fluoride guideline values to be unsuitable for Senegal. Their study indicated that in the hot climate of Senegal, both dental and skeletal fluorosis are more prevalent and more severe than would be expected from the suggested WHO maximum guideline limit. Hot weather not only increases the water intake but also increases the concentration of fluoride ingested. They found that 68.5% of children had mild dental fluorosis at the 1.0 ppm level. When the fluoride content exceeded 4.0 ppm, dental fluorosis reached 100%.

Other factors that control fluorine intoxication are the calcium and alkalinity levels of the drinking water, the length of time of ingestion, human age, economic and nutritional status of the people, the physical strain that the people are exposed to (consequently sex), and contributions of fluorine from sources other than drinking water (e.g. tea).

Chapter 4

METHODOLOGY

4.1 SITE LOCATIONS

Sampling sites were located in the field using a hand held Magellan or Trimble GPS receiver. It was anticipated that the differential mode in locating sites would have been employed, however, this was not possible because of a lack of appropriate bench marks in the area. Another reason that made it impossible to conduct differential measurements was the lack of facilities to receive GPS data simultaneously from two stations.

The Magellan GPS NAV 5000 PRO receiver features five parallel channels and, in single mode, provides positioning accuracy of ± 15 meters. The receiver measures in a number of datums and coordinate systems which include the World Geodetic System (WGS84). The Trimble receiver has characteristics similar to the Magellan, except that the former has more than 100 datums which include the Accra datum.

The GPS receivers and an altimeter were calibrated for use. The two conditions to be met when calibrating the equipment were a) the point to be used as a reference must be within 480 km of the area of interest; and b) the x,y,z coordinates of the point must be known as accurately as possible. The equipment was referenced on pillar numbers GCS T21/3 and

T21/4 in the village of Sumbrungo within the project area. Since altimeter readings are dependent on atmospheric pressure, variations in altitude with time of the day and over weekly periods were recorded so that the appropriate corrections could be applied.

In the field, GPS coordinates were determined using the WGS84 datum and the UTM (Ghana is in UTM zone 30) and latitude/longitude coordinate systems with the Magellan receiver. For comparison, the Trimble receiver was used occasionally to determine the coordinates of the same sites. Bench mark coordinates in Accra, capital city of Ghana, which were determined with the study GPS equipment, were compared with those of the Ghana Survey. It was found that the two sets of coordinates were very much in agreement.

The GPS coordinates and altitudes of about 400 wells were processed and the results formed the most important input to the spatial and vertical analysis of the data.

4.2 WATER SAMPLING

At each borehole site, the well was pumped for 5-10 minutes to ensure that the water to be sampled was fresh. Water samples were collected from 375 drilled wells, 31 hand dug wells, and 6 surface impoundments. At each site, three sub-samples were collected: one 60 ml polyethylene bottle, acidified for cation analysis; one 60 ml bottle, unacidified for anion analysis; and one 25 ml vial. A total of 1236 sub-samples were collected. All of the samples were refrigerated in the field and subsequently brought to Canada for analysis. Field

measurements were made for pH, electrical conductivity and temperature. The pH meter was regularly calibrated using two buffer solutions of pH values 4 and 10

There was good coverage of the area by the sampling program, with respect to spatial distribution of wells and the geology. Based on the results from GWSC and the British Geological Survey, greater emphasis was placed on areas that had known high fluoride concentrations in the groundwater. To enable a better understanding of the relationship between fluoride and depth, a number of surface sources and hand dug wells were sampled. Deep drilled wells were also targeted for sampling.

4.3 EXISTING DATA SOURCES

The majority of the borehole logs and pertinent information were obtained from the GWSC offices in Bolgatanga. Information in the borehole logs included lithologic descriptions of the rocks encountered during drilling, well depths, yields and the methods of well construction. Other information, such as the occurrence of pegmatite and quartz veins encountered during drilling, were noted in the logs. Color was one of the important characteristics of the Bongo granite.

Topographical field sheets and geological reports were also obtained from the Ghana Survey and the Geological Survey Departments.

4.4 DATA VERIFICATION

The first line of data verification was conducted by talking to personnel who were involved in the construction of the wells. All of them indicated there were no major errors created during the borehole drilling and construction phases. Some of the minor errors are as follows:

- a) The usual practice of drillers in borehole depth measurements is to subtract the length of that part of the drill rod above ground surface from the total length of the string of drill tools. From experience, an error of ± 2 feet (± 0.6 m) is normally associated with the measurement. Well drillers rarely measure lengths with a tape measure. Inaccurate well depths are often recorded.
- b) The drill rig table is sometimes taken as the reference point for depth measurements instead of the ground surface. This can also create depth discrepancies in the order of about +3 feet (0.9 m) since most drill rig tables are set at heights of about 3 feet (0.9 m). In other situations depth measurements are made from the total length of PVC casing that are used during the construction phase of the well and this may include the PVC stuck out at surface (0.3 - 0.9 m). In this case the geologic log may not correspond with the depth if there was any caved-in material after the drilling. In most cases the cumulative sum of all these errors does not exceed 5 feet (1.5 m).

c) Another source of error which sometimes occurs relates to improper supervision of the contractors. Drilling contractors may inflate depth figures in order to earn more money from their drilling activities. Contractors may also inflate yield figures so that clients become more confident of the status of their wells. There was good supervision of contractors during the time of drilling, thus, deliberate inflation of figures was probably minimal.

During the field work, data pertaining to 16 wells that were rehabilitated were collected and correlated with the depths recorded in the borehole logs. It was found that 12 of the data sets agreed within an error of $\pm 1\text{m}$

The water chemistry data from the GWSC (126 samples) and BGS(54) were compared with data from the present sampling program and it was found that there was an r value of almost +1 between the BGS and the present thesis data. The correlation between GWSC and BGS data was 0.8 and between GWSC and the thesis was 0.7

4.5 CHEMICAL ANALYSIS OF WATER SAMPLES

The water samples were analyzed at the Geological Survey of Canada (GSC) analytical chemistry laboratories. The unacidified samples were analyzed for HCO_3^- by alkalinity titration; results being converted to HCO_3^- . The unacidified samples were also analyzed for NO_2^- , NO_3^- , F, Br, SO_4^{2-} and Cl by ion chromatography. The estimate of absolute and

relative errors for the analysis of these elements was 5% and the detection limit for each element was 50 ppb.

The acidified samples were analyzed directly for Ca, Mg, Na, K, Si, Al, Fe, Mn, B, Ba, Li, Rb, Sr, U, V, Mo, Cu, and Zn using both ICP emission and mass spectrometry. The detection limits for these parameters can be found in Table 5.

Table 5 Limits of Detection of ICP Determination (ppb).

Element	Detection Limit	Element	Detection Limit
Ca	5	Ba	0.9
Mg	2	Li	1
Na	20	Rb	-
K	20	Sr	0.1
Si	10	U	-
Al	9	V	2
Fe	3	Mo	-
Mn	0.3	Cu	0.6
B	16	Zn	0.4

For all concentrations that were less than the detection limit, the values used for the chemical data analysis were half the detection limits of those parameters. Si values were converted to SiO₂. The ionic balances ranged from -3.62 to 7.20%. More than 96% of the samples had ionic balances within $\pm 5\%$ indicating that the analyses were generally within acceptable limits.

4.6 DATA ANALYSIS TECHNIQUES

Various basic statistical techniques were adopted for data analysis. Correlation coefficients (r), means, standard deviations (S.D.) and linear regressions were done using the Quattro-Pro and SYSTAT programs. A general assessment of the interrelations between the various parameters was obtained by plotting scatter diagrams using the SYSTAT program.

All maps were digitized using the ILWIS GIS program. Surface interpolation of data was done initially by the ILWIS and Surfer programs. The maps generated by the ILWIS GIS and Surfer programs were found to be very similar. However, the Surfer program was chosen for this study because of its user friendliness and its good output quality.

SURFER is a 3-D grid based contouring and surface interpolation package that can process data in the x , y and z format efficiently. The program has 6 contouring options. The suitability of each method depends on the nature of the data set. The chemistry analyses were first analyzed using the different methods to see which one method best suited the data. Among the six contouring methods, the Kriging and Radial Basis Function methods yielded the best results with the Kriging method eventually being used in this interpretation. Kriging attempts to express trends that are suggested in a data set, so that, for example, high points might be connected along a ridge.

In chapter 5, less confidence should be placed on the north-eastern and south-western parts of the contour and interpolated maps, because there were either no wells in these regions or the well sites were outside the study area.

All the major ions were converted to percentage milliequivalents of the total anions and cations. These results were used to plot piper diagrams using the Hydrowin program (Calmbach, L., 1995). The geochemical modelling programs Hydrowin (Calmbach, 1995) and WATEQ4F (Ball *et al.*, 1987) were also used to calculate the saturation indices of the water samples and the total dissolved solids of some samples.

Chapter 5

GENERAL RESULTS AND DISCUSSION

5.1 GENERAL GEOLOGY

Existing geological maps and field evidence were used to verify the geology recorded in borehole logs. Because lithologic descriptions were not comprehensive in the logs, it was not possible to make a detailed geological classification of the borehole records. However, in this thesis, borehole data and chemical water analyses have been divided into four lithologies, as described by Murray (1960). These four lithologies are: Upper Birimian Metavolcanics, Upper Birimian Metasediments, Upper Birimian Granitoids and Bongo Granites. The following descriptions are based on field observations and analysis of borehole records.

5.1.1 Geology of the Area North and West of Bolgatanga

The predominant rock type here is the Bongo granite, underlying more than 30% of the area (Figure 5). The prominent features in this part of the study area are the Bongo Hills, composed of Bongo granite. Outcrops of pink biotite granite can be observed between Yorogo, Bongo, Zoko and Bolgatanga. These rocks are well jointed and porphyritic, the phenocrysts are composed of microcline.

Towards the edges of the granite, rocks are syenitic. In some places, xenoliths of gneiss occur within the Bongo granite. The granite appears sheared between Bongo and about 5 miles southwest of Bongo.

Outcrops of the Bongo granite were observed beyond inferred and actual geological contacts on the geological map of the study area. The areas to the immediate north and east of Bongo are underlain by the Bongo granite, but were classified as Upper Birimian. Other areas that are underlain by the Bongo granite, but were classified under different lithologies include the area west of Zaare and west of Zoko. This information was very valuable for characterizing the wells according to geology.

The rest of the area north and west of Bolgatanga is underlain by biotite-hornblende granodiorite, and biotite gneiss with phyllite and schists further to the northwest. An outstanding outcrop of amphibolite also occurs in the northwest. Good outcrops of hornblende granodiorites were observed at Nyarega (in the vicinity of well number 445E37) and in Sumbrungu.

5.1.2 Geology of the Area South and West of Bolgatanga

Rock types that were observed in this area include migmatites, greenstones, conglomerates, granodiorites and Bongo granite. Outcrops of the Bongo granite can be seen about 0.5 miles southwest of the mapped southern contact of the main Bongo granite. Xenoliths of the Birimian rocks occur within the granite outcrops in many places. Conglomerates with

fragments of phyllite, were observed along the southern contact with the Bongo granite. About 4 miles further south of the contact, quartzite outcrops were encountered in the vicinity of well number 455H26.

5.1.3 Geology of the Area North and East of Bolgatanga

This area is underlain by most of the different rock types that underlie the overall study area. As with most of the rock units, there is a general northeast-southwest structural trend to the units in this area. The predominant rock types are greenstones, lavas, phyllites, schists and granodiorites. Lavas filled with quartz and calcite are fairly common in this area (Murray, 1960). Prominent topographic features in this area are the Nangodi Hills that are composed of greenstone.

A dike, that was mentioned by Murray (1960) to be trending from Bongo to the northeast, was verified in the field. The dike is composed of the Bongo granite suite. In the Adaboya area, a similar outcrop was encountered.

At Dua, close to well number 455F44, greenstone was sampled from a hand dug well. However, moving eastwards from this location towards the main Bongo granite outcrop, migmatites comprised of schist and the Bongo granite were observed.

In the Sekoti area, outcrops of granodiorite similar in composition to the Bongo granite, were observed. The rock is well jointed and porphyritic in places.

5.1.4 Geology of the Area South and East of Bolgatanga

The most abundant rock type is greenstone, followed by granodiorite. Both units trend northeast-southwest. Close to the southern end of the area, the Tongo granite intrudes into the greenstone and granodiorite.

5.1.5 Weathering

Overburden thickness of rocks is quite variable. From 191 well records, overburden thickness ranges from 2.7 - 37.0 m (9 to 121 feet), with a mean thickness of 20.4 m (67 feet).

Overburden thickness over the Birimian metasediments ranges from 17.4 - 33.2 m (57 to 109 feet), with a mean thickness of 27.1 m (89 feet). Depth of weathering for the Birimian granitoids ranges from 4.6 to 37.0 m (15 - 121 feet), while the mean thickness is 22.2 m (73 feet). The metavolcanics have overburden thicknesses ranging from 11.6 - 30.5 m (38 to 100 feet) and a mean thickness of 19.5 m (64 feet). The Bongo granite has the smallest mean overburden thickness of 16.8 m (55 feet) and the thickness ranges from 2.7 - 35.7 m (9 to 117 feet).

5.2 GROUNDWATER MOVEMENT

A map of the groundwater table was constructed using well locations and elevations (Figure 6). These parameters were obtained during the field work and from existing topographic maps of the study area. Appendix 1 contains well identification data. Wells

Figure 6 Groundwater table map superimposed on the main rivers in the study area. Contours are 50 feet apart.

used in this analysis are fairly shallow, ranging in depth from 3.0 - 38.7 m (10 to 127 feet). Static water levels were extracted from borehole records. A majority of the water levels were determined between 1975 to 1980, and they range from 1.5 - 17.7 m (5 to 58 feet) below ground surface. All of the groundwater levels were referenced to mean sea level using site elevations. Since water levels were measured over a large time period, variations in the data may exist which would not have been present if all measurements were made at the same time. Also, temporal and vertical variations(vertical gradients) may introduce errors to the water table map.

The most direct indicator of recharge and discharge areas is normally through piezometric measurements. However, comparable information can be obtained from available water-level data (Freeze and Cherry, 1979). A water-table map of the study area was constructed with the assumption that topography plays an important role in the depth of the water table. Also, a study conducted by Sommen *et al.* (1988) north of the current study area and underlain by similar rock types, indicated the presence of a continuous piezometric surface over large areas. In their study, groundwater level contour maps were constructed on the basis of topographic maps and water levels taken from wells intersecting the aquifers.

Although there might be errors associated with topographic and water level measurements used to construct Figure 6, it can be seen that there is a consistent picture of contours following the topography(Figure 7). If the water-table map is used as an indicator of potentiometric conditions, groundwater flow is generally from the north to the southwest and

Figure 7 Topographic contours of the study area(50 feet interval). Note the similarity between groundwater level (Fig. 6) and topographic contours.

southeast. The predominant recharge area is in the north, coinciding with the topographic high. The low lying areas in the southwest, and southeast where the main rivers drain, is likely to be the discharge area.

Previous isotopic studies (Akiti, 1976) indicate that the study area is characterized by groundwaters of both recent and old ages, suggesting both local and regional flow systems. Thus, there may be significant local groundwater flow systems.

5.3 GROUNDWATER GEOCHEMISTRY

This section will discuss basic groundwater geochemistry, and the spatial distribution and inter-relationships between various elements. Examination of groundwater types and factors that might have imparted such characteristics to groundwaters of the study area will be undertaken. A discussion of chemical analyses in relation to drinking water quality guidelines will also be undertaken. Results of field and laboratory chemistry data are contained in Appendix 2. Correlation matrix diagrams for all analyses and field parameters attached in Appendix 3. Data for surface ponds and high nitrate(>45 ppm) waters have not been added to the statistical analysis.

5.3.1 Field Parameters

Field pH for 367 waters ranged from 5.95 to 8.90, with a mean value of 7.04, a mode of 6.90, and a standard deviation of 0.38. Groundwaters of the study area are generally

slightly acidic to slightly alkaline. The slightly lower pH values may be indicative of oxidation of dissolved ferrous iron from laterites. Low pH values may also be associated with rusty underground parts of the hand pumps. The pH values do not show a strong correlation with any other parameter (Table 6). However, there are moderate positive correlations between pH and HCO_3 ($r = +0.32$), Ca ($r = +0.34$), and Mg ($r = +0.33$), and negative correlation with SiO_2 ($r = -0.35$).

Groundwater temperatures range from 27.0 to 32.5 °C, with a mean value of 31.2 °C (S.D. = 0.38). Shallow wells (< 30 feet, 9 m) had relatively lower temperatures than deep wells. These high temperatures may be due to insulating effect of the weathered zone. High temperatures accelerate biological and chemical processes in the water.

Electrical conductivity (EC) values ranged from 80 to 1310 $\mu\text{S}/\text{cm}$. Spatial distribution of the EC values superimposed on the assumed potentiometric lines can be found in Figure 8. There is no obvious relationship between the spatial distribution of conductivity values and the potentiometric surface. Under regional flow systems, EC values will normally increase in the direction of groundwater flow. In discharge areas, groundwater will usually experience a longer subsurface interaction time and will contain more dissolved elements. The apparent lack of such a correlation may be due to a predominance of local flow systems over regional flow systems.

Table 6. Correlation matrix diagram for field parameters and major ions.

	EC	pH	HCO ₃	NO ₃	SO ₄	Cl	F	Ca	Mg	Na	K	SiO ₂	Depth
EC	1.000												
pH	0.262	1.000											
HCO ₃	0.890	0.320	1.000										
NO ₃	0.106	-0.081	-0.249	1.000									
SO ₄	0.387	0.094	0.194	0.188	1.000								
Cl	0.348	-0.041	0.007	0.742	0.262	1.000							
F	-0.176	-0.090	-0.332	0.287	0.156	0.100	1.000						
Ca	0.871	0.341	0.865	-0.007	0.363	0.217	-0.307	1.000					
Mg	0.832	0.327	0.833	-0.013	0.276	0.233	-0.185	0.699	1.000				
Na	0.660	0.030	0.591	0.132	0.195	0.249	0.031	0.409	0.405	1.000			
K	0.192	-0.232	0.109	0.182	0.041	0.265	-0.044	0.059	0.081	0.331	1.000		
SiO ₂	-0.464	-0.353	-0.517	0.152	-0.121	-0.077	0.326	-0.524	-0.481	-0.087	0.066	1.000	
Depth	0.009	-0.103	0.015	-0.002	-0.076	-0.045	-0.014	-0.019	-0.031	0.116	0.136	0.123	1.000

Total = 373 samples
Confidence Level = 0.95

Figure 8 Spatial Distribution of Electrical Conductivity(EC) in uS/cm superimposed on potentiometric lines(in feet).

There is a strong positive correlation between EC and HCO_3^- , Ca, Mg and Na. There is a negative correlation between silica and EC.

5.3.2 Major Ion Chemistry

Groundwaters are generally low in mineral content. From electrical conductivity values, TDS values are estimated to range from about 60-580 ppm. This is generally characteristic of waters that traverse areas underlain predominantly by siliceous igneous rocks. A low content of minerals in water may also be due to a short contact time of water with bedrock.

5.3.2.1 Bicarbonate

The predominant anion is HCO_3^- , forming about 67.7 to 98.8% of the total anion concentration in groundwater samples. Concentration values range from 57.9 to 485.2 ppm and the mean value is 200.00 ppm (S.D.=78.5). These values are similar to those for groundwaters of the Bushveld Basement Complex in South Africa (Hem, 1985). However, the mean value (200.00 ppm) in this study is far higher than those quoted by Freeze and Cherry (1979) for groundwaters in similar rock terrains in Senegal and Chad (44.0 and 54.4 ppm, respectively).

Spatial distribution of HCO_3^- is portrayed in Figure 9. Spatial trends for groundwater HCO_3^- are diffuse. However, distribution of the ion very much follows that of EC, being high in the northeast, northwest, southeast and other isolated places. A high positive

Figure 9 Spatial Distribution of HCO_3 in the study area.

correlation exists between HCO_3^- and Ca ($r = +0.89$), Mg ($r = +0.82$), and Na ($r = +0.72$).

A moderate negative relationship also exists with SiO_2 ($r = -0.4$).

5.3.2.2 Sulphate

Sulphate concentrations in the groundwaters are very low, ranging from 0.13 to 49.30 ppm with a mean value of 4.40 ppm (S.D. = 6.00). The concentrations of the ion vary from 0.0 to 28.0% of the total anion concentration. Only 4 samples had SO_4 concentrations above 30 ppm. The mean value of sulphate in groundwaters is similar to those of groundwaters in similar lithologies in France (Freeze and Cherry, 1979). However, the mean sulphate concentration here is higher than values in groundwaters over the crystalline Basement rocks of Senegal and Chad (0.8 and 1.4 ppm, respectively; as by Freeze and Cherry 1979).

The spatial distribution of SO_4 is fairly uniform (Figure 10). Sulphate does not correlate well with any of the elements. A moderate correlation of +0.4 occurs between Ca and SO_4 . In crystalline rocks, sulphate occurs only in minor or trace concentrations. Their occurrence is normally attributed to atmospheric sources, to decomposition of organic matter in soil, and to trace sulphide in rocks and minerals (Freeze and Cherry, 1979). Oxidation of trace sulphide in bedrock may be the source of SO_4 in the groundwaters. In this type of terrain most sulphide would have been oxidised during laterization.

Figure 10 Spatial Distribution of SO_4 in the study area.

5.3.2.3 Chloride

Except for suspected contaminated samples, the distribution of chloride is very low and fairly uniform (Figure 11). Concentrations range from 0.72 to 125.00 ppm. The mean value for 371 wells was 4.40 ppm. There was no observed concentration increase with depth ($r = +0.05$). All the wells with concentrations in excess of 10 ppm were located in towns and larger villages.

The low Cl concentration values are expected, because igneous rocks do not yield high concentrations of Cl to normal circulating groundwaters (Hem, 1985). Low concentrations of chloride may be derived from trace elements in the rocks, while the high concentrations may be derived primarily through contamination.

5.3.2.4 Calcium

Calcium constitutes the predominant cation in groundwaters of the study area. It forms between 19.4 and 62.1% of the total cation concentration. Concentrations range from 6.6 to 72.0 ppm and the mean value is 32.4 ppm. Generally, Ca levels in groundwaters of the study area are higher than groundwaters from Basement rocks in Senegal and Chad.

Figure 11 Spatial Distribution of Cl in the study area.

The spatial distribution of Ca is displayed in Figure 12. The distribution of Ca very much follows that of HCO_3^- (Figure 13). Calcium concentrations increase with increasing HCO_3^- content ($r = +0.9$). This direct relationship between Ca and HCO_3^- may be explained as follows:

The dissolution of atmospheric and soil zone CO_2 can be represented by:

In the absence of carbonates, the H^+ ions attack feldspars(hydrolysis), causing them to alter to clay minerals and silica.

In a case where feldspar is Ca-rich, the release of Ca can be represented as follows.

H^+ in equation (2) is a product of equation (1)

High concentrations of H^+ , lower pH, (accompanied by HCO_3^-) will therefore lead to high concentrations of Ca, provided there are feldspar minerals present. Plagioclase is readily available for attack by the groundwaters of the study area because it is the most abundant mineral in the Birimian granites and the second most abundant mineral in the Bongo Granite suite.

5.3.2.5 Sodium

Sodium is the second most abundant cation in the groundwaters with concentrations ranging from 9.1 to 65.0 ppm and a mean value of 13.8 ppm. The spatial distribution of Na is displayed in Figure 14. Like Ca, the dissolution reactions of Na plagioclase (e.g. $\text{NaAlSi}_3\text{O}_8$) to release Na are similar to equations (1) and (2) above.

Figure 12 Spatial Distribution of Ca in the study area.

Figure 13 Comparison of spatial distributions of HCO_3 , Ca and Mg in the study area.

Figure 14 Spatial Distribution of Na in the study area.

There is a poor correlation ($r = +0.2$) between Na and Cl, therefore, the main source of Na may not be the dissolution of halite .

5.3.2.6 Magnesium

The spatial distribution of Mg can be found in Figure 15. Concentrations range from 2.4 to 40.0 ppm and the mean value is 13.4. Magnesium distribution is similar to that for Ca, EC, and HCO_3 (Figure 13). There is a strong correlation between Mg and EC ($r = +0.83$), Ca ($r = +0.70$), and HCO_3 ($r = +0.83$). Weathering of Mg-bearing minerals such as olivine and leaching of secondary minerals are the most likely sources of Mg

5.3.2.7 Potassium

Potassium in groundwaters varies from 0.16 to 11.00 ppm and the mean value is 2.10 ppm. Figure 16 depicts the spatial distribution of potassium. The distribution is fairly uniform, except in three isolated areas in the northwest, towards the southwest, and in the east, where concentrations are above 6 ppm. There is no significant correlation between K and any of the other elements. Weathering of K-bearing minerals and leaching of secondary minerals are the most likely sources of K.

Figure 15 Spatial Distribution of Mg in the study area.

Figure 16 Spatial Distribution of K in the study area.

5.3.2.8 Silica

Relative to the cations, silica is present in significant amounts in groundwaters of the region. The concentrations range from 32.1 to 88.0 ppm and the mean value is 58.4 ppm.

Davis (1964) compiled thousands of groundwater analyses from various areas in the United States and found that values for dissolved SiO_2 typically range from 10 to 30 ppm, with an average value of 17.0 ppm. Studies done elsewhere indicate that these values are reasonably representative on a global scale (Freeze and Cherry, 1979). In the Bushveld Precambrian-aged Basement rocks of South Africa, Donald *et al* (1964) have reported groundwater SiO_2 values of 45 and 76 ppm. Freeze and Cherry (1979) quoted mean concentrations, for similar rock types as found in the study area, of 15.0 ppm in France, 46.2 ppm in Senegal, 85.0 in Chad, 10.8 ppm in La Côte d'Ivoire and 18.7 ppm in Kenora, Canada. Silica concentrations are comparable with those of Senegal and Chad.

Figure 17 shows the spatial distribution of silica. Most parts of the study area which depict high values of silica coincide with the Bongo granite suite, which contains the highest amount of silica.

Silica in natural waters is mostly in the form of $\text{H}_4\text{SiO}_4(\text{aq})$. It is known that the release of silica to groundwaters is generally through leaching of secondary minerals such as gibbsite from the overburden, and the dissolution of feldspars and micas.

Figure 17 Spatial Distribution of SiO₂ in the study area.

Some of the common reactions (involving gibbsite, albite, anorthite and olivine) that describe these dissolution processes are as follows:

The direct dissolution of quartz to give H_4SiO_4 is another source of SiO_2 , but this is a very slow reaction and is generally a less significant contribution source than silicate decomposition (Hem, 1985). Quartz and amorphous silica contribute to the concentration of groundwater SiO_2 but generally, they are not an important influence on the level of SiO_2 (Freeze and Cherry, 1979). Quartz solubility is only 6 ppm at 25 °C (Morey *et al.*, 1962), therefore, quartz will not contribute significantly to groundwater silica concentration.

5.3.3 Groundwater Chemical Characterization

Piper plots, using the major dissolved ionic constituents of all the samples in the geologic subgroups, were drawn to aid in distinguishing between groundwater chemical types (Figure 18). All data plots indicated two main types of groundwater, referred to here as Type I and Type II. Concentrations of major ions expressed in percent milliequivalents/L for major ions and water types for each water source are contained in Appendix 3. Trilinear plots of waters draining the individual geologic subgroups are attached in Appendix 4.

Figure 18 Piper plot showing the major ion composition of wells in the study area.

in Figure 18, cations are clustered within the area 20-70%Ca, 5-50%Mg and 10-70 %Na+K, while the anions fall within the area 65-99% HCO_3 , 0-30% SO_4 and 0-30%Cl

Characterization of Type I Waters

The dominant cations of Type I waters are Ca and Mg. Most of these waters are located within the greenstones, lavas, amphibolites and tuff. Since these rocks contain a high percentage of ferromagnesian minerals, the Ca and Mg content is expected to be high. This is reflected in the piper diagram for the Upper Birimian Metavolcanics where $\text{CaMgHCO}_3 > \text{CaNaHCO}_3$ (Appendix 4). The predominance of CaMgHCO_3 waters over CaNaHCO_3 waters within the Metavolcanics can also be seen in Figure 19.

The mean concentration values for the major ions in milliequivalents per liter are plotted on a Schoeller diagram in Figure 20. Type I waters are higher in Ca, Mg, SO_4 and HCO_3 than type II waters. Silica and F are also lower (SiO_2 mean = 54.30 ppm; F mean = 0.89 ppm) in these samples than in type II waters (SiO_2 mean = 61.62 ppm, F mean = 1.04 ppm).

Characterization of Type II Waters

Type II waters have Ca and Na as the major ions and most of these samples are located in both the Birimian granitoids and the Bongo granites. This composition may indicate the dissolution of feldspars in the granites. Samples within the Bongo granite suite are spread between the CaMgHCO_3 and CaNaHCO_3 fields, but contain more CaNaHCO_3 than

2

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Figure 19 Distribution of hydrochemical water types overlain with geology.

Figure 20 Chemical analyses of water samples represented on a schoeller semi-logarithmic diagram

CaMgHCO₃ waters (Figure 20). In some areas Na- HCO₃ type waters occur along with high concentrations of F in the Bongo granite.

In an attempt to further identify the sources of ions in groundwaters, plots of Na and Cl; Ca and SO₄, and Ca+Mg and HCO₃ were constructed. The relationship between Na and Cl along with the halite dissolution line can be found in Figure 21. All the data points plot above the halite dissolution line. Also, there is a poor correlation ($r = +0.249$) between Na and Cl. Thus, the primary source of Na is not due to dissolution of halite or evapotranspiration processes. The source of Na is dissolution of silicates as described above. The source of Cl is discussed in section 5.4.

Calcium and sulphate ions are plotted along with the anhydrite (CaSO₄) dissolution line in Figure 22. All waters plot above the anhydrite line. The correlation ($r = +0.36$) between Ca and SO₄ in Table 7 is not strong. Therefore, the chemistry of the waters is not dominated by gypsum dissolution. With the exception of 8 samples, all waters have significantly high Ca concentrations with no increase in SO₄ concentration. The source of Ca is dissolution of silicates as described above. Sulphate is also derived from oxidation of sulphides in bedrock.

The relationship between Ca + Mg and HCO₃, along with the calcite and dolomite dissolution lines, is presented in Figure 23. All waters plot below both the calcite and dolomite dissolution lines. This suggests that the dissolution of calcite and dolomite are

Figure 21. [Na] versus [Cl] plot of groundwaters . Halite dissolution line shown.

Figure 22 [Ca] versus [SO₄] plot of groundwaters. Anhydrite dissolution line shown.

Figure 23 [Ca + Mg] versus [HCO₃] plot of groundwaters. Calcite and dolomite dissolution lines shown.

not dominant processes in the chemistry of these waters. This confirms the main sources of Ca and Mg to be dissolution of silicate minerals discussed above. The main source of HCO_3 is dissolution of atmospheric and soil zone CO_2 .

Saturation Indices

Determination of saturation indices (SI) of certain minerals is useful as an indicator of the chemical stability and possible behaviour of groundwaters. Saturation indices for waters were calculated using the groundwater modelling programs, WATEQF4 (Dall and Nordstrom, 1992) and HYDROWIN, and field data (i.e., temperature, pH). The results are attached in Appendix 5.

The results indicate that, on average, the groundwaters are undersaturated with respect to the minerals calcite, dolomite, aragonite, strontianite, gypsum and fluorite. Thus there should be no precipitation of these minerals from groundwaters. However, saturation indices only provide thermodynamic information about the minerals that could be dissolving or precipitating.

5.4 Groundwater Quality

Drinking water quality is assessed in this thesis because the water supply systems are mainly used for drinking purposes. In arriving at the guideline values for various substances in water, the total intake from air, food, and water for each substance is normally considered. The toxic effects of each substance in man, as predicted from studies

with laboratory animals, is sometimes considered. As in most countries, Ghana uses the WHO (1984) International guidelines for assessing drinking water quality because there is a lack of data directly pertinent to Ghana. Therefore, the WHO guidelines are compared with the analyses of this study in Table 7.

Apart from fluoride, which is discussed in Chapter 6, there are high occurrences of nitrate in some of the groundwaters. The nitrate values ranged from 0.03 to 211.00 ppm and the

Table 7. Water Quality Guideline values compared with Study Results.

Parameter	Guideline Values (ppm)	Range of values in the study (ppm)	No. of wells above or below optimum values
Fe	0.3	0.001-3.5	2
NO ₃	45	0.02-211	19
Al	0.2	0.002-12	2
Na	200	9.1-65	0
Mn	0.1	0.0001-0.7	11
Cu	1	0.0002-0.11	0
Cl	250	0.72-38.9	0
SO ₄	400	0.13-49.3	0
Zn	5	0.001-4.9	0
pH	6.5-8.5	5.95-8.90	16<6.5 and 1>8.5
TDS(μs/cm)	1000	80-770	0

mean value was 16.11 ppm. Twenty-one samples had concentrations in excess of the guideline value of 45 ppm. Consumption of water in excess of the guideline value, by infants, may cause an infantile disease known as methaemoglobinaemia.

It is reported that natural concentrations of nitrate in groundwater range from 0.1 to 10 ppm (Davis and DeWist, 1966). Nitrate enters the ground from several sources: atmospheric fixation of nitrogen by certain plants, decomposing plant debris, human and animal waste, and fertilizer (Driscoll, 1989). However, nitrate in groundwater originates most often from human waste and fertilizer.

It is inferred that groundwaters with exceptionally high NO_3 values have been contaminated principally through human activities such as farming and waste disposal. This is because wells with high nitrate concentrations are all located in and around towns and sizable villages (Bolgatanga, Zuarungu, Bongo, Zoko, Namongo, Bongo-Soe and Shiega), (Figure 24).

There is a correlation between Cl and NO_3 ($r = +0.74$) suggesting that both elements come from the same sources of pollution. Driscoll(1989) indicates that Cl in groundwater may indicate seepage from certain types of sewage facilities. He also states that human wastes are generally high in chloride content. Therefore, high nitrate together with chloride in groundwater is a more positive indication from seepage and animal waste.

Figure 24. Spatial Distribution of Nitrate in the Study area.

Comparing the spatial distributions of nitrate and chloride in Figure 25, it can be seen that there are close similarities between the two maps. Well number 455152 (located in Zuarungu), which had the highest concentration of Cl, also had the highest NO_3 concentration.

Only two waters (numbers 14 and 192) had concentrations of iron in excess of the guideline value of 0.3 ppm. These samples come from shallow handdug wells. The maximum concentration of iron in groundwaters is 3.5 ppm.

The recommended guideline limit for Al in drinking water is 0.2 ppm; two wells had Al concentrations of 12.0 and 4.0 ppm, respectively. Other high concentrations of Al are associated with shallow wells and ponds. There is a correlation of +1 between Fe and Al. Dissolution of weathered lateritic material (eg., Fe oxide, gibbsite, etc.) is the common source for Fe and Al.

Manganese concentrations are generally within acceptable limits, except for 11 wells that have concentrations above the guideline limit of 0.1 ppm. The high concentrations may be associated with manganiferous deposits.

With regard to pH, only one well had a pH value above the maximum limit of 8.5 and 16 samples had values (5.95 to 6.45) below the guideline limit of 6.5. All other elements listed in Table 5 were within acceptable limits.

Figure 25 Comparison between the spatial distributions of NO₃ and Cl in groundwaters of the study area.

Chapter 6

FLUORINE RESULTS AND DISCUSSION

6.1 LITHOGEOCHEMISTRY

The results of fluorine analyses for rocks in the project area, reported by Murray and Cook (1960), are summarized in Table 8. The highest fluorine contents were obtained for the Bongo

Table 8. Fluorine content in rocks of the study area(after Murray, 1960)

FORMATION	ROCK TYPE	RANGE (ppm)	MEAN (ppm)	
UPPER BIRIMIAN	Biotite schist	tr.	tr.(1) *	
	Greywacke	200-500	350(2)	
	Greenstone	tr.	tr.(1)	
BIRIMIAN GRANITOIDS	Biotite gneiss	tr.-100	33(3)	
	Biotite	tr.-500	225(4)	
	hornblende			
	granodiorite			
	Altered hornblende	tr.-500	100(10)	
	granodiorite			
	Sekoti	100 - 1,600	825(4)	
	granodiorite			
BONGO GRANITE SUITE	Bongo granite	200-2,000	72(9)	792(12)
	Tongo granite	500-900	700(2)	
	Feo micro-granite	1,600	1,600(1)	

tr = trace amount

* Nos. in brackets indicate total no. of samples

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	Biotite	tr -500	225(4)	
	hornblende			
	granodiorite			
	Altered hornblende	tr -500	100(10)	
	granodiorite	100 - 1,600	825(4)	
BONGO GRANITE SUITE	Bongo granite	200-2,000	72(9)	
	Tongo granite	500-900	700(2)	
	Feo micro-granite	1,600	1,600(1)	792(12)

tr = trace amount

* Nos. in brackets indicate total no. of samples

granite suite, with values ranging from 200-2,000 ppm and a mean value of 792 ppm. The Sekoti granodiorites also have high fluorine concentrations, which range from 100 to 1,600 ppm, with a mean value of 825 ppm.

The range of fluorine values for granitic rock samples associated with the Birimian Formation is from trace to 500 ppm and the mean value for 17 samples is 118 ppm. Fluorine levels for schist, greywacke and greenstone of the Birimian Formation range from trace to 500 ppm. The rocks of the Birimian Formation contain the lowest concentrations of fluorine.

In the present study, 16 rock samples were analyzed at the GSC for fluorine. Table 9 shows the results of these analyses. The highest fluorine concentrations are associated with the Bongo granite; the values ranging from 1182 to 1728 ppm. Sample numbers 3 and 4, which are weathered rocks, had the lowest concentrations of fluorine among the Bongo granites. This might be due to leaching of fluorine out of the samples during weathering.

The fluorine contents of two hornblende granodiorite samples are 734 and 703 ppm. The greenstone, quartzite, granodiorite and phyllite have F concentrations ranging from 278 to 537 ppm. Because hornblende is a fluorine-bearing mineral, the hornblende granodiorite is higher in fluorine content than the granodiorite.

Table 9 Fluorine content in rocks of the study area

Sample No.	Location	Geology/Remarks	Fluorine (ppm)
1	Bongo	Bongo Granite	1320
2	Bongo.	Bongo Granite. Sampled from a hand dug well.	1303
3	Bongo.	Bongo Granite Moderately weathered.	1194
4	Tongo Quarry	Bongo Granite	1454
5	Tarongo. Sampled around well no. 455E37	Bongo Granite. Weathered sample from a hand dug well	1182
6	Nyarega. Close to 455E5. Similar rock type in Sumbrungo	Hb. Granodiorite	734
7	Bongo(Anafobisi) Close to well no.	Bongo Granite	1728
8	Dubila. Close to 455F46	Granodiorite	397
9	Kabre. Close to 455C30	Greenstone	537
10	Yipala. Close to 455I4	Quartzite	494
11	Ndongo. Close to 456G15	Greenstone (weathered)	413
12	Tindonsobligo. Close to 455H26	Quartzite(weathered)	278
13	Dua. Close 455F44	Greenstone. Sampled from a hand dug well	254
14	Kumbusigo. Close to 455D20	Hb. Granodiorite	703
15	Kongo	Phyllite	479
16	Akuulyo. Close to 455C31	Laterite. Source rock is metavolcanic	209

Weathered greenstone and quartzite have lower fluorine concentrations than their fresh equivalents. Among the various rocks sampled, laterite contained the lowest amount of fluorine (209 ppm).

6.2 HYDROGEOCHEMISTRY

Statistical data for fluoride in groundwaters are displayed in Table 10. Correlation matrix diagrams for all elements are attached in Appendix 3. For 371 water samples, the fluoride concentrations range from 0.11 to 4.6 ppm, with a mean value of 0.97 ppm. Figure 26 displays the spatial distribution of F superimposed on geology.

Table 10 Basic statistics of fluoride in groundwaters of the study area.

Geology	Birimian Metavolcanics	Birimian Meta- sediments	Birimian Granitoids	Bongo Granites	All Data
Mean	0.29	0.46	0.49	2.29	0.97
S.D.	0.14	0.17	0.16	0.95	1.0
Minimum	0.11	0.25	0.12	0.61	0.11
Maximum	0.92	0.92	0.95	4.60	4.60
Median	0.25	0.44	0.48	2.20	0.51
Mode	0.20	0.34	0.50	1.51	0.22

Figure 26 Spatial distribution of fluoride superimposed on geology. Areas of high fluoride are confined mainly to the Bongo granite suite.

There have been differences in opinion about the classification of the Sekoti granodiorite. Coe (1953) classified them on the basis of field evidence as belonging to the Bongo granite, while Murray (1960), on the basis of chemical analyses placed them with the Birimian granitoids. In this study, the two units have been treated as one unit because of their similarity in fluorine content.

6.2.1 Groundwater Fluorine in Birimian metavolcanics

Fluoride in groundwaters of the Birimian metavolcanics range from 0.11 to 0.92 ppm with a mean value of 0.29 ppm. Since the fluoride content of groundwater is invariably dependent on the fluorine content of the host rock, it was expected that water in these rocks should contain low levels of fluoride.

Groundwater fluoride concentrations do not correlate significantly with any of the other elements analyzed. There is only a moderately positive correlation with SiO_2 ($r = +0.4$), V ($r = +0.4$), Na ($r = +0.3$), and K ($r = +0.3$). Calcium ($r = -0.3$) shows a moderately negative correlation with F .

The moderately positive correlation between fluoride and silica suggests that there may be a contribution of fluoride to groundwater from the decomposition of silicates. As would be expected, sodium and potassium are positively correlated with fluoride, while calcium is negatively correlated.

6.2.2 Groundwater Fluorine in Birimian Metasediments

Fluoride concentrations for groundwaters draining the Birimian Metasedimentary rocks range from 0.25 to 0.92 ppm, with a mean value of 0.46 ppm. With the exception of greywacke, the fluorine content of these rocks are quite low. Fluoride displays good positive correlations with B($r = +0.7$), Li($r = +0.7$), Rb($r = +0.7$), U($r = +0.8$), and Mo($r = +0.8$). A negative correlation exists between F and SiO₂ ($r = -0.5$).

Concentrations of fluoride in clastic sediments are usually tied up in micas and resistate minerals such as topaz and apatite. Thus, the strong positive correlations of F with Li and Rb may indicate the source of F to be the weathering of micas.

6.2.3 Groundwater Fluorine in Birimian Granitoids

The Birimian granitoids are comprised of granodiorites, gneisses and migmatites. Concentrations of groundwater fluoride range from 0.12 to 0.95 ppm, with a mean value of 0.49 ppm. Apart from a moderately negative correlation between F and Ca ($r = -0.3$), there is no correlation between F and any of the other elements.

The reason for the apparent lack of correlation between fluoride and any of the other elements is not known. However, the levels of groundwater fluoride associated with these granitoids are comparable with average values quoted by Boyle(1976) for similar rocks elsewhere in the world.

6.2.4 Groundwater Fluorine in Bongo Granites

The concentration of fluoride in groundwaters within the Bongo granite suite ranges from 0.61 to 4.60 ppm. While mean concentrations of fluoride in groundwaters associated with other rock types of the study area range from 0.29 to 0.49 ppm, the mean for the Bongo granite groundwaters is 2.29 ppm. The highest groundwater fluoride concentrations occur over the main granite body and the Bongo granite outliers at Adaboya, Sekote, and Tongo. It has been reported that two dykes belonging to the Bongo granite suite traverse the area; one from Bongo to Feo and the other around Kanseringa. These dykes are identical to the Adaboya micro-granites. There were no groundwater samples from these dykes, but it should be noted that wells located in these dykes will likely contain high concentrations of fluoride.

For groundwaters associated with the Bongo granite, fluoride does not correlate significantly with any of the other elements analyzed. However, moderate correlations exist between B($r = +0.3$), Sr($r = +0.4$), Mo($r = +0.3$) and Ca($r = +0.3$).

In order to determine whether base exchange softening processes are involved in concentrating F in the groundwaters in the Bongo granite, the cation exchange ratios of the waters were plotted against F concentration (Figure 27). The exchange ratios are represented by $(\text{Na} - 0.65\text{Cl}) / (\text{Ca} + \text{Mg})$, expressed in milliequivalents. There is no significant relationship between F uptake and the cation exchange ratio. Points are clustered and the correlation coefficient is only +0.055. In the Gaspé region of Canada, where base exchange softening processes enhance

Figure 27. Plot of cation exchange ratios $(\text{Na} - 0.65\text{Cl})/(\text{Ca} + \text{Mg})$ and fluoride in the Bongo granite groundwaters

the concentration of F in groundwaters, there is a significant correlation ($r = +0.645$) between F uptake and the cation exchange ratio (Boyle and Chagnon, 1995). Compared to the study area groundwaters, the Gaspé groundwaters display much higher pH values (up to 9.8). Therefore, base exchange softening processes do not contribute to the concentration of fluoride in the groundwaters associated with Bongo granite.

Since there are no correlations between F, Li and SiO_2 , the main source of F in the groundwaters of the Bongo granite is most probably the dissolution of fluorite (CaF_2). There is a moderate correlation ($r = +0.3$) between Ca and F. Fluorite concentrations range from 0.1 to 0.3% in the Bongo intrusives. Sodium dominated groundwaters also occur in some of these areas. When sodium concentrations in the water increase, the solubility of fluorite will increase correspondingly and there will be more fluoride released to groundwaters.

6.2.5 Spatial Distribution of Fluoride

As already indicated in the foregoing section, high concentrations of F in groundwaters only occur over the Bongo granite suite (Figure 26). There are four main areas of high fluoride in groundwaters over this intrusive suite; the main Bongo granite area, and the Tongo, Adaboya and Sekoti regions.

Even though appropriate calculations of hydraulic gradients and groundwater velocities have not been determined, it is generally known that in basement aquifers these parameters are low. In Figure 25, F is not dispersed much beyond the boundaries of the Bongo granite suite. Unlike

the other halogens (Cl and Br), the mobility of F is usually limited in aqueous solutions, mainly by Ca. These factors may account for the restricted distribution of groundwater F to immediate area of the Bongo granite suite.

High concentrations of F beyond the geological contacts of the Bongo granite may be due to inaccuracies in the positioning of geologic boundaries. For example, borehole records and field observations revealed that the area to the immediate north of Bongo is underlain by the Bongo granite. Other areas that are underlain by the Bongo granite, but which were classified under different lithologies include Sekoti, Yikene, and Tanzui. Fluorine in groundwaters can, be used, therefore, to improve geological mapping in the region.

Fluoride concentrations > 2.5 ppm are found between Bongo, Kadare and Yorogo, in and around Tarongo, Adaboya, Sekoti, and between Bolgatanga and Zaare. These communities are underlain predominantly by highly pegmatitic varieties of the Bongo granite. Pegmatites are known to contain high concentrations of fluoride. This may, therefore, explain why the highest concentrations of groundwater fluoride are found in these areas.

Groundwater fluoride concentrations ranging from 1.0 to 2.5 ppm occur over the main Bongo granite, its margins, and near Tongo, Adaboya and Sekoti.

The lowest values of groundwater F (< 1.00 ppm) occur at the boundaries of the Bongo granite and over the rest of the rock units. From the center towards its contacts, the Bongo granite

grades from well developed pegmatitic rocks to syenites. Rocks at the contacts, therefore, contain less F, and groundwaters traversing these rocks will have lower fluoride contents compared with interior rock phases.

6.2.6 Fluoride content in Pond Waters

The highest values of F in surface waters are associated with the Bongo granite. Ponds at Balungu and Bongo, which are within the Bongo granite, have F concentrations of 0.96 and 0.66 ppm, respectively, while the two ponds sampled outside of the Bongo granite had concentrations of 0.30 and 0.22 ppm. The largest surface reservoir in the area, the Veá Reservoir, is located within the Bongo granite and has a concentration of 0.39 ppm fluoride. The relatively lower values of F concentration associated with the Veá Reservoir may be due to its large volume and a lower evaporative ratio for the water body compared to smaller ponds within the Bongo granites. The concentration of fluoride in the Veá Reservoir is still higher than the two ponds which are located outside the Bongo granite.

6.2.7 Vertical Distribution of Fluoride in Bongo Granite Groundwaters

A scatter plot of F versus depth is shown in Figure 28. There is no obvious relationship between overall fluoride concentrations and well depth ($r = -0.11$). To further investigate the vertical variability of F in groundwaters, the Bongo granite borehole data were divided into four categories: 3.0 to 9.1 m, 9.1 to 18.3 m, 18.3 to 27.4 m, and 27.4 to 38.7 m (10-30 ft, 30-60ft, 60-90 ft and 90-127 ft). The mean F concentrations in the 4 different categories are 2.70, 2.33, 2.27 and 2.19 ppm, respectively.

Figure 28. Well depth and fluoride concentration plot of Bongo granite groundwaters

The histogram in Figure 29 displays the relationship between the four depth categories and F concentrations. The mean, minimum and maximum fluoride values are plotted for various depth intervals. The maximum fluoride values generally decrease with depth. There is a small decrease in mean fluoride concentration with depth. The difference between the mean fluoride values of the shallowest and deepest wells is 0.7 ppm. All groundwaters have at least 0.5 ppm fluoride and fluoride concentrations over 3.5 ppm are found in wells that are less than 27.4 m (90 feet) deep. The percentage of wells with fluoride over 3.5 ppm for the 4 groups of wells are 22.2, 25.0, 12.0 and 0 %, indicating a general decrease in the number wells with fluoride >3.5 ppm with increasing depth.

Data for 51 wells in the Bongo granite were separated into two groups based on surface stratigraphy, namely: overburden and slightly weathered rock and fresh bedrock. The mean groundwater fluoride content for overburden aquifers was 2.29 ppm, while that for slightly weathered rock and bedrock aquifers was 2.02 ppm. Overburden wells appear to contain slightly more fluoride than bedrock wells.

The variability of F with depth may have displayed different results if there were more samples from deeper wells. The deepest well used for this analysis is only 28.7 m (127 feet) and almost all the wells were completed within overburden. Also, the method of construction of these wells (see Appendix 6) does not preclude communication between deeper and shallow groundwaters. Therefore, in the deep wells the water samples may not be representative of their finishing depths, but may represent a large sampling interval. Higher concentrations of F

Figure 29 Plot of mean, minimum and maximum concentrations of fluoride in groundwater for certain well depth intervals in the Bongo granite area

Figure 29 Plot of mean, minimum and maximum concentrations of fluoride in groundwater for certain well depth intervals in the Bongo granite area

from the upper horizons could also be introduced to lower horizons by piping along the well gravel pack. An important analysis, which could not be undertaken due to insufficient data, was the relationship between F concentration and water level. Results for this correlation could have provided more insight into the depth variability of F.

The conclusion that can be drawn from the above data is that deeper wells, and bedrock wells on average, contain less fluoride than shallower overburden wells, which are often hand dug. The significance and validity of this conclusion will have to be investigated further. The weathered zones are expected to have F more available for leaching into groundwaters.

One well at a depth of 122.5 m (402 ft), which was not added to the statistical analysis, had a groundwater F concentration of 1.5 ppm. This result was not added to the analysis because, statistically, a sample size of one cannot be reliable. Also, since the well is located very close to the Bongo granite contact and the borehole log could not be found, it is not certain if the underlying geology of this well is the Bongo granite. Should the geology at this well be confirmed to be Bongo granite, this would be additional evidence to suggest a decrease in fluoride concentration with depth. Therefore, it is important to investigate the F concentration at deeper depths.

6.2.8 Chemical form of fluoride in groundwaters

The concentrations of F reported in most water analyses, and in this study, are normally in terms of free F (expressed as fluoride), because free F⁻ is the most predominant ionic phase in most groundwaters (Hem, 1985). However, F also exists as complex ions.

It is important to know the chemical form of F in drinking water because it is known that complexed F can be metabolized in the human body. Also, in choosing a treatment option for high F waters, a knowledge of the state of F and the associated chemical constituents in the water is very important. For example, a calcium-based treatment for high F water, containing a significant concentration of positively charged Al complexes, will lead to the breakdown of the Al complexes. Thus, the Al concentration in the treated water will increase and, depending on the concentration of the Al in the treated water, may have adverse effects on human health.

The present study did not analyze for the individual species of F, however, an attempt has been made to address this issue using the available data. The common complexes of fluorine in groundwaters are those of H, Al, Be, Fe, B and Si. According to Hem(1985), HF⁰ will probably form at a pH below 3.5, and SiF₆²⁻ or SiF₄⁰ will also form in acid solutions. Most of the study area groundwaters are neutral in pH and, therefore, these complexes are not likely to be present. Calculations by Hem(1968b) showed that Al-F complexes are likely to be found in water whose pH is slightly below neutral. He further stated that although most of the dissolved Al in such solutions would be complexed, the concentration of F would commonly exceed that of Al, and the proportion of the total F present as complexes might not be great.

From the foregoing explanations, the study area groundwaters may not contain significant amounts of Al-F complexes. Also, the Al concentrations in the samples are very low (99% of the samples had Al concentrations below 80 ppb) and there is no correlation between Al and F to suggest any complexation between the two elements. Although further tests will be required to ascertain the percentage of complexed F species, it can be deduced from the above arguments that the F concentrations determined in this study represent free fluoride.

6.3 MAPPING OF FLUORIDE IN GROUNDWATERS OF THE STUDY AREA

In order to determine the spatial distribution of fluoride in groundwaters of the study area, a contour map was generated (Figure 30), using the kriging method of interpolation discussed in section 4.3 of this thesis.

The WHO maximum guideline limit of 1.5 ppm for fluoride in drinking water was adopted for this study. The fluoride levels in drinking waters required to prevent tooth decay have been reported as ranging from 0.5 to 1.0 ppm. The minimum beneficial limit for this study is estimated at 0.5 ppm. Therefore, the optimum range for good dental health should be from 0.5 to 1.5 ppm. These values have been specified in Figure 30.

The advantage of interpolation is that it allows concentrations to be estimated at locations where data are not available. It also provides a smoothed average distribution of the F

TOWNS AND VILLAGES		
1 Sherigu	9 Gowri	17 Kpatia
2 Naylorogo	10 Bongo	18 Shiega
3 Namoo	11 Adaboya	19 Tongo
4 Zoko	12 Bolgatanga	20 Winduri
5 Balungu	13 Zuarungu	21 Winkogo
6 Feo	14 Kongo	22 Datoko
7 Sumbrungu	15 Nangodi	
8 Nyarega	16 Sekoti	

Figure 30 Interpolated Map of Groundwater Fluoride Distribution in the Study Area.

concentrations and their spatial correlation. The contoured map may not be very accurate because interpolation does not take into account geological variations but attempts to express trends suggested by the data set. However, the errors associated with the map may not be too large because, except for the corners of the study area, the sampling coverage was quite good. Also, the level of groundwater fluoride relates closely to the type of geology. Therefore, the geology is invariably linked to the contour map.

Groundwater fluoride distribution, expressed as a symbol plot, is also displayed in Figure 31 using the same intervals as in Figure 30. The status of each individual well in terms of WHO guideline values is specified in the legend of Figure 30. This map can also aid in hydrogeological mapping.

The number of wells within specific F concentration intervals for the entire study area and for the Bongo granite area are displayed in Table 11. For a total of 371 wells, 182 wells (49%) deliver water that is below the optimum F level (0.5 ppm), 104 wells (28%) fall within the optimum interval of 0.5 to 1.5 ppm, and 85 wells (23%) have concentrations above the recommended maximum guideline of 1.5 ppm. In the Bongo granites, no wells had fluoride concentrations below the minimum guideline value. Twenty-three wells (21.3%) had groundwater F concentrations within the optimum limits and 85 wells (78.7%) had values above the maximum guideline value of 1.5 ppm.

Figure 31 Interval symbol plot of groundwater fluoride. Numbers indicate sample numbers. Corresponding CIDA well identification numbers can be found in Appendix 1.

Table 11 Distribution of fluoride concentrations in sampled wells.

[F] interval	No.(all wells)	No. (Bongo granite wells)
0.11 - 0.25	49	0
0.25- 0.5	133	0
0.5 - 1.0	88	7
1.0 - 1.5	16	16
1.5 - 2.0	24	24
2.0 - 2.5	14	14
2.5 - 3.0	23	23
3.0 - 3.5	12	12
3.5 - 4.0	7	7
4.0 - 4.6	5	5
TOTAL	371	108

Eighty-five wells produce water that may cause dental fluorosis (>1.5 ppm F) in children drinking. Between 1.5 and 6.0 ppm fluoride, dental fluorosis is said to increase with increasing fluoride concentration. At a concentration of 6.0 ppm, the incidence of dental fluorosis in children is reported to be 100%. However, in Senegal, Brouwer *et al.*, (1988), have shown a mild dental fluorosis prevalence of 68.5% at 1.0 ppm and a dental fluorosis prevalence of 100% when fluoride concentrations exceeded 4.0 ppm.

It has been reported in the literature (Boyle, 1995) that the range of F concentrations expected to produce chronic and acute effects of skeletal fluorosis are respectively 5 to 10 ppm and > 10 ppm at 2L/person/day. These effects may be absent because the highest concentration of F in waters is 4.6 ppm. However, fluoride concentrations up to 3 to 4 ppm have produced skeletal fluorosis in India, while in other places, these levels have not produced any adverse effects.

Since the WHO fluoride limits are estimated based on an average water intake of 2L/person/day, the values may shift downwards in the study area if the water intake is higher than 2L/person/day. Local health surveys will be required in order to determine the actual health effects of fluoride in the area.

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

7.1 CONCLUSIONS

Geological, geochemical, and physical groundwater data were used to describe the physical flow of groundwater, groundwater geochemistry, and the genesis and distribution of groundwater fluoride in the Bolgatanga and Bongo Districts of Ghana.

Results indicate that the regional groundwater flow is generally from the north to the southwest and southeast. The predominant recharge area is in the north, coinciding with topographic highs. The low lying areas in the southwest and southeast, where the main rivers occur, are likely to be the discharge areas. Local groundwater flow may be more dominant than regional groundwater flow.

Groundwaters are low in mineral content, with a mean electrical conductivity of 343 $\mu\text{S}/\text{cm}$. This is characteristic for groundwaters draining metamorphic and igneous complex rocks in lateritic terrains. The distribution of major ions does not appear to be related to groundwater flow, possibly because of the dominance of local flow systems over regional systems. The range of pH values are from 5.95 to 8.90, with a mean value of 7.04. Calcium is the predominant cation in most of the groundwaters, with a mean

concentration of 32.4 ppm. Bicarbonate forms 67.7 to 98.8% of the total anion concentration and has a mean concentration of 200.0 ppm.

There are good positive correlations between calcium, magnesium, sodium and bicarbonate. Silica is quite high (mean = 58.4 ppm) in these groundwaters. For all the water samples, there is a moderately negative correlation between silica and calcium, magnesium, bicarbonate, pH, and electrical conductivity. The major source of ions in the groundwaters is the dissolution of feldspars and ferromagnesian minerals. The main groundwater types are CaMgHCO_3 and CaNaHCO_3 . Most of the groundwaters are undersaturated with respect to calcite, dolomite, gypsum and fluorite.

Groundwater fluoride contents range from 0.11 to 4.60 ppm. The highest concentrations are found over the Bongo Granite suite. While the Birimian metavolcanics, metasediments and granitoids contain groundwater fluoride concentrations ranging from 0.11 to 0.95 ppm, the range of values for the Bongo granite groundwaters is from 0.61 to 4.6 ppm. The Bongo Granite is enriched in fluorine (up to 1728 ppm) and supplies fluoride to traversing groundwaters mainly through the dissolution of the mineral fluorite (CaF_2).

The depth variability of groundwater fluoride in the Bongo granite has been analyzed and there is a small decrease in mean fluoride concentration with depth. The Bongo granite borehole data were divided into four categories: 3.0 to 9.1 m, 9.1 to 18.3 m, 18.3 to 27.4 m, and 27.4 to 38.7 m (10 to 30 ft, 30 to 60 ft, 50 to 90 ft and 90 to 127 ft). The difference

between the mean fluoride values of the shallowest and deepest wells is 0.7 ppm. All groundwaters draining the Bongo granite suite have at least 0.5 ppm fluoride. Fluoride concentrations over 3.5 ppm are generally found in wells that are less than 27.4 m (90 feet) deep. The percentage of wells with fluoride over 3.5 ppm, for the 4 categories of wells, are 22.2, 25.0, 12.0 and 0%, indicating a general decrease in the number of wells with fluoride >3.5 ppm with depth. The significance and validity of this conclusion will have to be investigated further by sampling more hand dug wells and deep bedrock wells during different seasons.

Maps portraying the distribution of fluoride relative to geology and the WHO drinking water guideline limits for fluoride have been created. For a total of 371 wells, 182 wells (49%) deliver water that is below the optimum level of F^- (0.5 ppm), 104 wells (28%) fall within the optimum interval of 0.5 to 1.5 ppm, and 85 wells (23%) have concentrations above the recommended maximum guideline of 1.5 ppm.

Eighty-five wells produce water that may cause dental fluorosis (>1.5 ppm F^-) in children. Chronic and acute effects of skeletal fluorosis may be absent because fluoride concentrations are below 5 ppm. These results need to be confirmed with medical surveys because different regions of the world show different levels of fluoride intoxication.

Other water quality issues of the study area have also been highlighted. Of particular concern is nitrate contamination in some of the groundwaters. Nitrate levels range from 0.02 to 211.00 ppm with 19 water samples exceeding the WHO recommended limit of 45 ppm. The sources of nitrate pollution are suspected to be anthropogenic, with the highest concentrations found in towns and larger villages.

7.2 RECOMMENDATIONS

- 1) It is recommended that communities within walking distances of the Bongo granite boundary obtain their drinking water supplies from adjacent lithologies. The width of the main Bongo granite suite varies between 4 and 8 km. There are many wells within the granite area which are located within 2 km of the Bongo granite contact(Figure 31). Thus, some of the high fluoride wells are located close to wells that produce acceptable levels of fluoride. Therefore, it should be possible for some of the communities located within the Bongo granite area to obtain their drinking water from adjoining geological units. With careful well siting, it should be possible to intersect groundwaters with low fluoride content in the Sekoti, Adaboya and Tongo areas.
- 2) It is recommended that further geological mapping of the study area be done, especially the Bongo granite. Zones within the Bongo granite which contain groundwater with low fluoride content should be delineated. Some of these zones

occur around Samboligo, Namoo, Gurogo and Dua. Communities close to these zones can also obtain their water supplies from these zones.

- 3) It is recommended that the vertical variability of fluoride concentration be researched further by sampling more hand dug wells and deep wells (> 30 m).
- 4) It is recommended that the seasonal fluctuation of groundwater fluoride concentrations be monitored.
- 5) It is recommended that dental surveys should relate fluoride concentrations in groundwater to the actual health effects in the area. Results of such a study will be useful in formulating a policy on suitable fluoride limits for the study area.
- 6) It is recommended that a treatment program for high fluoride waters be established. Such a program could start in the most vulnerable areas, such as the interior phases of the Bongo granite area and water sources that are used by schools.
- 7) It is recommended that education on the effects of fluoride on human health be initiated in communities relying on high fluoride waters.
- 8) It is recommended that efforts be made at ensuring that future groundwater-based water supply sites are located safely away from sanitary sites. Also, sanitation practices and other human activities should be conducted according to established regulations.
- 9) It is recommended that bacteriological studies should be conducted on polluted sources for pathogenic bacteria.

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APPENDIX 1

- * WELL IDENTIFICATION NUMBERS**
- * VILLAGE AND DISTRICT NAMES**
- * GPS COORDINATES (in WGS84 datum)**
- * WELL SITE ALTITUDE(ft)**
- * WELL DEPTH(ft)**
- * GEOLOGY**

UBMV - Upper Birimian Metavolcanics

UBMS - Upper Birimian Metasediments

UBG - Upper Birimian Granitoids

BG - Bongo Granites

No.	Survey No.	Well ID No.	Village	District	Easting	Northing	long	lat	Alt (feet)	Depth	Geology
1	3	455B1	Boko	Bongo	736137	1215287	0.839	10.965	744	44	UBG
2	4	455B2HDW	Boko	Bongo	736523	1214689	0.836	10.961	801	18	UBG
3	5	455B3	Zoko-Kodorogo	Bongo	728416	1208110	0.910	10.922	816	57	BG
4	6	455B5	Zoko-Kadare	Bongo	729184	1210455	0.905	10.949	681	71	BG
5	7	455B6	Zoko-Kadare	Bongo	730135	1210665	0.894	10.945	687	80	BG
6	8	455B7	Balungu	Bongo	732642	1209731	0.875	10.938	813	90	BG
7	9	455B9HDW	Balungu	Bongo	735477	1209444	0.845	10.933	849	15	BG
8	10	455B9	Balungu	Bongo	735995	1209884	0.841	10.937	819	48	BG
9	11	455B10	Kansoe	Bongo	734871	1213478	0.851	10.970	821	67	BG
10	12	455B11	Namoo	Bongo	735880	1214139	0.843	10.976	885	54	UBG
11	13	455B12	Samboligo	Bongo	733759	1212076	0.861	10.957	924	64	BG
12	14	455B12HDW	Sokabisi	Bongo	732772	1212365	0.870	10.960	782	38	BG
13	15	455B13HDW		Bongo	745930	1188775	0.849	10.755	482	25	UBMV
14	16	455B13	Nayorogo	Bongo	735012	1211408	0.850	10.951	855	76	BG
15	17	455B17	Nayorogo	Bongo	733971	1211276	0.859	10.950	833	88	BG
16	18	455B18	Nayorogo	Bongo	733495	1210813	0.864	10.946	915	84	BG
17	19	455B19	Namoo	Bongo	734245	1213972	0.856	10.975	857	86	BG
18	20	455B20	Namoo	Bongo	734781	1214630	0.852	10.980	927	68	BG
19	21	455B21HDW	Namoo	Bongo	734382	1216018	0.855	10.983	873		BG
20	22	455B21	Namoo	Bongo	733998	1215255	0.858	10.968	872	82	BG
21	23	455B22	Lungu	Bongo	735745	1208814	0.843	10.928	795	72	BG
22	24	455B23	Balungu	Bongo	735529	1210841	0.845	10.946	852	79	BG
23	25	455B23POND	Balungu	Bongo	735567	1210531	0.845	10.943	846		BG
24	26	455B24	Bungo	Bongo	735908	1211084	0.847	10.959	765	59	UBG
25	27	455B25	Zoko-Goo	Bongo	728960	1208459	0.904	10.924	834	48	BG
26	28	455B26	Zoko-Goo	Bongo	730450	1207905	0.892	10.920	891	55	BG
27	29	455B27	Samboligo	Bongo	732354	1210843	0.874	10.944	885	57	BG
28	30	455B28HDW	Samboligo	Bongo	733461	1213180	0.864	10.967	822	26	BG
29	31	455B28	Kansoe	Bongo	733900	1212949	0.860	10.965	939	101	BG
30	32	455B29	Samboligo	Bongo	730620	1212570	0.891	10.970	732	71	BG
31	33	455B30HDW	Longo	Bongo	735228	1207906	0.847	10.919	747	22	BG
32	34	455B32	Kadare	Bongo	731493	1209773	0.891	10.939	777		BG
33	35	455B34	Samboligo	Bongo	734017	1212268	0.859	10.959	930	118	BG
34	36	455B35	Samboligo	Bongo			0.880	10.963	789	95	BG
35	37	455C1	Bongo-Soe	Bongo	742849	1210303	0.778	10.941	845	78	UBG
36	38	455C2	Bongo-Soe	Bongo	742107	1210485	0.785	10.942	836	42	UBG
37	39	455C3	Kanseringa	Bongo	745868	1210959	0.900	10.946	810	62	UBG
38	40	455C4	Kanseringa	Bongo	745619	1210313	0.753	10.940	831	58	UBG
39	41	455C7	Samboligo	Bongo	740659	1213012	0.798	10.965	921	58	UBG
40	42	455C10HDW	Feo	Bongo	741015	1215936	0.794	10.991	837		UBG
41	43	455C11	Feo	Bongo	738698	1217005	0.816	11.001	795	77	UBG
42	44	455C13	Boko	Bongo	737088	1215086	0.830	10.984	738	67	UBG
43	45	455C14	Bongo-Soe	Bongo	743890	1212864	0.768	10.962	924	77	UBG
44	46	455C15	Soe Arabe	Bongo			0.749	10.963	894	58	UBMV
45	47	455C17	Bongo-Soe	Bongo	742094	1212847	0.784	10.964	855	81	UBG
46	48	455C18	Bongo-Soe	Bongo	742595	1212396	0.780	10.959	867	77	UBG
47	49	455C19	Feo	Bongo	738377	1215804	0.818	10.989	798	79	UBG
48	50	455C19HDW	Feo	Bongo	737611	1215429	0.825	10.991	834	26	UBG
49	51	455C23	Gurogo	Bongo	739068	1209981	0.813	10.938	768	66	UBG
50	52	455C24	Amanga	Bongo	739029	1210796	0.822	10.945	765	61	BG
51	53	455C25	Feo	Bongo	740309	1215288	0.801	10.983	849	58	UBG
52	54	455C27HDW	Feo	Bongo	740122	1216122	0.803	10.993	864	20	UBG
53	55	455C29	Bongo-Soe	Bongo	743876	1211560	0.769	10.952	912	98	UBG
54	56	455C30	Kabre	Bongo	744031	1210645	0.767	10.944	867	50	UBG
55	57	455C31	Akulyoo	Bongo	745495	1208448	0.754	10.924	867	86	UBMV
56	58	455C32	Akunduo	Bongo	740974	1209561	0.803	10.934	852	78	UBG
57	59	455C33	Bongo-Soe	Bongo	741842	1211649	0.787	10.953	869	46	UBG
58	60	455C34	Feo	Bongo	739359	1216070	0.806	10.993	828	100	UBG
59	61	455C35	Soboko-Akonka	Bongo	742408	1213782	0.782	10.972	878	46	UBG
60	62	455C36	Feo-Konkoa	Bongo	743900	1214800	0.768	10.979	927	101	UBG
61	63	455C37	Soboko	Bongo	743275	1213551	0.774	10.970	960	69	UBG
62	64	455C38	Feo	Bongo	743189	1215957	0.774	10.991	897	76	UBG
63	65	455C39	Gurogo	Bongo	738435	1208239	0.818	10.922	792	79	UBG
64	66	455C40	Gurogo	Bongo	737801	1208497	0.826	10.925	774	91	UBG
65	67	455C42	Ayopia	Bongo	739908	1210634	0.804	10.944	792	52	UBG
66	68	455C43	Amanga	Bongo	735474	1211618	0.827	10.953	747	54	UBG
67	69	455C44	Feo	Bongo	744898	1216061	0.759	10.992	720	62	UBG

No.	Survey No.	Well ID No.	Village	District	Easting	Northing	long	lat	Alt (feet)	Depth	Geology
68	71	455C45	Fao	Bongo	745187	1215255	0.758	10.985	726	81	UBG
69	73	455C47	Alulyoo	Bongo	745359	1208386	0.755	10.932	864	98	UBMV
70	74	455C48	Amanga	Bongo	737327	1213203	0.836	10.968	846	58	UBG
71	75	455D4	Sumbrungu	Bolga	728567	1198806	0.928	10.847	690	79	UBG
72	76	455D8	Sumbrungu	Bolga	727350	1200526	0.920	10.853	687	86	UBG
73	77	455D25	Sumbrungu	Bolga	724592	1198599	0.948	10.836	711	83	UBG
74	78	455D27	Sumbrungu	Bolga	728572	1198237	0.928	10.842	717	76	UBG
75	79	455D28	Sumbrungu	Bolga	728519	1201010	0.928	10.858	686	78	UBG
76	80	455D30	Sumbrungu	Bolga	727363	1202267	0.920	10.869		101	UBG
77	81	455D31	Zoko-Gambrongo	Bongo	727415	1204021	0.920	10.885	756	95	UBG
78	82	455D32	Zoko	Bongo	727233	1208800	0.921	10.908	750	61	UBG
79	83	455D33	Zoko-Kanga	Bongo	727159	1207309	0.921	10.914	741	55	UBG
80	84	455E2	Gowrie-Kesingo	Bongo	735584	1198901	0.845	10.846	717	95	BG
81	85	455E3POND	Vea Dam	Bolga	735158	1201836	0.849	10.868			BG
82	86	455E3	Gowrie-Nayire	Bongo	735949	1201382	0.842	10.880	696	127	BG
83	87	455E5	Nyarega	Bolga	729889	1200362	0.908	10.850	573	77	UBG
84	88	455E6	Zoko-Gambrongo	Bongo	729814	1202993	0.898	10.875	675	82	UBG
85	89	455E8 ?	Zoko-Gambrongo	Bongo	728252	1205457	0.912	10.898	774	72	UBG
86	90	455E9HDW	Zoko	Bongo	728821	1208442	0.906	10.907	627	46	UBG
87	91	455E9	Zoko-Kanga	Bongo	729364	1208448	0.901	10.907	837	58	BG
88	92	455E10	Zoko-Gambrongo	Bongo	730809	1203894	0.888	10.882	680	71	BG
89	93	455E11	Zaare	Bolga	731257	1198588	0.885	10.844	587	60	UBG
90	94	455E12	Nyarega	Bolga	730089	1201316	0.895	10.880	618	55	UBG
91	95	455E13	Zoko	Bongo	729417	1203089	0.903	10.876	672	73	UBG
92	96	455E15	Zoko-Tarango	Bongo	731211	1205550	0.885	10.898	681	94	BG
93	97	455E16HDW	Zoko	Bongo	729996	1206214	0.896	10.905	678	25	BG
94	98	455E17	Zoko-Tarango	Bongo	732063	1205658	0.877	10.899	855	92	BG
95	99	455E20	Zoko-Kanga	Bongo	731014	1206794	0.886	10.910	885	69	BG
96	100	455E21	Vea	Bongo	732410	1203458	0.874	10.880	792	74	BG
97	101	455E22	Vea	Bongo	733343	1202855	0.885	10.874	753	94	BG
98	102	455E23	Vea	Bongo	734036	1203455	0.859	10.879	729	79	BG
99	103	455E24	Vea	Bongo	733557	1203982	0.863	10.884	783	66	BG
100	104	455E25	Vea	Bongo	733109	1204449	0.867	10.888	837	67	BG
101	105	455E27	Sumbrungu	Bolga	729463	1199522	0.902	10.851	543	66	UBG
102	106	455E28	Sumbrungu	Bolga	728258	1201133	0.912	10.859	681	77	UBG
103	107	455E30	Zoko	Bongo			0.911	10.880	651	81	BG
104	108	455E33	Vea	Bongo	732291	1201747	0.875	10.864	585	64	UBG
105	109	455E33HDW	Vea	Bolga	733889	1201783	0.870	10.876	729	27	BG
106	110	455E35	Nyarega	Bolga	731818	1200410	0.879	10.852	555	64	UBG
107	111	455E36	Nyarega	Bolga	730796	1201486	0.889	10.862	597	61	UBG
108	112	455E37	Zoko-Tarango	Bongo	731574	1204997	0.882	10.894	825	65	BG
109	113	455E38	Zoko-Kanga	Bongo	728012	1208773	0.914	10.910	774	58	UBG
110	114	455E39	Lungu	Bongo						67	BG
111	115	455E42	Zoko-Goo	Bongo	733290	1207466	0.876	10.926	816	81	BG
112	116	455F1	Yorogo	Bolga	738759	1200801	0.816	10.855	720	118	BG
113	117	455F2	Bongo	Bongo	738688	1203817	0.817	10.884	885	118	BG
114	118	455F3	Bongo Anafobisi	Bongo	739213	1205585	0.811	10.898	858	56	BG
115	119	455F4	Bongo Bogrogo	Bongo	741835	1208115	0.788	10.903	936	78	BG
116	120	455F6HDW	Bongo	Bongo	739367	1208836	0.810	10.909	753	20	BG
117	121	455F6	Bongo	Bongo	739367	1208889	0.810	10.911	747	96	BG
118	122	455F7	Bongo	Bongo	739874	1208510	0.805	10.906	777	104	BG
119	123	455F8	Bongo Azaasi	Bongo	739954	1207731	0.804	10.917	723	70	BG
120	124	455F9	Bongo	Bongo	740577	1207376	0.799	10.914	879	78	BG
121	125	455F10	Bongo Bogrogo	Bongo	743472	1205559	0.773	10.896	849	78	UBMV
122	126	455F11	Amatayoko	Bongo	742412	1207750	0.783	10.918	891	69	UBMV
123	127	455F12	Akanaba	Bongo	745620	1208634	0.753	10.907	915	77	UBMV
124	128	455F13	Dua	Bongo	741226	1204422	0.793	10.887	903	34	BG
125	129	455F15	Dua Yikeni	Bongo	741091	1203854	0.794	10.882	891	58	BG
126	130	455F16	Yorogo	Bolga	737154	1198658	0.831	10.835	765	402	BG
127	131	455F17	Bongo	Bongo	739579	1207073	0.806	10.912	750	114	BG
128	132	455F18	Bongo	Bongo	739539	1207022	0.810	10.912	744	47	BG
129	133	455F19	Bongo	Bongo	739513	1207715	0.809	10.917	717	67	BG
130	134	455F22	Dachio	Bolga	745478	1198646	0.755	10.844	879	78	UBG
131	135	455F23	Dachio	Bolga	743999	1199548	0.768	10.843	822	96	UBG
132	136	455F25	Yorogo	Bolga	739114	1198629	0.779	10.846	878	68	UBMS
133	137	455F26	Yorogo	Bolga	739921	1201247	0.806	10.859	711	67	UBMS
134	138	455F27	Apae-Tanga	Bongo	744812	1207809	0.760	10.918	980	98	UBMV

No.	Survey No.	Well ID No.	Village	District	Easting	Northing	long	lat	AR (feet)	Depth	Geology
135	139	455F28		Bongo	744734	1205710	0.781	10.888	921		UBMV
136	140	455F29	Yorogo	Bolga	737859	1199899	0.824	10.847	729	98	BG
137	141	455F30	Yorogo	Bolga	738670	1202155	0.817	10.867	930	88	BG
138	142	455F31	Bongo	Bongo	738956	1205245	0.813	10.883	882	59	BG
139	143	455F32HDW	Bongo	Bongo	741251	1206794	0.800	10.915	890		BG
140	144	455F32POND	Bongo	Bongo	741323	1206723	0.798	10.903	810		BG
141	145	455F34	Bongo-Atampisi	Bongo	737737	1207047	0.833	10.919	795	101	BG
142	146	455F35	Alunduo	Bongo	741467	1208064	0.791	10.920	862	54	UBMV
143	147	455F36	Yorogo	Bolga	739679	1202003	0.808	10.866	747	97	BG
144	148	455F39	Apaglugro	Bongo	745815	1205613	0.752	10.898	948	71	UBMV
145	149	455F41	Bongo-Beo	Bongo	745805	1202213	0.751	10.888	758	99	UBG
146	150	455F42	Dua	Bongo	743416	1203798	0.773	10.882	795	74	UBMS
147	151	455F43	Dua	Bongo	742395	1203450	0.783	10.879	792	40	UBMV
148	152	455F44HDW	Dua	Bongo	741228	1202363	0.793	10.889	788	39	UBMV
149	153	455F44	Dua	Bongo	741080	1201684	0.795	10.883	732	52	UBMS
150	154	455F45	Dachio	Bolga	744380	1198970	0.785	10.838	819	98	UBG
151	155	455F46	Dubila	Bolga	745089	1200297	0.759	10.851	881	72	UBG
152	156	455F48	Bongo-Daliga	Bongo	737530	1204824	0.828	10.883	834	87	BG
153	157	455G1	Sumbrungu	Bolga	727756	1195982	0.917	10.812	633	62	UBG
154	158	455G2	Sherigu	Bolga	727318	1191021	0.921	10.788	702	97	UBG
155	159	455G5	Sherigu	Bolga	725339	1198097	0.942	10.822	522	71	UBG
156	160	455G6	Sumbrungu	Bolga	725310	1197245	0.940	10.823	693	87	UBG
157	161	455G9	Sumbrungu	Bolga	726614	1196125	0.935	10.822	531	65	UBG
158	162	455G11	Sumbrungu	Bolga	725684	1197121	0.936	10.823	687	72	UBG
159	163	455G12HDW		Bolga	723196	1197847	0.958	10.827	696		UBG
160	164	454G15	Kwatie	Bolga	746585	1190684	0.753	10.772			UBMV
161	165	455G20	Sumbrungu	Bolga	727100	1198389	0.923	10.834	681	64	UBG
162	166	455H1HDW	Zorbisi	Bolga	732232	1194585	0.883	10.976	686	14	BG
163	167	455H1	Zorbisi	Bolga	732815	1194834	0.873	10.802	660	73	BG
164	168	455H2	Sherigu	Bolga	728363	1190950	0.912	10.786	729	75	UBG
165	169	455H3	Sokabisi	Bolga	731669	1194080	0.882	10.795	738	81	BG
166	170	455H5	Sokabisi	Bolga			0.895	10.798	651	75	BG
167	171	455H6	Dorongo	Bolga	731531	1191359	0.882	10.770	702	57	UBMS
168	172	455H9	Sherigu	Bolga	731289	1195587	0.886	10.814	608	79	UBG
169	173	455H10	Sherigu	Bolga	729671	1192602	0.900	10.782	711	97	BG
170	174	455H11	Zaare	Bolga			0.880	10.824	686	79	BG
171	175	455H12	Zaare	Bolga	732827	1197295	0.873	10.828	678	81	BG
172	176	455H13	Dorongo	Bolga	731276	1192939	0.885	10.785	732	77	UBG
173	177	455H14	Yorogo	Bolga	734934	1198024	0.851	10.839	675	94	BG
174	178	455H15	Yikene	Bolga	732139	1195189	0.884	10.808	654	98	BG
175	179	455H15HDW	Yikene	Bolga	733969	1193699	0.896	10.796	654	17	BG
176	180	455H17	Gambibgo	Bolga	739615	1190821	0.837	10.785	600	111	UBG
177	181	455H19	Bolgatanga	Bolga	734402	1191701	0.961	10.779	528	114	UBG
178	182	455H20HDW	Zaare	Bolga	733954	1196335	0.867	10.825		20	BG
179	183	455H20	Zaare	Bolga	733721	1196827	0.870	10.821	690	63	BG
180	184	455H25	Polugu	Bolga	739684	1192311	0.837	10.787	672	107	UBG
181	185	455H26	Tindonsobligu	Bolga	732714	1190833	0.875	10.775	531	157	UBMS
182	186	455H29	Yikene	Bolga	729476	1195084	0.924	10.807	612	65	UBG
183	187	455H30	Sumbrungu	Bolga	728943	1197808	0.910	10.836	531	59	UBG
184	188	455H31	Bolga-Soe	Bolga	736379	1195399	0.841	10.810	624	45	UBMS
185	189	455H32	Yikene	Bolga	729790	1195833	0.908	10.817	579	78	UBG
186	190	455H33	Bolga-Soe	Bolga	735826	1194703	0.850	10.810	648	97	BG
187	191	455H34	Bolga-Soe	Bolga	736102	1194503	0.843	10.808	633	69	UBMS
188	192	455H34HDW	Bolga-Soe	Bolga	735805	1194445	0.850	10.808	636		UBMS
189	193	455H35HDW	Bolga-Soe	Bolga	735977	1195214	0.847	10.807	639	25	BG
190	194	455H36	Bolga-Soe	Bolga	735815	1196072	0.843	10.812	654	72	BG
191	195	455H37	Bolga-Soe	Bolga	736150	1197392	0.840	10.824	711	82	BG
192	196	455H38	Yorogo	Bolga	734703	1197742	0.855	10.834	683	116	BG
193	197	455H38HDW	Yorogo	Bolga	734033	1197777	0.886	10.835	690		UBG
194	198	455H39HDW	Zaare	Bolga	734752	1198875	0.855	10.822	702		UBG
195	199	455H39	Zaare	Bolga						90	UBG
196	200	455H40	Gambibgo	Bolga	735737	1189512	0.845	10.753	531	114	UBG
197	201	455H41	Sokabisi	Bolga	731653	1193501	0.881	10.789		93	UBG
198	202	455H42	Tindonsobligu	Bolga	734115	1190484	0.967	10.789	486	96	UBG
199	203	455H43	Tanzui	Bolga	732769	1194101	0.871	10.795	765	96	BG
200	204	455H44	Sumbrungu	Bolga	728403	1195175	0.918	10.808	576	60	UBG
201	205	455H45	Soribisi	Bolga	732756	1192487	0.875	10.789	569	76	BG

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202	206	455H45HDW	Tindomobulugu	Bolga	733201	1192484	0.888	10.789	587	28	BG
203	207	455H46	Sumbrungu	Bolga	727893	1197672	0.926	10.835	534	77	UBG
204	208	455H47	Erigu	Bolga	730638	1190303	0.891	10.761	714	62	UBMS
205	209	455H48	Sherigu	Bolga	726882	1189712	0.898	10.755	708	61	UBMS
206	210	455H49	Sumbrungu	Bolga	728086	1198576	0.923	10.837	546	86	UBG
207	211	455H50	Dorungu	Bolga	730712	1191688	0.890	10.773	723	78	UBMS
208	212	455H51	Yorogo	Bolga					698	79	BG
209	213	455H52	Yikene	Bolga	731152	1194748	0.888	10.801	648	80	UBG
210	214	455H53	Zaare	Bolga	733371	1197448	0.878	10.831	687	76	UBG
211	215	455H54	Tindomolgo	Bolga			0.875	10.784	546		BG
212	216	455H55	Gambibgo	Bolga	735762	1190628	0.844	10.764	519		UBG
213	217	455H56	Bolga-Soe	Bolga	732980	1195400	0.871	10.811	729		BG
214	218	455H57	Zaare	Bolga	733185	1195331	0.888	10.810	753		BG
215	219	455H58	Sherigu	Bolga	728911	1192193	0.907	10.767	738		UBG
216	220	455H59	Tindomolgo	Bolga	733850	1191591	0.899	10.776	528		UBMS
217	221	455H61		Bolga							BG
218	222	455I4	Yipala	Bolga	737357	1197111	0.829	10.822	657	47	BG
219	223	455I5	Gambibgo	Bolga	737241	1190086	0.831	10.758	573	74	UBG
220	224	455I7	Yarigabisi	Bolga	738435	1192188	0.820	10.777	639	76	UBG
221	225	455I9	Zuarungu	Bolga	744206	1194431	0.767	10.798	774	76	UBMV
222	226	455I9HDW	Nyokoku	Bolga	744264	1193481	0.766	10.788	768		UBMV
223	227	455I10	Kumbosigo	Bolga	739140	1194861	0.813	10.802	702	97	UBG
224	228	455I11	Kumbosigo	Bolga	738385	1193926	0.822	10.799	717	116	UBG
225	229	455I12	Zuarungu	Bolga	742529	1192512	0.732	10.780	738	97	UBG
226	230	455I13	Zuarungu	Bolga	741681	1191404	0.790	10.770	645	70	UBG
227	231	455I15	Zuarungu	Bolga	745758	1196427	0.752	10.815	585	78	UBMV
228	232	455I17	Zuarungu	Bolga	743056	1195225	0.777	10.804	786	91	UBG
229	233	455I24	Zuarungu	Bolga	739813	1192997	0.807	10.775	717		UBG
230	234	455I27	Kpatia	Bolga	745636	1190212	0.754	10.759	678	59	UBMV
231	235	455I31	Zuarungu	Bolga	740283	1194017	0.805	10.800		107	UBG
232	236	455I32	Zuarungu	Bolga	742084	1194644	0.786	10.799	608	65	UBG
233	237	455I33	Zuarungu	Bolga	741211	1193302	0.786	10.787	750	77	UBG
234	238	455I34	Zuarungu	Bolga	741139	1196814	0.802	10.820	732	97	UBG
235	239	455I35	Zuarungu	Bolga	744728	1197286	0.770	10.827	732	117	UBG
236	240	455I36	Zuarungu	Bolga	742011	1197212	0.789	10.826	711	117	UBG
237	241	455I38	Yorogo	Bolga	738725	1198716	0.816	10.836	684	58	UBMS
238	242	455I40	Tongo-Beo	Bolga	740398	1191076	0.802	10.767	702	79	UBG
239	243	455I41	Zuarungu	Bolga	740972	1195247	0.805	10.808	556	63	UBG
240	244	455I42	Tongo-Beo	Bolga	740324	1191711	0.802	10.773	702	91	UBG
241	245	455I43	Tongo-Beo	Bolga	741183	1189889	0.795	10.756	708	63	UBG
242	246	455I44	Dulugu	Bolga	739521	1191923	0.810	10.775	726	99	UBG
243	247	455I45	Kpatia	Bolga			0.754	10.770	675	97	UBG
244	248	455I46	Tongo-Beo	Bolga	740255	1192209	0.803	10.795	705	77	UBG
245	249	455I47	Zuarungu	Bolga	739561	1193496	0.809	10.790	744	79	UBG
246	250	455I47HDW	Kumborsugu	Bolga	739233	1193859	0.812	10.793	720	24	UBG
247	251	455I48	Sakote	Bolga	743566	1190583	0.777	10.789	642	58	UBMV
248	252	455I49HDW	Iunkua	Bolga	743659	1197494	0.775	10.830	690	27	UBG
249	253	455I50	Zuarungu	Bolga	742527	1198051	0.782	10.812	756	83	UBG
250	254	455I52	Zuarungu	Bolga	741286	1193451	0.792	10.788	729	53	UBG
251	255	455I53	Zuarungu	Bolga	741192	1192387	0.794	10.779	729	104	UBG
252	256	455I54POND	Dulugu	Bolga	737496	1189779	0.828	10.755	561		UBG
253	257	455I54	Dulugu	Bolga	738314	1190493	0.821	10.762	680	94	UBG
254	258	455I58	Zuarungu	Bolga	741740	1193853	0.790	10.792	768	75	UBG
255	259	455I59	Zuarungu	Bolga	745284	1194391	0.775	10.797	780	86	UBMV
256	260	P47	Sheringu	Bolga	728132	1211592	0.947	10.955	741		UBMV
257	261	P5	Sheringu	Bolga	725724	1211237	0.936	10.952	741		UBMV
258	262	P10		Bolga	727577	1213591	0.920	10.975			BG
259	263	P11	Merigu-Market	Navrongo	722500	1208303	0.973	10.929	732		UBG
260	264	456A1	Asebuga	Bongo	746167	1207715	0.748	10.917	783	72	UBMV
261	265	456C20			744206	1185090	0.787	10.712	618		UBMV
262	266	456D6	Solga-Nangodi	Bolga	753792	1196227	0.678	10.840	753	78	UBMV
263	267	456D7	Kongo	Bolga	749329	1200552	0.719	10.852	690	76	UBMV
264	268	456D8	Soliga	Bolga	752089	1199889	0.694	10.846	744	62	UBMV
265	269	456D9	Zoa	Bolga	752783	1200638	0.738	10.853	765	47	UBMV
266	270	456D11	Nangodi	Bolga	754741	1200489	0.671	10.852	765	107	UBMV
267	271	456D13	Kongo	Bolga	750710	1199346	0.707	10.841	672	62	UBMV
268	272	456D14	Adaboya	Bongo	746805	1205516	0.744	10.897	998	97	BG

No.	Survey No.	Well ID No.	Village	District	Easting	Northing	long	lat	Alt (feet)	Depth	Geology
269	273	456D17	Dusobliqu	Bolga	750262	1203042	0.711	10.874	918	73	UBMV
270	274	456D18	Zoa	Bolga	750712	1200306	0.707	10.886	726	59	UBMV
271	275	456D19	Nangodi	Bolga	752985	1199428	0.885	10.842	880	58	UBMV
272	276	456D20	Kumbusigo	Bolga	748146	1201286	0.730	10.859	858	77	UBG
273	277	456D21	Logre	Bolga	749222	1199281	0.720	10.841	915	61	UBMV
274	278	456D22	Bongo-Beo	Bolga	747017	1200888	0.740	10.853	834	121	UBG
275	279	456D25	Bungotua	Bolga	746467	1206775	0.745	10.808	942	81	UBG
276	280	456D27	Asebiga	Bolga	747435	1207444	0.736	10.914	785	98	UBG
277	281	456D28	Kongo	Bolga	748894	1200012	0.725	10.847	903	81	UBMV
278	282	456D29	Zuarungu-Moshie	Bolga	748829	1199485	0.742	10.843	882	100	UBG
279	283	456D32	Atonobogro	Bolga	746765	1204369	0.715	10.857	831		UBMS
280	284	456D33	Kansingo	Bolga	747350	1199829	0.737	10.844	900		UBMV
281	285	456D34	Kongo	Bolga	748858	1199830	0.714	10.838	705		UBMV
282	286	456E3	Nangodi	Bolga	755533	1201675	0.882	10.862	717	118	UBMV
283	287	456E4	Nangodi	Bolga	755328	1201154	0.884	10.857	753	79	UBMV
284	288	456G1	Zanlerigu	Bolga	747533	1196345	0.736	10.805	624	62	UBMV
285	289	456GHDW1	Genne	Bolga	746379	1195144	0.747	10.803	639	36	UBMV
286	290	456G3	Ndongo	Bolga	751067	1194894	0.704	10.799	792	64	UBG
287	291	456G3POND	Dusi-Tindongo	Bolga	751625	1190806	0.899	10.782	651		UBMV
288	292	456G5	Dusi	Bolga	752159	1192488	0.894	10.779	738	78	UBG
289	293	456G6	Dusi	Bolga	752597	1191817	0.892	10.773	723	80	UBMV
290	294	456G9	Gari	Bolga	751192	1199662	0.703	10.755	684	49	UBMV
291	295	456G10	Pelungu	Bolga	751913	1194460	0.898	10.797	750	120	UBG
292	296	456G11	Pelungu	Bolga	752901	1194199	0.890	10.794	714	118	UBG
293	297	456G12	Gari	Bolga	749954	1199991	0.714	10.756	759	57	UBMV
294	298	456G13	Gari	Bolga	750506	1190776	0.709	10.763	738	43	UBMV
295	299	456G16	Ndongo	Bolga	749898	1194785	0.715	10.800	852	73	UBMV
296	300	456G17	Logri	Bolga	750903	1196784	0.705	10.818	774	58	UBMV
297	301	456G18	Demugu	Bolga	752115	1196091	0.894	10.811		70	UBG
298	302	456G22	Zanlerigu	Bolga	750521	1193988	0.709	10.792	769	62	UBMV
299	303	456G23	Demolugu	Bolga	750803	1195536	0.708	10.807	861	62	UBMV
300	304	456G24	Pelungu	Bolga	753705	1198402	0.890	10.815	690	116	UBG
301	305	456G25	Deliga	Bolga	748324	1198089	0.729	10.812	678	65	UBMV
302	306	456G26	Zanlerigu	Bolga	747146	1193802	0.740	10.791	600	47	UBMV
303	307	456G27	Zanlerigu	Bolga	748297	1194825			672	72	UBMV
304	308	456G28	Logri	Bolga	750273	1199855	0.711	10.822	795	72	UBMV
305	309	456G30	Gbeeya	Bolga	750580	1190088	0.709	10.758	711	56	UBMV
306	310	456G31	Gari	Bolga	753089	1190563	0.896	10.761	606	34	UBMV
307	311	456G34	Zanlerigu	Bolga	748807	1194973	0.726	10.802	708	59	UBMV
308	312	456G36	Deliga	Bolga	749774	1196167	0.716	10.812	729	82	UBMV
309	313	456G37	Deliga	Bolga	749087	1195822	0.721	10.809	711	73	UBMV
310	314	456G39	Kongo	Bolga	751115	1198504	0.701	10.834	780	45	UBMV
311	315	456G43	Zanlerigu	Bolga	748840	1194188	0.726	10.794	675		UBMV
312	316	456H2HDW		Bolga	760324	1194357	0.619	10.795	567	14	UBG
313	317	456H2	Nyogbare	Bolga	757847	1192523	0.642	10.779	627	91	UBG
314	318	456H3	Kotintabiga-Sekoti	Bolga	757916	1195396	0.641	10.805	576	77	UBG
315	319	456H4	Yakole-Sekoti	Bolga	758020	1198440	0.656	10.833	724	107	UBG
316	320	456H5	Nyoboka	Bolga	758436	1197984	0.636	10.825		94	UBG
317	321	456H6	Nyoboka	Bolga	758681	1197192	0.652	10.821	621	96	UBG
318	322	456H7	Kotintabiga-Sekoti	Bolga	758681	1198271	0.652	10.813	615	96	UBG
319	323	456H8	Sekoti	Bolga	759319	1194941	0.629	10.801	627	95	BG
320	324	456H9	Sekoti	Bolga	760435	1194822	0.618	10.797		63	BG
321	325	456H10	Sekoti	Bolga	759817	1193572	0.626	10.786	606	103	BG
322	326	456H11	Namooranteng	Bolga	760804	1199788	0.615	10.754	636	103	BG
323	327	456H13	Nyogbare	Bolga	758512	1191108	0.636	10.786	648	52	BG
324	328	456H14	Nyogbare	Bolga	759247	1192220	0.629	10.778	678	93	BG
325	329	456H15	Namooranteng	Bolga	760238	1190549	0.621	10.761	686	79	BG
326	330	456H17	Sekoti	Bolga	758952	1195640	0.632	10.807	636	96	BG
327	331	453B1	Gorogu	Bolga			0.833	10.706	561	67	UBG
328	332	453B3	Winkogo	Bolga	739084	1189988	0.841	10.730	630	64	UBG
329	333	453B4	Winkogo	Bolga	735335	1187390	0.848	10.733	642	86	UBG
330	334	453B5	Winkogo	Bolga	732911	1184756	0.870	10.710	516	77	UBG
331	335	453B7	Winkogo	Bolga	732371	1184957	0.875	10.712	492	90	UBG
332	336	453B8	Winkogo	Bolga	732562	1186393	0.881	10.725	597	97	UBG
333	337	453B12	Gambibgo	Bolga	734709	1188829	0.854	10.747	474	76	UBG
334	338	453B13	Gambibgo	Bolga	735300	1189181	0.848	10.750	510	77	UBG
335	339	453B14	Gambibgo	Bolga	737135	1189396	0.832	10.752	561	76	UBG

No	Survey No.	Well ID No.	Village	District	Easting	Northing	long	lat	Alt (feet)	Depth	Geology
336	340	453B15	Winkogo(school)	Bolga	733788	1188074	0.862	10.722	603	198	UBG
337	341	453B16	Winkogo	Bolga	733421	1185569	0.866	10.718	531	185	UBG
338	342	453B19	Winkogo	Bolga	733332	1188679	0.866	10.728	627	138	UBG
339	343	453B20	Kunbangre	Bolga	733993	1188998	0.867	10.759	492	97	UBG
340	344	453B21	Pesuu-Namongo	Bolga	734205	1181390	0.859	10.690	693	81	UBG
341	345	453B22	Winkogo	Bolga	737263	1185519	0.849	10.717	618	84	UBG
342	346	453B25	Winkogo	Bolga	732919	1188907	0.870	10.730	612	96	UBG
343	347	453B26	Gorugu	Bolga			0.845	10.696	642	66	UBG
344	348	453B27	Besiengo	Bolga	729887	1188377	0.911	10.750	522	96	UBMS
345	349	453B28	Namongo	Bolga	731919	1183369	0.879	10.696	531	113	UBG
346	350	453C1	Baare	Bolga	739712	1187288	0.806	10.732	690	101	UBG
347	351	453C2	Baare	Bolga	739635	1188062	0.809	10.736	678	90	UBG
348	352	453C4	Baare	Bolga	740258	1187488	0.803	10.734	672	72	UBG
349	353	453C5	Wakii	Bolga	740015	1182631	0.808	10.692	711	118	BG
350	354	453C6	Baare	Bolga	740567	1186791	0.800	10.728	681	60	UBG
351	355	453C7	Tongo	Bolga	739635	1185367	0.807	10.715	591	59	UBG
352	356	453C8	Wakii	Bolga	740017	1183162	0.806	10.695	723	99	BG
353	357	453C9	Sapart	Bolga	737069	1182001	0.832	10.685	732	51	BG
354	358	453C10	Tongo	Bolga	740242	1184290	0.804	10.706	636	74	BG
355	359	453C11	Gorugu	Bolga	737395	1183131	0.830	10.696	693	59	BG
356	360	453C15	Tongo	Bolga	740846	1184564	0.799	10.709	609	56	UBG
357	361	453C16	Tongo	Bolga	741236	1185192	0.794	10.714	696	52	UBG
358	362	453C17	Baare(school)	Bolga	740939	1188170	0.797	10.741	654	94	UBMV
359	363	453C18	Tongo	Bolga	740003	1184396	0.806	10.707	678	79	BG
360	364	453C21	Tongo	Bolga	741997	1184891	0.787	10.711	672	38	UBMV
361	365	453C22	Tongo(Zubeggo)	Bolga	741341	1185672	0.793	10.720	708	61	UBG
362	366	453C23	Tongo	Bolga	739974	1184689	0.806	10.709	627	97	UBG
363	367	453C24	Tongo	Bolga	740262	1185317	0.803	10.715	585	61	UBG
364	368	453C25	Tongo	Bolga	740867	1184238	0.800	10.705	606	55	BG
365	369	453C26	Baare	Bolga	738706	1188246	0.817	10.742	654	96	UBG
366	370	453C27	Woog	Bolga	745101	1183120	0.780	10.745	591	97	UBMV
367	371	453C28	Gbanbega	Bolga	742662	1183714	0.781	10.700	621	56	UBMV
368	372	453C30	Baare	Bolga	737200	1187684	0.831	10.737	561	114	UBG
369	373	453E1	Bakungu	Bolga	733866	1177386	0.879	10.643	693	74	UBG
370	374	453E2	Bakungu	Bolga	732446	1177236	0.875	10.642	654	62	UBG
371	375	453E3	Bakungu	Bolga	733124	1177158	0.902	10.641	681	55	UBG
372	376	453E4	Shia	Bolga	736133	1179345	0.841	10.661	693	57	UBG
373	377	453E5	Luribongo	Bolga			0.890	10.655	648	78	UBG
374	378	453E6	Bakungu	Bolga	732051	1177248	0.879	10.643	657		UBG
375	379	453F1	Winduri	Bolga	737696	1178479	0.827	10.653	645	70	BG
376	381	454A1	Shiega	Bolga	749618	1187418	0.718	10.734	675	54	UBMV
377	382	454A2	Shiega	Bolga	749199	1186807	0.721	10.726	612	63	UBMV
378	383	454A4	Shiega	Bolga	749979	1187999	0.714	10.739	702	50	UBMV
379	384	454A6	Shiega	Bolga	749588	1188009	0.751	10.754	540	43	UBMV
380	385	454A10	Shiega	Bolga	748086	1189268	0.732	10.750	675	51	UBMV
381	386	454A11	Shiega	Bolga	748407	1187485	0.729	10.734	672	59	UBMV
382	387	454A12	Shiega	Bolga	750117	1188969	0.712	10.747	729	65	UBMV
383	388	454A12/1	Gbene	Bolga	750549	1188323	0.709	10.741	684		UBMV
384	389	454A16	Shiega	Bolga	748249	1185622	0.710	10.718	621	51	UBMV
385	390	454B1	Datoko	Bolga	757812	1185241			492	52	UBG
386	391	454B2	Datoko	Bolga	757242	1185458	0.648	10.715	459	70	UBG
387	392	454BHDV	Nyogbare	Bolga	758400	1190140	0.637	10.758	609	10	BG
388	393	454B4	Kupielga	Bolga	758231	1187988	0.639	10.738	585	64	BG
389	394	454B5	Kupielga	Bolga	758269	1189450	0.639	10.751	606	124	BG
390	395	454B6	Datoko	Bolga	758238	1182128	0.639	10.637	426	103	UBMS

APPENDIX 2A

FIELD MEASUREMENTS AND CHEMISTRY DATA **(ANIONS)**

*** FIELD MEASUREMENTS**

Temperature(Temp)
Electrical Conductivity(EC)
pH
Alkalinity as CaCO_3

*** CHEMISTRY DATA(ANIONS)**

Bicarbonate(HCO_3)
Sulphate (SO_4)
Chloride(Cl)
Nitrite(NO_2)
Nitrate(NO_3)
Fluoride(F)

No.	Survey No.	Well ID	Temp (C)	EC (uS/cm)	pH	Alk (ppm)	HCO3 (ppm)	SO4 (ppm)	Cl (ppm)	NO2 (ppb)	NO3 (ppm)	F (ppm)
1	3	455B1	31.0	620	7.39	241.98	285.22	9.10	20.70	361.00	72.30	0.38
2	4	455B2HDW		250	6.90	127.22	155.21	3.00	6.78	25.00	6.03	0.44
3	5	455B3		380	7.10	127.84	155.98	2.11	18.30	25.00	28.20	2.05
4	6	455B5		380	7.10	137.69	167.98	26.60	5.92	25.00	29.50	4.43
5	7	455B6		470	6.90	171.67	208.44	34.70	4.63	25.00	23.40	3.97
6	8	455B7		380	6.90	172.63	210.85	2.51	5.97	25.00	30.70	1.51
7	9	455B9HDW		180	7.50	84.12	102.63	0.57	6.26	25.00	16.84	4.60
8	10	455B9		340	7.20	155.47	189.67	1.70	5.00	213.00	21.84	3.80
9	11	455B10		270	7.00	147.08	178.44	3.45	5.86	25.00	14.23	2.75
10	12	455B11		580	6.90	197.69	241.43	7.04	17.60	508.00	56.55	0.89
11	13	455B12		140	6.10	57.38	70.00	0.81	5.18	25.00	21.10	0.61
12	14	455B12HDW		90	7.30	71.51	87.24	4.78	2.94	25.00	18.80	1.51
13	15	455B13HDW		460	7.40	236.78	266.67	6.10	5.14	25.00	15.04	0.24
14	16	455B13		290	7.10	126.98	154.92	3.42	4.45	25.00	14.35	2.16
15	17	455B17		270	6.80	92.28	112.58	3.44	10.80	25.00	31.35	3.21
16	18	455B18		210	6.90	91.79	111.98	1.94	2.62	25.00	17.89	2.80
17	19	455B19		230	6.10	55.10	67.22	4.87	14.30	25.00	42.60	0.70
18	20	455B20		270	6.90	137.68	167.95	1.61	4.89	25.00	11.89	1.61
19	21	455B21HDW		280	7.50	141.68	172.85	2.03	2.69	25.00	8.50	1.19
20	22	455B21		240	6.90	110.63	134.97	1.77	4.59	96.00	13.37	3.08
21	23	455B22		220	6.90	92.00	112.24	2.85	3.52	25.00	18.48	2.67
22	24	455B23		260	7.00	120.51	147.02	2.57	4.08	752.00	9.21	1.64
23	25	455B23POND		200	9.90	52.06	63.51	0.50	15.10	25.00	20.40	0.96
24	26	455B24		350	7.10	174.25	212.59	5.55	3.78	129.00	12.90	0.72
25	27	455B25		330	7.20	122.70	149.69	1.65	9.20	187.00	35.75	2.62
26	28	455B26		440	7.20	183.67	224.08	18.00	8.87	25.00	17.53	3.67
27	29	455B27		400	6.90	210.21	256.46	2.04	2.65	108.00	4.35	1.02
28	30	455B28HDW		310	6.80	118.84	144.74	5.96	8.44	25.00	33.80	2.78
29	31	455B28		220	6.70	75.95	92.66	2.70	7.39	25.00	29.20	2.57
30	32	455B29		550	6.90	275.32	335.89	12.20	4.66	25.00	7.01	1.51
31	33	455B30HDW		160	7.40	59.13	72.14	1.71	6.04	25.00	22.14	2.86
32	34	455B32		460	7.10	226.79	276.68	7.21	3.05	25.00	3.09	4.05
33	35	455B34		110	6.10	50.33	61.40	0.76	3.92	25.00	15.78	0.96
34	36	455B35		350	6.90	172.32	210.23	3.25	2.22	25.00	6.48	2.04
35	37	455C1	31.5	370	7.73	208.78	254.71	1.92	2.79	25.00	10.73	0.22
36	38	455C2	31.5	440	7.10	221.88	270.69	2.60	5.42	25.00	13.04	0.66
37	39	455C3	32.0	670	7.10	360.82	440.20	5.93	8.50	288.00	11.22	0.42
38	40	455C4	31.0	570	7.10	295.50	360.51	3.58	9.71	25.00	14.21	0.12
39	41	455C7	32.0	260	6.70	119.93	146.31	1.40	4.91	576.00	11.59	0.55
40	42	455C10HDW	27.0	140	7.28	76.62	93.48	0.95	4.50	25.00	8.58	0.50
41	43	455C11	31.5	130	7.01	62.67	76.70	0.13	1.08	25.00	7.03	0.31
42	44	455C13	31.5	450	7.55	211.84	258.44	3.69	10.20	25.00	23.24	0.64
43	45	455C14	31.5	170	6.50	84.55	103.15	0.87	2.07	25.00	6.68	0.53
44	46	455C15	32.0	460	7.10	266.33	324.92	5.65	2.18	25.00	2.14	0.53
45	47	455C17	30.0	470	7.12	146.43	178.64	8.55	30.00	666.00	55.00	0.50
46	48	455C18	31.0	160	7.14	86.12	105.07	1.24	2.53	25.00	9.04	0.65
47	49	455C19	31.0	320	7.18	144.27	176.01	2.68	8.73	25.00	23.55	0.74
48	50	455C19HDW		430	7.40	211.68	258.25	2.30	7.25	25.00	13.49	1.62
49	51	455C23		330	7.10	174.27	213.46	0.96	5.19	25.00	5.13	0.38
50	52	455C24		460	7.10	224.94	274.43	11.70	8.40	25.00	11.68	1.26
51	53	455C25	31.0	290	7.37	127.34	155.35	0.71	5.02	25.00	17.30	0.63
52	54	455C27HDW		220	7.20	91.66	111.83	1.23	6.39	25.00	25.00	0.85
53	55	455C29	32.0	200	6.80	79.59	97.10	2.01	5.26	25.00	21.95	0.22
54	56	455C30	32.0	550	7.10	312.26	380.96	0.96	2.96	25.00	2.31	0.44
55	57	455C31	32.0	110	6.70	63.56	77.54	0.21	0.88	25.00	0.03	0.34
56	58	455C32		680	7.00	375.75	456.42	9.67	6.39	25.00	1.74	0.65
57	59	455C33	31.0	260	7.00	145.21	177.16	1.40	2.57	25.00	1.32	0.38
58	60	455C34	31.0	150	7.02	96.36	117.56	0.39	1.09	25.00	1.96	0.49
59	61	455C35	31.0	330	6.90	155.81	190.09	1.49	7.98	25.00	13.79	0.73
60	62	455C36	31.0	470	6.90	243.75	297.37	5.96	3.77	25.00	6.06	0.55
61	63	455C37	31.5	280	6.80	136.43	166.44	1.07	2.73	25.00	12.49	0.51
62	64	455C38	31.0	320	6.90	155.73	189.99	1.25	5.06	25.00	14.87	0.40
63	65	455C39		400	7.10	193.78	236.41	1.10	4.03	473.00	7.30	0.41
64	66	455C40		340		183.32	223.65	2.27	3.84	25.00	6.40	0.67
65	67	455C42		530	6.70	274.95	335.44	2.17	10.10	348.00	10.64	0.43
66	68	455C43		380	7.30	193.59	236.18	2.13	1.31	25.00	18.00	0.49
67	69	455C44	32.0	160		88.14	107.53	0.46	2.57	25.00	11.87	0.83

No.	Survey No.	Well ID	Temp (C)	EC (uS/cm)	pH	Alk (ppm)	HCO ₃ (ppm)	SO ₄ (ppm)	Cl (ppm)	NO ₂ (ppb)	NO ₃ (ppm)	F (ppm)
68	71	455C45	31.0	250	7.21	112.58	137.32	1.42	8.20	25.00	17.85	0.51
69	73	455C47	32.0	640	7.10	354.07	431.87	1.88	7.24	25.00	9.04	0.33
70	74	455C48		320	7.00	170.30	207.77	0.98	1.19	25.00	7.14	0.53
71	75	455D4		250	7.10	130.08	158.67	1.08	2.24	25.00	8.45	0.48
72	76	455D6		200	6.90	98.99	118.33	0.88	3.28	217.00	7.16	0.28
73	77	455D25		390	7.30	180.81	220.59	2.08	8.30	25.00	44.80	0.56
74	78	455D27		230	7.00	98.71	117.99	1.85	6.33	176.00	27.90	0.47
75	79	455D28		290	7.10	138.63	189.13	2.03	5.38	25.00	12.90	0.43
76	80	455D30		390	7.20	170.12	207.95	7.49	5.17	204.00	12.46	0.54
77	81	455D31		470	6.90	233.15	284.44	5.92	4.80	25.00	14.50	0.40
78	82	455D32		350	7.00	125.79	183.48	4.54	11.40	25.00	26.40	0.47
79	83	455D33		440	7.00	187.58	241.05	3.81	13.30	299.00	8.77	0.48
80	84	455E2		170	6.70	89.71	109.45	1.42	1.06	25.00	4.44	1.50
81	85	455E3POND		90	8.00	47.82	58.10	0.39	2.02	25.00	0.03	0.39
82	86	455E3		350	7.20	182.12	197.79	3.94	4.78	25.00	16.62	2.91
83	87	455E5		350	6.90	170.27	207.73	1.87	4.57	25.00	17.15	0.49
84	88	455E8		300	7.30	183.88	198.93	0.82	1.10	25.00	9.53	0.64
85	89	455E8 ?		480	7.10	193.03	235.90	13.60	7.28	302.00	26.30	0.60
86	90	455E9HDW		300	7.10	131.33	180.22	1.51	6.38	25.00	23.00	0.70
87	91	455E9		360	7.20	127.94	158.08	3.69	18.20	407.00	34.53	1.84
88	92	455E10		240	7.40	117.14	142.91	5.98	1.60	25.00	3.87	0.89
89	93	455E11		180	7.10	63.85	77.90	0.64	6.60	299.00	26.90	0.61
90	94	455E12		340	7.30	170.47	207.97	1.16	5.75	172.00	16.78	0.58
91	95	455E13		380	7.30	198.23	241.84	1.80	3.08	25.00	10.72	0.52
92	96	455E15		350	7.30	142.88	174.07	27.00	2.05	25.00	2.38	3.17
93	97	455E16HDW		80	7.50	52.43	63.98	2.18	4.81	25.00	14.70	2.48
94	98	455E17			6.70	134.38	163.92	6.77	1.61	25.00	4.18	2.33
95	99	455E20		280	6.70	63.79	77.82	4.62	18.10	25.00	50.02	2.09
96	100	455E21		220	7.10	98.83	117.89	0.97	2.88	25.00	11.58	3.76
97	101	455E22		340	7.10	180.47	195.77	1.58	3.15	207.00	10.82	1.87
98	102	455E23		300	7.10	152.50	186.05	3.27	2.58	25.00	4.83	2.20
99	103	455E24		240	6.70	119.83	148.19	1.27	2.86	233.00	7.73	1.05
100	104	455E25		280	6.70	116.88	142.59	1.78	3.38	25.00	14.04	2.16
101	105	455E27		330	6.90	177.36	216.38	1.88	1.61	25.00	4.25	0.50
102	106	455E28		270	7.30	136.12	166.07	0.93	3.16	25.00	16.93	0.37
103	107	455E30		350	7.30							
104	108	455E33		480	7.40	238.10	291.70	1.42	8.40	405.00	11.71	0.54
105	109	455E33HDW		380	7.40	184.05	224.54	1.85	3.11	25.00	17.63	0.75
106	110	455E35		300	7.50	126.80	154.45	2.88	8.62	254.00	22.80	0.89
107	111	455E36		380	7.10	144.59	164.20	2.62	14.10	25.00	38.99	0.53
108	112	455E37		220	6.80	93.67	114.28	1.57	3.70	25.00	12.20	3.15
109	113	455E38		390	6.90	188.88	203.33	5.09	13.30	473.00	17.62	0.68
110	114	455E39				95.62	118.88	4.87	18.20	25.00	48.98	2.34
111	115	455E42		300	6.80	141.47	172.59	2.13	3.32	25.00	19.08	2.51
112	116	455F1	32.0	430	6.90	222.83	271.81	4.83	2.33	25.00	2.02	1.20
113	117	455F2		340	7.10	173.83	212.07	1.27	1.67	25.00	4.08	3.32
114	118	455F3		470	7.10	148.90	181.88	49.30	8.82	25.00	26.35	4.43
115	119	455F4		280	6.90	80.20	110.04	3.76	11.50	25.00	29.15	1.97
116	120	455F6HDW		490	6.70	57.32	89.93	9.78	42.10	25.00	115.00	1.90
117	121	455F6		480	7.10	76.37	93.17	10.20	33.70	25.00	109.00	2.80
118	122	455F7		400	6.90	116.37	141.97	8.80	17.00	25.00	60.32	2.98
119	123	455F8		300	6.80	83.28	101.60	6.25	18.10	252.00	41.04	1.76
120	124	455F9		260	7.30	112.10	136.76	6.07	4.75	25.00	10.98	3.16
121	125	455F10		170	6.70	85.99	117.11	0.93	1.19	25.00	0.14	0.64
122	126	455F11		770	7.20	421.02	513.64	7.82	8.14	25.00	19.26	0.69
123	127	455F12	31.0	650	7.10	350.07	427.09	5.18	7.07	25.00	12.50	0.29
124	128	455F13		420	6.90	218.03	266.00	3.21	6.19	25.00	1.87	1.88
125	129	455F15		210	6.80	86.64	105.70	2.54	3.87	25.00	15.83	1.61
126	130	455F16	31.0	380	7.50	193.83	236.47	1.72	4.57	25.00	9.91	1.55
127	131	455F17		500	6.80	98.01	119.57	11.60	35.10	25.00	90.06	2.07
128	132	455F18		640	6.80	93.08	113.56	18.30	43.10	25.00	144.00	2.00
129	133	455F19		330	6.90	109.30	133.35	5.46	14.50	312.00	25.50	1.73
130	134	455F22	31.0	440	6.90	227.31	277.32	2.17	3.79	25.00	13.40	0.39
131	135	455F23	31.0	580	7.00	264.49	322.68	4.61	9.42	25.00	27.50	0.24
132	136	455F25	31.5	370	6.80	203.54	248.32	3.05	1.97	25.00	0.03	0.25
133	137	455F26	32.0	410	6.90	224.62	274.04	1.10	1.51	25.00	0.03	0.39
134	138	455F27	32.0	480	6.90	261.72	319.30	1.61	1.56	25.00	2.01	0.39

No.	Survey No.	Well ID	Temp (C)	EC (uS/cm)	pH	Alk (ppm)	HCO ₃ (ppm)	SO ₄ (ppm)	Cl (ppm)	NO ₂ (ppb)	NO ₃ (ppm)	F (ppm)
135	138	455F28	31.5	530	6.80	281.91	343.93	2.32	5.53	25.00	4.21	0.21
136	140	455F29	31.0	250	7.10	98.66	121.83	1.13	4.04	25.00	17.58	2.91
137	141	455F30		330	6.90	137.65	167.93	1.78	6.82	25.00	18.15	3.33
138	142	455F31		290	7.10	85.45	116.45	3.58	6.38	25.00	35.06	3.63
139	143	455F32HDW		410	7.60	210.35	256.63	1.99	5.70	25.00	7.76	2.77
140	144	455F32POND		140	8.80	66.64	81.30	0.28	3.20	25.00	5.78	0.66
141	145	455F34		300	7.40	123.14	150.23	1.80	4.38	25.00	44.85	3.24
142	146	455F35		500	7.10	259.99	317.19	2.08	4.21	25.00	7.60	0.33
143	147	455F36	32.0	410	6.90	182.40	222.53	1.65	7.20	25.00	27.35	3.25
144	148	455F39	31.5	580	6.90	282.61	344.78	10.80	7.78	25.00	5.05	0.42
145	149	455F41	31.0	290	6.80	137.18	167.38	1.01	2.15	25.00	8.07	0.39
146	150	455F42		300	6.90	106.48	129.88	2.91	12.10	25.00	31.40	0.32
147	151	455F43		250	6.90	128.99	154.93	1.73	4.44	25.00	2.75	0.80
148	152	455F44HDW		450	7.40	218.62	266.72	4.62	3.35	25.00	9.78	0.92
149	153	455F44	32.0	400	7.10	208.11	253.89	3.73	3.54	213.00	4.71	0.46
150	154	455F45	31.0	420	7.00	194.24	236.97	3.09	4.86	25.00	20.15	0.33
151	155	455F46	31.0	510	7.10	248.31	300.50	1.81	6.64	25.00	17.66	0.36
152	156	455F49		340	7.40	145.01	176.91	2.44	3.24	25.00	20.25	2.94
153	157	455G1		390	6.70	197.71	241.21	1.20	1.96	25.00	3.24	0.43
154	158	455G2		360	7.40	183.96	224.43	3.81	4.18	25.00	0.03	0.50
155	159	455G5		240	6.80	136.52	166.55	1.98	3.60	25.00	8.62	0.50
156	160	455G6		400	7.30	208.80	254.74	1.70	2.83	148.00	9.70	0.45
157	161	455G9		410	6.70	205.34	250.51	3.14	3.72	25.00	11.17	0.43
158	162	455G11		340	7.20	126.20	153.96	2.16	12.80	25.00	26.75	0.61
159	163	455G12HDW		100	6.90	47.48	57.93	0.32	2.57	25.00	1.75	0.28
160	164	454G15		700	7.10	375.15	457.68	6.84	1.91	25.00	0.31	0.20
161	165	455G20		260	7.30	133.45	162.81	0.97	1.69	25.00	9.84	0.67
162	166	455H1HDW		90	6.80	27.26	33.11	0.70	2.84	25.00	16.81	1.59
163	167	455H1		310	6.70	89.27	108.91	11.70	18.80	25.00	27.25	2.83
164	168	455H2		350	7.40	171.18	208.64	1.99	5.20	226.00	3.92	0.79
165	169	455H3		240	7.40	85.95	106.08	1.24	10.50	25.00	33.77	1.98
166	170	455H5		280	7.60	140.56	171.48	1.49	2.97	25.00	10.27	1.08
167	171	455H6		400	7.40	216.93	264.65	5.14	4.34	142.00	2.38	0.45
168	172	455H9		300	6.90	166.08	212.62	0.90	3.43	25.00	5.50	0.38
169	173	455H10		300	7.80	138.21	168.62	1.55	5.81	247.00	6.75	1.36
170	174	455H11		270	7.10	122.69	149.68	1.19	2.57	25.00	13.71	2.81
171	175	455H12		240	7.00	111.34	135.83	13.90	4.03	221.00	11.90	3.39
172	176	455H13		260	7.00	85.65	80.09	1.32	18.60	25.00	32.78	0.63
173	177	455H14		210	6.80	100.13	122.16	1.37	2.74	25.00	5.84	2.08
174	178	455H15		190	7.00	81.06	98.89	1.03	2.98	25.00	16.44	2.91
175	179	455H15HDW		520	7.60	85.53	104.35	15.10	45.80	25.00	88.63	3.73
176	180	455H17		480	7.30	208.10	253.83	6.30	15.20	25.00	27.65	0.57
177	181	455H19		420	6.80	155.07	189.19	14.10	19.90	25.00	15.32	0.41
178	182	455H20HDW		130	6.90	55.71	67.97	2.23	5.73	25.00	16.56	1.36
179	183	455H20		230	6.90	110.57	134.90	3.43	4.21	25.00	12.74	3.62
180	184	455H25		390	6.90	171.34	209.03	3.75	9.54	25.00	18.15	0.47
181	185	455H26		510	7.10	253.81	308.65	2.94	6.53	25.00	17.93	0.47
182	186	455H29		350	6.70	156.74	191.22	1.24	9.27	25.00	19.44	0.61
183	187	455H30		280	6.70	110.31	134.58	1.77	5.65	25.00	26.65	0.46
184	188	455H31		240	7.20	109.26	133.30	1.38	1.37	25.00	11.16	0.72
185	189	455H32		400	6.90	189.38	231.04	2.23	3.16	25.00	9.93	0.68
186	190	455H33		280	6.80	73.89	90.15	2.20	16.90	25.00	40.52	2.55
187	191	455H34		640	7.30	279.63	341.15	11.20	22.70	5543.00	8.72	0.92
188	192	455H34HDW		280	7.40	51.66	63.03	10.90	20.60	25.00	42.42	0.44
189	193	455H35HDW		190	6.90	75.40	91.99	3.17	5.40	25.00	15.73	2.30
190	194	455H36		260	7.10	80.26	97.92	6.74	11.90	25.00	21.25	3.35
191	195	455H37	31.5	230	6.80	96.57	117.82	0.88	5.43	25.00	13.15	0.84
192	196	455H38		170	6.90	78.65	95.95	1.03	3.67	163.00	16.50	1.97
193	197	455H38HDW		340	7.30	66.32	80.91	7.22	32.20	25.00	58.88	0.50
194	198	455H39HDW		210	6.50	88.29	107.71	1.25	2.75	25.00	12.12	0.84
195	199	455H39				105.45	128.65	1.39	3.08	25.00	10.59	0.94
196	200	455H40		280	7.00	127.58	155.65	2.91	4.31	25.00	14.75	0.44
197	201	455H41		140	7.10	49.19	60.01	0.13	4.17	25.00	21.75	0.83
198	202	455H42		280	6.70	139.90	170.68	1.97	6.40	25.00	8.72	0.50
199	203	455H43		230	7.40	54.75	66.79	1.01	14.80	25.00	34.82	2.53
200	204	455H44		290	6.70	151.77	185.16	1.64	4.97	25.00	11.02	0.56
201	205	455H45		280	6.90	114.70	139.93	2.97	9.28	25.00	8.84	1.45

No	Survey No	Well ID	Temp (C)	EC (uS/cm)	pH	Alk (ppm)	HCO3 (ppm)	SO4 (ppm)	Cl (ppm)	NO2 (ppb)	NO3 (ppm)	F (ppm)
135	139	455F28	31.5	530	6.90	281.91	343.93	2.32	5.53	25.00	4.21	0.21
136	140	455F29	31.0	250	7.10	99.89	121.83	1.13	4.04	25.00	17.58	2.91
137	141	455F30		330	6.90	137.65	167.93	1.76	6.92	25.00	19.15	3.33
138	142	455F31		290	7.10	95.45	116.45	3.58	6.38	25.00	35.06	3.63
139	143	455F32HDW		410	7.60	210.35	256.63	1.99	5.70	25.00	7.76	2.77
140	144	455F32POND		140	8.80	66.64	81.30	0.26	3.20	25.00	5.76	0.66
141	145	455F34		300	7.40	123.14	150.23	1.60	4.36	25.00	44.65	3.24
142	146	455F35		500	7.10	259.99	317.19	2.08	4.21	25.00	7.60	0.33
143	147	455F36	32.0	410	6.90	182.40	222.53	1.65	7.20	25.00	27.35	3.25
144	148	455F39	31.5	590	6.90	282.61	344.78	10.80	7.78	25.00	5.05	0.42
145	149	455F41	31.0	290	6.80	137.18	167.36	1.01	2.15	25.00	8.07	0.39
146	150	455F42		300	6.90	106.46	129.88	2.91	12.10	25.00	31.40	0.32
147	151	455F43		250	6.90	126.99	154.93	1.73	4.44	25.00	2.75	0.60
148	152	455F44HDW		450	7.40	218.62	266.72	4.62	3.35	25.00	9.78	0.92
149	153	455F44	32.0	400	7.10	208.11	253.89	2.73	3.54	213.00	4.71	0.46
150	154	455F45	31.0	420	7.00	194.24	236.97	3.09	4.86	25.00	20.15	0.33
151	155	455F46	31.0	510	7.10	245.31	300.50	1.81	6.64	25.00	17.66	0.36
152	156	455F49		340	7.40	145.01	176.91	2.44	3.24	25.00	20.25	2.94
153	157	455G1		390	6.70	197.71	241.21	1.20	1.96	25.00	3.24	0.43
154	158	455G2		360	7.40	183.96	224.43	3.81	4.18	25.00	0.03	0.50
155	159	455G5		240	6.80	136.52	166.55	1.98	3.60	25.00	8.62	0.50
156	160	455G6		400	7.30	208.80	254.74	1.70	2.83	148.00	9.70	0.45
157	161	455G9		410	6.70	205.34	250.51	3.14	3.72	25.00	11.17	0.43
158	162	455G11		340	7.20	126.20	153.96	2.18	12.80	25.00	26.75	0.61
159	163	455G12HDW		100	6.90	47.48	57.93	0.32	2.57	25.00	1.75	0.28
160	164	454G15		700	7.10	375.15	457.68	6.84	1.91	25.00	0.31	0.20
161	165	455G20		260	7.30	133.45	162.81	0.97	1.69	25.00	9.84	0.67
162	166	455H1HDW		90	6.80	27.26	33.26	0.70	2.84	25.00	16.81	1.59
163	167	455H1		310	6.70	89.27	100.91	11.70	18.80	25.00	27.25	2.83
164	168	455H2		350	7.40	171.18	208.84	1.99	5.20	226.00	3.92	0.39
165	169	455H3		240	7.40	86.95	106.08	1.24	10.50	25.00	33.77	1.98
166	170	455H5		280	7.60	140.56	171.48	1.49	2.97	25.00	10.27	1.08
167	171	455H6		400	7.40	216.93	264.65	5.14	4.34	142.00	2.38	0.45
168	172	455H9		300	6.90	166.08	202.62	0.90	3.43	25.00	5.50	0.38
169	173	455H10		300	7.80	138.21	168.62	1.55	5.81	247.00	8.75	1.36
170	174	455H11		270	7.10	122.69	149.68	1.19	2.57	25.00	13.79	2.81
171	175	455H12		240	7.00	111.34	135.83	13.90	4.03	221.00	11.90	3.39
172	176	455H13		260	7.00	65.65	80.09	1.32	18.60	25.00	32.78	0.63
173	177	455H14		210	6.80	100.13	122.16	1.37	2.74	25.00	5.84	2.08
174	178	455H15		190	7.00	81.06	98.89	1.03	2.98	25.00	16.44	2.91
175	179	455H15HDW		520	7.60	85.53	104.35	15.10	45.80	25.00	88.63	3.73
176	180	455H17		480	7.30	208.10	253.88	6.30	15.20	25.00	27.55	0.57
177	181	455H19		420	6.80	155.07	189.19	14.10	19.90	25.00	15.32	0.41
178	182	455H20HDW		130	6.90	55.71	67.97	2.23	5.73	25.00	16.56	1.36
179	183	455H20		230	5.90	110.57	134.90	3.43	4.21	25.00	12.74	3.62
180	184	455H25		390	6.90	171.34	209.03	3.75	9.54	25.00	18.15	0.47
181	185	455H26		510	7.10	253.61	309.65	2.94	6.53	25.00	17.93	0.47
182	186	455H29		350	6.70	156.74	191.22	1.24	9.27	25.00	18.44	0.61
183	187	455H30		280	6.70	110.31	134.58	1.77	5.65	25.00	26.65	0.46
184	188	455H31		240	7.20	109.26	133.30	1.38	6.37	25.00	11.16	0.72
185	189	455H32		400	6.90	189.38	231.04	2.23	3.16	25.00	9.93	0.68
186	190	455H33		280	6.80	73.89	90.15	2.20	16.90	25.00	40.52	2.55
187	191	455H34		640	7.30	279.63	341.15	11.20	22.70	5543.00	8.72	0.92
188	192	455H34HDW		280	7.40	51.66	63.03	10.90	20.60	25.00	42.42	0.44
189	193	455H35HDW		190	6.70	75.40	91.99	3.17	5.40	25.00	15.73	2.30
190	194	455H36		260	7.10	80.26	97.92	6.74	11.90	25.00	21.25	3.35
191	195	455H37	31.5	230	6.80	96.57	117.82	0.88	5.43	25.00	13.15	0.84
192	196	455H38		170	6.90	78.65	95.95	1.03	3.67	163.00	16.50	1.97
193	197	455H38HDW		340	7.30	66.32	80.91	7.22	32.20	25.00	58.88	0.50
194	198	455H39HDW		210	6.50	88.29	107.71	1.25	2.75	25.00	12.12	0.84
195	199	455H39				105.45	128.65	1.39	3.08	25.00	10.59	0.94
196	200	455H40		280	7.00	127.58	155.65	2.91	4.31	25.00	14.75	0.44
197	201	455H41		140	7.10	49.19	60.01	0.13	4.17	25.00	2.75	0.83
198	202	455H42		280	6.70	139.90	170.68	1.97	6.40	25.00	8.72	0.50
199	203	455H43		230	7.40	54.75	66.79	1.91	14.60	25.00	34.82	2.53
200	204	455H44			6.70	151.77	185.16	1.64	4.97	25.00	11.02	0.56
201	205	455H45		2	6.90	114.70	139.93	2.97	9.26	25.00	8.84	1.45

No.	Survey No.	Well ID	Temp (C)	EC (uS/cm)	pH	Alk (ppm)	HCO ₃ (ppm)	SO ₄ (ppm)	Cl (ppm)	NO ₂ (ppb)	NO ₃ (ppm)	F (ppm)
202	206	455H45HDW		630	7.10	260.24	317.49	3.70	21.40	25.00	40.93	4.39
203	207	455H46		410	6.70	221.21	299.88	1.69	3.03	25.00	6.19	0.49
204	208	455H47		450	7.30	247.33	301.74	4.19	2.36	25.00	0.61	0.42
205	209	455H48		290	7.40	148.75	181.48	2.45	1.45	25.00	4.40	0.47
206	210	455H49		440	6.80	219.59	267.90	2.55	6.52	25.00	18.80	0.43
207	211	455H50		220	7.40	84.03	102.52	2.86	7.08	25.00	20.15	0.40
208	212	455H51		180	6.80	115.76	141.23	0.81	3.68	25.00	18.92	2.20
209	213	455H52		660	6.80	225.58	275.21	10.90	38.80	25.00	59.82	0.30
210	214	455H53		130	6.30	47.44	57.88	0.65	7.78	25.00	27.90	0.87
211	215	455H54		330	7.10	121.28	147.86	7.58	14.20	25.00	26.55	2.64
212	216	455H55		350	7.10	168.03	205.00	2.98	3.33	25.00	16.17	0.55
213	217	455H56		180	6.70	53.75	65.57	3.40	9.95	25.00	19.58	2.98
214	218	455H57		370	6.50	57.95	70.70	10.90	26.30	25.00	75.82	2.07
215	219	455H58		770	7.80	367.72	465.22	2.81	12.40	25.00	13.88	0.21
216	220	455H59		460	7.20	217.49	285.34	6.47	11.50	25.00	8.84	0.59
217	221	455H61				95.44	116.44	2.92	6.34	25.00	11.16	1.03
218	222	455I4	31.5	360	7.10	172.33	210.24	2.53	7.46	230.00	10.99	1.51
219	223	455I5		320	6.90	154.29	188.23	3.27	5.11	25.00	12.59	0.48
220	224	455I7		330	6.90	170.32	207.79	2.90	3.97	25.00	4.17	0.40
221	225	455I9		440	7.10	205.66	250.91	17.00	8.26	25.00	22.49	0.23
222	226	455I9HDW		570	7.80	277.09	338.05	11.50	8.93	25.00	25.95	0.22
223	227	455I10		460	7.10	220.51	268.02	3.04	6.56	25.00	17.10	0.27
224	228	455I11		440	6.90	213.20	280.10	4.84	6.32	25.00	21.80	0.34
225	229	455I12	31.0	380	7.80	210.78	257.15	2.52	4.88	25.00	0.03	0.46
226	230	455I13		300	7.10	145.91	178.01	2.80	7.88	25.00	14.00	0.58
227	231	455I15	32.0	300	7.63	161.35	196.85	1.57	1.33	100.00	6.87	0.11
228	232	455I17		380	7.10	181.92	221.94	3.36	5.97	25.00	15.97	0.35
229	233	455I24		540	7.30	190.24	232.09	13.70	19.60	25.00	52.44	0.51
230	234	455I27	31.0	320	7.20	154.74	188.78	2.18	3.15	25.00	1.91	0.20
231	235	455I31		500	7.10	215.46	262.86	5.99	9.94	25.00	27.70	0.30
232	236	455I32	31.0	460	6.80	194.31	237.06	9.19	11.70	291.00	16.21	0.43
233	237	455I33	31.0	330	6.80	158.76	193.69	4.07	5.37	25.00	14.97	0.31
234	238	455I34		410	6.90	185.10	225.82	3.62	7.29	25.00	28.10	0.30
235	239	455I35		260	6.90	141.71	172.89	0.84	0.79	25.00	4.54	0.30
236	240	455I36		420	6.90	223.91	273.17	2.89	2.98	25.00	9.47	0.43
237	241	455I38		380	7.10	198.88	242.63	3.08	7.80	302.00	5.96	0.52
238	242	455I40		350	7.80	171.84	209.84	12.00	3.93	25.00	8.54	0.55
239	243	455I41		580	7.10	249.53	304.43	22.40	9.12	25.00	28.25	0.69
240	244	455I42		260	7.00	113.84	138.88	9.50	4.57	25.00	12.89	0.44
241	245	455I43		310	7.30	158.87	191.38	1.28	3.94	25.00	2.50	0.45
242	246	455I44		480	7.40	150.50	183.61	8.21	18.90	378.00	54.31	0.71
243	247	455I45	32.0	330	7.20	164.05	200.14	1.63	8.40	25.00	17.96	0.27
244	248	455I46		380	7.00	139.03	169.62	16.60	16.00	219.00	20.50	0.52
245	249	455I47		520	7.20	245.41	299.40	4.90	8.85	25.00	20.20	0.46
246	250	455I47HDW		280	7.50	102.01	124.45	4.02	6.28	25.00	24.45	0.26
247	251	455I48		300	7.10	152.07	185.53	2.50	4.66	25.00	13.58	0.20
248	252	455I49HDW		350	7.10	195.66	238.71	1.65	1.56	25.00	3.39	0.33
249	253	455I50		270	7.00	132.48	161.63	1.90	1.83	25.00	12.69	0.36
250	254	455I52		1310	7.10	218.29	266.31	47.90	125.00		211.00	0.29
251	255	455I53		530	7.20	172.17	210.05	12.60	26.00	25.00	29.65	0.44
252	256	455I54POND		90	8.50	46.50	56.73	0.13	5.86	25.00	0.03	0.30
253	257	455I54		350	7.10	173.63	211.83	2.49	4.63	25.00	9.82	0.52
254	258	455I58		580	7.10	206.49	251.92	12.00	38.00	25.00	47.76	0.59
255	259	455I59		150	6.70	68.29	83.31	0.65	4.57	25.00	14.33	0.17
256	260	P4?		680	6.80	298.24	363.85	6.77	24.90	25.00	19.55	0.29
257	261	P5		310	6.40	154.71	188.75	0.79	3.50	25.00	14.32	0.40
258	262	P10		430	7.20	223.49	272.66	2.63	2.00	25.00	3.52	1.67
259	263	P11		550	7.30	262.95	320.80	34.00	3.47	25.00	6.84	0.48
260	264	456A1	31.5	210	6.90	102.55	125.11	0.49	1.66	25.00	0.54	0.27
261	265	456C20	31.0	350	6.60	175.28	213.84	2.67	3.70	99.00	7.64	0.13
262	266	456D6	32.0	470	7.48	280.38	342.06	1.53	3.42	25.00	0.03	0.28
263	267	456D7	31.5	510	7.71	288.29	351.71	1.00	3.08	25.00	1.14	0.31
264	268	456D8	31.0	350	7.54	177.02	215.96	3.65	3.19	25.00	1.76	0.37
265	269	456D9	31.0	340	7.72	187.14	228.31	1.61	1.57	25.00	7.31	0.40
266	270	456D11	32.0	450	7.60	254.80	310.86	2.36	6.32	25.00	0.03	0.18
267	271	456D13	31.0	510	7.45	275.35	335.93	6.06	3.99	25.00	0.03	0.23
268	272	456D14	30.5	470	6.90	127.65	155.73	6.37	31.00	25.00	58.50	3.37

No.	Survey No.	Well ID	Temp (C)	EC (uS/cm)	pH	Alk (ppm)	HCO3 (ppm)	SO4 (ppm)	Cl (ppm)	NO2 (ppb)	NO3 (ppm)	F (ppm)
269	273	456D17	31.5	270	6.80	134.08	183.59	0.78	2.98	25.00	2.34	0.44
270	274	456D18	31.0	350	8.21	198.34	241.97	1.78	2.74	25.00	9.27	0.26
271	275	456D19	31.0	340	7.83	140.94	171.95	6.64	10.40	296.00	20.75	0.23
272	276	456D20	31.0	270	6.90	139.80	170.56	1.13	2.27	25.00	5.10	0.35
273	277	456D21	32.5	550	6.90	307.78	375.49	4.17	1.88	25.00	2.33	0.25
274	278	456D22	31.0	250	6.70	135.16	164.90	0.59	1.27	25.00	0.92	0.20
275	279	456D25	31.5	450	6.90	223.89	273.15	3.28	3.05	25.00	2.27	0.41
276	280	456D27	31.0	320	7.10	166.47	203.09	0.93	1.87	25.00	0.78	0.48
277	281	456D28	31.0	400	6.90	192.71	235.11	2.98	9.86	25.00	12.45	0.32
278	282	456D29	31.0	360	6.90	165.99	202.51	2.34	3.48	25.00	27.55	0.38
279	283	456D32	31.0	300	6.90	170.10	207.52	0.68	1.13	25.00	0.03	0.35
280	284	456D33	31.0	290	6.70	124.52	151.91	3.06	9.15	25.00	17.65	0.40
281	285	456D34	31.0	290	7.45	145.13	177.06	2.48	1.14	25.00	2.31	0.27
282	286	456E3	31.0	510	7.90	294.09	358.79	6.43	4.11	25.00	2.82	0.16
283	287	456E4	32.0	500	7.67	281.99	344.03	10.80	3.23	181.00	1.00	0.23
284	288	456G1	32.0	380	7.53	212.54	259.30	2.36	5.65	25.00	6.67	0.39
285	289	456GHDW1	29.0	520	7.78	256.75	313.23	17.10	7.20	25.00	20.96	0.32
286	290	456G3	32.0	350	7.10	200.33	244.40	2.49	1.61	25.00	1.19	0.34
287	291	456G3POND	29.0	440	8.98	241.48	294.61	6.92	8.67	25.00	1.13	0.22
288	292	456G5	32.0	250	7.50	126.97	154.90	3.04	5.21	25.00	12.10	0.54
289	293	456G6	31.0	290	7.57	154.57	188.58	4.09	6.99	184.00	11.46	0.27
290	294	456G9	30.0	320	7.43	189.76	231.51	7.00	5.03	94.00	2.95	0.20
291	295	456G10	31.0	350	7.32	143.70	175.31	2.78	3.53	77.00	4.43	0.30
292	296	456G11	31.0	250	7.54	129.07	157.47	5.29	7.35	25.00	20.81	0.91
293	297	456G12	31.0	300	7.79	186.16	227.12	2.98	3.28	25.00	2.70	0.21
294	298	456G13	30.0	320	7.65	170.89	208.49	3.94	5.68	142.00	1.65	0.20
295	299	456G16	31.0	320	7.30	181.86	221.87	2.96	2.07	25.00	6.58	0.24
296	300	456G17	30.0	320	7.51	175.79	214.46	5.32	4.33	163.00	6.28	0.24
297	301	456G18	32.0	240	7.16	133.90	163.36	3.54	2.93	72.00	5.21	0.51
298	302	456G22	31.0	380	7.01	216.55	264.19	6.06	7.98	137.00	12.99	0.17
299	303	456G23	30.5	390	7.51	184.32	224.87	10.40	8.60	25.00	13.20	0.25
300	304	456G24	32.0	250	7.45	136.15	166.10	7.18	0.99	25.00	0.48	0.42
301	305	456G25	31.0	460	7.78	268.59	327.68	1.47	3.56	25.00	0.03	0.23
302	306	456G26	31.0	630	7.31	209.37	255.43	48.00	12.50	920.00	25.50	0.22
303	307	456G27	32.0	510	7.22	235.92	287.82	47.70	2.09	25.00	0.19	0.20
304	308	456G28	31.0	270	7.78	138.10	168.48	2.70	4.84	25.00	9.06	0.35
305	309	456G30	30.0	280	7.68	168.15	205.14	3.03	5.20	25.00	1.70	0.29
306	310	456G31	32.0	420	6.67	200.16	244.20	5.51	3.57	25.00	1.57	0.37
307	311	456G34	31.0	380	7.40	199.15	242.96	4.75	3.47	25.00	0.31	0.26
308	312	456G36	30.0	420	7.78	237.36	289.58	4.52	4.83	25.00	2.72	0.17
309	313	456G37	30.0	390	7.34	220.99	269.61	7.67	6.53	25.00	0.03	0.34
310	314	456G39	30.4	340	7.47	179.11	218.51	3.46	5.78	25.00	7.97	0.22
311	315	456G43	31.0	380	7.35	223.50	272.67	4.35	6.25	25.00	2.54	0.20
312	316	456H2HDW	27.0	110	6.01	62.39	76.12	3.98	2.81	25.00	0.03	0.50
313	317	456H2	31.0	740	7.34							
314	318	456H3	31.0	590	7.22	344.58	420.39	2.27	2.37	25.00	1.50	0.31
315	319	456H4	32.0	340	6.63	180.51	220.22	1.66	4.47	25.00	6.51	0.61
316	320	456H5	31.0	500	7.53	289.22	352.85	1.44	3.60	25.00	0.03	0.64
317	321	456H6	31.0	320	7.06	194.51	237.30	2.23	0.72	25.00	0.03	0.51
318	322	456H7	31.0	390	7.97	246.27	300.45	1.29	2.58	25.00	1.13	0.20
319	323	456H8	32.0	210	6.92	109.32	133.37	3.29	5.46	25.00	13.01	1.84
320	324	456H9	30.0	260	7.20	142.16	173.44	11.10	4.78	25.00	4.76	3.74
321	325	456H10	31.0	220	6.45	92.42	112.75	4.48	5.20	25.00	24.75	0.89
322	326	456H11	31.0	610	6.56	75	235.40	3.45	4.19	25.00	14.04	1.54
323	327	456H13	31.0	310	5.95	6	155.87	1.47	1.18	25.00	2.94	1.26
324	328	456H14	30.0	290	6.83	111.26	208.94	3.28	2.55	25.00	7.90	1.46
325	329	456H15	31.0	330	6.34	196.06	239.19	1.31	1.27	25.00	0.03	1.05
326	330	456H17	32.0	320	6.89	144.38	176.14	6.36	5.00	25.00	26.55	1.70
327	331	453B1	32.0	310	6.80	154.19	188.11	5.06	12.40	25.00	17.40	0.79
328	332	453B3	31.0	330	6.80	172.60	210.57	3.72	4.75	25.00	7.21	0.51
329	333	453B4	31.0	260	6.60	147.22	179.61	2.35	2.66	25.00	12.82	0.48
330	334	453B6	32.0	300	6.60	149.74	182.88	1.49	3.87	25.00	11.62	0.51
331	335	453B7		280	6.70	124.74	152.18	2.40	7.83	25.00	23.50	0.50
332	336	453B8	32.0	300	6.60	145.80	177.88	6.34	5.78	3700.00	0.32	0.48
333	337	453B12		170	6.80	105.70	128.95	1.13	1.96	25.00	2.95	0.31
334	338	453B13		320	6.90	137.25	167.45	4.04	4.61	25.00	20.15	0.54
335	339	453B14		290	6.90	156.41	190.82	1.81	2.81	25.00	3.98	0.46

No.	Survey No.	Well ID	Temp (C)	EC (uS/cm)	pH	Alk (ppm)	HCO3 (ppm)	SO4 (ppm)	Cl (ppm)	NO2 (ppb)	NO3 (ppm)	F (ppm)
336	340	453B15	32.0	230	6.30	111.16	135.82	1.17	3.98	25.00	7.70	0.39
337	341	453B16	32.0	310	6.60	144.97	176.86	4.46	8.39	25.00	22.50	0.47
338	342	453B19	31.0	230	6.70	189.09	230.89	3.72	4.26	25.00	14.78	0.42
339	343	453B20		180	6.70	105.53	128.75	0.89	0.86	25.00	0.03	0.33
340	344	453B21	31.0	350	6.90	145.58	177.81	4.41	13.50	25.00	27.90	0.69
341	345	453B22	32.0	250	6.80	151.79	186.18	1.04	2.24	25.00	0.03	0.58
342	346	453B25	31.0	310	6.50	180.63	195.97	4.50	8.90	25.00	20.21	0.49
343	347	453B26	32.0	270	6.50	144.79	176.84	2.43	6.07	25.00	6.38	0.65
344	348	453B27		320	6.90	182.52	198.27	1.21	3.95	74.00	13.86	0.34
345	349	453B28	32.0	190	6.50	123.09	150.17	0.40	1.32	25.00	0.16	0.36
346	350	453C1	32.0	270	6.30	139.32	169.97	1.09	5.30	25.00	7.52	0.67
347	351	453C2	31.0	370	6.30	190.95	232.86	4.60	6.71	25.00	0.03	0.61
348	352	453C4	31.0	300	6.50	142.07	173.33	2.97	10.60	25.00	13.96	0.55
349	353	453C5	32.0	180	6.20	65.01	79.31	3.27	5.55	117.00	18.78	1.22
350	354	453C6		250		99.17	120.89	3.55	13.00	25.00	19.30	0.49
351	355	453C7	32.0	230	6.50	88.28	107.70	4.45	9.31	111.00	30.30	0.54
352	356	453C8	31.0	200	6.20	57.42	70.05	4.87	10.40	728.00	32.74	2.72
353	357	453C9	32.0	300	6.70	121.90	148.72	4.89	11.60	189.00	26.80	2.34
354	358	453C10	31.0	210	6.50	94.81	115.67	3.43	3.96	119.00	14.04	2.51
355	359	453C11	31.0	380	6.90	203.27	247.99	2.80	8.33	25.00	5.14	2.51
356	360	453C15	32.0	300	6.30	96.32	117.51	8.79	19.20	25.00	31.98	0.40
357	361	453C16	32.0	300	6.70	136.55	166.59	7.63	9.14	25.00	20.04	0.32
358	362	453C17	31.0	260	6.70	152.96	186.61	2.51	2.72	25.00	8.00	0.74
359	363	453C18	31.0	180	6.10	86.89	106.01	2.91	7.42	25.00	12.52	1.52
360	364	453C21	31.0	380	6.60	200.15	244.18	9.98	7.71	25.00	3.53	0.27
361	365	453C22	32.0	430	6.60	192.10	234.36	6.77	14.10	25.00	25.75	0.23
362	366	453C23	32.0	170	6.60	254.24	310.17	2.46	3.39	112.00	11.38	0.57
363	367	453C24	31.0	210	6.60	104.06	126.95	2.93	3.68	25.00	14.41	0.63
364	368	453C25	32.0	290	6.80	149.86	182.83	4.02	6.11	107.00	8.10	1.58
365	369	453C26	32.0	390	6.50	199.12	242.93	2.93	6.86	25.00	4.48	0.45
366	370	453C27	31.5	490	6.70	234.35	285.91	4.32	4.79	25.00	18.08	0.25
367	371	453C28	32.0	370	6.70	189.21	230.84	5.12	4.58	93.00	9.18	0.19
368	372	453C30	32.0	320	6.70	196.65	242.35	2.04	1.91	25.00	0.03	0.42
369	373	453E1	32.0	330	7.00	186.21	227.18	0.94	4.35	115.00	1.84	0.22
370	374	453E2	32.0	290	7.00	155.33	189.50	4.06	4.36	71.00	12.02	0.40
371	375	453E3	32.0	260	7.10	145.53	177.55	1.36	1.21	58.00	0.61	0.24
372	376	453E4	31.0	260	6.70	139.83	170.59	3.73	4.85	87.00	12.28	0.95
373	377	453E5	31.0	260	6.70	140.76	171.73	2.02	1.29	25.00	2.73	0.63
374	378	453E6	32.0	290	6.50	162.91	198.75	1.27	3.89	25.00	3.69	0.34
375	379	453F1	32.0	420	6.90	212.77	259.58	7.25	5.57	25.00	13.37	1.60
376	381	454A1	30.0	230	7.72	131.10	159.94	1.97	3.30	25.00	5.72	0.21
377	382	454A2	31.0	290	6.80	119.59	145.90	11.90	13.20	25.00	23.27	0.14
378	383	454A4	31.0	220	7.63	124.77	152.22	2.57	5.73	25.00	3.02	0.19
379	384	454A6	30.5	280	6.80	111.30	135.79	8.42	11.90	25.00	26.92	0.23
380	385	454A10	31.0	260	7.10	144.80	176.66	2.60	3.02	25.00	0.03	0.34
381	386	454A11	31.5	230	6.60	134.29	163.83	2.47	1.61	25.00	2.93	0.17
382	387	454A12	31.0	270	7.71	160.13	195.36	3.62	5.64	25.00	11.63	0.30
383	388	454A12/1	31.0	450	7.84	196.87	240.18	10.50	12.70	25.00	40.47	0.13
384	389	454A16	32.5	350	8.90	226.69	276.56	1.37	1.06	25.00	0.50	0.20
385	390	454B1	31.0	670	7.11	330.24	402.89	11.50	8.85	25.00	9.41	0.63
386	391	454B2	32.0	590	7.27	281.70	343.67	4.90	7.91	695.00	12.43	0.40
387	392	454BHDW	27.0	380	6.67	174.72	213.16	4.74	2.02	25.00	0.03	1.67
388	393	454B4	32.0	300	6.77	124.52	151.91	5.93	4.48	58.00	15.55	2.37
389	394	454B5	31.0	360	6.54	139.65	170.37	2.53	3.48	66.00	14.77	1.25
390	395	454B6	32.0	450	7.36	251.48	306.81	1.43	1.71	25.00	0.25	0.34

APPENDIX 2B

*** CHEMISTRY DATA (CATIONS)**

Calcium(Ca)
Magnesium(Mg)
Sodium(Na)
Potassium(K)
Iron(Fe)
Manganese(Mn)
Aluminium(Al)
Silica(SiO₂)
Strontium(Sr)

No.	Survey No.	Well ID	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Fe (ppb)	Mn (ppb)	Al (ppb)	SiO2 (ppm)	Sr (ppb)
1	3	455B1	54.00	28.00	42.00	3.20	1.00	700.00	0.80	51.34	780.00
2	4	455B2HDW	21.00	9.80	21.00	1.70	1.00	0.80	0.20	38.50	290.00
3	5	455B3	26.00	17.00	20.00	1.70	1.00	2.20	0.20	49.20	540.00
4	6	455B5	33.00	13.00	28.00	1.50	41.00	2.80	0.20	51.34	1100.00
5	7	455B6	44.00	17.00	26.00	1.30	1.00	3.40	0.20	49.20	1300.00
6	8	455B7	31.00	15.00	31.00	1.00	10.00	4.10	0.20	57.75	1200.00
7	9	455B9HDW	16.00	5.80	22.00	1.30	1.00	0.10	4.90	74.87	380.00
8	10	455B9	22.00	14.00	33.00	2.50	1.00	14.00	0.20	51.34	420.00
9	11	455B10	26.00	13.00	22.00	2.40	1.00	1.00	0.20	59.89	590.00
10	12	455B11	42.00	23.00	38.00	2.40	1.00	7.90	0.20	47.06	770.00
11	13	455B12	8.20	2.80	21.00	3.00	1.00	0.50	3.10	68.45	420.00
12	14	455B12HDW	18.00	2.30	18.00	2.30	3500.00	7.10	12000.00	70.59	270.00
13	15	455B13HDW	56.00	12.00	26.00	2.70	1.00	1.80	0.20	53.48	1800.00
14	16	455B13	21.00	12.00	22.00	2.40	1.00	1.80	1.80	57.75	620.00
15	17	455B17	21.00	7.00	25.00	2.10	1.00	2.00	0.80	62.03	800.00
16	18	455B18	17.00	6.20	22.00	1.30	1.00	1.70	0.80	66.31	610.00
17	19	455B19	13.00	5.50	26.00	2.40	1.00	3.60	0.90	62.03	500.00
18	20	455B20	21.00	12.00	23.00	1.90	1.00	0.92	0.90	53.48	430.00
19	21	455B21HDW	26.00	9.40	22.00	2.30	1.00	0.10	4.80	51.34	420.00
20	22	455B21	20.00	13.00	16.00	1.30	1.00	4.70	0.20	59.89	390.00
21	23	455B22	16.00	8.10	20.00	1.80	1.00	1.30	0.80	59.89	600.00
22	24	455B23	20.00	11.00	19.00	3.20	8.00	38.00	0.20	55.61	380.00
23	25	455B23POND	5.50	2.10	25.00	9.10	1300.00	26.00	1400.00	18.61	210.00
24	26	455B24	32.00	18.00	15.00	4.20	8.00	80.00	0.20	44.92	510.00
25	27	455B25	25.00	15.00	21.00	2.80	9.00	1.90	0.80	51.34	420.00
26	28	455B26	36.00	15.00	37.00	1.90	1.00	1.70	0.80	49.20	1200.00
27	29	455B27	34.00	18.00	26.00	1.10	1.00	3.20	0.20	59.89	860.00
28	30	455B28HDW	26.00	8.50	29.00	2.40	1.00	0.10	1.80	64.17	890.00
29	31	455B28	17.00	10.00	15.00	3.00	1.00	1.40	1.10	72.73	460.00
30	32	455B29	45.00	21.00	43.00	2.40	10.00	86.00	1.00	55.61	640.00
31	33	455B30HDW	12.00	3.20	22.00	1.20	1.00	0.30	2.80	66.31	380.00
32	34	455B32	41.00	14.00	38.00	1.50	92.00	6.30	1.30	49.20	940.00
33	35	455B34	7.80	4.60	14.00	2.00	1.00	1.30	0.70	72.73	250.00
34	36	455B35	28.00	13.00	27.00	1.80	35.00	4.20	0.20	57.75	960.00
35	37	455C1	42.00	21.00	15.00	1.20	1.00	11.00	0.20	49.20	150.00
36	38	455C2	42.00	23.00	19.00	0.88	1.00	0.60	0.20	51.34	200.00
37	39	455C3	55.00	29.00	50.00	3.30	1.00	32.00	0.20	47.06	340.00
38	40	455C4	49.00	35.00	31.00	4.00	1.00	13.00	0.20	47.06	290.00
39	41	455C7	19.00	12.00	17.00	2.10	43.00	9.30	0.20	42.78	210.00
40	42	455C10HDW	11.00	5.80	17.00	0.97	8.00	4.10	20.00	47.06	200.00
41	43	455C11	9.40	3.20	14.00	1.60	1.00	1.00	1.30	74.87	250.00
42	44	455C13	39.00	18.00	32.00	3.10	1.00	4.30	0.60	42.78	680.00
43	45	455C14	14.00	3.10	20.00	1.30	1.00	0.10	0.20	79.14	380.00
44	46	455C15	39.00	21.00	41.00	1.80	1.00	0.90	0.20	51.34	240.00
45	47	455C17	40.00	17.00	35.00	2.70	1.00	25.00	2.90	57.75	560.00
46	48	455C18	16.00	7.00	13.00	0.97	1.00	2.00	1.20	77.00	170.00
47	49	455C19	26.00	13.00	26.00	1.80	1.00	0.30	2.00	62.03	560.00
48	50	455C19HDW	23.00	8.90	62.00	1.10	1.00	0.10	2.00	47.06	560.00
49	51	455C23	30.00	16.00	18.00	1.40	1.00	1.60	0.60	49.20	190.00
50	52	455C24	39.00	18.00	34.00	2.70	14.00	77.00	2.10	47.06	410.00
51	53	455C25	21.00	9.10	23.00	3.20	1.00	1.30	1.00	53.48	280.00
52	54	455C27HDW	19.00	8.30	18.00	0.97	1.00	0.10	2.70	72.73	340.00
53	55	455C29	16.00	7.90	15.00	1.50	1.00	1.00	0.60	59.89	140.00
54	56	455C30	43.00	29.00	37.00	1.80	1.00	2.50	0.50	53.48	290.00
55	57	455C31	6.60	4.30	13.00	1.00	1.00	3.30	0.50	64.17	88.00
56	58	455C32	64.00	33.00	35.00	2.90	1.00	180.00	1.20	53.48	340.00
57	59	455C33	27.00	14.00	10.00	1.40	1.00	1.10	0.60	51.34	180.00
58	60	455C34	13.00	7.50	14.00	2.40	1.00	23.00	1.20	74.87	220.00
59	61	455C35	26.00	11.00	30.00	3.70	7.00	3.10	0.20	49.20	300.00
60	62	455C36	43.00	19.00	33.00	3.70	4.00	13.00	0.20	53.48	490.00
61	63	455C37	22.00	10.00	24.00	2.60	150.00	65.00	0.20	59.89	300.00
62	64	455C38	27.00	15.00	22.00	2.80	18.00	1.50	0.60	62.03	330.00
63	65	455C39	33.00	21.00	20.00	1.30	290.00	35.00	0.20	55.61	240.00
64	66	455C40	29.00	19.00	23.00	2.20	12.00	87.00	0.70	57.75	360.00
65	67	455C42	41.00	30.00	35.00	1.80	33.00	50.00	0.20	40.64	380.00
66	68	455C43	36.00	20.00	25.00	3.40	3.00	220.00	0.20	49.20	410.00
67	69	455C44	16.00	6.20	18.00	1.70	1.00	3.60	0.60	72.73	200.00

No.	Survey No.	Well ID	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Fe (ppb)	Mn (ppb)	Al (ppb)	SO2 (ppm)	Sr (ppb)
68	71	455C45	21.00	7.20	25.00	1.80	1.00	52.00	1.00	72.73	310.00
69	73	455C47	80.00	38.00	28.00	4.70	1.00	4.30	0.20	47.06	710.00
70	74	455C48	25.00	17.00	23.00	2.50	6.00	4.20	43.00	49.20	380.00
71	75	455D4	21.00	11.00	21.00	3.20	1.00	0.10	1.20	66.45	320.00
72	76	455D6	16.00	8.00	16.00	3.00	1.00	0.10	1.30	74.87	300.00
73	77	455D25	27.00	17.00	34.00	4.10	1.00	5.40	0.70	49.20	300.00
74	78	455D27	18.00	7.40	23.00	2.60	1.00	0.10	1.00	81.28	310.00
75	79	455D28	23.00	13.00	21.00	3.30	1.00	0.10	0.70	70.59	380.00
76	80	455D30	26.00	17.00	30.00	3.50	1.00	0.10	1.90	64.17	370.00
77	81	455D31	41.00	23.00	29.00	1.60	26.00	9.30	0.20	66.31	790.00
78	82	455D32	27.00	14.00	19.00	3.30	1.00	8.90	0.20	66.31	380.00
79	83	455D33	33.00	21.00	27.00	5.40	1.00	230.00	0.70	66.45	420.00
80	84	455E2	14.00	4.60	21.00	2.70	1.00	1.90	1.50	87.70	610.00
81	85	455E3POND	6.70	3.00	7.40	2.90	1.00	0.60	0.90	10.70	220.00
82	86	455E3	32.00	15.00	25.00	1.80	1.00	1.40	0.90	64.17	990.00
83	87	455E5	31.00	14.00	26.00	2.90	1.00	0.10	39.00	51.34	470.00
84	88	455E6	25.00	12.00	27.00	2.30	1.00	0.10	2.10	70.59	460.00
85	89	455E8 ?	36.00	17.00	36.00	3.10	1.00	2.90	0.60	53.48	660.00
86	90	455E9HDW	27.00	9.70	24.00	1.70	1.00	0.10	1.60	49.20	470.00
87	91	455E9	30.00	19.00	18.00	3.10	1.00	0.90	1.10	64.17	630.00
88	92	455E10	22.00	12.00	14.00	3.10	12.00	5.00	0.20	83.42	370.00
89	93	455E11	13.00	6.20	17.00	1.70	1.00	0.30	1.20	77.00	230.00
90	94	455E12	27.00	15.00	30.00	3.60	1.00	0.30	1.20	51.34	430.00
91	95	455E13	28.00	15.00	32.00	3.20	1.00	0.10	1.00	59.89	460.00
92	96	455E15	33.00	8.70	29.00	2.10	1.00	35.00	0.20	72.73	990.00
93	97	455E16HDW	9.90	4.10	19.00	1.00	1.00	0.10	4.10	79.14	290.00
94	98	455E17	25.00	6.80	26.00	1.90	1.00	17.00	0.60	74.87	800.00
95	99	455E20	23.00	6.70	27.00	1.70	1.00	1.30	1.30	77.00	720.00
96	100	455E21	13.00	7.70	26.00	1.20	1.00	0.10	1.50	77.00	350.00
97	101	455E22	24.00	13.00	29.00	3.20	1.00	3.10	1.00	55.61	530.00
98	102	455E23	25.00	14.00	24.00	1.80	1.00	0.90	0.90	62.03	840.00
99	103	455E24	18.00	7.20	29.00	2.20	1.00	1.30	0.90	79.14	790.00
100	104	455E25	19.00	9.10	26.00	1.60	1.00	3.20	1.40	77.00	730.00
101	105	455E27	26.00	15.00	27.00	3.20	1.00	2.70	4.20	53.48	380.00
102	106	455E28	22.00	12.00	23.00	3.20	1.00	0.40	1.80	64.17	360.00
103	107	455E30	40.00	20.00	33.00	3.00	1.00	0.20	1.20	64.17	710.00
104	108	455E33	39.00	20.00	39.00	2.40	30.00	7.10	0.20	55.61	710.00
105	109	455E33HDW	35.00	8.80	36.00	2.90	1.00	0.10	5.20	57.75	630.00
106	110	455E35	23.00	12.00	27.00	1.50	1.00	1.60	0.70	70.59	370.00
107	111	455E36	27.00	14.00	29.00	2.80	1.00	0.20	1.30	59.89	410.00
108	112	455E37	18.00	7.50	21.00	1.90	1.00	1.60	0.90	77.00	410.00
109	113	455E38	32.00	19.00	22.00	3.20	140.00	8.00	0.70	62.03	610.00
110	114	455E39	24.00	12.00	28.00	2.80	3.00	2.10	3.60	64.17	960.00
111	115	455E42	24.00	10.00	28.00	1.40	1.00	0.40	2.20	62.03	830.00
112	116	455F1	36.00	19.00	30.00	3.30	1.00	11.00	0.50	55.61	850.00
113	117	455F2	27.00	17.00	22.00	2.10	1.00	4.10	2.30	66.45	870.00
114	118	455F3	43.00	19.00	29.00	1.20	1.00	2.60	0.90	66.31	1500.00
115	119	455F4	22.00	11.00	19.00	2.00	1.00	0.60	1.60	59.89	620.00
116	120	455F6HDW	35.00	19.00	28.00	3.10	1.00	0.10	1.60	74.87	840.00
117	121	455F6	39.00	19.00	26.00	2.10	3.00	1.90	0.90	72.73	800.00
118	122	455F7	30.00	19.00	24.00	1.50	4.00	2.90	0.70	66.45	650.00
119	123	455F8	27.00	11.00	19.00	2.50	1.00	0.10	1.10	74.87	670.00
120	124	455F9	24.00	11.00	17.00	1.90	1.00	1.50	0.80	57.75	500.00
121	125	455F10	12.00	6.40	21.00	1.50	1.00	2.80	0.90	66.31	130.00
122	126	455F11	37.00	23.00	120.00	1.80	1.00	1.80	0.90	51.34	260.00
123	127	455F12	64.00	26.00	49.00	2.70	1.00	1.10	0.20	51.34	650.00
124	128	455F13	29.00	19.00	38.00	2.40	3.00	8.70	2.30	53.48	690.00
125	129	455F15	16.00	8.50	17.00	1.30	1.00	1.90	0.70	57.75	350.00
126	130	455F16	17.00	22.00	38.00	2.30	1.00	0.10	1.20	34.22	610.00
127	131	455F17	42.00	22.00	22.00	1.90	1.00	0.20	0.60	74.87	1200.00
128	132	455F18	55.00	28.00	24.00	2.20	1.00	2.50	0.50	72.73	1500.00
129	133	455F19	26.00	13.00	20.00	2.50	1.00	0.50	0.80	77.00	550.00
130	134	455F22	55.00	12.00	28.00	3.00	1.00	0.80	0.80	59.89	810.00
131	135	455F23	70.00	16.00	30.00	3.30	1.00	1.20	0.50	59.89	1100.00
132	136	455F25	36.00	16.00	25.00	2.80	24.00	8.00	1.00	59.89	590.00
133	137	455F26	36.00	19.00	31.00	1.80	1.00	6.00	1.10	70.59	520.00
134	138	455F27	38.00	22.00	40.00	3.30	1.00	54.00	0.20	49.20	350.00

No.	Survey No.	Well ID	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Fe (ppb)	Mn (ppb)	Al (ppb)	S02 (ppm)	Sr (ppb)
135	139	455F28	38.00	38.00	27.00	3.00	1.00	3.90	0.20	53.48	410.00
136	140	455F29	21.00	9.60	18.00	2.30	1.00	1.40	1.20	68.45	710.00
137	141	455F30	29.00	15.00	21.00	1.60	1.00	1.60	0.70	72.73	930.00
138	142	455F31	21.00	12.00	21.00	1.20	1.00	0.20	1.10	66.31	520.00
139	143	455F32HDW	21.00	11.00	65.00	0.65	1.00	0.10	2.00	64.17	550.00
140	144	455F32POND	14.00	4.50	10.00	6.00	1.00	0.10	0.50	14.76	310.00
141	145	455F34	28.00	13.00	20.00	1.40	18.00	1.00	18.00	64.17	680.00
142	146	455F35	55.00	24.00	28.00	2.00	1.00	13.00	0.50	40.64	410.00
143	147	455F36	36.00	23.00	28.00	1.30	1.00	1.50	1.70	66.31	840.00
144	148	455F39	50.00	22.00	48.00	4.70	1.00	33.00	0.20	55.61	500.00
145	149	455F41	29.00	8.00	24.00	1.60	1.00	3.10	1.30	70.59	350.00
146	150	455F42	24.00	14.00	19.00	1.50	1.00	6.70	0.80	64.17	250.00
147	151	455F43	23.00	14.00	18.00	0.67	1.00	1.30	1.70	53.48	380.00
148	152	455F44HDW	35.00	14.00	48.00	1.50	1.00	0.10	0.20	64.17	800.00
149	153	455F44	41.00	21.00	23.00	1.30	1.00	27.00	0.90	57.75	480.00
150	154	455F45	50.00	12.00	28.00	2.30	1.00	2.40	0.80	51.34	830.00
151	155	455F46	63.00	16.00	29.00	2.70	1.00	0.10	0.90	57.75	910.00
152	156	455F49	28.00	17.00	21.00	1.60	15.00	2.90	0.60	59.89	910.00
153	157	455G1	30.00	17.00	30.00	3.10	1.00	0.10	1.00	51.34	330.00
154	158	455G2	33.00	16.00	24.00	2.30	1.00	22.00	0.20	62.03	340.00
155	159	455G5	22.00	12.00	22.00	2.80	1.00	0.10	0.60	49.20	250.00
156	160	455G6	31.00	17.00	36.00	2.90	1.00	0.30	1.20	64.17	400.00
157	161	455G9	33.00	18.00	34.00	2.30	1.00	1.70	0.50	59.89	400.00
158	162	455G11	26.00	11.00	28.00	2.00	1.00	0.20	0.90	53.48	310.00
159	163	455G12HDW	6.80	3.20	11.00	2.10	150.00	0.40	200.00	38.50	100.00
160	164	454G15	72.00	28.00	43.00	0.73	1.00	17.00	2.50	42.78	550.00
161	165	455G20	18.00	9.10	29.00	2.50	1.00	0.10	1.60	66.31	250.00
162	166	455H1HDW	3.40	1.20	17.00	0.84	1.00	0.80	15.00	96.26	96.00
163	167	455H1	25.00	13.00	20.00	2.00	1.00	1.30	2.00	74.67	680.00
164	168	455H2	22.00	14.00	33.00	2.10	15.00	5.00	0.20	51.34	270.00
165	169	455H3	22.00	13.00	15.00	2.70	1.00	1.20	0.20	77.00	680.00
166	170	455H5	23.00	15.00	16.00	1.50	1.00	0.40	6.60	64.17	500.00
167	171	455H6	34.00	14.00	41.00	3.00	1.00	2.50	1.00	55.61	390.00
168	172	455H9	23.00	19.00	17.00	2.70	1.00	0.10	0.90	57.75	240.00
169	173	455H10	24.00	15.00	17.00	1.50	1.00	4.70	0.90	51.34	360.00
170	174	455H11	23.00	12.00	17.00	2.30	1.00	0.80	3.20	74.67	670.00
171	175	455H12	24.00	12.00	19.00	2.00	1.00	0.10	0.50	74.67	720.00
172	176	455H13	19.00	11.00	16.00	3.60	1.00	0.60	0.90	74.67	630.00
173	177	455H14	17.00	7.30	22.00	1.80	1.00	0.20	2.20	74.67	680.00
174	178	455H15	16.00	8.60	16.00	1.90	1.00	0.10	1.80	74.67	420.00
175	179	455H15HDW	49.00	19.00	25.00	1.30	1.00	0.10	2.70	59.89	1200.00
176	180	455H17	58.00	12.00	32.00	2.40	1.00	0.80	2.10	55.61	700.00
177	181	455H19	40.00	10.00	29.00	11.00	1.00	0.10	0.90	36.36	890.00
178	182	455H20HDW	11.00	4.30	19.00	1.00	1.00	0.10	0.20	74.67	320.00
179	183	455H20	23.00	11.00	19.00	1.60	1.00	0.10	1.50	64.17	590.00
180	184	455H25	38.00	10.00	33.00	1.70	1.00	0.70	1.00	59.89	630.00
181	185	455H26	56.00	15.00	42.00	1.10	1.00	1.00	0.70	44.92	790.00
182	186	455H29	27.00	13.00	32.00	2.40	5.00	2.90	0.20	62.03	290.00
183	187	455H30	22.00	10.00	23.00	3.20	1.00	0.10	0.20	55.61	330.00
184	188	455H31	20.00	11.00	17.00	0.76	81.00	2.40	0.20	62.03	260.00
185	189	455H32	31.00	16.00	31.00	4.10	24.00	5.20	0.20	53.48	310.00
186	190	455H33	21.00	10.00	23.00	2.60	1.00	1.50	2.50	74.67	710.00
187	191	455H34	44.00	31.00	49.00	2.20	16.00	7.70	1.80	38.50	680.00
188	192	455H34HDW	16.00	5.10	27.00	12.00	1700.00	2.30	3900.00	29.95	650.00
189	193	455H35HDW	14.00	5.80	21.00	1.80	1.00	0.10	4.20	79.14	470.00
190	194	455H36	21.00	9.60	19.00	2.00	1.00	0.80	1.30	68.45	610.00
191	195	455H37	20.00	9.10	15.00	2.70	1.00	0.80	1.30	57.75	530.00
192	196	455H38	15.00	6.80	19.00	1.50	1.00	0.20	2.60	77.00	620.00
193	197	455H38HDW	24.00	6.80	29.00	18.00	1.00	0.10	1.00	57.75	780.00
194	198	455H39HDW	15.00	4.50	22.00	2.10	1.00	0.10	2.40	64.17	400.00
195	199	455H39	18.00	6.50	24.00	3.10	1.00	0.10	1.00	83.42	1200.00
196	200	455H40	27.00	6.20	27.00	1.80	1.00	0.40	0.80	68.45	680.00
197	201	455H41	9.20	5.40	14.00	3.00	1.00	0.30	0.50	72.73	250.00
198	202	455H42	26.00	10.00	24.00	1.30	16.00	3.80	0.20	72.73	400.00
199	203	455H43	16.00	8.50	18.00	1.50	1.00	0.70	1.30	81.28	450.00
200	204	455H44	25.00	12.00	27.00	4.00	7.00	0.10	0.90	57.75	340.00
201	205	455H45	20.00	12.00	20.00	1.40	13.00	5.90	0.90	55.61	390.00

No.	Survey No.	Well ID	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Fe (ppb)	Mn (ppb)	Al (ppb)	Sr (ppm)	Sr (ppb)
202	206	455H45HDW	48.00	25.00	54.00	2.70	1.00	2.60	1.50	49.20	970.00
203	207	455H46	36.00	21.00	25.00	2.70	1.00	0.10	0.20	64.17	540.00
204	208	455H47	36.00	22.00	31.00	2.20	1.00	9.60	0.20	55.61	400.00
205	209	455H48	23.00	9.10	29.00	1.30	41.00	24.00	0.20	57.75	230.00
206	210	455H49	35.00	20.00	31.00	4.30	1.00	0.10	1.30	55.61	510.00
207	211	455H50	15.00	8.20	19.00	1.30	1.00	2.60	0.70	62.03	160.00
208	212	455H51	21.00	13.00	17.00	1.70	1.00	0.80	2.20	77.00	530.00
209	213	455H52	53.00	36.00	29.00	2.10	1.00	19.00	0.20	51.34	620.00
210	214	455H53	9.10	4.10	22.00	2.00	1.00	0.20	0.90	85.56	380.00
211	215	455H54	27.00	18.00	21.00	1.40	1.00	0.30	0.20	53.48	480.00
212	216	455H55	37.00	9.20	26.00	3.00	1.00	1.50	0.20	66.31	640.00
213	217	455H56	13.00	5.90	18.00	2.40	7.00	2.70	1.10	77.00	380.00
214	218	455H57	25.00	12.00	30.00	2.20	1.00	0.60	1.40	79.14	820.00
215	219	455H58	85.00	40.00	54.00	1.60	1.00	1.50	0.80	57.75	580.00
216	220	455H59	55.00	16.00	27.00	1.20	1.00	28.00	0.60	51.34	470.00
217	221	455H61	15.00	10.00	20.00	0.71	1.00	2.50	0.90	72.73	310.00
218	222	455I4	28.00	16.00	26.00	1.40	8.00	3.60	0.20	62.03	510.00
219	223	455I5	29.00	8.10	34.00	1.20	1.00	1.50	0.80	57.75	540.00
220	224	455I7	32.00	11.00	25.00	2.30	1.00	2.60	0.80	53.48	420.00
221	225	455I9	43.00	19.00	31.00	1.60	1.00	0.10	0.20	57.75	280.00
222	226	455I9HDW	59.00	25.00	36.00	0.89	1.00	0.10	2.10	47.06	160.00
223	227	455I10	55.00	12.00	28.00	2.50	1.00	3.40	0.20	66.31	830.00
224	228	455I11	55.00	12.00	29.00	2.90	1.00	2.70	1.20	64.17	910.00
225	229	455I12	45.00	10.00	28.00	3.80	1.00	2.30	0.90	57.75	580.00
226	230	455I13	31.00	9.50	25.00	2.80	1.00	1.30	0.60	57.75	490.00
227	231	455I15	33.00	15.00	12.00	0.65	1.00	2.00	0.20	57.75	91.00
228	232	455I17	46.00	11.00	22.00	3.00	1.00	0.70	0.60	57.75	630.00
229	233	455I24	54.00	14.00	40.00	4.80	1.00	2.70	0.20	47.06	550.00
230	234	455I27	35.00	12.00	13.00	0.26	1.00	260.00	0.20	44.92	65.00
231	235	455I31	61.00	13.00	29.00	3.80	1.00	3.00	2.00	44.92	750.00
232	236	455I32	47.00	14.00	31.00	4.40	1.00	8.70	0.20	49.20	590.00
233	237	455I33	34.00	14.00	20.00	3.40	1.00	2.50	1.60	59.89	550.00
234	238	455I34	46.00	13.00	24.00	2.70	1.00	0.10	16.00	53.48	940.00
235	239	455I35	30.00	5.90	23.00	3.00	1.00	0.50	2.80	66.31	420.00
236	240	455I36	52.00	13.00	24.00	2.10	1.00	0.10	4.20	66.31	870.00
237	241	455I38	35.00	16.00	29.00	2.50	3.00	9.20	0.20	55.61	480.00
238	242	455I40	32.00	15.00	23.00	2.30	1.00	0.50	0.20	57.75	470.00
239	243	455I41	52.00	19.00	49.00	2.70	1.00	4.50	1.80	62.03	880.00
240	244	455I42	22.00	8.90	23.00	2.50	1.00	1.70	0.20	57.75	350.00
241	245	455I43	29.00	13.00	20.00	2.30	1.00	2.30	0.20	51.34	280.00
242	246	455I44	39.00	12.00	39.00	3.50	1.00	1.00	0.20	49.20	440.00
243	247	455I45	44.00	13.00	12.00	0.16	1.00	11.00	5.90	44.92	79.00
244	248	455I46	32.00	10.00	33.00	4.50	1.00	1.00	0.20	53.48	380.00
245	249	455I47	59.00	12.00	39.00	4.60	1.00	2.40	0.20	55.61	630.00
246	250	455I47HDW	27.00	4.50	22.00	3.30	1.00	0.10	2.30	42.78	390.00
247	251	455I48	31.00	14.00	14.00	0.73	18.00	87.00	0.70	55.61	69.00
248	252	455I49HDW	46.00	8.80	22.00	4.40	1.00	0.10	3.00	70.59	620.00
249	253	455I50	30.00	8.20	17.00	3.10	1.00	2.10	0.20	57.75	410.00
250	254	455I52	130.00	40.00	72.00	8.20	1.00	4.50	0.20	49.20	1700.00
251	255	455I53	50.00	14.00	36.00	6.30	1.00	3.00	0.20	47.06	510.00
252	256	455I54POND	7.70	2.50	8.00	5.60	1.00	0.20	7.30	4.28	200.00
253	257	455I54	32.00	8.00	34.00	2.70	1.00	4.40	0.20	49.20	310.00
254	258	455I58	59.00	20.00	40.00	4.30	1.00	2.90	0.20	49.20	1100.00
255	259	455I59	14.00	3.40	16.00	1.90	1.00	1.40	0.20	59.89	230.00
256	260	P4?	60.00	28.00	48.00	6.30	1.00	0.10	0.20	53.48	630.00
257	261	P5	29.00	14.00	19.00	2.80	1.00	0.10	8.60	62.03	320.00
258	262	P10	43.00	21.00	20.00	5.70	1.00	0.10	0.20	53.48	900.00
259	263	P11	58.00	26.00	27.00	6.30	1.00	0.40	2.80	49.20	560.00
260	264	456A1	13.00	8.30	18.00	1.60	1.00	4.20	0.20	53.48	150.00
261	265	456C20	36.00	16.00	11.00	0.33	1.00	5.90	0.20	36.36	130.00
262	266	456D6	48.00	21.00	41.00	0.45	1.00	0.60	0.20	42.78	200.00
263	267	456D7	51.00	25.00	36.00	2.20	1.00	9.60	0.20	49.20	350.00
264	268	456D8	41.00	14.00	13.00	0.35	1.00	0.30	0.20	44.92	56.00
265	269	456D9	40.00	18.00	12.00	0.32	1.00	130.00	0.20	55.61	51.00
266	270	456D11	47.00	21.00	33.00	0.29	1.00	26.00	0.20	38.50	300.00
267	271	456D13	53.00	19.00	34.00	0.28	1.00	9.10	0.20	53.48	320.00
268	272	456D14	45.00	16.00	27.00	3.20	1.00	0.40	1.40	57.75	1800.00

No.	Survey No.	Well ID	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Fe (ppb)	Mn (ppb)	Al (ppb)	Sr02 (ppm)	Sr (ppb)
269	273	456D17	28.00	8.40	17.00	2.30	1.00	8.90	0.20	49.20	320.00
270	274	456D18	46.00	15.00	16.00	0.23	1.00	40.00	0.20	42.78	120.00
271	275	456D19	34.00	17.00	12.00	0.21	1.00	260.00	0.20	55.61	89.00
272	276	456D20	28.00	7.30	20.00	2.20	1.00	2.50	1.00	55.61	350.00
273	277	456D21	61.00	21.00	36.00	0.47	1.00	110.00	0.20	57.75	220.00
274	278	456D22	25.00	6.30	21.00	2.60	1.00	4.00	0.70	64.17	440.00
275	279	456D25	39.00	17.00	30.00	2.30	4.00	50.00	0.20	57.75	660.00
276	280	456D27	26.00	11.00	25.00	2.20	120.00	56.00	0.50	53.48	400.00
277	281	456D28	40.00	13.00	27.00	3.70	1.00	3.00	0.20	51.34	420.00
278	282	456D29	41.00	11.00	23.00	3.60	1.00	3.40	0.20	57.75	540.00
279	283	456D32	30.00	10.00	22.00	2.90	1.00	3.70	0.50	57.75	810.00
280	284	456D33	24.00	8.40	27.00	3.30	1.00	1.50	0.20	55.61	340.00
281	285	456D34	28.00	11.00	13.00	0.22	1.00	6.80	0.20	32.09	65.00
282	286	456E3	46.00	32.00	33.00	0.34	1.00	1.90	0.80	32.09	400.00
283	287	456E4	56.00	19.00	29.00	0.23	1.00	0.10	0.20	36.50	370.00
284	288	456G1	36.00	17.00	26.00	0.49	1.00	23.00	0.20	51.34	160.00
285	289	456GHDW1	51.00	25.00	41.00	0.86	1.00	0.10	0.20	62.03	110.00
286	290	456G3	36.00	19.00	15.00	0.71	10.00	5.90	0.20	40.64	97.00
287	291	456G3POND	45.00	26.00	19.00	3.90	1.00	0.10	0.20	21.39	140.00
288	292	456G5	23.00	13.00	15.00	0.49	1.00	2.20	0.20	57.75	140.00
289	293	456G6	33.00	13.00	16.00	0.25	34.00	3.60	0.20	42.78	96.00
290	294	456G9	46.00	16.00	12.00	0.26	1.00	430.00	0.20	49.20	100.00
291	295	456G10	30.00	13.00	10.00	0.26	1.00	120.00	0.20	51.34	32.00
292	296	456G11	23.00	13.00	24.00	0.33	1.00	1.90	0.20	70.59	340.00
293	297	456G12	45.00	13.00	12.00	0.28	1.00	99.00	0.20	47.06	44.00
294	298	456G13	42.00	13.00	11.00	0.25	33.00	300.00	0.20	47.06	60.00
295	299	456G16	37.00	18.00	12.00	0.25	1.00	43.00	0.20	53.48	65.00
296	300	456G17	38.00	16.00	13.00	0.30	1.00	210.00	0.20	40.64	62.00
297	301	456G18	20.00	12.00	22.00	0.30	10.00	8.10	0.20	57.75	170.00
298	302	456G22	47.00	22.00	15.00	0.32	1.00	1.20	0.20	47.06	85.00
299	303	456G23	52.00	15.00	10.00	0.29	1.00	2.80	0.20	36.50	88.00
300	304	456G24	29.00	8.60	18.00	0.37	1.00	2.80	0.20	64.17	360.00
301	305	456G25	54.00	24.00	25.00	0.27	1.00	6.60	0.20	49.20	240.00
302	306	456G26	59.00	26.00	27.00	0.28	1.00	24.00	0.20	49.20	170.00
303	307	456G27	51.00	29.00	22.00	1.40	1.00	6.30	0.20	66.45	260.00
304	308	456G28	33.00	12.00	11.00	0.38	28.00	130.00	0.20	53.48	32.00
305	309	456G30	44.00	11.00	11.00	0.19	1.00	47.00	0.20	40.64	55.00
306	310	456G31	43.00	12.00	26.00	0.22	6.00	74.00	0.20	51.34	150.00
307	311	456G34	40.00	19.00	16.00	0.21	1.00	47.00	0.20	32.09	170.00
308	312	456G36	60.00	17.00	13.00	0.54	1.00	34.00	0.20	36.50	67.00
309	313	456G37	43.00	17.00	27.00	0.29	1.00	270.00	0.20	34.22	280.00
310	314	456G39	37.00	20.00	9.50	0.24	10.00	2.70	0.20	47.06	58.00
311	315	456G43	51.00	19.00	13.00	0.36	1.00	260.00	0.20	40.64	75.00
312	316	456H2HDW	14.00	2.40	11.00	1.50	66.00	0.50	320.00	32.09	300.00
313	317	456H2	62.00	33.00	41.00	2.90	1.00	1.70	0.20	42.78	850.00
314	318	456H3	62.00	29.00	37.00	1.40	1.00	140.00	0.20	36.36	480.00
315	319	456H4	31.00	15.00	26.00	0.38	1.00	7.80	0.20	74.87	260.00
316	320	456H5	42.00	32.00	25.00	8.40	1.00	13.00	0.20	62.03	320.00
317	321	456H6	37.00	11.00	27.00	0.50	1.00	45.00	0.20	57.75	230.00
318	322	456H7	50.00	20.00	22.00	0.39	1.00	2.10	0.20	55.61	220.00
319	323	456H8	24.00	5.70	21.00	1.90	1.00	2.00	0.20	72.73	520.00
320	324	456H9	39.00	7.60	19.00	1.40	1.00	19.00	0.80	49.20	970.00
321	325	456H10	20.00	3.90	28.00	2.00	1.00	1.70	0.20	83.42	750.00
322	326	456H11	45.00	12.00	27.00	0.67	1.00	3.00	0.20	59.89	820.00
323	327	456H13	25.00	5.60	20.00	1.60	1.00	7.00	0.20	72.73	590.00
324	328	456H14	37.00	9.30	25.00	2.10	1.00	2.10	0.20	64.17	710.00
325	329	456H15	38.00	12.00	26.00	1.30	1.00	6.40	0.20	66.31	650.00
326	330	456H17	37.00	7.70	24.00	1.70	1.00	3.20	0.20	72.73	630.00
327	331	453B1	28.00	15.00	28.00	2.90	1.00	1.50	0.80	57.75	480.00
328	332	453B3	27.00	14.00	29.00	3.60	1.00	4.60	0.20	49.20	400.00
329	333	453B4	28.00	6.90	28.00	2.80	1.00	0.40	7.40	64.17	540.00
330	334	453B6	28.00	8.00	26.00	1.70	1.00	0.50	0.20	77.00	670.00
331	335	453B7	27.00	6.70	25.00	2.40	1.00	3.90	81.00	74.87	550.00
332	336	453B8	26.00	6.80	31.00	2.20	1.00	6.30	1.00	81.28	710.00
333	337	453B12	15.00	4.60	26.00	1.00	1.00	0.10	0.20	79.14	360.00
334	338	453B13	30.00	9.30	26.00	0.83	1.00	2.10	0.80	70.59	730.00
335	339	453B14	31.00	5.70	28.00	0.92	1.00	3.90	0.80	70.59	660.00

No.	Survey No.	Well ID	Ca (ppm)	Mg (ppm)	Na (ppm)	K (ppm)	Fe (ppb)	Mn (ppb)	Al (ppb)	SiO2 (ppm)	Sr (ppb)
336	340	453B15	21.00	5.10	25.00	1.90	1.00	2.90	0.80	85.58	480.00
337	341	453B16	31.00	9.70	27.00	2.80	1.00	0.10	1.30	74.87	700.00
338	342	453B19	39.00	9.10	34.00	2.80	1.00	2.50	0.90	70.59	1000.00
339	343	453B20	15.00	3.70	25.00	1.30	1.00	2.40	0.80	77.00	410.00
340	344	453B21	28.00	15.00	28.00	3.90	1.00	4.20	9.80	53.48	420.00
341	345	453B22	23.00	7.20	29.00	3.10	1.00	2.10	2.90	70.59	510.00
342	346	453B25	32.00	8.90	33.00	3.20	1.00	1.60	1.40	74.87	690.00
343	347	453B26	21.00	11.00	28.00	2.40	1.00	0.10	0.20	62.03	310.00
344	348	453B27	33.00	9.50	26.00	1.30	1.00	1.60	0.60	55.61	350.00
345	349	453B28	21.00	4.40	25.00	2.30	1.00	2.70	0.90	79.14	530.00
346	350	453C1	33.00	8.10	14.00	4.00	1.00	0.10	0.20	55.61	450.00
347	351	453C2	37.00	13.00	27.00	3.60	1.00	8.30	6.80	62.03	630.00
348	352	453C4	33.00	8.70	22.00	4.30	1.00	0.10	0.70	51.34	330.00
349	353	453C5	11.00	4.10	24.00	1.70	1.00	3.10	0.70	70.59	250.00
350	354	453C6	22.00	11.00	19.00	2.00	1.00	0.70	2.40	57.75	340.00
351	355	453C7	20.00	9.50	17.00	2.90	1.00	29.00	1.70	68.45	240.00
352	356	453C8	15.00	6.90	21.00	1.00	1.00	3.00	0.50	70.59	270.00
353	357	453C9	24.00	12.00	27.00	1.30	1.00	0.40	4.00	66.31	370.00
354	358	453C10	16.00	7.90	20.00	2.40	1.00	22.00	1.30	64.17	210.00
355	359	453C11	30.00	18.00	38.00	1.40	1.00	16.00	3.10	49.20	380.00
356	360	453C15	25.00	13.00	18.00	2.80	1.00	1.30	0.80	64.17	330.00
357	361	453C16	34.00	17.00	10.00	0.72	1.00	0.10	1.00	47.06	100.00
358	362	453C17	27.00	9.30	25.00	3.20	1.00	0.90	0.80	51.34	280.00
359	363	453C18	17.00	5.80	22.00	1.40	1.00	2.00	0.80	70.59	310.00
360	364	453C21	45.00	18.00	13.00	0.89	7.00	7.00	0.20	57.75	92.00
361	365	453C22	47.00	24.00	15.00	2.50	1.00	2.60	34.00	53.48	320.00
362	366	453C23	38.00	19.00	33.00	5.50	1.00	62.00	6.20	53.48	480.00
363	367	453C24	17.00	9.90	15.00	2.30	1.00	140.00	0.20	70.59	210.00
364	368	453C25	26.00	12.00	26.00	1.80	1.00	11.00	18.00	51.34	240.00
365	369	453C26	40.00	14.00	25.00	4.10	1.00	11.00	0.62	55.61	520.00
366	370	453C27	58.00	24.00	26.00	0.39	1.00	16.00	0.20	34.22	220.00
367	371	453C28	42.00	19.00	13.00	0.49	1.00	18.00	0.20	44.92	85.00
368	372	453C30	37.00	17.00	20.00	3.40	1.00	10.00	0.20	49.20	390.00
369	373	453E1	35.00	18.00	13.00	0.53	1.00	67.00	2.00	51.34	99.00
370	374	453E2	30.00	15.00	18.00	3.60	32.00	28.00	80.00	38.50	220.00
371	375	453E3	24.00	14.00	14.00	1.20	1.00	150.00	1.70	44.92	88.00
372	376	453E4	29.00	14.00	12.00	1.70	1.00	1.70	3.70	57.75	140.00
373	377	453E5	22.00	11.00	20.00	2.60	1.00	3.10	0.20	53.48	310.00
374	378	453E6	24.00	14.00	24.00	2.60	1.00	4.20	8.20	51.34	330.00
375	379	453F1	50.00	21.00	13.00	2.00	1.00	170.00	9.60	57.75	120.00
376	381	454A1	32.00	8.10	9.50	0.25	1.00	21.00	0.20	36.36	45.00
377	382	454A2	39.00	13.00	9.10	0.23	1.00	24.00	1.50	53.48	53.00
378	383	454A4	28.00	11.00	9.50	0.19	1.00	130.00	0.20	55.61	35.00
379	384	454A6	39.00	8.50	11.00	0.27	8.00	16.00	0.60	34.22	70.00
380	385	454A10	29.00	13.00	10.00	0.25	1.00	0.70	0.20	47.06	41.00
381	386	454A11	28.00	12.00	11.00	0.19	1.00	2.30	0.20	42.78	47.00
382	387	454A12	39.00	15.00	11.00	0.23	1.00	0.70	0.20	51.34	62.00
383	388	454A12/1	63.00	18.00	13.00	0.27	1.00	110.00	0.60	42.78	98.00
384	389	454A16	56.00	16.00	15.00	0.26	1.00	14.00	0.20	40.64	86.00
385	390	454B1	72.00	24.00	47.00	2.60	1.00	13.00	1.10	38.50	960.00
386	391	454B2	57.00	24.00	34.00	1.40	14.00	71.00	0.20	38.50	390.00
387	392	454BHDW	38.00	8.80	24.00	2.50	1.00	0.10	1.70	64.17	820.00
388	393	454B4	35.00	5.10	19.00	1.40	1.00	0.90	0.50	64.17	880.00
389	394	454B5	34.00	6.30	21.00	1.70	1.00	1.40	1.00	74.87	740.00
390	395	454B6	47.00	23.00	24.00	0.88	33.00	12.00	0.20	42.78	320.00

APPENDIX 2C

*** CHEMISTRY DATA (CATIONS)**

Boron(B)

Barium(Ba)

Lithium(Li)

Rubidium(Rb)

Uranium(U)

Vanadium(V)

Molybdenum(Mo)

Copper(Cu)

Zinc(Zn)

No.	Survey No.	Well ID	B (ppb)	Ba (ppb)	Li (ppb)	Rb (ppb)	U (ppb)	V (ppb)	Mo (ppb)	Cu (ppb)	Zn (ppb)
1	3	455B1	18.00	540.00	5.00	0.10	0.70	28.00	0.90	38.00	53.00
2	4	455B2HDW	8.00	290.00	1.00	0.90	0.10	21.00	0.50	2.10	7.00
3	5	455B3	8.00	170.00	8.00	0.70	0.10	13.00	2.70	0.20	51.00
4	6	455B5	31.00	140.00	17.00	3.00	0.20	8.60	18.00	1.00	63.00
5	7	455B6	30.00	50.00	39.00	3.90	0.80	3.80	7.90	0.20	12.00
6	8	455B7	8.00	94.00	21.00	1.10	1.10	5.40	0.50	0.20	71.00
7	9	455B9HDW	8.00	84.00	5.00	1.90	0.30	33.00	0.50	0.60	3.00
8	10	455B9	8.00	69.00	11.00	0.10	0.10	17.00	4.90	0.20	7.00
9	11	455B10	8.00	200.00	8.00	0.10	0.10	22.00	1.80	0.20	120.00
10	12	455B11	8.00	310.00	4.00	0.30	0.10	13.00	0.90	0.20	21.00
11	13	455B12	8.00	310.00	5.00	2.10	0.10	4.60	0.50	3.60	310.00
12	14	455B12HDW	8.00	120.00	18.00	7.40	0.30	17.00	0.50	12.00	11.00
13	15	455B13HDW	8.00	130.00	0.90	1.60	0.50	5.50	0.50	21.00	12.00
14	16	455B13	8.00	140.00	11.00	0.10	0.10	23.00	1.10	0.70	24.00
15	17	455B17	8.00	80.00	42.00	0.50	0.10	6.90	0.90	1.20	140.00
16	18	455B18	8.00	130.00	26.00	0.30	0.30	5.20	0.50	3.30	100.00
17	19	455B19	8.00	120.00	7.00	8.30	0.10	3.30	0.50	2.00	77.00
18	20	455B20	8.00	120.00	13.00	0.20	0.10	19.00	1.00	0.70	6.00
19	21	455B21HDW	8.00	180.00	10.00	1.60	0.10	20.00	0.60	0.20	3.00
20	22	455B21	8.00	77.00	8.00	0.50	0.10	23.00	2.30	3.00	66.00
21	23	455B22	8.00	94.00	18.00	3.10	0.10	8.50	0.80	1.20	10.00
22	24	455B23	8.00	120.00	12.00	0.40	0.10	14.00	1.70	0.20	5.00
23	25	455B23POND	8.00	110.00	0.50	7.40	0.40	3.40	0.80	1.90	1.00
24	26	455B24	8.00	200.00	8.00	0.30	0.10	18.00	2.90	0.20	62.00
25	27	455B25	8.00	180.00	13.00	0.70	0.20	19.00	3.00	0.20	41.00
26	28	455B26	39.00	150.00	53.00	0.60	1.00	14.00	2.50	4.90	230.00
27	29	455B27	8.00	140.00	15.00	1.70	2.30	8.10	2.10	11.00	230.00
28	30	455B28HDW	8.00	340.00	18.00	9.10	0.10	5.00	0.60	1.30	8.00
29	31	455B28	8.00	170.00	8.00	1.60	0.10	17.00	0.90	1.10	13.00
30	32	455B29	8.00	110.00	26.00	0.40	4.40	12.00	8.40	0.20	36.00
31	33	455B30HDW	8.00	100.00	10.00	7.70	0.10	5.30	0.50	4.90	6.00
32	34	455B32	34.00	49.00	95.00	2.20	11.00	3.90	7.40	0.20	16.00
33	35	455B34	8.00	120.00	6.00	0.30	0.40	14.00	0.50	2.40	90.00
34	36	455B35	8.00	160.00	25.00	0.90	0.50	6.40	0.70	0.20	18.00
35	37	455C1	8.00	20.00	4.00	0.40	0.10	40.00	0.60	1.30	7.00
36	38	455C2	8.00	13.00	9.00	0.50	0.10	70.00	4.50	0.20	140.00
37	39	455C3	8.00	100.00	10.00	0.60	1.20	42.00	3.30	0.20	3.00
38	40	455C4	8.00	130.00	7.00	0.60	1.20	54.00	1.00	0.20	190.00
39	41	455C7	8.00	81.00	1.00	0.10	0.10	1.70	0.50	0.20	12.00
40	42	455C10HDW	8.00	100.00	3.00	0.90	0.10	9.10	0.50	2.70	54.00
41	43	455C11	8.00	100.00	4.00	0.10	0.10	22.00	0.50	15.00	91.00
42	44	455C13	8.00	310.00	5.00	0.10	0.10	21.00	0.50	5.80	34.00
43	45	455C14	8.00	120.00	5.00	0.10	0.10	6.00	0.50	0.20	5.00
44	46	455C15	8.00	87.00	17.00	0.10	1.90	44.00	1.60	0.20	41.00
45	47	455C17	8.00	180.00	12.00	0.10	0.10	3.40	0.70	9.50	7.00
46	48	455C18	8.00	140.00	12.00	0.10	0.10	5.80	0.90	11.00	98.00
47	49	455C19	8.00	250.00	5.00	0.10	0.10	40.00	0.50	80.00	5.00
48	50	455C19HDW	8.00	130.00	2.00	0.80	0.10	25.00	0.50	0.60	1.00
49	51	455C23	8.00	38.00	8.00	0.60	0.10	42.00	1.90	0.20	4.00
50	52	455C24	23.00	87.00	11.00	0.10	0.60	9.30	2.30	0.20	20.00
51	53	455C25	8.00	280.00	5.00	0.10	0.10	34.00	0.80	5.50	10.00
52	54	455C27HDW	8.00	130.00	3.00	0.80	0.10	36.00	0.50	2.40	5.00
53	55	455C29	8.00	69.00	12.00	0.10	0.10	19.00	1.50	0.20	21.00
54	56	455C30	8.00	92.00	9.00	0.20	0.60	52.00	0.90	0.20	17.00
55	57	455C31	8.00	15.00	20.00	0.10	0.10	19.00	0.50	0.20	13.00
56	58	455C32	8.00	190.00	38.00	0.40	3.10	33.00	24.00	0.20	13.00
57	59	455C33	8.00	34.00	6.00	0.50	0.10	34.00	3.70	0.70	20.00
58	60	455C34	8.00	190.00	5.00	0.10	0.10	27.00	0.50	7.30	6.00
59	61	455C35	8.00	370.00	3.00	0.10	0.10	14.00	0.50	0.50	19.00
60	62	455C36	58.00	140.00	9.00	0.10	0.10	7.30	1.00	0.20	11.00
61	63	455C37	8.00	270.00	5.00	0.10	0.10	3.40	0.50	1.40	46.00
62	64	455C38	8.00	140.00	7.00	0.10	0.10	26.00	0.50	0.20	1.00
63	65	455C39	8.00	42.00	18.00	0.20	0.10	24.00	2.70	0.20	3.00
64	66	455C40	36.00	59.00	24.00	0.40	0.10	11.00	1.20	2.00	86.00
65	67	455C42	8.00	99.00	17.00	1.30	0.40	30.00	1.60	0.20	9.00
66	68	455C43	28.00	140.00	6.00	0.10	0.10	16.00	0.70	0.20	14.00
67	69	455C44	8.00	70.00	3.00	0.10	0.10	13.00	0.50	1.80	120.00

No.	Survey No.	Well ID	B (ppb)	Ba (ppb)	Li (ppb)	Rb (ppb)	U (ppb)	V (ppb)	Mo (ppb)	Cu (ppb)	Zn (ppb)
68	71	455C45	8.00	180.00	10.00	0.10	0.10	4.00	0.50	4.50	120.00
69	73	455C47	8.00	320.00	24.00	0.80	1.30	36.00	1.10	0.20	24.00
70	74	455C48	8.00	210.00	8.00	0.30	0.10	24.00	0.50	0.20	57.00
71	75	455D4	8.00	180.00	5.00	0.30	0.10	13.00	0.50	0.20	1.00
72	76	455D8	8.00	240.00	8.00	0.10	0.10	15.00	0.50	0.20	1.00
73	77	455D25	8.00	320.00	10.00	0.20	0.10	13.00	0.50	0.80	110.00
74	78	455D27	8.00	170.00	5.00	0.10	0.10	12.00	0.50	0.20	4.00
75	79	455D28	8.00	250.00	7.00	0.10	0.10	19.00	0.50	0.20	1.00
76	80	455D30	8.00	220.00	4.00	0.30	0.10	20.00	0.50	0.20	1.00
77	81	455D31	8.00	380.00	13.00	0.80	0.70	14.00	0.50	0.20	45.00
78	82	455D32	19.00	140.00	14.00	0.10	0.10	15.00	0.50	0.20	27.00
79	83	455D33	8.00	280.00	19.00	0.10	0.80	36.00	1.70	0.20	5.00
80	84	455E2	8.00	230.00	7.00	0.30	0.10	9.00	0.50	1.00	24.00
81	85	455E3POND	8.00	63.00	0.50	2.20	0.10	0.70	0.50	0.70	1.00
82	86	455E3	8.00	240.00	20.00	0.50	1.10	6.80	2.60	0.20	73.00
83	87	455E5	8.00	380.00	4.00	0.10	0.10	20.00	0.50	0.20	3.00
84	88	455E6	8.00	330.00	4.00	0.10	0.10	36.00	0.50	0.20	1.00
85	89	455E8 ?	29.00	380.00	8.00	0.10	0.50	17.00	0.70	0.20	3.00
86	90	455E9HDW	8.00	140.00	7.00	1.70	0.20	18.00	0.50	0.20	1.00
87	91	455E9	8.00	190.00	13.00	0.30	0.10	27.00	1.00	0.20	16.00
88	92	455E10	18.00	82.00	5.00	0.30	0.10	21.00	3.80	0.20	17.00
89	93	455E11	8.00	110.00	4.00	0.10	0.10	30.00	0.50	0.20	2.00
90	94	455E12	8.00	300.00	4.00	0.10	0.10	19.00	0.50	0.70	5.00
91	95	455E13	8.00	380.00	6.00	0.30	0.10	19.00	0.50	0.20	1.00
92	96	455E15	67.00	46.00	53.00	0.80	0.80	2.80	2.10	0.20	10.00
93	97	455E16HDW	8.00	44.00	10.00	4.70	0.10	13.00	1.20	0.90	15.00
94	98	455E17	18.00	280.00	33.00	2.10	0.40	3.40	2.60	0.20	300.00
95	99	455E20	8.00	270.00	54.00	0.20	0.10	4.30	0.50	5.40	36.00
96	100	455E21	8.00	91.00	13.00	0.80	0.10	19.00	2.20	0.20	31.00
97	101	455E22	8.00	85.00	13.00	0.10	0.10	9.80	2.70	0.90	55.00
98	102	455E23	8.00	110.00	33.00	2.40	0.40	7.50	2.70	0.20	100.00
99	103	455E24	8.00	140.00	13.00	0.30	0.10	7.50	0.50	0.20	70.00
100	104	455E25	8.00	270.00	27.00	1.90	0.30	6.10	1.50	0.20	74.00
101	105	455E27	8.00	280.00	7.00	0.10	0.10	20.00	0.50	0.20	3.00
102	106	455E28	8.00	310.00	6.00	0.10	0.10	20.00	0.50	0.20	2.00
103	107	455E30	8.00	380.00	6.00	0.50	0.10	18.00	0.50	0.20	1.00
104	108	455E33	8.00	410.00	4.00	0.10	0.30	18.00	0.50	0.20	15.00
105	109	455E33HDW	8.00	130.00	4.00	5.80	0.10	17.00	0.50	0.70	11.00
106	110	455E35	8.00	170.00	4.00	0.50	0.10	27.00	1.50	0.20	3.00
107	111	455E36	8.00	340.00	6.00	0.10	0.10	23.00	0.50	0.20	1.00
108	112	455E37	8.00	140.00	11.00	4.00	0.40	6.40	2.00	1.80	4.00
109	113	455E38	19.00	110.00	18.00	0.80	0.20	12.00	2.10	0.20	9.00
110	114	455E39	8.00	150.00	14.00	0.30	0.10	5.40	0.70	1.70	50.00
111	115	455E42	8.00	340.00	16.00	0.10	0.10	7.20	0.80	0.20	12.00
112	116	455F1	35.00	120.00	30.00	0.10	1.30	9.80	5.00	0.20	96.00
113	117	455F2	8.00	83.00	40.00	1.30	0.40	12.00	0.80	0.20	120.00
114	118	455F3	45.00	110.00	33.00	1.40	0.30	7.80	3.80	0.20	7.00
115	119	455F4	8.00	170.00	18.00	0.20	0.10	9.80	1.30	0.20	250.00
116	120	455F6HDW	8.00	130.00	13.00	1.00	0.10	6.10	0.50	0.20	31.00
117	121	455F5	8.00	180.00	31.00	0.70	0.10	4.00	1.30	0.20	53.00
118	122	455F7	19.00	110.00	36.00	0.80	0.10	6.20	1.80	0.20	19.00
119	123	455F8	8.00	0.20	20.00	0.10	0.10	10.00	6.20	3.90	23.00
120	124	455F9	8.00	120.00	15.00	0.10	0.10	11.00	3.40	0.20	2.00
121	125	455F10	8.00	52.00	20.00	0.10	0.10	13.00	0.50	0.50	490.00
122	126	455F11	8.00	130.00	11.00	0.10	2.60	41.00	1.80	0.80	14.00
123	127	455F12	8.00	100.00	40.00	0.10	2.30	25.00	1.10	0.20	1.00
124	128	455F13	8.00	210.00	32.00	0.20	0.80	7.20	4.30	0.80	26.00
125	129	455F15	8.00	90.00	12.00	0.10	0.10	7.70	1.00	0.20	8.00
126	130	455F16	8.00	130.00	49.00	3.20	4.10	5.80	1.50	0.20	1.00
127	131	455F17	8.00	240.00	33.00	1.30	0.10	8.40	1.70	0.20	1.00
128	132	455F18	8.00	280.00	38.00	1.40	0.10	6.50	0.80	0.20	680.00
129	133	455F19	8.00	210.00	23.00	0.20	0.10	15.00	0.80	0.20	21.00
130	134	455F22	8.00	31.00	11.00	0.50	1.30	7.40	0.70	0.20	6.00
131	135	455F23	8.00	64.00	9.00	0.50	3.70	7.20	1.30	0.20	4.00
132	136	455F25	8.00	220.00	39.00	0.10	0.50	14.00	1.80	0.80	28.00
133	137	455F26	18.00	37.00	18.00	0.70	0.80	26.00	5.80	0.20	39.00
134	138	455F27	8.00	8.40	43.00	0.10	0.30	4.50	1.70	0.20	11.00

No.	Survey No.	Well ID	B (ppb)	Ba (ppb)	Li (ppb)	Rb (ppb)	U (ppb)	V (ppb)	Mo (ppb)	Cu (ppb)	Zn (ppb)
135	139	455F28	8.00	210.00	8.00	0.10	0.50	17.00	1.10	2.20	1.00
136	140	455F29	6.00	240.00	3.00	0.80	0.10	12.00	1.40	3.40	33.00
137	141	455F30	8.00	230.00	15.00	3.80	0.40	13.00	1.80	0.20	7.00
138	142	455F31	8.00	78.00	27.00	0.70	0.10	7.10	2.00	0.20	26.00
139	143	455F32HDW	8.00	81.00	0.50	0.80	1.20	25.00	1.80	2.10	1.00
140	144	455F32POND	8.00	86.00	0.50	3.20	0.10	1.30	0.80	6.80	1.00
141	145	455F34	8.00	230.00	17.00	0.80	0.10	7.80	2.80	0.20	52.00
142	146	455F35	8.00	51.00	33.00	0.80	1.50	14.00	1.80	0.20	78.00
143	147	455F36	8.00	100.00	12.00	1.70	1.00	13.00	2.40	1.30	32.00
144	148	455F38	8.00	180.00	28.00	0.10	3.10	9.40	4.90	0.20	1.00
145	149	455F41	8.00	21.00	18.00	0.10	0.10	6.80	2.70	3.80	87.00
146	150	455F42	8.00	22.00	6.00	0.10	0.10	31.00	1.10	0.20	1.00
147	151	455F43	8.00	23.00	3.00	1.00	0.10	40.00	0.50	0.20	3.00
148	152	455F44HDW	8.00	160.00	4.00	1.20	0.70	27.00	1.50	0.20	2.00
149	153	455F44	8.00	42.00	11.00	0.20	0.50	33.00	3.20	0.80	5.00
150	154	455F45	8.00	30.00	8.00	0.10	0.80	4.40	0.80	1.20	21.00
151	155	455F46	8.00	41.00	11.00	0.80	2.20	6.10	1.90	1.40	1.00
152	156	455F49	8.00	21.00	44.00	1.80	1.80	6.20	1.80	1.00	56.00
153	157	455G1	8.00	110.00	12.00	0.20	0.40	14.00	1.10	0.20	1.00
154	158	455G2	7.00	98.00	37.00	0.10	0.50	5.90	2.00	0.20	2.00
155	159	455G5	8.00	150.00	10.00	0.20	0.10	5.80	1.20	0.20	1.00
156	160	455G8	8.00	140.00	14.00	0.20	0.70	14.00	0.50	0.80	1.00
157	161	455G9	8.00	85.00	9.00	0.20	0.30	17.00	0.50	0.20	4.00
158	162	455G11	8.00	220.00	8.00	0.10	0.10	7.00	0.50	0.20	1.00
159	163	455G12HDW	8.00	99.00	2.00	4.80	0.10	3.80	1.30	0.70	1.00
160	164	454G15	25.00	3.20	17.00	0.80	1.10	0.79	3.40	1.00	2.00
161	165	455G20	8.00	150.00	7.00	0.10	0.10	28.00	0.50	0.20	1.00
162	166	455H1HDW	8.00	45.00	2.00	1.80	0.10	12.00	0.50	0.20	8.00
163	167	455H1	8.00	140.00	10.00	4.30	0.10	7.40	1.30	3.70	44.00
164	168	455H2	8.00	88.00	24.00	0.10	0.10	10.00	0.70	0.70	4.00
165	169	455H3	8.00	230.00	6.00	0.50	0.10	4.00	0.80	2.00	23.00
166	170	455H5	8.00	77.00	8.00	0.10	0.10	33.00	1.10	0.20	240.00
167	171	455H6	8.00	200.00	17.00	0.10	0.80	14.00	1.00	1.00	100.00
168	172	455H9	8.00	50.00	17.00	0.30	0.10	19.00	1.40	0.20	5.00
169	173	455H10	8.00	38.00	9.00	0.10	0.10	35.00	1.00	0.70	3.00
170	174	455H11	8.00	140.00	10.00	0.70	0.10	23.00	1.80	0.20	9.00
171	175	455H12	21.00	64.00	9.00	1.20	0.10	16.00	2.30	0.20	1.00
172	176	455H13	8.00	270.00	3.00	0.20	0.10	21.00	0.60	0.20	27.00
173	177	455H14	8.00	180.00	10.00	1.20	0.10	10.00	1.10	22.00	8.00
174	178	455H15	8.00	110.00	8.00	0.30	0.10	22.00	1.20	0.20	3.00
175	179	455H15HDW	8.00	150.00	18.00	3.50	0.10	5.10	2.80	0.20	9.00
176	180	455H17	8.00	21.00	17.00	0.40	1.90	5.90	4.30	4.10	130.00
177	181	455H19	8.00	320.00	7.00	1.00	0.30	2.70	0.80	1.90	6.00
178	182	455H20HDW	8.00	92.00	11.00	3.00	0.10	6.80	0.80	1.80	68.00
179	183	455H20	8.00	61.00	23.00	0.70	0.10	10.00	3.10	0.20	1.00
180	184	455H25	8.00	25.00	12.00	0.60	0.40	7.20	4.80	0.20	78.00
181	185	455H26	30.00	70.00	30.00	1.40	4.80	2.70	1.10	0.20	8.00
182	186	455H29	8.00	140.00	11.00	0.10	0.10	17.00	0.50	0.20	19.00
183	187	455H30	8.00	160.00	5.00	0.20	0.10	16.00	0.50	0.20	5.00
184	188	455H31	8.00	6.20	29.00	0.30	0.10	25.00	4.80	0.20	3.00
185	189	455H32	16.00	69.00	15.00	0.30	0.40	11.00	1.70	0.20	16.00
186	190	455H33	8.00	200.00	10.00	1.90	0.10	11.00	1.00	0.20	30.00
187	191	455H34	74.00	53.00	61.00	2.90	17.00	11.00	18.00	0.80	73.00
188	192	455H34HDW	8.00	520.00	0.50	18.00	0.10	3.80	0.50	1.50	11.00
189	193	455H35HDW	8.00	280.00	2.00	6.00	0.10	10.00	0.70	0.20	12.00
190	194	455H36	8.00	120.00	16.00	0.60	0.10	9.20	1.60	1.40	30.00
191	195	455H37	8.00	130.00	10.00	0.40	0.10	7.20	0.50	3.00	390.00
192	196	455H38	8.00	110.00	13.00	1.30	0.10	11.00	1.30	0.20	10.00
193	197	455H38HDW	8.00	340.00	7.00	10.00	0.10	4.00	0.50	11.00	6.00
194	198	455H39HDW	8.00	140.00	4.00	2.80	0.10	9.40	0.50	0.70	4.00
195	199	455H39	8.00	580.00	5.00	7.90	0.10	9.60	0.50	0.90	2.00
196	200	455H40	8.00	65.00	5.00	0.60	0.10	8.00	0.70	0.20	83.00
197	201	455H41	8.00	99.00	5.00	0.20	0.10	13.00	0.70	2.00	6.00
198	202	455H42	8.00	200.00	19.00	1.00	0.20	4.00	1.50	0.20	15.00
199	203	455H43	8.00	110.00	4.00	4.70	0.10	9.30	0.50	3.90	14.00
200	204	455H44	8.00	140.00	9.00	0.10	0.10	12.00	2.50	0.20	5.00
201	205	455H45	8.00	85.00	11.00	0.10	0.10	13.00	1.40	0.90	4.00

No.	Survey No.	Vwell ID	B (ppb)	Ba (ppb)	Li (ppb)	Rb (ppb)	U (ppb)	V (ppb)	Mo (ppb)	Cu (ppb)	Zn (ppb)
135	139	455F28	8.00	210.00	8.00	0.10	0.50	17.00	1.10	0.20	1.00
136	140	455F29	8.00	240.00	3.00	0.90	0.10	12.00	1.40	3.40	33.00
137	141	455F30	8.00	230.00	15.00	3.80	0.40	13.00	1.90	0.20	7.00
138	142	455F31	8.00	76.00	27.00	0.70	0.10	7.10	2.00	0.20	28.00
139	143	455F32HDW	8.00	91.00	0.50	0.80	1.20	25.00	1.80	2.10	1.00
140	144	455F32POND	8.00	86.00	0.50	3.20	0.10	1.30	0.90	6.80	1.00
141	145	455F34	8.00	230.00	17.00	0.90	0.10	7.90	2.60	0.20	52.00
142	146	455F35	8.00	51.00	33.00	0.80	1.50	14.00	1.80	0.20	78.00
143	147	455F36	8.00	100.00	12.00	1.70	1.00	13.00	2.40	1.30	32.00
144	148	455F39	8.00	160.00	26.00	0.10	3.10	9.40	4.90	0.20	1.00
145	149	455F41	8.00	21.00	16.00	0.10	0.10	6.80	2.70	3.90	87.00
146	150	455F42	8.00	22.00	6.00	0.10	0.10	31.00	1.10	0.20	1.00
147	151	455F43	8.00	23.00	3.00	1.00	0.10	40.00	0.50	0.20	3.00
148	152	455F44HDW	8.00	160.00	4.00	1.20	0.70	27.00	1.50	0.20	2.00
149	153	455F44	8.00	42.00	11.00	0.20	0.50	33.00	3.20	0.80	5.00
150	154	455F45	8.00	30.00	8.00	0.10	0.80	4.40	0.60	1.20	21.00
151	155	455F46	8.00	41.00	11.00	0.90	2.20	6.10	1.90	1.40	1.00
152	156	455F49	8.00	21.00	44.00	1.90	1.60	6.20	1.80	1.00	58.00
153	157	455G1	8.00	110.00	12.00	0.20	0.40	14.00	1.10	0.20	1.00
154	158	455G2	22.00	98.00	37.00	3.10	0.50	5.90	2.00	0.20	2.00
155	159	455G5	8.00	150.00	10.00	0.20	0.10	5.60	1.20	0.20	1.00
156	160	455G6	8.00	140.00	14.00	0.20	0.70	14.00	0.50	0.80	1.00
157	161	455G9	8.00	85.00	9.00	0.20	0.30	17.00	0.50	0.20	4.00
158	162	455G11	8.00	220.00	8.00	0.10	0.10	7.00	0.50	0.20	1.00
159	163	455G12HDW	8.00	99.00	2.00	4.60	0.10	2.60	1.30	0.70	1.00
160	164	454G15	25.00	3.20	17.00	0.60	1.10	0.79	3.40	1.00	8.00
161	165	455G20	8.00	150.00	7.00	0.10	0.10	29.00	0.50	0.20	1.00
162	166	455H1HDW	8.00	45.00	2.00	1.60	0.10	12.00	0.50	0.20	8.00
163	167	455H1	8.00	140.00	10.00	4.30	0.10	7.40	1.30	3.70	44.00
164	168	455H2	8.00	86.00	24.00	0.10	0.10	10.00	0.70	0.70	4.00
165	169	455H3	8.00	230.00	6.00	0.50	0.10	24.00	0.80	2.00	23.00
166	170	455H5	8.00	77.00	8.00	0.10	0.10	33.00	1.10	0.20	240.00
167	171	455H6	8.00	200.00	17.00	0.10	0.60	14.00	1.00	1.00	100.00
168	172	455H9	8.00	50.00	17.00	0.30	0.10	19.00	1.40	0.20	5.00
169	173	455H10	8.00	36.00	9.00	0.10	0.10	33.00	1.00	0.70	3.00
170	174	455H11	8.00	140.00	10.00	0.70	0.10	23.00	1.80	0.20	9.00
171	175	455H12	21.00	64.00	9.00	1.20	0.10	16.00	2.30	0.20	1.00
172	176	455H13	8.00	270.00	3.00	0.20	0.10	21.00	0.60	0.20	27.00
173	177	455H14	8.00	160.00	10.00	1.20	0.10	10.00	1.10	22.00	6.00
174	178	455H15	8.00	110.00	6.00	0.30	0.10	22.00	1.20	0.20	3.00
175	179	455H15HDW	8.00	150.00	18.00	3.50	0.10	5.10	2.60	0.20	9.00
176	180	455H17	8.00	21.00	17.00	0.40	1.90	5.90	4.30	4.10	130.00
177	181	455H19	8.00	320.00	7.00	1.00	0.30	2.70	0.60	1.90	6.00
178	182	455H20HDW	8.00	92.00	11.00	13.00	0.10	6.80	0.60	1.80	68.00
179	183	455H20	8.00	61.00	23.00	0.70	0.10	10.00	3.10	0.20	1.00
180	184	455H25	8.00	25.00	12.00	0.60	0.40	7.20	4.80	0.20	76.00
181	185	455H26	30.00	70.00	30.00	1.40	4.60	2.70	1.10	0.20	8.00
182	186	455H29	8.00	140.00	11.00	0.10	0.10	17.00	0.50	0.20	19.00
183	187	455H30	8.00	160.00	5.00	0.20	0.10	16.00	0.50	0.20	5.00
184	188	455H31	8.00	6.20	29.00	0.30	0.10	25.00	4.60	0.20	3.00
185	189	455H32	16.00	69.00	15.00	0.30	0.40	11.00	1.70	0.20	16.00
186	190	455H33	8.00	200.00	10.00	1.90	0.10	11.00	1.00	0.20	30.00
187	191	455H34	74.00	53.00	61.00	2.90	17.00	11.00	18.00	0.60	73.00
188	192	455H34HDW	8.00	520.00	0.50	18.00	0.10	3.80	0.50	1.50	11.00
189	193	455H35HDW	8.00	280.00	2.00	6.00	0.10	10.00	0.70	0.20	12.00
190	194	455H36	8.00	120.00	16.00	0.60	0.10	9.20	1.60	1.40	30.00
191	195	455H37	8.00	130.00	10.00	0.40	0.10	7.20	0.50	3.00	390.00
192	196	455H38	8.00	110.00	13.00	1.30	0.10	11.00	1.30	0.20	10.00
193	197	455H38HDW	8.00	340.00	7.00	10.00	0.10	4.00	0.50	11.00	6.00
194	198	455H39HDW	8.00	140.00	1.00	2.80	0.10	9.40	0.50	0.70	4.00
195	199	455H39	8.00	560.00	5.00	7.90	0.10	5.60	0.50	0.90	2.00
196	200	455H40	8.00	65.00	5.00	0.60	0.10	8.00	0.70	0.20	83.00
197	201	455H41	8.00	99.00	5.00	0.20	0.10	13.00	0.70	2.00	6.00
198	202	455H42	8.00	200.00	19.00	1.00	0.20	4.00	1.50	0.20	15.00
199	203	455H43	8.00	110.00	4.00	4.70	0.10	9.30	0.50	3.90	14.00
200	204	455H44	8.00	140.00	9.00	0.10	0.10	12.00	2.50	0.20	5.00
201	205	455H45	8.00	85.00	11.00	0.10	0.10	13.00	1.40	0.90	4.00

No.	Survey No.	Well ID	B (ppb)	Ba (ppb)	Li (ppb)	Rb (ppb)	U (ppb)	V (ppb)	Mo (ppb)	Cu (ppb)	Zn (ppb)
202	208	455H45HDW	8.00	110.00	3.00	2.80	4.00	13.00	2.50	110.00	34.00
203	207	455H46	19.00	330.00	7.20	0.40	0.20	22.00	0.50	1.50	2.00
204	208	455H47	8.00	1.70	20.00	0.10	0.70	9.30	1.70	1.00	17.00
205	209	455H48	8.00	3.90	16.00	0.10	0.10	6.90	1.70	0.20	80.00
206	210	455H49	8.00	470.00	6.00	0.10	0.10	33.00	0.50	0.20	1.00
207	211	455H50	8.00	24.00	20.00	0.10	0.10	11.00	0.80	0.70	7.00
208	212	455H51	8.00	130.00	4.00	0.50	0.10	19.00	2.00	3.30	2.00
209	213	455H52	8.00	140.00	14.00	0.10	0.50	28.00	0.80	0.20	27.00
210	214	455H53	8.00	150.00	6.00	2.30	0.10	8.80	0.50	0.20	10.00
211	215	455H54	8.00	53.00	16.00	0.10	0.20	10.00	3.10	1.20	85.00
212	216	455H55	8.00	27.00	13.00	0.10	0.40	9.80	2.80	0.20	280.00
213	217	455H56	8.00	130.00	6.00	1.10	0.10	13.00	1.50	0.20	610.00
214	218	455H57	8.00	280.00	7.00	2.00	0.10	8.50	0.80	3.10	140.00
215	219	455H58	8.00	81.00	23.00	0.50	2.50	37.00	0.70	0.20	35.00
216	220	455H59	8.00	40.00	60.00	2.10	5.30	14.00	6.10	0.20	53.00
217	221	455H61	8.00	78.00	14.00	1.30	0.10	8.40	2.40	0.50	6.00
218	222	455I4	8.00	88.00	11.00	0.10	0.30	12.00	1.80	0.20	4.00
219	223	455I5	8.00	6.50	7.00	0.80	0.30	5.10	0.50	6.80	46.00
220	224	455I7	8.00	27.00	11.00	0.30	0.10	2.90	1.80	1.10	4.00
221	225	455I9	8.00	6.70	6.00	0.20	0.50	10.00	42.00	2.40	64.00
222	226	455I9HDW	8.00	4.30	3.00	0.70	0.30	15.00	2.30	0.20	5.00
223	227	455I10	8.00	47.00	11.00	0.30	0.90	5.60	1.60	1.10	5.00
224	228	455I11	8.00	46.00	13.00	0.50	1.30	7.20	1.40	1.40	43.00
225	229	455I12	8.00	2.50	10.00	0.30	0.90	7.20	1.20	0.20	40.00
226	230	455I13	8.00	27.00	8.00	0.10	0.10	9.00	0.90	0.20	17.00
227	231	455I15	8.00	0.20	2.00	0.10	0.10	35.00	5.30	0.20	14.00
228	232	455I17	8.00	38.00	7.00	0.20	0.60	5.30	1.10	0.60	55.00
229	233	455I21	8.00	48.00	14.00	0.90	0.80	3.40	5.60	0.70	20.00
230	234	455I27	24.00	1.70	2.00	0.50	0.10	17.00	0.50	0.20	4.00
231	235	455I31	8.00	13.00	7.00	0.40	1.30	2.80	10.00	0.20	11.00
232	236	455I32	8.00	74.00	7.00	0.30	0.50	2.00	4.20	0.20	36.00
233	237	455I33	8.00	60.00	7.00	0.10	0.20	5.50	0.50	0.20	13.00
234	238	455I34	8.00	33.00	8.00	0.10	0.60	5.00	0.60	0.20	7.00
235	239	455I35	8.00	43.00	9.00	0.30	0.10	6.30	1.30	0.20	70.00
236	240	455I36	8.00	24.00	7.00	0.40	1.50	5.00	0.70	0.20	120.00
237	241	455I38	8.00	73.00	36.00	0.10	0.50	11.00	4.70	0.20	4.00
238	242	455I40	8.00	7.20	12.00	0.50	0.30	14.00	3.10	3.00	130.00
239	243	455I41	8.00	100.00	7.00	1.80	1.30	11.00	7.80	0.70	22.00
240	244	455I42	8.00	30.00	5.00	0.50	0.10	7.60	2.00	5.90	120.00
241	245	455I43	8.00	48.00	6.00	0.70	0.10	10.00	2.90	0.20	8.00
242	246	455I44	8.00	41.00	6.00	0.50	0.40	4.00	16.00	1.40	260.00
243	247	455I45	8.00	0.90	6.00	0.20	0.10	8.20	0.50	0.20	19.00
244	248	455I46	8.00	26.00	10.00	0.70	0.10	5.00	3.70	1.00	200.00
245	249	455I47	8.00	8.60	10.00	0.50	1.90	4.10	2.80	2.10	16.00
246	250	455I47HDW	8.00	40.00	2.00	4.00	0.10	4.70	0.60	0.20	19.00
247	251	455I48	8.00	3.90	1.00	0.50	0.10	6.90	4.90	1.40	20.00
248	252	455I49HDW	8.00	37.00	10.00	4.90	0.30	9.80	0.50	0.20	4.00
249	253	455I50	8.00	110.00	9.00	0.60	0.10	4.90	3.50	2.80	15.00
250	254	455I52	8.00	350.00	14.00	0.80	1.90	3.70	11.00	1.40	18.00
251	255	455I53	8.00	58.00	10.00	0.40	0.40	5.00	6.50	1.10	250.00
252	256	455I54POND	8.00	68.00	1.00	4.00	0.10	0.50	0.50	1.50	2.00
253	257	455I54	8.00	54.00	11.00	0.30	0.10	4.10	1.50	0.90	15.00
254	258	455I58	8.00	15.00	7.00	0.30	0.60	3.40	13.00	0.20	70.00
255	259	455I59	8.00	10.00	3.00	0.10	0.10	3.20	0.50	3.40	100.00
256	260	P47	8.00	410.00	15.00	0.50	4.80	16.00	0.70	0.20	2.00
257	261	P5	8.00	120.00	13.00	0.30	0.10	22.00	0.50	0.20	2.00
258	262	P10	8.00	24.00	14.00	4.10	1.10	14.00	4.80	0.20	3.00
259	263	P11	110.00	110.00	18.00	2.80	3.20	21.00	2.00	0.20	5.00
260	264	456A1	8.00	44.00	20.00	0.10	0.10	11.00	0.60	0.20	1.00
261	265	456C20	8.00	1.40	2.00	0.20	0.10	7.80	0.70	0.20	1.00
262	266	456D6	63.00	0.20	5.00	0.40	0.30	5.20	2.80	0.20	1.00
263	267	456D7	8.00	4.40	16.00	0.80	0.40	4.10	1.80	0.20	26.00
264	268	456D8	62.00	0.20	1.00	0.10	0.10	11.00	0.50	2.50	4.00
265	269	456D9	110.00	0.20	1.00	0.40	0.10	14.00	0.50	0.20	10.00
266	270	456D11	19.00	4.90	3.00	0.30	0.20	9.50	4.40	0.20	5.00
267	271	456D13	20.00	2.00	4.00	0.20	0.30	0.50	1.60	0.20	1.00
268	272	456D14	8.00	220.00	14.00	0.30	0.20	4.60	1.20	0.20	1.00

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269	273	456D17	8.00	5.80	4.00	0.20	0.10	2.10	0.80	0.20	11.00
270	274	456D18	8.00	0.80	5.00	0.30	0.10	17.00	4.60	0.20	15.00
271	275	456D19	8.00	0.20	1.00	0.20	0.10	14.00	0.50	0.20	8.00
272	276	456D20	8.00	2.60	3.00	0.30	0.10	2.80	4.50	0.20	180.00
273	277	456D21	8.00	0.80	4.00	0.70	0.30	5.80	0.80	0.20	8.00
274	278	456D22	8.00	24.00	4.00	1.20	0.10	5.50	1.00	0.60	9.00
275	279	456D25	8.00	80.00	44.00	0.10	0.50	5.10	3.30	0.20	17.00
276	280	456D27	8.00	150.00	27.00	0.10	0.10	11.00	2.10	0.70	5.00
277	281	456D28	8.00	14.00	10.00	0.10	0.40	5.30	1.60	0.20	35.00
278	282	456D29	8.00	26.00	17.00	0.40	0.40	6.40	2.30	3.40	34.00
279	283	456D32	8.00	89.00	4.00	0.10	0.10	9.20	2.50	7.80	130.00
280	284	456D33	8.00	27.00	8.00	0.20	0.10	6.50	2.20	0.20	140.00
281	285	456D34	8.00	0.20	5.00	0.10	0.10	1.80	0.60	0.20	3.00
282	286	458E3	24.00	10.00	4.00	0.40	0.30	0.20	3.50	0.20	1.00
283	287	458E4	8.00	0.20	5.00	0.20	0.20	1.30	3.10	0.20	1.00
284	288	458G1	8.00	0.20	7.00	0.30	0.10	11.00	16.00	0.20	140.00
285	289	458GHDW1	8.00	2.30	2.00	0.90	0.30	36.00	8.80	0.20	1.00
286	290	458G3	18.00	0.20	1.00	0.10	0.10	3.40	0.50	0.20	92.00
287	291	458G3POND	8.00	58.00	0.50	1.40	0.30	18.00	1.80	1.40	1.00
288	292	458G5	24.00	2.50	2.00	0.60	0.10	17.00	1.20	1.70	29.00
289	293	458G6	39.00	1.10	5.00	0.30	0.10	11.00	4.60	0.60	5.00
290	294	458G9	8.00	0.20	1.00	0.30	0.10	13.00	0.50	0.20	2.00
291	295	458G10	52.00	0.20	1.00	0.20	0.10	14.00	0.50	0.20	7.00
292	296	458G11	8.00	21.00	6.00	0.30	0.10	29.00	1.30	1.30	210.00
293	297	458G12	43.00	0.20	0.50	0.60	0.10	9.50	0.50	0.20	67.00
294	298	458G13	18.00	18.00	0.50	0.30	0.10	6.60	0.50	0.20	4.00
295	299	458G16	8.00	0.20	1.00	0.20	0.10	9.70	0.50	0.20	18.00
296	300	458G17	25.00	0.20	1.00	0.30	0.10	6.70	0.50	0.20	5.00
297	301	458G18	20.00	7.30	6.00	0.30	0.10	5.90	3.20	1.30	25.00
298	302	458G22	17.00	0.20	1.00	0.10	0.10	5.50	0.50	0.20	90.00
299	303	458G23	16.00	0.20	0.50	0.30	0.10	5.20	0.50	0.20	10.00
300	304	458G24	25.00	17.00	8.00	0.50	0.10	9.20	20.00	0.20	160.00
301	305	458G25	26.00	0.70	8.00	0.30	0.30	6.00	1.30	0.20	8.00
302	306	458G26	8.00	0.50	2.00	0.10	0.10	0.60	1.20	0.20	12.00
303	307	458G27	8.00	0.20	7.00	0.60	0.50	8.70	5.80	0.50	8.00
304	308	458G28	23.00	0.20	1.00	0.30	0.10	14.00	0.80	0.20	3.00
305	309	458G30	55.00	0.20	0.50	0.20	0.10	7.30	0.50	0.20	19.00
306	310	458G31	8.00	4.10	6.00	0.20	0.10	4.60	2.50	0.20	1.00
307	311	458G34	28.00	0.20	8.00	0.20	0.10	1.20	0.80	0.20	10.00
308	312	458G36	39.00	0.20	2.00	0.80	0.10	10.00	0.60	0.20	1.00
309	313	458G37	8.00	0.60	10.00	0.10	0.40	2.20	4.50	0.20	550.00
310	314	458G39	21.00	0.20	1.00	0.40	0.10	8.30	0.50	0.20	4.00
311	315	458G43	23.00	0.60	1.00	0.70	0.10	5.10	0.50	0.20	210.00
312	316	458H2HDW	8.00	50.00	1.00	0.70	0.10	1.30	1.40	0.70	4.00
313	317	458H2	29.00	1.20	17.00	1.20	8.20	9.20	9.10	0.20	1.00
314	318	458H3	8.00	7.90	10.00	1.50	1.60	7.80	2.80	0.20	54.00
315	319	458H4	39.00	5.70	9.00	0.50	0.10	8.10	23.00	0.20	23.00
316	320	458H5	8.00	180.00	16.00	1.90	1.80	35.00	5.00	0.20	17.00
317	321	458H6	8.00	18.00	14.00	0.60	0.10	0.90	12.00	0.20	510.00
318	322	458H7	8.00	0.20	6.00	0.40	0.10	17.00	1.30	0.20	10.00
319	323	458H8	8.00	120.00	31.00	0.60	0.10	8.20	0.50	1.70	22.00
320	324	458H9	8.00	70.00	38.00	1.80	3.60	6.40	0.50	0.20	120.00
321	325	458H10	8.00	67.00	9.00	0.30	0.10	7.50	0.50	2.20	400.00
322	326	458H11	8.00	46.00	34.00	0.30	1.50	5.00	0.50	0.20	26.00
323	327	458H13	8.00	95.00	26.00	0.70	0.10	5.40	0.50	1.60	14.00
324	328	458H14	8.00	66.00	32.00	2.00	0.60	8.90	0.50	0.60	66.00
325	329	458H15	8.00	50.00	19.00	0.20	1.10	3.30	0.50	1.20	16.00
326	330	458H17	8.00	74.00	33.00	0.80	0.30	4.50	0.50	0.20	18.00
327	331	453B1	8.00	45.00	10.00	0.10	0.10	20.00	1.90	0.20	62.00
328	332	453B3	8.00	32.00	12.00	0.30	0.10	6.00	1.30	0.20	4500.00
329	333	453B4	8.00	66.00	15.00	0.30	0.10	9.30	0.50	1.00	130.00
330	334	453B6	8.00	91.00	7.00	0.40	0.10	7.80	0.50	0.20	18.00
331	335	453B7	8.00	57.00	12.00	0.20	0.10	6.60	0.50	0.20	16.00
332	336	453B8	8.00	79.00	9.00	0.40	0.10	8.30	0.50	0.20	96.00
333	337	453B12	8.00	73.00	6.00	1.00	0.10	7.60	0.50	0.20	23.00
334	338	453B13	8.00	83.00	9.00	1.00	0.10	9.30	0.50	0.90	44.00
335	339	453B14	8.00	64.00	5.00	1.40	0.10	8.50	0.50	0.80	35.00

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336	340	453B15	8.00	84.00	14.00	0.20	0.10	7.30	0.50	0.20	9.00
337	341	453B16	8.00	78.00	14.00	0.40	0.10	8.50	0.50	0.20	10.00
338	342	453B19	8.00	66.00	12.00	0.20	0.20	8.40	0.50	2.70	64.00
339	343	453B20	8.00	44.00	9.00	0.50	0.10	9.30	2.20	1.80	30.00
340	344	453B21	8.00	78.00	11.00	0.10	0.10	20.00	0.60	0.20	30.00
341	345	453B22	8.00	110.00	10.00	0.20	0.10	14.00	1.00	1.40	70.00
342	346	453B25	8.00	85.00	15.00	0.20	0.10	10.00	0.50	1.70	130.00
343	347	453B26	8.00	49.00	9.00	0.10	0.10	20.00	3.30	0.20	58.00
344	348	453B27	8.00	21.00	24.00	0.20	0.50	3.30	0.70	0.60	5.00
345	349	453B28	8.00	61.00	9.00	0.10	0.10	11.00	0.50	0.20	380.00
346	350	453C1	8.00	18.00	6.00	0.10	0.10	9.20	1.50	0.20	24.00
347	351	453C2	8.00	50.00	6.00	0.10	0.10	11.00	0.70	1.50	4900.00
348	352	453C4	8.00	40.00	9.00	0.20	0.10	8.20	2.40	3.70	10.00
349	353	453C5	8.00	24.00	17.00	0.50	0.10	6.00	0.60	0.20	22.00
350	354	453C6	8.00	63.00	6.00	0.10	0.10	10.00	0.50	1.90	32.00
351	355	453C7	8.00	21.00	17.00	0.30	0.10	21.00	7.30	0.20	65.00
352	356	453C8	8.00	38.00	94.00	0.20	0.10	6.70	0.70	1.00	22.00
353	357	453C9	8.00	13.00	43.00	0.20	0.30	27.00	1.10	0.90	37.00
354	358	453C10	8.00	45.00	48.00	0.10	0.10	14.00	23.00	0.20	7.00
355	359	453C11	8.00	7.10	25.00	1.70	2.00	34.00	1.80	0.20	3.00
356	360	453C15	8.00	57.00	10.00	0.40	0.10	19.00	2.10	1.80	25.00
357	361	453C16	8.00	2.90	2.00	1.50	0.10	35.00	1.80	0.20	5.00
358	362	453C17	8.00	25.00	6.00	0.30	0.10	7.50	5.10	0.20	1.00
359	363	453C18	8.00	64.00	13.00	0.40	0.10	16.00	5.80	1.10	18.00
360	364	453C21	8.00	13.00	2.00	0.30	0.10	21.00	2.00	0.50	1.00
361	365	453C22	8.00	48.00	4.00	0.10	0.10	28.00	1.80	2.10	57.00
362	366	453C23	30.00	120.00	27.00	0.30	6.30	22.00	6.10	0.20	21.00
363	367	453C24	8.00	35.00	15.00	0.30	0.10	25.00	2.20	0.20	31.00
364	368	453C25	8.00	35.00	12.00	0.30	0.10	36.00	2.70	0.20	2.00
365	369	453C26	8.00	79.00	13.00	0.60	0.10	32.00	11.00	0.50	200.00
366	370	453C27	8.00	2.40	14.00	0.70	0.40	11.00	0.80	0.20	8.00
367	371	453C28	8.00	6.30	2.00	0.10	0.20	2.30	1.10	0.60	51.00
368	372	453C30	8.00	131.00	9.00	0.10	0.10	13.00	1.20	0.20	54.00
369	373	453E1	8.00	3.10	1.00	0.80	0.20	12.00	2.00	1.20	23.00
370	374	453E2	8.00	32.00	9.00	0.20	0.10	85.00	7.80	0.20	8.00
371	375	453E3	8.00	11.00	4.00	0.80	0.10	23.00	2.80	0.20	19.00
372	376	453E4	8.00	44.00	13.00	1.70	0.10	51.00	1.00	1.00	30.00
373	377	453E5	8.00	48.00	9.00	0.10	0.10	44.00	3.50	0.20	32.00
374	378	453E6	8.00	51.00	7.00	0.10	0.10	12.00	1.00	0.60	62.00
375	379	453F1	8.00	10.00	22.00	2.00	0.10	25.00	0.50	1.10	24.00
376	381	454A1	8.00	0.80	1.00	0.20	0.10	13.00	1.10	0.20	12.00
377	382	454A2	8.00	4.20	1.00	0.20	0.10	14.00	0.50	0.20	9.00
378	383	454A4	8.00	0.20	1.00	0.20	0.10	7.40	0.60	0.20	3.00
379	384	454A6	8.00	1.40	1.00	0.30	0.10	11.00	0.50	0.70	32.00
380	385	454A10	8.00	1.50	1.00	0.10	0.10	9.20	0.50	7.60	55.00
381	386	454A11	8.00	3.70	2.00	0.10	0.10	1.20	0.50	0.20	25.00
382	387	454A12	8.00	1.00	1.00	0.30	0.10	12.00	0.50	0.20	1.00
383	388	454A12/1	33.00	0.70	2.00	0.60	0.10	9.30	0.50	0.20	1.00
384	389	454A16	17.00	2.00	1.00	0.50	0.10	9.00	0.60	1.20	62.00
385	390	454B1	8.00	51.00	16.00	1.20	4.00	12.00	12.00	0.20	3.00
386	391	454B2	8.00	13.00	5.00	0.50	0.80	36.00	1.30	0.20	18.00
387	392	454BHDW	8.00	89.00	32.00	0.90	0.50	6.40	0.90	0.20	4.00
388	393	454B4	8.00	110.00	18.00	0.80	0.30	6.50	0.70	0.20	10.00
389	394	454B5	8.00	230.00	12.00	0.40	0.30	5.30	0.50	11.00	200.00
390	395	454B6	8.00	1.20	2.00	0.30	1.20	27.00	2.20	0.20	40.00

APPENDIX 2D

- * **Milliequivalents for water sample analyses**
- * **Errors associated with chemical analysis**

Survey No.	HCO ₃ (meq/L)	SO ₄ (meq/L)	Cl (meq/L)	Cl (meq/L)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Na+K (meq/L)	Sum Cations	Sum Anions	ERROR (%)
3	4.84	0.19	0.58	0.58	2.69	2.30	1.83	0.08	1.91	6.91	6.78	0.95
4	2.54	0.06	0.19	0.19	1.05	0.81	0.91	0.04	0.96	2.81	2.89	-1.46
5	2.56	0.04	0.52	0.52	1.30	1.40	0.87	0.04	0.91	3.61	3.57	0.54
6	2.75	0.60	0.17	0.17	1.65	1.07	1.22	0.04	1.26	3.97	3.99	-0.23
7	3.43	0.72	0.13	0.13	2.20	1.40	1.13	0.03	1.16	4.76	4.66	1.01
8	3.46	0.05	0.17	0.17	1.55	1.23	1.35	0.03	1.37	4.16	4.17	-0.20
9	1.68	0.01	0.18	0.18	0.80	0.46	0.96	0.03	0.99	2.25	2.14	2.44
10	3.11	0.04	0.14	0.14	1.10	1.15	1.44	0.06	1.50	3.75	3.64	1.51
11	2.94	0.07	0.16	0.16	1.30	1.07	0.96	0.06	1.02	3.39	3.40	-0.24
12	3.96	0.15	0.50	0.50	2.10	1.89	1.65	0.06	1.71	5.70	5.54	1.41
13	1.15	0.02	0.15	0.15	0.41	0.23	0.91	0.08	0.99	1.63	1.65	-0.64
14	1.43	0.10	0.08	0.08	0.90	0.19	0.78	0.06	0.84	1.93	1.92	0.36
15	4.73	0.13	0.14	0.14	2.79	0.99	1.22	0.07	1.29	5.07	5.25	-1.75
16	2.54	0.07	0.13	0.13	1.05	0.99	0.96	0.06	1.02	3.05	2.97	1.44
17	1.85	0.07	0.30	0.30	1.05	0.58	1.09	0.05	1.14	2.77	2.73	0.69
18	1.84	0.04	0.08	0.08	0.85	0.51	0.96	0.03	0.99	2.35	2.24	2.28
19	1.10	0.10	0.40	0.40	0.65	0.45	1.13	0.06	1.19	2.29	2.29	0.00
20	2.75	0.03	0.14	0.14	1.05	0.99	1.00	0.05	1.05	3.08	3.12	-0.51
21	2.83	0.04	0.08	0.08	1.30	0.77	0.96	0.06	1.02	3.09	3.09	-0.02
22	2.21	0.04	0.13	0.13	1.00	1.07	0.70	0.03	0.73	2.80	2.59	3.76
23	1.84	0.06	0.10	0.10	0.80	0.67	0.87	0.04	0.91	2.38	2.30	1.70
24	2.41	0.05	0.12	0.12	1.00	0.91	0.83	0.08	0.91	2.81	2.73	1.53
26	3.48	0.12	0.11	0.11	1.60	1.48	0.65	0.11	0.76	3.84	3.91	-0.99
27	2.45	0.03	0.26	0.26	1.25	1.23	0.91	0.07	0.99	3.47	3.32	2.11
28	3.67	0.37	0.25	0.25	1.80	1.23	1.61	0.05	1.66	4.69	4.58	1.16
29	4.20	0.04	0.07	0.07	1.70	1.48	1.13	0.03	1.16	4.34	4.39	-0.62
30	2.37	0.12	0.24	0.24	1.30	0.70	1.26	0.06	1.32	3.32	3.28	0.61
31	1.52	0.06	0.21	0.21	0.85	0.82	0.65	0.08	0.73	2.40	2.25	3.14
32	5.51	0.25	0.14	0.14	2.25	1.73	1.87	0.06	1.93	5.91	6.01	-0.87
33	1.18	0.04	0.17	0.17	0.60	0.26	0.96	0.03	0.99	1.85	1.75	2.90
34	4.53	0.15	0.09	0.09	2.05	1.15	1.65	0.04	1.69	4.89	4.82	0.71
35	1.01	0.02	0.11	0.11	0.39	0.38	0.61	0.05	0.66	1.43	1.39	1.44
36	3.45	0.07	0.06	0.06	1.40	1.07	1.17	0.04	1.22	3.68	3.68	0.03
37	4.17	0.04	0.08	0.08	2.10	1.73	0.65	0.03	0.68	4.51	4.47	0.45
38	4.44	0.05	0.15	0.15	2.10	1.89	0.83	0.02	0.85	4.84	4.85	-0.18
39	7.21	0.12	0.24	0.24	2.74	2.39	2.17	0.08	2.26	7.39	7.76	-2.43
40	5.91	0.07	0.27	0.27	2.45	2.88	1.35	0.10	1.45	6.78	6.49	2.18
41	2.40	0.03	0.14	0.14	0.95	0.99	0.74	0.05	0.79	2.73	2.75	-0.44
42	1.53	0.02	0.13	0.13	0.55	0.48	0.74	0.02	0.76	1.79	1.82	-0.74
43	1.26	0.00	0.03	0.03	0.47	0.26	0.61	0.04	0.65	1.38	1.40	-0.75
44	4.24	0.08	0.29	0.29	1.95	1.48	1.39	0.08	1.47	4.90	4.98	-0.78
45	1.69	0.02	0.06	0.06	0.70	0.26	0.87	0.03	0.90	1.86	1.87	-0.48
46	5.33	0.12	0.06	0.06	1.95	1.73	1.78	0.05	1.83	5.50	5.54	-0.32
47	2.93	0.18	0.85	0.85	2.00	1.40	1.52	0.07	1.59	4.99	4.84	1.50
48	1.72	0.03	0.07	0.07	0.80	0.58	0.57	0.02	0.59	1.96	1.97	-0.01
49	2.88	0.06	0.25	0.25	1.30	1.07	1.13	0.05	1.18	3.54	3.57	-0.32
51	3.50	0.02	0.15	0.15	1.50	1.32	0.78	0.04	0.82	3.63	3.75	-1.56
52	4.50	0.24	0.24	0.24	1.95	1.48	1.48	0.07	1.55	4.98	5.17	-1.89
55	2.55	0.01	0.14	0.14	1.05	0.75	1.00	0.08	1.08	2.88	2.98	-1.75
54	1.83	0.03	0.18	0.18	0.95	0.68	0.78	0.02	0.81	2.44	2.44	-0.06
55	1.59	0.04	0.15	0.15	0.80	0.65	0.65	0.04	0.69	2.14	2.14	0.08
56	6.24	0.02	0.08	0.08	2.15	2.39	1.61	0.05	1.66	6.19	6.38	-1.57
57	1.27	0.00	0.02	0.02	0.33	0.35	0.57	0.03	0.59	1.27	1.30	-1.02
58	7.51	0.20	0.18	0.18	3.19	2.72	1.52	0.07	1.60	7.51	7.92	-2.70
59	2.90	0.03	0.07	0.07	1.35	1.15	0.44	0.04	0.47	2.97	3.03	-0.94
60	1.93	0.01	0.03	0.03	0.65	0.62	0.61	0.06	0.67	1.94	2.00	-1.55
61	3.12	0.03	0.23	0.23	1.30	0.91	1.30	0.09	1.40	3.60	3.59	0.11
62	4.87	0.12	0.11	0.11	2.15	1.56	1.44	0.09	1.53	5.24	5.20	0.36

Survey No.	HCO ₃ (meq/L)	SO ₄ (meq/L)	Cl (meq/L)	Cl (meq/L)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Na+K (meq/L)	Sum Cations	Sum Anions	ERROR (%)
63	2.73	0.02	0.08	0.08	1.10	0.82	1.04	0.07	1.11	3.03	3.03	0.04
64	3.11	0.03	0.14	0.14	1.35	1.23	0.96	0.07	1.03	3.61	3.52	1.23
65	3.87	0.02	0.11	0.11	1.65	1.73	0.87	0.03	0.90	4.28	4.13	1.77
66	3.67	0.05	0.11	0.11	1.45	1.56	1.00	0.06	1.06	4.07	3.92	1.79
67	5.50	0.05	0.28	0.28	2.05	2.47	1.52	0.04	1.56	6.08	6.00	0.65
68	3.87	0.04	0.04	0.04	1.80	1.65	1.09	0.09	1.17	4.62	4.24	4.22
69	1.76	0.01	0.07	0.07	0.80	0.51	0.78	0.04	0.83	2.14	2.04	2.38
71	2.25	0.03	0.17	0.17	1.05	0.59	1.09	0.05	1.13	2.77	2.74	0.62
73	7.08	0.04	0.20	0.20	2.99	3.13	1.22	0.12	1.34	7.46	7.47	-0.08
74	3.41	0.02	0.03	0.03	1.25	1.40	1.00	0.06	1.06	3.71	3.57	1.87
75	2.60	0.02	0.06	0.06	1.05	0.91	0.91	0.08	1.00	2.95	2.82	2.18
76	1.94	0.01	0.09	0.09	0.80	0.66	0.70	0.08	0.77	2.23	2.16	1.55
77	3.62	0.04	0.23	0.23	1.35	1.40	1.48	0.10	1.58	4.33	4.62	-3.19
78	1.93	0.04	0.18	0.18	0.90	0.61	1.00	0.07	1.07	2.57	2.60	-0.56
79	2.77	0.04	0.15	0.15	1.15	1.07	0.91	0.08	1.00	3.22	3.17	0.65
80	3.40	0.16	0.15	0.15	1.30	1.40	1.30	0.09	1.39	4.09	3.90	2.33
81	4.66	0.12	0.14	0.14	2.05	1.89	1.26	0.04	1.30	5.24	5.15	0.83
82	2.52	0.09	0.32	0.32	1.35	1.15	0.83	0.08	0.91	3.41	3.36	0.78
83	3.95	0.08	0.38	0.38	1.65	1.73	1.17	0.14	1.31	4.69	4.55	1.52
84	1.79	0.03	0.03	0.03	0.70	0.38	0.91	0.07	0.98	2.06	1.93	3.37
86	3.24	0.08	0.13	0.13	1.60	1.23	1.09	0.05	1.13	3.96	3.73	3.09
87	3.40	0.03	0.13	0.13	1.55	1.15	1.13	0.07	1.21	3.90	3.85	0.76
88	3.28	0.02	0.03	0.03	1.25	0.99	1.17	0.06	1.23	3.47	3.48	-0.18
89	3.86	0.28	0.20	0.20	1.80	1.40	1.57	0.08	1.65	4.84	4.77	0.71
90	2.63	0.03	0.18	0.18	1.35	0.80	1.04	0.04	1.09	3.23	3.21	0.39
91	2.56	0.08	0.51	0.51	1.50	1.56	0.78	0.08	0.86	3.92	3.71	2.85
92	2.34	0.12	0.05	0.05	1.10	0.99	0.61	0.08	0.69	2.77	2.57	3.72
93	1.28	0.01	0.19	0.19	0.65	0.51	0.74	0.04	0.78	1.94	1.91	0.82
94	3.41	0.02	0.16	0.16	1.35	1.23	1.30	0.09	1.40	3.98	3.87	1.44
95	3.96	0.04	0.09	0.09	1.40	1.23	1.39	0.08	1.47	4.11	4.26	-1.86
96	2.85	0.56	0.06	0.06	1.65	0.72	1.26	0.05	1.32	3.68	3.51	2.32
97	1.05	0.05	0.14	0.14	0.49	0.34	0.83	0.03	0.85	1.68	1.47	6.89
98	2.69	0.14	0.05	0.05	1.25	0.56	1.22	0.05	1.27	3.07	2.94	2.22
99	1.28	0.10	0.51	0.51	1.15	0.55	1.17	0.04	1.22	2.92	2.69	4.06
100	1.93	0.02	0.08	0.08	0.65	0.63	1.13	0.03	1.16	2.44	2.21	4.92
101	3.21	0.03	0.09	0.09	1.20	1.07	1.26	0.08	1.34	3.61	3.50	1.49
102	3.05	0.07	0.07	0.07	1.25	1.15	1.04	0.05	1.09	3.49	3.27	3.28
103	2.40	0.03	0.08	0.08	0.90	0.59	1.26	0.06	1.32	2.81	2.63	3.32
104	2.34	0.04	0.10	0.10	0.95	0.75	1.13	0.04	1.17	2.87	2.70	3.11
105	3.55	0.04	0.05	0.05	1.30	1.23	1.17	0.08	1.26	3.79	3.70	1.19
106	2.72	0.02	0.09	0.09	1.10	0.99	1.00	0.08	1.08	3.17	3.10	1.02
107					2.00	1.65	1.44	0.08	1.51	5.15		
108	4.78	0.03	0.24	0.24	1.95	1.65	1.70	0.06	1.76	5.35	5.24	1.07
109	3.68	0.03	0.09	0.09	1.75	0.72	1.57	0.07	1.64	4.11	4.09	0.29
110	2.53	0.06	0.24	0.24	1.15	0.99	1.17	0.04	1.21	3.35	3.20	2.22
111	2.69	0.05	0.40	0.40	1.35	1.15	1.26	0.07	1.33	3.83	3.77	0.85
112	1.87	0.03	0.10	0.10	0.90	0.62	0.91	0.05	0.96	2.48	2.21	5.78
113	3.33	0.11	0.38	0.38	1.60	1.56	0.96	0.08	1.04	4.20	4.10	1.22
114	1.91	0.10	0.46	0.46	1.20	0.99	1.22	0.07	1.29	3.47	3.23	3.68
115	2.83	0.04	0.09	0.09	1.20	0.82	1.22	0.04	1.25	3.27	3.27	0.00
116	4.45	0.10	0.07	0.07	1.80	1.56	1.30	0.08	1.39	4.75	4.65	1.03
117	3.48	0.03	0.05	0.05	1.35	1.40	0.96	0.05	1.01	3.76	3.62	1.92
118	2.98	1.03	0.25	0.25	2.15	1.56	1.26	0.03	1.29	5.00	4.68	3.35
119	1.80	0.08	0.32	0.32	1.10	0.91	0.83	0.05	0.88	2.88	2.68	3.67
122	2.33	0.18	0.48	0.48	1.50	1.56	1.04	0.04	1.08	4.14	3.96	2.22
123	1.67	0.13	0.45	0.45	1.35	0.91	0.83	0.06	0.89	3.14	2.91	3.82
124	2.24	0.13	0.13	0.13	1.20	0.91	0.74	0.05	0.79	2.89	2.67	3.92

Survey No.	HCO ₃ (meq/L)	SO ₄ (meq/L)	Cl (meq/L)	Cl (meq/L)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Na-K (meq/L)	Sum Cations	Sum Anions	ERROR (%)
125	1.92	0.02	0.03	0.03	0.60	0.53	0.91	0.04	0.95	2.08	1.97	2.54
127	7.00	0.11	0.20	0.20	3.19	2.14	2.13	0.07	2.20	7.53	7.51	0.17
128	4.36	0.07	0.17	0.17	1.45	1.56	1.65	0.06	1.71	4.73	4.63	1.00
129	1.73	0.05	0.11	0.11	0.80	0.70	0.74	0.03	0.77	2.27	2.15	2.73
130	3.88	0.04	0.13	0.13	0.85	1.81	1.65	0.06	1.71	4.37	4.20	1.99
133	2.19	0.11	0.41	0.41	1.30	1.07	0.87	0.06	0.93	3.30	3.12	2.83
134	4.55	0.05	0.11	0.11	2.74	0.99	1.22	0.08	1.29	5.03	4.91	1.14
135	5.29	0.10	0.27	0.27	3.49	1.32	1.30	0.08	1.39	6.20	6.09	0.85
136	4.07	0.06	0.06	0.06	1.80	1.32	1.09	0.07	1.15	4.27	4.19	0.92
137	4.49	0.02	0.04	0.04	1.80	1.56	1.35	0.05	1.39	4.75	4.56	2.12
138	5.23	0.03	0.04	0.04	1.90	1.81	1.74	0.08	1.82	5.53	5.34	1.73
139	5.64	0.05	0.16	0.16	1.90	2.96	1.17	0.08	1.25	6.11	5.91	1.67
140	2.00	0.02	0.11	0.11	1.05	0.79	0.78	0.06	0.84	2.68	2.42	5.14
141	2.75	0.04	0.20	0.20	1.45	1.23	0.91	0.04	0.95	3.64	3.29	4.95
142	1.91	0.07	0.18	0.18	1.05	0.99	0.91	0.03	0.94	2.98	2.73	4.40
143	4.21	0.04	0.16	0.16	1.05	0.91	2.83	0.02	2.85	4.80	4.53	2.88
145	2.46	0.03	0.12	0.12	1.30	1.07	0.87	0.04	0.91	3.27	3.34	-1.00
146	5.20	0.04	0.12	0.12	2.74	1.97	1.13	0.05	1.18	5.90	5.48	3.67
147	3.65	0.03	0.20	0.20	1.80	1.89	1.13	0.03	1.16	4.85	4.33	5.75
148	5.65	0.22	0.22	0.22	2.49	1.81	2.09	0.12	2.21	6.51	6.18	2.65
149	2.74	0.02	0.06	0.06	1.45	0.66	1.04	0.04	1.08	3.19	2.95	3.83
150	2.13	0.06	0.34	0.34	1.20	1.15	0.83	0.04	0.86	3.21	3.04	2.84
151	2.54	0.04	0.13	0.13	1.15	1.15	0.78	0.02	0.80	3.10	2.74	6.07
152	4.37	0.10	0.09	0.09	1.75	1.15	2.09	0.04	2.13	5.02	4.72	3.13
153	4.16	0.08	0.10	0.10	2.05	1.73	1.00	0.03	1.03	4.81	4.41	4.26
154	3.88	0.06	0.14	0.14	2.49	0.99	1.13	0.06	1.19	4.67	4.41	2.88
155	4.93	0.04	0.19	0.19	3.14	1.32	1.26	0.07	1.33	5.79	5.44	3.17
156	2.90	0.05	0.09	0.09	1.40	1.40	0.91	0.04	0.95	3.75	3.37	5.37
157	3.95	0.02	0.06	0.06	1.50	1.40	1.30	0.08	1.38	4.28	4.09	2.32
158	3.68	0.08	0.12	0.12	1.65	1.32	1.04	0.06	1.10	4.07	3.88	2.39
159	2.73	0.04	0.10	0.10	1.10	0.99	0.96	0.07	1.03	3.11	3.01	1.67
160	4.18	0.04	0.08	0.08	1.55	1.40	1.57	0.07	1.64	4.59	4.45	1.54
161	4.11	0.07	0.10	0.10	1.65	1.48	1.48	0.06	1.54	4.67	4.46	2.29
162	2.52	0.05	0.36	0.36	1.30	0.91	1.22	0.05	1.27	3.47	3.36	1.61
163	0.95	0.01	0.07	0.07	0.34	0.26	0.48	0.05	0.53	1.13	1.06	3.56
164	7.50	0.14	0.05	0.05	3.59	2.30	1.87	0.02	1.89	7.79	7.70	0.54
165	2.67	0.02	0.05	0.05	0.90	0.75	1.26	0.06	1.33	2.97	2.90	1.32
167	1.79	0.24	0.53	0.53	1.25	1.07	0.87	0.05	0.92	3.24	3.00	3.85
168	3.42	0.04	0.15	0.15	1.10	1.15	1.44	0.05	1.49	3.74	3.67	0.87
169	1.74	0.03	0.30	0.30	1.10	1.07	0.65	0.07	0.72	2.89	2.61	5.16
170	2.81	0.03	0.08	0.08	1.15	1.23	0.70	0.04	0.73	3.12	3.09	0.41
171	4.34	0.11	0.12	0.12	1.70	1.15	1.78	0.08	1.86	4.71	4.61	1.11
172	3.32	0.02	0.10	0.10	1.15	1.56	0.74	0.07	0.81	3.52	3.53	-0.08
173	2.76	0.03	0.16	0.16	1.20	1.23	0.74	0.04	0.78	3.21	3.10	1.73
174	2.45	0.02	0.07	0.07	1.15	0.99	0.74	0.06	0.80	2.93	2.77	2.81
175	2.23	0.29	0.11	0.11	1.20	0.99	0.83	0.05	0.88	3.06	2.82	4.10
176	1.31	0.03	0.52	0.52	0.95	0.91	0.70	0.09	0.79	2.64	2.39	4.92
177	2.00	0.03	0.08	0.08	0.85	0.60	0.96	0.05	1.00	2.45	2.20	5.37
178	1.62	0.02	0.08	0.08	0.80	0.71	0.70	0.05	0.74	2.25	1.99	6.11
180	4.16	0.13	0.43	0.43	2.89	0.99	1.39	0.06	1.45	5.34	5.17	1.60
181	3.10	0.29	0.56	0.56	2.00	0.82	1.26	0.28	1.54	4.36	4.20	1.86
182	1.11	0.05	0.16	0.16	0.55	0.35	0.83	0.03	0.85	1.75	1.59	4.95
183	2.21	0.07	0.12	0.12	1.15	0.91	0.83	0.04	0.87	2.92	2.61	5.68
184	3.43	0.08	0.27	0.27	1.90	0.82	1.44	0.04	1.48	4.20	4.07	1.60
185	5.08	0.06	0.18	0.18	2.79	1.23	1.83	0.03	1.86	5.88	5.61	2.38
186	3.13	0.03	0.26	0.26	1.35	1.07	1.39	0.06	1.45	3.87	3.72	2.00
187	2.21	0.04	0.16	0.16	1.10	0.82	1.00	0.08	1.08	3.00	2.83	2.93

Survey No.	HCO ₃ (meq/L)	SO ₄ (meq/L)	Cl (meq/L)	Cl (meq/L)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Na+K (meq/L)	Sum Cations	Sum Anions	ERROR (%)
188	2.18	0.03	0.18	0.18	1.00	0.91	0.74	0.02	0.76	2.66	2.57	1.70
189	3.79	0.05	0.09	0.09	1.55	1.32	1.35	0.10	1.45	4.32	4.08	2.79
190	1.48	0.05	0.48	0.48	1.05	0.82	1.00	0.07	1.07	2.94	2.65	5.08
191	5.59	0.23	0.64	0.64	2.20	2.55	2.13	0.06	2.19	6.93	6.61	2.43
193	1.51	0.07	0.15	0.15	0.70	0.48	0.91	0.04	0.95	2.13	1.98	3.66
194	1.60	0.14	0.34	0.34	1.05	0.79	0.83	0.05	0.88	2.72	2.42	5.68
195	1.93	0.02	0.15	0.15	1.00	0.75	0.65	0.07	0.72	2.47	2.31	3.22
196	1.57	0.02	0.10	0.10	0.75	0.56	0.83	0.04	0.86	2.17	1.96	5.06
198	1.77	0.03	0.08	0.08	0.75	0.37	0.96	0.05	1.01	2.13	2.06	1.55
199	2.11	0.03	0.09	0.09	0.90	0.53	1.04	0.08	1.12	2.56	2.40	3.26
200	2.55	0.06	0.12	0.12	1.35	0.51	1.17	0.05	1.22	3.08	2.97	1.77
201	0.98	0.00	0.12	0.12	0.46	0.44	0.61	0.08	0.69	1.59	1.45	4.42
202	2.80	0.04	0.18	0.18	1.30	0.82	1.04	0.03	1.08	3.20	3.16	0.60
203	1.09	0.04	0.41	0.41	0.80	0.70	0.78	0.04	0.82	2.32	2.11	4.77
204	3.03	0.03	0.14	0.14	1.25	0.99	1.17	0.10	1.28	3.51	3.39	1.81
205	2.29	0.06	0.26	0.26	1.00	0.99	0.87	0.04	0.91	2.89	2.76	2.34
206	5.20	0.08	0.60	0.60	2.30	2.06	2.35	0.07	2.42	6.77	6.54	1.70
207	4.42	0.04	0.09	0.09	1.80	1.73	1.09	0.07	1.16	4.68	4.64	0.40
208	4.95	0.09	0.07	0.07	1.90	1.81	1.35	0.06	1.40	5.11	5.11	0.02
209	2.97	0.05	0.04	0.04	1.15	0.75	1.26	0.03	1.29	3.19	3.14	0.85
210	4.39	0.05	0.18	0.18	1.75	1.65	1.35	0.11	1.46	4.85	4.93	-0.82
211	1.68	0.06	0.20	0.20	0.75	0.67	0.83	0.03	0.86	2.28	2.26	0.42
212	2.31	0.02	0.10	0.10	1.05	1.07	0.74	0.04	0.78	2.90	2.74	2.84
213	4.51	0.23	1.10	1.10	2.64	2.96	1.26	0.05	1.32	6.92	6.80	0.89
214	0.95	0.01	0.22	0.22	0.45	0.34	0.96	0.05	1.01	1.80	1.63	4.91
215	2.43	0.16	0.40	0.40	1.35	1.32	0.91	0.04	0.95	3.61	3.41	2.87
216	3.36	0.06	0.09	0.09	1.85	0.76	1.13	0.08	1.21	3.81	3.78	0.45
217	1.07	0.07	0.28	0.28	0.65	0.49	0.70	0.06	0.76	1.89	1.74	4.11
219	7.95	0.05	0.35	0.35	3.24	3.29	2.35	0.04	2.39	8.93	8.58	1.97
220	4.35	0.13	0.32	0.32	2.74	1.32	1.17	0.03	1.21	5.27	4.95	3.12
221	1.91	0.06	0.18	0.18	0.75	0.82	0.87	0.02	0.89	2.46	2.33	2.75
222	3.45	0.05	0.21	0.21	1.40	1.32	1.13	0.04	1.17	3.88	3.89	-0.07
223	3.09	0.07	0.14	0.14	1.45	0.50	1.48	0.03	1.51	3.46	3.50	-0.60
224	3.41	0.06	0.11	0.11	1.60	0.91	1.09	0.06	1.15	3.65	3.65	0.04
225	4.11	0.35	0.23	0.23	2.15	1.56	1.35	0.04	1.39	5.10	5.06	0.36
226	5.54	0.24	0.25	0.25	2.94	2.06	1.57	0.02	1.59	6.59	6.45	1.07
227	4.41	0.06	0.19	0.19	2.74	0.99	1.22	0.06	1.28	5.01	4.93	0.81
228	4.26	0.10	0.23	0.23	2.74	0.99	1.26	0.07	1.34	5.07	4.95	1.17
229	4.21	0.05	0.14	0.14	2.25	0.82	1.22	0.10	1.32	4.38	4.41	-0.25
230	2.92	0.06	0.22	0.22	1.55	0.78	1.09	0.07	1.16	3.49	3.42	0.92
231	3.23	0.03	0.04	0.04	1.65	1.23	0.52	0.02	0.54	3.42	3.41	0.18
232	3.64	0.07	0.17	0.17	2.30	0.91	0.96	0.08	1.03	4.23	4.13	1.20
233	3.80	0.29	0.55	0.55	2.69	1.15	1.74	0.12	1.86	5.71	5.49	1.98
234	3.09	0.05	0.09	0.09	1.75	0.99	0.57	0.01	0.57	3.31	3.26	0.71
235	4.31	0.12	0.28	0.28	3.04	1.07	1.26	0.10	1.36	5.47	5.16	2.94
236	3.89	0.19	0.33	0.33	2.35	1.15	1.35	0.11	1.46	4.96	4.67	3.01
237	3.17	0.08	0.15	0.15	1.70	1.15	0.87	0.09	0.96	3.81	3.65	2.06
238	3.70	0.08	0.21	0.21	2.30	1.07	1.04	0.07	1.11	4.48	4.44	0.48
239	2.83	0.02	0.02	0.02	1.50	0.49	1.00	0.08	1.08	3.06	2.95	1.88
240	4.48	0.06	0.08	0.08	2.59	1.07	1.04	0.05	1.10	4.76	4.77	-0.13
241	3.98	0.06	0.22	0.22	1.75	1.32	1.26	0.06	1.33	4.39	4.36	0.36
242	3.44	0.25	0.11	0.11	1.60	1.23	1.00	0.06	1.06	3.89	3.93	-0.56
243	4.99	0.47	0.26	0.26	2.59	1.56	2.13	0.07	2.20	6.36	6.17	1.52
244	2.28	0.20	0.13	0.13	1.10	0.73	1.00	0.06	1.06	2.89	2.81	1.47
245	3.14	0.03	0.11	0.11	1.45	1.07	0.87	0.06	0.93	3.45	3.31	1.94
246	3.01	0.17	0.53	0.53	1.95	0.99	1.70	0.09	1.79	4.72	4.59	1.40
247	3.28	0.03	0.24	0.24	2.20	1.07	0.52	0.00	0.53	3.79	3.84	-0.65

Survey No.	HCO ₃ (meq/L)	SO ₄ (meq/L)	Cl (meq/L)	Cl (meq/L)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Na+K (meq/L)	Sum Cations	Sum Anions	ERROR (%)
248	2.78	0.35	0.45	0.45	1.60	0.82	1.44	0.12	1.55	3.97	3.91	0.80
249	4.91	0.10	0.25	0.25	2.94	0.99	1.70	0.12	1.81	5.75	5.58	1.42
250	2.04	0.08	0.18	0.18	1.35	0.37	0.96	0.08	1.04	2.76	2.70	1.17
251	3.04	0.05	0.13	0.13	1.55	1.15	0.61	0.02	0.63	3.33	3.44	-1.72
252	3.91	0.03	0.04	0.04	2.30	0.72	0.96	0.11	1.07	4.09	4.05	0.54
253	2.65	0.04	0.05	0.05	1.50	0.67	0.74	0.08	0.82	2.99	2.94	0.77
255	3.44	0.26	0.73	0.73	2.49	1.15	1.57	0.16	1.73	5.37	4.92	4.45
257	3.47	0.05	0.13	0.13	1.60	0.66	1.48	0.07	1.55	3.80	3.81	-0.13
258	4.13	0.25	1.07	1.07	2.94	1.65	1.74	0.11	1.85	6.44	6.22	1.73
259	1.37	0.01	0.13	0.13	0.70	0.28	0.70	0.05	0.74	1.72	1.74	-0.47
260	5.96	0.14	0.70	0.70	2.99	2.30	2.09	0.16	2.25	7.55	7.12	2.90
261	3.09	0.01	0.10	0.10	1.45	1.15	0.83	0.07	0.90	3.50	3.44	0.86
262	4.47	0.05	0.06	0.06	2.15	1.73	0.87	0.15	1.02	4.89	4.64	2.65
263	5.26	0.71	0.10	0.10	2.89	2.14	1.17	0.16	1.34	6.37	6.17	1.56
264	2.05	0.01	0.05	0.05	0.65	0.68	0.78	0.04	0.82	2.16	2.12	0.92
265	3.50	0.06	0.10	0.10	1.80	1.32	0.48	0.01	0.49	3.60	3.79	-2.55
266	5.61	0.03	0.10	0.10	2.40	1.73	1.78	0.01	1.80	5.92	5.74	1.57
267	5.76	0.02	0.09	0.09	2.54	2.06	1.57	0.06	1.62	6.22	5.89	2.75
268	3.54	0.08	0.09	0.09	2.05	1.15	0.57	0.01	0.57	3.77	3.73	0.51
269	3.74	0.03	0.04	0.04	2.00	1.48	0.52	0.01	0.53	4.01	3.94	0.88
270	5.09	0.05	0.18	0.18	2.35	1.73	1.44	0.01	1.44	5.52	5.32	1.78
271	5.51	0.13	0.11	0.11	2.64	1.56	1.48	0.01	1.49	5.69	5.75	-0.44
272	2.55	0.13	0.87	0.87	2.25	1.32	1.17	0.08	1.26	4.82	4.50	3.38
273	2.68	0.02	0.08	0.08	1.30	0.69	0.74	0.06	0.80	2.79	2.82	-0.58
274	3.97	0.04	0.08	0.08	2.30	1.23	0.70	0.01	0.70	4.23	4.23	0.02
275	2.82	0.14	0.29	0.29	1.70	1.40	0.52	0.01	0.53	3.62	3.58	0.53
276	2.80	0.02	0.06	0.06	1.40	0.60	0.87	0.06	0.93	2.92	2.97	-0.70
277	6.15	0.09	0.05	0.05	3.04	1.73	1.70	0.01	1.71	6.48	6.33	1.16
278	2.70	0.01	0.04	0.04	1.25	0.52	0.91	0.07	0.98	2.75	2.77	-0.36
279	4.48	0.07	0.09	0.09	1.95	1.40	1.30	0.06	1.36	4.71	4.67	0.44
280	3.33	0.02	0.05	0.05	1.30	0.91	1.09	0.06	1.14	3.35	3.41	-0.99
281	3.85	0.06	0.27	0.27	2.00	1.07	1.17	0.09	1.27	4.33	4.39	-0.62
282	3.32	0.05	0.10	0.10	2.05	0.91	1.00	0.09	1.09	4.04	3.91	1.68
283	3.40	0.01	0.03	0.03	1.50	0.82	0.96	0.07	1.03	3.35	3.45	-1.42
284	2.49	0.06	0.26	0.26	1.20	0.69	1.17	0.08	1.26	3.15	3.10	0.82
285	2.90	0.05	0.03	0.03	1.40	0.91	0.57	0.01	0.57	2.87	3.02	-2.54
286	5.88	0.13	0.12	0.12	2.30	2.63	1.44	0.01	1.44	6.37	6.18	1.57
287	5.64	0.22	0.09	0.09	2.79	1.56	1.26	0.01	1.27	5.63	5.97	-2.98
288	4.25	0.05	0.16	0.16	1.95	1.40	1.22	0.01	1.23	4.58	4.57	0.10
289	5.13	0.36	0.20	0.20	2.54	2.06	1.78	0.02	1.81	6.41	6.03	3.03
290	4.01	0.05	0.05	0.05	1.90	1.56	0.65	0.02	0.67	4.13	4.12	0.10
292	2.54	0.06	0.15	0.15	1.15	1.07	0.65	0.01	0.67	2.88	2.94	-1.06
293	3.09	0.09	0.20	0.20	1.65	1.07	0.78	0.01	0.79	3.51	3.56	-0.74
294	3.79	0.15	0.14	0.14	2.30	1.32	0.52	0.01	0.53	4.14	4.13	0.13
295	2.87	0.06	0.10	0.10	1.50	1.07	0.44	0.01	0.44	3.01	3.10	-1.54
296	2.58	0.11	0.21	0.21	1.15	1.07	1.04	0.01	1.05	3.27	3.23	0.55
297	3.72	0.06	0.09	0.09	2.25	1.07	0.52	0.01	0.53	3.84	3.92	-0.98
298	3.42	0.08	0.16	0.16	2.10	1.07	0.48	0.01	0.48	3.65	3.69	-0.48
299	3.64	0.06	0.06	0.06	1.85	1.48	0.52	0.01	0.53	3.86	3.86	-0.09
300	3.52	0.11	0.12	0.12	1.90	1.32	0.57	0.01	0.57	3.79	3.85	-0.83
301	2.68	0.07	0.08	0.08	1.00	0.99	0.96	0.01	0.96	2.95	2.92	0.55
302	4.33	0.13	0.23	0.23	2.35	1.81	0.65	0.01	0.66	4.82	4.89	-0.77
303	3.69	0.22	0.24	0.24	2.59	1.23	0.44	0.01	0.44	4.27	4.36	-1.00
304	2.72	0.15	0.03	0.03	1.45	0.71	0.78	0.01	0.79	2.95	2.91	0.68
305	5.37	0.03	0.10	0.10	2.69	1.97	1.09	0.01	1.09	5.76	5.50	2.32
306	4.19	1.00	0.35	0.35	2.94	2.14	1.17	0.01	1.18	6.27	5.95	2.58
307	4.72	0.99	0.06	0.06	2.54	2.39	0.96	0.04	0.99	5.92	5.77	1.30

Survey No.	HCO ₃ (meq/L)	SO ₄ (meq/L)	Cl (meq/L)	Cl (meq/L)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Na+K (meq/L)	Sum Cations	Sum Anions	ERROR (%)
308	2.76	0.06	0.14	0.14	1.65	0.99	0.48	0.01	0.49	3.12	3.10	0.36
309	3.36	0.06	0.15	0.15	2.20	0.91	0.48	0.00	0.48	3.58	3.60	-0.21
310	4.00	0.11	0.10	0.10	2.15	0.99	1.13	0.01	1.14	4.27	4.24	0.31
311	3.98	0.10	0.10	0.10	2.00	1.56	0.70	0.01	0.70	4.26	4.18	0.91
312	4.75	0.09	0.14	0.14	2.99	1.40	0.57	0.01	0.58	4.97	5.02	-0.48
313	4.42	0.16	0.18	0.18	2.15	1.40	1.17	0.01	1.18	4.73	4.76	-0.39
314	3.58	0.07	0.16	0.16	1.85	1.65	0.41	0.01	0.42	3.91	3.95	-0.43
315	4.47	0.09	0.18	0.18	2.54	1.56	0.57	0.01	0.57	4.68	4.78	-0.99
316	1.25	0.08	0.08	0.08	0.70	0.20	0.48	0.04	0.52	1.41	1.41	0.10
317					3.09	2.72	1.78	0.07	1.86	7.67		
318	6.89	0.05	0.07	0.07	3.09	2.39	1.61	0.04	1.65	7.13	7.03	0.69
319	3.61	0.03	0.13	0.13	1.55	1.23	1.13	0.01	1.14	3.92	3.88	0.60
320	5.78	0.03	0.10	0.10	2.10	2.63	1.09	0.21	1.30	6.03	5.92	0.97
321	3.89	0.05	0.02	0.02	1.85	0.91	1.17	0.01	1.19	3.94	3.96	-0.23
322	4.92	0.03	0.07	0.07	2.49	1.65	0.96	0.01	0.97	5.11	5.04	0.65
323	2.19	0.07	0.15	0.15	1.20	0.47	0.91	0.05	0.96	2.63	2.62	0.20
324	2.84	0.23	0.13	0.13	1.95	0.63	0.83	0.04	0.86	3.43	3.29	2.21
325	1.85	0.09	0.15	0.15	1.00	0.32	1.22	0.05	1.27	2.59	2.49	1.99
326	3.86	0.07	0.12	0.12	2.25	0.99	1.17	0.02	1.20	4.43	4.27	1.78
327	2.55	0.03	0.03	0.03	1.25	0.46	0.87	0.04	0.91	2.62	2.67	-0.88
328	3.42	0.07	0.07	0.07	1.85	0.77	1.09	0.05	1.14	3.75	3.69	0.82
329	3.92	0.03	0.04	0.04	1.90	0.99	1.13	0.03	1.16	4.05	3.98	0.80
330	2.89	0.13	0.14	0.14	1.85	0.63	1.04	0.04	1.09	3.57	3.59	-0.30
331	3.08	0.11	0.35	0.35	1.40	1.23	1.22	0.07	1.29	3.92	3.82	1.35
332	3.45	0.08	0.13	0.13	1.35	1.15	1.26	0.09	1.35	3.85	3.78	0.97
333	2.94	0.05	0.08	0.08	1.40	0.57	1.22	0.07	1.29	3.25	3.27	-0.30
334	2.99	0.03	0.11	0.11	1.40	0.66	1.13	0.04	1.17	3.23	3.32	-1.40
335	2.49	0.05	0.22	0.22	1.35	0.55	1.09	0.06	1.15	3.05	3.14	-1.56
336	2.92	0.13	0.16	0.16	1.30	0.56	1.35	0.06	1.40	3.26	3.22	0.71
337	2.11	0.02	0.06	0.06	0.75	0.38	1.13	0.03	1.16	2.28	2.24	0.97
338	2.74	0.08	0.13	0.13	1.50	0.77	1.13	0.02	1.15	3.41	3.28	1.95
339	3.13	0.04	0.08	0.08	1.55	0.47	1.22	0.02	1.24	3.26	3.31	-0.78
340	2.22	0.02	0.11	0.11	1.05	0.42	1.09	0.05	1.14	2.60	2.48	2.37
341	2.90	0.09	0.24	0.24	1.55	0.80	1.17	0.07	1.25	3.59	3.59	0.00
342	3.78	0.08	0.12	0.12	1.95	0.75	1.48	0.07	1.55	4.25	4.22	0.34
343	2.11	0.01	0.03	0.03	0.75	0.30	1.09	0.03	1.12	2.17	2.15	0.50
344	2.91	0.09	0.38	0.38	1.40	1.23	1.22	0.10	1.32	3.95	3.83	1.49
345	3.04	0.02	0.06	0.06	1.15	0.59	1.26	0.08	1.34	3.08	3.12	-0.64
346	3.21	0.09	0.25	0.25	1.60	0.73	1.44	0.08	1.52	3.85	3.88	-0.47
347	2.90	0.05	0.17	0.17	1.05	0.91	1.22	0.06	1.28	3.23	3.22	0.19
348	3.25	0.04	0.11	0.11	1.65	0.78	1.13	0.03	1.16	3.59	3.62	-0.44
349	2.46	0.01	0.04	0.04	1.05	0.36	1.09	0.06	1.15	2.56	2.51	0.93
350	2.79	0.02	0.15	0.15	1.65	0.67	0.61	0.10	0.71	3.02	3.08	-0.90
351	3.82	0.10	0.19	0.19	1.85	1.07	1.17	0.09	1.27	4.18	4.10	0.95
352	2.84	0.06	0.30	0.30	1.65	0.72	0.96	0.11	1.07	3.43	3.43	0.04
353	1.30	0.07	0.16	0.16	0.55	0.34	1.04	0.04	1.09	1.97	1.83	3.85
354	1.98	0.07	0.37	0.37	1.10	0.91	0.83	0.05	0.88	2.88	2.73	2.59
355	1.77	0.09	0.26	0.26	1.00	0.78	0.74	0.07	0.81	2.59	2.61	-0.30
356	1.15	0.10	0.29	0.29	0.75	0.57	0.91	0.03	0.94	2.26	2.07	4.26
357	2.44	0.10	0.33	0.33	1.20	0.99	1.17	0.03	1.21	3.39	3.30	1.45
358	1.90	0.07	0.11	0.11	0.80	0.65	0.87	0.06	0.93	2.38	2.31	1.59
359	4.06	0.06	0.23	0.23	1.50	1.48	1.65	0.04	1.69	4.67	4.44	2.48
360	1.93	0.18	0.54	0.54	1.25	1.07	0.78	0.07	0.85	3.17	3.17	0.09
361	2.73	0.16	0.26	0.26	1.70	1.40	0.44	0.02	0.45	3.55	3.47	1.12
362	3.06	0.05	0.08	0.08	1.35	0.77	1.09	0.08	1.17	3.28	3.32	-0.52
363	1.74	0.06	0.21	0.21	0.85	0.48	0.96	0.04	0.99	2.32	2.21	2.41
364	4.00	0.21	0.22	0.22	2.25	1.48	0.57	0.02	0.59	4.31	4.48	-1.93

Survey. No.	HCO ₃ (meq/L)	SO ₄ (meq/L)	Cl (meq/L)	Cl (meq/L)	Ca (meq/L)	Mg (meq/L)	Na (meq/L)	K (meq/L)	Na+K (meq/L)	Sum Cations	Sum Anions	ERROR (%)
365	3.84	0.14	0.40	0.40	2.35	1.97	0.65	0.06	0.72	5.04	4.80	2.46
366	5.08	0.05	0.10	0.10	1.90	1.56	1.44	0.14	1.58	5.04	5.41	-3.62
367	2.08	0.06	0.10	0.10	0.85	0.81	0.65	0.06	0.71	2.37	2.48	-2.14
368	3.00	0.08	0.17	0.17	1.30	0.99	1.13	0.05	1.18	3.46	3.38	1.15
369	3.98	0.06	0.19	0.19	2.00	1.15	1.09	0.10	1.19	4.34	4.31	0.37
370	4.69	0.09	0.14	0.14	2.89	1.97	1.13	0.01	1.14	6.01	5.20	7.20
371	3.78	0.11	0.13	0.13	2.10	1.56	0.57	0.01	0.58	4.24	4.17	0.83
372	3.97	0.04	0.05	0.05	1.85	1.40	0.87	0.09	0.96	4.20	4.07	1.61
373	3.72	0.02	0.12	0.12	1.75	1.48	0.57	0.01	0.58	3.81	3.90	-1.15
374	3.11	0.08	0.12	0.12	1.50	1.23	0.78	0.09	0.88	3.61	3.51	1.39
375	2.91	0.03	0.03	0.03	1.20	1.15	0.61	0.03	0.64	2.99	2.98	0.12
376	2.80	0.08	0.14	0.14	1.45	1.15	0.52	0.04	0.57	3.16	3.21	-0.69
377	2.81	0.04	0.04	0.04	1.10	0.91	0.87	0.07	0.94	2.94	2.94	0.04
378	3.26	0.03	0.11	0.11	1.20	1.15	1.04	0.07	1.11	3.46	3.45	0.10
379	4.25	0.15	0.16	0.16	2.49	1.73	0.57	0.05	0.62	4.84	4.78	0.64
381	2.62	0.04	0.09	0.09	1.60	0.67	0.41	0.01	0.42	2.68	2.85	-2.98
382	2.39	0.25	0.37	0.37	1.95	1.07	0.40	0.01	0.40	3.42	3.39	0.45
383	2.49	0.05	0.16	0.16	1.40	0.91	0.41	0.00	0.42	2.72	2.76	-0.70
384	2.23	0.18	0.34	0.34	1.95	0.70	0.48	0.01	0.49	3.13	3.17	-0.63
385	2.90	0.05	0.09	0.09	1.45	1.07	0.44	0.01	0.44	2.96	3.04	-1.28
386	2.69	0.05	0.05	0.05	1.40	0.99	0.48	0.01	0.48	2.87	2.83	0.68
387	3.20	0.08	0.16	0.16	1.95	1.23	0.48	0.01	0.48	3.66	3.62	0.56
388	3.94	0.22	0.36	0.36	3.14	1.48	0.57	0.01	0.57	5.20	5.17	0.30
389	4.53	0.03	0.03	0.03	2.79	1.32	0.65	0.01	0.66	4.77	4.60	1.82
390	6.60	0.24	0.25	0.25	3.59	1.97	2.04	0.07	2.11	7.68	7.24	2.91
391	5.63	0.10	0.22	0.22	2.84	1.97	1.48	0.04	1.51	6.33	6.16	1.41
392	3.49	0.10	0.06	0.06	1.90	0.72	1.04	0.06	1.11	3.73	3.65	1.06
393	2.49	0.12	0.13	0.13	1.75	0.42	0.83	0.04	0.86	3.03	2.99	0.63
394	2.79	0.05	0.10	0.10	1.70	0.52	0.91	0.04	0.96	3.17	3.18	-0.15
395	5.03	0.03	0.05	0.05	2.35	1.89	1.04	0.02	1.07	5.30	5.11	1.86

APPENDIX 3A

- * Descriptive Statistics-All data & Individual geologic units**
- * Correlation matrix Diagrams-All data & Individual geologic units**

Samples with > 45 ppm of NO₃ and Pond analyses are excluded.

DESCRIPTIVE STATISTICS - ALL DATA (373 wells)

	Temp	EC	Field pH	ALK2	NO3	NO2	NO3	SO4	Cl	F
Mean	31.24	343.07	7.04	163.88	199.84	81.28	14.12	4.39	6.34	0.97
Standard Error	0.04	6.38	0.02	3.33	4.08	18.68	0.84	0.30	0.28	0.05
Median	0.00	320.00	7.00	154.71	188.75	25.00	11.88	2.78	4.80	0.51
Mode	0.00	300.00	6.90	0.00	0.00	25.00	0.03	1.85	1.81	0.20
Standard Deviation	0.83	123.18	0.38	64.31	78.46	380.71	12.31	5.89	5.35	1.00
Variance	0.68	15174.35	0.14	4135.87	6155.85	130113.47	151.44	34.65	28.63	0.99
Kurtosis	-1.99	0.71	41.17	0.71	0.71	166.89	2.95	28.44	9.13	1.83
Skewness	0.14	0.51	-5.88	0.64	0.64	12.25	1.48	4.72	2.53	1.88
Range	32.50	770.00	8.90	387.72	485.22	5543.00	72.30	49.30	38.90	4.60
Minimum	27.00	80.00	5.98	47.44	57.88	25.00	0.03	0.13	0.72	0.11
Maximum	32.50	770.00	8.90	387.72	485.22	5543.00	72.30	49.30	38.90	4.60
Sum	5435.40	126570.00	2582.04	60801.12	74177.38	33856.00	5239.70	1629.85	2351.83	360.89
Count	174.00	369.00	367.00	371.00	371.00	371.00	371.00	371.00	371.00	371.00
Confidence Level(0.95)	0.12	12.57	0.04	6.54	7.98	36.70	1.25	0.60	0.54	0.10

	Ce	Mg	Na	K	Si	Al	Fe	Mn	B	Bo
Mean	32.39	13.82	24.51	2.09	27.29	35.49	15.31	20.12	11.83	98.68
Standard Error	0.70	0.34	0.46	0.07	0.28	32.18	9.44	3.13	0.82	5.24
Median	30.70	13.00	24.00	2.00	27.00	0.70	1.00	2.50	8.00	73.00
Mode	21.00	12.00	22.00	1.30	27.00	0.20	1.00	0.10	8.00	0.20
Standard Deviation	13.47	6.66	8.90	1.32	5.43	621.51	182.32	60.52	12.01	101.11
Variance	181.43	44.30	79.15	1.74	29.45	386269.70	33239.00	3662.19	144.19	10223.08
Kurtosis	-0.17	1.39	1.35	6.47	-0.48	372.17	361.80	51.85	28.56	2.59
Skewness	0.58	1.00	0.85	1.47	0.09	19.28	18.88	6.18	4.76	1.53
Range	65.40	37.70	55.90	10.84	26.00	11999.80	3499.00	699.90	102.00	559.80
Minimum	6.60	2.30	8.10	0.18	15.00	0.20	1.00	0.10	8.00	0.20
Maximum	72.00	40.00	65.00	11.00	41.00	12000.00	3500.00	700.00	110.00	560.00
Sum	12080.00	5156.40	9360.00	781.24	10181.00	13238.82	5710.00	7503.82	4411.00	36808.20
Count	373.00	373.00	373.00	373.00	373.00	373.00	373.00	373.00	373.00	373.00
Confidence Level(0.95)	1.37	0.68	0.90	0.13	0.55	63.07	18.50	6.14	1.22	10.26

	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Mean	12.58	0.79	458.58	0.54	13.85	2.31	1.70	70.19	76.02
Standard Error	0.65	0.07	14.43	0.07	0.57	0.20	0.39	18.13	1.55
Median	9.00	0.30	400.00	0.10	10.00	1.10	0.20	16.00	73.00
Mode	6.00	0.10	380.00	0.10	14.00	0.50	0.20	1.00	0.00
Standard Deviation	12.47	1.41	278.74	1.38	11.04	3.89	7.58	350.21	30.01
Variance	155.49	2.00	77695.73	1.89	121.80	15.14	57.17	122845.77	900.33
Kurtosis	11.00	24.41	1.87	67.22	6.62	37.67	144.83	165.78	21.60
Skewness	2.89	4.36	1.00	7.08	2.03	5.25	11.33	12.59	2.06
Range	94.50	12.90	1768.00	16.90	84.80	41.50	109.80	4899.00	402.00
Minimum	0.50	0.10	32.00	0.10	0.20	0.50	0.20	1.00	10.00
Maximum	95.00	13.00	1800.00	17.00	85.00	42.00	110.00	4900.00	402.00
Sum	4691.00	296.40	171052.00	200.70	5166.59	860.10	634.70	26162.00	26302.00
Count	373.00	373.00	373.00	373.00	373.00	373.00	373.00	373.00	346.00
Confidence Level(0.95)	1.27	0.14	28.29	0.14	1.12	0.39	0.77	35.54	3.16

Correlation between all field parameters and chemical analyses

	Temp	EC	Field pH	ALK	HCO ₃	NO ₂	NO ₃	SO ₄	Cl	F	Ca	Mg	Na	K	Si
Temp	1.000														
EC	0.077	1.000													
Field pH	-0.105	0.262	1.000												
ALK	0.130	0.890	0.320	1.000											
HCO ₃	0.130	0.890	0.320	1.000	1.000										
NO ₂	0.069	0.136	0.007	0.072	0.072	1.000									
NO ₃	-0.034	0.106	-0.061	-0.249	-0.249	0.019	1.000								
SO ₄	-0.064	0.367	0.064	0.194	0.194	0.111	0.188	1.000							
Cl	-0.068	0.348	-0.041	0.007	0.007	0.196	0.742	0.262	1.000						
F	-0.057	-0.176	-0.090	-0.332	-0.332	-0.021	0.287	0.156	0.100	1.000					
Ca	-0.007	0.871	0.341	0.865	0.865	0.034	-0.007	0.363	0.217	-0.307	1.000				
Mg	0.146	0.832	0.327	0.833	0.833	0.125	-0.013	0.276	0.233	-0.185	0.699	1.000			
Na	0.134	0.860	0.030	0.591	0.591	0.157	0.132	0.195	0.248	0.031	0.409	0.405	1.000		
K	0.080	0.192	-0.232	0.109	0.109	0.012	0.182	0.041	0.265	-0.044	0.059	0.061	0.331	1.000	
Si	0.188	-0.464	-0.353	-0.517	-0.517	-0.036	0.152	-0.121	-0.077	0.326	-0.524	-0.491	-0.001	0.066	1.000
Al	-0.369	-0.117	0.132	-0.079	-0.079	-0.010	0.018	0.002	-0.035	0.027	-0.060	-0.094	-0.042	0.008	0.060
Fe	-0.106	-0.110	0.035	-0.076	-0.076	-0.000	0.009	-0.002	-0.040	0.025	-0.063	-0.067	-0.045	0.003	0.041
Mn	-0.127	0.145	0.196	0.181	0.181	0.032	0.003	0.049	0.038	-0.159	0.211	0.206	-0.072	-0.127	-0.210
B	-0.050	0.178	0.255	0.191	0.191	0.188	-0.133	0.305	-0.056	0.003	0.226	0.201	0.007	-0.103	-0.197
Ba	-0.018	0.015	-0.137	-0.092	-0.092	-0.001	0.290	-0.082	0.162	0.182	-0.214	0.007	0.217	0.423	0.261
Li	0.038	0.155	-0.176	0.069	0.069	0.166	0.028	0.152	0.047	0.413	0.030	0.078	0.274	0.076	0.095
Rb	-0.144	-0.124	-0.015	-0.179	-0.179	0.014	0.107	0.068	0.009	0.304	-0.141	-0.162	0.014	0.011	0.163
Sr	-0.032	0.302	-0.176	0.103	0.103	0.069	0.324	0.240	0.253	0.470	0.179	0.025	0.449	0.347	0.245
U	-0.012	0.432	0.066	0.406	0.406	0.487	-0.052	0.147	0.156	0.066	0.354	0.351	0.435	0.139	-0.202
V	0.182	0.072	0.100	0.141	0.141	-0.006	-0.020	-0.115	-0.000	-0.080	-0.029	0.310	-0.001	0.094	-0.010
Mo	0.121	0.238	0.040	0.201	0.201	0.150	0.008	0.274	0.103	0.045	0.202	0.194	0.210	0.029	-0.102
Cu	-0.054	0.063	0.019	0.010	0.010	-0.012	0.134	-0.017	0.156	0.131	0.005	0.020	0.138	0.021	0.024
Zn	-0.031	-0.020	-0.120	-0.003	-0.003	-0.013	-0.063	-0.004	-0.005	-0.021	-0.022	-0.038	0.027	0.081	0.007
Depth	0.193	0.009	-0.103	0.015	0.015	-0.019	-0.002	-0.076	-0.045	-0.014	-0.019	-0.031	0.116	0.136	0.123

Correlation between all field parameters and chemical analysis

	Temp	EC	Field pH	ALK	HCO ₃	NO ₂	NO ₃	SO ₄	Cl	F	Ca	Mg	Na	K	Si
Temp	1.000														
EC	0.077	1.000													
Field pH	-0.105	0.262	1.000												
ALK	0.130	0.890	0.320	1.000											
HCO ₃	0.130	0.890	0.320	1.000	1.000										
NO ₂	0.069	0.136	0.007	0.072	0.072	1.000									
NO ₃	-0.031	0.106	-0.031	-0.249	-0.249	0.019	1.000								
SO ₄	-0.064	0.137	0.094	0.194	0.194	0.111	0.188	1.000							
Cl	-0.088	0.348	-0.041	0.007	0.007	0.196	0.742	0.262	1.000						
F	-0.057	-0.176	-0.090	-0.332	-0.332	-0.021	0.287	0.156	0.100	1.000					
Ca	-0.007	0.871	0.341	0.865	0.865	0.034	-0.007	0.363	0.217	-0.307	1.000				
Mg	0.148	0.832	0.327	0.833	0.833	0.125	-0.013	0.276	0.233	-0.185	0.699	1.000			
Na	0.134	0.660	0.030	0.591	0.591	0.157	0.132	0.195	0.246	0.031	0.409	0.405	1.000		
K	0.080	0.192	-0.232	0.109	0.109	0.012	0.182	0.041	0.265	-0.044	0.059	0.081	0.331	1.000	
Si	0.188	-0.464	-0.353	-0.517	-0.517	-0.038	0.152	-0.111	-0.077	0.326	-0.524	-0.491	-0.087	0.066	1.000
Al	-0.369	-0.112	0.032	-0.079	-0.079	-0.011	0.018	0.002	-0.035	0.027	-0.060	-0.094	-0.042	0.008	0.050
Fe	-0.108	-0.110	0.035	-0.076	-0.076	-0.000	0.009	-0.002	-0.040	0.023	-0.063	-0.087	-0.045	0.003	0.041
Mn	-0.127	0.145	0.196	0.181	0.181	0.032	0.003	0.049	0.038	-0.159	0.211	0.206	-0.072	-0.127	-0.210
B	-0.050	0.178	0.255	0.191	0.191	0.188	-0.133	0.305	-0.056	0.003	0.226	0.201	0.507	-0.103	-0.197
Ba	-0.018	0.715	-0.137	-0.092	-0.092	-0.001	0.290	-0.082	0.152	0.182	-0.214	0.007	0.217	0.423	0.261
Li	0.038	0.155	-0.176	0.089	0.089	0.166	0.028	0.152	0.047	0.413	0.030	0.078	0.274	0.076	0.095
Rb	-0.144	-0.124	-0.015	-0.179	-0.179	0.014	0.107	0.068	0.309	0.304	-0.141	-0.162	0.014	0.011	0.163
Sr	-0.032	0.302	-0.176	0.103	0.103	0.069	0.324	0.240	0.253	0.470	0.179	0.025	0.449	0.347	0.245
U	-0.012	0.432	0.066	0.406	0.406	0.487	-0.052	0.147	0.156	0.086	0.354	0.351	0.435	0.139	-0.202
V	0.182	0.072	0.100	0.141	0.141	-0.006	-0.020	-0.115	-0.030	-0.060	-0.029	0.310	-0.001	0.094	-0.010
Mo	0.121	0.238	0.040	0.201	0.201	0.150	0.008	0.274	0.103	0.045	0.202	0.194	0.210	0.029	-0.102
Cu	-0.054	0.063	0.019	0.010	0.010	-0.012	0.184	-0.017	0.156	0.131	0.005	0.020	0.138	0.021	0.024
Zn	-0.031	-0.020	-0.120	-0.003	-0.003	-0.013	-0.063	-0.064	-0.005	-0.021	-0.022	-0.038	0.027	0.081	0.007
Depth	0.193	0.009	-0.103	0.015	0.015	-0.019	-0.002	0.076	-0.045	-0.014	-0.019	-0.031	0.116	0.136	0.123

Correlation between all field parameters and chemical analyses

	Al	Fe	Mn	B	Ba	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Temp														
EC														
Field pH														
ALK														
HCO3														
NO2														
NO3														
SO4														
Cl														
F														
Ca														
Mg														
Na														
K														
Si														
Al	1.000													
Fe	0.993	1.000												
Mn	-0.012	-0.007	1.000											
B	-0.018	-0.014	0.147	1.000										
Ba	0.011	0.012	-0.005	-0.132	1.000									
Li	0.020	0.034	-0.083	0.107	0.012	1.000								
Rb	0.244	0.242	-0.086	0.017	0.129	0.077	1.000							
Sr	-0.037	-0.042	-0.194	-0.019	0.355	0.361	0.208	1.000						
U	-0.010	-0.002	-0.001	0.278	-0.029	0.465	0.115	0.291	1.000					
V	0.015	0.014	0.044	-0.098	0.147	-0.112	-0.104	-0.208	-0.022	1.000				
Mo	-0.025	-0.021	0.006	0.114	-0.180	0.176	-0.013	0.047	0.280	0.015	1.000			
Cu	0.070	0.066	0.094	-0.039	0.126	-0.071	0.063	0.140	0.074	0.052	-0.037	1.000		
Zn	-0.009	-0.013	-0.008	-0.037	-0.052	-0.012	-0.040	0.029	-0.029	-0.059	0.001	-0.005	1.000	
Depth	-0.071	-0.073	-0.137	0.007	-0.007	0.225	-0.134	0.195	0.137	-0.204	0.035	-0.083	0.028	1.000

DESCRIPTIVE STATISTICS-UPPER BIRIMIAN METAVOLCANICS

	Temp	EC	Field pH	ALK2	HCO3	NO2	NO3	SO4	Cl	F
Mean	31.13	386.67	7.28	201.97	246.41	55.56	7.91	5.75	5.24	0.29
Standard Error	0.08	15.08	0.05	7.87	9.60	13.47	0.98	0.94	0.44	0.02
Median	31.00	375.00	7.33	194.79	237.65	25.00	5.39	3.54	4.51	0.25
Mode	31.00	320.00	7.10	NA	NA	25.00	0.03	1.61	NA	0.20
Standard Deviation	0.70	127.94	0.46	66.77	81.46	114.26	8.36	8.01	3.76	0.14
Variance	0.49	16369.01	0.21	4458.47	6635.99	13056.05	69.85	64.22	14.12	0.02
Kurtosis	1.35	-0.16	0.66	-0.17	-0.17	47.45	2.31	20.39	9.63	6.93
Skewness	-1.81	0.41	0.46	0.35	0.35	6.46	1.46	4.25	2.41	2.28
Range	32.50	590.00	2.50	311.59	380.14	895.00	40.44	47.79	24.02	0.81
Minimum	29.00	110.00	6.40	63.56	77.54	25.00	0.03	0.21	0.66	0.11
Maximum	32.50	700.00	8.90	375.15	457.68	920.00	40.47	48.00	24.90	0.92
Sum	1867.90	27840.00	523.85	14542.14	17741.42	4000.00	569.34	414.11	377.41	20.69
Count	60.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00
Confidence Level(0.95)	0.18	29.55	0.11	15.42	18.82	26.39	1.93	1.85	0.87	0.03

	Ce	Mg	Na	K	Si	Al	Fe	Mn	B	Ba
Mean	41.84	17.28	21.93	1.07	22.71	0.47	2.89	48.33	16.14	28.96
Standard Error	1.55	0.81	1.37	0.15	0.48	0.13	0.77	10.30	2.01	8.45
Median	41.50	16.50	17.50	0.37	23.00	0.20	1.00	7.95	8.00	2.00
Mode	39.00	13.00	13.00	0.25	25.00	0.20	1.00	0.10	8.00	0.20
Standard Deviation	13.19	6.89	11.65	1.30	4.04	1.06	6.57	87.38	17.03	71.69
Variance	173.91	47.48	135.69	1.69	16.32	1.13	43.17	7635.98	289.87	5138.94
Kurtosis	0.11	0.65	-0.44	3.69	-0.48	49.72	15.07	5.99	13.39	14.37
Skewness	-0.30	0.64	0.84	1.93	-0.00	6.67	3.93	2.46	3.27	3.61
Range	65.40	34.60	39.90	6.11	17.00	8.40	33.00	429.90	102.00	409.80
Minimum	6.60	3.40	9.10	0.19	15.00	0.20	1.00	0.10	8.00	0.20
Maximum	72.00	38.00	49.00	6.30	32.00	8.60	34.00	430.00	110.00	410.00
Sum	3012.60	1244.10	1578.60	77.31	1635.00	33.60	208.00	3480.10	1162.00	2085.40
Count	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00
Confidence Level(0.95)	3.05	1.59	2.69	0.30	0.93	0.25	1.52	20.18	3.93	16.56

	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Mean	6.54	0.36	224.82	0.39	11.20	2.41	0.77	36.06	64.67
Standard Error	1.08	0.03	28.37	0.09	1.11	0.63	0.31	10.69	2.18
Median	3.00	0.30	140.00	0.10	9.35	0.80	0.20	8.00	59.00
Mode	1.00	0.10	65.00	0.10	11.00	0.50	0.20	1.00	0.00
Standard Deviation	9.12	0.30	240.77	0.74	9.41	5.31	2.62	90.67	18.52
Variance	83.25	0.09	57968.01	0.55	88.58	28.15	6.88	8221.01	343.03
Kurtosis	5.11	3.78	14.41	19.55	2.98	45.09	51.88	22.60	0.11
Skewness	2.22	1.74	3.12	4.13	1.69	6.28	6.92	4.58	-0.61
Range	42.50	1.50	1568.00	4.70	43.80	41.50	20.80	549.00	118.00
Minimum	0.50	0.10	32.00	0.10	0.20	0.50	0.20	1.00	25.00
Maximum	43.00	1.60	1600.00	4.80	44.00	42.00	21.00	550.00	118.00
Sum	499.50	25.90	16187.00	27.80	806.29	173.60	55.50	2596.00	4022.00
Count	72.00	72.00	72.00	72.00	72.00	72.00	72.00	72.00	62.00
Confidence Level(0.95)	2.11	0.07	55.61	0.17	2.17	1.23	0.61	20.94	4.61

Correlation between field and chemical parameters-Upper Birimian Metavolcanics

	Temp	EC	Field pH	ALK	HCO3	NO2	NO3	SO4	Cl	F	Ca	Mg	Na	K
Temp	1.000													
EC	0.205	1.000												
Field pH	-0.203	0.072	1.000											
ALK	0.249	0.933	0.178	1.000										
HCO3	0.249	0.933	0.178	1.000	1.000									
NO2	-0.055	0.161	0.087	-0.040	-0.040	1.000								
NO3	-0.247	0.156	-0.083	-0.086	-0.086	0.260	1.000							
SO4	-0.056	0.392	0.018	0.167	0.167	0.577	0.313	1.000						
Cl	-0.336	0.330	-0.100	0.105	0.105	0.245	0.688	0.302	1.000					
F	0.103	-0.066	-0.238	-0.081	-0.081	-0.130	-0.140	-0.159	-0.173	1.000				
Ca	0.006	0.848	0.333	0.835	0.835	0.115	0.194	0.346	0.313	-0.320	1.000			
Mg	0.189	0.859	0.120	0.857	0.857	0.114	0.051	0.337	0.217	-0.193	0.702	1.000		
Na	0.309	0.757	-0.120	0.737	0.737	-0.044	0.017	0.144	0.155	0.342	0.431	0.533	1.000	
K	0.244	0.359	-0.425	0.292	0.292	-0.151	0.130	-0.046	0.337	0.348	0.040	0.256	0.541	1.000
Si	0.212	-0.081	-0.290	-0.157	-0.157	-0.026	0.085	0.175	-0.007	0.363	-0.306	-0.099	0.188	0.352
Al	-0.043	-0.018	-0.258	-0.042	-0.042	-0.068	0.151	-0.055	-0.026	0.119	-0.070	-0.017	0.026	0.125
Fe	-0.181	-0.184	0.110	-0.192	-0.192	0.091	0.031	-0.061	0.062	-0.060	-0.122	-0.167	-0.208	-0.159
Mn	-0.343	-0.144	0.213	-0.113	-0.113	0.116	-0.097	-0.039	0.027	-0.177	0.028	-0.111	-0.276	-0.279
B	-0.148	-0.036	0.364	0.045	0.045	-0.061	-0.143	-0.128	-0.129	-0.052	0.132	0.002	-0.161	-0.278
Ba	0.220	0.430	-0.260	0.369	0.369	-0.103	0.121	-0.063	0.426	0.264	0.162	0.397	0.453	0.788
Li	0.330	0.363	-0.332	0.384	0.384	-0.143	-0.124	-0.102	-0.057	0.274	0.088	0.306	0.554	0.598
Rb	-0.069	0.325	0.204	0.332	0.332	-0.174	0.150	0.045	0.033	0.155	0.405	0.233	0.248	0.096
Sr	0.324	0.509	-0.159	0.485	0.485	-0.087	0.065	0.021	0.131	0.271	0.305	0.300	0.614	0.613
U	0.185	0.584	-0.190	0.514	0.514	-0.100	0.093	0.066	0.475	0.151	0.362	0.434	0.624	0.695
V	0.007	0.038	-0.035	0.042	0.042	-0.153	0.122	-0.083	0.033	0.351	-0.091	0.130	0.146	0.219
Mo	0.109	0.133	0.018	0.101	0.101	-0.048	0.176	0.228	0.072	0.006	0.047	0.104	0.230	0.056
Cu	0.007	-0.007	0.002	-0.013	-0.013	-0.055	0.082	-0.005	-0.034	-0.046	0.051	-0.149	0.003	0.114
Zn	-0.125	-0.178	-0.103	-0.132	-0.132	-0.065	-0.129	-0.062	-0.032	0.201	-0.187	-0.163	-0.008	-0.012
Depth	0.346	0.115	-0.092	0.205	0.205	-0.125	-0.146	-0.131	-0.130	-0.059	-0.041	0.249	0.244	0.312

Correlation between field and chemical parameters-Upper Birimian Metavolcanics

	Si	Al	Fe	Mn	B	Ba	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Temp															
EC															
Field pH															
ALK															
HCO3															
NO2															
NO3															
SO4															
Cl															
F															
Ca															
Mg															
Na															
K															
Si	1.000														
Al	0.172	1.000													
Fe	-0.008	-0.020	1.000												
Mn	-0.105	-0.114	0.213	1.000											
B	-0.195	-0.076	0.095	0.124	1.000										
Ba	0.234	0.109	-0.094	-0.187	-0.188	1.000									
Li	0.126	0.093	-0.155	-0.210	-0.224	0.393	1.000								
Rb	0.063	0.065	-0.031	-0.010	0.036	0.223	-0.076	1.000							
Sr	0.164	0.072	-0.188	-0.252	-0.216	0.600	0.375	0.526	1.000						
U	0.115	-0.040	-0.112	-0.155	-0.144	0.763	0.534	0.086	0.473	1.000					
V	0.381	0.160	-0.035	-0.113	-0.125	0.378	0.182	0.234	0.100	0.250	1.000				
Mo	0.167	-0.049	-0.009	-0.117	-0.107	-0.069	0.013	-0.043	0.039	0.034	0.031	1.000			
Cu	0.086	-0.041	-0.032	-0.110	-0.055	0.120	-0.126	0.408	0.595	-0.012	-0.102	0.025	1.000		
Zn	0.006	-0.035	-0.093	0.194	-0.100	-0.050	0.121	-0.138	-0.041	-0.057	-0.115	0.087	-0.004	1.000	
Depth	-0.170	0.030	-0.097	-0.210	-0.027	0.073	0.391	-0.263	0.025	0.113	-0.142	0.125	-0.276	0.093	1.000

DESCRIPTIVE STATISTICS-UPPER BIRIMIAN METASEDIMENTS

	Temp	EC	Field pH	ALK2	HCO3	NO2	NO3	SO4	Cl	F
Mean	31.70	383.75	7.14	192.68	235.07	409.31	6.14	3.41	6.00	0.48
Standard Error	0.11	26.77	0.05	14.42	17.59	342.86	2.24	0.64	1.41	0.04
Median	0.00	390.00	7.15	205.83	251.11	25.00	5.34	2.93	4.15	0.44
Mode	0.00	300.00	6.90	NA	NA	25.00	0.03	NA	NA	0.34
Standard Deviation	0.45	107.07	0.21	57.68	70.37	1371.46	6.96	2.57	5.64	0.17
Variance	0.20	11465.00	0.04	3327.09	4952.01	1880889.96	80.23	6.58	31.77	0.03
Kurtosis	-1.18	0.82	-1.44	-0.63	-0.63	15.86	1.64	5.27	4.41	2.99
Skewness	0.90	0.84	-0.21	-0.52	-0.52	3.98	1.34	2.05	1.93	1.59
Range	32.00	420.00	0.60	195.60	238.63	5518.00	31.37	10.52	21.57	0.67
Minimum	31.00	220.00	6.80	84.03	102.52	25.00	0.03	0.68	1.13	0.25
Maximum	32.00	640.00	7.40	279.63	341.15	5543.00	31.40	11.20	22.70	0.92
Sum	158.50	6140.00	114.26	3062.94	3761.19	6549.00	130.26	54.52	96.02	7.41
Count	5.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Confidence Level(0.95)	0.39	52.47	0.10	28.26	34.48	672.00	4.39	1.26	2.76	0.08

	Cs	Mg	Na	K	Si	Al	Fe	Mn	B	Ba
Mean	35.44	15.93	26.38	1.74	26.06	0.67	13.00	9.59	14.13	56.50
Standard Error	2.91	1.53	2.23	0.18	0.96	0.11	5.58	2.27	4.25	16.40
Median	35.50	15.50	26.50	1.40	26.50	0.65	1.00	7.20	8.00	38.50
Mode	36.00	16.00	19.00	1.30	26.00	0.20	1.00	NA	8.00	NA
Standard Deviation	11.63	6.14	8.94	0.73	3.82	0.44	22.33	9.10	17.01	65.61
Variance	135.33	37.64	79.85	0.53	14.60	0.19	498.53	82.75	289.32	4305.00
Kurtosis	-0.32	0.90	0.61	-1.14	0.49	1.49	5.27	0.59	11.69	2.62
Skewness	0.13	0.92	1.03	0.49	-0.59	0.98	2.24	1.33	3.34	1.79
Range	41.00	22.80	32.00	2.24	15.00	1.60	80.00	28.00	66.00	218.80
Minimum	15.00	8.20	17.00	0.76	18.00	0.20	1.00	1.00	8.00	1.20
Maximum	56.00	31.00	49.00	3.00	33.00	1.80	81.00	29.00	74.00	220.00
Sum	567.00	254.80	454.00	27.84	417.00	10.70	208.00	153.40	226.00	904.00
Count	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00
Confidence Level(0.95)	5.70	3.01	4.38	0.36	1.87	0.22	10.94	4.46	8.33	32.15

	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Mean	24.56	0.56	460.00	2.03	15.53	3.56	0.93	37.06	74.93
Standard Error	4.40	0.21	53.85	1.07	2.43	1.06	0.46	9.97	7.14
Median	20.00	0.15	430.00	0.50	12.50	1.95	0.40	22.50	64.50
Mode	20.00	0.10	NA	0.10	11.00	1.10	0.20	5.00	0.00
Standard Deviation	17.60	0.84	215.41	4.29	9.70	4.25	1.86	39.87	28.56
Variance	309.86	0.71	46400.00	18.40	94.10	18.08	3.45	1569.53	815.61
Kurtosis	0.45	3.54	-0.32	11.15	-0.93	9.67	14.93	0.37	2.21
Skewness	0.94	2.07	0.72	3.23	0.60	2.91	3.81	1.12	0.42
Range	59.00	2.80	720.00	16.90	30.30	17.30	7.60	129.00	157.00
Minimum	2.00	0.10	160.00	0.10	2.70	0.70	0.20	1.00	45.00
Maximum	61.00	2.90	880.00	17.00	33.00	18.00	7.80	130.00	157.00
Sum	393.00	8.90	7360.00	32.50	248.40	56.90	14.90	593.00	1049.00
Count	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	14.00
Confidence Level(0.95)	8.63	0.41	105.55	2.10	4.75	2.08	0.91	19.54	14.96

Correlation between field and chemical parameters-Upper Birimian Metasediments

	Temp	EC	Field pH	ALK2	HCO3	NO2	NO3	SO4	Cl	F	Ca	Mg	Na	K	Si
Temp	1.000														
EC	0.939	1.000													
Field pH	0.547	0.142	1.000												
ALK2	0.852	0.925	0.096	1.000											
HCO3	0.852	0.925	0.096	1.000	1.000										
NO2	0.375	0.842	0.203	0.409	0.409	1.000									
NO3	0.397	-0.245	-0.087	-0.536	-0.536	0.008	1.000								
SO4	0.335	0.705	0.357	0.468	0.468	0.816	0.044	1.000							
Cl	0.507	0.478	0.158	0.126	0.126	0.792	0.479	0.812	1.000						
F	0.452	0.446	0.426	0.228	0.228	0.739	0.038	0.692	0.730	1.000					
Ca	0.791	0.835	-0.029	0.856	0.856	0.300	-0.253	0.386	0.180	0.159	1.000				
Mg	0.959	0.856	0.148	0.787	0.787	0.663	-0.303	0.625	0.438	0.421	0.589	1.000			
Na	0.474	0.808	0.267	0.739	0.739	0.622	-0.183	0.666	0.411	0.458	0.542	0.529	1.000		
K	-0.890	0.150	-0.194	0.252	0.252	0.187	-0.430	0.211	-0.033	-0.114	-0.044	0.112	0.343	1.000	
Si	-0.060	-0.732	-0.408	-0.645	-0.645	-0.564	0.083	-0.573	-0.446	-0.445	-0.661	-0.541	-0.592	0.071	1.000
Al	0.163	0.507	-0.173	0.322	0.322	0.685	0.065	0.634	0.559	0.306	0.208	0.474	0.545	0.303	-0.150
Fe	0.182	-0.268	0.235	-0.258	-0.258	0.021	-0.114	-0.181	-0.068	0.340	-0.314	-0.103	-0.265	-0.392	0.002
Mn	0.561	0.152	0.217	0.157	0.157	-0.045	-0.241	0.230	0.003	0.114	0.299	0.205	-0.116	-0.255	-0.098
B	0.375	0.730	0.134	0.503	0.503	0.933	0.075	0.735	0.743	0.697	0.345	0.642	0.740	0.091	-0.569
Ba	-0.538	0.109	-0.256	0.207	0.207	-0.002	-0.298	0.142	-0.101	-0.210	0.116	-0.038	0.293	0.712	0.025
Li	-0.049	0.509	0.058	0.329	0.329	0.554	0.012	0.720	0.659	0.655	0.402	0.321	0.456	0.057	-0.385
Rb	0.606	0.760	0.147	0.528	0.528	0.731	0.086	0.772	0.765	0.719	0.610	0.558	0.623	-0.114	-0.614
Sr	-0.913	0.665	-0.325	0.644	0.644	0.521	-0.271	0.382	0.292	0.289	0.581	0.450	0.602	0.446	-0.464
U	0.734	0.784	0.213	0.539	0.539	0.925	0.057	0.865	0.829	0.757	0.473	0.665	0.701	0.051	-0.700
V	0.938	-0.114	-0.124	-0.131	-0.131	-0.119	0.047	-0.164	-0.023	-0.065	-0.100	0.273	-0.432	-0.271	0.331
Mo	0.440	0.639	0.132	0.434	0.434	0.909	-0.118	0.749	0.759	0.825	0.280	0.684	0.517	0.109	-0.435
Cu	-0.897	-0.192	-0.279	-0.077	-0.077	-0.054	-0.283	-0.231	-0.247	-0.201	-0.137	-0.228	-0.156	0.506	0.065
Zn	-0.836	0.148	0.177	0.226	0.226	0.230	-0.495	0.186	-0.051	0.100	0.049	0.005	0.329	0.538	-0.198
Depth	0.139	0.313	-0.111	0.281	0.281	-0.079	0.324	-0.133	-0.003	-0.224	0.571	-0.034	0.282	-0.361	-0.480

Correlation between field and chemical parameters-Upper Birimian Metasediments

	Al	Fe	Mn	B	Ba	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Temp														
EC														
Field pH														
ALK2														
HCO3														
NO2														
NO3														
SO4														
Cl														
F														
Ca														
Mg														
Na														
K														
Si														
Al	1.000													
Fe	-0.324	1.000												
Mn	-0.127	0.004	1.000											
B	0.711	-0.033	-0.151	1.000										
Ba	0.396	-0.189	-0.226	-0.008	1.000									
Li	0.392	0.033	0.161	0.547	0.174	1.000								
Rb	0.569	-0.082	0.176	0.812	-0.076	0.768	1.000							
Sr	0.513	-0.282	-0.141	0.647	0.371	0.393	0.581	1.000						
U	0.654	-0.050	0.053	0.941	-0.015	0.702	0.923	0.610	1.000					
V	0.081	0.206	0.246	-0.192	-0.168	-0.352	-0.174	-0.307	-0.207	1.000				
Mo	0.601	0.098	0.114	0.851	-0.089	0.657	0.807	0.522	0.885	0.033	1.000			
Cu	-0.050	-0.194	-0.190	-0.095	0.205	-0.313	-0.175	0.434	-0.120	-0.199	-0.082	1.000		
Zn	0.191	-0.049	0.072	0.172	0.342	-0.041	0.165	0.387	0.211	-0.248	0.216	0.632	1.000	
Depth	-0.008	-0.268	-0.354	0.199	-0.072	-0.029	0.292	0.348	0.162	-0.385	-0.209	-0.284	-0.198	1.000

DESCRIPTIVE STATISTICS-UPPER BIRIMIAN GRANITOIDS

	Temp	EC	Field pH	ALK2	HCO3	NO2	NO3	SO4	Cl	F
Mean	31.32	348.74	6.98	167.85	204.78	82.23	14.59	3.65	6.61	0.49
Standard Error	0.06	9.53	0.02	4.58	5.59	22.89	0.95	0.31	0.45	0.01
Median	0.00	330.00	7.00	157.82	192.54	25.00	12.20	2.38	4.87	0.48
Mode	0.00	350.00	6.90	NA	NA	25.00	0.03	0.13	2.57	0.50
Standard Deviation	0.84	126.43	0.32	60.82	74.19	300.96	12.57	4.09	5.94	0.16
Variance	0.71	15984.62	0.10	3698.51	5504.86	90576.00	157.98	16.69	35.33	0.03
Kurtosis	-2.00	0.85	33.32	1.86	1.86	120.74	4.22	19.70	9.97	0.62
Skewness	0.12	0.69	-5.63	0.82	0.82	10.22	1.73	3.65	2.71	0.37
Range	32.00	770.00	7.97	397.72	485.22	3700.00	72.30	34.00	38.90	0.95
Minimum	27.00	100.00	6.01	47.44	57.88	25.00	0.03	0.13	0.72	0.12
Maximum	32.00	770.00	7.97	397.72	485.22	3700.00	72.30	34.00	38.90	0.95
Sum	2599.50	61030.00	1201.11	29373.78	35836.03	16140.00	2553.03	638.65	1156.93	85.85
Count	83.00	175.00	172.00	175.00	175.00	175.00	175.00	175.00	175.00	175.00
Confidence Level(0.95)	0.18	18.73	0.05	9.01	10.99	44.59	1.86	0.61	0.88	0.02

	Ca	Mg	Na	K	Si	Al	Fe	Mn	B	Ba
Mean	32.66	13.69	25.58	2.83	27.41	5.75	7.96	18.03	10.81	114.46
Standard Error	1.01	0.52	0.60	0.10	0.39	2.25	2.31	4.75	0.78	8.53
Median	30.00	13.00	25.00	2.60	27.00	0.70	1.00	2.35	8.00	77.00
Mode	27.00	12.00	25.00	2.30	27.00	0.20	1.00	0.10	8.00	140.00
Standard Deviation	13.40	6.89	8.00	1.38	5.16	29.79	30.64	63.05	10.33	113.23
Variance	179.67	47.48	63.94	1.90	26.57	887.25	938.90	3975.03	106.66	12820.00
Kurtosis	0.14	1.88	0.80	8.47	-0.37	81.40	48.05	79.89	52.68	2.26
Skewness	0.74	1.21	0.54	1.77	0.23	8.59	6.45	8.00	6.46	1.56
Range	65.20	37.60	44.00	10.84	25.00	319.80	289.00	699.90	102.00	559.80
Minimum	6.80	2.40	10.00	0.16	15.00	0.20	1.00	0.10	8.00	0.20
Maximum	72.00	40.00	54.00	11.00	40.00	320.00	290.00	700.00	110.00	560.00
Sum	5748.50	2409.40	4502.00	463.06	4824.00	1012.52	1401.00	3173.10	1867.00	20144.50
Count	176.00	176.00	176.00	176.00	176.00	176.00	176.00	176.00	176.00	176.00
Confidence Level(0.95)	1.98	1.02	1.18	0.20	0.76	4.40	4.53	9.31	1.53	16.73

	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Mean	9.43	0.54	448.85	0.45	15.86	2.28	1.69	95.78	79.17
Standard Error	0.49	0.07	16.87	0.07	0.98	0.28	0.51	37.71	1.85
Median	8.00	0.30	395.00	0.10	12.00	1.00	0.20	17.50	77.00
Mode	6.00	0.10	310.00	0.10	14.00	0.50	0.20	1.00	77.00
Standard Deviation	6.44	0.90	223.75	0.98	13.04	3.67	6.77	500.27	24.52
Variance	41.44	0.82	50062.11	0.96	170.03	13.46	45.89	250267.22	601.27
Kurtosis	7.72	30.45	0.61	30.33	5.51	16.19	106.58	82.77	3.09
Skewness	2.22	4.88	0.88	4.96	1.94	3.76	9.75	9.06	-0.01
Range	43.00	7.80	1168.00	8.10	84.10	23.50	79.80	4899.00	198.00
Minimum	1.00	0.10	32.00	0.10	0.90	0.50	0.20	1.00	14.00
Maximum	44.00	7.90	1200.00	8.20	85.00	24.00	80.00	4900.00	198.00
Sum	1660.00	95.50	78645.00	79.50	2791.00	398.50	296.70	16857.00	13301.00
Count	176.00	176.00	176.00	176.00	176.00	176.00	176.00	176.00	168.00
Confidence Level(0.95)	0.95	0.13	33.06	0.14	1.93	0.54	1.00	73.91	3.71

Correlation between field and chemical parameters-Upper Birimian Granitoids

	Temp	EC	Field pH	ALK	HCO3	NO2	NO3	SO4	Cl	F	Ca	Mg	Na	K
Temp	1.000													
EC	0.074	1.000												
Field pH	-0.086	0.326	1.000											
ALK	0.143	0.880	0.288	1.000										
HCO3	0.143	0.880	0.288	1.000	1.000									
NO2	0.083	0.075	-0.038	0.023	0.023	1.000								
NO3	-0.046	0.321	0.104	-0.041	-0.041	0.043	1.000							
SO4	-0.011	0.467	0.117	0.289	0.289	0.100	0.344	1.000						
Cl	-0.044	0.472	0.035	0.118	0.118	0.109	0.771	0.472	1.000					
F	-0.083	-0.147	-0.043	-0.218	-0.218	0.028	0.153	0.051	0.088	1.000				
Ca	0.084	0.890	0.273	0.857	0.857	0.003	0.226	0.458	0.359	-0.273	1.000			
Mg	0.143	0.818	0.304	0.832	0.832	0.031	0.146	0.307	0.309	-0.129	0.652	1.000		
Na	0.023	0.719	0.187	0.852	0.852	0.137	0.304	0.372	0.363	0.077	0.579	0.452	1.000	
K	-0.018	0.276	-0.042	0.201	0.201	-0.020	0.178	0.370	0.297	0.065	0.249	0.153	0.292	1.000
Si	0.220	-0.430	-0.219	-0.398	-0.398	0.078	-0.057	-0.251	-0.194	0.200	-0.409	-0.450	-0.140	-0.183
Al	-0.554	-0.215	-0.227	-0.200	-0.200	-0.035	-0.099	-0.036	-0.072	-0.064	-0.172	-0.167	-0.214	-0.057
Fe	-0.167	-0.057	-0.044	-0.051	-0.051	0.104	-0.115	-0.093	-0.067	-0.026	-0.110	0.023	-0.124	-0.082
Mn	-0.020	0.223	0.117	0.215	0.215	0.080	0.208	0.078	0.115	-0.055	0.166	0.293	0.116	0.025
B	0.054	0.146	0.116	0.149	0.149	-0.020	-0.080	0.454	-0.090	0.045	0.147	0.214	0.006	0.097
Ba	-0.127	0.078	0.096	0.000	0.000	0.045	0.241	-0.025	0.101	0.256	-0.167	0.126	0.189	0.274
Li	0.067	0.307	-0.023	0.383	0.383	-0.014	-0.110	0.143	0.029	0.029	0.288	0.313	0.296	0.157
Rb	-0.180	0.003	0.041	-0.050	-0.050	-0.046	-0.086	0.119	-0.092	0.105	0.003	-0.081	-0.043	0.064
Sr	-0.088	0.486	-0.039	0.330	0.330	0.085	0.314	0.329	0.317	0.030	0.546	0.098	0.542	0.323
U	-0.028	0.514	0.150	0.814	0.814	-0.033	0.031	0.332	0.082	-0.088	0.593	0.454	0.421	0.227
V	0.174	0.138	0.147	0.229	0.229	-0.010	-0.021	-0.057	-0.015	0.099	0.009	0.444	-0.067	-0.033
Mo	0.146	0.280	0.056	0.259	0.259	-0.035	0.011	0.283	0.143	0.092	0.320	0.201	0.197	0.024
Cu	-0.089	-0.007	0.105	-0.056	-0.056	0.004	0.203	0.019	0.106	0.095	-0.033	-0.010	0.031	-0.052
Zn	-0.054	-0.003	-0.148	0.023	0.023	-0.021	-0.094	0.027	-0.009	0.052	0.002	-0.018	0.039	0.067
Depth	0.213	-0.037	-0.080	0.004	0.004	-0.018	-0.096	0.005	-0.066	-0.162	0.102	-0.189	0.071	0.050

Correlation between field and chemical parameters-Upper Birimian Granitoids

	Si	Al	Fe	Mn	B	Ba	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Temp															
EC															
Field pH															
ALK															
HCO3															
NO2															
NO3															
SO4															
Cl															
F															
Ca															
Mg															
Na															
K															
Si	1.000														
Al	-0.240	1.000													
Fe	-0.135	0.292	1.000												
Mn	-0.127	-0.038	0.037	1.000											
B	-0.090	-0.039	-0.014	0.123	1.000										
Ba	0.081	-0.042	0.016	0.230	-0.023	1.000									
Li	0.044	-0.136	0.107	0.114	0.134	-0.130	1.000								
Rb	0.011	0.164	0.075	-0.063	0.093	0.074	-0.085	1.000							
Sr	0.111	-0.110	-0.123	-0.001	-0.025	0.162	0.136	0.185	1.000						
U	-0.204	-0.051	-0.070	0.079	0.274	-0.110	0.363	0.106	0.368	1.000					
V	-0.121	-0.025	-0.024	0.134	-0.031	0.166	-0.023	-0.072	-0.309	-0.000	1.000				
Mo	-0.143	-0.025	-0.028	0.080	0.124	-0.241	0.279	0.014	0.043	0.312	0.011	1.000			
Cu	0.040	-0.022	-0.039	0.289	-0.018	0.191	-0.086	-0.069	0.060	-0.042	0.126	-0.072	1.000		
Zn	-0.016	-0.018	-0.037	-0.020	-0.037	-0.102	-0.005	-0.054	0.034	-0.049	-0.074	0.002	-0.013	1.000	
Depth	0.353	-0.207	-0.079	-0.143	0.130	-0.174	0.217	-0.146	0.260	0.080	-0.332	0.106	-0.036	0.021	1.000

DESCRIPTIVE STATISTICS-BONGO GRANITES

	Temp	EC	Field pH	ALK2	HCO3	NO2	NO3	SO4	Cl	F
Mean	31.13	297.74	6.94	127.80	185.91	66.36	18.40	4.84	6.68	2.29
Standard Error	0.10	9.72	0.03	4.71	5.75	11.20	1.21	0.85	0.49	0.09
Median	0.00	290.00	6.90	121.28	147.98	25.00	15.73	2.92	4.89	2.20
Mode	0.00	280.00	6.90	NA	NA	25.00	14.04	1.85	4.78	1.51
Standard Deviation	1.04	101.51	0.35	49.21	60.04	116.97	12.81	6.83	5.16	0.95
Variance	1.09	10303.40	0.12	2422.03	3604.98	13682.29	159.00	46.83	26.64	0.90
Kurtosis	-0.44	1.08	39.88	0.18	0.18	20.07	1.04	21.19	4.37	-0.48
Skewness	1.25	0.14	-5.99	0.52	0.52	4.15	1.05	4.24	1.89	0.29
Range	32.00	630.00	7.80	275.32	335.89	752.00	60.32	49.30	31.00	4.60
Minimum	27.00	80.00	5.95	80.33	61.40	25.00	0.03	0.57	1.08	0.61
Maximum	32.00	630.00	7.80	275.32	335.89	752.00	60.32	49.30	31.00	4.60
Sum	809.50	31560.00	742.82	13802.26	16838.74	7167.00	1987.07	522.37	721.47	247.04
Count	26.00	106.00	107.00	106.00	106.00	106.00	106.00	106.00	106.00	106.00
Confidence Level(0.95)	0.40	19.32	0.07	9.28	11.32	22.08	2.38	1.29	0.97	0.18

	Li	Rb	Cs	Mg	Na	K	Si	Al	Fe	Mn
Mean	19.62	1.52	25.25	11.45	23.94	1.95	30.32	111.76	35.72	6.40
Standard Error	1.55	0.21	0.90	0.48	0.74	0.07	0.45	110.08	32.09	1.91
Median	14.00	0.70	24.00	11.00	22.00	1.80	30.00	1.00	1.00	1.60
Mode	10.00	0.10	21.00	12.00	21.00	1.40	30.00	0.20	1.00	0.10
Standard Deviation	16.19	2.15	9.39	4.99	7.74	0.71	4.70	1149.23	335.05	19.93
Variance	262.02	4.63	88.12	24.89	59.86	0.51	22.09	1320736.43	112258.98	397.39
Kurtosis	7.04	9.12	-0.24	-0.38	8.19	5.60	-0.42	109.00	108.79	45.46
Skewness	2.23	2.76	0.56	0.42	2.25	1.50	-0.19	10.44	10.43	6.29
Range	94.50	12.90	42.20	22.70	52.00	4.99	25.00	11999.80	3499.00	169.90
Minimum	0.50	0.10	7.80	2.30	13.00	0.71	16.00	0.20	1.00	0.10
Maximum	95.00	13.00	50.00	25.00	65.00	5.70	41.00	12000.00	3500.00	170.00
Sum	2138.50	166.10	2751.90	1248.10	2609.00	213.03	3305.00	12182.00	3893.00	697.22
Count	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00
Confidence Level(0.95)	3.04	0.40	1.76	0.94	1.45	0.13	0.88	215.75	62.90	3.74

	B	Ba	Sr	U	V	Mo	Cu	Zn	Depth
Mean	10.61	125.45	631.74	0.56	12.12	2.12	2.46	56.29	77.75
Standard Error	0.83	7.31	26.24	0.12	0.73	0.29	1.03	9.13	3.92
Median	8.00	110.00	610.00	0.10	9.90	1.30	0.20	22.00	74.00
Mode	8.00	110.00	420.00	0.10	13.00	0.50	0.20	1.00	0.00
Standard Deviation	8.72	76.36	273.91	1.30	7.62	3.01	10.79	95.36	40.90
Variance	75.96	5830.53	75029.34	1.69	58.03	9.04	116.33	9094.34	1673.04
Kurtosis	19.28	0.78	2.73	39.87	1.19	27.84	93.79	12.68	28.57
Skewness	4.11	0.98	1.17	5.65	1.29	4.77	9.42	3.27	3.63
Range	59.00	359.80	1680.00	10.90	33.10	22.50	109.80	609.00	402.00
Minimum	6.00	0.20	120.00	0.10	2.90	0.50	0.20	1.00	10.00
Maximum	67.00	360.00	1800.00	11.00	36.00	23.00	110.00	610.00	402.00
Sum	1156.00	13674.30	68860.00	60.90	1320.90	231.10	287.60	6136.00	7930.00
Count	109.00	109.00	109.00	109.00	109.00	109.00	109.00	109.00	102.00
Confidence Level(0.95)	1.64	14.33	51.42	0.24	1.43	0.56	2.02	17.90	7.94

Correlation between field and chemical parameters-Bongo Granite

	Temp	EC	Field pH	Lab pH	ALK	HCO3	NO2	NO3	SO4	Cl	F	Ca	Mg	Na	K
Temp	1.000														
EC	-0.105	1.000													
Field pH	0.028	0.174	1.000												
Lab pH	-0.058	0.519	0.237	1.000											
ALK	-0.088	0.849	0.244	0.579	1.000										
HCO3	-0.088	0.849	0.244	0.579	1.000	1.000									
NO2	0.071	-0.065	-0.070	-0.019	-0.101	-0.101	1.000								
NO3	0.210	0.053	-0.054	-0.249	-0.357	-0.357	0.081	1.000							
SO4	-0.114	0.368	0.075	0.047	0.176	0.176	-0.058	0.090	1.000						
Cl	0.049	0.228	-0.037	-0.036	-0.171	-0.171	0.105	0.781	0.095	1.000					
F	-0.093	0.178	0.308	0.034	0.014	0.014	-0.086	0.264	0.398	0.192	1.000				
Ca	-0.183	0.863	0.181	0.533	0.799	0.799	-0.111	-0.020	0.438	0.113	0.273	1.000			
Mg	0.156	0.780	0.399	0.531	0.741	0.741	0.017	0.060	0.223	0.233	0.191	0.654	1.000		
Na	-0.047	0.606	0.125	0.241	0.632	0.632	-0.101	-0.040	0.168	0.092	0.148	0.371	0.353	1.000	
K	-0.192	0.120	0.048	-0.045	0.140	0.140	0.114	0.033	-0.090	0.125	-0.208	0.162	0.207	-0.018	1.000
Si	0.063	-0.564	-0.268	-0.221	-0.610	-0.610	-0.011	0.091	-0.154	-0.051	-0.082	-0.457	-0.573	-0.379	-0.113
Al	0.210	-0.201	0.101	-0.221	-0.111	-0.111	-0.035	0.003	-0.001	-0.070	-0.080	-0.075	-0.177	-0.074	0.047
Fe	0.071	-0.194	0.104	-0.221	-0.103	-0.103	-0.035	0.001	0.004	-0.073	-0.073	-0.068	-0.173	-0.068	0.044
Mn	0.168	0.271	-0.005	0.140	0.366	0.366	0.044	-0.169	0.159	-0.071	-0.118	0.366	0.269	0.055	0.093
B	0.169	0.318	0.140	0.040	0.234	0.234	-0.084	-0.099	0.770	-0.082	0.304	0.333	0.171	0.218	-0.005
Ba	-0.117	-0.065	-0.031	-0.239	-0.163	-0.163	-0.133	0.226	-0.125	0.131	-0.012	-0.089	-0.074	0.026	0.219
Li	-0.142	0.267	-0.131	0.072	0.220	0.220	0.177	-0.030	0.295	-0.041	0.231	0.270	0.095	0.193	-0.189
Rb	-0.152	-0.185	0.075	-0.252	-0.180	-0.180	-0.193	0.098	0.045	0.002	0.021	-0.146	-0.221	0.009	-0.038
Sr	-0.316	0.578	0.090	0.195	0.382	0.382	-0.206	0.198	0.499	0.189	0.362	0.603	0.352	0.323	0.089
U	-0.181	0.455	0.123	0.159	0.544	0.544	-0.109	-0.208	0.092	-0.071	0.185	0.399	0.329	0.473	-0.043
V	0.264	-0.087	0.381	0.161	0.069	0.069	0.140	-0.148	-0.197	-0.022	-0.001	-0.079	0.207	-0.073	0.083
Mo	0.021	0.208	-0.001	0.019	0.190	0.190	0.012	-0.042	0.353	-0.056	0.257	0.155	0.202	0.131	0.076
Cu	0.026	0.263	0.019	0.186	0.213	0.213	-0.051	0.165	-0.038	0.259	0.171	0.172	0.195	0.345	0.078
Zn	0.016	-0.123	-0.204	-0.146	-0.119	-0.119	-0.118	-0.018	-0.044	-0.025	-0.150	-0.120	-0.170	-0.086	0.060
Depth	0.145	0.071	0.002	0.119	0.081	0.081	-0.010	-0.027	-0.064	-0.079	-0.122	-0.063	0.187	0.049	0.064

Correlation between field and chemical parameters-Bongo Granite

	Si	Al	Fe	Mn	B	Ba	Li	Rb	Sr	U	V	Mo	Cu	Zn	Depth
Temp															
EC															
Field pH															
Lab pH															
ALK															
HCO3															
NO2															
NO3															
SO4															
Cl															
F															
Ca															
Mg															
Na															
K															
Si	1.000														
Al	0.055	1.000													
Fe	0.048	1.000	1.000												
Mn	-0.203	0.004	0.005	1.000											
B	-0.115	-0.029	-0.020	0.128	1.000										
Ba	0.184	-0.007	-0.009	-0.198	-0.117	1.000									
Li	-0.208	-0.010	0.002	0.087	0.394	-0.232	1.000								
Rb	0.088	0.284	0.284	-0.058	-0.022	0.084	-0.108	1.000							
Sr	-0.173	-0.128	-0.122	-0.179	0.416	0.241	0.245	-0.029	1.000						
U	-0.394	-0.019	0.001	0.129	0.242	-0.165	0.485	0.036	0.255	1.000					
V	-0.085	0.063	0.058	0.114	-0.174	-0.179	-0.341	-0.187	-0.419	-0.143	1.000				
Mo	-0.231	-0.052	-0.042	0.118	0.288	-0.183	0.222	-0.075	0.079	0.192	-0.009	1.000			
Cu	-0.095	0.086	0.084	-0.037	-0.047	0.011	-0.121	0.086	0.108	0.235	-0.014	-0.018	1.000		
Zn	0.088	-0.046	-0.047	-0.055	0.005	0.133	-0.039	-0.082	0.043	-0.029	-0.132	-0.088	0.011	1.000	
Depth	-0.149	-0.097	-0.097	-0.040	0.016	0.012	0.235	-0.193	0.088	0.306	-0.169	-0.029	-0.122	0.054	1.000

APPENDIX 3B

- * **Percent milliequivalents of major ions**
- * **Water type Characterization of individual wells.**

APPENDIX 3B

- * Percent milliequivalents of major ions
- * Water type Characterization of individual wells.

3

OF/DE

3

PM-1 3½"x4" PHOTOGRAPHIC MICROCOPY TARGET
NBS 1010a ANSI/ISO #2 EQUIVALENT

No.	Survey No.	Location No.	Village	%HCO ₃	%SO ₄	%Cl	%CA	%Mg	%NAK	Water type
1	3	455B1	Boko	87.12	1.52	11.36	25.15	14.11	60.74	CaMgHCO ₃
2	4	455B2HDW	Boko	95.46	0.91	3.63	21.83	18.92	59.25	CaNaHCO ₃
3	5	455B3	Zoko-Kodorogo	80.51	0.85	18.64	25.00	18.89	58.11	CaMgHCO ₃
4	6	455B5	Zoko-Kadare	84.97	4.58	10.46	27.92	17.26	55.33	CaNaHCO ₃
5	7	455B6	Zoko-Kadare	84.89	2.86	12.23	32.43	14.05	53.51	CaMgHCO ₃
6	8	455B7	Bakungu	68.75	6.25	25.00	28.38	19.65	51.97	CaNaHCO ₃
7	9	455B9HDW	Bakungu	98.14	0.47	1.40	34.56	13.82	51.61	CaNaHCO ₃
8	10	455B9	Bakungu	98.35	0.91	2.74	32.75	16.59	50.66	CaNaHCO ₃
9	11	455B10	Kansoe	84.68	4.03	11.29	28.99	20.12	50.30	CaMgHCO ₃
10	12	455B11	Namoo	88.52	4.31	7.18	38.61	12.36	49.03	CaMgHCO ₃
11	13	455B12	Samboligo	95.48	1.13	3.39	37.63	13.98	48.39	CaNaHCO ₃
12	14	455B12HDW	Sotabisi	84.09	3.79	12.12	31.25	19.89	48.30	CaNaHCO ₃
13	15	455B13HDW 7453		96.78	1.62	1.62	33.98	18.45	47.57	CaNaHCO ₃
14	16	455B13	Nayorogo	95.07	0.99	3.94	26.64	25.82	47.54	CaNaHCO ₃
15	17	455B17	Nayorogo	94.15	1.60	4.26	35.21	17.37	47.42	CaNaHCO ₃
16	18	455B1C	Nayorogo	97.87	0.00	2.33	34.06	18.84	47.10	CaNaHCO ₃
17	19	455B19	Namoo	95.62	1.20	3.19	32.03	21.00	46.98	CaNaHCO ₃
18	20	455B20	Namoo	92.23	0.97	6.80	30.09	23.01	46.90	CaNaHCO ₃
19	21	455B21HDW	Namoo	88.60	1.75	9.65	27.27	26.57	46.15	CaNaHCO ₃
20	22	455B21	Namoo	98.45	0.00	1.55	25.78	27.34	46.09	CaMgHCO ₃
21	23	455B22	Lungu	97.46	1.02	1.52	28.85	25.48	45.67	CaNaHCO ₃
22	24	455B23	Balungu	98.01	0.40	1.59	41.02	14.06	44.92	CaNaHCO ₃
23	26	455B24	Bungo	97.45	0.73	1.82	30.30	25.25	44.78	CaMgHCO ₃
24	27	455B25	Zoko-Goo	87.28	4.05	8.67	32.86	22.54	44.60	CaMgHCO ₃
25	28	455B26	Zoko-Goo	89.84	0.53	9.63	35.56	20.44	44.00	CaNaHCO ₃
26	29	455B27	Samboligo	94.62	1.35	4.04	35.29	20.78	43.92	CaMgHCO ₃
27	30	455B28HDW	Samboligo	94.47	0.85	4.68	40.23	16.09	43.68	CaNaHCO ₃
28	31	455B28	Kansoe	93.64	2.12	4.24	41.91	14.45	43.64	CaMgHCO ₃
29	32	455B29	Samboligo	88.82	6.21	4.97	46.63	9.84	43.52	CaNaHCO ₃
30	33	455B30HDW	Longo	97.44	0.64	1.92	37.34	19.16	43.51	CaNaHCO ₃
31	34	455B32	Kadare	89.09	0.01	10.91	28.93	27.67	43.40	CaNaHCO ₃
32	35	455B34	Samboligo	90.97	4.05	4.98	39.76	17.13	42.81	CaNaHCO ₃
33	36	455B35	Samboligo	90.73	0.86	8.61	40.46	16.18	42.77	CaNaHCO ₃
34	37	455C1	Bongo-Soe	86.57	2.99	10.45	36.48	20.60	42.49	CaMgHCO ₃
35	38	455C2	Bongo-Soe	91.07	1.19	7.74	30.73	26.82	42.46	CaMgHCO ₃
36	39	455C3	Kanseringa	95.83	2.19	1.97	34.79	22.86	42.35	CaMgHCO ₃
37	40	455C4	Kanseringa	93.88	2.04	4.08	36.17	21.70	42.13	CaMgHCO ₃
38	41	455C7	Samboligo	67.72	5.29	26.98	39.52	18.90	41.92	CaMgHCO ₃
39	42	455C10HDW	Feo	74.68	6.49	18.83	33.19	25.22	41.59	CaNaHCO ₃
40	43	455C11	Feo	89.77	1.86	8.37	34.88	23.64	41.47	CaNaHCO ₃
41	44	455C13	Boko	93.40	4.86	1.74	40.58	18.18	41.23	CaMgHCO ₃
42	45	455C14	Bongo-Soe	83.33	3.15	13.51	37.91	20.94	41.16	CaNaHCO ₃
43	46	455C15	Soe Arabe	94.35	1.61	4.03	33.10	26.13	41.77	CaNaHCO ₃
44	47	455C17	Bongo-Soe	95.07	1.37	3.56	41.99	17.32		CaNaHCO ₃
45	48	455C18	Bongo-Soe	94.79	1.42	3.79	34.55	24.39		CaNaHCO ₃
46	49	455C19	Feo	91.84	1.22	6.94	37.77	21.22	40.85	CaNaHCO ₃
47	51	455C23	Gurogo	97.06	1.63	1.31	36.05	23.51	40.44	CaMgHCO ₃
48	52	455C24	Amanga	88.49	0.68	12.84	33.51	26.29	40.21	CaNaHCO ₃
49	53	455C25	Feo	88.61	2.14	9.25	38.22	21.97	40.13	CaNaHCO ₃
50	54	455C27HDW	Feo	75.35	4.93	19.72	34.21	25.79	40.00	CaNaHCO ₃
51	55	455C29	Bongo-Soe	94.53	1.22	4.26	29.33	30.67	40.00	CaNaHCO ₃
52	56	455C30	Kebre	96.84	0.79	2.37	42.58	17.52	39.90	CaMgHCO ₃
53	57	455C31	Akulyoo	94.74	1.11	4.16	29.41	30.75	39.84	CaNaHCO ₃
54	58	455C32	Akunduo	86.81	4.40	8.79	39.16	21.08	39.76	CaMgHCO ₃
55	59	455C33	Bongo-Soe	93.41	2.20	4.40	43.83	16.58	39.61	CaMgHCO ₃
56	60	455C34	Feo	95.77	1.63	2.81	42.94	17.48	39.57	CaNaHCO ₃
57	61	455C35	Soboto-Akonika	92.95	1.60	5.45	32.41	28.09	39.51	CaNaHCO ₃
58	62	455C36	Feo-Konkos	94.97	2.41	2.63	36.09	24.42	39.49	CaMgHCO ₃
59	63	455C37	Soboto	90.42	2.54	7.04	41.56	18.98	39.48	CaNaHCO ₃
60	64	455C38	Feo	92.80	1.18	5.92	34.40	25.69	39.45	CaMgHCO ₃
61	65	455C39	Gurogo	95.80	0.99	3.21	19.45	41.42	39.13	CaMgHCO ₃
62	66	455C40	Gurogo	91.35	3.37	5.29	33.61	27.31	39.08	CaMgHCO ₃
63	67	455C42	Ayopia	95.65	0.54	3.80	37.96	23.84	38.97	CaMgHCO ₃
64	68	455C43	Amanga	77.65	9.78	12.57	40.20	20.60	38.94	CaMgHCO ₃
65	69	455C44	Feo	92.31	0.69	6.80	36.11	25.28	38.89	CaNaHCO ₃

No.	Survey No.	Location No.	Village	%HCO4	%SO4	%CL	%CA	%Mg	%NAK	Water type
66	71	455C45	Fee	93.50	1.50	5.00	36.29	25.00	36.71	CaNaHCO3
67	73	455C47	Alufyo	92.00	3.00	5.00	33.61	28.15	38.24	CaMgHCO3
68	74	455C48	Amanga	97.16	0.47	2.37	30.23	31.63	38.14	CaMgHCO3
69	75	455D4	Sumbrungu	95.81	1.35	3.04	36.99	25.00	38.11	CaNaHCO3
70	76	455D6	Sumbrungu	98.31	1.23	2.46	47.55	14.42	38.04	CaNaHCO3
71	77	455D25	Sumbrungu	81.13	4.56	14.29	41.23	20.93	37.84	CaNaHCO3
72	78	455D27	Sumbrungu	86.60	3.09	10.31	32.89	29.39	37.72	CaNaHCO3
73	79	455D28	Sumbrungu	80.22	1.81	7.97	44.26	18.03	37.70	CaMgHCO3
74	80	455D30	Sumbrungu	86.70	3.48	7.83	48.91	13.41	37.68	CaMgHCO3
75	81	455D31	Zoko-Gambrongo	94.44	0.37	5.19	36.46	26.04	37.50	CaNaHCO3
76	82	455D32	Zoko	91.52	0.88	7.60	34.86	27.65	37.47	CaMgHCO3
77	83	455D33	Zoko-Kanga	96.40	0.90	2.70	33.24	28.64	37.12	CaMgHCO3
78	84	455E2	Gowrie-Kasingo	77.33	4.05	18.62	34.46	28.45	37.07	CaNaHCO3
79	86	455E3	Gowrie-Nayire	87.36	7.66	4.98	36.06	25.26	36.66	CaMgHCO3
80	87	455E5	Nyaraga	96.47	0.71	2.83	36.30	27.06	36.63	CaNaHCO3
81	88	455E6	Zoko-Gambrongo	88.95	5.67	5.67	49.30	14.08	36.62	CaNaHCO3
82	89	455E8 ?	Zoko-Gambrongo	80.87	2.90	6.22	45.83	17.87	36.50	CaNaHCO3
83	90	455E9HDW	Zoko	85.01	1.71	12.29	37.36	26.15	36.49	CaNaHCO3
84	91	455E9	Zoko-Kanga	83.06	1.03	5.91	31.18	32.33	36.49	CaMgHCO3
85	92	455E10	Zoko-Gambrongo	94.97	2.01	3.02	45.86	17.65	36.47	CaMgHCO3
86	93	455E11	Zaare	94.69	0.94	4.38	35.61	26.21	36.47	CaNaHCO3
87	94	455E12	Nyaraga	73.63	2.49	23.88	35.71	27.89	36.39	CaNaHCO3
88	95	455E13	Zoko	94.78	1.52	3.70	30.72	33.05	36.23	CaNaHCO3
89	96	455E15	Zoko-Tarongo	95.53	0.96	3.51	43.34	20.43	36.22	CaNaHCO3
90	97	455E16HDW	Zoko	83.33	1.38	5.29	32.12	31.69	36.19	CaNaHCO3
91	98	455E17	Zoko-Tarongo	88.84	2.79	8.37	30.49	33.33	36.18	CaNaHCO3
92	99	455E20	Zoko-Kanga	89.40	2.12	8.46	34.33	29.55	36.12	CaNaHCO3
93	100	455E21	Vea	91.70	1.66	6.64	36.67	27.33	36.00	CaNaHCO3
94	101	455E22	Vea	82.13	16.14	1.73	44.84	19.57	35.87	CaNaHCO3
95	102	455E23	Vea	96.82	0.98	2.20	34.15	30.00	35.85	CaMgHCO3
96	103	455E24	Vea	97.21	0.93	1.86	33.77	30.50	35.73	CaNaHCO3
97	104	455E25	Vea	85.02	3.48	11.50	35.40	29.20	35.69	CaNaHCO3
98	105	455E27	Sumbrungu	88.44	1.36	10.20	33.92	30.36	35.69	CaNaHCO3
99	106	455E28	Sumbrungu	96.18	0.36	1.45	45.45	18.91	35.64	CaNaHCO3
100	107	455E30	Zoko	95.92	1.57	2.51	41.03	23.40	35.56	CaMgHCO3
101	108	455E33	Vea	96.50	0.80	0.90	36.02	28.53	35.45	CaNaHCO3
102	109	455E33HDW	Vea	85.55	6.62	5.83	36.36	26.23	35.39	CaNaHCO3
103	110	455E35	Nyaraga	70.78	2.80	26.62	34.48	30.17	35.34	CaNaHCO3
104	111	455E36	Nyaraga	78.46	7.34	14.18	45.87	18.81	35.32	CaNaHCO3
105	112	455E37	Zoko-Tarongo	94.99	0.56	4.46	34.01	30.98	35.26	CaNaHCO3
106	113	455E38	Zoko-Kanga	90.74	2.12	7.14	45.24	19.52	35.24	CaMgHCO3
107	114	455E39	Lungu	98.61	0.70	3.70	48.86	15.96	35.18	CaNaHCO3
108	115	455E42	Zoko-Goo	94.26	2.19	3.55	35.08	29.67	35.08	CaNaHCO3
109	116	455F1	Yorogo	89.78	2.79	7.43	43.18	22.26	34.82	CaMgHCO3
110	117	455F2	Bongo	97.70	1.15	1.15	47.71	17.56	34.73	CaMgHCO3
111	118	455F3	Bongo Anafobisi	85.67	1.99	12.74	35.25	30.03	34.73	CaNaHCO3
112	119	455F4	Bongo Bogrogo	87.24	8.22	4.55	40.79	24.57	34.65	CaMgHCO3
113	122	455F7	Bongo	94.97	3.14	1.89	41.92	23.52	34.56	CaNaHCO3
114	123	455F8	Bongo Azasi	97.97	0.51	1.52	33.51	31.98	34.54	CaMgHCO3
115	124	455F9	Bongo	95.10	0.49	4.41	35.71	29.46	34.38	CaNaHCO3
116	125	455F10	Bongo Bogrogo	91.04	2.15	6.81	37.37	28.83	34.16	CaNaHCO3
117	127	455F12	Akanaba	96.11	0.71	3.18	34.70	31.23	34.07	CaNaHCO3
118	128	455F13	Dua	88.94	6.45	4.61	37.11	28.87	34.02	CaNaHCO3
119	129	455F15	Dua Yikeni	92.31	2.46	5.23	37.46	28.53	34.01	CaNaHCO3
120	130	455F16	Yorogo	91.84	4.31	4.04	31.78	34.23	33.99	CaMgHCO3
121	133	455F19	Bongo	94.18	1.03	4.79	33.98	32.04	33.98	CaMgHCL 3
122	134	455F22	Dachio	92.78	3.61	3.61	38.25	27.80	33.95	CaNaHCO3
123	135	455F23	Dachio	97.94	0.99	1.47	38.69	27.06	33.93	CaNaHCO3
124	136	455F25	Yorogo	91.53	2.65	5.82	35.24	30.84	33.92	CaMgHCO3
125	137	455F26	Yorogo	97.01	0.75	2.24	35.99	30.85	33.80	CaMgHCO3
126	138	455F27	Apaa-Tanga	97.16	0.71	2.13	45.45	20.69	33.86	CaNaHCO3
127	139	455F28 to be F38		92.72	1.32	5.98	40.75	25.71	33.86	CaMgHCO3
128	140	455F29	Yorogo	92.61	1.06	6.34	41.80	24.77	33.75	CaNaHCO3
129	141	455F30	Yorogo	92.88	2.71	4.41	43.88	22.51	33.63	CaMgHCO3
130	142	455F31	Bongo	96.44	1.27	2.29	35.88	30.58	33.56	CaMgHCO3

No.	Survey No.	Location No.	Village	%HCO4	%SO4	%CL	%CA	%MG	%NAK	Water type
131	143	455F32HDW	Bongo	88.08	2.88	11.24	38.44	31.14	33.22	CaNaHCO3
132	145	455F34	Bongo-Atampisi	87.53	1.10	1.37	34.39	32.54	33.33	CaMgHCO3
133	146	455F35	Alunduo	88.71	1.47	8.82	39.09	27.98	33.33	CaMgHCO3
134	147	455F36	Yorogo	92.70	2.55	4.74	34.31	32.35	33.33	CaMgHCO3
135	148	455F39	Apaglugro	90.28	1.88	7.84	38.62	30.14	33.24	CaNaHCO3
136	149	455F41	Bongo-Beo	91.25	1.88	6.88	44.41	22.35	33.24	CaNaHCO3
137	150	455F42	Dua	98.73	2.18	1.09	35.39	31.40	33.21	CaMgHCO3
138	151	455F43	Dua	96.37	1.98	1.88	38.04	29.08	33.15	CaNaHCO3
139	152	455F44HDW	Dua	95.12	1.38	3.48	35.28	31.73	33.01	CaNaHCO3
140	153	455F44	Dua	95.93	1.38	2.71	42.07	24.92	33.01	CaMgHCO3
141	154	455F45	Dachio	98.03	1.84	2.34	35.33	31.89	32.98	CaNaHCO3
142	155	455F46	Dubila	94.02	1.38	4.62	37.26	29.57	32.83	CaNaHCO3
143	156	455F49	Bongo-Deliga	98.68	0.57	0.75	34.35	32.73	32.91	CaMgHCO3
144	157	455G1	Sumbrungu	87.01	3.11	9.89	35.71	31.38	32.91	CaMgHCO3
145	158	455G2	Sherigu	94.85	0.59	4.75	35.38	30.78	32.84	CaMgHCO3
146	159	455G5	Sherigu	94.19	1.18	4.85	35.40	31.42	32.74	CaMgHCO3
147	160	455G8	Sumbrungu	93.39	4.24	2.37	38.07	29.27	32.88	CaNaHCO3
148	161	455G9	Sumbrungu	81.90	6.25	11.85	47.19	20.18	32.83	CaNaHCO3
149	162	455G11	Sumbrungu	94.70	2.47	2.83	33.78	33.45	32.43	CaNaHCO3
150	163	455G12HDW		76.92	6.73	16.35	38.80	29.04	32.35	CaNaHCO3
151	164	454G15	Kwalia	95.59	1.18	3.24	45.96	21.73	32.31	CaMgHCO3
152	165	455G20	Sumbrungu	93.41	1.94	4.85	35.46	32.27	32.27	CaNaHCO3
153	167	455H1	Zobisi	89.33	2.25	8.43	37.38	30.37	32.24	CaMgHCO3
154	168	455H2	Sherigu	98.01	0.50	1.49	35.05	32.71	32.24	CaNaHCO3
155	169	455H3	Sotabisi	77.85	5.87	16.48	46.37	21.42	32.22	CaMgHCO3
156	170	455H5	Sotabisi	88.97	3.79	7.24	35.17	32.72	32.11	CaMgHCO3
157	171	455H6	Dorongo	95.88	0.88	3.24	34.68	33.24	32.08	CaNaHCO3
158	172	455H9	Sherigu	97.23	1.38	1.38	37.29	30.85	31.86	CaMgHCO3
159	173	455H10	Sherigu	73.99	4.55	21.46	40.08	28.08	31.86	CaMgHCO3
160	174	455H11	Zaare	97.22	0.69	2.08	47.78	20.48	31.74	CaMgHCO3
161	175	455H12	Zaare	95.73	1.71	2.56	48.43	19.90	31.88	CaNaHCO3
162	176	455H13	Dorongo	78.13	17.05	4.83	41.46	26.88	31.66	CaMgHCO3
163	177	455H14	Yorogo	95.49	1.13	3.38	47.45	20.92	31.63	CaNaHCO3
164	178	455H15	Yilene	86.53	3.56	9.91	31.70	36.74	31.56	CaNaHCO3
165	179	455H17	Gambibgo	88.43	3.24	8.33	35.23	33.22	31.54	CaNaHCO3
166	181	455H19	Bolgatanga	93.35	1.90	4.75	51.13	17.22	31.48	CaNaHCO3
167	182	455H20HDW	Zaare	95.25	1.68	3.07	43.72	24.86	31.42	CaNaHCO3
168	183	455H20	Zaare	87.74	2.30	9.96	34.48	34.14	31.38	CaMgHCO3
169	184	455H25	Polugu	97.13	0.96	1.91	37.70	30.95	31.35	CaNaHCO3
170	185	455H28	Tindonsobligo	93.90	0.94	5.16	39.18	29.48	31.34	CaNaHCO3
171	186	455H29	Yilene	83.49	4.25	12.28	38.61	30.12	31.27	CaNaHCO3
172	187	455H30	Sumbrungu	95.61	2.19	2.19	35.82	32.95	31.23	CaNaHCO3
173	188	455H31	Bolga-Soe	93.58	1.35	5.07	51.83	33.33	31.15	CaMgHCO3
174	189	455H32	Yilene	90.36	4.82	4.82	39.16	29.72	31.12	CaNaHCO3
175	190	455H33	Bolga-Soe	88.75	1.88	9.38	47.97	20.93	31.10	CaNaHCO3
176	191	455H34	Bolga-Soe	95.51	0.84	3.65	39.74	29.48	31.03	CaMgHCO3
177	193	455H35 ?HDW	Bolga-Soe	98.84	0.29	0.87	44.78	24.48	30.75	CaNaHCO3
178	194	455H36	Bolga-Soe	95.24	1.59	3.17	37.13	32.38	30.82	CaMgHCO3
179	195	455H37	Bolga-Soe	91.46	4.11	4.43	51.97	17.70	30.62	CaMgHCO3
180	196	455H38	Yorogo	81.82	2.89	15.29	38.06	31.49	30.45	CaNaHCO3
181	198	455H39HDW	Zaare	81.82	3.64	14.55	38.06	31.49	30.45	CaNaHCO3
182	199	455H39	Zaare	84.92	3.35	11.73	35.42	34.17	30.42	CaNaHCO3
183	200	455H40	Gambibgo	97.74	0.52	1.74	40.54	29.22	30.41	CaNaHCO3
184	201	455H41	Sotabisi	92.94	2.43	4.62	44.26	25.60	30.36	CaNaHCO3
185	202	455H42	Tindonsobligo	96.07	1.97	1.97	49.20	20.48	30.32	CaNaHCO3
186	203	455H43	Tanzui	93.43	1.41	5.16	39.86	30.07	30.30	CaNaHCO3
187	204	455H44	Sumbrungu	94.90	1.70	3.40	53.63	16.40	30.28	CaNaHCO3
188	205	455H45	Sotabisi	98.23	1.26	0.51	48.95	23.10	30.20	CaMgHCO3
189	208	455H45HDW	Tindombukugu	92.74	2.21	5.05	38.36	31.59	30.08	CaNaHCO3
190	207	455H46	Sumbrungu	92.99	1.35	5.66	35.99	33.93	30.08	CaMgHCO3
191	208	455H47	Sherigu	95.88	1.14	3.18	51.25	18.88	30.07	CaMgHCO3
192	209	455H48	Sherigu	95.02	1.08	3.90	38.01	33.95	30.04	CaNaHCO3
193	210	455H49	Sumbrungu	91.97	1.74	6.29	39.80	30.20	30.00	CaMgHCO3
194	211	455H50	Dorongo	85.90	3.25	10.85	38.84	33.16	30.00	CaNaHCO3
195	212	455H51	Yorogo	92.86	2.68	4.46	35.88	34.18	29.98	CaMgHCO3

No.	Survey No.	Location No.	Village	%HCO4	%SO4	%CL	%CA	%Mg	%NAK	Water type
196	213	455H52	Yilene	94.51	1.85	3.85	40.81	29.44	29.95	CaNaHCO3
197	214	455H53	Zaare	87.85	2.08	10.29	39.86	30.50	29.84	CaNaHCO3
198	215	455H54	Tindomolgo	95.82	2.74	1.84	51.08	19.35	29.84	CaMgHCO3
199	216	455H55	Gambilgo	70.43	1.61	27.96	35.85	34.34	29.81	CaNaHCO3
200	217	455H56	Belga-See	92.06	2.82	5.00	39.25	31.08	29.69	CaNaHCO3
201	218	455H58	Sherigu	89.21	4.31	7.48	47.38	23.19	29.44	CaNaHCO3
202	220	455H59	Tindomolgo	92.11	1.44	6.46	46.19	24.71	29.33	CaNaHCO3
203	221	455H61		96.32	2.16	1.32	37.97	32.91	29.32	CaNaHCO3
204	222	455H4	Yipala	95.76	1.50	2.74	42.36	28.42	29.22	CaMgHCO3
205	223	455H5	Gambilgo				38.88	31.91	29.21	CaNaHCO3
206	224	455H7	Yarigabai	98.88	0.44	0.88	37.82	32.77	29.20	CaNaHCO3
207	225	455H9	Zuarungu	95.49	2.35	2.16	41.03	29.77	29.20	CaMgHCO3
208	226	455HHDW	Nyelaku	91.80	0.95	7.14	40.49	30.36	29.15	CaNaHCO3
209	227	455H10	Kumbungu	95.76	0.80	3.45	39.54	31.38	29.08	CaNaHCO3
210	228	455H11	Kumbungu	93.39	1.17	5.45	34.80	36.26	28.94	CaNaHCO3
211	229	455H12	Zuarungu	98.55	1.51	1.94	41.40	29.72	28.87	CaNaHCO3
212	230	455H13	Zuarungu	75.78	4.59	19.63	45.85	25.82	28.73	CaNaHCO3
213	231	455H15	Zuarungu	96.40	0.72	2.88	46.59	24.73	28.67	CaMgHCO3
214	232	455H17	Zuarungu	84.79	11.03	4.18	39.09	32.25	28.66	CaNaHCO3
215	233	455H24	Zuarungu	96.25	0.75	1.00	46.91	24.44	28.64	CaNaHCO3
216	234	455H27	Kpata	89.42	1.09	9.49	35.13	35.55	28.61	CaNaHCO3
217	235	455H31	Zuarungu	98.55	0.58	0.67	33.69	37.74	28.57	CaNaHCO3
218	236	455H32	Zuarungu	94.82	0.91	4.27	37.40	34.07	28.53	CaNaHCO3
219	237	455H33	Zuarungu	91.21	1.26	7.53	37.45	34.08	28.46	CaMgHCO3
220	238	455H34	Zuarungu	93.91	2.32	3.77	40.30	30.98	28.46	CaNaHCO3
221	239	455H35	Zuarungu	89.92	9.38	20.70	38.58	33.02	28.40	CaNaHCO3
222	240	455H36	Zuarungu	90.88	4.38	4.74	57.57	13.82	28.29	CaNaHCO3
223	241	455H38	Yorogo	90.16	6.33	3.51	39.89	32.19	28.28	CaNaHCO3
224	242	455H40	Tongo-Beo	74.22	5.78	20.00	42.86	28.89	28.25	CaMgHCO3
225	243	455H41	Zuarungu	80.81	4.06	15.13	39.39	32.42	28.18	CaNaHCO3
226	244	455H42	Tongo-Beo	89.57	1.81	8.62	35.18	36.89	27.93	CaNaHCO3
227	245	455H43	Tongo-Beo	94.25	1.15	4.80	39.63	32.82	27.74	CaMgHCO3
228	246	455H44	Dufugu	96.27	3.39	10.34	39.99	33.33	27.66	CaNaHCO3
229	247	455H45	Kpata	93.09	3.39	3.53	46.81	25.88	27.51	CaNaHCO3
230	248	455H46	Tongo-Beo	96.72	1.46	1.82	50.17	22.41	27.42	CaNaHCO3
231	249	455H47	Zuarungu	94.09	1.42	4.49	46.08	26.50	27.42	CaNaHCO3
232	250	455H47HDW	Kumbungu	96.87	1.76	1.37	37.11	35.35	27.34	CaNaHCO3
233	251	455H48	Sakola	87.83	7.46	4.90	42.16	30.59	27.25	CaMgHCO3
234	252	455H49HDW	Iankua	90.53	6.58	2.89	41.13	31.62	27.25	CaNaHCO3
235	253	455H50	Zuarungu	89.80	5.20	5.20	41.38	31.38	27.24	CaNaHCO3
236	255	455H53	Zuarungu	96.46	0.79	2.76	39.12	33.67	27.21	CaNaHCO3
237	257	455H54	Dufugu	88.14	2.75	9.11	54.22	18.57	27.20	CaNaHCO3
238	258	455H56	Zuarungu	95.31	1.73	2.96	50.79	22.35	27.09	CaNaHCO3
239	259	455H59	Zuarungu	94.85	2.06	3.09	40.54	32.43	27.03	CaNaHCO3
240	260	P47	Sherigu	95.73	0.91	3.35	42.03	31.01	26.98	CaNaHCO3
241	261	P5	Sherigu	95.88	1.44	2.86	50.62	22.47	26.91	CaMgHCO3
242	262	P10		95.06	0.82	4.12	36.21	36.80	26.80	CaMgHCO3
243	263	P11	Mengu-Market	97.14	1.43	1.43	42.06	30.84	26.87	CaMgHCO3
244	264	456A1	Asebuga	97.75	0.84	1.40	35.90	37.23	26.86	CaNaHCO3
245	265	456C20		95.29	1.12	3.59	42.58	30.57	26.86	CaMgHCO3
246	266	456D6	Solga-Nangodi	72.83	6.79	20.39	39.43	33.75	26.81	CaNaHCO3
247	267	456D7	Kongo	95.21	0.80	4.19	36.32	36.88	26.79	CaMgHCO3
248	268	456D8	Solga	93.79	5.17	1.03	49.15	24.07	26.78	CaMgHCO3
249	269	456D9	Zoa	96.42	0.32	1.26	34.88	36.55	26.77	CaMgHCO3
250	270	456D11	Nangodi	97.45	0.93	1.62	39.17	34.10	26.73	CaMgHCO3
251	271	456D13	Kongo	84.19	2.37	13.44	37.27	35.71	26.71	CaMgHCO3
252	272	456D14	Adeboya	86.01	3.07	10.92	39.59	33.72	26.69	CaMgHCO3
253	273	456D17	Dutobigu	95.01	2.61	2.36	50.23	23.13	26.64	CaNaHCO3
254	274	456D18	Zoa	92.81	2.18	5.01	54.15	19.57	26.48	CaMgHCO3
255	275	456D19	Nangodi	97.77	1.43	0.79	46.91	26.70	26.39	CaMgHCO3
256	276	456D20	Kumbungu	81.27	5.35	13.38	37.29	36.46	26.24	CaNaHCO3
257	277	456D21	Logre	95.83	2.26	1.91	46.40	27.42	26.19	CaMgHCO3
258	278	456D22	Bongo-Beo	91.97	1.34	6.89	39.94	33.88	26.17	CaNaHCO3
259	279	456D25	Bungotua	96.24	0.75	1.01	56.23	17.60	26.16	CaNaHCO3
260	280	456D27	Asebuga	71.83	3.66	24.51	46.88	27.39	26.14	CaNaHCO3

No.	Survey No.	Location No.	Village	%HCO ₄	%SO ₄	%CL	%CA	%Mg	%NAK	Water type
281	281	458D28	Kongo	77.93	6.02	16.05	38.23	37.88	28.09	CaNaHCO ₃
282	282	458D29	Zuanungu-Moshie	92.86	1.66	5.46	35.71	38.21	28.07	CaNaHCO ₃
283	283	458D32	Alonobogro	95.82	1.31	2.87	35.63	38.33	28.04	CaNaHCO ₃
284	284	458D33	Kansingo	95.66	0.94	3.38	42.50	31.28	28.04	CaNaHCO ₃
285	285	458D34	Kongo	98.13	0.34	1.53	40.77	33.07	28.00	CaMgHCO ₃
286	286	458E3	Nangodi	93.73	1.48	4.80	37.10	37.10	25.81	CaMgHCO ₃
287	287	458E4	Nangodi	69.95	24.18	5.87	43.00	31.20	25.80	CaMgHCO ₃
288	288	458G1	Zanlerigu	96.56	0.31	3.13	41.43	32.86	25.71	CaMgHCO ₃
289	289	458GHDW1	Ganne	94.34	0.86	4.80	33.72	40.63	25.66	CaMgHCO ₃
270	290	458G3	Ndongo	96.60	1.06	2.34	54.47	19.68	25.65	CaMgHCO ₃
271	292	458G5	Duusi	94.64	1.29	4.08	54.69	19.76	25.55	CaMgHCO ₃
272	293	458G8	Duusi	95.10	1.47	3.43	53.32	21.20	25.48	CaMgHCO ₃
273	294	458G9	Gari	94.60	2.80	2.80	55.03	19.53	25.44	CaMgHCO ₃
274	295	458G10	Pelungu	95.39	1.84	2.96	37.33	37.33	25.33	CaMgHCO ₃
275	296	458G11	Pelungu	97.97	1.01	1.01	38.88	35.64	25.27	CaMgHCO ₃
276	297	458G12	Gari	82.05	1.28	16.87	38.01	38.78	25.21	CaMgHCO ₃
277	298	458G13	Gari	93.24	2.35	4.41	44.62	30.18	25.20	CaMgHCO ₃
278	299	458G16	Ndongo	92.86	3.36	3.78	45.45	29.80	24.95	CaMgHCO ₃
279	300	458G17	Lorgi	88.75	7.19	4.06	58.52	18.26	24.93	CaMgHCO ₃
280	301	458G18	Damugu	84.06	1.45	14.49	38.08	37.02	24.91	CaMgHCO ₃
281	302	458G22	Zanlerigu	91.51	2.55	5.94	55.58	19.56	24.86	CaMgHCO ₃
282	303	458G23	Damokugu	93.23	4.78	1.99	39.57	35.61	24.82	CaMgHCO ₃
283	304	458G24	Pelungu	94.72	2.44	2.85	39.12	36.07	24.81	CaNaHCO ₃
284	305	458G25	Daliga	92.73	2.01	5.26	51.34	23.88	24.78	CaMgHCO ₃
285	306	458G26	Zanlerigu	87.17	2.88	9.95	38.10	37.14	24.76	CaMgHCO ₃
286	307	458G27	Zanlerigu	97.14	0.88	1.98	36.38	36.89	24.73	CaMgHCO ₃
287	308	458G28	Lorgi	93.96	2.42	3.63	41.67	34.17	24.44	CaMgHCO ₃
288	309	458G30	Gbeaya	80.14	16.82	3.04	46.22	29.41	24.37	CaMgHCO ₃
289	310	458G31	Gari	93.56	1.02	5.42	37.38	38.32	24.30	CaNaHCO ₃
290	311	458G34	Zanlerigu	97.53	1.82	0.85	46.14	29.58	24.29	CaMgHCO ₃
291	312	458G36	Daliga				40.34	35.51	24.28	CaMgHCO ₃
292	313	458G37	Daliga	93.81	1.80	4.38	54.12	21.41	24.24	CaMgHCO ₃
293	314	458G39	Kongo	91.87	3.98	4.15	44.61	31.28	24.13	CaMgHCO ₃
294	315	458G43	Zanlerigu	94.07	0.77	5.15	37.11	38.97	23.92	CaMgHCO ₃
295	316	458H2HDW		94.62	1.68	3.70	44.87	31.12	23.85	CaNaHCO ₃
296	317	458H2	Nyogbare	94.26	0.88	5.07	54.46	22.11	23.43	CaMgHCO ₃
297	318	458H3	Kotintabiga-Sekoti	96.23	1.03	2.74	36.86	39.42	23.40	CaMgHCO ₃
298	319	458H4	Yakole-Sekoti	92.36	2.18	5.45	39.93	37.15	23.26	CaMgHCO ₃
299	320	458H5	Nyobola	96.97	1.30	1.73	54.53	22.53	23.16	CaNaHCO ₃
300	321	458H6	Nyobola	98.29	0.71	1.00	43.34	33.52	23.14	CaNaHCO ₃
301	322	458H7	Kotintabiga-Sekoti	96.51	0.58	2.91	32.67	44.32	23.01	CaMgHCO ₃
302	323	458H8	Sekoti	90.63	2.71	6.67	52.09	25.10	23.00	CaNaHCO ₃
303	324	458H9	Sekoti	95.54	0.78	3.68	54.23	22.80	22.97	CaNaHCO ₃
304	325	458H10	Sekoti	97.78	0.99	1.23	43.94	33.25	22.80	CaNaHCO ₃
305	326	458H11	Namooranteng	94.79	3.70	1.51	49.64	27.76	22.80	CaNaHCO ₃
306	327	458H13	Nyogbare	95.92	2.12	1.96	36.05	41.22	22.57	CaNaHCO ₃
307	328	458H14	Nyogbare	95.37	0.54	4.09	41.21	38.28	22.53	CaNaHCO ₃
308	329	458H15	Namooranteng	91.42	2.66	5.92	47.01	30.48	22.51	CaNaHCO ₃
309	330	458H17	Sekoti	93.46	1.77	4.77	56.38	21.32	22.46	CaNaHCO ₃
310	331	453B1	Gorogu	81.27	2.54	16.19	38.27	39.80	21.94	CaNaHCO ₃
311	332	453B3	Winkogo	97.80	0.51	1.69	34.83	43.62	21.56	CaNaHCO ₃
312	333	453B4	Winkogo	95.85	1.84	2.30	42.82	35.97	21.41	CaNaHCO ₃
313	334	453B6	Winkogo	97.98	1.01	1.01	40.13	38.46	21.40	CaNaHCO ₃
314	335	453B7	Winkogo	94.56	1.12	4.32	36.14	42.46	21.39	CaNaHCO ₃
315	336	453B8	Winkogo	95.18	2.53	2.28	42.53	36.27	21.33	CaNaHCO ₃
316	337	453B12	Gambigo	86.86	11.70	1.65	45.44	33.65	21.07	CaNaHCO ₃
317	338	453B13	Gambigo	96.75	0.50	2.75	36.56	40.42	21.03	CaNaHCO ₃
318	339	453B14	Gambigo	97.80	1.09	1.31	43.88	35.31	20.82	CaNaHCO ₃
319	340	453B15	Winkogo(school)	96.41	0.85	2.74	31.10	46.45	20.46	CaNaHCO ₃
320	341	453B16	Winkogo	98.43	0.59	0.98	44.34	35.66	20.19	CaNaHCO ₃
321	342	453B19	Winkogo	97.01	0.75	2.24	48.52	33.46	20.03	CaNaHCO ₃
322	343	453B20	Kunbangre	83.80	3.23	2.98	41.67	38.54	19.79	CaNaHCO ₃
323	344	453B21	Posu-Namongo	97.32	1.68	1.01	48.44	31.49	19.72	CaNaHCO ₃
324	345	453B22	Winkogo	77.23	3.94	18.84	38.21	42.84	19.10	CaNaHCO ₃
325	346	453B23	Winkogo	95.33	1.83	2.85	48.17	32.63	19.00	CaNaHCO ₃

Nr.	Survey No.	Location No.	Village	%HCO4	%SO4	%CL	%CA	%MG	%NAK	Water type
326	347	453B25	Gonugu	98.01	0.80	1.39	48.73	32.29	18.98	CaNaHCO3
327	348	453B27	Baelingo	97.84	0.55	1.82	48.70	34.20	18.92	CaNaHCO3
328	349	453B28	Namongo	94.41	1.56	4.04	48.55	34.53	18.92	CaNaHCO3
329	350	453C1	Baare	75.83	18.05	6.32	48.98	34.19	18.85	CaNaHCO3
330	351	453C2	Baare	92.72	2.85	4.84	45.88	36.38	18.04	CaNaHCO3
331	352	453C4	Baare	96.72	0.55	2.73	40.08	41.98	17.96	CaNaHCO3
332	353	453C5	Waki	95.89	1.06	3.23	43.38	39.05	17.56	CaNaHCO3
333	354	453C6	Baare	95.87	1.55	2.79	52.71	29.82	17.17	CaNaHCO3
334	355	453C7	Tengo	98.42	1.79	1.79	48.78	34.48	16.72	CaNaHCO3
335	356	453C8	Waki	81.80	17.16	1.04	42.83	40.30	16.88	CaNaHCO3
336	357	453C9	Separt	97.07	0.98	1.96	54.25	29.01	16.51	CaNaHCO3
337	358	453C10	Tengo	95.22	2.39	2.39	48.84	36.53	16.38	CaNaHCO3
338	359	453C11	Gonugu	97.57	1.22	1.22	48.00	37.77	16.22	CaNaHCO3
339	360	453C15	Tengo	97.88	0.91	1.21	48.25	35.96	15.79	CaNaHCO3
340	361	453C16	Tengo	98.87	1.00	2.33	45.30	38.98	15.77	CaNaHCO3
341	362	453C17	Baare(school)	93.24	2.03	4.73	52.72	31.83	15.85	CaNaHCO3
342	363	453C18	Tengo	95.27	1.45	3.27	58.48	24.91	15.61	CaNaHCO3
343	364	453C21	Tengo	81.08	6.55	12.38	62.10	22.29	15.81	CaMgHCO3
344	365	453C22	Tengo(Zubeggo)	92.22	1.85	5.83	51.47	33.48	15.44	CaMgHCO3
345	366	453C23	Tengo	98.37	0.52	3.11	45.83	38.85	15.22	CaNaHCO3
346	367	453C24	Tengo	95.42	2.16	2.43	54.23	30.42	15.08	CaMgHCO3
347	368	453C25	Tengo	97.20	0.93	1.86	48.56	38.36	15.08	CaNaHCO3
348	369	453C26	Baare	93.87	2.93	3.20	50.00	34.74	15.00	CaNaHCO3
349	370	453C27	Wooq	95.38	1.64	2.96	48.82	35.03	14.81	CaMgHCO3
350	371	453C28	Gbanbega	96.77	4.31	8.92	48.83	36.57	14.60	CaMgHCO3
351	372	453C30	Baare	94.72	1.98	3.30	49.67	35.43	14.57	CaMgHCO3
352	373	453E1	Balungu	87.67	3.20	9.13	48.72	39.17	14.31	CaMgHCO3
353	374	453E2	Balungu	92.38	0.85	6.78	58.05	28.23	13.98	CaMgHCO3
354	375	453E3	Balungu	96.88	0.65	0.65	58.48	27.67	13.84	CaMgHCO3
355	376	453E4	Shia	98.12	1.55	2.33	58.44	27.79	13.77	CaMgHCO3
356	377	453E5	Luribongo	96.81	1.60	1.60	47.93	38.34	13.73	CaNaHCO3
357	378	453E6	Balungu	92.32	2.77	4.90	48.78	37.55	13.68	CaMgHCO3
358	379	453F1	Winduri	94.03	2.74	3.23	49.53	36.79	13.68	CaMgHCO3
359	381	454A1	Shiega	90.28	4.74	4.97	52.08	34.26	13.66	CaMgHCO3
360	382	454A2	Shiega	95.63	1.64	2.73	49.88	36.57	13.57	CaMgHCO3
361	383	454A4	Shiega	94.12	1.68	4.20	61.28	25.35	13.37	CaMgHCO3
362	384	454A6	Shiega	98.16	0.79	1.05	49.88	38.91	13.22	CaMgHCO3
363	385	454A10	Shiega	93.44	2.19	4.37	57.38	29.23	13.11	CaMgHCO3
364	386	454A11	Shiega	93.02	2.33	4.65	53.13	33.51	13.08	CaMgHCO3
365	387	454A12	Shiega	93.20	3.29	3.51	51.45	35.74	12.81	CaMgHCO3
366	388	454A12/1	Gbane	92.88	3.68	3.43	56.42	31.81	12.77	CaMgHCO3
367	389	454A15	Shiega	88.67	5.08	8.25	47.75	38.33	12.84	CaMgHCO3
368	390	454B1	Datoko	94.30	1.90	3.80	54.27	33.33	12.18	CaNaHCO3
369	391	454B2	Datoko	95.38	1.81	2.81	60.18	28.17	11.87	CaMgHCO3
370	392	454BHDW	Nyogbare	79.40	8.31	12.29	58.85	31.20	11.88	CaNaHCO3
371	393	454B4	Kupielga	87.17	4.87	7.98	60.38	28.48	10.98	CaNaHCO3
372	394	454B5	Kupielga	93.96	1.84	4.20	47.19	42.08	10.71	CaNaHCO3
373	395	454B6	Datoko	88.92	5.30	5.78	60.65	28.81	10.30	CaMgHCO3

APPENDIX 4

- * Piper Plots for Major Ion Compositions.**

Index for piper diagrams: Cation triangle (left), anion triangle (right), and facies diamond. All cations and anions are converted to milliequivalents before plotting.

PIPER DIAGRAM FOR ALL WATER SAMPLES

PIPER DIAGRM FOR WATERS IN THE BIRIMIAN METAVOLCANICS

PIPER DIAGRM FOR WATERS IN THE BIRIMIAN METASEDIMENTS

PIPER DIAGRM FOR WATERS IN THE BIRIMIAN GRANITIDS

PIPER DIAGRM FOR WATERS IN THE BONGO GRANITES

APPENDIX 5

*** MINERAL SATURATION INDICES**

**Calcite
Aragonite
Dolomite
Strontianite
Magnesite
Gypsum
Fluorite**

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
1	3	0.251	0.112	0.462	-1.022	-0.181	-2.736	-1.991
2	4	-0.915	-1.057	-1.845	-2.243	-1.44	-3.467	-2.150
3	5	-0.584	-0.724	-1.108	-1.737	-0.916	-3.574	-0.794
4	6	-0.463	-0.603	-1.087	-1.398	-1.016	-2.359	-0.040
5	7	-0.454	-0.594	-1.078	-1.432	-1.016	-2.183	-0.028
6	8	-0.584	-0.724	-1.239	-1.461	-1.047	-3.436	-0.994
7	9							
8	10	-0.47	-0.609	-0.891	-1.66	-0.813	-3.73	-0.328
9	11	-0.602	-0.745	-1.344	-1.726	-1.252	-4.278	-0.214
10	12	-0.419	-0.558	-0.855	-1.601	-0.828	-2.917	-1.580
11	13	-2.389	-2.528	-4.999	-3.183	-3.002	-4.376	-2.281
12	14	-0.819	-0.961	-2.216	-2.121	-1.906	-3.294	-1.126
13	15	0.241	0.099	0.123	-0.741	-0.621	-2.829	-2.309
14	16	-0.667	-0.806	-1.331	-1.676	-1.057	-3.423	-0.821
15	17	-1.303	-1.443	-2.839	-2.329	-1.928	-3.41	-0.475
16	18	-1.085	-1.225	-2.363	-2.021	-1.67	-3.724	-0.731
17	19	-2.228	-2.368	-4.585	-3.13	-2.749	-3.446	-1.994
18	20	-0.831	-0.971	-1.661	-2	-1.221	-3.75	-1.076
19	21	-0.181	-0.0323	-0.487	-1.437	-0.816	-3.556	-1.201
20	22	-0.943	-1.083	-1.829	-2.136	-1.277	-3.722	-0.528
21	23	-1.112	-1.252	-2.275	-2.027	-1.555	-3.588	-0.737
22	24	-0.805	-0.944	-1.625	-2.01	-1.212	-3.556	-1.074
23	25							
24	26	-0.363	-0.502	-0.731	-1.628	-0.76	-3.074	-1.618
25	27	-0.517	-0.657	-1.012	-1.763	-0.886	-3.691	-0.596
26	28	-0.202	-0.342	-0.541	-1.136	-0.73	-2.533	-0.171
27	29	-0.458	-0.598	-0.948	-1.52	-0.882	-3.49	-1.294
28	30	-0.967	-1.11	-2.105	-1.89	-1.647	-3.105	-0.478
29	31	-1.373	-1.513	-2.732	-2.427	-1.751	-3.596	-0.75
30	32	-0.247	-0.382	-0.571	-1.537	-0.721	-2.641	-0.865
31	33	-0.972	-1.114	-2.202	-1.954	-1.739	-3.903	-0.739
32	34	-0.151	-0.291	-0.525	-1.25	-0.765	-2.872	-0.025
33	35	-2.462	-2.602	-4.909	-3.464	-2.839	-4.418	-1.902
34	36	-0.618	-0.758	-1.325	-1.556	-1.099	-3.343	-0.760
35	37	0.462	0.323	0.859	-1.448	0.019	-3.442	-2.548
36	38	-0.147	-0.286	-0.319	-1.928	-0.55	-3.322	-1.601
37	39	0.159	0.021	0.267	-1.488	-0.255	-2.91	-1.925
38	40	0.016	-0.124	0.131	-1.652	-0.277	-3.171	-3.042
39	41	-1.115	-1.254	-2.203	-2.56	-1.451	-3.841	-2.055
40	42	-1.013	-1.155	-1.988	-2.239	-1.485	-4.192	-2.286
41	43	-1.363	-1.502	-2.959	-2.451	-1.973	-5.094	-2.801
42	44	0.251	0.112	0.401	-0.967	-0.227	-3.195	-1.660
43	45	-1.583	-1.722	-3.585	-2.653	-2.379	-4.121	-2.180
44	46	-0.097	-0.236	-0.236	-1.765	-0.502	-3.019	-1.835
45	47	-0.356	-0.496	-0.82	-1.657	-0.886	-2.83	-1.857
46	48	-0.89	-1.03	-1.895	-2.361	-1.396	-3.929	-1.948

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
47	49	-0.448	-0.588	-0.953	-1.588	-0.897	-3.459	-1.674
48	50							
49	51	-0.382	-0.522	-0.792	-2.053	-0.802	-3.848	-2.191
50	52	-0.182	-0.322	-0.455	-1.615	-0.665	-2.698	-1.089
51	53	-0.392	-0.531	-0.902	-1.75	-0.902	-4.098	-1.887
52	54	-0.798	-0.94	-1.639	-2.016	-1.351	-3.888	-1.617
53	55	-1.258	-1.397	-2.596	-2.812	-1.701	-3.733	-2.911
54	56	0.005	-0.133	0.066	-1.617	-0.302	-3.775	-1.989
55	57	-1.81	-1.948	-3.579	-3.203	-2.132	-5.028	-2.871
56	58	0.125	-0.014	0.208	-1.581	-0.31	-2.647	-1.475
57	59	-0.598	-0.737	-1.238	-2.255	-1.03	-3.705	-2.220
58	60	-1.048	-1.188	-2.09	-2.32	-1.434	-4.513	-2.279
59	61	-0.692	-0.832	-1.513	-2.105	-1.213	-3.706	-1.682
60	62	-0.305	-0.444	-0.719	-1.703	-0.807	-2.951	-1.747
61	63	-0.906	-1.045	-1.919	-2.255	-1.39	-3.901	-2.057
62	64	-0.678	-0.817	-1.366	-2.064	-1.08	-3.775	-2.191
63	65	-0.306	-0.445	-0.563	-1.91	-0.649	-3.773	-2.098
64	66	-0.482	-0.622	-0.903	-1.857	-0.813	-3.502	-1.494
65	67	-0.484	-0.623	-0.858	-1.988	-0.766	-3.441	-1.998
66	68	-0.074	-0.213	-0.157	-1.479	-0.476	-3.458	-1.912
67	69	-1.009	-1.147	-2.202	-2.411	-1.556	-4.361	-1.989
68	71	-0.602	-0.742	-1.425	-1.918	-1.214	-3.786	-2.066
69	73	0.187	0.049	0.403	-1.177	-0.147	-3.368	-2.100
70	74	-0.572	-0.711	-1.067	-1.864	-0.887	-3.91	-1.979
71	75	-0.651	-0.791	-1.338	-1.952	-1.079	-3.913	-2.157
72	76	-1.082	-1.222	-2.221	-2.304	-1.53	-4.198	-2.750
73	77	-0.23	-0.369	-0.416	-1.645	-0.578	-3.587	-1.924
74	78	-0.945	-1.084	-2.03	-2.194	-1.478	-3.713	-2.203
75	79	-0.591	-0.731	-1.185	-1.851	-0.986	-3.616	-2.187
76	80	-0.363	-0.503	-0.686	-1.677	-0.695	-3.028	-1.957
77	81	-0.347	-0.486	-0.7	-1.516	-0.745	-2.982	-2.048
78	82	-0.672	-0.811	-1.383	-1.995	1.104	-3.215	-2.052
79	83	-0.403	-0.543	-0.758	-1.76	-0.747	-3.243	-1.969
80	84	-1.368	-1.507	-2.974	-2.228	-1.998	-3.917	-1.276
81	85							
82	86	-0.293	-0.433	-0.671	-1.271	-0.77	-3.218	-0.403
83	87	-0.584	-0.723	-1.268	-1.873	-1.076	-3.6	-1.962
84	88	-0.285	-0.424	-0.643	-1.496	-0.751	-3.929	-1.809
85	89	-0.283	-0.422	-0.647	-1.475	-0.756	-2.661	-1.747
86	90	-0.602	-0.744	-1.333	-1.822	-1.24	-3.679	-1.653
87	91	-0.428	-0.568	-0.81	-1.571	-0.774	-3.285	-0.835
88	92	-0.375	-0.515	-0.769	-1.634	-0.786	-3.148	-1.562
89	93	-1.153	-1.292	-2.383	-2.4	-1.622	-4.308	-2.098
90	94	-0.243	-0.383	-0.497	-1.511	-0.645	-3.816	-1.875
91	95	-0.164	-0.303	-0.354	-1.416	-0.582	-3.614	-1.957
92	96	-0.235	-0.375	-0.806	-1.225	-0.983	-2.357	-0.313

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
93	97	-1.001	-1.144	-2.069	-2.022	-1.578	-3.868	-0.944
94	98	-0.964	-1.103	-2.249	-1.94	-1.677	-3.041	-0.676
95	99	-1.33	-1.469	-2.951	-2.311	-2.013	-3.254	-0.816
96	100	-0.978	-1.117	-1.938	-2.039	-1.352	-4.138	-0.525
97	101	-0.514	-0.653	-1.049	-1.644	-0.927	-3.722	-0.899
98	102	-0.516	-0.656	-1.039	-1.466	-0.915	-3.381	-0.737
99	103	-1.148	-1.288	-2.45	-1.994	-1.693	-3.892	-1.499
100	104	-1.14	-1.28	-2.355	-2.04	-1.607	-3.734	-0.856
101	105	-0.638	-0.777	-1.269	-1.946	-1.024	-3.618	-2.013
102	106	-0.417	-0.557	-0.853	-1.683	-0.827	-3.971	-2.335
103	107							
104	108	0.145	-0.005	0.245	-1.051	-0.292	-3.615	-1.805
105	109	-0.054	-0.196	-0.392	-1.251	-0.847	-3.552	-1.497
106	110	-0.234	-0.373	-0.505	-1.503	-0.663	-3.469	-1.560
107	111	-0.549	-0.688	-1.138	-1.835	-0.981	-3.466	-1.957
108	112	-1.152	-1.291	-2.439	-2.285	-1.679	-3.794	-0.540
109	113	-0.586	-0.726	-1.154	-1.77	-0.96	-3.12	-1.674
110	114	-0.844	-0.984	-1.745	-1.713	-1.293	-3.236	-0.713
111	115	-0.866	-1.005	-1.867	-1.804	-1.393	-3.577	-0.639
112	116	-0.4	-0.539	-0.851	-1.492	-0.813	-3.092	-1.146
113	117	-0.431	-0.571	-0.818	-1.395	-0.779	-3.773	-0.354
114	118	-0.333	-0.473	-0.778	-1.233	-0.837	-2.052	-0.048
115	119	-0.995	-1.135	-2.047	-2.025	-1.444	-3.361	-0.882
116	120							
117	121							
118	122	-0.778	-0.918	-1.51	-1.901	-1.124	-2.923	-0.430
119	123	-1.049	-1.189	-2.243	-2.128	-1.586	-3.069	-0.902
120	124	-0.461	-0.6	-1.016	-1.623	-0.947	-3.112	-0.430
121	125	-1.404	-1.544	-2.837	-2.87	-1.825	-4.168	-2.081
122	126							
123	127	0.198	-0.059	0.25	-1.23	-0.34	-2.906	-2.171
124	128	-0.514	-0.653	-0.967	-1.601	-0.845	-3.365	-0.835
125	129	-1.236	-1.375	-2.501	-2.387	-1.657	-3.634	-1.172
126	130	-0.192	-0.331	-0.027	-1.104	-0.227	-3.855	-1.227
127	131							
128	132							
129	133	-0.847	-0.986	-1.75	-1.995	-1.295	-3.145	-0.933
130	134	-0.226	-0.365	-0.868	-1.515	-1.034	-3.278	-1.935
131	135	-0.027	-0.113	-0.343	-1.221	-0.762	-2.891	-2.280
132	136	-0.538	-0.677	-1.192	-1.792	-1.032	-3.284	-2.492
133	137	-0.394	-0.532	-0.838	-1.701	-0.807	-3.74	-2.119
134	138	-0.314	-0.543	-0.638	-1.809	-0.687	-3.574	-2.110
135	139	-0.299	-0.438	-0.386	-1.715	-0.464	-3.45	-2.659
136	140	-0.764	-0.903	-1.622	-1.72	-1.252	-3.887	-0.552
137	141	-0.702	-0.841	-1.445	-1.668	-1.135	-3.599	-0.321
138	142	-0.794	-0.933	-1.586	-1.877	-1.184	-3.409	-0.375

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
139	143	-0.02	-0.162	-0.005	-1.053	-0.494	-3.691	-0.587
140	144							
141	145	-0.299	-0.438	-0.654	-1.353	-0.747	-3.687	-0.394
142	146	-0.022	-0.117	-0.071	-1.555	-0.485	-3.328	-2.098
143	147	-0.491	-0.63	-0.95	-1.585	-0.821	-3.581	-0.287
144	148	-0.182	-0.321	-0.485	-1.629	-0.681	-2.658	-1.942
145	149	-0.791	-0.931	-1.897	-2.919	-1.498	-3.81	-2.166
146	150	-0.891	-1.031	-1.772	-2.349	-1.273	-3.451	-2.432
147	151	-0.824	-0.983	-1.618	-2.112	-1.186	-3.677	-1.890
148	152	0.011	-0.131	-0.061	-1.075	-0.581	-3.129	-1.334
149	153	-0.174	-0.313	-0.412	-1.588	-0.6	-3.164	-1.924
150	154	-0.231	-0.371	-0.838	-1.471	-0.998	-3.156	-2.116
151	155	0.058	-0.081	-0.234	-1.232	-0.684	-3.325	-1.961
152	156	-0.197	-0.336	-0.365	-1.155	-0.56	-3.478	-0.448
153	157	-0.735	-0.874	-1.471	-2.162	-1.129	-3.763	-2.092
154	158	-0.023	-0.163	-0.116	-1.48	-0.485	-3.217	-1.917
155	159	-0.913	-1.053	-1.845	-2.064	-1.324	-3.638	-2.070
156	160	-0.102	-0.242	-0.22	-1.456	-0.51	-3.32	-2.046
157	161	-0.684	-0.824	-1.387	-2.064	-1.095	-3.542	-2.062
158	162	-0.484	-0.624	-1.097	-1.882	-1.005	-3.824	-1.839
159	163	-1.788	-1.93	-3.587	-3.123	-2.309	-4.824	-2.966
160	164	0.277	-0.137	0.388	-1.273	-0.281	-2.744	-2.446
161	165	-0.506	-0.645	-1.063	-1.848	-0.949	-4.02	-1.896
162	166							
163	167	-1.153	-1.293	-2.346	-2.191	-1.585	-2.832	-0.524
164	168	-0.223	-0.363	-0.398	-1.609	-0.567	-3.653	-2.298
165	169	-0.512	-0.651	-1.007	-1.495	-0.887	-3.847	-0.379
166	170	-0.084	-0.224	-0.11	-1.226	-0.417	-3.752	-1.386
167	171	0.054	-0.086	-0.033	-1.35	-0.479	-3.087	-2.007
168	172	-0.718	-0.857	-1.273	-2.174	-0.948	-3.987	-2.302
169	173	0.126	-0.013	0.293	-1.176	-0.225	-3.718	-1.169
170	174	-0.64	-0.779	-1.317	-1.657	-1.069	-3.839	-0.550
171	175	-0.77	-0.909	-1.596	-1.769	-1.218	-2.763	-0.377
172	176	-1.092	-1.231	-2.176	-2.055	-1.476	-3.868	-1.928
173	177	-1.145	-1.284	-2.412	-2.035	-1.659	-3.872	-0.921
174	178	-1.063	-1.203	-2.151	-2.136	-1.48	-4.024	-0.656
175	179							
176	180	0.152	0.012	-0.136	-1.218	-0.68	-2.806	-1.593
177	181	-0.623	-0.762	-1.603	-1.738	-1.373	-2.577	-2.018
178	182	-1.532	-1.674	-3.155	-2.553	-2.133	-3.819	-1.416
179	183	-0.884	-1.024	-1.844	-1.957	-1.352	-3.376	-0.329
180	184	-0.497	-0.636	-1.328	-1.744	-1.224	-3.166	-1.915
181	185	0.22	-0.119	-0.286	-1.28	-0.699	-3.16	-1.780
182	186	-0.877	-1.017	-1.827	-2.318	-1.342	-3.781	-1.828
183	187	-1.107	-1.247	-2.312	-2.411	-1.597	-3.686	-2.144
184	188	-0.645	-0.784	-1.304	-2.017	-1.052	-3.821	-1.785

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
185	189	-0.541	-0.681	-1.124	-2.008	-0.975	-3.482	-1.682
186	190	-1.204	-1.343	-2.484	-2.153	-1.673	-3.615	-0.680
187	191	0.144	0.004	0.38	-0.994	-0.156	-2.717	-1.322
188	192							
189	193	-1.305	-1.447	-2.677	-2.257	-1.881	-3.583	-0.869
190	194	-0.862	-1.002	-1.819	-1.881	-1.349	-3.117	-0.434
191	195	-1.088	-1.227	-2.155	-2.155	-1.571	-4.006	-1.650
192	196	-1.202	-1.341	-2.502	-2.08	-1.692	-4.043	-1.019
193	197							
194	198	-1.604	-1.746	-3.415	-2.658	-2.32	-3.952	-1.711
195	199	-0.901	-1.04	-1.999	-1.567	-1.49	-3.846	-1.591
196	200	-0.654	-0.793	-1.702	-1.747	-1.44	-3.377	-2.092
197	201	-1.405	-1.545	-2.797	-2.475	-1.784	-5.125	-1.964
198	202	-0.932	-1.072	-2.034	-2.225	-1.494	-3.571	-2.000
199	203	-0.84	-0.979	-1.71	-1.878	-1.262	-3.767	-0.787
200	204	-0.918	-1.058	-1.91	-2.261	-1.384	-3.678	-1.926
201	205	-0.927	-1.067	-1.832	-2.121	-1.296	-3.496	-1.182
202	206	-0.123	-0.265	-0.194	-1.223	-0.581	-3.175	0.100
203	207	-0.616	-0.756	-1.221	-1.901	-0.997	-3.56	-1.913
204	208	-0.051	-0.089	0.109	-1.384	-0.334	-3.154	-2.031
205	209	-0.256	-0.396	-0.67	-1.738	-0.806	-3.522	-2.104
206	210	-0.436	-0.575	-0.869	-1.73	-0.826	-3.399	-2.045
207	211	-0.678	-0.817	-1.373	-2.14	-1.087	-3.611	-2.411
208	212	-1.005	-1.144	-1.973	-2.084	-1.36	-4.046	-0.803
209	213	-0.378	-0.518	-0.68	-1.742	-0.694	-2.675	-2.228
210	214	-2.231	-2.37	-4.563	-3.11	-2.724	-4.438	-1.935
211	215	-0.592	-0.731	-1.166	-1.811	-0.966	-3.003	-0.559
212	216	-0.312	-0.451	-0.983	-1.544	-1.063	-3.267	-1.783
213	217	-1.626	-1.766	-3.351	-2.657	-2.117	-3.578	-0.717
214	218							
215	219	0.748	-0.608	1.53	-0.743	0.39	-3.233	-2.464
216	220	0.052	-0.088	-0.188	-1.471	-0.632	-2.814	-1.581
217	221	-1.024	-1.163	-1.978	-2.198	-1.347	-3.606	-1.591
218	222	-0.416	-0.555	-0.839	-1.627	-0.8	-3.463	-1.033
219	223	-0.646	-0.786	-1.725	-1.853	-1.47	-3.308	-1.994
220	224	-0.564	-0.703	-1.347	-1.92	-1.175	-3.332	-2.115
221	225	-0.183	-0.323	-0.477	-1.821	-0.686	-2.502	-2.51
222	226	0.512	0.37	0.967	-1.478	-0.055	-2.581	-2.392
223	227	-0.04	-0.179	-0.179	-0.496	-3.6	-3.133	-2.256
224	228	-0.256	-0.396	-0.929	-1.493	-1.065	-2.934	-2.058
225	229	0.566	0.426	0.723	-0.782	-0.234	-3.271	-1.862
226	230	-0.444	-0.583	-1.156	-1.72	-1.104	-3.356	-1.804
227	231	0.17	0.031	0.224	-1.868	-0.308	-3.589	-3.233
228	232	-0.19	-0.33	-0.757	-1.518	-0.959	-3.142	-2.092
229	233	0.073	-0.067	-0.196	-1.364	-0.661	-2.515	-1.733
230	234	-0.263	-0.402	-0.746	-2.471	-0.875	-3.413	-2.673

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontia-nite	Magne-site	Gypsum	Fluorite
231	235	-0.013	-0.152	-0.452	-1.373	-0.831	-2.812	-2.131
232	236	-0.462	-0.602	-1.206	-1.82	-1.136	-2.716	-1.918
233	237	-0.674	-0.813	-1.488	-1.935	-1.208	-3.173	-2.318
234	238	-0.389	-0.528	-1.081	-1.538	-1.085	-3.122	-2.235
235	239	-0.66	-0.799	-1.781	-1.997	-1.513	-3.868	-2.375
236	240	-0.254	-0.393	-0.865	-1.49	-1.003	-3.177	-1.871
237	241	-0.27	-0.409	-0.634	-1.597	-0.757	-3.296	-1.866
238	242	0.331	0.191	0.577	-0.969	-0.146	-2.735	-1.851
239	243	-0.032	-0.171	-0.256	-1.243	-0.617	-2.331	-1.495
240	244	-0.792	-0.931	-1.732	-2.071	-1.332	-2.95	-2.179
241	245	-0.238	-0.378	-0.58	-1.731	-0.734	-3.723	-2.050
242	246	-0.056	-0.196	-0.38	-1.459	-0.716	-2.843	-1.567
243	247	-0.137	-0.276	-0.577	-2.354	-0.802	-3.469	-2.342
244	248	-0.563	-0.703	-1.368	-1.953	-1.216	-2.591	-1.902
245	249	0.129	-0.011	-0.19	-1.293	-0.71	-2.913	-1.775
246	250	-0.304	-0.446	-1.07	-1.611	-1.276	-3.231	-2.501
247	251	-0.427	-0.566	-0.954	-2.553	-0.919	-3.413	-2.731
248	252	-0.208	-0.351	-0.819	-1.532	-1.12	-3.44	-2.091
249	253	-0.592	-0.731	-1.502	-1.937	-1.302	-3.522	-2.221
250	254							
251	255	-0.095	-0.235	-0.498	-1.538	-0.795	-2.567	-1.882
252	256							
253	257	-0.357	-0.497	-1.071	-1.844	-1.106	-3.397	-1.889
254	258	-0.061	-0.2	-0.347	-1.229	-0.678	-2.557	-1.580
255	259	-1.483	-1.622	-3.335	-2.769	-2.244	-4.248	-3.162
256	260	-0.199	-0.339	-0.485	-1.613	-0.677	-2.817	-2.198
257	261	-1.148	-1.288	-2.368	-2.58	-1.612	-4	-2.158
258	262	-0.037	-0.177	-0.141	-1.176	-0.496	-3.3	-0.775
259	263	0.235	0.095	0.365	-1.217	-0.262	-2.118	-1.768
260	264	-1.137	-1.276	-2.234	-2.575	-1.474	-4.42	-2.806
261	265	-0.805	-0.944	-1.717	-2.718	-1.304	-3.334	-3.047
262	266	0.392	0.254	0.652	-1.443	-0.102	-3.508	-2.304
263	267	0.65	0.51	1.226	-0.964	0.199	-3.68	-2.191
264	268	0.195	0.056	0.169	-2.139	-0.418	-3.143	-2.083
265	269	0.384	0.245	0.667	-1.977	-0.109	-3.521	-2.033
266	270	0.486	0.327	0.808	-1.188	-0.02	-3.322	-2.691
267	271	0.383	0.244	0.566	-1.287	-0.209	-2.869	-2.422
268	272	-0.576	-0.716	-1.348	-1.425	-1.178	-2.907	-0.152
269	273	-0.836	-0.975	-1.926	-2.233	-1.468	-3.951	-2.105
270	274	0.957	0.817	-1.672	-1.091	0.323	-3.423	-2.351
271	275	0.302	0.163	0.549	-1.748	-0.146	-2.968	-2.581
272	276	-0.695	-0.835	-1.729	-2.082	-1.426	-3.769	-2.270
273	277	-0.045	-0.184	-0.337	-1.938	-0.639	-2.991	-2.317
274	278	-0.953	-1.093	-2.26	-2.196	-1.699	-4.086	-2.797
275	279	-0.369	-0.508	-0.862	-1.604	-0.871	-3.233	-2.037
276	280	-0.458	-0.597	-1.044	-1.749	-0.978	-3.9	-2.037

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
277	281	-0.426	-0.566	-1.096	-1.869	-1.062	-3.254	-2.231
278	282	-0.478	-0.618	-1.283	-1.825	-1.197	-3.343	-2.068
279	283	-0.587	-0.726	-1.406	-1.634	-1.211	-3.977	-2.251
280	284	-1.018	-1.157	-2.246	-2.346	-1.621	-3.411	-2.229
281	285	-0.131	-0.27	-0.422	-2.247	-0.684	-3.435	-2.498
282	286	0.792	0.652	1.671	-0.713	0.487	-2.93	-2.812
283	287	0.648	0.509	1.053	-0.984	0.042	-2.6	-2.413
284	288	0.246	0.108	0.359	-1.607	-0.25	-3.374	-2.085
285	289	0.599	0.456	1.203	-1.493	0.095	-2.462	-2.125
286	290	-0.215	-0.354	-0.505	-2.278	-0.652	-3.355	-2.208
287	291							
288	292							
289	293	0.075	-0.064	-0.009	-1.924	-0.476	-3.175	-2.446
290	294	0.144	0.004	0.092	-1.979	-0.473	-2.83	-2.568
291	295	-0.239	-0.378	-0.596	-2.69	-0.749	-3.367	-2.383
292	296	-0.186	-0.325	-0.375	-1.491	-0.581	-3.207	-1.541
293	297	0.506	0.366	0.717	-1.973	-0.181	-3.195	-2.537
294	298	0.288	0.148	0.329	-2.024	-0.38	-3.097	-2.594
295	299	-0.08	-0.22	-0.228	-2.304	-0.54	-3.285	-2.507
296	300	0.113	-0.027	0.114	-2.139	-0.421	-3.017	-2.484
297	301	-0.587	-0.726	-1.17	-2.144	-0.945	-3.42	-2.101
298	302	-0.207	-0.347	-0.499	-2.405	-0.684	-2.91	-2.728
299	303	0.266	0.126	0.245	-1.964	-0.427	-2.616	-2.335
300	304	-0.13	-0.269	-0.561	-1.521	-0.794	-2.955	-2.110
301	305	0.711	0.571	1.314	-1.093	-0.211	-3.483	-2.414
302	306	0.148	0.008	0.183	-1.824	-0.357	-1.969	-2.445
303	307	0.066	-0.073	0.112	-1.666	-0.317	-2.022	-2.592
304	308	0.243	0.104	0.292	-2.248	-0.343	-3.343	-2.211
305	309	0.333	0.193	0.326	-2.039	-0.428	-3.187	-2.249
306	310	-0.593	-0.732	-1.514	-2.52	-1.282	-2.952	
307	311	0.089	-0.051	0.099	-1.748	-0.382	-3.251	-2.411
308	312	0.695	0.555	1.105	-1.709	-0.011	-2.935	-2.611
309	313	0.085	-0.055	0.03	-1.557	-0.477	-2.829	-2.145
310	314	0.073	-0.067	0.135	-2.196	-0.348	-3.224	-2.579
311	315	0.186	0.046	0.188	-2.105	-0.39	-3.011	-2.546
312	316	-2.258	-2.4	-4.965	-3.419	3.217	-3.442	-2.165
313	317							
314	318	0.303	0.163	0.52	-1.247	-0.174	-3.272	-2.119
315	319	-0.814	-0.952	-1.716	-2.364	-1.265	-3.6	-1.780
316	320	0.38	0.241	0.887	-1.187	0.115	-3.609	-1.640
317	321	-0.287	-0.427	-0.857	-1.965	-0.961	-3.394	-1.847
318	322	0.837	0.698	1.521	-0.986	0.292	-3.553	-2.558
319	323	-0.832	-0.971	-2.062	-1.986	-1.592	-3.359	-0.901
320	324	-0.272	-0.412	-0.991	-1.344	-1.141	-2.664	-0.078
321	325	-1.467	-1.607	-3.399	-2.379	-2.324	-3.299	-1.600
322	326	-0.716	-0.856	-1.762	-1.919	-1.437	-3.144	-0.818

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
323	327	-1.727	-1.867	-3.859	-2.842	-2.524	-3.688	-1.192
324	328	-0.585	-0.725	-1.507	-1.77	-1.343	-3.222	-0.921
325	329	-0.994	-1.133	-2.243	-2.23	-1.641	-3.617	-1.210
326	330	-0.574	-0.713	-1.604	-1.817	-1.392	-2.935	-0.814
327	331	-0.959	-1.097	-1.962	-2.197	-1.366	-3.162	-1.603
328	332	-0.736	-0.876	-1.513	-2.036	-1.169	-3.306	-1.985
329	333	-0.979	-1.118	-2.321	-2.172	-1.734	-3.462	-2.005
330	334	-0.958	-1.097	-2.234	-2.062	-1.638	-3.661	-1.964
331	335	-0.967	-1.106	-2.293	-2.136	-1.719	-3.467	-1.985
332	336	-1.001	-1.139	-2.357	-2.047	-1.719	-3.058	-2.046
333	337	-1.17	-1.31	-2.609	-2.287	-1.831	-3.995	-2.621
334	338	-0.685	-0.824	-1.633	-1.773	-1.34	-3.21	-1.881
335	339	-0.607	-0.746	-1.704	-1.644	-1.489	-3.528	-1.996
336	340	-1.497	-1.636	-3.382	-2.65	-2.248	-3.854	-2.299
337	341	-0.937	-1.076	-2.152	-2.059	-1.578	-3.161	-2.004
338	342	-0.643	-0.782	-1.673	-1.7	-1.422	-3.158	-2.002
339	343	-1.268	-1.407	-2.898	-2.33	-2.023	-4.201	-2.562
340	344	-0.689	-0.839	-1.424	-1.99	-1.117	-3.226	-1.713
341	345	-0.83	-0.969	-1.939	-1.972	-1.471	-3.885	-1.927
342	346	-0.995	-1.134	-2.301	-2.131	-1.698	-3.148	-1.947
343	347	-1.196	-1.334	-2.445	-2.51	-1.612	-3.568	-1.875
344	348	-0.572	-0.711	-1.439	-2.02	-1.26	-3.5	-2.244
345	349	-1.25	-1.389	-2.952	-2.344	-2.065	-4.314	-2.317
346	350	-1.216	-1.355	-2.815	-2.565	-1.962	-3.724	-1.652
347	351	-1.061	-1.2	-2.331	-2.296	-1.662	-3.091	-1.700
348	352	-1.028	-1.167	-2.39	-2.503	-1.754	-3.303	-1.823
349	353	-2.1	-2.239	-4.403	-3.245	-2.665	-3.659	-1.573
350	354	-0.851	-0.991	-1.759	-2.144	-1.3	-3.381	-2.086
351	355	-1.429	-1.567	-2.954	-2.835	-1.888	-3.318	-2.052
352	356	-2.046	-2.186	-4.185	-3.279	-2.531	-3.383	-0.750
353	357	-1.021	-1.16	-2.117	-2.31	-1.458	-3.226	-0.717
354	358	-1.498	-1.638	-3.058	-2.87	-1.952	-3.506	-0.789
355	359	-0.529	-0.668	-1.035	-1.89	-0.898	-3.407	-0.568
356	360	-1.506	-1.645	-3.07	-2.862	-1.927	-2.956	-2.234
357	361	-0.827	-0.966	-1.728	-2.831	-1.264	-2.905	-2.303
358	362	-0.879	-1.018	-1.975	-2.341	-1.489	-3.452	-1.646
359	363	-1.907	-2.046	-4.035	-3.138	-2.521	-3.543	-1.194
360	364	-0.663	-0.803	-1.48	-2.813	-1.209	-2.694	-2.334
361	365	-0.659	-0.798	-1.384	-2.283	-1.087	-2.87	-2.481
362	366	-0.625	-0.764	-1.325	-1.984	-1.062	-3.384	-1.779
363	367	-1.334	-1.473	-2.657	-2.73	-1.716	-3.555	-1.967
364	368	-0.794	-0.932	-1.697	-2.308	-1.266	-3.272	-1.019
365	369	-0.797	-0.936	-1.824	-2.152	-1.389	-3.259	-1.944
366	370	-0.395	-0.534	-0.938	-2.266	-0.92	-2.993	-2.322
367	371	-0.601	-0.74	-1.32	-2.762	-1.082	-3.008	-2.676
368	372	-0.629	-0.768	-1.37	-2.078	-1.103	-3.447	-2.034

No.	Survey No.	Calcite	Aragonite	Dolomite	Strontianite	Magnetite	Gypsum	Fluorite
369	373	-0.378	-0.517	-0.818	-2.4	-0.803	-3.802	-2.614
370	374	-0.521	-0.66	-1.116	-2.131	-0.958	-3.219	-2.157
371	375	-0.533	-0.672	-1.073	-2.454	-0.903	-3.764	-2.678
372	376	-0.89	-1.029	-1.851	-2.682	-1.353	-3.262	-1.402
373	377	-0.997	-1.136	-2.049	-2.331	-1.445	-3.621	-1.864
374	378	-1.091	-1.229	-2.189	-2.433	-1.461	-3.806	-2.386
375	379	-0.285	-0.424	-0.72	-2.363	-0.798	-2.807	-0.765
376	381	0.142	0.001	-0.051	-2.19	-0.614	-3.473	-2.645
377	382	-0.739	-0.878	-1.71	-3.074	-1.363	-2.651	-2.951
378	383	-0.014	-0.153	-0.188	-2.401	-0.567	-3.415	-2.800
379	384	-0.771	-0.911	-1.951	-2.988	-1.586	-2.786	-2.506
380	385	-0.468	-0.608	-1.04	-2.798	-0.964	-3.406	-2.285
381	386	-1.007	-1.146	-2.146	-3.266	-1.516	-3.437	-2.905
382	387							
383	388	0.698	0.558	1.096	-1.557	0.006	-2.567	-2.849
384	389	0.3	0.16	0.429	-1.969	-0.263	-3.169	-2.287
385	390	0.232	0.093	0.232	-1.076	-0.392	-2.513	-1.448
386	391	0.249	0.11	0.349	-1.363	-0.262	-2.953	-1.934
387	392	-0.765	-0.907	-1.849	-1.888	-1.594	-3.048	-0.757
388	393	-0.772	-0.911	-2.154	-1.853	-1.744	-2.965	-0.533
389	394	-0.979	-1.118	-2.445	-2.119	-1.858	-3.351	-1.092
390	395	0.221	0.082	0.359	-1.405	-0.225	-3.539	-2.137

APPENDIX 6

WELL CONSTRUCTION PROFILE

Appendix 6 Typical well construction profile. Water could be introduced into lower horizons by piping along back-filled material and gravel pack.

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