

**NATURAL ATTENUATION OF AQUEOUS ZINC IN SHALLOW
SOILS OVER PERMAFROST DOWNSLOPE OF
GALKENO 300 MINE ADIT, UNITED KENO HILL MINES,
CENTRAL YUKON**

by

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ABSTRACT

This study investigated the natural attenuation of zinc in mine drainage at the Galkeno 300 mine site, located at the northern limit of the discontinuous permafrost zone in central Yukon Territory. The mine drainage contains ~150 mg/l Zn where it exits the mine; where these same waters enter the receiving environment of Christal Creek, the Zn concentrations have been reduced to ~2 mg/l. The research program examining this natural attenuation consisted of two phases. Phase 1 was comprised of a site investigation along with the collection of samples for chemical analyses and laboratory testing. Phase 2 consisted of laboratory characterisation and testing of samples collected during Phase 1.

The Phase 1 site investigation was carried out during summer 2000. A climate station was established to monitor precipitation and temperature during the study period. Site water balance was monitored through the erection of two weirs; inputs exceeded outputs by an average of 16%, indicating a minor degree of dilution. Water samples collected at sites along the longitudinal mine drainage flowpath showed no temporal trends, but clearly outlined a dramatic decrease in Zn concentrations with distance from the adit. Soil samples of upper organic and lower mineral horizons were collected from within and immediately adjacent to the flowpath. Chemical analysis of aliquots of these samples clearly showed elevation of Zn concentrations in samples in contact with mine drainage; upper organic horizon samples in particular were found to contain highly anomalous Zn levels.

The Phase 2 laboratory investigation subjected the collected samples to physical and chemical characterisation, as well as batch adsorption testing and column leaching with synthetic and natural mine drainage. Batch adsorption tests showed the organic soils to have the highest Zn attenuation capacity; in particular, organic soils from the midpoint of the site (site C) were found to have the highest adsorptivity. Similar results were obtained in the column leaching and desorption tests; organic samples from site C had both the highest Zn attenuation capacity and the greatest degree of Zn retention under increasingly aggressive desorbing conditions.

Selective extractions of the collected soils showed that the oxide fraction was the repository for much of the soil zinc. In the organic soils in particular, the oxide fraction dominates the geochemical fractionation of Zn in Galkeno 300 soils. High concentrations of Mn are removed from the mine drainage simultaneously with Zn; the coprecipitation of Mn-Zn oxides appears to be the dominant process of natural attenuation of Zn at the Galkeno 300 site.

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CHAPTER 1

INTRODUCTION

1.1 Statement of Problem

The extraction and beneficiation of mineral resources are activities which by their very nature produce large amounts of waste material containing a high concentration of heavy metals (Morin and Hutt, 1997). Ore deposits which consist chiefly of sulphide minerals have formed in reducing environments under chemical conditions very different from those found at the earth's surface (Krauskopf and Bird, 1995); exposure of waste materials to the common surficial conditions of abundant oxygen and water leads to oxidation of contained sulphide mineralisation (Boyle, 1994). Depending on disposal practices and site characteristics, mineral industry wastes can be a major source of heavy metal flux to the receiving environment (Lottermoser and Ashley, 1998).

In particular, zinc is a common constituent of waters draining from metal and coal mine wastes and workings (Odor et al., 1998; Younger, 2000; Black and Craw, 2001; Lee et al., 2001); the environmental fate of aqueous zinc and its impact on the downstream environment is of primary concern at many existing (Morin and Hutt, 1997) and abandoned (Clark et al., 2001) mine sites. High mining-induced aqueous zinc concentrations can have negative impacts on biota that inhabit the receiving environment; both mortality and sub-lethal effects have been observed at all trophic levels across a variety of species encompassing plants, bacteria, invertebrates and fish (Weatherley et al., 1980). In Canada, allowable concentrations of zinc in mining-related

discharges are governed by the Fisheries Act in national legislation entitled the Metal Mining Liquid Effluent Regulation (MMLER) (Canada, 1977). Under MMLER, mining-related water must contain less than 0.5 ppm of dissolved zinc to be legally discharged to surface waters.

Sulphide oxidation and the accompanying mobilisation of metals is a natural process that occurs at undeveloped mineral deposits as well as where mining of mineral resources has taken place (Fuge et al., 1994). There are a number of natural processes which act to limit the movement of zinc and other metals away from a mineral source; these processes include adsorption, precipitation and coprecipitation, and are collectively referred to as mechanisms of *natural attenuation*. Natural attenuation, in this context, is the removal of contaminants such as metals from an aqueous source impacted by mining through naturally existing processes and environmental conditions. Because of its ability to both dissolve metals and move particulate matter, flowing water is commonly the most important vector in transferring metals from a mineral deposit to the receiving environment. Natural attenuation mechanisms that act to reduce the metal load carried by metal-bearing surface and ground waters are thus important from the standpoint of limiting the dispersion and the environmental impacts of weathering-derived zinc and other metals (Kwong and Whittle, 1992). At some mine sites, acceptable discharge water quality is achieved through exploitation of natural attenuation mechanisms, either in isolation (Kwong and Gan, 1994; Kwong et al., 1997) or in conjunction with a constructed water treatment system (Germain et al., 1994).

Natural attenuation processes are resulting in a marked decrease in aqueous zinc concentrations at an inactive mine site in central Yukon Territory, Canada (Soprovitch, 2000). The region is at

the northern limit of the discontinuous permafrost zone; the site is underlain by permafrost, which acts as a barrier to vertical infiltration of water, and groundwater flow is confined to the shallow soils of the active layer. Water measuring ~150 mg/l dissolved zinc is issuing from the Galkeno 300 adit, at the northeast end of Galena Hill in the Keno Hill Mining District. This water flows downslope on surface and through shallow soils overlying permafrost for 1.7 kilometers before entering Christal Creek in the valley bottom. Immediately upstream of the confluence of the mine drainage with Christal Creek, zinc concentrations in the Galkeno 300 drainage were measured to be 2-3 mg/l during the summer of 2000. Natural attenuation processes appear to be removing >140 mg/l of dissolved zinc from the drainage of the Galkeno 300 adit. This phenomenon is at present protecting the ecology of Christal Creek and other downstream waters. Christal Creek is within the McQuesten River watershed; the McQuesten River is some of the most important habitat for chinook salmon and arctic grayling within the traditional territory of the local First Nation, the Na Cho Nyak Dun (Canada, 1995). The protection of this fisheries resource and the habitat it is dependent on is a priority for the First Nation, federal and territorial governments.

There are a limited number of possible explanations for the removal of zinc from the mine drainage over this flow path. Workers studying other mine drainage cases have found that metal removal from mine drainage can occur via sorption onto mineral (Herbert, 1997; Berger et al., 2000; Trivedi and Axe, 2000) and organic soil components (Herbert, 1997; Waybrant et al., 1998; Bendell-Young, 1999), or via formation of minerals (precipitation) (Nordstrom and Alpers, 1999; Nuttall and Younger, 2000; Kalin, 2001) or incorporation into the crystal lattice of other minerals (coprecipitation) (Herbert, 1996; Lin and Herbert, 1997; Latrille et al., 2001; Lee

et al., 2001). Each of these natural attenuation mechanisms has different implications with respect to bioavailability, attenuation capacity and the potential for future mobility. It is thus important not only to quantify the degree of natural attenuation occurring at a site, but also to examine the contributing factors and mechanisms of the attenuating process itself.

In the case of the Galkeno 300 drainage, attenuation via adsorption onto existing soil material would be limited in the long term by the adsorption capacity of the soil in question. In addition, changing environmental parameters could potentially cause desorption of attenuated metals; one such potential environmental change is a decrease in the pH of the mine drainage, a phenomenon that is conceivable if acid neutralisation potential within the drainage source area is depleted (Kwong et al., 1997). The desorption of attenuated metals would result in metal flux to Christal Creek in excess of the levels exiting the Galkeno 300 adit; the attenuating process(es) would have created a new source of metals.

Alternatively, attenuation via precipitation or coprecipitation mechanisms within the Galkeno 300 drainage is not limited by a finite capacity of the substrate; precipitation will occur under favourable conditions when the components are available at sufficient concentrations (Porile, 1987). Precipitation also forms minerals which are stable under existing site environmental conditions (Krauskopf and Bird, 1995); while potentially susceptible to dissolution under conditions of increasing acidity, the hydrated oxides commonly found in mine drainage streams are more resistant to dissolution than are carbonate minerals. In short, the details of the mechanism(s) of natural attenuation at a site are critical to an evaluation of the long term stability

and environmental impact of the attenuated contaminants. Additionally, an understanding of these details would better inform waste management decisions and long term reclamation plans.

Natural attenuation of waters contaminated with hydrocarbons and other organic compounds has received much attention in recent years (Cunningham et al., 2001; Eganhouse et al., 2001).

Organic contaminants often can be broken down, either biotically or abiotically, to yield end products that are much more environmentally benign (Nyer and Boettcher, 2001). Metals, on the other hand, are elements; no possibility of reducing environmental risk through degradation of stable metal isotopes exists (Eccles, 1998). Natural attenuation of water contaminated with metals from mining activities has been studied less frequently; much of the previous work has been done in the western United States (Webster et al., 1994; Berger et al., 2000) and other temperate regions (Odor et al., 1998; Black and Craw, 2001; Lee et al., 2001) and has been focused on the inorganic geochemistry of surface waters. There have been limited studies examining the role of natural wetlands in natural attenuation of mine drainage (Kwong and Vanstempvoort, 1994), though most wetland research focuses on constructed wetlands (Frankowski, 2000). The study of natural attenuation occurring under the harsh climatic conditions of the northern latitudes is very limited; the work of Kwong and others in Yukon Territory represents a large proportion of the research conducted to this point (Kwong and Whittley, 1992; Kwong et al., 1997). Studies undertaken in temperate regions have focused on the inorganic chemistry of waters impacted by mine drainage; similarly, this work examines the chemical interactions of mine drainage with the receiving environment, but at a site located at the northern limit of discontinuous permafrost in central Yukon.

1.2 Scope and Objectives

The research described in this thesis examined the natural attenuation occurring at the Galkeno 300 mine site in central Yukon with the goals of understanding the process(es) of attenuation and of gaining insight into the environmental mobility of the attenuated metal. The investigation consisted of two phases. During Phase 1, a site investigation was conducted to gather field information about the site and to collect samples for analysis and for laboratory testing. Phase 2 involved the characterisation and laboratory testing of contaminated and uncontaminated samples collected at the field site. The specific objectives of each phase were as follows.

Phase 1 objectives

1. To investigate the hydrological characteristics of the Galkeno 300 adit discharge.

Location of subsurface flow pathways was critical to ensure that no adit discharge was leaving the site by unknown pathways; this would effectively remove dissolved metal loads from the system and artificially inflate estimates of mass removal by attenuation processes. Measurement of flow volume inputs and outputs for the site allowed a water balance to be calculated and precipitation inputs to be estimated; this would allow a dilution factor due to precipitation to be determined, and facilitate a better estimate of metal mass removed by attenuation processes.

2. To investigate the chemical characteristics of the Galkeno 300 adit discharge.

Water samples collected throughout the field season and analysed for dissolved and total metal and nutrient contents identified the spatial and temporal nature of natural attenuation processes. These values permit the calculation of the mass of

zinc removed with distance downslope of the source, as well as calculation of total metal loadings to Christal Creek.

3. To investigate the shallow subsurface and collect representative samples for laboratory analysis.

Examination of the shallow unfrozen soil above the permafrost table permitted characterisation of the stratigraphy across the site. This permitted the sampling of soil material from different horizons and from different sample locations to ensure that site scale soil variability was accounted for. Samples collected form the basis of the second phase of the investigation.

4. To investigate the concentrations of zinc in soils in contact with the Galkeno 300 drainage and those adjacent to, but not in contact with, the Galkeno 300 drainage water.

Background zinc levels in soils adjacent to flow are contrasted with zinc levels in contact with flow. The degree of elevation of zinc in in-flow soils allows estimates of attenuation of zinc per mass of soil that has already occurred at the site. This data provides proof positive that the soil sampled is the repository of attenuated zinc and other metals.

Phase 2 objectives

1. To characterise field samples with respect to physico-chemical properties.

Characterising field samples on the basis of mineralogy, carbon content, soil pH, cation exchange capacity, particle size and specific surface area will permit correlation of attenuating behaviour of soils with specific properties. This will also permit comparison of soils at other sites with the soils examined in this study.

2. To determine the sorptive capacity of the various soils collected through batch adsorption testing.

Batch adsorption tests provide an estimate of the total capacity of soil materials to attenuate zinc in drainage waters; expressed as 'mass zinc adsorbed per mass soil substrate', these data permit comparison of the levels of zinc in the contaminated samples collected in the field with the upper limit of sorptive capacity determined through batch adsorption testing.

3. To determine the sorptive behaviour of the various soils collected under zinc concentrations of field conditions in leaching column tests.

Results from leaching column tests will indicate the capacity of the various soils to attenuate zinc to acceptable levels when influent zinc concentrations are representative of concentrations found in the field. These tests will remove the influence of the large chemical gradient which exists in batch adsorption tests and provide a more realistic estimate of what is actually happening at the field site.

4. To determine the retention mechanisms by which zinc is removed from the mine drainage water through selective extraction.

The speciation of attenuated zinc is important when bioavailability or remobilisation are considered. Selective extraction aims to determine the geochemical speciation of the attenuated zinc and allows inferences to be made about threats posed by attenuated forms.

1.3 Research Plan

In order to achieve the research objectives, a research plan was developed that consisted of a plan for the site investigation phase of the research (Phase 1) as well as a plan for the laboratory phase of the research. Figures 1.1a and 1.1b depict the schematic framework of the Phase 1 and 2 research plans, respectively.

1.4 Research Contributions

The natural attenuation of mining-derived metal contaminants in cold regions has been the subject of little study. This research illustrates a case study of environmental protection from metal pollution through natural attenuation at the northern limit of the discontinuous permafrost zone in Canada's Yukon Territory. The environmental processes which act to limit metal transport in shallow soils over permafrost at the study site have been identified; these findings have important implications for the development of treatment options to strip metals from mine drainage using local materials available at northern mine sites. Further, the results of this work also have implications for the management of soils contaminated by mine drainage; from a management perspective, residual contamination that is bound in stable, non-leachable materials poses minimal threat to downstream ecosystems.

Phase 1: Site investigation

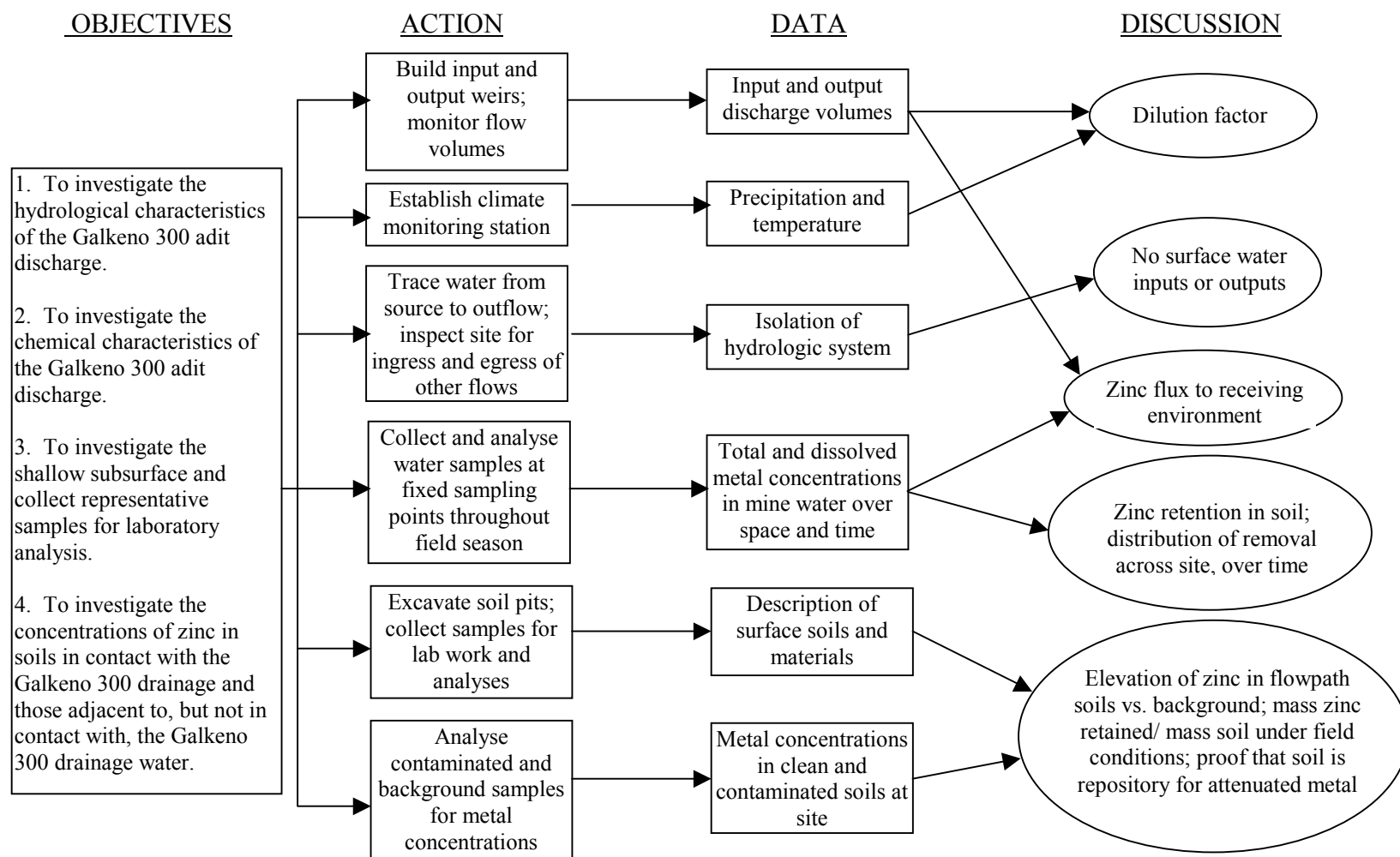


Figure 1.1a. Research plan for Phase 1: Site investigation.

Phase 2: Laboratory investigation

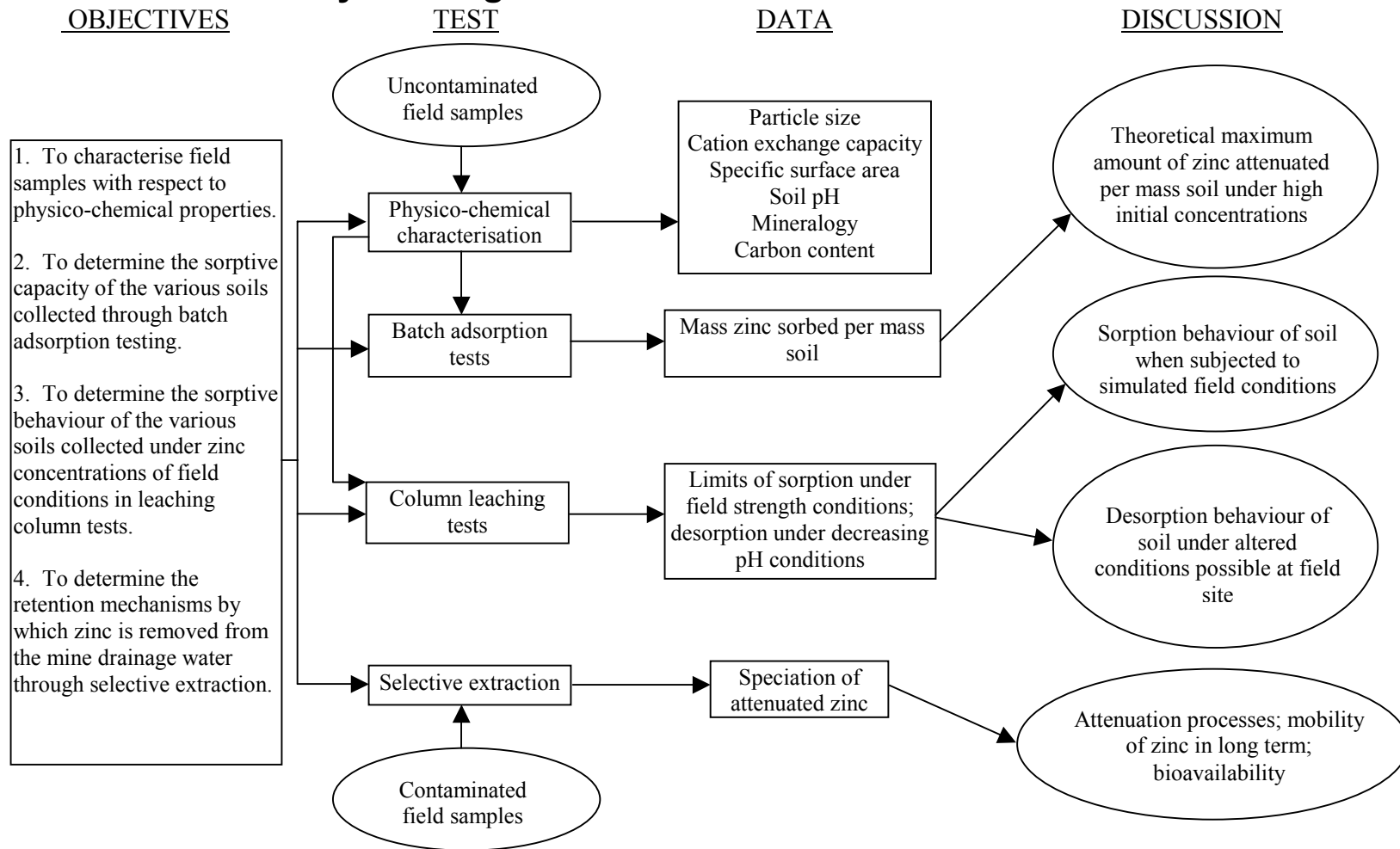


Figure 1.2b. Research plan for Phase 2: Laboratory investigation.

1.5 Organisation of Thesis

This thesis is composed of five chapters, each dealing with a different aspect of the underlying research project.

Chapter 1 introduces the general subject matter and outlines the position of this study within that subject matter. It also outlines previous related research and identifies the scope and objectives of this work, and details the plan for conducting this research.

Chapter 2 begins with a description of the field site and relevant details thereof; it then goes on to review the theoretical work presented in the literature that forms the basis for the investigative methods chosen and the interpretations of results which have followed. In particular, the nature of soil-contaminant interaction is reviewed in some detail.

Chapter 3 outlines the methods employed in Phases 1 and 2 of the investigation, and describes the equipment and materials used.

Chapter 4 presents the results of both Phases 1 and 2. Discussion of both field and laboratory results is included.

Chapter 5 records the conclusions that have been formed from the results of the investigation and briefly indicates the contribution of this research to the general body of knowledge.

Finally, recommendations for future research are outlined.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

This chapter describes the characteristics and history of the study site as well as the setting and rationale for the research undertaken. Related literature on which the research design and the interpretation of results are based is reviewed; particular emphasis is placed on the composition of soil, the nature of soil surfaces and the interaction of these surfaces with aqueous zinc and other metals.

2.1 Background information and site history

The research site is located 2.5 km west of Keno City in the Keno Hill Mining District (Figure 2.1). The Keno Hill mining district is centered at 63° 55' N, 135° 25' W in central Yukon, Canada. A summary of the site's physical characteristics and its historical activity will provide a basis for further discussion.

2.1.1 Physiography and Climate

The study area lies within the northeastern part of the Yukon plateau (Gleeson and Boyle, 1976). The study site occupies a northeast facing hillslope on the south side of the valley occupied by Christal Creek. The valley has the characteristic U-shaped cross-section typical of glacially scoured valleys (Bond, 1998); the topographic map in Figure 2.1 illustrates these features, as well as the study site's proximity to Keno City. Slope of the Galkeno 300 hillside generally varies between 10° and 20°, with a single local section at 25°. The lower slope has two

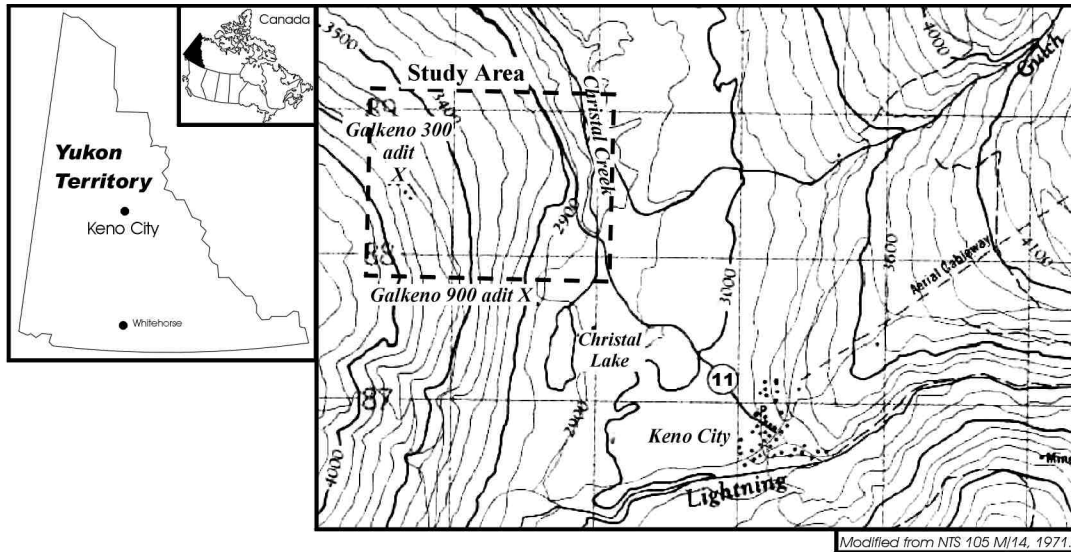


Figure 2.1. Location, topography and infrastructure of research site.

important areas of lower gradient, between 3° and 5°; these flats are characterised by higher accumulations of undecomposed and partially decomposed organic matter. Vegetation consists of open mature black spruce forest with willow and dwarf birch understory at higher elevations and transitions to a mixed forest dominated by black and white spruce, paper birch, balsam poplar and trembling aspen with willow and dwarf birch understory at lower elevations. Golden moss is the common ground cover across the site.

The region is located near the northern limit of the zone of discontinuous permafrost (Figure 2.2); in this zone, permafrost is widespread across a variety of terrain types, and is generally absent only on well-drained, south facing slopes that have little or no organic matter accumulated at the soil surface (Brown et al., 1981). The presence of open black spruce forest with a thick

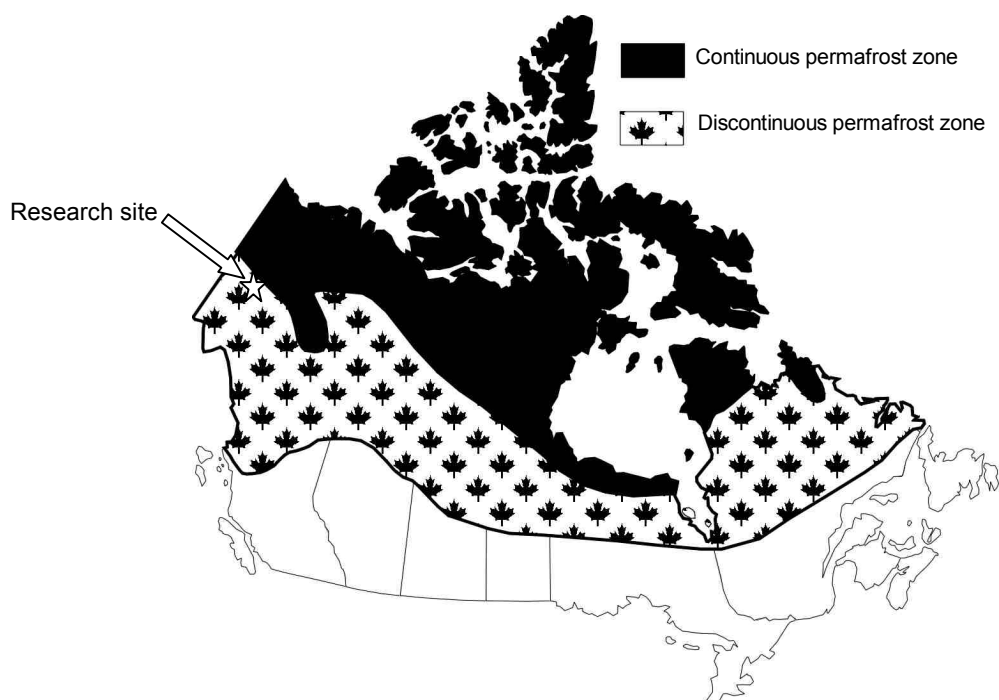


Figure 2.2. Distribution of permafrost in Canada (adapted from Natural Resources Canada, 1995).

accumulation of organic matter is a common vegetative indicator of the presence of permafrost, and is especially common on north facing slopes; the combination of the insulating capacity of organic matter and the minimal solar energy influx due to aspect create favourable conditions for the formation and stability of permafrost (Brown et al., 1981). Permafrost prevents the downward migration of surface and ground waters; this leads to ponded water in surface depressions and lowlands, and restricts groundwater flow to the near-surface active layer (Brown et al., 1981).

2.1.2 Geology

2.1.2.1 Surficial Geology

The valley occupied by Christal Creek contains a thick blanket (up to 30 m) of glacial sediment (silty sandy till and glacial outwash gravels) capped by a variably thick (up to 3 m) post-glacial accumulation of relatively undecomposed organic matter (Gleeson and Boyle, 1976). The glacial deposits quickly thin to a veneer on the adjacent slopes; the deposits on the steep valley sides have undergone varying degrees of colluviation, and bedrock blocks are commonly found mixed with the colluviated sediments. An accumulation of dead moss and other organic matter in varying states of decomposition is present on the steep valley sides, commonly up to 30 cm in thickness. The fine grained texture of the mineral sediments present a barrier to downward migration of water; the majority of subsurface water flow moving down the steep valley sides occurs in the relatively more porous upper organic layer. While flow of water generally is parallel to slope, local scale topography commonly causes flow deviations from this line.

2.1.2.2 Geology and Mineralogy of Keno Hill Ore Deposits

The geology of the vein material which formed the Galkeno 300 ore deposit and of the surrounding host rock together control the chemical nature of the mine drainage, and it is useful to briefly review this geology here. The host rock is sedimentary in nature, consisting of competent quartzites and weaker schists and phyllites with minor limestone lenses (Boyle, 1965). Occasional igneous greenstone bodies occur conformably within the sedimentary package. The sedimentary rocks contain up to 10% calcium carbonate (Kwong et al., 1994), which results in the host rock having considerable neutralisation capacity. The ore bodies formed in faults where low pressure zones developed at the contact between weaker schists and phyllites and more competent quartzite or, rarely, greenstone bodies (Boyle, 1956). The vein material that made up the economic deposits consisted of galena, sphalerite and freibergite in a gangue of manganiferous siderite, quartz and pyrite. Secondary weathering products of the primary vein minerals were common, and locally carried economic concentrations of silver (Gleeson and Boyle, 1976).

2.1.3 Mining

Silver ores have been mined in the Keno Hill mining district, central Yukon Territory, since 1906 (Mayo Historical Society, 1999); large scale mining in the district ended in 1989 with the closure of United Keno Hill Mines operations (Kwong et al., 1994). The Galkeno ore body was mined by underground methods in the late 1950's and early 1960's via adits at the 300 (1160 m elevation) and 900 (950 m elevation) levels (Figure 2.1); ore was hauled by rail car to the adit

mouth to be loaded onto trucks for transport to the mill, while waste rock consisting of quartzite and phyllites with minor sulphides was dumped at the adit mouth (Roberti, 2000).

2.1.4 Post-mining activity

Following the cessation of mining in the early 1960's, economic interest in the Galkeno property waned, and no further mining activity was conducted on the property. The underground workings were connected; the workings remained dewatered as gravity drainage discharged from the Galkeno 900 adit into the muskeg adjacent to Christal Lake (Figure 2.1). Anecdotal reports (Roberti, 2000) indicate that this drainage was of neutral pH, but carried levels of dissolved metals that consistently exceeded the discharge limits specified by UKHM's water license (Board, 1998). In 1995, a concrete plug was installed in the Galkeno 900 adit in an effort to halt the unacceptable discharge. Since that time, drainage with unacceptable metal concentrations has continued to discharge from the Galkeno 900 adit; bypass of the plug by drainage waters is occurring, perhaps through fractures in the surrounding rock, and a conventional lime treatment plant has been installed to precipitate metals from the drainage (Roberti, 2000).

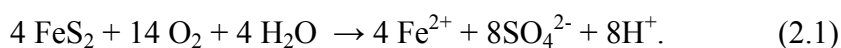
From the cessation of mining to the mid-1990's, the Galkeno 300 adit was observed to have water exiting its mouth only during periods of rapid snowmelt (Roberti, 2000). In 1997, 2 years after the plugging of the Galkeno 900 adit, small volumes of drainage were observed to constantly discharge from the Galkeno 300 adit. In 1998, the discharge was slightly greater, and again in 1999 and in 2000 the discharge volume was noted to increase (Soprovitch, 2000).

Dissolved zinc and other metals measured in grab samples taken during field examinations by government personnel showed metal concentrations up to 10 times higher than those observed at the lower Galkeno 900 adit (Soprovitch, 2000). It is possible that the plugging of the Galkeno 900 adit has caused flooding of the Galkeno workings to the 300 level. A plausible explanation for the increase in metal content of the Galkeno 300 drainage over the Galkeno 900 drainage is the dissolution of soluble secondary weathering products that had accumulated in the 40+ years since mining had taken place. Regardless of the cause, larger flows than had previously been observed, with high dissolved metal content, were exiting the Galkeno 300 adit during the period of June to August, 2000.

2.2 Sulphide Mineral Weathering

Many ore deposit types contain sulphide minerals as the economic target and as a component of the gangue and waste rock. These minerals commonly form in reducing environments, under conditions much different chemically from those at the surface (Morin and Hutt, 1997). When sulphide minerals are exposed to oxygen and water, the sulfur component oxidises to sulfate (SO_4^{2-}) and the metal cation is released into solution. This process occurs where sulphide-bearing rocks are exposed to atmospheric conditions either naturally through erosional or tectonic forces, or through human activity such as mining. During mining, large quantities of sulphide material are exposed to atmospheric conditions; rapid weathering of the fresh sulphide surfaces commonly ensues. This, in combination with the large surfaces presented by the freshly broken rock, can lead to high rates of metal release and of acid generation.

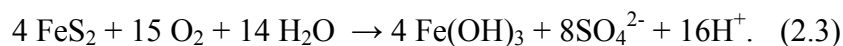
The most common sulphide mineral is pyrite (FeS_2); discussions of sulphide weathering commonly use pyrite oxidation as a model. Pyrite oxidation is modeled as occurring in two steps (Kwong and Whittle, 1992). Initially, pyrite oxidises in the presence of oxygen and water to yield ferrous iron, sulphate, and acidity:



A second step involving the oxidation of ferrous iron to ferric iron forms more acidity and an insoluble ferric hydroxide precipitate:



The overall reaction is expressed as



Oxidation of other sulphides is similar; sphalerite (ZnS) and Galena (PbS) oxidise according to the reactions



and



PbSO₄ is shown as undissociated because it commonly forms a solid precipitate, the mineral anglesite; this mineral often limits the concentration of lead in mine drainage waters (Krauskopf and Bird, 1995). Sulphide minerals with a 1:1 metal:sulfur ratio, such as sphalerite and galena, to not generate net acidity on weathering (Kwong, 1993).

As pyrite is often a principal component of mine wastes and workings, and as it is the most common source of acid generating potential (Kwong, 1993), understanding the process of pyrite oxidation lends insight into the overall problem of mine drainage. Under abiotic conditions, the oxidation of ferrous to ferric iron by oxygen depicted in equation 2.2 is a slow process; this component of the overall process controls the total reaction rate and is known as the ‘rate determining step’ (Stumm and Morgan, 1970). However, iron oxidising bacteria, such as *Thiobacillus ferrooxidans*, are known to catalyse this step and increase the total reaction rate by several orders of magnitude (Nordstrom and Alpers, 1999b; Elberling et al., 2000). The production of acidity due to the oxidation of pyrite solubilises the metals found in other sulphide

minerals and maintains them in solution (Nordstrom and Alpers, 1999a). The environmental fate of the acidity and metals that are the products of sulphide oxidation are often controlled by buffering reactions which take place between mine drainage and the substrate (Blowes and Ptacek, 1994). As pH decreases, acidity is initially buffered by carbonate phases which dissolve rapidly and maintain a pH of ≥ 5 . If the buffering capacity of carbonate phases is exhausted, Al hydroxides and Fe hydroxides will maintain acidity levels of around pH 4.0-4.3 and pH 3.5, respectively (Blowes and Ptacek, 1994). At pH levels below 3.5, most metals remain in solution and are transported advectively to a point where acidity decreases; this dissolved metal load is often very deleterious to aquatic life in receiving waters (Stumm and Morgan, 1970).

2.3 Environmental Fate of Zinc in Mine Drainage

The fate and transport of zinc in mine drainage ultimately determines its environmental impact. Aqueous zinc can be harmful to aquatic life at elevated concentrations; removal of aqueous zinc to the solid phase can mitigate the impacts that high dissolved zinc levels may pose. There are a number of mechanisms involving mineral and organic surfaces that can act to capture aqueous zinc. The environmental stability of the attenuated zinc is dependant on the nature of the attenuating mechanism; the physical and chemical properties of zinc are central to these processes.

2.3.1 Physical and chemical properties of zinc

Zinc is a group IIb element in the Periodic Table and has a corresponding $3d^{10}$, $4s^2$ outer electron configuration. In forming the aqueous zinc ion, the $4s^2$ electrons are transferred, resulting in a +2 oxidation state. The aqueous zinc ion does not tend to form coordination

complexes due to the saturated $3d$ subshell and associated weak crystal field effect; as such, zinc tends to remain in solution rather than coordinating about an anion. Another aspect of the filled $3d$ subshell and the empty $4s$ subshell of zinc is a small ionic radius ($0.74 \text{ \AA}$ (Krauskopf and Bird, 1995)) and a weakly shielded nuclear charge. These interactions are partially responsible for the tendency to form ion pairs in solution and the instability of covalent compounds. For example, the solubility of sphalerite (a covalent compound with substantial ionic character) in water is roughly 20 orders of magnitude higher than that of copper sulphide (a covalent compound with little ionic character) (Spear, 1981). As an aqueous ion, Zn^{2+} is coordinated by six water molecules in octahedral coordination. At neutral-to-acidic pH, zinc is not expected to form carbonate or hydroxide complexes; nearly 100% of zinc is expected to occur as the aqueous ion. Zinc does have a strong tendency to react with acidic, alkaline and inorganic compounds; because of its amphoteric nature, zinc readily forms a variety of salts such as chlorides, chlorates, sulphides and nitrates as well as organic complexes (Ohnesorge and Wilhelm, 1991).

2.3.2 Nature of surfaces of soil particles

Both organic and mineral soil components have the ability to remove aqueous zinc ions from solution. This ability arises from the nature of the surface of small soil particles- overall, these surfaces carry a net negative charge and thus attract aqueous cations to their surfaces. Soil particle size plays an important role; the specific surface area (SSA- the ratio of surface area per mass, commonly expressed in m^2 of surface area per gram of soil (m^2/g)) of particles increases as particle size decreases (Sparks, 1995). The behaviour of large particles such as pebbles and

sand grains is dominated by gravitational forces (Mitchell, 1993); the SSA of particles of this size is small and little of their mass forms the actual surface where attenuation reactions can take place. The behaviour of finer particles such as silts and clays is increasingly dominated by the electrical properties of their negative surfaces (Yong and Warkentin, 1975); the fine particle size fraction is commonly referred to as the ‘active fraction’, where the vast majority of attenuation occurs. Of the many materials found in soils, organic matter, clay minerals and fine-grained metal oxides are thought to dominate the processes of soil-contaminant interaction (Sparks, 1995). The nature the surfaces of each of these materials is discussed briefly in the following sections.

2.3.2.1 Clay minerals

Clay minerals are a specific group of minerals which *tend* to occur in the clay size fraction (Sparks, 1995). As a group, clay minerals are referred to as *phyllosilicates*, due to the plate-like morphology of the individual mineral particles. These minerals are made up of sheets of silica tetrahedra and aluminum (magnesium, other cations) octahedra (Figure 2.3). Specific minerals are identified by the stacking of tetrahedral and octahedral sheets into layers and by the mechanisms which bind those layers together (Mitchell, 1993); Figure 2.4 illustrates the assemblage of the common clay minerals and the unique configurations of tetrahedral and octahedral sheets that define each mineral.

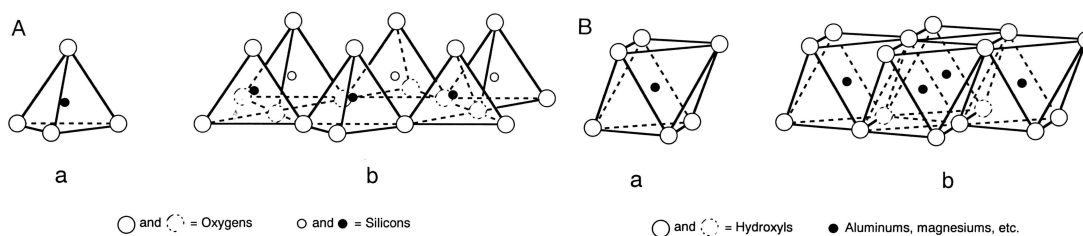


Figure 2.3. A) Schematic diagram showing a) a single silicon tetrahedra, and b) six tetrahedra forming a tetrahedral layer. B) Schematic diagram showing a) a single octahedra, and b) four octahedra forming an octahedral layer. (Adapted from Sparks, 1995; after Grimm, R.E. (1968), "Clay Mineralogy").

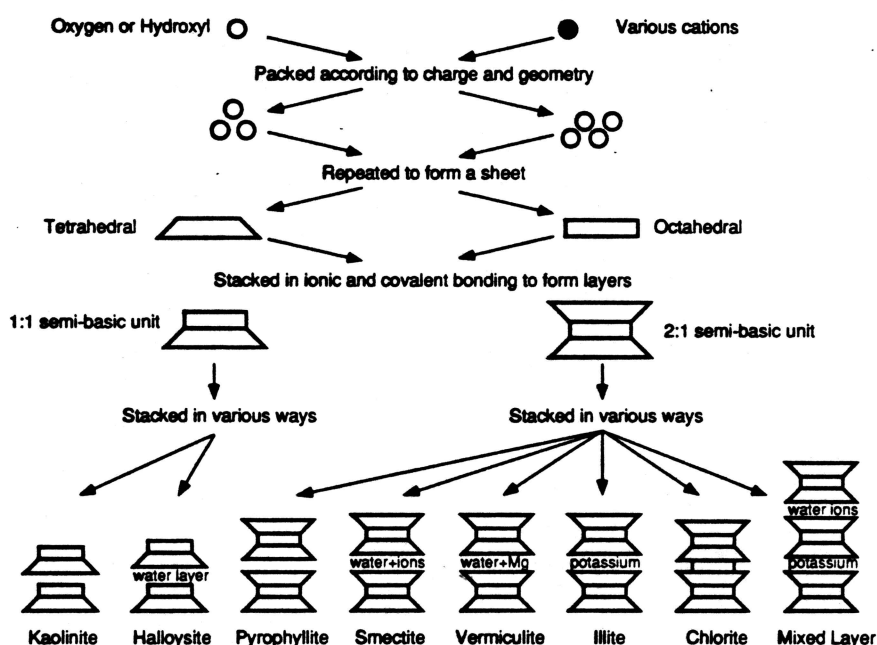


Figure 2.4. Conceptual diagram illustrating the assemblage of clay minerals through the formation of tetrahedral and octahedral sheets, and the stacking of these sheets to form individual minerals. The stacking order and the constituents of the interlayer space together define the different minerals (from Mitchell, 1993).

Clay mineral surfaces are negatively charged. This negative charge can have two components, referred to as permanent charge and pH-dependent charge. Permanent charge on clay mineral surfaces arises from isomorphous substitution; substitution of Al^{3+} for Si^{4+} in the tetrahedral sheet, and substitution of Mg^{2+} for Al^{3+} in the octahedral sheet, give rise to a net negative charge

discussed here as a model for the behaviour of all soil organic matter with respect to attenuation. Humic substances (HS) are the products of microbial decomposition of organic matter which are resistant to further microbial breakdown and are unrecognizable with respect to parent material (Yong et al., 1992). This refractory material makes up a large proportion of the organic matter present in typical soils (Stevenson, 1985); non-humic substances, which include proteins, lipids and carbohydrates, are rapidly broken down through microbial action and as such are not present in large quantities in natural or disturbed soil (Sparks, 1995). The structure of humic substances is complex and poorly understood. The conventional model of the structure of humic substances depicts a heterogeneous combination of aliphatic and aromatic hydrocarbons, lignins, waxes and proteins, arranged randomly in a three-dimensional structure, with large numbers of reactive functional groups attached to the carbon-based skeleton (Stevenson, 1994).

Figure 2.6 depicts a model humic substance proposed by Stevenson (1994).

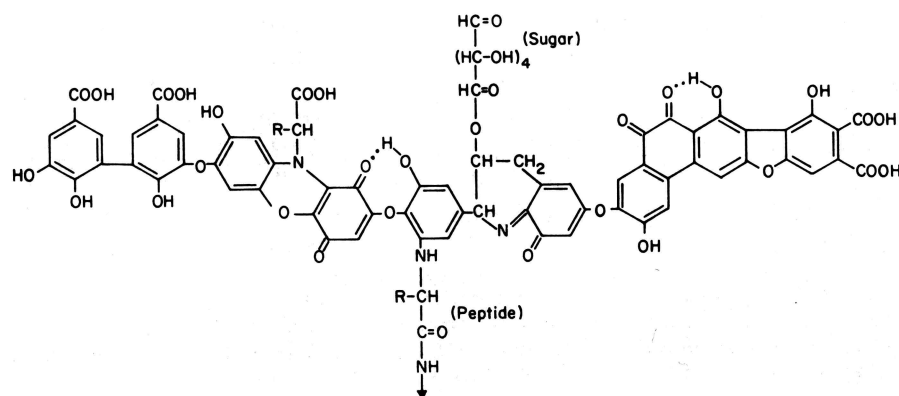


Figure 2.6. A model humic structure showing a backbone of aromatic groups with a variety of aliphatic and reactive functional groups (from Stevenson, 1985).

For purposes of classification, humic substances have been operationally divided into three categories on the basis of solubility in acid and alkali. Fulvic acids (FA's) are defined as those humic substances that are soluble in both acid and alkali. These tend to have relatively low molecular weights as shown in Table 2.1 and are readily dissolved in water. Humic acids (HA's) are defined as that fraction which is insoluble in acid but readily dissolves in alkali; HA's have intermediate molecular weights. The fraction of humic substances which is insoluble in both acid and alkali is referred to as humin; this material has the highest molecular weight and is the most resistant to decomposition (Theng, 1979).

Table 2.1. Properties of humic substances. Adapted from Theng (1979), p. 283-287.

	<u>C (%)</u>	<u>O (%)</u>	<u>N (%)</u>	<u>Soluble in alkali</u>	<u>Soluble in acid</u>	<u>Molecular weight</u>
Fulvic acid	40-50	45-48	<4	Yes	Yes	<2000
Humic acid	55-60	33-36	4	Yes	No	5000- 100 000
Humin	55- >60	32-34	>4	No	No	>300 000?

Functional groups

The ability of humic substances to bind aqueous zinc is derived from the multitude of reactive oxygen-containing functional groups on the surface of HS molecules (Yariv and Cross, 1979; Stevenson, 1985). These functional groups consist mainly of carboxyl, hydroxyl, carbonyl and amino groups; the properties of each functional group govern the group's capacity to bind with aqueous zinc.

Carboxyl group:

The carboxyl functional group consists of a carbon atom in a chain or ring of carbon atoms that forms a single bond with a hydroxyl group and a double bond with an oxygen atom (Figure 2.7a). The hydrogen in the hydroxyl group is capable of dissociating; the carboxyl group can thus function as a weak acid, donating a proton to the soil solution (Yong et al., 1992). On deprotonation, the remaining carbon and two oxygen atoms form a negatively charged functional group (COO^-) which is capable of binding with positively charged ions. Deprotonation is a function of the large molecule to which the carboxyl group is attached and is pH dependent; molecules more likely to deprotonate are classified as more acidic, while those less likely to deprotonate are considered to be more basic (Yariv and Cross, 1979).

Hydroxyl group:

The hydroxyl functional group consists of an OH^- ion bound to an aliphatic or aromatic molecule (Figure 2.7b). Aliphatic hydroxyls do not deprotonate (Yong et al., 1992) and thus form only hydrogen bonds with other molecules. On the other hand, aromatic hydroxyls will dissociate and attain a negative charge (Yariv and Cross, 1979); dissociation is pH dependent, and thus the effective activity of the aromatic hydroxyl is a function of pH. When hydroxyls are the only functional group attached to an aromatic ring, the molecule is referred to as a phenol or phenolic group, while hydroxyls attached to a chain or branched carbon structure form an alcohol. Both phenols and alcohols are common in soil humic substances.

Carbonyl group:

The carbonyl functional group is characterised by a carbon- oxygen double bond (Figure 2.7c) and forms a carboxyl group when joined with a hydroxyl ion. Carbonyl compounds typically have dipole moments due to a lack of symmetry in the electron sharing of the double bond (Yong et al., 1992). This asymmetry is the basis for the reactive nature of this functional group.

Amino group:

The amino functional group consists of a nitrogen atom bonded to two hydrogen atoms (Figure 2.7d) and forms both aliphatic and aromatic compounds (Yong et al., 1992). The amino group forms an essential building block in proteins and is common in low concentrations in humic substances (Krauskopf and Bird, 1995). Although relatively rare, as indicated by the low nitrogen contents of humic substances in Table 2.1, amino groups form very stable complexes with zinc and can be important in terms of mass of zinc bound per mass of HS (Giordano, 1994).



Figure 2.7. Important functional groups present in humic substances.

2.3.2.3 Metal Oxides

Metal oxides, hydroxides, and oxyhydroxides (collectively referred to herein as oxides) are important soil components in terms of attenuation capacity, due to their high specific surfaces areas and high reactivity (Sparks, 1995); of the different oxide minerals, those of iron and manganese exert the greatest influence on aqueous metal concentrations in mine drainage systems. These minerals may be primary in origin, although more commonly metal oxides are secondary soil minerals, having grown from components in solution (Schwertmann and Taylor, 1989). They commonly form fine-grained coatings on other soil particles and can thus influence chemical conditions to a greater extent than their relative abundance would indicate (McKenzie, 1989; Post, 1999). Fe and Mn oxides have no permanent structural charge due to isomorphous substitution; all surface charge is due to unsatisfied bonds at the edges of particles (McKenzie, 1989; Schwertmann and Taylor, 1989). Due to the very fine particles sizes common for these minerals, significant surface charge is present, which originates in the same fashion as portrayed in Figure 2.5 for kaolinite, with the exception that the pH at which protonation and hydroxylation occur varies for the different metal oxide minerals. The Fe and Mn cations are redox active, with the highly oxidised forms being less soluble in natural waters; the onset of reducing conditions can cause dissolution at the oxide surfaces, a concern in the context of remobilisation of attenuated zinc (Krauskopf and Bird, 1995).

2.3.3 Mechanisms of Natural Attenuation

A range of processes can be called upon to account for the natural removal of zinc from mine drainage waters that is occurring at the Galkeno 300 site. These processes revolve around the

geochemical speciation of zinc under drainage conditions and the interactions of dissolved zinc with the surfaces of inorganic and organic soil fractions. Cation exchange, precipitation, co-precipitation and complexation are the relevant processes which have the potential to remove metals from solution. The attenuated metal species are distributed between the exchangeable, carbonate, Fe- and Mn-oxyhydroxide and organic fractions. That zinc which occurs in the residual fraction is considered to be of primary origin and not environmentally available over short time periods. An overview of the theoretical aspects of the relevant attenuation processes will set the stage for later discussion of the mechanisms operating at the Galkeno site.

Cation Exchange

Cation exchange occurs when cations (e.g. Zn^{2+}) in solution replace other cations held as outer sphere complexes at the surface of negatively charged soil particles (Figure 2.8a). Cation exchange is a rapid and reversible phenomenon that occurs stoichiometrically with respect to charge (Sparks, 1995), and is considered to be an equilibrium process. The tendency for soil particles to form these outer sphere complexes with dissolved cations is dependent on both the permanent and variable charge of the surface and, in the case of variably charged surfaces, the solution pH; the measure of this tendency is known as the *cation exchange capacity* of the soil. In a natural soil, the exchange sites on clay mineral surfaces will be largely occupied by protons and by Na^+ , K^+ , Ca^{2+} and Mg^{2+} ions (Krauskopf and Bird, 1995). When a solution bearing anomalous concentrations of zinc or other heavy metals contacts the mineral surface, replacement of the sorbed ions by heavy metal ions, or cation exchange, may occur. The degree to which heavy metals will replace sorbed ions depends on the concentration of the heavy metals

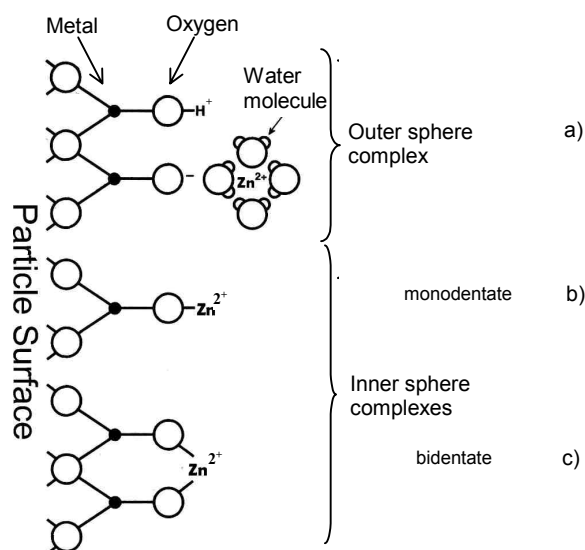


Figure 2.8. a) Conceptual depiction of an outer sphere complex, showing a hydrated zinc ion electrostatically bound to a negatively charged surface. b) Conceptual depiction of a monodentate inner sphere complex, showing a zinc ion bound directly to a surface oxygen with no intervening water. c) Conceptual depiction of a bidentate or chelate complex. (Adapted from Sparks, 1995; after Hayes, 1987).

in solution, the pH of the solution and the properties of the clay mineral. For ions with similar properties, those with the smallest hydrated ionic radius will be sorbed the strongest, as the positive nucleus of the ion is able to be closer to the negative clay surface (Yariv and Cross, 1979). Order of selectivity can be described for various cations on a given surface at a given pH; however, there appears to be no general statement that can be made regarding selectivity sequence across a variety of soil materials (Yong et al., 1992; Sparks, 1995).

Organic matter, clays and metal oxides have a finite cation exchange capacity that is specific to each material. Removal of heavy metals from contaminated waters via cation exchange results in accumulation of heavy metals within the attenuating soil. The long-term stability of the

sorbed metals requires that environmental conditions remain relatively constant. In particular, decreasing pH will commonly reduce the cation exchange capacity of the particle surface and release of metals may occur. The reduction in cation exchange capacity is due to a decrease in the magnitude of the negative charge on the particle surface; for each active soil material, there exists a specific pH at which the mineral surface has a net neutral character- this is known as the point of zero charge (PZC) (Yariv and Cross, 1979). If the acidity of the solution in contact with the particle surface decreases to the PZC, complete desorption of exchangeable ions will occur and a flush of metals will be released to the environment. Long term stability of adsorbed metals requires that environmental conditions remain favourable for adsorption.

Precipitation

Precipitation as a mechanism of removal of dissolved solutes from solution requires concentrations approaching the solubility limit for a given solute. In waters impacted by waste from mining and milling operations of base metals, the major species which are likely to precipitate are carbonates, sulfates, sulphides, and oxyhydroxides (Kimball et al., 1994). As a mechanism for removing heavy metals from contaminated waters, the importance of the precipitation of these mineral species varies depending on the metal ion of concern and the pH of the water (Yong et al., 1992). Lead is commonly removed from contaminated waters through precipitation of anglesite (PbSO_4) and cerussite (PbCO_3) (Lazareva et al., 1995); zinc and cadmium cations, however, reach the concentrations necessary for direct precipitation in an oxidising environment only under conditions where pH remains >6 (Bradl, 1998). Under anoxic conditions, dissolved sulphate is reduced to the sulphide ion, which readily combines with

divalent metal ions to form insoluble sulphide minerals. These sulphides precipitate out of solution; if conditions remain anoxic, or if rapid sedimentation isolates the newly-formed sulphides from the atmosphere, precipitation of sulphide minerals can form a stable long term sink for heavy metals in the residual fraction of the soil. The conditions necessary for this commonly occur in wetlands where decomposing organic matter imposes a high BOD or in deep poorly mixed lakes where oxygen transport to the bottom sediments is limited (Shotyk, 1984).

Coprecipitation

Coprecipitation refers to the removal of heavy metal ions from metal-bearing waters during precipitation of iron and manganese oxides, hydroxides and oxyhydroxides. At near-neutral pH, precipitation of iron, aluminum and manganese hydroxides and oxyhydroxides is known to be accompanied by coprecipitation of elements such as Cd, Cu, Pb and Zn (Karlsson et al., 1987). Mn oxide formation can be accompanied by the formation of ZnMn_2O_4 , a relatively stable product which can remove significant amounts of zinc from solution (Lind and Anderson, 1992); similarly, Post (1999) states that chalcophanite ($\text{ZnMn}_3\text{O}_7 \cdot 3\text{H}_2\text{O}$) is a common weathering product in many manganese-bearing base metal deposits. Fe and Mn oxide precipitation is catalysed by suspended particulate matter in solution; clay mineral, metal oxide and SOM surfaces also act as catalysts for Fe and Mn oxide precipitation (Yariv and Cross, 1979). Oxyhydroxides tend to coat the sediment on the perimeter of channels and in the oxidising zone of the subsurface, making the precipitate readily available to contaminated waters to enact metal removal (Jain and Ram, 1997). Coprecipitation of Zn and Cd has been shown to be the most significant process for sequestering these species in a sandy loam soil (Gong and Donahue,

1997). Similarly, Zn can be preferentially partitioned via substitution into secondary oxides and hydroxides in surface water and sediments (Carroll et al., 1998). Oxides, hydroxides and oxyhydroxides are stable under normal surface conditions and provide a safe long term sink for trace metals removed from contaminated waters. However, dissolution can also occur on exposure to reducing conditions (Sparks, 1995) and effect release of attenuated metals.

Complexation

Trace metals can form complexes with organic or inorganic ligands. Complexation can arise due to deprotonation of functional groups on organic molecules as well as due to dissolved inorganic anions in solution. Organic complexation is be very diverse, consisting of mono- and multidentate metal-ligand interactions and chelation of metals by two or more ligands (Sparks, 1995) (Figure 2.8 a,b). These complexes can take place in solution or on the surface of particulate matter, as well as on or in soils and sediments. Complexes consist of covalent bonds between the cation and the functional group. The capability of the ligand to form a covalent bond arises from an unbonded pair of electrons on an atom in the ligand. Multiple atoms in the ligand with unbonded electron pairs will allow multiple covalent bonds to form; this is multidentate complexation (Yong et al., 1992) and forms complexes known as chelates. Complexation is also referred to as specific adsorption or chemisorption; the inner sphere complexes that constitute this form of attenuation are less susceptible to remobilisation than the outer sphere complexes that form during cation exchange. As such, complexation is a more robust form of attenuation and is less likely to desorb zinc and other heavy metals following changes in solution properties such as increasing acidity (Post, 1999).

CHAPTER 3

METHODS AND MATERIALS

This study consists of two phases: an initial site investigation and a subsequent laboratory program. The methods of investigation for the respective phases are substantially different and will be described separately, beginning with a description of the site investigation.

3.1 Site Investigation

Site investigation was initiated with a detailed reconnaissance of the site and adjacent areas; this provided the information detailed in the previous chapter under site description. Following initial reconnaissance, two controls in the form of dam/weir pairs were constructed to volumetrically estimate water inputs to and outputs from the site; one of these was placed in the mouth of the Galkeno 300 adit, while the other was positioned just above the confluence of the adit discharge with Christal Creek. Precipitation inputs, as well as temperature, were monitored at a temporary climate station to monitor possible climatic influences. Water quality was assessed at 13 discrete times during the field season through collection of samples for analysis and measurement of in situ parameters. Shallow soils at the site were collected for chemical analysis and for laboratory testing. The following describes the methods and the materials employed in the field investigation.

3.1.1 Temperature and precipitation monitoring

A temporary climate monitoring station was established at Elsa, YT during the field investigation. The UKHM environmental office at Elsa was chosen as the location for the climate station for security and monitoring reasons; UKHM environmental staff agreed to take daily readings and to contact the principal researcher in the event of equipment failure or malfunction. This site is approximately seven kilometers west of the field site and is roughly the same elevation as the lower portion of the field site. The proximity of the Elsa location to the field site, the similarity of elevation and aspect between these two locations, and their location on the same larger scale physiographic feature (Galena Hill) makes the Elsa climate monitoring station an appropriate proxy for the Galkeno 300 site. Daily precipitation was measured using a Rain Gauge Type B (Environment Canada, 1992); measurements were taken by UKHM environmental staff at 9:30 am and reported to the nearest 0.5 mm. Maximum and minimum temperatures were measured by UKHM environmental staff using maximum and minimum thermometers installed in a Stevenson Screen (Environment Canada, 1992); measurements were taken at 9:30 am and were recorded to the nearest 0.5°. Gaps in data are due to staffing changes and absences of environmental staff at UKHM. UKHM staff undertook climatological monitoring because the principal researcher was not at the sampling location every day at the same time.

3.1.2 Flow measurement

An estimate of flow volumes at different locations across the study site is useful in understanding site water balance and levels of contaminant loading and attenuation. In particular, measuring

flow volumes exiting the Galkeno 300 adit provides an input volume of water that enters the downslope soil attenuation system; similarly, measuring flow volumes entering Christal Creek provides an output volume of water leaving the soil attenuation system. These input and output values, combined with estimates of precipitation and with geochemical analyses of water samples, allow calculation of the contribution of dilution to attenuation and the mass loadings to Christal Creek.

A 0.3 m sharp-crested rectangular weir with end contractions (Grant and Dawson, 1995) was constructed 2.5 m downstream from the adit mouth (Fig. 3.1). Although a V-notch weir may have been better suited to the adit discharge volume, it would require accumulating a greater head; site conditions and difficulty of dam construction favoured a lesser accumulation of water. As such, the rectangular configuration with end contractions was selected due to the minimal head required behind this style of weir for a given discharge. The weir was designed to have a drop of 30 cm- double the maximum expected depth of 15 cm flowing over the weir gate. A crude rock and earth dam was constructed with locally available materials; scrap plywood and roofing metal was used as a core, and a layer of polyethylene was placed within the fill to minimise dam permeability. Construction of the weir itself was problematic due to continuous flow from the adit; this was circumvented by building a frame with a low (5 cm) lip which could be anchored into the dam on both sides, while still allowing the adit flow to pass through the opening of the frame. An insert containing the 30 cm rectangular opening was designed to be placed in the frame when a flow measurement was desired. This allowed the construction of the weir in mid-channel without diverting the flow. In addition, this configuration of frame-and-



Figure 3.1. 0.3 m sharp-crested rectangular weir with end contractions installed at Galkeno 300 adit. Well-aerated, free falling nappe indicates suitability of weir to discharge volume.

insert permitted stresses on the dam to be minimised by impounding water only when a measurement was to be taken, and releasing the accumulated water by removing the weir insert following measurement. Very little leakage was observed through or around the dam or the weir insert. The weir was designed to handle flow volumes up to 15 L/s- all flows remained lower than the design level. This device allowed an accurate estimate of flow volumes issuing from the Galkeno 300 adit (Fig. 3.1). A similar 0.3 m sharp-crested rectangular weir with end contractions was installed at the bottom of the site in the ditch adjacent to the Galkeno 900 access road at the highway (Fig. 2.1). This weir was constructed in the same fashion and provided accurate estimates of flow volumes entering Christal Creek. Discharge volumes

estimated using properly configured weirs are considered to be accurate to +/- 10% of actual discharge (Grant and Dawson, 1995).

Flow estimates at individual sampling sites were made using the bucket flow method (Environment Canada, 1995) where the sample site configuration permitted; otherwise, visual estimates of flow volumes were made. The bucket flow method involved capturing the flow with a graduated 20 L bucket for a fixed amount of time (usually 2 or 4 seconds, depending on site discharge and capture of flow). An estimate of the proportion of flow captured was necessary; this is usually strongly influenced by site configuration. Where possible, the capture site was modified at the beginning of the field season to maximise captured flow, and bucket flow estimates were restricted to sites where greater than ~70% of the flow could be captured. This exercise was repeated 5 times at each sample site and the results were averaged to provide an estimate of the site flow volume on a given sampling day. Visual flow estimates are qualitative in nature and simply provide a reference for increases or decreases in flow volume relative to the previous visit to the site. These sample site flow volumes, coupled with water quality data from the same location, provide insight to levels of attenuation and contaminant loading across specific sections of the study area.

3.1.3 Water sampling

Water samples were taken at 11 principal sites (Fig. 3.2) along the longitudinal flow path on 10 different occasions (May 29, June 6 and 20, July 5, 22 and 29, and August 4, 12, 21 and 30) throughout the course of the field season; additionally, dissolved and total metal samples only

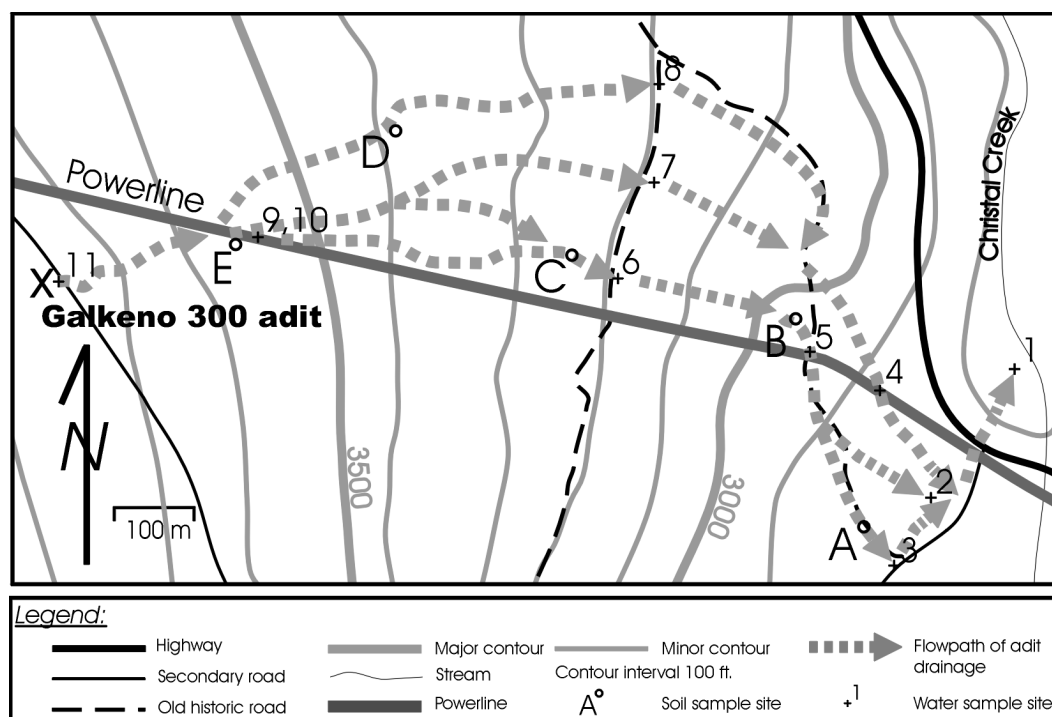


Figure 3.2. Site map displaying physiography, adit drainage flowpaths, site features and location of water and soil sampling sites.

were collected and analysed at input (adit) and output (discharge to creek) sites on June 13, June 28 and July 11. Position of samples sites was established by Global Positioning System (GPS). A brief description of each sampling site can be found in Appendix A. This sampling was done to characterise the nature of the hydrogeochemical system and to monitor changes in water quality spatially, along the longitudinal flow path, as well as temporally, over the course of the

field season. Sampling was always conducted from the lower elevations (lowest contaminant concentrations) to the higher elevations (highest contaminant concentrations). This routine was intended to minimise the possibility of cross contamination, as water containing lower concentrations of the analytes of interest were sampled first. In addition, this routine was intended to avoid changing downstream sample chemistry by disturbance due to upstream sampling. In addition, occasional grab sampling was conducted of waters peripheral to the flow path to characterise background water quality and to identify whether peripheral waters were chemically similar to the Galkeno flow, or whether the Galkeno flow was chemically distinct. A program of taking field duplicate samples, field split samples, field blanks and travel blanks was undertaken to monitor sample variability and for quality control purposes.

3.1.3.1 Sample analysis

All water sample analysis was done by staff at Environment Canada's Pacific Environmental Science Centre in North Vancouver. Samples were shipped from the field site to Whitehorse by truck; from Whitehorse, the samples were couriered to the analytical lab by air. Sample analysis was conducted within seven days of sample collection via the appropriate methods from Standard Methods for the Examination of Water and Wastewater (Clesceri et al., 1998).

3.1.3.2 Sample description

Three principal types of water samples were collected. These were nutrient samples, dissolved metal samples and total metal samples. All samples were collected according to water sampling protocols outlined in Environment Canada (1995). At the time of sampling, in situ measurements of several parameters were also recorded.

Nutrient samples:

1 L high-density polyethylene (HDPE) bottles were labeled with date, time, sample location/number, and type of sample. These were then filled to within 1 cm of the top by submersing in flow (where possible) or by capturing flow as required. Bottles were not rinsed due to the chance of particulate matter from the rinse water adhering to the walls of the bottle. These samples were placed in coolers containing ice and shipped to analytical lab within two days of sampling. Other than keeping cool, nutrient samples were not preserved (Environment Canada, 1995). Nutrients were analysed according to procedures outlined in *Standard Methods for the Examination of Water and Wastewater*(SMWW) (Clesceri et al., 1998).

Dissolved metal samples:

Samples were collected by filtering water into 125 mL trace metal HDPE bottles labeled with date, time, sample location/number, and type of sample. The filtration system consisted of a 60 mL single-use syringe and a 25 mm diameter, 0.45 micron single-use filter. The syringe was filled and purged three times. A 10 mL headspace was maintained between the plunger and the water surface within the syringe and the syringe was kept vertical to minimise the possibility of contamination due to leaching of analytes from the rubber plunger. After rinsing the syringe three times, the filter was placed on the syringe and the sample container was rinsed and shaken three times with 10 mL of filtered water. The bottle was then filled with filtered water to within 1 cm of the top; the filter was removed from the syringe and the syringe refilled twice during this process. Care was taken to avoid contaminating the filter during the refilling of the syringe. Following collection, samples were placed in a cooler with ice; at the end of the sampling day,

dissolved metal samples were preserved with 1 mL concentrated trace metal grade nitric acid. Samples were shipped to the analytical lab with nutrient samples, and analysed via procedures outlined in SMWW (Clesceri et al., 1998).

Total metal samples:

125 mL trace metal HDPE bottles labeled with date, time, sample location/number, and type of sample were rinsed three times with sample and then filled to within 1 cm of the top. Following collection, samples were placed in a cooler with ice; at the end of the sampling day, total metal samples were preserved with 1 mL concentrated nitric acid. Samples were shipped to the analytical lab with nutrient samples, and analysed via procedures outlined in SMWW (Clesceri et al., 1998).

3.1.3.3 *In-situ measurements*

Electrical conductivity and water temperature were measured at each sample site using a Yellow Springs Instruments (YSI) Model 33 meter (Environment Canada, 1995). A Hach One portable pH meter outfitted with a glass electrode with a Ag/AgCl reference junction was used to measure site pH (Environment Canada, 1995); the same meter outfitted with a YSI Oxidation-Reduction Potential (ORP) probe was used to measure in situ ORP (ASTM D 1498- 76).

3.1.4 Soil Sampling

In order to investigate the attenuating capacity of the soil, sampling was conducted at five locations along the longitudinal flow path (Fig. 3.2). Samples were taken for metal content analysis as well as for the purposes of laboratory testing.

3.1.4.1 Sample collection

Soil samples were collected by excavating a soil pit at the selected sampling location followed by stratigraphic sampling. Site reconnaissance revealed that shallow soils across the site consisted of an upper organic horizon, consisting largely of moss in various stages of decay, and a lower mineral horizon. Five sampling locations were selected to characterise the variation in soil properties of these two horizons along the longitudinal profile of the flow path.

Additionally, sites were selected such that samples could be taken from directly in the flow path, where the soil was in contact with Galkeno 300 effluent, as well as in similar soils adjacent to the flow path. In-flow samples were collected for the purposes of assessing soil zinc content and for determination of the geochemical speciation of attenuated zinc. Samples adjacent to the mine drainage flow path were collected to provide a measure of local background metal concentrations. Care was taken to ensure that samples taken adjacent to the flow path were representative of the horizon sampled within the flow path; sample sites were selected such that both sample locations had similar aspect, slope, vegetation and surficial geology, are were in close proximity to one another. Pits were excavated to the deepest depths possible, given the soil conditions and the method of excavation; permafrost and large rocks limited the depth of all pits to less than 1 m. The soil profile was logged and 1 to 5 kg samples were collected from each distinct soil horizon. 20 cm by 50 cm polyethylene bags were labeled with sample number and then filled with sample. Where large sticks, roots or rocks were present in a horizon, these were omitted from the collected sample. Moss was the predominant ground cover; both decomposed and undecomposed moss was collected separately at different locations in order to determine the role of moss in the attenuation process.

In addition to soils, a set of samples of the precipitate forming at and immediately below the Galkeno 300 was collected. This precipitate resembles the deep orange ferric oxyhydroxide precipitate commonly found in mine drainage in areas of sulphide mineralisation. These samples were collected every 20 paces along the surface flow path from the adit to the downstream disappearance of surface flow into the subsurface; every 60 paces (every third sample) a duplicate sample was taken. These samples consist of approximately 100 g of precipitate which was collected for metals analysis. These samples are intended to lend insight into the contribution of this ferric oxyhydroxide precipitation to the attenuation of zinc in the surface flows along the upper portion of the flowpath. Additionally, a few samples of distinctive green filamentous algae noted at a number of different locations were also collected for total metals analysis; these algae samples were collected to assess the potential metal (primarily zinc) removal from mine drainage via bioaccumulation in the Galkeno 300 drainage.

3.1.4.2 Sample analysis

The purpose of sampling soils in direct contact with the flow as well as those adjacent to the flow is to provide a measure of metal uptake by soil; metal levels of samples collected within the flow path can provide evidence of the occurrence and magnitude of metal retention in the soil, when compared with metal levels of samples collected adjacent to the flow, which are expected to represent background metal concentrations. An aliquot of each sample collected was sent to the Pacific Environmental Science Centre for metals analysis using the inductively coupled plasma (ICP) technique with aqua regia microwave digestion (Clesceri et al., 1998). The expectation is

that, if attenuation is occurring in soils along the flow path, samples in contact with the flow should yield higher metal contents than similar adjacent soils that have not been in contact with the flow. Duplicate samples were taken at each site of both soils in and adjacent to the flow path to facilitate estimates of field variability.

3.2 Laboratory Investigation of Natural Attenuation

The laboratory investigation phase of this project was carried out from September 2000 to September 2001. The intent of the lab investigation was to gain insight into the mechanisms of zinc attenuation that are operating in the shallow soils downslope of the Galkeno 300 adit. Specifically, the goals were 1) to determine the zinc retention capacity of the soils in question, and 2) to identify the geochemical speciation of the attenuated zinc within these soils. To achieve these goals, a number of laboratory tests and procedures were carried out. Sampled soils were characterised physically and chemically, then subjected to batch adsorption tests and column leaching tests to better understand zinc removal under various conditions, both qualitatively and quantitatively. In addition, selective extraction was performed on field contaminated samples to determine the geochemical speciation of attenuated zinc. The following describes the methods and materials employed during the different phases of the laboratory investigation.

3.2.1 Physical and Chemical Characterisation of Soils

Characterisation of site soils was undertaken in an attempt to correlate attenuating characteristics of the site soils with soil physicochemical properties. Recall that Galkeno 300 site soils are broadly distributed as an upper organic horizon consisting largely of moss in various states of

decomposition, and a lower mineral horizon consisting of a silty sandy till. The following properties of each were determined, where appropriate: cation exchange capacity, soil pH, specific surface area, mineralogy, and total carbon content. Particle size analysis was not conducted, as the measurement of particle size for samples of the important upper horizon is difficult to both conduct and interpret. Samples from soil sampling sites A, C and E (Fig. 3.2) were subjected to characterisation; these samples are from the lower, middle and upper regions of the site, respectively, and are thought to be sufficiently representative.

3.2.1.1 Cation exchange capacity

Cation exchange capacity (CEC) is the total number of cations that a soil material can adsorb at a given pH (Sparks, 1995); measuring the CEC of a soil provides an estimate of the capacity of a soil to exchange major ions on exchange sites for ions such as zinc from solution. The CEC of uncontaminated samples of both organic and mineral soils from the Galkeno 300 site was determined via the method of (Sumner and Miller, 1996); this method involves replacing all exchangeable cations with the ammonium cation (NH_4^+), followed by replacement of all ammonium ions with the potassium cation (K^+). Measurement of the number of displaced ammonium ions allows a determination of the number of cation exchange sites per unit mass of the soil material; ammonium was measured by Flow Injection Analysis (Clesceri et al., 1998).

3.2.1.2 Soil pH

The pH of a soil material is an important factor in determining the mobility of heavy metals such as zinc that come into contact with that soil. The pH of uncontaminated mineral and organic soil samples were measured on air dry samples sieved to <2 mm. The distilled water method of Thomas (1996) was followed; a 1:2 oven dry equivalent soil mass: distilled water ratio was used, as the organic samples were not sufficiently moistened with equal parts water and soil.

3.2.1.3 Specific surface area

The specific surface area (SSA) of a soil is the area of surface per unit of mass of a given soil sample, and is related to particle size. It is an important property with regard to contaminant attenuation. Particle size constrains the external surface area of a particle; however, many soil materials can also have internal surface area that is available to participate in attenuation. Attenuation often occurs at the reactive surface of soil particles; thus, a material that has a relatively large specific surface area may make a relatively large contribution to heavy metal attenuation. The specific surface area of both organic and mineral samples were measured by the method of Sheldrick (1984a). This premise of this method is the establishment of a monomolecular layer of ethylene glycol monoethyl ether (EGME) on all internal and external surfaces of the samples; the difference in sample mass prior to and following EGME treatment represents the mass of the monomolecular layer of EGME. An estimate of specific surface area is calculated from the area a monomolecular EGME layer of the measured mass would cover.

Analysis of SSA was conducted by staff at the Soil Chemistry Laboratory in the Faculty of Agricultural Sciences at the University of British Columbia.

3.2.1.4 Mineralogy

The clay mineralogy of site soils will influence to adsorption capacity of these soils. The clay mineralogy of three mineral samples, one each from sites A, C and E, was examined by x-ray diffraction (XRD). Organic samples were not subjected to XRD due to the low mineral content of these samples. Sample preparation was conducted as outlined in Jackson (1956). First, the samples were suspended in water and the $>2\ \mu\text{m}$ fraction was allowed to settle; settling velocity of a $2\ \mu\text{m}$ equivalent spherical diameter particle is 1 cm/42.5 minutes at 25°C (Hillel, 1998). The suspension containing a portion of the $<2\ \mu\text{m}$ (clay) fraction was drawn off via siphon, to a depth calculated according to the settling velocity, and the remaining material was resuspended. This settling and withdrawal process was conducted a total of three times; this is thought to remove the majority of the clay fraction from a soil sample (Jackson, 1956). The clay material was removed from suspension by centrifugation and then subjected to further treatment.

Jackson (1956) and Reynolds and Moore (1997) suggest a number of pretreatments to prepare a sample for analysis by XRD. Carbonates, organic matter and amorphous oxides contained within the clay fraction can interfere with XRD; removal of these fractions prior to scanning improves the likelihood of obtaining unambiguous diffraction patterns. A chemical treatment is required to remove each unwanted fraction; methods provided in Jackson (1956) were employed.

Carbonates were removed using a sodium acetate solution buffered at pH 5, organic matter was removed using 30% hydrogen peroxide at 80°C, and amorphous oxides were removed using the citrate-bicarbonate-dithionite method.

Following pretreatments, samples were prepared for scanning following the Glass Slide Method of Moore and Reynolds (1997). Suspensions of the treated sample and distilled water were dropped onto a clean glass slide using an eye dropper and the slides were allowed to air dry. Three slides of each sample were prepared; one was heated to 550°C for 1 hour, one was placed in a closed vessel with ethylene glycol for >24 hours, and one was untreated. A potassium saturated sample was prepared by removing half the remaining suspension to another container, saturating exchange sites with K⁺ (Jackson, 1956) and then preparing a slide. All four samples were scanned on a Siemens Diffraktometer D5000 with a voltage of 40 kV and a current of 30 mA. Each slide was scanned from 3 to 34° 2 θ , with a step size of 0.04 ° at a rate of 2 s/step. Heated and glycol-solvated slides were scanned immediately following treatment.

3.2.1.5 Total Carbon Content

Soil organic matter can play an important role in attenuation of zinc from the mine drainage water at the Galkeno 300 site; measurement of total carbon content is commonly used as an indicator of the amount of organic matter within a particular soil. Measurement of total carbon content of samples taken at sites A, C and E was done via the method of Sheldrick (1984b). This method employs the LECO induction furnace; the principle of operation for this apparatus relies

on the quantitative measurement of carbon dioxide (CO₂) evolved following destruction of organic carbon and carbonate minerals under high temperature. Analysis of total carbon content was conducted by staff at the Soil Chemistry Laboratory in the Faculty of Agricultural Sciences at the University of British Columbia.

While the result of total carbon analysis may reflect a contribution arising from the destruction of inorganic minerals, this method of estimating soil organic content is acceptable in low carbonate soils and is certainly preferable to “Loss on Ignition” methods (McGill, 1976). The uncertainty introduced by an unknown contribution from inorganic carbon could be mitigated by quantitatively analysing for carbonate carbon. Subtracting the inorganic carbon result from the total carbon result would yield a better estimate of organic carbon content only if there was sufficient carbonate carbon to exceed errors introduced in both methods. In light of the acceptance of total carbon content as a proxy measurement for organic carbon content in low carbonate soils, as well as the visually identifiable high organic/ low mineral content of the important upper soil horizon, the total carbon content measurements were not corrected for the contribution of carbonate carbon.

3.2.1.6 Specific Gravity

The specific gravity of organic samples tested in leaching columns was required to calculate the pore volume contained with the packed columns. Specific gravity determination was undertaken at room temperature (23° C) according to the method set out in Lambe (1951), using a 1000 ml

volumetric flask as a pycnometer. The specific gravity of each organic sample was determined in duplicate, and the resulting values were averaged for use in determination of leaching cell pore volumes.

3.2.2 Batch Adsorption Test Methods and Materials

Batch adsorption tests were used to determine sorption isotherms for zinc onto site organic and mineral soils from sites A, C and E. These isotherms allow the calculation of a distribution coefficient (K_d) with respect to zinc for both of these materials. The tests were conducted according to the guidelines set out by the United States Environmental Protection Agency (USEPA) (Roy et al., 1992). The following discusses the parameters selected.

Batch tests were conducted in duplicate at room temperature ($23 \pm 2^\circ \text{C}$) in 50 ml polypropylene centrifuge tubes; Figure 3.3 provides a schematic representation of the batch adsorption test procedure. A 1:20 soil:solution ratio was adopted, with 2.000 g soil being agitated with 40.0 ml of dosing solution. This ratio was adopted because, in the case of the organic soils tested, the more common 1:10 soil:solution ratio would not physically fit into the 50 ml centrifuge tubes with 40 ml of dosing solution. Agitation was accomplished in an end-over-end rotator at 22 revolutions per minute (rpm). This speed is somewhat less than the 29 ± 2 rpm suggested by the USEPA (Roy et al., 1992), but is not considered to compromise the test results. Separation of soil from solution was accomplished by centrifuging test tubes in an International Equipment Company Centrifuge Model CS for 15 minutes at 3000 rpm (roughly

2200 G); for samples where floating material (largely organic) remained following centrifugation, test tube filters (serum filters) were employed to separate solid from liquid.

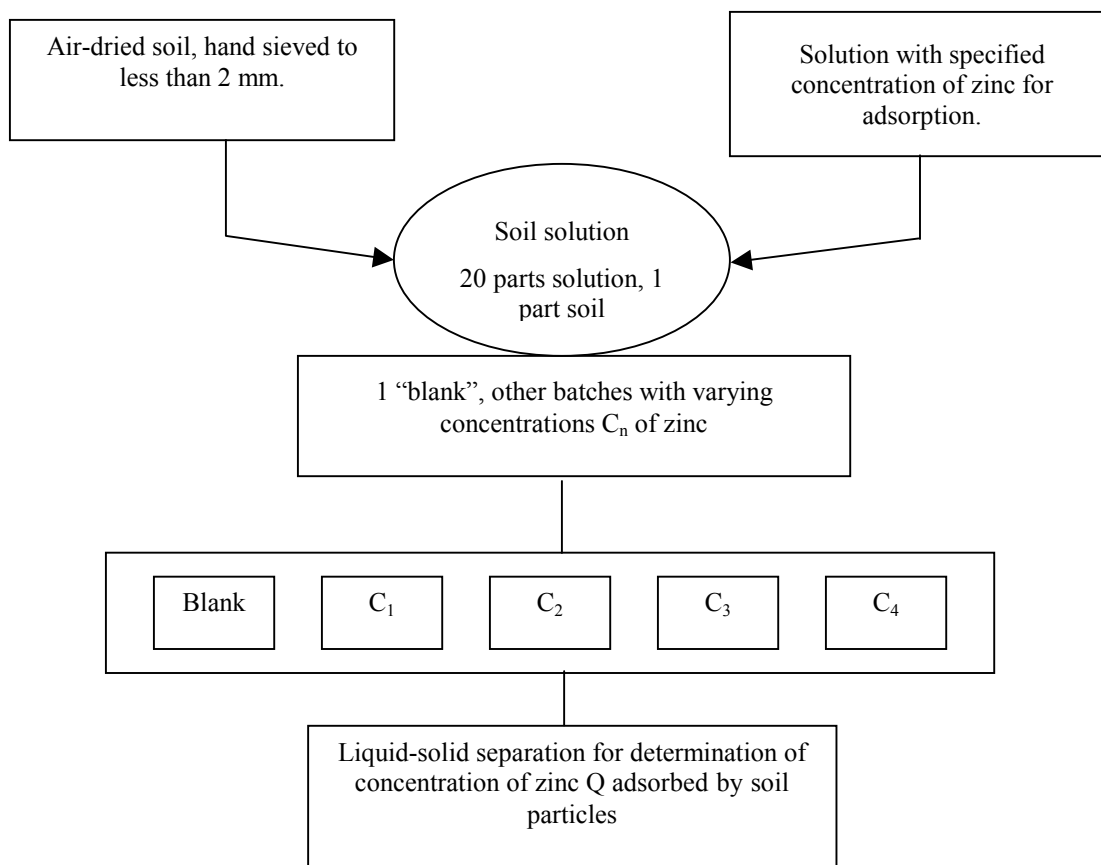


Figure 3.3. Schematic layout of the batch equilibrium test procedure.

Temperature of the soil-water system at the field site was 3 to 10° C; preliminary testing was done to compare the effects of conducting batch tests at 8° C (representing field conditions) vs. at 25° C (representing ambient laboratory conditions). These tests showed that equilibrium concentrations at 8 and 25° C varied little for air dry samples; these tests also showed that air drying sample material reduced the variability of equilibrium concentrations between replicate

samples (Fig. 3.4). As such, it was decided to conduct the tests at room temperature on air dry samples.

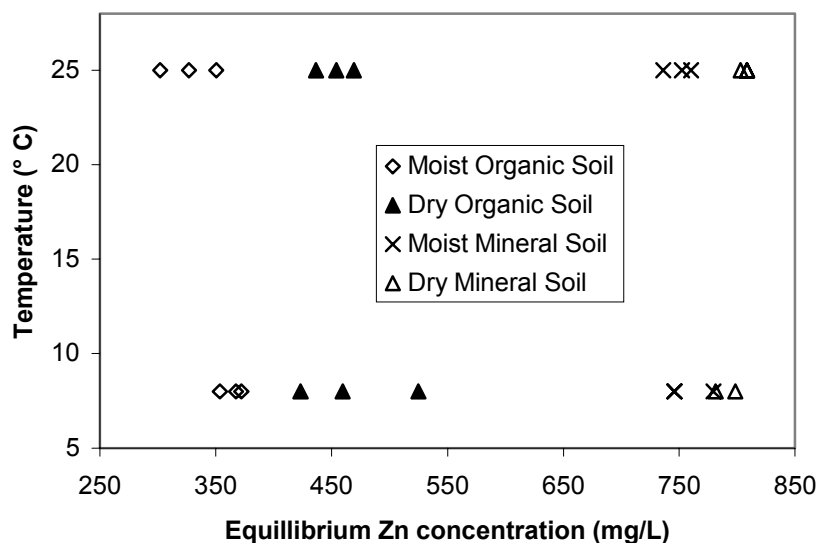


Figure 3.4. Preliminary test results showing equilibrium Zn concentration for moist and air dry soil samples at 8° C and at 25° C. Initial Zn concentration = 1000 mg/L.

The initial pH of the dosing solutions was adjusted to pH 6.5. This pH was chosen through examination of the range of pH values encountered across the majority of the site during the field investigation; the lower limit of observed pH was 6.5. This value was selected as the initial pH of the dosing solution due to its conservative nature; zinc mobility tends to increase with decreasing pH, and as such the adsorption of zinc from solution is expected to be a conservative estimate of what can be expected at the site.

3.2.3 Column Leaching Test Methods and Materials

Column leaching was conducted to better understand zinc attenuation in a flow-through configuration. While batch adsorption tests are relatively simple and can provide rapid and cost-effective insight into the behaviour of a sorbent-sorbate system, the ideal conditions of the batch test likely represent a high estimate of attenuation that will actually occur in a field setting. The contact between solution and soil in the batch test provides maximum opportunity for dissolved constituents such as zinc to come into contact with favourable sorption sites on solid surfaces. In actual field situations, and in the flow-through configuration of a leaching column, the packing of soil particles, the establishment of preferential flowpaths, and the higher ratio of solid to liquid mass can, either singularly or in concert, result in attenuation phenomena that are not easily predicted from the results of batch-type experiments alone.

Column leaching was performed only on previously characterised samples of the upper organic horizon from sites A, C and E. Batch test results and soil metal concentrations (Section 4.2.1) indicate that the upper organic horizon is by far the dominant substrate for natural attenuation of zinc at the Galkeno 300 site. These factors, as well as the field observation of much greater permeability of the upper organic horizon, led to this decision to limit column leaching tests to the organic samples.

3.2.3.1 Configuration of column leaching system

The configuration of the column leaching system is displayed in Figure 3.5. The system consists of an elevated primary influent reservoir feeding permeant to the bottom of a vertical cylindrical leaching column. Flow passes upwards through the column; this is done to ensure uniform flow through the column by avoiding the ‘fingering’ of flow which can occur in columns permeated top to bottom. Effluent is transferred to an effluent reservoir via tubing, where it is discharged to an overflowing tailwater intended to maintain a constant backpressure. Flow rate through the column is controlled by a combination of the elevation of the influent reservoir and by restriction of the effluent discharge tube through the use of a screw-type hose clip. Figure 3.6 shows an expanded schematic of a leaching column.

3.2.3.2 Materials and equipment used in column leaching system

The primary influent reservoir, the leaching cell and the effluent reservoir are constructed of acrylic (Plexiglas); the secondary influent reservoir is a polyethylene container. Tubing is made of vinyl (Fisher C-219-4); all fittings are nylon. The system has no metal surfaces in contact with the permeating fluid. Samples were collected from the effluent tube into glass test tubes and kept covered until analysed. All components which contact the permeating fluid were acid washed and rinsed with the permeating fluid prior to the initiation of each test. A 6-600 rpm Masterflex pump and pump controller with #16 pump heads was used to deliver permeant from the secondary influent reservoir to the primary influent reservoir.

3.2.3.3 Column leaching test procedure

The water content of the organic samples of interest was determined just prior packing of leaching cells. Conducting the leaching column tests at field water content was done to avoid changes in reactivity that can occur to organic samples on drying, as evidenced by preliminary batch test results (Fig. 3.4). Samples were hand packed into columns at the maximum possible density; hand packing was conducted due to the elasticity and water content of the organic samples. Initial attempts at mechanical compaction resulted in losses of sample water as well as lower sample densities than were achieved via the hand packing method. Leaching cells were weighed before and after packing with sample. The difference is the mass of the moist

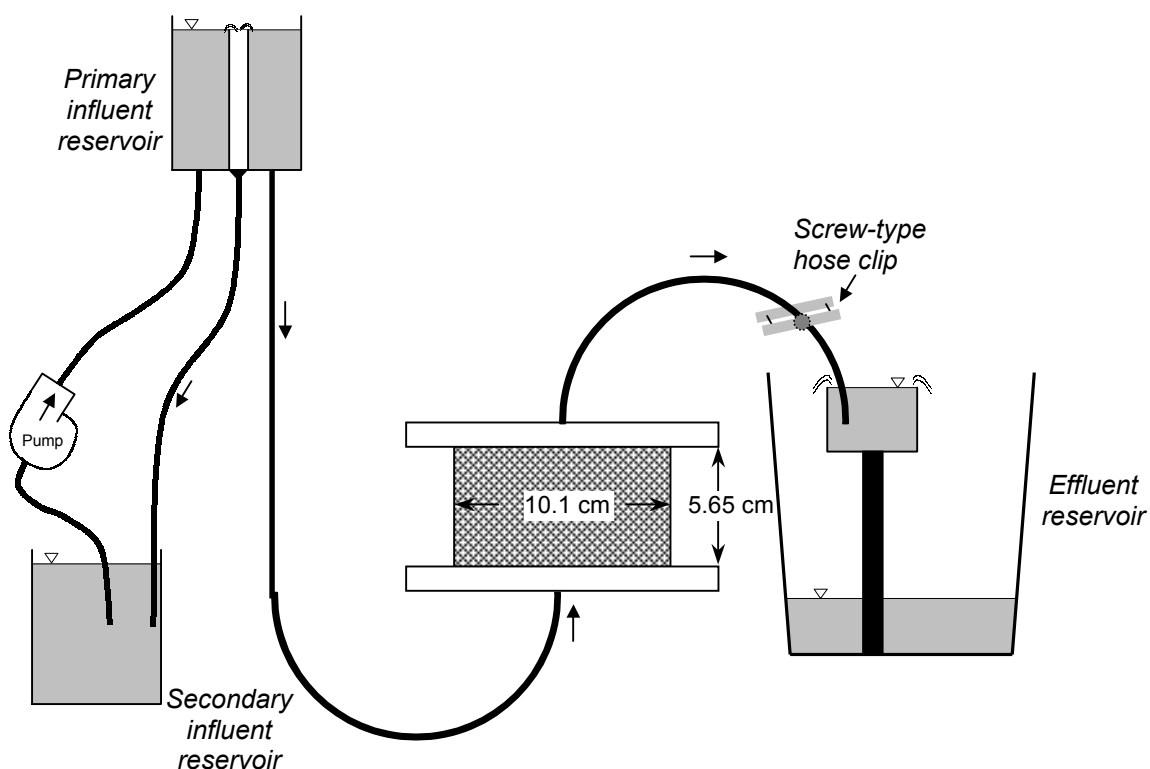


Figure 3.5. Schematic configuration of leaching column system. Not to scale- for illustrative purposes only.

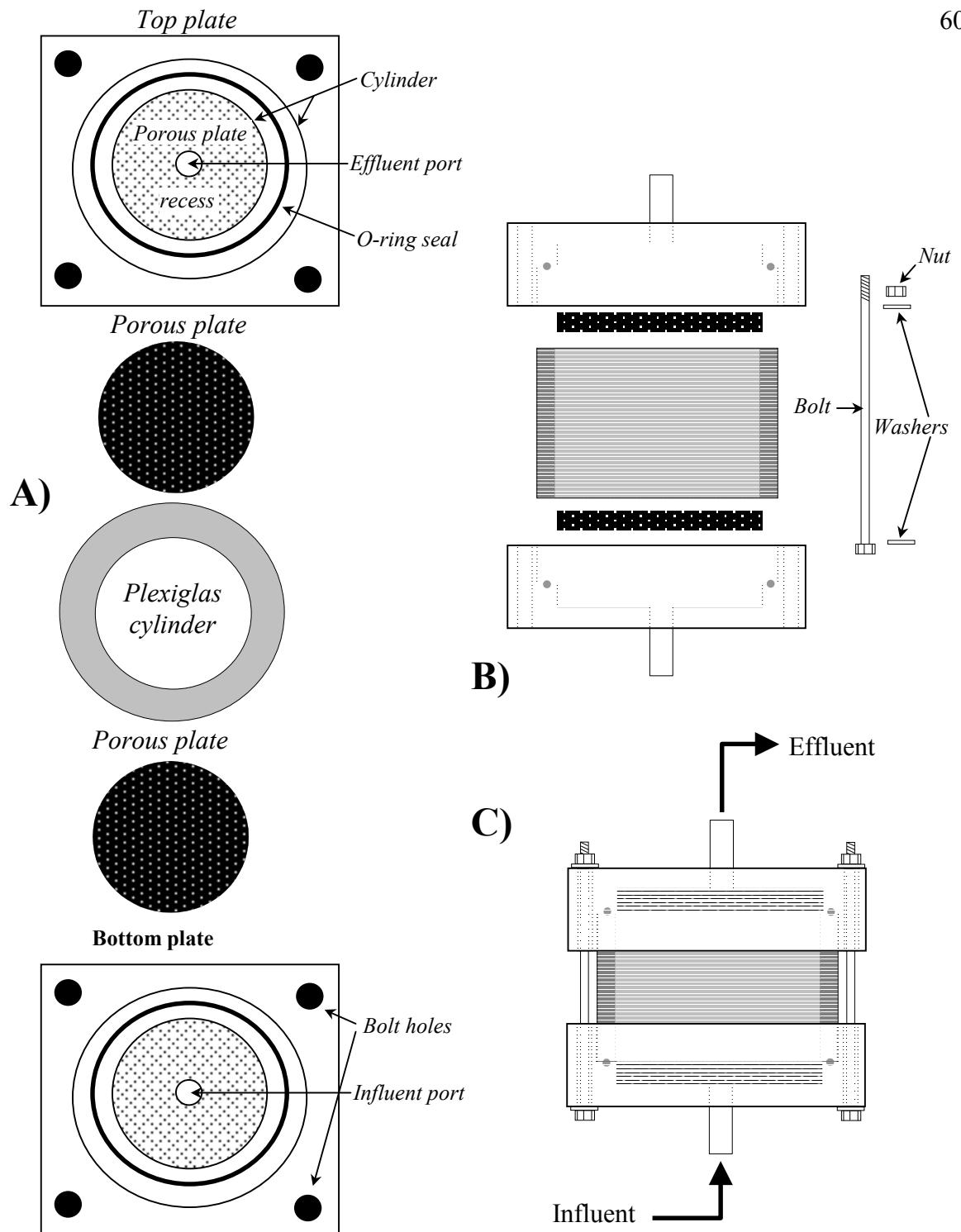


Figure 3.6. Schematic of leaching cell components. A) Exploded plan view of components of cell. B) Exploded profile view of components of cell. C) Profile view of assembled cell. Not to scale- for illustrative purposes only.

sample contained within the cell; the mass of solids within each cell was computed using the predetermined water content, the final sample mass and the volume of the cell. The volume of pore space within each cell was calculated by subtracting the volume of solids (computed using the specific gravity of each sample and the mass of solids in each cell) from the total cell volume. See Appendix B for methods of calculation of water content, sample specific gravity, mass of solids and pore volume within each cell.

After the columns were packed, the system was set up. The height of the primary influent reservoir was set at the minimum height that would exceed the desired flow rate; the flow was reduced to the desired rate through the use of a screw-type hose clip on the effluent tube. The design flow rate through the columns was 10 pore volumes per day (10 pvpd). This rate was selected as a reasonable estimate of in situ flow rates observed entering soil pits excavated at the Galkeno 300 site from the upper organic horizon (Appendix A). The pump which moved permeant from the secondary influent reservoir to the primary influent reservoir was set to exceed flow rates through the columns; excess permeant delivered to the primary reservoir was returned to the secondary reservoir by way of a overflow drain (Fig. 3.6).

Effluent samples were collected for analysis from the discharging end of the effluent tube. These samples were analysed for total Zn and Mn, as well as for pH. Columns were run until effluent metal concentrations stabilized or showed evidence of stabilising.

3.2.3.4 Experimental conditions of column leaching tests

Four sets of column tests were run, including one replicate. Each test involved permeating three organic samples (one each from sites A, C and E) with a specific influent (Table 3.1). Each influent was chosen to allow observations on the attenuation behaviour of the soil-fluid system under different conditions.

Table 3.1. Influent conditions of column leaching tests.

Test	pH	Zn (mg/l)	Mn (mg/l)	Flow rate
1	6.5	145	192	10 pvpd*
2	6.5	30	40	10 pvpd
3	6.5	145	192	10 pvpd
4a	5.5	0	0	10 pvpd
4b	4.5	0	0	10 pvpd

* pore volumes per day

Tests # 1 and # 3

Tests 1 and 3 were conducted under the same conditions. The results of these two tests serve as replicates which provide a check on the experimental process. The permeant for Tests 1 and 3 was actual Galkeno 300 adit drainage, collected at the end of the field season at the adit. Prior to column infiltration, the metal content and pH of the Galkeno water was measured. The pH of the permeant was adjusted to pH 6.5, using 0.088 M Ca(OH)₂. This pH adjustment was done to bring the pH in line with the lowest values observed, during the field investigation, where the adit drainage first contacts the soil material. This is considered to be conservative, as Zn mobility is higher with decreasing pH (increasing acidity); thus, adopting the low end of the

observed pH range for the permeant pH will not overestimate the attenuation factor. $\text{Ca}(\text{OH})_2$ was selected as the base for pH adjustment because calcium is the most common cation in the drainage, as indicated by field water quality data (Appendices C.1 and C.2). The minor addition of calcium was considered to have little effect on the chemical behaviour of the permeant.

Test # 2

Test 2 was conducted with pH 6.5 permeant, for the reasons and in the manner outlined above. To test the behaviour of attenuation in the soil-fluid system at zinc concentrations similar to those found near the midpoint of the flow path, the Galkeno 300 drainage water was diluted to 30 mg/l zinc. This dilution was accomplished using a solution of distilled water containing sufficient CaSO_4 to match the electrical conductivity (EC) of the mine drainage ($\sim 2000 \mu\text{S}/\text{cm}$). This was done to avoid observations resulting from changes in ionic strength, rather than resulting from soil-fluid interaction. The field observations indicate that ionic strength changes little over the flowpath, and this maintenance of a background ionic strength is consistent with field conditions. CaSO_4 was chosen as the background electrolyte because Ca^{2+} and SO_4^{2-} are the dominant ions in the mine drainage. Alteration of attenuating behaviour was expected to be minimised by maintaining ionic strength through these common ions.

Test 4

Test 4 is more properly two sequential tests on the same samples. One concern about the attenuation which is occurring at the Galkeno 300 site is that the pH of the drainage may decrease in the future (Kwong et al., 1994); as previously mentioned, zinc mobility increases with increasing acidity, and the concern is whether the attenuated zinc could be rapidly released

to the receiving environment. Test 4 is designed as a flow-through desorption test. Samples from Test 1, with their attenuated zinc, were subjected to barren permeant of lower pH. While permeant contained no zinc or manganese, pH and ionic strength were adjusted as discussed above, using $\text{Ca}(\text{OH})_2$ and CaSO_4 , respectively. Effluent zinc and manganese levels and pH were monitored as in previous tests.

In the first stage (Test 4a), influent pH was adjusted to pH 5.5. In mine drainage situations, acidity can be buffered at $\sim$ pH 5.5 by dissolution of iron carbonate minerals (eg. siderite) (Blowes and Ptacek, 1994). These carbonates are major components of the gangue mineral assemblage in the Galkeno ore body and as such are ubiquitous in the rocks contacting the mine drainage. Another significant buffering point with respect to mine drainage comes from the dissolution of aluminum oxide minerals at $\sim$ pH 4.5; Test 4B involved adjustment of influent pH to this level through the use of H_2SO_4 (for the arguments regarding common ions made earlier).

3.2.4 Selective Extraction Materials and Methods

Selective extraction is a technique for determining the speciation of metals in soils and sediments. The concept of selective extraction relies on the dissolution of a particular soil metal species or group of species through the application of an appropriate chemical reagent; numerous extraction schemes have been proposed, most being variations on the principles outlined by Tessier et al.(1979). Table 3.2 outlines five possible general geochemical forms that metals in soils can take, as well as the common reagents used to extract each form.

Table 3.2. Metal species and reagents which selectively extract these species (from Tessier et al., 1979).

<u>Fraction</u>	<u>Metal species</u>	<u>Extracting reagent</u>	<u>Treatment</u>
1	Exchangeable	1 M MgCl ₂ , pH 7.0	25° C, 1 hour agitation
2	Carbonate	1 M NaOAc, pH 5.0 w/ HOAc	25° C, 1 hour agitation
3	Oxide	0.04 M NH ₂ OH·HCl in 25% (v/v) HOAc + 3.2 M NH ₄ OAc	96° C, 6 hours with intermittent agitation
4	Organic	30 % H ₂ O ₂ (pH 2.0 w/ HNO ₃) + 0.02 M HNO ₃	85° C, 2 hr intermittent agitation; 2 nd addition of H ₂ O ₂ , 3 hr intermittent agitation
5	Residual*	HNO ₃ / HCl	Complete digestion (sub-boiling)

*Residual digestion in Tessier et al. (1979) is accomplished with 5:1 HF-HClO₄. These acids are extremely aggressive and their use requires dedicated facilities which were not available. The alternative nitric/hydrochloric acid digestion is considered a 'total recoverable metals' digestion which does not dissolve silicate minerals (USEPA, 1986).

The Tessier et al. (1979) method is intended to be performed in a sequential fashion, proceeding down the species listed in Table 3.2 from Fraction 1 through Fraction 5. Extractions are to be performed in centrifuge tubes; extractant and solid are to be separated following the completion of each extraction through centrifugation, and the next extraction in the sequence is then performed on the residue. As previously discussed, a fraction of the organic matter in the soils from the Galkeno 300 soils is less dense than water or than the aqueous extracting solutions; as such, separation via centrifugation is not a viable option. Considerable effort was expended in trying to devise a system for separating low density organic material from extracting solutions; however, the avenues investigated did not prove fruitful for myriad reasons, primarily involving quantitatively reserving the residue for further extraction.

Several other workers (Gupta et al., 1990; Bendell-Young et al., 1992; Thomas and Bendell-Young, 1998) have taken the Tessier et al. (1979) scheme and applied the extracting solutions for the individual fractions to five discrete samples. This procedure is referred to as *separate* or *simultaneous* selective extraction, as opposed to *sequential* selective extraction. The interpretation of results is somewhat more complicated, but is simplified in that each extraction step will also extract the metals bound in the fractions above it. For example, the oxide extraction will also liberate carbonate and exchangeable metals. This is a result of the nature of the extracting solutions; each solution is increasingly aggressive as the sequential extraction proceeds. Thus, determination of the respective metal distributions can be accomplished through subtraction of results of the preceding fractions in Table 3.2.

The method of selective extraction employed in the Galkeno 300 study was a modified Tessier et al. (1979) approach that employed a separate extraction procedure. Contaminated samples collected from within the mine drainage flowpath (sites A, C and E) were subjected to separate extractions for metals associated with the exchangeable, carbonate, oxide and organic fractions. In addition, these samples were subjected to ‘total recoverable metals’ digestion (USEPA, 1986) using hot nitric and hydrochloric acids. This method does not recover metals bound within the lattice of silicate minerals; however, these metals are released exceedingly slowly under environmental conditions, and this method is commonly employed to estimate *environmentally significant* metal concentrations. The other major modification to the Tessier et al. (1979) procedure was to repeat the application of extracting reagent until zinc recovery declined to a

minimum. This approach is recommended by Rauret et al. (1989a, b) for dealing with highly contaminated sediments.

3.2.5 Chemical Solutions

All laboratory solutions were prepared from reagent grade chemicals and distilled water. Zinc solutions were prepared from a stock solution of 10 000 ppm Zn in 0.5% nitric acid (HNO_3); this stock solution was prepared from reagent grade zinc nitrate ($\text{Zn}(\text{NO}_3)_2$), and was diluted to interstocks and dosing solutions as appropriate. Zinc concentrations in solution were confirmed via AAS. Adjustment of pH was accomplished using reagent grade nitric acid and sodium hydroxide (NaOH), except where otherwise noted. Glass- and plasticware used for preparation, storage or experimental purposes was acid washed, rinsed four times with tap water and three times with distilled water and air dried, to minimise the risk of contamination arising from metals of interest on the wetted surfaces of experimental apparatus.

3.2.6 Metals Analysis

Metal concentrations in reagent solutions and in supernatant resulting from batch adsorption and leaching cell tests were determined by atomic absorption spectrophotometry (AAS), utilising either a Varian SpectrAA 220 Fast Sequential Atomic Absorption Spectrophotometer or a Thermo Jarrell Ash Video 22 aa/ae Spectrophotometer- model 957. Standard solutions were prepared from Fisher 1000 mg/l certified reference standards, diluted to the desired concentration with 0.5% HNO_3 .

CHAPTER 4

RESULTS AND DISCUSSION

The results of the laboratory and field investigations form the basis of the conclusions and recommendations arising from the study of Galkeno 300 adit drainage. Chapter 4 presents the results of these investigations and provides discussion about the nature and implications of the results. Results are presented in the same order as the methods discussed in the previous chapter.

4.1 Results of Galkeno 300 Site Investigation

The results of the detailed site investigation carried out during the period June through August, 2000 provide valuable insight into the behaviour of the Galkeno 300 drainage system over this period and are paramount to the objectives of this study.

4.1.1 Temperature and precipitation monitoring

The results of temperature and precipitation monitoring are summarised in Figures 4.1 and 4.2. As previously indicated, gaps in temperature data are due to absences of UKHM environmental staff; during these absences, precipitation accumulated in the precipitation gauge and was cumulatively accounted for in the first precipitation measurement following the absence. Absences are indicated by lack of temperature data (Fig. 4.2); lack of precipitation data (Fig. 4.1) may indicate either staff absence or lack of precipitation. The cumulative measurement of precipitation data during absences provides an estimate of total precipitation input to the field site over the period, and as such minimises the likelihood of underestimating dilution due to input of meteoric water.

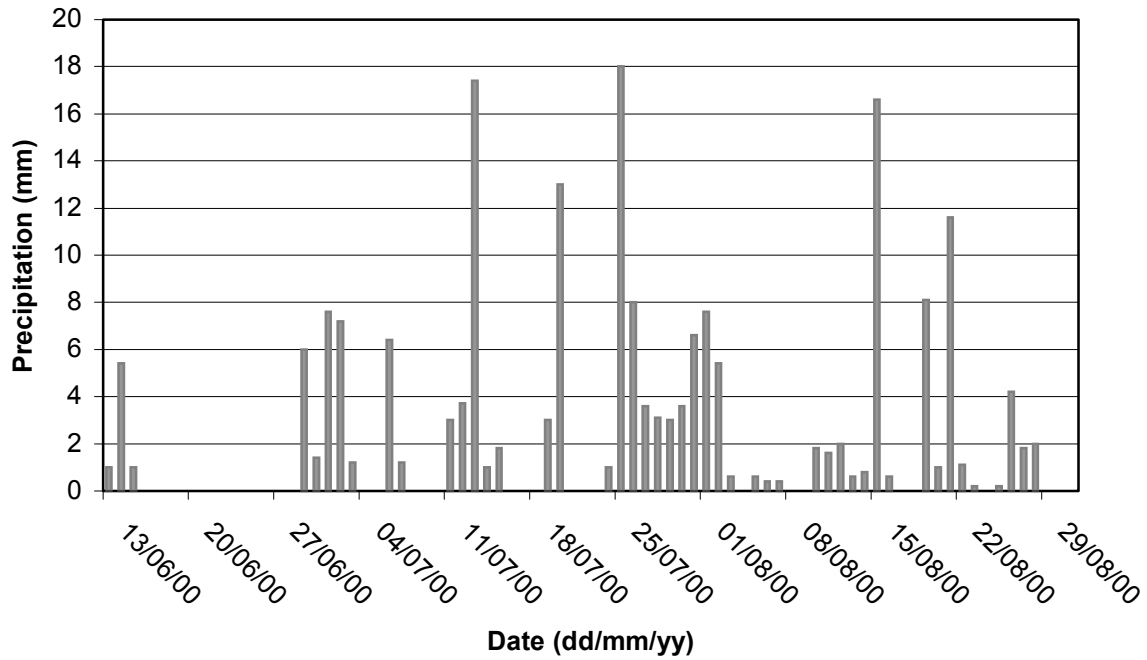


Figure 4.1. Precipitation measured at Elsa YT, summer 2000, elevation 850 m (2800 ft) asl.

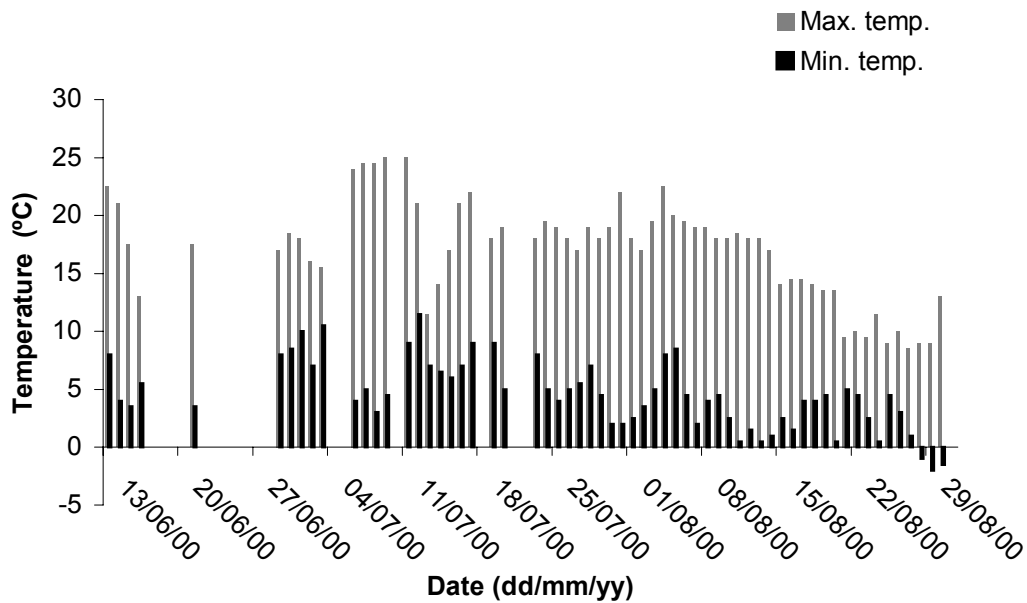


Figure 4.2. Maximum/ minimum temperatures at Elsa YT, summer 2000, elevation 850 m (2800 ft) asl.

4.1.2 Flow measurement

Flow volume of adit drainage was measured at two points, at the Galkeno 300 adit and at a point immediately upstream of Highway 11 (Fig. 3.2), prior to discharge of adit drainage into Christal Creek; the results of this flow measurement are given in Table 4.1 and displayed in Figure 4.3. The spike in flow volume at the discharge to Christal Creek on August 4 reflects anomalously high contribution from precipitation in the preceding week (Fig. 4.1); if this discharge value is withdrawn from the data set, the remaining discharge values indicate that there is roughly 16% greater flow volume at the bottom of the site than at the adit. This increase in discharge reflects the input of base flow to the adit drainage over the catchment, and is considered to be an appropriate estimate of the degree of dilution that commonly occurs in the catchment prior to discharge to Christal Creek. The precision of the v-notch weir method of discharge measurement is considered to be +/- 10% (Grant and Dawson, 1995). Approximately 70% of the flow volume followed the transect through water sample sites 11-9-6-5-3-1 (Figure 3.2).

4.1.3 Water quality

Water quality at the Galkeno 300 site was characterised through in situ measurement and through chemical analysis of samples collected at the site during the site investigation. The complete analytical and in situ results can be found in the appendices. Appendix C.1 summarises the water quality results according to sampling date; this format is conducive to examining spatial changes in water quality on a given sampling day. Appendix C.2 summarises the water quality data on the basis of sampling site; this format allows temporal changes in water quality at a particular site to be examined. The following discussion highlights pertinent results that provide

insight into the geochemical system in place at the Galkeno 300 site; unless otherwise noted, the analytical data from August 21, 2000 will be called upon for illustration.

Table 4.1. Measured input and output discharges at Galkeno 300 site, July-August 2000.

Date	Input: Galkeno 300 adit (L/s)	Output: 300 drainage @ Christal Ck. (L/s)	Output Q/ Input Q ratio
July 22, 2000	6.31	8.16	1.29
July 29, 2000	6.85	7.78	1.14
August 4, 2000	8.16	14.22	1.74
August 12, 2000	7.78	8.74	1.12
August 21, 2000	9.23	10.76	1.17
August 30, 2000	7.78	8.26	1.06
Average			1.16*

* average ratio by which downstream discharge exceeds upstream discharge, with anomalous data from August 4 factored out.

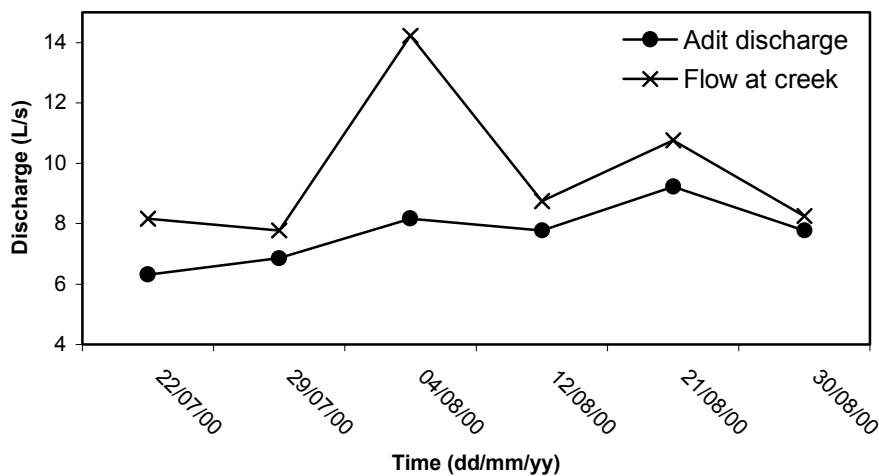


Figure 4.3. Flow volumes exiting Galkeno 300 adit and entering Christal Creek, summer 2000.

4.1.3.1 Zn and Mn concentrations in mine drainage

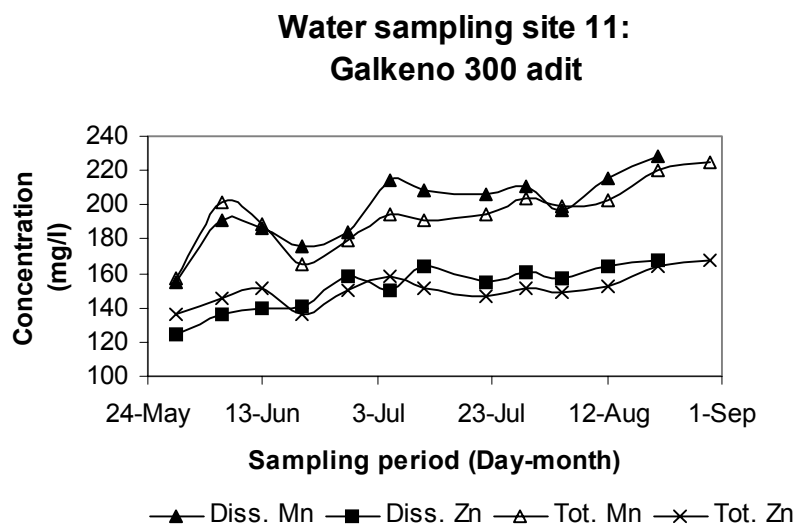
Dissolved and total zinc and manganese concentrations at the Galkeno 300 adit (water sample site 11, Fig. 3.2) were found to be on the order of 150 mg/l and 200 mg/l, respectively, over the course of the sampling season. At the discharge of Galkeno 300 drainage to Christal Creek (water sample site 1, Fig. 3.2), the dissolved and total zinc and manganese concentrations were, on average, 2.1 mg/l and 0.5 mg/l, respectively, over the same time period. Table 4.2 and Figure 4.4 display dissolved and total metal concentrations at the Galkeno 300 adit and at the discharge to Christal Creek (water sample sites 11 and 1, respectively) over the period of the site investigation; the difference between total and dissolved metal concentrations indicates the amount of metal transported on particulate matter larger than 0.45 µm (the pore size of the filter employed during collection of dissolved sample). Some samples indicate dissolved concentrations greater than total concentrations; the Pacific Environmental Science Centre's Inorganic Chemistry Section applies the following criteria when undertaking examination of analytical results.

- If the dissolved and total metals data are within $\pm 5 * \text{Method Detection Limit (MDL)}$, then data are deemed acceptable, and no re-analysis is required.
- If the dissolved value is greater than the total value by a Relative Percent Difference (RPD) of less than or equal to 10%, then data are deemed acceptable, and no re-analysis is required.

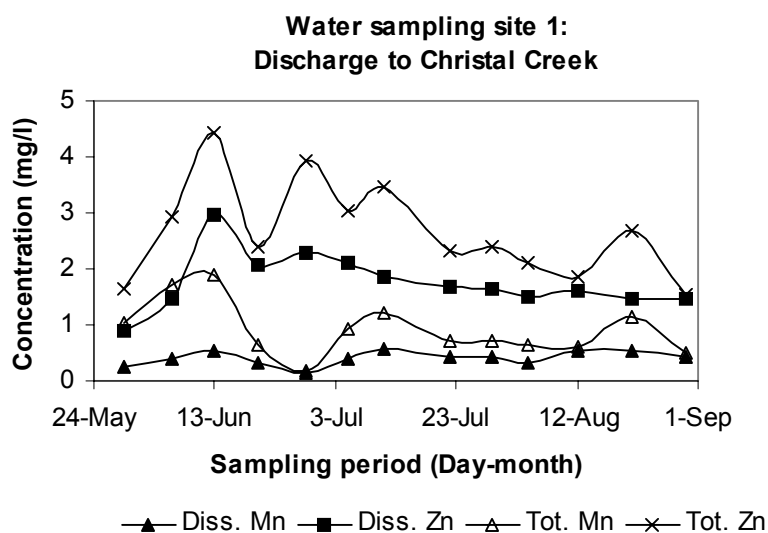
Table 4.2. Dissolved and total Mn and Zn concentrations (mg/l) in Galkeno 300 drainage at Site 1 and Site 11, summer 2000.

	29-May	6-Jun	13-Jun	20-Jun	28-Jun	5-Jul	11-Jul	22-Jul	29-Jul	4-Aug	12-Aug	21-Aug	30-Aug
<i>Site 11- Galkeno 300 adit</i>													
<u>Dissolved Mn</u>	155.2	191	186.4	176.3	184.0	214.76	208.4	206	211.00	197.00	216.00	228.50	*
<u>Total Mn</u>	156.8	201	188.1	165.9	179.0	194	190.8	194.9	204	199	203	220.7	225
<u>Dissolved Zn</u>	124	136	140	141	158	150	164	155	161	157	164	168	*
<u>Total Zn</u>	136	145	152	137	150	158	151	147	151	149	153	165	168
<i>Site 1- 300 drainage at Christal Ck</i>													
<u>Dissolved Mn</u>	0.235	0.390	0.549	0.318	0.132	0.385	0.554	0.429	0.416	0.330	0.520	0.529	0.439
<u>Total Mn</u>	1.040	1.710	1.890	0.650	0.165	0.919	1.219	0.700	0.710	0.647	0.619	1.145	0.488
<u>Dissolved Zn</u>	0.903	1.450	2.950	2.080	2.29	2.117	1.875	1.668	1.650	1.490	1.600	1.470	1.450
<u>Total Zn</u>	1.650	2.920	4.420	2.380	3.94	3.040	3.471	2.338	2.410	2.110	1.870	2.663	1.550

*value not available.



A)



B)

Figure 4.4. Total and dissolved metal concentrations in Galkeno 300 drainage, summer 2000. A) Zn and Mn concentrations in flow exiting Galkeno 300 adit. B) Zn and Mn concentrations entering receiving environment (Christal Creek).

RPD is calculated using the following formula:

$$\text{RPD} = \frac{(\text{Diss} - \text{Tot})}{(\text{Diss} + \text{Tot}) / 2} \times 100\%$$

The dissolved metals values (DMET) which exceed total metals values (TMET) but meet the above requirements are considered to be the result of a combination of analytical (dilution + method) error and sampling error arising from DMET and TMET analyses of different physical samples.

Notwithstanding the uncertainty arising from dissolved and total metal values of individual samples, the similarity of DMET and TMET for specific sample sites on specific dates indicates that little metal is being transported with filterable particulate material. Further, the DMET and TMET values clearly show the spatial changes in aqueous metal concentrations in the Galkeno 300 mine drainage.

The coincident reduction of zinc and manganese concentrations with distance along the flowpath is displayed in Figure 4.5. The results shown are for August 30, 2000; results from other sampling dates (Appendix C.1) display similar patterns. Of particular note is the removal of the majority of both zinc and manganese in the region of shallow subsurface flow; the joint decrease in aqueous Zn and Mn suggests that the two metals are being removed by the same or similar processes operating under the geochemical conditions present in the shallow soil environment.

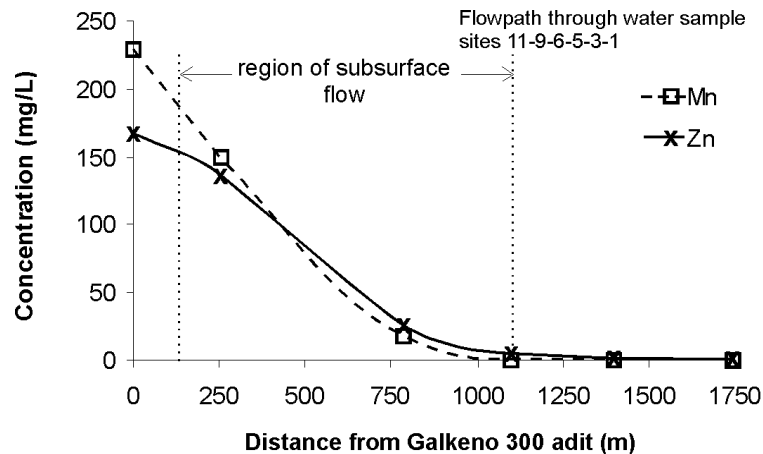


Figure 4.5. Reduction of total zinc and manganese concentrations in adit drainage with flowpath distance (August 30, 2000).

4.1.3.2 pH of mine drainage

The pH of the mine drainage was found to vary spatially, and to a more limited extent, temporally; Figure 4.6 displays the pH along the main flow transect (sites 11-9-6-5-3-1, Figure 3.2) for the major sampling events. The drainage emanating from the Galkeno 300 adit was found to be generally slightly acidic, in the range of pH 5.9 to 6.8. The pH immediately decreases to a generally below pH 5.5 within the first 250 m of flow downslope of the Galkeno 300 adit; the presence of abundant orange iron oxide precipitates in this region indicate that this decrease in pH is due to oxidation of ferrous iron and release of acidity through hydrolysis, according to the general process reviewed in reaction 2.2. This acidity is consumed via reaction with soil components over the following ~1000 m, as the mine drainage flows through the shallow soils of the site. This neutralisation occurs despite the contribution of acidity due to oxidation of manganese through hydrolysis over this same section of flowpath (Fig. 4.5). The

slight decrease in pH in the final 500 m of flow is thought to reflect the influence of organic acids; the slope over this final 500 m is much reduced, the accumulation of moss is much thicker and saturated conditions prevail. It is common to find waters draining such environments showing influence of organic acidity (Bendell-Young, 1999).

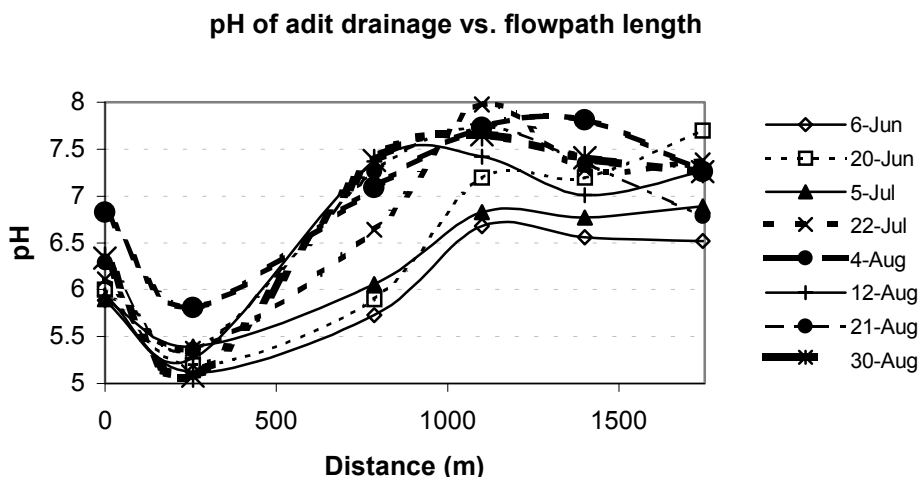


Figure 4.6. Variation of pH with distance downstream of Galkeno 300 adit, June-August 2000.

The temporal variation in pH throughout the period of site investigation is poorly understood, but is thought to be influenced by multiple factors, including temperature, flow volume and balance between the seasonal generation and neutralisation of acidity. Early season (June 6) pH is lower across the middle and lower reaches of the site than during other sampling periods (Figure 4.6). This is postulated to be a function of the lack of development of a thawed active layer through which acidic flows could access the neutralisation capacity of the shallow soils; little neutralisation can occur if the mine drainage flows over the frozen ground surface. Later pH

data display considerable variability, delivering mine effluent to the receiving waters with a pH ranging from 6.5 to 7.7.

4.1.3.3 Eh of Galkeno 300 drainage

Oxidation-reduction potential of Galkeno 300 waters was undertaken from July 29, 2000 on. The ORP probe was unavailable prior to this time. Figure 4.7 displays the results of this measurement, converted to conventional Eh units (mV). As with the preceding pH data, Eh results vary within a narrow range over time, and more considerably across the site. The initial rise in Eh from 0 to 250 m corresponds with the turbulent surface flow acquiring abundant oxygen via cascading over the Galkeno 300 waste rock dump. This initial increase in oxidation capacity also reflects the completion of the oxidation of ferrous iron and the consequent decrease in consumption of oxidation capacity. This peak in oxidation potential at 250 m is followed by a slow decline in Eh over the next 1000 m; this reflects subsurface flow and little opportunity for dissolution of atmospheric oxygen, as well as oxidation of reduced forms of manganese over this stretch. Eh increases sharply between ~1100 and ~1400 m, as flows return to surface, are locally turbulent, and are exposed to atmospheric oxygen. Between ~1400 and 1743 m, Eh decreases again, this time likely due to the addition of copious amounts of finely divided organic matter to the flow from the thawing of permafrost in the lower reaches of the drainage, between sites 1 and 3 (Fig 3.2).

It should be noted that the oxidation potential between station 9 (250 m) and station 5 (1100 m) (Fig. 4.7) is insufficient to result in inorganic oxidation of reduced manganese. It has been shown that oxidation potentials necessary for the inorganic precipitation of manganese do not occur in nature below pH values of ~ 9 (Krauskopf and Bird, 1995; Sikora et al., 2000). High concentrations of manganese are removed from the mine drainage over this stretch where

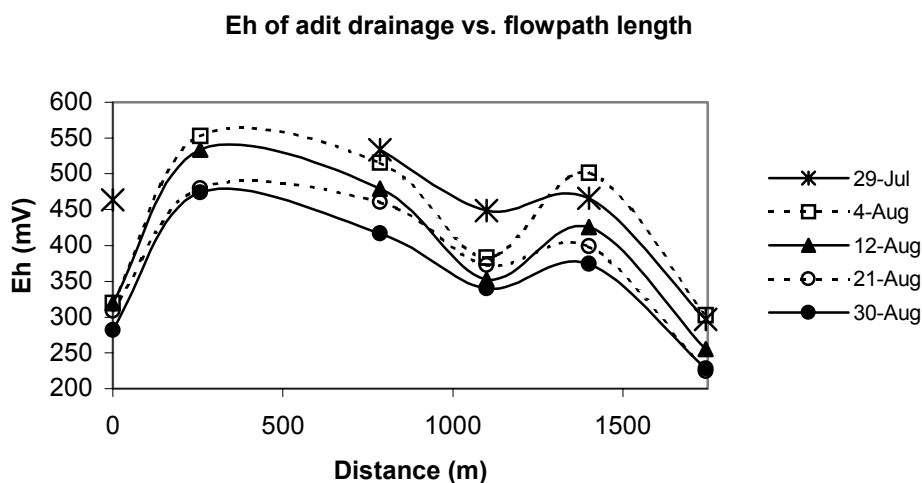


Figure 4.7. Variation of Eh with distance downstream of Galkeno 300 adit, July/August 2000.

oxidising conditions prevail; purplish-black residues typical of manganese oxide minerals (McKenzie, 1989) were observed in quantity over this interval. It is most likely that bacterially mediated oxidation is responsible for the precipitation of solid manganese oxide (Harvey and Fuller, 1998; Bargar et al., 2000; Sikora et al., 2000; Stein et al., 2001), containing considerable amounts of zinc, in this region of the flow path.

4.1.4 Metal content of Galkeno 300 site soils

Concentrations of 29 metals (Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Mo, Ni, P, K, Se, Si, Ag, Na, Sr, S, Sn, Ti, V, and Zn) were measured in soil samples collected at the Galkeno 300 site. The complete set of analytical results, along with sample location and a brief sample description, is provided in Appendix D. The following discussion focuses on the distribution of zinc and manganese in site soils.

4.1.4.1 Metal content of soils in flowpath and background samples

Zinc and manganese concentrations of flowpath and background samples from sites A, C and E (Figure 3.2) are shown in Table 4.3. These samples represent soil Zn and Mn concentrations in soils lower, middle and upper areas of the site, respectively. Figure 4.8 shows soil Zn and Mn concentrations for the upper organic and lower mineral horizons at each site. At site E, low background levels of Zn and Mn are slightly higher in the lower mineral horizon over the upper organic horizon. Mineral soils tend to have higher metal content than does plant tissue (Krauskopf and Bird, 1995); the background soils at site E conform to this tendency. Samples taken within the flowpath display 2-3 orders of magnitude greater concentrations of Zn and Mn; the scale of the figure has been truncated to provided detail at the low end. The upper organic horizon has accumulated nearly 3 fold more Zn and 18 fold more Mn than the underlying mineral horizon. Recall that site E is the soil sampling site in closest proximity to the Galkeno 300 adit, and the soils here are in contact with mine drainage carrying higher concentrations of metals than are soils further along the flowpath.

Table 4.3. Background and elevated total soil metal contents at selected sample sites.

<i>Sample site</i>	<i>Horizon</i>	<i>Background [Zn] (mg/kg)</i>	<i>Elevated [Zn] (mg/kg)</i>	<i>Background [Mn] (mg/kg)</i>	<i>Elevated [Mn] (mg/kg)</i>
A	upper organic	315	3010	1160	1210
A	lower mineral	289	277	532	482
C	upper organic	90	28600	4860	224000
C	lower mineral	237	1370	170	418
E	upper organic	156	13800	61	61300
E	lower mineral	312	4590	479	3344

Site C is located near the geographic center of the region of subsurface flow (Figure 4.5); this region is where the majority of the removal of both Zn and Mn from mine drainage has been shown to occur. Soils in the flowpath at site C are in contact with moderate metal concentrations (20-30 mg/l Zn and 15-25 mg/l Mn). Background soil Zn concentrations (Figure 4.8) are similar to those at site E, with higher values in the lower mineral soil than in the upper organic soil. The background lower mineral horizon was also low in Mn, as at site E; however, the upper organic layer at site C contained elevated Mn. This is unexpected, as the background sample site was elevated ~2 m above the flowpath, and 15 m laterally removed. Sampling equipment decontamination was carried out via scrubbing with material to be sampled before collecting the actual aliquot for analyses. Contamination is unlikely, as the background zinc is low; in addition, the field background duplicate taken at this site provides similar results (Appendix D). The high background Mn value is therefore taken as representative at site C.

The flowpath samples collected at site C show remarkable enrichment of both Zn and Mn in the upper organic layer (Figure 4.8). On sampling, the upper organic layer was noted to be very coarse and black when wet, similar to charred wood. On drying, the sample powdered to a purplish black dust that is characteristic of manganese oxides (McKenzie, 1989). This sample was found to be nearly 3 % Zn and over 22 % Mn, by weight (Fig. 4.8). Interestingly, the lower mineral horizon within the flowpath show little elevation of Mn, despite the preponderance of Mn in the overlying organic horizon. The lower mineral horizon did contain elevated zinc concentrations; this preferential uptake of zinc in the lower mineral horizon suggests that cation exchange within the mineral soil may be playing a minor role. However, it must be emphasized that the majority of zinc attenuation is occurring within the upper organic layer.

At site A, the lowest elevation soil sample site, the soils are in contact with mine drainage carrying low concentrations of Zn (0.27 – 2.0 mg/l) and virtually no Mn (at or near detection (0.001 mg/l)). Background levels of zinc are very similar in both organic and mineral soils; once again, background Mn in the upper organic horizon exceeds that in the lower mineral horizon. This is similar to the distribution noted at site C, although the Mn concentration in the upper organic layer at site A is less than 1/3 of that at site C. The flowpath sample returned very similar Mn concentrations to the background sample; this is as expected, due to the negligible amounts of manganese measured nearby during water sampling. Zn concentrations of the upper organic horizon within the flowpath are 2 orders of magnitude above background. This demonstrates that, despite the relatively low (up to 2 mg/l) concentrations of zinc in this section

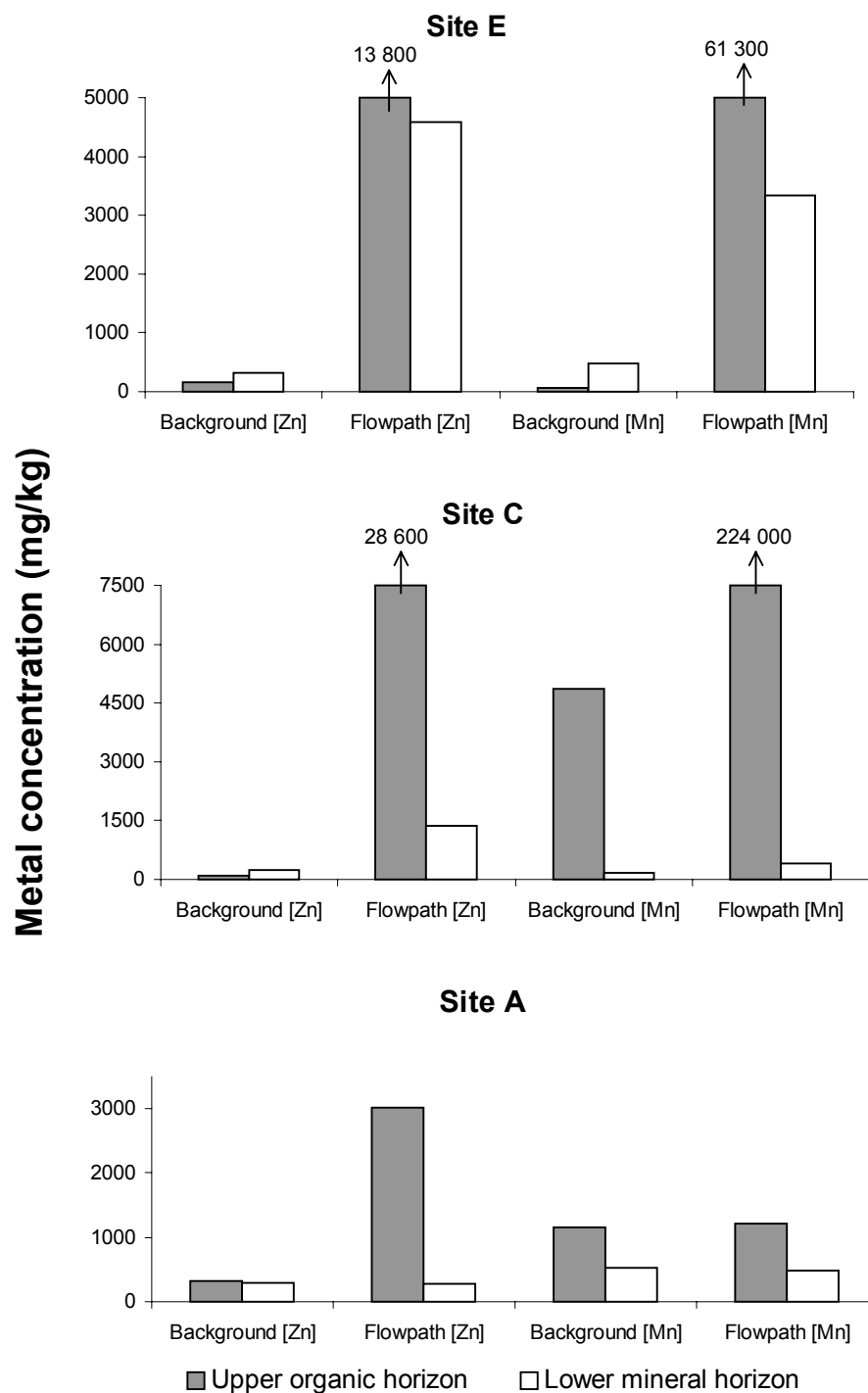


Figure 4.8. Background and flowpath Zn and Mn concentrations in soils of upper organic and lower mineral horizons at soil sampling sites E (highest elevation), C, and E (lowest elevation).

of the drainage, the near surface organics have removed substantial amounts of zinc from the flow. Flow at this site is partially on surface; the minimal contact that the drainage has with the organic material when flowing in this fashion nevertheless appears to be sufficient to allow adsorption of aqueous zinc ions to occur onto the surface organics. Mineral soils within the flowpath contain background concentrations of zinc; this indicates that transfer of aqueous zinc to the surface of mineral soil particles is not occurring. It appears that mineral soils provide little in the way of attenuation capacity at lower elevations.

4.2 Results of Laboratory Investigation of Natural Attenuation

Representative samples of Galkeno 300 site soils were collected during the detailed site investigation. Subsequently, these samples were subjected to a laboratory investigation to determine zinc adsorption capacity of the various samples as well as the mechanism(s) of zinc attenuation that are operating at the Galkeno 300 site. This investigation consisted of selective extraction procedures, batch and column adsorption experiments, as well as physical and chemical characterisation of mineral and organic samples.

4.2.1 Physical and Chemical Characterisation of Galkeno 300 site soils

The soils of the upper organic horizon and the lower mineral horizon have substantially different physical and chemical properties; the following chemical and physical characteristics of these soils were assessed: soil pH, cation exchange capacity, specific surface area, total carbon content, and mineralogy. The results of the chemical and physical characterisation are presented in Table 4.4.

4.2.1.1 Cation exchange capacity

The cation exchange capacity of upper organic and lower mineral soils differed considerably. The CEC of the upper organic soils was determined to range from 131 to 180 meq/100 g. In contrast, the CEC of the lower mineral soils ranged from 21 to 54 meq/100 g. The significantly higher CEC of the upper organic soils is indicative of the adsorption capacity of this horizon.

Table 4.4. Physical and chemical properties of selected Galkeno 300 site soils.

<i>Sample site</i>	<i>Horizon</i>	<i>Soil pH</i>	<i>Cation Exchange Capacity (meq/ 100 g)</i>	<i>Specific Surface Area (g/m²)</i>	<i>Total Carbon Content (%)</i>	<i>Soil organic matter (%)</i>	<i>Specific Gravity</i>	<i>Clay Mineralogy*</i>
E	upper organic	5.09	180	144	31.85	54.9	1.515	-
E	lower mineral	5.11	48	76	9.75	16.8	-	illite, kaolinite, vermiculite-montmorillonite, chlorite
C	upper organic	5.11	149	160	47.48	81.9	1.514	-
C	lower mineral	5.19	21	45	5.66	9.8	-	illite, kaolinite, vermiculite-montmorillonite, chlorite
A	upper organic	4.06	131	224	47.96	82.7	1.432	-
A	lower mineral	5.58	54	54	7.83	13.5	-	illite, kaolinite, vermiculite-montmorillonite, chlorite

* in order of decreasing abundance

4.2.1.2 Soil pH

The 1:2 soil water method of Thomas (1996) produced soil pH results in the range of pH 4.06-5.11 for upper organic soils across the site; lower mineral soil pH was found to be slightly more basic, ranging from pH 5.11-5.58 (Table 4.4). Soil pH is considered to play a minor role in the attenuation occurring at the Galkeno 300 site; the pH of the mine drainage dominates the system.

4.2.1.3 Specific surface area

Upper organic soils were found to have 2 to 4 times the specific surface area of lower mineral soils. Organic samples were found to have surface areas ranging from 144 to 224 g/m², while the surface areas of mineral samples were found to range from 45 to 76 g/m² (Table 4.4). The

high specific surface area of the organic soils, in combination with the higher CEC of this upper horizon, is indicative of the relatively greater adsorptive capacity of this material.

4.2.1.4 Total carbon content

Determination of a soil's carbon content permits an estimate of the proportion of the soil mass that consists of organic matter. Table 4.4 displays the total carbon content of upper organic and lower mineral soil samples, as well as the equivalent % soil organic matter. The upper organic soils range from 54.9 to 82.7% organic matter; the lower mineral soils have from 9.8 to 16.8% organic content. Carbon makes up approximately 58% of organic matter (Nelson and Sommers, 1982); thus, a soil with 58% carbon content consists 100% of organic matter.

4.2.1.5 Soil clay mineralogy

The four diffractograms (untreated, K-saturated, heated, and glycol-saturated) for samples from the lower mineral horizon at sites A, C, and E are shown in Figure 4.9. Inspection of the plots for the three samples shows that the samples are very similar in composition. The data are displayed as diffraction intensity vs. 2θ ; d-spacings (in Å) corresponding to the peaks are displayed on the top plot (sample 53b, site E). Characteristic peaks of illite (Moore and Reynolds, 1997) are present at 10.19, 5.03 and 3.35 Å, and are unaltered by the different treatments. The 12.65 Å peak which shifts to 15.72-16.86 Å indicates the present of montmorillonite; however, this appears to be an interlayered phase, as a pure montmorillonite diffraction would shift to the 17-18 Å range. In addition, the absence of 5.64 or 8.46 Å reflections on the glycol-solvated scan argues against the presence of montmorillonite. The small

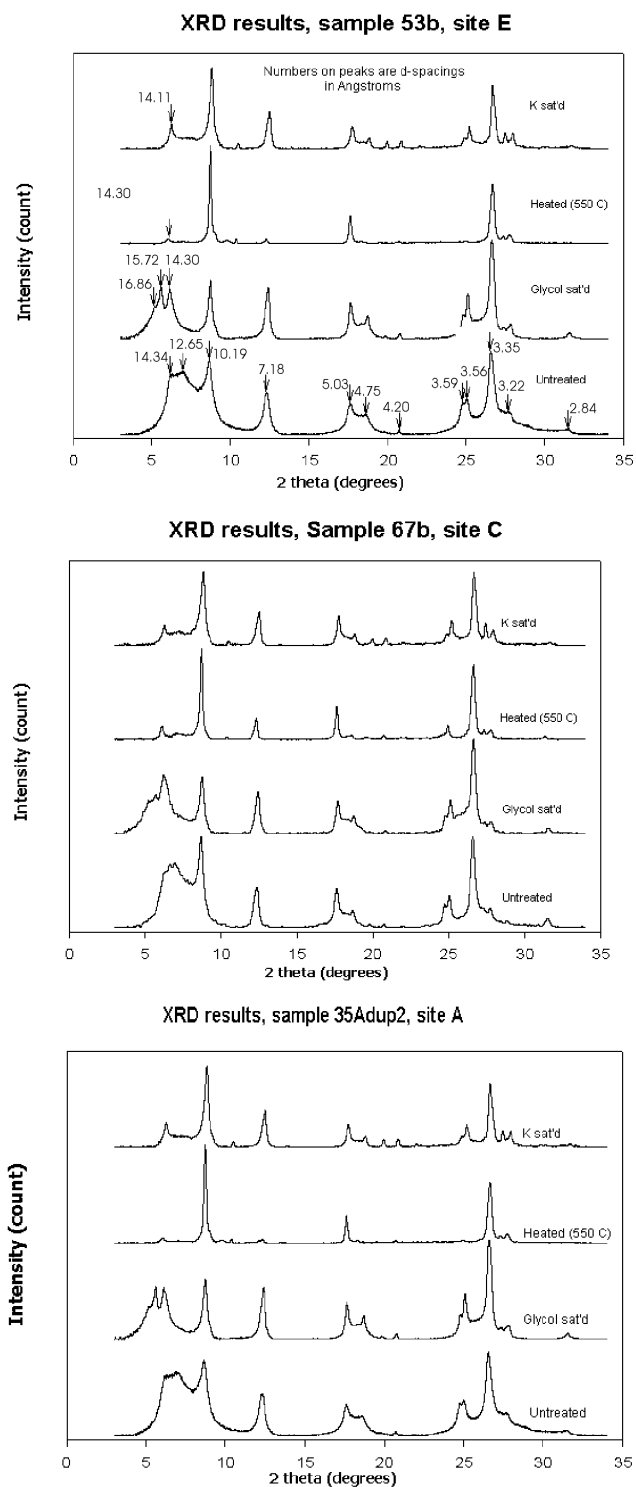


Figure 4.9. X-ray diffraction patterns of lower mineral soils from soil sampling sites E (highest elevation), C, and E (lowest elevation). Characteristic peaks are identified on the top diffractogram.

14.30 Å peak which remains after heating to 550° C indicates the presence of only minor chlorite; this is corroborated by the 4.75 Å peak on the untreated scan. The presence of kaolinite is inferred from the strong 7.18 Å peak all scans except that of the heated sample; the 3.59 Å peak is also characteristic of kaolinite. An abundance of vermiculite is inferred from the large 14.30 Å peak in the glycol-saturated sample (which indicates vermiculite and/or chlorite) in combination with the collapse of the majority of this peak on potassium saturation (14.3 Å peak after K-saturation indicates chlorite only). The very small peak at 4.28 Å indicates the minimal amount of quartz in the sample. All interpretation of results is based on information in Moore and Reynolds (1997).

In summary: illite and kaolinite dominate the clay fraction of these samples, along with a phase that exhibits some swelling characteristics (although less than pure montmorillonite) and collapses to an illite structure on potassium saturation. Moore and Reynolds (1997) indicate that such phases are poorly understood, but represent either interlayered vermiculite-montmorillonite or an expandable phase with layer charge between that of the pure vermiculite and montmorillonite minerals. Minor chlorite is also present. This mix of clay minerals is to be expected, as the parent material for these soils is weathered and glacially eroded granite and metamorphosed marine sedimentary rock (Bond, 1998).

4.2.1.6 Specific Gravity of organic samples

The results of the specific gravity determination on organic samples are provided in Table 4.4. The results for sites C and E show similar specific gravity, while the specific gravity of the soil at site A is slightly lower. This reflects the lesser degree of decomposition of organic soils in the fully saturated lower portion of the site, as observed in the field and in the lab.

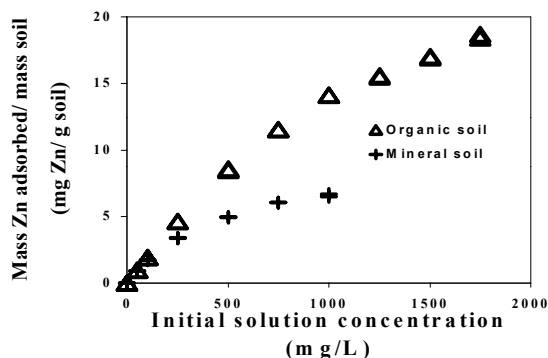
4.2.2 Sorption capacities of Galkeno 300 soils using batch adsorption tests

The zinc sorption capacities of mineral and organic soils from the Galkeno 300 site were evaluated using the batch adsorption test. Batch adsorption results are commonly graphically represented by a curve known as an adsorption isotherm (Kinniburgh, 1986; Roy et al., 1992; Yong et al., 1992; Krauskopf and Bird, 1995); this depicts the quantity of solute sorbed by a material as a function of either initial or equilibrium concentration of the solute remaining in the liquid phase. This relationship can be described mathematically by an adsorption equation. Kinniburgh (1986) discusses a variety of different adsorption equations; the most widely used is the Freundlich isotherm (Roy et al., 1992; Sparks, 1995; Maraqua, 2001), which takes the mathematical form

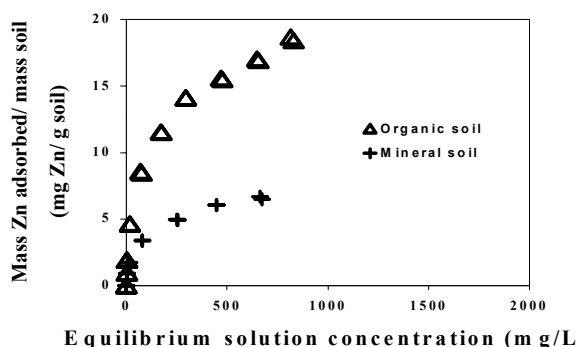
$$q = K_F C^b \quad (4.1)$$

where q is the mass of sorbate per unit mass sorbent, K_F is the Freundlich constant, C is the concentration of the sorbate in the liquid phase, and b is another constant (Yong et al., 1992). The values of the constants are functions of the affinity of the sorbate for the sorbent, and are determined through nonlinear regression such that the curve of the Freundlich equation best fits

the batch adsorption data. The data can be displayed in terms of either initial or equilibrium sorbate concentrations (Figure 4.10); plotting mass sorbed vs. initial concentration provides a wider distribution of data and reduces the sensitivity of the model to experimental error (Li, 1999).



A) Adsorption data showing mass sorbed against initial zinc concentrations.



B) Adsorption data showing mass sorbed against equilibrium zinc concentrations.

Figure 4.10. Example plots of batch adsorption data. A) Plot of mass sorbed (q) vs. initial zinc concentration (C_i), showing broad distribution of data. B) Plot of q vs. equilibrium concentration (C_e), showing narrower distribution range.

Freundlich isotherms were constructed from the batch adsorption data for Galkeno 300 soils.

Figure 4.11 summarises these isotherms, as well as corresponding equilibrium solution pH

values; units and scales on the horizontal and left vertical axes of the six plots are identical to facilitate visual comparison of adsorption results. In general, the Freundlich equation describes the batch adsorption data very well; both the Freundlich equation and the correlation coefficient (or coefficient of determination) are displayed on each plot for reference. Table 4.5 summarises the K_F and b values, and the correlation coefficients (R^2 values), for each soil data set. The correlation coefficient for the fit between the batch adsorption data and the fitted Freundlich isotherm is greater than 0.98 in all cases; this indicates greater than 98% confidence that the Freundlich isotherms accurately describe the observed data.

Table 4.5. Summary of K_F , b , and R^2 values for Galkeno 300 batch adsorption data.

<i>Sample site</i>	<i>Horizon</i>	K_F	b	R^2
E	upper organic	67.31	0.76	0.99440
E	lower mineral	123.6	0.57	0.99314
C	upper organic	51.2	0.82	0.99745
C	lower mineral	141.89	0.56	0.98793
A	upper organic	76.31	0.72	0.99347
A	lower mineral	92.72	0.69	0.98928

The upper organic soils, represented in Figure 4.11 A), C), and E), showed a substantially greater capacity to remove zinc from the test solutions. Within the organic soils, the soil from site C proved to have the highest sorption capacity. Soil metal data in Table 4.3 shows that the organic soils at site C have the highest background manganese levels found in the Galkeno 300 study area; the high organic (Table 4.4) and manganese contents of the site C organic soil horizon are likely jointly responsible for the high zinc sorption capacity of these soils. Table 4.3

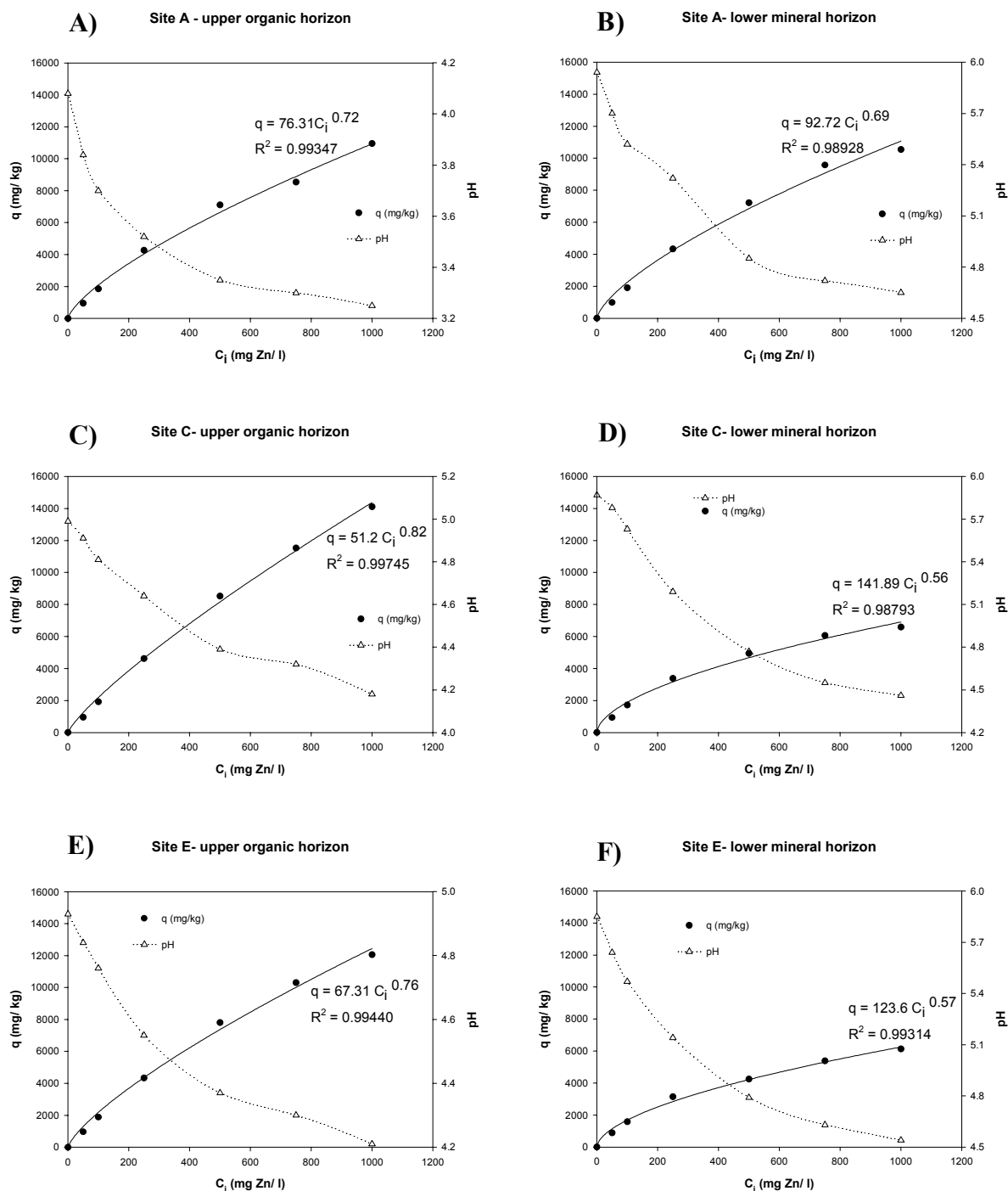


Figure 4.11. Results of batch adsorption testing of Galkeno 300 organic and mineral soils, showing mass sorbed per unit mass of soil material, and equilibrium pH, vs. initial solution Zn concentration. Batch tests were conducted at 25° C; initial pH of all solutions was pH 6.5.

also shows that the ‘elevated zinc’ levels at site C are the highest found at the study site; the lab evidence from the batch adsorption test suggests that the high levels of soil zinc found at site C during the field investigation are the result of the high sorption capacity of this soil material. A related observation is that the CEC of site C organic soil is not the highest at the Galkeno 300 site; this suggests that zinc sorption is occurring at least in part through specific adsorption rather than solely as a function of cation exchange. Specific complexation of zinc with manganese oxides, in site C soils to a great extent and to lesser degrees across the site, is an obvious consideration (McKenzie, 1989; Best et al., 1999; Post, 1999) and this process is likely an important mechanism of zinc removal from the Galkeno 300 mine drainage as it traverses the flow path between the mine and Christal Creek.

The lower mineral soils, represented in Figure 4.11 B), D), and F), showed a lesser capacity to remove zinc from the test solutions. Of the three mineral soils, the mineral sample from site A displayed the highest zinc sorption capacity. At site A, the CEC and soil pH are marginally higher than at sites C and E (Table 4.4); these factors could contribute to the greater observed sorption capacity of site A mineral soils. Within the mineral soils, sorption capacity is not correlated with background soil manganese levels (Table 4.3); it is postulated that mineral soil manganese may not be associated with oxide minerals and thus may not provide the additional sorption capacity typical of manganese oxides (McKenzie, 1989; Best et al., 1999; Post, 1999), and found in the upper organic horizon at the Galkeno 300 study site (Table 4.3). As the lower

mineral soils appear to play a minor role in the natural attenuation that is occurring at this site, no further explanation of the variation in zinc sorption capacities of site mineral soils was sought.

Equilibrium solution pH

Equilibrium pH results for the six soils subjected to batch adsorption testing are provided in Figure 4.11 to facilitate comparison with sorption data. These equilibrium pH results are summarised on a single plot in Figure 4.12 to permit comparison of changes in equilibrium solution pH between the six tests. In general, all tests show the same pattern of initial decrease in pH followed by an approach to constant pH levels at higher initial solution zinc concentrations. This trend indicates the replacement of H^+ ions on exchange sites with Zn^{2+} ions, and the corresponding decrease in equilibrium solution pH due to increased levels of H^+ ions in solution. At higher initial Zn^{2+} concentrations, virtually all of the exchangeable H^+ on the soil surface has been replaced; further decrease in equilibrium pH is limited by the lack of supply of H^+ ions.

Between the six data sets, the most notable difference is the offset of initial pH ($C_i = 0$ mg Zn/ l) values. This deviation from the initial solution pH (pH 6.5) is likely a function of soil acidity; the sample which produced the lowest equilibrium pH was also found to have the lowest soil pH (Table 4.3). The initial pH of the other data sets is also reflective of the relative soil acidity summarised in Table 4.3.

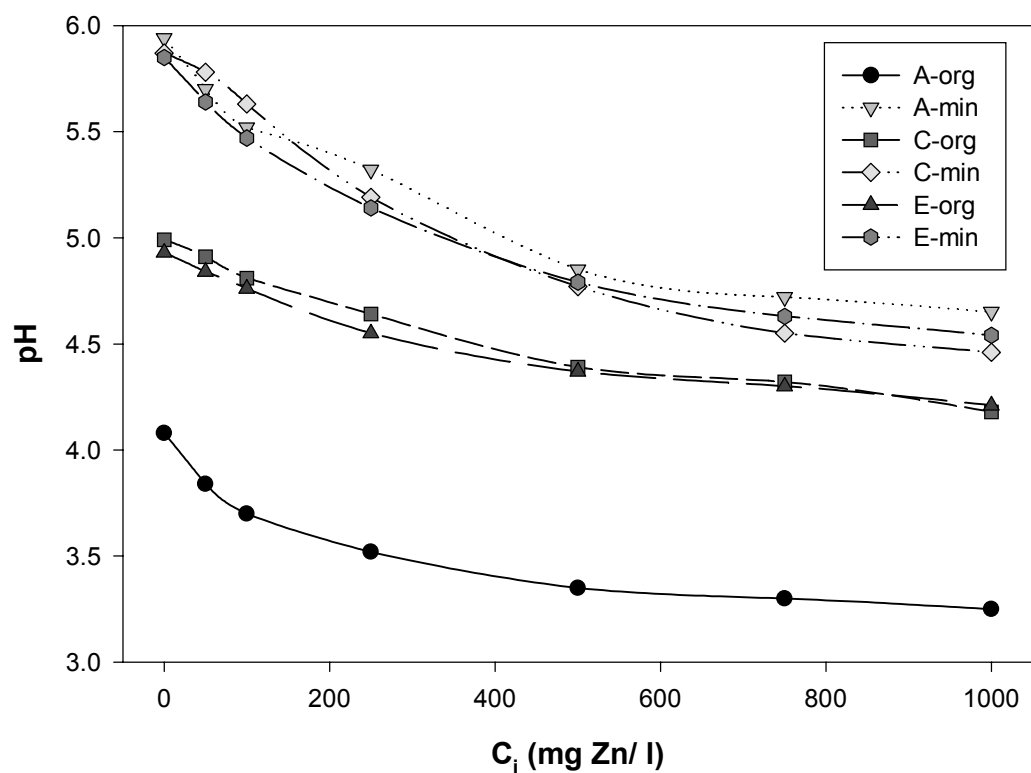


Figure 4.12. Summary of equilibrium solution pH results from batch adsorption testing of Galkeno 300 organic and mineral soils. 'A-org' is results from organic soil at site A, 'A-min' is results from mineral soil at site A, etc. Initial solution had a pH of 6.5.

4.2.3 Sorption capacities of Galkeno 300 soils using leaching column tests

Column leaching tests were undertaken on organic samples from soil sample sites A, C and E. These tests were conducted to better understand the limits of zinc removal from mine drainage per unit mass of soil material. While batch adsorption tests provide valuable insight into this relationship, the results of batch testing may overestimate attenuation capacity of a soil material due to low soil: solution ratios and excellent contact between sorbent and sorbate. Alternatively, column leaching tests can better approximate actual field conditions; the flow-through configuration allows sorbate/sorbent ratios and degree of contact to mimic those found in the field situation.

4.2.3.1 Removal of aqueous zinc in leaching columns

Two zinc removal scenarios were tested; under the first scenario (Tests 1 and 3), undiluted mine water collected at the Galkeno 300 adit was employed as the permeant. The Galkeno 300 water had a zinc concentration of 145 mg/l and for the purposes of the experiment was considered to be the maximum zinc concentration that would be encountered by the site soils; this approach is conservative, in that some removal of zinc from Galkeno 300 mine drainage occurs prior to the mine drainage entering the subsurface. The second scenario (Test 2) employed a permeant of Galkeno 300 mine water diluted to 30 mg/l Zn using a CaSO_4 solution with an ionic strength (2000 $\mu\text{S}/\text{cm}$ conductivity) similar to that of the Galkeno 300 mine water. This Zn concentration is typical of aqueous zinc concentrations near the midpoint of the Galkeno 300 flowpath (Figure 4.5), an area where soil zinc levels indicate that zinc attenuation is high (Table 4.3).

Results of permeating columns with undiluted mine water (Tests 1 and 3)

Figure 4.13 displays the results of Tests 1 and 3. In general terms, all Test 1 results show an initial rapid increase in aqueous Mn and Zn concentrations in column effluent. This is followed after ~15 pore volumes by the achievement of steady state effluent aqueous metal concentrations that are lower than influent concentrations. These general observations are supported by the results from Test 3, which show similar behaviour of approaching constant aqueous metal concentrations after ~ 15 pore volumes. The minor differences in the behaviour of the duplicate experimental results of Tests 1 and 3 are considered to result from sample heterogeneity and from uncertainty inherent to the experimental procedures employed. These differences are not considered to be indicative of different processes operating within the replicate columns.

Three important observations can be made from the isotherms in Figure 4.13. The first is that there is an initial period of increase in effluent metal concentrations. This suggests that sorption of Zn and Mn species to soil surfaces is occurring and that, as sorption sites become saturated, the amount of sorption decreases. The second observation is that effluent metal concentrations appear to reach a steady state in which effluent concentrations are less than influent concentrations. It is most likely that the process responsible for removing the mass differential between influent and effluent is precipitation. It is postulated that a Mn-Zn oxide precipitates within the column at a rate determined by influent concentrations as well as by redox conditions within the column. Redox conditions within the column were not characterised during this study. The third observation is that changes in pH are small in magnitude and do not display a general pattern; Figure 4.13 B) is anomalous in that, initially, effluent pH drops, stabilising at

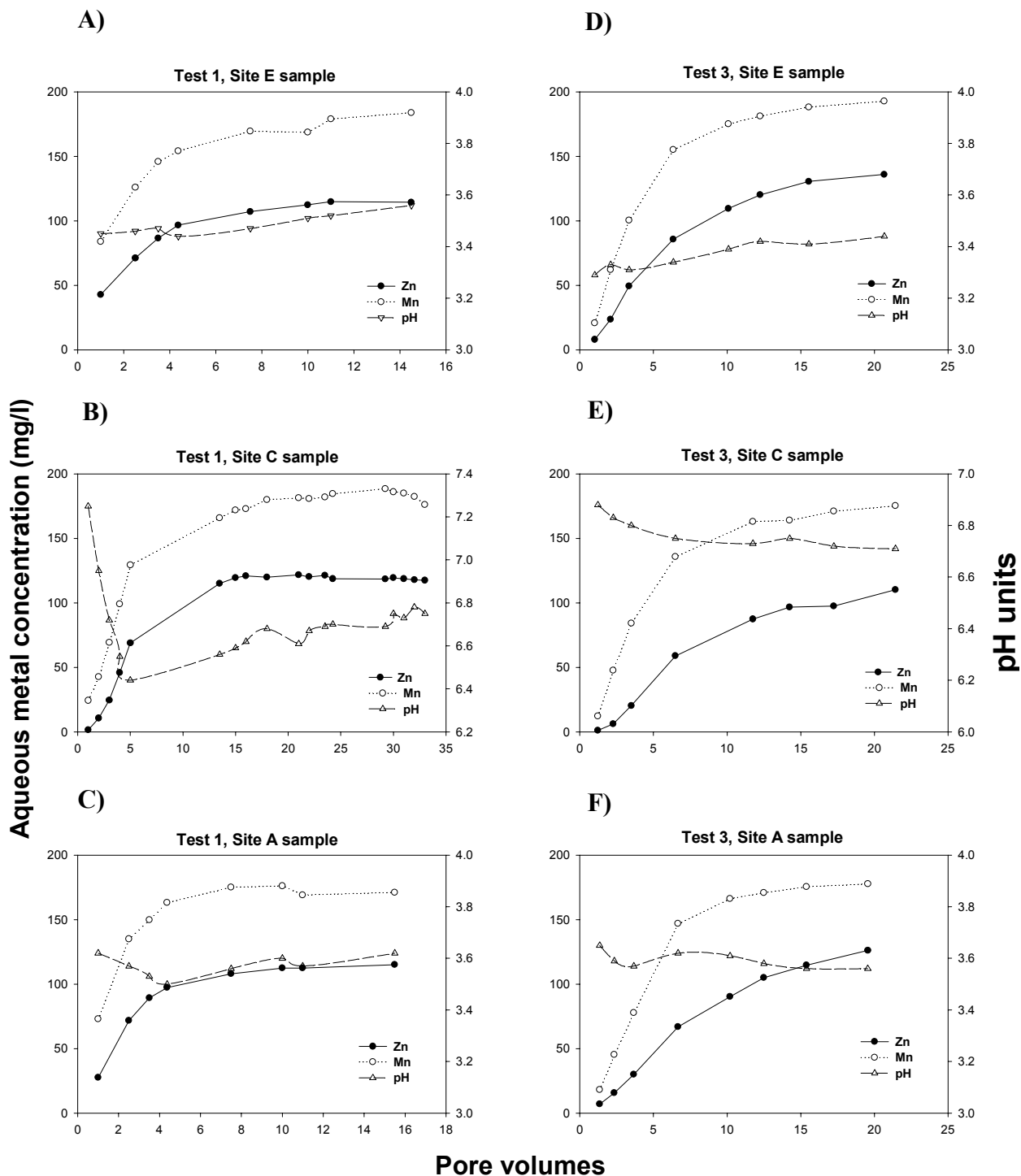


Figure 4.13. Summary of effluent Zn and Mn concentrations and pH during duplicate leaching column tests (Tests 1 and 3) using undiluted Galkeno 300 mine water (pH 6.5) as permeant. A-C) Results of Test 1. D-F) Results of Test 3.

a level slightly higher than the influent pH. Among the different soil samples, pH is not constant, but instead appears to be buffered at pH levels unique to each sample. In general, it appears that the soil materials determine the final effluent pH for each sample.

Figure 4.14 shows the cumulative mass of Mn and Zn removed from the influent as a function of the number of pore volumes passed. Rates of removal are indicated by the slope of the respective line, with greater slopes corresponding to greater removal rates. It is useful to note the initial rapid removal of both Mn and Zn, resulting from sorption and precipitation, followed by a lower metal removal rate attributed to precipitation alone. The most important aspect of Figure 4.14 is the depiction of continued metal mass removal from the column influent following the initial period of rapid metal removal through sorption; this continued removal suggests that the attenuation capacity of the soil system is not limited to its sorptive capacity. In the field situation, where the mine drainage encounters a much greater volume of soil, the additional attenuating capacity provided by the maintenance of conditions favourable to precipitation within the soil is substantial.

Results of permeating column with diluted mine water (Test 2)

Figure 4.15 A-C) displays the effluent metal concentration and pH data collected during Test 2, during which columns were permeated with mine water diluted to 30 ppm Zn. Both effluent pH and metal concentration in Test 2 show similar patterns, over a greater range of pore volumes, as those seen in Tests 1 and 3 (Figure 4.13). Due to the lower metal concentrations in Test 2 permeant, it was expected that more pore volumes would be necessary to approach

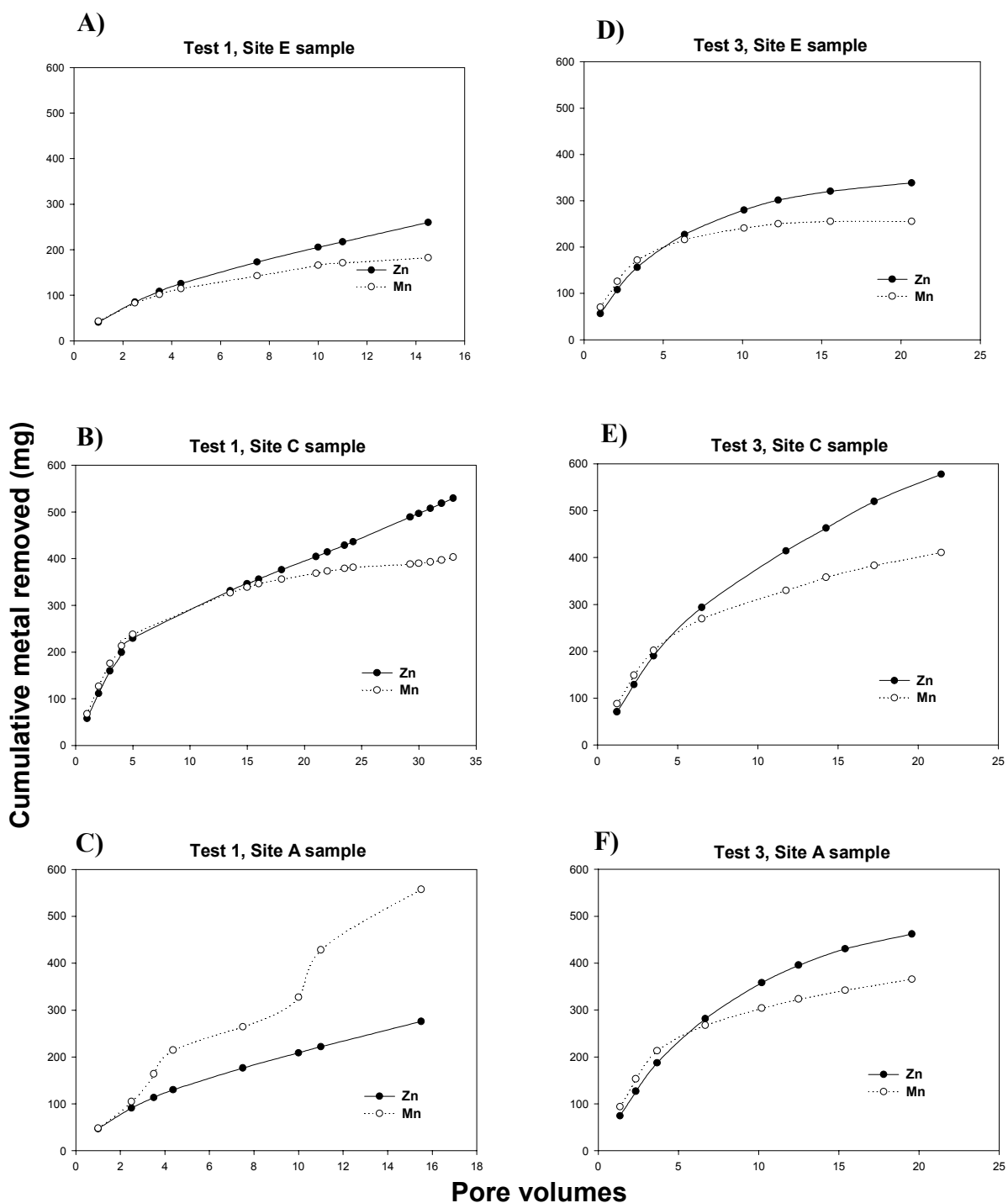


Figure 4.14. Cumulative mass of zinc and manganese removed from undiluted Galkeno 300 mine water permeant during duplicate column leaching tests (Tests 1 and 3). A-C) Zn, Mn mass removed during Test 1. D-F) Zn, Mn mass removed during Test 3.

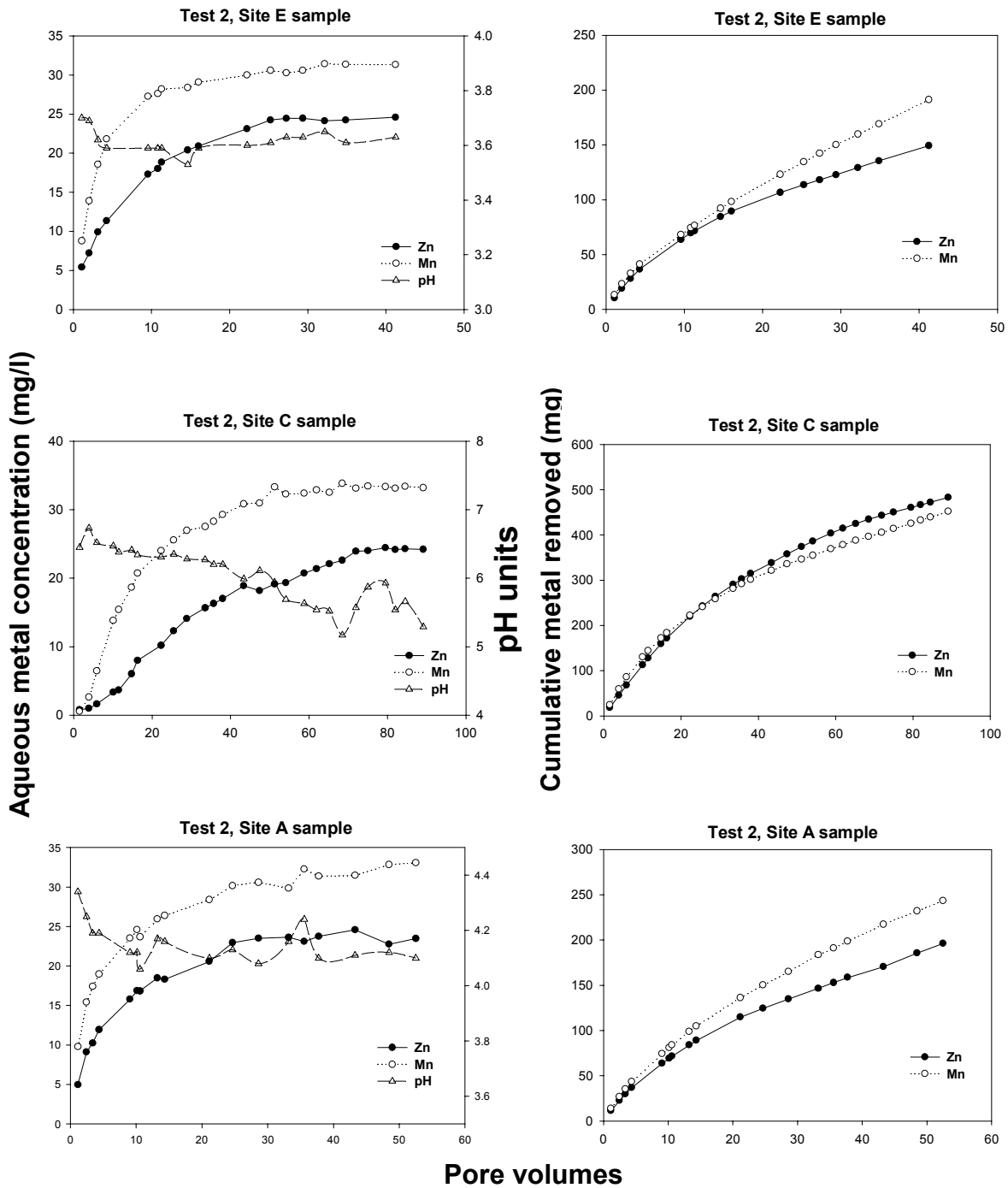


Figure 4.15. A-C) Summary of effluent Zn and Mn concentrations and pH with respect to number of pore volumes of diluted (30 ppm Zn) Galkeno 300 mine water passed during column leaching Test 2. D-F) Cumulative mass of zinc and manganese removed from permeant during Test 2.

equilibrium relative to Tests 1 and 3. That effluent metal and pH trends are similar across all three tests indicates that similar processes are acting in the three columns, representing two different metal concentrations that are experienced at the site. Figure 4.15 D-F) shows the cumulative mass of Zn and Mn removed from the permeant during Test 2. A rough comparison with Test 1 and 3 cumulative mass removal results in Figure 4.14 indicates that, at the number of pore volumes required to reach equilibrium effluent metal concentrations, similar masses of metal were removed. This indicates that, across the tested concentration range, metal attenuation processes within the columns were independent of concentration. Further, as in Tests 1 and 3, equilibrium metal concentrations in effluent were lower than influent metal concentrations. This once again suggests the coprecipitation of a manganese-zinc oxide as a equilibrium mechanism of attenuation.

4.2.3.2 Release of attenuated zinc from leaching columns

Following the conclusion of sorption tests, a stepped desorption test was undertaken on the undisturbed column used in Test 1 using 2000 $\mu\text{S}/\text{cm}$ CaSO_4 solution, initially adjusted to pH 5.5 (Test 4a). These conditions simulate a decrease in Galkeno 300 drainage pH, a condition which may arise following the exhaustion of calcium/magnesium carbonate buffers (Blowes and Ptacek, 1994). Under reducing conditions, mine drainage can be buffered at pH 5.5 through the dissolution of iron carbonate (siderite), which is why pH 5.5 was chosen as the initial pH of the desorption test. A further permeant pH reduction to pH 4.5 (Test 4B) was instituted after zinc release under pH 5.5 conditions stabilised at a low, near constant rate. Following consumption of siderite buffering capacity, mine drainage is commonly buffered at pH 4-4.5 through the

dissolution of aluminum hydroxide phases (Blowes and Ptacek, 1994); the second permeant pH value was selected on this basis.

Figure 4.16 A-C) shows the metal concentrations in Test 4a effluent. Metal concentrations declined rapidly in all three columns until 4-5 pore volumes of permeating solution were passed. Following this initial period of rapid metal release, effluent zinc and manganese concentrations declined at a markedly slower rate, indicated by the lower slopes of the curves in Figure 4.16 A-C) at later pore volumes. All trials in Test 4a were terminated between 15 and 19 pore volumes; the uniformity of the latter portions of the curves in Figure 4.16 A-C) suggest that conditions of kinetic equilibrium had been achieved in each column. Higher rates of Mn release from the site A sample, as indicated in Figure 4.16 C), are likely to due the large amount of Mn removed from the permeating solution during Test 1. Figure 4.14 C) displays the anomalous Mn uptake of this sample. Rationale for the behaviour of this particular sample was not investigated. Figure 4.16 D-F) shows the cumulative metal mass stripped from soil columns in Test 4a. These graphs indicate that rates of metal release were slowly declining, but remained significant at the termination of Test 4a; as Table 4.6 shows, substantial proportions of attenuated metal were released during Test 4a.

During Test 4b, permeant acidity was increased to pH 4.5. Figure 4.17 shows effluent metal concentrations and cumulative mass of Zn and Mn removed from the leaching columns. In all three samples, Zn displayed uniform release from soil solids with effluent concentrations decreasing with increasing numbers of pore volumes passed. Mn behaviour varied from constant

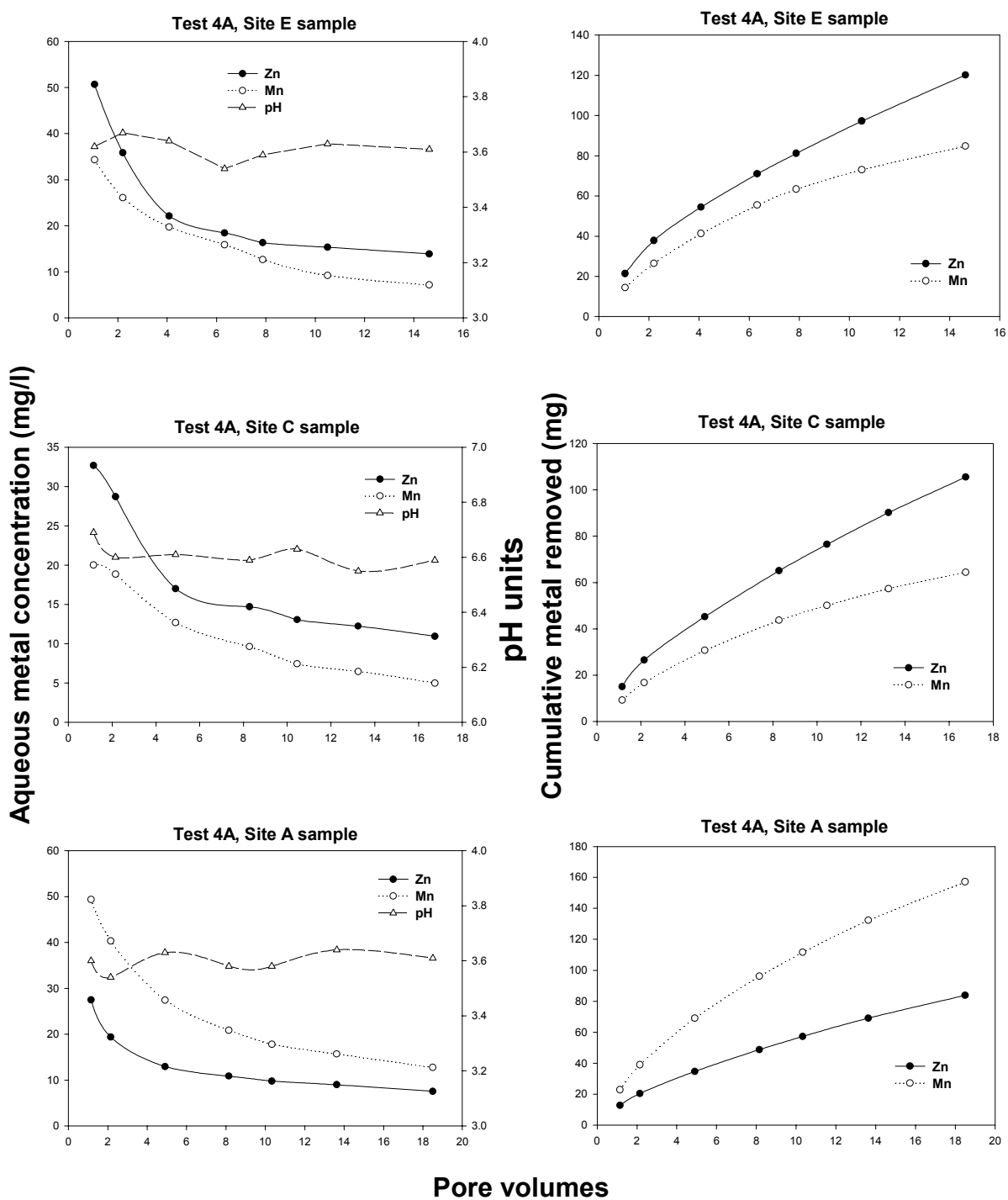


Figure 4.16. A-C) Summary of effluent Zn and Mn concentrations with respect to number of pore volumes of pH 5.5 passed during column desorption Test 4a. D-F) Cumulative mass of zinc and manganese removed from column during Test 4a.

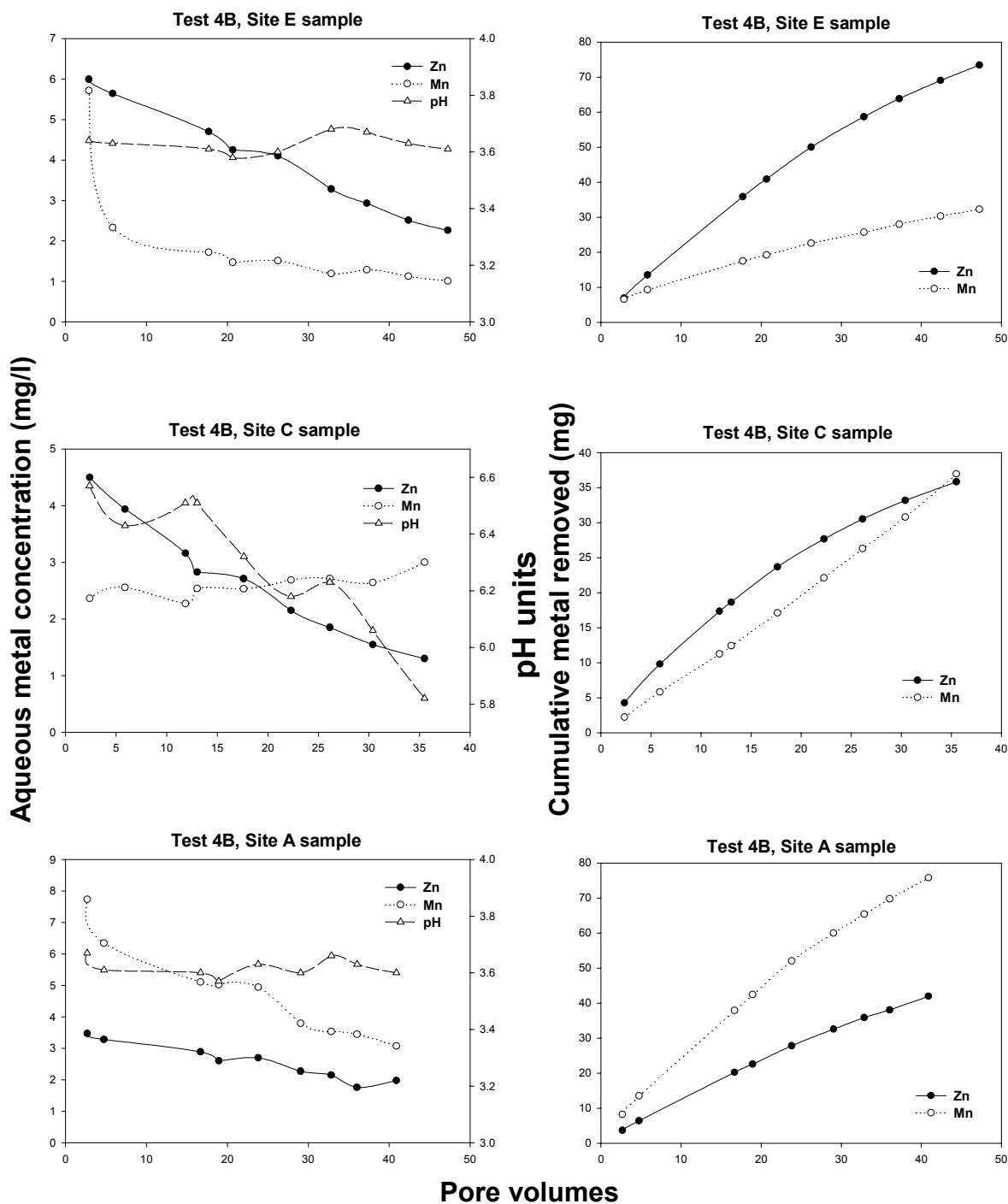


Figure 4.17. A-C) Summary of effluent Zn and Mn concentrations with respect to number of pore volumes of pH 4.5 passed during column desorption Test 4b. D-F) Cumulative mass of zinc and manganese removed from column during Test 4b.

Table 4.6. Summary of mass of Mn and Zn removed from solution by soil solids in Tests 1 and 3, and returned to solution in Test 4; values in brackets are percentages of Test 1 totals.

	<i>Sample Site</i>	Mass sorbed (mg)	Test 3 (for comparison)	Mass released (mg)	<i>Test 4b</i>	<i>Test 4 total</i>
		<i>Test 1</i>		<i>Test 4a</i>		
Mn	E	182	255	85 (47%)	32	117 (64%)
	C	403	411	64 (16%)	37	101 (25%)
	A	557	366	157 (28%)	76	232 (42%)
Zn	E	260	339	120 (46%)	73	193 (74%)
	C	529	577	105 (20%)	36	141 (27%)
	A	276	462	84 (30%)	42	126 (46%)

release rate in the Site C sample (Figure 4.17 B) to rapid initial release followed by a low, uniformly declining rate of release. Again, at the termination of Test 4b after 35 to 48 pore volumes, significant masses of Mn and Zn were being released; Table 4.6 displays the amount of total attenuated metal that was released in Test 4.

Test 4 simulates exposure of soil with attenuated zinc and manganese to increasingly aggressive solutions approximating the conditions which could be encountered during exhaustion of acid buffering capacity in a mine drainage setting. The design of the experiment was such that the samples in question were instantaneously exposed to solutions an order of magnitude more acidic; this is in all likelihood responsible for the rapid initial release of metals depicted in Figure 4.16. However, notwithstanding considerations of rates of release, Test 4 clearly indicates the potential for release of attenuated Zn and Mn from these soils under conditions of increasing acidity. Of note is the lower rates of removal and total attenuated metal release associated with the Site C sample; after the passage of over 55 pore volumes of increasingly aggressive

permeant, approximately $\frac{1}{4}$ of attenuated metal was remobilised. When compared with the metal remobilisation from Sites A and E (Table 4.6), it becomes obvious that Site C soils are an important geochemical barrier to aqueous metal movement through the soil system at the Galkeno 300 site.

4.2.4 Results of selective extraction of Galkeno 300 soils

As outlined in Chapter 3.2.4, low density organic matter within the Galkeno 300 soils necessitated that the individual stages of the selective extraction procedure be carried out on individual samples. The method of interpreting the results of the separate selective extractions is outlined in Figure 4.18; successive extractions are increasingly aggressive and destroy not only the target fraction but also those fractions removed by the preceding extractions. In the case of extraction #4 (the organic extraction), destruction of the oxide fraction is accomplished in the final step of the extraction when a reducing agent is added to dissolve any oxide solids that may have formed during the oxidation of the organic matter (Tessier et al., 1979).

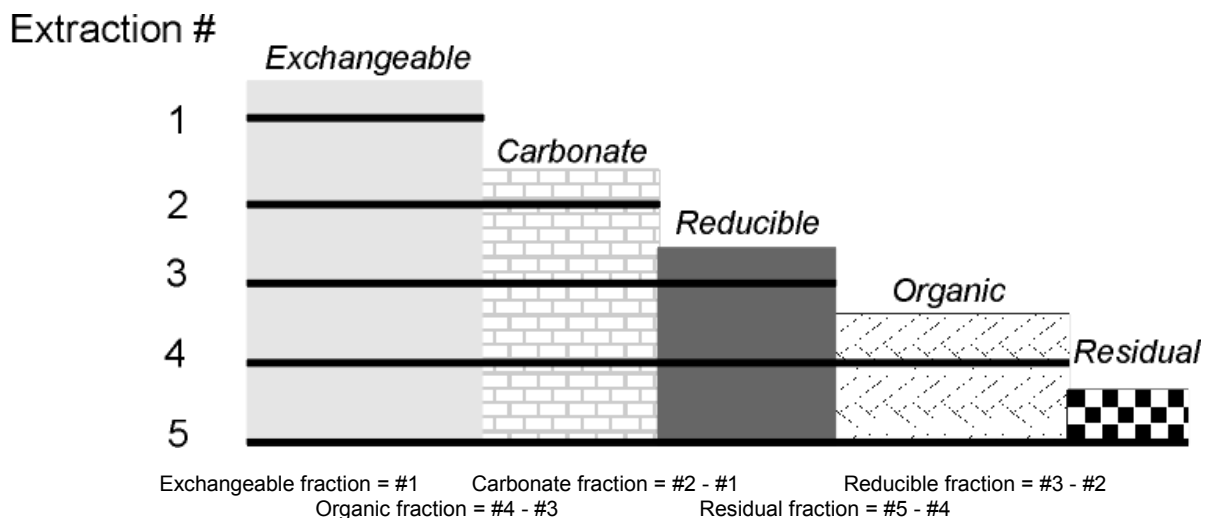


Figure 4.18. Method of interpretation of results of separate selective extraction procedure. Each successive extraction removes an additional fraction of metal from the soil solids.

Figure 4.19 shows the averaged results of duplicate extractions performed on organic and mineral samples collected at sites A, C and E; the absolute values used to generate those fractional proportions are provided in Appendix E. Figure 4.19 clearly shows that, in the surface organic horizons across the Galkeno 300 site, soil Zn is dominantly associated with the oxide and organic fractions. Exchangeable Zn constitutes 9.5-15% of total organic soil Zn; carbonate Zn is present only in Site C organic samples, which display the greatest degree of Zn accumulation (see Table 4.3). Zn in the residual fraction was not detected for any organic samples. In contrast, and as expected, all mineral samples displayed significant soil Zn associated with the residual fraction; the proportion of residual Zn is lowest in the Site C samples, which has the highest total Zn levels. The Site C mineral samples also displayed the highest proportion of organic bound Zn of the mineral soils, with soil Zn distributed equally between the organic and oxide fractions. The oxide fraction was important at Sites A and E as well, with 32 and 47% of total Zn, respectively.

The results from the Site C samples will be used for the purposes of further discussion. As Table 4.3 indicates, Site C organic samples approach 3%, by mass, of contained zinc. Visually, these samples consisted of a gritty, purplish black matrix in a skeleton of organic matter. Manganese oxides are typically purplish black in colour- the matrix of the Site C organic soils likely consists of these manganese-zinc oxides which have coprecipitated from the mine drainage. The geochemical conditions across the Galkeno site do not favour inorganic Mn oxide precipitation; it is therefore most likely that the precipitation process is microbially mediated

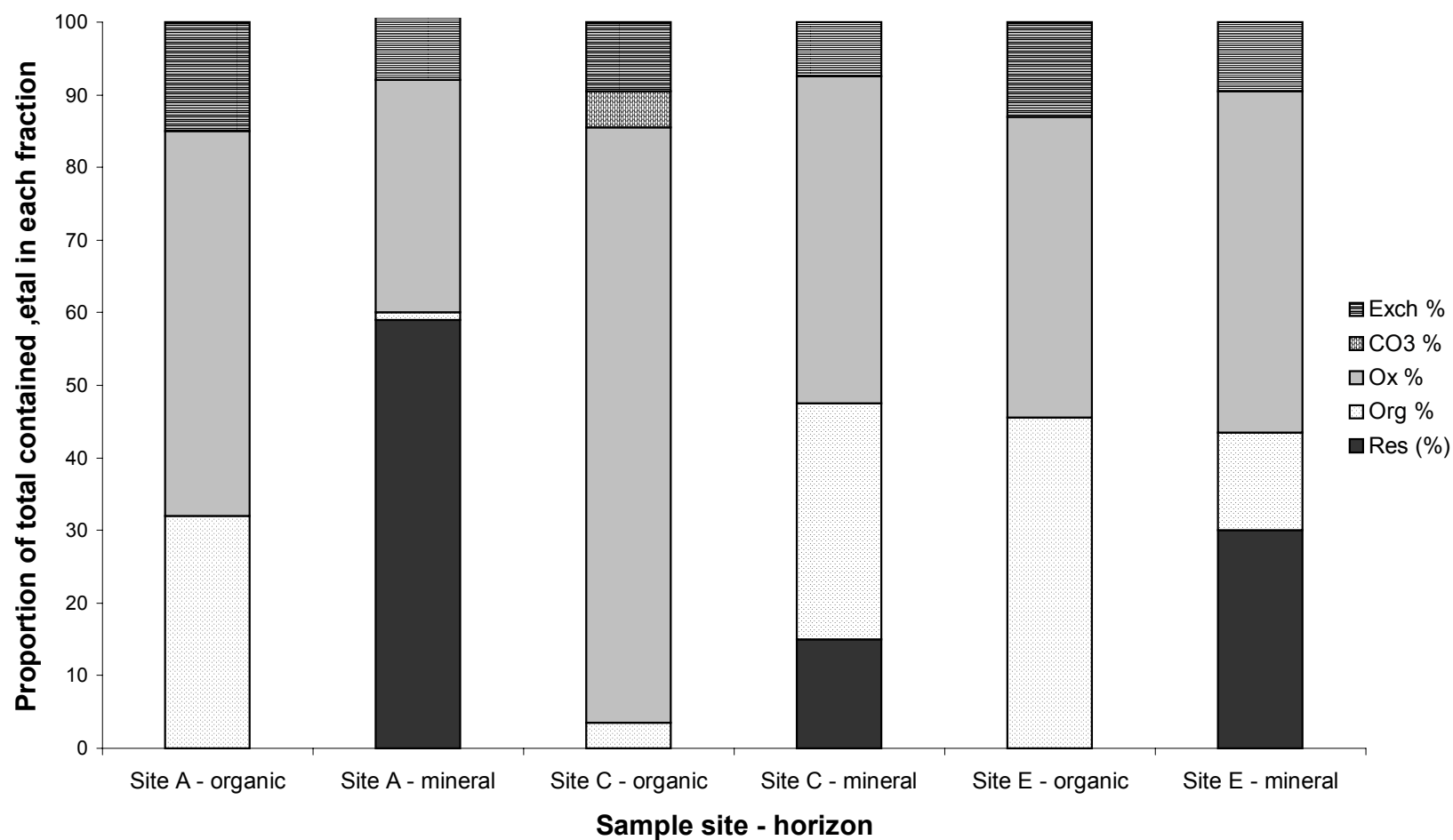


Figure 4.19. Average metal proportions in exchangeable, carbonate, oxide, organic and residual fractions of organic and mineral soils from soil sample sites A, C, and E at the Galkeno 300 site. Duplicate extractions were performed for each sample site.

(Harvey and Fuller, 1998; Bargar et al., 2000; Sikora et al., 2000; Stein et al., 2001). The anomalous soil metal concentrations and the dramatic decrease in aqueous Mn concentrations along the mine drainage flow path, together with the selective extraction results, indicate that the formation of Mn-Zn oxide coprecipitates is the most important process causing the removal of zinc from the Galkeno 300 mine drainage along its longitudinal flow path.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Field and laboratory investigations undertaken to examine the shallow soils and mine drainage of the Galkeno 300 site provide insight into the environmental fate of aqueous zinc carried by the Galkeno 30 adit discharge. The following discussions outline the conclusions of this study and the broader scientific context into which it fits. In addition, recommendations for further investigation are proposed.

5.1 CONCLUSIONS

The discussion of conclusions is best undertaken by examining first the conclusions arising from the site investigation, and secondly the conclusions arising from the laboratory investigations.

5.1.1 Conclusions from Galkeno 300 site investigation

The Galkeno 300 site investigation provided the physical and geographical framework for the broader study as a whole. Water sampling during summer 2000 and subsequent chemical analysis confirmed the removal of zinc from Galkeno 300 mine drainage along the 1.7 km flowpath between the adit and Christal Creek. This sampling also indicated where most of the zinc removal was occurring along this flowpath. Climate monitoring confirmed that precipitation inputs did not provide sufficient dilution to explain the decrease in aqueous concentrations; discharge monitoring of the drainage at Galkeno 300 adit and at Christal Creek

confirm that, on average, 16% of adit discharge volume is added via precipitation and baseflow. This degree of dilution falls far short of accounting for the decrease in aqueous zinc concentrations along the flowpath. The lack of observed surface and subsurface water inputs to the Galkeno 300 drainage, in combination with the precipitation and discharge monitoring, confirm that processes other than dilution are responsible for the attenuation of zinc from the Galkeno 300 drainage. In addition, observations of permafrost in soil pits supports the model of a frozen, impermeable surface at the base of the active layer which restricts Galkeno 300 drainage to shallow depths.

Chemical analysis of soils collected within and adjacent to the Galkeno 300 drainage show elevated Zn and Mn concentrations in those soils in contact with mine drainage. In particular, the upper organic horizon demonstrated particularly anomalous levels of Zn and Mn, indicating that this horizon was the repository for much of the attenuated zinc. Visual observation of Mn oxides in collected samples correlated with the highest measured zinc soil concentrations; the conclusion that Mn oxides play a significant attenuating role in the Galkeno 300 drainage was confirmed during the laboratory investigation via selective extraction.

5.1.2 Conclusions from Galkeno 300 laboratory investigation

The Galkeno 300 laboratory investigation provided an assessment of the physical and chemical properties of Galkeno 300 site soils and observed the interactions of these soils with natural and synthetic mine drainage solutions during specific laboratory procedures. Batch adsorption

testing demonstrated that the organic soils have a substantially higher adsorption capacity; in particular, site C samples containing high Mn concentrations had the highest adsorption capacity of all samples tested. These results clearly indicate that site C organic soil should be the primary candidate for material to be tested further for use in a mine drainage treatment system.

Column leaching tests confirmed that site C organic soils are the best substrate tested for the removal of zinc from natural and synthetic mine drainage; in addition, column testing indicated that a dynamic equilibrium process such as precipitation or coprecipitation was contributing to Zn removal from permeant. This lends additional support to the conclusion that Mn and Zn coprecipitation in the form of oxides provides an important control on Zn fate and transport in the Galkeno 300 drainage. Column desorption under conditions of decreasing pH demonstrated rapid initial release of Zn followed by an approach to equilibrium release rates at much lower concentrations. Total Zn released during desorption ranged from 27 to 74% of that removed during initial leaching tests; once again, soils from site C perform the most favourably, showing the lowest release of attenuated Zn of all samples tested. Initial rapid release of Zn under conditions of decreasing pH is likely an artifact of rapidly altered laboratory conditions; in the field setting, a decrease in pH is most likely to be gradual and as such would not trigger the rapid release observed in the lab. Notwithstanding the differences between field and laboratory conditions, the equilibrium release rates achieved in the column desorption result in aqueous Zn concentrations that are well above acceptable limits. The possibility of long term release of attenuated Zn cannot be ignored under conditions of increasing acidity.

The selective extraction testing indicated the importance of the oxide and organic soil fractions in regulating zinc fate and transport in the Galkeno 300 drainage. In the surface organic soils, these two fractions contain over 80% of all soil Zn in all samples assessed. Of note is the dominance of the oxide fraction for the site C sample; this location had by far the highest soil Zn concentrations, which makes the dominance of the oxide fraction that much more remarkable. The large decrease in aqueous Mn concentrations in the Galkeno 300 drainage indicates that the formation of Mn oxides is occurring under present environmental conditions in substantial amounts. Under near surface oxidising conditions, these newly formed precipitates are geochemically stable, and are unlikely to release structural zinc unless reducing conditions are prevalent for an extended duration. The exchangeable and carbonate Zn fractions, which are most susceptible to release under minor changes in environmental conditions, are relatively insignificant; that soil Zn is found dominantly in the oxide and organic fractions provides a greater measure of protection to the downstream receiving environment.

5.2 RESEARCH CONTRIBUTIONS

Results of this study are of value to case of the specific site studied, to other cases of mine drainage in permafrost regions, and to the broader body of scientific knowledge. These contributions are outlined as follows.

1. *Better understanding of fate and transport of Zn in Galkeno 300 drainage*

- a) The present study has quantified the mass flux of water and dissolved species from the Galkeno 300 adit to Christal Creek. In doing so, the measure of environmental protection achieved through natural attenuation of Zn in the shallow subsurface has been determined. This information may be useful for long term reclamation plans or waste management decisions.
- b) The surface organic soils occupying the Galkeno 300 flowpath have been shown to be the repository of attenuated zinc. Speciation of attenuated zinc has been determined via selective extraction, and geochemical stability has been inferred from that speciation.
- c) The presence of high concentrations of dissolved manganese in the mine drainage appears critical to the natural attenuation of zinc at this site.

2. *Application to similar mine sites in permafrost regions*

- a) Significant accumulations of partially decomposed organic material are common in permafrost regions. This research has demonstrated that this type of organic

material can play an important role in the fate and transport of metal species in mine drainage. Consideration of the locally available organic material when designing reactive walls or infiltration beds may be cost-effective; where permafrost restricts the downward infiltration of mine drainage, the organic material in the active layer can act in the fashion of a reactive barrier.

- b) Where Mn is present in mine drainage in significant quantities, removal of heavy metals may be enacted by altering conditions to favour Mn-oxide precipitation. Consideration of bacterial mediation in this process is important.

3. *Broader scientific context*

- a) Natural attenuation of metals in northern regions is little reported in the scientific literature. This work describes a case study of natural attenuation of zinc in mine drainage setting in the discontinuous permafrost zone which will add to the small body of work on this subject.
- b) The identification of the importance of Mn oxide precipitation within the Galkeno 300 system is an unusual example, as the high aqueous Mn concentrations found at the study site are not commonly observed.

5.3 RECOMMENDATIONS FOR FURTHER RESEARCH

In the context of the Galkeno 300 site, there are a number of points that may merit further consideration.

1. *Site conditions in winter*

The current study investigated the Galkeno 300 site during summer 2000. Geochemical behaviour of the system during the winter is largely unknown. Measurement of winter flow volumes exiting Galkeno 300 adit and entering Christal Creek should be undertaken; at the same time, sampling should be undertaken to assess winter water quality.

2. *Site conditions during freshet*

The current study caught the falling limb of the spring freshet hydrograph. Monitoring of the early freshet (rising limb of the hydrograph) would allow an assessment of whether mine drainage and associated dissolved metals accumulated as ice during the winter. If this occurs, the spring thaw may result in a flush of high concentrations of dissolved metals that have not been intimately in contact with the soil substrate. Water quality during the early freshet should be monitored.

3. *Geochemical modeling*

Consider evaluating the long term scenario using a computerised geochemical model such as PHREEQC. Consider effect of long term increase in acidity on attenuated zinc.

4. *Investigate likelihood of ARD onset*

At this time, it is unclear whether the Galkeno300 drainage will become increasingly acidic with time. The pH of the mine drainage is likely the single most important factor in the

natural protection of the receiving environment. A comprehensive investigation into the acid-generating and neutralizing capacities of the mine workings and waste rock will give a better feel for this important parameter.

5. *Use of soils in treatment facilities*

Consideration should be given to using soils from site C (or similar) in some form of treatment facility, either in situ or ex situ. The potential for these soils as a substrate for constructed wetlands should be investigated, as should their use as part of a conventional treatment system (perhaps in a pretreatment role).

Finally, in a more general context, the utility of dissolved Mn and appropriate bacteria as a component of a treatment plant should be considered. Where dissolved Mn is available, either in a mine drainage context or as a component of some other waste stream, there is potential for coprecipitation of Zn and other heavy metals through the introduction of conditions conducive to the precipitation of Mn oxide.

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APPENDIX A WATER SAMPLE SITE LOCATIONS AND DESCRIPTIONS

Sites at which water samples were collected during the site investigation are briefly described.

Table A1 provides the UTM coordinates of each site.

Table A1. Influent conditions of column leaching tests.

Site name	Site #	Easting*	Northing*
Galkeno 300 adit	11	482704	7088589
Sinkhole near Pole 500	10	482983	7088604
Seep near Pole 500	9	482986	7088601
Seep @ road piezo	8	483512	7088721
Seep 5	7	483461	7088576
Seep 8	6	483442	7088491
Old road at ROW crossing	5	483672	7088333
Seep 6+120	4	483755	7088296
Old road seep RHS limit	3	483817	7088047
Old road seep LHS limit	2	486847	7088079
300 drainage at Christal Creek	1	483977	7088356

*Universal Transverse Mercator grid, Zone 8V

Sample site descriptions

Galkeno 300 adit (site 11, Fig. 3.1.3.1): Flow exits Galkeno 300 adit and crosses waste rock dump before cascading over the edge of the dump. At adit mouth, flow is somewhat channelised and up to 20 cm deep. A short distance downstream, flow fans out to cover a wide area rarely deeper than 2-3 cm. Flowpath is marked by abundant yellowish orange to dark reddish orange iron oxide precipitate, miscellaneous wood and metal debris from mining operations and pebble-sized angular waste rock. Precipitate was actively forming over the course of the field season.

Sinkhole near Pole 500 (site 10, Fig. 3.1.3.1): This site marks the downstream limit of surface flow from adit. Water flowing parallel to power line right-of-way (ROW) is completely captured by a hole in the ground 20 m west of Pole 500. Flow to this point has been over the disturbed surface of the ROW, up to 3 cm deep; recent orange precipitate is evident over entire flowpath to this point. Surficial material is angular bedrock blocks with a matrix of angular bedrock chips, sand and silt, covered with a thin layer of organic rich soil (loam). Some grasses growing in flow.

Seep near Pole 500 (site 9, Fig. 3.1.3.1): This site is 4 m south of '*Sinkhole near Pole 500*', 15 m east-southeast of Pole 500, and marks the emergence of adit drainage that had percolated into the shallow subsurface upslope. No precipitate whatsoever was noted to have formed from the water exiting the ground at this location; during the mid- to late summer, an abundance of filamentous green algae was noted to be growing in the flow. Flow is spread out over 3 to 5 m, rarely greater than 3 cm deep. A comparison of the water quality between this site and the adjacent '*Sinkhole near Pole 500*' site testifies to the capacity of the subsurface materials to attenuate transported metals.

Seep @ road piezo (site 8, Fig. 3.1.3.1): Cut bank seepage pools in roadway 300 m north of ROW on Upper Old Road to a depth of 4 cm. During early June, flow spilled over downslope edge of road; by mid-June, entire flow was seeping into road surface. Road surface was covered with leaf litter; no sediment, filamentous green algae or orange precipitate was noted at this site.

Seep 5 (site 7, Fig. 3.1.3.1): Seepage from cut bank pools on Upper Old Road and flows over downslope edge 156 m north of ROW. Minor filamentous green algae noted at this site; during early June, large ice remnants on road were observed to have been stained by green algae. Recent fine sand and silt is present on bed of flow and there is no evidence of orange precipitate. Willows and grasses are common in the 2-3 cm deep flow.

Seep 8 (site 6, Fig. 3.1.3.1): Seepage from numerous places in the cut bank of the Upper Old Road coalesces to form a 5-8 cm deep channelised flow on the upslope (west) side of the road 75 m north of ROW. The bed of this flow is marked by leaf litter and by midsummer was coated with a similar green filamentous algae as observed at 'Seep near Pole 500'; no orange precipitate was evident. Willows and grasses grow in the flow, which does not flow over the road but rather seeps into the road surface at a local depression.

Old road at ROW crossing (site 5, Fig. 3.1.3.1): Channelised flow incised into moss flows around willow and dwarf birch; grasses growing on margins of flow are common. Flow varies from 10 to 40 cm deep and forms a series of 20 to 60 cm-wide branching channels. No sediment, orange precipitate or green filamentous moss is evident here. The flow above and below this site follow the Lower Old Road. The road is likely an early wagon trail in use during the early days of mining in the district and remains at present a topographic low that captures the adit drainage flow. The flow at this site appears to be the downstream expression of the flow at 'Seep 8'.

Seep 6+120 (site 4, Fig. 3.1.3.1): The flow here averages 4 cm in depth and occupies a well-defined channel, which is partially incised into the moss layer and has formed a bed of compact silt and fine sand. There is evidence of old orange precipitate in the bed sediment, but no recent precipitation has occurred and the grasses, moss and willows in the flow are unstained by oxide formation. No filamentous green moss is evident. This flow is the downstream expression of the flow at 'Seep 5' and represents the downstream limit of adit discharge flow prior to entering the recently excavated ditches on the lower slope of the study site. Immediately below this site, the flow encounters a 1.2 m drop where aeration likely occurs.

Old road seep RHS limit (site 3, Fig. 3.1.3.1): The flow at this site occupies the remnants of an old road that connects to 'Old road at ROW crossing'. The flow is on surface between these two sites, flowing spread out across the road through moss, grasses, willow and dwarf birch. No sediment, precipitate or green algae are noted along this entire flowpath. Significant flow likely occurs through the top layers of moss that are highly permeable.

Old road seep LHS limit (site 2, Fig. 3.1.3.1): This flow exits the subsurface 2m down the bank of a small thermokarst depression situated immediately above the Galkeno 900 access road. Fine sand, silt, and partially decomposed organics are deposited where the flow reaches the base of the depression where it forms a small thermokarst lake and a miniature delta. No precipitate or green filamentous algae are present at this site. The depression has formed by the local melting of permafrost and will continue to enlarge until caving of the banks is sufficient to insulate the remaining permafrost from further decay. This flow originates at 'Old road at ROW crossing' and enters the subsurface shortly thereafter.

300 drainage at Christal Creek (site 1, Fig. 3.1.3.1): The flow here occupies an incised channel into the recent floodplain of Christal Creek. The site is 20 m above the confluence of the Galkeno drainage with Christal Creek; water quality here determines the contaminant loading to the creek and defines the attenuation factor attributed to the flowpath downstream of the Galkeno 300 adit. No precipitate or green filamentous algae are present. Fine sand, silt and organics appear to have been deposited by the Galkeno flow; this sediment is originating largely from the erosion occurring in the recent ditching on the lower slopes above the highway.

APPENDIX B CALCULATIONS FOR LEACHING CELL PARAMETERS

Sample calculations for water content, specific gravity, the mass of solids in a leaching cell and the pore volume of a packed leaching cell.

Water content

Moist sample placed in weighed container, weighed to give total soil mass:

$$(\text{container mass} + \text{moist soil mass}) - \text{container mass} = \text{total soil mass } (M_T).$$

Oven dry sample at 105° C for at least 16 hours. Weigh container + dry sample.

Calculate mass of water and mass of solids:

$$(\text{container mass} + \text{moist soil mass}) - (\text{container mass} + \text{dry soil mass}) = \text{mass of water } (M_W)$$

$$(\text{container mass} + \text{dry soil mass}) - \text{container mass} = \text{mass of solids } (M_S).$$

Finally, calculate water content (W):

$$W = M_W / M_S.$$

Specific Gravity

The specific gravity of organic samples was required to calculate the volume of pore space in a packed leaching cell. These determinations were conducted following the method of Lambe (1951); this method is based on quantitative measurement of volumetric displacement of water by a known mass of soil particles. A 1000 ml volumetric flask was used as a pycnometer.

The formula used for the calculation of specific gravity is

$$G_s = (W_s G_T) / W_s - W_1 + W_2$$

where G_s is specific gravity, W_s is the mass of oven dried soil, G_T is the specific gravity of water at the temperature of the test, W_1 is the mass of the soil, the pycnometer and water to the appropriate volume (1000 ml), and W_2 is the mass of the pycnometer and the appropriate volume of water (1000 ml) without soil.

Leaching Cell Volume

Volume of a cylinder (V) = $\pi (d/2)^2 H$

Leaching cell: $H = 5.69$ cm; $d = 10.1$ cm

$$V = \pi * (10.1 \text{ cm}/2)^2 * 5.69 \text{ cm} = 456 \text{ cm}^3$$

Mass of solids in leaching cell

Determine water content (W) of sample.

Determine mass of empty leaching cell (M_C).

Pack cell with moist soil; weigh again to determine mass of cell + moist soil (M_{C+T}).

Determine mass of moist soil in cell:

$$M_{C+T} - M_C = M_T$$

Since $M_T = M_W + M_S$, $W = M_W / M_S$ and $W * M_S = M_W$, then the equation

$$M_T = (W * M_S) + M_S = (1 + W) * M_S$$

can be used to determine the mass of solids in the leaching cell.

Pore volume of leaching cell

The volume of the leaching cell that is not occupied by soil solids is known as the void space, the pore space or the pore volume. This is a useful quantity to know; the volume of permeant passing through a leaching cell can be usefully characterised in terms of number of pore volumes.

Given the total volume of a leaching cell (V_T) and the volume of a packed cell occupied by soil solids (V_S), the pore volume (V_V) is easily calculated from the relationship

$$V_T = V_V + V_S.$$

The quantity V_T is known from measurements of the leaching cell. The volume of solids can be calculated from the mass of the solids and the specific gravity of those solids using

$$M_S * G_S = V_S.$$

From this result, it is a simple matter to determine the pore volume using

$$V_T - V_S = V_V.$$

**APPENDIX C.1 WATER QUALITY DATA ORGANISED BY
SAMPLING DATE**

Organisation of results of water quality sampling by sampling date allows easy examination of changes in water quality spatially. The following data is organised such that the data from the main flowpath (sites 11-9-6-5-3-1, Figure 3.1.3.1) is presented to the left side of the tables, in order of increasing distance of sampling site from adit. Thus, reading values from left to right in this section of the table is analogous to moving from the adit down the hillside to the creek in the valley bottom. Remaining data, including quality control results, is presented at the right side of each table; the vertical break in the tables separates the two subsets of data.

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743

June 6-00

		Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit A	Above Christal Ck. Confluence
Acidity to pH 4.5	<	1	<	1	<	1	<
Acidity, total		248	181	60	9	4	6
Alkalinity to pH 4.5		14.9	1.3	3.6	38.3	35.1	46.2
Cl-	<	10	0.6	0.3	0.2	0.2	0.2
F	<	0.01	0.07	<	0.01	0.02	0.02
SO4		2,380	1240	1165	776	831	867
Br	<	5	<	0.05	<	0.05	<
Nitrate	<	0.2	0.7	0.192	0.111	0.013	0.059
Nitrite	<	0.005	<	0.005	<	0.005	<
P	<	5	<	0.05	<	0.05	<
pH		6.19	5.62	6.40	7.45	7.41	7.51
FR		1,960	1600	1600	1390	1210	1270
NFR		65	121	<	5	5	2750
Spec. Cond.		1,890	1640	1680	1550	1370	1430
GFAA (dissolved):							
Se	<	0.001	<	0.001	<	0.001	<
GFAA (total):							
Se	<	0.001	<	0.001	<	0.001	<
Hardness, Ca+Mg		653	686	961	907	794	851
Hardness, total		1,270	1020	1048	914	795	857
ICP, dissolved							
Al		0.17	0.21	<	0.05	<	0.05
Sb		0.34	0.27	0.10	<	0.05	<
As		0.11	<	0.05	<	0.05	<
Ba		0.006	0.016	0.022	0.027	0.026	0.120
Be		0.003	0.003	0.005	0.005	0.004	0.008
B		0.09	<	0.01	<	0.01	0.01
Cd		0.388	0.436	0.028	<	0.005	<
Ca		192.0	206	300.2	284	246	264
Cr		0.035	0.015	<	0.005	0.009	0.008
Co		0.137	0.012	<	0.005	<	0.005
Cu	<	0.005	0.050	<	0.005	<	0.005
Fe		35.7	<	0.005	<	0.005	1.47
Pb	<	0.05	<	0.05	<	0.05	<
Mg		42.1	41.6	51.3	48.1	43.5	46.7
Mn		191	93.7	18.2	0.028	0.001	0.390
Mo	<	0.01	<	0.01	<	0.01	<
Ni		1.72	1.01	0.27	<	0.02	<
P		1.0	0.5	0.2	<	0.1	<
K		0.7	1.0	1.4	1.1	0.9	0.9
Se		0.51	0.27	<	0.05	<	0.05
Si		4.29	5.50	6.26	5.00	4.28	4.29
Ag		0.03	0.02	<	0.01	<	0.01
Na		1.5	1.6	1.9	1.9	1.7	1.8
Sr		0.277	0.414	0.619	0.568	0.463	0.499
S		387	329	337	273	244	262
Sn	<	0.05	<	0.05	<	0.05	<
Ti	<	0.002	<	0.002	<	0.002	0.006
V	<	0.01	<	0.01	<	0.01	<
Zn		136	104	34.9	4.14	0.364	1.45
ICP, Total							
Al		0.28	2.81	<	0.05	<	0.05
Sb		0.31	0.26	0.08	<	0.05	<
As		0.21	<	0.05	<	0.05	<
Ba		0.008	0.084	0.022	0.027	0.028	1.04
Be		0.003	0.003	0.005	0.005	0.004	0.002
B		0.09	0.01	<	0.01	<	0.01
Cd		0.396	0.450	0.031	<	0.005	<
Ca		190	211	296	288	240	330
Cr		0.030	0.018	<	0.005	<	0.005
Co		0.138	0.008	<	0.005	<	0.005
Cu	<	0.005	0.072	<	0.005	<	0.005
Fe		39.7	2.47	<	0.005	0.036	0.055
Pb		0.08	<	0.05	<	0.05	<
Mg		42.6	43.6	51.5	49.2	43.2	70.4
Mn		201	102	18.5	0.027	0.003	1.71
Mo	<	0.01	<	0.01	<	0.01	<
Ni		1.78	1.07	0.28	<	0.02	<
P		1.0	0.6	0.2	<	0.1	<
K		0.8	1.5	1.4	1.2	0.9	5.8
Se		0.49	0.28	<	0.05	<	0.05
Si		4.46	9.48	6.25	5.16	4.22	60.5
Ag		0.03	0.02	<	0.01	<	0.01
Na		1.6	1.8	1.9	2.0	1.7	3.8
Sr		0.277	0.431	0.617	0.578	0.460	0.687
S		407	352	347	278	238	257
Sn	<	0.05	<	0.05	<	0.05	<
Ti		0.005	0.089	<	0.002	0.003	1.37
V	<	0.01	<	0.01	<	0.01	<
Zn		145	114	34.9	4.43	0.372	2.92
TIC		17.1	4.0	1.9	8.9	8.2	10.8
TOC	<	0.5	1.1	3.3	3.9	6.5	6.5
PO4		0.006	0.108	0.025	<	0.002	2.20
Field parameters:							
Water temp. (°C)		2.9	0.8	0.6	4.0	2.0	3.1
pH		5.89	5.12	5.73	6.68	6.56	6.52
Spec. cond. (uS/cm)		1820	1471	1590	1479	1404	1327
Cond. (uS/cm)		1050	800	860	880	790	770

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743

June 20-00	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage at Christal Ck
Acidity to pH 4.5	< 1 <	1 <	1 <	1 <	1 <	1
Acidity, total	267	217	71	14	4	5
Alkalinity to pH 4.5				42.5	29	56.3
Alkalinity, total	< 0.5 <	0.5	0.9			
Cl-	< 2 <	2 <	2 <	2 <	2 <	2
F	0.2 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
SO4	1180	1210	1160	1000	848.4	898.3
Br	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Nitrate	0.30	0.42	0.29	0.25 <	0.002	0.09
Nitrite	< 0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005
P	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
pH	5.49	5.08	5.8	7.62	7.37	7.61
FR	1,800	1840	1720	1560	1310	1410
NFR	45 <	5 <	5	69 <	5	958
Spec. Cond.	1,680	1750	1830	1770	1434	1298
GFAA (dissolved):						
Se	< 0.001 <	0.001 <	0.001 <	0.001 <	0.001 <	0.001
GFAA (total):						
Se	< 0.001 <	0.001 <	0.001 <	0.001 <	0.001 <	0.001
Hardness, Ca+Mg	577.7	791.4	999.0	1048.5	904.3	974.6
Hardness, total	1,161.5	1210.0	1098.8	1066.7	907.3	979.9
ICP, dissolved						
Al	0.39	0.23 <	0.05	0.06 <	0.05 <	0.05
Sb	0.34	0.31	0.10 <	0.05 <	0.05 <	0.05
As	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba	0.007	0.012	0.017	0.027	0.029	0.094
Be	0.003	0.004	0.005	0.006	0.005	0.005
B	0.06	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Cd	1.616	0.580	0.027	0.009 <	0.005 <	0.005
Ca	173.3	245.7	321.4	337.6	286.1	305.7
Cr	0.024	0.019 <	0.005 <	0.005 <	0.005 <	0.005
Co	0.105	0.009 <	0.005 <	0.005 <	0.005 <	0.005
Cu	0.096	0.081 <	0.005 <	0.005 <	0.005 <	0.005
Fe	24.7 <	0.005 <	0.005	0.039	0.016	0.429
Pb	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg	35.2	43.2	47.7	49.9	46.1	51.3
Mn	176.3	124.5	20.1	1.153	0.004	0.318
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	1.65	1.43	0.30	0.03 <	0.02 <	0.02
P	1.0	0.8	0.2 <	0.1 <	0.1 <	0.1
K	0.7	1.0	0.9	0.9	0.7	0.9
Se	0.35	0.33 <	0.05 <	0.05 <	0.05 <	0.05
Si	4.71	6.01	6.46	5.86	5.07	4.63
Ag	0.03	0.02 <	0.01	0.01 <	0.01 <	0.01
Na	1.6	1.9	2.1	2.2	1.9	2.0
Sr	0.228	0.424	0.599	0.609	0.537	0.568
S	377	396	370.7	299.5	267.6	284.1
Sn	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	< 0.002	0.007 <	0.002 <	0.002 <	0.002 <	0.002
V	< 0.01 <	0.01 <	0.01	0.02 <	0.01 <	0.01
Zn	141.4	124.3	40.8	9.87	1.59	2.08
ICP, Total						
Al	0.77	0.30	0.06	1.17 <	0.06	13.71
Sb	0.35	0.34	0.14 <	0.06	0.07 <	0.06
As	0.11 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba	0.006	0.011	0.022	0.059	0.028	0.391
Be	0.003	0.004	0.005	0.005	0.004	0.003
B	0.06	0.01 <	0.01 <	0.01 <	0.01	0.06
Cd	1.470	0.512	0.035	0.011 <	0.006	0.015
Ca	158.5	224.0	318.4	311.7	267.1	261.5
Cr	0.024	0.013 <	0.006 <	0.006 <	0.006	0.019
Co	0.123	0.016 <	0.006 <	0.006 <	0.006	0.016
Cu	0.100	0.075 <	0.006 <	0.006 <	0.006	0.034
Fe	26.8 <	0.006 <	0.006	1.344	0.012	23.9
Pb	0.15 <	0.06 <	0.06 <	0.06 <	0.06	0.07
Mg	35.7	45.4	54.4	53.2	46.2	49.2
Mn	165.9	120.1	20.5	1.180	0.001	0.650
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	1.57	1.33	0.32	0.03 <	0.02	0.04
P	1.0	0.8	0.3 <	0.1 <	0.1	1.0
K	0.8	1.1	1.4	1.4	0.8	2.7
Se	0.36	0.27 <	0.06 <	0.06 <	0.06 <	0.06
Si	4.38	5.64	6.54	7.07	4.65	24.02
Ag	0.03	0.02 <	0.01 <	0.01 <	0.01 <	0.01
Na	1.5	1.7	2.0	2.1	1.8	2.7
Sr	0.227	0.436	0.668	0.633	0.530	0.528
S	334	362	364.5	334.1	279.8	240
Sn	< 0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti	< 0.002 <	0.002 <	0.002	0.034 <	0.002	0.506
V	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.04
Zn	136.6	123.8	37.4	8.67	1.40	2.38
TIC	3.2	3.5	2.2	7.8	6.6	12.2
TOC	< 0.5	0.6	2.5	2.6	5.7	4.9
PO4	< 0.002 <	0.002	0.009	0.061	0.010	0.88
Field parameters:						
Water temp. (°C)	3.3	3.8	1.1	1.8	5.1	4.8
pH	6	5.2	5.9	7.2	7.2	7.7
Spec. cond. (uS/cm)	1680	1673	1750	1573	1434	1298
Cond. (uS/cm)	980	990	960	880	880	790

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743

July 5-00

		<i>Galkeno 300 adit</i>	<i>Seep nr. Pole 500</i>	<i>Seep 8</i>	<i>Old Rd. AT ROW Xing</i>	<i>Old Rd. Seep RHS Limit</i>	<i>300 drainage @ Christal Ck.</i>
Acidity to pH 4.5							
Acidity, total		273	195	61	7	4	8
Alkalinity to pH 4.5	<	0.5	1.7	3.3	37	31.2	59.2
Cl-	<	6	5.1	6	6	6	6
F	<	0.01	0.01	0.01	0.01	0.01	0.01
SO4		1330	1240	1150	1030	850	943
Br	<	0.05	0.05	0.05	0.05	0.05	0.05
Nitrate		0.33	0.33	0.25	0.002	0.002	0.002
Nitrite	<	0.005	0.005	0.005	0.005	0.005	0.005
P	<	0.05	0.05	0.05	0.05	0.05	0.05
pH		4.90	5.71	6.16	7.44	7.37	7.53
FR		2,000	1870	1670	1540	1270	1450
NFR		53	5	5	5	5	848
Spec. Cond.		1,674	1805	1766	1670	1430	1570
Hardness, Ca+Mg		616	756	1030	1080.5	858	985.2
Hardness, total		1,287	1184.6	1120	1087.9	861.4	991.2
ICP, dissolved							
Al		0.3	0	0.07	0.05	0.07	0.06
Sb		0.40	0.33	0.13	0.05	0.05	0.05
As		0.08	0.05	0.05	0.05	0.05	0.05
Ba		0.012	0.011	0.025	0.029	0.022	0.106
Be		0.003	0.004	0.005	0.006	0.005	0.006
B		0.07	0.01	0.01	0.01	0.01	0.01
Cd		1.230	0.511	0.032	0.005	0.005	0.005
Ca		179.0	225	320	343.1	269.1	305.5
Cr		0.033	0.016	0.008	0.005	0.005	0.005
Co		0.123	0.005	0.005	0.005	0.005	0.005
Cu		0.038	0.075	0.005	0.005	0.005	0.005
Fe		27.5	0.005	0.005	0.005	0.006	0.643
Pb	<	0.05	0.05	0.05	0.05	0.05	0.05
Mg		41.0	47	56.2	54.3	45.2	54.0
Mn		214.76	135.1	15.4	0.081	0.001	0.385
Mo	<	0.01	0.01	0.01	0.01	0.01	0.01
Ni		1.78	1.31	0.28	0.02	0.02	0.02
P		1.3	0.8	0.2	0.1	0.1	0.1
K		0.8	1.1	1.4	0.9	0.4	0.9
Se	<	0.001	0.001	0.001	0.001	0.001	0.001
Si		4.8	5.8	6.94	5.44	4.29	4.08
Ag		0.03	0.02	0.01	0.01	0.01	0.01
Na		1.7	1.7	2.1	2.5	2.3	2.3
Sr		0.247	0.434	0.663	0.629	0.494	0.564
S		402	388	357	319	268	300
Sn	<	0.05	0.05	0.05	0.05	0.05	0.05
Ti	<	0.002	0.002	0.002	0.002	0.002	0.002
V	<	0.01	0.01	0.01	0.01	0.01	0.01
Zn		149.6	118.37	36.3	4.24	1.711	2.12
ICP, Total							
Al		0.73	0.24	0.06	0.06	0.06	13.1
Sb		0.43	0.33	0.12	0.06	0.06	0.06
As		0.2	0.06	0.06	0.06	0.06	0.07
Ba		0.005	0.009	0.021	0.039	0.03	0.451
Be		0.004	0.004	0.005	0.006	0.005	0.005
B		0.07	0.01	0.01	0.01	0.01	0.07
Cd		1.210	0.490	0.012	0.006	0.006	0.012
Ca		172	211	308	324	268	309
Cr		0.018	0.009	0.006	0.006	0.006	0.025
Co		0.121	0.022	0.006	0.006	0.01	0.018
Cu		0.054	0.078	0.006	0.006	0.006	0.055
Fe		32.1	0.006	0.006	0.105	0.025	28.1
Pb	<	0.06	0.06	0.06	0.06	0.06	0.06
Mg		38.7	43.1	52.9	55.3	47.4	59.1
Mn		194	120	15	0.093	0.005	0.919
Mo	<	0.01	0.01	0.01	0.01	0.01	0.01
Ni		2	1.28	0.27	0.02	0.02	0.05
P		1.4	0.9	0.2	0.1	0.1	0.8
K		0.7	1	1.2	1.2	0.6	2.9
Se	<	0.001	0.001	0.001	0.001	0.001	0.001
Si		5	6	7.15	5.14	4.93	24.1
Ag		0.04	0.02	0.01	0.01	0.01	0.01
Na		1.5	1.6	2.0	2.4	2.1	3.3
Sr		0.241	0.417	0.654	0.722	0.589	0.697
S		377	351	336	332	268	300
Sn	<	0.06	0.06	0.06	0.06	0.06	0.06
Ti	<	0.002	0.002	0.002	0.005	0.002	0.458
V	<	0.01	0.01	0.01	0.01	0.01	0.05
Zn		158.0	119.37	37.5	4.05	1.690	3.04
TIC		11.7	4.5	3.3	10.5	9	16.2
TOC	<	0.5	0.6	2.7	2.1	5.6	4.1
PO4	<	0.002	0.002	0.002	0.002	0.002	0.783
Field parameters:							
Water temp. (°C)		2.3	2.8	1.5	3.3	5.5	6.7
pH		5.9	5.39	6.06	6.83	6.77	6.89
Spec. cond. (uS/cm)		1939	1721	1785	1560	1451	1496
Cond. (uS/cm)		1100	990	990	910	900	960

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743
July 22- 00						
	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
Acidity to pH 4.5	< 1 <	1 <	1 <	1 <	1 <	1
Acidity, total	253	193	54	7	4	6
Alkalinity to pH 4.5	3.1	1.9	4.1	49.9	43.9	82.5
Cl-	< 5 <	5 <	5 <	5 <	5 <	6
F	< 0.5 <	0.5 <	0.5 <	0.5 <	0.5 <	0.6
SO4	1344.1	1260.6	1148.9	984	850.4	981
Br	< 2.6 <	2.6 <	2.6 <	2.6 <	2.6 <	3.0
Nitrate	< 0.10	0.43	0.30	0.31 <	0.1 <	0.1
Nitrite	< 0.26 <	0.26 <	0.26 <	0.26 <	0.255 <	0.3
P	< 2.6 <	2.6 <	2.6 <	2.6 <	2.6 <	3.0
pH	5.63	5.63	6.20	7.57	7.44	7.72
FR	2,090	1930	1700	1340	1230	1480
NFR	78 <	5 <	5	16 <	5	636
Spec. Cond.	1.890	1810	1740	1640	1390	1560
Hardness, Ca+Mg	625	838	1054	1069	765	946
Hardness, total	679	1287.5	1134.7	1077	768.3	951.1
ICP, dissolved						
Al	0.3	0	0.17	0.08 <	0.05	0.14
Sb	0.46	0.39	0.15 <	0.05 <	0.05 <	0.05
As	0.06 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba	0.012	0.014	0.013	0.039	0.019	0.078
Be	0.010	0.005	0.007	0.007	0.005	0.005
B	0.08	0.02 <	0.01 <	0.01 <	0.01 <	0.01
Cd	0.854	0.568	0.025	0.009 <	0.005 <	0.005
Ca	183.8	250.1	329.1	336.6	238.4	292.8
Cr	0.053	0.020 <	0.005 <	0.005 <	0.005 <	0.005
Co	0.129	0.009 <	0.005 <	0.005 <	0.005 <	0.005
Cu	0.012	0.094 <	0.005 <	0.005 <	0.005 <	0.0005
Fe	29.095 <	0.005 <	0.0005	0.011 <	0.0005	0.434
Pb	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg	40.4	51.3	56.4	55.5	41.3	52.2
Mn	206	130.8	12.8	0.167 <	0.001	0.429
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	1.74	1.48	0.24 <	0.02 <	0.02 <	0.02
P	1.2	1	0.3	0.1 <	0.1	0.1
K	0.8	1.2	0.7	1	0.4	0.8
Se	< 0.001 <	0.001 <	0.001 <	0.001 <	0.001 <	0.001
Si	4.2	6.8	7.16	5.93	3.92	3.66
Ag	0.04	0.02	0.02	0.01 <	0.01 <	0.01
Na	2.1	2	2.6	2.5	2	2.1
Sr	0.24	0.479	0.66	0.651	0.438	0.52
S	377	452	407.1	359.9	242	288.96
Sn	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	0.016	0.008 <	0.002 <	0.002 <	0.002 <	0.002
V	< 0.01 <	0.01	0.03	0.02 <	0.01	0.01
Zn	155	125.1	36.521	4.38	1.466	1.67
ICP, Total						
Al	0.37	0.12 <	0.06	0.14 <	0.06	8.31
Sb	0.4	0.24	0.1 <	0.06 <	0.06 <	0.06
As	0.18 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba	0.007	0.011	0.02	0.04	0.026	0.27
Be	0.003	0.003	0.005	0.005	0.004	0.004
B	0.09	0.01 <	0.01 <	0.01 <	0.01	0.03
Cd	0.766	0.505	0.029 <	0.006 <	0.006 <	0.006
Ca	177.3	218.9	304.5	287.9	246	297
Cr	0.041	0.016 <	0.006 <	0.006	0.009	0.009
Co	0.121	0.020 <	0.006 <	0.006 <	0.006 <	0.006
Cu	0.018	0.076 <	0.006 <	0.006 <	0.006	0.033
Fe	34.4 <	0.006 <	0.006	0.271	0.043	14.507
Pb	0.08 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Mg	41.6	45.7	53.2	49.8	44.4	56
Mn	194.9	119.8	12.39	0.166	0.002	0.7
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	1.73	1.29	0.24 <	0.02 <	0.02	0.03
P	1.1	0.7	0.2 <	0.1 <	0.1	0.6
K	0.8	1.1	1.1	1.1	0.7	2.1
Se	< 0.001 <	0.001 <	0.001 <	0.001 <	0.001 <	0.001
Si	4	5.72	6.61	5.36	4.27	15.4
Ag	0.03 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Na	1.6	1.7	2.3	2.2	1.9	2.7
Sr	0.231	0.424	0.621	0.578	0.454	0.54
S	379	369.9	334.9	291	237	267
Sn	< 0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti	0.002	0.005 <	0.002	0.003 <	0.002	0.274
V	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.03
Zn	146.6	119.5	33.872	3.743	1.534	2.34
TIC	7.3	4.2	2.9	13.2	12	21.9
TOC	< 0.5	0.5	2.6	2.2	5.8	4.2
PO4	0.046 <	0.002 <	0.002	0.007 <	0.002	0.430
Field parameters:						
Water temp. (°C)	2.9	4.4	7.3	2.1	5.5	5.7
pH	6.11	5.37	6.64	7.98	7.28	7.38
Spec. cond. (uS/cm)	1924	1812	1532	1595	1338	1394
Cond. (uS/cm)	1110	1090	1000	900	830	870
Flow (m³/3/s)	0.052					0.062
Flow (L/s)	6.31					8.16

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743

July 29- 00

		Galkeno 300 adit		Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
Acidity to pH 4.5	<	1		< 1	< 1	< 1	1
Acidity, total		268		56	7	4	7
Alkalinity to pH 4.5		5.0		4.9	60.6	48.7	80.6
Cl-	<	5		< 5	< 5	< 5	5
F	<	0.5		< 0.5	< 0.5	< 0.5	0.5
SO4		1440		1140	948	712	880
Br	<	3.0		< 3.0	< 3.0	< 3.0	3.0
Nitrate	<	0.10		< 0.30	< 0.20	< 0.1	0.1
Nitrite	<	0.3		< 0.3	< 0.3	< 0.3	0.3
P	<	3.0		< 3.0	< 3.0	< 3.0	3.0
pH		5.96		6.40	7.65	7.54	7.77
FR		2,110		1710	1460	1100	1390
NFR		75	<	5	45	5	959
Spec. Cond.		1,940		1760	1580	1135	1530
Hardness, Ca+Mg		680		997	868	738	919.7
Hardness, total		1,370		1070	894	741	924.6
ICP, dissolved							
Al		0.2		0.08	0.1	< 0.05	< 0.05
Sb		0.42		0.1	0.06	< 0.05	< 0.05
As		0.08	<	0.05	< 0.05	< 0.05	< 0.05
Ba		0.007		0.015	0.029	0.019	0.066
Be		0.004		0.006	0.006	0.004	0.005
B		0.10	<	0.01	< 0.01	< 0.01	< 0.01
Cd		0.802		0.029	< 0.005	< 0.005	< 0.005
Ca		201.0		313	279	229	282
Cr		0.070	<	0.005	< 0.005	< 0.005	< 0.007
Co		0.149	<	0.005	< 0.005	< 0.005	< 0.005
Cu		0.005	<	0.005	< 0.005	< 0.005	< 0.005
Fe		33.5	<	0.005	< 0.005	0.012	0.515
Pb	<	0.05	<	0.05	< 0.05	< 0.05	< 0.05
Mg		43.2		52.4	46.3	40.1	52.5
Mn		211.00		14.8	0.148	0.01	0.416
Mo	<	0.01	<	0.01	< 0.01	< 0.01	< 0.01
Ni		1.72		0.22	< 0.02	< 0.02	< 0.01
P		1.0		0.2	< 0.1	< 0.1	< 0.1
K		0.8		0.9	0.7	0.5	0.9
Se	<	0.001	<	0.001	< 0.001	< 0.001	< 0.001
Si		4.5		5.3	4.78	4.23	3.89
Ag		0.04		0.01	0.02	< 0.01	< 0.01
Na		1.4		2.6	2.4	1.9	2.1
Sr		0.261		0.584	0.530	0.437	0.532
S		480		392	286	245	312
Sn	<	0.05	<	0.05	< 0.05	< 0.05	< 0.05
Ti		0.004	<	0.002	< 0.002	< 0.002	< 0.002
V	<	0.01	<	0.01	< 0.02	< 0.01	< 0.01
Zn		161		31.8	3.48	1.48	1.65
ICP, Total							
Al		0.36		0.13	1.05	< 0.06	8.72
Sb		0.41		0.11	< 0.06	< 0.06	< 0.06
As		0.19	<	0.06	< 0.06	< 0.06	< 0.06
Ba		0.008		0.022	0.064	0.023	0.271
Be		0.004		0.005	0.005	0.004	0.004
B		0.1	<	0.01	0.01	< 0.01	0.04
Cd		0.769		0.029	< 0.006	< 0.006	< 0.006
Ca		195		324	303.0	224	294
Cr		0.073		0.009	< 0.006	< 0.006	< 0.008
Co		0.135	<	0.006	< 0.006	< 0.006	< 0.006
Cu		0.014	<	0.006	< 0.006	< 0.006	< 0.031
Fe		39.2	<	0.006	1.44	0.019	16.3
Pb	<	0.06	<	0.06	< 0.06	< 0.06	< 0.09
Mg		46.1		58.1	53.2	41.3	56.9
Mn		204		14.2	0.224	0.003	0.71
Mo	<	0.01	<	0.01	< 0.01	< 0.01	< 0.01
Ni		1.89		0.27	< 0.02	< 0.02	< 0.03
P		1.2		0.1	< 0.1	< 0.1	< 0.8
K		0.9		1.2	1.3	0.6	1.8
Se	<	0.001	<	0.001	< 0.001	< 0.001	< 0.001
Si		4.90		5.81	5.65	4.27	15.4
Ag		0.03	<	0.01	< 0.01	< 0.01	< 0.01
Na		1.5		2.5	2.4	1.8	2.5
Sr		0.274		0.617	0.573	0.42	0.539
S		427		357	296	228	281
Sn	<	0.06	<	0.06	< 0.06	< 0.06	< 0.06
Ti		0.003	<	0.002	0.028	< 0.002	0.291
V	>	0.01	<	0.01	< 0.01	< 0.01	0.03
Zn		151.0		32.7	3.88	1.440	2.41
TIC		9.9		3.1	14.5	11.5	20
TOC	<	0.5		2.2	2.3	6.4	4.7
PO4	<	0.002	<	0.002	0.013	< 0.002	0.72
Field parameters:							
Water temp. (°C)		3.1		4.2	2.8	4.7	4.4
pH		6.22		7.72	7.89	6.5	7.04
Spec. cond. (uS/cm)		3585		4847	1547	1220	798
Cond. (uS/cm)		2080		2900	890	740	480
ORP (mV)		265		335	250	267	98
Eh (mV) (calc'd)		464		534	449	466	297
Flow (m³/3/s)		0.055					0.06
Flow (L/s)		6.85					7.78

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743
Aug 4- 00						
	<i>Galkeno</i> 300 adit	<i>Seep nr.</i> <i>Pole 500</i>	<i>Seep 8</i>	<i>Old Rd. AT</i> <i>ROW Xing</i>	<i>Old Rd.</i> <i>Seep RHS</i> <i>Limit</i>	<i>300 drainage</i> <i>@ Christal</i> <i>Ck.</i>
Acidity to pH 4.5	< 1 <	1 <	1 <	1 <	1 <	1
Acidity, total	250	211	54	10	5	8
Alkalinity to pH 4.5	8.1	1.9	5.7	65.4	49.6	81.1
Cl-	< 5 <	5 <	5 <	5 <	5 <	5
F	< 0.5 <	0.5 <	0.5 <	0.5 <	0.5 <	0.5
SO4	1288	1230	1090	855	601	793
Br	< 2.6 <	2.6 <	2.6 <	2.6 <	2.6 <	2.6
Nitrate	< 0.10	0.52	0.35	0.40	< 0.1	< 0.1
Nitrite	< 0.26 <	0.26 <	0.26 <	0.26 <	0.26 <	0.26
P	< 2.6 <	2.6 <	2.6 <	2.6 <	2.6 <	2.6
pH	5.98	5.69	6.30	7.57	7.52	7.68
FR	2,060	1930	1690	1340	970	1280
NFR	62	12 <	5	114 <	5	501
Spec. Cond.	1.870	1790	1663	1494	1135	1429
Hardness, Ca+Mg	699	723.3	1019	910	663	859
Hardness, total	1,359	1165.2	1100.8	919	668	864
ICP, dissolved						
Al	0.2	0 <	0.05 <	0.05	0.17	0.27
Sb	0.41	0.39	0.19 <	0.05	0.09 <	0.05
As	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba	0.003	0.012	0.015	0.048	0.023	0.060
Be	0.004	0.010	0.013	0.010	0.011	0.010
B	0.09	0.01 <	0.01	0.01 <	0.01 <	0.01
Cd	0.706	0.503	0.024	0.011 <	0.005 <	0.005
Ca	203.0	215	316	262	210	267
Cr	0.031	0.023 <	0.005	0.012 <	0.005 <	0.005
Co	0.127	0.009 <	0.005	0.007 <	0.005 <	0.005
Cu	< 0.005	0.065 <	0.005	0.009 <	0.005 <	0.005
Fe	32.9 <	0.005 <	0.005	0.068	0.011	0.584
Pb	< 0.05 <	0.05 <	0.05	0.06 <	0.05 <	0.05
Mg	46.8	45.3	56.0	50.2	38.7	46.8
Mn	197.00	132.8	18.56	0.339	0.004	0.330
Mo	< 0.01 <	0.01 <	0.01	0.02 <	0.01	0.01
Ni	1.78	1.2	0.26	0.04 <	0.02 <	0.02
P	1.1	0.7	0.3 <	0.1 <	0.1 <	0.1
K	0.6	0.9	0.6	1.2	0.5	0.8
Se	< 0.001 <	0.001 <	0.05	0.07 <	0.05 <	0.05
Si	4.6	5.5	6.46	5.19	4.29	3.66
Ag	0.03	0.02	0.01 <	0.01	0.01 <	0.01
Na	1.7	2.1	2.8	2.1	1.9	2.3
Sr	0.277	0.411	0.62	0.566	0.415	0.472
S	399	393	350.1	260	199	259
Sn	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	< 0.002 <	0.002 <	0.002	0.015 <	0.002	0.007
V	< 0.01 <	0.01	0.03 <	0.01	0.03 <	0.01
Zn	157	129.8	30.9	4.62	1.37	1.49
ICP, Total						
Al	< 3	0.36 <	0.06	2.20 <	0.06	6.75
Sb	0.36	0.33 <	0.06 <	0.06 <	0.06 <	0.06
As	0.14 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba	0.006	0.021	0.029	0.097	0.021	0.221
Be	0.003	0.011	0.012	0.004	0.003	0.004
B	0.1	0.02 <	0.01 <	0.01 <	0.01	0.03
Cd	0.680	0.280	0.038	0.014 <	0.006	0.009
Ca	188	242	317	282.0	202	279
Cr	< 0.3	0.03	0.015 <	0.006 <	0.006 <	0.006
Co	0.136 <	0.006 <	0.006	0.012 <	0.006	0.009
Cu	0.009	0.089 <	0.006 <	0.006 <	0.006	0.023
Fe	37.1	0.012 <	0.006	3.28	0.009	13.7
Pb	< 0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Mg	37.1	51.5	57.6	50.5	37.6	53.8
Mn	199	135.9	17.24	0.515 <	0.001	0.647
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	2	1.44	0.3 <	0.02 <	0.02	0.03
P	< 5	0.8	0.2	0.2 <	0.1	0.6
K	0.8	1.2	1.2	1.36	0.6	1.7
Se	< 3 <	0.001 <	0.06 <	0.06 <	0.06 <	0.06
Si	6	7	6.92	8.18	4.36	13.4
Ag	0.03	0.02 <	0.01 <	0.01 <	0.01 <	0.01
Na	1.5	1.8	2.5	2.2	1.6	2.3
Sr	0.245	0.476	0.647	0.573	0.403	0.539
S	402	416.8	357.2	268	197	263
Sn	< 0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti	0.004	0.008	0.002	0.069 <	0.002	0.203
V	< 0.01 <	0.01	0.01	0.01 <	0.01	0.02
Zn	149.3	124.1	31.9	4.96	1.350	2.11
TIC	13.2	5.5	3.9	17.2	12.7	20.6
TOC	< 0.5	0.5	2.5	3.1	8.2	6.1
PO4	0.005	0.013 <	0.002	0.100	0.014	0.518
Field parameters:						
Water temp. (°C)	3.0	5.4	3.8	3.2	3.9	8.1
pH	6.83	5.81	7.09	7.73	7.81	7.26
Spec. cond. (uS/cm)	2368	2117	1994	1719	1365	1379
Cond. (uS/cm)	1370	1310	1180	1000	810	920
ORP (mV)	121	354	316.9	184	303	104
Eh (mV) (calc'd)	320	553	515.9	383	502	303
Flow (m³/3/s)	0.062					0.091
Flow (L/s)	8.16					14.22

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743
Aug 12-00	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
Acidity to pH 4.5	< 1 <	1 <	1 <	1 <	1 <	1
Acidity, total	274	215	53	11	5	8
Alkalinity to pH 4.5	7.2	2.2	7.2	57.4	53.7	90.6
Cl-	< 5 <	5 <	5 <	5 <	5 <	5
F	< 0.5 <	0.5 <	0.5 <	0.5 <	0.5 <	0.5
SO4	1450	1380	1190	1000	847	955
Br	< 3 <	3 <	3 <	3 <	3 <	3
Nitrate	< 0.1 <	0.4 <	0.1 <	0.1 <	0.1 <	0.1
Nitrite	< 0.3 <	0.3 <	0.3 <	0.3 <	0.3 <	0.3
P	< 3 <	3 <	3 <	3 <	3 <	3
pH	5.93	5.83	6.44	7.31	7.43	7.60
FR	2,060	1930	1710	1480	1280	1460
NFR	68 <	5	7	50 <	5	345
Spec. Cond.	1.980	1910	1790	1650	1440	1630
Hardness, Ca+Mg	613	824	1030	1090	837	1150
Hardness, total	1,320	1290	1100	1100	840	1160
ICP, dissolved						
Al	< 2.5 <	3	0.05 <	0.05 <	0.05 <	0.05
Sb	0.42	0.45	0.15	0.1 <	0.05 <	0.05
As	0.07 <	0.05 <	0.05	0.07 <	0.05 <	0.05
Ba	0.003	0.009	0.017	0.056	0.024	0.061
Be	0.002	0.005	0.006	0.006 <	0.001	0.006
B	0.07 <	0.01 <	0.01	0.02 <	0.01 <	0.01
Cd	0.600	0.562	0.029	0.027 <	0.005 <	0.005
Ca	177.4	242	321	344	258	359
Cr	< 0.25	0.250 <	0.005	0.041 <	0.005 <	0.005
Co	0.115 <	0.005 <	0.005	0.037 <	0.005 <	0.005
Cu	< 0.005	0.078 <	0.005	0.024 <	0.005 <	0.005
Fe	34.83 <	0.3 <	0.005	0.090 <	0.005	0.510
Pb	< 0.05 <	0.05 <	0.05	0.13 <	0.05 <	0.05
Mg	41.1	53.4	54.2	55.5	47.2	62.0
Mn	216.00	142.0	16.8	0.410	0.006	0.520
Mo	< 0.01 <	0.01 <	0.01	0.02 <	0.01 <	0.01
Ni	2.90	1.9	0.27	0.07 <	0.02 <	0.02
P	< 5 <	5	0.2 <	0.1 <	0.1 <	0.1
K	0.5	1.0	1.2	1.7	0.6	1.2
Se	< 2.5 <	3 <	0.05	0.26 <	0.05 <	0.05
Si	5.3	7.0	6.1	5.61	4.48	4.15
Ag	< 0.01	0.03	0.01	0.01 <	0.01 <	0.01
Na	0.8	0.9	2.8	2.7	0.9	2.3
Sr	0.244	0.48	0.597	0.640	0.500	0.627
S	427	405	369	320	244	3030
Sn	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	< 0.002 <	0.002 <	0.002	0.035 <	0.002 <	0.002
V	< 0.01 <	0.01	0.01	0.01 <	0.01 <	0.01
Zn	164	133	29	6.40	1.68	1.60
ICP, Total						
Al	< 3 <	3	0.13	0.70 <	0.06	4.53
Sb	0.39	0.32	0.13 <	0.06 <	0.06 <	0.06
As	0.16 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba	0.005	0.029	0.026	0.061	0.026	0.156
Be	0.004	0.004	0.006	0.005	0.005	0.005
B	0.10	0.02 <	0.01 <	0.01 <	0.01	0.02
Cd	0.673	0.554	0.035	0.007 <	0.006 <	0.006
Ca	193.0	229	341	322.0	268	314
Cr	0.5 <	0.3	0.008 <	0.006 <	0.006 <	0.006
Co	0.148	0.036 <	0.006 <	0.006 <	0.006 <	0.006
Cu	0.009	0.083 <	0.006 <	0.006 <	0.006	0.012
Fe	39.1	0.9	0.051	1.03 <	0.006	8.52
Pb	< 0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Mg	44.4	49.7	60.1	56.4	49.2	60.6
Mn	203	138	16.5	0.438 <	0.001	0.619
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	2	2	0.32 <	0.02 <	0.02	0.03
P	< 5 <	5	0.2 <	0.1 <	0.1	0.3
K	0.8	1.3	1.3	1.3	0.8	1.7
Se	< 3 <	3 <	0.06 <	0.06 <	0.06 <	0.06
Si	6	9	7.07	6.71	4.70	10.7
Ag	0.03	0.03 <	0.01 <	0.01 <	0.01 <	0.01
Na	1.6	1.9	3	2.5	2.1	2.5
Sr	0.265	0.445	0.668	0.650	0.526	0.607
S	401	387	356	311	262	301
Sn	< 0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti	< 0.002	0.025	0.013	0.021 <	0.002	0.157
V	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.02
Zn	153.0	129	32.4	6.44	1.760	1.87
TIC	13.4	3.8	3.2	13.9	13.1	21.6
TOC	< 0.5	0.7	2.4	3.3	4.6	3.8
PO4	< 0.002 <	0.002 <	0.002	0.026 <	0.002	0.282
Field parameters:						
Water temp. (°C)	3.0	5.1	2.9	2.5	2.9	2.7
pH	5.94	5.27	7.37	7.42	7.01	7.26
Spec. cond. (uS/cm)	2005	1923	1751	1420	1335	1534
Cond. (uS/cm)	1160	1180	1010	810	770	880
ORP (mV)	120	335	280	154	227	56
Eh (mV) (calc'd)	319	534	479	353	426	255
Flow (m³/3/s)	0.06					0.065
Flow (L/s)	7.78					8.74

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743

Aug 21-00

Aug 21-00		Galkeno		Seep nr.		Seep 8		Old Rd. AT		Seep RHS		@ Christal
		300 adit		Pole 500				ROW Xing		Limit		Ck.
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1	<	1
Acidity, total		278		224		53		8		6		6
Alkalinity to pH 4.5		12.1		2.2		8.4		54.3		50.8		76.1
Cl-	<	20		1.3	<	25	<	25	<	20	<	2.5
F	<	0.25		0.09	<	0.01	<	0.01	<	0.01	<	0.01
SO4		1,496		1375		1263		1094		1033		992
Br	<	0.05	<	0.005	<	0.05	<	0.05	<	0.05	<	0.05
Nitrate		0.24		0.385		0.37		0.35		0.25		0.23
Nitrite	<	0.005	<	1.25	<	0.005	<	0.005	<	0.005	<	0.005
P	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
pH		6.13		5.81		6.44		7.48		7.45		7.67
FR		2,170		1990		1790		1600		1540		1440
NFR		74		10		29		22		918		1020
Spec. Cond.		2,010		1890		1820		1700		1630		1600
Hardness, Ca+Mg		748		826.4		1028		1054.9		1017		1060
Hardness, total		1,495				1105.6		1062.6		1023		1070
ICP, dissolved												
Al	<	2.5	<	2.5		0.17		0.11		0.05	<	0.05
Sb		0.46		0.37		0.16	<	0.05	<	0.05	<	0.05
As		0.10	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ba		0.007		0.012		0.015		0.044		0.087		0.096
Be		0.004		0.005		0.007		0.007		0.006		0.006
B		0.10	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Cd		0.659		0.59		0.025		0.006	<	0.005	<	0.005
Ca		218.0		244		321.5		329.5		316		327
Cr		0.49		0.430	<	0.005	<	0.005	<	0.005	<	0.005
Co		0.159		0.019	<	0.005	<	0.005		0.011	<	0.005
Cu		0.005		0.079	<	0.005	<	0.005	<	0.005	<	0.005
Fe	<	39.15	<	0.25	<	0.005		0.039		1.510		0.718
Pb	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Mg		49.4		52.8		55		56.4		55.1		59.5
Mn		228.50		149.8		17.23		0.247		0.218		0.529
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni		3.40		2.9		0.24	<	0.02	<	0.02	<	0.02
P	<	5.0	<	5		0.2		0.1	<	0.1	<	0.1
K		0.8		1.2		0.9		1.2		0.9		1.2
Se	<	2.5	<	2.5	<	0.05	<	0.05	<	0.05	<	0.05
Si		6.6		7.5		6.17		5.24		4.43		4.25
Ag		0.03		0.02		0.02		0.02	<	0.01	<	0.01
Na		1.8		1.8		3.7		3.1		2.7		2.5
Sr		0.296		0.473		0.598		0.640		0.577		0.614
S		443		416.3		375.2		323.6		290		295
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ti	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002
V	<	0.01	<	0.01		0.027		0.03		0.01	<	0.01
Zn		167.52		135.87		26.582		4.10		0.921		1.47
ICP, Total												
Al	<	3	<	3		0.25		0.48		14.41		16.89
Sb		0.40		0.37		0.09	<	0.06	<	0.06	<	0.06
As		0.22	<	0.06	<	0.06	<	0.06	<	0.06		0.08
Ba		0.009		0.015		0.028		0.061		0.406		0.488
Be		0.004		0.005		0.006		0.006		0.005		0.005
B		0.10		0.01	<	0.01	<	0.01		0.06		0.08
Cd		0.822		0.602		0.027		0.008		0.036		0.014
Ca		201.8		240.8		329.8		327.5		317.4		321.8
Cr	<	0.03	<	0.03	<	0.006	<	0.006		0.035		0.034
Co		0.164		0.026	<	0.006		0.020		0.027		0.033
Cu		0.015		0.095	<	0.006		0.006		0.063		0.068
Fe		43.400	<	0.3		0.214		0.793		25.206		34.694
Pb		0.1	<	0.06	<	0.06	<	0.06		0.13		0.09
Mg		47.30		53.1		62.4		59.1		60.8		64.3
Mn		220.7		151.06		17.35		0.278		0.612		1.145
Mo	<	0.01		0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni		4.00		3		0.32		0.04		0.07		0.07
P	<	5	<	5		0.2	<	0.1		0.9		1.3
K		1.0		1.4		1.3		1.5		2.6		3.2
Se	<	3	<	3	<	0.06		0.10	<	0.06	<	0.06
Si		5		8		7.17		5.21		22.30		25.47
Ag		0.03		0.02	<	0.01	<	0.01	<	0.01	<	0.01
Na		1.5		1.7		2.7		2.5		2.8		3
Sr		0.286		0.481		0.681		0.679		0.643		0.859
S		439		426		382.3		337		299.18		294.56
Sn	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06
Ti		0.005		0.004		0.007		0.002		0.446		0.561
V	<	0.01	<	0.01	<	0.01	<	0.01		0.04		0.05
Zn		164.7		139.9		31.586		4.439		1.859		2.66
TIC		13.4		6.8		4.6		13.9		13.9		21.1
TOC	<	0.5	<	0.5		2.2		1.7		3.0		2.6
PO4	<	0.002	<	0.002		0.018		0.012		0.668		0.731
Field parameters:												
Water temp. (°C)		3.1		5.1		2.3		1.9		4.0		3.9
pH		6.29		5.36		7.26		7.74		7.35		6.79
Spec. cond. (uS/cm)		2051		1891		1692		1676		975		1517
Cond. (uS/cm)		1190		1160		960		940		580		900
ORP (mV)		110		281		261.6		174		200		25.8
Eh (mV) (calc'd)		309		480		460.6		373		399		224.8
Flow (m³/3/s)		0.0675										0.075
Flow (L/s)		9.23										10.76

Site	11	9	6	5	3	1
Distance	0	257	786	1100	1400	1743

	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
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Aug 30-00

Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	1
Acidity, total	259	200	39	7	7	6
Alkalinity to pH 4.5	11.7	4.7	20.6	73.8	54.5	95.2

Cl-	2	1.7	0.5	0.4	0.4	0.6
F	0.52	0.5	0.01	0.01	0.01	0.03
SO4	1,500	1444	1279.1	1044	920	950

Br	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Nitrate	0.04	0.361	0.269	0.354	0.15	0.133
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05

pH	5.94	6.15	6.94	7.57	7.7	7.98
FR	2,170	2000	1720	1490	1300	1470
NFR	67	28	237	21	5	169
Spec. Cond.	2,000	1980	1830	1640	1480	1620

Hardness, Ca+Mg	741	848.4	1159.7	1120	926	1020
Hardness, total	1,155	1357.8	1206.6	1121.1	930	1020

ICP, dissolved

Al	76.10	4.30	0.06	< 0.05	< 0.05	0.05
Sb	0.45	0.38	0.14	< 0.05	< 0.05	0.05
As	0.14	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Ba	0.005	0.012	0.037	0.044	0.028	0.054
Be	0.004	0.004	0.006	0.006	0.005	0.005
B	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.01
Cd	0.638	0.654	0.024	0.005	< 0.005	0.005
Ca	222.0	257.3	361.8	347.5	285	309
Cr	9.640	0.270	< 0.005	< 0.005	< 0.005	0.005
Co	0.240	0.033	< 0.005	< 0.005	< 0.005	0.005
Cu	0.010	0.081	< 0.005	< 0.005	< 0.005	0.005
Fe	< 0.005	< 0.25	0.018	0.019	0.007	0.437
Pb	0.08	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Mg	45.6	50	62.2	59.8	52.2	59.9
Mn	44.2	152.8	3.59	0.229	0.002	0.439
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Ni	0.50	3.5	0.29	< 0.02	< 0.02	0.02
P	< 1.0	5	0.2	< 0.1	< 0.1	0.1
K	0.7	1.2	0.9	1.1	0.9	1.1
Se	< 0.05	< 2.50	< 0.05	< 0.05	< 0.05	0.05
Si	< 0.05	6.90	6.86	5.56	4.75	4.14
Ag	0.03	0.01	< 0.01	< 0.01	< 0.01	0.01
Na	1.2	1.7	3.6	3.1	2.6	2.4
Sr	0.277	0.452	0.655	0.671	0.554	0.598
S	88.1	422.5	74.1	62	281	59.7
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Ti	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Zn	32.8	139.96	25.666	3.817	2.05	1.45

ICP, Total

Al	< 3.00	< 3	2.56	0.21	< 0.06	1.82
Sb	0.39	0.38	0.10	< 0.06	< 0.06	0.06
As	0.20	< 0.06	< 0.06	< 0.06	< 0.06	0.06
Ba	0.005	0.016	0.1	0.047	0.029	0.091
Be	0.003	0.005	0.006	0.005	0.005	0.005
B	0.11	0.01	0.02	< 0.01	< 0.01	0.01
Cd	0.592	0.583	0.027	< 0.006	< 0.006	0.006
Ca	209	239.7	334.2	312.7	288	295
Cr	< 0.3	< 0.3	0.018	0.012	< 0.006	0.007
Co	0.159	0.015	0.010	< 0.006	< 0.006	0.006
Cu	0.007	0.084	< 0.006	< 0.006	< 0.006	0.006
Fe	45.0	< 0.3	3.156	0.315	0.012	3.73
Pb	0.01	< 0.06	< 0.06	< 0.06	< 0.06	0.06
Mg	48.2	51.8	62.7	56.4	49.9	56.9
Mn	225	146.22	19.08	0.229	0.004	0.488
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Ni	3	3	0.31	< 0.02	< 0.02	0.02
P	< 5	5	0.4	< 0.1	< 0.1	0.1
K	0.9	1.2	1.5	1.3	1	1.4
Se	< 3	< 3	< 0.06	< 0.06	< 0.06	0.06
Si	5.00	7.00	9.79	5.34	4.45	6.47
Ag	0.03	0.02	< 0.01	< 0.01	< 0.01	0.01
Na	1.6	2.1	3	2.5	2.2	2.3
Sr	0.292	0.468	0.665	0.639	0.537	0.579
S	453	421	392	295	264	291
Sn	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	0.06
Ti	< 0.002	0.005	0.086	0.006	< 0.002	0.063
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Zn	168	135.4	24.71	3.57	1.98	1.55

TIC	17.7	2.4	6.7	18.9	15	23
TOC	< 0.5	1.3	2.6	2.3	4.5	3.7
PO4	< 0.002	0.013	0.169	0.041	0.018	0.14

Field parameters:

Water temp. (°C)	3.0	4.9	2	1.4	0.8	1.3
pH	6.34	5.08	7.38	7.65	7.41	7.26
ec. cond. (uS/cm)	2057	1901	1582	1591	1452	1323
Cond. (uS/cm)	1190	1160	890	880	790	730
ORP (mV)	83	275	218	141.1	175.1	29.4
Eh (mV) (calc'd)	282	474	417	340.1	374.1	228.4
Flow (m^3/s)	0.06					0.0625
Flow (L/s)	7.78					8.26

May 29-00

	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Seep @ Old Rd. ROW Xing	Old Rd. Seep RHS Limit	300 drainage at Christal Ck
Site #	11	9	6	5	3	1
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	1
Acidity, total	213	140	62	8	4	4
Alkalinity, total	13.6	2.7	3.3	45.6	31.3	38.3
Cl-	1.0	1.7	0.3	0.3	0.5	0.4
F	0.21	0.07	0.02	0.02	0.02	0.03
SO4	1,070.0	988.9	971.4	771.5	522.0	490.3
Br	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Nitrate	0.047	0.370	0.094	0.092	0.009	0.038
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
pH	6.61	5.78	6.32	7.56	7.51	7.55
FR	1,650	1530	1470	1170	910	840
NFR	40	368	< 5	< 5	5	1350
Spec. Cond.	1.670	1590	1570	1380	1070	989
GFAA (dissolved):						
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
GFAA (total):						
Se	< 0.001	< 0.001	< 0.001	< 0.001	<	0.001
Hardness, Ca+Mg	570.4	714.8	852.0	822.4	586.3	548.6
Hardness, total	1,077.0	947.3	952.8	829.1	587.3	551.8
ICP, dissolved						
Al	0.12	0.20	0.06	< 0.05	< 0.05	0.05
Sb	0.32	0.16	0.10	< 0.05	< 0.05	0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Ba	0.005	0.023	0.020	0.021	0.022	0.042
Be	0.003	0.003	0.004	0.004	0.003	0.003
B	0.05	0.01	< 0.01	< 0.01	< 0.01	0.01
Cd	0.386	0.315	0.035	< 0.005	< 0.005	0.005
Ca	170.2	214.2	265.8	260.8	180.7	171.7
Cr	0.031	0.010	0.007	< 0.005	0.008	< 0.005
Co	0.162	0.032	< 0.005	< 0.005	< 0.005	0.006
Cu	< 0.005	0.066	< 0.005	< 0.005	< 0.005	0.005
Fe	18.3	1.492	< 0.005	0.024	0.042	0.443
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Mg	35.3	43.7	45.8	41.6	32.8	29.1
Mn	155.2	68.6	24.53	0.067	0.001	0.235
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Ni	1.47	0.73	0.34	< 0.02	< 0.02	0.02
P	0.7	0.3	0.3	< 0.1	< 0.1	0.1
K	0.7	1.0	1.4	1.1	0.8	0.7
Se	0.45	0.23	< 0.05	< 0.05	< 0.05	0.05
Si	3.66	5.95	5.79	4.69	3.64	3.30
Ag	0.02	0.01	< 0.01	< 0.01	< 0.01	0.01
Na	1.5	1.7	1.8	1.7	1.3	1.3
Sr	0.222	0.464	0.539	0.479	0.353	0.317
S	319.2	307.5	295.6	239.1	180.9	159.3
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Ti	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Zn	124.4	67.6	36.1	3.94	0.272	0.903
ICP, Total						
Al	0.22	8.48	0.06	< 0.06	<	21.50
Sb	0.32	0.16	0.09	< 0.06	<	0.06
As	0.08	< 0.06	< 0.06	< 0.06	<	0.09
Ba	0.006	0.260	0.023	0.022	<	0.655
Be	0.003	0.003	0.004	0.004	<	0.001
B	0.06	0.03	< 0.01	< 0.01	<	0.09
Cd	0.401	0.347	0.040	< 0.006	<	0.018
Ca	175.6	229.2	267.2	242.0	<	203.4
Cr	0.029	0.022	< 0.006	0.011	<	0.031
Co	0.163	0.047	< 0.006	< 0.006	<	0.030
Cu	< 0.006	0.108	< 0.006	< 0.006	<	0.062
Fe	22.6	10.8	< 0.006	0.117	<	40.8
Pb	0.12	< 0.06	< 0.06	< 0.06	<	0.10
Mg	36.5	48.0	47.6	42.2	<	44.2
Mn	156.8	75.3	26.07	0.084	<	1.04
Mo	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01
Ni	1.57	0.82	0.37	< 0.02	<	0.07
P	0.8	0.6	0.3	< 0.1	<	1.9
K	0.8	2.4	1.5	1.1	<	4.2
Se	0.40	0.18	< 0.06	< 0.06	<	0.06
Si	3.97	19.2	6.12	4.65	<	35.32
Ag	0.02	0.01	< 0.01	< 0.01	<	0.01
Na	1.6	2.4	1.9	1.7	<	3.0
Sr	0.231	0.512	0.562	0.484	<	0.443
S	345	336	324.2	239.5	<	159.4
Sn	< 0.06	< 0.06	< 0.06	< 0.06	<	0.06
Ti	< 0.002	0.279	< 0.002	< 0.002	<	0.842
V	< 0.01	0.01	< 0.01	< 0.01	<	0.08
Zn	136.4	77.1	36.3	3.42	<	1.65
TIC	8.4	13.3	2.8	12.3	8.7	8.9
TOC	< 0.5	0.7	5.3	5.1	12.9	17.6
PO4	0.010	0.17	< 0.002	0.004	0.005	0.52
Field parameters:						
Water temp. (°C)	2.54	0.05	0.24	1.14	3.16	3.23
pH	6.27	4.94	5.59	7.14	6.97	7.33
Spec. cond. (uS/cm)	1700	1592	1570	1331	1054	892
Cond. (uS/cm)	971	833	826	725	614	521

	Seep 5	Seep nr. Road Piezo	Seep 6 + 120	Old Rd. Seep LHS Limit	Seep Xing 900 Rd.
	7	8	4	2	
< 1	< 1	< 1	< 1	< 1	1
47	47	55	15	6	4
46.9	< 46.9	< 0.5	53.2	67.7	39.6
0.3	0.3	0.9	0.3	0.3	0.4
0.02	0.02	0.02	0.02	0.01	0.03
948.6	948.6	655.6	854.9	853.3	513.4
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05
0.242	< 0.242	< 0.002	0.185	0.009	0.038
< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.005
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06
7.3	7.3	5.28	7.62	7.82	7.54
1480	1480	1010	1310	1360	850
171	< 171	5	44	< 5	1760
1600	1600	1140	1510	1517	999
< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.001
< 0.001	< 0.001	< 0.001	<	<	0.001
910.0	910.0	510.3	886.9	908.9	548.4
972.2	972.2	637.1	903.8	909.7	551.6
< 0.05	< 0.05	0.12	< 0.05	< 0.05	0.05
0.08	0.08	0.08	< 0.05	< 0.05	< 0.05
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
0.018	0.018	0.026	0.018	0.03	0.038
0.005	0.005	0.002	0.004	0.005	0.003
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
0.051	0.051	0.064	0.010	< 0.005	< 0.005
283.5	283.5	159.1	281.9	282.4	171.4
< 0.005	< 0.005	0.009	< 0.005	0.011	< 0.005
< 0.005	< 0.005	0.011	< 0.005	< 0.005	0.011
< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
< 0.005	< 0.005	0.005	0.016	0.019	0.439
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
49.1	49.1	27.4	44.4	49.4	29.3
9.62	9.62	42.41	0.832	0.002	0.197
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
0.22	0.22	0.36	0.02	< 0.02	< 0.02
0.1	0.1	0.3	< 0.1	< 0.1	< 0.1
1.2	1.2	3.5	0.9	1.1	0.7
< 0.05	< 0.05	0.16	< 0.05	0.07	< 0.05
5.26	5.26	2.61	4.28	3.97	3.31
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1.9	1.9	1.1	1.8	1.9	1.3
0.564	0.564	0.268	0.524	0.497	0.319
292.76	292.76	204.6	261.5	265.5	158.5
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
28.7	28.7	31.8	9.555	0.048	0.996
3.57	3.57	0.13	<	<	26.9
0.06	0.06	0.07	<	<	0.06
< 0.06	< 0.06	< 0.06	<	<	0.12
0.091	0.091	0.028	<	<	0.806
0.004	0.004	0.003	<	<	0.001
0.01	0.01	< 0.01	<	<	0.12
0.055	0.055	0.064	<	<	0.023
293.7	293.7	158.5	<	<	206.2
0.007	0.007	< 0.006	<	<	0.039
0.012	0.012	< 0.006	<	<	0.029
0.025	0.025	< 0.006	<	<	0.074
4.213	4.213	0.014	<	<	53.7
< 0.06	< 0.06	< 0.06	<	<	0.09
51.9	51.9	27.9	<	<	47.0
11.4	11.4	44.4	<	<	1.212
< 0.01	< 0.01	< 0.01	<	<	0.01
0.25	0.25	0.38	<	<	0.08
0.3	0.3	0.3	<	<	2.0
1.9	1.9	3.6	<	<	5.2
< 0.06	< 0.06	0.10	<	<	0.06
10.98	10.98	2.71	<	<	43.03
< 0.01	< 0.01	< 0.01	<	<	0.01
2.3	2.3	1.1	<	<	3.2
0.600	0.600	0.274	<	<	0.456
318	318	208.7	<	<	158.1
< 0.06	< 0.06	< 0.06	<	<	0.06
0.140	0.140	< 0.002	<	<	1.09
< 0.01	< 0.01	< 0.01	<	<	0.10
30.0	30.0	31.3	<	<	1.76
15.3	15.3	1.1	13.7	18.3	9.4
3.8	3.8	20.7	4.5	4.9	17.7
0.161	0.161	0.039	0.016	0.006	1.02
0.29	0.29	1.66	0.04	2.27	3.05
6.86	6.86	4.8	7.3	7.33	6.89
1590	1590	1123	1493	1474	807
839	839	622	782	833	471

June 6-00													
	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage at Christal Ck		Seep 5	Seep at Road Piezo	Seep 6 + 120	Old Rd. Seep RHS Limit (dup.)		
Site #	11	9	6	5	3	1		7	8	4			
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1		< 1	< 1	< 1		< 1	
Acidity, total	248	181	60	9	4	6		50	68	15		4	
Alkalinity to pH 4.5	14.9	1.3	3.6	38.3	35.1	46.2		31.6	< 0.5	46.1		35.1	
Cl-	< 10	0.6	0.3	0.2	0.2	0.2		0.3	0.5	0.4		0.2	
F	< 0.01	0.07	< 0.01	0.01	0.02	0.02		0.02	0.02	0.02		0.02	
SO4	2,380	1240	1165	776	831	867		1100	1080	1000		819	
Br	< 5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		< 0.05	
Nitrate	< 0.2	0.7	0.192	0.111	0.013	0.059		0.306	0.004	0.215		0.013	
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005		< 0.005	
P	< 5	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		< 0.05	
pH	6.19	5.62	6.40	7.45	7.41	7.51		7.16	5.37	7.44		7.45	
FR	1,960	1600	1600	1390	1210	1270		1490	1410	1390		1160	
NFR	65	121	< 5	< 5	< 5	2750		114	< 5	657		< 5	
Spec. Cond.	1,890	1640	1680	1550	1370	1430		1620	1540	1540		1370	
GFAA (dissolved):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		< 0.001	
GFAA (total):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001	< 0.001	< 0.001		< 0.001	
Hardness, Ca+Mg	653	686	961	907	794	851		943	770	903		796	
Hardness, total	1,270	1020	1048	914	795	857		1011	937	920		797	
ICP, dissolved													
Al	0.17	0.21	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	0.15	< 0.05		< 0.05	
Sb	0.34	0.27	0.10	< 0.05	< 0.05	< 0.05		0.10	0.10	< 0.05		< 0.05	
As	0.11	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		< 0.05	
Ba	0.006	0.016	0.022	0.027	0.026	0.120		0.019	0.031	0.020		0.026	
Be	0.003	0.003	0.005	0.005	0.004	0.008		0.005	0.004	0.005		0.004	
B	0.09	< 0.01	< 0.01	< 0.01	< 0.01	0.01		< 0.01	< 0.01	< 0.01		< 0.01	
Cd	0.388	0.436	0.028	< 0.005	< 0.005	< 0.005		0.063	0.055	0.012		< 0.005	
Ca	192.0	206	300.2	284	246	264		294	238	283		247	
Cr	0.035	0.015	< 0.005	0.005	0.009	0.008		< 0.005	0.012	< 0.005		< 0.005	
Co	0.137	0.012	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005	0.011	< 0.005		< 0.005	
Cu	< 0.005	0.050	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005	< 0.005		< 0.005	
Fe	35.7	< 0.005	< 0.005	0.021	< 0.005	1.47		< 0.005	< 0.005	0.082		0.013	
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		< 0.05	
Mg	42.1	41.6	51.3	48.1	43.5	46.7		51.0	42.5	47.8		43.7	
Mn	191	93.7	18.2	0.028	0.001	0.390		11.6	59.9	0.755		0.002	
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		< 0.01	
Ni	1.72	1.01	0.27	< 0.02	< 0.02	< 0.02		0.22	0.49	0.02		< 0.02	
P	1.0	0.5	0.2	< 0.1	< 0.1	< 0.1		0.2	0.3	< 0.1		< 0.1	
K	0.7	1.0	1.4	1.1	0.9	0.9		1.3	3.3	1.1		0.9	
Se	0.51	0.27	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	0.17	< 0.05		< 0.05	
Si	4.29	5.50	6.26	5.00	4.28	4.29		5.56	3.84	4.58		4.25	
Ag	0.03	0.02	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	0.01	< 0.01		< 0.01	
Nb	1.5	1.6	1.9	1.9	1.7	1.9		1.9	1.7	1.9		1.7	
Sr	0.277	0.414	0.619	0.568	0.463	0.499		0.582	0.392	0.559		0.472	
S	387	329	337	273	244	262		326	290	277		245	
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		< 0.05	
Ti	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.006		< 0.002	0.003	0.002		< 0.002	
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		< 0.01	
Zn	136	104	34.9	4.14	0.364	1.45		30.1	36.7	9.78		0.361	
ICP, Total													
Al	0.28	2.81	< 0.05	< 0.05	< 0.05	33.4		2.34	0.14	10.8		< 0.05	
Sb	0.31	0.26	0.08	< 0.05	< 0.05	< 0.05		0.06	0.09	< 0.05		< 0.05	
As	0.21	< 0.05	< 0.05	< 0.05	< 0.05	0.14		< 0.05	< 0.05	< 0.05		< 0.05	
Ba	0.008	0.084	0.022	0.027	0.028	1.04		0.068	0.031	0.219		0.027	
Be	0.003	0.003	0.005	0.005	0.004	0.002		0.004	0.004	0.004		0.004	
B	0.09	0.01	< 0.01	< 0.01	< 0.01	0.14		0.01	< 0.01	0.03		< 0.01	
Cd	0.396	0.450	0.031	< 0.005	< 0.005	0.027		0.061	0.057	0.028		< 0.005	
Ca	190	211	296	288	240	330		282	231	295		242	
Cr	0.030	0.018	< 0.005	< 0.005	< 0.005	0.048		< 0.005	0.005	0.010		< 0.005	
Co	0.138	0.008	< 0.005	< 0.005	< 0.005	0.041		< 0.005	< 0.005	< 0.005		< 0.005	
Cu	< 0.005	0.072	< 0.005	< 0.005	< 0.005	0.096		< 0.016	< 0.005	0.056		< 0.005	
Fe	39.7	2.47	< 0.005	0.036	0.055	63.8		2.75	< 0.005	13.2		0.025	
Pb	0.08	< 0.05	< 0.05	< 0.05	< 0.05	0.18		< 0.05	< 0.05	< 0.05		< 0.05	
Mg	42.6	43.6	51.5	49.2	43.2	70.4		50.6	42.0	51.9		43.4	
Mn	201	102	18.5	0.027	0.003	1.71		12.6	61.3	1.10		0.001	
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	< 0.01	< 0.01		< 0.01	
Ni	1.78	1.07	0.28	< 0.02	< 0.02	0.11		0.23	0.49	0.06		< 0.02	
P	1.0	0.6	0.2	< 0.1	< 0.1	3.4		0.3	0.4	0.5		< 0.1	
K	0.8	1.5	1.4	1.2	0.9	5.8		1.7	3.3	2.8		0.9	
Se	0.49	0.28	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	0.16	< 0.05		< 0.05	
Si	4.46	9.48	6.25	5.16	4.22	60.5		8.95	3.73	21.2		4.24	
Ag	0.03	0.02	< 0.01	< 0.01	< 0.01	< 0.01		< 0.01	0.01	< 0.01		< 0.01	
Na	1.6	1.8	1.9	2.0	1.7	3.8		2.1	1.7	3.0		1.7	
Sr	0.277	0.431	0.617	0.578	0.460	0.687		0.572	0.383	0.608		0.463	
S	407	352	347	278	238	257		292	279	278		238	
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		< 0.05	< 0.05	< 0.05		< 0.05	
Ti	0.005	0.089	< 0.002	< 0.002	0.003	1.37		0.093	< 0.002	0.393		< 0.002	
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.12		< 0.01	< 0.01	0.03		< 0.01	
Zn	145	114	34.9	4.43	0.372	2.92		29.8	35.4	12.1		0.360	
TIC	17.1	4.0	1.9	8.9	8.2	10.8		8.0	1.0	11.0		8.2	
TOC	< 0.5	1.1	3.3	3.9	6.5	6.5		4.2	14.7	4.1		6.6	
PO4	0.006	0.108	0.025	< 0.002	< 0.002	2.20		0.161	0.036	0.595		0.003	
Field parameters:													
Water temp. (°C)	2.9	0.8	0.6	4.0	2.0	3.1		3.9	3.2	2.0		2.0	
pH	5.89	5.12	5.73	6.68	6.56	6.52		6.57	4.84	6.67		6.56	
Spec. cond. (uS/cm)	1820	1471	1590	1479	1404	1327		1534	1530	1333		1404	
Cond. (uS/cm)	1050	800	860	880	790	770		910	890	750		790	

June 13-00		Galkeno 300 adit		300 drainage at Christal Ck	
Site #		11			1
Acidity to pH 4.5					
Acidity, total					
Alkalinity, total					
Cl-					
F					
SO4					
Br					
Nitrate					
Nitrite					
P					
pH					
FR					
NFR					
Spec. Cond.					
GFAA (dissolved):					
Se	<	0.001	<		0.001
GFAA (total):					
Se	<	0.001	<		0.001
Hardness, Ca+Mg					
Hardness, total		605.1			985.6
		1,217.2			993.2
ICP, dissolved					
Al		0.31	<		0.05
Sb		0.32	<		0.05
As		0.09	<		0.05
Ba		0.009			0.094
Be		0.003			0.005
B		0.08	<		0.01
Cd		1.373	<		0.005
Ca		177.2			308.6
Cr		0.019	<		0.005
Co		0.119	<		0.005
Cu		0.076	<		0.005
Fe		31.7			0.786
Pb	<	0.05	<		0.05
Mg		39.5			52.2
Mn		186.4			0.549
Mo	<	0.01	<		0.01
Ni		1.78			0.02
P		1.0	<		0.1
K		0.8			1.0
Se		0.37	<		0.05
Si		4.66			4.74
Ag		0.03	<		0.01
Na		1.6			2.1
Sr		0.254			0.579
S		392			293.5
Sn	<	0.05	<		0.05
Ti		0.003	<		0.002
V	<	0.01	<		0.01
Zn		139.9			2.95
ICP, Total					
Al		0.49			27.09
Sb		0.27	<		0.06
As		0.16			0.13
Ba		0.006			0.778
Be		0.002			0.002
B		0.08			0.14
Cd		1.12			0.031
Ca		144.5			308.0
Cr		0.031			0.046
Co		0.108			0.029
Cu		0.068			0.092
Fe		30.1			58.9
Pb		0.13			0.13
Mg		33.2			61.3
Mn		188.1			1.89
Mo	<	0.01	<		0.01
Ni		1.37			0.11
P		0.8			2.8
K		0.7			4.3
Se		0.46	<		0.06
Si		3.74			40.6
Ag		0.03	<		0.01
Na		1.3			3.3
Sr		0.210			0.637
S		381			252.8
Sn	<	0.06	<		0.06
Ti	<	0.002			0.977
V	<	0.01			0.09
Zn		151.9			4.42
TIC					
TOC					
PO4					
Field parameters:					
Water temp. (°C)		3.1			3.5
pH		5.75			6.75
Spec. cond. (uS/cm)		1741			1364
Cond. (uS/cm)		1010			800

June 20-00

	Galkeno 300		Seep nr.		Seep 8		Old Rd. AT		Old Rd.		300	
	adit		Pole 500				ROW Xing		Seep RHS		drainage at	
Site #	11		9		6		5		3		1	
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1	<	1
Acidity, total		267		217		71		14		4		5
Alkalinity to pH 4.5								42.5		29		56.3
Alkalinity, total	<	0.5	<	0.5		0.9						
Cl-	<	2	<	2	<	2	<	2	<	2	<	2
F		0.2	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
SO4		1180		1210		1160		1000		848.4		898.3
Br	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Nitrate		0.30		0.42		0.29		0.25	<	0.002		0.09
Nitrite	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005
P	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
pH		5.49		5.08		5.8		7.62		7.37		7.61
FR		1.800		1840		1720		1560		1310		1410
NFR		45	<	5		5		69	<	5		958
Spec. Cond.		1.680		1750		1830		1770		1434		1298
GFAA (dissolved):												
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001
GFAA (total):												
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Hardness, Ca+Mg		577.7		791.4		999.0		1048.5		904.3		974.6
Hardness, total		1,161.5		1210.0		1098.8		1066.7		907.3		979.9
ICP, dissolved												
Al		0.39		0.23	<	0.05		0.06	<	0.05	<	0.05
Sb		0.34		0.31		0.10	<	0.05	<	0.05	<	0.05
As		0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ba		0.007		0.012		0.017		0.027		0.029		0.094
Be		0.003		0.004		0.005		0.006		0.005		0.005
B		0.06		0.01	<	0.01	<	0.01	<	0.01	<	0.01
Cd		1.616		0.580		0.027		0.009	<	0.005	<	0.005
Ca		173.3		245.7		321.4		337.6		286.1		305.7
Cr		0.024		0.019	<	0.005	<	0.005	<	0.005	<	0.005
Co		0.105		0.009	<	0.005	<	0.005	<	0.005	<	0.005
Cu		0.096		0.081	<	0.005	<	0.005	<	0.005	<	0.005
Fe		24.7	<	0.005	<	0.005		0.039		0.016		0.429
Pb	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Mg		35.2		43.2		47.7		49.9		46.1		51.3
Mn		176.3		124.5		20.1		1.153		0.004		0.318
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni		1.65		1.43		0.30		0.03	<	0.02	<	0.02
P		1.0		0.8		0.2	<	0.1	<	0.1	<	0.1
K		0.7		1.0		0.9		0.9		0.7		0.9
Se		0.35		0.33	<	0.05	<	0.05	<	0.05	<	0.05
Si		4.71		6.01		6.46		5.86		5.07		4.63
Ag		0.03		0.02	<	0.01		0.01	<	0.01	<	0.01
Na		1.6		1.9		2.1		2.2		1.9		2.0
Sr		0.228		0.424		0.599		0.609		0.537		0.568
S		377		396		370.7		299.5		267.6		284.1
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ti	<	0.002	<	0.007	<	0.002	<	0.002	<	0.002	<	0.002
V	<	0.01	<	0.01	<	0.01		0.02	<	0.01	<	0.01
Zn		141.4		124.3		40.8		9.87		1.59		2.08
ICP, Total												
Al		0.77		0.30		0.06		1.17	<	0.06		13.71
Sb		0.35		0.34		0.14	<	0.06		0.07	<	0.06
As		0.11	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06
Ba		0.006		0.011		0.022		0.059		0.028		0.391
Be		0.003		0.004		0.005		0.005		0.004		0.003
B		0.06		0.01	<	0.01	<	0.01	<	0.01		0.06
Cd		1.470		0.512		0.035		0.011	<	0.006		0.015
Ca		158.5		224.0		318.4		311.7		267.1		261.5
Cr		0.024		0.013	<	0.006	<	0.006	<	0.006		0.019
Co		0.123		0.016	<	0.006	<	0.006	<	0.006		0.016
Cu		0.100		0.075	<	0.006	<	0.006	<	0.006		0.034
Fe		26.8	<	0.006	<	0.006		1.344		0.012		23.9
Pb		0.15	<	0.06	<	0.06	<	0.06	<	0.06		0.07
Mg		35.7		45.4		54.4		53.2		46.2		49.2
Mn		165.9		120.1		20.5		1.180		0.001		0.650
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni		1.57		1.33		0.32		0.03	<	0.02		0.04
P		1.0		0.8		0.3	<	0.1	<	0.1		1.0
K		0.8		1.1		1.4		1.4		0.8		2.7
Se		0.36		0.27	<	0.06	<	0.06	<	0.06	<	0.06
Si		4.38		5.64		6.54		7.07		4.65		24.02
Ag		0.03		0.02	<	0.01	<	0.01	<	0.01	<	0.01
Na		1.5		1.7		2.0		2.1		1.8		2.7
Sr		0.227		0.436		0.668		0.633		0.530		0.528
S		334		362		364.5		334.1		279.8		240
Sn	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06
Ti	<	0.002	<	0.002	<	0.002	<	0.034	<	0.002		0.506
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01		0.04
Zn		136.6		123.8		37.4		8.67		1.40		2.38
TIC		3.2		3.5		2.2		7.8		6.6		12.2
TOC	<	0.5		0.6		2.5		2.6		5.7		4.9
PO4	<	0.002	<	0.002		0.009		0.061		0.010		0.88
Field parameters:												
Water temp. (°C)		3.3		3.8		1.1		1.8		5.1		4.8
pH		6		5.2		5.9		7.2		7.2		7.7
Spec. cond. (uS/cm)		1680		1673		1750		1573		1434		1298
Cond. (uS/cm)		980		990		960		880		880		790

Seep at Road Piezo		Seep 5		Seep 6 + 120		Galkeno 300 garage (analytical/ blank)	
8		7		4			
<	1 <	1 <		1 <		1	
	107	73		20 <		1	
	22.2 <	1 <		0.5		31.4	
		3.0 <		0.5			
<	2 <	2 <		2 <		0.1	
<	0.01 <	0.01 <		0.01 <		0.01	
	1170	1130		1040 <		0.5	
<	0.05 <	0.05 <		0.05 <		0.05	
	0.25	0.41		0.40		0.011	
<	0.005 <	0.005 <		0.005 <		0.005	
<	0.05 <	0.05 <		0.05 <		0.05	
	7.24	6.48		5.19		7.31	
	1760	1700		1590 <		10	
<	5	101		24 <		5	
	1820	1830		1830		1940	
<	0.001 <	0.001 <		0.001 <		0.001	
<	0.001 <	0.001 <		0.001 <		0.001	
	994.4	1023.9		1075.9 <		0.4	
	1202.4	1124.1		1099.4 <		0.4	
	0.21 <	0.05 <		0.05 <		0.05	
	0.14	0.05 <		0.05 <		0.05	
<	0.05 <	0.05 <		0.05 <		0.05	
	0.026	0.015		0.024		0.002	
	0.005	0.004		0.006 <		0.001	
<	0.01 <	0.01 <		0.01 <		0.01	
	0.083	0.083		0.021 <		0.005	
	314.6	327.1		343.8 <		0.1	
	0.012 <	0.005 <		0.005 <		0.005	
	0.008 <	0.005 <		0.005 <		0.005	
<	0.005 <	0.005 <		0.005 <		0.005	
<	0.005 <	0.005		0.031		0.017	
	0.06 <	0.05 <		0.05 <		0.05	
	50.7	50.3		52.8 <		0.1	
	66.2	16.8		0.178		0.043	
<	0.01 <	0.01 <		0.01 <		0.01	
	0.67	0.32		0.03 <		0.02	
	0.4	0.2 <		0.1 <		0.1	
	1.7	1.1		1.0 <		0.1	
	0.20 <	0.05 <		0.05 <		0.05	
	5.15	5.92		5.19 <		0.05	
	0.01 <	0.01 <		0.01 <		0.01	
	2.3	2.1		2.2		0.3	
	0.454	0.592		0.629 <		0.001	
	385	372.5		350.2		0.11	
<	0.05 <	0.05 <		0.05 <		0.05	
	0.012 <	0.002 <		0.002		0.006	
<	0.01 <	0.01 <		0.01 <		0.01	
	56.2	45.0		14.6		0.038	
	0.21	2.23		0.53 <		0.06	
	0.16	0.12		0.08 <		0.06	
<	0.06 <	0.06 <		0.06 <		0.06	
	0.024	0.066		0.034 <		0.001	
	0.005	0.005		0.005 <		0.001	
<	0.01	0.01 <		0.01 <		0.01	
	0.061	0.082		0.021 <		0.006	
	282.2	314.4		326.3 <		0.1	
	0.009 <	0.006 <		0.006 <		0.006	
	0.014 <	0.006 <		0.006 <		0.011	
<	0.006	0.012		0.007 <		0.006	
<	0.006	2.69		0.714		0.009	
<	0.06 <	0.06 <		0.06 <		0.06	
	52.1	55.3		55.3 <		0.1	
	58.6	17.64		0.191		0.054	
<	0.01 <	0.01 <		0.01 <		0.01	
	0.54	0.32		0.04 <		0.02	
	0.4	0.3 <		0.1 <		0.1	
	1.7	1.7		1.2 <		0.1	
	0.15 <	0.06 <		0.06 <		0.06	
	4.65	8.96		5.62 <		0.06	
	0.01 <	0.01 <		0.01 <		0.01	
	2.1	2.2		2.2 <		0.1	
	0.457	0.637		0.646 <		0.001	
	353	375.9		341.2		0.15	
<	0.06 <	0.06 <		0.06 <		0.06	
<	0.002	0.074		0.014 <		0.002	
<	0.01 <	0.01 <		0.01 <		0.01	
	49.3	40.6		13.1		0.052	
<	0.5	5.4		9.8 <		0.5	
	8.7	2.5		3.0 <		0.5	
	0.028	0.093		0.032		0.012	
	1.4	0.8		1.2		n/a	
	5.1	6.5		7.3		n/a	
	1645	1673		1636		n/a	
	910	910		900		n/a	

June 28-00

June 28-00	Galkeno 300		Seep6 + 120		Old Rd. seep		300 drainage	
Site #	adit				RHS limit		at Christal Ck	
	11		4		3		1	
Acidity to pH 4.5								
Acidity, total								
Alkalinity, total								
Cl-								
F								
SO4								
Br								
Nitrate								
Nitrite								
P								
pH								
FR								
NFR								
Spec. Cond.								
GFAA (dissolved):								
Se	<	0.001	<	0.001	<	0.001	<	0.001
GFAA (total):								
Se	<	0.001	<	0.001	<	0.001	<	0.001
Hardness, Ca+Mg		632.0		1120		1,110.0		1,090.0
Hardness, total		1,260.0		1140		1,110.0		1,100.0
ICP, dissolved								
Al		0.39	<	0.05	<	0.05	<	0.05
Sb		0.40	<	0.05	<	0.05	<	0.05
As		0.08	<	0.05	<	0.05	<	0.05
Ba		0.007		0.030		0.034		0.120
Be		0.003		0.005		0.005		0.005
B		0.07	<	0.01	<	0.01	<	0.01
Cd		1.800		0.015	<	0.005	<	0.005
Ca		176.0		349		335.0		325.0
Cr		0.032	<	0.005	<	0.005	<	0.005
Co		0.126	<	0.005	<	0.005	<	0.005
Cu		0.076	<	0.005	<	0.005	<	0.005
Fe		26.100		0.091		0.024		0.536
Pb	<	0.05	<	0.05	<	0.05	<	0.05
Mg		46.8		60.5		66.4		68.1
Mn		184.0		0.132		0.0		0.5
Mo	<	0.01	<	0.01	<	0.01	<	0.01
Ni		1.72		0.04		0.02	<	0.02
P		1.1	<	0.1	<	0.1	<	0.1
K		0.8		1.1		0.7		1.3
Se	<	0.001	<	0.001	<	0.001	<	0.001
Si		4.76		5.20		4.98		4.34
Ag		0.03	<	0.01	<	0.01	<	0.01
Na		1.5		2.2		2.1		2.1
Sr		0.245		0.684		0.645		0.632
S		375		365		308		319
Sn	<	0.05	<	0.05	<	0.05	<	0.05
Ti	<	0.002	<	0.002	<	0.002	<	0.002
V	<	0.01	<	0.01	<	0.01	<	0.01
Zn		158.0		13.6		1.9		2.29
ICP, Total								
Al		0.95		1.08	<	0.06		16.40
Sb		0.42	<	0.06	<	0.06	<	0.06
As		0.20	<	0.06	<	0.06		0.13
Ba		0.008		0.047		0.310		0.489
Be		0.004		0.005		0.005		0.005
B		0.07	<	0.01	<	0.01		0.08
Cd		1.51		0.017	<	0.01		0.01
Ca		168.0		340.0		309.0		343.0
Cr		0.023	<	0.006	<	0.006		0.009
Co		0.128	<	0.006	<	0.006		0.015
Cu		0.101	<	0.006	<	0.006		0.066
Fe		29.2		1.74		0.023		36.5
Pb		0.14	<	0.06	<	0.06	<	0.06
Mg		37.8		57.5		53.4		64.7
Mn		179.0		0.165		0.1		1.3
Mo	<	0.01	<	0.01	<	0.01	<	0.01
Ni		1.75		0.04	<	0.02		0.05
P		1.3	<	0.1	<	0.1		1.8
K		0.8		1.2		0.5		2.7
Se	<	0.001	<	0.001	<	0.001	<	0.001
Si		5.05		7.04		5.00		26.60
Ag		0.03	<	0.01	<	0.01	<	0.01
Na		1.5		2.1		1.9		2.9
Sr		0.238		0.682		0.613		0.704
S		356		331		335		295
Sn	<	0.06	<	0.06	<	0.06	<	0.06
Ti		0.003		0.030	<	0.002		0.524
V	<	0.01	<	0.01	<	0.01		0.07
Zn		150.0		14.30		1.82		3.94
TIC								
TOC								
PO4								
Field parameters:								
Water temp. (°C)		3.1		1.8		6.3		3.5
pH		5.75		7.20		6.84		6.75
Spec. cond. (uS/cm)		1741		1680		1576		1364
Cond. (uS/cm)		1010		940		1000		800

July 5-00							Galkeno Garage (field dup- Gk 300 adit)			
	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.	Seep at Road Piezo	Seep 5	Seep 6 + 120	
Site #	11	9	6	5	3	1	8	7	4	11
Acidity to pH 4.5										
Acidity, total		273	195	61	7	4	66	64	19	272
Alkalinity to pH 4.5	< 0.5	0.5	1.7	3.3	37	31.2	< 0.5	21.6	43.2	< 0.5
Cl-	< 6	< 5.1	< 6	< 6	< 6	< 6	< 6	< 6	< 6	< 6
F	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
SO4	1330	1240	1150	1030	850	943	1130	1140	1110	1320
Br	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate	0.33	0.33	0.25	< 0.002	< 0.002	< 0.002	0.22	0.34	0.50	0.239
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
pH	4.90	5.71	6.16	7.44	7.37	7.53	5.31	7.02	7.52	5.01
FR	2,000	1870	1670	1540	1270	1450	1650	1720	1630	2000
NFR	53	< 5	< 5	< 5	< 5	848	< 5	144	49	57
Spec. Cond.	1,674	1805	1766	1670	1430	1570	1700	1760	1740	1873
Hardness, Ca+Mg	616	756	1030	1080.5	858	985.2	965	1050.0	1110	614.6
Hardness, total	1,287	1184.6	1120	1087.9	861.4	991.2	1080	1150	1130	1287.5
ICP, dissolved										
Al	0.3	0	0.07	< 0.05	0.07	0.06	0.2	< 0.05	< 0.05	0.28
Sb	0.40	0.33	0.13	< 0.05	< 0.05	0.05	0.11	0.12	< 0.05	0.39
As	0.08	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1
Ba	0.012	0.011	0.025	0.029	0.022	0.106	0.027	0.025	0.03	0.014
Be	0.003	0.004	0.005	0.006	0.005	0.006	0.005	0.005	0.006	0.003
B	0.07	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.07
Cd	1.230	0.511	0.032	< 0.005	< 0.005	< 0.005	0.052	0.082	0.014	1.23
Ca	179.0	225	320	343.1	269.1	305.5	295	326	347	178
Cr	0.033	0.016	0.008	< 0.005	< 0.005	< 0.005	0.006	0.006	< 0.005	0.027
Co	0.123	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.122
Cu	0.038	0.075	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.044
Fe	27.5	< 0.005	< 0.005	< 0.005	0.006	0.643	< 0.005	< 0.005	0.054	27.600
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	41.0	47	56.2	54.3	45.2	54.0	55.3	57.9	59.4	41
Mn	214.76	135.1	15.4	0.081	< 0.001	0.385	32.2	16.1	0.16	216.25
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
Ni	1.78	1.31	0.28	< 0.02	< 0.02	< 0.02	0.35	0.31	0.04	1.78
P	1.3	0.8	0.2	< 0.1	< 0.1	< 0.1	0.3	0.2	< 0.1	1.3
K	0.8	1.1	1.4	0.9	0.4	0.9	0.9	1.3	1.2	0.9
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	4.8	5.8	6.94	5.44	4.29	4.08	5.02	6.12	5.17	4.82
Ag	0.03	0.02	< 0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	0.03
Na	1.7	1.7	2.1	2.5	2.3	2.3	2.3	2	2.2	1.6
Sr	0.247	0.434	0.663	0.629	0.494	0.564	0.465	0.643	0.678	0.246
S	402	388	357	319	268	300	330	361	347	394
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.004	0.006
V	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	149.6	118.37	36.3	4.24	1.711	2.12	37.7	40.8	13.10	149
ICP, Total										
Al	0.73	0.24	< 0.06	< 0.06	< 0.06	13.1	0.22	2.43	0.71	0.70
Sb	0.43	0.33	0.12	< 0.06	< 0.06	< 0.06	0.12	0.15	< 0.06	0.43
As	0.2	< 0.06	< 0.06	< 0.06	< 0.06	0.07	< 0.06	< 0.06	< 0.06	0.19
Ba	0.005	0.009	0.021	0.039	0.03	0.451	0.018	0.077	0.043	0.006
Be	0.004	0.004	0.005	0.006	0.005	0.005	0.005	0.006	0.005	0.003
B	0.07	< 0.01	< 0.01	< 0.01	< 0.01	0.07	< 0.01	0.01	< 0.01	0.07
Cd	1.210	0.490	0.012	< 0.006	< 0.006	0.012	0.05	0.083	0.012	12
Ca	172	211	308	324	268	309	282.0	310	326	172
Cr	0.018	0.009	< 0.006	< 0.006	< 0.006	0.025	< 0.006	< 0.006	< 0.006	0.021
Co	0.121	0.022	< 0.006	< 0.006	0.01	0.018	0.008	< 0.006	< 0.006	0.122
Cu	0.054	0.078	< 0.006	< 0.006	< 0.006	0.055	< 0.006	0.041	< 0.006	0.054
Fe	32.1	< 0.006	< 0.006	0.105	0.025	28.1	< 0.006	3.45	1.2	32
Pb	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	0.08
Mg	38.7	43.1	52.9	55.3	47.4	59.1	51.5	53.9	54.5	38.7
Mn	194	120	15	0.093	0.005	0.919	32.800	15.6	0.197	191.000
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	2	1.28	0.27	< 0.02	< 0.02	0.05	0.45	0.32	< 0.02	1.81
P	1.4	0.9	0.2	< 0.1	< 0.1	0.8	0.4	0.4	0.1	1.4
K	0.7	1	1.2	1.2	0.6	2.9	0.8	1.6	1	0.7
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	5	6	7.15	5.14	4.93	24.1	5.05	9.68	6.2	4.9
Ag	0.04	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03
Na	1.5	1.6	2.0	2.4	2.1	3.3	2.1	2.1	2.1	1.5
Sr	0.241	0.417	0.654	0.722	0.589	0.697	0.451	0.626	0.653	0.241
S	377	351	336	332	268	300	324	330	315	373
Sn	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	< 0.002	< 0.002	< 0.002	0.005	< 0.002	0.458	< 0.002	0.081	0.013	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	< 0.01	< 0.01	< 0.01	< 0.01
Zn	158.0	119.37	37.5	4.05	1.690	3.04	36.7	42.000	13.4	154.8
TIC	11.7	4.5	3.3	10.5	9	16.2	0.8	6.8	11.6	12.1
TOC	< 0.5	0.6	2.7	2.1	5.6	4.1	9.1	2.9	2	< 0.5
PO4	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.783	< 0.002	0.101	< 0.002	< 0.002
Field parameters:										
Water temp. (°C)	2.3	2.8	1.5	3.3	5.5	6.7	3.7	1.2	2.8	2.3
pH	5.9	5.39	6.06	6.83	6.77	6.89	5.02	6.41	6.77	5.9
Spec. cond. (uS/cm)	1939	1721	1785	1560	1451	1496	1627	1800	1721	1939
Cond. (uS/cm)	1100	990	990	910	900	960	960	990	990	1100

July 11-00		Galkeno 300 adit		Seep6 + 120		Old Rd. ar ROW Xing		300 drainage at Christal Ck	
Site #		11		4		5		1	
Acidity to pH 4.5									
Acidity, total									
Alkalinity, total									
Cl-									
F									
SO4									
Br									
Nitrate									
Nitrite									
P									
pH									
FR									
NFR									
Spec. Cond.									
GFAA (dissolved):									
Se	<	0.001	<	0.001	<	0.001	<	0.001	
GFAA (total):									
Se	<	0.001	<	0.001	<	0.001	<	0.001	
Hardness, Ca+Mg		684.5		1,116.2		1,075.1		995.9	
Hardness, total		1,371.1		1,137.6		1,083.6		1002.3	
ICP, dissolved									
Al		0.25	<	0.05		0.08		0.11	
Sb		0.44	<	0.05	<	0.05		0.05	
As		0.06	<	0.05	<	0.05	<	0.05	
Ba		0.004		0.033		0.046		0.137	
Be		0.003		0.004		0.006		0.006	
B	0.07		0.01		0.02		<	0.01	
Cd		1.170		0.027		0.019		0.008	
Ca		198.6		350.3		337.9		307.9	
Cr		0.031		0.016		0.037		0.013	
Co		0.126	<	0.005		0.013	<	0.005	
Cu	0.018		0.011		0.022			0.008	
Fe		30.445		0.067		0.041		0.74	
Pb	<	0.05	<	0.05		0.06		0.06	
Mg		45.8		58.6		56.1		55.1	
Mn		208.4		0.2		0.2		0.554	
Mo	< 0.01		< 0.01		0.02		<	0.01	
Ni		2.03		0.05		0.05		0.03	
P		1.5	<	0.1	<	0.1		0.1	
K		0.6		1.3		1.5		1.0	
Se	<	0.001	<	0.001	<	0.001	<	0.001	
Si		5.17		5.40		6.03		4.11	
Ag	0.02		< 0.01		< 0.01			0.02	
Na		1.5		2.1		2.4		2.3	
Sr		0.275		0.678		0.656		0.582	
S		475		390		377		283.16	
Sn	<	0.05	<	0.05	<	0.05	<	0.05	
Ti	<	0.002		0.013		0.027		0.012	
V	< 0.01		< 0.01		0.02			0.03	
Zn		163.9		13.1		4.6		1.875	
ICP, Total									
Al		0.56		1.60		0.26		19.29	
Sb		0.43		0.06	<	0.06	<	0.06	
As		0.15	<	0.06	<	0.06		0.08	
Ba		0.012		0.062		0.047		0.6	
Be		0.013		0.015		0.015		0.014	
B		0.08	<	0.01	<	0.01		0.08	
Cd		1.12		0.03		0.01		0.022	
Ca		182.2		337.6		310.8		337.1	
Cr	0.043		0.007		<	0.006		0.029	
Co		0.137	<	0.006	<	0.006		0.027	
Cu		0.040		0.016	<	0.006		0.072	
Fe		33.6		2.5		0.3		37.819	
Pb		0.10	<	0.06	<	0.06		0.09	
Mg		42.7		57.8		53.6		65.1	
Mn		190.8		0.3		0.2		1.219	
Mo	<	0.01	<	0.01	<	0.01	<	0.01	
Ni		1.88		0.04		0.02		0.08	
P		1.2	<	0.1	<	0.1		1.3	
K		0.9		1.3		1.1		3.2	
Se	< 0.001		< 0.06		0.09		<	0.001	
Si		4.93		7.45		5.92		29.3	
Ag		0.04		0.01	<	0.01	<	0.01	
Na		1.6		2.4		2.2		3.0	
Sr		0.259		0.674		0.628		0.684	
S		373		318		298		289.3	
Sn	<	0.06	<	0.06	<	0.06	<	0.06	
Ti		0.003		0.051		0.011		0.650	
V	<	0.01		0.03		0.02		0.09	
Zn		150.9		13.1		4.3		3.47	
TIC									
TOC									
PO4									
Field parameters:									
Water temp. (°C)		3.1		2.6		3.2		3.5	
pH		5.75		6.76		6.78		6.75	
Spec. cond. (uS/cm)		1741		1731		1633		1364	
Cond. (uS/cm)		1010		990		950		800	

July 22- 00

	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
Site #	11	9	6	5	3	1
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	253	193	54	7	4	6
Alkalinity to pH 4.5	3.1	1.9	4.1	49.9	43.9	82.5
Cl-	< 5	< 5	< 5	< 5	< 5	< 6
F	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.6
SO4	1344.1	1260.6	1148.9	984	850.4	981
Br	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 3.0
Nitrate	< 0.10	0.43	0.30	0.31	< 0.1	< 0.1
Nitrite	< 0.26	< 0.26	< 0.26	< 0.26	< 0.255	< 0.3
P	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 3.0
pH	5.63	5.63	6.20	7.57	7.44	7.72
FR	2,090	1930	1700	1340	1230	1480
NFR	78	< 5	< 5	16	< 5	636
Spec. Cond.	1,890	1810	1740	1640	1390	1560
Hardness, Ca+Mg	625	838	1054	1069	765	946
Hardness, total	679	1287.5	1134.7	1077	768.3	951.1

ICP, dissolved

Al	0.3	0	0.17	0.08	< 0.05	0.14
Sb	0.46	0.39	0.15	< 0.05	< 0.05	< 0.05
As	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.012	0.014	0.013	0.039	0.019	0.078
Be	0.010	0.005	0.007	0.007	0.005	0.005
B	0.08	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Cd	0.854	0.568	0.025	0.009	< 0.005	< 0.005
Ca	183.8	250.1	329.1	336.6	238.4	292.8
Cr	0.053	0.020	< 0.005	< 0.005	< 0.005	< 0.005
Co	0.129	0.009	< 0.005	< 0.005	< 0.005	< 0.005
Cu	0.012	0.094	< 0.005	< 0.005	< 0.005	< 0.0005
Fe	29.095	< 0.005	< 0.0005	0.011	< 0.0005	0.434
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	40.4	51.3	56.4	55.5	41.3	52.2
Mn	206	130.8	12.8	0.167	< 0.001	0.429
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	1.74	1.48	0.24	< 0.02	< 0.02	< 0.02
P	1.2	1	0.3	0.1	< 0.1	0.1
K	0.8	1.2	0.7	1	0.4	0.8
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	4.2	6.8	7.16	5.93	3.92	3.66
Ag	0.04	0.02	0.02	0.01	< 0.01	< 0.01
Na	2.1	2	2.6	2.5	2	2.1
Sr	0.24	0.479	0.66	0.651	0.438	0.52
S	377	452	407.1	359.9	242	288.96
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	0.016	0.008	< 0.002	< 0.002	< 0.002	< 0.002
V	< 0.01	< 0.01	0.03	0.02	< 0.01	0.01
Zn	155	125.1	36.521	4.38	1.466	1.67

ICP, Total

Al	0.37	0.12	< 0.06	0.14	< 0.06	8.31
Sb	0.4	0.24	0.1	< 0.06	< 0.06	< 0.06
As	0.18	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.007	0.011	0.02	0.04	0.026	0.27
Be	0.003	0.003	0.005	0.005	0.004	0.004
B	0.09	0.01	< 0.01	< 0.01	< 0.01	0.03
Cd	0.766	0.505	0.029	< 0.006	< 0.006	< 0.006
Ca	177.3	218.9	304.5	287.9	246	297
Cr	0.041	0.016	< 0.006	< 0.006	0.009	0.009
Co	0.121	0.020	< 0.006	< 0.006	< 0.006	< 0.006
Cu	0.018	0.076	< 0.006	< 0.006	< 0.006	0.033
Fe	34.4	< 0.006	< 0.006	0.271	0.043	14.507
Pb	0.08	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Mg	41.6	45.7	53.2	49.8	44.4	56
Mn	194.9	119.8	12.39	0.166	0.002	0.7
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	1.73	1.29	0.24	< 0.02	< 0.02	0.03
P	1.1	0.7	0.2	< 0.1	< 0.1	0.6
K	0.8	1.1	1.1	1.1	0.7	2.1
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	4	5.72	6.61	5.36	4.27	15.4
Ag	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.6	1.7	2.3	2.2	1.9	2.7
Sr	0.231	0.424	0.621	0.578	0.454	0.54
S	379	369.9	334.9	291	237	267
Sn	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	0.002	0.005	< 0.002	0.003	< 0.002	0.274
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03
Zn	146.6	119.5	33.872	3.743	1.534	2.34
TIC	7.3	4.2	2.9	13.2	12	21.9
TOC	< 0.5	0.5	2.6	2.2	5.8	4.2
PO4	0.046	< 0.002	< 0.002	0.007	< 0.002	0.430

Field parameters:

Water temp. (°C)	2.9	4.4	7.3	2.1	5.5	5.7
pH	6.11	5.37	6.64	7.98	7.28	7.38
Spec. cond. (uS/cm)	1924	1812	1532	1595	1338	1394
Cond. (uS/cm)	1110	1090	1000	900	830	870
Flow (m³/3s)	0.052					0.062
Flow (L/s)	6.31					8.16

Seep 5	Seep at Road Piezo	Seep 6 + 120	Old Rd. Seep LHS Limit	Galkeno Garage A (field duplicate Gk 300 adit)	Galkeno Garage B (field blank)
7	8	4	2	11	
< 1	< 1	< 1	< 1	< 1	< 1
57	11	15	5	49	< 1
41.8	4	60.2	47.1	3.7	2.6
< 5	< 5	< 5	< 5.1	< 5	< 0.1
< 0.5	< 0.5	< 0.5	< 0.51	< 0.5	< 0.01
1110.7	830.7	1125.6	1058.9	1161.8	< 0.5
< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 0.05
0.47	0.37	0.53	< 0.1	0.4	0.0
< 0.26	< 0.26	< 0.26	< 0.255	< 0.26	< 0.005
< 2.6	< 2.6	< 2.6	< 2.55	< 2.6	< 0.05
7.17	6.4	7.51	7.35	6.29	6.65
1710	1310	1650	1540	1700	< 10
105	< 5	213	595	< 5	< 5
1790	1440	1750	1650	1710	< 2
1033.1	913.3	1162.5	984	1086.6	< 0.4
1118.8	928.2	1183	989	1168.4	< 0.4

< 0.05	< 0.05	0.07	< 0.05	0.15	< 0.05
0.09	< 0.05	0.05	< 0.05	0.16	< 0.05
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
0.03	0.013	0.048	0.072	0.024	< 0.001
0.005	0.005	0.007	0.004	0.007	< 0.001
< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
0.077	0.01	0.011	< 0.005	0.04	< 0.005
322.2	278.1	367.2	308.8	338	< 0.1
0.009	< 0.005	< 0.005	< 0.005	0.025	< 0.005
< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
< 0.0005	< 0.0005	0.419	0.87	< 0.0005	0.007
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
55.5	53.1	59.7	51.7	58.9	< 0.1
14.04	0.147	0.3	0.149	12.83	0.012
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
0.29	0.03	< 0.02	< 0.02	0.28	< 0.02
0.2	< 0.1	0.1	< 0.1	0.3	< 0.1
1.1	0.2	0.8	0.2	1.3	< 0.1
< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
6.19	4.96	5.56	3.98	7.53	< 0.05
< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01
2.1	2.3	2.6	2.2	2.5	< 0.1
0.624	0.447	0.702	0.522	0.685	< 0.001
418.6	290.2	391.3	319	409	0.13
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
< 0.002	< 0.002	< 0.002	< 0.002	0.003	< 0.002
< 0.01	< 0.01	0.02	< 0.01	0.03	< 0.01
38.733	9.161	11.80	0.315	37.265	0.019

1.73	< 0.06	3.90	6.92	< 0.06	< 0.06
0.08	< 0.06	< 0.06	< 0.06	0.1	< 0.06
< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
0.064	0.013	0.106	0.254	0.018	0.005
0.005	0.004	0.005	0.004	0.005	0.009
0.01	< 0.01	0.02	0.03	< 0.01	< 0.01
0.072	0.007	0.015	< 0.006	0.027	< 0.006
312.5	241.9	318.6	312.9	288.9	< 0.1
< 0.006	0.009	< 0.006	0.009	< 0.006	< 0.006
< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
0.01	< 0.006	0.036	0.02	< 0.006	< 0.006
2.34	0.016	5.9	12.762	< 0.006	< 0.006
< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
54.1	46.4	54.5	56.8	51.1	< 0.1
12.86	0.134	0.502	0.318	11.890	0.01
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
0.3	0.03	0.04	< 0.02	0.23	< 0.02
0.3	< 0.1	0.2	0.3	0.2	< 0.1
1.3	0.4	1.4	1.7	1	< 0.1
< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
8.27	4.28	10.15	13.60	6.3	< 0.06
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
2.2	2.4	2.4	2.6	2.3	< 0.1
0.612	0.389	0.635	0.554	0.594	0.002
320.8	262.81	310.9	291	322.5	< 0.06
< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
0.066	0.006	0.112	0.214	< 0.002	0.002
< 0.01	< 0.01	0.02	0.02	< 0.01	0.02
37.724	8.025	11.19	0.616	32.266	0.002

11.1	1.3	16.4	13.2	2.2	< 0.5
2.3	7.6	2.2	3.8	2.9	< 0.5
0.061	< 0.002	0.32	0.410	< 0.002	0.023

2.8	1.8	2.0	4.0	7.3	n/a
6.94	7.05	7.41	7.63	6.64	n/a
1634	1269	1707	1311	1532	n/a
940	710	960	780	1000	n/a

July 29- 00

	<i>Galkeno 300 adit</i>	<i>Seep nr. Pole 500</i>	<i>Seep 8</i>	<i>Old Rd. AT ROW Xing</i>	<i>Old Rd. Seep RHS Limit</i>	<i>300 drainage @ Christal Ck.</i>
Site #	11	9	6	5	3	1
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	268	208	56	7	4	7
Alkalinity to pH 4.5	5.0	2.2	4.9	60.6	48.7	80.6
Cl-	< 5	< 5	< 5	< 5	< 5	< 5
F	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
SO4	1440	1270	1140	948	712	880
Br	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
Nitrate	< 0.10	0.40	0.30	0.20	< 0.1	< 0.1
Nitrite	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
P	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
pH	5.96	5.92	6.40	7.65	7.54	7.77
FR	2,110	1920	1710	1460	1100	1390
NFR	75	7	< 5	45	< 5	959
Spec. Cond.	1,940	1880	1760	1580	1135	1530
Hardness, Ca+Mg	680	733	997	868	738	919.7
Hardness, total	1,370	1170	1070	894	741	924.6

ICP, dissolved

Al	0.2	0	0.08	0.1	< 0.05	< 0.05
Sb	0.42	0.23	0.1	0.06	< 0.05	< 0.05
As	0.08	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.007	0.003	0.015	0.029	0.019	0.066
Be	0.004	0.002	0.006	0.006	0.004	0.005
B	0.10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	0.802	0.513	0.029	< 0.005	< 0.005	< 0.005
Ca	201.0	221	313	279	229	282
Cr	0.070	0.019	< 0.005	< 0.005	< 0.005	0.007
Co	0.149	0.010	< 0.005	< 0.005	< 0.005	< 0.005
Cu	0.005	0.052	< 0.005	< 0.005	< 0.005	< 0.005
Fe	33.5	< 0.005	< 0.005	< 0.005	0.012	0.515
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	43.2	43.9	52.4	46.3	40.1	52.5
Mn	211.00	135.0	14.8	0.148	0.01	0.416
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	1.72	1.14	0.22	< 0.02	< 0.02	< 0.01
P	1.0	0.5	0.2	< 0.1	< 0.1	< 0.1
K	0.8	0.7	0.9	0.7	0.5	0.9
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	4.5	5.47	5.3	4.78	4.23	3.89
Ag	0.04	< 0.01	0.01	0.02	< 0.01	< 0.01
Na	1.4	1.4	2.6	2.4	1.9	2.1
Sr	0.261	0.404	0.584	0.530	0.437	0.532
S	480	434	392	286	245	312
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	0.004	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
V	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01
Zn	161	122	31.8	3.48	1.48	1.65

ICP, Total

Al	0.36	0.34	0.13	1.05	< 0.06	8.72
Sb	0.41	0.31	0.11	< 0.06	< 0.06	< 0.06
As	0.19	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.008	0.012	0.022	0.064	0.023	0.271
Be	0.004	0.004	0.005	0.005	0.004	0.004
B	0.1	0.02	< 0.01	0.01	< 0.01	0.04
Cd	0.769	0.506	0.029	< 0.006	< 0.006	< 0.006
Ca	195	235	324	303.0	224	294
Cr	0.073	0.02	0.009	< 0.006	< 0.006	0.008
Co	0.135	0.013	< 0.006	< 0.006	< 0.006	< 0.006
Cu	0.014	0.088	< 0.006	< 0.006	< 0.006	0.031
Fe	39.2	< 0.006	< 0.006	1.44	0.019	16.3
Pb	< 0.06	0.08	< 0.06	< 0.06	< 0.06	0.09
Mg	46.1	49.8	58.1	53.2	41.3	56.9
Mn	204	130	14.2	0.224	0.003	0.71
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	1.89	1.34	0.27	< 0.02	< 0.02	0.03
P	1.2	0.7	0.1	< 0.1	< 0.1	0.8
K	0.9	1.2	1.2	1.3	0.6	1.8
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	4.90	6.06	5.81	5.65	4.27	15.4
Ag	0.03	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.5	1.9	2.5	2.4	1.8	2.5
Sr	0.274	0.43	0.617	0.573	0.42	0.539
S	427	393	357	296	228	281
Sn	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	0.003	0.002	< 0.002	0.028	< 0.002	0.291
V	> 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03
Zn	151.0	120	32.7	3.88	1.440	2.41

TIC	9.9	4.5	3.1	14.5	11.5	20
TOC	< 0.5	0.5	2.2	2.3	6.4	4.7
PO4	< 0.002	< 0.002	< 0.002	0.013	< 0.002	0.72

Field parameters:

<i>Water temp. (°C)</i>	3.1	6.3	4.2	2.8	4.7	4.4
<i>pH</i>	6.22	7.75	7.72	7.89	6.5	7.04
<i>Spec. cond. (µS/cm)</i>	3585	4570	4847	1547	1220	798
<i>Cond. (µS/cm)</i>	2080	2900	2900	890	740	480
<i>ORP (mV)</i>	265	530	335	250	267	98
<i>Eh (mV) (calc'd)</i>	464	729	534	449	466	297
<i>Flow (m³/3/s)</i>	0.055					0.06
<i>Flow (L/s)</i>	6.85					7.78

<i>Sinkhole nr. Pole 500</i>	<i>Seep 5</i>	<i>Seep 6 + 120</i>	<i>Old Rd. Seep LHS Limit</i>	<i>Galkeno Garage A (field dup. Seep 6+120)</i>	<i>Galkeno Garage B (field dup. Seep nr. Pole 500)</i>
10	7	4	2	4	9
< 1	< 1	< 1	< 1	< 1	< 1
259	60	8	5	14	204
< 0.5	42.7	62.5	48.3	63	2.4
< 5	< 5	< 5	< 5	< 5	< 5
< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1410	1070	1040	977	1050	1340
< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
< 0.10	0.40	0.40	< 0.1	0.4	< 0.3
< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
< 3.0	< 3.0	< 3.0	< 3.0	< 3.0	< 3.0
5.19	7.27	7.58	7.56	7.6	5.82
2070	1730	1600	1480	1590	1950
38	67	130	<i>no value</i>	148	7
1900	1800	1720	1620	1720	1880
635	1010.0	1180	992	1060	753
1270	1090	1200	996	1080	1200

< 0.05	0.11	0.1	0.05	< 0.05	0.06
0.31	0.13	0.1	< 0.05	< 0.05	0.23
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
< 0.001	0.036	0.037	0.061	0.040	0.011
0.002	0.006	0.007	0.006	0.005	0.003
0.04	0.02	< 0.01	< 0.01	< 0.01	0.01
0.725	0.086	0.010	< 0.005	0.019	0.53
187	320	375	307	338	226
0.042	0.028	< 0.005	< 0.005	0.009	0.04
0.114	0.019	< 0.005	< 0.005	< 0.005	0.024
< 0.005	0.018	< 0.005	< 0.005	< 0.005	0.073
14.1	0.013	0.117	0.993	0.133	< 0.005
< 0.05	0.14	< 0.05	< 0.05	0.08	< 0.05
41.0	51.0	59.4	54.5	52.5	45.6
207.0	13.3	0.279	0.163	0.255	136
< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01
1.56	0.29	< 0.02	< 0.02	0.05	1.18
0.8	0.2	0.1	< 0.1	< 0.1	0.5
0.4	1.5	0.7	0.7	1.1	1.2
< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
3.71	5.71	5.4	4.44	4.91	5.69
0.02	0.02	0.02	< 0.01	< 0.01	< 0.01
1.1	2.6	2.7	2.3	2.5	1.3
0.246	0.578	0.695	0.564	0.612	0.419
477	429	369	363	393	459
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
< 0.002	0.028	< 0.002	< 0.002	0.011	0.004
< 0.01	0.02	0.02	< 0.01	< 0.01	< 0.01
155	36	11.10	0.497	10.1	129

0.66	1.4	2.69	8	2.61	0.33
0.42	0.11	< 0.06	< 0.06	< 0.06	0.36
0.17	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
0.014	0.061	0.086	0.257	0.086	0.011
0.004	0.005	0.005	0.005	0.005	0.004
0.09	0.01	0.03	0.03	0.03	0.01
0.756	0.07	0.016	< 0.006	0.015	0.506
188	342	339	314.0	336	236
0.065	0.01	0.01	0.013	< 0.006	0.024
0.124	< 0.006	0.008	0.009	0.006	0.015
0.02	0.015	0.025	0.02	0.026	0.088
32.3	1.76	4.0	12.900	3.83	< 0.006
0.10	< 0.06	< 0.06	0.06	0.06	< 0.06
44.3	59.5	58.1	57.9	57.3	50
196	12.1	0.350	0.351	0.337	130.00
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1.81	0.29	0.03	< 0.02	0.04	1.35
1.2	0.1	< 0.1	0.5	0.1	0.7
1	1.4	1.3	1.7	1.4	1.2
< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
5	8.06	8.47	14.80	8.4	5.1
0.03	< 0.01	< 0.01	< 0.01	< 0.01	0.02
1.5	2.4	2.6	2.6	2.5	1.9
0.266	0.630	0.633	0.564	0.624	0.432
412	368	323	295	322	395
< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
0.010	0.043	0.076	0.253	0.078	< 0.002
< 0.01	< 0.01	0.01	0.03	0.01	< 0.01
148	36.300	10.7	0.825	10.6	120

1.1	10.4	14.8	12.8	14.8	3.4
0.5	2.1	2.3	3.8	2.3	0.6
< 0.002	0.026	0.066	1.900	0.075	< 0.002

6.9	7.7	2.5	4.2	2.5	6.3
7.69	7.31	6.51	6.71	6.51	7.75
4339	3485	1718	1387	1718	4570
2800	2300	980	830	980	2900
not measured	335	235	107	235	530
	534	434	306	434	729

Aug 4- 00

	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
Site #	11	9	6	5	3	1
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	250	211	54	10	5	8
Alkalinity to pH 4.5	8.1	1.9	5.7	65.4	49.6	81.1
Cl-	< 5	< 5	< 5	< 5	< 5	< 5
F	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
SO4	1288	1230	1090	855	601	793
Br	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6
Nitrate	< 0.10	0.52	0.35	0.40	0.1	0.1
Nitrite	< 0.26	< 0.26	< 0.26	< 0.26	< 0.26	< 0.26
P	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6
pH	5.98	5.69	6.30	7.57	7.52	7.68
FR	2060	1930	1690	1340	970	1280
NFR	62	12	< 5	114	< 5	501
Spec. Cond.	1870	1790	1663	1494	1135	1429
Hardness, Ca+Mg	699	723.3	1019	910	663	859
Hardness, total	1359	1165.2	1100.8	919	668	864
ICP, dissolved						
Al	0.2	0	< 0.05	< 0.05	0.17	0.27
Sb	0.41	0.39	0.19	< 0.05	0.09	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.003	0.012	0.015	0.048	0.023	0.060
Be	0.004	0.010	0.013	0.010	0.011	0.010
B	0.09	0.01	< 0.01	0.01	< 0.01	< 0.01
Cd	0.706	0.503	0.024	0.011	< 0.005	< 0.005
Ca	203.0	215	316	262	210	267
Cr	0.031	0.023	< 0.005	0.012	< 0.005	< 0.005
Co	0.127	0.009	< 0.005	0.007	< 0.005	< 0.005
Cu	< 0.005	0.065	< 0.005	0.009	< 0.005	< 0.005
Fe	32.9	< 0.005	< 0.005	0.068	0.011	0.584
Pb	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05
Mg	46.8	45.3	56.0	50.2	38.7	46.8
Mn	197.00	132.8	18.56	0.339	0.004	0.330
Mo	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.01
Ni	1.78	1.2	0.26	0.04	< 0.02	< 0.02
P	1.1	0.7	0.3	< 0.1	< 0.1	< 0.1
K	0.6	0.9	0.6	1.2	0.5	0.8
Se	< 0.001	< 0.001	< 0.05	0.07	< 0.05	< 0.05
Si	4.6	5.5	6.46	5.19	4.29	3.66
Ag	0.03	0.02	0.01	< 0.01	0.01	< 0.01
Na	1.7	2.1	2.8	2.1	1.9	2.3
Sr	0.277	0.411	0.62	0.566	0.415	0.472
S	399	393	350.1	260	199	259
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	< 0.002	< 0.002	0.015	< 0.002	0.007
V	< 0.01	< 0.01	0.03	< 0.01	0.03	< 0.01
Zn	157	129.8	30.9	4.62	1.37	1.49
ICP, Total						
Al	< 3	0.36	< 0.06	2.20	< 0.06	6.75
Sb	0.36	0.33	< 0.06	< 0.06	< 0.06	< 0.06
As	0.14	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.006	0.021	0.029	0.097	0.021	0.221
Be	0.003	0.011	0.012	0.004	0.003	0.004
B	0.1	0.02	< 0.01	< 0.01	< 0.01	0.03
Cd	0.680	0.280	0.038	0.014	< 0.006	0.009
Ca	188	242	317	282.0	202	279
Cr	< 0.3	0.03	0.015	< 0.006	< 0.006	< 0.006
Co	0.136	< 0.006	< 0.006	0.012	< 0.006	0.009
Cu	0.009	0.089	< 0.006	< 0.006	< 0.006	0.023
Fe	37.1	0.012	< 0.006	3.28	0.009	13.7
Pb	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Mg	37.1	51.5	57.6	50.5	37.6	53.8
Mn	199	135.9	17.24	0.515	< 0.001	0.647
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	2	1.44	0.3	< 0.02	< 0.02	0.03
P	< 5	0.8	0.2	0.2	< 0.1	0.6
K	0.8	1.2	1.2	1.36	0.6	1.7
Se	< 3	< 0.001	< 0.06	< 0.06	< 0.06	< 0.06
Si	6	7	6.92	8.18	4.36	13.4
Ag	0.03	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.5	1.8	2.5	2.2	1.6	2.3
Sr	0.245	0.476	0.647	0.573	0.403	0.539
S	402	416.8	357.2	268	197	263
Sn	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	0.004	0.008	0.002	0.069	< 0.002	0.203
V	< 0.01	< 0.01	0.01	0.01	< 0.01	0.02
Zn	149.3	124.1	31.9	4.96	1.350	2.11
TIC	13.2	5.5	3.9	17.2	12.7	20.6
TOC	< 0.5	0.5	2.5	3.1	8.2	6.1
PO4	0.005	0.013	< 0.002	0.100	0.014	0.518
Field parameters:						
Water temp. (°C)	3.0	5.4	3.8	3.2	3.9	8.1
pH	6.83	5.81	7.09	7.73	7.81	7.26
Spec. cond. (uS/cm)	2368	2117	1994	1719	1365	1379
Cond. (uS/cm)	1370	1310	1180	1000	810	920
ORP (mV)	121	354	316.9	184	303	104
Eh (mV) (calc'd)	320	553	515.9	383	502	303
Flow (m³/3/s)	0.062					0.091
Flow (L/s)	8.16					14.22

Sinkhole nr. Pole 500	Seep 5	Seep at Road Piezo	Seep 6 + 120	Old Rd. Seep LHS Limit	Galkeno Garage A (300 drainage duplicate)	Galkeno Garage B (Old Rd. Seep LHS Limit duplicate)	Galkeno Garage C (field dup. Seep 5)
10	7	8	4	2	1	2	7
< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
237	56	9	13	7	7	7	56
1.3	46.3	10	56.9	51.5	80.3	51.9	45.7
< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
1270	1100	792	989	989	777	903	1090
< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6
0.34	0.49	0.50	0.47	0.1	0.1	0.1	0.55
< 0.26	< 0.26	< 0.26	< 0.26	< 0.26	< 0.26	< 0.26	< 0.26
< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6	< 2.6
5.51	7.27	6.67	7.49	7.37	7.69	7.40	7.27
2070	1740	1250	1540	1440	1250	1400	1750
49	27	6	329	447	529	442	40
1627	1805	1347	1650	1556	1428	1543	1770
695.6	1074.7	759	1002	1022	858	1055.1	988.4
1314.4	1154.8	767	1018	1029	863	1061.6	1065.3
< 0.13	< 0.05	< 0.05	< 0.05	< 0.05	0.10	< 0.05	< 0.05
0.51	0.15	0.09	< 0.05	0.07	0.07	< 0.05	0.20
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
0.005	0.052	0.009	0.069	0.089	0.061	0.118	0.031
0.01	0.011	0.011	0.010	0.012	0.011	0.011	0.012
0.04	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
0.697	0.074	< 0.005	0.013	< 0.005	< 0.005	< 0.005	0.053
203	332	229	315	317	267	325	308
0.042	0.015	< 0.005	0.021	< 0.005	0.008	0.014	< 0.005
0.126	0.015	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
< 0.005	0.024	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005
14.1	0.068	< 0.005	0.304	2.00	0.534	2.24	0.023
< 0.05	0.07	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
45.9	69.4	45.3	52.6	56.0	46.7	59.1	53.0
196.7	13.84	0.018	0.298	0.216	0.327	0.292	13.92
< 0.01	0.03	< 0.01	0.02	< 0.01	0.01	< 0.01	< 0.01
1.74	0.32	< 0.02	0.04	< 0.02	< 0.02	< 0.02	0.22
1.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1
0.5	1.7	< 0.1	1.1	0.7	0.8	0.9	0.6
< 0.001	0.10	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
3.95	6.18	3.85	4.82	4.72	3.63	4.94	5.46
0.03	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02
1.7	2.1	2.5	2.2	2.5	2.4	2.1	2.5
0.277	0.654	0.366	0.603	0.585	0.470	0.614	0.590
402	360.8	232	293	298	255	301.1	358.7
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
< 0.002	0.026	< 0.002	0.016	< 0.002	0.005	< 0.002	< 0.002
< 0.01	< 0.01	0.03	< 0.01	0.02	0.01	< 0.01	0.03
153.1	35.2	4.78	8.39	0.715	1.44	0.719	33.1
< 3	0.98	< 0.06	6.28	7.33	5.00	17.1	0.86
0.38	0.09	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
0.09	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	0.07	< 0.06
0.007	0.061	0.019	0.176	0.240	0.179	0.487	0.067
0.003	0.005	0.011	0.006	0.004	0.004	0.004	0.013
0.07	< 0.01	< 0.01	0.02	0.04	0.02	0.08	0.01
0.699	0.078	0.012	0.021	0.014	0.007	0.018	0.080
192.2	340	241.0	332	312.0	274	319	348
< 0.3	< 0.006	< 0.006	0.013	0.012	0.012	0.026	0.021
0.143	0.014	< 0.006	0.007	0.019	0.014	0.039	< 0.006
0.015	< 0.006	< 0.006	0.062	0.023	0.017	0.056	0.010
27.2	1.30	0.077	10.0	16.300	10.3	36.6	1.14
0.08	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
44.3	59.3	47.8	57.0	57.1	52.2	59.8	60.2
203.22	12.96	0.050	0.569	0.600	0.560	1.28	13.19
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
3	0.29	< 0.02	0.03	0.03	0.03	0.05	0.30
< 5	0.3	< 0.1	0.4	0.9	0.5	1.8	0.2
1	1.6	0.3	1.7	1.7	1.5	2.5	1.4
< 0.001	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
7	7.70	4.31	13.6	14.60	11.0	26.1	7.67
0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1.5	2.4	2.3	2.5	2.5	2.2	3	2.4
0.253	0.665	0.396	0.655	0.600	0.526	0.630	0.684
413	367.5	252	325.2	299	259	296	369.1
< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
0.007	0.030	0.005	0.176	0.227	0.151	0.504	0.028
< 0.01	< 0.01	< 0.01	0.02	0.02	0.02	0.06	0.02
153.5	37.200	5.19	10.3	1.16	2.02	1.66	37.9
2.3	12.7	4.0	14.7	3.7	20.7	3.7	12.3
0.6	2.3	7.0	3.4	14.5	6.2	14.5	2.4
0.003	0.024	0.011	0.285	0.370	0.505	0.383	0.030
9.5	4.5	3.1	2.1	3.4	8.1	3.4	4.5
6.99	6.84	6.79	8.2	7.67	7.26	7.67	6.84
1974	2138	1900	1914	1743	1379	1743	2138
1370	1290	870	1080	1020	920	1020	1290
44.1	200	not measured	104	105	104	105	200
243.1	399		303	304	303	304	399
					0.091		
					14.22		

Aug 12-00

	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
Site #	11	9	6	5	3	1
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	274	215	53	11	5	8
Alkalinity to pH 4.5	7.2	2.2	7.2	57.4	53.7	90.6
Cl-	< 5	< 5	< 5	< 5	< 5	< 5
F	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
SO4	1450	1380	1190	1000	847	955
Br	<	3	<	3	<	3
Nitrate	< 0.1	0.4	< 0.1	< 0.1	< 0.1	< 0.1
Nitrite	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.3
P	<	3	<	3	<	3
pH	5.93	5.83	6.44	7.31	7.43	7.60
FR	2,060	1930	1710	1480	1280	1460
NFR	68	< 5	7	50	< 5	345
Spec. Cond.	1,980	1910	1790	1650	1440	1630
Hardness, Ca+Mg	613	824	1030	1090	837	1150
Hardness, total	1,320	1290	1100	1100	840	1160

ICP, dissolved

Al	<	2.5	<	3	0.05	< 0.05	< 0.05
Sb		0.42	0.45		0.15	0.1	< 0.05
As		0.07	< 0.05	< 0.05		0.07	< 0.05
Ba		0.003	0.009	0.017		0.056	0.024
Be		0.002	0.005	0.006		0.006	< 0.001
B		0.07	< 0.01	< 0.01		0.02	< 0.01
Cd		0.600	0.562	0.029		0.027	< 0.005
Ca		177.4	242	321		344	258
Cr	<	0.25	0.250	< 0.005		0.041	< 0.005
Co		0.115	< 0.005	< 0.005		0.037	< 0.005
Cu	<	0.005	0.078	< 0.005		0.024	< 0.005
Fe	34.83	< 0.3	< 0.005	< 0.005		0.090	< 0.005
Pb	<	0.05	< 0.05	< 0.05		0.13	< 0.05
Mg		41.1	53.4	54.2		55.5	47.2
Mn		216.00	142.0	16.8		0.410	0.006
Mo	< 0.01	< 0.01	< 0.01			0.02	< 0.01
Ni		2.90	1.9	0.27		0.07	< 0.02
P	<	5	< 5	0.2		< 0.1	< 0.1
K		0.5	1.0	1.2		1.7	0.6
Se	<	2.5	<	3	< 0.05	0.26	< 0.05
Si		5.3	7.0	6.1		5.61	4.48
Ag	< 0.01	0.03	0.01	0.01		0.01	< 0.01
Na		0.8	0.9	2.8		2.7	0.9
Sr	0.244	0.48	0.597	0.640		0.500	0.627
S	427	405	369	320		244	3030
Sn	< 0.005	< 0.005	< 0.005	< 0.005		< 0.005	< 0.005
Ti	< 0.0002	< 0.0002	< 0.0002	0.035		< 0.002	< 0.002
V	< 0.01	< 0.01	0.01	0.01		< 0.01	< 0.01
Zn	164	133	29	6.40		1.68	1.60

ICP, Total

Al	< 3	< 3	0.13	0.13	< 0.06	< 0.06	4.53
Sb		0.39	0.32		< 0.06	< 0.06	< 0.06
As		0.16	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba		0.005	0.029	0.026	0.061	0.026	0.156
Be		0.004	0.004	0.006	0.005	0.005	0.005
B		0.10	0.02	< 0.01	< 0.01	< 0.01	0.02
Cd		0.673	0.554	0.035	0.007	< 0.006	< 0.006
Ca		193.0	229	341	322.0	268	314
Cr	0.5	< 0.3	0.008	< 0.006	< 0.006	< 0.006	< 0.006
Co	0.148	0.036	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Cu		0.009	0.083	< 0.006	< 0.006	< 0.006	0.012
Fe		39.1	0.9	0.051	1.03	< 0.006	8.52
Pb	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Mg		44.4	49.7	60.1	56.4	49.2	60.6
Mn		203	138	16.5	0.438	< 0.001	0.619
Mo	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni		2	2	0.32	< 0.02	< 0.02	0.03
P	< 5	< 5	0.2	< 0.1	< 0.1	0.3	0.3
K		0.8	1.3	1.3	1.3	0.8	1.7
Se	< 3	< 3	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Si		6	9	7.07	6.71	4.70	10.7
Ag		0.03	0.03	< 0.01	< 0.01	< 0.01	< 0.01
Na		1.6	1.9	3	2.5	2.1	2.5
Sr		0.265	0.445	0.668	0.650	0.526	0.607
S		401	387	356	311	262	301
Sn	< 0.06	<	0.06	<	0.06	< 0.06	< 0.06
Ti	< 0.0002	0.025		0.013	0.021	< 0.002	0.157
V	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	0.02
Zn		153.0	129	32.4	6.44	1.760	1.87

TIC	13.4	3.8	3.2	13.9	13.1	21.6
TOC	< 0.5	0.7	2.4	3.3	4.6	3.8
PO4	< 0.002	< 0.002	< 0.002	0.026	< 0.002	0.282

Field parameters:

Water temp. (°C)	3.0	5.1	2.9	2.5	2.9	2.7
pH	5.94	5.27	7.37	7.42	7.01	7.26
Spec. cond. (uS/cm)	2005	1923	1761	1420	1395	1534
Cond. (uS/cm)	1160	1180	1010	810	770	880
ORP (mV)	120	335	280	154	227	56
Eh (mV) (calc'd)	319	534	479	353	426	255
Flow (m³/s)	0.06					0.065
Flow (L/s)	7.78					8.74

Sinkhole nr. Pole 500	Seep 5	Seep at Road Piezo	Seep 6 + 120	Old Rd. Seep LHS Limit	Galkeno Garage A (Trip blank)	Galkeno Garage B (Old Rd. Seep RHS Limit duplicate)	Galkeno Garage C (Seep @ Old Rd. ROW Xing split sample)	Galkeno Garage D (field duplicate Gk 300 adit)
10	7	8	4	2		3	5	11
< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
246	56	7	12	8	< 1	6	11	265
< 0.5	61.7	16.3	66.9	55.9	< 0.5	53.8	57.4	5.1
< 5	< 5	< 5	< 5	< 5	< 0.1	< 5	< 5	< 5
< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.01	< 0.5	< 0.5	< 0.5
1440	1180	808	1060	980	< 0.5	845	994	1440
<	3	<	3	<	3	0.05	<	3
< 0.1	0.5	0.7	0.5	< 0.1	<	0.002	< 0.1	< 0.1
< 0.3	< 0.3	< 0.3	< 0.3	< 0.3	< 0.005	< 0.3	< 0.3	< 0.3
<	3	<	3	<	3	0.05	<	3
4.80	7.22	6.78	7.44	7.31	5.29	7.41	7.34	5.93
2080	1720	1160	1560	1480	< 10	1270	1460	2010
62	58	49	329	130	< 5	< 5	46	66
1920	1860	1350	1740	1620	< 2	1450	1650	1970
703	1050.0	791	1210	891	0.5	995	904.0	592
1550	1140	798	1230	897	0.5	999	914	1300

68.5	< 0.05	< 0.05	0.15	< 0.05	< 0.05	< 0.05	< 0.05	< 3
0.52	< 0.05	< 0.05	0.13	0.08	< 0.05	< 0.05	< 0.05	0.41
< 0.05	0.08	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
0.003	0.061	0.004	0.08	0.086	0.002	0.026	0.041	< 0.001
0.004	< 0.001	0.005	0.008	0.055	< 0.001	0.006	0.004	0.003
< 0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06
0.675	0.100	< 0.005	0.019	< 0.005	< 0.005	< 0.005	0.011	0.575
204	334	243	390	275	< 0.1	314	286	171
8.630	0.054	< 0.005	0.012	< 0.005	< 0.005	< 0.005	< 0.005	< 0.3
0.191	0.042	< 0.005	0.013	< 0.005	0.006	< 0.005	0.013	0.091
0.006	0.037	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
< 0.005	0.052	< 0.005	0.087	1.920	< 0.005	< 0.005	0.051	35.1
< 0.05	0.13	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
47.0	53.7	44.6	58.4	49.9	< 0.1	51.5	46.4	40.3
202	18.1	0.004	0.574	0.280	< 0.001	< 0.001	< 0.001	216
0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
?	0.39	< 0.02	0.04	< 0.02	< 0.02	< 0.02	< 0.02	2.7
?	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 5
0.5	1.9	0.1	1.1	0.7	< 0.1	0.8	1.2	0.3
< 0.05	0.23	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	<
< 0.05	5.71	3.98	5.33	4.01	< 0.05	4.86	4.64	5.2
0.03	< 0.01	< 0.01	0.03	< 0.01	< 0.01	0.01	< 0.01	0.02
1	2	2.6	3	1.7	0.1	2.4	2.5	0.8
0.281	0.605	0.364	0.688	0.509	< 0.001	0.561	0.533	0.236
453	374	278	337	260	< 0.05	267	300	430
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
< 0.002	0.047	< 0.002	0.006	< 0.002	< 0.002	< 0.002	0.005	< 0.002
< 0.01	< 0.01	< 0.01	0.04	< 0.01	< 0.01	0.01	< 0.01	< 0.01
144	33.1	4.63	9.15	0.660	< 0.002	1.94	5.46	164

< 3	1.18	0.53	6.73	2.24	< 0.06	< 0.06	0.76	< 3	
0.42	0.14	< 0.06	< 0.06	< 0.06	0.06	< 0.06	< 0.06		0.40
0.07	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		0.17
0.005	0.076	0.061	0.196	0.147	< 0.001	0.026	0.063	0.006	
0.004	0.007	0.005	0.006	0.005	< 0.001	0.004	0.005	0.004	
0.07	< 0.01	< 0.01	0.03	0.01	< 0.01	< 0.01	< 0.01	0.10	
0.674	0.083	< 0.006	0.016	< 0.006	< 0.006	< 0.006	0.010	0.686	
194	360	252.0	355	309	< 0.1	263	328	197	
0.5	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.3	
0.129	0.011	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.147	
< 0.006	< 0.006	< 0.006	0.058	< 0.006	< 0.006	< 0.006	< 0.006	0.011	
26.0	1.55	0.646	13	5.440	0.008	0.019	1.106	40.1	
0.07	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	
44.6	64.1	49	60.8	57.4	< 0.1	48.7	57.1	45.0	
204	18.06	0.334	0.83	0.366	< 0.001	< 0.001	0.443	208	
< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01
2	0.37	< 0.02	0.05	< 0.02	< 0.02	< 0.02	< 0.02	< 3	
< 5	0.3	< 0.1	0.4	0.2	< 0.1	< 0.1	< 0.1	< 5	
0.8	1.6	0.5	1.8	1.1	< 0.1	0.8	1.3	0.8	
< 3	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 3	
9	8.31	5.19	14.8	7.70	0.46	4.65	6.87	7	
0.03	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		0.03
1.6	2.8	2.7	2.9	2.4	< 0.1	2.1	2.6	1.7	
0.266	0.731	0.402	0.701	0.591	< 0.001	0.521	0.659	0.268	
404	371	255	328	310	< 0.06	258	308	411	
< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	
< 0.002	0.034	0.019	0.188	0.069	< 0.002	< 0.002	0.023	< 0.002	
< 0.01	0.01	< 0.01	0.03	0.01	< 0.01	< 0.01	< 0.01	< 0.01	
154	39.200	5.1	10.1	0.833	< 0.002	1.75	6.54	157	

Aug 21-00

	Galkeno 300		Seep nr.			Old Rd. AT	Old Rd.	300 drainage
Site #	adit	Pole 500	Seep 8	ROW Xing	Seep RHS	Limit	@ Christal	Ck.
	11	9	6	5	3		1	
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	
Acidity, total	278	224	53	8	6	6	6	
Alkalinity to pH 4.5	12.1	2.2	8.4	54.3	50.8	76.1		
Cl-	<	20	1.3	< 25	< 25	< 20	< 2.5	
F	<	0.25	0.09	< 0.01	< 0.01	< 0.01	< 0.01	
SO4	1.496	1375	1263	1094	1033	992		
Br	<	0.05	<	0.005	<	0.05	<	0.05
Nitrate	0.24	0.385	0.37	0.35	0.25	0.23		
Nitrite	< 0.005	< 1.25	< 0.005	< 0.005	< 0.005	< 0.005		
P	<	0.05	<	0.05	<	0.05	<	0.05
pH	6.13	5.81	6.44	7.48	7.45	7.67		
FR	2,170	1990	1790	1600	1540	1440		
NFR	74	10	29	22	918	1020		
Spec. Cond.	2.010	1890	1820	1700	1630	1600		
Hardness, Ca+Mg	748	826.4	1028	1054.9	1017	1060		
Hardness, total	1.495		1105.6	1062.6	1023	1070		

ICP, dissolved

Al	<	2.5	<	2.5	0.17	0.11	0.05	< 0.05
Sb	0.46	0.37		< 0.05	< 0.05	< 0.05	< 0.05	
As	0.10	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Ba	0.007	0.012	0.015	0.044	0.087	0.096		
Be	0.004	0.005	0.007	0.007	0.006	0.006		
B	0.10	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Cd	0.659	0.59	0.025	0.006	< 0.005	< 0.005		
Ca	218.0	244	321.5	329.5	316	327		
Cr	0.49	0.430	< 0.005	< 0.005	< 0.005	< 0.005		
Co	0.159	0.019	< 0.005	< 0.005	0.011	< 0.005		
Cu	<	0.005	0.079	< 0.005	< 0.005	< 0.005		
Fe	39.15	< 0.25	< 0.005	0.039	1.510	0.718		
Pb	<	0.05	<	0.05	<	0.05	<	0.05
Mn	49.4	52.8	55	56.4	55.1	59.5		
Mo	228.50	149.8	17.23	0.247	0.218	0.529		
Ni	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
P	3.40	2.9	0.24	< 0.02	< 0.02	< 0.02		
K	0.8	< 5	0.2	0.1	< 0.1	< 0.1		
Se	<	2.5	<	0.05	<	0.05	<	0.05
Si	6.6	7.5	6.17	5.24	4.43	4.25		
Ag	0.03	0.02	0.02	0.02	< 0.01	< 0.01		
Na	1.8	1.8	3.7	3.1	2.7	2.5		
Sr	0.296	0.473	0.598	0.640	0.577	0.614		
S	443	416.3	375.2	323.6	290	295		
Sn	<	0.05	<	0.05	< 0.05	< 0.05		
Ti	<	0.002	<	0.002	< 0.002	< 0.002		
V	< 0.01	< 0.01	0.027	0.03	0.01	< 0.01		
Zn	167.52	135.87	26.582	4.10	0.921	1.47		

ICP, Total

Al	< 3	< 3	0.25	0.48	14.41	16.89		
Sb	0.40	0.37	0.09	< 0.06	< 0.06	< 0.06		
As	0.22	< 0.06	< 0.06	< 0.06	< 0.06	0.08		
Ba	0.009	0.015	0.028	0.061	0.406	0.488		
Be	0.004	0.005	0.006	0.006	0.005	0.005		
B	0.10	0.01	< 0.01	< 0.01	0.06	0.08		
Cd	0.822	0.602	0.027	0.008	0.036	0.014		
Ca	201.8	240.8	329.8	327.5	317.4	321.8		
Cr	< 0.03	< 0.03	< 0.006	<	0.006	0.034		
Co	0.164	0.026	< 0.006	0.020	0.063	0.033		
Cu	0.015	0.095	< 0.006	0.006	25.206	0.068		
Fe	43.400	< 0.3	0.214	0.793	0.13	34.694		
Pb	0.1	0.06	<	0.06	0.09	0.09		
Mg	47.30	53.1	62.4	59.1	60.8	64.3		
Mn	220.7	151.06	17.35	0.278	0.612	1.145		
Mo	<	0.01	<	0.01	<	0.01	<	0.01
Ni	4.00	3	0.32	0.04	0.07	0.07		
P	< 5	< 5	0.2	< 0.1	0.9	1.3		
K	1.0	1.4	1.3	1.5	2.6	3.2		
Se	< 3	< 3	< 0.06	0.10	< 0.06	< 0.06		
Si	5	8	7.17	5.21	22.30	25.47		
Ag	0.03	0.02	<	0.01	< 0.01	< 0.01		
Na	1.5	1.7	2.7	2.5	2.8	3		
Sr	0.286	0.481	0.681	0.679	0.643	0.859		
S	439	426	382.3	337	299.18	294.56		
Sn	<	0.06	<	0.06	< 0.06	< 0.06		
Ti	0.005	0.004	0.007	0.002	0.446	0.561		
V	< 0.01	< 0.01	<	0.01	< 0.01	0.05		
Zn	164.7	139.9	31.586	4.439	1.859	2.66		
TIC	13.4	6.8	4.6	13.9	13.9	21.1		
TOC	< 0.5	< 0.5	2.2	1.7	3.0	2.6		
PO4	< 0.002	< 0.002	0.018	0.012	0.668	0.731		

Field parameters:

Water temp. (°C)	3.1	5.1	2.3	1.9	4.0	3.9
pH	6.29	5.36	7.26	7.74	7.35	6.79
Spec. cond. (µS/cm)	2051	1891	1692	1676	975	1517
Cond. (µS/cm)	1190	1160	960	940	580	900
ORP (mV)	110	281	261.6	174	200	25.8
Eh (mV) (calc'd)	309	480	460.6	373	399	224.8
Flow (m³/3s)	0.0675					0.075
Flow (L/s)	9.23					10.76

	Sinkhole nr.	Seep 5	Seep at Road Piezo	Seep 6 + 120	Old Rd. Seep LHS Limit	Galkeno Garage A (Field blank)	Galkeno Garage B (Field dup- Sinkhole nr. Pole 500)	Galkeno Garage C (Field dup- Seep 6+120)	Galkeno Garage D (Field dup- Seep 8)
	10	7	8	4	2		10	4	6
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	230	44	7	13	5		230	13	53
Alkalinity to pH 4.5	3.8	49.3	23.9	74	49.3	2.2	1.3	74.3	8.9
Cl-	1.4	< 25	< 0.1	< 20	< 10	< 0.1	< 20	< 2	< 2.5
F	0.2	< 0.01	< 0.01	< 0.01	< 0.01	0.03	< 0.25	< 0.01	< 0.01
SO4	1339	1263	< 0.05	1130	881	< 0.5	1375	1123	1261
Br	<	12.5	<	1.00	<	0.05	<	0.05	<
Nitrate	0.124	0.43	< 0.002	0.47	0.18	0.018	0.23	0.5	0.44
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
P	<	0.05	<	0.05	<	0.05	<	0.05	<
pH	5.96	7.21	6.94	7.61	7.48	6.96	5.49	7.61	6.46
FR	1950	1690	1200	1610	1340	< 10	1990	1640	1770
NFR	304	137	17	285	< 5	< 5	172	327	24
Spec. Cond.	1840	1810	1360	1770	1490	< 2	1880	1760	1820
Hardness, Ca+Mg	659.3	979.4	750.2	1100.4	966	< 0.4	674.6	1116.6	1016.8
Hardness, total	1283.3	1036.3	755.2	1115	970	< 0.4	1315.3	1130.6	1091.7

Al	<	2.5	0.11	0.09	< 0.05	0.07	< 0.05	< 2.50	0.06	< 0.05
Sb	0.39	0.10	0.06	< 0.05	< 0.05	< 0.05	< 0.05	0.36	< 0.05	< 0.05
As	<	0.05	0.09	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05
Ba	0.007	0.054	0.008	0.049	0.034	< 0.001	0.006	0.006	0.052	0.018
Be	0.003	0.006	0.005	0.006	0.006	< 0.001	0.004	0.006	0.006	0.004
B	0.05	0.03	< 0.01	< 0.01	< 0.01	< 0.01	0.05	< 0.01	< 0.01	< 0.01
Cd	0.568	0.073	< 0.005	0.011	< 0.005	< 0.005	5.82	0.013	0.029	
Ca	192	307.8	229.3	348	300	< 0.1	196	248.5	317.9	
Cr	<	0.250	0.055	< 0.005	< 0.005	< 0.005	0.530	< 0.005	< 0.005	
Co	0.143	0.040	< 0.005	< 0.005	< 0.009	< 0.005	0.139	< 0.005	< 0.005	
Cu	<	0.005	0.052	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	
Fe	15.2	0.085	< 0.005	0.081	0.016	0.005	17.76	0.087	< 0.005	
Pb	<	0.05	0.12	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Mn	44	51.2	43.2	56.3	52.7	< 0.1	44.7	59.8	54.1	
Mo	203.1	9.483	0.004	0.415	0.014	0.003	207.9	0.4	16.96	
Ni	< 0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
P	2.6	0.29	< 0.02	< 0.02	< 0.02	< 0.02	3.2	0.02	0.28	
K	< 5	0.2	< 0.1	< 0.1	< 0.1	< 0.1	5	< 0.1	0.2	
Se	0.8	1.9	0.1	0.8	1.2	< 0.1	0.7	0.9	1.0	
Si	<	2.5	0.30	0.05	<	0.05	<	2.5	<	0.1
Ag	4.8	5.35	3.68	4.99	4.86	< 0.05	3.60	5.18	6.15	
Na	0.03	0.02	0.02	< 0.01	0.01	< 0.01	0.03	0.01	< 0.01	
Sr	1.5	3.6	3.5	2.9	2.6	< 0.1	1.6	2.7	3.5	
S	0.265	0.547	0.342	0.651	0.580	< 0.001	0.270	0.683	0.588	
Sn	398.4	297.97	226	331.8	277	0.07	406.6	339.2	376.4	
Ti	<	0.05	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
V	<	0.002	0.061	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	
Zn	< 0.01	0.02	0.02	< 0.01	0.02	< 0.01	< 0.01	0.01	< 0.01	
	146.35	24.941	2.8	8.29	2.13	0.004	149.92	7.984	28.350	

3	2.4	< 0.06	4.53	< 0.06	< 0.06	< 3	4.57	0.18	
0.38	0.08	< 0.06	< 0.06	< 0.06	< 0.06	0.43	< 0.06		0.09
1.52	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	0.76	< 0.06	<	0.06
0.019	0.092	0.012	0.138	0.035	0.002	0.014	0.139	0.027	
0.005	0.006	0.004	0.006	0.006	< 0.001	0.004	0.007	0.006	
0.29	0.02	< 0.01	0.02	< 0.01	< 0.01	0.16	0.02	< 0.01	
0.675	0.053	< 0.006	0.020	< 0.006	< 0.006	0.635	0.017	0.029	
186.3	332.4	231.0	344.8	283.2	< 0.1	190.8	355.3	322.6	
< 0.03	< 0.006	< 0.006	0.007	0.009	0.012	< 0.3	0.016	< 0.006	
	0.142	< 0.006		0.013	< 0.006	0.026		0.147	0.019
0.12	0.031	< 0.006	0.037	< 0.006	< 0.006	0.061	0.046	< 0.006	
132	3.26		7.17		0.012	72.5	0.101	0.101	
	0.60	< 0.06	< 0.06	< 0.06	< 0.06		0.32	< 0.06	< 0.06
43.5	61.4	46.1	60.6	52.6	< 0.1	44.6	62.2	61.1	
199.93	0.22	0.036	0.61	0.022	0.004	202.14	0.655	17.58	
< 3	0.01	< 0.01	0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	0.01
3	0.26	0.03	0.06	< 0.02	< 0.02	3	0.06	0.31	
5	0.2	< 0.1	0.2	< 0.1	< 0.1	< 5	0.3	0.2	
1	1.6	0.3	1.8	1.4	0.1	1.0	1.8	1.3	
< 3	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 3	0.09	< 0.06	
7	9.41	4.11	11.71	4.87	< 0.06	6.00	11.78	6.94	
0.03	<	0.01	<	0.01	< 0.01	0.03	< 0.01	<	0.01
1.4	2.5	2.4	2.7	2.1	< 0.1	1.4	2.7	2.7	
0.268	0.656	0.384	0.703	0.579	0.001	0.273	0.723	0.667	
407	322.9	233.45	350.8	277	0.07	410	355.1	386.1	
<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	0.06
0.012	0.080	0.007	0.148	< 0.002	< 0.002	0.005	0.143	0.009	
< 0.01		0.01	0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	
163.2	29.048	2.997	9.215	2.106	0.007	156.2	9.586	30.975	
4.4	13.3	7.9	18.5	13.2	< 0.5	3.9	16.5	4.9	
0.6	2.7	6	1.7	7.3	< 0.5	0.7	1.7	2.2	
0.134	0.096	0.015	0.182	< 0.002	< 0.002	0.071	0.185	0.010	

Aug 30-00						
Site #	Galkeno 300 adit	Seep nr. Pole 500	Seep 8	Old Rd. AT ROW Xing	Old Rd. Seep RHS Limit	300 drainage @ Christal Ck.
	11	9	6	5	3	1
Acidity to pH 4.5	< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	259	200	39	7	7	6
Alkalinity to pH 4.5	11.7	4.7	20.6	73.8	54.5	95.2
Cl-	2	1.7	0.5	0.4	0.4	0.6
F	0.52	0.5	0.01	0.01	0.01	0.03
SO4	1,500	1444	1279.1	1044	920	950
Br	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate	0.04	0.361	0.269	0.354	0.15	0.133
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
pH	5.94	6.15	6.94	7.57	7.7	7.98
FR	2,170	2000	1720	1490	1300	1470
NFR	67	28	237	21	< 5	169
Spec. Cond.	2,000	1980	1830	1640	1480	1620
Hardness, Ca+Mg	741	848.4	1159.7	1120	926	1020
Hardness, total	1,155	1357.8	1206.6	1121.1	930	1020
ICP, dissolved						
Al	4.30		0.06	< 0.05	< 0.05	< 0.05
Sb	0.38		0.14	< 0.05	< 0.05	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.012	0.037		0.044	0.028	0.054
Be	0.004	0.006		0.006	0.005	0.005
B	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	0.654	0.024		0.005	< 0.005	< 0.005
Ca	257.3	361.8		347.5	285	309
Cr		0.270	< 0.005	< 0.005	< 0.005	< 0.005
Co		0.033	< 0.005	< 0.005	< 0.005	< 0.005
Cu		0.081	< 0.005	< 0.005	< 0.005	< 0.005
Fe	< 0.25		0.018	0.019	0.007	0.437
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	50	62.2		59.8	52.2	59.9
Mn	152.8	3.59		0.229	0.002	0.439
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	3.5	0.29		< 0.02	< 0.02	< 0.02
P	< 5	0.2		< 0.1	< 0.1	< 0.1
K	1.2	0.9		1.1	0.9	1.1
Se	< 2.50	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Si	6.90	6.86		5.56	4.75	4.14
Ag	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.7	3.6		3.1	2.6	2.4
Sr	0.452	0.655		0.671	0.554	0.598
S	422.5	74.1		62	281	59.7
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01
Zn	139.96	25.666		3.817	2.05	1.45
ICP, Total						
Al	< 3.00	< 3	2.56	0.21	< 0.06	1.82
Sb	0.39	0.38	0.10	< 0.06	< 0.06	< 0.06
As	0.20	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.005	0.016	0.1	0.047	0.029	0.091
Be	0.003	0.005	0.006	0.005	0.005	0.005
B	0.11	0.01	0.02	< 0.01	< 0.01	0.01
Cd	0.592	0.583	0.027	< 0.006	< 0.006	< 0.006
Ca	209	239.7	334.2	312.7	268	295
Cr	< 0.3	< 0.3	0.018	0.012	< 0.006	0.007
Co	0.159	0.015	0.010	< 0.006	< 0.006	< 0.006
Cu	0.007	0.084	< 0.006	< 0.006	< 0.006	< 0.006
Fe	45.0	< 0.3	3.156	0.315	0.012	3.73
Pb	0.01	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Mg	48.2	51.8	62.7	56.4	49.9	56.9
Mn	225	146.22	19.08	0.229	0.004	0.488
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	3	3	0.31	< 0.02	< 0.02	< 0.02
P	< 5	< 5	0.4	< 0.1	< 0.1	0.1
K	0.9	1.2	1.5	1.3	1	1.4
Se	< 3	< 3	< 0.06	< 0.06	< 0.06	< 0.06
Si	5.00	7.00	9.79	5.34	4.45	6.47
Ag	0.03	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.6	2.1	3	2.5	2.2	2.3
Sr	0.292	0.468	0.665	0.639	0.537	0.579
S	453	421	392	295	264	291
Sn	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	< 0.002	0.005	0.086	0.006	< 0.002	0.063
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	168	135.4	24.71	3.57	1.98	1.55
TIC	17.7	2.4	6.7	18.9	15	23
TOC	< 0.5	1.3	2.6	2.3	4.5	3.7
PO4	< 0.002	0.013	0.169	0.041	0.018	0.14
Field parameters:						
Water temp. (°C)	3.0	4.9	2	1.4	0.8	1.3
pH	6.34	5.08	7.38	7.65	7.41	7.26
ec. cond. (uS/cm)	2057	1901	1582	1591	1452	1323
Cond. (uS/cm)	1190	1160	890	880	790	730
ORP (mV)	83	275	218	141.1	175.1	29.4
Eh (mV) (calc'd)	282	474	417	340.1	374.1	228.4
Flow (m³/3/s)	0.06					0.0625
Flow (L/s)	7.78					8.26

					Galkeno Garage B		Galkeno Garage C		Galkeno Garage D	
Sinkhole nr. Pole 500	Seep 5	Seep at Road Piezo	Seep 6 + 120	Old Rd. Seep LHS Limit	Galkeno Garage A (Field blank)	Field dup-300 drainage @ (Christal Ck.)	Field dup-300 drainage @ (Field split- Seep 5)	Field dup-300 drainage @ (Field split- Seep nr. Pole 500)		
10	7	8	4	2		1	7	9		
< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1		
241	52	5	12	6	< 1	6	52	204		
4.8	61.6	30.6	81.7	65.9	0.6	93.1	60.7	4.8		
2.6	0.6	0.4	0.4	0.4	0.7	0.7	0.7	1.6		
0.15	< 0.01	0.02	0.02	0.01	< 0.01	0.02	< 0.01	0.05		
1494	1249	857	1147	1050	< 0.5	1000	1259	1413		
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.09	< 0.05	< 0.05		
0.089	0.371	< 0.5	0.418	0.201	< 0.002	0.089	0.38	0.353		
< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005		
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		
5.5	7.42	7.34	7.74	7.74	5.94	7.85	7.41	6.12		
2190	1760	1260	1610	1460	< 10	1480	1770	2020		
78	73	11	34	105	< 5	168	89	35		
1990	1920	1400	1760	1650	< 2	1620	1900	2000		
776.4	1153.9	866.4	1120	1030	< 0.4	1030	1271.8	928.1		
1498	1217.5	872	1130	1030	< 0.4	1030	1339.8	1432.3		
3.70		0.13	< 0.05	0.08	< 0.05	< 0.05	0.07	3.4		
0.44	0.15	< 0.05	0.06	< 0.05	< 0.05	< 0.05	0.09	0.33		
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		
0.006	0.037	0.014	0.044	0.058	< 0.001	0.053	0.042	0.01		
0.004	0.007	0.004	0.007	0.006	< 0.001	0.006	0.007	0.004		
0.06	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.001	< 0.001		
0.65	0.076	0.017	0.006	< 0.005	< 0.005	< 0.005	0.091	0.707		
231.2	366.3	266.4	352	316	< 0.1	313	404.2	282.3		
	0.350	< 0.005	0.020	< 0.005	< 0.005	< 0.005	0.006	< 0.25		
	0.162	< 0.005	0.029	< 0.005	< 0.005	< 0.005	< 0.005	0.021		
< 0.005	< 0.005	0.020	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.08		
21.56	< 0.005	0.018	0.093	1.25	< 0.005	0.46	< 0.005	< 0.25		
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		
48.3	58.1	48.9	57.8	58.2	< 0.1	59.8	63.8	54.2		
228.1	4.01	0.014	0.421	0.158	0.001	0.442	4.14	152.21		
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
4.2	0.35	0.05	0.03	< 0.02	< 0.02	< 0.02	0.38	3.1		
< 5	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.3	< 5		
0.8	1.1	0.6	0.7	0.8	< 0.1	1.1	1.3	1.2		
< 2.50	< 0.05	0.12	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 2.5		
5.30	6.06	4.17	5.09	4.55	< 0.05	4.15	6.65	6.9		
0.03	0.02	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
2.1	2.1	2	3.1	2.8	< 0.1	2.5	2.1	1.5		
0.294	0.654	0.394	0.661	0.592	< 0.001	0.6	0.721	0.494		
445	73.5	265	67.3	63	0.07	58.5	75.5	425		
< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		
< 0.002	< 0.002	0.023	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002		
< 0.01	0.02	< 0.01	0.02	0.01	< 0.01	< 0.01	< 0.01	< 0.01		
165.3	35.89	3.3	7.39	1.01	< 0.002	1.48	38.789	139.54		
< 3	0.82	0.17	0.76	1.62	< 0.06	1.78	0.89	< 3		
0.38	0.07	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	0.12	0.37		
0.21	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
0.008	0.063	0.01	0.063	0.089	< 0.001	0.089	0.061	0.018		
0.003	0.009	0.004	0.006	0.005	< 0.001	0.005	0.006	0.004		
0.09	0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	0.01		
0.600	0.084	< 0.006	0.011	< 0.006	< 0.006	< 0.006	0.079	0.592		
207.2	351.3	240.4	335	309	0.1	297	345	243.5		
0.5	0.009	< 0.006	< 0.006	< 0.006	0.011	< 0.006	< 0.006	< 0.3		
0.143	0.032	< 0.006	< 0.006	< 0.006	0.007	< 0.006	< 0.006	0.012		
0.018	0.014	< 0.006	0.008	< 0.006	< 0.006	< 0.006	0.008	0.084		
38.6	1.16	0.181	1.270	3.65	0.007	3.602	1.183	< 0.3		
0.21	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
47.8	63.5	48.8	57.8	57.1	< 0.1	56.5	61.1	52.6		
221.23	21.52	0.051	0.446	0.188	0.002	0.489	21.17	150.59		
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
3	0.4	< 0.02	0.03	< 0.02	< 0.02	< 0.02	0.37	3		
< 5	0.3	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.3	< 5		
0.8	1.5	0.4	1.1	1.1	< 0.1	1.4	1.6	1.3		
< 3	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 3		
7.00	7.42	4.01	5.92	6.65	< 0.06	6.28	7.13	7		
0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02		
2.4	2.6	2.6	2.6	2.4	< 0.1	2.4	2.6	2.1		
0.291	0.712	0.395	0.665	0.592	< 0.001	0.578	0.684	0.475		
453	396	244.58	417	337	0.09	284	388.6	437		
< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
< 0.002	0.033	0.005	0.025	0.061	< 0.002	0.058	0.028	0.01		
< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
166.7	36.5	3.079	7.27	1.09	0.006	1.55	34.641	139.4		
4.3	15.8	8.7	20.1	16.9	< 0.5	22.8	15.8	4.9		
0.6	2	5.8	2.7	2.9	< 0.5	3.9	2.1	0.8		
< 0.002	0.085	0.023	0.05	0.09	< 0.002	0.128	0.106	0.02		
11	3.9	2.4	0.9	1.5	n/a	1.3	3.9	4.9		
6.18	7.45	7.56	7.65	7.4	n/a	7.26	7.45	5.08		
1962	1736	1213	1723	1568	n/a	1323	1736	1901		
1420	1030	690	940	870	n/a	730	1030	1160		
-22.5	153	202	77.5	45.9	n/a	29.4	153	275		
176.5	352	401	276.5	244.9	n/a	228.4	352	474		
						0.0625				
						8.26				

APPENDIX C.2 WATER QUALITY DATA ORGANISED BY SAMPLING SITE

Organisation of results of water quality sampling by sampling site allows easy examination of changes in water quality over the sampling period. Data is organised with early sampling results on the left and later results on the right. Reading across the table from left to right is analogous to moving through time from early to late summer.

Site 11- Galkeno 300

adit	May-29	Jun-06	Jun-13	Jun-20	Jun-28	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1		< 1		< 1		< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	213	248		267		273		253	268	250	274	278	259
Alkalinity, total	13.6	14.9		0.5		0.5		3.1	5.0	8.1	7.2	12.1	11.7
Cl-	1.0	< 10		< 2		< 6		< 5	< 5	< 5	< 5	20	2
F	0.21	< 0.01		0.2		< 0.01		< 0.5	< 0.5	< 0.5	< 0.5	0.25	0.52
SO4	1,070.0	2,380		1180		1330		1344.1	1440	1288	1450	1,496	1,500
Br	< 0.05	< 5		< 0.05		< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
Nitrate	0.047	< 0.2		0.30		0.33		< 0.10	< 0.10	< 0.10	< 0.1	0.24	0.04
Nitrite	< 0.005	< 0.005		< 0.005		< 0.005		< 0.26	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005
P	< 0.05	< 5		< 0.05		< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
pH	6.61	6.19		5.49		4.90		5.63	5.96	5.98	5.93	6.13	5.94
FR	1,650	1,960		1,800		2,000		2,090	2,110	2,060	2,060	2,170	2,170
NFR	40	65		45		53		78	75	62	68	74	67
Spec. Cond.	1.670	1.890		1.680		1.674		1.890	1.940	1.870	1.910	2.010	2.000
GFAA (dissolved):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
GFAA (total):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
Hardness, Ca+Mg	570.4	653	605.1	577.7	632.0	616	684.5	625	680	699	613	748	741
Hardness, total	1,077.0	1,270	1,217.2	1,161.5	1,260.0	1,287	1,371.1	679	1,370	1,359	1,320	1,495	1,155
ICP, dissolved													
Al	0.12	0.17	0.31	0.39	0.39	0.3	0.25	0.3	0.2	0.2	< 2.5	< 2.5	
Sb	0.32	0.34	0.32	0.34	0.40	0.40	0.44	0.46	0.42	0.41	0.42	0.46	
As	< 0.05	0.11	0.09	0.05	0.08	0.08	0.06	0.06	0.08	< 0.05	0.07	0.10	
Ba	0.005	0.006	0.009	0.007	0.007	0.012	0.004	0.012	0.007	0.003	0.003	0.007	
Be	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.010	0.004	0.004	0.002	0.004	
B	0.05	0.09	0.08	0.06	0.07	0.07	0.07	0.08	0.10	0.09	0.07	0.10	
Cd	0.386	0.388	1.373	1.616	1.800	1.230	1.170	0.854	0.802	0.706	0.600	0.659	
Ca	170.2	192.0	177.2	173.3	176.0	179.0	198.6	183.8	201.0	203.0	177.4	218.0	
Cr	0.031	0.035	0.019	0.024	0.032	0.033	0.031	0.053	0.070	0.031	< 0.25	0.49	
Co	0.162	0.137	0.119	0.105	0.126	0.123	0.126	0.129	0.149	0.127	0.115	0.159	
Cu	< 0.005	< 0.005	0.076	0.096	0.076	0.038	0.018	0.012	0.005	< 0.005	< 0.005	< 0.005	
Fe	18.3	35.7	31.7	24.7	26.100	27.5	30.445	29.095	33.5	32.9	34.83	39.15	
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Mg	35.3	42.1	39.5	35.2	46.8	41.0	45.8	40.4	43.2	46.8	41.1	49.4	
Mn	155.2	191	186.4	176.3	184.0	214.76	208.4	206	211.00	197.00	216.00	228.50	
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Ni	1.47	1.72	1.78	1.65	1.72	1.78	2.03	1.74	1.72	1.78	2.90	3.40	
P	0.7	1.0	1.0	1.0	1.1	1.3	1.5	1.2	1.0	1.1	< 5	< 5.0	
K	0.7	0.7	0.8	0.7	0.8	0.8	0.6	0.8	0.8	0.6	0.5	0.8	
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Si	3.66	4.29	4.66	4.71	4.76	4.8	5.17	4.2	4.5	4.6	5.3	6.6	
Ag	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.04	0.04	0.03	< 0.01	0.03	
Na	1.5	1.5	1.6	1.6	1.5	1.7	1.5	2.1	1.4	1.7	0.8	1.8	
Sr	0.222	0.277	0.254	0.228	0.245	0.247	0.275	0.24	0.261	0.277	0.244	0.296	
S	319.2	387	392	377	375	402	475	377	480	399	427	443	
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Ti	< 0.002	< 0.002	0.003	< 0.002	< 0.002	< 0.002	< 0.002	0.016	0.004	< 0.002	< 0.002	< 0.002	
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Zn	124	136	140	141	158	150	164	155	161	157	164	168	
ICP, Total													
Al	0.22	0.28	0.49	0.77	0.95	0.73	0.56	0.37	0.36	< 3	< 3	< 3	3.00
Sb	0.32	0.31	0.27	0.35	0.42	0.43	0.43	0.4	0.41	0.36	0.39	0.40	0.39
As	0.08	0.21	0.16	0.11	0.20	0.2	0.15	0.18	0.19	0.14	0.16	0.22	0.20
Ba	0.006	0.008	0.006	0.006	0.008	0.005	0.012	0.007	0.008	0.006	0.005	0.009	0.005
Be	0.003	0.003	0.002	0.003	0.004	0.004	0.013	0.003	0.004	0.003	0.004	0.004	0.003
B	0.06	0.09	0.08	0.06	0.07	0.07	0.08	0.09	0.1	0.1	0.10	0.10	0.11
Cd	0.401	0.396	1.12	1.470	1.51	1.210	1.12	0.766	0.769	0.680	0.673	0.822	0.592
Ca	175.6	190	144.5	158.5	168.0	172	182.2	177.3	195	188	193.0	201.8	209
Cr	0.029	0.030	0.031	0.024	0.023	0.018	0.043	0.041	0.073	< 0.3	0.5	< 0.3	
Co	0.163	0.138	0.108	0.123	0.128	0.121	0.137	0.121	0.135	0.136	0.148	0.164	0.159
Cu	< 0.006	< 0.005	0.068	0.100	0.101	0.054	0.040	0.018	0.014	0.009	0.009	0.015	0.007
Fe	22.6	39.7	30.1	26.8	29.2	32.1	33.6	34.4	39.2	37.1	39.1	43.400	45.0
Pb	0.12	0.08	0.13	0.15	0.14	< 0.06	0.10	0.08	< 0.06	< 0.06	< 0.06	0.1	0.01
Mg	36.5	42.6	33.2	35.7	37.8	38.7	42.7	41.6	46.1	37.1	44.4	47.30	48.2
Mn	156.8	201	188.1	165.9	179.0	194	190.8	194.9	204	199	203	220.7	225
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	1.57	1.78	1.37	1.57	1.75	2	1.88	1.73	1.89	2	2	4.00	3
P	0.8	1.0	0.8	1.0	1.3	1.4	1.2	1.1	1.2	< 5	< 5	< 5	5
K	0.8	0.8	0.7	0.8	0.8	0.7	0.9	0.8	0.9	0.8	0.8	1.0	0.9
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	3.97	4.46	3.74	4.38	5.05	5	4.93	4	4.90	6	6	5	5.00
Ag	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Na	1.6	1.6	1.3	1.5	1.5	1.5	1.6	1.6	1.5	1.5	1.6	1.5	1.6
Sr	0.231	0.277	0.210	0.227	0.238	0.241	0.259	0.231	0.274	0.245	0.265	0.286	0.292
S	345	407	381	334	356	377	373	379	427	402	401	439	453
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	< 0.002	0.005	< 0.002	< 0.002	0.003	< 0.002	0.003	0.002	0.003	0.004	< 0.002	0.005	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	136	145	152	137	150	158	151	147	151	149	153	165	168
TIC	8.4	17.1		3.2		11.7		7.3	9.9	13.2	13.4	13.4	17.7
TOC	< 0.5	< 0.5		< 0.5		< 0.5		< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
PO4	0.010	0.006		< 0.002		< 0.002		0.046	< 0.002	0.005	< 0.002	< 0.002	< 0.002
Field parameters:													
Water temp. (°C)	2.54	2.9	3.1	3.3	3.1	2.3	3.1	2.9	3.1	3.0	3.0	3.1	3.0
pH	6.27	5.89	5.75	6.00	5.75	5.9	5.75	6.11	6.22	6.83	5.94	6.29	6.34
Spec. cond. (uS/cm)	1700	1820	1741	1680	1741	1939	1741	1924	3585	2368	2005	2051	2057
Cond. (uS/cm)	971	1050	1010	980	1010	1100	1010	1110	2080	1370	1160	1190	1190
ORP (mV)									265	121	120	110	83
Eh (mV) (calc'd)									464	320	319	309	282
Flow (m³/s)								0.052	0.055	0.062	0.06	0.0675	0.06
Flow (L/s)								6.31	6.85	8.16	7.78	9.23	7.78

Site 10- Sinkhole nr.

Pole 500		Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	<	1 <	1 <	1 <	1 <	1
Acidity, total		259	237	246	230	241
Alkalinity, total	<	0.5	1.3 <	0.5	3.8	4.8
Cl-	<	5 <	5 <	5	1.4	2.6
F	<	0.5 <	0.5 <	0.5	0.2	0.15
SO4		1410	1270	1440	1339	1494
Br	<	3.0 <	2.6 <	3 <	12.5 <	0.05
Nitrate	<	0.10	0.34 <	0.1	0.124	0.089
Nitrite	<	0.3 <	0.26 <	0.3 <	0.005 <	0.005
P	<	3.0 <	2.6 <	3 <	0.05 <	0.05
pH		5.19	5.51	4.80	5.96	5.5
FR		2070	2070	2080	1950	2190
NFR		38	49	62	304	78
Spec. Cond.		1900	1627	1920	1840	1990
Hardness, Ca+Mg		635	695.6	703	659.3	776.4
Hardness, total		1270	1314.4	1550	1283.3	1498
ICP, dissolved						
Al	<	0.05	0.13	68.5 <	2.5	3.70
Sb		0.31	0.51	0.52	0.39	0.44
As	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba	<	0.001	0.005	0.003	0.007	0.006
Be		0.002	0.01	0.004	0.003	0.004
B		0.04	0.04 <	0.01	0.05	0.06
Cd		0.725	0.697	0.675	0.568	0.65
Ca		187	203	204	192	231.2
Cr		0.042	0.042	8.630 <	0.250	0.350
Co		0.114	0.126	0.191	0.143	0.162
Cu	<	0.005 <	0.005	0.006 <	0.005 <	0.005
Fe		14.1	14.1 <	0.005	15.2	21.56
Pb	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg		41.0	45.9	47.0	44	48.3
Mn		207.0	196.7	202	203.1	228.1
Mo	<	0.01 <	0.01	0.01 <	0.01 <	0.01
Ni		1.56	1.74		2.6	4.2
P		0.8	1.1	<	5 <	5
K		0.4	0.5	0.5	0.8	0.8
Se	<	0.001 <	0.001 <	0.05 <	2.5 <	2.50
Si		3.71	3.95 <	0.05	4.8	5.30
Ag		0.02	0.03	0.03	0.03	0.03
Na		1.1	1.7	1	1.5	2.1
Sr		0.246	0.277	0.281	0.265	0.294
S		477	402	453	398.4	445
Sn	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	<	0.002 <	0.002 <	0.002 <	0.002 <	0.002
V	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Zn		155	153.1	144	146.35	165.3
ICP, Total						
Al		0.66 <	3 <	3 <	3 <	3
Sb		0.42	0.38	0.42	0.38	0.38
As		0.17	0.09	0.07	1.52	0.21
Ba		0.014	0.007	0.005	0.019	0.008
Be		0.004	0.003	0.004	0.005	0.003
B		0.09	0.07	0.07	0.29	0.09
Cd		0.756	0.699	0.674	0.675	0.600
Ca		188	192.2	194	186.3	207.2
Cr		0.065 <	0.3	0.5 <	0.03	0.5
Co		0.124	0.143	0.129	0.142	0.143
Cu		0.02	0.015 <	0.006	0.12	0.018
Fe		32.3	27.2	26.0	132	38.6
Pb		0.10	0.08	0.07	0.60	0.21
Mg		44.3	44.3	44.6	43.5	47.8
Mn		196	203.22	204	199.93	221.23
Mo	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni		1.81	3	2	3	3
P		1.2 <	5 <	5 <	5 <	5
K		1	1	0.8	1	0.8
Se	<	0.001 <	0.001 <	3 <	3 <	3
Si		5	7	9	7	7.00
Ag		0.03	0.03	0.03	0.03	0.03
Na		1.5	1.5	1.6	1.4	2.4
Sr		0.266	0.253	0.266	0.268	0.291
S		412	413	404	407	453
Sn	<	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti		0.010	0.007 <	0.002	0.012 <	0.002
V	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Zn		148	153.5	154	163.2	166.7
TIC		1.1	2.3	3.2	4.4	4.3
TOC		0.5	0.6	0.7	0.6	0.6
PO4	<	0.002	0.003 <	0.002	0.134 <	0.002
Field parameters:						
Water temp. (°C)		6.9	9.5	6.9	6.9	11
pH		7.69	6.99	6.19	6.35	6.18
Spec. cond. (uS/cm)		4339	1974	1891	1813	1962
Cond. (uS/cm)		2800	1370	1220	1170	1420
ORP (mV)	not measured		44.1	27	67.1	-22.5
Eh (mV) (calc'd)			243.1	226	266.1	176.5

Site 9- Seep nr. Pole

500	May-29	Jun-06	Jun-20	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1
Acidity, total	140	181	217	195	193	208	211	215	224	200
Alkalinity, total	2.7	1.3	<	0.5	1.7	1.9	2.2	1.9	2.2	2.2
Cl-	1.7	0.6	<	2	<	5.1	<	5	<	5
F	0.07	0.07	<	0.01	<	0.01	<	0.5	<	0.5
SO4	988.9	1240	1210	1240	1260.6	1270	1230	1380	1375	1444
Br	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0
Nitrate	0.370	0.7	0.42	0.33	0.43	0.40	0.52	0.4	0.385	0.361
Nitrite	<	0.005	<	0.005	<	0.005	<	0.26	<	0.3
P	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0
pH	5.78	5.62	5.08	5.71	5.63	5.92	5.69	6.11	5.81	6.15
FR	1530	1600	1840	1870	1930	1920	1930	1930	1990	2000
NFR	368	121	<	5	<	5	7	12	<	5
Spec. Cond.	1590	1640	1750	1805	1810	1880	1790	1850	1890	1980
GFAA (dissolved):										
Se	<	0.001	<	0.001	<	0.001				
GFAA (total):										
Se	<	0.001	<	0.001	<	0.001				
Hardness, Ca+Mg	714.8	686	791.4	756	838	733	723.3	824	826.4	848.4
Hardness, total	947.3	1020	1210.0	1184.6	1287.5	1170	1165.2	1290		1357.8
ICP, dissolved										
Al	0.20	0.21	0.23	0.27	0.28	0.06	0.14	<	3	<
Sb	0.16	0.27	0.31	0.33	0.39	0.23	0.39	0.45	0.37	0.38
As	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ba	0.023	0.016	0.012	0.011	0.014	0.003	0.012	0.009	0.012	0.012
Be	0.003	0.003	0.004	0.004	0.005	0.002	0.010	0.005	0.005	0.004
B	0.01	<	0.01	0.01	<	0.01	0.02	<	0.01	<
Cd	0.315	0.436	0.580	0.511	0.568	0.513	0.503	0.562	0.59	0.654
Ca	214.2	206	245.7	225	250.1	221	215	242	244	257.3
Cr	0.010	0.015	0.019	0.016	0.020	0.019	0.023	0.250	0.430	0.270
Co	0.032	0.012	0.009	<	0.005	0.009	0.010	0.009	<	0.005
Cu	0.066	0.050	0.081	0.075	0.094	0.052	0.065	0.078	0.079	0.081
Fe	1.492	<	0.005	<	0.005	<	0.005	<	0.3	<
Pb	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Mg	43.7	41.6	43.2	47	51.3	43.9	45.3	53.4	52.8	50
Mn	68.6	93.7	124.5	135.1	130.8	135.0	132.8	142.0	149.8	152.8
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni	0.73	1.01	1.43	1.31	1.48	1.14	1.2	1.9	2.9	3.5
P	0.3	0.5	0.8	0.8	1	0.5	0.7	<	5	<
K	1.0	1.0	1.0	1.1	1.2	0.7	0.9	1.0	1.2	1.2
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Si	5.95	5.50	6.01	5.8	6.8	5.47	5.5	7.0	7.5	6.90
Ag	0.01	0.02	0.02	0.02	0.02	<	0.01	0.02	0.03	0.02
Na	1.7	1.6	1.9	1.7	2	1.4	2.1	0.9	1.8	1.7
Sr	0.464	0.414	0.424	0.434	0.479	0.404	0.411	0.48	0.473	0.452
S	307.5	329	396	388	452	434	393	405	416.3	422.5
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ti	<	0.002	<	0.002	0.007	<	0.002	0.008	<	0.002
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Zn	67.6	104	124.3	118.37	125.1	122	129.8	133	135.87	139.96
ICP, Total										
Al	8.48	2.81	0.30	0.24	0.12	0.34	0.36	<	3	<
Sb	0.16	0.26	0.34	0.33	0.24	0.31	0.33	0.32	0.37	0.38
As	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06
Ba	0.260	0.084	0.011	0.009	0.011	0.012	0.021	0.029	0.015	0.016
Be	0.003	0.003	0.004	0.004	0.003	0.004	0.011	0.004	0.005	0.005
B	0.03	0.01	0.01	<	0.01	0.01	0.02	0.02	0.01	0.01
Cd	0.347	0.450	0.512	0.490	0.505	0.506	0.280	0.554	0.602	0.583
Ca	229.2	211	224.0	211	218.9	235	242	229	240.8	239.7
Cr	0.022	0.018	0.013	0.009	0.016	0.02	0.03	<	0.3	<
Co	0.047	0.008	0.016	0.022	0.020	0.013	<	0.006	0.036	0.026
Cu	0.108	0.072	0.075	0.078	0.076	0.088	0.089	0.083	0.095	0.084
Fe	10.8	2.47	<	0.006	<	0.006	<	0.012	0.9	<
Pb	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06
Mg	48.0	43.6	45.4	43.1	45.7	49.8	51.5	49.7	53.1	51.8
Mn	75.3	102	120.1	120	119.8	130	135.9	138	151.06	146.22
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni	0.82	1.07	1.33	1.28	1.29	1.34	1.44	2	3	3
P	0.6	0.6	0.8	0.9	0.7	0.7	0.8	<	5	<
K	2.4	1.5	1.1	1	1.1	1.2	1.2	1.3	1.4	1.2
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Si	19.2	9.48	5.64	6	5.72	6.06	7	9	8	7.00
Ag	0.01	0.02	0.02	0.02	<	0.01	0.02	0.02	0.03	0.02
Na	2.4	1.8	1.7	1.6	1.7	1.9	1.8	1.9	1.7	2.1
Sr	0.512	0.431	0.436	0.417	0.424	0.43	0.476	0.445	0.481	0.468
S	336	352	362	351	369.9	393	416.8	387	426	421
Sn	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06
Ti	0.279	0.089	<	0.002	<	0.005	0.002	0.008	0.025	0.004
V	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<
Zn	77.1	114	123.8	119.37	119.5	120	124.1	129	139.9	135.4
TIC	13.3	4.0	3.5	4.5	4.2	4.5	5.5	3.8	6.8	2.4
TOC	0.7	1.1	0.6	0.6	0.5	0.5	0.5	0.7	<	0.5
PO4	0.17	0.108	<	0.002	<	0.002	<	0.013	<	0.002
Field parameters:										
Water temp. (°C)	0.05	0.8	3.8	2.8	4.4	6.3	5.4	5.1	5.1	4.9
pH	4.94	5.12	5.2	5.39	5.37	7.75	5.81	5.27	5.36	5.08
Spec. cond. (uS/cm)	1592	1471	1673	1721	1812	4570	2117	1923	1891	1901
Cond. (uS/cm)	833	800	990	990	1090	2900	1310	1180	1160	1160
ORP (mV)						530	354	335	281	275
Eh (mV) (calc'd)						729	553	534	480	474

Site 8- Seep at Road

Piezo	May-29	Jun-06	Jun-20	Jul-05	Jul-22	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	1
Acidity, total	55	68	107	66	11	9	7	7	5
Alkalinity, total	< 0.5	< 0.5	22.2	< 0.5	4	10	16.3	23.9	30.6
Cl-	0.9	0.5	< 2	< 6	< 5	< 5	< 5	0.1	0.4
F	0.02	0.02	< 0.01	< 0.01	< 0.5	< 0.5	< 0.5	< 0.01	0.02
SO4	655.6	1080	1170	1130	830.7	792	808	< 0.05	857
Br	< 0.05	< 0.05	< 0.05	< 0.05	< 2.6	< 2.6	< 3	< 0.05	< 0.05
Nitrate	< 0.002	0.004	0.25	0.22	0.37	0.50	0.7	0.002	< 0.5
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.26	< 0.26	< 0.3	< 0.005	< 0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	< 2.6	< 2.6	< 3	< 0.05	< 0.05
pH	5.28	5.37	7.24	5.31	6.4	6.67	6.78	6.94	7.34
FR	1010	1410	1760	1650	1310	1250	1160	1200	1260
NFR	< 5	< 5	< 5	< 5	< 5	< 6	< 49	< 17	< 11
Spec. Cond.	1140	1540	1820	1700	1440	1347	1350	1360	1400
GFAA (dissolved):									
Se	< 0.001	< 0.001	< 0.001						
GFAA (total):									
Se	< 0.001	< 0.001	< 0.001						
Hardness, Ca+Mg	510.3	770	994.4	965	913.3	759	791	750.2	866.4
Hardness, total	637.1	937	1202.4	1080	928.2	767	798	755.2	872
ICP, dissolved									
Al	0.12	0.15	0.21	0.2	< 0.05	< 0.05	< 0.05	0.09	< 0.05
Sb	0.08	0.10	0.14	0.11	< 0.05	0.09	< 0.05	0.06	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.026	0.031	0.026	0.027	0.013	0.009	0.004	0.008	0.014
Be	0.002	0.004	0.005	0.005	0.005	0.011	0.005	0.005	0.004
B	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	0.064	0.055	0.083	0.052	0.01	< 0.005	< 0.005	< 0.005	0.017
Ca	159.1	238	314.6	295	278.1	229	243	229.3	266.4
Cr	0.009	0.012	0.012	0.006	< 0.005	< 0.005	< 0.005	< 0.005	0.020
Co	0.011	0.011	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.029
Cu	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.020
Fe	0.005	< 0.005	< 0.005	< 0.005	< 5E-04	< 0.005	< 0.005	< 0.005	0.018
Pb	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	27.4	42.5	50.7	55.3	53.1	45.3	44.6	43.2	48.9
Mn	42.41	59.9	66.2	32.2	0.147	0.018	0.004	0.004	0.014
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	0.36	0.49	0.67	0.35	0.03	< 0.02	< 0.02	< 0.02	0.05
P	0.3	0.3	0.4	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	3.5	3.3	1.7	0.9	< 0.2	< 0.1	< 0.1	< 0.1	0.6
Se	0.16	0.17	0.20	< 0.001	< 0.001	< 0.05	< 0.05	< 0.05	0.12
Si	2.61	3.84	5.15	5.02	4.96	3.85	3.98	3.68	4.17
Ag	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01
Na	1.1	1.7	2.3	2.3	2.3	2.5	2.6	3.5	2
Sr	0.268	0.392	0.454	0.465	0.447	0.366	0.364	0.342	0.394
S	204.6	290	385	330	290.2	232	278	226	265
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	0.003	0.012	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.023
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.02	< 0.01
Zn	31.8	36.7	56.2	37.7	9.161	4.78	4.63	2.8	3.3
ICP, Total									
Al	0.13	0.14	0.21	0.22	< 0.06	< 0.06	0.53	< 0.06	0.17
Sb	0.07	0.09	0.16	0.12	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
As	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.028	0.031	0.024	0.018	0.013	0.019	0.061	0.012	0.01
Be	0.003	0.004	0.005	0.005	0.004	0.011	0.005	0.004	0.004
B	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	0.064	0.057	0.061	0.05	0.007	0.012	< 0.006	< 0.006	< 0.006
Ca	158.5	231	282.2	282.0	241.9	241.0	252.0	231.0	240.4
Cr	< 0.006	0.005	0.009	< 0.006	0.009	< 0.006	< 0.006	< 0.006	< 0.006
Co	< 0.006	< 0.005	0.014	0.008	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Cu	< 0.006	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Fe	0.014	< 0.005	< 0.006	< 0.006	0.016	0.077	0.646	0.058	0.181
Pb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Mg	27.9	42.0	52.1	51.5	46.4	47.8	49	46.1	48.8
Mn	44.4	61.3	58.6	32.800	0.134	0.050	0.334	0.036	0.051
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	0.38	0.49	0.54	0.45	0.03	< 0.02	< 0.02	0.03	< 0.02
P	0.3	0.4	0.4	0.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	3.6	3.3	1.7	0.8	0.4	0.3	0.5	0.3	0.4
Se	0.10	0.16	0.15	< 0.001	< 0.001	< 0.06	< 0.06	< 0.06	< 0.06
Si	2.71	3.73	4.65	5.05	4.28	4.31	5.19	4.11	4.01
Ag	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.1	1.7	2.1	2.1	2.4	2.3	2.7	2.4	2.6
Sr	0.274	0.383	0.457	0.451	0.389	0.396	0.402	0.384	0.395
S	208.7	279	353	324	262.81	252	255	233.45	244.58
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	< 0.002	< 0.002	< 0.002	< 0.002	0.006	0.005	0.019	0.007	0.005
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	31.3	35.4	49.3	36.7	8.025	5.19	5.1	2.997	3.079
TIC	1.1	1.0	< 0.5	0.8	1.3	4.0	5.4	7.9	8.7
TOC	20.7	14.7	8.7	9.1	7.6	7.0	5.8	6	5.8
PO4	0.039	0.036	0.028	< 0.002	< 0.002	0.011	0.022	0.015	0.023
Field parameters:									
Water temp. (°C)	1.66	3.2	1.4	3.7	1.8	3.1	3.1	1.4	2.4
pH	4.8	4.84	5.1	5.02	7.05	6.79	7.28	7.61	7.56
Spec. cond. (uS/cm)	1123	1530	1645	1627	1269	1500	1224	1229	1213
Cond. (uS/cm)	622	890	910	960	710	870	710	680	690
ORP (mV)							255	227.6	202
Eh (mV) (calc'd)							454	426.6	401

Site 7- Seep 5													
	May-29	Jun-06	Jun-20	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30			
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1	<	1	
Acidity, total	47	50	73	64	57	60	56	56	44	52			
Alkalinity, total	46.9	31.6	3.0	21.6	41.8	42.7	46.3	61.7	49.3	61.6			
Cl-	0.3	0.3	<	2	<	6	<	5	<	5	<	0.6	
F	0.02	0.02	<	0.01	<	0.01	<	0.5	<	0.5	<	0.01	
SO4	948.6	1100	1130	1140	1110.7	1070	1100	1180	1263	1249			
Br	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	0.05	
Nitrate	0.242	0.306	0.41	0.34	0.47	0.40	0.49	0.5	0.43	0.371			
Nitrite	<	0.005	<	0.005	<	0.005	<	0.26	<	0.3	<	0.005	
P	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	0.05	
pH	7.3	7.16	6.48	7.02	7.17	7.27	7.27	7.22	7.21	7.42			
FR	1480	1490	1700	1720	1710	1730	1740	1720	1690	1760			
NFR	171	114	101	144	105	67	27	58	137	73			
Spec. Cond.	1600	1620	1830	1760	1790	1800	1805	1860	1810	1920			
GFAA (dissolved):													
Se	<	0.001	<	0.001	<	0.001							
GFAA (total):													
Se	<	0.001	<	0.001	<	0.001							
Hardness, Ca+Mg	910.0	943	1023.9	1050.0	1033.1	1010.0	1074.7	1050.0	979.4	1153.9			
Hardness, total	972.2	1011	1124.1	1150	1118.8	1090	1154.8	1140	1036.3	1217.5			
ICP, dissolved													
Al	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.13	
Sb	0.08	0.10	0.05	0.12	0.09	0.13	0.15	<	0.05	0.10	0.15		
As	<	0.05	<	0.05	<	0.05	<	0.05	<	0.08	<	0.05	
Ba	0.018	0.019	0.015	0.025	0.03	0.036	0.052	0.061	0.054	0.037			
Be	0.005	0.005	0.004	0.005	0.005	0.006	0.011	<	0.001	0.006	0.007		
B	<	0.01	<	0.01	<	0.01	<	0.01	<	0.02	<	0.01	
Cd	0.051	0.063	0.083	0.082	0.077	0.086	0.074	0.100	0.073	0.076			
Ca	283.5	294	327.1	326	322.2	320	332	334	307.8	366.3			
Cr	<	0.005	<	0.005	<	0.005	<	0.009	<	0.028	<	0.005	
Co	<	0.005	<	0.005	<	0.005	<	0.019	<	0.015	<	0.005	
Cu	<	0.005	<	0.005	<	0.005	<	0.005	<	0.018	<	0.005	
Fe	<	0.005	<	0.005	<	0.005	<	0.0005	<	0.013	<	0.068	
Pb	<	0.05	<	0.05	<	0.05	<	0.05	<	0.14	<	0.07	
Mg	49.1	51.0	50.3	57.9	55.5	51.0	69.4	53.7	51.2	58.1			
Mn	9.62	11.6	16.8	16.1	14.04	13.3	13.84	18.1	9.483	4.01			
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.03	<	0.02	
Ni	0.22	0.22	0.32	0.31	0.29	0.29	0.32	0.39	0.29	0.35			
P	0.1	0.2	0.2	0.2	0.2	0.2	0.1	<	0.1	0.2	0.3		
K	1.2	1.3	1.1	1.3	1.1	1.5	1.7	1.9	1.9	1.1			
Se	<	0.05	<	0.05	<	0.001	<	0.001	<	0.10	<	0.23	
Si	5.26	5.56	5.92	6.12	6.19	5.71	6.18	5.71	5.35	6.06			
Ag	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.02	
Na	1.9	1.9	2.1	2	2.1	2.6	2.1	2	3.6	2.1			
Sr	0.564	0.582	0.592	0.643	0.624	0.578	0.654	0.605	0.547	0.654			
S	292.76	326	372.5	361	418.6	429	360.8	374	297.97	73.5			
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	
Ti	<	0.002	<	0.002	<	0.002	<	0.028	<	0.026	<	0.002	
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.02	
Zn	28.7	30.1	45.0	40.8	38.733	36	35.2	33.1	24.941	35.89			
ICP, Total													
Al	3.57	2.34	2.23	2.43	1.73	1.4	0.98	1.18	2.4	0.82			
Sb	0.06	0.06	0.12	0.15	0.08	0.11	0.09	0.14	0.08	0.07			
As	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	
Ba	0.091	0.068	0.066	0.077	0.064	0.061	0.061	0.076	0.092	0.063			
Be	0.004	0.004	0.005	0.006	0.005	0.005	0.005	0.007	0.006	0.009			
B	0.01	0.01	0.01	0.01	0.01	0.01	<	0.01	<	0.01	0.02	0.01	
Cd	0.055	0.061	0.082	0.083	0.072	0.07	0.078	0.083	0.053	0.084			
Ca	293.7	282	314.4	310	312.5	342	340	360	332.4	351.3			
Cr	0.007	<	0.005	<	0.006	<	0.006	<	0.006	<	0.006	0.009	
Co	0.012	<	0.005	<	0.006	<	0.006	<	0.014	<	0.011	<	0.006
Cu	0.025	0.016	0.012	0.041	0.01	0.015	<	0.006	<	0.006	0.031	0.014	
Fe	4.213	2.75	2.69	3.45	2.34	1.76	1.30	1.55	3.26	1.16			
Pb	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	
Mg	51.9	50.6	55.3	53.9	54.1	59.5	59.3	64.1	61.4	63.5			
Mn	11.4	12.6	17.64	15.6	12.86	12.1	12.96	18.06	0.22	21.52			
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	
Ni	0.25	0.23	0.32	0.32	0.3	0.29	0.29	0.37	0.26	0.4			
P	0.3	0.3	0.3	0.4	0.3	0.1	0.3	0.3	0.2	0.3			
K	1.9	1.7	1.7	1.6	1.3	1.4	1.6	1.6	1.6	1.5			
Se	<	0.06	<	0.05	<	0.06	<	0.001	<	0.001	<	0.06	
Si	10.98	8.95	8.96	9.68	8.27	8.06	7.70	8.31	9.41	7.42			
Ag	<	0.01	<	0.01	<	0.01	<	0.01	<	0.02	<	0.01	
Na	2.3	2.1	2.2	2.1	2.2	2.4	2.4	2.8	2.5	2.6			
Sr	0.600	0.572	0.637	0.626	0.612	0.630	0.665	0.731	0.656	0.712			
S	318	292	375.9	330	320.8	368	367.5	371	322.9	396			
Sn	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	
Ti	0.140	0.093	0.074	0.081	0.066	0.043	0.030	0.034	0.080	0.033			
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	
Zn	30.0	29.8	40.6	42.000	37.724	36.300	37.200	39.200	29.048	36.5			
TIC	15.3	8.0	5.4	6.8	11.1	10.4	12.7	15.1	13.3	15.8			
TOC	3.8	4.2	2.5	2.9	2.3	2.1	2.3	2	2.7	2			
PO4	0.161	0.161	0.093	0.101	0.061	0.026	0.024	0.035	0.096	0.085			
Field parameters:													
Water temp. (°C)	0.29	3.9	0.8	1.2	2.8	7.7	4.5	3.2	2.4	3.9			
pH	6.86	6.57	6.5	6.41	6.94	7.31	6.84	7.29	7.46	7.45			
Spec. cond. (uS/cm)	1590	1534	1673	1800	1634	3485	2138	705	1564	1736			
Cond. (uS/cm)	839	910	910	990	940	2300	1290	410	890	1030			
ORP (mV)						335	200	164	172.4	153			
Eh (mV) (calc'd)						534	399	363	371.4	352			

Site 6- Seep 8		May-29	Jun-06	Jun-20	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30							
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1	<	1						
Acidity, total		62	60	71	61	54	56	54	53	53	39							
Alkalinity, total		3.3	3.6	0.9	3.3	4.1	4.9	5.7	7.2	8.4	20.6							
Cl-		0.3	0.3	<	2	<	6	<	5	<	25	0.5						
F		0.02	<	0.01	<	0.01	<	0.5	<	0.5	<	0.01						
SO4		971.4	1165	1160	1150	1148.9	1140	1090	1190	1263	1279.1							
Br	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	2.6	<	3	<	0.05	<	0.05
Nitrate		0.094	0.192	0.29	0.25	0.30	0.30	0.35	<	0.1	0.37	0.269						
Nitrite	<	0.005	<	0.005	<	0.005	<	0.26	<	0.3	<	0.26	<	0.3	<	0.005	<	0.005
P	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	2.6	<	3	<	0.05	<	0.05
pH		6.32	6.40	5.8	6.16	6.20	6.40	6.30	6.44	6.44	6.94							
FR		1470	1600	1720	1670	1700	1710	1690	1710	1790	1720							
NFR	<	5	<	5	<	5	<	5	<	5	7	29	237					
Spec. Cond.		1570	1680	1830	1766	1740	1760	1663	1750	1820	1830							
GFAA (dissolved):																		
Se	<	0.001	<	0.001	<	0.001												
GFAA (total):																		
Se	<	0.001	<	0.001	<	0.001												
Hardness, Ca+Mg		852.0	961	999.0	1030	1054	997	1019	1030	1028	1159.7							
Hardness, total		952.8	1048	1098.8	1120	1134.7	1070	1100.8	1100	1105.6	1206.6							
ICP, dissolved																		
Al		0.06	<	0.05	<	0.05	0.07	0.17	0.08	<	0.05	0.05	0.17	0.06				
Sb		0.10	0.10	0.10	0.13	0.15	0.1	0.19	0.15	0.15	0.16	0.14						
As	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05				
Ba		0.020	0.022	0.017	0.025	0.013	0.015	0.015	0.017	0.015	0.037							
Be		0.004	0.005	0.005	0.005	0.007	0.006	0.013	0.006	0.007	0.006							
B	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01				
Cd		0.035	0.028	0.027	0.032	0.025	0.029	0.024	0.029	0.025	0.024							
Ca		265.8	300.2	321.4	320	329.1	313	316	321	321.5	361.8							
Cr		0.007	<	0.005	<	0.005	0.008	<	0.005	<	0.005	<	0.005	<	0.005			
Co	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005		
Cu	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005		
Fe	<	0.005	<	0.005	<	0.005	<	0.0005	<	0.005	<	0.005	<	0.005	<	0.018		
Pb	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05		
Mg		45.8	51.3	47.7	56.2	56.4	52.4	56.0	54.2	55	62.2							
Mn		24.53	18.2	20.1	15.4	12.8	14.8	18.56	16.8	17.23	3.59							
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01				
Ni		0.34	0.27	0.30	0.28	0.24	0.22	0.26	0.27	0.24	0.29							
P		0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2							
K		1.4	1.4	0.9	1.4	0.7	0.9	0.6	1.2	0.9	0.9							
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001				
Si		5.79	6.26	6.46	6.94	7.16	5.3	6.46	6.1	6.17	6.86							
Ag	<	0.01	<	0.01	<	0.01	0.02	0.01	0.01	0.01	0.02	<	0.01					
Na		1.8	1.9	2.1	2.1	2.6	2.6	2.8	2.8	3.7	3.6							
Sr		0.539	0.619	0.599	0.663	0.66	0.584	0.62	0.597	0.598	0.655							
S		295.6	337	370.7	357	407.1	392	350.1	369	375.2	74.1							
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05				
Ti	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002				
V	<	0.01	<	0.01	<	0.01	0.03	<	0.01	0.03	0.01	0.027	<	0.01				
Zn		36.1	34.9	40.8	36.3	36.521	31.8	30.9	29	26.582	25.666							
ICP, Total																		
Al		0.06	<	0.05	0.06	<	0.06	<	0.13	<	0.06	0.13	0.25	2.56				
Sb		0.09	0.08	0.14	0.12	0.1	0.11	<	0.06	0.13	0.09	0.10						
As	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06				
Ba		0.023	0.022	0.022	0.021	0.02	0.022	0.029	0.026	0.028	0.1							
Be		0.004	0.005	0.005	0.005	0.005	0.005	0.012	0.006	0.006	0.006							
B	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.02				
Cd		0.040	0.031	0.035	0.012	0.029	0.029	0.038	0.035	0.027	0.027							
Ca		267.2	296	318.4	308	304.5	324	317	341	329.8	334.2							
Cr	<	0.006	<	0.005	<	0.006	<	0.006	0.009	0.015	0.008	<	0.006	0.018				
Co	<	0.006	<	0.005	<	0.006	<	0.006	<	0.006	<	0.006	<	0.010				
Cu	<	0.006	<	0.005	<	0.006	<	0.006	<	0.006	<	0.006	<	0.006				
Fe	<	0.006	<	0.005	<	0.006	<	0.006	<	0.006	0.051	0.214	3.156					
Pb	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06				
Mg		47.6	51.5	54.4	52.9	53.2	58.1	57.6	60.1	62.4	62.7							
Mn		26.07	18.5	20.5	15	12.39	14.2	17.24	16.5	17.35	19.08							
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01				
Ni		0.37	0.28	0.32	0.27	0.24	0.27	0.3	0.32	0.32	0.31							
P		0.3	0.2	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.4							
K		1.5	1.4	1.4	1.2	1.1	1.2	1.2	1.3	1.3	1.5							
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001				
Si		6.12	6.25	6.54	7.15	6.61	5.81	6.92	7.07	7.17	9.79							
Ag	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01				
Na		1.9	1.9	2.0	2.0	2.3	2.5	2.5	3	2.7	3							
Sr		0.562	0.617	0.668	0.654	0.621	0.617	0.647	0.668	0.681	0.665							
S		324.2	347	364.5	336	334.9	357	357.2	356	382.3	392							
Sn	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06				
Ti	<	0.002	<	0.002	<	0.002	<	0.002	0.002	0.013	0.007	0.086						
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01				
Zn		36.3	34.9	37.4	37.5	33.872	32.7	31.9	32.4	31.586	24.71							
TIC		2.8	1.9	2.2	3.3	2.9	3.1	3.9	3.2	4.6	6.7							
TOC		5.3	3.3	2.5	2.7	2.6	2.2	2.5	2.4	2.2	2.6							
PO4	<	0.002	0.025	0.009	<	0.002	<	0.002	<	0.002	0.018	0.169						
Field parameters:																		
Water temp. (°C)		0.24	0.6	1.1	1.5	7.3	4.2	3.8	2.9	2.3	2							
pH		5.59	5.73	5.9	6.06	6.64	7.72	7.09	7.37	7.26	7.38							
Spec. cond. (uS/cm)		1570	892	1750	1785	1532	4847	1994	1751	1692	1582							
Cond. (uS/cm)		826	860	960	990	1000	2900	1180	1010	960	890							
ORP (mV)							335	317	280	262	218							
Eh (mV) (calc'd)							534	516	479	461	417							

Site 5- Old Rd. AT ROW Xing													
	May-29	Jun-06	Jun-20	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30		
Acidity to pH 4.5	< 1	< 1	< 1		< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Acidity, total	8	9	14	7		7	7	10	11	8	7		
Alkalinity, total	45.6	38.3	42.5	37		49.9	60.6	65.4	57.4	54.3	73.8		
Cl-	0.3	0.2	< 2	< 6		< 5	< 5	< 5	< 5	< 25	0.4		
F	0.02	0.01	< 0.01	< 0.01		< 0.5	< 0.5	< 0.5	< 0.5	< 0.01	0.01		
SO4	771.5	776	1000	1030		984	948	855	1000	1094	1044		
Br	< 0.05	< 0.05	< 0.05	< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05		
Nitrate	0.092	0.111	0.25	< 0.002		0.31	0.20	0.40	< 0.1	0.35	0.354		
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005		< 0.26	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005		
P	< 0.05	< 0.05	< 0.05	< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05		
pH	7.56	7.45	7.62	7.44		7.57	7.65	7.57	7.31	7.48	7.57		
FR	1170	1390	1560	1540		1340	1460	1340	1480	1600	1490		
NFR	< 5	< 5	69	< 5		16	45	114	50	22	21		
Spec. Cond.	1380	1550	1770	1670		1640	1580	1494	1650	1700	1640		
GFAA (dissolved):													
Se	< 0.001	< 0.001	< 0.001		< 0.001								
GFAA (total):													
Se	< 0.001	< 0.001	< 0.001		< 0.001								
Hardness, Ca+Mg	822.4	907	1048.5	1080.5	1,075.1	1069	868	910	1090	1054.9	1120		
Hardness, total	829.1	914	1066.7	1087.9	1,083.6	1077	894	919	1100	1062.6	1121.1		
ICP, dissolved													
Al	< 0.05	< 0.05	0.06	< 0.05	0.08	0.08	0.1	< 0.05	< 0.05	0.11	< 0.05		
Sb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	0.1	< 0.05	< 0.05		
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.07	< 0.05	< 0.05		
Ba	0.021	0.027	0.027	0.029	0.046	0.039	0.029	0.048	0.056	0.044	0.044		
Be	0.004	0.005	0.006	0.006	0.006	0.007	0.006	0.010	0.006	0.007	0.006		
B	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	0.02	< 0.01	< 0.01		
Cd	< 0.005	< 0.005	0.009	< 0.005	0.019	0.009	< 0.005	0.011	0.027	0.006	0.005		
Ca	260.8	284	337.6	343.1	337.9	336.6	279	262	344	329.5	347.5		
Cr	< 0.005	0.005	< 0.005	< 0.005	0.037	< 0.005	< 0.005	0.012	0.041	< 0.005	< 0.005		
Co	< 0.005	< 0.005	< 0.005	< 0.005	0.013	< 0.005	< 0.005	0.007	0.037	< 0.005	< 0.005		
Cu	< 0.005	< 0.005	< 0.005	< 0.005	0.022	< 0.005	< 0.005	0.009	0.024	< 0.005	< 0.005		
Fe	0.024	0.021	0.039	< 0.005	0.041	0.011	< 0.005	0.068	0.090	0.039	0.019		
Pb	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	0.06	0.13	< 0.05	< 0.05		
Mg	41.6	48.1	49.9	54.3	56.1	55.5	46.3	50.2	55.5	56.4	59.8		
Mn	0.067	0.028	1.153	0.081	0.2	0.167	0.148	0.339	0.410	0.247	0.229		
Mo	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01		
Ni	< 0.02	< 0.02	0.03	< 0.02	0.05	< 0.02	< 0.02	0.04	0.07	< 0.02	< 0.02		
P	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1		
K	1.1	1.1	0.9	0.9	1.5	1	0.7	1.2	1.7	1.2	1.1		
Se	< 0.05	< 0.05	< 0.05	< 0.001	< 0.001	< 0.001	< 0.001	0.07	0.26	< 0.05	< 0.05		
Si	4.69	5.00	5.86	5.44	6.03	5.93	4.78	5.19	5.61	5.24	5.56		
Ag	< 0.01	< 0.01	0.01	< 0.01	0.01	0.01	0.02	< 0.01	0.01	0.02	< 0.01		
Na	1.7	1.9	2.2	2.5	2.4	2.5	2.4	2.1	2.7	3.1	3.1		
Sr	0.479	0.568	0.609	0.629	0.656	0.651	0.530	0.566	0.640	0.640	0.671		
S	239.1	273	299.5	319	377	359.9	286	260	320	323.6	62		
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		
Ti	< 0.002	< 0.002	< 0.002	< 0.002	0.027	< 0.002	< 0.002	0.015	0.035	< 0.002	< 0.002		
V	< 0.01	< 0.01	0.02	< 0.01	0.02	0.02	0.02	< 0.01	0.01	0.03	< 0.01		
Zn	3.94	4.14	9.87	4.24	4.6	4.38	3.48	4.62	6.40	4.10	3.817		
ICP, Total													
Al	< 0.06	< 0.05	1.17	< 0.06	0.26	0.14	1.05	2.20	0.70	0.48	0.21		
Sb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
As	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
Ba	0.022	0.027	0.059	0.039	0.047	0.04	0.064	0.097	0.061	0.061	0.047		
Be	0.004	0.005	0.005	0.006	0.015	0.005	0.005	0.004	0.005	0.006	0.005		
B	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Cd	< 0.006	< 0.005	0.011	< 0.006	0.01	< 0.006	< 0.006	0.014	0.007	0.008	< 0.006		
Ca	242.0	288	311.7	324	310.8	287.9	303.0	282.0	322.0	327.5	312.7		
Cr	0.011	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.012		
Co	< 0.006	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.012	< 0.006	0.020	< 0.006		
Cu	< 0.006	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006		
Fe	0.117	0.036	1.344	0.105	0.3	0.271	1.44	3.28	1.03	0.793	0.315		
Pb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
Mg	42.2	49.2	53.2	55.3	53.6	49.8	53.2	50.5	56.4	59.1	56.4		
Mn	0.084	0.027	1.180	0.093	0.2	0.166	0.224	0.515	0.438	0.278	0.229		
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Ni	< 0.02	< 0.02	0.03	< 0.02	0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.04	< 0.02		
P	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	0.2	< 0.1	< 0.1	< 0.1		
K	1.1	1.2	1.4	1.2	1.1	1.1	1.3	1.36	1.3	1.5	1.3		
Se	< 0.06	< 0.05	< 0.06	< 0.001	0.09	< 0.001	< 0.001	< 0.06	< 0.06	0.10	< 0.06		
Si	4.65	5.16	7.07	5.14	5.92	5.36	5.65	8.18	6.71	5.21	5.34		
Ag	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Na	1.7	2.0	2.1	2.4	2.2	2.2	2.4	2.2	2.5	2.5	2.5		
Sr	0.484	0.578	0.633	0.722	0.628	0.578	0.573	0.573	0.650	0.679	0.639		
S	239.5	278	334.1	332	298	291	296	268	311	337	295		
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
Ti	< 0.002	< 0.002	0.034	0.005	0.011	0.003	0.028	0.069	0.021	0.002	0.006		
V	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01		
Zn	3.42	4.43	8.67	4.05	4.3	3.743	3.88	4.96	6.44	4.439	3.57		
TIC	12.3	8.9	7.8	10.5		13.2	14.5	17.2	13.9	13.9	18.9		
TOC	5.1	3.9	2.6	2.1		2.2	2.3	3.1	3.3	1.7	2.3		
PO4	0.004	< 0.002	0.061	< 0.002		0.007	0.013	0.100	0.026	0.012	0.041		
Field parameters:													
Water temp. (°C)	1.14	4.0	1.8	3.3	3.2	2.1	2.8	3.2	2.5	1.9	1.4		
pH	7.14	6.68	7.2	6.83	6.78	7.98	7.89	7.73	7.42	7.74	7.65		
Spec. cond. (uS/cm)	1331	1479	1573	1560	1633	1595	1547	1719	1420	1676	1591		
Cond. (uS/cm)	725	880	880	910	950	900	890	1000	810	940	880		
ORP (mV)							250	184	154	174	141.1		
Eh (mV) (calc'd)							449	383	353	373	340.1		

Site 4- Seep 6 + 120												
	May-29	Jun-06	Jun-20	Jun-28	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1 <	1 <	1				< 1 <	1 <	1 <	1 <	1 <	1
Acidity, total	15	15	20		19		15	8	13	12	13	13
Alkalinity, total	53.2	46.1	no value		43.2		60.2	62.5	56.9	66.9	74	74
Cl-	0.3	0.4 <	2	< 6		< 5 <	5 <	5 <	5 <	5 <	20 <	20
F	0.02	0.02 <	0.01	< 0.01		< 0.5 <	0.5 <	0.5 <	0.5 <	0.5 <	0.01 <	0.01
SO4	854.9	1000	1040		1110		1125.6	1040	989	1060	1130	1130
Br	< 0.05 <	0.05 <	0.05	< 0.05		< 2.6 <	3.0 <	2.6 <	3 <	0.05 <	0.05	0.05
Nitrate	0.185	0.215	0.40		0.50		0.53	0.40	0.47	0.5	0.47	0.47
Nitrite	< 0.005 <	0.005 <	0.005	< 0.005		< 0.26 <	0.3 <	0.26 <	0.3 <	0.005 <	0.005	0.005
P	< 0.05 <	0.05 <	0.05	< 0.05		< 2.6 <	3.0 <	2.6 <	3 <	0.05 <	0.05	0.05
pH	7.62	7.44	5.19		7.52		7.51	7.58	7.49	7.44	7.61	7.61
FR	1310	1390	1590		1630		1650	1600	1540	1560	1610	1610
NFR	44	657	24		49		213	130	329	329	285	285
Spec. Cond.	1510	1540	1830		1740		1750	1720	1650	1740	1770	1770
GFAA (dissolved):												
Se	< 0.001 <	0.001 <	0.001 <	0.001		< 0.001						
GFAA (total):												
Se	<	0.001 <	0.001 <	0.001		< 0.001						
Hardness, Ca+Mg	886.9	903	1075.9	1120	1110	1,116.2	1162.5	1180	1002	1210	1100.4	1100.4
Hardness, total	903.8	920	1099.4	1140	1130	1,137.6	1183	1200	1018	1230	1115	1115
ICP, dissolved												
Al	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05	0.07	0.1 <	0.05	0.15 <	0.05 <	0.05
Sb	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05	0.05	0.1 <	0.05	0.13 <	0.05 <	0.05
As	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba	0.018	0.020	0.024	0.030	0.03	0.033	0.048	0.037	0.069	0.08	0.049	0.049
Be	0.004	0.005	0.006	0.005	0.006	0.004	0.007	0.007	0.010	0.008	0.006	0.006
B	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Cd	0.010	0.012	0.021	0.015	0.014	0.027	0.011	0.010	0.013	0.019	0.011	0.011
Ca	281.9	283	343.8	349	347	350.3	367.2	375	315	390	348	348
Cr	< 0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.016 <	0.005 <	0.005	0.021	0.012 <	0.005 <	0.005
Co	< 0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.013 <	0.005 <	0.005
Cu	< 0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.011 <	0.005 <	0.005	0.008 <	0.005 <	0.005 <	0.005
Fe	0.016	0.082	0.031	0.091	0.054	0.067	0.419	0.117	0.304	0.087	0.081	0.081
Pb	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg	44.4	47.8	52.8	60.5	59.4	58.6	59.7	59.4	52.6	58.4	56.3	56.3
Mn	0.832	0.755	0.178	0.132	0.16	0.2	0.3	0.279	0.298	0.574	0.415	0.415
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.02 <	0.01 <	0.01 <	0.01
Ni	0.02	0.02	0.03	0.04	0.04	0.05 <	0.02 <	0.02	0.04	0.04 <	0.02 <	0.02
P	< 0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1	0.1	0.1 <	0.1 <	0.1 <	0.1 <	0.1
K	0.9	1.1	1.0	1.1	1.2	1.3	0.8	0.7	1.1	1.1	0.8	0.8
Se	< 0.05 <	0.05 <	0.05 <	0.001 <	0.001 <	0.001 <	0.001 <	0.001 <	0.05 <	0.05 <	0.05 <	0.05
Si	4.28	4.58	5.19	5.20	5.17	5.40	5.56	5.4	4.82	5.33	4.99	4.99
Ag	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.02 <	0.01	0.03 <	0.01 <	0.01
Na	1.8	1.9	2.2	2.2	2.2	2.1	2.6	2.7	2.2	3	2.9	2.9
Sr	0.524	0.559	0.629	0.684	0.678	0.678	0.702	0.695	0.603	0.688	0.651	0.651
S	261.5	277	350.2	365	347	390	391.3	369	293	337	331.8	331.8
Sn	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	< 0.002	0.002 <	0.002 <	0.002	0.004	0.013 <	0.002 <	0.002	0.016	0.006 <	0.002 <	0.002
V	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.02	0.02 <	0.01	0.04 <	0.01 <	0.01
Zn	9.555	9.78	14.6	13.6	13.10	13.1	11.80	11.10	8.39	9.15	8.29	8.29
ICP, Total												
Al		10.8	0.53	1.08	0.71	1.60	3.90	2.69	6.28	6.73	4.53	4.53
Sb	<	0.05	0.08 <	0.06 <	0.06	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
As	<	0.05 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba		0.219	0.034	0.047	0.043	0.062	0.106	0.086	0.176	0.196	0.138	0.138
Be		0.004	0.005	0.005	0.005	0.015	0.005	0.005	0.006	0.006	0.006	0.006
B		0.03 <	0.01 <	0.01 <	0.01 <	0.01	0.02	0.03	0.02	0.03	0.02	0.02
Cd		0.028	0.021	0.017	0.012	0.03	0.015	0.016	0.021	0.016	0.020	0.020
Ca		295	326.3	340.0	326	337.6	318.6	339	332	355	344.8	344.8
Cr		0.010 <	0.006 <	0.006 <	0.006	0.007 <	0.006	0.01	0.013 <	0.006	0.007	0.007
Co	<	0.005 <	0.006 <	0.006 <	0.006 <	0.006 <	0.006	0.008	0.007 <	0.006	0.013	0.013
Cu		0.056	0.007 <	0.006 <	0.006	0.016	0.036	0.025	0.062	0.058	0.037	0.037
Fe		13.2	0.714	1.74	1.2	2.5	5.9	4.0	10.0	13	7.17	7.17
Pb	<	0.05 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Mg		51.9	55.3	57.5	54.5	57.8	54.5	58.1	57.0	60.8	60.6	60.6
Mn		1.10	0.191	0.165	0.197	0.3	0.502	0.350	0.569	0.83	0.61	0.61
Mo	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.01
Ni		0.06	0.04	0.04 <	0.02	0.04	0.04	0.03	0.03	0.05	0.06	0.06
P		0.5 <	0.1 <	0.1	0.1 <	0.1	0.2 <	0.1	0.4	0.4	0.2	0.2
K		2.8	1.2	1.2	1	1.3	1.4	1.3	1.7	1.8	1.8	1.8
Se	<	0.05 <	0.06 <	0.001 <	0.001 <	0.06 <	0.001 <	0.001 <	0.06 <	0.06 <	0.06 <	0.06
Si		21.2	5.62	7.04	6.2	7.45	10.15	8.47	13.6	14.8	11.71	11.71
Ag	<	0.01 <	0.01 <	0.01 <	0.01	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Na		3.0	2.2	2.1	2.1	2.4	2.4	2.6	2.5	2.9	2.7	2.7
Sr		0.608	0.646	0.682	0.653	0.674	0.635	0.633	0.655	0.701	0.703	0.703
S		278	341.2	331	315	318	310.9	323	325.2	328	350.8	350.8
Sn	<	0.05 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti		0.393	0.014	0.030	0.013	0.051	0.112	0.076	0.176	0.188	0.148	0.148
V		0.03 <	0.01 <	0.01 <	0.01	0.03	0.02	0.01	0.02	0.03	0.01	0.01
Zn		12.1	13.1	14.30	13.4	13.1	11.19	10.7	10.3	10.1	9.215	9.215
TIC	13.7	11.0	9.8		11.6		16.4	14.8	14.7	16.5	18.5	18.5
TOC	4.5	4.1	3.0		2		2.2	2.3	3.4	2.5	1.7	1.7
PO4	0.016	0.595	0.032	<	0.002		0.32	0.066	0.285	0.239	0.182	0.182
Field parameters:												
Water temp. (°C)	0.04	2.0	1.2	1.8	2.8	2.6	2.0	2.5	2.1	2.0	2.2	2.2
pH	7.3	6.67	7.3	7.20	6.77	6.76	7.41	6.51	8.2	7.45	7.74	7.74
Spec. cond. (uS/cm)	1493	1333	1636	1680	1721	1731	1707	1718	1914	1635	1573	1573
Cond. (uS/cm)	782	750	900	940	990	990	960	980	1080	920	890	890
ORP (mV)								235	104	116	95.2	95.2
Eh (mV) (calc'd)								434	303	315	294.2	294.2

Site 3- Old Rd. Seep
RHS Limit

	May-29	Jun-06	Jun-13	Jun-20	Jun-28	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1	< 1	< 1		<	< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	4	4	4	4		4	4	4	5	5	6	7
Alkalinity, total	31.3	35.1	29	29		31.2	43.9	48.7	49.6	53.7	50.8	54.5
Cl-	0.5	0.2	< 2	< 2	<	6	5	5	5	5	20	0.4
F	0.02	0.02	< 0.01	< 0.01	<	0.01	0.5	0.5	0.5	0.5	0.01	0.01
SO4	522.0	831	848.4	848.4		850	850.4	712	601	847	1033	920
Br	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
Nitrate	0.009	0.013	< 0.002	< 0.002	<	0.002	< 0.1	< 0.1	< 0.1	< 0.1	0.25	0.15
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.255	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
pH	7.51	7.41	7.37	7.37		7.37	7.44	7.54	7.52	7.43	7.45	7.7
FR	910	1210	1310	1310		1270	1230	1100	970	1280	1540	1300
NFR	< 5	< 5	< 5	< 5	<	5	< 5	< 5	< 5	< 5	918	< 5
Spec. Cond.	1070	1370	1434	1434		1430	1390	1135	1135	1440	1630	1480
GFAA (dissolved):												
Se	< 0.001	< 0.001	< 0.001	< 0.001	<	0.001						
GFAA (total):												
Se	< 0.001	< 0.001	< 0.001	< 0.001	<	0.001						
Hardness, Ca+Mg	586.3	794	904.3	904.3	1,110.0	858	765	738	663	837	1017	926
Hardness, total	587.3	795	907.3	907.3	1,110.0	861.4	768.3	741	668	840	1023	930
ICP, dissolved												
Al	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	0.07	< 0.05	< 0.05	0.17	< 0.05	< 0.05
Sb	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	0.09	< 0.05	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.022	0.026	0.029	0.029	0.034	0.022	0.019	0.019	0.023	0.024	0.087	0.028
Be	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.004	0.011	< 0.001	0.006	0.005
B	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Ca	180.7	246	286.1	286.1	335.0	269.1	238.4	229	210	258	316	285
Cr	0.008	0.009	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Co	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.011	< 0.005
Cu	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Fe	0.042	< 0.005	0.016	0.016	0.024	0.006	< 0.0005	0.012	0.011	< 0.005	1.510	0.007
Pb	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	32.8	43.5	46.1	46.1	66.4	45.2	41.3	40.1	38.7	47.2	55.1	52.2
Mn	0.001	0.001	0.004	0.004	0.0	< 0.001	< 0.001	0.01	0.004	0.006	0.218	0.002
Mo	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	< 0.02	< 0.02	< 0.02	< 0.02	<	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
P	< 0.1	< 0.1	< 0.1	< 0.1	<	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	0.8	0.9	0.7	0.7	0.7	0.4	0.4	0.5	0.5	0.6	0.9	0.9
Se	< 0.05	< 0.05	< 0.05	< 0.05	<	0.001	< 0.001	< 0.001	< 0.05	< 0.05	< 0.05	< 0.05
Si	3.64	4.28	5.07	5.07	4.98	4.29	3.92	4.23	4.29	4.48	4.43	4.75
Ag	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.3	1.7	1.9	1.9	2.1	2.3	2	1.9	1.9	0.9	2.7	2.6
Sr	0.353	0.463	0.537	0.537	0.645	0.494	0.438	0.437	0.415	0.500	0.577	0.554
S	180.9	244	267.6	267.6	308	268	242	245	199	244	290	281
Sn	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	< 0.002	< 0.002	< 0.002	<	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.03	< 0.01	0.01	0.01
Zn	0.272	0.364	1.59	1.59	1.9	1.711	1.466	1.48	1.37	1.68	0.921	2.05
ICP, Total												
Al	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	14.41	< 0.06
Sb	< 0.05	< 0.07	< 0.07	< 0.07	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
As	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.028	0.028	0.028	0.028	0.310	0.03	0.026	0.023	0.021	0.026	0.406	0.029
Be	0.004	0.004	0.004	0.004	0.005	0.005	0.004	0.004	0.003	0.005	0.005	0.005
B	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06	< 0.01
Cd	< 0.005	< 0.006	< 0.006	< 0.006	<	0.01	< 0.006	< 0.006	< 0.006	< 0.006	0.036	< 0.006
Ca	240	267.1	267.1	267.1	309.0	268	246	224	202	268	317.4	268
Cr	< 0.005	< 0.006	< 0.006	< 0.006	<	0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.035	< 0.006
Co	< 0.005	< 0.006	< 0.006	< 0.006	<	0.006	< 0.01	< 0.006	< 0.006	< 0.006	0.027	< 0.006
Cu	< 0.005	< 0.006	< 0.006	< 0.006	<	0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.063	< 0.006
Fe	0.055	0.012	0.012	0.012	0.023	0.025	0.043	0.019	0.009	< 0.006	25.206	0.012
Pb	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	0.13	< 0.06
Mg	43.2	46.2	46.2	46.2	53.4	47.4	44.4	41.3	37.6	49.2	60.8	49.9
Mn	0.003	0.001	0.001	0.001	0.1	0.005	0.002	0.003	< 0.001	< 0.001	0.612	0.004
Mo	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	< 0.02	< 0.02	< 0.02	< 0.02	<	0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.07	< 0.02
P	< 0.1	< 0.1	< 0.1	< 0.1	<	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	< 0.1
K	0.9	0.8	0.8	0.8	0.5	0.6	0.7	0.6	0.6	0.8	2.6	1
Se	< 0.05	< 0.06	< 0.06	< 0.06	<	0.001	< 0.001	< 0.001	< 0.06	< 0.06	< 0.06	< 0.06
Si	4.22	4.65	4.65	4.65	5.00	4.93	4.27	4.27	4.36	4.70	22.30	4.45
Ag	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.7	1.8	1.8	1.8	1.9	2.1	1.9	1.8	1.6	2.1	2.8	2.2
Sr	0.460	0.530	0.530	0.530	0.613	0.589	0.454	0.42	0.403	0.526	0.643	0.537
S	238	279.8	279.8	279.8	335	268	237	228	197	262	299.18	264
Sn	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	0.003	< 0.002	< 0.002	< 0.002	<	0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.446	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.04	< 0.01
Zn	0.372	1.40	1.40	1.40	1.82	1.690	1.534	1.440	1.350	1.760	1.859	1.98
TIC	8.7	8.2	6.6	6.6		9	12	11.5	12.7	13.1	13.9	15
TOC	12.9	6.5	5.7	5.7		5.6	5.8	6.4	8.2	4.6	3.0	4.5
PO4	0.005	< 0.002	0.010	0.010	<	0.002	< 0.002	< 0.002	0.014	< 0.002	0.668	0.018
Field parameters:												
Water temp. (°C)	3.16	2.0	5.1	5.1	6.3	5.5	5.5	4.7	3.9	2.9	4.0	0.8
pH	6.97	6.56	7.2	7.2	6.84	6.77	7.28	6.5	7.81	7.01	7.35	7.41
Spec. cond. (uS/cm)	1054	1404	1434	1434	1576	1451	1338	1220	1365	1335	975	1452
Cond. (uS/cm)	614	790	880	880	1000	900	830	740	810	770	580	790
ORP (mV)								267	303	227	200	175.1
Eh (mV) (calc'd)								466	502	426	399	374.1

Site 2- Old Rd. Seep

LHS Limit		May-29	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	<	1 <	1 <	1 <	1 <	1 <	1 <	1
Acidity, total		6	5	5	7	8	5	6
Alkalinity, total		67.7	47.1	48.3	51.5	55.9	49.3	65.9
Cl-		0.3 <	5.1 <	5 <	5 <	5 <	10	0.4
F		0.01 <	0.51 <	0.5 <	0.5 <	0.5 <	0.01	0.01
SO4		853.3	1058.9	977	989	980	881	1050
Br	<	0.05 <	2.6 <	3.0 <	2.6 <	3 <	0.05 <	0.05
Nitrate		0.009 <	0.1 <	0.1 <	0.1 <	0.1	0.18	0.201
Nitrite	<	0.005 <	0.255 <	0.3 <	0.26 <	0.3 <	0.005 <	0.005
P	<	0.05 <	2.55 <	3.0 <	2.6 <	3 <	0.05 <	0.05
pH		7.82	7.35	7.56	7.37	7.31	7.48	7.74
FR		1360	1540	1480	1440	1480	1340	1460
NFR	<	5	595	2720	447	130 <	5	105
Spec. Cond.		1517	1650	1620	1556	1620	1490	1650
GFAA (dissolved):								
Se	<	0.001						
GFAA (total):								
Se								
Hardness, Ca+Mg		908.9	984	992	1022	891	966	1030
Hardness, total		909.7	989	996	1029	897	970	1030
ICP, dissolved								
Al	<	0.05 <	0.05	0.05 <	0.05 <	0.05	0.07 <	0.05
Sb	<	0.05 <	0.05 <	0.05	0.07	0.08 <	0.05 <	0.05
As	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba		0.03	0.072	0.061	0.089	0.086	0.034	0.058
Be		0.005	0.004	0.006	0.012	0.055	0.006	0.006
B	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Cd	<	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005
Ca		282.4	308.8	307	317	275	300	316
Cr		0.011 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005
Co	<	0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.009 <	0.005
Cu	<	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005
Fe		0.019	0.87	0.993	2.00	1.920	0.016	1.25
Pb	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg		49.4	51.7	54.5	56.0	49.9	52.7	58.2
Mn		0.002	0.149	0.163	0.216	0.280	0.014	0.158
Mo	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	<	0.02 <	0.02 <	0.02 <	0.02 <	0.02 <	0.02 <	0.02
P	<	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1
K		1.1	0.2	0.7	0.7	0.7	1.2	0.8
Se		0.07 <	0.001 <	0.001 <	0.05 <	0.05 <	0.05 <	0.05
Si		3.97	3.98	4.44	4.72	4.01	4.86	4.55
Ag	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.01 <	0.01
Na		1.9	2.2	2.3	2.5	1.7	2.6	2.8
Sr		0.497	0.522	0.564	0.585	0.509	0.580	0.592
S		265.5	319	363	298	260	277	63
Sn	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	<	0.002 <	0.002 <	0.002 <	0.002 <	0.002 <	0.002 <	0.002
V	<	0.01 <	0.01 <	0.01	0.02 <	0.01	0.02	0.01
Zn		0.048	0.315	0.497	0.715	0.660	2.13	1.01
ICP, Total								
Al			6.92	8	7.33	2.24 <	0.06	1.62
Sb	<	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
As	<	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba		0.254	0.257	0.240	0.147	0.035	0.089	
Be		0.004	0.005	0.004	0.005	0.006	0.005	
B		0.03	0.03	0.04	0.01 <	0.01	0.01	
Cd	<	0.006 <	0.006	0.014 <	0.006 <	0.006 <	0.006 <	
Ca		312.9	314.0	312.0	309	283.2	309	
Cr		0.009	0.013	0.012 <	0.006	0.009 <	0.006	
Co	<	0.006	0.009	0.019 <	0.006 <	0.006 <	0.006	
Cu		0.02	0.02	0.023 <	0.006 <	0.006 <	0.006	
Fe		12.762	12.900	16.300	5.440	0.034	3.65	
Pb	<	0.06	0.06 <	0.06 <	0.06 <	0.06 <	0.06	
Mg		56.8	57.9	57.1	57.4	52.2	57.1	
Mn		0.318	0.351	0.600	0.366	0.022	0.188	
Mo	<	0.01 <	0.01 <	0.01 <	0.01	0.01 <	0.01	
Ni	<	0.02 <	0.02	0.03 <	0.02 <	0.02 <	0.02	
P		0.3	0.5	0.9	0.2 <	0.1 <	0.1	
K		1.7	1.7	1.7	1.1	1.4	1.1	
Se	<	0.001 <	0.001 <	0.06 <	0.06 <	0.06 <	0.06	
Si		13.60	14.80	14.60	7.70	4.87	6.65	
Ag	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	
Na		2.6	2.6	2.5	2.4	2.1	2.4	
Sr		0.554	0.564	0.600	0.591	0.579	0.592	
S		291	295	299	310	277	337	
Sn	<	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06	
Ti		0.214	0.253	0.227	0.069 <	0.002	0.061	
V		0.02	0.03	0.02	0.01 <	0.01 <	0.01	
Zn		0.616	0.825	1.16	0.833	2.106	1.09	
TIC		18.3	13.2	12.8	3.7	14.4	13.2	16.9
TOC		4.9	3.8	3.8	14.5	3.3	3.3	2.9
PO4		0.006	0.410	1.900	0.370	0.081 <	0.002	0.09
Field parameters:								
Water temp. (°C)		2.27	4.0	4.2	3.4	2.1	2.9	1.5
pH		7.33	7.63	6.71	7.67	6.95	7.45	7.4
Spec. cond. (uS/cm)		1474	1311	1387	1743	1560	1439	1568
Cond. (uS/cm)		833	780	830	1020	880	830	870
ORP (mV)				107	105	74	55.2	45.9
Eh (mV) (calc'd)				306	304	273	254.2	244.9

Site 1- 300 drainage at
Christal Ck

	May-29	Jun-06	Jun-13	Jun-20	Jun-28	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1		< 1			< 1	< 1	< 1	< 1	< 1	< 1	
Acidity, total	4	6		5		8		6	7	8	8	6	6
Alkalinity, total	38.3	46.2		56.3		59.2		82.5	80.6	81.1	90.6	76.1	95.2
Cl-	0.4	0.2		< 2	< 6		< 6	< 5	< 5	< 5	< 5	< 2.5	0.6
F	0.03	0.02		< 0.01	< 0.01		< 0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.01	0.03
SO4	490.3	867		898.3	943		981	880	793	955	992	992	950
Br	< 0.05	< 0.05		< 0.05	< 0.05		< 3.0	< 3.0	< 2.6	< 3	< 0.05	< 0.05	
Nitrate	0.038	0.059		0.09	< 0.002		< 0.1	< 0.1	< 0.1	< 0.1	0.23	0.133	
Nitrite	< 0.005	< 0.005		< 0.005	< 0.005		< 0.3	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005	
P	< 0.05	< 0.05		< 0.05	< 0.05		< 3.0	< 3.0	< 2.6	< 3	< 0.05	< 0.05	
pH	7.55	7.51		7.61	7.53		7.72	7.77	7.68	7.60	7.67	7.98	
FR	840	1270		1410	1450		1480	1390	1280	1460	1440	1470	
NFR	1350	2750		958	848		636	959	501	345	1020	169	
Spec. Cond.	989	1430		1298	1570		1560	1530	1429	1630	1600	1620	
GFAA (dissolved):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
GFAA (total):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
Hardness, Ca+Mg	548.6	851	985.6	974.6	1120	985.2	995.9	946	919.7	859	1150	1060	1020
Hardness, total	551.8	857	993.2	979.9	1140	991.2	1002.3	951.1	924.6	864	1160	1070	1020
ICP, dissolved													
Al	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	0.11	0.14	< 0.05	0.27	< 0.05	< 0.05	< 0.05
Sb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.042	0.120	0.094	0.094	0.090	0.106	0.137	0.078	0.066	0.060	0.061	0.096	0.054
Be	0.003	0.008	0.005	0.005	0.005	0.006	0.006	0.005	0.005	0.010	0.006	0.006	0.005
B	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	< 0.005	< 0.005	< 0.005	< 0.005	0.015	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Ca	171.7	264	308.6	305.7	349	305.5	307.9	292.8	282	267	359	327	309
Cr	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	0.013	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005
Co	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cu	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.0005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Fe	0.443	1.47	0.786	0.429	0.091	0.643	0.74	0.434	0.515	0.584	0.510	0.718	0.437
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	29.1	46.7	52.2	51.3	60.5	54.0	55.1	52.2	52.5	46.8	62.0	59.5	59.9
Mn	0.235	0.390	0.549	0.318	0.132	0.385	0.554	0.429	0.416	0.330	0.520	0.529	0.439
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	< 0.02	< 0.02	0.02	< 0.02	0.04	< 0.02	0.03	< 0.02	< 0.01	< 0.02	< 0.02	< 0.02	< 0.02
P	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	0.7	0.9	1.0	0.9	1.1	0.9	1.0	0.8	0.9	0.8	1.2	1.2	1.1
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	3.30	4.29	4.74	4.63	5.20	4.08	4.11	3.66	3.89	3.66	4.15	4.25	4.14
Ag	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.3	1.8	2.1	2.0	2.2	2.3	2.3	2.1	2.1	2.3	2.3	2.5	2.4
Sr	0.317	0.499	0.579	0.568	0.684	0.564	0.582	0.52	0.532	0.472	0.627	0.614	0.598
S	159.3	262	293.5	284.1	365	300	283.16	288.96	312	259	3030	295	59.7
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	0.006	< 0.002	< 0.002	< 0.002	< 0.002	0.012	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	0.903	1.45	2.95	2.08	13.6	2.12	1.875	1.67	1.65	1.49	1.60	1.47	1.45
ICP, Total													
Al	21.50	33.4	27.09	13.71	1.08	13.1	19.29	8.31	8.72	6.75	4.53	16.89	1.82
Sb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
As	0.09	0.14	0.13	< 0.06	< 0.06	0.07	0.08	< 0.06	< 0.06	< 0.06	< 0.06	0.08	< 0.06
Ba	0.655	1.04	0.778	0.391	0.047	0.451	0.6	0.27	0.271	0.221	0.156	0.488	0.091
Be	0.001	0.002	0.002	0.003	0.005	0.005	0.014	0.004	0.004	0.004	0.005	0.005	0.005
B	0.09	0.14	0.14	0.06	< 0.01	0.07	0.08	0.03	0.04	0.03	0.02	0.08	0.01
Cd	0.018	0.027	0.031	0.015	0.017	0.012	0.022	< 0.006	< 0.006	0.009	< 0.006	0.014	< 0.006
Ca	203.4	330	308.0	261.5	340.0	309	337.1	297	294	279	314	321.8	295
Cr	0.031	0.048	0.046	0.019	< 0.006	0.025	0.029	0.009	0.008	< 0.006	< 0.006	0.034	0.007
Co	0.030	0.041	0.029	0.016	< 0.006	0.018	0.027	< 0.006	< 0.006	0.009	< 0.006	0.033	< 0.006
Cu	0.062	0.096	0.092	0.034	< 0.006	0.055	0.072	0.033	0.031	0.023	0.012	0.068	< 0.006
Fe	40.8	63.8	58.9	23.9	1.74	28.1	37.819	14.507	16.3	13.7	8.52	34.694	3.73
Pb	0.10	0.18	0.13	0.07	< 0.06	< 0.06	0.09	< 0.06	0.09	< 0.06	< 0.06	0.09	< 0.06
Mg	44.2	70.4	61.3	49.2	57.5	59.1	65.1	56	56.9	53.8	60.6	64.3	56.9
Mn	1.04	1.71	1.89	0.650	0.165	0.919	1.219	0.7	0.71	0.647	0.619	1.145	0.488
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	0.07	0.11	0.11	0.04	0.04	0.05	0.08	0.03	0.03	0.03	0.03	0.07	< 0.02
P	1.9	3.4	2.8	1.0	< 0.1	0.8	1.3	0.6	0.8	0.6	0.3	1.3	0.1
K	4.2	5.8	4.3	2.7	1.2	2.9	3.2	2.1	1.8	1.7	1.7	3.2	1.4
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	35.32	60.5	40.6	24.02	7.04	24.1	29.3	15.4	15.4	13.4	10.7	25.47	6.47
Ag	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	3.0	3.8	3.3	2.7	2.1	3.3	3.0	2.7	2.5	2.3	2.5	3	2.3
Sr	0.443	0.687	0.637	0.528	0.682	0.697	0.684	0.54	0.539	0.539	0.607	0.859	0.579
S	159.4	257	252.8	240	331	300	289.3	267	281	263	301	294.56	291
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	0.842	1.37	0.977	0.506	0.030	0.458	0.650	0.274	0.291	0.203	0.157	0.561	0.063
V	0.08	0.12	0.09	0.04	< 0.01	0.05	0.09	0.03	0.03	0.02	0.02	0.05	< 0.01
Zn	1.65	2.92	4.42	2.38	14.30	3.04	3.47	2.34	2.41	2.11	1.87	2.66	1.55
TIC	8.9	10.8		12.2		16.2		21.9	20	20.6	21.6	21.1	23
TOC	17.6	6.5		4.9		4.1		4.2	4.7	6.1	3.8	2.6	3.7
PO4	0.52	2.20		0.88		0.783		0.430	0.72	0.518	0.282	0.731	0.14
Field parameters:													
Water temp. (°C)	3.23	3.1	3.5	4.8	6.3	6.7	3.5	5.7	4.4	8.1	2.7	3.9	1.3
pH	7.33	6.52	6.75	7.7	7.27	6.89	6.75	7.38	7.04	7.26	7.26	6.79	7.26
Spec. cond. (uS/cm)	892	1327	1364	1298	1592	1496	1364	1394	798	1379	1534	1517	1323
Cond. (uS/cm)	521	770	800	790	1010	960	800	870	480	920	880	900	730
ORP (mV)									98	104	56	25.8	29.4
Eh (mV) (calc'd)									297	303	255	224.8	228.4
Flow (m³/3/s)								0.062	0.06	0.091	0.065	0.075	0.0625
Flow (L/s)								8.16	7.78	14.22	8.74	10.76	8.26

Site 11- Galkeno 300

adit	May-29	Jun-06	Jun-13	Jun-20	Jun-28	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1		< 1		< 1		< 1	< 1	< 1	< 1	< 1	< 1
Acidity, total	213	248		267		273		253	268	250	274	278	259
Alkalinity, total	13.6	14.9		0.5		0.5		3.1	5.0	8.1	7.2	12.1	11.7
Cl-	1.0	< 10		< 2		< 6		< 5	< 5	< 5	< 5	20	2
F	0.21	< 0.01		0.2		< 0.01		< 0.5	< 0.5	< 0.5	< 0.5	0.25	0.52
SO4	1,070.0	2,380		1180		1330		1344.1	1440	1288	1450	1,496	1,500
Br	< 0.05	< 5		< 0.05		< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
Nitrate	0.047	< 0.2		0.30		0.33		< 0.10	< 0.10	< 0.10	< 0.1	0.24	0.04
Nitrite	< 0.005	< 0.005		< 0.005		< 0.005		< 0.26	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005
P	< 0.05	< 5		< 0.05		< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
pH	6.61	6.19		5.49		4.90		5.63	5.96	5.98	5.93	6.13	5.94
FR	1,650	1,960		1,800		2,000		2,090	2,110	2,060	2,060	2,170	2,170
NFR	40	65		45		53		78	75	62	68	74	67
Spec. Cond.	1.670	1.890		1.680		1.674		1.890	1.940	1.870	1.910	2.010	2.000
GFAA (dissolved):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
GFAA (total):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
Hardness, Ca+Mg	570.4	653	605.1	577.7	632.0	616	684.5	625	680	699	613	748	741
Hardness, total	1,077.0	1,270	1,217.2	1,161.5	1,260.0	1,287	1,371.1	679	1,370	1,359	1,320	1,495	1,155
ICP, dissolved													
Al	0.12	0.17	0.31	0.39	0.39	0.3	0.25	0.3	0.2	0.2	< 2.5	< 2.5	
Sb	0.32	0.34	0.32	0.34	0.40	0.40	0.44	0.46	0.42	0.41	0.42	0.46	
As	< 0.05	0.11	0.09	0.05	0.08	0.08	0.06	0.06	0.08	< 0.05	0.07	0.10	
Ba	0.005	0.006	0.009	0.007	0.007	0.012	0.004	0.012	0.007	0.003	0.003	0.007	
Be	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.010	0.004	0.004	0.002	0.004	
B	0.05	0.09	0.08	0.06	0.07	0.07	0.07	0.08	0.10	0.09	0.07	0.10	
Cd	0.386	0.388	1.373	1.616	1.800	1.230	1.170	0.854	0.802	0.706	0.600	0.659	
Ca	170.2	192.0	177.2	173.3	176.0	179.0	198.6	183.8	201.0	203.0	177.4	218.0	
Cr	0.031	0.035	0.019	0.024	0.032	0.033	0.031	0.053	0.070	0.031	< 0.25	0.49	
Co	0.162	0.137	0.119	0.105	0.126	0.123	0.126	0.129	0.149	0.127	0.115	0.159	
Cu	< 0.005	< 0.005	0.076	0.096	0.076	0.038	0.018	0.012	0.005	< 0.005	< 0.005	< 0.005	
Fe	18.3	35.7	31.7	24.7	26.100	27.5	30.445	29.095	33.5	32.9	34.83	39.15	
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Mg	35.3	42.1	39.5	35.2	46.8	41.0	45.8	40.4	43.2	46.8	41.1	49.4	
Mn	155.2	191	186.4	176.3	184.0	214.76	208.4	206	211.00	197.00	216.00	228.50	
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Ni	1.47	1.72	1.78	1.65	1.72	1.78	2.03	1.74	1.72	1.78	2.90	3.40	
P	0.7	1.0	1.0	1.0	1.1	1.3	1.5	1.2	1.0	1.1	< 5	< 5.0	
K	0.7	0.7	0.8	0.7	0.8	0.8	0.6	0.8	0.8	0.6	0.5	0.8	
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	
Si	3.66	4.29	4.66	4.71	4.76	4.8	5.17	4.2	4.5	4.6	5.3	6.6	
Ag	0.02	0.03	0.03	0.03	0.03	0.03	0.02	0.04	0.04	0.03	< 0.01	0.03	
Na	1.5	1.5	1.6	1.6	1.5	1.7	1.5	2.1	1.4	1.7	0.8	1.8	
Sr	0.222	0.277	0.254	0.228	0.245	0.247	0.275	0.24	0.261	0.277	0.244	0.296	
S	319.2	387	392	377	375	402	475	377	480	399	427	443	
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Ti	< 0.002	< 0.002	0.003	< 0.002	< 0.002	< 0.002	< 0.002	0.016	0.004	< 0.002	< 0.002	< 0.002	
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	
Zn	124	136	140	141	158	150	164	155	161	157	164	168	
ICP, Total													
Al	0.22	0.28	0.49	0.77	0.95	0.73	0.56	0.37	0.36	< 3	< 3	< 3	3.00
Sb	0.32	0.31	0.27	0.35	0.42	0.43	0.43	0.4	0.41	0.36	0.39	0.40	0.39
As	0.08	0.21	0.16	0.11	0.20	0.2	0.15	0.18	0.19	0.14	0.16	0.22	0.20
Ba	0.006	0.008	0.006	0.006	0.008	0.005	0.012	0.007	0.008	0.006	0.005	0.009	0.005
Be	0.003	0.003	0.002	0.003	0.004	0.004	0.013	0.003	0.004	0.003	0.004	0.004	0.003
B	0.06	0.09	0.08	0.06	0.07	0.07	0.08	0.09	0.1	0.1	0.10	0.10	0.11
Cd	0.401	0.396	1.12	1.470	1.51	1.210	1.12	0.766	0.769	0.680	0.673	0.822	0.592
Ca	175.6	190	144.5	158.5	168.0	172	182.2	177.3	195	188	193.0	201.8	209
Cr	0.029	0.030	0.031	0.024	0.023	0.018	0.043	0.041	0.073	< 0.3	0.5	< 0.3	
Co	0.163	0.138	0.108	0.123	0.128	0.121	0.137	0.121	0.135	0.136	0.148	0.164	0.159
Cu	< 0.006	< 0.005	0.068	0.100	0.101	0.054	0.040	0.018	0.014	0.009	0.009	0.015	0.007
Fe	22.6	39.7	30.1	26.8	29.2	32.1	33.6	34.4	39.2	37.1	39.1	43.400	45.0
Pb	0.12	0.08	0.13	0.15	0.14	< 0.06	0.10	0.08	< 0.06	< 0.06	< 0.06	0.1	0.01
Mg	36.5	42.6	33.2	35.7	37.8	38.7	42.7	41.6	46.1	37.1	44.4	47.30	48.2
Mn	156.8	201	188.1	165.9	179.0	194	190.8	194.9	204	199	203	220.7	225
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	1.57	1.78	1.37	1.57	1.75	2	1.88	1.73	1.89	2	2	4.00	3
P	0.8	1.0	0.8	1.0	1.3	1.4	1.2	1.1	1.2	< 5	< 5	< 5	5
K	0.8	0.8	0.7	0.8	0.8	0.7	0.9	0.8	0.9	0.8	0.8	1.0	0.9
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	3.97	4.46	3.74	4.38	5.05	5	4.93	4	4.90	6	6	5	5.00
Ag	0.02	0.03	0.03	0.03	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
Na	1.6	1.6	1.3	1.5	1.5	1.5	1.6	1.6	1.5	1.5	1.6	1.5	1.6
Sr	0.231	0.277	0.210	0.227	0.238	0.241	0.259	0.231	0.274	0.245	0.265	0.286	0.292
S	345	407	381	334	356	377	373	379	427	402	401	439	453
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	< 0.002	0.005	< 0.002	< 0.002	0.003	< 0.002	0.003	0.002	0.003	0.004	< 0.002	0.005	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	136	145	152	137	150	158	151	147	151	149	153	165	168
TIC	8.4	17.1		3.2		11.7		7.3	9.9	13.2	13.4	13.4	17.7
TOC	< 0.5	< 0.5		< 0.5		< 0.5		< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5
PO4	0.010	0.006		< 0.002		< 0.002		0.046	< 0.002	0.005	< 0.002	< 0.002	< 0.002
Field parameters:													
Water temp. (°C)	2.54	2.9	3.1	3.3	3.1	2.3	3.1	2.9	3.1	3.0	3.0	3.1	3.0
pH	6.27	5.89	5.75	6.00	5.75	5.9	5.75	6.11	6.22	6.83	5.94	6.29	6.34
Spec. cond. (uS/cm)	1700	1820	1741	1680	1741	1939	1741	1924	3585	2368	2005	2051	2057
Cond. (uS/cm)	971	1050	1010	980	1010	1100	1010	1110	2080	1370	1160	1190	1190
ORP (mV)									265	121	120	110	83
Eh (mV) (calc'd)									464	320	319	309	282
Flow (m³/s)								0.052	0.055	0.062	0.06	0.0675	0.06
Flow (L/s)								6.31	6.85	8.16	7.78	9.23	7.78

Site 10- Sinkhole nr.

Pole 500		Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	<	1 <	1 <	1 <	1 <	1
Acidity, total		259	237	246	230	241
Alkalinity, total	<	0.5	1.3 <	0.5	3.8	4.8
Cl-	<	5 <	5 <	5	1.4	2.6
F	<	0.5 <	0.5 <	0.5	0.2	0.15
SO4		1410	1270	1440	1339	1494
Br	<	3.0 <	2.6 <	3 <	12.5 <	0.05
Nitrate	<	0.10	0.34 <	0.1	0.124	0.089
Nitrite	<	0.3 <	0.26 <	0.3 <	0.005 <	0.005
P	<	3.0 <	2.6 <	3 <	0.05 <	0.05
pH		5.19	5.51	4.80	5.96	5.5
FR		2070	2070	2080	1950	2190
NFR		38	49	62	304	78
Spec. Cond.		1900	1627	1920	1840	1990
Hardness, Ca+Mg		635	695.6	703	659.3	776.4
Hardness, total		1270	1314.4	1550	1283.3	1498
ICP, dissolved						
Al	<	0.05	0.13	68.5 <	2.5	3.70
Sb		0.31	0.51	0.52	0.39	0.44
As	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba	<	0.001	0.005	0.003	0.007	0.006
Be		0.002	0.01	0.004	0.003	0.004
B		0.04	0.04 <	0.01	0.05	0.06
Cd		0.725	0.697	0.675	0.568	0.65
Ca		187	203	204	192	231.2
Cr		0.042	0.042	8.630 <	0.250	0.350
Co		0.114	0.126	0.191	0.143	0.162
Cu	<	0.005 <	0.005	0.006 <	0.005 <	0.005
Fe		14.1	14.1 <	0.005	15.2	21.56
Pb	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg		41.0	45.9	47.0	44	48.3
Mn		207.0	196.7	202	203.1	228.1
Mo	<	0.01 <	0.01	0.01 <	0.01 <	0.01
Ni		1.56	1.74		2.6	4.2
P		0.8	1.1	<	5 <	5
K		0.4	0.5	0.5	0.8	0.8
Se	<	0.001 <	0.001 <	0.05 <	2.5 <	2.50
Si		3.71	3.95 <	0.05	4.8	5.30
Ag		0.02	0.03	0.03	0.03	0.03
Na		1.1	1.7	1	1.5	2.1
Sr		0.246	0.277	0.281	0.265	0.294
S		477	402	453	398.4	445
Sn	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	<	0.002 <	0.002 <	0.002 <	0.002 <	0.002
V	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Zn		155	153.1	144	146.35	165.3
ICP, Total						
Al		0.66 <	3 <	3 <	3 <	3
Sb		0.42	0.38	0.42	0.38	0.38
As		0.17	0.09	0.07	1.52	0.21
Ba		0.014	0.007	0.005	0.019	0.008
Be		0.004	0.003	0.004	0.005	0.003
B		0.09	0.07	0.07	0.29	0.09
Cd		0.756	0.699	0.674	0.675	0.600
Ca		188	192.2	194	186.3	207.2
Cr		0.065 <	0.3	0.5 <	0.03	0.5
Co		0.124	0.143	0.129	0.142	0.143
Cu		0.02	0.015 <	0.006	0.12	0.018
Fe		32.3	27.2	26.0	132	38.6
Pb		0.10	0.08	0.07	0.60	0.21
Mg		44.3	44.3	44.6	43.5	47.8
Mn		196	203.22	204	199.93	221.23
Mo	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni		1.81	3	2	3	3
P		1.2 <	5 <	5 <	5 <	5
K		1	1	0.8	1	0.8
Se	<	0.001 <	0.001 <	3 <	3 <	3
Si		5	7	9	7	7.00
Ag		0.03	0.03	0.03	0.03	0.03
Na		1.5	1.5	1.6	1.4	2.4
Sr		0.266	0.253	0.266	0.268	0.291
S		412	413	404	407	453
Sn	<	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti		0.010	0.007 <	0.002	0.012 <	0.002
V	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Zn		148	153.5	154	163.2	166.7
TIC		1.1	2.3	3.2	4.4	4.3
TOC		0.5	0.6	0.7	0.6	0.6
PO4	<	0.002	0.003 <	0.002	0.134 <	0.002
Field parameters:						
Water temp. (°C)		6.9	9.5	6.9	6.9	11
pH		7.69	6.99	6.19	6.35	6.18
Spec. cond. (uS/cm)		4339	1974	1891	1813	1962
Cond. (uS/cm)		2800	1370	1220	1170	1420
ORP (mV)	not measured		44.1	27	67.1	-22.5
Eh (mV) (calc'd)			243.1	226	266.1	176.5

Site 9- Seep nr. Pole

500	May-29	Jun-06	Jun-20	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1
Acidity, total	140	181	217	195	193	208	211	215	224	200
Alkalinity, total	2.7	1.3	<	0.5	1.7	1.9	2.2	1.9	2.2	2.2
4.7										
Cl-	1.7	0.6	<	2	<	5.1	<	5	<	5
F	0.07	0.07	<	0.01	<	0.01	<	0.5	<	0.5
SO4	988.9	1240	1210	1240	1260.6	1270	1230	1380	1375	1444
Br	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0
Nitrate	0.370	0.7	0.42	0.33	0.43	0.40	0.52	0.4	0.385	0.361
Nitrite	<	0.005	<	0.005	<	0.005	<	0.26	<	0.3
P	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0
pH	5.78	5.62	5.08	5.71	5.63	5.92	5.69	6.11	5.81	6.15
FR	1530	1600	1840	1870	1930	1920	1930	1930	1990	2000
NFR	368	121	<	5	<	5	7	12	<	5
Spec. Cond.	1590	1640	1750	1805	1810	1880	1790	1850	1890	1980
GFAA (dissolved):										
Se	<	0.001	<	0.001	<	0.001				
GFAA (total):										
Se	<	0.001	<	0.001	<	0.001				
Hardness, Ca+Mg	714.8	686	791.4	756	838	733	723.3	824	826.4	848.4
Hardness, total	947.3	1020	1210.0	1184.6	1287.5	1170	1165.2	1290		1357.8
ICP, dissolved										
Al	0.20	0.21	0.23	0.27	0.28	0.06	0.14	<	3	<
Sb	0.16	0.27	0.31	0.33	0.39	0.23	0.39	0.45	0.37	0.38
As	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ba	0.023	0.016	0.012	0.011	0.014	0.003	0.012	0.009	0.012	0.012
Be	0.003	0.003	0.004	0.004	0.005	0.002	0.010	0.005	0.005	0.004
B	0.01	<	0.01	0.01	<	0.01	0.02	<	0.01	<
Cd	0.315	0.436	0.580	0.511	0.568	0.513	0.503	0.562	0.59	0.654
Ca	214.2	206	245.7	225	250.1	221	215	242	244	257.3
Cr	0.010	0.015	0.019	0.016	0.020	0.019	0.023	0.250	0.430	0.270
Co	0.032	0.012	0.009	<	0.005	0.009	0.010	0.009	<	0.005
Cu	0.066	0.050	0.081	0.075	0.094	0.052	0.065	0.078	0.079	0.081
Fe	1.492	<	0.005	<	0.005	<	0.005	<	0.3	<
Pb	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Mg	43.7	41.6	43.2	47	51.3	43.9	45.3	53.4	52.8	50
Mn	68.6	93.7	124.5	135.1	130.8	135.0	132.8	142.0	149.8	152.8
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni	0.73	1.01	1.43	1.31	1.48	1.14	1.2	1.9	2.9	3.5
P	0.3	0.5	0.8	0.8	1	0.5	0.7	<	5	<
K	1.0	1.0	1.0	1.1	1.2	0.7	0.9	1.0	1.2	1.2
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Si	5.95	5.50	6.01	5.8	6.8	5.47	5.5	7.0	7.5	6.90
Ag	0.01	0.02	0.02	0.02	0.02	<	0.01	0.02	0.03	0.02
Na	1.7	1.6	1.9	1.7	2	1.4	2.1	0.9	1.8	1.7
Sr	0.464	0.414	0.424	0.434	0.479	0.404	0.411	0.48	0.473	0.452
S	307.5	329	396	388	452	434	393	405	416.3	422.5
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05
Ti	<	0.002	<	0.002	0.007	<	0.002	0.008	<	0.002
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Zn	67.6	104	124.3	118.37	125.1	122	129.8	133	135.87	139.96
ICP, Total										
Al	8.48	2.81	0.30	0.24	0.12	0.34	0.36	<	3	<
Sb	0.16	0.26	0.34	0.33	0.24	0.31	0.33	0.32	0.37	0.38
As	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06
Ba	0.260	0.084	0.011	0.009	0.011	0.012	0.021	0.029	0.015	0.016
Be	0.003	0.003	0.004	0.004	0.003	0.004	0.011	0.004	0.005	0.005
B	0.03	0.01	0.01	<	0.01	0.01	0.02	0.02	0.01	0.01
Cd	0.347	0.450	0.512	0.490	0.505	0.506	0.280	0.554	0.602	0.583
Ca	229.2	211	224.0	211	218.9	235	242	229	240.8	239.7
Cr	0.022	0.018	0.013	0.009	0.016	0.02	0.03	<	0.3	<
Co	0.047	0.008	0.016	0.022	0.020	0.013	<	0.006	0.036	0.026
Cu	0.108	0.072	0.075	0.078	0.076	0.088	0.089	0.083	0.095	0.084
Fe	10.8	2.47	<	0.006	<	0.006	<	0.012	0.9	<
Pb	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06
Mg	48.0	43.6	45.4	43.1	45.7	49.8	51.5	49.7	53.1	51.8
Mn	75.3	102	120.1	120	119.8	130	135.9	138	151.06	146.22
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01
Ni	0.82	1.07	1.33	1.28	1.29	1.34	1.44	2	3	3
P	0.6	0.6	0.8	0.9	0.7	0.7	0.8	<	5	<
K	2.4	1.5	1.1	1	1.1	1.2	1.2	1.3	1.4	1.2
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001
Si	19.2	9.48	5.64	6	5.72	6.06	7	9	8	7.00
Ag	0.01	0.02	0.02	0.02	<	0.01	0.02	0.02	0.03	0.02
Na	2.4	1.8	1.7	1.6	1.7	1.9	1.8	1.9	1.7	2.1
Sr	0.512	0.431	0.436	0.417	0.424	0.43	0.476	0.445	0.481	0.468
S	336	352	362	351	369.9	393	416.8	387	426	421
Sn	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06
Ti	0.279	0.089	<	0.002	<	0.002	0.005	0.002	0.008	0.025
V	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<
Zn	77.1	114	123.8	119.37	119.5	120	124.1	129	139.9	135.4
TIC	13.3	4.0	3.5	4.5	4.2	4.5	5.5	3.8	6.8	2.4
TOC	0.7	1.1	0.6	0.6	0.5	0.5	0.5	0.7	<	0.5
PO4	0.17	0.108	<	0.002	<	0.002	<	0.013	<	0.002
0.013										
Field parameters:										
Water temp. (°C)	0.05	0.8	3.8	2.8	4.4	6.3	5.4	5.1	5.1	4.9
pH	4.94	5.12	5.2	5.39	5.37	7.75	5.81	5.27	5.36	5.08
Spec. cond. (uS/cm)	1592	1471	1673	1721	1812	4570	2117	1923	1891	1901
Cond. (uS/cm)	833	800	990	990	1090	2900	1310	1180	1160	1160
ORP (mV)						530	354	335	281	275
Eh (mV) (calc'd)						729	553	534	480	474

Site 8- Seep at Road

Piezo	May-29	Jun-06	Jun-20	Jul-05	Jul-22	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1	1	< 1	< 1	< 1	< 1	< 1	1
Acidity, total	55	68	107	66	11	9	7	7	5
Alkalinity, total	< 0.5	< 0.5	22.2	< 0.5	4	10	16.3	23.9	30.6
Cl-	0.9	0.5	< 2	< 6	< 5	< 5	< 5	0.1	0.4
F	0.02	0.02	< 0.01	< 0.01	< 0.5	< 0.5	< 0.5	< 0.01	0.02
SO4	655.6	1080	1170	1130	830.7	792	808	< 0.05	857
Br	< 0.05	< 0.05	< 0.05	< 0.05	< 2.6	< 2.6	< 3	< 0.05	< 0.05
Nitrate	< 0.002	0.004	0.25	0.22	0.37	0.50	0.7	< 0.002	< 0.5
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	< 0.26	< 0.26	< 0.3	< 0.005	< 0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	< 2.6	< 2.6	< 3	< 0.05	< 0.05
pH	5.28	5.37	7.24	5.31	6.4	6.67	6.78	6.94	7.34
FR	1010	1410	1760	1650	1310	1250	1160	1200	1260
NFR	< 5	< 5	< 5	< 5	< 5	< 6	< 49	< 17	< 11
Spec. Cond.	1140	1540	1820	1700	1440	1347	1350	1360	1400
GFAA (dissolved):									
Se	< 0.001	< 0.001	< 0.001						
GFAA (total):									
Se	< 0.001	< 0.001	< 0.001						
Hardness, Ca+Mg	510.3	770	994.4	965	913.3	759	791	750.2	866.4
Hardness, total	637.1	937	1202.4	1080	928.2	767	798	755.2	872
ICP, dissolved									
Al	0.12	0.15	0.21	0.2	< 0.05	< 0.05	< 0.05	0.09	< 0.05
Sb	0.08	0.10	0.14	0.11	< 0.05	< 0.09	< 0.05	0.06	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.026	0.031	0.026	0.027	0.013	0.009	0.004	0.008	0.014
Be	0.002	0.004	0.005	0.005	0.005	0.011	0.005	0.005	0.004
B	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	0.064	0.055	0.083	0.052	0.01	< 0.005	< 0.005	< 0.005	0.017
Ca	159.1	238	314.6	295	278.1	229	243	229.3	266.4
Cr	0.009	0.012	0.012	0.006	< 0.005	< 0.005	< 0.005	< 0.005	0.020
Co	0.011	0.011	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.029
Cu	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.020
Fe	0.005	< 0.005	< 0.005	< 0.005	< 5E-04	< 0.005	< 0.005	< 0.005	0.018
Pb	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	27.4	42.5	50.7	55.3	53.1	45.3	44.6	43.2	48.9
Mn	42.41	59.9	66.2	32.2	0.147	0.018	0.004	0.004	0.014
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	0.36	0.49	0.67	0.35	0.03	< 0.02	< 0.02	< 0.02	0.05
P	0.3	0.3	0.4	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	3.5	3.3	1.7	0.9	< 0.2	< 0.1	< 0.1	< 0.1	0.6
Se	0.16	0.17	0.20	< 0.001	< 0.001	< 0.05	< 0.05	< 0.05	0.12
Si	2.61	3.84	5.15	5.02	4.96	3.85	3.98	3.68	4.17
Ag	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.02	< 0.01
Na	1.1	1.7	2.3	2.3	2.3	2.5	2.6	3.5	2
Sr	0.268	0.392	0.454	0.465	0.447	0.366	0.364	0.342	0.394
S	204.6	290	385	330	290.2	232	278	226	265
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	0.003	0.012	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.023
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.02	< 0.01
Zn	31.8	36.7	56.2	37.7	9.161	4.78	4.63	2.8	3.3
ICP, Total									
Al	0.13	0.14	0.21	0.22	< 0.06	< 0.06	0.53	< 0.06	0.17
Sb	0.07	0.09	0.16	0.12	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
As	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.028	0.031	0.024	0.018	0.013	0.019	0.061	0.012	0.01
Be	0.003	0.004	0.005	0.005	0.004	0.011	0.005	0.004	0.004
B	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	0.064	0.057	0.061	0.05	0.007	0.012	< 0.006	< 0.006	< 0.006
Ca	158.5	231	282.2	282.0	241.9	241.0	252.0	231.0	240.4
Cr	< 0.006	0.005	0.009	< 0.006	0.009	< 0.006	< 0.006	< 0.006	< 0.006
Co	< 0.006	< 0.005	0.014	0.008	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Cu	< 0.006	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006
Fe	0.014	< 0.005	< 0.006	< 0.006	0.016	0.077	0.646	0.058	0.181
Pb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Mg	27.9	42.0	52.1	51.5	46.4	47.8	49	46.1	48.8
Mn	44.4	61.3	58.6	32.800	0.134	0.050	0.334	0.036	0.051
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	0.38	0.49	0.54	0.45	0.03	< 0.02	< 0.02	0.03	< 0.02
P	0.3	0.4	0.4	0.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	3.6	3.3	1.7	0.8	0.4	0.3	0.5	0.3	0.4
Se	0.10	0.16	0.15	< 0.001	< 0.001	< 0.06	< 0.06	< 0.06	< 0.06
Si	2.71	3.73	4.65	5.05	4.28	4.31	5.19	4.11	4.01
Ag	< 0.01	0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.1	1.7	2.1	2.1	2.4	2.3	2.7	2.4	2.6
Sr	0.274	0.383	0.457	0.451	0.389	0.396	0.402	0.384	0.395
S	208.7	279	353	324	262.81	252	255	233.45	244.58
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	< 0.002	< 0.002	< 0.002	< 0.002	0.006	0.005	0.019	0.007	0.005
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	31.3	35.4	49.3	36.7	8.025	5.19	5.1	2.997	3.079
TIC	1.1	1.0	< 0.5	0.8	1.3	4.0	5.4	7.9	8.7
TOC	20.7	14.7	8.7	9.1	7.6	7.0	5.8	6	5.8
PO4	0.039	0.036	0.028	< 0.002	< 0.002	0.011	0.022	0.015	0.023
Field parameters:									
Water temp. (°C)	1.66	3.2	1.4	3.7	1.8	3.1	3.1	1.4	2.4
pH	4.8	4.84	5.1	5.02	7.05	6.79	7.28	7.61	7.56
Spec. cond. (uS/cm)	1123	1530	1645	1627	1269	1500	1224	1229	1213
Cond. (uS/cm)	622	890	910	960	710	870	710	680	690
ORP (mV)							255	227.6	202
Eh (mV) (calc'd)							454	426.6	401

Site 7- Seep 5																	
	May-29	Jun-06	Jun-20	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30							
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1	<	1					
Acidity, total	47	50	73	64	57	60	56	56	44	52							
Alkalinity, total	46.9	31.6	3.0	21.6	41.8	42.7	46.3	61.7	49.3	61.6							
Cl-	0.3	0.3	<	2	<	6	<	5	<	5	<	0.6					
F	0.02	0.02	<	0.01	<	0.01	<	0.5	<	0.5	<	0.01					
SO4	948.6	1100	1130	1140	1110.7	1070	1100	1180	1263	1249							
Br	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	0.05					
Nitrate	0.242	0.306	0.41	0.34	0.47	0.40	0.49	0.5	0.43	0.371							
Nitrite	<	0.005	<	0.005	<	0.005	<	0.26	<	0.3	<	0.005					
P	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	0.05					
pH	7.3	7.16	6.48	7.02	7.17	7.27	7.27	7.22	7.21	7.42							
FR	1480	1490	1700	1720	1710	1730	1740	1720	1690	1760							
NFR	171	114	101	144	105	67	27	58	137	73							
Spec. Cond.	1600	1620	1830	1760	1790	1800	1805	1860	1810	1920							
GFAA (dissolved):																	
Se	<	0.001	<	0.001	<	0.001											
GFAA (total):																	
Se	<	0.001	<	0.001	<	0.001											
Hardness, Ca+Mg	910.0	943	1023.9	1050.0	1033.1	1010.0	1074.7	1050.0	979.4	1153.9							
Hardness, total	972.2	1011	1124.1	1150	1118.8	1090	1154.8	1140	1036.3	1217.5							
ICP, dissolved																	
Al	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.13					
Sb	0.08	0.10	0.05	0.12	0.09	0.13	0.15	<	0.05	0.10	0.15						
As	<	0.05	<	0.05	<	0.05	<	0.05	<	0.08	<	0.05					
Ba	0.018	0.019	0.015	0.025	0.03	0.036	0.052	0.061	0.054	0.037							
Be	0.005	0.005	0.004	0.005	0.005	0.006	0.011	<	0.001	0.006	0.007						
B	<	0.01	<	0.01	<	0.01	<	0.01	<	0.02	<	0.01					
Cd	0.051	0.063	0.083	0.082	0.077	0.086	0.074	0.100	0.073	0.076							
Ca	283.5	294	327.1	326	322.2	320	332	334	307.8	366.3							
Cr	<	0.005	<	0.005	<	0.005	<	0.009	0.028	0.042	0.054	<	0.005				
Co	<	0.005	<	0.005	<	0.005	<	0.005	0.019	0.015	0.042	0.040	<	0.005			
Cu	<	0.005	<	0.005	<	0.005	<	0.005	0.018	0.024	0.037	0.052	<	0.005			
Fe	<	0.005	<	0.005	<	0.005	<	0.005	0.00005	0.013	0.068	0.052	0.085	<	0.005		
Pb	<	0.05	<	0.05	<	0.05	<	0.05	0.14	0.07	0.13	0.12	<	0.05			
Mg	49.1	51.0	50.3	57.9	55.5	51.0	69.4	53.7	51.2	58.1							
Mn	9.62	11.6	16.8	16.1	14.04	13.3	13.84	18.1	9.483	4.01							
Mo	<	0.01	<	0.01	<	0.01	<	0.01	0.01	0.03	0.02	0.03	<	0.01			
Ni	0.22	0.22	0.32	0.31	0.29	0.29	0.32	0.39	0.29	0.35							
P	0.1	0.2	0.2	0.2	0.2	0.2	0.1	<	0.1	0.2	0.3						
K	1.2	1.3	1.1	1.3	1.1	1.5	1.7	1.9	1.9	1.1							
Se	<	0.05	<	0.05	<	0.05	<	0.001	<	0.001	<	0.001	0.10	0.23	0.30	<	0.05
Si	5.26	5.56	5.92	6.12	6.19	5.71	6.18	5.71	5.35	6.06							
Ag	<	0.01	<	0.01	<	0.01	<	0.01	0.02	<	0.01	<	0.01	0.02	0.02		
Na	1.9	1.9	2.1	2	2.1	2.6	2.1	2	3.6	2.1							
Sr	0.564	0.582	0.592	0.643	0.624	0.578	0.654	0.605	0.547	0.654							
S	292.76	326	372.5	361	418.6	429	360.8	374	297.97	73.5							
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	0.05	<	0.05		
Ti	<	0.002	<	0.002	<	0.002	<	0.002	0.028	0.026	0.047	0.061	<	0.002			
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	0.02	0.02			
Zn	28.7	30.1	45.0	40.8	38.733	36	35.2	33.1	24.941	35.89							
ICP, Total																	
Al	3.57	2.34	2.23	2.43	1.73	1.4	0.98	1.18	2.4	0.82							
Sb	0.06	0.06	0.12	0.15	0.08	0.11	0.09	0.14	0.08	0.07							
As	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	0.06		
Ba	0.091	0.068	0.066	0.077	0.064	0.061	0.061	0.076	0.092	0.063							
Be	0.004	0.004	0.005	0.006	0.005	0.005	0.005	0.007	0.006	0.009							
B	0.01	0.01	0.01	0.01	0.01	0.01	<	0.01	<	0.01	0.02	0.01					
Cd	0.055	0.061	0.082	0.083	0.072	0.07	0.078	0.083	0.053	0.084							
Ca	293.7	282	314.4	310	312.5	342	340	360	332.4	351.3							
Cr	0.007	<	0.005	<	0.006	<	0.006	<	0.006	<	0.006	<	0.006	0.009			
Co	0.012	<	0.005	<	0.006	<	0.006	<	0.006	<	0.014	0.011	<	0.006	0.032		
Cu	0.025	0.016	0.012	0.041	0.01	0.015	<	0.006	<	0.006	0.031	0.014					
Fe	4.213	2.75	2.69	3.45	2.34	1.76	1.30	1.55	3.26	1.16							
Pb	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	0.06		
Mg	51.9	50.6	55.3	53.9	54.1	59.5	59.3	64.1	61.4	63.5							
Mn	11.4	12.6	17.64	15.6	12.86	12.1	12.96	18.06	0.22	21.52							
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	0.01		
Ni	0.25	0.23	0.32	0.32	0.3	0.29	0.29	0.37	0.26	0.4							
P	0.3	0.3	0.3	0.4	0.3	0.1	0.3	0.3	0.2	0.3							
K	1.9	1.7	1.7	1.6	1.3	1.4	1.6	1.6	1.6	1.5							
Se	<	0.06	<	0.05	<	0.06	<	0.001	<	0.001	<	0.06	<	0.06	<	0.06	
Si	10.98	8.95	8.96	9.68	8.27	8.06	7.70	8.31	9.41	7.42							
Ag	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	0.01		
Na	2.3	2.1	2.2	2.1	2.2	2.4	2.4	2.8	2.5	2.6							
Sr	0.600	0.572	0.637	0.626	0.612	0.630	0.665	0.731	0.656	0.712							
S	318	292	375.9	330	320.8	368	367.5	371	322.9	396							
Sn	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	0.06		
Ti	0.140	0.093	0.074	0.081	0.066	0.043	0.030	0.034	0.080	0.033							
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	0.01		
Zn	30.0	29.8	40.6	42.000	37.724	36.300	37.200	39.200	29.048	36.5							
TIC	15.3	8.0	5.4	6.8	11.1	10.4	12.7	15.1	13.3	15.8							
TOC	3.8	4.2	2.5	2.9	2.3	2.1	2.3	2	2.7	2							
PO4	0.161	0.161	0.093	0.101	0.061	0.026	0.024	0.035	0.096	0.085							
Field parameters:																	
Water temp. (°C)	0.29	3.9	0.8	1.2	2.8	7.7	4.5	3.2	2.4	3.9							
pH	6.86	6.57	6.5	6.41	6.94	7.31	6.84	7.29	7.46	7.45							
Spec. cond. (uS/cm)	1590	1534	1673	1800	1634	3485	2138	705	1564	1736							
Cond. (uS/cm)	839	910	910	990	940	2300	1290	410	890	1030							
ORP (mV)						335	200	164	172.4	153							
Eh (mV) (calc'd)						534	399	363	371.4	352							

Site 6- Seep 8		May-29	Jun-06	Jun-20	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30							
Acidity to pH 4.5	<	1	<	1	<	1	<	1	<	1	<	1						
Acidity, total		62	60	71	61	54	56	54	53	53	39							
Alkalinity, total		3.3	3.6	0.9	3.3	4.1	4.9	5.7	7.2	8.4	20.6							
Cl-		0.3	0.3	<	2	<	6	<	5	<	25	0.5						
F		0.02	<	0.01	<	0.01	<	0.5	<	0.5	<	0.01	0.01					
SO4		971.4	1165	1160	1150	1148.9	1140	1090	1190	1263	1279.1							
Br	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	2.6	<	3	<	0.05	<	0.05
Nitrate		0.094	0.192	0.29	0.25	0.30	0.30	0.35	<	0.1	0.37	0.269						
Nitrite	<	0.005	<	0.005	<	0.005	<	0.26	<	0.3	<	0.26	<	0.3	<	0.005	<	0.005
P	<	0.05	<	0.05	<	0.05	<	2.6	<	3.0	<	2.6	<	3	<	0.05	<	0.05
pH		6.32	6.40	5.8	6.16	6.20	6.40	6.30	6.44	6.44	6.94							
FR		1470	1600	1720	1670	1700	1710	1690	1710	1790	1720							
NFR	<	5	<	5	<	5	<	5	<	5	7	29	237					
Spec. Cond.		1570	1680	1830	1766	1740	1760	1663	1750	1820	1830							
GFAA (dissolved):																		
Se	<	0.001	<	0.001	<	0.001												
GFAA (total):																		
Se	<	0.001	<	0.001	<	0.001												
Hardness, Ca+Mg		852.0	961	999.0	1030	1054	997	1019	1030	1028	1159.7							
Hardness, total		952.8	1048	1098.8	1120	1134.7	1070	1100.8	1100	1105.6	1206.6							
ICP, dissolved																		
Al		0.06	<	0.05	<	0.05	0.07	0.17	0.08	<	0.05	0.05	0.17	0.06				
Sb		0.10	0.10	0.10	0.13	0.15	0.1	0.19	0.15	0.15	0.16	0.14						
As	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05				
Ba		0.020	0.022	0.017	0.025	0.013	0.015	0.015	0.017	0.015	0.037							
Be		0.004	0.005	0.005	0.005	0.007	0.006	0.013	0.006	0.007	0.006							
B	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01				
Cd		0.035	0.028	0.027	0.032	0.025	0.029	0.024	0.029	0.025	0.024							
Ca		265.8	300.2	321.4	320	329.1	313	316	321	321.5	361.8							
Cr		0.007	<	0.005	<	0.005	0.008	<	0.005	<	0.005	<	0.005	<	0.005			
Co	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005		
Cu	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005	<	0.005		
Fe	<	0.005	<	0.005	<	0.005	<	0.0005	<	0.005	<	0.005	<	0.005	<	0.018		
Pb	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05		
Mg		45.8	51.3	47.7	56.2	56.4	52.4	56.0	54.2	55	62.2							
Mn		24.53	18.2	20.1	15.4	12.8	14.8	18.56	16.8	17.23	3.59							
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01		
Ni		0.34	0.27	0.30	0.28	0.24	0.22	0.26	0.27	0.24	0.29							
P		0.3	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2							
K		1.4	1.4	0.9	1.4	0.7	0.9	0.6	1.2	0.9	0.9							
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001		
Si		5.79	6.26	6.46	6.94	7.16	5.3	6.46	6.1	6.17	6.86							
Ag	<	0.01	<	0.01	<	0.01	0.02	0.01	0.01	0.01	0.02	<	0.01	<	0.01			
Na		1.8	1.9	2.1	2.1	2.6	2.6	2.8	2.8	3.7	3.6							
Sr		0.539	0.619	0.599	0.663	0.66	0.584	0.62	0.597	0.598	0.655							
S		295.6	337	370.7	357	407.1	392	350.1	369	375.2	74.1							
Sn	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05	<	0.05		
Ti	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002	<	0.002		
V	<	0.01	<	0.01	<	0.01	0.03	<	0.01	0.03	0.01	0.027	<	0.01	<	0.01		
Zn		36.1	34.9	40.8	36.3	36.521	31.8	30.9	29	26.582	25.666							
ICP, Total																		
Al		0.06	<	0.05	0.06	<	0.06	<	0.13	<	0.06	0.13	0.25	2.56				
Sb		0.09	0.08	0.14	0.12	0.1	0.11	<	0.06	0.13	0.09	0.10						
As	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06		
Ba		0.023	0.022	0.022	0.021	0.02	0.022	0.029	0.026	0.028	0.1							
Be		0.004	0.005	0.005	0.005	0.005	0.005	0.012	0.006	0.006	0.006							
B	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.02		
Cd		0.040	0.031	0.035	0.012	0.029	0.029	0.038	0.035	0.027	0.027							
Ca		267.2	296	318.4	308	304.5	324	317	341	329.8	334.2							
Cr	<	0.006	<	0.005	<	0.006	<	0.006	0.009	0.015	0.008	<	0.006	0.018				
Co	<	0.006	<	0.005	<	0.006	<	0.006	<	0.006	<	0.006	<	0.006	0.010			
Cu	<	0.006	<	0.005	<	0.006	<	0.006	<	0.006	<	0.006	<	0.006	<	0.006		
Fe	<	0.006	<	0.005	<	0.006	<	0.006	<	0.006	0.051	0.214	3.156					
Pb	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06		
Mg		47.6	51.5	54.4	52.9	53.2	58.1	57.6	60.1	62.4	62.7							
Mn		26.07	18.5	20.5	15	12.39	14.2	17.24	16.5	17.35	19.08							
Mo	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01		
Ni		0.37	0.28	0.32	0.27	0.24	0.27	0.3	0.32	0.32	0.31							
P		0.3	0.2	0.3	0.2	0.2	0.1	0.2	0.2	0.2	0.4							
K		1.5	1.4	1.4	1.2	1.1	1.2	1.2	1.3	1.3	1.5							
Se	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001	<	0.001		
Si		6.12	6.25	6.54	7.15	6.61	5.81	6.92	7.07	7.17	9.79							
Ag	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01		
Na		1.9	1.9	2.0	2.0	2.3	2.5	2.5	3	2.7	3							
Sr		0.562	0.617	0.668	0.654	0.621	0.617	0.647	0.668	0.681	0.665							
S		324.2	347	364.5	336	334.9	357	357.2	356	382.3	392							
Sn	<	0.06	<	0.05	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06	<	0.06		
Ti	<	0.002	<	0.002	<	0.002	<	0.002	0.002	0.013	0.007	0.086						
V	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01	<	0.01		
Zn		36.3	34.9	37.4	37.5	33.872	32.7	31.9	32.4	31.586	24.71							
TIC		2.8	1.9	2.2	3.3	2.9	3.1	3.9	3.2	4.6	6.7							
TOC		5.3	3.3	2.5	2.7	2.6	2.2	2.5	2.4	2.2	2.6							
PO4	<	0.002	0.025	0.009	<	0.002	<	0.002	<	0.002	0.018	0.169						
Field parameters:																		
Water temp. (°C)		0.24	0.6	1.1	1.5	7.3	4.2	3.8	2.9	2.3	2							
pH		5.59	5.73	5.9	6.06	6.64	7.72	7.09	7.37	7.26	7.38							
Spec. cond. (uS/cm)		1570	892	1750	1785	1532	4847	1994	1751	1692	1582							
Cond. (uS/cm)		826	860	960	990	1000	2900	1180	1010	960	890							
ORP (mV)							335	317	280	262	218							
Eh (mV) (calc'd)							534	516	479	461	417							

Site 5- Old Rd. AT ROW Xing													
	May-29	Jun-06	Jun-20	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30		
Acidity to pH 4.5	< 1	< 1	< 1		< 1	< 1	< 1	< 1	< 1	< 1	< 1		
Acidity, total	8	9	14	7		7	7	10	11	8	7		
Alkalinity, total	45.6	38.3	42.5	37		49.9	60.6	65.4	57.4	54.3	73.8		
Cl-	0.3	0.2	< 2	< 6		< 5	< 5	< 5	< 5	< 25	0.4		
F	0.02	0.01	< 0.01	< 0.01		< 0.5	< 0.5	< 0.5	< 0.5	< 0.01	0.01		
SO4	771.5	776	1000	1030		984	948	855	1000	1094	1044		
Br	< 0.05	< 0.05	< 0.05	< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05		
Nitrate	0.092	0.111	0.25	< 0.002		0.31	0.20	0.40	< 0.1	0.35	0.354		
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005		< 0.26	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005		
P	< 0.05	< 0.05	< 0.05	< 0.05		< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05		
pH	7.56	7.45	7.62	7.44		7.57	7.65	7.57	7.31	7.48	7.57		
FR	1170	1390	1560	1540		1340	1460	1340	1480	1600	1490		
NFR	< 5	< 5	69	< 5		16	45	114	50	22	21		
Spec. Cond.	1380	1550	1770	1670		1640	1580	1494	1650	1700	1640		
GFAA (dissolved):													
Se	< 0.001	< 0.001	< 0.001		< 0.001								
GFAA (total):													
Se	< 0.001	< 0.001	< 0.001		< 0.001								
Hardness, Ca+Mg	822.4	907	1048.5	1080.5	1,075.1	1069	868	910	1090	1054.9	1120		
Hardness, total	829.1	914	1066.7	1087.9	1,083.6	1077	894	919	1100	1062.6	1121.1		
ICP, dissolved													
Al	< 0.05	< 0.05	0.06	< 0.05	0.08	0.08	0.1	< 0.05	< 0.05	0.11	< 0.05		
Sb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	0.1	< 0.05	< 0.05		
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.07	< 0.05	< 0.05		
Ba	0.021	0.027	0.027	0.029	0.046	0.039	0.029	0.048	0.056	0.044	0.044		
Be	0.004	0.005	0.006	0.006	0.006	0.007	0.006	0.010	0.006	0.007	0.006		
B	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	0.02	< 0.01	< 0.01		
Cd	< 0.005	< 0.005	0.009	< 0.005	0.019	0.009	< 0.005	0.011	0.027	0.006	0.005		
Ca	260.8	284	337.6	343.1	337.9	336.6	279	262	344	329.5	347.5		
Cr	< 0.005	0.005	< 0.005	< 0.005	0.037	< 0.005	< 0.005	0.012	0.041	< 0.005	< 0.005		
Co	< 0.005	< 0.005	< 0.005	< 0.005	0.013	< 0.005	< 0.005	0.007	0.037	< 0.005	< 0.005		
Cu	< 0.005	< 0.005	< 0.005	< 0.005	0.022	< 0.005	< 0.005	0.009	0.024	< 0.005	< 0.005		
Fe	0.024	0.021	0.039	< 0.005	0.041	0.011	< 0.005	0.068	0.090	0.039	0.019		
Pb	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	0.06	0.13	< 0.05	< 0.05		
Mg	41.6	48.1	49.9	54.3	56.1	55.5	46.3	50.2	55.5	56.4	59.8		
Mn	0.067	0.028	1.153	0.081	0.2	0.167	0.148	0.339	0.410	0.247	0.229		
Mo	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.02	0.02	< 0.01	< 0.01		
Ni	< 0.02	< 0.02	0.03	< 0.02	0.05	< 0.02	< 0.02	0.04	0.07	< 0.02	< 0.02		
P	< 0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1		
K	1.1	1.1	0.9	0.9	1.5	1	0.7	1.2	1.7	1.2	1.1		
Se	< 0.05	< 0.05	< 0.05	< 0.001	< 0.001	< 0.001	< 0.001	0.07	0.26	< 0.05	< 0.05		
Si	4.69	5.00	5.86	5.44	6.03	5.93	4.78	5.19	5.61	5.24	5.56		
Ag	< 0.01	< 0.01	0.01	< 0.01	0.01	0.01	0.02	< 0.01	0.01	0.02	< 0.01		
Na	1.7	1.9	2.2	2.5	2.4	2.5	2.4	2.1	2.7	3.1	3.1		
Sr	0.479	0.568	0.609	0.629	0.656	0.651	0.530	0.566	0.640	0.640	0.671		
S	239.1	273	299.5	319	377	359.9	286	260	320	323.6	62		
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05		
Ti	< 0.002	< 0.002	< 0.002	< 0.002	0.027	< 0.002	< 0.002	0.015	0.035	< 0.002	< 0.002		
V	< 0.01	< 0.01	0.02	< 0.01	0.02	0.02	0.02	< 0.01	0.01	0.03	< 0.01		
Zn	3.94	4.14	9.87	4.24	4.6	4.38	3.48	4.62	6.40	4.10	3.817		
ICP, Total													
Al	< 0.06	< 0.05	1.17	< 0.06	0.26	0.14	1.05	2.20	0.70	0.48	0.21		
Sb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
As	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
Ba	0.022	0.027	0.059	0.039	0.047	0.04	0.064	0.097	0.061	0.061	0.047		
Be	0.004	0.005	0.005	0.006	0.015	0.005	0.005	0.004	0.005	0.006	0.005		
B	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Cd	< 0.006	< 0.005	0.011	< 0.006	0.01	< 0.006	< 0.006	0.014	0.007	0.008	< 0.006		
Ca	242.0	288	311.7	324	310.8	287.9	303.0	282.0	322.0	327.5	312.7		
Cr	0.011	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.012		
Co	< 0.006	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.012	< 0.006	0.020	< 0.006		
Cu	< 0.006	< 0.005	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006	< 0.006		
Fe	0.117	0.036	1.344	0.105	0.3	0.271	1.44	3.28	1.03	0.793	0.315		
Pb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
Mg	42.2	49.2	53.2	55.3	53.6	49.8	53.2	50.5	56.4	59.1	56.4		
Mn	0.084	0.027	1.180	0.093	0.2	0.166	0.224	0.515	0.438	0.278	0.229		
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Ni	< 0.02	< 0.02	0.03	< 0.02	0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.04	< 0.02		
P	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	0.2	< 0.1	< 0.1	< 0.1		
K	1.1	1.2	1.4	1.2	1.1	1.1	1.3	1.36	1.3	1.5	1.3		
Se	< 0.06	< 0.05	< 0.06	< 0.001	0.09	< 0.001	< 0.001	< 0.06	< 0.06	0.10	< 0.06		
Si	4.65	5.16	7.07	5.14	5.92	5.36	5.65	8.18	6.71	5.21	5.34		
Ag	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01		
Na	1.7	2.0	2.1	2.4	2.2	2.2	2.4	2.2	2.5	2.5	2.5		
Sr	0.484	0.578	0.633	0.722	0.628	0.578	0.573	0.573	0.650	0.679	0.639		
S	239.5	278	334.1	332	298	291	296	268	311	337	295		
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06		
Ti	< 0.002	< 0.002	0.034	0.005	0.011	0.003	0.028	0.069	0.021	0.002	0.006		
V	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01		
Zn	3.42	4.43	8.67	4.05	4.3	3.743	3.88	4.96	6.44	4.439	3.57		
TIC	12.3	8.9	7.8	10.5		13.2	14.5	17.2	13.9	13.9	18.9		
TOC	5.1	3.9	2.6	2.1		2.2	2.3	3.1	3.3	1.7	2.3		
PO4	0.004	< 0.002	0.061	< 0.002		0.007	0.013	0.100	0.026	0.012	0.041		
Field parameters:													
Water temp. (°C)	1.14	4.0	1.8	3.3	3.2	2.1	2.8	3.2	2.5	1.9	1.4		
pH	7.14	6.68	7.2	6.83	6.78	7.98	7.89	7.73	7.42	7.74	7.65		
Spec. cond. (uS/cm)	1331	1479	1573	1560	1633	1595	1547	1719	1420	1676	1591		
Cond. (uS/cm)	725	880	880	910	950	900	890	1000	810	940	880		
ORP (mV)							250	184	154	174	141.1		
Eh (mV) (calc'd)							449	383	353	373	340.1		

Site 4- Seep 6 + 120												
	May-29	Jun-06	Jun-20	Jun-28	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1 <	1 <	1				< 1 <	1 <	1 <	1 <	1 <	1
Acidity, total	15	15	20		19		15	8	13	12	13	13
Alkalinity, total	53.2	46.1	no value		43.2		60.2	62.5	56.9	66.9	74	74
Cl-	0.3	0.4 <	2	< 6		< 5 <	5 <	5 <	5 <	5 <	20 <	20
F	0.02	0.02 <	0.01	< 0.01		< 0.5 <	0.5 <	0.5 <	0.5 <	0.5 <	0.01 <	0.01
SO4	854.9	1000	1040		1110		1125.6	1040	989	1060	1130	1130
Br	< 0.05 <	0.05 <	0.05	< 0.05		< 2.6 <	3.0 <	2.6 <	3 <	0.05 <	0.05	0.05
Nitrate	0.185	0.215	0.40	0.50		0.53	0.40	0.47	0.5	0.47	0.5	0.47
Nitrite	< 0.005 <	0.005 <	0.005	< 0.005		< 0.26 <	0.3 <	0.26 <	0.3 <	0.005 <	0.005	0.005
P	< 0.05 <	0.05 <	0.05	< 0.05		< 2.6 <	3.0 <	2.6 <	3 <	0.05 <	0.05	0.05
pH	7.62	7.44	5.19	7.52		7.51	7.58	7.49	7.44	7.61	7.61	7.61
FR	1310	1390	1590	1630		1650	1600	1540	1560	1610	1610	1610
NFR	44	657	24	49		213	130	329	329	285	285	285
Spec. Cond.	1510	1540	1830	1740		1750	1720	1650	1740	1770	1770	1770
GFAA (dissolved):												
Se	< 0.001 <	0.001 <	0.001 <	0.001		< 0.001						
GFAA (total):												
Se	<	0.001 <	0.001 <	0.001		< 0.001						
Hardness, Ca+Mg	886.9	903	1075.9	1120	1110	1,116.2	1162.5	1180	1002	1210	1100.4	1100.4
Hardness, total	903.8	920	1099.4	1140	1130	1,137.6	1183	1200	1018	1230	1115	1115
ICP, dissolved												
Al	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05	0.07	0.1 <	0.05	0.15 <	0.05 <	0.05
Sb	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05	0.05	0.1 <	0.05	0.13 <	0.05 <	0.05
As	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba	0.018	0.020	0.024	0.030	0.03	0.033	0.048	0.037	0.069	0.08	0.049	0.049
Be	0.004	0.005	0.006	0.005	0.006	0.004	0.007	0.007	0.010	0.008	0.006	0.006
B	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Cd	0.010	0.012	0.021	0.015	0.014	0.027	0.011	0.010	0.013	0.019	0.011	0.011
Ca	281.9	283	343.8	349	347	350.3	367.2	375	315	390	348	348
Cr	< 0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.016 <	0.005 <	0.005	0.021	0.012 <	0.005 <	0.005
Co	< 0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.013 <	0.005 <	0.005
Cu	< 0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.011 <	0.005 <	0.005	0.008 <	0.005 <	0.005 <	0.005
Fe	0.016	0.082	0.031	0.091	0.054	0.067	0.419	0.117	0.304	0.087	0.081	0.081
Pb	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg	44.4	47.8	52.8	60.5	59.4	58.6	59.7	59.4	52.6	58.4	56.3	56.3
Mn	0.832	0.755	0.178	0.132	0.16	0.2	0.3	0.279	0.298	0.574	0.415	0.415
Mo	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.02 <	0.01 <	0.01 <	0.01
Ni	0.02	0.02	0.03	0.04	0.04	0.05 <	0.02 <	0.02	0.04	0.04 <	0.02 <	0.02
P	< 0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1	0.1	0.1 <	0.1 <	0.1 <	0.1 <	0.1
K	0.9	1.1	1.0	1.1	1.2	1.3	0.8	0.7	1.1	1.1	0.8	0.8
Se	< 0.05 <	0.05 <	0.05 <	0.001 <	0.001 <	0.001 <	0.001 <	0.001 <	0.05 <	0.05 <	0.05 <	0.05
Si	4.28	4.58	5.19	5.20	5.17	5.40	5.56	5.4	4.82	5.33	4.99	4.99
Ag	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.02 <	0.01	0.03 <	0.01 <	0.01
Na	1.8	1.9	2.2	2.2	2.2	2.1	2.6	2.7	2.2	3	2.9	2.9
Sr	0.524	0.559	0.629	0.684	0.678	0.678	0.702	0.695	0.603	0.688	0.651	0.651
S	261.5	277	350.2	365	347	390	391.3	369	293	337	331.8	331.8
Sn	< 0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	< 0.002	0.002 <	0.002 <	0.002	0.004	0.013 <	0.002 <	0.002	0.016	0.006 <	0.002 <	0.002
V	< 0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.02	0.02 <	0.01	0.04 <	0.01 <	0.01
Zn	9.555	9.78	14.6	13.6	13.10	13.1	11.80	11.10	8.39	9.15	8.29	8.29
ICP, Total												
Al		10.8	0.53	1.08	0.71	1.60	3.90	2.69	6.28	6.73	4.53	4.53
Sb	<	0.05	0.08 <	0.06 <	0.06	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
As	<	0.05 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba		0.219	0.034	0.047	0.043	0.062	0.106	0.086	0.176	0.196	0.138	0.138
Be		0.004	0.005	0.005	0.005	0.015	0.005	0.005	0.006	0.006	0.006	0.006
B		0.03 <	0.01 <	0.01 <	0.01 <	0.01	0.02	0.03	0.02	0.03	0.02	0.02
Cd		0.028	0.021	0.017	0.012	0.03	0.015	0.016	0.021	0.016	0.020	0.020
Ca		295	326.3	340.0	326	337.6	318.6	339	332	355	344.8	344.8
Cr		0.010 <	0.006 <	0.006 <	0.006	0.007 <	0.006	0.01	0.013 <	0.006	0.007	0.007
Co	<	0.005 <	0.006 <	0.006 <	0.006 <	0.006 <	0.006	0.008	0.007 <	0.006	0.013	0.013
Cu		0.056	0.007 <	0.006 <	0.006	0.016	0.036	0.025	0.062	0.058	0.037	0.037
Fe		13.2	0.714	1.74	1.2	2.5	5.9	4.0	10.0	13	7.17	7.17
Pb	<	0.05 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Mg		51.9	55.3	57.5	54.5	57.8	54.5	58.1	57.0	60.8	60.6	60.6
Mn		1.10	0.191	0.165	0.197	0.3	0.502	0.350	0.569	0.83	0.61	0.61
Mo	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.01
Ni		0.06	0.04	0.04 <	0.02	0.04	0.04	0.03	0.03	0.05	0.06	0.06
P		0.5 <	0.1 <	0.1	0.1 <	0.1	0.2 <	0.1	0.4	0.4	0.2	0.2
K		2.8	1.2	1.2	1	1.3	1.4	1.3	1.7	1.8	1.8	1.8
Se	<	0.05 <	0.06 <	0.001 <	0.001 <	0.06 <	0.001 <	0.001 <	0.06 <	0.06 <	0.06 <	0.06
Si		21.2	5.62	7.04	6.2	7.45	10.15	8.47	13.6	14.8	11.71	11.71
Ag	<	0.01 <	0.01 <	0.01 <	0.01	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Na		3.0	2.2	2.1	2.1	2.4	2.4	2.6	2.5	2.9	2.7	2.7
Sr		0.608	0.646	0.682	0.653	0.674	0.635	0.633	0.655	0.701	0.703	0.703
S		278	341.2	331	315	318	310.9	323	325.2	328	350.8	350.8
Sn	<	0.05 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ti		0.393	0.014	0.030	0.013	0.051	0.112	0.076	0.176	0.188	0.148	0.148
V		0.03 <	0.01 <	0.01 <	0.01	0.03	0.02	0.01	0.02	0.03	0.01	0.01
Zn		12.1	13.1	14.30	13.4	13.1	11.19	10.7	10.3	10.1	9.215	9.215
TIC	13.7	11.0	9.8		11.6		16.4	14.8	14.7	16.5	18.5	18.5
TOC	4.5	4.1	3.0		2		2.2	2.3	3.4	2.5	1.7	1.7
PO4	0.016	0.595	0.032	<	0.002		0.32	0.066	0.285	0.239	0.182	0.182
Field parameters:												
Water temp. (°C)	0.04	2.0	1.2	1.8	2.8	2.6	2.0	2.5	2.1	2.0	2.2	2.2
pH	7.3	6.67	7.3	7.20	6.77	6.76	7.41	6.51	8.2	7.45	7.74	7.74
Spec. cond. (uS/cm)	1493	1333	1636	1680	1721	1731	1707	1718	1914	1635	1573	1573
Cond. (uS/cm)	782	750	900	940	990	990	960	980	1080	920	890	890
ORP (mV)								235	104	116	95.2	95.2
Eh (mV) (calc'd)								434	303	315	294.2	294.2

Site 3- Old Rd. Seep
RHS Limit

	May-29	Jun-06	Jun-13	Jun-20	Jun-28	Jul-05	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1	< 1	< 1		<	1	< 1	< 1	< 1	< 1	1
Acidity, total	4	4	4	4		4	4	4	5	5	6	7
Alkalinity, total	31.3	35.1	29	29		31.2	43.9	48.7	49.6	53.7	50.8	54.5
Cl-	0.5	0.2	< 2	< 2	<	6	< 5	< 5	< 5	< 5	20	0.4
F	0.02	0.02	< 0.01	< 0.01	<	0.01	< 0.5	< 0.5	< 0.5	< 0.5	< 0.01	0.01
SO4	522.0	831	848.4	848.4		850	850.4	712	601	847	1033	920
Br	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
Nitrate	0.009	0.013	< 0.002	< 0.002	<	0.002	< 0.1	< 0.1	< 0.1	< 0.1	0.25	0.15
Nitrite	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.255	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005
P	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 2.6	< 3.0	< 2.6	< 3	< 0.05	< 0.05
pH	7.51	7.41	7.37	7.37		7.37	7.44	7.54	7.52	7.43	7.45	7.7
FR	910	1210	1310	1310		1270	1230	1100	970	1280	1540	1300
NFR	< 5	< 5	< 5	< 5	<	5	< 5	< 5	< 5	< 5	918	< 5
Spec. Cond.	1070	1370	1434	1434		1430	1390	1135	1135	1440	1630	1480
GFAA (dissolved):												
Se	< 0.001	< 0.001	< 0.001	< 0.001	<	0.001						
GFAA (total):												
Se	< 0.001	< 0.001	< 0.001	< 0.001	<	0.001						
Hardness, Ca+Mg	586.3	794	904.3	904.3	1,110.0	858	765	738	663	837	1017	926
Hardness, total	587.3	795	907.3	907.3	1,110.0	861.4	768.3	741	668	840	1023	930
ICP, dissolved												
Al	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	0.07	< 0.05	< 0.05	0.17	< 0.05	< 0.05
Sb	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	0.09	< 0.05	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.022	0.026	0.029	0.029	0.034	0.022	0.019	0.019	0.023	0.024	0.087	0.028
Be	0.003	0.004	0.005	0.005	0.005	0.005	0.005	0.004	0.011	< 0.001	0.006	0.005
B	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Ca	180.7	246	286.1	286.1	335.0	269.1	238.4	229	210	258	316	285
Cr	0.008	0.009	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Co	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.011	< 0.005
Cu	< 0.005	< 0.005	< 0.005	< 0.005	<	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Fe	0.042	< 0.005	0.016	0.016	0.024	0.006	< 0.0005	0.012	0.011	< 0.005	1.510	0.007
Pb	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	32.8	43.5	46.1	46.1	66.4	45.2	41.3	40.1	38.7	47.2	55.1	52.2
Mn	0.001	0.001	0.004	0.004	0.0	< 0.001	< 0.001	0.01	0.004	0.006	0.218	0.002
Mo	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	< 0.02	< 0.02	< 0.02	< 0.02	<	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
P	< 0.1	< 0.1	< 0.1	< 0.1	<	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	0.8	0.9	0.7	0.7	0.7	0.4	0.4	0.5	0.5	0.6	0.9	0.9
Se	< 0.05	< 0.05	< 0.05	< 0.05	<	0.001	< 0.001	< 0.001	< 0.001	< 0.05	< 0.05	< 0.05
Si	3.64	4.28	5.07	5.07	4.98	4.29	3.92	4.23	4.29	4.48	4.43	4.75
Ag	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.3	1.7	1.9	1.9	2.1	2.3	2	1.9	1.9	0.9	2.7	2.6
Sr	0.353	0.463	0.537	0.537	0.645	0.494	0.438	0.437	0.415	0.500	0.577	0.554
S	180.9	244	267.6	267.6	308	268	242	245	199	244	290	281
Sn	< 0.05	< 0.05	< 0.05	< 0.05	<	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	< 0.002	< 0.002	< 0.002	<	0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.03	< 0.01	0.01	0.01
Zn	0.272	0.364	1.59	1.59	1.9	1.711	1.466	1.48	1.37	1.68	0.921	2.05
ICP, Total												
Al	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	14.41	< 0.06
Sb	< 0.05	< 0.07	< 0.07	< 0.07	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
As	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ba	0.028	0.028	0.028	0.028	0.310	0.03	0.026	0.023	0.021	0.026	0.406	0.029
Be	0.004	0.004	0.004	0.004	0.005	0.005	0.004	0.004	0.003	0.005	0.005	0.005
B	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06	< 0.01
Cd	< 0.005	< 0.006	< 0.006	< 0.006	<	0.01	< 0.006	< 0.006	< 0.006	< 0.006	0.036	< 0.006
Ca	240	267.1	267.1	267.1	309.0	268	246	224	202	268	317.4	268
Cr	< 0.005	< 0.006	< 0.006	< 0.006	<	0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.035	< 0.006
Co	< 0.005	< 0.006	< 0.006	< 0.006	<	0.006	< 0.01	< 0.006	< 0.006	< 0.006	0.027	< 0.006
Cu	< 0.005	< 0.006	< 0.006	< 0.006	<	0.006	< 0.006	< 0.006	< 0.006	< 0.006	0.063	< 0.006
Fe	0.055	0.012	0.012	0.012	0.023	0.025	0.043	0.019	0.009	< 0.006	25.206	0.012
Pb	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	0.13	< 0.06
Mg	43.2	46.2	46.2	46.2	53.4	47.4	44.4	41.3	37.6	49.2	60.8	49.9
Mn	0.003	0.001	0.001	0.001	0.1	0.005	0.002	0.003	< 0.001	< 0.001	0.612	0.004
Mo	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	< 0.02	< 0.02	< 0.02	< 0.02	<	0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.07	< 0.02
P	< 0.1	< 0.1	< 0.1	< 0.1	<	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.9	< 0.1
K	0.9	0.8	0.8	0.8	0.5	0.6	0.7	0.6	0.6	0.8	2.6	1
Se	< 0.05	< 0.06	< 0.06	< 0.06	<	0.001	< 0.001	< 0.001	< 0.001	< 0.06	< 0.06	< 0.06
Si	4.22	4.65	4.65	4.65	5.00	4.93	4.27	4.27	4.36	4.70	22.30	4.45
Ag	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.7	1.8	1.8	1.8	1.9	2.1	1.9	1.8	1.6	2.1	2.8	2.2
Sr	0.460	0.530	0.530	0.530	0.613	0.589	0.454	0.42	0.403	0.526	0.643	0.537
S	238	279.8	279.8	279.8	335	268	237	228	197	262	299.18	264
Sn	< 0.05	< 0.06	< 0.06	< 0.06	<	0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	0.003	< 0.002	< 0.002	< 0.002	<	0.002	< 0.002	< 0.002	< 0.002	< 0.002	0.446	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	<	0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.04	< 0.01
Zn	0.372	1.40	1.40	1.40	1.82	1.690	1.534	1.440	1.350	1.760	1.859	1.98
TIC	8.7	8.2	6.6	6.6		9	12	11.5	12.7	13.1	13.9	15
TOC	12.9	6.5	5.7	5.7		5.6	5.8	6.4	8.2	4.6	3.0	4.5
PO4	0.005	< 0.002	0.010	0.010	<	0.002	< 0.002	< 0.002	0.014	< 0.002	0.668	0.018
Field parameters:												
Water temp. (°C)	3.16	2.0	5.1	5.1	6.3	5.5	5.5	4.7	3.9	2.9	4.0	0.8
pH	6.97	6.56	7.2	7.2	6.84	6.77	7.28	6.5	7.81	7.01	7.35	7.41
Spec. cond. (uS/cm)	1054	1404	1434	1434	1576	1451	1338	1220	1365	1335	975	1452
Cond. (uS/cm)	614	790	880	880	1000	900	830	740	810	770	580	790
ORP (mV)								267	303	227	200	175.1
EH (mV) (calc'd)								466	502	426	399	374.1

Site 2- Old Rd. Seep

LHS Limit		May-29	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	<	1 <	1 <	1 <	1 <	1 <	1 <	1
Acidity, total		6	5	5	7	8	5	6
Alkalinity, total		67.7	47.1	48.3	51.5	55.9	49.3	65.9
Cl-		0.3 <	5.1 <	5 <	5 <	5 <	10	0.4
F		0.01 <	0.51 <	0.5 <	0.5 <	0.5 <	0.01	0.01
SO4		853.3	1058.9	977	989	980	881	1050
Br	<	0.05 <	2.6 <	3.0 <	2.6 <	3 <	0.05 <	0.05
Nitrate		0.009 <	0.1 <	0.1 <	0.1 <	0.1	0.18	0.201
Nitrite	<	0.005 <	0.255 <	0.3 <	0.26 <	0.3 <	0.005 <	0.005
P	<	0.05 <	2.55 <	3.0 <	2.6 <	3 <	0.05 <	0.05
pH		7.82	7.35	7.56	7.37	7.31	7.48	7.74
FR		1360	1540	1480	1440	1480	1340	1460
NFR	<	5	595	2720	447	130 <	5	105
Spec. Cond.		1517	1650	1620	1556	1620	1490	1650
GFAA (dissolved):								
Se	<	0.001						
GFAA (total):								
Se								
Hardness, Ca+Mg		908.9	984	992	1022	891	966	1030
Hardness, total		909.7	989	996	1029	897	970	1030
ICP, dissolved								
Al	<	0.05 <	0.05	0.05 <	0.05 <	0.05	0.07 <	0.05
Sb	<	0.05 <	0.05 <	0.05	0.07	0.08 <	0.05 <	0.05
As	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ba		0.03	0.072	0.061	0.089	0.086	0.034	0.058
Be		0.005	0.004	0.006	0.012	0.055	0.006	0.006
B	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Cd	<	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005
Ca		282.4	308.8	307	317	275	300	316
Cr		0.011 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005
Co	<	0.005 <	0.005 <	0.005 <	0.005 <	0.005	0.009 <	0.005
Cu	<	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005 <	0.005
Fe		0.019	0.87	0.993	2.00	1.920	0.016	1.25
Pb	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Mg		49.4	51.7	54.5	56.0	49.9	52.7	58.2
Mn		0.002	0.149	0.163	0.216	0.280	0.014	0.158
Mo	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01 <	0.01
Ni	<	0.02 <	0.02 <	0.02 <	0.02 <	0.02 <	0.02 <	0.02
P	<	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1 <	0.1
K		1.1	0.2	0.7	0.7	0.7	1.2	0.8
Se		0.07 <	0.001 <	0.001 <	0.05 <	0.05 <	0.05 <	0.05
Si		3.97	3.98	4.44	4.72	4.01	4.86	4.55
Ag	<	0.01 <	0.01 <	0.01 <	0.01 <	0.01	0.01 <	0.01
Na		1.9	2.2	2.3	2.5	1.7	2.6	2.8
Sr		0.497	0.522	0.564	0.585	0.509	0.580	0.592
S		265.5	319	363	298	260	277	63
Sn	<	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05 <	0.05
Ti	<	0.002 <	0.002 <	0.002 <	0.002 <	0.002 <	0.002 <	0.002
V	<	0.01 <	0.01 <	0.01	0.02 <	0.01	0.02	0.01
Zn		0.048	0.315	0.497	0.715	0.660	2.13	1.01
ICP, Total								
Al			6.92	8	7.33	2.24 <	0.06	1.62
Sb	<	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
As	<	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06 <	0.06
Ba		0.254	0.257	0.240	0.147		0.035	0.089
Be		0.004	0.005	0.004	0.005		0.006	0.005
B		0.03	0.03	0.04	0.01 <		0.01	0.01
Cd	<	0.006 <	0.006	0.014 <	0.006 <		0.006 <	0.006
Ca		312.9	314.0	312.0	309		283.2	309
Cr		0.009	0.013	0.012 <	0.006		0.009 <	0.006
Co	<	0.006	0.009	0.019 <	0.006 <		0.006 <	0.006
Cu		0.02	0.02	0.023 <	0.006 <		0.006 <	0.006
Fe		12.762	12.900	16.300	5.440		0.034	3.65
Pb	<	0.06	0.06 <	0.06 <	0.06 <		0.06 <	0.06
Mg		56.8	57.9	57.1	57.4		52.2	57.1
Mn		0.318	0.351	0.600	0.366		0.022	0.188
Mo	<	0.01 <	0.01 <	0.01 <	0.01		0.01 <	0.01
Ni	<	0.02 <	0.02	0.03 <	0.02 <		0.02 <	0.02
P		0.3	0.5	0.9	0.2 <		0.1 <	0.1
K		1.7	1.7	1.7	1.1		1.4	1.1
Se	<	0.001 <	0.001 <	0.06 <	0.06 <		0.06 <	0.06
Si		13.60	14.80	14.60	7.70		4.87	6.65
Ag	<	0.01 <	0.01 <	0.01 <	0.01 <		0.01 <	0.01
Na		2.6	2.6	2.5	2.4		2.1	2.4
Sr		0.554	0.564	0.600	0.591		0.579	0.592
S		291	295	299	310		277	337
Sn	<	0.06 <	0.06 <	0.06 <	0.06 <		0.06 <	0.06
Ti		0.214	0.253	0.227	0.069 <		0.002	0.061
V		0.02	0.03	0.02	0.01 <		0.01 <	0.01
Zn		0.616	0.825	1.16	0.833		2.106	1.09
TIC		18.3	13.2	12.8	3.7		13.2	16.9
TOC		4.9	3.8	3.8	14.5		3.3	2.9
PO4		0.006	0.410	1.900	0.370		0.002	0.09
Field parameters:								
Water temp. (°C)		2.27	4.0	4.2	3.4		2.9	1.5
pH		7.33	7.63	6.71	7.67		6.95	7.4
Spec. cond. (uS/cm)		1474	1311	1387	1743		1439	1568
Cond. (uS/cm)		833	780	830	1020		830	870
ORP (mV)				107	105		55.2	45.9
Eh (mV) (calc'd)				306	304		254.2	244.9

Site 1- 300 drainage at
Christal Ck

	May-29	Jun-06	Jun-13	Jun-20	Jun-28	Jul-05	Jul-11	Jul-22	Jul-29	Aug-04	Aug-12	Aug-21	Aug-30
Acidity to pH 4.5	< 1	< 1		< 1			< 1	< 1	< 1	< 1	< 1	< 1	
Acidity, total	4	6		5		8		6	7	8	8	6	6
Alkalinity, total	38.3	46.2		56.3		59.2		82.5	80.6	81.1	90.6	76.1	95.2
Cl-	0.4	0.2		< 2	< 6		< 6	< 5	< 5	< 5	< 5	< 2.5	0.6
F	0.03	0.02		< 0.01	< 0.01		< 0.6	< 0.5	< 0.5	< 0.5	< 0.5	< 0.01	0.03
SO4	490.3	867		898.3	943		981	880	793	955	992	992	950
Br	< 0.05	< 0.05		< 0.05	< 0.05		< 3.0	< 3.0	< 2.6	< 3	< 0.05	< 0.05	
Nitrate	0.038	0.059		0.09	< 0.002		< 0.1	< 0.1	< 0.1	< 0.1	0.23	0.133	
Nitrite	< 0.005	< 0.005		< 0.005	< 0.005		< 0.3	< 0.3	< 0.26	< 0.3	< 0.005	< 0.005	
P	< 0.05	< 0.05		< 0.05	< 0.05		< 3.0	< 3.0	< 2.6	< 3	< 0.05	< 0.05	
pH	7.55	7.51		7.61	7.53		7.72	7.77	7.68	7.60	7.67	7.98	
FR	840	1270		1410	1450		1480	1390	1280	1460	1440	1470	
NFR	1350	2750		958	848		636	959	501	345	1020	169	
Spec. Cond.	989	1430		1298	1570		1560	1530	1429	1630	1600	1620	
GFAA (dissolved):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
GFAA (total):													
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001		< 0.001						
Hardness, Ca+Mg	548.6	851	985.6	974.6	1120	985.2	995.9	946	919.7	859	1150	1060	1020
Hardness, total	551.8	857	993.2	979.9	1140	991.2	1002.3	951.1	924.6	864	1160	1070	1020
ICP, dissolved													
Al	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	0.11	0.14	< 0.05	0.27	< 0.05	< 0.05	< 0.05
Sb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.05	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
As	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ba	0.042	0.120	0.094	0.094	0.090	0.106	0.137	0.078	0.066	0.060	0.061	0.096	0.054
Be	0.003	0.008	0.005	0.005	0.005	0.006	0.006	0.005	0.005	0.010	0.006	0.006	0.005
B	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Cd	< 0.005	< 0.005	< 0.005	< 0.005	0.015	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Ca	171.7	264	308.6	305.7	349	305.5	307.9	292.8	282	267	359	327	309
Cr	< 0.005	0.008	< 0.005	< 0.005	< 0.005	< 0.005	0.013	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005
Co	0.006	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Cu	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.008	< 0.0005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Fe	0.443	1.47	0.786	0.429	0.091	0.643	0.74	0.434	0.515	0.584	0.510	0.718	0.437
Pb	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Mg	29.1	46.7	52.2	51.3	60.5	54.0	55.1	52.2	52.5	46.8	62.0	59.5	59.9
Mn	0.235	0.390	0.549	0.318	0.132	0.385	0.554	0.429	0.416	0.330	0.520	0.529	0.439
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	< 0.02	< 0.02	0.02	< 0.02	0.04	< 0.02	0.03	< 0.02	< 0.01	< 0.02	< 0.02	< 0.02	< 0.02
P	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
K	0.7	0.9	1.0	0.9	1.1	0.9	1.0	0.8	0.9	0.8	1.2	1.2	1.1
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	3.30	4.29	4.74	4.63	5.20	4.08	4.11	3.66	3.89	3.66	4.15	4.25	4.14
Ag	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	1.3	1.8	2.1	2.0	2.2	2.3	2.3	2.1	2.1	2.3	2.3	2.5	2.4
Sr	0.317	0.499	0.579	0.568	0.684	0.564	0.582	0.52	0.532	0.472	0.627	0.614	0.598
S	159.3	262	293.5	284.1	365	300	283.16	288.96	312	259	3030	295	59.7
Sn	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Ti	< 0.002	0.006	< 0.002	< 0.002	< 0.002	< 0.002	0.012	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
V	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Zn	0.903	1.45	2.95	2.08	13.6	2.12	1.875	1.67	1.65	1.49	1.60	1.47	1.45
ICP, Total													
Al	21.50	33.4	27.09	13.71	1.08	13.1	19.29	8.31	8.72	6.75	4.53	16.89	1.82
Sb	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
As	0.09	0.14	0.13	< 0.06	< 0.06	0.07	0.08	< 0.06	< 0.06	< 0.06	< 0.06	0.08	< 0.06
Ba	0.655	1.04	0.778	0.391	0.047	0.451	0.6	0.27	0.271	0.221	0.156	0.488	0.091
Be	0.001	0.002	0.002	0.003	0.005	0.005	0.014	0.004	0.004	0.004	0.005	0.005	0.005
B	0.09	0.14	0.14	0.06	< 0.01	0.07	0.08	0.03	0.04	0.03	0.02	0.08	0.01
Cd	0.018	0.027	0.031	0.015	0.017	0.012	0.022	< 0.006	< 0.006	0.009	< 0.006	0.014	< 0.006
Ca	203.4	330	308.0	261.5	340.0	309	337.1	297	294	279	314	321.8	295
Cr	0.031	0.048	0.046	0.019	< 0.006	0.025	0.029	0.009	0.008	< 0.006	< 0.006	0.034	0.007
Co	0.030	0.041	0.029	0.016	< 0.006	0.018	0.027	< 0.006	< 0.006	0.009	< 0.006	0.033	< 0.006
Cu	0.062	0.096	0.092	0.034	< 0.006	0.055	0.072	0.033	0.031	0.023	0.012	0.068	< 0.006
Fe	40.8	63.8	58.9	23.9	1.74	28.1	37.819	14.507	16.3	13.7	8.52	34.694	3.73
Pb	0.10	0.18	0.13	0.07	< 0.06	< 0.06	0.09	< 0.06	0.09	< 0.06	< 0.06	0.09	< 0.06
Mg	44.2	70.4	61.3	49.2	57.5	59.1	65.1	56	56.9	53.8	60.6	64.3	56.9
Mn	1.04	1.71	1.89	0.650	0.165	0.919	1.219	0.7	0.71	0.647	0.619	1.145	0.488
Mo	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ni	0.07	0.11	0.11	0.04	0.04	0.05	0.08	0.03	0.03	0.03	0.03	0.07	< 0.02
P	1.9	3.4	2.8	1.0	< 0.1	0.8	1.3	0.6	0.8	0.6	0.3	1.3	0.1
K	4.2	5.8	4.3	2.7	1.2	2.9	3.2	2.1	1.8	1.7	1.7	3.2	1.4
Se	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Si	35.32	60.5	40.6	24.02	7.04	24.1	29.3	15.4	15.4	13.4	10.7	25.47	6.47
Ag	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Na	3.0	3.8	3.3	2.7	2.1	3.3	3.0	2.7	2.5	2.3	2.5	3	2.3
Sr	0.443	0.687	0.637	0.528	0.682	0.697	0.684	0.54	0.539	0.539	0.607	0.859	0.579
S	159.4	257	252.8	240	331	300	289.3	267	281	263	301	294.56	291
Sn	< 0.06	< 0.05	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06	< 0.06
Ti	0.842	1.37	0.977	0.506	0.030	0.458	0.650	0.274	0.291	0.203	0.157	0.561	0.063
V	0.08	0.12	0.09	0.04	< 0.01	0.05	0.09	0.03	0.03	0.02	0.02	0.05	< 0.01
Zn	1.65	2.92	4.42	2.38	14.30	3.04	3.47	2.34	2.41	2.11	1.87	2.66	1.55
TIC	8.9	10.8		12.2		16.2		21.9	20	20.6	21.6	21.1	23
TOC	17.6	6.5		4.9		4.1		4.2	4.7	6.1	3.8	2.6	3.7
PO4	0.52	2.20		0.88		0.783		0.430	0.72	0.518	0.282	0.731	0.14
Field parameters:													
Water temp. (°C)	3.23	3.1	3.5	4.8	6.3	6.7	3.5	5.7	4.4	8.1	2.7	3.9	1.3
pH	7.33	6.52	6.75	7.7	7.27	6.89	6.75	7.38	7.04	7.26	7.26	6.79	7.26
Spec. cond. (uS/cm)	892	1327	1364	1298	1592	1496	1364	1394	798	1379	1534	1517	1323
Cond. (uS/cm)	521	770	800	790	1010	960	800	870	480	920	880	900	730
ORP (mV)									98	104	56	25.8	29.4
Eh (mV) (calc'd)									297	303	255	224.8	228.4
Flow (m³/3/s)								0.062	0.06	0.091	0.065	0.075	0.0625
Flow (L/s)								8.16	7.78	14.22	8.74	10.76	8.26

APPENDIX D SOIL METAL CONTENT

The following data are the results of ICP analysis of total soil metal content for samples collected from the Galkeno 300 site during summer 2000. Sample location and a brief description of each sample, including a description of the sampling site, sampling depth, and a description of the sample itself are noted for each sample. UTM coordinates provide grid references for sample locations.

Sample #	Sample site	Sample description	Location	Al	Sb	As	Ba	Be	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Mg	Mn	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Sn	Ti	V	Zn
DM00-35 A1	A	Moss layer; outside flowpath																														
DM00-35 A2	A	Silt layer; outside flowpath		5743	< 8	9	189	0.4	20	9	15591	8.9	5	23	6140	25	1782	1160	< 2	40	1184	1672	< 8	2018	2	146	48.7	2225	< 8	289	18	315
DM00-35 A3	A	Upper 5 cm of permafrost; out of flowpath		20700	< 8	14	508	0.5	48	3.1	8367	29.3	7.8	40.9	18500	59	5026	532	< 2	29	1021	3019	< 8	1199	< 2	255	47.7	713	< 8	1110	63	289
DM00-35 A4	A	Permafrost sample 10 cm-15 cm interval below pf table; out of flowpath		16298	< 8	11	443	0.4	41	2.8	6636	23.7	8.5	41.1	15900	42	4454	348	< 2	40	900	1794	< 8	972	< 2	157	35.6	716	< 8	986	53	299
DM00-35 Adup1	A	Moss/lichen; not in contact with drainage		29930	< 8	21	920	0.8	61	3.6	7402	42.4	8.5	43	22100	59	5614	393	< 2	30	899	5937	< 8	614	< 2	493	56.2	926	< 8	1390	89	319
DM00-35 Adup2	A	Inorganic sandy material; not in contact with drainage		2869	< 8	< 8	243	0.6	15	27.2	23041	1.2	5.6	44.4	3700	15	1285	895	< 2	30	1004	750	< 8	2107	< 2	115	69	2460	< 8	90.2	6	557
DM00-35 B1	A	Moss layer; seepage into pit suggests possible contamination		24941	< 8	35	510	0.8	64	4.9	9277	35.5	9.3	38.6	24400	64	5282	565	< 2	34	1037	4819	< 8	600	< 2	394	55.4	562	< 8	1280	80	402
DM00-35 B2	A	Moss + silt (50/50); silt fills pores of moss; seepage		2465	< 8	< 8	58.8	0.3	12	3.3	13995	3.9	1.1	19.8	2970	19	1836	327	< 2	16	711	1179	< 8	2411	< 2	126	34.3	3036	< 8	137	9	393
DM00-35 B3	A	Basal layer of undecomposed moss; seepage		22300	< 8	91	1110	1.1	183	28.8	25000	< 24	44.7	84.6	32672	43	2185	1428	3	< 90	1020	817	< 240	1240	9	92	71.7	3607	< 8	165	39	892
DM00-35 C1	A	Surface moss layer; likely contacted minor flow of mine drainage		21331	< 8	54	421	0.6	80	5.5	9876	30.8	12.4	36.4	31700	77	5269	1320	< 2	33	1171	3408	< 8	1075	< 2	283	48.9	953	< 8	1140	75	380
DM00-35 C2	A	Silty organic layer; potentially in contact with mine drainage		3570	< 8	< 8	142	0.5	17	11	26352	4.1	4.5	19.3	4320	13	2282	545	< 2	34	1161	933	< 8	2178	< 2	149	64.2	4105	< 8	208	12	254
DM00-35 C3	A	Basal moss/ peat layer; potentially in contact with mine drainage		22321	< 8	103	446	0.7	93	6.4	10323	31.1	6.4	42.5	37800	73	5467	442	< 2	25	1231	3696	< 8	1300	< 2	294	53.3	911	< 8	1100	81	467
DM00-35 D1	A	Moss at ground surface; tried to avoid living matter; seepage noted		19069	< 8	33	899	1	67	7.4	18300	23.3	6.9	98.5	25400	31	3357	1020	< 2	43	2051	2830	< 8	1489	< 2	267	71.5	3331	< 8	570	51	455
DM00-35 D2	A	Organic rich silt layer immediately beneath moss, seepage noted		2660	8	< 8	219	0.7	16	8	30188	3.8	2.4	19.7	3950	20	2580	2520	< 2	34	845	795	< 8	2159	< 2	202	63.9	5345	< 8	113	8	338
DM00-35 D3	A	Buried moss layer		23031	< 8	< 8	477	0.7	42	6.5	9490	32.2	2.9	48.2	14100	65	5344	208	< 2	21	991	4267	< 8	891	< 2	332	50.3	1031	< 8	1070	69	339
DM00-35 D4	A	Top 5 cm of pf		13183	< 8	87	893.3	1	85	17	22301	16.3	8.9	106.4	34500	30	3149	1161	2	47	1750	1702	< 8	1269	3	186	68.9	4577	< 8	351	40	402
DM00-35 D5	A	Sampled from >10 cm depth below pf table		31112	< 8	19	1260	0.8	64	4.9	7805	43.2	20	84.3	22700	65	5949	1150	< 2	42	952	5313	< 8	966	< 2	422	50.2	1620	< 8	1030	83	450
DM00-35 E1	A	CENTER OF FLOWPATH!! Surf OM		31379	< 8	23	1100	0.9	71	4.3	6974	42.9	16	75.1	26090	81	5863	1240	< 2	52	1033	5215	< 8	954	< 2	410	49	1186	< 8	1030	88	389
DM00-35 E2	A	CENTER OF FLOWPATH!! Framework of OM with a silty matrix, depth 6-36 cm		12519	12	13	277	0.5	45	9.5	18852	18.1	4.9	43.2	14500	32	4189	1210	< 2	38	1166	2798	< 8	965	< 2	200	60.7	4798	< 8	825	41	3010
DM00-35 E3	A	CENTER OF FLOWPATH!! 85% OM, 36-62 cm, highly saturated		21208	< 8	42	451	0.7	77	3.7	13105	29.6	9.4	39.6	30500	70	5364	1175	< 2	34	1183	3549	< 8	966	< 2	291	59.1	1265	< 8	1080	70	455
				23890	< 8	36	598	0.8	52	6.5	12213	33.1	10	49.4	18800	69	5238	210	< 2	39	981	4488	< 8	618	< 2	377	60.4	4344	< 8	1140	74	394

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APPENDIX E SELECTIVE EXTRACTION DATA

The following data are the results of the selective extraction procedure performed on organic and mineral soil samples collected at the Galkeno 300 study site. Absolute Zn values (mg/kg) for each fraction extracted are provided to categorise the magnitude of metal contained within the respective soil fractions; proportional Zn values (%) are provided to illustrate the relative importance of each fraction with respect to the total soil metal levels.

Table E1. Absolute selective extraction results.

	Resid (mg/kg)	Org (mg/kg)	Ox (mg/kg)	CO3 (mg/kg)	Exch (mg/kg)	Total mass Zn (mg/kg)
Site A - org	0	1510	1781	0	581	3872
Site A - org	0	1007	2417	0	604	4028
Site A - min	179	7	108	0	33	326
Site A - min	177	0	89	0	29	286
Site C - org	0	1803	20350	1288	2318	25760
Site C - org	0	0	20485	1205	2410	24100
Site C - min	271	558	638	0	128	1594
Site C - min	202	465	775	0	109	1550
Site E - org	0	5947	6372	0	1841	14160
Site E - org	0	6595	5115	0	1750	13460
Site E - min	1692	308	2615	0	513	5128
Site E - min	1369	1065	2181	0	456	5072

Table E2. Proportional selective extraction results.

	Resid %	Org %	Ox %	CO3 %	Exch %
Site A - org	0	39	46	0	15
Site A - org	0	25	60	0	15
Site A - min	55	2	33	0	10
Site A - min	62	0	31	0	10
Site C - org	0	7	79	5	9
Site C - org	0	0	85	5	10
Site C - min	17	35	40	0	8
Site C - min	13	30	50	0	7
Site E - org	0	42	45	0	13
Site E - org	0	49	38	0	13
Site E - min	33	6	51	0	10
Site E - min	27	21	43	0	9