Baseline hydrogeochemistry and connectivity among landscape units of two wetland-rich Boreal sites in the Athabasca Oil Sands Region, Alberta

by

Caren Küsel
BSc, University of Waterloo, 2003
BEd, Lakehead University, 2007

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in the Department of Geography

Supervisory Committee

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Abstract

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Developing critical loads for nitrogen (N) in the Athabasca Oil Sands Region (AOSR) requires an understanding of the hydrological connectivity and potential for N transport among uplands, fens and bogs typical in the wetland-rich Boreal region of northern Alberta. The Cumulative Environmental Management Association's (CEMA) overarching mandate is to determine a nitrogen critical load specific to the Boreal region of northern Alberta. To this end, nitrogen amendment experiments were initiated at two Boreal wetland sites: an upland – rich fen gradient at Jack Pine High (JPH) and an upland – fen – bog mosaic at Mariana Lakes (ML), 45 km north and 100 km south of Fort McMurray respectively.

The objectives of this study are to use geochemical and isotopic tracers to describe baseline hydrogeochemical variability and connectivity between bog, fens and upland areas in the AOSR. Sites were instrumented with piezometer nests and water table wells along transects that cover the targeted landscape units (n = 108 sampling locations). Fieldwork related to this thesis was conducted during the open-water season: in June and August 2011, and in May, July, and September 2012. Field campaigns also included a snow survey (March 2012), and spring melt/freshet sampling (April 2012). The analysis of spatiotemporal variability of water isotopes and geochemistry in the years 2011-2012 yielded: i) a characterization of baseline conditions from which perturbations can be assessed, and ii) evidence of connectivity among landscape units.

No evidence for elevated concentrations of nitrogen related to the amendment experiments was found in 2011 or 2012. The baseline characterization and annual monitoring did show increasing concentrations of inorganic ammonium with increasing depth associated with increasing solute concentrations: average concentrations of

inorganic ammonium were 23 mg/L at deepest sampling locations (7 m) at ML bog and ML fen landscape units. These ammonium concentrations in porewaters, given a porosity of 0.90 for peatlands, constitute a store of ammonium that may be a significant source of nitrogen if the hydrology is altered due to co-occurring changes in vegetation (due to, for example, elevated nitrogen inputs), climate and/or landuse.

Hydrologic connectivity at JPH is likely driven by topography. Hydraulic head in 2011 and 2012 field seasons showed that flow persisted from the upland to the fen. The consistent and distinct geochemical signatures and isotopic labelling of mid-depth and deep groundwater samples of fen and upland landscape units is consistent with such a stable groundwater continuum. Near-surface water samples at JPH fen however varied hydrogeochemically in response to seasonal changes in precipitation inputs, water levels, and biogeochemical productivity. At ML, hydrological connectivity is a function of antecedent moisture conditions (which determines run-off) and low and variable (10^{-6} to 10^{-9} m/s) hydrological conductivity of the peatland substrate (which may result in lateral flow where hydraulic head shows potential for vertical re- or discharge). Near-surface samples showed greater temporal than spatial variability as snowmelt inputs, variations in antecedent moisture conditions and seasonal changes in biogeochemical process rates affected nutrient and solute concentrations. In contrast, shallow, mid-depth and deep samples showed greater spatial than temporal variability. The spatial distributions of parameters could be associated to some degree with vegetation, distance along a surficial flowpath, or depth to mineral substrate or distance from the upland/edge transition.

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Acknowledgments

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For inspiration, fieldwork and lab support, technical and logistical advice, I also thank: Amy Vallarino, Mike Moncur, Yi Yi, Paul Eby, Kevin Tattrie, Ed Bryson, and Tom Edwards. For the staging of fieldwork I commend Greyling for hosting the 'science' quarters and 'scientists'. I would like to acknowledge the staff and faculty of the Dept. of Geography (University of Victoria) for their commitment to student success. I appreciate the AITF[1] desk space and resources made available to me off campus. I am grateful for the financial support from CEMA[2] and NSTP[3].

I feel this has been a very rewarding part of an ongoing journey which has allowed me many opportunities to learn from and grow. Some of which were moving to the island, travelling to annual meetings or conferences, and experiencing road trips to the Athabasca Oil Sands Region.

And I am thankful for the support, encouragement, and sense of humour of friends, family, and co-workers. Without which, in spite of *peat*'s sake, I could have *bog*ged down.

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[1] Alberta Innovates Technology Futures

[2] Cumulative Environmental Management Association

[3] Northern Scientific Training Program

Dedication

This work is dedicated to W Giles, for the paths we have travelled since Ennadai, 2001.

Chapter 1.
Introduction

1.1. Context of Research

Industrial development in the Athabasca Oil Sands Region (AOSR) is intensifying, so atmospheric nitrogen loading associated mainly with emissions from mining fleet vehicles and extraction processes is anticipated to increase (Allen 2004). Increased nitrogen loading may affect the integrity of ecosystems, causing eutrophication, acidification, or species succession (Galloway *et al.* 1995, 2008; Schindler *et al.* 2006; Schlesinger 2008). To quantify and qualify the response to increased nitrogen loading of wetland-rich sites in the Boreal region of northern Alberta, the Cumulative Environmental Management Association (CEMA) is conducting experimental nitrogen application studies (CEMA 2008). CEMA's mandate is to establish a nitrogen critical load (CL) that is specific to the Boreal region of northern Alberta. A CL is "a quantitative estimate of an exposure to … pollutants above which significant adverse effects on specified sensitive elements of the environment may occur, according to present knowledge" (article 1 of the 1979 Guthenburg Protocol, cited by Allen 2004, p.9). Within the framework of CEMA's research project, this thesis describes 1) the baseline hydrogeochemistry of surface and sub-surface waters at the two selected research sites, and 2) connectivity among the among upland, fen, and bog landscape units at the sites. This work aims to refine the understanding of and the ability to quantify hydrologic and nutrient fluxes of wetland-rich sites in the AOSR.

1.2. CEMA's Experimental Nitrogen Application Study

The purpose of CEMA's research project is to understand "the fate and effects of atmospherically deposited nitrogen in order to determine nitrogen CL's for sensitive Boreal ecosystems in the Regional Municipality of Wood Buffalo (RMWB)" (Spink 2013, p.18). The response of wetland-rich regions in the AOSR to increased nitrogen (N) is poorly understood (CEMA 2008). Further, CEMA's Interim Nitrogen Eutrophication

Management Plan (CEMA 2008) recommends the critical evaluation of applying European CL's to the AOSR. A region-specific CL for nitrogen will be presented by CEMA in 2016, upon conclusion of the five-year nitrogen addition experiments started in 2011.

The nitrogen addition experiments in bog, fen, and jack pine upland plots are planned to run over five years from 2011 – 2016. Applications occur 5 – 7 times a year, during the ice-free season. Total amounts of N applied are 0, 5, 10, 15, 20 and 25 kg N/ha/yr as liquid ammonium nitrate. In comparison, CL's set for Europe range from 5 – 10 for raised and blanket bogs and 15 – 25 for rich fens (Spink 2013).

Two study sites containing target landscape units – bog, fen, and jack pine upland - were selected by CEMA based on their representativeness and accessibility (to control/limit overall costs). Study site JPH (57.12°N, 111.44°W) includes upland adjacent to fen landscape units with long-term experimental plots in the upland location. Study site ML (55.89°N, 112.09°W) includes upland, fen and bog areas with long-term experimental plots in fen and bog locations. Both JPH and ML are road-accessible by permit. At each site, ecosystem processes, ecosystem responses and ecosystem connectivity are being studied (CEMA 2008).

Ecosystem processes and responses (CEMA 2013): Growth, nitrogen concentrations and C:N ratios of plants are being measured to evaluate changes in biodiversity and plant nutrition cycles. Nitrogen mineralization, nitrification, and nitrate leaching rates are monitored to analyse potential changes to nitrogen pathways in each landscape unit under long-term elevated atmospheric nitrogen inputs. Researchers are assessing relative sensitivity of plants and their resistance to stressors. Also, at JPH the potential acidification of soils is being monitored. And at ML, the potential reduction of biological nitrogen-fixation rates is being evaluated.

Ecosystem connectivity (CEMA 2013): The hydrology research group is delineating the movement of nitrogen between the target landscape units. Researchers are studying the effect of snowmelt, rain events, and antecedent moisture conditions on nitrogen mobility/cycling and flux within landscape units. A regional CL for the study sites under long-term elevated atmospheric nitrogen inputs is to be determined upon completion of the five-year project.

1.3. Objectives

The objectives of this study are to use geochemical and isotopic tracers to describe hydrogeochemical variability and connectivity between bog, fen and upland areas in two wetland-rich ecosystems in the AOSR. The rich fen – upland gradient at JPH, and the bog – fen – upland mosaic at ML contain landscape units common in the Boreal region. Chapter 3 describes the geochemical and isotopic compositions of water and solutes present in the different landscape units types. Characterizing the ranges and variability in geochemical and isotopic parameters is necessary to establish baseline conditions so that perturbations can be identified. Chapter 4 examines in more detail the temporal and spatial variations in geochemical and isotopic parameters to see if these parameters can be used to evaluate connectivity between the bogs, fens and uplands and to understand geochemical processes occurring along flowpaths connecting them. The pathways of nitrogen through the integrated landscapes are described generally, given the understanding of hydrological connectivity among and within landscape units that is developed in this thesis.

1.4. Research Questions

Chapter 3:

In terms of the hydrogeochemical and isotopic compositions of water samples:

1. What are *at-a-glance* differences between target landscape units?
2. What is the baseline characterization of JPH and ML landscape units?
3. Do water samples from targeted landscape units have distinct hydrogeochemistry at different depths? Are distinctions affected by temporal trends or spatial heterogeneity?
4. Which variables explain some of the inter- and intra site variability?

Chapter 4:

In analyzing time series of the spatial distributions of data in plan view and/or along transects, within the context of physical hydrology and hydrologic regime:

5. Is there evidence of connectivity at an upland – fen transect at JPH?

6. Is there evidence of connectivity along an upstream – downstream transect within the fen at JPH?
7. Is there evidence of lateral connectivity at near-surface or at shallow depths at the ML study site?
8. Is there evidence of connectivity along a transect that follows a potential surficial pathway identified at ML?

Given the understanding of hydrological connectivity and characterization of landscape units:

9. What are some general implications for the fate and behaviour of nitrogen?

Chapter 2.
Background

2.1. Critical Loads of Nitrogen

Nitrogen is recognized as accumulating and adversely impacting the environment (Galloway *et al.*1995, 2008; Schindler *et al*. 2006; Schlesinger 2008). The anthropogenic inputs of nitrogen (from agriculture, industry, production of fertilizer, and combustion of fossil fuels) are increasing globally, and have been estimated to be quantitatively equal to the total pre-industrial input, upsetting the balance of the nitrogen cycle (Galloway *et al.* 1995, 2008). The ecosystem and human health implications of this effective doubling of nitrogen are not fully understood, anticipated, or mitigated (Galloway *et al*. 2008, Schlesinger 2008).

The environmental impacts of increasing nitrogen and the desire to mitigate adverse effects have led to scientific research initiatives at a range of foci and scales, especially in Europe where immediate and imminent effects had an associated urgency (Aber *et al.* 1998, Bobbink *et al.* 2010). Sulphur emissions, linked to acidification of lakes in Europe in the 1960s, had precipitated international cooperation, i.e. the Convention on Long-Range Transboundary Air Pollution in 1979, to manage emissions (Erisman 2004). Methodological approaches include: observations (long-term regional and plot-scale monitoring), experiments (field or laboratory application, i.e., amendment studies), and models (Allen 2004, Bourbonniere 2009). Objectives that direct research initiatives include: identification of sources, quantification and projection of loads and fluxes, study of impacts, and implementation of mitigation strategies. Policies addressing nitrogen in the environment are informed by a critical load (CL) that is based on water yield and chemistry data. However, a static and regional CL is of limited effectiveness when it is evident that water yield and chemistry are variable in space and time (Gibson *et al.* 2010a, 2010b). The application of a CL needs to be evaluated carefully within projected climate and land use changes and site-specific geological, hydrological and ecological factors.

The need for research focused on nitrogen pathways in the AOSR is driven by an incomplete understanding of nitrogen fate and behaviour in the context of intensifying industrial development. A CL for nitrogen has not been established specifically for the AOSR and the transferability of European CL's not empirically evaluated (CEMA 2008). Not only are emissions a significant and increasing source of anthropogenic atmospheric nitrogen (Allen 2004, Schindler *et al.* 2006), "the rate of bitumen extraction in northeastern Alberta, Canada, is outpacing the state of ecological understanding… so that the extent of potential disturbances caused by atmospheric deposition remains largely unknown" (Hazewinkel *et al.* 2008, p.1554).

2.2. Boreal Wetlands

Peatlands cover about 3% of the land mass globally and one third of all peatlands are located in Canada (Rydin & Jeglum 2006). Peatlands are wetlands – regions with continuously high water tables such as bogs, fens, swamps, marshes, or shallow water – with at least 40 cm of accumulated peat (National Wetlands Working Group 1997 cited in Price & Waddington 2000). In northeastern Alberta, the Boreal landscape consists primarily of peatlands surrounded by forested uplands (Allen 2004). Bogs and fens constitute about 30% of the AOSR and are variably groundwater and/or rainwater fed (Bennett *et al.* 2008 in Whitfield 2009). The types of peatland that form depend on the topography, geological substrate, vegetation, climate, hydrology, and biogeochemistry (Bourbonniere 2009, Bridgham *et al.* 1996, Branfireun 2004, Malmer *et al*. 1992).

Changes in land-use are anticipated in the AOSR and changes in climate are outlined by the International Panel on Climate Change (IPCC). However, the effects of changes in land-use or climate on the relative sequestration and release of carbon dioxide, methane, and nitrates are uncertain (Turetsky *et al*. 2002, Whitfield *et al*. 2009). Peatlands contain significant pools of carbon and nitrogen, and are thus considered a significant link in the global carbon and nitrogen cycles (Gorham 1991), which respond to natural and anthropogenic forcings. An increase of dissolved organic carbon (DOC) globally may be associated with anthropogenic "drivers [that] have the potential to act independently and interactively" (Armstrong *et al.* 2012, p.182): increasing temperatures, changes in atmospheric inputs, and changes in hydrology. Further, peatlands support various animal and plant species, provide ecosystem services, attenuate floodwaters, and purify water (Rydin & Jeglum 2006, Turetsky & St. Louis 2006). Studies of peatlands are thus relevant in the context of economics, environmental impact and climate change.

2.3. Geochemistry of Peatlands

Understanding a wetland-dominated ecosystem relies on both spatial and temporal delineation of water chemistry and a consideration of the relationship between chemistry and living matter (Bourbonniere 2009, Pelster *et al.* 2008, Vitt *et al.* 1995). The geochemistry of porewater present in peatlands is a function of the water sources (groundwater, runoff, precipitation, snowmelt), hydrological processes (evaporation, evapotranspiration), geochemical processes (diffusion, advection, cation exchange), and biologically-mediated and reduction-oxidation chemical processes (respiration, decomposition, and mineralization) (Devito & Dillon 1993, Vitt *et al.* 1995, Mitchell & Branfireun 2005) all of which vary both spatially and temporally. Vegetation has an effect on porewater geochemistry and both quality and quantity of litter; vegetation also has an influence on the microbial and fauna assemblage, the local temperature and the water table (Armstrong *et al.* 2012, Pelster *et al.* 2008). A high degree of variability in the geochemistry of peatland porewaters is often observed due to heterogeneity of vegetation (affecting concentrations of biologically-mediated chemical species) (Branfireun 2004), variations in moisture conditions and hydrological connectivity (Frei *et al.* 2012, Mitchell & Branfireun 2005). The greatest seasonal variations in peatland porewater geochemistry are in near-surface samples where “biogeochemical processes [may] represent a continuum of opposing and competing processes that is shifted by soil moisture levels” (Blodau *et al.* 2012, slide 3). Less temporal variability is evident for deeper peat samples, which are typically more integrated/well mixed. Temporal changes are related to long-term hydrological trends such as sustained upwelling during multi-year droughts (Wieder & Vitt 2006).

Depth profiles of geochemical parameters in peatland complexes reflect the combined effects of advection and diffusion, and are further complicated by biogeochemical processes. Modelled diffusion and/or advection depth profiles are used to interpret the relative proportion of surface inputs to groundwater (Freeze & Cherry 1979, Siegel &

Glaser 2006, Siegel *et al.* 1995). Modelled depth profiles are curvilinear for simple diffusion and linear for simple mixing (Chesworth *et al.* 2006, Fraser *et al.* 2001a, Levy *et al.* 2013, Wieder & Vitt 2006). Observed profiles differ from modelled profiles randomly or systematically. Systematic variation from a model may be induced by sustained changes in discharge or recharge regimes (Siegel *et al.* 1995). For example, changes in cation concentrations and electrical conductivity accompany flow reversals. From changes in the depth profiles over time, changes in source water contribution can be inferred, notably as dilution during spring due to infiltration of melt water, or as concentration in summer due to evaporation of surface water. As water table levels change, hydraulic heads change, and hydrologic regimes shift among recharge, lateral flow, and discharge. Intra-annual variability in flow regimes also exists at fine-scale, caused by the variability in microtopography within a peatland (Drexler *et al.* 1999). Hydrological models have also been used to simulate the flow of infiltration at the microtopography scale (Frei 2012) or to simulate vertical flow and dispersive mixing in a peatland (Reeve *et al.* 2000, 2001). Constituents are redistributed by advection in the direction of flow (lateral or vertical), and further, by diffusion along a concentration gradient (Chesworth *et al.* 2006).

Not all constituents of water samples are conservative (or passive) in the context of advection. Material may be attenuated to a significant degree given the high cation exchange capacity of peat (Turetsky & St. Louis 2006). Redox reactions, and aerobic and anaerobic microbial and biogeochemical reactions also alter the chemical composition of water (Rydin & Jeglum 2006). The processes are further influenced by water table fluctuations, which in turn affect temperature, redox state, and infiltration of nutrients (Ulanowski & Branfireun 2013). Heterogeneity in vegetation composition and microtopography contributes to variability inherent in surface water geochemistry, a variability compounded by “hot spots” or “hot moments” of increased reaction rates (Morris *et al.* 2011). Hot spots are attributed to the convergence of flowpaths that change the availability of rate limiting substrates and terminal electron acceptors. Hot spots have been modelled in virtual experiments. For example Frei *et al*. (2012) show hot spots developing in response to complex subsurface flow initiated by infiltration of input water.

Hot spots driven by changes in water level and connectivity were identified at a peatland – upland interface by Mitchell & Branfireun (2005).

Redox Potential (Eh)

Eh is a measure of electron potential and is an important control on many geochemical processes that occur in peatlands (Mitsch & Gosselink 1993, Rydin & Jeglum 2006). The reduction potential determines the progression of redox reactions: redox couples vary in energy efficiency at different pH levels and are reduced sequentially from high to low Eh (Borch *et al.* 2010). Eh decreases from oxic to anoxic conditions, thus generally decreasing with depth in peatlands (Chesworth *et al.* 2006). Oxygen is the strongest oxidising agent; in the absence of oxygen, other redox couples may act as electron donors/acceptors. A diverse suite of mechanisms and specialized micro-organisms have developed to function at a wide range of redox conditions (Husson 2012). "[A]vailable moisture/redox potential coupled with decomposition and mineralization are the most important factors responsible for nutrient levels in peatlands" (Vitt *et al.* 1995, p.604). Reducing conditions (low Eh) are expected in waterlogged (anoxic) environments. The reduction potential may be buffered or poised at a given pH by redox pairs (Husson 2012, Rydin & Jeglum 2006). For example an equilibrium system at pH7 is poised at 250 mV in the presence of nitrate, at 120 mV for iron hydroxide reduction to ferric iron, at -150 to -75 mV in the presence of sulphate reduction, or below -250 mV for methanogenesis.

Dissolved Organic Carbon (DOC)

Carbon, both allochthonous (introduced in groundwater, runoff or precipitation) and autochthonous (generated within the peat), is present in surface and subsurface waters as particulate matter (PM), dissolved organic matter (DOM), dissolved inorganic carbon (DIC), volatile organic compounds (VOC), gaseous methane (CH_4), or carbon dioxide (CO_2) (Anderson 2012). DOC is the carbon component of dissolved organic matter (DOM). The term *dissolved* is based on a size criterion: a 0.45 μm filter retains particulate matter (PM) but not DOM (Schiff *et al.* 1997). Humic substances constitute 20 – 90% of DOC (Schiff *et al.* 1997) and are a mixture of carbon chains of variable lengths and thus molecular weight (Moore 2003). It is the carboxyl group of humic substances that contributes to acidity in peat (Shvartsev et al. 2012).

DOC concentrations can be expected to be variable as the controlling factors are variable: "vegetation type, redox conditions, temperature, presence and abundance of micro (organisms) and nutrient availability" (Ulanowski & Branfireun 2013, p.216). Increasing DOC concentrations may indicate greater bacterial productivity (decomposition of organic matter), high water tables (where inundation by water creates a greater area of contribution of DOC), residence time (where slow flow allows accumulation) or recharge through organic rich soils (e.g. Fraser *et al.* 2001b, Moore 2003). At the plot scale, concentrations of DOC are constrained by the availability of substrate and temperature which in turn affect the rates of respiration and methanogenesis (Fraser *et al.* 2001b). Quality and production of DOC in the near-surface is related to vegetation type and associated microbial and soil fauna assemblages (Armstrong *et al.* 2012). Recalcitrant DOC (of poor quality not easily processed biogeochemically) is present in groundwater and sequestered in peat, accumulating at depth. Labile DOC is younger, and is redistributed through peat profiles by convection (sum of advection and diffusion) where it is consumed microbially (Fraser *et al.* 2001b).

Saturation Index (SI)

The calculation of saturation indices (SI's) is a tool to determine which mineral phases a solution is in near-equilibrium with, based on the concentrations of solutes present in solution. Solutes are derived from the dissolution of minerals along the groundwater or sub-surface flowpath, are input as dry or wet deposition, or are modified by biogeochemical processes and mixing interactions. Based on ion activity products and reaction constants at specified temperatures, SI's indicate undersaturation ($SI < -0.4$), equilibrium ($-0.4 < SI < +0.4$) and supersaturation ($SI > +0.4$). Supersaturation occurs after long-term equilibration with substrates, facilitated by slow flow, high temperatures, or long flowpaths. Dissolution and precipitation of a mineral may also occur due to common ion effects where water sources mix, or where equilibrium chemistry is dynamically altered by changes in redox state, pH, temperature, and biological or microbial processes (Kehew 2001).

Relevant at JPH and ML are substrate geology, surficial soils and vegetation, water flowpaths and flow rates, variable water levels, anoxic conditions of waterlogged peat, and presence of organic material. Equilibrium ($-0.4 < SI < +0.4$) and supersaturation ($SI > +0.4$) conditions were calculated for samples at JPH and ML with respect to quartz, siderite, iron oxides and pyrite, and so a brief discussion of these minerals follows. Quartz (SiO_2) is present in water flowing through weathered silicate rock, as in sandy substrates (Kehew 2001). Presence of siderite ($FeCO_3$) is indicative of water flowing through shales and clay sediments (Kehew 2001). Iron oxides, such as hematite (Fe_2O_3) and goethite (FeOOH), and pyrites (ferrous minerals) are precipitated by groundwater, in oxygen and iron rich environments (i.e., the reduction of Fe^{3+}), or are produced in bacteria-mediated processes. Pyrite (FeS_2) is a sink for reduced sulphur in anaerobic conditions (Li *et al.* 2012). In anoxic environments, bacteria-mediated decomposition of organic matter is facilitated by the reduction of SO_4^{2-} to H_2S; subsequently, divalent metals such as Fe^{2+} may bind with S^{2-} (Moncur *et al.* 2006). Evidence of this process is an observed increase in pH and alkalinity, and decrease in SO_4^{2-} concentration (Moncur *et al.* 2006).

2.4. Stable Isotopes

The relative abundance of rare, “heavy” stable isotopes (such as ^{2}H, ^{18}O, ^{15}N, ^{13}C, ^{34}S) is detectable by mass spectrometry, a technology that continues to evolve since developed by Urey in the 1930s (Clark & Fritz 1997). The isotopic ratio of a sample, expressed in delta (δ) - notation (1), is typically expressed in permil (‰) by applying a factor of 1000. The δ - value of a sample is the isotope ratio of the sample relative to the isotope ratio of a reference material (Clark & Fritz 1997).

$$\delta\text{sample ratio (‰)} = (\text{sample ratio} - \text{reference ratio})/\text{reference ratio} * 1000 \qquad (1)$$

The isotope signature of a sample reflects its source and any changes in which the heavier or lighter isotope is preferentially used in kinetic, equilibrium, or physiological processes. The preferential use of one stable isotope rather than another in kinetic or biochemical processes is measured as the fractionation factor (Clark & Fritz 1997). So, stable isotopes, because they behave predictably, have become a useful tool in tracing material (Clark & Fritz 1997). Considered within well-defined and appropriately constrained contexts, isotope ratios are useful in understanding dominant biogeochemical processes, inferring connectivity or quantifying hydrological budgets (Kendall & McDonnell 1998, Siegel *et al.* 2001, Price *et al.* 2005, Gibson *et al.* 2002, Levy *et al.* 2013).

Isotopes of Hydrogen (^2H, ^1H) and Oxygen (^{18}O, ^{16}O)

Stable isotope ratios of water samples are routinely plotted in delta-delta space (δ^2H vs. $\delta^{18}O$) and shown relative to the Global Meteoric Water Line (GMWL) (2) (Craig 1961); sample ratios are reported relative to an international reference material, Vienna standard mean ocean water (VSMOW).

$$\delta^2H = 8*\delta^{18}O + 10 ‰ \qquad (2)$$

Water isotope data are systematically offset from and shifted along the GMWL because water samples have different signatures depending on their temporal and spatial origin and evolution (Dansgaard 1964, Gat 1996, Rozanski et al. 1993). For example, isotope signatures of surface waters depend on the origin of precipitation input (related to latitude, altitude, and season) as well as the hydrologic regime (groundwater, surface and subsurface inputs) and ratio of evaporation to evapotranspiration. Evaporation discriminates against heavier isotopes of both hydrogen and oxygen, so a residual sample during evaporation will become progressively heavier in both deuterium and oxygen-18, though the kinetic effects of non-equilibrium evaporation on oxygen-18 are more pronounced (Dansgaard 1964). Deuterium excess (d-excess) is a quantitative measure of the offset from the GMWL described by d-excess = $\delta^2H - 8*\delta^{18}O$ (Dansgaard 1964). The d-excess value decreases with increased evaporative enrichment. In contrast, evapotranspiration is a process in which water retains its isotopic signature (Mitsch & Gosselink 1993). Under similar environmental conditions, the d-excess calculated for a water sample from an evaporating body of open-water will be lower than the d-excess value obtained for a vegetated body of water where transpiration dominates (Mitsch & Gosselink 1993). The systematic offset from the GMWL due to location has led to the definition of site-specific meteoric water lines and evaporation lines. Local meteoric water lines (LMWL) and evaporation lines (LEL) are defined based on long-term precipitation data sets and constrained by site-specific climate factors (relative humidity and temperature) and the isotopic composition of atmospheric moisture (Gibson et al. 2005, Gibson et al. 2008).

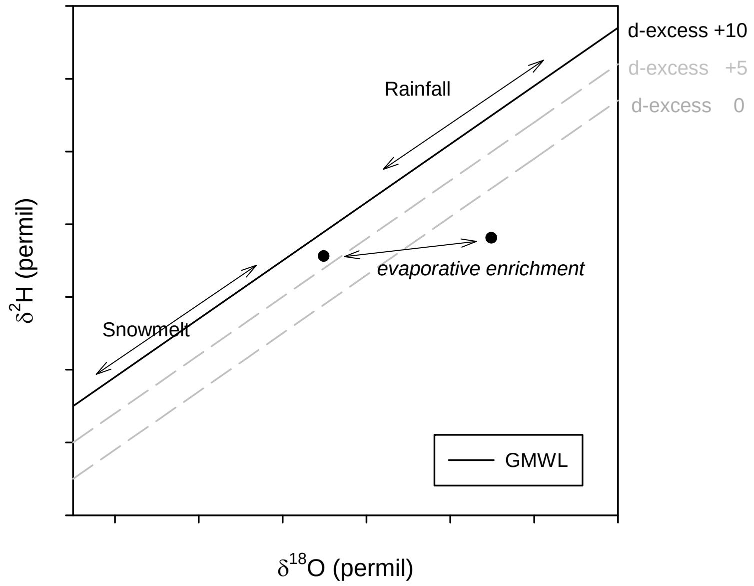

Figure 1 Snowmelt and rainfall samples, the Global Meteoric Water Line (GMWL) and evaporative enrichment in δ^2H-δ^{18}O space. GMWL: $\delta^2H = 8*\delta^{18}O + 10$. Evaporative enrichment of a sample results in progressively lower d-excess values, illustrated by the dashed lines parallel to the GMWL (following Turner *et al.* 2014).

Isotopes of Nitrogen (^{14}N, ^{15}N)

Nitrogen is an essential nutrient that is cycled in a series of complex dynamic biogeochemical reactions. The isotopic signature of a nitrogen source changes as the lighter isotope of nitrogen is preferentially used in reactions (Robinson 2001, Choi *et al.* 2003). Less energy is required to break bonds that include the lighter isotope of nitrogen (^{14}N). For example, microbes will discriminate against the heavier isotope (^{15}N). Similarly, in nitrification, the product (NO_3^-) is depleted in the heavier isotope relative to the substrate (Mariotti *et al.* 1981). Some pathways - mineralization, denitrification, assimilation, fixation, volatization - have known fractionation factors (summarized in Robinson 2001). But in practice, the pathways of nitrogen are often a combination rather than a one-dimensional process. The sources and sinks of nitrogen are difficult to isolate, describe, or quantify; and solving mass balance equations is not always possible. The source(s) of nitrogen and dominant process mechanisms can be inferred from $\delta^{15}N$ signatures only if taking into account that sources may be mixtures that have undergone a number of transformations, each with an associated fractionation value (Robinson 2001, Rydin & Jeglum 2006, Pardo & Nadelhoffer 2010). As a tracer, $\delta^{15}N$ signatures may allow inferences about the source(s) of nitrogen, if they have significantly different isotopic signatures, possible pathways, and dominant process mechanisms (Rydin & Jeglum 2006).

Isotopes of Carbon (^{13}C, ^{12}C)

Quantifying carbon sequestration, sources and sinks, methane flux, and DOC export continues to be of interest where effects of changes in climate, land-use, and depositions of carbon and nitrogen are uncertain (Fraser *et al.* 2001b, Schiff *et al.* 1997). As such the carbon cycle in peatlands has been extensively studied and is conceptually defined. But as with nitrogen, carbon cycling is dynamic, and temperature- and pH-dependent. Decomposition, respiration, uptake, flushing or sorption occur simultaneously, complicating the delineation of carbon flux (Schiff *et al.* 1997). Isotopic signatures and fractionation factors are useful in interpreting dominant processes, sources, and sinks. Distinct $\delta^{13}C$ ranges have been tabulated from empirical (for example, Kendall & McDonnell1998) and theoretical evidence (Figure 2 following Clark & Fritz 1997).

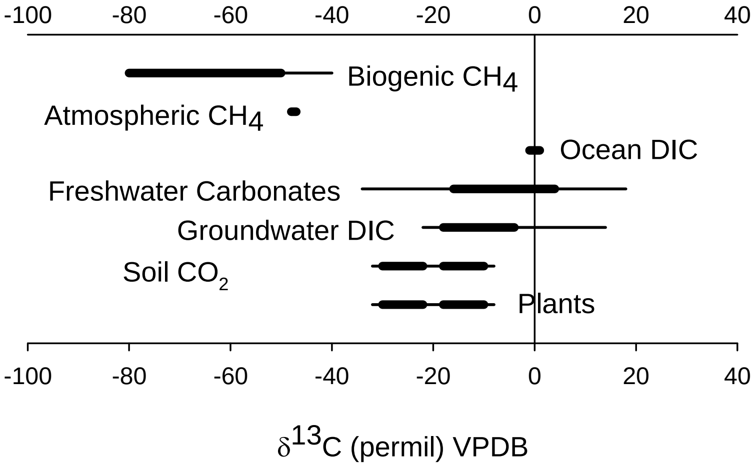

Figure 2 Comparison of $\delta^{13}C$ ranges for carbon source materials. Ranges of $\delta^{13}C$ for plants, soil carbon dioxide, groundwater dissolved inorganic carbon (DIC), freshwater carbonates, ocean DIC, atmospheric and biogenic methane, following Clark & Fritz (1997, Figure 5-1). VPDB, Vienna Pee Dee Belemnite.

Groundwater DIC typically has $\delta^{13}C$ values between -16 and -11 ‰ (Mook 2000), though values between -22 and 18 ‰ have been reported (Figure 2). In the oxidation of plant matter, fractionation effects are minimal so that the ratio $^{13}C/^{12}C$ (DIC) is essentially the same as the ratio of the parent material (Kendall & McDonnell 1998). However, anoxic degradation of plant matter has measurable fractionation factors. For example, $\delta^{13}C$ of DIC derived from methanogenesis has positive values such as 10 ‰ (Kendall & McDonnell 1998). If reduction of sulphate is the primary process, DIC is enriched in $\delta^{13}C$ by 5 ‰ relative to the parent plant matter $\delta^{13}C$ (Kendall & McDonnell 1998). Depth profiles and seasonal changes in $\delta^{13}C$ of DIC may reflect both rate and pathway; however, fractionation effects due to reactions with the gas phase, during dissolution and assimilation, and with changes in pH need to be taken into account (Clark & Fritz 1997). For example, dominant carbonate species shift with changes in pH: $\delta^{13}C$ of DIC increases from -24 to -21 ‰ as pH increases from 4 to 6 (Clark & Fritz 1997). Diffusion of CO_2 also results in fractionation as lighter molecules preferentially diffuse (Christensen 2007 in Wallin *et al.* 2013).

Isotopes of Particulate Matter

Particulate Organic Matter (POM) contains carbon and nitrogen. The ratio C:N changes as a function of litter quality and stage of decomposition. Peatland bulk vegetation has a C:N ratio > 30 (Malmer & Holm 1984). Relative rates of C and N mineralization and sequestration result in changes to the C:N ratio (Belyea & Warner 1996). A decreasing ratio occurs during decomposition, where N accumulates in the microbial biomass *in situ* while C is lost due to respiration. The differential uses of heavier isotopes in aerobic and anaerobic degradation affect $\delta^{13}C$ and $\delta^{15}N$ values of POM. Initially, the carbon isotope signature in plants is determined mainly by the photosynthesis metabolic pathway. Values of $\delta^{13}C$ for C3 plants (including peatland vegetation) range from -26 to -32 ‰ (Figure 2). Some variability in values would be due to temperature, humidity, moisture regime or nutrient availability for a given growing season (Engel *et al.* 2010). The initial nitrogen isotope signature is less well defined, and affected by source nitrogen isotopic values and assimilation pathways (nitrate or ammonium uptake). Dry and wet nitrogen deposition may be regionally and locally variable and so inputs and their $\delta^{15}N$ values may span a wide range (Pardo & Nadelhoffer 2010).

Methanogenesis

Methane (CH_4), a greenhouse gas, is sequestered in and released from wetlands. Oxidation (decomposition of organic matter) and respiration occur actively in the near-surface environment. In peatlands at depth, labile organic carbon is finally mineralized to CO_2 or CH_4: in such anoxic environments, biogeochemical reactions are mediated by the presence of microbe niche communities (Rosenberry *et al.* 2006). Anaerobic methanogenesis occurs predominantly by CO_2 reduction ($CO_2 + 4H_2 \rightarrow CH_4 + 2H_20$) in bogs and poor fens (Hines *et al.* 2008, Siegel *et al.* 2001) but by acetate fermentation ($CH_3COOH \rightarrow CH_4 + CO_2$) in fens, although the pathways were found to vary seasonally at a Michigan study site (Avery Jr. *et al.* 1999). Prevalence of methanogenesis by CO_2 reduction was inferred from acetate accumulation and heavier $\delta^{13}C$ of porewater methane; conversely, methanogenesis by acetate fermentation was inferred from declining acetate concentrations and lighter $\delta^{13}C$ porewater methane signatures (Avery Jr.

et al. 1999). Aerobic methanogenesis by acetate cleavage follows a pathway that does not affect the isotopic signature of the porewater, but anaerobic methanogenesis by CO_2 reduction increases the δ^2H value of the porewater due to preferential use of the lighter isotope (^1H). Siegel *et al.* (2001) compared enrichment of porewater due to methane production in a bog and in a landfill. Evidence for methanogenesis by CO_2 reduction was available at both locations so enrichment in δ^2H for porewaters was expected. Enrichment for δ^2H of porewater samples was quantified based on how far along the δ^2H axis samples plotted above the LMWL in δ^2H-$\delta^{18}O$ space. The enrichment for porewater δ^2H was between +6 ‰ and +11 ‰ at the bog and +70 ‰ at the landfill, the latter due to higher methane production.

2.5. Hydrology of Boreal Wetlands

Hydrology studies are traditionally concerned with a watershed or basin that has a well-defined boundary, generally delineated by topography (Dooge 1968 in Devito *et al.* 2005). More recently studies suggest that the actively contributing area of wetlands is variable in extent (by area) and function (discharge or recharge) and not satisfactorily predicted by topography (Devito *et al.* 2005). Instead, factors defining the functioning of hydrologic response units may be more effectively considered in the following order of importance (Devito *et al.* 2005): climate, bedrock geology, surficial geology, soil type and depth (including wetlands), and topography and drainage networks.

Some general remarks regarding the anticipated hydrologic functioning of Boreal wetlands in the AOSR are based on the classification scheme of Devito *et al.* (2005). The regional climate pattern is such that snowmelt is a significant input to the hydrologic budget, and precipitation usually exceeds evaporation (a pattern that facilitates the occurrence peatlands). Typically storage, uptake and vertical flow is expected to be of greater importance than runoff; however, in wet years runoff and lateral flow is expected to dominate. Bedrock in the AOSR is generally permeable and groundwater flow networks act at local, intermediate and regional scales (Devito *et al.* 2005). The connectivity within and among landscape units is affected by peatland depth and type and local surficial geology underlying the peatlands. Devito *et al.* (2005) caution that catchment area boundaries (defining areas that are hydrologically connected) are not static. Hydraulic conductivity in peatlands is anisotropic and varies spatially and temporally. The physical property also varies with antecedent moisture conditions (AMC) as porosity and compressibility change in response to the weight of saturated near-surface layers (Belyea 2009, Rydin & Jeglum 2006).

Early hydrologic understanding of peatlands was grounded in conceptual models of peatland formation (Belyea & Baird 2006). Prior to work by Siegel, Glaser and Hill (e.g. Siegel 1988, Siegel & Glaser 1987, Siegel *et al.* 1995, Hill & Siegel 1991), peatlands were often considered to have neither hydrologically active nor quantitatively significant subsurface or groundwater components. In both the groundwater mound hypothesis (Ingram 1982) and the bog growth model (Clymo 1984), an active (acrotelm) layer was compared to an inactive (catotelm) layer and differentiated based on hydrologic function and productivity. The anoxic waterlogged peat was thought of as effectively stagnant and non-transmittive. The two layers - acrotelm and catotelm - remain popular terms but their original definitions based on Clymo (1984) arguably do not apply (Morris *et al.* 2011). More general terms such as active/inactive, oxic/anoxic or mesic/humic are proposed as adequate descriptors (Morris *et al.* 2011), while hot and cold spots or moments would support conceptual modeling of heterogeneous complex biogeochemical processes and variable hydrologic connectivity (Morris *et al.* 2011).

Near-surface waters do recharge to depths below the acrotelm/catotelm interface. Siegel (1988) and Siegel & Glaser (1987) compared time series of depth profiles of conductivity, calcium concentrations, and $\delta^{18}O$. The comparison illustrated that infiltration of precipitation does occur to significant depths in bogs and fens, diluting the solutes present due to groundwater discharge. Recharge and discharge regimes enable the redistribution of nutrients within the peat profile, and the significance for biogeochemical processes is as yet unknown. Drexler *et al.* (1999) similarly combined hydrochemical analyses with hydrological data, but at a fine spatial and temporal scale, showing that flow regimes are variable at fine spatiotemporal resolutions. Levy *et al.* (2013) studied the depth profiles of porewater isotope signatures of samples from fen and bog landscape units, and showed that, based on the isotopic labelling of groundwater and precipitation, surface water infiltrated to depths of 1.5 to 3 m.

Among landscape units connectivity is variable in terms of spatial extent and flux, in part controlled by the compressibility and storativity of peat. Antecedent moisture conditions (AMC's) affect hydraulic conductivity and storage capacity is highest for the near-surface peat. The interaction between hydraulic conductivity and storage capacity serves to regulate to some extent the water level (Belyea 2009): as the water inputs increase initially, a large storage capacity allows a large volume of water to be stored with a small change in water level. As the water levels increase, the near-surface, which has a high saturated hydraulic conductivity, becomes increasingly a zone of active discharge. So connectivity of wetlands is affected by antecedent moisture conditions and microtopography (Martin 2011). During sustained dry periods, subsurface flow dominates and may or may not be connected to adjacent landscape units. However, during sustained wet periods, ponded water may spill out of depressions/hollows creating overland runoff connectivity with adjacent landscape units. Expansion and connectivity of saturated peatland surfaces significantly control runoff, which affects the regional hydrologic budget (Devito *et al.* 2005).

2.6. Selected Research near the AOSR

Vitt & Chee (1990) studied surface water chemistry of 23 fens in central Alberta and found pH, alkalinity, conductivity, magnesium and calcium concentrations differed among peatland types whereas nutrient concentrations (of nitrates and phosphates) did not vary significantly with peatland type. Such relationships between surface water pH, cations and peatland type had been well documented (for example Shotyk 1988 or Sjörs 1952). However, anions and nutrients had been investigated infrequently (Vitt & Chee 1990). Also, studies with a temporal and vertical spatial gradient component were rare (Vitt *et al.* 1995). To address the knowledge gap, Vitt *et al.* (1995) investigated spatial and temporal variability of pH, alkalinity, conductivity, nutrients and major ions along a bog - rich fen gradient in Alberta. They sampled surface and sub-surface water (0.5, 1.0 and 1.5 m depths) of five peatland types, every week in 1989 and every two weeks in 1990. This site characterization of ML landscape units in this thesis is complementary to the seasonal variation study by Vitt *et al.* (1995) in that it investigates spatial and temporal trends, though at a lower temporal and higher spatial resolutions.

Whitfield *et al.* (2010) studied water chemistry variability within and among three peatland complexes. The study sites were located in two catchments, to the south and northeast of Fort McMurray, Alberta. The dominant processes affecting surface water chemistry were identified as cation exchange, biotic cycling, microbial reduction, evaporation and groundwater discharge, where "hydrological influences … are difficult to discern owing to variable spatial influence" (p.2153). Given the spatial and seasonal variability, Whitfield *et al.* (2010) cautioned against the generalized characterization of peatlands based on few samples at few sampling locations.

Long-term (> 10 years) research projects include HEAD (the hydrology, ecology and disturbance project) at Utikuma Lake or FORWARD (forest watershed and riparian disturbance) at Swan Hills. HEAD was initiated in the Utikuma Lake area, about 100 km north of Slave Lake, central Alberta. Here, Ferone & Devito (2004) studied the connectivity among upland, pond, and wetland landscape units at wetland complexes. The interactions are counter-intuitive as wetlands recharge hillslopes in the sub-surface during dry periods; event-based surface runoff from uplands contributes water to peatlands. They described the connectivity as "dynamic", as responses to wet and dry precipitation regimes were contrasting. Petrone *et al.* (2008) found that compressibility and subsidence of peat was of little significance to hydrological connectivity among landscape units in the region. Resistance to compressibility and subsidence was linked to the frost cycles and degree of decomposition.

Hydrologic connectivity among mineral uplands and lowland freshwater wetlands in the Western Boreal Plain is considered "sporadic and sensitive to infrequent wet periods" (Scarlett & Price 2013, p.2). Less well documented in the region is the hydrologic connectivity between freshwater bogs and saline wetlands. To address this knowledge gap, Scarlett & Price (2013) investigated the persistence of a freshwater bog adjacent to a saline fen, located about 18 km south of Fort McMurray, Alberta. Movement of saline water from the fen into the bog was generally precluded by a groundwater mound maintained by local substrate topography (a ledge of low conductivity clay). Transmissivity, varying with wetness, was generally higher in the bog along the fen margin, so water was directed away from and around the bog. During high water table elevations in exceptionally wet periods however, hydraulic gradients indicated the potential flow of water from the saline fen to the bog. The comparison of fen and bog water chemistry showed that intrusion of salt water had not effected long-term changes in the bog water. Scarlett & Price (2013) iterated the influence of plot-scale heterogeneities found in substrate topography on hydrological controls. They also concluded that higher water levels due to warmer wetter conditions expected with climate change may change hydrologic connectivity among wetland landscape units, altering water chemistry and thus ecology.

2.7. Connectivity

The exchange of water between groundwater and wetlands may shift from recharge to discharge and is related to the precipitation regime and specific yield of the landscape units (McLaughlin & Cohen 2013). Hydrologic connectivity then is a function of water table response to precipitation events and antecedent moisture conditions (for example, Devito *et al.* 1997). Under sustained dry conditions, groundwater flow may be directed from wetlands into uplands; during sustained wet conditions or sufficiently large precipitation events, groundwater may be directed from the uplands into the wetlands (Devito *et al.* 1997, McLaughlin & Cohen 2013). Nutrient flux and cycling is influenced by these variable hydrological linkages and also by biogeochemical processes which are affected by temperature and residence time.

Responses to changes in climate, pollution, and land-use are typically modelled using lumped parameters for wetland-rich areas (Price *et al.* 2010). Extrapolations based on such lumped landscape parameters are limited by a generalized or compartmentalized approach in which the variable connectivity within an ecosystem is not yet fully understood (Mitchell & Branfireun 2005). Scenarios to be run for the AOSR have an uncertainty that is further compounded by the limited number of site-specific studies that investigate the sources, sinks, and transformations of nutrients and major ions at a small (plot) scale (Fraser *et al.* 2001a, Whitfield *et al.* 2010). The spatial and temporal heterogeneity and hydrologic connectivity of landscape units within wetland-rich peatland areas in the AOSR is still poorly understood (Price *et al.* 2010), but is a requirement for identifying and quantifying hydrogeochemical and nutrient fluxes.

Developing fluxes and delineating connectivity is possible because the composition of water samples is a function of the contributing sources, physical processes, and chemical processes (Vitt *et al.* 1995). Exchanges among waters and their respective interactions with organic matter or inorganic substrates are variable, spatially and temporally; so observing changes of geochemical profiles in time is a useful tool in investigation relations among and processes within waters (Shvartsev *et al.* 2012). Tracers useful in determining connectivity include isotopic signatures of water and elements, and parameters such as temperature, conductivity, pH, and geochemical concentrations (Price & Waddington 2000, Price *et al.* 2005).

2.8. Methodology

Fieldwork related to this thesis was conducted during the open-water season: in June and August 2011, and in May, July, and September 2012. Field campaigns also included a snow survey (March 2012), and spring melt/freshet sampling (April 2012). Instrumentation at each site consisted of: a monitoring well network, rain collectors, weirs at the outflow, and meteorological stations. During fieldwork, hydrological (water amount) and water chemistry (water quality) data were collected.

2.8.1. Site Description

The two study sites JPH and ML are situated 45 km north and 100 km south of Fort McMurray, Alberta respectively. The sites are in the Boreal plains ecozone, and have a continental Boreal climate. Mean temperature at Fort McMurray ranges from 16.6 °C in July to −19.8 °C in January. Average annual precipitation is 464 mm, of which 342 mm is rain in the summer season (Environment Canada 2012).

The forested uplands of JPH, at an elevation of 333 m asl (LiDAR), are dominated by jack pine (*Pinus banksiana*) and lichen (*Cladina mitis*). The wetland is classified as a rich fen (Vitt D, Pers. Comm. 2012). The upland soil is well drained, dry and nutrient poor (Bovar 1996). The soil is considered acid sensitive, with low pH and base saturation (AMEC 2002). The sandy substrate is of glaciofluvial origin, overlying non-calcareous, non-saline glaciofluvial deposit. Mean hydraulic conductivity of $4.35*10^{-5}$ ms^{-1} and

$2.08*10^{-6}$ ms^{-1} were measured at upland and deep fen sites respectively (Vallarino 2014). The near-surface deposit is underlain by the (consecutively deeper) Grand Rapids, Clearwater, Fort McMurray and Devonian formations (Turchenek & Lindsay 1982). The site is part of the Muskeg River watershed which drains into the Athabasca River. Though the JPH site had been considered relatively unaffected by industrial development, it is subject to higher emission depositions than ML, and is near land ear-marked for development. In 2013 the upland west of the fen had been logged.

ML, at an elevation of about 699 m asl (LiDAR), is a peatland complex in the Mariana Lakes area located on the Stony Mountain plateau. The upland sites at ML are dominated by jack pine. The wetlands, dominated by sphagnum, consist of bog, wet fen and dry fen areas (Graham 2012). The peatlands of Mariana Lakes are about 5000 years old, with 7 to 40 m of peat on top of a clay and mineral rich substrate (CEMA, Pers.Comm. 2011): Nicholson & Vitt (1990) had conducted detailed paleoecological study at a peatland complex of the Mariana Lakes area (55.90°N, 112.07°W). Peat formation (as a floating mat) on mineral-rich lake basins was initiated about 8200 BP. Fen areas established around 5800 BP and eventually remaining drainage paths also paludified around 3000 BP. The 4 m peat cores demonstrated this succession. Cores had limnic sediments at depth, layers of unstructured peat debris at mid-depth and highly fibrous remains nearer the surface. Nicholson & Vitt (1990), based on their understanding of the Mariana Lakes peatland development, determined that the influence of groundwater would have been continuous while the establishment of ombrotrophic areas is relatively rare and recent. Hydraulic conductivity within the ML wetland complex is variable, partly due to variable degrees of compaction, decomposition and plant composition in the peat profile. Hydraulic conductivity ranged from 10^{-6} ms^{-1} to 10^{-9} ms^{-1} (Vallarino 2014). The surface geology at ML consists of a glacial till layer (sandy outwash with some clay) that is 30 – 180 m deep (Ozoray & Lytviak 1980). Bedrock consists of the La Biche sandstones and shales (Upper and Lower Cretaceous marine shales) which overly Pelican, Jon Fou, Grand Rapids, Clearwater and finally McMurray formations (Nicholson 1987). The study site was selected as it is unaffected by emissions related to developments in the AOSR. Highway 63 and a pipeline corridor run north-south to the west of the site. The service road used to access the study site continues westward past the peatland complex.

2.8.2. Instrumentation

Monitoring Well Network

The spatial configuration of the monitoring well network was designed to facilitate the sampling of multiple transects that i) cross target landscape units (upland, fen, and bog), ii) follow dominant flowpaths (as identified during project scoping), and iii) avoid interference with, but are near experimental nitrogen application sites.

JPH, about 0.30 sq kms, is instrumented with 11 piezometer nests and 7 water table wells (Figure 3). ML, approximately 0.42 sq kms, is instrumented with 19 piezometer nests and 18 water table wells (Figure 4). Piezometer nests and wells at both sites were installed in June 2011. Location and elevations were surveyed in June 2011; a complementary survey was completed in August 2011 to confirm data. Elevations were also compared with LiDAR maps generated from survey flights over both sites in 2011. The position, elevation, depth, and landscape unit of each piezometer and well are tabulated in Appendix A (JPH) and Appendix C (ML).

Deepest piezometers have stainless steel drive-point piezometer tips (Solinst^{TM} 615) attached to lengths of 0.75 inch diameter galvanised steel pipe. Shallow piezometers and water table wells have PVC standpipe piezometer tips (Solinst^{TM} 601) attached to 1.25 inch diameter PVC pipe. Piezometer tips are slotted, screened, and fitted with polyethylene sample tubing that is fed through the entire length of steel or PVC casing. By design, water table wells are perforated along their entire subsurface length and not fitted with sample tubing. A Nytex^{TM} mesh is sewn to snugly fit the length of the well, screening out sediment (following a University of Waterloo prototype; Tattrie 2011).

The wells were installed using a portable hammer drill. Changes in substrate were experienced as a difference in resistance to installation. The substrate at JPH and ML is described based on the installation observations (Tattrie K, Fieldbooks 2011). JPH upland substrate is sandy up to a depth of ~ 8 m, then soft, with the exception of a small hard area at 8 m for JPHP05. JPH fen substrates are soft at all depths except at JPHP08 where the substrate is increasingly hard at depths beyond ~ 6 m. ML upland substrates (nests MLP01, MLP02, MLP07, MLP14) are described as till (< 1.1 m), then sand (1.1 – 1.65 m) then till (> 1.65 m). ML edge sites (nests MLP03, MLP06, MLP13) consist of silty sand (< 2 m), silty clay (2 – 4 m) then harder clay (> 4 m). ML peatland sites are described as peat for the shallowest well (< 2.33 m), soft substrate for the mid-depth well, and then hard till for the deepest well. The deepest wells are installed at different depths in the complex, indicating a non-uniform structure. Deepest wells increase with depth along the fen – bog gradient.

Water levels need to be measured relative to a fixed level – the top of the piezometers and wells. The deepest piezometer is assumed to maintain its fixed elevation as it is driven into the mineral substrate at depths of 4 m or more. At ML, shallow wells in the wetland were secured with steel clamps to a length of rebar driven into the substrate, and, within a nest of wells, the displacement of a shallow well could be noted relative to the deepest well as wells in a nest were installed side-by-side and had equal stick-up heights. Boardwalks were placed along main paths and platforms were placed at sampling locations, in an effort to reduce peatland disturbance. Platforms distribute the pressure exerted by field personnel and equipment, which otherwise may affect water level readings or compromise the integrity of the wetland structure.

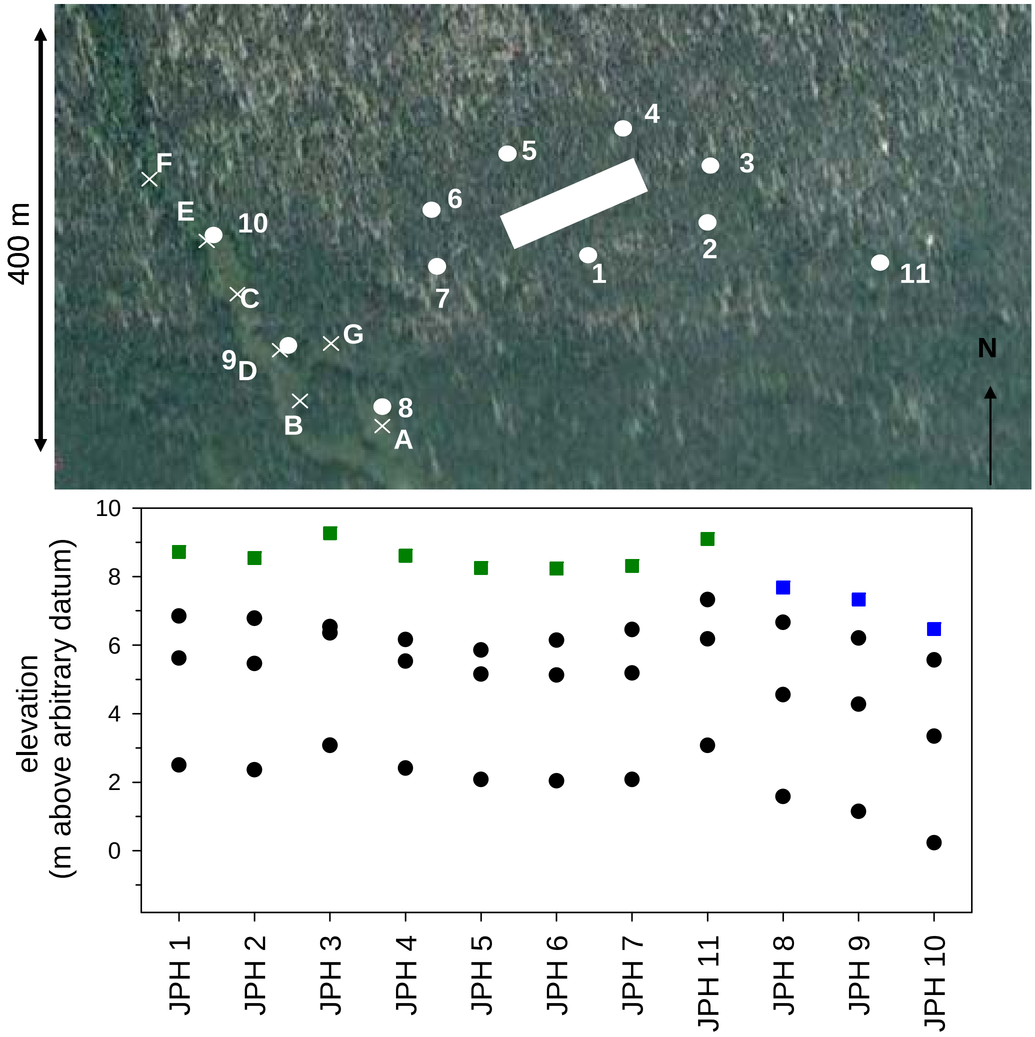

Figure 3 Instrumentation at JPH. Top: Location of piezometer nests 1 – 11 and water table wells A – G relative to the amendment site (white solid). Bottom: Well depths (circles) relative to the surface elevation (squares), in m above an arbitrary datum. Upland – green, rich fen – blue. Image source: Google™earth.

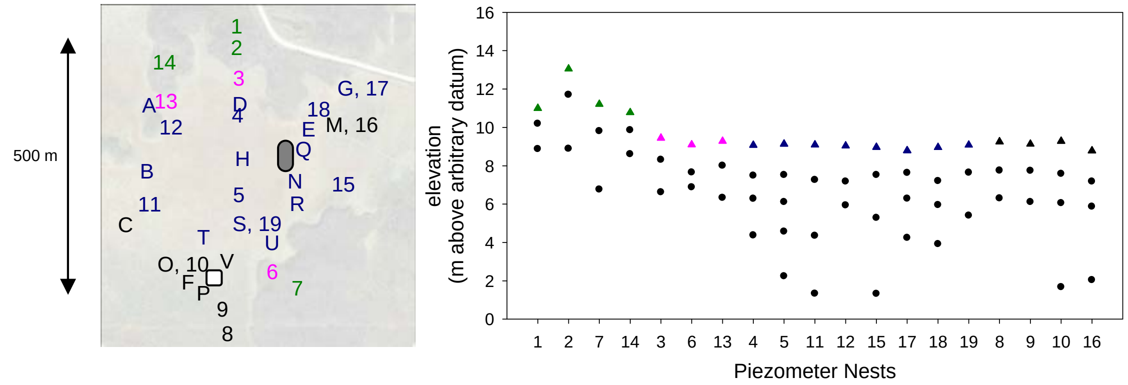

Figure 4 Instrumentation at ML. Left: Location of piezometer nests 1 – 19 and water table wells A – H & M – V relative to the amendment sites in the bog (white solid) and fen (grey solid). Right: Well depths (circles) and surface elevation (triangles), in m above an arbitrary datum. Upland – green, upland edge – pink, fen – blue, and bog – black. Image source: Google™earth.

Rain Collectors

Rain collectors, for bulk rain and precipitation event samples, were installed at both sites at the beginning of every open-water season. To minimize interference by wildlife and interception by vegetation, multiple rain collectors were installed and secured above ground in open spaces. Rain collectors were modified to minimize evaporation which would change the isotopic signature of water. An 8 inch diameter funnel was inserted into to a 0.75 inch diameter tube that extended, with minimal clearance, to the base of a 10 L container. Connections were sealed with silicone and the 10 L jug was vented via 3 m of coiled 4 mm tubing inserted near the top of the jug. Precipitation sample water was thereby effectively isolated from exchange with water in the atmosphere.

Weirs

V-notched weirs were installed in 2011 at sites selected during initial project scoping. Water is routed across the v-notch weir and the stage height is measured at a known height and distance from the weir. A measure of discharge is calculated based on the physical configuration of the weir. At JPH a weir was installed downstream from the rich fen in a channel with variable flow. Flow was low during initial fieldwork campaigns and, with high flow, a secondary channel routed water around the weir. At ML a weir was installed where the peatland complex discharges into a creek. A stilling well was installed behind the weir and water level (stage height) readings were continuously recorded by an Odyssey^{TM} capacitance data logger until the weir was overwhelmed after spring melt 2012.

Meteorological Stations

Meteorological parameters were measured throughout the year by automated solar-powered Campbell Scientific meteorological stations. Two meteorological stations, located in the upland and fen, were installed at JPH in May 2012. For 2011, data was requested from the meteorological station installed near JPH, maintained by Terrestrial Environmental Effects Monitoring (TEEM). Two meteorological stations, in the fen and the bog, were installed at ML in 2011, disassembled for the winter season, and re-installed in May 2012. The Campbell Scientific, Inc. data logger (CR23X), mounted on a tripod, records and processes the readings from the following instruments that were installed: a relative humidity sensor, net radiometers (incoming and reflected radiation), an anemometer (propeller and vane for wind speed and direction), a barometer (air pressure), thermisters (ambient air temperature, at two heights), thermocouples (soil temperature, at three depths), and a tipping bucket (precipitation amounts).

2.8.3. Data and Sample Collection

Hydrological Data

Water levels in piezometers were recorded at the beginning and end of each field campaign using a Solinst^{TM} water level meter marked in increments to the nearest mm. Water levels in water table wells were continuously recorded by Odyssey^{TM} capacitance data loggers in hourly intervals during the winter and every ten minutes during the open-water season. Hydraulic conductivity was determined from the recovery of water levels in slug and bail tests (Freeze & Cherry 1979).

Hydrogeochemical Data

Water samples were collected on a number of dates during the open-water season to investigate the variability of geochemical and stable isotope signatures. Subsurface water samples were collected from piezometer nests at 2 or 3 depths; shallow surface water samples were collected from water table wells, weirs and culverts; and event and bulk precipitation samples were collected from rain collectors. The number and types of analyses completed in the field and number of samples submitted to laboratories are tabulated in Appendix B (JPH) and Appendix D (ML). Precision, detection and quantification limits are included with the data tables in Appendix I. Quality control measures included: following field sampling, sample storage, and shipping procedures; running duplicates, standards and blanks; considering lab-specific data quality control; calculating charge balance error for major ions (Oliver *et al.* 1983); correcting conductivity for hydrogen ions (Sjörs 1952); sealing rain collectors to minimize evaporation; and maintaining and calibrating equipment.

Sample collection and measurement of physical parameters occurred after the manual measurement of water levels in piezometers. A portable Geotech Geopump^{TM} peristaltic pump powered by a rechargeable 12V battery was used to extract sample water via polyethylene tubing inserted into the well tip. The piezometer and water table wells were purged and allowed to recharge prior to sample collection. The tubing was thus rinsed with the sample water prior to sample collection and measurement of physical parameters. Sample vials were also pre-rinsed three times with sample water. The polyethylene tubing was rinsed with deionized water after use at each sampling point. However, rinsing of tubing and vials with sample water was omitted (and only deionized water was used) when a particular piezometer site did not yield much sufficient volume.

Temperature, pH, Eh, and conductivity were recorded in the field using Thermo Scientific Orion Star^{TM} hand-held meter and probes. The meter, which autocorrects for temperature, was calibrated routinely for pH and conductivity, using pH buffer solutions (pH 4.01, 7.00, and 10.00) and a conductivity standard (1413 μS/cm). Redox potential (Eh) is measured relative to zero set for the H^+-H_2 redox couple - the standard hydrogen electrode (SHE). A Zobell solution is used to calibrate the Eh probe (Nordstrom 1977, Nordstrom & Wilde 2005). A flow-through cell was used to allow for equilibration of probes with each water sample. The flow-through cell ensured that the anaerobic condition of a sample was maintained during readings. Also, pumping speed was regulated so that recharge rate was not exceeded to maintain steady water flow without introducing air bubbles.

Samples for the analysis of particulate matter were collected in opaque 1L HDPE bottles pre-rinsed with sample water. If the sampling location yielded enough water, the bottles were overfilled to minimize headspace. Samples were vacuum-filtered within 3 weeks in 2011 and within 48 hours in 2012. Particulate matter was captured on 45 µm glass carbon filters, which had been baked at 400 ºC for 4 hours to avoid sample contamination. The samples (filters) were stored in sterile Petri dishes and oven-dried at approximately 25 ºC, overnight or longer. Few results were available for JPH. Filtering greater volumes of sample water did not improve data yield. Instead, data return was maximized by refining the thresholds previously set for the mass spectrometer (further discussed in Appendix E).

In 2011 water samples were collected in opaque HDPE bottles, kept on ice in coolers, stored at 4 ºC, and filtered within 48 hours (using vacuum filtration through 45µm Whatman polydisc filters). Once filtered, every sample was split for shipment to various laboratories. Remaining (filtered) sample was processed for alkalinity using a Hach digital titration kit (Model 16900) and for major ions using a Hach Colorimeter (Series DR/890) and associated procedures (Hach 2006, 2009). Samples with high sediment or organic content took a long time (> 2 hours) to filter, which potentially exposed sample water to the atmosphere. Exposure of anaerobic porewater samples to oxygen in this way was thought to have compromised the integrity of the samples as redox-sensitive species will undergo redox reactions and organic matter will oxidise.

Instead, samples were filtered inline in 2012. Mostly, medium-high turbidity filters (high capacity disposable 45µm Geotech dispos-a-filter^{TM} disposable filters) were used. Some piezometers had small sample yields, in which case 45 µm inline syringe filters (Whatman) were used. So samples were split at the time of sampling. Using inline filters introduced a sense of efficiency and reduced sample handling as, at the same time as measuring physical parameters and collecting samples, major ions were determined by colorimetry at the sample site. As outlined in the Hach DR/890 colorimeter procedures manual (Hach 2009), redox sensitive species, notably sulphide and nitrite, must be analysed immediately; others, such as ammonium, iron or phosphate must be either analysed or preserved as soon as possible; and nitrate should be analysed within 24 - 48 hours. Samples were analysed for alkalinity by digital titration (Hach 2006) at the fieldwork staging site within 48 hours.

Water samples were stored in tightly sealed HDPE vials (clear, except for DOC samples which required opaque bottles). Vials were filled to minimize headspace, and the samples were preserved (i.e. kept at 4 ºC and samples for cation analyses were also acidified with 16M nitric acid). Samples were shipped on ice in coolers to various laboratories for analyses.

Stable isotopes ^{2}H and ^{18}O of water and ^{13}C of DIC were analysed at AITF, Victoria (Delta V Advantage). Results are reported relative to Vienna Standard Mean Ocean Water (VSMOW) for water isotopes and Vienna Pee Dee Belemnite (VPDB) for carbon isotopes. Stable isotopes ^{15}N and ^{13}C of particulate matter were analysed at AITF, Victoria (isotope ratio mass spectrometer (IRMS) Thermo Finnigan 253). Samples for stable isotopes ^{18}O and ^{15}N of dissolved nitrates were run at the Isotope Science Laboratory, University of Calgary (IRMS Thermo Finnigan Delta V). Dissolved organic carbon (DOC) was analysed at AITF, Vegreville (segmented flow analysis – acid digestion then persulphate UV digestion, followed by color loss measurement). Major ions and trace metals were run at the Earth and Environmental Sciences Department, University of Waterloo (on ICP-MS X or ICP-OES iCAP 6500 and IC-OH or IC-CO3 systems respectively).

Nitrogen Isotope Data

An objective of the CEMA study is to delineate the fate and behaviour of nitrogen. As tracer, $\delta^{15}N$ signatures may allow inferences about the source(s) of nitrogen, possible pathways, and dominant process mechanisms (Rydin & Jeglum 2006). So porewater samples, amendment samples, and atmospheric nitrogen samples from resin exchange collectors were analysed for $\delta^{15}N$ of nitrates. In 2011 and 2012, concentrations of nitrates in porewaters were too low for isotopic analysis (Taylor S, Pers. Comm. 2012). Nitrogen from the amendments would likely not have been detected as nitrate in porewaters in the first or second year of application as peatlands are nitrogen-limited and nitrogen is generally retained until saturation is reached (Rosen *et al.* 1992, Xing *et al.* 2010). And results from accompanying studies indicate that nitrate from the applications was not detected within experimental plots within 24 hours (CEMA, Pers. Comm. 2012). However, in future campaigns, samples for $\delta^{15}N$ analysis of ammonium will be submitted as ammonium concentrations were above the required minimum concentrations for $\delta^{15}N$ analysis. Further, wetlands have been classified as a sink for inorganic nitrogen – which is efficiently sequestered/immobilized – and as a source of organic nitrogen (Petrone *et al.* 2007). So dissolved organic nitrogen (N-ammonia and Total N) in porewaters will be analysed in future sampling campaigns, both for concentration and $\delta^{15}N$. The modifications to the sampling regime are expected to yield useful information regarding nitrogen cycling at the study sites.

2.8.4. Data Analysis

The database was compiled and managed in Microsoft Excel. Transform functions and filters were used to generate desired data subsets for use in other computer programs. As a first approach, spatial and temporal variability of data were explored using graphing applications in SigmaPlot and AquaChem. For example, depth profiles and isoconcentration contour maps conveyed spatial and temporal trends, scatter plots showed correlation among parameters, box plots gave an indication of skewdness and variance, and trilinear diagrams grouped water types. Descriptive statistics (such as average, range, variance, correlation) were generated in both SigmaPlot and AquaChem. Multivariate statistical methods, using SPSS® (IBM® SPSS® Statistics 20), such as principal component analysis (PCA), were applied to reduce variables to the few components controlling the hydrogeochemistry at the study sites.

Data Corrections

Guler *et al.* (2002) reviewed water geochemistry data management, including the ways missing or non-detect data are treated. Generally, data is screened to render the database useful, for example in terms of presenting data (what conventions are used by the target audience?). Data is validated to eliminate systematic errors, for example in considering similar studies (are the data plausible?), in submitting split samples or blanks (is analytical laboratory data accurate?), or in calculating the charge balance error (is the water sample neutral or is an ion missing?). Data may be modeled to expand the database to include parameters that were not measured, for example saturation indices or ion species.

Electrical Conductivity (EC)

All EC data reported for JPH and ML were corrected for pH. Sjörs (1952) presented the formula (2) that is used to correct measured electrical conductivity (EC_{meas}) to account for EC of hydrogen ions (EC_{H}^{+}) (3).

$$EC = EC_{meas} - EC_{H}^{+} \qquad (2)$$

$$EC_{H}^{+} = 3.49 \times 10^{5} \times 10^{-pH} \qquad (3)$$

Systematic Errors

Hach colorimeter nitrate data (2011 and 2012), nitrite data (2011 only) and sulphide data (2011 only) were excluded from statistical analyses due to systematic errors. Hach colorimetry field data for nitrate and nitrite (2011) differed in orders of magnitude from analytical analyses and/or previous fieldwork (CEMA researchers, Pers. Comm. 2012 - 2013). Accuracy and precision of nitrate (and ammonium) were investigated by analysing blank samples and step-wise dilutions of standard solutions. Ammonium results were accurate and precise. However, 2011 and 2012 nitrate data were concluded not significantly different from a background reading due to reagents (further discussed in Appendix F). A reagent correction should have been applied in the field for each new batch of reagents (Hach Colorimeter Procedures Manual, Hach 2009). In 2011, nitrite was analysed using an incorrect program number and sulphide was not analysed immediately as prescribed; so results were invalidated due to systematic error.

Charge Balance Error (CBE)

Data were not excluded based on CBE's found. The error (following Oliver *et al.* 1983) was considered for samples with a full suite of pH, alkalinity, and ion data. Carbonate species concentrations, not measured, were modeled based on pH and alkalinity in AquaChem (Birks SJ, Pers. Comm. 2013). The CBE calculations indicated an anion deficit up to 95 % and a cation deficit up to 87 %. Large errors are typical in dilute samples, where the error is propagated by analytical detection limits and errors (Moncur M, Pers. Comm. 2013). The range of CBE at JPH and ML appears to converge closer to zero as ionic strength of samples increases (Figure 5). Further, in organic rich samples, an anion deficit (a positive CBE) is expected, and attributed to organic charge, which is carried by dissolved organic matter (DOM) but not measured (for example, Whitfield *et al.* 2010). The CBE at JPH and ML may be considered consistent with organic rich and/or dilute samples.

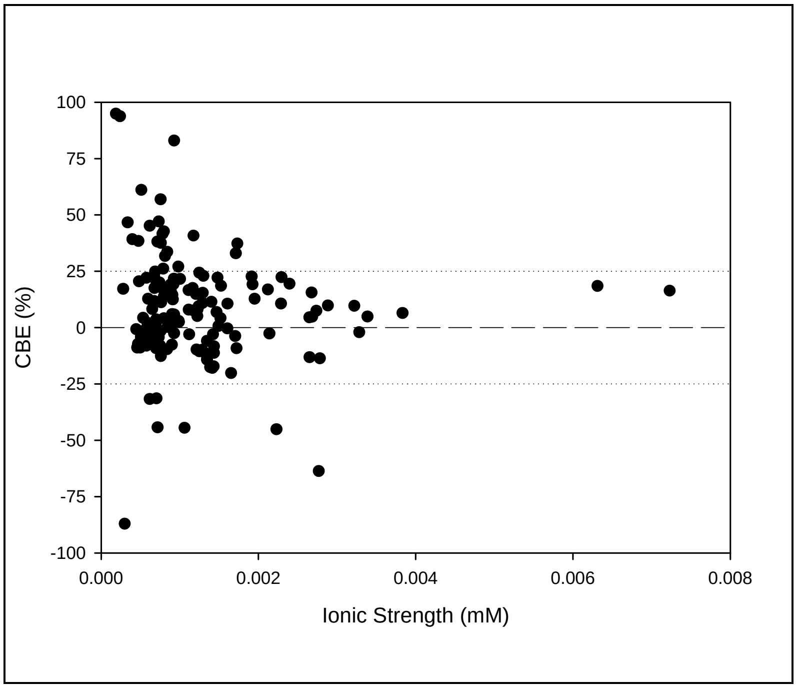

Figure 5 Charge balance error (CBE, %) vs. ionic strength (mM) at JPH and ML. The range of CBE's decreases with an increase in ionic strength. Positive errors were present for 60% of the samples.

2.8.5. Statement to Conclude Research Methods

This study aims to describe hydrological connectivity as characterized by hydrogeochemistry at two distinct sites in the Boreal landscape of the AOSR. Hydrogeochemistry and hydrology (Vallarino 2014) are complementary study streams with a range of inputs and a common end goal, as illustrated by the schematic (Figure 6). The hydrogeochemistry component has two objectives: to characterize the landscape units (objective 1) and provide evidence of hydrological connectivity (objective 2). The analysis of hydrology, meteorology, and isotope data also provides a conceptual understanding of connectivity (objective 2). The two objectives are part of a research framework that addresses the fate and behaviour of nitrogen at the study sites.

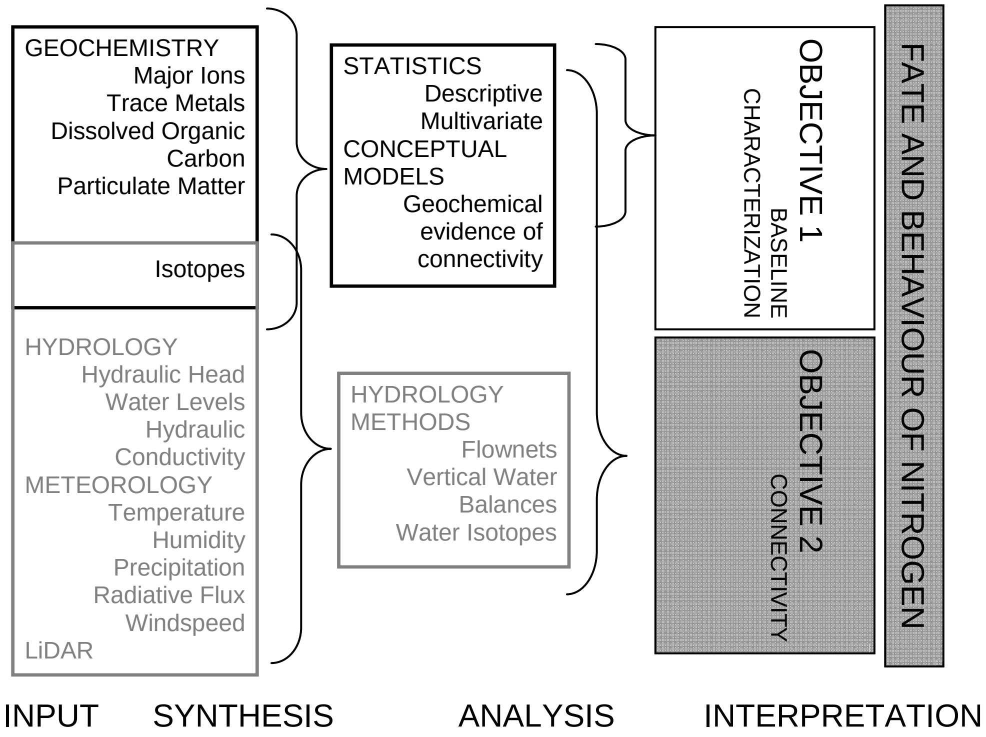

Figure 6 Schematic of the research framework. Concurrent study components, hydrogeochemistry (black) and hydrology (grey), converge to describe the fate and behaviour of nitrogen at JPH and ML.

Chapter 3.
Results – Baseline Characterization

This chapter, in three parts, presents the hydrogeochemical data obtained in 2011 and 2012 (Appendix I). The first section introduces the target landscape units, highlighting *at-a-glance* differences using average data, box plots of a subset of parameters, and water isotopes plotted relative to the global meteoric water line (GMWL) in δ^2H - δ^{18}O space. The second section, the detailed baseline characterization, describes in detail the depth profiles of 2012 hydrochemistry data. In the concluding section, with the aid of Piper plots and multivariate statistics, the research question is revisited: do water samples from the target landscape units have distinct hydrochemistry? This chapter provides a benchmark against which perturbations could be assessed and is the groundwork for discussing connectivity (Chapter 4).

3.1. Landscape Units

Sampling locations (Section 2.8.2. Instrumentation) were distributed in target landscape units, within and among which connectivity is being investigated. The sampling design is thus stratified rather than random, so presenting results based on the target landscape units - JPH upland, JPH fen, ML upland, ML fen and ML bog - follows naturally. Also, peatlands are often considered in terms of two layers: an active/living shallow layer and inactive/decomposed deep layer. To introduce the peatland landscape units JPH fen, ML fen, and ML bog, average data from water table wells (< 0.5 m) are contrasted with data aggregated from shallow and intermediate wells (1.5 m < 4 m). And for the JPH upland landscape unit, average data from shallowest wells are contrasted with data from the deepest wells (Table 1).

Table 1. Average values of a subset of parameters introduce the target landscape units at JPH and ML. Number of samples (n) in italics. JPH upland: shallow (~1.5 m) and deep (~6.5 m) wells are compared. JPH fen, ML fen, ML bog: water table wells (WT) (~0.5 m) are compared with shallow and mid-depth wells (deeper) (1.5 to 4 m). (HC) indicates that Hach Colorimeter methods were used in the field.

Physical Parameters	JPH upland *shallow*	JPH upland *deep*	JPH fen *WT*	ML fen *WT*	ML bog *WT*	JPH fen *deeper*	ML fen *deeper*	ML bog *deeper*
n	*42*	*41*	*35*	*63*	*32*	*30*	*87*	*40*
pH	5.86	6.04	5.74	4.36	4.22	6.00	5.20	5.15
Eh (mV)	146	-65	30	170	183	-153	137	124
Conductivity (µS/cm)	37	90	71	23	23	77	102	94
DOC (mg/L)	2.1	20.3	25.5	48.6	63.2	24.9	70.9	54.5
NO_2 (mg/L)	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
NO_3 (mg/L)	< 0.05	< 0.05	0.11	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
NH_4 (mg/L) (HC)	< 0.02	0.15	0.22	0.08	0.07	0.14	7	7
SO_4 (mg/L)	8.5	2.1	7.2	0.1	0.1	6.0	0.1	0.2
Ca (mg/L)	3.8	8.9	6.2	1.3	1.4	6.8	8.5	7.0
d-excess (‰)	3.7	3.5	3.3	3.5	4.4	2.9	2.9	5.6

Peatland surface waters were generally acidic and dilute, whereas waters from upland mineral soils were characterized by a higher pH and higher conductivity (Table 1). A decrease in pH was observed in WT samples along the rich fen – bog gradient, with pH values of 5.74, 4.36, and 4.22 for JPH fen, ML fen and ML bog respectively. Generally, with depth at all landscape units, pH, conductivity and calcium concentrations increased, and Eh and sulphate content decreased. However, trends with depth among landscape units varied for DOC, ammonium, and d-excess.

The geochemistry of JPH fen was diametrically opposed to both ML fen and ML bog (Table 1). Based on average data, JPH fen, compared with ML fen, had a lower Eh (30 vs. 170 mV), higher conductivity (71 vs. 23 µS/cm), lower DOC content (25.5 vs. 48.6 mg/L), higher nitrate (0.11 vs. < DL) and ammonium concentrations (0.22 vs. 0.08 mg/L), and higher sulphate (7.2 vs. 0.1 mg/L) and calcium content (6.2 vs. 1.3 mg/L). ML bog was comparable within few units to ML fen, except in regards to DOC, which was higher at ML bog (63.2 mg/L) than ML fen (48.6 mg/L). The changes with depth were greater at ML fen (and ML bog) than at JPH fen. At JPH fen, parameters showed little change with depth. For example conductivity increased from 71 to 77 µS/cm and sulphate decreased from 7.2 to 6.0 mg/L; however Eh decreased from 30 mV to -153 mV. Trends at ML fen and ML bog were similar to each other for all parameters except DOC. Measurements of DOC increased from 48.6 to 70.9 mg/L at ML fen but decreased from 63.2 to 54.5 mg/L at ML bog. At depth, ML fen had relatively high conductivity (102 µS/cm), high ammonium levels (7 mg/L), and high calcium content (8.5 mg/L). Similarly, ML bog at depth had high conductivity (94 µS/cm), high ammonium levels (7 mg/L), and high calcium content (8 mg/L). At ML fen and ML bog, Eh decreased slightly with depth (from about 177 to 131 mV), and nitrite and nitrate concentrations remained below DL, and sulphate levels remained unchanged and low (~ 0.15 mg/L) at depth. JPH upland was characterized, relative to the entire data set, by (shallow and deep respectively) a higher pH (5.86 and 6.04), intermediate Eh (146 and -65 mV), intermediate conductivity (37 and 90 µS/cm), low DOC concentrations (2.1 and 20.3 mg/L), high sulphate concentrations (8.5 and 2.1 mg/L), and high calcium concentrations (3.8 and 8.9 mg/L). Though geochemically ML fen and ML bog are fairly similar and in turn different from both JPH fen and JPH upland, trends in d-excess differentiate ML bog from the other landscape units. The d-excess at ML bog increased from 4.4 to 5.6 ‰ with depth, whereas d-excess at JPH fen and ML fen decreased respectively from 3.3 and 3.5 to 2.9 ‰ with depth.

The differences among landscape units and their trends with depth are explored further using box plots. The box plots (Figure 7) show the range of data acquired, which provides a sense of variability due to seasonality, inherent heterogeneity, or both. The box plots in Figure 7 are based on 2011 – 2012 sampling campaigns, include all landscape units, and show each depth category. In Figure 7 landscape units are differentiated by fill color: upland - white, fen - grey and bog - dark grey. Water table, shallow, mid-depth, and deep categories are labelled WT, S, MD, and D respectively. The box plots show the median value as a line within the box, 25th and 75th percentiles as the limits of the box, and the 10th and 90th percentiles as whiskers and error bars. An off-center median is indicative of skewed data, and the size of the box is a measure of the variance of data.

Selected parameters are intentionally paired to compare and contrast data ranges. Consistent with groundwater input, increases with depth were measured for pH and alkalinity (Figure 7 A, B), and conductivity and calcium concentrations (Figure 7 C, D). Parameters pH, alkalinity, conductivity and calcium spanned greater ranges of values at ML and showed more variability than at JPH. Notable is the high pH (up to 12) and calcium content (up to 500 mg/L) of ML upland porewaters. Decreases with depth were recorded for temperature and Eh (Figure 7 E, F). Temperature and Eh were similarly variable at the two study sites, but had greater ranges at JPH than ML. Data ranges for concentrations of DOC, NH_4, sulphate, and chloride are different for the two study sites. DOC and ammonium concentrations are higher at ML than JPH, whereas sulphate and chloride concentrations are lower (Figure 7 G, H, I, J). Finally, water isotope data had similar variability, but different trends with depth for $\delta^{18}O$ and d-excess at the various landscape units (Figure 7 K, L). For example, $\delta^{18}O$ shows little change with depth at ML fen, a decrease at ML bog, and an increase at JPH upland. The d-excess shows little change with depth at JPH upland and JPH fen, a slight decrease with depth at ML fen, and highest values at ML bog.

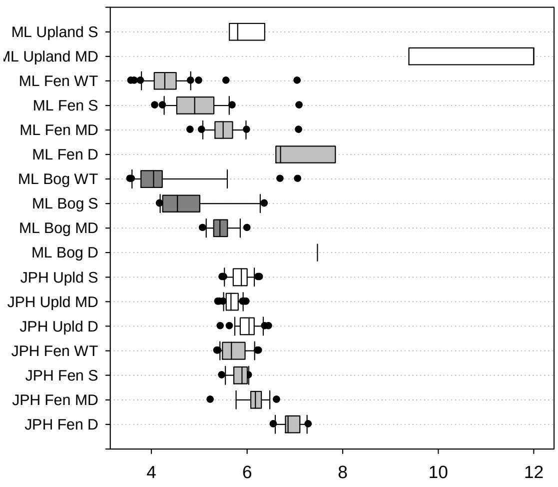

Figure 7A: pH

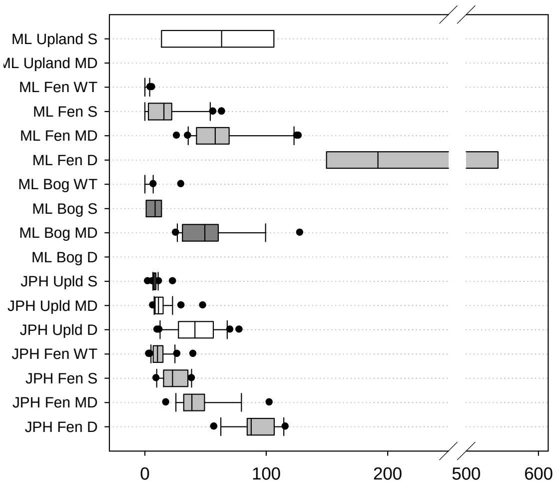

Figure 7B: Alkalinity (mg/L $CaCO_3$)

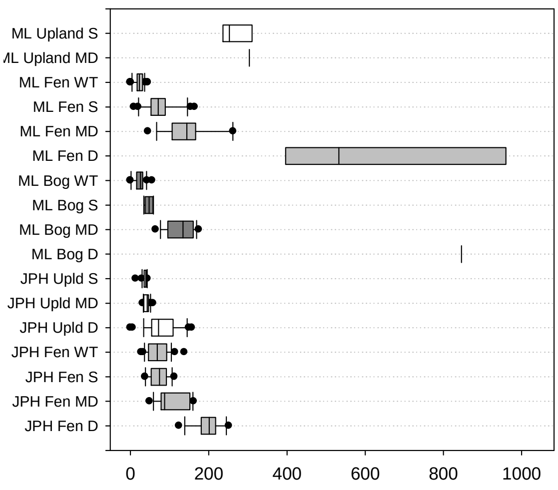

Figure 7C: Conductivity (μS/cm)

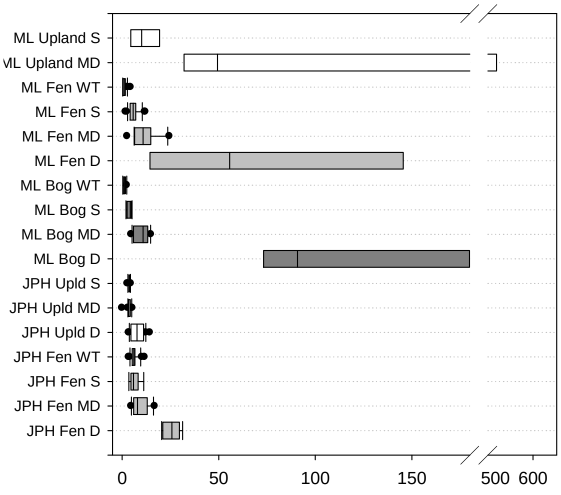

Figure 7D: Calcium (mg/L)

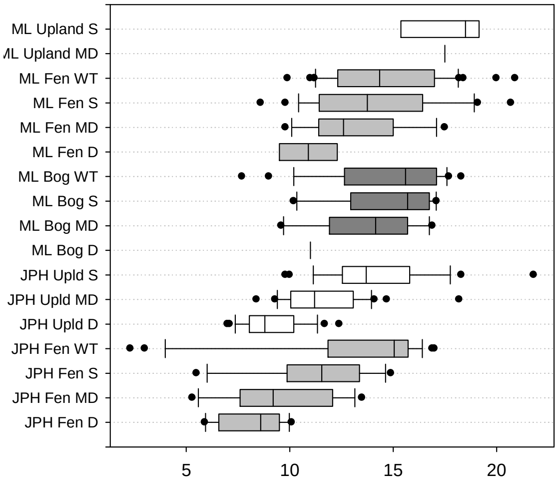

Figure 7E: Temperature (°C)

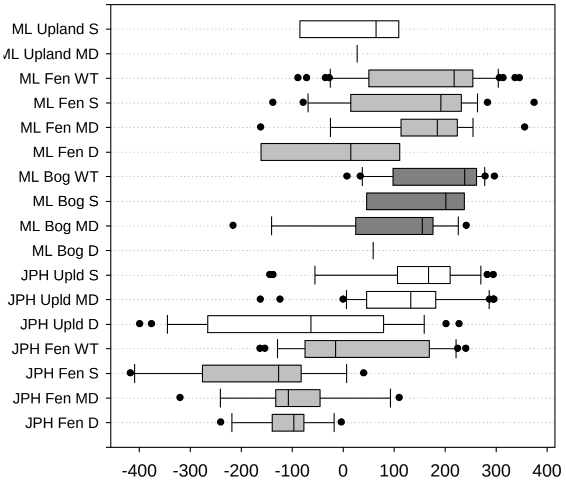

Figure 7F: Eh (mV)

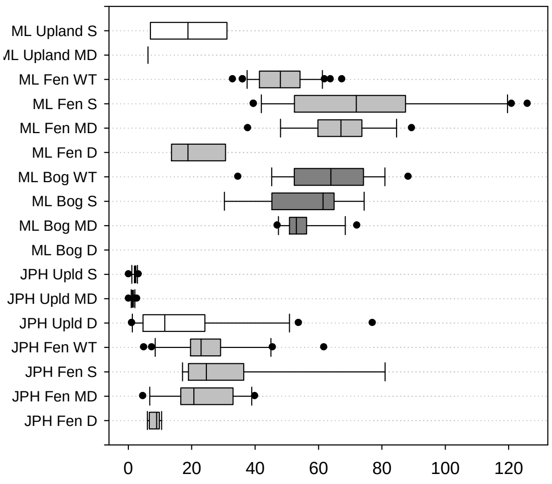

Figure 7G: DOC (mg/L)

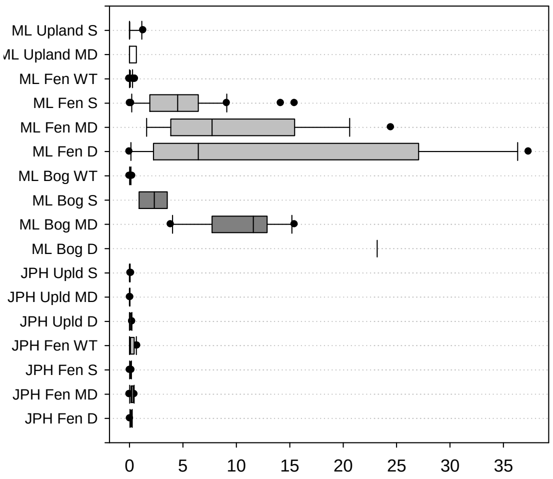

Figure 7H: NH_4 (mg/L)

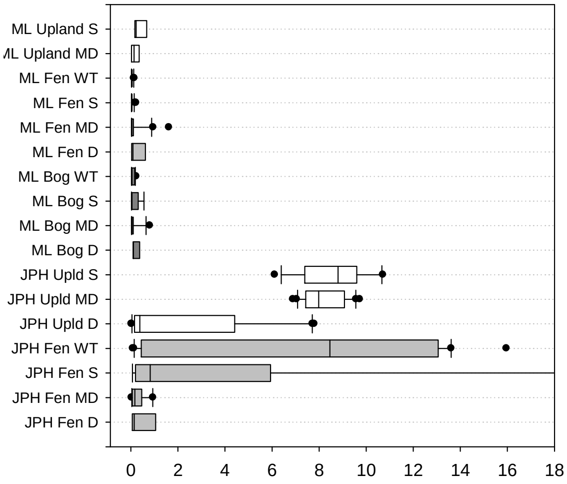

Figure 7I: SO_4 (mg/L)

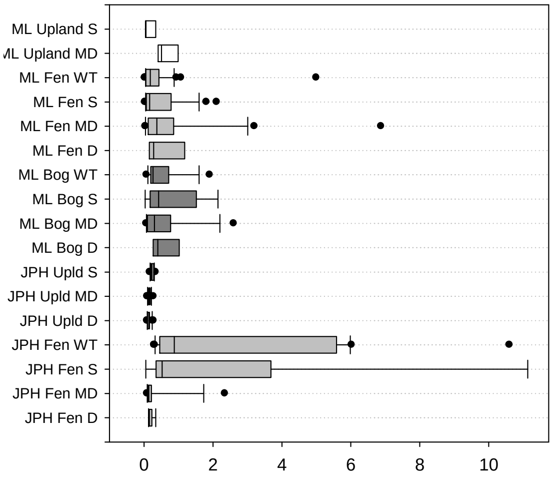

Figure 7J: Cl (mg/L)

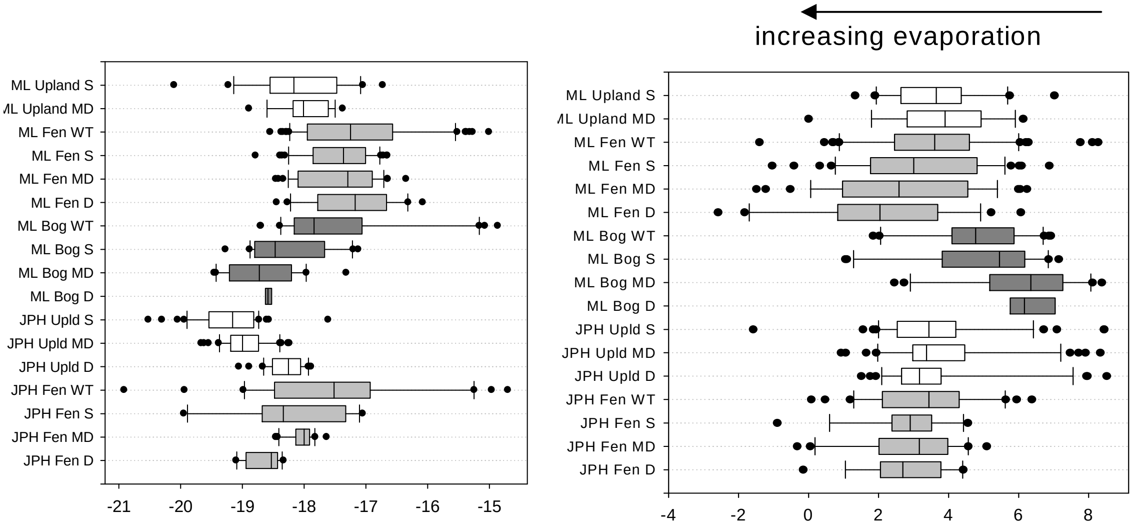

Figure 7K: δ^{18}O (‰) Figure 7L: d-excess (‰)

Figure 7 Box plots comparing 2011-2012 mean values at different sampling depths and landscape units at JPH and ML. The line within the box is the median, the limits of the box are the 25th and 75th percentiles, whiskers are the 10th and 90th percentile, and outliers are plotted. Depth categories: WT – water table, S – shallow, MD – mid-depth, D – deep. Landscape unit fill colors: upland – white, fen – grey, bog – dark grey.

In hydrological applications, δ^{2}H and δ ^{18}O of water samples are routinely plotted relative to the GMWL and/or LMWL in δ^{2}H - δ ^{18}O space. JPH and ML samples clustered generally along the LMWL for Edmonton[1] (δ^{2}H = 7.67*δ^{18}O – 1) (Yi Y, Pers. Comm. 2011). As is expected (for example, Gat 1996, or Gibson *et al.* 2005), snow samples plotted along the Edmonton LMWL and were relatively light (-23 to -22 ‰ for δ^{18}O), whereas rain samples were relatively heavier and varied throughout the season (-19 to -15 ‰ for δ^{18}O). At the study sites, which are at northern latitude, a LEL would be fairly close to the LMWL (Gibson *et al.* 2008). Furthermore, at JPH and ML fractionating evaporation and non-fractionating evapotranspiration compete, so the offset of surface water samples below the LMWL is expected to be small. In Figure 8, ML and JPH data are plotted separately to allow examination of landscape units. Variability with

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[1] This LMWL for Edmonton is the regression line in δ^{2}H - δ ^{18}O space of Edmonton precipitation isotope data, which is available through the Global Network of Isotopes in Precipitation (GNIP).

depth, season, and along flowpaths is considered in detail in the accompanying study by Vallarino (2013). Of the WT samples, bog surface samples plotted closest to and fen surface samples furthest from the LMWL, consistent with increasing water loss due to evaporation along a bog – fen gradient (Mitsch & Gosselink 1993).

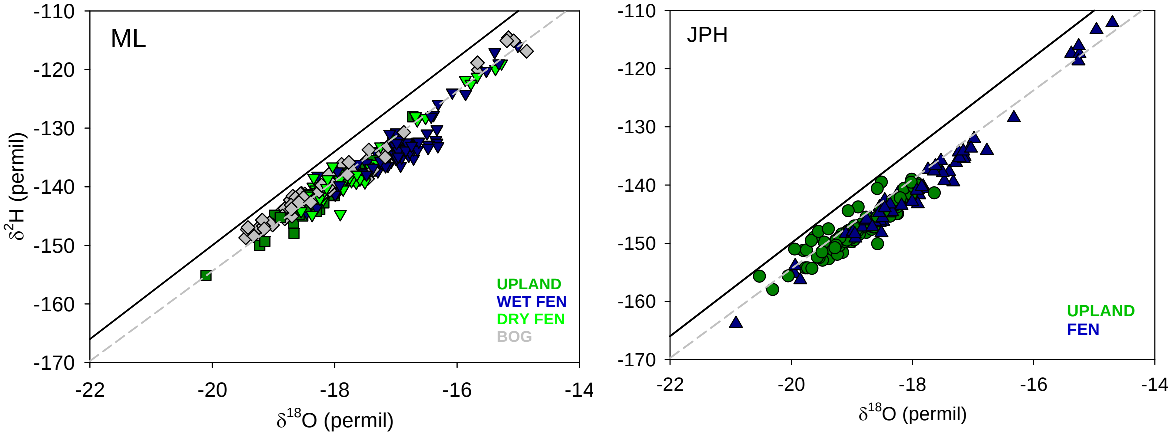

Figure 8 Isotope data (2011-2012) plotted in δ^2H-δ^{18}O space for ML (left) and JPH (right). Solid line is the GMWL ($\delta^2H = 8*\delta^{18}O + 10$). Dashed grey line is the Edmonton LMWL ($\delta^2H = 7.67*\delta^{18}O - 1$). Left: ML upland (green square), ML wet fen (blue inverted triangle), ML dry fen (green inverted triangle) and ML bog (grey diamond). Right: JPH upland (green circle), JPH fen (blue triangle).

3.2. Detailed Baseline Characterization

This detailed baseline hydrogeochemical characterization is based on 2012 data (May, July, and September campaigns), representative of one snow-free season. Mean values and standard deviation (sd) are used to describe general trends with depth at target landscape units (JPH upland, JPH fen, ML upland, ML fen, ML bog). The trends with depth for individual sampling campaigns are not shown, and unless mentioned otherwise, the trend with depth based on 2012 mean data is representative for the landscape unit. For organizational purposes, the four nominal depth categories are labelled water table (WT), shallow (S), mid-depth (M), and deep (D) (about 0.5 m, 1.5 m, 3 m, and 6.5 m deep respectively). Connectivity is under investigation both among and within landscape units and at the interface between wetland units and the deeper substrates. So in depth profile plots, color is used to systematically differentiate samples that originate within the wetlands (black) and the substrate underlying the wetlands (dark grey) and the uplands (grey).

Parameters are grouped into five topics of interest: (1) physical parameters, (2) isotopes (of water, dissolved organic carbon (DIC), and particulate matter) and dissolved organic carbon (DOC), (3) nitrogen species, (4) major ions, (5) trace metals and (6) saturation indices. Data in Tables 2-1 to 2-6 correspond to the six groups. Sampling locations did not always yield enough water for analysis, particularly at ML upland sites and deep locations in ML fen and ML bog, so descriptive statistics were based on few data points. Also, all of the parameters were not measured for all three sampling campaigns (May, July and September 2012). In 2012 DOC and major ions were analysed in May and September, and PM in July and September.

3.2.1. Physical Parameters

Mean temperature of water samples (Figure 9) were lower at JPH (7.9 – 13.1 ºC) than at ML (10.5 – 14.7 ºC). Within each landscape unit, average temperature decreased with depth, with the exception of ML bog, which showed a slightly higher average temperature for shallow piezometers (14.7 ºC) than WT wells (14.2 ºC). This trend from WT to shallow depth at ML bog varied with sampling campaign. Average temperature values from WT to shallow depth decreased in May 2012 (from 11.2 to 10.2 ºC) and July 2012 (from 16.7 to 15.9 ºC) but increased slightly in September 2012 (from 14.6 to 15.4ºC). Similarly from WT to shallow depths at ML fen, average temperature decreased in May 2012 (from 12.2 to 10.6 ºC) and July 2012 (from 17.6 to 15.2 ºC) but increased slightly in September 2012 (from 14.7 to 16.6ºC).

Average pH (Figure 9) was consistent with other research where pH increases along the bog-rich fen gradient and generally increases with depth to pH values similar to that of the mineral groundwater (for example Nicholson & Vitt 1990, Vitt *et al.* 1995). Near the surface (WT depth), ML bog was acidic (3.96), ML fen somewhat acidic (4.30), and JPH fen slightly acidic (5.68). At depth, ML bog, ML fen, and JPH fen were near neutral (7.48, 7.15, and 6.90 respectively). In upland landscape units pH also increased with depth, from 5.93 to 6.07 at JPH, and from 5.74 to ~12 at ML.

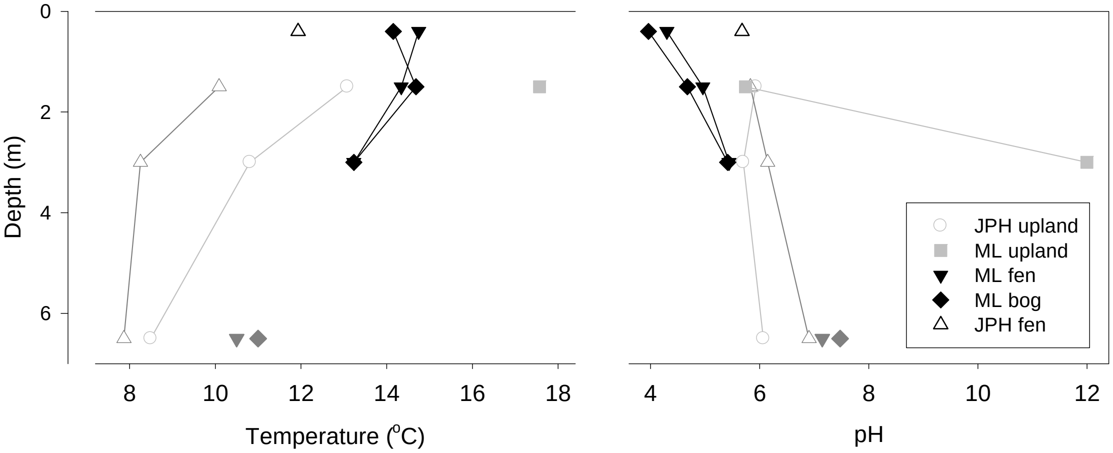

Figure 9 Temperature (°C, left) and pH (right) depth profiles of 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

Average conductivity and average alkalinity increased with depth in each landscape unit, consistent with landscape units that are subject to the infiltration of precipitation (low conductivity, low alkalinity) and input of mineral rich and near neutral groundwater. Ranges of conductivity and alkalinity were greater at ML than JPH (Figure 10). Average conductivity ranged from 36 to 198 µS/cm at JPH, and from 20 to 846 µS/cm at ML. And average alkalinity (mg/L $CaCO_3$) ranged from 9 – 92 mg/L at JPH, and from 1 – 315 mg/L at ML. Seasonally conductivity values change slightly but maintain their trend, except at JPH fen: the trend from shallow to mid-depth changes from increasing (60 – 90 µS/cm in May 2012 or 79 – 92 µS/cm in July 2012) to decreasing (from 99 – 87 µS/cm in September 2012).

The ML bog and ML fen mean conductivity and alkalinity depth profiles are within ranges reported in other studies. Conductivity ranged from 0 – 263 µS/cm from shallow to mid-depths. Nicholson & Vitt (1990) reported conductivity values of 0 – 232 µS/cm within the top 1.5 m along a bog-poor fen gradient. For ML bog and ML fen near-surface to shallow samples, alkalinity ranged from 0 – 64 mg/L $CaCO_3$. Similarly, the surface waters of bog and poor fen samples analysed by Vitt *et al.* (1995) had low alkalinity values. Vitt *et al.* (1995) observed that conductivity and alkalinity measurements were more similar among landscape units near the surface (0 & 0.5 m) than at depth (1.5 m). In agreement with their observation, depth profiles for average conductivity and average alkalinity diverged from WT (~ 0.4 m) to S (~ 1.5 m) among landscape units at ML. This study analysed porewaters at depths beyond ~ 1.5 m. Building on Vitt *et al.* (1995), at ~ 3 m this study found that the parameters had increased further and were offset from each other to the same extent as at 1.5 m.

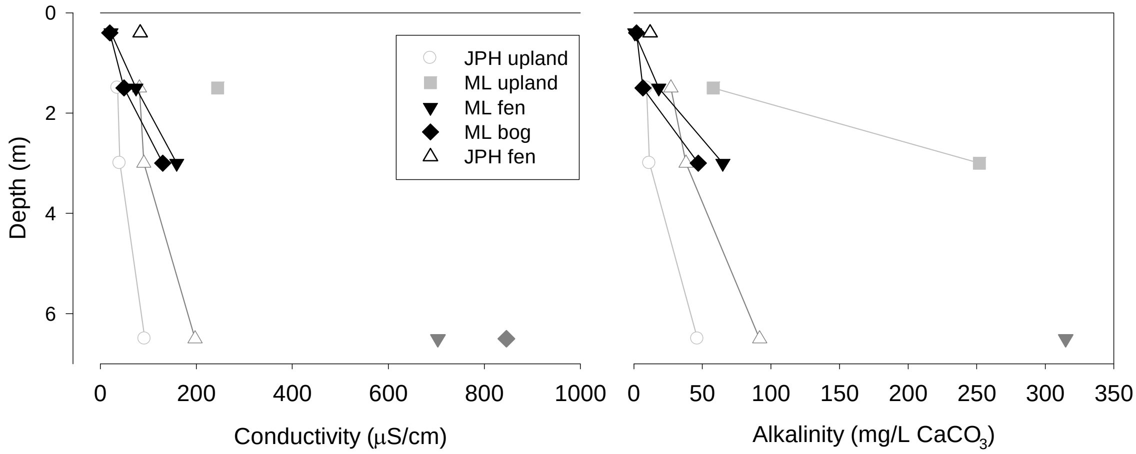

Figure 10 Conductivity (μS/cm, left) and alkalinity (mg/L $CaCO_3$, right) depth profiles of 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

The average Eh values measured at both sites had the general trend of decreasing (becoming more reducing) with depth, except at JPH fen landscape units (Figure 11). JPH fen mean Eh values were lowest for shallow wells (-203 mV) and then increased but remained negative to wells at depth (-116 mV). Low Eh values indicate reducing conditions, which are expected in waterlogged (anoxic) environments. The standard deviations of the Eh measurements were particularly high (from 63 mV at depth for ML bog to 200 mV at depth for JPH upland). This may be due to difficulties in measuring redox potential (Freeze & Cherry 1979, Nordstrom & Wilde 2005). Some of the variability in our measurements (high standard deviations) may be due to not having sufficient concentrations of a redox pair. Where measurement variability is not a problem, the variations in Eh may reflect changes in oxygen driven by changes in water levels (Lamers *et al.* 2012). The trends (with depth at each landscape unit) of average Eh for the three sampling campaigns are comparable (see Figure 58 in Appendix G), except for ML bog for which the number of samples are low (for example one data point for the shallow depth category in either May or July 2012).

Average Eh measurements were below 200 mV at all sampling sites. A system in equilibrium would be poised at 250 mV by the presence of nitrates or higher by the presence of oxygen (Husson 2012, Rydin & Jeglum 2006). Eh readings are consistent with anoxic conditions at JPH and ML where nitrates were generally below detection levels (< 0.05 mg/L). The Eh values measured at the ML fens and bogs are within the range expected for iron hydroxide reduction to ferric iron (120 mV). At JPH the low Eh values often coincided with the range expected for sulphate reduction (-150 to -75 mV) and the presence of hydrogen sulphide, detected by its characteristic odour. Nordstrom & Wilde (2005) caution that redox species may not be in equilibrium in natural systems and Eh values do not absolutely imply the presence or absence of redox couples.

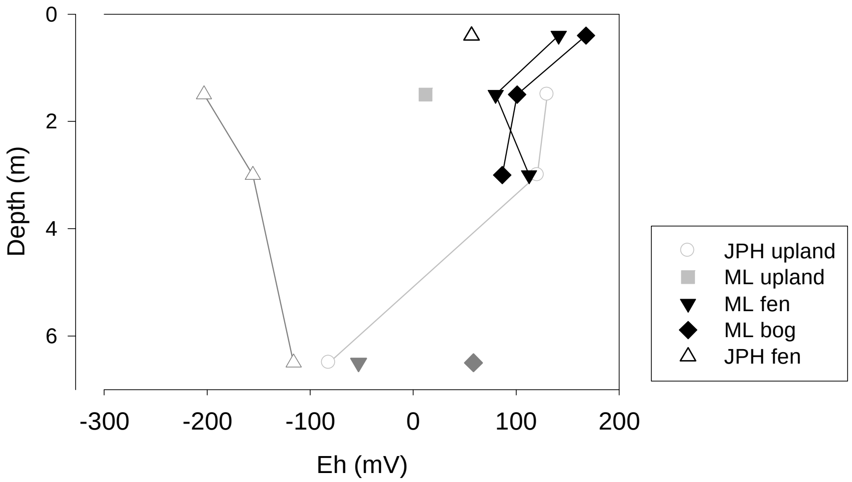

Figure 11 Eh (mV) depth profiles of 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color and symbols as for Figure 10.

Tables 2-1 to 2-6. Average 2012 data for JPH and ML target landscape units and depth categories. 2-1 Physical parameters; 2-2 Isotopes and dissolved organic carbon (DOC); 2-3 Inorganic nitrogen; 2-4 Major ions; 2-5 Trace metals, 2-6 Saturation indices. Average value, standard deviation in parentheses, number of samples in italics. Depth categories are nominal: water table (WT) ~ 0.4 m, shallow (S) ~ 1.5 m, mid-depth (M) ~ 3 m, deep (D) ~ 6.5 m. Not all sampling locations yielded enough water for analysis (N/A). *HC indicates Hach colorimetry methods were used in the field.

Table 2-1 Average temperature (Temp, °C), pH, Eh (mV), conductivity (Cond, μS/cm), and average concentration of alkalinity (Alk, mg/L $CaCO_3$).

		JPH upland	JPH fen	ML upland	ML fen	ML bog
Temp (ºC)						
	WT	--	11.9 (5.0) *19*	--	14.7 (3.1) *34*	14.2 (3.0) *18*
	S	13.1 (1.8) *17*	10.1 (2.4) *9*	17.6 (2.7) *3*	14.3 (3.4) *20*	14.7 (2.6) *6*
	M	10.8 (1.4) *24*	8.3 (2.4) *9*	N/A	13.2 (2.6) *13*	13.2 (2.4) *9*
	D	8.5 (0.9) *24*	7.9 (1.6) *9*	--	10.5 (1.3) *4*	11.0 (1.6) *2*
pH						
	WT	--	5.68 (0.27) *19*	--	4.30 (0.40) *34*	3.96 (0.27) *18*
	S	5.93 (0.18) *15*	5.83 (0.18) *9*	5.74 (0.16) *3*	4.96 (0.41) *20*	4.68 (0.43) *6*
	M	5.70 (0.15) *22*	6.15 (0.38) *9*	~12 (0) *4*	5.44 (0.30) *13*	5.41 (0.21) *9*
	D	6.07 (0.23) *23*	6.90 (0.23) *9*	--	7.15 (0.65) *4*	7.48 (0.19) *2*
Eh (mV)						
	WT	--	57 (139) *19*	--	141 (124) *33*	168 (103) *15*
	S	130 (130) *16*	-203 (133) *9*	12 (137) *2*	80 (130) *20*	101 (112) *4*
	M	121 (124) *23*	-156 (72) *8*	N/A	113 (130) *13*	86 (148) *9*
	D	-82 (200) *23*	-116 (66) *9*	--	-53 (131) *4*	59 (63) *2*
Cond (μS/cm)						
	WT	--	83 (20) *19*	--	22 (11) *34*	20 (12) *18*
	S	36 (8) *15*	82 (20) *9*	245 (12) *2*	74 (38) *19*	49 (11) *5*
	M	41 (6) *22*	91 (14) *7*	N/A	159 (52) *13*	130 (28) *9*
	D	93 (49) *23*	198 (30) *9*	--	703 (260) *5*	846 (N/A) *1*

Alk (mg/L)						
	WT	--	12 (9) *19*	--	1 (2) *36*	2 (7) *18*
	S	9 (4) *16*	27 (10) *9*	58 (55) *5*	18 (19) *23*	7 (6) *7*
	M	11 (4) *21*	38 (7) *9*	252 (N/A) *1*	65 (29) *16*	47 (16) *10*
	D	46 (22) *21*	92 (12) *9*	--	315 (195) *6*	N/A

Table 2-2 Average δ^{18}O and δ^{2}H of water, δ^{13}C of dissolved inorganic carbon (DIC), δ^{15}N and δ^{13}C of particulate matter (PM), and concentration of dissolved organic carbon (DOC).

		JPH upland	JPH fen	ML upland	ML fen	ML bog
δ^{18}O (‰)						
	WT	--	-17.0 (1.6) *20*	--	-16.9 (1.0) *36*	-16.9 (1.3) *18*
	S	-19.5 (0.5) *24*	-18.0 (0.9) *9*	-18.1 (0.6) *20*	-17.4 (0.5) *27*	-18.3 (0.6) *12*
	M	-19.0 (0.4) *24*	-18.1 (0.2) *9*	-18.0 (0.5) *12*	-17.4 (0.6) *24*	-18.8 (0.5) *12*
	D	-18.3 (0.3) *24*	-18.6 (0.3) *9*	--	-17.3 (0.7) *17*	-18.6 (0.1) *6*
δ^{2}H (‰)						
	WT	--	-132.67(13.39)*20*	--	-131.14 (7.95) *36*	-130.64 (10.49) *18*
	S	-151.78 (2.63) *24*	-141.49 (6.63) *9*	-141.45 (3.9) *20*	-136.49 (2.93) *27*	-141.33 (3.17) *12*
	M	-147.66 (1.72) *24*	-141.68 (1.14) *9*	-140.03 (2.97) *12*	-136.37 (3.13) *24*	-144.17 (3.07) *12*
	D	-142.27 (2.21) *24*	-146.09 (1.91) *9*	--	-136.36 (3.70) *12*	-142.7 (0.57) *12*
d-excess (‰)						
	WT	--	3.5 (1.0) *20*	--	3.7 (1.5) *36*	4.9 (1.5) *18*
	S	4.0 (2.2) *24*	2.7 (1.5) *9*	3.6 (1.2) *20*	3.0 (1.8) *27*	4.7 (2.0) *12*
	M	4.2 (1.9) *24*	3.3 (1.6) *9*	4.2 (1.2) *12*	2.6 (2.0) *24*	6.3 (1.7) *12*
	D	3.9 (2.1) *24*	2.8 (1.4) *9*	--	1.7 (2.4) *12*	6.0 (0.5) *6*
δ^{13}C DIC (‰)						
	WT	--	-21.74 (1.34) *20*	--	-7.44 (5.68) *36*	-13.45 (6.15) *18*
	S	-19.43 (1.31) *24*	-19.02 (3.21) *9*	-15.91 (4.69) *20*	4.7 (2.80) *27*	0.81 (4.64) *12*
	M	-21.38 (0.93) *24*	-18.81 (0.58) *9*	-17.25 (4.30) *10*	7.68 (3.23) *24*	4.27 (3.18) *12*
	D	-15.59 (3.31) *24*	-14.79 (2.10) *9*	--	7.98 (5.34) *12*	8.18 (1.50) *6*

δ^{13}C PM (‰)						
	WT	--	-28.34 (0.40) *13*	--	-30.63 (2.66) *24*	-29.05 (1.17) *12*
	S	-30.12 (3.48) *6*	-28.14 (0.59) *6*	-25.82 (1.23) *5*	-29.67 (2.41) *14*	-27.78 (1.82) *5*
	M	-30.74 (2.08) *10*	-27.95 (0.32) *5*	-26.49 (1.34) *2*	-27.63 (1.12) *12*	-29.68 (3.30) *7*
	D	-29.05 (0.60) *12*	-25.46 (1.92) *6*	--	-23.68 (4.21) *5*	-26.11 (N/A) *1*
δ^{15}N PM (‰)						
	WT	--	1.9 (1.0) *7*	--	-0.4 (0.7) *18*	0.4 (0.9) *8*
	S	N/A	0.9 (N/A) *1*	0.0 (N/A) *1*	-7.1 (1.7) *11*	-2.7 (1.6) *3*
	M	N/A	N/A	N/A	-3.7 (2.8) *11*	-2.4 (3.4) *5*
	D	-7.3 (N/A) *2*	N/A	--	-3.0 (3.1) *3*	N/A
C:N						
	WT	--	10.5 (4.2) *7*	--	10.4 (1.6) *18*	12.3 (2.4) *8*
	S	N/A	17.3 (N/A) *1*	8.7 (N/A) *1*	8.4 (0.8) *11*	11.1 (3.6) *3*
	M	N/A	N/A	(N/A)	13.6 (3.2) *11*	14.7 (5.1) *5*
	D	13.1 (N/A) *1*	N/A	--	27.5 (10.6) *3*	N/A
DOC (mg/L)						
	WT	--	23 (13) *13*	--	46 (8) *24*	60 (12) *12*
	S	2 (1) *11*	35 (24) *6*	11 (7) *3*	70 (25) *17*	50 (16) *5*
	M	1 (0) *16*	22 (4) *6*	N/A	68 (11) *10*	52 (3) *7*
	D	23 (22) *16*	9 (1) *6*	--	22 (11) *3*	N/A

Table 2-3 Average concentrations of inorganic ammonium (NH_4^+), nitrate (NO_3^-) and nitrite (NO_2^-) (mg/L).

		JPH upland --, *24, 24, 24*	JPH fen *21, 9, 9, 9*	ML upland --, 21, 21, --	ML fen 36, 27, 24, 18	ML bog 18, 12, 12, 6
NH_4^+ (mg/L) *HC						
	WT	--	0.20 (0.27) *18*	--	0.05 (0.06) *29*	0.08 (0.06) *17*
	S	0.02 (0.04) *19*	0.11 (0.05) *9*	0.14 (0.43) *9*	5 (4) *21*	2 (1) *5*
	M	0.01 (0.02) *24*	0.21 (0.05) *9*	0.21 (0.37) *3*	12 (6) *15*	10 (4) *7*
	D	0.16 (0.14) *24*	0.16 (0.07) *9*	--	15 (14) *9*	23 (7) *2*
NO_3^- (mg/L)						
DL 0.05	WT	---	0.15 (0.36)	--	< DL *24*	< DL *12*
	S	0.04 (0.02) *9*	< DL *14*	< DL *6*	< DL *19*	< DL *6*
	M	< DL *16*	< DL *6*	0.08 (0.06) *7*	0.05 (0.03) *14*	< DL *8*

	D	< DL *16*	< DL *6*	--	0.04 (0.02) *7*	< DL *3*
NO_2^- (mg/L)						
DL 0.05	WT	--	< DL *14*	--	< DL *24*	< DL *12*
	S	< DL *9*	< DL *6*	< DL *6*	< DL *19*	< DL *6*
	M	< DL *16*	< DL *6*	< DL *7*	< DL *14*	< DL *8*
	D	< DL *16*	< DL *6*	--	< DL *7*	< DL *3*
NO_2^- (mg/L) *HC		*17 – 23*				
	WT	--	< DL *19*	--	< DL *31*	< DL *17*
	S	0.035 (0.038)	< DL *9*	< DL *5*	< DL *21*	< DL *4*
	M	0.026 (0.028)	< DL *9*	N/A	< DL *12*	< DL *7*
	D	0.014 (0.026)	< DL *9*	--	< DL *2*	N/A

Table 2-4 Mean concentration of major ions chloride (Cl^-), sulphate (SO_4^{2-}), sodium (Na), calcium (Ca), magnesium (Mg), and hydrogen sulphide (H_2S) (mg/L).

		JPH upland	JPH fen	ML upland	ML fen	ML bog
Cl^- (mg/L)						
	WT	--	3.57 (3.15) *14*	--	0.16 (0.14) *24*	0.21 (0.06) *12*
	S	0.24 (0.06) *9*	3.21 (4.58) *6*	0.45 (0.99) *6*	0.45 (0.69) *19*	0.93 (0.91) *6*
	M	0.14 (0.03) *16*	0.16 (0.06) *6*	1.05 (1.49) *7*	0.80 (1.79) *14*	0.64 (0.94) *8*
	D	0.12 (0.02) *16*	0.15 (0.02) *6*	--	0.65 (0.81) *7*	0.56 (0.40) *3*
SO_4^{2-} (mg/L)						
	WT	--	10.58 (3.72) *14*	--	0.07 (0.03) *24*	0.11 (0.07) *12*
	S	8.85 (1.34) *9*	16.35 (33.92) *6*	0.28 (0.22) *6*	0.07 (0.05) *19*	0.22 (0.22) *6*
	M	8.18 (0.89) *16*	0.17 (0.12) *6*	0.29 (0.41) *7*	0.23 (0.47) *14*	0.20 (0.27) *8*
	D	2.01 (2.77) *16*	0.87 (1.18) *6*	--	0.29 (0.33) *7*	0.19 (0.16) *3*
K^+ (mg/L)						
	WT	--	0.58 (0.70) *14*	--	0.65 (0.58) *24*	0.67 (0.33) *12*
	S	0.54 (0.17) *9*	0.12 (0.10) *6*	0.25 (0.13) *5*	0.38 (0.30) *19*	0.46 (0.14) *6*
	M	0.59 (0.10) *16*	0.35 (0.06) *6*	4.21 (5.13) *5*	0.58 (0.60) *13*	0.70 (0.36) *8*
	D	0.54 (0.09) *16*	0.66 (0.07) *6*	--	1.93 (1.02) *7*	1.56 (0.26) *3*

Na$^+$ (mg/L)						
	WT	--	2.41 (0.55) *14*	--	0.57 (0.22) *24*	0.37 (0.04) *12*
	S	0.76 (0.23) *9*	2.06 (0.82) *6*	3.60 (1.70) *5*	0.81 (0.62) *19*	0.94 (0.74) *6*
	M	1.29 (0.43) *16*	1.65 (0.22) *6*	44.97 (57.22) *5*	1.31 (1.92) *13*	0.86 (0.94) *8*
	D	2.57 (0.40) *16*	2.52 (0.36) *6*	--	2.96 (1.04) *7*	3.04 (0.84) *3*
Ca^{2+} (mg/L)						
	WT	--	6.65 (2.06) *14*	--	0.91 (0.74) *24*	1.04 (0.42) *12*
	S	3.78 (0.48) *9*	7.56 (2.50) *6*	9.91 (8.16) *5*	6.05 (2.59) *19*	3.96 (1.29) *6*
	M	3.72 (0.70) *16*	6.82 (1.63) *6*	223.94 (270.41) *5*	12.02 (5.95) *13*	9.47 (3.83) *8*
	D	9.03 (4.03) *16*	25.36 (3.93) *6*	--	83.30 (62.70) *7*	114.63 (57.20) *3*
Mg^{2+} (mg/L)						
	WT	--	1.71 (0.50) *14*	--	0.29 (0.12) *24*	0.38 (0.10) *12*
	S	0.97 (0.29) *9*	1.75 (0.61) *6*	3.83 (4.23) *5*	1.18 (0.61) *9*	0.60 (0.24) *6*
	M	0.69 (0.31) *16*	1.36 (0.35) *6*	11.99 (18.74) *5*	2.50 (1.37) *13*	1.89 (0.74) *8*
	D	2.31 (1.38) *16*	5.01 (0.87) *6*	--	21.18 (15.58) *7*	35.53 (3.42) *3*
Fe^{2+} (mg/L)						
	WT	--	3.27 (4.14) *14*	--	4.93 (5.92) *24*	6.15 (9.58) *12*
	S	0.12 (0.06) *9*	8.08 (3.51) *6*	7.16 (8.51) *5*	1.41 (1.12) *19*	0.39 (0.12) *6*
	M	0.39 (0.21) *16*	13.52 (3.71) *6*	0.17 (0.17) *5*	7.24 (17.97) *13*	1.11 (0.71) *8*
	D	8.32 (5.39) *16*	9.42 (3.48) *6*	--	50.57 (54.66) *7*	17.18 (15.50) *3*
H_2S (mg/L) *HC						
	WT	--	0.03 (0.05) *12*	--	< DL *9*	0.02 (0.01) *10*
	S	0.04 (0.09) *6*	0.38 (0.25) *9*	0.04 (0.05) *4*	0.02 (0.01) *9*	< DL *4*
	M	< DL *16*	0.20 (0.09) *9*	N/A	0.02 (0.01) *8*	< DL *4*
	D	0.14 (0.11) *16*	0.05 (0.03) *9*	--	< DL *3*	N/A
Si (mg/L)						
	WT	--	3.24 (1.04) *14*	--	2.14 (1.40) *24*	1.38 (0.46) *12*
	S	2.74 (0.29) *9*	4.11 (0.89) *6*	7.96 (2.53) *5*	6.37 (2.70) *19*	3.45 (1.01) *6*
	M	3.70 (0.72) *16*	5.17 (0.67) *6*	3.59 (4.57) *5*	6.34 (3.32) *13*	4.06 (0.97) *8*
	D	6.01 (1.15) *16*	7.09 (0.49) *6*	--	10.29 (5.89) *7*	8.29 (4.09) *3*

Table 2-5 Concentration of trace metals aluminum (Al), arsenic (As), cadmium (Cd), copper (Cu), lithium (Li), manganese (Mn), nickel (Ni), lead (Pb), vanadium (V), zinc (Zn) (μg/L).

		JPH upland	JPH fen	ML upland	ML fen	ML bog
Al (μg/L)						
	WT	--	222 (134) *14*	--	85 (54) *24*	109 (43) *12*
	S	15 (5) *9*	537 (352) *6*	109 (59) *5*	91 (48) *19*	59.6 (21.2) *6*
	M	9 (3) *16*	170 (37) *6*	61 (64) *5*	65 (65) *13*	76.4 (46.7) *8*
	D	112 (95) *16*	17 (11) *6*	--	4.6 (3.8) *7*	4.8 (0.5) *3*
As (μg/L)						
	WT	--	1.15 (1.06) *14*	--	0.42 (0.42) *24*	0.79 (1.42) *12*
	S	0.16 (0.25) *9*	2.28 (1.17) *6*	9.15 (8.48) *5*	0.59 (0.32) *19*	0.51 (0.34) *6*
	M	1.28 (2.91) *16*	1.56 (0.91) *6*	0.89 (0.53) *5*	0.44 (0.30) *13*	0.33 (0.18) *8*
	D	1.07 (1.52) *16*	0.08 (0.11) *6*	--	19.94 (34.47) *7*	2.07 (3.35) *3*
Cd (μg/L)						
	WT	--	0.06 (0.09) *14*	--	0.01 (0.03) *24*	0.42 (1.42) *12*
	S	0.03 (0.03) *9*	< DL *6*	0.03 (0.04) *5*	0.03 (0.05) *19*	0.04 (0.04) *6*
	M	0.59 (1.62) *16*	< DL *6*	< DL *5*	0.03 (0.06) *13*	0.06 (0.08) *8*
	D	0.34 (1.25) *16*	< DL *6*	--	0.05 (0.07) *7*	2.36 (2.89) *3*
Cu (μg/L)						
	WT	--	84 (112) *14*	--	38.5 (114.6) *24*	123 (191) *12*
	S	1.26 (1.32) *9*	1.21 (2.38) *6*	3.33 (4.47) *5*	5.04 (18.95) *19*	8.01 (12.14) *6*
	M	1.00 (2.50) *16*	0.39 (0.65) *6*	24.54 (29.03) *5*	1.83 (3.58) *13*	1.25 (1.24) *8*
	D	0.86 (2.86) *16*	0.58 (0.94) *6*	--	0.98 (0.99) *7*	4.03 (4.82) *3*
Li (μg/L)						
	WT	--	0.08 (0.03) *14*	--	< DL *12*	< DL *6*
	S	< DL *7*	< DL *6*	2.28 (3.89) *3*	< DL *10*	< DL *3*
	M	< DL *16*	< DL *6*	6.96 (6.82) *4*	< DL *7*	< DL *4*
	D	< DL *16*	< DL *6*	--	10.96 (7.90) *2*	7.07 (N/A) *1*

Mn (µg/L)						
	WT	--	136 (130) *14*	--	110 (57) *24*	107 (93) *12*
	S	4.85 (2.91) *9*	154 (59) *6*	352 (412) *5*	80 (31) *19*	27.14 (6.94) *6*
	M	28.19(25.08)*16*	272 (97) *6*	682 (937) *5*	207 (311) *13*	61.25 (11.79) *8*
	D	143 (108) *16*	238 (23) *6*	--	1661 (745) *7*	2211 (311) *3*
Ni (µg/L)						
	WT	--	3.51 (3.46) *14*	--	2.98 (2.90) *24*	5.01 (6.38) *12*
	S	1.00 (0.42) *9*	1.58 (1.00) *6*	17.89 (18.51) *5*	1.21 (0.61) *19*	0.83 (0.36) *6*
	M	2.42 (2.15) *16*	1.17 (1.40) *6*	23.36 (14.82) *5*	2.75 (3.43) *13*	1.91 (1.66) *8*
	D	1.75 (3.84) *16*	0.31 (0.47) *6*	--	12.73 (12.11) *7*	20.07 (4.90) *3*
Pb (µg/L)						
	WT	--	10.66(15.21) *14*	--	9.21 (19.43) *24*	22.18 (37.08) *12*
	S	0.28 (0.43) *9*	0.24 (0.27) *6*	0.47 (0.37) *5*	0.58 (1.13) *19*	1.61 (2.51) *6*
	M	1.71 (4.35) *16*	0.15 (0.09) *6*	0.51 (0.38) *5*	0.74 (1.72) *13*	0.44 (0.49) *8*
	D	0.78 (2.44) *16*	0.17 (0.16) *6*	--	0.18 (0.20) *7*	5.73 (9.72) *3*
V (µg/L)						
	WT	--	2.80 (2.00) *14*	--	0.30 (0.21) *24*	0.62 (0.81) *12*
	S	0.01 (0.00) *9*	3.57 (2.63) *6*	3.74 (3.86) *5*	0.22 (0.17) *19*	0.21 (0.02) *6*
	M	0.55 (1.44) *16*	10.58 (6.11) *6*	1.63 (1.97) *5*	0.16 (0.18) *13*	0.12 (0.17) *8*
	D	7.72 (5.29) *16*	3.03 (1.06) *6*	--	2.90 (4.72) *7*	1.10 (1.89) *3*
Zn (µg/L)						
		--	724 (1127) *14*	--	39 (85) *24*	84 (125) *12*
		< DL *9*	0.10 (0.17) *6*	21.15 (18.67) *5*	106 (238) *19*	163 (238) *6*
		0.72 (1.72) *16*	< DL *6*	0.51 (0.60) *5*	109 (323) *13*	14.14 (17.55) *8*
		0.38 (1.02) *16*	< DL *6*	--	11.18 (8.07) *7*	13.40 (16.63) *3*

Table 2-6 Saturation indices (SI) of goethite, hematite, pyrite, quartz, siderite.

SI's were modelled using PHREEQC (AquaChem 2005).

		JPH upland	JPH fen	ML upland	ML fen	ML bog
Goethite						
	WT	--	0.09 (2.82) *13*	--	N/A	N/A
	S	1.21 (2.98) *5*	-3.53 (2.87) *6*	N/A	-0.55 (2.49) *9*	-4.20 (N/A) *1*
	M	1.78 (2.32) *11*	0.16 (3.19) *6*	N/A	1.05 (3.00) *10*	0.41 (2.47) *6*
	D	0.80 (3.00) *12*	1.87 (1.90) *6*	--	3.12 (2.26) *2*	N/A
Hematite						
	WT	--	2.11 (5.62) *13*	--	N/A	N/A
	S	4.36 (5.97) *5*	-5.13 (5.72) *6*	N/A	0.85 (4.97) *9*	-6.44 (N/A) *1*
	M	5.50 (4.64) *11*	2.24 (6.39) *6*	N/A	4.05 (6.00) *10*	2.77 (4.93) *6*
	D	3.52 (6.00) *12*	5.66 (3.80) *6*	--	8.26 (4.49) *2*	N/A
Pyrite						
	WT	--	-25.54 (35.95) *13*	--	N/A	N/A
	S	-54.72 (42.35) *5*	3.51 (5.06) *6*	N/A	-37.74 (28.59) *9*	-2.90 (N/A) *1*
	M	-53.84 (30.45) *11*	3.91 (4.79) *6*	N/A	-50.36 (34.20) *10*	-40.85 (30.21) *6*
	D	-26.10 (31.68) *12*	-11.82 (18.41) *6*	--	-14.04 (32.05) *2*	N/A
Quartz						
	WT	--	-0.07 (0.12) *13*	--	N/A	N/A
	S	-0.18 (0.07) *5*	0.05 (0.08) *6*	N/A	0.12 (0.28) *9*	0.03 (N/A) *1*
	M	-0.03 (0.09) *11*	0.17 (0.06) *6*	N/A	0.20 (0.18) *10*	0.02 (0.08) *6*
	D	0.23 (0.07) *12*	0.31 (0.04) *6*	--	0.56 (0.00) *2*	N/A
Siderite						
	WT	--	-2.45 (0.80) *13*	--	N/A	N/A
	S	-3.72 (0.68) *5*	-1.24 (0.37) *6*	N/A	-2.51 (0.29) *9*	-4.16 (N/A) *1*
	M	-2.92 (0.38) *11*	-0.35 (0.27) *6*	N/A	-2.05 (0.50) *10*	-2.22 (0.22) *6*
	D	-0.89 (0.79) *12*	0.51 (0.22) *6*	--	1.73 (1.11) *2*	N/A

3.2.2. Stable isotopes and DOC

The water isotope signatures of near-surface samples were similar among landscape units JPH fen, ML fen and ML bog (-17 sd 1.3 ‰ δ^{18}O and -131 sd 11 ‰ δ^{2}H). The 2012 mean values fall near the long-term amount-weighted average isotope signature of regional precipitation (-17.7 ‰ δ^{18}O, -134.6 ‰ δ^{2}H, CNIP 2004). At depths greater than 0.4 m, landscape units differed in hydrogen and oxygen isotope signature ranges (Figure 12). Such a distinction in isotope signatures between bog and fen landscape units was also noted by Levy *et al.* (2013). Similarly, average d-excess values set bog, fen, and upland samples apart (Figure 12), with highest average d-excess values for ML bog samples (4.9 – 6.0 ‰), and lowest for JPH fen and ML fen (2.7 – 3.5 ‰ and 1.7 – 3.7 ‰ respectively). Values for d-excess are an indirect measure of evaporation effects, with lower d-excess values indicative of greater evaporation. As d-excess was highest at ML bog, it is inferred that fractionating evaporation or summer precipitation recharge played a more significant role fingerprinting water at the other landscape units.

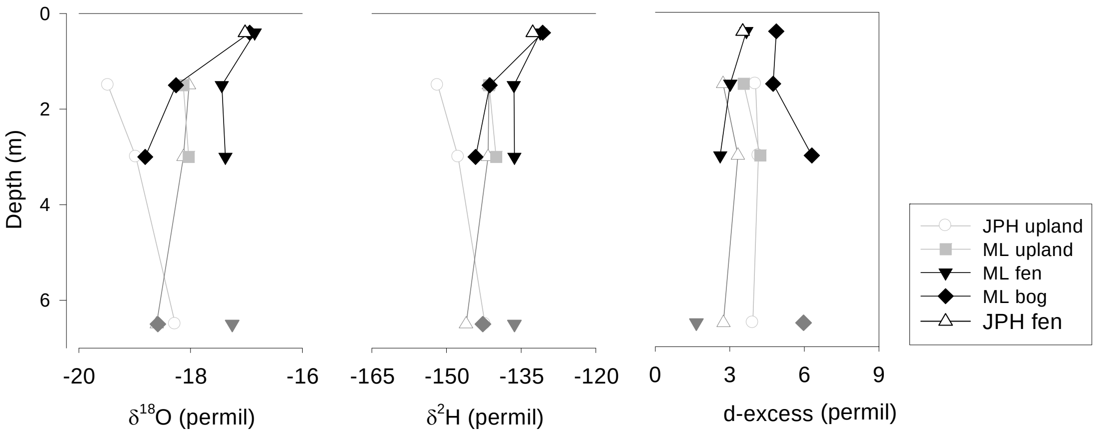

Figure 12 δ^{18}O, δ^{2}H and d-excess depth profiles of 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

Depth profiles of $\delta^{18}O$ and $\delta^{2}H$ for a given landscape unit were comparable in trend (Figure 12). For example, at JPH upland, oxygen and hydrogen isotope signatures both steadily increased with depth. Comparable relative changes indicate that processes are affecting both isotopes similarly. For example, evaporation discriminates against both oxygen-18 and deuterium so that residual samples become enriched in both isotopes; evapotranspiration does not have fractionation effects on either deuterium or oxygen-18. Anaerobic methanogenesis by CO_2 reduction, however, is an example in which deuterium would show fractionation effects as the lighter hydrogen isotope is utilized whereas oxygen is not utilized (Rosenberry *et al.* 2006). It is not clear whether hydrogen fractionation due to methanogenesis is present but is masked by mixing and evaporation effects.

Mean stable isotope signatures of $\delta^{13}C$ in DIC of JPH upland, ML upland and JPH fen samples were found to be relatively depleted compared with ML fen and ML bog samples (Figure 13). JPH fen $\delta^{13}C$ values of DIC ranged from -21.74 (WT) to -14.79 ‰ (at depth). The values of $\delta^{13}C$ at ML bog were more enriched: -13.45 (WT) to +8.18 ‰ (at depth). At ML fen, $\delta^{13}C$ values were also enriched: -7.44 (WT) to +7.98 ‰ (deep). Methanogenesis is a process that would account for the heavy $\delta^{13}C$ signatures in DIC at ML fen and ML bog as shown in Figure 13 (following Avery Jr. *et al*. 1999 or Siegel *et al*. 2001).

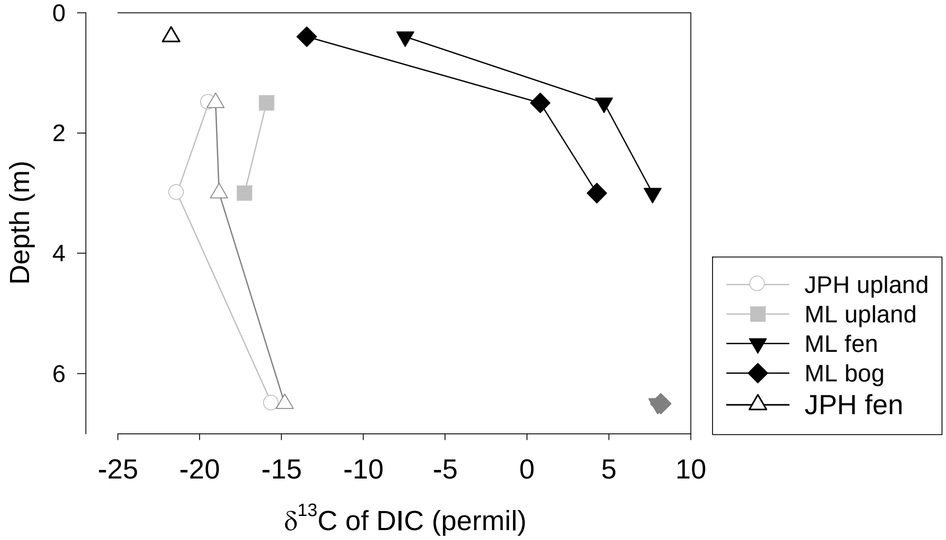

Figure 13 Dissolved inorganic carbon (DIC) δ^{13}C depth profiles of 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

Particulate matter (PM) was collected as residue on a 0.45 µm filter. The matter collected from upland sites or mineral substrates beneath wetlands was expected to be inorganic, whereas matter from the fen and bog sites was expected to be organic. Data are thus plotted in different colors to keep in mind the difference in material compared. Average stable isotope signatures of δ^{13}C in PM at ML fen showed enrichment with depth, from -30.63 (WT) to -27.63 ‰ (M). The values for ML bog and JPH fen fell within this range, but their spread was less (Figure 14). The average values of δ^{13}C at JPH upland (-30.74 to -29.05 ‰) were more negative than at ML upland (-26.49 to -25.82 ‰). The highest values of PM δ^{13}C were found at depth in the wetland landscape units, -26.11, -25.46, and -23.68 ‰ at ML bog, JPH fen, and ML fen respectively. Schiff *et al.* (1997) similarly had found δ^{13}C values for solid carbon to have low variability (-26 sd 2 ‰), and they concluded that dominant processes or sources could not be inferred from their particulate carbon isotope data.

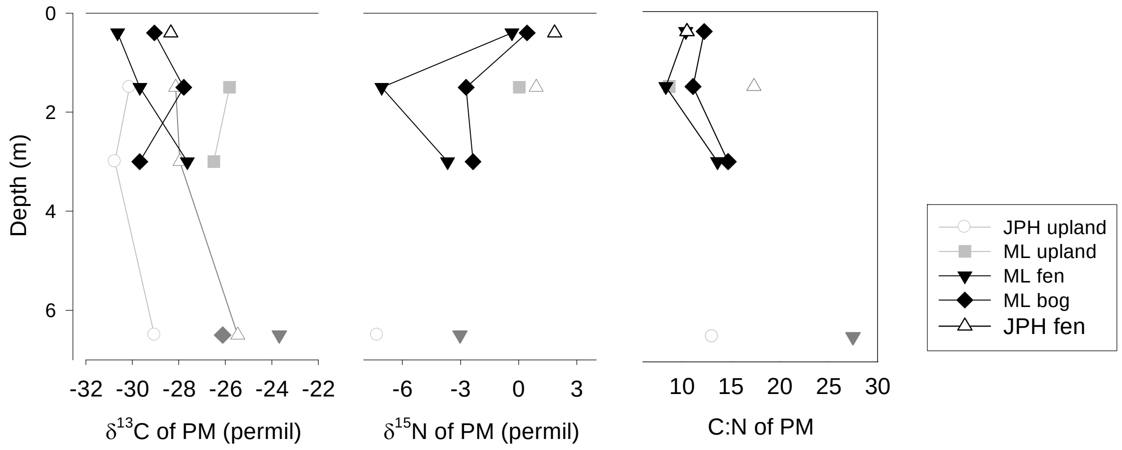

Figure 14 Depth profiles of particulate matter (PM) δ^{13}C, δ^{15}N, and C:N for 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

Data for δ^{15}N and the C:N ratio of PM were limited at JPH upland and ML upland sites due to very low concentrations of PM. JPH fen samples showed an increase in average C:N ratio from 10.5 (WT) to 17.3 (shallow) with no data for deeper sample sites (Figure 14, right). ML bog mean C:N ratios were higher than ML fen ratios at the same depths (Figure 14): decomposition and mineralization rates are slower in bogs than fens so C:N ratios remain higher; fens immobilize mineralized nitrogen at faster rates than bogs would (Verhoeven 1986). Trends with depth for ML fen and bog showed lowest ratios for shallow sampling depths, 8.4 and 11.1 respectively. Peatland vegetation has C:N ratios > 30, but within upper peat layers the range of the C:N ratio is lower, generally between 10 and 25 (Verhoeven 1986). C:N values of PM from WT and shallow JPH and ML sampling sites range from 8.4 to 17.3. Lower C:N ratios reflect the sequestration of N. In N limited environments particularly, N cycling is efficient. For ML fen and bog samples the depth profiles showed decreasing δ^{15}N of PM as C:N decreased and increasing δ^{15}N of PM as the C:N ratio increased (Figure 14). The pattern did not hold for JPH fen samples as δ^{15}N of PM became more negative with depth whereas the C:N ratio increased.

DOC average concentrations (Figure 15) were generally higher at ML sites (22 – 70 mg/L) than JPH sites (1 – 35 mg/L). At JPH upland the average concentration increased from 1 or 2 mg/L in shallow and mid-depth wells to 23 mg/L in the deepest wells. A trend could not be determined at ML upland as DOC was only analysed at one depth (shallow), for which the average concentration was 11 mg/L. Highest average DOC concentrations were measured for ML fen samples (70 mg/L at 1.5 m depth or 68 mg/L at 3 m depth). On average, DOC concentrations of water table wells decreased in the order ML bog, ML fen, and JPH fen, with average concentrations of 60, 46, and 23 mg/L respectively. DOC concentrations increased before decreasing with depth at both fen landscape units (JPH fen and ML fen). DOC production is highest in upper peat layers where vegetation introduces litter mass to the decomposition cycle and living roots contribute DOC (Jager *et al.* 2009). DOC concentrations increased before decreasing with depth at both fen landscape units (JPH fen and ML fen). ML fen mean DOC concentration is less than the mean concentration at ML bog although DOC production rates are slower in bogs than fens. In a wet year, such as 2012, near-surface hydrologic connectivity could lead to lower concentrations as DOC is flushed out (following Ulanowski & Branfireun 2013). DOC that accumulated at depth would be recalcitrant, i.e., resistant to biogeochemical processes.

Dissolved inorganic carbon concentrations reported are an indirect measurement[1] based on incidental data acquired during the analysis of $^{13}C/^{12}C$ of DIC (Eby P, Pers. Comm. 2013). In all landscape units, DIC concentrations increase with depth, to a four-fold greater degree in ML samples (Figure 15). DIC is continuously produced during respiration and decomposition and younger labile C has been shown to recharge deeper peat (by both advection and diffusion) and fuel methanogenesis (Moore 2003).

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[1] Mass spectroscopy data output includes a signal area which corresponds to DIC concentration. The function relating peak area and DIC concentration is based on a range of peak areas of standard materials and their known DIC concentrations. So DIC concentrations of samples were estimated by solving the function for acquired signal peak areas.

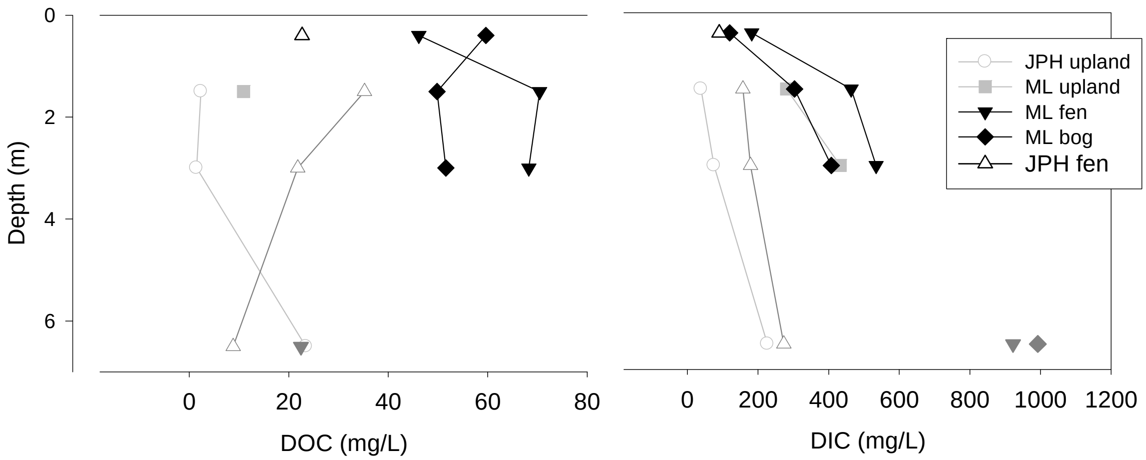


Figure 15 Depth profiles of dissolved organic carbon (DOC, left) and dissolved inorganic carbon (DIC, right); 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

3.2.3. Nitrogen Species

Water samples had increasing average concentrations of ammonium with depth at all landscape units (Figure 17), with the exception of JPH fen where the average concentrations (0.11 – 0.21 mg/L) did not show a single consistent trend with depth. JPH upland ammonium values were low at shallow and mid-depth well locations (0.02 and 0.01 mg/L respectively), with an average concentration of 0.16 mg/L at the deepest wells. ML upland mean ammonium values increased with depth, from 0.14 (shallow) to 0.21 mg/L (mid-depth). Vitt *et al.* (1995) reported significant increases of ammonium for peatland samples from the surface (< 0.5 mg/L) to samples at 1.5 m depth (< 20 mg/L). Mean ammonium concentrations at ML bog and fen samples increased similarly and continued to increase with depth: the largest range was at ML bog, where values increased from 0.08 mg/L near the surface to 23 mg/L in deepest wells. ML fen average ammonium concentrations were low at the surface (0.05 mg/L) and increased substantially with depth, to 15 mg/L in deepest wells. In contrast, and in agreement with Vitt *et al.* (1995), nitrite and nitrate average concentrations were close to or below detection limit throughout sampling depths and landscape units (Figure 17), with the exception of nitrite in piezometer nests at JPH upland decreasing with depth (0.035 – 0.014 mg/L), and nitrate in water table well samples at JPH fen (0.15 mg/L). Note that the average 0.15 mg/L nitrate value for JPH fen water table wells is affected by seasonal outliers: nitrate concentrations were generally below DL (0.05 mg/L) with the exception of May 2012. In May 2012 nitrate concentrations of 1.5 mg/L and 0.1 mg/L were measured at two locations (JPH E and at JPH G respectively).

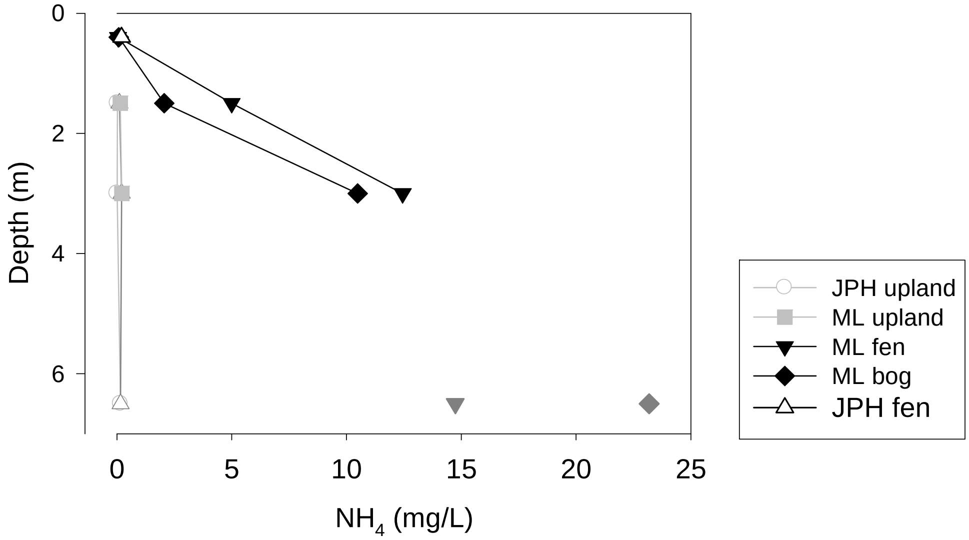


Figure 16 Depth profiles of mean inorganic ammonium (NH_4) concentrations (mg/L); 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

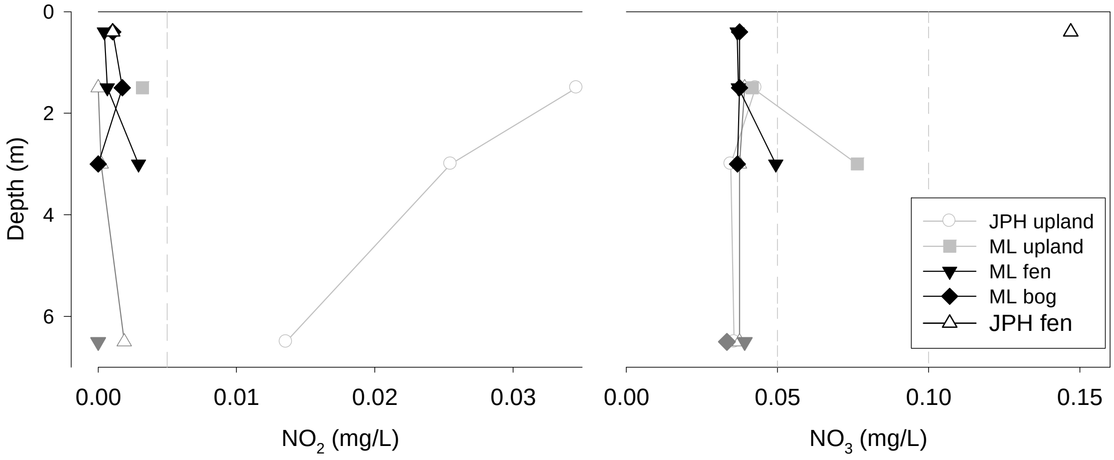


Figure 17 Depth profiles of mean nitrite (NO_2, left) and nitrate (NO_3, right) concentrations (mg/L); 2012 mean data at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

3.2.4. Major Ions

WT and shallow water samples at target landscape units were generally more dilute than mid-depth or deep samples, consistent with conductivity values which increased with depth. At JPH and ML the ions dominant in all landscape units and at all depths (Ca^{2+} and SO_4^{2-}) were present in concentrations that differed by an order of magnitude (Figure 18). Calcium concentrations were lower at JPH (3.72 – 25.36 mg/L) than at ML (0.91 – 223.94 mg/L). Magnesium concentrations were similarly lower at JPH (0.69 – 5.07 mg/L) than at ML (0.29 – 35.53 mg/L). Sulphate concentrations were higher at JPH (0.17 – 16.35 mg/L) than at ML (0.07 – 0.29 mg/L). JPH is nearer the AOSR and is subject to higher atmospheric deposition of sulphates (Laxton *et al.* 2010). Concentrations of anions followed $SO_4^{2-} > Cl^-$ at all landscape units at all depths, except at ML upland where $Cl^- > SO_4^{2-}$ at all depths. At JPH upland, JPH fen, and ML upland, concentrations of cations from highest to lowest concentrations were $Ca^{2+} > Na^+ \approx Mg^{2+} > K^+ > NH_4^+$. At near-surface ML fen and ML bog $Ca^{2+} > K^+ > Na^+ > Mg^{2+} > NH_4^+$ and at depth, $Ca^{2+} > NH_4^+ > Mg^{2+} > Na^+ > K^+$. Concentrations of potassium were low: though K^+ is leached from decomposing plant material and recycled to an extent, K^+ is not attenuated by peat, and is flushed from porewaters (Shvartzev *et al.* 2012). Finally, silicon (Si), which is indicative of groundwater inputs (Shvartzev *et al.* 2012), increased with depth at all landscape units except ML upland.

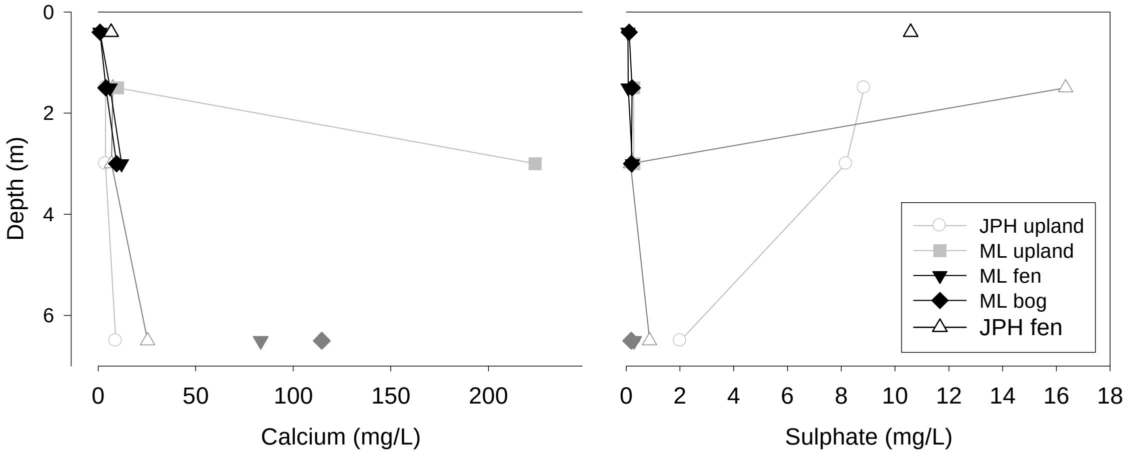


Figure 18 Depth profiles of dominant ions calcium (Ca, left) and sulphate (SO_4, right); 2012 mean data in mg/L at target landscape units. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

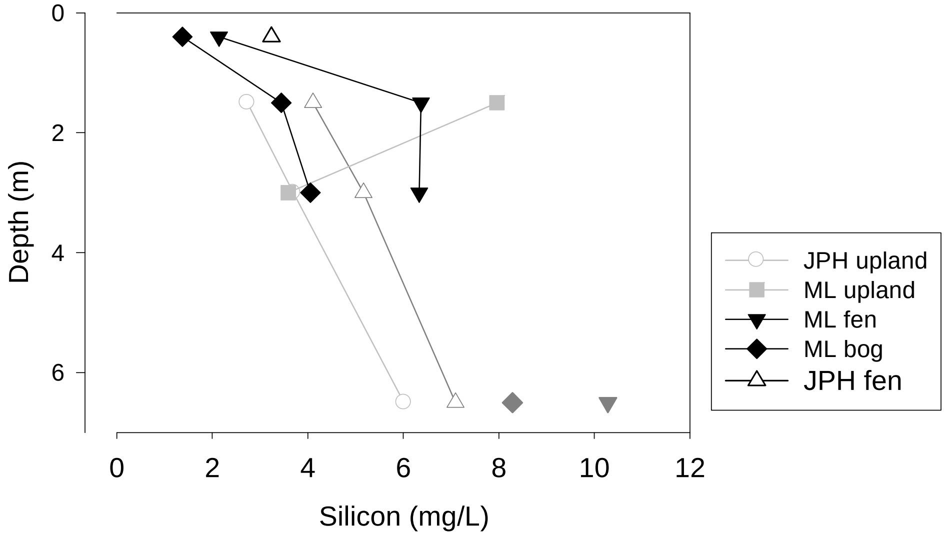


Figure 19 Depth profile of average silicon concentrations (Si, mg/L) at target landscape units (2012 data). Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

3.2.5. Subset of Trace Metals

A suite of 26 trace metals was analysed; in this section, results for 11 trace metals are presented. The selection of elements is based on recommendations by CEMA's air working group, reports of elevated concentrations in snow in the AOSR, and research elsewhere. Depth profiles for mean concentrations of Al, As, Cd, Cu, Li, Mn, Ni, Pb, V, and Zn are shown in Figure 20. Standard deviations are relatively high for many of the trace metals, indicative of high spatiotemporal variability. For Cu, Ni, Pb, Zn the variability may be considered seasonal as near-surface sampling locations had higher average values in May 2012 than September 2012. For Al, the variability may be spatial and temporal: for most landscape unit depth categories Al concentrations changed less than 25 µg/L between seasons, but at the shallow fen at JPH Al concentrations were higher in September 2012 (726 µg/L) than in May 2012 (349 µg/L).

Of concern, given industrial development in the AOSR, are trace metals either present in emissions associated with extraction and refinement, or a risk to human or ecological health, such as: Al, Cd, Hg, Ni, and V (CEMA 2002). Overall similarities for this subset of trace metals were seen at ML bog and ML fen. At these landscape units, Cd and V were consistently very low, Ni decreased from < 5 μg/L at the near-surface to mid-depth but had higher concentrations (< 20 μg/L) at depth, and Al decreased with depth (from < 150 μg/L at the surface to < 5 μg/L at depth). At ML upland, mean concentrations for this subset of metals were within the same range as ML fen and bog, except for Ni which increased with depth from < 20 to < 25 μg/L. At JPH, Cd was consistently below DL at all landscape units and depths. The highest average concentrations were measured for Al at JPH fen: 222 μg/L at the near-surface, 537 μg/L at 1.5 m depth, 170 μg/L at mid-depth and 17 μg/L at depth. Data for Hg was not available for 2012.

Elevated concentrations of Cu and Pb were measured in a snow survey conducted in the AOSR recently (Birks SJ, Pers. Comm. 2013). Depth profiles for Cu and Pb of 2012 mean data were similar among landscape units. At WT depths, concentrations for both elements were highest at ML bog (123 μg/L Cu and 22 μg/L Pb) and lowest at ML fen (39 μg/L Cu and 9 μg/L Pb), with intermediate values at JPH fen. Mean concentrations of Cu and Pb decreased to less than 6 μg/L at depth.

Following Shvartzev *et al.* (2012), trace metals of interest in organic-rich water samples are those that may be found at elevated concentrations as they form complexes with humic organic matter – copper (Cu), manganese (Mn), lead (Pb), and zinc (Zn). Both Cu and Pb mean concentrations were highest at the near-surface and decreased rapidly with depth (as discussed in the previous paragraph). Of Cu, Mn, Pb and Zn, only Mn was found at appreciable concentrations at depth, and only at ML fen and ML bog. At ML fen and ML bog, Mn and Zn had fairly similar trends with depth, increasing from the surface to shallow and mid-depths; however, at depth concentrations of Mn were relatively appreciable (~ 2000 μg/L) and of Zn very low (< 15 μg/L). At JPH fen and upland, Mn concentrations increased with depth, and Zn concentrations decreased with depth. Highest concentrations for Zn were measured at the near-surface of JPH fen (724 μg/L). In contrast, trace metals cadmium (Cd), arsenic (As), lithium (Li) do not bind and are not anticipated in porewaters (Shvartzev *et al.* 2012). At JPH and ML (all depth categories), Cd, As and Li were consistently below 25 μg/L.

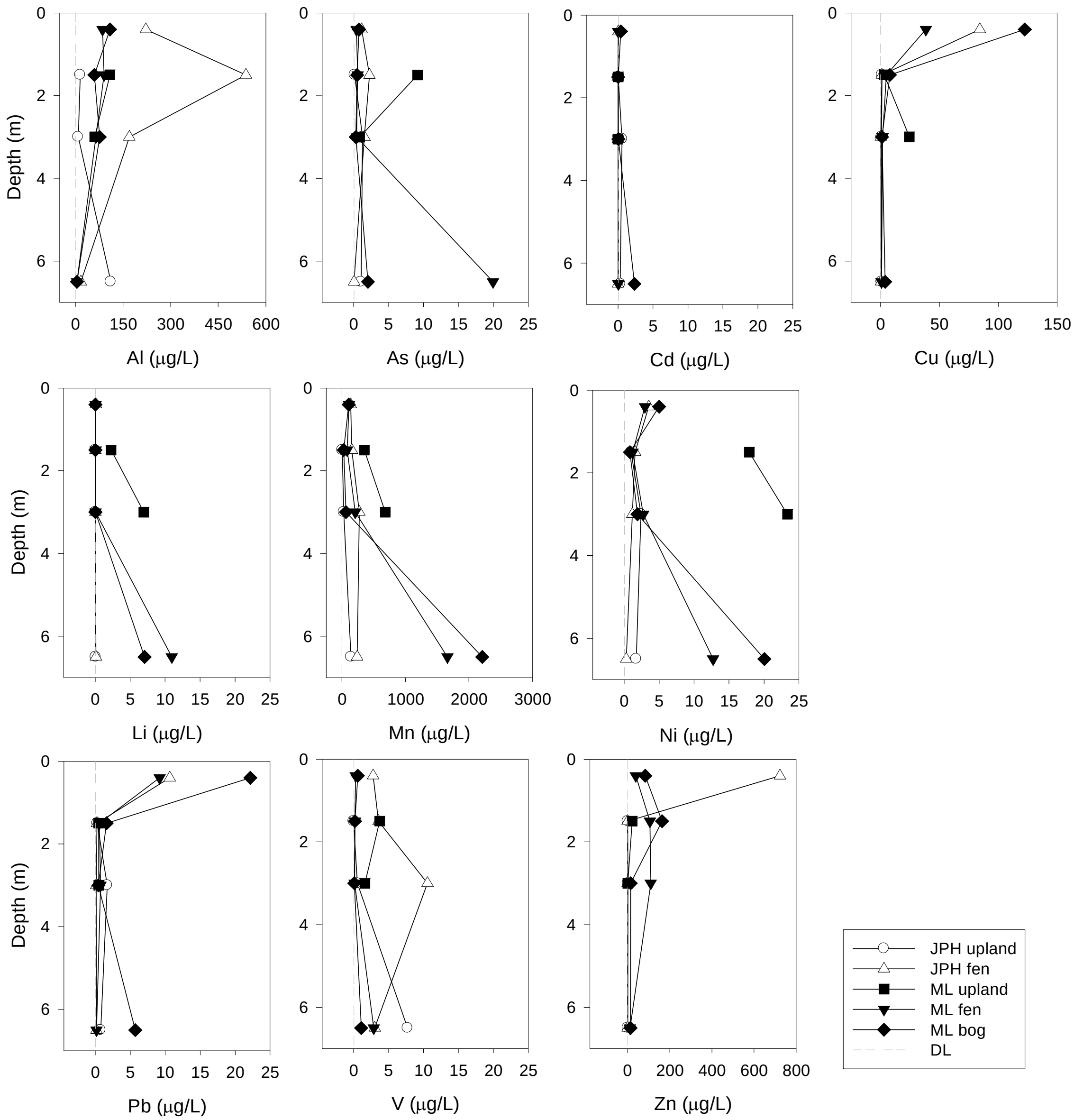


Figure 20 Depth profiles of trace metal concentrations (μg/L); 2012 mean data of Al, As, Cd, Cu, Li, Mn, Ni, Pb, V, Zn at target landscape units. Detection limits (DL) shown in grey dashed reference lines. Depths are nominal: water table – 0.4 m, shallow – 1.5 m, mid-depth – 3 m, deep – 6.5 m. Color indicates sampling matrix: peatlands (black), substrate underlying wetlands (dark grey), and uplands (light grey). Symbols differentiate landscape units: JPH upland (open circle), JPH fen (open triangle), ML upland (filled square), ML fen (filled inverted triangle), and ML bog (filled diamond).

3.2.6. Saturation Indices (SI)

At JPH and ML, average SI values increased with depth and were highest with respect to hematite. Most samples were in equilibrium or supersaturated with respect to hematite (up to an average SI of 8.26), goethite (up to an average SI of 3.12), and quartz (up to and average SI of 0.56). Additionally, JPH fen shallow and mid-depth samples were in equilibrium or at supersaturation with respect to pyrite (average SI 3.51 and 3.91 respectively). JPH fen shallow and mid-depth data indicate reducing conditions (Table-1) and presence of organic material (Table-2), iron (Table-5), and sulphates (Table-4). During decomposition of organic material in anaerobic/reducing conditions, reduced sulphur (H_2S) is produced which in the presence of iron (Fe^{2+}) may form pyrite (FeS_2) (Moncur *et al.* 2006). JPH fen deep and ML fen deep samples, overlying clay deposits - a source of siderite - were additionally supersaturated with respect to siderite (0.51 and 1.73 respectively). Data input sets were not complete for ML fen WT, ML bog WT, ML bog deep, or ML upland (shallow and mid-depth) locations so SI values were not calculated. SI's were modelled using PHREEQC in AquaChem (2005).

At JPH and ML, SI's had high variability indicated by high sd values (0.04 – 6.39). Closer examination of SI data (Appendix H) may reveal seasonal effects of temperature on solubility (as solubility differs with temperature) or microbial activity (as metabolism is slower with decreasing temperatures). Water level changes affect redox conditions that drive equilibrium reactions. And temporal variability in the inputs of precipitation and flow regimes may, by dilution and/or inputs of solutes, affect equilibrium states.

3.3. Do different landscape units have distinct hydrogeochemistry?

Water samples from JPH and ML are differentiated based on their water type, and data is explored using multivariate statistics. A summative Piper plot compares the water types at JPH with those at ML. Intra-site analyses follow in which detailed Piper plots, PCA results, and box plots are presented for JPH then ML. A Piper plot facilitates the visual grouping of similar water samples based on their proportional concentrations of major cations (Ca^{2+}, Mg^{2+}, $K^+ + Na^+$), and major anions (SO_4^{2-}, Cl^-, $HCO_3^- + CO_3^{2-}$). And principal component analysis (PCA) is used to reduce the number of variables to two components that account for the variability of the data and to explore the extent of similarity or difference among landscape units and sampling depths.

The Piper plot of 2011 – 2012 data highlights some inter-site differences, shown by the greater scatter of JPH samples (unfilled) than ML samples (filled) in the rhombus plot (Figure 21). JPH fen and JPH upland samples are of calcium-sulphate or calcium-bicarbonate type; ML bog and ML fen samples are of calcium-bicarbonate type. Spatial or temporal variability is significant for scattered data; a wide range of anions is seen for JPH generally (unfilled, Figure 21 bottom right), and for cations of ML upland samples (filled squares, Figure 21 bottom left).

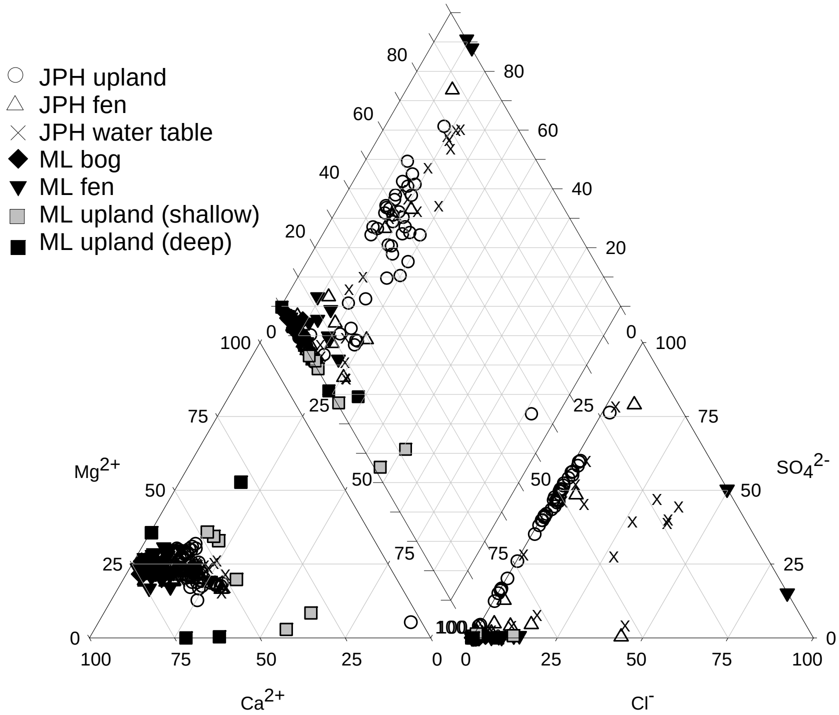


Figure 21 Piper plot of JPH and ML samples. Data includes August 2011, May 2012 and September 2012 samples. JPH upland (open circle), JPH fen (open triangle), JPH fen water table (X), ML fen (filled inverted triangle), ML bog (filled diamond), ML upland (shallow grey filled square and deep black filled square). ML water table wells are not included.

JPH Piper Plots To investigate spatio-temporal variability, two Piper plots were plotted for JPH upland (Figure 22 top), and JPH fen (Figure 22 bottom); shades of grey classify the same data by time (left) or depth (right). Generally, JPH upland and fen samples were typically dominated by calcium type with no discernable landscape or depth differentiation: data form clusters in the cation trilinear plot (left). Greater variability in time and space for both JPH upland and fen landscape units was evident for anions. In the anion trilinear plot (right), data plot along a continuum of dominant sulphate or carbonate type. At JPH upland, time differentiates August 2011 mid-depth samples systematically from other mid-depth samples, which may relate to the dry hydrologic regime. Generally, upland samples are grouped primarily by depth. At JPH fen, mid-depth and deep samples group closely in time and space. But shallow and WT fen samples show relatively high scatter, with fairly strong grouping by sampling campaign.

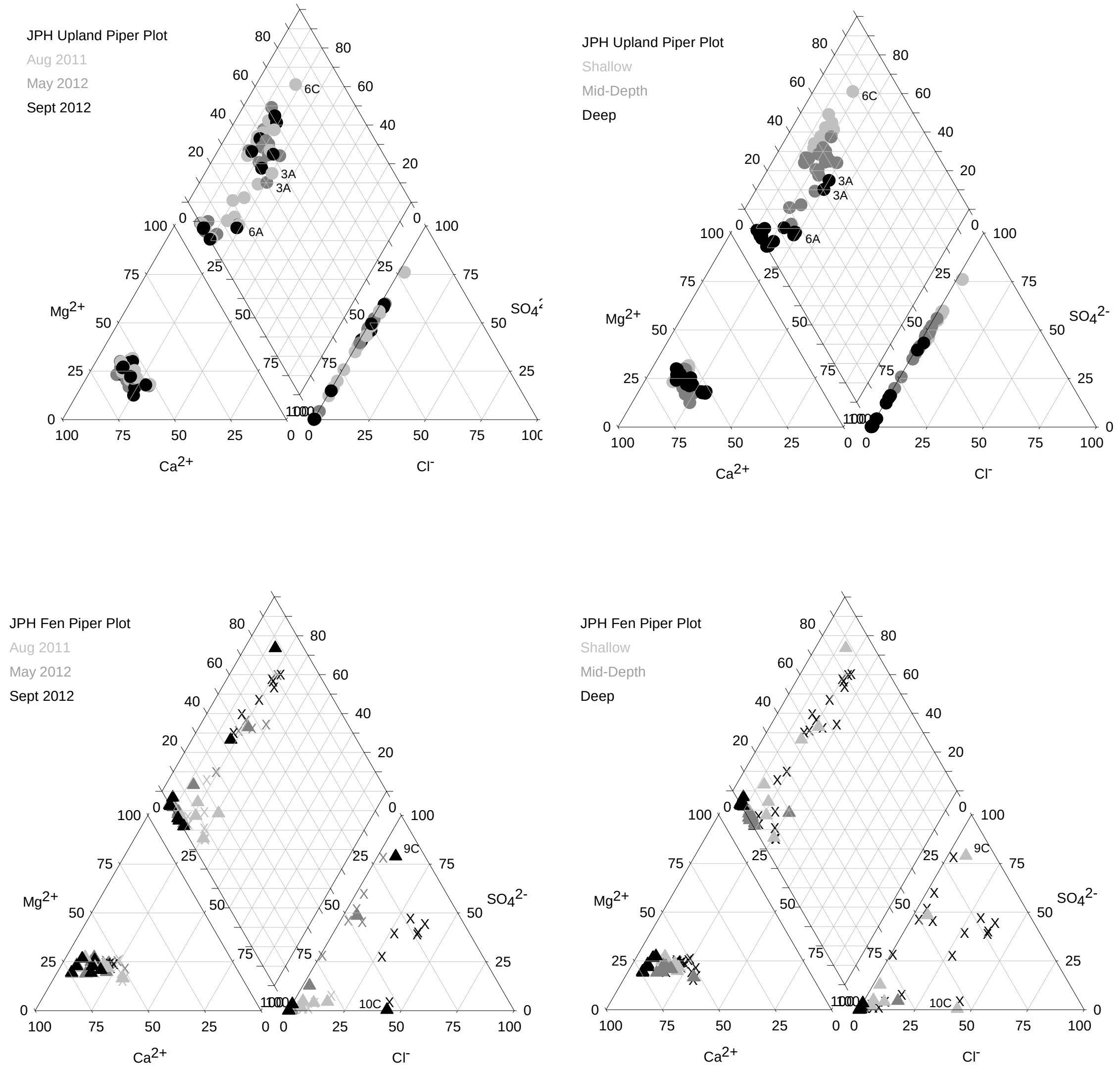


Figure 22 Piper plots of 2011 – 2012 water samples at JPH upland (top) and JPH fen (bottom). JPH upland – circles, JPH fen – triangles, water table – X. Shades of grey classify the same data by time (left) and depth (right). Light to dark – August 2011 to September 2012. Light to dark – shallow to deep.

Water types at JPH upland and mid-depth and deep fen samples were consistent and distinct, which suggests that there are no changes in hydrologic connectivity at these units. Near-surface fen samples changed in time, primarily showing greater relative domination by chloride anions in summer (September 2012) samples. The presence (or absence) of surface water and seasonal evaporative enrichment drive changes in watertype of shallow samples, and deeper samples are part of a well-mixed groundwater continuum.

JPH Multivariate Statistics PCA was used to reduce measured parameters to components that account for the variability of the data. In this analysis, 2011 – 2012 data means of 38 parameters were input and loading and score plots generated for the first two components extracted for JPH (Figure 23). At JPH, the first two components combined explain 48.7% of the variability and differentiate all samples by landscape unit and depth except deep upland samples. The first component is dominated by sulphate (SO_4), reduction potential (Eh) and transition elements such as iron (Fe) and manganese (Mn). Deep upland samples coincide to varying degrees with mid-depth fen or mid-depth upland samples (Figure 23). From the loading plot, parameters of interest are those that are far from the origin, including SO_4, Mn, strontium (Sr), dissolved organic carbon (DOC), ammonium (NH_4), and aluminum (Al).

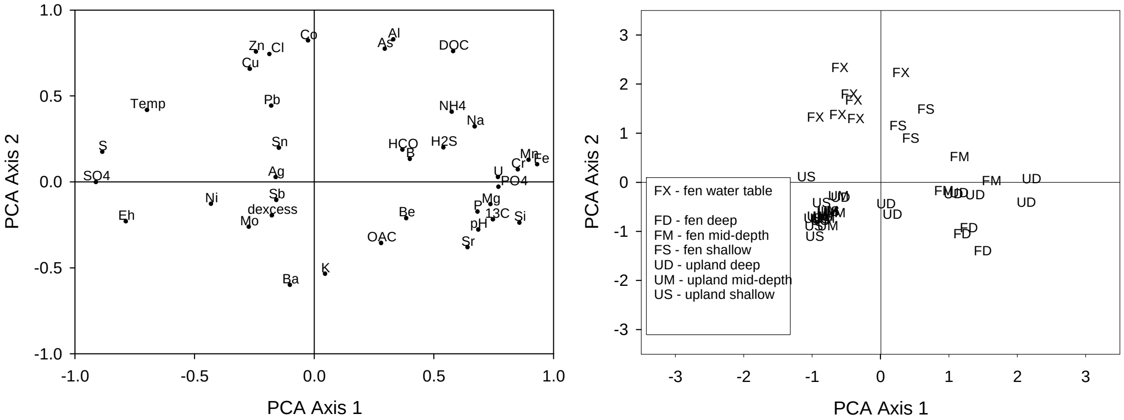


Figure 23 PCA loading plot (left) and scoreplot (right) of JPH 2011 – 2012 average data. In the scoreplot, sampling locations are coded: the first letter refers to landscape unit (F – fen, U – upland), the second letter to depth (FX – fen water table, S – shallow, M – mid-depth, D – deep).

JPH box plots Means and ranges of parameters at each depth category in the fen and upland can be compared in box plots (Figure 24). The box plots highlight that sulphate concentrations were high in near-surface samples at JPH (up to 14 mg/L, compared with

ML samples which were < 1 mg/L) and decreased with depth. Cation concentrations (e.g. calcium) and trace metals (e.g. strontium) generally increased with depth. Concentrations of DOC, NH_4, Al and Mn increased with depth in the upland, while concentrations in the fen were highest at shallow or mid-depth. For example, Al concentrations were highest in for the shallow fen samples and lowest for deepest fen samples, while Mn and NH_4 concentrations were highest in mid-depth samples.

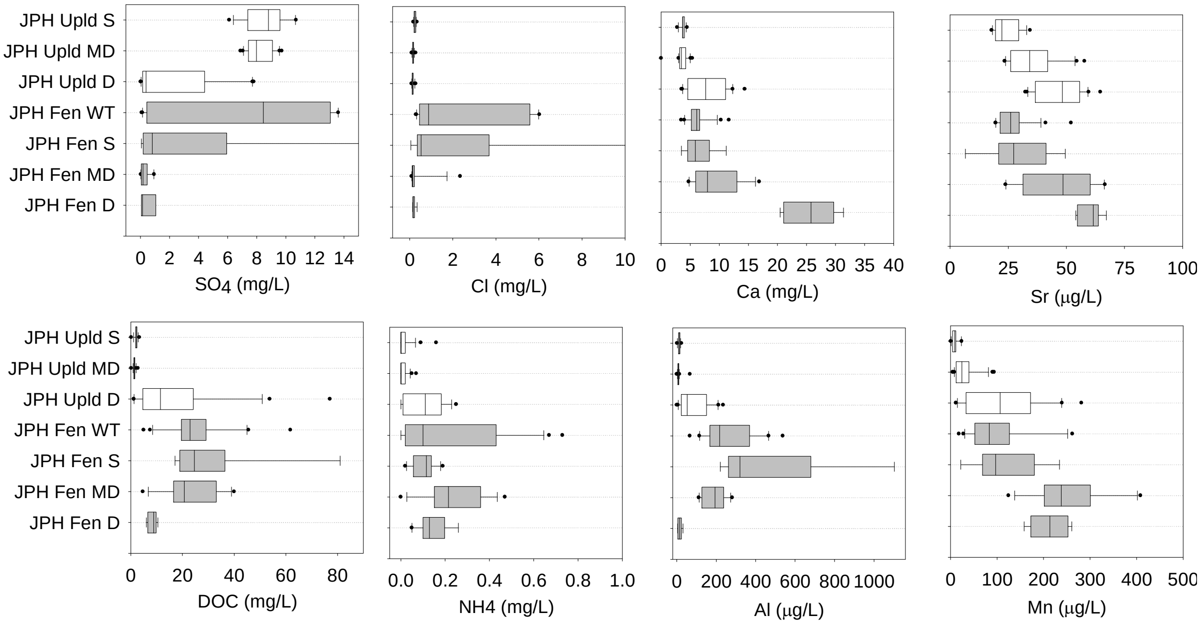
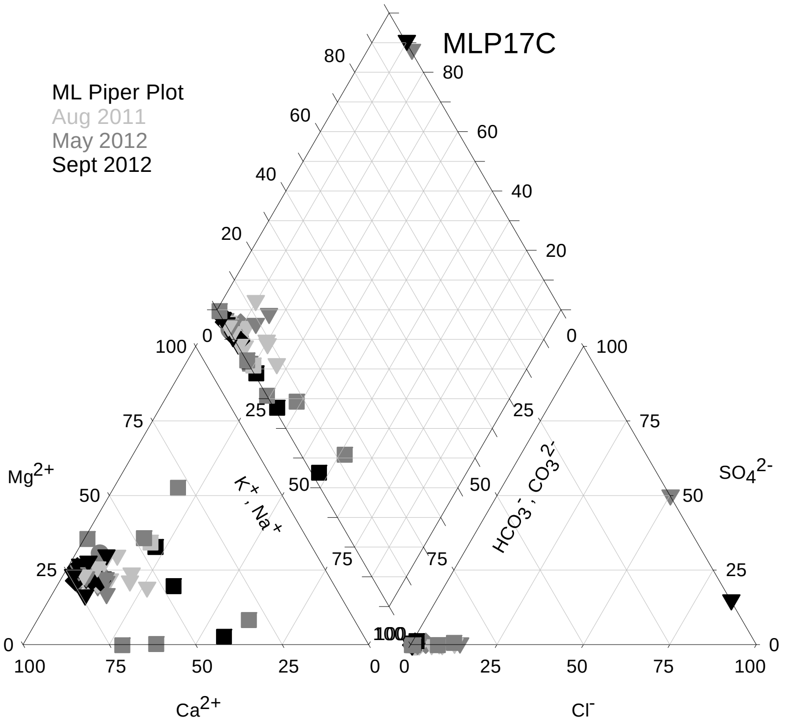


Figure 24 Boxplots of 2011 – 2012 data for different depths at JPH upland (Upld) and fen. Depth categories are nominal: water table, shallow, mid-depth and deep – WT, S, MD, and D respectively. First row: concentration of ions sulphate (SO4), chlorine (Cl), calcium (Ca) and strontium (Sr). Second row: concentrations of DOC and redox sensitive species ammonium (NH4), aluminum (Al) and manganese (Mn). The line within the box is the median, the limits of the box are the 25th and 75th percentiles, whiskers are the 10th and 90th percentile, and outliers are plotted.

ML Piper plots Spatiotemporal variability of 2011 – 2012 data at ML is investigated comparing two Piper plots (Figure 25) in which shades of grey differentiate the same data by time (top) or depth (bottom). At ML, spatial and temporal variability of major ions was generally small, as demonstrated by close clustering of data points with the exception of MLP17C, a shallow fen well. Shallow ML fen samples (light grey inverted triangles) fall near but outside of the tight cluster of ML samples (Figure 25). Upland samples (squares) vary in dominant cation type. Water table well data were excluded as samples were very dilute, dominated by organic acid contribution, and small changes in actual concentration would represent a disproportionate shift in water type. At ML, peatland porewaters are found to be of similar water type with greatest spatio-temporal variability attributed to the shallow fen samples. And upland porewaters have site-specific cation concentrations, consistent with different substrates and/or proximity to the peatland edge.



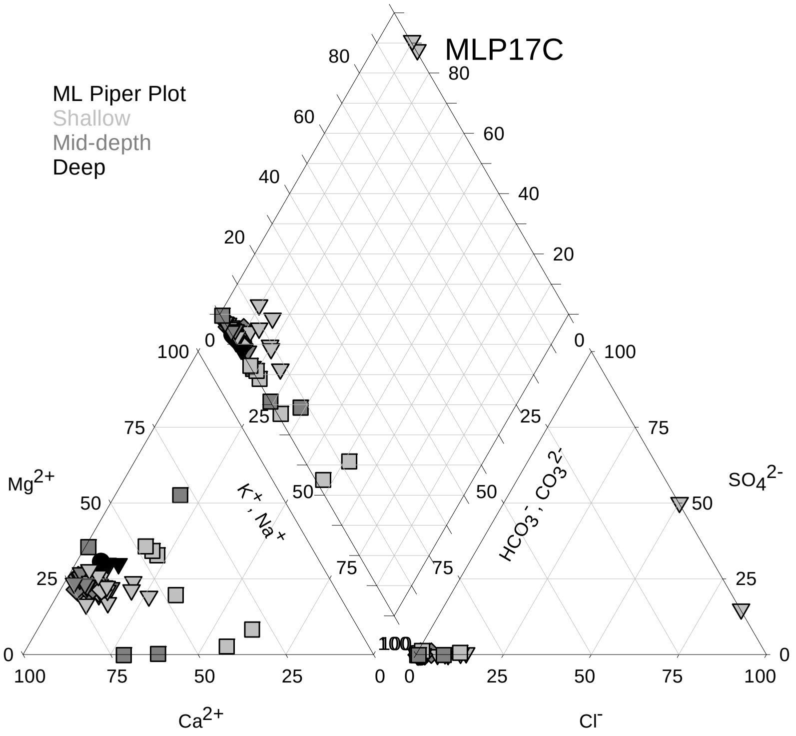


Figure 25 Piper plots of 2011 – 2012 ML data show the same data using shades of grey to differentiate time (top) and depth (bottom). Symbols represent landscape unit: diamond – bog, inverted triangle – fen, square – upland. Light to dark grey scale differentiates time (top) – August 2011 to September 2012 or depth (bottom) – shallow to deep.

ML multivariate statistics PCA, as for JPH data, was used to reduce 38 variables to fewer components that explain the variability in the 2011 – 2012 ML data set. At ML, the two main components explained 34.8% of the variability. Variables of interest, which plot at a distance from the origin along the major axes (Figure 26, left), are dissolved organic carbon (DOC) and redox potential (Eh), a group of cations including calcium (Ca) and strontium (Sr), and transition elements magnesium (Mg) and manganese (Mn). In the scoreplot (Figure 26, right), water table (WT) samples of ML bog and ML fen cluster closely, as do most shallow and mid-depth samples. The clustering reflects their general similarity and points to a complexity of co-occurring biogeochemical and hydrological controls. Outliers in the score plot are from the upland (i.e., upland mid-depth, UM) or the mineral substrate underlying the peatland (i.e., bog deep, BD, or fen deep, FD).

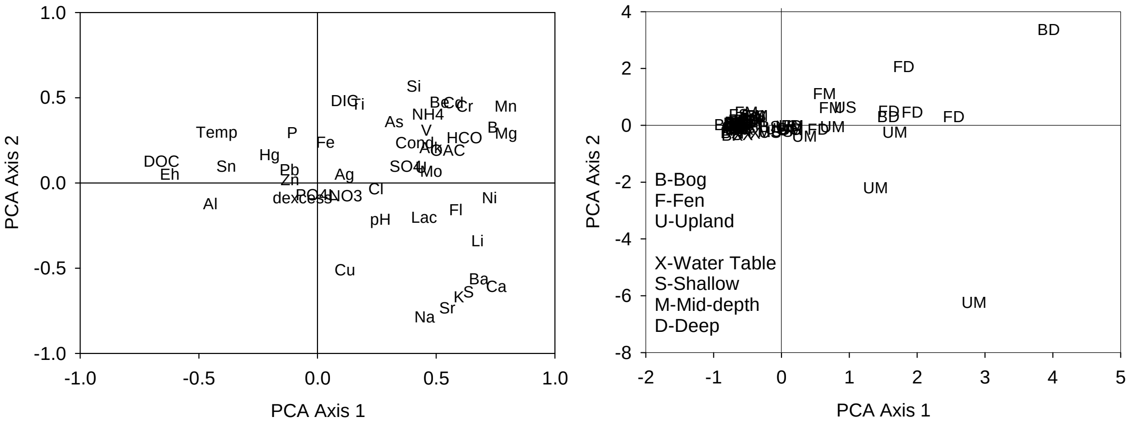


Figure 26 PCA loading plot (left) and scoreplot (right) of ML 2011 – 2012 average data. In the scoreplot, the first letter refers to landscape unit (B – Bog, F – Fen, U – Upland) and the second letter to depth (X – water table, S – shallow, M – mid-depth, D – deep).

ML box plots From the suite of box plots (Figure 27), porewaters of fen and bog sites are similar in their data ranges and trends with depth. Overall, the box plots show low anion (sulphate and chlorine) concentration ranges, and high cation (calcium, manganese, strontium) concentration ranges only for upland and mineral substrates underlying the peatland. Porewaters especially at the near-surface were dilute. Whereas ammonium (NH4) increased with depth, aluminum (Al) decreased with depth in the fen and bog.

DOC concentrations decreased with depth in the bog, but increased before decreasing with depth in the fen.

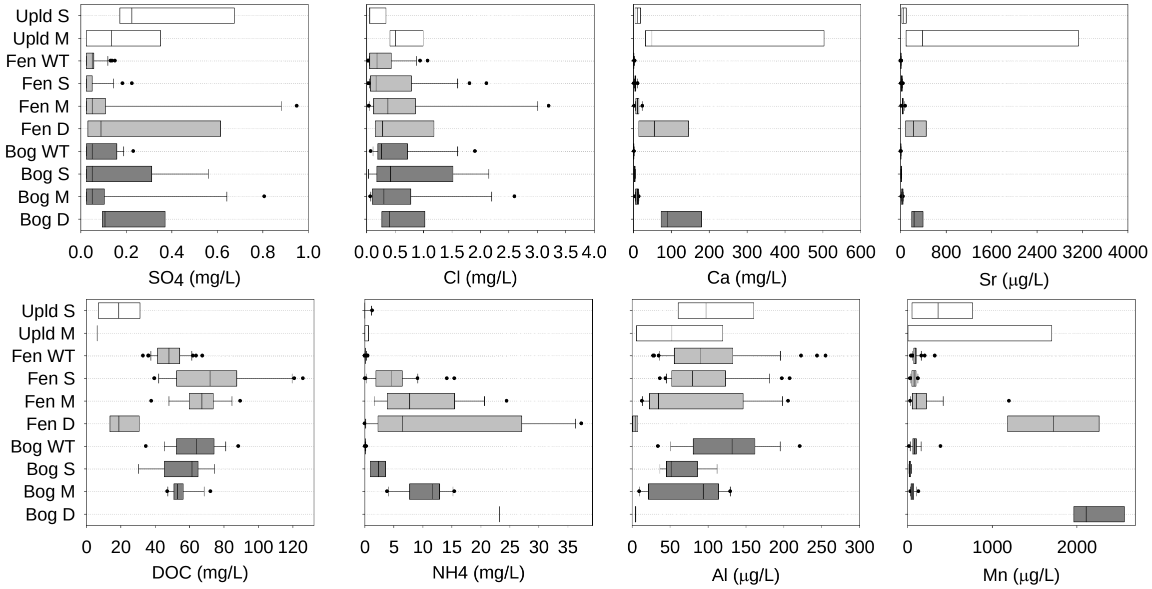


Figure 27 Box plots of 2011 – 2012 data at different depths and landscape units at ML. Landscape colors: Upland (Upld) – white, fen – light grey, and bog – dark grey. Depth categories are nominal: Water table (WT) – 0.4 m, shallow (S) – 1.5 m, mid-depth (M) – 3 m, deep (D) – 6.5 m. First row: concentration of ions sulphate (SO4), chlorine (Cl), calcium (Ca) and strontium (Sr). Second row: concentrations of DOC and redox sensitive species ammonium (NH4), aluminum (Al) and manganese (Mn). The line within the box is the median, the limits of the box are the 25th and 75th percentiles, whiskers are the 10th and 90th percentile, and outliers are plotted.

Chapter 4.
Discussion – Evidence of Connectivity

Connectivity within and among landscape units refers to the exchange of water and the dissolved and particulate matter within it (Bracken *et al.* 2013), an understanding of which can be used to identify and quantify hydrological budgets and nutrient fluxes. A hydrological budget is the balance of precipitation inputs, evapotranspiration, interception, surface runoff/on, sub-surface in/outflows, and changes in water storage. The overall nutrient flux needs to take into account inputs from wet and dry atmospheric deposition, surface and groundwater in/ and outputs, and the balance of cation exchange, redox reactions and biological processes. Hydrological connectivity is sensitive to - in decreasing order of importance (Devito *et al.* 2005) – climate (Section 4.1); bedrock geology, surficial geology, and soil type/depth including wetlands (described in Section 2.8.1); and topography/drainage networks (considered in developing conceptual models of connectivity at JPH, Section 4.2, and ML, Section 4.3).

The sections on hydrological connectivity for JPH and ML are introduced by highlighting key physical hydrology findings. A conceptual model describes the hydrological budget, potential flowpaths, and the biogeochemical and physical processes driving changes in geochemical and isotopic composition of water samples. Connectivity is analysed by relating spatial contour plots of parameters to landscape units and considering depth profiles along transects across landscape units. Continuous hydrological connectivity results in waters that have similar geochemistry, though changes in Eh along a flowpath may alter the concentrations of redox-sensitive species, and changes in productivity in time and space may further alter the concentrations of nutrients. Dynamic short-term hydrological connectivity results in localized pulse inputs of solutes. Insights regarding origin and evolution (mixing and/or evaporation) of water samples are gained from the isotopic signatures of waters. And to conclude, the fate and behaviour of nitrogen is addressed for each study site in the context of hydrological connectivity.

4.1. Climate Context

In terms of climate, temperature and precipitation departures from climate normals indicate above-average temperature and annual precipitation for 2011 – 2012 for the Northwestern Forest region in which JPH and ML are located (Figure 28, years of study are marked with open squares). The greatest positive precipitation departure for years 1948 – 2013 was for 2012. The years of study (2011 and 2012) differed in terms of cumulative precipitation. Snow accumulation for the winter of 2010/2011 exceeded the snow accumulation in 2011/2012 (CEMA, Pers. Comm. 2013). And in 2011 most precipitation events occurred early in the year, whereas in 2012 precipitation events continued into fall. To illustrate, cumulative precipitation (grey solid), and minimum and maximum daily temperatures (red dotted and black solid lines respectively) are shown for Lac La Biche, 120 km south of ML (Figure 29) (Environment Canada 2013). The timing of sampling campaigns in 2011 and 2012 are superimposed as vertical arrows. In the discussions on connectivity, three sampling campaigns are compared: August 2011 is a dry end of year, May 2012 is early after snowmelt, and September 2012 is the end of a wet year.

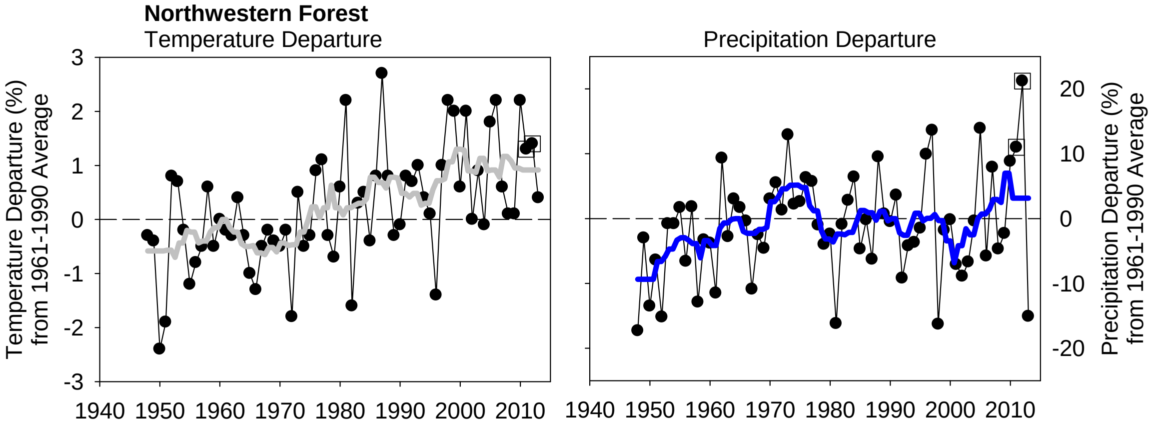


Figure 28 Temperature (left) and precipitation departures (right) from 1961 – 1990 averages for the Northwestern Forest region of Canada (Environment Canada 2014). Running means (5 year) are superimposed. Sampling years 2011 and 2012 are indicated with open squares. Both years were wetter than the long-term average. Note that 2012 was the wettest year in the record.

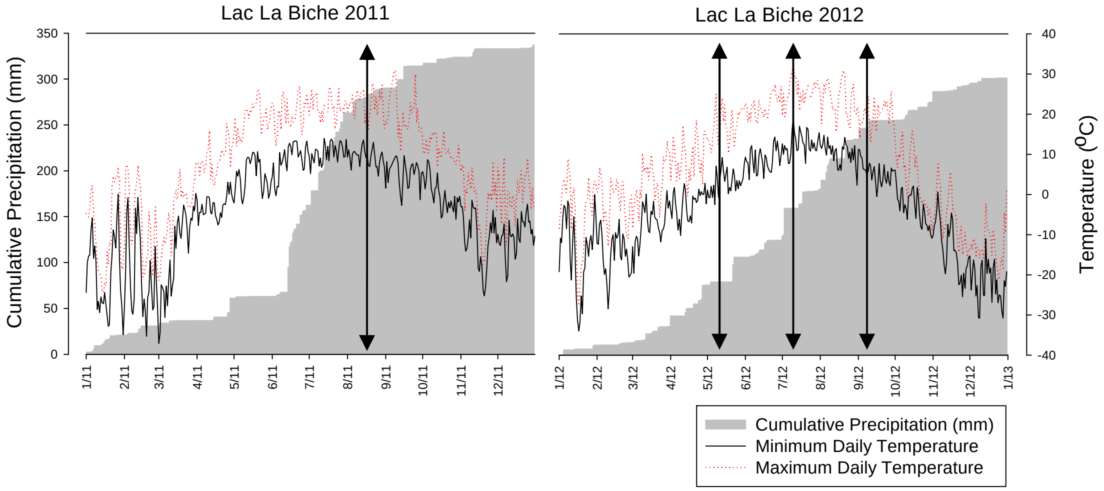


Figure 29 Precipitation and temperature at Lac La Biche for 2011 (left) and 2012 (right). Precipitation is cumulative (grey solid), temperatures are daily maximum (red dashed line) and daily minimum (black line). Lac La Biche is 120 km south of ML. Vertical arrows show the timing of sampling campaigns at ML.

4.2. Connectivity at JPH

4.2.1. JPH Hydrological Context

The two field seasons of monitoring included a wide range of hydrologic regimes. Observations during the site reconnaissance in early 2011 described water flow in the JPH fen creek as ‘vigorous’. Later that year, in August 2011, the surficial flow was slow and nearly stagnant in some areas. In contrast, by late 2012, aside from the creek flowing ‘vigorously’ again, the fen around the meteorological station was flooded. Upstream of the study site, the extent of ponded water changed dramatically, from ‘open-water’ early in 2011, to nearly dry by August 2011, to about 30 cm deep in September 2012. Water table levels in the fen varied 1.6 – 2.1 m from their average levels during the two field seasons.

A description of the hydrology at JPH is based on surface drainage networks that were modelled using LiDAR data and flownets that were created using hydraulic head measurements (Vallarino 2014). Surface flow follows topography and is directed northward in the fen. Shallow groundwater flow from the uplands was directed westward towards the fen in 2011 and was directed northwest towards the fen (i.e. further downstream) in 2012. In August 2011 flow in the fen was parallel to the surface and in September 2012 flow recharged at the upstream well nest JPHP08. Vertical gradients consistently showed recharge in the upland, with few exceptions, e.g. at JPHP04 where the direction of the hydraulic head gradient changed (not shown). Hydraulic head gradients were lower in 2011 than in 2012, so groundwater fluxes would have been lower (and water residence time higher) in 2011 than in 2012. Hydraulic conductivity, determined by falling head and/or slug test, was higher at the upland and shallow fen sites ($4.35*10^{-5}$ ms^{-1}) than the deep fen ($2.08*10^{-6}$ ms^{-1}) (Vallarino 2014). Hydrological connectivity may be driven by topography at JPH and is summarized as follows:

a) flow is directed from the upland to the fen,

b) recharge to depth persists in the upland,

c) flow is parallel to the surface topography in the fen, but recharge may occur within the fen when water table levels are high.

4.2.2. Geochemical Evidence of Connectivity at JPH

To facilitate the description of connectivity, study site JPH is conceptualized as a fen – upland transect (Figure 30). The JPH upland landscape unit is at a slightly higher elevation a few hundred meters from the fen and constitutes, compared to the fen, a more uniform landscape unit. The fen WT, perennially saturated, is productive and biogeochemical processes vary spatially and temporally. Of the fen sampling sites, nest 8 (upstream) is episodically inundated. The hydrology at the JPH fen sites, *viz.* changes in surface ponding and channelized flow, is variable as the terrain, channel width, and vegetation are not uniform. The schematic of the rich fen – upland gradient at study site JPH (Figure 30) illustrates the drivers that affect sample isotopic signatures and geochemistry: physical hydrological processes (rectangles: precipitation, evaporation, transpiration, runoff, infiltration, interflow, recharge/discharge) and biogeochemical processes that occur along flowpaths or *in-situ* (in italics: biological demand, decomposition, anaerobic processes, dissolution, leaching and redox reactions).

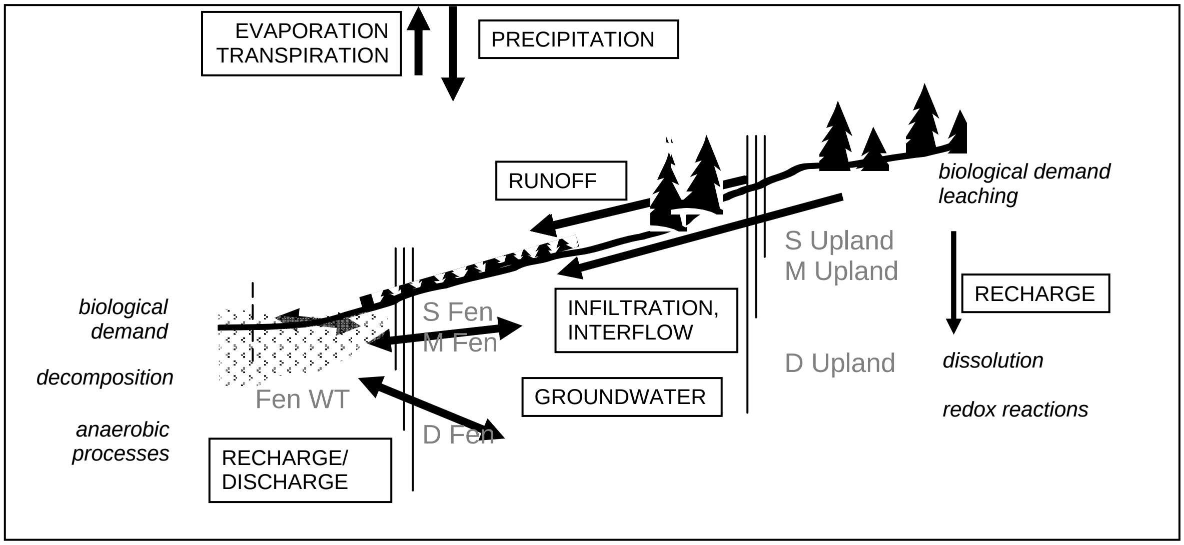


Figure 30 Schematic cross-section of the JPH study site. Physical hydrology (rectangles) and biogeochemical processes (italics) affect the water chemistry. Double-sided arrows show areas of potential connectivity, which are the focus of this study.

As determined from the baseline characterization (Chapter 3), the shallow portions of the fen (fen WT and shallow wells) have the greatest seasonal variations in hydrogeochemistry, and mid-depth fen and deep upland samples have some similarity. Geochemical evidence of connectivity is explored along two cross-sections at JPH (Figure 31). Data from the W-E transect at A-A^1 are used to explore the connectivity between the fen and the upland, and includes water table well E, fen piezometer nest 10, and upland nests 7 – 1 – 2 – 11. Data from the transect B-B^1 that follows the channel in the fen are used to explore evolution along the flowpath and connectivity within the fen. Transect B-B^1 includes water table wells A – B – D – C – E – F and fen piezometer nests 8 – 9 – 10. Piezometer nest 10 and water table well E are common to both transects. Cross-section contour plots of various parameters are shown for August 2011, May 2012, and September 2012, respectively windows into a dry end of year, the time soon after spring melt, and the end of a wet year (Figure 33 & Figure 37 for transect A-A^1 and Figure 35 & Figure 36 for transect B-B^1). In exploring connectivity, parameters such as δ^{18}O and calcium show spatiotemporal trends consistent with physical hydrological processes, whereas parameters such as Eh, DOC, nitrogen or sulphur species are sensitive to chemical processes governed by redox conditions and rates of metabolism and decomposition. The latter processes are affected by temperature and residence time.

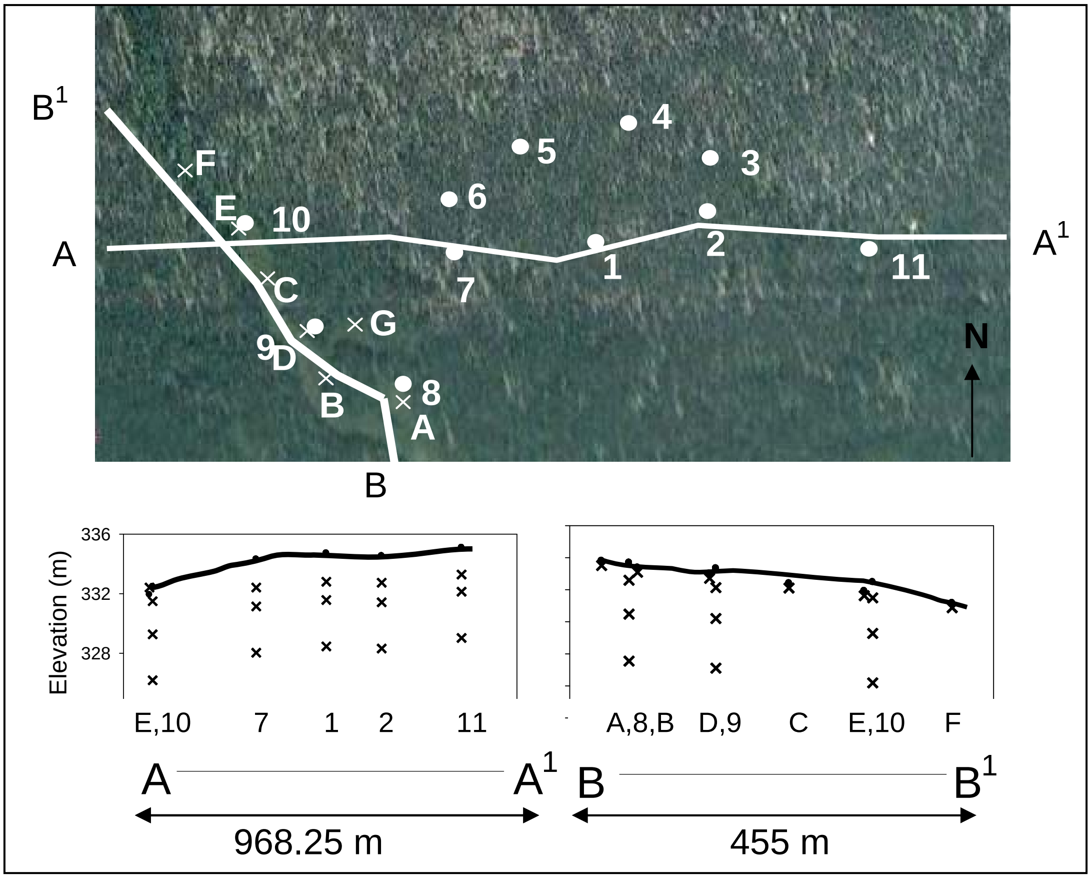


Figure 31 JPH plan view map (top) of transects and cross sections of transects A-A^1 (lower left) and B-B^1 (lower right). The true orientation of transects A-A^1 and B-B^1 are simplified as E-W and N-S respectively. Transect A-A^1 includes water table well E near fen piezometer nest 10 and upland nests 7 – 1 – 2 – 11. Transect B-B^1 includes water table wells A – B – D – C – E – F and fen piezometer nests 8 – 9 – 10. In the cross-section plots (bottom), x's are sampling elevations, the y-axis is elevation, and the x-axis is longitude for transect A-A^1 and latitude for transect B-B^1. The respective vertical exaggeration factors are 43.7 and 20.5. Image source: Google^{TM}earth.

Transect A-A^1 Flow potential persists from the upland toward the fen, as shown by contour plots of hydraulic head (Figure 32). The lateral hydraulic head gradient for transect A-A^1 is between 1.7 and 2 m over ~950 m, and vertical gradients often < 0.1 m over a depth of 4 m, with few exceptions. Time series of contour plots for $\delta^{18}O$, Ca, and DOC for the fen – upland transect are presented in Figure 33. The contour plots highlight the uniform depth profiles within the upland and reiterate that seasonal variability is most pronounced at the shallow fen and fen WT.

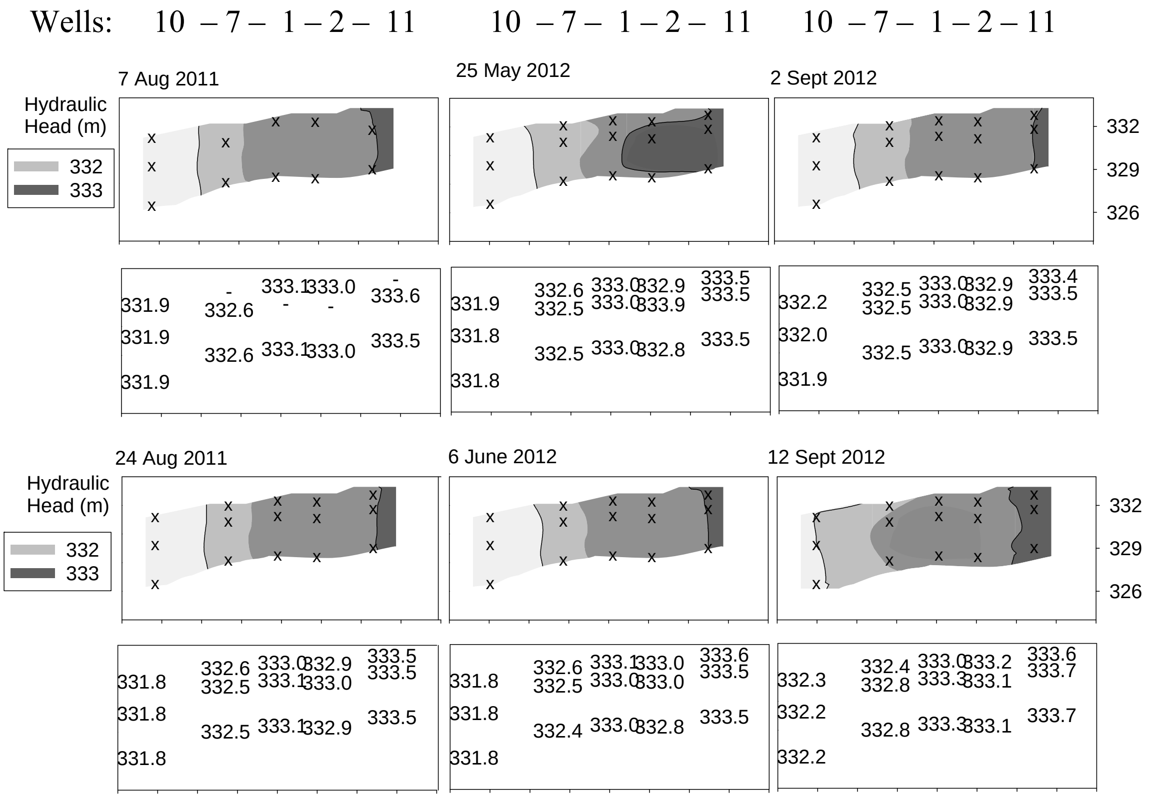


Figure 32 Time series of hydraulic head contour plots for transect A-A^1 at JPH.

Constant $\delta^{18}O$ values of -18 ‰ are observed at the deepest piezometers at JPH consistent with a well-mixed groundwater system (Figure 33). Water is more depleted (-19 ‰) at mid-depth in the upland, and falls within a narrow range of variability (-20 to -19 ‰) in the shallow upland sampling depths. Recharge of snowmelt, a depleted water source, could explain lower isotope values measured in May 2012, and terrain-dependent infiltration accounts for variability. The isotopic signatures of groundwater samples from the shallow fen and fen WT wells vary seasonally. In May 2012, the shallow fen and fen WT water samples are -18 ‰, similar to the deep groundwater signatures; whereas in August 2011, the signatures (-19 ‰) are similar to the shallow upland groundwater signatures. In September 2012, the shallow fen sample is enriched (-17 ‰), and fen WT sample more so (-15 ‰). Such enrichment may be due to the evaporation of the body of water or the input of isotopically heavier summer rainfall events. D-excess values, used to differentiate the two processes, are lower for samples that have been evaporatively enriched than for samples from heavier rainfall. At JPH, d-excess of rainfall samples ranged from -3 to 7, and of snowpack from 4 to 10. In September 2012, the relatively high d-excess value of 5.9 is more likely related to the input of summer rainfall than post-depositional evaporative enrichment.

Evidence of hypothesized connectivity may be gained from calcium isoconcentration plots (Figure 33). At JPH, calcium has a strong depth gradient and variability is limited to the near-surface sampling locations in the fen. Generally calcium concentrations increase with depth and at mid-depth and deep sampling categories concentrations are stable within 1 – 2 mg/L. A greater increase, from 6 to 11 mg/L Ca, was measured for the shallow fen from May 2012 to September 2012. The fen WT has a lower concentration (7 mg/L) so recharge from the immediate fen surface water would not account for the change. Possible explanations for elevated calcium include: recharge by an earlier pulse of high-calcium surface water, recharge by higher-calcium groundwater or higher-calcium upstream fen water, biological or evaporative concentration of calcium, or increased *in-situ* dissolution of calcium as water levels increased.

Some sampling locations have large variations in DOC concentrations (Figure 33). DOC concentration ranges in the shallow upland (0 – 3 mg/L) and fen WT (17 – 20 mg/L) remain within 2 mg/L for the three field seasons. The elevated value (81 mg/L) at the shallow fen in September 2012 compares with 30 – 31 mg/l in May 2012 and August 2011. The mid-depth fen increases between August 2011 and May 2012 from 5 to 20 mg/L. And DOC at depth in the upland is higher in September 2012 (40 – 77 mg/L) than May 2012 or August 2011 (12 – 37 mg/L). During high water levels in May or September 2012, elevated DOC concentrations in shallow and mid-depth fen samples may imply connectivity, i.e., recharge of high-DOC waters from the fen water table to shallow and mid-depth fen locations. In the upland, rainfall leaching through the litter layer may gain DOC that infiltrates to depth in the upland and is transported to the fen along the potential flow paths from the upland to the fen indicated by hydraulic head measurements. Water levels were lower in August 2011 and residence time may have been longer. A lower input of DOC (due to less rainfall leaching DOC from the near-surface to depth) and longer residence times (implying more time for DOC degradation) may contribute to the lower DOC concentrations observed in August 2011. A wetter season may mobilize groundwater with higher DOC content, if the site is underlain by strata with greater organic content or if regional lateral connectivity is established between deep upland water and scattered wetland landscape units that are a DOC input.

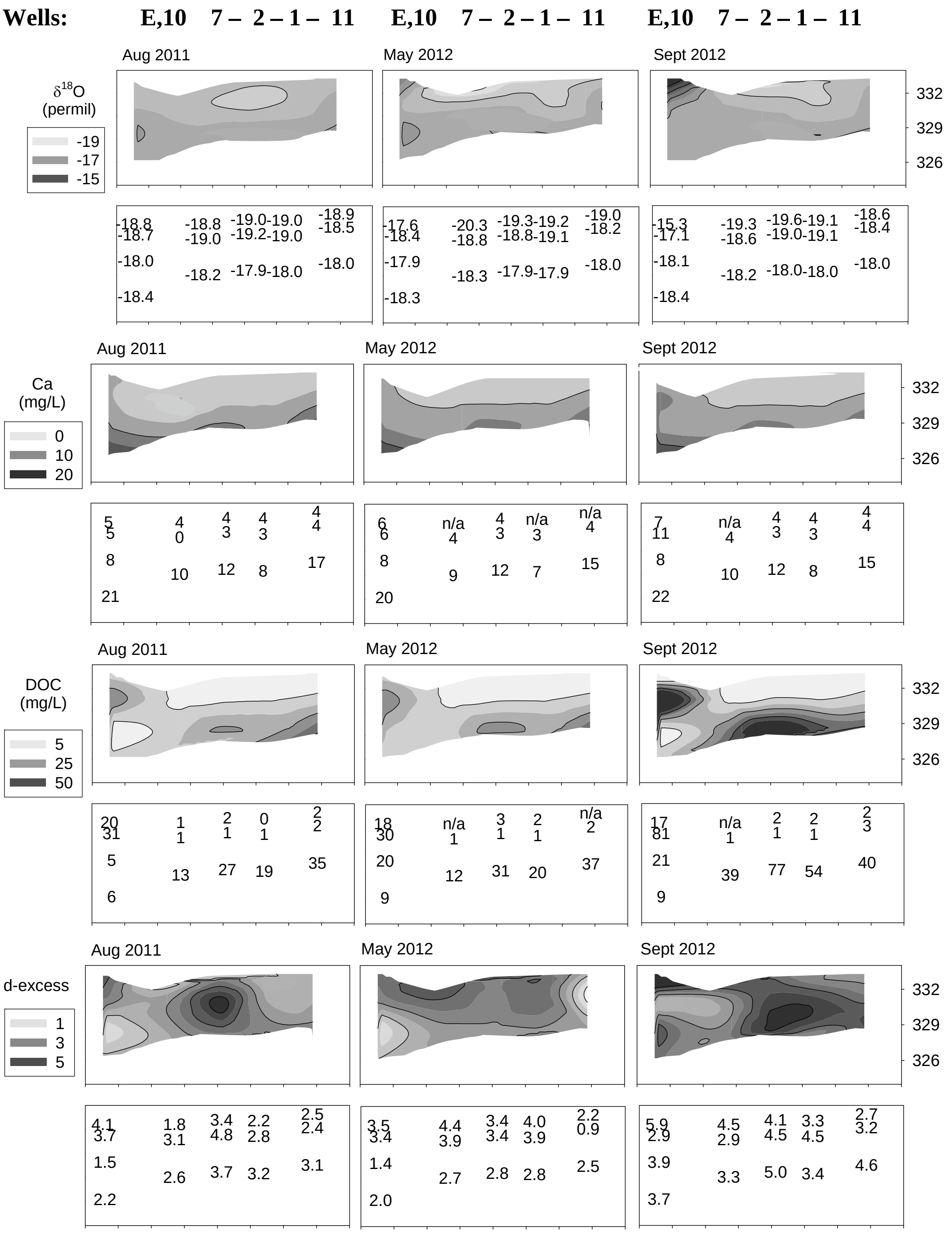


Figure 33 Time series contour plots for δ^{18}O, Ca, DOC, and d-excess along transect A-A[1] at JPH for August 2011, May 2012 and September 2012.

Transect B-B^1 The time series of hydraulic head at transect B-B^1 (Figure 34) indicate shallow groundwater flow northward and recharge from shallow to deeper wells. On a few occasions (7 August 2011 and 6 June 2012) the mid-depth well at nest 8 had higher potentials than the shallow and deep wells, possibly indicating a pulse of water moving at mid-depth. Well nest 8 is episodically inundated, is underlain by a layer described as *harder* during well installation, and is located near the site where water ponding occurs.

Wells: **8 9 10** ; **8 9 10** ; **8 9 10**

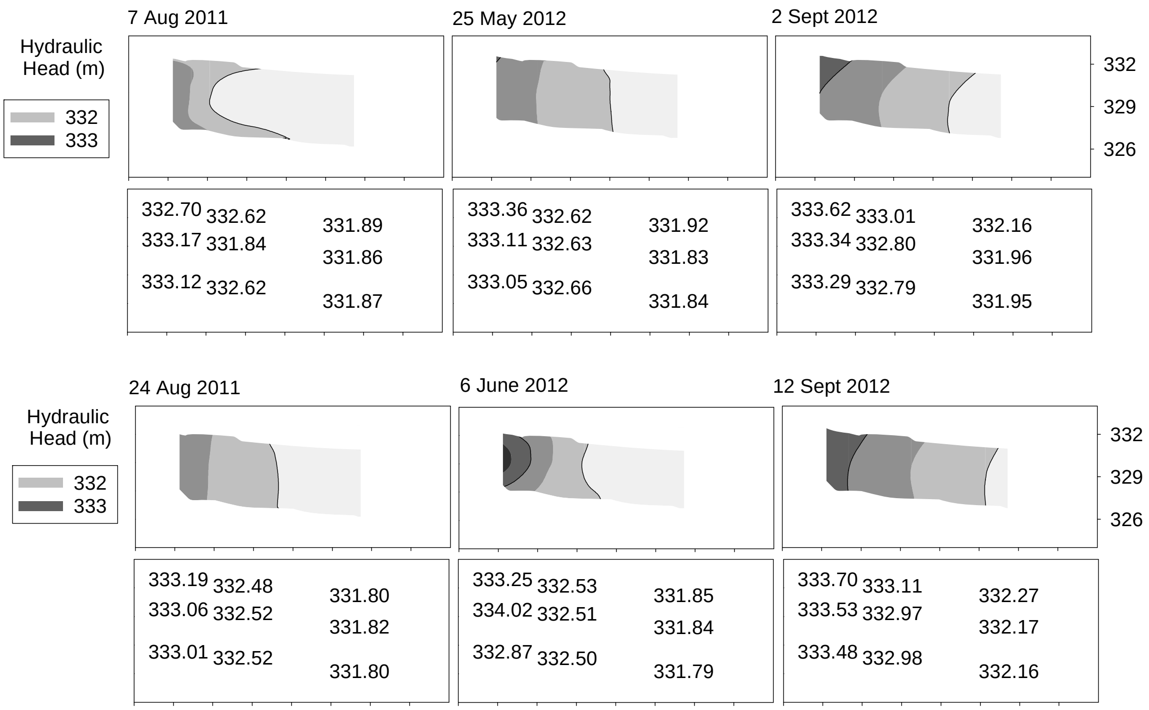


Figure 34 Hydraulic head time series for transect B-B^1 at JPH.

Within the fen, hypothesized connectivity is explored using depth contour plots for δ^{18}O, Ca, Cl, and DOC (Figure 35) and NH$_4$ and SO$_4$ (Figure 36) over the two field seasons. Apart from a general concentration gradient with depth, trends are not easily generalized for the fen. The complexities arise from inhomogeneous fen morphology and vegetation, which drive water ponding, subsurface storage, and channelized flow and affect biological processes.

In the contour plots for transect B-B^1 (Figure 35), $\delta^{18}O$ values are consistently about -18 ‰ for samples taken from the mid-depth. For the samples from the deepest wells, $\delta^{18}O$ values are similarly around -18 ‰, with instances of lower values (-19 ‰). The temporal trends of $\delta^{18}O$ of the samples from the shallow fen and WT locations are comparable, though there are exceptions. August 2011 signatures range from -18 ‰ to -19 ‰, except at WT wells A and F. The sample from WT well A shows an enriched signature (-16 ‰). WT well A is relatively unshaded and near a source of open ponded water that by August 2011 was drying up. The d-excess value of this sample was 2.1 ‰, which is the lowest value for the transect in August 2011 so enrichment due to evaporation of surface water was likely for this sample. It is of interest to note that the enriched water is not reflected in other sampling locations in August 2011, suggesting localized influence and limited exchange, i.e., connectivity. In contrast, the August 2011 sample from WT well F, furthest downstream, is depleted (-20 ‰ for $\delta^{18}O$) and has a d-excess of 5.6 ‰. Groundwater (and snowmelt stores) have a depleted signature, so perhaps the fen near water table well F is being recharged by upland or deeper fen groundwater inputs. May 2012 fen WT samples have a range of negative $\delta^{18}O$ values (-21 to -19 ‰) and samples from piezometer nests 8 and 10 also have depleted signatures (-20 and -18 ‰ respectively). By September 2012, successive rain events would have increasingly heavier signatures and near-surface waters may further become isotopically heavier due to evaporation. Along the transect at WT wells, $\delta^{18}O$ values are -15 ‰ and d-excess values range from 4.5 to 6.4 ‰, except at water table well C (-19 ‰, d-excess 2.6 ‰). Fen WT locations in September 2012 are likely recharged by summer rainfall, except fen WT C, which has isotopic signatures similar to groundwater inputs. The shallow fen samples show a 1 ‰ enrichment from May 2012 to September 2012, which reflects inputs of heavier WT waters recharging and mixing with subsurface water. Evaporation of subsurface waters through an unsaturated zone may also cause enrichment, though at this riparian site potential for recharge more likely eplains the increase in $\delta^{18}O$. D-excess values for the near-surface fen samples at nests 8 and 9 are highest in September 2012, consistent with inputs from rainfall recharge rather than evaporative enrichment.

Depth plots for the fen transect (B-B^1) show that calcium concentrations increase with depth (Figure 35). Fen WT and shallow fen sampling locations also have low variability, with exceptions at WT wells B and C and shallow well 10, where concentration changes were ~ 5 mg/L. At WT C, groundwater inputs in September 2012 would account for the isotope signature of -19 ‰ and the elevated calcium concentrations. Along the fen transect such changes in calcium concentrations are localized – at WT B in May 2012 and at WTC and JPHP10 in September 2012 – and so may not be a significant observation in the context of a riparian landscape. Along a transect such as the fen at JPH, heterogeneity in geochemistry or isotopic labelling may occur where flow speeds and flowpaths are variable due to local topography, geomorphology and vegetation. Variable flow speeds allow for different rates of biogeochemical reactions and solute retention. Flowpaths may include shallow recharge and discharge points not captured by hydraulic head which showed overall flow potential parallel to the surface in the downslope direction.

Chloride and DOC concentration contour plots (Figure 35) also reveal geochemical stability at depth and some variability at the near-surface. Chloride concentrations are < 2.5 mg/L at all sampling locations in August 2011 and May 2012 but range from 0 – 11 mg/L in shallow fen and fen WT wells in September 2012. Downstream locations, WT wells C and the shallow well at nest 10, had highest concentrations. Chloride concentrations increase in summer months as evaporation concentrates solutes in surface water. Further, the elevated chloride concentrations in September 2012 are associated with the high water levels in fen, and may be explained by the upstream input that was less connected during low water levels. This upstream input may be characterized by the surface grab samples taken from a ponded area upstream of WT A. At the ponded upstream location, chloride concentrations were lowest in May 2012 (0.70 mg/L) consistent with low-chloride snowmelt inputs, and concentrations were elevated in July 2012 (11.47 mg/L) and September 2012 (5.52 mg/L).

DOC concentrations (Figure 35) at depth range from 6 – 11 mg/L but range less than 3 mg/L at each well. Spatial and temporal variability of DOC concentrations is greater for shallow fen samples. At piezometer nest 10 (downstream) shallow values range from 30 – 81 mg/L, and at piezometer nest 8 (upstream) shallow the range is lower (18 – 42 mg/L). At WT well F (downstream) values range from 5 – 30 mg/L, and at WT well C values are higher (20 – 62 mg/L). Considering the fen WT, DOC concentrations are lowest in May 2012, highest in September 2012 for downstream locations, and highest in August 2011 for upstream locations. At the weir location (downstream of water table F, not included in transect), as for downstream samples generally, DOC concentrations were highest in September 2012. At the open-water location (upstream of water table A, not shown), DOC concentrations were highest in August 2011. At mid-depth, DOC concentrations were highest in September 2012. A wetter year may mobilize and/or generate more DOC in the subsurface. Seasonally, DOC concentrations are expected to increase from spring to fall as biological productivity increases and spring melt dilutes samples to varying degrees. Hydrological and biogeochemical controls are site-specific in the near-surface locations at the JPH fen, as demonstrated by the spatial and temporal variability of DOC concentrations.

Ammonium and sulphate concentration depth plots are considered for the fen-upland transect A-A^1 (Figure 37) and the fen transect B-B^1 (Figure 36). Nitrogen and sulphur are essential nutrients, so ammonium and sulphate are associated with biological processes (decomposition and metabolism) as well as reactive redox reactions and microbial processes. Contour plots of the depth distributions of these parameters may indicate hot-spots of biological activity or reflect changes in response to changes in reduction potential. Ammonium concentrations are < 0.55 mg/L in the upland and < 0.35 mg/L throughout the fen and range from 0.1 – 1.0 mg/L in the fen WT. Highest values (1.0 mg/L) are seen at WT wells C and F. In the upland highest values (0.5 mg/L) are at nest 11. For ammonium, spatial variability is greater than temporal variability. Sulphate concentrations are low (0 < 3.5 mg/L) at the deep upland, mid-depth fen and deep fen. At the mid-depth and shallow uplands, sulphate concentrations are somewhat higher in May 2012 (7 – 11 mg/L) than in either August 2011 or September 2012 (7 – 9 mg/L). The sulphate concentration ranges at the fen WT are elevated in May 2012 (13 – 16 mg/L), compared with either August 2011 (0 < 1.5 mg/L) or September 2012 (1 – 12 mg/L).

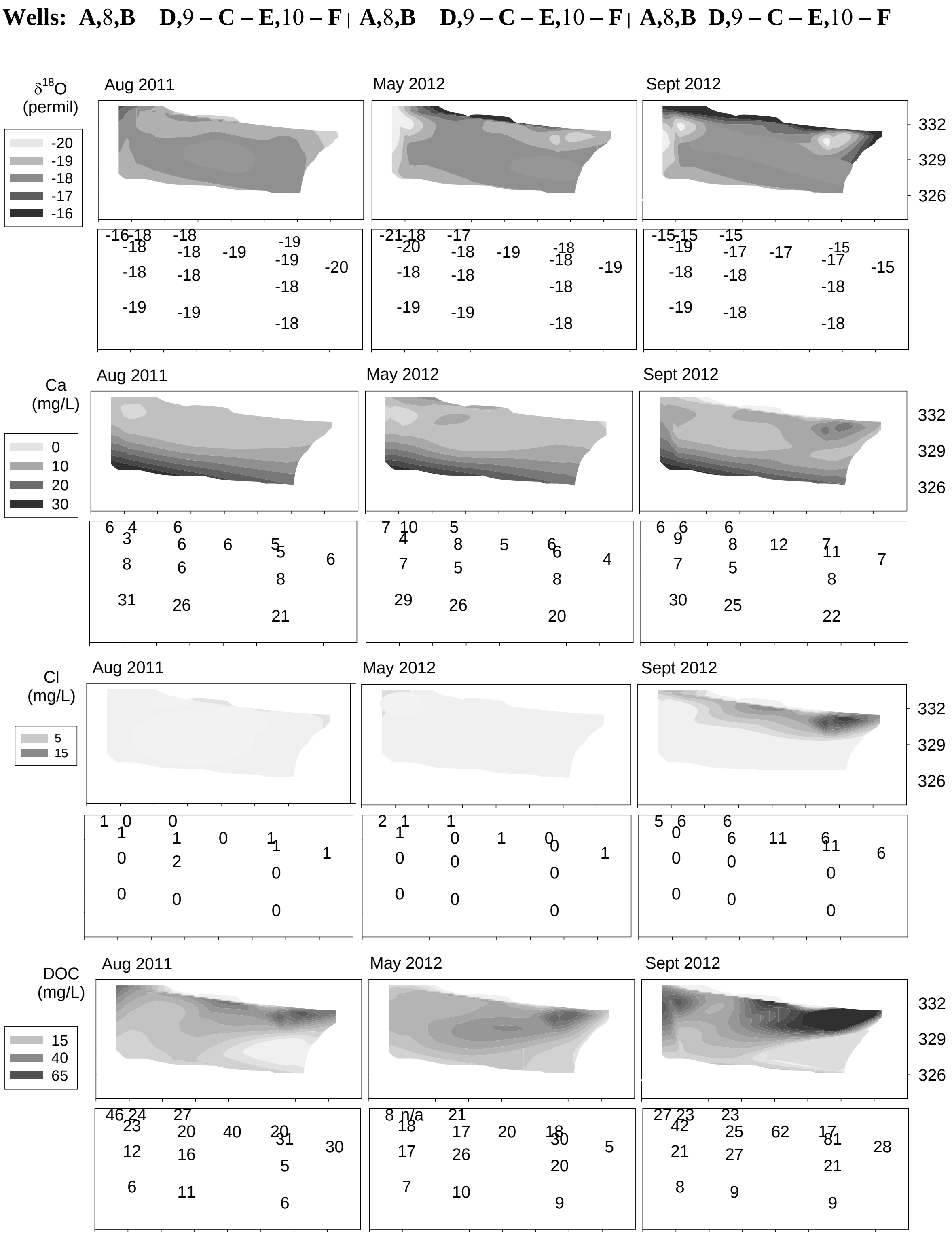


Figure 35 Time series of δ^{18}O, Ca, Cl, and DOC depth plots at transect B-B[1], JPH.

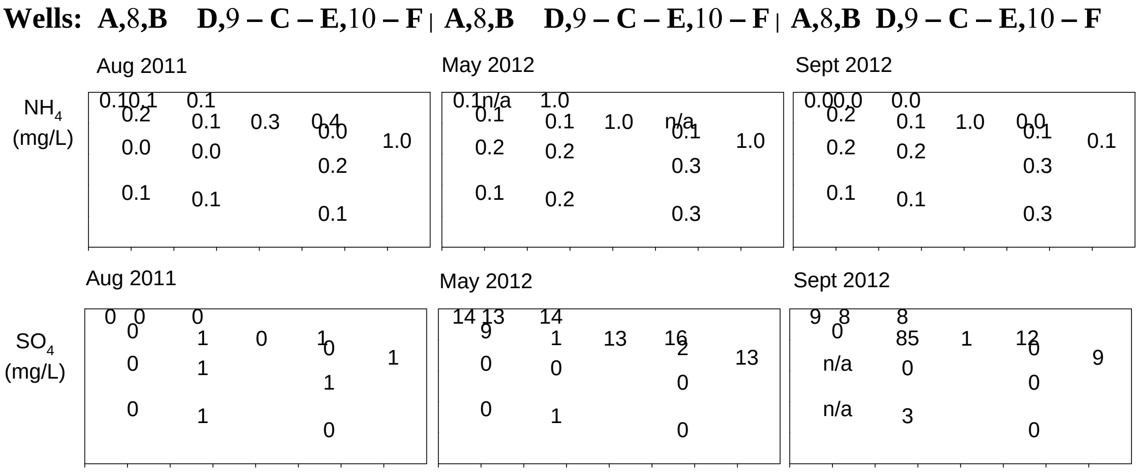


Figure 36 Cross-section plot of NH_4 and SO_4 concentrations at sampling locations along transect B-B^1 at JPH.

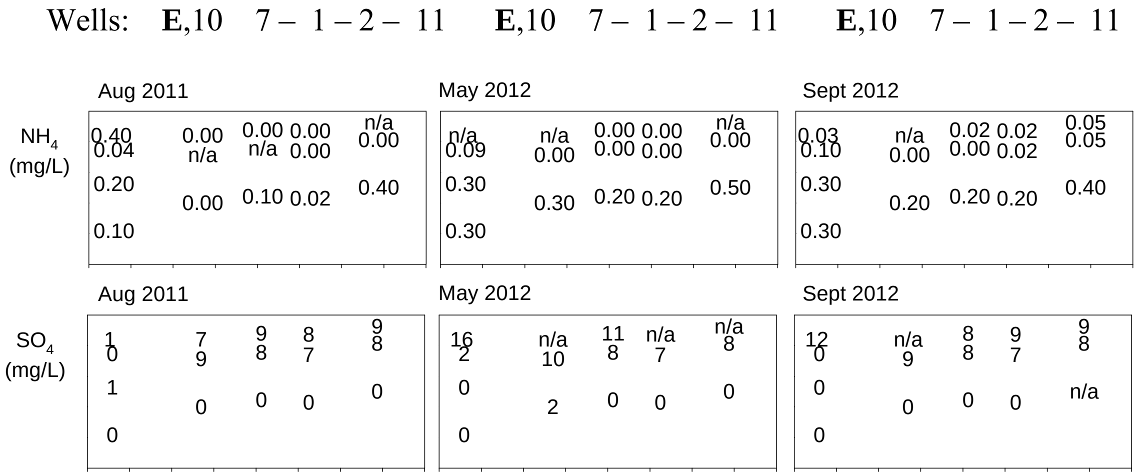


Figure 37 Cross-section plot of NH_4 and SO_4 concentrations at sampling locations along transect A-A^1 at JPH.

Sulphate (and similarly nitrate) inputs may be elevated in the spring due to atmospheric deposition that accumulated in the snowpack. In Figure 38 the temporal evolution of WT, and surface samples show an increase in sulphate and nitrate concentrations and a decrease in DOC concentrations for May 2012. The higher concentrations of sulphate and nitrate may represent a pulse input with snowmelt during the time of year that productivity is low and biological uptake of nitrate and sulphates may be low. DOC concentrations are also lowest in May 2012 consistent with low productivity rates and dilution by snowmelt inputs. The $\delta^{18}O$ time series shows that upland samples have an unchanging signature. Water table wells, downstream and upstream surface waters vary in isotopic signature, due to isotopically light snowmelt inputs (April or May 2012), heavier rainfall inputs (August 2011 or September 2012), and/or evaporation (some fen WT locations in August 2011).

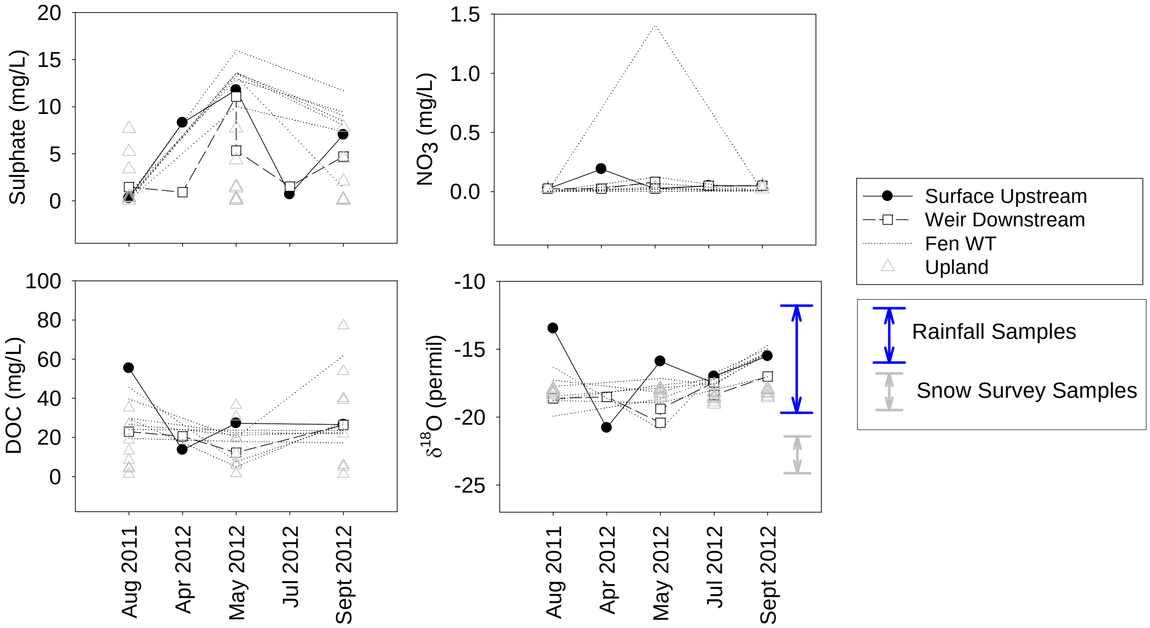


Figure 38 Evolution of sulphate, nitrate, DOC and $\delta^{18}O$ for fen WT, upstream surface, downstream surface and deep upland wells at JPH. The $\delta^{18}O$ signature ranges of rainfall samples and snow samples from sampling campaigns in 2012 are shown.

4.2.3. Summary of Hydrological Connectivity at JPH

The connectivity statements summarized in the introductory JPH hydrological context section (Section 4.2.1) (Vallarino 2014) are addressed, given the analysis of spatial and temporal variability of water isotopes and geochemical signatures at JPH.

a) Flow is directed from the upland to the fen:

- excluding fen water table and shallow fen locations, groundwaters from the fen and upland landscape units have distinct and consistent geochemical and isotopic signatures, which suggests that connectivity did not change significantly. Also, the water isotope variability of mid-depth and deep fen and upland samples was low, consistent with groundwater that is well mixed. The landscape units may be considered part of a groundwater continuum where connectivity between the fen and upland is driven by topography.

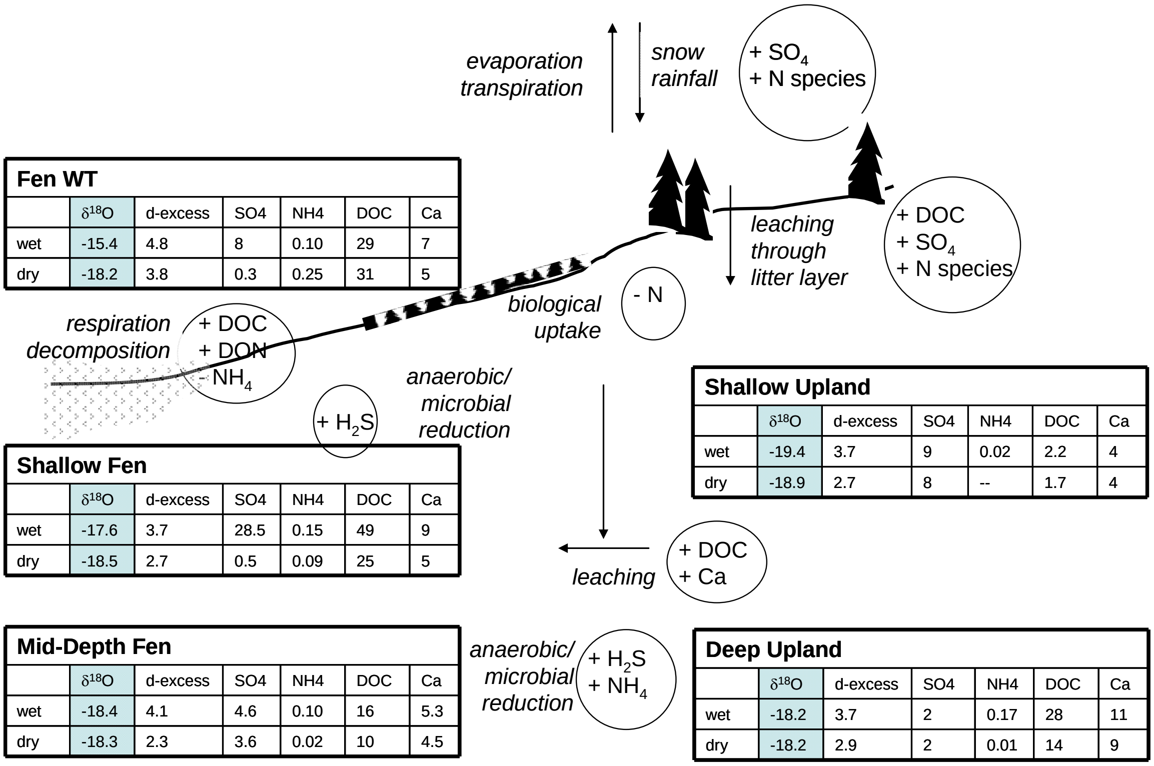
b) Recharge persists in the upland:

- depth profiles showed more spatial than temporal variability, which suggests that the hydrology at a given location had a dominant persistent regime; at JPH upland, recharge dominates, and depth profiles are characterized by dilute and sulphate-rich shallow samples and high-conductivity deep samples.

c) Flow is parallel to the surface topography in the fen, but recharge may occur within the fen when water table levels are high:

- geochemical evidence for flow within the fen is obscured by high variability in water table and shallow fen samples. However, samples at depth were consistently low in DOC and ammonium and high in conductivity, indicating that recharge of surface water to depth is unlikely. Water isotopes of fen water table and shallow fen samples varied with season and so were most negative in the spring (snowmelt input), similar to groundwater in the dry year (groundwater flux), and most positive at the end of the wet year (summer rainfall input). Some variability of shallower samples may be due to recharge and discharge locations at the micro-topography scale, and due to inherent heterogeneity along the fen transect, i.e., fen width, geomorphology and vegetation.

The fen – upland schematic of JPH highlights the physical hydrology and chemical processes that affect the isotopic signature and nitrogen, sulphur and organic carbon content of water samples along flowpaths within landscape units (Figure 39). Included on the schematic are data tables of averages for wet (September 2012) and dry (August 2011) hydrologic regimes. Precipitation inputs as snow or rain are a source of sulphur and nitrogen species. Water is returned to the atmosphere by evaporation and transpiration. During infiltration, leaching through the litter layer introduces sulphates and nitrates and DOC to the water while biological demand efficiently immobilizes inorganic nitrogen. In the subsurface, aerobic and/or anaerobic microbial and reduction processes reduce sulphates and nitrates to hydrogen sulphide and ammonium, shown as (transformative) inputs in the subsurface. Groundwater becomes enriched in calcium and other solutes due to dissolution of minerals along the flowpath. Groundwater DOC inputs are from water leaching through the litter layer and recharging to depth in the upland and from recharge of DOC-rich wetland waters in the fen. The rich fen is productive and chemical processes associated with respiration and decomposition variably consume and release inorganic nitrogen and carbon species, also generating organic nitrogen and carbon. Not explicit in the schematic is the variable discharge (as channelized flow) from the fen WT. At JPH seasonal variability of hydrogeochemistry is seen in the shallow fen and fen WT and for some parameters in the deep upland. At JPH, discharge from the fen to the upland may be precluded by saturation of the adjacent area and a relatively greater increase in water table in the upland, which leads to ponding and channelled overland flow.



Fen WT

	δ18O	d-excess	SO4	NH4	DOC	Ca
wet	-15.4	4.8	8	0.10	29	7
dry	-18.2	3.8	0.3	0.25	31	5

Shallow Fen

	δ18O	d-excess	SO4	NH4	DOC	Ca
wet	-17.6	3.7	28.5	0.15	49	9
dry	-18.5	2.7	0.5	0.09	25	5

Mid-Depth Fen

	δ18O	d-excess	SO4	NH4	DOC	Ca
wet	-18.4	4.1	4.6	0.10	16	5.3
dry	-18.3	2.3	3.6	0.02	10	4.5

Shallow Upland

	δ18O	d-excess	SO4	NH4	DOC	Ca
wet	-19.4	3.7	9	0.02	2.2	4
dry	-18.9	2.7	8	--	1.7	4

Deep Upland

	δ18O	d-excess	SO4	NH4	DOC	Ca
wet	-18.2	3.7	2	0.17	28	11
dry	-18.2	2.9	2	0.01	14	9

Figure 39 Schematic showing precipitation inputs, biogeochemistry/physical hydrology controls on water isotopes and hydrogeochemistry. Means of a subset of parameters at JPH landscape units compare wet (September 2012) *vs*. dry (August 2011) hydrologic regimes. Sulphate, inorganic ammonium, DOC and calcium concentrations in mg/L; $\delta^{18}O$ and d-excess values in ‰.

4.2.4. Fate and Behaviour of Nitrogen at JPH

The fate of redox-sensitive species and essential nutrients such as nitrogen, beyond movement with water flow, is governed by biological activity and reduction potential. Eh in turn is affected by water level and may be poised by the presence of redox pairs. Ultimately, nitrogen in its reduced or organic form would be transported within and among the landscape units at JPH depending on the extent of connectivity that is established under varying hydrologic regimes.

Sulphate may infiltrate into the shallow and mid-depth upland and remain unchanged due to low biological demand or activity and a reduction potential that is consistently above the value at which sulphate reduces. Nitrate is efficiently immobilized by biological demands. Some of any leached nitrate would denitrify in shallow and mid-depths. Sulphate that infiltrates to the deep upland is reduced to hydrogen sulphide, as evidenced by the characteristic smell and the concentration levels (0 – 0.36 mg/L H_2S, not shown). Nitrate that infiltrates to depth in the upland is reduced to ammonium, as supported by the measured concentrations (up to 0.55 mg/L). Sulphate and nitrate inputs to the fen may be taken up by plants or reduced.

Dissolved inorganic nitrogen concentrations were low at JPH, detectable as ammonium only in the deep upland or fen WT. Monitoring organic nitrogen may shed light on nitrogen exports and is recommended for future sampling at JPH. The fate of inorganic nitrogen is primarily uptake by biological demand in this ecosystem that is not yet nitrogen saturated. Nitrate undergoes reduction or is lost as gaseous nitrogen and nitrogen species will be transported within the groundwater. Retention time is a factor in describing transformative cycles. For example, immobilization by biological processes is less efficient when retention time is short. The fen, due to biological processes, may act as a sink for inorganic nitrogen inputs and a source of organic nitrogen.

4.3. Connectivity at ML

4.3.1. ML Hydrological Context

Under the contrasting hydrologic regimes, water table and runoff responses to precipitation events were different because antecedent moisture conditions (AMC) were different. As determined by Vallarino (2014), changes in water level in response to precipitation events were muted in the bog compared with the fen. And based on vertical water balances, runoff at the bog exceeded runoff at the fen during times of high AMC. Between June 2011 and September 2012 surface water levels fluctuated 0.49 – 1.25 m about their mean water level. Greatest hydraulic head changes were recorded in the deepest wells (0.72 – 2.63 m), which were driven to a depth of refusal so are considered to be in a confining layer with low hydraulic conductivity. At shallow depth, the hydraulic head values fluctuated most at wells in areas designated *wet fen* (following Graham 2012). And at mid-depth, wells with highest hydraulic head fluctuations were aligned with areas designated *dry fen*. The association of this variability with landscape units may relate to a relationship between peatland formation/succession and hydrologic controls.

Observations regarding hydrology at ML are based on the delineation of surficial flowpaths from LiDAR data and flownets based on hydraulic head measurements (Vallarino 2014). From the modelling of surficial drainage networks, there is a surface divide running north-south within the peatland complex at ML. From hydraulic head potentials, shallow groundwater flow is directed towards the outflow at WT well G in June 2011, towards piezometer nest 13 in August 2011, towards piezometer nest 15 early in 2012, and towards nest 17 and 12 later in 2012. Connectivity between landscape units was described in the hydrology study by Vallarino (2014):

a) flow may occur overland between the upland and adjacent fen,
b) connectivity between the upland and adjacent fen may exist at depths below the upland instrumentation,
c) sites at the fen – upland interface showed small lateral hydraulic head gradients and had low hydraulic conductivity so recharge or discharge flux would be small or insignificant,
d) surface flow may occur from the bog to the adjacent fen in fill-and-spill events,
e) downward movement of surface water occurs in the fen, which is seen in isotopic signatures and lateral hydraulic head gradients,
f) at nests 17 and 18 vertical hydraulic head gradients changed from recharge to discharge regimes at different times.

4.3.2. Geochemical Evidence of Connectivity at ML

The ML study site is a mosaic of forested island, fen and bog units surrounded by forested upland areas. The depths to the confining layer vary, as illustrated in the schematic cross-section of the ML study site which shows instrumentation along a typical bog – fen gradient (Figure 40). In the figure, factors that affect the geochemistry and isotopic signatures of porewaters are related to physical hydrology and chemical process, respectively rectangles (precipitation, groundwater, runoff, vertical flow, lateral flow, diffusion, evaporation and transpiration) and ovals (redox reactions and biogeochemistry – a balance of biological demand, decomposition, and anoxic respiration). Different biogeochemical processes dominate at different depths, for example productivity is highest in the near-surface layer that supports living vegetation and microbially mediated redox reactions are present at depth.

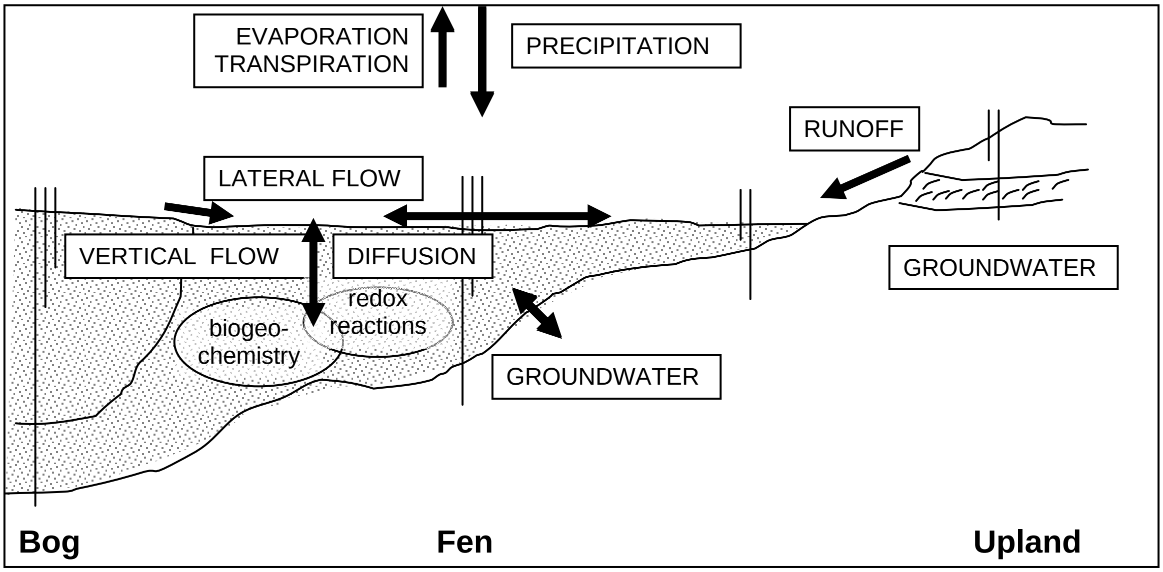


Figure 40 Cross-section of a bog – fen gradient at the ML study site. Water flux, connectivity, diffusion, redox reactions and biogeochemistry affect the isotopic and geochemical composition of bog and fen water samples.

Geochemistry and isotope data from water table (WT, ~0.4 m) sampling locations would likely reflect inter- and intraseasonal changes, whereas data from shallow and mid-depth peat samples (1.1 – 4.7 m) would show greater spatial variability than temporal variability. And deep samples (~7.5 to 4.5 m along the bog – fen gradient), which originate in or near the mineral substrate, would have isotope and geochemistry signatures typical of groundwater from a mineral or clay substrate. Ombrotrophic bogs by definition are dependent on precipitation inputs and thought of as disconnected from both mineral groundwater and lateral flow inputs from adjacent wetland landscape units. Under high water table levels, however, water may run off from and to adjacent landscape units. Bog samples then reflect long-term precipitation recharge and would be dilute and have low pH to the depths at which bog vegetation is present. Bogs at ML were established on poor fens (Nicholson & Vitt 1990), so at and below the transition groundwater influence would be present. Depending on the water level also, bogs may be source of water to shallow or deep adjacent landscape units. The fen sites, depending on the hydrologic regime, recharge or are recharged by the uplands and/or groundwater, and drain into the local watershed, so the isotopic and geochemical profiles within the fen likely reflect mixing of precipitation and upland and/or groundwater inputs. Of interest are sites at the upland-peatland and peatland-mineral substrate interfaces, and also at the transition from bog to fen where highest runoff potentials were found (Vallarino 2014).

Spatial Contour Plots Plan view contour plots of $\delta^{18}O$ (Figure 41), dissolved organic carbon (DOC) (Figure 43 top) and calcium (Figure 43 bottom) concentrations show how the distribution of these parameters are related to landscape units. Symbols differentiate the sampling locations: uplands, wet fen, dry fen and bog are plotted as squares, inverted triangles, circles, and diamonds respectively. These figures show the evolution in time (from left to right) for the water table and shallow depths.

The distribution of $\delta^{18}O$ in the samples from the water table wells (Figure 41) appears to be strongly influenced by precipitation inputs. The input of depleted snowmelt in the spring (May 2012) is seen in the shift towards more negative $\delta^{18}O$ values for southern sampling locations. Snowmelt runs off or infiltrates depending on site-specific thawing and frost persistence. Conceivably for the central band of wet fen and dry fen sites, light snowmelt water has run off or actively mixed with heavier surface water by May 2012. By September 2012, most sampling locations show relative enrichment, consistent with the input of late summer precipitation that is heavier and/or enriched due to evaporation of surface water. The zones of light water (to the southeast and less so to the north) may indicate groundwater input. The $\delta^{18}O$ contour plots show a systematic pattern for shallow depths in which the SE bog sites are more depleted and central dry and wet fen sites are relatively enriched. Bogs recharged predominantly by snowmelt show most depleted signatures. During the summer, active evapotranspiration can result in very little of the summer precipitation being available to recharge beyond the water table. So the more negative $\delta^{18}O$ values in the SE bog sites are explained by lack of connectivity with adjacent fens and lack of recharge of summer precipitation. In contrast, fen shallow sites are recharged by summer rainfall or evaporated (isotopically heavier) surface water so a (isotopically light) snowmelt signature is not preserved. Further, snowmelt may run off rather than recharge the fen if frost persists during snowmelt or the hydrologic regime dictates runoff rather than recharge early in the season.

Greatest DOC concentrations were measured in the WT wells in the bog (SE) and at shallow depth at localized areas near the uplands (N and SE) (Figure 42). Seasonal changes are seen for few sampling locations and those changes are consistently a lower concentration for the time after snowmelt when productivity is lowest and/or snowmelt input dilutes the shallow waters. The systematic patterns for shallow DOC are similarly reflected in the shallow calcium contour plots (Figure 43). Calcium shows high ranges near upland interfaces to the SE and N, NE. However, at the WT, calcium concentrations are highest in August 2011, possibly a concentration factor as the water levels decreased by evaporation and evapotranspiration. Generally, central fen locations at the WT have lowest calcium concentrations which supports hypothesized long-term flushing by precipitation under sustained recharge gradients and distance from possible groundwater inputs from the adjacent uplands.

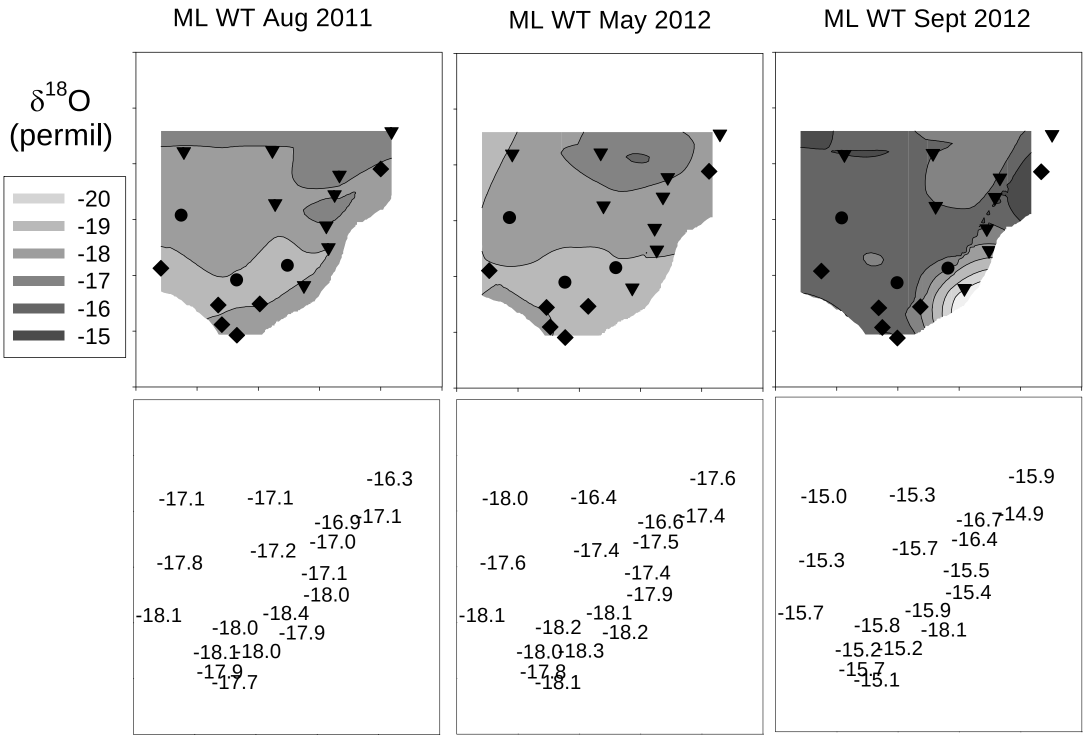


Figure 41 Plan view contour plots of δ18O concentrations at ML. Shown are near-surface sampling locations for August 2011, May 2012 and September 2012 (left to right). Sampling locations are coded by their landscape unit: bog – diamond, dry fen – circle, wet fen – inverted triangle, and upland/edge – square.

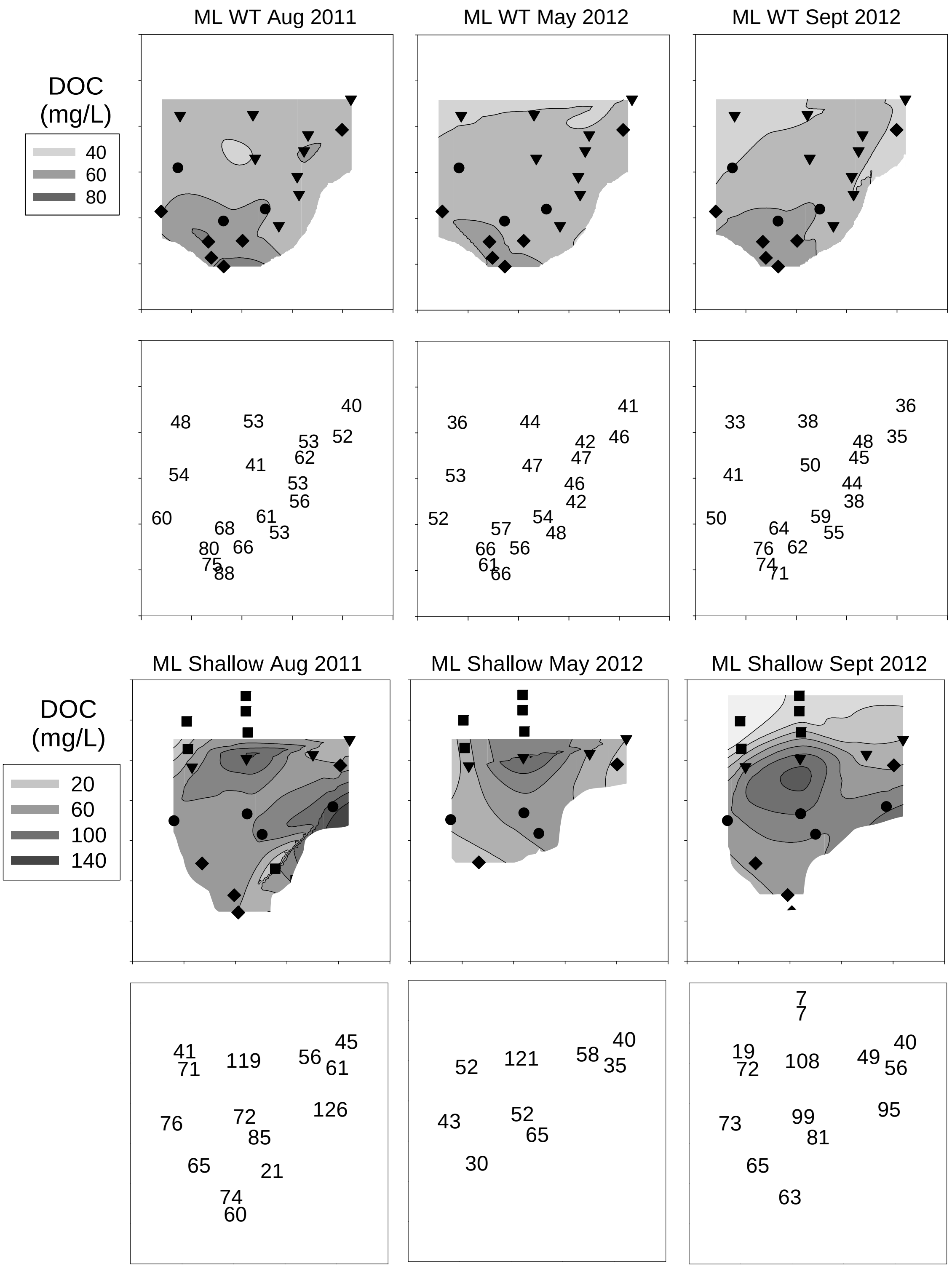


Figure 42 Isoconcentration contour plots of dissolved organic carbon (DOC) at ML. Description as for Figure 43.

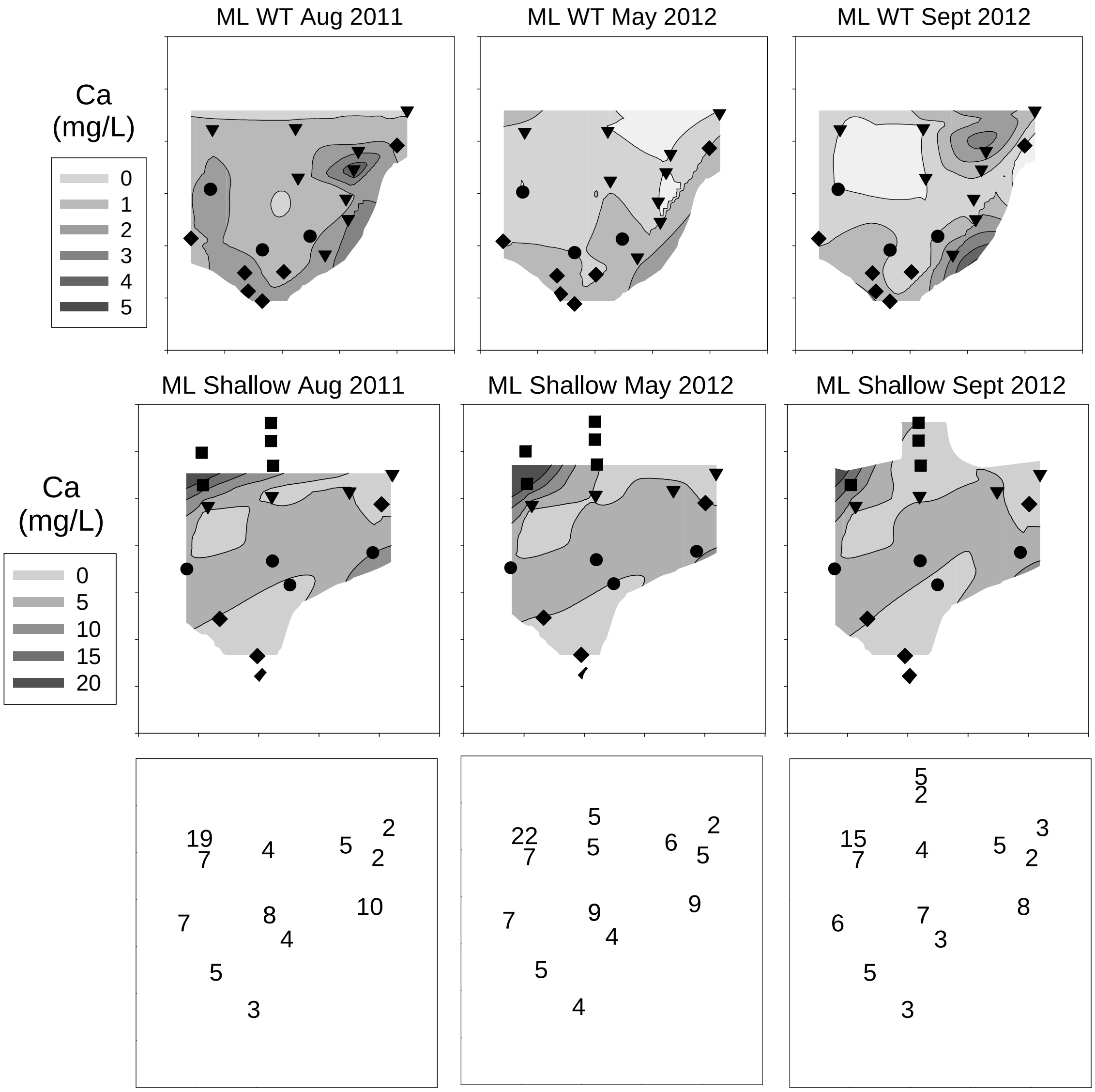


Figure 43 Isoconcentration contour plots of calcium (Ca) at ML. Top: water table (WT) sampling locations, about 0.4 m. Bottom: shallow sampling locations, about 1.5 m. Left to right: August 2011, May 2012, and September 2012. The two depths have different scales for concentration contour shades. Sampling locations: bog – diamond, dry fen – circle, wet fen – inverted triangle, and upland/edge – square.

Transect C-C^1 The ML transect C-C^1 from the SE bog at well O to the outflow at well G follows a potential surficial flow path (Figure 44). Depth profile contour plots of a subset of parameters are used to visualize the evolution of porewater geochemistry along the bog-fen gradient. Stable isotopes of water are used to draw conclusions about water source, movement and evaporation. Elevated conductivity and calcium concentrations indicate the presence of mineral or adjacent upland groundwater inputs and would have a strong depth gradient. Redox conditions are sensitive to saturation (the exclusion of oxygen) and subsequent successive consumption of redox pairs in anaerobic conditions. DOC and ammonium are associated with productivity and decomposition; concentrations of both parameters have a strong depth gradient and temporal signal.

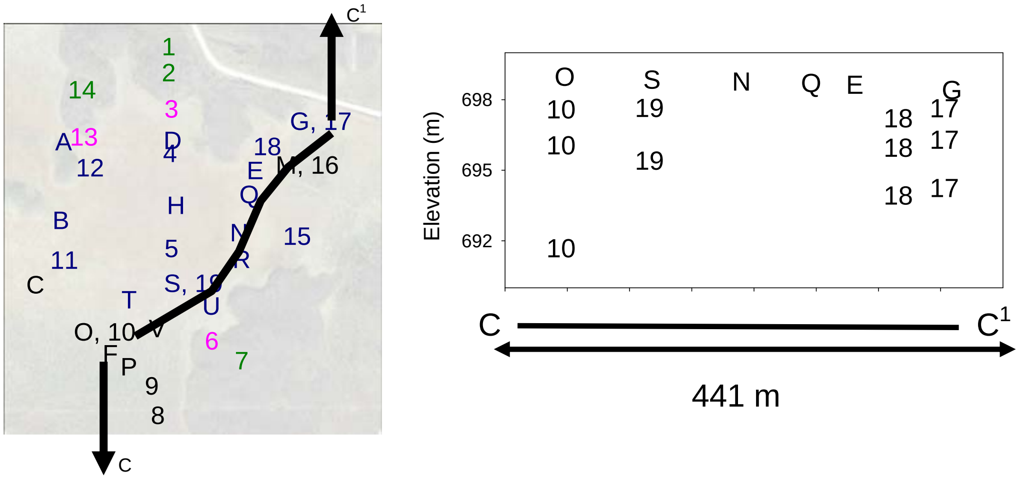


Figure 44 ML plan view map (left) of transect C-C^1; well depths along the transect (right). Transect C-C^1 includes water table well O – S – N – Q – E – G and piezometer nests 10 – 19 – 18 – 17. Sites are in the fen with the exception of well O and nest 10 (bog sites), and well S and nest 19 (transition sites from bog to fen). The simplified orientation of the transect is N-S. In the cross-section plot (right), the y-axis is sampling elevation and the x-axis is latitude, resulting in a vertical exaggeration factor of 20.4.

Vertical recharge persisted along transect C-C^1, based on hydraulic head measured over the two field seasons. Hydraulic conductivities at the site are low, ranging from $5*10^{-8}$ to $5*10^{-6}$ ms^{-1} for shallow peat and from $2*10^{-9}$ to $5*10^{-6}$ ms^{-1} for peat at depth. Gradients are generally small between the shallow and mid-depth wells (head differences less than 0.2 m downward), except at well nest 10 where the shallow to mid-depth hydraulic head difference was 0.8 m downward on 6 June 2012 and well nest 18 where the shallow to mid-depth hydraulic head differences were as high as 1.5 m downward (28 August 2011) or 0.8 m upward (6 June 2012). Potential flow may be directed toward nest 18 where stronger gradients developed. Many of the deeper piezometers in the fens and bogs have significantly lower hydraulic conductivities (Vallarino 2014) which is consistent with these large hydraulic head gradients. Throughout, hydraulic head is lowest at depth, so the system is dominated by a balance of shallow lateral flow and recharge potentials, though flux would be small based on low hydraulic conductivity. It is possible for significant water movement to occur where low hydraulic conductivity is offset by preferential flow pathways.

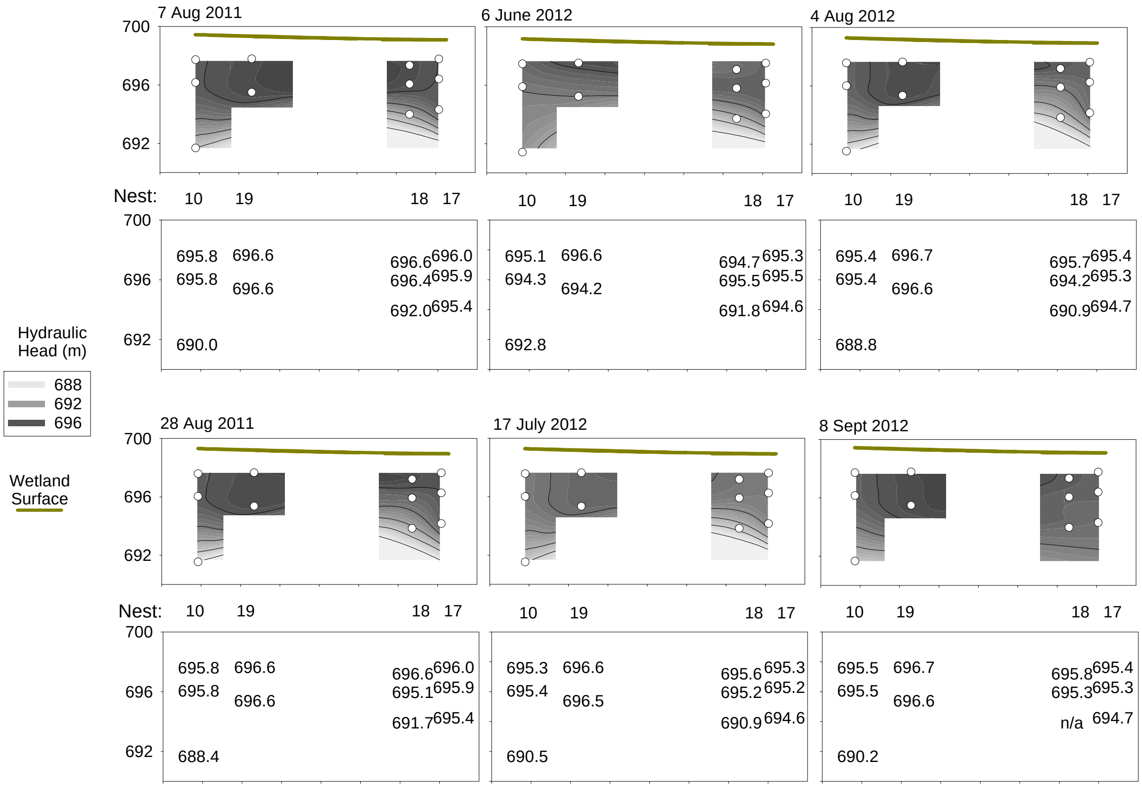


Figure 45 Hydraulic head measured at transect C-C^1, ML, various dates 2011 – 2012.

The contour plots of d-excess and δ^{18}O show a gradient from the bog (nest 10) to the outflow (nest 17), with higher d-excess and more negative δ^{18}O at the bog (Figure 46). Temporal changes of these parameters at the near-surface are related to the input of isotopically depleted snowmelt water and summer isotopically heavier rainfall events. Below the WT, temporal changes in δ^{18}O and d-excess are small, except at depth for nest 18, where the δ^{18}O values are -17.8 ‰ in August 2011 and -16.5 ‰ in May 2012, and the d-excess values are 3.4 ‰ and -1.1 ‰. Heavier water from the previous summer might have recharged to depth at nest 18 by an appreciable amount due to higher hydraulic gradients recorded in late August 2011.

Chlorine concentrations (Figure 46) decrease at wells 19 (shallow), 17 (mid-depth), N, Q and E for the August 2011 to September 2012 time series. At the bog, a high August 2011 chlorine concentration at the WT (1.91 mg/L) is followed by high May 2012 concentrations at shallow (2.15 mg/L) and mid-depths (1.59 mg/L). Nest 19 shows a similar concentration trend for chlorine. Comparing August 2011 and May 2012 at nest 19, chlorine concentrations of the shallow well decrease from 0.83 to 0.50 mg/L and concentrations of the mid-depth well increase from 0.15 to 0.52 mg/L. It is conceivable that a pulse of high chlorine concentrations is moving to depths by advection following the recharge gradient, and/or by diffusion. The pulse of high chlorine concentrations in near-surface samples may result from the concentration effect of net water loss in the dry season (August 2011). Data for nest 18 is sparse though the high value at mid-depth in August 2011 is worth noting (3.20 mg/L). Well G near the outflow shows a wide range of values: 5.00 mg/L in August 2011, 0.07 mg/L in May 2012 and 0.59 mg/L in September 2012.

The range of reduction potential (Eh) changes in time (Figure 47). Eh may decrease as saturation of the peatland complex increases. Saturation decreases the depth of the aerated zone (excludes oxygen). August 2011 was the end of a dry year (125 to 376 mV), May 2012 received snowmelt inputs (15 to 251 mV) and September 2012 was the end of a wet year (-183 to 50 mV). Generally the reduction potential has a decreasing trend with depth, consistent with reducing conditions expected in anaerobic anoxic peatlands.

DOC concentrations along transect C-C^1 at ML (Figure 48, top) show little variation with depth at the bog (~52 mg/L) and dry fen sites (~ 61 mg/L), and show some variability near the outflow at nest 17 (13 – 21 mg/L). DOC concentrations are highest in August 2011 for most of the WT wells in this transect and lowest in May 2012, explained by a combination of snowmelt dilution and low productivity rates early in the open-water season. Spatially DOC concentrations decreased towards the outflow, i.e., along the bog – fen gradient.

For inorganic ammonium concentrations (Figure 48, bottom) the increase with depth is significant. For example, ammonium concentrations increase from < 1mg/L at the WT to up to 28 mg/L at depth at nest 10 (September 2012). The increase of ammonium concentration with depth is only up to 3 mg/L near the outflow at 17 (no data for 18). At nest 17, comparatively low concentrations of both DOC and ammonium at depth may relate to the hydrology at this fen site where active flushing of shallow and/or mid-depth porewater by surface water may redistribute DOC and ammonium.

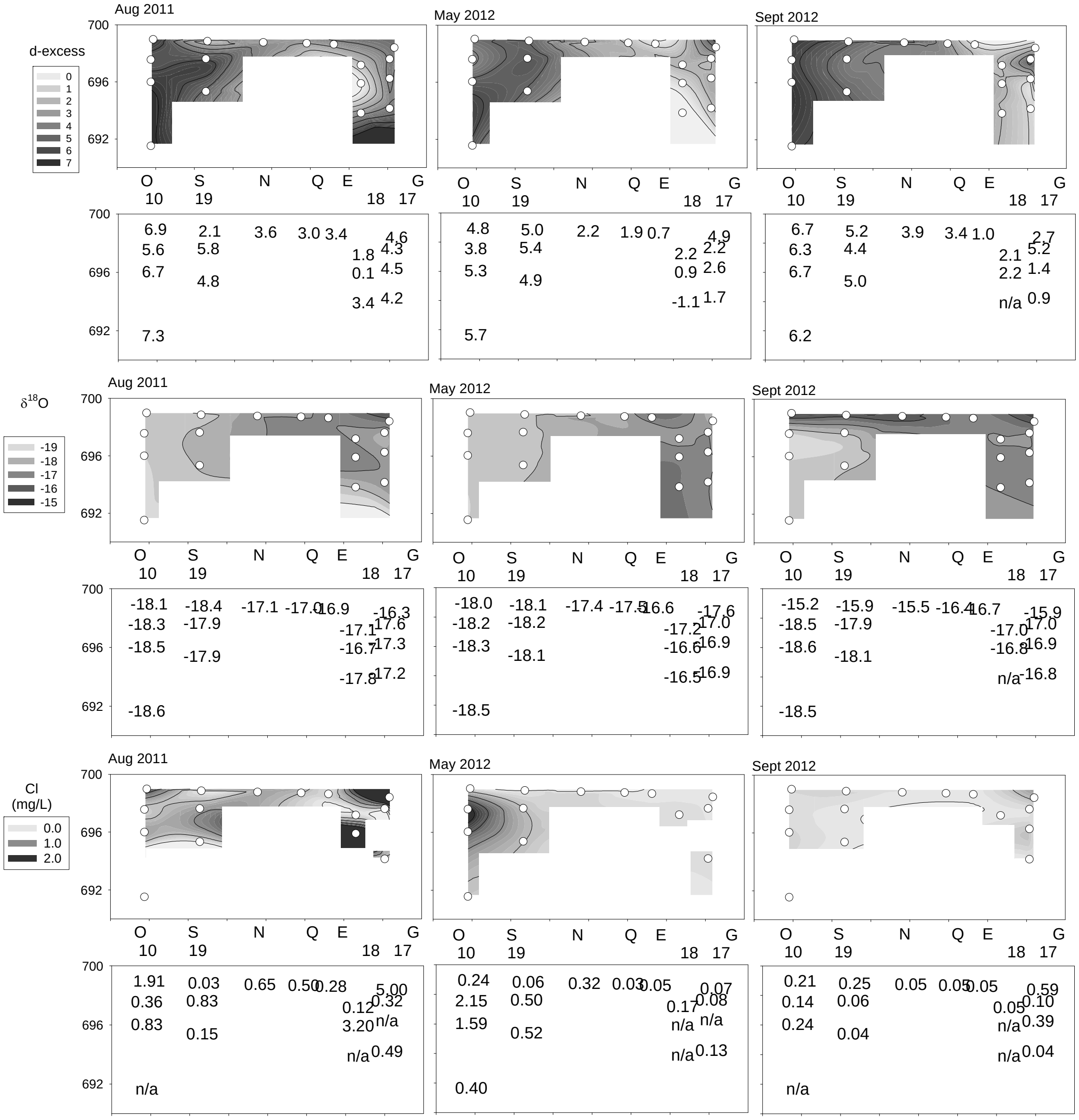


Figure 46 Time series of contour plots of d-excess (‰), $\delta^{18}O$ (‰) and Cl (mg/L) along transect C-C^1 at ML.

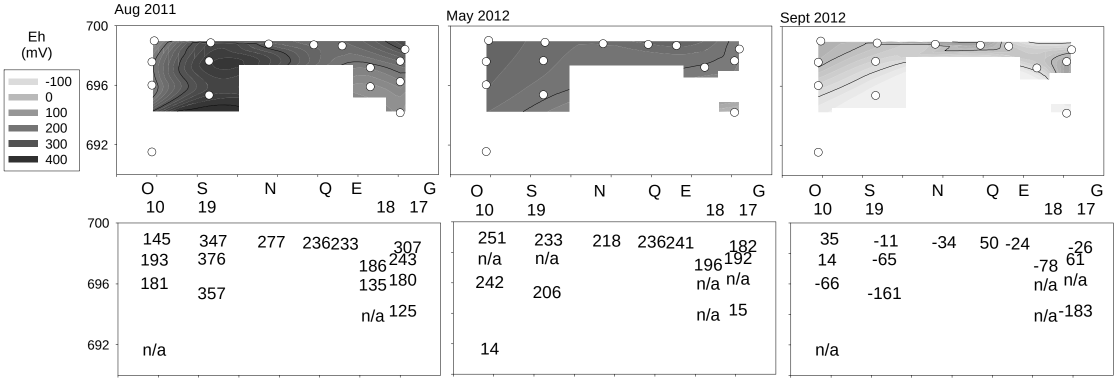


Figure 47 Time series contour plots of reduction potential (Eh) along transect C-C^1 at ML.

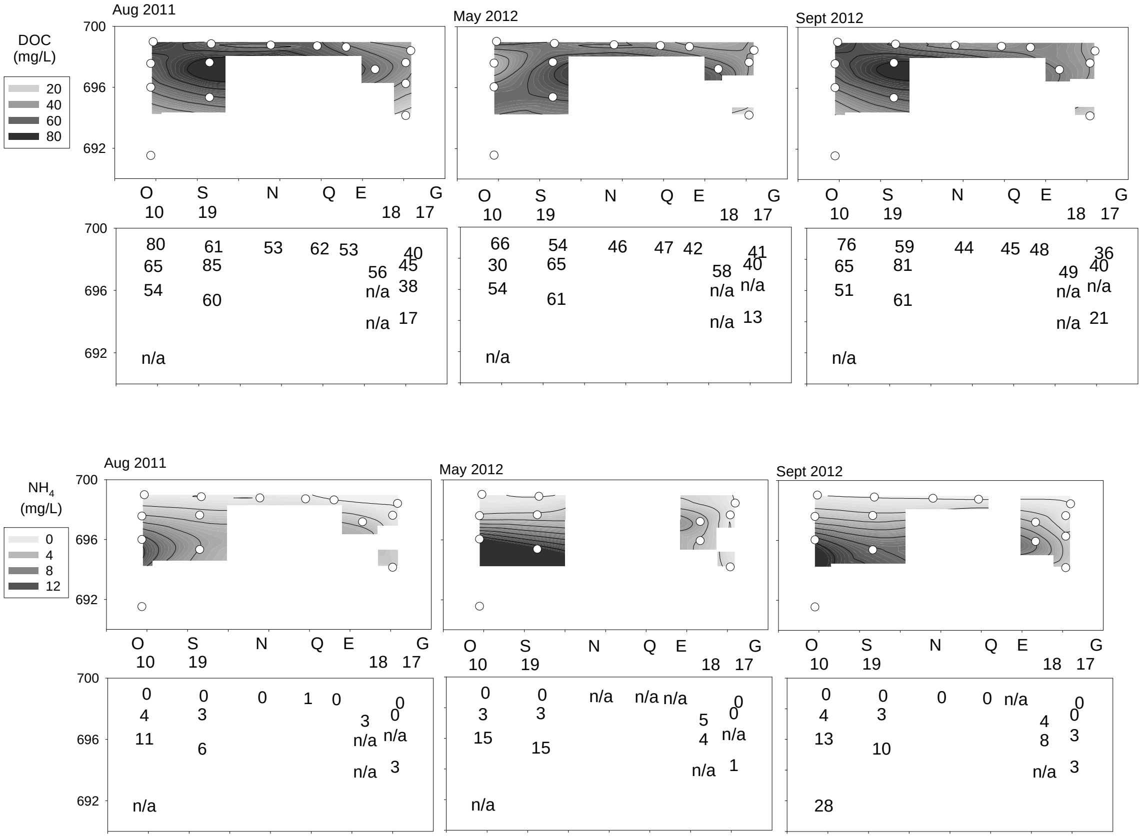


Figure 48 Time series contour plots of dissolved organic carbon (DOC) and ammonium (NH_4) along transect C-C^1 at ML.

Principal Component Analysis Depth profiles of some isotopic and geochemical parameters are consistent at (and thus may be characteristic of) sampling locations along the ML bog – fen gradient when WT well data, which have high temporal variability, are excluded. Low temporal variability may reflect the long-term persistence of physical, hydrological and biogeochemical processes that both affect and are affected by the vegetation that characterize the bog, dry fen and wet fen landscape units. Diffusion along a concentration gradient is a slow process, so the distance to source material is critical, i.e., the relative depth to mineral substrate and distance to the upland are relevant factors. Advection redistributes particulate and dissolved matter, so the connectivity and hydraulic conductivity of landscape units are critical also. Biogeochemical processes affect water chemistry and vary spatially within and among landscape units.

PCA is used to explore geochemistry and isotope data for the subset including ML bog and ML fen WT, shallow and mid-depth porewater samples. The purpose is to determine if combinations of parameters can account for variability of the data, and if the variability can be meaningfully related to hydrological controls associated with landscape units and their connectivity. PCA was used to identify combinations of parameters that account for data variability (Figure 50). The first two components account for 31.9 % and 18.3 % of the variability respectively. As such, the parameters include tracers (such as δ^{18}O, d-excess, conductivity), dissolved inorganic parameters indicative of groundwater inputs (such as calcium, strontium, magnesium), parameters associated with biogeochemical processes (DOC, ammonium) and trace elements (manganese, aluminum and silicon). The primary axis relates to the persistent trends seen with depth, and is negatively loaded with δ^{18}O and positively loaded with conductivity (also calcium and magnesium), ammonium and DIC. For each landscape unit, conductivity, ammonium and DIC increase with depth whereas δ^{18}O decreases with depth. The secondary axis differentiates the wet fen from the bog and dry fen samples, and is negatively loaded with d-excess and positively loaded with DOC, Si, Al, and Mn: d-excess was generally highest for wet fen samples, and concentrations of DOC and Mn were generally lowest for wet fen samples. The scoreplot (Figure 50) illustrate that at shallow and mid-depths the wet fen samples cluster apart from the bog and dry fen samples. At the water table, the landscape units cannot be differentiated by the combinations of parameters that explain variability as generated in PCA. As a complement to the PCA results, the suite of box plots based on 2011 – 2013 data shows that the ranges of values (that include the WT, S and M sampling depths) for the wet fen, dry fen, and bog locations are comparable yet persistently subtly different (Figure 51).

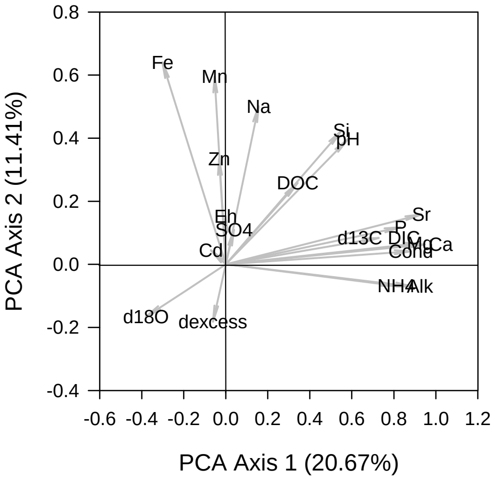


Figure 49 Loading plot of PCA based on 2011-2012 bog, dry fen and wet fen data for water table, shallow and mid-depths.

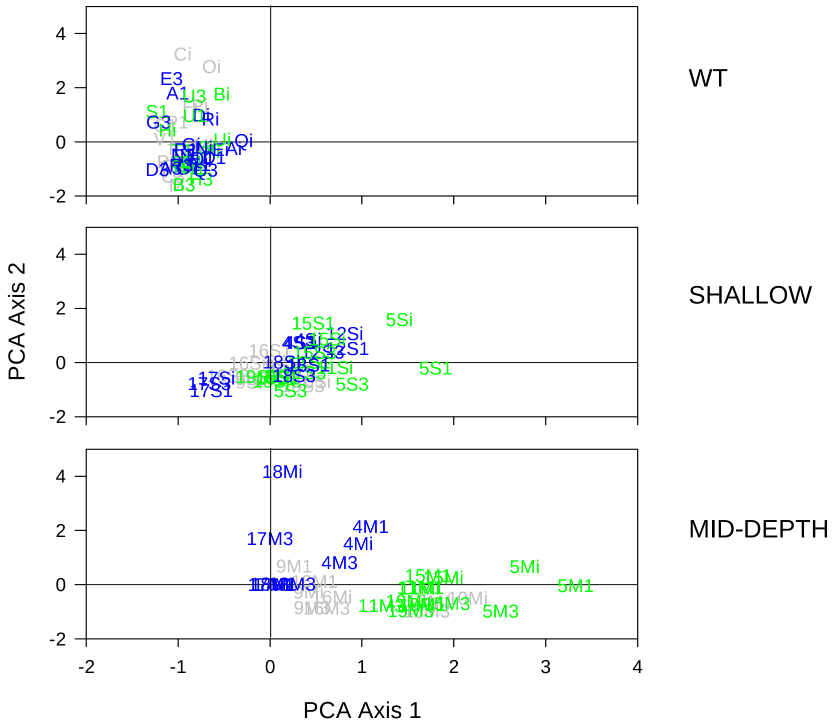


Figure 50 Scoreplots of a PCA based on 2011 - 2012 data for ML bog (grey), dry fen (green) and wet fen (blue) samples at water table, shallow (S) and mid-depth (M) sampling depths. Labels show location (letters for water table wells and numbers for piezometer nests) followed by depth (S or M) followed by sampling campaign (Aug 2011 – i, May 2012 – 1, Sept 2012 – 3).

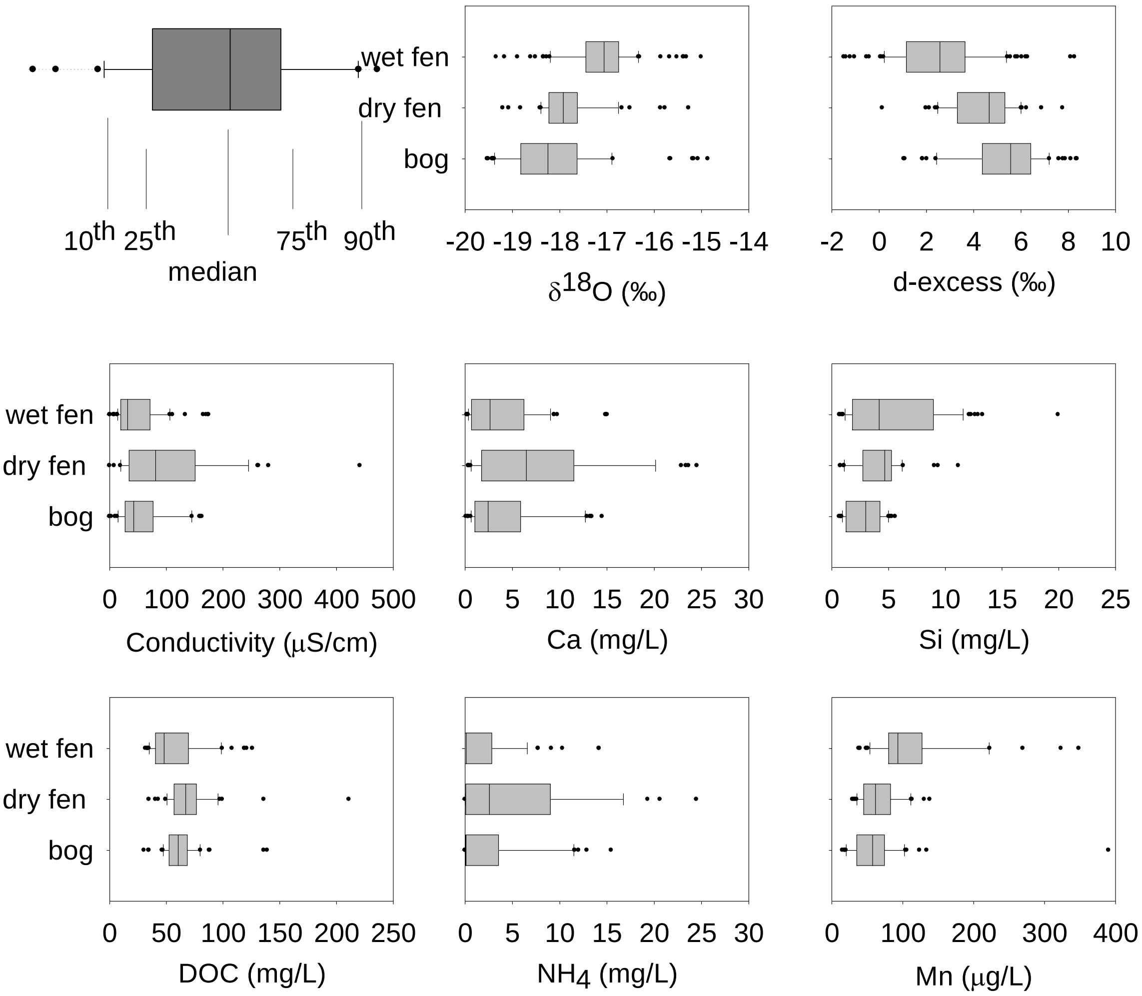


Figure 51 Box plots show the ranges of values for various parameters for wet fen, dry fen and bog landscape units at ML. Based on 2011 – 2012 data and water table, shallow and mid-depth sampling depth categories.

The spatial variability of fen and bog samples (excluding the WT) is greater than their temporal variability, illustrated for the calcium concentrations of shallow and mid-depth samples (Figure 52). Greater spatial than temporal variability is similarly seen for magnesium concentration and conductivity depth profiles (Figure 59 and Figure 60 in Appendix G). Increased calcium concentrations with increased depth is expected due to the presence of groundwater. Quantitatively, the inputs of groundwater vary for different hydrological reasons. Within the same landscape, a bog may have low calcium concentrations because it is understood to be disconnected from groundwater inputs and a fen, though connected to groundwater, may have low calcium concentrations because it is actively flushed by surface water (low-calcium precipitation) during recharge regimes thus diluting the groundwater solutes.

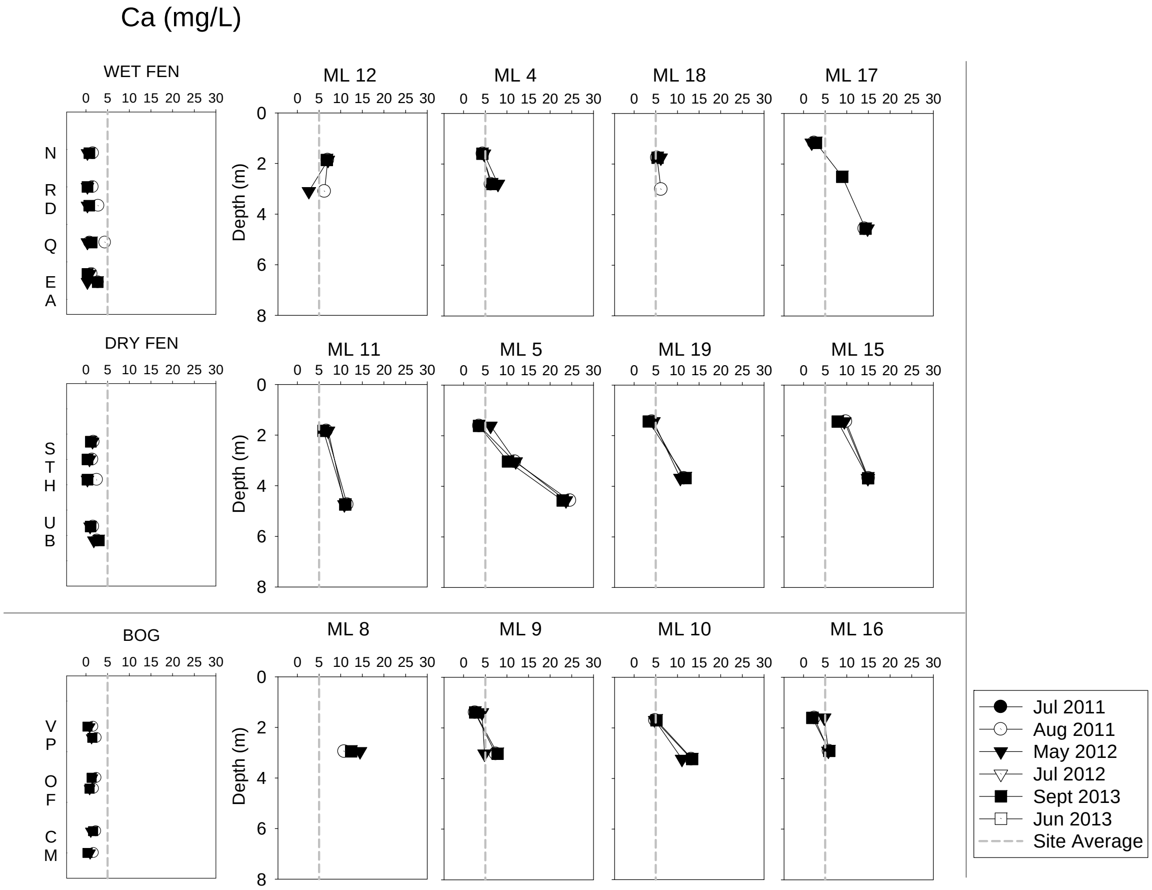


Figure 52 Depth profiles of calcium concentrations at ML sampling locations show greater spatial than temporal variability. Bog (bottom): nests 8, 9, 10, 16; dry fen (middle row): nests 11, 5, 19, 15; wet fen (top row): nests 12, 4, 18, 17.

The $\delta^{18}O$ depth profiles cluster in groups associated with landscape units (Figure 53). Samples from the ML bog site nest 10 have depleted values around -18 ‰ throughout the profile. The $\delta^{18}O$ depth profiles cluster at progressively more positive values for bog, dry fen, and wet fen sites. The increase in value is consistent with an increasing proportion of enriched inputs (rainfall or evaporated surface water) and may relate to distance along flowpath. Nest 16 is apparently different: water samples have an enriched signature at shallow depth (-17 ‰) and depleted signature at depth (-18 to -19 ‰). This enriched signature at shallow depth is more typical of a fen site; the depleted signature at mid-depth and depth is similar to values observed for dry fen and bog sites. Two factors determine the isotopic labelling of porewaters. First, at shallower depths, location relative to the outflow, i.e., distance along the flowpath determines the isotopic labelling, which is most positive at well sites near the outflow. Second, considering the depth profile, vertical flux determines the depth to which recharge flushes the profile and the relative proportion of enriched inputs (heavy summer rainfall and/or evaporatively enriched surface water) to light groundwater, where groundwater is a long-term integrated mixture of snow and rainfall inputs. Fen depth profiles show the greatest proportion of heavy inputs to groundwater. Spatial variability is greater than temporal variability for porewaters below depths of 1 m at ML, which supports a connectivity model in which flow is most active in the shallow zone and the spatial distribution of values persists in time and is associated with vegetation and location relative to the outflow.

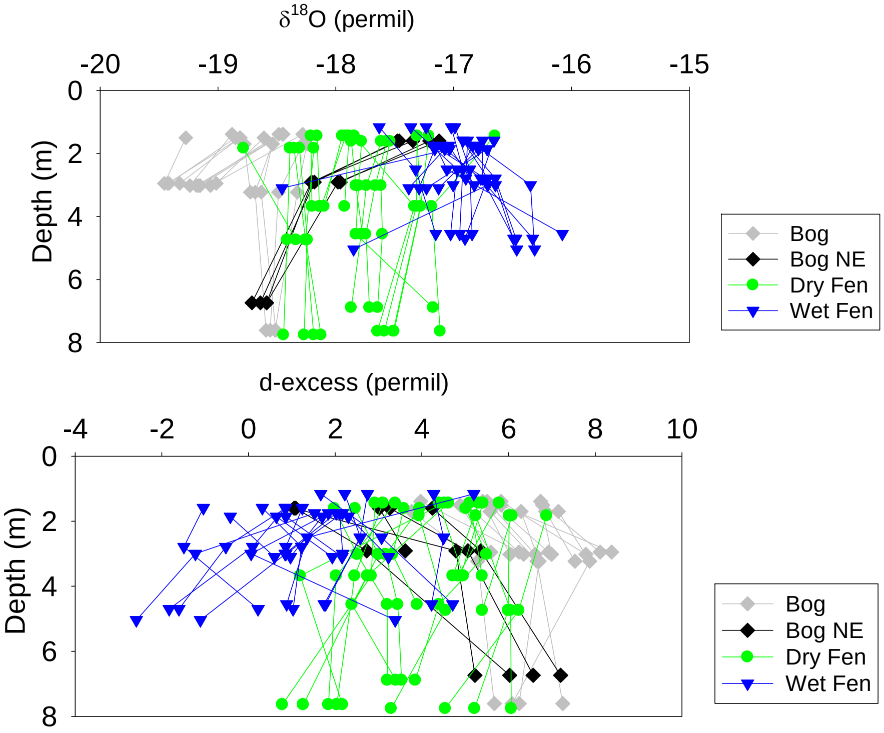


Figure 53 Depth profiles of δ^{18}O (top) and d-excess (bottom) based on 2011-2012 data, color-coded by landscape units at ML: bog – grey, bog NE – black, dry fen – green, wet fen – blue. Bog NE refers to bog nest 16.

4.3.3. Summary of Hydrological Connectivity at ML

Geochemical and isotope data are seasonally variable for water table well samples. Snowmelt inputs changed the isotopic values of near-surface samples and diluted the samples and evapotranspiration concentrated the samples. The concentrations of some parameters, e.g. DOC, of near-surface samples varied with season as productivity increased. Proximity to the outflow (or position along flow path) and distance from adjacent upland landscape units were a factor in spatial distributions of concentrations, for example, DOC concentrations were low near the outflow and calcium concentrations were lowest at central locations. Recharge of surface water to depths did occur, but there was a time lag because hydraulic conductivity is low and hydraulic head gradients were small. For example, increased concentrations of chlorine or high $\delta^{18}O$ values at WT sampling depths in one sampling campaign was followed by similar values at shallow sampling depths during the next sampling campaign.

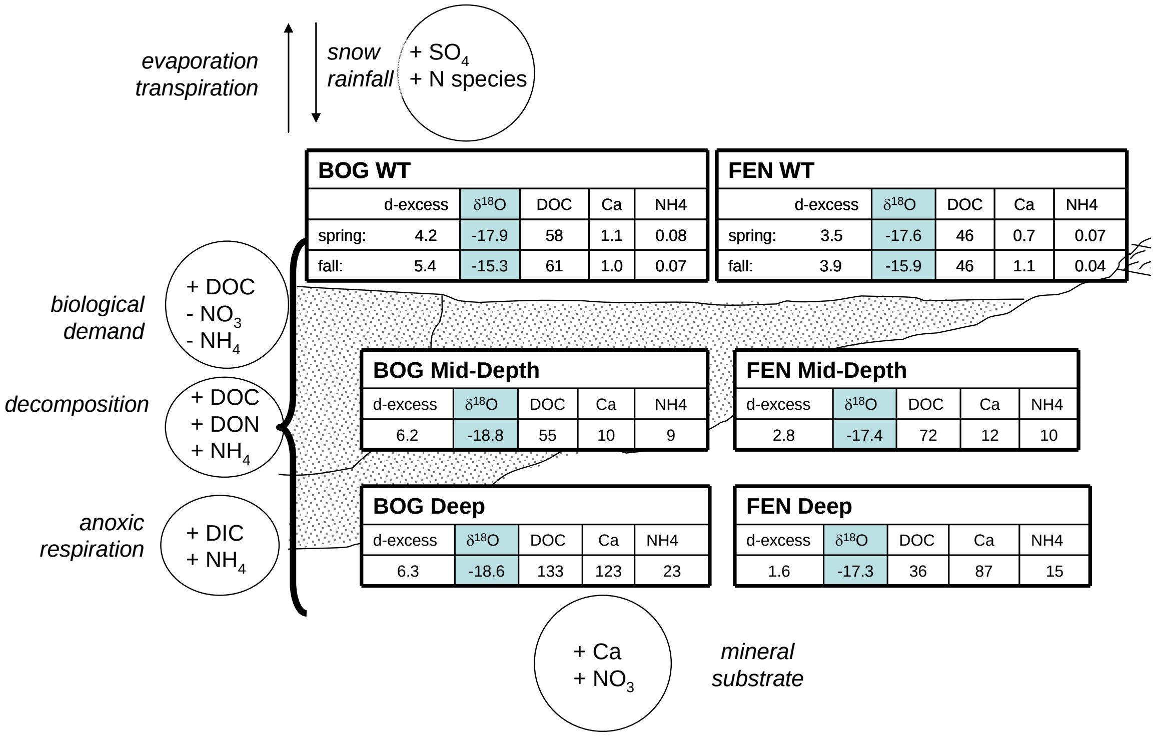
General observations (Vallarino 2014) regarding the hydrology had been stated in the context section for ML connectivity (section 4.2.1); here responses to the question ‘is there geochemical evidence’ are provided for each observation.

a) Flow may occur overland between the upland and adjacent fen:
    - inconclusive; although an association of isotope and geochemical data distributions can be made with the transition from upland to wetland, data analysis did not address this potential flow path.
b) Connectivity between the upland and adjacent fen may exist at depths below the upland instrumentation:
    - plan view contour plots of parameters show increased calcium concentrations measured near upland sites, which may be evidence for upland groundwater inputs.
c) Sites at the fen – upland interface showed small lateral hydraulic head gradients and had low hydraulic conductivity so recharge or discharge flux would be small or insignificant:
    - plan view contour plots of parameters show higher concentrations near the fen – upland interface, which may be evidence for groundwater

inputs from the mineral substrate; depth to the mineral substrate increases with increasing distance away from the fen – upland interface so groundwater influence may be greatest at the near upland locations.

d) Surface flow may occur from the bog to the adjacent fen in fill-and-spill events:
    - temporal variability of surface samples is greater than spatial variability and so the effect of such redistribution of dilute surface bog waters under high water levels and thus higher flux would likely be unnoticed in the water isotopes and geochemistry of samples.
e) Downward movement of surface water occurs in the fen, which is seen in isotopic signatures and lateral hydraulic head gradients:
    - downward movement is also seen in lower concentrations of various parameters at wet fen sites, e.g. DOC, ammonium and calcium which suggests flushing of the deeper pore waters by dilute surface water.
f) At nests 17 and 18 hydraulic head gradients changed direction, shifting between potential recharge and discharge regimes:
    - inconclusive; time series of data is incomplete for most parameters and so any changes in geochemical signatures cannot be definitively associated with changes in hydraulic head.

Systematic geochemical and isotopic differences were found within but also between the bog, dry fen and wet fen landscape units at the ML site. The geochemical and istopic signatures result from the mixture of groundwater and precipitation inputs and also any modifications by biogeochemical processes and connectivity. In this context lateral and vertical connectivity may be thought of as the flushing of porewaters. Summary statistics of δ^{18}O, d-excess, DOC and ammonium are presented for fen and bog sites (Figure 54) in the context of factors that affect them: physical hydrological (evaporation, transpiration, advection, diffusion) and biogeochemical (biological demand, decomposition) processes.



BOG WT

	d-excess	$\delta^{18}O$	DOC	Ca	NH4
spring:	4.2	-17.9	58	1.1	0.08
fall:	5.4	-15.3	61	1.0	0.07

FEN WT

	d-excess	$\delta^{18}O$	DOC	Ca	NH4
spring:	3.5	-17.6	46	0.7	0.07
fall:	3.9	-15.9	46	1.1	0.04

BOG Mid-Depth

d-excess	$\delta^{18}O$	DOC	Ca	NH4
6.2	-18.8	55	10	9

FEN Mid-Depth

d-excess	$\delta^{18}O$	DOC	Ca	NH4
2.8	-17.4	72	12	10

BOG Deep

d-excess	$\delta^{18}O$	DOC	Ca	NH4
6.3	-18.6	133	123	23

FEN Deep

d-excess	$\delta^{18}O$	DOC	Ca	NH4
1.6	-17.3	36	87	15

Figure 54 Schematic showing precipitation inputs, biogeochemical/physical drivers of hydrogeochemistry, and spring, fall or annual 2012 statistics at ML landscape units. Units for d-excess and $\delta^{18}O$: ‰; units for DOC, Ca, and NH4: mg/L.

4.3.4. Fate and Behaviour of Nitrogen at ML

Total inputs of nitrate and ammonium to the study site were determined using resin collectors placed in treed and open areas of the bog and fen (CEMA, Pers. Comm. 2014). For 2011 and 2012 inputs ranged from 0.05 to 3 kg nitrate/ha/yr and 0.08 to 4 kg ammonia/ha/yr, with higher values associated with treed locations. Nitrogen concentrations measured at ML were below the quantification limit (QL) in rain, surface, and peat pore waters, and above the QL in some of the deepest wells of nests in the fen or uplands only (Figure 55). Nitrate data is available for fen nest 12 for all sampling campaigns, and at depth concentrations were above QL only in May 2012 (0.14 mg/L). Nitrate data is available only for May 2012 at depth for fen nest 5 (0.07 mg/L). Upland nest 1 at depth had nitrate concentrations of 0.19 mg/L for May 2012, the only sampling campaign for which data were available. Data at upland nest 2 at depth were available for May 2012 (0.12 mg/L) and July 2012 (0.08 mg/L). Inorganic ammonium concentrations (Figure 55) were consistently low in rain, surface and WT pore waters, and significant at depth. Bog and dry fen sites were sampled to greater depths than the wet fen sites.

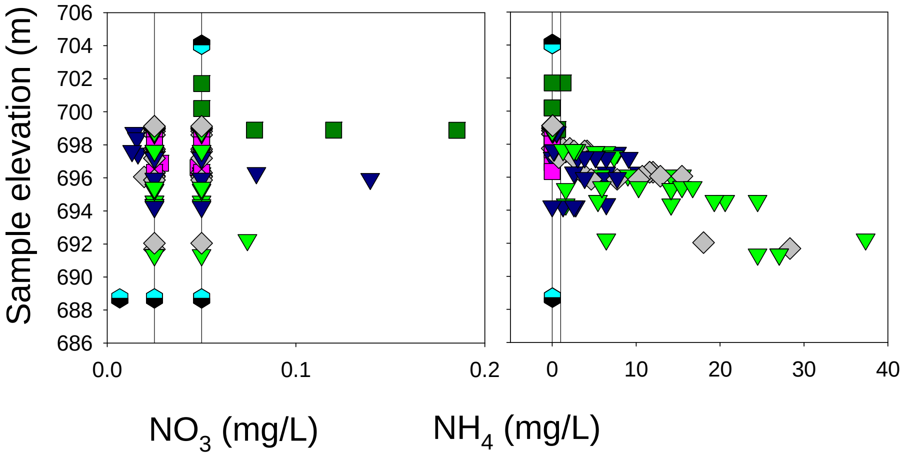


Figure 55 Depth profile plots of inorganic nitrate (NO_3, left) and ammonium (NH_4, right) concentrations at ML differentiated by landscape unit. Quantification limits for nitrate (vertical reference lines) are 0.05 mg/L for August 2011 and May 2012 data, and 0.1 mg/L for September 2012 data. The detection limit for ammonium was 1 mg/L for high range colorimetry and 0.02 mg/L for low range colorimetry. Landscape units: upland – green square, edge – pink square, wet fen – blue triangle, dry fen – green triangle, bog – grey diamond bog, weir – hexagon, (lower half black), and precipitation – hexagon (top half black).

Inorganic nitrogen as nitrate was efficiently immobilized within the ML peatland sites. Though the peatland is a sink for inorganic nitrate, decomposition is a source of organic nitrogen (DON). And inorganic ammonium, which has a low diffusion coefficient, is produced *in situ* and accumulates during peat formation. Inorganic ammonium concentrations in the ML peatland were on average 23 mg/L at deep dry fen and bog piezometers (7 m) and on average 9 mg/L at deep wet fen locations (5 m), and so the peatland is a sink for inorganic nitrogen. This store of inorganic ammonium in porewaters needs to be quantified and considered as an input in scenarios that model changes in hydrology and water level.

Some of the deepest well samples had nitrate concentrations that are consistent with the presence of groundwater. The deepest well samples however also had high ammonium concentrations. At the interface between the anoxic peat environment and the groundwater, the concentration gradient may result in diffusion of ammonium and/or nitrate. And oxidation of organic substrate material may be facilitated by microbes and the reduction of nitrates. The nitrogen sequestered as ammonium may be a significant store that needs to be taken into account when calculating nitrogen budgets or considering land-use and/or climate changes.

Finally, the fate of nitrogen may be generalized for peatland complexes similar to the ML study site that are subject to similar hydrologic regimes. Flowpaths for DON, inorganic ammonium and DOC may be comparable and are controlled by hydrological connectivity. Bog locations are a sink for DON, ammonium and DOC, which accumulate with depth. During episodic high AMC, lateral flow may occur from the bog to adjacent landscape units, which would distribute near-surface water, which may have significant DON and DOC concentrations but low ammonium concentrations. Dry fen locations similarly are a sink for DON, DOC and ammonium, which are accumulated at depth. Wet fen locations that are flushed by near-surface waters convey rather than store DON, DOC and ammonium. Though inorganic nitrates are efficiently immobilized and transformed, excess nitrates in near-surface waters would be transported along hydrological flowpaths. The flowpath for excess nitrates would be similar to the flowpaths of DOC or DON: excess nitrates would recharge at bog and dry fen locations, recharge or be conveyed laterally at wet fen sites, and be transported laterally in surficial flowpaths established during high AMC. Excess nitrates recharging at depths will be reduced to ammonium, further increasing the inorganic ammonium stores. Such inputs of excess nitrates may have implications for the abundance or composition of microbial communities that exist in the anoxic peatland.

Chapter 5.
Conclusion and Recommendations

5.1. Conclusion

The main objectives of this thesis are i) to provide a description of the baseline hydrogeochemistry of water samples at study sites JPH and ML and ii) to use geochemical evidence to identify connectivity within/between bog, fen, and upland landscape units. The research was conducted as part of an interdisciplinary project by CEMA, of which the purpose is to understand the fate and behaviour of nitrogen in Boreal wetland-rich ecosystems typical of the AOSR. From the baseline geochemistry, perturbations (*viz.* nitrogen amendments, climate change, land-use change, anthropogenic atmospheric input changes) may be assessed. From the evidence of connectivity, implications for nitrogen flux are identified for different hydrologic regimes that arise due to natural climate variability or anticipated changes in climate and/or land-use.

Baseline geochemistry Descriptive statistics, depth profiles, Piper plots and exploratory principal component analysis were used to describe the baseline hydrogeochemistry. Intra-site differences included higher sulphate, higher chloride, lower DOC and lower ammonium concentration ranges at the JPH site than the ML site. Consistent trends with depth were observed for some parameters at both study sites: for example, pH, conductivity and calcium concentration increased with depth and oxidation-reduction potential, and sulphate concentrations decreased with depth. Temporal changes in water type were most significant in near-surface sampling locations. The porewaters present in the different landscape units at JPH could be differentiated based on sulphate concentrations, presence of transition elements, redox-sensitive species, and nutrients. At ML, very few groundwater samples were obtained from the deepest piezometers in the bog and fen and from piezometers in the upland areas, but in general these were characterized with higher electrical conductivities and pH values, with no obvious spatial or temporal trends. Within the peatland, bog and fen samples generally showed similar geochemical and isotope data ranges and trends with depth. Depth profiles of a subset of data (including $\delta^{18}O$, Mn, ammonium, calcium and DOC) grouped ML peatland sampling locations along the bog – fen gradient as they related to depth to mineral substrate, distance from the outflow or edge, and surface vegetation classification (following Graham 2012).

Hydrological connectivity Time series of isotope and geochemical contour plots and depth profiles were examined along transects at the study sites to identify geochemical evidence of connectivity among landscape units. Hydrology, and so connectivity, at the two study sites is fundamentally different: spatial configuration, vegetation, hydraulic conductivity and depth to mineral substrate affected antecedent moisture conditions, flow potential, and the capacity to store and transmit water. Residence time is an important factor, as biological processes alter the geochemistry and mixing and evaporation effect changes in the isotopic signature of bodies of water.

At JPH groundwater flow was directed from the upland to the fen sites, which is supported by the geochemically and isotopically consistent mid-depth and deep upland and fen water samples. The physical and chemical processes in the fen changed with season and hydrological regime, as seen in significant spatiotemporal variability of the hydrogeochemistry and isotopic signatures of surface and shallow fen samples.

At ML, antecedent moisture conditions affected connectivity. Storage capacity must be exceeded for run-off to occur, and AMC determines the strength of the lateral connectivity as highest hydraulic conductivities will be at saturated near-surface layers. Both bog and fen landscape units were dominated by potential for vertical recharge, though hydraulic head variations within the substrate may lead to preferential lateral connectivity. The bog sites were characterized by more negative $\delta^{18}O$ and $\delta^{2}H$ values, higher DOC and ammonium concentrations; fen sites were characterized by higher electrical conductivity, pH and more positive $\delta^{18}O$ and $\delta^{2}H$ values. At ML fen and bog landscape units, temporal variability in data was significant in the near-surface samples and trends with depth were similar for fen and bog samples. Spatial variability at shallow, mid-depth and deep samples was greater than temporal variability, indicating that long-term vertical recharge and discharge regimes result in location-specific amounts of groundwater and precipitation inputs within a profile. The subtle differences in isotope and geochemical depth profiles were related to varying connectivity with groundwater along the bog – fen gradient. So the spatial relationship to landscape units is associated with confounding factors: hydrological connectivity, depths to mineral substrate, and surface vegetation.

Nitrogen Elevated nitrogen concentrations related to the amendment experiments, measured as either inorganic ammonium or nitrate, were not found in 2011 or 2012 at either JPH or ML study sites. At JPH, inorganic nitrate concentrations were above quantification limits (0.1 mg/L) only in May 2012 in few fen locations, which may be indicative of a seasonal signal related to low productivity (nitrate uptake) and snowmelt (nitrate input). At ML, nitrates were below quantification limits (< 0.1 mg/L) for fen and bog porewaters, with the exception of one mid-depth sample in the fen (0.14 mg/L in May 2012), and nitrate concentrations were present in water samples from ML upland wells (up to 0.19 mg/L). Ammonium concentrations in the JPH upland increased with depth, and were less than 0.35 mg/L; ammonium concentrations in the JPH fen were lowest at depth, but otherwise variable up to 1.14 mg/L, depending on water level and season. And ammonium concentrations increased with depth to an average of 23 mg/L (as high as 37 mg/L) in the peatland at ML. The ammonium concentrations at ML may constitute a significant store, which, since it is present in porewaters, may be readily available as an input under a changed hydrological regime associated with (co-occurring) changes in vegetation, landuse or climate.

5.2. Looking Forward (Recommendations)

Future research should build on this hydrogeochemical study and the concurrent hydrology study (Vallarino 2014) and utilize or expand upon the monitoring network that is in place. Looking forward, some recommendations are made that pertain to research plans already in place (a – c) and some suggestions are offered for consideration (d – g).

a) The geochemical baseline characterization for 2012 will be complemented by sampling in other years for the analysis of temporal variability or assessment of perturbations. Cherry M (Pers. Comm. 2013) for her MSc study is leading 2013 and 2014 field work sampling campaigns. Recommendations are as follows:

- Sampling has been modified to include the analysis of organic nitrogen concentrations, likely a significant component of the nitrogen budget, as concentrations of inorganic nitrate were generally low. Also, sampling will include the analysis of $\delta^{15}N$ isotopes of organic nitrogen and inorganic ammonium.
- A sampling campaign should include the sampling of multiple locations within a landscape unit. Spatial variability was a significant factor contributing to the overall variability of geochemical and isotopic data at these study sites.
- Data from some deep wetland and upland piezometers installed at ML was available for few or no dates. At these locations, sampling for nitrate and ammonium should be prioritized, also to confirm the concentrations measured in 2011 and 2012.

b) Along the bog – fen gradient at the ML site, the sub-classification into bog, dry fen and wet fen is warranted due to subtle differences in sample isotopic and geochemical signatures. The depth of the deepest wells decreases along the bog – dry fen – wet fen gradient, which may be of significance when modelling the site hydrology or geochemistry.

c) At ML, sub-surface structural details of the peatland complex were not fully defined. For example, the depth to mineral substrate was assumed equal to the depth of refusal during well installation. Peat core analysis may be used to refine structural depth profiles (*viz.* bulk density, specific yield, and porosity). Shulba W (Pers. Comm. 2013) in his MSc research is addressing this knowledge gap: peat cores were extracted in 2013 and the peatland complex will be mapped using ground penetrating radar (GPR) in 2014.

d) The conceptual understanding of hydrological connectivity at the ML study site includes that vertical recharge occurs to different depths and at different time scales at the bog and fen landscape units. So different fractions of recent water should be present at depth at the ML bog and ML fen sites. Tritium analysis as an indicator of peatland porewater age may refine our understanding. Depending on the outcome of a tritium analysis, a complementary or alternate method would be carbon-dating dissolved inorganic or dissolved organic carbon.

e) At JPH, from hydraulic head, potential flow persisted from the upland to the fen. Additional piezometer nests along the fen transect and between the fen and upland would be required to determine if the direction of flow potential changes at a physical scale smaller than the scale of the monitoring well network installed in 2011.

f) Isotopic and geochemical depth profiles at ML could be compared with modelled advection and diffusion profiles (based on equations describing the mixing and dispersion of solutes) to determine the depth to which recharge of surface water occurs (following Siegel & Glaser 2006). Modelled and observed depths of surface water influence could be compared with the calculation of a throughflow index (following Levy *et al.* 2013).

g) The application of mass balances could be used to calculate flux and solve nutrient budgets at the study sites. Also (as in Petrone *et al.* 2007), biological and chemical process can be quantified as the difference between conservative modeled values and reactive measurements.

Lately industrial development in the Athabasca Oil Sands Region has attracted scientific (and media) attention, bringing with it research initiatives such as this project, and attendant demands for accountability, collaboration, and transparency (Schindler 2010). This work improves the understanding of peatland ecosystem connectivity in the Athabasca Oil Sands Region, which has important implications for hydrological modelling, environmental monitoring, rehabilitation of wetlands, and reconstruction of peatlands – and so will help to inform stewardship of the Boreal region in the context of anticipated changes in climate and land-use.

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Appendix A
JPH Instrumentation (location, depth, vegetation)

	Vegetation	Latitude	Longitude	Elevation (masl)	Well Depth (m)
Water Table Wells					
JPHA	fen	57.1193	-111.4436	333.88	water table
JPHB	fen	57.1196	-111.4452	333.31	water table
JPHC	fen	57.1211	-111.4464	332.40	water table
JPHD	fen	57.1203	-111.4456	332.85	water table
JPHE	fen	57.1218	-111.4469	331.83	water table
JPHF	fen	57.1226	-111.4480	331.17	water table
JPHG	fen	57.1204	-111.4446	333.61	water table
Piezometer Nests **Drivepoints are classified as Steel (S) or PVC (PVC)**					
JPHP01A (S)	upland	57.1216	-111.4398	334.72	6.26
JPHP01B (S)	upland	57.1216	-111.4398	334.72	3.14
JPHP01C (S)	upland	57.1216	-111.4398	334.72	1.91
JPHP02A (S)	upland	57.1220	-111.4375	334.54	6.22
JPHP02B (S)	upland	57.1220	-111.4375	334.54	3.12
JPHP02C (S)	upland	57.1220	-111.4375	334.54	1.80
JPHP03A (S)	upland	57.1228	-111.4375	335.27	6.23
JPHP03B (S)	upland	57.1228	-111.4375	335.27	2.95
JPHP03C (S)	upland	57.1228	-111.4375	335.27	2.77
JPHP04A (S)	upland	57.1233	-111.4391	334.61	6.24
JPHP04B (S)	upland	57.1233	-111.4391	334.61	3.12
JPHP04C (S)	upland	57.1233	-111.4391	334.61	2.49
JPHP05A (S)	upland	57.1230	-111.4413	334.25	6.22
JPHP05B (S)	upland	57.1230	-111.4413	334.25	3.14
JPHP05C (S)	upland	57.1230	-111.4413	334.25	2.44
JPHP06A (S)	upland	57.1222	-111.4427	334.23	6.24
JPHP06B (S)	upland	57.1222	-111.4427	334.23	3.15
JPHP06C (S)	upland	57.1222	-111.4427	334.23	2.13
JPHP07A (S)	upland	57.1214	-111.4426	334.31	6.28
JPHP07B (S)	upland	57.1214	-111.4426	334.31	3.17
JPHP07C (S)	upland	57.1214	-111.4426	334.31	1.90
JPHP08A (S)	fen	57.1196	-111.4436	333.68	6.14
JPHP08B (S)	fen	57.1196	-111.4436	333.68	3.20
JPHP08C (PVC)	fen	57.1196	-111.4436	333.68	1.09
JPHP09A (S)	fen	57.1204	-111.4454	333.33	6.23
JPHP09B (S)	fen	57.1204	-111.4454	333.33	3.13
JPHP09C (PVC)	fen	57.1204	-111.4454	333.33	1.20
JPHP10A (S)	fen	57.1219	-111.4468	332.47	6.28
JPHP10B (S)	fen	57.1219	-111.4468	332.47	3.20
JPHP10C (PVC)	fen	57.1219	-111.4468	332.47	0.98
JPHP11A (S)	upland	57.1215	-111.4343	335.10	6.07
JPHP11B (S)	upland	57.1215	-111.4343	335.10	2.96
JPHP11C (S)	upland	57.1215	-111.4343	335.10	1.81
JPHP12 (PVC)	upland	57.1242	-111.4411	332.63	2.63

Appendix B
JPH Sampling Details

Site: JPH	Number of samples analyzed						
	number of sampling sites = **44** 12 piezometer nests = 34 sampling sites 7 water table wells = 7 sampling sites open-water, rain collector, weir = 3 sampling sites						
Fieldwork Campaign	July 2011	Aug 2011	Mar 2012	Apr 2012	May-June 2012	July-Aug 2012	Sep 2012
SUBMITTED FOR LAB ANALYSIS:							
Water Isotopes (^{18}O, ^{2}H) [1]	40	43	12	3	45	49	45
DIC (^{13}C) [1]	40	43			43	49	44
Particulates (C:N, ^{13}C, ^{15}N) [1]		40	11	3		44	29
Nitrates (^{15}N, ^{18}O) [2] *… too dilute for analysis*						*44*	*44*
DOC [3]		43		3	38		42
Major ions [4]		42		3	36	2	42
Trace metals [4]		42		3	36	2	42
FIELDWORK:							
Alkalinity		42			38	43	32
pH		41			35	39	35
Temperature		41			35	39	40
Eh		41			35	39	36
Conductivity		41			34	38	37
COLORIMETRY FIELDWORK:							
Sulphide		33			34	9	35
Nitrogen, Ammonium		35			37	39	41
Iron		42			36	39	40
Phosphate		41			36	38	40
Nitrate		41			38	39	42
Nitrite		32			38	36	39
Sulphate		40			38	39	40

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[1] Alberta Innovates Technology Futures, Victoria
[2] Isotope Science Laboratory, University of Calgary
[3] Alberta Innovates Technology Futures, Vegreville
[4] Dept of Earth and Environmental Sciences, University of Waterloo

Appendix C
ML Instrumentation (location, depth, vegetation)

	Vegetation	Latitude	Longitude	Elevation (masl)	Well Depth (m)
Water Table Wells					
MLA	wet fen	55.8982	-112.0964	698.94	~0.5
MLB	dry fen	55.8971	-112.0965	698.98	~0.5
MLC	bog	55.8961	-112.0972	699.12	~0.5
MLD	wet fen	55.8983	-112.0935	699.03	~0.5
MLE	wet fen	55.8978	-112.0914	698.94	~0.5
MLF	bog	55.8951	-112.0952	699.25	~0.5
MLG	wet fen	55.8986	-112.0897	698.71	~0.5
MLH	dry fen	55.8973	-112.0935	699.12	~0.5
MLM	bog	55.8979	-112.0900	698.90	~0.5
MLN	wet fen	55.8969	-112.0918	699.07	~0.5
MLO	bog	55.8955	-112.0953	699.28	~0.5
MLP	bog	55.8949	-112.0947	699.33	~0.5
MLQ	wet fen	55.8975	-112.0915	699.01	~0.5
MLR	wet fen	55.8965	-112.0917	699.04	~0.5
MLS	dry fen	55.8962	-112.0930	699.15	~0.5
MLT	dry fen	55.8959	-112.0947	699.14	~0.5
MLU	dry fen	55.8958	-112.0925	699.11	~0.5
MLV	bog	55.8955	-112.0940	699.42	~0.5
Piezometer Nests **Drivepoints are classified as Steel (S), Jumbo (J), or PVC (PVC)**					
MLP01A (S)	upland	55.8996	-112.0936	701.00	2.12
MLP01B (J)	upland	55.8996	-112.0936	701.00	0.80
MLP02A (S)	upland	55.8992	-112.0936	703.06	4.17
MLP02B (J)	upland	55.8992	-112.0936	703.06	1.35
MLP03A (S)	edge	55.8987	-112.0936	699.45	2.82
MLP03B (J)	edge	55.8987	-112.0936	699.45	1.13
MLP04A (S)	wet fen	55.8981	-112.0936	699.08	4.70
MLP04B (J)	wet fen	55.8981	-112.0936	699.08	2.79
MLP04C (J)	wet fen	55.8981	-112.0936	699.08	1.59
MLP05A (S)	dry fen	55.8967	-112.0936	699.13	6.89
MLP05B (J)	dry fen	55.8967	-112.0936	699.13	4.56
MLP05C (J)	dry fen	55.8967	-112.0936	699.13	3.02
MLP05D (J)	dry fen	55.8967	-112.0936	699.13	1.61
MLP06A (S)	edge	55.8953	-112.0925	699.10	2.22
MLP06B (S)	edge	55.8953	-112.0925	699.10	1.45
MLP07A (S)	upland	55.8950	-112.0917	701.21	4.44
MLP07B (S)	upland	55.8950	-112.0917	701.21	1.40
MLP08A (S)	bog	55.8942	-112.0939	699.25	2.95
MLP08B (S)	bog	55.8942	-112.0939	699.25	1.50
MLP09A (S)	bog	55.8947	-112.0941	699.13	3.02
MLP09B (J)	bog	55.8947	-112.0941	699.13	1.39
MLP10A (S)	bog	55.8955	-112.0953	699.29	7.61
MLP10B (S)	bog	55.8955	-112.0953	699.29	3.23
MLP10C (J)	bog	55.8955	-112.0953	699.29	1.70

	Vegetation	Latitude	Longitude	Elevation (masl)	Well Depth (m)
Piezometer Nests Cont.					
MLP11A (S)	dry fen	55.8965	-112.0964	699.09	7.76
MLP11B (J)	dry fen	55.8965	-112.0964	699.09	4.74
MLP11C (J)	dry fen	55.8965	-112.0964	699.09	1.83
MLP12A (S)	wet fen	55.8979	-112.0957	699.04	3.10
MLP12B (J)	wet fen	55.8979	-112.0957	699.04	1.86
MLP13A (S)	edge	55.8983	-112.0959	699.28	2.95
MLP13B (J)	edge	55.8983	-112.0959	699.28	1.28
MLP14A (S)	upland	55.8990	-112.0959	700.78	2.17
MLP14B (J)	upland	55.8990	-112.0959	700.78	0.92
MLP15A (S)	dry fen	55.8969	-112.0902	698.97	7.64
MLP15B (S)	dry fen	55.8969	-112.0902	698.97	3.68
MLP15C (PVC)	dry fen	55.8969	-112.0902	698.97	1.44
MLP16A (S)	bog	55.8979	-112.0900	698.78	6.74
MLP16B (S)	bog	55.8979	-112.0900	698.78	2.91
MLP16C (PVC)	bog	55.8979	-112.0900	698.78	1.60
MLP17A (S)	wet fen	55.8985	-112.0896	698.79	4.55
MLP17B (S)	wet fen	55.8985	-112.0896	698.79	2.50
MLP17C (PVC)	wet fen	55.8985	-112.0896	698.79	1.16
MLP18A (S)	wet fen	55.8982	-112.0910	698.96	5.04
MLP18B (S)	wet fen	55.8982	-112.0910	698.96	3.00
MLP18C (PVC)	wet fen	55.8982	-112.0910	698.96	1.75
MLP19A (S)	dry fen	55.8962	-112.0930	699.08	3.68
MLP19B (J)	dry fen	55.8962	-112.0930	699.08	1.44

Appendix D
ML Sampling Details

Site: ML	Number of samples analyzed						
	number of sampling sites = **69** 19 piezometer nests = 47 sampling sites 18 water table wells = 18 sampling sites rain collector, discharge, weir = 4 sampling sites						
Fieldwork Campaign	July 2011	Aug 2011	Mar 2012	Apr 2012	May-June 2012	July-Aug 2012	Sep 2012
SUBMITTED FOR LAB ANALYSIS:							
Water Isotopes (^{18}O, ^{2}H) [1]	48	61	18	6	75	74	67
DIC (^{13}C) [1]	48	60			74	70	62
Particulates (C:N, ^{13}C, ^{15}N) [1]		58	18	2		60	40
Nitrates (^{15}N, ^{18}O) [2] *…too dilute for analysis*						*54*	*64*
DOC [3]		47		1	38		51
Major ions [4]		45		1	54	3	54
Trace metals [4]		45		1	54	3	54
FIELDWORK:							
Alkalinity		67			38	56	40
pH		42			40	35	37
Temperature		42			40	35	37
Eh		42			38	29	35
Conductivity		41			39	33	37
COLORIMETRY FIELDWORK:							
Sulphide		31			32	0	21
Nitrogen, Ammonium		42			36	33	55
Iron		42			32	31	42
Phosphate		42			32	31	42
Nitrate		34			35	31	53
Nitrite		4			32	30	41
Sulphate		25			31	32	39

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[1] Alberta Innovates Technology Futures, Victoria

[2] Isotope Science Laboratory, University of Calgary

[3] Alberta Innovates Technology Futures, Vegreville

[4] Dept of Earth and Environmental Sciences, University of Waterloo

Appendix E
Thresholds in the Elemental Analysis of Particulate Matter

Introduction: Combustion of particular matter (along with the filter) yields gaseous products, the amount and isotopic signature of which are then measured by a mass spectrometer. The desired size of an acquired signal falls within a narrow range. Beyond this range, the size of the signal is obscured and cannot be interpreted accurately. Background noise and combustion of the filter itself contribute to the signal. This interference is negligible above a predetermined threshold. Further, the size of the sample is limited by physical constraints (i.e. size of the combustion chamber). Representative samples of ML were run, and the sample size requested was the top half-layer of a quarter of the filter. The lower limit for the signal amplitude was set at 1000. JPH samples had amplitudes well below the limit.

Objective: to maximize the data yielded by samples with low levels of particulate matter, as in JPH samples.

Method: The investigation was developed with the help of laboratory technician Paul Eby (Pers. Comm. 2012). The effort to revise the sample size limit focussed on: A) the sample sizes itself and B) the proportion of filter material relative to sample size.

A) Series of duplicates were run at full and half the requested size.

B) Standard material was weighed out in incrementally smaller volumes and run in the presence of filter material at full and twice the requested size.

Results:

A) Precision and accuracy were maintained at signal amplitudes as low as 500.

B) The proportion of filter material relative to sample size had no significant effect at amplitudes as low as 500.

Conclusion: JPH samples were revisited and data were considered meaningful if the signal amplitude was greater than the revised minimum. The data yielded increased.

Appendix F
Hach Colorimetry QA/QC for Nitrate

Step-wise dilutions of a standard sample were prepared and run to determine Hach Colorimeter precision and accuracy. Data for the standards were systematically offset from the expected values (Figure 56). A series of sample blanks were run. The blank concentrations, 0.9 – 1.4 mg/L, are considered a background reading caused by reagents. Upon applying the blank correction factor (Hach 2009), nitrate standards were read correctly. In Figure 57, fieldwork data (grey circles) plot within the same range as blank samples (black circles). As the reagent correction factor had not been previously applied, Hach colorimeter nitrate data is considered to have been either below detection limit for 2011 and 2012 or uncertain. There is uncertainty as every reagent batch has its own reagent correction factor, and different batches were used in the sampling campaigns.

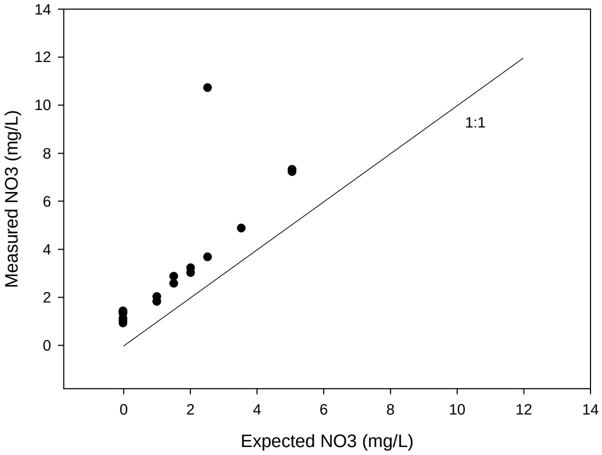

Figure 56 Hach Colorimeter QA/QC for Nitrate. Concentrations of dilutions of standard solution are plotted against expected values. Values for the standard solutions were systematically higher than expected.

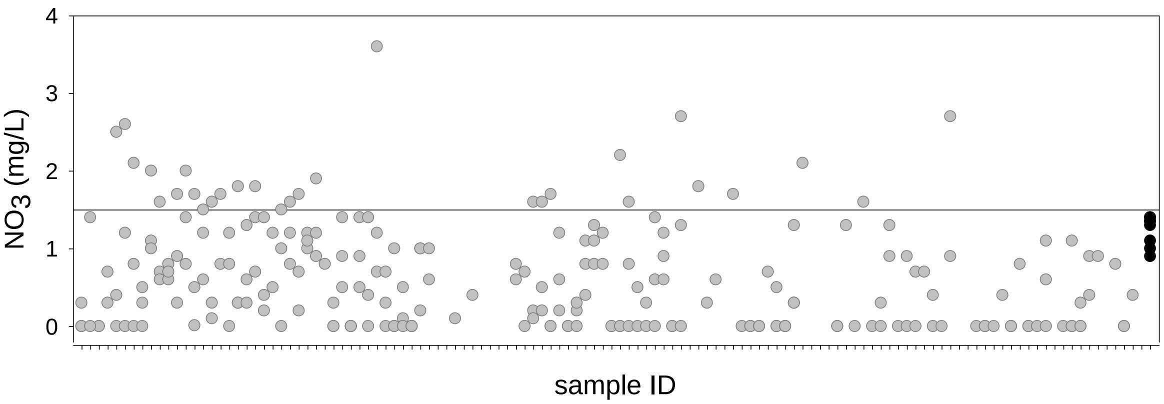

Figure 57 Hach Colorimeter Reagent Correction Error for Nitrate Method. Nitrate concentrations of blank samples, solid black circles, range from 0.9 – 1.4 mg/L. Nitrate date for 2011 and 2012, grey shaded circles, generally fall below 1.4 mg/L, marked by the horizontal line.

Appendix G
Supplementary Figures

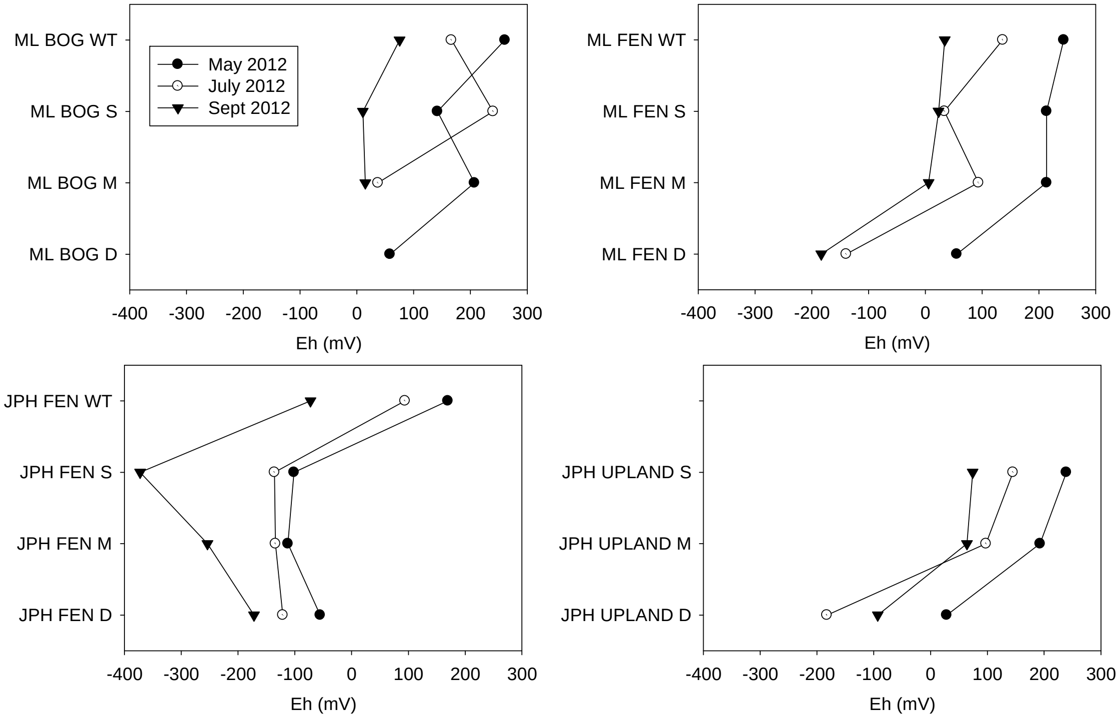

Figure 58 Depth profiles of Eh, comparing 2012 sampling campaign averages for landscape units and depth categories at ML (top row) and JPH (bottom row).

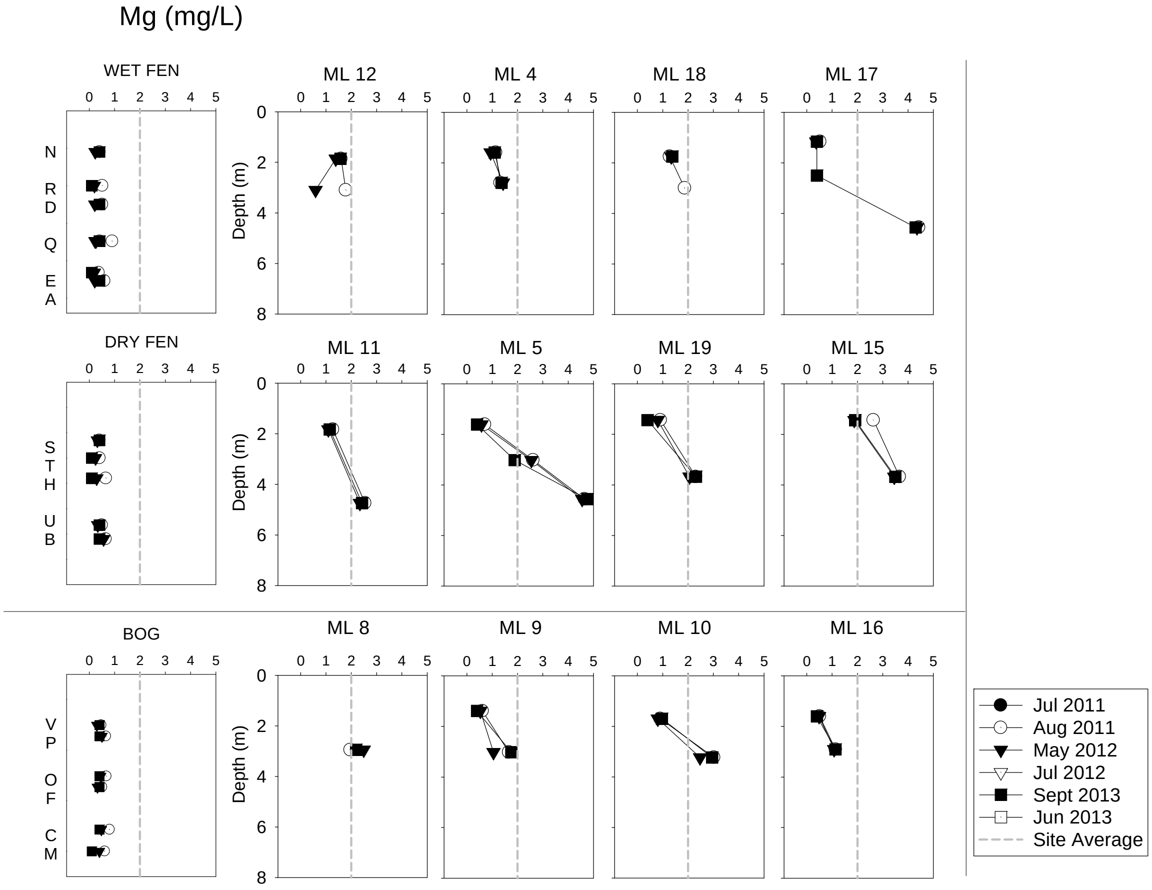

Figure 59 Depth profiles of magnesium concentrations at ML sampling locations show greater spatial than temporal variability. Bog (bottom): water table wells, nests 8, 9, 10, 16; dry fen (middle row): water table wells, nests 11, 5, 19, 15; wet fen (top row): water table wells nests, 12, 4, 18, 17.

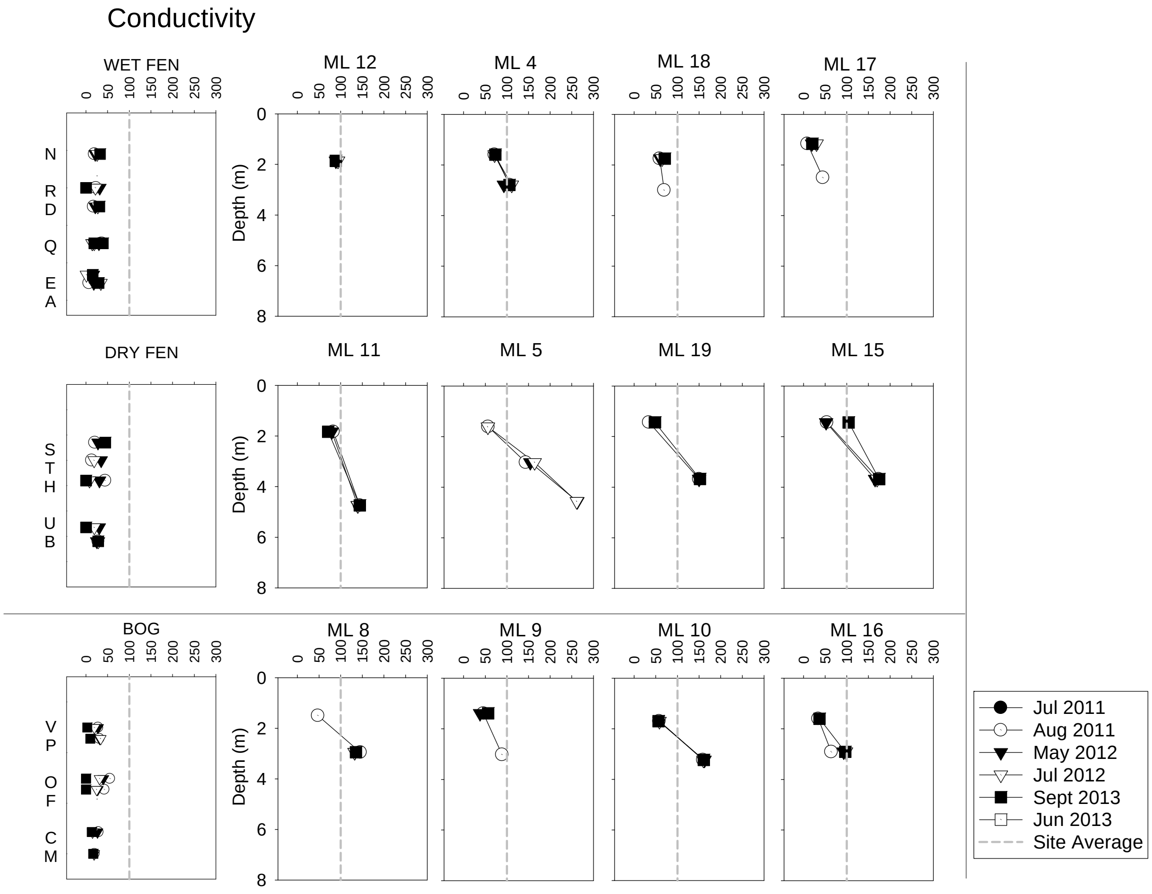

Figure 60 Depth profiles of conductivity (in microS/cm) at ML sampling locations show greater spatial than temporal variability. Bog (bottom): water table wells, nests 8, 9, 10, 16; dry fen (middle row): water table wells, nests 11, 5, 19, 15; wet fen (top row): water table wells nests, 12, 4, 18, 17.

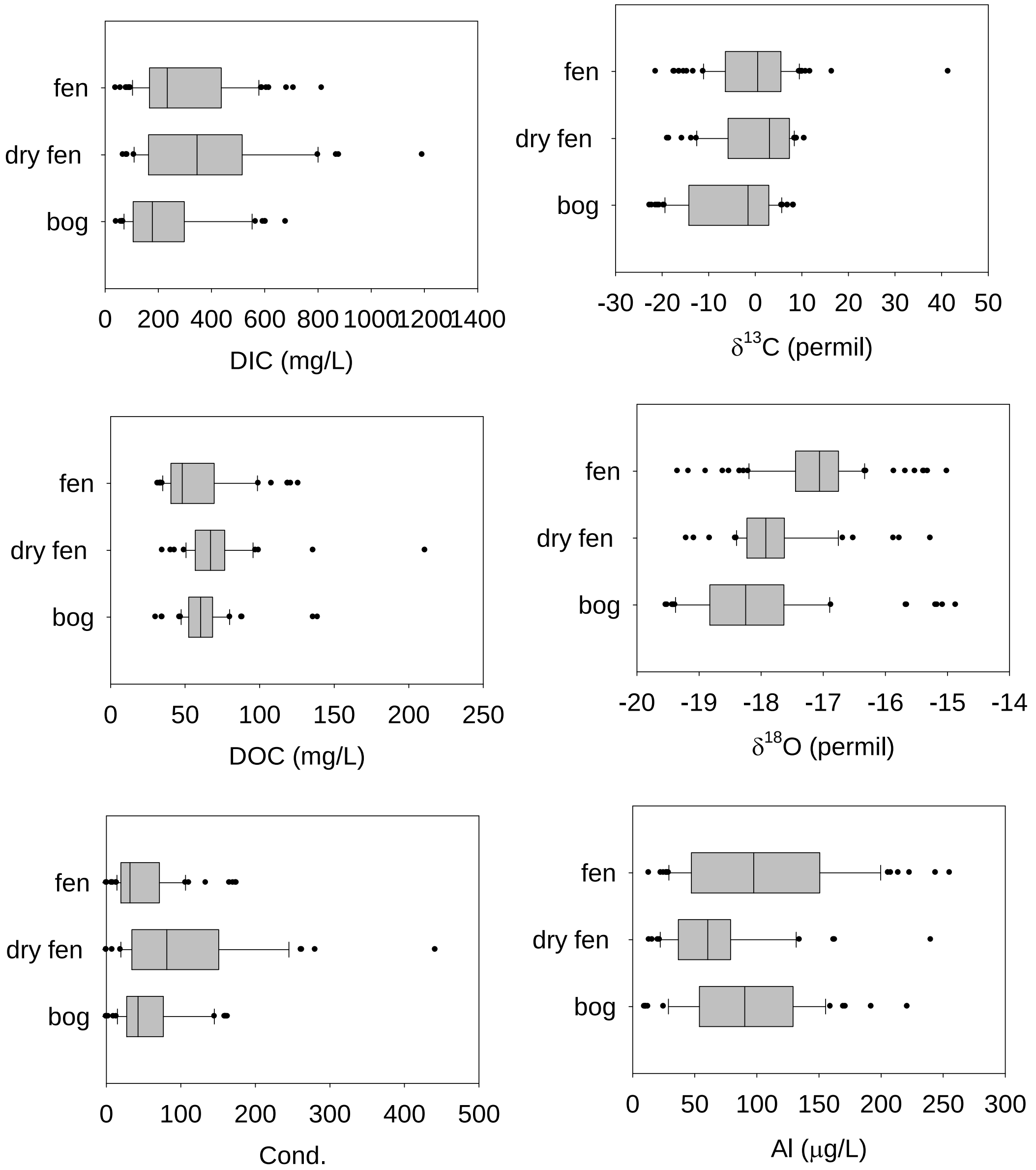

Figure 61 Box Plots of 2011-2012 mid-depth, shallow and WT data at ML fen, dry fen and bog. Conductivity (Cond.) is in microS/cm.

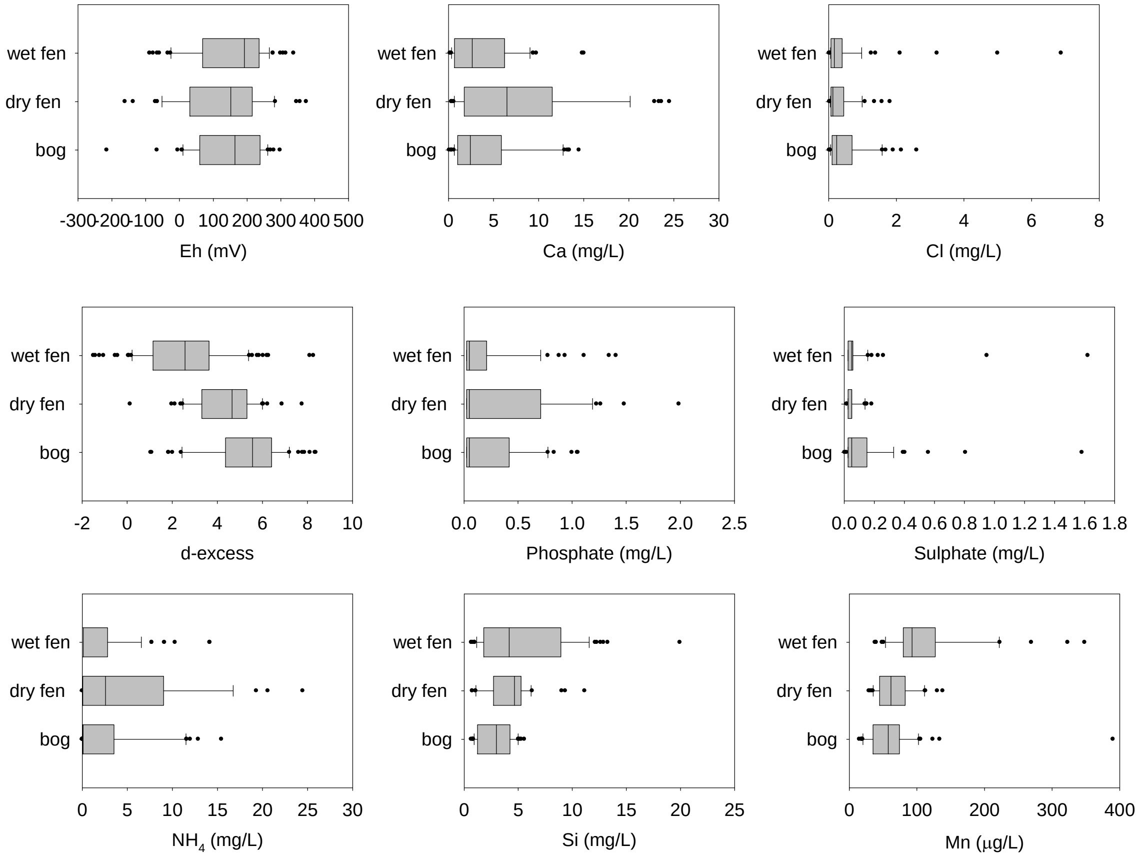

Figure 62 Box Plots of 2011-2012 mid-depth, shallow and WT data at ML fen, dry fen and bog.

Appendix H
Saturation Index (SI) modelled using PHREEQC (AquaChem 2005)

*BOLD : -0.5 < SI < 0.5					SI		
Sample	Date	Water Type	Goethite	Hematite	Pyrite	Quartz	Siderite
JPH WT							
JPHA	25-May-12	Fe-SO4	2.68	7.27	-60.77	**0.14**	-2.20
JPHA	5-Sep-12	SO4	-2.23	-2.49	4.58	**-0.22**	-2.75
JPHB	5-Sep-12	SO4	-2.89	-3.82	5.25	**-0.06**	-3.49
JPHC	25-May-12	SO4	3.24	8.37	-62.29	**-0.27**	-2.17
JPHC	5-Sep-12	Fe-Ca-NH4	-2.41	-2.87	8.01	**0.05**	-1.16
JPHD	25-May-12	SO4	3.32	8.55	-69.26	**-0.19**	-2.62
JPHD	5-Sep-12	Fe-Ca-SO4	-1.96	-1.96	1.15	**-0.08**	-2.98
JPHE	25-May-12	SO4	2.40	6.70	-69.79	**-0.06**	-3.59
JPHE	4-Sep-12	SO4	-3.92	-5.89	8.34	**-0.05**	-2.97
JPHF	26-May-12	Fe-SO4	**0.46**	2.85	-3.54	**0.00**	-1.03
JPHF	4-Sep-12	SO4	**0.37**	2.70	-29.33	**-0.09**	-2.93
JPHG	25-May-12	Fe-Ca-HCO3	4.24	10.40	-74.74	**-0.12**	-1.81
JPHG	5-Sep-12	SO4	-2.15	-2.34	10.33	**0.06**	-2.09
JPH UPLAND							
JPHP01A	28-May-12	Fe-Ca-HCO3	-1.36	-0.80	7.59	**0.33**	**-0.35**
JPHP01A	2-Sep-12	Fe-SO4-HCO3	5.16	12.26	-72.93	**0.32**	**-0.39**
JPHP02A	2-Sep-12	Fe-Ca-HCO3	-0.95	**0.03**	-7.44	**0.22**	-1.22
JPHP02A	28-May-12	Fe-HCO3	-1.51	-1.09	8.08	**0.20**	-0.75
JPHP03A	28-May-12	SO4	3.10	8.13	-71.62	**0.14**	-2.83
JPHP04A	4-Sep-12	Fe-SO4-HCO3	-2.57	-3.20	3.44	**0.22**	**-0.02**
JPHP04A	28-May-12	Fe-Ca-HCO3	4.01	9.94	-50.06	**0.22**	**-0.04**
JPHP05A	27-May-12	Fe-HCO3	0.56	3.05	-19.66	**0.18**	-1.36
JPHP06A	27-May-12	Fe-SO4	2.95	7.83	-52.06	**0.13**	-1.38
JPHP06A	3-Sep-12	Fe-SO4	-4.32	-6.72	5.79	**0.17**	-1.26
JPHP07A	27-May-12	Fe-HCO3	3.79	9.51	-53.07	**0.24**	-0.63
JPHP11A	27-May-12	Fe-Ca-HCO3	0.67	3.27	-11.30	**0.37**	**-0.29**
JPHP01B	28-May-12	SO4	0.60	3.13	-42.08	**-0.06**	-3.26
JPHP01B	2-Sep-12	Fe-SO4	4.01	9.97	-84.46	**-0.01**	-3.01
JPHP02B	28-May-12	SO4	0.80	3.53	-45.91	**0.02**	-3.32
JPHP03B	28-May-12	SO4	3.68	9.30	-85.48	**-0.09**	-3.24
JPHP04B	28-May-12	SO4	5.04	12.00	-91.96	**-0.16**	-2.54
JPHP04B	4-Sep-12	SO4	-3.18	-4.42	9.71	**-0.15**	-3.10
JPHP05B	27-May-12	SO4	1.77	5.47	-55.35	**-0.11**	-3.12
JPHP06B	3-Sep-12	Fe-SO4	**-0.41**	1.11	-20.62	**0.13**	-2.54
JPHP06B	27-May-12	Fe-SO4	3.02	8.00	-60.64	**-0.02**	-2.25
JPHP07B	27-May-12	SO4	2.88	7.69	-72.90	**0.05**	-3.18
JPHP11B	27-May-12	SO4	1.38	4.69	-42.58	**0.06**	-2.53
JPHP01C	28-May-12	SO4	0.80	3.55	-61.54	**-0.24**	-4.59
JPHP01C	2-Sep-12	SO4	4.61	11.17	-90.03	**-0.18**	-3.02
JPHP04C	28-May-12	SO4	3.48	8.91	-92.99	**-0.25**	-4.25
JPHP04C	4-Sep-12	SO4	-2.98	-4.01	9.83	**-0.19**	-3.17
JPHP06C	3-Sep-12	SO4	**0.13**	2.20	-38.86	**-0.05**	-3.56

Sample	Date	Water Type	Goethite	Hematite	Pyrite	Quartz	Siderite
JPH FEN							
JPHP08A	5-Sep-12	Fe-Ca-HCO3	1.47	4.87		**0.27**	0.54
JPHP08A	27-May-12	Fe-Ca-HCO3	3.22	8.37	-19.54	**0.28**	0.83
JPHP09A	5-Sep-12	Fe-Ca-HCO3	-1.09	**-0.25**	9.53	**0.37**	**0.16**
JPHP09A	26-May-12	Fe-Ca-HCO3	4.19	10.29	-35.90	**0.37**	0.52
JPHP10A	4-Sep-12	Fe-Ca-HCO3	0.74	3.40	3.55	**0.28**	**0.41**
JPHP10A	26-May-12	Fe-Ca-HCO3-SO4	2.69	7.30	-16.72	**0.31**	0.60
JPHP08B	5-Sep-12	Fe-HCO3	5.81	13.57		**0.14**	-0.51
JPHP08B	27-May-12	Fe-HCO3	-1.00	**-0.06**	9.31	**0.18**	-0.75
JPHP09B	5-Sep-12	Fe-HCO3	-3.70	-5.46	1.74	**0.09**	**-0.32**
JPHP09B	26-May-12	Fe-HCO3	1.19	4.30	-2.95	**0.13**	**-0.01**
JPHP10B	5-Sep-12	Fe-HCO3	-1.06	**-0.20**	7.21	**0.21**	**-0.10**
JPHP10B	26-May-12	Fe-HCO3	**-0.30**	1.30	4.24	**0.24**	**-0.43**
JPHP08C	27-May-12	Fe-SO4	-1.07	**-0.21**	8.50	**-0.10**	-1.67
JPHP08C	6-Sep-12	Fe-Ca-HCO3	-6.29	-10.63	-2.57	**0.09**	-0.83
JPHP09C	26-May-12	Fe-HCO3	**-0.50**	0.92	**0.68**	**0.09**	-0.87
JPHP09C	5-Sep-12	Fe-SO4	-7.03	-12.10	2.62	**0.03**	-1.66
JPHP10C	26-May-12	Fe	-1.46	-1.00	10.69	**0.06**	-1.32
JPHP10C	5-Sep-12	Fe-Ca-HCO3	-4.85	-7.75	1.15	**0.12**	-1.09
ML FEN							
MLP17A	9-Sep-12	NH4-HCO3	1.55	5.09	8.62	0.56	1.81
MLP17A	10-Jun-12	Fe-NH4-HCO3	4.75	11.44	-36.70	0.56	1.66
MLP04B	8-Sep-12	NH4-Fe	-2.35	-2.74	1.17	**0.42**	-1.72
MLP04B	7-Jun-12	NH4-Fe	3.84	9.63	-68.85	**0.48**	-1.07
MLP19A	9-Sep-12	NH4	-4.44	-6.91	2.67	**-0.01**	-2.44
MLP19A	9-Jun-12	NH4	2.08	6.10	-66.90	**0.04**	-2.51
MLP05B	7-Jun-12	NH4	3.92	9.78	-82.40	**0.15**	-1.54
MLP05C	7-Jun-12	NH4	4.19	10.32	-87.92	**0.14**	-1.80
MLP11B	8-Sep-12	Fe-Ca-HCO3-PO4	1.30	4.56	-62.08	**0.05**	-2.48
MLP11B	9-Jun-12	NH4	2.76	7.45	-71.31	**0.10**	-2.04
MLP15B	11-Jun-12	Ca-HCO3-PO4	1.22	4.37	-55.13	**0.36**	-2.32
MLP15B	9-Sep-12	NH4	-2.02	-2.08	-12.87	**0.31**	-2.55
MLP12B	8-Sep-12	Fe-PO4-HCO3	-4.01	-6.06	4.27	**0.32**	-2.37
MLP12B	9-Jun-12	NH4-Fe	1.93	5.79	-58.17	**0.30**	-2.15
MLP17C	9-Sep-12	Fe-NH4-Ca	-3.72	-5.46	-13.37	**-0.28**	
MLP17C	10-Jun-12	NH4-Fe-Ca	-1.89	-1.84	-42.67	**-0.28**	
MLP18C	24-Jul-12	NH4-Fe	1.84	5.63	-64.78	**0.32**	-2.50
MLP18C	10-Sep-12	NH4-Fe	-2.64	-3.34	5.75	**0.35**	-2.24
MLP18C	10-Jun-12	NH4-Fe	1.11	4.15	-55.29	**0.43**	-2.64
ML BOG							
MLP11C	8-Sep-12	Fe-Ca-PO4-HCO3	0.66	3.29	-55.42	**0.00**	-3.00
MLP11C	9-Jun-12	NH4	1.75	5.45	-59.96	**-0.04**	-2.70
MLP08A	7-Sep-12	NH4	**0.26**	2.46	-34.77	**0.04**	-2.02
MLP08A	11-Jun-12	Ca-HCO3-PO4	1.80	5.53	-58.31	**0.07**	-2.07
MLP10B	7-Sep-12	NH4	-3.51	-5.07	3.81	**-0.02**	-2.59
MLP10B	9-Jun-12	NH4	3.32	8.60	-76.32	**-0.13**	-2.10
MLP16B	11-Jun-12	Ca-PO4-HCO3	1.83	5.61	-61.76	**0.09**	-2.39
MLP16B	9-Sep-12	NH4-Fe	-1.22	**-0.48**	-17.76	**0.07**	-2.15
MLP16C	9-Sep-12	NH4-Fe	-4.20	-6.44	-2.90	**0.03**	-4.16

Appendix I
Data Tables

DL	Detection Limit
QL	Quantification Limit
H	High Range (for Hach Colorimetry NH4)
Fieldwork parameters	
Temp	Temperature
pH	
Eh	Reduction potential
Cond	Conductivity
Alk	Alkalinity
Stable isotopes: water	
d2H	$\delta^{2}H$
d18O	$\delta^{18}O$
d-ex	d-excess
d13C DIC	$\delta^{13}C$ of DIC
DIC	Dissolved Inorganic Carbon
Stable isotopes: particulate matter (PM)	
d15N	$\delta^{15}N$ of PM
d13C	$\delta^{13}C$ of PM
C/N	Carbon:Nitrogen ratio of PM
Hach Colorimetry	
H2S	Hydrogen sulphide
NH4	Inorganic ammonium
Fe	Iron
PO4-3	Phosphate, PO_4^{3-}
NO3	Nitrate, NO_3
NO2	Nitrite, NO_2
SO42-	Sulphate, SO_4^{2-}

Analytical Laboratory

DOC	Dissolved Organic Carbon

Anions

Fluoride, Chloride, Nitrite, Bromide, Nitrate, Phosphate, Sulfate

Lac	Lactate
OAC	Acetate
OPr	Propionate
HCO	Formate

Cations/Trace Metals

Ca, K, Mg Na Si S Fe, Be, B, Al, P, K, Ti, V, Cr, Mn, Co, Ni, Cu, Zn, As, Se, Sr, Mo, Cd, Sn, Sb, Ba, Cd, Sn, Sb, Ba, Ag, Tl, Pb, U, Hg, Li

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N	H2S	NH4
units	^{0}C	--	mV	µS/cm	mg/L CaCO$_3$	mg/L	permil	permil	permil	permil	mg/L	permil	permil		mg/L	mg/L
precision	0.1	0.002	0.2	0.1	0.4	0.8	1	0.2	1	0.3	n/a	0.04	0.15	0.83	0.01	0.02 (5 H)
DL (QL)						0.2									0.02	0.02 (1 H)
JPHA																
Jul-11	--	--	--	--	--	--	-137.7	-17.39	1.4	-15.99	37.6	--	--	--	--	--
Aug-11	15.1	5.65	41	46	14	45.6	-128.5	-16.33	2.1	-13.22	27.3	1.3	-29.07	18.8	--	0.06
May-12	6.3	5.47	211	76	14	7.5	-163.8	-20.91	3.5	-18.31	153.4	--	--	--	0.02	0.10
Jul-12	16.1	6.25	83	138	40	--	-134.1	-16.77	0.1	-19.80	214.2	1.3	-28.25	18.9	--	0.06
Sep-12	15.6	5.38	-60	66	8	26.5	-113.3	-14.96	6.4	-23.86	75.2	3.1	-28.42	8.2	0.00	0.02
JPHB																
Jul-11	--	--	--	--	--	--	-140.9	-17.93	2.5	-16.40	44.9	--	--	--	--	--
Aug-11	15.4	5.85	-10	32	11	24.0	-144.0	-18.46	3.7	-14.42	28.3	--	-29.01	--	0.01	0.09
May-12	--	--	--	--	--	--	-140.3	-17.85	2.5	-21.26	127.9	--	--	--	--	--
Jul-12	16.9	5.66	124	97	7	--	-135.8	-17.53	4.4	-21.18	54.2	2.9	-28.75	12.7	--	0.00
Sep-12	14.0	5.40	-64	65	5	23.4	-117.4	-15.38	5.6	-21.92	36.5	--	-28.29	--	0.00	0.00
JPHC																
Jul-11	--	--	--	--	--	--	-139.3	-17.47	0.5	-11.72	70.1	--	--	--	--	--
Aug-11	15.0	5.95	-30	38	24	39.6	-146.2	-18.78	4.0	-14.63	36.7	1.1	-28.38	13.0	0.01	0.29
May-12	3.0	5.98	186	68	12	19.9	-148.4	-18.95	3.2	-21.93	50.7	--	--	--	0.02	0.63
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	13.0	5.64	-162	101	20	61.8	-133.7	-17.03	2.6	-21.23	160.1	--	-28.76	--	0.10	0.50
JPHD																
Jul-11	--	--	--	--	--	--	-142.9	-18.01	1.2	-14.01	49.5	--	--	--	--	--
Aug-11	16.0	5.90	-119	43	15	26.7	-137.3	-17.74	4.6	-11.89	38.5	1.4	-28.44	13.8	--	0.13
May-12	4.4	5.86	219	77	9	21.1	-135.5	-17.15	1.7	-22.39	63.8	--	--	--	0.02	0.61
Jul-12	16.2	5.70	93	95	7	--	-136.7	-17.62	4.3	-20.84	76.9	--	-28.60	--	--	0.02
Sep-12	15.1	5.46	-51	65	5	22.5	-117.5	-15.24	4.5	-21.33	60.3		-29.10	--	0.00	0.02
JPHE																
Jul-11	--	--	--	--	--	--	-144.8	-18.55	3.6	-20.29	45.1	--	--	--	--	--
Aug-11	14.1	6.13	-75	44	14	19.5	-145.9	-18.76	4.1	-9.75	40.2	-0.6	-29.03	15.3	--	0.36
May-12	2.3	5.54	242	67	4	17.9	-137.6	-17.64	3.5	-22.18	34.3	--	--	--	0.01	--
Jul-12	15.7	5.49	169	95	6	--	-135.4	-17.22	2.4	-21.65	60.0	--	-27.66	--	--	0.02
Sep-12	13.1	5.46	-153	70	6	17.2	-116.1	-15.26	5.9	-23.05	45.2		-27.85	--	--	0.03
JPHF																
Jul-11	--	--	--	--	--	--	-148.0	-18.98	3.8	-11.82	61.4	--	--	--	--	--
Aug-11	15.2	6.07	-93	43	10	29.5	-153.9	-19.94	5.6	-17.50	45.0	0.9	-28.69	16.9	--	0.67
May-12	8.4	6.23	-66	68	15	5.0	-147.2	-18.66	2.1	-22.22	88.1	--	--	--	0.16	0.56
Jul-12	15.2	5.60	-75	114	16	--	-134.2	-17.16	3.1	-22.44	159.3	0.1	-28.22	7.6	--	0.73
Sep-12	14.4	5.45	76	69	4	27.9	-112.1	-14.70	5.5	-24.03	45.9	2.2	-27.96	7.9	0.01	0.10
JPHG																
Jul-11	--	--	--	--	--	--	-137.9	-17.50	2.1	-14.85	41.2	--	--	--	--	--
Aug-11	15.8	5.95	-20	28	10	29.8	-136.1	-17.28	2.1	-16.01	11.8	1.3	-27.90	11.7	--	0.13
May-12	6.3	6.06	226	92	27	22.3	-143.5	-18.18	1.9	-20.55	97.6	--	--	--	0.02	0.19
Jul-12	17.0	5.69	171	79	7	--	-132.0	-16.98	3.8	-21.32	68.0	1.5	-28.24	10.5	--	0.00
Sep-12	13.7	5.51	-91	79	13	21.9	-118.7	-15.26	3.4	-23.27	134.1	1.9	-28.35	7.7	0.01	0.06

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N	H2S	NH4
	^{0}C	--	mV	µS/cm	mg/L $CaCO_3$	mg/L	permil	permil	permil	permil	mg/L	permil	permil		mg/L	mg/L
JPHP01A																
Jul-11	--	--	--	--	--	--	-141.8	-18.01	2.2	-6.48	89.6	--	--	--	--	--
Aug-11	12.4	6.06	-74	129	78	26.5	-139.7	-17.93	3.7	-8.59	105.1	--	-46.34	--	0.01	0.14
May-12	7.4	6.15	-164	133	52	30.5	-140.3	-17.89	2.8	-12.56	260.8	--	--	--	0.33	0.19
Jul-12	10.2	6.10	-398	0	63	--	-139.5	-18.51	8.5	-13.09	260.2	--	-29.58	--	--	0.17
Sep-12	8.8	6.10	203	132	49	77.1	-139.1	-18.01	5.0	-13.82	347.3		-29.30	--	0.36	0.20
JPHP01B																
Jul-11	--	--	--	--	--	--	-150.5	-19.20	3.1	-12.74	14.4	--	--	--	--	--
Aug-11	13.0	5.54	131	34	8	0.9	-148.5	-19.16	4.8	-17.82	25.4	--	-27.66	--	0.00	--
May-12	10.0	5.59	120	33	8	1.2	-146.9	-18.79	3.4	-21.96	55.4	--	--	--	0.00	0.00
Jul-12	11.3	5.53	112	33	8	--	-147.1	-18.79	3.2	-21.41	82.8	--	-29.77	--	--	0.04
Sep-12	10.7	5.73	281	39	8	1.1	-147.1	-18.95	4.5	-22.65	43.5		-31.57		0.03	0.00
JPHP01C																
Jul-11	--	--	--	--	--	--	-152.7	-19.38	2.3	-12.36	19.0	--	--	--	--	--
Aug-11	15.4	5.49	155	35	7	2.3	-148.2	-18.95	3.4	-17.32	22.2	--	-27.78	--	--	0.00
May-12	13.2	5.71	183	39	7	2.5	-151.2	-19.31	3.4	-19.81	33.4	--	--	--	0.00	0.00
Jul-12	16.0	5.87	209	38	10	--	-149.5	-18.96	2.2	-18.39	58.1	--	--	--	--	0.03
Sep-12	12.7	6.01	283	35	9	2.0	-152.4	-19.56	4.1	-20.46	5.8		-33.39		--	0.02
JPHP02A																
Jul-11	--	--	--	--	--	--	-142.4	-18.17	2.9	-10.51	79.4	--	--	--	--	--
Aug-11	10.5	5.97	-75	65	56	18.8	-141.2	-18.04	3.2	-12.73	79.4	--	-35.18	--	0.00	0.02
May-12	9.2	6.08	-157	83	35	19.9	-140.6	-17.93	2.8	-16.03	170.3	--	--	--	0.30	0.17
Jul-12	8.2	5.97	64	86	64	--	-140.7	-18.58	7.9	-16.61	193.5	--	-29.38	--	--	0.18
Sep-12	8.5	5.45	-17	88	52	53.8	-140.4	-17.97	3.4	-16.50	216.8	--	--	--	0.29	0.19
JPHP02B																
Jul-11	--	--	--	--	--	--	-148.8	-19.01	3.2	-13.20	17.0	--	--	--	--	--
Aug-11	12.1	5.65	119	38	21	1.2	-149.2	-19.00	2.8	-16.97	20.4	--	-26.40	--	0.00	0.00
May-12	8.4	5.64	133	33	8	1.3	-148.9	-19.10	3.9	-21.43	53.8	--	--	--	0.00	0.00
Jul-12	10.9	5.64	190	34	10	--	-149.0	-19.62	7.9	-21.35	78.9	--	-31.45	--	--	0.03
Sep-12	10.4	--	168	--	8	0.9	-148.0	-19.07	4.5	-22.32	50.0	--	--	--	0.02	0.02
JPHP02C																
Jul-11	--	--	--	--	--	--	-147.1	-18.90	4.2	-25.34	50.3	--	--	--	--	--
Aug-11	14.6	5.62	162	41	9	0.2	-149.4	-18.96	2.2	-16.20	20.2	--	-28.40	--	0.00	0.00
May-12	--	--	--	--	8	2.2	-149.3	-19.17	4.0	-19.20	38.1	--	--	--	--	0.00
Jul-12	14.7	5.82	203	40	12	--	-151.3	-19.80	7.1	-19.35	62.4	--	-27.58	--	--	0.09
Sep-12	12.4	--	171	--	10	2.3	-149.2	-19.06	3.3	-20.92	70.4	--	--	--	0.00	0.02
JPHP03A																
Jul-11	--	--	--	--	--	--	-147.3	-18.65	1.9	-13.24	30.0	--	--	--	--	--
Aug-11	10.2	5.64	121	50	10	1.2	-147.3	-18.63	1.8	-15.78	24.7	--	-27.27	--	0.01	0.00
May-12	8.8	5.77	228	41	12	1.5	-146.0	-18.60	2.8	-20.33	69.1	--	--	--	0.04	0.00
Jul-12	8.0	6.32	79	42	13	--	-146.9	-18.67	2.4	-20.10	93.9	--	-27.90	--	--	0.06
Sep-12	9.6	5.86	-179	44	--	1.2	-145.5	-18.57	3.1	-21.72	81.5	--	--	--	0.02	0.01

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N	H2S	NH4
	^{0}C	--	mV	µS/cm	mg/L $CaCO_3$	mg/L	permil	permil	permil	permil	mg/L	permil	permil		mg/L	mg/L
JPHP03B																
Jul-11	--	--	--	--	--	--	-149.6	-19.25	4.5	-13.58	19.3	--	--	--	--	--
Aug-11	13.1	5.52	181	43	7	1.3	-149.2	-19.18	4.2	-17.09	23.2	--	-26.99	--	0.00	0.00
May-12	10.0	5.57	295	32	8	1.4	-149.1	-19.20	4.6	-21.57	50.5	--	--	--	0.00	0.00
Jul-12	11.7	5.74	43	33	23	--	-149.6	-19.66	7.7	-21.03	69.8	--	-31.20	--	--	0.07
Sep-12	11.8	5.40	-161	35	--	1.2	-147.6	-18.91	3.7	-22.15	43.1	--	--	--	0.00	0.00
JPHP03C																
Jul-11	--	--	--	--	--	--	-148.1	-19.02	4.0	-12.39	17.5	--	--	--	--	--
Aug-11	18.3	5.98	169	33	7	1.4	-147.8	-18.82	2.8	-14.32	16.5	--	--	--	0.00	0.00
May-12	--	--	--	--	--	--	-154.3	-19.76	3.8	-18.98	19.8	--	--	--	--	--
Jul-12	12.9	6.02	65	29	6	--	-155.7	-20.52	8.4	-17.77	49.0	--	--	--	--	0.16
Sep-12	13.4	5.78	-137	30	--	1.3	-154.4	-19.65	2.9	-21.06	18.6	--	--	--	0.01	0.00
JPHP04A																
Jul-11	--	--	--	--	--	--	-141.4	-18.09	3.3	-10.31	68.7	--	--	--	--	--
Aug-11	11.2	6.04	-63	66	40	8.5	-141.6	-18.17	3.8	-12.52	100.9	--	-31.80	--	0.00	--
May-12	7.0	6.46	87	144	58	19.3	-140.9	-18.06	3.5	-9.98	226.7	--	--	--	0.04	0.22
Jul-12	8.2	6.33	-286	149	67	--	-140.6	-18.13	4.4	-10.96	295.2	--	-29.35	--	--	0.14
Sep-12	9.5	6.30	-266	157	70	21.8	-140.0	-17.91	3.3	-11.65	522.2		-28.08	--	0.05	0.25
JPHP04B																
Jul-11	--	--	--	--	--	--	-147.7	-18.99	4.2	-14.36	23.5	--	--	--	--	--
Aug-11	13.6	5.89	101	46	13	0.2	-148.5	-18.96	3.2	-17.14	38.5	--	-26.60	--	0.00	--
May-12	9.8	5.96	297	46	12	2.0	-149.5	-19.08	3.1	-19.97	67.4	--	--	--	0.00	0.00
Jul-12	11.1	5.91	1	46	15	--	-150.4	-19.26	3.6	-19.36	100.6	--	-30.20	--	--	0.00
Sep-12	11.4	5.83	-123	45	12	1.7	-150.8	-19.27	3.4	-21.29	80.6	--	-29.57	--	0.02	0.00
JPHP04C																
Jul-11	--	--	--	--	--	--	-150.4	-19.22	3.3	-13.55	23.1	--	--	--	--	--
Aug-11	13.9	5.72	141	41	9	2.0	-146.5	-18.76	3.5	-16.02	27.5	--	-27.29	--	--	0.00
May-12	13.7	5.94	295	13	9	2.9	-153.0	-19.48	2.9	-18.78	31.0	--	--	--	0.00	0.00
Jul-12	11.9	5.88	26	42	9	--	-154.3	-19.73	3.5	-17.87	60.5	--	-35.50	--	--	0.00
Sep-12	12.5	5.99	-143	43	7	3.3	-155.7	-20.05	4.7	-18.08	27.9		-29.20	--	0.03	0.02
JPHP05A																
Jul-11	--	--	--	--	--	--	-143.8	-18.31	2.7	-12.18	46.7	--	--	--	--	--
Aug-11	11.3	5.91	-29	72	25	4.5	-142.7	-18.33	3.9	-14.60	56.1	--	-29.19	--	0.00	0.04
May-12	8.0	6.00	4	63	32	5.6	-143.2	-18.22	2.6	-17.31	168.0	--	--	--	0.13	0.08
Jul-12	7.1	5.87	-375	70	30	--	-143.8	-18.89	7.3	-17.11	181.0	--	--	--	--	0.00
Sep-12	7.8	--	--	--	30	5.8	-142.5	-18.27	3.6	-18.53	192.6		-29.82	--	0.11	0.05
JPHP05B																
Jul-11	--	--	--	--	--	--	-149.8	-19.11	3.1	-14.50	18.6	--	--	--	--	--
Aug-11	13.1	5.51	153	36	30	1.2	-148.0	-19.01	4.1	-16.83	23.8	--	-26.28	--	0.00	--
May-12	10.3	5.67	168	33	8	1.3	-149.1	-19.19	4.4	-22.03	65.2	--	--	--	0.01	0.00
Jul-12	10.9	5.72	31	38	9	--	-148.0	-19.55	8.3	-21.49	96.0	--	--	--	--	0.00
Sep-12	9.4	--	--	--	9	1.3	-147.8	-19.04	4.5	-22.87	57.7		-31.24	--	0.01	0.04

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N	H2S	NH4
	^{0}C	--	mV	µS/cm	mg/L $CaCO_3$	mg/L	permil	permil	permil	permil	mg/L	permil	permil		mg/L	mg/L
JPHP05C																
Jul-11	--	--	--	--	--	--	-151.6	-19.15	1.6	-15.55	38.5	--	--	--	--	--
Aug-11	15.6	5.95	216	40	8	2.4	-147.4	-18.73	2.4	-15.17	19.3	--	-27.22	--	0.00	--
May-12	--	--	--	--	--	--	-152.6	-19.54	3.7	-20.65	31.2	--	--	--	--	--
Jul-12	12.9	6.24	80	33	7	--	-151.1	-19.94	8.4	-17.74	49.8	--	-27.70	--	--	0.00
Sep-12	10.0	--	--	--	--	2.4	-151.5	-19.49	4.4	-19.29	-1.7	--	--	--	--	0.00
JPHP06A																
Jul-11	--	--	--	--	--	--	-144.4	-18.40	2.8	-11.32	40.4	--	--	--	--	--
Aug-11	10.8	5.79	-5	54	28	3.9	-145.4	-18.37	1.5	-14.47	56.1	--	-31.60	--	0.00	--
May-12	8.4	5.84	148	57	24	6.5	-144.1	-18.51	4.0	-17.52	145.5	--	--	--	0.08	0.02
Jul-12	8.5	5.83	-317	6	43	--	-144.5	-19.06	8.0	-17.19	138.9	--	-28.80	--	--	0.01
Sep-12	7.4	5.92	-267	63	27	4.8	-144.5	-18.47	3.2	-18.64	256.1		-29.68	--	0.06	0.01
JPHP06B																
Jul-11	--	--	--	--	--	--	-147.1	-18.70	2.5	-15.21	36.4	--	--	--	--	--
Aug-11	18.2	5.92	182	58	48	2.1	-147.7	-18.67	1.6	-15.11	30.8	--	-27.30	--	0.00	--
May-12	14.7	5.81	179	48	14	1.6	-147.2	-18.86	3.7	-20.95	76.7	--	--	--	0.02	0.00
Jul-12	11.7	5.83	28	53	19	--	-147.6	-19.38	7.5	-20.13	85.4	--	-28.82	--	--	0.00
Sep-12	9.3	5.61	36	50	14	1.3	-147.0	-18.72	2.8	-21.92	51.1		-35.58		0.02	0.04
JPHP06C																
Jul-11	--	--	--	--	--	--	-147.9	-18.81	2.6	-12.43	23.6	--	--	--	--	--
Aug-11	16.2	5.54	217	39	3	2.1	-148.9	-18.94	2.6	-17.82	28.4	--	-26.90	--	0.00	0.00
May-12	--	--	--	--	7	2.8	-149.9	-19.45	5.7	-20.09	26.2	--	--	--	--	0.00
Jul-12	12.1	5.76	111	43	23	--	-151.2	-19.74	6.7	-19.83	58.9	--	--	--	--	0.00
Sep-12	9.8	5.62	105	43	7	1.9	-150.4	-19.23	3.5	-20.36	--		--		--	0.02
JPHP07A																
Jul-11	--	--	--	--	--	--	-143.8	-18.26	2.2	-10.69	84.7	--	--	--	--	--
Aug-11	11.7	6.10	-57	78	50	13.1	-143.0	-18.21	2.6	-13.43	130.3	--	--	--	0.01	0.00
May-12	9.0	6.16	128	97	40	11.5	-143.5	-18.27	2.7	-17.02	182.7	--	--	--	0.18	0.25
Jul-12	8.8	6.12	-337	109	54	--	-142.8	-18.21	2.9	-15.70	203.2	--	-28.87	--	--	0.16
Sep-12	8.3	6.38	-206	107	--	39.0	-142.2	-18.20	3.3	-17.15	398.6	-7.3	-29.00	13.1	0.12	0.15
JPHP07B																
Jul-11	--	--	--	--	--	--	-148.0	-18.90	3.2	-8.24	47.9	--	--	--	--	--
Aug-11	13.6	5.54	178	47	8	1.3	-148.5	-18.95	3.1	-16.26	36.2	--	-26.33	--	0.00	--
May-12	10.0	5.64	241	40	9	1.3	-146.7	-18.83	3.9	-21.21	61.3	--	--	--	0.00	0.00
Jul-12	13.4	5.43	91	44	11	--	-146.6	-18.67	2.8	-21.25	102.6	--	--	--	--	0.00
Sep-12	9.4	5.66	46	43	--	1.3	-145.9	-18.60	2.9	-22.99	152.8	--	--	--	0.01	0.00
JPHP07C																
Jul-11	--	--	--	--	--	--	-147.9	-18.81	2.6	-11.91	14.8	--	--	--	--	--
Aug-11	17.4	6.02	159	43	9	1.1	-148.2	-18.76	1.8	-15.53	22.5	--	-27.28	--	0.00	0.00
May-12	--	--	--	--	--	--	-158.0	-20.30	4.4	-22.40	16.0	--	--	--	--	--
Jul-12	14.9	6.27	210	39	10	--	-152.0	-19.24	1.9	-20.96	51.1	--	--	--	--	0.00
Sep-12	--	--	--	--	--	--	-149.6	-19.26	4.5	-17.47	31.3	--	--	--	--	--

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N	H2S	NH4
	^{0}C	--	mV	µS/cm	mg/L CaCO$_3$	mg/L	permil	permil	permil	permil	mg/L	permil	permil		mg/L	mg/L
JPHP08A																
Jul-11	--	--	--	--	--	--	-148.3	-19.08	4.4	-11.96	206.0	--	--	--	--	--
Aug-11	9.7	7.15	-125	251	116	6.4	-149.2	-18.94	2.4	-12.54	225.6	--	-27.58	--	0.00	0.05
May-12	9.1	7.29	-91	215	98	6.8	-148.4	-19.10	4.4	-12.03	317.8	--	--	--	0.02	0.13
Jul-12	8.7	6.85	-100	230	111	--	-148.3	-18.51	-0.2	-12.27	362.2	--	-24.67	--	0.01	0.10
Sep-12	10.1	6.96	-136	219	110	8.4	-148.1	-18.99	3.8	-12.33	316.9	--	-22.40	--	0.02	0.05
JPHP08B																
Jul-11	--	--	--	--	--	--	-142.3	-18.20	3.3	-12.53	50.9	--	--	--	--	--
Aug-11	12.2	6.00	-112	79	32	11.6	-141.6	-18.11	3.4	-13.25	66.3	--	-33.52	--	0.00	0.04
May-12	9.4	6.08	-132	75	31	17.3	-143.4	-18.43	4.0	-18.79	159.1	--	--	--	0.34	0.22
Jul-12	8.9	6.10	-118	80	36	--	-143.3	-17.91	0.0	-19.38	208.7	--	-28.10	--	0.23	0.21
Sep-12	13.0	6.15	--	--	39	20.7	-142.6	-18.46	5.1	-19.77	217.6		-28.24	--	0.29	0.15
JPHP08C																
Jul-11	--	--	--	--	--	--	-135.1	-17.14	2.0	-14.91	46.6	--	--	--	--	--
Aug-11	14.9	5.84	-125	40	15	22.6	-143.8	-18.34	2.9	-15.80	31.4	--	-28.21	--	0.01	0.15
May-12	10.1	5.95	-101	51	10	17.5	-156.3	-19.85	2.5	-19.79	36.2	--	--	--	0.15	0.12
Jul-12	11.6	5.72	-178	90	36	--	-139.5	-17.33	-0.9	-16.45	231.2	0.9	-28.49	17.4	0.17	0.14
Sep-12	13.0	5.71	-392	93	39	41.5	-143.8	-18.54	4.6	-13.55	261.0	--	-28.96	--	0.22	0.19
JPHP09A																
Jul-11	--	--	--	--	--	--	-147.3	-18.82	3.3	-12.99	163.2	--	--	--	--	--
Aug-11	9.5	6.82	-54	173	85	10.5	-146.5	-18.54	1.9	-13.92	153.2	--	-33.86	--	--	0.10
May-12	6.0	7.18	-3	200	84	10.2	-146.2	-18.53	2.1	-16.20	242.5	--	--	--	0.05	0.16
Jul-12	5.9	6.87	-169	194	89	--	-146.3	-18.62	2.7	-16.87	221.0	--	-25.90	--	0.09	0.12
Sep-12	8.0	6.80	-239	189	87	8.9	-145.6	-18.49	2.3	-17.46	201.5		-28.00	--	0.08	0.13
JPHP09B																
Jul-11	--	--	--	--	--	--	-141.2	-17.93	2.3	-13.84	26.1	--	--	--	--	--
Aug-11	13.5	6.32	-108	49	18	16.3	-140.6	-17.82	1.9	-13.55	28.4	--	-28.89	--	0.02	0.00
May-12	5.7	6.63	-102	86	31	25.6	-140.5	-18.01	3.6	-18.71	122.6	--	--	--	0.27	0.19
Jul-12	7.4	6.41	-159	88	36	--	-141.0	-18.14	4.1	-18.83	123.0	--	-27.54	--	0.11	0.15
Sep-12	9.3	6.20	-319	87	33	26.9	-140.6	-17.99	3.3	-19.28	139.8		-27.68	--	0.23	0.16
JPHP09C																
Jul-11	--	--	--	--	--	--	-155.2	-19.95	4.3	-16.89	20.4	--	--	--	--	--
Aug-11	14.0	6.00	41	62	17	20.4	-146.3	-18.48	1.6	-17.05	42.3	--	-28.10	--	0.02	0.08
May-12	5.5	6.02	-74	90	38	17.1	-140.2	-17.82	2.4	-21.18	224.5	--	--	--	0.27	0.11
Jul-12	9.8	5.96	-136	86	34	--	-140.5	-17.93	3.0	-20.63	228.3	--	-28.20	--	0.50	0.05
Sep-12	11.5	5.83	-416	92	23	24.6	-134.4	-17.24	3.5	-23.45	108.7		-28.24	--	0.80	0.13
JPHP10A																
Jul-11	--	--	--	--	--	--	-144.4	-18.43	3.1	-12.91	153.0	--	--	--	--	--
Aug-11	8.5	6.85	-91	178	57	6.0	-144.8	-18.38	2.2	-12.79	144.8	--	-29.53	--	0.00	0.13
May-12	7.1	6.97	-73	124	75	9.4	-144.6	-18.33	2.0	-15.98	244.8	--	--	--	0.08	0.26
Jul-12	6.4	6.56	-94	204	85	--	-143.9	-18.49	4.0	-14.52	261.2	--	-26.76	--	0.01	0.21
Sep-12	9.5	6.66	-140	203	88	9.2	-143.3	-18.37	3.7	-15.47	289.6	--	-25.05	--	0.08	0.26

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N	H2S	NH4
	^{0}C	--	mV	µS/cm	mg/L $CaCO_3$	mg/L	permil	permil	permil	permil	mg/L	permil	permil		mg/L	mg/L
JPHP10B																
Jul-11	--	--	--	--	--	--	-140.8	-17.91	2.5	-13.74	66.7	--	--	--	--	--
Aug-11	11.7	6.18	-58	68	46	4.7	-142.3	-17.98	1.5	-14.40	86.5	--	-27.91	--	0.00	0.15
May-12	5.3	6.17	-102	111	41	19.6	-141.7	-17.89	1.4	-18.14	191.0	--	--	--	0.13	0.28
Jul-12	6.2	5.24	-125	110	47	--	-141.3	-18.24	4.6	-18.16	210.4	--	--	--	0.12	0.22
Sep-12	9.1	6.34	-189	--	49	20.7	-140.7	-18.07	3.9	-18.26	236.8		-28.19	--	0.12	0.27
JPHP10C																
Jul-11	--	--	--	--	--	--	-150.0	-19.05	2.4	-16.94	21.9	--	--	--	--	--
Aug-11	13.5	6.01	-79	37	10	31.3	-145.8	-18.68	3.7	-16.01	33.9	--	-27.29	--	0.01	0.04
May-12	7.2	6.04	-129	58	18	29.6	-143.7	-18.39	3.4	-19.02	98.1	--	--	--	0.41	0.09
Jul-12	10.4	5.48	-93	60	24	--	-141.5	-18.10	3.3	-15.59	120.5	--	-27.47	--	0.71	0.02
Sep-12	11.7	5.74	-309	112	23	81.0	-133.5	-17.05	2.9	-21.55	105.7	--	-27.45	--	0.15	0.12
JPHP11A																
Jul-11	--	--	--	--	--	--	-140.5	-17.91	2.7	-6.75	154.6	--	--	--	--	--
Aug-11	12.4	6.08	36	157	64	35.1	-140.6	-17.96	3.1	-7.75	146.9	-6.0	-44.25	8.4	0.01	0.39
May-12	8.4	6.07	-45	152	59	36.5	-141.6	-18.02	2.5	-11.09	279.4	--	--	--	0.07	0.47
Jul-12	10.5	6.21	111	152	103	--	-141.4	-17.63	-0.3	-11.81	276.1	--	-28.81	--	--	0.41
Sep-12	8.2	6.24	80	162	--	40.0	-139.6	-18.02	4.6	-11.78	276.1	--	--	--	0.05	0.42
JPHP11B																
Jul-11	--	--	--	--	--	--	-145.0	-18.37	1.9	-13.44	25.8	--	--	--	--	--
Aug-11	14.1	5.68	139	51	16	1.6	-145.4	-18.47	2.4	-16.12	37.8	--	-26.50	--	0.00	0.00
May-12	10.7	5.76	112	44	12	1.6	-145.0	-18.24	0.9	-20.03	83.7	--	--	--	0.01	0.00
Jul-12	11.9	5.99	288	44	15	--	-145.0	-18.26	1.1	-20.28	113.3	--	-28.00	--	--	0.00
Sep-12	10.2	5.73	201	47	--	2.8	-143.9	-18.39	3.2	-21.42	87.1	--	--	--	0.00	0.05
JPHP11C																
Jul-11	--	--	--	--	--	--	-146.7	-18.78	3.6	-6.00	24.1	--	--	--	--	--
Aug-11	21.8	5.52	199	36	7	1.9	-148.5	-18.87	2.5	-17.14	26.0	--	-27.09	--	0.00	--
May-12	--	--	--	--	--	--	-149.8	-19.00	2.2	-17.55	15.9	--	--	--	--	--
Jul-12	16.7	6.00	256	37	8	--	-150.1	-18.57	-1.6	-19.38	59.4	--	-27.34	--	--	0.00
Sep-12	12.6	6.00	165	39	--	2.2	-146.2	-18.61	2.7	-20.01	73.3	--	--	--	0.22	0.05
JPHP12																
Jul-12	--	--	--	--	--	--	-137.1	-17.61	3.8	-19.88	105.9	--	--	--	--	--
Sep-12	--	--	--	--	--	--	-145.6	-18.76	4.5	-15.43	87.9	--	--	--	--	--
Surface Water at JPHA																
Aug-11	--	--	--	--	200	55.4	-118.8	-13.47	-11.1	-18.55	21.3	-0.2	-29.85	15.6	0.02	0.04
Apr-12	--	--	--	--	--	13.6	-160.8	-20.79	5.5	--	--	0.5	-30.11	8.3	--	--
May-12	25.1	6.21	260	52	5	27.2	-135.0	-15.89	-7.9	--	14.5	--	--	--	--	0.02
Jul-12	--	--	--	--	42	--	-133.6	-17.50	6.4	-16.46	201.2	1.2	-29.25	18.3	--	--
Jul-12	--	--	--	--	8	--	-135.6	-17.00	0.4	-19.99	57.4	--	-28.71	--	--	--
Sep-12	--	--	--	--	8	26.5	-117.6	-15.50	6.4	-20.39	38.0	2.9	-28.36	10.0	--	--

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N	H2S	NH4
	^{0}C	--	mV	μS/cm	mg/L CaCO$_3$	mg/L	permil	permil	permil	permil	mg/L	permil	permil		mg/L	mg/L
JPH Weir																
Aug-11	17.1	6.13	140	43	14	22.9	-145.5	-18.63	3.5	-14.42	32.2	--	--	--	--	0.31
Apr-12	--	--	--	--	--	20.5	-144.6	-18.51	3.5	--	--	-2.2	-30.48	22.7	--	--
Apr-12	--	--	--	--	--	25.7	-162.5	-20.42	0.8	--	--	-0.3	-27.75	13.7	--	--
May-12	14.6	6.03	166	48	11	12.2	-153.2	-19.40	2.0	-18.23	68.0	--	--	--	0.01	0.21
Jul-12	--	--	--	--	8	--	-135.2	-17.44	4.3	-21.41	42.2	6.4	-24.21	6.1	--	--
Jul-12	--	--	--	--	22	--	-140.4	-18.37	6.6	-21.22	128.1	--	--	--	--	--
Sep-12	14.8	6.16	-136	78	14	26.3	-131.2	-17.01	4.9	-19.28	79.7	0.0	-28.79	16.9	--	0.20
JPH Rain Events																
15-Aug-11	--	--	--	--	--	5.1	-101.3	-13.03	2.9	-19.74	11.1	--	--	--	--	--
5-Jun-12	--	--	--	--	6	--	-128.3	-15.56	-3.9	-24.01	108.5	--	--	--	--	--
17-Jul-12	--	--	--	--	--	--	-129.2	-15.98	-1.3	-23.70	54.9	4.0	-26.52	8.0	--	--
13-Sep-12	--	--	--	--	--	4.4	-119.4	-15.78	6.9	-13.35	31.0	--	--	--	--	--
JPH Bulk Rain																
(April - May 2012)	--	--	--	--	--	3.0	-153.5	-19.76	4.6	--	17.1	--	--	--	--	0.00
(5 June - 17July 2012)	--	--	--	--	--	--	-131.7	-16.09	-3.0	-18.69	36.3	--	--	--	--	--
(5 June - 17July 2012)	--	--	--	--	--	--	-143.7	-18.71	5.9	-20.61	42.1	--	--	--	--	--
(10days)	--	--	--	--	--	--	-123.2	-15.04	-2.9	-22.85	69.0	--	--	--	--	--
(17 July - 3 Aug)	--	--	--	--	--	--	-127.0	-15.84	-0.3	-24.54	125.3	2.1	-29.22	17.5	--	--
(17 July - 2 Sep)	--	--	--	--	--	--	-99.2	-12.03	-3.0	--	-20.4	--	--	--	--	0.01
Snow Survey																
JPHA	--	--	--	--	--	--	-184.0	-23.88	7.0	--	--	0.3	-26.05	23.6	--	--
JPHE	--	--	--	--	--	--	-179.9	-23.53	8.4	--	--	-5.8	-28.30	25.7	--	--
JPHG	--	--	--	--	--	--	-191.5	-25.20	10.0	--	--	-4.6	-28.15	31.0	--	--
JPHP1	--	--	--	--	--	--	-178.5	-23.01	5.6	--	--	-2.6	-28.09	32.8	--	--
JPHP2	--	--	--	--	--	--	-183.0	-23.71	6.7	--	--	-2.8	-28.42	27.0	--	--
JPHP3	--	--	--	--	--	--	-177.9	-22.99	6.0	--	--	-2.3	-26.22	33.3	--	--
JPHP4	--	--	--	--	--	--	-179.5	-23.11	5.4	--	--	-4.1	-28.32	24.5	--	--
JPHP5	--	--	--	--	--	--	-173.9	-22.27	4.3	--	--	--	--	--	--	--
JPHP6	--	--	--	--	--	--	-176.5	-22.69	5.0	--	--	-3.2	-28.16	23.4	--	--
JPHP7	--	--	--	--	--	--	-179.1	-23.01	4.9	--	--	-3.6	-28.44	25.3	--	--
JPHP8	--	--	--	--	--	--	-182.2	-23.80	8.2	--	--	-3.0	-28.60	34.1	--	--
JPHP11	--	--	--	--	--	--	-178.1	-23.08	6.5	--	--	-2.0	-27.14	35.4	--	--

	Site ID	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate	Lac	OAC	OPr	HCO
units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
precision		0.017	0.05	0.2	0.001	0.5	0.01	0.01	0.04	0.03	0.03	0.02	0.03	0.01	0.01	0.02	0.02
DL (QL)		0.03	0.05	0.2	0.005 (2 H)	4.9	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	JPHA																
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.03	0.01	0.0	--	0	0.06	0.88	< 0.05	< 0.05	< 0.05	< 0.05	0.14	--	--	--	--
	May-12	2.06	0.00	0.3	0.000	11	0.01	2.27	< 0.05	< 0.05	0.04	< 0.05	13.58	< 0.05	< 0.05	< 0.05	0.04
	Jul-12	> 3.30	0.00	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.27	0.08	0.0	0.000	5	0.01	4.64	< 0.1	< 0.1	< 0.1	< 0.1	9.03	< 0.1	< 0.1	< 0.1	< 0.1
	JPHB																
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.01	0.00	0.0	0.000	0	0.03	0.35	< 0.05	< 0.05	< 0.05	< 0.05	0.25	--	--	--	--
	May-12	--	--	--	--	--	0.03	0.71	< 0.05	< 0.05	< 0.05	0.18	13.49	< 0.05	< 0.05	< 0.05	< 0.05
	Jul-12	0.02	0.07	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.07	0.06	0.0	0.000	4	0.01	5.76	< 0.1	< 0.1	< 0.1	< 0.1	8.02	< 0.1	< 0.1	< 0.1	< 0.1
	JPHC																
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.13	0.18	3.5	0.000	0	0.04	0.46	< 0.05	< 0.05	< 0.05	< 0.05	0.17	--	--	--	--
	May-12	0.12	0.00	0.7	0.000	12	0.01	0.85	< 0.05	< 0.05	0.02	< 0.05	13.23	< 0.05	< 0.05	< 0.05	0.01
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	2.28	0.43	0.3	0.000	--	0.02	10.60	< 0.1	< 0.1	< 0.1	< 0.1	1.37	< 0.1	0.03	< 0.1	0.09
	JPHD																
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.03	0.06	2.0	--	0	0.03	0.29	< 0.05	< 0.05	< 0.05	< 0.05	0.35	--	--	--	--
	May-12	0.00	0.04	0.4	0.000	15	0.02	0.61	< 0.05	< 0.05	0.07	< 0.05	13.62	< 0.05	< 0.05	< 0.05	0.02
	Jul-12	0.06	0.03	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.60	0.19	2.5	0.000	0	0.01	5.84	< 0.1	< 0.1	< 0.1	< 0.1	8.46	< 0.1	< 0.1	< 0.1	< 0.1
	JPHE																
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.06	0.15	2.2	--	0	0.04	0.99	< 0.05	< 0.05	< 0.05	< 0.05	0.53	--	--	--	--
	May-12	0.02	0.01	2.6	0.000	15	0.01	0.45	< 0.05	< 0.05	1.41	< 0.05	15.97	< 0.05	< 0.05	< 0.05	0.01
	Jul-12	0.00	0.07	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.25	0.20	1.2	0.016	8	0.01	5.68	< 0.1	< 0.1	< 0.1	< 0.1	11.71	< 0.1	< 0.1	< 0.1	< 0.1
	JPHF																
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.17	0.37	6.1	--	0	0.02	1.26	< 0.05	< 0.05	< 0.05	< 0.05	0.84	--	--	--	--
	May-12	2.72	0.01	0.8	0.000	12	0.02	0.76	< 0.05	< 0.05	0.02	< 0.05	12.89	< 0.05	< 0.05	< 0.05	0.03
	Jul-12	> 3.30	0.09	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.36	0.15	2.1	0.004	7	0.01	6.02	< 0.1	< 0.1	< 0.1	< 0.1	9.41	< 0.1	< 0.1	< 0.1	< 0.1
	JPHG																
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.06	0.03	0.0	--	1	0.04	0.40	< 0.05	< 0.05	< 0.05	< 0.05	0.09	--	--	--	--
	May-12	0.33	0.00	0.3	0.000	0	0.01	0.31	< 0.05	< 0.05	0.12	< 0.05	10.01	< 0.05	< 0.05	< 0.05	0.05
	Jul-12	0.04	0.09	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.84	0.13	0.5	0.000	7	0.02	5.49	< 0.1	< 0.1	< 0.1	< 0.1	7.35	< 0.1	< 0.1	< 0.1	< 0.1

Site ID	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate	Lac	OAC	OPr	HCO
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
JPHP01A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1.70	1.26	21.7	0.000	1	0.05	0.22	< 0.05	< 0.05	< 0.05	< 0.05	0.37	--	--	--	--
May-12	1.94	0.62	1.1	0.000	0	0.04	0.12	< 0.05	< 0.05	< 0.05	0.35	0.11	< 0.05	< 0.05	< 0.05	0.05
Jul-12	> 3.30	0.80	1.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.96	0.87	2.0	0.020	2	0.03	0.17	< 0.1	< 0.1	0.02	0.33	0.11	< 0.1	0.60	< 0.1	< 0.1
JPHP01B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.07	0.09	2.7	1.000	3	0.01	0.21	< 0.05	< 0.05	< 0.05	< 0.05	7.61	--	--	--	--
May-12	0.23	0.00	0.7	0.000	3	0.01	0.13	< 0.05	< 0.05	< 0.05	< 0.05	8.01	< 0.05	< 0.05	< 0.05	0.03
Jul-12	0.38	0.21	0.6	0.044	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.38	0.60	1.6	0.090	2	< 0.1	0.14	< 0.1	< 0.1	< 0.1	< 0.1	7.77	< 0.1	< 0.1	< 0.1	< 0.1
JPHP01C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.01	2.5	--	4	0.01	0.27	< 0.05	< 0.05	< 0.05	< 0.05	8.80	--	--	--	--
May-12	0.00	0.04	0.6	0.004	3	0.01	0.29	< 0.05	< 0.05	< 0.05	< 0.05	10.66	< 0.05	< 0.05	< 0.05	0.01
Jul-12	0.01	0.16	0.8	0.084	4	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.00	0.08	0.7	0.000	4	< 0.1	0.34	< 0.1	< 0.1	0.03	< 0.1	7.78	< 0.1	< 0.1	< 0.1	< 0.1
JPHP02A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	2.60	2.48	7.1	0.000	0	0.04	0.28	< 0.05	< 0.05	< 0.05	< 0.05	0.38	--	--	--	--
May-12	2.83	0.47	0.3	0.000	0	0.03	0.09	< 0.05	< 0.05	< 0.05	0.15	0.24	< 0.05	< 0.05	< 0.05	0.03
Jul-12	> 3.30	0.41	1.7	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.79	0.48	0.9	0.000	0	0.03	0.09	< 0.1	< 0.1	< 0.1	0.16	0.12	< 0.1	< 0.1	< 0.1	< 0.1
JPHP02B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.10	0.06	6.2	0.000	3	0.01	0.15	< 0.05	< 0.05	< 0.05	< 0.05	7.05	--	--	--	--
May-12	0.23	0.04	2.0	0.006	2	0.01	0.09	< 0.05	< 0.05	0.03	< 0.05	7.12	< 0.05	< 0.05	< 0.05	0.03
Jul-12	0.39	0.20	0.8	0.063	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.17	0.10	1.4	0.012	3	< 0.1	0.10	< 0.1	< 0.1	0.02	< 0.1	7.37	< 0.1	< 0.1	< 0.1	< 0.1
JPHP02C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.06	0.21	2.7	1.000	4	0.01	0.22	< 0.05	< 0.05	< 0.05	< 0.05	7.85	--	--	--	--
May-12	--	0.01	0.0	0.000	4	--	--	--	--	--	--	--	--	--	--	--
Jul-12	0.07	0.12	0.5	0.102	4	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.03	0.11	1.7	0.000	6	< 0.1	0.21	< 0.1	< 0.1	< 0.1	< 0.1	9.26	< 0.1	< 0.1	< 0.1	< 0.1
JPHP03A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.11	0.00	8.4	1.000	4	0.02	0.25	< 0.05	< 0.05	< 0.05	< 0.05	7.66	--	--	--	--
May-12	0.33	0.11	1.2	0.000	3	0.01	0.13	< 0.05	< 0.05	< 0.05	< 0.05	7.72	< 0.05	< 0.05	< 0.05	0.04
Jul-12	0.50	0.25	0.6	0.098	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.34	0.08	1.5	0.046	4	0.01	0.15	< 0.1	< 0.1	< 0.1	< 0.1	7.80	< 0.1	< 0.1	< 0.1	< 0.1

Site ID	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate	Lac	OAC	OPr	HCO
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
JPHP03B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	0.15	4.4	1.000	4	0.01	0.18	< 0.05	< 0.05	< 0.05	< 0.05	9.00	--	--	--	--
May-12	0.31	0.01	0.3	0.003	3	0.01	0.11	< 0.05	< 0.05	< 0.05	< 0.05	6.89	< 0.05	< 0.05	< 0.05	0.02
Jul-12	0.13	0.06	0.1	0.072	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.00	0.07	1.6	0.030	3	0.00	0.11	< 0.1	< 0.1	< 0.1	< 0.1	8.37	< 0.1	< 0.1	< 0.1	< 0.1
JPHP03C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	0.09	2.7	0.000	6	0.01	0.20	< 0.05	< 0.05	< 0.05	< 0.05	6.12	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	0.01	0.09	0.8	0.093	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.00	0.11	1.7	0.018	2	< 0.1	0.17	< 0.1	< 0.1	< 0.1	< 0.1	6.46	< 0.1	< 0.1	< 0.1	< 0.1
JPHP04A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1.53	0.25	4.4	0.000	0	0.03	0.15	< 0.05	< 0.05	< 0.05	< 0.05	0.32	--	--	--	--
May-12	2.41	0.37	0.8	0.000	0	0.03	0.11	< 0.05	< 0.05	< 0.05	0.15	0.04	< 0.05	0.01	< 0.05	0.05
Jul-12	> 3.30	0.36	0.0	0.042	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.91	0.51	1.2	0.012	2	0.03	0.10	< 0.1	< 0.1	< 0.1	0.14	0.03	< 0.1	< 0.1	< 0.1	0.07
JPHP04B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.37	0.09	3.1	1.000	4	0.01	0.15	< 0.05	< 0.05	< 0.05	< 0.05	7.75	--	--	--	--
May-12	0.42	0.05	0.3	0.000	3	0.00	0.17	< 0.05	< 0.05	< 0.05	< 0.05	7.72	< 0.05	< 0.05	< 0.05	0.00
Jul-12	0.46	0.09	0.3	0.038	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.25	0.11	1.8	0.047	4	< 0.1	0.17	< 0.1	< 0.1	< 0.1	< 0.1	7.95	< 0.1	< 0.1	< 0.1	< 0.1
JPHP04C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.04	2.4	--	4	0.00	0.22	< 0.05	< 0.05	< 0.05	< 0.05	9.02	--	--	--	--
May-12	0.00	0.06	0.3	0.000	4	0.00	0.19	< 0.05	< 0.05	< 0.05	< 0.05	9.40	< 0.05	< 0.05	< 0.05	0.03
Jul-12	0.18	0.07	0.6	0.028	5	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.04	0.12	1.3	0.065	5	< 0.1	0.23	< 0.1	< 0.1	< 0.1	< 0.1	9.80	< 0.1	< 0.1	< 0.1	< 0.1
JPHP05A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1.41	0.09	7.5	0.000	1	0.03	0.16	< 0.05	< 0.05	< 0.05	< 0.05	3.36	--	--	--	--
May-12	2.41	0.52	0.7	0.000	0	0.02	0.15	< 0.05	< 0.05	< 0.05	< 0.05	1.35	< 0.05	< 0.05	< 0.05	0.04
Jul-12	2.78	0.36	1.4	0.069	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.47	0.35	1.8	0.000	0	0.01	0.12	< 0.1	< 0.1	< 0.1	< 0.1	2.07	< 0.1	< 0.1	< 0.1	< 0.1
JPHP05B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.18	0.21	5.3	0.000	3	0.01	0.20	< 0.05	< 0.05	< 0.05	< 0.05	7.26	--	--	--	--
May-12	0.29	0.23	0.4	0.003	2	0.01	0.16	< 0.05	< 0.05	< 0.05	< 0.05	7.85	< 0.05	< 0.05	< 0.05	0.03
Jul-12	0.37	0.19	0.2	0.061	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.39	0.10	1.4	0.000	2	0.01	0.15	< 0.1	< 0.1	0.02	< 0.1	7.36	< 0.1	< 0.1	< 0.1	< 0.1

Site ID	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate	Lac	OAC	OPr	HCO
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
JPHP05C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.03	0.12	3.5	1.000	2	0.01	0.26	< 0.05	< 0.05	< 0.05	< 0.05	6.76	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	0.11	0.10	0.5	0.070	3	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.00	0.05	1.2	--	4	< 0.1	0.28	< 0.1	< 0.1	0.04	< 0.1	7.58	< 0.1	< 0.1	< 0.1	< 0.1
JPHP06A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.04	0.12	2.2	1.000	4	0.02	0.16	< 0.05	< 0.05	< 0.05	< 0.05	5.23	--	--	--	--
May-12	> 3.30	0.19	1.0	0.000	1	0.02	0.15	< 0.05	< 0.05	< 0.05	< 0.05	4.34	< 0.05	< 0.05	< 0.05	0.04
Jul-12	> 3.30	--	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.50	0.20	1.5	0.000	2	0.01	0.13	< 0.1	< 0.1	< 0.1	< 0.1	4.49	< 0.1	< 0.1	< 0.1	< 0.1
JPHP06B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.07	0.12	0.4	0.001	3	0.02	0.28	< 0.05	< 0.05	< 0.05	< 0.05	9.19	--	--	--	--
May-12	0.82	0.17	0.8	0.000	5	0.01	0.17	< 0.05	< 0.05	< 0.05	0.04	9.58	< 0.05	< 0.05	< 0.05	0.04
Jul-12	0.87	0.94	1.2	0.049	5	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.86	0.38	1.6	0.011	4	0.01	0.16	< 0.1	< 0.1	0.04	< 0.1	9.55	< 0.1	0.03	< 0.1	0.04
JPHP06C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.18	0.09	4.9	1.000	5	0.01	0.27	< 0.05	< 0.05	< 0.05	< 0.05	10.71	--	--	--	--
May-12	--	0.02	0.7	0.005	5	--	--	--	--	--	--	--	--	--	--	--
Jul-12	0.02	0.45	0.2	0.033	5	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.00	0.06	1.7	0.007	5	< 0.1	0.29	< 0.1	< 0.1	0.07	< 0.1	10.00	< 0.1	< 0.1	< 0.1	0.04
JPHP07A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1.27	1.38	14.2	0.000	0	0.04	0.16	< 0.05	< 0.05	< 0.05	0.15	0.31	--	--	--	--
May-12	2.34	0.57	1.0	0.000	0	0.03	0.11	< 0.05	< 0.05	< 0.05	0.24	1.52	< 0.05	< 0.05	< 0.05	0.04
Jul-12	> 3.30	0.81	1.2	0.026	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.94	0.84	1.1	0.000	0	0.03	0.10	< 0.1	< 0.1	< 0.1	0.33	0.18	< 0.1	< 0.1	< 0.1	< 0.1
JPHP07B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.08	0.18	2.7	0.001	5	0.01	0.21	< 0.05	< 0.05	< 0.05	< 0.05	9.48	--	--	--	--
May-12	0.27	0.01	1.2	0.012	5	0.01	0.15	< 0.05	< 0.05	0.05	< 0.05	9.73	< 0.05	< 0.05	< 0.05	0.04
Jul-12	0.40	0.17	0.9	0.037	4	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.54	0.28	1.9	0.008	4	0.01	0.13	< 0.1	< 0.1	< 0.1	< 0.1	9.10	< 0.1	< 0.1	< 0.1	< 0.1
JPHP07C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.09	0.09	1.3	0.000	4	0.01	0.28	< 0.05	< 0.05	< 0.05	< 0.05	7.20	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	0.02	0.19	0.8	0.080	4	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate	Lac	OAC	OPr	HCO
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
JPHP08A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.15	0.2	0.001	0	0.06	0.28	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	--	--	--	--
May-12	1.54	0.69	0.0	0.000	0	0.05	0.17	< 0.05	< 0.05	< 0.05	0.21	0.05	< 0.05	< 0.05	< 0.05	0.03
Jul-12	1.28	0.68	0.3	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.08	0.37	0.0	0.000	0	0.05	0.17	< 0.1	< 0.1	< 0.1	< 0.1	--	< 0.1	0.35	< 0.1	0.08
JPHP08B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.59	0.09	7.5	0.000	1	0.03	0.13	< 0.05	< 0.05	< 0.05	< 0.05	0.29	--	--	--	--
May-12	1.75	0.34	1.4	0.000	0	0.03	0.11	< 0.05	< 0.05	< 0.05	0.13	0.35	< 0.05	< 0.05	< 0.05	< 0.05
Jul-12	2.81	0.47	0.5	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.14	0.33	0.9	0.000	0	0.02	0.09	< 0.1	< 0.1	< 0.1	< 0.1	--	< 0.1	0.02	< 0.1	< 0.1
JPHP08C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.35	0.98	7.5	0.000	0	0.04	0.53	< 0.05	< 0.05	< 0.05	< 0.05	0.25	--	--	--	--
May-12	2.22	0.05	0.0	0.000	3	0.02	0.91	< 0.05	< 0.05	0.04	< 0.05	9.47	< 0.05	< 0.05	< 0.05	0.01
Jul-12	> 3.30	0.17	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.49	0.25	0.0	0.000	0	0.02	0.27	< 0.1	< 0.1	< 0.1	< 0.1	0.06	< 0.1	0.03	< 0.1	0.14
JPHP09A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.26	4.6	--	0	0.04	0.15	< 0.05	< 0.05	< 0.05	< 0.05	0.54	--	--	--	--
May-12	2.00	0.69	0.9	0.000	0	0.04	0.15	< 0.05	< 0.05	< 0.05	0.28	1.23	< 0.05	< 0.05	< 0.05	0.05
Jul-12	2.54	1.05	0.5	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.42	0.85	1.4	0.011	0	0.03	0.13	< 0.1	< 0.1	< 0.1	< 0.1	2.80	< 0.1	< 0.1	< 0.1	0.02
JPHP09B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	0.25	2.2	0.000	0	0.07	2.35	< 0.05	< 0.05	< 0.05	< 0.05	0.95	--	--	--	--
May-12	> 3.30	0.50	0.4	0.000	0	0.02	0.22	< 0.05	< 0.05	< 0.05	0.24	0.20	< 0.05	0.01	< 0.05	0.07
Jul-12	> 3.30	0.59	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.23	0.74	1.4	0.000	0	0.03	0.20	< 0.1	< 0.1	< 0.1	0.30	0.05	< 0.1	< 0.1	< 0.1	0.04
JPHP09C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1.01	0.52	5.8	0.000	0	0.02	0.52	< 0.05	< 0.05	< 0.05	< 0.05	0.82	--	--	--	--
May-12	2.67	0.15	0.7	0.000	0	0.01	0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.82	< 0.05	< 0.05	< 0.05	0.03
Jul-12	> 3.30	0.22	1.2	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.00	0.23	3.6	0.000	0	0.01	6.45	< 0.1	< 0.1	< 0.1	< 0.1	85.21	< 0.1	< 0.1	< 0.1	0.05
JPHP10A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	0.09	2.7	0.000	0	0.06	0.34	< 0.05	< 0.05	< 0.05	< 0.05	0.09	--	--	--	--
May-12	2.81	0.45	0.3	0.000	1	0.04	0.15	< 0.05	< 0.05	< 0.05	0.09	0.17	< 0.05	< 0.05	< 0.05	0.01
Jul-12	> 3.30	0.63	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.15	0.54	0.7	0.006	0	0.05	0.14	< 0.1	< 0.1	< 0.1	< 0.1	0.11	< 0.1	0.36	< 0.1	< 0.1

Site ID	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate	Lac	OAC	OPr	HCO
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
JPHP10B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.80	2.33	14.2	0.000	1	0.04	0.16	< 0.05	< 0.05	< 0.05	0.39	0.81	--	--	--	--
May-12	3.24	0.73	0.0	0.000	0	0.04	0.20	< 0.05	< 0.05	< 0.05	0.35	0.15	< 0.05	< 0.05	< 0.05	< 0.05
Jul-12	> 3.30	0.90	0.0	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.89	0.90	1.0	0.002	0	0.04	0.12	< 0.1	< 0.1	< 0.1	0.47	0.08	< 0.1	< 0.1	< 0.1	< 0.1
JPHP10C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.10	0.67	--	--	--	0.03	0.63	< 0.05	< 0.05	< 0.05	0.08	0.37	--	--	--	--
May-12	> 3.30	0.13	0.5	0.000	0	0.02	0.43	< 0.05	< 0.05	< 0.05	0.04	2.41	< 0.05	< 0.05	< 0.05	0.06
Jul-12	> 3.30	0.34	0.1	0.000	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.43	0.38	0.0	0.000	0	0.02	11.13	< 0.1	< 0.1	< 0.1	< 0.1	0.14	< 0.1	0.03	< 0.1	0.08
JPHP11A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.07	1.20	10.6	0.000	0	0.06	0.30	< 0.05	0.05	< 0.05	0.11	0.06	--	--	--	--
May-12	2.00	0.64	0.0	0.000	0	0.04	0.11	< 0.05	< 0.05	< 0.05	0.37	0.03	< 0.05	< 0.05	< 0.05	0.06
Jul-12	> 3.30	0.68	0.0	--	0	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.21	0.81	0.0	0.000	0	0.04	0.11	< 0.1	< 0.1	< 0.1	< 0.1	--	< 0.1	< 0.1	< 0.1	0.08
JPHP11B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.07	0.21	4.4	3.000	4	0.01	0.22	< 0.05	< 0.05	< 0.05	< 0.05	8.44	--	--	--	--
May-12	0.67	0.05	1.0	0.000	5	0.01	0.18	< 0.05	< 0.05	0.02	< 0.05	8.48	< 0.05	< 0.05	< 0.05	0.04
Jul-12	0.58	0.10	0.2	--	4	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.64	0.22	1.0	0.000	3	0.01	0.16	< 0.1	< 0.1	< 0.1	< 0.1	8.05	< 0.1	< 0.1	< 0.1	0.02
JPHP11C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	0.18	4.0	2.000	4	0.01	0.21	< 0.05	< 0.05	< 0.05	< 0.05	9.12	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	0.03	0.06	0.6	--	5	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.00	0.11	1.0	0.000	4	< 0.1	0.18	< 0.1	< 0.1	< 0.1	< 0.1	8.72	< 0.1	< 0.1	< 0.1	n.a.
JPHP12																
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Surface Water at JPHA																
Aug-11	0.06	--	0.9	0.000	--	0.05	0.60	< 0.05	< 0.05	< 0.05	< 0.05	0.29	--	--	--	--
Apr-12	--	--	--	--	--	0.01	1.74	< 0.05	< 0.05	0.19	0.03	8.30	--	--	--	--
May-12	0.11	--	0.6	0.000	9	0.02	0.70	< 0.05	< 0.05	< 0.05	< 0.05	11.77	< 0.05	< 0.05	< 0.05	0.03
Jul-12	--	--	--	--	--	0.05	11.47	< 0.1	< 0.1	< 0.1	0.46	0.69	< 0.1	< 0.1	< 0.1	< 0.1
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	0.8	--	--	0.01	5.52	< 0.1	< 0.1	< 0.1	< 0.1	7.02	0.07	0.01	< 0.1	0.11

Site ID	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate	Lac	OAC	OPr	HCO
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
JPH Weir																
Aug-11	0.03	0.07	0.0	--	0	0.04	1.21	< 0.05	< 0.05	< 0.05	< 0.05	1.46	--	--	--	--
Apr-12	--	--	--	--	--	0.03	0.50	< 0.05	0.02	0.01	0.12	0.93	--	--	--	--
Apr-12	--	--	--	--	--	0.01	1.33	< 0.05	0.02	0.08	0.02	11.07	--	--	--	--
May-12	0.32	0.01	0.0	0.000	0	0.02	0.85	< 0.05	< 0.05	< 0.05	< 0.05	5.33	< 0.05	< 0.05	< 0.05	0.01
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	0.02	6.29	< 0.1	< 0.1	< 0.1	< 0.1	1.52	< 0.1	< 0.1	< 0.1	< 0.1
Sep-12	2.50	0.11	0.7	0.000	0	0.01	4.36	< 0.1	< 0.1	< 0.1	< 0.1	4.71	< 0.1	< 0.1	< 0.1	< 0.1
JPH Rain Events																
15-Aug-11	--	--	--	--	--	< 0.05	0.23	< 0.05	< 0.05	0.92	< 0.05	2.79	--	--	--	--
5-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13-Sep-12	--	--	--	--	--	< 0.1	0.06	< 0.1	< 0.1	< 0.1	< 0.1	0.13	< 0.1	< 0.1	< 0.1	0.02
JPH Bulk Rain																
(April - May 2012)	0.03	--	0.4													
(5 June - 17July 2012)	--	--	--													
(5 June - 17July 2012)	--	--	--													
(10days)	--	--	--													
(17 July - 3 Aug)	--	--	--													
(17 July - 2 Sep)	--	--	0.1													

Site ID	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al	P	K	Ti	V	Cr	Mn
units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
precision																
DL (QL)	.2 (.7)	.2 (.7)	.2 (.7)	.2 (.6)	.1 (.2)	.4 (1.2)	.3 (.8)	.005 (.02)	.08 (.3)	.05 (.2)	4 (14)	2 (8)	.02 (.06)	.004 (.01)	.005 (.02)	.005 (.02)
JPHA																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	6.33	0.36	1.41	3.75	2.89	0.59	2.77	0.124	135.90	370.30	< 4	271.4	2.16	0.628	0.766	73.05
May-12	6.62	0.84	1.75	2.09	4.38	4.67	3.10	< 0.005	12.00	195.80	< 4	733.3	1.13	1.657	0.500	139.70
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	6.45	< 0.2	1.72	2.48	2.74	3.70	1.23	< 0.009	< 1	146.70	< 2	216.8	1.68	2.609	0.645	113.40
JPHB																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	4.24	0.16	0.86	2.88	4.30	0.49	3.85	< 0.005	56.70	358.50	< 4	167.1	5.47	0.958	0.598	55.58
May-12	10.30	2.63	2.96	2.32	2.35	5.29	10.98	< 0.005	4.01	466.30	< 14	2575.0	11.28	7.834	1.130	516.10
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	5.80	< 0.2	1.55	2.88	3.75	3.23	< 0.7	< 0.009	< 1	115.10	< 2	< 4	1.36	1.560	0.516	27.92
JPHC																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	5.62	0.19	1.27	2.15	3.74	0.57	5.42	0.138	25.30	368.90	13.19	171.5	4.20	2.390	0.676	72.63
May-12	5.03	1.04	1.48	2.11	1.50	4.60	1.41	< 0.005	3.27	192.60	< 4	998.4	2.02	1.339	0.482	211.10
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	11.67	< 0.7	2.59	3.53	4.63	1.67	13.31	< 0.009	< 1	538.20	< 7	290.7	6.42	5.934	1.294	262.10
JPHD																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	6.12	0.10	1.41	2.06	4.47	0.53	3.50	0.300	36.32	281.20	< 4	117.4	5.25	2.439	1.152	58.92
May-12	4.58	1.19	1.17	2.44	1.88	4.70	0.82	< 0.005	3.73	198.60	< 4	1203.0	1.36	2.515	0.564	97.95
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	6.35	< 0.2	1.67	2.78	3.72	3.38	0.98	< 0.009	< 1	127.45	< 2	< 15	1.66	1.833	0.614	42.12
JPHE																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	5.35	0.91	1.70	2.48	4.77	0.57	3.76	0.142	37.22	463.10	2.24	871.1	24.09	1.379	0.811	104.50
May-12	5.54	< 0.7	1.50	2.16	2.44	5.43	0.44	< 0.02	3.10	189.60	< 4	516.8	1.66	2.342	0.468	18.09
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	6.66	< 0.2	1.67	2.67	3.71	4.38	0.90	< 0.009	< 1	120.75	< 2	< 15	1.84	2.380	0.616	41.82
JPHF																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	5.72	0.36	1.05	1.59	2.98	0.78	5.19	0.282	11.05	297.10	28.51	282.7	3.95	3.190	0.623	83.20
May-12	3.99	< 0.7	1.09	1.41	3.50	4.35	6.90	< 0.005	< 0.3	66.72	< 4	207.6	1.08	0.717	0.391	109.90
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	6.83	< 0.2	1.61	3.08	3.55	3.74	1.50	< 0.009	< 1	217.80	< 2	165.8	2.53	4.333	0.761	90.50
JPHG																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.46	0.28	0.59	2.11	3.82	0.39	2.35	0.279	102.30	406.10	< 4	315.5	5.01	1.012	1.685	49.01
May-12	6.32	0.94	1.70	1.88	2.39	3.29	1.05	< 0.005	3.76	204.70	< 4	962.1	2.47	1.736	0.802	74.62
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	7.01	< 0.7	1.55	1.87	4.84	2.91	2.85	< 0.009	< 0.4	325.80	< 2	293.0	1.55	2.417	0.740	158.40

Site ID	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al	P	K	Ti	V	Cr	Mn
JPHP01A	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	11.90	0.66	3.35	2.94	7.75	0.54	12.82	0.547	5.28	196.40	107.90	489.3	10.39	6.839	2.472	183.90
May-12	12.28	< 0.7	3.32	2.56	7.11	< 1.2	13.46	0.212	14.91	212.10	141.60	576.2	14.48	11.420	2.998	234.00
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	12.32	< 0.7	3.33	2.77	7.29	0.59	13.57	< 0.03	38.90	235.70	199.30	714.3	12.34	12.080	3.121	239.80
JPHP01B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.39	0.52	0.69	1.31	3.87	2.60	0.08	0.488	< 0.08	2.49	< 4	438.6	0.03	0.076	0.172	26.23
May-12	3.18	< 0.7	0.63	1.03	3.19	2.58	0.28	< 0.02	5.06	6.82	< 4	469.7	< 0.02	< 0.01	0.382	41.52
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.26	< 0.7	< 0.8	1.17	3.67	2.65	< 0.7	< 0.009	16.07	11.83	< 2	636.5	< 0.04	< 0.008	0.235	45.38
JPHP01C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.70	0.34	0.86	0.80	2.90	2.97	0.03	0.317	< 0.08	12.33	< 4	368.7	0.14	< 0.004	0.142	9.13
May-12	4.09	< 0.7	0.92	0.75	2.36	3.53	0.01	< 0.005	4.74	17.89	< 4	406.2	< 0.06	< 0.004	0.288	5.46
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.76	< 0.7	0.85	0.77	2.66	2.77	< 0.3	< 0.009	< 1	15.40	< 2	554.6	< 0.04	< 0.008	0.322	9.49
JPHP02A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	7.66	0.53	1.86	2.81	6.23	0.43	7.72	0.628	< 0.08	134.30	6.12	493.9	5.84	5.206	2.079	93.07
May-12	7.47	< 0.7	1.68	2.47	5.61	< 1.2	7.98	0.234	< 0.08	168.00	< 14	564.9	8.11	8.986	3.066	106.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	7.85	< 0.7	1.81	2.62	5.82	0.43	8.23	< 0.03	< 1	178.20	85.12	627.5	9.32	9.929	3.078	115.60
JPHP02B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.21	0.50	0.69	1.30	4.27	2.37	0.12	0.222	< 0.08	67.00	< 4	448.4	0.09	0.070	0.283	9.87
May-12	3.02	< 0.7	0.64	1.12	3.59	2.36	0.23	1.519	15.75	7.78	< 4	528.9	1.94	2.352	6.152	10.12
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.24	< 0.7	< 0.8	1.27	4.09	2.46	< 0.7	< 0.009	< 1	7.78	< 2	609.5	< 0.1	< 0.008	0.291	11.52
JPHP02C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.66	0.19	1.08	0.89	3.12	2.64	0.35	0.178	< 0.08	5.37	< 4	216.0	0.21	0.116	0.584	22.79
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	4.49	< 0.7	1.25	0.96	2.96	3.27	< 0.3	< 0.009	< 0.4	10.18	< 2	380.3	< 0.1	< 0.008	0.273	5.78
JPHP03A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.90	0.47	0.83	2.33	5.39	2.59	0.16	0.157	13.10	0.47	< 4	438.4	0.02	0.348	0.151	28.30
May-12	3.53	< 0.7	0.75	1.98	4.88	2.49	0.36	< 0.005	< 0.08	6.83	< 4	494.7	< 0.02	0.244	0.313	11.73
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.64	< 0.7	< 0.8	2.08	4.97	2.72	< 0.7	< 0.009	< 0.4	8.12	< 2	522.1	< 0.04	0.424	0.245	12.04

Site ID	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al	P	K	Ti	V	Cr	Mn
JPHP03B	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.80	0.50	0.80	1.16	3.75	3.02	0.13	0.014	< 0.08	4.51	< 4	481.1	0.15	0.122	0.248	25.98
May-12	3.04	< 0.7	0.63	0.83	3.01	2.33	0.30	< 0.005	< 0.08	8.25	< 4	430.4	< 0.06	< 0.01	0.424	18.77
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.43	< 0.7	< 0.8	0.98	3.48	2.87	< 0.3	< 0.009	< 0.4	8.86	< 2	558.4	< 0.04	< 0.03	0.273	8.22
JPHP03C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.01	0.27	0.81	0.90	3.13	2.09	0.16	0.212	< 0.08	3.40	< 4	279.0	0.21	< 0.004	0.209	10.43
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.77	< 0.7	< 0.8	< 0.8	2.87	2.29	< 0.3	< 0.03	< 0.4	9.35	< 2	418.9	1.42	< 0.008	1.318	3.54
JPHP04A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	7.75	0.49	2.16	2.91	7.33	0.36	5.25	0.142	1.24	36.75	< 4	427.0	2.49	2.589	1.767	142.90
May-12	12.27	< 0.7	3.26	3.30	5.52	< 1.2	12.31	0.158	< 0.08	52.62	< 14	557.7	6.90	11.710	2.823	236.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	14.39	< 0.7	4.01	3.41	5.92	0.40	14.09	< 0.03	< 1	56.43	102.80	656.4	10.36	15.740	9.401	281.55
JPHP04B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	4.69	0.67	1.53	1.04	3.06	2.71	0.40	0.106	< 0.08	4.96	< 4	627.7	<0.02	0.152	0.234	27.08
May-12	4.26	0.76	1.35	0.77	2.50	2.55	0.44	< 0.005	< 0.08	8.04	< 4	651.0	< 0.02	< 0.004	0.274	8.15
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	4.16	0.76	1.35	0.84	2.77	2.82	< 0.3	< 0.009	< 0.4	8.07	< 2	827.3	< 0.1	0.406	0.556	4.95
JPHP04C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.77	0.64	1.37	0.91	3.00	3.04	0.28	0.180	< 0.08	15.81	< 4	608.8	0.21	0.033	0.538	8.75
May-12	3.75	< 0.7	1.31	0.77	2.43	3.07	0.01	< 0.005	< 0.08	17.94	< 4	686.6	< 0.02	< 0.01	0.283	2.57
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.67	0.73	1.25	0.82	2.62	3.40	< 0.3	< 0.009	< 0.4	23.72	< 2	802.3	1.42	< 0.008	0.660	0.83
JPHP05A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	6.25	0.58	1.47	2.59	5.80	1.27	2.50	0.173	< 0.08	16.16	< 4	432.6	0.45	1.500	0.514	34.03
May-12	6.35	< 0.7	1.39	2.35	5.21	< 1.2	2.57	< 0.005	< 0.08	32.79	< 4	581.3	0.89	3.806	1.043	38.40
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	6.52	< 0.7	1.48	2.53	5.43	2.15	2.64	< 0.009	< 0.4	36.18	< 7	593.6	< 0.1	4.119	1.052	39.87
JPHP05B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.26	0.45	0.81	1.04	3.50	2.47	0.15	0.173	< 0.08	5.08	< 4	401.9	0.09	< 0.004	0.105	26.51
May-12	3.10	< 0.7	0.79	0.87	2.90	2.44	0.32	3.738	< 0.08	14.01	< 4	472.7	4.53	5.474	8.488	17.06
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.18	< 0.7	< 0.8	0.97	3.33	2.51	< 0.7	< 0.009	< 0.4	11.85	< 2	542.1	< 0.04	< 0.008	0.274	13.12

Site ID	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al	P	K	Ti	V	Cr	Mn
JPHP05C	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.71	0.52	1.14	0.80	2.82	2.32	0.27	0.078	< 0.08	8.33	< 4	488.2	0.21	0.015	0.372	10.05
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.58	< 0.7	1.05	< 0.8	2.50	2.72	< 0.3	< 0.009	< 0.4	11.31	< 2	579.2	< 0.1	< 0.008	0.301	1.59
JPHP06A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	4.61	0.49	0.91	2.54	5.30	1.86	4.22	0.201	< 0.08	7.02	< 4	441.4	0.15	0.900	0.653	25.32
May-12	4.41	< 0.7	0.86	2.35	4.70	1.58	4.65	0.208	< 0.08	37.10	< 4	549.8	1.66	4.223	1.310	32.85
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	4.53	< 0.7	0.91	2.42	4.92	1.70	4.71	< 0.03	< 0.4	29.09	< 7	563.9	< 0.1	2.545	0.743	34.12
JPHP06B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	5.09	0.49	0.92	2.16	5.15	3.13	0.17	0.161	8.89	0.41	< 4	525.0	<0.02	0.041	0.212	90.61
May-12	5.37	< 0.7	0.87	1.82	4.19	3.08	0.84	< 0.02	< 0.08	6.97	< 4	573.9	0.98	0.254	0.717	93.96
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	4.91	< 0.7	0.82	1.91	4.83	3.28	0.86	< 0.009	< 0.4	3.48	< 7	630.2	< 0.04	< 0.03	0.223	72.44
JPHP06C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	4.27	0.58	0.98	1.13	3.66	3.58	0.48	0.126	< 0.08	12.75	< 4	530.8	0.21	< 0.004	0.291	12.48
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	4.16	0.75	0.86	1.08	3.22	3.43	< 0.3	< 0.009	< 0.4	13.50	< 2	705.6	< 0.04	< 0.03	0.286	7.33
JPHP07A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	9.85	0.38	2.41	2.51	6.99	0.43	7.76	0.255	< 0.08	96.81	149.60	298.4	4.73	3.187	1.283	120.80
May-12	9.37	< 0.7	2.17	2.19	6.11	< 1.2	7.84	0.199	< 0.08	85.23	145.10	341.0	5.22	4.097	1.866	144.60
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	10.28	< 0.7	2.44	2.42	6.26	0.41	8.63	< 0.03	< 1	109.10	386.20	430.3	6.88	4.594	1.639	160.10
JPHP07B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	<.2	0.01	0.00	0.00	0.00	0.07	0.081	< 0.08	6.34	< 4	584.3	2.10	< 0.004	0.089	36.02
May-12	3.55	< 0.7	0.67	1.80	4.10	3.20	0.27	< 0.02	< 0.08	11.11	< 4	631.7	< 0.06	0.234	0.529	20.39
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.55	0.72	< 0.8	1.87	4.47	3.08	< 0.7	< 0.009	< 0.4	11.44	< 2	712.6	< 0.04	< 0.008	0.298	40.96
JPHP07C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.69	0.34	1.11	0.91	2.86	2.50	0.04	< 0.005	< 0.08	2.19	< 4	338.4	0.02	0.011	0.108	24.14
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al	P	K	Ti	V	Cr	Mn
JPHP08A	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	31.35	0.66	5.87	3.44	7.15	0.65	0.50	0.098	22.27	4.40	< 4	599.2	0.02	0.436	0.360	172.30
May-12	29.13	< 0.7	5.89	2.82	6.79	< 1.2	8.15	< 0.005	9.36	4.71	178.50	726.2	1.12	1.852	0.725	249.90
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	30.24	0.76	5.94	3.04	6.93	0.46	7.69	< 0.009	13.90	6.73	137.40	680.8	< 0.1	1.725	0.716	260.80
JPHP08B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	7.96	0.31	1.40	1.96	6.04	0.54	7.88	0.207	1.90	245.10	19.84	209.9	5.90	3.743	1.098	169.00
May-12	7.06	< 0.7	1.21	1.41	5.42	< 1.2	8.86	< 0.02	< 0.08	194.90	< 14	259.0	6.99	5.568	2.127	199.10
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	7.35	< 0.7	1.32	1.73	5.69	0.47	9.15	< 0.03	< 0.4	215.90	83.19	349.9	8.72	5.933	2.328	208.80
JPHP08C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.50	0.14	0.66	2.29	3.51	0.41	3.69	0.054	12.28	262.30	< 4	< 2	2.01	0.346	0.187	22.09
May-12	3.90	< 0.2	0.76	1.64	2.88	3.57	4.34	< 0.005	< 0.08	320.40	< 4	97.3	3.57	1.113	0.627	83.87
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	8.66	< 0.2	1.70	2.11	5.01	0.88	12.49	< 0.009	< 0.4	811.60	< 2	196.2	8.53	3.917	1.130	193.30
JPHP09A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	26.45	0.68	4.23	2.31	8.38	0.80	2.33	0.642	20.58	19.41	59.17	677.4	2.25	0.848	0.664	158.20
May-12	25.77	0.74	3.98	2.34	7.42	< 1.2	6.70	< 0.005	8.60	14.58	187.60	708.3	2.81	2.878	1.082	207.00
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	25.05	0.78	4.00	2.06	7.94	1.51	6.31	< 0.009	< 1	16.81	234.20	718.0	2.94	3.564	1.211	213.70
JPHP09B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	5.56	0.49	1.06	3.43	4.72	0.75	2.54	0.574	57.99	117.00	< 4	471.5	6.42	1.930	1.741	124.80
May-12	4.75	< 0.7	0.97	1.41	4.22	< 1.2	16.91	0.245	< 0.08	192.80	< 14	336.8	12.86	19.130	2.358	212.80
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	4.93	< 0.7	1.03	1.55	4.46	0.48	17.38	< 0.03	< 0.4	155.10	190.00	317.3	11.32	17.540	2.550	218.60
JPHP09C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	5.88	0.22	1.37	2.37	2.45	0.62	5.12	0.508	7.52	271.40	< 4	252.0	4.67	1.418	1.021	97.01
May-12	7.96	< 0.2	2.15	1.77	3.76	< 1.2	7.64	< 0.005	< 0.08	220.90	< 4	189.6	3.46	1.913	1.135	167.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	7.85	< 0.2	2.03	1.87	4.07	3.06	6.87	< 0.009	< 0.4	262.50	< 7	229.8	7.28	1.805	1.057	156.80
JPHP10A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	20.65	0.59	5.36	2.80	6.86	0.49	0.20	0.158	23.27	8.57	< 4	535.3	0.70	0.175	0.434	173.30
May-12	20.47	< 0.7	4.99	2.32	6.66	< 1.2	13.69	< 0.005	< 0.3	31.95	< 14	586.2	2.70	4.062	1.290	243.90
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	21.50	< 0.7	5.28	2.51	6.82	0.42	13.96	< 0.009	< 1	27.99	115.20	570.0	2.86	4.120	1.370	255.40

Site ID	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al	P	K	Ti	V	Cr	Mn
JPHP10B	mg/L	mg/L	mg/L	mg/L	mg/L	mg/	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	7.99	0.37	1.74	2.05	6.16	0.62	11.67	0.386	3.20	111.80	326.40	351.4	4.34	4.099	1.525	262.00
May-12	8.42	< 0.7	1.82	1.88	5.43	< 1.2	14.22	< 0.02	< 0.08	135.90	206.30	401.4	8.28	6.976	2.006	386.10
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	8.41	< 0.7	1.84	1.89	5.80	0.43	14.60	< 0.03	< 0.4	124.20	272.80	418.9	8.45	8.326	2.251	408.70
JPHP10C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	5.21	0.17	1.30	1.90	3.98	0.54	6.23	0.179	4.87	547.70	35.13	62.0	11.22	2.843	1.841	53.83
May-12	5.82	< 0.2	1.40	1.31	3.78	1.40	4.97	< 0.02	< 0.08	505.40	< 4	< 8	10.62	4.451	1.140	90.12
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	11.20	< 0.2	2.47	3.65	5.16	1.28	12.17	< 0.03	< 0.4	1103.00	< 7	< 15	23.13	8.227	1.762	234.20
JPHP11A																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	16.89	0.50	5.16	3.50	9.09	0.59	12.16	0.546	30.99	202.70	154.30	479.4	8.17	5.897	5.942	257.60
May-12	14.57	< 0.7	4.48	2.82	8.09	< 1.2	16.00	0.305	8.29	256.10	170.50	466.6	18.09	14.370	3.967	292.60
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	14.68	< 0.7	4.70	2.94	8.40	0.51	15.68	< 0.03	< 1	281.55	241.15	444.7	19.50	15.300	4.308	303.30
JPHP11B																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	4.50	0.75	0.91	2.17	5.01	3.25	0.23	0.192	3.75	7.22	< 4	542.1	<0.02	0.095	0.278	33.88
May-12	4.15	< 0.7	0.80	1.54	4.26	2.92	0.67	< 0.005	< 0.08	7.10	< 4	558.8	< 0.02	< 0.004	0.300	22.86
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	4.07	< 0.7	< 0.8	1.85	4.79	2.93	< 0.7	< 0.009	< 0.4	7.74	< 2	550.6	< 0.04	< 0.03	0.434	21.53
JPHP11C																
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	3.92	0.30	0.88	1.10	3.27	3.11	0.01	0.115	0.64	10.04	< 4	292.8	< 0.02	< 0.004	0.037	23.07
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	3.76	< 0.7	0.82	0.91	3.00	3.14	< 0.3	< 0.009	< 0.4	16.48	< 2	311.5	< 0.1	< 0.008	0.339	7.10
JPHP12																
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Surface Water at JPHA																
Aug-11	7.50	0.22	1.35	2.74	2.87	0.76	8.90	< 0.005	61.98	249.30	< 4	186.3	1.83	1.949	1.460	9.52
Apr-12	< 0.4	--	0.93	1.41	< 0.098	< 0.8	0.30	1.268	< 0.7	52.94	< 15	3787.0	2.06	1.592	3.907	21.26
May-12	4.99	< 0.7	1.29	2.77	0.29	4.33	0.76	< 0.005	9.85	169.10	< 4	608.7	0.93	1.412	0.606	16.78
Jul-12	22.09	2.01	5.55	5.09	8.59	1.70	20.58	< 0.009	47.28	319.60	179.10	1924.0	6.31	8.219	1.415	692.60
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	6.35	< 0.2	1.69	3.22	3.64	2.99	< 0.7	< 0.009	25.40	120.50	70.57	154.4	1.23	1.610	0.777	35.78

Site ID JPH Weir	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	S mg/L	Fe mg/L	Be µg/L	B µg/L	Al µg/L	P µg/L	K µg/L	Ti µg/L	V µg/L	Cr µg/L	Mn µg/L
Aug-11	5.29	0.54	1.18	2.00	3.01	0.86	2.41	0.113	41.71	164.20	< 4	489.6	1.42	0.414	0.500	80.28
Apr-12	8.26	--	1.85	1.43	4.63	< 0.2	2.77	<0.01	< 0.7	174.30	< 15	332.1	4.63	2.059	1.183	131.90
Apr-12	5.48	--	1.82	1.64	< 0.098	< 0.8	0.66	< 0.02	< 2	92.42	< 15	2609.5	1.36	0.336	0.674	202.35
May-12	4.71	< 0.7	1.16	1.84	2.56	1.89	1.93	< 0.005	< 0.08	107.00	< 4	282.0	1.00	0.618	0.477	144.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	10.16	< 0.7	2.35	3.33	4.63	1.40	6.69	< 0.009	< 1	387.50	< 7	659.4	2.46	2.204	1.092	381.10
Sep-12	7.11	< 0.7	1.67	2.67	3.87	2.16	4.59	< 0.009	< 0.4	183.10	< 2	308.9	3.30	2.245	1.067	140.70
JPH Rain Events																
15-Aug-11	1.24	0.16	0.21	0.26	0.17	1.01	0.02	0.051	7.55	12.56	< 4	188.7	0.00	0.042	0.136	13.48
5-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
17-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
13-Sep-12	< 0.7	< 0.2	< 0.2	< 0.2	< 0.1	< 0.4	< 0.3	< 0.009	< 0.4	1.70	< 2	< 4	< 0.04	< 0.008	0.232	2.72

	Site ID	Co	Ni	Cu	Zn	As	Se	Sr	Mo	Cd	Sn	Sb	Ba
units		µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
precision													
DL (QL)		.005 (.02)	.006 (.02)	.01 (.04)	.04 (.1)	.005 (.02)	.2 (.7)	.002 (.007)	.005 (.02)	.001 (.005)	.02 (.05)	.003 (.009)	.003 (.01)
	JPHA												
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.703	1.903	29.50	164.70	1.841	< 0.2	26.85	0.075	< 0.001	0.02	< 0.003	197.50
	May-12	2.132	3.245	129.40	496.70	0.932	< 0.2	25.89	0.987	< 0.005	< 0.05	0.420	19.26
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	2.062	1.671	20.09	61.32	0.689	< 0.2	26.72	0.253	0.148	0.89	0.324	18.37
	JPHB												
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.434	0.706	44.59	101.10	2.097	< 0.2	19.65	< 0.005	< 0.001	0.29	< 0.003	107.30
	May-12	3.701	10.150	201.00	2214.00	4.174	< 0.2	41.11	0.598	0.171	< 0.05	0.312	25.69
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.752	1.020	1.76	< 0.03	0.353	< 0.2	25.50	< 0.01	< 0.001	< 0.05	0.220	15.74
	JPHC												
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	1.033	0.993	3.16	52.49	2.354	< 0.2	26.05	< 0.005	< 0.001	0.06	< 0.003	111.90
	May-12	1.261	4.493	75.74	1118.00	0.639	< 0.2	20.36	0.175	0.060	< 0.02	0.176	14.02
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	2.648	3.453	44.79	64.61	2.543	< 0.2	52.05	< 0.01	< 0.003	< 0.05	0.441	33.02
	JPHD												
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.330	0.939	36.19	52.37	1.471	< 0.2	29.87	< 0.005	< 0.001	0.38	< 0.003	72.95
	May-12	2.793	9.134	335.90	2977.00	1.608	< 0.2	19.70	0.210	0.143	< 0.02	0.440	16.78
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.901	0.990	6.62	< 0.9	0.632	< 0.2	27.75	0.315	< 0.001	0.71	0.559	17.34
	JPHE												
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.980	1.302	117.00	171.10	4.530	< 0.2	25.02	0.115	< 0.001	2.60	< 0.003	83.71
	May-12	0.436	0.833	69.19	78.16	0.299	< 0.2	22.40	0.181	< 0.005	< 0.05	0.278	15.69
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.494	0.795	1.18	5.76	0.602	< 0.2	29.49	0.375	0.023	0.78	0.989	32.56
	JPHF												
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.861	0.818	9.97	42.65	1.758	0.3	27.35	< 0.005	< 0.001	0.18	< 0.003	42.98
	May-12	1.764	1.396	6.94	193.60	0.445	< 0.2	20.58	0.157	< 0.001	< 0.02	0.158	20.87
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	0.961	1.348	2.06	< 0.9	0.897	< 0.2	29.93	0.441	0.039	< 0.05	1.170	21.90
	JPHG												
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	0.675	2.264	18.83	103.70	2.258	< 0.2	19.56	< 0.005	< 0.001	0.07	< 0.003	91.73
	May-12	2.276	9.356	280.70	2924.00	1.598	< 0.2	25.07	0.371	0.290	< 0.05	0.495	16.54
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	1.867	1.261	5.48	< 0.9	0.679	< 0.2	31.02	< 0.01	< 0.003	0.87	0.292	19.00

Site ID	**Co**	**Ni**	**Cu**	**Zn**	**As**	**Se**	**Sr**	**Mo**	**Cd**	**Sn**	**Sb**	**Ba**
JPHP01A	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**mg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.270	1.427	16.13	13.35	0.125	0.2	48.30	0.427	0.001	0.08	0.349	58.35
May-12	0.353	< 0.02	< 0.04	< 0.04	1.224	< 0.2	55.64	0.974	< 0.005	< 0.02	1.992	50.01
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.325	15.800	1.24	< 0.9	0.908	< 0.2	57.14	0.627	< 0.001	< 0.05	0.332	50.15
JPHP01B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.392	10.550	7.24	15.60	0.442	1.2	34.56	0.553	0.019	0.00	0.207	57.02
May-12	0.520	0.982	< 0.04	1.37	0.351	< 0.2	34.62	0.617	< 0.005	< 0.05	1.198	55.39
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.485	2.742	< 0.05	< 0.03	0.292	< 0.2	36.60	0.340	< 0.003	< 0.05	0.323	61.12
JPHP01C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.139	3.614	55.26	17.86	<0.005	0.4	23.52	0.267	0.022	0.01	0.147	58.87
May-12	0.200	0.957	< 0.04	< 0.1	0.349	< 0.2	27.44	0.397	< 0.005	< 0.05	0.735	60.98
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.706	1.388	1.86	< 0.03	< 0.03	< 0.2	26.47	0.209	< 0.003	< 0.05	0.281	63.34
JPHP02A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.082	0.311	10.87	15.91	0.105	0.5	49.07	0.154	0.010	< 0.02	0.125	39.70
May-12	0.268	< 0.02	< 0.01	< 0.04	0.726	< 0.2	52.14	< 0.02	< 0.001	< 0.05	0.125	34.51
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.404	1.077	< 0.05	< 0.03	0.767	< 0.2	55.84	0.200	< 0.001	< 0.05	0.222	35.81
JPHP02B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.256	6.010	8.67	18.12	<0.005	< 0.2	30.65	0.124	0.016	0.06	0.101	41.13
May-12	2.528	3.315	5.75	3.90	5.900	< 0.2	30.84	12.560	3.191	< 0.05	20.190	33.97
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.408	1.568	< 0.05	< 0.03	< 0.03	< 0.2	33.91	< 0.01	< 0.001	< 0.05	0.173	31.82
JPHP02C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.744	4.780	18.13	16.00	0.172	0.4	22.06	0.265	0.013	0.05	0.097	42.95
May-12	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.220	1.475	0.65	< 0.03	< 0.008	< 0.2	29.08	< 0.01	0.040	< 0.05	0.144	47.78
JPHP03A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	2.692	15.280	27.45	40.38	0.372	1.6	36.59	0.611	0.047	1.01	0.879	60.70
May-12	0.859	1.909	< 0.01	1.33	0.224	< 0.2	35.06	0.192	< 0.001	0.61	0.272	19.38
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.826	2.225	< 0.02	< 0.03	< 0.03	< 0.2	37.55	< 0.01	< 0.001	0.56	< 0.007	20.11

Site ID	Co	Ni	Cu	Zn	As	Se	Sr	Mo	Cd	Sn	Sb	Ba
JPHP03B	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.416	4.693	11.73	15.96	1.162	0.7	31.09	0.303	0.019	0.18	0.098	67.29
May-12	0.422	0.640	< 0.04	< 0.04	< 0.02	< 0.2	25.93	< 0.02	< 0.001	< 0.05	0.231	49.60
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	2.237	1.33	< 0.03	< 0.03	< 0.2	29.75	< 0.01	< 0.003	< 0.01	< 0.007	53.63
JPHP03C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.312	16.140	15.65	17.41	0.437	< 0.2	21.40	0.666	0.020	0.07	0.217	50.81
May-12	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.169	1.304	3.69	< 0.03	0.681	< 0.2	22.27	1.168	0.099	< 0.05	9.176	43.82
JPHP04A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.151	3.076	25.06	15.24	0.458	0.9	36.75	0.272	< 0.001	0.03	0.194	36.95
May-12	0.189	1.356	< 0.01	< 0.04	0.567	< 0.2	55.04	0.277	< 0.001	< 0.05	0.355	34.04
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.213	2.621	11.5	< 0.9	6.504	< 0.2	64.64	13.791	< 0.003	< 0.01	16.764	38.28
JPHP04B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.246	1.366	10.48	17.97	<0.005	0.1	24.23	0.150	< 0.001	0.03	0.103	43.47
May-12	0.333	0.410	< 0.01	< 0.04	0.213	< 0.2	23.53	0.273	< 0.001	< 0.05	0.270	38.34
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.180	8.376	< 0.05	< 0.03	0.787	< 0.2	23.50	0.711	< 0.003	< 0.05	1.621	40.34
JPHP04C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.203	5.398	54.07	16.04	0.064	0.9	18.48	0.270	0.025	< 0.02	0.083	50.49
May-12	0.183	0.578	0.51	< 0.04	< 0.02	< 0.2	20.40	< 0.02	< 0.001	< 0.02	0.207	52.27
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	0.523	3.01	< 0.03	0.349	< 0.2	18.61	0.498	< 0.003	< 0.05	1.238	39.29
JPHP05A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.036	0.548	10.77	10.36	<0.005	0.2	54.00	0.037	0.010	< 0.02	0.056	26.14
May-12	0.196	< 0.02	< 0.01	< 0.04	0.197	< 0.2	58.10	< 0.005	< 0.001	< 0.02	< 0.009	19.89
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.371	< 0.04	< 0.05	< 0.03	< 0.03	< 0.2	59.62	< 0.01	< 0.001	< 0.01	0.106	19.57
JPHP05B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.425	1.131	1.54	13.65	0.190	< 0.2	25.75	0.043	0.013	0.02	0.042	54.30
May-12	5.276	5.399	8.65	5.98	10.780	< 0.2	25.36	16.330	5.890	< 0.02	26.140	54.88
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	0.874	< 0.02	< 0.03	< 0.03	< 0.2	26.47	< 0.01	< 0.001	< 0.05	0.110	51.46

Site ID	Co	Ni	Cu	Zn	As	Se	Sr	Mo	Cd	Sn	Sb	Ba
JPHP05C	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.225	4.932	5.43	14.42	0.401	< 0.2	17.88	0.219	0.035	0.02	0.116	37.22
May-12	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	0.565	0.63	< 0.03	< 0.008	< 0.2	18.34	< 0.01	< 0.001	< 0.05	0.090	30.76
JPHP06A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.264	4.674	7.65	13.09	1.250	0.9	45.61	0.113	0.017	< 0.02	0.258	31.40
May-12	0.352	0.344	< 0.04	< 0.1	1.022	< 0.2	46.07	0.734	0.177	< 0.02	2.121	22.90
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.221	1.249	< 0.02	< 0.03	0.577	< 0.2	47.02	0.262	< 0.003	< 0.05	0.266	22.16
JPHP06B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1.095	2.743	13.20	29.55	0.736	< 0.2	52.86	0.354	0.020	0.00	0.211	45.97
May-12	1.203	4.835	< 0.04	< 0.1	0.992	< 0.2	57.83	0.871	0.088	0.58	1.290	19.18
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.491	2.577	< 0.02	< 0.03	< 0.03	< 0.2	54.52	< 0.01	< 0.001	< 0.05	0.120	21.36
JPHP06C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.192	9.229	4.14	29.61	<0.005	0.2	32.56	0.513	0.010	< 0.02	0.104	80.52
May-12	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.005	1.510	< 0.05	< 0.03	< 0.008	< 0.2	34.44	< 0.01	0.035	0.70	0.110	89.85
JPHP07A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.050	0.552	1.96	12.21	2.043	< 0.2	33.01	0.152	0.001	0.06	0.208	41.90
May-12	0.647	0.247	< 0.04	< 0.04	1.381	< 0.2	32.41	0.382	0.188	0.55	0.815	27.35
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.359	0.577	< 0.02	< 0.03	1.359	< 0.2	35.69	0.264	< 0.001	< 0.05	0.147	29.60
JPHP07B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.234	2.579	4.84	14.06	0.388	< 0.2	42.79	0.237	0.001	0.25	0.179	48.50
May-12	0.379	1.091	< 0.04	< 0.1	0.416	< 0.2	42.97	0.317	0.197	< 0.05	0.561	41.67
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.264	1.446	< 0.02	< 0.03	< 0.03	< 0.2	42.02	< 0.01	< 0.003	< 0.05	0.110	40.75
JPHP07C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.338	8.573	39.13	13.43	0.516	0.2	21.32	0.364	< 0.001	< 0.02	0.079	37.79
May-12	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	Co	Ni	Cu	Zn	As	Se	Sr	Mo	Cd	Sn	Sb	Ba
JPHP08A	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.164	0.260	1.72	19.75	<0.005	< 0.2	61.86	0.067	0.004	0.03	0.114	82.63
May-12	< 0.02	< 0.02	< 0.01	< 0.04	0.267	< 0.2	63.36	0.207	< 0.005	< 0.05	0.450	51.48
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.177	< 0.04	< 0.02	< 0.03	< 0.008	< 0.2	67.19	< 0.01	< 0.003	< 0.05	0.153	65.58
JPHP08B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.163	1.326	0.85	13.15	0.107	0.5	66.62	0.126	< 0.001	0.04	0.091	52.61
May-12	0.242	0.351	< 0.01	< 0.04	0.809	< 0.2	61.70	0.213	< 0.005	< 0.02	0.456	34.20
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	< 0.04	< 0.02	< 0.03	0.666	< 0.2	65.60	< 0.004	< 0.003	< 0.01	0.128	37.26
JPHP08C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.145	0.204	3.32	15.15	0.180	0.6	6.59	< 0.005	0.020	0.09	0.064	32.27
May-12	1.198	0.508	< 0.04	< 0.1	2.125	< 0.2	17.12	0.428	< 0.005	0.56	0.676	15.41
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.069	1.351	1.24	< 0.03	4.105	< 0.2	38.95	< 0.01	< 0.001	< 0.05	0.138	33.61
JPHP09A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.009	0.841	2.38	12.51	0.273	0.9	54.09	0.615	< 0.001	0.15	0.735	53.97
May-12	< 0.02	< 0.02	< 0.01	< 0.04	< 0.02	< 0.2	54.27	< 0.02	< 0.001	2.14	0.164	44.67
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	< 0.04	1.19	< 0.03	< 0.008	< 0.2	55.28	< 0.01	< 0.003	< 0.01	0.303	44.08
JPHP09B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.861	1.142	36.35	72.45	0.028	0.0	26.55	0.056	< 0.001	0.05	< 0.003	109.80
May-12	1.589	0.745	< 0.04	< 0.04	1.196	< 0.2	23.88	< 0.02	< 0.001	< 0.05	< 0.009	18.59
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.447	0.763	1.62	< 0.03	1.375	< 0.2	24.34	< 0.01	< 0.001	< 0.05	0.292	18.56
JPHP09C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.768	1.183	1.03	12.32	1.247	0.3	27.34	0.033	< 0.001	0.22	< 0.003	42.18
May-12	1.354	1.349	< 0.01	< 0.04	1.181	< 0.2	42.45	< 0.005	< 0.001	< 0.02	< 0.009	16.44
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	1.284	1.431	< 0.05	< 0.03	1.455	< 0.2	40.07	< 0.01	< 0.001	0.68	0.316	17.44
JPHP10A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.286	0.587	17.60	29.86	0.132	0.0	58.89	< 0.005	< 0.001	0.04	< 0.003	98.98
May-12	0.403	0.738	< 0.04	< 0.04	0.189	< 0.2	61.56	< 0.02	< 0.001	< 0.02	0.154	46.83
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.643	1.072	2.24	< 0.03	< 0.03	< 0.2	64.17	0.255	< 0.001	0.53	0.530	50.40

Site ID	Co	Ni	Cu	Zn	As	Se	Sr	Mo	Cd	Sn	Sb	Ba
JPHP10B	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.293	1.072	5.84	10.49	1.649	< 0.2	45.62	< 0.005	< 0.001	0.04	< 0.003	45.85
May-12	0.524	3.901	< 0.04	< 0.1	3.017	< 0.2	48.03	< 0.02	< 0.001	< 0.02	0.141	34.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	1.263	0.64	< 0.03	2.269	< 0.2	50.32	0.181	< 0.001	< 0.05	0.841	32.99
JPHP10C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1.830	2.059	4.87	18.96	2.057	0.1	25.11	0.097	< 0.001	0.23	< 0.003	126.70
May-12	0.932	1.330	< 0.04	< 0.04	1.543	< 0.2	24.58	0.194	< 0.001	< 0.05	0.339	20.43
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	2.326	3.493	5.97	< 0.9	3.278	< 0.2	49.53	0.176	< 0.003	< 0.05	0.599	44.39
JPHP11A												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.350	2.474	2.13	39.04	0.460	0.1	55.87	< 0.005	< 0.001	0.18	< 0.003	101.10
May-12	0.428	0.502	< 0.01	4.00	0.991	< 0.2	46.72	0.708	< 0.001	0.75	0.891	41.93
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.259	< 0.04	0.81	< 0.03	0.579	< 0.2	49.05	< 0.01	< 0.003	< 0.05	0.105	39.25
JPHP11B												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.476	5.856	12.87	18.23	<0.005	< 0.2	40.00	< 0.005	< 0.001	0.07	< 0.003	51.02
May-12	0.340	0.995	< 0.01	< 0.04	0.272	< 0.2	41.56	0.342	< 0.001	< 0.05	0.407	41.54
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.251	1.293	< 0.05	< 0.03	0.369	< 0.2	41.67	0.335	< 0.003	< 0.05	0.701	42.40
JPHP11C												
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.445	24.970	2.12	13.44	0.451	< 0.2	29.91	0.920	< 0.001	0.01	< 0.003	71.82
May-12	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.02	0.716	0.91	< 0.03	< 0.03	< 0.2	32.39	< 0.01	0.057	< 0.05	0.220	82.72
JPHP12												
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--
Surface Water at JPHA												
Aug-11	0.500	2.403	3.23	79.10	2.562	0.6	33.29	0.085	< 0.001	0.05	< 0.003	133.10
Apr-12	1.801	2.169	5.07	23.72	2.029	--	9.70	3.759	2.013	<0.03	3.807	9.96
May-12	1.042	1.281	0.89	3.12	1.074	< 0.2	22.40	0.548	< 0.001	< 0.02	0.451	18.09
Jul-12	4.170	19.890	2.62	180.50	5.827	< 0.2	94.22	0.581	0.049	< 0.05	0.212	298.80
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.234	1.107	< 0.05	60.60	0.752	< 0.2	25.83	0.266	0.055	0.55	0.190	76.85

Site ID JPH Weir	Co µg/L	Ni µg/L	Cu µg/L	Zn µg/L	As µg/L	Se mg/L	Sr µg/L	Mo µg/L	Cd µg/L	Sn µg/L	Sb µg/L	Ba µg/L
Aug-11	0.146	0.464	2.90	47.00	0.587	< 0.2	26.75	< 0.002	< 0.001	0.01	< 0.003	69.89
Apr-12	<0.01	<0.05	0.72	23.53	0.454	--	26.78	<0.002	<0.01	<0.09	<0.002	20.49
Apr-12	0.458	0.976	1.80	32.69	0.372	--	20.52	<0.003	0.104	0.88	0.185	16.20
May-12	1.025	0.363	< 0.04	2.81	0.505	< 0.2	23.43	0.185	< 0.001	< 0.02	0.214	17.58
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	2.434	2.454	2.62	17.15	1.455	< 0.2	46.38	0.168	< 0.003	< 0.05	0.130	53.44
Sep-12	1.159	1.153	< 0.05	< 0.03	0.898	< 0.2	34.58	0.399	< 0.003	< 0.01	1.043	25.58
JPH Rain Events												
15-Aug-11	0.077	0.759	4.02	41.76	0.158	< 0.2	2.54	< 0.005	< 0.001	0.09	< 0.003	25.48
5-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--
17-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--
13-Sep-12	0.492	< 0.04	0.84	< 0.03	< 0.008	< 0.2	0.78	< 0.004	< 0.001	< 0.05	0.455	0.71

	Site ID	Ag	Tl	Pb	U	Hg	Li
units		μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
precision							
DL (QL)		.004 (.01)	.0009 (.003)	.001 (.002)	.0007 (.002)	0.876	0.07 (0.2)
	JPHA						
	Jul-11	--	--	--	--	--	--
	Aug-11	--	< 0.001	2.311	< 0.0007	0.677	--
	May-12	< 0.01	< 0.003	18.930	< 0.0007	--	--
	Jul-12	--	--	--	--	--	--
	Sep-12	0.118	0.028	2.431	< 0.0007	--	< 0.2
	JPHB						
	Jul-11	--	--	--	--	--	--
	Aug-11	--	< 0.001	2.018	< 0.0007	1.581	--
	May-12	< 0.004	< 0.003	25.570	< 0.002	--	--
	Jul-12	--	--	--	--	--	--
	Sep-12	3.829	< 0.002	0.453	< 0.0007	--	< 0.2
	JPHC						
	Jul-11	--	--	--	--	--	--
	Aug-11	--	< 0.001	2.592	< 0.0007	1.079	--
	May-12	< 0.004	< 0.003	6.859	< 0.0007	--	--
	Jul-12	--	--	--	--	--	--
	Sep-12	< 0.009	0.046	13.880	0.0250	--	< 0.07
	JPHD						
	Jul-11	--	--	--	--	--	--
	Aug-11	--	< 0.001	1.967	0.0270	0.148	--
	May-12	< 0.004	< 0.003	53.880	< 0.002	--	--
	Jul-12	--	--	--	--	--	--
	Sep-12	0.163	0.031	1.220	0.0049	--	< 0.2
	JPHE						
	Jul-11	--	--	--	--	--	--
	Aug-11	--	< 0.001	23.970	< 0.0007	0.524	--
	May-12	< 0.004	< 0.001	2.435	< 0.0007	--	--
	Jul-12	--	--	--	--	--	--
	Sep-12	0.052	0.05	0.381	< 0.0007	--	< 0.2
	JPHF						
	Jul-11	--	--	--	--	--	--
	Aug-11	--	< 0.001	1.687	0.0160	0.538	--
	May-12	< 0.004	< 0.001	0.537	< 0.002	--	--
	Jul-12	--	--	--	--	--	--
	Sep-12	0.259	0.061	0.524	< 0.0007	--	< 0.2
	JPHG						
	Jul-11	--	--	--	--	--	--
	Aug-11	--	< 0.001	2.346	0.1080	0.685	--
	May-12	< 0.004	< 0.003	20.630	0.0250	--	--
	Jul-12	--	--	--	--	--	--
	Sep-12	0.114	< 0.002	1.550	0.0100	--	< 0.07

Site ID	Ag	Tl	Pb	U	Hg	Li
JPHP01A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--
Aug-11	--	0.06	2.513	0.1580	2.498	--
May-12	0.273	0.1	0.273	0.1600	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	0.023	0.436	0.2370	--	< 0.2
JPHP01B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.041	1.188	< 0.0007	2.538	--
May-12	0.483	0.1	0.176	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.002	0.132	0.0170	--	< 0.07
JPHP01C						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.041	3.762	< 0.0007	4.141	--
May-12	< 0.004	< 0.003	0.093	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.002	0.289	0.0140	--	< 0.07
JPHP02A						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.031	1.833	0.0760	0.797	--
May-12	< 0.004	< 0.001	0.044	0.1000	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.0006	0.127	0.1340	--	< 0.2
JPHP02B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.032	1.692	0.0010	2.171	--
May-12	2.066	1.4	10.910	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.002	0.069	0.0090	--	< 0.07
JPHP02C						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.02	3.303	< 0.0007	2.382	--
May-12	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.002	0.060	0.0130	--	< 0.07
JPHP03A						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.019	4.045	0.0010	2.639	--
May-12	0.425	< 0.001	0.050	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.0006	0.041	< 0.0007	--	< 0.07

Site ID	Ag	Tl	Pb	U	Hg	Li
JPHP03B	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
Jul-11	--	--	--	--	--	--
Aug-11	--	0.019	3.017	< 0.0007	0.462	--
May-12	0.530	< 0.003	0.047	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.002	0.226	< 0.0007	--	< 0.07
JPHP03C						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.016	2.693	< 0.0007	0.626	--
May-12	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.202	0.162	1.345	< 0.0007	--	< 0.07
JPHP04A						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.013	3.860	0.0610	< 0.876	--
May-12	< 0.01	< 0.003	0.063	0.0730	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.751	0.7295	9.924	0.1040	--	< 0.07
JPHP04B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.01	2.236	< 0.0007	0.129	--
May-12	< 0.01	< 0.003	0.053	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.443	0.08	0.310	< 0.0007	--	< 0.07
JPHP04C						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.012	4.689	< 0.0007	1.349	--
May-12	< 0.004	< 0.003	0.051	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.158	0.082	0.497	0.0080	--	< 0.07
JPHP05A						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.004	2.163	0.0070	0.999	--
May-12	< 0.01	< 0.001	< 0.002	< 0.002	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.0006	0.063	0.0190	--	< 0.07
JPHP05B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.009	0.643	< 0.0007	0.851	--
May-12	4.552	3.6	14.540	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.0006	0.038	< 0.0007	--	< 0.07

Site ID	Ag	Tl	Pb	U	Hg	Li
JPHP05C	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--
Aug-11	--	0.016	0.872	0.0630	1.331	--
May-12	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.0006	0.092	< 0.0007	--	< 0.07
JPHP06A						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.082	1.619	< 0.0007	0.494	--
May-12	0.237	0.2	0.548	< 0.002	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.002	0.090	0.0180	--	< 0.07
JPHP06B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.006	1.114	< 0.0007	< 0.876	--
May-12	0.960	0.1	0.336	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.258	< 0.0006	0.047	< 0.0007	--	< 0.07
JPHP06C						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.015	0.765	< 0.0007	0.468	--
May-12	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.002	0.046	0.0080	--	< 0.07
JPHP07A						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.007	0.704	0.0520	0.841	--
May-12	< 0.01	0.1	0.311	0.0440	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.0006	0.069	0.0660	--	< 0.2
JPHP07B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.007	1.221	< 0.0007	< 0.876	--
May-12	< 0.01	0.1	0.282	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	< 0.002	0.045	0.0049	--	< 0.07
JPHP07C						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.011	7.576	< 0.0007	0.377	--
May-12	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--

Site ID	Ag	Tl	Pb	U	Hg	Li
JPHP08A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--
Aug-11	--	0.005	0.587	0.0220	< 0.876	--
May-12	< 0.01	0.0	0.125	< 0.002	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.178	< 0.002	0.056	0.0200	--	< 0.2
JPHP08B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.007	0.975	0.1370	0.153	--
May-12	< 0.004	< 0.003	0.114	0.0980	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.0006	0.052	0.1200	--	< 0.07
JPHP08C						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.007	0.821	0.0020	< 0.876	--
May-12	< 0.004	< 0.003	0.152	< 0.002	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.0006	0.202	0.0350	--	< 0.07
JPHP09A						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.059	1.045	0.0080	5.163	--
May-12	< 0.004	< 0.001	0.026	0.0350	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	0.031	0.412	0.0490	--	< 0.2
JPHP09B						
Jul-11	--	--	--	--	--	--
Aug-11	--	0.019	3.016	0.1440	4.974	--
May-12	< 0.004	< 0.001	0.056	0.1300	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.115	< 0.002	0.264	0.1290	--	< 0.07
JPHP09C						
Jul-11	--	--	--	--	--	--
Aug-11	--	< 0.001	0.447	< 0.0007	3.128	--
May-12	< 0.01	< 0.001	0.029	0.0320	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	0.03	0.111	0.0220	--	< 0.07
JPHP10A						
Jul-11	--	--	--	--	--	--
Aug-11	--	< 0.001	4.967	< 0.0007	2.113	--
May-12	< 0.004	< 0.001	0.071	0.0370	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.196	< 0.002	0.307	0.0360	--	< 0.2

Site ID	Ag	Tl	Pb	U	Hg	Li
JPHP10B	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--
Aug-11	--	< 0.001	2.509	0.0330	1.557	--
May-12	< 0.004	< 0.001	0.196	0.0760	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.003	0.027	0.214	0.1010	--	< 0.07
JPHP10C						
Jul-11	--	--	--	--	--	--
Aug-11	--	< 0.001	1.055	0.0360	2.688	--
May-12	< 0.004	< 0.001	0.152	0.0570	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	0.091	0.777	0.0950	--	< 0.07
JPHP11A						
Jul-11	--	--	--	--	--	--
Aug-11	--	< 0.001	1.071	0.1440	1.911	--
May-12	0.925	< 0.003	0.210	0.1820	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.006	< 0.0006	0.174	0.2215	--	< 0.2
JPHP11B						
Jul-11	--	--	--	--	--	--
Aug-11	--	< 0.001	2.150	< 0.0007	2.374	--
May-12	< 0.01	< 0.003	0.076	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Sep-12	0.388	0.029	0.119	0.0380	--	< 0.07
JPHP11C						
Jul-11	--	--	--	--	--	--
Aug-11	--	< 0.001	0.750	< 0.0007	0.679	--
May-12	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--
Sep-12	< 0.009	< 0.002	0.028	0.0090	--	< 0.07
JPHP12						
Jul-12	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--
Surface Water at JPHA						
Aug-11	--	< 0.001	0.871	< 0.0007	0.342	--
Apr-12	--	1.335	4.928	<0.005	--	--
May-12	< 0.004	< 0.003	0.165	< 0.0007	--	--
Jul-12	< 0.009	0.028	0.284	0.0160	--	3.31
Jul-12	--	--	--	--	--	--
Sep-12	0.124	0.026	0.116	< 0.0007	--	< 0.2

Site ID	Ag	Tl	Pb	U	Hg	Li
JPH Weir	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Aug-11	--	< 0.001	0.768	< 0.0007	0.705	--
Apr-12	--	0.029	0.093	0.0360	--	--
Apr-12	--	0.0595	0.223	<0.003	--	--
May-12	< 0.004	< 0.001	0.030	< 0.0007	--	--
Jul-12	--	--	--	--	--	--
Jul-12	0.374	< 0.002	0.247	0.0230	--	< 0.07
Sep-12	< 0.003	0.045	0.182	0.0160	--	< 0.2
JPH Rain Events						
15-Aug-11	--	< 0.001	1.181	< 0.0007	0.897	--
5-Jun-12	--	--	--	--	--	--
17-Jul-12	--	--	--	--	--	--
13-Sep-12	< 0.009	< 0.0006	0.032	< 0.0007	--	< 0.07

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
units	^{0}C	--	mV	μS/cm	mg/L	mg/L	permil	permil	permil	permil	mg/L	permil	permil	
precision	0.1	0.002	0.2	0.1	0.4	0.8	1	0.2	1	0.3	theoretical	0.04	0.15	0.83
DL (QL)						0.2								
MLA														
Jul-11	--	--	--	--	--	--	-137.6	-17.51	2.5	-10.83	28.5	--	--	--
Aug-11	--	--	--	--	--	47.9	-132.9	-17.06	3.6	1.96	140.5	-5.6	-34.56	7.8
May-12	12.7	4.46	215	17	0	36.2	-140.1	-18.03	4.2	-2.01	245.7	--	--	--
Jul-12	20.9	4.03	-88	1	0	--	-133.9	-16.96	1.8	-1.16	193.6	0.7	-39.86	9.8
Sep-12	18.1	4.49	24	15	2	33.0	-115.9	-15.01	4.1	-6.77	95.9	--	-29.24	--
MLB														
Jul-11	--	--	--	--	--	--	-139.0	-17.72	2.8	-11.42	26.3	--	--	--
Aug-11	17.1	7.06	184	44	1	54.1	-138.5	-17.76	3.6	-5.64	113.7	-2.4	-28.20	9.5
May-12	11.0	4.22	250	31	0	53.3	-137.9	-17.64	3.2	-11.32	146.1	--	--	--
Jul-12	18.4	3.83	-71	8	0	--	-128.3	-16.51	3.9	-12.03	109.0	-0.3	-30.53	10.2
Sep-12	14.4	3.65	116	0	0	40.5	-119.0	-15.27	3.2	-12.52	68.3	-1.0	-30.93	9.6
MLC														
Jul-11	--	--	--	--	--	--	-145.0	-18.70	4.5	-12.62	90.0	--	--	--
Aug-11	17.1	7.07	172	42	4	59.8	-139.6	-18.15	5.6	-13.75	123.4	-3.8	-27.41	9.8
May-12	12.1	4.29	238	27	0	52.5	-140.6	-18.08	4.0	-13.99	100.2	--	--	--
Jul-12	17.7	4.15	--	25	0	--	-139.9	-18.19	5.7	-8.54	103.5	0.4	-31.37	11.0
Sep-12	12.4	3.60	241	0	0	50.3	-120.1	-15.65	5.2	-17.06	72.8	--	-30.01	--
MLD														
Jul-11	--	--	--	--	--	--	-136.0	-17.48	3.9	-11.70	43.3	--	--	--
Aug-11	14.2	4.21	263	23	--	53.3	-130.9	-17.10	5.9	0.93	206.6	-1.5	-36.55	7.7
May-12	13.0	4.33	338	32	0	43.9	-127.8	-16.38	3.3	--	83.8	--	--	--
Jul-12	18.2	4.05	213	22	0	--	-132.6	-16.99	3.3	-4.86	123.0	0.2	-34.03	7.7
Sep-12	17.8	3.79	25	0	0	38.1	-118.9	-15.32	3.6	-6.39	173.0	-0.7	-29.37	9.3
MLE														
Jul-11	--	--	--	--	--	--	-134.3	-16.92	1.1	-1.71	98.4	--	--	--
Aug-11	13.1	4.19	233	7	2	52.8	-132.0	-16.92	3.4	-0.20	158.0	-2.2	-27.13	10.1
May-12	11.7	4.37	241	18	0	42.2	-132.3	-16.62	0.7	-6.53	178.8	--	--	--
Jul-12	17.3	4.42	245	34	0	--	-130.2	-16.33	0.4	-10.39	151.1	-0.3	-33.23	8.8
Sep-12	12.5	5.57	-24	29	0	48.0	-133.0	-16.74	1.0	4.01	528.5	0.1	-27.74	14.3
MLF														
Jul-11	--	--	--	--	--	--	-139.6	-17.99	4.3	-20.11	44.5	--	--	--
Aug-11	17.5	4.25	215	29	--	74.5	-136.2	-17.89	6.9	-12.06	110.0	-4.7	-30.94	9.8
May-12	11.4	4.31	298	27	0	61.1	-137.9	-17.79	4.4	-18.47	68.1	--	--	--
Jul-12	16.9	3.83	--	15	0	--	-135.8	-17.77	6.3	-13.45	130.6	-0.3	-30.73	10.1
Sep-12	14.0	3.76	69	14	0	74.1	-118.8	-15.67	6.5	-12.89	100.1	--	-29.13	--
MLG														
Jul-11	--	--	--	--	--	--	-140.8	-17.94	2.8	-16.33	41.6	--	--	--
Aug-11	14.8	4.17	307	35	--	40.4	-125.9	-16.31	4.6	-14.62	58.7	-1.2	-27.67	10.5
May-12	14.3	4.08	182	15	0	40.5	-136.1	-17.63	4.9	-17.47	40.1	--	--	--
Jul-12	18.0	4.22	110	14	4	--	-135.5	-17.25	2.5	0.37	176.5	0.6	-33.46	11.8
Sep-12	17.0	4.52	-26	19	2	36.1	-124.2	-15.86	2.7	-1.31	190.9	-0.3	-29.32	13.2

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	μS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLH														
Jul-11	--	--	--	--	--	--	-140.5	-17.86	2.4	-16.02	76.3	--	--	--
Aug-11	12.5	3.95	299	13	--	41.1	-133.1	-17.25	4.9	-9.68	92.8	-1.1	-33.04	10.2
May-12	11.4	4.12	315	35	0	47.3	-136.9	-17.41	2.4	-15.31	115.2	--	--	--
Jul-12	16.2	3.78	98	19	0	--	-119.9	-15.37	3.1	-21.36	79.5	0.2	-29.88	11.0
Sep-12	--	--	--	--	0	49.8	-121.2	-15.67	4.2	-10.88	147.5	-0.4	-31.72	11.3
MLM														
Jul-11	--	--	--	--	--	--	-134.4	-17.23	3.4	-18.91	144.6	--	--	--
Aug-11	14.1	4.10	279	20	--	52.0	-133.1	-17.13	3.9	-14.33	150.8	-6.1	-30.22	9.1
May-12	11.6	4.16	246	19	0	46.4	-137.1	-17.37	1.8	-5.82	175.3	--	--	--
Jul-12	15.5	4.04	128	19	0	--	-135.0	-17.17	2.4	-8.99	188.5	0.9	-29.35	12.5
Sep-12	15.8	3.99	8	17	0	34.7	-116.9	-14.86	2.0	-8.88	67.3	1.2	-27.39	16.5
MLN														
Jul-11	--	--	--	--	--	--	-143.6	-18.29	2.7	-10.46	121.7	--	--	--
Aug-11	15.0	4.29	277	20	--	53.3	-132.8	-17.05	3.6	-5.73	106.6	-1.2	-29.38	13.2
May-12	11.6	4.33	218	22	0	45.6	-136.7	-17.37	2.2	-8.32	197.8	--	--	--
Jul-12	16.4	4.54	211	26	6	--	-135.2	-16.98	0.7	-7.59	185.3	-0.7	-30.30	11.3
Sep-12	12.3	4.83	-34	33	0	43.6	-120.2	-15.52	3.9	-4.60	187.2	--	-28.96	--
MLO														
Jul-11	--	--	--	--	--	--	-142.7	-18.39	4.5	-16.84	91.5	--	--	--
Aug-11	17.5	6.70	145	55	2	80.1	-137.9	-18.10	6.9	-10.08	147.7	-3.0	-34.09	8.7
May-12	15.0	4.47	251	40	7	66.4	-139.5	-18.04	4.8	-2.51	329.1	--	--	--
Jul-12	18.3	4.11	246	31	30	--	-139.7	-18.21	6.0	-0.73	296.8	0.7	-28.26	15.5
Sep-12	16.3	3.56	35	0	0	75.5	-114.6	-15.16	6.7	-18.11	42.1	-1.2	-28.89	11.0
MLP														
Jul-11	--	--	--	--	--	--	-141.6	-18.21	4.1	-18.63	78.1	--	--	--
Aug-11	16.5	3.89	261	31	--	88.4	-136.8	-17.68	4.7	-22.63	169.3	-3.0	-29.19	12.2
May-12	9.0	4.05	270	32	0	66.4	-140.1	-18.11	4.7	-17.27	74.9	--	--	--
Jul-12	17.1	3.79	--	34	0	--	-133.7	-17.44	5.8	-17.93	104.3	1.5	-28.57	11.5
Sep-12	13.4	3.67	48	10	0	70.8	-115.1	-15.07	5.5	-19.67	60.0	--	-28.33	--
MLQ														
Jul-11	--	--	--	--	--	--	-136.5	-17.17	0.9	-9.64	48.6	--	--	--
Aug-11	13.3	5.00	236	37	3	62.0	-133.1	-17.01	3.0	2.89	193.9	-4.9	-27.17	9.8
May-12	11.3	4.09	236	30	0	47.3	-137.9	-17.48	1.9	-3.73	207.6	--	--	--
Jul-12	17.0	3.97	235	19	0	--	-133.8	-16.84	0.9	-8.70	125.5	-1.5	-30.33	9.9
Jul-12	--	--	--	--	--	--	-134.8	-16.96	0.9	-7.39	--	--	--	--
Sep-12	12.4	4.43	50	39	0	44.9	-128.0	-16.42	3.4	-0.10	301.8	-1.8	-30.13	9.7
MLR														
Jul-11	--	--	--	--	--	--	-141.3	-17.99	2.6	-9.42	55.2	--	--	--
Aug-11	13.8	4.27	277	18	--	55.9	-137.4	-17.95	6.3	-5.02	115.5	-2.8	-28.35	10.5
May-12	11.2	4.49	220	22	0	42.2	-139.7	-17.92	3.6	-9.09	115.6	--	--	--
Jul-12	16.3	4.67	--	27	5	--	-138.1	-18.28	8.1	-5.95	166.4	-0.5	-30.78	9.6
Sep-12	11.7	4.81	-13	31	0	38.3	-117.0	-15.38	6.0	-8.08	139.7	-1.1	-28.90	11.1

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	μS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLS														
Jul-11	--	--	--	--	--	--	-144.2	-18.55	4.2	-17.25	51.0	--	--	--
Aug-11	16.8	4.17	347	21	--	60.9	-144.8	-18.37	2.1	-9.76	115.4	-3.1	-28.71	9.8
May-12	17.0	4.65	233	28	0	54.2	-140.2	-18.15	5.0	-6.02	342.7	--	--	--
Jul-12	--	--	--	--	0	--	-140.2	-18.13	4.8	-4.88	217.0	0.4	-32.56	9.7
Sep-12	20.0	4.27	-11	44	0	58.9	-121.8	-15.87	5.2	-9.13	80.6	--	-30.58	--
MLT														
Jul-11	--	--	--	--	--	--	-142.0	-18.24	3.9	-18.54	47.6	--	--	--
Aug-11	--	--	--	--	--	67.5	-136.5	-18.03	7.8	-15.71	113.4	-3.7	-27.54	13.0
May-12	11.2	3.98	277	30	0	56.8	-140.7	-18.17	4.6	-7.19	139.9	--	--	--
Jul-12	17.9	3.79	156	19	0	--	-128.0	-16.68	5.5	-18.51	83.7	--	-29.12	--
Sep-12	13.8	3.58	5	0	0	63.9	-122.4	-15.77	3.8	-12.57	129.1	--	-29.29	--
MLU														
Jul-11	--	--	--	--	--	--	-138.8	-17.92	4.6	-11.37	68.9	--	--	--
Aug-11	16.7	4.44	225	28	--	53.1	-144.7	-17.91	-1.4	-6.20	185.5	-2.4	-26.63	10.1
May-12	9.9	4.60	202	25	5	48.1	-140.2	-18.21	5.4	-5.64	366.8	--	--	--
Jul-12	16.5	4.62	254	28	0	--	-138.5	-18.34	8.3	-6.96	246.6	0.0	-28.39	8.6
Sep-12	12.0	4.51	261	28	0	54.8	-138.7	-18.12	6.2	2.75	477.3		-26.52	
MLV														
Jul-11	--	--	--	--	--	--	-143.8	-18.70	5.8	-16.47	27.8	--	--	--
Aug-11	17.5	3.92	261	28		66.2	-153.5	-18.03	-9.3	-13.33	89.6	-3.4	-27.22	11.5
May-12	7.7	4.14	263	28	0	55.9	-140.8	-18.25	5.2	-17.75	87.0	--	--	--
Jul-12	14.9	3.78	127	19	0	--	-130.7	-16.87	4.2	-19.49	89.1	--	-28.76	--
Sep-12	15.7	3.59	52	3	0	61.6	-115.1	-15.19	6.4	-20.55	65.8	0.2	-27.76	10.1
MLP01A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	12.00	--	--	--	--	-143.5	-18.48	4.3	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP01B														
Jul-11	--	--	--	--	--	--	-155.1	-20.10	5.7	-20.50	164.0	--	--	--
Aug-11	--	--	--	--	--	--	-150.0	-19.23	3.8	-18.71	62.8	5.1	-24.75	11.1
May-12	--	--	--	--	--	--	-149.4	-19.14	3.8	-17.22	32.6	--	--	--
Jul-12	--	--	--	--	14	--	-145.0	-18.52	3.2	-16.40	139.0	--	-24.99	--
Sep-12	--	--	--	--	--	7.4	-143.7	-18.51	4.3	-18.61	87.5	--	--	--
MLP02A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--		--	-138.2	-17.55	2.2	-21.67	29.1	--	--	--
May-12	--	12.00	--	--	--	--	-140.4	-18.16	4.9	-18.39	55.5	--	--	--
Jul-12	--	12.00	--	--	--	--	-139.0	-17.66	2.3	-24.77	77.0	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	μS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLP02B														
Jul-11	--	--	--	--	--	--	-132.1	-17.05	4.3	-15.69	23.6	--	--	--
Aug-11	--	--	--	--	--	--	-137.1	-17.43	2.3	-21.99	120.8	-8.1	-24.77	6.8
May-12	--	--	--	--	--	--	-144.9	-18.99	7.0	-20.53	30.8	--	--	--
Jul-12	--	--	--	--	12	--	-137.3	-17.52	2.9	-19.43	163.5	0.0	-25.36	8.7
Sep-12	--	--	--	--	--	6.5	-134.8	-17.09	1.9	-21.46	92.0	--	--	--
MLP03A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	12.00	--	--	--	--	-145.3	-18.89	5.9	-16.84	6.5	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP03B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-148.0	-18.66	1.3	-19.29	101.4	--	--	--
May-12	--	--	--	--	--	--	-146.2	-18.67	3.2	-21.32	229.6	--	--	--
Jul-12	--	--	--	--	33	--	-143.9	-18.24	2.1	-17.12	124.0	--	-25.27	--
Sep-12	--	--	--	--	--	--	-138.0	-17.72	3.7	-19.77	151.6	--	--	--
MLP04A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-135.0	-16.90	0.2	-2.17	153.6	--	--	--
May-12	--	--	--	--	--	--	-132.5	-16.33	-1.8	14.89	951.4	--	--	--
Jul-12	--	--	--	--	150	--	-130.9	-16.49	1.0	8.31	827.0	--	-23.94	--
Sep-12	--	--	--	--	--	--	-133.4	-16.47	-1.6	12.88	1078.0	--	--	--
MLP04B														
Jul-11	--	--	--	--	--	--	-134.3	-16.90	0.9	4.25	110.5	--	--	--
Aug-11	12.6	5.20	219	107	36	77.1	-135.2	-16.71	-1.5	9.69	243.7	-3.9	-25.88	13.8
May-12	13.5	5.54	214	93	36	89.5	-134.1	-16.77	0.1	7.25	708.6	--	--	--
Jul-12	12.1	5.23	113	111	44	--	-132.8	-16.76	1.2	9.90	501.5	--	-27.80	--
Sep-12	16.1	4.82	-25	106	37	68.0	-133.7	-16.65	-0.5	8.94	814.5	-6.8	-29.84	14.0
MLP04C														
Jul-11	--	--	--	--	--	--	-133.8	-16.88	1.2	8.46	167.2	--	--	--
Aug-11	15.1	4.56	241	71	4	119.0	-136.4	-16.92	-1.0	4.82	199.0	-6.8	-24.75	7.8
May-12	--	--	--	--	8	121.0	-132.4	-16.66	0.8	3.11	463.2	--	--	--
Jul-12	16.7	4.66	48	72	10	--	-133.7	-16.75	0.3	4.87	384.5	--	-32.95	--
Sep-12	17.4	4.52	80	73	--	108.0	-134.5	-16.92	0.9	6.21	588.3	--	--	--
MLP05A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-137.8	-17.65	3.4	6.97	931.8	0.0	-27.57	22.5
May-12	--	--	--	--	--	--	-138.5	-17.71	3.2	9.98	1322.8	--	--	--
Jul-12	--	--	--	--	--	--	-139.4	-17.87	3.5	8.62	943.3	--	--	--
Sep-12	--	--	--	--	--	--	-133.5	-17.17	3.8	--	1088.7	--	--	--

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	μS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLP05B														
Jul-11	--	--	--	--	--	--	-138.3	-17.77	3.9	2.19	371.9	--	--	--
Aug-11	12.4	5.76	185	--	112	67.1	-138.4	-17.60	2.4	6.86	493.4	-4.6	-42.40	11.1
May-12	9.8	5.79	250	263	106	70.8	-138.8	-17.75	3.2	7.38	1192.2	--	--	--
Jul-12	11.8	5.71	33	261	126	--	-138.8	-17.78	3.4	8.91	797.2	--	--	--
Sep-12	--	--	--	--	127	56.8	-138.2	-17.83	4.4	8.65	800.3	-7.3	-25.80	10.4
MLP05C														
Jul-11	--	--	--	--	--	--	-139.3	-17.83	3.3	2.51	304.4	--	--	--
Aug-11	12.7	5.50	191	144	20	73.9	-137.9	-17.62	3.0	0.24	420.4	-5.9	-26.30	9.0
May-12	9.8	5.62	284	154	56	84.1	-138.8	-17.67	2.5	8.07	699.7	--	--	--
Jul-12	12.4	5.48	-137	164	64	--	-138.8	-17.74	3.2	8.69	596.2	--	--	--
Sep-12	--	--	--	--	64	64.9	-137.0	-17.81	5.5	2.72	501.1	-10.5	-24.42	9.3
MLP05D														
Jul-11	--	--	--	--	--	--	-139.4	-17.87	3.6	-7.96	141.9	--	--	--
Aug-11	11.3	4.24	231	57	--	71.6	-137.9	-17.54	2.5	1.51	274.5	-7.5	-26.03	8.4
May-12	--	--	--	--	11	52.4	-138.6	-17.57	2.0	-0.04	295.7	--	--	--
Jul-12	15.2	4.71	30	56	0	--	-137.0	-17.61	3.9	2.86	389.2	-8.3	-27.92	9.3
Sep-12	--	--	--	--	8	99.4	-137.2	-17.78	5.0	5.94	537.7	-8.0	-31.16	7.6
MLP06A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	17.5	6.77	27	304		6.2	-141.5	-18.10	3.3	-14.94	342.9	--	--	--
May-12	--	--	--	--	--	--	-141.4	-18.44	6.1	-16.35	606.5	--	--	--
Jul-12	--	--	--	--	252	--	-140.7	-18.11	4.2	-12.93	389.7	--	-27.44	--
Sep-12	--	--	--	--	--	--	-140.4	-18.18	5.0	-8.57	516.3	--	--	--
MLP06B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	18.0	6.52	65	311	--	20.8	-140.0	-18.04	4.4	-14.24	402.3	0.6	-26.55	17.5
May-12	--	--	--	--	--	--	-142.0	-18.29	4.4	-5.53	508.2	--	--	--
Jul-12	--	--	--	--	137	--	-140.7	-18.14	4.4	-13.95	528.7	--	-28.00	--
Sep-12	--	--	--	--	--	--	-141.0	-18.17	4.3	-2.95	652.4	--	--	--
MLP07A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-139.9	-17.92	3.5	--	--	--	--	--
May-12	--	--	--	--	--	--	-142.8	-18.18	2.6	--	15.3	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP07B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-141.5	-18.00	2.5	-17.53	115.7	--	--	--
May-12	--	--	--	--	--	--	-143.3	-18.26	2.8	-17.97	121.3	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	-144.2	-18.30	2.2	-15.68	212.2	--	--	--

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	μS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLP08A														
Jul-11	--	--	--	--	--	--	-148.7	-19.45	6.9	9.73	121.1	--	--	--
Aug-11	13.7	5.58	43	145	48	50.7	-146.5	-19.02	5.6	-0.07	180.2	-13.4	-62.86	6.4
May-12	9.6	5.55	170	133	50	52.4	-148.4	-19.32	6.2	3.22	482.0	--	--	--
Jul-12	12.7	5.46	-215	132	59	--	-147.3	-19.43	8.1	5.00	272.8	0.1	-28.17	21.0
Sep-12	12.9	5.53	75	135	49	47.1	-147.0	-19.42	8.4	8.25	603.6		-28.31	--
MLP08B														
Jul-11	--	--	--	--	--	--	-148.5	-19.27	5.7	-4.62	61.9	--	--	--
Aug-11	16.0	4.60	209	48	--	59.8	-144.0	-18.61	4.9	-5.78	128.1	-1.7	-45.00	12.9
May-12	--	--	--	--	--	--	-145.5	-18.81	5.0	-5.97	282.5	--	--	--
Jul-12	--	--	--	--	4	--	-143.7	-18.81	6.8	-9.39	131.4	-1.0	-27.59	15.3
Sep-12	--	--	--	--	--	--	-145.0	-18.85	5.8	0.20	199.6	--	--	--
MLP09A														
Jul-11	--	--	--	--	--	--	-146.9	-19.24	7.0	4.17	73.1	--	--	--
Aug-11	15.7	5.41	147	89	--	53.6	-146.2	-19.06	6.3	1.34	419.0	-3.7	-30.42	12.7
May-12	--	--	--	--	--	--	-146.7	-19.16	6.6	-0.77	250.1	--	--	--
Jul-12	--	--	--	--	31	--	-145.7	-19.18	7.8	-0.89	243.9	-1.1	-27.60	18.6
Sep-12	--	--	--	--	--	48.0	-147.2	-19.15	6.0	8.21	143.9	--	--	--
MLP09B														
Jul-11	--	--	--	--	--	--	-144.3	-18.88	6.7	-7.93	61.7	--	--	--
Aug-11	15.4	4.18	239	46	--	74.4	-142.3	-18.28	4.0	-4.81	127.8	-2.6	-24.36	10.1
May-12	10.2	5.44	142	38	--	--	-142.4	-18.48	5.5	-0.25	350.5	--	--	--
Jul-12	16.9	4.25	--	--	0	--	-141.8	-18.45	5.8	-0.24	139.3	--	-25.28	--
Sep-12	13.4	4.40	--	57	--	63.0	-142.2	-18.45	5.4	2.39	258.6	--	--	--
MLP10A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-141.2	-18.56	7.3	3.51	520.2	-0.3	-25.64	20.9
May-12	12.1	7.61	14	--	--	--	-142.5	-18.52	5.7	8.28	818.0	--	--	--
Jul-12	--	--	--	--	--	--	-142.7	-18.59	6.1	7.84	1042.2	--	--	--
Sep-12	--	--	--	--	--	--	-141.8	-18.51	6.2	7.92	1361.5	--	--	--
MLP10B														
Jul-11	--	--	--	--	--	--	-142.3	-18.73	7.5	11.03	228.7	--	--	--
Aug-11	16.9	6.01	181	159	128	54.4	-141.2	-18.49	6.7	5.56	221.2	-10.1	-41.26	7.0
May-12	15.7	5.62	242	163	58	54.2	-141.3	-18.33	5.3	5.66	546.5	--	--	--
Jul-12	16.6	5.71	163	160	64	--	-141.6	-18.68	7.9	4.57	266.1	-8.4	-36.48	8.2
Sep-12	14.6	5.21	-66	161	71	51.2	-142.4	-18.63	6.7	4.86	601.3		-31.54	--
MLP10C														
Jul-11	--	--	--	--	--	--	-143.4	-18.78	6.9	-7.68	130.3	--	--	--
Aug-11	17.1	6.37	193	58	35	64.5	-140.7	-18.28	5.6	0.14	156.7	-4.2	-27.02	14.4
May-12	--	--	--	--	12	30.3	-142.2	-18.24	3.8	1.89	379.8	--	--	--
Jul-12	14.9	4.87	240	58	11	--	-141.2	-18.54	7.1	2.79	199.6	--	-29.18	--
Sep-12	16.7	4.60	14	57	--	65.3	-142.0	-18.54	6.3	4.25	593.9	--	--	--

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	µS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLP11A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-140.5	-18.13	4.5	3.19	682.8	-0.3	-26.99	16.0
May-12	12.1	7.84	--	1031	--	--	-141.5	-18.44	6.1	6.96	816.7	--	--	--
Jul-12	--	--	--	--	544	--	-140.9	-18.27	5.2	7.97	1241.1	-5.5	-24.18	16.1
Sep-12	--	--	--	--	--	--	-142.2	-18.19	3.3	8.65	1349.9	--	--	--
MLP11B														
Jul-11	--	--	--	--	--	--	-141.3	-18.34	5.4	0.88	285.5	--	--	--
Aug-11	15.0	7.09	173	144	60	60.1	-139.8	-18.26	6.2	8.10	348.7	-5.4	-26.02	9.4
May-12	10.1	5.46	231	139	49	67.3	-141.3	-18.41	6.0	7.33	878.8	--	--	--
Jul-12	17.5	5.31	4	140	59	--	-139.9	-18.24	6.0	5.46	311.9	-1.7	-27.44	17.2
Sep-12	13.0	5.06	216	144	54	54.8	-141.5	-18.26	4.6	7.50	749.1	-4.0	-27.15	9.6
MLP11C														
Jul-11	--	--	--	--	--	--	-144.2	-18.78	6.1	-2.51	122.9	--	--	--
Aug-11	16.5	7.10	193	83	16	75.5	-140.0	-18.36	6.9	4.37	293.6	-6.8	-25.55	7.6
May-12	12.8	5.33	194	79	16	43.0	-141.9	-18.39	5.2	2.47	283.6	--	--	--
Jul-12	18.9	4.93	-31	--	16	--	-140.5	-18.31	6.0	6.05	365.5	--	-31.74	--
Sep-12	15.9	4.88	199	71	19	73.1	-141.6	-18.19	3.9	7.87	515.9	-6.3	-29.56	8.3
MLP12A														
Jul-11	--	--	--	--	--	--	-144.4	-18.46	3.2	-11.21	49.6	--	--	--
Aug-11	--	--	--	--		--	-136.9	-17.38	2.2	10.14	267.6	-2.6	-27.25	18.7
May-12	--	--	--	--	--	--	-137.4	-17.29	1.0	6.42	682.3	--	--	--
Jul-12	--	--	--	--	41	--	-135.9	-17.23	1.9	10.09	383.6	-4.5	-25.97	16.8
Sep-12	--	--	--	--	--	--	-136.4	-17.13	0.6	10.86	438.5	--	--	--
MLP12B														
Jul-11	--	--	--	--	--	--	-134.0	-17.04	2.3	-7.18	299.0	--	--	--
Aug-11	--	--	--	--	24	71.0	-135.8	-17.08	0.9	-1.28	311.6	-4.6	-26.77	10.8
May-12	11.0	5.18	201	89	22	52.4	-135.6	-17.16	1.7	7.95	573.8	--	--	--
Jul-12	15.2	5.10	-65	94	30	--	-133.1	-16.72	0.6	7.12	488.7	-7.3	-30.79	8.6
Sep-12	14.5	4.62	-59	89	31	72.2	-134.7	-16.79	-0.4	9.46	403.2	-7.3	-30.34	7.4
MLP13A														
Jul-11	--	--	--	--	--	--	--	--	0.0	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-138.2	-17.78	4.0	-25.44	174.1	--	--	--
May-12	--	--	--	--	--	--	-137.0	-17.75	5.0	-20.53	1014.9	--	--	--
Jul-12	--	--	--	--	--	--	-136.6	-17.56	3.9	-18.14	973.3	--	-25.54	--
Sep-12	--	--	--	--	--	--	-137.7	-17.59	3.0	-17.32	994.3	--	--	--
MLP13B														
Jul-11	--	--	--	--	--	--	-128.1	-16.73	5.7	-14.40	200.2	--	--	--
Aug-11	--	--	--	--	96	41.4	-136.5	-17.51	3.6	-13.87	351.9	3.6	-26.15	18.3
May-12	14.5	5.92	109	236	--	--	-136.2	-17.42	3.1	-16.88	863.5	--	--	--
Jul-12	19.2	5.61	--	--	93	--	-136.1	-17.44	3.4	-12.57	451.7	--	-25.48	--
Sep-12	19.0	5.69	-85	253	--	18.8	-137.3	-17.41	1.9	-15.49	979.4	--	--	--

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	µS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLP14A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	-135.5	-17.37	3.5	-18.62	110.9	--	--	--
MLP14B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	-141.9	-18.40	5.3	-15.22	52.6	--	--	--
Jul-12	--	--	--	--	--	--	-138.2	-17.73	3.6	-15.19	72.8	--	--	--
Sep-12	--	--	--	--	--	--	-144.7	-18.58	3.9	-14.92	123.1	--	--	--
MLP15A														
Jul-11	--	--	--	--	--	--	-134.8	-17.11	2.2	8.29	691.0	--	--	--
Aug-11	--	--	--	--	--	--	-138.8	-17.51	1.3	3.86	1112.9	0.6	-58.09	15.0
May-12	9.7	7.88	96	936	--	--	-139.3	-17.65	1.8	14.26	1357.5	--	--	--
Jul-12	--	--	--	--	584	--	-139.3	-17.51	0.8	11.89	899.7	-4.0	-16.57	29.1
Sep-12	--	--	--	--	--	33.9	-138.7	-17.59	2.0	12.84	1325.2	--	--	--
MLP15B														
Jul-11	--	--	--	--	--	--	-136.3	-17.19	1.2	9.59	274.5	--	--	--
Aug-11	11.3	5.53	254	174	60	73.7	-135.5	-17.28	2.7	5.28	225.7	-3.8	-31.22	14.0
May-12	10.4	5.47	165	165	65	81.4	-136.6	-17.33	2.0	4.63	516.9	--	--	--
Jul-12	14.6	5.42	224	170	70	--	-135.4	-17.28	2.8	6.84	499.9	-3.6	-28.04	13.7
Sep-12	14.6	5.36	-7	175	54	72.2	-136.1	-17.32	2.4	11.78	312.8	-4.3	-27.90	12.4
MLP15C														
Jul-11	--	--	--	--	--	--	-128.7	-16.65	4.5	-11.16	205.3	--	--	--
Aug-11	12.5	4.47	255	54	2	126.0	-133.9	-17.31	4.6	-2.52	299.3	-5.7	-26.83	7.3
May-12	10.5	5.70	--	52	--	--	-139.4	-17.84	3.4	0.46	616.3	--	--	--
Jul-12	--	--	--	--	7	--	-134.8	-17.21	2.9	2.81	477.3	-3.8	-27.93	9.6
Sep-12	17.4	5.02	--	104	--	95.1	-135.4	-17.31	3.1	4.77	590.8	--	--	--
MLP16A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-141.9	-18.64	7.2	-3.86	504.8	-1.0	-27.46	11.2
May-12	9.9	7.34	103	846	--	--	-143.5	-18.59	5.2	5.84	594.5	--	--	--
Jul-12	--	--	--	--	--	--	-143.1	-18.71	6.6	8.70	1034.9	--	-26.11	--
Sep-12	--	--	--	--	--	--	-142.7	-18.59	6.0	10.49	1101.9	--	--	--
MLP16B														
Jul-11	--	--	--	--	--	--	-140.1	-17.96	3.6	4.68	100.7	--	--	--
Aug-11	10.2	5.37	174	64	28	59.6	-140.1	-18.18	5.4	0.65	149.3	-5.3	-35.65	8.0
May-12	12.5	5.22	209	93	30	56.8	-140.9	-18.20	4.8	3.22	459.7	--	--	--
Jul-12	9.8	5.33	164	98	26	--	-140.6	-18.21	5.1	1.66	344.0	-1.6	-28.17	13.2
Sep-12	14.7	5.08	35	96	32	51.6	-141.1	-17.98	2.7	8.21	678.8	-0.8	-27.49	12.7

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	μS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
MLP16C														
Jul-11	--	--	--	--	--	--	-134.6	-17.20	3.0	-10.11	331.1	--	--	--
Aug-11	11.6	4.20	233	34	--	61.4	-135.6	-17.48	4.2	-1.78	211.4	-4.6	-25.62	7.1
May-12	--	--	--	--	14	34.5	-138.6	-17.46	1.0	1.16	241.7	--	--	--
Jul-12	--	--	--	--	0	--	-135.5	-17.35	3.3	5.92	298.3	-4.1	-27.01	9.7
Sep-12	16.0	4.49	8	37	6	56.1	-135.9	-17.12	1.1	7.00	566.4	-3.0	-29.86	8.5
MLP17A														
Jul-11	--	--	--	--	--	--	-123.9	-16.08	4.7	8.92	150.2	--	--	--
Aug-11	12.5	6.55	125	135	128	16.8	-133.0	-17.15	4.2	6.67	226.8	-2.7	-26.93	14.7
May-12	10.9	6.77	15	491	190	12.6	-133.8	-16.95	1.7	4.43	553.5	--	--	--
Jul-12	9.3	6.62	-139	484	192	--	-134.4	-17.03	1.8	4.84	318.1	0.4	-26.97	37.2
Sep-12	--	6.63	-183	575	230	20.9	-133.9	-16.84	0.9	5.59	959.2	--	-26.74	--
MLP17B														
Jul-11	--	--	--	--	--	--	-133.4	-17.06	3.1	1.47	124.8	--	--	--
Aug-11	12.3	5.58	180	45	26	37.8	-134.1	-17.32	4.5	0.57	194.1	-0.1	-27.62	10.9
May-12	--	--	--	--	--	--	-132.8	-16.92	2.6	0.93	90.2	--	--	--
Jul-12	--	--	--	--	--	--	-133.2	-16.97	2.6	4.64	242.1	0.5	-27.58	14.2
Sep-12	--	6.00	--	--	--	--	-133.5	-16.86	1.4	4.68	206.7	--	--	--
MLP17C														
Jul-11	--	--	--	--	--	--	-136.2	-17.23	1.7	-4.53	77.2	--	--	--
Aug-11	12.9	4.33	243	9	3	45.3	-136.8	-17.63	4.3	-5.58	170.8	-2.7	-24.87	11.7
May-12	11.1	4.27	192	20	0	39.6	-133.9	-17.02	2.2	1.79	257.6	--	--	--
Jul-12	15.3	4.57	159	30	0	--	-136.2	-17.36	2.7	1.16	220.1	--	-29.45	--
Sep-12	19.1	4.28	61	20	0	39.6	-130.7	-16.99	5.2	2.40	300.7	-6.5	-26.70	7.7
MLP18A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	-139.4	-17.85	3.4	-13.08	43.0	--	--	--
May-12	--	--	--	--	--	--	-132.8	-16.46	-1.1	-6.45	335.7	--	--	--
Jul-12	--	--	--	--	--	--	-133.1	-16.31	-2.6	2.03	310.4	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP18B														
Jul-11	--	--	--	--	--	--	-135.2	-17.00	0.8	2.33	141.8	--	--	--
Aug-11	14.5	5.67	135	70	--	--	-133.6	-16.71	0.1	6.94	293.6	--	-27.74	--
May-12	--	--	--	--	--	--	-132.3	-16.65	0.9	3.68	261.8	--	--	--
Jul-12	--	--	--	--	--	--	-132.0	-16.35	-1.2	9.46	425.0	1.2	-27.41	18.7
Sep-12	--	--	--	--	--	--	-132.4	-16.83	2.2	16.46	430.9	--	--	--
MLP18C														
Jul-11	--	--	--	--	--	--	-132.7	-16.84	2.0	5.05	123.5	--	--	--
Aug-11	11.8	5.23	186	59	18	56.2	-135.0	-17.10	1.8	4.39	184.4	-6.7	-25.08	6.6
May-12	8.6	5.05	196	60	17	57.6	-135.2	-17.17	2.2	6.96	569.8	--	--	--
Jul-12	13.0	5.01	232	65	22	--	-132.9	-16.80	1.5	7.04	484.9	-5.2	-29.42	8.7
Sep-12	11.3	5.38	-78	71	19	49.4	-134.2	-17.04	2.1	8.14	607.0	-6.7	-33.45	7.4

Site ID	Temp ^{0}C	pH --	Eh mV	Cond µS/cm	Alk mg/L	DOC permil	d2H permil	d18O permil	d-ex permil	d13C DIC permil	DIC permil	d15N permil	d13C permil	C/N
MLP19A														
Jul-11	--	--	--	--	--	--	-140.9	-18.20	4.7	10.86	182.6	--	--	--
Aug-11	15.9	5.40	357	150	52	59.8	-138.6	-17.92	4.8	7.31	232.4	-4.7	-33.07	11.0
May-12	11.4	5.54	206	150	46	61.3	-140.2	-18.14	4.9	7.85	869.6	--	--	--
Jul-12	--	--	--	--	69	--	-139.4	-18.10	5.4	4.04	459.8	-6.3	-29.09	8.7
Sep-12	17.1	5.39	-161	152	58	60.7	-140.0	-18.12	5.0	10.55	252.0	-3.5	-27.58	14.4
MLP19B														
Jul-11	--	--	--	--	--	--	-140.4	-18.21	5.3	-11.07	162.0	--	--	--
Aug-11	16.2	4.08	376	34	--	84.9	-137.3	-17.89	5.8	-1.84	276.4	-5.9	-26.17	10.8
May-12	--	--	--	--	0	64.6	-139.9	-18.16	5.4	2.11	513.5	--	--	--
Jul-12	--	--	--	--	0	--	-138.5	-17.95	5.1	2.17	365.5	-7.9	-29.59	8.2
Sep-12	20.7	4.82	-65	48	--	81.1	-138.9	-17.92	4.4	3.78	427.6	--	--	--
ML Highway 63 Weir														
Apr-12	--	--	--	--	--	--	-151.5	-19.40	3.7	--	--	--	-27.84	--
Apr-12	--	--	--	--	--	27.0	--	--	--	--	--	--	-27.65	--
Aug-11	--	--	--	--	10	44.2	--	--	--	--	--	--	-28.00	--
May-12	--	--	--	--	--	--	-133.1	-16.86	1.8	-20.40	11.6	--	--	--
May-12	--	--	--	--	--	--	-133.2	-16.78	1.0	-22.21	26.6	--	--	--
May-12	--	--	--	--	--	42.2	-133.3	-16.90	1.9	--	7.4	--	--	--
May-12	--	--	--	--	--	--	-133.4	-16.81	1.1	--	9.0	--	--	--
Jul-12	--	--	--	--	0	--	-119.1	-15.26	3.0	-17.47	43.6	--	--	--
Jul-12	--	--	--	--	--	--	-121.0	-15.59	3.7	-15.86	40.7	--	--	--
Jul-12	--	--	--	--	--	--	-122.6	-15.51	1.5	--	39.4	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	12.9	4.30	274	24	0	40.9	-108.7	-15.04	11.6	-23.95	24.5		-28.18	--
Sep-12	--	--	--	--	0	38.7	-115.3	-14.87	3.7	--	41.1		-28.40	
ML Access Road Culvert														
Aug-11	--	--	--	--	10	45.3	--	--	--	--	--	-1.6	-28.55	27.9
Apr-12	--	--	--	--	--	--	-155.1	-19.78	3.1	--	--	--	--	--
Apr-12	--	--	--	--	--	--	-155.2	-19.94	4.3	--	--	--	--	--
May-12	15.1	4.18	226	14	0	--	-134.1	-17.12	2.8	-16.41	79.7	--	--	--
May-12	--	--	--	--	--	--	-135.0	-17.14	2.1	-17.48	94.9	--	--	--
Jul-12	--	--	--	--	0	--	-128.4	-16.01	-0.3	-19.30	45.8	--	--	--
Jul-12	--	--	--	--	--	--	-119.7	-15.51	4.4	-20.05	62.3	--	--	--
Sep-12	--	--	--	--	--	35.6	-113.7	-14.68	3.8	-21.07	33.3	--	--	--
ML Access Road Culvert (E)														
Jul-12	--	--	--	--	--	--	-120.8	-15.70	4.8	--	37.9	--	--	--
Jul-12	--	--	--	--	--	--	-121.9	-15.95	5.7	-20.09	65.3	--	--	--
Sep-12	--	--	--	--	0	37.8	-114.3	-14.79	4.1	-22.31	30.3		-27.83	

Site ID	Temp	pH	Eh	Cond	Alk	DOC	d2H	d18O	d-ex	d13C DIC	DIC	d15N	d13C	C/N
	^{0}C	--	mV	μS/cm	mg/L	permil	permil	permil	permil	permil	permil	permil	permil	
ML Rain Events														
18-Aug-11	--	--	--	--	--	--	--	--	--	--	--	-4.1	-24.80	8.3
12-Jun-12	--	--	--	--	--	--	-100.2	-12.39	-1.0	-23.11	60.2	--	--	--
12-Jun-12	--	--	--	--	--	--	-100.3	-12.35	-1.5	-23.22	56.1	--	--	--
25-Jul-12	--	--	--	--	6	--	-87.3	-11.58	5.4	-16.09	39.6	-1.4	-26.78	9.6
27-Jul-12	--	--	--	--	--	--	-88.7	-11.06	-0.3	-21.34	47.6	--	--	--
29-Jul-12	--	--	--	--	--	--	-117.8	-14.94	1.7	--	--	--	--	--
25-Jul-12	--	--	--	--	3	--	-113.3	-14.71	4.4	-17.92	60.4	--	-27.28	--
4-Aug-12	--	--	--	--	--	--	-132.4	-16.98	3.4	--	41.2	--	--	--
7-Sep-12	--	--	--	--	3	1.7	-105.9	-14.52	10.2	--	9.0	-0.3	-27.95	8.9
ML Bulk Rain														
(April to June 2012)	--	--	--	--	--	--	-130.8	-16.84	4.0	-20.86	11.3	--	--	--
(May - 18 July 2012)	--	--	--	--	29	--	-130.7	-17.24	7.3	-19.09	43.9	-0.5	-27.39	9.6
(17 July - 1 Sept 2012)	--	--	--	--	2	2.9	-102.1	-13.23	3.8	--	9.7	-1.8	-28.08	9.4
2012	--	--	--	--	4	2.0	-111.1	-14.50	4.8	--	28.5	-1.8	-27.41	10.8
Snow Survey														
MLA	--	--	--	--	--	--	-169.7	-21.86	5.2	--	--	--	-27.56	--
MLE	--	--	--	--	--	--	-168.6	-21.65	4.6	--	--	--	-28.30	--
MLO	--	--	--	--	--	--	-170.5	-22.15	6.7	--	--	--	-27.66	--
MLU	--	--	--	--	--	--	-172.0	-22.30	6.4	--	--	--	-24.00	--
MLP1	--	--	--	--	--	--	-175.1	-22.81	7.4	--	--	--	-26.32	--
MLP2	--	--	--	--	--	--	-173.8	-22.01	2.3	--	--	--	-26.14	--
MLP3	--	--	--	--	--	--	-171.3	-22.03	4.9	--	--	--	-27.01	--
MLP4	--	--	--	--	--	--	-166.4	-21.49	5.6	--	--	--	-27.17	--
MLP5	--	--	--	--	--	--	-179.7	-23.32	6.8	--	--	--	-27.15	--
MLP6	--	--	--	--	--	--	-172.8	-22.36	6.1	--	--	--	-27.08	--
MLP12	--	--	--	--	--	--	-175.3	-22.82	7.3	--	--	--	-26.35	--
MLP13	--	--	--	--	--	--	-172.9	-22.37	6.1	--	--	-2.6	-26.26	13.2
MLP14	--	--	--	--	--	--	-173.5	-22.58	7.1	--	--	--	-25.75	--
MLP16	--	--	--	--	--	--	-179.6	-23.56	8.9	--	--	--	-26.95	--
MLP17	--	--	--	--	--	--	-171.0	-22.09	5.7	--	--	--	-26.93	--
MLP18	--	--	--	--	--	--	-173.5	-22.42	5.9	--	--	--	-28.07	--
MLP19	--	--	--	--	--	--	-171.9	-22.37	7.0	--	--	--	-27.64	--
ML SHED	--	--	--	--	--	--	-168.4	-21.46	3.2	--	--	--	-25.87	--

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
precision	0.01	0.02 (5 H)	0.017	0.05	0.2	0.001	0.5	0.01	0.01	0.04	0.03	0.03	0.02	0.03
DL (QL)	0.02	0.02 (1 H)	0.03	0.05	0.2	0.005 (2 H)	4.9	0.01	0.01	0.01	0.01	0.01	0.01	0.01
MLA														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	0.41	0.92	0.00	0.0	--	--	< 0.05	0.84	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.31	2.72	0.05	0.2	0.000	0	0.00	0.24	< 0.05	< 0.05	< 0.05	0.26	0.13
Jul-12	--	0.06	1.46	0.08	0.1	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.10	0.79	0.08	1.6	0.008	0	< 0.1	0.25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLB														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.09	0.64	0.00	--	--	--	0.03	1.08	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.00	0.01	1.97	0.12	0.2	0.000	0	< 0.05	0.09	< 0.05	< 0.05	< 0.05	< 0.05	0.14
Jul-12	--	0.07	0.83	0.09	1.6	0.006	0	--	--	--	--	--	--	--
Sep-12	0.01	--	1.47	0.13	0.5	0.000	0	< 0.1	0.18	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLC														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.06	1.98	0.00	--	--	--	< 0.05	0.66	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.02	> 3.30	0.09	0.0	0.000	0	0.01	0.16	< 0.05	< 0.05	< 0.05	< 0.05	0.15
Jul-12	--	0.10	2.24	0.04	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.05	1.69	0.23	1.7	0.000	0	< 0.1	0.27	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLD														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	0.02	0.13	0.10	0.1	--	0	< 0.05	0.94	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.02	0.02	0.44	0.09	0.2	0.000	0	0.01	0.14	< 0.05	< 0.05	0.01	< 0.05	0.07
Jul-12	--	0.11	2.15	0.12	1.2	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.01	0.67	0.16	0.6	0.000	0	< 0.1	0.40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLE														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	0.06	1.74	0.00	0.0	0.000	0	< 0.05	0.28	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.00	0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Jul-12	--	0.00	> 3.30	0.05	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	--	--	2.92	0.03	0.0	0.000	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLF														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.04	0.07	> 3.30	0.00	0.0	--	0	< 0.05	0.70	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.02	3.20	0.24	0.2	0.000	0	0.00	0.12	< 0.05	< 0.05	< 0.05	0.08	0.16
Jul-12	--	0.08	2.10	0.40	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.03	0.10	1.52	0.59	0.3	0.000	0	< 0.1	0.26	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLG														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	0.00	0.38	0.02	0.5	--	0	< 0.05	5.00	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.02	0.54	0.30	1.1	0.000	0	0.01	0.07	< 0.05	< 0.05	0.02	< 0.05	0.11
Jul-12	--	0.03	2.27	0.23	0.4	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.01	1.35	0.03	0.8	0.000	--	< 0.1	0.59	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLH														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	0.19	0.23	0.03	0.0	--	0	< 0.05	0.31	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.02	0.65	0.08	1.1	0.000	0	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	0.05
Jul-12	--	0.02	0.30	0.10	0.8	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.03	1.85	0.33	1.3	0.000	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLM														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.06	0.03	0.08	0.0	0.000	0	0.02	0.77	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	--	--	--	--	--	--	0.00	0.08	< 0.05	< 0.05	< 0.05	< 0.05	0.18
Jul-12	--	0.01	3.02	0.11	1.2	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.04	1.35	0.02	0.8	0.000	0	< 0.1	0.27	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLN														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	0.09	2.80	0.00	0.0	0.000	0	< 0.05	0.65	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.01	0.32	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Jul-12	--	0.04	2.95	0.00	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.08	2.77	0.03	0.0	0.000	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLO														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.03	0.09	1.30	0 0	0 0	--	0 0	0.02	1.91	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.26	> 3.30	1.90	0.0	0.000	0	0.03	0.24	< 0.05	< 0.05	< 0.05	1.05	0.23
Jul-12	--	0.17	> 3.30	0.54	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.03	0.06	0.75	0.11	2.2	0.000	0	< 0.1	0.21	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.03	0.07	0.78	0.07	0.0	--	--	0.02	0.89	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.02	0.05	1.85	0.61	0.0	0.000	0	0.01	0.18	< 0.05	< 0.05	< 0.05	0.19	0.18
Jul-12	--	0.10	3.11	0.38	1.6	0.000	0	--	--	--	--	--	--	--
Sep-12	0.04	0.09	1.56	0.84	0.8	0.000	0	< 0.1	0.21	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLQ														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	0.52	1.38	0.04	0.0	--	0	< 0.05	0.50	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.00	0.03	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Jul-12	--	0.01	2.02	0.02	0.5	0.000	0	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	0.08	1.34	0.10	0.0	0.000	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLR														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	0.50	1.35	0.19	0.0	--	0	< 0.05	0.47	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.01	0.18	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Jul-12	--	0.06	3.80	0.00	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.03	1.12	0.16	0.3	0.000	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLS														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.03	2.35	0.00	--	--	--	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.02	0.03	2.58	0.00	0.0	0.000	0	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Jul-12	--	0.01	1.26	0.06	1.4	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.01	1.52	0.09	0.6	0.000	0	< 0.1	0.25	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLT														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	0.06	1.71	0.02	1.0	--	--	< 0.05	0.44	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.02	0.05	1.63	0.15	1.2	0.000	0	< 0.05	0.17	< 0.05	< 0.05	< 0.05	< 0.05	0.15
Jul-12	--	0.06	0.74	0.12	0.9	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.08	1.16	0.27	0.6	0.000	0	< 0.1	0.35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLU														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.05	1.77	0.00	--	--	--	0.02	0.19	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.01	0.07	< 0.05	< 0.05	< 0.05	0.12	0.06
Jul-12	--	0.03	3.94	0.18	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.02	0.00	2.02	0.39	0.0	0.000	0	< 0.1	0.04	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLV														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	0.03	0.85	0.00	--	--	--	< 0.05	1.57	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.04	1.78	0.10	0.0	0.000	0	< 0.05	0.20	< 0.05	< 0.05	< 0.05	< 0.05	0.16
Jul-12	--	0.05	1.82	0.10	1.3	0.000	0	--	--	--	--	--	--	--
Sep-12	0.03	0.06	0.95	0.23	2.7	0.018	0	< 0.1	0.27	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP01A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	0.04	0.41	< 0.05	< 0.05	0.19	0.52	0.14
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP01B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	0.00	--	0.34	1.8	0.004	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.03	0.00	--	--	--	--	--	0.00	0.04	< 0.1	< 0.1	< 0.1	< 0.1	0.22
MLP02A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	0.64	--	0.10	0.3	--	--	0.08	4.37	< 0.05	< 0.05	0.12	1.04	< 0.05
Jul-12	--	--	--	--	--	--	--	0.03	0.99	< 0.05	< 0.05	0.08	0.81	0.19
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLP02B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	1.29	1.66	0.09	0.6	0.004	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.00	0.00	--	--	--	--	--	0.00	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.22
MLP03A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	0.17	0.09	< 0.05	< 0.05	0.05	0.38	0.11
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP03B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	0.01	0.03	0.20	1.7	0.000	1	0.12	2.46	< 0.05	< 0.05	< 0.05	< 0.05	0.35
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.02	0.00	--	--	--	--	--	0.01	0.06	< 0.1	< 0.1	< 0.1	< 0.1	0.05
MLP04A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	6.44	--	0.00	0.0	--	10	0.05	0.29	< 0.05	< 0.05	< 0.05	< 0.05	0.06
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP04B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	2.72	2.13	1.28	0.0	--	0	< 0.05	0.36	< 0.05	< 0.05	< 0.05	1.11	0.16
May-12	0.03	10.30	2.57	1.67	0.0	0.000	0	0.02	0.30	< 0.05	< 0.05	< 0.05	1.41	< 0.05
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.02	6.44	1.63	1.57	0.0	0.000	0	< 0.1	0.05	< 0.1	< 0.1	< 0.1	0.78	< 0.1
MLP04C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.03	2.00	0.68	0.94	0.0	--	0	< 0.05	0.36	< 0.05	< 0.05	< 0.05	0.40	0.03
May-12	0.04	6.44	0.76	1.15	0.0	0.000	0	0.01	0.21	< 0.05	< 0.05	0.02	0.45	0.04
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	7.73	1.08	1.18	0.0	0.000	0	< 0.1	0.09	< 0.1	< 0.1	< 0.1	0.33	< 0.1
MLP05A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	0.01	6.44	--	0.17	0.7	--	--	0.03	2.15	< 0.05	< 0.05	0.07	0.20	0.80
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	37.35	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLP05B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	5.44	0.04	1.53	0.0	--	0	< 0.05	0.86	< 0.05	< 0.05	< 0.05	0.42	0.03
May-12	0.03	24.47	0.50	2.41	0.0	0.000	0	0.02	0.27	< 0.05	< 0.05	< 0.05	1.99	< 0.05
Jul-12	--	20.61	0.33	2.51	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	--	19.32	0.31	2.33	0.5	0.007	0	0.00	< 0.1	< 0.1	< 0.1	< 0.1	0.14	< 0.1
MLP05C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	5.76	0.08	0.92	0.0	--	--	0.08	1.36	< 0.05	< 0.05	< 0.05	0.36	0.03
May-12	0.01	15.46	0.67	1.41	0.0	0.000	0	0.01	0.08	< 0.05	< 0.05	< 0.05	1.26	< 0.05
Jul-12	--	14.17	0.73	1.58	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	--	9.02	0.37	0.74	0.0	0.000	0	< 0.1	0.11	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP05D														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	1.60	0.26	0.77	0.0	--	0	< 0.05	0.16	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.02	2.58	0.23	0.22	0.3	0.000	0	< 0.05	1.58	< 0.05	< 0.05	< 0.05	< 0.05	0.03
Jul-12	--	6.44	0.36	1.08	0.3	0.000	0	--	--	--	--	--	--	--
Sep-12	--	5.15	0.40	0.89	1.3	0.005	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.03	< 0.1
MLP06A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	0.00	--	--	2.1	--	--	0.18	0.56	< 0.05	< 0.05	0.03	1.54	< 0.05
MLP06B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	0.00	--	--	--	--	--	--	--	--	--	--	--	--
MLP07A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP07B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLP08A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	12.00	0.17	0.80	0.0	--	--	< 0.05	0.72	< 0.05	< 0.05	< 0.05	0.58	< 0.05
May-12	--	--	--	--	--	--	--	0.02	0.14	< 0.05	< 0.05	< 0.05	0.77	0.03
Jul-12	--	11.59	--	--	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.02	11.59	0.69	1.37	0.0	0.000	0	< 0.1	0.08	< 0.1	< 0.1	< 0.1	0.70	< 0.1
MLP08B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	1.29	--	--	1.3	--	--	--	--	--	--	--	--	--
MLP09A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	0.03	0.69	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.01	2.60	< 0.05	< 0.05	< 0.05	< 0.05	0.81
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	3.86	1.08	0.30	0.0	0.000	0	< 0.1	0.30	< 0.1	< 0.1	< 0.1	< 0.1	0.08
MLP09B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	2.08	0.31	0.18	0.0	--	--	< 0.05	0.69	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.00	1.35	< 0.05	< 0.05	< 0.05	< 0.05	0.22
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.01	0.00	0.47	0.52	1.6	0.007	0	< 0.1	0.22	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP10A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	0.00	--	--	--	--	--	--	0.06	0.40	< 0.05	< 0.05	< 0.05	< 0.05	0.09
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	28.34	--	--	0.0	--	--	--	--	--	--	--	--	--
MLP10B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	10.72	0.14	1.10	--	--	--	0.03	0.83	< 0.05	< 0.05	< 0.05	1.05	< 0.05
May-12	0.00	15.46	0.12	1.78	0.0	0.000	0	0.01	1.59	< 0.05	< 0.05	0.02	0.78	0.39
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.01	12.88	0.18	1.02	0.3	0.000	0	< 0.1	0.24	< 0.1	< 0.1	< 0.1	0.83	< 0.1
MLP10C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	4.16	0.15	0.50	--	--	--	< 0.05	0.36	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.00	2.58	0.28	0.31	0.9	0.000	0	0.01	2.15	< 0.05	< 0.05	< 0.05	0.30	0.56
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.01	3.86	0.30	0.93	1.3	0.000	0	< 0.1	0.14	< 0.1	< 0.1	< 0.1	0.37	< 0.1

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLP11A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	0.06	0.27	< 0.05	< 0.05	< 0.05	< 0.05	0.27
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	27.05		0.31	0.0	--	--	--	--	--	--	--	--	--
MLP11B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	1.60	0.33	1.17	--	--	0	0.02	0.54	< 0.05	< 0.05	< 0.05	0.58	< 0.05
May-12	0.00	14.17	0.74	1.77	0.0	0.000	0	0.01	0.12	< 0.05	< 0.05	< 0.05	1.48	0.07
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.01	--	0.70	1.63	0.9	0.028	0	0.03	0.04	< 0.1	< 0.1	< 0.1	1.08	< 0.1
MLP11C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	7.36	0.23	0.44	--	--	0	< 0.05	0.66	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.02	5.15	0.41	0.18	0.0	0.000	0	0.01	1.81	< 0.05	< 0.05	< 0.05	0.10	0.14
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	0.70	0.82	0.7	0.000	0	< 0.1	0.05	< 0.1	< 0.1	< 0.1	0.40	< 0.1
MLP12A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	0.04	0.86	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.00	6.88	< 0.05	< 0.05	0.14	0.48	0.95
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	6.44	--	--	0.7	--	--	0.03	0.90	< 0.1	< 0.1	< 0.1	1.34	< 0.1
MLP12B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	9.12	2.21	1.00	0.0	--	--	0.07	0.90	< 0.05	< 0.05	< 0.05	0.36	< 0.05
May-12	0.02	6.44	2.39	0.73	0.4	0.000	0	0.02	1.39	< 0.05	< 0.05	< 0.05	0.93	0.18
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	0.04	1.86	1.65	0.0	0.000	0	< 0.1	0.05	< 0.1	< 0.1	< 0.1	0.88	< 0.1
MLP13A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	0.53	0.41	< 0.05	< 0.05	< 0.05	< 0.05	1.19
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	0.00	--	--	0.0	--	--	0.50	0.51	< 0.1	< 0.1	< 0.1	< 0.1	0.35
MLP13B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	0.02	1.56	0.01	0.1	--	--	0.15	0.34	< 0.05	< 0.05	< 0.05	< 0.05	0.77
May-12	--	0.00	> 3.30	0.17	0.9	0.000	0	0.17	0.07	< 0.05	< 0.05	< 0.05	0.25	0.17
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.12	0.00	> 3.30	1.12	2.7	0.008	--	0.14	0.03	< 0.1	< 0.1	< 0.1	0.23	0.68

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLP14A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP14B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP15A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	0.08	0.23	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Jul-12	--	27.05	> 3.30	0.00	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.01	24.47	--	--	--	--	--	0.06	1.41	< 0.1	< 0.1	< 0.1	< 0.1	0.73
MLP15B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	1.60	0.14	0.81	0.5	--	0	< 0.05	0.55	< 0.05	< 0.05	< 0.05	0.55	< 0.05
May-12	--	--	--	--	--	--	--	0.01	0.30	< 0.05	< 0.05	< 0.05	0.53	0.11
Jul-12	--	14.17	0.41	1.32	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.03	14.17	0.42	0.82	0.0	0.000	0	< 0.1	0.08	< 0.1	< 0.1	< 0.1	0.58	< 0.1
MLP15C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.04	2.76	1.26	0.43	0.0	--	0	0.02	0.36	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	--	0.01	2.11	< 0.05	< 0.05	< 0.05	< 0.05	0.23
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.03	5.15	1.28	0.43	0.0	0.000	0	< 0.1	0.06	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP16A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	0.10	0.27	< 0.05	< 0.05	< 0.05	< 0.05	0.11
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	18.03	--	--	0.4	--	--	0.08	1.02	< 0.1	< 0.1	< 0.1	< 0.1	0.37
MLP16B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	4.64	0.18	0.84	0.0	--	0	< 0.05	0.31	< 0.05	< 0.05	< 0.05	0.56	< 0.05
May-12	--	--	--	--	--	--	--	0.01	0.11	< 0.05	< 0.05	< 0.05	1.00	0.13
Jul-12	--	10.30	0.92	1.48	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.01	7.73	2.16	0.99	0.0	0.000	0	< 0.1	0.07	< 0.1	< 0.1	< 0.1	0.64	< 0.1

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLP16C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	0.77	0.37	0.60	0.4	--	0	< 0.05	0.42	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.00	--	--	--	--	--	--	0.01	1.69	< 0.05	< 0.05	< 0.05	0.06	0.40
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	2.58	0.54	0.26	0.8	0.000	0	< 0.1	0.03	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP17A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.03	2.80	> 3.30	0.00	0 (0)	--	0	0.05	0.49	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	1.29	2.59	0.48	0.0	0.000	0	0.03	0.13	< 0.05	< 0.05	< 0.05	< 0.05	0.11
Jul-12	--	0.00	> 3.30	--	--	--	0	--	--	--	--	--	--	--
Sep-12	--	2.58	--	--	0.0	--	--	0.03	0.04	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP17B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	2.58	--	--	0.0	--	--	< 0.2	0.39	< 0.05	< 0.05	0.08	0.17	< 0.05
MLP17C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	0.21	0.27	0.03	0.3	0.000	0	< 0.05	0.32	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	0.23	0.21	0.09	0.6	0.000	0	< 0.05	0.08	< 0.05	< 0.05	0.01	< 0.05	0.11
Jul-12	--	0.21	0.39	0.13	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	--	0.16	0.49	0.15	1.1	0.009	0	< 0.1	0.10	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
MLP18A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP18B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	0.03	3.20	< 0.05	< 0.05	< 0.05	< 0.05	0.26
May-12	--	3.86	> 3.30	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	0.03	1.26	< 0.1	< 0.1	< 0.1	< 0.1	1.62
Sep-12	--	7.73	--	0.28	0.0	--	--	--	--	--	--	--	--	--
MLP18C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.00	3.04	0.84	0.47	0.0	--	0	< 0.05	0.12	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.01	5.15	1.85	0.48	0.0	0.000	0	0.02	0.17	< 0.05	< 0.05	< 0.05	0.22	0.08
Jul-12	--	5.15	1.57	0.66	0.0	0.000	0	< 0.1	0.03	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sep-12	--	3.86	0.97	0.62	1.1	0.000	0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.03	< 0.1

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
MLP19A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.02	5.92	0.14	1.05	0.0	--	0	< 0.05	0.15	< 0.05	< 0.05	< 0.05	0.79	< 0.05
May-12	0.02	15.46	0.08	1.46	0.3	0.000	0	0.01	0.52	< 0.05	< 0.05	< 0.05	1.13	0.09
Jul-12	--	16.74	0.23	1.58	0.0	0.000	0	--	--	--	--	--	--	--
Sep-12	0.03	10.30	0.27	0.43	0.0	0.000	0	< 0.1	0.04	< 0.1	< 0.1	< 0.1	0.89	< 0.1
MLP19B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	2.88	0.42	0.05	0.3	--	--	< 0.05	0.83	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	0.00	2.58	0.35	0.26	0.9	0.000	0	0.01	0.50	< 0.05	< 0.05	< 0.05	< 0.05	0.04
Jul-12	--	1.29	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	2.58	0.48	0.29	0.4	0.000	0	< 0.1	0.06	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
ML Highway 63 Weir														
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Apr-12	--	--	--	--	--	--	--	0.01	3.20	< 0.05	0.01	0.01	0.02	0.80
Aug-11	0.02	0.03	0.17	0.03	0.3	--	0	< 0.05	0.46	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
May-12	--	--	--	--	--	--	0	0.01	0.04	< 0.05	< 0.05	< 0.05	< 0.05	0.11
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	0.02	0.03	0.32	0.06	0.0	0.000	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	0.01	0.24	0.03	0.0	--	0	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	0.02	0.17	0.26	0.4	0.000	0	< 0.1	0.39	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
Sep-12	--	--	--	--	--	--	--	0.00	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
ML Access Road Culvert														
Aug-11	0.06	0.04	0.08	0.15	0.0	--	--	0.06	1.11	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	0.04	0.15	0.27	0.0	0.000	0	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	< 0.1	0.04	< 0.1	< 0.1	< 0.1	0.01	0.02
ML Access Road Culvert (E)														
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

Site ID	H2S	NH4	Fe	PO4-3	NO3	NO2	SO4	Fluoride	Chloride	Nitrite	Bromide	Nitrate	Phosphate	Sulfate
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ML Rain Events														
18-Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
27-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
29-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4-Aug-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7-Sep-12	--	--	--	--	--	--	--	< 0.1	0.04	< 0.1	< 0.1	< 0.1	< 0.1	0.18
ML Bulk Rain														
(April to June 2012)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(May - 18 July 2012)	--	0.00	0.03	0.07	0.8	0.000	0	--	--	--	--	--	--	--
(17 July - 1 Sept 2012)	--	0.03	--	--	1.4	--	--	< 0.1	0.04	< 0.1	< 0.1	< 0.1	< 0.1	0.67
2012	--	0.00	--	--	0.9	--	--	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.04

	Site ID	Lac	OAC	OPr	HCO	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al
units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µ g/L	µ g/L	µ g/L
precision		0.01	0.01	0.02	0.02										
DL (QL)						.2 (.7)	.2 (.7)	.2 (.7)	.2 (.6)	.1 (.2)	.4 (1.2)	.3 (.8)	.005 (.02)	.08 (.3)	.05 (.2)
	MLA														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	--	--	--	--	1.27	0.85	0.37	1.66	3.76	0.22	2.61	< 0.005	79.70	65.82
	May-12	< 0.05	4.09	0.91	0.27	0.86	2.08	0.20	0.69	2.25	< 0.4	4.76	< 0.005	14.43	36.82
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 0.1	0.44	< 0.1	< 0.1	< 0.7	< 0.7	< 0.2	< 0.8	1.71	< 0.3	3.32	< 0.009	< 1	29.30
	MLB														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	--	--	--	--	2.50	0.61	0.66	2.20	2.27	0.29	5.71	< 0.005	211.80	89.20
	May-12	< 0.05	0.16	< 0.05	0.12	< 0.7	< 0.7	0.29	0.39	1.08	< 0.4	2.20	< 0.005	< 0.3	53.31
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 0.1	< 0.1	< 0.1	0.03	< 0.7	< 0.7	< 0.2	< 0.8	0.76	< 0.3	1.17	< 0.009	17.01	38.82
	MLC														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	--	--	--	--	1.81	0.54	0.50	1.09	1.75	0.33	11.57	0.04	79.83	123.60
	May-12	< 0.05	1.24	< 0.05	0.29	0.84	< 0.7	0.32	0.36	1.07	< 0.4	6.78	< 0.005	3.73	71.93
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 0.1	< 0.1	< 0.1	0.07	0.83	< 0.7	< 0.8	< 0.8	0.85	< 0.3	2.75	< 0.009	< 0.4	81.35
	MLD														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	--	--	--	--	1.54	1.70	0.52	1.93	4.17	0.41	0.50	< 0.005	66.07	92.14
	May-12	0.01	0.31	< 0.05	0.13	< 0.7	2.01	0.20	1.20	1.47	< 1.2	0.87	< 0.005	10.24	27.99
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	< 0.7	1.39	< 0.2	1.01	2.19	< 0.3	1.32	< 0.009	< 1	39.74
	MLE														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	--	--	--	--	2.75	0.25	0.60	0.63	5.20	0.27	5.88	< 0.005	25.99	110.70
	May-12	< 0.05	0.06	< 0.05	0.14	< 0.7	< 0.7	0.22	0.46	1.74	< 0.4	2.41	< 0.005	< 0.08	35.30
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 0.1	0.63	< 0.1	0.02	2.71	< 0.2	< 0.8	< 0.8	4.76	< 0.3	28.46	< 0.009	< 0.4	104.30
	MLF														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	--	--	--	--	2.32	1.33	0.81	1.21	2.33	0.42	7.25	< 0.005	77.53	169.80
	May-12	< 0.05	0.06	< 0.05	0.15	1.10	1.02	0.48	0.29	1.29	< 0.4	5.86	< 0.005	4.42	100.00
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 0.1	4.74	0.22	0.13	1.66	0.89	< 0.8	< 0.8	1.20	0.43	4.11	< 0.009	< 1	149.05
	MLG														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	--	--	--	--	0.85	4.89	0.42	1.07	2.22	0.24	2.99	< 0.005	15.09	112.60
	May-12	< 0.05	< 0.05	< 0.05	0.09	< 0.7	< 0.7	0.27	0.79	1.90	< 0.4	0.73	< 0.005	4.50	77.54
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 0.1	0.17	< 0.1	0.15	1.33	0.72	< 0.8	0.81	2.00	< 0.3	8.25	< 0.009	< 0.4	166.60

Site ID	Lac	OAC	OPr	HCO	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	μg/L	μg/L	μg/L
MLH														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	1.42	0.44	0.40	0.81	1.31	0.28	0.46	< 0.005	63.67	96.73
May-12	< 0.05	< 0.05	< 0.05	0.12	0.82	< 0.2	0.25	0.39	0.97	< 0.4	1.01	< 0.005	3.32	47.35
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	< 0.7	< 0.7	< 0.2	< 0.8	0.83	< 0.3	1.47	< 0.009	< 0.4	54.42
MLM														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	1.76	0.41	0.61	1.73	2.35	0.27	1.00	< 0.005	178.00	78.25
May-12	< 0.05	1.83	0.02	0.19	0.96	< 0.2	0.40	0.34	1.71	< 0.4	6.91	2.15	< 0.3	52.84
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	< 0.7	< 0.7	< 0.2	< 0.8	0.87	< 0.3	1.49	< 0.009	< 0.4	34.29
MLN														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	1.60	0.42	0.40	0.78	2.83	0.29	4.20	< 0.005	29.17	111.40
May-12	< 0.05	0.10	< 0.05	0.15	< 0.7	0.84	0.23	0.61	1.82	< 0.4	3.60	< 0.005	< 0.08	59.15
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	0.00	0.80	< 0.2	< 0.8	< 0.8	1.68	< 0.3	7.58	< 0.009	< 0.4	68.90
MLO														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	2.40	2.04	0.68	1.50	2.99	0.41	13.99	< 0.005	116.00	159.40
May-12	< 0.05	11.89	0.13	0.93	1.48	1.27	0.45	0.36	2.53	< 1.2	35.63	< 0.005	< 0.3	130.60
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	0.03	1.30	0.89	< 0.8	< 0.8	1.19	0.40	< 0.7	< 0.009	< 0.4	145.10
MLP														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	2.43	2.03	0.66	1.53	2.99	0.40	14.09	< 0.005	212.70	221.30
May-12	< 0.05	< 0.05	< 0.05	0.07	1.28	0.79	0.50	0.29	1.44	< 1.2	5.26	< 0.005	4.15	132.80
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	1.47	< 0.7	< 0.8	< 0.8	1.19	0.38	1.39	< 0.009	< 0.4	171.50
MLQ														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	4.39	0.53	0.91	0.40	6.87	0.34	5.61	< 0.005	9.02	157.20
May-12	< 0.05	< 0.05	< 0.05	0.08	< 0.7	1.13	0.23	0.59	2.21	< 0.4	1.94	< 0.005	< 0.08	72.62
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	0.00	< 0.1	0.00	1.32	< 0.2	< 0.8	< 0.8	1.82	< 0.3	3.28	< 0.009	< 0.4	75.18
MLR														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	2.83	0.32	0.51	0.95	6.11	0.31	3.03	< 0.005	20.22	223.10
May-12	< 0.05	0.03	< 0.05	0.05	< 0.7	1.11	0.22	0.65	1.56	< 0.4	5.17	< 0.005	< 0.3	74.42
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	0.76	< 0.7	< 0.8	< 0.8	1.82	< 0.3	5.46	< 0.009	< 0.4	77.43

Site ID	Lac	OAC	OPr	HCO	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	μg/L	μg/L	μg/L
MLS														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	1.74	0.14	0.40	0.65	3.27	0.32	5.12	< 0.005	24.89	162.80
May-12	< 0.05	0.64	< 0.05	0.18	1.52	< 0.7	0.32	0.55	2.72	< 0.4	6.71	< 0.005	< 0.3	127.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	0.03	1.12	< 0.7	< 0.8	< 0.8	1.73	< 0.3	2.37	< 0.009	< 1	117.20
MLT														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	1.64	0.94	0.49	0.63	1.98	0.34	2.91	< 0.005	20.20	162.00
May-12	< 0.05	0.23	< 0.05	0.12	0.95	1.11	0.33	0.44	1.52	< 0.4	2.95	< 0.005	3.39	101.90
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	1.08	1.18	< 0.8	< 0.8	1.22	0.36	1.44	< 0.009	< 0.4	134.50
MLU														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	2.55	0.16	0.65	1.08	5.57	0.36	3.38	< 0.005	38.27	255.40
May-12	< 0.05	3.00	0.12	0.36	1.81	< 0.7	0.57	0.73	4.81	< 0.4	7.84	< 0.005	< 0.08	183.60
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	2.12	< 0.1	0.10	2.97	< 0.2	< 0.8	0.80	6.80	0.41	13.94	< 0.009	< 0.4	244.10
MLV														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	1.65	1.52	0.47	0.89	2.32	0.33	2.11	< 0.005	41.32	192.30
May-12	< 0.05	< 0.05	< 0.05	0.07	0.86	< 0.7	0.30	0.36	1.66	< 0.4	2.91	< 0.005	< 0.3	90.22
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	0.53	< 0.1	0.04	< 0.7	1.18	< 0.8	< 0.8	1.54	0.35	< 0.7	< 0.009	< 0.4	149.40
MLP01A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.2	7.04	< 0.2	1.64	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP01B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	5.16	< 0.7	1.32	2.03	6.05	1.19	2.89	< 0.009	17.15	91.33
MLP02A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.2	< 0.2	< 0.2	< 0.2	24.96	< 0.7	< 0.2	8.73	2.70	< 0.2	< 0.2	< 0.008	21.16	52.38
Jul-12	< 0.2	2.81	< 0.2	3.33	375.80	8.44	< 0.2	66.41	< 0.2	9.95	< 0.2	< 0.008	39.96	161.00
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	Lac mg/L	OAC mg/L	OPr mg/L	HCO mg/L	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	S mg/L	Fe mg/L	Be µg/L	B µg/L	Al µg/L
MLP02B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	2.35	< 0.7	< 0.8	1.79	6.30	0.88	< 0.7	< 0.03	< 1	65.28
MLP03A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.2	4.17	< 0.2	0.50	630.40	11.01	< 0.2	136.20	0.48	16.04	< 0.2	< 0.008	< 0.5	78.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP03B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	< 0.05	< 0.05	0.01	5.26	< 0.2	0.88	5.87	6.38	< 0.4	0.26	< 0.02	10.30	47.14
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	--	--	--	--	--	--	--	--	--	--
MLP04A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	65.56	< 0.05	1.82	47.91	3.03	18.28	3.86	3.12	1.30	47.01	< 0.005	28.37	2.55
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP04B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	6.29	0.43	1.32	1.23	13.29	0.37	9.42	0.03	1.88	198.20
May-12	< 0.05	0.08	0.06	0.06	7.97	< 0.7	1.43	1.31	12.63	< 1.2	10.59	< 0.005	< 0.3	205.90
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	0.70	< 0.1	0.08	6.53	< 0.7	1.37	1.15	12.12	< 0.3	10.67	< 0.009	< 0.4	167.30
MLP04C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	4.42	1.12	1.14	1.05	11.19	0.37	1.56	0.15	12.59	179.40
May-12	< 0.05	< 0.05	< 0.05	0.06	4.74	0.80	0.93	0.71	8.59	< 1.2	1.44	< 0.005	< 0.08	142.80
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	4.33	< 0.7	1.10	0.79	10.75	0.37	1.78	< 0.009	< 0.4	169.30
MLP05A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	< 0.05	< 0.05	0.01	63.53	1.66	10.35	3.90	3.22	1.98	0.21	< 0.005	16.17	7.51
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	Lac mg/L	OAC mg/L	OPr mg/L	HCO mg/L	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	S mg/L	Fe mg/L	Be µg/L	B µg/L	Al µg/L
MLP05B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	24.53	1.10	4.65	1.50	5.90	0.74	0.32	< 0.005	71.42	34.64
May-12	< 0.05	< 0.05	0.06	0.03	23.64	0.89	4.55	0.60	5.18	< 1.2	0.95	< 0.005	7.45	33.16
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	22.88	0.78	4.76	< 0.8	5.32	0.54	< 0.7	< 0.009	< 1	13.41
MLP05C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	11.80	1.32	2.62	3.78	5.74	0.42	0.56	< 0.005	380.10	62.64
May-12	< 0.05	1.42	0.03	0.04	12.05	< 0.7	2.55	0.39	4.99	< 1.2	1.26	< 0.005	< 0.3	64.72
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	10.27	< 0.7	1.89	1.43	3.74	0.54	0.79	< 0.009	< 1	45.29
MLP05D														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	3.60	0.93	0.70	0.49	5.18	0.34	0.37	0.17	18.03	57.34
May-12	< 0.05	< 0.05	< 0.05	0.03	6.22	< 0.7	0.58	1.51	3.05	< 1.2	0.41	< 0.005	5.40	36.85
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	3.54	< 0.7	< 0.8	< 0.8	4.94	0.37	< 0.7	< 0.009	< 0.4	50.01
MLP06A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.2	3.71	< 0.2	< 0.2	49.37	< 0.1	16.69	< 0.8	11.39	< 0.2	< 0.2	< 0.008	< 2	3.64
MLP06B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP07A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP07B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	Lac	OAC	OPr	HCO	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	μg/L	μg/L	μg/L
MLP08A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	10.85	1.32	1.96	0.59	4.83	0.43	0.57	0.32	25.47	99.16
May-12	< 0.05	0.42	< 0.05	0.03	14.49	1.02	2.49	0.53	4.27	< 1.2	0.90	< 0.005	5.59	90.27
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	12.43	0.74	2.19	< 0.8	4.46	0.42	0.92	< 0.009	< 1	100.20
MLP08B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP09A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	7.43	0.94	1.66	1.13	4.20	0.39	1.54	0.20	43.29	105.10
May-12	< 0.05	< 0.05	< 0.05	< 0.05	4.81	1.50	1.05	3.07	2.14	< 1.2	0.82	< 0.005	8.55	54.65
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	7.86	< 0.7	1.76	< 0.8	3.87	0.41	1.66	< 0.009	< 1	93.77
MLP09B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	2.64	1.07	0.61	0.51	3.51	0.33	0.26	0.10	20.17	79.90
May-12	< 0.05	0.39	0.45	0.11	4.24	< 0.7	0.53	1.50	1.99	< 1.2	0.24	< 0.005	3.90	49.57
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	5.60	0.31	0.23	2.68	< 0.7	< 0.8	< 0.8	3.30	0.38	< 0.7	< 0.009	< 0.4	88.79
MLP10A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	16.40	< 0.05	8.09	179.90	1.64	31.63	2.14	12.96	4.32	35.08	2.68	36.20	5.05
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP10B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	13.22	0.85	3.02	0.77	4.48	0.41	0.49	< 0.005	31.68	10.81
May-12	< 0.05	0.59	< 0.05	0.03	11.04	< 0.7	2.47	1.27	3.36	< 1.2	0.48	< 0.005	6.51	9.62
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	13.41	< 0.7	2.95	< 0.8	4.14	0.35	< 0.7	< 0.009	< 1	10.87
MLP10C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	4.87	0.50	0.90	0.60	4.31	0.34	0.31	0.02	37.54	42.78
May-12	< 0.05	1.64	0.11	0.05	4.83	< 0.7	0.81	1.26	3.44	< 1.2	0.55	< 0.005	4.07	47.77
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	10.03	0.06	< 0.1	5.16	< 0.7	0.97	< 0.8	4.13	0.37	< 0.7	< 0.009	< 0.4	36.75

Site ID	Lac mg/L	OAC mg/L	OPr mg/L	HCO mg/L	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	S mg/L	Fe mg/L	Be µg/L	B µg/L	Al µg/L
MLP11A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	10.76	< 0.05	< 0.05	155.60	1.83	35.41	2.58	12.51	3.62	7.16	< 0.02	30.60	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP11B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	11.49	0.77	2.54	0.63	5.01	0.40	0.71	< 0.005	16.60	65.96
May-12	< 0.05	1.36	0.05	0.06	10.87	< 0.7	2.34	0.44	4.62	< 1.2	1.16	< 0.005	< 0.3	69.72
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	0.16	< 0.1	0.05	11.07	< 0.7	2.42	< 0.8	4.66	< 0.3	0.86	< 0.009	< 0.4	62.22
MLP11C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	6.70	0.92	1.27	0.71	5.00	0.35	1.10	< 0.005	24.67	49.00
May-12	< 0.05	< 0.05	< 0.05	0.03	7.11	< 0.7	1.10	1.49	3.72	< 1.2	0.84	< 0.005	4.91	46.86
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	0.90	< 0.1	< 0.1	6.02	< 0.7	1.15	< 0.8	4.61	0.34	0.87	< 0.009	30.18	44.10
MLP12A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	6.27	0.72	1.78	2.41	19.95	0.29	35.25	0.34	26.44	150.70
May-12	< 0.05	< 0.05	< 0.05	< 0.05	2.63	2.44	0.59	7.15	0.97	< 1.2	1.89	< 0.005	15.31	13.21
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	--	--	--	--	--	--	--	--	--	--
MLP12B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	7.01	0.52	1.60	2.61	9.98	0.34	3.91	< 0.005	108.40	109.10
May-12	< 0.05	2.36	0.11	0.12	7.07	< 0.7	1.38	1.45	7.59	< 1.2	3.40	< 0.005	3.97	84.54
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	1.70	< 0.1	0.28	6.81	< 0.2	1.57	< 0.8	9.14	< 0.3	4.59	< 0.009	< 1	102.50
MLP13A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	< 0.05	< 0.05	< 0.05	39.18	1.21	42.96	13.12	3.30	1.34	0.47	< 0.005	22.48	8.20
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	0.09	< 0.1	< 0.1	--	--	--	--	--	--	--	--	--	--
MLP13B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	18.60	0.21	8.38	4.31	10.73	0.88	12.60	0.11	54.41	103.50
May-12	< 0.05	0.73	0.33	0.08	21.66	< 0.2	9.93	4.29	9.23	< 1.2	18.92	< 0.02	22.18	187.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	15.10	< 0.2	6.61	4.01	11.85	2.38	13.40	< 0.03	26.20	151.50

Site ID	Lac	OAC	OPr	HCO	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L
MLP14A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP14B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP15A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	37.99	< 0.05	20.99	139.30	2.91	39.97	3.49	7.86	3.11	6.20	< 0.005	29.82	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.65	18.79	< 0.1	0.07	147.60	2.85	35.57	3.68	12.34	2.08	42.71	< 0.009	36.82	5.43
MLP15B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	15.03	0.83	3.67	0.71	9.35	0.55	0.50	< 0.005	22.31	32.69
May-12	< 0.05	9.18	< 0.05	0.40	14.86	< 0.7	3.46	0.61	8.60	< 1.2	0.47	< 0.005	5.66	33.92
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	14.94	< 0.7	3.50	< 0.8	8.95	0.44	< 0.7	< 0.009	< 1	32.24
MLP15C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	9.76	1.44	2.63	0.78	10.81	0.58	2.56	< 0.005	9.52	197.70
May-12	< 0.05	0.91	0.55	0.25	9.44	0.94	1.88	2.68	7.21	< 1.2	1.60	< 0.02	7.29	141.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	7.90	< 0.7	1.91	< 0.8	10.00	0.57	1.75	< 0.009	< 0.4	208.00
MLP16A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 0.05	17.54	< 0.05	0.04	73.23	1.24	36.94	3.19	5.38	2.02	8.43	< 0.02	21.93	4.22
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	0.26	36.56	< 0.1	0.05	90.76	1.88	38.01	3.80	6.52	1.29	8.03	< 0.009	21.11	5.12
MLP16B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	5.83	0.78	1.14	0.64	5.58	0.29	1.02	0.05	38.16	128.90
May-12	< 0.05	2.47	0.06	0.16	5.75	0.71	1.08	0.41	5.02	< 0.4	1.25	< 0.02	< 0.3	122.50
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	5.94	< 0.7	1.14	< 0.8	5.17	< 0.3	2.55	< 0.009	< 0.4	129.60

Site ID	Lac mg/L	OAC mg/L	OPr mg/L	HCO mg/L	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	S mg/L	Fe mg/L	Be µg/L	B µg/L	Al µg/L
MLP16C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	2.49	1.04	0.51	0.56	5.30	0.30	1.37	< 0.005	37.46	111.90
May-12	< 0.05	3.16	0.66	0.08	4.80	< 0.7	0.49	1.97	2.90	< 1.2	0.51	< 0.005	4.81	51.39
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	2.05	< 0.7	< 0.8	< 0.2	4.92	0.34	< 0.7	< 0.009	< 1	83.34
MLP17A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	14.09	0.90	4.43	2.79	16.83	0.35	45.87	< 0.005	99.82	1.67
May-12	< 0.05	3.20	< 0.05	0.19	14.80	0.71	4.35	1.31	13.70	< 1.2	113.50	< 0.02	15.31	7.34
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	1.37	< 0.1	0.04	14.33	< 0.7	4.30	1.91	19.24	< 0.3	137.20	< 0.03	19.15	9.32
MLP17B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.2	0.97	< 0.2	< 0.2	8.95	< 0.1	< 0.8	< 0.2	5.50	< 0.2	< 0.7	< 0.008	< 0.5	146.20
MLP17C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	2.46	0.22	0.53	1.20	2.76	0.23	1.11	< 0.005	104.60	97.54
May-12	< 0.05	< 0.05	< 0.05	0.04	1.88	< 0.2	0.37	0.39	2.05	< 0.4	0.36	< 0.005	< 0.3	50.66
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	0.03	2.90	< 0.2	< 0.8	< 0.8	2.72	< 0.3	< 0.7	< 0.009	< 0.4	62.99
MLP18A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP18B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	6.23	3.15	1.87	2.39	12.90	0.44	12.04	0.05	54.13	144.20
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	< 0.1	25.99	< 0.1	0.07	9.41	1.16	3.29	3.14	5.03	1.55	65.73	< 0.009	< 1	22.84
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP18C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	5.30	0.13	1.28	0.67	9.32	0.32	5.74	0.09	10.62	124.00
May-12	< 0.05	< 0.05	< 0.05	0.04	6.15	< 0.2	1.34	0.57	9.30	< 1.2	2.07	< 0.005	< 0.08	120.50
Jul-12	< 0.1	< 0.1	< 0.1	< 0.1	5.28	< 0.2	1.38	< 0.8	8.54	< 0.3	1.99	< 0.009	< 0.4	103.60
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	5.41	< 0.2	1.37	< 0.8	8.67	< 0.3	1.94	< 0.009	< 0.4	106.90

Site ID	Lac	OAC	OPr	HCO	Ca	K	Mg	Na	Si	S	Fe	Be	B	Al
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	µg/L	µg/L	µg/L
MLP19A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	11.51	0.29	2.31	0.84	4.98	0.47	0.44	< 0.005	35.78	22.84
May-12	< 0.05	0.22	< 0.05	0.02	10.67	< 0.7	2.06	0.87	4.15	< 1.2	0.33	< 0.005	7.62	20.49
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	11.88	< 0.2	2.31	< 0.8	4.63	0.45	< 0.7	< 0.009	< 1	21.90
MLP19B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	4.13	1.43	0.91	0.55	6.30	0.38	0.45	< 0.005	15.27	70.90
May-12	< 0.05	< 0.05	< 0.05	0.04	4.46	0.80	0.81	0.76	5.53	< 1.2	0.70	< 0.005	< 0.3	74.65
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	0.05	3.40	< 0.7	< 0.8	< 0.8	5.90	0.34	< 0.7	< 0.009	< 0.4	68.17
ML Highway 63 Weir														
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Apr-12	--	--	--	--	< 0.1	--	0.49	1.27	<0.327	< 0.2	0.73	<0.01	<0.7	110.80
Aug-11	--	--	--	--	1.79	0.10	0.66	0.71	1.93	0.25	1.16	< 0.005	10.32	141.70
May-12	< 0.05	< 0.05	< 0.05	0.05	1.33	< 0.2	0.54	0.54	1.22	< 0.4	0.64	< 0.005	< 0.3	134.90
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	1.76	< 0.7	< 0.8	< 0.8	1.76	< 0.3	1.02	< 0.009	< 0.4	162.30
Sep-12	< 0.1	< 0.1	< 0.1	0.00	2.00	< 0.7	< 0.8	1.19	1.76	< 0.3	0.94	< 0.009	33.08	155.65
ML Access Road Culvert														
Aug-11	--	--	--	--	2.91	0.38	1.03	2.25	4.51	0.32	5.92	< 0.005	116.30	392.20
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	0.98	< 0.7	< 0.8	< 0.8	1.50	< 0.3	1.36	< 0.009	19.44	150.70
ML Access Road Culvert (E)														
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	1.35	< 0.7	< 0.8	< 0.8	1.62	< 0.3	1.01	< 0.009	< 1	136.50

Site ID	Lac mg/L	OAC mg/L	OPr mg/L	HCO mg/L	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	Si mg/L	S mg/L	Fe mg/L	Be µg/L	B µg/L	Al µg/L
ML Rain Events														
18-Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
27-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
29-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4-Aug-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7-Sep-12	< 0.1	< 0.1	< 0.1	< 0.1	< 0.7	< 0.2	< 0.2	< 0.2	< 0.1	< 0.3	< 0.3	< 0.009	< 1	4.01
ML Bulk Rain														
(April to June 2012)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(May - 18 July 2012)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(17 July - 1 Sept 2012)	< 0.1	< 0.1	< 0.1	< 0.1	< 0.7	< 0.2	< 0.2	< 0.2	< 0.1	< 0.3	< 0.3	< 0.009	< 0.4	2.44
2012	< 0.1	< 0.1	< 0.1	< 0.1	< 0.7	< 0.2	< 0.2	< 0.2	< 0.1	< 0.3	< 0.3	< 0.009	< 0.4	2.28

	Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
units		µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
precision															
DL (QL)		4 (14)	2 (8)	.02 (.06)	.004 (.01)	.005 (.02)	.005 (.02)	.005 (.02)	.006 (.02)	.01 (.04)	.04 (.1)	.005 (.02)	.2 (.7)	.002 (.007)	.005 (.02)
	MLA														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	< 4	815.40	0.79	0.169	0.91	68.79	0.28	1.98	32.48	102.50	<0.005	< 0.2	5.26	< 0.005
	May-12	< 14	2164.00	0.97	0.153	0.90	113.80	1.63	5.00	158.30	301.50	2.16	< 0.2	3.47	2.21
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 2	419.80	2.09	0.304	0.92	91.66	0.62	2.27	12.69	< 0.9	< 0.03	< 0.2	1.00	0.33
	MLB														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	81.54	631.00	1.23	0.348	0.79	103.30	0.46	5.06	281.40	220.50	0.43	< 0.2	8.83	0.52
	May-12	< 4	476.60	0.90	0.304	0.76	71.10	1.45	1.86	0.56	6.47	0.29	< 0.2	2.23	0.26
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 2	424.80	< 0.1	< 0.008	0.38	71.06	0.21	0.81	< 0.05	< 0.9	< 0.03	< 0.2	1.37	0.53
	MLC														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	103.90	586.80	0.78	0.113	1.45	99.88	0.80	7.66	537.20	162.30	3.23	< 0.2	6.13	0.78
	May-12	< 4	530.50	1.17	0.602	1.33	96.79	1.29	5.20	3.20	6.13	0.61	< 0.2	2.71	0.88
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 2	401.50	< 0.1	< 0.008	0.58	57.99	0.59	1.95	4.76	< 0.9	0.31	< 0.2	2.67	0.25
	MLD														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	46.15	1732.00	1.60	0.106	0.51	86.43	0.26	0.70	355.30	101.80	0.92	< 0.2	7.05	< 0.005
	May-12	< 4	1897.00	0.65	0.324	0.67	79.95	1.26	0.57	10.76	21.79	0.41	< 0.2	0.84	< 0.02
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 2	1414.67	0.70	< 0.03	0.79	74.81	0.36	0.69	8.07	9.70	0.53	< 0.2	1.36	< 0.004
	MLE														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	24.22	288.00	0.90	< 0.004	0.53	72.79	0.55	2.27	24.39	42.49	1.06	< 0.2	10.87	0.22
	May-12	< 4	448.70	0.66	0.285	0.53	96.13	1.77	2.13	7.41	12.60	0.22	< 0.2	1.62	< 0.005
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 2	< 4	< 0.1	0.304	2.21	323.30	3.55	14.00	1.11	9.33	0.41	< 0.2	10.68	1.14
	MLF														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	142.60	1393.00	0.99	0.387	1.44	88.66	0.45	5.46	318.00	102.80	1.12	< 0.2	7.26	0.57
	May-12	< 4	877.30	1.03	0.391	0.86	83.16	0.78	3.63	2.73	7.63	0.45	< 0.2	3.38	0.26
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	98.65	856.50	1.87	0.400	0.71	97.45	0.72	2.72	1.04	11.50	0.35	< 0.2	4.76	0.29
	MLG														
	Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Aug-11	< 4	4804.00	0.78	< 0.004	0.57	91.59	0.24	0.77	6.93	25.06	<0.005	< 0.2	3.32	< 0.005
	May-12	< 4	339.70	1.68	< 0.004	0.67	88.03	1.08	0.62	13.34	16.68	0.54	< 0.2	1.36	< 0.005
	Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
	Sep-12	< 2	635.90	3.29	0.594	1.41	165.20	1.37	4.05	1.27	10.96	0.42	< 0.2	5.44	0.78

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLH	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	29.35	477.40	3.32	0.247	0.38	71.25	0.08	0.67	570.40	78.69	1.44	< 0.2	5.52	< 0.005
May-12	< 4	157.10	0.76	0.417	0.49	82.63	1.59	0.79	0.71	14.64	0.28	< 0.2	1.77	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	197.45	< 0.1	< 0.03	0.61	94.85	0.55	0.71	1.03	< 0.9	< 0.03	< 0.2	1.65	< 0.01
MLM														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	2.97	442.60	1.56	0.100	0.50	52.87	0.13	1.56	14.58	154.40	<0.005	< 0.2	7.21	< 0.005
May-12	< 4	228.50	3.10	3.111	10.24	133.90	6.29	9.13	377.90	293.70	5.28	< 0.2	3.21	11.05
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	271.20	< 0.1	< 0.03	0.56	73.77	0.52	1.18	7.11	< 0.9	< 0.03	< 0.2	1.70	< 0.01
MLN														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	444.20	0.75	< 0.004	0.63	72.88	0.32	1.89	10.58	49.22	1.38	< 0.2	5.43	0.04
May-12	< 4	820.00	1.04	0.181	0.60	98.45	2.57	2.95	2.54	9.44	0.18	< 0.2	1.59	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	224.90	< 0.1	0.316	1.16	139.10	0.81	4.71	2.60	11.34	0.38	< 0.2	2.35	0.23
MLO														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	111.40	2013.00	1.68	0.243	1.54	123.70	0.78	9.81	48.38	139.60	1.10	0.65	8.65	1.24
May-12	411.30	1173.00	1.72	0.531	4.14	390.30	3.80	23.74	202.30	159.00	0.44	< 0.2	4.94	2.29
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	907.50	2.50	0.520	0.59	61.51	0.58	0.85	< 0.05	< 0.9	0.42	< 0.2	3.54	< 0.01
MLP														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	165.70	1286.00	2.05	0.121	0.81	67.76	0.23	2.59	20.17	189.10	0.92	< 0.2	9.79	0.15
May-12	< 14	725.20	1.34	0.508	0.72	105.60	1.55	5.58	553.20	318.80	0.44	< 0.2	4.19	0.22
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 7	667.20	2.92	0.574	0.56	72.43	0.52	1.30	1.09	< 0.9	0.42	< 0.2	4.27	< 0.01
MLQ														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	56.04	559.80	0.47	0.286	0.42	96.98	0.65	2.46	3.64	28.51	<0.005	0.16	16.51	0.40
May-12	< 4	1106.00	1.36	0.242	0.47	101.40	2.01	1.55	34.85	45.07	0.26	< 0.2	2.24	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	< 15	< 0.1	0.402	0.62	91.79	0.71	1.45	3.26	12.19	0.29	< 0.2	4.48	< 0.01
MLR														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	343.70	0.80	0.086	2.53	65.25	0.68	3.89	11.07	32.59	1.18	1.184	10.85	0.56
May-12	< 4	1095.00	1.22	0.435	0.95	88.37	1.31	4.15	52.21	13.73	0.32	< 0.2	1.86	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	400.90	< 0.1	< 0.03	1.19	89.70	1.03	3.02	5.83	11.35	0.26	< 0.2	2.69	0.35

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLS	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	**mg/L**	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	188.40	0.86	0.125	0.85	60.80	0.31	2.36	6.41	36.76	0.52	< 0.2	5.39	0.22
May-12	< 4	478.00	2.04	0.636	0.84	113.10	1.58	3.67	554.30	320.70	0.47	< 0.2	4.07	0.20
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	270.80	1.31	0.639	0.79	60.55	1.26	1.17	14.51	10.06	0.40	< 0.2	3.29	< 0.01
MLT														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	887.20	2.57	0.406	0.61	41.54	0.19	1.55	5.04	31.16	0.18	0.342	4.74	0.05
May-12	< 4	1070.00	2.94	0.452	0.52	59.47	1.07	2.04	16.93	34.15	0.33	< 0.2	3.07	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	1179.00	1.86	< 0.03	0.57	71.45	0.54	1.83	< 0.05	9.24	0.30	< 0.2	3.02	0.16
MLU														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	16.20	140.30	1.15	0.425	0.70	68.90	0.62	1.63	9.12	51.99	0.19	< 0.2	10.94	0.10
May-12	< 4	329.90	1.95	0.636	1.13	158.80	2.67	4.44	11.35	28.89	0.73	< 0.2	7.47	0.20
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 7	< 4	1.82	0.419	1.60	204.30	2.04	6.95	10.87	16.51	0.86	< 0.2	12.92	0.90
MLV														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	903.10	0.55	0.064	0.50	18.30	0.15	1.08	11.49	34.92	0.56	0.015	3.06	< 0.005
May-12	< 4	297.60	1.56	0.410	0.70	76.44	2.50	3.85	301.10	206.70	0.32	< 0.2	3.03	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	1146.00	< 0.1	0.355	0.73	31.25	0.24	1.03	15.61	< 0.9	0.45	< 0.2	1.84	0.20
MLP01A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP01B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 7	437.25	< 0.1	2.092	0.75	101.33	1.44	4.32	1.10	48.96	5.00	< 0.2	25.41	0.34
MLP02A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 5	--	< 0.1	4.524	0.72	2.48	0.73	27.21	10.90	< 0.6	1.19	--	83.52	7.56
Jul-12	< 5	--	< 0.04	2.800	1.75	3.91	0.20	43.98	66.07	< 0.6	0.62	--	2003.00	5.47
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLP02B	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	**mg/L**	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	333.90	< 0.1	0.481	1.14	57.53	1.00	4.89	1.15	< 0.9	1.43	< 0.2	15.15	0.86
MLP03A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 5	--	< 0.04	< 0.02	1.20	< 0.05	0.20	20.96	43.53	< 0.6	0.30	--	4258.00	4.58
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP03B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 4	128.70	0.94	0.530	0.56	33.98	2.03	4.98	2.78	27.53	2.88	< 0.2	27.20	0.42
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP04A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 4	2986.00	0.93	0.495	0.74	2179.00	17.72	35.76	2.55	17.83	2.25	< 0.2	546.60	5.83
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP04B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	851.80	492.80	1.49	0.222	0.45	146.20	1.81	3.34	5.65	30.78	1.64	< 0.2	30.83	0.56
May-12	528.80	335.30	2.54	0.502	0.93	221.70	3.31	5.05	0.70	30.67	1.20	< 0.2	35.95	0.26
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	472.00	225.50	< 0.1	< 0.03	0.69	207.20	2.86	4.47	< 0.05	20.93	0.78	< 0.2	31.90	< 0.004
MLP04C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	641.40	1076.00	1.87	0.365	0.42	91.50	0.66	1.60	17.71	65.43	2.05	0.084	17.83	< 0.005
May-12	243.60	740.00	2.86	0.512	0.62	101.90	2.34	1.94	0.55	21.12	1.36	< 0.2	17.67	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	321.70	661.80	2.08	0.286	0.98	106.60	1.25	2.39	2.18	966.30	0.85	< 0.2	16.81	< 0.004
MLP05A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 4	1635.00	< 0.06	0.355	0.62	280.40	2.30	2.78	2.07	12.11	0.43	< 0.2	165.60	2.91
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLP05B	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	**mg/L**	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1213.00	1096.00	0.31	0.172	0.41	85.15	0.38	0.80	2.82	96.24	1.17	0.83	83.39	0.09
May-12	723.60	828.60	1.30	0.289	0.65	110.00	1.25	0.89	0.55	20.58	0.20	< 0.2	71.61	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	767.40	652.70	< 0.04	< 0.03	0.32	101.90	0.45	< 0.04	< 0.02	< 0.9	< 0.03	< 0.2	71.62	< 0.004
MLP05C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	691.60	1308.00	0.75	0.062	0.85	61.11	0.55	0.97	25.92	412.00	<0.005	< 0.2	42.44	< 0.005
May-12	439.40	624.60	1.00	0.217	0.65	84.67	1.68	0.84	< 0.04	19.22	0.37	< 0.2	37.07	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	121.50	495.60	< 0.1	< 0.03	0.53	61.54	0.52	0.82	1.82	15.06	0.31	< 0.2	36.73	< 0.004
MLP05D														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	504.80	827.00	0.68	< 0.004	0.33	51.85	0.32	0.34	7.58	37.24	1.54	< 0.2	11.39	< 0.005
May-12	< 4	597.20	0.99	0.319	0.47	44.72	0.97	0.64	0.81	20.98	0.27	< 0.2	24.09	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	221.80	287.70	< 0.04	< 0.03	0.36	58.97	0.70	0.46	< 0.05	< 0.9	0.31	< 0.2	10.58	< 0.004
MLP06A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 5	--	< 0.04	0.173	0.72	1846.00	6.43	2.61	0.89	< 0.2	0.71	--	107.70	0.58
MLP06B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP07A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP07B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Site ID	P µg/L	K µg/L	Ti µg/L	V µg/L	Cr µg/L	Mn µg/L	Co µg/L	Ni µg/L	Cu µg/L	Zn µg/L	As µg/L	Se mg/L	Sr µg/L	Mo µg/L
MLP08A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	503.60	1295.00	0.11	0.101	0.55	36.52	0.22	3.63	81.01	38.87	<0.005	< 0.2	32.56	0.76
May-12	272.20	936.10	2.41	0.187	1.08	65.52	3.38	5.71	< 0.04	7.10	0.38	< 0.2	45.02	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	418.00	589.30	< 0.1	0.418	0.61	53.65	0.51	1.82	1.53	< 0.9	< 0.03	< 0.2	39.26	< 0.01
MLP08B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP09A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	186.90	992.70	0.60	0.158	0.52	33.61	0.33	0.97	6.43	71.33	<0.005	< 0.2	20.92	0.42
May-12	< 4	1422.00	< 0.06	< 0.01	0.69	41.95	4.12	2.56	3.18	21.54	0.32	< 0.2	15.32	0.73
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	223.20	520.70	< 0.1	< 0.03	0.43	50.08	0.84	1.55	0.60	< 0.9	0.35	< 0.2	22.75	< 0.01
MLP09B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	38.04	1098.00	0.38	0.254	0.49	18.04	0.32	0.38	32.96	49.04	0.18	< 0.2	8.26	0.17
May-12	< 4	462.60	< 0.06	0.318	0.71	29.36	4.16	0.74	0.66	10.78	0.33	< 0.2	17.15	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	127.40	594.80	< 0.1	0.278	1.19	20.05	0.99	0.51	0.59	15.91	0.35	< 0.2	9.41	< 0.01
MLP10A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	185.40	1551.00	4.07	3.286	14.88	2560.00	8.28	18.42	9.54	6.57	5.94	< 0.2	393.90	14.28
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP10B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	738.30	832.60	1.00	0.037	0.22	52.63	0.12	0.29	1.41	49.39	0.82	< 0.2	40.71	0.18
May-12	335.80	565.60	< 0.06	< 0.01	0.35	61.78	0.70	0.90	1.17	11.93	0.22	< 0.2	37.11	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	544.10	168.50	< 0.1	< 0.008	0.61	74.63	0.38	0.54	2.97	54.12	0.34	< 0.2	43.28	0.17
MLP10C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	312.50	464.50	0.30	0.105	0.37	15.04	0.12	0.52	1.70	51.83	0.47	0.196	14.37	< 0.005
May-12	181.90	405.50	0.66	0.236	0.62	23.14	1.57	0.57	14.03	19.51	0.32	< 0.2	16.38	< 0.02
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	293.90	210.70	< 0.04	< 0.03	1.23	20.35	0.36	0.63	0.62	163.30	0.32	< 0.2	15.39	< 0.01

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLP11A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	**mg/L**	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 4	1711.00	< 0.06	0.190	0.94	1790.00	4.27	7.05	0.56	1.46	0.29	< 0.2	283.50	4.25
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP11B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	796.40	729.10	0.58	< 0.004	0.25	31.14	0.46	1.14	2.91	46.23	0.94	0.899	30.97	0.14
May-12	532.30	290.00	1.19	0.295	0.69	43.53	2.37	1.25	< 0.04	23.42	0.42	< 0.2	29.94	0.21
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	615.45	249.00	2.2	< 0.03	0.34	35.87	0.74	1.22	< 0.05	15.11	0.36	< 0.2	31.55	< 0.01
MLP11C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	302.40	892.70	0.58	0.159	0.51	29.27	0.20	0.82	7.22	52.46	0.75	0.274	19.41	0.14
May-12	< 14	536.40	1.32	< 0.004	0.61	38.41	1.23	1.05	0.66	13.30	0.79	< 0.2	25.11	0.59
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	241.50	415.00	< 0.1	< 0.008	0.45	35.16	1.24	0.89	< 0.05	< 0.9	0.70	< 0.2	17.51	1.56
MLP12A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	1908.00	695.70	12.45	3.828	4.09	419.30	11.16	14.76	4.62	75.80	5.06	< 0.2	36.05	0.31
May-12	< 4	2259.00	1.12	< 0.01	0.59	54.29	62.33	3.67	5.19	39.82	0.28	< 0.2	12.71	0.82
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP12B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	693.10	536.00	0.62	0.300	0.45	87.47	1.25	1.36	5.17	202.50	1.04	< 0.2	25.38	0.14
May-12	290.70	347.00	0.82	0.378	0.55	101.10	2.68	1.85	0.46	21.08	0.73	< 0.2	27.03	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	501.00	< 15	< 0.1	0.277	0.47	121.10	2.03	1.59	< 0.05	15.34	0.97	< 0.2	25.00	0.59
MLP13A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 4	1206.00	< 0.06	0.628	0.30	1560.00	5.33	22.05	1.31	1.57	1.65	< 0.2	382.90	59.86
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP13B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	259.30	1.42	1.843	1.07	706.00	13.93	27.94	3.46	55.39	13.73	< 0.2	93.96	0.89
May-12	< 14	148.30	2.00	9.029	1.87	951.50	26.43	43.64	0.44	8.89	19.99	< 0.2	109.80	0.52
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	222.90	178.00	2.21	6.545	1.41	616.40	14.65	31.60	11.18	19.90	16.47	< 0.2	80.34	0.41

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLP14A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	**mg/L**	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP14B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP15A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 4	2927.00	< 0.06	< 0.004	0.65	1106.00	2.77	7.21	< 0.04	< 0.1	< 0.02	< 0.2	446.50	1.91
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	175.50	2883.00	< 0.1	0.731	1.33	1659.00	0.29	1.29	1.10	21.85	0.39	< 0.2	451.00	0.69
MLP15B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	516.60	797.60	0.27	0.012	0.26	90.10	0.18	0.58	4.89	35.69	0.90	0.779	43.96	0.68
May-12	269.50	344.50	< 0.06	0.169	0.40	127.20	2.32	0.75	0.41	7.43	0.42	< 0.2	44.11	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	348.80	359.40	< 0.04	< 0.008	0.39	130.00	0.43	0.55	< 0.02	< 0.9	0.42	< 0.2	44.09	< 0.004
MLP15C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	313.00	1415.00	0.34	0.226	0.60	91.92	0.92	1.28	27.03	124.30	2.17	< 0.2	32.65	< 0.005
May-12	< 14	948.00	1.32	0.325	0.73	92.98	4.17	2.12	83.16	133.00	1.11	< 0.2	34.91	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	85.54	318.10	1.40	0.438	0.85	81.31	1.92	1.92	4.21	31.12	0.53	< 0.2	26.42	0.28
MLP16A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	< 4	1311.00	< 0.06	< 0.01	0.69	2108.00	18.12	16.20	0.66	1.27	0.26	< 0.2	235.80	2.00
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	1829.00	< 0.1	< 0.03	0.73	1964.00	22.92	25.58	1.88	32.35	< 0.03	< 0.2	194.80	1.47
MLP16B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	606.60	789.30	0.15	0.079	0.33	39.96	0.26	0.52	1.31	52.32	0.70	0.831	17.82	< 0.005
May-12	348.10	700.20	0.87	0.327	0.46	67.75	6.22	1.37	0.53	5.90	0.66	< 0.2	17.62	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	417.20	736.80	< 0.1	< 0.008	0.33	74.61	1.05	0.83	< 0.05	11.61	0.33	< 0.2	17.60	< 0.004

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLP16C	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	**mg/L**	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	413.40	1032.00	3.28	0.355	0.64	42.85	0.34	1.12	5.83	46.68	0.74	0.383	9.31	0.05
May-12	< 4	581.90	1.32	0.375	0.80	34.14	1.67	1.41	30.34	141.70	1.16	< 0.2	19.30	0.31
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 7	493.40	< 0.1	< 0.03	2.37	35.77	0.60	1.12	1.83	628.50	0.58	< 0.2	6.37	< 0.004
MLP17A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	808.20	0.28	0.385	0.69	1408.00	16.63	16.95	13.09	56.83	0.70	0.192	75.35	6.65
May-12	145.60	726.40	3.56	6.090	1.75	2322.00	26.83	15.13	< 0.04	10.24	50.40	< 0.2	85.60	9.27
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	530.90	658.70	12.18	12.420	3.35	2291.00	29.02	19.90	0.58	14.74	85.83	< 0.2	86.48	18.50
MLP17B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 5	--	< 0.1	0.411	0.96	348.40	8.26	4.79	12.71	1183.50	0.62	--	35.51	0.17
MLP17C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	< 4	212.60	0.91	0.308	0.59	39.94	0.37	0.72	2.70	99.04	0.29	< 0.2	9.47	0.03
May-12	< 4	< 8	1.18	0.343	0.71	39.61	2.39	0.50	0.40	6.37	< 0.02	< 0.2	7.49	0.27
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	< 15	1.52	0.388	0.80	49.47	0.98	0.60	< 0.05	35.72	0.45	< 0.2	10.96	0.50
MLP18A														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP18B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	318.20	3072.00	5.94	0.908	1.28	269.40	4.45	8.01	13.03	102.40	2.21	< 0.2	30.17	0.44
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	< 7	1105.00	2.23	< 0.03	0.50	1199.00	8.44	12.34	0.59	21.74	0.33	< 0.2	56.40	0.26
Sep-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
MLP18C														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	312.20	99.45	1.32	0.101	1.28	83.80	0.83	2.19	4.48	46.68	0.10	< 0.2	18.45	0.18
May-12	< 14	105.80	0.78	0.224	0.49	125.20	2.44	1.46	< 0.04	15.22	0.57	< 0.2	21.89	< 0.005
Jul-12	186.30	< 4	< 0.1	0.306	0.66	122.10	0.98	1.18	< 0.05	11.47	0.50	< 0.2	19.76	< 0.01
Sep-12	168.10	< 4	< 0.1	< 0.03	0.63	122.20	1.87	1.37	< 0.05	163.90	0.52	< 0.2	19.77	< 0.01

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
MLP19A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	**mg/L**	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	734.90	286.00	1.73	0.060	0.38	43.11	0.18	0.58	3.99	52.31	<0.005	< 0.2	33.55	0.02
May-12	342.90	349.00	< 0.06	< 0.01	0.36	56.51	1.69	0.72	1.00	10.10	0.30	< 0.2	32.18	0.18
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	463.30	< 15	< 0.1	0.322	0.38	60.21	0.30	< 0.04	< 0.05	48.50	0.34	< 0.2	34.45	0.20
MLP19B														
Jul-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Aug-11	73.71	1442.00	0.67	0.035	0.25	53.59	0.26	0.39	1.30	41.25	0.51	< 0.2	10.38	< 0.005
May-12	< 4	715.50	1.61	< 0.01	0.48	69.66	1.15	0.45	1.35	23.33	0.39	< 0.2	11.65	< 0.005
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	69.71	414.70	< 0.1	< 0.03	1.68	64.80	0.66	0.96	< 0.05	495.50	0.43	< 0.2	10.39	< 0.01
ML Highway 63 Weir														
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Apr-12	<15	3450.00	2.25	0.561	0.60	71.68	0.34	0.59	1.47	23.73	0.37	--	3.20	<0.002
Aug-11	15.01	260.60	1.08	0.238	0.86	51.89	0.22	0.93	2.82	25.60	0.64	< 0.2	5.11	< 0.005
May-12	< 4	< 8	2.21	0.329	0.61	64.53	0.73	0.73	< 0.04	6.06	0.36	< 0.2	4.22	< 0.005
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	283.10	2.34	0.421	0.82	78.39	0.73	0.94	< 0.05	< 0.9	0.49	< 0.2	5.55	< 0.01
Sep-12	109.25	308.45	2.33	0.399	0.84	93.09	0.44	0.74	< 0.05	155.80	0.47	< 0.2	7.59	< 0.004
ML Access Road Culvert														
Aug-11	138.80	399.30	8.21	0.437	1.22	148.70	0.96	1.34	1.21	157.00	2.01	< 0.2	9.36	0.04
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Apr-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	446.90	3.55	0.602	0.71	91.58	0.44	0.83	< 0.05	18.36	0.55	< 0.2	3.35	0.16
ML Access Road Culvert (E)														
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Sep-12	< 2	376.50	3.12	0.456	0.64	49.06	0.29	0.82	2.25	12.82	1.05	< 0.2	3.75	0.82

Site ID	P	K	Ti	V	Cr	Mn	Co	Ni	Cu	Zn	As	Se	Sr	Mo
ML Rain Events	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	mg/L	µg/L	µg/L
18-Aug-11	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
27-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
29-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
4-Aug-12	--	--	--	--	--	--	--	--	--	--	--	--	--	--
7-Sep-12	< 2	< 4	< 0.1	< 0.008	0.34	6.12	< 0.005	< 0.04	1.82	42.83	< 0.008	< 0.2	0.61	< 0.004
ML Bulk Rain														
(April to June 2012)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(May - 18 July 2012)	--	--	--	--	--	--	--	--	--	--	--	--	--	--
(17 July - 1 Sept 2012)	< 2	< 15	< 0.04	< 0.03	0.36	13.94	1.71	0.58	0.89	< 0.9	< 0.03	< 0.2	0.76	0.17
2012	< 2	< 4	< 0.04	< 0.03	0.30	2.69	0.54	< 0.04	3.99	< 0.9	< 0.008	< 0.2	0.97	< 0.004

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
units	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L	μg/L
precision										
DL (QL)	.001 (.005)	.02 (.05)	.003 (.009)	.003 (.01)	.004 (.01)	.009 (.003)	.001 (.002)	.007 (.002)	0.876	0.07 (0.2)
MLA										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.35	< 0.003	183.70	--	< 0.001	1.48	< 0.0007	< 0.876	--
May-12	< 0.005	2.75	1.83	5.08	< 0.01	< 0.003	54.75	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	2.37	0.11	3.18	2.18	< 0.002	0.32	< 0.0007	--	< 0.2
MLB										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	2.91	0.25	314.20	--	< 0.001	56.37	< 0.0007	0.22	--
May-12	< 0.005	< 0.05	0.29	1.74	< 0.004	< 0.003	0.27	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	1.13	0.20	1.22	< 0.009	< 0.002	0.20	< 0.0007	--	< 0.07
MLC										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	35.98	0.57	135.90	--	< 0.001	77.50	< 0.0007	0.39	--
May-12	< 0.005	1.11	1.85	2.95	< 0.01	0.07	2.49	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	0.95	0.21	2.38	< 0.009	0.03	0.74	< 0.0007	--	< 0.07
MLD										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	0.15	19.94	0.32	126.90	--	< 0.001	92.78	< 0.0007	< 0.876	--
May-12	< 0.005	0.58	0.47	2.49	< 0.01	0.03	1.04	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.06	3.33	< 0.007	1.50	0.31	< 0.002	0.98	< 0.0007	--	< 0.2
MLE										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.83	0.04	57.63	--	< 0.001	3.07	< 0.0007	0.60	--
May-12	< 0.001	0.89	< 0.003	2.33	< 0.004	< 0.001	2.87	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	0.18	14.87	< 0.003	0.04	1.50	< 0.0007	--	< 0.07
MLF										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.77	0.35	154.10	--	< 0.001	14.22	< 0.0007	< 0.876	--
May-12	< 0.005	< 0.05	< 0.009	2.89	< 0.004	< 0.003	1.18	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	0.16	4.19	< 0.009	0.03	0.47	< 0.002	--	< 0.07
MLG										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	0.05	0.14	< 0.003	27.21	--	< 0.001	1.59	< 0.0007	< 0.876	--
May-12	< 0.001	< 0.05	0.24	2.53	< 0.004	< 0.001	1.38	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.01	0.84	7.46	< 0.003	0.05	2.10	< 0.0007	--	< 0.2

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLH	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	0.34	9.06	0.34	76.99	--	< 0.001	46.63	< 0.0007	1.27	--
May-12	< 0.005	< 0.02	0.49	3.14	< 0.01	< 0.003	0.25	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	0.21	1.89	< 0.003	< 0.0006	5.78	< 0.0007	--	< 0.07
MLM										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.24	0.06	232.50	--	< 0.001	38.53	< 0.0007	< 0.876	--
May-12	4.92	2.32	17.59	8.36	3.01	2.01	120.00	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.11	0.78	< 0.009	2.26	0.1	< 0.0006	3.07	< 0.0007	--	< 0.07
MLN										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.30	< 0.003	49.07	--	< 0.001	32.76	< 0.0007	< 0.876	--
May-12	< 0.001	0.77	< 0.003	2.04	< 0.004	< 0.001	1.49	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	0.59	0.08	3.10	< 0.009	< 0.002	0.79	< 0.0007	--	< 0.07
MLO										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.93	0.41	225.10	--	< 0.001	39.34	< 0.0007	0.83	--
May-12	< 0.005	2.58	0.53	5.25	< 0.004	0.03	54.42	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	0.51	0.18	3.85	< 0.009	0.03	0.27	< 0.0007	--	< 0.07
MLP										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.74	0.11	317.60	--	< 0.001	10.28	< 0.0007	0.01	--
May-12	< 0.005	2.12	0.21	4.29	< 0.004	< 0.003	25.05	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	0.16	4.42	< 0.003	0.03	0.50	< 0.0007	--	< 0.07
MLQ										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.41	0.32	43.20	--	< 0.001	30.06	< 0.0007	< 0.876	--
May-12	< 0.001	< 0.05	< 0.003	3.24	< 0.004	< 0.001	18.12	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.06	0.64	0.19	6.34	0.15	< 0.002	1.42	< 0.0007	--	< 0.07
MLR										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	0.03	0.59	0.00	37.71	--	< 0.001	25.91	< 0.0007	< 0.876	--
May-12	< 0.001	1.23	< 0.003	2.54	< 0.004	< 0.003	4.84	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.04	< 0.05	0.18	4.20	< 0.003	0.05	1.80	< 0.0007	--	< 0.07

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLS	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.45	0.04	37.11	--	< 0.001	25.38	< 0.0007	0.01	--
May-12	< 0.005	1.24	0.35	5.75	< 0.004	< 0.003	80.16	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.05	0.75	0.36	3.41	< 0.003	0.03	1.71	< 0.0007	--	< 0.07
MLT										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.30	< 0.003	29.44	--	< 0.001	11.25	< 0.0007	0.40	--
May-12	< 0.005	< 0.05	0.21	3.18	< 0.004	0.04	28.63	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.09	1.26	0.22	4.24	< 0.003	0.03	0.42	< 0.0007	--	< 0.07
MLU										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.15	< 0.003	82.56	--	< 0.001	11.02	< 0.0007	< 0.876	--
May-12	< 0.005	< 0.05	< 0.009	10.89	< 0.004	< 0.001	6.53	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.04	0.58	0.57	20.39	0.25	0.03	3.61	< 0.0007	--	< 0.07
MLV										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.20	< 0.003	44.71	--	< 0.001	17.50	< 0.0007	< 0.876	--
May-12	< 0.005	0.87	0.31	2.96	< 0.01	< 0.003	54.91	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.05	< 0.01	0.34	2.31	< 0.009	< 0.002	3.09	< 0.0007	--	< 0.07
MLP01A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP01B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	1.63	0.65	136.35	< 0.003	< 0.002	0.40	0.09	--	< 0.07
MLP02A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	< 0.004	< 0.05	1.73	25.67	< 0.008	0.09	1.01	0.05	--	2.38
Jul-12	< 0.004	< 0.05	0.38	590.60	< 0.002	< 0.003	0.22	< 0.0007	--	1.19
Sep-12	--	--	--	--	--	--	--	--	--	--

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLP02B	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.05	1.64	1.67	44.17	4.93	0.04	0.18	0.03	--	< 0.07
MLP03A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	< 0.004	< 0.05	0.20	2317.00	< 0.002	0.03	0.53	< 0.0007	--	16.12
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP03B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	0.10	1.52	0.74	20.86	< 0.01	0.05	0.28	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP04A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	< 0.005	< 0.05	2.69	579.80	0.49	0.06	0.19	0.60	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP04B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	0.04	2.00	0.60	60.64	--	0.04	2.14	< 0.0007	< 0.876	--
May-12	< 0.005	5.81	0.67	52.33	< 0.004	< 0.003	0.42	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	0.83	0.22	52.19	< 0.003	< 0.002	0.14	< 0.0007	--	< 0.2
MLP04C										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	0.07	1.02	0.01	35.97	--	< 0.001	3.64	< 0.0007	< 0.876	--
May-12	0.05	2.46	0.85	11.36	< 0.004	0.03	0.31	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.05	0.82	0.21	13.80	< 0.003	< 0.002	0.86	< 0.0007	--	< 0.2
MLP05A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	< 0.005	< 0.05	0.72	90.90	< 0.004	< 0.003	0.05	0.22	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLP05B	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	3.40	0.48	191.50	--	< 0.001	0.93	< 0.0007	< 0.876	--
May-12	< 0.001	3.17	0.53	23.51	< 0.004	< 0.003	0.20	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.001	1.04	0.13	22.02	< 0.003	< 0.002	0.07	< 0.0007	--	< 0.07
MLP05C										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	0.01	1.36	< 0.003	720.70	--	< 0.001	3.29	< 0.0007	0.73	--
May-12	< 0.001	2.78	0.52	13.95	< 0.004	< 0.003	0.20	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	4.47	0.21	10.78	< 0.003	< 0.002	0.26	< 0.0007	--	< 0.07
MLP05D										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.23	0.39	29.02	--	< 0.001	2.58	< 0.0007	< 0.876	--
May-12	< 0.005	4.25	0.61	6.59	< 0.004	< 0.003	0.18	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	1.89	0.24	4.33	< 0.009	< 0.002	0.17	< 0.0007	--	< 0.07
MLP06A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.001	< 0.01	0.70	135.20	44.42	< 0.003	0.71	0.15	--	8.13
MLP06B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP07A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP07B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLP08A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.11	0.79	45.81	--	0.01	9.77	< 0.0007	4.02	--
May-12	< 0.001	2.31	0.51	19.81	< 0.004	< 0.001	0.16	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.001	< 0.05	0.15	17.71	< 0.003	< 0.002	0.21	< 0.0007	--	< 0.07
MLP08B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP09A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.17	0.79	105.00	--	< 0.001	1.87	< 0.0007	2.29	--
May-12	0.14	1.35	2.22	14.92	< 0.004	< 0.001	0.39	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.08	< 0.05	0.35	21.82	< 0.003	< 0.002	0.13	0.01	--	< 0.07
MLP09B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.70	1.00	39.57	--	< 0.001	4.46	< 0.0007	3.52	--
May-12	< 0.001	8.37	1.33	4.80	1.83	< 0.001	0.28	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.05	3.57	0.33	5.83	0.12	< 0.002	0.21	< 0.0007	--	< 0.07
MLP10A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	5.59	< 0.05	20.63	615.40	0.89	2.25	16.95	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP10B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.12	0.04	72.87	--	< 0.001	0.85	< 0.0007	0.77	--
May-12	< 0.005	< 0.05	0.44	11.48	< 0.004	< 0.001	0.21	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.20	< 0.05	0.34	13.42	0.49	< 0.002	1.62	< 0.0007	--	< 0.07
MLP10C										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.53	0.48	84.04	--	< 0.001	1.37	< 0.0007	2.54	--
May-12	< 0.005	5.64	0.79	5.52	< 0.01	< 0.003	6.61	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	1.32	0.32	5.34	< 0.003	< 0.002	0.36	< 0.0007	--	< 0.07

Site ID	**Cd**	**Sn**	**Sb**	**Ba**	**Ag**	**Tl**	**Pb**	**U**	**Hg**	**Li**
MLP11A	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/L**	**µg/**	**µg/L**	**µg/L**	**µg/L**	**µg/L**
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	0.06	< 0.05	0.62	319.10	< 0.004	0.05	0.18	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP11B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	2.24	0.15	50.98	--	< 0.001	1.62	< 0.0007	< 0.876	--
May-12	< 0.005	3.62	0.88	23.46	< 0.004	< 0.003	0.46	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	1.31	0.24	24.67	< 0.006	< 0.002	0.20	< 0.0007	--	< 0.07
MLP11C										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.28	0.55	74.67	--	< 0.001	3.00	< 0.0007	0.78	--
May-12	< 0.005	6.47	1.88	9.30	0.49	0.04	0.49	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.06	1.66	0.61	22.83	0.41	0.02	0.15	0.01	--	< 0.2
MLP12A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.23	1.26	163.50	--	< 0.001	1.15	0.06	0.57	--
May-12	0.17	< 0.05	1.57	19.44	< 0.004	0.03	0.15	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP12B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.27	0.11	426.20	--	< 0.001	3.72	< 0.0007	0.56	--
May-12	< 0.005	3.62	0.51	21.39	< 0.004	< 0.003	0.22	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	6.32	0.44	24.56	< 0.003	< 0.002	0.32	< 0.0007	--	< 0.2
MLP13A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	< 0.001	0.64	0.95	103.40	< 0.004	< 0.001	0.06	0.98	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP13B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.81	0.46	144.30	--	< 0.001	0.95	0.03	0.77	--
May-12	< 0.001	2.93	0.53	67.12	< 0.004	< 0.001	0.39	0.06	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	1.75	0.15	65.57	< 0.003	< 0.002	1.11	0.05	--	6.77

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLP14A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP14B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP15A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	< 0.001	< 0.05	0.14	321.60	< 0.004	< 0.001	0.02	0.09	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.20	< 0.05	0.10	501.60	0.10	< 0.0006	0.06	0.02	--	16.55
MLP15B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.23	1.86	39.22	--	< 0.001	1.46	< 0.0007	0.78	--
May-12	< 0.005	1.34	0.79	15.29	< 0.004	< 0.003	0.41	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	0.60	< 0.003	16.22	0.19	< 0.002	0.06	< 0.0007	--	< 0.2
MLP15C										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.52	0.58	37.17	--	< 0.001	7.24	< 0.0007	1.63	--
May-12	0.10	4.01	0.93	19.21	0.46	< 0.003	5.16	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.19	1.73	0.14	20.06	0.10	< 0.002	0.62	< 0.0007	--	< 0.2
MLP16A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	0.05	< 0.05	0.62	222.40	< 0.004	0.04	0.15	0.33	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	1.44	< 0.05	0.21	160.60	< 0.003	< 0.0006	0.09	0.04	--	7.07
MLP16B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.04	< 0.003	78.95	--	< 0.001	0.83	< 0.0007	< 0.876	--
May-12	0.05	< 0.05	1.03	7.99	< 0.004	0.04	0.46	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	0.63	< 0.003	8.87	< 0.003	< 0.002	0.33	< 0.0007	--	< 0.07

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLP16C	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.36	1.15	64.68	--	< 0.001	1.45	< 0.0007	0.82	--
May-12	0.08	3.00	1.92	6.26	< 0.004	0.05	1.72	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.08	1.48	0.21	5.17	< 0.003	0.03	0.49	< 0.0007	--	< 0.07
MLP17A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.02	< 0.003	291.00	--	< 0.001	1.70	0.35	< 0.876	--
May-12	< 0.001	< 0.05	0.22	225.30	3.65	< 0.001	0.13	0.13	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.10	0.62	8.69	283.80	1.21	0.16	0.61	0.25	--	5.37
MLP17B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.16	< 0.05	0.68	59.53	< 0.008	< 0.003	6.42	< 0.0007	--	< 0.1
MLP17C										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.60	< 0.003	137.20	--	< 0.001	1.87	< 0.0007	< 0.876	--
May-12	< 0.001	2.85	0.15	3.40	< 0.004	< 0.001	0.37	< 0.002	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.07	2.35	1.40	6.10	0.18	0.05	0.30	0.02	--	< 0.2
MLP18A										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP18B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.33	1.63	145.20	--	< 0.001	1.74	< 0.0007	< 0.876	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	0.05	1.47	0.39	90.58	< 0.009	< 0.002	0.11	0.01	--	< 0.07
Sep-12	--	--	--	--	--	--	--	--	--	--
MLP18C										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.07	0.01	41.60	--	< 0.001	1.17	< 0.0007	0.39	--
May-12	< 0.001	2.55	0.26	7.48	0.20	< 0.001	0.23	< 0.0007	--	--
Jul-12	< 0.003	< 0.05	0.18	21.64	1.22	< 0.002	0.11	< 0.0007	--	< 0.07
Sep-12	< 0.003	0.77	0.35	13.43	< 0.003	0.02	0.08	< 0.0007	--	< 0.2

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
MLP19A	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	0.09	0.24	102.00	--	< 0.001	1.34	< 0.0007	0.41	--
May-12	< 0.005	< 0.02	0.42	11.97	< 0.004	< 0.003	0.67	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	0.56	11.87	< 0.003	0.03	0.37	< 0.0007	--	< 0.07
MLP19B										
Jul-11	--	--	--	--	--	--	--	--	--	--
Aug-11	< 0.001	1.47	0.38	24.06	--	< 0.001	1.81	< 0.0007	< 0.876	--
May-12	< 0.005	2.08	0.66	8.40	< 0.004	< 0.003	0.74	< 0.0007	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	0.09	1.89	0.69	6.41	0.65	0.07	0.28	0.01	--	< 0.07
ML Highway 63 Weir										
Apr-12	--	--	--	--	--	--	--	--	--	--
Apr-12	<0.01	<0.03	<0.002	5.96	--	<0.002	0.27	<0.002	--	--
Aug-11	< 0.001	0.54	< 0.003	20.01	--	< 0.001	1.64	< 0.0007	< 0.876	--
May-12	< 0.001	< 0.05	< 0.003	4.31	< 0.004	< 0.001	0.13	< 0.0007	--	--
May-12	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	0.17	5.76	< 0.003	< 0.002	0.15	< 0.0007	--	< 0.07
Sep-12	0.04	< 0.05	< 0.007	199.40	< 0.007	< 0.002	0.16	< 0.0007	--	< 0.2
ML Access Road Culvert										
Aug-11	< 0.001	0.10	< 0.003	263.80	--	< 0.001	0.81	< 0.0007	< 0.876	--
Apr-12	--	--	--	--	--	--	--	--	--	--
Apr-12	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
May-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	0.27	93.52	0.28	< 0.002	0.16	0.02	--	< 0.07
ML Access Road Culvert (E)										
Jul-12	--	--	--	--	--	--	--	--	--	--
Jul-12	--	--	--	--	--	--	--	--	--	--
Sep-12	< 0.003	< 0.05	1.01	22.98	< 0.009	0.02	0.29	0.03	--	< 0.07

Site ID	Cd	Sn	Sb	Ba	Ag	Tl	Pb	U	Hg	Li
ML Rain Events	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
18-Aug-11	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--
12-Jun-12	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--
27-Jul-12	--	--	--	--	--	--	--	--	--	--
29-Jul-12	--	--	--	--	--	--	--	--	--	--
25-Jul-12	--	--	--	--	--	--	--	--	--	--
4-Aug-12	--	--	--	--	--	--	--	--	--	--
7-Sep-12	< 0.001	0.85	0.08	36.00	< 0.003	< 0.0006	0.19	< 0.0007	--	< 0.07
ML Bulk Rain										
(April to June 2012)	--	--	--	--	--	--	--	--	--	--
(May - 18 July 2012)	--	--	--	--	--	--	--	--	--	--
(17 July - 1 Sept 2012)	< 0.001	2.67	0.30	8.43	0.22	< 0.0006	0.19	< 0.0007	--	< 0.07
2012	0.08	< 0.05	0.59	1.14	< 0.003	< 0.002	0.51	< 0.0007	--	< 0.07